# NATIONAL INVENTORY DOCUMENT 2026

# PORTUGAL

SUBMISSION UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

Lisboa,
April, 15th 2026

Agência para o Clima

Technical Reference

| | |
|---|---|
| Title | PORTUGUESE NATIONAL INVENTORY DOCUMENT ON GREENHOUSE GASES, 1990-2024<br><br>SUBMISSION UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE |
| Edition | Portuguese Climate Agency |
| Date | 15th April 2026 |
| Place | Lisboa |


Lead Authors:

| | |
|---|---|
| Teresa Costa Pereira | General Chapters and Cross-Cutting Issues / Waste |
| Mariana Moreira | Energy |
| Rita Silva | Industrial Processes and Product Use / Energy |
| Andrea Santos | Agriculture |
| Sílvia Catarino | Land Use, Land Use Change and Forestry |

To obtain a copy of this report, the Common Reporting Tables (CRT) tables or any other information concerning methodologies, activity data or emission factors, and to send comments and suggestions, please contact:

Agência para o Clima
Departamento de Alterações Climáticas (DAC)
Rua de "O Século", nº 51
1200-433 Lisboa – PORTUGAL
tel:+351 213 231 500
e-mail: geral@apclima.pt

Acknowledgements

The authors wish to express their appreciation to the Focal Points and the Involved Entities of the National System (SNIERPA) who have participated in the preparation of the Inventory, for their contribution with data, technical advice and to the continuous improvement of the inventory, in particular:

ANAC – Autoridade Nacional da Aviação Civil

APA/DRES – Agência Portuguesa do Ambiente / Departamento de Resíduos

APA/DRH – Agência Portuguesa do Ambiente / Departamento de Recursos Hídricos

DGAE – Direção Geral das Atividades Económicas

DGEG – Direção Geral de Energia e Geologia

DRAAC-A – Direção Regional do Ambiente e Alterações Climáticas / Secretaria Regional do Ambiente e Alterações Climáticas / Região Autónoma dos Açores

DRAAC-M – Direção Regional do Ambiente e Alterações Climáticas / Secretaria Regional do Ambiente, Recursos Naturais e Alterações Climáticas / Região Autónoma da Madeira

EDP – Energias de Portugal

GEE-ME – Gabinete de Estratégia e Estudos / Ministério da Economia e Mar

GPP – Gabinete de Planeamento, Políticas e Administração Geral / Ministério da Agricultura e Alimentação

IAPMEI - Agência para a Competitividade e Inovação

ICNF – Instituto da Conservação da Natureza e das Florestas

IFAP – Instituto de Financiamento da Agricultura e Pescas

IGP – Instituto Geográfico Português

IMT – Instituto da Mobilidade e dos Transportes

INE – Instituto Nacional de Estatística

INIAV – Instituto Nacional de Investigação Agrária e Veterinária

IST – Instituto Superior Técnico

REN – Redes Energéticas Nacionais

The authors also wish to express their appreciation to other Institutions whose contribution has been highly relevant to this report: Acail, ACAP, Aldifrio, Air Liquide, ANIMEE, APIGRAF, APSEI, Amkor Technology, Brenntag, Cimpor, EDP-Produção, EDP-Distribuição, E-REDES, Filipe Bela, Gasin, Linde, Infarmed, Secil, Siemens, EuPIA, ESIG, TENSAI.

# Preface

The Portuguese Climate Agency (*ApC - Agência para o Clima, I.P.*)/ Portuguese Ministry of Environment and Energy (*Ministério do Ambiente e Energia*), in accordance to its attributions of national entity responsible for the overall coordination and reporting of the Portuguese inventory of air pollutants emissions, annually prepares the National Inventory of Greenhouse Gas (GHGs) Emissions and Sinks in order to comply with the international commitments under the United Nations Framework Convention on Climate Change (UNFCCC) and the European Commission.

This report aims to comply with the international commitments under the UNFCCC and the European Commission (EU), taking into account the Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention agreed by the Conference of the Parties at its nineteenth session (decision 24/CP.19), and set out in document FCCC/CP/2013/10/Add.3 [1], and the requirements of Article 26 of the Regulation (EU) No 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, providing elements of the Portuguese National Inventory Document (NID) necessary for the preparation of the Community greenhouse gas inventory report.

An annual GHG inventory submission shall consist of a national inventory document (NID) and the common reporting tables (CRTs) as specified in the Annex of Decision 18/CMA.1, Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement FCCC/PA/CMA/2018/3/Add.2.

The present submission includes two parts:

1 – The National Inventory Document (the present document);

2 – CRT (Common Reporting Tables) data tables for the period 1990-2024, which were compiled with the ETF GHG inventory Tool (Metadata version 1.30.5);

[1] http://unfccc.int/resource/docs/2013/cop19/eng/10a03.pdf#page=2

# General Index

EXECUTIVE SUMMARY

1. Introduction
2. Trends in Portuguese GHG Emissions
3. Energy (CRT 1)
4. Industrial Processes and Product Use (CRT 2)
5. Agriculture (CRT 3)
6. Land-Use, Land-Use Change and Forestry (CRT 4)
7. Waste (CRT 5)
8. Other (CRT 6)
9. Indirect Carbon Dioxide and Nitrous Oxide Emissions
10. Recalculations and Improvements

LIST OF ACRONYMS

REFERENCES

ANNEXES

ANNEX A – Energy Balance

ANNEX B – Energy

ANNEX C – Agriculture

ANNEX D – Waste

ANNEX E – Key Category Analysis

ANNEX F – Uncertainty Assessment

ANNEX G – Identification of Organic Soils in Portugal

ANNEX H – Activity data for HWP

ANNEX I – WG1 Paper on guidance related to the reporting of indirect emissions

# EXECUTIVE SUMMARY

*Updated: March 2026*

- Portuguese greenhouse gas emissions without land-use, land-use change and forestry (LULUCF) totals 51.5 Mt $CO_2$ equivalent ($CO_2e$) in 2024, representing, respectively, a decrease of 12.6 %, 40.1 % and 3.0 % in relation to 1990, 2005 and 2023.
- When considering the LULUCF sector, emissions in 2024 totalled 52.1 Mt $CO_2e$, corresponding, respectively, to a 18.7 %, 42.9 % and 1.0 % decrease in relation to 1990, 2005 and 2023.
- The largest contributor to the Portuguese emissions is the Energy sector (65.6 % of total emissions in 2024), with transports being the prominent sub-sector amounting to 35.2 % of total emissions but presenting a decrease compared to 2023 (0.7 %).
- Total national emissions reduction is related in majority to the energy industries. This sub-sector registers, for many years, a sustained reduction due to development of renewables. This sector shows the biggest decrease (26.4 %) of emissions compared to 2023.
- In 2024, the renewable domestic electric production raised approx. 21 % over the previous year, because of a more favourable hydric availability and the resulting greater hydroelectric production (+ 25 %) and to the increase in the photovoltaic production (+10 %). The import balance of electricity raised (+ 2 %) compared to the previous year.
- In 2024, GDP registered a positive variation of + 2.1% compared to 2024. The carbon intensity of emissions in 2024 is 0.23 kt CO2 e./M €, representing a decrease of approx. 50% compared to 2005.

## ES 1. Background information

As a Party to the United Nations Framework Convention on Climate Change (UNFCCC), Portugal is requested to provide each year an update of its inventory of emissions and removals of greenhouse gas (GHG) not controlled by the Montreal Protocol. As a member of the European Union, the country is also required to report emission inventories data under Article 26 of the Regulation (EU) No 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action.

The GHG emission inventory is the official annual accounting of all anthropogenic (human-induced) emissions and removals of greenhouse gases in Portugal. The inventory measures Portugal's progress against obligations under the United Nations Framework Convention on Climate Change (Climate Change Convention) and the European Union agreements (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).

This report presents a description of the methods, assumptions and background data used in the preparation of the 2026 national inventory submission of GHG.

The period covered is 1990-2024.

The 2006 IPCC Guidelines (2006, IPCC) have been primarily applied. The 2019 IPCC Guidelines (2019, IPCC) have been utilized to the Waste Sector.

The GHG covered refer to emissions and removals of the carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride ($SF_6$) and nitrogen trifluoride ($NF_3$). The indirect GHG, carbon monoxide (CO), sulphur dioxide ($SO_2$), oxides of nitrogen ($NO_X$) and non-methane volatile organic compounds (NMVOCs) are also included.

The information is reported under the five large sectors: Energy; Industrial Processes and Product Use (IPPU); Agriculture; Land Use, Land-Use Change and Forestry (LULUCF); and Waste.

The inventory covers the whole Portuguese territory, i.e., mainland Portugal and the two Autonomous regions of Madeira and Azores Islands. Emission estimates from aviation and navigation that took place between all national areas are also included.

Changes in methodology, source coverage or scope of the data were reflected in the estimation of the emissions for all years in the period from 1990 to 2023, i.e., the inventory is internally consistent.

The Portuguese Climate Agency (*ApC - Agência para o Clima, I.P.*)/ Portuguese Ministry of Environment and Energy (*Ministério do Ambiente e Energia*), in accordance to its attributions of national entity responsible for the overall coordination and reporting of the Portuguese inventory of air pollutants emissions, annually prepares the National Inventory of Greenhouse Gas (GHGs) Emissions and Sinks in order to comply with the international commitments under the United Nations Framework Convention on Climate Change (UNFCCC) and the European Commission.

The current legal and institutional national arrangement, the Council of Ministers Resolution no. 20/2015 restructures and elaborates the previous legal framework on the National System (SNIERPA) to take into account the developments at international level relating to the UNFCCC and the Kyoto Protocol, and the monitoring and reporting requirements under the EU Regulations, as well as complementary internal adjustments.

## ES.2 Summary of national emissions and removal related trends

In 2024, total Portuguese GHG emissions, including indirect CO2, without land-use, land-use change and forestry (LULUCF) were estimated at about 51.5 Mt CO2e, representing a decrease of 12.6 % compared to 1990 levels, a variation of -40.1 % compared to 2005 levels, and -3.0 % compared to the previous year (2023).

When considering the LULUCF sector, the national level of emissions in 2024 totalled 52.1 Mt CO2e., corresponding to a 18.7 % decrease in relation to 1990, a reduction of 42.9 % comparing to 2005, and a reduction of 1.0 % from 2023 to 2024.

Throughout this report, emissions values are presented in CO2e using IPCC AR5 GWP values.

The reference to “total emissions” along the report is meant to refer to “total emissions without LULUCF, including CO2 indirect emissions”.

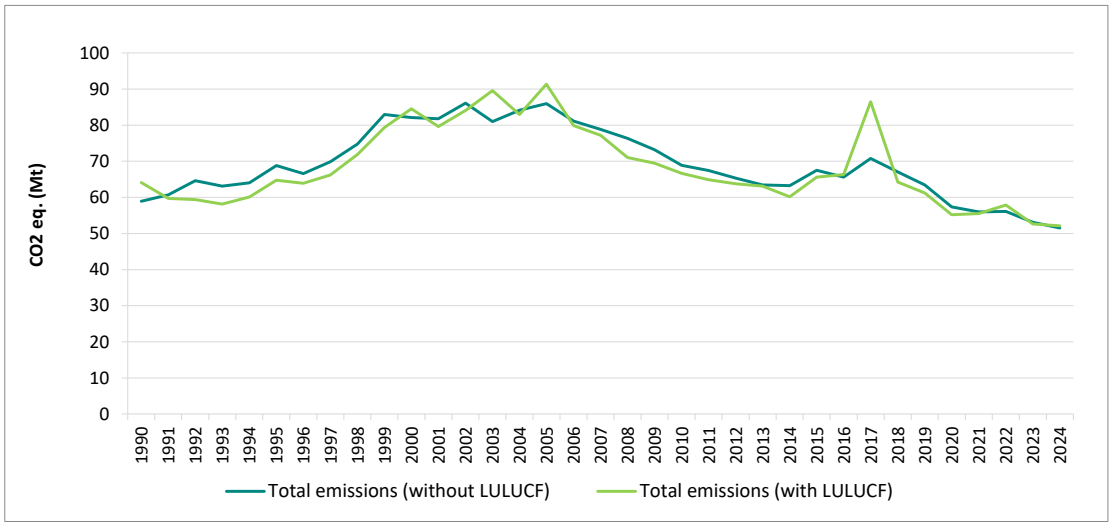



***Figure ES.1: GHG emissions***

National emissions developed rapidly during the 1990s, reflecting the evolution of the Portuguese economy, which was characterized by a strong growth associated with increased energy demand and mobility.

In the early 2000s, the growth of emissions has been more moderate and started to stagnate, registering thereafter, in particular after 2005, a decrease. This reduction is the result of the implementation of several measures such as the replacement of more polluting energy sources such as fuel oil with natural gas (introduced since 1997), the implementation of combined cycle power plants to NG (1999), the progressive installation of cogeneration units, the improvement of energy and technological efficiency of industrial processes, improvements in automobile efficiency (fleet renewal), and the improvement of fuels quality, among others.

These measures were accompanied by a continuous decline in energy consumption (both primary and final) verified in the country since 2005, with a significant expression in the period 2009-2013, fact that may be also explained by the internal economic recession, along with the European economic and financial crisis.

These years registered a slowdown of industrial activity and the cessation of some activities in the country such as black carbon production in 2013 and the production of ammonia in 2009 with the relocation of the production facilities.

In 2014 there was an inversion of this pattern. The evolution of the primary, and particularly, the final energy consumption trend increased, accompanying the positive evolution of the Portuguese economy.

The level of emissions shows, however, significant inter-annual variations, which are mostly occurring in the energy sector and are mainly related to the pronounced fluctuations of hydroelectric power generation that is highly affected by annual variations in precipitation.

The figure below illustrates the relative contribution of direct GHG to the total emissions for 1990 and 2024, showing $CO_2$ as the primary GHG, accounting for about 70 % of Portuguese emissions on a carbon equivalent basis in 2024 (LULUCF excluded). The second most important gas is $CH_4$, representing 19 % of total emissions in 2024.

Portugal has chosen 1995 as the base year for reporting fluorinated gases. In 2024, these gases represented about 4 % of total GHG emissions. $NF_3$ emissions are non-occurring in Portugal.

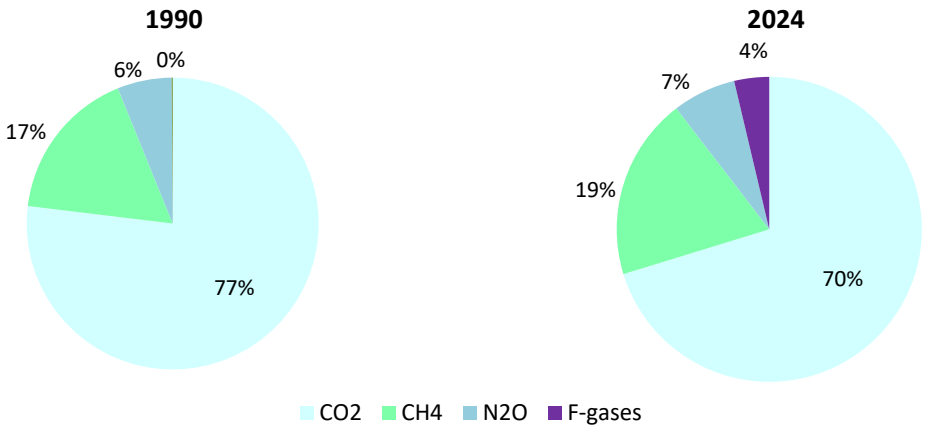



***Figure ES.2: GHG emissions by gas***

Over the 1990-2024 period, CO2, CH4 and N2O registered a reduction. F-gases have significantly increased in importance, particularly in latest years (around 2800 % since 1995).

*Table ES.1: GHG emissions and removals in Portugal by gas*

| GHGs EMISSIONS | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (Gg) | | | | | | | | | | | | | | | | | |
| CO2 emissions without net CO2 from LULUCF | 45,291 | 46,926 | 50,933 | 49,450 | 50,221 | 54,472 | 51,786 | 54,647 | 59,190 | 66,853 | 65,466 | 65,122 | 69,512 | 64,411 | 67,220 | 69,575 | 64,801 | 62,319 |
| CO2 emissions with net CO2 from LULUCF | 49,634 | 45,468 | 45,482 | 44,303 | 45,930 | 50,039 | 48,831 | 50,839 | 56,065 | 63,059 | 67,424 | 62,636 | 67,030 | 71,997 | 65,663 | 73,989 | 63,224 | 60,428 |
| CH4 emissions without CH4 from LULUCF | 9,979 | 10,126 | 10,136 | 10,153 | 10,299 | 10,521 | 10,780 | 11,032 | 11,296 | 11,629 | 11,893 | 11,873 | 11,842 | 11,812 | 11,809 | 11,641 | 11,539 | 11,366 |
| CH4 emissions with CH4 from LULUCF | 10,556 | 10,411 | 10,197 | 10,210 | 10,436 | 10,704 | 10,868 | 11,058 | 11,384 | 11,652 | 12,142 | 12,041 | 12,061 | 12,489 | 11,962 | 12,203 | 11,650 | 11,419 |
| N2O emissions without N2O from LULUCF | 3,547 | 3,521 | 3,484 | 3,400 | 3,395 | 3,552 | 3,749 | 3,813 | 3,857 | 3,968 | 4,173 | 4,071 | 3,991 | 3,879 | 4,175 | 3,745 | 3,652 | 3,831 |
| N2O emissions with N2O from LULUCF | 3,825 | 3,725 | 3,632 | 3,546 | 3,562 | 3,731 | 3,911 | 3,966 | 4,032 | 4,134 | 4,403 | 4,288 | 4,228 | 4,239 | 4,410 | 4,090 | 3,891 | 4,062 |
| HFCs | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | 54 | 76 | 136 | 203 | 291 | 372 | 473 | 556 | 645 | 706 | 807 | 916 | 1,072 |
| PFCs | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| SF6 | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | 12 | 13 | 13 | 13 | 14 | 14 | 14 | 15 | 17 | 18 | 19 | 20 | 19 |
| NF3 | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO |
| **Total (without LULUCF)** | **58,816** | **60,573** | **64,553** | **63,003** | **63,915** | **68,611** | **66,405** | **69,641** | **74,558** | **82,755** | **81,917** | **81,553** | **85,917** | **80,764** | **83,927** | **85,786** | **80,928** | **78,607** |
| **Total (with LULUCF)** | **64,014** | **59,603** | **59,310** | **58,059** | **59,928** | **64,540** | **63,699** | **66,012** | **71,697** | **79,149** | **84,356** | **79,453** | **83,890** | **89,387** | **82,758** | **91,107** | **79,702** | **77,001** |
| **Total (without LULUCF, with indirect)** | **58,910** | **60,664** | **64,650** | **63,100** | **64,063** | **68,794** | **66,577** | **69,840** | **74,750** | **82,948** | **82,100** | **81,747** | **86,109** | **80,973** | **84,142** | **85,990** | **81,131** | **78,815** |
| **Total (with LULUCF, with indirect)** | **64,107** | **59,694** | **59,407** | **58,156** | **60,076** | **64,723** | **63,871** | **66,211** | **71,890** | **79,343** | **84,539** | **79,647** | **84,083** | **89,596** | **82,973** | **91,311** | **79,905** | **77,209** |

| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | % change |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (Gg) | | | | | | | | | | | | | | | | | 1990-2024 |
| CO2 emissions without net CO2 from LULUCF | 59,929 | 57,061 | 52,861 | 51,738 | 49,796 | 48,055 | 47,802 | 52,130 | 50,218 | 55,071 | 51,245 | 47,479 | 41,646 | 40,173 | 40,591 | 37,595 | 36,097 | **-20.3** |
| CO2 emissions with net CO2 from LULUCF | 54,416 | 52,911 | 50,145 | 48,786 | 47,833 | 47,286 | 44,450 | 49,975 | 50,444 | 69,629 | 48,239 | 45,015 | 39,260 | 39,533 | 42,015 | 36,955 | 36,374 | **-26.7** |
| CH4 emissions without CH4 from LULUCF | 11,169 | 11,043 | 10,807 | 10,739 | 10,472 | 10,263 | 10,150 | 9,994 | 10,035 | 10,112 | 10,183 | 10,260 | 10,156 | 10,244 | 10,232 | 10,062 | 9,927 | **-0.5** |
| CH4 emissions with CH4 from LULUCF | 11,186 | 11,171 | 11,017 | 10,852 | 10,642 | 10,477 | 10,172 | 10,069 | 10,262 | 10,915 | 10,227 | 10,308 | 10,236 | 10,275 | 10,380 | 10,108 | 10,093 | **-4.4** |
| N2O emissions without N2O from LULUCF | 3,761 | 3,561 | 3,574 | 3,263 | 3,264 | 3,257 | 3,399 | 3,378 | 3,347 | 3,450 | 3,471 | 3,541 | 3,472 | 3,480 | 3,343 | 3,406 | 3,453 | **-2.7** |
| N2O emissions with N2O from LULUCF | 3,983 | 3,811 | 3,844 | 3,509 | 3,525 | 3,529 | 3,623 | 3,616 | 3,616 | 3,857 | 3,678 | 3,741 | 3,672 | 3,660 | 3,545 | 3,574 | 3,643 | **-4.7** |
| HFCs | 1,249 | 1,372 | 1,440 | 1,524 | 1,593 | 1,669 | 1,731 | 1,796 | 1,861 | 1,941 | 1,963 | 1,998 | 1,904 | 1,861 | 1,828 | 1,883 | 1,888 | – |
| PFCs | NO | NO | NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | – |
| Unspecified mix of HFCs and PFCs | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | – |
| SF6 | 18 | 19 | 20 | 14 | 15 | 16 | 16 | 15 | 16 | 17 | 15 | 14 | 13 | 14 | 15 | 16 | 14 | – |
| NF3 | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | – |
| **Total (without LULUCF)** | **76,126** | **73,057** | **68,702** | **67,276** | **65,140** | **63,260** | **63,099** | **67,313** | **65,476** | **70,591** | **66,876** | **63,292** | **57,191** | **55,772** | **56,009** | **52,962** | **51,379** | **-12.6** |
| **Total (with LULUCF)** | **70,852** | **69,284** | **66,466** | **64,684** | **63,608** | **62,976** | **59,992** | **65,470** | **66,199** | **86,359** | **64,122** | **61,076** | **55,085** | **55,343** | **57,782** | **52,537** | **52,012** | **-18.7** |
| **Total (without LULUCF, with indirect)** | **76,313** | **73,228** | **68,888** | **67,452** | **65,321** | **63,425** | **63,255** | **67,473** | **65,629** | **70,750** | **67,017** | **63,455** | **57,331** | **55,955** | **56,136** | **53,086** | **51,507** | **-12.6** |
| **Total (with LULUCF, with indirect)** | **71,039** | **69,455** | **66,652** | **64,860** | **63,789** | **63,142** | **60,149** | **65,630** | **66,353** | **86,518** | **64,262** | **61,239** | **55,224** | **55,527** | **57,909** | **52,661** | **52,140** | **-18.7** |

NA- Not applicable; NE - Not estimated; NO - Not occurring

## ES.3 Overview of source and sink category's emission estimates and trends

According to the UNFCCC Reporting Guidelines, emissions estimates are grouped into five large IPCC categories: Energy, Industrial Processes and Product Uses (IPPU), Agriculture, LULUCF, and Waste.

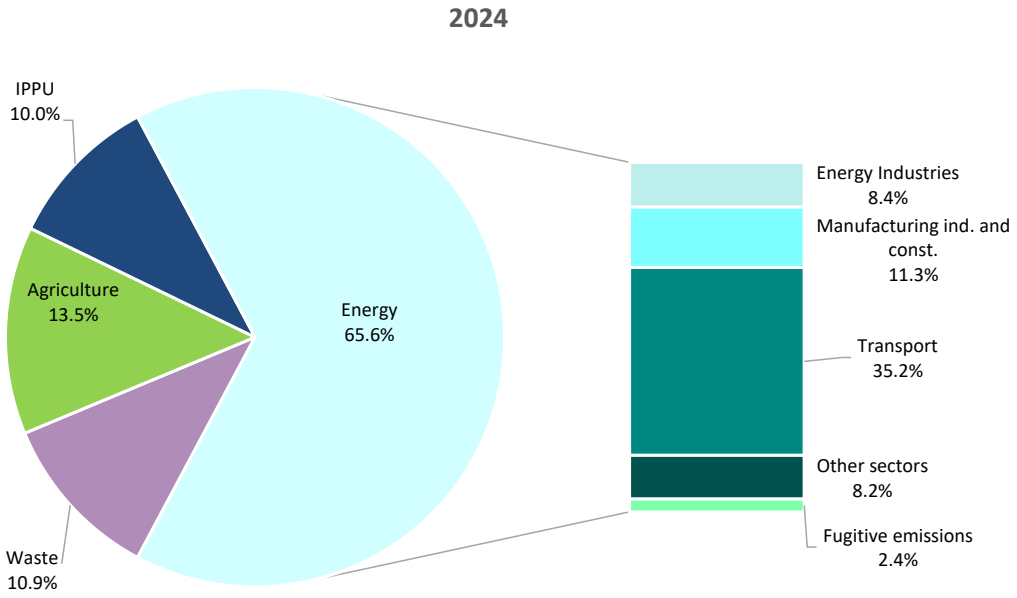



***Figure ES.3: GHG emissions in Portugal by sector (LULUCF excluded)***

Energy is by far the most important sector, accounting for approximately 65.6 % of total emissions in 2024 and registering a decrease of 17.2 % over the 1990-2024 period. Transport is the most important source representing 35.2 % of total emissions. Energy industries which were in the past one of the most prominent sources of emissions, have nowadays a lesser importance corresponding in 2024 to 8.4 % of total emissions.

Within the energy industries, public electricity and heat production represented 5.5 % of the total emissions in 2024. This sector reduced importance since 2017 (66 % reduction from 2017 to 2021), due to both the effect of the greater importance of renewables in electricity generation and to the shift from coal to natural gas in thermal energy production. The use of coal in electricity production ended definitively at the end of 2021.

In 2024, the renewable domestic electric production raised approx. 21 % over the previous year as a result of a balance between a more favourable hydraulic availability (IH = 1.16 compared to 0.99 in 2023) and consequently a greater hydroelectric production (+ 25 %), and an increase in the photovoltaic production (+37 %). Furthermore, the import balance of electricity raised (+ 2.3 %) compared to the previous year.

Mobile sources, which are largely dominated by road traffic, are one of the sectors that have risen faster since 1990, due to the steady growth of vehicle fleets (in particular with more powerful engines) and road travel from 1990 to the early 2000s, reflecting the increase in family income and the strong investment in the road infrastructure of the country in the 1990s and

2000-10s decades. Indirectly, the increase in road traffic activity also augments emissions from fossil fuel storage, handling and distribution. As previously mentioned, the situation stabilized in the early 2000s and started to decline in 2005. An inversion of this tendency is, however, registered in most recent years, with an increase in transport emissions since 2013.

Still within the energy sector, the category "other sectors", which include the residential and commercial activities, also registered a significant increase of emissions in the 1990-2004 period (74 %), but this tendency has decelerated (43 % decrease) since then, due to the implementation of energy efficiency measures.

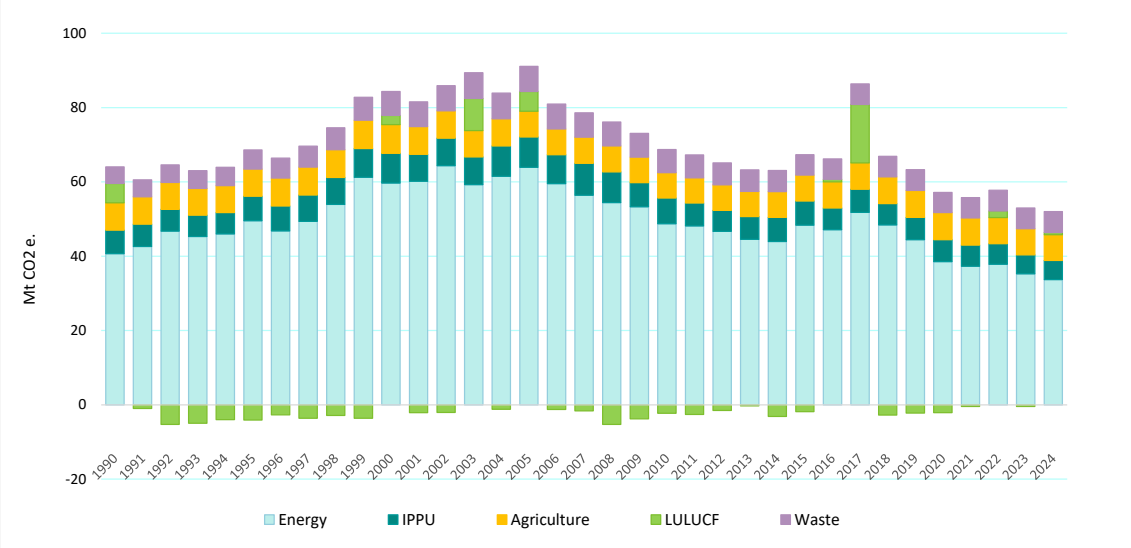



***Figure ES.4: GHG emissions and removals by sector***

Industrial processes represented about 10 % of the Portuguese emissions in 2024 and have decreased approximately 19 % since 1990. Emissions from this sector, which are generated as by-products of many non-energy-related activities, have been driven particularly until the mid-2000s by the evolution of the mineral and chemical industry. From the late 2000s onwards, chemical industry contribution has been reduced significantly, mainly due to end of ammonia production in the country. On the other hand, Products Uses as ODS substitutes (2F and 2G) have progressively gained importance in IPPU sector, representing about 37% of total IPPU emissions in 2024.

Agriculture was, in the period analysed, a significant source of GHG emissions, responsible for 13.5 % of the Portuguese emissions in 2024, corresponding to a decrease of 6.0 % since 1990. This fact is related to the reduction in the livestock production of certain categories of animals (sheep and swine) and more recently of dairy cattle. Furthermore, the extensification of bovine (non-dairy cattle) production and the decreased consumption of fertilizers which relates in a certain extent to the conversion of arable crops to pasture also contributes to this trend. However, since the mid-2000s, particularly after 2011, this downward trend was reversed, registering since then a growing tendency until 2020 (+ 7.0% emissions variation from 2011-2020), supported mainly by a significant increase in the population of non-dairy cattle, sheep and poultry. The sector registers since 2020 a negative variation (- 5.2 % from 2020 to 2024).

Waste represented approximately 11 % of Portuguese emissions in 2024 and increased 26.6 % since 1990. The sector recorded, an expressive increase of emissions until 2004 (approximately 57 %). This increase is primarily related to the rise of waste generation (associated with the development of household income and the growth of urbanization recorded in the country during the 1990s) and the deposition of waste predominantly in landfills. The reduction in emissions in the following years is associated to biogas recovery in waste and the promotion of Mechanical and Biological Treatment with the aim to divert urban waste from landfilling and the increase of recycling. Emissions are estimated to increase 1.2% since 2015 as a result namely to the increase of WWTP with tertiary treatment (N removal). Portugal implemented for the EU submission of March 2024 the methodological approach proposed by the 2019 IPCC Refinements, which represents a major change compared with the 2006 IPCC Guidance for the Wastewater Treatment sub-sector. The main revision refers to the N2O emissions, which underwent a profound change leading to a greater importance. In fact, while in the previous guidelines (IPCC, 2006) N2O emissions in WWTPs were considered almost negligible, with this approach, N2O emissions have a bigger importance. CH4 emissions also recorded a significant revision and include now the emissions that occur after the discharge of wastewater into the water environment, where previously only N2O emissions were accounted for. The change in the estimation methodology and the consideration of some emission factors substantially changed the level of emissions associated with this subsector in relation to previous submissions.

Estimates of emissions and sinks from land use change and forestry category show that this sector has changed from being a net emitter in 1990 (5.2 Mt CO2 eq.) to a carbon sink in 1991. This situation was again reverted in the years 2000, 2003 and 2005 due to the severe forest wildfires events registered in these years. In 2017, this sector became a net emitter again, with a total of 15.8 Mt CO2e., representing 18.2 % of the country´ total emissions including the sector for that year. This situation was related to an exceptional and tragic year in terms of forest wildfires, associated to an exceptional dry year, high temperatures, occurring namely outside the normal summer period (biggest wildfires took place in June and October). Unusual strong winds also occurred, namely Ophelia hurricane, which swept the coast of the Iberian Peninsula in October 2017, a phenomenon that can be related to climate change.

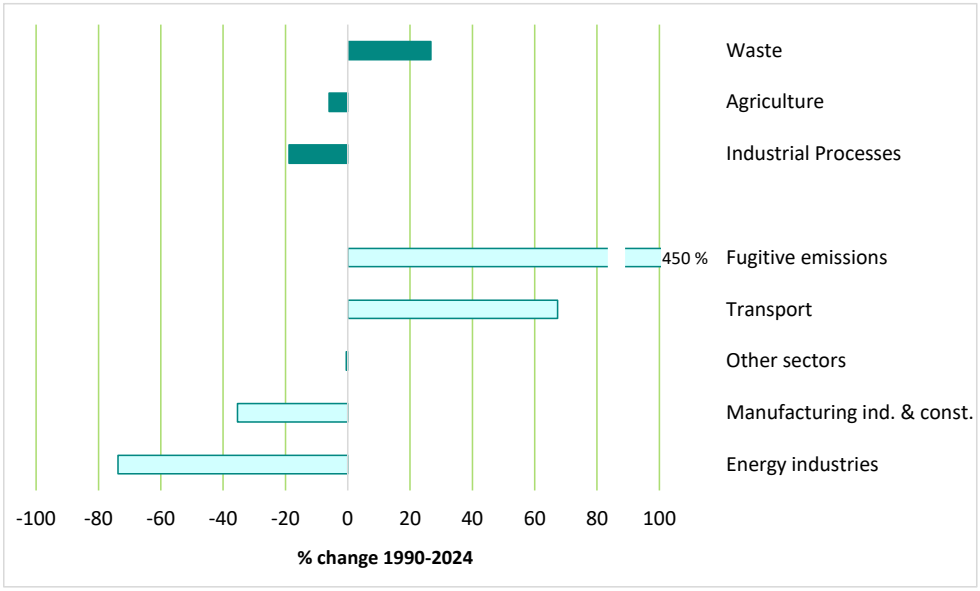



***Figure ES.5: GHG emissions' percentage change (1990-last available year) by IPCC category (LULUCF excluded)***

***Table ES.2: GHG emissions and removals by sector***

| GHGs SOURCE AND SINK CATEGORIES | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (Gg) | | | | | | | | | | | | | | | | | |
| 1. Energy | 40,683 | 42,612 | 46,768 | 45,299 | 45,996 | 49,563 | 46,797 | 49,368 | 53,922 | 61,261 | 59,717 | 60,175 | 64,340 | 59,239 | 61,525 | 63,913 | 59,525 | 56,432 |
| 2. Industrial processes and product use | 6,346 | 5,998 | 5,832 | 5,727 | 5,739 | 6,604 | 6,733 | 7,127 | 7,274 | 7,717 | 7,990 | 7,236 | 7,435 | 7,512 | 8,161 | 8,161 | 7,815 | 8,571 |
| 3. Agriculture | 7,358 | 7,388 | 7,272 | 7,214 | 7,241 | 7,294 | 7,486 | 7,514 | 7,473 | 7,606 | 7,723 | 7,476 | 7,354 | 7,073 | 7,281 | 6,947 | 6,898 | 7,018 |
| 4. Land use, land-use change and forestry (4) | 5,198 | -970 | -5,243 | -4,944 | -3,987 | -4,071 | -2,706 | -3,629 | -2,861 | -3,605 | 2,439 | -2,100 | -2,026 | 8,623 | -1,169 | 5,322 | -1,226 | -1,607 |
| 5. Waste | 4,429 | 4,575 | 4,681 | 4,762 | 4,939 | 5,150 | 5,389 | 5,632 | 5,889 | 6,171 | 6,487 | 6,667 | 6,787 | 6,940 | 6,960 | 6,764 | 6,690 | 6,586 |
| 6. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |

| GHGs SOURCE AND SINK | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | % change 1990-2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (Gg) | | | | | | | | | | | | | | | | | |
| 1. Energy | 54,456 | 53,309 | 48,759 | 48,163 | 46,678 | 44,533 | 43,960 | 48,351 | 47,113 | 51,787 | 48,394 | 44,421 | 38,553 | 37,314 | 37,818 | 35,269 | 33,703 | **-17.2** |
| 2. Industrial processes and product use | 8,265 | 6,463 | 6,894 | 6,145 | 5,685 | 6,130 | 6,503 | 6,525 | 5,893 | 6,220 | 5,772 | 6,031 | 5,910 | 5,666 | 5,564 | 5,112 | 5,148 | **-18.9** |
| 3. Agriculture | 6,967 | 6,904 | 6,836 | 6,794 | 6,821 | 6,782 | 6,921 | 6,940 | 6,981 | 7,095 | 7,177 | 7,276 | 7,299 | 7,293 | 7,015 | 7,003 | 6,918 | **-6.0** |
| 4. Land use, land-use change and forestry (4) | -5,274 | -3,773 | -2,236 | -2,592 | -1,532 | -283 | -3,107 | -1,843 | 723 | 15,768 | -2,755 | -2,216 | -2,107 | -429 | 1,773 | -425 | 633 | **-87.8** |
| 5. Waste | 6,438 | 6,380 | 6,213 | 6,176 | 5,956 | 5,814 | 5,715 | 5,497 | 5,489 | 5,489 | 5,533 | 5,563 | 5,429 | 5,498 | 5,612 | 5,578 | 5,609 | **26.6** |
| 6. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | **NO** |

NA- Not applicable; NE - Not estimated; NO - Not occurring

## ES.4 Other information

Several gases do not have a direct influence in climate change but affect the formation or destruction of other GHG. CO, NOx, and NMVOC are precursor substances for ozone, which is a GHG. SOx contributes to the formation of aerosols, which are extremely small particles or liquid droplets that can also affect the absorptive characteristics of the atmosphere.

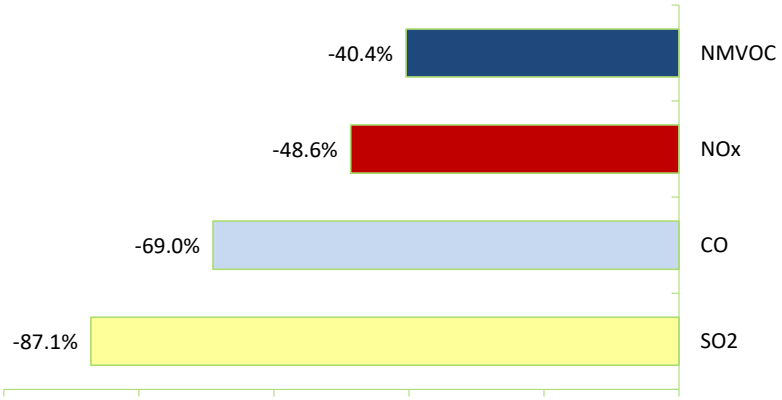



***Figure ES.6: Indirect GHG and $SO_x$ emissions: 1990-last year available variation***

In 2024, emissions from all these gases have decreased compared to 1990 levels as previous figure shows.

Energy sector is the most responsible for emissions of NOx, SOx and CO. Its contribution for NMVOC emissions is also significant, together with IPPU sector.

Within energy, transportation is responsible for the largest share of $NO_x$ emissions, approx. 48 % of 2024 totals. Despite the fast-growing trends of the transport sector (mainly road) since the 90s, the introduction of new petrol-engine passenger cars with catalysts converters and stricter regulations on diesel vehicles emissions, resulted in the limitation of the growth of these emissions or even in their decrease. In fact, the situation started to shift in the mid-2000s, as transport emissions growth has first stabilized and started to decline since 2005. In the most recent years, the situation has been inversed with an increase of emissions after 2013. In the reporting period, 1990-2024, $NO_x$ emissions from transport decreased 40 %; and CO and NMVOC emissions registered reductions of more than 80 %. Other sectors (commercial/institutional, residential and agriculture/forestry) is a primary source of CO emissions representing approx. 42 % of the 2024 totals.

$SO_x$ emissions are mainly generated in the energy industry sector (approximately 32 % of total emissions in 2024) and combustion in manufacturing industries (approximately 42 % of total emissions in 2024), which are major consumers of fossil fuels. In the past, oil and coal represented the biggest share of the fuel mix used in thermal electrical production in the country. The situation shifted along the years with the significant development of renewable sources and its greater importance in electrical production, and the introduction of new stricter laws regulating the residual fuel oil (Decree-Law No. 281/2000, 10$^{th}$ November). The introduction of natural gas and its increasing use since 1997 was a major step in the control of $SO_x$ emissions. In 2024, natural gas represented the main fuel used in electric thermal generation.

The period 1990-2024 shows, in fact, a decrease in $SO_x$ emissions in both sub-categories: energy industries (-94 %) and manufacturing industries (-78 %). Since 2007, $SO_x$ emissions from energy

industries registered a significant reduction (approximately 88 %), which is explained by the implementation of new abatement systems (desulfurization in two Large Point Source Energy Plants in Mainland Portugal).

The decline in emissions in electricity production in latest years is the result of the phase-down in the use of coal in thermal production which was definitively phased-out at the end of 2021 with the closure of the last Portuguese coal thermal plant (Pego), and the greater proportion of the renewable domestic production (without hydric) which grew more than 1000 % from 2005 to 2024, mainly due to development of wind power.

***Table ES.3: Indirect GHG and SOx emissions: 1990-2024***

| Gas emissions | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (Gg) | | | | | | | | | | | | | | | | | |
| CO | 775 | 786 | 815 | 787 | 791 | 798 | 771 | 752 | 723 | 691 | 656 | 610 | 590 | 565 | 537 | 501 | 468 | 441 |
| NOx | 256 | 270 | 291 | 281 | 279 | 291 | 273 | 275 | 288 | 299 | 292 | 290 | 296 | 272 | 275 | 277 | 255 | 245 |
| NMVOC | 354 | 358 | 360 | 338 | 339 | 330 | 340 | 351 | 356 | 362 | 359 | 341 | 335 | 318 | 305 | 290 | 275 | 268 |
| SO2 | 318 | 308 | 367 | 310 | 288 | 322 | 263 | 275 | 322 | 331 | 294 | 277 | 277 | 185 | 188 | 189 | 165 | 157 |

| Gas emissions | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | % change 1990-2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (Gg) | | | | | | | | | | | | | | | | | |
| CO | 404 | 380 | 369 | 347 | 332 | 313 | 297 | 302 | 289 | 288 | 270 | 278 | 248 | 277 | 243 | 243 | 240 | **-69.0** |
| NOx | 228 | 216 | 199 | 182 | 168 | 164 | 162 | 164 | 156 | 159 | 154 | 149 | 132 | 133 | 133 | 132 | 132 | **-48.6** |
| NMVOC | 252 | 229 | 235 | 221 | 212 | 214 | 224 | 229 | 213 | 215 | 225 | 227 | 231 | 223 | 227 | 227 | 211 | **-40.4** |
| SO2 | 104 | 72 | 62 | 57 | 52 | 48 | 43 | 45 | 45 | 46 | 47 | 44 | 38 | 39 | 41 | 41 | 41 | **-87.1** |

# 1 Introduction

## Table of Contents


1 Introduction ..... 1-1

1.1 Background information on greenhouse gas inventories and climate change ..... 1-3

1.1.1 Global warming and climate change ..... 1-3

1.1.2 Climate change in Portugal ..... 1-3

1.1.3 The Convention, the Kyoto Protocol, the Paris Agreement and national commitments ..... 1-5

1.1.4 History of national inventories ..... 1-7

1.1.5 Greenhouse gas emissions inventories ..... 1-9

1.1.6 Global warming potentials ..... 1-9

1.2 Institutional arrangements for inventory preparation ..... 1-10

1.2.1 National Inventory System ..... 1-10

1.2.2 Overview of inventory planning ..... 1-14

1.3 Inventory Preparation Process ..... 1-16

1.3.1 Responsibility ..... 1-16

1.3.2 Calculation, data archiving and documentation system ..... 1-16

1.4 General overview of methodologies and data sources used ..... 1-17

1.5 Brief description of key source categories ..... 1-21

1.6 Information on QA/QC ..... 1-22

1.7 General uncertainty evaluation, including data on the overall uncertainty for the inventory totals 1-25

1.8 Overview of the completeness ..... 1-25

1.9 Reporting on consistency of the reported data on air pollutants (CO, $SO_2$, NOx and NMVOC) .. 1-25

1.10 Comparison of the sectoral approach with the reference approach ..... 1-26

1.11 Future developments ..... 1-26

# List of Figures

Figure 1.1: Mean air temperature anomalies, by decades, in Portugal Mainland ..... 1-4
Figure 1.2: Precipitation anomalies, by decades, in Portugal Mainland ..... 1-4
Figure 1.3: SNIERPA's main elements relations ..... 1-11
Figure 1.4: Main bodies of national system (SNIERPA) ..... 1-13
Figure 1.5: Electronic System Structure of the estimation and reporting system ..... 1-17
Figure 1.6: Comparison between MMR and NECD estimates on air pollutants ..... 1-26

# List of Tables

Table 1.1: Global Warming Potentials (100-year time horizon) ..... 1-10
Table 1.2: Calendar for the inventory process ..... 1-15
Table 1.3: Summary of methods and emission factors (CRT summary 3 table) ..... 1-18
Table 1.4: Main data sources used in the Portuguese inventory ..... 1-20
Table 1.5: Overview of key categories (without LULUCF) using Approach 1 and 2 for 1990 and 2022 inventory year ..... 1-21
Table 1.6: Overview of key categories (with LULUCF) using Approach 1 and 2 for 1990 and latest inventory year ..... 1-22

# 1 Introduction

*Updated: March 2026*

## 1.1 Background information on greenhouse gas inventories and climate change

### 1.1.1 Global warming and climate change

Although key greenhouse gases - $CO_2$, $CH_4$, $N_2O$, Ozone – occur naturally in the atmosphere, human activities have increased their atmospheric concentrations since the pre-industrial era. Other substances which are exclusively produced by industrial activities are also greenhouse gases: stratospheric ozone depleting substances (CFCs, HCFCs and halons, which are covered by the Montreal Protocol), and some other fluorine-containing halogenated substances – hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride ($SF_6$), and nitrogen trifluoride ($NF_3$) - do not deplete stratospheric ozone but are potent greenhouse gases. These latter substances are considered by the UNFCCC and accounted for in national greenhouse gas inventories.

There are also several gases that do not have a direct effect in global warming but affect the formation or destruction of other GHG. CO, $NO_x$, and NMVOCs are precursor substances for ozone which is a GHG. $SO_x$ contributes to the formation of aerosols, which are extremely small particles or liquid droplets that can also affect the absorptive characteristics of the atmosphere.

Land-Use and Land-Use Change, particularly deforestation, is another factor that contributes to the phenomenon of global warming and climate change, as it changes carbon stocks and carbon sequestration and, consequently, the $CO_2$ fluxes from and to the atmosphere.

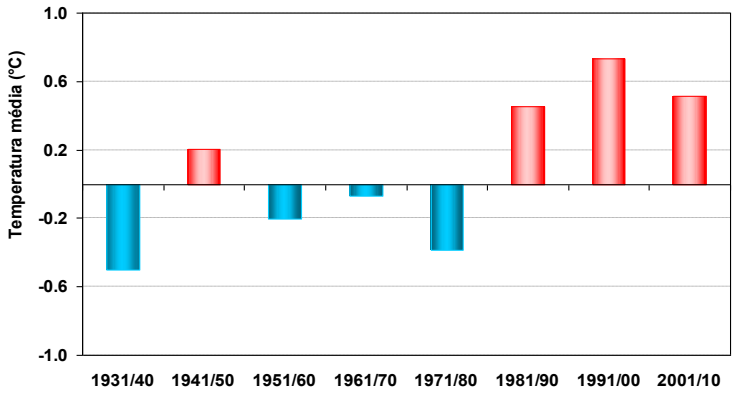
According to the IPCC, the average surface temperature of the earth has risen by about 0.6-0.7°C in the past 100 years and will rise by another 1.4-5.8°C in the next 100 years, depending on the GHG's emissions scenario.

An increase in global temperatures can result in a cascade of environmental effects, including the rise of sea level and changes in the amount and pattern of precipitation. These changes may increase the frequency and intensity of extreme weather events, such as floods, droughts, heat waves, hurricanes, and tornados. Other consequences include higher or lower agricultural yields, glacial retreat, reduced summer stream flows, extinction of species and increases in the ranges of disease vectors.

### 1.1.2 Climate change in Portugal

The mean temperature has risen in all regions of Portugal since the 1970s, at a rate of approximately 0.3 ºC per decade. The time-series analysis of the mean annual temperature since 1931 shows that 1997 was the warmest year, and the five warmest years occurred after the 1990s. The year of 2017 is the second warmest of the last 88 years and is among the four driest since 1931, with the average annual total precipitation around 60 % of the normal levels.

In Portugal Mainland, the decade of 1991/2000 was the warmest (next figure).



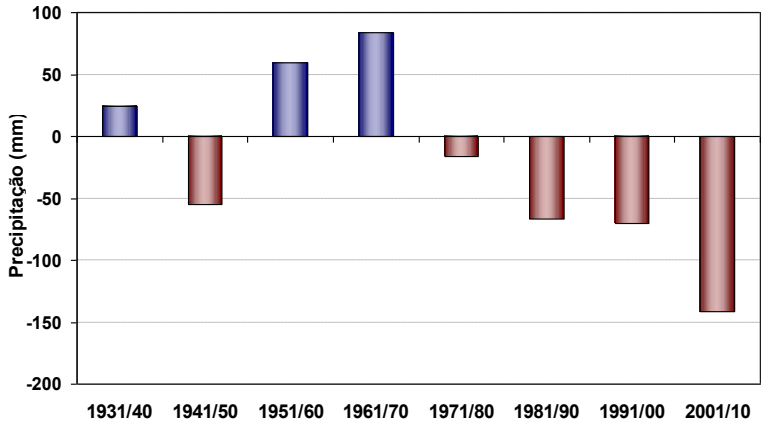

Source: IPMA, 2013

***Figure 1.1: Mean air temperature anomalies, by decades, in Portugal Mainland***

Also, an observation of temperature indexes indicates that the increase of the mean temperature was accompanied by a change in the frequency of very hot days and a decrease in the frequency of very cold ones.

The heat wave duration index has also been rising. Heat waves are defined when, in a period of at least 6 consecutive days, the daily maximum temperature is 5 ºC higher than the daily mean value of the reference period (1961-1990). Although they can occur at any time of the year, heat waves have a more significant impact in the summer months. Heat waves were more frequent in the 1990s. The heat waves of 1981, 1991, 2003 and 2006 were of particular significance due to their duration and spatial extension.

The last 2 decades of the 20$^{th}$ century were particularly dry in mainland Portugal, as opposed to the average values registered between 1961 and 1990. In fact, only in 6 of the last 20 years of the past century the annual precipitation was higher than the average. In 2001 and 2002, however, the annual precipitation values were higher than the average observed in the reference period. The driest of the past 75 years was 2005, and 2004 was the second driest on record. The first decade of the 21$^{st}$ century (2001/2010) was the driest since 1932 (next figure).




Source: IPMA, 2013

***Figure 1.2: Precipitation anomalies, by decades, in Portugal Mainland***

The seasonal trend in the mean precipitation values recorded since 1931 shows a systematic and statistically significant reduction in precipitation in the spring over the last three decades of the 20th century, with slight increases during the other seasons. In 2000 and 2001, spring precipitation rose to values not observed since the late 1960s.

Annual variability of winter precipitation increased over the last 30 years, with the occurrence of both drier and rainier winters. The winter of 2000/2001 was particularly rainy (the third most rainy of the last 30 years), and winter of 2001/2002 was the fifth driest of the last 3 decades. The winter of 2004/2005 was the driest winter observed in the last 75 years. The autumn of 2006 was the third most rainy since 1931.

All models from the different scenarios forecast a significant increase in the mean temperature for all regions of Portugal until the end of the 21st century. In the mainland, summer maximum temperature increases are estimated to vary between 3 ºC and 7 ºC in coastal and interior areas, respectively, accompanied by a strong increment in the frequency and intensity of heat waves.

With regards to precipitation, future climatic uncertainty is considerably stronger. Nevertheless, most models project a reduction in total precipitation in all regions, with more intense periods of rain in shorter time frames in the winter.

### 1.1.3 The Convention, the Kyoto Protocol, the Paris Agreement and national commitments

The United Nations Framework Convention on Climate Change (UNFCCC) was created as an answer of the international community to the emerging evidence of climate change and was adopted and opened for signature in Rio de Janeiro in 1992.

The ultimate objective of the Convention is the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." Portugal ratified the UNFCCC on May 31st, 1994.

The Kyoto Protocol (KP), adopted some years later in 1997, represented a deepening in the commitments inscribed in the Convention. The Protocol introduced legally binding commitments for developed countries to reduce their collective emissions of greenhouse gases by at least 5 % by the period 2008-2012 (first commitment period of the Protocol), below their 1990 level.

Portugal signed and ratified the KP on the April 29th, 1998, and May 31st, 2002, respectively. The EU agreed to an 8 % reduction. Under the EU burden-sharing agreement Portugal is committed to limiting its emissions during the first commitment period to no more than +27 % compared to the 1990 level.

The KP entered into force on February 16th, 2005, after Russia's ratification in November 2004 which fulfilled the requirement that at least 55 Parties to the Convention, including developed countries accounting for at least 55 % of that group's $CO_2$ emissions in 1990.

Detailed rules for the implementation of the Protocol were set out at the 7th Conference of the Parties (in Marrakech) and are described in the Marrakech Accords adopted in 2001. At the first Conference of the Parties serving as the Meeting of the Parties to the Protocol (COP/MOP) held in Canada (December 2005) the rules for the implementation of the Protocol agreed at COP7 were adopted.

In Doha, Qatar, on 8 December 2012, the Doha Amendment to the Kyoto Protocol was adopted. This launched a second commitment period, starting on 1 January 2013 until 2020, with a revised list of GHG to be reported and necessary updates for several articles of the Kyoto Protocol.

For the second commitment period, Parties committed to reduce GHG emissions by at least 18 % below 1990 levels in the eight-year period from 2013 to 2020. The EU and its Member States have committed to this second phase of the Kyoto Protocol and established to reduce their collective emissions to 20 % below their levels in 1990 or other chosen base years. The target was fulfilled jointly with Iceland.

The 2015 Paris Agreement, adopted in Paris on 12 December 2015, marks the latest step in the evolution of the UN climate change regime and builds on the work undertaken under the Convention. The Paris Agreement charts a new course in the global effort to combat climate change for the period after 2020.

The Paris Agreement's central aim is to strengthen the global response to the threat of climate change by holding the increase in the global average temperature to well below 2 ºC above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 ºC above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change. It also sets the goal of increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production. Finally, it also sets the goal of making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.

The Paris Agreement entered into force on 4 November 2016, thirty days after the date on which at least 55 Parties to the Convention accounting in total for at least an estimated 55 % of the total global greenhouse gas emissions have deposited their instruments of ratification.

In this framework, the European Union and its Member States are committed to a binding target of at least a 55% GHG reduction by 2030 compared to 1990 levels, including the Land Use, Land-Use Change and Forestry (LULUCF) sector. At the European level, this emission reduction target is divided between the sectors subject to the Emission Trading System (ETS) and non-ETS sectors, respectively, as a 62% reduction and a 40% reduction below the 2005 levels.

Portugal is committed to achieve in 2030 an overall reduction of 28.7% in emissions compared to 2005 levels for the sectors and categories included in the EU Effort Sharing Regulation (ESR). Regarding Land use, Land-Use Change, and Forestry (LULUCF) the commitments were revised by the Regulation (EU) 839/2023 LULUCF: fixing the Portuguese target for 2030 for a net removal equal to, at least, -1.4 Mt CO2 eq.

In 2016, following the ratification of the Paris Agreement, Portugal assumed the compromise to achieve net-zero emissions by the end of 2050 and established the 2050 Carbon Neutrality Roadmap (RNC 2050) that outlined a trajectory of -45 % to -55 % GHG emissions´ reduction by 2030, -65 % to -75 % by 2040 and -85 % to -90 % by 2050. It identifies the main decarbonisation vectors in all sectors (energy and industry, mobility and transport, waste and wastewater and agriculture and forests) and the path to reduce all GHG emissions under different scenarios of socio-economic development.

RNC 2050 is the Portuguese Long-term Strategy and was submitted to the UNFCCC, in accordance with the Paris Agreement, on the 20th of September 2019, and to the European Commission. Aligned with the long-term strategy Portugal also developed an integrated National Energy and Climate Plan (NECP 2030), that is the main instrument of energy and climate policy for the 2021-2030 decade.

Furthermore, the Portuguese Climate Law has entered into force on February 1, 2022, and it recognizes the climate emergency, confirms the commitment to achieve climate neutrality by 2050 and stipulates the study, by 2025, of the anticipation of this target to 2045. It also establishes national emission reduction targets, in line with previously established trajectories in RNC 2050, stipulating reductions of, at least, 55% by 2030; 65% to 75% by 2040; at least 90% by 2050; and a net CO2 eq sink of the LULUCF sector by at least 13 million tonnes between 2045 and 2050.

### 1.1.4 History of national inventories

Air emission inventories in Portugal were only initiated in the late 80s, early 90s when the first estimates of $NO_x$, $SO_x$ and VOC emissions from combustion were made under the development of the National Energetic Plan (PEN - Plano Energético Nacional), and emissions from combustion and industrial processes were made under OECD inventory and under CORINAIR85 programme. A major breakthrough occurred during the CORINAIR90 inventory done during 1992 and 1993 by the General-Directorate of Environment (DGA, presently the Portuguese Environment Agency -APA). This inventory exercise, aiming also to respond to EMEP and OECD/IPCC, extended the range of the pollutants ($SO_x$, $NO_x$, NMVOC, $CH_4$, CO, $CO_2$, $N_2O$ and $NH_3$) and emission sources covered, including not only combustion activities but also storage and distribution of fossil fuels, production processes, use of solvents, agriculture, urban and industrial waste and nature (forest fires and NMVOC from forest). Information received under the Large Combustion Plant (LCP) directive was also much helpful to improve inventory quality and the individualization of Large Point Sources, as well as statistical information received from the National Statistical Institute (INE) allowing the full coverage of activity data for most emission sources. The CORINAIR90 Default Emission Factors Handbook (second edition), updating the first edition from CORINAIR85 was used extensively in the development of the current inventory and it was also a key point in the amelioration of the inventory.

The fulfilment of international commitments under the UNFCCC and CLRTAP conventions, together with the publication of the IPCC Draft Guidelines for National Greenhouse Gas Inventories (IPPC, 1995) and latter of the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 1997), resulted in substantial improvement of the methodologies that are used in the inventory, particularly for agriculture and waste, and that were included by the first time in the First National Communication in 1994.

The inventory that resulted from CORINAIR90 (CEC, 1992) and subsequent modifications from IPCC methodology still structures the present-day methodology in what concerns activity data and methodology. Under the evaluation of the first communication the inventory was subject to a review made by an international team. All national communications up until the present day (last was the 8$^{th}$ National Communication, submitted in 2021) were also reviewed by international experts. These exercises had an important role in problem detection and contribute to overall improvement.

Since its first compilation, the Portuguese inventory has been continuously amended mainly due to the use of more detailed methodologies, better access to underlying data allowing the development of the comprehensiveness of the inventory, and better database storage and calculation structure.

Changes in methodology, source coverage or scope of the data were reflected in the estimation of the emissions for the different years considered, i.e., the inventory is internally consistent.

Some major studies have contributed to the improvement of the inventory:

- Study of VOC emissions in Portugal, in 1995. This study made in collaboration with FCT college (Faculdade de Ciências e Tecnologia) led to an important improvement in emission estimates from solvent sector, which is still used as basic information source for this sector;

- Study of Emission and Control of GHG in Portugal (Seixas et al, 2000). This project aimed the first development of projections toward 2010 and the identification of control measures to accomplish the Kyoto Protocol. This also led to improvements in the inventory: extension of the inventory including for the first time also carbon dioxide sinks (forest); a fist attempt to estimate solid waste methane emissions from urban solid wastes using a Tier 2 approach and, in general terms, a better insight into additional parameters used in the inventory methodologies, and that has resulted from interaction with several

institutional agents: General Directorate of Energy, Ministry of Agriculture; and the inter-ministerial transport group;

- Study for the quantification of carbon sinks in Portugal (Pereira *et al.*, 2002), made under the development of PNAC and PTEN national programmes;
- Revision of the Energy Balances with comparison of information collected at APA (LCP Directive) and Statistical Information received at DGEG: Energy Balances. The 1990s – DGE (2003);
- PNAC 2004 (National Plan for Climate Change) approved by Ministers Council and published recently in the National Official Journal (OJ nº 179, 31 July 2004, I Série B/ Resolução do Conselho de Ministros nº 119/2004);
- PNAC 2006 (National Plan for Climate Change) approved by Ministers Council and published in the National Official Journal (OJ nº 162, 23 August 2006, I Série B/ Resolução do Conselho de Ministros nº 104/2006);
- Sectoral Studies and Proposal for a PTEN (National Plan on Emission Ceilings);
- PNALE (National Plan for Allocation of Emissions) 2005-2007 or Portuguese PNALE I, adopted by Ministers Council (Resolução do Conselho de Ministros n.o 53/2005) and published in the National Official Journal (OJ No.44, 3 March 2005, I Série B);
- Bilateral meetings (APA/UE) for the determination of the Baseline Scenario under the CAFE program (APA, 2004);
- Methodological Development Plan (PDM) under the implementation of the National Inventory System;
- UNFCCC reviews, in particular the in-depth review (September/October 2004), and the centralised reviews (October 2005 and September 2008);
- UNFCCC in-depth review of the Initial Report in May 2007 which fixed the Assigned Amount for the first commitment period;
- 2012 technical review of the greenhouse gas emission inventory of Portugal to support the determination of annual emission allocations under Decision No.406/2009/EC;
- UNFCCC in-depth review of the 2012 greenhouse gas emission inventory in September 2012;
- UNFCCC centralised review of the 2013 and 2014 greenhouse gas emission inventory in September 2013 and 2014;
- 2016 EU comprehensive review of national greenhouse gas inventory data pursuant to Article 19(1) of Regulation (EU) No.525/2013;
- UNFCCC centralised review of the 2015 and 2016 greenhouse gas emission inventory in September 2016;
- 2017 and 2018 Comprehensive Technical Reviews of National Emission Inventories pursuant to the Directive on the Reduction of National Emissions of Certain Atmospheric Pollutants (Directive (EU) 2016/2284);

- UNFCCC in-depth review of the 2018 greenhouse gas emission inventory in September 2018;
- 2020 Comprehensive Review of National Greenhouse Gas Inventory Data pursuant to Article 4(3) of Regulation (EU) No.2018/842 and to Article 3 of Decision No.406/2009/EC;
- UNFCCC centralised review of the 2020 greenhouse gas emission inventory in October 2020;
- 2021 annual review of national greenhouse gas inventory data pursuant to Article 19(2) of Regulation (EU) No.525/2013;
- UNFCCC centralised review of the 2022 greenhouse gas emission inventory in October 2022.

### 1.1.5 Greenhouse gas emissions inventories

Parties to the Convention (Article 4(1)(a)) "shall develop, periodically update, publish and make available to the COP (…), national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies".

Portugal, as a Party to the Convention, is required to produce and regularly update National Greenhouse Gas Inventories. Furthermore, Parties shall submit a National Inventory Document (NID) containing detailed and complete information on their inventories, in order to ensure the transparency of the inventory.

The inventory covers the 6 gaseous air pollutants included in Annex A to the Kyoto Protocol: carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), hydrofluorocarbons (HFC), perfluorocarbons (PFCs), sulphur hexafluoride ($SF_6$), and nitrogen trifluoride ($NF_3$), as well as estimates for indirect GHGs, including carbon monoxide (CO), nitrogen oxides ($NO_x$), and non-methane volatile organic compounds (NMVOC). Data are also reported for sulphur oxides ($SO_x$). Emissions are estimated for each civil year since 1990.

As a general rule, the inventory covers emissions occurring in the whole Portuguese territory, i.e., mainland Portugal and the two autonomous regions of Madeira and Azores Islands. Emissions from aviation and navigation occurred within national territory, including movements between the Mainland and the Islands, are also included in national emissions´ total.

The economic sectors covered are the following: energy production and transformation, combustion in industry, domestic, agriculture, fisheries, institutional and commerce sectors, transportation (road, rail, maritime and air), industrial production and use of solvents, waste production, disposition and treatment (urban, industrial and hospitals solid wastes, and domestic and industrial waste water), agriculture, animal husbandry emissions, as well as emissions and removals from forestry and land use change.

### 1.1.6 Global warming potentials

A Global Warming Potential (GWP) is defined as the cumulative radiative forcing over a specified time horizon resulting from the emission of a unit mass of gas relative to some reference gas (IPCC, 1997).

The reference gas used is $CO_2$. The mass emission of each gas multiplied by its GWP gives the equivalent emission of the gas as carbon dioxide equivalents ($CO_2$ e). The Parties to the UNFCCC have agreed to use GWPs based on a 100-year time horizon.

The present GWP considered are the values proposed by the *IPCC Fifth Assessment Report* (AR5) (IPCC 2014) as required by the revised UNFCCC reporting guidelines.

***Table 1.1: Global Warming Potentials (100-year time horizon)[1]***

| GHG | SAR | AR4 | AR5 |
|---|---|---|---|
| CO2 | 1 | 1 | 1 |
| CH4 | 21 | 25 | 28 |
| N2O | 310 | 298 | 265 |
| HFC-23 | 11 700 | 14 800 | 12 400 |
| HFC-32 | 650 | 675 | 677 |
| HFC-43-10mee | 1 300 | 1 640 | 1 650 |
| HFC-125 | 2 800 | 3 500 | 3170 |
| HFC-134a | 1 300 | 1 430 | 1 300 |
| HFC-152a | 140 | 124 | 138 |
| HFC-143a | 3 800 | 4 470 | 4 800 |
| HFC-227ea | 2 900 | 3 220 | 3 350 |
| HFC-236fa | 6 300 | 9 810 | 8 060 |
| CF4 | 6 500 | 7 390 | 6 630 |
| C2F6 | 9 200 | 12 200 | 11 100 |
| C3F8 | 7 000 | 8 830 | 8 900 |
| C4F10 | 7 000 | 8 860 | 9 200 |
| C6F14 | 7 400 | 9 300 | 7 910 |
| SF6 | 23 900 | 22 800 | 23 500 |
| NF3 | NA | 17 200 | 16 100 |

Source: IPCC Fourth Assessment Report (AR4) (IPCC 2007); IPCC Fifth Assessment Report (AR5) (IPCC 2014)

## 1.2 Institutional arrangements for inventory preparation

### 1.2.1 National Inventory System

No major changes occurred in the national inventory system and the institutional arrangements since the 2025 submission.

The current legal national arrangement for a National Inventory System was adopted in 2015 (Council of Ministers Resolution No.20/2015). It builds on the previous version (Council of Ministers Resolution No.68/2005), which has been revised and reorganized to take into account the developments at international level relating to the UNFCCC and the Kyoto Protocol, and the monitoring and reporting requirements provided at the EU level by Regulation (EU) 525/2013 of the European Parliament and of the Council of 21 May 2013, on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change, that has been repealed by Regulation (EU) No 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action and the requirements under the CLRTAP and the NECD.

The 2015 Council of Ministers Resolution, restructures and elaborates the previous legal framework on the National System (SNIERPA), specifying its 4 different components:

i) a calculation and archiving system of the national inventory;
ii) the QA\QC System;
iii) the Methodological development Plan (PDM);
iv) the Archiving System.

[1] https://www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf

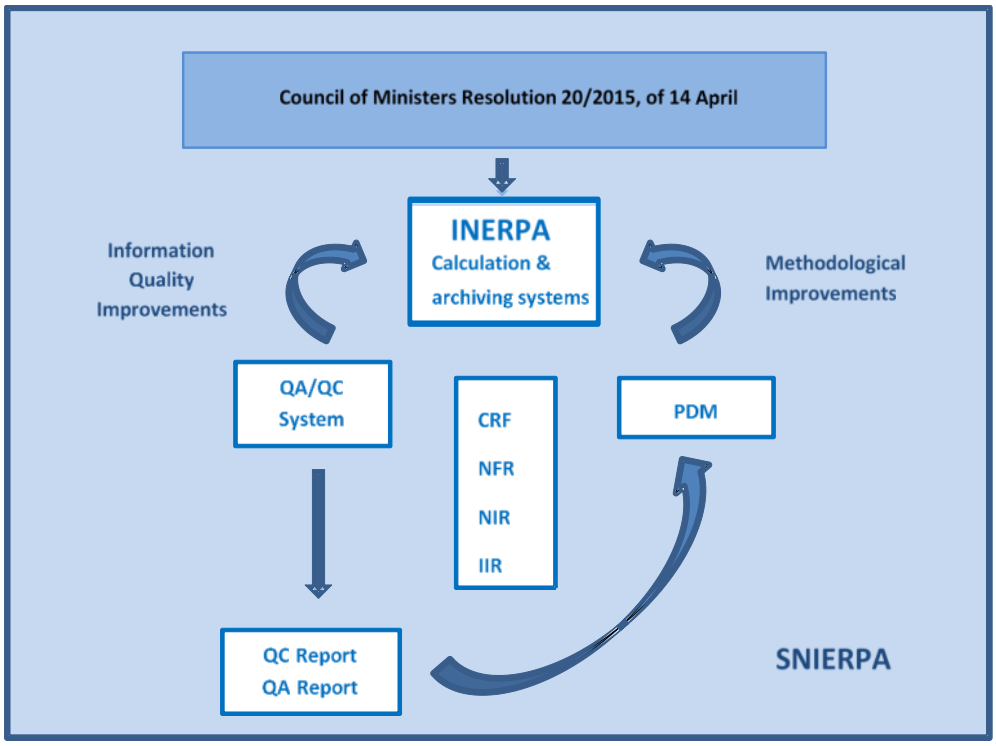



***Figure 1.3: SNIERPA's main elements relations***

Furthermore, it identifies the several outputs and formats of reporting to the international bodies, and specifies the functions of the entities making part of SNIERPA:

i) the coordinating entity;
ii) the Sectoral Focal Points;
iii) the entities involved.

Following the recent reorganization of Portugal's national climate governance framework, as established by Decree-Law No 122/2024 of 31 December, which created the Portuguese Climate Agency (Agência para o Clima, I.P.), and by its statutes approved through Ordinance No 248-A/2025 of 30 May, the responsibility for the preparation of the National Inventory of Greenhouse Gas (GHGs) Emissions and Sinks has been transferred from the Portuguese Environment Agency (Agência Portuguesa do Ambiente, I.P.) to the Climate Agency.

In accordance with Article 4(f) of Decree-Law No. 122/2024, the Portuguese Climate Agency is designated as the competent authority for the National System for Emissions by Sources and Removals by Sinks of Atmospheric Pollutants (SNIERPA). The Climate Agency is responsible for the technical and methodological coordination of the inventory, as well as for ensuring institutional cooperation among the entities involved in the inventory process, in line with Portugal's reporting obligations under Regulation (EU) 2018/1999 and with UNFCCC.

Therefore, ApC is, since January 2025, the coordinating entity responsible for the overall coordination and updating of the National Emissions Inventory (INERPA); the inventory's approval, after consulting the sectoral focal points and the involved entities; and its submission to the European Commission, the UNFCCC and other international bodies under which Portugal has reporting obligations, in the several communication and information formats, thus ensuring compliance with the adopted requirements and directives.

ApC´s Climate Change Department (DAC) is the unit responsible for the general administration of the inventory and for all aspects related to its compilation, reporting and quality management. ApC is the Responsible Body that assures the overall coordination and updating of the National Emissions Inventory

(INERPA); the inventory's approval, after consulting the Focal Points and the involved entities; and its submission to EC and international bodies to which Portugal is associated, in the several communication and information formats, thus ensuring compliance with the adopted requirements and directives.

ApC´s Climate Change Department (DAC) is the unit responsible for the general administration of the inventory and for all aspects related to its compilation, reporting and quality management.

Data from different sources is collected and processed by the inventory team, who is also responsible for the application of QA/QC procedures, the assessment of uncertainty and key category analysis, the compilation of the CRT tables and the preparation of the NID, the response to the review processes and data archiving and documentation.

The Sectoral Focal Points work with ApC/DAC in the preparation of INERPA and are responsible for fostering intra and inter-sectoral cooperation to ensure a more efficient use of resources. Their main task includes coordinating the work and participation of the relevant sectoral entities over which it has jurisdiction. It is also the Focal Points duty to provide expert advice on methodological choice, emission factor determination and accuracy of the activity data used. Focal Points play a vital role in sectoral quality assurance and methodological development. They are also responsible to produce statistical information and data publication that are used in the inventory estimates.

The involved entities are public or private bodies which generate or hold relevant information to INERPA, and which actions are subordinate to the Focal Points or directly to the Responsible Body.

All governmental entities have the responsibility to ensure, at a minimum, co-funding of the investment needed to ensure the accuracy, completeness and reliability of the emissions inventory.

Following the publication of the Council of Ministers Resolution No. 20/2015 of 14 April, which restructured the SNIERPA, a set of implementing procedures were agreed within SNIERPA to facilitate the good functioning of the national system, defining in more detail some competences, such as the regularity of the meetings and the deadlines for the information´ transmission, among other issues.

The following figure presents the main entities that are part of the national system.

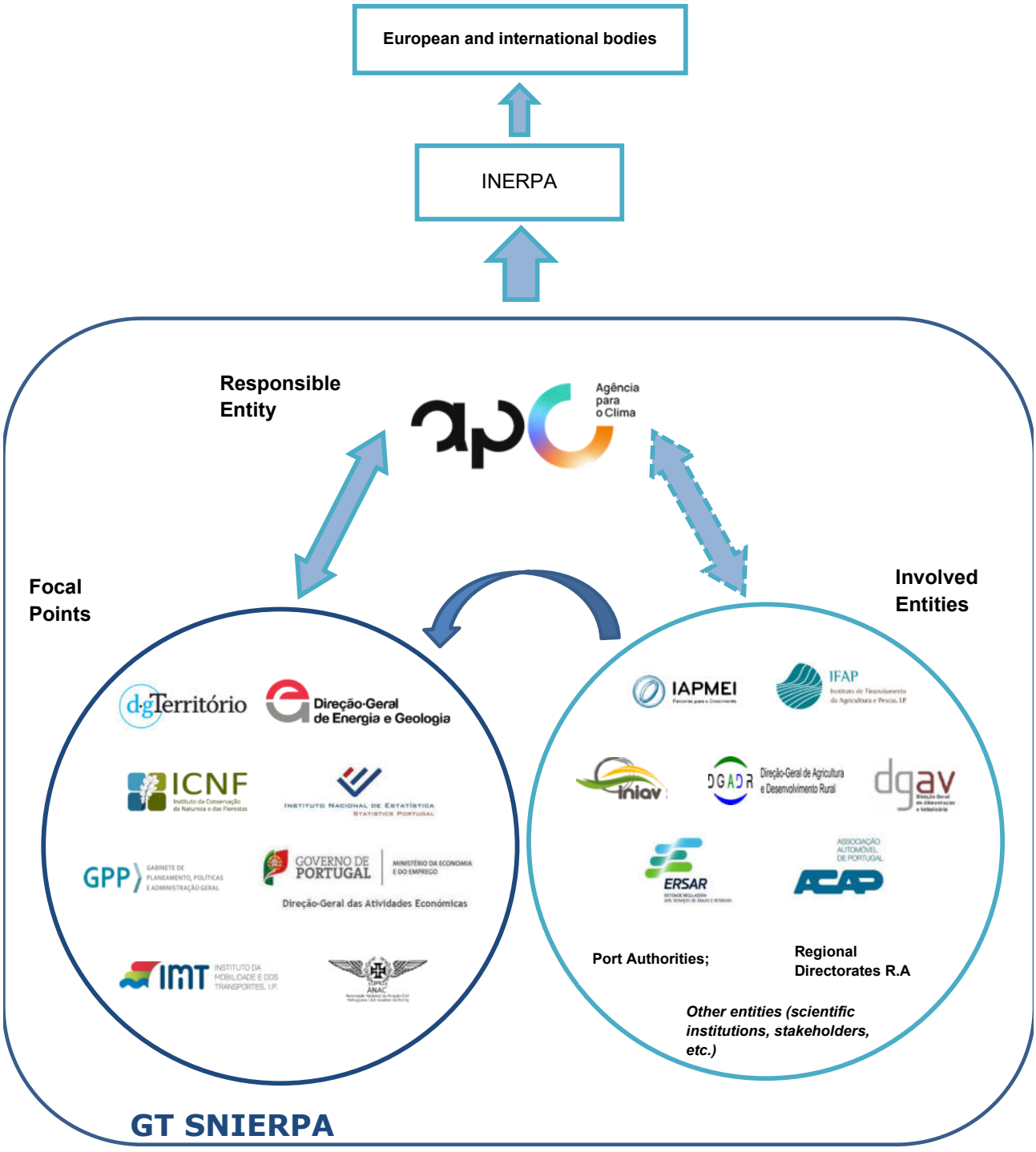



*Figure 1.4: Main bodies of national system (SNIERPA)*

### 1.2.2 Overview of inventory planning

All the participating organizations represented in SNIERPA support the annual production of the national inventories and the fulfilment of the reporting requirements.

Future planned improvements are compiled annually for each sector by the relevant inventory experts and the inventory coordinator, having as a basis the issues raised and the recommendations from the annual review processes and the problems identified from the application of QA/QC procedures, as well as future new reporting obligations. All identified items are gathered in a Methodological Development Plan (PDM – Plano de Desenvolvimento Metodológico) which is updated every year. A priority level is attributed to each issue identified, considering their importance in terms of the contribution to total GHG emissions, the level of uncertainty associated and the economic and technical resources available.

Each year, typically in June according to the agreed calendar of INERPA, ApC, as coordinator of SNIERPA, organizes a kick-off meeting to plan and launch, in coordination with the sectoral focal points and the involved entities, the work for the following inventory submission(s). Bilateral meetings occur as necessary as consequence of this meeting aiming at discussing the specific issues related to each sector and to agree on the actions to be implemented in the framework of SNIERPA during this inventory compilation regarding the next submission.

The following table presents the overall calendar of the INERPA's elaboration process, which includes four main phases: planning, compilation, QA/QC verification and improvement (PDM activities).

***Table 1.2: Calendar for the inventory process***

| Date | Task | Process | Tasks |
|---|---|---|---|
| May - June | - Elaboration of QA/QC plan<br>- Definition/update of inventory development priorities (PDM) | Inventory Planning | - setting of quality objectives<br>- identification of priorities taking into account the latest reviews and QA/QC checks |
| June | Kick-off meeting of SNIERPA WG for the launch of the annual inventory work | Inventory Planning | - discussion of the QA/QC plan<br>- discussion and of the inventory development priorities (PDM) |
| June - December | - end September: deadline for rotine data collection/ delivery by FP and/or IE to the APA<br>- end October: deadline for the implementation of Methodological Development Plan (PDM) improvements | Inventory Compilation/ Improvement/ Verification | - approval of the QA/QC plan and of the PDM<br>- collection of activity data and EFs update<br>- implementation of methodological improvements<br>- estimation of emissions/ removals<br>- aplication of QA/QC checks<br>- uncertainty and KC assessment<br>- archiving of information<br>- preparation of submissions by the inventory team |
| *15 January* | *Preliminary CRF and Short NIR submission to EC (DG CLIMA) [Monitoring Mech. of GHG under EU]* | *Reporting* | - |
| | Preparation of NFR submission | Inventory Verification/ Improvement | - aplication of QA/QC checks<br>- implementation of corrections and late data updates |
| *14 February* | *Official consideration/approval of the NFR submission to UNECE [CLRTAP]* | *Approval* | *Approval by President of ApC* |
| *15 February* | *Official NFR submission to NECD [EU] and UNECE [CLRTAP]* | *Reporting* | - |
| | - Revision of CRF submission<br>- Preparation of NIR and IIR<br>- Circulation of NIR and IIR comments among FP and/or IE | Inventory Verification/ Improvement | - aplication of QA/QC checks<br>- implementation of corrections and late data updates |
| 9 March | - Deadline for NIR and IIR comments from FP and/or IE | Inventory Verification | - |
| *14 March* | *Official consideration/approaval of the CRF and NIR submission to EC (DG CLIMA) [Monitoring Mech. of GHG under EU]* | *Approval* | *Approval by President of ApC* |
| *15 March* | *Submission of CRF and NIR (final versions) to the EC (DG CLIMA) [Monitoring Mech. of GHG under EU]* | *Reporting* | - |
| *15 March* | *Submission of IIR to NECD [EU] and UNECE [CLRTAP]* | *Reporting* | - |
| | - Implementation of QA/QC checks | Inventory Verification | - aplication of QA/QC checks including the NIR |
| *15 April* | *Submission of CRF and NIR (final version) to the UNFCCC [UNFCCC]* | *Reporting* | - |

## 1.3 Inventory Preparation Process

### 1.3.1 Responsibility

As referred in section 1.2.1, ApC/DAC is the national entity responsible for the overall coordination of the Portuguese inventory of air pollutants emissions. According to these attributions, ApC reports an annual compilation of the Portuguese Inventory of air emissions which includes GHG's sources and sinks, acidifying substances as well as other pollutants. The reporting obligations to the EU and the international instances are also under the responsibility of ApC.

The designated representative is:

Agência para o Clima

Departamento de Alterações Climáticas (DAC)

Address: Rua de "O Século", 51, 1200-433 Lisboa, Portugal

Telephone: +351 213 231 500

Contact: Joana Veloso – joana.veloso@apclima.pt (Head of Department)

### 1.3.2 Calculation, data archiving and documentation system

The emissions' calculations have been performed by ApC/DAC. However, many other institutions and agencies contributed to the inventory process, providing activity data, sectoral expert judgment, technical support and comments. All calculation and reporting rely in a set of different Excel spreadsheet workbooks which had been developed in order that all information and calculations occur automatically. The structure of the information system is outlined in figure below.

The information received from the several data suppliers is stored in its original format (paper or digital). A copy of this information is converted into the working workbooks, where data is further processed, linkage made and calculations performed, maintaining hence the integrity of the original data sources.

The IT system has been developed to answer to the various international obligations and national needs. At present, the different demands refer to: UNFCCC (CRT format); UNECE/CLRTAP (NFR format); LCP Directive (NFR format); as well as national needs such as the State of Environment Reports. There is independency between emission calculations and the required structure necessary for each obligation which allows flexibility in the inventory.

In what refers to the maintenance of the annual inventory documentation, the information is archived in a way that enables each inventory estimate to be fully documented and reproduced if necessary. When major changes are done in methodology and emission factors, and particularly after a reporting cycle, the older spreadsheets are frozen and work restarts with copies of those spreadsheets, making a clear reference to the period when they were used. Minor corrections, which do not affect the estimations, are not stored due to storage area limitations.

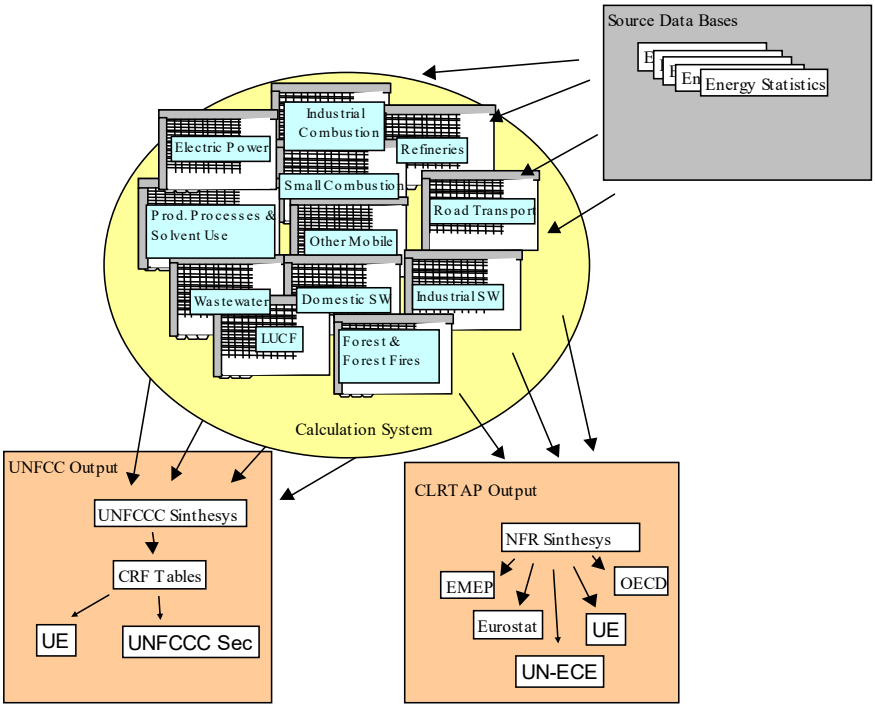



***Figure 1.5: Electronic System Structure of the estimation and reporting system***

All the inventory material, calculation files and reported tables, as well as the underlying data, the scientific documentation and studies used are stored and archived electronically, on a data server located at the ApC premises where the inventory team key is located. All data are backed up daily. Hence, the present system existing in ApC is considered to ensure the basic requirements/functions of an IT system: centralized data processing and storage.

The archiving system includes also the documentation related to the explanation of the inventory compilation and calculation process. In the latest years an effort has been made by the inventory team in order to better document and explain the calculation process and data sources used and procedures applied during an annual cycle for each sector. The several documents produced are stored in the inventory IT area, enabling a smoother transmission of knowledge and facilitation the continuity of the inventory compilation process in case of changes within the inventory team.

## 1.4 General overview of methodologies and data sources used

Methodologies are consistent with the IPCC Guidelines (IPCC, 1997; IPCC, 2000; IPCC, 2003; IPCC, 2006, IPCC, 2019) and EMEP/EEA Guidebooks (EMEP/CORINAIR, 2007; EMEP/EEA, 2009; EMEP/EEA, 2013; EMEP/EEA, 2016; EMEP/EEA 2019; EMEP/EEA 2023).

The table below gives an overview of the methodologies and emission factors used in the inventory. Default methods and emission factors used and the choice between Tier 1 and Tier 2 approaches, were case by case dictated by the availability of proper background information and from national circumstances.

*Table 1.3: Summary of methods and emission factors (CRT summary 3 table)*

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$ | | $CH_4$ | | $N_2O$ | | HFCs | | PFCs | | $SF_6$ | | Unspecified mix of HFCs and PFCs | | $NF_3$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Method applied | Emission factor | Method applied | Emission factor | Method applied | Emission factor | Method applied | Emission factor | Method applied | Emission factor | Method applied | Emission factor | Method applied | Emission factor | Method applied | Emission factor |
| **1. Energy** | ,NE,NO,T1,T2,T3 | 'S,D,NE,NO,OTH,PS | CR,NO,OTH,T1,T2,T3 | CR,D,NO,OTH,PS | O,OTH,T1,T2,T3 | CR,D,NO,OTH,PS | | | | | | | | | | |
| A. Fuel combustion | NE,NO,T1,T2,T3 | 'S,D,NE,NO,OTH,PS | NO,T1,T2,T3 | CR,D,NO,OTH,PS | O,OTH,T1,T2,T3 | CR,D,NO,OTH,PS | | | | | | | | | | |
| 1. Energy industries | T1,T2,T3 | CR,D,PS | T1,T2 | CR,D | T1,T2 | CR,D | | | | | | | | | | |
| 2. Manufacturing industries and construction | T1,T2,T3 | CR,D,PS | T1,T2,T3 | CR,D,PS | T1,T2,T3 | CR,D,PS | | | | | | | | | | |
| 3. Transport | NE,T1,T2,T3 | D,NE,OTH | T1,T2,T3 | CR,D,OTH | OTH,T1,T2,T3 | D,OTH | | | | | | | | | | |
| 4. Other sectors | NO,T1,T2 | CS,D,NO | NO,T1,T2 | D,NO,OTH | NO,T1,T2 | D,NO,OTH | | | | | | | | | | |
| 5. Other | T1 | D | T1 | D | T1 | D | | | | | | | | | | |
| B. Fugitive emissions from fuels | D,NO | D,NO | CR,NO,OTH | CR,NO,OTH | D,NO | D,NO | | | | | | | | | | |
| 1. Solid fuels | | | NO | NO | | | | | | | | | | | | |
| 2. Oil and natural gas | D,NO | D,NO | CR,NO,OTH | CR,NO,OTH | D,NO | D,NO | | | | | | | | | | |
| C. $CO_2$ transport and storage | | | | | | | | | | | | | | | | |
| **2. Industrial processes** | CR,NO,T1,T2,T3 | 'R,CS,D,NO,OTH,PS | D,NO | CR,NO,OTH | D,T1 | D,PS | NO,T2 | D,NO | NO,T2 | D,NO | NO,T1 | NO | NO | NO | NO | NO |
| A. Mineral industry | T1,T3 | OTH | | | | | | | | | | | | | | |
| B. Chemical industry | NO | NO | D,NO | CR,NO,OTH | D | PS | | | | | | | | | | |
| C. Metal industry | NO,T1,T3 | D,NO,PS | | | | | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | CR,NO,T2 | CR,CS,NO,OTH | NO | NO | | | | | | | | | | | | |
| E. Electronic industry | | | | | | | | | | | | | | | | |
| F. Product uses as ODS substitutes | | | | | | | NO,T2 | D,NO | NO,T2 | D,NO | NO | NO | NO | NO | NO | NO |
| G. Other product manufacture and use | | | | | T1 | D | NO | NO | NO | | T1 | NO | | | | |
| H. Other | | | | | | | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | T1 | D | T1,T2 | CS,D | T1,T2 | CS,D | | | | | | | | | | |
| A. Enteric fermentation | | | T1,T2 | CS,D | | | | | | | | | | | | |
| B. Manure management | | | T2 | CS,D | T2 | CS,D | | | | | | | | | | |
| C. Rice cultivation | | | T1 | CS,D | | | | | | | | | | | | |
| D. Agricultural soils[3] | | | | | T1,T2 | CS,D | | | | | | | | | | |
| E. Prescribed burning of savannas | | | | | | | | | | | | | | | | |
| F. Field burning of agricultural residues | | | T1,T2 | D | T1,T2 | D | | | | | | | | | | |
| G. Liming | T1 | D | | | | | | | | | | | | | | |
| H. Urea application | T1 | D | | | | | | | | | | | | | | |
| I. Other carbon-containing fertilizers | | | | | | | | | | | | | | | | |
| J. Other | | | | | | | | | | | | | | | | |
| **4. Land use, land-use change and forestry** | CS,D,T2 | CS,D | D | D | D | D | | | | | | | | | | |
| A. Forest land | CS,T2 | CS,D | D | D | D | D | | | | | | | | | | |
| B. Cropland | | | D | D | D | D | | | | | | | | | | |
| C. Grassland | | | D | D | D | D | | | | | | | | | | |
| D. Wetlands | | | | | | | | | | | | | | | | |
| E. Settlements | | | | | | | | | | | | | | | | |
| F. Other land | | | | | | | | | | | | | | | | |
| G. Harvested wood products | D | D | | | | | | | | | | | | | | |
| H. Other | | | | | | | | | | | | | | | | |
| **5. Waste** | T1,T2 | CS,D | T1,T2 | CS,D | D,T1 | CS,D | | | | | | | | | | |
| A. Solid waste disposal | | | T2 | CS,D | | | | | | | | | | | | |
| B. Biological treatment of solid waste | | | T1 | D | T1 | D | | | | | | | | | | |
| C. Incineration and open burning of waste | T1,T2 | CS,D | T1 | D | T1 | D | | | | | | | | | | |
| D. Waste water treatment and discharge | | | T2 | CS,D | D | CS,D | | | | | | | | | | |
| E. Other | | | T1 | D | T1 | D | | | | | | | | | | |
| **6. Other** ***(as specified in summary 1.A)*** | | | | | | | | | | | | | | | | |

Use the following notation keys to specify the method applied:

**D** (IPCC default) **T1a, T1b, T1c** (IPCC Tier 1a, Tier 1b and Tier 1c, respectively) **CR** (CORINAIR) **M** (model)
**RA** (Reference Approach) **T2** (IPCC Tier 2) **CS** (Country Specific)
**T1** (IPCC Tier 1) **T3** (IPCC Tier 3) **OTH** (Other)

If using more than one method within one source category, list all the relevant methods. Explanations regarding country-specific methods, other methods or any modifications to the default IPCC methods, as well as information regarding the use of different methods per source category where more

Use the following notation keys to specify the emission factor used:

**D** (IPCC default) **CS** (Country Specific) **OTH** (Other)
**CR** (CORINAIR) **PS** (Plant Specific) **M** (model)

One of the primary sources of information used for the energy sector is the Energy Balances, produced annually by the General Direction of Energy (DGEG). The basic information for road transport, shipping and aviation, such as the number of vehicles, harbour statistics and aircraft landing and take-off cycles are provided to ApC, within the SNIERPA arrangements, from different national entities, such as the Institute of Mobility and Transports (IMT), the National Civil Aviation Authority (ANAC), the National Ports and different sectoral associations.

For the more recent years, data collected at APA (currently collected by ApC) under the European Union Emissions Trading Scheme (ETS) on production data, fuel consumption, fuel energy content and emission factors are also used in the inventory compilation. ETS data are used differently whenever the sectoral coverage is complete; or not, as ETS data do not always entirely cover the source categories whereas national statistics, such as the national energy balance, provide a more complete data set needed for the Portuguese emission inventory. Nevertheless, ETS data are used to develop plant-specific emission factors and check activity data levels.

Data sources for the industrial sector are diverse and include: annual production data from the IAPI (INE), EU-ETS data, data collected from the National Pollutant Release and Transfer Register (E-PRTR) under the Regulation (EC) no.166/2006 and data collected directly from some plants or industrial associations.

The inventory considers, both for the energy and the industrial processes sectors, individual point sources based on detailed information, such as fuel consumption, from large point sources collected under the framework of the European Directive on Large Combustion Plants.

For sectors related to the use of products as substitutes for ODS, the inventory uses, at a limited extent, data from a national reporting tool (https://formularios.apambiente.pt/GasesF/) where national operators report the use of fluorinated gases, as proposed in article 6 of Regulation (EU) No. 573/2024 on fluorinated greenhouse gases and repealing Regulation (EU) No 517/2014.

The collection of data regarding the Large Combustion Plant Directive and the E-PRTR Regulation is under the responsibility of APA and made available upon request to ApC's inventory team.

Data sources for the agriculture sector rely largely in the information provided by the INE on annual crop production and number of animals.

For the LULUCF sector, the forest areas and forest parameters are derived from national forest inventories provided by the Ministry of Agriculture/ICNF, which prepares also official information on the areas subject to fires. The cartographic products used in the compilation of Land Use and Land Use Change, are prepared by DGT.

Data on waste are collected annually at APA via the Integrated System for Electronic Registry on Waste (SIRER) within the SILIAMB electronic platform and made available upon request to ApC's inventory team.

The following table presents a summary of the activity data and sources used.

***Table 1.4: Main data sources used in the Portuguese inventory***

| IPCC Sector | Activity Data | Data Sources |
|---|---|---|
| **1 – Energy** | | |
| **1 A – Energy. Fuel Combustion** | | |
| 1A1 – Energy Industry | Fuel sales | Large Point Source Surveys (LPS)<br>Large Combustion Plants (LCP)<br>EDP Sustainability Annual Reports<br>Energy Balance - General Directorate for Geology and Energy (DGEG)<br>Autonomous Government of Azores<br>National Statistical Institute (INE)<br>European Emissions Trading Scheme (ApC) |
| 1A2 - Manufacturing Industries and Construction | | LPS, LCP, EPER/PCIP<br>Energy Balance (DGEG)<br>European Emissions Trading Scheme (ApC) |
| 1A3 – Transport | Airport movements<br>Vehicle sales<br>Fuel sales<br>Vehicle inspection data / Port movements | ANAC<br>ACAP<br>Energy Balance (DGEG)<br>IMT |
| 1A4 – Other Sectors | Fuel sales<br>Equipments and fuel used | Energy Balance (DGEG)<br>Survey on Energy Consumption in the Residential Sector (DGEG) |
| 1A5 – Other | Fuel sales | Energy Balance (DGEG) |
| **1 B – Fugitive Emissions from Fuels** | Extraction, production and consumption amounts | Energy Balance and statistical yearbooks (DGEG)<br>National Laboratory of Energy and Geology (LNEG)<br>GALP<br>European Emissions Trading Scheme (ApC) |
| **2 – IPPU** | | |
| 2A - Mineral industry | Products produced<br>Fuel sales<br>Carbonates consumption | LPS, LCP<br>CIMPOR, SECIL<br>Energy Balance (DGEG)<br>Portuguese Association of Producers of Bitumen Materials (APORBET)<br>European Asphalt Pavement Association (EAPA)<br>Technology Centre for Ceramics and Glass (CTCV)<br>European Emissions Trading Scheme (APA)<br>National Statistical Institute (INE) |
| 2B - Chemical industry | Production amounts | National Statistical Institute (INE)<br>Energy Balance (DGEG)<br>LCP |
| 2C - Metal industry | Production amounts | National Statistical Institute (INE) / Worldsteel Association<br>Energy Balance (DGEG)<br>LCP<br>MEGASA |
| 2D - Non-energy products from fuels and solvent use | Production and consumption amounts | Energy Balance (DGEG)<br>Gen-Dir for Economic Activities (DGAE)<br>National Statistical Institute (INE) |
| 2F - Product uses as ODS substitutes | Equipment assembled, operated and disposed<br>Fluid amounts | National Statistical Institute (INE)<br>APIRAC<br>Data from Industry Importers<br>EDP, REN<br>Fluorinated Gas Reporting (ApC) |
| 2G - Other product manufacture and use | Equipment assembled, operated and disposed<br>Fluid amounts | National Statistical Institute (INE)<br>EDP; REN<br>Fluorinated Gas Reporting (ApC) |
| 2H - Other | Production amounts | National Statistical Institute (INE) |
| **3 – Agriculture** | | |
| | Agriculture survey, Animal and Crop production, Fertilizer consumption | GPP<br>IFAP<br>INE<br>APA |
| **4 – Land Use, Land Use Change and Forestry** | | |
| | Biomass increment, Burnt area, Harvest<br>Land use area, LUC<br>Biomass increment | ICNF<br>COS cartography (DGT)<br>ISA |
| **5 – Waste** | | |
| 5A – Solid Waste Disposal on Land | Amount of Waste (Municipal)<br>Amount of Waste (Industrial) | APA<br>APA-INE |
| 5B – Biological Treatment | Amount of Waste | APA |
| 5C – Waste Incineration | Amount of Waste | APA |
| 5D – Wastewater Handling | Industrial Production, Protein consumption | APA, ERSAR, INE |

## 1.5 Brief description of key source categories

Key category analysis to the 2026 Portuguese inventory estimates (1990-2024) was conducted using Approach 1 and Approach 2 with and without the LULUCF sector.

In accordance with the recommendations from the last UNFCCC review, the disaggregation level of the key category analysis intends to follow the guidance from 2006 IPCC.

Level assessment was undertaken for the base year and the latest reported inventory year; the trend assessment was performed for the 1990-2024 period. The analysis performed without LULUCF resulted in the identification of 34 key categories, listed in the following table.

More detailed information is presented in Annex E - Key Category Analysis of this report.

***Table 1.5: Overview of key categories (without LULUCF) using Approach 1 and 2 for 1990 and 2024 inventory year***

| IPCC CATEGORIES | GHG | Key source Category Flag | Criteria for Identification | Current year emissions (kton CO2 eq.) |
|---|---|---|---|---|
| 1.A.3.b Road Transportation | CO2 | √ | Level 1 and 2, Trend 1 and 2 | 17,044.6 |
| 5.A Solid waste disposal | CH4 | √ | Level 1 and 2, Trend 1 and 2 | 4,076.8 |
| 3.A Enteric fermentation | CH4 | √ | Level 1 and 2, Trend 1 | 3,800.4 |
| 1.A.2 Manufacturing industries and construction - Gaseous fuels | CO2 | √ | Level 1, Trend 1 | 3,457.4 |
| 1.A.4 Combustion Other Sectors - Liquid fuels | CO2 | √ | Level 1, Trend 1 | 2,551.8 |
| 2.A.1 Mineral Industry - Cement production | CO2 | √ | Level 1 and 2, Trend 1 and 2 | 2,265.4 |
| 1.A.1 Energy industries - Gaseous fuels | CO2 | √ | Level 1, Trend 1 | 2,100.2 |
| 1.A.2 Manufacturing industries and construction - Liquid fuels | CO2 | √ | Level 1 and 2, Trend 1 | 1,908.4 |
| 2.F.1 Refrigeration and Air Conditioning | Fgases | √ | Level 1 and 2 | 1,767.4 |
| 1.A.1 Energy industries - Liquid fuels | CO2 | √ | Level 1 and 2, Trend 1 and 2 | 1,639.9 |
| 3.D.1 Direct N2O Emissions From Managed Soils | N2O | √ | Level 1 and 2, Trend 2 | 1,501.6 |
| 1.A.4 Combustion Other Sectors - Gaseous fuels | CO2 | √ | Level 1, Trend 1 | 1,224.4 |
| 1.B.2.a Fugitive emissions - Oil | CO2 | √ | Level 1, Trend 1 | 1,036.7 |
| 3.B Manure Management | CH4 | √ | Level 1 and 2 | 810.6 |
| 5.D Wastewater treatment and discharge | N2O | √ | Level 1 and 2, Trend 1 and 2 | 778.5 |
| 5.D Wastewater treatment and discharge | CH4 | √ | Level 1 and 2, Trend 1 and 2 | 575.4 |
| 1.A.3.a Civil (domestic) aviation | CO2 | √ | Level 1 and 2, Trend 1 and 2 | 567.4 |
| 1.A.1 Energy industries - Other fossil fuels | CO2 | √ | Level 1, Trend 1 | 513.2 |
| 3.D.2 Indirect N2O Emissions From Managed Soils | N2O | √ | Level 1 | 389.8 |
| 2.A.2 Mineral Industry - Lime production | CO2 | √ | Level 1 and 2, Trend 2 | 369.4 |
| 1.A.3.d Domestic navigation - Residual fuel oil | CO2 | √ | Level 1 and 2 | 300.6 |
| 1.A.4 Combustion Other Sectors - Biomass | CH4 | √ | Level 1 | 228.8 |
| 3.B Manure Management | N2O | √ | Level 2 | 199.7 |
| 2.D Non-energy products from fuels and solvent use | CO2 | √ | Level 1 and 2 | 190.2 |
| 1.B.2.c Venting and Flaring | CO2 | √ | Trend 2 | 105.7 |
| 2.C.1 Metal Industry - Iron and Steel production | CO2 | √ | Level 1, Trend 1 and 2 | 65.8 |
| 5.B Biological treatment of solid waste | CH4 | √ | Trend 2 | 64.4 |
| 1.B.2.b Fugitive emissions - Natural Gas | CH4 | √ | Trend 2 | 54.1 |
| 5.C Incineration and open burning of waste | CO2 | √ | Trend 2 | 38.0 |
| 2.B.2 Chemical Industry - Nitric acid production | N2O | √ | Level 1, Trend 1 | 35.9 |
| 1.B.1.Fugitive emissions – Solid Fuels | CH4 | √ | Level 2, Trend 2 | 16.5 |
| 2.B.8 Chemical Industry - Petrochemical and Carbon Black production | CO2 | √ | Level 1, Trend 1 | 14.7 |
| 1.A.2 Manufacturing industries and construction - Solid fuels | CO2 | √ | Level 1, Trend 1 and 2 | 10.7 |
| 1.B.2.a Fugitive emissions - Oil | CH4 | √ | Level 2, Trend 2 | 1.9 |

Including the LULUCF sector in the analysis, 41 categories were identified, as shown in the next table.

***Table 1.6: Overview of key categories (with LULUCF) using Approach 1 and 2 for 1990 and latest inventory year***

| | GHG | Key source Category Flag | Criteria for Identification | Current year emissions (kton CO2 eq.) |
|---|---|---|---|---|
| 1.A.3.b Road Transportation | CO2 | √ | Level 1 and 2, Trend 1 and 2 | 17,044.6 |
| 5.A Solid waste disposal | CH4 | √ | Level 1 and 2, Trend 1 and 2 | 4,076.8 |
| 3.A Enteric fermentation | CH4 | √ | Level 1 and 2, Trend 1 and 2 | 3,800.4 |
| 1.A.2 Manufacturing industries and construction - Gaseous fuels | CO2 | √ | Level 1, Trend 1 | 3,457.4 |
| 1.A.4 Combustion Other Sectors - Liquid fuels | CO2 | √ | Level 1, Trend 1 | 2,551.8 |
| 2.A.1 Mineral Industry - Cement production | CO2 | √ | Level 1 and 2, Trend 1 and 2 | 2,265.4 |
| 1.A.1 Energy industries - Gaseous fuels | CO2 | √ | Level 1, Trend 1 | 2,100.2 |
| 1.A.2 Manufacturing industries and construction - Liquid fuels | CO2 | √ | Level 1 and 2, Trend 1 | 1,908.4 |
| 2.F.1 Refrigeration and Air Conditioning | Fgases | √ | Level 1 and 2 | 1,767.4 |
| 1.A.1 Energy industries - Liquid fuels | CO2 | √ | Level 1 and 2, Trend 1 | 1,639.9 |
| 3.D.1 Direct N2O Emissions From Managed Soils | N2O | √ | Level 1 and 2, Trend 1 and 2 | 1,501.6 |
| 1.A.4 Combustion Other Sectors - Gaseous fuels | CO2 | √ | Level 1, Trend 1 | 1,224.4 |
| 4.A.1. Forest land remaining Forest land | CO2 | √ | Level 1 and 2, Trend 1 and 2 | 1,053.5 |
| 1.B.2.a Fugitive emissions - Oil | CO2 | √ | Level 1, Trend 1 | 1,036.7 |
| 4.B.2 Land converted to Cropland | CO2 | √ | Level 1 and 2, Trend 1 | 845.5 |
| 3.B Manure Management | CH4 | √ | Level 1 and 2, Trend 1 and 2 | 810.6 |
| 5.D Wastewater treatment and discharge | N2O | √ | Level 1 and 2, Trend 1 and 2 | 778.5 |
| 5.D Wastewater treatment and discharge | CH4 | √ | Level 1 and 2, Trend 1 and 2 | 575.4 |
| 1.A.3.a Civil (domestic) aviation | CO2 | √ | Level 1 and 2, Trend 1 and 2 | 567.4 |
| 1.A.1 Energy industries - Other fossil fuels | CO2 | √ | Level 1, Trend 1 | 513.2 |
| 3.D.2 Indirect N2O Emissions From Managed Soils | N2O | √ | Level 1, Trend 1 | 389.8 |
| 2.A.2 Mineral Industry - Lime production | CO2 | √ | Level 1 and 2, Trend 1 and 2 | 369.4 |
| 1.A.3.d Domestic navigation - Residual fuel oil | CO2 | √ | Level 1 and 2, Trend 1 and 2 | 300.6 |
| 4.E.2 Land converted to Settlements | CO2 | √ | Level 1 and 2, Trend 1 and 2 | 291.0 |
| 4.D.2 Land converted to Wetlands | CO2 | √ | Level 1, Trend 1 | 290.8 |
| 1.A.2 Manufacturing industries and construction - Other fossil fuels | CO2 | √ | Level 1 | 257.4 |
| 1.A.4 Combustion Other Sectors - Biomass | CH4 | √ | Level 1 | 228.8 |
| 3.B Manure Management | N2O | √ | Level 2, Trend 2 | 199.7 |
| 2.D Non-energy products from fuels and solvent use | CO2 | √ | Level 1 and 2 | 190.2 |
| 4.A.1. Forest land remaining Forest land | CH4 | √ | Level 1 | 116.2 |
| 2.C.1 Metal Industry - Iron and Steel production | CO2 | √ | Level 1 | 65.8 |
| 4.C.1. Grassland remaining Grassland | CH4 | √ | Level 2 | 40.6 |
| 2.B.2 Chemical Industry - Nitric acid production | N2O | √ | Level 1 | 35.9 |
| 1.B.1.Fugitive emissions – Solid Fuels | CH4 | √ | Level 2 | 16.5 |
| 2.B.8 Chemical Industry - Petrochemical and Carbon Black production | CO2 | √ | Level 1 | 14.7 |
| 1.A.2 Manufacturing industries and construction - Solid fuels | CO2 | √ | Level 1 | 10.7 |
| 1.B.2.a Fugitive emissions - Oil | CH4 | √ | Level 2, Trend 2 | 1.9 |
| 4.G. Other (Harvested Wood Products) | CO2 | √ | Level 1, Trend 1 | -88.0 |
| 4.B.1. Cropland remaining Cropland | CO2 | √ | Level 1 and 2, Trend 1 | -513.3 |
| 4.C.1. Grassland remaining Grassland | CO2 | √ | Level 1 and 2, Trend 1 | -754.5 |
| 4.A.2 Land converted to Forest land | CO2 | √ | Level 1 and 2, Trend 1 and 2 | -792.1 |

## 1.6 Information on QA/QC

Quality Assurance (QA) and Quality Control (QC) and verification activities are integral parts of the inventory system aiming to support the development of the national inventory of greenhouse gas emissions.

ApC has the overall responsibility for the national inventories in Portugal, including the competence for the coordination of the QA/QC System.

The QA/QC system is composed of several main elements, in particular:

- Designation of an inventory compiler who is also responsible for coordinating QA/QC and verification activities and definition of roles/responsibilities within the inventory;
- QA/QC plan;
- Procedures Manual defining General QC procedures that apply to all inventory categories and Category-specific QC procedures, QA and review procedures;
- Verification activities;
- Reporting, documentation, and archiving procedures.

A QC system is designed to provide routine and consistent checks to ensure data integrity, correctness, and completeness, aiming to identify and address errors and omissions; it also includes procedures to document and archive the inventory material and record all QC activities.

In this context ApC elaborated a new QA/QC procedures manual, describing QA/QC procedures and verification activities to be followed during the inventory compilation and aiming at the inventory improvement. This QA/QC procedures manual is based on the QA/QC requirements set out in the 2006 IPCC Guidelines.

QC procedures defined in the QA/QC Manual include a series of checklists, which consider basic checks on the accuracy of data acquisition processes (including, e.g. transcription errors) and checks on calculation procedures, data and parameters. It includes also cross-checking among subcategories in terms of data consistency, verification of NID and CRT tables.

Documentation and archiving procedures include checks on information handling which should enable the recalculation of the inventory. All the documents and electronic files used for the inventory preparation are stored at the APC. All information relating to the planning, preparation, and management of inventory activities should be documented and archived, including:

- Responsibilities, institutional arrangements, and procedures for the planning, preparation, and management of the inventory process;
- Assumptions and criteria for the selection of activity data and emission factors;
- Emission factors and other estimation parameters used, including references to the IPCC document for default factors or to published references or other documentation for emission factors used in higher tier methods;
- Activity data or sufficient information to enable activity data to be traced to the referenced source;
- Information on the uncertainty associated with activity data and emission factors;
- Rationale for choice of methods;
- Methods used, including those used to estimate uncertainty and those used for recalculations;
- Changes in data inputs or methods from previous inventories (recalculations);
- Identification of individuals providing expert judgement for uncertainty estimates and their qualifications to do so;
- Electronic databases or software used in the production of the inventory, including versions,
- Worksheets for category estimates calculation;
- Inventory reports and any analysis of trends;
- QA/QC plans and outcomes of QA/QC procedures.

Routine general checks, source specific quality control procedures should be applied on a case by case basis focusing on key categories and on categories where significant methodological and data revision have taken place or on new sources.

QA/QC procedures are to be applied by the inventory team during the inventory calculation and compilation following a yearly defined QA/QC plan.

A QA/QC coordinator is designated annually in order to ensure that the objectives of the QA/QC plan are met and to guarantee the good implementation of the QA\QC procedures defined.

The inventory staff is responsible for the implementation of QA/QC procedures related to data gathering, handling, processing, documenting, archiving and reporting procedures related to the inventory.

Other procedures include technical verifications of emission factors, activity data, and comparison of results among different approaches and also comparisons between national data and international databases, and emission intensity indicators among countries, having as a basis information compiled by the EC and the UNFCCC.

Each Involved Entity (IE) within the Portuguese national system (SNIERPA) contributing with data to the inventory is responsible for the quality of their own data.

The sectoral Focal Points within SNIERPA have also an important role in the implementation of QA\QC activities. As foreseen in the implementing procedures document agreed under SNIERPA, APC transmits the reports to the focal points on each official submission for validation purposes of each sectoral component and proposed amendments and perform QA\QC validation procedures.

Quality assurance activities also include feedback from different inventory users and checks and reviews made under the EC and UNFCCC.

Among these are consistency data checks performed in the context of the Regulation (EU) No 2018/1999 of on the Governance of the Energy Union and Climate, which requires EU Member States to report in textual and tabular format data on inconsistencies. Other checks refer to consistency comparisons that should be done among data on air pollutants reported under Directive (EU) 2016/2284 are consistent with the corresponding emission estimates reported under the Regulation (EU) 2018/1999. When the differences exceed +/–5 % between the total emissions for a specific pollutant an explanation should be provided. Another important check done consists on the comparison of emissions estimated under Regulation (EU) 2018/199 with data reported under the EU emissions trading scheme (ETS). Furthermore, a comparison between the reference approach calculated on the basis of the data included in the GHG inventory and the reference approach calculated on the basis of the data reported pursuant to Article 4 and Annex B to Regulation (EC) No 1099/2008 on energy statistics, should be realised. Differences of more than +/– 2 % in the total national apparent fossil fuel consumption at aggregate level for all fossil fuel categories, should be reported.

The results of quality control of national submissions under the Commission Implementing Regulation (EU) 2020/1208 on structure, format, submission processes and review of information (e.g. completeness checks, consistency checks), and the issues raised during the annual review process of the UNFCCC or other reviews in the context of the European Effort Sharing Decision (ESD) and the National Emission Ceilings Directive (NECD), constitute additional processes of technical verification and represent valuable sources of error detection and methodological improvement.

Inventory data users, such as people from universities, from regional departments or other interested entities, or interactions and feedback received from external teams involved in the preparation of the Climate Change Plans, Climate Road maps or more recently the 2050 Road map for Carbon Neutrality, as well as Air Emissions Reduction Plans are also valuable instruments that have been used to improve the quality of the Portuguese inventory.

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

The Portuguese uncertainty analysis follows Approach 1, based on the error propagation equations, proposed by the 2006 IPCC Guidelines.

Despite the efforts done to cover all the categories considered in the inventory, it was not yet possible to include HWP and indirect $CO_2$ in the uncertainty analysis.

The uncertainty values, both for activity data and emission factors, are discussed in the detailed analysis of emission estimates for each individual source sector.

A more detailed information on Tier 1 uncertainty calculation per category and pollutant can be found in Annex F of this report.

For the 2024 total emission estimates without indirect $CO_2$, an uncertainty of 9.0 % is estimated. The uncertainty in trend from 1990 to 2024 is 6.2 %.

## 1.8 Overview of the completeness

The inventory covers the gaseous air pollutants included in Annex A to the Kyoto Protocol: carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), hydrofluorocarbons (HFC), perfluorocarbons (PFCs) and sulphur hexafluoride ($SF_6$), as well as estimates for indirect GHGs, including carbon monoxide (CO), nitrogen oxides ($NO_x$), and non-methane volatile organic compounds (NMVOC). Data are also reported for sulphur oxides ($SO_x$). $NF_3$ emissions do not to occur in Portugal.

As a general rule, the inventory covers emissions from the whole Portuguese territory, i.e., mainland Portugal and the two autonomous regions of Madeira and Azores Islands.

## 1.9 Reporting on consistency of the reported data on air pollutants (CO, $SO_2$, NOx and NMVOC)

As specified in Annex V of Regulation (EU) 2018/1999, Member States are required to report on the results of the checks between emissions estimates of carbon monoxide (CO), sulphur dioxide (SO2), nitrogen oxides (NOx) and volatile organic compounds, in inventories submitted under Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 and under the UNECE Convention on Long-range Transboundary Air Pollution, and the corresponding emission estimates in greenhouse gas inventories under Regulation (EU) 2018/1999.

The next figure presents the results of the assessment made using the latest submission (15th March 2023) under the NECD (Directive (EU) 2016/2284 of the European Parliament and of the Council (http://cdr.eionet.europa.eu/pt/eu/nec/envvoqlvw/) and data provided in this submission.

The differences are the result in geographical coverage between submissions. The NECD refers to Portugal Mainland and the EU Governance Regulation/UNFCCC submissions refer to the national total which includes the two Autonomous Regions of Azores and Madeira.

The differences for NMVOC and CO emissions are in the range below 5 %. Differences for NOx are related to industry related sectors and to the transport sector.

For $SO_2$, the disparities are more significant after 2007. The difference in $SO_2$ after 2007 is the result of the implementation of the abatement systems (desulfurization in two Large Point Source Coal Energy Plants) in Portugal Mainland. In the latest years, however, the use of coal in thermal production has been phased-down

and was definitively phased-out at the end of 2021 with the closure of the last Portuguese coal thermal plant (Pego in Mainland). At present, natural gas is the main fuel used in electric thermal generation in Mainland, while in the two Autonomous Regions of Azores and Madeira, electrical generation is based on heavy fuel and diesel thermal plants.

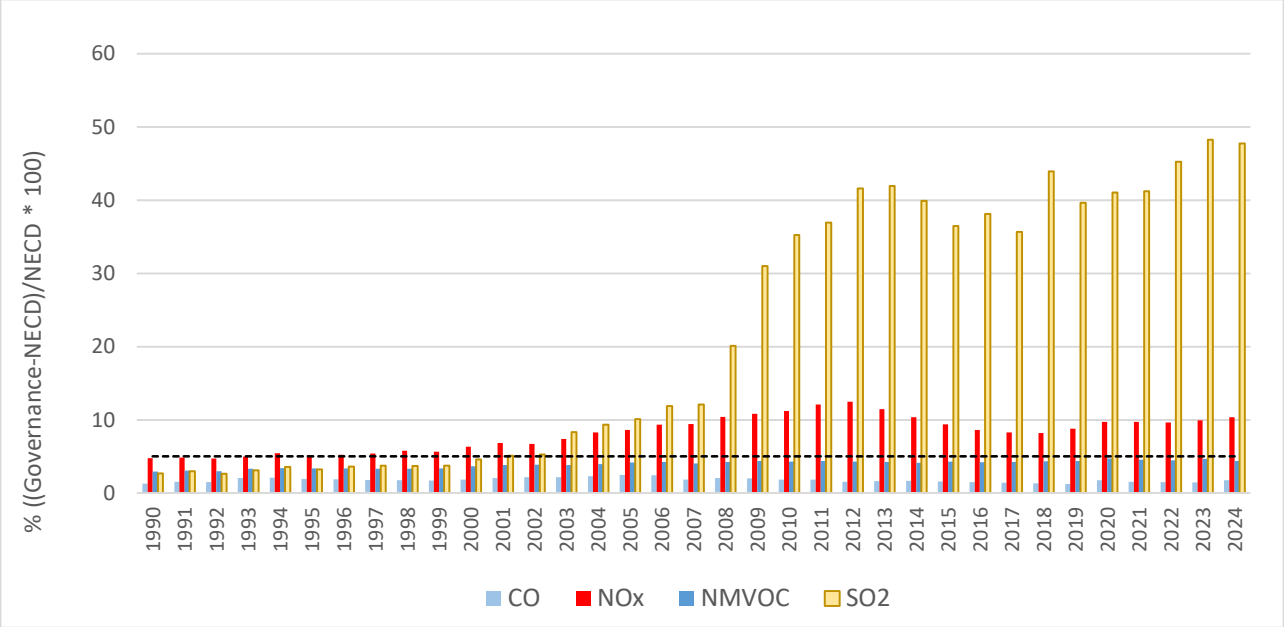



***Figure 1.6: Comparison between MMR and NECD estimates on air pollutants***

## 1.10 Comparison of the sectoral approach with the reference approach

Point (j)(iii) of Part 1 of Annex V to Regulation (EU) 2018/1999, defines that Member States shall report information on the comparison between the sectoral approach used in the greenhouse gas inventory and the reference approach calculated on the basis of the data reported pursuant to Article 4 of, and Annex B to, Regulation (EC) No 1099/2008 on energy statistics.

In the assessment made for this provisional submission, significant differences were found (of more than +/– 2 % in the total national apparent fossil fuel consumption) for the years 1996, 1997, 1998, 2000, 2006 and 2013, that result from some missing information and other possible factors which require further development. The difference between sectoral and reference approaches is -0.69% for 2024.

It is noted the improvement of the comparison exercise between the reference approach and the sectoral approach, namely in terms of the PDM, working together with the national energy authority (DGEG) to clarify the origin of these differences.

## 1.11 Future developments

Future improvements are defined for each sector by the relevant inventory compiler and put together in a PDM which is settled/updated each year. The most relevant issues are discussed in the context of SNIERPA and the methodological developments and improvements are performed under the responsibility of the APC in cooperation with the sectoral Focal Points.

The PDM intends to reflect the results of the various review processes, particularly the UNFCCC reviews, the annual inventory compilation process (all experts and entities involved can make proposals for methodological development), and generally the outcomes of the application procedures of Quality Control and Quality Assurance, considering the results of the key category assessment.

# 2 Trends in Portuguese GHG Emissions

## Table of Contents


2 Trends in Portuguese GHG Emissions ..... 2-1

2.1 Trends of Total Emissions ..... 2-2

2.2 Emissions by Gas ..... 2-6

2.3 Emissions by Sector ..... 2-8

2.4 Indirect GHG and SOx emissions ..... 2-12


## List of Figures


Figure 2.1: GHG emissions ..... 2-2

Figure 2.2: Hydraulic index ..... 2-3

Figure 2.3: GHG emissions per capita, per unit of GDP and energy consumption ..... 2-3

Figure 2.4: GHGs emissions percentage change (2023-2024) by IPCC category (LULUCF excluded) ..... 2-4

Figure 2.5: Gross electric power production, electric import balance and emissions from electricity and heat generation ..... 2-5

Figure 2.6: Primary energy consumption by energy source ..... 2-5

Figure 2.7: GHG emissions by gas ..... 2-6

Figure 2.8: Change of GHG emissions by gas over the period 1990-2024 ..... 2-6

Figure 2.9 - GHG emissions in Portugal by sector (LULUCF excluded) ..... 2-8

Figure 2.10: GHG emissions and removals by sector ..... 2-9

Figure 2.11: GHGs emissions percentage change (1990-2024) by IPCC category (LULUCF excluded) ..... 2-10

Figure 2.12: Indirect GHG and $SO_x$ emissions: 1990-2024 variation ..... 2-12


## List of Tables


Table 2.1: GHG emissions and removals in Portugal by gas ..... 2-7

Table 2.2: GHG emissions and removals by sector ..... 2-11

Table 2.3: Indirect GHG and SOx emissions: 1990-2024 ..... 2-14

# 2 Trends in Portuguese GHG Emissions

*Updated: March 2026*

## 2.1 Trends of Total Emissions

In 2024, total Portuguese GHG emissions, including indirect $CO_2$, without land-use, land-use change and forestry (LULUCF) were estimated at about 51.5 Mt $CO_2e$, representing a decrease of 12.6 % and 3.0 % compared to 1990 levels and to the previous year (2023), respectively.

When considering the LULUCF sector, the national level of emissions in 2024 totalled 52.1 Mt $CO_2e$., corresponding to a 18.7 % decrease in relation to 1990 and a reduction of 1.0 % from 2023 to 2024.

Throughout this report, emissions values are presented in $CO_2e$ using IPCC AR5 GWP values.

The reference to "total emissions" along the report is meant to refer to "total emissions without LULUCF, including $CO_2$ indirect emissions".

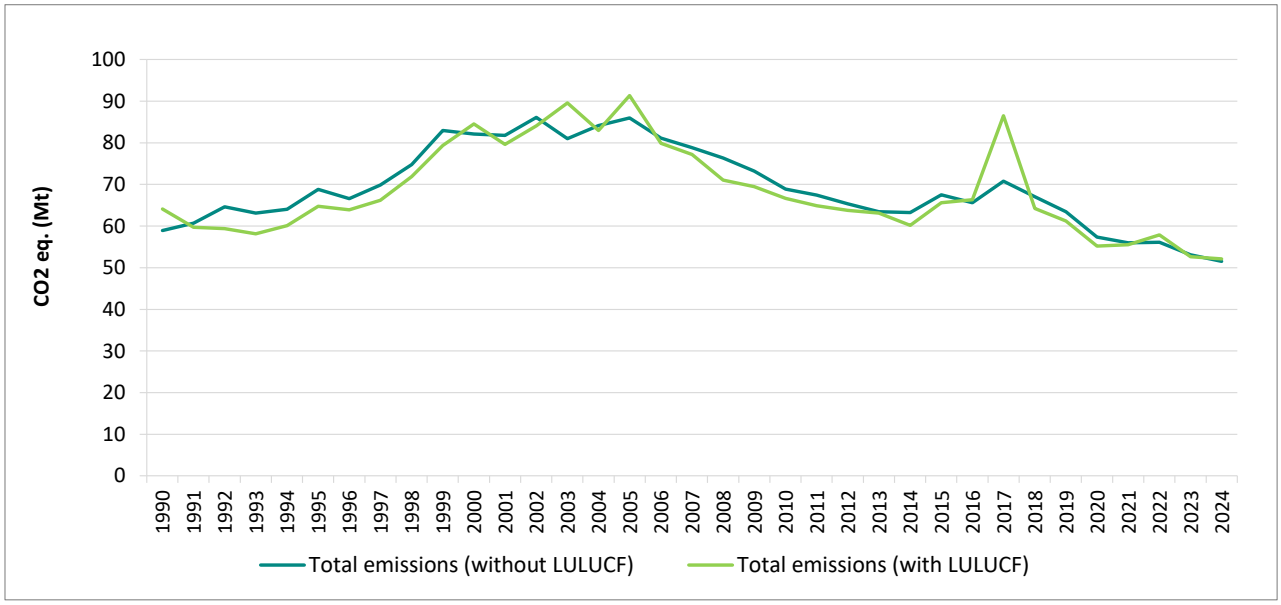



***Figure 2.1: GHG emissions***

National emissions developed rapidly during the 1990s, reflecting the evolution of the Portuguese economy, which was characterized by a strong growth associated with increased energy demand and mobility.

In the early 2000s, the growth of emissions has been more moderate and started to stagnate, registering thereafter, particularly after 2005, a decrease. This reduction is the result of the implementation of several measures such as the replacement of more polluting energy sources such as fuel oil with natural gas (introduced since 1997), the implementation of combined cycle power plants to NG (1999), the progressive installation of cogeneration units, the improvement of energy and technological efficiency of industrial processes, improvements in automobile efficiency (fleet renewal), and the improvement of fuels quality, among others.

These measures were accompanied by a continuous decline in energy consumption (both primary and final) verified in the country since 2005, with a significant expression in the period 2009-2013, fact that may be also explained by the internal economic recession, along with the European economic and financial crisis.

These years registered a slowdown of industrial activity and the cessation of some activities in the country such as black carbon production in 2013 and the production of ammonia in 2009, with the relocation of the production facilities.

In 2014 there was an inversion of this pattern. The evolution of the primary, and particularly the final energy consumption trend increased, accompanying the positive evolution of the Portuguese economy.

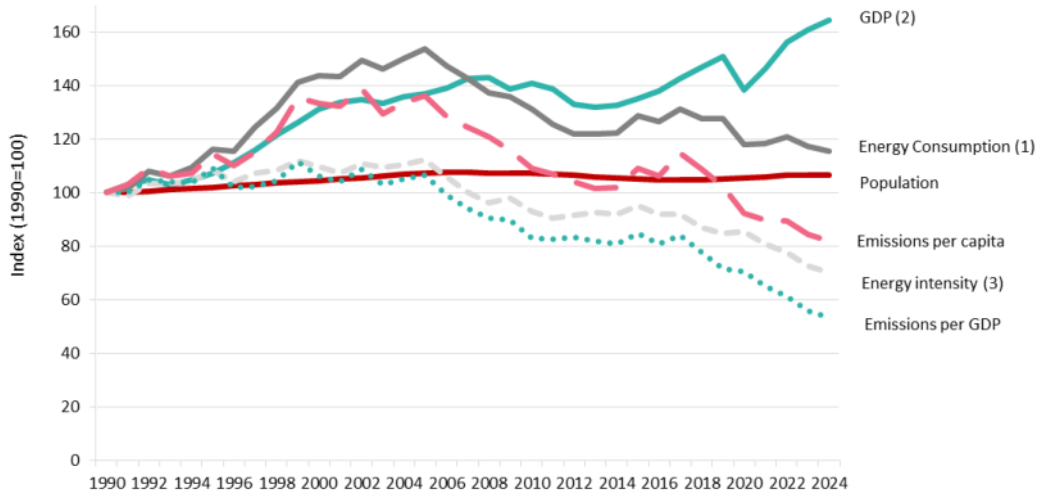
The level of emissions shows, however, significant inter-annual variations, which are mostly occurring in the energy sector and are mainly related to the pronounced fluctuations of hydroelectric power generation that is highly affected by annual variations in precipitation (figure below).

Note: HI = 1 corresponds to the average hydrologic availability.

Source: EDP, REN

***Figure 2.2: Hydraulic index***

The decrease of carbon intensity (GHG emissions per GDP unit) which is observed since the mid-2000s (following figure), has been accentuated in the most recent years and is in part related to the expressive development of renewable energy sources (mainly wind and hydro) in electricity production.




Notes: (1) Primary Energy Consumption; (2) GDP at 2016 prices; (3) Energy Consumption per GDP

Sources: INE, DGEG

***Figure 2.3: GHG emissions per capita, per unit of GDP and energy consumption***

After the abrupt economic slowdown verified in 2020 due to the COVID-19 shutdown measures to contain the pandemic, GDP registered since then a positive variation: 5.7% in 2021, 6.8% in 2022, 3.1% in 2023 and 2.1% in 2024.

The primary energy consumption, which decreased by 8.2% in 2020 compared to 2019, reflecting the economic effects of the pandemic, continues to present a lower level as compared to the pre-pandemic primary energy consumption (- 8% in relation to 2019), representing an improvement in the energy intensity of the economy with a greater wealth created by unit of primary energy consumed.

In 2024, the total national emissions decreased 3.0 % as compared to 2023.

This reduction is explained mostly to the decrease of emissions related to the energy industries, which are registering, since 2017, a sustained reducing trend and shows a drop of emissions in 2024 compared to 2023 of 26 %.

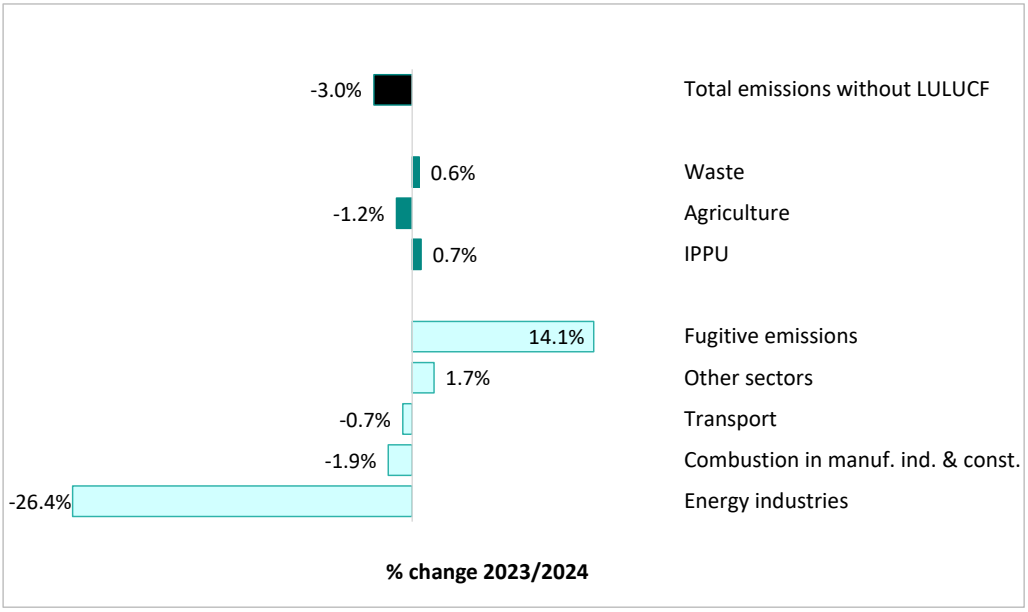
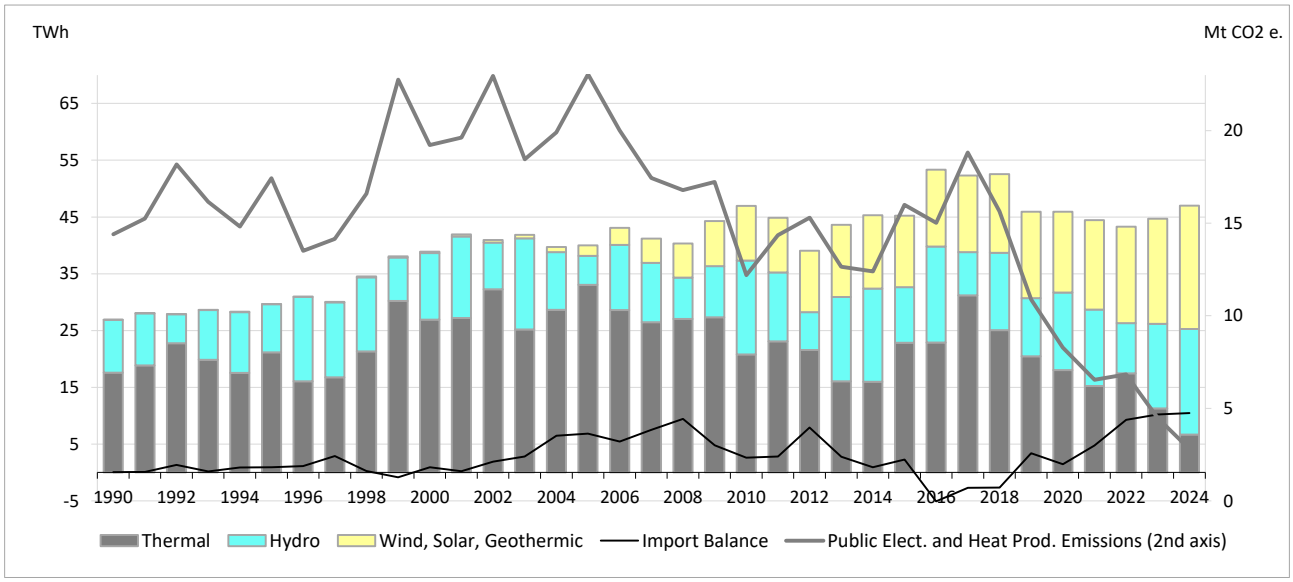



***Figure 2.4: GHGs emissions percentage change (2023-2024) by IPCC category (LULUCF excluded)***

In 2024, the renewable domestic electric production raised approx. 21 % over the previous year because of a more favourable hydraulic availability (IH = 1.16 compared to 0.99 in 2023) and consequently a greater hydroelectric production (+ 25 %), and an increase in the photovoltaic production (+37 %). Furthermore, the import balance of electricity raised (+ 2.3 %) compared to the previous year.



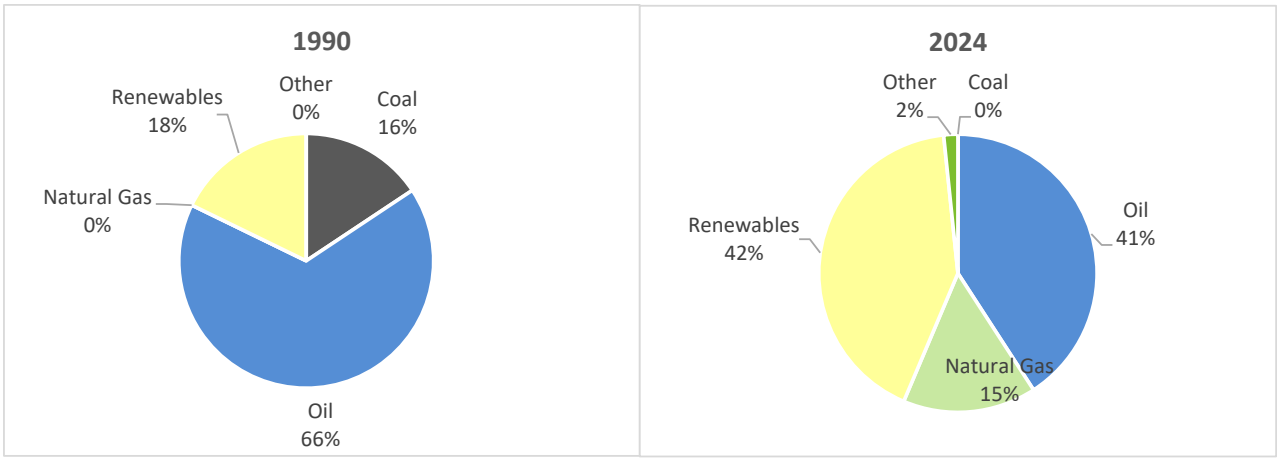

Source: DGEG

***Figure 2.5: Gross electric power production, electric import balance and emissions from electricity and heat generation***

In 2024, primary energy consumption decreased by 1.5% compared to 2023, mainly due to the reduction in natural gas consumption (-17.3%).

The analysis of the consumption of different energy sources in 2023 shows that Oil remains the main primary energy supply, followed by Renewables and Natural Gas. The relevance of Oil relates to the transport sector, particularly to road transport, and its use in the petrochemical industry.

Nevertheless, the weight of Oil has decreased over the years (66 % in 1990 vs. 41 % in 2024) whereas that of Renewables has increased (18 % in 1990 vs. 42 % in 2024). Natural gas, non-existing in 1990, represents 15 % in 2024.




Source: DGEG

***Figure 2.6: Primary energy consumption by energy source***

## 2.2 Emissions by Gas

The figure below illustrates the relative contribution of direct GHG to the total emissions for 1990 and 2024, showing $CO_2$ as the primary GHG, accounting for about 70 % of Portuguese emissions on a carbon equivalent basis in 2024 (LULUCF excluded). The second most important gas is $CH_4$, followed by $N_2O$, representing, respectively, 19 % and 7 % of total emissions in 2024.

Portugal has chosen 1995 as the base year for fluorinated gases. In 2024, these gases represented about 4 % of total GHG emissions. $NF_3$ emissions are non-occurring in Portugal.

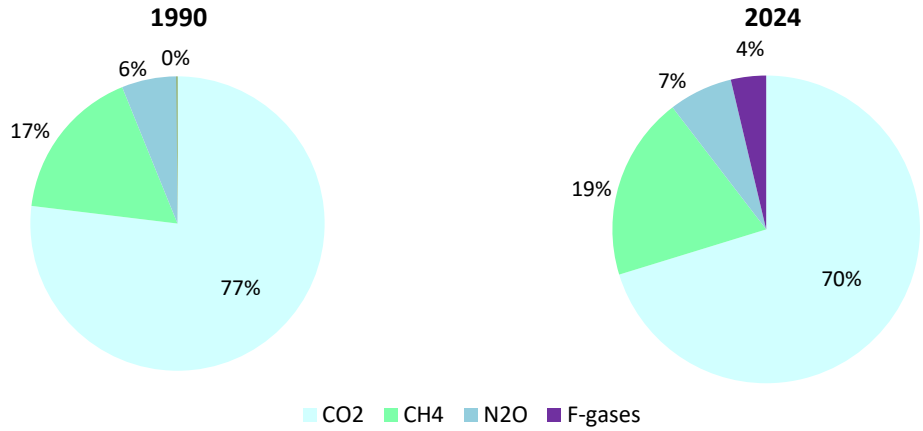



***Figure 2.7: GHG emissions by gas***

Over the 1990-2024 period, CO2, CH4 and N2O registered a reduction of 20 %, 0.7 % and 4 %, respectively. F-gases that have significantly increased in importance, particularly in latest years (around 2800 % since 1995), are excluded from the following figure.

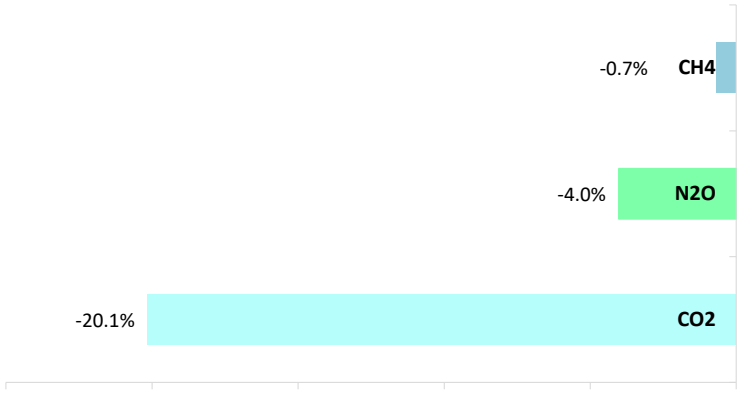



***Figure 2.8: Change of GHG emissions by gas over the period 1990-2024***

*Table 2.1: GHG emissions and removals in Portugal by gas*

| GHGs EMISSIONS | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (Gg) | | | | | | | | | | | | | | | | | |
| CO2 emissions without net CO2 from LULUCF | 45,291 | 46,926 | 50,933 | 49,450 | 50,221 | 54,472 | 51,786 | 54,647 | 59,190 | 66,853 | 65,466 | 65,122 | 69,512 | 64,411 | 67,220 | 69,575 | 64,801 | 62,319 |
| CO2 emissions with net CO2 from LULUCF | 49,634 | 45,468 | 45,482 | 44,303 | 45,930 | 50,039 | 48,831 | 50,839 | 56,065 | 63,059 | 67,424 | 62,636 | 67,030 | 71,997 | 65,663 | 73,989 | 63,224 | 60,428 |
| CH4 emissions without CH4 from LULUCF | 9,979 | 10,126 | 10,136 | 10,153 | 10,299 | 10,521 | 10,780 | 11,032 | 11,296 | 11,629 | 11,893 | 11,873 | 11,842 | 11,812 | 11,809 | 11,641 | 11,539 | 11,366 |
| CH4 emissions with CH4 from LULUCF | 10,556 | 10,411 | 10,197 | 10,210 | 10,436 | 10,704 | 10,868 | 11,058 | 11,384 | 11,652 | 12,142 | 12,041 | 12,061 | 12,489 | 11,962 | 12,203 | 11,650 | 11,419 |
| N2O emissions without N2O from LULUCF | 3,547 | 3,521 | 3,484 | 3,400 | 3,395 | 3,552 | 3,749 | 3,813 | 3,857 | 3,968 | 4,173 | 4,071 | 3,991 | 3,879 | 4,175 | 3,745 | 3,652 | 3,831 |
| N2O emissions with N2O from LULUCF | 3,825 | 3,725 | 3,632 | 3,546 | 3,562 | 3,731 | 3,911 | 3,966 | 4,032 | 4,134 | 4,403 | 4,288 | 4,228 | 4,239 | 4,410 | 4,090 | 3,891 | 4,062 |
| HFCs | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | 54 | 76 | 136 | 203 | 291 | 372 | 473 | 556 | 645 | 706 | 807 | 916 | 1,072 |
| PFCs | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| SF6 | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | 12 | 13 | 13 | 13 | 14 | 14 | 14 | 15 | 17 | 18 | 19 | 20 | 19 |
| NF3 | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO |
| **Total (without LULUCF)** | **58,816** | **60,573** | **64,553** | **63,003** | **63,915** | **68,611** | **66,405** | **69,641** | **74,558** | **82,755** | **81,917** | **81,553** | **85,917** | **80,764** | **83,927** | **85,786** | **80,928** | **78,607** |
| **Total (with LULUCF)** | **64,014** | **59,603** | **59,310** | **58,059** | **59,928** | **64,540** | **63,699** | **66,012** | **71,697** | **79,149** | **84,356** | **79,453** | **83,890** | **89,387** | **82,758** | **91,107** | **79,702** | **77,001** |
| **Total (without LULUCF, with indirect)** | **58,910** | **60,664** | **64,650** | **63,100** | **64,063** | **68,794** | **66,577** | **69,840** | **74,750** | **82,948** | **82,100** | **81,747** | **86,109** | **80,973** | **84,142** | **85,990** | **81,131** | **78,815** |
| **Total (with LULUCF, with indirect)** | **64,107** | **59,694** | **59,407** | **58,156** | **60,076** | **64,723** | **63,871** | **66,211** | **71,890** | **79,343** | **84,539** | **79,647** | **84,083** | **89,596** | **82,973** | **91,311** | **79,905** | **77,209** |

| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | % change |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (Gg) | | | | | | | | | | | | | | | | | 1990-2024 |
| CO2 emissions without net CO2 from LULUCF | 59,929 | 57,061 | 52,861 | 51,738 | 49,796 | 48,055 | 47,802 | 52,130 | 50,218 | 55,071 | 51,245 | 47,479 | 41,646 | 40,173 | 40,591 | 37,595 | 36,097 | **-20.3** |
| CO2 emissions with net CO2 from LULUCF | 54,416 | 52,911 | 50,145 | 48,786 | 47,833 | 47,286 | 44,450 | 49,975 | 50,444 | 69,629 | 48,239 | 45,015 | 39,260 | 39,533 | 42,015 | 36,955 | 36,374 | **-26.7** |
| CH4 emissions without CH4 from LULUCF | 11,169 | 11,043 | 10,807 | 10,739 | 10,472 | 10,263 | 10,150 | 9,994 | 10,035 | 10,112 | 10,183 | 10,260 | 10,156 | 10,244 | 10,232 | 10,062 | 9,927 | **-0.5** |
| CH4 emissions with CH4 from LULUCF | 11,186 | 11,171 | 11,017 | 10,852 | 10,642 | 10,477 | 10,172 | 10,069 | 10,262 | 10,915 | 10,227 | 10,308 | 10,236 | 10,275 | 10,380 | 10,108 | 10,093 | **-4.4** |
| N2O emissions without N2O from LULUCF | 3,761 | 3,561 | 3,574 | 3,263 | 3,264 | 3,257 | 3,399 | 3,378 | 3,347 | 3,450 | 3,471 | 3,541 | 3,472 | 3,480 | 3,343 | 3,406 | 3,453 | **-2.7** |
| N2O emissions with N2O from LULUCF | 3,983 | 3,811 | 3,844 | 3,509 | 3,525 | 3,529 | 3,623 | 3,616 | 3,616 | 3,857 | 3,678 | 3,741 | 3,672 | 3,660 | 3,545 | 3,574 | 3,643 | **-4.7** |
| HFCs | 1,249 | 1,372 | 1,440 | 1,524 | 1,593 | 1,669 | 1,731 | 1,796 | 1,861 | 1,941 | 1,963 | 1,998 | 1,904 | 1,861 | 1,828 | 1,883 | 1,888 | – |
| PFCs | NO | NO | NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | – |
| Unspecified mix of HFCs and PFCs | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | – |
| SF6 | 18 | 19 | 20 | 14 | 15 | 16 | 16 | 15 | 16 | 17 | 15 | 14 | 13 | 14 | 15 | 16 | 14 | – |
| NF3 | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | – |
| **Total (without LULUCF)** | **76,126** | **73,057** | **68,702** | **67,276** | **65,140** | **63,260** | **63,099** | **67,313** | **65,476** | **70,591** | **66,876** | **63,292** | **57,191** | **55,772** | **56,009** | **52,962** | **51,379** | **-12.6** |
| **Total (with LULUCF)** | **70,852** | **69,284** | **66,466** | **64,684** | **63,608** | **62,976** | **59,992** | **65,470** | **66,199** | **86,359** | **64,122** | **61,076** | **55,085** | **55,343** | **57,782** | **52,537** | **52,012** | **-18.7** |
| **Total (without LULUCF, with indirect)** | **76,313** | **73,228** | **68,888** | **67,452** | **65,321** | **63,425** | **63,255** | **67,473** | **65,629** | **70,750** | **67,017** | **63,455** | **57,331** | **55,955** | **56,136** | **53,086** | **51,507** | **-12.6** |
| **Total (with LULUCF, with indirect)** | **71,039** | **69,455** | **66,652** | **64,860** | **63,789** | **63,142** | **60,149** | **65,630** | **66,353** | **86,518** | **64,262** | **61,239** | **55,224** | **55,527** | **57,909** | **52,661** | **52,140** | **-18.7** |

NA- Not applicable; NE - Not estimated; NO - Not occurring

## 2.3 Emissions by Sector

According to the UNFCCC Reporting Guidelines, emissions estimates are grouped into five large IPCC categories: Energy, Industrial Processes and Product Uses (IPPU), Agriculture, Land Use, Land-Use Change and Forestry (LULUCF), and Waste.

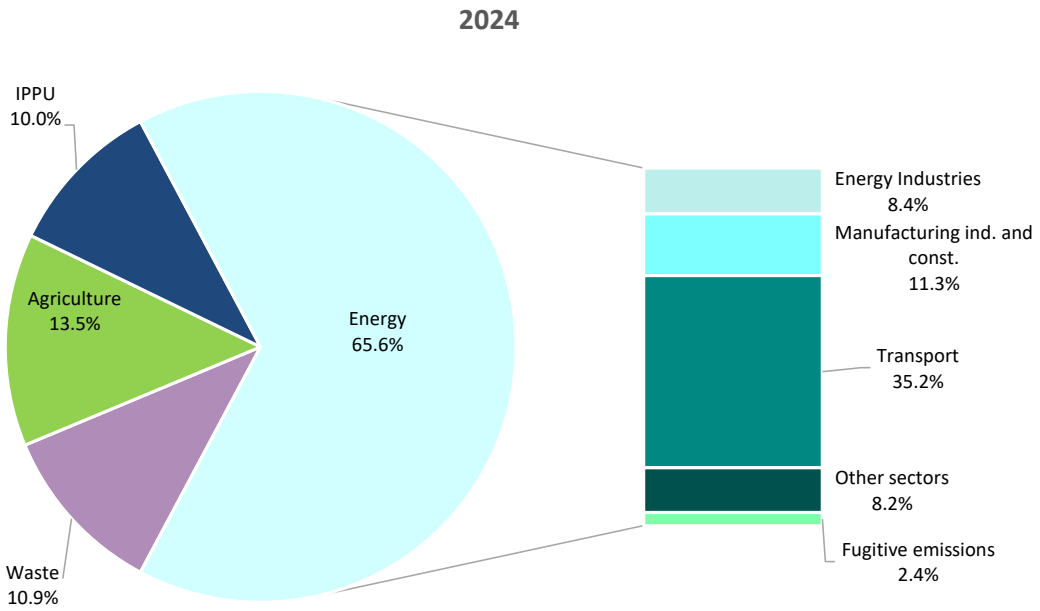



***Figure 2.9 - GHG emissions in Portugal by sector (LULUCF excluded)***

Energy is by far the most important sector, accounting for approximately 65.6 % of total emissions in 2024 and registering a decrease of 17.2 % over the 1990-2024 period. Transport is the most important source representing 35 % of total emissions in 2024. Energy industries which were in the past one of the most important sources of emissions, have nowadays a lesser importance corresponding in 2024 to 8.4 % of total emissions.

Within the energy industries, public electricity and heat production represented 5.5 % of the total emissions in 2024. This sector reduced prominence since 2017 (66 % reduction from 2017 to 2021), due to both the effect of the greater importance of renewables in electricity generation and in to the shift from coal to natural gas in thermal energy production. The use of coal in electricity production ended definitively at the end of 2021.

Mobile sources, which are largely dominated by road traffic, are one of the sectors that have risen faster since 1990, due to the steady growth of vehicle fleets (in particular with more powerful engines) and road travel from 1990 to the early 2000s, reflecting the increase in family income and the strong investment in the road infrastructure of the country in the 1990s and 2000-10s decades. Indirectly, the increase in road traffic activity also augments emissions from fossil fuel storage, handling and distribution. As previously mentioned, the situation stabilized in the early 2000s and started to decline in 2005. An inversion of this tendency is however registered in most recent years with an increase in transport emissions since 2013.

Still within the energy sector, the category “other sectors”, which include the residential and commercial activities, also registered a significant increase of emissions in the 1990-2004 period (74 %), but this tendency has decelerated (43 % decrease) since then, due to the implementation of energy efficiency measures.

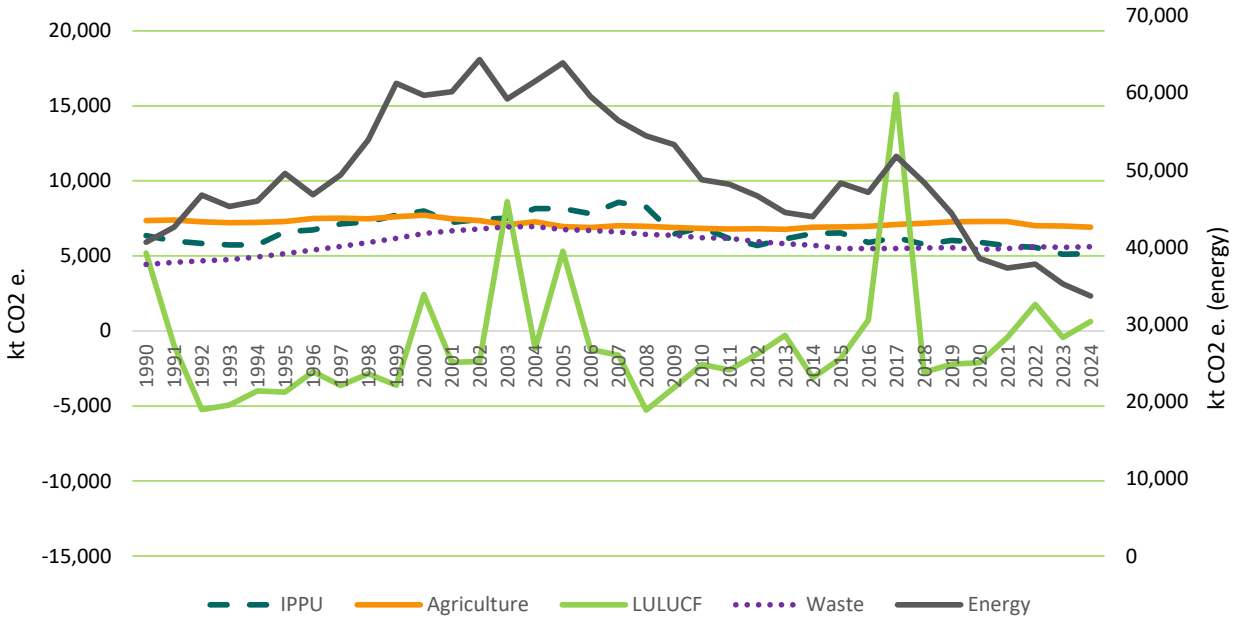



***Figure 2.10: GHG emissions and removals by sector***

Industrial processes represent about 10 % of the Portuguese emissions in 2024 and have decreased approximately 19 % since 1990. Emissions from this sector, which are generated as by-products of many non-energy-related activities, have been driven particularly until the mid-2000s by the evolution of the mineral and chemical industry. From the late 2000s onwards, chemical industry contribution has been reduced significantly, mainly due to end of ammonia production in the country. On the other hand, Products Uses as ODS substitutes (2F and 2G) have progressively gained importance in IPPU sector, representing about 38% of total IPPU emissions in 2024.

Agriculture was, in the period analysed, a significant source of GHG emissions, responsible for 13.5 % of the Portuguese emissions in 2024, corresponding to a decrease of 6.0 % since 1990. This fact is related to the reduction in the livestock production of certain categories of animals (sheep and swine) and more recently of dairy cattle. Furthermore, the extensification of bovine (non-dairy cattle) production and the decreased consumption of fertilizers which relates in a certain extent to the conversion of arable crops to pasture also contributes to this trend. However, since the mid-2000s, particularly after 2011, this downward trend was reversed, registering since then a growing tendency until 2020 (+ 7.0% emissions variation from 2011-2020), supported mainly by a significant increase in the population of non-dairy cattle, sheep and poultry. The sector registers since 2020 a negative variation (- 5.2 % from 2020 to 2024).

Waste represented approximately 11 % of Portuguese emissions in 2024 and increased 26.6 % since 1990. The sector recorded, an expressive increase of emissions until 2004 (approximately 57 %). This increase is primarily related to the rise of waste generation (associated with the development of household income and the growth of urbanization recorded in the country during the 1990s) and the deposition of waste predominantly in landfills.

The reduction in emissions in the following years is associated to biogas recovery in waste treatment systems, and the promotion of Mechanical and Biological Treatment, with the aim to divert urban waste from landfilling and the increase of recycling.

The emissions are estimated to increase 1.2% since 2015 as a result namely to the increase of WWTP with tertiary treatment (N removal).

Portugal implemented for the EU submission of March 2024 the methodological approach proposed by the 2019 IPCC Refinements, which represents a major change compared with the 2006 IPCC Guidance for the Wastewater Treatment sub-sector.

The main revision refers to the N2O emissions, which underwent a profound change leading to greater importance. In fact, while in the previous guidelines (IPCC, 2006) N2O emissions in WWTPs were considered almost negligible, with this approach, N2O emissions have a bigger importance.

CH4 emissions recorded also a significant revision and include now the emissions that occur after the discharge of wastewater into the water environment, where previously only N2O emissions were accounted for.

The change in the estimation methodology and the consideration of some emission factors substantially changed the level of emissions associated with this subsector in relation to previous submissions.

Estimates of emissions and sinks from land use change and forestry category show that this sector has changed from being a net emitter in 1990 (5.2 Mt CO2 eq.) to a carbon sink in 1991. This situation was again reverted in the years 2000, 2003 and 2005 due to the severe forest wildfires events registered in these years. In 2017, this sector became a net emitter again, with a total of 15.8 Mt CO2e., representing 18.2 % of the country´ total emissions including the sector for that year. This situation was related to an exceptional and tragic year in terms of forest wildfires, associated to an exceptional dry year, high temperatures, occurring namely outside the normal summer period (biggest wildfires took place in June and October). Unusual strong winds also occurred, namely Ophelia hurricane, which swept the coast of the Iberian Peninsula in October 2017, a phenomenon that can be related to climate change.

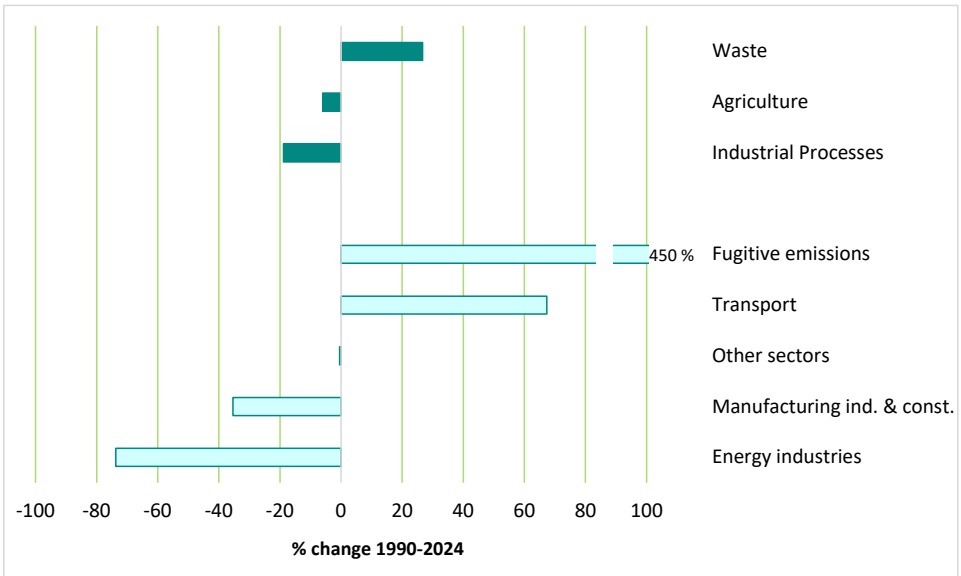



***Figure 2.11: GHGs emissions percentage change (1990-2024) by IPCC category (LULUCF excluded)***

*Table 2.2: GHG emissions and removals by sector*

| GHGs SOURCE AND SINK CATEGORIES | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (Gg) | | | | | | | | | | | | | | | | | |
| 1. Energy | 40,683 | 42,612 | 46,768 | 45,299 | 45,996 | 49,563 | 46,797 | 49,368 | 53,922 | 61,261 | 59,717 | 60,175 | 64,340 | 59,239 | 61,525 | 63,913 | 59,525 | 56,432 |
| 2. Industrial processes and product use | 6,346 | 5,998 | 5,832 | 5,727 | 5,739 | 6,604 | 6,733 | 7,127 | 7,274 | 7,717 | 7,990 | 7,236 | 7,435 | 7,512 | 8,161 | 8,161 | 7,815 | 8,571 |
| 3. Agriculture | 7,358 | 7,388 | 7,272 | 7,214 | 7,241 | 7,294 | 7,486 | 7,514 | 7,473 | 7,606 | 7,723 | 7,476 | 7,354 | 7,073 | 7,281 | 6,947 | 6,898 | 7,018 |
| 4. Land use, land-use change and forestry (4) | 5,198 | -970 | -5,243 | -4,944 | -3,987 | -4,071 | -2,706 | -3,629 | -2,861 | -3,605 | 2,439 | -2,100 | -2,026 | 8,623 | -1,169 | 5,322 | -1,226 | -1,607 |
| 5. Waste | 4,429 | 4,575 | 4,681 | 4,762 | 4,939 | 5,150 | 5,389 | 5,632 | 5,889 | 6,171 | 6,487 | 6,667 | 6,787 | 6,940 | 6,960 | 6,764 | 6,690 | 6,586 |
| 6. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |

| GHGs SOURCE AND SINK | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | % change 1990-2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (Gg) | | | | | | | | | | | | | | | | | |
| 1. Energy | 54,456 | 53,309 | 48,759 | 48,163 | 46,678 | 44,533 | 43,960 | 48,351 | 47,113 | 51,787 | 48,394 | 44,421 | 38,553 | 37,314 | 37,818 | 35,269 | 33,703 | **-17.2** |
| 2. Industrial processes and product use | 8,265 | 6,463 | 6,894 | 6,145 | 5,685 | 6,130 | 6,503 | 6,525 | 5,893 | 6,220 | 5,772 | 6,031 | 5,910 | 5,666 | 5,564 | 5,112 | 5,148 | **-18.9** |
| 3. Agriculture | 6,967 | 6,904 | 6,836 | 6,794 | 6,821 | 6,782 | 6,921 | 6,940 | 6,981 | 7,095 | 7,177 | 7,276 | 7,299 | 7,293 | 7,015 | 7,003 | 6,918 | **-6.0** |
| 4. Land use, land-use change and forestry (4) | -5,274 | -3,773 | -2,236 | -2,592 | -1,532 | -283 | -3,107 | -1,843 | 723 | 15,768 | -2,755 | -2,216 | -2,107 | -429 | 1,773 | -425 | 633 | **-87.8** |
| 5. Waste | 6,438 | 6,380 | 6,213 | 6,176 | 5,956 | 5,814 | 5,715 | 5,497 | 5,489 | 5,489 | 5,533 | 5,563 | 5,429 | 5,498 | 5,612 | 5,578 | 5,609 | **26.6** |
| 6. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | **NO** |

NA- Not applicable; NE - Not estimated; NO - Not occurring

## 2.4 Indirect GHG and SOx emissions

Several gases do not have a direct influence in climate change but affect the formation or destruction of other GHG. CO, NOx, and NMVOC are precursor substances for ozone which is a GHG. SOx produce aerosols, which are extremely small particles or liquid droplets that can also affect the absorptive characteristics of the atmosphere.

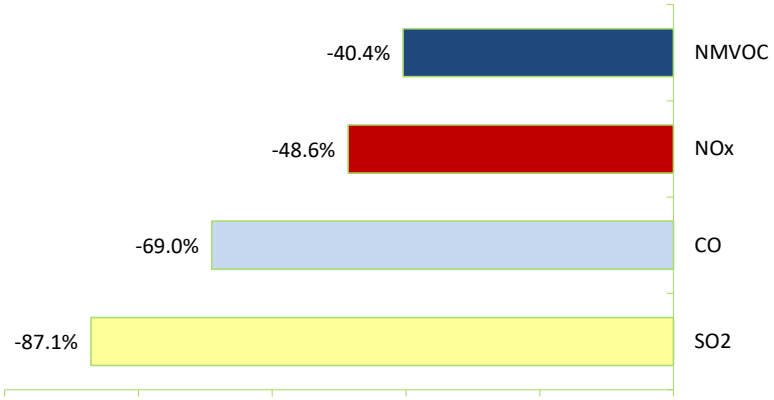



***Figure 2.12: Indirect GHG and $SO_x$ emissions: 1990-2024 variation***

In 2024, emissions from all these gases have decreased compared to 1990 levels.

Energy is the major responsible sector for emissions of NOx, SOx and CO. Its contribution for NMVOC emissions is also significant, together with IPPU sector.

Within energy, transportation is responsible for the largest share of $NO_x$ emissions, approx. 48 % of 2024 totals. Despite the fast-growing trends of the transport sector (mainly road) since the 90s, the introduction of new petrol-engine passenger cars with catalysts converters and stricter regulations on diesel vehicles emissions, resulted in the limitation of the growth of these emissions or even in their decrease. In fact, the situation started to shift in the mid-2000s, as transport emissions growth has first stabilized and started to decline since 2005. In the most recent years, the situation has been inversed with an increase of emissions after 2013. In the reporting period, 1990-2024, $NO_x$ emissions from transport decreased 40 %; and CO and NMVOC emissions registered reductions of more than 80 %. Other sectors (commercial/institutional, residential and agriculture/forestry) is a primary source of CO emissions representing approx. 42 % of the 2024 totals.

$SO_x$ emissions are mainly generated in the energy industry sector (approximately 32 % of total emissions in 2024) and combustion in manufacturing industries (approximately 42 % of total emissions in 2024), which are major consumers of fossil fuels. In the past, oil and coal represented the biggest share of the fuel mix used in thermal electrical production in the country. The situation shifted along the years with the significant development of renewable sources and its greater importance in electrical production, and the introduction of new stricter laws regulating the residual fuel oil (Decree-Law No. 281/2000, 10$^{th}$ November). The introduction of natural gas and its increasing use since 1997 was a major step in the control of $SO_x$ emissions. In 2024, natural gas represented the main fuel used in electric thermal generation.

The period 1990-2024 shows, in fact, a decrease in $SO_x$ emissions in both sub-categories: energy industries (-94 %) and manufacturing industries (-78 %). Since 2007, $SO_x$ emissions from energy industries registered a significant reduction (approximately 88 %), which is explained by the implementation of new abatement systems (desulfurization in two Large Point Source Energy Plants in Mainland Portugal).

The decline in emissions in electricity production in latest years is the result of the phase-down in the use of coal in thermal production which was definitively phased-out at the end of 2021 with the closure of the last Portuguese coal thermal plant (Sines), and the greater proportion of the renewable domestic production (without hydric) which grew more than 1000 % from 2005 to 2024, mainly due to an increase of wind power.

***Table 2.3: Indirect GHG and SOx emissions: 1990-2024***

| Gas emissions | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (Gg) | | | | | | | | | | | | | | | | | |
| CO | 775 | 786 | 815 | 787 | 791 | 798 | 771 | 752 | 723 | 691 | 656 | 610 | 590 | 565 | 537 | 501 | 468 | 441 |
| NOx | 256 | 270 | 291 | 281 | 279 | 291 | 273 | 275 | 288 | 299 | 292 | 290 | 296 | 272 | 275 | 277 | 255 | 245 |
| NMVOC | 354 | 358 | 360 | 338 | 339 | 330 | 340 | 351 | 356 | 362 | 359 | 341 | 335 | 318 | 305 | 290 | 275 | 268 |
| SO2 | 318 | 308 | 367 | 310 | 288 | 322 | 263 | 275 | 322 | 331 | 294 | 277 | 277 | 185 | 188 | 189 | 165 | 157 |

| Gas emissions | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | % change 1990-2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (Gg) | | | | | | | | | | | | | | | | | |
| CO | 404 | 380 | 369 | 347 | 332 | 313 | 297 | 302 | 289 | 288 | 270 | 278 | 248 | 277 | 243 | 243 | 240 | **-69.0** |
| NOx | 228 | 216 | 199 | 182 | 168 | 164 | 162 | 164 | 156 | 159 | 154 | 149 | 132 | 133 | 133 | 132 | 132 | **-48.6** |
| NMVOC | 252 | 229 | 235 | 221 | 212 | 214 | 224 | 229 | 213 | 215 | 225 | 227 | 231 | 223 | 227 | 227 | 211 | **-40.4** |
| SO2 | 104 | 72 | 62 | 57 | 52 | 48 | 43 | 45 | 45 | 46 | 47 | 44 | 38 | 39 | 41 | 41 | 41 | **-87.1** |

# 3 Energy (CRT Sector 1)

## Table of Contents


3 Energy (CRT Sector 1) ..... 3-1

3.1 Overview of the sector ..... 3-9

3.1.1 Fuel Combustion Activities (CRT 1.A) ..... 3-12

3.1.2 Fugitive Emissions from Fuels (CRT 1.B) ..... 3-13

3.2 International Bunker Fuels ..... 3-14

3.2.1 International aviation bunkers ..... 3-14

3.2.2 International marine bunkers ..... 3-15

3.3 Energy Industries (CRT 1.A.1) ..... 3-16

3.3.1 Public Electricity and Heat Production (CRT 1.A.1.a) ..... 3-16

3.3.2 Petroleum Refining (CRT 1.A.1.b) ..... 3-29

3.3.3 Manufacture of solid fuels and other energy industries (CRT 1.A.1.c) ..... 3-33

3.4 Manufacturing Industries and Construction (CRT 1.A.2) ..... 3-38

3.4.1 Methodology ..... 3-42

3.4.2 Activity data ..... 3-45

3.4.3 Emission Factors ..... 3-63

3.4.4 Uncertainty Assessment ..... 3-67

3.4.5 Category-specific QA/QC and verification ..... 3-68

3.4.6 Recalculations ..... 3-68

3.4.7 Further Improvements ..... 3-68

3.5 Transport (CRT 1.A.3) ..... 3-69

3.5.1 Civil Aviation (CRT 1.A.3.a) ..... 3-69

3.5.2 Road Transportation (CRT 1.A.3.b) ..... 3-80

3.5.3 Railways (CRT 1.A.3.c) ..... 3-92

3.5.4 Water-Borne Navigation (CRT 1.A.3.d) ..... 3-95

3.5.5 Other Mobile Sources (CRT 1.A.3.e) ..... 3-101
3.6 Other Sectors (CRT 1.A.4) ..... 3-102
3.6.1 Category description ..... 3-102
3.6.2 Methodology ..... 3-104
3.6.3 Activity Data ..... 3-106
3.6.4 Emission Factors ..... 3-113
3.6.5 Uncertainty Assessment ..... 3-115
3.6.6 Category-specific QA/QC and Verification ..... 3-115
3.6.7 Recalculations ..... 3-119
3.6.8 Further Improvements ..... 3-119
3.7 Other (Not Else-where specified) (CRT 1.A.5) ..... 3-120
3.7.1 Military Aviation (CRT 1.A.5.b) ..... 3-120
3.8 Fugitive Emissions from Fossil Fuels (CRT 1.B) ..... 3-122
3.8.1 Solid Fuels: Coal Mining and Handling (CRT 1.B.1.a) ..... 3-122
3.8.2 Solid fuels: Solid fuel transformation (CRT 1.B.1.b) ..... 3-127
3.8.3 Oil and natural gas and other emissions from energy production: Oil (CRT 1.B.2.a) ..... 3-129
3.8.4 Oil and natural gas and other emissions from energy production: Natural Gas (CRT 1.B.2.b) .. 3-139
3.8.5 Oil and natural gas and other emissions from energy production: Venting and Flaring (CRT 1.B.2.c) 3-144
3.8.6 Other Fugitive Emissions (Geothermal Electricity Production) (CRT 1.B.2.d) ..... 3-147
3.8.7 Other Fugitive Emissions (City Gas Production) (CRT 1.B.2.d) ..... 3-150
3.9 Sector-specific QA/QC and verification ..... 3-151
3.10 Further Improvements ..... 3-152
3.11 Reference Approach ..... 3-153
3.11.1 Category description ..... 3-153
3.11.2 Methodology ..... 3-153
3.11.3 Actual Carbon Dioxide Emissions ..... 3-156
3.11.4 Results - Comparison of Reference Approach and Sectoral Approach ..... 3-156
3.11.5 Feedstock ..... 3-158

# List of Figures

Figure 3-1: Energy emissions from the total greenhouse gas emissions in 2024 ..... 3-9

Figure 3-2: Total $CO_2e$ emissions from the Energy Sector (CRT 1) ..... 3-11

Figure 3-3: Trend of total GHG emissions in source 1A, expressed as $CO_2e$, by sub-sector. ..... 3-12

Figure 3-4: Trend of total GHG emissions in source 1B, expressed as $CO_2e$, by sub-sector ..... 3-13

Figure 3-5: International navigation and aviation bunkers ..... 3-14

Figure 3-6: International aviation bunkers ..... 3-15

Figure 3-7: International marine bunkers ..... 3-15

Figure 3-8: Trends of fuel consumption per fuel type ..... 3-23

Figure 3-9: Trends of fuel consumption in Azores and Madeira Archipelagos ..... 3-24

Figure 3-10: Trends in consumption of fuels in non-public co-generation plants ..... 3-24

Figure 3-11: Comparison of total fuel consumption in large power plants, between values used in the inventory (INERPA) and in the Energy Balance ..... 3-26

Figure 3-12: Comparison of fuel consumption between DGEG energy balance and IEA energy statistics.. 3-27

Figure 3-13: Fuel consumption in refineries ..... 3-31

Figure 3-14: Net Calorific Value (NCV) expressed in MJ/kg by fuel type ..... 3-31

Figure 3-15: Coking coal consumption and coke, coke oven gas and coal tar production in the coke plant .. 3-36

Figure 3-16: Consumption of fuels in co-generation in city gas production ..... 3-36

Figure 3-17: GHG's emissions from 1990 to 202 for Manufacturing Industries and contructions subcategories ..... 3-41

Figure 3-18: Final energy consumption for Diesel and Biodiesel ..... 3-44

Figure 3-19: Distribution of Large Point Sources in Portugal mainland ..... 3-46

Figure 3-20: General procedure for emissions estimate ..... 3-47

Figure 3-21: Total Energy Consumption in Manufacturing Industries and Construction ..... 3-50

Figure 3-22: Share of energy consumption by source & Greenhouse gases emissions intensity ..... 3-51

Figure 3-23: Share of energy consumption by source & Greenhouse gases emissions intensity ..... 3-52

Figure 3-24: Share of energy consumption by source & Greenhouse gases emissions intensity ..... 3-53

Figure 3-25: Share of energy consumption by source & Greenhouse gases emissions intensity ..... 3-54

Figure 3-26: Share of energy consumption by source & Greenhouse gases emissions intensity ..... 3-55

Figure 3-27 Energy consumption for the 4 main sub-sectors of category 1.A.2.f broken down by fuel type. 3-56

Figure 3-28: Share of energy consumption by source & Greenhouse gases emissions intensity ..... 3-57

Figure 3-29: Comparison of total LPS consumption in Paper Pulp units with the reported consumption in the EB for the sector “Paper pulp and paper production” ..... 3-59

Figure 3-30: Comparison of total LPS consumption in Petrochemical units with the reported consumption in the EB for the sector “Chemical and Plastics” . ..... 3-59

Figure 3-31: Comparison of total LPS consumption in Cement Plant with the reported consumption in the EB for the sector “Cement and Lime” (Due to confidentiality issue y axis values are not shown) ..... 3-60

Figure 3-32: Total paper pulp production: Kraft and sulphide paper pulp ..... 3-61

Figure 3-33: Ceramic Production according to type of ceramic ..... 3-62

Figure 3-34: Glass production by glass type (excluding flat glass production) ..... 3-62

Figure 3-35: Decision tree for emissions from aviation (EMEP/EEA, 2019) ..... 3-70

Figure 3-36: Decision tree for LTOCycle emission calculation ..... 3-72

Figure 3-37: Decision tree for distinction between domestic and international emissions. ..... 3-78

Figure 3-38: Total Fuel consumption of aviation gasoline and jet fuel (Source: DGEG). ..... 3-78

Figure 3-39: Fuel and lubricant consumption from Road Transportation sector (TJ). ..... 3-84

Figure 3-40: Number of Passenger Cars by fuel type. ..... 3-88

Figure 3-41: Kilometers travelled by vehicle type (kvkm). ..... 3-89

Figure 3-42: Consumption of fuels in the railway transport sector. ..... 3-93

Figure 3-43: Generic methodology flowchart. ..... 3-96

Figure 3-44: Ship fleet. ..... 3-98

Figure 3-45: Split in Thermal Uses for Commercial/Institutional Sector ..... 3-106

Figure 3-46: Split in Thermal Uses for Residential Sector ..... 3-107

Figure 3-47: Split in appliances/technologies for Residential Sector – Wood Burning ..... 3-107

Figure 3-48: Split in Thermal Uses for Agriculture Sector - Diesel ..... 3-108

Figure 3-49: Energy consumption in Comercial/Institutional sector - by Fuel, Source and Final Use ..... 3-109

Figure 3-50: Energy consumption in Residential sector - by Fuel, Source and Final Use ..... 3-110

Figure 3-51: Energy consumption in Agriculture sector - by Fuel, Source and Final Use ..... 3-111

Figure 3-52: Energy consumption in fishing sector - by Fuel, Source and Final Use ..... 3-112

Figure 3-53: Energy consumption comparison between Inventory, National Energy Balance and EUROSTAT data by sector ..... 3-116

Figure 3-54: Energy consumption comparison between National Energy Balance and Inventory data by fuel type ..... 3-118

Figure 3-55: Energy Consumption in Military aviation. ..... 3-121

Figure 3-56: Amount of coal extracted from mines in Portugal ..... 3-125

Figure 3-57: Coke production in the coke plant ..... 3-127

Figure 3-58: Total amount of crude arriving in Marine Terminals ..... 3-130

Figure 3-59: Coke burned in the Fluid Catalytic Cracking Unit ..... 3-132
Figure 3-60: Coke burned in Platforming/Continuous Catalyst Regeneration (CCR) ..... 3-134
Figure 3-61: Fuel consumption and Hydrogen production in the hydrogen steam reformers ..... 3-135
Figure 3-62: Total amount of crude throughput ..... 3-137
Figure 3-63: Fugitive Emissions from Natural Gas ..... 3-140
Figure 3-64: Natural Gas transported by High, Medium and Low Pressure Networks ..... 3-142
Figure 3-65: Total consumption of flare gas in Portuguese refineries and Low Heating Value ..... 3-145
Figure 3-66: Total amount of crude throughput in refineries ..... 3-146
Figure 3-67: Total Geothermal Production in Azores ..... 3-148
Figure 3-68: Apparent energy consumption ..... 3-155
Figure 3-69: Fuel consumption excluded from Apparent Consumption ..... 3-156
Figure 3-70: Comparison of Energy Consumption and $CO_2$ emissions between the National approach and the Reference Approach ..... 3-157
Figure 3-71: Carbon dioxide ($CO_2$) emissions from non-energy use by sector ..... 3-158

## List of Tables

Table 3-1: Total Greenhouse Gas Emissions from Energy (Mt $CO_2e$) ..... 3-10
Table 3-2: Key categories in Energy Sector (CRT 1) and methodologies used in emission estimates ..... 3-11
Table 3-3: Large Point Sources in the sector of Public Electricity and Heat Production ..... 3-17
Table 3-4: Electricity Power Plants in the Azores and Madeira ..... 3-19
Table 3-5: Emission Factors for energy production sector. Greenhouse Gases ..... 3-21
Table 3-6: $CO_2$ Emission Factors for energy production sector – Plant specific ..... 3-21
Table 3-7: Emission Factors for thermo-electricity production in Azores and Madeira. Greenhouse Gases .. 3-22
Table 3-8: Emission Factors for non public co-generation self producers. Greenhouse Gases ..... 3-22
Table 3-9: Low Heating Value per fuel type ..... 3-23
Table 3-10: LHV per fuel type ..... 3-24
Table 3-11: LHV per fuel type used for non-public co-generation plants estimates ..... 3-25
Table 3-12: Greenhouse Gases' emission factors for combustion sources in Petroleum Refining ..... 3-30
Table 3-13: Emission factors used in the carbon balance for the coke plant ..... 3-34
Table 3-14: $CH_4$ emission factor from coke production ..... 3-35
Table 3-15: Emission Factors used for the coke plant and city gas production ..... 3-35
Table 3-16: NCV/LHV per fuel type for city gas production ..... 3-37

Table 3-17: Subcategories under the Manufacturing Industries and Construction category ..... 3-38

Table 3-18: Key categories in Manufacturing Industries and Construction (CRT 1A2) and methodologies used in emission estimates ..... 3-38

Table 3-19: Total Greenhouse Gas Emissions from Manufacturing Industries and Construction (Mt $CO_2$eq) 3-39

Table 3-20: Incorporation rate of biodiesel (% toe/toe) ..... 3-43

Table 3-21: Structure of the Portuguese Energy Balance. Sectoral categories ..... 3-48

Table 3-22: Structure of the Portuguese Energy Balance. Fuel categories ..... 3-48

Table 3-23: Definition of Sectors in accordance with Economic Activity Classes ..... 3-49

Table 3-24: Total Paper Pulp Production (Kraft and sulphide paper pulp) ..... 3-61

Table 3-25: Ceramic Production according to type of ceramic (kt) ..... 3-62

Table 3-26: Glass production by glass type (kt/yr) excluding flat glass production ..... 3-63

Table 3-27: Default emission factors of Greenhouse gases for combustion equipments in Manufacturing Industry ..... 3-63

Table 3-28: Emission factors of Greenhouse gases in the extractive industry ..... 3-64

Table 3-29: Emission factors for Greenhouse gases in the building and construction industry ..... 3-64

Table 3-30: Emission factors for use in LPS units in the iron and steel sector ..... 3-65

Table 3-31: Emission factors for use in LPS units in the Chemical Industry: Greenhouse Gases from combustion ..... 3-65

Table 3-32: Emission factors used in LPS units in the Paper Pulp Industry: Greenhouse Gases from combustion – Energy Approach ..... 3-65

Table 3-33: Emission factors used in LPS units in the Paper Pulp Industry: Greenhouse Gases from combustion – Production Approach ..... 3-66

Table 3-34: Greenhouse Gases Emission Factors for ceramic production using the Production Approach: Greenhouse gases ..... 3-66

Table 3-35: Emission Factors for glass production using the Production Approach: $SO_x$ and Indirect Precursor gases (kg/t glass) ..... 3-66

Table 3-36: Emission Factors for glass production using the Production Approach: Greenhouse Gases ..... 3-67

Table 3-37: Greenhouse Gases Emission Factors for Cement Industry using the Energy Approach ..... 3-67

Table 3-38: Greenhouse Gases Emission Factors for Off-road vehicles and other machinery ..... 3-67

Table 3-39: Estimated emissions from Civil Aviation (kt $CO_2$ eq). ..... 3-69

Table 3-40: IPCC 2006 source categories. ..... 3-70

Table 3-41: Emissions factors for most common aircraft movements in national airports. ..... 3-74

Table 3-42: Airport based LTO emission factors (kg/movement). ..... 3-75

Table 3-43: Cruise emissions and fuel consumption. ..... 3-76

Table 3-44: Fuel dependent emission factors ..... 3-77

Table 3-45: $LTO_{Cycle}$ per airport. ..... 3-77
Table 3-46: Aviation activity level uncertainty. ..... 3-79
Table 3-47: Estimated emissions from Road Transportation (Kt $CO_2$ eq). ..... 3-80
Table 3-48: Road Transportation distance based implied emission factor for 2023 (g/km and mg/km). ..... 3-81
Table 3-49: Monthly average ambient temperatures (ºC) and relative air humidity (%). ..... 3-82
Table 3-50: Fuel specifications. ..... 3-82
Table 3-51: Sulphur content in petrol and diesel (ppm wt). ..... 3-83
Table 3-52: Reid Vapour Pressure (kPa). ..... 3-83
Table 3-53: Incorporation rate of Biodiesel in Diesel (%). ..... 3-84
Table 3-54: Incorporation rate of Bioethanol in Petrol (%) ..... 3-84
Table 3-55: COPERT 5 segments. ..... 3-85
Table 3-56: Technology classification according to first registry year. ..... 3-86
Table 3-57: Vehicle fleet synthesis. ..... 3-87
Table 3-58: Assumed mileage percentage driven by driving mode and vehicle type for 2023. ..... 3-90
Table 3-59: Assumed vehicle speeds by driving mode and vehicle type. ..... 3-90
Table 3-60: Estimated emissions from Railways (Gg $CO_2e$) ..... 3-92
Table 3-61: Low Heating Value (LHV) – Railways. ..... 3-93
Table 3-62: Oxidation factor and Percentage of carbon from fossil origin in fuels – Railways ..... 3-93
Table 3-63: Emission factors for Greenhouse gases in Railways. ..... 3-93
Table 3-64: Incorporation rate of biodiesel (% toe/toe) ..... 3-94
Table 3-65: Estimated emissions from Water-Borne Navigation (kt $CO_2$ eq). ..... 3-95
Table 3-66: Low Heating Value (LHV) – Navigation. ..... 3-97
Table 3-67: Carbon content – Navigation. ..... 3-97
Table 3-68: Emission factors for Greenhouse gases – Navigation. ..... 3-97
Table 3-69: Consumption factors. ..... 3-97
Table 3-70: Ship docks. ..... 3-98
Table 3-71: Total fuel sales (ton). ..... 3-99
Table 3-72: Estimated fuel consumption (ton). ..... 3-99
Table 3-73: Estimated fuel consumption after top-down calibration (ton). ..... 3-99
Table 3-74: Criteria employed in the tugs fuel consumption estimation. ..... 3-99
Table 3-75: Ship type classification for tugs fuel consumption estimation. ..... 3-99
Table 3-76: Navigation activity level uncertainty. ..... 3-100
Table 3-77: Subcategories considered and coverage of estimated Greenhouse gases ..... 3-102

Table 3-78: Estimated emissions from Other Sectors (Gg $CO_2$ eq.) ..... 3-103
Table 3-79: Key categories in Other Sectors (CRT 1.A.4) and methodologies used in emission estimates 3-103
Table 3-80: Methodological approaches and main source of emissions for each sub-category ..... 3-104
Table 3-81: Emissions factors for Category 1.A.4.a.i – Commercial/Institutional: Stationary ..... 3-113
Table 3-82: Emissions factors for Category 1.A.4.b.i – Residential: Stationary ..... 3-113
Table 3-83: Emissions factors for Category 1.A.4.c.i – Agriculture / Forestry / Fishing: Stationary ..... 3-114
Table 3-84: Emissions factors for Categories 1.A.4.a.ii, 1.A.4.b.ii and 1.A.4.c.ii – Mobile sources ..... 3-114
Table 3-85: Emissions factors for Categories 1.A.4.c.iii – Mobile sources ..... 3-114
Table 3-86: Emission factors ..... 3-120
Table 3-87: Emission Factors for coal extraction and processing ..... 3-124
Table 3-88: Total number of abandoned mines in each time band since 1901 ..... 3-125
Table 3-89: Percentage of abandoned underground coal mines that are gassy ..... 3-125
Table 3-90: Emission Factors ..... 3-130
Table 3-91: $CO_2$ emission Factor ..... 3-132
Table 3-92: $CO_2$ emission factors ..... 3-133
Table 3-93: $CO_2$ emission factors ..... 3-135
Table 3-94: $CH_4$ emission factor for fugitive emissions in oil refining ..... 3-136
Table 3-95: Ajustment Factor for Natural Gas Leaks ..... 3-141
Table 3-96: Characteristics of natural gas ..... 3-142
Table 3-97: Emission Factors for flaring in refineries ..... 3-145
Table 3-98: Emission Factors for Geothermal Electricity Production ..... 3-148
Table 3-99: Carbon content of fuels and Oxidation Factor used in the Reference Approach ..... 3-154

# 3 Energy (CRT Sector 1)

*Mariana Moreira*

*Mónica Borges*

*Rita Silva*

*Updated: March 2025 and March 2026*

## 3.1 Overview of the sector

Energy-related activities are the major sources of Portuguese GHG emissions, accounting in 2024 for 65.6 % of total emissions of $CO_2e$ excluding LULUCF and including indirect $CO_2$. In 2024, Energy category accounted for 33.7 Mt of Portugal's total GHG emissions, with a 17.2% (6.98 Mt) decrease in overall emissions since 1990 (refer to Table 3–1 for more details). Energy emissions are primarily related to fossil fuel combustion.

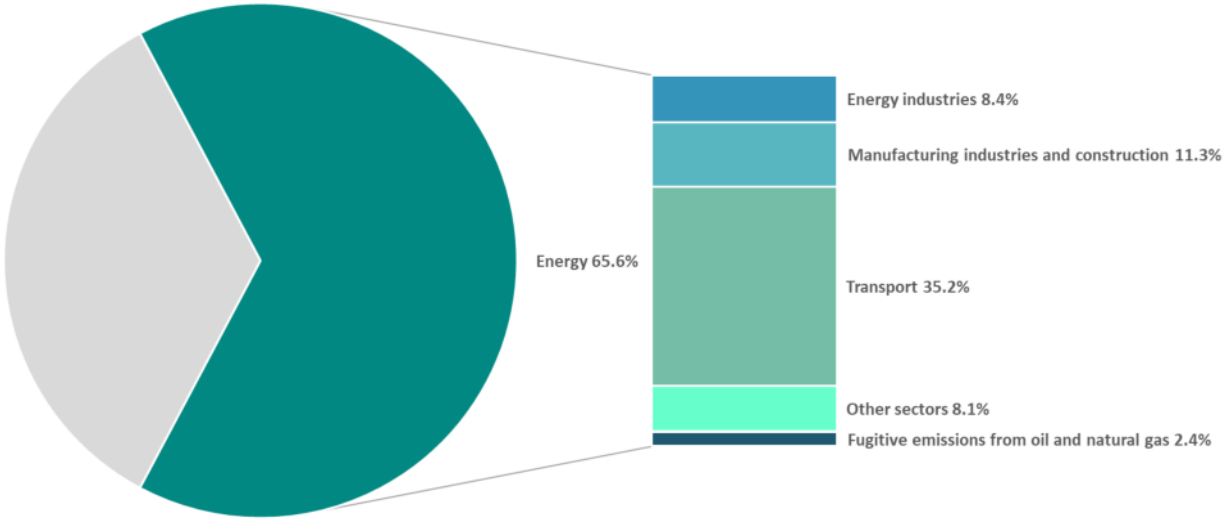



***Figure 3-1: Energy emissions from the total greenhouse gas emissions in 2024***

In Portugal, the transports sector was the primary source of Portuguese GHG emissions, representing, 35.2% of total GHG emissions excluding LULUCF in year 2024. It is noticeable the significant increase in emissions from transportation in comparison to the other sub-source categories.

Manufacturing industries and construction accounted for 11.3% of total GHG emissions in 2024, followed by energy industries with 8.4%. Other sectors, including residential, commercial/institutional, agriculture/forestry and fisheries (excluding bunkers), represented 8.1% of total sector emissions. Still with some impact on emissions in 2024, fugitive emissions from oil and natural gas arose with 2.4% of emissions. More details regarding the fugitive emissions categories in 3.1.2 Fugitive Emissions from Fuels (CRT 1.B).

*Table 3-1: Total Greenhouse Gas Emissions from Energy (Mt $CO_2e$)*

| | Source /Gas | 1990 | 2005 | 2022 | 2023 | 2024 | Δ 2024-2023 | Δ 2024-2005 | Δ 2024-1990 |
|---|---|---|---|---|---|---|---|---|---|
| | | kt $CO_2$ eq. | | | | | % | | |
| **1.A.1** | **Energy industries** | | | | | | | | |
| | $CO_2$ | 16 365.6 | 25 338.1 | 8 252.5 | 5 779.0 | 4 253.4 | -26.4 | -83.2 | -74.0 |
| | $CH_4$ | 6.7 | 17.8 | 12.6 | 12.4 | 12.5 | 1.1 | -29.7 | 87.5 |
| | $N_2O$ | 43.2 | 147.0 | 108.3 | 74.2 | 51.5 | -30.6 | -65.0 | 19.3 |
| **1.A.2** | **Manufacturing industries and construction** | | | | | | | | |
| | $CO_2$ | 8 853.3 | 10 382.0 | 6 633.7 | 5 749.7 | 5 633.9 | -2.0 | -45.7 | -36.4 |
| | $CH_4$ | 34.8 | 51.9 | 60.1 | 59.4 | 60.7 | 2.2 | 17.0 | 74.5 |
| | $N_2O$ | 105.5 | 145.0 | 113.1 | 110.0 | 114.5 | 4.1 | -21.0 | 8.5 |
| **1.A.3** | **Transport** | | | | | | | | |
| | $CO_2$ | 10 618.0 | 19 694.6 | 16 941.8 | 18 067.7 | 17 936.5 | -0.7 | -8.9 | 68.9 |
| | $CH_4$ | 111.3 | 69.4 | 21.0 | 21.5 | 22.4 | 3.9 | -67.8 | -79.9 |
| | $N_2O$ | 91.3 | 180.5 | 144.5 | 152.2 | 149.9 | -1.5 | -17.0 | 64.1 |
| **1.A.4** | **Other sectors** | | | | | | | | |
| | $CO_2$ | 3 463.3 | 6 716.6 | 3 799.4 | 3 697.1 | 3 776.3 | 2.1 | -43.8 | 9.0 |
| | $CH_4$ | 482.6 | 296.8 | 239.4 | 243.3 | 233.1 | -4.2 | -21.5 | -51.7 |
| | $N_2O$ | 192.8 | 168.2 | 148.6 | 154.2 | 150.2 | -2.6 | -10.7 | -22.1 |
| **1.A.5** | **Other** | | | | | | | | |
| | $CO_2$ | 96.1 | 73.3 | 89.5 | 48.8 | 54.3 | 11.2 | -26.0 | -43.6 |
| | $CH_4$ | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 11.2 | -26.0 | -43.6 |
| | $N_2O$ | 0.7 | 0.5 | 0.7 | 0.4 | 0.4 | 11.2 | -26.0 | -43.6 |
| **1.B.1** | **Fugitive emissions from solid fuels** | | | | | | | | |
| | $CO_2$ | 2.9 | 0.0 | 0.0 | 0.0 | 0.0 | n.a | n.a | -100.0 |
| | $CH_4$ | 156.9 | 22.3 | 16.8 | 16.7 | 16.5 | -1.1 | -26.0 | -89.5 |
| | $N_2O$ | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | n.a | n.a | n.a |
| **1.B.2** | **Fugitive emissions from oil and natural gas** | | | | | | | | |
| | $CO_2$ | 53.7 | 563.2 | 1 174.6 | 1 023.5 | 1 177.8 | 15.1 | 109.1 | 2092.9 |
| | $CH_4$ | 2.5 | 43.3 | 59.0 | 56.8 | 57.6 | 1.4 | 32.8 | 2228.2 |
| | $N_2O$ | 2.1 | 2.6 | 2.0 | 1.9 | 2.1 | 15.4 | -18.0 | 2.5 |
| Total | $CO_2$ | 39 452.9 | 62 767.8 | 36 891.6 | 34 365.9 | 32 832.1 | -4.5 | -47.7 | -16.8 |
| | $CH_4$ | 794.7 | 501.6 | 409.0 | 410.0 | 402.8 | -1.8 | -19.7 | -49.3 |
| | $N_2O$ | 435.6 | 643.9 | 517.2 | 492.8 | 468.6 | -4.9 | -27.2 | 7.6 |
| Total | All gases | 40 683.2 | 63 913.3 | 37 817.8 | 35 268.7 | 33 703.4 | -4.4 | -47.3 | -17.2 |

Total emissions from this sector have decrease 17.2% from base year to last year. The year with maximum emissions occurred in 2002, as may be seen in Figure 3-2. The oscillations in $CO_2e$ emission for the energy sector are mainly due to inter-annual variation in availability of hydropower. In recent years there has been a decreasing trend in emission resulting not only from a period of economic stagnation in Portugal but also with the implementation of measures that had a positive impact in the reduction of emissions, such as the introduction of lower carbon intensive fuels, the installation of combined cycle thermoelectric plants and co-generation units, and the use of renewable energy sources.

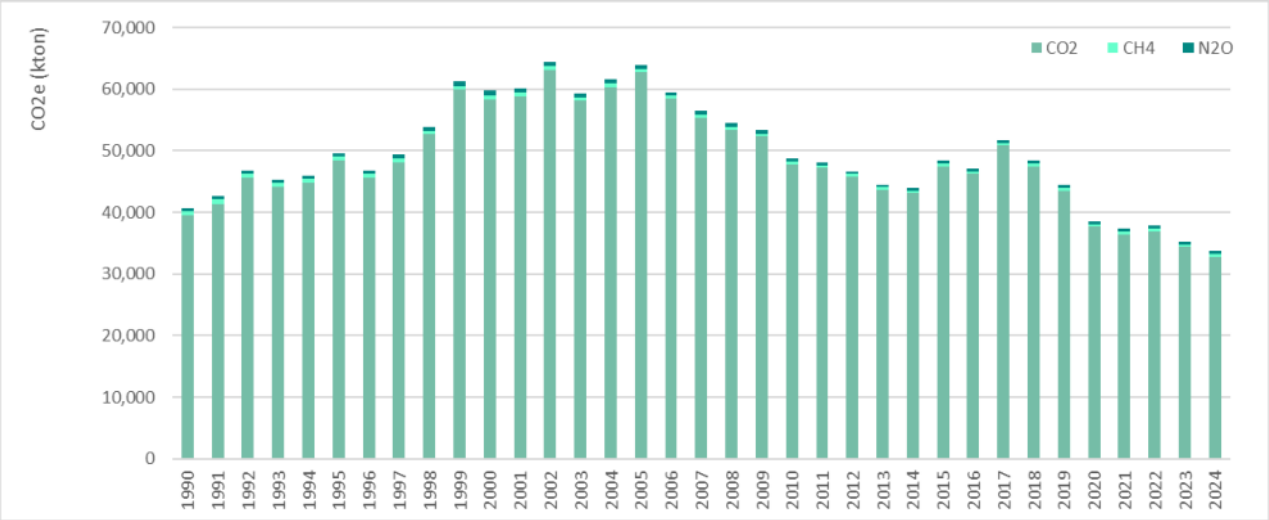



***Figure 3-2: Total $CO_2e$ emissions from the Energy Sector (CRT 1)***

Fifteen key categories have been identified for this sector in 2024, for level and trend assessment, using both the IPCC Approach 1 and Approach 2:

***Table 3-2: Key categories in Energy Sector (CRT 1) and methodologies used in emission estimates***

| IPCC category | Gas | Criteria | Method |
|---|---|---|---|
| **1.A.3.b Road Transportation** | $CO_2$ | L,T | T1 |
| **1.A.1 Energy industries** - Gaseous fuels | $CO_2$ | L,T | T2, T3 |
| **1.A.2 Manufacturing industries and construction** - Gaseous fuels | $CO_2$ | L,T | T2, T3 |
| **1.A.2 Manufacturing industries and construction** - Liquid fuels | $CO_2$ | L,T | T1 |
| **1.A.4 Combustion Other Sectors** - Liquid fuels | $CO_2$ | L | T1 |
| **1.A.1 Energy industries** - Liquid fuels | $CO_2$ | L,T | T1 |
| **1.A.4 Combustion Other Sectors** - Gaseous fuels | $CO_2$ | L,T | T2 |
| **1.B.2.a Fugitive emissions** - Oil | $CO_2$ | L,T | T2, T3 |
| **1.A.1 Energy industries** - Other fossil fuels | $CO_2$ | L,T | T1, T3 |
| **1.A.3.a Civil (domestic) aviation** | $CO_2$ | L | T1, T3 |
| **1.A.2 Manufacturing industries and construction** - Other fossil fuels | $CO_2$ | L,T | T1, T3 |
| **1.A.3.d Domestic navigation** - Residual fuel oil | $CO_2$ | L | T2 |
| **1.A.4 Combustion Other Sectors** - Biomass | $CH_4$ | L | T1, T2 |
| **1.B.1.Fugitive emissions** – Solid Fuels | $CH_4$ | LT | T1 |
| **1.A.2 Manufacturing industries and construction** - Solid fuels | $CO_2$ | L,T | T2, T3 |

### 3.1.1 Fuel Combustion Activities (CRT 1.A)

Energy emissions are primarily related to fossil fuel combustion. In Portugal, transports remain the main source of GHG emissions, representing 35.2% of total emissions excluding LULUCF in 2024. Within Fuel Combustion Activities, manufacturing industries and construction accounted for 11.3% of total GHG emissions, followed by energy industries with 8.4%. Other sectors, including residential, commercial/institutional, agriculture/forestry, and fisheries (excluding bunkers), represent 8.1% of total sector emissions. Emissions for the full-time trend in Figure 3-3. The emissions from the incineration of municipal solid wastes (MSW) that occurs with energy recovery are accounted in this sector as recommended by the IPCC GPG.

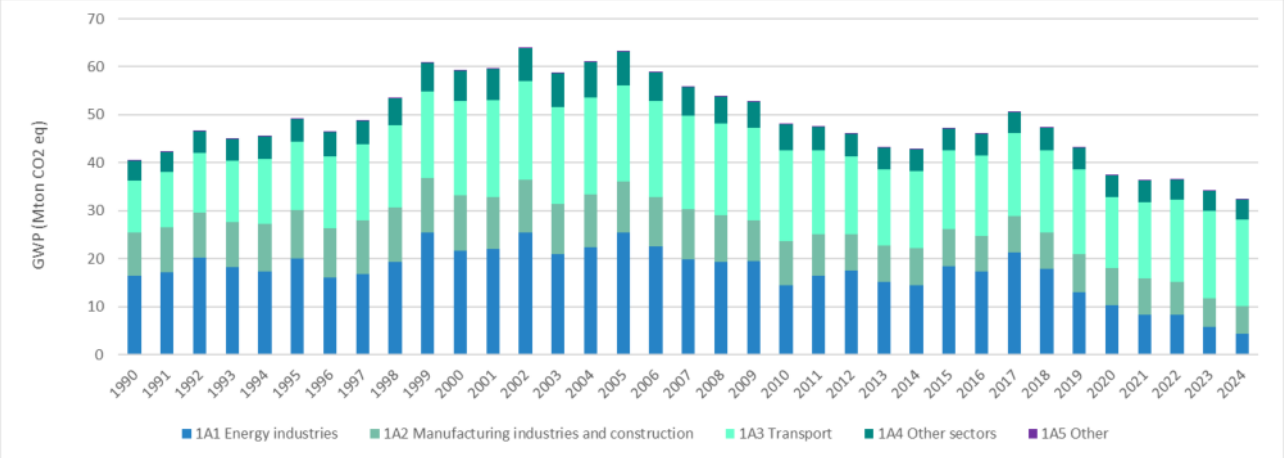



***Figure 3-3: Trend of total GHG emissions in source 1A, expressed as $CO_2e$, by sub-sector.***

GHG emissions from this activity sector are almost fully dominated by direct $CO_2$ emissions, which represent about 97.6 % of GHG emissions in 2024. $CH_4$ and $N_2O$ are minor sources, respectively 1.2 % and 1.3 % of total GHG emissions from the 1.A sector in 2024.

$CO_2$ emissions are dependent on the carbon content of the fuel used and, for this reason, estimates of $CO_2$ emissions are more accurate and methodology simpler to apply using fuel consumption data only. During the combustion process some carbon is released in smaller amounts in the form of other gases, including $CH_4$, CO, NMVOC and airborne particulate matter. It is presumed that all these other carbon containing non-$CO_2$ gases oxidise to $CO_2$ in the atmosphere and are include in carbon dioxide estimates (ultimate $CO_2$)[1].

Emissions from fossil fuel combustion include also other atmospheric contaminants such as $N_2O$, $NO_x$, $SO_x$; $NH_3$, particulate matter, heavy metals and toxic organic compounds. Unlike $CO_2$, emissions estimates of these air contaminants require more detailed information, such as operating conditions, combustion and emission control technologies and fuel characteristics.

Fossil fuel combustion from international bunkers, i.e., international aviation and maritime transportation, also generates air emissions in a similar way to other fuel combustion activity. In accordance with international guidelines, these emissions are not included in national totals but are reported separately as a memo item.

[1] Three $CO_2$ quantities may be referred in the inventory with different definitions: (1) End of pipe $CO_2$ - Carbon dioxide effectively emitted from the source: exhaust, chimney, etc; (2) Ultimate $CO_2$ - carbon dioxide increase contribution to atmosphere. Includes end of pipe $CO_2$ but also the conversion of other gases and particles that are emitted to atmosphere containing carbon and that are supposedly latter converted in $CO_2$; (3) Fossil ultimate $CO_2$ - $CO_2$ emissions resulting from carbon with fossil origin: fossil fuels, mineral rocks and all other non biomass carbon.

Biomass combustion also generates gas emissions. Carbon dioxide emissions from this source are estimated in the inventory but not included in national emissions totals being considered that there are no net emissions of $CO_2$, as carbon released during biomass combustion had been in fact fixed from atmosphere by the photosynthetic process and when is burnt and returns to atmosphere does not increase the atmospheric/biosphere $CO_2$ pool. This activity is reported separately for information purposes only. Nevertheless, non-$CO_2$ emissions from combustion of biofuels and other biomass fuels are considered in inventory totals.

### 3.1.2 Fugitive Emissions from Fuels (CRT 1.B)

Apart from fuel combustion emissions, the Energy sector includes also other from production, transmission, storage and distribution of fossil fuels. Generated gases from these sources are $CO_2$, NMVOC, $SO_x$, $CH_4$, $NO_x$ and CO, and emissions per sub-sector source are presented in the figure below, where the major importance of emissions due to oil refining, transport and distribution for the beginning of the period may be seen, while the importance of emissions from storage and transportation of natural gas, became more relevant in recent years.

GHG emissions occurring as $CO_2$ are responsible for 93.9 % of 1.B total emissions in 2024. Emissions occurring as $CH_4$ represent 5.9 % of 1.B total emissions and $N_2O$ represent only 0.2 %.

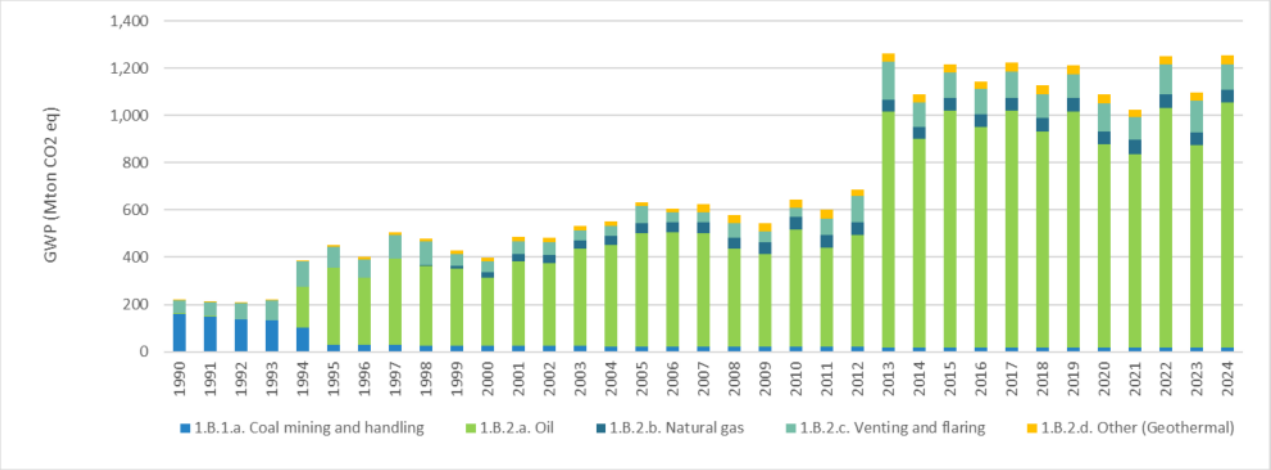



***Figure 3-4: Trend of total GHG emissions in source 1B, expressed as $CO_2e$, by sub-sector***

## 3.2 International Bunker Fuels

International bunker fuels used in international aviation and international navigation are presented in the figure below.

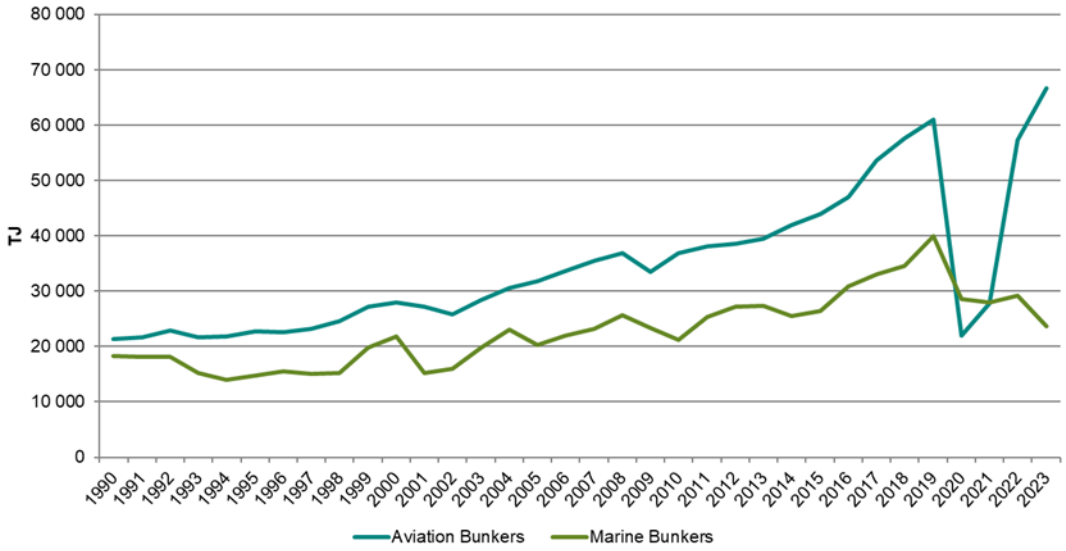



***Figure 3-5: International navigation and aviation bunkers***

### 3.2.1 International aviation bunkers

Most of the jet fuel is used for international aviation. In 2023 the quantity of jet fuel for international aviation was about 90% of total jet fuel. This percentage was estimated according with the origin and destiny of the flight as recommended by 2006 IPCC guidelines.

Until 2006, the classification for international fuel used by the national fuel authority (DGEG) was different from the one used in national inventory. DGEG split was based in the flag of the aircraft rather than in the origin and destiny of the flight. Some efforts were made in the fuel balance to use the IPCC criteria and since 2007 the difference between the reference approach (RA) and the sectoral approach (SA) has decreased. For the period between 1990 and 2006, the reference approach uses the energy consumption data from EUROSTAT.

The 1990 peak in the difference between sectoral approach and reference approach is due to a question raised during the 2016 UNFCC centralized review related with a higher consumption of jet kerosene in civil aviation. This question led to the identification of an error in the cruise consumption compilation and the correction of the jet kerosene consumption in that year.

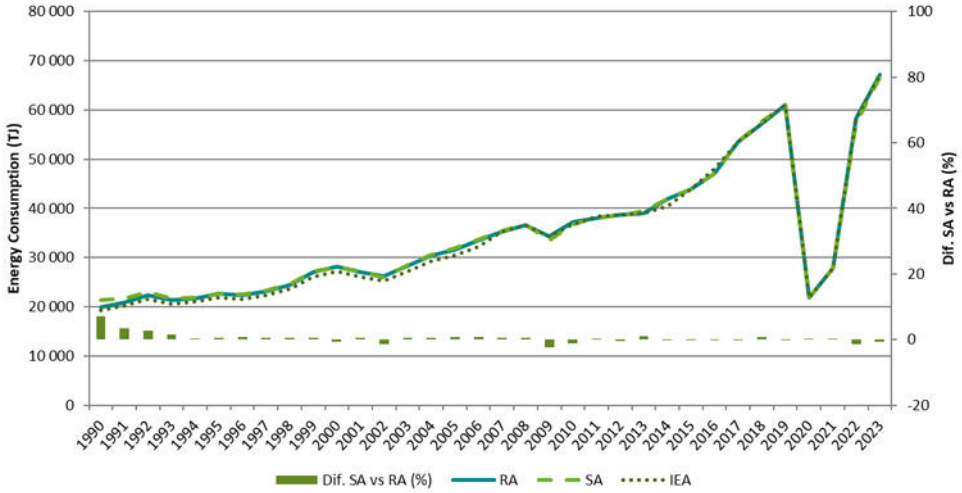



***Figure 3-6: International aviation bunkers***

### 3.2.2 International marine bunkers

In 2023 the energy consumption for international navigation was about 86% of the total energy used in marine navigation. This percentage was estimated according with the origin and destiny of the movement as recommended by 2006 IPCC guidelines.

Until 2012, the international fuel classification used by the national fuel authority (DGEG) was different from the one used in national inventory. DGEG split was based in the flag of the ship rather than in the origin and destiny of the movement. As consequence the international consumption from the reference approach (RA) differs from the consumption estimated using the sectoral approach (SA) until this date. Some efforts were made in the fuel balance to use the IPCC criteria and since 2013 the difference between the reference approach (RA) and the sectoral approach (SA) has decreased.

The international navigation energy consumption data from the IEA differ to some extent from the DGEG fuel balance. The data from IEA includes consumption from domestic navigation and this occurs because domestic consumption is missed classified as international bunkers when reported to the IEA.

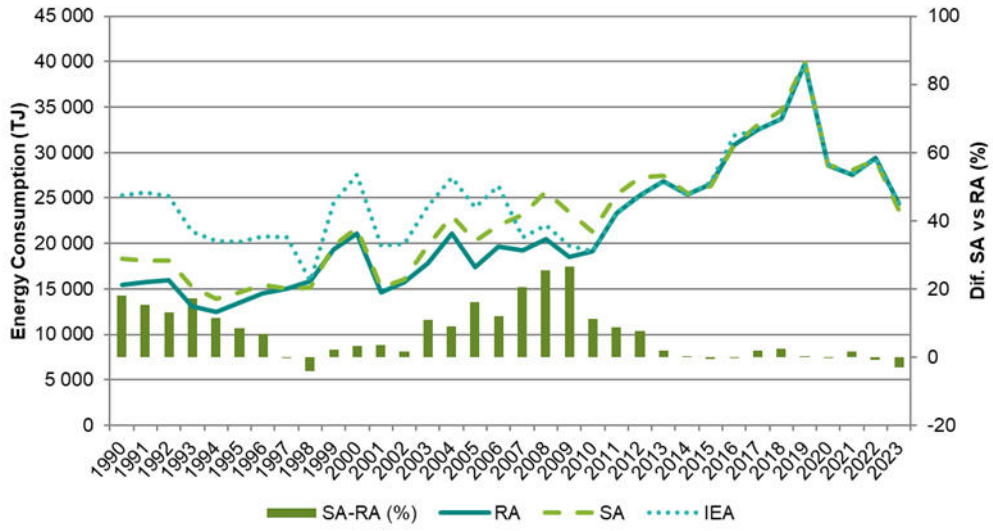



***Figure 3-7: International marine bunkers***

## 3.3 Energy Industries (CRT 1.A.1)

### 3.3.1 Public Electricity and Heat Production (CRT 1.A.1.a)

#### 3.3.1.1 Category description

Until 1950 electric energy production in Portugal was based in small power plant units using coal as energy source. In the 50s increase in the demand for industry consumers induced the development of hydro-electric production units and the built of *Tapada do Outeiro* power plant using low energy coal (lignite) obtained from Portuguese mines. The next decade saw the entrance of petroleum products as the main energy sources, and three additional power plants were built: *Carregado*, *Barreiro* and *Setúbal*. After the energy crisis of 1973/74 and 1979/81 there was a political shift towards the preference for imported coal (*Sines* and *Pêgo* power plants, started in 1985 and 1993 respectively) and, more recently, towards natural gas (*Turbogás* power plant already in operation and the new TER[2] unit, build near the old unit in *Carregado entered its final testing period at the end of 2003*). In the islands of Azores and Madeira, the discontinuity in territory caused the prevalence of smaller units, basically one per island, working on fuel-oil or diesel-oil.

Apart from the dedicated electric power plants, auto-producers generate electric energy for own consumption and to sales to the public system. However not all combustion from these sources are included here because, according to the 2006 IPCC Guidelines, emissions from auto-producers are to be reported under the industrial or commercial branch in which their main economic activity occurs. The present source sector includes only emissions resulting from main power producers[3].

Several components of the electricity and heat producing sector where arbitrarily individualized in the inventory of air emissions from the energy sector for the sake of making explanation easier and they are discussed separately in the following paragraphs.

This category includes also the emissions associated with the incineration of municipal solid wastes (MSW) with energy recovery.

#### 3.3.1.2 Large Point Source Energy Plants in Mainland Portugal

The number of Large Point Source Energy Plants (LPS-EP) in continental Portugal has increased from 6 units in 1990 to 16 units at present. Power plants and installed power are listed in table below together with their main relevant characteristics.

[2] TER – Termoeléctrica do Carregado

[3] Main Power Producers generate and sell electricity or heat as their main activity (primary activity) either public owned or private owned. In contrast there are other Auto-producers of electricity or heat, that also are agents producing or selling electricity or heat, but as a secondary activity and not as main business.

***Table 3-3: Large Point Sources in the sector of Public Electricity and Heat Production***

| Power Plant | Location | Start | Situation | Fuel*** | Power | Technology | Treatment of Gas Effluents**** | Stack Height (m) | Comments |
|---|---|---|---|---|---|---|---|---|---|
| Tapada do Outeiro | Gondomar | 1959 | Deactivated (2003) | LIG + FO | 150/100/47* MWe | Boiler + Steam Turbine. | ESP | 60 (x3) | Lignite use stopped in 1997 |
| Portgen (new Tapada do Outeiro) | Gondomar | 1998 | Working | NG + GO + LPG | 990 (3x330) MWe | Combined Cycle. | DLE (only for one group) | 60 (x3) | - |
| Soporgen | Lavos | 2001 | Working | NG | 67 (44+23) MWe | Co-generation. Combined Cycle | DLE | 50 (x2) | - |
| Energin | Alhandra | 2002 | Deactivated (2014) | NG | 43.7 MWe | Co-generation. Combined Cycle | - | 31 (x1) | - |
| Mortágua | Mortágua | 1999 | Working | WW + NG + GO | 30 MWe | Boiler + Steam Turbine. | ESP | - | - |
| Pêgo | Abrantes | 1993 | Working | NG + GO + FO + WW | 1632 MWe | Boiler + Steam Turbine. | ESP + LNOX + WFGD + SCR | 225 (x1) | WFGD after 2008 SCR after 2008 |
| Pêgo (Elecgás) | Abrantes | 2010 | Working | NG + GO | 800 MWe | Combined Cycle | DLE | 80 (x2) | |
| Carregado | Alenquer | 1968 | Deactivated (2011) | FO + NG + GO + LPG | 750 (6x125) MWe | Boiler + Steam Turbine. | ESP | 100 (x3) | Natural gas introduced in 1997 |
| TER | Alenquer | 2004 | Working | NG + GO | 1170 MWe | Combined Cycle. | - | 75 (x3) | - |
| Carriço | Sines | 2006 | Working | NG + GO | 487 MWe | Co-generation. | - | 30 (x1) | - |
| Alto do Mira | Amadora | 1975 | Deactivated (2003) | GO | 132 MWe | Gas Turbine. | - | 13.5 (x1) | - |
| Barreiro | Barreiro | 1978 | Deactivated (2010) | FO + LPG | 65 (32+33) MWe | Co-generation. | - | 104 (x1) | - |
| Fisigen | Barreiro | 2009 | Working | NG | 121 MWt | Co-generation. | - | - | - |
| Setúbal | Setúbal | 1979 | Deactivated (2013) | FO + GO + LPG | 1000 (4x250) MWe | Boiler + Steam Turbine. | ESP | 201 (x2) | - |
| Sines | Sines | 1985 | Deactivated (2021) | HC + FO | 1256 (4X314) MWe | Boiler + Steam Turbine. | ESP + LNOX + WFGD + SCR | 225 (x2) | WFGD after 2008 SCR after 2011 |
| Tunes | Silves | 1973 | Deactivated (2013) | GO | 199.2 (2x16.3 + 2x83.3) MWe | Gas turbine. | - | 13.5 | Groups 1 and 2 deactivated in 2007. |
| Lares | Figueira da Foz | 2009 | Working | NG + GO | 1428 MWt | Combined Cycle. | - | - | - |
| Constância | Constância | 2009 | Working | WW + FO + LPG | 39.2 MWt | Boiler + Steam Turbine. | - | - | - |
| Figueira da Foz | Figueira da Foz | 2009 | Working | WW + NG | 31.2 MWt | Boiler + Steam Turbine. | DLE + ESP | 80 | - |
| Cacia | Cacia | 2009 | Working | WW + NG + GO | 49.75 MWt | Boiler + Steam Turbine. | - | - | - |
| CB Setúbal | Setúbal | 2009 | Working | WW + NG + GO | 49.75 MWt | Boiler + Steam Turbine. | - | - | - |
| Rodão | Vila Velha do Rodão | 2008 | Working | WW + FO + LPG + GO | 39.1 MWt | Boiler + Steam Turbine. | - | - | - |
| Artelia | Sines | 2011 | Working | NG + BG | 269.7 (135.9 + 33.8 + 100) MWt | Combined Cycle. | LNOX | 45 | - |

* 250 MW in 2 groups using fuel oil and natural gas.
** The smaller power value refers to situation after 2 of the 3 initial groups where closed. The intermediate value refers to the situation when 2 groups where operating.
*** HC - hard-coal; LIG - Lignite; FO - fuel-oil; GO - Diesel oil; NG - Natural Gas; WW – Wood Waste; BG - Biogas ; LPG – Liquid Petroleum Gas
**** WFGD – Wet Flue Gas Desulfurization; DLE – Dry Low Emissions; ESP – Electrostatic Precipitators; LNOx – Low Nox Burners; SCR - Selective Catalytic Reduction

There are two small gas turbine power plants included in the public service: one near Lisbon to sustain peak power demands and another in Tunes, in the southern province of Algarve, which is used to support the increase of demand during touristy seasonal peak demands. The unit near Lisbon (Alto do Mira) has interrupted its activity in 2003.

There has also been a change in the production structure since 1990, with a reduction in the importance of the use of petroleum products (fuel-oil) and an increase in the use of imported coal - in first place - and then natural gas. The only other energy source used in these units was Orimolsion, that was used as fuel in Setúbal power plant but only in 1994 and its use had no continuation. In most recent years new power plants using wood waste were commissioned.

- In 1990 three units (Carregado, Setúbal and Barreiro) were using fuel-oil, one unit (Sines) was consuming imported hard coal and another unit (Tapada do Outeiro) was using lignite coal and fuel-oil;

- A new build coal unit (Pêgo) using hard coal, started producing electricity in 1993 and doubled its production capacity in 1995. The use of hard coal ceased in 2021, being replaced by biomass;

- The old unit in northern Portugal (Tapada do Outeiro) that was burning low heating value lignite coal, partly mined in Portugal, stopped using this fuel in 1997 but was kept producing electricity with a small consumption of fuel-oil since;

- Between 1995 and 1997 Carregado power plant shifted part of its production groups from residual fuel-oil to natural gas;

- A new unit (Portgen) consuming natural gas was build in northern Portugal near the old unit of Tapada do Outeiro and started producing in 1998;

- A new unit - TER - also using natural gas was installed, and started activity in the end of 2003, near the old unit of Carregado;

- The Mortágua unit in central Portugal initiated production in 1999 using a combination of natural gas and wood wastes;

- Soporgen and Energin, in central Portugal and Carriço (in the south) start production (Soporgen in 2001, Energin in 2002 and Carriço in 2006) using natural gas. They exist in close connection, respectively, with an industrial paper pulp plant, a chemical industry plant and a crude oil refinery;

- In 2009 a new power plant was built in Lavradio – Fisigen. This new plant replaced the Barreiro plant in 2010. Also in 2009 a new power plant was built in Figueira da Foz – Lares, which burn NG as fuel;

- In later years (2008 and 2009) new small power plants were built that burn wood waste;

- In 2010 a new combined cycle plant was inaugurated in Abrantes;

- Artelia new combined cycle plant began its operation in 2011.

#### 3.3.1.2.1 Energy Plants in Azores and Madeira Autonomous Regions

Electricity production in the autonomous regions of Madeira and Azores islands depends mostly on small and medium scale power plants using imported residual fuel oil and/or diesel oil.

***Table 3-4: Electricity Power Plants in the Azores and Madeira***

| Power Station | Location | Fuel* | Power |
|---|---|---|---|
| Porto Santo | Porto Santo | FO + GO | 51.9 MWt |
| Vitória | Funchal | FO + GO + NG | 326.4 MWt |
| Caniçal | Caniçal | FO + GO + LPG | 144 MWt |
| Santa Bárbara | Faial | FO + GO | 41.16 MWt |
| Belo Jardim | Terceira | FO + GO | 158.8 MWt |
| Caldeirão | São Miguel | FO + GO | 254.84 MWt |
| Pico | Pico | FO + GO | 26.28 MWt |
| Graciosa | Graciosa | GO | 4.26 MWe |
| São Jorge | São Jorge | GO | 7.03 MWe |
| Flores | Flores | GO | 2.31 MWe |
| Corvo | Corvo | GO | 0.56 MWe |
| Santa Maria | Santa Maria | GO | 5.68 MWe |

*LPG – Liquid Petroleum Gas; FO - fuel-oil; GO - Diesel oil; NG - Natural Gas.

#### 3.3.1.2.2 Non public co-generation Energy Producers

Auto-producers not included in their industrial and commercial branches were considered non public co-generation energy producers. These smaller private owned co-generation units started after 1993 and although working actually in close association with other industrial activities, are independent companies, in legal terms, which the main activity is defined as electric and heat production. Consequently, they were included in this source sector and not in industry sector as emissions from other co-generation units are.

#### 3.3.1.2.3 Municipal Solid Waste incineration

This issue is considered in the Waste (CRT 5) chapter in order to avoid repetition.

### 3.3.1.3 Methodology

#### 3.3.1.3.1 Thermo-electricity Power Plants

A bottom-up sectoral Tier 2 approach was used to estimate emissions of $CO_2$ and other air pollutants from this activity. For carbon dioxide, a mass balance approach could be used in principle to estimate emissions from the carbon content of fuels. But because that information is not available from most power plants, the IPCC recommendation of using emission factors based on energy consumption was used: "Emission factors for $CO_2$ from fossil fuel combustion are expressed on a per unit energy basis because the carbon content of fuels is generally less variable when expressed on a per unit energy basis than when expressed on a per unit mass basis" (IPCC, 1996).

Total $CO_2$ and ultimate $CO_2$ emissions from fossil origin were estimated from:

$$U_{CO2(u,f,y)} = EF_{CO2} * Fac_{OX(f)} * Energy_{Cons(u,f,y)} * 10^{-3}$$

$$Fossil_{CO2(y)} = \Sigma_u \Sigma_f [U_{CO2(u,f,y)} * C_{Fossil(f)} * 10^{-2}]$$

**Where:**

$U_{CO2(y)}$ – Total carbon released to atmosphere from consumption of fuel f in unit plant u, expressed in total carbon dioxide emissions (t);

$Fossil_{CO2(y)}$ - Emissions of carbon dioxide from fossil origin (non biomass) (t);

$EF_{CO2}$ – Carbon content of fuel expressed in total Carbon Dioxide emissions (kg $CO_2$/GJ);

$C_{Fossil}$ - Percentage of carbon from fossil origin in fuel f (%);

$Fac_{OX(f)}$ – Oxidation factor for fuel f (ratio 0..1);

$Energy_{Cons(u,f,y)}$ - Consumption of energy (Low Heating Value) from fuel f in power plant u in year y (GJ).

This formula reflects the fact that some carbon in fuel is not oxidized and not emitted to atmosphere. Although, some carbon in the fuel is not released directly as carbon dioxide but instead in the form of carbon monoxide, methane, volatile organic compounds and even in soot, ash and particulate matter as consequence of the incomplete combustion of fuel. Emissions of these compounds in airborne fraction are transformed sooner or later into $CO_2$ in the atmosphere or after deposition on soil. Emissions of $CO_2$ at stack exhaust (End-of-pipe emissions) may be estimated from final $CO_2$ emissions from:

$$Stack_{CO2} = U_{CO2} - 44/12*(NMVOC * C_{NMVOC} + CO * 12/28 + CH_4 * 12/16 + TPM * C_{TPM}) * 10^{-3}$$

**Where:**

$Stack_{CO2}$ - end of pipe emissions of carbon dioxide (kt);

NMVOC - Emissions of non-methanic Volatile Organic Compounds (t);

CO - carbon monoxide emissions (t);

$CH_4$ - Methane emissions (t);

TPM - Total Particulate Matter emissions (t);

$C_{NMVOC}$ - Carbon content in NMVOC (w/w);

$C_{TPM}$ - Carbon content of Total Particulate Matter (w/w).

Since EU-ETS data is available for inventory use plant's specific carbon content was use in those cases where fuel analysis were made by the plant operator.

For methane and nitrous oxide, emission estimates were based on the application of emission factors to energy consumption (GJ/yr). The following equation was used:

$$Emission_{(u,f,y,p)} = Energy_{Cons(u,f,y)} * EF_{(u,f,y,p)} * 10^{-6}$$

**Where:**

$Emission_{(u,f,y,p)}$ - Emission of pollutant p estimated from consumption of fuel f in power plant u in year y (t);

$Energy_{Cons(u,f,y)}$ - Consumption of energy (Low Heating Value/ Net Calorific Value) from fuel f in power plant u in year y (GJ);

$EF_{(u,f,y,p)}$ - Emission factor pollutant p, for fuel f consumed in power plant u in year y (g/GJ).

### 3.3.1.4 Emission Factors

#### 3.3.1.4.1 Large Point Source Energy Plants

Emission factors presented in the next table are only function of fuel type and they were established from available emission factors from international bibliography, while trying as much as possible to choose those that best match national circumstances:

- IPCC 2006 Revised Guidelines (IPCC, 2006);
- EU-ETS.

***Table 3-5: Emission Factors for energy production sector. Greenhouse Gases***

| Fuel | $UCO_2$ (i) kg/GJ | FacOX (i) 0..1 | FossilC % | $CH_4$ (i) g/GJ | $N_2O$ (i) g/GJ |
|---|---|---|---|---|---|
| Lignite | 101.0 | 1.00 | 100 | 1.0 | 1.5 |
| Hard Coal | 96.1 | 1.00 | 100 | 1.0 | 1.5 |
| Fuel-oil | 77.4 | 1.00 | 100 | 0.8 | 0.3 |
| Orimulsion | 77.0 | 1.00 | 100 | 3.0 | 0.6 |
| Natural Gas | 56.4 (ii) | 1.00 | 100 | 1.0 | 1.0 – 3.0 |
| LPG | 63.1 | 1.00 | 100 | 1.0 | 0.1 |
| Biomass | 112.0 | 1.00 | 0 | 11.0 | 7.0 |
| Diesel | 74.1 | 1.00 | 100 | 3.0 | 0.6 |

(i) IPCC (2006); (ii) Country Specific

The following table shows the plant specific $CO_2$ emission factors obtained in the EU-ETS.

***Table 3-6: $CO_2$ Emission Factors for energy production sector – Plant specific***

| Fuel | $UCO_2$ (i) kg/GJ | FacOX (i) 0..1 |
|---|---|---|
| Hard Coal | 92.4 - 95.2 | 0.991 - 0.995 |
| Fuel-oil | 79.2 - 79.5 | 0.990 - 0.995 |
| Natural Gas | 56.1 – 57.3 | 0.990 - 0.995 |

#### 3.3.1.4.2 Other Thermo-electricity Power Plants

The other smaller - non LPS - power plants are seldom subjected to the continuous *Autocontrolo* program, and the scarce available information does not allow the establishment of plant specific emission factors. Therefore, emission factors reflect an expert best guess from the available bibliography, which again is available from:

- IPCC 2006 Revised Guidelines (IPCC, 2006);

The emission factors that were used in the inventory are shown in Table 3-7 for the power plants belonging to the public system in Azores and Madeira, and in Table 3-8 for the non-public co-generation self producers[4].

[4] Power producers as main activity only.

***Table 3-7: Emission Factors for thermo-electricity production in Azores and Madeira. Greenhouse Gases***

| Region | Fuel | $UCO_2$ (i) kg/GJ | FacOX (I) 0..1 | FossilC % | $CH_4$ g/GJ | $N_2O$ (i) g/GJ |
|---|---|---|---|---|---|---|
| Azores | Fuel-oil | 77.4 | 1.00 | 100 | 3.0 | 0.6 |
| Azores | Diesel oil | 74.1 | 1.00 | 100 | 3.0 | 0.6 |
| Madeira | Fuel-oil | 77.4 | 1.00 | 100 | 3.0 | 0.6 |
| Madeira | Diesel oil | 74.1 | 1.00 | 100 | 3.0 | 0.6 |
| Madeira | LPG | 63.1 | 1.00 | 100 | 1.0 | 0.1 |
| Madeira | Natural Gas | 56.4 (ii) | 1.00 | 100 | 1.0 | 3.0 |

(i) IPCC (2006); (ii) Country Specific

***Table 3-8: Emission Factors for non public co-generation self producers. Greenhouse Gases***

| Fuel | $UCO_2$ (i) kg/GJ | FacOX (i) 0..1 | FossilC % | $CH_4$ g/GJ | $N_2O$ (i) g/GJ |
|---|---|---|---|---|---|
| LPG | 63.1 | 1.00 | 100 | 1.0 | 0.1 |
| Fuel –oil | 77.4 | 1.00 | 100 | 3.0 | 0.6 |
| Diesel oil | 74.1 | 1.00 | 100 | 3.0 | 0.6 |
| Natural Gas | 56.4 | 1.00 | 100 | 1.0 | 1.0 |

(i) IPCC (2006); (ii) Country Specific

#### 3.3.1.4.2.1 Activity Data

Activity data has different origins according to specific energy plants:

### 3.3.1.4.3 Large Point Source Energy Plants

Data on fuel consumption, by fuel type, for LPS are available from these sources:

- Large Combustion Plants (LCP) directive - which relies in direct information reported from the individual plant producer to the Environment Ministry;
- Self-control program (*Programa Autocontrolo*)[5];
- Plant activity reports from EDP;
- EU-ETS – European Union Emission Trading System.

For the latest years (mainly 2009 onwards) the EU-ETS completely replaced the other sources of information. Although different information sources have been used the consistency in time series is guaranteed considering that the same original source (power plant companies) is ultimately used.

As a general rule power plant units report information about consumption in t or cubic meters of gas together with the Low Heating Value [6] for that specific year from where consumption of fuels in energy units are calculated from:

Energy (GJ) = Consumption (t/year) * LHV (MJ/kg)

or:

[5] The *Auto-controlo* program is a legal obligation for major emitters.

[6] Low Heating Value (LHV) or Net Calorific Values (NCV) measure the quantity of heat liberated by the complete combustion of a unit volume or mass of a fuel, assuming that the water resulting from combustion remains as a vapour and the heat of the vapour is not recovered (GPG). In contrast, Gross Calorific Value (GCV) or Gross Heating Value (GHV) are estimated assuming that this water vapour is completely condensed and the heat is recovered (GPG). The default in IPCC Guidelines is to use the NCV.

Energy (GJ) = Consumption ($Nm^3$/year) * LHV (MJ/Nm3)

When LHV/NCV was not available it was estimated from interpolation or extrapolation from the remaining available time series. The average value and range of the reported LHV per fuel type is presented in next table.

***Table 3-9: Low Heating Value per fuel type***

| Fuel | LHV/NCV | |
|---|---|---|
| Lignite | 16.42 (15.57 - 17.02) | MJ/kg |
| Hard Coal | 25.62 (24.45 - 27.23) | MJ/kg |
| Fuel-oil | 40.24 (39.42 - 41.15) | MJ/kg |
| Orimulsion | 28.00 | MJ/kg |
| Diesel oil | 43.30 | MJ/kg |
| Natural Gas | 38.16 (36.02 - 39.16) | MJ/Nm3 |
| GPL | 47.44 (47.28-48.55) | MJ/kg |
| Biomass | 7.8 | MJ/kg |

Source: The same as for the fuel consumption (including in some cases plants specific information)

Total consumption per fuel type in comparable energy units (PJ) may be verified in the figure below.

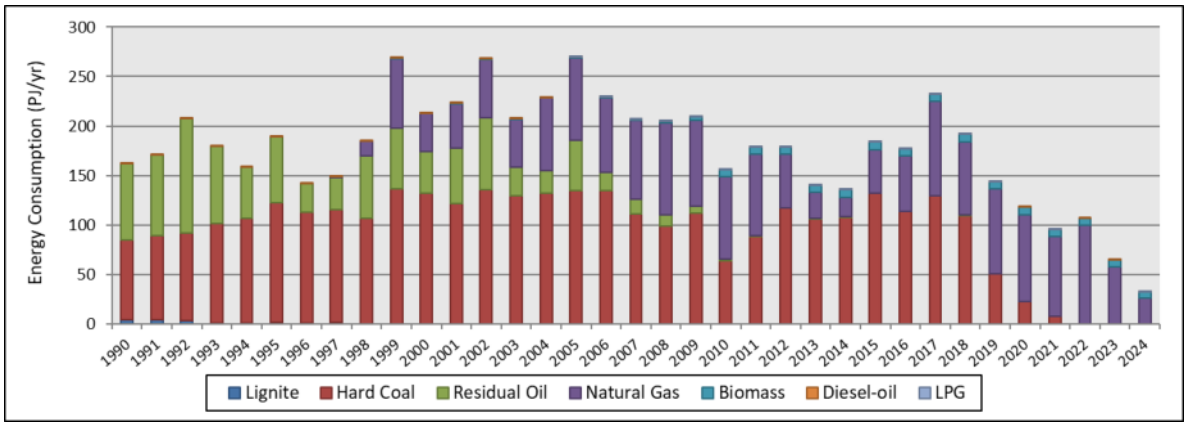



***Figure 3-8: Trends of fuel consumption per fuel type***

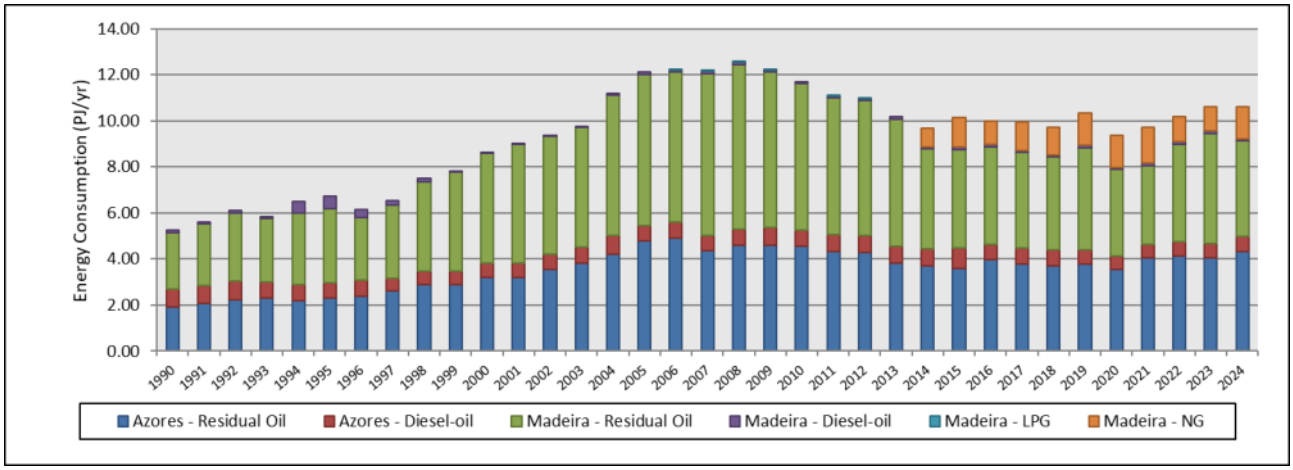
Not visible in the graph is the increase in biomass consumption (wood waste) from 1999 to 2024 (mostly in 2010 and 2011). The consumption of diesel-oil presents no clear trend since 1990 even though we can identify a slight decrease in the later years of the time series. LPG represents only a small franction of total fuel consumption in this sector (less than 0.001 %). The relevancy of residual oil has been decreasing since 2005, representing only a fraction of total consumption in 2013 due to Barreiro power plant deactivation. In 2015 there is an increase in the consumption of Coal and Natural Gas, largely due to a dry year, reducing in this way the potential producer of hydro power plants. However, since the deactivation of the Sines Power Plant in 2021, hard coal consumption has ceased. Furthermore, natural gas consumption significantly decreased by 73% since 2022, which was offset by an increase in electricity imports and a rise in domestic renewable electricity production.

#### 3.3.1.4.4 Energy Plants in Azores and Madeira Autonomous Regions

The quantity of residual fuel-oil, diesel oil and GPL used in Madeira and Azores in electricity production is available from the following two sources:

- Madeira and Azores Regional Environmental entities;
- EU-ETS.

Full fuel consumption time series can be observed in the figure below:




Note: Consumption of diesel oil and LPG in Madeira represent a very small quantity and is barely visible in the figure.

***Figure 3-9: Trends of fuel consumption in Azores and Madeira Archipelagos***

Consumption of fuels expressed in energy units was estimated from the above consumption figures assuming the Low Heating Value (LHV/NCV) values presented in the following table.

***Table 3-10: LHV per fuel type***

| Region | Fuel type | LHV/NCV (MJ/kg) |
|---|---|---|
| Azores | Residual fuel oil | 40.17 |
| | Diesel oil | 43.30 |
| Madeira | Residual fuel oil | 40.17 |
| | Diesel oil | 43.30 |
| | LPG | 47.28 |
| | Natural Gas | 37.9 – 38.0 |

Source: The same as for the fuel consumption

### 3.3.1.4.5 Non-public co-generation Energy Producers

Consumption of fuels in the auto-producers co-generation units (classified as energy producers) are reported in toe units in the Energy Balance (DGEG). These values can be observed in the figure below.

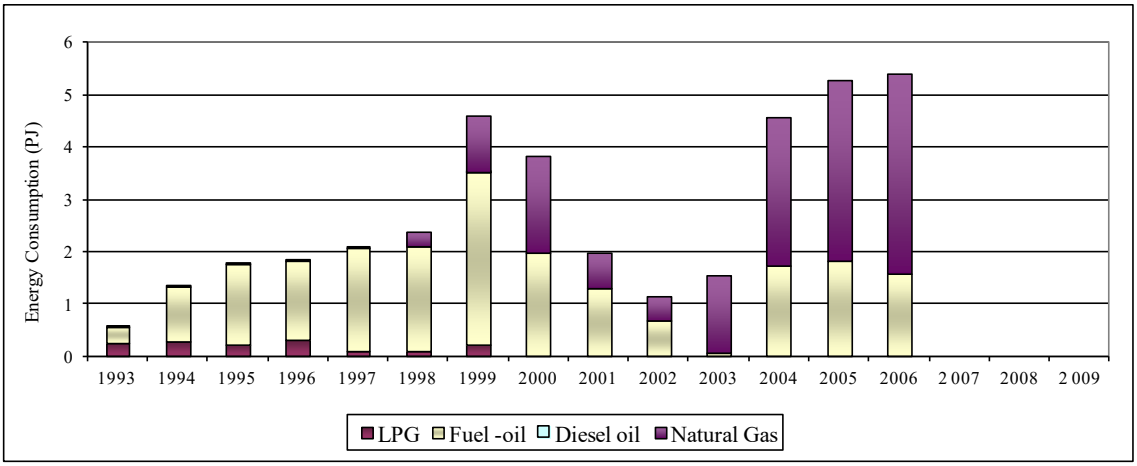



***Figure 3-10: Trends in consumption of fuels in non-public co-generation plants***

The figure above shows a decrease in consumption between 1999 and 2002 and then an increase in energy consumption between 2003 and 2006.

The variation occurs because the evolution of natural gas consumption in cogeneration associated with the production of electricity was strongly influenced by the separation of cogeneration units in fiscally autonomous companies for the production of electricity and heat. These companies were mainly those included in the IAIT survey (an annual survey of manufacturing industries).

The growing tendency to create different companies to manage the energy production aspect of industrial co-generation plants led to the necessity, by DGEG, to shift these units from the energy-production co-generation category back to their industrial co-generation category in the Energy Balance. As a result of this shift, from 2007 onwards the energy-production co-generation category in the Energy Balance considers only two units already included, because of their size, in the LPS estimations. Because of this and to avoid double-counting fuel consumption from 2007 onwards was made 0. Since DGEG transferred fuel consumption to the industrial co-generation category, which is used for estimating combustion emissions in the industrial sector (CRT 1A2), the emission inventory maintains its completeness.

Assumed values for LHV per fuel type are presented in next table.

***Table 3-11: LHV per fuel type used for non-public co-generation plants estimates***

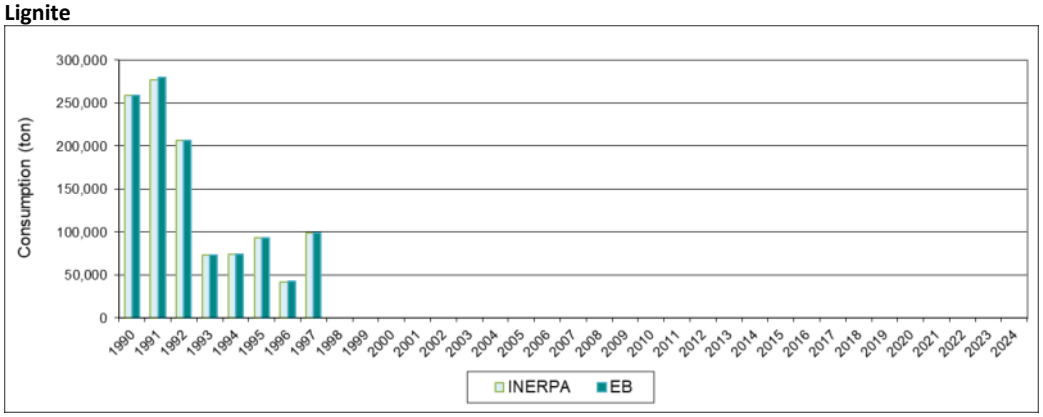
| Fuel | LHV (MJ/kg) |
|---|---|
| LPG | 49.76 |
| Fuel -oil | 40.00 |
| Diesel oil | 42.60 |
| Natural Gas | 38.72 (MJ/Nm3) |

Source: The same as for the fuel consumption

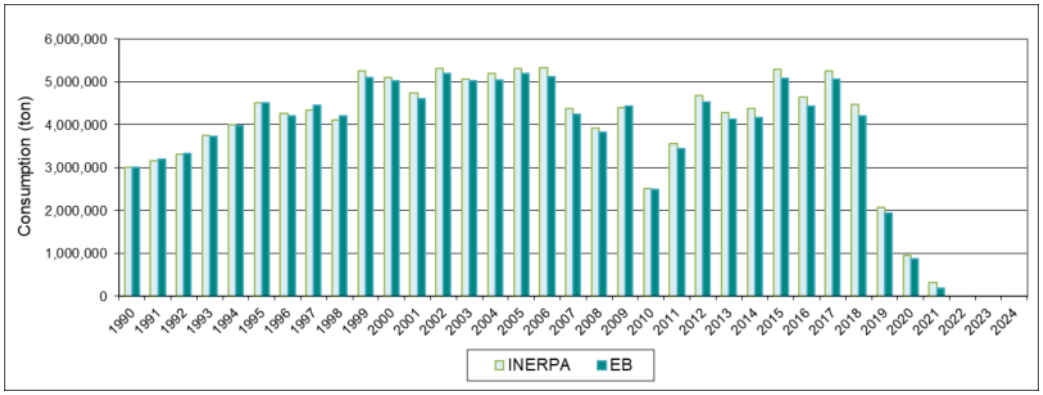
#### 3.3.1.4.6 Comparison of LPS data vs. National Statistics

Consumption of fuel for electricity production in large units is also published in the Energy Balance of DGEG. Total consumption in all units was compared between the data in the inventory (INERPA) and the Energy Balance (EB) and graphs for the most important energy sources are presented in the figures below. For these analyses, contacts were made with DGEG to obtain the complete list of installations covered in each energy production category of the last energy balance (small differences with previous EB are expected due to reclassification). Generally, there is an acceptable agreement between the two sources of information and, because data was acquired in an independent mode, this match gives a high degree of confidence to the results.

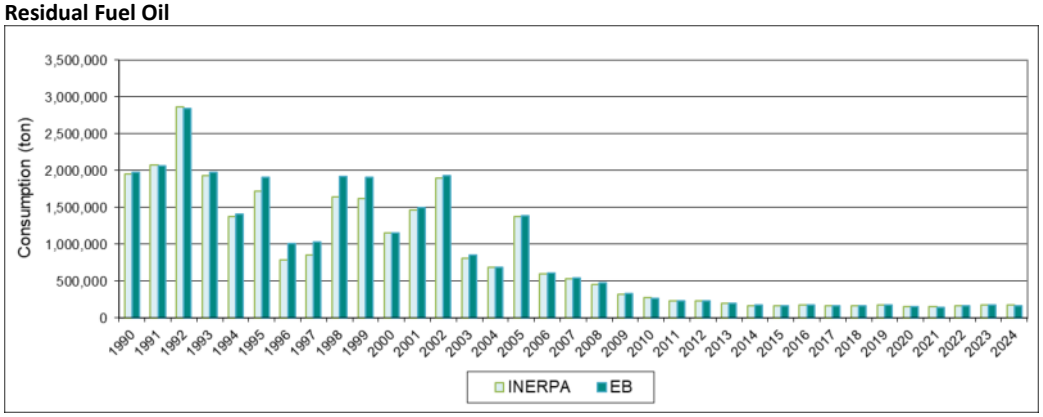
**Lignite**




**Hard Coal**




**Residual Fuel Oil**




**Natural Gas**

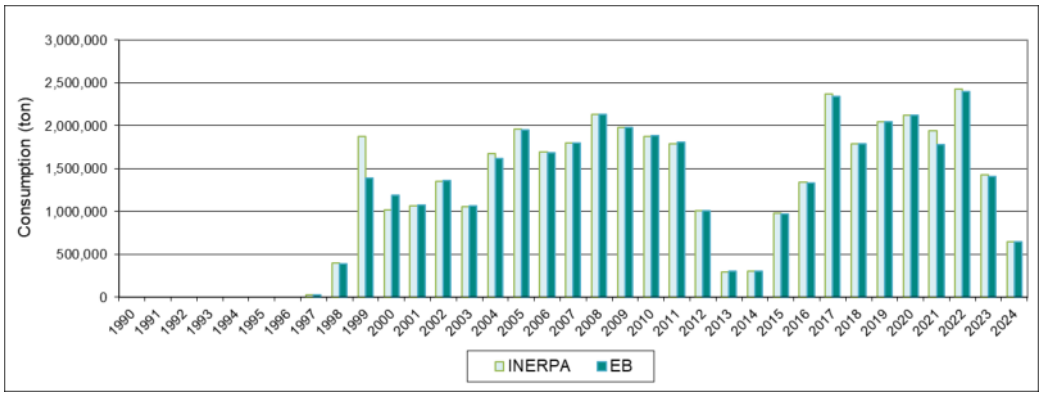



***Figure 3-11: Comparison of total fuel consumption in large power plants, between values used in the inventory (INERPA) and in the Energy Balance***

#### 3.3.1.4.7 Comparison of Energy Balance vs. IEA Energy Statistics

Total energy consumption reported in DGEG energy balance was compared with IEA (International Energy Agency) energy statistics values. This comparison is included in the QA/QC procedures applied to this inventory. The energy statistic values from IEA were collect from their website. Unfortunately, IEA data is only publicly available for the n-1 year (n being the latest inventory year). Following the fuel classification presented in the IEA energy statistics, three fuel types were analyzed: coal and peat, petroleum products and natural gas, connected to 8 emission sources: Electricity Plants, CHP Plants, Industry, Residential, Commercial and Public Services, Agriculture/Forestry, Fishing and Distribution Losses. The comparison between DGEG energy balance and IEA energy statistics, for 2023, is shown in the figure below.

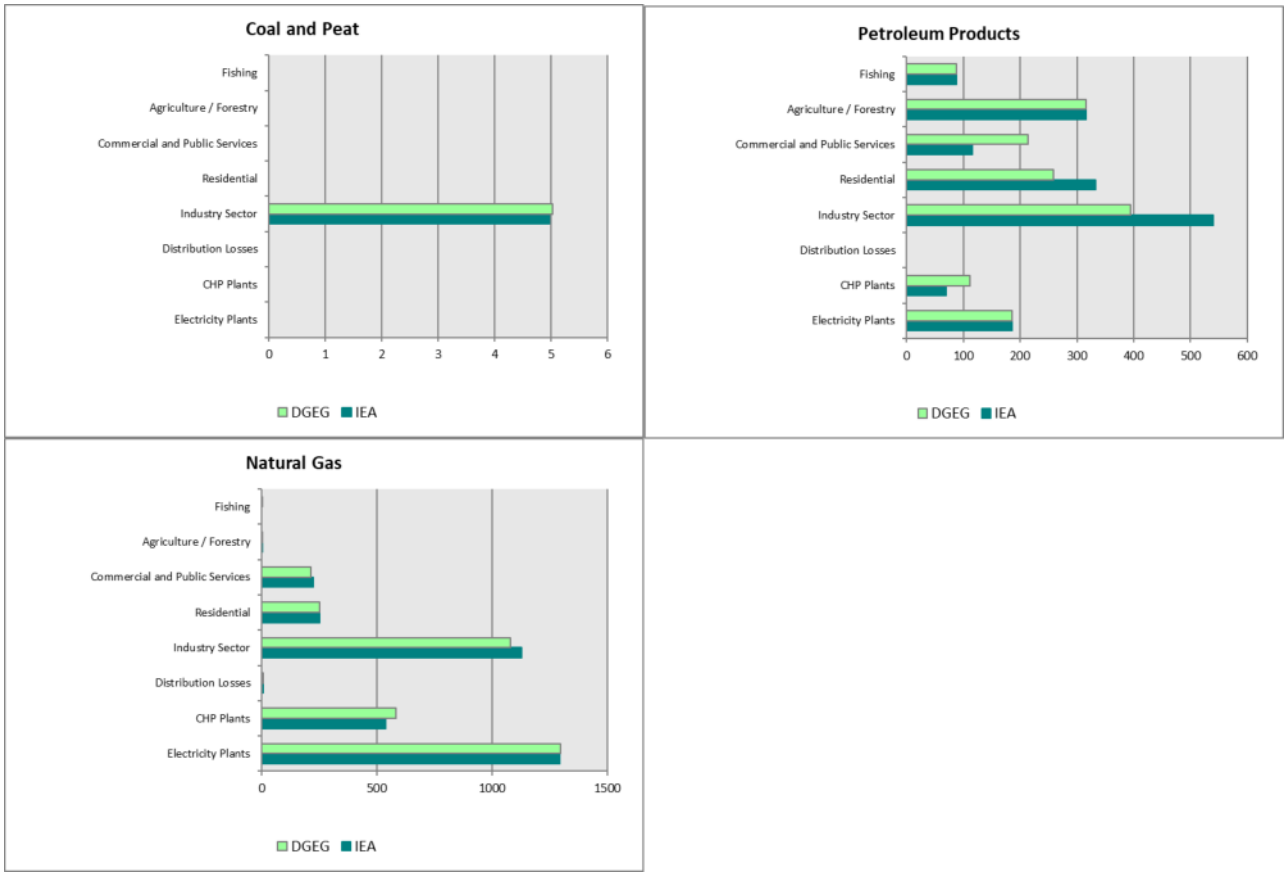



***Figure 3-12: Comparison of fuel consumption between DGEG energy balance and IEA energy statistics***

For natural gas and for coal and peat, the differences between the two data sources are very small. The consumption of petroleum products shows discrepancies for four of the eight analysed sectors: CHP Plants, Residential, Industry, Commercial and Public Services. These differences may imply a problem in the fuel consumption classification. Upon our contact DGEG reported that there was compilation errors in the information sent to IEA, which may explain the differences found between the two data sources.

### 3.3.1.5 Uncertainty Assessment

The accuracy of activity data collected from direct reporting (LPS data) is expected to have a lower error than data collect in an aggregated form for the elaboration of the energy balances, in particular for those categories in the energy balance comprehending units small, multiple and dispersed.

Therefore, different uncertainty values were considered in accordance with different provenience of data:

- for LPS the uncertainty value was set at 1 %, which is in the higher range of the uncertainty considered in GPG when good quality surveys are considered, which is the case; For some older information was employed the value of 2 % uncertainty;
- for area sources an uncertainty of 5 % was considered for this sector, which is fixed according to a conservative approach, considering the double of the upper range of the values that IPCC proposes when data was obtained from surveys in a less developed statistical system. This conservativeness factor is used because the surveys were made indirectly to industrial plants via fuel suppliers.

The uncertainty associated with $CO_2$ varies between 2 and 17 %, lower values are associated with monitoring facilities and the highest values correspond to default emission factors for fuels such as biomass. The uncertainty values in association with the other gases, methane and nitrous oxide, was also set in accordance with the GPG proposals, 150 % for $CH_4$ and 150 % for $N_2O$.

The EU-ETS defines a maximum uncertainty value of 7.5 % for the $CaCO_3$ consumption data reported by each plant.

Since 2009 submission, the use of plant specific data for the power plants in Azores and Madeira has decreased uncertainty.

#### 3.3.1.6 Category-specific QA/QC and verification

QA/QC procedures were implemented primarily to check the time series consistency for fuel consumption data collect from different information sources. There were also made general checks to the emission compilation spreadsheets from which resulted several small corrections to reported emission.

For large combustion plants a comparison between fuel consumption collected by the inventory team and data reported in the energy balance was made (as described in Comparison of LPS data vs. National Statistics chapter). Also, a comparison between the energy balance and IEA statistics has been made to strengthen the QA/QC procedures. For this source category no major differences were found in this comparison between data sources.

#### 3.3.1.7 Recalculations

Recalculations made since last submission refer to the revision of natural gas consumption following the publication of an updated Energy Balance for 2023.

#### 3.3.1.8 Further Improvements

Even though efforts were made to increase the percentage of units treated as LPS in this year inventory, the inclusion of more LPS plants is an ongoing objective for this sector as well as for industrial combustion. These efforts are in accordance with the goals that the EC[7] has set to streamline data collection for the inventories and for the EU-ETS[8]. In the same sense on-going efforts should be maintained for the compatibilization of LPS data collection from APA and DGEG in order for a better consistency of the data that is used for the Energy Balance and for the LPS data used in the inventory.

[7] European Commission.
[8] European $CO_2$ trading scheme.

## 3.3.2 Petroleum Refining (CRT 1.A.1.b)

### 3.3.2.1 Category description

In 1990 there were three oil refining plants in Portugal: Porto, Lisbon and Sines. In 1993, the Lisbon unit was closed.

Porto refinery, located in Matosinhos in northern Portugal since 1966, converts crude oil and other intermediate materials received from Sines refinery by atmospheric and vacuum distillation, cracking, platforming and several treatments processes (dessulphurization). This refinery unit has also units for the production of oils, lubricants and aromatics (benzene, hexane, toluene, xilene, etc). This facility has terminated its refining activities in April 2021.

Sines refinery, installed in 1978 in southern Portugal, has also extensive transformation of crude products after atmospheric and vacuum distillation, which are subjected to Fluid Catalytic Cracking (FCC), platforming, hydrocracking, alquilation and asphalts blowing. Sines is the only refining unit that remains in operation.

The nowadays closed refinery located in Lisbon performed mostly cracking. Refinery gas from this unit was used as combustible gas for domestic, service and industry use in Lisbon city.

Following the UNFCCC source categories classification guidance, only emissions resulting from combustion in boilers and furnaces are included in this source sector. Process fugitive emissions, including combustion emissions occurred in the FCC unit are included in sub-chapter 3.8.3.5 Refining and Storage (CRT 1.B.2.a.4).

$SO_x$ and NMVOC emissions also result from sulphur that is removed from intermediate or final products, mostly regarding environmental regulations, and conveyed in final flux gases. Elemental sulphur from the refining process is later recovered in both Sines and Porto refineries but emissions from this source are considered under sub-chapter 3.8.5 Oil and natural gas and other emissions from energy production: Venting and Flaring (CRT 1.B.2.c).

### 3.3.2.2 Methodology

A bottom-up sectoral Tier 3 approach was used to estimate emissions of $CO_2$ from combustion in refineries, either in boilers or process furnaces. and other air emissions Emissions were estimated individually for each combustion equipment when discrimination was possible.

As explained in more detail in sector "Public Electricity and Heat Production", total $CO_2$ and ultimate $CO_2$ emissions to atmosphere from fossil origin were estimated using the following equation set:

$$U_{CO2} = EF_C \times Fac_{OX(f)} \times Energy_{Cons(f)} \times 44/12 \times 10^{-3}$$

$$Fossil_{CO2} = U_{CO2} \times C_{Fossil(f)} \times 10^{-2}$$

**Where:**

$U_{CO2}$: Total carbon dioxide emissions (t)

$EF_C$: Carbon content of fuel f expressed in total carbon dioxide emissions (kg $CO_2$/GJ)

$Fac_{OX(f)}$: Oxidation factor for fuel f (ratio 0..1)

$Energy_{Cons(u,f)}$: Consumption of energy (Low Heating Value) from fuel f in power plant (GJ)

$Fossil_{CO2}$: Emissions of carbon dioxide from fossil origin (non biomass) (t)

$C_{Fossil}$: Percentage of carbon from fossil origin in fuel f (%)

For all other pollutants the following equation was applied to estimate air emissions:

$$Emission_{(e,f,p)} = Energy_{Cons(e,f)} \times EF_{(e,f,p)} \times 10^{-6}$$

**Where:**

$Emission_{(e,f,p)}$: Emission of pollutant p estimated from consumption of fuel f in combustion equipment e (t)

$Energy_{Cons(e,f)}$: Consumption of energy (Low Heating Value) from fuel f in combustion equipment e (GJ)

$EF_{(e,f,p)}$: Emission factor pollutant p, for fuel f under burning conditions in combustion equipment e (g/GJ)

### 3.3.2.3 Emission Factors

From 2005 onwards, $CO_2$ emission factors were obtained directly from EU-ETS data for Porto and Sines refineries. From 1990 to 2004, due to lack of information, $CO_2$ emission factors for Porto and Sines refineries were assumed equal to the first EU-ETS year (2005). Regarding Lisbon refinery (in operation until 1993), $CO_2$ emission factors were considered the same as Sines refinery (the nearest facility).

To estimate emissions, direct data from ETS were used. Using this information, it was possible to separate fuel consumption for combustion, from fuel used in the flares and fuel used in fluid catalytic cracking, catalyst regeneration and platforming or hydrogen production. The $CO_2$ EF considered in ETS is a Tier 3, and thus it is obtained directly from fuel analysis. The fuel considered in each combustion is only the fuel that is burned and not the total amount of fuel that is bought or result from a refinery process.

The same set of $CH_4$ and $N_2O$ emission factors were used for all three refineries and were obtained in the 2006 IPCC Guidelines. The chosen emission factors are presented in the table below.

***Table 3-12: Greenhouse Gases' emission factors for combustion sources in Petroleum Refining***

| Fuel | $CO_2$ (1990-2004) (i) | $CO_2$ from 2005 onwards (ii) | FacOX (I) 0..1 | FossilC % | $CH_4$ (iii) g/GJ | $N_2O$ (iii) g/GJ |
|---|---|---|---|---|---|---|
| Fuel-oil | 75.7-81.25 kg/GJ | 78.34-87.99 kg/GJ | 1 | 100 | 3.0 | 0.6 |
| Fuel gas | 38.57-65.94 kg/GJ | 51.23-63.14 kg/GJ | 1 | 100 | 1.0 | 0.1 |
| LPG | - | 63.10 kg/GJ | 1 | 100 | 1.0 | 0.1 |
| Diesel oil | 74.13 kg/GJ | 73.49-74.73 kg/GJ | 1 | 100 | 3.0 | 0.6 |
| Natural Gas | 60.91 kg/GJ | 53.8-56.80 kg/GJ | 1 | 100 | 1.0 | 0.1 |
| Acid Soluble Oil (ASO) | 72.61 kg/GJ | 63.02-72.77 kg/GJ | 1 | 100 | 3.0 | 0.6 |
| Off Gas | 3.35-3.63 t $CO_2$/t fuel | 2.38-2.80 t $CO_2$/t fuel | 1 | 100 | 3.0 | 0.6 |
| Tail Gas | 0.21-1.12 t $CO_2$/t fuel | 0.21-1.13 t $CO_2$/t fuel | 1 | 100 | 3.0 | 0.6 |

(i) Source: Assumed equal to 2005 EU-ETS year; (ii) Source: EU-ETS; (iii) Source: Table 2.2, Chapter 2, Vol. 2, 2006 IPCC Guidelines

### 3.3.2.4 Activity Data

In 1990 there were three oil refining plants in Portugal: Porto, Lisbon and Sines. After 1993, the Lisbon unit was closed. Porto has terminated its refining activities in April 2021. Only Sines unit remains in operation. The three refinery units consume self-produced residual fuel oil, fuel gas, liquefied petroleum gases (LPG) and gas oil.

The quantities of fuel consumption from 1990 to 2004 were collected directly from the facilities under the Large Combustion Plants (LCP) directive and may be observed in the next figure. From 2005 onwards, fuel consumption data source is EU-ETS. The use of natural gas is becoming more relevant since 2008 and the use of fuel oil (RPC) less relevant. In one of the refineries there is also consumption of Acid Soluble Oil (ASO), Off Gas and Tail Gas.

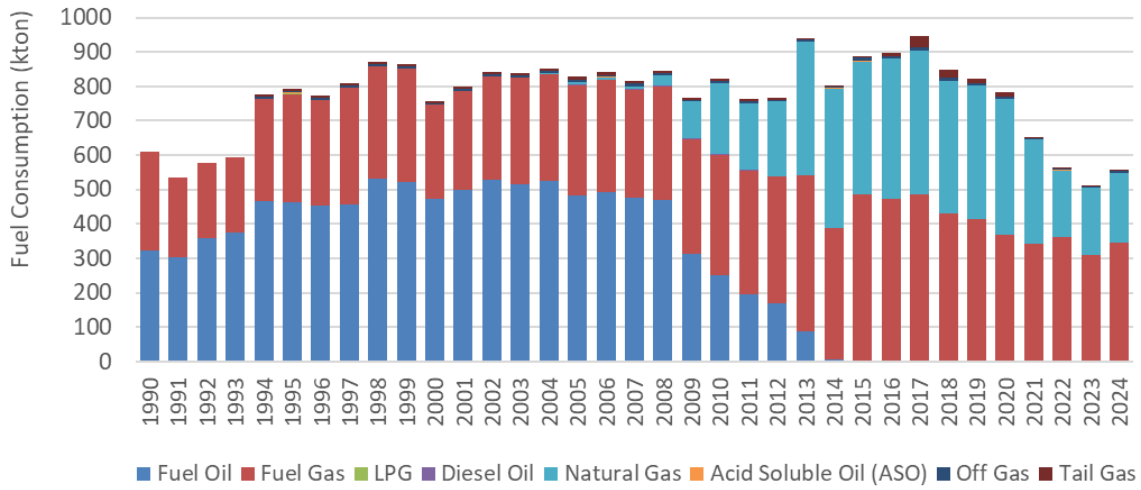



***Figure 3-13: Fuel consumption in refineries***

Consumption expressed in energy was calculated with the following time series of Net Calorific Values. This time series reflects actual information given by each refinery also under LCP directive (1990-2004) or EU-ETS (from 2005 onwards) and are weighted averages for all three plants.

From 2015 onwards there is no fuel oil consumption and there is an increase in fuel gas consumption. Fuel Oil $CO_2$ emission factor lies between 3.15-3.17 t $CO_2$/t fuel oil and fuel gas $CO_2$ emission factor lies between 2.55-2.74 t $CO_2$/t fuel gas. The decrease in the implied emission factor for liquid fuels is due to the increase of the contribution of a fuel with a lower emission factor (fuel gas).

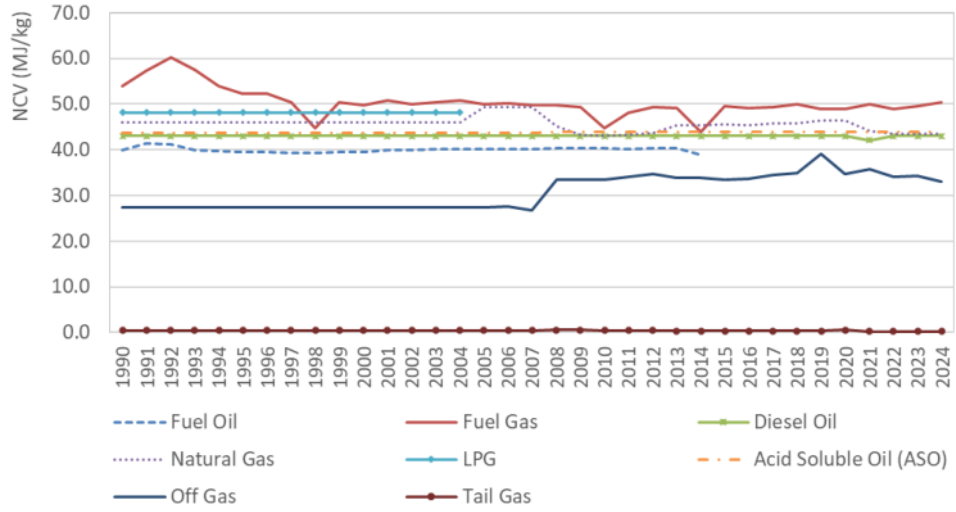



***Figure 3-14: Net Calorific Value (NCV) expressed in MJ/kg by fuel type***

### 3.3.2.5 Uncertainty Assessment

The uncertainty value was established at 1 %, in accordance with the fact that all data was obtained from direct inquiry to refinery units.

The uncertainty associated with the $CO_2$ emission factor is 5 %, which is the value proposed for traded fuels (IPCC, 2000). The uncertainty values in association with the other gases, methane and nitrous oxide, was also set in accordance with the GPG proposals, 150 % for $CH_4$ and 1000 % for $N_2O$.

#### 3.3.2.6 Recalculations

CO2 emission factor for Natural Gas in 2023 was updated following the identification of a compilation error in the previous submission.

Also, a new Sulphur Recovery Unit began operating in 2022 and by mistake, it was not being accounted for due to a compilation error. This unit also consumes fuel tail gas, hence recalculations will only affect CO2 emissions in the 2022-2023 period.

#### 3.3.2.7 Further Improvements

No further improvements are expected.

### 3.3.3 Manufacture of solid fuels and other energy industries (CRT 1.A.1.c)

#### 3.3.3.1 Category description

The following two sub-sources are included in this category:

- External fuel consumed in the coke plant that was part of the only integrated iron and steel plant in Portugal, which was dismantled in 2001 (detailed info regarding all emission streams for iron and steel operations, as well as the categories under which emissions are reported can be found in Table 4-36 and section 4.4.2.1 of the IPPU chapter). Coke gas was the only fuel combustion used as energy source in the coke plant;
- Combustion emissions done for the production of city gas that was consumed in the city of Lisbon. This activity was replaced as consequence of the substitution of this energy source by Natural Gas and was fully deactivated in 2001.

Fugitive emissions from coke production in the coke plant are estimated and reported under category 1.B.1.b.

#### 3.3.3.2 Methodology

**Metallurgical coke production**

Metallurgical coke production is considered an energy transformation of fossil fuel and leads to emissions of carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide ($N_2O$). This section estimates emissions of $CO_2$ and $CH_4$. No methodologies are available for $N_2O$ emissions estimation given that, according to the IPCC guidelines, are likely to be small and therefore negligible.

$CO_2$ emissions from metallurgical coke production were estimated according to a carbon mass balance approach based on 2019 Refinement to the 2006 IPCC Guidelines, as shown in the following equation:

$$Emi_{CO2} = [(C_{COAL} \times CC_{COAL}) - (COKE \times CC_{COKE}) - (COG \times CC_{COG}) - (TAR \times CC_{TAR})] \times 44/12$$

**Where:**

$Emi_{CO2}$: $CO_2$ emissions (t)

$C_{COAL}$: Coking coal consumed (t)

$CC_{COAL}$: Country specific coking coal carbon content (t C/t Coking coal)

COKE: Metallurgical coke produced (t)

$CC_{COKE}$: Country specific metallurgical coke carbon content (t C/t metallurgical coke)

COG: Coke oven gas produced but not recirculated and therefore not consumed for metallurgical coke production (t)

$CC_{COG}$: Country specific coke oven gas carbon content (t C/t Coke oven gas)

TAR: Coal Tar produced (coke oven by-product) (t)

$CC_{TAR}$: Country specific coal tar carbon content (t C/t Coal Tar)

$CH_4$ emissions from stacks were estimated according to a product approach and using default emission factor (Tier 1a), described in the following equation:

$$E_{CH4} = COKE \times EF_{CH4}$$

**Where:**

$E_{CH4,}$: $CH_4$ emissions from coke production (t)

COKE: Quantity of coke produced (t)

$EF_{CH4}$: $CH_4$ emission factor (t $CH_4$/t coke produced)

### City Gas Production

For City gas production, total $CO_2$ and of ultimate $CO_2$ emissions from fossil origin were estimated according to the following equation set:

$$U_{CO2(y)} = EF_{CO2} \times Fac_{OX(f)} \times Energy_{Cons(u,f,y)} \times 10^{-3}$$

$$Fossil_{CO2(y)} = U_{CO2(y)} \times C_{Fossil(f)} \times 10^{-2}$$

**Where:**

$U_{CO2(y)}$: $CO_2$ emissions (t)

$EF_{CO2}$: Carbon content of fuel expressed in total carbon dioxide emissions (kg $CO_2$/GJ)

$Fac_{OX(f)}$: Oxidation factor for fuel f (ratio 0..1)

$Energy_{Cons(u,f,y)}$: Consumption of energy (Low Heating Value) from fuel f in power plant u in year y (GJ)

$Fossil_{CO2(y)}$: Emissions of carbon dioxide from fossil origin (non biomass) u in year y (ton)

$C_{Fossil(f)}$: Percentage of carbon from fossil origin in fuel f (%)

For $CH_4$ and $N_2O$ the following equation was applied to estimate emissions:

$$Emission_{(y,p)} = Energy_{Cons\ (f,y)} \times EF_{(f,p)} \times 10^{-6}$$

**Where:**

$Emission_{(y,p)}$: Emission of pollutant p in year y (t)

$Energy_{Cons\ (f,y)}$: Consumption of energy in fuel f (Low Heating Value) in year y (GJ)

$EF_{(f,p)}$: Emission factor pollutant p from fuel f combustion (g/GJ)

## 3.3.3.3 Emission Factors

### Metallurgical coke production

Emission factors used in the carbon balance for the coke plant are listed in the table below.

***Table 3-13: Emission factors used in the carbon balance for the coke plant***

| Material | Carbon Content (t C/t material) | EF (t $CO_2$/t material) |
|---|---|---|
| Coking Coal | 0.730 | 2.677 |
| Metallurgical Coke | 0.830 | 3.043 |
| Coal Tar | 0.801 | 2.937 |
| Coke Oven Gas [1] | 12.11 | 44.40 |
| [1] – Carbon Content of Coke Oven Gas in kg C/GJ; EF in kg $CO_2$/GJ | | |

$CH_4$ emission factor from coke production is reported in the table below.

***Table 3-14: $CH_4$ emission factor from coke production***

| Process | Emission Factor | Unit | Source |
|---|---|---|---|
| Coke Production | 0.089 | kg $CH_4$/t coke produced | Table 4.2, Chapter 4 Metal Industry Emissions of the 2019 Refinement to the 2006 IPCC Guidelines |

### City Gas Production

Emission factors for combustion of fuel in the city gas factory are listed in the table below.

***Table 3-15: Emission Factors used for the coke plant and city gas production***

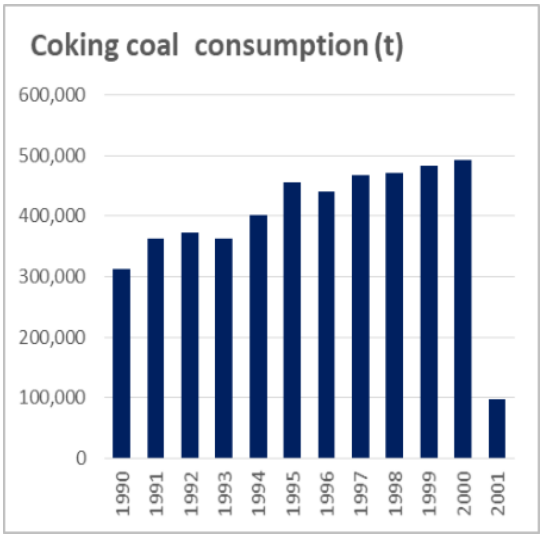
| Source | City Gas Production | | | Unit |
|---|---|---|---|---|
| Fuel | FO | Naphta | NG | |
| $U_{CO2}$ (i) | 76.6 | 72.6 | 56.4 (ii) | kg/GJ |
| $Fac_{OX}$ (i) | 1 | 1 | 1 | ratio |
| $Fossil_C$ | 100 | 100 | 100 | % |
| $CH_4$ (i) | 3.0 | 3.0 | 1.0 | g/GJ |
| $N_2O$ (i) | 0.6 | 0.6 | 0.1 | |

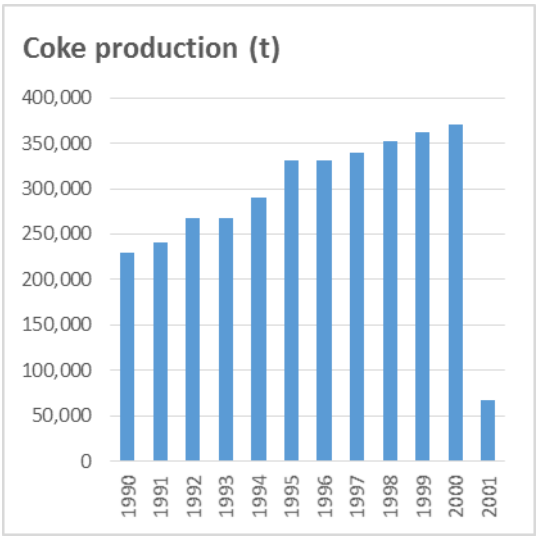
(i) IPCC (2006); (ii) Country Specific

## 3.3.3.4 Activity Data

### Metallurgical coke production

From 1990 to 2001, coking coal consumption and coke, coke oven gas and coal tar production data were obtained from DGEG (Coke plant Balance) and are presented in the figures below. From 2002 onwards, there is no coke production in the iron and steel industry in Portugal.



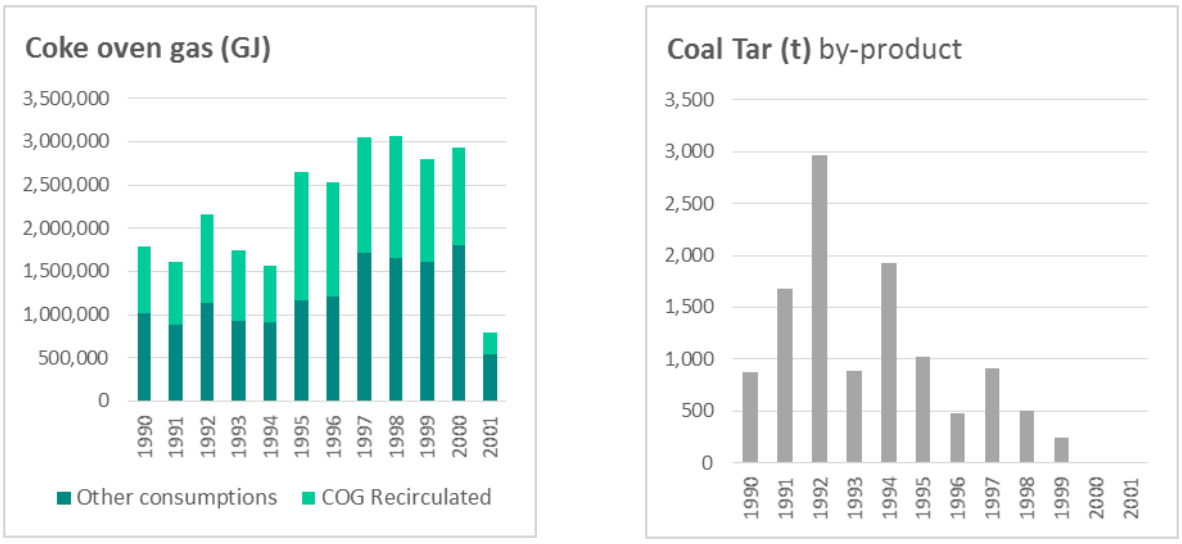



***Figure 3-15: Coking coal consumption and coke, coke oven gas and coal tar production in the coke plant***

### City Gas Production

According to the energy balances from DGEG, this activity has used fuel oil, naphtha and, more recently, natural gas as energy sources under co-generation process, from 1990 to 2001[9]. The available time series is presented in the next figure.

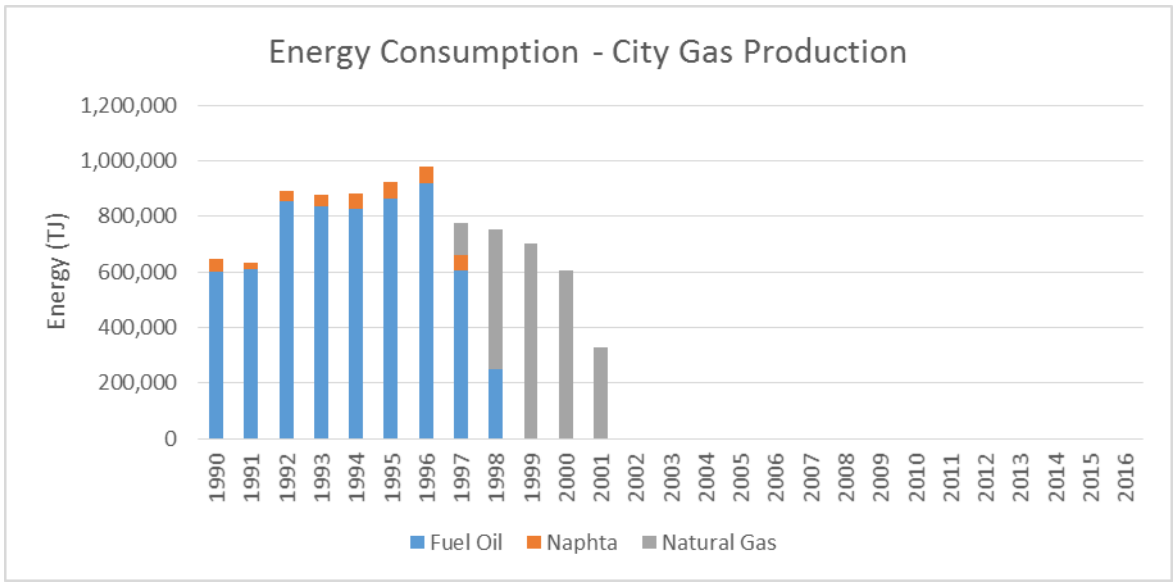



***Figure 3-16: Consumption of fuels in co-generation in city gas production***

All consumption of oil products as feedstock are reported in a single category in the energy balance, therefore making it difficult to determine the quantities used in city gas production alone. Therefore, all consumption of Naphta, Fuel Oil and Natural Gas is assumed to be combusted, and a methodology of energy consumption was applied.

The following Net Calorific Values (NCV) or Low Heating Values (LHV) values were used.

[9] This activity uses also fuel gas, LPG, fueloil, naphta and natural gas as feedstocks. These quantities, separated in the energy balance, are not included in the inventory at this point but in use of city gas as fuel.

*Table 3-16: NCV/LHV per fuel type for city gas production*

| Fuel | NCV (MJ/kg) |
|---|---|
| Fuel-oil | 40.0 |
| Naphta | 44.0 |
| Natural Gas | 46.0 |

#### 3.3.3.5 Uncertainty Assessment

10% uncertainty were assumed for both coke production activity data and emission factors, according to Chapter 4.2.3 of Volume 4: Metal Industry Emissions of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

In the case of city gas production, in a consistent way to what was used for power plant units, an uncertainty of 4% was considered adequate.

In a similar way to all other stationary combustion sources, the uncertainty associated with the $CO_2$ emission factor was set at 5%, which is the value proposed for traded fuels (IPCC, 2000), and the uncertainty values for methane and nitrous oxide, are in accordance with the GPG proposed values, 150% for $CH_4$ and 1000% for $N_2O$.

#### 3.3.3.6 Recalculations

No recalculations were made for city gas production nor coke production.

#### 3.3.3.7 Further Improvements

We intend to obtain the series of consumption of petroleum products as feedstock in the production of City Gas, in order to increase the transparency and separation between energy and non-energy consumption.

Currently, the Inventory considers that all the energy consumption reported in Energy Balance for this category were made with the purpose of supplying energy to the process. However, all the consumption of oil products as feedstock are reported in a single Energy Balance category, making it difficult to determine the quantities used only in the city's gas production.

## 3.4 Manufacturing Industries and Construction (CRT 1.A.2)

Emissions covered in this source category are those resulting from combustion activities in manufacturing industry and building and construction industry. $CO_2$ emissions from raw materials decarbonising in cement, lime, glass and ceramics industries are addressed and reported under Industrial Processes (Chapters 4.2.2 to 4.2.9). The following subsections present the six UNFCCC assigned subcategories under the Manufacturing Industries and Construction category.

Total emissions for this sub-sector comprehend the sum of different industrial activities, using diverse fuels and combustion technologies and refer to the full combustion emissions of the industry sector: boilers, process dedicated fuel combustion in furnaces and kilns and all emissions originated in co-generation units[10].

***Table 3-17: Subcategories under the Manufacturing Industries and Construction category***

| CRT Code | Categories | Category description |
|---|---|---|
| **1.A.2.a** | **Iron and Steel** | Manufacture and casting of iron and steel |
| **1.A.2.b** | **Non-Ferrous Metals** | Manufacture and casting of non-ferrous metals |
| **1.A.2.c** | **Chemicals** | Manufacture of chemicals and chemical products |
| **1.A.2.d** | **Pulp, Paper and Print** | Manufacture of paper and paper products and Priting |
| **1.A.2.e** | **Food Processing, Beverages and Tobacco** | Manufacture of food products, beverages and tobacco products |
| **1.A.2.f** | **Non-metallic Minerals** | Manufacture of products such as glass, lime, ceramic, cement, etc |
| **1.A.2.g** | **Other Industries** | Manufacture of metal products and machinery<br>Manufacture of motor vehicles and other transport equipments<br>Manufacture of wood and Wood products<br>Manufacture of textiles, leather and footwear<br>Manufacture of rubber products<br>Mining of metal ores & Other mining and quarrying<br>Offroad and other mobile machinery in industry<br>Construction |

Three key categories have been identified for this sector in 2024, for level and trend assessment, using both the IPCC Approach 1 and Approach 2:

***Table 3-18: Key categories in Manufacturing Industries and Construction (CRT 1A2) and methodologies used in emission estimates***

| IPCC category | Gas | Criteria | Method |
|---|---|---|---|
| **1.A.2 Manufacturing industries and construction** - Gaseous fuels | $CO_2$ | L,T | T2,T3 |
| **1.A.2 Manufacturing industries and construction** - Liquid fuels | $CO_2$ | L,T | T1 |
| **1.A.2 Manufacturing industries and construction** - Solid fuels | $CO_2$ | L,T | T2,T3 |

[10] Only when the co-generation activity is reported in the energy balance as referring to the manufacturing industry. When economic activity is referred as Energy Production then emissions are included in source category CRT 1A1a (See chapter 3.2.A.1 for further explanations).

In 2024, the Manufacturing Industries and Construction category accounted for 5.81 Mt (11.3%) of Portugal's total GHG emissions, with a 35.4% (3.18 Mt) decrease in overall emissions since 1990 (refer to the Table below for more details). Within the Manufacturing Industries and Construction category, 2.52 Mt (42.6%) of the GHG emissions are from the Non-metallic Minerals, which is made up of Cement, Glass and Ceramic Industries. This subcategory is followed by, in order of decreasing contributions, Other Industries (1.23 Mt, 20.8%), Pulp, Paper and Print (0.82 Mt, 13.8%), Food Processing, Beverages and Tobacco (0.63 Mt, 10.6%), Chemicals (0.51 Mt, 8.6%); and Iron and Steel (0.10 Mt, 1.8%) subcategories.

***Table 3-19: Total Greenhouse Gas Emissions from Manufacturing Industries and Construction (Mt $CO_2$eq)***

| | Source /Gas | 1990 | 2005 | 2022 | 2023 | 2024 | Δ 2024-2023 | Δ 2024-2005 | Δ 2024-1990 |
|---|---|---|---|---|---|---|---|---|---|
| | | kt $CO_2$ eq. | | | | | % | | |
| **1.A.2.a** | **Iron and Steel** | | | | | | | | |
| | $CO_2$ | 373.3 | 121.4 | 95.8 | 100.3 | 104.2 | 3.8 | -14.2 | -72.1 |
| | $CH_4$ | 0.2 | 0.1 | 0.0 | 0.1 | 0.1 | 3.7 | -43.4 | -66.6 |
| | $N_2O$ | 0.3 | 0.1 | 0.0 | 0.0 | 0.0 | 3.7 | -65.6 | -80.5 |
| **1.A.2.b** | **Non-Ferrous Metals** | | | | | | | | |
| | $CO_2$ | IE | IE | IE | IE | IE | n.a | n.a | n.a |
| | $CH_4$ | IE | IE | IE | IE | IE | n.a | n.a | n.a |
| | $N_2O$ | IE | IE | IE | IE | IE | n.a | n.a | n.a |
| **1.A.2.c** | **Chemicals** | | | | | | | | |
| | $CO_2$ | 1 412.2 | 1 555.2 | 1 120.9 | 651.0 | 503.6 | -22.6 | -67.6 | -64.3 |
| | $CH_4$ | 1.6 | 1.7 | 0.7 | 0.4 | 0.3 | -13.1 | -80.4 | -78.8 |
| | $N_2O$ | 4.0 | 6.4 | 3.3 | 2.4 | 2.6 | 8.7 | -59.7 | -35.8 |
| **1.A.2.d** | **Pulp, Paper and Print** | | | | | | | | |
| | $CO_2$ | 753.7 | 599.0 | 969.5 | 814.7 | 734.2 | -9.9 | 22.6 | -2.6 |
| | $CH_4$ | 17.0 | 22.2 | 29.0 | 29.2 | 30.4 | 4.2 | 36.9 | 78.3 |
| | $N_2O$ | 24.6 | 32.2 | 46.9 | 50.2 | 53.8 | 7.1 | 66.9 | 118.5 |
| **1.A.2.e** | **Food Processing, Beverages and Tobacco** | | | | | | | | |
| | $CO_2$ | 830.4 | 895.9 | 647.6 | 623.8 | 620.2 | -0.6 | -30.8 | -25.3 |
| | $CH_4$ | 1.9 | 1.7 | 0.8 | 0.6 | 0.6 | -2.6 | -65.7 | -68.6 |
| | $N_2O$ | 8.7 | 9.4 | 5.7 | 4.7 | 4.8 | 2.1 | -49.5 | -45.5 |
| **1.A.2.f** | **Non-metallic Minerals** | | | | | | | | |
| | $CO_2$ | 3 289.1 | 4 436.1 | 2 468.3 | 2 352.1 | 2 472.2 | 5.1 | -44.3 | -24.8 |
| | $CH_4$ | 10.9 | 22.4 | 27.0 | 27.0 | 27.1 | 0.6 | 20.8 | 148.9 |
| | $N_2O$ | 33.2 | 42.0 | 22.3 | 22.2 | 23.8 | 7.3 | -43.3 | -28.4 |
| **1.A.2.g** | **Other** | | | | | | | | |
| | $CO_2$ | 2 194.6 | 2 774.4 | 1 331.7 | 1 207.8 | 1 199.6 | -0.7 | -56.8 | -45.3 |
| | $CH_4$ | 3.2 | 3.7 | 2.6 | 2.3 | 2.2 | -0.6 | -39.9 | -30.6 |
| | $N_2O$ | 34.7 | 54.9 | 34.9 | 30.5 | 29.6 | -3.2 | -46.1 | -14.9 |
| Total | $CO_2$ | 8 853.3 | 10 382.0 | 6 633.7 | 5 749.7 | 5 633.9 | -2.0 | -45.7 | -36.4 |
| | $CH_4$ | 34.8 | 51.9 | 60.1 | 59.4 | 60.7 | 2.2 | 17.0 | 74.5 |
| | $N_2O$ | 105.5 | 145.0 | 113.1 | 110.0 | 114.5 | 4.1 | -21.0 | 8.5 |
| Total | All gases | 8 993.6 | 10 578.9 | 6 806.9 | 5 919.1 | 5 809.1 | -1.9 | -45.1 | -35.4 |

Emissions of GHG's in this category, show a growth trend between 1990 and 2005 and a reduction in emission levels in the period between 2006 and 2024 similar to what happens in other categories of the Energy Sector.

Regarding the sub-sectors of category 1.A.2, some of them show more marked reductions (iron and steel, non metallic minerals, chemicals), other sub-sectors (pulp and paper) increased their emissions. In 2009-2011 an overall reduction of emissions for all the sectors occurred due to the effects of the economic recession (refer to figure below for more details).

The expressive decrease in GHG's emissions in Iron and Steel sub-category that can be observed from 2001 to 2002 is explained by the significant changes in the only integrated iron and steel plant that existed in Portugal, particularly the closure and dismantling of the production of coke, sinter and of the blast furnace. Presently, iron and steel are produced from scrap and metallic foils.

In Chemicals sub-sector, fuel consumption was based on residual fuel oil, traded or by-product of the unit, and residual gases, also obtained as a by-product from the production processes. More recently, natural gas has gained a relevant importance as the third energy source. The introduction of Natural Gas in this sub-sector is one of the main reasons for the reduction of $CO_2$ emissions by about 67.6% between 2005 and 2024. A temporary reduction in industrial activity in the chemical sector for 2023 and 2024 also contributed to the decrease in emissions.

Emissions report in Paper and Paper Pulp sector include all the eight paper pulp plants that existed in Portugal from 1990 to 2024 (six Kraft plants and two bisulphite smaller plants), but also smaller units dedicated to paper production. The increasing trend in total emissions is evident and was almost continuous in the period. Except for the decreasing values in 2002-2007 that reflects a re-qualification period for one unit from fueloil to natural gas. Considering the energy sources, there is a dominance of biomass fuels (black liquor and wood waste), this explains the relative importance (> 5%) of GHG's emissions from $CH_4$ and $N_2O$, when compared to the other sub-sectors of category 1.A.2.

Non-metallic minerals emission trend is driven by the cement and ceramic industries which strongly reduced their production levels between 2009 and 2012, in relation to the economic recession and the crisis of building construction sector. GHG's emissions from Glass Industry peaked in 1998. Between 1999 and 2010, the sector saw an almost complete replacement of LPG and Fueloil by Natural Gas, which resulted in a reduction in emissions. Since 2010, GHG's emissions have remained constant in Glass Industry.

In the Other Industries sub-category, the Textile and Leather Industry (1.A.2.g.vi) sector stands out as the main responsible for GHG emissions. In such a way that it is possible to verify the effect that the transition from petroleum derived fuels to natural gas, occurred at Textile and Leather Industry, had on the total emissions of category 1.A.2.g. It is also possible to identify a similar tendency to reduce emissions due to the transition to natural gas consumption in sectors such as Manufacturing of machinery (1.A.2.g.i) and Wood and wood products (1.A.2.g.iv).

Also in Other Industries sub-category, sectors that preferentially consume petroleum-based fuels can be identified, such as Construction (1.A.2.g.v), Off-road vehicles and other machinery (1A.2.g.vii) and Mining and quarrying (1.A.2.g.iii). In these subsectors, there was also a reduction in emissions after the peak in 2005, with the most significant decrease being seen after 2012, probably influenced by the crisis of building construction sector.

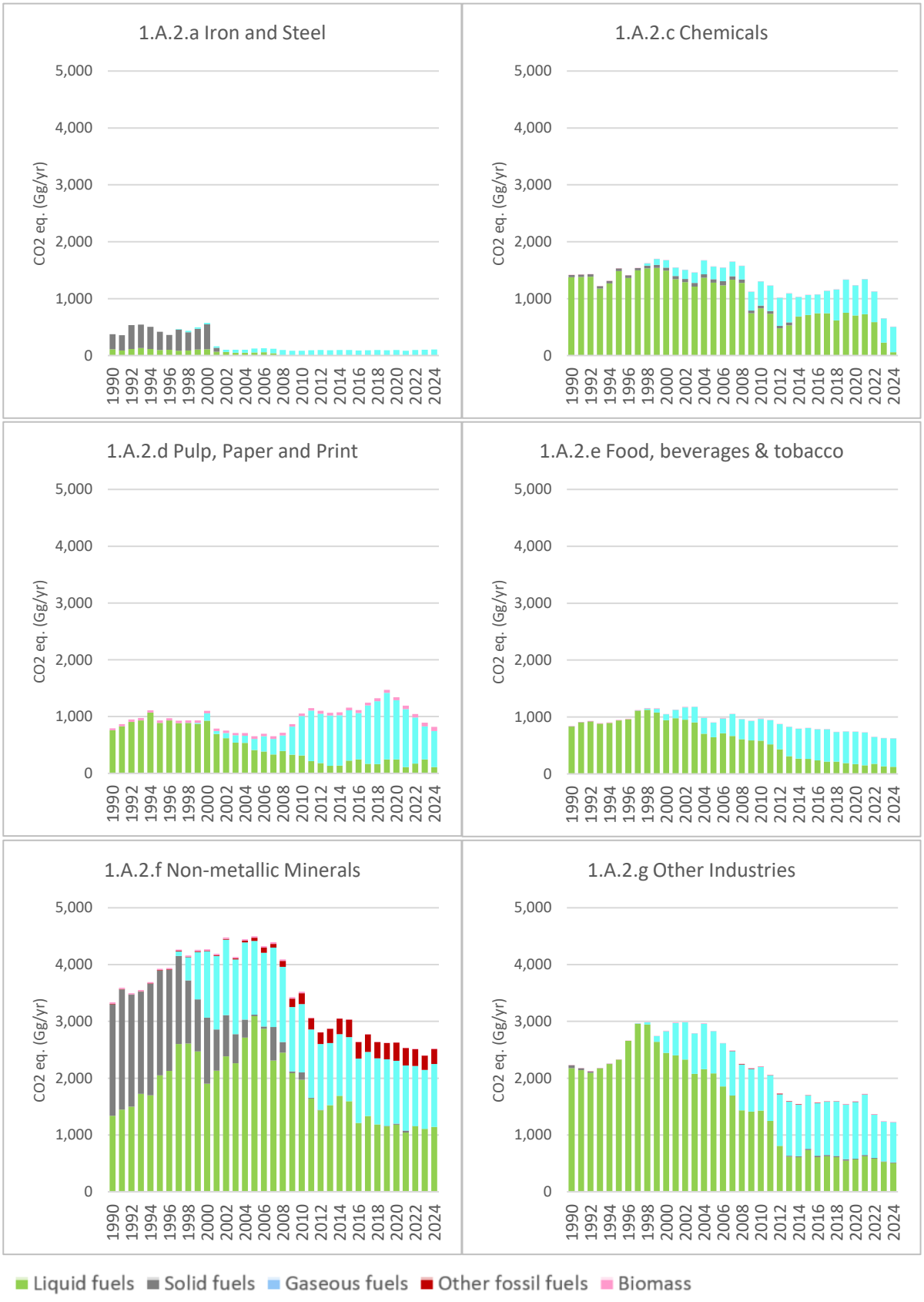



***Figure 3-17: GHG's emissions from 1990 to 202 for Manufacturing Industries and contructions subcategories***

### 3.4.1 Methodology

Air emissions from combustion of manufacturing industries and construction are estimated using a Tier 2 methodology, but two basic approaches are used: energy approach or production approach.

According to the energy-based approach, emissions are estimated multiplying emission factors by the energy consumption according to the following equations.

For carbon dioxide ($CO_2$), total emissions and ultimate fossil emissions are estimated using:

$$U_{CO2(y)} = EF_{CO2} * Fac_{OX(f)} * Energy_{Cons(u,f,y)} * 10^{-3}$$

$$Fossil_{CO2(y)} = U_{CO2(y)} * C_{Fossil(f)} * 10^{-2}$$

**Where:**

$U_{CO2(y)}$: Emissions to atmosphere of total carbon dioxide emissions (t)

$Fossil_{CO2(y)}$: Emissions of carbon dioxide from fossil origin (non biomass) (t)

$EF_{CO2}$: Carbon content of fuel expressed in total Carbon Dioxide emissions (kg $CO_2$/GJ)

$C_{Fossil}$: Percentage of carbon from fossil origin in fuel f (%)

$Fac_{OX(f)}$: Oxidation factor for fuel f (ratio 0..1)

$Energy_{Cons(u,f,y)}$: Consumption of energy (Low Heating Value) from fuel f in power plant u in year y (GJ)

For $CH_4$, $N_2O$ and other GHG when the energy consumption approach is used the equation simplifies to:

$$Emi_{(p)} = \sum_f \sum_s \sum_t [EF_{(p,f,s,t)} * Energy_{(f,s,t)}] * 10^{-6}$$

**Where:**

$Emi_{(p)}$: Total emissions of pollutant p (t/yr except $CO_2$ in kt/yr)

$EF_{(p,f,s,t)}$: Emission Factor for pollutant p, specific of fuel type f, sector activity s and technology/ combustion equipment t (g/GJ except $CO_2$ in kg/GJ)

Activity $_{(f,s,t)}$: Energy Consumption of fuel type f, sector activity s and technology/ combustion equipment t (GJ)

When in the production process occurs contact between combustion gases and product, which is the case of sintering and lime kilns in the iron and steel industry, cement kilns, glass ovens, ceramic ovens and dryers and lime kilns in paper pulp industry, or when combustion occurs also with the purpose of recovery of combustion products, which is the case for the recovery boiler in paper pulp industry (green liquor), emissions are more appropriately estimated using produced quantities as activity data, and the associated emission factor is expressed in kg/t. For these situations, where the production approach is used, emissions from combustion activities are estimated using the following equation:

$$Emi_{(p)} = EF_{(p)} * Production * 10^{-3}$$

**Where:**

$Emi_{(p)}$: Total emissions of pollutant p (t/yr except $CO_2$ in kt)

$EF_{(p)}$: Emission Factor for pollutant (kg/t)

Production: Production activity rate (t/yr)

It is important to point out that following a meeting with the energy balance team from DGEG new procedures were established to include biodiesel in the INERPA estimates. Hence all estimates derived from the energy balance consider biodiesel. This new approach for obtaining biodiesel results from the fact that from 2006 onwards the gas oil reported in the energy balance contained a percentage of biodiesel. The methodology for obtaining the total pure biodiesel and pure gas oil consumed in each industrial sector follows the steps[11]:

- Total pure gas oil consumed was obtained by subtracting the total biodiesel produced (that is going to be incorporated in gas oil) to the gas oil reported in the energy balance;
- With the pure gas oil and the pure biodiesel values an incorporation rate was derived;
- For each industrial sector this incorporation rate was applied to obtain value for total gas oil and total biodiesel consumed;
- Not all the gas oil reported has biodiesel. Because of this, before applying the incorporation rate the total gas oil for heating was subtracted;
- In the end we have, for each industrial sector, the total gas oil consumed (heating gas oil plus gas oil with biodiesel removed) and the total biodiesel consumed (biodiesel from gas oil plus pure biodiesel purchased directly by the industrial unit).

The table below represents the incorporation rate derived for the period 2006-2024.

***Table 3-20: Incorporation rate of biodiesel (% toe/toe)***

| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|
| Incorporation rate | 1.31 | 2.50 | 2.43 | 4.16 | 6.03 | 6.25 | 6.20 | 6.05 | 5.93 | 6.81 |
| | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | |
| Incorporation rate | 5.15 | 5.10 | 5.49 | 5.43 | 5.76 | 7.27 | 6.55 | 5.85 | 5.85 | |

When comparing the Final Consumption values considered by the Inventory with the consumption values published by EUROSTAT, we see that there is an adequate adjustment in the series. Justifying the correction that is made to the consumption data of the Energy Balance.

[11] Note: This procedure does not apply to gas oil reporter under co-generation in the energy balance. The DGEG has no documentation to differentiate this fuel as heating gas oil or as gas oil with biodiesel.

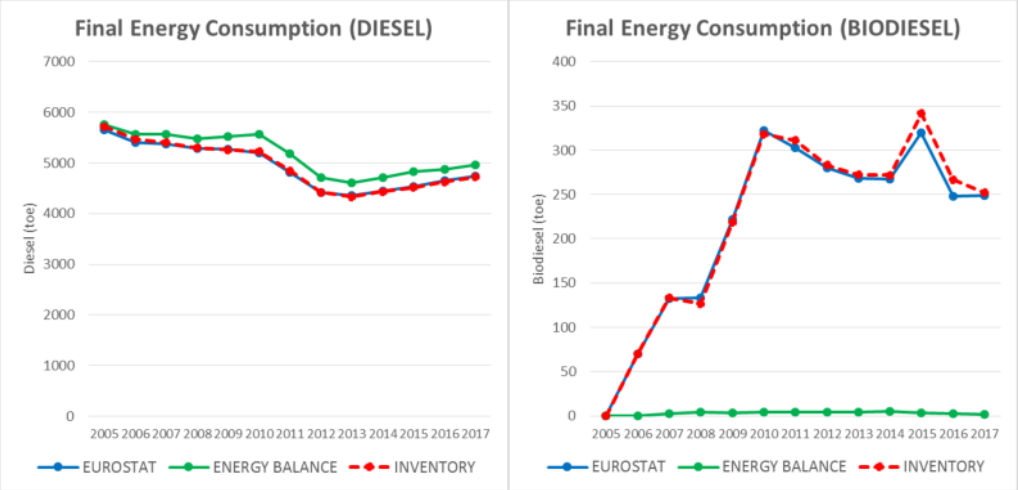



***Figure 3-18: Final energy consumption for Diesel and Biodiesel***

Emissions from the following industries were estimated based only on fuel consumption as activity data (energy approach): metallurgy; chemical and plastic industry; food, beverages and tobacco, textile industry; clothing, shoes and leather manufacturing; wood industry; rubber manufacturing; machines manufacturing industry and other metal equipment industry; extractive industry; building and construction and all other unspecified industry. Following the recommendation made by the review team, since the 2011 inventory all emissions from lime production are reported in 2.A.2. For the following industrial sectors specific estimation procedures were taken.

#### 3.4.1.1 Paper and Pulp Production

Emissions of $SO_x$, $NO_x$, NMVOC and methane from the recovery boilers and lime kilns in the Kraft and Acid Sulphide paper pulp plants were estimated using production data, for each industrial plant, as activity data (production approach). The remaining pollutants emitted from these combustion equipments and all pollutants for the remaining combustion equipments of this industry sector were estimated using energy consumption as activity data (energy approach).

#### 3.4.1.2 Clinker Production

Emissions from combustion in clinker kilns were estimated based on production data or consumption of energy obtained for each individual industrial plant, according to the original units of the emission factors. For this sector, most emission factors are plant specific and obtained from information monitored at industrial plants. The remaining fuel use in this sector that is consumed in equipments other than kilns is converted into emission using the general purpose emission factors (energy approach). $CO_2$ emissions from decarbonising limestone and dolomite in clinker production are addressed in IPPU chapter 4.2.2 and reported in CRT sector 2.A.1.

#### 3.4.1.3 Lime Production

Both Lime and Clinker production are included in the energy balance of the cement sector. $CO_2$ emissions from decarbonising limestone and dolomite in lime production are addressed in IPPU chapter 4.2.3 and reported in CRT sector 2.A.2.

#### 3.4.1.4 Ceramic Industry

Emissions of $SO_x$, $NO_x$, NMVOC, $CH_4$ and CO from combustion processes in furnaces in the ceramic industry are estimated using the production approach. Emissions estimates from combustion in other equipment,

boilers and engines, and emission estimates for the other pollutants, also for furnaces, are based on the energy approach.

#### 3.4.1.5 Glass Production

Similarly to ceramic industry, emissions of $SO_x$, $NO_x$, $CH_4$ and CO are estimated using production information as activity data (production approach). Emissions for the remaining pollutants, $CO_2$ and $N_2O$ from furnaces and for all pollutants from other combustion equipments are estimated using energy consumption as activity data indicator. $CO_2$ emissions from glass production comprehend both oxidation of carbon, that are estimated using the general emission factors based on energy consumption, and decarbonising or materials, which are included in production process and are addressed in IPPU chapter 4.2.7 and reported in CRT sector 2.A.3.

#### 3.4.1.6 Iron and Steel Production

Air emissions from sintering ($SO_x$, $NO_x$, NMVOC and CO) integrated in the iron and steel production sector are estimated using production as activity data (production approach). The remaining pollutants resulting from the iron and steel industry were estimated using the energy approach. For simplicity's sake, detailed info regarding all emission streams for iron and steel operations, as well as the categories under which emissions are reported can be found in Table 4-37 and section 4.4.2.1 of the IPPU chapter.

#### 3.4.1.7 Off-road vehicles and other machinery

This category reports combustion emissions from mobile sources in the Construction category (1.A.2.g.v) and from the Iron and Steel Industry (1.A.2.a/2.C.1).

The energy consumption considered in the Construction category obtained through the consumption of diesel reported for this sub-sector in the Energy Balance crossed with the thermal uses split according to JRC-IDEES [12] database between 2000 and 2015, allowing the separation of diesel consumption for heating and for mobile sources.

In order to obtain the energy consumption of mobile sources of the Iron and Steel industry, specific information from the installations was used, which discriminate the consumption of stationary and mobile sources.

The considered emission factors can be consulted in Table 3-38 of this same report.

### 3.4.2 Activity data

Energy consumption for this sector is reported in the Energy Balance (see Annex 5). The data comprise specification of consumption for 14 sub-sectors and more than 30 fuels. These very detailed data, combined with EU-ETS, E-PRTR and industrial production data, allow for a good estimation of all the fuel used by most industrial sectors, with the details required by CRT format.

Activity data comprehends consumption of fuels and industrial production rates. The subsequent chapters will follow this division.

#### 3.4.2.1 Combustion Data

Data on fuel consumption for LPS were obtained from several sources:

[12] JRC-IDEES is developed by the European Commission's Joint Research Centre and offers a consistent set of disaggregated energy-economy-environment historical time series from the year 2000 onwards for all EU Member States

- directly from Large Combustion Plants (LCP) submitted to APA under the provisions of the LCP Directive;
- information received by APA from special surveys;
- from EPER/PRTR inventory;
- from Self-control program (*Programa Autocontrolo*);
- from direct request to the LCP operators;
- since the 2009 inventory from EU-ETS.

Presently LPS comprehend one petrochemical unit, eight paper pulp plants (in most cases divided in different fiscal entities), six cement plants (covering all clinker producing units), five lime plants, seven glass plants and two iron and steel facilities.

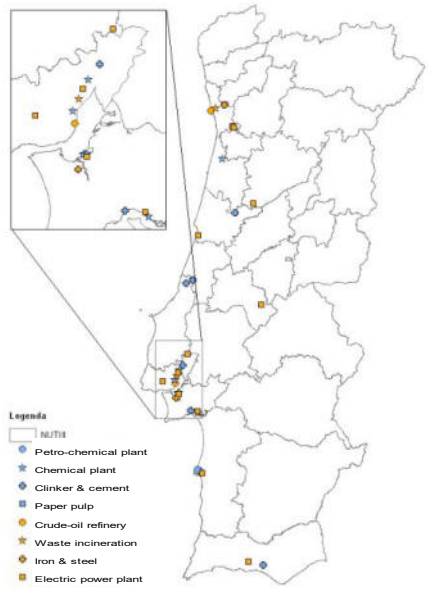



***Figure 3-19: Distribution of Large Point Sources in Portugal mainland[13]***

The remaining national energy consumption for each sector was estimated subtracting LPS consumption data from the figures reported in the energy balance compiled annually by DGEG and with detailed consumption data for each industrial sector and for each fuel. This procedure is synthesized in the figure below and in the following formula set:

$$Cons_{EB\,(f,s)} = \sum_c \{Energy_{EB\,(f,s,c)} / LHV_{EB\,(f,s)}\}$$

$$Energy_{AREA\,(f,s,e)} = \{Frac_{Equi\,(s,f)} * [Cons_{EB\,(f,s)} - \sum_u Cons_{LPS(u,f,e)}\ ]\ \} * LHV_{AREA(f,s,e)}$$

$$Energy_{LPS(u,f,e)} = Cons_{LPS(u,f,e)} * LHV_{LPS(u,f,e)}$$

**Where:**

$Energy_{EB(f,s,c)}$: Reported energy consumption of fuel f in activity sector s, according to the energy balance, either in co-generation or not (index c) (toe/yr)

[13] This map includes also LPS that are accounted as process emissions (CRT 2).

$Cons_{LPS(u,f,e)}$: Reported consumption of fuel f consumed by LPS unit u in equipment e (t/yr or $Nkm^3/yr$)

$Cons_{EB\ (f,s)}$: Calculated consumption of fuel f consumed in sector s, in both co-generation or non-cogeneration (c index), according to the Energy Balance (t/yr or $Nkm^3/yr$)

$Energy_{AREA(s,f,e)}$: Remaining energy consumption of fuel f in non-LPS – Area Sources - in activity sector s and in equipment e (GJ/yr)

$Energy_{LPS(u,f,e)}$: Energy consumption of fuel f estimated for LPS unit u in equipment e (GJ/yr)

$Frac_{Equi\ (s,f)}$: Fraction of consumption of fuel f in sector s that is used in equipment e (0..1)

$LHV_{LPS(u,f,e)}$: Low Heating Value/ Net Calorific Value, reported by LPS unit u, for fuel f in combustion equipment e (MJ/kg or $MJ/Nm^3$)

$LHV_{EB(f,s)}$: Low Heating Value/ Net Calorific Value used by DGEG in the compilation of the Energy Balance for fuel f in activity sector s (toe/t or $toe/Nkm^3$)

$LHV_{AREA(f,s,e)}$: Low Heating Value/ Net Calorific Value used in the Inventory for fuel f in equipment e for area sources (combustion in non LPS) (MJ/kg or $MJ/Nm^3$)[14]

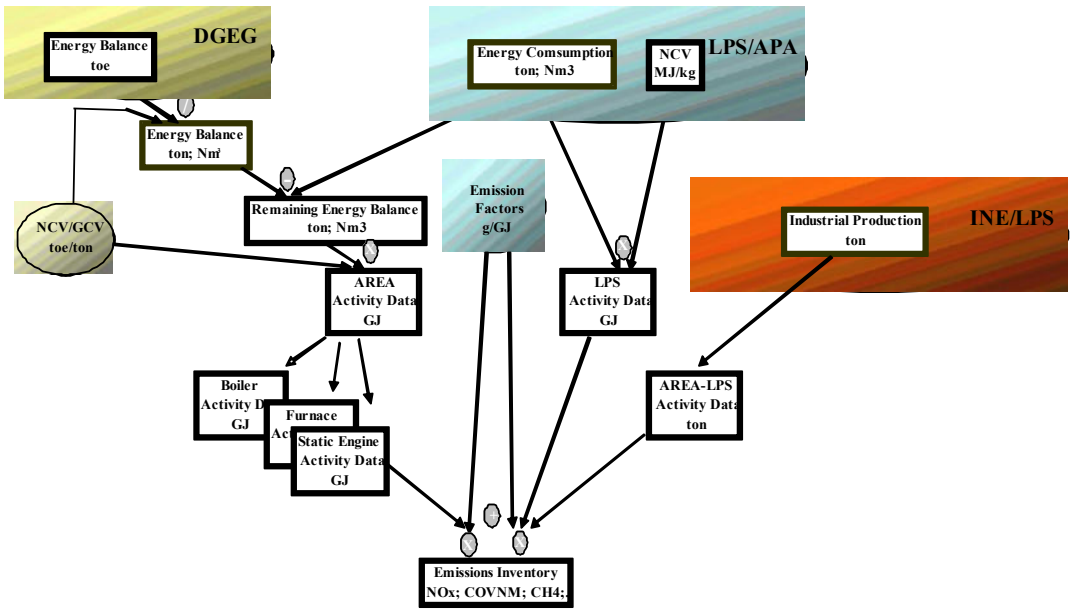



***Figure 3-20: General procedure for emissions estimate***

Characterization of the combustion equipments was also taken from LPS sources, as well as some characteristics of the fuels. For the non LPS sources, or the remaining energy consumed that are accounted in the energy balances, there is no detailed information about in which equipment combustion takes place, apart from division between co-generation and non co-generation. Hence separation of fuel consumption among boilers, furnaces and engines was made by expert judgment according to each economic sector, and also considering that the original data of fuel consumption in the DGEG's energy balances make a separation between quantities used in co-generation and quantities used without co-generation.

[14] In most cases similar values to Energy Balance are used

### 3.4.2.2 The Energy Balance

The Portuguese Energy Balance (EB) is published annually by DGEG covering all national territory and without any disaggregation at regional level. The structure of the report table is summarized in the next tables. The Energy Balance for 2024 is presented in ANNEX A.

***Table 3-21: Structure of the Portuguese Energy Balance. Sectoral categories***

| | | | | | |
|---|---|---|---|---|---|
| Primary | Imports | Co-generation | Electric producers | Final Consumption | **Agriculture** |
| | Indigenous Production | | Barreiro power plant | | **Fisheries** |
| | Stock variations | | Crude oil refineries | | **Mining Industry** |
| | Exports | | City gas | | Manufacturing Industry: Food and Beverages |
| | Foreign ships | | Agriculture | | Manufacturing Industry: Textile |
| | Foreign aircraft | | Food and Beverages | | Manufacturing Industry: Paper pulp and paper |
| | Primary Energy Consumption | | Textile | | Manufacturing Industry: Chemical and Plastics |
| For production of secondary energy sources | Briqettes | | Paper pulp and paper | | Manufacturing Industry: Ceramic |
| | Coke | | Chemical and Plastics | | Manufacturing Industry: Glass |
| | Crude oil products | | Ceramic | | Manufacturing Industry: Cement |
| | City gas | | Glass | | Manufacturing Industry: Metalurgy |
| | Petro-chemical | | Cement | | Manufacturing Industry: Iron and steel |
| | Electricity | | Metalurgy | | Manufacturing Industry: Cloth, shoes, leather |
| Consumption in the Energy sector | Refineries (own consumption) | | Iron and steel | | Manufacturing Industry: Wood |
| | Refineries (losses) | | Cloth, shoes, leather | | Manufacturing Industry: Rubber |
| | Coquerie | | Wood | | Manufacturing Industry: Equipment |
| | Electric Power Plants | | Rubber | | Manufacturing Industry: Other Manufacturing Industries |
| | Hidropower pumping | | Equipment | | **Construction and Publick Works** |
| | City gas | | Other Manufacturing Industries | | Transport: National airplanes |
| | Mining Industry | | Extractive | | Transport: National ships |
| | Transport and distribution (losses) | | Services | | Transport: Railways |
| **Feedstocks** | | | | | Transport: road |
| **Corrections** | | | | | **Domestic** |
| | | | | | **Services** |

***Table 3-22: Structure of the Portuguese Energy Balance. Fuel categories***

| | | | |
|---|---|---|---|
| Coal | Imported coal | Non Energ Products | Lubricants |
| | National coal | | Asphalts |
| | coal coke | | Parafin |
| Oil | Intermediate refinery products | | Solvents |
| | LPG | | Propylene |
| | Gasoline | Electricity | Hydro-electricity |
| | Kerosene | | Wind and Geothermal |
| | Jets | | Thermo-electricity |
| | Diesel oil | | |
| | Residual fuel oil | | |
| | Naphta | | |
| | Petro coke | | |
| Gases | Natural gas | | |
| | City Gas | | |
| | Coke oven gas | | |
| | Blast Furnace gas | | |
| | Petrochemical gas | | |
| | Hydrogen | | |
| Other | Tar | | |
| | Wood and vegetable wastes | | |
| | Solid Urban Waste | | |
| | Industrial Waste | | |
| | Biogas | | |
| | Biodiesel | | |
| | Liquors | | |
| | Other | | |

The sub classes presented below represent the most detailed information available limited by the detail reported in the National Energy Balances from DGEG. Each group represents an aggregation of specific Categories of Economic Activities (CAE).

***Table 3-23: Definition of Sectors in accordance with Economic Activity Classes***

| Sub sector | EAC (1977) |
|---|---|
| Agriculture | 111, 112, 113, 121, 122 |
| Fisheries | 130 |
| Extractive Industry | 220, 230, 290 |
| Food processing, beverages and tobacco | 311, 312, 313 |
| Textile | 321 |
| Paper and paper pulp | 341 |
| Chemical and Plastic Industry | 351, 352, 356 |
| Ceramic | 361, 3691 |
| Glass | 362 |
| Cement | 369 except 3691 |
| Metallurgy | 271, 272 except Iron and Steel |
| Iron and Steel Industry | Iron and Steel |
| Clothing, shoes and leather | 322, 323, 324 |
| Wood & wood products | 331, 332 |
| Rubber | 355 |
| Manufacturing of machines and metallic Equipments | 381, 382, 383, 384 |
| Other | 390, 314, 342, 385 |
| Construction & Building | 500 |

### 3.4.2.3 Industrial sector energy profiles

In this section the energy profiles of the different sub-sectors are described, considering consumption, share of fuels, emissions intensity and source of data.

The figures below represent the energy consumption for Manufacturing Industries and Construction for the different sub-sectors and level of information disaggregation – data from industrial plants or data from subsector of the national Energy Balance.

Iron and Steel (1.A.2.a) – Both facilities are included in EU ETS. Activity data information was also collected via a questionnaire, sent directly to the plants' operators.

Chemicals (1.A.2.c) - EU-ETS data from petrochemical facilities are considered. The remaining energy consumption of this subsector is collected through the Energy balance.

Pulp, Paper and Print (1.A.2.d) - Most of the operators in the paper and pulp sector are included in EU ETS, while only a few of the printing installations are included.

Food, beverages & tobacco (1.A.2.e) - A comprehensive activity data for this sector is not available; the subsector comprises many small and medium size enterprises, with thousands of different products. Limited info on this sector can be found in ETS survey, the sector is not included in the scope of ETS.

Non-metallic minerals (1.A.2.f) - This sector comprises emissions from many different industrial subsectors, some of which are subject to EU ETS and some not. Cement Industry subsector is energy intensive and it is subject to EU ETS. However, in the construction material subsector (Ceramic Industry), there are many small and medium sized enterprises, so the operators subject to ETS are only a part of the total.

Other Industries (1.A.2.g) - This sector comprises emissions from many different industrial subsectors, mainly not subject to EU ETS.

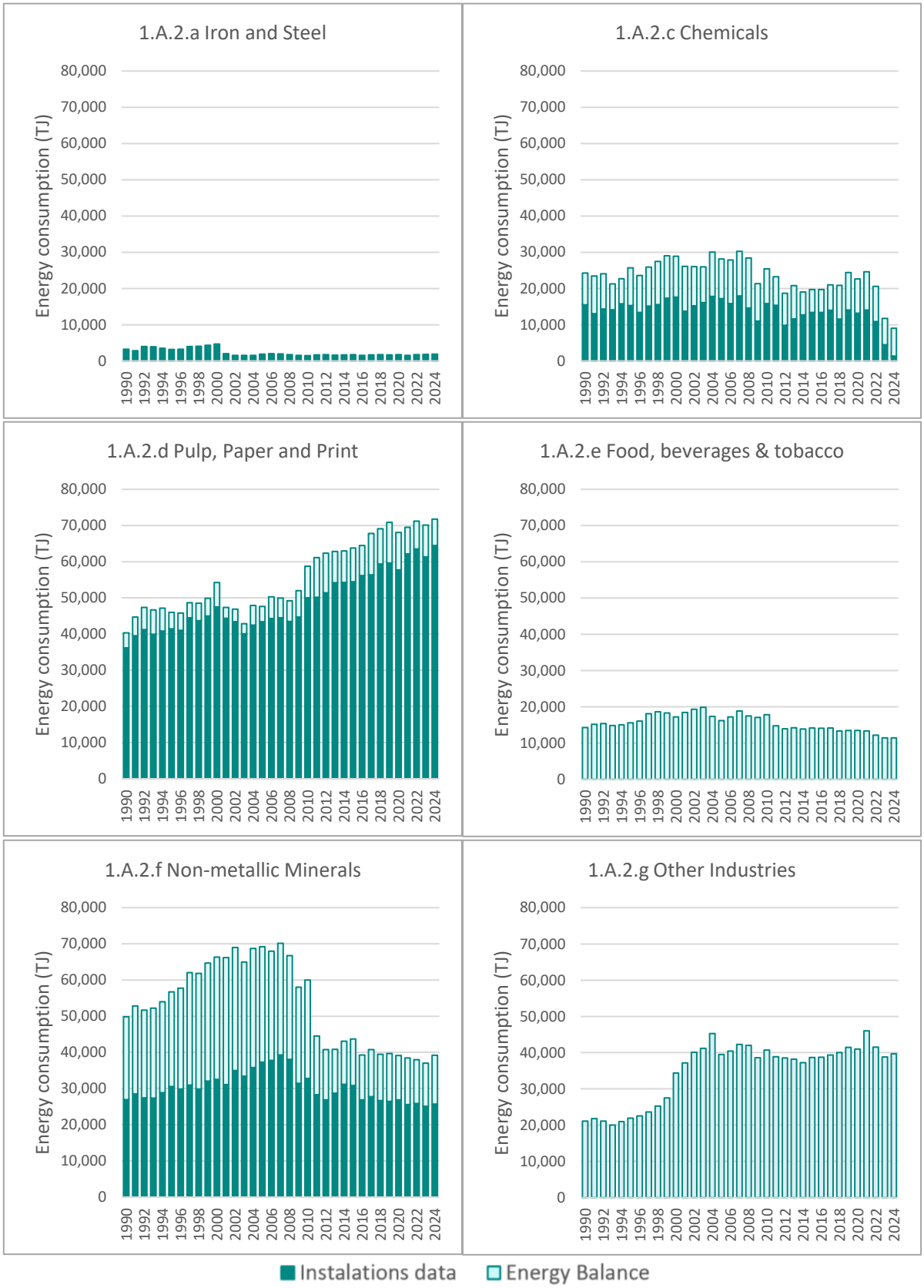
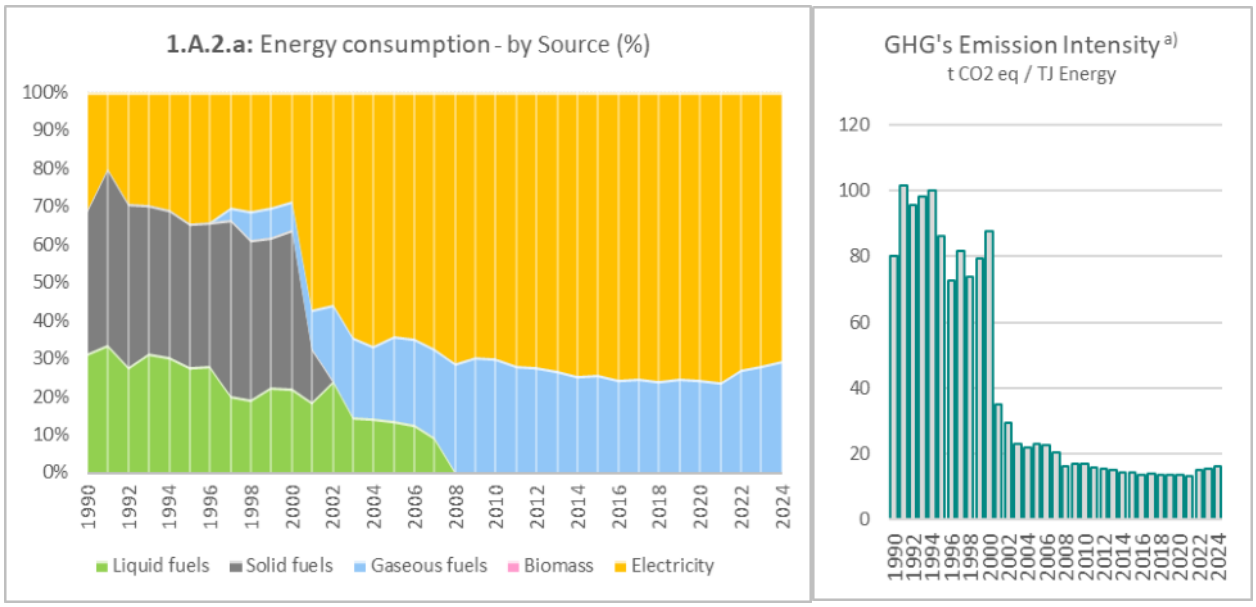



***Figure 3-21: Total Energy Consumption in Manufacturing Industries and Construction***

### 3.4.2.3.1 Iron and Steel Industry (CRT 1.A.2.a)

There are two distinct periods in recent history of the Iron and Steel sector in Portugal: between 1990 and 2001, when one of the plants operated on an integrated regime (coke production, sinter production, pig iron production and BOF steel production), and from 2002 onwards, when the two iron and steel plants only produced steel using the electric arc furnace and scrap and metallic foils as raw materials. This change has also caused substantial changes in the contribution of fuels, with the cessation of coke oven gas and blast furnace gas (solid fuels), and the increase in the use of natural gas (gaseous fuels), that not only was used to replace the other by-product gases, but also partially the use of LPG and residual fuel oil (liquid fuels). The change from the Basic Oxygen Furnace to the Electric Arc Furnace in one of the facilities also meant an increase in electricity consumption, which became the main source of energy from 2002 onwards.




a) GHG's Emission Intensity is estimated considering the total emissions of greenhouse gases ($CO_2$, $CH_4$ and $N_2O$) reported in category *1.A.2.a Iron and Steel* in relation to the total energy consumed (fossil fuels, biomass and electricity). $CO_2$ emissions from biomass as well as GHG's emissions associated with electrical production are not included in the calculation of this parameter, as they are considered in the estimates of other categories of the Inventory.

***Figure 3-22: Share of energy consumption by source & Greenhouse gases emissions intensity***

The trend of emissions intensity is also marked by changes in steel production methods. By abandoning the integrated regime and the Basix Oxygen furnace, GHG's emissions associated with combustion are significantly reduced. It is also possible to identify the transition period between liquid and gaseous fuels between 2002 and 2008. Natural gas is currently the main source of fossil emissions from the energy component of this sector used in rolling mills.

Detailed info regarding all emission streams for iron and steel operations, as well as the categories under which emissions are reported can be found in Table 4-37 and section 4.4.2.3 of the IPPU chapter.

### 3.4.2.3.2 Non-Ferrous Metals

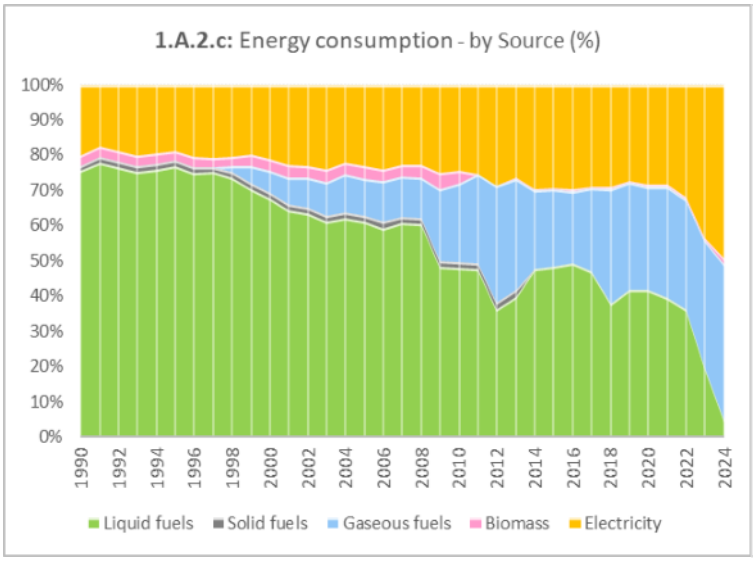
The Portuguese Energy Balance does not have disaggregated information for the industrial sub-sector "Non-Ferrous Metals". When asked where these consumptions were included, it was clarified by DGEG, the national energy authority that these consumptions would be included in the category corresponding to the Metallurgy Industry.

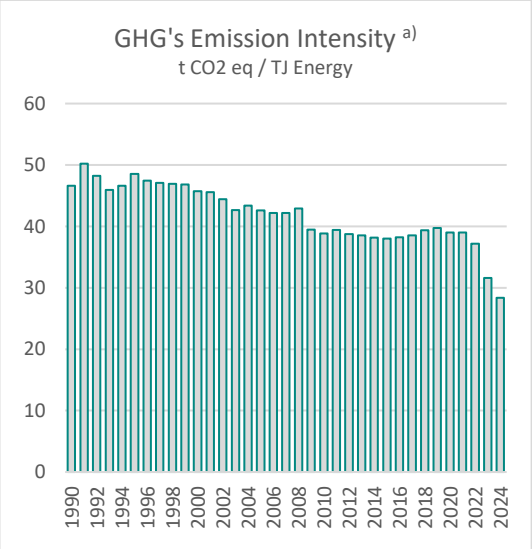
Since it is impossible to determine the consumption of the industrial sub-sector "Non-Ferrous Metals", emissions from 1.A.2.b are allocated in Manufacturing of Machinery (1.A.2.gi).

#### 3.4.2.3.3 Chemical and Plastics Industry

Two industrial plants in this sector were treated as Large Point Sources, representing a substantial component of total energy consumption. In the beginning of the period under analysis, fuel consumption was based on residual fuel oil, traded or by-product of the unit, and residual gases, also obtained as a by-product from the production processes. The consumption of coke time series presents an anomalous value in 2000. When questioned about this, the energy balance team at DGEG could not justify the inconsistent value.

The trend towards a reduction in the intensity of GHG emissions that occurred after 2000 is essentially due to the change in consumption between residual fuel oil and natural gas.



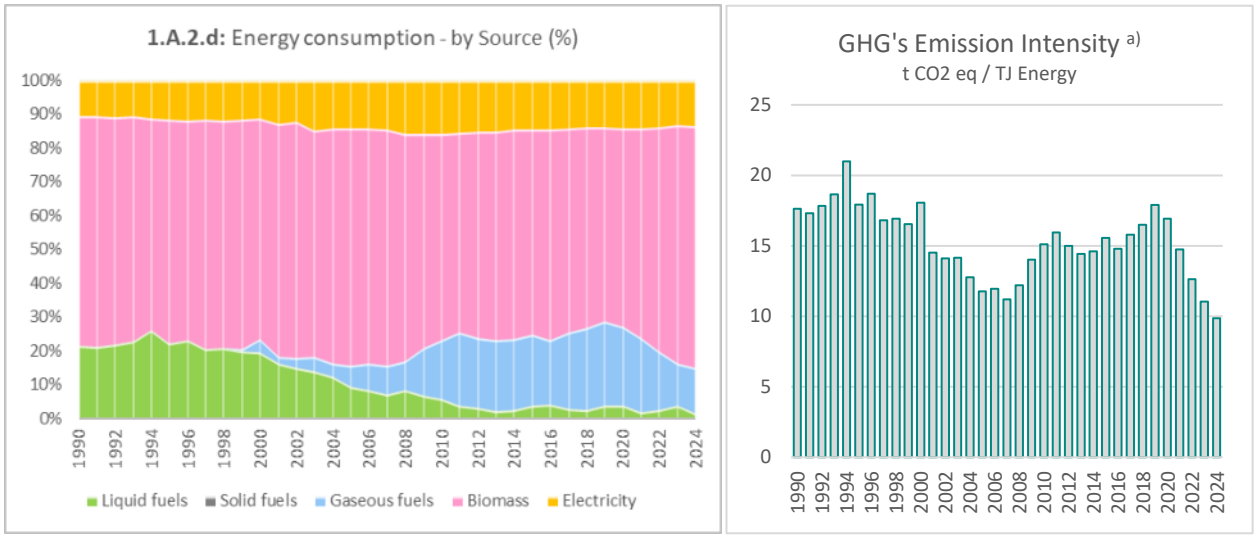




a) GHG's Emission Intensity is estimated considering the total emissions of greenhouse gases ($CO_2$, $CH_4$ and $N_2O$) reported in category 1.A.2.c Chemicals in relation to the total energy consumed (fossil fuels, biomass and electricity). $CO_2$ emissions from biomass as well as GHG's emissions associated with electrical production are not included in the calculation of this parameter, as they are considered in the estimates of other categories of the Inventory.

***Figure 3-23: Share of energy consumption by source & Greenhouse gases emissions intensity***

#### 3.4.2.3.4 Paper and Paper Pulp Industry

Black liquor is the main source of energy in the pulp production plants, and throughout the time series it is responsible for more than 50% of energy consumption. Other relevant fuels in this subsector are wood and wood products, residual fuel oil and natural gas. These last two have different periods of use - Fuel oil being the main auxiliary fuel between 1990 and 2007, which would later be replaced by Natural Gas, which has gained main prominence since 2010, even replacing some consumption of wood products.



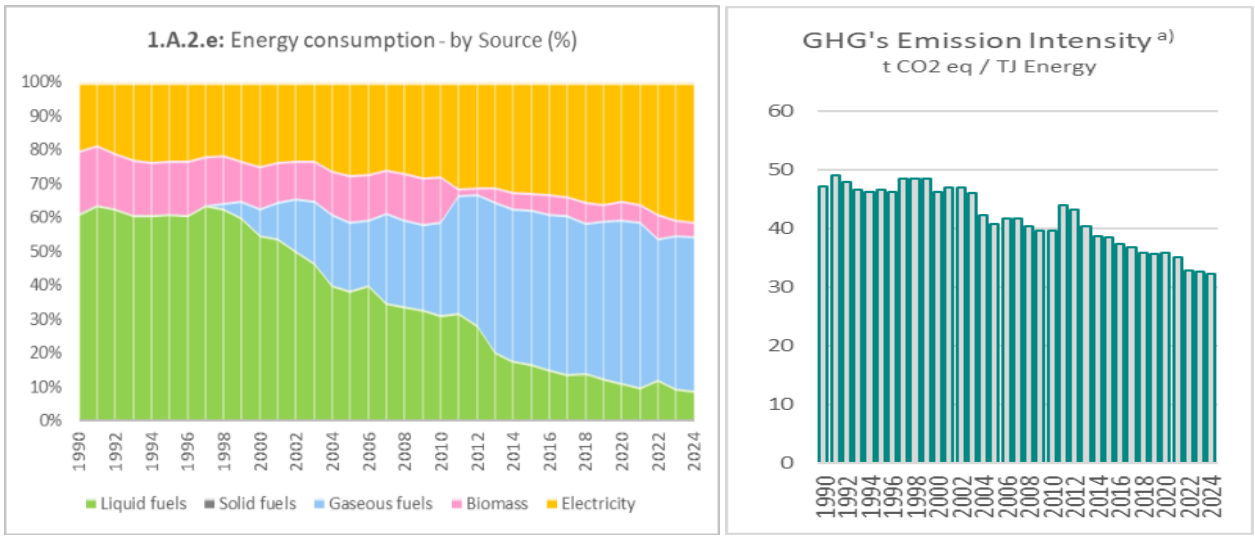

a) GHG's Emission Intensity is estimated considering the total emissions of greenhouse gases ($CO_2$, $CH_4$ and $N_2O$) reported in category 1.A.2.d Pulp, Paper and Print in relation to the total energy consumed (fossil fuels, biomass and electricity). $CO_2$ emissions from biomass as well as GHG's emissions associated with electrical production are not included in the calculation of this parameter, as they are considered in the estimates of other categories of the Inventory.

***Figure 3-24: Share of energy consumption by source & Greenhouse gases emissions intensity***

The use of Biomass (black liquor and wood products) as the main source of energy makes this subsector a low emitter when analyzing GHG's Emissions Intensinty. The variations in Emission Intensity that occur over the time series are related first to the replacement of liquid fuels with gaseous fuels (1997-2007) and later by the increase in natural gas consumption (2007-2020).

### 3.4.2.3.5 Food Processing, Beverages and Tobacco

Like other sectors of the industry, the Food Industry sub-sector saw large consumption of fueloil residuals in the early 1990s, with other preferred fuels being LPG and Wood products. Like other subsectors, the introduction of Natural Gas in Portugal in 1997, revolutionized the consumption profile of this industry. Natural gas currently covers about 45% of total consumption. It is important to mention the electrification that has been taking place in this sector, electricity consumption in 2020 was twice as high as in 1990, and is now responsible for around 30% of total energy consumption.




a) GHG's Emission Intensity is estimated considering the total emissions of greenhouse gases ($CO_2$, $CH_4$ and $N_2O$) reported in category *1.A.2.e Food Processing, Beverages and Tobacco* in relation to the total energy consumed (fossil fuels, biomass and electricity). $CO_2$ emissions from biomass as

well as GHG's emissions associated with electrical production are not included in the calculation of this parameter, as they are considered in the estimates of other categories of the Inventory.

***Figure 3-25: Share of energy consumption by source & Greenhouse gases emissions intensity***

The transition from petroleum-based fuels to natural gas is the driver of the trend towards reducing GHG's Emission Intensity. However, there is an anomaly in 2011 and 2012, due to Biomass consumption values especially low for the sector.

#### 3.4.2.3.6 Non-metallic Minerals

Category 1.A.2.f Non-Metallic Minerals enfolds emissions from fuel combustion in cement, lime, glass and bricks & tiles industries.

In the early 1990s, the breakdown of sectors by type of fuel used was evident. With a large part of the cement industry being fueled by coal combustion, the glass industry preferably used fuel oil and Ceramicas with a combination of biomass and LPG combustion.

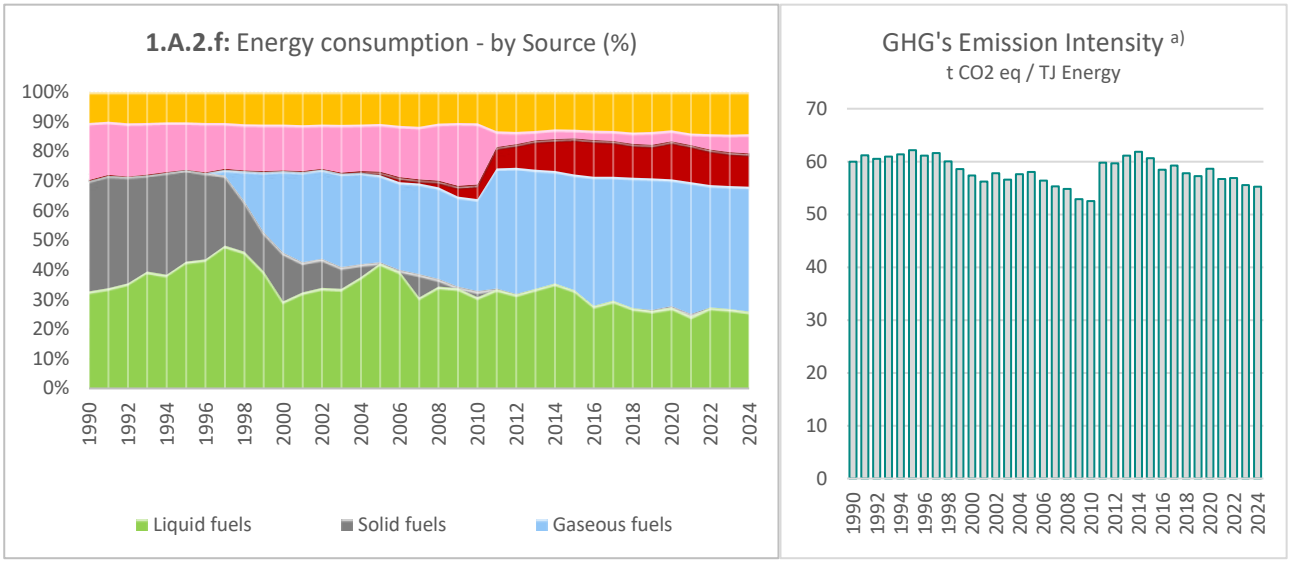
Once again, a milestone in the consumption of fossil fuels in the Portuguese industry was the introduction of Natural Gas. However, the transition occurred at different times for the sub-sectors. The first sub-sector to adopt natural gas was the glass industry, becoming the main fuel from 2000 onwards.

In the case of the Ceramics industry, the introduction of natural gas was slower, with the energy consumption of the subsector being divided between Biomass and Natural Gas until 2012, when after a significant drop in the consumption of Biomass, Natural Gas becomes the main fuel consumed.

In the lime-producing industry, the consumption of natural gas began in the year 2000, with one of the main factories starting the transition from petroleum-derived fuels to natural gas. This option to use natural gas as the main fuel was also verified in new installations that started working after 2017, which made natural gas the main source of energy for the lime production industry.

The cement industry underwent a different transition, with the substitution of coal for petroleum coke between 1998 and 2005. As of 2008, and after a political decision, the incineration of tires and other industrial waste started in Portuguese cement plants. Currently, the combustion of other fossil fuels represents about 25% of energy consumption in the cement industry.

The incineration of residues in the cement plants began in 2005. The main residues burned are used tyres, RDF, fluff, animal and vegetable residues and hazardous industrial residues. Thus, increasing the share of "Other fossil fuels" in the subcategory to around 10%.




a) GHG's Emission Intensity is estimated considering the total emissions of greenhouse gases ($CO_2$, $CH_4$ and $N_2O$) reported in category *1.A.2.f Non-metallic Minerals* in relation to the total energy consumed (fossil fuels, biomass and electricity) . $CO_2$ emissions from biomass as well as GHG's emissions associated with electrical production are not included in the calculation of this parameter, as they are considered in the estimates of other categories of the Inventory.

***Figure 3-26: Share of energy consumption by source & Greenhouse gases emissions intensity***

Regarding the Intensity of GHG Emissions, the sector underwent a reduction in intensity when transitioning from oil-based fuels to natural gas. There is a significant increase after 2011, due to the sharp decrease in the consumption of Biomass in the ceramic industry.

In the next figure it is possible to observe in greater detail the energy consumption of the main subsectors of category 1.A.2.f. It is evident that both the Ceramic Industry, Lime Production and Glass Production had a transition between liquid fuels and natural gas, however in the cement production industry the transition happened differently.

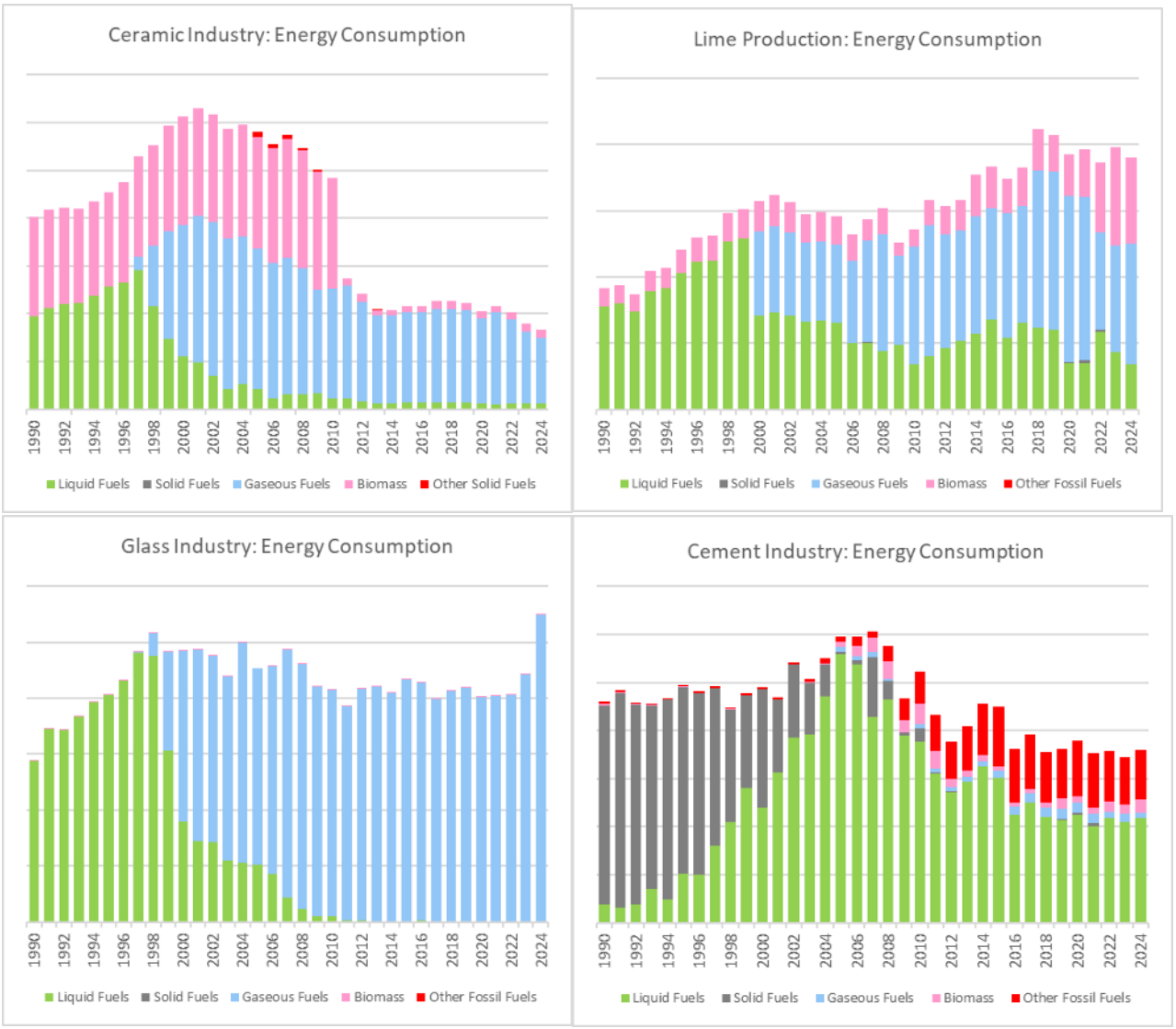
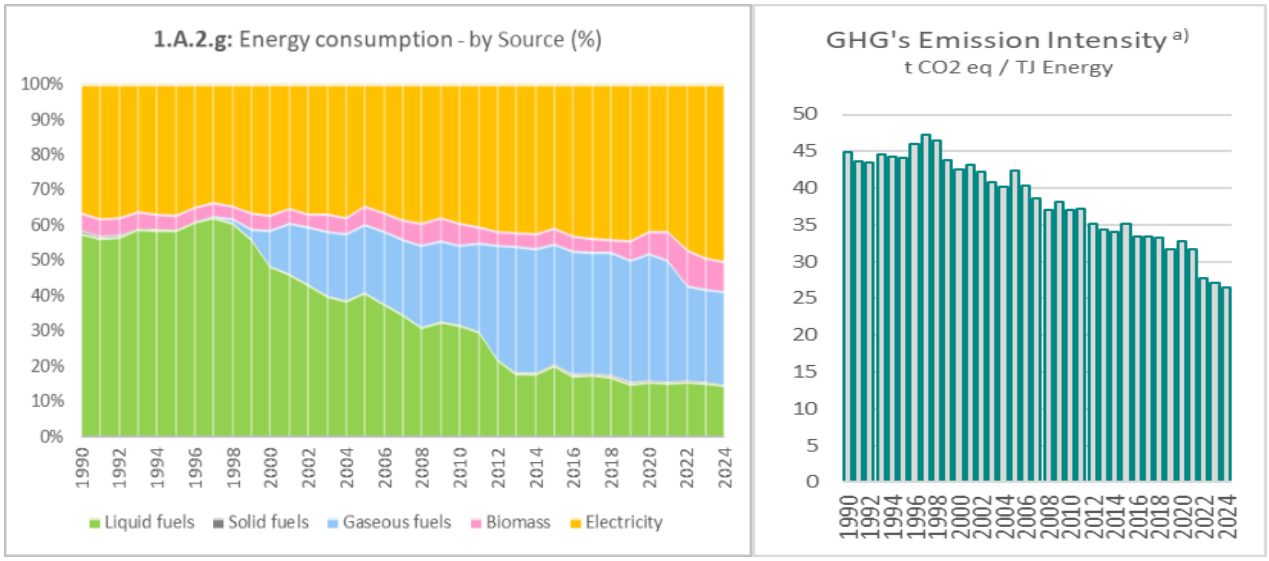



***Figure 3-27 Energy consumption for the 4 main sub-sectors of category 1.A.2.f broken down by fuel type.***

### 3.4.2.3.7 Other Industries

This category comprises several industrial subsectors that are classified as light industry. This allows for greater electrification of energy consumption, with electricity accounting for around 35%-40% of the total energy consumed. Regarding fossil fuels, here it is also possible to identify an option for more "lighter" fuels, with LPG and Gasoil being used more prominently than fuel oil. The introduction of Natural Gas in Portugal in 1997 initiated a transition process for these industrial sectors, thus exchanging petroleum-based fuels for Natural Gas. Currently, only Diesel remains as a prominent fuel to be consumed preferably in the extractive and construction industry.

Regarding the Intensity of GHG Emissions, the sector saw a reduction in intensity when transitioning from oil-based fuels to natural gas with lower carbon content.




a) GHG's Emission Intensity is estimated considering the total emissions of greenhouse gases ($CO_2$, $CH_4$ and $N_2O$) reported in category *1.A.2.g Other Industries* in relation to the total energy consumed (fossil fuels, biomass and electricity). $CO_2$ emissions from biomass as well as GHG's emissions associated with electrical production are not included in the calculation of this parameter, as they are considered in the estimates of other categories of the Inventory.

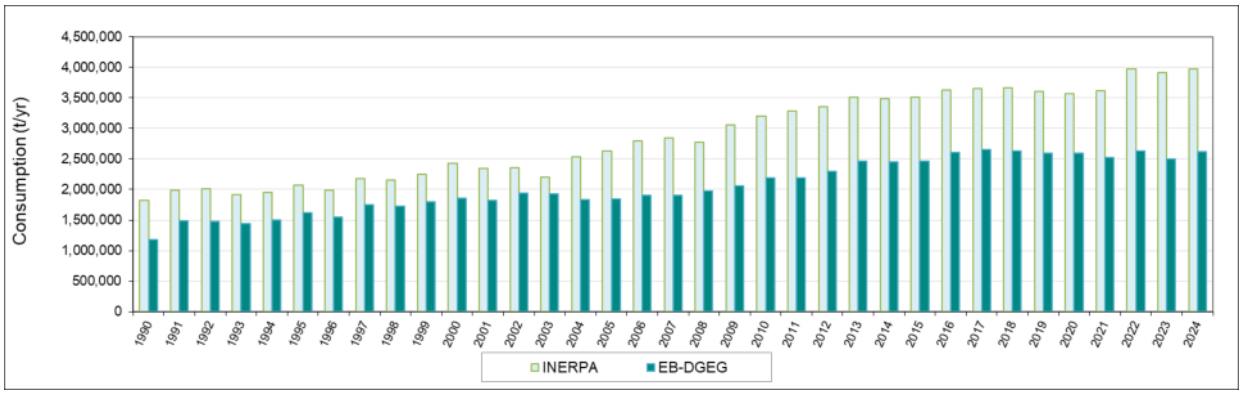
***Figure 3-28: Share of energy consumption by source & Greenhouse gases emissions intensity***

### 3.4.2.4 Comparison of LPS data vs. Energy Balance

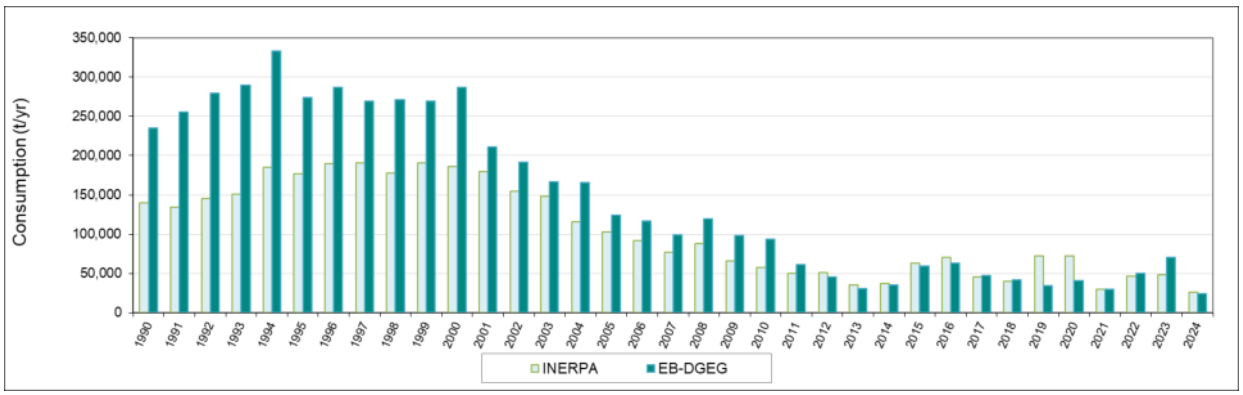
Total consumption in LPS per sector was compared with the correspondent value in the energy balance for the most important fuels, in order to verify the applicability of the methodology in use, which mixes a top-down approach (EB) with a bottom-up approach (LPS data). The following figures present the comparison done for sectors: (1) Paper Pulp; (2) Chemical Manufacturing; (3) Cement Industry and (4) Iron and Steel Plants.

Before hand, it must be realized that to conclude for consistency between both distinct datasets, the comparison should result in higher or equal consumption in the EB than in the inventory, because apart from specific fuels (black liquor in the paper and pulp industry, coke oven gas and blast furnace gas in the iron industry, and coal, coke and tires in the cement industry) the universe considered by the Energy Balance covers more units than the set of LPS (E.g. the paper and paper pulp sector also includes consumption in the manufacturing of paper, for which there are several small units).

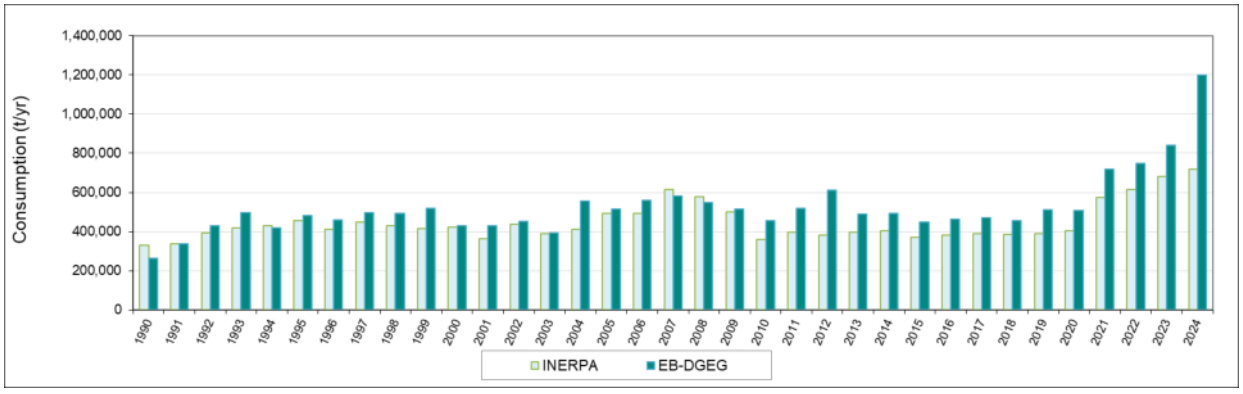
**Black Liquor**




**Residual Fuel Oil**




**Biomass**




**Natural Gas**

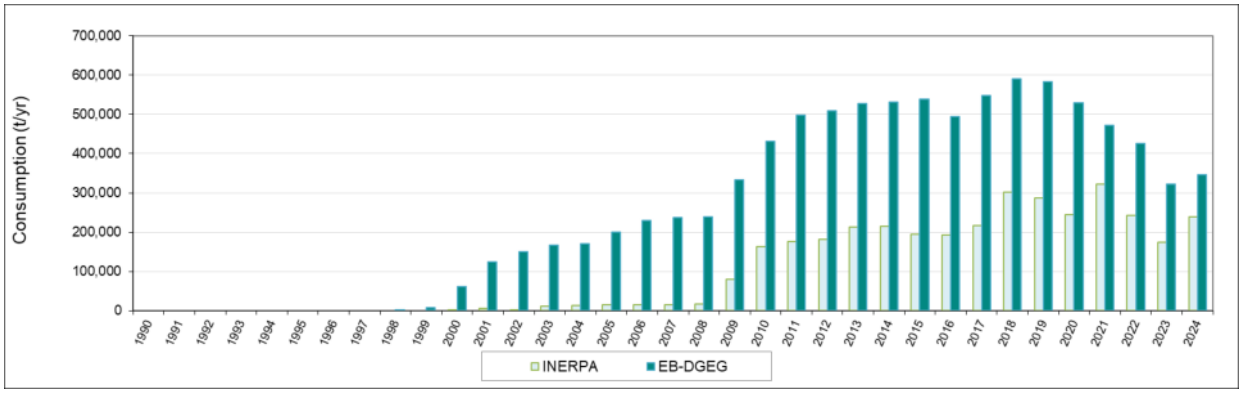


***Figure 3-29: Comparison of total LPS consumption in Paper Pulp units with the reported consumption in the EB for the sector "Paper pulp and paper production"***

The comparison made for the paper and pulp industry shows that differences occur but are not substantial for the major fuels: black liquor and biomass. Part of the differences were analysed before (DGEG,2003) and could be explained by the use of different LHV in the Energy Balance, which occurs commonly for biomass fuels, given the variability in water content. Careful estimations were made not double count the emissions.

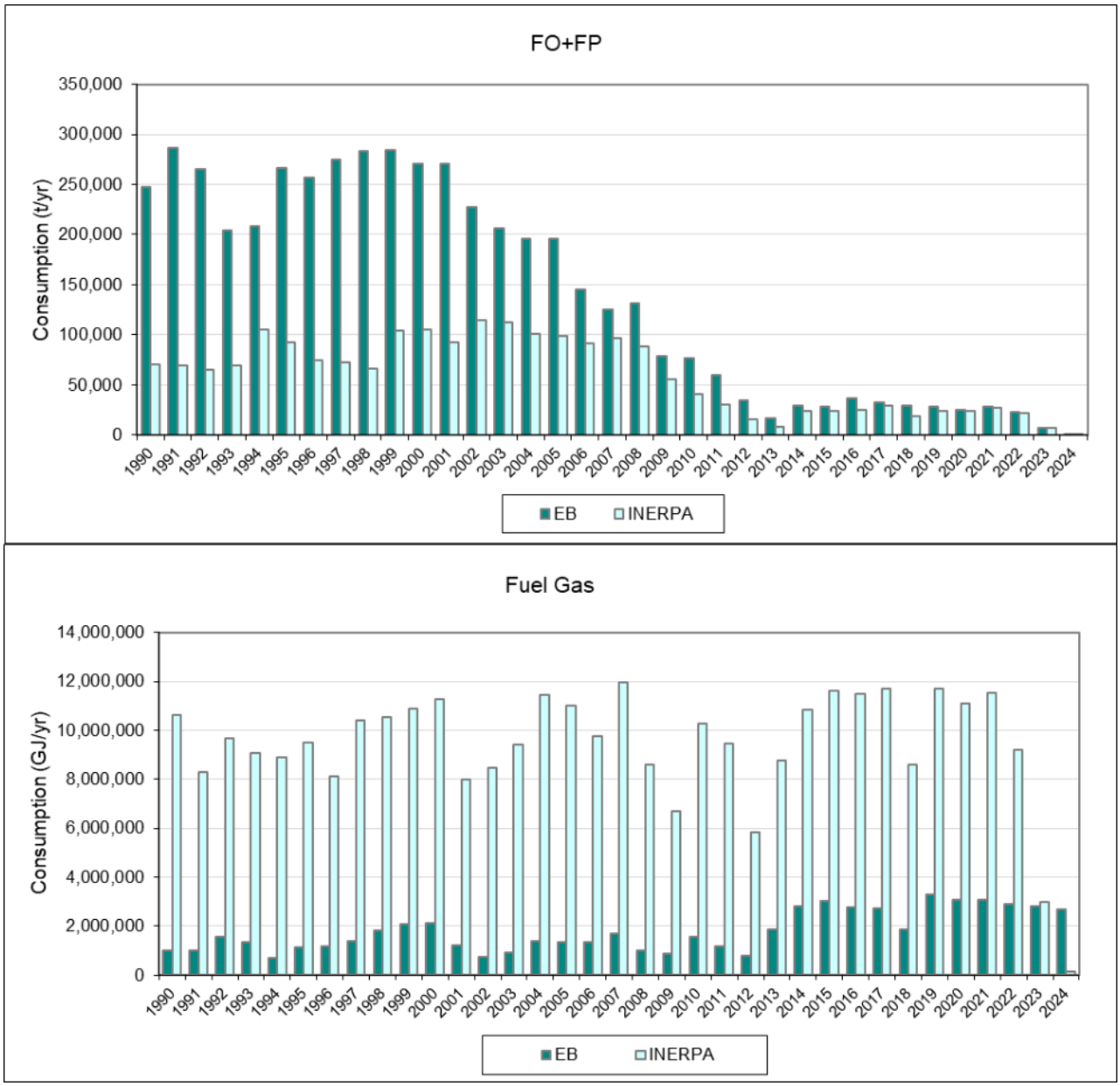



***Figure 3-30: Comparison of total LPS consumption in Petrochemical units with the reported consumption in the EB for the sector "Chemical and Plastics"*** [15].

For the Petrochemical industry the comparison shows that the share of LPS in the consumption of residual fuel oil[16] is about 50 % until 2005. The two values show a tendency to converge in the later years. Also important to note that in 2012 LPS values surpasse energy balance data by 8 %. Consumption of fuel gas as

[15] Units in the vertical axis are not indicated due to confidentiality issues.

[16] This category includes residual fuel oil, a traded fuel, and fuel pyrolisis, a non-traded by product fuel, used inside the industrial unit that produces it.

reported from the LPS data shows much higher values than in the EB. After consultation with DGEG it was realized that the EB does not covers consumption of fuel gas that is not traded or used in co-generation.

The match for the iron and steel industry shows a good consistency, except for intermediate years, and for the slightly higher consumption of Blast Furnace Gas. This last difference may result from the use of different LHV values.

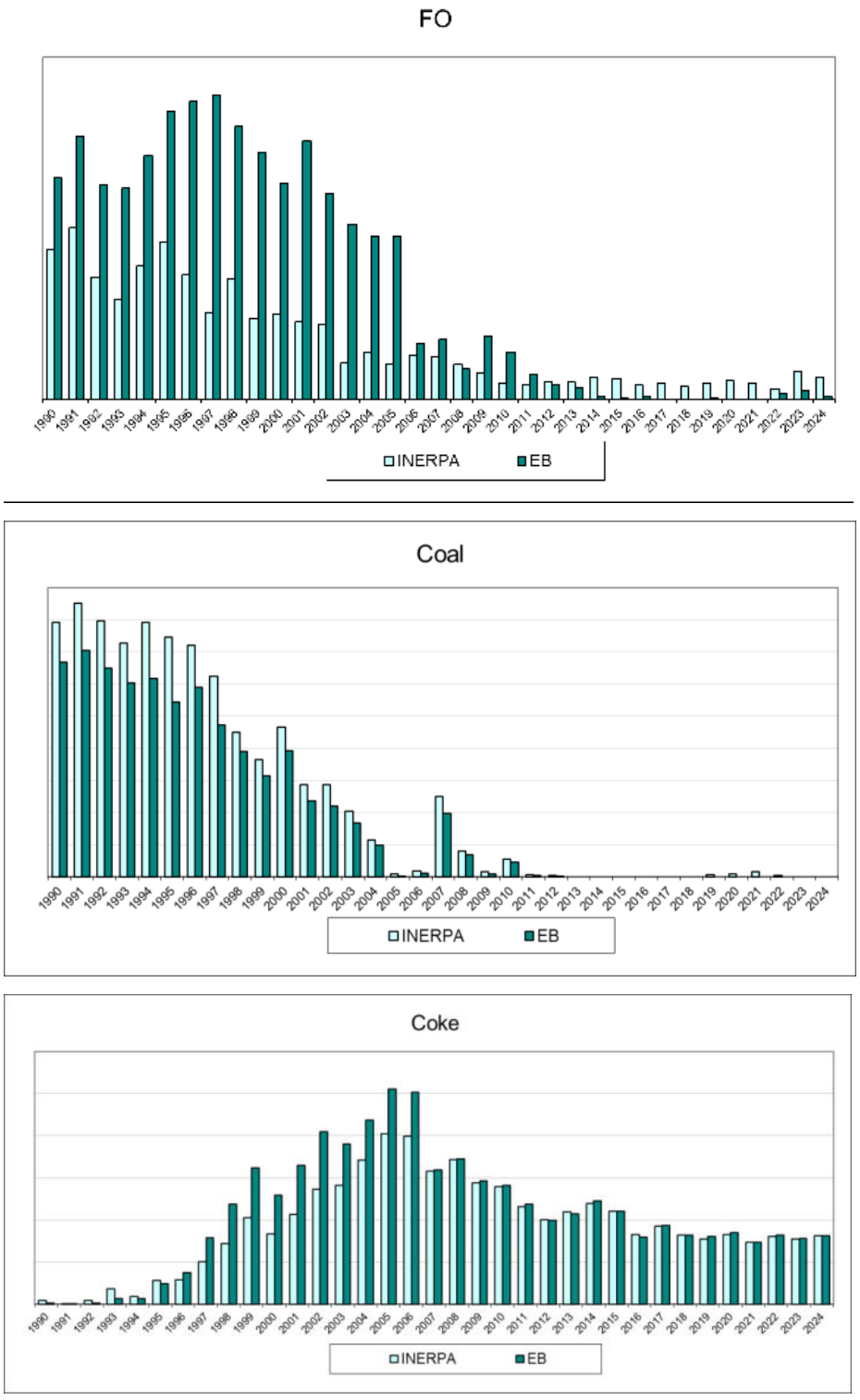



***Figure 3-31: Comparison of total LPS consumption in Cement Plant with the reported consumption in the EB for the sector "Cement and Lime" (Due to confidentiality issue y axis values are not shown)***

Concerning the cement industry, an acceptable coherence exists between both information sources, except for fuel oil consumption which can be explained by the inclusion of lime production in this energy balance category.

In conclusion, the analysis indicates that albeit certain differences, there is an acceptable agreement between both data sets. Nevertheless, efforts should be maintained in order for the streamlining of data between the inventory and the energy balance, and for the inclusion of all fuels, either traded or not, in the energy balance.

#### 3.4.2.5 Production Data

The production activity rates that were used to estimate of air emissions (production approach) are presented in the tables below. Although for some activities, such as cement production, emissions were estimated at plant level with plant specific emission factors this information was considered confidential and may not be published in NID.

Total production of paper pulp is reported in Table 3-24. Production data for Kraft paper pulp was obtained fro the following data sources:

- LCP Directive – 1990 to 2000;
- CELPA – 2003 to 2009 (Kraft paper pulp);
- INE industrial production data – 2003 to 2009 (Acid sulphite paper pulp);
- EU-ETS – 2010 onwards.

Even though different sources were used the ultimate data source was the same: the industrial plants.

***Table 3-24: Total Paper Pulp Production (Kraft and sulphide paper pulp)***

| Product | Unit | 1990 | 2005 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|
| Pulp Production | kt | 1,398 | 2,010 | 2,808 | 2,872 | 2,713 | 2,783 |

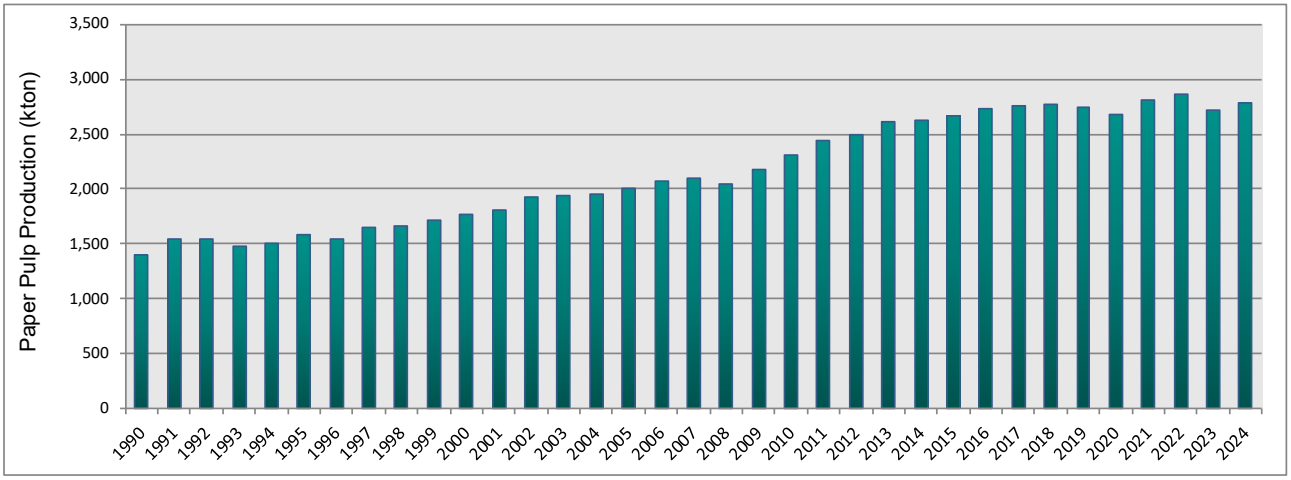



***Figure 3-32: Total paper pulp production: Kraft and sulphide paper pulp***

Clinker production values cannot be reported due to confidentiality issues.

Data on annual manufacturing of ceramic products is available from 1990 to 2024 from INE statistical database. The time series for total production is shown in the following Table and Figure, according to type of ceramic.

***Table 3-25: Ceramic Production according to type of ceramic (kt)***

| Product | Unit | 1990 | 2005 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|
| Bricks & roof tiles | kt | 2,290 | 3,923 | 1,790 | 1,790 | 1,864 | 1,540 |
| Tiles & other const | kt | 478 | 1,327 | 811 | 811 | 811 | 978 |
| Refractory | kt | 31 | 100 | 14 | 14 | 12 | 15 |
| Other ceramic | kt | 104 | 278 | 345 | 345 | 302 | 329 |

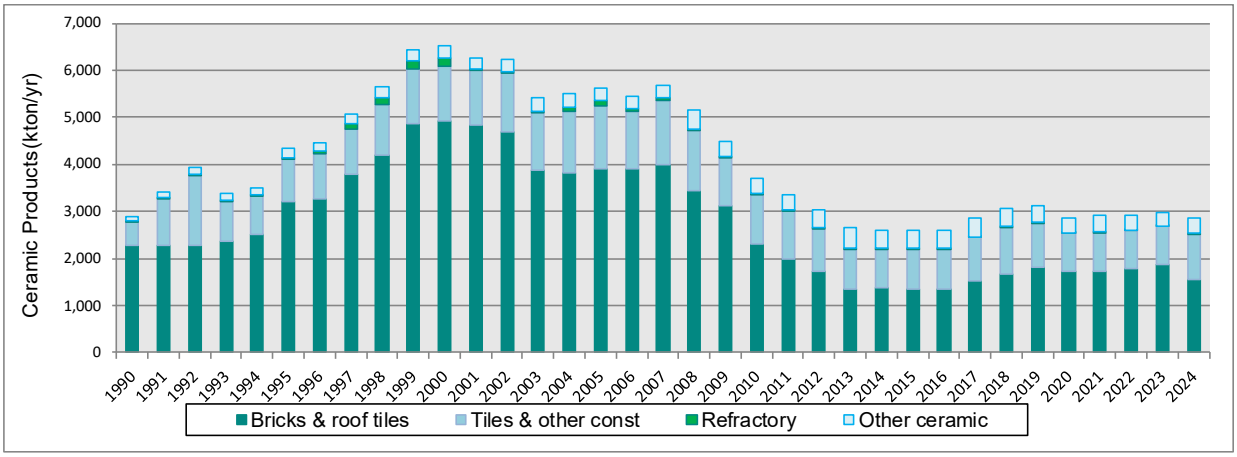



***Figure 3-33: Ceramic Production according to type of ceramic***

The production values for container glass and lead crystal glass are presented in Figure 3-34 and in Table 3-26, and they were established from the INE statistical databases and information received from Technology Centre for Ceramics and Glass (CTCV). More detailed discussion of the origins of data sources should be consulted in chapter 4.2.9. Because of confidentiality concerns the production of flat glass may not be published in NID.

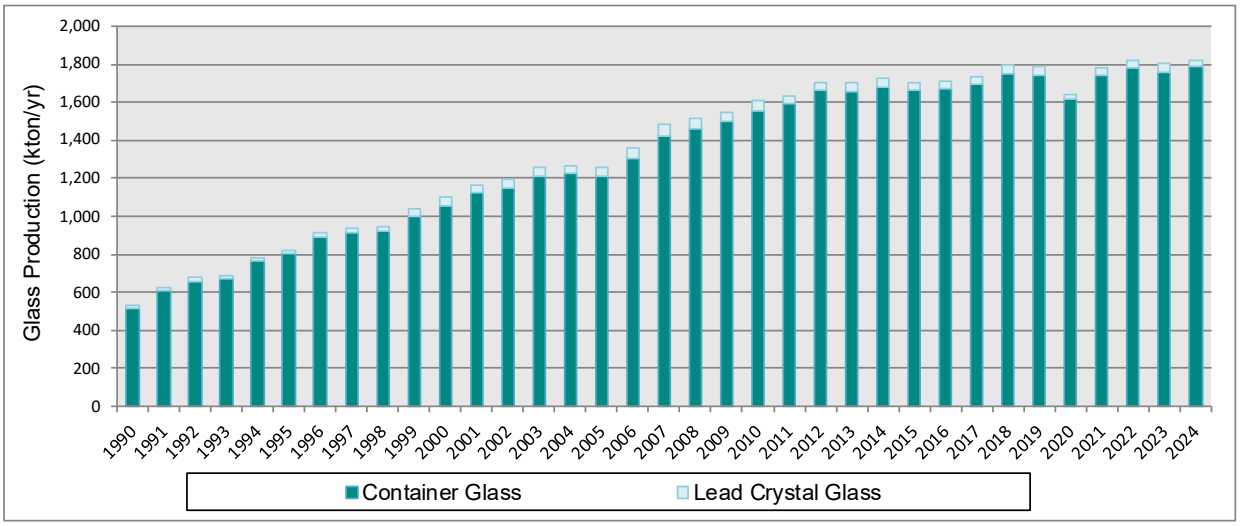



***Figure 3-34: Glass production by glass type (excluding flat glass production)***

*Table 3-26: Glass production by glass type (kt/yr) excluding flat glass production*

| Product | Unit | 1990 | 2005 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|
| Container Glass | kt | 518 | 1,210 | 1,743 | 1,780 | 1,760 | 1,788 |
| Lead Crystal Glass | kt | 16 | 45 | 42 | 44 | 44 | 36 |

Sinter and lime production in iron and steel integrated plan are reported in chapter 2.C.1 – Industrial Processes: Iron and Steel Production.

### 3.4.3 Emission Factors

The emissions factors that were used are dependent, in most cases, on the fuels characteristics and do not vary with the typology of equipments, except in what concerns the division between fuel use in boilers/furnaces and static engines. It is still not possible to differentiate emission factors for boilers and process furnaces. These emission factors are presented in a separate table where relevant.

In the great majority of cases emission factors were taken from international sources:

- 2006 IPCC Guidelines (IPCC, 2006);

The set of following tables present the emission factors that were used as default national emission factors in all cases where no specific emission factors may be used, either because there are no specific methodologies and emission factors available in the bibliography or either because country specific emission factors were not developed from national studies and monitoring data. They are presented in the subsequent tables.

The $CO_2$ emission factors presented in the tables below correspond to values prior multiplication with the corresponding oxidation factor, unless specified otherwise.

*Table 3-27: Default emission factors of Greenhouse gases for combustion equipments in Manufacturing Industry*

| Equipment | Fuel | | Code | $CO_2$ [(i)] (kg/GJ) | Oxidation factor [(i)] (ratio) | % C fossil | $CH_4$ [(i)] (g/GJ) | $N_2O$ [(i)] (g/GJ) |
|---|---|---|---|---|---|---|---|---|
| Boilers | Steam Coal | S | 102 | 98.3 | 1.00 | 100 | 10.0 | 1.5 |
| | Brown Coal/Lignite | S | 105 | 101.0 | 1.00 | 100 | 10.0 | 1.5 |
| | Coke from Coal | S | 107 | 94.6 | 1.00 | 100 | 10.0 | 1.5 |
| | LPG | L | 303 | 63.1 | 1.00 | 100 | 0.9 | 4.0 |
| | City Gas | G | 308 | 44.4 | 1.00 | 100 | 1.0 | 0.1 |
| | Coke Oven Gas | S | 304 | 44.4 | 1.00 | 100 | 1.0 | 0.1 |
| | Blast Furnace Gas | S | 305 | 260.0 | 1.00 | 100 | 1.0 | 0.1 |
| | Fuel Gas, Hydrogen | G | 399 | 63.1 | 1.00 | 100 | 0.9 | 4.0 |
| | Biomass Wood | B | 111 | 112.0 | 1.00 | 0 | 11.0 | 7.0 |
| | Kerosene | L | 206 | 71.9 | 1.00 | 100 | 3.0 | 0.6 |
| | Diesel Oil | L | 204 | 74.1 | 1.00 | 100 | 3.0 | 0.6 |
| | Residual Oil | L | 203 | 77.4 | 1.00 | 100 | 3.0 | 0.6 |
| | Natural Gas | G | 301 | 56.4 [(ii)] | 1.00 | 100 | 1.0 | 1.0 |
| | Biodiesel | B | 223 | 70.8 | 1.00 | 0 | 3.0 | 0.6 |

| Equipment | Fuel | Code | | $CO_2$ [(i)] (kg/GJ) | Oxidation factor [(i)] (ratio) | % C fossil | $CH_4$ [(i)] (g/GJ) | $N_2O$ [(i)] (g/GJ) |
|---|---|---|---|---|---|---|---|---|
| Static Engines | Gasoline | L | 208 | 69.3 | 1.00 | 100 | 3.0 | 0.6 |
| | Gas Oil | L | 204 | 74.1 | 1.00 | 100 | 3.0 | 0.6 |
| | Biogas | B | 309 | 54.6 | 1.00 | 0 | 1.0 | 0.1 |
| | Biodiesel | B | 223 | 70.8 | 1.00 | 0 | 3.0 | 0.6 |

(i) IPCC (2006); (ii) Country Specific

***Table 3-28: Emission factors of Greenhouse gases in the extractive industry***

| Equipment | Fuel | | NAPFUE | $CO_2$ (kg/GJ) | Oxidation factor (ratio) | % C fossil | $CH_4$ (g/GJ) | $N_2O$ (g/GJ) |
|---|---|---|---|---|---|---|---|---|
| Boilers | LPG | L | 303 | 63.1 | 1.00 | 100 | 1.5 | 1.4 |
| | Gasoline | L | 208 | 68.6 | 1.00 | 100 | 0.1 | 0.6 |
| | Kerosene | L | 206 | 71.9 | 1.00 | 100 | 0.6 | 0.6 |
| | Diesel Oil | L | 204 | 74.1 | 1.00 | 100 | 0.6 | 0.6 |
| | Residual Oil | L | 203 | 76.6 | 1.00 | 100 | 1.4 | 0.6 |
| | Natural Gas | G | 301 | 56.4 [(ii)] | 1.00 | 100 | 1.4 | 1.4 |
| | Lignite | S | 105 | 101.2 | 1.00 | 100 | 2.4 | 0.7 |
| Static Engines | Gasoline | L | 208 | 69.3 | 1.00 | 100 | 60 | 0.6 |
| | Gas Oil | L | 204 | 74.1 | 1.00 | 100 | 60 | 0.6 |

(i) IPCC (2006); (ii) Country Specific

***Table 3-29: Emission factors for Greenhouse gases in the building and construction industry***

| Fuel | | NAPFUE | $CO_2$ | | | $CH_4$ | $N_2O$ |
|---|---|---|---|---|---|---|---|
| | | | kg/GJ | Oxidation Factor | % C fossil | g/GJ | g/GJ |
| Residual Oil | L | 203 | 77.4 | 1.00 | 100 | 3.0 | 0.6 |
| Gas Oil | L | 204 | 74.1 | 1.00 | 100 | 3.0 | 0.6 |
| Kerosene | L | 206 | 71.9 | 1.00 | 100 | 5.0 | 0.6 |
| Motor Gasoline | L | 208 | 69.3 | 1.00 | 100 | 9.9 | 0.6 |
| LPG | L | 303 | 63.1 | 1.00 | 100 | 1.0 | 0.1 |
| Natural Gas | G | 301 | 56.4 [(ii)] | 1.00 | 100 | 1.0 | 0.1 |

(i) IPCC (2006); (ii) Country Specific

Other specific emission factors were used for some industrial units, several of them obtained from direct measurements in LPS or as a result from bibliographic references specific of the industrial sector. Some of the emission factors are used in the process approach and are applied to production data instead of fuel consumption data. These emission factors are listed in the tables below, arranged by sector and indicating if they only apply to LPS.

***Table 3-30: Emission factors for use in LPS units in the iron and steel sector***

| GHG | Fuel | | | | | | | Unit |
|---|---|---|---|---|---|---|---|---|
| | Fuel Oil | Coke Oven Gas | Blast Furnace Gas | Coal Tar | Natural Gas | LPG | Diesel | |
| $CO_2$ | 77.40 | 44.4 | 260 | 80.7 | 55.56 – 57.43 (1) | 63.1 | 74.1 | kg/GJ |
| $CH_4$ | 3.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 3.00 | g/GJ |
| $N_2O$ | 0.6 | 0.1 | 0.1 | 1.5 | 0.1 | 0.1 | 0.6 | g/GJ |

Source: Table 2.2 of Chapter 2 of the 2006 IPCC Guidelines

(1) Country specific; EU-ETS

***Table 3-31: Emission factors for use in LPS units in the Chemical Industry: Greenhouse Gases from combustion***

| Equipment | Fuel | | NAPFUE | $CO_2$ (kg/GJ) (i) | Oxidation Factor (ratio) | % C fossil | $CH_4$ (g/GJ) | $N_2O$ (g/GJ) |
|---|---|---|---|---|---|---|---|---|
| Boilers | Residual Fuel Oil | L | 203 | 77.4 | 1.00 | 100 | 3 | 0.6 |
| | Pyrolysis Fuel Oil | L | 203 | 77.4 | 1.00 | 100 | 3 | 0.6 |
| | Fuel Gas | L | 307 | 47.6 – 50.7 | 1.00 | 100 | 1.0 | 0.1 |
| Furnaces | Fuel Gas | L | 307 | 47.6 – 50.7 | 1.00 | 100 | 1.0 | 0.1 |
| | Propane | L | 303 | 63.1 | 1.00 | 100 | 1.5 | 1.4 |
| Static Engines | Residual Fuel Oil | L | 203 | 77.4 | 1.00 | 100 | 3 | 0.6 |
| | Diesel Oil | L | 204 | 74.1 | 1.00 | 100 | 3 | 0.6 |
| Flares | Flare Gas | L | 307 | 55.0 – 74.4 | 1.00 | 100 | 1.0 | 0.1 |

(i) 2006 IPCC Guidelines

In the 2012 inventory, for the paper and pulp industrial sector, efforts were made to improve the emission estimation by reviewing and update emission factors when possible. To this end new EF data sources were used (EEA, 2009) as well as an in depth revision of the plant specific emission factors for non-direct GHG. The EF used for this industrial sector (LPS estimation only) can be found in the tables below.

***Table 3-32: Emission factors used in LPS units in the Paper Pulp Industry: Greenhouse Gases from combustion – Energy Approach***

| Equipment | Fuel | NAPFUE | | $CO_2$(i) | | $CH_4$ | $N_2O$ |
|---|---|---|---|---|---|---|---|
| | | | | EF (kg/GJ) | %C fossil | EF (g/GJ) | EF (g/GJ) |
| Auxiliary Boilers | Residual Oil | L | 203 | 77.4 | 100 | 3.0 | 0.6 |
| | Natural Gas | G | 301 | 56.4 (ii) | 100 | 1.4 | 1.4 |
| Biomass Boilers | Wood Waste | B | 111 | 112.0 | 0 | 30.0 | 4.3 |
| | Residual Oil | L | 203 | 77.4 | 100 | 3.0 | 0.6 |
| | Natural Gas | G | 301 | 56.4 (ii) | 100 | 1.4 | 1.4 |
| | LPG | L | 303 | 63.1 | 100 | 1.4 | 1.4 |
| Recovery Boilers | Residual Oil | L | 203 | 77.4 | 100 | 3.0 | 0.6 |
| | Natural Gas | G | 301 | 56.4 (ii) | 100 | - | 1.4 |
| | Gas Oil | L | 204 | 74.1 | 100 | - | 0.6 |
| | Bisulfite Liquor | B | 215 | 95.3 | 0 | 30.0 | 0.6 |
| | Black Liquor | B | 215 | 95.3 | 0 | - | 0.6 |

| Equipment | Fuel | NAPFUE | | $CO_2$[(i)] | | $CH_4$ | $N_2O$ |
|---|---|---|---|---|---|---|---|
| | | | | EF (kg/GJ) | %C fossil | EF (g/GJ) | EF (g/GJ) |
| | Methanol | B | 111 | 63.1 | 0 | - | 1.4 |
| Flare | LPG | L | 303 | 63.1 | 100 | 1.4 | 1.4 |
| Lime Kiln | Gasified Biomass | B | 111 | 112.0 | 0 | - | 4.3 |
| | Residual Oil | L | 203 | 77.4 | 100 | - | 0.6 |
| | Natural Gas | G | 301 | 56.4 [(ii)] | 100 | - | 1.4 |
| | Gas Oil | L | 204 | 74.1 | 100 | - | 0.6 |
| | NCG | B | 111 | 56.4 [(ii)] | 0 | - | 1.4 |
| | Tall-oil | B | 111 | 74.1 | 0 | - | 0.6 |
| Static Engine | Gas Oil | L | 204 | 74.1 | 100 | 9.9 | 0.6 |
| Gas Turbine | Natural Gas | G | 301 | 56.4 [(ii)] | 100 | 1.4 | 1.4 |

(i)The $CO_2$ emission factors presented in this table include the corresponding oxidation factor; (ii) Country Specific; NCG- Non-condensable gases

***Table 3-33: Emission factors used in LPS units in the Paper Pulp Industry: Greenhouse Gases from combustion – Production Approach***

| Equipment | $CH_4$[(i)] |
|---|---|
| | EF (kg/t pulp) |
| Recovery Boilers | 0.23 |
| Lime Kiln | 0.029 |

(i)Source EEA, 2002.

For the cement source, sector emissions were estimated using either activity data as energy consumption (energy approach) or either cement produced (production approach), although both represent similar emissions in cement kiln. Emission factors will not be presented in this report because of confidentiality issues (please see Activity Date chapter for more explanations). Most emission factors result from plant specific emission factors developed from monitoring at each installation, as reported to EPER exercise.

***Table 3-34: Greenhouse Gases Emission Factors for ceramic production using the Production Approach: Greenhouse gases***

| Ceramic | $CO_2$ [(b)] (kg/t) | $CH_4$ [(a)] (kg/t) |
|---|---|---|
| Bricks and roof tiles | 0.14 | 0.029 |
| Tiles & other construction materials | 18.57 | 0.022 |
| Refractory | - | 0.029 |
| Other ceramic | - | 0.022 |

Source: (a) 10 % of VOC emissions; (b) EU-ETS

***Table 3-35: Emission Factors for glass production using the Production Approach: $SO_x$ and Indirect Precursor gases (kg/t glass)***

| Type of Glass | $SO_x$ | $NO_x$ | NMVOC | CO |
|---|---|---|---|---|
| Flat Glass | 1.5 | 4 | 0.1 | 0.1 |
| Container Glass | 1.7 | 3.1 | 4.5 | 0.1 |
| Lead Crystal Glass | 2.8 | 4.3 | 4.7 | 0.1 |
| Other Glass | 2.8 | 4.3 | 4.7 | 0.1 |

Source: USEPA (1986)

***Table 3-36: Emission Factors for glass production using the Production Approach: Greenhouse Gases***

| Type of Glass | $CO_2$ kg/t | $CH_4$ kg/t |
|---|---|---|
| Flat Glass | 126 | 0.01 |
| Container Glass | 130 | 0.45 |
| Lead Crystal Glass | 239 | 0.47 |
| Other Glass | 239 | 0.47 |

Source: $CH_4$ USEPA (1986); $CO_2$ EUTS data

Emission factors for sinter and lime production in iron and steel integrated plan are reported in chapter 4.4.2 of Industrial Processes sector: Iron and Steel Production.

***Table 3-37: Greenhouse Gases Emission Factors for Cement Industry using the Energy Approach***

| Cement Industry | $CO_2$ (kg/GJ) | %C Fossil |
|---|---|---|
| Tires | 85.0 | 72 % |
| Industrial Waste | 81.4 | 52 % |
| Hazardous Industrial Waste | 66.2 – 149.0 | 100 % |
| Animal + Wood Waste | 109.6 | 0% |

***Table 3-38: Greenhouse Gases Emission Factors for Off-road vehicles and other machinery***

| Cement Industry | $CO_2$ (kg/GJ) | $CH_4$ (kg/TJ) | $N_2O$ (kg/TJ) | Source |
|---|---|---|---|---|
| Motor Diesel | 74.1 | 4.2 | 28.6 | Table 3.3.1 – 2006 IPPC GL – Vol.2 Mobile Combustion |
| Motor Gasoline 4-stroke | 69.3 | 50.0 | 2.0 | Table 3.3.1 – 2006 IPPC GL – Vol.2 Mobile Combustion |
| Motor Gasoline 2-stroke | 69.3 | 130 | 0.4 | Table 3.3.1 – 2006 IPPC GL – Vol.2 Mobile Combustion |

### 3.4.4 Uncertainty Assessment

Different uncertainty values were attributed to different types of sub-sources considering that different sources of information have diverse error and also assuming that industries for which energy consumption is a more important factor (Energy intensive industries) tend to have and report more accurate data. Consequently, in concordance to what is proposed in IPCC (2000) but always assuming a conservative posture, the following rules were used to establish the uncertainty associated with activity data:

- when fuel consumption was obtained directly from a Large Point Source (LPS) the uncertainty of activity data was set at 3 % for energy intensive industrial sectors (iron and steel, cement, paper pulp, glass and ceramics) and 5 % for all other sources;
- if fuel consumption, other than biomass, results from statistical information gathered from the National Energy balances then uncertainty is 5 % for energy intensive sectors and 10 % for all other sectors;
- the uncertainty in biomass consumption is always higher, at least because the moisture content is always doubtful, and the uncertainty was set in all area sources as 60 %.

The uncertainty of $CO_2$ emission factors is 5 % for all situations, which is consistent with GPG recommendations. Finally the uncertainty for methane is 150 % and an order of magnitude for $N_2O$.

### 3.4.5 Category-specific QA/QC and verification

Similar to 1.A.1.a, the majority of the QA/QC procedures were implemented to check consistency between years for the fuel consumption time series of all industrial sectors. Since LHV for several industries show variability between years, a general consistency check was also made.

For industrial sectors where fuel consumption data for individualized plants was available: Paper Pulp, Chemical Manufacturing, Cement Industry and Iron and Steel Plants, a comparison between plant specific data and energy balance fuel consumption was made (see the appropriate chapter for more information).

To further improve the QA/QC analysis, a comparison between fuel consumption values reported by DGEG and IEA (International Energy Agency) was made (please see the chapter Comparison of Energy Balance vs. IEA Energy Statistics). Several differences were identified between data sources for this sector, which may imply problems in the fuel consumption classification for IEA values. Also DGEG reported that there were compilation errors in the information sent to IEA, which may explain the differences found.

### 3.4.6 Recalculations

In the 2026 submission, main recalculations related to GHG emissions in category 1.A.2 resulted from:

- the revision of fuel consumption data following the publication of an updated National Energy Balance for 2023;
- the revision of 2023 biodiesel incorporation rate;
- the correction of an outlier in ceramics production in 2021-2023 provided by the National Statistics Office.

### 3.4.7 Further Improvements

For the Manufacturing industries and construction category, the main issues to be improved are:

- Make efforts to develop TIER 2 $CO_2$ emission factors for liquid fuels, since it is a key category of the Inventory. This is a cross-cutting problem for all categories of the Energy Chapter and is identified as one of the main priorities in the Methodological Development Plan.
- Increase the amount of information that is collected from the premises, using EU-ETS data preferably, but also through E-PRTR information and other sectoral sources. In particular for the Food, beverages & tobacco (1.A.2.e) and Other Industries (1.A.2.g) subsectors.
- Further investigate the sharp decrese in energy consumption of biomass that occurs between 2011 and 2012, with a particular impact on the ceramic industry.
- Continue to develop the estimates for category 1.A.2.g.vii Off-road vehicles and other machinery. We intend to continue to identify and correctly allocate energy consumption that occurs in the Industry and that originates from mobile sources.
- The updating and improvement of the explanation of the methodology and clarifications present in this chapter of the NID was identified as a task that allows the improvement of the inventory report. However, it is a time-consuming task that we believe will be accomplished through a stepwise approach. It is then expected that the next NID submissions will contain some changes in content and structure.

## 3.5 Transport (CRT 1.A.3)

*Mónica Borges*

*Updated: March 2025*

**DISCLAIMER***:*

For the 2026 submission, the chapters 3.4.1 (CRT 1.A.3.a), 3.4.2 (CRT 1.A.3.b) and 3.4.4 (CRT 1.A.3.d) have not been fully updated and therefore the detailed information remains as reported in the previous submission (2023 submission).

The 2024 emissions reported in the 2026 submitted CRT tables were estimated using a proxy approach based on the variation in fuel consumption between 2023 and 2024, as presented in Energy Balances. This approach was applied to ensure the timely reporting of emissions for the transport sector.

Consequently, the update carried out in this submission was limited to the emission estimates. The detailed information in this chapter will be updated in a future submission. During this process, a compilation error concerning the 2021 fuel consumption for an airport was identified and has been corrected in CRT 1.A.3.a.

### 3.5.1 Civil Aviation (CRT 1.A.3.a)

#### 3.5.1.1 Category description

In 2023 emissions from Civil Aviation in Portugal amounted to 5 327 kt $CO_2$ eq, from which 515 kt $CO_2$ eq are from domestic flights and 4 812 kt $CO_2$ eq are from international flights. Emissions from aviation come from the combustion of jet fuel and aviation gasoline. Emissions from combustion in aircraft mobile activities comprehend all air emissions associated with fuel combustion in airplanes, either realized in passenger or freight planes, and either realized during flight or in land activities: idle and taxi. Aircraft operations are divided into:

- Landing/Take-off cycle and;
- Cruise.

Emissions from military aircraft are included in sector 1.A.5.b Other Mobile Sources.

***Table 3-39: Estimated emissions from Civil Aviation (kt $CO_2$ eq).***

| Source Category/Pollutant | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|
| **Domestic Aviation** | **180.23** | **221.19** | **322.96** | **392.78** | **404.60** | **369.06** | **259.49** | **480.83** | **515.11** |
| $CO_2$ | 177.82 | 218.41 | 319.75 | 389.14 | 401.08 | 365.96 | 257.30 | 476.78 | 510.75 |
| $CH_4$ | 1.10 | 1.16 | 0.84 | 0.75 | 0.54 | 0.39 | 0.28 | 0.51 | 0.57 |
| $N_2O$ | 1.32 | 1.62 | 2.37 | 2.88 | 2.97 | 2.71 | 1.91 | 3.53 | 3.79 |
| **International Aviation*** | **1 547.57** | **1 646.19** | **2 019.87** | **2 298.55** | **2 658.75** | **3 166.80** | **1 581.62** | **4 138.13** | **4 812.21** |
| $CO_2$ | 1 532.67 | 1 630.47 | 2 002.31 | 2 279.59 | 2 637.08 | 3 141.39 | 1 568.89 | 4 104.99 | 4 773.60 |
| $CH_4$ | 3.54 | 3.63 | 2.72 | 2.06 | 2.12 | 2.13 | 1.10 | 2.72 | 3.23 |
| $N_2O$ | 11.36 | 12.09 | 14.84 | 16.90 | 19.55 | 23.29 | 11.63 | 30.43 | 35.39 |

*Memo item. Emissions not included in national totals.

For the elaboration of the greenhouse gases emissions inventory which is reported to the EU[17] and to the UNFCCC, emissions from flights to and from the autonomous regions of Azores and Madeira islands are included in national totals.

Emissions of domestic and international flights must be reported separately to UNFCCC. In order to strictly follow UNFCCC good practice, the separation is done according to the following table.

***Table 3-40: IPCC 2006 source categories.***

| Source Category | Coverage |
|---|---|
| 1 A 3 a Domestic Aviation | Emissions from civil domestic passenger and freight traffic that departs and arrives in the same country (commercial, private, agriculture, etc.), including take-offs and landings for these flight stages. |
| 1 D 1 International Aviation (International Bunkers) | Emissions from flights that depart in one country and arrive in a different country. Include take-offs and landings for these flight stages. |
| 1 A 5 b Mobile (aviation component) | Emissions from military aviation. |

### 3.5.1.2 Methodology

The methodology that is used in the inventory to estimate emissions from jet fuel is a Tier 3 according with 2019 EMEP/EEA Guidebook (see figure below). This method uses data from individual flights with information on the origin and destination, aircraft type, engines type, and date of the flight. This method provides a good accurate separation between domestic and international flights.

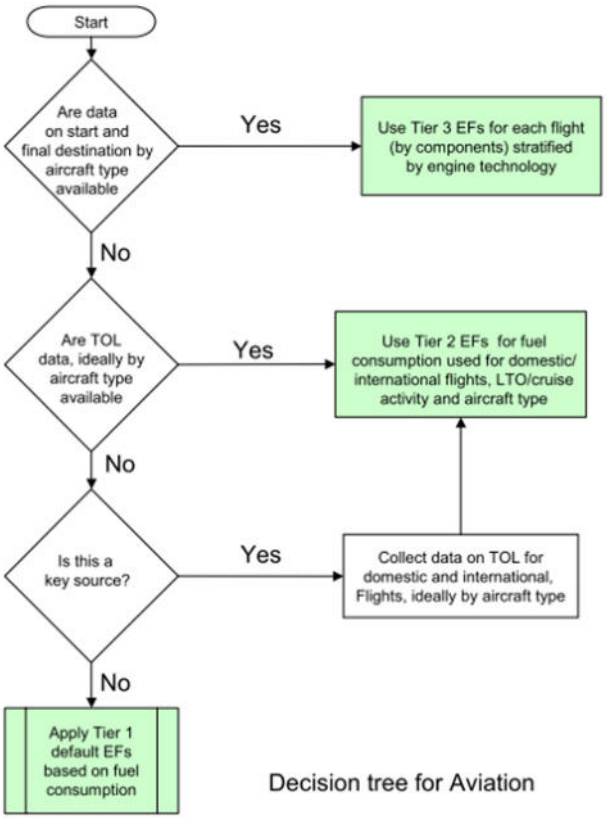



***Figure 3-35: Decision tree for emissions from aviation (EMEP/EEA, 2019)***

[17] Decision 2004/280/CE

The method to estimate emissions from aviation gasoline is a Tier 1 according with IPCC 2006 which is based primarily in energy statistics.

The choice of methods allows the harmonization between inventories covering greenhouse gas emissions and inventories covering other air pollutants.

Emissions are calculated separately for:

- Landing and Take-off Cycle emissions ($LTO_{Cycle}$). Emissions from activities realized near airport in the ground and on flight under an altitude of 3000 feet (914 m): idle, taxi-in, taxi-out, take-off, climbing and descending;
- Cruise emissions. All emissions realized above 3000 feet, including ascend and descend between cruise altitude and 3000 feet;
- Fuel type: jet fuel and aviation gasoline. Jet fuel is used mostly in large commercial aircraft. Aviation gasoline is used in piston engine aircrafts;
- Origin and destination of the flight;
- Movement type: arrival and departure;
- Aircraft type.

#### 3.5.1.2.1 Landing/Take-off Cycle

The general approach to estimate emissions during $LTO_{Cycle}$ is:

$$Emission_{LTO(p,d,a,s,y)} = Emission_{Arrival(p,d,a,s,y)} + Emission_{Departure(p,d,a,s,y)}$$
$$Emission_{Arrival(p,d,a,s,y)} = N_{Arrival(d,a,s,y)} \times EF_{Arrival(p,s)} \times 10^{-3}$$
$$Emission_{Departure(p,d,a,s,y)} = N_{Departure(d,a,s,y)} \times EF_{Departure(p,s)} \times 10^{-3}$$

**Where:**

$Emission_{LTO\ (p,d,a,s,y)}$ – Emissions of pollutant p from origin/destiny d in airport a performed by aircraft s during year y (t/yr);

$Emission_{Arrival(p,d,a,s,y)}$, $Emission_{Departure(p,d,a,s,y)}$ – Arrival and departure emissions of pollutant p from, respectively, origin and destiny d in airport a performed by aircraft s during year y (t/yr);

$N_{arrival}$, $N_{departure}$ – Number of arrival and departure movements performed in year y, by aircraft s in airport a from origin/destiny d;

$EF_{Arrival(p,s)}$ – Sum of approach and taxi-in emission factor for pollutant p and aircraft s (kg/movement);

$EF_{Departure(p,s)}$ – Sum of taxi-out, take-off and climb emission factor for pollutant p and aircraft s (kg/movement);

p – pollutant;

d – origin/destination;

a – airport;

s – aircraft;

y – year.

However, the aircraft type is not always available. For these cases the approach is based on an airport specific emission factor as follows:

$$Emission_{LTO(p,d,a,y)} = Emission_{Arrival(p,d,s,y)} + Emission_{Departure(p,d,a,y)}$$
$$Emission_{Arrival(p,d,a,y)} = N_{Arrival(d,a,y)} \times EF_{Arrival(p,a)} \times 10^{-3}$$
$$Emission_{Departure(p,d,a,y)} = N_{Departure(d,a,y)} \times EF_{Departure(p,a)} \times 10^{-3}$$

The next figure outlines the process whereby $LTO_{Cycle}$ emissions are estimated.

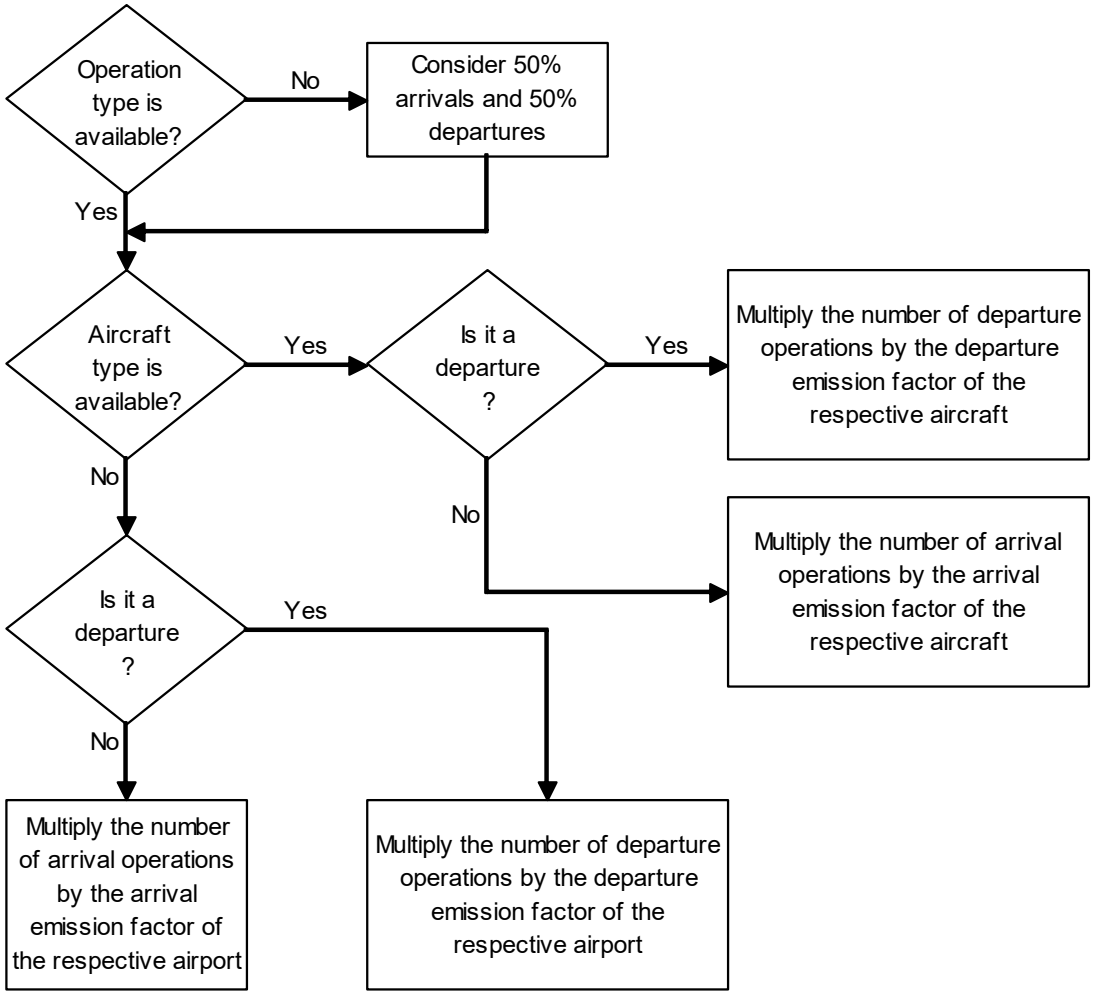



***Figure 3-36: Decision tree for LTOCycle emission calculation.***

#### 3.5.1.2.2 Cruise

Domestic cruise emissions are estimated based on aircraft movement data. The approach relies on a origin and destination matrix. The distances between airports are calculated from an airport coordinates database (Partow, 2003) applied to a great circle distance algorithm (GCD) assuming the Earth as a perfect sphere. Emission factors are given for each aircraft type and for a specific flight distance. International cruise emissions are estimated from fuel consumption. The international fuel consumption is estimated by subtracting the $LTO_{Cycle}$ and the domestic cruise fuel from the total fuel sales.

$$Emission_{cruise(p,d,a,s,y)} = N_{LTO(d,a,s,y)} \times EF_{cruise(p,d,s,t,y)} \times 10^{-3}$$

**Where:**

Emissioncruise(p,d,a,s,y) – Domestic cruise emissions of pollutant p resulting from flight with origin/destiny d in airport a performed by aircraft s during year y (t/yr);

NLTO(d,a,s,y) – number domestic $LTO_{Cycle}$ from origin/destiny d in airport a performed by aircraft type s during year y;

EFcruise(p,d,a,s,t,y) – Emission factor for pollutant p specific for flight with origin/destination d taking time t performed by aircraft type s in year y (kg/LTO).

In national airports the same national flight is registered in origin airport as a departure and in destiny airport as an arrival therefore the number of national movements must be divided by two to avoid double counting.

### 3.5.1.3 Emission Factors

#### 3.5.1.3.1 LTO

##### 3.5.1.3.1.1 Aircraft Based LTO Emission Factors

Emissions factors for LTO were set for each aircraft type according to information from ICAO Emission Factor Databank which contains emission factors for each operation condition: idle, take off, climb out and approach conditions. Emissions factors for arrival and departure were than set from the default time in mode proposed by FAEED table and from the emission factor for each operation condition where:

Departure includes taxi-out (idle), take off and climb out modes;

Arrival includes approach and taxi in (idle) conditions.

***Table 3-41: Emissions factors for most common aircraft movements in national airports.***

| Aircraft | Take-off (kg/movement) | | | | | Land (kg/movement) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | FC | HC | CO | $NO_x$ | PM | FC | HC | CO | $NO_x$ | PM |
| Airbus A318/319/320/321 | 674.7 | 1.8 | 15.6 | 26.5 | 6.3 | 273.0 | 0.7 | 6.1 | 4.7 | 3.0 |
| Airbus A320-100/200 | 674.7 | 1.8 | 15.6 | 26.5 | 6.3 | 273.0 | 0.7 | 6.1 | 4.7 | 3.0 |
| Airbus A319 | 546.4 | 0.8 | 8.7 | 15.1 | 5.1 | 224.6 | 0.3 | 3.7 | 2.9 | 2.4 |
| British Aerospace ATP | 813.2 | 1.4 | 15.5 | 27.3 | 7.6 | 354.5 | 0.6 | 6.6 | 5.7 | 3.9 |
| Boeing 737 all pax models | 685.2 | 4.4 | 16.3 | 13.4 | 6.3 | 287.4 | 1.9 | 7.8 | 2.9 | 3.1 |
| Fokker 100 | 481.0 | 1.9 | 12.4 | 9.5 | 4.4 | 202.8 | 0.8 | 5.3 | 1.7 | 2.1 |
| Shorts SD.360 | 63.9 | 8.7 | 10.0 | 0.5 | 0.6 | 34.1 | 4.0 | 4.9 | 0.2 | 0.4 |
| Embraer RJ135 / RJ140 / RJ145 | 232.5 | 0.8 | 5.3 | 4.9 | 2.2 | 105.2 | 0.4 | 2.4 | 1.2 | 1.1 |
| Airbus A321-100/200 | 674.7 | 1.8 | 15.6 | 26.5 | 6.3 | 273.0 | 0.7 | 6.1 | 4.7 | 3.0 |
| Embraer RJ145 Amazon | 232.5 | 0.8 | 5.3 | 4.9 | 2.2 | 105.2 | 0.4 | 2.4 | 1.2 | 1.1 |
| Boeing 757 all pax models | 804.2 | 1.4 | 15.5 | 27.3 | 7.5 | 328.7 | 0.6 | 6.5 | 5.2 | 3.6 |
| Boeing 737-800 (winglets) pax | 581.4 | 1.3 | 11.3 | 16.7 | 5.4 | 243.2 | 0.5 | 4.7 | 3.9 | 2.6 |
| Airbus A310-200 Freighter | 996.1 | 4.7 | 20.7 | 37.3 | 9.4 | 421.2 | 1.9 | 8.9 | 6.9 | 4.7 |
| Airbus A310 all pax models | 1136.9 | 1.3 | 9.0 | 50.1 | 10.5 | 499.0 | 0.5 | 3.8 | 8.0 | 5.4 |
| Cessna 172 Mescalero | 2.5 | 0.1 | 2.2 | 0.0 | 0.0 | 1.4 | 0.0 | 1.5 | 0.0 | 0.0 |
| Boeing 757 Mixed Configuration | 804.2 | 1.4 | 15.5 | 27.3 | 7.5 | 328.7 | 0.6 | 6.5 | 5.2 | 3.6 |
| Fairchild Dornier Do.228 | 111.3 | 5.4 | 14.7 | 2.3 | 1.0 | 54.2 | 2.4 | 7.7 | 0.6 | 0.6 |
| Boeing 737-300 Freighter | 548.5 | 1.2 | 18.4 | 11.3 | 5.1 | 235.0 | 0.5 | 7.6 | 3.1 | 2.5 |
| McDonnell Douglas MD80 | 656.6 | 2.7 | 9.3 | 16.5 | 6.1 | 281.9 | 1.5 | 4.6 | 3.8 | 3.0 |
| Beechcraft 1900/1900C/1900D | 131.6 | 16.2 | 16.2 | 1.5 | 1.2 | 60.5 | 6.8 | 8.7 | 0.4 | 0.6 |
| Boeing 737-700 (winglets) pax | 505.6 | 1.5 | 12.1 | 12.1 | 4.7 | 215.5 | 0.5 | 5.2 | 3.2 | 2.3 |
| CASA / IPTN 212 Aviocar | 378.0 | 4.2 | 14.2 | 11.0 | 3.5 | 171.1 | 1.9 | 7.0 | 2.3 | 1.9 |
| Boeing 737-500 pax | 548.5 | 1.2 | 18.4 | 11.3 | 5.1 | 235.0 | 0.5 | 7.6 | 3.1 | 2.5 |
| Beechcfrat 1900/1900C | 131.6 | 16.2 | 16.2 | 1.5 | 1.2 | 60.5 | 6.8 | 8.7 | 0.4 | 0.6 |
| Aerospatiale Fennec (AS-550) | 94.1 | 1.5 | 3.4 | 1.3 | 1.0 | 94.1 | 1.5 | 3.4 | 1.3 | 1.1 |
| Dassault (Breguet Mystere) Falcon | 42.2 | 0.4 | 2.0 | 0.9 | 0.4 | 34.1 | 0.4 | 2.4 | 0.3 | 0.3 |
| Airbus A340 all models | 1376.4 | 11.8 | 74.4 | 106.1 | 12.8 | 557.3 | 4.4 | 28.6 | 18.2 | 6.1 |
| Boeing 767 all pax models | 996.1 | 4.7 | 20.7 | 37.3 | 9.4 | 421.2 | 1.9 | 8.9 | 6.9 | 4.7 |
| Mooney M-20 | 3.0 | 0.1 | 3.1 | 0.0 | 0.0 | 2.1 | 0.0 | 2.5 | 0.0 | 0.0 |

#### 3.5.1.3.1.2 Airport Based LTO Emission Factors

Specific airport LTO emission factors were needed for movements where information about the aircraft type was not available. Therefore, weighted averaged departure and arrival emission factors were estimated from the fleet composition for each airport and year. This set of averaged airport based LTO emission factors, was used mainly in movements from 1990 to 1999 since this was the period for which information on aircraft characteristics was scarce.

***Table 3-42: Airport based LTO emission factors (kg/movement).***

| Airport | Operation | Parameter | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Lisboa (LIS) | Take-off | Fuel Consumption | 670.2 | 608.9 | 567.4 | 452.6 | 451.6 | 468.4 | 453.3 | 415.5 | 454.1 |
| | | VOC | 16.4 | 14.9 | 15.2 | 9.3 | 2.8 | 2.3 | 2.5 | 2.1 | 2.0 |
| | | CO | 37.1 | 33.7 | 35.4 | 21.5 | 13.8 | 12.8 | 13.7 | 11.7 | 12.0 |
| | | $NO_x$ | 26.3 | 23.9 | 23.6 | 16.2 | 15.9 | 17.1 | 16.1 | 14.6 | 16.1 |
| | | $PM_{10}$ | 6.2 | 5.6 | 5.2 | 4.2 | 4.2 | 4.4 | 4.2 | 3.9 | 4.2 |
| | Landing | Fuel Consumption | 291.0 | 264.4 | 240.2 | 204.2 | 206.6 | 223.7 | 194.7 | 182.2 | 198.7 |
| | | VOC | 7.0 | 6.4 | 6.0 | 4.4 | 1.5 | 1.2 | 1.3 | 1.2 | 1.1 |
| | | CO | 17.8 | 16.2 | 16.3 | 11.1 | 7.0 | 6.5 | 6.4 | 5.8 | 5.9 |
| | | $NO_x$ | 4.9 | 4.4 | 4.3 | 3.3 | 3.4 | 3.8 | 3.3 | 3.0 | 3.3 |
| | | $PM_{10}$ | 3.1 | 2.8 | 2.6 | 2.2 | 2.2 | 2.4 | 2.1 | 2.0 | 2.1 |
| Porto (OPO) | Take-off | Fuel Consumption | 530.0 | 481.5 | 401.1 | 374.4 | 427.6 | 358.1 | 374.0 | 352.1 | 355.3 |
| | | VOC | 8.2 | 7.5 | 6.5 | 4.1 | 3.3 | 2.6 | 2.2 | 2.2 | 2.2 |
| | | CO | 26.3 | 23.9 | 23.0 | 13.7 | 12.8 | 10.7 | 11.2 | 10.6 | 10.6 |
| | | $NO_x$ | 19.1 | 17.3 | 15.0 | 11.9 | 14.7 | 11.9 | 12.5 | 11.4 | 11.7 |
| | | $PM_{10}$ | 4.9 | 4.5 | 3.7 | 3.5 | 4.0 | 3.3 | 3.5 | 3.3 | 3.3 |
| | Landing | Fuel Consumption | 236.2 | 214.6 | 181.3 | 172.9 | 191.7 | 171.1 | 170.8 | 161.3 | 157.8 |
| | | VOC | 3.7 | 3.3 | 2.9 | 2.2 | 1.6 | 1.4 | 1.3 | 1.2 | 1.2 |
| | | CO | 12.7 | 11.5 | 11.1 | 7.2 | 6.3 | 5.8 | 6.0 | 5.6 | 5.4 |
| | | $NO_x$ | 3.8 | 3.5 | 3.0 | 2.6 | 3.2 | 2.8 | 2.9 | 2.6 | 2.5 |
| | | $PM_{10}$ | 2.5 | 2.3 | 1.9 | 1.9 | 2.1 | 1.8 | 1.8 | 1.7 | 1.7 |
| Faro (FAO) | Take-off | Fuel Consumption | 514.8 | 467.7 | 443.6 | 348.7 | 339.1 | 263.5 | 245.8 | 205.8 | 240.8 |
| | | VOC | 5.3 | 4.8 | 4.9 | 3.0 | 2.4 | 2.1 | 2.1 | 1.9 | 2.1 |
| | | CO | 19.2 | 17.4 | 17.2 | 12.2 | 11.0 | 8.5 | 8.0 | 7.4 | 8.5 |
| | | $NO_x$ | 17.4 | 15.8 | 16.0 | 11.0 | 10.0 | 7.7 | 7.2 | 5.6 | 7.2 |
| | | $PM_{10}$ | 4.8 | 4.3 | 4.1 | 3.2 | 3.1 | 2.4 | 2.3 | 1.9 | 2.2 |
| | Landing | Fuel Consumption | 231.8 | 210.6 | 198.9 | 158.2 | 161.1 | 139.3 | 119.1 | 106.8 | 116.9 |
| | | VOC | 2.7 | 2.5 | 2.5 | 1.7 | 1.4 | 1.4 | 1.5 | 1.4 | 1.4 |
| | | CO | 10.0 | 9.1 | 9.0 | 6.5 | 5.9 | 5.0 | 4.8 | 4.6 | 5.0 |
| | | $NO_x$ | 3.5 | 3.2 | 3.1 | 2.3 | 2.4 | 2.0 | 1.7 | 1.5 | 1.7 |
| | | $PM_{10}$ | 2.5 | 2.3 | 2.1 | 1.7 | 1.7 | 1.5 | 1.3 | 1.1 | 1.2 |

### 3.5.1.3.2 Cruise Emissions

#### 3.5.1.3.2.1 Aircraft Based Cruise Emissions

Cruise emissions were estimated from EMEP/CORINAIR detailed methodology. Cruise emissions are given for typical cruise distances (see EMEP/CORINAIR Emission Inventory Guidebook, December 2001: ppB851-22, Table 8.4; Annex 1; Annex 2). This information was used to derive emissions for specific distances according with a trend line established between discrete samples provided in the EMEP/CORINAIR Emission Inventory Guidebook.

The table below shows an example of cruise emission for Airbus and Boeing models.

***Table 3-43: Cruise emissions and fuel consumption.***

| Aircraft | Distance (km) | Fuel Consumption (kg) | $NO_X$ (kg) | HC (g) | CO (g) |
|---|---|---|---|---|---|
| Airbus A310 all pax models | 0 | 0 | 0 | 0 | 0 |
| | 232 | 1 270 | 30 | 290 | 1587 |
| | 463 | 2 359 | 49 | 490 | 2651 |
| | 926 | 4 450 | 64 | 763 | 3848 |
| | 1389 | 6 541 | 89 | 1026 | 4913 |
| | 1852 | 8 632 | 113 | 1288 | 5977 |
| | 2778 | 12 992 | 166 | 1836 | 8193 |
| | 3704 | 17 441 | 214 | 2378 | 10345 |
| | 4630 | 22 159 | 273 | 2960 | 12678 |
| | 5556 | 27 135 | 340 | 3585 | 15206 |
| | 6482 | 32 223 | 408 | 4223 | 17790 |
| Airbus A318/319/320/321 | 0 | 0 | 0 | 0 | 0 |
| | 232 | 842 | 17 | 149 | 1096 |
| | 463 | 1 695 | 27 | 267 | 1742 |
| | 926 | 2 858 | 45 | 508 | 3108 |
| | 1389 | 3 903 | 56 | 684 | 3571 |
| | 1852 | 5 225 | 73 | 915 | 4688 |
| | 2778 | 7 530 | 99 | 1311 | 6166 |
| | 3704 | 10 064 | 130 | 1747 | 7849 |
| | 4630 | 12 639 | 159 | 2189 | 9532 |
| Boeing 727 all pax models | 0 | 0 | 0 | 0 | 0 |
| | 231.5 | 1303.9 | 11 | 907 | 3459 |
| | 463 | 2341.8 | 17 | 2206 | 5869 |
| | 926 | 4247.3 | 43 | 2311 | 8837 |
| | 1389 | 6080.4 | 58 | 3072 | 11842 |
| | 1852 | 8058.3 | 74 | 3746 | 14568 |
| | 2778 | 12131.4 | 108 | 5279 | 20688 |
| | 3704 | 16459.4 | 147 | 6871 | 27075 |
| | 4630 | 20825.2 | 185 | 8477 | 33515 |

Source: EMEP/CORINAIR

#### 3.5.1.3.2.2 Airport Based Cruise Emissions

Averaged airport cruise emission factors were needed for movements where information about the aircraft type was not available. For this purpose, weighted averaged cruise emission factors were estimated from the fleet profile in each airport, year and origin/destination.

Again, this set of averaged airport based cruise emissions, were used mainly in movements from 1990 to 1999 since this was the period for which information on aircraft characteristics was scarce.

### 3.5.1.3.3 Correspondence between aircraft type and representative aircraft

The availability of emissions factor is limited to a certain number of engines and frames. Therefore, a representative aircraft is needed when an emission factor is not available for a specific airplane. Annex B shows the correspondence between aircrafts and representative aircrafts for LTO and cruise emissions factors.

#### 3.5.1.3.4 Fuel dependent emission factors

Fuel dependent emission factors were set for $CO_2$ and $N_2O$. Emission factors for $CO_2$ and $N_2O$ are IPCC default. The LHV were obtained from the national energy authority (DGEG).

***Table 3-44: Fuel dependent emission factors***

| Pollutant | Aviation Gasoline | Jet Fuel |
|---|---|---|
| LHV (MJ/kg) | 44.0 | 43.0 |
| $CO_2$ (t/TJ) | 70 | 71.5 |
| $N_2O$ (kg/TJ) | 2.00 | 2.00 |

Source: IPCC 2006; DGEG

### 3.5.1.4 Activity Data

#### 3.5.1.4.1 Flight movements in Airports

Very important activity data for this source activity is the number of arrival and departure movements. The number of movements by airport, aircraft, origin/destiny and movement type (arrival or departure) for the period between 1990 and 2023 was provided by the *Autoridade Nacional da Aviação Civil* (ANAC). This database is being improved and the coverage of it is increasing as new airports (mostly regional and local airports) are connected to the movements' database from ANAC.

***Table 3-45: $LTO_{Cycle}$ per airport.***

| Region | Airport Code | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|
| Mainland | LIS | 30 862 | 34 932 | 56 073 | 68 168 | 73 783 | 84 385 | 45 980 | 102 572 | 114 675 |
| | OPO | 11 574 | 13 348 | 23 280 | 25 910 | 28 502 | 35 248 | 22 317 | 46 339 | 52 262 |
| | FAO | 11 252 | 13 067 | 18 243 | 20 397 | 22 359 | 22 330 | 12 560 | 29 891 | 33 331 |
| | **TOTAL** | **53 688** | **61 347** | **97 596** | **114 475** | **124 643** | **141 963** | **80 856** | **178 801** | **200 268** |

| Region | Airport Code | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|
| Islands | FNC | 6 475 | 9 460 | 12 040 | 15 952 | 12 697 | 12 442 | 6 180 | 15 086 | 16 506 |
| | TER | 3 801 | 4 049 | 4 501 | 4 875 | 4 988 | 4 755 | 3 819 | 6 587 | 6 846 |
| | PDL | 2 954 | 3 382 | 4 134 | 7 196 | 8 182 | 8 499 | 8 111 | 12 756 | 13 627 |
| | PXO | 2 403 | 4 243 | 3 788 | 3 688 | 2 325 | 2 103 | 1 093 | 1 909 | 1 954 |
| | HOR | 1 237 | 1 542 | 1 756 | 2 964 | 2 919 | 2 331 | 2 107 | 2 793 | 2 963 |
| | SMA | 634 | 893 | 1 557 | 1 649 | 1 275 | 1 073 | 1 203 | 1 618 | 1 719 |
| | FLW | 281 | 357 | 552 | 1 101 | 1 136 | 1 002 | 1 104 | 1 460 | 1 447 |
| | **TOTAL** | **17 785** | **23 924** | **28 327** | **37 425** | **33 521** | **32 204** | **23 616** | **42 207** | **45 061** |

Source: ANAC

Data concerning aircraft operation characteristics, particularly, the origin/destiny, the aircraft type and the movement type was sometimes not included in the records database. The worst case refers to the period between 1990 and 1994, for this period the only information available was the number of operations, all other information was missing. There is also the period between 1995 and 1999 with missing data on aircraft type. For all these cases an alternative approach had to be set.

An alternative database was however available with information on the number of operations and the aircraft types. This data was very useful to determine the aircraft fleet profile in each airport between 1990 and 1999 whereby airport representative arrival and departure emission factors were determined.

On the other hand, for records with missing information on origin and destiny, a yearly fraction of international, domestic and European flights was derived for each airport relying on the movements which had this information. This was necessary to differentiate emissions between domestic and international.

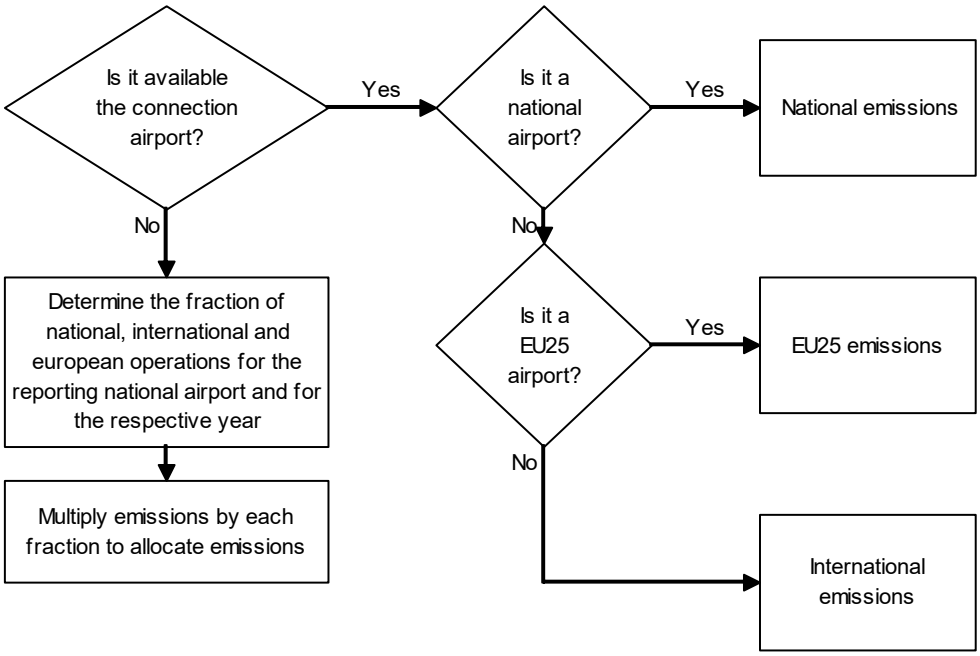
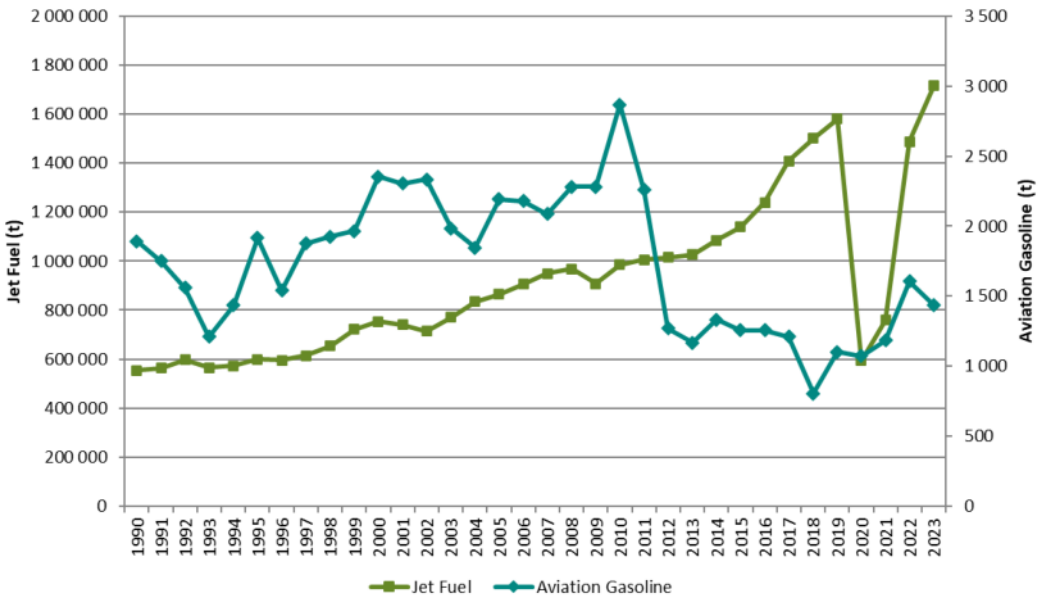



***Figure 3-37: Decision tree for distinction between domestic and international emissions.***

#### 3.5.1.4.2 Fuel Consumption

Fuel consumption is available from fuel sales statistics from DGEG for main territory and islands. $LTO_{Cycle}$ and domestic cruise fuel consumption is estimated with a bottom-up approach. International cruise consumption is estimated as the difference to the total fuel sales. This approach guarantees that the total fuel for aviation equals the fuel sales.




Source: DGEG

***Figure 3-38: Total Fuel consumption of aviation gasoline and jet fuel (Source: DGEG).***

### 3.5.1.5 Uncertainty Assessment

Activity level refers to the fuel domestic consumption wich was estimated for LTO and Cruise separately according with the following couple equations.

$$U_{cruise} = \sqrt{U_{movements}^2 + U_{time}^2 + U_{FCcruise}^2}$$

$$U_{lto} = \sqrt{U_{movements}^2 + U_{FClto}^2}$$

The activity level uncertainty ($U_{global}$) is therefore obtained from:

$$U_{global} = \frac{\sqrt{(E_{cruise} \times U_{cruise})^2 + (E_{lto} \times U_{lto})^2}}{E_{cruise} + E_{lto}}$$

**Where:**

Ecruise, Elto = domestic energy consumption under cruise and LTO (GJ).

***Table 3-46: Aviation activity level uncertainty.***

| Source | Parameter | Unit | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| All | Uglobal | % | 71 | 72 | 35 | 36 | 35 | 35 | 34 | 36 | 37 |
| Cruise | Ucruise | % | 99 | 99 | 47 | 49 | 48 | 47 | 46 | 48 | 49 |
| LTO | Ulto | % | 100 | 100 | 48 | 49 | 48 | 47 | 45 | 46 | 47 |

The uncertainties of emissions factors were set at 5% for $CO_2$, 100% for methane and one order of magnitude for $N_2O$, following the recommendations from GPG.

### 3.5.1.6 Category-specific QA/QC and verification

Energy consumption was compared with data from the energy balance reported by DGEG. No differences were found between total fuel estimated with the described methodology and total fuel reported in the energy balance.

### 3.5.1.7 Recalculations

A compilation error concerning the 2021 fuel consumption for an airport was detected and corrected.

### 3.5.1.8 Further Improvements

No further improvements are planned for this sector.

## 3.5.2 Road Transportation (CRT 1.A.3.b)

### 3.5.2.1 Category description

Road Transportation is one of the most important emitters of greenhouse gases (GHG) such as carbon dioxide ($CO_2$), methane ($CH_4$) and nitrous oxide ($N_2O$).

Exhaust greenhouse gases emissions from Road Transportation were estimated at about 17 405 Kt $CO_2$ eq in 2023, representing an increase of 71% when compared to 10 180 Kt $CO_2$ eq estimated for 1990.

Emissions of $N_2O$ have doubled since 1990 due to the introduction of catalytic converters. These emissions increased by a factor of 4.6 between 1990 and 2000 and have since then been slowly diminishing to less than half that record value. The introduction of catalytic converters has some disadvantages including the increase of $CO_2$ and $NH_3$ emissions which contribute to climate change and acid deposition. It is difficult to assess the extent to which $CO_2$ emissions have increased as a result of fitting catalytic converters, because improvements in fuel economy have been made at the same time as development of the engine management systems that are required to minimize $NO_x$ and VOC emissions.

***Table 3-47: Estimated emissions from Road Transportation (Kt $CO_2$ eq).***

| Source Category/Pollutant | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|
| 1A3b - $CO_2$ Fossil | 10 000.59 | 13 261.92 | 18 629.75 | 19 013.95 | 18 102.17 | 15 523.36 | 14 195.28 | 15 174.09 | 16 165.98 |
| 1A3b - $CO_2$ Biomass* | 0.00 | 0.00 | 0.00 | 0.00 | 859.02 | 899.84 | 688.41 | 970.78 | 948.09 |
| 1A3b - $CH_4$ | 108.80 | 113.88 | 97.82 | 67.38 | 43.76 | 28.39 | 19.14 | 20.54 | 21.94 |
| 1A3b - $N_2O$ | 69.85 | 169.18 | 323.63 | 171.18 | 140.48 | 130.87 | 126.79 | 138.92 | 150.20 |
| **1A3b - Road Transportation** | **10 179.25** | **13 544.98** | **19 051.20** | **19 252.52** | **18 286.40** | **15 682.62** | **14 341.22** | **15 333.55** | **16 338.13** |
| **2D1 - Lubricants in 4-stroke** | **20.75** | **25.87** | **33.62** | **34.41** | **35.49** | **31.55** | **28.58** | **30.88** | **32.69** |
| **2D3c - Urea** | **0.00** | **0.00** | **0.00** | **0.00** | **3.13** | **5.73** | **8.95** | **10.29** | **11.45** |

*Information item. Emissions not included in national totals.

Exhaust emissions from Road Transportation include emission from the combustion of lubricant use in two-stroke engines, which represent, in 2023, 0.008% of the total exhaust emissions from Road Transportation.

Greenhouse gases emissions from Road Transportation also include non-combustive $CO_2$ emissions from the use of urea-based additives in catalytic converters (reported under 2D3c) and from lubricants that enter accidentally in the four-stroke engines combustion chambers (reported in 2D1). In 2023, these emissions represented respectively 0.07% and 0.2% of the total emissions from Road Transportation.

### 3.5.2.2 Methodology

Emissions from Road Transportation are estimated using the COPERT 5[18] (Version 5.8.1 – September 2024) and includes the following type of emissions:

- Exhaust Emissions from Fuel (1A3bi, 1A3bii, 1A3biii, 1A3iv) - $CO_2$[19], $CH_4$ and $N_2O$;
- Exhaust Emissions from Lubricants use in two-stroke engines (1A3iv) – $CO_2$;
- Emissions from Lubricants use in four-stroke engines (2D1) – $CO_2$
- Urea based catalytic converters emissions - SCR (Selective Catalytic reduction) (2D3c) – $CO_2$.

[18] https://www.emisia.com/utilities/copert/
[19] Exhaust emissions from fuels include estimation of the $CO_2$ emissions from the fossil part of biofuels.

For the calculation of these emissions, beyond COPERT 5 emission factors, several National Activity Data and Input Variables are used:

- Environmental Information (Temperature, Humidity)
- Trip Characteristics (Trip length, Trip duration)
- Fuel Characteristics and Specifications
- Energy Consumption
- Vehicle Fleet
- Distance travelled (Mean Activity - Km)
- Circulation Data (Average Speed, Mileage % per driving mode)

An additional tool was developed by APA to calculate the vehicle fleet and distance travelled with information from vehicle inspection centers, sales and abatements.

The energy consumption is provided by the national energy authority. To ensure that the statistical energy consumption match the calculated energy consumption, COPERT 5 adjust the blend type and share, and the annual distance travelled (mean activity).

Estimated emissions from Road Transportation are based in Tier 1 method for $CO_2$ emissions and Tier 3 for non-$CO_2$ emissions.

### 3.5.2.3 Emission Factors

Emissions factors for Exhaust Emissions and non-combustive $CO_2$ emissions from the use of urea-based additives in catalytic converters were determined using COPERT 5.

#### 3.5.2.3.1 Implied Emission Factors

Distance Implied Emission Factors were calculated for Vehicle Category and Fuel and are presented in the next table.

***Table 3-48: Road Transportation distance based implied emission factor for 2023 (g/km and mg/km).***

| | | $CO_2$ fossil* | $CO_2$ bio | $CH_4$ | $N_2O$ |
|---|---|---|---|---|---|
| **Category** | **Fuel** | **g/km** | **g/km** | **mg/km** | **mg/km** |
| Passenger Cars | Petrol | 201.18 | 3.60 | 21.32 | 3.62 |
| Passenger Cars | Petrol Hybrid | 197.43 | 3.53 | 19.92 | 1.37 |
| Passenger Cars | Diesel | 194.91 | 11.77 | 1.52 | 7.13 |
| Passenger Cars | LPG Bifuel | 192.50 | - | 32.59 | 7.21 |
| Light Commercial Vehicles | Petrol | 273.21 | 4.89 | 79.39 | 8.77 |
| Light Commercial Vehicles | Diesel | 234.95 | 14.19 | 2.91 | 6.38 |
| Heavy Duty Trucks | Diesel | 566.53 | 34.15 | 17.55 | 25.73 |
| Buses | Diesel | 1 236.58 | 74.50 | 36.52 | 22.93 |
| Buses | CNG | 1 341.43 | - | 990.16 | 101.00 |
| L-Category - Mopeds | Petrol | 68.38 | 1.17 | 117.40 | 1.00 |
| L-Category - Motorcycles | Petrol | 123.40 | 2.19 | 49.99 | 2.00 |

*includes lubricants and SCR emissions

More detailed Implied Emission Factors based on distance (g/km and mg/km) and different Vehicle Category, Fuel, Segment and Euro Standard, for 2023, are presented in Annex B.

The Implied Emission Factors based on energy (t/TJ), for 2023, were determined for different Vehicle Category, Fuel, Segment and Euro Standard and are also presented in Annex B.

### 3.5.2.4 Activity Data and Input Variables

#### 3.5.2.4.1 Environmental information

The **monthly average ambient minimum and maximum temperatures** and **monthly average relative air humidity** were inputted into COPERT 5. The temperature data was received from 15 climatological stations of the *Portuguese Sea and Atmosphere Institute* (IPMA) and concerns a long period average from 1971 to 2000. The humidity information is related to modeled historical data from 1971 to 2000. The same values were used for all years in analysis.

***Table 3-49: Monthly average ambient temperatures (ºC) and relative air humidity (%).***

| Month | Minimum Temperature | Maximum Temperature | Relative Humidity |
|---|---|---|---|
| January | 4.5 | 13.1 | 85 |
| February | 5.6 | 14.6 | 82 |
| March | 6.8 | 17.0 | 79 |
| April | 8.1 | 18.2 | 76 |
| May | 10.5 | 21.0 | 72 |
| June | 13.5 | 25.4 | 65 |
| July | 15.6 | 28.7 | 57 |
| August | 15.5 | 28.8 | 56 |
| September | 14.2 | 26.3 | 63 |
| October | 11.2 | 21.2 | 76 |
| November | 7.9 | 16.8 | 83 |
| December | 6.1 | 13.9 | 85 |

Source: (http://portaldoclima.pt/en/)

#### 3.5.2.4.2 Trip Characteristics

According to COPERT 5 methodology some country properties related with trip characteristics are necessary. For Portugal the average **trip length** considered was 10 km (as described in the EMEP/EEA Guidebook 2019, table 3.35) while the average **trip duration** is 12 minutes.

#### 3.5.2.4.3 Fuel Characteristics and Specifications

Some fuel specifications used, like energy content, density, H:C and O:C ratio, were default COPERT 5 values set accordingly with EMEP/EEA Guidebook 2019.

***Table 3-50: Fuel specifications.***

| Fuel | Energy Content (Mj/kg) | Density (kg/m3) | H:C Ratio | O:C Ratio |
|---|---|---|---|---|
| Petrol | 43.77 | 750.00 | 1.86 | 0.00 |
| Diesel | 42.70 | 840.00 | 1.86 | 0.00 |
| LPG | 46.56 | 520.00 | 2.53 | 0.00 |
| CNG | 48.00 | 175.00 | 4.00 | 0.00 |
| Biodiesel | 37.30 | 890.00 | 1.95 | 0.11 |
| Bioethanol | 28.80 | 794.00 | 3.00 | 0.50 |

The **Sulphur content** in Petrol and Diesel was set in line with National Legislation values. For LPG, CNG, Biodiesel and Bioethanol it was assumed a 0% Sulphur content.

***Table 3-51: Sulphur content in petrol and diesel (ppm wt).***

| Fuel | 1990-1999 |
|---|---|
| Leaded Petrol | 1000 |

| Fuel | 1990-1995 | 1996-2001 | 2002-2004 | 2005-2008 | 2008-2023 |
|---|---|---|---|---|---|
| Unleaded Petrol | 1000 | 500 | 150 | 50 | 10 |

| Fuel | 1990-1994 | 1995 | 1996-2000 | 2001-2004 | 2005-2008 | 2009-2023 |
|---|---|---|---|---|---|---|
| Diesel | 3000 | 2000 | 500 | 350 | 50 | 10 |

Source: National Legislation (Portaria n.º124/89, Portaria n.º125/89, Portaria 949/94, Portaria n.º1489/95, Decreto-Lei nº 104/2000, Decreto-Lei nº 235/2004, Decreto-Lei nº 142/2010 e Decreto-Lei nº 214-E/2015).

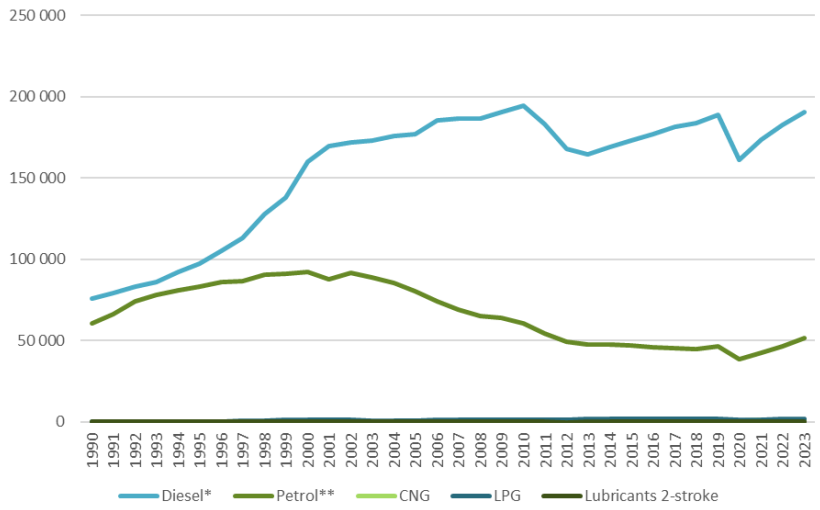
Monthly values of fuel volatility (RVP - Reid Vapour Pressure) were established from Portuguese Legislation.

***Table 3-52: Reid Vapour Pressure (kPa).***

| Month | 1990 to 1995 | 1996 to 1999 | 2000 to 2023 |
|---|---|---|---|
| January | 98 | 95 | 90 |
| February | 98 | 95 | 90 |
| March | 98 | 95 | 90 |
| April | 83 | 80 | 90 |
| May | 83 | 80 | 60 |
| June | 70 | 70 | 60 |
| July | 70 | 70 | 60 |
| August | 70 | 70 | 60 |
| September | 70 | 70 | 60 |
| October | 83 | 95 | 90 |
| November | 98 | 95 | 90 |
| December | 98 | 95 | 90 |

#### 3.5.2.4.4 Energy Consumption

Fuel consumption from Road Transportation sector is available from the Energy Balances from DGEG while the lubricant consumption is calculated by COPERT 5. Fuel consumption and lubricant consumed in 2-stroke engines is presented in the following figure and Annex B.



* includes incorporation of Biodiesel
** includes incorporation of Biopetrol and excludes petrol evaporation

***Figure 3-39: Fuel and lubricant consumption from Road Transportation sector (TJ).***

In adition to the "10.05.04 Road Transport" category of the Energy Balance the Road Transportation sector also considers petrol from "10.4 services" category and part of diesel from "10.01.01 Agriculture" category as described in 3.6 Other Sectors (1A4).

**Lubricant consumption** that contributes to exhaust emission in Road Transportation includes lubricant consumed as energy in two-stroke engines.

Emission from lubricants used in vehicle engines to reduce friction and cool components that are not combusted and emissions from lubricant that enters accidentally in the four-stroke engines combustion chambers are included in section related to Lubricants Use (CRT 2.D.1).

In Portugal the incorporation of Biodiesel in Diesel starts in 2006 and the incorporation of Bioepetrol in Petrol starts in 2012. The incorporation rates in the Road Transportation Sector are presented in the next tables.

***Table 3-53: Incorporation rate of Biodiesel in Diesel (%).***

| 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|
| 1.31% | 2.50% | 2.43% | 4.16% | 6.03% | 6.25% | 6.20% | 6.05% | 5.93% |
| **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2023** |
| 6.81% | 5.15% | 5.10% | 5.49% | 5.43% | 5.76% | 7.24% | 6.55% | 5.85% |

Source: DGEG

***Table 3-54: Incorporation rate of Bioethanol in Petrol (%)***

| 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.09% | 0.16% | 0.16% | 1.73% | 1.89% | 0.28% | 0.52% | 0.68% | 0.55% | 1.99% | 2.56% | 1.96% |

Source: (DGEG)

#### 3.5.2.4.5 Vehicle Fleet

The active fleet of Passenger Cars, Light Commercial Vehicles, Heavy Duty Trucks and Buses, for the period between 2003 and 2023, was obtained from data from the national vehicle inspection centres from *Instituto da Mobilidade e dos Transportes* (IMT) complemented with data on vehicle sales from *Associação Automóvel de Portugal* (ACAP).

For the period between 1990 and 2002, due to the absence of information from the inspections centers, to determine the active fleet per year for Passenger Cars, Light Commercial Vehicles, Heavy Duty Trucks and Buses was applied a function that considers the vehicle survival rates. The backcasting for the estimation of the active fleet, for the period between 1990 and 2002, was estimated taking into account the survival rates of the data from the national vehicle inspection centers, between 2003 and 2016, and the vehicle fleet for 2003 for the different vehicle and fuel categories.

Despite the different splicing techniques to resolve data gaps presented in the 2006 IPCC Guidelines Volume I, we considered that due to the fact that technical conditions changes throughout the time series and that the backcast was not applied directly to the emission estimation but to one of the activity data considered, was necessary to develop this customised approach for the vehicle fleet estimation for the period between 1990 and 2003.

The number of mopeds and motorcycles was obtained from insurance data from *Autoridade de Supervisão de Seguros e Fundos de Pensões* (ASF) since these vehicles are excluded from the vehicle inpection programe. The classification by type of segment and age was possible with data from *Instituto da Mobilidade e dos Transportes* (IMT) and *Associação Automóvel de Portugal* (ACAP).

The application of COPERT 5 vehicle segment to the data from vehicle inspection centers was based on *Associação Automóvel de Portugal* (ACAP) segmentation data considering weight and/or cylinder power ranges.

***Table 3-55: COPERT 5 segments.***

| COPERT 5 Vehicle Category | COPERT 5 Vehicle Segment | Fuel | Weight (kg) | Cylinder Power (cm³) |
|---|---|---|---|---|
| Passenger Cars | Mini | Petrol<br>Petrol Hibrid<br>Diesel<br>LPG Bifuel | < 1 400 | < 1 000 |
| | Small | | < 1 800 | < 1 600 |
| | Medium | | < 2400 | < 1 900 |
| | Large-SUV-Executive | | > 2400 | > 1 900 |
| Light Commercial Vehicles | N1-I | Petrol<br>Diesel | < 1 900 | - |
| | N1-II | | 1 900 - 2 600 | - |
| | N1-III | | > 2 600 | - |
| Heavy Duty Trucks | Rigid <=7,5 t | Diesel | <= 7 500 | - |
| | Rigid 7,5 - 12 t | | 7 500 - 12 000 | - |
| | Rigid 12 - 14 t | | 12 000 - 14 000 | - |
| | Rigid 14 - 20 t | | 14 000 - 20 000 | - |
| | Rigid 20 - 26 t | | 20 000 - 26 000 | - |
| | Rigid 26 - 28 t | | 26 000 - 28 000 | - |
| | Rigid 28 - 32 t | | 28 000 - 32 000 | - |
| | Rigid >32 t | | > 32 000 | - |
| | Articulated 14 - 20 t | | < 20 000 | - |
| | Articulated 20 - 28 t | | 20 000 - 28 000 | - |
| | Articulated 28 - 34 t | | 28 000 - 34 000 | - |
| | Articulated 34 - 40 t | | 34 000 - 40 000 | - |
| | Articulated 40 - 50 t | | 40 000 - 50 000 | - |
| | Articulated 50 - 60 t | | > 50 000 | - |
| Buses | Urban Buses Midi <=15 t | Diesel | <= 15 000 | - |
| | Urban Buses Standard 15 - 18 t | | 15 000 - 18 000 | - |
| | Urban Buses Articulated >18 t | | > 18 000 | - |
| | Coaches Standard <=18 t | | <= 18 000 | - |
| | Coaches Articulated >18 t | | > 18 000 | - |
| | Urban CNG Buses | CNG | - | - |
| L-Category | Mopeds 2-stroke <50 cm³ | Petrol | - | <50 |
| | Mopeds 4-stroke <50 cm³ | | - | <50 |
| | Motorcycles 2-stroke >50 cm³ | | - | >50 |
| | Motorcycles 4-stroke <250 cm³ | | - | <250 |
| | Motorcycles 4-stroke 250 - 750 cm³ | | - | 250 - 750 |
| | Motorcycles 4-stroke >750 cm³ | | - | >750 |

Vehicle technology was determined according with European and National legislation and the vehicle first registry year as presented in table below.

***Table 3-56: Technology classification according to first registry year.***

| Vehicle Category | Fuel | Euro Standard | First Registry year | |
|---|---|---|---|---|
| | | | from | to |
| Passenger Cars | Petrol | PRE ECE | … | 1971 |
| | | ECE 15/00-01 | 1972 | 1977 |
| | | ECE 15/02 | 1978 | 1980 |
| | | ECE 15/03 | 1981 | 1985 |
| | | ECE 15/04 | 1986 | 1992 |
| | | Euro 1 | 1993 | 1996 |
| | | Euro 2 | 1997 | 2000 |
| | | Euro 3 | 2001 | 2005 |
| | Petrol / Petrol Hybryd | Euro 4 | 2006 | 2010 |
| | | Euro 5 | 2011 | 2014 |
| | | Euro 6 a/b/c | 2015 | 2018 |
| | | Euro 6 d-temp | 2019 | 2020 |
| | | Euro 6 d/e | 2021 | … |
| | Diesel | Conventional | … | 1992 |
| | | Euro 1 | 1993 | 1996 |
| | | Euro 2 | 1997 | 2000 |
| | | Euro 3 | 2001 | 2005 |
| | | Euro 4 | 2006 | 2010 |
| | | Euro 5 | 2011 | 2014 |
| | | Euro 6 a/b/c | 2015 | 2018 |
| | | Euro 6 d-temp | 2019 | 2020 |
| | | Euro 6 d/e | 2021 | … |
| | LPG Bifuel | Conventional | … | 1992 |
| | | Euro 1 | 1993 | 1996 |
| | | Euro 2 | 1997 | 2000 |
| | | Euro 3 | 2001 | 2005 |
| | | Euro 4 | 2006 | 2010 |
| | | Euro 5 | 2011 | 2014 |
| | | Euro 6 a/b/c | 2015 | 2016 |
| | | Euro 6 d-temp | 2017 | 2019 |
| | | Euro 6 d/e | 2020 | … |
| Light Commercial Vehicles - N1-I | Petrol | Conventional | … | 1994 |
| | | Euro 1 | 1995 | 1997 |
| | | Euro 2 | 1998 | 2000 |
| | | Euro 3 | 2001 | 2005 |
| | | Euro 4 | 2006 | 2010 |
| | | Euro 5 | 2011 | 2015 |
| | | Euro 6 a/b/c | 2016 | 2017 |
| | | Euro 6 d-temp | 2018 | 2020 |
| | | Euro 6 d/e | 2021 | … |
| | Diesel | Conventional | … | 1994 |
| | | Euro 1 | 1995 | 1997 |
| | | Euro 2 | 1998 | 2000 |
| | | Euro 3 | 2001 | 2005 |
| | | Euro 4 | 2006 | 2010 |
| | | Euro 5 | 2011 | 2014 |
| | | Euro 6 a/b/c | 2015 | 2017 |
| | | Euro 6 d-temp | 2018 | 2020 |
| | | Euro 6 d/e | 2021 | … |
| Light Commercial Vehicles - N1-II/N1-III | Petrol | Conventional | … | 1994 |
| | | Euro 1 | 1995 | 1998 |

| Vehicle Category | Fuel | Euro Standard | First Registry year | |
|---|---|---|---|---|
| | | | from | to |
| | | Euro 2 | 1999 | 2001 |
| | | Euro 3 | 2002 | 2006 |
| | | Euro 4 | 2007 | 2011 |
| | | Euro 5 | 2012 | 2015 |
| | | Euro 6 a/b/c | 2016 | 2017 |
| | | Euro 6 d-temp | 2018 | 2020 |
| | | Euro 6 d/e | 2021 | ... |
| | Diesel | Conventional | ... | 1994 |
| | | Euro 1 | 1995 | 1998 |
| | | Euro 2 | 1999 | 2001 |
| | | Euro 3 | 2002 | 2006 |
| | | Euro 4 | 2007 | 2011 |
| | | Euro 5 | 2012 | 2014 |
| | | Euro 6 a/b/c | 2015 | 2017 |
| | | Euro 6 d-temp | 2018 | 2020 |
| | | Euro 6 d/e | 2021 | ... |
| Heavy Duty Trucks and Buses | Diesel | Conventional | ... | 1993 |
| | | Euro I | 1994 | 1996 |
| | | Euro II | 1997 | 2001 |
| | | Euro III | 2002 | 2006 |
| | | Euro IV | 2007 | 2009 |
| | | Euro V | 2010 | 2013 |
| | | Euro VI A/B/C | 2014 | 2018 |
| | | Euro VI D/E | 2019 | ... |
| Buses | CNG | Euro I | 1994 | 1996 |
| | | Euro II | 1997 | 2001 |
| | | Euro III | 2002 | 2006 |
| | | EEV | 2007 | ... |
| Mopeds | Petrol | Conventional | ... | 2000 |
| | | Euro 1 | 2001 | 2002 |
| | | Euro 2 | 2003 | 2006 |
| | | Euro 3 | 2007 | 2017 |
| | | Euro 4 | 2018 | 2020 |
| | | Euro 5 | 2021 | ... |
| Motorcycles | Petrol | Conventional | ... | 2000 |
| | | Euro 1 | 2001 | 2003 |
| | | Euro 2 | 2004 | 2006 |
| | | Euro 3 | 2007 | 2016 |
| | | Euro 4 | 2017 | 2020 |
| | | Euro 5 | 2021 | ... |

The following table shows the vehicle fleet by vehicle category.

***Table 3-57: Vehicle fleet synthesis.***

| Vehicle Category | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023* |
|---|---|---|---|---|---|---|---|---|---|
| Passenger Cars | 1 552 912 | 2 516 415 | 3 546 152 | 3 962 031 | 4 386 247 | 4 611 618 | 5 006 277 | 5 198 427 | 5 304 362 |
| Light Commercial Vehicles | 290 461 | 591 823 | 960 124 | 1 177 894 | 1 255 037 | 1 210 303 | 1 200 552 | 1 240 029 | 1 262 274 |
| Heavy Duty Trucks | 52 054 | 79 076 | 108 924 | 115 517 | 107 452 | 93 413 | 102 618 | 110 983 | 112 240 |
| Buses | 6 209 | 8 405 | 11 946 | 13 851 | 14 666 | 14 255 | 14 464 | 14 807 | 14 375 |
| L-Category | 900 822 | 774 282 | 673 994 | 487 589 | 497 024 | 527 431 | 674 100 | 766 164 | 797 234 |
| **Total** | **2 802 458** | **3 970 001** | **5 301 140** | **5 756 882** | **6 260 426** | **6 457 020** | **6 998 011** | **7 330 410** | **7 490 484** |

* provisional data

Detailed information, regarding vehicle fleet, with information of Vehicle Category, Fuel, Segment and Euro Standard is presented in Annex B.

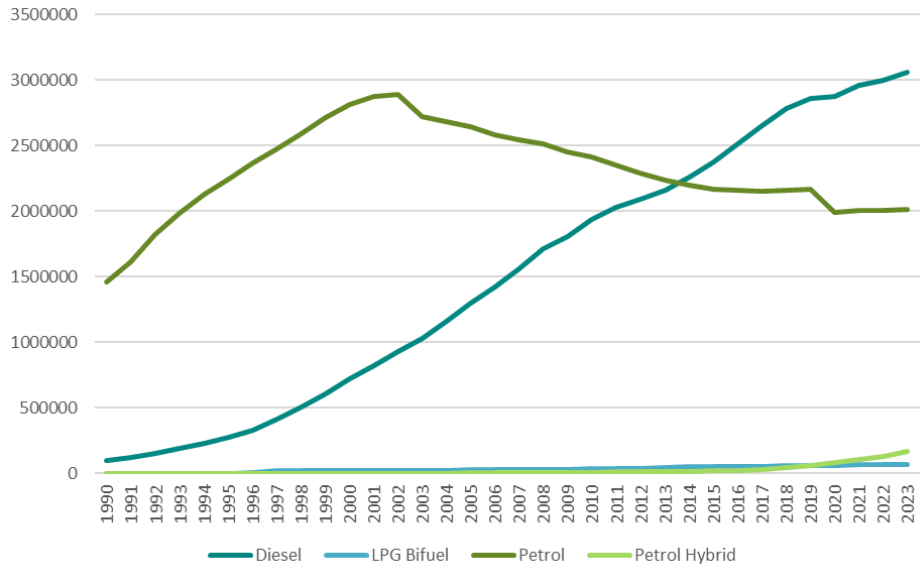



***Figure 3-40: Number of Passenger Cars by fuel type.***

The number of gasoline passenger cars has decreased over the last years. It was observed a decrease in the number of this type of vehicles while diesel passenger cars have increased. After an initial growth, LPG fuelled vehicles have stabilized as a small percentage of passenger cars.

#### 3.5.2.4.6 Distances Travelled

Distance travelled for each year for Passenger Cars, Light Commercial Vehicles, Heavy Duty Trucks and Buses was established using a model based on data from vehicle inspection centers. This model uses the total number of km made by each vehicle segment, considering the first registration date, and estimates the total kilometers traveled in a year, dividing the total km of a given vehicle by its age. For the period between 2003 and 2023 the total mileage figures are obtained directly from the inspection centers, while for the period from 1990 to 2002 a backcast method is used to estimate the km made by different vehicle category considering its age. This approach, although more complex and detailed, can be considered a trend extrapolation as defined in point 5.3.3.4. of Section 5.3 "Resolving Data Gaps" in Volume 1: General Guidance and Reporting Guidelines of the IPCC 2006 Guidelines In addition, an adjustment is made to the km traveled by each vehicle considering the national fuel sales reported in the energy balance, using an approach similar to that described in point 5.3.3.2 Surrogate Data.

For Mopeds and Motorcycles the average distance travelled was obtained by the TRACCS Project ().

Total road traffic activity has increased 98% between 1990 and 2023.

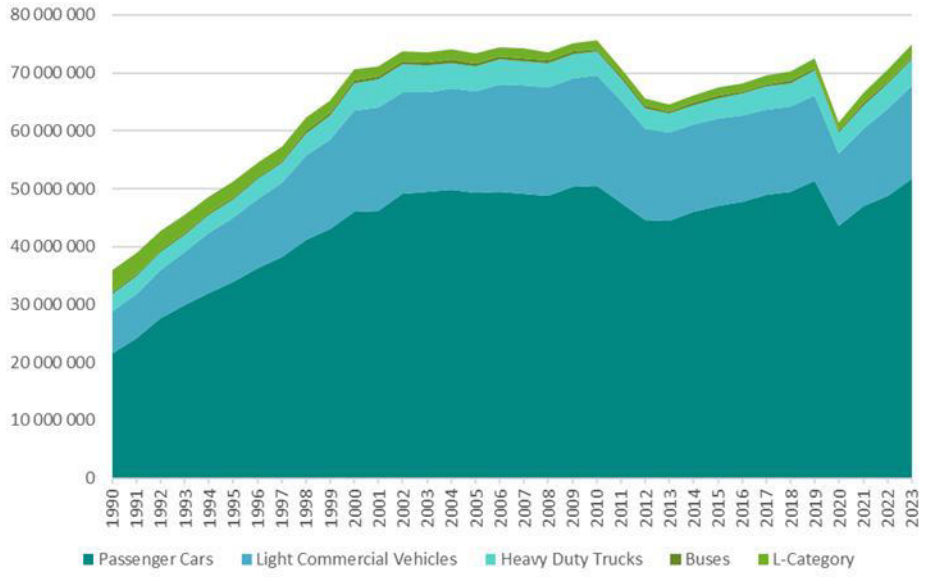



***Figure 3-41: Kilometers travelled by vehicle type (kvkm).***

Detailed information on total activity, for the period between 1990 and 2023, regarding different Vehicle Categories, Fuel types, Segments and Euro Standard is presented in Annex B.

#### 3.5.2.4.7 Circulation data

Three driving modes were individualized: urban, rural and highway.

The distance travelled were allocated to the driving modes. Information on Vehicle-kilometers (vkm) driven under highways derives from the *Instituto da Mobilidade e dos Transportes* (IMT) which is the technical regulator for mobility and transport. Originally this data is communicated to IMT by the highway service providers. The remaining vkm are allocated to urban and rural driving modes according with the population living in each area.

***Table 3-58: Assumed mileage percentage driven by driving mode and vehicle type for 2023.***

| Driving Mode | Vehicle Type | Assumed share |
|---|---|---|
| Highway | Passenger Car | 30.09% |
| | Light Duty Vehicles | 30.09% |
| | Heavy Duty Vehicles | 47.13% |
| | Urban Buses | 0.00% |
| | Coaches | 47.13% |
| | Mopeds | 0.00% |
| | Motorcycles | 30.09% |
| Rural | Passenger Car | 24.32% |
| | Light Duty Vehicles | 24.32% |
| | Heavy Duty Vehicles | 18.39% |
| | Urban Buses | 0.00% |
| | Coaches | 52.87% |
| | Mopeds | 34.79% |
| | Motorcycles | 24.32% |
| Urban | Passenger Car | 45.59% |
| | Light Duty Vehicles | 45.59% |
| | Heavy Duty Vehicles | 34.47% |
| | Urban Buses | 100.00% |
| | Coaches | 0.00% |
| | Mopeds | 65.21% |
| | Motorcycles | 45.59% |

For each driving mode average speeds had to be set by vehicle type whereas vehicle fuel consumption and exhaust emissions are strongly dependent on speed.

***Table 3-59: Assumed vehicle speeds by driving mode and vehicle type.***

| Driving Mode | Vehicle Type | Assumed Speed (km/h) | Source |
|---|---|---|---|
| Highway | Passenger Car | 124 | Lemonde, 2000 |
| | Light Duty Vehicles | 124 | Lemonde, 2000 |
| | Heavy Duty Vehicles | 103 | LNEC, 2002 |
| | Coaches | 103 | LNEC, 2002 |
| | Motorcycles | 124 | Lemonde, 2000 |
| Rural | Passenger Car | 61 | LNEC, 2002 |
| | Light Duty Vehicles | 61 | LNEC, 2002 |
| | Heavy Duty Vehicles | 56 | LNEC, 2002 |
| | Coaches | 56 | LNEC, 2002 |
| | Mopeds | 40 | Maximum Legal Value |
| | Motorcycles | 61 | LNEC, 2002 |
| Urban | Passenger Car | 24.9 | Gois et al., 2005 |
| | Light Duty Vehicles | 24.9 | Gois et al., 2005 |
| | Heavy Duty Vehicles | 24.9 | Gois et al., 2005 |
| | Buses | 14.8 | Carris, 2005 |
| | Coaches | 24.9 | Gois et al., 2005 |
| | Mopeds | 24.9 | Gois et al., 2005 |
| | Motorcycles | 24.9 | Gois et al., 2005 |

#### 3.5.2.5 Uncertainty Assessment

In accordance with the chapter of Road Vehicles in the GPG, the uncertainty of methane emission factor is 40% and the uncertainty for nitrous oxide should be at least 50%. The uncertainty in $CO_2$ is 5%, also in accordance with the same source of information. The uncertainty of activity data was assumed to be 5%.

#### 3.5.2.6 Category-specific QA/QC and verification

Energy consumption data from the Energy Balance reported by DGEG, the Total Fuel Sales imported to COPERT and the Total Fuel Consumption exported from COPERT were compared and no significant differences were found.

#### 3.5.2.7 Recalculations

A compilation error concerning 2021 fuel consumption for an airport was detected and corrected.

#### 3.5.2.8 Further Improvements

Continue with the efforts to develop country-specific parameters for gasoline and diesel oil in order to follow the UNFCCC recommendations.

## 3.5.3 Railways (CRT 1.A.3.c)

*Mariana Moreira*

*Updated: March 2026*

### 3.5.3.1 Category description

Although there has been a growing electrification of railway lines in Portugal during latest years, locomotives, shunting locomotives and railcars are still responsible for substantial part of rail transport and consequent emission of GHG in exhaust.

***Table 3-60: Estimated emissions from Railways (Gg $CO_2e$).***

| Source Category/Pollutant | 1990 | 2005 | 2021 | 2022 | 2023 | **2024** |
|---|---|---|---|---|---|---|
| **Railways** | **195.6** | **90.9** | **27.9** | **24.1** | **26.5** | **26.3** |
| $CO_2$ | 177.2 | 82.4 | 25.1 | 21.7 | 23.9 | 23.7 |
| $CH_4$ | 0.3 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| $N_2O$ | 18.1 | 8.4 | 2.8 | 2.4 | 2.6 | 2.6 |

*Information item. Emissions not included in national totals.

### 3.5.3.2 Methodology

Emissions to atmosphere of ultimate $CO_2$ from fossil origin were estimated from $CO_2$ total emissions by:

$$Fossil_{CO2(y)} = \sum_f [EF_{CO2\,(f)} * Fac_{OX\,(f)} * C_{Fossil(f)} * Cons_{Fuel(f,y)} * LHV_{(f)}] * 10^{-5}$$

**Where:**

$Fossil_{CO2(y)}$ - Emissions of carbon dioxide to atmosphere from combustion of fossil fuel f (t);

$EF_{CO2\,(f)}$ – Total carbon content of fuel expressed in total $CO_2$ emissions ($kgCO_2/GJ$);

$C_{Fossil}$ - Percentage of carbon from fossil origin in fuel f (%);

$Fac_{OX(f)}$ – Oxidation factor for fuel f (ratio 0..1);

$Cons_{Fuel(f,y)}$ - Consumption of fuel f in year y (t/yr);

$LHV_{(f)}$ - Low Heating Value (MJ/kg).

For all other pollutants the following formula was used:

$$Emission_{(p,y)} = \sum_f [EF_{(f,p)} * Cons_{Fuel(f,y)}] * 10^{-3}$$

**Where:**

$Emission_{(p,y)}$ - Emission of pollutant p in year y (t/yr);

$EF_{(f,p)}$ - Quantity of pollutant p emitted from fuel f (kg/t);

$Cons_{Fuel(n,f,y)}$ - consumption of fuel f during in year y (t/yr).

### 3.5.3.3 Emission Factors

Emission factors were set from available proposed emission factors in IPCC 2006 Guidelines.

***Table 3-61: Low Heating Value (LHV) – Railways.***

| Fuel | Fuel type | Low Heating Value | |
|---|---|---|---|
| | | Value | Unit |
| Sub-bituminous Coal | S | 24.66 | MJ/kg |
| Coaking Coal | S | 30.81 | MJ/kg |
| Diesel-oil | L | 43.00 | MJ/kg |
| Biodiesel | B | 37.00 | MJ/kg |

Source: DGEG

***Table 3-62: Oxidation factor and Percentage of carbon from fossil origin in fuels – Railways.***

| Fuel | Oxidation Factor | | % C Fossil | |
|---|---|---|---|---|
| | Value | Unit | Value | Unit |
| Sub-bituminous Coal | 1.00 | MJ/kg | 100 | % |
| Coaking Coal | 1.00 | MJ/kg | 100 | % |
| Diesel-oil | 1.00 | MJ/kg | 100 | % |
| Biodiesel | 1.00 | MJ/kg | 100 | % |

***Table 3-63: Emission factors for Greenhouse gases in Railways.***

| Fuel | $CO_2$ EF | | $CH_4$ EF | | $N_2O$ EF | |
|---|---|---|---|---|---|---|
| | Value | Unit | Value | Unit | Value | Unit |
| Sub-bituminous Coal | 96.1 | kg/GJ | 0.002 | kg/GJ | 0.002 | kg/GJ |
| Coaking Coal | 96.1 | kg/GJ | 0.002 | kg/GJ | 0.002 | kg/GJ |
| Diesel-oil | 74.1 | kg/GJ | 0.004 | kg/GJ | 0.028 | kg/GJ |
| Biodiesel | 70.8 | kg/GJ | 0.004 | kg/GJ | 0.028 | kg/GJ |

Source: 2006 IPCC Guidelines - Volume 2: Energy - 1A Mobile Combustion (Table 3.4.1)

### 3.5.3.4 Activity Data

Consumption of fuel in the railway transport sector is available by fuel type from 1990 to 2023 from the energy balance. Besides some very small use of coal and coke until 1996, the majority of combustible energy refers to use of gas oil[20]. The quantities that were consumed have been decreasing steadily since 1992 due to electrification of the power lines, as can be seen in the next Figure.

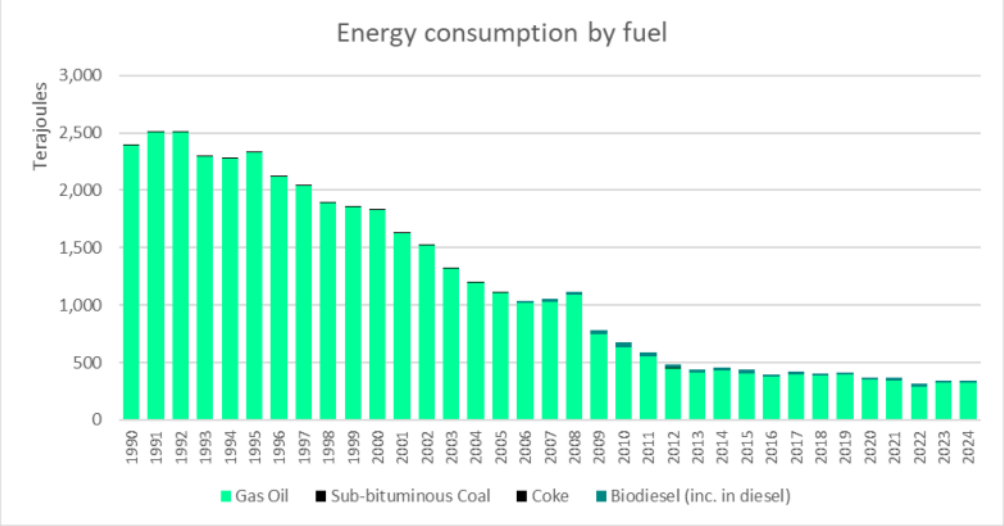



***Figure 3-42: Consumption of fuels in the railway transport sector.***

[20] Gas oil represents no less than 93 % of total annual use of combustible energy.

Between 1990 and 1997, there was a decrease in the consumption of coal in rail transport that accompanies a process of electrification of the rail network. The abrupt increase since 1998 is explained by a Locomotive that operated only for tourist purposes between 1998 and 2012 on the Douro Line. The consumption of this locomotive would be of the order of 1.5 tons of coal per trip, having taken about 20 trips/year, so Portugal assumed a consumption of 20 toe/year for the activity of this vehicle.

As of 2006, the diesel consumed by rail transport has incorporated biodiesel, similarly to what happens with road transport, however this diesel is colored and marked and the supply is made directly at some railway stations with their own tanks. Below is the annual import rate considered for the period between 2006 and 2023.

***Table 3-64: Incorporation rate of biodiesel (% toe/toe)***

| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Incorporation rate | 1.31 | 2.50 | 2.43 | 4.16 | 6.03 | 6.25 | 6.20 | 6.05 | 5.93 | |
| | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2023** | **2024** |
| Incorporation rate | 6.81 | 5.15 | 5.10 | 5.49 | 5.43 | 5.76 | 7.24 | 6.55 | 5.85 | 5.85 |

### 3.5.3.5 Uncertainty Assessment

The uncertainty of fuel consumption was set equal to the uncertainty that was also considered for road traffic: 5 %. In a similar way the uncertainties in methane and nitrous oxide emission factors were set at 40 % and 50 % respectively, the same values that were used for road traffic. The general error of 5 %, set for most combustion sources, was used for the calculation of uncertainties of carbon dioxide emissions.

### 3.5.3.6 Category-specific QA/QC and verification

General revision of time series consistency for fuel consumption and emission factors was the only QA/QC procedure adopted for this sector.

### 3.5.3.7 Recalculations

The changes between submissions result from the update of Energy Balances data provided by DGEG and the incorporation rate of biodiesel, between years 2018 and 2023.

### 3.5.3.8 Further Improvements

No further improvements are planned for this sector.

## 3.5.4 Water-Borne Navigation (CRT 1.A.3.d)

### 3.5.4.1 Category description

This sector refers to domestic ship transport between Portuguese ports including traffic to the Azores and Madeira islands.

***Table 3-65: Estimated emissions from Water-Borne Navigation (kt $CO_2$ eq).***

| Source Category/Pollutant | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|
| **Domestic Water-Borne Navigation** | **265.0** | **229.4** | **203.3** | **211.2** | **231.3** | **285.5** | **203.8** | **280.4** | **295.3** |
| $CO_2$ | 262.5 | 227.3 | 201.4 | 209.2 | 229.1 | 282.8 | 201.9 | 277.8 | 292.6 |
| $CH_4$ | 0.7 | 0.6 | 0.5 | 0.5 | 0.6 | 0.7 | 0.5 | 0.7 | 0.8 |
| $N_2O$ | 1.8 | 1.6 | 1.4 | 1.5 | 1.6 | 2.0 | 1.4 | 1.9 | 2.0 |
| **International Water-Borne Navigation*** | **1 413.2** | **1 129.4** | **1 682.8** | **1 567.8** | **1 650.0** | **2 042.8** | **2 213.0** | **2 253.8** | **1 820.8** |
| $CO_2$ | 1 400.0 | 1 118.8 | 1 667.0 | 1 553.1 | 1 634.5 | 2 023.7 | 2 192.2 | 2 232.6 | 1 803.7 |
| $CH_4$ | 3.6 | 2.9 | 4.3 | 4.0 | 4.2 | 5.2 | 5.6 | 5.7 | 4.6 |
| $N_2O$ | 9.7 | 7.8 | 11.5 | 10.7 | 11.3 | 14.0 | 15.2 | 15.5 | 12.5 |

*Memo item. Emissions not included in national totals

For recreational craft, since it is not possible to separate consumption in the Energy Balance, we consider that emissions may also be included in Road Transport (1.A.3.b) and National Fishing (1.A.4.c.iii).

### 3.5.4.2 Methodology

The methodology used for the calculation of emissions from shipping activities is in accordance with the ship movement methodology from the detailed methodology of EMEP/CORINAR air pollutant emission inventory guidebook (version from August 2002). This methodology takes into account ship movement data, fuel used as well as the type of ship, the distance travelled and the speed of vessel. Therefore, according with IPCC Guidelines, this approach consists in a detailed method (tier 2 or 3). Since fuel consumption is used for top-down calibration, tier 2 method could be regarded as the method used to estimate emissions from shipping activities.

The general approach could be described as follows:

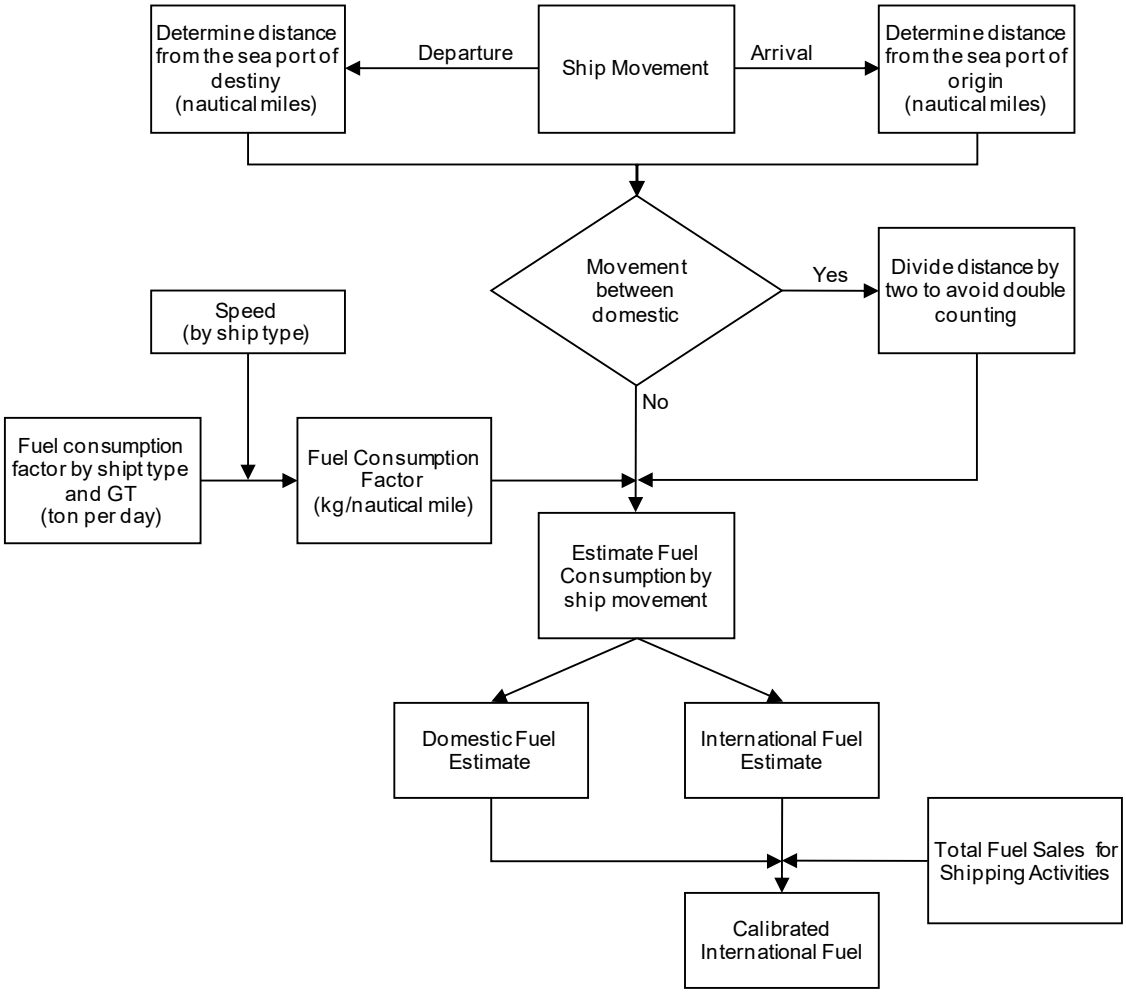



***Figure 3-43: Generic methodology flowchart.***

For each dock (which includes one arrival and one departures) is possible to calculate domestic and international distance and fuel consumtion.

Domestic and international fuel consumption is estimated with a bottom-up approach using the fuel consumption factors and distance travelled by each ship. The fuel consumption factores, in tonne/day, is calculated with the gross tonnage of each ship and coverted to kg/nautical mikes with the ship speed. Detailed ship movements and ships technical information (such as gross tonnage, ship type and speed) is provided by National Seaports.

The international fuel consumption estimated is calibrated with the total fuel sales data from the energy balance provided by the energy authority (DGEG). This top down calibration does not affect the domestic fuel consumption estimated whith the bottom-up approach.

Domestic navigation also takes into account the tugs fuel consumption for each maneuvering.

Since emissions factors vary according with the type of fuel, to distinguish between residual and distillate fuel we consider the fraction of destilate fuel oil and residual fuel oil sold in marine bunkers.

### 3.5.4.3 Emission Factors

Emission factors and energy content were obtained from several sources. The energy content of residual and distillate fuels was provided by the energy authority (DGEG). The carbon emission factors, expressed in t/TJ, and the $CH_4$ and $N_2O$ emission factors were obtained from IPCC 2006 Guidelines.

***Table 3-66: Low Heating Value (LHV) – Navigation.***

| Fuel | | NAPFUE | LHV |
|---|---|---|---|
| | | | MJ/kg |
| Gas-oil | L | 204 | 42.60 |
| Residual Fuel-oil | L | 203 | 40.00 |

Source: DGEG

***Table 3-67: Carbon content – Navigation.***

| Fuel | Default carbon content | | |
|---|---|---|---|
| | Value | Unit | Reference |
| Gas-oil | 20.20 | t/TJ | IPCC 2006 |
| Residual Fuel-oil | 21.10 | t/TJ | IPCC 2006 |

***Table 3-68: Emission factors for Greenhouse gases – Navigation.***

| Fuel | $CO_2$ | | | $CH_4$ | | | $N_2O$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | Value | Unit | Reference | Value | Unit | Reference | Value | Unit | Reference |
| Gas-oil | 74.1 | t /TJ | IPCC 2006 | 7.0 | kg/TJ | IPCC 2006 | 2.0 | kg/TJ | IPCC 2006 |
| Residual Fuel-oil | 77.4 | t /TJ | IPCC 2006 | 7.0 | kg/TJ | IPCC 2006 | 2.0 | kg/TJ | IPCC 2006 |

The fuel consumption factors (expressed in tonne per day) are dependent from the ship type and from the gross tonnage. The equations used to derive fuel consumption factors were obtained from IPCC 2006.

***Table 3-69: Consumption factors.***

| Ship Type | Consumption at full power (tonne/day)[(a)] |
|---|---|
| Solid bulk | 20.186 + 0.00049 × gt |
| Liquid bulk | 14.685 + 0.00079 × gt |
| General cargo | 9.8197 + 0.00143 × gt |
| Container | 8.0552 + 0.00235 × gt |
| Passenger/Ro-Ro/Cargo | 12.834 + 0.00156 × gt |
| Passenger | 16.904 + 0.00198 × gt |
| High speed ferry | 39.483 + 0.00972 × gt |
| Inland cargo | 9.8197 + 0.00143 × gt |
| Sail ships | 0.4268 + 0.00100 × gt |
| Tugs | 5.6511 + 0.01048 × gt |
| Fishing | 1.9387 + 0.00448 × gt |
| Other ships | 9.7126 + 0.00091 × gt |
| All ships | 16.263 + 0.001 × gt |

Legend:
gt – gross tonnage
[(a)] – a factor of 0.8 was applied to obtain consumption for cruise.
Source: (IPCC 2006)

### 3.5.4.4 Activity Data

#### 3.5.4.4.1 Ships movements in national sea ports

The activity data from navigation is based on ship movement for individual ships in each national seaport comprehending nine ports in Portugal mainland and four in islands of Madeira and Azores.

The data provided by national seaports reports to the years 1990 and 1995; and to the period between 2000 and 2023. The number of movements and the distances travelled for the period 1991-1994 and 1996-1999 were estimated according with an interpolation established between years with available data.

For most cases, data on origin and destiny was also available per movement which allowed to estimate the distances travelled and to distinguish between domestic and international movements.

***Table 3-70: Ship docks.***

| Sea Port | Location | Unit | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Aveiro | Mainland | docks | 876 | 1 098 | 1 009 | 1 028 | 961 | 1 025 | 990 | 1 073 | 1 021 |
| Caniçal | Madeira | docks | 76 | 76 | 76 | 178 | 390 | 241 | 246 | 265 | 276 |
| Faro | Mainland | docks | 163 | 163 | 163 | 32 | 12 | 85 | 46 | 20 | 23 |
| Figueira da Foz | Mainland | docks | 315 | 297 | 307 | 321 | 476 | 496 | 484 | 475 | 442 |
| Funchal | Madeira | docks | 1 063 | 1 063 | 1 063 | 948 | 758 | 664 | 382 | 742 | 732 |
| Leixões | Mainland | docks | 2 742 | 2 896 | 3 050 | 2 814 | 2 612 | 2 735 | 2 477 | 2 434 | 2 391 |
| Lisboa | Mainland | docks | 5 586 | 4 993 | 3 869 | 3 474 | 3 129 | 2 605 | 1 661 | 2 492* | 2 236 |
| Ponta Delgada | Azores | docks | 1 080 | 1 080 | 1 080 | 1 078 | 1 035 | 831 | 684 | 845 | 879 |
| Portimão | Mainland | docks | 34 | 34 | 37 | 42 | 136 | 70 | 4 | 61 | 54 |
| Porto Santo | Madeira | docks | 402 | 402 | 402 | 400 | 392 | 348 | 318 | 392 | 396 |
| Setúbal | Mainland | docks | 1 453 | 1 453 | 1 699 | 1 592 | 1 632 | 1 627 | 1 598 | 1 560 | 1 683 |
| Sines | Mainland | docks | 1 038 | 979 | 808 | 1 124 | 1 632 | 2 173 | 1 995 | 1 912 | 1 865 |
| Viana do Castelo | Mainland | docks | 254 | 293 | 348 | 214 | 179 | 198 | 202 | 244 | 225 |

* provisional data

### 3.5.4.4.2 Ship Fleet

The fleet from the figure below refers to all ships that docked in national seaports irrespective of domestic or international movements.

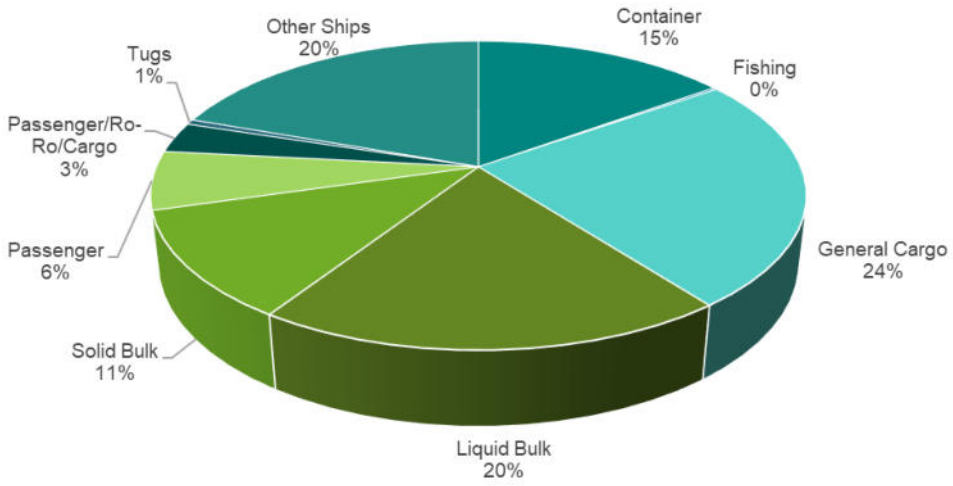



***Figure 3-44: Ship fleet.***

### 3.5.4.4.3 Fuel consumption

Fuel consumption is estimated with a bottom-up approach using fuel consumption factors combined with a top-down calibration with the energy balance. In a first step, domestic and international consumption are estimated with the bottom up approach. Then the international consumption is re-calculated by subtracting the estimated domestic consumption from the total sales reported in the energy balance, this is considered the top down calibration. This calibration does not affect the domestic fuel consumption calculated with the bottom-up approach.

$$FuelConsumption_{International} = FuelSales - FuelConsumption_{Domestic}$$

***Table 3-71: Total fuel sales (ton).***

| Fuel Sales | | NAPFUE | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Gas-oil | L | 204 | 126 903 | 141 272 | 125 554 | 110 197 | 94 064 | 139 277 | 157 452 | 198 044 | 191 755 |
| Residual Fuel-oil | L | 203 | 407 823 | 290 920 | 475 743 | 457 115 | 506 320 | 603 295 | 613 084 | 609 283 | 481 863 |

Source: DGEG

***Table 3-72: Estimated fuel consumption (ton).***

| Fuel | Region | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|
| Residual Fuel-oil | Domestic | 61 244 | 53 023 | 46 988 | 48 804 | 53 458 | 65 968 | 47 037 | 64 802 | 68 250 |
| Residual Fuel-oil | International | 431 554 | 448 716 | 430 253 | 411 428 | 515 738 | 805 707 | 782 099 | 716 783 | 806 255 |
| **Residual Fuel-oil** | **Total** | **492 797** | **501 739** | **477 242** | **460 233** | **569 196** | **871 676** | **829 136** | **781 585** | **874 506** |
| Gas-oil | Domestic | 23 132 | 20 027 | 17 748 | 18 434 | 20 192 | 24 917 | 17 766 | 24 476 | 25 779 |
| Gas-oil | International | 163 002 | 169 485 | 162 511 | 155 401 | 194 799 | 304 324 | 295 407 | 270 736 | 304 531 |
| **Gas-oil** | **Total** | **186 135** | **189 512** | **180 259** | **173 835** | **214 991** | **329 241** | **313 173** | **295 213** | **330 310** |

***Table 3-73: Estimated fuel consumption after top-down calibration (ton).***

| Fuel | Region | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|
| Residual Fuel-oil | Domestic | 61 244 | 53 023 | 46 988 | 48 804 | 53 458 | 65 968 | 47 037 | 64 802 | 68 250 |
| Residual Fuel-oil | International | 346 579 | 237 897 | 428 754 | 408 311 | 452 862 | 537 327 | 566 047 | 544 482 | 413 613 |
| **Residual Fuel-oil** | **Total** | **407 823** | **290 920** | **475 743** | **457 115** | **506 320** | **603 295** | **613 084** | **609 283** | **481 863** |
| Gas-oil | Domestic | 23 132 | 20 027 | 17 748 | 18 434 | 20 192 | 24 917 | 17 766 | 24 476 | 25 779 |
| Gas-oil | International | 103 770 | 121 244 | 107 806 | 91 763 | 73 872 | 114 360 | 139 685 | 173 568 | 165 976 |
| **Gas-oil** | **Total** | **126 903** | **141 272** | **125 554** | **110 197** | **94 064** | **139 277** | **157 452** | **198 044** | **191 755** |

#### 3.5.4.4.3.1 Tugs Fuel consumption

Data concerning tugs assistance operations within the national seaports allowed the incorporation of these emissions in the inventory. Tug fuel consumption was estimated for each manoeuvering ship in a seaport following the criteria shown in the next Table. Specific tug fuel consumption factors were supplied by DGRM.

***Table 3-74: Criteria employed in the tugs fuel consumption estimation.***

| Ship Type | Seaport | Assisted Arrivals (%) | Assisted Departures (%) | N.º Of Tugs/Arrival | N.º Of Tugs/Departure |
|---|---|---|---|---|---|
| Small Size | All | 20 | 0 | 1 | 0 |
| Medium Size | All | 50 | 25 | 1 | 1 |
| Large Size | All | 100 | 100 | 2 | 1 |
| Super Large Size | Sines and Leixões | 100 | 100 | 3 | 2 |
| Super Large Size | All except Sines and Leixões | 100 | 100 | 2 | 2 |

This estimation required the ship size classification expressed in table below.

***Table 3-75: Ship type classification for tugs fuel consumption estimation.***

| Ship Type | gt |
|---|---|
| Small Size | gt≤1000 |
| Medium Size | 10000≤gt<1000 |
| Large Size | 50000≤gt<10000 |
| Super Large Size | gt>50000 |

gt: gross tonnage

Finally, the fuel consumption was added to the ship that needed the tugs service. The fuel tables presented above include fuel consumption in tugs operations.

### 3.5.4.5 Uncertainty Assessment

Activity level uncertainty refers to the fuel consumption uncertainty which depends on the number of movements, the distance travelled and fuel consumption factors. The global uncertainty is therefore obtained from:

$$U_{global} = \sqrt{U_{movements}^2 + U_{distance}^2 + U_{FC}^2}$$

Movement's uncertainty was assumed to be 5% as suggested in IPCC Good Practice Guidance and Uncertainty Management. The distance uncertainty was calculated assuming that ships speeds were constant between origin and destiny seaports. This allows the indirect assessment of the uncertainty trough the travelling time between seaports. For the same OD it is possible to estimate uncertainty according with differences between travelling times performed by the same type of ships. Finally, it was assumed an uncertainty of 48% for fuel consumption factors proposed by EMEP/EEA. Activity level uncertainty was estimated about 50% as referred in the next Table.

***Table 3-76: Navigation activity level uncertainty.***

| Source | Parameter | Value |
|---|---|---|
| All | Uglobal | 50% |
| Movements | Umovements | 5% |
| Distance Travelled | Udistance | 15% |
| Fuel Consumtion Factor | Ufc | 48% |

Following the recommendations of GPG the uncertainties of emission factor for $CH_4$ and $N_2O$, and for all types of vessels and navigation, were set respectively to 100% and 1000%.

### 3.5.4.6 Category-specific QA/QC and verification

Energy consumption was compared with data from the energy balance reported by DGEG. No differences were found between total fuel estimated with the described methodology and total fuel reported in the energy balance.

### 3.5.4.7 Recalculations

No recalculations were made.

### 3.5.4.8 Further Improvements

No further improvements are planned for this sector.

### 3.5.5 Other Mobile Sources (CRT 1.A.3.e)

#### 3.5.5.1 Category description

Pipeline transportation activities in Portugal are exclusively supported by electricity, therefore no combustion emission are considered in 1.A.3.e.i (Pipeline Transport)

Fuel consumption for off-road (1.A.3.e.ii), like ground activities in airports and offroad activities not otherwise reported under Agriculture (1.A.4.c) or Manufacturing Industries and Construction (1.A.2), is reported in the Portuuguese Energy Balance under the item “Serviços” and the related combustion emission are included in the category Commercial/Institutional (under Other Sectors – 1.A.4) because is not possible to separate the fuel consumption for this sectors in the Energy Balance.

## 3.6 Other Sectors (CRT 1.A.4)

### 3.6.1 Category description

This source category refers to combustion in stationary and mobile sources (off-road) equipments that occur in commercial/institutional, residential, and agriculture/forestry/fishing activity sectors. The following stationary combustion equipments were included in this sector: boilers, co-generation equipment, machines and static engines are included in sector. Also included in 1.A.4 are emissions from fisheries bunkers and off road-road vehicles in agriculture/ forestry sector. Emissions resulting from mobile equipment associated with the "Commercial / Institutional" and "Residential" sub-sectors are also considered.

In the 2020 submission there was a thorough review of the methodology for estimating GHG emissions for this category. This involved estimating new sub-categories, reviewing activity data and updating emission factors.

In the table below it is possible to consult the subcategories considered in Other Sectors (CRT 1.A.4).

***Table 3-77: Subcategories considered and coverage of estimated Greenhouse gases***

| CRT Category | Categories | GHG's coverage | Source Category |
|---|---|---|---|
| 1A4ai | **Commercial/institutional:** Stationary combustion | $CO_2$, $CH_4$ and $N_2O$ | Industrial & commercial combustion<br>Public sector combustion<br>Railways - stationary combustion |
| 1A4aii | **Commercial/institutional:** Off-road vehicles and other machinery | $CO_2$, $CH_4$ and $N_2O$ | Commercial mobile sources |
| 1A4bi | **Residential:** Stationary combustion | $CO_2$, $CH_4$ and $N_2O$ | Domestic combustion |
| 1A4bii | **Residential**: Household and gardening | $CO_2$, $CH_4$ and $N_2O$ | House and garden machinery |
| 1A4ci | **Agriculture/Forestry/Fishing**: Stationary combustion | $CO_2$, $CH_4$ and $N_2O$ | Agriculture and Fishing stationary combustion |
| 1A4cii | **Agriculture/Forestry/Fishing:** Off-road vehicles and other machinery | $CO_2$, $CH_4$ and $N_2O$ | Agriculture - tractors and mobile machinery |
| 1A4ciii | **Agriculture/Forestry/Fishing:** National fishing | $CO_2$, $CH_4$ and $N_2O$ | Fishing Vessels |

In 2024, the Other Sectors category accounted for 4.16 Mt (8.1%) of Portugal's total GHG emissions, with a 0.5% (0.02 Mt) increase in overall emissions since 1990 (refer to Table 3–78 for more details). Within the Other Sectors category, 1.82 Mt (43.7%) of the GHG emissions are from the Residential sector, this subcategory is followed by, in order of decreasing contributions, Agriculture/Forestry/Fishing (1.35 Mt, 32.4%), and Commercial/institutional (0.99 Mt, 23.8%) subcategories.

***Table 3-78: Estimated emissions from Other Sectors (Gg $CO_2$ eq.)***

| | Source /Gas | 1990 | 2005 | 2022 | 2023 | 2024 | Δ 2024-2023 | Δ 2024-2005 | Δ 2024-1990 |
|---|---|---|---|---|---|---|---|---|---|
| | | kt $CO_2$ eq. | | | | | % | | |
| **1.A.4.a** | **Commercial/institutional** | | | | | | | | |
| | $CO_2$ | 704.5 | 3,024.7 | 982.5 | 1,137.9 | 982.8 | -13.6 | -67.5 | 39.5 |
| | $CH_4$ | 1.0 | 1.7 | 0.9 | 0.9 | 0.9 | 0.9 | -45.5 | -5.5 |
| | $N_2O$ | 2.3 | 10.2 | 8.2 | 11.0 | 8.2 | -25.0 | -19.2 | 257.6 |
| **1.A.4.b** | **Residential** | | | | | | | | |
| | $CO_2$ | 1,639.9 | 2,388.9 | 1,587.5 | 1,287.6 | 1,505.4 | 16.9 | -37.0 | -8.2 |
| | $CH_4$ | 479.4 | 293.1 | 235.9 | 239.6 | 229.4 | -4.2 | -21.7 | -52.1 |
| | $N_2O$ | 151.7 | 102.4 | 85.3 | 86.5 | 83.7 | -3.3 | -18.3 | -44.8 |
| **1.A.4.c** | **Agriculture / Forestry / Fishing** | | | | | | | | |
| | $CO_2$ | 1,118.9 | 1,303.0 | 1,229.4 | 1,271.6 | 1,288.0 | 1.3 | -1.2 | 15.1 |
| | $CH_4$ | 2.2 | 2.0 | 2.6 | 2.7 | 2.8 | 1.2 | 36.6 | 24.7 |
| | $N_2O$ | 38.9 | 55.6 | 55.2 | 56.7 | 58.3 | 2.8 | 4.8 | 50.0 |
| Total | $CO_2$ | 3,463.3 | 6,716.6 | 3,799.4 | 3,697.1 | 3,776.3 | 2.1 | -43.8 | 9.0 |
| | $CH_4$ | 482.6 | 296.8 | 239.4 | 243.3 | 233.1 | -4.2 | -21.5 | -51.7 |
| | $N_2O$ | 192.8 | 168.2 | 148.6 | 154.2 | 150.2 | -2.6 | -10.7 | -22.1 |
| Total | All gases | 4,138.8 | 7,181.6 | 4,187.5 | 4,094.6 | 4,159.6 | 1.6 | -42.1 | 0.5 |

Note: Totals may not sum due to independent rounding. Emissions values are presented in $CO_2$eq mass units using IPCC AR5 GWP values ($CH_4$ - 28; $N_2O$ - 265).

### *Key categories*

Four key categories have been identified for this sector in 2024, for level and trend assessment, using both the IPCC Approach 1 and Approach 2:

***Table 3-79: Key categories in Other Sectors (CRT 1.A.4) and methodologies used in emission estimates***

| IPCC category | Gas | Criteria | Method |
|---|---|---|---|
| **1.A.4 Combustion Other Sectors** - Liquid fuels | $CO_2$ | L,T | T1 |
| **1.A.4 Combustion Other Sectors** - Gaseous fuels | $CO_2$ | L,T | T2 |
| **1.A.4 Combustion Other Sectors** - Biomass | $CH_4$ | L,T | T2,T1 |
| **1.A.4 Combustion Other Sectors** - Liquid fuels | $N_2O$ | L,T | T2,T1 |

### 3.6.2 Methodology

This category underwent profound methodological changes during this submission, which allow to apply higher methodological tiers for estimating $CH_4$ and $N_2O$ emissions for key categories. It also allowed the separation between stationary combustion and mobile combustion for the Commercial / institutional and Residential subcategories. The table below summarizes the methodological approaches adopted and the main source of emissions for each sub-category.

***Table 3-80: Methodological approaches and main source of emissions for each sub-category***

| Categories | Method Approach | Main source of emissions |
|---|---|---|
| **Commercial/institutional** | | |
| 1A4ai - Stationary combustion | TIER 2 - Technology-specific<br>TIER 2 - Country specific<br>TIER 1 - Energy consumption | Combustion of diesel and natural gas in Commercial and Public plants for space heating |
| 1A4aii - Mobile | TIER 1 - Energy consumption | Combustion of liquid fuels in mobile sources |
| **Residential** | | |
| 1A4bi - Stationary combustion | TIER 2 - Technology-specific<br>TIER 2 - Country specific<br>TIER 1 - Energy consumption | Combustion of wood and LPG in households for space heating, water heating and cooking |
| 1A4bii - Household and gardening | TIER 1 - Energy consumption | Combustion of Liquid fuels in mobile sources |
| **Agriculture / Forestry / Fishing** | | |
| 1A4ci - Stationary combustion | TIER 2 - Technology-specific<br>TIER 2 - Country specific<br>TIER 1 - Energy consumption | Combustion of diesel for heating purposes |
| 1A4cii - Off-road vehicles and other machinery | TIER 1 - Energy consumption | Combustion of diesel in tractors and other agricultural machinery |
| 1A4ciii - National fishing | TIER 1 - Energy consumption | Combustion of diesel in deep sea and coastal fishing vessels |

To apply a TIER 2 methodology its required information on the fuels and technologies used in the sector. While fuel consumption, by this type of fuel, is easily obtained through the National Energy Balance, a consistent time series that correctly characterizes the split technology of this sector is not available.

Previously, the Inventory used as a source of information for the technological split, a survey on energy consumption in the Residential Sector (DGEG), which characterized only the year 2010.

Although the information was detailed regarding some of the thermal uses and equipment used, it failed in the task of portraying the time series.

Thus, in order to apply the Tier 2 methodology to these key categories, the Inventory relied on two sources of information:

- Appliance type split according to IIASA GAINS[21] model for years 2000, 2005 and 2010

- Thermal uses split according to JRC-IDEES [22]database between 2000 and 2015

In both cases, since this information does not cover the entire time series, the missing years have been estimated through interpolations and extrapolations. The result of this estimate can be found ahead in section 3.6.3.1 Technology Split.

IIASA's Appliance type split was applied only to wood combustion in the residential sector and allowed to disaggregate the consumption of wood by type of equipment.

The JRC-IDEES Database allowed to apply a split based on Thermal Use (space heating, water heating and cooking) for the most significant fuels in each sub-sector. In order to apply technology dependent emissions factors, it was chosen based on the 2010* Survey to the residential sector, which equipment is associated with each type of thermal use, thus having a better characterization of the appliances used in Portugal. The choice of end-use technology can be found in the section 3.2.6.4 Emission Factors.

Below we describe the methodological approaches considered for the estimation of emissions.

General Approach for Tier 2 Method

The Tier 2 approach for emissions from category 1.A.4 uses the general equation:

$$E_i = \sum_j \sum_k EF_{i,j,k} \cdot A_{j,k}$$

where

$E_i$ – annual emission of pollutant *i*,

$EF_{i,k,j}$ – default emission factor of pollutant i for appliance type j and fuel k,

$A_{j,k}$ – annual consumption of fuel k in appliance type j.

General Approach for Tier 1 Method

The Tier 1 approach for emissions from category 1.A.4 uses the general equation:

$$E_{pollutant} = AR_{fuelconsumption} \times EF_{pollutant}$$

where

$E_{pollutant}$ – the emission of the specified pollutant,

$AR_{fuelconsumption}$ – the activity rate for fuel consumption,

$EF_{pollutant}$ – the emission factor for this pollutant.

[21] Tables 3.36, 3.37 and 3.38 of EMEP/EEA Guidebook – 1A4 Small Combustion 2016

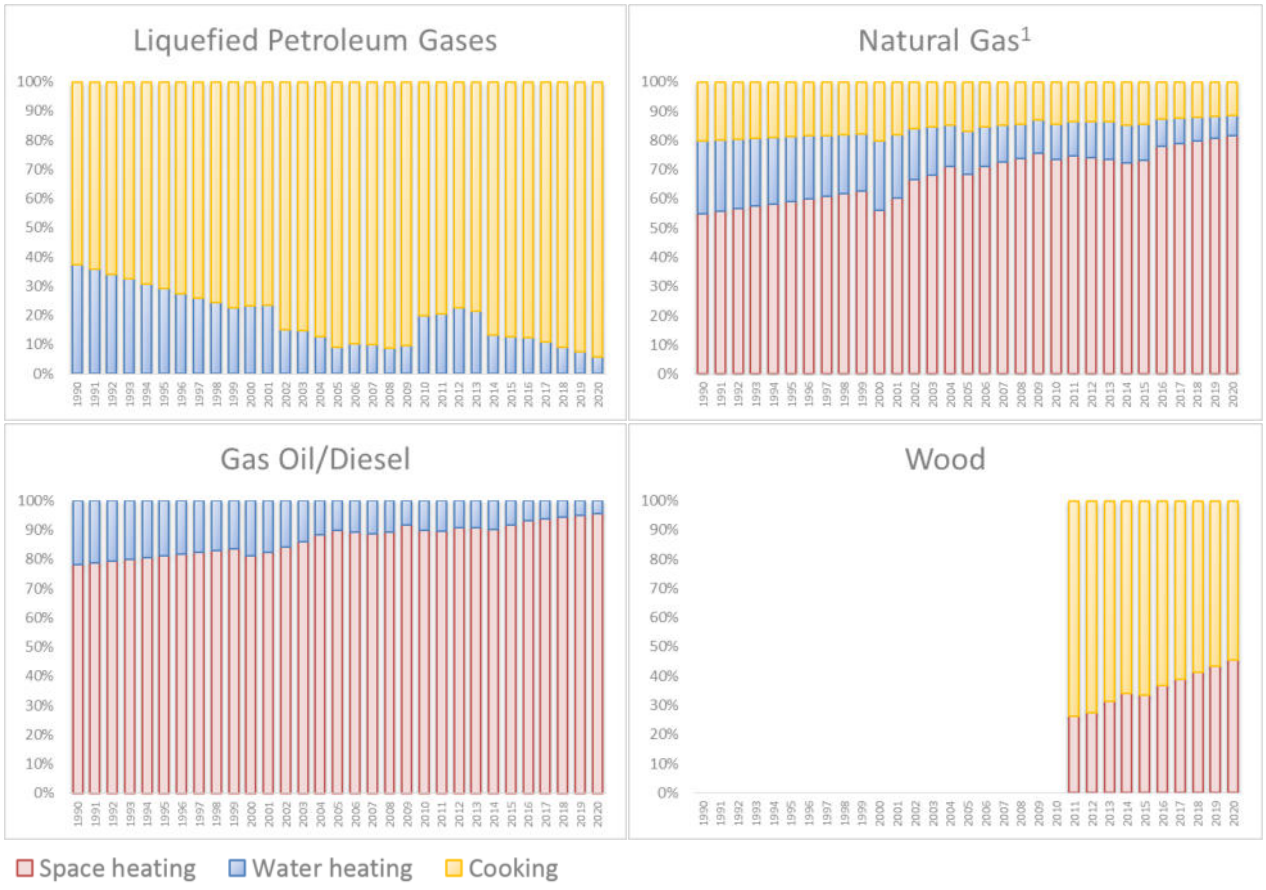
[22] JRC-IDEES is developed by the European Commission's Joint Research Centre and offers a consistent set of disaggregated energy-economy-environment historical time series from the year 2000 onwards for all EU Member States

### 3.6.3 Activity Data

#### 3.6.3.1 Technology Split

As explained in the previous point the technological split was made based on two different sources - IIASA GAINS Model and JRC-IDEES Database.

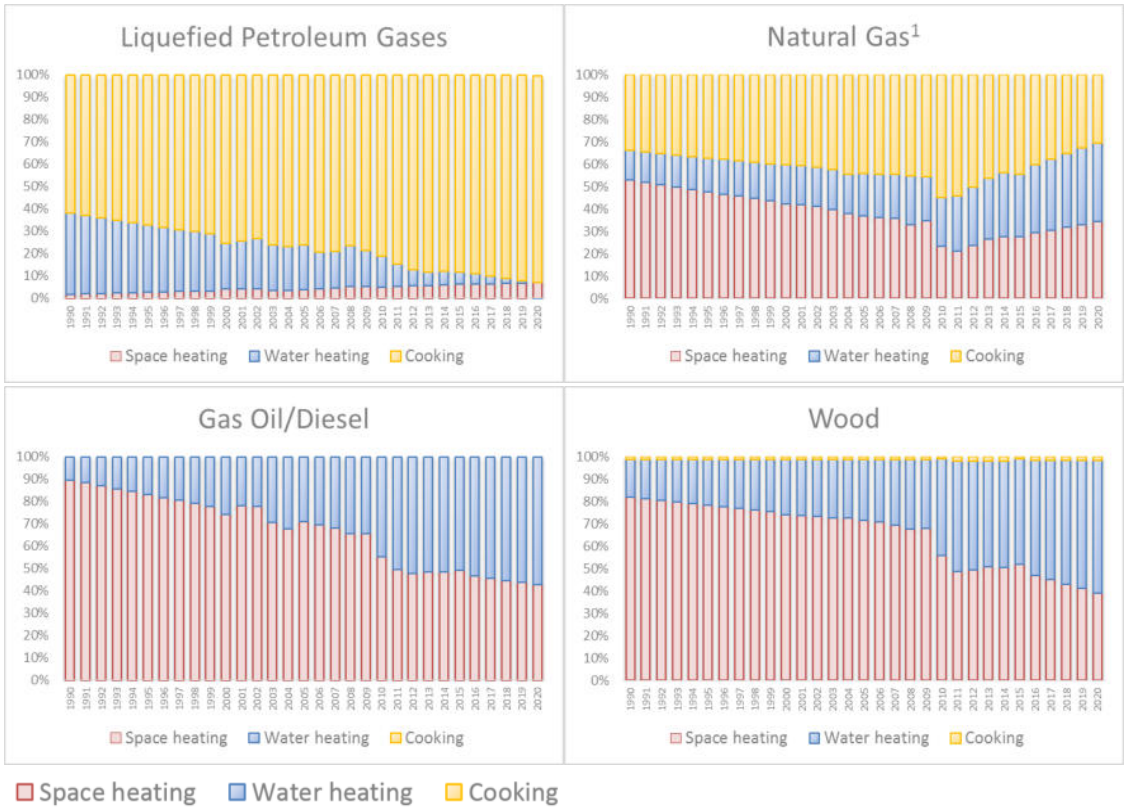
Commercial and Institutional sector, it is characterized on the one hand by the heating needs supplied by Diesel and Natural Gas in small plants of heat generation and by the other side by the consumption of LPG and Solid Biomass in the Restoration sector.




1 Include Gas Work Gas

***Figure 3-45: Split in Thermal Uses for Commercial/Institutional Sector***

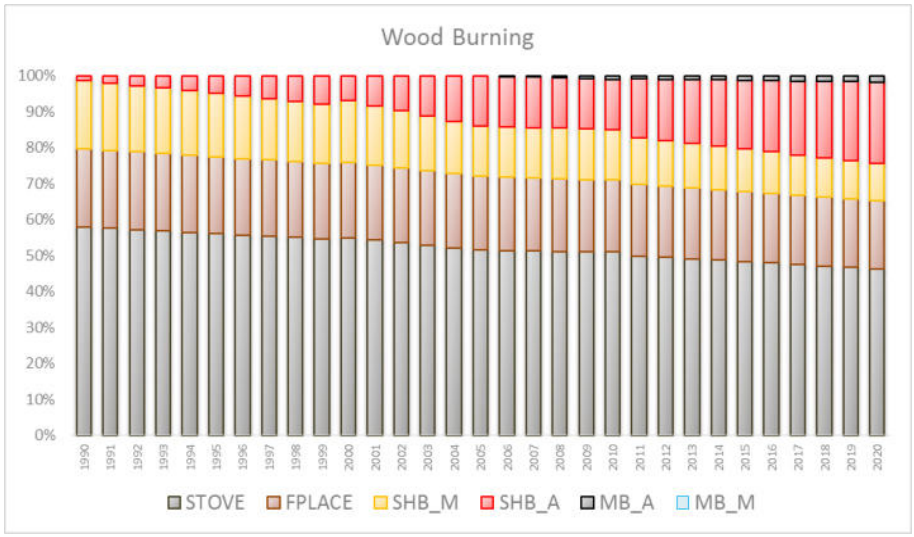
In the residential sector, the main fuels consumed are LPG and solid Biomass. Between the two are covered the three types of thermal uses. Since LPG is preferentially used in stoves intended for cooking, and the wood is burned in stoves, boilers and fireplaces for the purpose of space heating. Another trend observed between these two fuels is the use of wood in the heating of water from 2010, coinciding with the reduction of LPG consumption for this purpose. See figure below.




1 Includes Gas Work Gas

***Figure 3-46: Split in Thermal Uses for Residential Sector***

The figure below shows the split in appliances/tecnhologies considered for the residential combustion of wood. The main trend observed is the replacement of Conventional Stoves with more modern technologies like pellets stoves, pellets boilers and automatic boilers. Even so, the appliances used in Portugal can be considered as traditional since, even in recent years, conventional stoves and boilers as well as open fireplaces represent about 80% of the consumption of wood.




**STOVE** - Conventional stoves; **FPLACE** - Open fireplaces; **SHB_M** - Conventional boilers
**SHB_A** - Pellet stoves and boilers; **MB_A** - Automatic Boilers; **MB_M** - Wood combustion

***Figure 3-47: Split in appliances/technologies for Residential Sector – Wood Burning***

The methodological update made this year, allowed to separate more correctly the consumption of Diesel in the Agriculture sector. Until then, it was considered that all Diesel consumed in this sector was attributed to combustion in tractors and other off-road machines.

Using the information from JRC-IDEES Database, we can conclude that this assumption would be incorrect, and diesel consumption of these vehicles represents about 50% of the total diesel consumption of agricultural sector.

This correction in diesel consumption resulted in the allocation of emissions from the category Off-road vehicles and machinery (1A4cii) to the category Agriculture/Forestry/Fishing: Stationary (1A4ci). Assuming these allocated emissions refer to heating and pumping activities by stationary sources in agriculture.

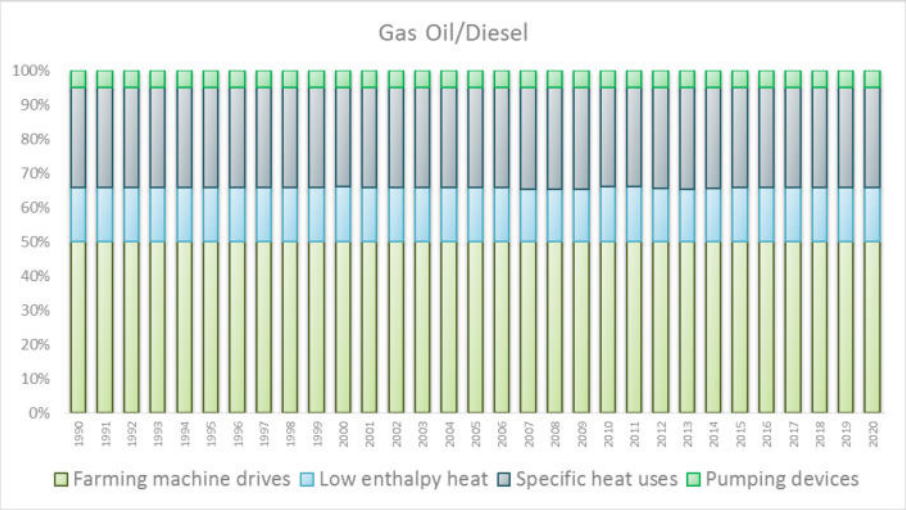



***Figure 3-48: Split in Thermal Uses for Agriculture Sector - Diesel***

### 3.6.3.2 Energy consumption

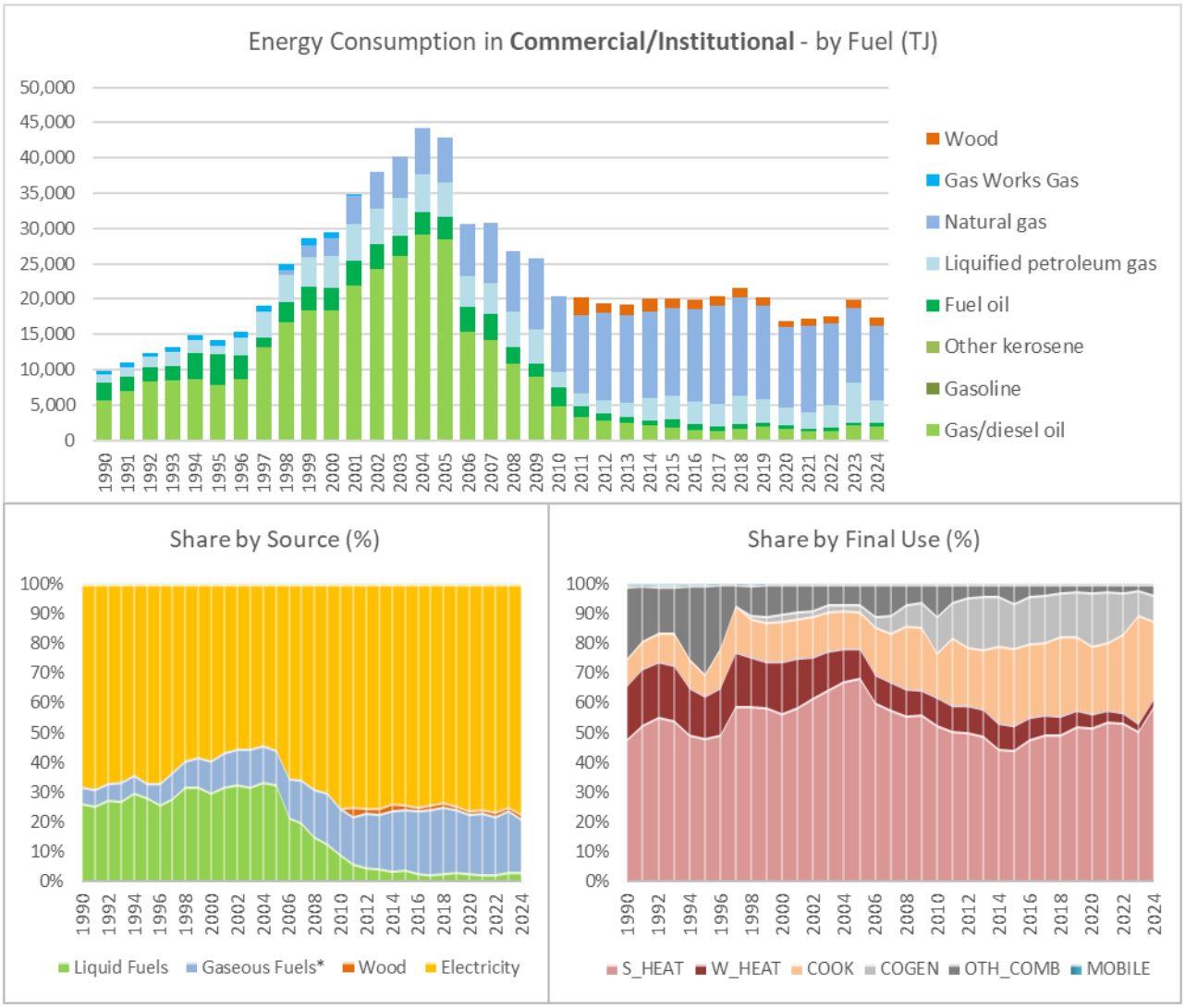
Data on fuel consumption was obtained from the annual energy balances compiled by DGEG and are presented in the following figures and ANNEX A.

**Commercial/Institutional**

Natural Gas, more recently, and Diesel, until 2010, are the main fuels used in the combustion that occurs in the Commercial sector. Both are generally used in the production of heat by small plants. As mentioned above, the consumption of diesel was higher in the period between 1990 and 2010, after which it was replaced by natural gas and electric heating solutions. This electrification trend also leads to a small increase of the cogeneration share in this sector.

Another use that has gained some preponderance in the last years has been the combustion for the purpose of cooking. Here the main fuel is the LPG that is supplied to the restaurant now through piped LPG or through propane and butane jars.

The Diesel/Gas Oil time series show a drop in consumption from 2005 to 2006. This fact results from reallocation, in the energy balance, of road gas oil from services not specified to agriculture (DGEG). There is a decrease in diesel oil consumption in 2010 for the services sector that results from the incorporation of data from the 2010 Survey on Energy Consumption in the Residential Sector. This decrease is coupled with an increase in diesel consumption in the residential sector.




S_HEAT: Space Heating; W_HEAT: Water Heating; COOK: Cooking; OTH_COMB: Other Combustion

***Figure 3-49: Energy consumption in Comercial/Institutional sector - by Fuel, Source and Final Use***

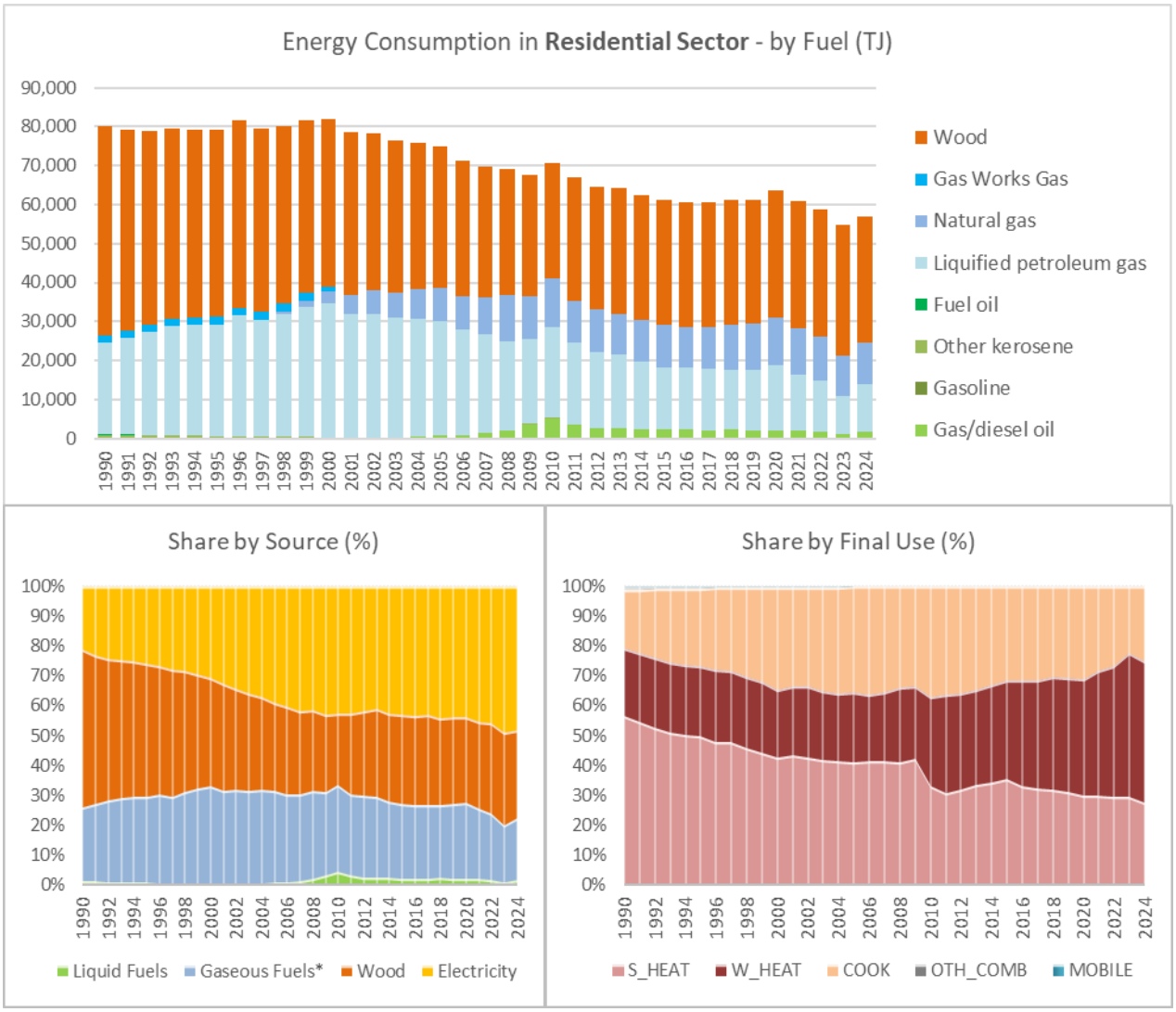
**Residential**

In the Residential sector, solid biomass and LPG are the main fuel consumed. With LPG being mainly used for the purpose of cooking, and the solid biomass being used for heating both water and space.

The trend of decreasing energy consumption in this sector has been largely due to its electrification. This situation has main importance in the reduction of wood consumption, since nowadays, the Portuguese population uses more electrified equipment's for space heating than in the 90s.

Also, Natural Gas has some highlight in the consumption of this sector, having gained market share through solutions that cover the entire spectrum of thermal solutions (space heating, water heating and cooking)

There is an increase in diesel oil consumption in 2010 for the residential sector that results from the incorporation of data from the 2010 Survey on Energy Consumption in the Residential Sector. This increase is coupled with a decrease in diesel consumption in the services sector.




S_HEAT: Space Heating; W_HEAT: Water Heating; COOK: Cooking; OTH_COMB: Other Combustion

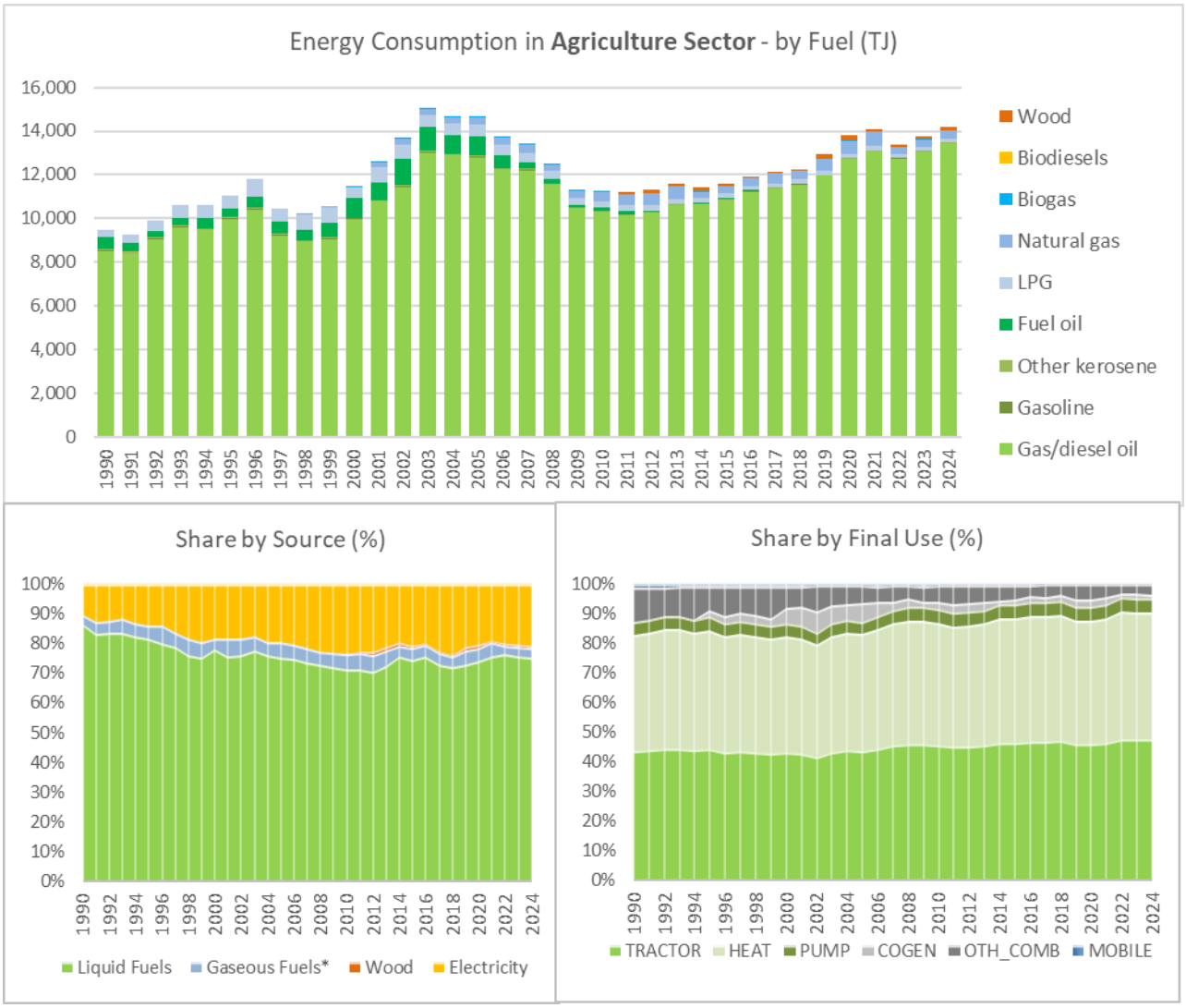
***Figure 3-50: Energy consumption in Residential sector - by Fuel, Source and Final Use***

**Agriculture**

In this sector the main fuel is diesel, the consumption of which is distributed by both stationary and mobile sources.

There is still some electrification in this sector, with consumption referring to stationary consumption. And a residual portion of cogeneration, currently produced through the combustion of natural gas and biogas.

One of the main end uses of fossil fuels in these subsectors are agricultural machines and tractors, responsible for more than 40% of energy consumption. These mobile sources have a particular preponderance in the $N_2O$ emissions of the subcategory 1.A.4.c Agriculture / Forestry / Fishing.

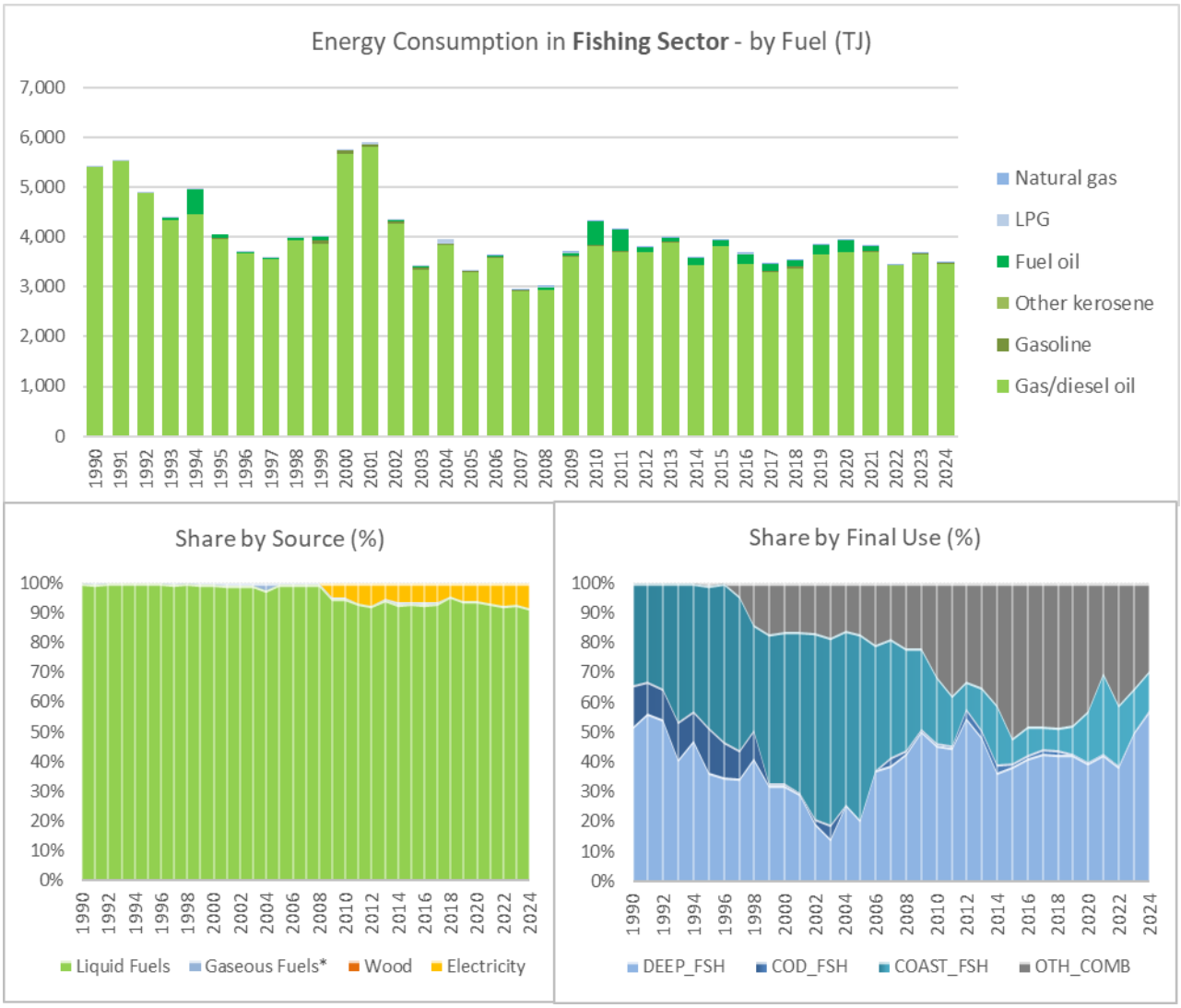



TRACTOR: Mobile machinery; HEAT: Heat uses; PUMP: Pumping devices; COGEN: Cogeneration; OTH_COMB: Other Combustion

***Figure 3-51: Energy consumption in Agriculture sector - by Fuel, Source and Final Use***

**Fishing**

In fishing sector like in agriculture sector, diesel is the main fuel consumed, being used by both mobile and stationary sources. Electricity consumption in this sector is very low, but the share has nevertheless increased in the last decade. The trend of growth of consumption by source sources needs to be clarified because it may result from an inefficient separation between costal fishing consumption and stationary sources.




DEEP_FSH: Deep Sea Fishing; COD_FSH: Cod Fishing; COAST_FSH: Coastal Fishing; OTH_COMB: Other Combustion

***Figure 3-52: Energy consumption in fishing sector - by Fuel, Source and Final Use***

### 3.6.4 Emission Factors

***Table 3-81: Emissions factors for Category 1.A.4.a.i – Commercial/Institutional: Stationary***

| Fuel | Technology | $CO_2$ [1] kg/GJ | $CH_4$ [1] g/GJ | $N_2O$ [1] g/GJ |
|---|---|---|---|---|
| Liquefied Petroleum Gases | Medium Boilers [2] | 63.1 | 0.9 | 4.0 |
| | Stove, Hobs and Ovens [2] | 63.1 | 0.9 | 4.0 |
| Natural Gas [4] | Medium Boilers | 56.4 | 1.0 | 1.0 |
| | Heat Pump | 56.4 | 1.0 | 1.0 |
| | Stove, Hobs and Ovens | 56.4 | 1.0 | 1.0 |
| | Gas Turbines [3] | 56.4 | 0.3 | 0.1 |
| Gas Work Gas | Medium Boilers | 44.4 | 5.0 | 0.1 |
| | Heat Pump | 44.4 | 5.0 | 0.1 |
| | Stove, Hobs and Ovens | 44.4 | 5.0 | 0.1 |
| | Gas Turbines | 44.4 | 5.0 | 0.1 |
| Gas Oil | Medium Boilers [2] | 74.1 | 0.7 | 0.4 |
| Wood and Wood Waste | Medium Boilers [2] | 112.0 | 11.0 | 7.0 |
| | Ovens [2] | 112.0 | 11.0 | 7.0 |
| Fueloil | Boilers (> 50KWth <1MWth) [3] | 77.4 | 3.0 | 0.6 |
| | Boilers (> 1MWth <50MWth) | 77.4 | 10.0 | 0.6 |

1 Source: 2006 IPCC Guidelines - Volume 2: Energy - 1A Stationary Combustion [Table 2.4]
2 Source: 2006 IPCC Guidelines - Volume 2: Energy - 1A Stationary Combustion [Table 2.10]
3 Source: 2006 IPCC Guidelines - Volume 2: Energy - 1A Stationary Combustion [Table 2.2]
4 $CO_2$ EF for Natural Gas is Country Specific

***Table 3-82: Emissions factors for Category 1.A.4.b.i – Residential: Stationary***

| Fuel | Technology | $CO_2$ [1] kg/GJ | $CH_4$ [1] g/GJ | $N_2O$ [1] g/GJ |
|---|---|---|---|---|
| Liquefied Petroleum Gases | LPG Heaters [2] | 63.1 | 1.1 | 4.0 |
| | Condensing boilers [3] | 63.1 | 0.9 | 4.0 |
| | Stove, Hobs and Ovens | 63.1 | 5.0 | 0.1 |
| Natural Gas [4] | Small Boilers | 56.4 | 1.0 | 1.0 |
| | Condensing boilers | 56.4 | 1.0 | 1.0 |
| | Stove, Hobs and Ovens | 56.4 | 1.0 | 1.0 |
| Gas Work Gas | Small Boilers | 44.4 | 1.0 | 1.0 |
| | Condensing boilers | 44.4 | 1.0 | 1.0 |
| | Stove, Hobs and Ovens | 44.4 | 1.0 | 1.0 |
| Gas Oil | Small Boilers [3] | 74.1 | 0.7 | 0.4 |
| Wood and Wood Waste | Heating stoves [2, 5] | 112.0 | 428.5 | 11.3 |
| | Open fireplaces [2] | 112.0 | 300.0 | 9.0 |
| | Conventional boilers <50 kWth [3] | 112.0 | 11.0 | 7.0 |
| | Pellet stoves and boilers [3] | 112.0 | 11.0 | 7.0 |
| | Automatic Boilers <1MW [3] | 112.0 | 11.0 | 7.0 |
| | Manual Boilers <1MW [3] | 112.0 | 11.0 | 7.0 |
| Fueloil [1] | - | 77.4 | 10.0 | 0.6 |
| Other Kerosene [1] | - | 71.9 | 10.0 | 0.6 |

1 Source: 2006 IPCC Guidelines - Volume 2: Energy - 1A Stationary Combustion [Table 2.4]
2 Source: 2006 IPCC Guidelines - Volume 2: Energy - 1A Stationary Combustion [Table 2.9]
3 Source: 2006 IPCC Guidelines - Volume 2: Energy - 1A Stationary Combustion [Table 2.10]
4 $CO_2$ EF for Natural Gas is Country Specific
5 Average of non-catalytic and catalytic EF's for wood stoves

***Table 3-83: Emissions factors for Category 1.A.4.c.i – Agriculture / Forestry / Fishing: Stationary***

| Fuel | Technology | $CO_2$ [1] kg/GJ | $CH_4$ [1] g/GJ | $N_2O$ [1] g/GJ |
|---|---|---|---|---|
| Gas Oil | Boilers (> 50KWth <1MWth) [2] | 74.1 | 0.7 | 0.4 |
| | Reciprocating engines [2] | 74.1 | 0.7 | 0.4 |
| Liquefied Petroleum Gases | Boilers (> 1MWth <50MWth) | 63.1 | 5.0 | 0.1 |
| Natural Gas [4] | Boilers (> 1MWth <50MWth) | 56.4 | 5.0 | 0.1 |
| | Gas Turbines [3] | 56.4 | 0.3 | 0.1 |
| Wood Waste | Medium boilers (> 50kWth) | 112.0 | 300.0 | 4.0 |
| Fueloil | Boilers (> 50KWth <1MWth) [3] | 77.4 | 3.0 | 0.6 |
| | Boilers (> 1MWth <50MWth) | 77.4 | 10.0 | 0.6 |
| Other Kerosene | - | 71.9 | 10.0 | 0.6 |

1 Source: 2006 IPCC Guidelines - Volume 2: Energy - 1A Stationary Combustion [Table 2.4]
2 Source: 2006 IPCC Guidelines - Volume 2: Energy - 1A Stationary Combustion [Table 2.10]
3 Source: 2006 IPCC Guidelines - Volume 2: Energy - 1A Stationary Combustion [Table 2.2]
4 EF for Natural Gas is Country Specific

***Table 3-84: Emissions factors for Categories 1.A.4.a.ii, 1.A.4.b.ii and 1.A.4.c.ii – Mobile sources***

| Fuel | Technology | $CO_2$ [1] kg/GJ | $CH_4$ [1] g/GJ | $N_2O$ [1] g/GJ |
|---|---|---|---|---|
| Gas Oil | Tractors, Harvesters, Others | 74.1 | 4.2 | 28.6 |
| Motor Gasoline 4-Stroke | Commercial: mobile | 69.3 | 50.0 | 2.0 |
| Other Kerosene | Commercial: mobile | 71.9 | 50.0 | 2.0 |
| Motor Gasoline 2-Stroke | Residential: mobile | 69.3 | 180.0 | 0.4 |
| Other Kerosene [2] | Residential: mobile | 71.9 | 180.0 | 0.4 |
| Motor Gasoline 4-Stroke | Agriculture: mobile | 69.3 | 80.0 | 2.0 |
| Other Kerosene [2] | Agriculture: mobile | 71.9 | 80.0 | 2.0 |

1 Source: 2006 IPCC Guidelines - Volume 2: Energy - 1A Mobile Combustion [Table 3.3.1]
2 The other kerosene EFs for $CH_4$ and $N_2O$ gases were considered equal to the EFs for gasoline.

***Table 3-85: Emissions factors for Categories 1.A.4.c.iii – Mobile sources***

| Fuel | Technology | $CO_2$ [1] kg/GJ | $CH_4$ [1] g/GJ | $N_2O$ [1] g/GJ |
|---|---|---|---|---|
| Gas Oil | Fishing Vessels | 74.1 | 7.0 | 2.0 |
| Thick Fuel Oil | Fishing Vessels | 77.4 | 7.0 | 2.0 |
| Thin Fuel Oil | Fishing Vessels | 77.4 | 7.0 | 2.0 |

1 Source: 2006 IPCC Guidelines - Volume 2: Energy - 1A Mobile Combustion [Table 3.5.2]

### 3.6.5 Uncertainty Assessment

The uncertainty in activity data was established from the knowledge of the way that activity data information was collected in the inventory but nevertheless trying as much as possible to make an assessment consistent to what is proposed in the GPG. Therefore, for fuel consumption except biomass, uncertainty was set at 10 %. For biomass fuels, considering that the quantification error is higher, namely due to lack of clarification of the actual moisture content in which biomass is reported, the uncertainty was assumed to be 60 %.

The uncertainty of $CO_2$ emission factors was assumed to be 5 % for all situations, in coherence with the other stationary combustion sources. In a similar mode, the uncertainties for methane and $N_2O$ were set respectively at 150 % and an order of magnitude.

### 3.6.6 Category-specific QA/QC and Verification

To further improve the QA/QC analysis a comparison between fuel consumption values considered by the Inventory, reported by DGEG in Energy Balance and Eurostat Energy Balance was made.

The QA/QC analysis makes it evident that there are issues related to the allocation of consumption, consistency of the activity data series, both in the Eurostat and Energy Balance databases (see figure below).

The main problems identified in the “Other sectors” category relate to:

- Gasoline consumption in the Commercial / institutional subcategory (1990 – 2007)

- Biomass consumption in the Residential subcategory (1996 – 2010)

- Diesel consumption in the Agriculture / Forestry subcategory (1990 – 1997 & 2003 – 2004).

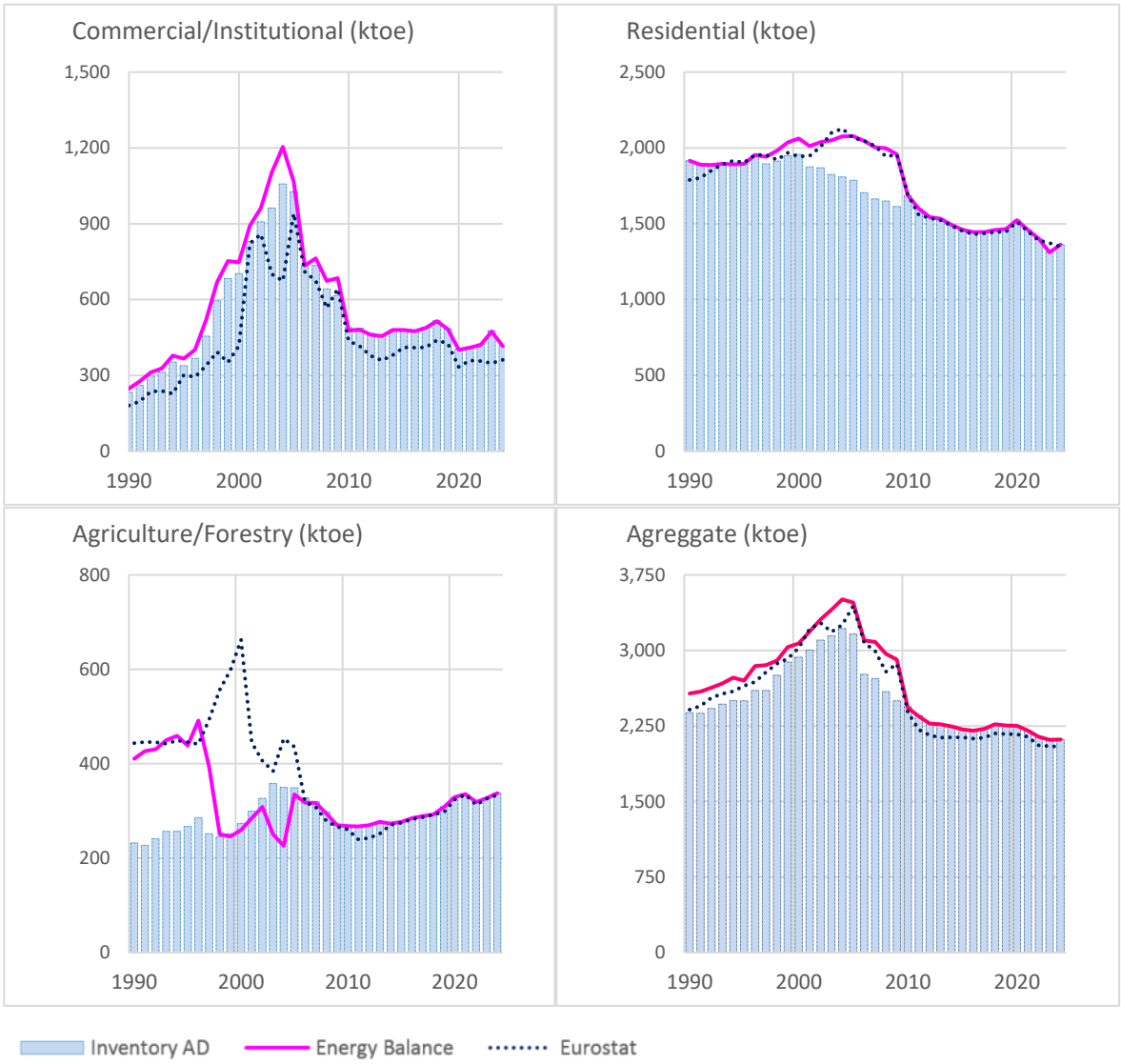



***Figure 3-53: Energy consumption comparison between Inventory, National Energy Balance and EUROSTAT data by sector***

The need to improve the consistency of the activity data series had long been identified. After working together with DGEG, the authority responsible for producing the energy balance, it was possible to obtain extra information that allowed the Inventory team to change the consumption time series.

Gasoline consumption in the Commercial / institutional subcategory (1.A.4.a)

Until 2007, the sale of gasoline affects the "Commercial / institutiontal" sector, mainly in public administration and defense, retail trade, machine rental, associative activities, hotels, post and telecommunications, diplomatic corps, etc. The end use of gasoline in these economic activities was essentially in transport.

Since 2008, with the entry into force of the methodological revision of the category classification, DGEG started to reallocate gasoline sales made to public gas stations, for the transport sector. Between 2008 and 2011, insignificant consumption of gasoline continues to be reported in this category of the Energy Balance.

In order to ensure consistency and accuracy, all gasoline sales reported in the "10.4 Services" category of the Energy Balance has been allocated to the Road Transport sector, with emissions from this gasoline consumption now estimated and reported in CRT category 1.A.3.b.

Biomass consumption in the Residential subcategory (1.A.4.b)

The inventory uses the Energy Balance as a source of information for the consumption of wood and wood products in the residential sector. The data published in the EB, originated in the publication "Survey on Energy Consumption in the Domestic Sector", which was carried out on three different dates 1989, 1996 and 2010. The results of the 2010 Survey show that there was a significant decrease in wood consumption between 1996 and 2010 (around -40%). The 2010 survey also concludes that, in relation to the energy consumption data reported in the 2009 Energy Balance: "Globally, the deviation stood at -8.9%, mainly due to wood, thus meeting expectations, given the known changes in consumption habits and the outdated information in previous editions of ICESD (used as a basis for preparing EB)".

In order to guarantee consistency throughout the time series, thus avoiding the series break between 2009 and 2010, it was assumed that there is a linear decrease in consumption between 1996 and 2010. This adjustment is the main reason for the differences in energy consumption between Inventory data and Energy Balance and Eurostat data.

Diesel consumption in the Agriculture / Forestry subcategory (1.A.4.c)

The introduction of colored and marked diesel for agriculture occurred in mid-1997. Until then, access to diesel for agriculture (cheaper than what was used for transport), was done through the presentation of a card (at gas stations), which proved that the buyer was engaged in this agriculture activity, with diesel fuel being the same as road diesel oil (without any marker). This method did not prevent the misuse of this fuel in automobiles. If we compare consumption in 1996 (last year that used this method in full) with consumption in 1998 (first year in which marked diesel was used) consumption in agriculture dropped to about half.

In order to identify the amount of diesel consumed in automobiles and other means of transport and reported incorrectly in the Energy Balance category "10.1.1 Agriculture", the ratio between diesel consumption and the Gross Value Added (GVA) of the sector was used between 1998-2016 to estimate consumption for the period 1990-1997.

The consumption of diesel considered in over-counting was allocated to the road transport sector, with emissions from this gasoline consumption now estimated and reported in CRT category 1.A.3.b.

Differences are also identified for the years 2003 and 2004. Coincident with the introduction of colored and marked heating oil, the entry of this new category of diesel was responsible for incorrect allocations between the Commercial / institutional sector and the Agricultural sector, due to confusion between colored agricultural diesel and colored and marked diesel for heating.

The figure below compares fuel energy consumption for category 1.A.4 Other sectors. The differences found reflect the clarifications provided in the previous paragraphs.

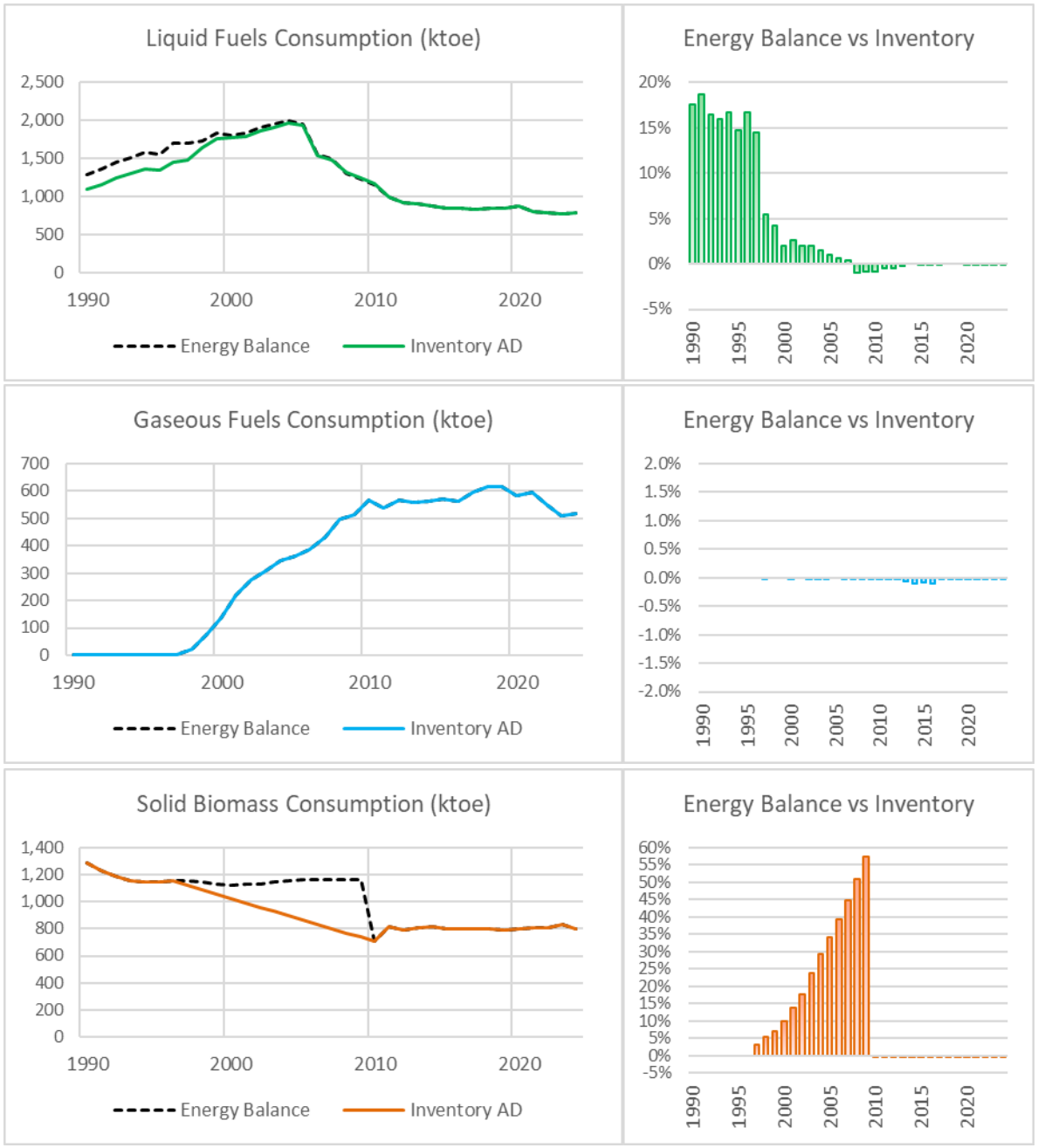



***Figure 3-54: Energy consumption comparison between National Energy Balance and Inventory data by fuel type***

### 3.6.7 Recalculations

There are no significant recalculations for category 1.A.4. The changes between submissions result from the update of the 2023 Energy Balance data provided by DGEG.

### 3.6.8 Further Improvements

Future improvements for this category include:

- Improvement of the consistency of energy consumption series. We intend to continue working together with the national authority responsible for producing the Energy Balance, to explain consumption trends and correct inconsistencies in the reporting and allocation of energy consumption. Currently, the consumption of biomass in the residential sector is identified as the main priority;

- Improve the detail in the Diesel consumption series, namely the separation between road diesels, agricultural diesel, heating diesel, also taking into account the different rates of incorporation of biodiesel in different types of diesel;

- Despite the great effort made during in past submissions to distribute the energy consumptions by the thermal uses and combustion equipment, it is our intention to improve this distribution of energy consumptions through the information being made available.

## 3.7 Other (Not Else-where specified) (CRT 1.A.5)

*Mónica Borges*

*Updated: March 2025*

**DISCLAIMER***:*

For the 2026 submission, this chapter has not been fully updated and therefore the detailed information remains as reported in the previous submission (2023 submission).

The 2024 emissions reported in the 2026 submitted CRT tables were estimated using a proxy approach based on the variation in fuel consumption between 2023 and 2024, as presented in Energy Balances. This approach was applied to ensure the timely reporting of emissions for the transport sector.

Consequently, the update carried out in this submission was limited to the emission estimates. The detailed information in this chapter will be updated in a future submission.

Emissions reported under category 1A5 refer to mobile military aviation. There is no information to disaggregate stationary emissions of military origin and therefore it is considered that these fuel consumption and associated emissions occur in category 1.A.4.ai Commercial, services and institutional and therefore the notation key "IE" - Included Elsewhere is applied to category 1.A.5.a.

### 3.7.1 Military Aviation (CRT 1.A.5.b)

#### 3.7.1.1 Methodology

The energy balance does not provide a specific fuel consumption classification for military operations. Fuel consumed in military operations is reported under category “Serviços”. Therefore, emissions from military operations, except military aviation, are reported under category 1.A.4.ai Commercial, services and institutional. For military aviation it was assumed that all jet fuel reported under category “Serviços” was used for military aviation since jet fuel could be considered as an aviation specific fuel.

According with the IPCC Guidelines 2006, all the jet fuel for military operations was considered to be domestic since there is no information available regarding origins and destinies of the military aircraft movements that could be used to distinct domestic from international consumption.

#### 3.7.1.2 Emission Factors

The emission factors used to estimate emissions are IPCC Guidelines 2006 default emission factors.

***Table 3-86: Emission factors.***

| Fuel | $CO_2$ | | | $CH_4$ | | | $N_2O$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | Value | Unit | Reference | Value | Unit | Reference | Value | Unit | Reference |
| Jet Fuel | 71.5 | $tCO_2/TJ$ | IPCC 2006 | 0.5 | kg/TJ | IPCC 2006 | 2.0 | kg/TJ | IPCC 2006 |

#### 3.7.1.3 Activity data

The following table shows the amount of jet fuel used for military operations provided by the national energy balance under the *Serviços* classification. All fuels under *Serviços* were already considered in the inventory besides jet fuel. Energy was estimated using a country specific LHV of 43.00 MJ/kg reported by the national energy authority.

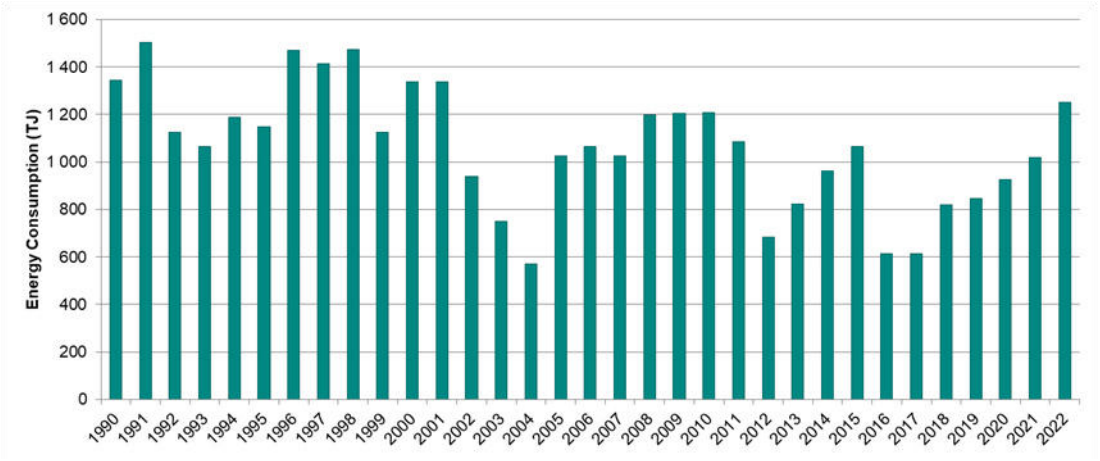



***Figure 3-55: Energy Consumption in Military aviation.***

The fluctuations in Jet Fuel consumption is related to the budget availability and frequency of training and missions of the military aviation activities.

#### 3.7.1.4 Uncertainty Assessment

The uncertainty of fuel consumption was set equal to the uncertainty that was considered for road traffic: 5 %.

In a similar way, the uncertainties for emission factors used were the same as for road transportation: methane and nitrous oxide emission factors were set at 40 % and 50 % respectively. The general error of 5 % was used for the calculation of uncertainties of carbon dioxide emissions.

#### 3.7.1.5 Recalculations

No recalculation were made.

#### 3.7.1.6 Further Improvements

No further improvements are planned for this sector.

## 3.8 Fugitive Emissions from Fossil Fuels (CRT 1.B)

### 3.8.1 Solid Fuels: Coal Mining and Handling (CRT 1.B.1.a)

#### 3.8.1.1 Category description

Coal contains some fraction of $CO_2$ and $CH_4$ trapped in its structure that is usually emitted to atmosphere during and after extraction of coal from surface mines. Emissions at extraction result from ventilation of mine gas which is done for safety reasons at underground mines. Post-mining emissions result from the slower liberation of $CH_4$ still entrapped in coal after it is extracted and stored at surface in piles, or from crushing and drying operations applied to modified and improve coal characteristics. In underground mines, post-mining emissions may occur in fact during extraction if degasification systems are installed but, nevertheless, total emissions remain relatively unaffected.

Portugal lacks coal exploration potential. Nonetheless, the main coal mining activities identified occurred in XIX and XX centuries, due to the two world wars, and were located in:

- Santa Susana Basin, in the south region;
- Mondego Basin, in the centre region;
- Vale do Lena Carboniferous Basin, in the centre region;
- Rio Maior Basin, in the centre region;
- Douro Carboniferous Basin, in the northwestern region.

In Santa Susana Basin, the main coal group mines were named Moinho da Ordem, of the underground type. The coal (bituminous coal) extraction began in 1839 and was latter closed down in 1944.

In Mondego Basin, the main coal group mines were located in Cabo Mondego and Buarcos group of underground mines. The coal (lignite) extraction began in 1750 and was latter closed down in 1967 due to a fire.

In Vale do Lena Carboniferous Basin, the main coal underground group mines were located in Porto de Mós and Batalha municipalities. The coal (lignite) extraction began around 1740, however, its operation has been inconstant over time and was latter closed down in 1959.

In Rio Maior Basin, the main coal group mines were located in Espadanal and Quinta da Várzea, of the underground type. The coal (lignite) extraction began in the early XX century and was latter closed down in 1970.

In Douro Carboniferous Basin, the main coal group mines were located in S. Pedro da Cova and Pejão. The coal extraction began in the XIX century, was latter closed down in 1992 and 1994, respectively, and did not resume activity since. Both groups of mines are of the underground type and are located in northern region of Portugal. Coal from these mines is classified as hard-coal (anthracite), it has a low energy value and it was used mainly as fuel for one public power energy plant near Porto (*Tapada do Outeiro* power plant). Moreover, the coal production during the exploration period was of small importance (less than 300 kt in 1990, see figure in Activity Data section).

Available information gathered states that all coal mines in Portugal were of the underground type.

From 1995 onwards all coal mines in Portugal were abandoned.

$CO_2$ and $SO_x$ emissions from mining activity may occur when:

- burning of coal deposits occurs or;
- flaring is used to control air emissions or recover energy.

Because the occurrence of coal burning on-site or flaring is unknown for Portuguese mines, we assume these activities do not occur, hence, emissions of these pollutants from this source are not included in the inventory.

Emissions of $CH_4$ from abandoned mines may still continue after mine closure, even if mines are sealed.

Emissions from fuel consumption in coal extraction are included in category 1.A.2.g iii (see Section 3.3.2.2.1.2.15 Extractive Industry).

### 3.8.1.2 Methodology

Emission estimates include:

- $CO_2$ and $CH_4$ emissions from extraction of coal in the period 1990-onwards (mining);
- $CH_4$ emissions resulting from coal processing (post-mining);
- $CH_4$ emissions from abandoned underground mines (from 1901 onwards).

Emissions were estimated based on a Tier 1 approach for undergroung coal mines proposed in 2019 refinement to the 2006 IPCC Guidelines, which was considered sufficient given the scarcity of technical information concerning these mines and because this emission source is of small relevance (it was not identified as key category). There is no available data on $CO_2$ or $CH_4$ recovered from drainage, ventilation air, or abandoned mines in Portugal, so we assumed that none of these GHG is recovered and utilized for energy production or flared.

Mining related to underground coal mines

$CO_2$ and $CH_4$ emissions from mining were estimated according to the following equation:

$$Emi = EF_U^{ex} * Coal_U * CF * 10^{-3}$$

**Where:**

Emi: Emissions (t)

$EF_U^{ex}$: Emission factor for extraction in underground mining ($m^3/t$)

$Coal_U$: Quantity of coal extracted from underground mines (t)

CF: Conversion factor - density of GHG at 20ºC and atmospheric pressure ($kg/m^3$)

Post-mining related to underground coal mines

$CH_4$ emissions related to these activities were estimated using the following equation:

$$Emi_{CH4} = EF_U^{post} * Coal_U * CF * 10^{-3}$$

**Where:**

$Emi_{CH4}$: Methane emissions (t)

$EF_U^{post}$: Emission factor for post-extraction emissions in underground mining ($m^3/t$)

$Coal_U$: Quantity of coal extracted from underground mines (t)

CF: Conversion factor - the density of methane at 20ºC and atmospheric pressure ($0.67 \times 10^{-6}$ $Gg/m^3$)

Abandoned underground coal mines

To estimate $CH_4$ emissions related to this item, it was applied a Tier 1 approach proposed in equation 4.1.10 of 2006 IPCC Guidelines:

$$Emi_{CH4} = Number_{ACM} * f_{GCM} * EF * CF * 10^3$$

**Where:**

$Emi_{CH4}$: Methane emissions (t)

$Number_{ACM}$: Number of abandoned coal mines remaining unflooded (number)

$f_{GCM}$: Fraction of gassy Coal Mines (adimensional)

$EF_{CH4}$: $CH_4$ emission factor for abandoned underground mines ($10^6$ $m^3$ $CH_4$/mine)

CF: Conversion factor - the density of methane at 20ºC and atmospheric pressure (0.67 x $10^{-6}$ Gg/$m^3$)

### 3.8.1.3 Emission Factors

Mining and Post-mining related to underground coal mines

According to 2006 IPCC Guidelines, countries using Tier 1 approach should consider country-specific variables such as the depth of major coal seams to determine the $CH_4$ emission factor to be used. Available information states that both Pejão and S. Pedro da Cova group of underground mines (the only ones that remain active in the period 1990-1994) had around 420/450 m depth, hence, the higher default emission factors were used for both mines, which are presented in the table below (Chapter 4.1.3.2 Volume 2 of the 2006 IPCC Guidelines).

According to Chapter 4.1.3.2 of the 2019 Refinement to the 2006 IPCC Guidelines, countries should use the Average $CO_2$ Emission Factor unless there is country-specific evidence to support use of an alternative factor within the low/high range. Therefore, given that there is no available information at national level, the average EF for $CO_2$ (5.9 $m^3$/ton) was applied.

***Table 3-87: Emission Factors for coal extraction and processing***

| Parameter | Type of Emission | Emission Factor | Value | Unit | Source |
|---|---|---|---|---|---|
| $CH_4$ | Extraction | $EF_U^{ex}$ | 25 | $m^3$/ton | 2006 IPCC Guidelines |
| | Post-mining | $EF_U^{post}$ | 4.0 | $m^3$/ton | |
| $CH_4$ density | - | CF | 0.67 | kg/m3 | |
| $CO_2$ | Extraction | $EF_U^{ex}$ | 5.9 | $m^3$/ton | 2019 Refinement to the 2006 IPCC Guidelines |
| $CO_2$ density | - | CF | 1.84 | kg/m3 | |

Abandoned underground coal mines

One of the parameters for this item is the total number of abandoned mines in each time band since 1901 remaining unflooded. According to 2006 IPCC Guidelines, if there is no knowledge on the extent of flooding it is good practice to assume that 100 % of mines remain unflooded. In Portugal there is no available data concerning mines that remain unflooded. The table below identifies the total number of abandoned mines in each time band since 1901.

***Table 3-88: Total number of abandoned mines in each time band since 1901***

| Time Interval | No. abandoned mines |
|---|---|
| 1901-1925 | 0 |
| 1926-1950 | 1 |
| 1951-1975 | 3 |
| 1976-2000 | 2 |
| 2001-Present | 0 |
| **TOTAL** | **6** |

Given that there is no available data concerning mines that, when were actively producing coal, were considered gassy, the fraction of gassy coal mines was estimated assuming the average values for abandoned underground mines, provided in Table 4.1.5 of Chapter 4 of Volume 2 of the 2006 IPCC Guidelines.

***Table 3-89: Percentage of abandoned underground coal mines that are gassy***

| Time Interval | Unit | 2006 IPCC Range | | Medium value |
|---|---|---|---|---|
| | | Low | High | |
| 1901-1925 | % | 0 | 10 | 5 |
| 1926-1950 | % | 3 | 50 | 26.5 |
| 1951-1975 | % | 5 | 75 | 40 |
| 1976-2000 | % | 8 | 100 | 54 |
| 2001-Present | % | 9 | 100 | 54.5 |

The $CH_4$ emission factors for abandoned underground mines were obtained from the updated Table 4.1.6 of Chapter 4 of 2019 Refinement to the 2006 IPCC Guidelines.

### 3.8.1.4 Activity data

The activity data for mining and post-mining activities is the amount of coal extracted.

For mining and post-mining activities from 1990-onwards we considered the only two coal mines still active in Portugal (specifically, in the period 1990-1994), both of the underground type. The amount of coal extracted decreased towards the final closure of both mines in 1993 and 1994, respectively, as may be seen in the figure below. Statistical information on the amount of coal extracted was obtained from Geological Resources reports from DGEG.

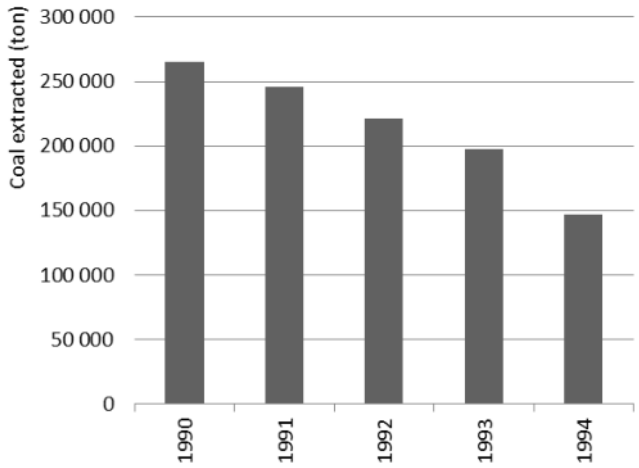



***Figure 3-56: Amount of coal extracted from mines in Portugal***

The activity data for abandoned underground mines is the number of abandoned underground coal mines (or group of mines), as mentioned in section 3.8.1.3 Emission Factors, Table 3-88 obtained from LNEG.

In CRT tables, activity data for underground mines (Table 1.B.1, category 1.B.1.a.i) is the amount of fuel produced. However, from 1995 onwards all coal mines in Portugal were abandoned, hence, no amount of fuel produced. Furthermore, the activity data for abandoned underground mines (in the period 1995-onwards there are only abandoned underground mines) is the number of abandoned underground coal mines (or group of mines). For these reasons, for the period 1995-onwards the AD is reported as NO.

### 3.8.1.5 Uncertainty Assessment

A value of 5 % was considered for the uncertainty of coal production (activity data) which is a conservative factor according to the proposed values by IPCC (2000). Also in accordance with table 2.14 of the GPG, the uncertainty values for $CH_4$ emission factors were set at 100 % for underground mines. The uncertainties in $CO_2$ emission factors were set equal to uncertainties of $CH_4$ emission factors, considering that $CO_2$ emissions are simply atmospheric conversion of methane emissions.

### 3.8.1.6 Recalculations

No recalculations were made.

### 3.8.1.7 Further Improvement

No further improvements are planned for this sector.

## 3.8.2 Solid fuels: Solid fuel transformation (CRT 1.B.1.b)

### 3.8.2.1 Category description

Metallurgical Coke was produced in the coke plant of the integrated iron and steel facility that existed from 1990 to 2001. This category includes $CH_4$ fugitive emissions from coke production in the coke plant. We assumed no flaring in coke production. Detailed info regarding all emission streams for iron and steel operations, as well as the categories under which emissions are reported can be found in Table 4-36 and section 4.4.2.1 of the IPPU chapter.

### 3.8.2.2 Methodology

$CH_4$ fugitive emissions from coke production were estimated based on a Tier 1 production approach of the 2019 Refinement to the 2006 IPPC Guidelines, according to the following equation:

$$Emi_{CH4} = EF_{CH4} \times Coke_{Prod} \times 10^{-3}$$

**Where:**

$Emi_{CH4}$: $CH_4$ fugitive emissions (t)

$EF_{CH4}$: $CH_4$ emission factor (kg/t coke)

$Coke_{Prod}$: Quantity of coke produced (t)

### 3.8.2.3 Emission Factors

$CH_4$ emission factor for coke production in the period 1990-2001 appplied was 0.049 kg/ton coke and was taken from Table 4.3.5 of the 2019 Refinement to the 2006 IPPC Guidelines.

### 3.8.2.4 Activity data

Annual coke production was obtained from DGEG (Coke plant Balance) from 1990 to 2001. From 2002 onwards, there is no coke production in the iron and steel industry in Portugal.

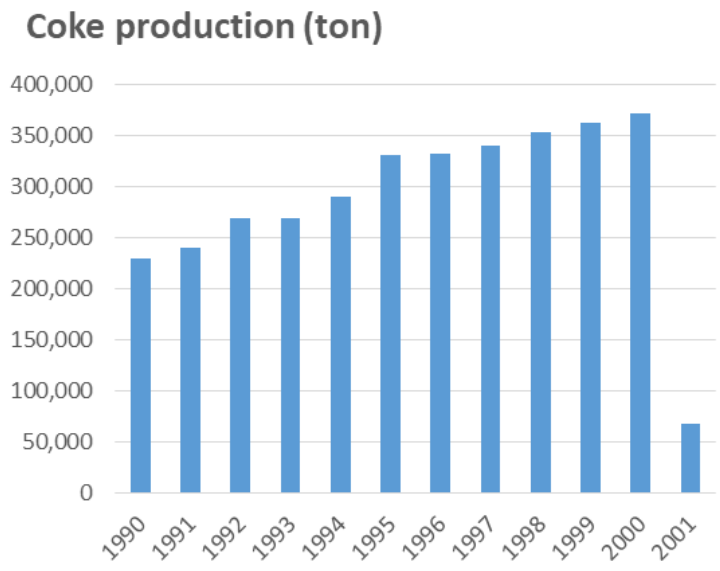



***Figure 3-57: Coke production in the coke plant***

#### 3.8.2.5 Uncertainty Assessment

A value of 5 % was considered for the uncertainty of coke production (activity data). $CH_4$ emission factor was set at 100 %.

#### 3.8.2.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

#### 3.8.2.7 Recalculations

No recalculations were made.

#### 3.8.2.8 Further Improvement

No further improvements are planned for this sector.

## 3.8.3 Oil and natural gas and other emissions from energy production: Oil (CRT 1.B.2.a)

### 3.8.3.1 Category description

Extraction and production of crude oil never occurred in the Portuguese territory. Therefore, fugitive emissions are related to those resulting from refining, storage and transport of crude oil, other raw materials, intermediate products and final products - particularly gasoline - from terminal receiving of crude oil and other petroleum products till delivering to final consumer. According to available methodologies air emissions considered include:

- Marine Terminals and Ballast water;
- Emissions from refinery operations not including emissions from combustion of fuels, such as: Flaring and venting in oil refining and;
- Emissions due to storage of raw materials, intermediate products and final products in the refinery;
- Emissions from refinery dispatch station;
- Emissions from the transport and distribution of petroleum products in the Portuguese Territory, including transport depots and service stations.

### 3.8.3.2 Exploration (CRT 1.B.2.a.1)

There is no oil exploration in Portugal.

### 3.8.3.3 Production (CRT 1.B.2.a.2)

There is no crude oil production in Portugal.

### 3.8.3.4 Transport (CRT 1.B.2.a.3)

#### 3.8.3.4.1 Category description

In 1990 there were three oil refining plants in Portugal: Porto, Lisbon and Sines. After 1993, the Lisbon unit was closed. Porto has terminated its refining activities in April 2021. Only Sines unit remains in operation.

Emissions from this source consist mainly of volatile organic compounds, including methane, that escape to atmosphere during transport of crude oil to refineries for processing. The three oil refineries considered in the inventory where all located at a small distance from the sea coast. Crude oil is received near refineries by sea tankers and transported directly to each refinery by small connecting pipelines.

#### 3.8.3.4.2 Methodology

$CO_2$ and $CH_4$ emissions were estimated according to the following equation:

$$Emis_{CO2} = \frac{(Crude_{cons} \times EF_{CO2})}{1 \times 10^6}$$

**Where:**

$Emi_p$: GHG p emissions (kt)

$Crude_{cons}$: Crude received in refineries ($m^3$)

$EF_p$: GHG p emission factor ($kg/m^3$)

#### 3.8.3.4.3 Emission Factors

***Table 3-90: Emission Factors***

| Parameter | Unit | Emission Factor | Source |
|---|---|---|---|
| $CO_2$ | kg/$m^3$ crude | 4.9 x $10^{-7}$ | Table 4.2.4 of Volume 2: Energy of 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Developed Countries; Category: Oil Transport; Sub-category: Pipelines) |
| $CH_4$ | kg/ 1000 $m^3$ crude | 5.4 x $10^{-3}$ | Table 4.2.4 of Volume 2: Energy of 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Developed Countries; Category: Oil Transport; Sub-category: Pipelines) |

#### 3.8.3.4.4 Activity data

Activity Data reported under this subcategory concerns crude that arrives in marine terminals, before being consumed in the refineries, and is presented in the figure below. In the period 1990 to 2004, data on crude received was obtained from DGEG. From 2005 onwards, data was obtained from refineries.

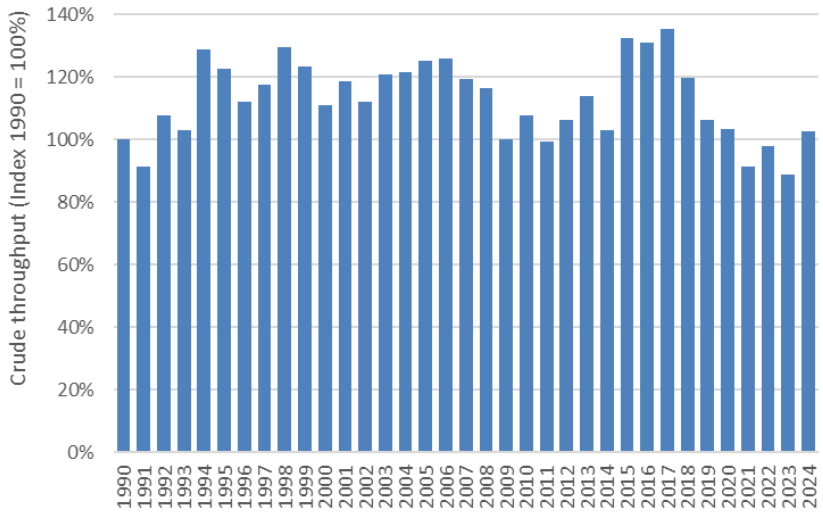



***Figure 3-58: Total amount of crude arriving in Marine Terminals***

#### 3.8.3.4.5 Uncertainty Assessment

An uncertainty value (3 %) similar to that that was considered for fuel consumption data in industrial LPS was also used for quantification of uncertainty of activity data for this source sector reflecting the fact that in this case data was also collected directly from refinery plants, where crude oil is uploaded, and used to build the energy balance of DGEG. The uncertainty of $CO_2$ emissions was considered to be 50 %, which is the double (conservative approach) of the value proposed in chapter 2.7 of GPG for high quality emission factors for most gases.

#### 3.8.3.4.6 Recalculations

No recalculations were made.

#### 3.8.3.4.7 Further Improvement

No further improvements are planned for this sector.

### 3.8.3.5 Refining and Storage (CRT 1.B.2.a.4)

#### 3.8.3.5.1 Category description

In 1990 there were three oil refining plants in Portugal: Porto, Lisbon and Sines. After 1993, the Lisbon unit was closed. Porto has terminated its refining activities in April 2021. Only Sines unit remains in operation.

The refining process converts crude oil - which is a complex mixture of hydrocarbon compounds with impurities of sulphur, nitrogen, oxygen and heavy metals - into oil products used as fuels, asphalts, lubricants or feedstock for the organic and inorganic chemical industry. Processes included in Portuguese refineries include:

- Separation process: isolation of individual constituents of crude using differences in boiling-point, using atmospheric and vacuum distillation and recovery of light end gases;
- Conversion process. These may be also classified as:
  - Cracking - Chemical transformation of separated fractions breaking molecules of heavy molecular weight into smaller ones, including visbreaking;
  - Polymerization of small molecules combined in bigger molecules with different characteristics. Alkylation has similar purposes;
  - Chemical transformations that change molecular structure such as Isomerization, reforming and asphalt blowing;
- Treatment processes. Operations which include hydrodesulphurization, hydrotreating, chemical sweetening, acid gas removal, deasphalting and desalting, that are used to remove impurities, the most important is sulphur;
- Blending of individual fractions and intermediate products to obtain final commercial products with characteristics as desired.

Emissions of storage of crude oil and other materials, intermediate products and final products are also included in this source sector as they are fugitive emissions occurring as part of the refining process. Because emissions from organic liquids in storage occur both from the evaporative loss of the liquid as well as from changes in the liquid level, the emission sources vary significantly with tank design. Six basic tank designs are usually used for organic liquid storage vessels: fixed roof (vertical and horizontal), external floating roof, domed external (or covered) floating roof, internal floating roof, variable vapour space, and pressure (low and high).

NMVOC and $CH_4$ emissions may also result from “normal” leaks[23] scattered through the refinery site in pneumatic devices such as valves, failure of connections, flanges, pump and compressor shafts, seals and instruments. Release of gases may also follow system failure, that usually occurs during unplanned events, such as sudden pressure surge from failure of a pressure regulator, and pressure relief systems that protect the equipment from damage. In Portuguese refineries, pressure relief systems are usually connected to collection system and transported to a flare. There may be also NMVOC emissions resulting from non-condensable fraction at the steam ejectors or vacuum pumps of the Vacuum distillation. Emissions in flares are discussed in “Venting and Flaring in Oil Industry” below.

Use of some catalytic converters, such as Fluid Catalytic Cracking and Platforming units, are used to convert heavy oils into lighter products, by action of heat, pressure and catalysts. Fluidized-bed Catalytic Cracking (FCC) use finely divided catalysts suspended in a riser with hot vapour from the fresh feed.

[23] Sometimes only these emissions are referred as fugitive emissions from refineries.

Catalytic processes result in operations emissions, when the coke that is deposited in the catalytic bed over time has to be burned in the regenerator equipment. Emissions from catalyst regeneration are also included in this source category.

#### 3.8.3.5.2 Fluid Catalytic Cracking (FCC)

##### 3.8.3.5.2.1 Methodology

$CO_2$ emissions were estimated according to the following equation:

$$Emi = Coke_{cons} \times EF_{CO2} \times 10^{-3}$$

**Where:**

Emi: $CO_2$ emissions (kt)

$Coke_{cons}$: Coke burned in fluid catalytic cracking (t coke)

$EF_{CO2}$: $CO_2$ emission factor (t $CO_2$/t coke)

##### 3.8.3.5.2.2 Emission Factors

$CO_2$ emission factor was obtained from EU-ETS and is presented in the table below.

***Table 3-91: $CO_2$ emission Factor***

| Pollutant | Unit | EF |
|---|---|---|
| $CO_2$ | t $CO_2$/t coke | 3.25-3.44 |

##### 3.8.3.5.2.3 Activity Data

There is only one refinery with a fluid catalytic cracking unit in Portugal since 1994. Given so, we present data in the figure below as an index value related to the amount of coke burned in 1994.

From 2005 onwards, the amount of coke burned was obtained from EU-ETS. From 1994 to 2004 we use data provided by the refinery on coke burned in fluid catalytic cracking unit.

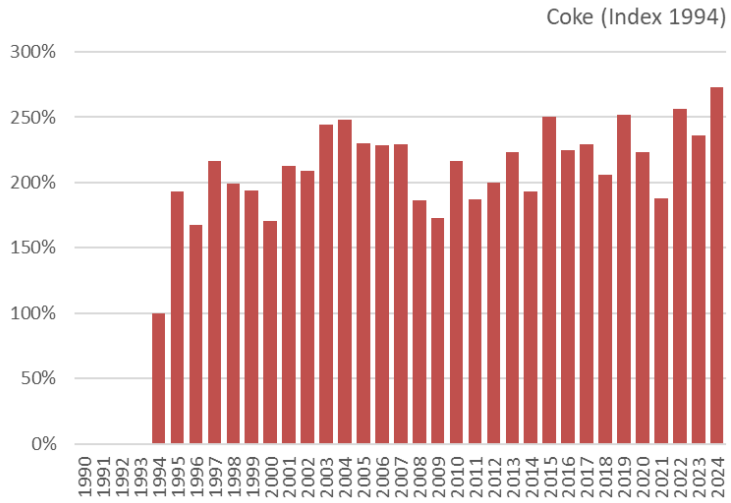



***Figure 3-59: Coke burned in the Fluid Catalytic Cracking Unit***

#### 3.8.3.5.2.4 Uncertainty Assessment

Most of the activity data that was obtained to estimate emissions comes directly from the refinery units. Therefore, a low uncertainty of 3 % may be assumed for this sub-source in a similar mode to other LPS combustion data.

Uncertainty of emission factors for $CO_2$ were set as 50 %, at the higher range of possible uncertainties proposed by IPCC (2000), although the fact that some emission factors use plant specific information.

#### 3.8.3.5.2.5 Recalculations

No recalculations were made.

#### 3.8.3.5.2.6 Further Improvement

No further improvements are planned for this sector.

### 3.8.3.5.3 Platforming/Continuous Catalyst Regenerators (CCR)

#### 3.8.3.5.3.1 Methodology

$CO_2$ emissions were estimated according to the following equation:

$$Emi = Coke_{cons} \times EF_{CO2} \times 10^{-3}$$

**Where:**

Emi: $CO_2$ emissions (kt)

$Coke_{cons}$: Coke burned in continuous catalyst regeneration (t coke)

$EF_{CO2}$: $CO_2$ emission factor (t $CO_2$/t coke)

#### 3.8.3.5.3.2 Emission Factors

$CO_2$ emission factors were obtained from EU-ETS from Sines refinery and regeneration of catalysts at Porto refinery.

***Table 3-92: $CO_2$ emission factors***

| Pollutant | Unit | EF |
|---|---|---|
| $CO_2$ | t $CO_2$/t coke | 3.63-3.66 |

#### 3.8.3.5.3.3 Activity Data

Porto has terminated its refining activities in April 2021. Only Sines unit remains in operation.

Data regarding coke burned in Platforming/Continuous Catalyst Regenerators was provided by the refineries and is presented in the figure below.

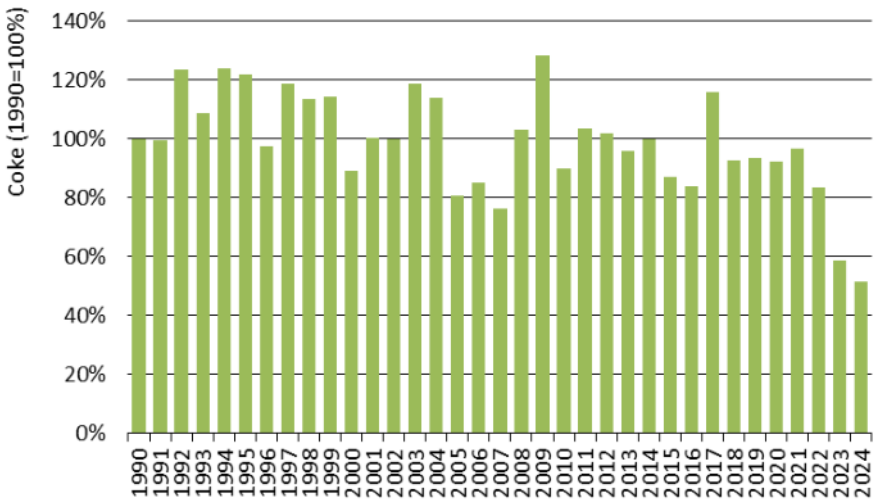



***Figure 3-60: Coke burned in Platforming/Continuous Catalyst Regeneration (CCR)***

#### 3.8.3.5.3.4 Uncertainty Assessment

Most of the activity data that was obtained to estimate emissions comes directly from the refinery units. Therefore, a low uncertainty of 3 % may be assumed for this sub-source in a similar mode to other LPS combustion data.

Uncertainty of emission factors for $CO_2$ were set as 50 %, at the higher range of possible uncertainties proposed by IPCC (2000), although the fact that some emission factors use plant specific information.

#### 3.8.3.5.3.5 Recalculations

No recalculations were made.

#### 3.8.3.5.3.6 Further Improvements

No further improvements are planned for this sector.

### 3.8.3.5.4 Hydrogen production in the Steam Reformer

#### 3.8.3.5.4.1 Methodology

Only Sines refinery has Hydrogen units. There are two Hydrogen Production Units in Sines: one began in 2004 (in pilot phase during 2004 and full operation from 2005 onwards) and produces the hydrogen required to the desulphurisation of gas oils and gasolines; the other one began in 2013 and produces the hydrogen required for the hydrocracking unit. They both remain in operation ever since.

$CO_2$ emissions from Hydrogen production in the Steam Reformers were estimated according to the following equation:

$$Emi = Fuel_{cons} \times EF_{CO2} \times 10^{-3}$$

**Where:**

Emi: $CO_2$ emissions (kt)

$Fuel_{cons}$: Fuel consumption in steam reformers (t fuel)

$EF_{CO2}$: $CO_2$ emission factor (t $CO_2$/t fuel)

#### 3.8.3.5.4.2 Emission Factors

$CO_2$ emission factors applied to fuel consumption in the steam reformer units in Sines refinery were obtained from EU-ETS from 2005 onwards and are indicated in the table below.

***Table 3-93: $CO_2$ emission factors***

| Pollutant | Unit | EF |
|---|---|---|
| $CO_2$ | t $CO_2$/t fuel | 2.75-2.80 |

#### 3.8.3.5.4.3 Activity Data

These units use natural gas as input and also nafta since 2021. 2004 fuel consumption data was obtained directly from the facility. From 2005 onwards, fuel consumption in the steam reformers is obtained from EU-ETS data.

Given that there is only one refinery producing hydrogen in steam reformer units, due to confidentiality constrains, data is presented in the figure below as an index related to 2004 fuel consumption value. From 1990 to 2003 there was no hydrogen production unit operating. From 2013 onwards fuel consumption increases significantly due to the entry into full operation of the new hydrocracking unit in 2013.

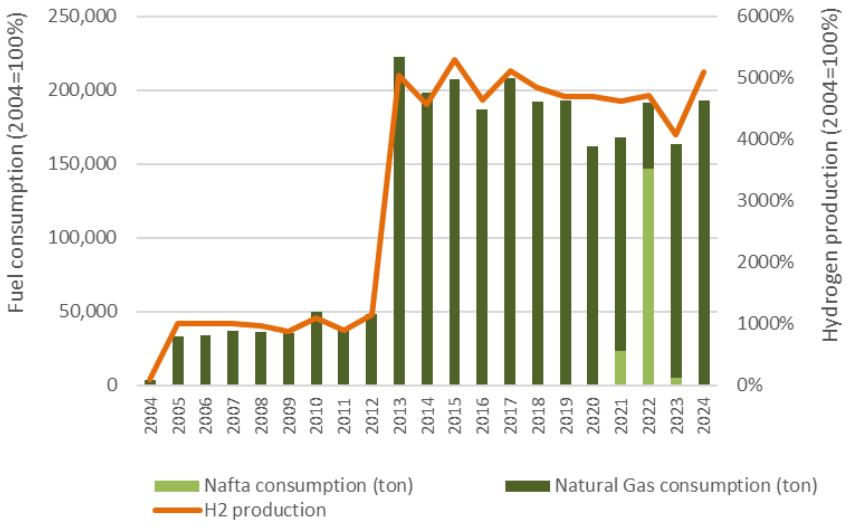



***Figure 3-61: Fuel consumption and Hydrogen production in the hydrogen steam reformers***

#### 3.8.3.5.4.4 Uncertainty Assessment

Both activity data and $CO_2$ emission factors used to estimate emissions come directly from the refinery facility, therefore, a low uncertainty of 3 % may be assumed for this sub-source in a similar mode to other LPS combustion data.

#### 3.8.3.5.4.5 Recalculations

No recalculations were made.

#### 3.8.3.5.4.6 Further Improvements

No further improvements are planned for this sector.

### 3.8.3.5.5 Oil-Water collection and treatment systems

#### 3.8.3.5.5.1 Category description

There are only indirect $CO_2$ emissions related to NMVOC emissions. Please check Portugal IIR for NMVOC emissions estimates.

### 3.8.3.5.6 Storage Tanks

#### 3.8.3.5.6.1 Category description

Regarding Storage tanks, there are only indirect $CO_2$ emissions related to NMVOC emissions.

In order to estimate NMVOC emissions from this category, it was used Total throughput from storage and tanks in each refinery as activity data. Total throughput represents not only crude oil entered into the refinery (which constitutes the activity data for category 1.B.2.a.3) but also other petroleum products that are imported or moved between refineries.

Since in this category there are only indirect $CO_2$ emissions related to NMVOC emissions, information on the activity data, methodology and emission factors is provided in the Portuguese IIR submission.

### 3.8.3.5.7 Fugitive emissions from oil refining/storage

#### 3.8.3.5.7.1 Category description

Emissions from this source consist mainly of methane, that escapes to atmosphere during refining and transport operations. Crude oil is refined and storaged in the refineries.

#### 3.8.3.5.7.2 Methodology

$CH_4$ emissions were estimated according to the following equation:

$$Emi_{CH4} = \frac{(Crude_{cons} \times EF_{CH4})}{10\text{^}6}$$

**Where:**

$Emi_{CH4}$: $CH_4$ emissions (t)

$Crude_{cons}$: Crude throughput in refineries ($m^3$)

$EF_{CH4}$: $CH_4$ emission factor ($Gg/10^3\ m^3$)

#### 3.8.3.5.7.3 Emission Factors

Given that there is no available data concerning plant or country specific emission factors for fugitive emission from oil refining and storage, $CH_4$ fugitive emission factor was estimated assuming the average value of the range provided in Table 4.2.4 of Chapter 4 of Volume 2 of the 2006 IPCC Guidelines for Developed Countries (Category: Oil Refining; Sub-category: All).

***Table 3-94: $CH_4$ emission factor for fugitive emissions in oil refining***

| Parameter | Unit | 2006 IPCC Range | | Medium value |
|---|---|---|---|---|
| | | Low | High | |
| $CH_4$ | $Gg/10^3\ m^3$ oil refined | $2.6 \times 10^{-6}$ | $41.0 \times 10^{-6}$ | $2.18 \times 10^{-5}$ |

The emission factor provided by the 2006 IPCC Guidelines is related to the amount of oil refined, however, we assumed that all crude throughput arriving at the refineries is refined. Therefore, the activity data used was crude throughput in the refineries, in $m^3$.

#### 3.8.3.5.7.4 Activity data

Data on crude throughput was obtained from refineries for the whole time series.

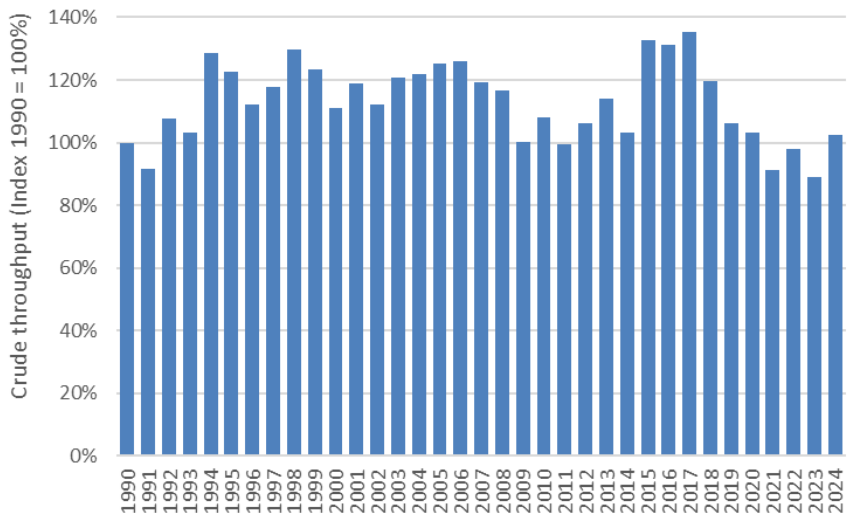



***Figure 3-62: Total amount of crude throughput***

#### 3.8.3.5.7.5 Uncertainty Assessment

Most of the activity data that was obtained to estimate emissions comes directly from the refinery units. Therefore a low uncertainty of 3 % may be assumed for this sub-source in a similar mode to other LPS combustion data.

Uncertainty of emission factors for $CH_4$ were set as 50 %, at the higher range of possible uncertainties proposed by IPCC (2000).

#### 3.8.3.5.7.6 Recalculations

No recalculations were made.

#### 3.8.3.5.7.7 Further Improvement

No further improvements are planned for this sector.

### 3.8.3.6 Distribution of Oil Products (CRT 1.B.2.a.5)

#### 3.8.3.6.1 Category description

This sub-source sector includes emissions from distribution of refinery products, mainly gasoline in:

- (1) Terminal Dispatch Stations in Refineries. Emissions of volatile organic compounds occurring inside refineries during filling of transport vehicles - trucks, rail cars - when dispatching products of the refining unit. Most emissions occur when light products with high level of volatile compounds are dispatched;
- (2) Transport and Depots, occurring in storage tanks outside the refineries and over the country;
- (3) Service Stations, including emissions from tank loading from trucks and when refuelling consumer cars.

Emissions may result from:

- Leakage. Evaporation of liquid products by flaws and seal leakage, pumps and valve systems;
- Displacement emissions, due to displacement of air in tanks by the incoming liquid;
- Breathing emissions in tanks;
- Vapours emitted when filling vehicles in result of displacement of filling air and from splashing and turbulence during filling;
- Unwanted spillage.

There are only indirect $CO_2$ emissions related to NMVOC emissions. Please check Portugal IIR for NMVOC emissions estimates.

### 3.8.4 Oil and natural gas and other emissions from energy production: Natural Gas (CRT 1.B.2.b)

#### 3.8.4.1 Category description

There is no production of natural gas in Portugal. The use of natural gas in Portugal was initiated only in 1997 (DGEG). At that time this energy source was received by ship from Algeria and used mainly in electric power production and in combustion in industry. Since then, its use has become more widespread and it is now consumed also in the manufacturing industry, domestic, service, institutions, commerce, building and construction, agriculture and even a small quantity in road transport. All natural gas is imported and received through shipping transport from Algeria and Nigeria as Liquefied Natural Gas (LNG). There are also no major processing operations in Portugal.

Natural gas pipelines may be classified in two different sub-groups:

- Transmission lines. Operating at high pressure, are used to transport natural gas in bulk over large distances till distribution centres;
- Distribution networks. Comprehend the network of extensive pipelines that convey natural gas to the end-user. They tend to work on lower pressure and with smaller diameter lines. There are distribution networks of natural gas distributing for industrial consumers, services and domestic users.

The gas received from Algeria in ships is re-gasified in a plant in Sines, in southern Portugal.

Methane emissions from natural gas result mostly from leaks of unmodified natural gas, in pipes or in the plant. Although these losses happen as result of maintenance operations or abnormal accident situations (pressure surges due to failure of equipment that controls pressure), they occur also constantly as result of normal operations of the system in operation valves or in chronic leaks due to seal failure, flawed valves, small cracks and holes in the lines or reservoirs.

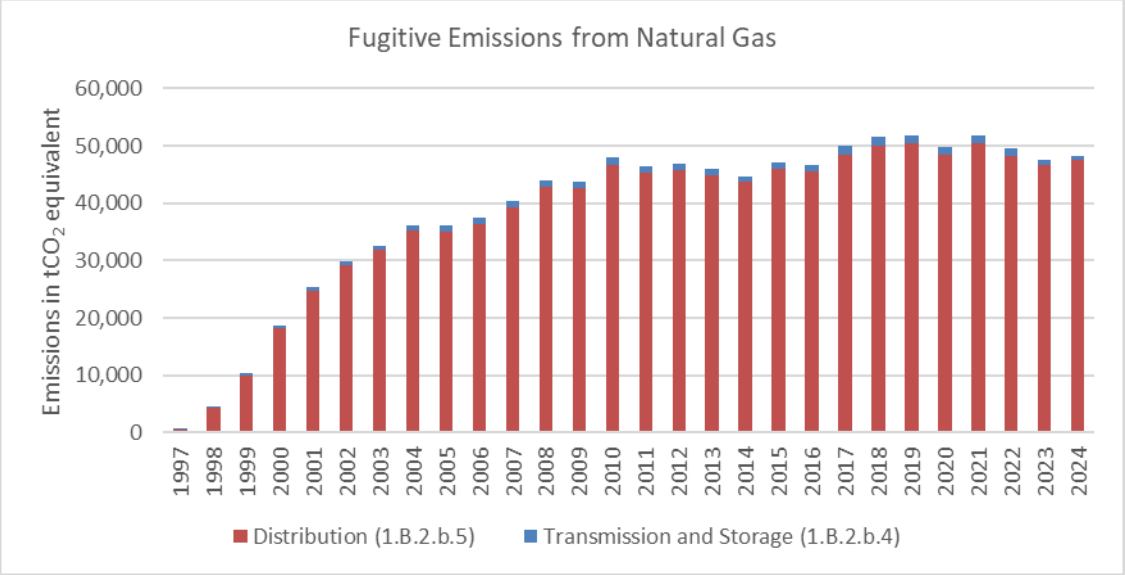


***Figure 3-63: Fugitive Emissions from Natural Gas***

### 3.8.4.2 Methodology

Estimates of fugitive emissions related to the transport of natural gas are separated into two categories. One relates to fugitive emissions during transport of Natural Gas to High Pressure and is reported in code CRT *1.B.2.b.4. - Transmission and Storage*. The other refers to the distribution networks operating medium and low pressure, these are reported in code CRT *1.B.2.b.5. – Distribution*.

Losses of natural gas through leaks are estimated through adjustment factors published by ERSE - National regulatory body of the Natural Gas market. This adjustment factors are published to estimate own consumption and leakage occurring along the national natural gas network. Including:

- National Natural Gas Transportation Network - (Leakage during maintenance interventions, or resulting from incidents affecting the infrastructure)
- Reception, storage and regasification terminals for Natural Gas Liquid - (Purges and natural gas burning)
- Underground Storage (mostly own consumption)
- Distribution networks (gas released in safety valves, incident on distribution networks).

The $CO_2$ and $CH_4$ emissions are estimated considering the composition of Natural Gas imported by Portugal.

**Transmission and Storage (1.B.2.b.4)**

The adjustment factor considered for the National Natural Gas Transportation Network at High Pressure simultaneously considers the transmission processes and storage processes.

In order to obtain the amount of Natural Gas circulating in a year in the National High-Pressure Natural Gas Transport Network, it is necessary to remove from the total imported NG the one that arrives in the country via trucks directly to autonomous units that intrude the gas directly into the networks of distribution.

NG Transmission Network HP = NG Imported – NG from Autonomous units

NG Transmission Network Leaks = NG Transmission Network HP * Adjustment Factor HP

Transmission $CH_4$ Fugitive Emissions = NG Transmission Network HP Leaks * % of $CH_4$ in National NG

Transmission $CO_2$ Fugitive Emissions = NG Transmission Network HP Leaks * % of $CO_2$ in National NG

**Distribution (1.B.2.b.5)**

ERSE publishes differentiated adjustment factors for medium and low pressure distribution networks. Thus the natural gas consumptions reported in the energy balance were divided according to the type of supply network.

NG Distribution Network Leaks = NG Distribution MP Leaks + NG Distribution LP Leaks

The quantities of Natural Gas distributed by the two types of network are obtained through the Energy balance, which differentiates consumption by sector. Therefore:

NG Distribution Medium Pressure: Manufacturing industries

NG Distribution Low Pressure: Residential, Services, Commercial, Agriculture & Fisheries

The amount of natural gas leaks is estimated as follows:

NG Distribution LP Leaks = NG Distribution MP * Adjustment Factor MP

NG Distribution MP Leaks = NG Distribution HP * Adjustment Factor LP

Distribution $CH_4$ Fugitive Emissions = NG Transmission Distribution Leaks * % of $CH_4$ in National NG

Distribution $CO_2$ Fugitive Emissions = NG Transmission Distribution Leaks * % of $CO_2$ in National NG

#### 3.8.4.3 Emission Factors

The adjustment factors for losses and self-consumption are applied for the purpose of determining the quantities of natural gas that market agents must place at the entrance of the Portuguese Natural Gas Network infrastructures, in order to guarantee the delivery of the natural gas necessary to supply the expected consumption for the Customers. These adjustment factors derived from the losses and self-consumption recorded by the different operators.

**Leaks in Natural Gas Transportation Network** (high pressure) occur during maintenance interventions or resulting from incidents affecting the infrastructure and, based on the information provided by ERSE, consist of two factors: "self-consumption" and "purges and leaks".

According to ERSE, the "self-consumption" parcel represents the great majority (98.67%) of losses verified in the natural gas transmission network.

The "purges and leaks" parcel is considered, according to the annual ERSE report, 0.11% of all Natural Gas transmitted and is not very significant compared to the "self-consumption" parcel.

Thus, the value presented in the table below for Leaks in Natural Gas Transportation Network (high pressure) – 0.0015% - was obtained from the multiplication of these two factors: 0.11% X (100%-98.67%).

**Leaks in Natural Gas Distribution Network** are derived from gas releases in safety valves or incident on distribution networks. ERSE publishes differentiated adjustment factors for medium and low pressure distribution networks, based on the values provided by the natural gas distribution operators. Thus, the values presented in the table below for Leaks in Natural Gas Distribution Network in medium and low pressure are, respectively, 0.07% and 0.34%.

***Table 3-95: Ajustment Factor for Natural Gas Leaks***

| Adjustment Factor | Value | Unit |
|---|---|---|
| Leaks in Natural Gas Transportation Network (high pressure) | 0.0015 | % of Natural Gas Transmitted |
| Leaks in Natural Gas Distribution Network (medium pressure) | 0.07 | % of Natural Gas Distributed (med) |
| Leaks in Natural Gas Distribution Network (low pressure) | 0.34 | % of Natural Gas Distributed (low) |

The leakage values in the high pressure transport network are low because in this system the total losses are marginal (0.11% of all Natural Gas transmitted) and only a small part are NG leaks (1.33% of all losses), the remaining losses Are self-consumption that are considered in the chapter of the combustion of energy.

In the NG distribution network, leaks are associated with leaks in mechanical elements such as valves, purges, reduction stations, reduction and counting stations, mechanical connections, etc. In addition, losses are also associated with the network operation resulting from the purge for commissioning of new sections, the commissioning of new customers, gas emissions into the air resulting from the operation of safety systems, network maintenance operations, etc.. Also included in the technical losses are the possible leakages of natural gas, in the particular installations of the consumers, upstream of the meters.

The verification of natural gas characteristics is carried out by ORT - Transmission System Operator (REN Gasoduto), which periodically publishes the parameters on reference natural gas distributed in Portugal. The final composition of the natural gas varies according to its provenance and mixture, and the national average values are presented according to the following table.

***Table 3-96: Characteristics of natural gas***

| | Unit | value |
|---|---|---|
| Methane | mole % | 90.05 |
| Ethane (COVNM) | mole % | 6.45 |
| Propane (COVNM) | mole % | 1.74 |
| i-butane (COVNM) | mole % | 0.23 |
| n-butane (COVNM) | mole % | 0.27 |
| i-pentane (COVNM) | mole % | 0.02 |
| n-pentane (COVNM) | mole % | 0.01 |
| n-hexane (COVNM) | mole % | 0.01 |
| Nitrogen | mole % | 0.58 |
| $CO_2$ | mole % | 0.63 |

### 3.8.4.4 Activity data

According to the above explained methodology, activity data comprehends:

- Imports of natural gas, obtained from the DGEG's Energy Balance;
- Consumption of Natural Gas.

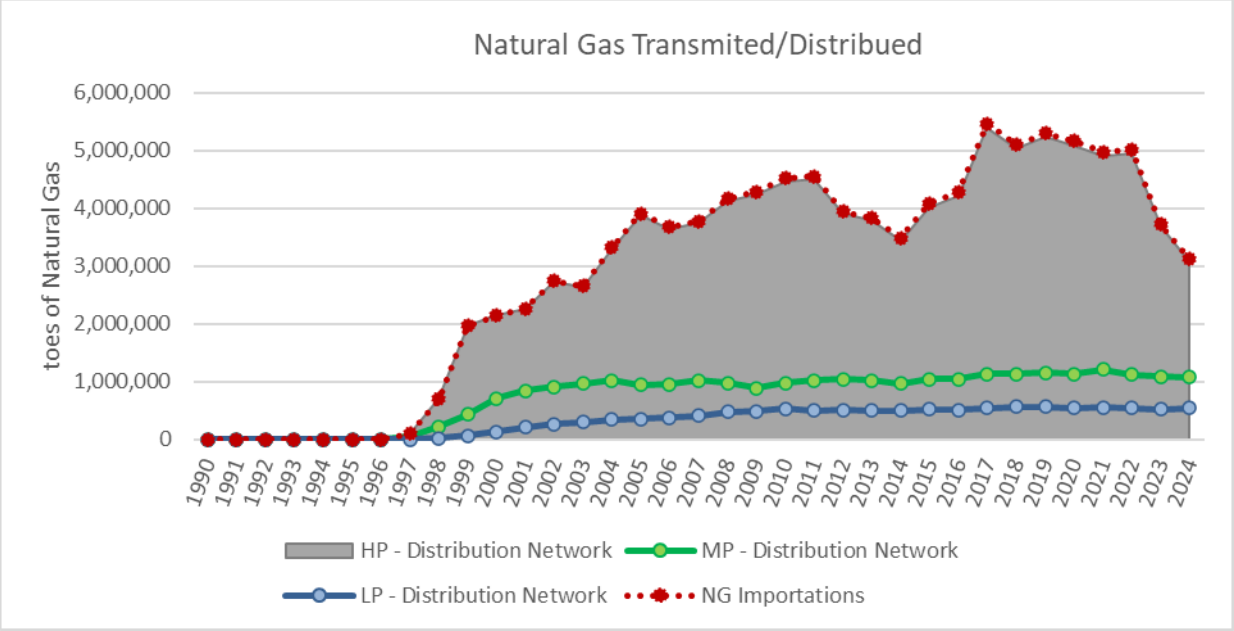



***Figure 3-64: Natural Gas transported by High, Medium and Low Pressure Networks***

### 3.8.4.5 Uncertainty Analysis

The uncertainty in activity data was considered to be 5 %, the value that was used for other statistical information gathered from the Energy Balance as area sources. The uncertainty in $CH_4$ emission factor,

considering a low quality inventory, was assumed to be 150 %, and the same value was considered for $CO_2$ emissions which were determined simply from simple conversion of emissions in methane form.

#### 3.8.4.6 Category-specific QA/QC and verification

General revision of time series consistency for fuel consumption and emission factors was the only QA/QC procedure adopted for this sector.

To further improve the QA/QC analysis a comparison between fuel consumption values reported by DGEG and IEA (International Energy Agency) was made (please see the chapter Comparison of Energy Balance vs. IEA Energy Statistics). No significant differences were found between data sources for this category.

#### 3.8.4.7 Recalculations

No recalculations in this submission.

#### 3.8.4.8 Further Improvements

We intend, if possible, to obtain information on leaks in the transportation and distribution of Natural Gas related to the period prior to 2009.

## 3.8.5 Oil and natural gas and other emissions from energy production: Venting and Flaring (CRT 1.B.2.c)

### 3.8.5.1 Category description

Venting activities do not occur in Portugal.

Regarding flaring activities in Portugal, flaring of natural gas and waste gas/vapor streams at gas facilities do not occur in Portugal, they occur only in oil industry. Flares were used at the three refineries in Portugal to control and burn non-condensable gases recovered from leakages and blow down operations, which would otherwise be emitted as volatile organic compounds. Although smokeless and complete combustion is always an objective, sometimes the gas influx exceeds flare combustion capacity and partly unburned organic compounds are emitted: NMVOC, $CH_4$ and CO.

### 3.8.5.2 Methodology

All carbon emitted in compounds, such as CO, NMVOC and $CH_4$, has fossil origin and must be included in the estimate of ultimate $CO_2$ emissions. Individual pollutants (end of pipe $CO_2$, NMVOC, $CH_4$ and CO) are converted into ultimate $CO_2$ according to:

$$U_{CO2} = EndofPipe_{CO2} + 44/12 \text{ X } (0.60 \text{ X NMVOC} + 12/16 \text{ X } CH_4 + 12/28 \text{ X CO}) \text{ X } 10^{-3}$$

Air emissions in flaring, resulting from combustion of gas collected from leaks and blowdown system, were estimated either from the quantity of gas flared or total feed to refinery.

$CO_2$ emissions were estimated according to the following equation:

$$Emi_{CO2(y)} = Flare_{Gas(y)} \text{ X } LHV_{Gas(y)} \text{ X } EF_{CO2} \text{ X } OF_{Gas(y)} \text{ X } 10^{-3}$$

**Where:**

$Emi_{CO2(y)}$: Emission of $CO_2$ in year y (t/yr)

$Flare_{Gas(y)}$: Quantity of gas flared in year y (t/yr)

$LHV_{Gas(y)}$: Low Heating Value of gas flared in year y (GJ/t)

$EF_{CO2}$: Emission factor of $CO_2$ (kg/GJ)

$OF_{Gas(y)}$: Oxidation factor of gas flared in year y (dimensionless)

$CH_4$ emissions were estimated according to the following equation:

$$Emi_{(p,y)} = EF_{(p)} \text{ X } Flare_{GAS(y)} \text{ X } m_{(p,y)}/m_{(gas,y)} \text{ X } 10^{-3}$$

**Where:**

$Emi_{CH4(y)}$: Emission of $CH_4$ in year y (t/yr)

$Flare_{GAS(y)}$: Quantity of gas flared in year y (t/yr)

$EF_{CH4}$: Emission factor of $CH_4$ (Kg/t gas)

$m_{(CH4,y)}/m_{(gas,y)}$: Mass fraction of $CH_4$ in year y

$N_2O$ emissions were estimated according to the following equation:

$$Emi_{N2O(y)} = EF_{N2O} \text{ X Crude}$$

**Where:**

$Emi_{N2O(y)}$: Emission of $N_2O$ in year y (t/yr)

$EF_{N2O}$: Emission factor of $N_2O$ ($Gg/10^3\ m^3$)

Crude: Total amount of crude throughput (t)

For NMVOC and CO emissions, please check Portugal IIR.

### 3.8.5.3 Emission Factors

Emission factors for $CO_2$ were derived from EU-ETS data for Sines and Porto refineries and from US-EPA (1991) for Lisbon refinery.

Emission factors for $CH_4$ were set from "Concawe – Air pollutant emission estimation methods for E-PRTR reporting by refineries – report no. 4/17 (2017 Edition)".

$N_2O$ emission factor was taken from Table 4.2.4 of Chapter 4 of Volume 2 of the 2006 IPCC Guidelines.

Feed density was assumed equal to 0.85 $t/m^3$ for API crude oil 30-40ºC.

***Table 3-97: Emission Factors for flaring in refineries***

| Pollutant | EF Unit | EF |
|---|---|---|
| $CO_2$ (kg/GJ) | Kg/GJ | 46.6 - 62.6 |
| $CH_4$ | kg/t gas | 5 |
| $N_2O$ | $Gg/10^3\ m^3$ | 6.4E-07 |

### 3.8.5.4 Activity data

Porto has terminated its refining activities in April 2021. Only Sines unit remains in operation.

For estimating $CO_2$ and $CH_4$ emissions, total flare gas consumed in the three units and Low Heating Value was made available from PETROGAL for the period 1990-2004. From 2005 onwards data is obtained from EU-ETS.

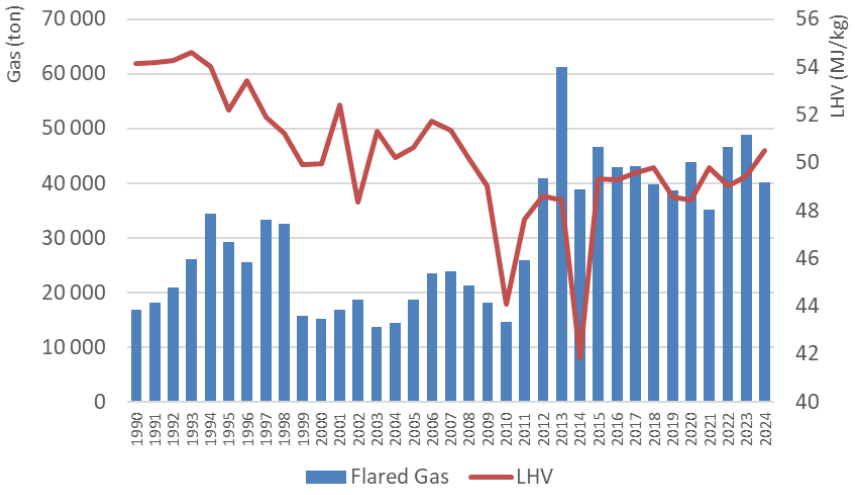



***Figure 3-65: Total consumption of flare gas in Portuguese refineries and Low Heating Value***

Activity data used for estimating $N_2O$ emissions was the total amount of crude throughput, which was obtained from DGEG for the whole time series.

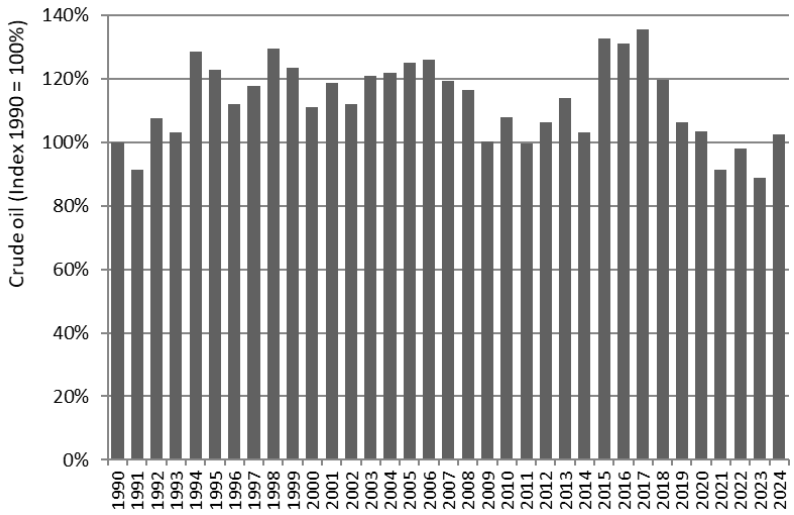



***Figure 3-66: Total amount of crude throughput in refineries***

### 3.8.5.5 Uncertainty Assessment

The uncertainty in activity data was considered to be 3 %, the value used when activity data refer data directly collected from the units. The uncertainty in NMVOC/$CO_2$ emission factor is 50 % and the double of that value for $CH_4$ and $N_2O$ emissions.

### 3.8.5.6 Recalculations

No recalculations were made.

### 3.8.5.7 Further Improvement

No further improvements are planned for this sector.

## 3.8.6 Other Fugitive Emissions (Geothermal Electricity Production) (CRT 1.B.2.d)

### 3.8.6.1 Category description

A small amount of electricity is produced from two geothermic sources in Azores archipelago: *Pico Vermelho* (commissioned in 1980) and *Ribeira Grande* (commissioned in 1994) Plants, and they are assumed to increment the release of carbon dioxide to atmosphere.

The available reporting (CRT) categories do not consider a specific place to report $CO_2$ emissions from geothermal electricity production. Nevertheless, emissions from these activities are clearly related to sector 1 (Energy) and must be better considered as fugitive emissions. However, for fugitive emissions the CRT nomenclature allows only the classes Solid Fuels (1B1) and Oil and Natural Gas (1B2), which are not exactly suitable for this activity. Sector 7 (Other) could be used in principle but would imply that emissions from this category would be no longer included in the energy sector.

Fugitive emissions from geothermal electricity production are therefore reported in category 1B2d (Other fugitive emissions from oil and natural gas).

The category has been identified as key in the KC analysis in previous submissions and was included the 2014 Methodological Development Plan (PDM), which lead to the revision of estimates based on new data collected by the Autonomous Region of Azores.

### 3.8.6.2 Methodology

From 1994 till 1999, the Regional Authority of Economy (Secretaria Regional da Economia. Direcção Regional do Comércio, Indústria e Energia) performed estimates of carbon dioxide released to atmosphere from geothermic units and these were considered in the National Inventory.

These data have been considered as inadequate and not consistent with reality by the authorities of the Autonomous Region of Azores, who made available new data referring to the characterization of a real situation of the Geothermal Electricity Production in Azores for 2008-2011 period.

The fraction from steam geothermal fluid captured in geothermal wells was chemical analysed. Those results allowed the estimation of $CO_2$ mass released to the atmosphere and the calculation of a $CO_2$ emission factor for unit of electricity produced.

Since the 2010 inventory all data concerning geothermal production is obtained from the Azores environmental entity (this time series starts in 2003). For the years prior to 2003 emissions of $CO_2$ were estimated from electricity production reported by DGEG.

### 3.8.6.3 Emission factors

Measurements of carbon dioxide emissions available from Ribeira Grande and Pico Vermelho from 2008 till 2011, presented in next table, were provided by the regional authority of the Autonomous Region of Azores[24]. These results were used to estimate an average emission factor applied to the whole period on both plants (Ribeira Grande and Pico Vermelho).

The calculation of the amount of $CO_2$ released by a geothermal power station is based on point-by-point chemical analyzes carried out on the gas fraction of the geothermal fluid, the results of which are extrapolated for the year.

[24] Secretaria Regional dos Recursos Naturais – Direcção Regional do Ambiente.

Thus, the calculation of the $CO_2$ emission is significantly influenced by the exploration effort of the plants, being directly affected by the unavailability of the geothermal wells of the production and of the auxiliary generating groups in the presence of maintenance needs.

In order to minimize the influence of these factors in the determination of the emission factor, a period of 3 years was defined for this calculation, considering that it is a reasonable time horizon to represent the evolution of the extraction effort and consequently of the $CO_2$ emissions in the course of the operation of the Ribeira Grande and Pico Vermelho geothermal plants.

***Table 3-98: Emission Factors for Geothermal Electricity Production***

| Parameter | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|
| **Production (GWh)** | 171 | 162 | 174 | 186 |
| **$CO_2$ (t)** | 19 573 | 28 206 | 36 054 | 40 094 |
| **Emission Factor** observed **(t/GWh)** | 115 | 174 | 207 | 215 |
| **Emission Factor to Geothermal Electricity Production ($tCO_2$/GWh)** (Average of last three years) | | | | 198.7 |

Source: Grupo EDA – Energia dos Açores

The variation of the emission factor observed is due to the different flow of $CO_2$ emitted by each geothermal well and flexible operating regime of the geothermal plants. The $CO_2$ emission factor adopted for geothermal power plants is the average of the last three years, 199 $tCO_2$/GWh.

### 3.8.6.4 Activity Data

Activity data consists of geothermal production. The time series was constructed using data from the regional authority in Azores:

- Pico Vermelho (old power plant) – from 1990 to 2005;
- Pico Vermelho (new power plant) – from 2006 to 2024;
- Ribeira Grande – from 1994 to 2024.
- Pico Alto – from 2017 to 2024.

Data from DGEG was used to fill in information gaps mainly for Pico Vermelho 1990 to 1999 geothermal production. The following figure shows the total geothermal production time series in Azores.

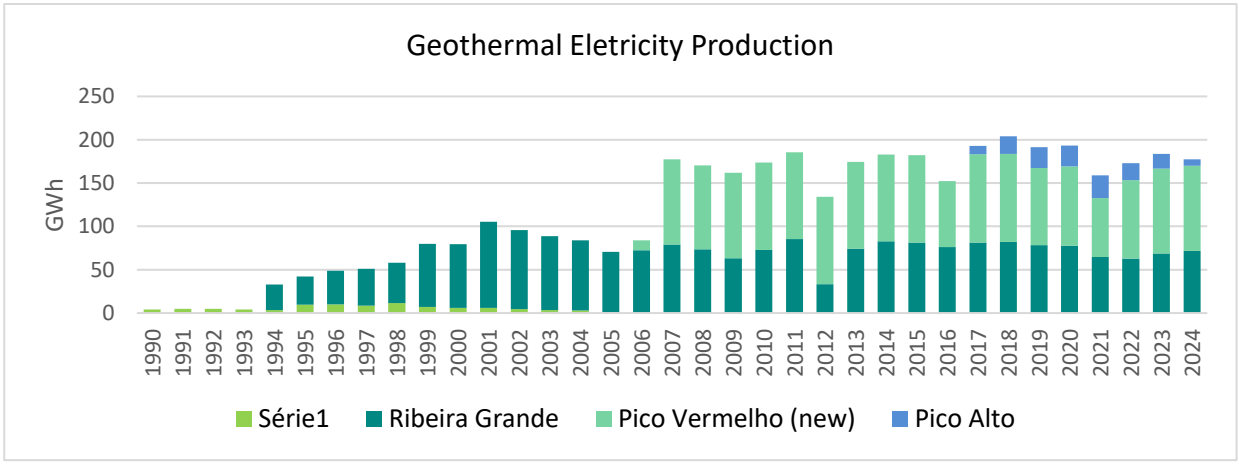



***Figure 3-67: Total Geothermal Production in Azores***

In 2006 a new power plant was commissioned in *Pico Vermelho* following the decommissioning of the old installation. This new plant tripled the installed power of *Pico Vermelho* (from 3 MW to 10 MW). For *Ribeira Grande* improvements were made in 1998 to the existing instalation that almost tripled the installed power (from 5 MW to 13 MW).

#### 3.8.6.5 Uncertainty Analysis

The uncertainty of the activity data is 5 % considering that the statistical information is reliable, but some extrapolations have been performed for earlier years, namely, to separate data per power plant.

The uncertainty in the emission factor has been estimated as 21.9 % based on the variation of the EF (measured data).

#### 3.8.6.6 Recalculations

No recalculations were made.

#### 3.8.6.7 Further Improvements

No further improvements are planned for this sector.

## 3.8.7 Other Fugitive Emissions (City Gas Production) (CRT 1.B.2.d)

### 3.8.7.1 Category description

According to the energy balances from DGEG, this activity has used fuel oil, naphtha and, more recently, natural gas as energy sources under co-generation process, from 1990 till 2001. Explanations concerning the combustion emissions associated with the production of City Gas are explained in chapter 3.3.1.2 Manufacture of solid fuels and other energy industries (CRT 1.A.1.c.).

The 2006 IPCC guidebook does not provide $CH_4$ and $CO_2$ emission factors for the estimation of emissions for the city gas production sector. Therefore, we decided to report the Notation Key "NE" category for the 1990-2001 period and thereafter "NO".

## 3.9 Sector-specific QA/QC and verification

A Streamline of Emission Factors and Low Heating Values used in the estimation of $CO_2$ emissions was implemented to the Energy Sector, the goal of this activity was to bring closer the estimation process in this sector.

$CO_2$ Emission Factor (EF) and the Low Heating Value (LHV) for specific fuels were compared for the different categories in the Energy Sector:

- Electricity and Heat Production (1.A.1.a)
- Manufacturing Industries (Combustion) (1.A.2)
- Transports (1.A.3)

Low Heating Value:

The main sources of LHV data used in the inventory come from

- Energy Balance (DGEG)
- Operators measuring's for specific unit (CELE)
- Operators reporting's (Autocontrolo)

No major differences in values were detected between sub-sectors. Although, a deeper analysis to the solid fuel was needed to clarify different fuel nomenclature and the respective LHV's.

Whenever available, the operators measured data was kept for energy consumption estimations in specific units. The LHV data from DGEG was used as a default for the inventory.

$CO_2$ Emission Factor:

In the inventory the $CO_2$ EF from 2006 IPCC Guidelines was used as default; when available, measured data from operators (CELE and Autocontrolo) was used instead.

No major differences were detected.

## 3.10 Further Improvements

Considering that the energy sector is the most prevalent emission source, special efforts must always be made to improve emission estimates, even if they affect smaller energy sub-sectors. Future improvements to the inventory will depend on the conclusions of the PDM in the scope of SNIERPA's implementation, which is being made with direct contact with the main stakeholders of the energy sector, and in close collaboration of the inventory team from APA. Although the main conclusions from this report are still not set in a final report and plan, the following preliminary routes may be here identified.

- Better integration between activity data in the air emissions inventory and other surveys such as LCP directive, Autocontrolo program, EPER/E-PRTR, the EU-ETS and the energy surveys (co-generation) made annually by DGEG. Contacts are being made to implement it. Particular work is being done to streamline the collection of data and emission estimates between the inventory and the EU-ETS, following the promotion efforts that are being made by the European Commission;

- Determination of country-specific emission factors ($SO_x$ and $NO_x$) from monitoring data collected from the Autocontrolo program and $CO_2$ emission factors for information collected under carbon market;

- Consistency Checks on Refining/Storage timeseries.

## 3.11 Reference Approach

### 3.11.1 Category description

The reference approach consists in the estimate of $CO_2$ emissions using the simple approach tier 1 of IPCC. Although the Portuguese National Inventory uses a sectoral approach (National Approach) of higher tier level, nevertheless the UNFCCC reporting guidelines request that parties make also a top-down "reference approach"[25] for estimation of $CO_2$ emissions from fossil fuel combustion, in addition to the bottom-up sectoral methodology.

The Reference Approach is a top-down approach, using a country's energy supply data to calculate the emissions of $CO_2$ from combustion of mainly fossil fuels. The Reference Approach is a straightforward method that can be applied based on relatively easily available energy supply statistics. Excluded carbon has increased the requirements for data to some extent. However, improved comparability between the sectoral and reference approaches continues to allow a country to produce a second independent estimate of $CO_2$ emissions from fuel combustion with limited additional effort and data requirements. It is good practice to apply both a sectoral approach and the reference approach to estimate a country's $CO_2$ emissions from fuel combustion and to compare the results of these two independent estimates (IPCC. 2006).

The Reference Approach requires simple statistics for production of fuels and their external trade as well as changes in their stocks. It also needs a limited number of values for the consumption of fossil products used for non-energy purposes, where carbon may be stored.

### 3.11.2 Methodology

The following methodological steps were made in accordance with IPCC (2006):

- Step 1: Estimate Apparent Fuel Consumption in Original Units;
- Step 2: Convert to a Common Energy Unit;
- Step 3: Multiply by Carbon Content to Compute the Total Carbon;
- Step 4: Compute the Excluded Carbon;
- Step 5: Correct for Carbon Unoxidised and Convert to $CO_2$ Emissions.

#### 3.11.2.1 Fuel consumption

Apparent consumption was estimated from energy balances from DGEG according to:

Apparent Consumption = Production + Imports - Exports- Stock Change.

for primary fuels and,

Apparent Consumption = Imports - Exports- Bunkers - Stock Change.

for secondary fuels.

National production is not considered because the carbon in these fuels was already included in the supply of primary fuels from which they were derived.

[25] This does not mean that a "bottom-up" approach should not be followed for estimating $CO_2$ emissions but the total emissions must be compared with those obtained from the Reference Approach.

### 3.11.2.2 Energy Consumption

The Portuguese National Balance reports consumption in energy units (toe[26]), apparent consumption needs only to be converted to TJ using the multiplier 41.868 GJ/toe.

### 3.11.2.3 Carbon Content of Fuels

Carbon content in apparent consumption is estimated in reference approach from:

$$\text{Apparent Consumption}_{(\text{Gg C})} = \text{Apparent Consumption}_{(\text{TJ})} * \text{Carbon Content}_{(\text{MgC / TJ})} * 10^{-3}$$

The carbon content of fuels was determined using the Carbon Emission Factors used in the sectoral approach, which are presented in the Table below.

***Table 3-99: Carbon content of fuels and Oxidation Factor used in the Reference Approach***

| Fuel | | | C content (t C/TJ) | $Fac_{ox}$ 0 - 1 |
|---|---|---|---|---|
| Liquid Fossil | Primary Fuels | Crude Oil | 20.0 | 1.00 |
| | | Orimulsion | 21.0 | 1.00 |
| | | Natural Gas Liquids | - | - |
| | Secondary Fuels | Gasoline | 18.9 | 1.00 |
| | | Jet Kerosene | 19.5 | 1.00 |
| | | Other Kerosene | 19.6 | 1.00 |
| | | Shale Oill | - | - |
| | | Gas / Diesel Oil | 20.2 | 1.00 |
| | | Residual Fuel Oil | 21.1 | 1.00 |
| | | LPG | 17.2 | 1.00 |
| | | Ethane | - | - |
| | | Naphtha | 20.0 | 1.00 |
| | | Bitumen | 22.0 | 1.00 |
| | | Lubricants | 20.0 | 1.00 |
| | | Petroleum Coke | 26.6 | 1.00 |
| | | Refinery Feedstocks | 20.0 | 1.00 |
| | | Other Oil | 20.0 | 1.00 |
| Solid Fossil | Primary Fuels | Anthracite (a) | 26.8 | 1.00 |
| | | Coking Coal | 25.8 | 1.00 |
| | | Other Bit. Coal | 25.8 | 1.00 |
| | | Sub-bit. Coal | 26.2 | 1.00 |
| | | Lignite | 27.6 | 1.00 |
| | | Oil Shale and tar sand | 29.1 | 1.00 |
| | Secondary Fuels | BKB & Patent Fuel | 22.0 | 1.00 |
| | | Coke Oven/Gas Coke | 29.2 | 1.00 |
| | | Coal tar | - | - |
| Gaseous Fossil | | Natural Gas (Dry) | 15.3 | 1.00 |
| Waste (non-biomass fraction) | | | 21.8 | 1.00 |
| Peat | | | - | - |
| Biomass | | Solid Biomass | 29.9 | 1.00 |
| | | Liquid Biomass | 20.0 | 1.00 |
| | | Gas Biomass | 30.6 | 1.00 |

[26] Ton of oil equivalent

### 3.11.2.4 Carbon Excluded

The aim of the Reference Approach is to provide an estimate of fuel combustion emission, so the amout of carbon which does not lead to fuel combustion emissions is excluded. Carbon excluded from fuel combustion is either emitted in another sector of the inventory (industrial process emission) or is stored in a product manufactured from the fuel.

The main flows of carbon concerned in the calculation of excluded carbon are those used as feedstock, reductant or as non-energy products.

Feedstock - Carbon emissions from the use of fuels listed above as feedstock are reported within the source categories of the Industrial Processes and Product Use (IPPU) chapter. Consequently, all carbon in fuel delivered as feedstock is excluded from the total carbon of apparent energy consumption.

Non-energy products use – The Inventory excludes consumptions of bitumen, lubricants, paraffin, solvents and propylene, these are classified as non-energy oil in the National Energy Balance.

The quantity of carbon to be excluded from the estimation of fuel combustion emissions is calculated according to following equation:

$$\text{Excluded Carbon}_{fuel}\,(\text{Gg C}) = \text{Activity Data}_{fuel}\,(\text{TJ}) \times \text{Carbon Content}_{fuel}\,(\text{C/TJ}) \times 10^{-3}$$

In the figure below it is possible to observe the total energy excluded from apparent consumption during the time series.

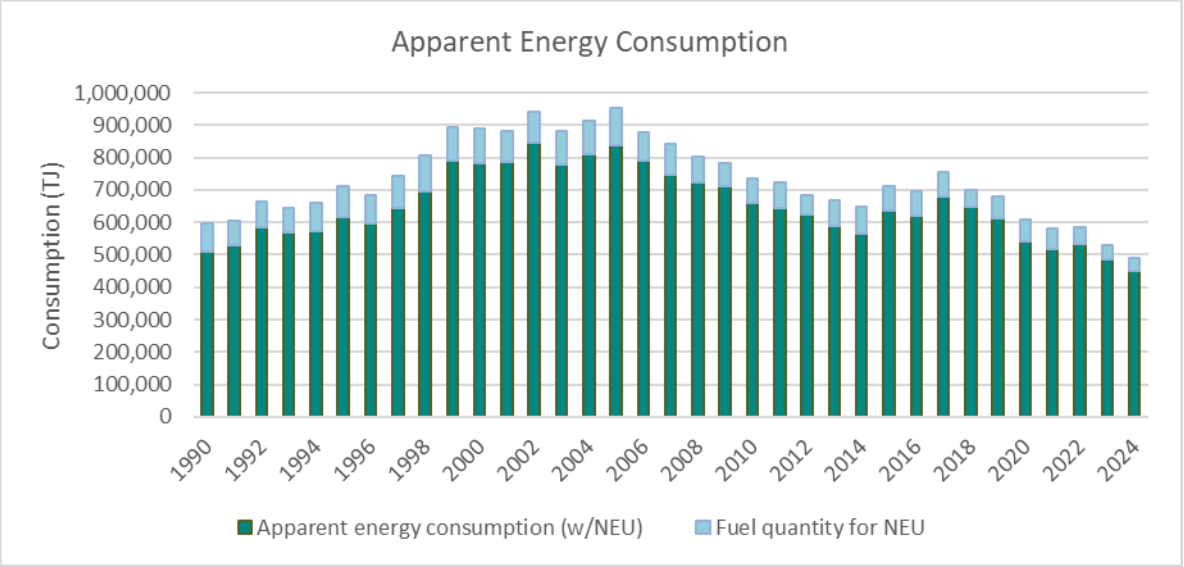



***Figure 3-68: Apparent energy consumption***

This excluded energy concerns mainly the consumption as a feedstock of Naphtha and more recently LPG and Natural Gas in the Industrial Processes sector and non-energetic use of Bitumen, Lubricants and Other oil. Some losses associated with oil refining were also excluded from the reference approach, since these were not classified as energy consumptions.

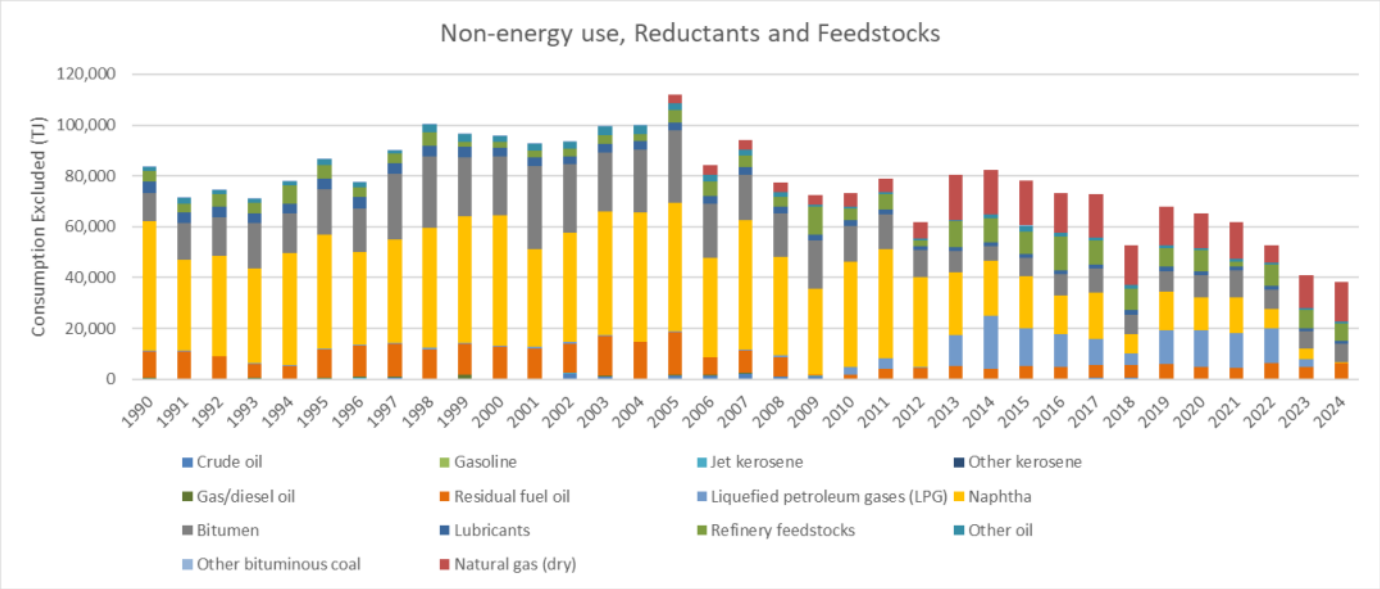



***Figure 3-69: Fuel consumption excluded from Apparent Consumption***

### 3.11.3 Actual Carbon Dioxide Emissions

Estimated simply from:

$CO_2$ Emission = 44/12 * (Apparent Consumption - Excluded Carbon) * Oxidation Factor

### 3.11.4 Results - Comparison of Reference Approach and Sectoral Approach

Detailed data used in the reference approach calculation is reported in CRT tables and is not duplicated in NID. The emissions estimated according to reference approach and national approach are presented in the figure below and show differences in both energy consumption and carbon emissions.

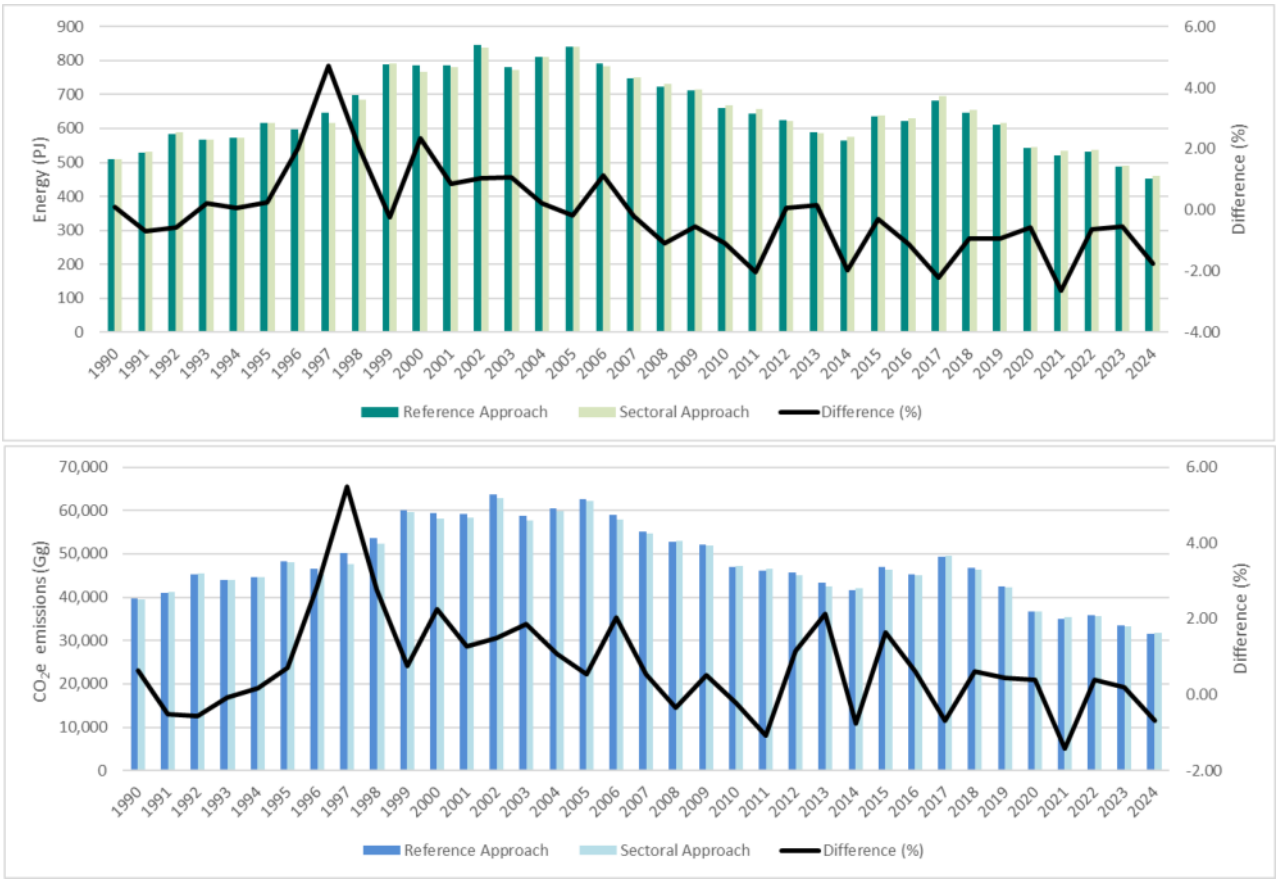



***Figure 3-70: Comparison of Energy Consumption and $CO_2$ emissions between the National approach and the Reference Approach***

Differences are mostly explained by the following:

- differences in the Energy Balance and the energy activity data used by the inventory – where data collected directly from emission units (Large Point Sources) play a very representative role – and a different approach to account for emissions from carbon stored in products;
- specific LHV values for LPS are not always considered in the Energy Balance;
- the % of feed-stocks which carbon is stored in products are default values and not specific of the national conditions reflected in the inventory;
- the energy balance as been updated in order to follow the IPCC criteria to distinguish between domestic and international fuel use. This improvement contributes to decrease the difference between the reference and the sectoral approach. Portugal is still developing efforts to further improve the split between domestic and international consumption in the energy balance.

The difference between the approaches in terms of $CO_2$, has been reduced after 2001, which is coincident with the efforts that were made by DGEG and APA in order to improve consistency between the different approaches. The slight increase in the difference between the two approaches from 2008 to 2009 may be due to the reclassification of lime production and the corrections of double counting for some co-generation power plants. Differences in $CO_2$ emissions are mainly associated with emissions of industrial waste and

municipal solid waste. As they are about carbon contents with great variability, it is our intention to estimate a national value to use in the reference approach.

### 3.11.5 Feedstock

Emissions of greenhouse gas emissions from feedstock use are only clearly accounted in the inventory in the following situations:

- emission of $CO_2$ resulting from use of feedstock sub-products as energy sources. That is the case of emissions from consumption of fuel gas in refinery and petrochemical industry;
- emission of $CO_2$ liberated as sub-product in production processes such as ammonia production;
- emission of NMVOC from fossil fuel origin, and occurring from solvent use and evaporation. Although in this case it is not possible to establish which part results from feedstock consumption in Portugal in the energy balance.

However, some potential emissions are not estimated or are only partly estimated. Those that are estimated in the reference approach but not in sectoral approach are:

- emissions from mineral oil use as lubricants;
- emissions from wear of bitumen in roads.

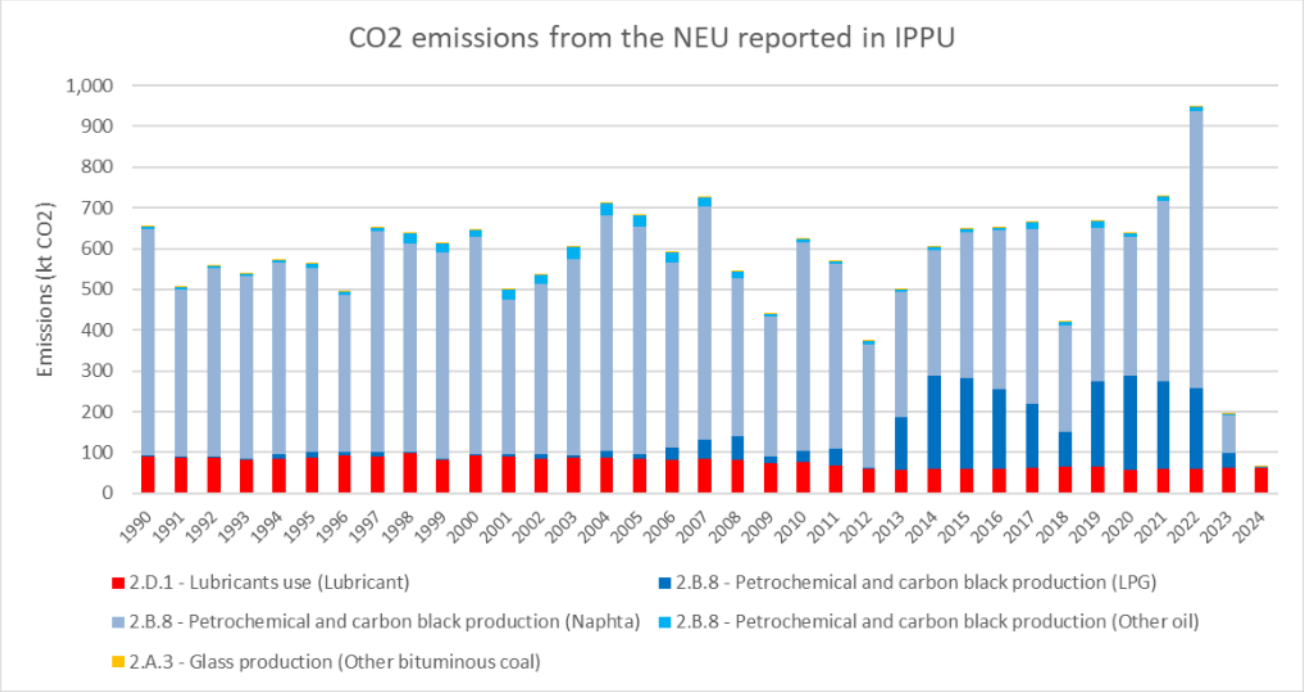



***Figure 3-71: Carbon dioxide ($CO_2$) emissions from non-energy use by sector***

CRT Table 1.A. (d) reports consumption of fuels whose carbon content is excluded from the reference approach. Non-energy uses are also associated with emissions that occur in the IPPU sector from the use of such fuels as feedstocks, reductants and other non-energy uses. However, as explained, in the methodology some of the excluded carbon refers to losses in the refinery sector that are reported in the energy balance. These losses do not relate to non-energy uses and may be allocated to the fugitive emissions sector 1B. Hence reporting NO for some of the fuels that have NEU amounts but have no associated emissions in the IPPU sector.

The values of Natural Gas excluded from the Reference Approach analysis in Table1.A (D) refer to non-energy consumption of natural gas that occurs in Oil Refineries and that are considered in fugitive emissions sector.

The inability to choose this category from the drop-down list in table 1.A (d) does not allow reporting this information transparently.

In this way the values reported in cell I39 of Table 1.A(d) are considered in the Sectoral Approach in Table 1.B.2 cell H13, which includes other emission sources in addition to hydrogen production.

The sharp decreases in 2018 and 2023 were due to scheduled interruptions for maintenance/cleaning in the only ethylene production facility (2.B.8), which affected the production lines. In 2024 there was no ethylene production due to market constraints.

# 4 Industrial Processes and Products Use (CRT Sector 2)

## Table of Contents


4 Industrial Processes and Products Use (CRT Sector 2) ..... 4-1

4.1 Overview of the sector ..... 4-12

4.2 Mineral Industry (CRT 2.A) ..... 4-18

4.2.1 Overview ..... 4-18

4.2.2 Cement Production (CRT 2.A.1) ..... 4-18

4.2.3 Lime Production in dedicated plants (CRT 2.A.2) ..... 4-23

4.2.4 Lime Production in Iron and Steel (CRT 2.A.2) ..... 4-30

4.2.5 Lime Production in Paper Pulp (CRT 2.A.2) ..... 4-33

4.2.6 Lime production in Other Sectors (CRT 2.A.2) ..... 4-35

4.2.7 Glass Production (CRT 2.A.3) ..... 4-38

4.2.8 Glass Wool Production (CRT 2.A.3) ..... 4-43

4.2.9 Other Process Uses of Carbonates - Ceramics (CRT 2.A.4.a) ..... 4-44

4.2.10 Other Process Uses of Carbonates-Other Uses of Soda Ash (CRT 2.A.4.b) ..... 4-49

4.2.11 Other Process Uses of Carbonates-Non Metallurgical Magnesia Production (CRT 2.A.4.c) 4-52

4.2.12 Other Process Uses of Carbonates – Other (CRT 2.A.4.d) ..... 4-53

4.2.13 Other - Rock wool Production (CRT 2.A.5) ..... 4-57

4.3 Chemical Industry (CRT 2.B) ..... 4-60

4.3.1 Overview ..... 4-60

4.3.2 Ammonia Production (CRT 2.B.1) ..... 4-60

4.3.3 Nitric Acid Production (CRT 2.B.2) ..... 4-64

4.3.4 Adipic Acid Production (CRT 2.B.3) ..... 4-67

4.3.5 Caprolactam, Glyoxal and Glyoxylic Acid Production (CRT 2.B.4) ..... 4-67

4.3.6 Silicon Carbide and Calcium Carbide Production (CRT 2.B.5) ..... 4-67

4.3.7 Titanium Dioxide Production (CRT 2.B.6) ..... 4-67

4.3.8 Soda Ash Production (CRT 2.B.7) ..... 4-70

4.3.9 Petrochemical and Carbon Black Production – Methanol (CRT 2.B.8.a) ..... 4-70
4.3.10 Petrochemical and Carbon Black Production – Ethylene (CRT 2.B.8.b) ..... 4-70
4.3.11 Petrochemical and Carbon Black Production– Ethylene Dichloride and Vinyl Chloride Monomer (VCM) (CRT 2.B.8.c) ..... 4-72
4.3.12 Petrochemical and Carbon Black Production – Ethylene Oxide (CRT 2.B.8.d) ..... 4-72
4.3.13 Petrochemical and Carbon Black Production – Acrylonitrile (CRT 2.B.8.e) ..... 4-72
4.3.14 Petrochemical and Carbon Black Production – Carbon Black (CRT 2.B.8.f) ..... 4-73
4.3.15 Petrochemical and Carbon Black Production – Other (CRT 2.B.8.g) ..... 4-75
4.3.16 Fluorochemical Production (CRT 2.B.9) ..... 4-75
4.3.17 Other - Sulphuric Acid Production (CRT 2.B.10.b) ..... 4-76
4.3.18 Other – Explosives Production (CRT 2.B.10.b) ..... 4-76
4.3.19 Other – Solvent Use in Plastic Manufacturing (CRT 2.B.10.d) ..... 4-76
4.4 Metal Industry (CRT 2.C) ..... 4-77
4.4.1 Overview ..... 4-77
4.4.2 Iron and Steel Production (CRT 2.C.1) ..... 4-77
4.4.3 Ferroalloys Production (CRT 2.C.2) ..... 4-87
4.4.4 Aluminium Production (CRT 2.C.3) ..... 4-88
4.4.5 Magnesium Production (CRT 2.C.4) ..... 4-88
4.4.6 Lead Production (CRT 2.C.5) ..... 4-88
4.4.7 Zinc Production (CRT 2.C.6) ..... 4-90
4.4.8 Copper Production (CRT 2.C.7.a) ..... 4-90
4.5 Non-energy Products from Fuels and Solvents Use (CRT 2.D) ..... 4-91
4.5.1 Overview ..... 4-91
4.5.2 Lubricants Use (CRT 2.D.1) ..... 4-91
4.5.3 Paraffin Wax Use (CRT 2.D.2) ..... 4-93
4.5.4 Solvent Use – Solvent Use (CRT 2.D.3.a) ..... 4-95
4.5.5 Solvent Use – Road Paving with Asphalt and Asphalt Blowing in Refineries (CRT 2.D.3.b) . 4-95
4.5.6 Solvent Use – Urea based catalytic converters (CRT 2.D.3.c) ..... 4-96
4.6 Electronics Industry (CRT 2.E) ..... 4-97
4.6.1 Overview ..... 4-97
4.6.2 Integrated Circuit or Semiconductor (CRT 2.E.1) ..... 4-97
4.6.3 TFT Flat Panel Display (CFT 2.E.2) ..... 4-97
4.6.4 Photovoltaics (CRT 2.E.3) ..... 4-98
4.6.5 Heat Transfer Fluid (CRT 2.E.4) ..... 4-98

4.7 Products Uses as substitutes for ODS (CRT 2.F) ..... 4-99
4.7.1 Overview ..... 4-99
4.7.2 Commercial Refrigeration (CRT 2.F.1.a) ..... 4-103
4.7.3 Domestic Refrigeration (CRT 2.F.1.b) ..... 4-112
4.7.4 Industrial Refrigeration (CRT 2.F.1.c) ..... 4-118
4.7.5 Transport Refrigeration (CRT 2.F.1.d) ..... 4-122
4.7.6 Mobile Air Conditioning (CRT 2.F.1.e) ..... 4-127
4.7.7 Stationary Air Conditioning (CRT 2.F.1.f) ..... 4-137
4.7.8 Foam Blowing (CRT 2.F.2) ..... 4-145
4.7.9 Fire Protection (CRT 2.F.3) ..... 4-148
4.7.10 Aerosols – Metered Dose Inhalers (CRT 2.F.4.a) ..... 4-153
4.7.11 Aerosols – Other Aerosols (CRT 2.F.4.b) ..... 4-154
4.8 Other Product Manufacture and Use (CRT 2.G) ..... 4-156
4.8.1 Overview ..... 4-156
4.8.2 Manufacture of Electrical Equipment (CRT 2.G.1.a) ..... 4-156
4.8.3 Use of Electrical Equipment (CRT 2.G.1.b) ..... 4-158
4.8.4 SF6 and PFCs from Other Product Use (CRT 2.G.2) ..... 4-163
4.8.5 $N_2O$ from Product Use – Medical Application (CRT 2.G.3.a) ..... 4-164
4.8.6 $N_2O$ from Product Use – Propellant for pressure and aerosol products (CRT 2.G.3.b) ..... 4-165
4.9 Other (CRT 2.H) ..... 4-166
4.9.1 Overview ..... 4-166
4.9.2 Pulp and Paper Industry (CRT 2.H.1) ..... 4-166
4.9.3 Food Manufacturing (CRT 2.H.2) ..... 4-168
4.9.4 Drink Manufacturing (CRT 2.H.2) ..... 4-168
4.9.5 Wood Chipboard Production (CRT 2.H.3.a) ..... 4-168
4.9.6 Carbon electrodes consumption (CRT 2.H.3.b) ..... 4-168

## List of Figures

Figure 4-1: IPPU emissions from total GHG emissions in 2024, by source sub-sector ..... 4-14
Figure 4-2: Total GHG emissions from IPPU per source sub-sector (kt $CO_2e$) ..... 4-14
Figure 4-3: Emissions of IPPU by sub-source sector in Portugal in year 1990 and 2024 (kt $CO_2e$) ..... 4-15
Figure 4-4: GHG Emissions from IPPU per gas in 2024 ..... 4-15
Figure 4-5: Raw meal consumption in Portugal ..... 4-21

Figure 4-6: Total clinker production in Portugal ..... 4-21
Figure 4-7: Clinker production data – comparison of approaches ..... 4-22
Figure 4-8: Lime production from different sources ..... 4-26
Figure 4-9: Lime production reported in the CRT tables ..... 4-27
Figure 4-10: Lime production in dedicated plants – comparison of approaches ..... 4-29
Figure 4-11: Lime production and steel production from BOF in Iron and Steel ..... 4-31
Figure 4-12: Lime production in Iron and Steel ..... 4-32
Figure 4-13: Lime Production in paper pulp ..... 4-34
Figure 4-14: $CaCO_3$ Consumption in paper pulp ..... 4-34
Figure 4-15: Glass production ..... 4-39
Figure 4-16: Raw materials consumption ..... 4-41
Figure 4-17: Cullet incorporation by type of glass ..... 4-41
Figure 4-18: Raw materials consumption in EU-ETS plants in 2024 ..... 4-47
Figure 4-19: Energy consumption in ceramics sector by fuel type (Source: Energy Balance) ..... 4-47
Figure 4-20: % Energy consumption in ceramics sector in 2024 ..... 4-48
Figure 4-21: Raw materials consumption in ceramics sector ..... 4-48
Figure 4-22: Soda ash apparent consumption ..... 4-51
Figure 4-23: Consumption of carbonate materials in fertilizer industry ..... 4-55
Figure 4-24: Recalculations in Carbonates fertilisers sub-category ..... 4-56
Figure 4-25: Rock wool production and limestone consumption ..... 4-59
Figure 4-26: Ammonia Production by Partial Oxidation ..... 4-61
Figure 4-27: Trend in Ammonia and Urea production ..... 4-63
Figure 4-28: Ammonia production data – comparison of approaches ..... 4-64
Figure 4-29: Trend in Nitric Acid production ..... 4-66
Figure 4-30: Trend in Titanium Dioxide Production ..... 4-68
Figure 4-31: Trend in Ethylene production ..... 4-71
Figure 4-32: Ethylene production data – comparison of approaches ..... 4-72
Figure 4-33: Carbon Black production ..... 4-74
Figure 4-34: Integrated iron and steel facility – production of steel and intermediate products (1990-2001) ..... 4-84
Figure 4-35: Steel production by process ..... 4-85
Figure 4-36: Crude steel production in Portugal – comparison of approaches ..... 4-86
Figure 4-37: Secondary Lead production data (Index 1990=100%) ..... 4-89
Figure 4-38: Amount of Lubricants used in Portugal ..... 4-92

Figure 4-39: Amount of Paraffin Wax used in Portugal ..... 4-94
Figure 4-40: Trends in emissions from product uses as substitutes for ODS ..... 4-99
Figure 4-41: Share of emissions by subcategory ..... 4-100
Figure 4-42: Commercial refrigeration equipment assembled in Portugal and share of fluid by type/blend . 4-107
Figure 4-43: Number of commercial establishments by type ..... 4-108
Figure 4-44: Number of commercial refrigeration equipment ..... 4-109
Figure 4-45: Recalculations in 2.F.1.a: comparison in assembly phase and total 2.F.1.a ..... 4-111
Figure 4-46: Domestic refrigeration equipment assembled in Portugal by type of fluid ..... 4-113
Figure 4-47: Domestic refrigeration equipment in operation in Portugal by type of fluid and share of households with refrigeration equipment ..... 4-114
Figure 4-48: Domestic refrigeration equipment disposed in Portugal by type of fluid ..... 4-116
Figure 4-49: Recalculations in 2.F.1.c ..... 4-121
Figure 4-50: Number of equipment assembled and shares of fluids in assembly phase in Portugal ..... 4-124
Figure 4-51: Number of registered vehicles in circulation and shares of fluids in operation phase in Portugal ..... 4-124
Figure 4-52: Disposal of equipment using HFC ..... 4-125
Figure 4-53: Recalculations in Transport Refrigeration ..... 4-126
Figure 4-54: Vehicles assembled in Portugal by type of MAC fluid ..... 4-131
Figure 4-55: Fleet of vehicles circulating in Portugal by type of MAC fluid ..... 4-132
Figure 4-56: Vehicles at end-of-life by type of MAC fluid ..... 4-134
Figure 4-57: AC equipment assembled in Portugal and share of fluid by type/blend ..... 4-140
Figure 4-58: AC equipment in operation in Portugal by type of fluid and share of households with AC equipment ..... 4-141
Figure 4-59: AC equipment disposed in Portugal by type of fluid ..... 4-142
Figure 4-60: AC equipment in operation in Portugal by type of fluid and share of households with AC equipment ..... 4-143
Figure 4-61: HFC consumption in new Fire protection equipment by type of gas ..... 4-150
Figure 4-62: Stocks of HFC in Fire protection equipment by type of gas ..... 4-150
Figure 4-63: Recalculations in 2.F.3: comparison of amounts of HFC fluid in assembly and operation phase and total 2.F.3 emissions ..... 4-152
Figure 4-64: Recalculations in 2.F.4.b: comparison of amounts of HFC fluid (total assembly and operation phase) and total 2.F.4.b emissions ..... 4-155
Figure 4-65: Recalculations in electrical equipment manufacturing: comparison in activity data and emissions in CO2 eq ..... 4-157
Figure 4-66: Flowchart of the National Electric System ..... 4-158

Figure 4-67: Map of National Network of Electric Energy Transport ..... 4-159
Figure 4-68: Total SF6 in stock in electric equipment in Portugal ..... 4-162
Figure 4-69: Recalculations in electrical equipment in operation: comparison in activity data and emissions in CO2 eq ..... 4-163
Figure 4-70: $N_2O$ consumption data ..... 4-164
Figure 4-71: Total production of paper pulp ..... 4-167
Figure 4-72: Consumption of carbon electrodes in industry ..... 4-169

## List of Tables

Table 4-1: Total GHG emissions from IPPU ..... 4-13
Table 4-2: Key categories in IPPU (CRT 2) and methodologies used in emission estimates ..... 4-17
Table 4-3: Uncertainty values related to emissions reported under CRT 2.A.1 ..... 4-22
Table 4-4: Emission Factors considered ..... 4-25
Table 4-5: Uncertainty values related to emissions reported under CRT 2.A.2 – dedicated plants ..... 4-27
Table 4-6: Uncertainty values related to emissions reported under CRT 1.A.2.f ..... 4-28
Table 4-7: Emission Factors ..... 4-30
Table 4-8: Uncertainty values related to emissions reported under CRT 2.A.2 – Iron and Steel ..... 4-32
Table 4-9: Emission Factors ..... 4-33
Table 4-10: Uncertainty values related to emissions reported under CRT 2.A.2 – paper pulp ..... 4-35
Table 4-11: Emission Factors ..... 4-36
Table 4-12: Uncertainty values – other sectors ..... 4-37
Table 4-13: Emission Factors ..... 4-39
Table 4-14: Uncertainty values related to emissions reported under CRT 2.A.3 – Glass Production ..... 4-41
Table 4-15: Uncertainty values related to emissions reported under CRT 1.A.2.f ..... 4-42
Table 4-16: Emission Factors ..... 4-43
Table 4-17: Uncertainty values related to emissions reported under CRT 2.A.3 – Glass Wool Production 4-44
Table 4-18: Emission Factors of raw materials ..... 4-46
Table 4-19: Uncertainty values ..... 4-48
Table 4-20: Emission factors of soda ash ..... 4-50
Table 4-21: Uncertainty values ..... 4-51
Table 4-22: Emission factors of carbonate materials ..... 4-55
Table 4-23: Uncertainty values ..... 4-56
Table 4-24: Emission Factors ..... 4-58

Table 4-25: Uncertainty values related to emissions reported under CRT 2.A.4.d – Rock Wool Production .. 4-59
Table 4-26: Emission Factors and parameters considered ..... 4-62
Table 4-27: Uncertainty values ..... 4-63
Table 4-28: Emission Factors considered ..... 4-65
Table 4-29: Uncertainty values ..... 4-66
Table 4-30: CO2 emission factors related to TiO2 production ..... 4-68
Table 4-31: Uncertainty values ..... 4-68
Table 4-32: Emission Factors ..... 4-71
Table 4-33: Uncertainty values ..... 4-71
Table 4-34: Emission Factors for Carbon Black process emissions ..... 4-74
Table 4-35: Reporting of Other Petrochemical and Carbon Black Production ..... 4-75
Table 4-36: Emission streams for iron and steel industry ..... 4-80
Table 4-37: Emission Factors for Iron and Steel Production in the period 1990-2001 ..... 4-82
Table 4-38: Carbon bearing materials: carbon content and $CO_2$ stoichiometric EF ..... 4-83
Table 4-39: Uncertainty values related to emissions reported under CRT 2.C.1 ..... 4-85
Table 4-40: CO2 emission factor related to Lead production ..... 4-88
Table 4-41: Uncertainty values ..... 4-89
Table 4-42: Emission factors for Lubricant Use (2.D.1) ..... 4-92
Table 4-43: Uncertainty values ..... 4-93
Table 4-44: Emission factors for Paraffin Waxes Use ..... 4-94
Table 4-45: Uncertainty values ..... 4-94
Table 4-46: Overall parameters applied for 2.F sub-categories reported ..... 4-102
Table 4-47: Emission Factors considered in assembly ..... 4-104
Table 4-48: Emission Factors for F-gas emissions from commercial refrigeration equipment (hypermarkets not included) ..... 4-105
Table 4-49: Emission Factors for F-gas emissions in hypermarkets ..... 4-105
Table 4-50: Use of each Gas/Mixture in the assembled units (%) - $HFC_y$ ..... 4-107
Table 4-51: Number of refrigeration equipment per commercial unit in Portugal ..... 4-108
Table 4-52: Number of refrigeration equipment per commercial unit in Portugal ..... 4-109
Table 4-53: Classification of refrigeration equipment by area ..... 4-109
Table 4-54: Stand-alone commercial units (Hypermarkets equipment not included) ..... 4-110
Table 4-55: Medium & Large commercial units (Hypermarkets equipment) ..... 4-110
Table 4-56: Emission Factors and parameters of F-gases from Domestic Refrigeration equipment ..... 4-112

Table 4-57: Domestic Refrigeration – Fridge ..... 4-116
Table 4-58: Domestic Refrigeration –Freezers ..... 4-116
Table 4-59: Industrial Refrigeration emission factors ..... 4-119
Table 4-60: Industrial Refrigeration ..... 4-120
Table 4-61: Transport Refrigeration emission factors ..... 4-123
Table 4-62: Uncertainty parameters for Transport Refrigeration ..... 4-125
Table 4-63: Mobile Air Conditioning emission factors and parameters for Road Transportation ..... 4-128
Table 4-64: Mobile Air Conditioning emission factors and parameters for Railways ..... 4-129
Table 4-65: AC shares considered to characterize the national vehicle fleet, by type of vehicle and EURO-Standard ..... 4-130
Table 4-66: Passenger cars and light duty vehicles ..... 4-134
Table 4-67: Heavy duty vehicles ..... 4-135
Table 4-68: Buses and Coaches ..... 4-135
Table 4-69: Railways ..... 4-135
Table 4-70: Emission Factors and parameters of F-gases from Residential AC equipment ..... 4-137
Table 4-71: Emission Factors and parameters of F-gases from Non-residential AC equipment ..... 4-138
Table 4-72: Use of each Gas/Mixture in Stationary Air Conditioning assembled units (%) ..... 4-139
Table 4-73: Residential AC ..... 4-143
Table 4-74: Non-residential AC ..... 4-144
Table 4-75: Foam losses emission factors ..... 4-146
Table 4-76: Foam Blowing (Closed Cell) ..... 4-147
Table 4-77: Foam Blowing (Open Cell) ..... 4-147
Table 4-78: Fire Protection losses emission factors ..... 4-149
Table 4-79: Fire protection ..... 4-151
Table 4-80: Metered Dose Inhalers ..... 4-153
Table 4-81: Other Aerosols ..... 4-155
Table 4-82: Average SF6 charge for each kind of equipment ..... 4-162
Table 4-83: Electric Equipment ..... 4-163
Table 4-84: Emission Factors for paper pulp production (non-combustion) ..... 4-167
Table 4-85: Emission factors of carbonate materials ..... 4-169
Table 4-86: Uncertainty values ..... 4-170

# List of Equations

Equation 4-1: $CO_2$ emissions from clinker production – 2005-onwards ..... 4-19
Equation 4-2: $CO_2$ emissions from clinker production – 1990-2004 ..... 4-20
Equation 4-3: Chemical conversion equations ..... 4-23
Equation 4-4: $CO_2$ Emissions from lime production – 2005-onwards ..... 4-24
Equation 4-5: $CO_2$ Emissions from lime production – 1990-2004 ..... 4-25
Equation 4-6: $CO_2$ Emissions from lime production in iron and steel ..... 4-30
Equation 4-7: Lime production estimated for 1990 and 1995-2001 ..... 4-31
Equation 4-8: Chemical conversion equations ..... 4-33
Equation 4-9: $CO_2$ Emissions from carbonates consumption in paper pulp ..... 4-33
Equation 4-10: $CO_2$ Emissions from lime production in other sectors ..... 4-36
Equation 4-11: $CO_2$ Emissions from glass production ..... 4-38
Equation 4-12: $CO_2$ Emissions from crystal glass production ..... 4-38
Equation 4-13: Carbonate consumption – 1990-2004 ..... 4-40
Equation 4-14: $CO_2$ Emissions from glass production ..... 4-43
Equation 4-15: Annual national carbonate consumption in ceramics – 2015-onwards ..... 4-45
Equation 4-16: Annual national $CO_2$ emissions from ceramics – 2015-onwards ..... 4-45
Equation 4-17: EU-ETS carbonates consumption - 1990-2014 ..... 4-45
Equation 4-18: Annual national carbonate consumption – 1990-2014 ..... 4-46
Equation 4-19: Annual national $CO_2$ emissions from ceramics - 1990-2014 ..... 4-46
Equation 4-20: Soda ash apparent consumption ..... 4-49
Equation 4-21: Soda ash apparent consumption in other sectors ..... 4-50
Equation 4-22: $CO_2$ Emissions from soda ash consumption (other sectors) ..... 4-50
Equation 4-23: Chemical conversion equations ..... 4-53
Equation 4-24: $CO_2$ emissions ..... 4-54
Equation 4-25: $CO_2$ emissions ..... 4-54
Equation 4-26: $SO_2$ removals ..... 4-54
Equation 4-27: $CO_2$ Emissions from rock wool production ..... 4-57
Equation 4-28: Limestone consumption - 1997-2004 ..... 4-58
Equation 4-29: Chemical conversion equation ..... 4-60
Equation 4-30: Chemical conversion equation ..... 4-60
Equation 4-31: Chemical conversion equations ..... 4-61
Equation 4-32: $CO_2$ emissions from ammonia production ..... 4-62

Equation 4-33: $CO_2$ recovered for urea production ..... 4-62
Equation 4-34: $N_2O$ Emissions from nitric acid production ..... 4-65
Equation 4-35: $CO_2$ emissions from titanium dioxide production ..... 4-67
Equation 4-36: $CO_2$ and $CH_4$ emissions from ethylene production ..... 4-70
Equation 4-37: Emissions from black carbon production ..... 4-73
Equation 4-38: Carbon mass balance ..... 4-73
Equation 4-39: Emissions from sinter production ..... 4-81
Equation 4-40: Emissions from iron and steel (BOF) production ..... 4-81
Equation 4-41: Emissions from steel production (EAF) – 1990-2001 ..... 4-82
Equation 4-42: Sinter production in the integrated iron and steel facility ..... 4-83
Equation 4-43: EAF steel production in the integrated iron and steel facility – 1990-2001 ..... 4-84
Equation 4-44: $CO_2$ emissions from lead production ..... 4-88
Equation 4-45: Lubricants accounted for in this category ..... 4-91
Equation 4-46: $CO_2$ emissions from lubricants consumption ..... 4-92
Equation 4-47: $CO_2$ emissions from paraffin wax consumption ..... 4-93
Equation 4-48: Emissions when charging new equipment ..... 4-103
Equation 4-49: Emissions during equipment lifetime ..... 4-103
Equation 4-50: Emissions at system end-of-life (Disposal) ..... 4-104
Equation 4-51: Emissions when charging new equipment ..... 4-118
Equation 4-52: Emissions during equipment lifetime ..... 4-118
Equation 4-53: Emissions at system end-of-life (Disposal) ..... 4-119
Equation 4-54: Emissions when charging new equipment ..... 4-122
Equation 4-55: Emissions during equipment lifetime ..... 4-122
Equation 4-56: Emissions at system end-of-life (Disposal) ..... 4-123
Equation 4-57: Emissions when charging new MAC equipment ..... 4-127
Equation 4-58: Emissions during MAC equipment lifetime ..... 4-127
Equation 4-59: Emissions at MAC system end-of-life (Disposal) ..... 4-128
Equation 4-60: AC equipment assembled annually ..... 4-140
Equation 4-61: First year losses ..... 4-145
Equation 4-62: F-gas in closed-cell ..... 4-145
Equation 4-63: Annual losses ..... 4-145
Equation 4-64: Emissions during equipment lifetime ..... 4-148
Equation 4-65: Bank of F-gas ..... 4-148

Equation 4-66: F-gas emissions from metered dose inhalers ..... 4-153
Equation 4-67: 2015 Portuguese activity data for other aerosols ..... 4-154
Equation 4-68: Portuguese activity data for other aerosols for year y ..... 4-154
Equation 4-69: F-gas emissions from other aerosols ..... 4-154
Equation 4-70: $SF_6$ emissions from manufacture of electrical equipment..... 4-156
Equation 4-71: Correspondent States Principle ..... 4-159
Equation 4-72: $SF_6$ emissions..... 4-161
Equation 4-73: Emissions from Pulp and Paper Industry ..... 4-166
Equation 4-74: $CO_2$ emissions..... 4-169

# 4 Industrial Processes and Products Use (CRT Sector 2)

*Rita Silva*

*Updated: March 2026*

## 4.1 Overview of the sector

Industrial Processes and Product Use (IPPU) sector generates GHG emissions resulting from the chemical and physical transformation of raw materials in the industrial transformation processes, excluding emissions that result from combustion processes aiming for energy production1. GHG emissions also result from the use of greenhouse gases in products and from non-energy uses of fossil fuel carbon. According to UNFCCC reporting guidelines, in this sector are also included emissions of fluorinated compounds (HFC, PFC and SF6) that are used in different applications - not solely industrial, but also in domestic and services sector - as substitutes to ozone depleting substances (ODS).

Industrial processes, either involving combustion or not, result also in the release of other atmospheric pollutants like acidifying gases and indirect GHG: $NO_x$, NMVOC and $SO_x$. Industrial processes are also relevant sources of particulate matter (TSP, $PM_{10}$, $PM_{2.5}$ and $PM_1$) and local air pollutants such CO and Heavy Metals. The methodologies and emission factors that are used in the Portuguese air emission inventory for estimating emissions from these sources are discussed in the Inventory Informative Report (IIR)[2].

Industrial production has registered a moderate stabilization in 2023-2024. The industrial sector in Portugal in 2024 recorded a mixed performance, with a slight nominal decrease in production (-0.9%), influenced by declines in the energy sector despite the growth in the logistics sector (+31%) and an increase in goods exports. Industry accounted for 21.2% of the GVA.

In 2024, the Industrial Production Index increased by 0.2%, after the 3.1% decrease recorded in the previous year. The main products produced in 2024, considering the sales value, were from the *Food Industry*, followed by the *Manufacturing of automobile vehicles and the Manufacturing of coke, refined petroleum products and fuel agglomerates*.

[1] Emissions from combustion are considered in this sector if they are considered a production process and not as a way to obtain energy, even if the energy is used directly in the production process such as in a furnace. Emissions from combustion processes in industry with the sole purpose of obtaining energy (boilers, furnaces, engines) are included in the Energy sector.

[2] IIR is the report of emissions elaborated under the reporting obligations of the Convention on Long Range Transboundary Air Pollution (CLRTAP) of the UNECE. It will be available also in https://apambiente.pt/.

The table below presents total GHG emissions from IPPU, by sector and by gas.

***Table 4-1: Total GHG emissions from IPPU***

| Source /Gas | Base Year[3] | 2005 | 2022 | 2023 | 2024 | Δ 2024-2023 | Δ 2024-2005 | Δ 2024-Base Year |
|---|---|---|---|---|---|---|---|---|
| | kt $CO_2$ e | | | | | % | | |
| **2.A Mineral Industry** | | | | | | | | |
| $CO_2$ | 3,648.3 | 4,856.0 | 2,888.0 | 2.725.3 | 2,893.0 | 6.2% | -40.4% | -20.7% |
| **2.B Chemical Industry** | | | | | | | | |
| $CO_2$ | 1,408.7 | 1,523.7 | 477.7 | 140.2 | 14.7 | -89.5% | -99.0% | -99.0% |
| $CH_4$ | 28.6 | 30.0 | 22.5 | 6.1 | - | -100.0% | -100.0% | -100.0% |
| $N_2O$ | 460.4 | 496.4 | 27.7 | 23.9 | 35.9 | 50.2% | -92.8% | -92.2% |
| **2.C Metal Industry** | | | | | | | | |
| $CO_2$ | 446.4 | 109.2 | 69.5 | 78.1 | 80.8 | 3.5% | -26.0% | -81.9% |
| $CH_4$ | 0.7 | - | - | - | - | - | - | - |
| **2.D Non-energy products from fuels and solvent use** | | | | | | | | |
| $CO_2$ | 278.7 | 268.0 | 208.8 | 210.3 | 190.2 | -9.6% | -29.0% | -31.7% |
| **2.F Product uses as ODS substitutes** | | | | | | | | |
| HFC | 53.7 | 806.8 | 1,827.8 | 1,882.9 | 1,888.4 | 0.3% | 134.1% | 3417.0% |
| PFC | - | - | - | - | - | - | - | - |
| **2.G Other product manufacture and use** | | | | | | | | |
| $N_2O$ | 73.7 | 52.0 | 26.7 | 29.3 | 30.8 | 5.4% | -40.7% | -58.2% |
| $SF_6$ | 12.1 | 18.6 | 14.9 | 16.1 | 14.1 | -12.2% | -24.1% | 16.3% |
| **Total** | | | | | | | | |
| $CO_2$ | 5,782.3 | 6,756.9 | 3,644.0 | 3,153.9 | 3,178.7 | 0.8% | -53.0% | -45.0% |
| $CH_4$ | 29.3 | 30.0 | 22.5 | 6.1 | - | -100.0% | -100.0% | -100.0% |
| $N_2O$ | 534.1 | 548.4 | 54.5 | 53.2 | 66.8 | 25.5% | -87.8% | -87.5% |
| HFC | 53.7 | 806.8 | 1,827.8 | 1,882.9 | 1,888.4 | 0.3% | 134.1% | 3417.0% |
| PFC | - | - | - | - | - | - | - | - |
| $SF_6$ | 12.1 | 18.6 | 14.9 | 16.1 | 14.1 | -12.2% | -24.1% | 16.3% |
| **Total** | | | | | | | | |
| All gases (Base Year 1990) | 6,345.6 | 8,160.7 | 5,563.6 | 5,112.2 | 5,148.0 | 0.7% | -36.9% | -18.9% |

Note: Totals may not sum due to independent rounding. Emissions values are presented in kt $CO_2$e mass units using IPCC AR5 GWP values (please consult Table 1-1 in Chapter 1).

Total GHG emissions from this source sector have decreased from about 6.3 Mt $CO_2$e in 1990 to 5.2 Mt $CO_2$e in 2024, as may be seen in the table above, representing a decrease of about 199 % when compared to 1990[4]. Industrial processes represented about 10 % of the Portuguese emissions in 2024.

[3] Base Year refers to 1990 for all GHG with the exception of F-gases (HFC, PFC and $SF_6$), which refers to 1995.

[4] Base year for F-gases reporting is, however, 1995.

The majority of emissions, expressed in $CO_2e$, are associated with the Mineral Industry (2A), responsible for 57 % of total emissions from this sector in 1990, and about 56 % of total emissions from this sector in 2024. The second largest contributor is Products Uses as ODS substitutes (2F), responsible for 1 % of total emissions from this sector in 1995 (base year), and about 37 % of total emissions from this sector in 2024, as may be seen in the figure below. The remaining sub-source sectors (2B, 2C, 2D, 2E, 2G and 2H) contribute about 7 % of total emissions in 2024.

The figure below presents the contribution of IPPU's emissions in the country's total GHG emissions in 2024.

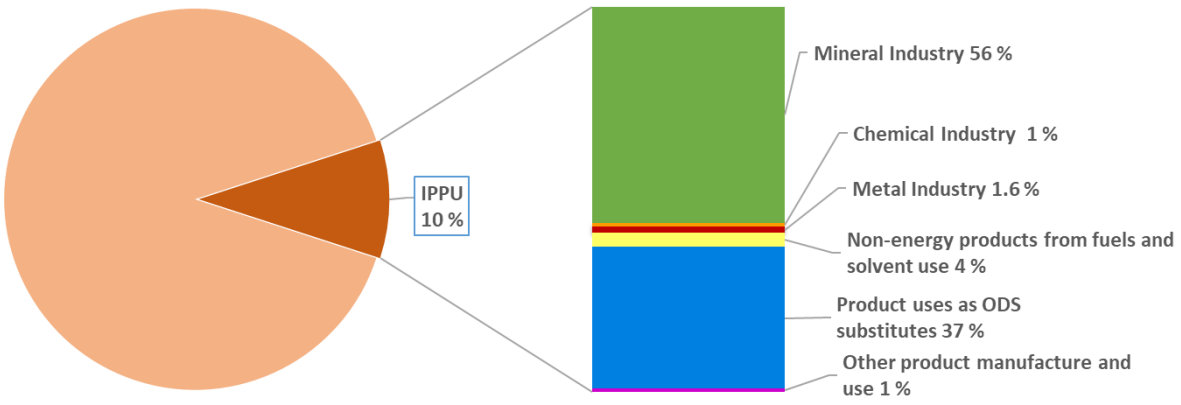



***Figure 4-1: IPPU emissions from total GHG emissions in 2024, by source sub-sector***

Emissions from this sector, which are generated as by-products of many non-energy-related activities, have been driven particularly until the mid-2000s by the evolution of the mineral and chemical industry. From the late 2000s onwards, chemical industry contribution has been reduced significantly, mainly due to end of ammonia production in the country. Particularly since 2023, the significant reduction in chemical industry's emissions was due to several interruptions for maintenance as well as market constraints in one of the most important chemical installations in the country, which led to a production halt. On the other hand, Products Uses as ODS substitutes (2F) have progressively gained importance in IPPU sector, representing about 37% of total IPPU emissions in 2024.

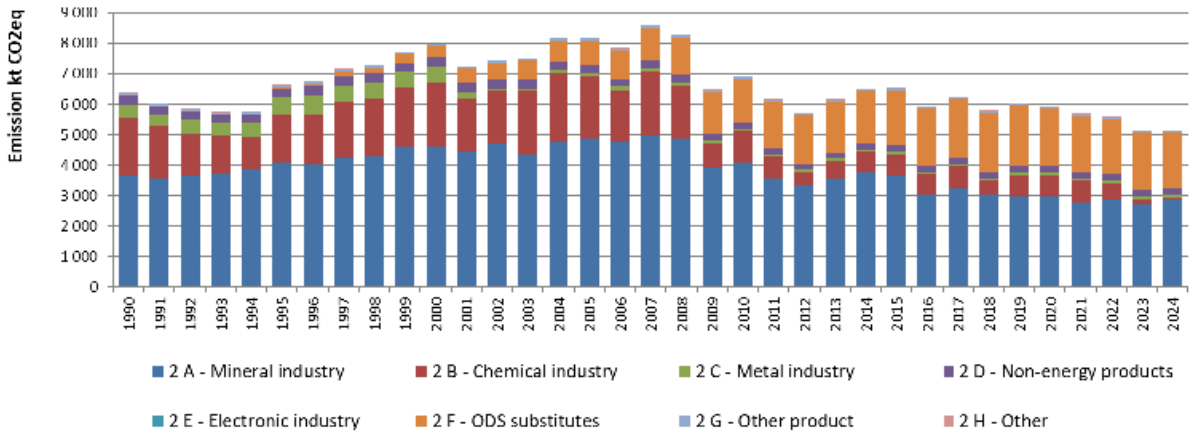



***Figure 4-2: Total GHG emissions from IPPU per source sub-sector (kt $CO_2e$)***

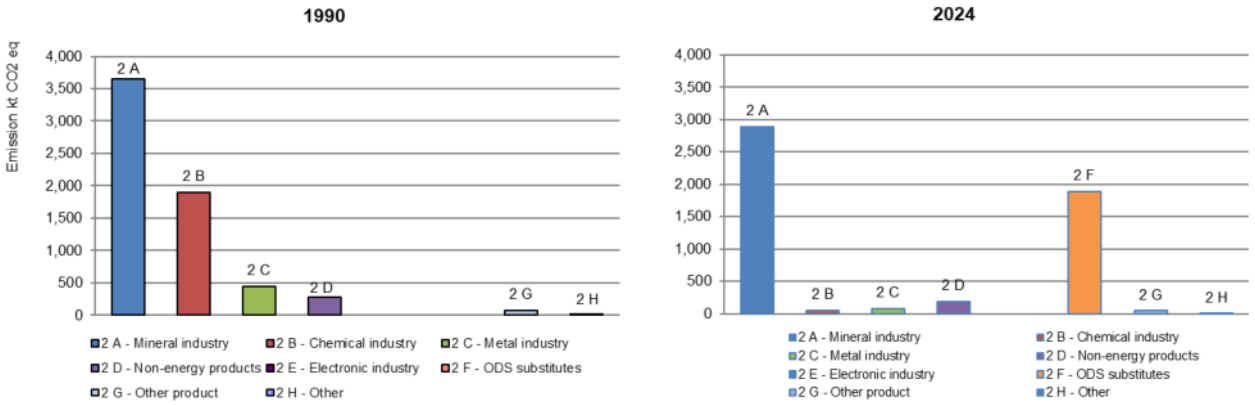



***Figure 4-3: Emissions of IPPU by sub-source sector in Portugal in year 1990 and 2024 (kt $CO_2e$)***

The majority of GHG emissions in IPPU sector is released directly as $CO_2$, while $N_2O$ represents a smaller proportion of emissions and $CH_4$ emissions are a non-relevant part, as may be seen in the figure below. Fluorinated gases have become a relevant source of GHG emissions in IPPU sector.

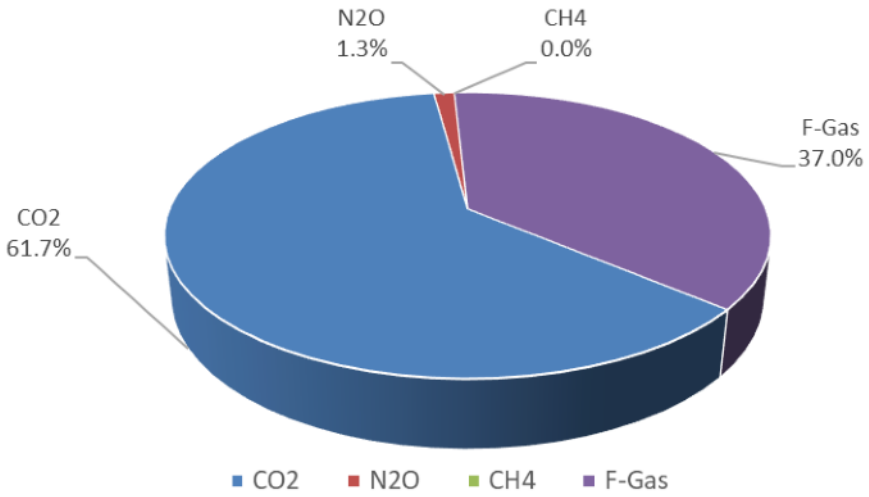



***Figure 4-4: GHG Emissions from IPPU per gas in 2024***

*Recalculations*

**2.A.3 (Glass Production):** Correction of compilation error in CO2 emissions in 2022-2023, found during QA/QC procedures to Glass production sector;

**2.A.4.a (Other Uses of Carbonates in Ceramics):** Update of 2023 activity data on electricity consumption in ceramics sector, according to 2023 Energy Balance update from data provider DGEG;

**2.A.4.b (Other Uses of Soda Ash):** Update of 2022-2023 activity data as a result of the updates in 2.A.3 e 2.A.4.a (see above);

**2.A.4.d (Carbonates in Fertilizers):** Update of activity data time series according to QA/QC analysis by the data provider (National Statistics Office - INE), following a recommendation from the 2025 ESD Review;

**2.C.5 (Lead Production):** Minor activity data updates in 1990-1991 according to GVA trend on basic metal industries;

**2.C.7 (Copper Production):** Minor activity data updates in 1990-1992 according to GVA trend on basic metal industries;

**2.D.1 (Lubricants use):** Update of 2023 activity data on lubricants consumption according to 2023 Energy Balance update from data provider DGEG;

**2.D.3.a (Solvent Use):** Activity data update for some sub-categories (please consult IIR 2026);

**2.F.1.a (Commercial Refrigeration):** Update of assembly methodology assumptions and activity data for the whole time series, following a recommendation from the 2025 ESD Review;

**2.F.1.b (Domestic refrigeration):** Minor recalculations in R-134a emissions in the period 2002-2023 due to the revision of total annual classic accommodations as main residence in Portugal, during QA/QC procedures to national statistics database;

**2.F.1.c (Industrial refrigeration):** revision and update on the industrial refrigeration equipment assembled in Portugal in 2010-2023 according to GDP trend, following a recommendation from the 2025 ESD Review; following further analysis to the national F-gases reporting tool (FGF) from 2013 onwards, PFC activity data and respective emissions (C2F6 and C3F8) were eliminated from this category;

**2.F.1.d (Transport refrigeration):** 2006-2023 activity data update in assembly according to GDP trend, following a recommendation from the 2025 ESD Review; update on assembly and operation F-gas fluids and share assumptions for the whole time series, based on the national F-gases reporting tool (FGF);

**2.F.1.e (Mobile air-conditioning):** update on assembled vehicles in Portugal in 2023, according to sectoral vehicle association ACAP;

**2.F.1.f (Stationary Air Conditioning):** Activity data update in 2002-2023 regarding fluid stocks in operation phase, following sectoral QA/QC activities;

**2.F.2 (Foam Blowing):** Update of assembly methodology assumptions and activity data for open cell foams in 2023, according to the most recent F-gas Regulation;

**2.F.3 (Fire Protection):** Update of methodology assumptions and activity data for the whole time series, following a recommendation from the 2025 ESD Review;

**2.F.4 (Other Aerosols):** Minor activity data updates in 2022-2023; following a question from the 2026 ESD review, assembly amounts of HFC-134a in 2.F.4.b were updated from 2018 onwards according to EU F-gas Regulation;

**2.G.1.a (Electrical Equipment manufacturing):** Update of assembly methodology assumptions and activity data for assembly phase for the whole time series following QA/QC procedures to the category and contacts with the data provider;

**2.G.1.b (Electrical Equipment operation):** Update of 2011-2023 activity data following QA/QC procedures to the category and contacts with the data provider;

**2.G.3.b ($N_2O$ from Product Uses):** Population data update in 2022-2023 according to INE;

**Several minor sub-categories**: Update on surrogate data such as Gross Domestic Product (GDP) and Gross Value Added (GVA) for 1990-1994 and 2022-2023.

### *Key categories*

The key categories in IPPU are summarised in the tables below.

***Table 4-2: Key categories in IPPU (CRT 2) and methodologies used in emission estimates***

| IPCC category | Gas | Criteria | Method |
|---|---|---|---|
| 2.A.1 Cement Production | $CO_2$ | L, T | T3, T1 |
| 2.F.1 Refrigeration and Air Conditioning | F-gases | L | T2, T1 |
| 2.A.2 Lime Production | $CO_2$ | L, T | T3, T1 |
| 2.D Non-energy products from fuels and solvent use | $CO_2$ | L | T2 |
| 2.C.1 Iron and Steel | $CO_2$ | L | T3, T1 |
| 2.B.2 Nitric Acid Production | $N_2O$ | L | T1, T3 |
| 2.B.8 Petrochemical and Carbon Black Production | $CO_2$ | L | T1, T3 |

## 4.2 Mineral Industry (CRT 2.A)

### 4.2.1 Overview

This chapter is intended to estimate process-related carbon dioxide ($CO_2$) emissions resulting from the use of carbonate raw materials in the production and use of a variety of mineral industry products. There are two broad pathways for release of $CO_2$ from carbonates: calcination and the acid-induced release of $CO_2$. The primary process resulting in the release of $CO_2$ is the calcination of carbonate compounds, during which, through heating, a metallic oxide is formed. According to the 2006 IPCC Guidelines, although methane ($CH_4$) and nitrous oxide ($N_2O$) may be emitted from some minerals industry source categories, given current scientific knowledge, these emissions are assumed to be negligible and thus are not addressed in this chapter.

### 4.2.2 Cement Production (CRT 2.A.1)

#### 4.2.2.1 Category description

This sector is identified as key category for $CO_2$ emissions.

There are six cement production plants operating in Portugal, mostly dedicated to Portland cement production[5] and almost all located in the southern half of the country. Five of these clinker producing units use the dry process while the remaining one uses both the dry and the semi-wet process, although the dry process is prevalent in that unit too. All dry process units have short kilns with pre-heaters, and 5 kilns in four units are provided with pre-calciners[6].

In cement production, $CO_2$ emissions occur during the production of clinker, specifically from the conversion of $CaCO_3$ and $MgCO_3$, the main constituents of limestone, to lime (CaO) and magnesia (MgO), leaving $CO_2$ as by product to atmosphere (decarbonisation).

Other types of carbonate inputs for Portugal's cement industry are sand, malm, mixed carbonate and dolomite, kaolin, limestone cream, sludge with limestone, however, these are considered negligible sources of emissions.

Category 2.A.1 only reports $CO_2$ emissions from limestone decarbonizing. $CO_2$ emissions from liberation of carbon in fuel during combustion are addressed in the Energy chapter (3.4 - Manufacturing Industries and Construction) and reported in the Energy sector (CRT 1.A.2). Emissions of other pollutants, although might result from both fuel and raw material, are also addressed in the Energy chapter and reported in the Energy sector, for simplicity's sake. However, although combustion emissions and process emissions are estimated separately, they are in fact emitted at same place and are inseparable in concept.

#### 4.2.2.2 Methodology

Since there are different data sources available depending on the years, two different methodologies were used throughout the time series.

Since 2005, when European Union Emissions Trading System (EU ETS) was set up, clinker production process emissions are estimated by the facilities according to Method A (Kiln Input based) from No. 9 of Annex IV of Regulation (EU) No. 2066/2018 (https://eur-lex.europa.eu/legal-content/pt/TXT/?uri=CELEX%3A32018R2066).

[5] There is also some production of white Portland cement, which is characterized by a lower iron and manganese constant than grey cement, and it is used mainly for decorative purposes (EPA, 1995). In Portugal, there are also smaller additional cement plants that do not produce clinker.

[6] One calciner is a false pre-calciner.

Emissions are estimated with a Tier 3 methodology, based on raw meal consumption and the respective emission factor, which are determined in laboratory and provided by the facilities.

From 2005-onwards, the following equation is used:

***Equation 4-1: $CO_2$ emissions from clinker production – 2005-onwards***

$$Emi_{CO2} = Mi \times EF_i \times F_i - M_d \times C_d \times (1-F_d) \times EF_d + M_k \times X_k \times EF_k$$

**Where:**

$Emi_{CO2}$: Emissions of $CO_2$ from clinker production (kt)

$M_i$: Mass of raw meal kiln input (t)

$EF_i$: Emission factor of raw meal kiln input (kt $CO_2$/t of raw meal)

$F_i$: Fraction calcination achieved for raw meal kiln input (0 to 1)

$M_d$: Mass of CKD (Cement Kiln Dust) not recycled to the kiln (t)

$C_d$: Fraction of original carbonate in the CKD not recycled to the kiln (0 to 1)

$F_d$: Fraction calcination achieved for CKD not recycled to the kiln (0 to 1)

$EF_d$: Emission factor of the uncalcined carbonate in CKD not recycled to the kiln (kt $CO_2$/t of carbonate)

$M_k$: Mass of organic carbon-bearing non-fuel raw meal (t)

$X_k$: Fraction of total organic carbon in specific non-fuel raw meal (0 to 1)

$EF_k$: Emission factor for organic carbon-bearing non-fuel raw meal (kt $CO_2$/t of raw meal)

Considering the temperatures achieved and the residence time in the kilns, it is assumed complete carbonates calcination (100%), hence the conversion factor Fi is 1.

During the manufacture of clinker, CKD is generated in various points of the process and captured by dust control technology.

Until 2019, in the Portuguese cement facilities, all CKD captured was recycled to the kilns or raw meal storage silos and, therefore, accounted for in emissions estimation through a correction in raw meal consumption (Mi). This correction is performed by each facility and is based on the raw meal weighted before the kilns and a recirculation factor.

As of 2020, EU-ETS approved the methodology for accounting bypass dust emissions in clinker production facilities, which began being reported as a separate raw material input. This part of the raw meal, which is not fully calcined, upon entering the pre-heater equipment, is dragged along with the exhaust gases and captured by specific dust control technology. Hence, this amount has to be deducted from raw meal consumption and has a significantly lower emission factor. This part of CKD does not return to the storage silos or the kilns (due to excessive alkali content), instead is captured and stored separately for future marketing.

$CO_2$ emissions from non-carbonate carbon in the non-fuel raw materials are also accounted for in total $CO_2$ process emissions. However, non-carbonate carbon represents a fraction between 0,15% and 0,35% of raw meal weight, therefore may be ignored in the Energy sector. Plus, these emissions cannot be disaggregated from total $CO_2$ emissions calculated by each facility.

Given there is no EU-ETS system in the period 1990 to 2004, the splicing technique "overlap" (section 5.3.1.1 of Vol.1 of the 2006 IPCC Guidelines) was used in order to estimate $CO_2$ emissions from clinker production, according to the following equation:

***Equation 4-2: $CO_2$ emissions from clinker production – 1990-2004***

$$Emi\ CO2_y = Clinker\ Prod_y \times \frac{Emi\ CO2_{2005-2009}}{Clinker\ Prod_{2005-2009}}$$

**Where:**

$Emi_{CO2,y}$: Emissions of $CO_2$ in year y (kt)

Clinker $Prod_y$: Clinker production in year y (t)

Emi $CO_{2,\ 2005\text{-}2009}$: Average $CO_2$ emissions in period 2005-2009 (kt $CO_2$)

Clinker $Prod_{2005\text{-}2009}$: Average Clinker production in period 2005-2009 (t)

From 1990 to 2004, clinker production (Clinker $Prod_y$) was obtained from the facilities.

In order to ensure time series consistency between the two methodologies, $CO_2$ emissions for the period 1990-2004 (Emi CO2y) were based on the ratio between the average EU-ETS $CO_2$ emissions in the period 2005-2009 and the average clinker production in the period 2005-2009.

EU-ETS $CO_2$ emissions in the period 2005-2009 were obtained from EU-ETS according to Equation 4-2. Clinker production in the period 2005-2009 was obtained from the facilities.

For the 1994-2004 data overlap, we decided to fix the data used as the average of the period 2005-2009, in order to avoid yearly corrections associated to the introduction of last year ratios and given it is the closest period with available and reliable data.

#### 4.2.2.3 Emission Factors

From 2005 to 2012, we have used plant specific raw meal carbon content characterization to estimate $CO_2$ emissions based on raw meal consumption in the kilns. This information was obtained from the facilities.

From 2013 onwards, cement facilities in EU-ETS system were obliged to measure $CO_2$ emission factors in laboratory from representative samples of the raw meal. The method used is based on the direct calculation of the $CO_2$ emitted through heating process, between 500 and 975 Celsius degrees. The error associated with this determination lies in the fact that the organic carbon present in the raw meal will also be accounted for as $CO_2$. However, since this content is always very low (approximately 0,1%), the error can be considered to be lower than that of which would result from the calculation of emissions based on the determination of Ca and Mg contents in the form of carbonates.

From 2005 to 2009 we have estimated plant specific average ratio between $CO_2$ emissions and clinker production for each facility and used this average value to back cast $CO_2$ emissions in the period 1990-2004, taking also into consideration clinker production for each facility in the period 1990-2004. We decided to fix the data used to the retropolation as the average of the period 2005-2009 in order to avoid yearly corrections associated to the introduction of last year ratios.

The fluctuation in the implied emission factor (IEF) from 2005 onwards is due to changes in raw meal carbon content.

#### 4.2.2.4 Activity Data

From 2005 onwards, EU-ETS data on raw meal consumption is used.

We do not have access to disaggregated data on the types and quantities of carbonates consumed to produce clinker, as well as their emission factors, as recommended in Tier 3 methodology of 2006 IPCC Guidelines.

Due to the existence of Ca and Mg in non-carbonated form in raw meal, $CO_2$ emission estimates through Ca and Mg analysis would generate several uncertainties due to the need to account for all individual parcels and to carry out on each of them the corresponding analysis.

$CO_2$ process emissions would thus be overestimated. Hence, since it was not possible to dissociate the carbonates in non-carbonated form, it was decided to use the amount of raw meal.

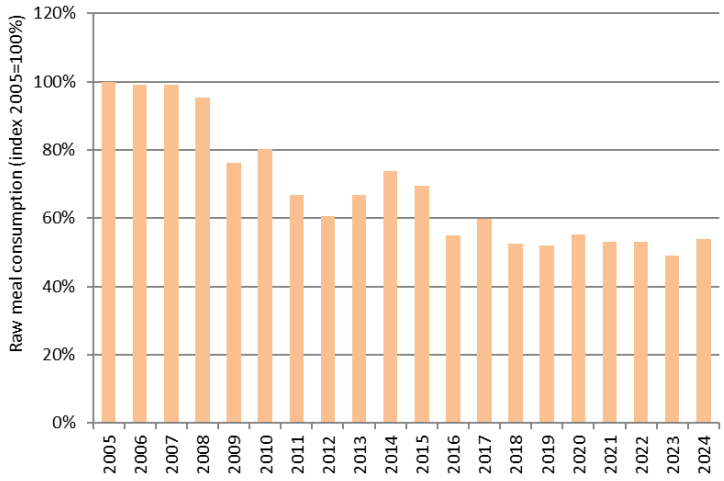



***Figure 4-5: Raw meal consumption in Portugal***

Clinker production was obtained directly from each facility for the whole time series, and the correspondent time series may be observed in next figure.

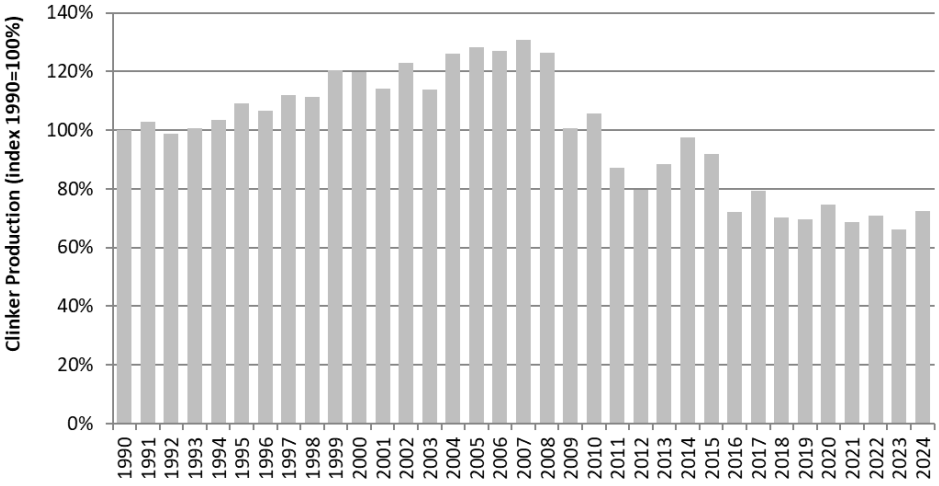



***Figure 4-6: Total clinker production in Portugal***

The decrease from 2008 to 2012 is due to a demand decrease in Portugal, Spain and North Africa market. From 2013 to 2014 there is an overall increase in clinker production of 0.54 Mt due to exports rise to Africa and South America. In 2015-2016 there is a sharp decrease on clinker production, due to a contraction of external market sales, related both to supply excess in the Mediterranean area and to a consumption decrease in Africa.

### 4.2.2.5 Uncertainty Assessment

***Table 4-3: Uncertainty values related to emissions reported under CRT 2.A.1***

| Parameter | Type of Uncertainty | Uncertainty | Source |
|---|---|---|---|
| Activity Data | Composition | 7.0% | Table 2.3 of "Chapter 2: Mineral Industry Emissions" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories":<br>2% - Kerogen (or other non-carbonate carbon) determination:<br>2% - Overall chemical analysis pertaining to carbonate content (mass) & type:<br>3% - Assumption that carbonate species is 100% $CaCO_3$ |
| Activity Data | Uncertainty of plant-level weighing of raw materials | 2.0% | Table 2.3 of "Chapter 2: Mineral Industry Emissions" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories". |
| Activity Data | Uncertainty on CKD | 30.0% | Table 2.3 of "Chapter 2: Mineral Industry Emissions" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories": |
| Activity Data | Combined Uncertainty | 30.9% | - |
| $CO_2$ EF | Combined Uncertainty | 1.4-5.4% | Uncertainty = [(Highest-Lowest)/Average/2]X100<br><br>Data on CO2 emissions obtained from ETS. |

Uncertainty estimates based on fuel consumption are reported under CRT 1.A.2.f.

### 4.2.2.6 Category specific QA/QC and verification

Emissions estimates were based on a bottom-up approach with collection of plant specific clinker production data. A comparison was made using a top-down approach based on clinker production data obtained from national production statistics (IAPI) from 1992 onwards. There are slight differences using the two different approaches but, generally, data is consistent. Due to confidentiality constraints, activity data is presented as an index value related to 1992 data.

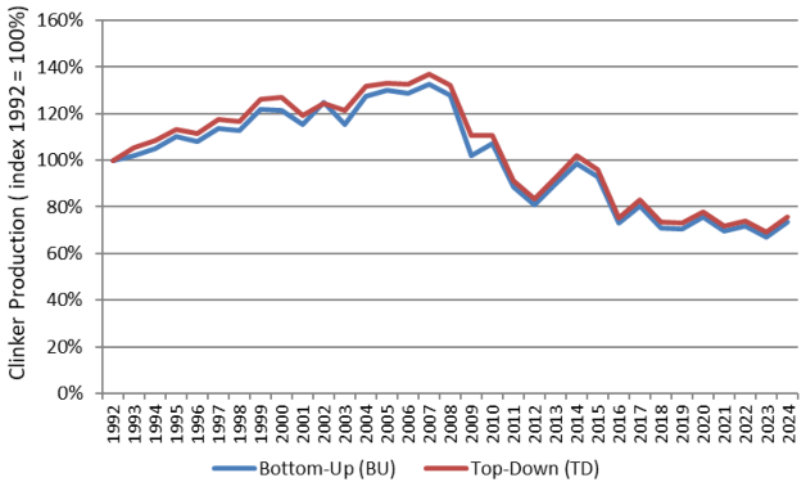



***Figure 4-7: Clinker production data – comparison of approaches***

When cross-checking 2020 EU-ETS data (process emissions) for cement production with 2020 clinker production data from the facilities, it was noticed a deviation of about 3% from the IEF average value compared to previous years.

Following contacts with the Portuguese EU-ETS team, we learned that they had already contacted clinker facilities regarding this issue, providing the following main clarifications:

. CO2 emissions from clinker production are estimated based on a Tier 3 approach, where the weights and compositions of all carbonate inputs from all raw material and fuel sources, emission factors for the carbonates, and the fraction of calcination achieved accounted for and reported by the facilities to the EU-ETS. Overall, in 2020 the majority of facilities consumed raw material with less carbonate content, thus, reducing carbon content in raw meal and limiting CO2 emissions from calcination;

. Also in 2020, dust control technology was fine-tuned, consequently capturing CKD (cement kiln dust) more efficiently. Therefore, there was an increase in the amount of CKD captured and recycled to the storage silos, thus resulting in an increase in the recirculation factor and a decrease in raw meal consumption correction;

. Finally, in 2020 EU-ETS approved the methodology for accounting of bypass dust emissions in clinker production facilities, which began being reported as a separate raw material input. This material, which is not fully calcined, is generated in the pre-heater equipment, dragged along with the exhaust gases and captured by specific dust control technology. Hence, this amount has to be deducted from raw meal consumption and has a significantly lower emission factor, which contributes to a slight decrease in CO2 emissions. This dust does not, however, return to the storage silos or the kilns, instead is captured and stored separately for future marketing.

#### 4.2.2.7 Recalculations

No recalculations were made.

#### 4.2.2.8 Further Improvements

No further improvements are planned.

### 4.2.3 Lime Production in dedicated plants (CRT 2.A.2)

#### 4.2.3.1 Category description

Lime is produced through calcination in a kiln, a process of thermal conversion (at temperatures at about 900-1200 Celsius degrees) of carbonate bearing materials (mostly limestone and dolomite, but aragonite, chalk, marble or seashells could be also used) releasing carbon dioxide and leaving lime (CaO) or magnesia (MgO) as valuable products. The following chemical conversion equation applies, where for each mol of oxide produced a mol of carbon dioxide is emitted:

***Equation 4-3: Chemical conversion equations***

$$CaCO3\ (limestone) + heat \rightarrow CaO + CO2$$

$$CaCO3.MgCO3\ (dolomite) + heat \rightarrow CaO.MgO + 2CO2$$

Lime products include several different forms:

- Quicklime or high calcium lime: a material composed of calcium oxide (CaO), it is produced by heating limestone with heavy $CaCO_3$ content (at least 50 %) to high temperatures. It is used in construction, agriculture and chemical processes (manufacture of $Na_2CO_3$, NAOH, steel, refractory material, $SO_2$ absorption, $CaC_2$, glass, pulp and paper, sugar and ore concentration and refining). It is also used in waste and water treatment;

- Dolomite quicklime: produced in a similar mode to quicklime but from dolomitic limestone or magnesite rocks that contain both calcium carbonate and magnesium carbonate (MgO is usually around 30 to 45 % in content). Dolomite quicklime is a mixture of CaO and MgO;

- Calcium Hydroxide, slaked lime, dead lime, burned lime or hydrated lime: $Ca(OH)_2$ it is produced from CaO and water. When an equivalent quantity of water is used is called slaked lime, when an excess water is used is milk of lime and a clear solution of $Ca(OH)_2$ in water is limewater. It is used as an industrial alkali and in the preparation of mortar (slaked lime plus sand) which sets to solid by reconversion of the hydroxide to CaCO3 (Sharp, 1981);

- Hydraulic Lime: a mixture of calcium oxide (CaO) and silicates, it is an intermediate product between lime and cement.

There are 5 dedicated lime production plants under ETS in Portugal.

#### 4.2.3.2 Methodology

Since 2005, when European Union Emissions Trading System (EU ETS) was set up, $CO_2$ process emissions from lime production are Kiln Input based, estimated by the facilities according to No. 10 of Annex IV of Regulation (EU) No. 2066/2018 (https://eur-lex.europa.eu/legal-content/pt/TXT/?uri=CELEX%3A32018R2066). Calculation is based on the amount of carbonates in the raw materials consumed (Tier 3), according to the following equation:

***Equation 4-4: $CO_2$ Emissions from lime production – 2005-onwards***

$$Emi_{CO2} = Mi \times EF_i \times F_i - M_d \times C_d \times (1-F_d) \times EF_d$$

**Where:**

$Emi_{CO2}$: Emissions of $CO_2$ from lime production (kt)

$M_i$: Mass of carbonate I consumed (t)

$EF_i$: Emission factor of carbonate I consumed (kt $CO_2$/t of raw meal)

$F_i$: Fraction calcination achieved for carbonate i (0 to 1)

$M_d$: Mass of LKD (Lime Kiln Dust) not recycled to the kiln (t)

$C_d$: Fraction of original carbonate in the LKD not recycled to the kiln (0 to 1)

$F_d$: Fraction calcination achieved for LKD not recycled to the kiln (0 to 1)

$EF_d$: Emission factor of the uncalcined carbonate in LKD not recycled to the kiln (kt $CO_2$/t of carbonate)

Considering the temperatures achieved and the residence time in the kilns, it is assumed complete carbonates calcination (100 %), hence the conversion factor Fi is 1.

During lime production, LKD is generated and can be recycled directly to the kilns or captured by dust control technology and returned to the storage silos. Either way, for all 5 dedicated lime production plants, all LKD is recycled and therefore accounted for in emissions estimation, through a correction in carbonate bearing materials (Mi). This correction is performed by each facility and is based on the carbonate bearing materials weighted before the kilns and a recirculation factor of approximately 0.2%.

Given there is no EU-ETS system in the period 1990 to 2004, the splicing technique "overlap" (section 5.3.1.1 of the 2006 IPCC Guidelines) was used in order to estimate $CO_2$ emissions from lime production, according to the following equation:

***Equation 4-5: $CO_2$ Emissions from lime production – 1990-2004***

$$Emi\ CO2_y = Lime\ Prod_y \times \frac{Emi\ CO2_{2005-2009}}{Lime\ Prod_{2005-2009}}$$

**Where:**

$Emi_{CO2,y}$: Emissions of $CO_2$ in year y (kt)

$Lime\ Prod_y$: Lime production in year y (t quicklime and hydraulic lime)

$Emi\ CO_{2,\ 2005-2009}$: Average $CO_2$ emissions in period 2005-2009 (kt $CO_2$)

$Lime\ Prod_{2005-2009}$: Average Lime production in period 2005-2009 (t quicklime and hydraulic lime)

From 1990 to 2004, lime production ($Lime\ Prod_y$) was obtained from National Statistics.

In order to ensure time series consistency between the two methodologies, $CO_2$ emissions for the period 1990-2004 (Emi CO2y) were based on the ratio between the average EU-ETS $CO_2$ emissions in the period 2005-2009 and the average lime production in the period 2005-2009.

EU-ETS $CO_2$ emissions in the period 2005-2009 were obtained from EU-ETS according to Equation 4-4. National lime production in the period 2005-2009 was obtained from National Statistics.

For the 1994-2004 data overlap, we decided to fix the data used as the average of the period 2005-2009, in order to avoid yearly corrections associated to the introduction of last year ratios and given it is the closest period with available and reliable data.

#### 4.2.3.3 Emission Factors

From 2005 to 2012, $CO_2$ emission factors in EU-ETS were estimated by converting kiln input materials composition data, using the following stoichiometric ratios (Table 1 of Annex VIII of Decision 2007/589/EC).

***Table 4-4: Emission Factors considered***

| Raw Material | Unit | EF |
|---|---|---|
| $CaCO_3$ | t $CO_2$/t CaCO3 | 0.440 |
| $MgCO_3$ | t $CO_2$/t MgCO3 | 0.522 |

From 2013 onwards, lime production facilities in EU-ETS system were obliged to measure $CO_2$ emission factors in laboratory from representative samples of the raw meal. The method used is based on the direct calculation of the $CO_2$ emitted through heating process, between 500 and 975 Celsius degrees.

From 2005 to 2009 we have estimated the average ratio between total $CO_2$ emissions and lime production and used this average value to back cast $CO_2$ emissions in the period 1990-2004, taking also into consideration total lime production in the period 1990-2004. We decided to fix the data used to the retropolation as the average of the period 2005-2009 in order to avoid yearly corrections associated to the introduction of last year ratios.

2020 UNFCCC Review identified that the implied emission factor (t $CO_2$/t carbonate) of one facility increased from 0.31 in the year 2009 to more than 1 in the period 2010-2013. Further analysis clarified that there were two different sources of information for carbonates consumption (PRTR and EU-ETS) in the period 2009-2013 and this might be the reason for the significant increase in the implied emission factor identified by the ERT. Portugal contacted the facility, confirming that there had been a reporting error.

Therefore, in the 2021 submission, carbonates consumption values in the period 2010-2013 were corrected according to new information obtained from the facility, in order to improve time series consistency in that period.

#### 4.2.3.4 Activity Data

From 2005 onwards, information on kiln type and LKD correction was obtained directly from the facilities.

From 2005 onwards, activity data used to estimate EU-ETS $CO_2$ emissions is the consumption of raw materials, obtained from EU-ETS. From 1990 to 2004 there is no available data on consumption of raw materials.

From 1990 to 2004, activity data used to estimate $CO_2$ emissions is lime production, obtained from National Statistics (INE) IAPI industrial survey.

Therefore, we have two different sets of activity data (raw materials and lime production) for different periods, but can only report one series in the CRT tables.

In order to ensure time series consistency of the activity data reported in the CRT tables, we collected national lime production from National Statistics for the whole time series and compared it with lime production collected from the facilities Annual Environmental reports (RAA) (figure below). However, from RAAs source, we only have access to lime production data from 2010 onwards. We contacted the facilities in order to provide us lime production data for the missing years (1990-2009), however, quite many of them no longer possess those data due to company restructuration or human resources allocation.

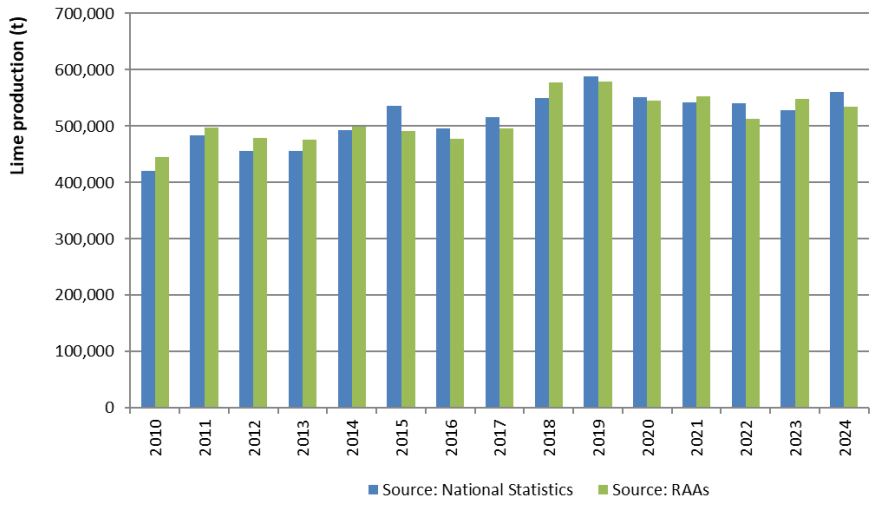



***Figure 4-8: Lime production from different sources***

Given the relative consistency between the two sets of data, we decided to report in the CRT tables:

. from 1990 to 2009 - Lime production from National Statistics (INE) IAPI industrial survey;

. from 2010 onwards - Lime production from E-PRTR.

From 1990 to 2009 we decided to use lime production data by type of lime from INE rather than use an approximate value obtained from a splicing technique. Moreover, there is no consistent plant specific lime production data for that period. For consistency purposes, it was only considered the production of quicklime and hydraulic lime. Slaked lime amounts were not considered, because this type of lime is produced from quicklime and there are no $CO_2$ emissions related to calcination.

From 2010 onwards, for each lime production plant, it was gathered information on kiln type and lime production by type of lime (quicklime, hydraulic lime and slaked lime), based on annual environmental reports and on additional data provided by the facilities.

Carbonates´ consumption is presented in the figure below for the whole time series.

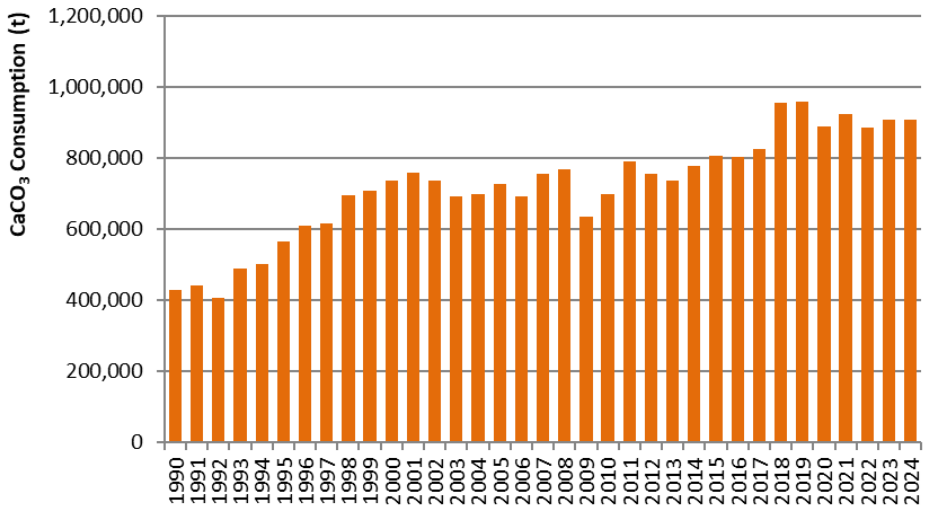



***Figure 4-9: Lime production reported in the CRT tables***

In the end of the second quarter of 2008, one facility terminated operation and was excluded from EU-ETS, hence the significant decrease in lime production from 2008 to 2009.

In the end of the first quarter of 2017, a new facility began operating and was included in ETS, however, it was on a pilot phase and, therefore, working intermittently. Formally, this facility only started fully operating in early 2018, hence the significant increase in lime production from 2017 to 2018. In 2020 there is a slight decrease in carbonates´ consumption due to COVID19 pandemic.

#### 4.2.3.5 Uncertainty Assessment

***Table 4-5: Uncertainty values related to emissions reported under CRT 2.A.2 – dedicated plants***

| Parameter | Type of Uncertainty | Uncertainty | Source |
|---|---|---|---|
| Activity Data | Lime production data | 1.5% (average of 1.0-2.0% range) | Average of the range 1.0-2.0% of Table 2.5 of Chapter 2: Mineral Industry Emissions of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. |
| Activity Data | Lime Production | 35% (highest of 25-35% range) | Highest value of the range (25-35%) of "Default Values" of CKD/LKD in Table 2.3 of Chapter 2: Mineral Industry Emissions of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. |
| Activity Data | Combined Uncertainty | 35.03% | - |
| $CO_2$ EF | CaO in lime | 6.0% (average of 4.0-8.0% range) | Average of the range 4.0-8.0% of "Table 2.5" of "Chapter 2: Mineral Industry Emissions" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories". |
| $CO_2$ EF | EF of High Calcium Lime | 2.0% | "Emission factor high calcium lime" (2%) of "Table 2.5" of "Chapter 2: Mineral Industry Emissions" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories". |
| $CO_2$ EF | Combined Uncertainty | 6.3% | - |

***Table 4-6: Uncertainty values related to emissions reported under CRT 1.A.2.f***

| Parameter | Fuel Type | 1990-2004 | 2005-2007 | 2008 onwards |
|---|---|---|---|---|
| Activity Data | L | 10% (i) | 3% (ii) | 2% (iii) |
| | S | 10% (i) | 3% (ii) | 2% |
| | G | 10% (i) | 3% (ii) | 2% |
| | B | 10% (i) | 3% (ii) | 2% |
| | O | 10% (i) | 3% (ii) | 2% |
| $CO_2$ EF | L | 3% (iv) | 3% (iv) | 3% (iv) |
| | S | 7% (v) | 7% (v) | 7% (v) |
| | G | 7% (v) | 7% (v) | 7% (v) |
| | B | 7% (v) | 7% (v) | 7% (v) |
| | O | 7% (v) | 7% (v) | 7% (v) |
| $CH_4$ EF | L | 100% (vi) | 100% (vi) | 100% (vi) |
| | S | 100% (vi) | 100% (vi) | 100% (vi) |
| | G | 100% (vi) | 100% (vi) | 100% (vi) |
| | B | 100% (vi) | 100% (vi) | 100% (vi) |
| | O | 100% (vi) | 100% (vi) | 100% (vi) |
| $N_2O$ EF | L | 150% (vii) | 150% (vii) | 150% (vii) |
| | S | 150% (vii) | 150% (vii) | 150% (vii) |
| | G | 150% (vii) | 150% (vii) | 150% (vii) |
| | B | 150% (vii) | 150% (vii) | 150% (vii) |
| | O | 150% (vii) | 150% (vii) | 150% (vii) |

(i) Chapter 2: Stationary Combustion of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Highest value of the range 5-10% of "Extrapolation" in "Less developed statistical systems".

(ii) Chapter 2: Stationary Combustion of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Highest value of the range 2-3% of "Surveys" in "Well developed statistical systems".

(iii) Chapter 2: Stationary Combustion of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Lowest value of the range 2-3% of "Surveys" in "Well developed statistical systems".

(iv) Chapter 2: Stationary Combustion of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Highest value for "Oil" in "Table 2.13".

(v) Chapter 2: Stationary Combustion of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Average value for "Coke, oil, gas" in "Table 2.13".

(vi) Highest value of Table 2.14 of "Volume 2: Energy" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories".

(vii) Average UK value in "Table 2.14" of "Volume 2: Energy" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories".

#### 4.2.3.6 Category specific QA/QC and verification

Emissions estimates were based on a bottom-up approach with collection of plant specific lime production data. A comparison was made using a top-down approach based on lime production data obtained from national production statistics (IAPI). We only present data from 2010 onwards given the significant lack of plant specific lime production data from 1990 to 2009. Upon contact, several facilities responded that they did not possess such old data due to company restructuration or human resources allocation. As presented in the figure below, from 2010 onwards there are slight differences using the two approaches but, generally, data is consistent. Due to confidentiality constraints, activity data is presented as an index value related to 2007 data.

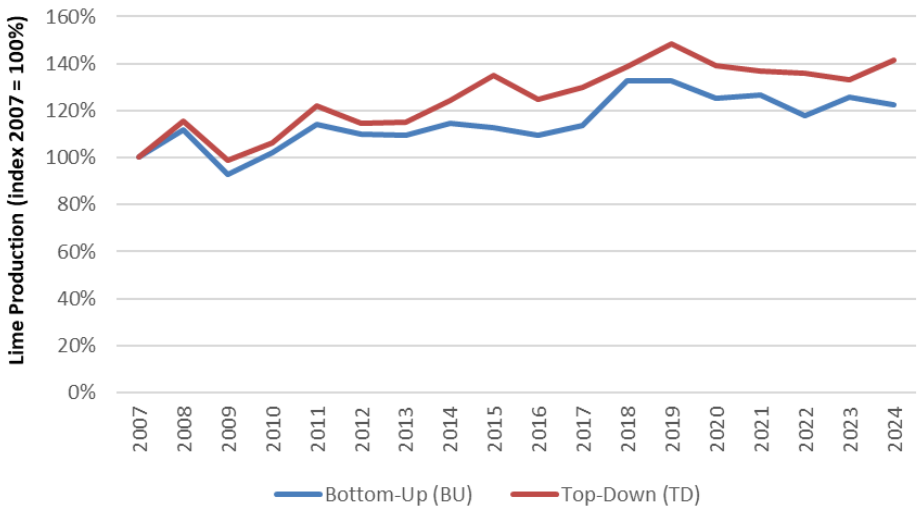



***Figure 4-10: Lime production in dedicated plants – comparison of approaches***

Following QA/QC procedures to the sector, lime production data series reported in CRT tables from 1990 to 2009 was revised and corrected, due to a compilation error. This correction does not affect $CO_2$ emissions because these values were already being used, they were just not being correctly reported in the CRT tables.

Further QA/QC procedures to the sector identified a compilation error regarding 2018 and 2019 lime production values for one facility. Again, this correction also does not affect $CO_2$ emissions because from 2005 onwards, lime production data is not used to estimate $CO_2$ emissions.

#### 4.2.3.7 Recalculations

No recalculations were made.

#### 4.2.3.8 Further Improvements

In the future, we intend to analyse further the consistency of the entire time series of this category in order to address differences in the IEF in the period 2005-2007. However, for the time being, we considered we have already made progresses towards this issue in the last submissions.

## 4.2.4 Lime Production in Iron and Steel (CRT 2.A.2)

### 4.2.4.1 Category description

Besides the production of lime in the lime industry to furnish market requirements, lime is also produced and consumed inside industrial sectors. That is the case of iron and steel production, whereas emissions from this activity are also reported in this source category. There are two iron and steel facilities in Portugal. One of the facilities has always purchased lime from national lime dedicated plants, whose emissions are accounted for in chapter 4.2.3, above. From 1990-2001, only one iron and steel facility produced lime as a non-marketed intermediate product, to consume internally in its kilns. Those emissions are addressed in this chapter. More information is provided in chapter 4.4.2 – Iron and Steel Production (2.C.1).

### 4.2.4.2 Methodology

Emissions were estimated based on a Tier 1 approach according to chapter 2.3 of the 2006 IPCC Guidelines:

***Equation 4-6: $CO_2$ Emissions from lime production in iron and steel***

$$Emi(CO_2) = m(Lime) \times Cont(CaO) \times \frac{m(CO_2)}{m(CaO)} \times 10^{-3}$$

**Where:**

Emi($CO_2$): Emissions of $CO_2$ (kt $CO_2$)

m(Lime): Lime production in lime kilns (t)

Cont(CaO): CaO content in lime (dimensionless)

m($CO_2$)/m(CaO): stoichiometric ratio between $CO_2$ and CaO in lime kilns (t $CO_2$/t CaO)

According to the 2006 IPCC Guidelines (Section 2.3.1.1 of Volume 3), in a Tier 1 approach it is not necessary for *good practice* to gather information on country-specific information on lime production by type, nor to account for LKD.

### 4.2.4.3 Emission Factors

The following parameters were applied in order to estimate $CO_2$ emissions:

***Table 4-7: Emission Factors***

| Parameter | Unit | EF | Source |
|---|---|---|---|
| $CO_2$/CaO | t $CO_2$/t CaO | 0.785 | Table 2.4 of Volume 3: Industrial Processes and Product Use of 2006 IPCC Guidelines for National Greenhouse Gas Inventories |
| CaO content in High-Calcium Lime | t CaO/t Lime | 0.950 | Table 2.4 of Volume 3: Industrial Processes and Product Use of 2006 IPCC Guidelines for National Greenhouse Gas Inventories |

### 4.2.4.4 Activity Data

Regarding lime production in the integrated iron and steel facility, upon contact, the facility indicated that does not possess information concerning consumption of limestone/dolomite for other purposes than lime production, due to company restructuration in 2001 and consequent loss of old data. During the 2022 UNFCCC review, the ERT also referred that if half of the limestone/dolomite used for lime production were to be used as flux in steel production, it would result in a 0.01% difference in emissions from the use of limestone and dolomite, which is below the significance threshold established in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines.

Therefore, we will continue to consider that in the period 1990-2001, all limestone/dolomite were used for lime production and that there were no other uses for limestone/dolomite in the iron and steel facility.

Lime production in the iron and steel facility was obtained directly from the facility for the period 1991-1994.

Given there is no available lime production data for 1995-2001, the splicing technique "overlap" (section 5.3.1.1 of the 2006 IPCC Guidelines) was used in order to estimate lime production for the missing years, using as surrogate data total steel production series:

***Equation 4-7: Lime production estimated for 1990 and 1995-2001***

$$Lime\ Prod_y = Steel\ Prod_y \times \frac{\text{Lime } Prod_{1991-1994}}{Steel\ Prod_{1991-1994}}$$

**Where:**

Lime $Prod_y$: Lime production in year y (t)

Steel $Prod_y$: Total steel production in year y (t)

Lime $Prod_{1991\text{-}1994}$: Average lime production in period 1991-1994 (t)

Steel $production_{1991\text{-}1994}$: Average total steel production in period 1991-1994 (t)

In order to ensure time series consistency between the two data sets, lime production for the period 1995-2001 and 1990 (Lime $Prod_y$) was based on the ratio between the average steel production in the period 1991-1994 and the average lime production in the period 1991-1994.

Steel production from BOF (Basic Oxygen Furnace) data in the period 1990-2001 was obtained from the facility. The rationale used to choose this dataset was that, as an integrated iron and steel facility, the close relationship between intermediate products and steel produced from BOF is notorious, since their production is intrinsically related to the final amount of steel produced. Therefore, we opted to use steel production as proxy instead of fuel consumption.

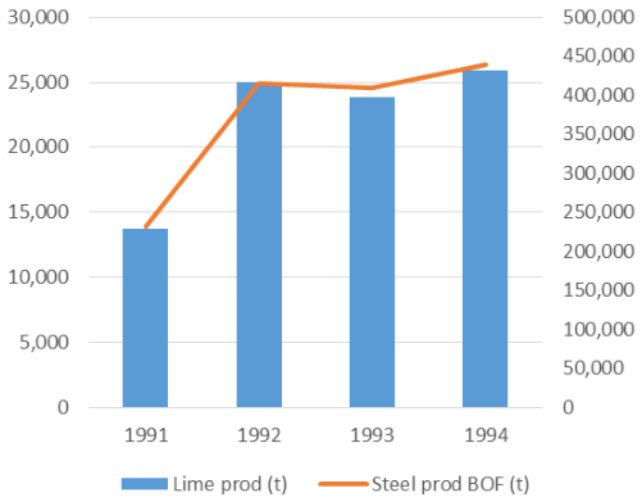



***Figure 4-11: Lime production and steel production from BOF in Iron and Steel***

For the 1995-2001 and 1990 data overlap, we decided to fix the data used as the average of the period 1991-2004, given it is the only available data.

Lime production data in that iron and steel plant is presented in the next figure.

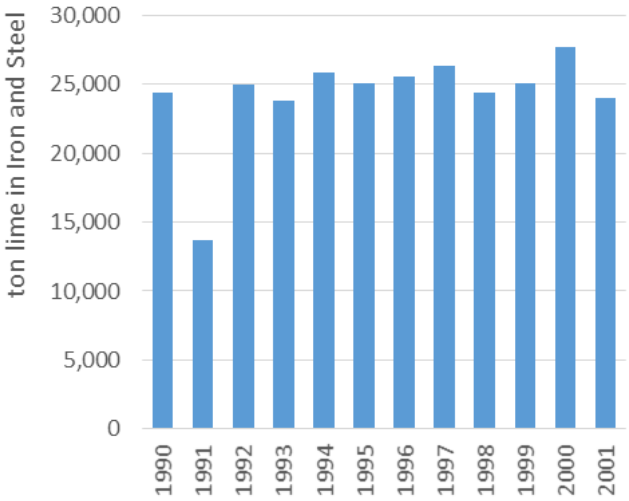



***Figure 4-12: Lime production in Iron and Steel***

In 2002, the iron and steel facility terminated internal lime production and the lime production line became an independent lime dedicated plant, accounted and reported in chapter 4.2.2.

From 2002 onwards, lime used in iron and steel facilities comes from national lime production, which is accounted for in 2.A.2, chapter 4.2.3 above (Lime production in dedicated plants). Emissions from lime production are estimated based on a Tier 3 approach, where LKD correction is accounted for.

### 4.2.4.5 Uncertainty Assessment

***Table 4-8: Uncertainty values related to emissions reported under CRT 2.A.2 – Iron and Steel***

| Parameter | Type of Uncertainty | Uncertainty | Source |
|---|---|---|---|
| Activity Data | Lime production data | 1.5% (average of 1.0-2.0% range) | Average of the range 1.0-2.0% of Table 2.5 of Chapter 2: Mineral Industry Emissions of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. |
| $CO_2$ EF | CaO in lime | 6.0% (average of 4.0-8.0% range) | Average of the range 4.0-8.0% of "Table 2.5" of "Chapter 2: Mineral Industry Emissions" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories". |
| $CO_2$ EF | EF of High Calcium Lime | 2.0% | "Emission factor high calcium lime" (2%) of "Table 2.5" of "Chapter 2: Mineral Industry Emissions" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories". |
| $CO_2$ EF | Combined Uncertainty | 6.3% | - |

### 4.2.4.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation, formulas verification, data and parameters verification and the information provided in this report.

### 4.2.4.7 Recalculations

No recalculations were made.

### 4.2.4.8 Further Improvements

No further improvements are planned.

## 4.2.5 Lime Production in Paper Pulp (CRT 2.A.2)

### 4.2.5.1 Category description

Lime is also produced in Kraft paper pulp plants. In this case, quicklime is produced from carbonates in lime kilns and it is used to regenerate green liquor to white liquor.

### 4.2.5.2 Methodology

We consider both $CaCO_3$ used to produce lime in lime kilns and $Na_2CO_3$ used in causticisers to convert green liquor in white liquor. The $CaCO_3$ produced in the causticiser from $Na_2CO_3$ is subsequently transformed in CaO in the lime kilns.

***Equation 4-8: Chemical conversion equations***

$$CaCO_3 \rightarrow CaO + CO_2 \qquad (Reaction\ in\ the\ Lime\ Kiln)$$

$$Ca(OH)_2 + Na_2CO_3 \rightarrow 2NaOH + CaCO_3 \qquad (Reaction\ in\ the\ Causticiser)$$

$CO_2$ emissions are estimated through a mass balance, from the quantification of carbon in $CaCO_3$ and $Na_2CO_3$ and the quantities of $CO_2$ that are liberated in the conversion process. Therefore, emissions are estimated from consumption of carbonate materials, according to the following equation:

***Equation 4-9: $CO_2$ Emissions from carbonates consumption in paper pulp***

$$Emi_{CO2} = M_i \text{ X } EF_i \text{ X } 10^{-3}$$

**Where:**

$Emi_{CO2}$: $CO_2$ emissions (kt)

$M_i$: Mass of carbonate i consumed (t)

$EF_i$: Emission factor of carbonate i consumed (t $CO_2$/t of carbonate)

According to EU-ETS reporting, in 2019 an amount of $CO_2$ generated from fossil carbon from one paper pulp facility was captured and combined with sodium hydroxide (NaOH) in order to produce calcium carbonate ($CaCO_3$). That amount of $CO_2$ was chemically bound to the carbonate and was not released into the atmosphere, therefore, was discounted from the facility's reported emissions. $CO_2$ recovered emissions were collected from EU-ETS. However, further analysis and contact with the facility showed that, in fact, these $CO_2$ recovered emissions are mostly derived from the fuel rather than the carbonate material. Moreover, this $CO_2$ capture was already made in some years, however, was not reported in the EU-ETS as such. For these reasons, we decided to not include these amounts in category 2.A.2 and assess this issue more thoroughly in the future.

### 4.2.5.3 Emission Factors

***Table 4-9: Emission Factors***

| Carbonate | Unit | EF |
|---|---|---|
| $CaCO_3$ | t $CO_2$/t $CaCO_3$ | 0.440 |
| $Na_2CO_3$ | t $CO_2$/t Na2$CO_3$ | 0.415 |

### 4.2.5.5 Activity Data

In the period 1990-2004, data on consumption of $CaCO_3$ (in paper pulp lime kilns) and $Na_2CO_3$ (in causticisers) was obtained directly from the facilities. From 2005 onwards, these data were obtained from EU-ETS. Time series consistency is guaranteed between the both sets of data, given the report to the EU-ETS is also made by the facilities.

In the estimates of CaO, we only consider additional $CaCO_3$ that is bought to produce CaO. The amounts of carbonaceous sludge consumed ($CaCO_3$) are not considered since they correspond to a closed cycle of carbon in the liquors cycle.

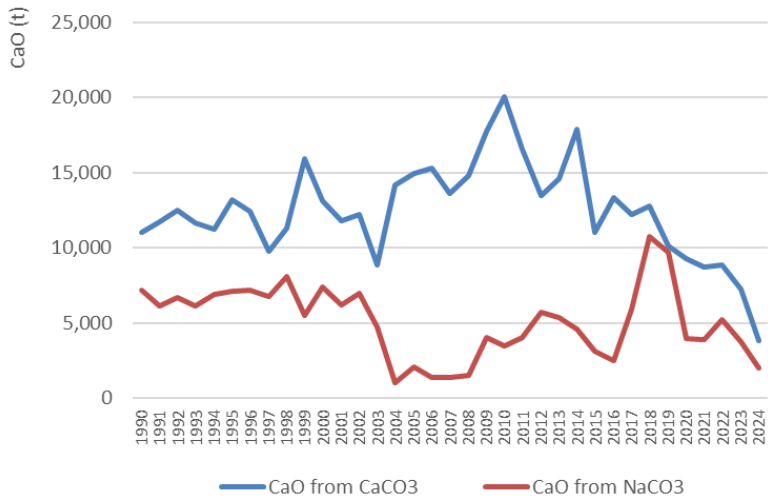



***Figure 4-13: Lime Production in paper pulp***

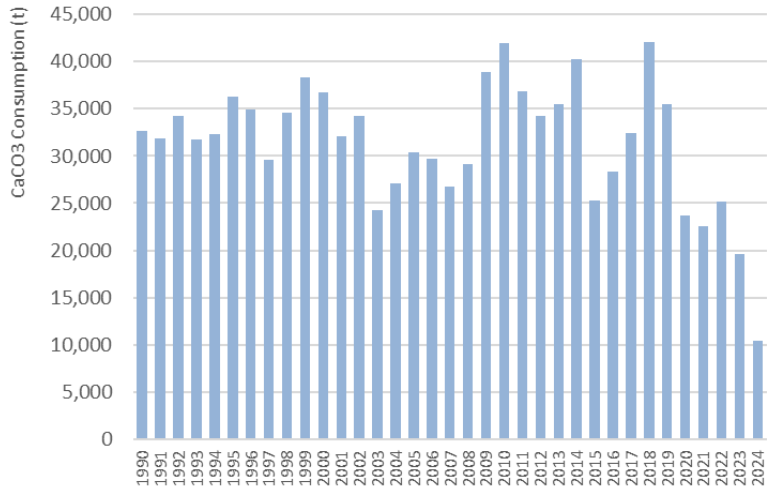



***Figure 4-14: $CaCO_3$ Consumption in paper pulp***

#### 4.2.5.6 Uncertainty Assessment

***Table 4-10: Uncertainty values related to emissions reported under CRT 2.A.2 – paper pulp***

| Parameter | Type of Uncertainty | Uncertainty | Source |
|---|---|---|---|
| Activity Data | Lime production data | 1.5% (average of 1.0-2.0% range) | Average of the range 1.0-2.0% of Table 2.5 of Chapter 2: Mineral Industry Emissions of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. |
| $CO_2$ EF | CaO in lime | 6.0% (average of 4.0-8.0% range) | Average of the range 4.0-8.0% of "Table 2.5" of "Chapter 2: Mineral Industry Emissions" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories". |
| $CO_2$ EF | EF of High Calcium Lime | 2.0% | "Emission factor high calcium lime" (2%) of "Table 2.5" of "Chapter 2: Mineral Industry Emissions" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories". |
| $CO_2$ EF | Combined Uncertainty | 6.3% | - |

#### 4.2.5.7 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

#### 4.2.5.8 Recalculations

No recalculations were made.

#### 4.2.5.9 Further Improvements

No further improvements are expected.

### 4.2.6 Lime production in Other Sectors (CRT 2.A.2)

#### 4.2.6.1 Category description

Besides the production of lime in the above-mentioned sectors, lime production in sugar mills and artisanal production of lime for sanitation purposes or for whitewash may be also sources of emissions.

Currently, there are 2 operating units in Portugal (RAR and Sidul) that use milk of lime in their carbonatation process. Portugal investigated these potential activities in order to estimate related $CO_2$ emissions. This milk of lime refers to calcium hydroxide produced outside these units (purchased lime) and consequently do not result in extra $CO_2$ emissions, as they are already accounted in lime production dedicated plants (chapter 4.2.3). Therefore, we consider that currently there are no emissions related to these sources.

There was another sugar mill in the past (Sociedade de Desenvolvimento Agro-Industrial/DAI, not operating anymore), which started operating in 1996/97, and produced lime until 2008, according to its Environmental Licence and Environmental Reports. From August 2008 to 2015, lime was purchased and consequently does not result in extra $CO_2$ emissions, as it is already accounted in lime production dedicated plants (chapter 4.2.3). The facility terminated operations in May 2015.

Following a 2018 ESD review question, we obtained data on lime production from this facility for the period 1997-2008 (when the lime kiln operated) and made conservative $CO_2$ estimates, which were far below (max. 0.013%) the level of significance. Energy related emissions were not considered as already included in the energy sector.

The artisanal production of lime for sanitation purposes or for whitewash does not exist anymore.

In 1997 there were still 6 or 7 traditional kilns in operation in the south region of the country. They were intermittent ovens (unprofitable). In 2007, only 2 existed, which have since ceased to work. There are no statistics available on this production, as it referred to artisanal and traditional small kilns. Following further research in order to assess the relevance of the potential underestimation, rough conservative $CO_2$ estimates were made. Artisanal production of lime was obtained for 1990-2019 from "MARGALHA, Maria Goreti - The use of lime in mortars in Alentejo (in Portuguese). Masters thesis, Évora University, Évora, 1997" and upon contact with some facilities. A Tier 1 $CO_2$ emission factor was applied according to 2006 IPCC Guidelines, considering high-calcium lime (Table 2.4 of chapter "2 - Mineral Industry Emissions" Volume 3).

These estimates were found to be well below the threshold of significance (bellow 0.013%), therefore, we consider emissions from artisanal production of lime not relevant/negligible.

#### 4.2.6.2 Methodology

The methodology applied regarding lime production in sugar mills was the same as previous sub-chapter (Lime Production in Paper Pulp Production), i.e. the $CO_2$ emissions were estimated from the quantification of carbon in $CaCO_3$, and therefore were estimated from consumption of carbonate materials:

***Equation 4-10: $CO_2$ Emissions from lime production in other sectors***

$$Emi_{CO2} = M_i \text{ X } EF_i \text{ X } 10^{-3}$$

**Where:**

$Emi_{CO2}$: $CO_2$emissions (kt)

$M_i$: mass of carbonate i consumed (t)

$EF_i$: Emission factor of carbonate i consumed (t $CO_2$/t of carbonate)

#### 4.2.6.3 Emission Factors

***Table 4-11: Emission Factors***

| Carbonate | Unit | EF |
|---|---|---|
| $CaCO_3$ | t $CO_2$/t $CaCO_3$ | 0.440 |
| $Na_2CO_3$ | t $CO_2$/t Na2$CO_3$ | 0.415 |

#### 4.2.6.4 Activity Data

At the present, there are two sugar mills operating in Portugal. In their carbonatation processes, they use calcium hydroxide produced outside the facilities (purchased lime) and, consequently, do not generate extra $CO_2$ emissions, as these are already accounted for in lime production dedicated plants (Chapter 4.2.3).

There was another sugar mill (not operating since May 2015), that began operating in 1996/97 and produced lime until 2008. However, from August 2008 to May 2015, lime production was discontinued and lime was purchased during this period. We have estimated conservative $CO_2$ emissions for the period 1997-2008, when the lime kiln operated, based on data received from the company, that are not presented due to confidentially constraints.

#### 4.2.6.5 Uncertainty Assessment

***Table 4-12: Uncertainty values – other sectors***

| Parameter | Type of Uncertainty | Uncertainty | Source |
|---|---|---|---|
| Activity Data | Lime production data | 1.5% (average of 1.0-2.0% range) | Average of the range 1.0-2.0% of Table 2.5 of Chapter 2: Mineral Industry Emissions of 2006 IPCC Guidelines. |
| $CO_2$ EF | CaO in lime | 6.0% (average of 4.0-8.0% range) | Average of the range 4.0-8.0% of Table 2.5 of Chapter 2: Mineral Industry Emissions of 2006 IPCC Guidelines. |
| $CO_2$ EF | EF of High Calcium Lime | 2.0% | Emission factor high calcium lime (2%) of Table 2.5 of Chapter 2: Mineral Industry Emissions of 2006 IPCC Guidelines. |
| $CO_2$ EF | Combined Uncertainty | 6.3% | - |

#### 4.2.6.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

#### 4.2.6.7 Recalculations

No recalculations were made.

#### 4.2.6.8 Further Improvements

No further improvements are planned.

## 4.2.7 Glass Production (CRT 2.A.3)

### 4.2.7.1 Category description

Glass is normally made from sand, limestone, soda ash, and possibly recycled broken glass (cullet). It is made submitting these materials to a high temperature which are thereafter made solid without crystallization (semi-solid state).

Glass involves $CO_2$ emissions from decarbonizing of limestone and carbonate materials under high temperature conditions. Carbonate materials vary with the desired product and comprehend typically limestone, dolomite, soda ash (sodium carbonate) and other carbonate compounds of potassium, barium or strontium.

Combustion emissions from glass production addressed and reporter in source sector 1.A.2, estimated from fuel consumption data or production data. Some anthracite coal is used also as additive in glass production. However, because the consumption of this material is already considered in the energy balance, to avoid double counting of emissions from coal use are not considered here[7]

National glass production is essentially made up of the glass segments of packaging, flat glass and domestic glass, differing from the verified in the European Union (EU15) as the production of glass fibers, special glasses and high-tech products for very specific activities (optics, electronics and chemistry).

### 4.2.7.2 Methodology

For each type of glass except for crystal glass, $CO_2$ emissions from glass production are Kiln Input based, estimated by the facilities according to No. 11 of Annex IV of Regulation (EU) No. 2066/2018 (https://eur-lex.europa.eu/legal-content/pt/TXT/?uri=CELEX%3A32018R2066). Calculation is based on the amount of carbonates in the raw materials consumed (Tier 3), according to the following equation:

***Equation 4-11: $CO_2$ Emissions from glass production***

$$Emission_{CO2} = Carbonate_i \times EF_{CO2(i)} \times F_i$$

**Where:**

$Emission_{CO2}$: $CO_2$ emissions from consumption of specific carbonate (kt)

$Carbonate_i$: Mass of carbonate i consumed (t)

$EF_{CO2i}$: Emission factor from consumption of carbonate i (t $CO_2$/t of carbonate)

$F_i$: fraction calcination achieved for carbonate i (0-1)

Given the fact that there is no calcination factor monitoring in ETS, we assumed complete calcination, therefore, $F_i$ equal to 1 (100%).

There is only one crystal glass plant reporting data under ETS. Thus, in order to estimate national $CO_2$ emissions related to crystal glass production, the following methodology is applied:

***Equation 4-12: $CO_2$ Emissions from crystal glass production***

$$Total_{CO2} = ETS_{CO2} \times \frac{Total_{prod}}{ETS_{prod}}$$

[7] They were not used to derive the country specific emission factors for instance.

**Where:**

$Total_{CO2}$: $CO_2$ emissions related to national total crystal glass production (t)

$ETS_{CO2i}$: $CO_2$ emissions obtained from the only crystal glass plant that reports data under ETS (t)

$Total_{prod}$: National total crystal glass production (t)

$ETS_{prod}$: Crystal glass production of the only crystal glass plant that reports data under ETS (t)

#### 4.2.7.3 Emission Factors

The following emission factors from Annex IX of Directive 2003/87/EC were considered:

***Table 4-13: Emission Factors***

| Raw material | EF | Unit EF |
|---|---|---|
| $CaCO_3$ | 0.440 | t $CO_2$/t carbonate |
| $MgCO_3$ | 0.477-0.523 | t $CO_2$/t carbonate |
| $Na_2CO_3$ | 0.415 | t $CO_2$/t carbonate |
| $BaCO_3$ | 0.223 | t $CO_2$/t carbonate |
| $Li_2CO_3$ | 0.596 | t $CO_2$/t carbonate |
| $K_2CO_3$ | 0.318 | t $CO_2$/t carbonate |
| $NaHCO_3$ | 0.524 | t $CO_2$/t carbonate |
| $XY(CO_3)Z$ | var | t $CO_2$/t carbonate |
| $Ca(OH)_2$ | 0.098-0.114 | t $CO_2$/t |

#### 4.2.7.4 Activity Data

We don't use data from INE because not all products are reported in weight, but instead are measured in area-units ($m^2$) or number of produced pieces.

Data on container glass production was obtained from AIVECERV/CTCV (Container Glass National Association). Flat Glass production data was obtained from the only industrial unit in Portugal. In 1996 there was no flat glass production due to an interruption in the production lines. From 2009 onwards, there is no Flat Glass production in Portugal. Crystal Glass production data was obtained from AIC (Crystal Glass National Association).

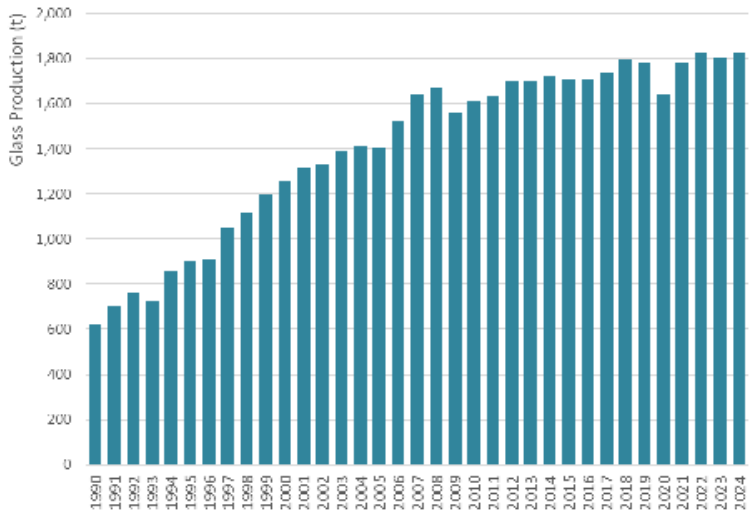



***Figure 4-15: Glass production***

Due to confidentiality constraints concerning flat glass data (there was only one facility in Portugal until 2009), we don't present glass production data by glass type.

From 2005 onwards $Na_2CO_3$, $MgCO_3$, $CaCO_3$, $BaCO_3$, coal and other carbonate raw materials consumption in the kilns are collected from EU-ETS.

Given there is no available carbonates consumption data for 1990-2004, the splicing technique "overlap" (section 5.3.1.1 of the 2006 IPCC Guidelines) was used in order to estimate carbonates consumption for the missing years, using glass production as surrogate data:

***Equation 4-13: Carbonate consumption – 1990-2004***

$$Carbonate_y = Glass\ Prod_y \times \frac{\text{Carbonate}_{2005-2009}}{Glass\ Prod_{2005-2009}}$$

**Where:**

$Carbonate_y$: Carbonate consumption in year y (t)

$Glass\ Production_y$: Glass production in year y (t)

$Carbonate_{2005\text{-}2009}$: Average carbonate consumption in period 2005-2009 (t)

$Glass\ Production_{2005\text{-}2009}$: Average glass production in period 2005-2009 (t)

In order to ensure time series consistency between the two data sets, carbonate consumption for the period 1990-2004 ($Carbonate_y$) was based on the ratio between the average carbonate consumption in the period 2005-2009 and the average glass production in the period 2005-2009.

In the period 1990-2004, glass production data by type of glass (flat, container, crystal) was obtained from national glass associations, since there is no detailed data on carbonate raw material consumption from ETS in that period.

For the 1990-2004 data overlap, we decided to fix the data used as the average of the period 2005-2009, in order to avoid yearly corrections associated to the introduction of last year ratios and given it is the closest period with available and reliable data.

For flat glass and container glass, the facilities that report data under ETS correspond to the national total. Flat glass production terminated in 2009.

For crystal glass it is used the ETS data from the largest facility that reports data under ETS and data is extrapolated for the remaining crystal glass facilities based on crystal glass production.

According to EU-ETS, since 2019 a facility is testing the incorporation of a new raw material $Ca(OH)_2$ (hydrated lime) in its container glass production process. According to the facility, this raw material aims to improve the quality of glass and reduce energy consumption and $CO_2$ emissions.

Raw materials consumption is presented in the figure below.

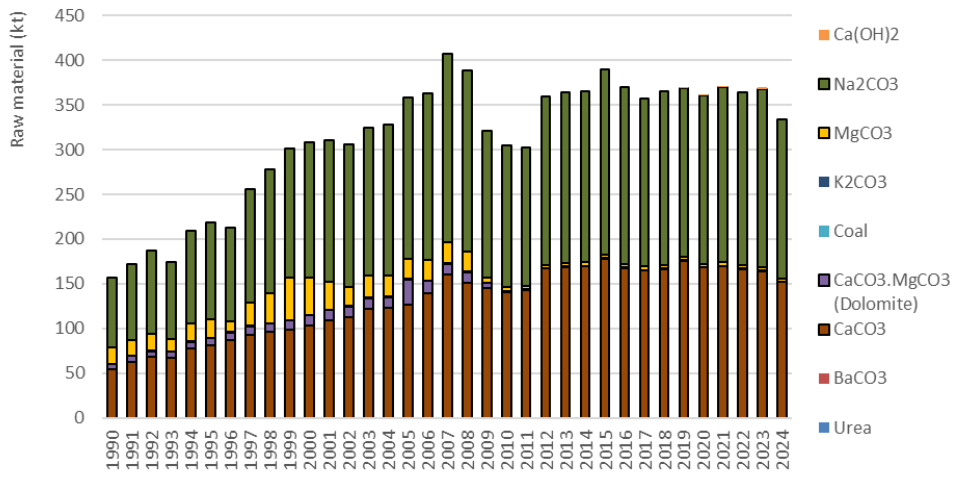



***Figure 4-16: Raw materials consumption***

Cullet incorporation is not directly included in the estimates. However, the increase of cullet incorporation leads to a decrease in other raw materials consumption, as could be observed in years 2010 and 2011. Cullet incorporation ratio by type of glass can be checked in the figure below.

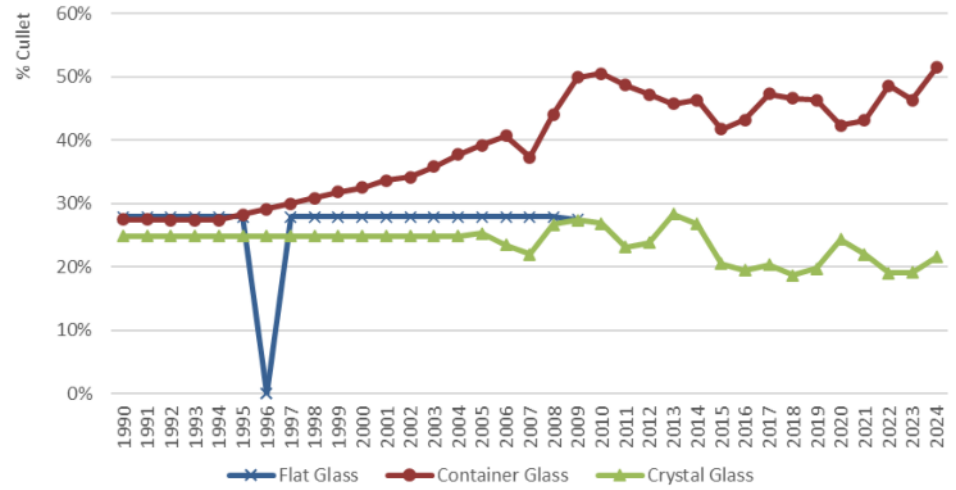



***Figure 4-17: Cullet incorporation by type of glass***

### 4.2.7.5 Uncertainty Assessment

***Table 4-14: Uncertainty values related to emissions reported under CRT 2.A.3 – Glass Production***

| Parameter | Type of Uncertainty | Uncertainty | Source |
|---|---|---|---|
| Activity Data | Weighing or proportioning raw materials | 2.0% (average of 1.0-3.0% range) | Subchapter 2.4.2.2 of chapter 2: Mineral Industry Emissions of 2006 IPCC Guidelines. |
| Activity Data | Glass Production | 5.0% | Subchapter 2.4.2.2 of chapter 2: Mineral Industry Emissions of 2006 IPCC Guidelines. |
| Activity Data | Combined Uncertainty | 5.4% | - |
| CO2 EF | Stoichiometric ratio | 2.0% (average of 1.0-3.0% range) | Subchapter 2.4.2.1 of chapter 2: Mineral Industry Emissions of 2006 IPCC Guidelines |
| CO2 EF | Calcination of the carbon input | 1.0% | Subchapter 2.4.2.1 of chapter 2: Mineral Industry Emissions of 2006 IPCC Guidelines. |
| CO2 EF | Combined Uncertainty | 2.2% | - |

***Table 4-15: Uncertainty values related to emissions reported under CRT 1.A.2.f***

| Parameter | Fuel Type | 1990-2004 | 2005-2007 | 2008 onwards |
|---|---|---|---|---|
| Activity Data | L | 10% (i) | 3% (ii) | 2% (iii) |
| | S | 10% (i) | 3% (ii) | 2% |
| | G | 10% (i) | 3% (ii) | 2% |
| | B | 10% (i) | 3% (ii) | 2% |
| | O | 10% (i) | 3% (ii) | 2% |
| $CO_2$ EF | L | 3% (iv) | 3% (iv) | 3% (iv) |
| | S | 7% (v) | 7% (v) | 7% (v) |
| | G | 7% (v) | 7% (v) | 7% (v) |
| | B | 7% (v) | 7% (v) | 7% (v) |
| | O | 7% (v) | 7% (v) | 7% (v) |
| $CH_4$ EF | L | 100% (vi) | 100% (vi) | 100% (vi) |
| | S | 100% (vi) | 100% (vi) | 100% (vi) |
| | G | 100% (vi) | 100% (vi) | 100% (vi) |
| | B | 100% (vi) | 100% (vi) | 100% (vi) |
| | O | 100% (vi) | 100% (vi) | 100% (vi) |
| $N_2O$ EF | L | 150% (vii) | 150% (vii) | 150% (vii) |
| | S | 150% (vii) | 150% (vii) | 150% (vii) |
| | G | 150% (vii) | 150% (vii) | 150% (vii) |
| | B | 150% (vii) | 150% (vii) | 150% (vii) |
| | O | 150% (vii) | 150% (vii) | 150% (vii) |

(viii) Chapter 2: Stationary Combustion of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Highest value of the range 5-10% of "Extrapolation" in "Less developed statistical systems".

(ix) Chapter 2: Stationary Combustion of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Highest value of the range 2-3% of "Surveys" in "Well developed statistical systems".

(x) Chapter 2: Stationary Combustion of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Lowest value of the range 2-3% of "Surveys" in "Well developed statistical systems".

(xi) Chapter 2: Stationary Combustion of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Highest value for "Oil" in "Table 2.13".

(xii) Chapter 2: Stationary Combustion of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Average value for "Coke, oil, gas" in "Table 2.13".

(xiii) Highest value of Table 2.14 of "Volume 2: Energy" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories".

(xiv) Average UK value in "Table 2.14" of "Volume 2: Energy" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories".

#### 4.2.7.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

#### 4.2.7.7 Recalculations

Recalculations occurred due to a compilation error correction in EU-ETS CO2 emissions in 2023.

#### 4.2.7.8 Further Improvements

No further improvements are planned.

## 4.2.8 Glass Wool Production (CRT 2.A.3)

### 4.2.8.1 Category description

Glass wool is a category of mineral wool, where the production process is similar to glass making, already addressed in the previous chapter.

Glass wool production began being reported in the EU-ETS in 2019, as one facility entered in operation. Glass wool from this facility is produced from sand, sodium carbonate and recycled broken glass (cullet), submitting these materials to a high temperature, causing them to melt and then spun into fibres and mixed with organic resin before curing into products.

Glass wool production generates $CO_2$ emissions from decarbonizing of carbonate materials under high temperature conditions. There are, also, indirect $CO_2$ emissions related to NMVOC. The methodology used to estimate NMVOC emissions could be checked in the Portuguese IIR. Indirect $CO_2$ emissions related to NMVOC emissions from glass wool production are reported in CRT Table 6.

Combustion emissions from glass wool production are reported in source sector 1.A.2, estimated from fuel consumption data.

### 4.2.8.2 Methodology

$CO_2$ emissions from glass wool production are reported in EU-ETS, estimated by the facilities according to No. 11 of Annex IV of Regulation (EU) No. 2066/2018 (https://eur-lex.europa.eu/legal-content/pt/TXT/?uri=CELEX%3A32018R2066). Estimates are Kiln Input based on the amount of carbonates in the raw materials consumed (Tier 3), according to the following equation:

***Equation 4-14: $CO_2$ Emissions from glass production***

$$Emission_{CO2} = Carbonate \times EF_{CO2} \times FC$$

**Where:**

$Emission_{CO2}$: $CO_2$ emissions from consumption of sodium carbonate (kt)

Carbonate: Mass of sodium carbonate consumed (t)

$EF_{CO2}$: Emission factor from consumption of sodium carbonate (t $CO_2$/t of carbonate)

FC: fraction calcination achieved for sodium carbonate (0-1)

Given the fact that there is no calcination factor monitoring in ETS, we assumed complete calcination, therefore, FC equals 1 (100%).

### 4.2.8.3 Emission Factors

The following emission factor was considered:

***Table 4-16: Emission Factors***

| Carbonate | EF | Unit EF |
|---|---|---|
| $Na_2CO_3$ | 0.415 | t $CO_2$/t carbonate |

### 4.2.8.4 Activity Data

Glass wool production began being reported in the EU-ETS in 2019, as one facility entered in operation that year. Carbonate consumption data for year 2019 was obtained from EU-ETS. Glass wool production is obtained from the facility Annual environmental report (RAA).

Due to confidentiality constraints (there is only one facility in Portugal), we don't present activity data.

Therefore, we have two different sets of activity data (raw materials and glass wool production) for the same period but can only report one series in the CRT tables. In order to ensure time series consistency of the activity data reported in the CRT tables, given that glass production (from chapter 4.2.7) is also reported in CRT 2.A.3, we decided to report glass wool production as activity data in CRT tables.

#### 4.2.8.5 Uncertainty Assessment

***Table 4-17: Uncertainty values related to emissions reported under CRT 2.A.3 – Glass Wool Production***

| Parameter | Type of Uncertainty | Uncertainty | Source |
|---|---|---|---|
| Activity Data | Weighing or proportioning raw materials | 2.0% (average of 1.0-3.0% range) | Subchapter 2.4.2.2 of chapter 2: Mineral Industry Emissions of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. |
| Activity Data | Glass Wool Production | 5.0% | Subchapter 2.4.2.2 of chapter 2: Mineral Industry Emissions of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. |
| Activity Data | Combined Uncertainty | 5.4% | - |
| CO2 EF | Stoichiometric ratio | 2.0% (average of 1.0-3.0% range) | Subchapter 2.4.2.1 of chapter 2: Mineral Industry Emissions of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. |
| CO2 EF | Calcination of the carbon input | 1.0% | Subchapter 2.4.2.1 of chapter 2: Mineral Industry Emissions of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. |
| CO2 EF | Combined Uncertainty | 2.2% | - |

#### 4.2.8.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

#### 4.2.8.7 Recalculations

No recalculations were made.

#### 4.2.8.8 Further Improvements

No further improvements are planned.

### 4.2.9 Other Process Uses of Carbonates - Ceramics (CRT 2.A.4.a)

#### 4.2.9.1 Category description

Process-related emissions from ceramics result from the calcination of carbonates in the clay, as well as the additions to the kiln.

In Portugal, part of the ceramics sector is included in the EU-ETS from 2013 onwards. However, we only consider that there is a robust characterization of raw materials consumption in the ceramic plants under ETS from 2015 onwards.

#### 4.2.9.2 Methodology

From 2015 onwards, $CO_2$ emissions from ceramics reported in EU-ETS are estimated by the facilities according to No. 12 of Annex IV of Regulation (EU) No. 2066/2018 (https://eur-lex.europa.eu/legal-content/pt/TXT/?uri=CELEX%3A32018R2066). Estimates are Kiln Input based on the amount of carbonates in the raw materials consumed (Tier 3).

Firstly, and given that only part of the ceramics sector is included in the EU-ETS, we work with the Energy Balance in order to obtain total fuel consumption for the ceramics sector and then infer total raw material consumption. From 2015 onwards, national carbonate consumption in ceramics is estimated according to:

***Equation 4-15: Annual national carbonate consumption in ceramics – 2015-onwards***

$$Total\ Mat_{Carb(m)} = EU - ETS\ Mat_{Carb(m)} \times \frac{EB\ Fuel\ Cons_{(Ceramics)}}{EU - ETS\ Fuel\ Cons_{(Ceramics)}}$$

**Where:**

Total $Mat_{Carb(m)}$: Total Raw material m consumption for ceramics sector, EU-ETS and non-EU-ETS plants (t)

EU-ETS $Mat_{Carb(m,y)}$: Raw material m consumption for ceramic plants under EU-ETS (t)

EB Fuel $Cons_{(Ceramics)}$: Total fuel consumption for ceramics sector (obtained from the Energy Balance), EU-ETS and non-ETS plants (GJ)

EU-ETS Fuel $Cons_{(Ceramics)}$: Fuel consumption for Ceramic plants under ETS (GJ)

From 2015 onwards, $CO_2$ emissions are estimated through a mass balance between the quantification of carbon in original raw materials and $CO_2$ emissions generated in the conversion process, according to the following equation:

***Equation 4-16: Annual national $CO_2$ emissions from ceramics – 2015-onwards***

$$Emi_{CO2} = \sum [\ Mat_{Carb\ (m)} X\ EF_{(m)}\ ]\ X\ 10^{-3}$$

**Where:**

$Emi_{CO2}$: Total annual $CO_2$ emissions for ceramics sector (kt $CO_2$)

$Mat_{Carb\ (m)}$: Annual consumption of carbonate containing material m (t)

$EF_{(m)}$: Emission factor of material m consumed (t $CO_2$/t material m)

Given there is a lack in ceramics characterization in the period 1990-2014, the splicing technique "overlap" (section 5.3.1.1 of the 2006 IPCC Guidelines) was used in order to estimate EU-ETS carbonates consumption for ceramics production, according to the following equation:

***Equation 4-17: EU-ETS carbonates consumption - 1990-2014***

$$EU - ETS\ Mat_{Carb(m,y)} = EB\ Fuel\ Cons_{(\mathrm{Ceramics,y})} \times \frac{EU - ETS\ Mat_{\mathrm{Carb(m,2015-2018)}}}{EB\ Fuel\ Cons_{(Ceramics,\mathrm{2015-2018})}}$$

**Where:**

EU-ETS $Mat_{Carb(m,y)}$: Raw material m consumption in year y for ceramic plants under EU-ETS (t)

EB Fuel $Cons_{(Ceramics,y)}$ : Energy Balance Ceramics fuel consumption in year y, EU-ETS and non-ETS plants (GJ)

EU-ETS $Mat_{Carb(m,\ 2015\text{-}2018)}$ : Average raw material m consumption in the period 2015-2018 for ceramic plants under ETS (t)

EB Fuel $Cons_{(Ceramics,2015\text{-}2018)}$ : Average Energy Balance Ceramics fuel consumption in the period 2015-2018, ETS and non-ETS plants (GJ)

In the period 1990 to 2014, the splicing technique "overlap" (section 5.3.1.1 of the 2006 IPCC Guidelines) was used in order to estimate national carbonates consumption for ceramics production, according to the following equation:

***Equation 4-18: Annual national carbonate consumption – 1990-2014***

$$Total\ Mat_{Carb(m,y)} = EB\ Fuel\ Cons_{(Ceramics,y)} \times \frac{EU-ETS\ Mat_{Carb(m,2015-2018)}}{EU-ETS\ Fuel\ Cons_{(Ceramics,2015-2018)}}$$

**Where:**

Total $Mat_{Carb(m,y)}$: Raw material m consumption in year y for all national ceramics, both ETS and non-ETS plants (t)

EB Fuel $Cons_{(Ceramics,y)}$: Energy Balance Ceramics fuel consumption in year y, EU-ETS and non-ETS plants (GJ)

EU-ETS $Mat_{Carb(m,2015-2018)}$: Average raw material m consumption in 2015-2018 for ceramic plants under EU-ETS (t)

EU-ETS Fuel $Cons_{(Ceramics,2015-2018)}$: Average Energy Balance Ceramics fuel consumption in the period 2015-2018, for EU-ETS Ceramic plants (GJ)

Finally, $CO_2$ emissions for the period 1990-2014 are estimated according to:

***Equation 4-19: Annual national $CO_2$ emissions from ceramics - 1990-2014***

$$Emi_{CO2\ (y)} = Mat_{Carb\ (m,y)} X\ EF_{\ (m)}\ X\ 10^{-3}$$

**Where:**

$Emi_{CO2\ (y)}$: Emission of $CO_2$ in year y (kt $CO_2$)

$Mat_{Carb\ (m,y}$: Consumption of carbonate containing material m in year y (t)

$EF_{\ (m)}$: Emission factor of material m consumed in year y (t $CO_2$/t material m)

### 4.2.9.3 Emission Factors

The emission factors applied are listed in the following table.

From 2015 onwards, in order to ensure time series consistency, emission factors are obtained from EU-ETS data. From 1990 to 2014, information was backcasted based on the average values of raw material consumption and CO2 emissions from EU-ETS data from 2015 to 2018.

***Table 4-18: Emission Factors of raw materials***

| Raw material | Unit | Emission Factors | | | |
|---|---|---|---|---|---|
| | | 1990-2014 (1) | 2021 (2) | 2022 (2) | 2023 (2) |
| Clay | t CO2/t Clay | 0.0227 | 0.0168 | 0.0138 | 0.0145 |
| BaCO3 | t CO2/t BaCO3 | 0.2230 | 0.2230 | 0.2230 | 0.2230 |
| CaCO3 | t CO2/t CaCO3 | 0.4399 | 0.4401 | 0.4401 | 0.4398 |
| Kaolin | t CO2/t Kaolin | 0.0104 | 0.0145 | 0.0135 | 0.0141 |
| Dolomite | t CO2/t Dolomite | 0.4709 | 0.4700 | 0.4705 | 0.4668 |
| MgCO3 | t CO2/t MgCO3 | 0.5220 | 0.5220 | 0.5220 | 0.5220 |
| Na2CO3 | t CO2/t Na2CO3 | 0.4150 | 0.4150 | 0.4150 | 0.4150 |
| Other Carbonates | t CO2/t Other Carbonates | 0.0384 | 0.0635 | 0.0547 | 0.0539 |
| Ceramic Paste | t CO2/t Ceramic Paste | 0.0099 | 0.0078 | 0.0061 | 0.0090 |
| Polystyrene | t CO2/t Polystyrene | 3.3850 | 3.3850 | 3.3850 | 3.3850 |
| (1) Backcasted using average value from 2015 to 2018<br>(2) Source: EU-ETS from 2015 onwards | | | | | |

### 4.2.9.4 Activity Data

Despite there are data available in the EU-ETS on raw materials in ceramics since 2013, we only consider this data to be reliable from 2015 onwards.

From 2015 onwards, both raw materials consumption and respective emission factors have been obtained from ETS data. Since not all ceramics are covered under ETS, raw materials total national consumption have been extrapolated based on energy consumption in ceramics reported both under ETS (just ETS plants) and in the Energy Balance provided by DGEG (total national - both ETS and non-ETS plants), as described in the methodology section above.

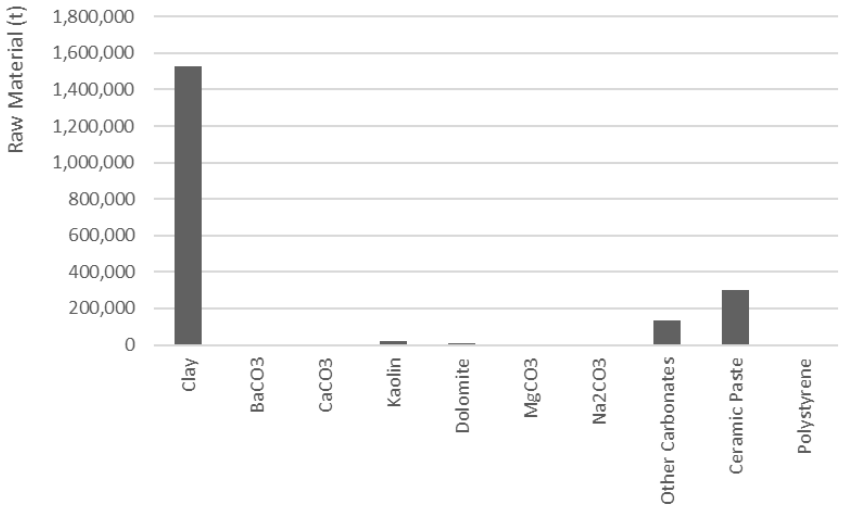



***Figure 4-18: Raw materials consumption in EU-ETS plants in 2024***

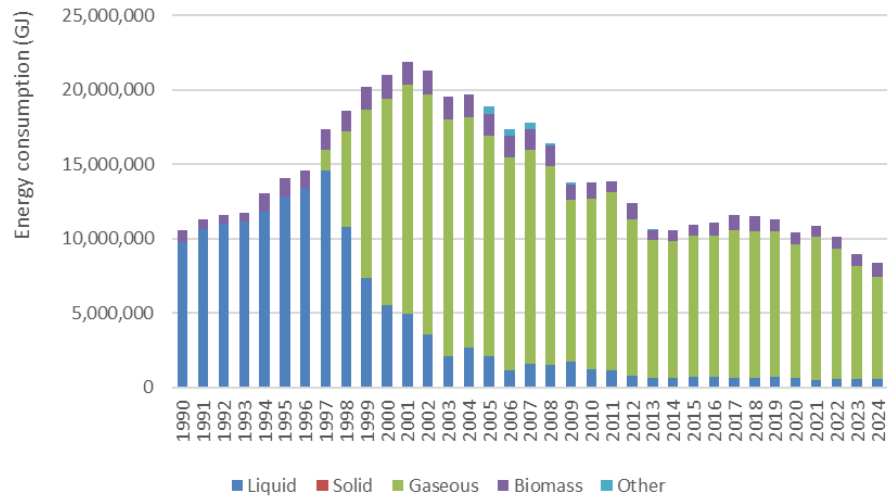



***Figure 4-19: Energy consumption in ceramics sector by fuel type (Source: Energy Balance)***

In order to estimate the representativeness of the ceramics sector in the EU-ETS we consider Total National Energy Consumption in Ceramics sector from the Energy Balance, obtained from DGEG, and Energy consumption from the ceramic facilities included in EU-ETS and estimate the percentage of ceramic facilities included in EU-ETS.

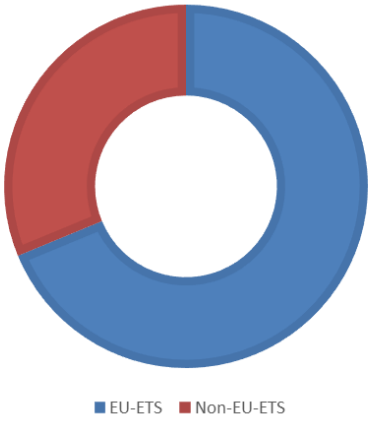



***Figure 4-20: % Energy consumption in ceramics sector in 2024***

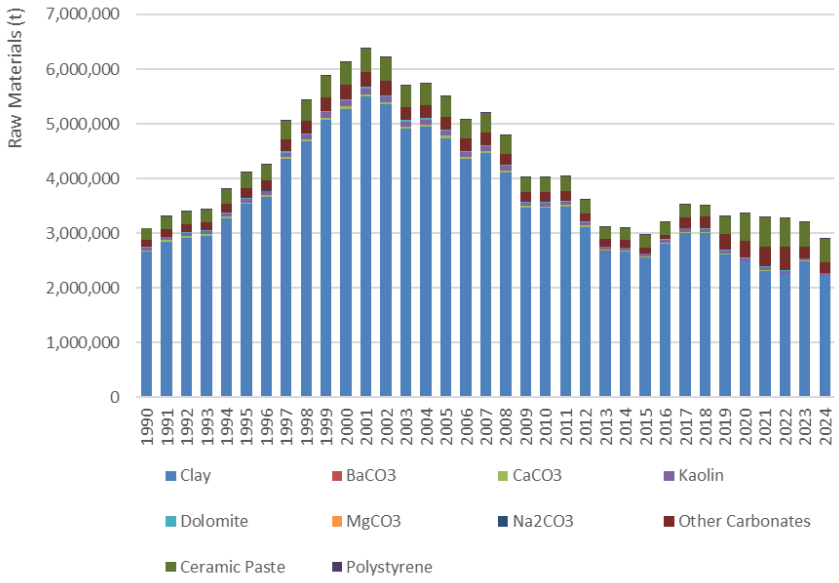



***Figure 4-21: Raw materials consumption in ceramics sector***

### 4.2.9.5 Uncertainty Assessment

***Table 4-19: Uncertainty values***

| Parameter | Type of Uncertainty | Uncertainty | Source |
|---|---|---|---|
| Activity Data | Weighing or proportioning raw materials | 2.0% (average of 1.0-3.0% range) | Table 2.3 of "Chapter 2: Mineral Industry Emissions" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories" |
| Activity Data | Carbon content | 2.0% | Table 2.3 of "Chapter 2: Mineral Industry Emissions" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories" |
| Activity Data | Combined Uncertainty | 2.8% | - |
| CO2 EF | Fractional purity | 3.0% (average of 1.0-5.0% range) | Average value of the range 1-5% of chapter 2.5.2.1 of Volume 3: Industrial Processes and Product Uses of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. |

### 4.2.9.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

#### 4.2.9.7 Recalculations

Electricity and fuel consumption data in 2023 were updated after the publication of a revised Energy Balance by DGEG.

#### 4.2.9.8 Further Improvements

Further improvements include pursuing contacts with national ceramics associations in order to gather reliable data on ceramics production for the whole time series and improve information transparency and time series consistency.

### 4.2.10 Other Process Uses of Carbonates-Other Uses of Soda Ash (CRT 2.A.4.b)

#### 4.2.10.1 Category description

Soda Ash ($Na_2CO_3$) is consumed as a raw material in the Glass and Glass Wool Production (CRT 2.A.3), in Paper Pulp production (CRT 2.H.1), Ceramics production (CRT 2.A.4.a). Soda ash consumptions from these identified sectors are available in EU-ETS and its emissions are reported in the respective end-use sectors.

Available information from National Statistics indicates that there are other uses for soda ash in Portugal besides the ones above mentioned. These other uses of soda ash include soap and detergents, food and beverages and water treatment. However, Portugal's EU-ETS does not include data from such activities and the inventory team is still not able to quantify and report them in the respective categories. Therefore, for the time being, apparent consumption of soda ash from all other unidentified activities is accounted in category 2.A.4.b. The inventory team considers that the use of soda ash in these sectors may not generate $CO_2$ emissions, however, is unable to confirm such situation.

Due to confidentiality constraints, emissions from this sector are reported in CRT 2.A.4.d along with "Other Process Uses of Carbonates", hence the notation key IE (Included Elsewhere) in CRT tables.

#### 4.2.10.2 Methodology

In a first step, we estimate soda ash apparent consumption, based on national production, imports and exports data:

***Equation 4-20: Soda ash apparent consumption***

$$\text{Apparent Consumption} = \text{National Production} + \text{Imports} - \text{Exports}$$

**Where:**

Apparent Consumption: Total soda ash apparent consumption (t $Na_2CO_3$)

National Production: Soda ash national production (t $Na_2CO_3$)

Imports: Total soda ash imports (t $Na_2CO_3$)

Exports: Total soda ash exports (t $Na_2CO_3$)

In a second step, we estimate the soda ash apparent consumption in identified sectors for which EU-ETS collects data, such as Paper Pulp, Ceramics, Glass and Glass Wool Production. We subtract these values to national total apparent consumption and ultimately obtain the apparent consumption for the remaining sectors (not addressed under EU-ETS), according to the following equation:

***Equation 4-21: Soda ash apparent consumption in other sectors***

Apparent Consumption (other sectors) = AC (total) – AC (Glass/Glass Wool) – AC (Paper Pulp) – AC (Ceramics)

**Where:**

Apparent Consumption (other sectors): Soda ash apparent consumption in sectors other than Glass Production or Paper Pulp Production (t $Na_2CO_3$)

AC (Total): Soda ash national total apparent consumption (t $Na_2CO_3$)

AC (Glass): Soda ash consumption in Glass Production (t $Na_2CO_3$)

AC (Paper and Pulp): Soda ash consumption in Paper and Pulp Production (t $Na_2CO_3$)

AC (Ceramics): Soda ash consumption in Ceramics (t $Na_2CO_3$)

Finally, $CO_2$ emissions related to other unidentified uses of soda ash are estimated based on a Tier 1 approach according to chapter 3.8 of the 2006 IPCC Guidelines:

***Equation 4-22: $CO_2$ Emissions from soda ash consumption (other sectors)***

$$\text{Emi (CO2)} = \text{AD} \times \text{EF } (CO2) \times 10^{-3}$$

**Where:**

Emi ($CO_2$): Emissions of $CO_2$ (kt $CO_2$)

AD: Soda ash apparent consumption (other sectors) (t)

EF $CO_2$: $CO_2$ emissions factor (t $CO_2$/t soda ash consumed)

### 4.2.10.3 Emission Factors

Emission factor of soda ash was set from molecular stoichiometry:

***Table 4-20: Emission factors of soda ash***

| Material | EF | Unit |
|---|---|---|
| $Na_2CO_3$ (Soda Ash) | 0.415 | t $CO_2$/t soda ash |

### 4.2.10.4 Activity Data

According to available information from EU-ETS, soda ash is used in the following end-use sectors: Glass Production, Glass Wool Production, Paper Pulp Production and Ceramics. Soda ash consumptions from these identified sectors were obtained from EU-ETS.

Available information from National Statistics indicates that there are other uses for soda ash in Portugal besides the ones above mentioned, however, these uses are not quantified. Following the 2022 UNFCCC Review, upon contact to our Focal Points as well as National Statistics 'Office, we learned that other uses of soda ash in Portugal include pH correction in water treatment plants (supply water), as a biogas purifier in urban wastewater treatment and soaps and detergents industry. However, Portugal's EU-ETS does not include data from such activities, and the inventory team is still not able to identify them and report in the respective categories.

Therefore, for the time being, apparent consumption of soda ash from all other unidentified activities is estimated based on National Production, Imports and Exports. Soda Ash imports and exports data were obtained from INE for the whole time series.

Soda ash production data was obtained from the only soda ash producing facility in Portugal, which operated from 1990 to 2014. Since 2015, there is no soda ash production in Portugal.

Due to confidentiality constraints, activity data for the entire time series is presented as an index value related to 1990 data.

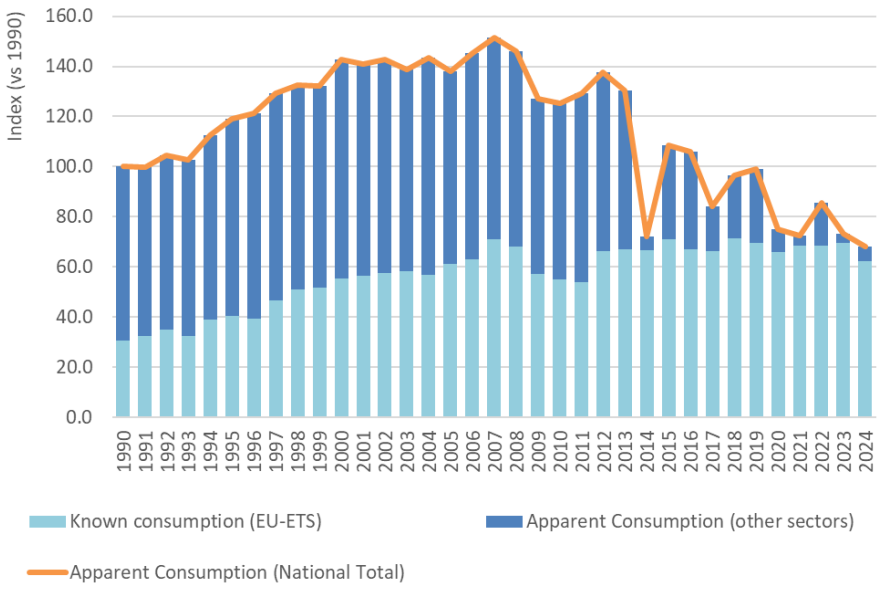



***Figure 4-22: Soda ash apparent consumption***

### 4.2.10.5 Uncertainty Assessment

***Table 4-21: Uncertainty values***

| Parameter | Type of Uncertainty | Uncertainty | Source |
|---|---|---|---|
| Activity Data | Weighing or proportioning raw materials | 2.0% (average of 1.0-3.0% range) | Table 2.3 of "Chapter 2: Mineral Industry Emissions" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories" |
| Activity Data | Carbon content | 2.0% | Table 2.3 of "Chapter 2: Mineral Industry Emissions" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories" |
| Activity Data | Combined Uncertainty | 2.8% | - |
| CO2 EF | Fractional purity | 3.0% (average of 1.0-5.0% range) | Average value of the range 1-5% of chapter 2.5.2.1 of Volume 3: Industrial Processes and Product Uses of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. |

### 4.2.10.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

Following QA/QC procedures to the sector, the Party identified a compilation error related to consumption of Na2CO3 in the glass production process which affected the whole time series.

#### 4.2.10.7 Recalculations

Minor recalculations resulted from the 2023 revisions in 2.A.4 a Ceramics and 2.A.3 Glass Production.

#### 4.2.10.8 Further Improvements

In the course of the 2022 UNFCCC Review recommendation, we investigated other Portuguese end-use sectors where soda ash is used, by contacting National Statistics as well as our Focal Points on IPPU. We learned that soda ash was used in water treatment plants (supply water) for pH correction.

Also, we learned that soda ash was used in the soaps and detergents industry, as well as in urban wastewater treatment as a biogas purifier, although in not very expressive amounts.

However, Portugal's EU-ETS does not include data from such activities and the inventory team is still not able to identify them and report in the respective categories. Furthermore, we believe that these other uses of soda ash do not result in $CO_2$ emissions but cannot confirm such fact.

### 4.2.11 Other Process Uses of Carbonates-Non Metallurgical Magnesia Production (CRT 2.A.4.c)

There is no non-metallurgical magnesium production in Portugal.

## 4.2.12 Other Process Uses of Carbonates – Other (CRT 2.A.4.d)

### 4.2.12.1 Category description

$CO_2$ liberation to atmosphere occurs from several industrial activities that use limestone ($CaCO_3$), dolomite rock ($CaCO_3.MgCO_3$) or other carbonates, but only when original materials are not incorporated as inert components but suffer a chemical removal of carbon, as for example when calcium carbonate is added to nitric acid to form calcium nitrate:

$$2\ HNO_3 + CaCO_3 \rightarrow Ca(NO_3)_2 + H_2O + CO_2$$

Currently, this category considers Carbonates uses in Fertilizers production and Desulfurization in Large Point Source Energy Plants in Mainland Portugal.

Concerning CRT Tables reporting, this category also reports Other uses of soda ash (not reported in CRT 2.A.4.b due to confidentiality constraints) and Rock wool production (not reported in CRT 2.A.5 given CRT tables do not include such category).

Carbonate materials consumption in glass industry is covered in category 2.A.3 – chapter 4.2.7.

While consumption of carbonate materials is reported in the National Statistics Database (INE) for other industrial activities, some do not correspond to uses where carbon is liberated and no emissions are estimated: paint, soap, pharmaceutical and agrochemical products, cleaning products, perfumeries and hygiene products, glues and adhesives, tire and rubber products, plastic products and synthetic fibres, and all food and beverage industry.

Lime production involves consumption and decarbonizing of carbonate materials as well, limestone or dolomite rock. There are dedicated lime production facilities and there is also lime production in lime kilns in paper pulp industry and in iron and steel industry. $CO_2$ emissions from lime production are reported in category 2.A.2 – chapters 4.2.3, 4.2.4 and 4.2.5.

Regarding Desulfurization in Large Point Source Energy Plants in Mainland Portugal, from the information gathered, only two plants in Portugal implemented this kind of abatement system: Pêgo and Sines. Both plants ceased working in 2021 and used hard coal and fuel oil in the combustion processes. Abatement equipment operated since 2008 (for both plants).

In a wet flue gas desulfurization the $SO_2$ emissions are absorbed by lime, forming $CO_2$ and plaster (gypsum + $H_2O$) as by-products.

***Equation 4-23: Chemical conversion equations***

$$SO_2 + H_2O \rightarrow H_2SO_3$$
$$CaCO_3 + H_2SO_3 \rightarrow CaSO_3 + CO_2 + H_2O$$
$$CaSO_3 + 1/2O_2 + 2H_2O \rightarrow CaSO_4.2H_2O$$

These equations show that the wet flue gas desulfurization reduces the $SO_2$ emissions but increment $CO_2$ emissions.

Since there is no specific CRT category for desulfurization, and given it derives from carbonates consumption, total $CO_2$ emissions from this abatement system were included in category 2.A.4.d.

### 4.2.12.2 Methodology

#### *CARBONATES USES IN FERTILIZERS*

$CO_2$ emissions are estimated from the quantification of carbon in original raw materials and through a mass balance for the quantities of $CO_2$ that are liberated in the conversion process. Therefore, emissions are estimated from consumption of carbonate materials:

***Equation 4-24: $CO_2$ emissions***

$$Emi_{CO2} = 44/12 \text{ X } Mat_{Carb\ (m)} \text{ X } EF_{(m)} \text{ X } 10^{-3}$$

**Where:**

$Emi_{CO2}$: $CO_2$ emissions (kt $CO_2$)

$Mat_{Carb\ (m,y}$: Consumption of carbonate containing material m (t)

$EF_{(m)}$: Emission factor of material m consumption (t $CO_2$/t material m)

#### DESULFURIZATION IN LARGE POINT SOURCE ENERGY PLANTS IN MAINLAND PORTUGAL

In the desulfurization processes it is important to determine the emission of $CO_2$ and the reduction of $SO_2$. For both determinations the lime consumption was used as activity data:

***Equation 4-25: $CO_2$ emissions***

$$CO_2 \text{ Emission}_{(u,y)} = CaCO_{3Cons(u,\ y)} \text{ X } CO_2\text{Ratio X } 10^{-3}$$

***Equation 4-26: $SO_2$ removals***

$$SO_2 \text{ Removal}_{(u,y)} = CaCO_{3Cons(u,\ y)} \text{ X } SO_2\text{Ratio X } 10^{-3}$$

**Where:**

$CO_2$ Emission $_{(u,y)}$: Emission of $CO_2$ estimated from $CaCO_3$ consumption in power plant u in year y (t)

$SO_2$ Removal $_{(u,y)}$: Quantity of $SO_2$ not emitted estimated from $CaCO_3$ consumption in power plant u in year yt)

$CaCO_{3Cons\ (u,\ y)}$: Consumption of $CaCO_3$ in power plant u in year y (t)

$CO_2$Ratio: Ratio between $CO_2$ emitted and $CaCO_3$ consumption

$SO_2$Ratio: Ratio between the $SO_2$ removed and $CaCO_3$ consumption

Since both energy plants were included in the EU-ETS, the $CO_2$ ratio reported under this scheme was used in the inventory – 0.44 t $CO_2$/t Ca. Monitoring data from the two plants was used for determining the $SO_2$ ratio: estimation based in $CaCO_3$ consumption and the difference between the expected $SO_2$ emissions without abatement system (based in the fuel sulphur content) and what was actually emitted. Therefore, the $SO_2$ ration was plant specific and varied over time.

Since the methodology for determining combustion $SO_2$ does not consider the use of abatement systems, the quantity of $SO_2$ removed in the desulfurization equipment was subtracted to the total $SO_2$ emissions.

### 4.2.12.1 Emission Factors

Emission factors of materials consumed in Portugal was set from molecular stoichiometry[8]:

***Table 4-22: Emission factors of carbonate materials***

| Material | EF |
|---|---|
| Limestone (1) | 0.44 |
| Dolomite (2) | 0.48 |
| (1) assumed pure calcium carbonate<br>(2) Ca and Mg carbonate in equal share | |

### 4.2.12.2 Activity Data

#### *CARBONATES USES IN FERTILISERS*

Due to the unavailability of statistical information concerning consumption of carbonate materials in the fertilizer industry (for the production of calcium and magnesium nitrates) they had to be estimated from fertilizer production data and considering that, stoichiometrically, two moles of nitrogen require one mole of either $CaCO_3$ or $MgCO_3$. From 1996 onwards, fertilizer production data was available from INE database. In the period 1990-1995, data has been estimated based on the average 1996-2000 production and on 1990-1995 GVA trend on *Manufacture of chemicals and chemical products*.

Final total consumption of carbonate materials is presented in the figure below. In the period 2009-2011 there is a strong decrease in limestone and dolomite consumption related to a decrease in calcium nitrate production. The slight decrease in 2020-2021 is related to market restrictions during the COVID pandemic. Following the identification of an outlier in 2023 fertilisers 'production data obtained from the National Statistics Office, the Party obtained a corrected activity data time series from the data provider.

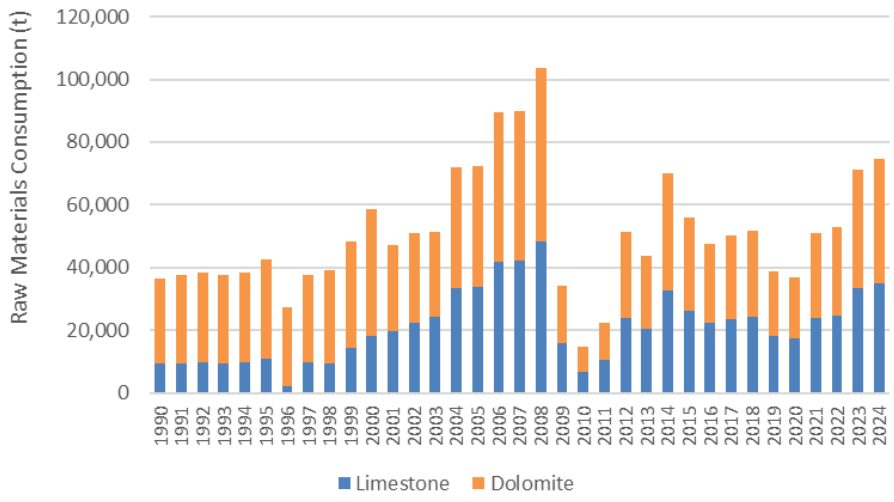



***Figure 4-23: Consumption of carbonate materials in fertilizer industry***

#### DESULFURIZATION IN LARGE POINT SOURCE ENERGY PLANTS IN MAINLAND PORTUGAL

From 2008 (when desulfurization began in both plants) to 2021, total limestone consumed for desulfurization in each plant was obtained from the EU-ETS. For confidentiality constraints and since there were only two plants in Portugal that used this kind of abatement system, the $CaCO_3$ consumption cannot be reported.

[8] It was assumed that limestone was totally pure, which causes over-estimated emissions.

### 4.2.12.3 Uncertainty Assessment

***Table 4-23: Uncertainty values***

| Parameter | Type of Uncertainty | Uncertainty | Source |
|---|---|---|---|
| Activity Data | Weighing or proportioning raw materials | 2.0% (average of 1.0-3.0% range) | Table 2.3 of "Chapter 2: Mineral Industry Emissions" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories" |
| Activity Data | Carbon content | 2.0% | Table 2.3 of "Chapter 2: Mineral Industry Emissions" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories" |
| Activity Data | Combined Uncertainty | 2.8% | - |
| CO2 EF | Fractional purity | 3.0% (average of 1.0-5.0% range) | Average value of the range 1-5% of chapter 2.5.2.1 of Volume 3: Industrial Processes and Product Uses of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. |

### 4.2.12.4 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

Following QA/QC procedures to the sector, the Party identified an outlier in 2023 fertilisers 'production data obtained from the National Statistics Office. The Party contacted the National Statistics Office in order to obtain a revised activity data time series.

### 4.2.12.5 Recalculations

Recalculations occurred in sub-category Carbonates in Fertilisers, following the identification of an outlier in 2023 fertilisers 'production data obtained from the National Statistics Office. The Party contacted the data provider relating this issue, which clarified that fertilizer production data for 2023 was correct, however, they identified a compilation error regarding the units of the fertilisers' amounts reported throughout the rest of the time series (1996-2022). Following a question from the 2025 ESD review, the Party obtained a revised activity data time series from the data provider and presented revised estimates for this sub-category.

Recalculations on Activity data and CO2 emissions are presented in the figures below.

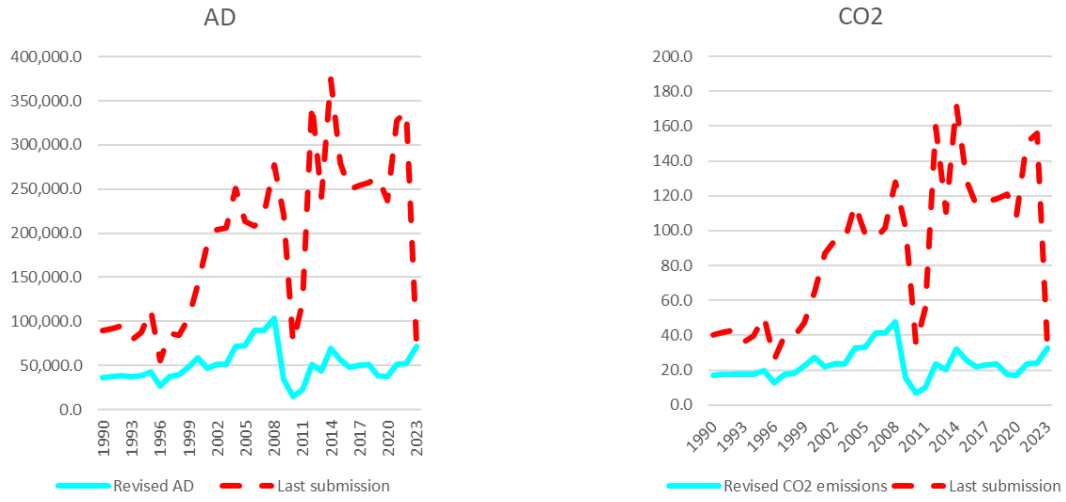



***Figure 4-24: Recalculations in Carbonates fertilisers sub-category***

#### 4.2.12.6 Further Improvements

Efforts will be made in order to obtain necessary statistical information or alternative methodologies to estimate emissions from carbonate use in the production of synthetic fertilizers (nitrates of calcium and magnesium and ammonium nitrate with calcium and magnesium).

### 4.2.13 Other - Rock wool Production (CRT 2.A.5)

#### 4.2.13.1 Category description

Rock wool is a category of mineral wool, where the production process is similar to glass making, already addressed in chapter 2.A.3.

There is rock wool production in Portugal at least since 1974, from one facility. In 1997, that facility was deactivated (and was never included in EU-ETS) and gave place to a new one, which has been working ever since. In 2004, a new facility has begun operating and has been working ever since. There was another facility, which operated from 2009 to 2012, however, had insufficient installed capacity to be included in EU-ETS. All facilities above mentioned are owned by the same company.

In short, currently there are two operating rock wool production plants in Portugal, both included in EU-ETS system since 2008. Rock wool from these facilities is produced from basalt and limestone. It is made submitting these materials to a high temperature, causing them to melt.

According to the 2006 IPCC Guidelines, where the production of rock wool is emissive, these emissions should be reported under IPCC Subcategory 2A5. However, since CRT tables do not include category 2.A.5, $CO_2$ emissions from rock wool production are reported in CRT category 2.A.4.d.

Combustion emissions from Rock wool production are reported in source sector 1.A.2, estimated from fuel consumption data.

#### 4.2.13.2 Methodology

From 1974 to 1996, rock wool was made entirely from basalt and not from limestone. From 1997 onwards, limestone was added to the process, in order to correct any deviations to basalt's chemical composition. However, basalt is still, by far, the predominant raw material.

In 2006 IPCC guidelines there is no $CO_2$ emission factor for basalt and no methodology for estimating emissions from rock wool production. Also, EU-ETS only reports limestone consumption data for these facilities and not basalt consumption.

Furthermore, we assume that basalt´s composition does not include carbonates, therefore, $CO_2$ process emissions from rock wool production originate only from limestone as raw material.

Resuming, it is assumed that no $CO_2$ emissions occur from carbonates when basalt is the only raw material (no $CO_2$ process emissions from rock wool production in the period 1990-1996).

$CO_2$ emissions from rock wool production are Kiln Input based, estimated by the facilities according to No. 11 of Annex IV of Regulation (EU) No. 2066/2018 (https://eur-lex.europa.eu/legal-content/pt/TXT/?uri=CELEX%3A32018R2066). Calculation is based on the amount of carbonates in the raw materials consumed (Tier 3), according to the following equation:

***Equation 4-27: $CO_2$ Emissions from rock wool production***

$$Emission_{CO2} = Carbonate \times EF_{CO2} \times F$$

**Where:**

$Emission_{CO2}$: $CO_2$ emissions from consumption of limestone (kt)

Carbonate: Amount of limestone consumed (t)

$EF_{CO2}$: Emission factor from consumption of limestone (t $CO_2$/t of carbonate)

F: fraction of calcination achieved for limestone (0-1)

Given the fact that there is no calcination factor monitoring in EU-ETS, we assumed complete calcination, therefore, F equals 1 (100%).

### 4.2.13.3 Emission Factors

The following emission factor was considered:

***Table 4-24: Emission Factors***

| Carbonate | EF | Unit EF |
|---|---|---|
| $CaCO_3$ | 0.44 | t $CO_2$/t carbonate |

### 4.2.13.4 Activity Data

From 1990 to 2004, rock wool production was obtained from national statistics (IAPI/INE). From 2005 onwards, rock wool production was obtained directly from the facilities or from Environmental Annual Reports.

From 2005 onwards, limestone consumption was obtained directly from the facilities or from EU-ETS.

We contacted the company in order to provide us limestone consumption for the missing years (1997-2004), however, they no longer possess those data due to company restructuration or human resources allocation.

Given there is no EU-ETS system in the period 1997 to 2004, the splicing technique "overlap" (section 5.3.1.1 of the 2006 IPCC Guidelines) was used in order to estimate limestone consumption, according to the following equation:

***Equation 4-28: Limestone consumption - 1997-2004***

$$Limestone\ Cons_y = Rock\ wool\ Prod\ NS_y \times \frac{Limestone\ Cons_{\ 2005-2009}}{Rock\ wool\ Prod\ NS_{2005-2009}}$$

**Where:**

Limestone $Cons_y$: Limestone consumption in year y (t)

Rock wool Prod $NS_y$: Rock wool production from national statistics in year y (t)

Limestone $Cons_{2005\text{-}2009}$: Average plant specific limestone consumption in period 2005-2009 (t)

Rock wool Prod $NS_{2005\text{-}2009}$: Average Rock wool production from national statistics in period 2005-2009 (t)

In order to ensure time series consistency, the overlap technique to backcast limestone consumption for the missing years was based on rock wool production from national statistics and the average data from EU-ETS for 2005-2009. We decided to fix the data used to the retropolation as the average on the 2005-2009 in order to avoid yearly corrections associated to the introduction of last year ratios.

In 2022, one company reported the introduction of a new raw material to the rockwool production process – dunite – as alternative to limestone. Dunite, also known as olivinite (not to be confused with the mineral olivenite), is an intrusive igneous rock of ultramafic composition and with phaneritic (coarse-grained) texture. The mineral assemblage is greater than 90% olivine, with minor amounts of other minerals such as pyroxene,

chromite, magnetite, and pyrope. There is a rising trend in use of dunite and pyroxenite in sintering and as a fluxing agent in blast furnace in place of dolomite.

As well as for basalt, in the 2019 IPCC guidelines there is no $CO_2$ emission factor for dunite and no methodology for estimating emissions from rock wool production. Also, EU-ETS only reports limestone consumption data for these facilities and not basalt or dunite consumption.

Rock wool production and limestone consumption are presented in the figure below for the whole time series. In light of the information given above, there is a significant decrease in carbonates consumption, which leads to a decrease in CO2 emissions resulting from this process.

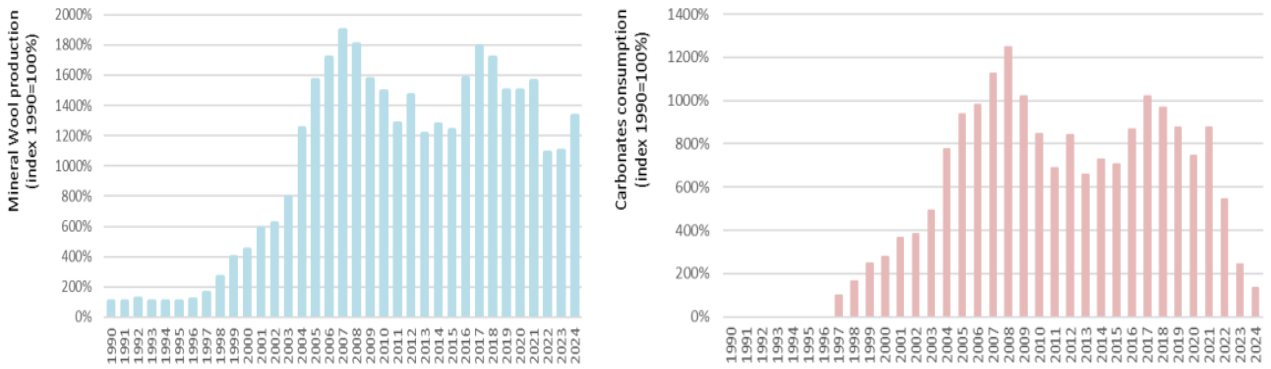



***Figure 4-25: Rock wool production and limestone consumption***

### 4.2.13.5 Uncertainty Assessment

***Table 4-25: Uncertainty values related to emissions reported under CRT 2.A.4.d – Rock Wool Production***

| Parameter | Type of Uncertainty | Uncertainty | Source |
|---|---|---|---|
| Activity Data | Weighing or proportioning raw materials | 2.0% (average of 1.0-3.0% range) | Subchapter 2.4.2.2 of chapter 2: Mineral Industry Emissions of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. |
| Activity Data | Rock Wool Production | 5.0% | Subchapter 2.4.2.2 of chapter 2: Mineral Industry Emissions of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. |
| Activity Data | Combined Uncertainty | 5.4% | - |
| CO2 EF | Stoichiometric ratio | 2.0% (average of 1.0-3.0% range) | Subchapter 2.4.2.1 of chapter 2: Mineral Industry Emissions of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. |
| CO2 EF | Calcination of the carbon input | 1.0% | Subchapter 2.4.2.1 of chapter 2: Mineral Industry Emissions of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. |
| CO2 EF | Combined Uncertainty | 2.2% | - |

### 4.2.13.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

### 4.2.13.7 Recalculations

No recalculations were made.

### 4.2.13.8 Further Improvements

No further improvements are planned.

## 4.3 Chemical Industry (CRT 2.B)

### 4.3.1 Overview

This chapter is intended to estimate process related GHG emissions that result from the production of various inorganic and organic chemicals, which have significant contributions to global or individual national greenhouse gas emission levels.

Most chemical sector companies in Portugal are small and micro companies, mostly operating around consumer products. Larger operators are active in basic chemicals, fertilizers, petrochemicals, polymers, fibers and specialties. There is also a small but very dynamic group of companies in the fine chemicals area, with a significant contribution to value added exports (Source: CEFIC).

There are no significant $CO_2$, $CH_4$ and $N_2O$ emissions to report in chemical production in Portugal. However, there are mostly indirect $CO_2$ emissions related to NMVOC. The methodology used to estimate NMVOC emissions could be checked in the Portuguese IIR. Indirect $CO_2$ emissions related to NMVOC emissions from chemical industry are reported in CRT Table 6.

### 4.3.2 Ammonia Production (CRT 2.B.1)

#### 4.3.2.1 Category description

In 1990 there were two facilities producing ammonia in Portugal, but one of them stopped activity already in the beginning of that year. From 1991 to 2008 there was only one facility producing ammonia. In 2009, this facility was restructured and the ammonia production unit was relocated to India.

Ammonia is synthesized from nitrogen and hydrogen, by the following reaction:

***Equation 4-29: Chemical conversion equation***

$$N_2 + 3H_2 \leftrightarrow 2NH_3$$

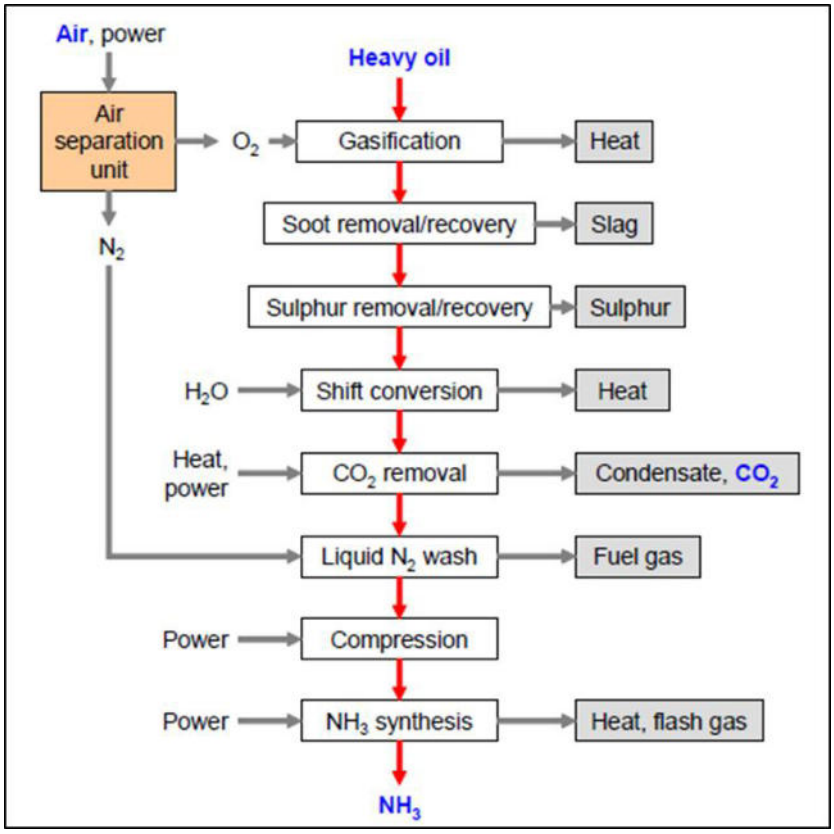
Nitrogen is obtained from atmospheric air.

Depending on the type of fossil fuel, two different methods were applied to produce the hydrogen for ammonia production: steam reforming or partial oxidation. In Portugal, hydrogen was obtained from partial oxidation of a very high viscosity residue RAAV (heavy fraction from petroleum distillation). This process was very flexible in terms of fuel input, allowing the use of the heavier fractions of oil distillation, namely vacuum residues, due to its smaller range of applications and also because they were available on the market at lower prices. Given that no detailed information is available concerning the type of fuel used, it is assumed the fuel was very variable in terms of composition, since it was a residue from petroleum distillation, not subject to refining.

Gasification of heavy hydrocarbons follows the reaction:

***Equation 4-30: Chemical conversion equation***

$$2CH_n + O_2 \rightarrow 2CO + nH_2$$




Source: Best available techniques Reference document developed under the IPPC Directive and the IED

***Figure 4-26: Ammonia Production by Partial Oxidation***

After cooling the exit gas from the shift conversion, the process condensate is separated. The gas is chilled and scrubbed with chilled methanol (imported), which absorbs $CO_2$ and $H_2S$. Pure $CO_2$, may be used for urea production, and these amounts need to be subtracted to $CO_2$ emissions estimated based on $NH_3$ production in order to avoid double counting.

Other pollutants that result from the process, either from escape of ammonia ($NH_3$) or either from release of products from feedstock, like CO. The methodology used to estimate CO emissions could be checked in the Portuguese IIR. Indirect $CO_2$ emissions related to CO emissions from ammonia production are reported in CRT Table 6.

NMVOC emissions from ammonia production by partial oxidation are reported as Not Estimated.

Urea is synthesized from $NH_3$ and $CO_2$, which are fed into the reactor at high pressure and temperature, following the two step reaction below:

***Equation 4-31: Chemical conversion equations***

$$2NH_3 + CO_2 \leftrightarrows NH_2COONH_4\ (Ammonium\ Carbamate)$$

$$NH_2COONH_4 \leftrightarrows H_2O + NH_2CONH_2\ (Urea)$$

### 4.3.2.2 Methodology

Information regarding the production process, ammonia production data as well as urea production is available at plant level. However, the facilities were unable to provide information on fuel type, nor its carbon content.

Therefore, $CO_2$ emissions from ammonia production were estimated using a Tier 1 methodology according to equation 3.1 from chapter 3.2.2.1 of Volume 3 IPPU of the 2006 IPCC Guidelines:

***Equation 4-32: $CO_2$ emissions from ammonia production***

$$E_{CO_2} = AP \; x \; FR \; x \; CCF \; x \; COF \; x \; \frac{44}{12} \; - R_{CO_2}$$

**Where:**

$E_{CO2}$ : $CO_2$ emissions from ammonia production (kg)

AP: Ammonia production (t)

FR: Fuel requirement per unit of output (GJ/ton ammonia produced)

CCF: Carbon content factor of the fuel (kg C/GJ)

COF: Carbon oxidation factor of the fuel (%)

$R_{CO2}$: $CO_2$ recovered for downstream use in urea production (kg)

$CO_2$ recovered for downstream use was estimated based on the quantity of urea produced, according to page 3.12 of chapter 3.2.2.1 of Volume 3 IPPU of the 2006 IPCC Guidelines. $CO_2$ emissions are estimated by multiplying urea production by 44/60, the stoichiometric ratio of CO2 to urea, according to the following equation:

***Equation 4-33: $CO_2$ recovered for urea production***

$$R_{CO_2} = UP \times \frac{M(CO_2)}{M(Urea)}$$

**Where:**

$R_{CO2}$: $CO_2$ recovered for urea production (kt)

UP: Urea production (kt)

$M(CO_2)$: Molar mass of $CO_2$ (44 g/mol)

M(Urea): Molar mass of Urea (60 g/mol)

### 4.3.2.3 Emission Factors

Default parameters and emissions factor applied were taken from Table 3.1 of chapter 3.2.2.2 of Volume 3 IPPU of the 2006 IPCC Guidelines and are listed in the table below.

According to the guidelines, for the Tier 1 method, if no information on fuel type is available, it is good practice to use the average value shown in Table 3.1 for partial oxidation (production process used in Portugal from 1990 to 2008).

***Table 4-26: Emission Factors and parameters considered***

| Production / Process | Parameter | Unit | Value |
|---|---|---|---|
| Average value- partial oxidation | Total fuel requirement | GJ/ton $NH_3$ | 42.5 |
| | Carbon content | kg/GJ | 21.0 |
| | Carbon oxidation factor | fraction | 1 |

### 4.3.2.4 Activity Data

In 1990 there were two plants producing ammonia in Portugal, but one of the plants stopped activity already in the beginning of that year. From 1991 to 2008 there was only one plant producing ammonia. In 2009, this plant was restructured and the ammonia production unit was relocated to India.

In the period 1990-2008, ammonia and urea production data were obtained from the facilities. From 2009 onwards there is no ammonia production. Data is consistent with national statistics ammonia production data. Concerning fuel requirements, upon several contacts, ammonia production facilities indicated that they have long since terminated ammonia production and do not possess such old data due to company restructuration.

Due to confidentiality constraints, ammonia and urea production are presented in the figure below as an index value related to 1990 data. It is evident the significant inter-annual changes in the period 1991-1996. According to information provided by the facility, the sharp decrease in the period 1992-1994 was due to technical problems that led to several interruptions in the production.

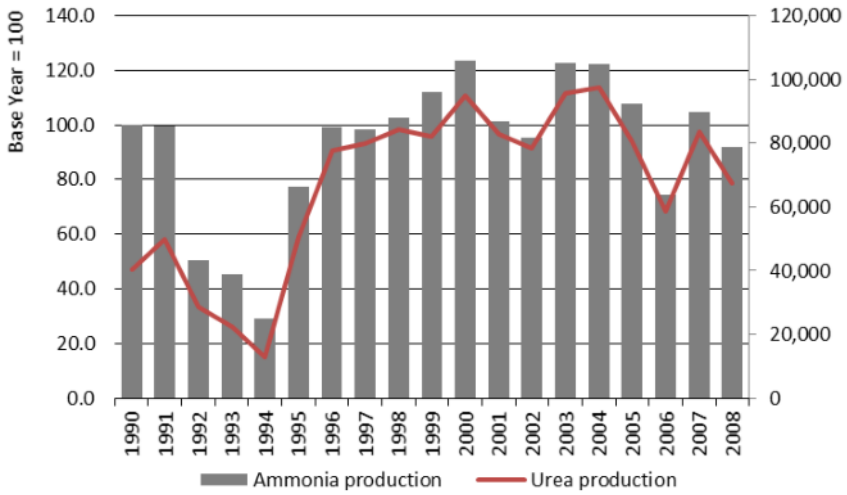



***Figure 4-27: Trend in Ammonia and Urea production***

### 4.3.2.5 Uncertainty Assessment

***Table 4-27: Uncertainty values***

| Parameter | Type of Uncertainty | Uncertainty | Source |
|---|---|---|---|
| Activity Data | Ammonia Production | 2% | Subchapter 3.2.3.2 of Chapter 3: Chemical Industry Emissions of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. |
| Activity Data | Urea Production | 2% | |
| $CO_2$ EF | Fuel requirement | 7% | Table 3.1 of Chapter 3: Chemical Industry Emissions of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. |

### 4.3.2.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

A comparison was made using a top-down approach based on ammonia production data obtained from national production statistics (IAPI) from 1990 to 2009. We intend to further investigate the differences between the two approaches in the period 1994-1998, other than that, data is generally consistent.

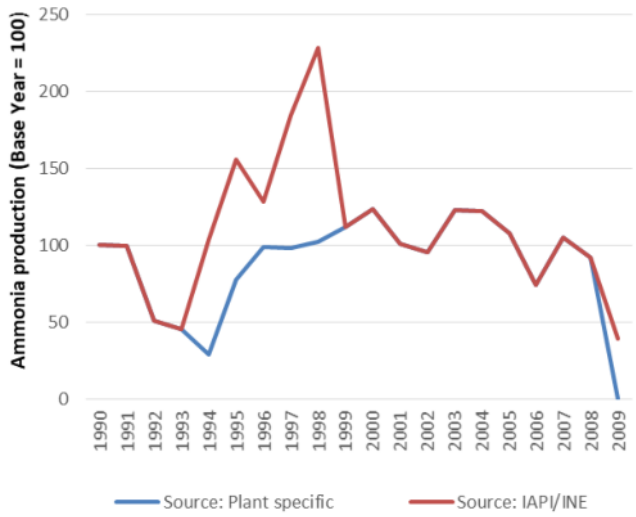



***Figure 4-28: Ammonia production data – comparison of approaches***

#### 4.3.2.7 Recalculations

No recalculations were made.

#### 4.3.2.8 Further Improvements

As good practice, Portugal acknowledges and pursues the application of Tier 2 methodologies or higher for Key Categories as much as technically possible.

However, in order to do so, it is required specific information from the ammonia production facilities such as fuel requirement and its carbon content and carbon oxidation factor. Portugal does not possess data on fuel input in ammonia production such as the described above. Upon contact in order to obtain these data, the facilities informed that they did not possess such old data due to company restructuration, since they have long since terminated ammonia production.

Therefore, no further improvements are planned, due to lack of data from the facilities.

### 4.3.3 Nitric Acid Production (CRT 2.B.2)

#### 4.3.3.1 Category description

Currently, three industrial plants produce nitric acid in Portugal. In 2 units, weak nitric acid (60 %) is produced from ammonia, using catalytic (Platinum-rhodium alloy catalysts) oxidation of ammonia with air to $NO_2$ at medium pressure, and subsequent absorption with water to form nitric acid in a dual-stage process. From 1990 to 2011 there was also another nitric acid facility operating at "dual-pressure" medium/high (M/H). This facility, however, was closed during 2011 and was replaced by a new facility, which began operating in 2010 also at "dual-pressure" medium/high (M/H).

Nitric Acid production results in air emissions of Nitrous Oxide ($N_2O$), $NO_x$ (NO and $NO_2$), trace amounts of $HNO_3$ acid mist and ammonia ($NH_3$). The great majority of emissions are conveyed in the tail gas from the absorption tower. $NO_x$ and $NH_3$ emissions from Nitric Acid production are estimated and reported in the Portuguese IIR.

#### 4.3.3.2 Methodology

Since there are different data sources available depending on the years, two different methodologies were used throughout the time series.

From 2013 onwards, $N_2O$ emissions are estimated by facilities according to No. 16 of Annex IV of Regulation (EU) No. 2066/2018 (https://eur-lex.europa.eu/legal-content/pt/TXT/?uri=CELEX%3A32018R2066) and reported directly under the EU-ETS.

From 1990 to 2012, $N_2O$ emissions are estimated according to the following equation:

***Equation 4-34: $N_2O$ Emissions from nitric acid production***

$$E_{N2O} = NP \times EF_{N2O} \times 10^{-3}$$

**Where:**

$E_{N2O}$: $N_2O$ emissions from nitric acid production (t)

NP: Nitric Acid production (t)

$EF_{N2O}$: $N_2O$ Emission factor (kg/t)

#### 4.3.3.3 Emission Factors

Regarding the nitric acid facility in operation from 1990 to 2011, due to lack of information, $N_2O$ emission factor applied for the whole time series is a default value (Tier 1) from Table 3.7 of the BREF for the Production of Large Volume Organic Chemicals (2007) for medium/high pressure nitric acid facilities - 6.7 kg/ton $HNO_3$.

Regarding the nitric acid facility in operation from 2010 onwards (which replaced the later above):

. from 2013 onwards, Tier 3 $N_2O$ emission factors are collected from EU-ETS;

. from 2010 to 2012, in order to ensure time series consistency, $N_2O$ emission factor is based on the average EU-ETS $N_2O$ emission factors in the period 2013-2017.

Regarding the other 2 nitric acid facilities:

. from 2013 onwards, Tier 3 $N_2O$ emission factors are collected from EU-ETS;

. from 1990 to 2012, Tier 3 $N_2O$ emission factors are based on monitoring data obtained from facilities.

***Table 4-28: Emission Factors considered***

| Facility | Period | Parameter | Value | Unit | Source |
|---|---|---|---|---|---|
| 1 | 1990-2011 | EF | 6.7 | kg/ton HNO3 | Table 3.7 of the BREF for the Production of Large Volume Organic Chemicals (2007) for medium/high pressure nitric acid facilities |
| 2 | 2010-2012 | EF | 0.112 | kg/ton HNO3 | EU-ETS (average EF from 2013-2017) |
| | 2013-onwards | EF | 0.039-0.117 | kg/ton HNO3 | EU-ETS |
| 3 and 4 | 1990-2012 | EF | confidential | kg/ton HNO3 | Monitoring from facilities |
| | 2013-onwards | EF | 0.326-0.972 | kg/ton HNO3 | EU-ETS |

Due to confidentiality constraints, it is not possible to publish the emission factors based on monitoring data.

Following contacts with the facilities, it was found that the variation in emissions is a result of the variation in nitric acid production and is expected within the range of operating conditions verified (capacity for heat

recovery, state of the catalytic screens, fouling of various exchangers, etc.) and operating conditions of the unit of gas abatement (amount of NOx and $N_2O$ treated, tail gas temperature, etc.).

In 2010, Facility 3 implemented BAT "catalytic $N_2O$ decomposition" in the reactor chamber, in order to reduce emissions of $N_2O$ and to achieve lower emission factors or emission concentration levels.

According to this BAT, $N_2O$ can be decomposed in $N_2$ and $O_2$ just after being formed, by a selective De-$N_2O$ catalyst in the high temperature zone (between 800 and 950 ºC). Additional information on this BAT can be consulted in BREF Large Volume Inorganic Chemicals – Ammonia, Acids and Fertilisers, published in 2007. The catalyst was installed in 19/11/2010, hence, as the result of this BAT implementation, a decrease in $N_2O$ emissions from this facility was noted from 2011 onwards.

During 2009, Facility 4 also implemented BAT "catalytic $N_2O$ decomposition" in the reactor chamber, hence a decrease in $N_2O$ emissions from this facility was noted from 2010 onwards. In 2013, the catalyst was replaced by a new one, further decreasing $N_2O$ emissions in this facility.

#### 4.3.3.4 Activity Data

Nitric acid production is obtained directly from the facilities and from Environmental Annual Reports for the whole time series. One of the plants was closed during 2011 and was replaced by a new facility, which began operating in 2010. In 2020 there is a slight decrease in nitric acid production due to COVID19 pandemic.

The activity data that was used to estimate emissions from this sub-source sector is subjected to confidentiality constraints due to the limited number of existing production units and therefore is presented in the figure below in relation to production in 1990 (trends).

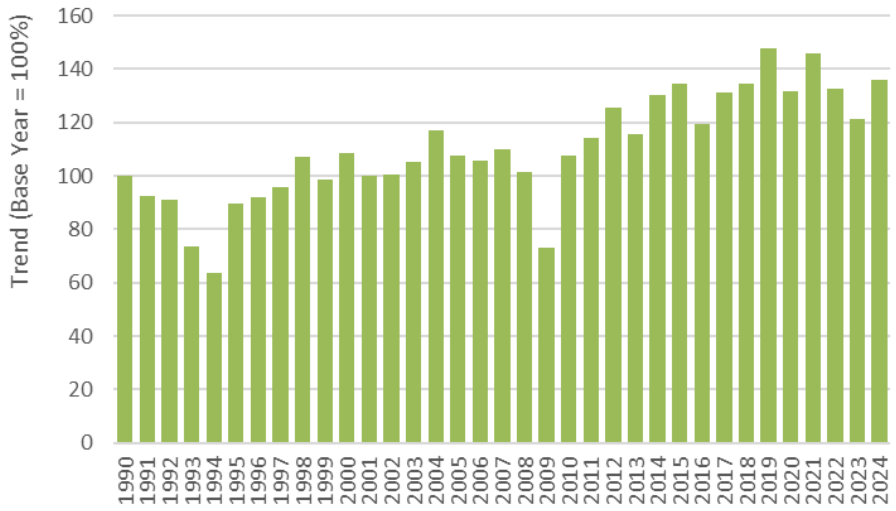



***Figure 4-29: Trend in Nitric Acid production***

#### 4.3.3.5 Uncertainty Assessment

***Table 4-29: Uncertainty values***

| Parameter | Type of Uncertainty | Uncertainty | Source |
|---|---|---|---|
| Activity Data | Nitric Acid Production | 2% | Subchapter 3.3.3.2 of Chapter 3: Chemical Industry of 2006 IPCC Guidelines. |
| $N_2O$ EF | N2O emission factor | 20% | Table 3.3 of Chapter 3: Chemical Industry of 2006 IPCC Guidelines. |

Nitric Acid production data was obtained directly from the plants (2% uncertainty).

#### 4.3.3.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

#### 4.3.3.7 Recalculations

No recalculations were made.

#### 4.3.3.8 Further Improvements

No further improvements are planned.

### 4.3.4 Adipic Acid Production (CRT 2.B.3)

There is no adipic acid production in Portugal.

### 4.3.5 Caprolactam, Glyoxal and Glyoxylic Acid Production (CRT 2.B.4)

There is no caprolactam, glyoxal or glyoxylic acid production in Portugal.

### 4.3.6 Silicon Carbide and Calcium Carbide Production (CRT 2.B.5)

There is no silicon carbide or calcium carbide production in Portugal.

### 4.3.7 Titanium Dioxide Production (CRT 2.B.6)

#### 4.3.7.1 Category description

This chapter addresses emissions estimates from the production of Titanium dioxide ($TiO_2$). $TiO_2$ pigments are made from one of two chemical processes: the chloride route, which leads to $TiO_2$ products by reacting titanium ores with chlorine gas; and the sulphate route, which leads to $TiO_2$ products by reacting titanium ores with sulphuric acid. In both processes, pure $TiO_2$ powder is extracted from its mineral feedstock after which it is milled and treated to produce a range of products designed to be suitable for efficient incorporation into different substrates.

Titanium dioxide production generates $CO_2$ emissions, as well as SOx, NOx, CO and particulate matter. The methodology used to estimate atmospheric pollutants can be checked in the Portuguese IIR. Indirect $CO_2$ emissions related to CO emissions from titanium dioxide production are reported in CRT Table 6.

#### 4.3.7.2 Methodology

Emissions are estimated using a Tier 1 approach according to the following equation:

***Equation 4-35: $CO_2$ emissions from titanium dioxide production***

$$E_{CO2} = \frac{\left(AD_{Chloride} \times EF_{Chloride} + AD_{Sulphate} \times EF_{Sulphate}\right)}{1000}$$

**Where:**

$E_{CO2}$: $CO_2$ emissions from Titanium Dioxide production (t)

$AD_{Chloride}$: Titanium Dioxide produced by the Chloride Process (t)

$EF_{Chloride}$: $CO_2$ EF related to Titanium Dioxide produced by the Chloride Process (t $CO_2$/t $TiO_2$)

$AD_{Sulphate}$: Titanium Dioxide produced by the Sulphate Process (t)

$EF_{Sulphate}$: $CO_2$ EF related to Titanium Dioxide produced by the Sulphate Process (t $CO_2$/t $TiO_2$)

### 4.3.7.3 Emission Factors

***Table 4-30: CO2 emission factors related to TiO2 production***

| Pollutant | Process | Unit | EF | Source |
|---|---|---|---|---|
| $CO_2$ | Chloride Process | t CO2/t $TiO_2$ | 1.34 | Table 3.9 of "Chapter 3: Chemical Industry Emissions" of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. |
| | Sulphate Process | t CO2/t TiO2 | 1.43 | |

### 4.3.7.4 Activity Data

From 2014 onwards, Titanium Dioxide production data was obtained from EUROSTAT.

There is no information on the share of each technology/practice. We considered the share proposed in the BREF document of «Large Volume Inorganic Chemicals – Solids and Others» and assume that 30% of the Titanium Dioxide is produced by the Chloride Process and 70% by the Sulphate Process.

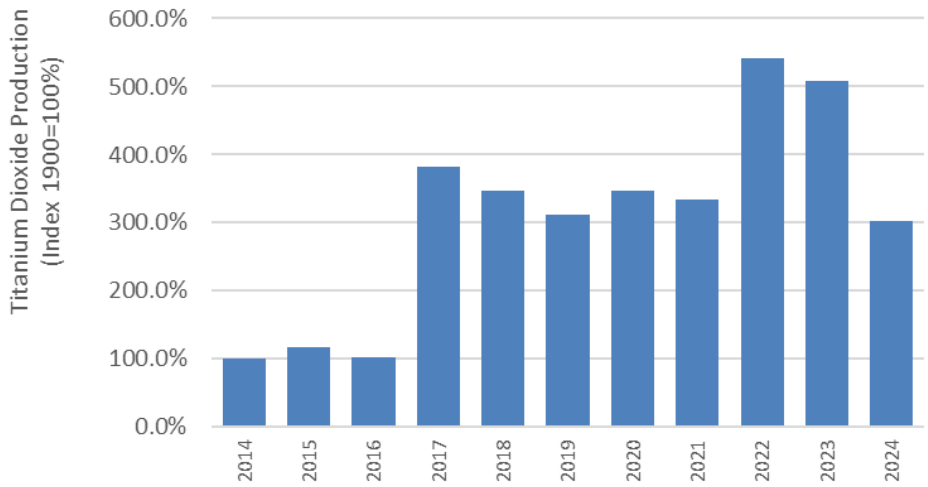



***Figure 4-30: Trend in Titanium Dioxide Production***

### 4.3.7.5 Uncertainty Assessment

***Table 4-31: Uncertainty values***

| Parameter | Type of Uncertainty | Uncertainty | Source |
|---|---|---|---|
| Activity Data | Titanium Dioxide Production | 2% | Expert Judgement |
| $CO_2$ EF | Chloride Process | 15% | Table 3.3 of Chapter 3: Chemical Industry Emissions of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. |
| | Sulphate Process | 10% | |

### 4.3.7.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

#### 4.3.7.7 Recalculations

No recalculations were made.

#### 4.3.7.8 Further Improvements

Efforts will be made in order to check the reason why Titanium Dioxide production data is reported in Eurostat but not in National Statistics, as well as to obtain the share of each Titanium Dioxide technology in Portugal, by collecting plant specific data.

### 4.3.8 Soda Ash Production (CRT 2.B.7)

In Portugal there was only one plant producing Soda Ash by the Solvay process. $CO_2$ was generated in two pyrolysis processes, captured, compressed and directed to Solvay precipitating towers for consumption in a mixture of brine (aqueous NaCl) and ammonia. Although $CO_2$ is generated as a by-product, it is recovered and recycled for use in the carbonation stage and in theory the process is neutral, i.e., generation of $CO_2$ equals uptake.

Upon a contact with the facility, we were informed that soda ash production terminated in 2014.

### 4.3.9 Petrochemical and Carbon Black Production – Methanol (CRT 2.B.8.a)

There is no methanol production in Portugal.

### 4.3.10 Petrochemical and Carbon Black Production – Ethylene (CRT 2.B.8.b)

#### 4.3.10.1 Category description

There is only one ethylene production plant in Portugal, located in the southern part of the country, near Sines. The basic process in this unit is by Thermal Steam Cracking of petroleum feedstock. This unit produces Low Density Polyethylene (LDPE) and High-Density Polyethylene (HDPE) from ethylene. As by product of ethylene production, other organic compounds are produced, such as propylene, butadiene and C4 fraction, aromatics and a residual fuel oil used in the unit as energy source.

Ethylene production results in $CO_2$, $CH_4$, as well as NMVOC emissions. The methodology used to estimate NMVOC emissions can be checked in the Portugal IIR. Indirect $CO_2$ emissions related to NMVOC emissions from ethylene production are reported in CRT Table 6.

#### 4.3.10.2 Methodology

$CO_2$ and $CH_4$ emissions estimates were based on a Tier 1 approach according to the following:

***Equation 4-36: $CO_2$ and $CH_4$ emissions from ethylene production***

$$\text{Emission}_p = EF_p \times AD \times 10^{-3} \times GAF/100$$

**Where:**

$\text{Emission}_p$: Emission of pollutant p (t)

$EF_p$: Emission factor (kg/t Ethylene)

AD: Ethylene production data (t)

GAF: Geographic Adjustment Factor (%)

Since Portugal is located in Western Europe, according to Table 3.15 of Chapter 3 (Chemical Industry Emissions) of Vol.3 of the 2006 IPCC Guidelines, GAF was considered 100%.

### 4.3.10.3 Emission Factors

The following emission factors were applied:

***Table 4-32: Emission Factors***

| Pollutant | Unit | EF | Source |
|---|---|---|---|
| $CO_2$ EF | t $CO_2$/t ethylene | 1.73 | Table 3.14 of Chapter 3: Chemical Industry Emissions of 2006 IPCC Guidelines for National Greenhouse Gas Inventories |
| $CH_4$ EF | kg $CH_4$/t ethylene | 3.00 | Table 3.16 of Chapter 3: Chemical Industry Emissions of 2006 IPCC Guidelines for National Greenhouse Gas Inventories |

### 4.3.10.4 Activity Data

There is only one plant producing ethylene in Portugal. Ethylene production data was obtained from Environmental Annual Reports and cross-checked with national statistics data (QA/QC).

Due to confidentiality constraints, activity data is presented as an index value related to 1990 data for the whole time series. The sharp decrease in ethylene production in 2018 and 2022-2023 was due to scheduled interruptions for maintenance/cleaning, which affected the production lines. In 2024, the company reported no ethylene production, due to market constraints.

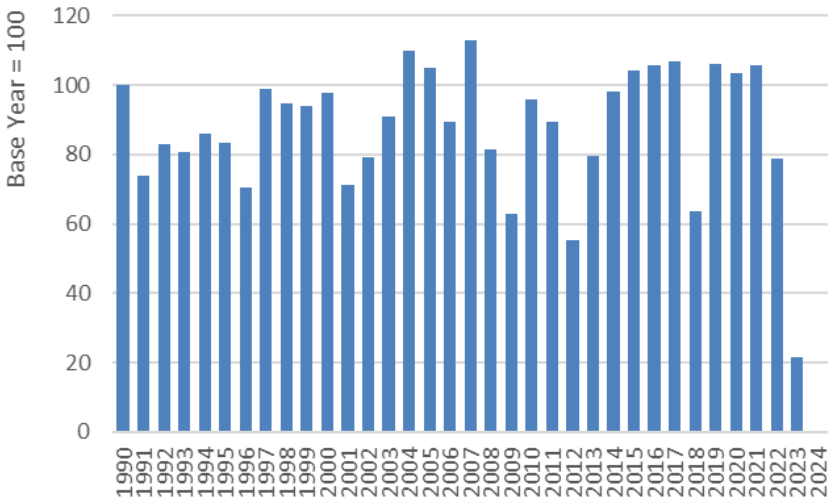



***Figure 4-31: Trend in Ethylene production***

### 4.3.10.5 Uncertainty Assessment

***Table 4-33: Uncertainty values***

| Parameter | Type of Uncertainty | Uncertainty | Source |
|---|---|---|---|
| Activity Data | Ethylene Production | 10% | Subchapter 3.9.3 of Chapter 3: Chemical Industry Emissions of 2006 IPCC Guidelines for National Greenhouse Gas Inventories |
| $CO_2$ EF | $CO_2$ emission factor for ethylene production | 10% | |
| $CH_4$ EF | $CH_4$ emission factor for ethylene production | 10% | |

### 4.3.10.6 Category specific QA/QC and verification

Emissions estimates were based on a bottom-up approach with collection of plant specific ethylene production data. A comparison was made using a top-down approach based on ethylene production data obtained from national production statistics (IAPI). We only present data from 1996 onwards given the lack of national statistics ethylene production data from 1990 to 1995. As presented in the figure below, from

1996 onwards data is consistent using the two approaches. Due to confidentiality constraints, activity data is presented as an index value related to 1996 data.

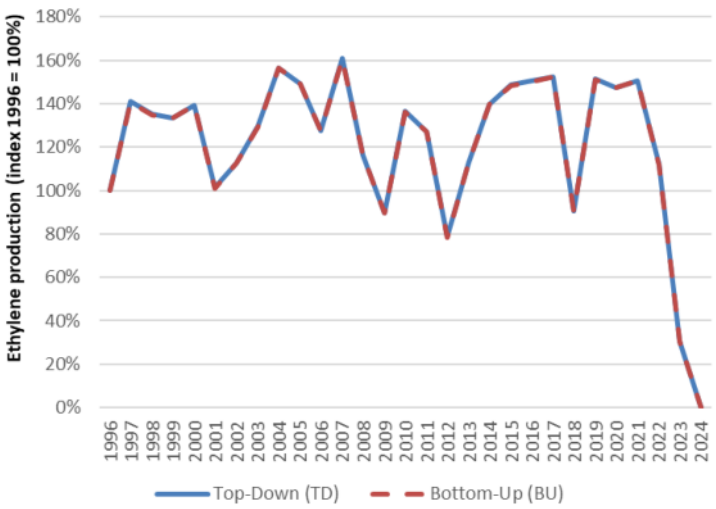



***Figure 4-32: Ethylene production data – comparison of approaches***

#### 4.3.10.7 Recalculations

No recalculations were made.

#### 4.3.10.8 Further Improvements

In the future, we intend to revise the emission factors based on monitoring data.

### 4.3.11 Petrochemical and Carbon Black Production– Ethylene Dichloride and Vinyl Chloride Monomer (VCM) (CRT 2.B.8.c)

Following a question regarding VCM production in the 2022 UNFCCC Review, upon investigation, the Party found there is no ethylene dichloride production in Portugal.

Concerning vinyl chloride monomer (VCM) production, following a 2022 review recommendation, further contacts to our Focal Points confirmed that currently there is no such activity in the country.

There is only one company in Portugal using VCM as raw material for the production of polyvinylchloride (PVC). Further contacts to the facility confirmed that they had its own VCM production line from 1963 to 1986. The annual production of VCM in that period varied from 3,200 to 14,000 tons. From 1987 onwards, VCM is imported.

VCM production is reported as NO for the whole time series.

### 4.3.12 Petrochemical and Carbon Black Production – Ethylene Oxide (CRT 2.B.8.d)

There is no ethylene oxide production in Portugal.

### 4.3.13 Petrochemical and Carbon Black Production – Acrylonitrile (CRT 2.B.8.e)

There is no acrylonitrile production in Portugal.

## 4.3.14 Petrochemical and Carbon Black Production – Carbon Black (CRT 2.B.8.f)

### 4.3.14.1 Category description

There was only one carbon black facility in Portugal, located in the southern part of the country, near Sines. This facility produced carbon black by the Oil Furnace Process, a partial combustion process where feedstock with a high content of aromatic material was converted by incomplete combustion, thermal cracking and dehydrogenation to carbon black. Emissions resulted from Gas Vent, combined dryer vent and fugitive emission in the vacuum system vent.

Carbon black production resulted in emissions of $CO_2$, $CH_4$, as well as other atmospheric pollutants. The methodology used to estimate atmospheric pollutants emissions can be checked in the Portugal IIR. Indirect $CO_2$ emissions related to NMVOC and CO emissions from carbon black production are reported in CRT Table 6.

Carbon black production ceased in 2013.

### 4.3.14.2 Methodology

For this sub-sector emissions estimates are extensively based on the use of emission factors multiplied by quantity of material produced:

***Equation 4-37: Emissions from black carbon production***

$$Emission_{(p,y)} = EF_{(p)} \times ActivityRate_{(y)} \times 10^{-3}$$

**Where:**

$Emission_{(p,y)}$: Annual emission of pollutant p in year y (t)

$EF_{(p)}$: Emission factor (kg/t)

$ActivityRate_{(y)}$: Indicator of activity in the production process. Quantity of product produced per year is used as a general rule for this emission source sector (t)

Where $CO_2$ emissions result from liberation of carbon in tail gas to atmosphere, emissions were estimated using a simple mass balance:

***Equation 4-38: Carbon mass balance***

$$C_{TailGas} \times 44/12 = C_{Feedstock} + C_{AuxFuels} - C_{CarbonBlack}$$

**Where:**

$C_{TailGas}$: Carbon emitted in tail gas (t C)

$C_{Feedstock}$: Carbon entered in feedstock (t C)

$C_{AuxFuels}$ : Additional carbon entered into system in fuels (t C)

$C_{CarbonBlack}$: carbon stored in carbon black and not emitted to atmosphere (t C)

### 4.3.14.3 Emission Factors

In the period 2009-2012, carbon black industrial unit was subjected to a detailed inventory exercise. Consequently, emission factors were established and emission estimates were extended for the rest of the time series using carbon black production as indicator of activity rate. Carbon Gas emissions also include emissions suffering partial combustion.

*Table 4-34: Emission Factors for Carbon Black process emissions*

| Pollutant | Emission factor | Unit | EF source |
|---|---|---|---|
| $CO_2$ | 2,379 | kg/t carbon black | Carbon Balance Approach |
| $CH_4$ | 0.060 | kg/t carbon black | IPCC 2006 Guidelines |

### 4.3.14.4 Activity Data

Due to confidentiality constraints, carbon black production data is presented as an index value related to year 1990 production. Carbon black production terminated in 2013.

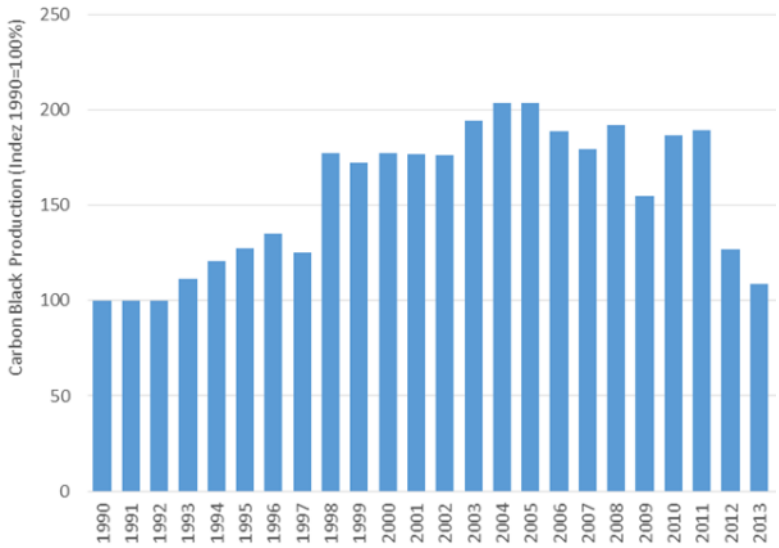



*Figure 4-33: Carbon Black production*

### 4.3.14.5 Uncertainty Assessment

The uncertainty of activity data received from Large Point Sources was set as 10 %.

### 4.3.14.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

### 4.3.14.7 Recalculations

No recalculations were made.

### 4.3.14.8 Further Improvements

No further improvements are planned.

### 4.3.15 Petrochemical and Carbon Black Production – Other (CRT 2.B.8.g)

This category includes the production of several chemical products such as: PEBD, PEAD, Polypropylene, Polystyrene, Formaldehyde, Phthalic Anhydride, Polyester, PVC, Polystyrene Foam and Polyurethane Foam.

Information on how emissions from these sub-categories are reported is given in the table below.

There are no direct $CO_2$, $CH_4$ and $N_2O$ emissions from PEBD, PEAD, Polypropylene, Polystyrene, Formaldehyde and Phthalic Anhydride production. There are, however, NMVOC and CO emissions. The methodology used to estimate NMVOC and CO emissions can be checked in the Portugal IIR. Indirect $CO_2$ emissions related to NMVOC and CO emissions from these sub-categories are reported in CRT Table 6.

There are also no direct $CO_2$, $CH_4$ and $N_2O$ emissions from the other 2.B.8.g sub-categories. There are, however, NMVOC emissions. The methodology used to estimate NMVOC emissions from the other sub-categories can also be checked in the Portugal IIR. Indirect $CO_2$ emissions related to NMVOC emissions from these other 2.B.8.g sub-categories are reported in CRT Table2(I).A-Hs1, under 2.B.8.g.

This report was agreed among EU countries with the aim of ensure consistency between KP commitment periods (CP). Countries, like Portugal, reported indirect $CO_2$ emissions from these other 2.B.8.g sub-categories in inventory submissions before 2015 (CP 1) in previous CRT table 3 (Sectoral report for solvents and other products use). Hence, for the following commitment period and in order to ensure the highest consistency with 2006 IPCC Guidelines and with the previous inventory submissions, countries should continue reporting these emissions in the same manner. Therefore, Portugal continues to report NMVOC emissions from the other 2.B.8.g sub-categories as indirect $CO_2$ emissions in CRT Table2(I).A-Hs1, for KP consistency purposes. On that matter, the paper "*Guidance related to the reporting of indirect emissions*" from EEA SHAREPOINT is presented in **ANNEX I** and includes further explanation to the approaches taken by Portugal and all other EU MS.

***Table 4-35: Reporting of Other Petrochemical and Carbon Black Production***

| CRT | Category | Emissions | Reporting |
|---|---|---|---|
| 2.B.8.gi | PEBD | NMVOC | CRT Table 6 – indirect CO2 |
| 2.B.8.gii | PEAD | NMVOC | |
| 2.B.8.giii | Polypropylene | NMVOC | |
| 2.B.8.giv | Polystyrene | NMVOC | |
| 2.B.8.gv | Formaldehyde | NMVOC; CO | |
| 2.B.8.gvi | Phthalic Anhydride | NMVOC; CO | |
| 2.B.8.gvii | Polyamide Fiber | NMVOC | CRT Table2(I).A-Hs1 – direct $CO_2$<br><br>(refer to indirect $CO_2$ emissions) |
| 2.B.8.gviii | Polyester | NMVOC | |
| 2.B.8.gix | Polystyrene Foam | NMVOC | |
| 2.B.8.gx | Polypropylene Fiber | NMVOC | |
| 2.B.8.gxi | PVC Fiber | NMVOC | |
| 2.B.8.gxii | Acrylic Fiber | NMVOC | |
| 2.B.8.gxiii | Acrylonitrile Fiber | NMVOC | |
| 2.B.8.gxiv | PVC | NMVOC | |
| 2.B.8.gxv | Polyurethane Foam | NMVOC | |

### 4.3.16 Fluorochemical Production (CRT 2.B.9)

There is no fluorochemical production in Portugal.

### 4.3.17 Other - Sulphuric Acid Production (CRT 2.B.10.b)

There are no direct $CO_2$, $CH_4$ and $N_2O$ emissions to report in this subsector in Portugal.

There are, however, $SO_x$ emissions from sulphuric acid production. The methodology used to estimate $SO_x$ emissions from this category can be checked in Portugal IIR. SOx emissions from sulphuric acid production are reported in CRT Table 2(I)s1.

### 4.3.18 Other – Explosives Production (CRT 2.B.10.b)

There are no direct $CO_2$, $CH_4$ and $N_2O$ emissions to report in this subsector in Portugal. There are, however, $SO_x$ and $NO_x$ emissions from explosives production. The methodology used to estimate $SO_x$ and $NO_x$ emissions from this category can be checked in Portugal IIR. $SO_x$ and $NO_x$ from explosives production are reported in CRT Table 2(I)s1.

### 4.3.19 Other – Solvent Use in Plastic Manufacturing (CRT 2.B.10.d)

There are no direct $CO_2$, $CH_4$ and $N_2O$ emissions to report in this subsector in Portugal. There are, however, indirect $CO_2$ emissions related to NMVOC. The methodology used to estimate NMVOC emissions from this category can be checked in the Portugal IIR. Indirect $CO_2$ emissions related to NMVOC emissions from Solvent Use in Plastic Manufacturing are reported in CRT Table 6.

These emissions are included and reported in sub-category 2.B.8.g.

## 4.4 Metal Industry (CRT 2.C)

### 4.4.1 Overview

This chapter is intended to estimate process related GHG emissions that result from the production of various kinds of metals.

### 4.4.2 Iron and Steel Production (CRT 2.C.1)

#### 4.4.2.1 Category description

Iron and steel production leads to $CO_2$, $CH_4$ and $N_2O$ emissions. According to the 2006 IPPC Guidelines, $N_2O$ emissions from Iron and Steel are likely to be small, hence no methodologies are provided for this GHG.

There are two iron and steel production plants operating in Portugal, dedicated to steel billets production, which are then processed mostly into long-product rolling like wire rod and rebar in straight lengths.

One of the plants started in 1976 and remained ever since as a secondary steel-making facility, producing steel mainly from recycled steel scrap in an Electric Arc Furnace (EAF).

The other plant started in 1961, as a primary facility that produced both iron and steel from iron ore as well as scrap, otherwise known as an integrated iron and steel production facility. Since this process did not consume all the available scrap, the surplus was also used to produce steel, but in an independent EAF. This facility integrated iron and steel production until 2001.

The following units were part of the integrated iron and steel production facility that operated from 1961 to 2001:

- Metallurgical Coke production
- Lime production
- Sinter production
- Cogeneration facility
- Ironmaking in Blast Furnace
- Steelmaking: in Basic Oxygen Furnace (BOF) and EAF
- Rolling mills

In the integrated iron and steel production facility, the main raw materials - national iron ores and limestone as well as imported coal -, were transported to the premises and were stored in silos.

**METALLURGICAL COKE PRODUCTION**

Metallurgical Coke was produced in the coke plant by destructive distillation of imported coal in coke ovens, where coal was subjected to heat in an oxygen-free atmosphere until all volatile components in the coal evaporate. Process heat came from the combustion of gases between the coke chambers. The material remaining was called coke. Metallurgical coke was then used in the blast furnace to reduce iron ore to iron. Tar and coke oven gas were by-products of metallurgical coke production. Coke oven gas was partly recirculated to be used as fuel in the coke ovens. The remaining coke oven gas was used as fuel as well, in other units of the integrated iron and steel production facility.

According to the 2006 IPCC Guidelines, metallurgical coke production is considered an energy use of fossil fuel, hence emissions are addressed and reported under category 1.A.1.c – Manufacture of solid fuels - section 3.3.3 of the Energy chapter. Similarly, all fuel consumed in this source category not allocated as input to the sinter plants and blast furnace is considered fuel combustion and addressed in category 1.A.1.c.

Fugitive emissions from coke production may result from coal preparation, coal charging, oven leakage during the coking period, coke removal and hot coke quenching. Leaks may also occur from poorly sealed doors, charge lids, off take caps, collecting main and from cracks that may develop in oven brickwork (USEPA, 2000). $CH_4$ fugitive emissions from coke production in the coke plant are estimated and reported under category 1.B.1.b – Solid fuel transformation - section 3.8.2 of the Energy chapter.

#### LIME PRODUCTION

In iron and steel production, lime is used in the production of sinter, in the production of liquid steel in blast furnace charging and EAF mixtures, for slag formation and to promote steel desulphurization and dephosphorization. There are no emissions from lime use in these kilns. However, production of lime from limestone results in $CO_2$ emissions from decarbonizing.

From 1990-2001, the integrated iron and steel facility produced lime as a non-marketed intermediate product, to consume internally in its kilns. Those emissions are reported in category 2.A.2 and addressed in chapter 4.2.4 - Lime Production in Iron and Steel. In 2002, one company carried out an extensive investment program to autonomize the lime kiln of the industrial structure and automate the operation, restarting operations as an independent dedicated lime production facility. Lime production emissions from this company are reported in category 2.A.2 and addressed in chapter 4.2.3 - Lime Production in Dedicated Plants.

Note: The other facility has always purchased lime from national lime dedicated plants. Lime production emissions are reported in category 2.A.2 and addressed in section 4.2.3 - Lime Production in Dedicated Plants.

#### SINTER PRODUCTION

In the sinter production unit, the fines of the iron ores sieved together with other iron bearing materials such as pyrite ash or iron scrap, the lime and the coke breeze, were mixed in the correct proportion and heated under vacuum. High temperatures lead to the melting of iron ore particles, which caused the materials to agglomerate in order to obtain a product called sinter which had excellent reducibility qualities to be sent to the blast furnace.

Part of the coke oven gas produced onsite in the coke plant was used as fuel in the sinter plant.

Operation of the sinter production unit produced $CO_2$ emissions from oxidation of the coke breeze and other inputs. These emissions are reported and addressed in this chapter. Off gas from sinter production also contained $CH_4$, NMVOC and other hydrocarbons.

Emissions from combustion process in the sintering unit (namely NOx, SOx and CO) are reported under category 1.A.2.a – Manufacture Industries and construction.

#### COGENERATION UNIT

This unit generated electricity for consumption at the integrated iron and steel production facility. The fuels used were the following:

- Total tar quantity produced onsite in the coke plant;
- Part of the coke oven gas produced onsite in the coke plant;
- Part of the blast furnace gas produced onsite in the blast furnace;

- Fuel oil.

Operation of the cogeneration unit produced combustion emissions which are reported under category 1.A.2.a – Manufacture Industries and construction.

#### IRONMAKING IN BLAST FURNACE

In the ironmaking facility, coke, lime and sinter were added to the blast furnace, where iron oxides and coke and fluxes reacted with blast air to form molten reduced iron (pig iron), carbon monoxide and slag. Emissions occurred during casting and in the blast furnace top.

Carbon served a dual purpose in the ironmaking process, primarily as a reducing agent to convert iron oxides to iron, but also as an energy source to provide heat when carbon and oxygen react exothermically. According to the 2006 IPCC Guidelines, all carbon used in blast furnaces should be considered process-related IPPU emissions.

In order to achieve a higher combustion temperature, the ironmaking facility included 3 cowpers, discontinuous type heat exchangers where a stack of refractory was alternately heated by the gas from the combustion of blast furnace gas and cooled by the circulation of the insufflated air, thus transferring energy accumulated in it during the heating period. In this way, the gas resulting from process in the blast furnace - blast furnace gas -, with a high CO content, was partly recirculated to be used as fuel in the blast furnace. The remaining blast furnace gas was used as fuel as well in the cogeneration unit. Part of the coke oven gas produced onsite in the coke plant was also used as fuel in the blast furnace.

Emissions from combustion process in the blast furnace (namely NOx, SOx and CO) are reported under category 1.A.2.a – Manufacture Industries and construction. $CO_2$ process emissions resulting from casting operations and seal leaks at top of the furnace are addressed and reported in this chapter.

Pig iron resulting from the blast furnace and scrap were then transformed into steel in subsequent furnaces, namely in a Basic Oxygen Furnace and in an Electric Arc Furnace.

#### STEELMAKING IN BASIC OXYGEN FURNACE (BOF) AND EAF

In the Basic Oxygen Furnace, molten pig iron from the blast furnace and steel scrap were melted with the injection of a substantial source of oxygen and oxidized part of the carbon associated with iron to produce steel. This carbon was emitted mostly as CO (contributing nevertheless to ultimate $CO_2$ emissions). Other emissions from BOF were iron oxides, oxides of other metals, sulphur and particulate matter.

Regarding EAF, although located in the integrated iron and steel plant, it consisted of a stand-alone operation because of its fundamental reliance on scrap as a raw material instead of iron. In the EAF, pig iron and steel scrap are subjected to an electric discharge through carbon (graphite) electrodes that reduces its carbon content to produce steel.

Since the EAF process is mainly one of melting scrap and not reducing oxides, carbon's role is not as dominant as it is in the blast furnace/BOF process. In the EAF, $CO_2$ emissions are mainly associated with carbon additives such as graphite electrodes, anthracite and coke consumption. According to the 2006 IPCC Guidelines, all carbon used in EAFs and other steelmaking processes should be considered process-related IPPU emissions.

Next, the adjustment of the molten steel is carried out in a separate oven, known as a pot oven. In this oven, the homogenization of steel is promoted as well as the introduction of additions and metallic alloys, to adjust its composition.

After adjustment, molten steel from the pot oven is shaped into ingots or billets.

### ROLLING MILLS

In some cases, ingots or billets are reheated in a kiln and processed in rolling mills, in order to be reshaped into long-product rolling like wire rod and rebar in straight lengths.

Emissions from this finishing process are mostly particulate matter besides combustion pollutants. Combustion emissions from this process are reported in category 1.A.2.a - Manufacture Industries and construction.

--

Ultimate fossil $CO_2$ emissions are the result of the oxidation of carbon in coke, anodes and electrodes. Part of the carbon is sequestered in the final product – billets - and is not emitted to atmosphere as $CO_2$. Emissions of carbon may occur as CO and NMVOC but it is assumed that they are subsequently converted in atmosphere in $CO_2$. The methodology used to estimate NMVOC and CO emissions can be checked in the Portugal IIR. Indirect $CO_2$ emissions related to NMVOC and CO emissions are reported in CRT Table 6.

Some carbon may remain in pig iron after initial reducing in blast furnace and part may be emitted from oxidation in the BOF. EAF operations also result in carbon emission but mostly from consumption of graphite anodes in the process.

Around 2001, Portuguese economy entered a recession period that culminated with the dismantling of the integrated iron and steel production facility. From 2002 onwards, only the EAF process remained in operation in this facility.

The other plant has a similar steelmaking process through an EAF. From 2002 onwards, there is only secondary steel production through EAF in Portugal.

The table below indicates all emission streams for iron and steel operations and provides information on the categories under which these emissions are reported. However, although combustion emissions and process emissions are estimated separately, they are in fact emitted at same place and are inseparable in concept.

***Table 4-36: Emission streams for iron and steel industry***

| Process/Activity description | Reporting period | GHG coverage | Emission stream | CRT Code Report | NID Section |
|---|---|---|---|---|---|
| Coke production | 1990-2001 | $CO_2$, $CH_4$, $N_2O$ | Combustion | 1A1c | 3.3.3 |
| | | $CH_4$ | Fugitive emissions | 1B1b | 3.8.2 |
| Lime production | 1990-2001 | $CO_2$ | Process | 2A2 | 4.2.4 |
| Sinter production | 1990-2001 | $CO_2$, $CH_4$ | Process | 2C1d | 4.4.2 |
| Cogeneration | 1990-2001 | $CO_2$, $CH_4$, $N_2O$ | Combustion | 1A2a | 3.4 |
| Ironmaking | 1990-2001 | $CO_2$ | Process | 2C1b | 4.4.2 |
| Steelmaking: BOF | 1990-2001 | $CO_2$ | Process | 2C1a | 4.4.2 |
| Steelmaking: EAF | 1990-onwards | $CO_2$ | Process | 2C1a | 4.4.2 |
| Rolling mills, pot ovens and reheating ovens | 1990-onwards | $CO_2$, $CH_4$, $N_2O$ | Combustion | 1A2a | 3.4 |
| Other machinery operation (a) | 1990-onwards | $CO_2$, $CH_4$, $N_2O$ | Combustion | 1A2gvii | 3.4 |
| (a) Consumption of fuels in other iron and steel related activities such as blowtorches, emergency generators, lift trucks operation, etc. | | | | | (b) |

#### 4.4.2.2 Methodology

Since there are different processes and different data sources available depending on the years, distinguished methodologies were used throughout the time series.

From 1990-2001, process emissions from the integrated iron and steel production facility were estimated according to two different approaches – product approach and carbon balance.

##### SINTER PRODUCTION

Operation of sinter plants produces $CO_2$ emissions from oxidation of the coke breeze and other inputs. Off gas from sinter production also contains methane and other hydrocarbons. $CO_2$ and $CH_4$ emissions from sinter production were estimated according to a product approach, as shown in the following equation:

***Equation 4-39: Emissions from sinter production***

$$Emi = SI \times EF$$

**Where:**

Emi: $CO_2$ / $CH_4$ emissions (t)

SI: Sinter produced (t)

EF: $CO_2$ / $CH_4$ emission factor ($t/t_{sinter}$)

Emissions from sintering are reported in source code 2.C.1.d – Metal Industry (sinter).

##### IRONMAKING IN BLAST FURNACE AND STEELMAKING IN BOF

$CO_2$ emissions from pig iron production in the blast furnace, as well as from steel production in BOF were estimated according to a carbon balance approach, described in the following equation:

***Equation 4-40: Emissions from iron and steel (BOF) production***

$$Emi = [ \sum (FC_i \times EF_i) ] - [ \sum (PP_j \times EF_j) ]$$

**Where:**

Emi: $CO_2$ emissions (t)

$FC_i$: Annual consumption of feedstock i (t)

$EF_i$: $CO_2$ emission factor of feedstock i ($t/t_{feedstock\ i}$)

$PP_j$: Annual production of product j (t)

$EF_j$: $CO_2$ emission factor of product j ($t/t_{product\ j}$)

Emissions from ironmaking are reported in source code 2.C.1.b – Metal Industry (pig iron).

Although 2006 IPCC Guidelines provide a Tier 1 methodology for estimating $CH_4$ emissions from pig iron production, they do not provide a corresponding emission factor. Furthermore, although 1995 IPCC Guidelines provide a Tier 1 methodology and $CH_4$ emission factor for estimating emissions from pig iron production, it is not appropriate to use because $CO_2$ emissions were estimated using the Tier 2 mass balance methodology above mentioned. The mass balance methodology makes a basic assumption that all carbon that enters the pig iron production process either exits the process as part of a carbon-containing output or as $CO_2$ emissions. $CH_4$ emissions estimation is precluded.

According to the 2006 IPCC Guidelines, $CH_4$ may be emitted from steelmaking processes as well, however those emissions are assumed to be negligible, hence are reported as Not Estimated (NE). Emissions from steelmaking in BOF are reported in source code 2.C.1.a – Metal Industry (steel).

#### STEELMAKING IN EAF

From 2002 onwards, $CO_2$ emissions from steel production in EAF are estimated according to a carbon balance approach, already described above. From 2005 onwards, when European Union Emissions Trading System (EU ETS) was set up, all Iron and Steel plants are required to prepare carbon balances as part of the monitoring reports.

From 1990-2001, $CO_2$ emissions from steel production in EAF were estimated according to the following equation:

***Equation 4-41: Emissions from steel production (EAF) – 1990-2001***

$$Emi = ST \times EF_{(2002\text{-}2006)}$$

**Where:**

Emi: $CO_2$ / $CH_4$ emissions (t)

ST: Steel produced (t)

EF: Average $CO_2$ implied emission factor in 2002-2006 period ($t/t_{steel}$)

As already mentioned, $CH_4$ emissions are assumed to be negligible, hence are reported as Not Estimated (NE).

Emissions from steelmaking in EAF are reported in source code 2.C.1.a – Metal Industry (steel).

#### OTHER OPERATIONS AND EMISSIONS RELATED TO IRON AND STEEL SECTOR

Emissions related with Rolling mills, pot ovens and reheating ovens are reported under category 1.A.2.a.

Emissions from lime production are addressed in chapters 4.2.3. and 4.2.4.

Methodology for estimating $NO_X$, CO, NMVOC and $SO_2$ emissions is provided in IIR.

### 4.4.2.3 Emission Factors

Emission factors for Iron and Steel Production in the period 1990-2001 are provided in the table below.

***Table 4-37: Emission Factors for Iron and Steel Production in the period 1990-2001***

| Pollutant | Sinter | Ironmaking | Steel making (BOF) | Steelmaking (EAF) | Unit |
|---|---|---|---|---|---|
| $CO_2$ | 0.20 (a) | 0.71-1.32 (b) | 0.12-0.14 (b) | 0.84 (c) | t/t |
| $CH_4$ | 0.07 (a) | - | - | - | kg/t |
| NOx | 558 (d) | 8 (d) | 10 (e) | 130 (e) | g/t |
| CO | 18 000 (d) | 27 (d) | 3500 (e) | 1700 (e) | g/t |
| NMVOC | 138 (e) | NE (e) | NE (e) | 46 (e) | g/t |
| $SO_2$ | 463 (d) | 38 (d) | NE (e) | 60 (e) | g/t |

(a) 2006 IPCC Guidelines, Vol. 3, Tables 4.1 and 4.2
(b) Implied emission factor (IEF) obtained from carbon balance approach
(c) Average IEF from 2002-2006
(d) EMEP/EEA guidebook 2019, Vol. 1.A.2, Tables 3-7, 3-8
(e) EMEP/EEA guidebook 2019, Vol. 2.C.1, Tables 3-14, 3-15

From 2002 onwards, $CO_2$ emission factors for EAF operation used for the two iron and steel plants were determined from consumption of carbon bearing materials in those units.

It was assumed that the same carbon content exists in both scrap and final steel produced in EAF furnaces and, consequently, no additional emissions are estimated apart from carbon in additives. The $CO_2$ stoichiometric emission factors from carbon bearing materials are listed in the table below.

From 2005 onwards, carbon content of raw materials and emission factors are obtained from the EU-ETS for the two facilities.

***Table 4-38: Carbon bearing materials: carbon content and $CO_2$ stoichiometric EF***

| Material | C Content (t C/t material) | EF (t $CO_2$/t material) |
|---|---|---|
| Scrap Iron | 0.040 | 0.147 |
| Steel Scrap | 0.010 | 0.037 |
| Purchased Pig Iron | 0.047 | 0.172 |
| Hot Briquetted Iron (HBI) | 0.020 | 0.073 |
| EAF Carbon Electrodes | 0.820 | 3.007 |
| EAF Coal | 0.890 | 3.263 |
| Coke | 0.830 | 3.043 |
| Petroleum Coke | 0.870 | 3.190 |
| Limestone ($CaCO_3$) | 0.121 | 0.444 |
| Dolomite ($MgCO_3.MgCO_3$) | 0.130 | 0.477 |
| Steel (Billets) | 0.010 | 0.037 |

From 2016 onwards, EU-ETS iron and steel operators were required to perform carbon content monitoring in scrap iron materials. The emission factors obtained in the monitoring were far lower than the default value that was being applied from 1990 to 2015, which lead to a major decrease in $CO_2$ emissions from iron and steel. However, given that we find there is not enough reliable EU-ETS monitoring data in order to establish a consistent time series, we decided, for the time being, to maintain the default emission factor for scrap iron for the whole time series, for each facility.

#### 4.4.2.4 Activity Data

Concerning the integrated iron and steel production facility, there are differences in the activity data used in estimates for the period 1990-2001 and from 2002 onwards.

Activity data for emissions estimates related to the integrated iron and steel production facility for the period 1990-2001 comprehend coke consumption, sinter, pig iron and steel production and also scrap consumption. The following sources of information were used to establish activity data time series:

- Annual coke production was obtained from DGEG (Coke plant Balance) from 1990 to 2001. From 2002 onwards, there is no coke production in the iron and steel industry in Portugal;

- Annual production of sinter and pig iron were obtained directly from the facility from 1991 to 1994. For 1990 and from 1995 to 2001, pig iron production was obtained from Worldsteel Association. For 1990 and from 1995 to 2001, sinter production was estimated using pig iron production as surrogate data, given that all sinter produced was consumed in the blast furnace to produce pig iron. Therefore, for the missing years, sinter production was estimated according to the following equation:

***Equation 4-42: Sinter production in the integrated iron and steel facility***

$$SI_y = PI_y \times \frac{SI_{1991-1994}}{PI_{1991-1994}}$$

**Where:**

$SI_y$: Sinter production in year y (t)

$PI_y$: Pig iron production in year y (t)

$SI_{1991-1994}$: Average Sinter production in period 1991-1994 (t)

$PI_{1991-1994}$: Average Pig iron production in period 1991-1994 (t)

- From 2002 onwards there is no sinter and pig iron production;
- Annual total steel production from BOF as well as from EAF were obtained from Worldsteel Association from 1990 to 2001, although some years were corrected with existing national data. From 1990 to 2001, annual steel production from EAF for the integrated facility was estimated based on the following equation:

***Equation 4-43: EAF steel production in the integrated iron and steel facility – 1990-2001***

$$ST_{EAF\ IN\ I\&S} = ST_{EAF\ IN\ WSA} - ST_{EAF\ IN\ OF}$$

**Where:**

$ST_{EAF\ IN\ I\&S}$: Annual steel production from EAF for the integrated facility (t)

$ST_{EAF\ IN\ WSA}$: Annual total steel production from EAF from Worldsteel Association (t)

$ST_{EAF\ IN\ OF}$: Annual steel production from EAF for the other facility (t) (detail addressed further ahead)

- From 2002 onwards there is no steel production resulting from BOF;
- Annual scrap consumption was obtained directly from the facility from 1990 to 1994. From 1995 to 2001, scrap consumption was estimated using steel production as surrogate data.

Production of total steel and intermediate products in the integrated iron and steel facility is presented in the figure below for the period 1990-2001. As an integrated iron and steel facility, the close relationship between intermediate products and steel produced through BOF is notorious, since their production is intrinsically related to the final amount of steel produced. On the other hand, steel produced from EAF is an independent operation, given that the raw material used is scrap and not iron. From 1990 to 2000, steel produced from EAF represents a minor contribution for total steel production. As we approach the end of this period, steel produced from EAF begins to have more relevance, given the recession effects and the fact that scrap is a cheaper raw material.

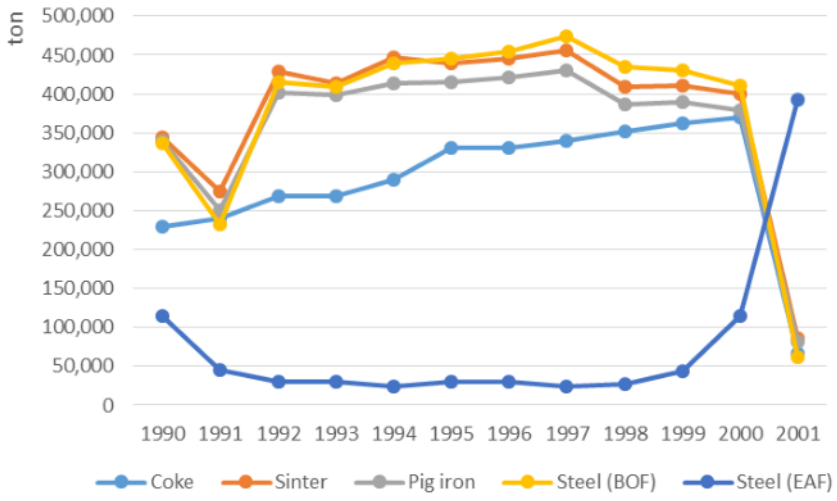



***Figure 4-34: Integrated iron and steel facility – production of steel and intermediate products (1990-2001)***

Activity data for estimation of $CO_2$ emissions from iron and steel production from 2002 onwards comprehends fuel consumption (natural gas, gasoil and propane), raw materials consumption. The emissions related to the fuel consumption are reported in source code 1.A.2.a.

From 2002 to 2005:

- Annual steel production from EAF was estimated based on Equation 4-43;
- Annual scrap and pig iron consumption were estimated using steel production as surrogate data.

Concerning the other facility, annual steel production from EAF as well as annual scrap and pig iron consumption from 1990 to 2004 were obtained directly from the facility.

From 2005 onwards, data on consumption of raw materials as well as steel production (as billets) were obtained from EU-ETS for the two facilities.

The figure below presents the trend in national steel production by process for the whole time series.

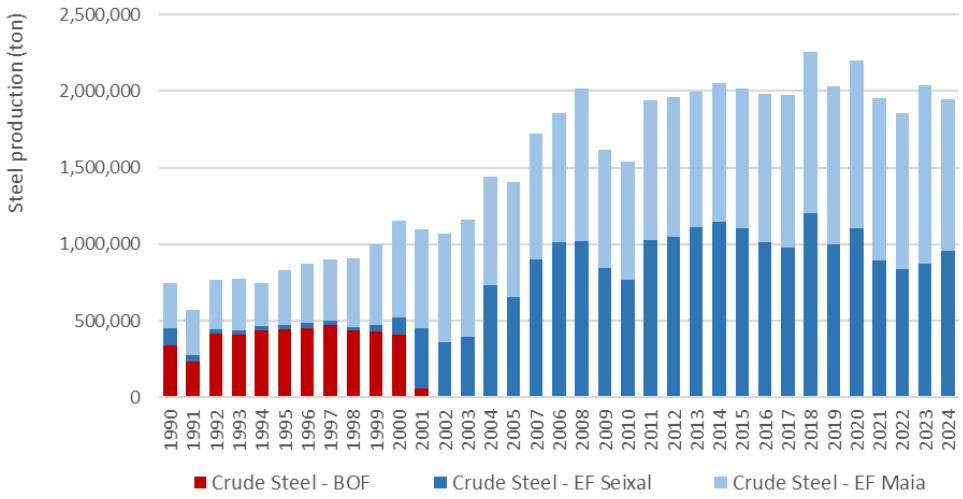



***Figure 4-35: Steel production by process***

The figure above shows the recession period in the Portuguese economy that culminated in the dismantling of the integrated iron and steel production plant (red), remaining steel production through the EAF (dark blue).

### 4.4.2.5 Uncertainty Assessment

Uncertainty assessment was based on Chapter 4.2.3 of Volume 4: Metal Industry Emissions of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

***Table 4-39: Uncertainty values related to emissions reported under CRT 2.C.1***

| Parameter | | Uncertainty |
|---|---|---|
| Activity Data | Sinter production | 10% |
| | Ironmaking | 10% |
| | Steelmaking | 10% |
| $CO_2$ EF | Sinter production | 25% |
| | Ironmaking | 10% |
| | Steelmaking | 10% |
| $CH_4$ EF | Sinter production | 25% |

#### 4.4.2.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

Emissions estimates were based on a bottom-up approach with collection of plant specific crude steel production data. A comparison was made using a top-down approach based on crude steel production data obtained from the WorldSteel Association. There are slight differences using the two different approaches but, generally, data is consistent.

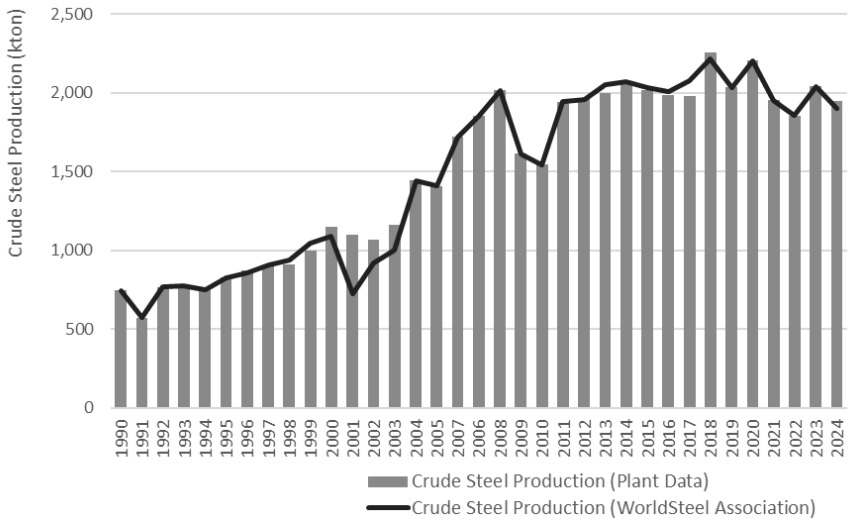



***Figure 4-36: Crude steel production in Portugal – comparison of approaches***

Data received from the two plants is also cross-checked with data obtained from the energy balance. Part of the differences (fuel consumption data in the national energy balance and in the EU ETS) is considered under source "1.A.2.a". The differences related to other fuels are reported under source "1.A.2.g.i", since this could be a misallocation from the energy balance.

#### 4.4.2.7 Recalculations

No recalculations were made.

#### 4.4.2.8 Further Improvements

In the future, we intend to gather information regarding carbon content in raw materials and in steel produced, in order to obtain a more accurate and consistent time series of activity data and $CO_2$ emissions.

### 4.4.3 Ferroalloys Production (CRT 2.C.2)

Concerning ferroalloys production, following a 2018 UNFCCC In-Country Review recommendation, a EUROSTAT Sold Production Database research showed production data for ferroalloys in Portugal, specifically "Production of ferro-cerium, pyrophoric alloys, articles of combustibles, n.e.c. (in kg)", however, there are too many missing years in order to create a consistent time series.

In order to assess the relevance of emissions resulting from the above-mentioned activity data, rough conservative $CO_2$ and $CH_4$ estimates were made. Available activity data (from 2011-2014, 2017-2022) was obtained from national statistics and EUROSTAT. Tier 1 emission factors were applied according to 2006 IPCC Guidelines (Tables 4.5 and 4.7 of chapter "4 - Metal Industry Emissions" Volume 3). These estimates were found to be below the threshold of significance (bellow 0.004%). In 2024, considering a production of about 159 ton of ferrocerium and applying the respective conservative EFs – 10 t CO2/ton and 2.4 kg CH4/ton – the resulting emissions are of 1.6 kton of CO2 and 0.4 ton of CH4.

Therefore, and given the scarcity of the activity data in order to assess a timeline, we report 2.C.2 as Not Estimated.

### 4.4.4 Aluminium Production (CRT 2.C.3)

Aluminium production will result in $CO_2$ emissions when it is reduced using carbon electrodes in smelting pots and ultimate $CO_2$ emissions are the result of consumption of electrodes. This situation occurs when aluminium is manufactured from bauxite ore, using the Soderberg process, for example.

In Portugal, according to information received from the General Directorate of Economic Activities (DGAE), there is only secondary aluminium production from recycled ingots. Secondary aluminium, also known as recycled aluminium, originates from the smelting of aluminium scrap from various sources, such as production off-cuts from new parts, machining swarf, and end-of-life aluminium products.

There is no IPCC guidance on estimating IPPU GEE emissions from secondary aluminium production, only from primary aluminium. Emissions from the combustion of fossil fuels associated with aluminium production from recycled sources are covered in chapter 1A2 from CRT Energy sector.

### 4.4.5 Magnesium Production (CRT 2.C.4)

There is no Magnesium Production in Portugal.

### 4.4.6 Lead Production (CRT 2.C.5)

#### 4.4.6.1 Category description

This chapter addresses emissions $CO_2$ estimates from the production of lead. There is only secondary Lead production in Portugal.

#### 4.4.6.2 Methodology

$CO_2$ Emissions from lead production were estimated in accordance with:

***Equation 4-44: $CO_2$ emissions from lead production***

$$\text{Emi } CO_2 = EF \times \text{Lead Production} \times 10^{-3}$$

**Where:**

Emi $CO_2$: $CO_2$ Emissions (kt)

EF: $CO_2$ emission factor (t $CO_2$/t Lead)

Lead Production: Lead Production (t Lead)

#### 4.4.6.3 Emission Factors

***Table 4-40: CO2 emission factor related to Lead production***

| Pollutant | Unit | EF | Source |
|---|---|---|---|
| $CO_2$ | t $CO_2$/t Lead | 0.52 | Table 4.21 of Chapter 4: Metal Industry Emissions of 2006 IPCC Guidelines |

#### 4.4.6.4 Activity Data

There is only secondary Lead production in Portugal.

Data on secondary lead production is obtained from INE from 1992-2005, 2007-2015 and 2017-onwards.

In the period 1990-1991, data has been estimated based on 1992 production and on GDP trend. Missing data in 2006 and 2016 are derived from the average between 2005 and 2007, and 2015 and 2017, respectively. EUROSTAT data series on secondary lead production in Portugal was obtained for QA/QC purposes, however, there are too many missing years in order to create a consistent time series.

Due to confidentiality constraints data is presented as an index value related to 1990 production, in the graphic below.

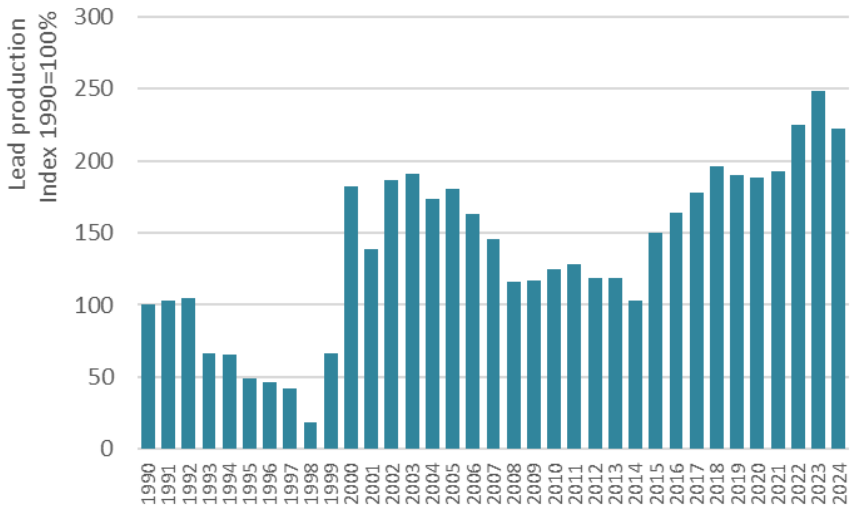



***Figure 4-37: Secondary Lead production data (Index 1990=100%)***

#### 4.4.6.5 Uncertainty Assessment

***Table 4-41: Uncertainty values***

| Parameter | Type of Uncertainty | Uncertainty | Source |
|---|---|---|---|
| Activity Data | Lead national production data | 10% | Table 4.23 of Chapter 4: Metal Industry Emissions of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. |
| $CO_2$ EF | Default Emission Factor | 50% | |

#### 4.4.6.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

#### 4.4.6.7 Recalculations

Recalculations in the period 1990-1991 resulted from the change on surrogate data used to estimate secondary lead production. Before this submission, 1990-1991 data was being estimated based on 1992 production and on national Gross Domestic Product (GDP).

#### 4.4.6.8 Further Improvements

In order to improve time series consistency, Portugal intends to contact national statistics to obtain secondary lead production for the whole time series and prevent using several sources of AD.

### 4.4.7 Zinc Production (CRT 2.C.6)

According to INE, there is no Zinc Production in Portugal.

### 4.4.8 Copper Production (CRT 2.C.7.a)

There are no direct $CO_2$, $CH_4$ and $N_2O$ emissions to report in this subsector in Portugal. There are, however, $SO_x$ emissions. The methodology used to estimate $SO_x$ emissions from this category can be checked in Portugal IIR. $SO_x$ emissions from copper production are reported in CRT Table2(I)s1.

## 4.5 Non-energy Products from Fuels and Solvents Use (CRT 2.D)

### 4.5.1 Overview

This chapter addresses the estimates of process-related GHG emissions that result from the first use of fossil fuels as a product for primary purposes other than combustion for energy purposes and use as feedstock or reducing agent. Emissions from these exceptions are accounted for in chemical industry (chapter 4.3) and in metal industry (chapter 4.4). The products covered in this chapter comprise lubricants, paraffin waxes, bitumen/asphalt and solvents.

$CO_2$ emissions reported in CRT Table2(I)s1 in categories 2.D.3.a - Solvent use and 2.D.3.b - Road paving with asphalt refer to indirect $CO_2$ emissions. This report was agreed among EU countries with the aim of ensure consistency between KP commitment periods (CP). Countries, like Portugal, reported indirect $CO_2$ emissions from these categories in inventory submissions before 2015 (CP 1) in previous CRT table 3 (Sectoral report for solvents and other products use). Hence, for the following commitment period and in order to ensure the highest consistency with 2006 IPCC Guidelines and with the previous inventory submissions, countries should continue reporting these emissions in the same manner. Therefore, Portugal continues to report NMVOC emissions from these categories as indirect $CO_2$ emissions in CRT Table2(I).A-Hs1, for KP consistency purposes. On that matter, the paper "*Guidance related to the reporting of indirect emissions*" from EEA SHAREPOINT is presented in **ANNEX I** and includes further explanation to the approaches taken by Portugal and all other EU MS.

According to the 2006 IPCC Guidelines, $CH_4$ emissions from the activities covered in this chapter are expected to be minor or not to occur at all. Although some $CH_4$ emissions occur from asphalt production and use for road paving, no method to estimate $CH_4$ emissions is provided by the guidelines, since these emissions are expected to be negligible.

### 4.5.2 Lubricants Use (CRT 2.D.1)

#### 4.5.2.1 Category description

Lubricants are produced either at refineries through separation from crude oil or at petrochemical facilities. In Portugal, they are used in several sectors, however the most relevant uses are road transportation, transforming industries, agriculture and services.

#### 4.5.2.2 Methodology

Lubricants accounted for in this category can be estimated according to the following:

***Equation 4-45: Lubricants accounted for in this category***

$$Lubricants_{Cons} = Lubricants_{Cons}\ (Total) - Lubricants_{Cons}\ (Road\ Transport\ combustion)$$

**Where:**

$Lubricants_{Cons}$: Consumption of Lubricants except in two-stroke engines in Road Transportation (GJ)

$Lubricants_{Cons}$ (Total): Total Consumption of Lubricants (GJ)

$Lubricants_{Cons}$ (Road Transport combustion): Consumption of Lubricants used as energy in two-stroke engines in Road Transportation (GJ)

Lubricant consumption related with combustion that contributes to exhaust emission in Road Transport includes lubricant consumed as energy in two-stroke engines. These emissions are included in Road Transportation (CRT 1.A.3.b) chapter.

$CO_2$ emissions related to lubricants consumption (reported under CRT 2.D.1) were estimated according to:

***Equation 4-46: $CO_2$ emissions from lubricants consumption***

$$CO_2 \text{ Emissions} = \text{Lubricants}_{Cons} (2D1) \text{ X } (DCC \text{ X } 44/12 \text{ X } 10^{-3}) \text{ X } ODU$$

**Where:**

$CO_2$ Emissions: $CO_2$ emissions (t)

$\text{Lubricants}_{Cons}$(2D1): Consumption of Lubricants except in two-stroke engines in Road Transportation (GJ)

DCC: Default Carbon Content (= 20 kg C/GJ)

ODU: Oxidized During Use factor (dimensionless)

Emissions from 2D1 also include $CO_2$ emission from lubricants that enter accidentally in the four-stroke engines combustion chambers in road transportation. The methodology used for this estimation is described in Road Transportation (1.A.3.b) chapter.

### 4.5.2.3 Emission Factors

Both default carbon content and oxidized during used factor were obtained from 2006 IPCC Guidelines (Chapter 5.2.2.2 of IPPU Volume).

***Table 4-42: Emission factors for Lubricant Use (2.D.1)***

| Parameter | Unit | Value | Source |
|---|---|---|---|
| Default Carbon Content | Kg C/GJ | 20 | 2006 IPCC Guidelines |
| Oxidized During Use Factor | adimensional | 0.2 | 2006 IPCC Guidelines (Table 5.2) |

### 4.5.2.4 Activity Data

The amounts of lubricants used in Portugal were obtained from the national Energy Balance, provided by DGEG.

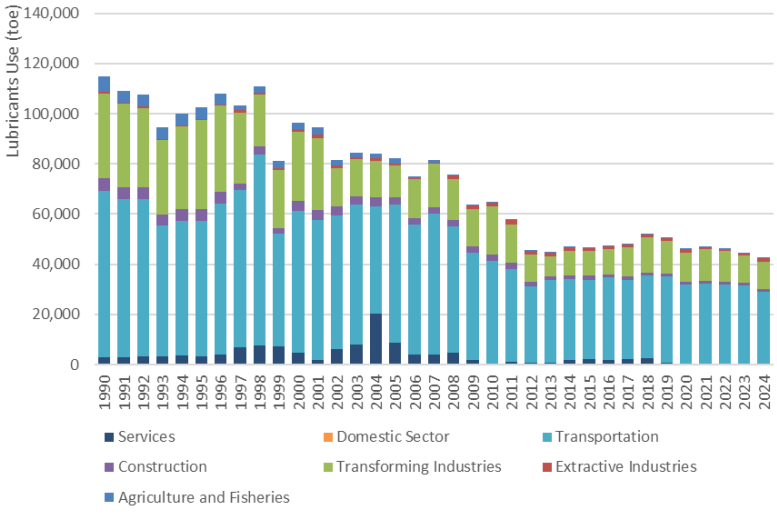



***Figure 4-38: Amount of Lubricants used in Portugal***

#### 4.5.2.5 Uncertainty Assessment

***Table 4-43: Uncertainty values***

| Parameter | Uncertainty | Source |
|---|---|---|
| Activity Data | 5.0% | "Well-developed energy statistics" in "subchapter 5.2.3.2" of "Volume 3: Industrial Processes and Product Use" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories". |
| CO2 EF – ODU Factor | 50.0% | Subchapter 5.2.3.1 of "Volume 3: Industrial Processes and Product Use" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories". |
| CO2 EF – Carbon Content | 3.0% | Subchapter 5.2.3.1 of "Volume 3: Industrial Processes and Product Use" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories". |
| CO2 EF – Combined | 50.1% | - |

#### 4.5.2.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

#### 4.5.2.7 Recalculations

Lubricants consumption data were revised by DGEG for the energy balance for 2023.

#### 4.5.2.8 Further Improvements

No further improvements are expected.

### 4.5.3 Paraffin Wax Use (CRT 2.D.2)

#### 4.5.3.1 Category description

Paraffin waxes are separated from crude oil during the production of light lubricating oils and are used in applications such as candles, corrugated boxes, paper coating, board sizing, food production, wax polishes and surfactants. In Portugal, the most relevant sectors were paraffin waxes are used are chemical/plastics industry, wood products, rubber industry, metalworking industry and paper industry.

#### 4.5.3.2 Methodology

$CO_2$ emissions are estimated based on:

***Equation 4-47: $CO_2$ emissions from paraffin wax consumption***

$$CO_2 \text{ Emissions} = PW \times (CC_{Wax} \times 44/12 \times 10^{-3}) \times ODU_{Wax}$$

**Where:**

$CO_2$ Emissions: $CO_2$ emissions (t)

PW: Consumption of Paraffin Waxes (GJ)

$CC_{Wax}$: Paraffin Waxes Default Carbon Content (= 20 kg C/GJ)

$ODU_{Wax}$: Paraffin Waxes Oxidized During Use factor)

### 4.5.3.3 Emission Factors

Both default carbon content and oxidized during used factor were obtained from 2006 IPCC Guidelines (Chapter 5.3.2.2 of IPPU Volume.

***Table 4-44: Emission factors for Paraffin Waxes Use***

| Parameter | Unit | Value | Source |
|---|---|---|---|
| Default Carbon Content | Kg C/GJ | 20 | 2006 IPCC Guidelines |
| Oxidized During Use Factor | adimensional | 0.2 | 2006 IPCC Guidelines |

### 4.5.3.4 Activity Data

The amounts of paraffin waxes used in Portugal were obtained from the national Energy Balance provided by DGEG.

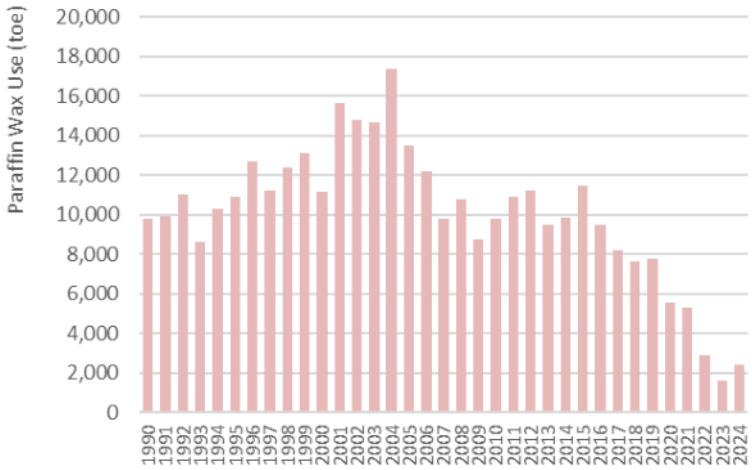



***Figure 4-39: Amount of Paraffin Wax used in Portugal***

### 4.5.3.5 Uncertainty Assessment

***Table 4-45: Uncertainty values***

| Parameter | Uncertainty | Source |
|---|---|---|
| Activity Data | 5.0% | "Well-developed energy statistics" in "subchapter 5.3.3.2" of "Volume 3: Industrial Processes and Product Use" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories". |
| CO2 EF – ODU Factor | 100.0% | Subchapter 5.3.3.1 of "Volume 3: Industrial Processes and Product Use" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories". |
| CO2 EF – Carbon Content | 5.0% | Subchapter 5.3.3.1 of "Volume 3: Industrial Processes and Product Use" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories". |
| CO2 EF – Combined | 100.1% | - |

### 4.5.3.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

### 4.5.3.7 Recalculations

No recalculations were made.

### 4.5.3.8 Further Improvements

No further improvements are expected.

### 4.5.4 Solvent Use – Solvent Use (CRT 2.D.3.a)

There are no direct $CO_2$, $CH_4$ and $N_2O$ emissions from solvent use. There are, however, indirect $CO_2$ emissions related to NMVOC emissions. The methodology used to estimate NMVOC emissions can be checked in the Portugal IIR. Indirect CO2 emissions related to NMVOC emissions from solvent use are reported in CRT Table2(I).A-Hs2, under 2.D.3. This report was agreed among EU countries with the aim of ensure consistency between KP commitment periods(CP). Countries, like Portugal, reported indirect $CO_2$ emissions from this category in inventory submissions before 2015 (CP 1) in previous CRT table 3 (Sectoral report for solvents and other products use). Hence, for the following commitment period and in order to ensure the highest consistency with 2006 IPCC Guidelines and with the previous inventory submissions, countries should continue reporting these emissions in the same manner. Therefore, Portugal continues to report NMVOC emissions from solvent use as indirect $CO_2$ emissions in CRT Table2(I).A-Hs2, for KP consistency purposes.

On that matter, the paper "*Guidance related to the reporting of indirect emissions*" from EEA SHAREPOINT is presented in **ANNEX I** and includes further explanation to the approaches taken by Portugal and all other EU MS.

### 4.5.5 Solvent Use – Road Paving with Asphalt and Asphalt Blowing in Refineries (CRT 2.D.3.b)

#### 4.5.5.1 Category description

Emission estimates reported in this source category include emissions occurring from paving road surfaces with asphalt materials as well as emissions occurring during operation of hot mix asphalt plants. Emissions from cold asphalt mixtures are not included in the inventory estimates, being assumed that they are negligible.

Road paving with asphalt is done by the application of several layers over roadbed. In volume, the majority of pavement is composed of layers of a compact aggregate and an asphalt binder (asphalt concrete). Asphalt concretes are classified either as hot mix or as cold mixes: cutback and emulsified asphalts. Liquefied asphalts – cutbacks and emulsions - are also used directly in seal and priming roadbed operations, sometimes in intermediate layers between applications of asphalt cement layers.

Aggregate materials incorporated in asphalt concrete are usually composed of coarse unconsolidated rock fragments, either obtained from rock crushing, natural alluvial deposits or by products from metal ore refining.

Hot mix asphalts are made by mixing the aggregate material together with the asphalt cement using high temperatures (150º-160º)[9]. Cold mix plants also involve mixing aggregate materials with an asphalt binder, but now the binder is an asphalt emulsion or is cutback cement, and this process takes place at much lower temperature (40-60 Celsius degrees).

Asphalt emulsions are mixtures of asphalt cement with water and emulsifiers[10]. Cure may result from water evaporation alone or from the formation of chemical ionic bonds between aggregate materials (anionic and

[9] That are needed to fluidize the asphalt cement.

[10] And also a solvent in several emulsion types.

cationic emulsions). Asphalt cut backs are asphalt cements fluidized by mixture with petroleum distillates: heavy fuel oil (Slow Cure), Kerosene (Medium Cure) or Gasoline/naphtha (Rapid Cure).

Emissions from application of pavement are mostly composed of NMVOC and certain toxic substances as PAH. Cutback asphalts result in the highest emissions due to the evaporation of part of the diluents containing VOC. Emulsified asphalts may also result in NMVOC emissions if they contain solvents in their composition – and they may contain up to 12 % of solvents. Hot mix asphalts in the other hand, result in minimum NMVOC emissions during application, because the organic component has high molecular weight and low vapour pressure (USEPA, 2001 – EIIP Volume III Chapter 17).

Asphalt pavements dominate road paving activity in Portugal, whereas rigid cement pavements are only about 5 % of total paved areas (APORBET).

According to the 2006 IPCC Guidelines, direct greenhouse gas emissions, e.g., $CO_2$ or $CH_4$, associated with the production and use of asphalt are negligible since the majority of the light hydrocarbon compounds were extracted during the refining process to produce commercial fuels.

Emissions during fabrication of asphalt concretes consist mainly in NMVOC and particulate matter that escape mostly from the drier. The methodology used to estimate these emissions can be checked in the Portugal IIR. Indirect $CO_2$ emissions related to NMVOC emissions from road paving with asphalt are reported in CRT Table2(I).A-Hs2. Other pollutants are also emitted but they result mostly from combustion of fuels and are considered in the Energy chapter (1.A.2)[11].

It was still not possible to distinguish the part of asphalt materials that is used in road pavement and other uses, such as building isolation or asphalt roofing, and therefore all emissions from production of asphalts – except emissions from fuel combustion – are included in this source category.

Emissions related to asphalt blowing were estimated based on the amount of asphalt produced in the asphalt blowing units of each refinery. There are no direct $CO_2$, $CH_4$ and $N_2O$ emissions from asphalt blowing. There are, however, NMVOC emissions. The methodology used to estimate NMVOC emissions can be checked in the Portugal IIR. Indirect $CO_2$ emissions related to NMVOC emissions from this sub-category are reported in CRT Table2(I).A-Hs2.

### 4.5.6 Solvent Use – Urea based catalytic converters (CRT 2.D.3.c)

The use of urea-based additives in catalytic converters in road transportation generates $CO_2$ emissions. The methodology used for estimating direct $CO_2$ emissions from this category is described in Road Transportation (1.A.3.b) chapter, in the Energy sector.

[11] To avoid double counting and because from statistical information is not possible to separate fuel use in this particular activity sector.

## 4.6 Electronics Industry (CRT 2.E)

### 4.6.1 Overview

This chapter addresses fluorinated compounds emissions that result from the electronics manufacturing processes. Emissions from this category sector include CF4, C2F6, C3F8, c-C4F8, c-C4F8O, C4F6, C5F8, CHF3, CH2F2, nitrogen trifluoride (NF3), and sulphur hexafluoride (SF6).

### 4.6.2 Integrated Circuit or Semiconductor (CRT 2.E.1)

Concerning Integrated Circuit or Semiconductor production, upon contact with our Focal Point, we acknowledged a national company which provides wafer-level fan-out (WLFO) semiconductor packaging solutions.

During the 2022 UNFCCC Review, Portugal clarified that this company was only a packaging and assembling facility, regarding semiconductor encapsulation, which did not lead to F-gases emissions. However, upon further contact after the review, we learned this company consumes very small amounts CF4 in silicon wafer etching processes since 2012.

Upon further research, we learned that, since 2011, a Portuguese university laboratory consumes SF6, CF4 and C3F8 in plasma etching silicon containing materials, in Transmission Electron Microscopes and in cleaning chemical vapour deposition (CVD) tool chamber-walls where silicon has deposited.

In order to assess the relevance of emissions resulting from the above-mentioned activity data, conservative $CO_2$ eq estimates were made following the guidance from section 6.2.1.1, chapter 6, Volume 3 of the 2006 IPCC Guidelines. Activity data (average annual consumption of each fluorinated compound from 2011 to 2024) was obtained from both facilities. Default Tier 2a emission factors for FC emissions from semiconductor manufacturing were applied according to 2006 IPCC Guidelines (Tables 6.2 and 6.6 of chapter 6 – Electronics Industry Emissions, Volume 3). These estimates were found to be well below the threshold of significance (below 0.005%). In 2024, considering a total consumption of 20 kg of SF6, 334 kg of CF4 and 5 kg of C3F8 and applying the respective Tier 2 EFs, the resulting total emissions are of 0.188 kton of $CO_2$ eq.

Therefore, we report 2.E.1 as Not Occurring from 1995 to 2010 and as Not Estimated from 2011 onwards.

### 4.6.3 TFT Flat Panel Display (CFT 2.E.2)

Concerning TFT Flat Panel Display production, we have contacted our Focal Point which informed us that are unaware of any TFT flat panel displays production in Portugal.

After the 2022 UNFCCC Review and upon further investigation, we have also contacted the Portuguese Association of Companies in the Electrical and Electronic Sector (ANIMEE), which informed us there never was TFT flat panel displays production in Portugal. There are only TFT imports.

Therefore, we report 2.E.2 as Not Occurring for the whole time series.

### 4.6.4 Photovoltaics (CRT 2.E.3)

Concerning photovoltaics production, during the 2022 UNFCCC Review, the Party clarified that a joint-venture facility concerning photovoltaic cell production and distribution was planned to open but it became insolvent before it was fully developed.

Portugal also reported that a solar panel production facility was in operation in the country since 2008 and closed in 2018 due to strong competition from Chinese companies in the renewable energy market. During the 2022 UNFCCC Review, Portugal clarified the annual capacity production of the facility above mentioned - around 90,000 mono and polycrystalline silicon PV modules per year (Source: Thomas Fischer, Publication "Sun&Wind Energy", 7/2009), which corresponds to an area of 270,000 m2 of cells, assuming average dimensions of large PV modules. Adopting a conservative approach and based on default data from the 2006 IPCC Guidelines using the PV-cells EFs from table 6.2, the total emissions per operating year were estimated in the order of 10.6 kt $CO_2$ eq. The level of emissions is below 0.05 % of national total emissions, which can be considered negligible.

However, upon further contact with the solar panel facility after the review, we learned that fluorinated compounds were not used in cell production. Photovoltaic cells were mounted in vacuum.

After the review and upon further contact with the Portuguese Association of Renewable Energies (APREN), we learned that another Portuguese facility in the manufacturing and design of photovoltaic modules sector is in operation since 1994. Upon contact with the facility, they informed that photovoltaic cells used to assemble photovoltaic modules are imported, and there is no F-gases consumption.

Therefore, given that photovoltaics activities occur in Portugal but do not result in emissions or removals of F-gases in the country, we report 2.E.3 as Not Applicable for the whole time series.

### 4.6.5 Heat Transfer Fluid (CRT 2.E.4)

Concerning Heat Transfer Fluid, we have contacted our Focal Point which informed us that are unaware of any Heat Transfer Fluid consumption in Portugal.

After the 2022 UNFCCC Review and upon further investigation, we have also contacted the Portuguese Association of Companies in the Electrical and Electronic Sector (ANIMEE), which informed us there never was Heat Transfer Fluid consumption in Portugal.

Therefore, we report 2.E.4 as Not Occurring for the whole time series.

## 4.7 Products Uses as substitutes for ODS (CRT 2.F)

### 4.7.1 Overview

This category intends to estimate emissions that result from the following activities:

- Commercial Refrigeration (CRT 2.F.1.a);
- Domestic Refrigeration (CRT 2.F.1.b);
- Industrial Refrigeration (CRT 2.F.1.c);
- Transport Refrigeration (CRT 2.F.1.d);
- Mobile Air Conditioning (CRT 2.F.1.e);
- Stationary Air Conditioning (CRT 2.F.1.f);
- Foam Blowing (CRT 2.F.2);
- Fire Protection (CRT 2.F.3);
- Metered Dose Inhalers (CRT 2.F.4.a);
- Other Aerosols (CRT 2.F.4.b).

As shown in the figure below, there is a strong increase in emissions from product uses as substitutes for ODS until about 2019. The entering into force of the F-gas Regulation, imposed progressive restrictions and bans to the placing of some of the high GWP HFC fluids in new equipment, which is starting to be reflected on the Portuguese F-gas emissions. The most recent revision of the F-Gas Regulation, in 2024, imposed new and harsher restrictions regarding F-gas placing on the market.

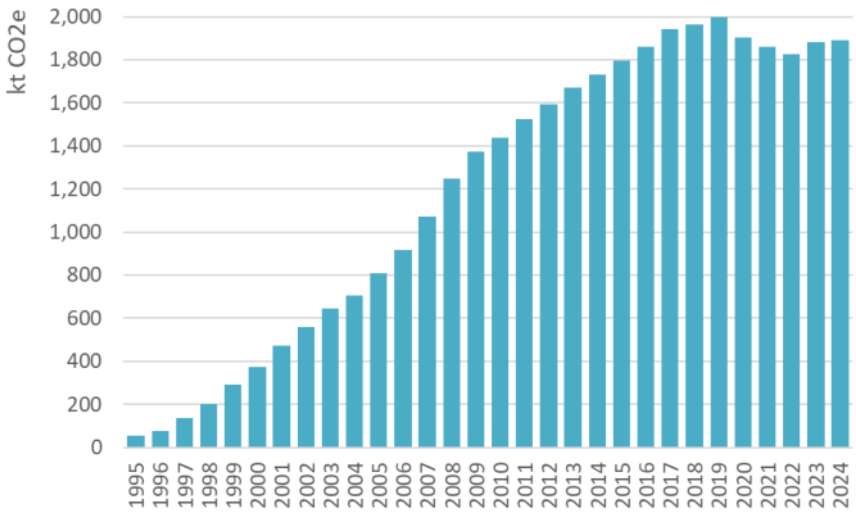



***Figure 4-40: Trends in emissions from product uses as substitutes for ODS***

Total HFC emissions from this source sector have increased from about 53.7 kt $CO_2e$ in 1995 (base year) to about 2000 kt $CO_2e$ in 2019. The slight decrease registered the following years was mostly due to the restrictions resulting from the COVID pandemic In 2024, Sector 2.F represented circa 3.7% of National total GHG emissions (without LULUCF) and about 37% of IPPU total GHG emissions (circa 3400 % increase from 1995 to 2024).
In 2024, the most relevant F-gas subcategories remained commercial refrigeration (51%) and mobile air conditioning (31%).

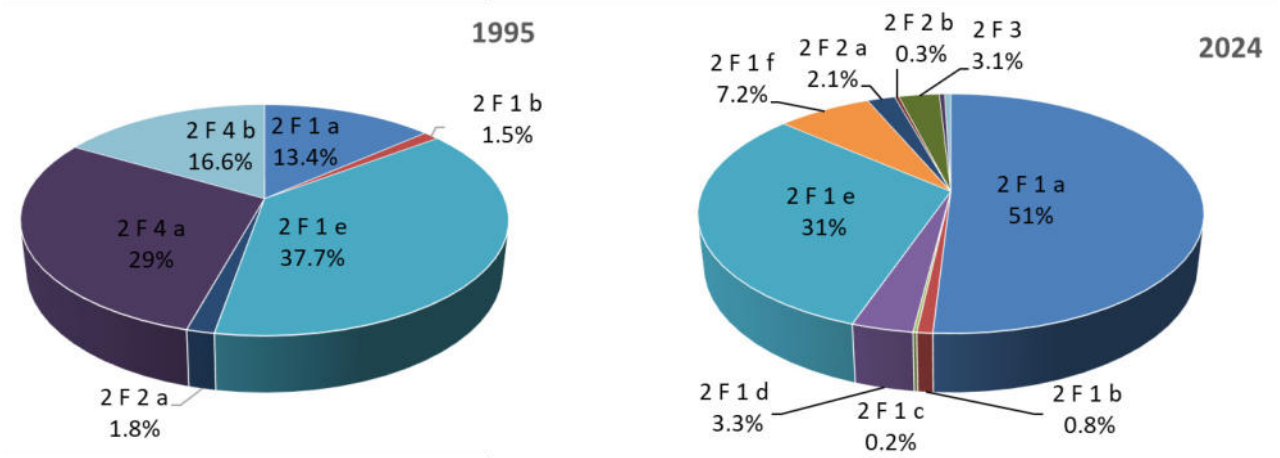



***Figure 4-41: Share of emissions by subcategory***

Regulation (EC) No 842/2006 proposed obligatory reporting of the use of fluorinated gases. In Portugal, there is a national reporting tool (https://formularios.apambiente.pt/GasesF/) since 2013, where about 10,000 national operators report the use/consumption of fluorinated greenhouse gases. Until 2014, all operators were obliged to report on the national reporting tool.

In 2014, Regulation (EU) No. 517/2014 ("F-gas Regulation") regarding F-gases entered into force and required a stepwise reduction of the F-gases placed on the EU market (expressed in CO2 equivalents) from 1 January 2015 onwards (the so-called HFC phase down). This reduction scheme has triggered technical innovation and the market introduction of numerous alternatives which mostly contain lower shares of HFCs and have lower Global Warming Potential (GWP) than the conventional HFCs used in different applications. The F-gas Regulation also includes a number of bans on the use of F-gases in new products and equipment, where less harmful alternatives are widely available, and F-gas use restrictions. According to this Regulation, in the first phase, from 01/01/2015 to 31/12/2016, only those operators that fulfilled one of the following two requirements – whose equipment contains a load of 5 ton of $CO_2$ eq or more, and fluid amounts equal to or greater than 3 kg - were required to report in the national F-gas reporting tool. More recently, from 01/01/2017 onwards, only those operators that fulfilled the first requirement were required to report in the national F-gas reporting tool.

Recently, Regulation (EU) 2024/573 focusing on F-gases, was adopted by the co-legislators on 7 February 2024 and entered into force on March 11, 2024. This piece introduced amendments to Directive (EU) 2019/1937, repeals Regulation (EU) No 517/2014 (also known as the F-Gas Regulation), and lays down revised and more stricter rules in order to further reduce and limit F-gases.

Information from the national F-gas reporting tool is used in the national inventory, however, currently only to a limited extent:

. to learn about the types of fluids/blends used in Portugal for several sub-categories such as commercial and industrial refrigeration, transport refrigeration, stationary air condition and fire protection;

. to establish the annual share of each gas/blend for each type of equipment for several sub-categories such as transport refrigeration, stationary air condition and fire protection.

Also, this analysis allows for an assessment of the status of the implementation of policies for the replacement of fluorinated gases with a high GWP by less potent ones or by natural fluids (such as hydrocarbons).

From 2015 onwards, not all national operators report in the national reporting tool, therefore, year 2014 is the more accurate to establish a share of each gas/blend for each type of equipment close to national reality.

The Directive 2006/40/EC ("MAC Directive") prohibited the use of F-gases with a GWP of over 150 in new passenger cars since 2017. The Directive leads to replacement of HFC-134a as refrigerant in passenger car air conditioning systems by low GWP solutions. HFC-1234yf is the major refrigerant for air conditioning systems in passenger cars and replaced HFC-134a in new vehicles since 2017.

The table below presents overall values of EFs, their data sources, and brief description of data sources of activity data for 2.F sub-categories reported in this inventory.

*Table 4-46: Overall parameters applied for 2.F sub-categories reported*

| CRF Code | | Categories | Initial Charge (kg/equip) | Initial Charge Source | Initial Emission (k) - % of Initial Charge/year (1) | Operation Emissions (x) - % of Initial Charge/year (2) | Initial Charge Remaining (p) - % (2) | Recovery Efficiency (ηrec,d) - % | Emission Factor Source | IPCC Table |
|---|---|---|---|---|---|---|---|---|---|---|
| **2F1** | | **1. Refrigeration and air conditioning** | | | | | | | | |
| 2F1 | a | Commercial Refrigeration - Stand-alone Commercial Applications | 0.87 | Manufactures | 1.75 | 0.2 | 80 | 60 | IPCC 2006 Guidelines | Table 7.9 |
| 2F1 | a | Commercial Refrigeration - Medium & Large Commercial Applications | var | Survey (4) | 1.75 | 5.5 | 80 | 60 | IPCC 2006 Guidelines | Table 7.9 |
| 2F1 | b | Domestic refrigeration - Fridge | 0.11 | Manufacturers | 0.6 | 0.2 | 80 | 60 | IPCC 2006 Guidelines | Table 7.9 |
| 2F1 | b | Domestic refrigeration - Freezer | 0.18 | Manufacturers | 0.6 | 0.2 | 80 | 60 | IPCC 2006 Guidelines | Table 7.9 |
| 2F1 | c | Industrial refrigeration | var | Industrial Companies | 1.75 | 22.5 | 80 | 60 | IPCC 2006 Guidelines | Table 7.9 |
| 2F1 | d | Transport refrigeration | 5.35 | Manufacturers | 0.6 | 32.5 | 50 | 60 | IPCC 2006 Guidelines | Table 7.9 |
| 2F1 | e | Mobile air-conditioning - Passengers Cars / Light Duty Vehicles | 0.77 | Manufacturers | 0.35 | 15 | 40 (3) | 35 | IPCC 2006 Guidelines | Table 7.9 |
| 2F1 | e | Mobile air-conditioning - Heavy Duty Vehicles | 1.2 | IPCC 2006 Guidelines | 0.35 | 15 | 40 (3) | 35 | IPCC 2006 Guidelines | Table 7.9 |
| 2F1 | e | Mobile air-conditioning - Buses and Coaches | 7.5 | Manufacturers | 0.35 | 15 | 40 (3) | 35 | IPCC 2006 Guidelines | Table 7.9 |
| 2F1 | e | Mobile air-conditioning - Railways | var | Manufacturers | 0.5 (2) | 6 | 40 (3) | 35 | IPCC 2006 Guidelines | Table 7.9 |
| 2F1 | f | Stationary air-conditioning - Residential AC | 0.3 | AC Association | 0.6 | 5.5 | 75 | 40 | IPCC 2006 Guidelines | Table 7.9 |
| 2F1 | f | Stationary air-conditioning - Small Chillers | 100 | AC Association | 0.6 | 5.5 | 90 (1) | 60 | IPCC 2006 Guidelines | Table 7.9 |
| 2F1 | f | Stationary air-conditioning - Medium Chillers | 200 | AC Association | 0.6 | 5.5 | 90 (1) | 60 | IPCC 2006 Guidelines | Table 7.9 |
| 2F1 | f | Stationary air-conditioning - Large Chillers (Shopping Centers) | 441 | AC Association | 0.6 | 5.5 | 90 (1) | 60 | IPCC 2006 Guidelines | Table 7.9 |
| 2F1 | f | Stationary air-conditioning - Large Chillers (Other) | 600 | AC Association | 0.6 | 5.5 | 90 (1) | 60 | IPCC 2006 Guidelines | Table 7.9 |
| **2F2** | | **2. Foam blowing agents** | | | | | | | | |
| 2F2 | a | Closed cells | F-Gas Consumption in Manufacturing | Manufacturers | 10 | 4.5 | - | - | IPCC GP Guidance | Table 3.17 |
| 2F2 | b | Open cells | F-Gas Consumption in Manufacturing | Manufacturers | 100 | - | - | - | IPCC GP Guidance | Table 3.17 |
| **2F3** | | **3. Fire protection** | | | | | | | | |
| 2F3 | | Fire Protection | F-Gas Consumption in Manufacturing | Manufacturers | - | - | 100 (7) | 0 | - | - |
| **2F4** | | **4. Aerosols** | | | | | | | | |
| 2F4 | a | Metered dose inhalers | F-Gas in Pharmaceutical Products | Ass. Pharmaceutical Products | - | 100 (6) | - | - | - | - |
| **2F5** | | **5. Solvents** | | | | | | | | |
| **2F6** | | **6. Other applications** | | | | | | | | |

(1) Average value of the range suggested by the 2006 IPCC Guidelines

(2) Within the range of values proposed by the 2006 IPCC Guidelines (0-70%)

(3) IPCC good Pratice Guidance (Table 3.23) Updated default values = 40%

(4) For further information consult Section 4.7.2.3.2 "Activity Data - Operation and Servicing"

(6) It is assumed that the entire HFC contained in the equipment is issued during operation phase

(7) It is assumed that the entire HFC contained in the equipment is issued at the time of disposal

## 4.7.2 Commercial Refrigeration (CRT 2.F.1.a)

### 4.7.2.1 Category description

Commercial Refrigeration represented the largest share of HFC emissions within the Portuguese 2.F sector in 2024 (51%).

### 4.7.2.2 Methodology

Emissions from Commercial Refrigeration Equipment were estimated using a bottom-up approach Tier 2a according to chapter 7.5 of Volume 3 of the 2006 IPCC Guidelines.

Regarding Commercial Refrigeration, we only consider emissions from equipment filled with HFCs, given that R-12 and R-22 are not a GHGs (moreover, was already covered by the Montreal Protocol) and CRT tables do not include low-GWP refrigerants such as HFOs or natural refrigerants such as CO2 or propane.

Fluid mixtures/blends used in this sector will be disaggregated and emissions will be reported in their single components. The composition and the GWPs of the blends used by the inventory were obtained from the Portuguese Environment Agency and can be consulted (temporarily) in the following link: https://apambiente.pt/sites/default/files/2025-03/base-de-dados-de-gases-fluorados-isolados-e-em-misturas-bd_fgases_site_10_2022.pdf.

Emissions when charging new equipment are estimated by the following equation:

***Equation 4-48: Emissions when charging new equipment***

$$E_{charge\ (t,y)} = N_t \times m_t \times \frac{HFC_y}{100} \times \frac{k}{100}$$

**Where:**

$E_{charge\ (t,y)}$: Emissions of fluid y during system manufacture/assembly in year t (t of fluid)

$N_t$: Number of equipment charged in year t

$m_t$: Amount of refrigeration fluid charged into each equipment in year t (t of fluid)

$HFC_y$: HFC y charged in new equipment (%)

K: Emission factor of assembly losses of the HFC charged into new equipment, per sub-application (%)

Parameter HFCy refers to the percentage of each Gas/Mixture, regardless of the type of equipment, and can be consulted in Table 4-50.

Emissions during equipment lifetime are estimated by the following equation:

***Equation 4-49: Emissions during equipment lifetime***

$$E_{lifetime\ (t,y)} = B_t \times \frac{HFC_y}{100} \times \frac{\chi}{100}$$

**Where:**

$E_{lifetime\ (t,y)}$: Emissions of fluid y during system lifetime in year t (t of fluid)

$B_t$: Amount of fluid banked in existing systems in year t (t of fluid)

$HFC_y$: HFC y banked in existing equipment (%)

χ: Annual emission rate of HFC of each sub-application bank during operation, accounting for average annual leakage and average annual emissions during servicing (%)

Parameter Bt refers to the total amount of fluid banked in existing systems, regardless of the type of gas/mixture, and is estimated according to the following equation:

$$Bt = n.º\ Equipment \times initial\ charge/equipment \times 10^{-3}$$

**Where:**

Bt: Total national amount of fluid banked in equipment (t of fluid)

n.º equipment: Number of equipment

initial charge/equipment: Amount of fluid charged into each equipment (kg/unit)

Chapter *4.7.2.4.2 Activity Data – Operation and Servicing* describes the methodology to assess the number and dimension of non-domestic refrigeration equipment used in commerce, industry, tourism, services and institutional activities. Initial charge/equipment (kg/unit) can be consulted in Table 4-45.

Emissions at system end-of-life (Disposal) are estimated by the following equation:

***Equation 4-50: Emissions at system end-of-life (Disposal)***

$$E_{end-of-life(t,y)} = B_{t-d} \times \frac{HFC_y}{100} \times \frac{Disp}{100} \times \frac{P}{100} \times \left(1 - \frac{\eta_{rec,d}}{100}\right)$$

**Where:**

$E_{end\text{-}of\text{-}life\ (t,y)}$: Emissions of fluid y at system disposal in year t (t of fluid)

$B_{t\text{-}d}$: Amount of fluid banked in existing systems in year (t-d) (t)

$HFC_y$: HFC y banked in existing equipment in year (t-d) (t)

Disp: Annual disposal rate of equipment (%)

P: Residual charge of HFC in equipment being disposed of, expressed in percentage of full charge (%)

$H_{rec,d}$: Recovery efficiency at disposal (%)

d: Year of charging

### 4.7.2.3 Emission Factors

#### 4.7.2.3.1 Emission Factors – Assembly

The value proposed for commercial refrigeration equipment´s initial charge by type is based on a national manufacturers survey. Given that there is no national data available regarding the other parameters, the First charge emission factor considered is an average value taken from Table 7.9 of chapter 7, Volume 3 of the 2006 IPCC Guidelines (0.5-3.0 % of initial charge for Stand-alone and Medium&Large Commercial Applications).

***Table 4-47: Emission Factors considered in assembly***

| Description | Unit | Value |
|---|---|---|
| First charge ($m_t$) | kg/unit | 0.87 |
| First charge emissions (k) | % | 1.75 |

#### 4.7.2.3.2 Emission Factors – Operation and Servicing

***Table 4-48: Emission Factors for F-gas emissions from commercial refrigeration equipment (hypermarkets not included)***

| Type of Equipment | Charging - kg/unit (1) | Lifetime Emissions - % (2) | Residual Charge of HFC in equipment being disposed (P) -%- (3) | Recovery Efficiency at disposal (ηrec) -%- (4) | Annual disposal rate - %- (5) | Lifetime (6) |
|---|---|---|---|---|---|---|
| Mini-Fridge | 0.05 | 0.20 | 80 | 60 | 8.3 | 12 |
| Fridge | 0.11 | 0.20 | 80 | 60 | 8.3 | 12 |
| Horizontal Freezer | 0.87 | 5.50 | 80 | 60 | 8.3 | 12 |
| Congelation Chamber | 1.20 | 5.50 | 80 | 60 | 8.3 | 12 |
| Refrigeration Chamber | 1.20 | 5.50 | 80 | 60 | 8.3 | 12 |
| Supermarket Vertical Freezer Showcase | 0.87 | 5.50 | 80 | 60 | 8.3 | 12 |
| Vertical Freezer | 0.87 | 5.50 | 80 | 60 | 8.3 | 12 |
| Under Bench Refrigerator | 1.31 | 5.50 | 80 | 60 | 8.3 | 12 |
| Supermarket Horizontal Freezer Showcase | 1.31 | 5.50 | 80 | 60 | 8.3 | 12 |
| Fridge (Bottles) | 1.31 | 5.50 | 80 | 60 | 8.3 | 12 |
| Wine Fridge Showcase | 0.87 | 5.50 | 80 | 60 | 8.3 | 12 |
| Ice Machine | 0.05 | 5.50 | 80 | 60 | 8.3 | 12 |
| Juice Machine | 0.05 | 5.50 | 80 | 60 | 8.3 | 12 |
| Ice Cream Machine | 0.05 | 5.50 | 80 | 60 | 8.3 | 12 |
| Chantilly Machine | 0.05 | 5.50 | 80 | 60 | 8.3 | 12 |
| Tap drink cooler | 0.05 | 5.50 | 80 | 60 | 8.3 | 12 |
| Can Vendor | 0.11 | 0.20 | 80 | 60 | 8.3 | 12 |
| Tap beer cooler | 0.05 | 5.50 | 80 | 60 | 8.3 | 12 |

(1) Portuguese manufacturers survey in 2005 (in line with the values proposed in Table 7.9 of the 2006 IPCC Guidelines (0.2-6.0 kg of initial charge for Stand-alone Commercial Applications)
(2) Portuguese manufacturers survey in 2005 (in line with the values proposed in Table 7.9 of the 2006 IPCC Guidelines (1-15 % of initial charge for Stand-alone Commercial Applications)
(3) In line with the values proposed in Table 7.9 of the 2006 IPCC Guidelines (0-80 % for Stand-alone Commercial Applications)
(4) In line with the values proposed in Table 7.9 of the 2006 IPCC Guidelines (0-70 % for Stand-alone Commercial Applications)
(5) Assuming a lifetime of 12 years as stated above, it is assumed that 8.3% (1/12 x 100) of stocks are abated per year, so that at the end of 12 years the stock for a given year has been depleted
(6) Average value taken from Table 7.9 of the 2006 IPCC Guidelines (10-15 for Stand-alone Commercial Applications)

***Table 4-49: Emission Factors for F-gas emissions in hypermarkets***

| Area ($m^2$) | Category | Positive Temperature Initial Charge (kg (1)) | Negative Temperature Initial Charge (kg) (2) | Initial Emission (k) - % of Initial Charge/year (3) | Operation Emissions (x) - % of Initial Charge/year (4) | p (residual charge at disposal) -% (5) | η (recovery efficiency at disposal) - % (6) |
|---|---|---|---|---|---|---|---|
| Area >4500 | Big | 1800 | 1250 | 1.75 | 22.5 | 80 | 60 |
| 1000 ≤ Area ≤ 4500 | Medium | 550 | 350 | 1.75 | 22.5 | 80 | 60 |
| Area < 1000 | Small | 350 | 250 | 1.75 | 22.5 | 80 | 60 |

(1) (2) Portuguese manufacturers survey in 2005
(3) Average value taken from Table 7.9 of the 2006 IPCC Guidelines (0.5-3.0 % of initial charge for Medium & Large Commercial Applications)
(4) Average value taken from Table 7.9 of the 2006 IPCC Guidelines (10-35 % of initial charge for Medium & Large Commercial Applications)
(5) In line with the values proposed in Table 7.9 of the 2006 IPCC Guidelines (0-80 % for Stand-alone Commercial Applications)
(6) In line with the values proposed in Table 7.9 of the 2006 IPCC Guidelines (0-70 % for Stand-alone Commercial Applications)

#### 4.7.2.4 Activity Data

##### 4.7.2.4.1 Activity Data – Assembly

Methodology applied for commercial refrigeration equipment in assembly phase considers the number of new equipment assembled in Portugal and the share of refrigeration fluids used. Due to unavailability of national data regarding the penetration of the different refrigeration fluids in new equipment in Portugal, we assumed the following:

- From 2001 onwards, following the Montreal Protocol, no commercial refrigeration equipment assembled in Portugal is filled with ODS R-12;
- From 2001 onwards, all commercial refrigeration equipment assembled in Portugal were filled with ODS substitutes – high-GWP HFC refrigerants such as R-404a and R-134a;
- From 2009 onwards, commercial refrigeration equipment assembled in Portugal began being replaced with refrigerants with lower GWPs such as R-449A, R-407F or R-422D;
- According to EU F-Gas Regulation, refrigerants exceeding a GWP of 2500 are not allowed in new commercial refrigeration equipment since 2020. Moreover, refrigerants exceeding a GWP of 150 are not allowed in new commercial refrigeration equipment since 2022. The Regulation does not specify any alternative refrigerant or system, leaving the technical choice to manufacturers. Nevertheless, commercial refrigeration industry began launching new equipment using refrigerants such as R-1234ze, which is an HFO with low GWP;
- From 2022 onwards, following the EU F-Gas Regulation restrictions, no commercial refrigeration equipment assembled in Portugal is filled with F-gases;
- According to the refrigeration industry, some equipment brands begun to introduce refrigerants with lower GWPs in new equipment already before the commitment periods established by the legislation (Montreal Protocol and F-Gas Regulation, respectively). However, given there is no available national data on that matter, and assuming that the complete transition to a new refrigerant technology takes place over a 10 year period (according to 2006 IPCC Guidelines), for the time being we assumed a linear transition tendency between the different refrigerant fluids.

The number of assembled commercial refrigeration units in Portugal was obtained from the Industrial Production Survey (IAPI), published by the National Statistics 'Office (INE) from 1992-onwards. 1990-1991 data were interpolated based on 1992-1996 average equipment assembled.

The figures below present the number of equipment assembled in Portugal and fluids installed.

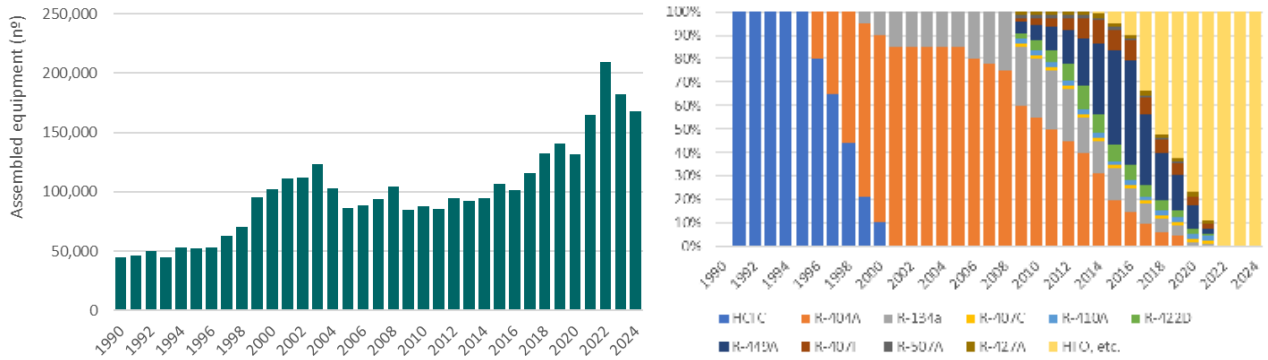



***Figure 4-42: Commercial refrigeration equipment assembled in Portugal and share of fluid by type/blend***

The percentage of each Gas/Mixture, regardless of the type of equipment, can be consulted in the table below. The composition and the GWPs of the blends used by the inventory were obtained from the Portuguese Environment Agency and can be consulted (temporarily) in the following link: https://apambiente.pt/sites/default/files/2025-03/base-de-dados-de-gases-fluorados-isolados-e-em-misturas-bd_fgases_site_10_2022.pdf.

***Table 4-50: Use of each Gas/Mixture in the assembled units (%) - $HFC_y$***

| % of Fluid | Unit | 1995 | 2005 | 2015 | 2020 | 2021 | 2022-onwards |
|---|---|---|---|---|---|---|---|
| CFC-12 | % | 35 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| HCFC-22 | % | 65 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| R-404A | % | 0.0 | 85 | 20 | 0.0 | 0.0 | 0.0 |
| HFC-134A | % | 0.0 | 15 | 13 | 2.0 | 1.0 | 0.0 |
| R-407C | % | 0.0 | 0.0 | 1.5 | 1.5 | 1.5 | 0.0 |
| R-410A | % | 0.0 | 0.0 | 2.0 | 2.0 | 2.0 | 0.0 |
| R-422D | % | 0.0 | 0.0 | 7.0 | 2.0 | 1.0 | 0.0 |
| R-449A | % | 0.0 | 0.0 | 40 | 10 | 2.0 | 0.0 |
| R-407F | % | 0.0 | 0.0 | 9.0 | 4.0 | 2.0 | 0.0 |
| R-507A | % | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 |
| R-427A | % | 0.0 | 0.0 | 1.5 | 1.5 | 1.5 | 0.0 |
| HFOs, etc. | % | 0.0 | 0.0 | 5.0 | 77.0 | 89.0 | 100 |

Source:
. From 1995 to 2004, the sector's experts association (APIRAC);
. From 2014 onwards, the F-gas tool;
. From 2005 to 2013 the information was back casted based on the average of the years 2005 and 2014;
. From 2022 onwards, no commercial refrigeration equipment assembled in Portugal is filled with F-gases.

#### 4.7.2.4.2 Activity Data – Operation and Servicing

There are no available national statistics concerning the number and dimension of non-domestic refrigeration equipment used in commerce, industry, tourism, services and institutional activities. A survey to Hotels, Hostels and Camping Parks was conducted with the support of "Turismo de Portugal, I.P." and "AHP – Associação da Hotelaria de Portugal", in order to obtain real data concerning the number and dimension of non-domestic refrigeration equipment. Data pertaining to other commerce and services activities was estimated with the technical support of APIRAC, Fluorinated Gases Distributors and DGAE (Economic Activities General Directorate). Calculations for Hypermarkets were made separately.

The number of refrigeration equipment was estimated based on the unit numbers available from INE, for the economic activities indicated in the figure below. 2020 numbers are slightly lower due to the COVID pandemic.

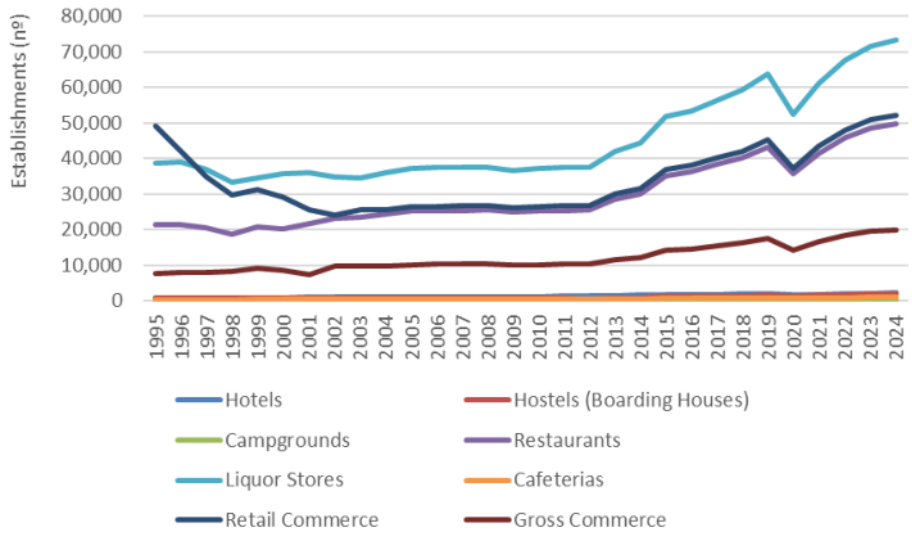



***Figure 4-43: Number of commercial establishments by type***

The following assumptions were made:

- Retail Commerce and Gross Commerce do not include Hypermarkets (large, medium or small);
- For Hotels, Hostels, Boarding Houses, Other Establishments and Campgrounds, the following data was considered:

***Table 4-51: Number of refrigeration equipment per commercial unit in Portugal***

| Type of refrigeration equipments | Hotels | Hostels and Boarding Houses | Campgrounds |
|---|---|---|---|
| Mini-Fridge | 71 | 14 | 40 |
| Fridge | 5 | 2 | 5 |
| Horizontal Freezer | 3 | 2 | 4 |
| Congelation Chamber | 1 | 1 | 1 |
| Refrigeration Chamber | 3 | 2 | 1 |
| Supermarket Vertical Freezer Showcase | 2 | 2 | 2 |
| Vertical Freezer | 1 | 1 | 2 |
| Under Bench Refrigerator | 4 | 2 | 2 |
| Supermarket Horizontal Freezer Showcase | 1 | 1 | 2 |
| Fridge (Bottles) | 1 | 1 | 3 |
| Wine Fridge Showcase | 1 | 1 | 3 |
| Ice Machine | 2 | 1 | 1 |
| Juice Machine | 0 | 0 | 1 |
| Ice Cream Machine | 0 | 1 | 1 |
| Chantilly Machine | 0 | 1 | 0 |
| Tap drink cooler | 1 | 1 | 2 |
| Can Vendor | 0 | 1 | 2 |
| Tap beer cooler | 2 | 1 | 2 |

Source: Survey with the support of "Turismo de Portugal, IP" and "AHP – Associação da Hotelaria de Portugal"

When it was not possible to use real data, the number of equipment per activity was set by expert judgement and through visits to some installations, according to the following table:

***Table 4-52: Number of refrigeration equipment per commercial unit in Portugal***

| Type of refrigeration equipment | Equipment | | | |
|---|---|---|---|---|
| | Frigorific/Congelation Chamber (unit) | Fridge Showcase (m/unit) | Freezer (unit) | Fridge (unit) |
| Restaurants | 1 | 4 | 2 | 1 |
| Liquor stores | - | 4 | - | - |
| Cafeterias | 2 | 4 | 3 | - |
| Retail Commerce | 2 | 10 | - | - |
| Gross Commerce | 2 | 50 | - | - |

Source: Expert Judgement based on local survey

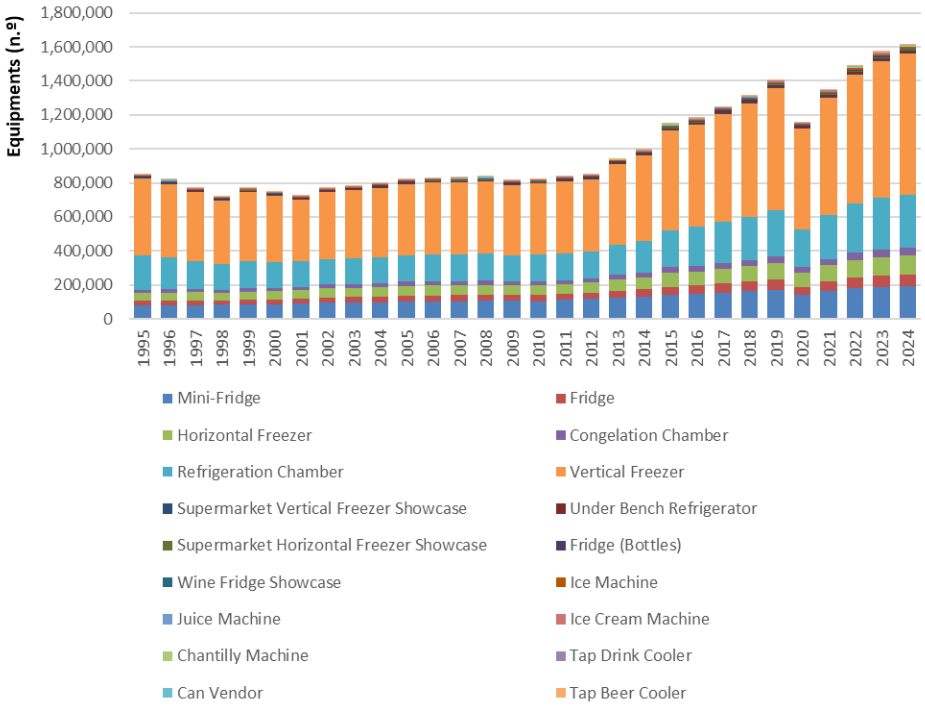



***Figure 4-44: Number of commercial refrigeration equipment***

2020-2021 numbers are slightly lower due to the COVID pandemic. For Hypermarkets, calculations were made using data on average numbers of specific equipment (showcase fridges/freezers, frigorific chambers, freezing chambers) for each category (big, medium and small).

***Table 4-53: Classification of refrigeration equipment by area***

| Area ($m^2$) | Category | Showcase Fridge/Freezer (m) | | Refrigeration Chambers (m2) | Congelation Chambers (m2) |
|---|---|---|---|---|---|
| | | Positive Temperature | Negative Temperature | | |
| Area >4500 | Big | 218 | 110 | 550 | 180 |
| 1000 ≤ Area ≤ 4500 | Medium | 96 | 48 | 75 | 82 |
| Area < 1000 | Small | 40 | 38 | 10 | 20 |

Source: Hypermarket Company

The number of disposed equipment in each year was assumed equal to the number of assembled equipment 12 years before. For disposal calculations, it was considered that the F-gas composition equals that of the year when the equipment was assembled, i.e. that of emission year less the lifetime of the equipment[12]. It was assumed an average lifetime of 12 years.

#### 4.7.2.5 Uncertainty Assessment

We used a triangular distribution to estimate uncertainty values based on the minimum and maximum of the range proposed by the guidelines and the more probable value (expert judgment).

***Table 4-54: Stand-alone commercial units (Hypermarkets equipment not included)***

| Parameter | Minimum Value | Maximum Value | Selected Value | U(%) |
|---|---|---|---|---|
| Number of equipment per commercial place | 0 | 391 | 71.2 | 112.0% |
| Initial Charge | 0.40 | 0.46 | 0.44 | 2.8% |
| AD Combined Uncertainty | - | - | - | 112.5% |
| Lifetime | 10 | 15 | 12 | 8.5% |
| Initial Emission | 0.5 | 3 | 1.75 | 29.2% |
| Lifetime Emission | 1 | 15 | 8 | 35.7% |
| Residual charge remaining at disposal | 0 | 80 | 80 | 20.4% |
| Recovery efficiency at disposal | 0 | 70 | 60 | 23.8% |
| EF Combined Uncertainty | - | - | - | 56.4% |

***Table 4-55: Medium & Large commercial units (Hypermarkets equipment)***

| Parameter | Minimum Value | Maximum Value | Selected Value | U(%) |
|---|---|---|---|---|
| Number of commercial places | - | - | - | 10% |
| Initial Charge | 350 | 1800 | 550 | 53.8% |
| % HFC | - | - | - | 30% |
| AD Combined Uncertainty | - | - | - | 62.4% |
| Lifetime | 10 | 15 | 12 | 8.5% |
| Initial Emission | 0.5 | 3 | 1.75 | 29.2% |
| Lifetime Emission | 10 | 35 | 22.5 | 22.7% |
| Residual charge remaining at disposal | 50 | 100 | 80 | 12.8% |
| Recovery efficiency at disposal | 0 | 70 | 60 | 23.8% |
| EF Combined Uncertainty | - | - | - | 46.6% |

#### 4.7.2.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

#### 4.7.2.7 Recalculations

Following a 2025 ESD review recommendation, methodological changes were made to commercial refrigeration's assembly phase in order to better reflect national circumstances.

Recalculations occurred are mostly due to:

. the revision of activity data time series. In previous submissions, the Party was only working with the number of assembled units from national statistics Industrial Survey (IAPI) available in the period 1995-2007

[12] In consequence no emissions of HFC from disposal are estimated for the reported period.

and missing years were estimated based on GDP values. Following further research to IAPI's database, the Party obtained a complete data series of the number of assembled units, from 1992 to 2024;

. the revision of the fluids considered in assembly phase. Working with data from national F-gas reporting tool, available from 2013 onwards, we learned about the fluids/blends used in commercial equipment in Portugal;

. the revision of the shares of fluids considered in assembly phase. Working with data from national F-gas reporting tool, available from 2013 onwards, we learned about the shares and stocks of fluids/blends used in commercial equipment in Portugal. Also, the Party took into account the placing on the market of refrigeration equipment according to the EU F-gas Regulation. In previous submissions, Portugal was not considering the introduction of the new low-GWP refrigerants, moreover, was considering that high-GWP refrigerants such as R-404a were still being introduced in new equipment. However, according to EU F-Gas Regulation, refrigerants exceeding a GWP of 2500 are not allowed in new commercial refrigeration equipment since 2020. Also, refrigerants exceeding a GWP of 150 are not allowed in new commercial refrigeration equipment since 2022. Therefore, the Party revised the type of fluids and respective shares introduced in assembly phase, according to the trends in national F-gases reporting tool and current restrictions in EU F-gas Regulation.

Emission factors and parameters considered in assembly phase were not revised.

Revised estimates for the assembly phase of 2.F.1.a category resulted in a significant decrease in CO2 eq emissions from 2014 onwards. However, these recalculations were not significant regarding the category's total emissions.

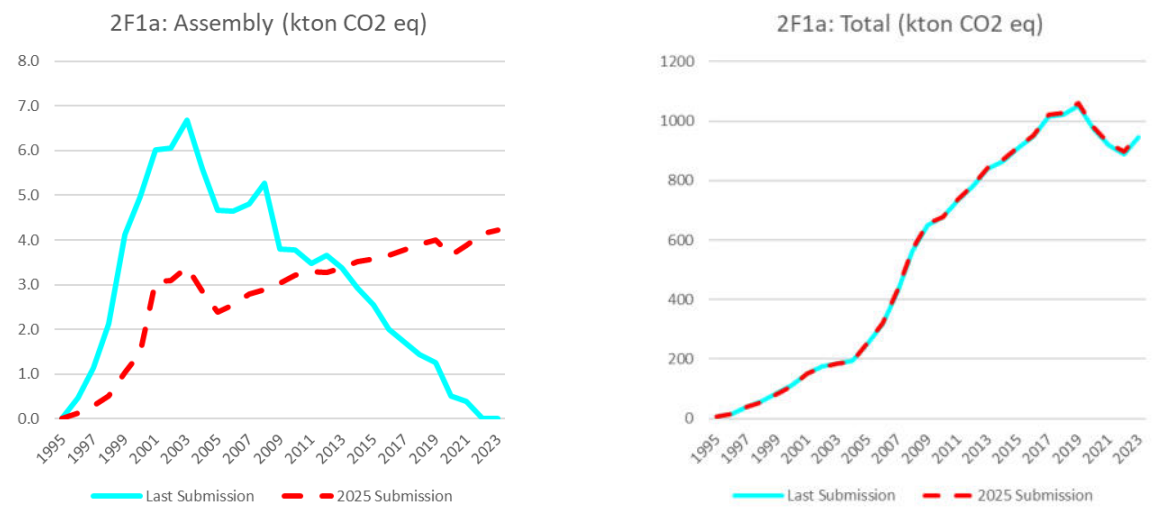



***Figure 4-45: Recalculations in 2.F.1.a: comparison in assembly phase and total 2.F.1.a***

### 4.7.2.8 Further Improvements

We intend to keep working on annual data from the national F-gases reporting tool (FGF) from 2013 onwards and collect information regarding shares and types of fluids in commercial refrigeration in order to revise activity data in operation phase. We also intend to collect further information in order to revise emission factors parameters for this category. Due to human resources constraints and to other priority issues in our Methodological Plan (PDM), we have not yet been able to revise the whole category but intend to do so in a future submission.

## 4.7.3 Domestic Refrigeration (CRT 2.F.1.b)

### 4.7.3.1 Category description

Domestic Refrigeration represented less than 1% of HFC emissions within the Portuguese 2.F sector in 2024.

### 4.7.3.2 Methodology

Regarding domestic refrigeration, we only consider emissions from equipment filled with HFC-134a, given that R-12 is not a GHG (moreover, was already covered by the Montreal Protocol) and CRT tables do not include refrigerant HC-600a.

HFC-134a emissions from Domestic Refrigeration equipment were estimated using a bottom-up approach Tier 2a according to chapter 7.5 of Volume 3 of the 2006 IPCC Guidelines, already described in Commercial Refrigeration (CRT 2.F.1.a). Please check section 4.7.2.2.

### 4.7.3.3 Emission Factors

Emission factors and parameters considered for this activity are listed in the table below. The values proposed for domestic refrigeration equipment´s initial charge by type are based on national manufacturers and suppliers. Given that there is no national data available regarding the other parameters, 2006 IPCC Guidelines for "Domestic Refrigeration" recommend the use of default emission factors shown in Table 7.9 of chapter 7, Volume 3. The values considered are within the ranges proposed in Table 7.9.

***Table 4-56: Emission Factors and parameters of F-gases from Domestic Refrigeration equipment***

| Description | Unit | Refrigerators | Freezers |
|---|---|---|---|
| Initial Charge (1) | Kg/equipment | 0.11 | 0.18 |
| Initial Emission (k) (2) | % | 0.6 | 0.6 |
| Operation Emission (χ) (3) | % | 0.2 | 0.2 |
| p (initial charge remaining) (4) | % | 80 | 80 |
| η (recovery efficiency at disposal) (5) | % | 60 | 60 |
| Lifetime (6) | years | 16 | 16 |
| (1) Average value based on Portuguese manufacturers survey in 2022 (in line with Table 7.9 of the 2006 IPCC Guidelines)<br>(2) Average value taken from Table 7.9 of the 2006 IPCC Guidelines (0.2-1.0 % of initial charge for Domestic Refrigeration)<br>(3) Average value taken from Table 7.9 of the 2006 IPCC Guidelines (0.1-0.5 % of initial charge for Domestic Refrigeration)<br>(4) In line with the values proposed in Table 7.9 of the 2006 IPCC Guidelines (0-80 % for Domestic Refrigeration)<br>(5) In line with the values proposed in Table 7.9 of the 2006 IPCC Guidelines (0-70 % for Domestic Refrigeration)<br>(6) Average value taken from Table 7.9 of the 2006 IPCC Guidelines (12-20 years for Domestic Refrigeration) | | | |

### 4.7.3.4 Activity Data

#### GENERAL ASSUMPTIONS

Regarding domestic refrigeration, we only consider refrigerators and freezers as household refrigeration appliances. The first domestic refrigerators in Portugal date back to the 1950s, and their purchase has become widespread for Portuguese homes since then. In the 1990s and until around 2000, ODS R-12 (GWP of 10,200) was used as refrigerant in domestic fridges and freezers in Portugal.

Following the Montreal Protocol, ODS R-12's phasing-out process lead to the globalization of the use of the refrigerant HFC-134a (GWP of 1,300) in new appliances. In the last few years, HFC-134a's phasing-out has already been taking place, due to the EU F-Gas Regulation No. 517/2014.

According to this Regulation, refrigerants exceeding a GWP of 150 are not allowed in new domestic fridges and freezers since 2015. The Regulation does not specify any alternative refrigerant or system, leaving the technical choice to manufacturers.

Nevertheless, the domestic refrigeration industry began launching new equipment using refrigerant R-600a (isobutane), which is why this low GWP (3) hydrocarbon has been adopted globally.

Therefore, we only consider emissions from domestic refrigeration equipment filled with HFC-134a, given that R-12 is not a GHG (moreover, was already covered by the Montreal Protocol) and CRT tables do not include hydrocarbons such as R-600a. We also consider that fluid mixtures/blends are not used in this sector.

#### ASSEMBLY PHASE

Methodology applied for equipment assembly phase considers the number of new equipment assembled in Portugal and the share of refrigeration fluids used. Due to unavailability of national data regarding the penetration of the different refrigeration fluids in new equipment in Portugal, we assumed the following:

- From 1996 onwards, following the Montreal Protocol, no domestic refrigeration equipment assembled in Portugal is filled with ODS R-12;
- From 1996 to 2005, all domestic refrigeration equipment assembled in Portugal were filled with refrigerant HFC-134a;
- From 2015 onwards, following the F-Gas Regulation, all domestic refrigeration equipment assembled in Portugal were filled with refrigerant R-600a;
- According to the refrigeration industry, some equipment brands begun to introduce R-134a and R-600a in new equipment already before the commitment periods established by the legislation (Montreal Protocol and F-Gas Regulation, respectively). However, given there is no available national data on that matter, and assuming that the complete transition to a new refrigerant technology takes place over a 10 year period (according to 2006 IPCC Guidelines), for the time being we assumed a linear transition tendency between the different refrigerant fluids.

The number of assembled domestic refrigeration units (refrigerators and freezers) in Portugal was obtained from the Industrial Production Survey, published by the National Statistics 'Office (INE) from 1992 onwards. The figure below presents the number of equipment's assembled in Portugal and fluids installed. The significant decrease observed in 2005 in assembled units was due to the closure of a large refrigeration manufacturer in Portugal.

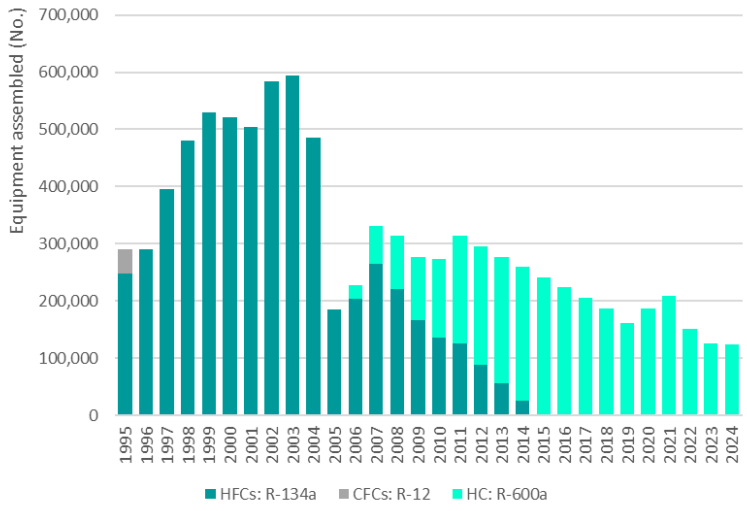



***Figure 4-46: Domestic refrigeration equipment assembled in Portugal by type of fluid***

### OPERATION PHASE

Methodology applied for equipment operation phase takes into account the number of existing refrigeration appliances in households, assumptions made in relation to fluid introduction in assembly phase, as well as a 16-year lifetime for this equipment. Due to unavailability of national data regarding the penetration of the different refrigeration fluids in existing equipment in Portugal, we assumed the following:

- There was no retrofit of R-12 with R-134a in Portugal. Equipment with R-12 maintained it until the end of its life. All new equipment was already assembled with R-134a;
- There is no retrofit of R-134a with R-600a in Portugal. Equipment with R-134a maintained it until the end of its life. All new equipment was already assembled with R-600a;
- It is possible that R-600a is not the only fluid with GWP <150 in household refrigeration appliances in Portugal, however, we can assume that, for the time being, the existence of fluids with GWP <150 other than R-600a is negligible, according to contacts established with Portuguese manufacturers.

Due to unavailability of national data regarding the number of refrigerators/freezers in operation in Portugal, we considered the percentage of households with refrigeration equipment provided by the *Household Consumption Survey*, published by INE/DGEG in every 10 years. We also considered a common household to be a *classic accommodation as main residence* in Portugal. Total annual classic accommodations as main residence in Portugal were obtained from INE's annual publication *Construction and Housing Statistics*.

Also, a 16-year lifetime was considered for these equipment, assumption validated with Portuguese manufacturers. Refrigerators/freezers in operation each year were estimated considering the existing stock in the previous year, adding assembled equipment and subtracting abated equipment.

The figure below presents the domestic refrigeration stock in Portugal and fluids installed.

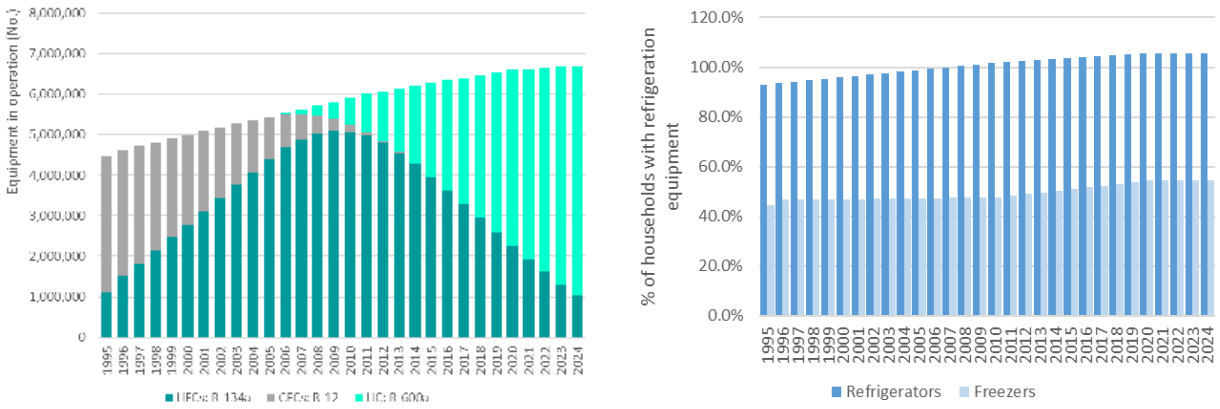



***Figure 4-47: Domestic refrigeration equipment in operation in Portugal by type of fluid and share of households with refrigeration equipment***

### DISPOSAL PHASE

Prohibitions in the use of some HFCs and the phase-down of these compounds only started in the last decade, and therefore little data are available regarding their destruction. Nevertheless, much improvement still needs to be achieved in the recovery and management of F-gases and other refrigerants in Portugal. Despite having legislation that regulates these procedures since around 2006, when entities for management of waste from electrical and electronic equipment (WEEE) were created in Portugal, the country still faces challenges in order to efficiently manage refrigerants, namely:

. low collection rate of this equipment, most of which continues to be sent to non-certified operators, which are not prepared to collect refrigerant fluids, causing their release to the atmosphere;
. city councils have great difficulty in combating the theft of economic value domestic refrigeration equipment, such as compressors, which contain the refrigeration fluids;
. lack of supervision of operators that collect and forward scrap metal for recycling;
. lack of supervision of operators that crush metal scrap, which are the final destination of most refrigeration equipment diverted from the legal circuit;
. WEEE management entities face great challenges in creating efficient collection circuits for refrigeration equipment;
. economic capacity to implement efficient (and sometimes expensive) technologies to improve the collection, recovery, reclaim and destruction of F-gases.

In Portugal, there are no F-gases recovery or destruction facilities; domestic refrigeration equipment is collected and stored in order to be sent abroad (mostly Spain). Emissions of GHGs may occur during the transport of the equipment from the site where they were stored to the recovery/destruction facility and during the destruction process, however, no data is available regarding these issues.

National circumstances over the years have caused an overall growing of the average lifespan of domestic refrigeration equipment. This means that the majority of that equipment currently at end-of-life in Portugal is above 12 years old and is equipped with R-134a fluid. The small (but growing) percentage of end-of-life equipment filled with R-600a is not accounted for in the inventory, for reasons already mentioned.

Upon contact with sectoral authorities, we have learned that illegal dismantling of refrigeration equipment still occurs in Portugal in order to recover metals (mostly compressors, due to its market value) and other material, with no concerns for the potential refrigerant release. However, we have not been able to quantify exactly how much of this illegal activity occurs in Portugal. No national data on initial charge remaining on refrigeration equipment at end-of-life or recovery efficiencies are available, therefore, a default value within the range suggested in Table 7.9 of chapter 7.5.2.2 Volume 3 of the 2006 IPCC Guidelines was used.

There is no available national data regarding the number of disposed refrigerators/freezers in Portugal. Therefore, the number of disposed refrigerators/freezers in Portugal was estimated in parallel with the domestic refrigeration stock estimates, where all equipment purchased annually since 1970 (obtained from INE) is considered, as well as its disposal 16 years later (considering a normal lifetime distribution around 16 years).

The figure below presents the domestic refrigeration at end-of-life in Portugal by type of fluid installed.

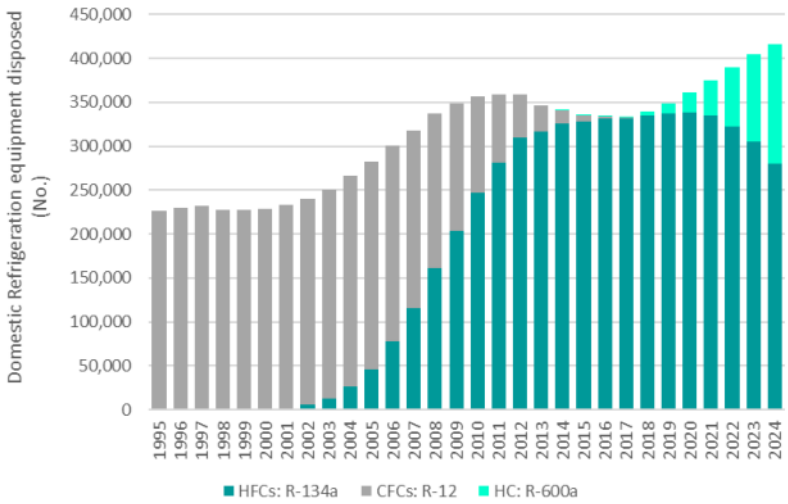



***Figure 4-48: Domestic refrigeration equipment disposed in Portugal by type of fluid***

### 4.7.3.5 Uncertainty Assessment

A triangular distribution was used to estimate uncertainty values based on the minimum and maximum of the range proposed by 2006 IPCC Guidelines and the more probable value (expert judgment).

***Table 4-57: Domestic Refrigeration – Fridge***

| Parameter | Minimum Value | Maximum Value | Selected Value | U(%) |
|---|---|---|---|---|
| Number of equipment | - | - | - | 10.0% |
| Initial Charge | 0.10 | 0.12 | 0.11 | 3.8% |
| % HFC | | | | 30.0% |
| AD Combined Uncertainty | - | - | - | 31.8% |
| Lifetime | 12 | 20 | 12 | 13.6% |
| Initial Emission | 0.2 | 1.0 | 0.6 | 27.2% |
| Lifetime Emission | 0.1 | 0.5 | 0.2 | 40.8% |
| Residual charge remaining at disposal | 0 | 80 | 80 | 20.4% |
| Recovery efficiency at disposal | 0 | 70 | 60 | 23.8% |
| EF Combined Uncertainty | - | - | - | 59.8% |

***Table 4-58: Domestic Refrigeration –Freezers***

| Parameter | Minimum Value | Maximum Value | Selected Value | U(%) |
|---|---|---|---|---|
| Number of equipment | - | - | - | 10.0% |
| Initial Charge | 0.10 | 0.26 | 0.18 | 18.3% |
| % HFC | | | | 30.0% |
| AD Combined Uncertainty | - | - | - | 36.5% |
| Lifetime | 12 | 20 | 12 | 13.6% |
| Initial Emission | 0.2 | 1.0 | 0.6 | 27.2% |
| Lifetime Emission | 0.1 | 0.5 | 0.2 | 40.8% |
| Residual charge remaining at disposal | 0 | 80 | 80 | 20.4% |
| Recovery efficiency at disposal | 0 | 70 | 60 | 23.8% |
| EF Combined Uncertainty | - | - | - | 59.8% |

#### 4.7.3.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

2002-2023 data on total annual classic accommodations as main residence in Portugal was revised, during QA/QC procedures to national statistics database.

a compilation error was identified regarding a 2021 abatement formula.

#### 4.7.3.7 Recalculations

Minor recalculations occurred in R-134a emissions in the period 2002-2023 due to the revision of total annual classic accommodations as main residence in Portugal, during QA/QC procedures to national statistics database.

#### 4.7.3.8 Further Improvements

No further improvements are expected.

## 4.7.4 Industrial Refrigeration (CRT 2.F.1.c)

### 4.7.4.1 Category description

Industrial Refrigeration represented less than 1% of HFC emissions within the Portuguese 2.F sector in 2024.

### 4.7.4.2 Methodology

Emissions from Industrial Refrigeration equipment were estimated using a bottom-up approach Tier 2a.

Emissions when charging new equipment are estimated by the following equation:

***Equation 4-51: Emissions when charging new equipment***

$$E_{charge\ (t,y)} = N_t \times m_t \times \frac{HFC_y}{100} \times \frac{k}{100}$$

**Where:**

$E_{charge\ (t,y)}$: Emissions of fluid y during system manufacture/assembly in year t (t of fluid)

$N_t$: Number of equipment charged in year t

$m_t$: Amount of refrigeration fluid charged into each equipment in year t (t of fluid)

$HFC_y$: HFC y charged in new equipment (%)

K: Emission factor of assembly losses of the HFC charged into new equipment, per sub-application (%)

Parameter HFCy refers to the percentage of each Gas/Mixture, regardless of the type of equipment, can be consulted in Table 4-48.

Emissions during equipment lifetime are estimated by the following equation:

***Equation 4-52: Emissions during equipment lifetime***

$$E_{lifetime\ (t,y)} = B_t \times \frac{HFC_y}{100} \times \frac{\chi}{100}$$

**Where:**

$E_{lifetime\ (t,y)}$: Emissions of fluid y during system lifetime in year t (t of fluid)

$B_t$: Amount of fluid banked in existing systems in year t (t of fluid)

$HFC_y$: HFC y banked in existing equipment (%)

χ: Annual emission rate of HFC of each sub-application bank during operation, accounting for average annual leakage and average annual emissions during servicing (%)

Parameter Bt refers to the total amount of fluid banked in existing systems, regardless of the type of gas/mixture, and is estimated according to the following equation:

$$Bt = \text{n.º Equipment} \times \text{initial charge/equipment} \times 10^{-3}$$

**Where:**

Bt: Total national amount of fluid banked in equipment (t of fluid)

n.º equipment: Number of equipment

initial charge/equipment: Amount of fluid charged into each equipment (kg/unit)

Chapter *4.7.4.4 Activity Data* describes the methodology to assess the number and dimension of non-domestic refrigeration equipment used in commerce, industry, tourism, services and institutional activities. Initial charge/equipment (kg/unit) can be consulted in Table 4-60.

Emissions at system end-of-life (Disposal) are estimated by the following equation:

***Equation 4-53: Emissions at system end-of-life (Disposal)***

$$E_{end-of-life(t,y)} = N_{t-d} \times m_{t-d} \times \frac{HFC_y}{100} \times \frac{P}{100} \times \left(1 - \frac{\eta_{rec,d}}{100}\right)$$

**Where:**

$E_{end\text{-}of\text{-}life\ (t,y)}$: Emissions of fluid y at system disposal in year t (t of fluid)

$N_{t\text{-}d}$: Number of equipment charged in year t-d (Nr)

$m_{t\text{-}d}$: Amount of fluid banked in existing systems in year (t-d) (t)

$HFC_y$: HFC y banked in existing equipment in year (t-d) (t)

Disp: Annual disposal rate of equipment (%)

P: Residual charge of HFC in equipment being disposed of, expressed in percentage of full charge (%)

$H_{rec,d}$: Recovery efficiency at disposal (%)

d: Year of charging

### 4.7.4.3 Emission Factors

The following emission factors and parameters were considered for this activity, usually corresponding to values within the ranges proposed in Table 7.9 of chapter 7 of the 2006 IPCC Guidelines for "Industrial Refrigeration including Food Processing and Cold Storage". The composition and the GWPs of the blends used by the inventory were obtained from the Portuguese Environment Agency and can be consulted (temporarily) in the following link: https://apambiente.pt/sites/default/files/2025-03/base-de-dados-de-gases-fluorados-isolados-e-em-misturas-bd_fgases_site_10_2022.pdf.

***Table 4-59: Industrial Refrigeration emission factors***

| Description | Unit | Emission Factor | Source |
|---|---|---|---|
| Initial Emission (k) | % | 1.75 | Average value taken from Table 7.9 of the 2006 IPCC Guidelines (0.5-3.0 % of initial charge for Industrial Refrigeration) |
| Lifetime Emission (x) | % | 22.5 | In line with the values proposed in Table 7.9 of the 2006 IPCC Guidelines (7-25 % of initial charge for Industrial Refrigeration) |
| Lifetime | Years | 12 | In line with the values proposed in Table 7.9 of the 2006 IPCC Guidelines (7-15 for Medium & Large Commercial Refrigeration) |
| p (residual charge at disposal) | % | 80 | In line with the values proposed in Table 7.9 of the 2006 IPCC Guidelines (50-100 % for Industrial Refrigeration) |
| η (recovery efficiency at disposal) | % | 60 | In line with the values proposed in Table 7.9 of the 2006 IPCC Guidelines (0-90 % for Industrial Refrigeration) |

#### 4.7.4.4 Activity Data

Activity data was obtained from companies that use industrial refrigeration equipment in their activity. Unavailable data was forecasted by APA based on GDP trend. Due to confidentiality constraints, it is not possible to present activity data.

The percentage of each Gas/Mixture, regardless of the type of equipment, can be consulted in the table below. The composition and the GWPs of the blends used by the inventory were obtained from the Portuguese Environment Agency and can be consulted (temporarily) in the following link: https://apambiente.pt/sites/default/files/2025-03/base-de-dados-de-gases-fluorados-isolados-e-em-misturas-bd_fgases_site_10_2022.pdf.

#### 4.7.4.5 Uncertainty Assessment

We used a triangular distribution to estimate uncertainty values based on the minimum and maximum of the range proposed by the 2006 IPCC Guidelines and the more probable value (expert judgment).

***Table 4-60: Industrial Refrigeration***

| Parameter | Minimum Value | Maximum Value | Selected Value | U(%) |
|---|---|---|---|---|
| Number of industrial plants | - | - | - | 10.0% |
| Initial Charge | 350 | 1800 | 550 | 53.8% |
| % HFC | | | | 30.0% |
| AD Combined Uncertainty | - | - | - | 62.4% |
| Lifetime | 10 | 15 | 12 | 8.5% |
| Initial Emission | 0.5 | 3 | 1.75 | 29.2% |
| Lifetime Emission | 10 | 35 | 22.5 | 22.7% |
| Residual charge remaining at disposal | 50 | 100 | 80 | 12.8% |
| Recovery efficiency at disposal | 0 | 70 | 60 | 23.8% |
| EF Combined Uncertainty | - | - | - | 46.6% |

#### 4.7.4.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

#### 4.7.4.7 Recalculations

During 2025 ESD review, the TERT verified that some estimates for 2.F.1.c Industrial refrigeration were constant across some years. Due to unavailability of national data regarding the industrial refrigeration equipment assembled in Portugal, 2010-2023 activity data was reviewed and updated according to GDP trend.

Following further analysis to the national F-gases reporting tool (FGF) from 2013 onwards, the Party verified that no PFCs are reported by industrial operators, therefore, PFC activity data and respective emissions (C2F6 and C3F8) were eliminated from this category.

Emission factors and parameters considered were not revised.

Revised estimates of 2.F.1.c category resulted in a significant decrease in CO2 eq emissions and are presented in the figure below. Previously, this category represented about 2% of total 2.F emissions.

Recalculations concerning category 2.F.1.c emissions represented 0% in 1995 (base year for F-gases), - 88% in 2005 and -90% in 2023.

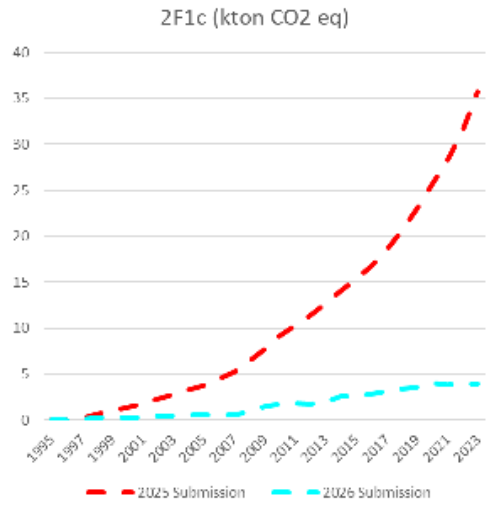



***Figure 4-49: Recalculations in 2.F.1.c***

### 4.7.4.8 Further Improvements

The Party intends to resume the already started task on obtaining annual data from the national F-gases reporting tool (FGF) from 2013 onwards and collect information regarding industrial refrigeration. We also intend to collect further information in order to revise the assumptions on the shares of fluids and emission factors parameters for this category. Due to human resources constraints and to other priority issues in our Methodological Plan (PDM), we have not yet been able to finalise the revision of these estimates but intend to do so in a future submission.

### 4.7.5 Transport Refrigeration (CRT 2.F.1.d)

#### 4.7.5.1 Category description

Transport Refrigeration represented about 3% of HFC emissions within the Portuguese 2.F sector in 2024.

#### 4.7.5.2 Methodology

Emissions from Transport Refrigeration Equipment were estimated using a bottom-up approach Tier 2a.

Emissions when charging new equipment are estimated by the following equation:

***Equation 4-54: Emissions when charging new equipment***

$$E_{charge\ (t,y)} = N_t \times m_t \times \frac{HFC_y}{100} \times \frac{k}{100}$$

**Where:**

$E_{charge\ (t,y)}$: Emissions of fluid y during system manufacture/assembly in year t (t of fluid)

$N_t$: Number of equipment charged in year t (Nr)

$m_t$: Amount of refrigeration fluid charged into each equipment in year t (t of fluid)

$HFC_y$: HFC y charged in new equipment (%)

K: Emission factor of assembly losses of the HFC charged into new equipment, per sub-application (%)

Parameter HFCy refers to the percentage of each Gas/Mixture, regardless of the type of equipment, and can be consulted in Table 4-48.

Emissions during equipment lifetime are estimated by the following equation:

***Equation 4-55: Emissions during equipment lifetime***

$$E_{lifetime\ (t,y)} = B_t \times \frac{HFC_y}{100} \times \frac{\chi}{100}$$

**Where:**

$E_{lifetime\ (t,y)}$: Emissions of fluid y during system lifetime in year t (t of fluid)

$B_t$: Amount of fluid banked in existing systems in year t (t of fluid)

$HFC_y$: HFC y banked in existing equipment (%)

χ: Annual emission rate of HFC of each sub-application bank during operation, accounting for average annual leakage and average annual emissions during servicing (%)

Parameter Bt refers to the total amount of fluid banked in existing systems, regardless of the type of gas/mixture, and is estimated according to the following equation:

$$Bt = \text{n.º Equipment} \times \text{initial charge/equipment} \times 10^{-3}$$

**Where:**

Bt: Total national amount of fluid banked in equipment (t of fluid)

n.º equipment: Number of equipment

initial charge/equipment: Amount of fluid charged into each equipment (kg/unit)

Chapter *4.7.5.4.2 Activity Data – Operation and Servicing* describes the methodology to assess the number and dimension of non-domestic refrigeration equipment used in commerce, industry, tourism, services and institutional activities. Initial charge/equipment (kg/unit) can be consulted in Table 4-62.

Emissions at system end-of-life (Disposal) are estimated by the following equation:

***Equation 4-56: Emissions at system end-of-life (Disposal)***

$$E_{end-of-life(t,y)} = N_{t-d} \times m_{t-d} \times \frac{HFC_y}{100} \times \frac{P}{100} \times \left(1 - \frac{\eta_{rec,d}}{100}\right)$$

**Where:**

$E_{end\text{-}of\text{-}life\ (t,y)}$: Emissions of fluid y at system disposal in year t (t of fluid)

$N_{t\text{-}d}$: Number of equipment charged in year t-d (Nr)

$m_{t\text{-}d}$: Amount of fluid banked in existing systems in year (t-d) (t)

$HFC_y$: HFC y banked in existing equipment in year (t-d) (t)

Disp: Annual disposal rate of equipment (%)

P: Residual charge of HFC in equipment being disposed of, expressed in percentage of full charge (%)

$H_{rec,d}$: Recovery efficiency at disposal (%)

D: Year of charging

### 4.7.5.3 Emission Factors

The value for initial charge was assumed to be 5.35 kg/unit (average of the values proposed by national manufacturers and suppliers) which is within the recommended IPCC range (3 to 8 kg/unit). Lifetime was set at 10 years (average of the values proposed by manufacturers and suppliers).

***Table 4-61: Transport Refrigeration emission factors***

| Description | Unit | Emission Factor | Source |
|---|---|---|---|
| Initial Charge | Kg/equipment | 5.35 | Average value based on Portuguese manufacturers survey in 2005 (in line with the values proposed in Table 7.9 of the 2006 IPCC Guidelines - 3-8 kg for Transport Refrigeration) |
| Initial Emission (k) | % | 0.6 | Average value taken from Table 7.9 of the 2006 IPCC Guidelines (0.2-10 % of initial charge for Transport Refrigeration) |
| Lifetime Emission (x) | % | 32.50 | Average value taken from Table 7.9 of the 2006 IPCC Guidelines (15-50 % of initial charge for Transport Refrigeration) |
| Lifetime | Years | 10 | Average value based on Portuguese manufacturers survey in 2005 |
| p (residual charge at disposal) | % | 50.00 | In line with the values proposed in Table 7.9 of the 2006 IPCC Guidelines (0-50 % for Transport Refrigeration) |
| η (recovery efficiency at disposal) | % | 60.00 | In line with the values proposed in Table 7.9 of the 2006 IPCC Guidelines (0-70 % for Transport Refrigeration) |

### 4.7.5.4 Activity Data

#### 4.7.5.4.1 Activity Data – Assemblage

It was assumed that, before 1996, CFC-12 was used in Portugal as Refrigeration Fluid instead of HFC. From 1996 onwards it is assumed that 20% of the equipment are assembled with HFC-134a and 80% with R-404A. From 2011 onwards it is assumed that other fluids with lower GWP are introduced in assembled units. Data on the number of equipment assembled in Portugal was collected from equipment manufacturers in the period 1996-2010. From 2011 onwards, this number was estimated based on year 2010 value and on GDP trend. 2020-2021 numbers are slightly lower due to the COVID pandemic.

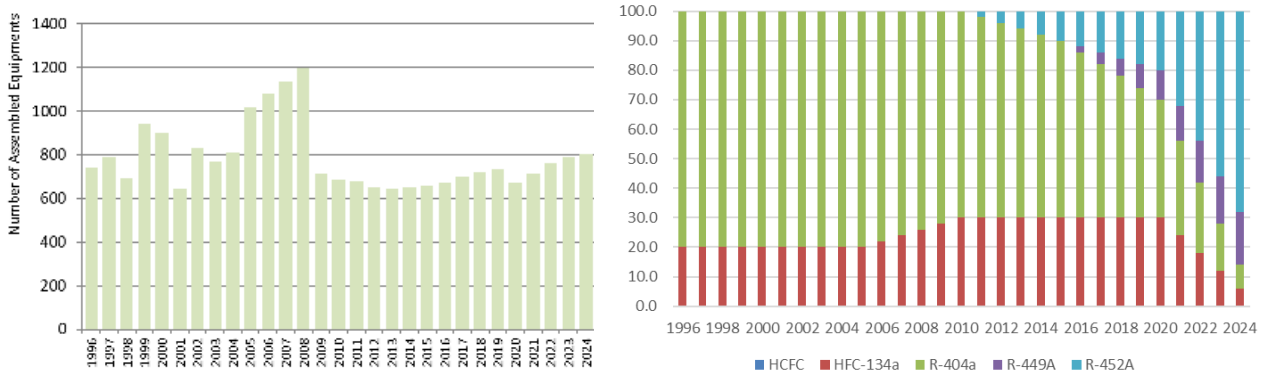



***Figure 4-50: Number of equipment assembled and shares of fluids in assembly phase in Portugal***

#### 4.7.5.4.2 Activity Data – Operation and Servicing

Data on the number of registered vehicles was provided by the Portuguese Authority on Vehicles (ex-DGV) in the period 1996-2005. From 2006 onwards, this number was estimated based on year 2005 value and on GDP trend.

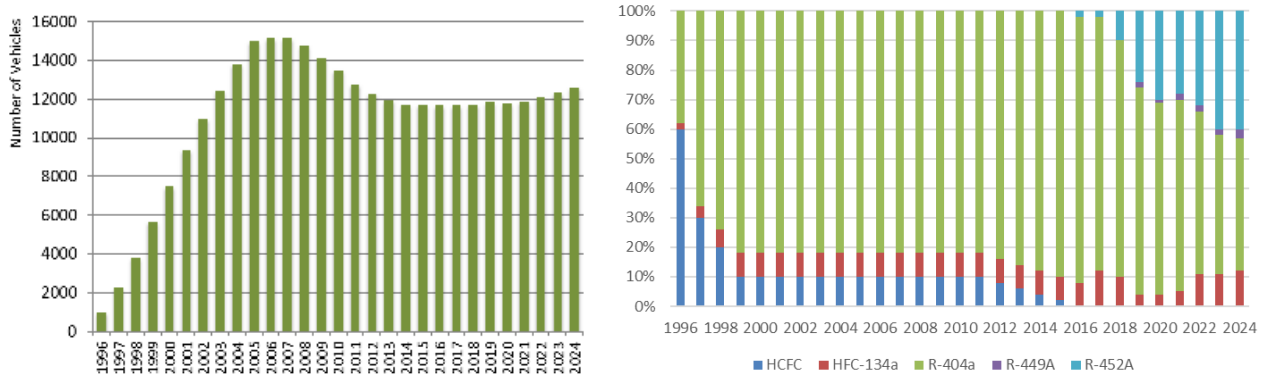



***Figure 4-51: Number of registered vehicles in circulation and shares of fluids in operation phase in Portugal***

The percentage of each Gas/Mixture, regardless of the type of equipment, can be consulted in the table below. The composition and the GWPs of the blends used by the inventory were obtained from the Portuguese Environment Agency and can be consulted (temporarily) in the following link: https://apambiente.pt/sites/default/files/2025-03/base-de-dados-de-gases-fluorados-isolados-e-em-misturas-bd_fgases_site_10_2022.pdf.

Activity Data – Disposal

It was assumed a lifetime of 10 years.

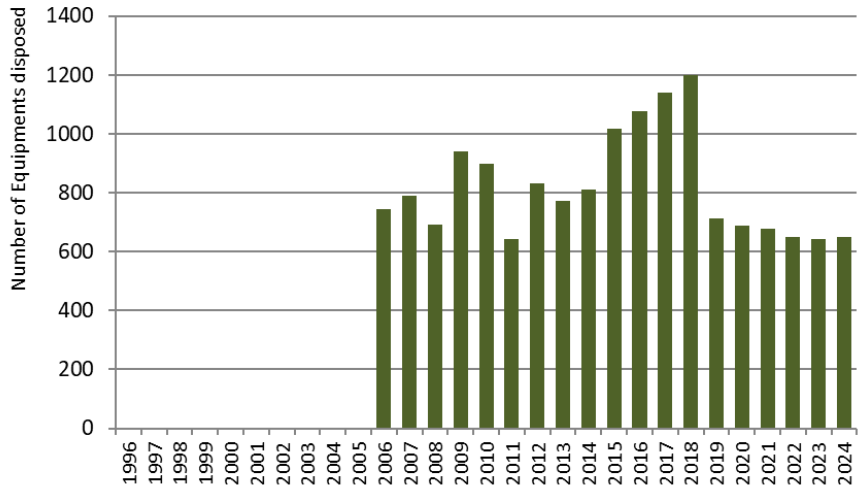



***Figure 4-52: Disposal of equipment using HFC***

### 4.7.5.5 Uncertainty Assessment

We used a triangular distribution to estimate uncertainty values based on the minimum and maximum of the range proposed by the 2006 IPCC Guidelines and the more probable value (expert judgment).

***Table 4-62: Uncertainty parameters for Transport Refrigeration***

| Parameter | Minimum Value | Maximum Value | Selected Value | U(%) |
|---|---|---|---|---|
| Number of equipment | - | - | - | 10.0% |
| Initial Charge | 1.57 | 10.00 | 5.35 | 32.2% |
| % HFC | | | | 30.0% |
| AD Combined Uncertainty | - | - | - | 45.1% |
| Lifetime | 6 | 10 | 10 | 8.2% |
| Initial Emission | 0.2 | 1.0 | 1.0 | 16.3% |
| Lifetime Emission | 15 | 50 | 32.5 | 22.0% |
| Residual charge remaining at disposal | 0 | 50 | 50 | 20.4% |
| Recovery efficiency at disposal | 0 | 70 | 70 | 23.8% |
| EF Combined Uncertainty | - | - | - | 42.4% |

### 4.7.5.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

### 4.7.5.7 Recalculations

Following a 2025 ESD review recommendation, methodological changes were made to 2.F.1.d Transport refrigeration assembly and operation phases in order to better reflect national circumstances.

Recalculations occurred are mostly due to:

. the revision of assembly activity data time series. During 2025 ESD review, the TERT verified that some estimates for 2.F.1.d Transport refrigeration were constant across some years. Due to unavailability of national data regarding refrigerated trucks equipment assembled in Portugal, 2006-2023 activity data was reviewed and updated according to GDP trend;

. the revision of the types of fluids considered in assembly and operation phases. In previous submissions, we were only considering R-134a and R-404a fluids. Working with data from national F-gas reporting tool, available from 2013 onwards, we learned and revised the types of fluids/blends used in transport refrigeration equipment in Portugal;

. the revision of the shares of fluids considered in assembly and operation phases. Working with data from national F-gas reporting tool, available from 2013 onwards, we learned about the shares and stocks of fluids/blends used in refrigerated transport in Portugal. Also, the Party revised the type of fluids and respective shares introduced in assembly phase, according to the trends in national F-gases reporting tool and current restrictions in EU F-gas Regulation.

Emission factors and parameters considered in this sub-category were not revised.

Revised estimates of 2.F.1.d category are presented in the figures below and resulted in a slight increase in CO2 eq emissions, due to the revision of the types and shares of fluids. However, these recalculations were not significant regarding the category's 2.F.1 total emissions.

Recalculations concerning category 2.F.1.d CO2 eq emissions represented -41% in 1996, 27% in 2005 and - 5% in 2023.

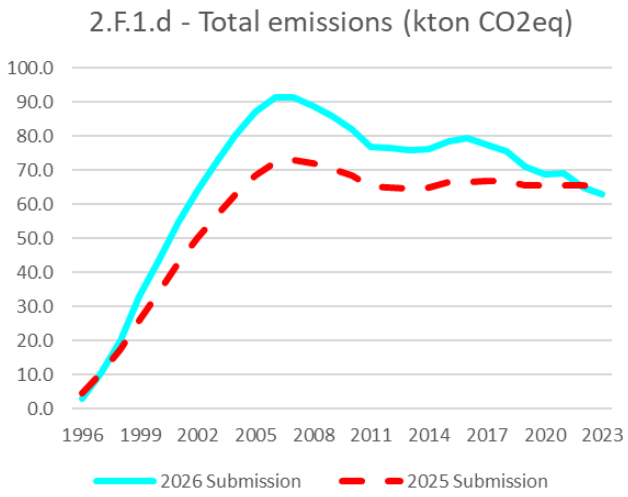



***Figure 4-53: Recalculations in Transport Refrigeration***

### 4.7.5.8 Further Improvements

We intend to resume work and collect information regarding transport refrigeration equipment assembled in Portugal. We also intend to collect further information in order to revise the assumptions on the shares of fluids and emission factors parameters for this category. Due to human resources constraints and to other priority issues in our Methodological Plan (PDM), we have not yet been able to complete the revision to these estimates but intend to do so in a future submission.

## 4.7.6 Mobile Air Conditioning (CRT 2.F.1.e)

### 4.7.6.1 Category description

This chapter intends to estimate emissions from Mobile air conditioning systems from road transportation and railways in Portugal.

Mobile air conditioning systems represented the second largest share of HFC emissions within the Portuguese 2.F sector in 2024 (31%).

### 4.7.6.2 Methodology

Regarding railways, HFC emissions from MAC systems were estimated using the same methodology as in Transport Refrigeration (2.F.1.d).

As for mobile air conditioning systems from road transportation, we only consider emissions from MACs filled with HFC-134a, given that R-12 is not a GHG (moreover, was already covered by the Montreal Protocol) and CRT tables do not include refrigerant HFO-1234yf.

HFC-134a emissions from Mobile Air Conditioning equipment were estimated using a bottom-up approach Tier 2a according to chapter 7.5 of Volume 3 of the 2006 IPCC Guidelines.

#### ASSEMBLY PHASE

HFC-134a emissions when charging new MAC equipment into vehicles were estimated by the following equation:

***Equation 4-57: Emissions when charging new MAC equipment***

$$Emi_{charge} = N_{MAC} \times \frac{m_{MAC}}{1000} \times \frac{k}{100}$$

**Where:**

$Emi_{charge}$: Emissions of HFC-134a during vehicle manufacture/assembly, by type of vehicle (t of fluid)

$N_{MAC}$: Number of vehicles manufactured/assembled in Portugal with MAC filled with HFC-134a, by type of vehicle (nr)

$m_{MAC}$: Initial charge of HFC-134a into each MAC, by type of vehicle (kg fluid/equipment)

k: Initial emission factor of HFC-134a charged into new MAC, by type of vehicle (%)

#### OPERATION PHASE

HFC-134a emissions during MAC equipment lifetime were estimated by the following equation:

***Equation 4-58: Emissions during MAC equipment lifetime***

$$Emi_{lifetime} = V_{MAC} \times \frac{m_{MAC}}{1000} \times \frac{\chi}{100}$$

**Where:**

$Emi_{lifetime}$: Emissions of HFC-134a during MAC system lifetime, by type of vehicle (t of fluid)

$V_{MAC}$: Number of vehicles circulating in Portugal with MAC filled with HFC-134a, by type of vehicle (nr)

$m_{MAC}$: Initial charge of HFC-134a in each MAC, by type of vehicle (kg fluid/equipment)

$\chi$: Operation emission factor of HFC-134a in MAC, by type of vehicle (%)

#### DISPOSAL PHASE

HFC-134a emissions at MAC system end-of-life (Disposal) assumed that a MAC system has the same lifetime as the vehicle and were estimated by the following equation:

***Equation 4-59: Emissions at MAC system end-of-life (Disposal)***

$$Emi_{end-of-life} = V_{end-of-life} \times \frac{m_{MAC}}{100} \times \frac{p}{100} \times \left(1 - \frac{\eta_{rec}}{100}\right)$$

**Where:**

$E_{end\text{-}of\text{-}life}$: Emissions of HFC-134a during MAC system disposal, by type of vehicle (t of fluid)

$V_{end\text{-}of\text{-}life}$: Number of vehicles at end-of-life in Portugal with MAC filled with HFC-134a, by type of vehicle (nr)

$m_{MAC}$: Initial charge of HFC-134a in each MAC, by type of vehicle (kg fluid/equipment)

p: Initial charge of HFC-134a remaining in MAC at vehicle disposal (%)

$\eta_{rec}$: Recovery efficiency at disposal (%)

### 4.7.6.3 Emission Factors

#### 4.7.6.3.1 Emission Factors – Road Transportation

Emission factors and parameters considered for this activity are listed in the table below. The values proposed for MAC´s initial charge by type of vehicle are based on national manufacturers and suppliers. Given that there is no national data available regarding the other parameters, 2006 IPCC Guidelines for "Mobile AC" recommend the use of default emission factors shown in Table 7.9 of chapter 7, Volume 3. The values considered are within the ranges proposed in Table 7.9.

***Table 4-63: Mobile Air Conditioning emission factors and parameters for Road Transportation***

| Description | Unit | Passenger Cars | Light Duty Vehicles | Heavy Duty Vehicles | Buses and Coaches |
|---|---|---|---|---|---|
| Initial Charge (1) | Kg/equipment | 0.77 | 0.77 | 1.20 | 7.50 |
| Initial Emission (k) (2) | % | 0.35 | 0.35 | 0.35 | 0.35 |
| Operation Emission (χ) (3) | % | 15 | 15 | 15 | 15 |
| p (initial charge remaining) (4) | % | 40 | 40 | 40 | 40 |
| η (recovery efficiency at disposal) (5) | % | 35 | 35 | 35 | 35 |
| (1) Average value based on Portuguese manufacturers survey in 2005<br>(2) Average value taken from Table 7.9 of the 2006 IPCC Guidelines (0.2-0.5 % of initial charge for Mobile A/C)<br>(3) Average value taken from Table 7.9 of the 2006 IPCC Guidelines (10-20 % of initial charge for Mobile A/C)<br>(4) Default value from Table 3.23 of the IPCC Good Practice Guidance (in line with the values proposed in Table 7.9 of the 2006 IPCC Guidelines - 0-50 % for Mobile A/C)<br>(5) In line with the values proposed in Table 7.9 of the 2006 IPCC Guidelines (0-50 % for Mobile A/C) | | | | | |

#### 4.7.6.3.2 Emission Factors – Railways

The following emission factors and parameters were considered for this activity, the majority corresponding to values within the ranges proposed in Table 7.9 of chapter 7 of the 2006 IPCC Guidelines for "Mobile AC". MAC´s initial charge by crew/passenger room values proposed are based on national manufacturers and suppliers.

*Table 4-64: Mobile Air Conditioning emission factors and parameters for Railways*

| Description | Unit | Value | Source |
|---|---|---|---|
| Initial Charge | Kg/equipment | 1.05-1.50 (crew room)<br>4-20 (passenger room) | Average value based on Portuguese manufacturers survey in 2005 |
| Initial Emission (k) | % | 0.5 | German NID |
| Operation Emission (χ) | % | 6 | German NID |
| Lifetime (d) | Years | 25 | German NID |
| p (initial charge remaining) | % | 40 | Default value from Table 3.23 of the IPCC Good Practice Guidance (in line with the values proposed in Table 7.9 of the 2006 IPCC Guidelines - 0-50 % for Mobile A/C) |
| η (recovery efficiency at disposal) | % | 35 | In line with the values proposed in Table 7.9 of the 2006 IPCC Guidelines (0-50 % for Mobile A/C) |

### 4.7.6.4 Activity Data

Estimates for Road Transportation and Railways were made separately.

#### 4.7.6.4.1 Activity Data – Road Transportation

**BRIEF CONTEXTUALIZATION**

In the 1980s there were practically no cars circulating with Mobile Air Conditioning (MAC) in Portugal.

In the 1990s and until around 2000, ODS R-12 (GWP of 10900) was used in MAC systems, but only for top-of-the-range passenger vehicles circulating in Portugal. All other vehicles in Portugal did not have MAC.

Following the Montreal Protocol, ODS R-12's phasing-out process lead to the globalization of the use of the refrigerant HFC-134a (GWP of 1430), specifically in the mobile air conditioning sector. Therefore, in the period 2000-2005, when the use of vehicles became widespread in Portugal, there was a generalized use of MAC systems filled with HFC-134a fluid.

In the last few years, HFC-134a's phasing-out has already been taking place, due to regulations in the European Union such as the MAC Directive[13] and their implementation, which covers MACs fitted to passenger cars (vehicles of category M1) and light commercial vehicles (category N1, class 1).

According to this Directive, AC-refrigerants exceeding a GWP of 150 are not allowed for new car models since 2011. Since 2017, no new cars with AC-refrigerants exceeding GWP 150 are allowed. MAC directive does not specify any refrigerant or system, leaving the technical choice to car manufacturers. Nevertheless, the automotive industry began launching new vehicle models using refrigerant HFO-1234yf (GWP 4), which is why this low GWP refrigerant gas has been adopted globally. However, due to supply problems with alternative use of HFO-1234yf generally adopted by vehicle industry, the European Commission accepted to refrain from launching infringement procedures in cases where vehicle production would continue to be done with the gas R134a until 31 December 2012. Therefore, there has been a delay in the replacement of HFC-134a, namely in Portugal.

Retrofitting of R-12 / HFC-134a with HFO-1234yf is not possible (incompatible AC systems). Vehicles equipped in MAC filled with R-12 / HFC-134a fluids maintain them until the end of its life. In these cases, any repairs / maintenance carried out to MAC systems are made with the original fluid until equipment / vehicle's end of life or until more restrictive legislation comes out that requires it.

[13] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32006L0040&from=EN

### OVERVIEW OF THE ACTIVITY DATA

In order to apply the Tier 2a methodology suggested in chapter 7.5.2, Volume 3 of the 2006 IPCC Guidelines, detailed information regarding vehicles assembled, in circulation or at end-of-life was required for the whole time series. However, due to unavailability of such national data, we used information from the automotive industry and vehicle inspection services in circulation and assumptions regarding the penetration of AC technology in the road transport sector.

The following table compiles the assumptions considered to characterize the national vehicle fleet. The values presented in this table are the result of the combination of default information provided by COPERT V (software used to estimate combustion emissions from the road sector)[14] and expert judgment from the automotive sector experts in order to better portray the penetration of MAC systems in Portugal and the fluids used in this equipment.

***Table 4-65: AC shares considered to characterize the national vehicle fleet, by type of vehicle and EURO-Standard***

| Category | Segment | Euro Standard | From | to | Vehicles with AC [%] | Share of R-134a usage on AC [%] |
|---|---|---|---|---|---|---|
| Passenger Cars | All segments | PRE Euro | … | *1992* | 1% | 9% |
| | | Euro 1 | *1993* | *1996* | 20% | 85% |
| | | Euro 2 | *1997* | *2000* | 60% | 100% |
| | | Euro 3 | *2001* | *2005* | 85% | 100% |
| | | Euro 4 | *2006* | *2010* | 95% | 100% |
| | | Euro 5 | *2011* | *2014* | 95% | 94% |
| | | Euro 6 a/b/c | *2015* | *2018* | 95% | 19% |
| | | Euro 6 d-temp | *2019* | *2020* | 95% | 0% |
| | | Euro 6 d | *2021* | … | 95% | 0% |
| Light Commercial Vehicles | All segments | PRE Euro | … | *1994* | 1% | 9% |
| | | Euro 1 | *1995* | *1998* | 20% | 100% |
| | | Euro 2 | *1999* | *2001* | 60% | 100% |
| | | Euro 3 | *2002* | *2006* | 85% | 100% |
| | | Euro 4 | *2007* | *2011* | 95% | 100% |
| | | Euro 5 | *2012* | *2015* | 95% | 92% |
| | | Euro 6 a/b/c | *2016* | *2017* | 95% | 61% |
| | | Euro 6 d-temp | *2018* | *2020* | 95% | 55% |
| | | Euro 6 d | *2021* | … | 95% | 0% |
| Heavy Duty Trucks & Buses and Coaches | All segments | PRE Euro | | *1993* | 0% | 1.3% |
| | | Euro I | *1994* | *1996* | 8% | 93% |
| | | Euro II | *1997* | *2001* | 48% | 100% |
| | | Euro III | *2002* | *2006* | 85% | 100% |
| | | Euro IV | *2007* | *2009* | 95% | 100% |
| | | Euro V | *2010* | *2013* | 95% | 100% |
| | | Euro VI A/B/C | *2014* | *2018* | 95% | 100% |
| | | Euro VI D/E | *2019* | … | 95% | 100% |

[14] This software considers the operation of air conditioning systems in estimating fuel consumption. For detailed information regarding this software please consult chapter 3.5.2 of the Energy sector.

### ASSEMBLY PHASE

Methodology applied for vehicle assembly phase takes into account the MAC Directive, as well as the number of new vehicles assembled in Portugal, by type of vehicle and EURO-standard.

The total number of vehicles assembled in Portugal, by type of vehicle, was obtained from ACAP for the whole time series. The number of vehicles assembled with AC systems and fluids installed are based on the shares from the table above. This table reflects the following assumptions considered for vehicle assembly in Portugal:

- From 1995 to 2013, all MAC systems in vehicles assembled in Portugal were filled with refrigerant HFC-134a;
- It is possible that some vehicle brands have begun to introduce low-GWP fluids in MAC systems already before the commitment periods established by the MAC directive. However, given there is no available national data on that matter, for the time being we assumed the implementing dates of the Directive;
- According to the MAC directive, from 2011 onwards all new type-approved vehicles (new models) should be equipped with low-GWP fluids. However, according to the above-mentioned European Commission's decision, we assume that this measure only started to take force since 2013, and in a phased manner in Portugal. We considered that from 2013 to 2017 was a period of transition between HFC-134a and HFO-1234yf for passenger cars (vehicles of category M1) and light commercial vehicles (category N1, class 1);
- Also according to the MAC Directive, since 1 January 2017, MAC systems in all new passenger cars (vehicles of category M1) and light commercial vehicles (category N1-I) put on the market are no longer filled HFC-134a;
- Assuming a conservative approach, MAC systems in all new light commercial vehicles from categories N1-II and N1-III, as well as heavy duty trucks, buses and L-Category vehicles, are filled with HFC-134a.

The figure below presents the number of vehicles assembled in Portugal with AC systems and fluids installed.

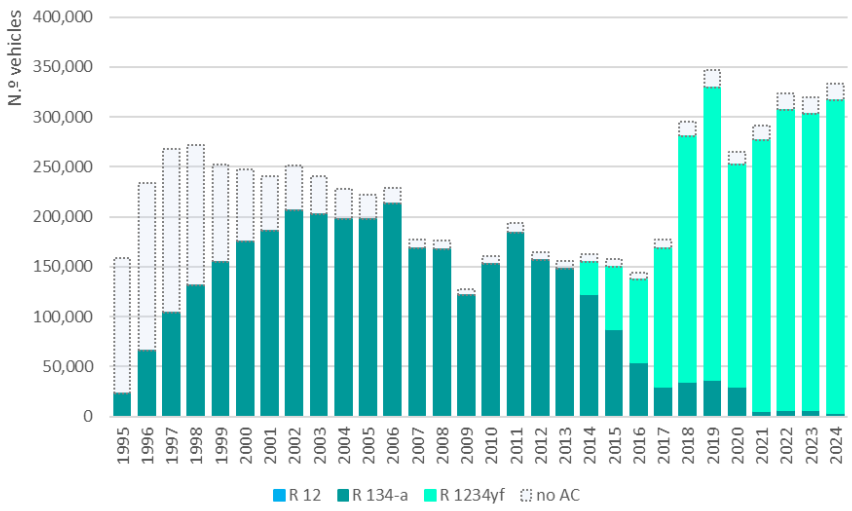



***Figure 4-54: Vehicles assembled in Portugal by type of MAC fluid***

### OPERATION PHASE

Methodology applied for the operation phase takes into account vehicles circulating in Portugal by type of vehicle and EURO-standard.

Sub-chapter 3.5.2.4.5 Vehicle Fleet of the Energy sector details how information regarding the total number of vehicles circulating in Portugal, by type of vehicle, for the whole time series, was obtained. The number of vehicles circulating with AC systems and fluids installed are based on the shares from Table 4-65.

The following assumptions were made regarding the national vehicle fleet circulating in Portugal:

- National circumstances over the years have caused an overall growing of the vehicle fleet, but also of the average lifespan of vehicles. This means that a large percentage of vehicles currently circulating in Portugal are above 13 years old;
- Upon contact with sectoral automobile associations, we consider there was no retrofit of R-12 with R-134a in Portugal. Vehicles with MAC filled with R-12 maintained it until the end of its life. All new vehicles were already assembled with MACs filled with R-134a;
- It is possible that HFO-1234yf is not the only fluid with GWP <150 in MAC systems in vehicles circulating in Portugal, however, we can assume that, for the time being, the existence of fluids with GWP <150 other than HFO-1234yf is negligible.

The figure below presents the number of vehicles circulating in Portugal with AC systems and fluids installed.

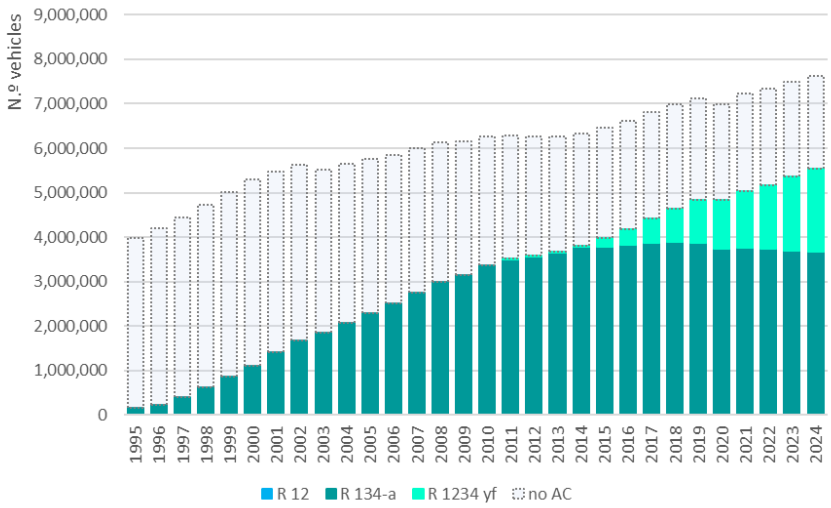



***Figure 4-55: Fleet of vehicles circulating in Portugal by type of MAC fluid***

### DISPOSAL PHASE

Methodology applied for the disposal phase takes into account the national vehicle fleet, by type of vehicle and EURO-standard.

End-of-life vehicle fleet in each year was estimated considering the vehicles that stopped performing periodic inspections in each year and therefore assumed to be removed from circulation. The number of vehicles at end-of-life with AC systems and fluids installed are based on the shares from the Table 4-65.

The following assumptions were made regarding vehicles at end-of-life in Portugal:

- National circumstances over the years have caused an overall growing of the average lifespan of vehicles. This means that the majority of vehicles currently at end-of-life in Portugal is above 20 years old. Therefore, the default lifetime values suggested in Table 7.9 of chapter 7.5.2.2 Volume 3 of the 2006 IPCC Guidelines were not used, as it is understood that they do not reflect the Portuguese reality. This also means that the majority of vehicles currently at end-of-life in Portugal is not equipped with MAC systems;

- The small (but growing) percentage of end-of-life vehicles equipped with MAC systems is still filled with R-12 (not accounted for in the inventory, for reasons already mentioned) or HFC-134a. Upon contact with vehicle abatement association, we considered the percentage of end-of-life vehicles equipped with HFO-1234yf MAC systems negligible;

- Not all vehicles at end-of-life are delivered in licensed abatement operators, however, we considered that percentage negligible;

- Most vehicles at end-of-life that are delivered in licensed abatement operators are of passenger and light commercial type. Upon contact with the vehicle abatement association, we found that up to 2018, statistics relating to end-of-life vehicles abatement only concerned passenger and light commercial vehicle types. Only from 2018 onwards, statistics relating to end-of-life vehicles abatement encompass all vehicle types. Therefore, these statistics were not used for the time being, given that they do not reflect the totality of national circumstances;

- In Portugal, the recovery of the fluid in MAC systems of end-of-life vehicles in licensed abatement operators became mandatory since 2003, however, it only concerns passenger and light commercial vehicle types. Before 2003, no national data on fluid recovery from MAC equipment is available. Therefore, these data were not used for the time being, given that they do not reflect the totality of national circumstances, and a recovery efficiency default value within the range suggested in Table 7.9 of chapter 7.5.2.2 Volume 3 of the 2006 IPCC Guidelines was used;

- No national data on initial charge remaining on MAC equipment at end-of-life is available. Therefore, a default value within the range suggested in Table 7.9 of chapter 7.5.2.2 Volume 3 of the 2006 IPCC Guidelines was used;

- For the time being, the existence of fluid HFO-1234yf in MAC systems of end-of-life vehicles is considered negligible.

The figure below presents the number of vehicles at end-of-life in Portugal with AC systems and fluids installed.

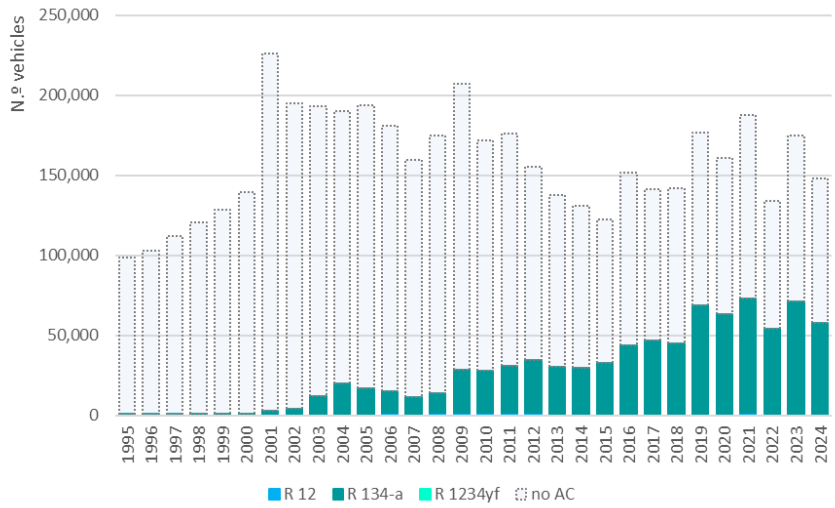



***Figure 4-56: Vehicles at end-of-life by type of MAC fluid***

#### 4.7.6.4.2 Activity Data – Railways

In MAC equipment associated to Trains and Subway, HFC-134a, R-407C and R-422d fluids are used. The composition of the blends used by the inventory is the one provided by IPCC 2006 Guidelines in Table 7.8 of chapter 7 of Volume 3.

For trains, the initial charge amount was considered 1.05-1.5 kg/MAC equipment (sectoral expert judgment) and 4-20 kg/MAC equipment (sectoral expert judgment), on the crew room and on passenger rooms, respectively. Data on the fleet was obtained from national companies that explore trains and subways. Due to unavailability of national data regarding the mobile air conditioning in railways in Portugal, data from 2004-onwards was equalled to year 2004.

### 4.7.6.5 Uncertainty Assessment

We used a triangular distribution to estimate uncertainty values based on the minimum and maximum of the range proposed by the guidelines and the more probable value (expert judgment).

***Table 4-66: Passenger cars and light duty vehicles***

| Parameter | Minimum Value | Maximum Value | Selected Value | U(%) |
|---|---|---|---|---|
| Number of equipment | - | - | - | 10.0% |
| Initial Charge | 0.59 | 0.90 | 0.77 | 8.3% |
| % HFC | | | | 10.0% |
| AD Combined Uncertainty | - | - | - | 16.4% |
| Lifetime | 9 | 16 | 16 | 8.9% |
| Initial Emission | 0.20 | 0.50 | 0.35 | 17.5% |
| Lifetime Emission | 10 | 20 | 15 | 13.6% |
| Residual charge remaining at disposal | 0 | 50 | 40 | 25.5% |
| Recovery efficiency at disposal | 0 | 50 | 35 | 29.2% |
| EF Combined Uncertainty | - | - | - | 45.5% |

***Table 4-67: Heavy duty vehicles***

| Parameter | Minimum Value | Maximum Value | Selected Value | U(%) |
|---|---|---|---|---|
| Number of equipment | - | - | - | 10.0% |
| Initial Charge | 0.50 | 1.50 | 1.20 | 17.0% |
| % HFC | | | | 10.0% |
| AD Combined Uncertainty | - | - | - | 22.1% |
| Lifetime | 9 | 16 | 16 | 8.9% |
| Initial Emission | 0.20 | 0.50 | 0.35 | 17.5% |
| Lifetime Emission | 10 | 20 | 15 | 13.6% |
| Residual charge remaining at disposal | 0 | 50 | 40 | 25.5% |
| Recovery efficiency at disposal | 0 | 50 | 35 | 29.2% |
| EF Combined Uncertainty | - | - | - | 45.5% |

***Table 4-68: Buses and Coaches***

| Parameter | Minimum Value | Maximum Value | Selected Value | U(%) |
|---|---|---|---|---|
| Number of equipment | - | - | - | 10.0% |
| Initial Charge | 4.50 | 10.00 | 7.50 | 15.0% |
| % HFC | | | | 10.0% |
| AD Combined Uncertainty | - | - | - | 20.6% |
| Lifetime | 9 | 16 | 16 | 8.9% |
| Initial Emission | 0.20 | 0.50 | 0.35 | 17.5% |
| Lifetime Emission | 10 | 20 | 15 | 13.6% |
| Residual charge remaining at disposal | 0 | 50 | 40 | 25.5% |
| Recovery efficiency at disposal | 0 | 50 | 35 | 29.2% |
| EF Combined Uncertainty | - | - | - | 45.5% |

***Table 4-69: Railways***

| Parameter | Minimum Value | Maximum Value | Selected Value | U(%) |
|---|---|---|---|---|
| Number of equipment | - | - | - | 10.0% |
| Initial Charge | - | - | - | 10.0% |
| % HFC | | | | 10.0% |
| AD Combined Uncertainty | - | - | - | 17.3% |
| Lifetime | 20 | 30 | 25 | 8.2% |
| Initial Emission | 0.2 | 1.0 | 0.5 | 32.7% |
| Lifetime Emission | 1 | 10 | 6 | 30.6% |
| Residual charge remaining at disposal | - | - | - | 45.5% |
| Recovery efficiency at disposal | - | - | - | 10.0% |
| EF Combined Uncertainty | - | - | - | 10.0% |

### 4.7.6.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

### 4.7.6.7 Recalculations

Total number of vehicles assembled in Portugal in 2023, by type of vehicle, was updated according to the data provider (ACAP).

#### 4.7.6.8 Further Improvements

During 2025 ESD review, the TERT verified that some estimates for 2.F.1.e Mobile air conditioning were constant across some years. Due to unavailability of national data regarding the mobile air conditioning in railways in Portugal, the Party was not yet able to review and update this estimate. However, and due to the overall importance of this sub-category in CRT 2F, we intend to obtain annual data and collect further information in order to revise the assumptions on the shares of fluids and emission factors parameters for railways. Due to human resources constraints and to other priority issues in our Methodological Plan (PDM), we have not yet been able to revise these estimates but intend to do so in a future submission.

Regarding mobile air conditioning in road transportation, we intend to gather information from regulatory authority in end-of-life vehicles in order to update activity data regarding the disposal phase.

## 4.7.7 Stationary Air Conditioning (CRT 2.F.1.f)

### 4.7.7.1 Category description

Stationary Air Conditioning represented about 7% of HFC emissions within the Portuguese 2.F sector in 2024.

Stationary air conditioning includes air-to-air systems, heat pumps, and chillers for building and residential applications.

### 4.7.7.2 Methodology

Emissions from Stationary Air Conditioning equipment were estimated using a bottom-up approach Tier 2a according to chapter 7.5 of Volume 3 of the 2006 IPCC Guidelines, already described in Commercial Refrigeration (CRT 2.F.1.a). Please check section 4.7.2.2.

In order to estimate emissions from Stationary Air Conditioning, two different methodological approaches were used according to the type of application:

1. emissions that occur in the residential sector, that is, equipment installed in Portuguese households;

2. emissions that originate in non-residential sectors such as Commercial, Services and Industry.

Regarding stationary air conditioning, we only consider emissions from equipment filled with HFCs, given that R-22 is not a GHG (moreover, was already covered by the Montreal Protocol) and CRT tables do not include low-GWP refrigerants such as R-1234yf and R-600.

Fluid mixtures/blends used in this sector will be disaggregated and emissions will be reported in their single components. The composition and the GWPs of the blends used by the inventory were obtained from the Portuguese Environment Agency and can be consulted (temporarily) in the following link: https://apambiente.pt/sites/default/files/2025-03/base-de-dados-de-gases-fluorados-isolados-e-em-misturas-bd_fgases_site_10_2022.pdf.

### 4.7.7.3 Emission Factors

#### *STATIONARY AIR CONDITIONING: RESIDENTIAL*

Emission factors and parameters considered for this activity are listed in the table below. The value proposed for residential AC equipment´s initial charge by type is based on national suppliers. Given there is no national data available regarding other parameters, 2006 IPCC Guidelines for "Residential and Commercial AC" recommend the use of default emission factors shown in Table 7.9 of chapter 7, Volume 3. The values considered are within the ranges proposed in Table 7.9.

***Table 4-70: Emission Factors and parameters of F-gases from Residential AC equipment***

| Description | Unit | Residential AC |
|---|---|---|
| Initial Charge (1) | Kg/equipment | 0.5 |
| Initial Emission (k) (2) | % | 0.6 |
| Operation Emission (χ) (3) | % | 4 |
| p (initial charge remaining) (4) | % | 40 |
| η (recovery efficiency at disposal) (5) | % | 40 |
| Lifetime (6) | years | 15 |
| (1) Average value based on Portuguese manufacturers survey in 2023 (in line with Table 7.9 of the 2006 IPCC Guidelines)<br>(2) Average value taken from Table 7.9 of the 2006 IPCC Guidelines (0.2-1.0 % of initial charge for Residential and Commercial AC)<br>(3) In line with the values proposed Table 7.9 of the 2006 IPCC Guidelines (1-10 % of initial charge for Residential/Commercial AC)<br>(4) Average value taken from Table 7.9 of the 2006 IPCC Guidelines (0-80 % for Residential and Commercial AC)<br>(5) Average value taken from Table 7.9 of the 2006 IPCC Guidelines (0-70 % for Residential and Commercial AC)<br>(6) Average value taken from Table 7.9 of the 2006 IPCC Guidelines (10-20 years for Residential and Commercial AC) | | |

#### STATIONARY AIR CONDITIONING: NON-RESIDENTIAL

Emission factors and parameters considered for this activity are listed in the table below. Given that there is no national data available regarding emission factors and parameters, 2006 IPCC Guidelines for "Residential and Commercial AC" recommend the use of default emission factors shown in Table 7.9 of chapter 7, Volume 3. The values considered are within the ranges proposed in Table 7.9.

***Table 4-71: Emission Factors and parameters of F-gases from Non-residential AC equipment***

| Description | Unit | Non-Residential AC |
|---|---|---|
| Initial Charge (1) | Kg/equipment | NA |
| Initial Emission (k) (2) | % | 0.6 |
| Operation Emission (χ) (3) | % | 4 |
| p (initial charge remaining) (4) | % | NA |
| η (recovery efficiency at disposal) (5) | % | 40 |
| Lifetime (6) | years | NA |
| (1) Not applicable: consult section 4.7.7.4 Activity Data<br>(2) Average value taken from Table 7.9 of the 2006 IPCC Guidelines (0.2-1.0 % of initial charge for Residential and Commercial AC)<br>(3) In line with the values proposed Table 7.9 of the 2006 IPCC Guidelines (1-10 % of initial charge for Residential/Commercial AC)<br>(4) Not applicable: consult section 4.7.7.4 Activity Data<br>(5) Average value taken from Table 7.9 of the 2006 IPCC Guidelines (0-70 % for Residential and Commercial AC)<br>(6) Not applicable: consult section 4.7.7.4 Activity Data | | |

### 4.7.7.4 Activity Data

#### GENERAL ASSUMPTIONS

The first stationary air conditioning appliances in Portugal date back to the 1970s, and their purchase became widespread for Portuguese homes in the 1990s, around the time the first mobile air conditioning systems were assembled in road transportation. Around the 2000s, the first single split air-conditioning systems were assembled in Portugal.

Throughout the 1990s and until early 2000s, ODS R-22 (GWP of 1,760) was used in stationary AC in Portugal. In 2004, R-22 was banned from use in new equipment and in 2010, virgin R-22 was banned from being used during maintenance and repairs. On 1st January 2015, the EU's 'Ozone Regulation' made it illegal to use virgin, recycled or reclaimed R-22 to maintain or repair AC equipment.

Following the Montreal Protocol, ODS R-22's phasing-out process led to the globalization of the use of other refrigerants such as R-134a and blends like R-407c and R-410a in new AC appliances. In the last few years, the phasing-out of fluorinated greenhouse gases with GWP of 750 or more has already been taking place, due to the EU F-Gas Regulation No. 517/2014.

According to this Regulation, from 2025 onwards, refrigerants exceeding a GWP of 750 will be banned in new single split air-conditioning systems containing less than 3 kg of fluorinated greenhouse gases. The Regulation does not specify any alternative refrigerant or system, leaving the technical choice to manufacturers. Nevertheless, the AC industry began launching new equipment using low-GWP refrigerants such as R-32 (GWP of 677) or the HFO blend R-513a (GWP of 573).

Therefore, we only consider emissions from stationary AC equipment filled with R-134a, R-407c and R-410a given that R-22 is not a GHG (moreover, was already covered by the Montreal Protocol) and CRT tables do not include HFOs such as R-513a.

### *STATIONARY AIR CONDITIONING: RESIDENTIAL*

#### ASSEMBLY PHASE

Methodology applied for equipment assembly phase considers the number of new equipment assembled in Portugal and the share of refrigeration fluids used. Due to unavailability of national data regarding the penetration of the different refrigeration fluids in new equipment in Portugal, we assumed the following:

- A conservative approach which considers that all AC equipment installed in Portugal is also "filled with refrigerant fluid" in Portugal, therefore, all assembly emissions take place in Portugal regardless of where the equipment is produced;
- Emissions in assembly phase are related to the moment the AC equipment is filled with the fluid and not the moment the AC is installed in a household;
- Until 1995, all AC equipment assembled in Portugal were filled with ODS R-22;
- From 1996 to 2004, ODS R-22 was progressively phased-out from new AC equipment assembled in Portugal and new HFC refrigerants such as R-134a and blends like R-407c and R-410a were introduced;
- From 2005 onwards, following the Montreal Protocol, no AC equipment assembled in Portugal is filled with ODS R-22;
- From 2011 onwards, following the F-Gas Regulation, new low GWP refrigerants such as R-32 or the HFO refrigerant blend R-513a were progressively introduced;
- According to the refrigeration and air conditioning industry, some equipment brands begun to introduce HFCs and, later, new low GWP refrigerants in new equipment already before the commitment periods established by the legislation (Montreal Protocol and F-Gas Regulation, respectively). However, given there is no available national data on that matter, and assuming that the complete transition to a new refrigerant technology takes place over a 10-year period (according to 2006 IPCC Guidelines), for the time being we assumed a linear transition tendency between the different refrigerant fluids.

The table below presents the shares of fluids considered throughout the time series. The composition of the blends used by the inventory are those provided by IPCC 2006 Guidelines in Table 7.8 of chapter 7 of Volume 3. The composition and the GWPs of the blends used by the inventory were obtained from the Portuguese Environment Agency and can be consulted (temporarily) in the following link: https://apambiente.pt/sites/default/files/2025-03/base-de-dados-de-gases-fluorados-isolados-e-em-misturas-bd_fgases_site_10_2022.pdf.

***Table 4-72: Use of each Gas/Mixture in Stationary Air Conditioning assembled units (%)***

| Mistura | Unit | 1995 | 2005 | 2010 | 2015 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|
| HCFC | % of gas | 100 | 0 | 0 | 0 | 0 | 0 | 0 |
| R-410A | % of gas | 0 | 45 | 55 | 60 | 30 | 20 | 10 |
| R-407C | % of gas | 0 | 25 | 20 | 15 | 6.0 | 4.0 | 2.0 |
| R-134a | % of gas | 0 | 20 | 20 | 15 | 6.0 | 4.0 | 2.0 |
| R-417A | % of gas | 0 | 3.0 | 1.0 | 1.0 | 0.6 | 0.4 | 0.2 |
| R-422D | % of gas | 0 | 4.0 | 3.0 | 3.0 | 1.8 | 1.2 | 0.6 |
| R-404A | % of gas | 0 | 3.0 | 1.0 | 1.0 | 0.6 | 0.4 | 0.2 |
| R-513A | % of gas | 0 | 0.0 | 0.0 | 3.0 | 27.5 | 35 | 42.5 |
| R-32 | % of gas | 0 | 0.0 | 0.0 | 2.0 | 27.5 | 35 | 42.5 |
| **Total** | **% of gas** | **100** | **100** | **100** | **100** | **100** | **100** | **100** |

Due to unavailability of national data regarding new equipment in Portugal, the number of assembled AC units in Portugal was obtained using the following equation:

***Equation 4-60: AC equipment assembled annually***

$$Assemblage_y = (Stocks_y - Stocks_{y-1}) + Disposal_y$$

Where:

$Assemblage_y$: AC equipment assembled in year y (nº)

$Stocks_y$: Stocks (AC equipment in operation) of the year y (nº)

$Stocks_{y-1}$: Stocks of the year y-1 (nº)

$Disposal_y$: Disposal of equipment in year y (nº)

The figures below present the number of equipment assembled in Portugal and fluids installed.

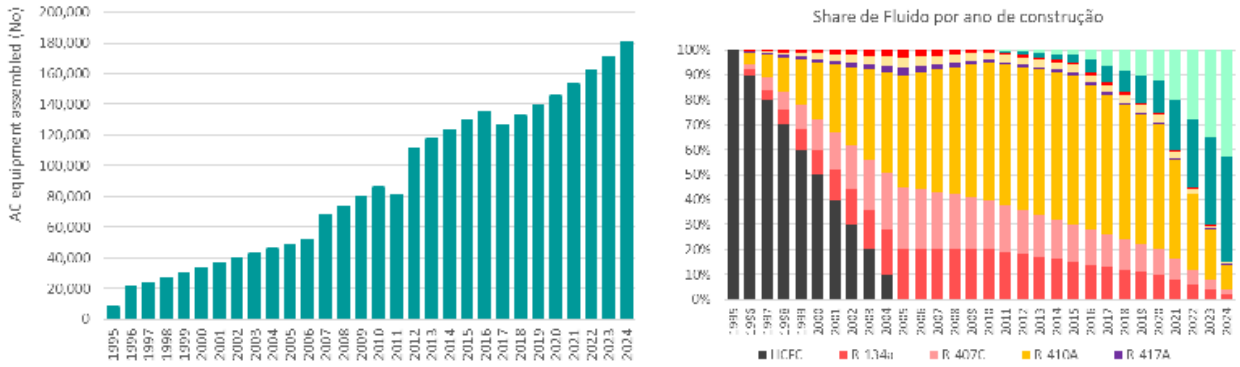



***Figure 4-57: AC equipment assembled in Portugal and share of fluid by type/blend***

### OPERATION PHASE

National F-gas reporting tool does not work with residential data, only with company (commercial, services and industry) data.

Due to unavailability of national data regarding the number of residential AC equipment in operation in Portugal, we considered the percentage of households with AC equipment provided by the *Household Consumption Survey*, published by INE/DGEG in every 10 years. We also considered a common household to be a *classic accommodation as main residence* in Portugal. Total annual classic accommodations as main residence in Portugal were obtained from INE's annual publication *Construction and Housing Statistics*.

Also, a 15-year lifetime was considered for this type of equipment, assumption validated with Portuguese manufacturers. AC equipment in operation each year were estimated considering the existing stock in the previous year, adding assembled equipment and subtracting abated equipment.

The next figure presents the AC equipment stock in Portugal and fluids installed.

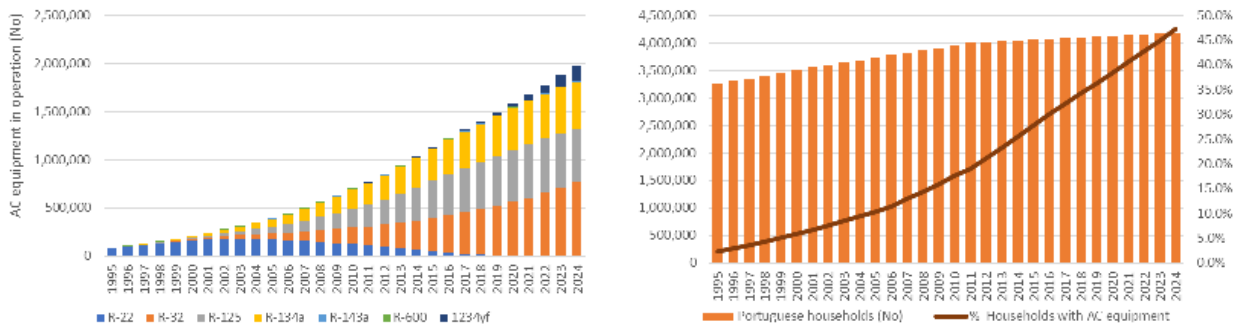



***Figure 4-58: AC equipment in operation in Portugal by type of fluid and share of households with AC equipment***

### DISPOSAL PHASE

Prohibitions in the use of some HFCs and the phase-down of these compounds only started in the last decade, and therefore little data are available regarding their destruction. Nevertheless, much improvement still needs to be achieved in the recovery and management of F-gases and other refrigerants in Portugal. Despite having legislation that regulates these procedures since around 2006, when entities for management of waste from electrical and electronic equipment (WEEE) management entities were created in Portugal, the country still faces challenges in order to efficiently manage refrigerants, namely:

. low collection rate of this equipment, most of which continues to be sent to non-certified operators, which are not prepared to collect refrigerant fluids, causing their release to the atmosphere;
. WEEE management entities face great challenges in creating efficient collection circuits for AC and refrigeration equipment;
. economic capacity to implement efficient (and sometimes expensive) technologies to improve the collection, recovery, reclaim and destruction of F-gases.

In Portugal, there are no F-gases recovery or destruction facilities; AC equipment is collected and stored in order to be sent abroad (mostly Spain). Emissions of GHGs may occur during the transport of the equipment from the site where they were stored to the recovery/destruction facility and during the destruction process, however, no data is available regarding these issues.

Although the presence of AC equipment is still very recent in Portuguese households, national circumstances show that it is very likely that there may be an overall growing of the average lifespan of these appliances. This means that most of that equipment at end-of-life in Portugal is likely to be above 15 years old.

No national data on initial charge remaining on AC equipment at end-of-life or recovery efficiencies are available, therefore, a default value within the range suggested in Table 7.9 of chapter 7.5.2.2 Volume 3 of the 2006 IPCC Guidelines was used.

There is no available national data regarding the number of disposed AC equipment in Portugal. Therefore, the number of disposed AC equipment in Portugal was estimated in parallel with the AC stock estimates, where all equipment purchased annually since 1990 (obtained from INE) is considered, as well as its disposal 15 years later (considering a normal lifetime distribution around 15 years).

The figure below presents AC equipment at end-of-life in Portugal by type of fluid installed.

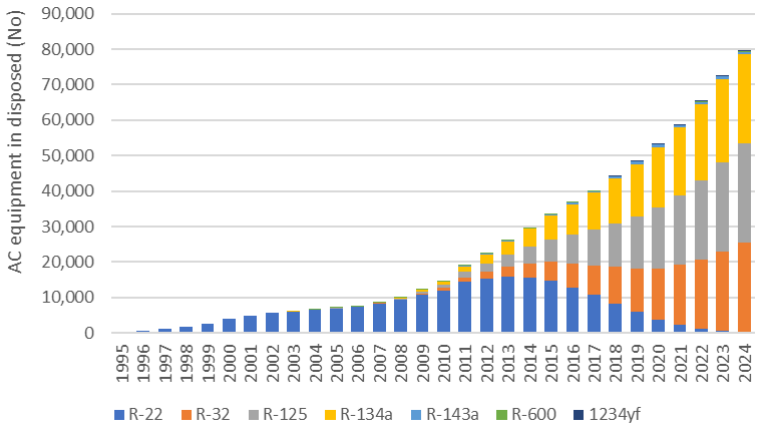



***Figure 4-59: AC equipment disposed in Portugal by type of fluid***

## STATIONARY AIR CONDITIONING: NON-RESIDENTIAL

### ASSEMBLY PHASE

Due to data unavailability of national data regarding the number of new non-residential AC equipment assembled in Portugal and the share of refrigeration fluids used, activity data was estimated based on:

. residential AC assembling trends;

. stocks of non-residential AC equipment by type of fluid/blend obtained from commercial and services operators via the national F-gas reporting tool.

Therefore, annual shares of fluid assembled were estimated considering the trends in fluid assembled in residential air conditioning sector. Those shares were applied to operation stocks in the non-residential sector.

Assuming these percentages means assuming that both residential and non-residential had similar growth and investment in new equipment.

### OPERATION PHASE

Due to unavailability of national data regarding the number of non-residential AC equipment in operation in Portugal, stocks of AC equipment by type of fluid/blend were obtained from commercial and services operators via the national F-gas reporting tool from 2013 onwards.

From 1995 to 2012, due to data unavailability, data on stocks and shares of fluids was estimated based on residential AC stocks trends. The figure below presents non-residential AC equipment stock in Portugal and fluids installed.

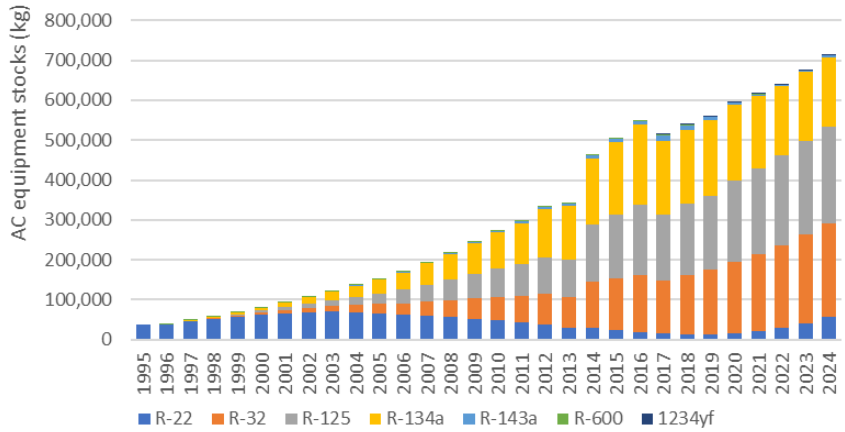



***Figure 4-60: AC equipment in operation in Portugal by type of fluid and share of households with AC equipment***

DISPOSAL PHASE

Due to data unavailability of national data regarding the number of non-residential AC equipment disposed in Portugal and the share of refrigeration fluids used, data was estimated based on:

. residential AC abatement trends;

. stocks of non-residential AC equipment by type of fluid/blend obtained from commercial and services operators via the national F-gas reporting tool.

Therefore, annual shares of fluid disposed were estimated considering the fluid stocks in operation in the residential sector. Those shares were applied to operation stocks in the non-residential sector.

Assuming these percentages means assuming that both residential and non-residential sectors end up having a similar life expectancy, as well as the remaining quantities at the end of their life.

### 4.7.7.5 Uncertainty Assessment

We used a triangular distribution to estimate uncertainty values based on the minimum and maximum of the range proposed by the guidelines and the more probable value (expert judgment).

***Table 4-73: Residential AC***

| Parameter | Minimum Value | Maximum Value | Selected Value | U(%) |
|---|---|---|---|---|
| Number of equipment | - | - | - | 10.0% |
| Initial Charge | 0.5 | 100 | 0.5 | 54.4% |
| % HFC | | | | 30.0% |
| AD Combined Uncertainty | - | - | - | 63.0% |
| Lifetime | 10 | 20 | 15 | 15.7% |
| Initial Emission | 0.2 | 1.0 | 0.6 | 27.2% |
| Lifetime Emission | 1.0 | 10.0 | 4.0 | 33.4% |
| Residual charge remaining at disposal | 0 | 80 | 40 | 40.8% |
| Recovery efficiency at disposal | 0 | 80 | 40 | 40.8% |
| EF Combined Uncertainty | - | - | - | 65.1% |

***Table 4-74: Non-residential AC***

| Parameter | Minimum Value | Maximum Value | Selected Value | U(%) |
|---|---|---|---|---|
| Number of equipment | - | - | - | NA |
| Initial Charge | 0.5 | 100 | - | NA |
| % HFC | | | | 30.0% |
| AD Combined Uncertainty | - | - | - | 30.0% |
| Lifetime | 10 | 20 | - | NA |
| Initial Emission | 0.2 | 1.0 | 0.6 | 27.2% |
| Lifetime Emission | 1.0 | 10.0 | 4 | 33.4% |
| Residual charge remaining at disposal | 0 | 80 | 40 | 40.8% |
| Recovery efficiency at disposal | 0 | 80 | 40 | 40.8% |
| EF Combined Uncertainty | - | - | - | 66.1% |

#### 4.7.7.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

2002-2023 data on total annual classic accommodations as main residence in Portugal was revised during QA/QC procedures to national statistics database. Following QA/QC procedures to national F-gas reporting tool, recalculations in commercial AC equipment resulted from stationary air conditioning equipment activity data update in 2013-2023.

#### 4.7.7.7 Recalculations

Minor recalculations occurred in residential AC emissions in the period 2002-2023 due to the revision of total annual classic accommodations as main residence in Portugal, during QA/QC procedures to national statistics database.

Following QA/QC procedures to national F-gas reporting tool, recalculations in commercial AC equipment resulted from stationary air conditioning equipment activity data update in 2013-2023.

#### 4.7.7.8 Further Improvements

No further improvements are planned.

## 4.7.8 Foam Blowing (CRT 2.F.2)

### 4.7.8.1 Category description

Fluorinated gases are nowadays used as blowing agents in the manufacture of foams that are used as insulating, cushioning and packaging materials.

The foam blowing agent is eventually ventilated to the atmosphere, but at a rate dependent on the type of foam and its structure. Open cell foams emit virtually all blowing agent at the time of manufacture. Closed-cell foams emit the HFC blowing agent during their lifetime at three distinct phases:

- Foam Manufacturing: emissions occur during the first year at the location where the foam is manufactured;
- Annual losses: occur where the foam is applied, resulting from the slow release of the blowing agent trapped inside the foam;
- Disposal: emissions occur when foam is removed and destroyed. The remaining gas in cells is emitted to atmosphere.

This category represented less than 3% of HFC emissions within the Portuguese 2.F sector in 2024.

Activity data on the use of HFC in foam manufacturing in Portugal is available, allowing the estimation of manufacturing emissions. Annual losses are, however, harder to estimate because it is not known neither the quantity of closed-cells imported that were manufactured with F-gases, nor the quantities of foams that were exported with HFC. Nonetheless, assumptions are based on expert judgement.

In Portugal, there is production of Polystyrene closed-cell foams and Polyurethane open-cell foams, associated to the use of HFC-134a and HFC-152a as blowing agents.

### 4.7.8.2 Methodology

Methodology is classified as Tier 2a, using national data, but considering default emission factors.

First year losses from Foam Manufacture and Installation were estimated using the following equation:

***Equation 4-61: First year losses***

$$FGas_{Emi\,(t,j)} = FGas_{Consumption\,(t)} \times HFC_{\%(j,t)} \times (k/100)$$

Annual losses were estimated using the following equations:

***Equation 4-62: F-gas in closed-cell***

$$FGas_{inFoam\,(t,j)} = \sum_{y=t}^{t\text{-}Lifetime} [FGas_{Consumption\,(y)} \times HFC_{\%\,(j,y)}]$$

***Equation 4-63: Annual losses***

$$FGas_{Emi\,(t,j)} = FGas_{in\ Foam\,(t)} \times HFC_{\%(j,t)} \times (x/100)$$

**Where:**

$FGas_{Emi(t,j)}$: Emission at year t of F-gas j (t)

$FGas_{Consumption\,(t)}$: Total F gas consumption at year t used in closed-cell manufacturing (t)

$HFC_{\%(j,t)}$: Percentage of Fluorine gas j used at year t in closed-cell manufacturing (%)

$FGas_{inFoam\ (t,j)}$: Amount of F gas j in closed-cell existing in the country at year t[15] (t)

K: First year loss emission factor (%)

X: Annual loss emission factor (%)

Emissions due to decommissioning of foams were not included in estimates due to the lack of necessary information about foam stock and the expected lifetime of foams.

#### 4.7.8.3 Emission Factors

Due to unavailability of country-specific information, default emission factors from the 2006 IPCC Guidelines were used and are listed in the table below.

***Table 4-75: Foam losses emission factors***

| Type of Foam | Parameter | Emission Factor (% Original Charge) | Source |
|---|---|---|---|
| Open Cell | First Year Losses (k) | 100 | Section 7.4.2.1, Chapter 7, Volume 3, 2006 IPCC Guidelines |
| Closed Cell | First Year Losses (k) | 10 | Table 7.5, Chapter 7, Volume 3, 2006 IPCC Guidelines |
| Closed Cell | Annual Losses (x) | 4.5 | Table 7.5, Chapter 7, Volume 3, 2006 IPCC Guidelines |

#### 4.7.8.4 Activity Data

From 1995 to 2010, data on amounts of imported and exported foams by type of product were obtained from DGAE (Economic Activities General Directorate) and data on produced amounts of foam were provided by DGAE and manufacturers. From 2011 onwards, data was estimated based on the average of the period 2008-2010 and on the GDP trend.

It was considered that the use of F-gases as foam blowing agents in foams produced in Portugal was introduced in 2003. For foams imported and applied in Portugal it was considered the use of F-gases from 1995 onwards. Nowadays, HFCs are still used in specific foam blowing applications in Portugal, but their use is highly restricted and declining under EU F-gas Regulation. Foam industry is progressively shifting to the use of non-HFC agents.

The composition of the blends used by the inventory are those provided by IPCC 2006 Guidelines in Table 7.8 of chapter 7 of Volume 3. The composition and the GWPs of the blends used by the inventory were obtained from the Portuguese Environment Agency and can be consulted (temporarily) in the following link: https://apambiente.pt/sites/default/files/2025-03/base-de-dados-de-gases-fluorados-isolados-e-em-misturas-bd_fgases_site_10_2022.pdf.

[15] For the time being the stock is restricted to foam filled in Portugal.

#### 4.7.8.5 Uncertainty Assessment

We used a triangular distribution to estimate uncertainty values based on the minimum and maximum of the range proposed by the guidelines and the more probable value (expert judgment).

***Table 4-76: Foam Blowing (Closed Cell)***

| Parameter | Minimum Value | Maximum Value | Selected Value | U(%) |
|---|---|---|---|---|
| Amount of foam produced | - | - | - | 50.0% |
| % HFC | - | - | - | 30.0% |
| AD Combined Uncertainty | - | - | - | 58.3% |
| Lifetime | 12 | 50 | 20 | 38.8% |
| Emission in first year | 7.5 | 12.5 | 10.0 | 10.2% |
| Emission in subsequent years | 0.5 | 4.5 | 4.5 | 18.1% |
| EF Combined Uncertainty | - | - | - | 44.0% |

***Table 4-77: Foam Blowing (Open Cell)***

| Parameter | Minimum Value | Maximum Value | Selected Value | U(%) |
|---|---|---|---|---|
| Amount of foam produced | - | - | - | 50.0% |
| % HFC | - | - | - | 30.0% |
| AD Combined Uncertainty | - | - | - | 58.3% |
| Emission in first year | 100 | 100 | 100 | 0.0% |
| EF Combined Uncertainty | - | - | - | 0.0% |

#### 4.7.8.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

#### 4.7.8.7 Recalculations

Following a 2025 ESD review recommendation, changes were made to foam blowing's assembly phase in order to better reflect current EU F-gas regulation market restrictions. For category 2.F.2 and emissions of HFCs and the year 2023 the TERT noted that the Party still reported emissions from open cell foams of HFCs with a GWP>150, which in fact is prohibited by the EU F-gas Regulation 517/2014 (and revised 2024/573).

The Party therefore took into account the placing on the market prohibitions for open-cell foams that contain HFCs with GWP >150 from 2023 onwards according to the EU F-gas Regulation and assumed no emissions from R-134a in open-cell foams manufacturing in 2023. In previous submissions, Portugal was still considering that this high-GWP refrigerant was still being introduced in open-cell foams manufacturing.

Activity data, emission factors and parameters considered in assembly phase were not revised.

Revised estimates for the assembly phase of 2.F.2 category resulted in a 44% decrease in CO2 eq emissions in 2023 and in a 15% decrease in 2.F.2 total CO2 eq emissions in 2023.

#### 4.7.8.8 Further Improvements

We intend to collect information regarding amounts of open and closed cell foams assembled in Portugal. We also intend to collect further information in order to revise the assumptions on the shares of fluids and emission factors parameters for this category. Due to human resources constraints and to other priority issues in our Methodological Plan (PDM), we have not yet been able to complete the revision to these estimates but intend to do so in a future submission.

### 4.7.9 Fire Protection (CRT 2.F.3)

#### 4.7.9.1 Category description

Fire protection category represented about 3% of HFC emissions within the Portuguese 2.F sector in 2024.

Information on the national fire protection sector was collected upon several contacts with the Portuguese Association for Security – APSEI. The HFC consumption in fire protection systems in Portugal started in 1998. The fire protection equipment used in Portugal typically contains R-23 and HFC-227ea and, more recently, NOVEC-1230.

The use of HFC-236fa is restricted to the maritime and aviation (Air Force) sectors, with no documented application in fixed fire protection systems for buildings. Their occurrence is limited to portable or mobile fire extinguishers, which are exclusively manufactured outside of Portugal. According to the national FGF reporting tool, the use of HFC-236fa in Portugal is irrelevant (from 2013 to 2024, annual stocks of HFC-236fa represented less than 0.2% of total HFC stocks in 2.F.3).

HFC-236ea is used exclusively in refrigeration and is not applicable to the fire protection sector. Although it possesses fire-extinguishing properties, its commercial application in this field is negligible compared to its isomer HFC-236fa or HFC-236cb.

The use of NOVEC-1230 in Portugal began slowly around 2012-2013, seeing a significant increase from 2015 onwards. It is currently the most widely installed agent, effectively achieving a 100% replacement rate of HFCs in new fire protection equipment.

#### 4.7.9.2 Methodology

Regarding Fire Protection, we only consider emissions from equipment filled with HFCs, given that Halons are not GHGs (moreover, they were already covered by the Montreal Protocol) and CRT tables do not include new low-GWP refrigerants such as NOVEC-1230, etc.

We assume emissions from the assembly of the fire protection equipment as irrelevant, according to APSEI's understanding.

Emissions during equipment lifetime are estimated considering the stock of fluid present in all fire protection equipment in Portugal in a given year and applying a conservative lifetime emission factor of 4% per year, according to the following equation:

***Equation 4-64: Emissions during equipment lifetime***

$$Emissions_{Op} = Bank_y \times EF/100$$

**Where:**

$Emissions_{Op}$: Total emissions from operation of fire protection equipment (t)

$Bank_y$: bank of F-Gas in fire protection equipment in year y (t)

EF: fraction of F-Gas in equipment emitted each year (%)

The bank of F-gas in each year is estimated considering the Stock Existing in the Previous Year, Fluid in new equipment and the Fluid in Disposed Equipment, according to the following equation:

***Equation 4-65: Bank of F-gas***

$$Bank_y = Bank_{y-1} + FGas_{NE\,y} - FGas_{DE\,y}$$

**Where:**

$Bank_y$: bank of F-Gas in fire protection equipment in year y (t)

$Bank_{y-1}$: bank of F-Gas in fire protection equipment in previous year (t)

$FGas_{NE\ y}$: amount of F-Gas in new equipment in year y (t)

$FGas_{DE\ y}$: amount of F-Gas in Disposed Equipment in year y (t)

According to APSEI, during operation phase, fire protection equipment is periodically checked for leak detection by certified companies to ensure they are in good condition. If they are not, they are discarded, but the gas is reused. Therefore, emissions due to end-of-life are reported as "IE" (in operation phase).

#### 4.7.9.3 Emission Factors

Due to unavailability of country-specific information, a default lifetime emission factor from the 2006 IPCC Guidelines (Section 7.6.2.2, Chapter 7, Volume 3) was used. According to APSEI, hydrostatic testing of pressurized gas containers is mandatory every 10 years. As such, since containers are often subjected to hydrostatic testing twice during their service life, the overall lifespan of these systems can be considered ranging between 20 and 30 years.

***Table 4-78: Fire Protection losses emission factors***

| Parameter | Unit | Emission Factor/Parameter | Source |
|---|---|---|---|
| Lifetime Emission (x) | % | 4 | Conservative average annual emission rate (2-6%) |
| Lifetime | Years | 20-30 | Average typical lifetime for flooding systems (APSEI) |

#### 4.7.9.4 Activity Data

We consider HFC consumption in two general types of fire protection (fire suppression) equipment that use HFCs and/or PFCs as partial replacements for halons: portable (streaming) equipment, and fixed (flooding) equipment.

##### ASSEMBLY PHASE

Some of the key aspects and assumptions considered in this category are the following:

. Following Regulation EU No. 2037/2000, of June 29, fire protection systems and extinguishers containing halons were replaced by December 31, 2003. Therefore, from 2004 onwards, following the Montreal Protocol, no fire protection equipment assembled in Portugal was filled with ODS;

. The consumption of HFC in fire protection systems in Portugal started in 1998. According to EU F-Gas Regulation, HFC-23 is not allowed in new fire protection equipment since 2016. The Regulation does not specify any alternative fluid or system, leaving the technical choice to manufacturers. Nevertheless, fire protection industry in Portugal began launching new equipment using low-GWP fluid Novec-1230;

. According to national sectoral fire protection association (APSEI), low-GWP Novec 1230 (fluoroketone) began subtly around 2012/2013, seeing a significant increase from 2015 onwards. It is currently the most widely installed agent in assembled units, effectively achieving a 100% replacement rate of HFCs;

. From 2018 onwards, there is no HFC consumption in assembly of fire protection equipment;

. We assume there are no emissions from the assembly of the fire protection equipment.

The amount of HFC fluids and share on assembled fire protection systems in Portugal from 1998-2018 was obtained from APSEI and is presented in the next figure. The replacement of halons by HFC during 2000-2004 period in order to fulfil Regulation (EC) No. 2037/2000 is reflected in the consumption increase. In the period 2005-2009 there is a decrease in consumption values associated to market saturation.

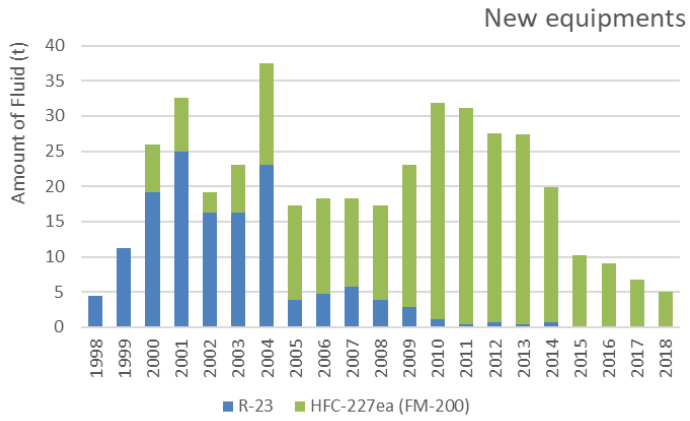



***Figure 4-61: HFC consumption in new Fire protection equipment by type of gas***

### OPERATION AND DISPOSAL PHASE

Some of the key aspects and assumptions considered are the following:

. According to the national FGF reporting tool, fire protection equipment in operation in Portugal is filled with R-23 and HFC-227ea. The use of HFC-236fa in Portugal is irrelevant (from 2013 to 2024, annual stocks of HFC-236fa represented less than 0.2% of total HFC stocks in 2.F.3);

. During operation phase, fire protection equipment is periodically checked for leak detection by certified companies. Emissions during the operating phase due to equipment firing are related to its use against real fires, accidental firing, or other causes, and are estimated considering the stock of fluid present in all fire protection equipment in Portugal in a given year and applying a lifetime emission factor of 4% per year (Average value taken from section 7.6.2.2 of the 2006 IPCC Guidelines);

. End-of-life emissions from the equipment are included in operation phase: during operation phase, the equipment is periodically checked by certified operators in order to ensure they are in good condition; if they are not, they are discarded, but the gas is reused, recycled or destroyed. Therefore, end-of-life emissions from fire protection systems are reported as "IE".

From 2013 onwards, the stocks of HFC fluids in fire protection systems in Portugal were obtained from the national FGF reporting tool. From 1999-2012, stocks were estimated based on the trend of fluid amount in assembly phase and the HFC stocks' trends according to the FGF tool.

HFC stocks by type of fluid in fire protection equipment are presented in the next figure.

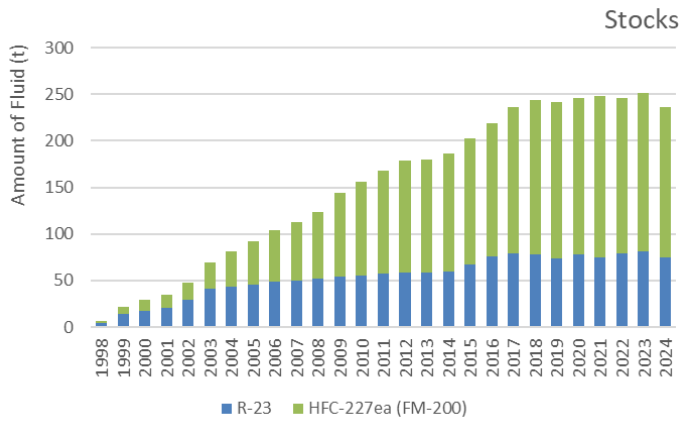



***Figure 4-62: Stocks of HFC in Fire protection equipment by type of gas***

#### 4.7.9.5 Uncertainty Assessment

We used a triangular distribution to estimate uncertainty values based on the minimum and maximum of the range proposed by the guidelines and the more probable value (expert judgment).

***Table 4-79: Fire protection***

| Parameter | Minimum Value | Maximum Value | Selected Value | U(%) |
|---|---|---|---|---|
| Charge amount | - | - | - | 30.0 |
| % HFC | - | - | - | 30.0 |
| AD Combined Uncertainty | - | - | - | 42.4 |
| Lifetime | 20 | 30 | - | - |
| Lifetime emissions (%) | 2 | 6 | 4 | 20.4 |
| EF Combined Uncertainty | - | - | - | 21.2 |

#### 4.7.9.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

#### 4.7.9.7 Recalculations

Following a 2025 ESD review recommendation, methodological changes were made to fire protection sector in order to better reflect national circumstances. Revised estimates presented during the review were further improved. After the review and following contacts with APSEI, revised informations and assumptions were collected and new estimates were presented in this submission.

Recalculations occurred are mostly due to:

. the revision of activity data time series in assembly phase. In previous submissions, the Party was only working with data on amounts of used gases in fire extinguishing equipment for the period 1999-2010, provided by sellers and responsible enterprises for equipment filling and missing years were forecasted based on the average of the period 2005-2010. Following contacts with the Portuguese Association for Security APSEI, the Party obtained a complete data series of the assembled amounts of HFC, by type of fluid, from 1998 to 2018 (from 2019 onwards no F-gases are used in fire protection equipment assembled in Portugal). In previous submissions, Portugal was not considering the introduction of new low-GWP refrigerants, moreover, was considering that high-GWP refrigerants such as R-32 were still being introduced in new equipment;

. the revision of the shares and fluids considered in operation phase. Working with data from national F-gas reporting tool, available from 2013 onwards, we learned about the stocks and fluids/blends used in fire protection equipment in Portugal. Therefore, the Party revised the type of fluids and respective shares in operation phase according to the trends in national F-gases reporting tool and trends in assembly phase.

. the revision of the assumptions in disposal phase. Previous assumptions were based on a conservative approach of 0 % gas recovery, following the guidance of chapter 7.6.2.2 of Volume 3 of the 2006 IPCC guidelines. However, the Party considered that such approach is not the most adequate. Upon contacts with APSEI, we learned that during operation phase, the equipment is periodically checked by certified operators in order to ensure they are in good condition; if they are not, they are discarded, but the gas is reused, recycled or destroyed. Therefore, end-of-life emissions from fire protection systems are reported as "IE", included in operation phase.

Emission factor in operation was not revised.

Revised estimates for 2.F.3 category resulted in a significant decrease in CO2 eq emissions from 2018 onwards. Previously, this category represented about 6% of total 2.F emissions.

Recalculations concerning category 2.F.3 CO2 eq emissions represented 227% in 2005 and -40% in 2023.

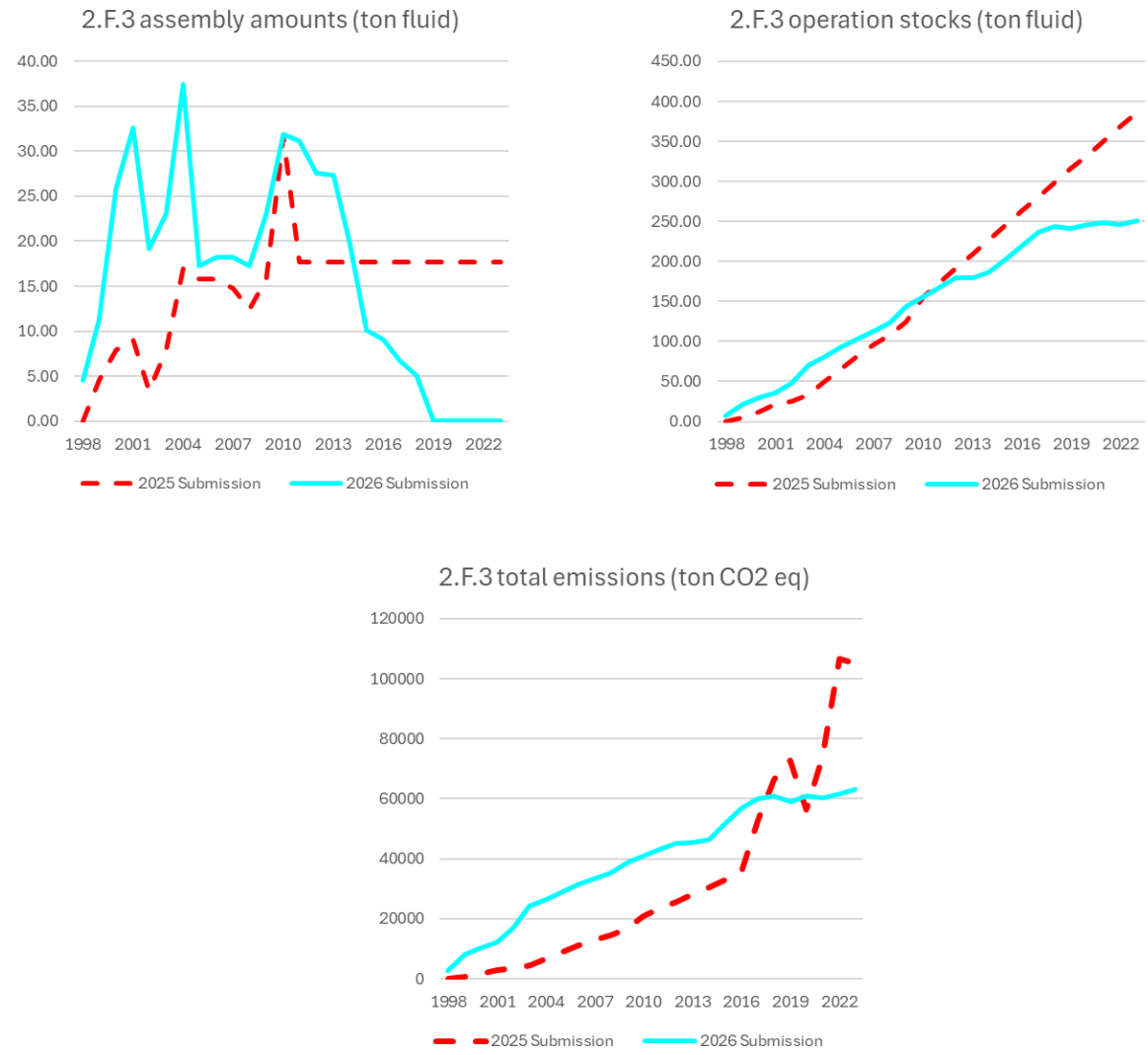



***Figure 4-63: Recalculations in 2.F.3: comparison of amounts of HFC fluid in assembly and operation phase and total 2.F.3 emissions***

### 4.7.9.8 Further Improvements

We intend to resume contacts with APSEI in order to collect information regarding emission factors in Fire Protection systems.

## 4.7.10 Aerosols – Metered Dose Inhalers (CRT 2.F.4.a)

### 4.7.10.1 Category description

Fluorinated gases are used as propellants in pressurized solutions (metered dose inhalers) in the treatment of asthma. This sub-category represented less than 0.5% of HFC emissions within the Portuguese 2.F sector in 2024.

### 4.7.10.2 Methodology

It is assumed that the gas is partly emitted during the same year the inhaler is sold and in the subsequent year, according to the following equation:

***Equation 4-66: F-gas emissions from metered dose inhalers***

$$Emi_{HFCt} = [\Sigma(Sold\ MDI_{t-1} \times K_{t-1}) + \Sigma\ (Sold\ MDI_t \times K_t)] / 2 \times 1X10^{-6}$$

**Where:**

$Emi_{HFCB\,t}$: F-Gas emissions from metered dose inhalers in year t (t)

Sold $MDI_{t-1}$: Number of sold units of each MDI in year t-1

$K_{t-1}$: Charge of gas of each equipment sold in year t-1

Sold $MDI_t$: Number of sold units of each MDI in year t

$K_t$: Charge of gas of each equipment sold in year t

### 4.7.10.3 Emission Factors

Each manufacturer provided charge values for each type of inhaler. However, the yearly average emission factor lies in the range [12.05-14.75] g/inhaler.

### 4.7.10.4 Activity Data

Information was gathered on the amounts of sold inhalers charged with F-gases in the period 1990-2010. From 2011 onwards, data was estimated based on the trend on GDP. Information on the % of propellant (F-gas) for each type of inhaler was also provided. The two F-gases in inhalers are HFC-134a and HFC-227ea.

### 4.7.10.5 Uncertainty Assessment

***Table 4-80: Metered Dose Inhalers***

| Parameter | U(%) |
|---|---|
| AD Combined Uncertainty | 30 |
| EF Combined Uncertainty | 50 |

### 4.7.10.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

### 4.7.10.7 Recalculations

2023 activity Data was updated.

### 4.7.10.8 Further Improvements

We intend to further analyse MDI charge values by establishing contacts with the Portuguese Association for Pharmaceutical Products.

## 4.7.11 Aerosols – Other Aerosols (CRT 2.F.4.b)

### 4.7.11.1 Category description

Emissions from fluorinated gases used as other aerosols were estimated based on Spain data. This sub-category represented less than 0.5% of HFC emissions within the Portuguese 2.F sector in 2024.

### 4.7.11.2 Methodology

Emissions from other aerosols were estimated according to the following equations:

***Equation 4-67: 2015 Portuguese activity data for other aerosols***

$$AD_{Portugal,2015} = AD_{Spain,2015} \times \frac{Population_{Portugal,2015}}{Population_{Spain,2015}}$$

**Where:**

$AD_{Portugal,2005}$ : Activity data in Portugal in year 2015 (t HFC-134a)

$AD_{Spain,2015}$ : Activity data in Spain in year 2015 (t HFC-134a)

$Population_{Portugal,2015}$: Population in Portugal in year 2015 (Number of persons)

$Population_{Spain,2015}$: Population in Spain in year 2015 (Number of persons)

***Equation 4-68: Portuguese activity data for other aerosols for year y***

$$AD_{Portugal,y} = AD_{Portugal,2015} \times \frac{Population_{Portugal,y}}{Population_{Portugal,2015}}$$

**Where:**

$AD_{Portugal,y}$: Activity data in Portugal in year "y" (t HFC-134a)

$AD_{Portugal,2015}$: Activity data in Portugal in year 2015 (t HFC-134a)

$Population_{Portugal,y}$: Population in Portugal in year "y" (Number of persons)

$Population_{Portugal,2015}$: Population in Portugal in year 2015 (Number of persons)

***Equation 4-69: F-gas emissions from other aerosols***

$$Emis_{Portugal,y} = AD_{Portugal,y} \times EF$$

**Where:**

$Emis_{Portugal,y}$: Emissions in Portugal in year "y" (t HFC-134a)

$AD_{Portugal,y}$: Activity data in Portugal in year "y" (t HFC-134a)

EF: Emission Factor (%)

### 4.7.11.3 Emission Factors

We have considered a product manufacturing factor of 1.5% and a product life factor of 100%.

### 4.7.11.4 Activity Data

We have assumed the Spanish activity data relating to 2015 (136.32 t of R-134a filled into new manufactured products and 29.57 in operating systems) and did a correction to the Portuguese reality based on the difference between Spain and Portugal population.

### 4.7.11.5 Uncertainty Assessment

***Table 4-81: Other Aerosols***

| Parameter | U(%) |
|---|---|
| AD Combined Uncertainty | 10 |
| EF Combined Uncertainty | 2 |

### 4.7.11.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

### 4.7.11.7 Recalculations

Spanish population minor updates for the whole time series, according to EUROSTAT database.

2022-2023 Portuguese population minor updates based on National Statistics Office (INE).

Following a question from the 2026 ESD review, assembly amounts of HFC-134a were updated from 2018 onwards according to placing on the market prohibition for technical aerosols that contain HFCs with GWP of 150 or more, except if required to meet national safety standards or when used for medical applications is in place since 2018 (EU F-gas Regulation 2024/573, Annex IV). Therefore, the Party assumed no aerosols were filled with HFC-134a from 2018 onwards.

Recalculations concerning category 2.F.4.b CO2 eq emissions represented -6% in 2023 and are presented in the figures below.

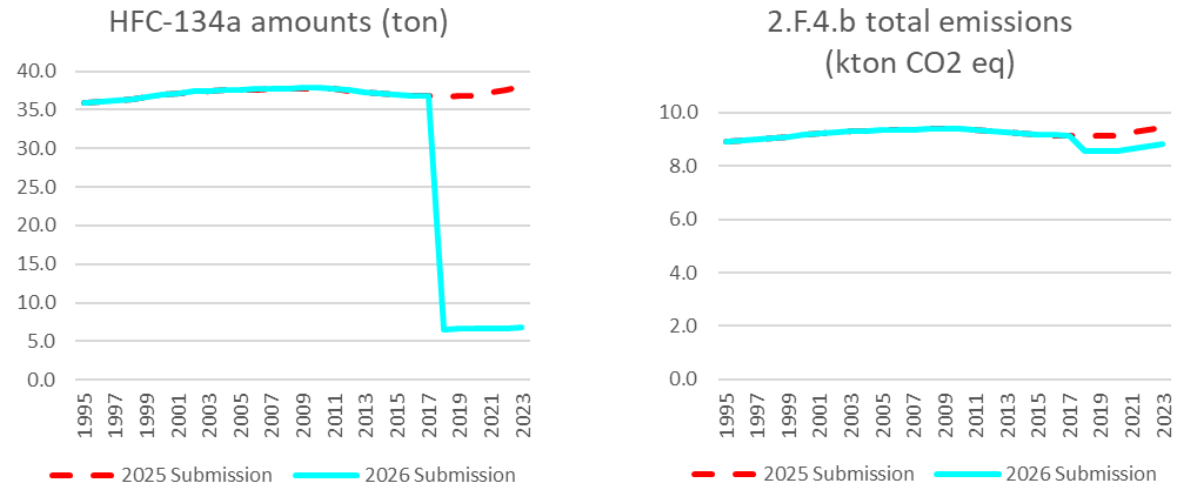



***Figure 4-64: Recalculations in 2.F.4.b: comparison of amounts of HFC fluid (total assembly and operation phase) and total 2.F.4.b emissions***

### 4.7.11.8 Further Improvements

Regarding category 2.F.4.b, it has not yet been possible to verify the use and emissions for this subcategory. Due to human and technical resources constraints, Portugal has still not been able to gather information in order to make further updates to this sector.

We intend to make efforts in order to obtain national data on other aerosols applications in Portugal.

## 4.8 Other Product Manufacture and Use (CRT 2.G)

### 4.8.1 Overview

This chapter is intended to estimate $SF_6$ and PFCs that result from the manufacture and use of electrical equipment and a number of other products. It also provides methods for estimating emissions of nitrous oxide from several products. In most of these applications, the $SF_6$, PFC, or $N_2O$ is deliberately incorporated into the product to exploit one or more of the physical properties of the chemical.

### 4.8.2 Manufacture of Electrical Equipment (CRT 2.G.1.a)

#### 4.8.2.1 Category description

In Portugal, sulphur hexafluoride ($SF_6$) is used in the electrical equipment manufacturing sector, as current interruption media in switch-gears and circuit breakers. Due to the scarce number of national electrical equipment manufacturers, activity data and emission factors are reported as "C" (confidential) and we only present $SF_6$ emission values.

#### 4.8.2.2 Methodology

It is used a Tier 1 methodology based on $SF_6$ consumption by manufacturers and on emission factors in line with the 2006 IPCC Guidelines.

Emissions are estimated using the following equation:

***Equation 4-70: $SF_6$ emissions from manufacture of electrical equipment***

$$\text{Emissions} = EF \times SF_6 \text{ consumption}$$

**Where:**

Emissions: $SF_6$ emissions (t)

EF: Fraction of $SF_6$ emitted during electrical equipment manufacturing (%)

$SF_6$ consumption: Annual $SF_6$ consumption (t)

#### 4.8.2.3 Emission Factors

Due to confidentiality constraints, it was not possible to publish the chosen emission factors, however they are in line with the 2006 IPCC Guidelines. We assume that 100% of the manufactured equipment are sealed pressure, according to national electrical equipment manufacturers.

#### 4.8.2.4 Activity Data

From 1995 onwards, activity data on $SF_6$ consumption in electric equipment manufacturing was obtained from national equipment producers, however, due to confidentiality constraints, it was not possible to publish the chosen activity data. We assume that 100% of the manufactured equipment are sealed pressure, according to national electrical equipment manufacturers.

#### 4.8.2.5 Uncertainty Assessment

The uncertainty in activity data was set at 10 %, since $SF_6$ consumption in electrical equipment manufacturing was obtained directly from manufacturers. It was used a 20% uncertainty for sealed-pressure equipment emission factor, as advised in Table 8.5 of 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

#### 4.8.2.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

#### 4.8.2.7 Recalculations

During the 2025 ESD review, the TERT noted that the Product Manufacturing Factor (PMF) for this category was high compared to other countries. Upon contact with electrical equipment manufacturers, the Party revised assumptions and activity data for this category.

In previous submissions, the Party assumed that 50% of the manufactured equipment were sealed pressure and the other 50% were closed pressure. Upon contacts with contact with electrical equipment manufacturers, we learned that 100% of the manufactured equipment are sealed pressure. We also obtained a revised series concerning $SF_6$ consumption in electric equipment manufacturing.

Revised estimates of 2.G.1.a category are presented in the figures below and resulted in an overall decrease in CO2 eq emissions, due to the revision of the activity data and assumptions on the type of equipment (closed/sealed pressure). Recalculations concerning category 2.G.1.a emissions represented -70% in 1995, -71% in 2005 and -72% in 2023.

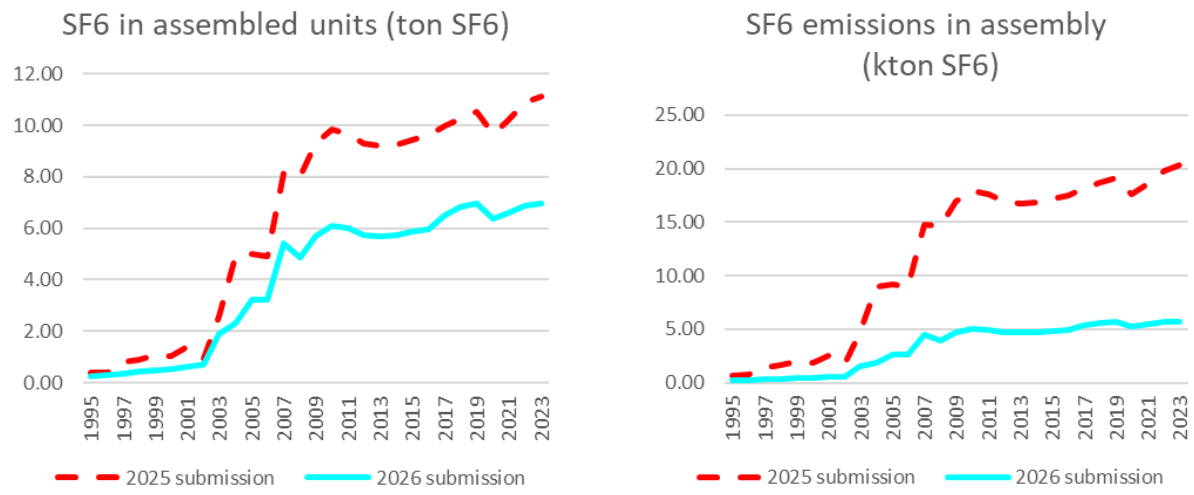



***Figure 4-65: Recalculations in electrical equipment manufacturing: comparison in activity data and emissions in CO2 eq***

#### 4.8.2.8 Further Improvements

The Party intends to resume contact with electrical equipment manufacturers and revise the emissions factors currently applied in the category.

### 4.8.3 Use of Electrical Equipment (CRT 2.G.1.b)

#### 4.8.3.1 Category description

In Portugal, sulphur hexafluoride ($SF_6$) is used in the electrical sector, both as insulation gas in substations and as current interruption media, mostly in switchgear and in circuit breakers. While most gas is recovered at equipment disposal, emissions occur annually as consequence of leaks and equipment failure.

The Portuguese National Electric System (SEN) is comprised by the Public Service Electric System (SEP) and by the Independent Electric System (SEI). In the second semester of 2000, the separation between the network for electricity transport at very high voltage (concession to REN – National Electric Net) and the network for electricity distribution at low, medium and high voltage (E-REDES – former EDP-Distribuição) took place.

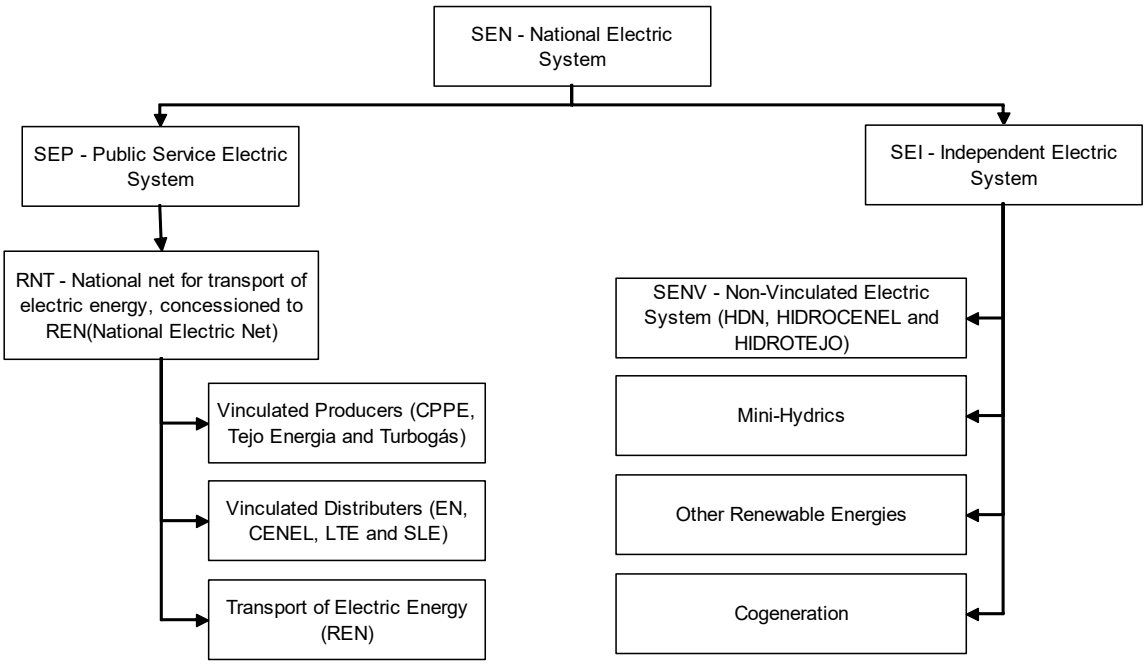



***Figure 4-66: Flowchart of the National Electric System***

In SEP (Public Service Electric System), "REN (National Electric Net)" is responsible for electricity distribution at Very High Voltage (>110 kV), "E-REDES" is responsible for distribution at Low (≤1 kV), Medium (>1 kV and ≤45 kV) and High Voltage (>45 kV and ≤110 kV) and includes vinculated distributors. "EDP Produção" includes vinculated producers "CPPE" units and great part of SEI (Independent Electric System). "Tejoenergia" and "Turbogás" are SEP (Public Service Electric System) vinculated producers.

***Figure 4-67: Map of National Network of Electric Energy Transport***

### 4.8.3.2 Methodology

There are different estimates methodologies for:

- REN;
- E-REDES, EDP Produção, Tejoenergia and Turbogás;
- Other Companies.

#### 4.8.3.2.1 REN

In this case, a methodology based on "Correspondent States Principle" was used:

***Equation 4-71: Correspondent States Principle***

$$P \times V = Z \times n \times R \times T$$

$$n_i = \frac{P_i \cdot V}{R \cdot T_i} \cdot \frac{1}{Z_i}$$

$$n_f = \frac{P_f \cdot V}{R \cdot T_f} \cdot \frac{1}{Z_f}$$

$$m = (n_f - n_i) \cdot M$$

**Where:**

P: Pressure

V: Compartment volume filled with $SF_6$ inside the equipment

Z: Compressibility factor (obtained from tabled values for Reduced Pressure and Temperature)

n: Mole number of $SF_6$

R: Gases Constant

T: Temperature

Ti and Pi: Measured Temperature and Pressure at the beginning of reposition of lost $SF_6$

Tf and Pf: Measured Temperature and Pressure at the end of reposition of lost $SF_6$

Zi: Compressibility Factor at Pressure Pi and Temperature Ti

Zf: Compressibility Factor at Pressure Pf and Temperature Tf

ni: Mole number of SF6 at pressure Pi and Tf before the reposition of gas

nf: Mole number of SF6 at pressure Pf and Tf after the reposition of gas

M: $SF_6$ molecular mass

m: $SF_6$ mass emitted

There are two alarm situations that require an intervention and reposition of $SF_6$:

- Loss of SF6 slightly above Service Pressure (≈70 % of Maximum Pressure);
- Loss of SF6 below Service Pressure (<70 % of Maximum Pressure) - in this situation the equipment doesn't work at all.

Besides these two situations there is a team that does regular gas repositions (each 15 days) after temperature and pressure measurements on containers. Each intervention is registered in a database and the equipment used is identified.

#### 4.8.3.2.2 EDP Distribuição

In E-REDES (former EDP Distribuição), separate estimates were made for:

- Gas Circuit Breakers;
- Outdoor Gas Insulated Switchgears;
- Gas Insulated Switchgears;
- High and Medium Voltage Sectioning Posts.

Actual emissions of $SF_6$ from electrical equipment were estimated with a Tier 3b, based on data provided by "E-REDES", excluding the details in life-cycle and using a country-specific emission factor.

Emissions were determined using the following equation:

***Equation 4-72: $SF_6$ emissions***

$$Emi_{SF6} = Stock_{SF6} \times (EF/100)$$

**Where:**

$Emi_{SF6}$: Equipment use emissions, including leakage emissions, servicing and maintenance (t)

$Stock_{SF6}$: Total $SF_6$ gas in existence at year t in all electrical equipment

EF: Emission Factor, corresponding to the percentage of $SF_6$ in stock at year t that is emitted to atmosphere

#### 4.8.3.2.3 EDP Produção, Tejoenergia and Turbo gás

The used methodology was identical to the one described for "E-REDES".

Disposal or retiring units were not included in the inventory as emission sources because, according to industry experts, the collection of gas at end of lifetime is done in a systematic and efficient way. Manufacturing and installation emissions were assumed to be included in emissions from equipment usage.

### 4.8.3.3 Emission Factors

There are different emission factors for the methodologies described above.

#### 4.8.3.3.1 REN

The database on $SF_6$ repositions by equipment was available for the period 2003-2010. For the period 1995-2002 and from 2011 onwards, an average of the estimated loss (0.38 %) for the period 2003-2010 was considered.

#### 4.8.3.3.2 E-REDES

In E-REDES, different emission factors were considered for:

- Gas Circuit Breakers: all circuit breakers are "Closed Pressure" equipment and the emission factor is 2.6 %/year as proposed on table 8.3 of "2006 IPCC Guidelines for National Greenhouse Gas Inventories" for "Closed Pressure Electrical Equipment";
- Outdoor Gas Insulated Switchgears: all outdoor gas insulated switchgears are "Sealed Pressure" equipment and the emission factor is 0.2 %/year as proposed on table 8.2 of "2006 IPCC Guidelines for National Greenhouse Gas Inventories" for "Sealed Pressure Electrical Equipment";
- Gas Insulated Switchgears: it is assumed by the company's expert judgment that 27 % of equipment are "Sealed Pressure" and 73 % are "Closed Pressure"; the emission factors are 0.2 %/year to "Sealed Pressure" as proposed on table 8.2 of "2006 IPCC Guidelines for National Greenhouse Gas Inventories" for "Sealed Pressure Electrical Equipment" and 2.6 %/year to "Closed Pressure" as proposed on table 8.3 of "2006 IPCC Guidelines for National Greenhouse Gas Inventories" for "Closed Pressure Electrical Equipment";
- High and Medium Voltage Sectioning Posts: all high and medium voltage sectioning posts are "Sealed Pressure" equipment and the emission factor is 0.2 %/year as proposed on table 8.2 of "2006 IPCC Guidelines for National Greenhouse Gas Inventories" for "Sealed Pressure Electrical Equipment".

#### 4.8.3.3.3 EDP Produção

Different emission factors are used for:

- Sealed Pressure Equipment: emission factor is 0.2 %/year as proposed on table 8.2 of "2006 IPCC Guidelines for National Greenhouse Gas Inventories" for "Sealed Pressure Electrical Equipment";
- Closed Pressure Equipments: EDP Produção has a database on SF6 stock amounts in "Closed Pressure" equipments from 2000 onwards. There is no data related to SF6 stock in the period 1995-1999 and it is used an average emission factor of 0.93 % based on 2000-2006 data period.

#### 4.8.3.3.4 Tejoenergia and Turbo gás

It is assumed by "Tejoenergia" and "Turbogás" expert judgment that all equipment are "Closed Pressure" and that the emission factor is 2.6 %/year as proposed on table 8.3 of "2006 IPCC Guidelines for National Greenhouse Gas Inventories" for "Closed Pressure Electrical Equipment".

#### 4.8.3.3.5 Other Companies

It is assumed that 50% of the equipment are "Closed Pressure" and 50% are "Sealed Pressure. We use the emission factors proposed on table 8.3 of "2006 IPCC Guidelines for National Greenhouse Gas Inventories" for "Closed Pressure Electrical Equipment" and "Sealed Pressure Equipment".

### 4.8.3.4 Activity Data

Although it is not possible to differentiate activity data in this report, the information on the yearly total amount of $SF_6$ in Electric Equipment is available (see the figure below). From 2013 onwards we started using data reported by companies under the F-Gas Tool (https://formularios.apambiente.pt/GasesF/).

***Table 4-82: Average SF6 charge for each kind of equipment***

| Equipment | $SF_6$ (kg) |
|---|---|
| Gas Circuit Breaker | 1.200 |
| Outdoor Gas Insulated Switchgear | 0.720 |
| Gas Insulated Switchgear | 0.484 |

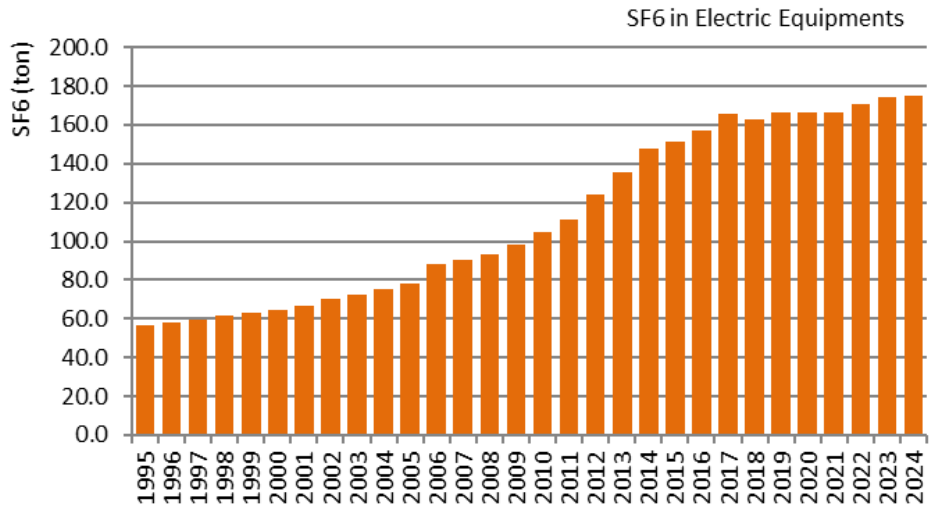



***Figure 4-68: Total SF6 in stock in electric equipment in Portugal***

#### 4.8.3.5 Uncertainty Assessment

***Table 4-83: Electric Equipment***

| Parameter | U (%) |
|---|---|
| AD Combined Uncertainty | 10.0% |
| Manufacture | 30.0% |
| Use (Includes leakage, major failures/arc faults and maintenance losses) | 30.0% |
| Lifetime EF | 40.0% |
| EF Combined Uncertainty | 58.3% |

#### 4.8.3.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

#### 4.8.3.7 Recalculations

Upon contact with electrical equipment companies, the Party revised activity data for the whole time series for this category.

Revised estimates of 2.G.1.b category are presented in the figures below. Recalculations concerning category 2.G.1.b SF6's emissions represented -13% in 1995, -13% in 2005 and 57% in 2023.

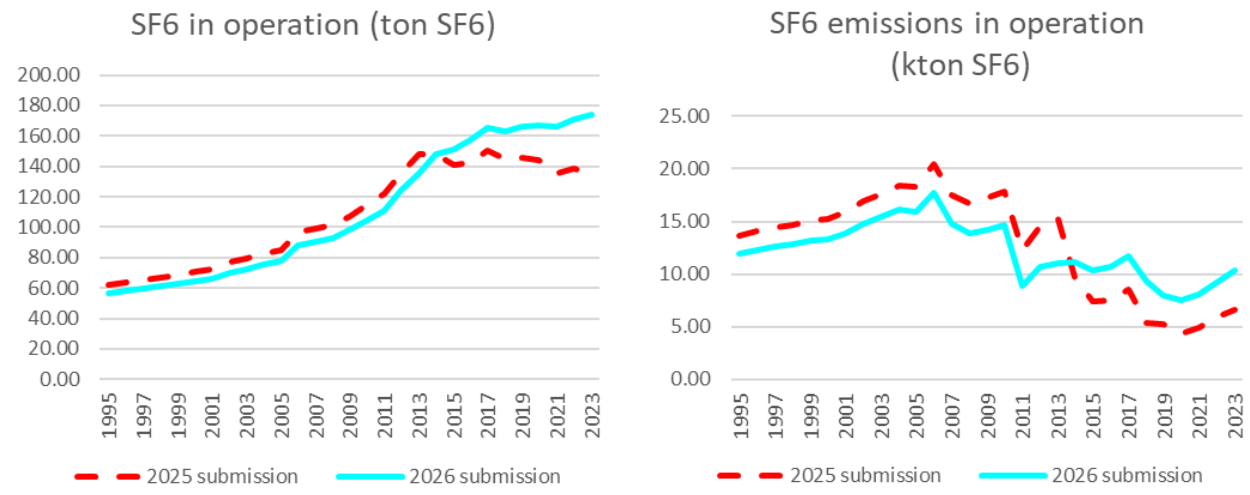



***Figure 4-69: Recalculations in electrical equipment in operation: comparison in activity data and emissions in CO2 eq***

#### 4.8.3.8 Further Improvements

No further improvements are expected.

### 4.8.4 SF6 and PFCs from Other Product Use (CRT 2.G.2)

There are no other product uses of $SF_6$ and PFCs in Portugal.

## 4.8.5 $N_2O$ from Product Use – Medical Application (CRT 2.G.3.a)

### 4.8.5.1 Category description

Evaporative emissions of nitrous oxide ($N_2O$) can arise from various types of product use. In general, medical applications (anaesthesia use, analgesic use and veterinary use) and use as a propellant in aerosol products are likely to be larger sources among others.

### 4.8.5.2 Methodology

The $N_2O$ consumed in Portugal is primarily for medical use as anaesthesia. According to Chapter 8.4.2.1 of Volume 3 of 2006 IPCC Guidelines, it is good practice to estimate $N_2O$ emissions from data of quantity of $N_2O$ supplied that are obtained from manufacturers and distributors of $N_2O$ products: "There will be a time delay between manufacture, delivery and use but this is probably small in the case of medical applications because hospitals normally receive frequent deliveries to avoid maintaining large stocks. Therefore, it is reasonable to assume that the $N_2O$ products supplied will be used in one year."

### 4.8.5.3 Emission Factors

According to Chapter 8.4.2.2 of Volume 3 of 2006 IPCC Guidelines, it is assumed that none of the administered $N_2O$ is chemically changed by the body, and all is returned to the atmosphere. It is reasonable to assume an emission factor of 1.0.

### 4.8.5.4 Activity Data

Currently, there are 5 companies that commercialize $N_2O$ for medical use as anaesthesia. Consumption of $N_2O$ is provided directly by the companies. This set of activity data includes estimates due to lack of data. Due to confidentiality constraints, the activity data is presented in index (1990 year = 100).

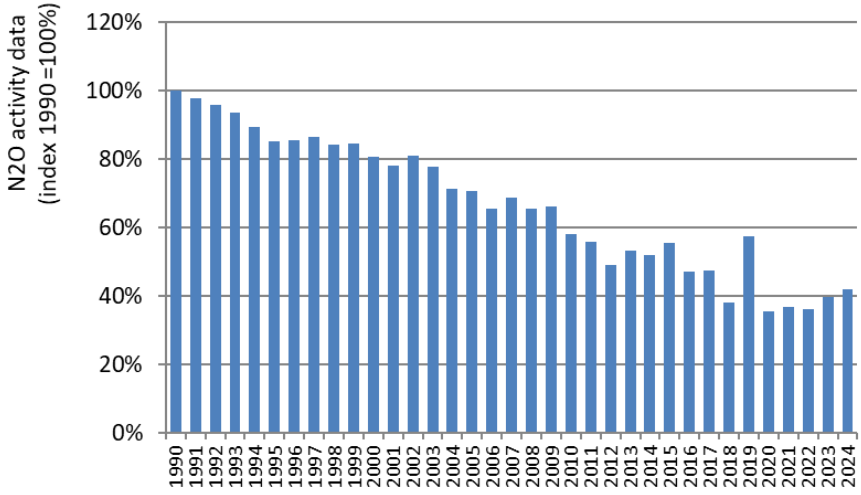



***Figure 4-70: $N_2O$ consumption data***

### 4.8.5.5 Uncertainty Assessment

The uncertainty is associated with the activity data which refers to information collected from the 5 producers/importers that commercialize N2O for medical use as anaesthesia and includes estimates for the previous years. Values considered are: 1990-2000: 25 %; 2001-2007: 10 %; from 2008 onwards: 1 %.

Regarding emission factors, it is assumed that none of the administered N2O is chemically changed by the body, and that all is returned to the atmosphere (EF = 1.0). For this reason, a zero value was considered for the EF uncertainty.

#### 4.8.5.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

#### 4.8.5.7 Recalculations

No recalculations were made.

#### 4.8.5.8 Further Improvements

No further improvements are expected.

### 4.8.6 $N_2O$ from Product Use – Propellant for pressure and aerosol products (CRT 2.G.3.b)

$N_2O$ is also used as a propellant in aerosol products primarily in food (pressure-packaged whipped cream, etc.).

Portugal considers these emissions as negligible and reports this category as not estimated (NE).

In order to evaluate the order of magnitude of the potential underestimation, the average per capita emissions for several countries (Italy-Spain-France-Austria-Netherlands-Denmark) has been considered as a conservative approach: 1.860 kg/inh/year. Considering the Portuguese population, the estimated emissions for this category are: 1990: 18.6 kt CO2 eq. 2024: 20 kt CO2 eq. Even though these estimates are considered to be highly conservative, they are below (0.039 %) the level of significance (0.05 % of national total emissions). Therefore, and for the time being, Portugal considers these emissions as negligible and currently has no plans to estimate these emissions.

## 4.9 Other (CRT 2.H)

### 4.9.1 Overview

This chapter is intended to estimate GHG emissions that result from other industrial processes not included in the above addressed categories. In this category, the following activities are reported: pulp and paper production, food and drink manufacturing, wood chipboard production and carbon electrodes consumption.

There are direct $CO_2$ process emissions from carbon electrodes consumption. There are no direct $CO_2$, $CH_4$ and $N_2O$ process emissions from the other activities. There are, however, emissions related to $SO_x$, $NO_x$ and indirect $CO_2$ emissions related to NMVOC.

### 4.9.2 Pulp and Paper Industry (CRT 2.H.1)

#### 4.9.2.1 Category description

In Portugal there were in 1990 six paper pulp plants using the kraft process and two units using the acid sulphide process. Later, in 1993, one of the smaller of the acid sulphide plants was decommissioned and nowadays only 6 plants remain in operation.

Kraft pulping is essentially a digestion process of wood by a solution of sodium sulphide ($Na_2S$) and sodium hydroxide (NaOH) (white liquor) at elevated temperature and pressure that dissolves lignin and leaves cellulose fibbers unbind. Apart from digestion other relevant industrial processes include pulp washing, pulp drying, chemical recovery of reactants (sulphur and quicklime) and possibly bleaching. Recovery of sulphur from the spend cooking liquor and washing water (black liquor) includes combustion in the recovery furnace, after concentration in evaporators, and reaction with water and quicklime of the green liquor in a causticizing tank generating white liquor and lime mud. Quicklime is recovered by combustion in a lime kiln.

Emissions of sulphur compounds, including mercaptans, dimethyl sulphide, dimethyl disulphide and $H_2S$, occur in digester and blow tank relieves, in evaporators, and in the lime kiln. In the recovery furnace sulphur compounds are oxidized to $SO_x$, but these are emissions already included in combustion in manufacturing industries (1.A.2 source sector).

Acid sulphide involves also chemical digestion of wood but using $SO_2$ absorbed in a base solution. Washing, drying and recovery of chemicals are also part of this production process.

Emissions of $CO_2$, $CH_4$ and $N_2O$ from combustion equipment of this industry sector were estimated using energy consumption as activity data (energy approach) and were included in combustion in manufacturing industries (1.A.2 source sector).

#### 4.9.2.2 Methodology

$SO_x$, $NO_x$ and NMVOC process emissions are estimated according to:

***Equation 4-73: Emissions from Pulp and Paper Industry***

$$Emi_p = EF_{(p)} \times Pulp_{PROD} \times 10^{-3}$$

**Where:**

$Emi_p$: Annual emission of pollutant p (t)

$EF_{(p)}$: Emission factor for pollutant p (kg/t)

$Pulp_{PROD}$: Annual Paper pulp production (t)

### 4.9.2.3 Emission Factors

The following emissions factors were used to estimate process emissions, respectively for the Kraft and sulphide process plants. They were set from US-EPA AP42 and other sources and include emissions from:

- Kraft process: Digester, Brown Stock Washers, Black Liquor Evaporators, Non condensable gases, Smelt dissolving tank, Fluid Bed Calciner and Bleaching;
- Acid sulphide: Digester and Blow Pit.

***Table 4-84: Emission Factors for paper pulp production (non-combustion)***

| Process | $SO_x$ | $NO_x$ | NMVOC |
|---|---|---|---|
| Kraft | 0.31 | 1.95 | 2.74 |
| Sulphide | 35.5 | NA | NA |

### 4.9.2.4 Activity Data

In the period 1990-2009, production of paper pulp expressed in air dried weight was obtained directly from CELPA (the Portuguese Paper Industry Association). From 2010 onwards, activity data is obtained from EU-ETS. Acid Sulphide production is only a minor component of total production[16] but may not be published individualised due to confidentiality constraints. However, sulphide production is about 5 to 8 % of total paper pulp produced in Portugal, according to years. Paper pulp production has been increasing during the reporting period.

The following figure presents total national production of paper pulp.

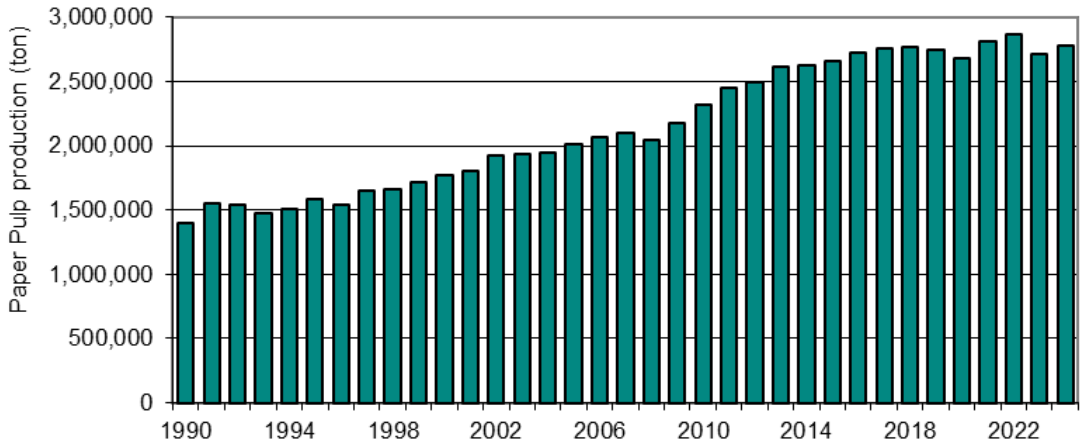



***Figure 4-71: Total production of paper pulp***

### 4.9.2.5 Uncertainty Assessment

This information will be provided in future submissions.

[16] Specific information for sulphide pulping cannot be delivered because presently there is only one plant operating which raised confidential constraints.

#### 4.9.2.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

#### 4.9.2.7 Recalculations

Revision of fuel consumption data following the publication of an updated National Energy Balance for 2023.

#### 4.9.2.8 Further Improvements

No further improvements are planned.

### 4.9.3 Food Manufacturing (CRT 2.H.2)

There are no direct $CO_2$, $CH_4$ and $N_2O$ emissions to report in this subsector in Portugal. There are, however, NMVOC emissions. The methodology used to estimate NMVOC emissions can be checked in the Portugal IIR. Indirect $CO_2$ emissions related to NMVOC emissions are reported in CRT Table 6.

### 4.9.4 Drink Manufacturing (CRT 2.H.2)

There are no direct $CO_2$, $CH_4$ and $N_2O$ emissions to report in this subsector in Portugal. There are, however, NMVOC emissions. The methodology used to estimate NMVOC emissions can be checked in the Portugal IIR. Indirect $CO_2$ emissions related to NMVOC emissions are reported in CRT Table 6.

### 4.9.5 Wood Chipboard Production (CRT 2.H.3.a)

There are no direct $CO_2$, $CH_4$ and $N_2O$ emissions to report in this subsector in Portugal. There are, however, NMVOC emissions. The methodology used to estimate NMVOC emissions can be checked in the Portugal IIR. Indirect $CO_2$ emissions related to NMVOC emissions are reported in CRT Table 6.

### 4.9.6 Carbon electrodes consumption (CRT 2.H.3.b)

#### 4.9.6.1 Category description

According to national statistics, there is national consumption of carbon electrodes in four distinct activities in Portugal: electric arc furnaces in iron and steel industry, manufacture and repair of rolling stock for railways, manufacture of machinery for the extractive and construction industries and in the repair and maintenance of other transport equipment.

$CO_2$ emissions from consumption of carbon electrodes in electric arc furnaces in iron and steel industry are estimated and reported in sector 2.C.1, based on a mass balance, in which the carbon contained in the raw materials is accounted for and the carbon contained in the billets is subtracted. In 2.C.1 sector there is a wide range of materials that contain carbon (not just coal electrodes).

Therefore, this category reports $CO_2$ emissions from the other activities listed above.

### 4.9.6.2 Methodology

$CO_2$ emissions are estimated from the quantification of carbon in carbon electrodes, through a mass balance for the quantities of $CO_2$ that are liberated in the conversion process. Therefore, emissions are estimated from consumption of carbon materials according to the following equation:

***Equation 4-74: $CO_2$ emissions***

$$Emi_{CO2} = 44/12 \text{ X } Carb_{Elect} \text{ X EF X } 10^{-3}$$

**Where:**

$Emi_{CO2}$: $CO_2$ emissions (kt $CO_2$)

$Carb_{Elect}$: Consumption of carbon electrodes (t)

EF: Emission factor (t $CO_2$/t carbon electrode)

### 4.9.6.3 Emission Factors

Emission factors of materials consumed in Portugal was set from molecular stoichiometry:

***Table 4-85: Emission factors of carbonate materials***

| Material | EF |
|---|---|
| Carbon (Electrodes) | 3.67 |

### 4.9.6.4 Activity Data

From 1996 to 2010, carbon electrodes consumption data was available from national statistics (IAPI/INE). For the period 1990-1995, data has been estimated based on 1996 production data and on GDP for the 1990-1995 period. From 2011 onwards, data has been estimated based on 2010 production data and on GDP trend.

Final total consumption of carbon electrodes is presented in the figure below.

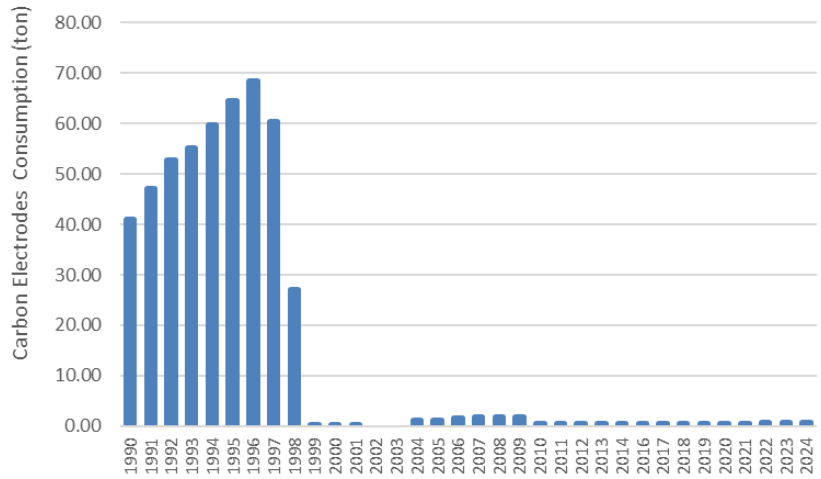



***Figure 4-72: Consumption of carbon electrodes in industry***

#### 4.9.6.5 Uncertainty Assessment

***Table 4-86: Uncertainty values***

| Parameter | Type of Uncertainty | Uncertainty | Source |
|---|---|---|---|
| Activity Data | Weighing or proportioning raw materials | 2.0% (average of 1.0-3.0% range) | Table 2.3 of "Chapter 2: Mineral Industry Emissions" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories" |
| Activity Data | Carbon content | 2.0% | Table 2.3 of "Chapter 2: Mineral Industry Emissions" of "2006 IPCC Guidelines for National Greenhouse Gas Inventories" |
| Activity Data | Combined Uncertainty | 2.8% | - |
| $CO_2$ EF | Fractional purity | 3.0% (average of 1.0-5.0% range) | Average value of the range 1-5% of chapter 2.5.2.1 of Volume 3: Industrial Processes and Product Uses of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. |

#### 4.9.6.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

#### 4.9.6.7 Recalculations

Minor recalculations relate to 1990-1995 and 2023 GDP trend update.

#### 4.9.6.8 Further Improvements

Efforts will be made in order to obtain necessary statistical information for the missing years from carbon electrodes consumption.

# 5 Agriculture (CRT Sector 3)

## Table of Contents


5 Agriculture (CRT Sector 3) ..... 5-1

5.1 Overview of the sector ..... 5-8

5.2 $CH_4$ Emissions from Enteric Fermentation (CRT 3.A) ..... 5-14

5.2.1 Category description ..... 5-14

5.2.2 Methodological issues ..... 5-15

5.2.3 Emission Factors ..... 5-15

5.2.4 Activity Data ..... 5-29

5.2.5 Uncertainty Assessment ..... 5-32

5.2.6 Category specific QA/QC and verification ..... 5-33

5.2.7 Category specific recalculations ..... 5-35

5.2.8 Category specific planned improvements ..... 5-35

5.3 $CH_4$ Emissions from Manure Management (CRT 3.B.a) ..... 5-36

5.3.1 Category description ..... 5-36

5.3.2 Methodological issues ..... 5-37

5.3.3 Emission Factors ..... 5-37

5.3.4 Activity Data ..... 5-46

5.3.5 Uncertainty Assessment ..... 5-46

5.3.6 Category specific QA/QC and verification ..... 5-48

5.3.7 Category specific recalculations ..... 5-48

5.3.8 Category specific planned improvements ..... 5-48

5.4 $CH_4$ Emissions from Rice Cultivation (CRT 3.C) ..... 5-49

5.4.1 Category description ..... 5-49

5.4.2 Methodological issues ..... 5-49

5.4.3 Emission Factors ..... 5-49

5.4.4 Activity Data ..... 5-52

5.4.5 Uncertainty Assessment ..... 5-52

5.4.6 Category specific QA/QC and verification ..... 5-52
5.4.7 Category specific recalculations ..... 5-52
5.4.8 Category specific planned improvements ..... 5-52
5.5 $N_2O$ Emissions from Manure Management (CRT 3.B.b) ..... 5-53
5.5.1 Direct $N_2O$ Emissions from Manure Management ..... 5-53
5.5.2 Indirect $N_2O$ Emissions from Manure Management ..... 5-62
5.5.3 Category specific QA/QC and verification ..... 5-63
5.5.4 Category specific recalculations ..... 5-63
5.5.5 Category specific planned improvements ..... 5-63
5.6 $N_2O$ Emissions from Managed Soils (CRT 3.D) ..... 5-64
5.6.1 Direct $N_2O$ Emissions from Managed Soils ..... 5-64
5.6.2 Indirect $N_2O$ Emissions from Managed Soils ..... 5-74
5.6.3 Category specific QA/QC and verification ..... 5-78
5.6.4 Category specific recalculations ..... 5-79
5.6.5 Category specific planned improvements ..... 5-79
5.7 Field Burning of Agriculture Residues (CRT 3.F and CRT 5.C.2) ..... 5-80
5.7.1 Category description ..... 5-80
5.7.2 Methodological issues ..... 5-81
5.7.3 Emission Factors ..... 5-81
5.7.4 Activity Data ..... 5-82
5.7.5 Uncertainty Assessment ..... 5-83
5.7.6 Category specific QA/QC and verification ..... 5-84
5.7.7 Category specific recalculations ..... 5-84
5.7.8 Category specific planned improvements ..... 5-84
5.8 $CO_2$ Emissions from Liming (CRT 3.G) ..... 5-85
5.8.1 Category description ..... 5-85
5.8.2 Methodological issues ..... 5-85
5.8.3 Emission Factors ..... 5-85
5.8.4 Activity Data ..... 5-85
5.8.5 Uncertainty Assessment ..... 5-86
5.8.6 Category specific QA/QC and verification ..... 5-86
5.8.7 Category specific recalculations ..... 5-86
5.8.8 Category specific planned improvements ..... 5-86

5.9 $CO_2$ Emissions from Urea application (CRT 3.H) ..... 5-87
5.9.1 Category description ..... 5-87
5.9.2 Methodological issues ..... 5-87
5.9.3 Emission Factors ..... 5-87
5.9.4 Activity Data ..... 5-87
5.9.5 Uncertainty Assessment ..... 5-88
5.9.6 Category specific QA/QC and verification ..... 5-88
5.9.7 Category specific recalculations ..... 5-88
5.9.8 Category specific planned improvements ..... 5-88
5.10 $CO_2$ Emissions from Other Carbon-containing fertilizers (CRT 3.I) ..... 5-89
5.10.1 Category description ..... 5-89
5.10.2 Methodological issues ..... 5-89
5.10.3 Emission factors ..... 5-91
5.10.4 Activity Data ..... 5-92
5.10.5 Uncertainty Assessment ..... 5-92
5.10.6 Category specific QA/QC and verification ..... 5-92
5.10.7 Category specific recalculations ..... 5-92
5.10.8 Category specific planned improvements ..... 5-92

## List of Figures

Figure 5-1: Agricultural emissions from the total greenhouse gas emissions in 2024 ..... 5-8
Figure 5-2: Importance of agriculture sub sectors greenhouse gas emissions in 1990 and 2024 ..... 5-10
Figure 5-3: Methane emissions from agriculture- trend by source ..... 5-10
Figure 5-4: Nitrous Oxide emissions from agriculture- trend by source ..... 5-11
Figure 5-5: Overview of Methodology ..... 5-12
Figure 5-6: Relative importance of $CH_4$ emissions from enteric fermentation per animal species, in 2024 5-14
Figure 5-7: Evolution pattern growth for sheep (a) and goats (b) ..... 5-30
Figure 5-8: Lambs and Kids: average carcass weight at slaughtering ..... 5-31
Figure 5-9: Livestock numbers: comparison between National Statistics and FAO database ..... 5-34
Figure 5-10: Relative importance of $CH_4$ emissions from Manure Management per animal species in 2024 5-36
Figure 5-11: Climate regions presentation ..... 5-41
Figure 5-12: Rice cultivation relevant practices for EF calculation ..... 5-50

Figure 5-13: Rice area cultivated in Portugal, ha ..... 5-51
Figure 5-14: Direct $N_2O$ emissions from manure management, per system, 2024 ..... 5-54
Figure 5-15: Direct $N_2O$ emissions from manure management by livestock category, 2024 ..... 5-54
Figure 5-16: Distribution of total nitrogen in manure produced in 2024 (%) ..... 5-59
Figure 5-17: Origin of total nitrogen in manure produced in 2024, per animal type ..... 5-59
Figure 5-18: Share of nitrogen in manure stored and treated per MMS, in 2024 ..... 5-60
Figure 5-19: Origin, by livestock category, of nitrogen in manure stored and treated in 2024 ..... 5-60
Figure 5-20: Relative importance of the losses of volatile nitrogen and of leached nitrogen from manure management systems, in 2024 ..... 5-62
Figure 5-21: Contribution of the various sub sources to direct $N_2O$ emissions from managed soils, 2024. 5-65
Figure 5-22: Relevance of the sources of direct input of Nitrogen to agricultural soils in 2024 ..... 5-67
Figure 5-23: Use of inorganic N fertilizers (t $N.yr^{-1}$) ..... 5-68
Figure 5-24: Application of sewage sludge (t dm) and quantities of N (t N) in agriculture soils ..... 5-70
Figure 5-25: Application of Municipal Solid Waste (MSW) compost (t) and quantities of N (t N) in agriculture soils ..... 5-71
Figure 5-26: Share of indirect $N_2O$ emissions from managed soils by pathway: volatilization and leaching/runoff, 2024 ..... 5-74
Figure 5-27: Share of indirect $N_2O$ emissions from managed soils by source, 2024 ..... 5-74
Figure 5-28: Databases comparison of inorganic N fertilizers (t $N.yr^{-1}$) ..... 5-79
Figure 5-29: Share of GHG emissions from field burning agriculture residues, by crop, 2024 ..... 5-81
Figure 5-30: Annual biomass burnt (t dm $.yr^{-1}$) for the time series ..... 5-83
Figure 5-31: $CaCO_3$ used on agriculture land (t.$yr^{-1}$) ..... 5-85
Figure 5-32: $CaMg(CO_3)_2$ used on agriculture land (t.$yr^{-1}$) ..... 5-86
Figure 5-33: $MgCO_3$ used on agriculture land (t.$yr^{-1}$) ..... 5-86
Figure 5-34: Urea fertilizer application on agriculture land (t. $yr^{-1}$) ..... 5-88
Figure 5-35: Calcium Ammonium Nitrate (CAN) applied to soils and corresponding $CaCO_3$ amount ..... 5-92

## List of Tables

Table 5-1: Total Greenhouse Gas Emissions from Agriculture (kt $CO_2eq$) ..... 5-8
Table 5-2: Key categories in Agriculture (CRT 3) and methodologies used in emission estimates ..... 5-13
Table 5-3: $CH_4$ emissions from enteric fermentation (kt) ..... 5-14
Table 5-4: Country parameters relevant to methane emission factor of dairy cows enteric fermentation 5-17
Table 5-5: Methane emission factor from enteric fermentation – dairy cows ..... 5-17
Table 5-6: Livestock population by age – Non-dairy cattle ..... 5-19

Table 5-7: Parameters used in the determination of Net Energies for non-dairy cattle ..... 5-21

Table 5-8: Parameters used in the determination of Net Energies (non – dairy mother cows) ..... 5-21

Table 5-9: Non-dairy cattle estimated Gross Energy (GE) and $CH_4$ Emission Factor (EF) from enteric fermentation ..... 5-22

Table 5-10: Methane implied emission factor (IEF) for non-dairy cattle category in the time series ..... 5-23

Table 5-11: Parameters used in determination of Net Energies for sheep and goats from 1990 to 1998 .. 5-25

Table 5-12: Parameters used in determination of Net Energies for sheep and goats from 2013 onwards 5-25

Table 5-13: Sheep and goats estimated Gross Energy (GE) and $CH_4$ Emission Factor (EF) from enteric fermentation – from 1990 to 1998 ..... 5-26

Table 5-14: Sheep and goats estimated Gross Energy (GE) and $CH_4$ Emission Factor (EF) from enteric fermentation – from 2013 onwards ..... 5-26

Table 5-15: Methane implied emission factor (IEF) for sheep category in the time series ..... 5-27

Table 5-16: Methane implied emission factor (IEF) for goat category in the time series ..... 5-27

Table 5-17: Parameters used in determination of Gross Energy (GE) and enteric fermentation methane emission factor for swine and rabbits ..... 5-28

Table 5-18: Parameters used in determination of Gross Energy (GE) – Poultry ..... 5-29

Table 5-19: Livestock population (thousands) ..... 5-32

Table 5-20: Livestock population uncertainty assessment ..... 5-32

Table 5-21: $CH_4$ emissions from Manure Management (kt) ..... 5-36

Table 5-22: Parameters used in the estimates of volatile solids and EF per animal category ..... 5-38

Table 5-23: Share (%) of each Manure Management System per animal type from 1990 to 2024 ..... 5-39

Table 5-24: Share (%) of livestock population by climate region ..... 5-43

Table 5-25: Methane Conversion Factors (MCF), %, for determination of $CH_4$ emissions from manure management ..... 5-44

Table 5-26: Manure management $CH_4$ Implied Emission Factors (IEF) and comparison with IPCC 2006 default emission factors (kg $CH_4.hd^{-1}.yr^{-1}$) ..... 5-46

Table 5-27: Uncertainty values, in %, of the $CH_4$ Emission Factors of the manure management ..... 5-48

Table 5-28: $CH_4$ emissions from Rice cultivation ..... 5-49

Table 5-29: Parameters and Emission Factors used to calculate CH4 emissions from rice paddies in Portugal ..... 5-52

Table 5-30: Uncertainty values (in %) of the Emission Factor of $CH_4$ emissions from rice cultivation ..... 5-52

Table 5-31: $N_2O$ emissions from manure management (kt) ..... 5-53

Table 5-32: $N_2O$ emission factors per manure management system ..... 5-55

Table 5-33: Nitrogen excretion rates (Nex) of dairy cows in the time series ..... 5-56

Table 5-34: Nitrogen excretion rates (Nex) of non-dairy cattle in the time series ..... 5-57

Table 5-35: Nitrogen excretion rates (Nex) of all livestock other than cattle ..... 5-58

Table 5-36: Uncertainty values (in %) of the activity data for $N_2O$ emissions from manure management. 5-61

Table 5-37: Amount of N lost due to volatilization ($NH_3$+$NO_x$) and leaching, during animal housing and manure storage (t $N.yr^{-1}$) ..... 5-63

Table 5-38: $N_2O$ emissions from managed soils (kt) ..... 5-64

Table 5-39: Emission factors used to estimate direct $N_2O$ emissions from managed soils ..... 5-66

Table 5-40: Total amounts of Nitrogen (t N/yr) added to managed soils. Activity data for direct $N_2O$ emissions ..... 5-67

Table 5-41: Rice cultivation- Nitrogen amount applied on flooded rice fields (t N/yr) ..... 5-69

Table 5-42: Average amount of straw used in animal bedding-solid manure management systems and N content of straw ..... 5-69

Table 5-43: Estimates of manure management nitrogen available for application to soils (t $N.yr^{-1}$) ..... 5-69

Table 5-44: Estimates of annual amounts of nitrogen sewage sludge in agriculture soils ..... 5-70

Table 5-45: Parameters used to estimate nitrogen from crop residues to soil ..... 5-72

Table 5-46: Crop Yield Fresh ($kg.ha^{-1}$) ..... 5-73

Table 5-47: Annual N amounts (t) that volatilized as $NH_3$ and NOx, disaggregated by source input ..... 5-76

Table 5-48: $Frac_{GASF}$ and $Frac_{GASM}$ annual values ..... 5-76

Table 5-49: Emission factor used for calculation of indirect $N_2O$ emissions from managed soils ..... 5-78

Table 5-50: Uncertainty values (%) of the fractions of N volatilized and N leached/runoff and of the emission factors ..... 5-78

Table 5-51: $CH_4$ and $N_2O$ emissions estimates from field burning of agriculture residues (kt) ..... 5-80

Table 5-52: Emission factors for field burning agriculture residues, g. kg dm $burnt^{-1}$ ..... 5-82

Table 5-53: Activity data and parameters used to estimate emissions from field burning of crop residues, 2024 ..... 5-83

Table 5-54: Uncertainty values (in %) of the activity data for on field burning crop residues ..... 5-83

Table 5-55: Uncertainty values (in %) of the emission factors, $CH_4$ and $N_2O$, for on field burning crop residues ..... 5-84

Table 5-56: % of use of each “Nitrolusal” fertilizer type ..... 5-89

Table 5-57: Molar Mass of Ca, C, O, $CaCO_3$ and $CO_2$ ..... 5-91

## List of Equations

Equation 5-1: Enteric fermentation emissions from a livestock category and subcategories ..... 5-15

Equation 5-2: $CH_4$ emission factor for enteric fermentation from a livestock category ..... 5-16

Equation 5-3: Swines estimated Gross Energy (GE) ..... 5-27

Equation 5-4: Poultry estimated Gross Energy (GE) ..... 5-29
Equation 5-5: $CH_4$ emissions from Manure Management ..... 5-37
Equation 5-6: $CH_4$ emission factor from Manure Management ..... 5-37
Equation 5-7: Volatile solid excretion rates ..... 5-38
Equation 5-8: $CH_4$ emissions from Rice cultivation ..... 5-49
Equation 5-9: Emission factor, seasonally integrated and adjusted, for rice cultivation ..... 5-49
Equation 5-10: $N_2O$ direct emissions from manure management, per system ..... 5-55
Equation 5-11: Direct $N_2O$ emissions from managed soils ..... 5-65
Equation 5-12: Annual Consumption of inorganic N fertilizers ..... 5-68
Equation 5-13: $N_2O$ from atmospheric deposition of N volatilized from managed soils ..... 5-75
Equation 5-14: $N_2O$ emissions from leaching/runoff from managed soils ..... 5-77
Equation 5-15: Estimation of GHG emissions from field burning of crop residues ..... 5-81

# 5 Agriculture (CRT Sector 3)

*Andrea Santos*

*Updated: April 2026*

## 5.1 Overview of the sector

Agriculture activities generate emissions of greenhouse gas from a variety of sources. This chapter refers to the quantification of: $CH_4$ emissions from enteric fermentation (3.A); $CH_4$ and $N_2O$ emissions from manure management (3.B); $N_2O$ emissions from agriculture soils (3.D); $CH_4$ from rice cultivation (3.C); $CH_4$ and $N_2O$ emissions from field burning of agriculture residues (3.F) and $CO_2$ from liming, urea application and other carbon containing fertilizers (3.G-H-I). There are no ecosystems in Portugal that could be considered natural savannahs, and no greenhouse gas emissions exist therefore for this sub-category (3.E). GHG emissions from combustion processes in agriculture are discussed in sector Energy: Other sectors (1A4). Estimates of $CO_2$ release and uptake resulting from conversion of agriculture land and grazing land to other uses, conversion of other uses to agriculture land and grazing land, conversion of agriculture land to grazing land and vice versa, and substantial changes in agriculture practices, such as conversion of annual crops to perennial crops and the opposite, are estimated in the inventory but included in chapter Land Use, Land Use Change and Forestry (LULUCF).

The importance of agriculture greenhouse gas emissions to total national emissions (excluding LULUCF and international bunkers) has remained relatively stable from 1990 (12.5%) to 2024(13.5%).

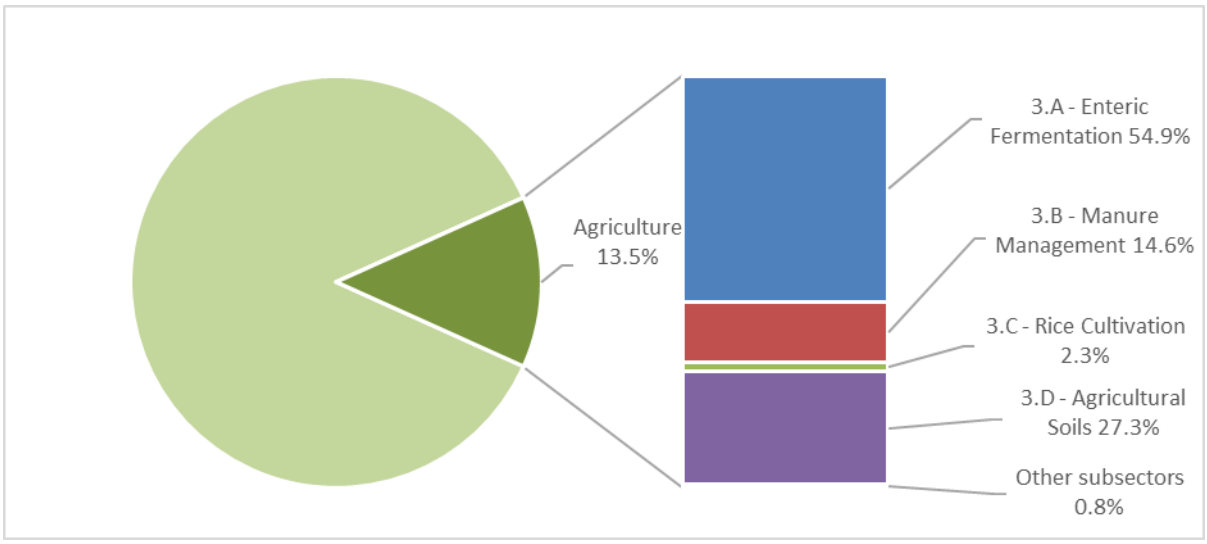



***Figure 5-1: Agricultural emissions from the total greenhouse gas emissions in 2024***

Total greenhouse gas emissions from agriculture sector have decreased about 6.0% over the period 1990 to 2024, 0.4% from 2005 to 2024 and 5.2% from 2020 to 2024. Between 2023 and 2024, there was a decrease of 1.2% in total agriculture emissions (Table 5-1).

***Table 5-1: Total Greenhouse Gas Emissions from Agriculture (kt $CO_2$eq)***

| | Source /Gas | 1990 | 2005 | 2020 | 2023 | 2024 | Δ 2024-2023 | Δ 2024-2020 | Δ 2024-2005 | Δ 2024-1990 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | kt CO2 eq. | | | | | % | | | |
| **3.A** | **Enteric Fermentation** | | | | | | | | | |
| | $CH_4$ | 3 941.7 | 3 966.9 | 4 054.9 | 3 915.5 | 3 800.4 | -2.9 | -6.3 | -4.2 | -3.6 |
| **3.B** | **Manure Management** | | | | | | | | | |
| | $CH_4$ | 907.3 | 781.1 | 837.1 | 817.8 | 810.6 | -0.9 | -3.2 | 3.8 | -10.7 |
| | $N_2O$ | 238.8 | 183.3 | 198.2 | 200.6 | 199.7 | -0.5 | 0.7 | 8.9 | -16.4 |
| **3.C** | **Rice Cultivation** | | | | | | | | | |
| | $CH_4$ | 150.0 | 131.0 | 139.5 | 162.7 | 159.2 | -2.1 | 14.1 | 21.6 | 6.2 |
| **3.D** | **Agricultural Soils Management** | | | | | | | | | |
| | $N_2O$ | 2 059.0 | 1 837.7 | 2 018.2 | 1 859.9 | 1 891.4 | 1.7 | -6.3 | 2.9 | -8.1 |
| **3.F** | **Field Burning of crop residues** | | | | | | | | | |
| | $CH_4$ | 10.3 | 7.3 | 6.2 | 7.4 | 7.2 | -2.1 | 16.0 | -0.3 | -29.4 |
| | $N_2O$ | 2.5 | 1.8 | 1.5 | 1.8 | 1.8 | -2.1 | 16.0 | -0.3 | -29.4 |
| **3.G** | **Liming** | | | | | | | | | |
| | $CO_2$ | 6.5 | 6.2 | 11.8 | 9.8 | 13.4 | 37.6 | 13.5 | 116.1 | 106.8 |
| **3.H** | **Urea Application** | | | | | | | | | |
| | $CO_2$ | 21.3 | 18.9 | 22.1 | 21.1 | 30.0 | 42.0 | 35.5 | 58.8 | 40.9 |
| **3.I** | **Other Carbon containing Fertilizers** | | | | | | | | | |
| | $CO_2$ | 20.7 | 13.2 | 9.2 | 6.9 | 4.5 | -34.4 | -50.7 | -65.9 | -78.2 |
| **Total** | $CH_4$ | 5 009.3 | 4 886.2 | 5 037.7 | 4 903.3 | 4 777.5 | -2.6 | -5.2 | -2.2 | -4.6 |
| | $N_2O$ | 2 300.3 | 2 022.8 | 2 218.0 | 2 062.3 | 2 092.8 | 1.5 | -5.6 | 3.5 | -9.0 |
| | $CO_2$ | 48.4 | 38.3 | 43.1 | 37.8 | 47.9 | 26.9 | 11.2 | 25.0 | -1.1 |
| **Total** | **All gases** | 7 358.1 | 6 947.4 | 7 298.8 | 7 003.4 | 6 918.2 | -1.2 | -5.2 | -0.4 | -6.0 |

Note: Totals may not sum due to independent rounding. Emissions values are presented in CO2eq mass units using IPCC AR4 GWP values ($CH_4$ - 25; NO - 298).

In 2024, the contribution of each greenhouse gas emissions in the total emissions from agriculture, expressed in $CO_2$eq, was: $CH_4$ emissions 69.1% (68.1%% in 1990); $N_2O$ emissions 30.3% (31.3% in 1990) and $CO_2$ emissions 0.7% (0.7% in 1990).

Most emissions from agriculture in 1990 and 2024 are the result of three main 3 sub sources (Figure 5-2): Enteric Fermentation (3.A), Agriculture Soils (3.D) and Manure Management (3.B), hierarchically listed in order of the most prevalent. Rice cultivation (3.C), Field burning of crop residues (3.F) and Liming (3.G), Urea application (3.H) and other carbon-containing fertilizers (3.I) are minor sub sources.

Rounded values are often used in this inventory report; accurate figures used in the calculation are reported in CRT tables.

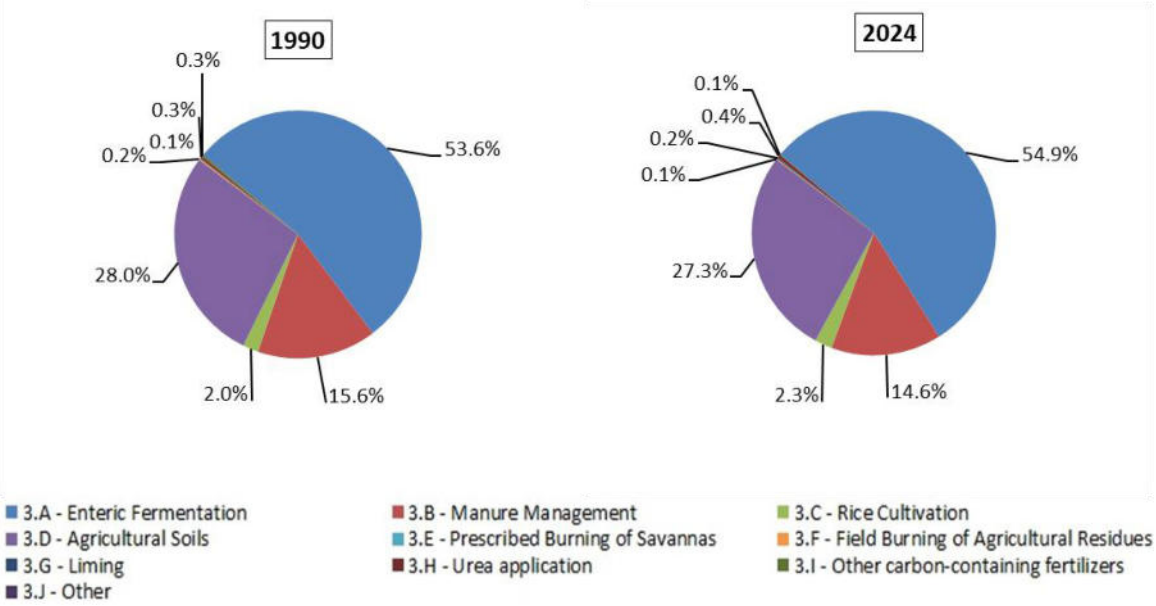



***Figure 5-2: Importance of agriculture sub sectors greenhouse gas emissions in 1990 and 2024***

Annual emissions of $CH_4$ from agriculture have decreased 4.63 % from 1990 to 2024 (figure below). Enteric Fermentation (3.A) was responsible, in 2024, for 79.5% of the sectoral methane emissions and Manure Management (3.B) accounted for 17.0% of the sectoral emissions in the same year. The remaining 3.3% of emissions result mainly from Rice Cultivation (3.C), with only a very small contribution from Field Burning of Crop Residues (3.F), 0.2%.

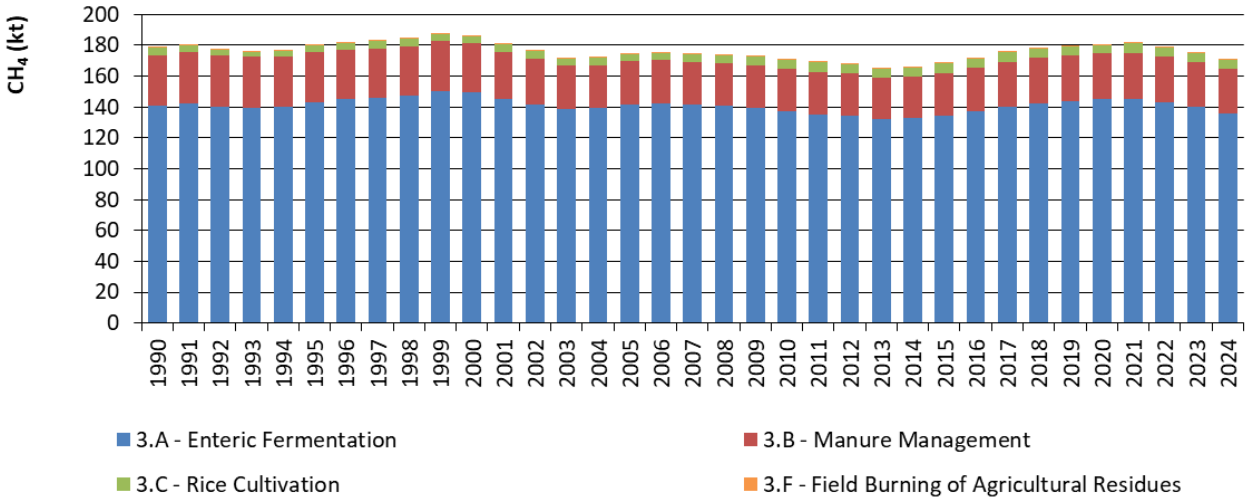



***Figure 5-3: Methane emissions from agriculture- trend by source***

$N_2O$ emissions have decreased 9.02% from 1990 to 2024 (Figure 5-4). The great majority of emissions in 2024 were related to direct and indirect emissions from Agricultural Soils (3.D), 90.4%, Manure Management (3.B) is responsible for 9.5% of emissions, while the small remaining fraction results from Field Burning of agricultural crop residues (3.F), 0.1%.

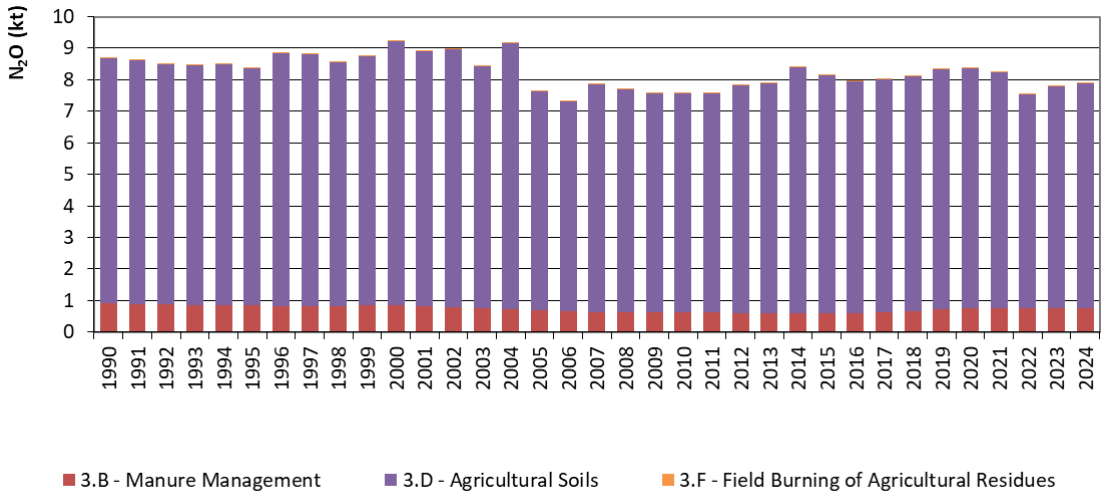



***Figure 5-4: Nitrous Oxide emissions from agriculture- trend by source***

$CO_2$ emissions from Liming, Urea application and other carbon-containing fertilizers are minor sources on total agricultural emissions. Liming and Urea application are the main sources with a share of about 28.01% and 62.57% in 2024.

Some inter annual variation in the time series are mainly caused by fluctuations in activity data due to changes in the number of animals in production and in the areas/yields of cultivated/harvested crops. Changes in animal numbers are normally linked to agricultural policy and subsidies. Depending on animal species, variations of livestock population affect the enteric fermentation ($CH_4$) and the manure management ($CH_4$ and $N_2O$) emissions, as well as the managed soils ($N_2O$) emissions from sub source urine and dung deposited by grazing animals. Changes in the areas and yields of cultivated crops depends on many factors, for example the climatic conditions occurring during the year, especially in the sowing period and/or the harvest time, the fluctuation of internal and world market prices, among others. The amount of synthetic fertilizers annually used is closely related to the cultivated crops variation.

Emissions were estimated following as far as possible the methodology recommended by *IPCC 2006 Guidelines for National Greenhouse Gas Inventories* (IPCC 2006) and were done in a consistent way: the same activity data is used and balanced for all source categories. A general overview of methodology is presented in the next figure.

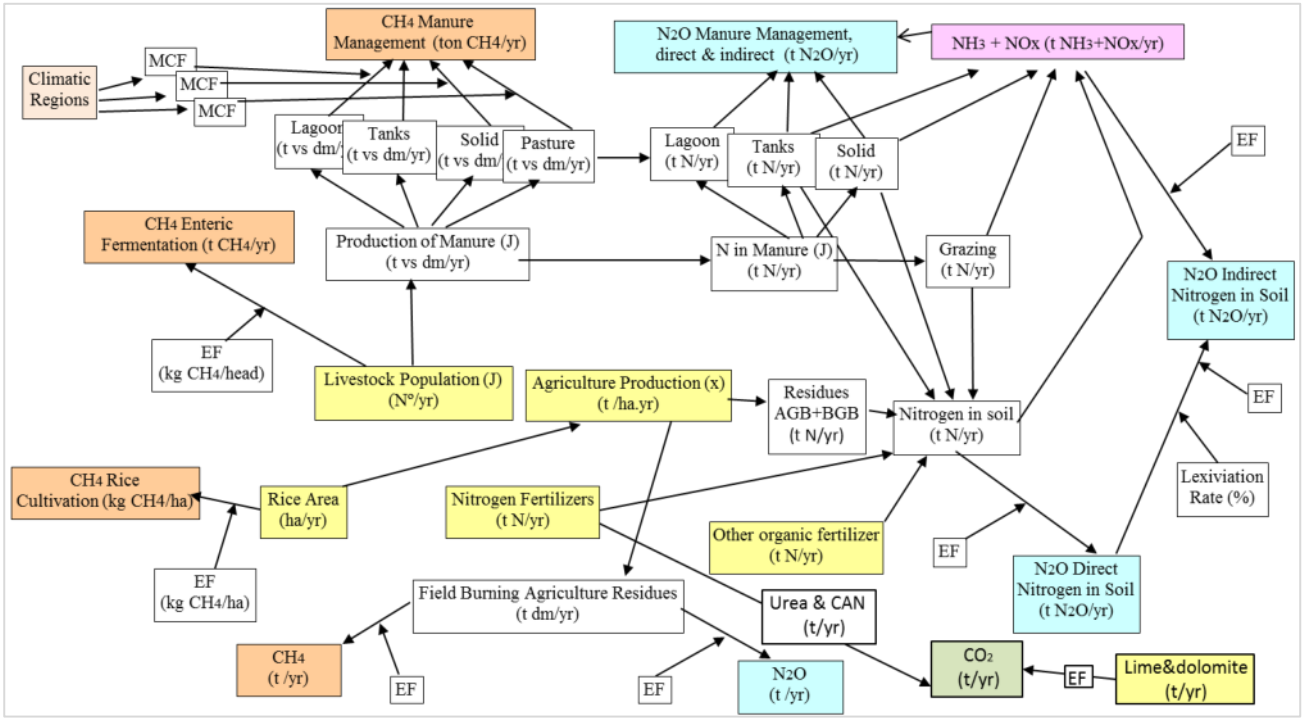



***Figure 5-5: Overview of Methodology***

This integration of calculus means that changes in methodology are done also in a consistent and coherent way among the several source sectors. Improvements in methodology in each source sector are reflected in changes in other related sources.

### *Recalculations*

Changes between submissions are due to the:

- Rice Cultivation (3C): updated 2023-2024 rice cultivation area (ha)
- Agricultural soils (3D): Update of 2023-2024 CAN activity data;
- Urea application (3H): Update of 2023-2024 Urea activity data;
- Other carbon-containing fertilizers (3I): Update of 2019 and 2023-2024 CAN activity data.

### *Key categories*

The key categories in agriculture are summarised in Table 5-2.

***Table 5-2: Key categories in Agriculture (CRT 3) and methodologies used in emission estimates***

| IPCC category | Gas | Criteria | Method |
|---|---|---|---|
| **3.A Enteric Fermentation** | $CH_4$ | Level 1 and 2, Trend 1 and 2 | T2 |
| **3.B Manure Management** | $CH_4$ | Level 1 and 2, Trend 1 and 2 | T2 |
| **3.B Manure Management** | $N_2O$ | Level 2, Trend 2 | T2 |
| **3.D.1 Direct $N_2O$ emissions from Managed Soils** | $N_2O$ | Level 1 and 2, Trend 1 and 2 | T1" |
| **3.D.2 Indirect $N_2O$ emissions from Managed Soils** | $N_2O$ | Level 1, Trend 1 | T1" |
| "Default EFs but country specific AD & parameters | | | |

## 5.2 $CH_4$ Emissions from Enteric Fermentation (CRT 3.A)

### 5.2.1 Category description

Methane emissions from enteric fermentation in animals result from this gas being produced as a by-product during the digestive process of carbohydrates by micro-organisms in the digestive system. This process occurs specially in ruminant animals (cattle, sheep, goats), due to the activity of specific micro-organisms in their upper digestive tracts, but also in smaller quantities in monogastric animals (swine, equines, poultry, and rabbits). The estimates in this inventory include only emissions in domestic animals. Emissions from wild animals and semi-domesticated game are not quantified, neither there is quantification of emissions from humans or pet animals.

In Table 5-3 are presented the estimates of $CH_4$ emission from enteric fermentation.

***Table 5-3: $CH_4$ emissions from enteric fermentation (kt)***

| Livestock type | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Dairy cattle** | 38.19 | 37.34 | 39.92 | 35.53 | 32.70 | 31.03 | 31.58 | 31.04 | 30.90 | 30.37 |
| **Non-dairy cattle** | 60.19 | 61.39 | 66.30 | 71.14 | 73.36 | 75.23 | 83.17 | 81.92 | 79.03 | 76.06 |
| **Swine** | 3.09 | 3.07 | 2.79 | 2.32 | 2.31 | 2.47 | 2.57 | 2.55 | 2.49 | 2.49 |
| **Sheep** | 31.72 | 34.02 | 33.83 | 27.21 | 23.21 | 20.40 | 22.45 | 22.76 | 22.50 | 22.00 |
| **Goats** | 5.69 | 4.93 | 4.51 | 3.71 | 3.62 | 3.43 | 3.39 | 3.24 | 3.14 | 3.02 |
| **Horses** | 1.77 | 1.89 | 1.74 | 1.68 | 1.90 | 1.51 | 1.61 | 1.68 | 1.72 | 1.73 |
| **Poultry** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Rabbits** | 0.13 | 0.11 | 0.09 | 0.08 | 0.07 | 0.04 | 0.04 | 0.06 | 0.06 | 0.07 |
| **Total** | **140.78** | **142.74** | **149.17** | **141.67** | **137.16** | **134.11** | **144.82** | **143.23** | **139.84** | **135.73** |
| Note: Totals may not sum due to independent rounding | | | | | | | | | | |

$CH_4$ emissions from enteric fermentation are a key source, both by level and trend assessment. The share of each animal type is observable in Figure 5-6. Dairy cattle and non-dairy cattle are significant sources: dairy cattle represent, according to different years, 21.7% to 27.1% of total $CH_4$ emissions from Enteric Fermentation, while non-dairy cattle represent about 42.7% to 57.4% of total $CH_4$ from enteric fermentation. Together, in 2024, cattle were responsible for about 78.4% of total $CH_4$ emissions from enteric fermentation.

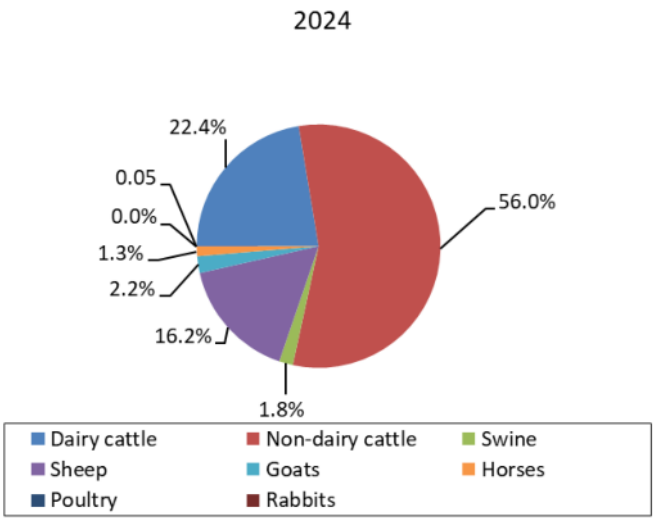



***Figure 5-6: Relative importance of $CH_4$ emissions from enteric fermentation per animal species, in 2024***

Sheep category is also an important source of methane which emissions oscillating in the time series from 15.2% to 24.0% of the total $CH_4$ emissions from enteric fermentation. Emissions associated to goats have a

variation from 2.2% to 4.0 % and the variation of the emissions associated to swine was from 1.6% to 2.3% of the total enteric fermentation emissions. All other animal categories are minor source of methane emissions from enteric fermentation representing in the time series between 1.0% and 1.5%.

### 5.2.2 Methodological issues

Emissions were estimated for each animal type[1] by multiplication of the number of animals by the respective emission factor, in accordance to equation 10.19 and 10.20[2] of the IPCC 2006.

***Equation 5-1: Enteric fermentation emissions from a livestock category and subcategories***

$$Emi_{CH_4\,(y)} = \Sigma_t\,[EF_{(i,y)} * N_{(i,y)}]$$

**Where:**

$Emi_{CH_4\,(y)}$ - methane emissions from enteric fermentation in year y, kg $CH_4$.year$^{-1}$

$EF_{(i,y)}$ - emission factor for the specific population of animal type i in year y, kg.head$^{-1}$.year$^{-1}$

$N_{(i,y)}$ - number of animals of type i in year y

### 5.2.3 Emission Factors

For cattle (dairy and non-dairy), sheep, goats and swine categories the emission factors used, by animal type and subcategory, were calculated using a methodology level Tier 2. Methodological approach will be further discussed ahead for each one.

The default emission factors proposed by IPCC 2006 in table 10.10[3] were maintained for horses, mules and asses, due to the unavailability of a more detailed livestock characterization.

There are no emissions factors in IPCC 2006 for broilers, laying hens, turkeys, ducks, geese and other poultry, thus the emissions from these livestock categories were not estimated and were assumed as negligible. In Portugal, there are no livestock populations of Buffalo, Camels or Lamas.

***Determination of Tier 2 emission factors***

For the most significant animal types, a tier 2 analysis was implemented to establish the respective emission factors for the enteric fermentation.

According to the IPCC 2006, at Tier 2 level, the emission factors for enteric fermentation are developed following the equation 10.21[4], described below:

[1] For most animal types an enhanced characterization of livestock, with subdivision per age, sex and management conditions was used. This is discussed in more detail under activity data chapter.
[2] Volume 4, chapter 10, page 10.28
[3] Volume 4, chapter 10, page10.28
[4] Volume 4, chapter 10, page 10.31

***Equation 5-2: $CH_4$ emission factor for enteric fermentation from a livestock category***

$$EF_{CH4} = \{[GE * (Y_m/100) * 365 \text{ days}] / 55.65\}$$

**Where:**

$EF_{CH4}$ – emission factor, kg $CH_4$.head$^{-1}$ year$^{-1}$

GE – gross energy intake, Mj.head$^{-1}$.day$^{-1}$

$Y_m$ – methane conversion factor (% of gross energy in feed that is converted to methane)

The factor 55.65 (MJ.kg$^{-1}$$CH_4$) is the energy content of methane

### 5.2.3.1 Dairy Cattle

For dairy cattle and to the Gross Energy (GE) estimation, two country regions were considered separate, due to differences on feed situation, diet characteristics and milk production. In Portugal Mainland, dairy cows are predominantly stalled with a feed diet based on maize silage (40%) and hay/straw (10%) as raw feed and compound feed (50%). In Azores archipelago dairy cows diet are based on pasture, maize or grass silage and compound feed, being the ratio pasture and, or silage/compound feed about 65/35. Feed digestibility (DE%) of these two different dairy cows feed diets was estimated by experts[5] of the National Institute for Agriculture and Veterinary Research (INIAV) based on available feed tables data: 74% for mainland region and 71% for Azores.

Milk production (kg.hd$^{-1}$.d$^{-1}$) was estimated dividing the annual production over the number of cows in production[6] and 365 days. Therefore, lactating and non–lactating periods are included in the estimation of the $CH_4$ dairy cattle emission factor.

Livestock numbers, annual milk production and fat content of milk are published by National Statistical Institute (INE) disaggregated by region.

Most cows used for milk production in Portugal belong to the Frisians race. The average weight of 600 kg for mature Frisian cows was supplied by experts[7] of the General Directorate for Food and Veterinary (DGAV) of Ministry of Agriculture (MA), based on the analysis of the available national information and international studies.

The fraction of cows giving birth annually, disaggregated by region, was estimated from available data (1999-2024) of National Animal Registration (SNIRA)[8] . For the period 1990–1998 data were completed through a linear regression developed by the Statistics Unit (DSE) of GPP (MAM).

Table 5-4 presents the time series (1990-2024) for the relevant country specific parameters used to estimated $CH_4$ dairy cow emissions from enteric fermentation.

[5] Drª Olga Moreira e Engª Teresa Dentinho - Unit of Animal Production and Health,2014
[6] The same time series used in the inventory but not averaged over 3 years.
[7] Dr Vicente de Almeida - Animal Genetic Resources Department ; Dr José Neves – Unit of Animal Identification, Registration and Movement,2014
[8] Provided by Funding Institute for Agriculture and Fisheries (IFAP)

***Table 5-4: Country parameters[9] relevant to methane emission factor of dairy cows enteric fermentation***

| Year | Average Weight (kg $hd^{-1}$) | Average Milk production (kg $hd^{-1}$ $d^{-1}$) | Fat content in milk (%) | Cows giving birth in the year (%) | Cows with predominance of pasture on diet (%) |
|---|---|---|---|---|---|
| **1990** | 600 | 12.23 | 3.96 | 75.03 | 22.87 |
| **1995** | 600 | 12.48 | 3.91 | 74.80 | 23.90 |
| **2000** | 600 | 17.16 | 3.86 | 75.37 | 27.96 |
| **2005** | 600 | 19.81 | 3.84 | 74.96 | 30.84 |
| **2010** | 600 | 21.63 | 3.78 | 74.45 | 34.30 |
| **2015** | 600 | 22.70 | 3.76 | 76.57 | 37.21 |
| **2020** | 600 | 23.48 | 3.77 | 78.28 | 38.18 |
| **2022** | 600 | 23.80 | 3.77 | 80.88 | 37.90 |
| **2023** | 600 | 24.52 | 3.77 | 81.12 | 37.44 |
| **2024** | 600 | 24.88 | 3.77 | 74.21 | 37.49 |

The improvement in breeding conditions and of the technological development of dairy farms led to a general increase in milk yield in the overall period.

Table 5-5 shows the time series for the different Net Energies required for maintenance, animal activity, lactation, pregnancy, growth and work ($NE_m$, $NE_a$, $NE_l$, $NE_p$, $NE_g$, $NE_{work}$), the results for Gross Energy (Mj $d^{-1}$) and the estimated $CH_4$ Emission Factor (kg $CH_4$ $hd^{-1}$ $yr^{-1}$) from dairy cows enteric fermentation, which were calculated based on the equations described in IPCC 2006[10] (Net energies equations 10.3, 10.4, 10.6, 10.8, 10.11, 10.13 and Gross energy equation 10.16 which includes equation 10.14 for REM fraction calculation).

A constant methane conversion factor of 6.5% (IPCC 2006 value from table 10.12) of gross energy intake was applied.

***Table 5-5: Methane emission factor from enteric fermentation – dairy cows***

| Year | NEm | NEa | NEg[(1)] | NEl | NEw | NEp | REM | GE (Mj hd-1 $d^{-1}$) | EF (kg CH4 hd-1yr-1) |
|---|---|---|---|---|---|---|---|---|---|
| **1990** | 46.80 | 1.82 | 0.00 | 37.35 | 0.00 | 3.53 | 0.54 | 227.17 | 96.99 |
| **1995** | 46.80 | 1.90 | 0.00 | 37.89 | 0.00 | 3.51 | 0.54 | 228.67 | 97.73 |
| **2000** | 46.80 | 2.22 | 0.00 | 51.63 | 0.00 | 3.52 | 0.54 | 265.33 | 113.16 |
| **2005** | 46.80 | 2.45 | 0.00 | 60.41 | 0.00 | 3.49 | 0.54 | 287.74 | 122.91 |
| **2010** | 46.80 | 2.73 | 0.00 | 65.03 | 0.00 | 3.46 | 0.54 | 300.81 | 128.45 |
| **2015** | 46.80 | 2.96 | 0.00 | 67.57 | 0.00 | 3.59 | 0.54 | 309.24 | 131.88 |
| **2020** | 46.80 | 3.04 | 0.00 | 70.53 | 0.00 | 3.70 | 0.54 | 317.44 | 135.38 |
| **2021** | 46.80 | 3.04 | 0.00 | 71.07 | 0.00 | 3.81 | 0.54 | 319.05 | 136.10 |
| **2022** | 46.80 | 3.01 | 0.00 | 71.46 | 0.00 | 3.82 | 0.54 | 319.76 | 136.45 |
| **2023** | 46.80 | 2.98 | 0.00 | 73.48 | 0.00 | 3.83 | 0.54 | 324.55 | 138.56 |
| **2024** | 46.80 | 2.98 | 0.00 | 74.80 | 0.00 | 3.51 | 0.54 | 327.31 | 139.68 |

[1] assumed no gain weight as definition of dairy cows category are mature cows

[9] Weighted average
[10] Volume 4, Chapter 10

For the year 2024 the estimated EF is 139.68 $CH_4$ $hd^{-1}$ $yr^{-1}$ which is higher than the default value[11] for North America (138 kg $CH_4$. $hd^{-1}$ $yr^{-1}$) but not so different. Milk production in Portugal (more than 8000 kg/head/year) exceeds the value indicated for Western Europe (7410 kg/head/year) and is much higher than the one indicated for Eastern Europe (4000 kg/head/year) but is closer to that of North America (10250 kg/head/year). Therefore, Portugal Inventory Team used for the comparison the default IPCC EF for North America (138 kg $CH_4$/head/year) instead of the value for Western Europe (126 kg $CH_4$/head/year) or Eastern Europe (93 kg $CH_4$/head/year) (2019 Refinement to the 2006 IPCC Guidelines, vol. 4, chap. 10, table 10.11 (updated)).

#### 5.2.3.2 Non - dairy Cattle

The Ministry of Agriculture (MA[12]) compiled in 1998, information from the existing breeder associations in Portugal. This database comprehending: number of registered producers, number of animals, main productive function (milk, meat), weaning age, slaughtering, use as working animal, territorial range and biometric parameters such as weight at the birth, at 7 months and at adult age. Most breeds in the 1998 database are indigenous breeds, with two being exotic breeds[13].

The update of the 1998 database information was carried out from 2017 to the middle of 2019, through a work developed with the involvement of the Breeders Associations of the most representative breeds used in Portugal and of the experts on Nutrition and Animal Production and on Chemical and Nutritive Evaluation of Animal Feed, from the National Institute for Agriculture and Veterinary Research (INIAV)[14] and from the University of Évora (UEvora)[15]. Of the work developed[16] we highlighted the following updates and sources:

- Through the National Animal Registration database (SNIRA) it was possible to obtain the latest information about the composition of the non-dairy cattle population from 2013[17] to 2017, i.e: the most representative purebreds (10 indigenous and 3 exotics)[18] and, also, the proportion and the territorial distribution of pure and of crossbred animals.
- For each purebred, an update of animal characteristics was collected from the breeder Associations through a specific survey, providing relevant information, such as: live weights of males and females at different stages of growth (birth, 4 months, 7 months, 12 months, 24 months and adult age), average weight gains per day, feeding practises and type of animal management.
- The characterization of crossbred animals, in the same way as the purebred animals, i. e, average live weights at different stages of growth, average weight gains per day, feed situation and type of animal management, was done in collaboration with the breeders Associations and the experts on Animal Production and Animal Genetic Improvement.
- Representative diets compositions, such as the type and proportion of food ingested (milk, grass pasture, forage supplement and compound feed) were established based on the collected information from the specific surveys responded by the breeder Associations and the experts collaborations of INIAV and UEvora on Nutrition and Animal Production;

[11] The average dairy cow's milk production in Portugal (8600 kg.hd-1 yr-1) is closer to the average milk production in North America (8400 kg.hd-1 yr-1) than to the average milk production in Western Europe (6000 kg.hd-1 yr-1). The default IPCC value for North America is 138 kg $CH_4$ $hd^{-1}$ $yr^{-1}$ and that is the reason to indicate this value instead of the 126 kg $CH_4$ $hd^{-1}$ $yr^{-1}$ for Western Europe.
[12] General Directorate for Food and Veterinary.
[13] Indegenous breeds: Alentejana, Arouquesa Barrosã, Marinhoa, Maronesa, Mertolenga, Minhota, Mirandesa, Preta; Exotic breeds: Charolesa, Limousine
[14] Engº Nuno Carolino – Animal Production and Conservation and Animal Genetic Improvement, 2018; Engª Teresa Dentinho – Chemical and Nutritive evaluation of animal feed, 2018.
[15] Prof. Manuel Cancela d'Abreu - Nutrition, Animal Feed and Animal Production
[16] Documento nº 2/2019/ GT SNIERPA Agricultura of 8.04.2019.
[17] First year where the detailed information needed became available
[18] Indegenous breeds: Alentejana, Arouquesa Barrosã, Brava de lide, Cachena, Maronesa, Mertolenga, Minhota, Mirandesa e Preta; Exotic breeds: Abardeen-Angus, Charolesa e Limousine

– Digestible energy (DE%) of the representative diets were estimated by the expert of INIAV on Chemical and Nutritive evaluation of Animal Feed, considering the proportion and the data of the different feed constituents of each diet.

With the updated information the calculations of the non-dairy cattle, emission factors from enteric fermentation were reviewed.

The calculation was made individually for each subcategory, determined from the available statistical information as presented in Table 5-6.

***Table 5-6: Livestock population by age – Non-dairy cattle***

| Age | Population |
|---|---|
| <1 yr | Beef Calves |
| | Calves, Males for Replacements |
| | Calves, Females for Replacements |
| 1-2 yr | Males |
| | Beef Females |
| | Females for Replacement |
| >2 yr | Steers |
| | Heifers for Beef |
| | Heifers for Replacements |
| | Non-dairy cows |

Gross Energy estimates for each cattle subcategory were determined using the energy model of the IPCC 2006[19]. First, Net Energies required for maintenance, animal activity, lactation, pregnancy, growth and work ($NE_m$, $NE_a$, $NE_l$, $NE_p$, $NE_g$, $NE_{work}$) were calculated using equations 10.3, 10.4, 10.8, 10.13, 10.6 and 10.11, respectively.

The ratios of the net energy available for maintenance and for growth in a diet to digestible energy consumed, REM and REG, were calculated using equations 10.14 and 10.15 (IPCC 2006).

Finally Gross Energy intake (GE), expressed in energy, was calculated using equation 10.16 (IPCC 2006).

For each cattle breed, purebred or crossbreed, the values used for parameters, such as weight, weight gain, feeding situation, diets and digestible energy, were those resulting from the updating data work, as explained above. Considering the average characteristics of the different breeds, the management systems and their territorial distribution, four non–dairy cattle groups were constituted: (1) Exotic breeds[20]; (2) Traditional indigenous breeds on pasture[21]; (3) Traditional indigenous breeds on range[22] (4) Crossbreed cattle. The difference between traditional animals "on pasture" and "on range" depends on the topography conditions, being assumed: the range situation is applied to breeds mostly existing in the south plains ("Montados"); the pasture situation occurs when in small grazing plots ("Prados" and "Lameiros"), as the existing in the north and centre regions. Most Crossbreed cattle, over 70 %, are mostly on the south plains.

[19] Volume 4, Chapter 10, pages 10.15 to 10.21
[20] Aberdeen-Angus, Charolesa and Limousine
[21] Arouquesa, Barrosã, Cachena, Maronesa, Mertolenga, Minhota and Mirandesa
[22] Alentejana, Brava de Lide, Mertolenga and Preta.

For each cattle group were established the representative diets composition, type and proportion of food ingested (milk, pasture, forage and compound feed), considering three animal subcategories: less than 1 year, between 1 and 2 years and more than 2 years.

Depending on the cattle group and the subcategory the proportion of pasture on diet have a variation of 20% to 80%, forage supplemental a variation of 10% to 20% and compound feed a variation from 10% to 70%. Milk is only relevant for subcategory less than 1 year and the portion variation between cattle groups goes from 20% to 60%.

Digestible energy (DE %) of the different representative diets were calculated considering the proportion and the data of the different feed constituents of each diet. For the northern grass pasture, the calculated DE value is 55.4% while for the grass pasture in the south the calculated DE value is 65.2%. For both type of pasture, the respective DE values are an average of estimated seasonal DE values.

Also, supplemental forage components to north and south part are different and therefore the calculated DE values are 51.0% and 46.4% respectively. For compound feed it is considered a DE value of 82%. Considering the DE value of each food component and its proportion in the respective diet, the DE value of the total diet is obtained by weighting.

The calculations for each Cattle group and subcategories were done separately. The country weighted average values of the parameters and of the weighted average values of the calculated Net Energies, Gross Energy and Emission Factors are presented in Table 5-7 through

Table 5-9.

***Table 5-7: Parameters used in the determination of Net Energies for non-dairy cattle***

| Sub - categories | W (kg) | WG (kg/day) | Cfi | NEm (MJ/day) | Ca | NEa (MJ/day) | C | NEg (MJ/day) |
|---|---|---|---|---|---|---|---|---|
| Beef calves (<1 yr) | 244 | 0.905 | 0.322 | 19.873 | 0.171 | 3.413 | 0.9 | 9.451 |
| Calves, Males for Rep. (<1 yr) | 261 | 0.973 | 0.322 | 20.865 | 0.176 | 3.679 | 1.0 | 8.652 |
| Calves, Females for Rep. (<1 yr) | 228 | 0.837 | 0.322 | 18.863 | 0.176 | 3.326 | 0.8 | 10.646 |
| Males 1-2 yrs | 536 | 0.733 | 0.322 | 35.831 | 0.140 | 4.957 | 1.0 | 10.876 |
| Beef Fem. 1-2 yrs | 428 | 0.479 | 0.322 | 30.263 | 0.140 | 4.174 | 0.8 | 9.306 |
| Females for R. 1-2 yrs | 428 | 0.479 | 0.322 | 30.263 | 0.176 | 5.336 | 0.8 | 9.306 |
| Steers (>2 yrs) | 772 | 0.188 | 0.370 | 54.116 | 0.265 | 14.341 | 1.2 | 2.802 |
| Heifers for Beef (>2 yrs) | 548 | 0.062 | 0.322 | 36.435 | 0.265 | 9.655 | 0.8 | 1.177 |
| Heifers for Rep. (>2 yrs) | 548 | 0.062 | 0.322 | 36.435 | 0.265 | 9.655 | 0.8 | 1.177 |
| non-Dairy cows | 581 | 0.000 | 0.346 | 40.848 | 0.265 | 10.825 | 0.8 | 0.000 |

***Table 5-8: Parameters used in the determination of Net Energies (non – dairy mother cows)***

| Parameter | Value |
|---|---|
| Percent Pregnant | 0.67 |
| Milking Period (days/yr) | 201 |
| Milk Yield during milking period (kg/d) | 6.49 |
| Fat content of Milk (%) | 4.00 |
| NEl (MJ/day) | 10.98 |
| Cpregnancy | 0.10 |
| NEp (MJ/day) | 2.74 |

***Table 5-9: Non-dairy cattle estimated Gross Energy (GE) and $CH_4$ Emission Factor (EF) from enteric fermentation***

| Sub -categories | NE (Mj / day) | REM (ratio) | REG (ratio) | DE (%) | GE (MJ/day) | Ym (%) | FE (kg CH4/hd/yr) |
|---|---|---|---|---|---|---|---|
| **Beef calves (<1 yr)** | 32.74 | 0.55 | 0.37 | 81.77 | 82.49 | 5.50 | 16.47 |
| **Calves, Males for Rep. (<1 yr)** | 33.20 | 0.55 | 0.37 | 81.77 | 82.65 | 5.50 | 29.81 |
| **Calves, Females for Rep. (<1 yr)** | 32.83 | 0.55 | 0.37 | 81.77 | 83.99 | 5.50 | 30.30 |
| **Males 1-2 yrs** | 51.66 | 0.53 | 0.34 | 71.95 | 150.80 | 4.23 | 41.85 |
| **Beef Fem. 1-2 yrs** | 43.74 | 0.53 | 0.34 | 71.95 | 127.52 | 4.23 | 35.21 |
| **Females for R. 1-2 yrs** | 44.91 | 0.53 | 0.34 | 71.95 | 130.47 | 6.50 | 55.62 |
| **Steers (>2 yrs)** | 71.30 | 0.51 | 0.30 | 62.73 | 230.96 | 6.50 | 98.46 |
| **Heifers for Beef (>2 yrs)** | 47.27 | 0.51 | 0.30 | 62.73 | 151.53 | 6.50 | 64.60 |
| **Heifers for Rep. (>2 yrs)** | 47.27 | 0.51 | 0.30 | 62.73 | 151.53 | 6.50 | 64.60 |
| **non-Dairy cows** | 65.39 | 0.51 | 0.30 | 62.73 | 206.04 | 6.50 | 87.84 |

The updated emission factors presented in

Table 5-9 are applicable from 2013 onwards. For the period 1990 to 1998 the previous emission factors, calculated with the information of 1998 database, were kept. Emission factors for the intermediate period, 1999 to 2012, were estimated by linear interpolation of 1998 and 2013 values.

Methane implied emission factors for non-dairy cattle category in the time series are presented in Table 5-10.

***Table 5-10: Methane implied emission factor (IEF) for non-dairy cattle category in the time series***

| Year | IEF (kg CH4 hd-1yr-1) |
|---|---|
| **1990** | 61.52 |
| **1995** | 62.45 |
| **2000** | 62.80 |
| **2005** | 60.27 |
| **2010** | 59.75 |
| **2015** | 57.74 |
| **2020** | 58.22 |
| **2021** | 58.19 |
| **2022** | 58.29 |
| **2023** | 58.27 |
| **2024** | 58.03 |

In 2024, the non-dairy cattle implied emission factor (IEF) was 58.03 kg $CH_4$ $hd^{-1}$ $yr^{-1}$, which roughly equal the default IPCC 2006 values of 57/58 kg $CH_4$ $hd^{-1}$ $yr^{-1}$.

### 5.2.3.3 Sheep and Goats

The same 1998 database from MA that was referenced previously for non-dairy cattle includes also information for the twelve indigenous breeds of sheep[23] and the five indigenous breeds of goats[24]. Three exotic breeds of sheep[25] are also referenced, but no characterization data was available for them. The database includes information such as the number of registered animals, the number of producers, the main productive functions (milk, meat or wool), the dominant reproductive period, the weaning age and slaughtering, the weights (at birth, at 90 days and at adult age, for males and females separately), the milk and wool productions and the territorial distribution.

In 2019 , the work of updating the 1998 database information was started, following the same methodology used on the non-dairy cattle update information, i.e, with the involvement of the Breeders Associations of the current most representative sheep and goats breeds used in Portugal and the experts on Nutrition and Animal Production and on Chemical and Nutritive Evaluation of Animal Feed, from the National Institute for Agriculture and Veterinary Research (INIAV)[26] and from the University of Évora (UEvora)[27]. The work was finished in the middle of 2021[28], and we highlighted the following updates and sources:

- Through the system for the identification and registration of ovine and caprine animals[29] database it was possible to obtain the latest information about the composition of the sheep and goats

[23] Campaniça, Churra Algarvia, Churra Badana, Churra da Terra Quente, Churra Galega Bragançana, Churra Galega Mirandesa, Merina Branca, Merina Preta, Merina da Beira Baixa, Mondegueira, Saloia and Serra da Estrela.
[24] Algarvia, Bravia, Charnequeira, Serpentina and Serrana.
[25] Assaf, Ile de France and Merino Precoce.
[26] Engº Nuno Carolino – Animal Production and Conservation and Animal Genetic Improvement; Engª Teresa Dentinho – Chemical and Nutritive evaluation of animal feed.
[27] Prof. Manuel Cancela d'Abreu - Nutrition, Animal Feed and Animal Production
[28] Documento nº 3/2021/ GT SNIERPA Agricultura,6.07.2021
[29]Council Regulation (EU) 2016/429 of 9 March 2016 (consolidated version), Decreto-Lei nº 142/2006 de 27 de julho (consolidated version)

populations from 2013[30] to 2018, i.e: the most representative sheep and goats breeds (7 indigenous and 2 exotics for sheep[31] and 5 indigenous and 2 exotics for goats[32]) and also the proportion and the territorial distribution of purebred and of crossbred animals.

- For each purebred, an update of animal characteristics was collected from the breeders Associations through a specific survey, providing relevant information, such as: live weights of males and females at different stages of growth (from birth to adult age, including weights at weaning and at slaughtering age of lambs and kids), average weight their gains per day, wool production per year, feeding practises and type of animal management. For ewes and does it was also collected information about average milk production per year and the number of lambs/kids per birth (single, double or triple births).
- The characterization of crossbred animals, in the same way as the purebred animals, i. e, average live weights at different stages of growth, average weight gains per day, wool production per year, feed situation and type of animal management and the specific female characteristics milk production and lambs/kids per birth, was done in collaboration with the breeders Associations and the experts on Animal Production and Animal Genetic Improvement.
- Representative diets compositions, such as the type and proportion of food ingested (milk, grass pasture, forage supplement, compound feed and also tree and shrub vegetation in the case of the goats), were established based on the collected information from the specific surveys responded by the Breeders Associations and the experts' collaborations of INIAV and UEvora on Nutrition and Animal Production.
- Digestible energy (DE%) of the representative diets were estimated by the expert of INIAV on Chemical and Nutritive evaluation of Animal Feed, considering the proportion and the data of the different feed constituents of each diet.

In a similar mode to that used for cattle, the energy model proposed in the IPCC 2006[33] for sheep and in the IPCC Refinement 2019[34] for goats, was used.

Net Energies required for maintenance, animal activity, lactation, pregnancy and wool production ($NE_m$, $NE_a$, $NE_l$, $NE_p$, $NE_g$, $NE_{wool}$) were calculated using equations 10.3, 10.5, 10.9, 10.13, 10.7 and 10.12 (IPCC 2006 and Refinement 2019[35]).

The ratios of the net energy available for maintenance and for growth in a diet to digestible energy consumed, REM and REG, were calculated using equations 10.14 and 10.15 (IPCC 2006).

Finally Gross Energy Intake (GE), expressed in energy, was calculated using equation 10.16 (IPCC 2006 and Refinement 2019).

Estimates were done individually for each breed, purebred or crossbred, and distinctly for females (ewes and does), males (rams and bucks) and lambs and kids (for slaughtering). Parameters and final energy values were averaged using the number of registered animals as weighting factor and are presented in the next set of Tables.

[30] First year where the detailed information needed became available
[31] Indegenous breeds: Campaniça, Bordaleira de Entre Douro e Minho, Churra Galega Bragançana, Churra da Terra Quente, Churra Galega Mirandesa, Merino and Serra da Estrela; Exotic breeds: Assaf e Lacaune
[32] Indegenous breeds: Algarvia, Bravia, Charnequeira, Serpentina and Serrana; Exotic breeds: Murciano-Granadino and Saanen
[33] Volume 4, Chapter 10, pages 10.15 to 10.21
[34] Volume 4, Chapter 10, pages 10.22 to 10.29
[35] In the Refinement 2019 to IPCC Guidelines the same equations are updated to be used also for goats.

*Table 5-11: Parameters used in determination of Net Energies for sheep and goats from 1990 to 1998*

| Parameters | Sheep | | | Goats | | |
|---|---|---|---|---|---|---|
| | Ram | Ewe | Lamb | Buck | Doe | Kid |
| Lifetime (days.yr$^{-1}$) | 365 | 365 | 80 | 365 | 365 | 53 |
| W (kg) | 79.89 | 53.83 | 19.13 | 37.50 | 28.50 | 9.99 |
| Cfi[1] | 0.25 | 0.22 | 0.25 | 0.25 | 0.22 | 0.25 |
| NEm (Mj.day$^{-1}$) | 6.58 | 4.30 | 2.28 | 3.79 | 2.68 | 1.43 |
| Ca[2] | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| NEa (Mj.day$^{-1}$) | 1.39 | 0.93 | 0.33 | 0.90 | 0.68 | 0.24 |
| WG (kg.day$^{-1}$) | - | - | 0.06 | - | - | 0.16 |
| NEg (Mj.day$^{-1}$) | - | - | 0.90 | - | - | 1.08 |
| Wool (kg.yr$^{-1}$) | 6.47 | 3.56 | - | - | - | - |
| NEwool (Mj.day$^{-1}$) | 0.43 | 0.23 | - | - | - | - |
| Milk production (kg.day$^{-1}$) | - | 0.18 | - | - | 1.24 | - |
| Energy value milk (Mj.kg$^{-1}$) | - | 4.60 | - | - | 2.80 | - |
| NEi (Mj.day$^{-1}$) | | 0.84 | | | 3.47 | |
| Cpregnancy[3] | - | 0.08 | - | - | 0.08 | - |
| NEp (Mj.day$^{-1}$) | - | 0.33 | - | - | 0.21 | - |

[1]Ram and Bucks Cfi value was increased 15% for intact males

[2] Sheep – average for different feed situations: grazing flat and hilly pasture rams, grazing flat and housed ewes, grazing flat and housed fattening lambs; Goats – lowland and grazing hilly pasture

[3] Sheep – average single and double births; Goats – single, double and triple births

*Table 5-12: Parameters used in determination of Net Energies for sheep and goats from 2013 onwards*

| Parameters | Sheep | | | Goats | | |
|---|---|---|---|---|---|---|
| | Ram | Ewe | Lamb | Buck | Doe | Kid |
| Lifetime (days.yr$^{-1}$) | 365 | 365 | 80 | 365 | 365 | 53 |
| W (kg) | 79.89 | 53.83 | 19.13 | 49.03 | 64.95 | 11.41 |
| Cfi[1] | 0.25 | 0.22 | 0.24 | 0.32 | 0.32 | 0.32 |
| NEm (Mj.day$^{-1}$) | 5.00 | 5.29 | 2.90 | 7.18 | 5.81 | 1.95 |
| Ca[2] | 0.02 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 |
| NEa (Mj.day$^{-1}$) | 1.53 | 0.72 | 0.25 | 1.13 | 0.50 | 0.10 |
| WG (kg.day$^{-1}$) | - | - | 0.18 | - | - | 0.13 |
| NEg (Mj.day$^{-1}$) | - | - | 2.35 | - | - | 1.12 |
| Wool (kg.yr$^{-1}$) | 2.47 | 1.78 | - | - | - | - |
| NEwool (Mj.day$^{-1}$) | 0.16 | 0.12 | - | - | - | - |
| Milk production (kg.day$^{-1}$) | - | 0.33 | - | - | 0.54 | - |
| Energy value milk (Mj.kg$^{-1}$) | - | 4.60 | - | - | 3.00 | - |
| NEi (Mj.day$^{-1}$) | | 1.54 | | | 1.62 | |
| Cpregnancy[3] | - | 0.10 | - | - | 0.13 | - |
| NEp (Mj.day$^{-1}$) | - | 0.45 | - | - | 0.69 | - |

[1]Ram and Bucks Cfi value was increased 15% for intact males

[2] Sheep – average for different feed situations: grazing flat and hilly pasture rams, grazing flat and housed ewes, grazing flat and housed fattening lambs; Goats – lowland and grazing hilly pasture

[3] Sheep – average single and double births; Goats – single, double and triple births

*Table 5-13: Sheep and goats estimated Gross Energy (GE) and $CH_4$ Emission Factor (EF) from enteric fermentation – from 1990 to 1998*

| Parameters | Sheep | | | Goats | | |
|---|---|---|---|---|---|---|
| | Ram | Ewe | Lamb | Buck | Doe | Kid |
| REM | 0.495 | 0.495 | 0.529 | 0.495 | 0.495 | 0.529 |
| REG | 0.278 | 0.278 | 0.333 | 0.278 | 0.278 | 0.333 |
| DE (%) | 60 | 60 | 70 | 60 | 60 | 70 |
| GE (MJ/day) | 29.38 | 22.98 | 10.94 | 15.80 | 23.71 | 9.14 |
| Ym (%) | 6.5 | 6.5 | 4.5 | 5 | 5 | 5 |
| FE (g CH4/hd/yr) | 12.53 | 9.81 | 3.23 | 5.18 | 7.78 | 3.00 |

*Table 5-14: Sheep and goats estimated Gross Energy (GE) and $CH_4$ Emission Factor (EF) from enteric fermentation – from 2013 onwards*

| Parameters | Sheep | | | Goats | | |
|---|---|---|---|---|---|---|
| | Ram | Ewe | Lamb | Buck | Doe | Kid |
| REM | 0.505 | 0.509 | 0.563 | 0.490 | 0.496 | 0.568 |
| REG | 0.295 | 0.300 | 0.388 | 0.270 | 0.280 | 0.398 |
| DE (%) | 62.89 | 63.65 | 89.02 | 59.46 | 61.00 | 94.90 |
| GE (MJ/day) | 21.46 | 25.31 | 13.25 | 28.98 | 28.45 | 6.78 |
| Ym (%) | 6.50 | 6.50 | 4.50 | 5.00 | 5.00 | 4.00 |
| FE (g CH4/hd/yr) | 9.15 | 10.79 | 3.91 | 9.50 | 9.33 | 1.78 |

The updated emission factors presented in Table 5-14 are applicable from 2013 onwards. For the period 1990 to 1998 the previous emission factors, calculated with the information of 1998 database, were kept. Emission factors for the intermediate period, 1999 to 2012, were estimated by linear interpolation of 1998 and 2013 values.

Methane implied emission factors for sheep and goats' categories in the complete time series are presented in the next two Tables.

***Table 5-15: Methane implied emission factor (IEF) for sheep category in the time series***

| Year | IEF (kg $CH_4$ hd-1.yr$^{-1}$) |
|---|---|
| **1990** | 9.73 |
| **1995** | 9.91 |
| **2000** | 9.76 |
| **2005** | 9.27 |
| **2010** | 9.24 |
| **2015** | 9.48 |
| **2020** | 9.74 |
| **2022** | 9.84 |
| **2023** | 9.96 |
| **2024** | 9.92 |

***Table 5-16: Methane implied emission factor (IEF) for goat category in the time series***

| Year | IEF (kg $CH_4$ hd-1.yr$^{-1}$) |
|---|---|
| **1990** | 7.02 |
| **1995** | 6.94 |
| **2000** | 6.98 |
| **2005** | 7.19 |
| **2010** | 7.20 |
| **2015** | 7.26 |
| **2020** | 7.29 |
| **2022** | 7.27 |
| **2023** | 8.95 |
| **2024** | 7.26 |

In 2024, the implied emission factors (IEF) for sheep enteric fermentation was 9.92 (kg $CH_4$.hd$^{-1}$.yr$^{-1}$) and the IEF for goats enteric fermentation was 7.26 (kg $CH_4$.hd$^{-1}$.yr$^{-1}$). Both IEFs are higher than the respective default values IPCC 2006, but similar with the values of other countries that used a Tier 2 approach to estimate emission factors from enteric fermentation of sheep and goats.

### 5.2.3.4 Swines and Rabbits

The methodology used by the French I.N.R.A. (INRA, 1984) was used to estimate feed intake for each swine sub-class, according to the following equation:

***Equation 5-3: Swines estimated Gross Energy (GE)***

$$GE = Feed_{ED} / (DE / 100)$$

**Where:**

GE – gross energy intake, Mj . $hd^{-1}$. $day^{-1}$

$Feed_{ED}$ – recommended feed ingestion, expressed in digestible energy, $MJ_{ED}.day^{-1}$

DE – digestible energy, expressed as a percentage of gross energy, %

The characteristics of each animal class as they were used to derive final emission factors for $CH_4$ emissions from enteric fermentation were obtained from INRA (1984) for each animal sub-class and are presented in Table 5-17.

***Table 5-17: Parameters used in determination of Gross Energy (GE) and enteric fermentation methane emission factor for swine and rabbits***

| | W (kg) | ED (Mj.d-1) | DE (%) | EF ‹g CH4.hd-1.yı | Ym (%) | Notes |
|---|---|---|---|---|---|---|
| **Swine** | | | | | | |
| Piglets (<20 kg) | 10 | 6.2 | 88.2 | 0.28 | 0.6 | Avg. 22 to 42 d. |
| Fattening Pigs (20-50 kg) | 35 | 23.4 | 83.4 | 1.11 | 0.6 | Regression |
| Fattening Pigs (50-80 kg) | 65 | 34.5 | 83.4 | 1.63 | 0.6 | |
| Fattening Pigs (80-110 kg) | 95 | 41.3 | 83.4 | 1.95 | 0.6 | ED = 17.93*Ln(W)-40.13 |
| Fattening Pigs (> 110 kg) | 120 | 45.5 | 83.4 | 2.15 | 0.6 | (r2 - 0.998) |
| Boars (>50 kg) | 250 | 32.4 | 78.2 | 1.63 | 0.6 | |
| Sows, pregnant | 170 | 31.4 | 78.2 | 1.58 | 0.6 | Sow in gestation |
| Sows, non-pregnant | 195 | 64.9 | 78.2 | 3.26 | 0.6 | Sow in lactation |
| **Rabbits** | | | | | | |
| Reproductive Female | - | 4 | 59 | 0.27 | 0.6* | Per female cage |
| *From Italian NIR | | | | | | |

In 2024, the IEF from enteric fermentation by swines was 1.13 (kg $CH_4.hd^{-1}.yr^{-1}$) which is lower than the default IPCC 2006 but not so different.

#### 5.2.3.5 Poultry[36]

The methodology that was used to derive Gross Energy ingestion is similar to the one used for swines and rabbits, albeit Metabolic Energy (ME) is used as indicator of feed ingestion, and digestibility is replaced by Metabolisability (McDonald et al, 2002; INRA, 1985):

***Equation 5-4: Poultry estimated Gross Energy (GE)***

$$GE = Feed_{ME} / [(EM/GE) / 100]$$

**Where:**

GE – gross energy, $Mj.hd^{-1}.day^{-1}$

$Feed_{ED}$ – recommended metabolic energy, $MJ.day^{-1}$

EM/GE – Metabolisability, metabolic energy expressed as a percentage of gross energy, %.

***Table 5-18: Parameters used in determination of Gross Energy (GE) – Poultry***

| | Energy intake (Mj.d-1) | Metabolizability (Mj.d-1) | GE (Mj.d-1) | Ym (%) |
|---|---|---|---|---|
| **Broiler** | 1.08 | 68.3 | 1.58 | NA |
| **Laying hens** | 1.39 | 63.5 | 2.20 | NA |
| **Laying hens** | 1.36 | 63.5 | 2.15 | NA |
| **Turkeys** | 3.23 | 68.0 | 4.75 | NA |
| **Ducks*** | 1.46 | 65.8 | 2.22 | NA |
| *used as reference for other poultry | | | | |

It is important to point out that for poultry there is no methane conversion rate and thus no enteric fermentation emissions. The choice to include the GE methodology for poultry in this chapter was made to maintain coherence between animal types.

### 5.2.4 Activity Data

General census on agriculture[37] and animal husbandry activities are made every 10 years by the National Statistical Institute (INE) in accordance with UE requirements. The first census was made in 1952/54, followed by exercises in 1968, 1979, 1989, 1999, 2009 and 2019. Last census (RA, 2019) considered the survey of all national territory at the same time. Inquiries were done at each individual production unit by direct interview.

The general agriculture census is subjected to several Quality Control measures by INE. The complete National Methodological Report is available at Eurostat website[38].

Also, through Farm Structure Survey (FSS) about 40 000 farms (production units) were surveyed, every two years. From 2010 the interval between surveys has been extended[39] to 3 years. The complete National Methodological Report of 2013 and 2016 FSS is also available at Eurostat website[40].

[36] $CH_4$ emissions from Enteric Fermentation are not estimated for Poultry. Nevertheless GE is estimated for these animal types for the estimate of $CH_4$ emissions from Manure Management. GE is reported here for better comparison to the GE values for other animal types

[37] In portuguese Recenseamento Geral Agrícola (RGA 1989 and RGA 1999), Recenseamento Agrícola (RA 2009, RA 2019)

[38] Methodology - Agriculture - Eurostat (europa.eu) > Structure of agricultural holdings - metadata > *National metadata* > Portugal

[39] Regulation (EU) nº **2018/1091**, on integrated farm statistics and repealing Regulations (EC) nº 1166/2008 and (EU) nº 1337/2011 (*See consolidated version*).

[40] Methodology - Agriculture - Eurostat (europa.eu) Structure of agricultural holdings - metadata > *National quality reports*>Portugal.

Annually livestock numbers[41] for cattle, swine, sheep and goats are estimated through the National Animal Registration database (SNIRA).

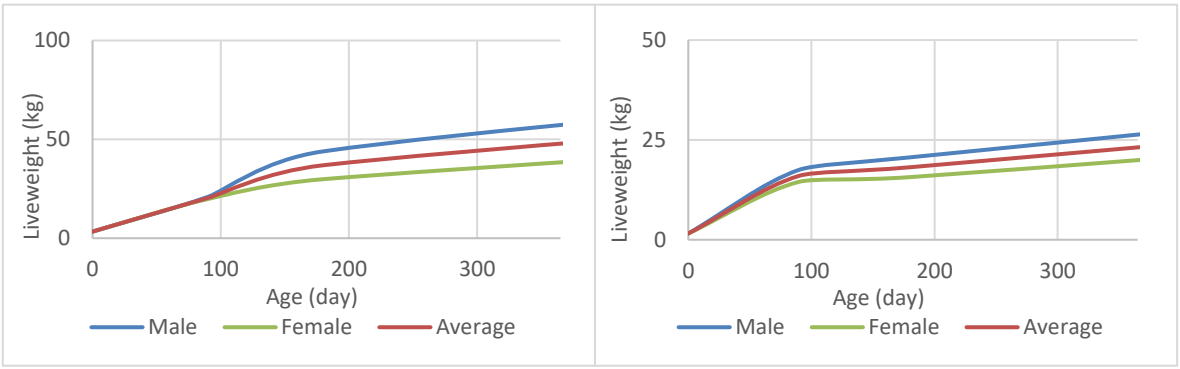
Using these data sources, INE built consistent time series of annual livestock numbers from 1987 to 2024 for cattle, swine, sheep and goats, disaggregated per region[42], age and sex.

All original figures in statistical database represent the annual average population.

Statistical data from the INE for the sheep and the goats does not distinguish the category "lambs" or "kids". The annual sheep and goat population is disaggregated between two broad categories: "ewes" and "other ovine", for sheep, and "does" and "other caprine", for goats. Thus, the annual number of lambs and kids was set from the number of registered slaughtered animals, as published by the National Statistics Institute (INE). The number of lambs and kids reported as activity data represents the equivalent annual average of animals, i.e.:

$$\text{Lambs/Kids (hd)} = \text{Annual Slaughter (hd/yr)} * \text{Age_Slaughter (days)} / 365$$

The age at which slaughter occurs (Age_Slaughter) was determined from the inverse function of the growth models[43] for both species, **Erro! A origem da referência não foi encontrada.**, using the weight at slaughter as published by INE, which values are presented in Figure 5-8. Resultant average ages vary from 107 to 134 days for lambs and 69 to 104 days for kids.




**(a)** **(b)**

***Figure 5-7: Evolution pattern growth for sheep (a) and goats (b)***

[41] Regulation (EC) nº 1165/2008, concerning livestock and meat statistics and repealing Council Directives 93/23/EEC, 93/24/EEC and 93/25/EEC (*See* consolidated version)

[42] A total of 7 regions were available: the 5 regions in mainland Portugal (NUT II level), Norte, Centro, Lisboa e Vale do Tejo, Alentejo and Algarve and the two Autonomous regions of Azores and Madeira.

[43] Set up from the information on existing breeds in Portugal, complemented by information of Jarrige (1988) related with growth patterns.

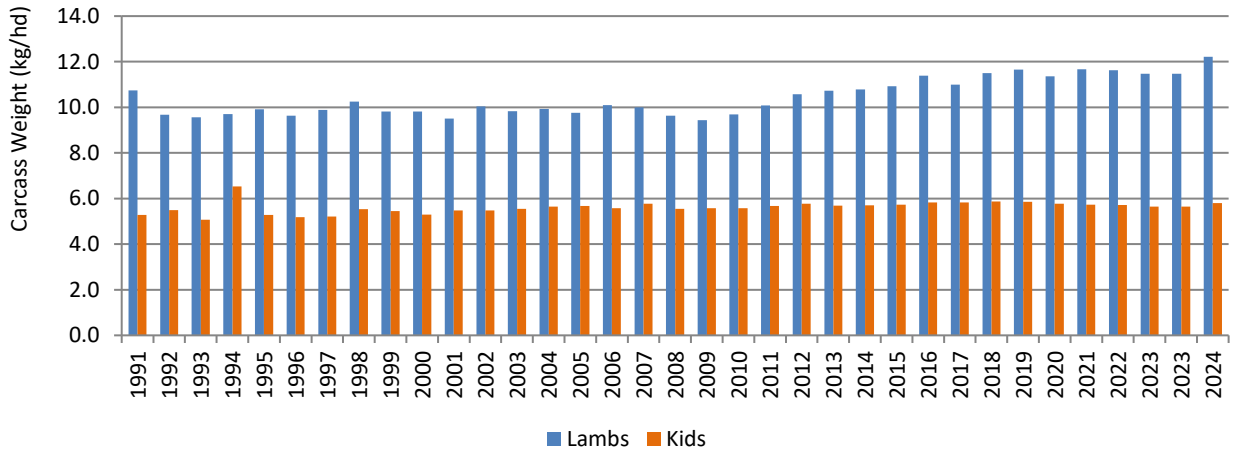



***Figure 5-8: Lambs and Kids: average carcass weight at slaughtering***

The number of animals remaining from the total Sheep and Goats populations after subtraction of number of females (ewes and does) and the number of youngsters (lambs and kids) is reported as "Other Ovine" and "Other Caprine". These animals are mostly adult males, but also young animals that are kept to reproductive functions and are not slaughtered.

The population of horses, mules and asses is established from the results of the Agricultural Census and the Farm Structure Survey. Gaps in the livestock time series were corrected with linear interpolation.

The population of poultry and rabbits (reproductive females) is established from the results of the Agricultural Census and the Farm Structure Survey until 2019. From 2020 onwards, due to lack of national statistical information, the population has been forecasted based on the trend verified in the period 2016-2019. The disaggregation of hens for industrial egg production and hens for production of chicks was obtained from the Annual Survey of eggs production and the Annual Survey of Industrial Poultry, published by INE. Gaps in the livestock time series were corrected with linear interpolation.

For all animal types, the value that was considered as activity data is the average of the last three years, i.e, the activity data reported for year n (1990 given as example) is the average of livestock numbers for n-2, n-1 and n (1988, 1989 and 1990).

In Table 5-19 is presented the annual livestock numbers (1990, 1995, 2000, 2005, 2010, 2015,2020 and the three last years) that are activity data for $CH_4$ emission estimates from enteric fermentation (CRT 3A). In a consistent way same activity data are used to estimate $CH_4$ emissions and $N_2O$ emissions from manure management systems (CRT 3B) and $N_2O$ emissions from animal manure applied to soil and from urine and dung deposited by grazing animals (CRT 3D). The complete time series data is included in the ANNEX C: Agriculture.

***Table 5-19: Livestock population (thousands)***

| Animal class | Sub-class | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Dairy cattle** | Dairy cows | 394 | 383 | 353 | 290 | 255 | 235 | 233 | 232 | 228 | 223 | 218 |
| **Non-Dairy cattle** | Beef calves (<1 yr) | 46 | 60 | 67 | 104 | 114 | 112 | 107 | 102 | 100 | 91 | 85 |
| | Calves M.Rep. (<1 yr) | 186 | 162 | 144 | 136 | 123 | 152 | 175 | 181 | 180 | 179 | 176 |
| | Calves F Rep. (<1 yr) | 177 | 158 | 174 | 183 | 171 | 209 | 236 | 243 | 242 | 241 | 238 |
| | Males 1-2 yrs | 112 | 103 | 82 | 81 | 66 | 58 | 70 | 66 | 59 | 53 | 53 |
| | Beef Fem. 1-2 yrs | 18 | 22 | 17 | 17 | 20 | 15 | 16 | 16 | 16 | 15 | 15 |
| | Females rep. 1-2 yrs | 111 | 109 | 127 | 135 | 137 | 148 | 157 | 155 | 148 | 139 | 133 |
| | Steers (>2 yrs) | 38 | 33 | 26 | 25 | 38 | 37 | 62 | 60 | 58 | 52 | 47 |
| | Heifers Beef (>2 yrs) | 4 | 10 | 6 | 9 | 12 | 15 | 12 | 11 | 12 | 11 | 11 |
| | Heifers rep. (>2 yrs) | 45 | 52 | 67 | 94 | 110 | 96 | 98 | 94 | 88 | 83 | 76 |
| | Non-Dairy cows | 242 | 273 | 345 | 397 | 438 | 461 | 497 | 504 | 503 | 491 | 475 |
| **Swine** | Piglets (<20 kg) | 727 | 726 | 663 | 574 | 597 | 713 | 797 | 815 | 812 | 816 | 814 |
| | Fatt. Pigs (20-50 kg) | 662 | 660 | 585 | 467 | 448 | 485 | 453 | 440 | 415 | 404 | 389 |
| | Fatt. Pigs (50-80 kg) | 525 | 525 | 483 | 368 | 360 | 380 | 387 | 394 | 402 | 411 | 412 |
| | Fatt. Pigs (80-110 kg) | 218 | 198 | 174 | 214 | 244 | 285 | 319 | 309 | 306 | 287 | 298 |
| | Fatt. Pigs (> 110 kg) | 44 | 44 | 38 | 41 | 36 | 30 | 45 | 51 | 54 | 46 | 44 |
| | Boars (>50 kg) | 26 | 26 | 20 | 12 | 7 | 6 | 5 | 5 | 5 | 5 | 5 |
| | Sows, pregnant | 210 | 211 | 195 | 191 | 179 | 162 | 163 | 160 | 156 | 153 | 151 |
| | Sows, non-pregnant | 124 | 132 | 124 | 68 | 66 | 71 | 72 | 72 | 73 | 73 | 73 |
| **Sheep** | Ewes | 2 292 | 2 339 | 2 410 | 2 293 | 1 915 | 1 620 | 1 668 | 1 678 | 1 659 | 1 629 | 1 578 |
| | Other Ovine | 663 | 817 | 734 | 234 | 192 | 237 | 406 | 426 | 458 | 469 | 477 |
| | Lambs | 307 | 278 | 319 | 322 | 277 | 194 | 186 | 185 | 172 | 162 | 154 |
| **Goats** | Does | 614 | 517 | 460 | 380 | 356 | 324 | 322 | 312 | 307 | 297 | 284 |
| | Other Caprine | 149 | 151 | 129 | 57 | 40 | 39 | 38 | 37 | 36 | 36 | 36 |
| | kids | 47 | 41 | 33 | 26 | 29 | 20 | 18 | 18 | 19 | 18 | 17 |
| **Equidae** | Horses | 33 | 48 | 58 | 60 | 92 | 78 | 85 | 87 | 88 | 90 | 91 |
| | Asses & Mules | 118 | 103 | 69 | 60 | 24 | 11 | 9 | 9 | 9 | 9 | 9 |
| **Poultry** | Hens, reproductive | 3 421 | 3 271 | 2 644 | 3 056 | 3 453 | 2 920 | 4 059 | 4 214 | 4 180 | 4 169 | 4 136 |
| | Hens eggs | 7 539 | 7 745 | 9 060 | 7 349 | 7 867 | 6 710 | 10 612 | 11 158 | 11 304 | 11 344 | 11 466 |
| | Broilers | 18 524 | 18 813 | 24 374 | 18 686 | 19 207 | 19 395 | 32 968 | 34 162 | 34 409 | 34 475 | 34 673 |
| | Turkeys | 1 149 | 945 | 1 208 | 798 | 1 445 | 785 | 1 738 | 1 858 | 1 871 | 1 874 | 1 884 |
| | Other poultry | 1 571 | 1 551 | 1 622 | 1 376 | 1 522 | 1 284 | 3 216 | 3 362 | 3 360 | 3 318 | 3 284 |
| **Other** | Rabbits* | 475 | 401 | 336 | 289 | 255 | 148 | 169 | 190 | 212 | 233 | 255 |

*Female reproductive

## 5.2.5 Uncertainty Assessment

Uncertainties estimates of livestock numbers are based on the information provided by the National Statistical Institute (INE) and are presented in Table 5-20.

***Table 5-20: Livestock population uncertainty assessment***

| Animal type | U (%) |
|---|---|
| **Dairy Cattle** | 1.19 |
| **Non-dairy cattle** | 3.47 |
| **Sheep** | 0.59 |
| **Goats** | 7.46 |
| **Swine** | 6.04 |
| **Equidae** | 7.82 |
| **Poultry** | 15.03 |
| **Rabbits** | 20.00 |

The calculated uncertainty of diet digestibility estimates for dairy cows has a value of 6.5%. It was determined using the error propagation equation considering the standards deviations associated to the digestibility value of each food component included in dairy cows' diets in use on the milk productions regions of Azores and Mainland.

The calculated uncertainty of diet digestibility estimates for non-dairy cattle has a value of 9.7%. In the same way of the dairy cows' calculations, it was determined using the error propagation equation considering the standards deviations associated to the digestibility value each food component included in the diets of each non–dairy cattle group and subcategories.

Uncertainty calculation of DE% diets for dairy cattle and non-dairy cattle, was derived from the results of chemical and nutritional analysis of each food component of the diet, carried out by the experts on Chemical and Nutritive evaluation of animal feed of the National Institute for Agriculture and Veterinary Research (INIAV) and from the expert judgement on Nutrition and Animal Production of the experts from INIAV and University of Évora for the proportion of the food components on each diets, dairy and non-dairy cattle.

For the uncertainties calculations the error propagation equation of IPCC's Approach 1 analysis was used. Equation 3.1 and 3.2 were used to combine the uncertainties of food components and of its proportion in each diet. This procedure was repeated for each of the different diets established. In the case of dairy cows two diets were considered: one for the mainland region and another for the Azores region. The overall uncertainty of DE% at a national level was derived from the combination of the DE uncertainty calculated for each milk production region (Mainland and Azores) with the uncertainties of the number of dairy cows in each of those regions. The uncertainties of dairy cows per region are derived from the National Statistics Authority data.

In the case of non-dairy cattle, the same procedure was used considering the different diets established (food components and proportion on diet) for each cattle group and subcategories (Groups: exotics, traditional on pasture, traditional on range and crossbreed cattle; subcategories: less than 1 year, 1 to 2 years, more than two years)

The uncertainty of digestibility for all animals' categories other than cattle, where tier 2 was used, was assumed 20% in line with the IPCC 2006 (section 10.2.3, chapter 10, Volume 4). The uncertainty of the emission factor was assumed to be 20% for all animals where tier 2 was used and 50% when tier 1 emission factors were used, in accordance with the IPCC 2006 (section 10.3.4, chapter 10, Volume 4).

### 5.2.6 Category specific QA/QC and verification

For this source category QA/QC procedures were focused on the livestock data obtained from INE.

Two quality assessments on the livestock numbers were produced:

- Comparison between data from Agricultural General Census (every 10 year) and data from Farm Structure Survey (every two or three years) concerning horses, mules & asses, poultry and rabbits to check any outliers;
- Comparison between livestock data obtained from INE and FAO numbers for cattle, sheep, goats and swine population.

Livestock numbers used in the inventory, as collected from National Statistics, were compared to FAO livestock numbers for years 1990-2023 and the results are presented in the Figure 5-9 for cattle, swine and sheep.

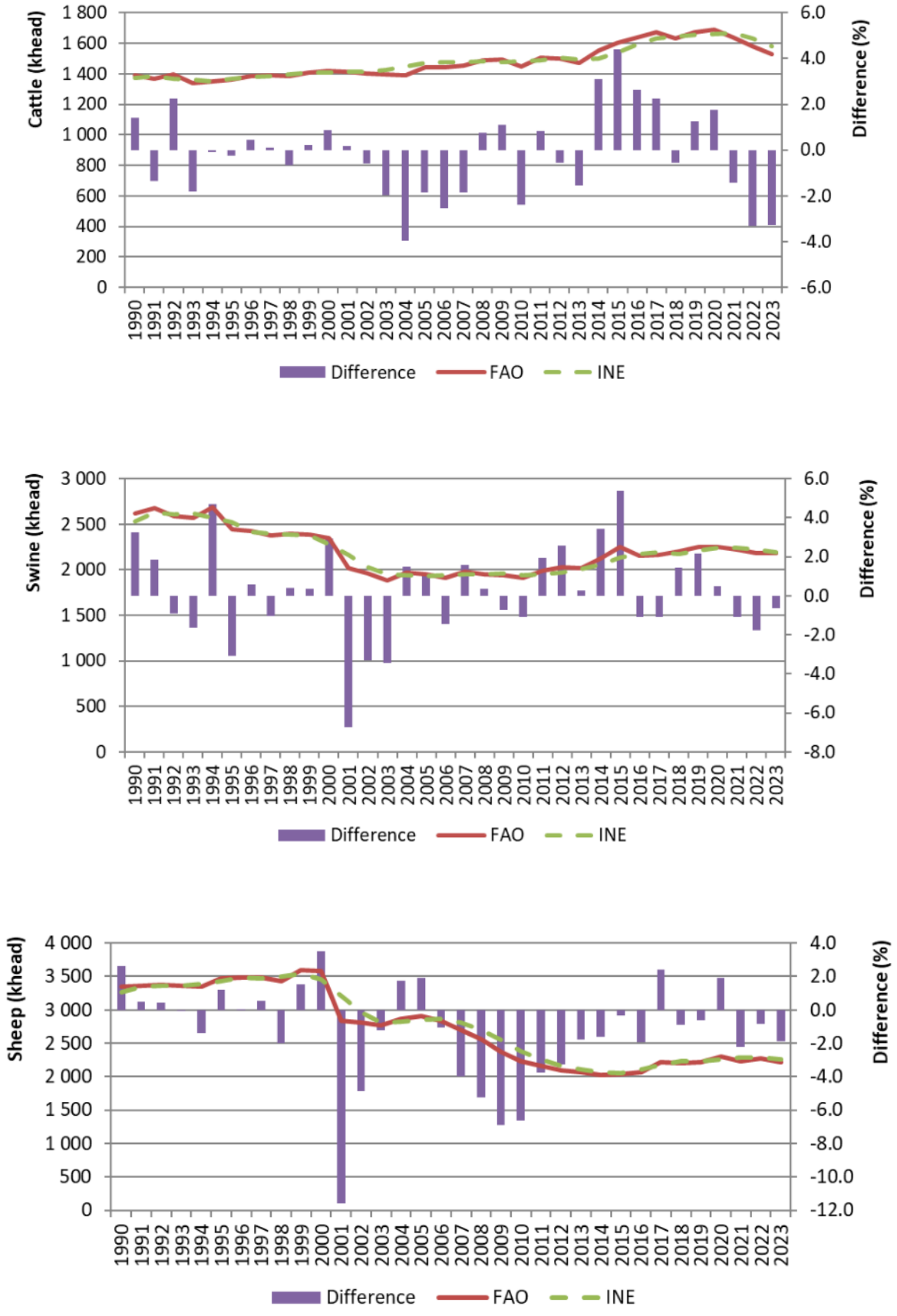



***Figure 5-9: Livestock numbers: comparison between National Statistics and FAO database***

FAO and INE livestock numbers have some differences, particularly relevant in the period 2001-2015 for sheep.

QA/QC also included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

### 5.2.7 Category specific recalculations

No recalculations were made.

### 5.2.8 Category specific planned improvements

It is planned to continue the efforts to achieve a disaggregation by growth stage for sheep and goats, together with the competent authorities, INE, DGAV, INIAV, GPP, but given the complexity of the changes, we do not know when we will be able to update the data.

## 5.3 $CH_4$ Emissions from Manure Management (CRT 3.B.a)

### 5.3.1 Category description

Methane emissions from manure occur when the organic material it contains, either solid or dung or liquid as urine, decomposes during storage or treatment, in anaerobic environments by the action of methanogenic bacteria. The quantity that is emitted depends mostly on the existence of anaerobic conditions during storage of manure that promotes the activity of methanogenic microorganisms. Methane emissions resulting from manure deposited directly in soil during grazing and pasture are also included in this source category[44].

In Table 5-21 are presented the estimates of $CH_4$ emission from manure management.

***Table 5-21: $CH_4$ emissions from Manure Management (kt)***

| Livestock type | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Dairy cattle** | 5.76 | 5.91 | 6.77 | 6.44 | 6.29 | 6.02 | 6.16 | 6.06 | 6.03 | 5.92 |
| **Non-Dairy cattle** | 2.17 | 2.25 | 2.38 | 2.50 | 2.48 | 2.45 | 2.75 | 2.69 | 2.58 | 2.48 |
| **Sheep** | 1.34 | 1.38 | 1.31 | 0.98 | 0.77 | 0.67 | 0.75 | 0.76 | 0.76 | 0.74 |
| **Goats** | 0.26 | 0.22 | 0.19 | 0.14 | 0.12 | 0.11 | 0.10 | 0.10 | 0.10 | 0.09 |
| **Horses** | 0.12 | 0.16 | 0.18 | 0.16 | 0.21 | 0.18 | 0.20 | 0.21 | 0.21 | 0.22 |
| **Mules and Asses** | 0.18 | 0.15 | 0.09 | 0.07 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| **Swine** | 20.24 | 20.30 | 18.50 | 15.46 | 15.41 | 16.45 | 16.69 | 16.51 | 16.13 | 16.09 |
| **Poultry** | 2.20 | 2.20 | 2.56 | 2.08 | 2.34 | 1.99 | 3.20 | 3.34 | 3.34 | 3.35 |
| **Rabbits** | 0.13 | 0.11 | 0.09 | 0.07 | 0.06 | 0.04 | 0.04 | 0.05 | 0.06 | 0.06 |
| **Total** | **32.40** | **32.67** | **32.07** | **27.90** | **27.71** | **27.91** | **29.90** | **29.72** | **29.21** | **28.95** |
| Note: Totals may not sum due to independent rounding | | | | | | | | | | |

Methane emission from Manure Management in Portugal is a key source. According to origin of manure by specie, most emissions in 2024 result from swine manure, with 55.58%, and from cattle manure, with 29.00% (20.45% dairy and 8.55% non-dairy cattle), as may be seen in Figure 5-10.

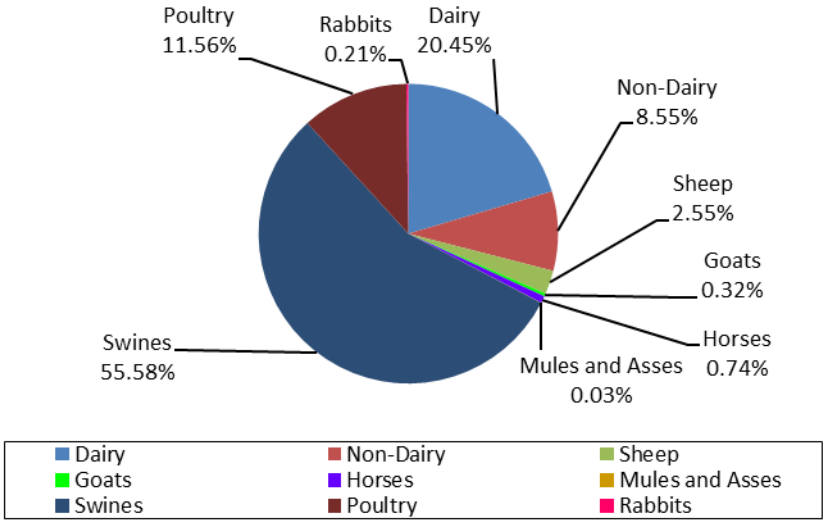



***Figure 5-10: Relative importance of $CH_4$ emissions from Manure Management per animal species in 2024***

[44] Nitrous oxide emissions from manure deposited in soil during grazing and pasture are nevertheless included in source category $N_2O$ from agricultural soil: Animal production, in accordance with UNFCCC reporting guidelines.

### 5.3.2 Methodological issues

Following the IPCC 2006, emission estimates are calculated based on the equation 10.22[45], applied for each animal type and considering emission factors dependent on animal type and climatic conditions. By this procedure both the quantity of manure produced per animal and the storage conditions are included in the determination of the emission factor and will be discussed thereafter.

***Equation 5-5: $CH_4$ emissions from Manure Management***

$$Emi_{CH_4} = \Sigma_t \Sigma_c.[EF_{(i,k)} * N_{(i,k)}]$$

**Where:**

$Emi_{CH}$: methane emissions from manure management, for the animal type population, kg $CH_4.yr^{-1}$

$EF_{(i,k)}$: emission factor for the animal type population i, living in climate region k, $kg.head^{-1}.yr^{-1}$

$N_{(i,k)}$: total number of the animals of type i, living in climate region k, head

### 5.3.3 Emission Factors

Emissions Factors for each animal type were established according to the tier 2 methodology proposed in IPCC 2006 (equation 10.23), which considers the use of country specific information concerning the quantity of manure produce per animal and the share of each Manure Management System (MMS) that is used for each animal type. The equation used for the calculation of the EF for each animal species is therefore:

***Equation 5-6: $CH_4$ emission factor from Manure Management***

$$EF_{(i)} = (VS_{(i)} * 365) *[ Bo_{(i)} * 0.67 * \Sigma_{jk} MCF_{(jk)}/100*MMS_{(ijk)}]$$

**Where:**

$EF_{(i)}$: annual emission factor for a defined animal species i, kg $CH_4$ $hd^{-1}$ $yr^{-1}$

$VS_{(i)}$: daily volatile solids excreted for animal species i, living in climate region k, kg $dm.day^{-1}$

$Bo_{(i)}$: maximum $CH_4$ production capacity from manure for animal species i, $m^3$ $CH_4.kg^{-1}$ VS excreted

0.67 : conversion factor of $m^3$ $CH_4$ to kg $CH_4$

$MCF_{(jk)}$: methane conversion factor for each MMS j and for each climate region k, %

$MMS_{(ijk)}$: fraction of total manure from animal species i handled with MMS j and for each climate region k

$B_o$ values were set according to IPCC 2006.

[45] Volume 4, chapter 10

The amount of volatile solids (VS) excreted per animal was estimated using the same data that were used to calculate Gross Energy (GE) intake for the determination of the emission factors of $CH_4$ from enteric fermentation, and using equation 10.24 of the IPCC 2006:

***Equation 5-7: Volatile solid excretion rates***

$$VS = \{GE * [1- (DE\%/100)] + (UE*GE)\} * [(1 - ASH) /18.45]$$

**Where:**

VS: volatile solids excreted per day on a dry matter basis, kg VS.day$^{-1}$

GE: daily gross energy intake, Mj.day$^{-1}$

DE%: digestibility of the feed in percent

(UE*GE): urinary energy expressed as fraction of GE

ASH: the ash content of manure calculated as fraction of the dry matter feed intake

18.45: conversion factor for dietary DE per kg of dry matter, Mj.kg$^{-1}$

Table 5-22 presents the values that were used for ash content in manure (ASH) and for the maximum methane production capacity from manure (Bo) for each animal type. VS values change along years as consequence of the change in Gross Energy estimates. For cattle, sheep and goats categories the urinary energy considered was 0.04 of GE.

For equidae (horses, mules and asses) no estimates were done to calculate GE for the determination of the emission factors of $CH_4$ from enteric fermentation. It was used the default emission factors (Tier1) and so the values of VS in use are also the default ones of table 10A-9 of IPCC2006, 2.13 and 0.94 kg VS.day$^{-1}$ respectively.

***Table 5-22: Parameters used in the estimates of volatile solids and EF per animal category***

| Animal class | ASH | Bo (m3.kg-1 VS) |
|---|---|---|
| **Dairy cattle** | 0.080 | 0.24 |
| **Non-Dairy cattle** | 0.080 | 0.17 |
| **Swine** | 0.045 | 0.45* |
| **Sheep** | 0.080 | 0.19 |
| **Goats** | 0.080 | 0.18 |
| **Hens** | 0.048" | 0.39 |
| **Broilers** | 0.020" | 0.36 |
| **Turkeys** | 0.026" | 0.36 |
| **Other poultry** | 0.020" | 0.36 |
| **Rabbits (per female cage)** | 0.034" | 0.32 |
| All values IPCC default, except: * INIAV , " INRA | | |

Expert guess[46], based on survey data and field knowledge of technical personnel of the Ministry of Agriculture was used to establish the % of each Manure Management System (MMS) in 1990. The same expertise was used to establish a prevailing trend in the period 1990-2010, considering the practices that are becoming more common and some results of legislation and institutional control.

[46] Information received from Eng. Carlos Pereira, from the Ministry of Agriculture in 3, March 2005, and in 7, October 2009, following update.

The 2009 General Agriculture Census (RA09) included in the inquiry to the farmers, for the first time, a question related with the type of manure management system in use on the farm.

Based on that information collected from the RA09 and on the information resident in the National Animal Registration database (SNIRA) about the number of livestock produced in extensive mode (pasture), the trend 1990-2010 was updated in September 2017[47] for cattle (dairy cows, non-dairy cows, other cattle), sheep (ewes, other ovine), goats (does, other caprine) and equidae (horses, mules and asses).

Although the exact year at which the situation changes is unknown, a linear evolution between year 1990 and the target year of 2010 was assumed.

From 2010 onwards we assume the same distribution. In future submissions, and after detailed ongoing discussions with National Statistics and agriculture experts, we expect to update Table 5-23 based on data obtained from 2019 Census.

The values for the fraction of manure handled in each MMS in 1990 and in 2024 are presented in Table 5-23.

***Table 5-23: Share (%) of each Manure Management System per animal type from 1990 to 2024***

| Animal Type | Manure Management System | Unit | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dairy cows | Lagoon system | % | 0.0 | 3.0 | 6.0 | 9.0 | 12.0 | 12.0 | 12.0 | 12.0 | 12.0 | 12.0 |
| | Tanks/ Earthen pond | % | 35.0 | 32.5 | 30.0 | 27.5 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 |
| | Solid Storage | % | 35.0 | 32.3 | 29.5 | 26.8 | 24.0 | 24.0 | 24.0 | 24.0 | 24.0 | 24.0 |
| | Pasture/range/ paddock | % | 30.0 | 32.3 | 34.5 | 36.8 | 39.0 | 39.0 | 39.0 | 39.0 | 39.0 | 39.0 |
| | **Total** | **%** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |
| Non-dairy cows | Lagoon system | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Tanks/ Earthen pond | % | 0.0 | 0.3 | 0.5 | 0.8 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | Solid Storage | % | 0.0 | 1.5 | 3.0 | 4.5 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 |
| | Pasture/ range/ paddock | % | 100.0 | 98.3 | 96.5 | 94.8 | 93.0 | 93.0 | 93.0 | 93.0 | 93.0 | 93.0 |
| | **Total** | **%** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |
| Other cattle | Lagoon system | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Tanks/ Earthen pond | % | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| | Solid Storage | % | 70.0 | 55.5 | 41.0 | 26.5 | 12.0 | 12.0 | 12.0 | 12.0 | 12.0 | 12.0 |
| | Pasture/ range/ paddock | % | 30.0 | 44.0 | 58.0 | 72.0 | 86.0 | 86.0 | 86.0 | 86.0 | 86.0 | 86.0 |
| | **Total** | **%** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |

| Animal Type | Manure Management System | Unit | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sows | Lagoon system | % | 80.0 | 81.3 | 82.5 | 83.8 | 85.0 | 85.0 | 85.0 | 85.0 | 85.0 | 85.0 |
| | Tanks/ Earthen pond | % | 15.0 | 12.8 | 10.5 | 8.3 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 |
| | Solid Storage | % | 3.0 | 2.5 | 2.0 | 1.5 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | Pasture/ range/ paddock | % | 2.0 | 3.5 | 5.0 | 6.5 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 |
| | **Total** | **%** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |
| Other swine | Lagoon system | % | 80.0 | 81.3 | 82.5 | 83.8 | 85.0 | 85.0 | 85.0 | 85.0 | 85.0 | 85.0 |
| | Tanks/ Earthen pond | % | 15.0 | 13.3 | 11.5 | 9.8 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 |
| | Solid Storage | % | 3.0 | 2.8 | 2.5 | 2.3 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| | Pasture/ range/ paddock | % | 2.0 | 2.8 | 3.5 | 4.3 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| | **Total** | **%** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |

[47] Documento n.º 1/2017/GT SNIERPA Agricultura

| Animal Type | Manure Management System | Unit | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ewes | Lagoon system | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Tanks/ Earthen pond | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Solid Storage | % | 20.0 | 17.3 | 14.5 | 11.8 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 |
| | Pasture/ range/ paddock | % | 80.0 | 82.8 | 85.5 | 88.3 | 91.0 | 91.0 | 91.0 | 91.0 | 91.0 | 91.0 |
| | **Total** | **%** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |
| Other ovine | Lagoon system | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Tanks/ Earthen pond | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Solid Storage | % | 20.0 | 17.3 | 14.5 | 11.8 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 |
| | Pasture/ range/ paddock | % | 80.0 | 82.8 | 85.5 | 88.3 | 91.0 | 91.0 | 91.0 | 91.0 | 91.0 | 91.0 |
| | **Total** | **%** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |
| Does | Lagoon system | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Tanks/ Earthen pond | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Solid Storage | % | 20.0 | 17.8 | 15.5 | 13.3 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 |
| | Pasture/ range/ paddock | % | 80.0 | 82.3 | 84.5 | 86.8 | 89.0 | 89.0 | 89.0 | 89.0 | 89.0 | 89.0 |
| | **Total** | **%** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |
| Other caprine | Lagoon system | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Tanks/ Earthen pond | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Solid Storage | % | 20.0 | 17.8 | 15.5 | 13.3 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 |
| | Pasture/ range/ paddock | % | 80.0 | 82.3 | 84.5 | 86.8 | 89.0 | 89.0 | 89.0 | 89.0 | 89.0 | 89.0 |
| | **Total** | **%** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |

| Animal Type | Manure Management System | Unit | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hens | Lagoon system | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Tanks/ Earthen pond | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Solid Storage | % | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | Pasture/ range/ paddock | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |
| Broilers | Lagoon system | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Tanks/ Earthen pond | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Solid Storage | % | 99.9 | 98.9 | 98.0 | 97.0 | 96.0 | 96.0 | 96.0 | 96.0 | 96.0 | 96.0 |
| | Pasture/ range/ paddock | % | 0.1 | 1.1 | 2.1 | 3.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| | **Total** | **%** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |
| Turkeys | Lagoon system | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Tanks/ Earthen pond | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Solid Storage | % | 100.0 | 100.0 | 100.0 | 99.9 | 99.9 | 99.9 | 99.9 | 99.9 | 99.9 | 99.9 |
| | Pasture/ range/ paddock | % | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| | **Total** | **%** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |
| Other poultry | Lagoon system | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Tanks/ Earthen pond | % | 0.0 | 2.5 | 5.0 | 7.5 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | Solid Storage | % | 100.0 | 97.5 | 95.0 | 92.5 | 90.0 | 90.0 | 90.0 | 90.0 | 90.0 | 90.0 |
| | Pasture/ range/ paddock | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |

| Animal Type | Manure Management System | Unit | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rabbits | Lagoon system | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Tanks/ Earthen pond | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Solid Storage | % | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | Pasture/ range/ paddock | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |
| Equidae | Lagoon system | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Tanks/ Earthen pond | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Solid Storage | % | 60.0 | 47.8 | 35.5 | 23.3 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 |
| | Pasture/ range/ paddock | % | 40.0 | 52.3 | 64.5 | 76.8 | 89.0 | 89.0 | 89.0 | 89.0 | 89.0 | 89.0 |
| | **Total** | **%** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |

Two climate regions occur in Portugal, in accordance with reporting table[48] classification: temperate (annual average temperature between 15ºC and 25ºC) and cool (annual average temperature below 15ºC). In next Figure is presented the map with the representation of the two climate regions in the mainland territory. Both Archipelagos, Azores and Madeira, are only in one climate region, temperate.

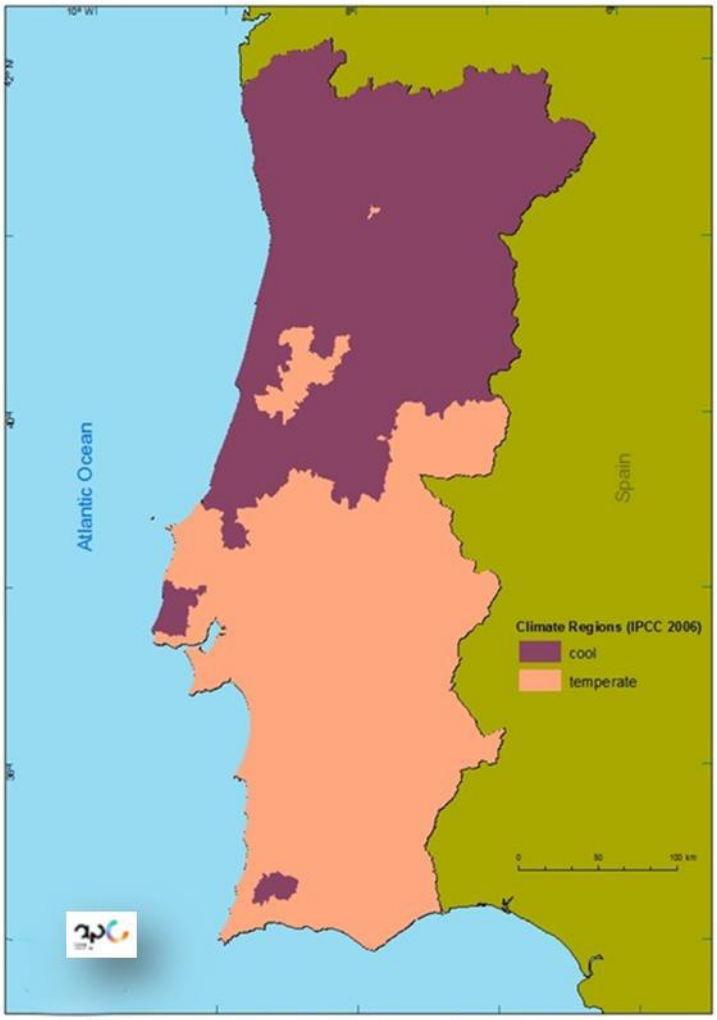



***Figure 5-11: Climate regions presentation***

Livestock populations living in each climate region were determined according to the following mode:

- the percentage of livestock numbers at each climate region was determined for each *concelho* territorial unit[49] and for each animal subtype;
- livestock numbers per animal type were available at c*oncelho* level from three Agriculture General Census (1989, 1999, 2009 and 2019)[50]. Data for 1999, 2009 and 2019 were available for all animal types and subtypes and for 1989 only for dairy cattle, other cattle, ewes, other sheep, female goats and other goats, sows and other swine;

[48] CRT 3B classification of climate regions is different than IPPC 2006 Guidelines (page 3.39 of volume 4, chapter 3 and page G.11 of the Glossary).
[49] Concelho territorial unit in Portugal is the designation to land areas associated with one municipal administrative authority. There are 308 concelhos in Portugal with an average area of 289 km$^2$.
[50] Recenseamento Geral da Agricultura 1989, Recenseamento Geral da Agricultura 1999, Recenseamento Agrícola 2009 and Recenseamento Agrícola 2019, extensive agriculture census made by INE every 10 years.

- the average annual temperature of each *concelho* area was provided by the national authority in the fields of meteorology and climate, IPMA[51], based on the results of 30 years observations, climatological normal 1971–2000. The classification of each *concelho* in climate region cool or temperate was done according to the respective mean annual temperature provided by IPMA. The same source was used to produce the map above;

- livestock numbers in each *concelho* area were allocated to each climate region, for the years 1999, 2009 and 2019, according to IPMA data and to the Census data for the same territorial unit. For 1989 it was assumed the livestock distribution of each subtype animal equal to 1999 given the unavailability of disaggregated animal information in the 1989 Agriculture Census;

- the information at c*oncelho* level, number of animals allocated at each climate region, was then grouped at a higher territorial unit level corresponding to NUT II[52] region. For each NUT II region, based on the data of the set of *concelhos* included in that NUT, was established the share (in %) of animals (by subtype) allocated at each climate region for the years 1989, 1999, 2009 and 2019;

- for the intermediate years, 1990 to 1998, 2000 to 2008 and 2010 to 2018 the animal share (by subtype) allocated to each climate region, result from the interpolation of the values of 1989 and 1999, the values of 1999 and 2009 and the values of 2009 and 2019 respectively;

- livestock population in each climate region and by NUT II was estimated annually from total livestock population in NUT, considering the share values established for the NUT.

For the complete timeseries the percentage of livestock population (by animal subtype) living in cool climate regions, calculated in accordance with the above explained procedure, is presented in ANNEX C: Agriculture.

[51] IPMA, Instituto Português do Mar e da Atmosfera

[52] NUT – Nomenclature of territorial units for statistics. There are 7 NUT II regions in Portugal, 5 in mainland Portugal, 1 for whole Archipelago of Azores and 1 for whole Archipelago of Madeira

In Table 5-24, is presented the percentage of national livestock population living in cool climate regions, for major animal types.

***Table 5-24: Share (%) of livestock population by climate region***

| Animal Type | Climate Region | Unit | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dairy Cows | **Cool** | % | 64.4 | 64.7 | 59.7 | 54.5 | 49.5 | 47.2 | 46.1 | 45.8 | 45.9 | 46.2 |
| | **Temperate** | % | 35.6 | 35.3 | 40.3 | 45.5 | 50.5 | 52.8 | 53.9 | 54.2 | 54.1 | 53.8 |
| | **Warm** | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |
| Other Cattle | **Cool** | % | 52.9 | 45.7 | 39.6 | 31.3 | 29.5 | 28.1 | 25.4 | 25.4 | 26.1 | 26.3 |
| | **Temperate** | % | 47.1 | 54.3 | 60.4 | 68.7 | 70.5 | 71.9 | 74.6 | 74.6 | 73.9 | 73.7 |
| | **Warm** | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |
| Sheep | **Cool** | % | 30.8 | 32.2 | 31.8 | 32.8 | 34.8 | 33.5 | 29.3 | 28.7 | 28.5 | 28.3 |
| | **Temperate** | % | 69.2 | 67.8 | 68.2 | 67.2 | 65.2 | 66.5 | 70.7 | 71.3 | 71.5 | 71.7 |
| | **Warm** | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |
| Goats | **Cool** | % | 57.1 | 57.3 | 55.4 | 55.8 | 54.2 | 52.4 | 56.4 | 55.9 | 55.7 | 55.6 |
| | **Temperate** | % | 42.9 | 42.7 | 44.6 | 44.2 | 45.8 | 47.6 | 43.6 | 44.1 | 44.3 | 44.4 |
| | **Warm** | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |
| Horses | **Cool** | % | 41.7 | 41.6 | 43.7 | 42.8 | 45.8 | 45.2 | 41.6 | 38.1 | 39.0 | 39.7 |
| | **Temperate** | % | 58.3 | 58.4 | 56.3 | 57.2 | 54.2 | 54.8 | 58.4 | 61.9 | 61.0 | 60.3 |
| | **Warm** | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |
| Mules and Asses | **Cool** | % | 68.0 | 68.4 | 72.4 | 73.9 | 82.7 | 86.6 | 87.9 | 87.9 | 87.9 | 87.9 |
| | **Temperate** | % | 32.0 | 31.6 | 27.6 | 26.1 | 17.3 | 13.4 | 12.1 | 12.1 | 12.1 | 12.1 |
| | **Warm** | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |
| Swine | **Cool** | % | 46.9 | 45.4 | 44.0 | 39.5 | 36.8 | 34.2 | 43.7 | 43.6 | 43.8 | 44.1 |
| | **Temperate** | % | 53.1 | 54.6 | 56.0 | 60.5 | 63.2 | 65.8 | 56.3 | 56.4 | 56.2 | 55.9 |
| | **Warm** | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |
| Poultry | **Cool** | % | 72.8 | 71.5 | 71.4 | 73.8 | 73.0 | 76.0 | 84.6 | 85.6 | 85.7 | 85.7 |
| | **Temperate** | % | 27.2 | 28.5 | 28.6 | 26.2 | 27.0 | 24.0 | 15.4 | 14.4 | 14.3 | 14.3 |
| | **Warm** | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |
| Rabbits | **Cool** | % | 80.6 | 81.3 | 85.2 | 87.3 | 89.5 | 88.8 | 91.3 | 93.0 | 93.5 | 94.0 |
| | **Temperate** | % | 19.4 | 18.7 | 14.8 | 12.7 | 10.5 | 11.2 | 8.7 | 7.0 | 6.5 | 6.0 |
| | **Warm** | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |

Methane Conversion Factors (MCF) for each MMS are the default[53] ones from IPCC 2006, shown in Table 5-25, considering a mean annual temperature of 17ºC for temperate climate region and a mean annual temperature of 14ºC for the cool climate region.

***Table 5-25: Methane Conversion Factors (MCF), %, for determination of $CH_4$ emissions from manure management***

| MMS | MCF | | Table 10.17* | CRT 3Ba |
|---|---|---|---|---|
| **Country designation** | **Temperate** | **Cool** | **Designation** | **Classification** |
| **Lagoon system** | 32 | 25 | Liquid/slurry without natural crust | Liquid system |
| **Tanks/Earthen pond** | 20 | 15 | Liquid/slurry with natural crust | Liquid system |
| **Solid Storage** | 4 | 2 | Solid Storage | Solid storage and dry lot |
| **Pasture/range/paddock** | 1.5 | 1 | Pasture/range/paddock | Pasture/range/paddock |
| *IPCC 2006, Vol.4, chapter 10 | | | | |

In Table 5-25, it was considered the IPCC equivalent to the national MMS classification. However, there was no additional information or description of the Lagoon system and tanks/earthen ponds that could establish their correspondence with categories liquid/slurry with and without natural crust cover as described in the 2006 IPCC Guidelines. The definition considered for lagoon system in Portugal National Inventory is the one from table 3.13 of Volume 3.B Manure Management of EMEP/EEA air pollutant emission inventory Guidebook 2023 that says “storage with large surface area to depth ratio: normally shallow excavations in the soil”.

The terms lagoon, tank/earth ponds are commonly used in Portugal for liquid/slurry manure storage, i.e. manure that is stored as excreta or with a minimal addition of water outside the animal housing, usually for periods less than 1 year (IPCC definition). There are no country-specific manure management systems, but only national classifications aligned, by expert judgment[54], with the terms and definitions of both Guidelines (2006 IPCC Guidelines and EMEP), in order to ensure coherence, accuracy and completeness of national emission estimates in both inventories.

The emission factors (EF) estimates for all livestock categories and subcategories are presented in the ANNEX C: Agriculture, for the full time series.

In

[53] Table 10.17, Volume 4, chapter 10
[54] Documento n.º 1/2017/GT SNIERPA Agricultura

Table 5-26 are shown the implied emission factors (IEF) of methane emissions from Manure Management for each livestock category, expressed in kg $CH_4$.$hd^{-1}$.$yr^{-1}$. The comparison with the default emission factors was done considering the description of the manure management situations that better corresponded to the characteristics of the country manure management, with special focus on the following aspects:

- dairy cows on pasture have a significant expression in Portugal;
- most of non-dairy cattle is kept on pasture (extensive production);
- some traditional swine are kept outdoors and foraging in pasture range;
- daily spread and usage as fuel are practically unknown in Portugal;
- some poultry is kept outside, either in small farms or industrial production of country poultry;
- there are no substantial seasonal variations in the share of management system.

***Table 5-26: Manure management $CH_4$ Implied Emission Factors (IEF) and comparison with IPCC 2006 default emission factors (kg $CH_4.hd^{-1}.yr^{-1}$)***

| Animal type | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 | 2024 | Default * (cool temperate) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Dairy cattle** | 14.62 | 15.44 | 19.18 | 22.22 | 24.67 | 25.59 | 26.39 | 26.61 | 26.99 | 27.19 | 29-40 (*Liquid/slurry and pit storage systems (WE)*. Portugal also has a significant % of manure directly deposited on pasture,table 5-23 of this report) |
| **Non-Dairy cattle** | 2.22 | 2.29 | 2.25 | 2.12 | 2.02 | 1.88 | 1.92 | 1.92 | 1.90 | 1.89 | 1-2 (Non-Dairy manure is usually managed as solid and deposited on pastures (NAm). Portugal has the same situation. See table 5-23 of this report) |
| **Swine** | 7.98 | 8.05 | 8.10 | 7.99 | 7.95 | 7.72 | 7.45 | 7.43 | 7.35 | 7.36 | 8-15 (*Liquid /slurry and pit storage systems are commonly used(WE)*. Portugal has also 5 to 8 % of swine manure deposited on pasture. See table 5-23 of this report) |
| **Sheep** | 0.41 | 0.40 | 0.38 | 0.34 | 0.32 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.19-0.28 |
| **Goats** | 0.32 | 0.31 | 0.30 | 0.29 | 0.27 | 0.28 | 0.27 | 0.27 | 0.27 | 0.27 | 0.13-0.20 |
| **Horses** | 3.77 | 3.42 | 3.03 | 2.69 | 2.30 | 2.30 | 2.34 | 2.38 | 2.37 | 2.36 | 1.56-2.34 |
| **Mules and Asses** | 1.55 | 1.41 | 1.24 | 1.10 | 0.93 | 0.91 | 0.90 | 0.90 | 0.90 | 0.90 | 0.76-1.10 |
| **Poultry** | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.02-0.09 |
| **Rabbits** | 0.27 | 0.27 | 0.26 | 0.26 | 0.25 | 0.25 | 0.25 | 0.24 | 0.24 | 0.24 | 0.08 (The default value is per animal . Emission estimates in Portugal are calculated per female cage. See tables 5.19 and 5.23 of this report) |

*Table 10.14, page 10.38 (Cattle and Swine); Table 10.15, page 10.40 (Other animal species) and Table 10.16, page 10.41; WE – Western Europe; NAm - North America; 1Per female cage

### 5.3.4 Activity Data

In a consistent manner, livestock numbers are the same that were used in previous source category ($CH_4$ from enteric fermentation) although for this source category more species are considered in the emissions estimates, namely poultry.

### 5.3.5 Uncertainty Assessment

Livestock numbers are considered to be the activity data of this source category, and the uncertainty values were equal to uncertainty values discussed for $CH_4$ emissions from Enteric Fermentation, as explained in the previous chapter.

Concerning the uncertainty levels associated with emission factors they were set in the following mode:

- total uncertainty in the emission factor was determined calculating the propagation of error in accordance with the equation that was used for the determination of the Emission Factors and

incorporating an additional factor for the uncertainty for the average annual mean temperature of each *concelho* estimated by IPMA;

- uncertainty for the quantity excreted, VS parameter, was set at 20%, considering the use of an enhanced livestock characterization, similar to that used in the derivation of the emission factor of $CH_4$ from Enteric Fermentation;

- the uncertainty of the allocation of manure for each Manure Management System (MMS) was determined comparing the share patterns that were previously used with the latest revised patterns[55]. This error was combined with the error associated with the MCF parameter: the uncertainty was assumed to be 80 % for Lagoons, given the possible range in the IPCC defaults (IPCC 2006), for Liquid and solid storage and pasture, the uncertainty values of 50% reflect the variation of this parameter;

- the error associated with the parameter $B_o$ is specie dependent and was establish from the range of possible values in the IPCC 2006, for developed and developing nations. Uncertainty values vary from 10.61% for horses, mules and asses up to 26.74% for non-dairy cattle. The uncertainty of the biogas density was assumed not to be determinant of the overall uncertainty value;

- the evaluation of the errors associated with the territorial distribution of the annual mean temperature was done by IPMA. The values of the standard errors calculated for each *concelho* territorial unit shows that 17.6% of them a change in climate region classification could occur in either direction, cool or temperate, nevertheless the maximum error is always lower than 1ºC (0.52ºC) Considering the modification that could exert in the percentage of livestock numbers allocated as either in cool or temperate region was assumed 20% as a representative value of uncertainty for this factor.

[55] Although these two patterns are not fully independent, they represent information from two different sources, and could be representative of the range of possible values.

The individual uncertainty values are presented in Table 5-27.

***Table 5-27: Uncertainty values, in %, of the $CH_4$ Emission Factors of the manure management***

| Animal Type | ∑MMS*MCF | VS | Bo | Region | EF |
|---|---|---|---|---|---|
| **Dairy Cows** | 43.95 | 20.00 | 22.92 | 20.00 | 57.07 |
| **Non-Dairy cows** | 52.33 | 20.00 | 26.47 | 20.00 | 65.11 |
| **Other cattle** | 58.93 | 20.00 | 26.47 | 20.00 | 70.52 |
| **Sheep** | 51.75 | 20.00 | 15.79 | 20.00 | 61.05 |
| **Goats** | 50.59 | 20.00 | 13.90 | 20.00 | 59.60 |
| **Swine** | 79.16 | 20.00 | 21.11 | 20.00 | 86.67 |
| **Poultry** | 60.09 | 20.00 | 20.83 | 20.00 | 69.61 |
| **Rabbits** | 60.99 | 20.00 | 20.83 | 20.00 | 69.61 |
| **Equidae** | 60.99 | 20.00 | 10.61 | 20.00 | 68.06 |

### 5.3.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification, and the information provided in this report.

### 5.3.7 Category specific recalculations

No recalculations were made

### 5.3.8 Category specific planned improvements

It is planned to continue the improvement of the characterization of the manure management systems framed by the national law[56] related with livestock farming. Further efforts will be done to obtain more detailed information exploring new sources of information.

[56] Decree-Law nº 81/2013

## 5.4 $CH_4$ Emissions from Rice Cultivation (CRT 3.C)

### 5.4.1 Category description

Methane production is enhanced in rice cultivation areas (rice paddies) due to the prevalence of anaerobic conditions which result from flooding and high levels of organic material in soil surface. The methane that is formed in soil underwater escapes to atmosphere as greenhouse gas emission, as visible bobbles or trough transport inside plant stems. In Table 5-28 are presented the estimates of $CH_4$ emission from rice cultivation.

***Table 5-28: $CH_4$ emissions from Rice cultivation***

| | Unit | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Rice cultivation | t CH4 | 5.36 | 4.16 | 4.70 | 4.68 | 5.53 | 6.03 | 4.98 | 5.35 | 5.81 | 5.69 |

### 5.4.2 Methodological issues

Methane emissions from rice production were estimated following the equation 5.1 of IPCC 2006[57]. but simplified because there is no appreciable differentiation in Portugal in what concerns water management regimes or any other conditions that are known to affect emissions from this source sector.

Original formula was therefore simplified to:

***Equation 5-8: $CH_4$ emissions from Rice cultivation***

$$E_Rice_{CH4(y)} = EF * Rice_{Area\ (y)} * 10^{-3}$$

**Where:**

$E_Rice_{CH4(y)}$: emission from rice production estimated for year y, t $CH_4.yr^{-1}$

EF: final emission factor seasonally integrated and adjusted for management practices, kg $CH_4$ $ha^{-1}$ $yr^{-1}$

$Rice_{Area\ (y)}$: area under rice cultivation in year y, ha

### 5.4.3 Emission Factors

According to equation 5.2 of IPCC 2006[58], the final value for the emission factor results from the multiplication of several scaling factors:

***Equation 5-9: Emission factor, seasonally integrated and adjusted, for rice cultivation***

$$EF = EF_{ct} * SF_w * SF_p * SF_o * SF_s$$

**Where:**

EF: final emission factor seasonally integrated and adjusted for management practices, kg $CH_4$ $ha^{-1}$ $yr^{-1}$

$EF_{ct}$: baseline emission factor for continuously flooded fields without organic amendments, for the cultivation period of rice, kg $CH_4$ $ha^{-1}$ $yr^{-1}$

$SF_w$: scaling factor for water management regime during the cultivation period of rice

$SF_p$: scaling factor to account for the differences in water regime in the pre-season before the cultivation period

[57] Volume 4, chapter 5
[58] Volume 4, chapter 5, page 5.48

**$SF_o$**: scaling factor for the type of organic amendment applied (rice straw, manure, compost, wastes), because easily decomposable carbon increase methane formation

$SF_s$: scaling factor for soil type

**$EF_{ct}$:**

The default daily baseline emission factor, 1.30 kg $CH_4$ $ha^{-1}$ $yr^{-1}$, proposed in Table 5-11[59] of IPCC 2006, is the most appropriate to use in Portugal[60]because a country specific $EF_c$ sufficiently robust was not yet determined. The cultivation period of rice in Portugal has, in average, duration of 153 days.

**$SF_w$ and $SF_p$:**

Rice cultivation has a long-time tradition in Portugal with homogeneous practices in all national territory. In Figure 5-12 are shown the main cultural practices usually done during the rice growing season.

The culture is produced in a controlled flooding system with some aeration periods. The first aeration period occurs after rice germination to promote the rooting of the plants. Fields are drained for one week or more (7 to 10 days).

The second aeration period (or periods, it could be more than one) is done for weed control and it last only 2 or 3 days. A third and final aeration takes place to create dry conditions for harvest. Water regime is controlled by human activity (water diversion, irrigation and dikes). All areas under rice cultivation are situated close to river banks almost at sea level (lowland). In accordance with IPCC 2006 classification the water management regime for rice cultivation in Portugal is classified as intermittently flooded – single aeration (only one aeration period of more than 3 days, not including final aeration). Considering all the aspects described the value for parameter $SF_w$ was set as 0.60 based on Table 5.12 of IPCC 2006, and for parameter $SF_p$ the value considered was 0.68 (table 5.13, IPCC 2006).

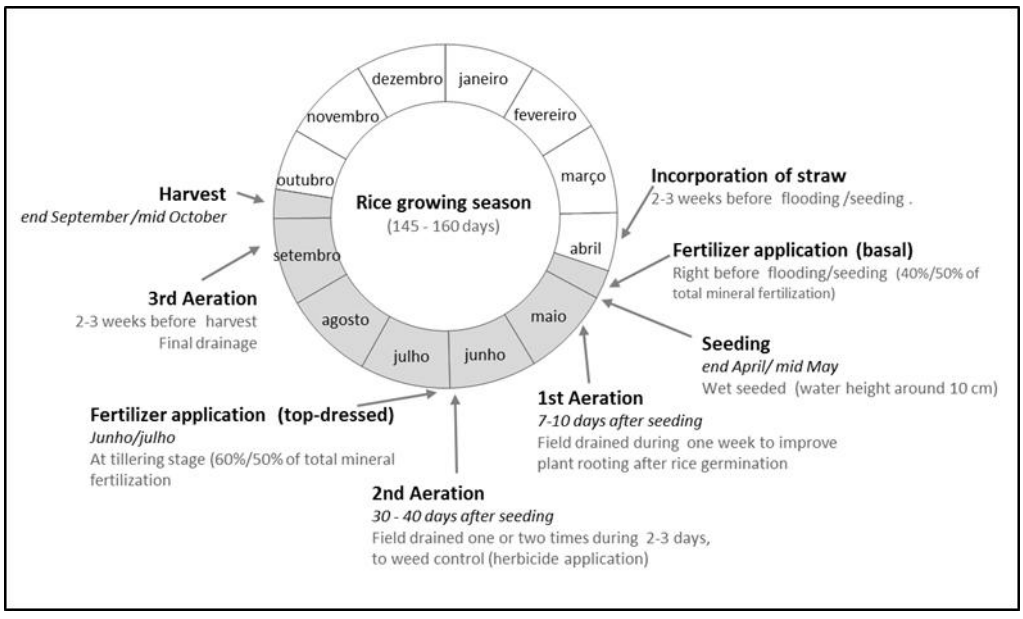



***Figure 5-12: Rice cultivation relevant practices for EF calculation***

[59] Volume 4, chapter 5, page 5.49

[60] José Pereira et al.(2013) – "*Effects of elevated temperature and atmospheric carbon dioxide concentration on the emissions of methane and nitrous oxide from Portuguese flooded rice fields*" . Atmospheric Environment 80, 464-471

**$SF_o$:**

Commonly the major fraction of rice stubbles and straw are burnt in the fields. Nevertheless, the practice of incorporating straw into the soil often occurs too with special relevance on rice producing areas inside Natura 2000[61] limits. In these situations, the practice of burning crop residues is forbidden[62], for reasons of conservation of natural habitats and animal species, since 2000 until nowadays.

Straw is left on ground and incorporated into soil by ploughing before next crop season.

The next figure shows the evolution of rice cultivation areas where the practice of residues burnt is not allowed.

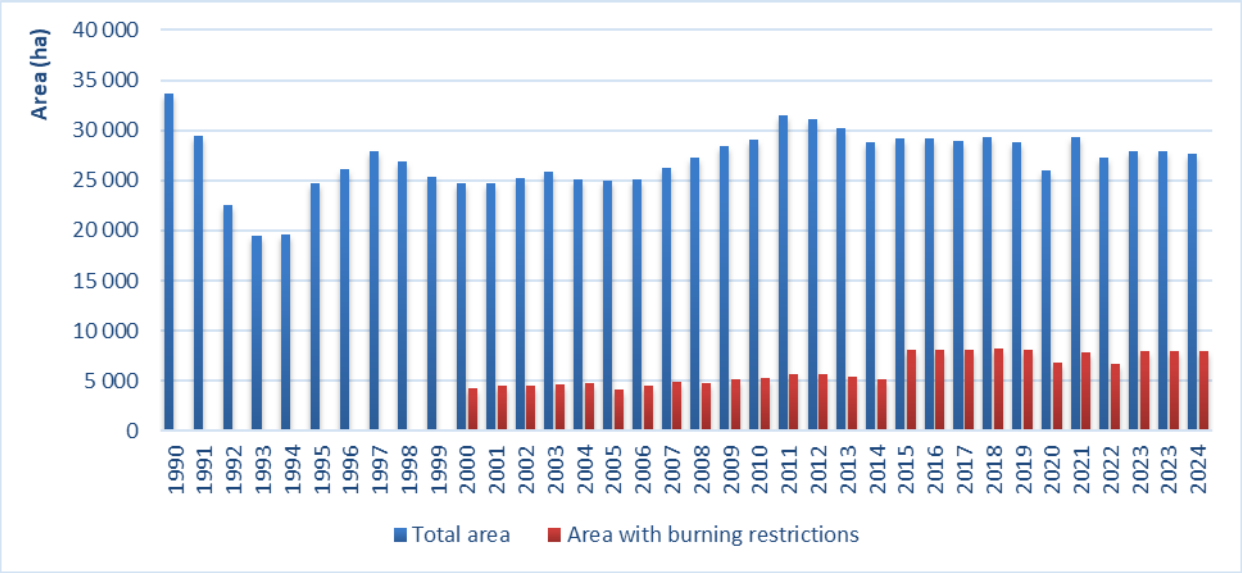



***Figure 5-13: Rice area cultivated in Portugal, ha***

Due to the above described, the amount of straw annually incorporated into the soil has variations along the time series, from a minimum of 2.13 t dm/ha to a maximum of 3.89 t dm/ha. The scaling factor $Sf_o$, for organic amendment applied, was determined using the equation 5.3[63] of IPCC 2006, where the conversion factor (CFOA) took the value of one, corresponding to straw incorporated shortly before cultivation (<30 days), in accordance with default value of Table 5.14[64].

**$SF_s$:**

Finally, no information is available to establish the influence of soil type and $SF_s$ was set to one.

In Table 5-29 are summarized the parameters and emissions factors used to estimate methane emissions from rice cultivation in Portugal, for the full time series.

[61] Natura 2000 network includes Special Zones for Conservation (ZPC) established under Habitats Directive (92/43/ CEE) and Special Protection Zones (ZPE) established under Birds Directive (last revision 2009/147/CE).
[62] National Laws: DL 140/99 artº 11º (revised by DL 49/2005); RCM 177/2008 artº 21º; RCM 182/2008 artº 8º.
[63] Volume 4, chapter 5, page 5.50
[64] Volume 4, chapter 5, page 5.51

***Table 5-29: Parameters and Emission Factors used to calculate CH4 emissions from rice paddies in Portugal***

| Year | $EF_{ct}$ kg $CH_4$ $ha^{-1}$ $yr^{-1}$ | $SF_w$ | $SF_o$ | $SF_s$ | $SF_p$ | EF kg $CH_4$ $ha^{-1}$ $yr^{-1}$ |
|---|---|---|---|---|---|---|
| **1990** | 198.90 | 0.60 | 1.96 | 1.00 | 0.68 | 159.24 |
| **1995** | 198.90 | 0.60 | 2.08 | 1.00 | 0.68 | 168.53 |
| **2000** | 198.90 | 0.60 | 2.34 | 1.00 | 0.68 | 190.26 |
| **2005** | 198.90 | 0.60 | 2.31 | 1.00 | 0.68 | 187.36 |
| **2010** | 198.90 | 0.60 | 2.34 | 1.00 | 0.68 | 190.05 |
| **2015** | 198.90 | 0.60 | 2.55 | 1.00 | 0.68 | 206.89 |
| **2020** | 198.90 | 0.60 | 2.37 | 1.00 | 0.68 | 192.11 |
| **2022** | 198.90 | 0.60 | 2.42 | 1.00 | 0.68 | 196.24 |
| **2023** | 198.90 | 0.60 | 2.56 | 1.00 | 0.68 | 207.96 |
| **2024** | 198.90 | 0.60 | 2.53 | 1.00 | 0.68 | 205.18 |

### 5.4.4 Activity Data

Rice cultivated area is available from annual statistics from National Statistical Institute, which time series is presented in Figure 5-13. It is noticeable the existence of significant variations in annual rice paddy areas, expressing annual variations in hydrological conditions. There is only one rice crop per year.

### 5.4.5 Uncertainty Assessment

For activity data, the standard deviation of inter-annual area under rice cultivation was considered: 10.2%.

Total uncertainty in the emission factor was determined calculating the propagation of error in accordance with the equation that was used for the determination of the Emission Factor:

- the error associated with the parameters $SF_w$ and $SF_p$ were establish from the range of possible errors for each scaling factor (IPCC 2006);
- the error associated with the scaling factor $SF_o$ was obtained by the combination of the uncertainties of the parameters ROA and CFOA and the exponent of the $SF_o$ equation;
- the error associated with the baseline $Ef_{ct}$ was obtained from the range of possible error values.

The individual uncertainty values are presented in Table 5-30.

***Table 5-30: Uncertainty values (in %) of the Emission Factor of $CH_4$ emissions from rice cultivation***

| SFw | SFp | Sfo | Efct | EF |
|---|---|---|---|---|
| 28.3 | 16.2 | 8.5 | 53.8 | 63.5 |

### 5.4.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification, and the information provided in this report.

### 5.4.7 Category specific recalculations

Minor recalculations were made due to Rice Cultivation area (ha) update in 2023-2024.

### 5.4.8 Category specific planned improvements

No further improvements planned.

## 5.5 $N_2O$ Emissions from Manure Management (CRT 3.B.b)

The estimates of total $N_2O$ emissions from manure management, direct and indirect emissions, are presented in Table 5-31. In the following chapters 5.5.1 – Direct $N_2O$ emissions from manure management and 5.5.2 – Indirect $N_2O$ emissions from manure management, further details will be developed.

***Table 5-31: $N_2O$ emissions from manure management (kt)***

| Livestock type | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Direct emissions** | 0.54 | 0.49 | 0.50 | 0.40 | 0.36 | 0.33 | 0.43 | 0.44 | 0.44 | 0.44 |
| Dairy cattle | 0.19 | 0.17 | 0.18 | 0.14 | 0.11 | 0.11 | 0.11 | 0.10 | 0.10 | 0.10 |
| Non- Dairy cattle | 0.08 | 0.07 | 0.06 | 0.06 | 0.05 | 0.05 | 0.06 | 0.06 | 0.05 | 0.05 |
| Sheep | 0.04 | 0.04 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Swine | 0.04 | 0.03 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Goats | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Horses | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Mules and asses | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Poultry | 0.14 | 0.14 | 0.17 | 0.13 | 0.15 | 0.13 | 0.22 | 0.23 | 0.23 | 0.23 |
| Rabbits | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 |
| **Indirect emissions** | 0.36 | 0.35 | 0.35 | 0.29 | 0.27 | 0.26 | 0.32 | 0.32 | 0.32 | 0.32 |
| **Total** | 0.90 | 0.84 | 0.85 | 0.69 | 0.63 | 0.59 | 0.75 | 0.76 | 0.76 | 0.75 |

### 5.5.1 Direct $N_2O$ Emissions from Manure Management

#### 5.5.1.1 Category description

Part of the Nitrogen (N) that is in manure, either in faeces or urine is emitted as $N_2O$ during management or during storage of manure, before application to soil, as consequence of the nitrification-denitrification processes affecting ammonia nitrogen.

Emissions of $N_2O$ that occur during manure application on soil and urine and dung deposited directly into soil by grazing are reported in the category $N_2O$ from managed soils (CRT 3D) following the UNFCCC reporting guidelines.

In a short description, this is a biological based process where emission of $N_2O$ from manure require the previous oxidation of organic nitrogen in ammonia form, which results from bacterial mineralization of organic nitrogen, into nitrites and nitrates (nitrification, a biological process mediated by bacteria such as Nitrobacter and Nitrosomonas) in an aerobic environment and, thereafter, the reduction of this compounds in an anaerobic environment (the denitrification process where nitrate is converted to $N_2$ and nitrous oxide).

In terms of the relevance by Manure Management System, observable in Figure 5-14, the great majority of emissions result from solid storage totalizing in 2024, 83.7% of direct $N_2O$ emissions from Manure Management. The remaining 16.3 % $N_2O$ emissions are from liquid systems.

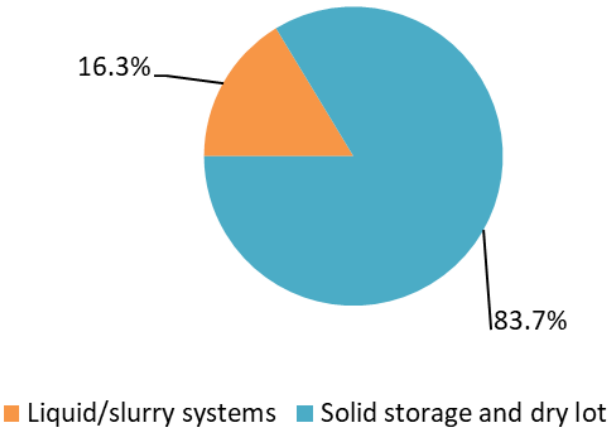



***Figure 5-14: Direct $N_2O$ emissions from manure management, per system, 2024***

In terms of origin by animal type, emissions are dominated by poultry 53.5% and cattle 35.0% (dairy – 23.1%, non-dairy – 11.9%), which together comprehend about 88.5% of total $N_2O$ direct emissions for the year 2024, as can be seen in Figure 5-15.

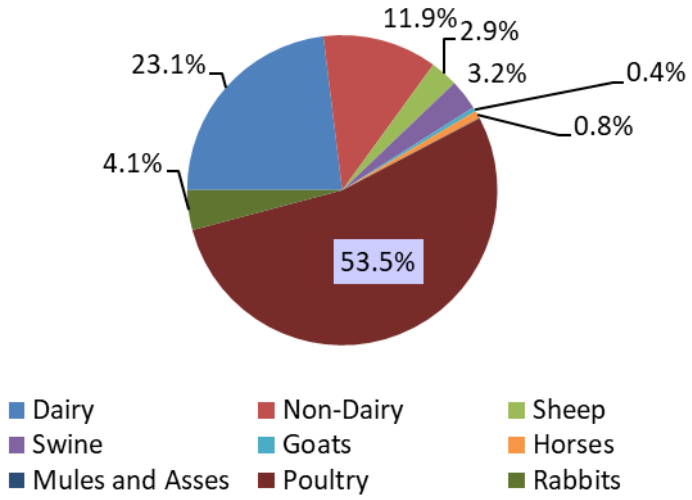



***Figure 5-15: Direct $N_2O$ emissions from manure management by livestock category, 2024***

### 5.5.1.2 Methodological issues

Direct $N_2O$ emissions from manure for each Manure Management System (MMS) were estimated from the following equation:

***Equation 5-10: $N_2O$ direct emissions from manure management, per system***

$$EN_2O_{(s)} = \Sigma_i[N_{(i)} * Nex_{(i)} * MS_{(i,s)}] * EF_{3(s)} * 44/28$$

**Where:**

$EN_2O_{(s)}$: direct $N_2O$ emissions from manure in manure management System s, kg $N_2O.yr^{-1}$

$N_{(i)}$: number of individuals from livestock species/category i in the country, head

$Nex_{(i)}$: annual average N excretion per head of the species/category i, kg $N.head^{-1}.yr^{-1}$

$MS_{(i,s)}$: fraction of manure Nitrogen from livestock species/category i that is managed in manure management System s, %

$EF_{3(s)}$ : $N_2O$ emission factor for Manure Management System s, kg $N_2O$ – N.kg $N^{-1}$ in manure

s: manure management system

i : species/category of livestock

44/28: conversion of ($N_2O$ – N) emissions to $N_2O$ emissions

Total $N_2O$ emissions result from the sum of the estimated emissions for each manure management system considered. This formulation follows the one proposed in IPCC 2006 (equation 10.25)[65].

Manure Management Systems are the same that were used to estimate methane emissions from manure management (Table 5-23 of Chapter 5.3.3 of this report).

$N_2O$ emissions from manure deposited in soil during grazing (Pasture/range/paddock) are further discussed in 5.6 - "Direct $N_2O$ Emissions from Managed Soils".

Parameters $N_{(i)}$, $Nex_{(i)}$ and $MS_{(i,s)}$ will be discussed under "activity data" and $EF3_{(s)}$ will be discussed as "emission factor".

### 5.5.1.3 Emission factors

$N_2O$ emission factors for the MMS in use are the default IPCC 2006 emission factors (table 10.21)[66] and are presented in Table 5-32.

***Table 5-32: $N_2O$ emission factors per manure management system***

| MMS | $EF_3$ (kg $N_2O$-N.kg $N^{-1}$) | Table 10.21* | CRT 3Bb |
|---|---|---|---|
| Lagoon system | 0 | Liquid/slurry without natural crust | Liquid system |
| Tanks/ Earthen pond | 0.005 | Liquid/slurry with natural crust | Liquid system |
| Solid Storage | 0.005 | Solid Storage | Solid storage and dry lot |
| *IPCC 2006, Vol.4, chapter 10 | | | |

[65] Volume 4, chapter 10, page 10.54
[66] Volume 4, chapter 10, pages 10.62 and 10.63

#### 5.5.1.4 Activity Data

The livestock population numbers used to estimate total nitrogen excretion are the same as those used to estimate emissions of $CH_4$ from Enteric Fermentation and $CH_4$ from Manure Management that have already been presented in the chapter concerning $CH_4$ emissions from Enteric Fermentation.

Most of the nitrogen excretion rates (Nexc) used in the inventory were established based on the Nexc proposed by the Revised Code of Good Agricultural Practice[67] (CBPA).

The following chapters present the methodology used to establish the country specific Nexc for dairy-cattle (which vary with milk production) and for estimates of nitrogen excreted by non–dairy cattle. For all other animals, nitrogen excretion rates were based on CBPA Nexc, considering animal species, age and sex, according to the livestock characterization used in the inventory.

***a) Dairy Cattle Nex***

CBPA defines the nitrogen excretion rate of dairy-cattle as a function of milk production. The base nitrogen value for dairy-cattle is 115 kg $N.hd^{-1}.yr^{-1}$ for 7000 kg milk $produced.hd^{-1}.year^{-1}$. For different milk production values, the extrapolation procedures defined in CBPA are the following:

- the Nex decreases 10 % for every 1000 kg less of milk production;
- the Nex increases 2 % for every 1000 kg extra of milk production.

Milk production values and corresponding Nex in the time series are presented in Table 5-33.

***Table 5-33: Nitrogen excretion rates (Nex) of dairy cows in the time series***

| Year | Milk per Cow ($kg.\ hd^{-1}.year^{-1}$) | Nex ($kg.\ hd^{-1}.year^{-1}$) |
|---|---|---|
| **1990** | 4 464 | 85.8 |
| **1995** | 4 556 | 86.9 |
| **2000** | 6 262 | 106.5 |
| **2005** | 7 232 | 115.5 |
| **2010** | 7 894 | 117.1 |
| **2015** | 8 287 | 118.0 |
| **2020** | 8 571 | 118.6 |
| **2022** | 8 689 | 118.9 |
| **2023** | 8 949 | 119.5 |
| **2024** | 9 081 | 119.8 |

The 2024 Nex value of 119.8 kg. $hd^{-1}.yr^{-1}$ is higher than the default IPCC 2006 value of 105.1 kg. $hd^{-1}.yr^{-1}$ for Western Europe (table 10.19[68] considering an average weight of 600 kg per dairy cow), but is close to those used by other countries.

[67] Portugal published his first CBPA in 1997. In 2010 it was revised and recently it was published including not only good practices to follow in nitrogen fertilization of crops but also the good practices for phosphate fertilization (Despacho nº 1230/2018, 5th February

[68] Volume 4, chapter 10, page10.59

### b) Non - Dairy Cattle Nex

The Nex estimates for non-dairy cattle subcategories were calculated in coherence with the review done to the emission factors from enteric fermentation, using IPCC 2006 equations 10.31, 10.32 and 10.33[69]. The values used of gross energy (GE), weight gain (WG), net energy for growth (NEg), milk production and fat content of milk, are the same that were calculated and described in chapter 5.2.3 of this report.

The percent crude protein in the representative diets were estimated by the expert[70] of INIAV[71] on Chemical and Nutritive evaluation of Animal Feed, considering the proportion and the data of the different feed constituents of each diet. In Table 5-34 are presented the weighted average values of Nex by subcategory of non-dairy cattle, for the time series.

***Table 5-34: Nitrogen excretion rates (Nex) of non-dairy cattle in the time series***

| Non dairy cattle subcategories | Nex (kg. $hd^{-1}.year^{-1}$) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 | 2024 |
| Beef calves (<1 yr) | 25.0 | 25.0 | 24.8 | 24.3 | 23.7 | 23.4 | 23.4 | 23.4 | 23.4 | 23.4 |
| Calves M.Rep. (<1 yr) | 25.0 | 25.0 | 27.1 | 32.5 | 37.8 | 41.0 | 41.0 | 41.0 | 41.0 | 41.0 |
| Calves F Rep. (<1 yr) | 25.0 | 25.0 | 27.1 | 32.5 | 37.8 | 44.8 | 44.8 | 44.8 | 44.8 | 44.8 |
| Males 1-2 yrs | 40.0 | 40.0 | 42.6 | 49.1 | 55.5 | 59.4 | 59.4 | 59.4 | 59.4 | 59.4 |
| Beef Fem. 1-2 yrs | 40.0 | 40.0 | 41.7 | 45.9 | 50.0 | 52.5 | 52.5 | 52.5 | 52.5 | 52.5 |
| Females rep. 1-2 yrs | 40.0 | 40.0 | 41.8 | 46.5 | 51.1 | 53.9 | 53.9 | 53.9 | 53.9 | 53.9 |
| Steers (>2 yrs) | 41.0 | 41.0 | 47.7 | 64.4 | 81.1 | 91.1 | 91.1 | 91.1 | 91.1 | 91.1 |
| Heifers Beef (>2 yrs) | 55.0 | 55.0 | 55.7 | 57.6 | 59.4 | 60.5 | 60.5 | 60.5 | 60.5 | 60.5 |
| Heifers rep. (>2 yrs) | 55.0 | 55.0 | 55.7 | 57.6 | 59.4 | 60.5 | 60.5 | 60.5 | 60.5 | 60.5 |
| Non-Dairy cows | 80.0 | 80.0 | 78.7 | 75.3 | 71.9 | 69.9 | 69.9 | 69.9 | 69.9 | 69.9 |
| **Average Nexc** | **44.4** | **46.3** | **49.5** | **51.9** | **54.8** | **55.8** | **56.5** | **56.5** | **56.4** | **56.3** |

The average Nex, weighted by the 2024 non-dairy cattle population is 56.3 kg. $hd^{-1}.yr^{-1}$, which is higher but close of the default value for Western Europe (considering the average weight of 437.4 kg of the non-dairy cattle population in 2024).

### c) Nex for all livestock categories other than cattle

Table 5-35 presents the nitrogen excretion rates applied in the estimation of $N_2O$ emissions from Manure Management and the defaults Nex, estimated with equation 10.30[72] as proposed in the IPCC 2006. There is an acceptable agreement between country-specific values and IPCC defaults for all species other than sheep and goats. For these two categories the nitrogen excretion rate appears to below, when in comparison to IPCC default, but it has similarities to those used by other parties.

[69] Volume 4, chapter 10, pages 10.58 and 10.59
[70] Engª Teresa Dentinho – "Dados portugueses para determinação das emissões de azoto de bovinos não leiteiros – Valor proteico das dietas".
[71] National Institute of Agrarian and Veterinary Research
[72] Volume 4, chapter 10, page10.57

***Table 5-35: Nitrogen excretion rates (Nex) of all livestock other than cattle***

| Animal type | Sub category | Nex | | | |
|---|---|---|---|---|---|
| | | Country specific | Typical animal mass (average) | IPCC default | |
| | | (kg N.hd$^{-1}$.yr$^{-1}$) | (kg) | Kg N (1000 kg animal mass)$^{-1}$ .day$^{-1}$ | Kg N hd$^{-1}$yr$^{-1}$ |
| **Swine** | Piglets (<20 kg) | 0.00 | 65.00 | 0.51 | 12.10 |
| | Fatt. Pigs (20-50 kg) | 9.00 | | | |
| | Fatt. Pigs (50-80 kg) | 13.00 | | | |
| | Fatt. Pigs (80-110 kg) | | | | |
| | Fatt. Pigs (> 110 kg) | | | | |
| | Boars (>50 kg) | 18.00 | 205.00 | 0.42 | 31.43 |
| | Sows, pregnant | 20.00 | | | |
| | Sows, non-pregnant | 42.00 | | | |
| **Sheep** | Ewes | 9.17 | 54.00 | 0.85 | 16.75 |
| | Other Ovine | 6.60 | | | |
| | Lambs | 0.00 | | | |
| **Goats** | Does | 7.00 | 30.00 | 1.28 | 14.02 |
| | Other Caprine | 6.60 | | | |
| | kids | 0.00 | | | |
| **Equidae** | Horses | 44.00 | 550.00 | 0.26 | 52.20 |
| | Asses & Mules | 22.00 | 245.00 | | 23.25 |
| **Poultry** | Hens, reproductive | 0.34 | 1.80 | 0.96 | 0.63 |
| | Hens eggs | 0.80 | | | |
| | Broilers | 0.45 | 0.90 | 1.10 | 0.36 |
| | Turkeys | 1.40 | 6.80 | 0.74 | 1.84 |
| | Other poultry | 0.45 | 2.70 | 0.83 | 0.82 |
| **Other** | Rabbits[1] | 9.00 | - | - | 8.10 |
| [1]Per female cage | | | | | |

Values for Piglets (< 20kg), lambs and goat kids, are 0 kg N.hd$^{-1}$.yr$^{-1}$ because the Nex is included in the Nex of their respective mothers.

The Nex values for rabbits correspond to a breeding female with 40 young animals with a final weight of 2.7/3.0 kg per rabbit per year.

There is an acceptable agreement between country-specific values and IPCC 2006 defaults for all species other than sheep and goats. These two categories nitrogen excretion rate appears to be low, when in comparison with default values, but it has similarities to those used by other parties.

The total quantity of nitrogen in manure produced (including deposition on pasture) per animal type, and its annual variation in the period 1990 to 2024, is presented in the ANNEX C: Agriculture. For the year of 2024 the distribution of N manure by manure management system and deposition on pasture is shown in Figure 5-16. The major contributors to total nitrogen from livestock manure in Portugal in 2024 were non-dairy cattle and poultry, as may be seen in Figure 5-17.

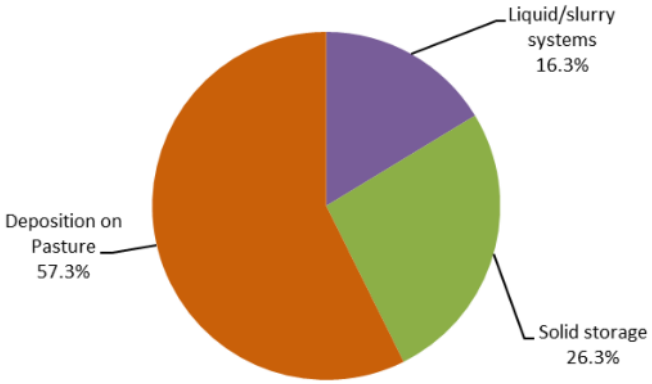



***Figure 5-16: Distribution of total nitrogen in manure produced in 2024 (%)***

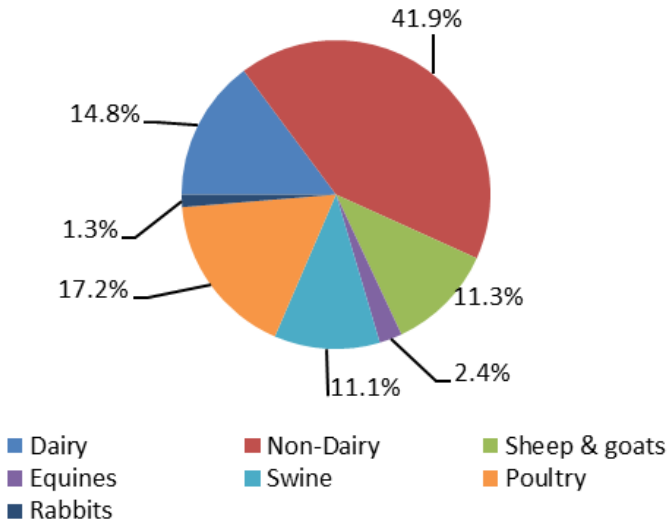



***Figure 5-17: Origin of total nitrogen in manure produced in 2024, per animal type***

The $N_2O$ emissions estimates from urine and dung directly deposited on pasture are included in chapter 5.6 N2O Emissions from Managed Soils (CRT 3.D), and so the annual amount of nitrogen that constitutes activity data for estimation of those emissions will be further discussed there.

The percentage of nitrogen in manure stored and treated, per manure management system, is presented in the next Figure for the year 2024.

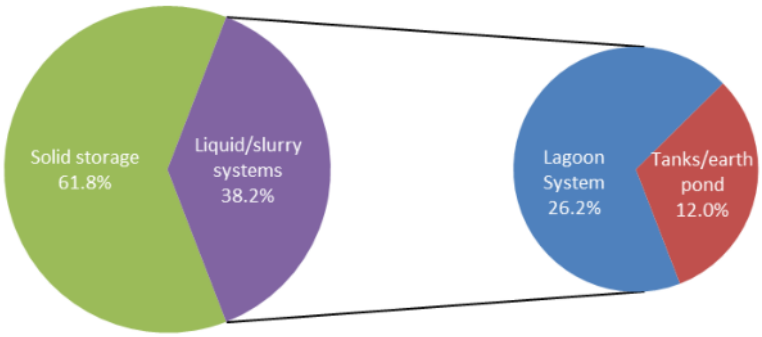



***Figure 5-18: Share of nitrogen in manure stored and treated per MMS, in 2024***

The major contribution for stored and treated manure in 2024, were poultry, swine and dairy cattle, as it is shown in the next Figure.

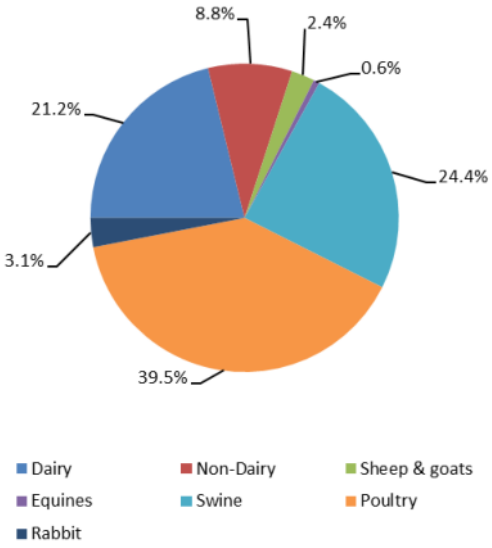



***Figure 5-19: Origin, by livestock category, of nitrogen in manure stored and treated in 2024***

The percentage of manure that is attributed to each Manure Management System and to deposition on pasture was established in a coherent mode with the share considered for $CH_4$ emissions from Manure Management (Table 5-23 of this report).

### 5.5.1.5 Uncertainty Assessment

Uncertainty in activity data is the result of the combined uncertainties in livestock number, nitrogen excretion rates and the distribution by each manure management system. The values for uncertainty in livestock numbers are the same that were for sector $CH_4$ emissions from enteric fermentation. The uncertainty in N-excretion rate was set at 37.5%, considering an intermediate situation between the uncertainty values recommended by IPCC 2006 for default N-excretion rates (50%) and the lower uncertainty when country-specific values are based on accurate national statistics (25%). Uncertainty in MMS share was determined as the maximum difference in total excretion for each MMS considering the previous allocation per MMS used, and the last revised share of MMS. Individual values and the overall uncertainty values for activity data are presented in Table 5-36.

*Table 5-36: Uncertainty values (in %) of the activity data for $N_2O$ emissions from manure management*

| Animal type | Livestock numbers | Nexc | MMS allocation | Total U_AD |
|---|---|---|---|---|
| **Dairy cattle** | 1.19 | 37.5 | 38 | 53.05 |
| **Non- dairy cattle** | 3.47 | 37.5 | 38 | 53.15 |
| **Sheep** | 0.59 | 37.5 | 38 | 53.04 |
| **Goats** | 6.04 | 37.5 | 38 | 53.38 |
| **Swine** | 7.46 | 37.5 | 38 | 53.56 |
| **Poultry** | 15.03 | 37.5 | 38 | 55.12 |
| **Rabbits** | 20 | 37.5 | 38 | 56.68 |
| **Equidae** | 7.82 | 37.5 | 38 | 53.61 |

The uncertainty of $N_2O$ emission factor was set from the error range considered in IPCC 2006, resulting 75% for all MMS.

### 5.5.2 Indirect $N_2O$ Emissions from Manure Management

#### 5.5.2.1 Category description

Indirect $N_2O$ emissions result from volatile nitrogen losses, in forms of $NH_3$ and $NO_x$, during manure collection and storage and from nitrogen lost through runoff and leaching into soil from solid storage of manure. Nitrogen losses begin at the point of excretion on houses and continue through on-site management in storage systems.

The contribution of N losses from volatilization and from leaching and runoff to indirect $N_2O$ emissions from manure management is shown in the next Figure for the 2024 year.

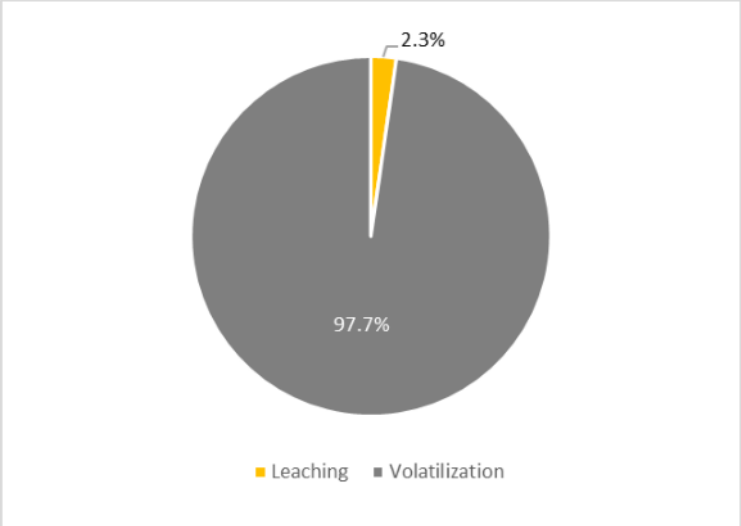



***Figure 5-20: Relative importance of the losses of volatile nitrogen and of leached nitrogen from manure management systems, in 2024***

#### 5.5.2.2 Methodological issues

Indirect $N_2O$ emissions were estimated with equation 10.27[73] (IPCC 2006), in the case of the N lost due to volatilization, and with equation 10.29[74] (IPCC 2006) for the indirect $N_2O$ emissions due to N manure leached from manure management systems.

#### 5.5.2.3 Emission Factors

Emission factors used were the default emission factors, $EF_4$ (volatilization) and $EF_5$ (leaching), both from table 11.3[75] of IPCC 2006.

#### 5.5.2.4 Activity Data

The amount of N that is lost due to volatilization, in form of $NH_3$ and $NO_x$, during animal housing and storage and treatment of the manure, was estimated using mass flow approach described in the EMEP/EEA Guidebook 2023, chapter 3B – Manure management, in coherence with UNECE/CLRTAP emissions inventory.

Portugal has no country specific value for the N fraction leached into soil from liquid/slurry or solid storage manure. The national legislation[76] requires that the storage of liquid/slurry manure is in containers with

[73] Volume 4, chapter 10, page 10.56
[74] Volume 4, chapter 10, page10.57
[75] Volume 4, chapter 11, page 11.24
[76] Decreto-Lei nº 81/2013, of june 14, and Portaria 631/2009, of june 9, with the change introduced by the Portaria 114-A /2011, of march 23

waterproof bottom. The solid storage should have the concrete or similar materials on the bottom and the leachate collection system. Nevertheless, manure heaps near the field are permitted for limited time after storage aimed at spreading.

Leaching of N during manure management is thus restricted to these manure heaps after storage. On the basis of that information $Frac_{LeachMMs}$ is assumed equal to 1%, the lower bound of the typical range of IPCC 2006.

The amount of N lost due to volatilization and due to leaching and runoff for the time series is presented in Table 5-37.

***Table 5-37: Amount of N lost due to volatilization ($NH_3$+$NO_x$) and leaching, during animal housing and manure storage (t N.yr$^{-1}$)***

| Year | Volatilization | Leaching |
|---|---|---|
| **1990** | 22 552 | 530 |
| **1995** | 21 682 | 486 |
| **2000** | 22 082 | 491 |
| **2005** | 18 161 | 395 |
| **2010** | 17 098 | 360 |
| **2015** | 16 227 | 325 |
| **2020** | 19 916 | 451 |
| **2022** | 20 175 | 466 |
| **2023** | 19 993 | 464 |
| **2024** | 19 893 | 464 |

#### 5.5.2.5 Uncertainty Assessment

The uncertainty of activity data is the same discussed in direct $N_2O$ emissions. Emission factors uncertainties were set based on the error ranges referred in IPCC2006. Given that, the uncertainty of $EF_4$ was estimated in 135.0% and the uncertainty of $EF_5$ in 163.3%.

### 5.5.3 Category specific QA/QC and verification

For this source category QA/QC procedures included the comparison between inventory Nex values and the corresponding IPCC default and a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

### 5.5.4 Category specific recalculations

No recalculations were made.

### 5.5.5 Category specific planned improvements

It is planned to continue the improvement of the characterization of the manure management systems framed by the new national law[77] related with livestock farming. Further efforts will be done to obtain more detailed information exploring new sources of information.

[77] Decree-Law nº 81/2013

## 5.6 $N_2O$ Emissions from Managed Soils (CRT 3.D)

The estimates of total $N_2O$ emissions from managed soils, direct and indirect emissions, are presented in Table 5-38. In the following chapters 5.6.1 – Direct N2O Emissions from Managed Soils and 5.6.2- Indirect N2O Emissions from Managed Soils, further details will be developed.

***Table 5-38: $N_2O$ emissions from managed soils (kt)***

| Category | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Direct Emissions** | **6.04** | **5.86** | **6.53** | **5.46** | **5.49** | **5.96** | **6.03** | **5.38** | **5.55** | **5.62** |
| - Synthetic Fertilizers | 2.44 | 2.26 | 2.64 | 1.58 | 1.54 | 1.81 | 1.59 | 1.03 | 1.32 | 1.46 |
| - Organic Fertilizers | 0.96 | 0.91 | 0.89 | 0.74 | 0.68 | 0.67 | 0.79 | 0.78 | 0.78 | 0.78 |
| - Urine and dung deposited by grazing animals | 1.81 | 1.97 | 2.31 | 2.52 | 2.70 | 2.79 | 3.04 | 3.01 | 2.92 | 2.83 |
| - Crop residues | 0.82 | 0.72 | 0.69 | 0.62 | 0.57 | 0.69 | 0.61 | 0.56 | 0.53 | 0.55 |
| **Indirect Emissions** | **1.73** | **1.66** | **1.84** | **1.45** | **1.42** | **1.56** | **1.54** | **1.35** | **1.42** | **1.47** |
| **Total (Direct and Indirect Emissions)** | **7.77** | **7.52** | **8.37** | **6.91** | **6.91** | **7.52** | **7.57** | **6.72** | **6.98** | **7.10** |
| Note: Totals may not sum due to independent rounding | | | | | | | | | | |

### 5.6.1 Direct $N_2O$ Emissions from Managed Soils

#### 5.6.1.1 Category description

In agricultural soils, emission of $N_2O$ is enhanced by an increase in available mineral nitrogen which promotes soil biogenic activities of nitrification and denitrification. Increase of available nitrogen in soil may be caused by anthropogenic activities such as the addition of nitrogen to soil as a fertilizer, in crop residues or as consequence of cultivation of organic soils where degradation of organic matter is enhanced liberating fixed nitrogen. Nitrous oxide emissions considered in this inventory include therefore only the increase in soil emissions that are due to human management of soils, and not comprehending the Nitrous Oxide emissions that would occur in the same area under unmanaged conditions (background emissions).

Although some scientific references indicate that soils may also be soil sinks of $N_2O$, there are no available sound estimate techniques and consequently these were not estimated in this inventory.

Direct emissions of $N_2O$ resulting from the increase of nitrogen added to cultivated soils due to agricultural activities includes the following source categories:

- application of synthetic N fertilizers;
- application of organic N as fertilizer (animal manure and other organic fertilizers);
- urine and dung deposited on pasture, range and paddock by grazing animals;
- N input from incorporation of crop residues into soils.

Most effort was placed to made estimates of this source fully consistent in what concerns:

- whole time series. All activity data for each sub source was obtained from the same data source for all inventory years;
- methodology is the same applied to all inventory years;
- coherence with activity data for other source activities. Because activity data for this source is also used - or results from - emission estimates of other sources: $N_2O$, $CH_4$, $NH_3$ and $NO_2$.

Considering climate conditions, and the long period since when soils have been subjected to agriculture in Portugal, histosols are not present in Portugal and $N_2O$ emissions from histosols may be reported as not occurring.

This is also supported by FAO Harmonized World Soil Database, see map from http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/harmonized-world-soil-database-v12/en/ , which does not contain references to histosols in Portugal.

The comparative relevance of the several sub source activities for 2024 to direct $N_2O$ emissions from managed soils is shown in Figure 5-21, from where it is evident the major contribution from direct deposition of urine and dung on pasture with 52.6% and synthetic fertilizers with 23.8%, which may be considered significant sources in accordance with the IPCC rule of thumb. Organic fertilizers are also an important source, representing 13.6% and crop residues source is responsible for 9.5% of the direct $N_2O$ emissions from managed soils. The remaining 0.4% are from other organic fertilizers (sewage sludge+ compost of municipal solid waste).

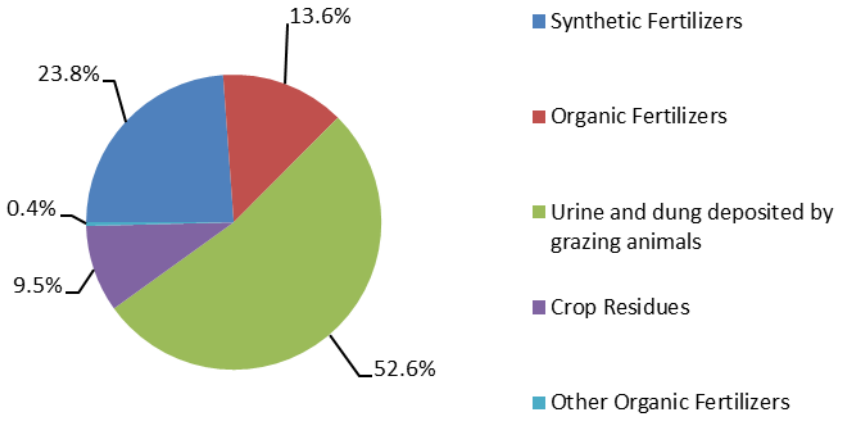



***Figure 5-21: Contribution of the various sub sources to direct $N_2O$ emissions from managed soils, 2024***

### 5.6.1.2 Methodological issues

The approach used to estimate direct $N_2O$ emissions from managed soils follows the IPCC 2006 Tier 1 methodology with country specific activity data.

Final $N_2O$ emissions are estimated with a formulation derived from equation 11.1[78] of IPCC 2006:

***Equation 5-11: Direct $N_2O$ emissions from managed soils***

$$EN_2O_{Direct} = (N_2O - N_{N\ inputs} + N_2O\text{-}N_{N\ prp}) * 44/28$$

$$N_2O\text{-}N_{N\ inputs} = (F_{SN} + F_{AM} + F_{SEW} + F_{MSW} + F_{CR}) * EF_1$$

$$N_2O\text{-}N_{N\ prp} = (F_{prp,\ cpp} * EF_{3\ prp,cpp}) + (F_{prp,\ so} * EF_{3\ prp,so})$$

**where:**

$EN_2O_{Direct}$: total direct emission of $N_2O$ from managed soils, kg $N_2O.yr^{-1}$

$N_2O\text{-}N_{N\ inputs}$: annual direct $N_2O$-N emissions from N inputs to managed soils, kg $N_2O$-$N.yr^{-1}$

$N_2O\text{-}N_{N\ prp}$ : annual direct $N_2O$-N emissions from urine and dung deposited by grazing animals, kg $N_2O$-$N.yr^{-1}$

44/28: conversion of $N_2O$-N emissions to $N_2O$ emissions

[78] Volume 4, chapter 11, page 11.7

$F_{SN}$: annual amount of synthetic fertilizer nitrogen applied to soils, kg N.yr$^{-1}$

$F_{AM}$: annual amount of animal manure nitrogen applied to soils, kg N.yr$^{-1}$

$F_{SEW}$: annual amount of nitrogen in sludge applied to agriculture soils, kg N.yr$^{-1}$

$F_{MSW}$: annual amount of nitrogen in compost from biological treatment of municipal solid waste that is applied to agriculture soils kg N.yr$^{-1}$

$F_{CR}$: annual amount of nitrogen in crop residues returned to soils, kg N.yr$^{-1}$

$EF_1$: emission factor for $N_2O$ emissions from N inputs to soil, kg $N_2O$-N.kg N$^{-1}$ input

$F_{prp,\ cpp}$: annual amount of urine and dung N deposited by grazing cattle, poultry and Swines (cpp) on pasture, kg N.yr$^{-1}$

$F_{prp,\ so}$: annual amount of urine and dung N deposited by grazing sheep and other animals (so) on pasture, kg N.yr$^{-1}$

$EF_{3\ prp,cpp}$: emission factor for $N_2O$ emissions from urine and dung N deposited by grazing animals (cpp) on pasture, kg $N_2O$-N.kg N$^{-1}$ input

$EF_{3\ prp,so}$: emission factor for $N_2O$ emissions from urine and dung N deposited by grazing animals (so) on pasture, kg $N_2O$-N.kg N$^{-1}$ input.

The annual amount of nitrogen in mineral soils that is mineralised ($F_{SOM}$) with loss of C soil from soil organic matter as a result of changes to land use (cropland remaining cropland) and the direct emissions of $N_2O$ are reported in CRT 3D.1.e but estimates are done in LULUCF sector. Methodologies, emission factors and activity data used are described in LULUCF chapter 6.11 - Direct and Indirect N2O emissions from N Mineralization/Immobilization associated with Loss/Gain of Soil Organic Matter resulting from change of LU or management of Mineral Soils (CRT 4(III)).

### 5.6.1.3 Emission Factors

The emissions factors used for $N_2O$ emissions from $N_{inputs}$ to soil ($EF_1$) other than rice cultivated areas, for $N_2O$ emissions from urine and dung N deposited by grazing animals on pasture ($EF_{3\ prp,\ cpp}$ and $EF_{3\ prp,so}$) and for flooded rice fields were the default values of IPCC 2006, table 11.1[79].

In Table 5-39 are shown the values used for $EF_1$, $EF_{3\ prp,\ cpp}$ and $EF_{3\ prp,so}$.

***Table 5-39: Emission factors used to estimate direct $N_2O$ emissions from managed soils***

| Emission Factor | Value (Kg $N_2O$-N.kg N input$^{-1}$) |
|---|---|
| **$EF_1$** | 0.01 |
| **$EF_{3\ prp,\ cpp}$** | 0.02 |
| **$EF_{3\ prp,so}$** | 0.01 |
| **$EF_{1FR}$** | 0.003 |

### 5.6.1.4 Activity Data

The estimated amounts of nitrogen added to agricultural soils from each specific source, which are activity data for determining direct $N_2O$ emissions, are shown in Table 5-40 and in ANNEX C**:** Agriculture**,** for the complete time series.

Total nitrogen added to soil was in 2024 about 18% lower than what it was applied in 1990.

[79] Volume 4, chapter 11, page 11.11

***Table 5-40: Total amounts of Nitrogen (t N/yr) added to managed soils. Activity data for direct $N_2O$ emissions***

| Sources | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|
| Synthetic Fertilizer | 158 500 | 145 815 | 170 009 | 102 663 | 100 249 | 117 906 | 103 171 | 68 041 | 86 694 | 95 422 |
| Organic Fertilizer (manure) | 61 042 | 57 570 | 56 544 | 46 453 | 42 908 | 40 908 | 48 174 | 48 617 | 48 119 | 47 843 |
| Pasture | 70 561 | 76 943 | 88 030 | 92 985 | 97 800 | 98 898 | 107 922 | 106 841 | 104 007 | 100 914 |
| Crop Residues | 52 286 | 45 918 | 43 941 | 39 751 | 36 374 | 43 796 | 38 998 | 35 350 | 33 654 | 35 136 |
| Other Organic Fertilizer (Sewage & Compost) | 319 | 319 | 263 | 366 | 491 | 1 648 | 1 963 | 1 275 | 1 445 | 1 879 |
| **Total** | **342 708** | **326 566** | **358 786** | **282 217** | **277 822** | **303 155** | **300 228** | **260 123** | **273 918** | **281 194** |
| *agriculture and forestry use | | | | | | | | | | |

For the last year of the inventory there are two source categories that represent the majority of nitrogen added to soil: synthetic fertilizers (52.9%) and organic fertilizers - manure (26.5%) as shown in the next figure.

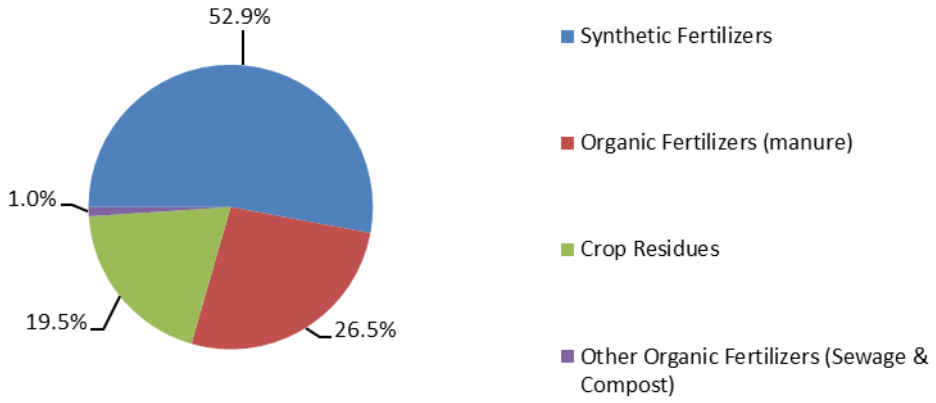



***Figure 5-22: Relevance of the sources of direct input of Nitrogen to agricultural soils in 2024***

#### 5.6.1.4.1 Synthetic Fertilizers

There are no available records of statistical information concerning the annual amount of nitrogen used to agricultural soils or even available statistical information concerning sales of inorganic N fertilizers. However, following the need to answer to other communitarian and international requests, such as the calculation of Agri-environmental Indicators "Nitrogen Balance" and "Fertilizer Consumption" for the EUROSTAT and OECD, the National Statistical Institute, in collaboration with the *Laboratório Químico Agrícola Rebelo da Silva*[80] and ADP[81], having found the same lack of available data, produced a methodology (INE,2004) that estimates the Apparent Consumption of Fertilizers in the Agriculture activity (ACFA) by a simple mass balance, from national production[82] and international market information data.

[80] Laboratório Químico Agrícola Rebelo da Silva is a public laboratory, under the Ministry of Agriculture, and proceeds to soil, plant and fertilizer analysis.Presently integrated in the National Institute for Agriculture and Veterinary Research (INIAV).
[81] ADP, Adubos de Portugal, S.A., is the main producer of fertilizers in Portugal, and responsible for about 75% of fertilizer sales (INE,2004)
[82] IAPI – Annual Survey of Industrial Production made by INE to the Manufacturing Industry.

The fertilizer consumption data reported by INE are obtained by the following methodology:

***Equation 5-12: Annual Consumption of inorganic N fertilizers***

$$\text{Consumption}_{(f)} = \text{Production}_{(f)} + \text{Import}_{(f)} - \text{Export}_{(f)}$$

**where:**

Consumption $_{(f)}$: annual consumption in Portugal of inorganic N fertilizer f (t N.yr$^{-1}$)

Production $_{(f)}$: annual production in industrial plants in Portugal of inorganic N fertilizer f (t N.yr$^{-1}$)

Import $_{(f)}$: annual imports in Portugal of inorganic N fertilizer f (t N.yr$^{-1}$)

Export $_{(f)}$: annual exports in Portugal of Nitrogen inorganic N fertilizer f (t N.yr$^{-1}$)

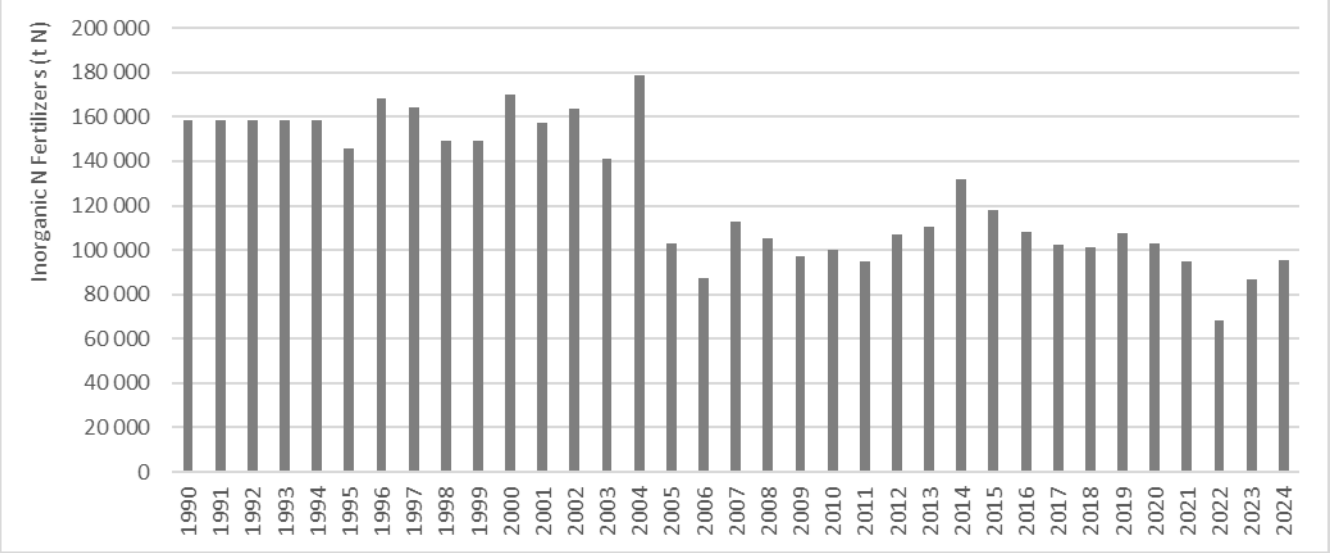
Two simplifications were made: (1) Only inorganic fertilizers were considered; (2) The effect of losses and stock variation was not accounted. According to INE (2004) these factors have no significant influence in the outcome. Another important note is that fertilizers use determined by INE includes fertilizers for agriculture and forestry use.

The ACFA time series data produced by INE are only available from 1995, not covering the inventory base year (1990). Given the fact that there is not a clear trend in the available time-series, the average amount of inorganic fertilizers in the period 1995-2002 (158 500 t N.yr$^{-1}$) was applied for all lacking years (1990-1994).

The available time series is presented in Figure 5-23. It shows a period until 2002 with a higher consumption of inorganic fertilizers and then a sharp decrease in 2003 closely linked with the significant change, at that time, of the direct support schemes under the common agricultural policy (Council Regulation (EC) nº 1782/2003). The annual fluctuations are due to the different climatic conditions occurring each year, which may constrain production management decisions, for example carrying out the sowing of some crops.

The sharp decrease in the application of inorganic N fertilizers in soils in 2022 is due to:

- Decreases in production resulting from drought.
- Increase of the prices of the means of production.




Source INE, 1995-2024; simple average value 1990-1994

***Figure 5-23: Use of inorganic N fertilizers (t N.yr$^{-1}$)***

In ANNEX C: Agriculture is also presented the annual amount of N inorganic fertilizer, disaggregated by type of N fertilizer, for the complete time series.

In Portugal, the total amount of N applied on rice fields is usually of 110 to 140 kg $N.ha^{-1}.yr^{-1}$ [83] depending on the soils. The N fertilizer application is done in two different periods as shown in Figure 5-15, chapter 5.4 of this report. The annual amount of N added on rice fields, calculated using an average of 125 kg $N.ha^{-1}.yr^{-1}$, is provided in Table 5-41.

***Table 5-41: Rice cultivation- Nitrogen amount applied on flooded rice fields (t N/yr)***

| | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Nitrogen amount applied on flooded rice fields** | 4 205 | 3 086 | 3 088 | 3 121 | 3 640 | 3 643 | 3 242 | 3 407 | 3 493 | 3 465 |

### 5.6.1.4.2 Animal Manure applied to soil

The fraction of manure handled in each manure management system considered in the Portuguese inventory is presented in Table 5-23.

The amount of managed manure nitrogen available for application to soil as fertilizer was estimated based on the equation 10.34[84] (IPCC 2006). In Table 5-43 are presented the final results of the estimates of the N manure from housing and storage systems that is available for application to managed soils. The use of manure for feed, fuel or construction purposes is not known in Portugal.

In the total N losses from manure management systems ($Frac_{LossMS}$) are considered the losses of N in form of $NH_3$, $NO_X$, $N_2O$ and $N_2$ that occur at housing and storage systems and the N loss through leaching from solid storage. The N input from organic bedding material (straw) was also considered for solid storage systems, based on the default values of table 3.7 of EMEP/EEA Guidebook 2023, chapter 3 B – Manure management, and are shown in Table 5-42.

***Table 5-42: Average amount of straw used in animal bedding-solid manure management systems and N content of straw***

| Animal type | Straw ($kg.hd^{-1}.yr^{-1}$) | N added in straw ($kg.hd^{-1}.yr^{-1}$) |
|---|---|---|
| **Dairy cattle** | 1 453.16 | 5.81 |
| **Non Dairy cattle** | 195.92 | 0.78 |
| **Sheep & goats** | 29.93 | 0.12 |
| **Sows** | 562.80 | 2.25 |
| **Other swine** | 191.80 | 0.77 |
| **Horses & asses** | 260.57 | 1.04 |

***Table 5-43: Estimates of manure management nitrogen available for application to soils (t $N.yr^{-1}$)***

| Year | N in manure managed | N from bedding material | N total losses | N available to be applied to soil as manure |
|---|---|---|---|---|
| **1990** | 89 615 | 1 612 | 30 185 | 61 042 |
| **1995** | 85 202 | 1 192 | 28 823 | 57 570 |
| **2000** | 85 303 | 808 | 29 567 | 56 544 |
| **2005** | 70 212 | 499 | 24 259 | 46 453 |
| **2010** | 65 422 | 315 | 22 828 | 42 908 |
| **2015** | 62 060 | 295 | 21 447 | 40 908 |
| **2020** | 75 188 | 299 | 27 313 | 48 174 |
| **2022** | 76 156 | 292 | 27 832 | 48 617 |
| **2023** | 75 458 | 286 | 27 625 | 48 119 |
| **2024** | 75 085 | 278 | 27 520 | 47 843 |

[83] PDM 2014, ponto 2.a) Sistema de Produção do arroz em Portugal – Práticas culturais
[84] Volume 4, chapter 10, page 10.65

### 5.6.1.4.3 Sewage sludge (Other organic fertilizers applied to soil)

The quantities of sewage sludge applied as soil amendment refer to data reported under the EU Directive 86/278/EEC on sewage sludge. Data for the latest years are considered to have a higher level of certainty and refer to data collected under national legislation[85] which establishes the use of sewage sludge on agricultural soils, transposing for the internal legal order the referred Directive. Data on the agriculture use of sludge under this legal provision is collected by the DRAPs (Regional Directorates for Agriculture and Fisheries) and are annually reported to the APA (Waste Department).

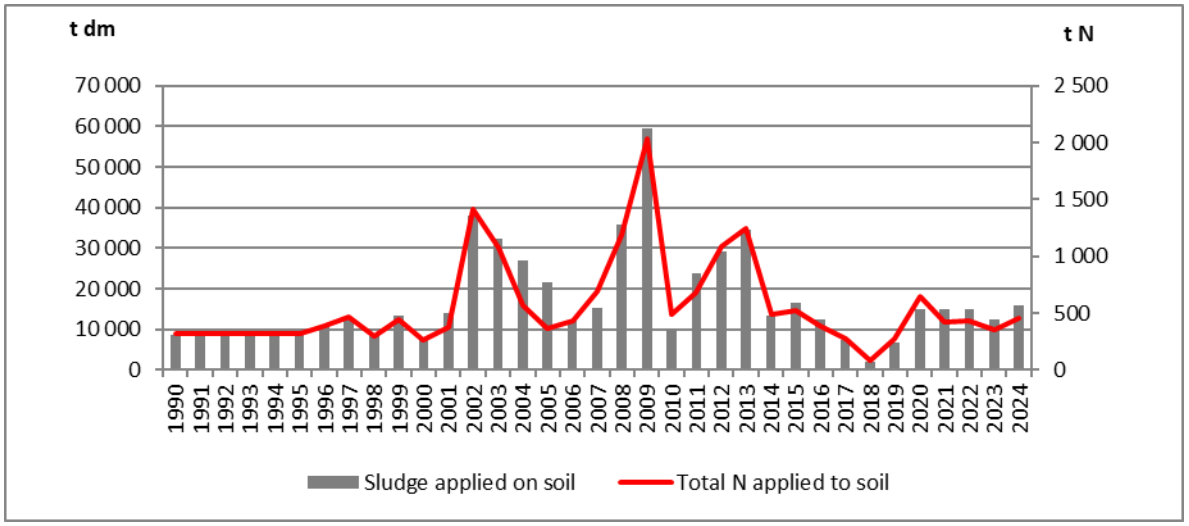



***Figure 5-24: Application of sewage sludge (t dm) and quantities of N (t N) in agriculture soils***

The estimated quantities of N applied in soils from sewage sludge were calculated on the basis of the data on concentrations of Total N reported.

***Table 5-44: Estimates of annual amounts of nitrogen sewage sludge in agriculture soils***

| Year | Sewage sludge applied (t dm) | N content (kg N.kg dm-1) | Total N (t N) |
|---|---|---|---|
| **1990** | 8 800 | 0.0363 | 319 |
| **1995** | 8 800 | 0.0363 | 319 |
| **2000** | 7 435 | 0.0354 | 263 |
| **2005** | 21 533 | 0.0170 | 366 |
| **2010** | 9 967 | 0.0493 | 491 |
| **2015** | 16 508 | 0.0318 | 525 |
| **2020** | 14 960 | 0.0431 | 645 |
| **2022** | 14 987 | 0.0287 | 429 |
| **2023** | 12 363 | 0.0287 | 354 |
| **2024** | 15 971 | 0.0287 | 458 |

[85] Decree-Law n.º 276/2009

#### *5.6.1.4.4 Compost from municipal solid waste* (Other organic fertilizers applied to soil)

The compost resulting from biological treatment of municipal solid waste (MSW) was only recognized as a fertilizer from June 2015[86]. The national legislation establishes quality standards and control measures including the monitoring of the compost applied to agricultural soils. These provisions are now applied under Decree-Law 30/2022 (repealing Decree Law 103/2015), which establishes the rules to be followed by the placing on the market of fertilizer materials, ensuring the fulfilment of the obligations arising from the Regulation (EC) 2003/2003 and Regulation (EU) 2019/1009. Therefore, the accounting of this type of N amendment begins in 2015 and emissions from this source category are estimate from that year onwards.

In 2024 a total amount of 71 092 t of MSW compost was applied to agricultural soils, which corresponds to the N amount application of 1422 t N.

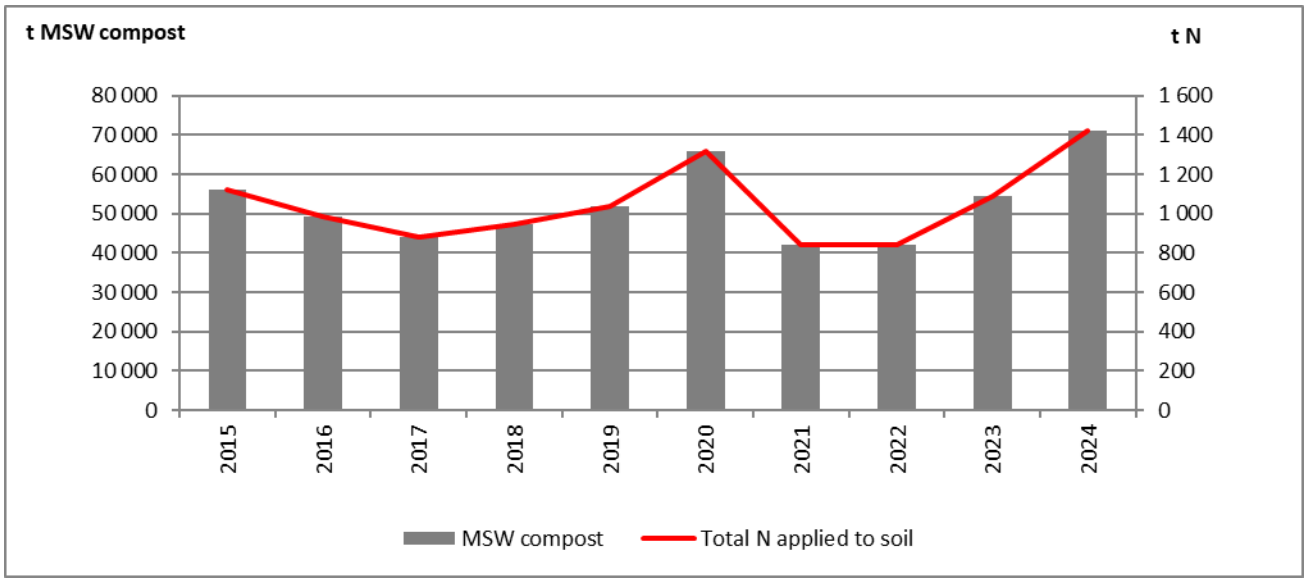



***Figure 5-25: Application of Municipal Solid Waste (MSW) compost (t) and quantities of N (t N) in agriculture soils***

##### 5.6.1.4.4.1 Category Specific recalculations

No recalculations were made.

#### 5.6.1.4.5 Urine and dung from grazing animals

Total amount of urine and dung N deposited on pasture by grazing animals was estimated with the same N excretion rates and disaggregated livestock population that were used to estimate $N_2O$ emissions from Manure Management (CRT 3Bb). The fraction of total annual N excretion deposited on pasture for each livestock species are presented in Table 5-23 of this report.

The results of the calculation using equation 11.5[87] of IPCC 2006 are presented in Table 5-40 and in the ANNEX C: Agriculture for the complete time series.

[86] Decree Law 103/2015, updated by Decree Law 9/2021
[87] Volume 4, chapter 11, page 11.13

#### 5.6.1.4.6 Crop residues returned to soil

The annual amount of N in crop residues (above and below ground) that returned to soils was estimated according to the equation 11.7A [88]of IPCC 2006. The regression equations of table 11.2[89] of IPCC 2006 were used for the major crops. Annual crop production (fresh) and area harvested, allowing the estimate of crop yield, was supplied by INE for the major crops.

Country specific data were used for the values of the fraction of crop that is harvested/removed from the fields ($Frac_{remove}$) and for the % of crop area with residues burnt *in situ* ($Area_{burnt}$), according to the INE information, based on data from the Agricultural General Census (RA09) which included a set of questions about some agricultural practices. On chapter 5.7 – Field Burning of Agriculture Residues, further details are given about crop residues burnt on field.

Whenever data for $Frac_{remove}$ are not available it was assumed no removal, according to IPCC 2006 recommendation.

Country specific data were also used for dry matter fraction ($dm_F$) of harvested crop[90] for some legumes and N content of above ground residues ($N_{AG}$) for cereals, potatoes and some legumes.[91] When national values are not available default values were used (table 11.2 IPCC 2006). In the same way, default values were used for the ratio of below ground residues to above ground biomass ($R_{BG-BIO}$) and for N content of below-ground residues ($N_{BG}$).

***Table 5-45: Parameters used to estimate nitrogen from crop residues to soil***

| Crop | $dm_F$ | $Frac_{Removed}$ | $N_{AG}$ (kg N.kg $dm^{-1}$) | $R_{BG-BIO}$ (ratio) | $N_{BG}$ (kg N.kg $dm^{-1}$) |
|---|---|---|---|---|---|
| **Wheat** | 0.89 | 0.67 [a)] | 0.0057 [a)] | 0.24 | 0.009 |
| **Triticale** | 0.88 | 0.67 [a)] | 0.0085 [a)] | 0.22 | 0.009 |
| **Maize grain** | 0.87 | 0.65 [a)] | 0.0095 [a)] | 0.22 | 0.007 |
| **Barley** | 0.89 | 0.67 [a)] | 0.0045 [a)] | 0.22 | 0.014 |
| **Rye** | 0.88 | 0.67 [a)] | 0.0085 [a)] | 0.22 | 0.011 |
| **Oats** | 0.89 | 0.67 [a)] | 0.0056 [a)] | 0.25 | 0.008 |
| **Rice** | 0.89 | year specific [c)] | 0.0088 [a)] | 0.16 | 0.009 |
| **Tobacco** | 0.88 | | 0.006 | 0.22 | 0.009 |
| **Sunflower** | 0.87 | | 0.0103 [a)] | 0.22 | 0.009 |
| **Potatoes** | 0.19 [a)] | | 0.0142 [a)] | 0.2 | 0.014 |
| **Other root crops** | 0.22 | | 0.019 | 0.2 | 0.014 |
| **Peas fresh** | 0.11 [a)] | | 0.1818 [a)] | 0.19 | 0.008 |
| **Beans fresh** | 0.10 [a)] | | 0.019 | 0.19 | 0.008 |
| **Dry beans** | 0.88 | | 0.1 | 0.19 | 0.008 |
| **Broad beans** | 0.89 [a)] | | 0.0337 [a)] | 0.19 | 0.008 |
| **Peanuts** | 0.94 | | 0.016 | 0.19 | 0.008 |
| **Other legumes** | 0.91 | | 0.008 | 0.19 | 0.008 |
| **Tomatoes** | 0.06 [a)] | | 0.019 | 0.2 | 0.009 |
| **Maize for forage** | 0.30 [a)] | 0.91 [b)] | 0.006 | 0.22 | 0.012 |
| **Cereals for forage** | 0.30 [a)] | 0.91 [b)] | 0.007 | 0.22 | 0.012 |
| **Other forage** | 0.9 | 0.91 [b)] | 0.027 | 0.4 | 0.019 |

a) Country specific; b) Jarrige (1988); c) description at chapter 5.5 – rice cultivation

[88] Volume 4, chapter 11, page 11.15
[89] Volume 4, chapter 11, page 11.17
[90] "In "Manual de Culturas Hortícolas", Volume I e II de Domingos Almeida
[91] CBPA -Código das Boas Práticas Agrícolas. Agriculture Good Practice Code concerning the protection of waters against pollution caused by nitrates from agricultural sources, approved by the Ministry of Agriculture-

The annual crop yield (fresh) is presented in Table 5-46. The final amounts of Nitrogen added to soil from crop residues returned to soil are shown in Table 5-40 and in the ANNEX C: Agriculture, for the complete time series.

***Table 5-46: Crop Yield Fresh (kg.ha$^{-1}$)***

| Crop | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|
| Wheat | 1 858 | 1 679 | 1 366 | 1 504 | 1 430 | 2 023 | 2 677 | 1 927 | 1 354 | 3 261 |
| Triticale | 1 478 | 1 388 | 1 295 | 1 262 | 1 057 | 1 693 | 1 635 | 1 151 | 656 | 1 955 |
| Maize grain | 3 083 | 4 375 | 5 793 | 5 293 | 6 929 | 8 452 | 9 345 | 9 620 | 10 177 | 9 477 |
| Barley | 1 430 | 1 464 | 1 345 | 1 675 | 1 514 | 2 097 | 3 147 | 2 250 | 1 847 | 3 850 |
| Rye | 1 020 | 815 | 965 | 914 | 859 | 856 | 1 195 | 950 | 852 | 983 |
| Oats | 911 | 902 | 1 092 | 1 064 | 1 071 | 1 212 | 1 261 | 919 | 693 | 1 574 |
| Rice | 4 665 | 5 787 | 5 940 | 5 747 | 5 845 | 6 345 | 5 119 | 5 707 | 6 400 | 6 210 |
| Hops | 1 851 | 1 176 | 1 152 | 1 333 | 1 278 | 2 091 | 1 500 | 800 | 15 | 700 |
| Tobacco | 2 235 | 2 606 | 2 795 | 2 955 | 3 343 | 2 262 | 0 | 0 | 0 | 0 |
| Tea | 664 | 663 | 2 733 | 3 321 | 2 946 | 4 243 | 2 730 | 3 243 | 3 622 | 4 568 |
| Sunflower | 639 | 313 | 486 | 473 | 544 | 1 242 | 1 592 | 1 658 | 1 959 | 2 187 |
| Potatoes | 11 671 | 14 644 | 14 831 | 16 000 | 15 034 | 19 771 | 23 371 | 22 041 | 22 453 | 21 719 |
| Sugar Beet | 48 901 | 45 007 | 58 009 | 72 990 | 26 082 | 57 610 | 0 | 0 | 0 | 0 |
| Yams | 9 700 | 9 095 | 14 782 | 16 028 | 16 551 | 20 022 | 16 691 | 16 484 | 17 039 | 16 986 |
| Sugar Cane | 75 207 | 80 000 | 80 000 | 81 250 | 85 000 | 51 302 | 55 276 | 57 902 | 57 161 | 57 548 |
| Peas fresh | 5 643 | 6 591 | 7 016 | 6 927 | 6 221 | 16 488 | 6 786 | 4 139 | 4 719 | 3 651 |
| Beans fresh | 7 781 | 9 472 | 10 013 | 12 741 | 15 344 | 16 979 | 13 416 | 13 169 | 14 028 | 11 724 |
| Dry beans | 524 | 541 | 512 | 446 | 582 | 567 | 703 | 522 | 402 | 489 |
| Broad beans | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Peanuts | 1 192 | 1 656 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Chick Peas | 560 | 693 | 520 | 518 | 563 | 854 | 986 | 824 | 649 | 903 |
| Lupins | 660 | 955 | 1 018 | 984 | 1 072 | 607 | 0 | 0 | 0 | 0 |
| Tomatoes | 46 169 | 56 378 | 69 746 | 78 137 | 83 096 | 92 714 | 93 020 | 84 792 | 98 210 | 90 861 |
| Maize for forage | 34 005 | 37 978 | 38 363 | 37 750 | 35 517 | 39 022 | 43 870 | 45 127 | 44 496 | 44 869 |
| Cereals for forage | 24 568 | 21 224 | 21 818 | 21 942 | 22 162 | 16 032 | 19 078 | 14 521 | 14 445 | 18 766 |
| Other forage | 11 800 | 9 593 | 9 779 | 9 752 | 9 563 | 21 880 | 22 973 | 20 525 | 19 070 | 21 506 |

### 5.6.1.5 Uncertainty Assessment

The IPCC 2006 presents no information concerning the uncertainty in activity data, and therefore, the values were set in the following mode:

- Synthetic Fertilizers: the uncertainty value was estimated by comparison of the data (N amount in fertilizers) of apparent consumption of N fertilizers produced by INE with the consumption data of N fertilizers produced by IFA. A maximum uncertainty of 22.9% was obtained.
- For nitrogen in animal manure applied to soil the uncertainty value of 54.0% was set based in the same uncertainty values that were used for activity data in $N_2O$ from Manure Management.
- An uncertainty error of 35.6% in crop residues production was considered in accordance with the range of errors of equation to estimate the above ground residue dry matter (table 11.2 IPCC 2006) for the most relevant crops contributing to N returned to soil.
- For urine and dung deposited on pasture by grazing animals the uncertainty value of 37.5% was set based in the same methodology used to determine uncertainty values in MMS used in the $N_2O$ direct emissions from manure management.

The uncertainties of emission factors $EF_1$ for N additions from mineral, organic and crop residues and $EF_3$ for urine and dung deposited on pasture by grazing animals were determined from the possible range of errors of the default values. The calculated uncertainty values are: $EF_1$ 135.0% and $EF_3$ 133.2%.

### 5.6.2 Indirect $N_2O$ Emissions from Managed Soils

#### 5.6.2.1 Category description

In addition to direct $N_2O$ emissions from managed soils, emissions of $N_2O$ also occur through two indirect pathways: via volatilization in form of $NH_3$ and $NO_x$ and via N lost from leaching and runoff.

Some of the N added to soils from synthetic and organic fertilizers and from urine and dung deposited by grazing animals is volatilized as $NH_3$ and $NO_x$. A fraction of the N volatilized returns to the ground and is then re-emitted as $N_2O$. In the same way, a fraction of the N added to soil, crop residues included, is lost through leaching and runoff and indirectly becomes $N_2O$.

Share of indirect $N_2O$ emissions from managed soils, by pathway and by source, is shown in the next two figures for 2024.

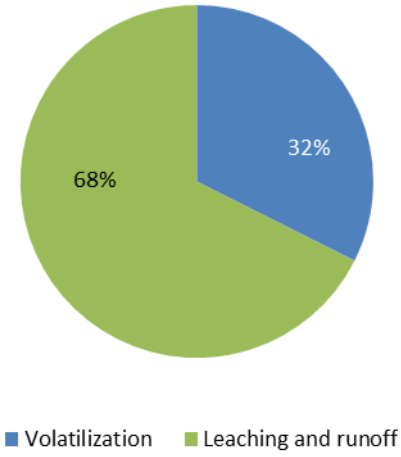



***Figure 5-26: Share of indirect $N_2O$ emissions from managed soils by pathway: volatilization and leaching/runoff, 2024***

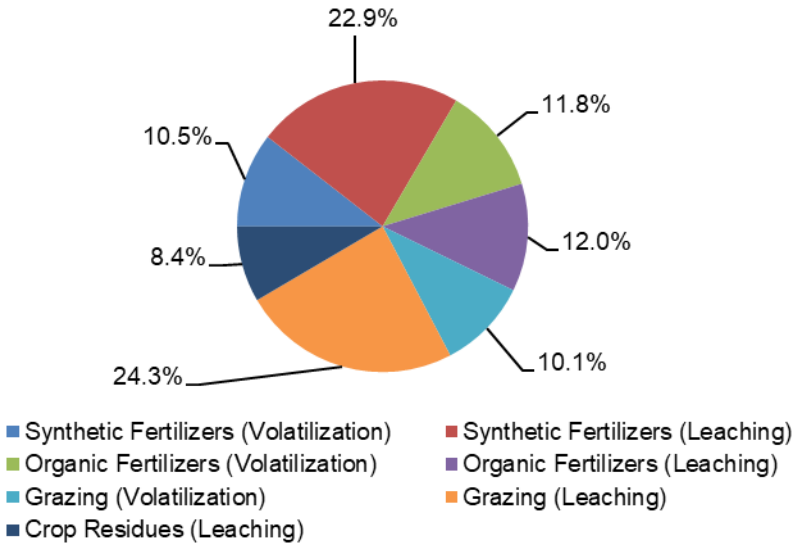



***Figure 5-27: Share of indirect $N_2O$ emissions from managed soils by source, 2024***

### 5.6.2.2 Methodological issues

***Volatilization/atmospheric deposition***

Indirect $N_2O$ emissions due to volatilization/atmospheric deposition of N added to soils were estimated based on equation 11.9[92] of IPCC 2006.

***Equation 5-13: $N_2O$ from atmospheric deposition of N volatilized from managed soils***

$$N_2O_{(ATD)} = [(F_{SN}*Frac_{GASF})+(F_{ON}+F_{PRP})*Frac_{GASM})]*EF_4*44/28$$

**where:**

$N_2O_{(ATD)}$: $N_2O$ emissions from atmospheric deposition of N volatilized from managed soils, kg $N_2O.yr^{-1}$

$F_{SN}$: annual amount of N synthetic fertilizers applied to soils, kg $N.yr^{-1}$

$F_{ON}$: annual amount of organic fertilizers (manure + sewage sludge + $compost_{MSW}$) applied to soils, kg $N.yr^{-1}$

$F_{PRP}$: annual amount of N from urine and dung deposited by grazing animals on pasture, kg $N.yr^{-1}$

$Frac_{GASF}$: fraction of N from synthetic fertilizers that volatilizes as $NH_3$ and $NO_x$, kg $N.yr^{-1}$

$Frac_{GASM}$: fraction of N from organic fertilizers (manure + sewage sludge + $compost_{MSW}$) and from urine and dung deposited by grazing animals on pasture that volatilizes as $NH_3$ and $NO_x$, kg $N.yr^{-1}$

$EF_4$: emission factor for $N_2O$ emissions from atmospheric deposition of N on soils, kg $N_2O$-N.(kg $NH_3$-N + $NO_x$-N volatilized)$^{-1}$

44/28: conversion of $N_2O$-N emissions to $N_2O$ emissions

The collection of activity data for $F_{SN}$, $F_{ON}$ and $F_{PRP}$ is described under chapter 5.6.1 - Direct N2O Emissions from Managed Soils.

For all source categories within managed soils, the methodologies used to estimate the annual amounts of N that volatilized in form of $NH_3$ and $NO_x$ are estimated using the methodologies described, for each one, in EMEP/EEA Guidebook 2023, in consistency with UNECE/CLRTAP emissions inventory.

The amount of N from synthetic fertilizers application that volatilized as $NH_3$ was estimated using the tier 2 approach[93], which provides different emissions factors[94] by type of fertilizer and emission region (combination of the soil pH and the climate zone as defined in IPCC 2006).

The amount of N from synthetic fertilizers application that volatilized as $NO_x$ was estimated using a tier 1 methodology[95] (no tier 2 available).

The amount of N from manure application and from urine and dung deposited on soil by grazing animals that volatilized as $NH_3$ and $NO_X$ was estimated using the tier 2 methodology[96] (N_flow approach) as recommended by IPCC 2006[97].

[92] Volume 4, chapter, page 11.21
[93] Chapter 3D-Agricultural soils, page 16 of EMEP/EEA Guidebook 2023
[94] Table 3-2 of Chapter 3D – Agricultural soils, page 17 of EMEP/EEA Guidebook 2023.
[95] Chapter 3D – Agricultural soils, page 21 of EMEP/EEA Guidebook 2023.
[96] Chapter 3B – Manure management, page 20 of EMEP/EEA Guidebook 2023.
[97] Page 10.61, Emission factors for indirect $N_2O$ emissions from manure management, chapter 10, Volume 4

The amount of N from sewage sludge and compost additions on soils that volatilized as $NH_3$ and $NO_x$ was estimated using a tier 1 methodology.[98]

In Table 5-47 are presented the estimated annual amounts of N, expressed in tonnes, volatilized as $NH_3$ and $NO_x$, disaggregated by source input.

***Table 5-47: Annual N amounts (t) that volatilized as $NH_3$ and NOx, disaggregated by source input***

| Year | Synthetic Fertilizers | Animal Manure | Grazing Animals | Other Organic Additions |
|---|---|---|---|---|
| **1990** | 14 174 | 12 585 | 6 013 | 38 |
| **1995** | 12 869 | 12 222 | 6 666 | 38 |
| **2000** | 15 886 | 12 376 | 7 753 | 31 |
| **2005** | 9 449 | 10 429 | 8 422 | 44 |
| **2010** | 8 414 | 9 774 | 9 131 | 59 |
| **2015** | 12 179 | 9 405 | 9 227 | 150 |
| **2020** | 9 242 | 10 873 | 10 043 | 180 |
| **2022** | 5 916 | 10 919 | 9 949 | 117 |
| **2023** | 8 182 | 10 781 | 9 697 | 127 |
| **2024** | 9 836 | 10 697 | 9 424 | 166 |

In Table 5-48 are presented the annual calculated values of $Frac_{GASF}$ and $Frac_{GASM}$ according to report requirements (CRT 3 D – Additional information).

***Table 5-48: $Frac_{GASF}$ and $Frac_{GASM}$ annual values***

| Year | $Frac_{GASF}$ | $Frac_{GASM}$ |
|---|---|---|
| **1990** | 0.089 | 0.141 |
| **1995** | 0.088 | 0.140 |
| **2000** | 0.093 | 0.139 |
| **2005** | 0.092 | 0.135 |
| **2010** | 0.084 | 0.134 |
| **2015** | 0.103 | 0.133 |
| **2020** | 0.090 | 0.133 |
| **2021** | 0.093 | 0.134 |
| **2022** | 0.087 | 0.134 |
| **2023** | 0.094 | 0.134 |
| **2024** | 0.103 | 0.135 |

The annual variation of $Frac_{GASF}$ is mostly related with the amount and type of N synthetic fertilizers consumption in each year. In ANNEX C: Agriculture is presented, for the time series, the annual amounts of N synthetic fertilizers used by type of fertilizer.

The annual variation of $Frac_{GASM}$ is associated with the livestock population in each year and the proportion of manure managed (housing and storage) and manure not managed (urine and dung deposited on soils). In $Frac_{GASM}$ is also included other organic amendments to the soil.

For both cases, $Frac_{GASF}$ and $Frac_{GASM,}$ the calculated values are within the range of possible values, table 11.3[99] of IPCC 2006.

[98] Chapter 3D – Agricultural soils, page 15 of EMEP/EEA Guidebook 2023.
[99] Volume 4, chapter 11, page 11.24

***Leaching and runoff***

Indirect $N_2O$ emissions from leaching and runoff originate from applied N from synthetic fertilizer ($F_{SN}$), organic N amendments ($F_{ON}$), N excreta deposited by grazing animals ($F_{PRP}$) and N from above and below ground crop residues ($F_{CR}$) were estimated based on equation 11.10[100], IPCC 2006.

***Equation 5-14: $N_2O$ emissions from leaching/runoff from managed soils***

$$N_2O_{(L)} = (F_{SN}+F_{ON}+F_{PRP}+F_{CR})*Frac_{LEACH})]*EF_5*44/28$$

**where:**

$N_2O_{(L)}$: $N_2O$ emissions produced from leaching and runoff of N additions to managed soils, kg $N_2O.yr^{-1}$

$F_{SN}+F_{ON}+F_{PRP}+F_{CR}$: defined above, kg $N.yr^{-1}$

$Frac_{LEACH}$: fraction of all N added to soils that is lost through leaching and runoff, kg N.kg N $added^{-1}$

$EF_5$: emission factor for $N_2O$ emissions from leaching and runoff, kg $N_2O$- N. kg N leached and $runoff^{-1}$

44/28: conversion of $N_2O$-N emissions to $N_2O$ emissions

The collection of activity data for $F_{SN}$, $F_{ON}$, $F_{PRP}$ and $F_{CR}$ is described under chapter 5.6.1 - Direct $N_2O$ emissions from managed soils.

The value used for $Frac_{LEACH}$ is the default value of 0.30 kg N. kg N $additions^{-1}$ or deposition by grazing animals proposed in table 11.3 of IPCC 2006.

N losses through runoff and leaching occurs not only during the rainy season because of rainfall but also during the irrigation season because of irrigated systems and practices. In Portugal the rainy season (October to March) is the period when the autumn/winter crops, such as wheat, barley, rye, triticale, potatoes and some legumes, are sowed and grown and the irrigation season (April to September) is the period when the spring/summer crops, such as maize, rice, tomato and other legumes, are cultivated and need to be irrigated because in normal weather conditions there is no rain during this period. Permanents crop, such as pastures, vineyards, olive groves and orchards are subjected to different agricultural practices along the two seasons. The water holding capacity of agriculture soils (where crops are grown) is exceeded because of both rainfall during the rainy season (autumn/winter crops) and irrigation practices associated with spring/summer crops. Hence, the same estimate of the fraction of N lost through leaching and runoff is used for agricultural soils across the entire territory.

The national river basins[101] management plans (aggregated in eight hydrographic regions[102] in the continental territory, and one hydrographic region in each of the archipelagos of Azores and Madeira) were recently approved[103]. They include estimates of N losses to the water bodies through runoff/leaching of the total N inputs resulting from all the agricultural activities, at the order of 17-17.5% for water surface and 12-12.4% for groundwater bodies. These means that for every unit of N applied to the soil or deposited by grazing animals, 29-29.9% is lost to the water bodies through runoff and leaching, which is very close to the default value kept for inventory calculations.

[100] Volume 4, chapter 11, page 11.21

[101] http://snirh.pt/snirh/_atlasagua/galeria/mapasweb/pt/aa1002.pdf, continental territory; http://servicos-sraa.azores.gov.pt/grastore/DRA/PGRHA_20162021/PGRH-A_2016-2021_RT_Parte2.pdf, archipelago of Açores; http://www.madeira.gov.pt//Portals/12/Documentos/Ambiente/RecHidricos/PGRH/PGRH10_Parte%202%20-%20Caraterizacao%20e%20Diagnostico.pdf, archipelago of Madeira.

[102] https://www.apambiente.pt/index.php?ref=16&subref=7&sub2ref=9&sub3ref=848

[103] September 2016, continental river basins plans; December 2016, Madeira river basins plans and February 2017 Açores river basins plans.

#### 5.6.2.3 Emission Factors

The emission factors used are shown in Table 5-49 and correspond to the default values of table 11.3 of IPCC 2006.

***Table 5-49: Emission factor used for calculation of indirect $N_2O$ emissions from managed soils***

| Emission Factor | Value |
|---|---|
| $EF_4$ | 0.010 Kg $N_2O$-N.kg $(NH_3\text{-}N+NO_X\text{-}N)^{-1}$ |
| $EF_5$ | 0.0075 Kg $N_2O$-N. kg N leaching/runoff$^{-1}$ |

#### 5.6.2.4 Activity Data

The collection of activity data for $F_{SN,}$ $F_{ON}$, $F_{PRP}$ and $F_{CR}$ is described under chapter 5.6.1 - Direct $N_2O$ emissions from Managed Soils, and the annual N amounts added to soil, by source, are summarized in Table 5-40 and in the ANNEX C: Agriculture for the complete time series.

#### 5.6.2.5 Uncertainty Assessment

Uncertainties in estimates of indirect $N_2O$ emissions from managed soils are the result of combined uncertainties related to the fractions of N volatilized from mineral fertilizers applications ($Frac_{GASF}$), from organic fertilizers amendments and urine and dung deposited on pasture ($Frac_{GASM}$), and to the fraction o N lost by leaching/runoff ($Frac_{Leach}$) and the uncertainties related with the emission factors $EF_4$ (volatilization and re-deposition) and $EF_5$ (leaching and run off).

The individual uncertainty values are presented in Table 5-50.

***Table 5-50: Uncertainty values (%) of the fractions of N volatilized and N leached/runoff and of the emission factors***

| $Frac_{GASF}$ | $Frac_{GASM}$ | $Frac_{Leach}$ | $EF_4$ | $EF_5$ |
|---|---|---|---|---|
| 135 | 112.5 | 116.7 | 135 | 163.3 |

### 5.6.3 Category specific QA/QC and verification

The QA/QC procedures applied in this source category comprehend a comparison between inventory data produced by National Statistical Authority (INE) and the databases of FAO and of IFA[104] (https://www.ifastat.org/databases/plant-nutrition) for the period 2002 – 2023. For previous years (1990-2001) FAO database archive has no data registers. In both databases (FAO and IFA) 2023 is the last year available. Comparison results are shown in the next figure.

[104] International Fertilizers Association

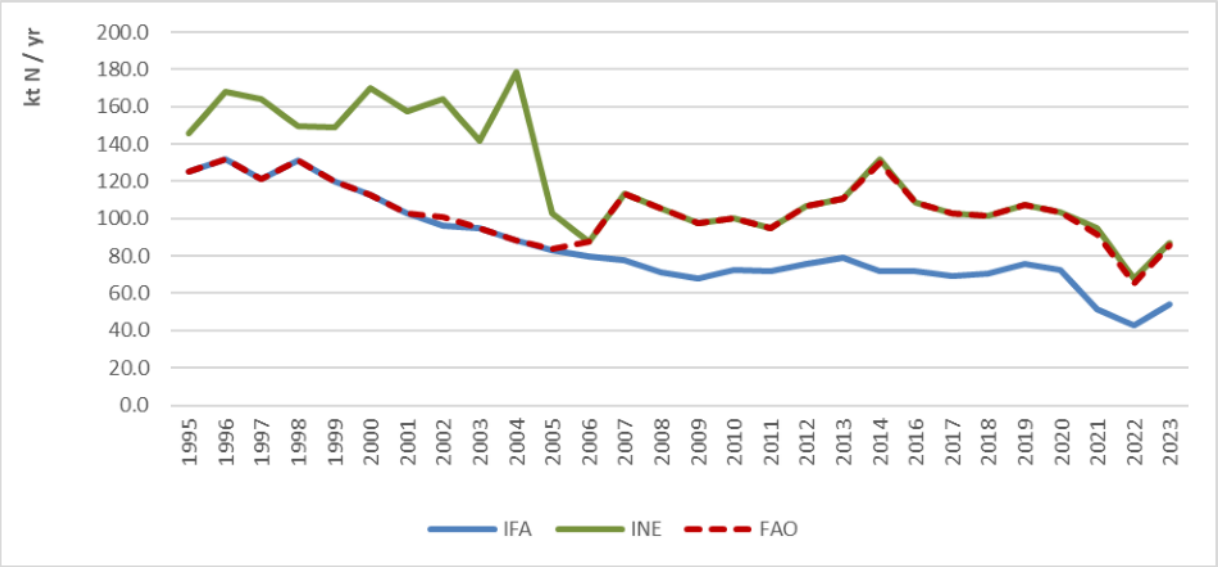



***Figure 5-28: Databases comparison of inorganic N fertilizers (t N.yr$^{-1}$)***

FAO and INE series agree quite well from 2006 onwards. IFA data are lower than INE ones because IFA consumption statistics follow the IFA definition "*relate, to the extent possible, to real consumption*" and not the apparent consumption concept. The restriction access to detailed information about the construction of IFA data set prevented a further understanding of these statistics, namely how "*real consumption*" were produced, for instance if consumption in forestry areas is accounted. We decided to keep INE statistics on apparent consumption to estimate emissions from synthetic fertilizers in a conservative approach.

Nevertheless, we underline that both series trends show a decrease in fertilizer consumption when comparing with base year, 1990.

The QA/QC procedures also included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

### 5.6.4 Category specific recalculations

Minor recalculations occurred due to the update of 2023-2024 CAN activity data.

### 5.6.5 Category specific planned improvements

As referred in the sources categories related with manure management (CRT 3.B.a and CRT 3.B.b) it is planned to continue the improvement of the characterization of the manure management systems framed by the new national law[105] related with livestock farming. Further efforts will be done to obtain more detailed information exploring new sources of information. It is likely that the possible outcome will also have impact in the $N_2O$ emissions from manure applied to soil and from urine and dung deposited on pasture, range and paddock by grazing animals.

[105] Decree-Law nº 81/2013

## 5.7 Field Burning of Agriculture Residues (CRT 3.F and CRT 5.C.2)

In Table 5-51 are presented the estimates emissions from field burning of agriculture residues.

***Table 5-51: $CH_4$ and $N_2O$ emissions estimates from field burning of agriculture residues (kt)***

| Gas/Source | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CH4** | **1.71** | **1.57** | **1.47** | **1.36** | **1.28** | **1.29** | **1.28** | **1.32** | **1.34** | **1.33** |
| Wheat | 0.02 | 0.02 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Barley | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Maize | 0.02 | 0.02 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| Rice | 0.31 | 0.26 | 0.23 | 0.23 | 0.26 | 0.25 | 0.19 | 0.22 | 0.24 | 0.23 |
| Other cereals | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Perennial woody crops | 1.35 | 1.26 | 1.19 | 1.10 | 0.99 | 1.01 | 1.06 | 1.07 | 1.08 | 1.07 |
| **N2O** | **0.08** | **0.08** | **0.07** | **0.07** | **0.06** | **0.06** | **0.06** | **0.07** | **0.07** | **0.07** |
| Wheat | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Barley | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Maize | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Rice | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Other cereals | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Perennial woody crops | 0.07 | 0.07 | 0.07 | 0.06 | 0.05 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |
| Note: Totals may not sum due to independent rounding | | | | | | | | | | |

### 5.7.1 Category description

In-site burning of agricultural or forest residues is still practiced nowadays in Portugal, being however restricted by the National System for the Defence of the Forest against Fires[106]: is forbidden when the level of danger of rural fire is «very high» or «maximum» and, when the level of rural fire danger is below, may be authorized by the competent authorities. These burning, result in emissions of trace gases as in other combustion processes, including methane, nitrous oxide, carbon monoxide and volatile organic compounds. Carbon dioxide is of course also emitted in this process, but because it has biomass origin and it is in principle re-absorbed during next growing season, it is not considered in GHG emissions inventory.

The burning of agricultural residues occurs with the straw of cereals and with the material of pruning permanent crops such as vineyards, olive groves and other orchards. Considering equivalent carbon dioxide emissions (Figure 5-29), burning of residues from vineyards is the most significant source of this non-key source.

Emissions from field burning of agriculture residues of cereals are reported in CRT 3F.

Emissions from field burning of agriculture residues of perennial crops (orchards, vineyards, and olive groves) are reported in CRT 5C2.

[106] Decree-Law 82/2021, of October 13, in is updated version

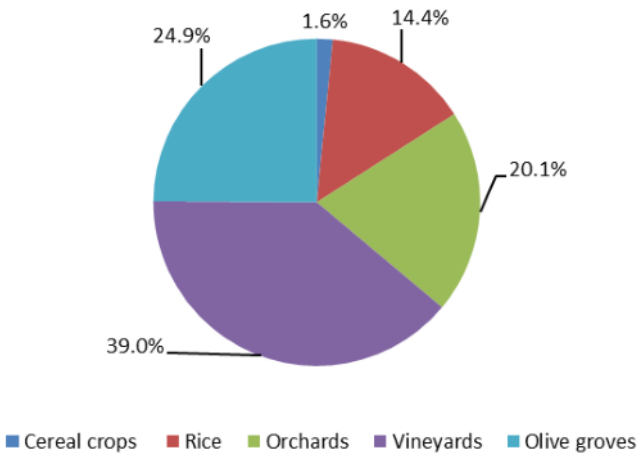



***Figure 5-29: Share of GHG emissions from field burning agriculture residues, by crop, 2024***

### 5.7.2 Methodological issues

Emissions of in-site burning of agriculture residues were estimated based on equation 2.27[107] from the IPCC 2006 which is summarized in the following equation:

***Equation 5-15: Estimation of GHG emissions from field burning of crop residues***

$$Emission_{(p,crop)} = A_{(crop)} * M_{B(crop)} * C_f * EF_{(p,crop)} * 10^{-3}$$

**where:**

$Emission_{(p,crop)}$ : emission estimates of pollutant p from field burning of residues from a specific crop, $t.yr^{-1}$

$A_{(crop)}$: correspond to the crop area where the practice of field burning residues occurs, $ha.yr^{-1}$

$C_f$: combustion factor, dimensionless

$M_{B(crop)}$: biomass of a specific crop that is available for combustion, $t\ dm.ha^{-1}.yr^{-1}$

$EF_{(p,crop)}$: emission factor from field burning of agriculture residues of a specific crop, $g.kg\ dm\ burnt^{-1}$

### 5.7.3 Emission Factors

The emission factors used to estimate, $CH_4$, $N_2O$, CO, NMVOC and $NO_X$ emissions from field burning agriculture residues are the default values from IPCC 2006 (table 2.5[108]) and from EMEP/EEA Guidebook 2023 (chapter 3F). They are presented in Table 5-52 with source indication by crop and pollutant.

[107] Volume 4, chapter 2, pag. 2.42
[108] Volume 4, chapter 2, pag. 2.47

*Table 5-52: Emission factors for field burning agriculture residues, g. kg dm burnt$^{-1}$*

| Crop | $CH_4$ | $N_2O$ | NOx | NMVOC | CO |
|---|---|---|---|---|---|
| **Wheat** | 2.7[a)] | 0.07[a)] | 2.3[c)] | 0.5[c)] | 66.7[c)] |
| **Barley** | 2.7[a)] | 0.07[a)] | 2.7[c)] | 11.7[c)] | 98.7[c)] |
| **Maize** | 2.7[a)] | 0.07[a)] | 1.8[c)] | 4.5[c)] | 38.8[c)] |
| **Rice** | 2.7[a)] | 0.07[a)] | 2.4[c)] | 6.3[c)] | 58.9[c)] |
| **Other cereals** | 2.7[a)] | 0.07[a)] | 2.3[b)] | 0.5[b)] | 66.7[b)] |
| **Orchards** | 4.7[a)] | 0.26[a)] | 3.0[a)] | 0.7[d)] | 107.0[a)] |
| **Vineyards** | 4.7[a)] | 0.26[a)] | 3.0[a)] | 0.6[d)] | 107.0[a)] |
| **Olive grove** | 4.7[a)] | 0.26[a)] | 3.0[a)] | 1.4[d)] | 107.0[a)] |

a) Table 2.5 of IPCC guidelines 2006; b) Table 3-1 of EMEP/EEA guidebook 2023; chapter 3F; c) Wheat, barley, maize and rice values from tables 3-3, 3-4, 3-5 and 3-6 of EMEP/EEA guidebook 2023; chapter 3F; d) Table 2.5-5 AP-42 USEPA

### 5.7.4 Activity Data

For cereals, other than rice, the practice of straw burning occurs in about 1% of the cultivated area according to the INE information based on General Agricultural Census (RA09) which included a set of questions about some agricultural practice.

In chapter 5.4 - CH4 Emissions from Rice Cultivation (CRT 3.C), has already been described the relevant rice cultivation practices in Portugal, including the burning of rice residues on field. The major fraction of rice stubbles and straw are burnt on fields except in the rice producing areas inside Natura 2000 where that practice is forbidden for reasons of conservation of natural habitats and animal species. The evolution of rice cultivation areas where the practice of burning residues is not allowed is shown in Figure 5-13 in chapter 5.4 - CH4 Emissions from Rice Cultivation (CRT 3.C).

Each year the orchards, vineyards and olive groves are pruned and much of the resulting material of this action is burned in situ. This practice occurs in 22% of the orchards area, 52% of the vineyard areas and 65% of olive grove areas, according to the information collected in the General Agricultural Census (RA09).

The amount of biomass available for combustion for cereal crops (rice included) was estimated based on the same methodology used to estimate crop residues production, i.e., the regression equations in table 11.2[109] of IPCC 2006, in consistence with calculations to estimate the amount of crop residues that returned to soil dealt on the chapter 5.6 - N2O Emissions from Managed Soils (CRT 3.D) of this report.

The amounts of pruning material produced for each of the permanent crops are country specific[110] values presented in Table 5-53.

Activity data and parameters used to estimate emissions from cereal and permanent crops residues burnt on field are summarized in Table 5-53 for 2024. Combustion factors used for cereals are the default values from Table 2.6 of IPCC 2006[111]. For pruning material from permanent crops, the combustion factor considered was made equal to 1, following the recommendation of the EMEP/EEA Guidebook 2023[112].

[109] Volume 4. chapter 11, page 11.17
[110] Dias, J.J. Mestre (2002), "Utilização da biomassa: avaliação dos resíduos e utilização de pellets em caldeiras domésticas".
[111] Volume 4, chapter 2, page 2.49
[112] Chapter 3F, page 6

*Table 5-53: Activity data and parameters used to estimate emissions from field burning of crop residues, 2024*

| Crop | Area burnt* (kha) | Biomass available for combustion (t dm.ha-1) | Combustion Factor |
|---|---|---|---|
| **Wheat** | 0.2 | 4.9 | 0.9 |
| **Barley** | 0.1 | 3.9 | 0.9 |
| **Maize** | 0.9 | 9.1 | 0.8 |
| **Rice** | 14.0 | 7.7 | 0.8 |
| **Other cereals** | 0.6 | 2.2 | 0.9 |
| **Orchards** | 33.7 | 1.6 | 1.0 |
| **Vineyards** | 89.2 | 1.2 | 1.0 |
| **Olive grove** | 247.5 | 0.3 | 1.0 |
| *Area where the on field burning practice of crop residues occurs | | | |

In the next Figure is shown the annual biomass burnt from 1990 onwards.

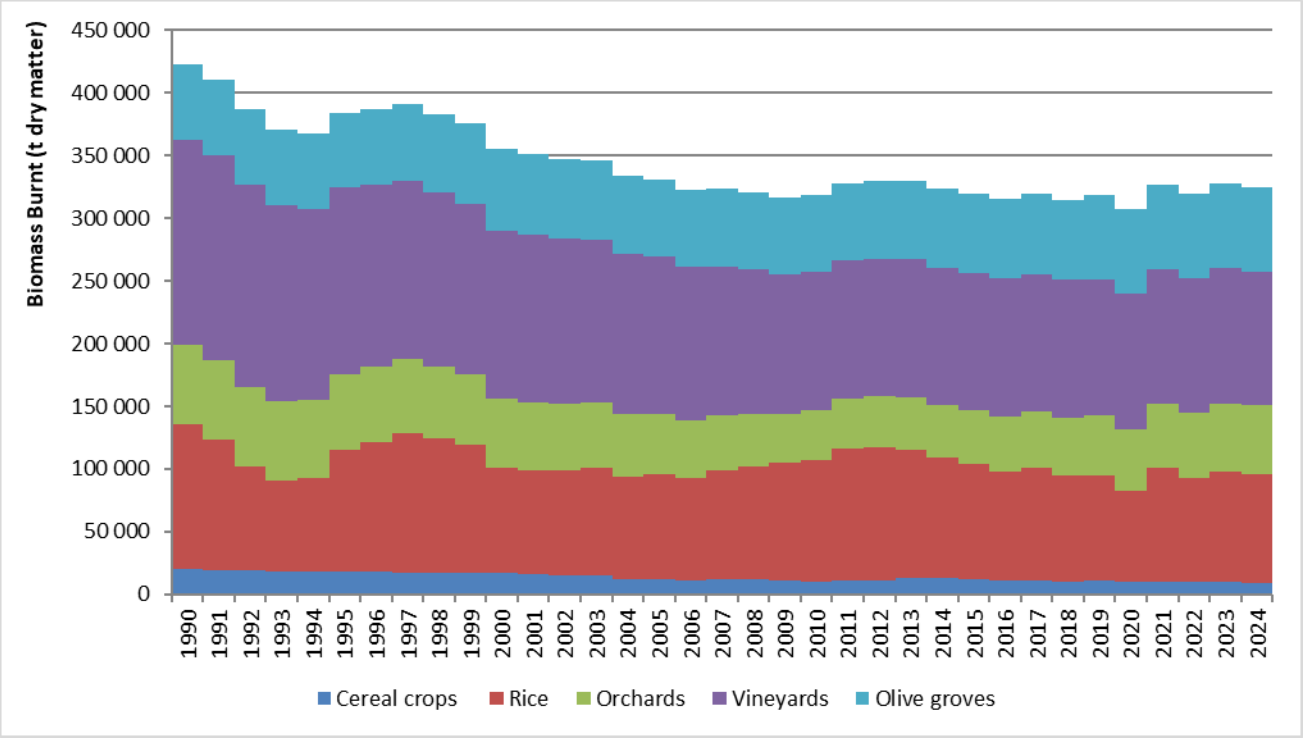



*Figure 5-30: Annual biomass burnt (t dm .yr$^{-1}$) for the time series*

### 5.7.5 Uncertainty Assessment

The uncertainty in activity data was obtained from the combined uncertainties related with the areas where on field burning practice occurs and with the crop biomass available for combustion. The individual uncertainties and the final value for activity data uncertainty is presented in Table 5-54.

*Table 5-54: Uncertainty values (in %) of the activity data for on field burning crop residues*

| Crop | Area burnt | Biomass available | Activity Data |
|---|---|---|---|
| **Cereals** | 25 | 35.7 | 43. 6 |
| **Perennial Woody crops*** | 25 | 25 | 35.4 |
| *Pruning material | | | |

The uncertainty of the emission factors was calculated considering the uncertainties ranges in IPCC 2006 and are presented in Table 5-55.

***Table 5-55: Uncertainty values (in %) of the emission factors, $CH_4$ and $N_2O$, for on field burning crop residues***

| Crop | EF $CH_4$ | EF $N_2O$ |
|---|---|---|
| **Cereals** | 39.1 | 47.6 |
| **Perennial Woody crops*** | 40.4 | 26.9 |
| *Pruning material | | |

### 5.7.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification, and the information provided in this report.

### 5.7.7 Category specific recalculations

No recalculations were made.

### 5.7.8 Category specific planned improvements

No specific improvements are planned.

## 5.8 $CO_2$ Emissions from Liming (CRT 3.G)

### 5.8.1 Category description

Liming of soils in agricultural and forest land is considered a minor practice in Portugal and information on the application of lime in soils is scarce. Prior to the 2015 submission, emissions from lime and dolomite were reported under LULUCF chapter.

In 2024, emissions from liming were estimated in 13.49 kt $CO_2$, corresponding to an increase of 106.8% compared to 1990 emissions (6.5 kt $CO_2$).

### 5.8.2 Methodological issues

Emissions associated with liming were estimated using a Tier 1 method (equation 11.12[113], IPCC 2006).

### 5.8.3 Emission Factors

It was used the default emission factors for carbon conversion of 0.12 for limestone ($CaCO_3$), 0.13 for dolomite ($MgCO_3$) and 0.143 for $CaMg(CO_3)_2$, which are equivalent to carbonate carbon contents of the materials (12% for $CaCO_3$, 13% for$MgCO_3$ and 14.3% for $CaMg(CO_3)_2$).

### 5.8.4 Activity Data

The amount of carbonate containing lime applied annually to soils in the country was estimated based on the information collected directly from the national producing limestone and dolomite for agricultural use. It was obtained information both on carbonate containing lime production, imports, exports and on the constitution of each carbonate containing lime applied to soils in Portugal.

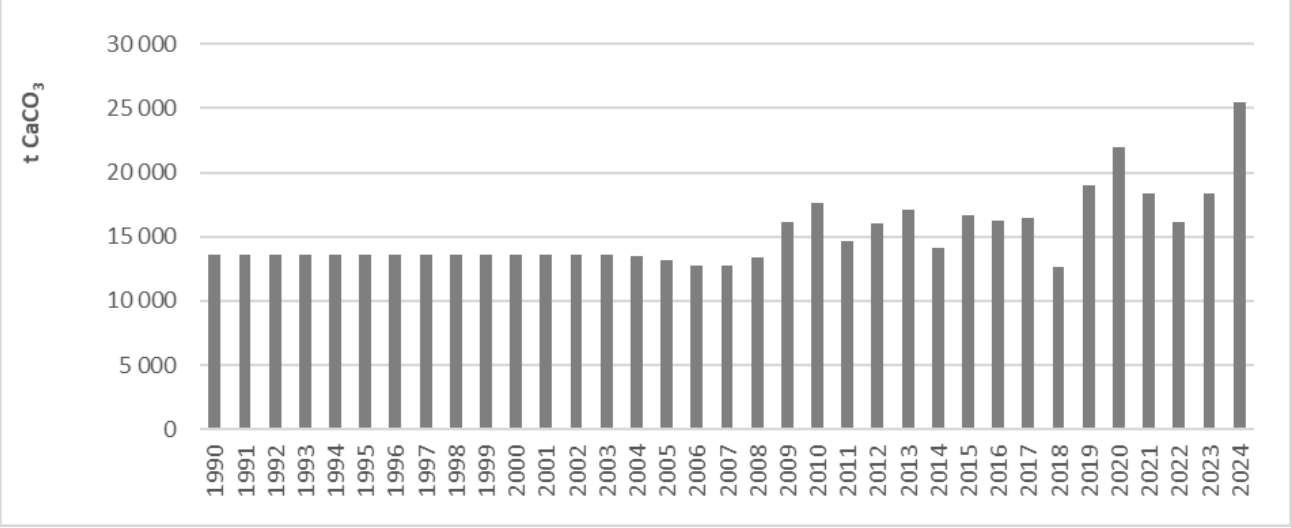



***Figure 5-31: $CaCO_3$ used on agriculture land ($t.yr^{-1}$)***

[113] Volume 4, chapter 11, page 11.27

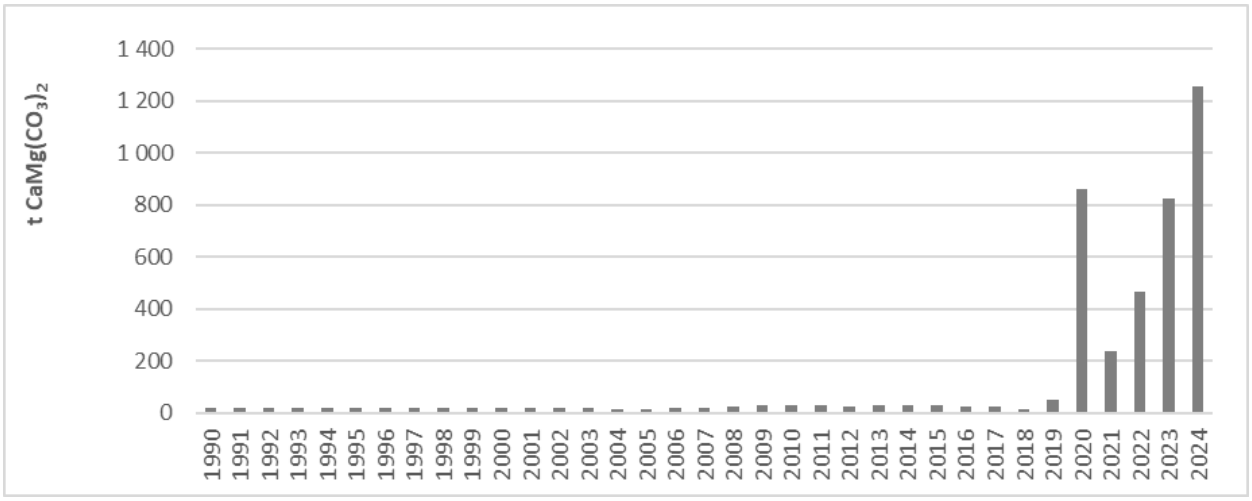



***Figure 5-32: $CaMg(CO_3)_2$ used on agriculture land ($t.yr^{-1}$)***

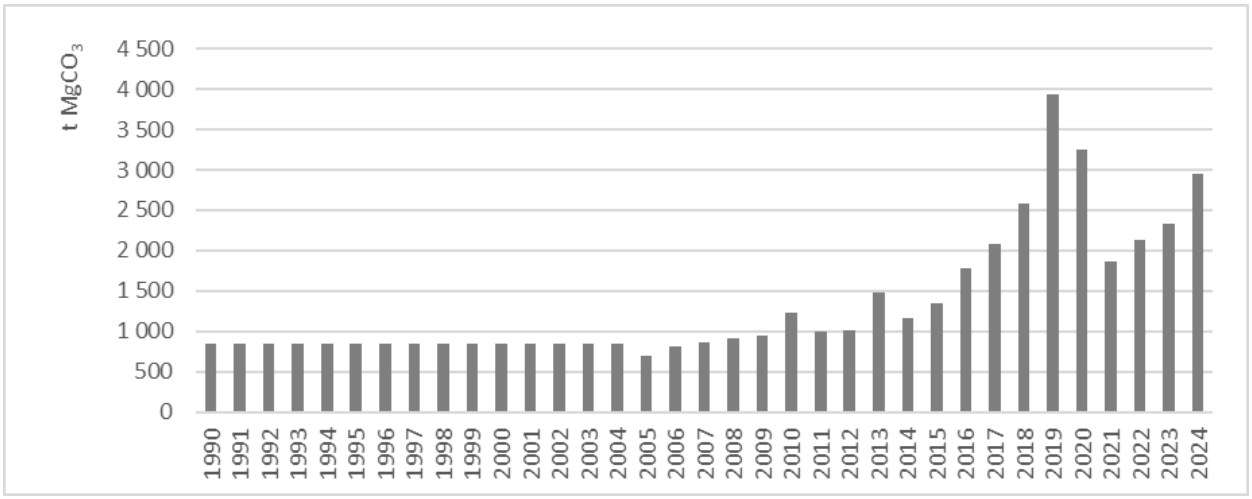



***Figure 5-33: $MgCO_3$ used on agriculture land ($t.yr^{-1}$)***

### 5.8.5 Uncertainty Assessment

Under the IPCC 2006 Tier 1 methodology, the default emission factor was used, which assume conservatively that all carbon from liming is emitted as $CO_2$ into the atmosphere. The default emission factor represents the absolute maximum emissions associated with liming added to soils so is assumed certain.

Activity data uncertainty was considered of 50 %.

### 5.8.6 Category specific QA/QC and verification

QA/QC procedures included the verification of calculation formulas and the consistency with previous submission estimates.

### 5.8.7 Category specific recalculations

No recalculations were made.

### 5.8.8 Category specific planned improvements

No specific improvements are planned.

## 5.9 $CO_2$ Emissions from Urea application (CRT 3.H)

### 5.9.1 Category description

Urea fertilizer is one of the N fertilizer types used in Portugal and in 2024 it accounts about 19.7% of the N synthetic fertilizers applications to the soil, 2.35 times higher than in 1990 (8,4%).

$CO_2$ emissions from urea application produced 29.9 kt $CO_2$ in 2024. This represents a increase of 40.9% compared to 1990 $CO_2$ emissions from urea applied to agricultural soils.

There is also a increase of 10.1% in 2024 N fertilizer consumption in agriculture when compared to 2023 value.

The evolution of apparent consumption of inorganic fertilisers between 2021 and 2024 is mainly justified by fertiliser prices. In 2022, the price index for fertilisers and soil improvers increased by 89.8% and apparent consumption of these products fell by 32.9%. In 2023, the price index fell by 24.8% while apparent consumption increased by 34.1%. In 2024, the price index fell by 18.3% and apparent consumption increased by 15.1%

### 5.9.2 Methodological issues

Emissions associated with urea application were estimated using a Tier 1 method (equation 11.13[114], IPCC 2006).

### 5.9.3 Emission Factors

It was used the default emission factor for carbon conversion of 0.20 which is equivalent to carbonate carbon contents of urea in an atomic basis.

### 5.9.4 Activity Data

Data on nitrogen fertilizers consumption, urea included, are provided by INE and are obtained as it was explained in chapter 5.5.1.4.1 - Synthetic Fertilizers (activity data). The total amount of urea fertilizer use is shown in the next Figure.

This year, INE updated the values for nitrogen fertilisers consumption for 2024.

[114] Volume,4, chapter 11, page 11.32

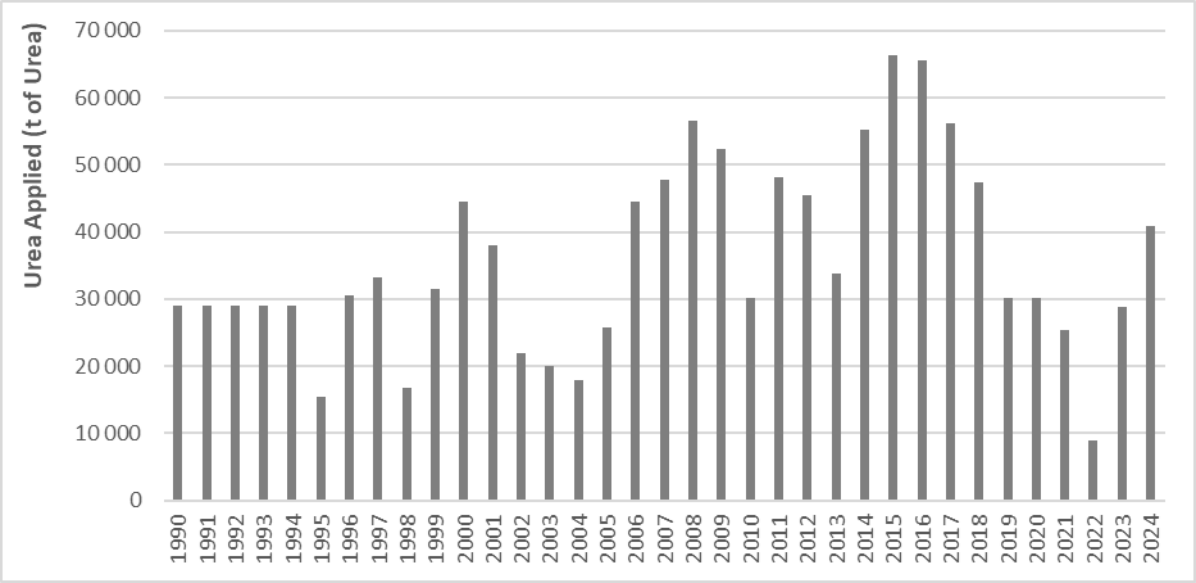



***Figure 5-34: Urea fertilizer application on agriculture land (t. yr$^{-1}$)***

### 5.9.5 Uncertainty Assessment

Under the IPCC 2006 Tier 1 methodology, the default emission factor was used, which assume conservatively that all carbon in the urea is emitted as $CO_2$ into the atmosphere. The default emission factor represents the absolute maximum emissions associated with urea fertilization so is assumed certain.

The uncertainty of activity data, apparent consumption of urea, was assumed the same that was considered for N synthetic fertilizers in direct $N_2O$ emissions from managed soils, i.e., 22.9%.

### 5.9.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data collection verification and the information provided in this report.

### 5.9.7 Category specific recalculations

Minor recalculations occurred due to the update of 2023-2024 Urea activity data.

### 5.9.8 Category specific planned improvements

No specific improvements are planned.

# 5.10 $CO_2$ Emissions from Other Carbon-containing fertilizers (CRT 3.I)

## 5.10.1 Category description

To ensure the completeness of the agricultural inventory, $CO_2$ emissions from Calcium Ammonia Nitrate (CAN) fertilizer are reported under the category 3.I Other carbon containing fertilizers.

In 2024, $CO_2$ emissions from CAN application were estimated in 4.51 =kt $CO_2$, corresponding to a decrease of 78.2% compared to 1990 emissions (20.68 kt $CO_2$).

## 5.10.2 Methodological issues

Emissions associated with CAN fertilizer use were estimated using a Tier 1 method (equation 11.12[115], IPCC 2006) because CAN in Portugal contains limestone.

The CAN fertilizer used in Portugal, according to the information provided by the National Statistics Authority, INE, are the so called "Nitrolusal", a mixture of ammonium nitrate ($NH_4NO_3$) and limestone (Ca $CO_3$). There are two types of "Nitrolusal" fertilizers with different $CaCO_3$ contents. Nitrolusal 27N has an estimated $CaCO_3$ fraction of about 23%, and the Nitrolusal 20.5N has an estimated $CaCO_3$fraction of about 41%. The share of use of each fertilizer type is presented in the next table.

***Table 5-56: % of use of each "Nitrolusal" fertilizer type***

| Type of Fertilizer | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **CAN (20.5 N)** | 26.3% | 16.0% | 0.0% | 18.1% | 18.2% | 10.1% | 10.1% | 8.4% | 1.8% | 3.1% | 3.3% |
| **CAN (27 N)** | 73.7% | 84.0% | 100.0% | 81.9% | 81.8% | 89.9% | 89.9% | 91.6% | 98.2% | 96.9% | 96.7% |

- Step 1 -

$$N \text{ in } Nitrolusal_{27N} = N \text{ in } CAN_{fertilizer} \times \%Nitrolusal_{27N}$$

**Where:**

| | | |
|---|---|---|
| N in $Nitrolusal_{27N}$ | - | Amount of N used in fertilizer with 27% N in its constitution (kg of N) |
| N in $CAN_{fertilizer}$ | - | Amount of N used both in fertilizers with 27% N and 20.5% N (kg of N) |
| $\%Nitrolusal_{27N}$ | - | Average % of CAN fertilizer sold with 27 % N (%) |

$$N \text{ in } Nitrolusal_{20.5N} = CAN_{fertilizer} \times \%Nitrolusal_{20.5N}$$

**Where:**

| | | |
|---|---|---|
| N in $Nitrolusal_{20.5N}$ | - | Amount of N used in fertilizer with 20.5% N in its constitution (kg of N) |
| N in $CAN_{fertilizer}$ | - | Amount of N used both in fertilizers with 27% N and 20.5% N (kg of N) |
| $\%Nitrolusal_{20.5N}$ | - | Average % of CAN fertilizer sold with 20.5 % N (%) |

[115] Volume 4, chapter 11, page 11.27

- Step 2 -

$$Nitrolusal_{27N} = \frac{N \text{ in } Nitrolusal_{27N}}{0.27}$$

**Where:**

| | | |
|---|---|---|
| $Nitrolusal_{27N}$ | - | Amount of fertilizer used with 27% N in its constitution (kg of $Nitrolusal_{27N}$ fertilizer) |
| N in $Nitrolusal_{27N}$ | - | Amount of N in fertilizer used with 27% N in its constitution (kg of N) |

$$Nitrolusal_{20.5N} = \frac{N \text{ in } Nitrolusal_{20.5N}}{0.205}$$

**Where:**

| | | |
|---|---|---|
| $Nitrolusal_{20.5N}$ | - | Amount of fertilizer used with 20.5% N in its constitution (kg of $Nitrolusal_{20.5N}$ fertilizer) |
| N in $Nitrolusal_{20.5N}$ | - | Amount of N in fertilizer used with 20.5% N in its constitution (kg of N) |

- Step 3 -

$$CaCO_3 \text{ in } Nitrolusal_{27N} = Nitrolusal_{27N} \times \left[100\% - \left(\%N2 \text{ in } Nitrolusal_{27N} \times \frac{M(NH_4NO_3)}{M(N_2)}\right)\right]$$

**Where:**

| | | |
|---|---|---|
| $CaCO_3$ in $Nitrolusal_{27N}$ | - | Amount of $CaCO_3$ in fertilizer used with 27% N in its constitution (kg of $CaCO_3$) |
| $Nitrolusal_{27N}$ | - | Amount of fertilizer used with 27% N in its constitution (kg of $Nitrolusal_{27N}$ fertilizer) |
| %N2 in $Nitrolusal_{27N}$ | - | % of N2 in the fertilizer used with 27% N in its constitution (% mass/mass) = 27% |
| $M(NH_4NO_3)$ | - | Molar Mass of $NH_4NO_3$ (g/mol) |
| $M(N_2)$ | - | Molar Mass of $N_2$ (g/mol) |

$$CaCO_3 \text{ in Nitrolusal}_{20.5N} = \text{Nitrolusal}_{20.5N} \times \left[100\% - \left(\%N2 \text{ in Nitrolusal}_{20.5N} \times \frac{M(NH_4NO_3)}{M(N_2)}\right)\right]$$

**Where:**

| | | |
|---|---|---|
| $CaCO_3$ in $Nitrolusal_{20.5N}$ | - | Amount of $CaCO_3$ in fertilizer used with 20.5% N in its constitution (kg of $CaCO_3$) |
| $Nitrolusal_{20.5N}$ | - | Amount of fertilizer used with 20.5% N in its constitution (kg of $Nitrolusal_{27N}$ fertilizer) |
| %N2 in $Nitrolusal_{20.5N}$ | - | % of N2 in the fertilizer used with 20.5% N in its constitution (% mass/mass) = 20.5% |
| $M(NH_4NO_3)$ | - | Molar Mass of $NH_4NO_3$ (g/mol) |
| $M(N_2)$ | - | Molar Mass of $N_2$ (g/mol) |

- Step 4 -

$$CO_2 \text{ from Nitrolusal}_{27N} = CaC0_3 \text{ in Nitrolusal}_{27N} \times \frac{M(CO_2)}{M(CaCO_3)}$$

**Where:**

| | | |
|---|---|---|
| $CO_2$ from $Nitrolusal_{27N}$ | - | $CO_2$ emissions from the application of fertilizer used with 27% N in its constitution (kg of $CO_2$) |
| $CaCO_3$ in $Nitrolusal_{27N}$ | - | Amount of $CaCO_3$ in fertilizer used with 27% N in its constitution (kg of $CaCO_3$) |
| $M(CO_2)$ | - | Molar Mass of $CO_2$ (g/mol) |
| $M(CaCO_3)$ | - | Molar Mass of $CaCO_3$ (g/mol) |

$$CO_2 \text{ from Nitrolusal}_{20.5N} = CaC0_3 \text{ in Nitrolusal}_{20.5N} \times \frac{M(CO_2)}{M(CaCO_3)}$$

**Where:**

| | | |
|---|---|---|
| $CO_2$ from $Nitrolusal_{20.5N}$ | - | $CO_2$ emissions from the application of fertilizer used with 20.5% N in its constitution (kg of $CO_2$) |
| $CaCO_3$ in $Nitrolusal_{20.5N}$ | - | Amount of $CaCO_3$ in fertilizer used with 20.5% N in its constitution (kg of $CaCO_3$) |
| $M(CO_2)$ | - | Molar Mass of $CO_2$ (g/mol) |
| $M(CaCO_3)$ | - | Molar Mass of $CaCO_3$ (g/mol) |

### 5.10.3 Emission factors

It was used the default emission factor for carbon conversion of 0.12 which is equivalent to carbonate carbon contents of limestone in an atomic basis.

***Table 5-57: Molar Mass of Ca, C, O, $CaCO_3$ and $CO_2$***

| Parameter | Unit | Molar Mass |
|---|---|---|
| **$N_2$** | g/mol | 28 |
| **$NH_4NO_3$** | g/mol | 80 |
| **Ca** | g/mol | 40 |
| **C** | g/mol | 12 |
| **O** | g/mol | 16 |
| **$CaCO_3$** | g/mol | 100 |
| **$CO_2$** | g/mol | 44 |

### 5.10.4 Activity Data

Data on nitrogen fertilizers consumption, CAN included, are provided by INE and are obtained as it was explained in chapter 5.5.1.4.1 - Synthetic Fertilizers (activity data).

The total amount of CAN fertilizer uses and the corresponding $CaCO_3$ amount are shown in the next figure.

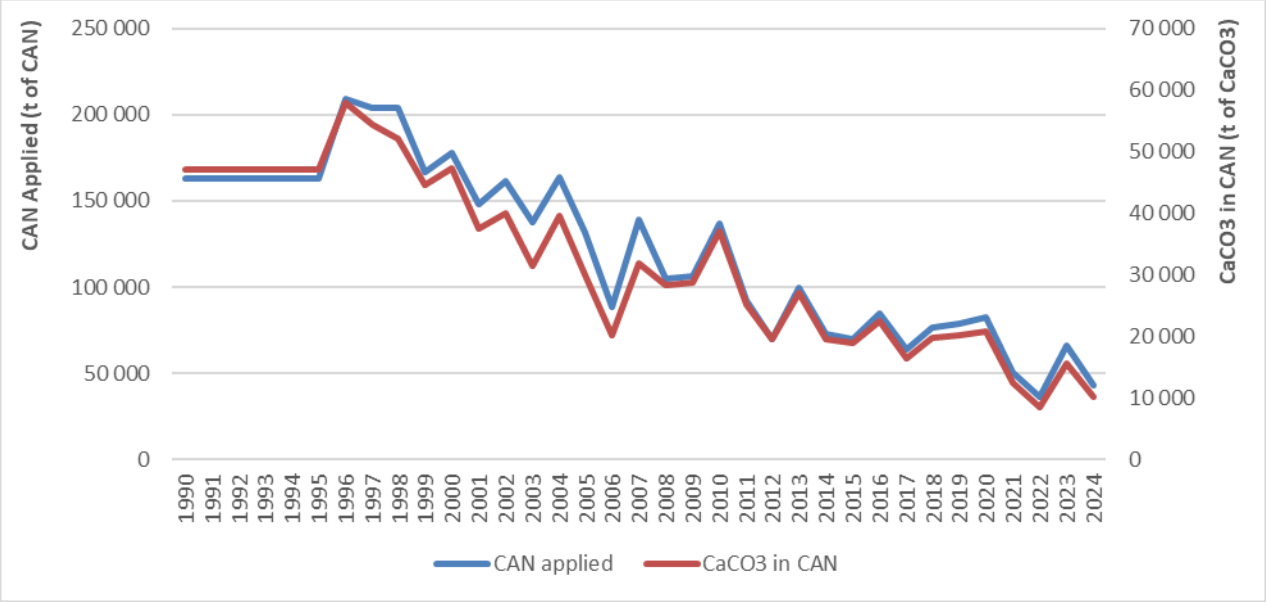



***Figure 5-35: Calcium Ammonium Nitrate (CAN) applied to soils and corresponding $CaCO_3$ amount***

### 5.10.5 Uncertainty Assessment

Under the IPCC 2006 Tier 1 methodology, the default emission factor was used, which assume conservatively that all carbon in the CAN fertilizer is emitted as $CO_2$ into the atmosphere. The default emission factor represents the absolute maximum emissions associated with urea fertilization so is assumed certain.

The uncertainty of activity data, apparent consumption of CAN, was assumed the same that was considered for N synthetic fertilizers in direct $N_2O$ emissions from managed soils, i.e., 22.9%.

### 5.10.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data collection verification and the information provided in this report.

### 5.10.7 Category specific recalculations

Minor recalculations occurred due to the update of 2023 and 2024 CAN activity data.

### 5.10.8 Category specific planned improvements

No specific improvements are planned.

# 6 Land-Use, Land-Use Change and Forestry (CRT Sector 4)

## Table of Contents


6 Land-Use, Land-Use Change and Forestry (CRT Sector 4) ..... 6-1

6.1 Overview of the sector LULUCF ..... 6-5

6.1.1 Representation of Land-Areas and Land-Use Changes ..... 6-8

6.1.2 Generic Methodologies and Information Sources applicable to multiple Land-Use Categories 6-21

6.2 Forest Land (CFR 4.A) ..... 6-31

6.2.1 Forest Land remaining Forest Land ..... 6-32

6.2.2 Land converted to Forest ..... 6-37

6.3 Cropland (CRT 4.B) ..... 6-39

6.3.1 Cropland remaining Cropland ..... 6-39

6.3.2 Land converted to Cropland ..... 6-42

6.4 Grassland (CRT 4.C) ..... 6-43

6.4.2 Grassland remaining Grassland ..... 6-44

6.4.3 Land converted to Grassland ..... 6-46

6.5 Wetlands (CRT 4.D) ..... 6-47

6.5.1 Wetlands remaining Wetlands ..... 6-48

6.5.2 Land converted to Wetlands ..... 6-49

6.6 Settlements (CFR 4.E) ..... 6-51

6.6.1 Settlements remaining Settlements ..... 6-51

6.6.2 Land converted to Settlements ..... 6-52

6.7 Other Land (CRT 4.F) ..... 6-54

6.8 Harvested Wood Products (CRT 4.G) ..... 6-54

6.9 Direct $N_2O$ Emissions from N-Inputs to Managed Soils (CRT 4(I)) ..... 6-56

6.10 Emissions and Removals from Drainage and Rewetting and other Management of Organic and Mineral soils (CRT 4(II)) ..... 6-56

6.11 Direct and Indirect $N_2O$ emissions from N Mineralization/Immobilization associated with Loss/Gain of Soil Organic Matter resulting from change of LU or management of Mineral Soils (CRT 4(III)) ..... 6-56

6.11.1 Activity Data ..... 6-56
6.11.2 Emission estimation ..... 6-57
6.12 Emissions from Biomass Burning (CRT 4(IV)) ..... 6-58
6.12.1 Estimation of Burned Areas ..... 6-58
6.12.2 Estimation of Biomass Loss due to Fires ..... 6-59
6.12.3 Direct $CO_2$ Emissions from Fires ..... 6-60
6.12.4 Direct $CH_4$ Emissions from Fires ..... 6-60
6.12.5 Direct $N_2O$ Emissions from Fires ..... 6-60
6.12.6 Indirect $CO_2$ Emissions from Fires ..... 6-61
6.13 Uncertainty Assessment ..... 6-62
6.14 QA/QC ..... 6-62
6.15 Recalculations and Data Improvements ..... 6-63
6.16 Further Developments ..... 6-64

## List of Figures

Figure 6-1: Overview of emissions and removals in the LULUCF sector ..... 6-5
Figure 6-2: Portuguese territorial units ..... 6-8
Figure 6-3: Map of the mainland-uses in Mainland Portugal in 1995 and 2018 – Forest Land ..... 6-11
Figure 6-4: Map of the mainland-uses in Mainland Portugal in 1995 and 2018 - Cropland ..... 6-11
Figure 6-5: Map of the mainland-uses in Mainland Portugal in 1995 and 2018 – Grassland and Settlements 6-12
Figure 6-6: Map of the mainland-uses in Mainland Portugal in 1995 and 2018 – Wetlands and Other Land. 6-12
Figure 6-7: Trend in GL1 “Pastures”, ST1 “Settlements” and WT1 “Flooded Areas” ..... 6-14
Figure 6-8: Changes in total land-use in Mainland Portugal ..... 6-15
Figure 6-9: Changes in total land-use in the Region of Azores ..... 6-18
Figure 6-10: Changes in total land-use in the Region of Madeira ..... 6-18
Figure 6-11: Changes in total land-use in Portugal ..... 6-19
Figure 6-12: Total areas per UNFCCC reporting categories ..... 6-20
Figure 6-13: Areas of Forest Land per UNFCCC reporting category ..... 6-31
Figure 6-14: Total emissions and removals in Forest Land ..... 6-31
Figure 6-15: Industrial Harvest per forest type ..... 6-35
Figure 6-16: “Other Harvest” per forest type ..... 6-36
Figure 6-17: Areas of Cropland per UNFCCC reporting category ..... 6-39

Figure 6-18: Total emissions and removals in Cropland ..... 6-39
Figure 6-19: Areas of Grassland per reporting category (1000 ha) ..... 6-43
Figure 6-20: Total emissions and removals in Grassland ..... 6-43
Figure 6-21: Areas of Wetlands per reporting category (1000 ha) ..... 6-47
Figure 6-22: Total emissions and removals in Wetlands ..... 6-47
Figure 6-23: Areas of Settlements per reporting category ..... 6-51
Figure 6-24: Total emissions and removals in Settlements ..... 6-51
Figure 6-25: Areas of Other Land per reporting category ..... 6-54
Figure 6-26: Reported activity data for Harvested Wood Products – Sawnwood ..... 6-55
Figure 6-27: Reported activity data for Harvested Wood Products – Wood Panels ..... 6-55
Figure 6-28: Reported activity data for Harvested Wood Products – Paper and Paper board ..... 6-55
Figure 6-29: Evolution of carbon stocks and carbon stock changes in Harvested Wood Products ..... 6-56
Figure 6-30: Total Area under N Mineralization (kha) ..... 6-57
Figure 6-31: $N_2O$ Emissions from areas under N Mineralization (kt $N_2O$) ..... 6-57
Figure 6-32: Burned areas per reporting category (ha) ..... 6-59
Figure 6-33: Estimation of Indirect Fire emissions ..... 6-61
Figure 6-34: Total emissions from biomass burning per land-use category ..... 6-62
Figure 6-35: Effect of recalculations in the LULUCF emissions and removals ..... 6-64

## List of Tables

Table 6-1: Total GHG emissions from LULUCF ..... 6-6
Table 6-2: Key categories in the LULUCF sector (CRT 4) ..... 6-7
Table 6-3: Land-use categories used in the estimation of emissions and removals in the LULUCF sector ... 6-9
Table 6-4: Annual land-use changes (ha) in Mainland Portugal the period 1970-1995 ..... 6-16
Table 6-5: Total Carbon Stocks and annual Growth Rates per Forest type ..... 6-21
Table 6-6: Biomass estimates, Wood Volume, Biomass conversion factors, and Root-to-shoot ratios used. 6-22
Table 6-7: Above and Below Ground Biomass in Permanent Crops, according to age after plantation ..... 6-23
Table 6-8: Carbon Stock Annual Gains in Above and Below Ground Biomass in Permanent Crops, according to age after plantation ..... 6-23
Table 6-9: Carbon Stock Annual Gains and Losses related to pruning of Above Ground Biomass in Permanent crops, according to age after plantation ..... 6-24
Table 6-10: Above and Below Ground Biomass in Shrublands, according to age ..... 6-24

Table 6-11: Carbon stock annual gains in Above and Below Ground Biomass in Shrublands, according to age ..... 6-25

Table 6-12: Above and Below Ground Biomass and Annual Carbon Stock Gains and Losses in Annual Crops, Pastures and Other Wetlands. ..... 6-25

Table 6-13: Litter Carbon Stocks at maturity by land-use ..... 6-26

Table 6-14: Annual emission/sequestration factors for Litter ..... 6-27

Table 6-15: Number of sample plots per land-use and soil depth ..... 6-28

Table 6-16: Average C Stock measured per land-use and soil depth ..... 6-28

Table 6-17: Average Soil C Stock 0-40 cm per land-use ..... 6-29

Table 6-18: Annual emission/sequestration factors for Soil ..... 6-30

Table 6-19: Summary of types of losses in Living Biomass considered in the estimations of emissions and removals in Forest Land ..... 6-34

Table 6-20: Combustion factors per biomass component used in the estimation of Fire Emissions ..... 6-59

Table 6-21: Fire mortality rates ..... 6-61

## List of Equations

Equation 6-1: Estimation of annual land-use change 1995-2018 ..... 6-12

Equation 6-2: Estimation of land-use changes, when only net-changes in area are known ..... 6-15

Equation 6-3: Estimation of land conversions for UNFCCC reporting ..... 6-19

Equation 6-4: Estimation of Land remaining Land for UNFCCC reporting ..... 6-20

Equation 6-5: Estimation of Carbon Stock in Above Ground Living Biomass in Forests ..... 6-21

Equation 6-6: Estimation of Carbon Stock in Below Ground Living Biomass in Forests ..... 6-21

Equation 6-7: Estimation of Above Ground Living Biomass in Shrubland ..... 6-24

Equation 6-8: Estimation of Litter emission factors for all land use-changes ..... 6-26

Equation 6-9: Estimation of Soil emission factors ..... 6-29

Equation 6-10: Estimation of Above Ground Biomass Gains in Forest Land Remaining Forest Land ..... 6-32

Equation 6-11: Estimation of Below Ground Biomass Gains in Forest Land Remaining Forest Land ..... 6-32

Equation 6-12: Estimation of losses in living biomass in Forest Land remaining Forest Land ..... 6-36

Equation 6-13: $N_2O$ emissions from managed soils ..... 6-57

Equation 6-14: Estimation of Direct $CO_2$ Emissions from Fires ..... 6-60

Equation 6-15: Estimation of Direct $CH_4$ emissions from Fires ..... 6-60

Equation 6-16: Estimation of Direct $N_2O$ emissions from Fires ..... 6-60

# 6 Land-Use, Land-Use Change and Forestry (CRT Sector 4)

*Sílvia Catarino*

*Updated: April 2026*

## 6.1 Overview of the sector LULUCF

The Land Use, Land-Use Change and Forestry (LULUCF) sector comprises greenhouse gas (GHG) emissions and removals resulting from changes in carbon stocks in biomass, dead organic matter and soils associated with land use, land-use change and land management activities. Unlike other inventory sectors, LULUCF includes both emission sources and carbon sinks. The sector reports emissions and removals of carbon dioxide ($CO_2$), as well as emissions of methane ($CH_4$) and nitrous oxide ($N_2O$). The methodologies and emission factors applied are consistent with the *2006 IPCC Guidelines*.

In Portugal, the LULUCF sector is strongly influenced by land management practices, climatic conditions and extreme events. In recent years, interannual variability in emissions and removals has been largely driven by the occurrence of large wildfire events.

For the period 1990-2024, the LULUCF sector was estimated on average as a net-sink of -807 $ktCO_{2eq}$. However, there is considerable inter-annual variability, including 8 years for which LULUCF was a net-emitter (Figure 6-1). The highest net-emission occurred in 2017 (+15 768 $ktCO_{2eq}$) and the highest net sequestration occurred in 2008 (-5 274 $ktCO_{2eq}$). In 2024 the LULUCF sector emissions and removals are estimated as a net-emission of 633 $ktCO_{2eq}$.

The main contributors for the observed inter-annual variations are the wildfires, largely driven by changes in weather patterns from year to year. The year 2017 experienced exceptionally high wildfire activity, and a record high value of 558 kha of burned area was achieved (6% of the country area).

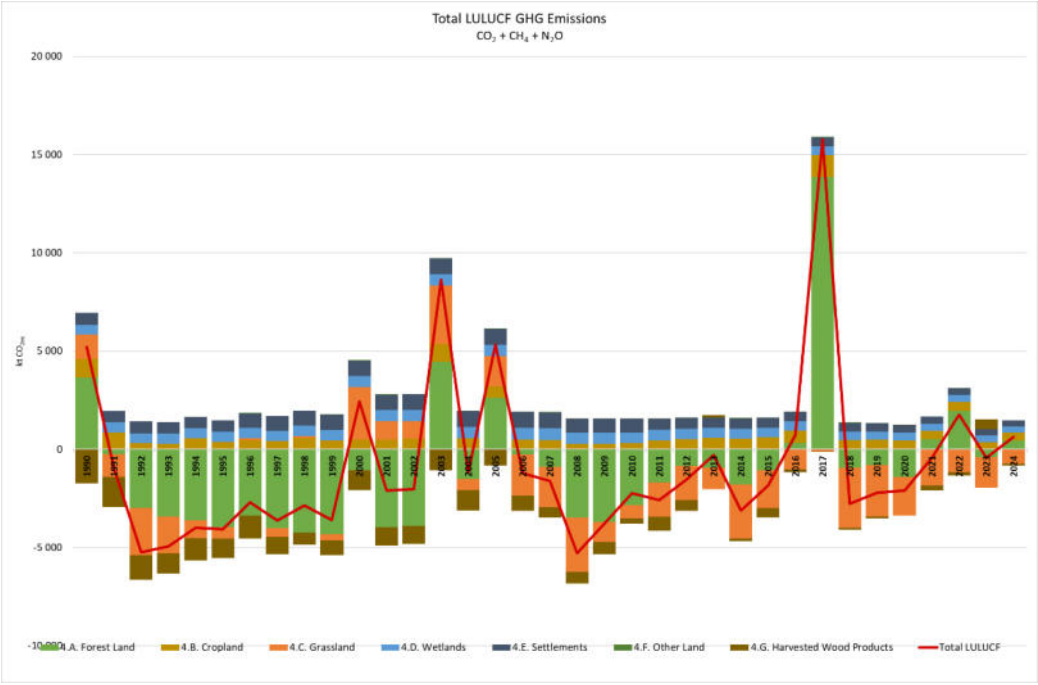



***Figure 6-1: Overview of emissions and removals in the LULUCF sector***

Table 6-1 presents total GHG emissions and removals from LULUCF, by sector and by gas.

***Table 6-1: Total GHG emissions from LULUCF***

| Source/ Gas | 1990 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | $ktCO_2eq$ | | | | |
| **4.A Forest Land** | | | | | | | | | |
| $CO_2$ | 3 223.04 | -1 211.31 | 2 104.24 | -3 050.75 | -1 193.51 | -1 535.90 | 1 769.06 | -494.15 | 261.44 |
| $CH_4$ | 306.92 | 81.11 | 348.31 | 109.14 | 45.22 | 54.22 | 104.32 | 29.18 | 116.57 |
| $N_2O$ | 122.15 | 79.15 | 160.71 | 104.49 | 86.34 | 69.80 | 74.87 | 52.12 | 70.38 |
| **4.B Cropland** | | | | | | | | | |
| $CO_2$ | 850.49 | 456.64 | 527.87 | 249.22 | 548.09 | 394.55 | 387.28 | 300.28 | 332.26 |
| $CH_4$ | 55.66 | 5.31 | 11.32 | 4.02 | 2.03 | 3.19 | 8.05 | 1.74 | 5.34 |
| $N_2O$ | 44.77 | 37.21 | 44.05 | 45.06 | 53.25 | 56.53 | 58.85 | 57.81 | 59.27 |
| **4.C Grassland** | | | | | | | | | |
| $CO_2$ | 966.32 | 2 450.45 | 1 263.95 | -816.42 | -1 996.02 | -2 006.31 | -1 241.72 | -1 577.39 | -810.20 |
| $CH_4$ | 214.68 | 163.35 | 202.35 | 96.62 | 27.63 | 21.81 | 35.20 | 15.15 | 43.79 |
| $N_2O$ | 54.18 | 50.51 | 69.87 | 49.86 | 35.19 | 25.47 | 25.44 | 18.68 | 24.20 |
| **4.D Wetlands** | | | | | | | | | |
| $CO_2$ | 474.63 | 517.36 | 556.76 | 492.97 | 459.10 | 364.40 | 327.45 | 308.79 | 290.34 |
| $CH_4$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| $N_2O$ | 32.33 | 35.64 | 39.01 | 37.75 | 34.09 | 26.77 | 23.83 | 22.35 | 20.88 |
| **4.E Settlements** | | | | | | | | | |
| $CO_2$ | 560.02 | 758.37 | 779.95 | 687.72 | 485.20 | 368.03 | 329.79 | 310.04 | 290.99 |
| $CH_4$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| $N_2O$ | 24.16 | 28.21 | 31.74 | 33.05 | 29.21 | 21.72 | 18.78 | 17.31 | 15.84 |
| **4.F Other Land** | | | | | | | | | |
| $CO_2$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| $CH_4$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| $N_2O$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **4.G Harvested Wood Products** | | | | | | | | | |
| $CO_2$ | -1 731.42 | -1 012.84 | -818.35 | -278.68 | -458.36 | 28.90 | -147.89 | 512.77 | -88.05 |
| **Total** | | | | | | | | | |
| $CO_2$ | 4 343.09 | 1 958.66 | 4 414.42 | -2 715.95 | -2 155.51 | -2 386.33 | 1 423.97 | -639.66 | 276.80 |
| $CH_4$ | 577.26 | 249.77 | 561.99 | 209.79 | 74.87 | 79.22 | 147.56 | 46.08 | 165.70 |
| $N_2O$ | 277.59 | 230.72 | 345.39 | 270.21 | 238.08 | 200.30 | 201.77 | 168.27 | 190.57 |
| All gases | 5 197.94 | 2 439.15 | 5 321.79 | -2 235.95 | -1 842.56 | -2 106.81 | 1 773.30 | -425.31 | 633.07 |

Note: Totals may not equal the sum of components due to rounding.

### *Key categories*

The key categories related to the LULUCF sector are summarised in table below.

***Table 6-2: Key categories in the LULUCF sector (CRT 4)***

| IPCC category | GHG | Criteria | Method |
|---|---|---|---|
| **4.A.1. Forest land remaining Forest land** | $CO_2$ | L1, L2, T1, T2 | Tier 2 |
| **4.B.2 Land converted to Cropland** | $CO_2$ | L1, L2, T1 | Tier 1, Tier 2 |
| **4.E.2 Land converted to Settlements** | $CO_2$ | L1, L2, T1, T2 | Tier 1, Tier 2 |
| **4.D.2 Land converted to Wetlands** | $CO_2$ | L1, T1 | Tier 1, Tier 2 |
| **4.A.1. Forest land remaining Forest land** | $CH_4$ | L 1 | Tier 2 |
| **4.C.1. Grassland remaining Grassland** | $CH_4$ | L 2 | Tier 1, Tier 2 |
| **4.G. Other (Harvested Wood Products)** | $CO_2$ | L1, T1 | Tier 1 |
| **4.B.1. Cropland remaining Cropland** | $CO_2$ | L1, L2, T1 | Tier 1, Tier 2 |
| **4.C.1. Grassland remaining Grassland** | $CO_2$ | L1, L2, T1 | Tier 1, Tier 2 |
| **4.A.2 Land converted to Forest land** | $CO_2$ | L1, L2, T1, T2 | Tier 1, Tier 2 |

Criteria: L- Level; T- Trend

Higher tier methods are applied where data and methodological capacity are available. However, Tier 1 approaches are still used for some key categories due to the lack of sufficiently detailed country-specific data and nationally derived emission factors for several carbon pools and land-use categories. The implementation of higher-tier methods in line with the decision trees of the *2006 IPCC Guidelines* would require the development of disaggregated national datasets by land use, land-use transition and management practices, including country-specific estimates of carbon stocks and stock changes. These improvements would require the establishment of new data collection systems, periodic data collection and significant financial and human resources, which are not currently available. Therefore, it has not been possible to apply higher-tier methods for all key categories. In accordance with paragraph 23 of the MPGs (Decision 18/CMA.1), the use of Tier 1 methods is considered an interim solution, and these categories are prioritized for future methodological improvement.

### 6.1.1 Representation of Land-Areas and Land-Use Changes

#### 6.1.1.1 Approaches to land representation

The Portuguese territory is composed of three territorial units (see Figure 6-2): Mainland, the Archipelago of Azores (9 inhabited islands) and the Archipelago of Madeira (2 inhabited islands).

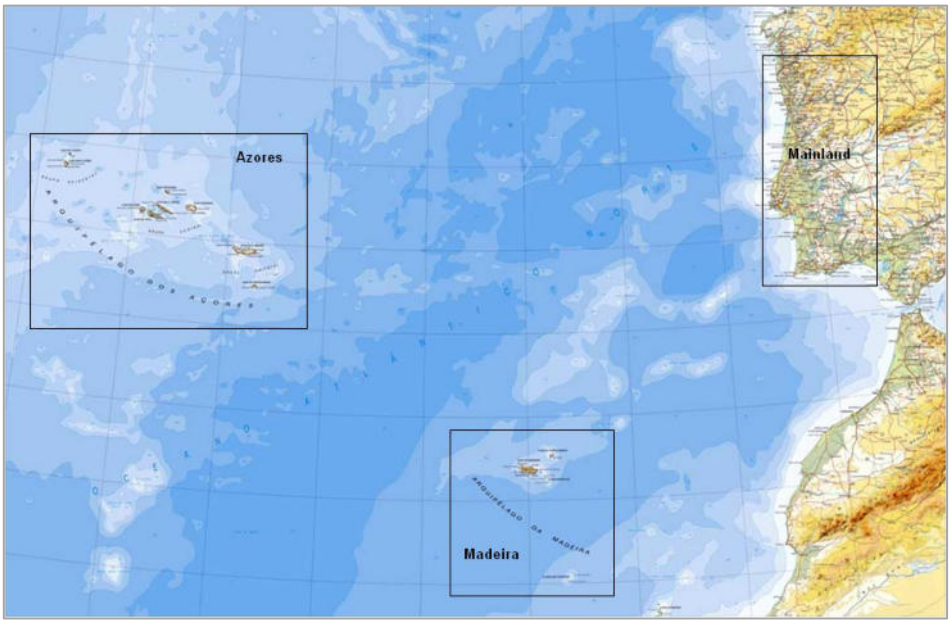



***Figure 6-2: Portuguese territorial units***

Portugal has 9 239 318 ha, divided by the Mainland with 8 927 540 ha (96.6%), the Archipelago of Azores with 231 676 ha (2.5%) and Archipelago of Madeira with 80 102 ha (0.9%).

Under the Portuguese constitutional law, the Archipelagos of Azores and Madeira are each an Autonomous Region, and as a result of that legal status the information sources (used for activity data) for each region are not exactly the same.

The sections below describe how the data on land-use and land-use change were derived in each of the three regions. The land representation approaches applied vary according to territory and time period, reflecting differences in the availability, spatial resolution, and temporal coverage of data sources. In mainland Portugal, Approach 3 is applied from 1995 onwards based on successive national land-use maps (*Carta de Ocupação do Solo* – COS), while earlier years rely on non-spatial data and are represented applying Approach 1. In the Autonomous Regions, spatially explicit information is derived primarily from CORINE Land Cover (CLC) datasets complemented by regional inventories and statistical sources, allowing the application of Approach 3 for most of the time series. Overall, the inventory is dominated by Approach 3, which ensures geographically explicit tracking of land-use conversions for the majority of the reporting period, while earlier years or data-limited circumstances are represented using the best available information consistent with IPCC guidance.

#### 6.1.1.2 Land-Use data stratification

The same land-use stratification scheme is applied across the three national regions (mainland Portugal, the Autonomous Region of the Azores and the Autonomous Region of Madeira), despite differences in the underlying land-use data sources used for each region.

In total, 21 land-use categories were defined and used in the LULUCF calculations. These categories represent a disaggregation of the six IPCC land-use classes reported under the UNFCCC (Forest Land, Cropland, Grassland, Wetlands, Settlements and Other Land) into nationally relevant subcategories. The stratification allows more accurate estimation of carbon stock changes by capturing the diversity of Portuguese land-use systems, particularly within forest and agricultural lands.

The land-use categories adopted for the inventory are presented in Table 6-3.

***Table 6-3: Land-use categories used in the estimation of emissions and removals in the LULUCF sector***

| UNFCCC Category | Land-use Category Name | Description |
|---|---|---|
| **FL: Forest Land** | FL1: Pinus pinaster | Forests dominated by maritime pine |
| | FL2: Pinus pinea | Forests dominated by umbrella pine |
| | FL3: Other coniferous | Forests dominated by any other coniferous species |
| | FL4: Eucalyptus spp. | Forests dominated by eucalypt species |
| | FL5: Quercus suber | Forests dominated by cork oak |
| | FL6: Quercus rotundifolia | Forests dominated by holm oak |
| | FL7: Quercus spp. | Forests dominated by other oak species |
| | FL8: Other broadleaves | Forests dominated by any other broadleaf species |
| **CL: Cropland** | CL1: Rainfed annual crops | Includes all land cultivated with annual crops without irrigation<br>Includes fallow-land integrated into crop-rotations |
| | CL2: Irrigated annual crops | Includes all land cultivated with annual crops that is under irrigation (except rice), nurseries and greenhouses |
| | CL3: Rice paddies | Includes all land prepared for rice cultivation |
| | CL4: Vineyards | Includes all areas used for cultivation of table and/or wine grapes |
| | CL5: Olive groves | Includes all areas used for cultivation of *Olea europea*[1] |
| | CL6: Other permanent crops | Includes all areas used for cultivation of all other species of woody crops, including fruit orchards[2] |
| **GL: Grassland** | GL1: All grasslands | Includes all lands covered in permanent herbaceous cover |
| | GL2: Shrubland | Includes all lands covered in woody vegetation that do not meet the forest or permanent crop definitions |
| **WT: Wetlands** | WT1: Flooded areas | Includes all lands permanently covered in water, such as water reservoirs and inland natural lagoons, lakes and estuaries |
| | WT2: Other wetlands | Includes all natural wetlands that do not meet the Flooded areas definition |
| **ST: Settlements** | ST1: Settlements | Includes all artificial territories, including cities and villages, industries, mines, roads and railway, ports and airports |
| **OL: Other Land** | OL1: Other land | Includes all lands that do not meet the previous definitions, such as lands covered in rocks, sand dunes, etc |
| | OO1: Oceans | Includes natural or man-made land-use change transitions to or from Oceans[3] |

[1] Olive trees used for the production of olive oil and/or olives. The Wild Olive Tree (*Olea europea* subsp. *europea* var. *sylvestrys*) is reported as Forest Land / Other Broadleaves.

[2] Except Sweet Chestnut (*Castanea sativa*), Carob Trees (*Ceratonia siliqua*) and Umbrella Pines (*Pinus pinea*), which are reported to FAO as forest land, even though their main production objective is the respective fruit.

[3] E.g. construction or expansion of a sea port; natural expansion or loss of sand dunes along the coastline. NB: Only land-use changes are considered; emissions and removals from oceans as such are not included.

### 6.1.1.3 Mainland Portugal

The land-use and land-use change data for Mainland Portugal 1970-2024 was divided into two different time periods: 1970-1995 and 1995-2024. This separation was needed due to the type and quality of information available. The period 1995-2024 can be estimated using an Approach type 3 (spatially-explicit land-use conversion data), while the data for the period 1970-1995 only allowed for the use of an Approach type 1 (total land-use area, no data on conversions between land-uses). The methodologies used for each of the periods are described below.

#### 6.1.1.3.1 Period 1995-2024

The main information source for this period is the *Cartografia de Ocupação de Solo*[4] (COS). For the purposes of this inventory submission, COS data available up to 2018 were used, including maps for the years 1995, 2007, 2010, 2015 and 2018.

COS is a polygon-based land use map produced for mainland Portugal by the Portuguese *Direção-Geral do Território* (DGT). It is based primarily on the visual interpretation of high-resolution orthorectified aerial imagery, supported by auxiliary datasets from different sources. The maps follow common technical specifications across the series, including a minimum mapping unit of 1 ha, a minimum width of 20 m for linear features and polygons, and a hierarchical classification system. To ensure comparability over time, a consistent methodological framework was applied across all reference years of the series (1995, 2007, 2010, 2015 and 2018), based on full national aerial image coverage. While updates and improvements were introduced over time, the COS series was specifically designed to support consistent land representation over the period 1995–2018.

COS (2007) was the first to be produced and served as the basis to derive COS (1995) and COS (2010), using the full aerial photography cover of mainland Portugal available for the respective years. COS (2015) and COS (2018) were subsequently derived from the previous maps. This approach minimises the chances for topological and geometric inconsistencies between maps.

For the purposes of the GHG inventory, the original COS legend was converted into the 21 strata described in section 6.1.2.2, which are used as a basis for both UNFCCC reporting. Forest classes were defined as areas where forest tree cover was higher than 10% and include also areas temporarily unstocked. This allows for a representation of forests consistent with the KP Forest Definition of Portugal.

In the 2018 exercise an additional QA/QC check was conducted, by overlapping all maps and checking (and correcting when needed) for mistakes and/or very improbable land-use changes. Consequently, all previous COS maps have been revised. An example is illustrated in the table below:

| 1995 | 2007 | 2010 | 2015 | 2018 |
|---|---|---|---|---|
| Q. suber | Q. suber | Q. suber | Q. rotundifolia | Q. suber |
| The value for 2015 was identified as a mistake and corrected to: | | | | |
| Q. suber | Q. suber | Q. suber | Q. suber | Q. suber |

The Final Report of COS further elaborates on the criteria used for land classification and generalization.

[4] Land-Use Cartography. COS in the Portuguese acronym.

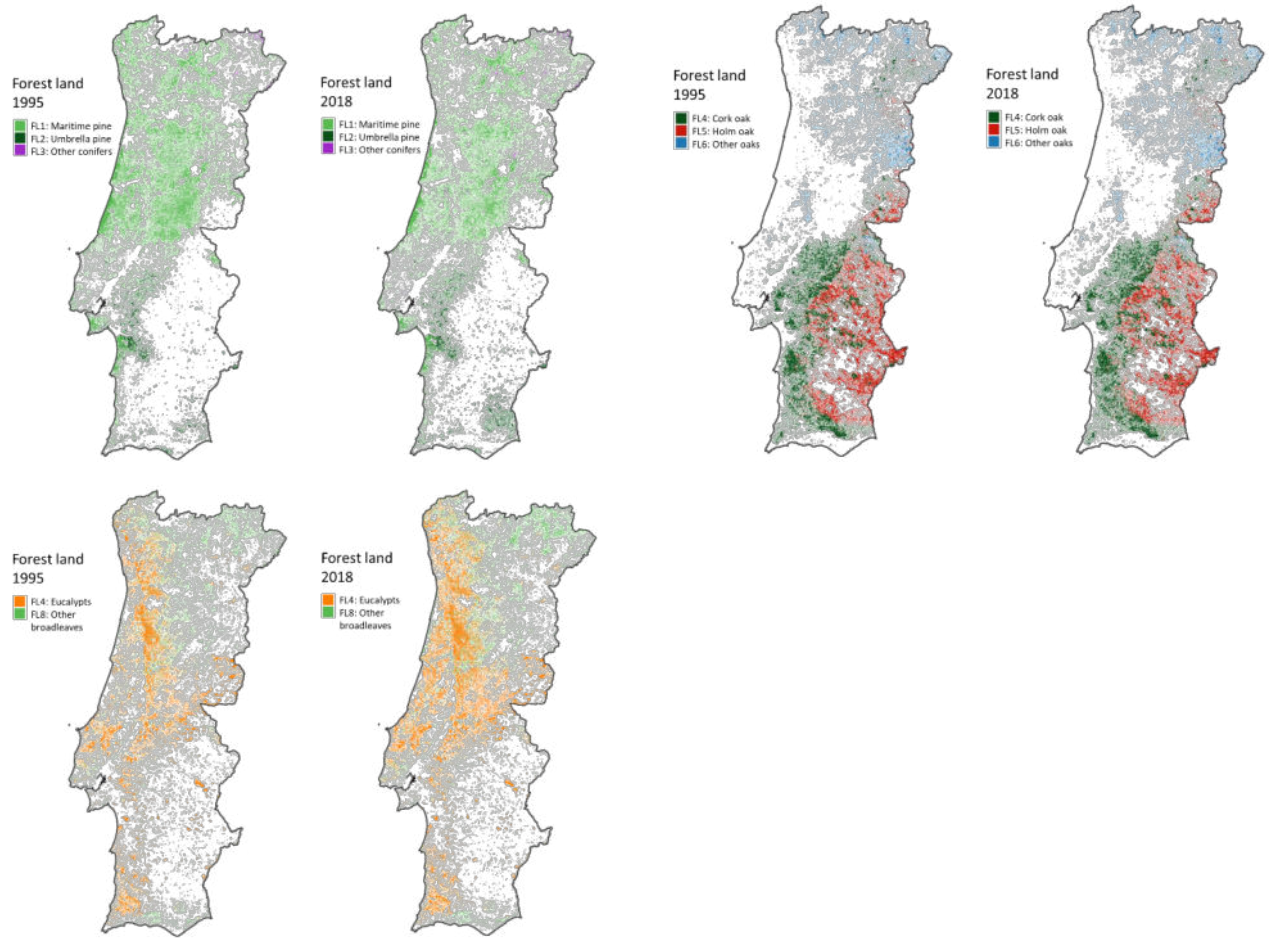



***Figure 6-3: Map of the mainland-uses in Mainland Portugal in 1995 and 2018 – Forest Land***

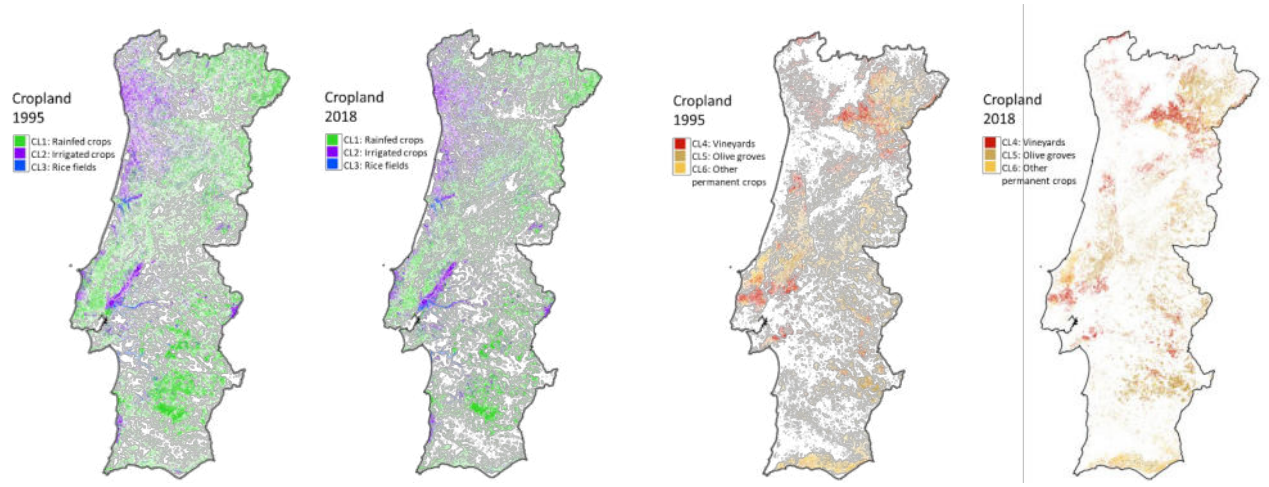



***Figure 6-4: Map of the mainland-uses in Mainland Portugal in 1995 and 2018 - Cropland***

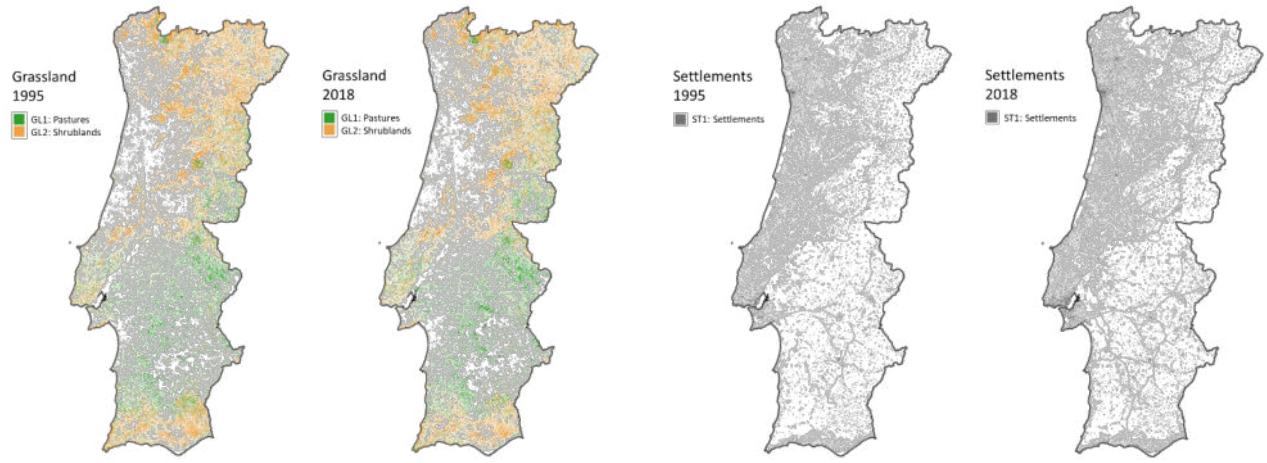



***Figure 6-5: Map of the mainland-uses in Mainland Portugal in 1995 and 2018 – Grassland and Settlements***

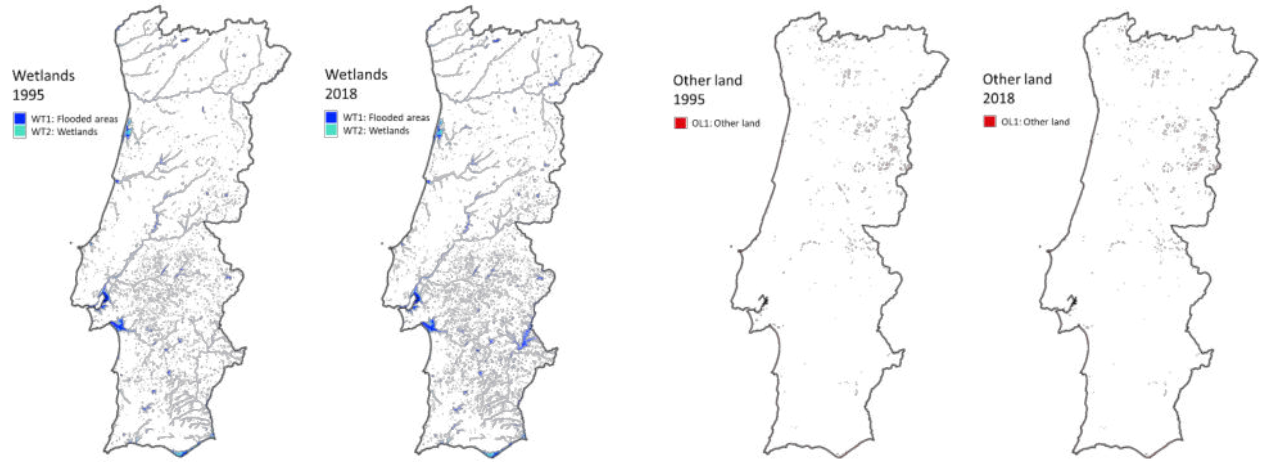



***Figure 6-6: Map of the mainland-uses in Mainland Portugal in 1995 and 2018 – Wetlands and Other Land***

Total land-use changes were compiled for the periods 1995-2007, 2007-2010, 2010-2015 and 2015-2018 by overlapping the respective land-use maps. The results were then annualised by dividing for the period between maps (respectively 12, 3, 5 and 3 years).

***Equation 6-1: Estimation of annual land-use change 1995-2018***

$$LUC_{x\to y[Y_i]} = \frac{LUC_{x\to y[1995-2007]}}{12}$$, $Y_i$ = any year in [1995-2007]

$$LUC_{x\to y[Y_i]} = \frac{LUC_{x\to y[2007-2010]}}{3}$$, $Y_i$ = any year in [2007-2010]

$$LUC_{x\to y[Y_i]} = \frac{LUC_{x\to y[2010-2015]}}{5}$$, $Y_i$ = any year in [2010-2015]

$$LUC_{x\to y[Y_i]} = \frac{LUC_{x\to y[2015-2018]}}{3}$$, $Y_i$ = any year in [2015-2018]

**Where:**

$LUC_{x\to y[Y_i]}$= Annual land-use change in Year i (ha $yr^{-1}$)

$LUC_{x\to y[1995-2007]}$= Total land-use change in the period 1995-2007 (ha)

$LUC_{x\to y[2007-2010]}$= Total land-use change in the period 2007-2010 (ha)

$LUC_{x\to y[2010-2015]}$= Total land-use change in the period 2010-2015 (ha)

$LUC_{x\to y[2015-2018]}$= Total land-use change in the period 2015-2018 (ha)

For the years following 2018, the land-use changes are assumed to be equal to those of the previous period, i.e. to the trends of 2015-2018.

#### 6.1.1.3.2 Period 1970-1995

Spatially explicit land-use information from the national land-use maps (COS) is available only from 1995 onwards. For the period prior to 1995, and starting in 1970, available information is more limited, heterogeneous across sources and generally provides estimates of total land areas rather than direct observations of land-use conversions. Consequently, the methodology applied for this period relies primarily on non-spatial information.

For forest land (FL1–FL8), the main source of information is the National Forest Inventories (NFIs), specifically IFN2 (1974), IFN3 (1985) and IFN4 (1995), which provide species-level estimates of forest area based on systematic field surveys.

However, differences exist between forest area estimates derived from the NFIs and those obtained from COS due to differences in data acquisition methods, spatial resolution and classification approaches. To ensure consistency between the historical NFI-based estimates and the COS-based time series from 1995 onwards, the following estimation methodology was used:

1. The linear trend for total forest area per species of IFN2 (1974) and IFN3 (1985) was applied to back cast an NFI estimate of total forest area per species in 1970;

| | 1970 | 1974 | 1985 |
|---|---|---|---|
| | estimated 74/85 | IFN2 | IFN3 |
| FL1 | 1 329 431 | 1 311 556 | 1 262 399 |

2. The "NFI" value for 1970 was then compared to the value in NFI 4 (1995) for the same species and a ratio between the 2 values was calculated;

| | 1970 | 1995 | ratio |
|---|---|---|---|
| | NIF estimate | IFN4 | 70/95 |
| FL1 | 1 329 431 | 986 532 | 1,348 |

3. This ratio was then applied to the COS 1995 forest area value to ensure a consistent value with the rest of the time series and a consistent trend with the observed values in the NFI.

| Forest NFI Data | 1995 | ratio | 1970 |
|---|---|---|---|
| | COS | 70/95 | final estimate |
| FL1 | 1 096 440 | 1,348 | 1 477 541 |

The COS is based on wall-to-wall remote sensing interpretation and provides spatially explicit land-use information for the entire national territory, enabling consistent tracking of land-use changes from 1995 onwards. In contrast, the NFIs provide detailed information on forest composition and structure but do not offer complete spatial coverage and therefore do not support geographically explicit tracking of land-use change. For the purposes of the LULUCF inventory, COS data are therefore used as the primary source for forest land area from 1995 onwards, while NFI information is used to reconstruct historical area estimates prior to 1995, ensuring temporal consistency across the time series in accordance with the IPCC principle of using the best available data.

This combined approach allows the inventory to maintain a consistent long-term trend based on field-derived forest statistics while providing spatially explicit representation of forest land for the period where such data are available.

A similar approach was used for CL1-CL6 "Cropland" but using as a basis for information the General Census of Agriculture from RGA (1979), RGA (1989) and RGA (1999).

However, there are also differences in total areas per land use in COS and RGA. To maintain time series consistency, the following estimation methodology was used:

1. The linear trend for total area 1979-1989 was applied was applied to backcast an RGA estimate of total cropland area per type in 1970;

| | 1970 | 1979 | 1989 |
|---|---|---|---|
| | estimated 79/89 | RGA | RGA |
| CL1 | 1 463 578 | 1 596 130 | 1 743 410 |

2. The linear trend for total area 1989-1999 was applied to interpolate an RGA estimate of total cropland area per type in 1995 (year of the first COS);

| | 1989 | 1999 | 1995 | |
|---|---|---|---|---|
| | RGA89 | RGA99 | estimated 89/99 | COS |
| CL1 | 1 743 410 | 1 093 437 | 1 353 426 | 1 301 933 |

3. The "RGA" value for 1970 was then compared to the value the "RGA" value for 1995 for the same cropland type and a ratio between the 2 values was calculated;

| | 1970 | 1995 | ratio |
|---|---|---|---|
| | RGA estimate | RGA estimate | 70/95 |
| CL1 | 1 463 578 | 1 353 426 | 1,081 |

4. This ratio was then applied to the COS 1995 cropland type area value to ensure a consistent value with the rest of the time series and a consistent trend with the observed values in the RGA.

| | 1995 | ratio | 1970 |
|---|---|---|---|
| | COS | 70/95 | final estimate |
| CL1 | 1 301 933 | 1,081 | 1 407 894 |

For GL1 "Pastures", ST1 "Settlements" and WT1 "Flooded Areas", the value for 1970 was backcasted from the trend obtained in the time series from COS 1995-2018.

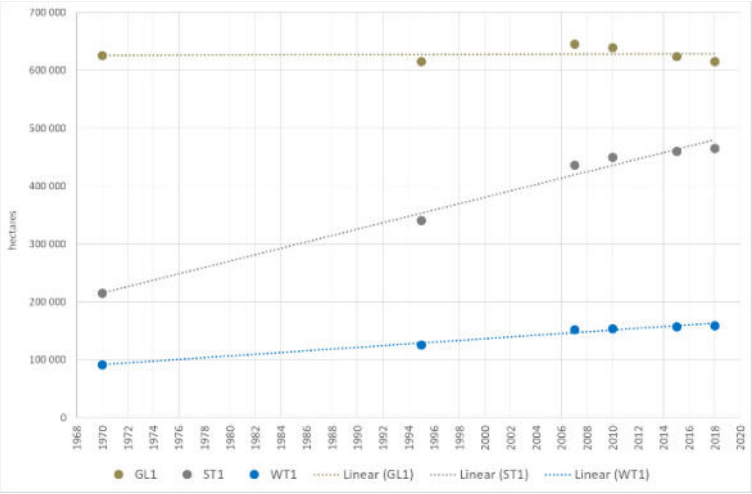



***Figure 6-7: Trend in GL1 "Pastures", ST1 "Settlements" and WT1 "Flooded Areas"***

For OL1 "Other Land", and WT2 "Other Wetlands", categories with small total areas and very low LUC in the period 1995/2018, the value for 1970 was assumed to be the same as in COS 1995.

Finally, totals for Mainland Portugal were maintained constant in the period 1970-1995 by adjusting the category GL2 "Shrubland". The results for the full time series 1970-2024 are presented in Figure 6-8.

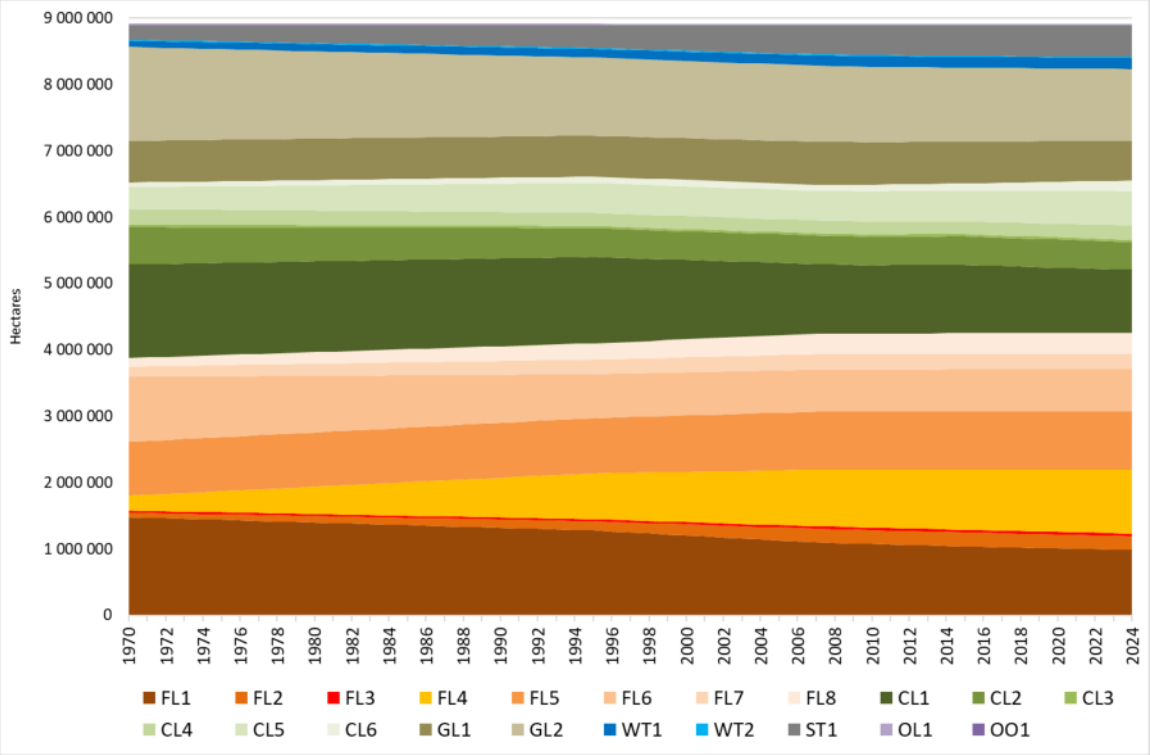



***Figure 6-8: Changes in total land-use in Mainland Portugal***

As mentioned above, land-use changes for the period 1970-1995 cannot be estimated separately for X→Y (e.g. gross afforestation) and Y→X (e.g. gross deforestation), as the only information available is the total of net-changes in area in each period, i.e. X→Y plus Y→X (e.g. net gains in forest area).

However, as the country's total remains constant over time, the total sum of net-gains in area of a particular set of land-uses needs to be equal to the net-losses in area of all other land-uses. This principle was applied to derive land-use change estimates for all land-uses using Equation 6-2.

***Equation 6-2: Estimation of land-use changes, when only net-changes in area are known***

$$LUC_{x\to y,Y_i} = \sum LUC_{x\to all,Y_i} \times \frac{\sum LUC_{all\to y,Y_i}}{\sum LUC_{all,Y_i}}$$

**Where:**

$LUC_{x\to y,Y_i}$ = Land-use change from land-use x to land-use y in Year i (ha);

$Y_i$ = Any year in the period [1970-1995[;

$\sum LUC_{x\to all,Y_i}$ = Net area loss of land-use type x in Year i (ha);

$\sum LUC_{all\to y,Y_i}$ = Net area gains of land-use type y in Year i (ha);

$\sum LUC_{all,Y_i}$ = Total land-use changes in Year i (ha).

The resulting annual land-use change matrices for this period are presented in Table 6-4.

***Table 6-4: Annual land-use changes (ha) in Mainland Portugal the period 1970-1995***

| 1970 \ 1995 | | CL | | | | | | FL | | | | | | | | GL | | OL | OO | ST | WT | | Annual Losses 1970 - 1995 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PT1 | | CL1 | CL2 | CL3 | CL4 | CL5 | CL6 | FL1 | FL2 | FL3 | FL4 | FL5 | FL6 | FL7 | FL8 | GL1 | GL2 | OL1 | OO1 | ST1 | WT1 | WT2 | | |
| CL | CL1 | | | | | 490,86 | 107,35 | 0,00 | 281,45 | 0,00 | 1 905,96 | 80,05 | 0,00 | 256,49 | 471,42 | 0,00 | 0,00 | 0,00 | 0,00 | 508,73 | 136,12 | 0,00 | 4 238,44 | 11 175,41 |
| | CL2 | | | | | 604,93 | 132,30 | 0,00 | 346,86 | 0,00 | 2 348,87 | 98,65 | 0,00 | 316,10 | 580,97 | 0,00 | 0,00 | 0,00 | 0,00 | 626,95 | 167,76 | 0,00 | 5 223,39 | |
| | CL3 | | | | | 27,10 | 5,93 | 0,00 | 15,54 | 0,00 | 105,23 | 4,42 | 0,00 | 14,16 | 26,03 | 0,00 | 0,00 | 0,00 | 0,00 | 28,09 | 7,52 | 0,00 | 234,02 | |
| | CL4 | | | | | 171,35 | 37,47 | 0,00 | 98,25 | 0,00 | 665,34 | 27,94 | 0,00 | 89,54 | 164,56 | 0,00 | 0,00 | 0,00 | 0,00 | 177,59 | 47,52 | 0,00 | 1 479,57 | |
| | CL5 | | | | | | | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | |
| | CL6 | | | | | | | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | |
| FL | FL1 | 0,00 | 0,00 | 0,00 | 0,00 | 918,18 | 200,80 | | 526,48 | | 3 565,20 | 149,74 | | 479,78 | 881,81 | 0,00 | 0,00 | 0,00 | 0,00 | 951,61 | 254,63 | 0,00 | 7 928,24 | 20 701,26 |
| | FL2 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | | | | | | | | | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | |
| | FL3 | 0,00 | 0,00 | 0,00 | 0,00 | 8,63 | 1,89 | | 4,95 | | 33,50 | 1,41 | | 4,51 | 8,29 | 0,00 | 0,00 | 0,00 | 0,00 | 8,94 | 2,39 | 0,00 | 74,50 | |
| | FL4 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | | | | | | | | | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | |
| | FL5 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | | | | | | | | | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | |
| | FL6 | 0,00 | 0,00 | 0,00 | 0,00 | 1 470,63 | 321,62 | | 843,25 | | 5 710,32 | 239,84 | | 768,46 | 1 412,38 | 0,00 | 0,00 | 0,00 | 0,00 | 1 524,18 | 407,83 | 0,00 | 12 698,52 | |
| | FL7 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | | | | | | | | | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | |
| | FL8 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | | | | | | | | | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | |
| GL | GL1 | 0,00 | 0,00 | 0,00 | 0,00 | 48,53 | 10,61 | 0,00 | 27,83 | 0,00 | 188,44 | 7,91 | 0,00 | 25,36 | 46,61 | | | 0,00 | 0,00 | 50,30 | 13,46 | 0,00 | 419,04 | 9 944,50 |
| | GL2 | 0,00 | 0,00 | 0,00 | 0,00 | 1 103,15 | 241,26 | 0,00 | 632,54 | 0,00 | 4 283,44 | 179,91 | 0,00 | 576,44 | 1 059,46 | | | 0,00 | 0,00 | 1 143,32 | 305,92 | 0,00 | 9 525,45 | |
| OL | OL1 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| OO | OO1 | 0,00 | 0,00 | 0,00 | 0,00 | -0,31 | -0,07 | 0,00 | -0,18 | 0,00 | -1,20 | -0,05 | 0,00 | -0,16 | -0,30 | 0,00 | 0,00 | 0,00 | | -0,32 | -0,09 | 0,00 | -2,67 | -2,67 |
| ST | ST1 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | | 0,00 | 0,00 | 0,00 | 0,00 |
| WT | WT1 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | | | 0,00 | 0,00 |
| | WT2 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | | | 0,00 | |
| Annual Gains 1970 - 1995 | | 0,00 | 0,00 | 0,00 | 0,00 | 4 843,04 | 1 059,17 | 0,00 | 2 776,97 | 0,00 | 18 805,10 | 789,83 | 0,00 | 2 530,68 | 4 651,24 | 0,00 | 0,00 | 0,00 | 0,00 | 5 019,40 | 1 343,07 | 0,00 | 41 818,49 | |
| | | 5 902,21 | | | | | | 29 553,82 | | | | | | | | 0,00 | | 0,00 | 0,00 | 5 019,40 | 1 343,07 | | | |

### 6.1.1.4 Autonomous Region of Azores and Autonomous Region of Madeira

For both the Azores and Madeira, the main sources of information available were:

1. Corine Land-Cover (CLC) (1990, 2000, 2006, 2012, 2018) – full wall-to-wall map
2. IFRAA (2007) – Regional Forest Inventory of the Autonomous Region of Azores
3. IFRAM (2004, 2010) – Regional Forest Inventory of the Autonomous Region of Madeira
4. RGA (1989, 1999, 2009) – General Census of Agriculture

The basis for the estimation of land-use and land-use change in the Azores and Madeira was CLC spatially explicit land-use change data (Approach 3). The minimum area considered in each individual map was 25 ha. All areas bigger than 1ha resulting from the interception of these maps were considered in subsequent analysis.

The interception of all CLC charts at the most detailed level showed considerable problems, most notably in the comparison of areas obtained by CLC and through other sources, like the IFRAA/IFRAM and the RGA. We decided not to use the full legend at that level. However, the match between sources largely improved at higher levels of legend aggregation. Therefore, the extensive CLC legend was converted into only 8 classes: “Cropland”; “Forest Land”; “Pastures”; “Shrubland”; “Settlements”; “Flooded Areas”; “Other Wetlands” and “Other Land”.

A further disaggregation into the 21 strata described in section 6.1.1.2, which are used as a basis for both UNFCCC and KP reporting, was made using the % distribution obtained from IFRAA/IFRAM or from the RGA.

For “Forest Land” the following estimation methodology was used:

1. The total area of forest land (in hectares) of CLC was used directly in the CLC reference years. In the remaining years total forest area was interpolated from the nearest CLCs. In addition, total area of forest was considered stable (i.e. no land-use change) in the period 1970-1990.
2. For the period 1970-2024 the following assumptions were made:
    a. In Madeira,
        i. the area per forest type in the period 1970-2003 was estimated from the annual total forest area multiplied by the share of that forest type in IFRAM 2004;

ii. the area per forest type in the period 2004-2010 was estimated from the annual total forest area multiplied by the share of that forest type interpolated from the shares in IFRAM 2004 and IFRAM 2010;
iii. the area per forest type in the period 2011-2024 was estimated from the annual total forest area multiplied by the share of that forest type in IFRAM 2010.

b. In the Azores,
   i. the area per forest type in the period 1970-2024 was estimated from the annual total forest area multiplied by the share of that forest type in IFRAA 2007.

For "Cropland" the following estimation methodology was used:

1. The total area of cropland (in hectares) of CLC was used directly in the CLC reference years. In the remaining years total forest area was interpolated from the nearest CLCs. In addition, total area of cropland was considered stable (i.e. no land-use change) in the period 1970-1990.
2. For the period 1970-2024 the following assumptions were made:
   a. In Madeira and in the Azores,
      i. the area per crop type in the period 1970-1989 was estimated from the annual total cropland area multiplied by the share of that crop type in RGA 1989;
      ii. the area per crop type in the period 1990-1999 was estimated from the annual total cropland area multiplied by the share of that crop type interpolated from RGA 1989 and RGA 1999;
      iii. the area per crop type in the period 2000-2009 was estimated from the annual total cropland area multiplied by the share of that crop type interpolated from RGA 1999 and RGA 2009;
      iv. the area per crop type in the period 2010-2024 was estimated from the annual total cropland area multiplied by the share of that crop type in RGA 2009.
3. The total area of all remaining land-uses (in hectares) of CLC were used directly in the CLC reference years. In the remaining years total area per land-use type was interpolated from the nearest CLCs. In addition, total area per land-use was considered stable (i.e. no land-use change) in the period 1970-1990.

The results for the full time series 1970-2024 are presented in Figure 6-9 for the Azores, and in Figure 6-10 for Madeira.

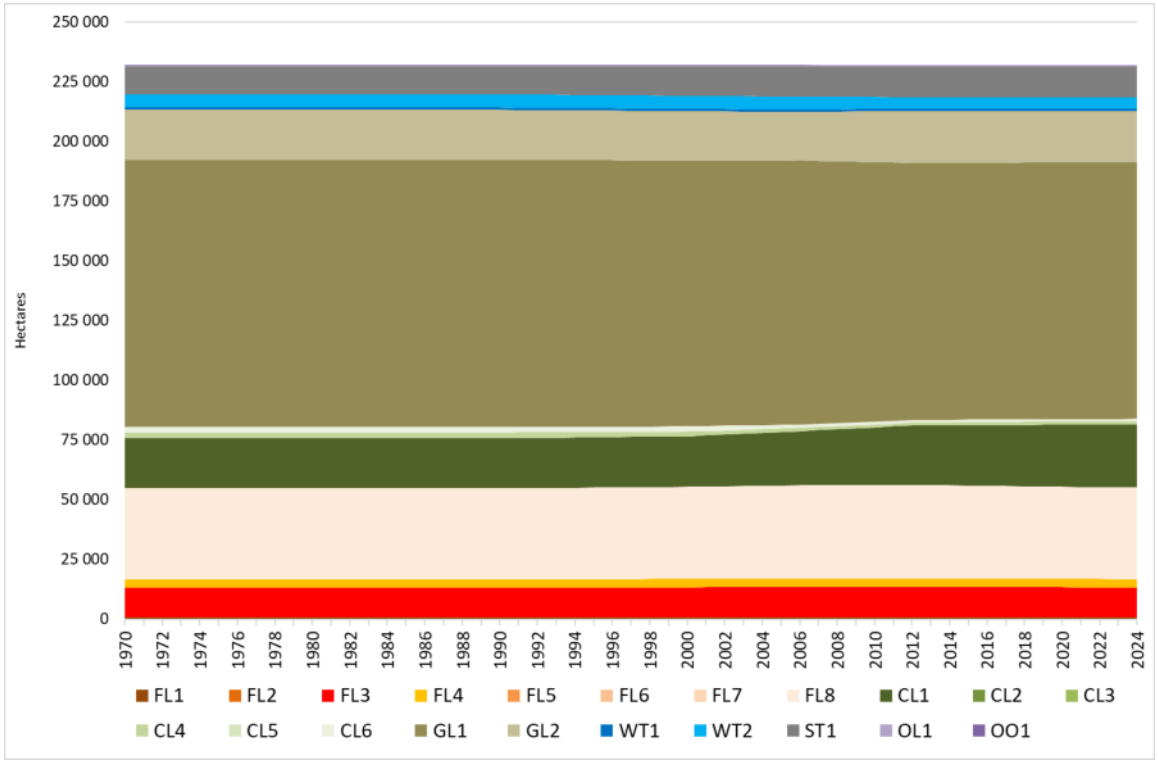



***Figure 6-9: Changes in total land-use in the Region of Azores***

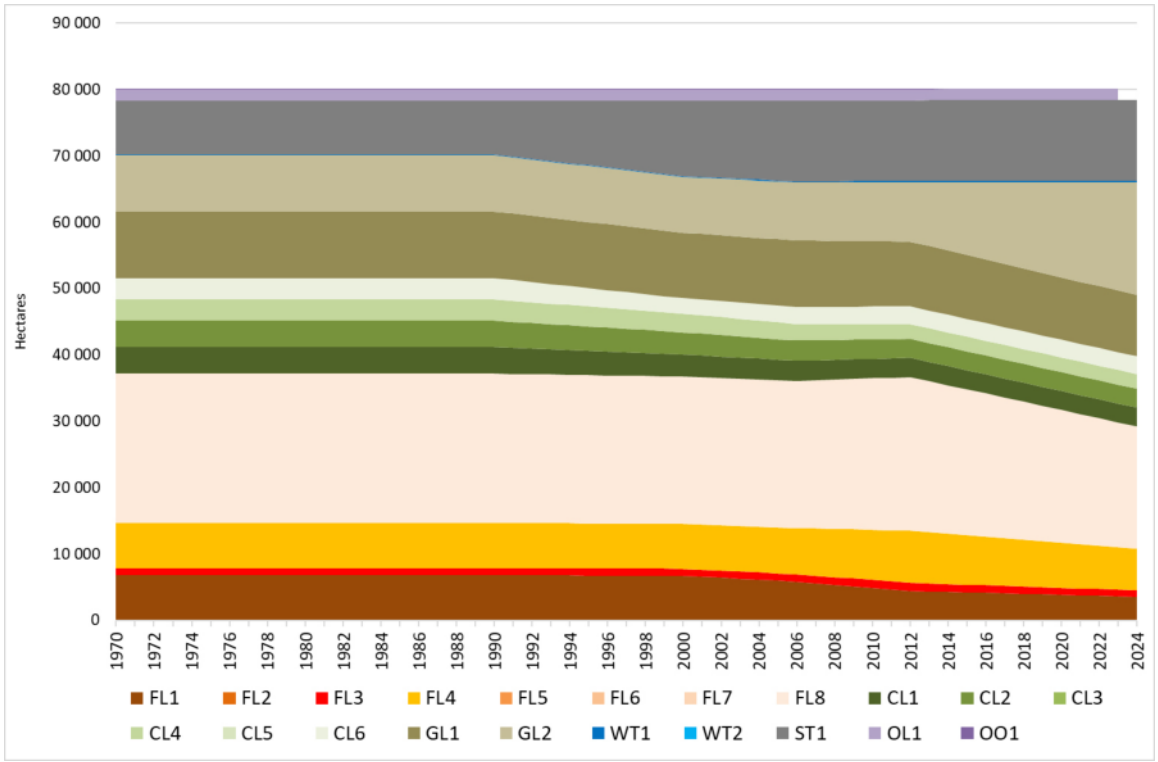



***Figure 6-10: Changes in total land-use in the Region of Madeira***

### 6.1.1.5 Overview of annual land-use estimates for Portugal

The compilation of the estimates for land-use in Portugal, derived from the sum of the estimates made for Mainland Portugal, Azores and Madeira, as outlined in the previous sections, is presented in Figure 6-11.

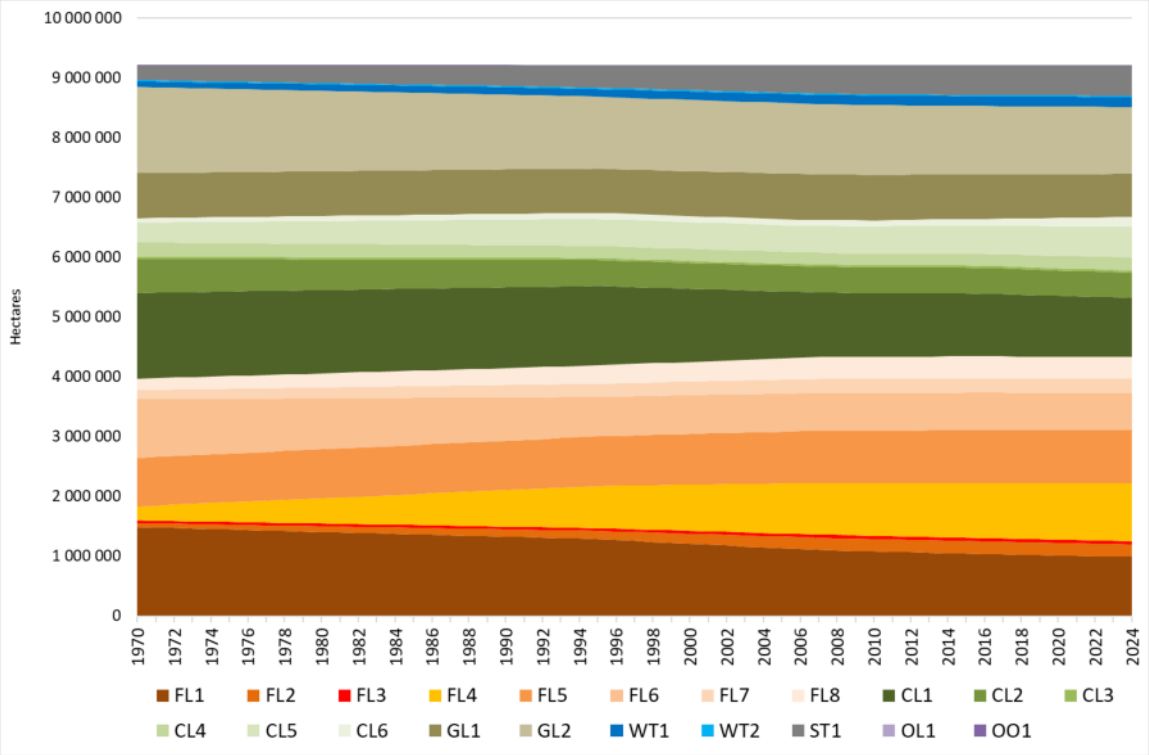



***Figure 6-11: Changes in total land-use in Portugal***

### 6.1.1.6 Allocation of land-use and land-use change to UNFCCC reporting categories

The allocation of each of the 21 land-use categories to each of the UNFCCC reporting categories was described in Table 6-3.

The allocation of land to the sub-categories land remaining land and land X converted to land Y was made using the annual land-use changes described in Table 6-4, assuming a 20 year conversion period, as shown in Equation 6-3.

***Equation 6-3: Estimation of land conversions for UNFCCC reporting***

$$LC_{y \to x,\, RY_i} = \sum_{i-20}^{i} ALUC_{y \to x,i}$$

**Where:**

$LC_{y \to x,\, RY_i}$ = Land Y converted to Land X in reporting year i (ha)

$ALUC_{y \to x,i}$ = Annual Land-use change from Y to X (ha)

The area of "land remaining land" categories was estimated by the difference between the total area of each land use in each year subtracted from the land under that land-use considered in transition, as shown in Equation 6-4.

***Equation 6-4: Estimation of Land remaining Land for UNFCCC reporting***

$$LRL_{x,\,RY_i} = TA_{x,\,RY_i} - LC_{y \to x,\,RY_i}$$

**Where:**

$LRL_{x,\,RY_i}$ = Land Y remaining Land X in reporting year i (ha)

$TA_{x,\,RY_i}$ = Total Reported Area of land-use X in reporting year I, as shown in Figure 6-11 (ha)

$LC_{y \to x,\,RY_i}$ = Land Y converted to Land X in reporting year i (ha)

Land conversions within each broad UNFCCC reporting categories (e.g. changes from FL1 Maritime Pine to FL4 Eucalyptus) were also estimated and used for estimating emissions and removals but were reported as "Land remaining Land" (in the previous example, as "forest land remaining forest land").

Although some lands may be considered as unmanaged (e.g. GL2 Shrubland; WT2 Other Wetlands; OL1 Other Land) the area and emissions estimates include the total of the territory.

The results of this exercise are presented in Figure 6-12.

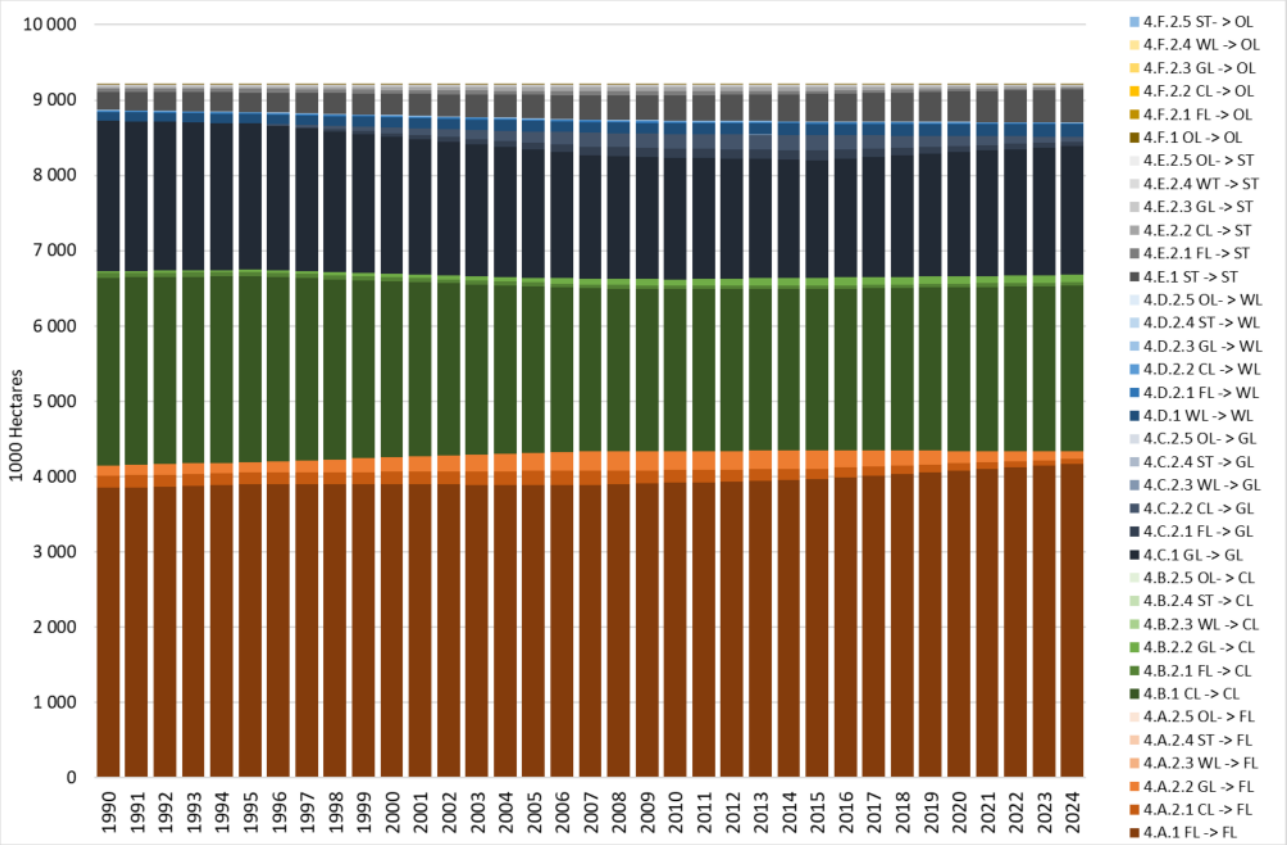



***Figure 6-12: Total areas per UNFCCC reporting categories***

## 6.1.2 Generic Methodologies and Information Sources applicable to multiple Land-Use Categories

### 6.1.2.1 Biomass and Carbon Stocks, Gains and Losses

#### 6.1.2.1.1 Forests (FL1-FL8)

Living biomass carbon stocks in Forest Land were estimated from standing volume by applying biomass conversion and expansion factors (BCEF), root-to-shoot (RTS) ratios, and carbon fraction (CF) values. Carbon stocks in above-ground biomass (AGB) and below-ground biomass (BGB) were calculated separately for each forest type using Equation 6-5 to Equation 6-6.

***Equation 6-5: Estimation of Carbon Stock in Above Ground Living Biomass in Forests***

$$C_{AGB\,f} = \sum_{y} AVol_{yf} \times BCEF_{y} \times CF_{y}$$

***Equation 6-6: Estimation of Carbon Stock in Below Ground Living Biomass in Forests***

$$C_{BGB\,f} = \sum_{y} AVol_{yf} \times BCEF_{y} \times RTS_{y} \times CF_{y}$$

**Where:**

$C_{AGB\,f}$ = Average Carbon Stock in Above Ground Biomass of forest type f (tC ha$^{-1}$)

$C_{BGB\,f}$ = Average Carbon Stock in Below Ground Biomass of forest type f (tC ha$^{-1}$)

$AVol_{yf}$ = Average Standing Volume of species y in forest type f (m³ ha$^{-1}$)

$BCEF_{y}$ = Biomass Conversion and Expansion Factor for forest species y (tDM m$^{-3}$)

$RTS_{y}$ = Root-to-Shoot Factor for species y

$CF_{y}$ = Carbon Fraction for species y (tC tDM$^{-1}$)

Total living biomass carbon stocks (ktC) for benchmark years were derived from the National Forest Inventory (NFI), disaggregated by forest type. The NFIs are based on a systematic sampling approach applied consistently across the national territory, ensuring representative and statistically robust estimates of standing volume, biomass and carbon stocks. This framework has been supported by national airborne aerial imagery coverages since 1995. While the methodology has evolved to incorporate additional variables, the core design principles (systematic sampling and field-based measurements) have been maintained, ensuring consistency and comparability over time. The benchmark values derived from the NFIs provide observed reference points for 1995, 2005 and 2015, as shown in Table 6-5.

***Table 6-5: Total Carbon Stocks and annual Growth Rates per Forest type***

| | | Increment | AGB Total C Stock | | | BGB Total C Stock | | |
|---|---|---|---|---|---|---|---|---|
| | | m³.ha$^{-1}$.y$^{-1}$ | NFI4 (1995) ktC | NFI5 (2005) ktC | NFI6 (2015) ktC | NFI4 (1995) ktC | NFI5 (2005) ktC | NFI6 (2015) ktC |
| FL1 | Maritime Pine | 4,5 | 27 327 | 23 688 | 18 301 | 7 652 | 6 633 | 5 124 |
| FL2 | Umbrella Pine | 3,0 | 4 336 | 3 778 | 4 554 | 173 | 151 | 182 |
| FL3 | Other Coniferous | 12,0 | 2 240 | 2 266 | 3 312 | 605 | 612 | 894 |
| FL4 | Eucalypts | 9,0 | 12 442 | 15 047 | 14 104 | 3 110 | 3 762 | 3 526 |
| FL5 | Cork Oak | 0,5 | 13 577 | 14 093 | 14 438 | 1 901 | 1 973 | 2 021 |
| FL6 | Holm Oak | 0,5 | 2 911 | 2 918 | 2 688 | 2 184 | 2 188 | 2 016 |
| FL7 | Other Oaks | 2,0 | 2 239 | 2 532 | 2 688 | 6 49 | 734 | 780 |
| FL8 | Other Broadleaves | 3,0 | 4 964 | 6 234 | 10 363 | 3 673 | 4 613 | 7 669 |

Between NFI benchmark years, forest biomass carbon stocks are updated annually using a mass-balance approach that accounts for: (i) gains from biomass growth; and losses from (ii) harvest/removals, (iii) deforestation (land converted out of Forest Land), and (iv) disturbances (including forest fires), consistent with the gain-loss framework described in the IPCC guidance.

Annual gains from growth are calculated by applying net annual increment. Growth rates were obtained by expert judgement, involving a number of different experts from forest authorities, forest owners' organisations and forest companies, and were assumed to be constant throughout the reporting period.

The biomass conversion parameters are derived directly from the most recent NFI6, which provides estimates of standing volume as well as AGB and BGB for each forest type. These values were used to calculate the biomass conversion and expansion factors (BCEF) and root-to-shoot ratios (RtS) applied in the biomass estimation equations. Specifically, BCEF values were calculated as the ratio between AGB and standing volume for each forest type, while RtS were derived as the ratio between BGB and AGB, as shown in Table 6-6Table 6-6.

***Table 6-6: Biomass estimates, Wood Volume, Biomass conversion factors, and Root-to-shoot ratios used.***

| | | AGB | BGB | Volume | BCEF | RtS |
|---|---|---|---|---|---|---|
| | | tDM | tDM | m3 | tDM/m3 | add. |
| **FL1** | Maritime Pine | 35 884 836 | 10 047 754 | 67 747 394 | 0.5297 | 0.28 |
| **FL2** | Umbrella Pine | 8 930 000 | 357 200 | 5 220 000 | 1.7107 | 0.04 |
| **FL3** | Other Coniferous | 6 494 013 | 1 753 384 | 12 167 730 | 0.5337 | 0.27 |
| **FL4** | Eucalypts | 29 382 453 | 7 345 613 | 45 791 797 | 0.6417 | 0.25 |
| **FL5** | Cork Oak | 30 080 000 | 4 211 200 | 25 380 000 | 1.1852 | 0.14 |
| **FL6** | Holm Oak | 5 600 000 | 4 200 000 | 6 970 000 | 0.8034 | 0.75 |
| **FL7** | Other Oaks | 5 600 000 | 1 624 000 | 5 740 000 | 0.9756 | 0.29 |
| **FL8** | Other Broadleaves | 21 589 800 | 15 976 452 | 23 605 514 | 0.9146 | 0.74 |
| | **Source** | NFI6 | NFI6 | NFI6 | AGB/Volume | BGB/AGB |

The carbon content of biomass per land-use type was assumed to be constant over time, and the default values from IPCC 2006 (51% for conifers and 48% for broadleaves) was used. These values are used to convert biomass estimates into Carbon estimates.

To ensure time-series consistency and to avoid artificial trends, annual gains and losses are reconciled to reproduce the observed total biomass carbon stocks reported in successive NFIs at each benchmark year. Where reported industrial roundwood removals do not fully explain the change in stocks between two benchmark years, an additional balancing component ("Other harvest/other losses") is calculated for each forest type and NFI period as the residual required for the annual stock balance to match the NFI benchmark stock at the end of the period. This component represents biomass losses not fully captured by reported industrial removals (e.g. non-industrial removals, unreported harvest, and/or natural mortality) and is kept constant within each NFI period. For years after the most recent NFI benchmark, average values from the historical NFI periods are applied by forest type until updated NFI data become available.

Biomass losses from forest fires were estimated and reported under disturbance-related categories (CRT Table 4(IV)) (see section 6.12), while gains and losses from forest land remaining forest land are reported in CRT Table 4.A. This allocation ensures that total carbon stock changes in living biomass are fully captured without double counting.

For land-use conversions involving categories where biomass carbon stocks vary with vegetation age and where age cannot be explicitly determined, particularly in early years of the time series or for areas that remained within the same land-use category until conversion, biomass carbon stock losses are estimated using the average carbon stock per hectare of the land-use category in the year of conversion. Average

carbon stocks per ha were derived annually from the ratio of total carbon stocks to total area for each category. Forest land total stocks are initialized using NFI data and updated annually using a mass-balance approach that accounts for growth, harvest, disturbances and land-use changes. This approach ensures consistency between carbon stocks reported for land remaining in the category and emissions from land-use conversions and provides a transparent proxy for age-dependent biomass losses when explicit age information is unavailable.

#### 6.1.2.1.2 Permanent Crops (CL4-CL6)

For permanent crops (CL4–CL6), biomass carbon stock changes are explicitly estimated. Data for carbon stocks and annual gains and losses in permanent crops were obtained from LIFE Project MediNet[5], which aimed to improve the transparency, consistency, comparability, completeness and accuracy of cropland and grassland reporting of emissions and removals in Mediterranean Countries.

The project focused on data collection and analysis from carbon and biomass assessments in Mediterranean Countries, mainly in Portugal, Italy and Spain. Based on these data, growth curves were derived for above-ground and below-ground biomass for Olive Orchards, Vineyards and Other Permanent Crops.

The carbon stock values are defined for each year after plantation and are presented in Table 6-7Table 6-7. Annual biomass carbon gains were derived from the difference between successive age-specific stock values and are presented in

Table 6-8. During the establishment phase, annual increments vary according to the age-dependent growth functions. After the establishment period, biomass dynamics are represented using a constant net annual increment corresponding to mature stand conditions.

***Table 6-7: Above and Below Ground Biomass in Permanent Crops, according to age after plantation***

| AGB | age of orchard | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C Stock | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 50 |
| CL4 | 0.18 | 0.25 | 0.34 | 0.48 | 0.65 | 0.89 | 1.18 | 1.56 | 2.00 | 2.50 | 3.04 | 3.59 | 4.11 | 4.59 | 5.00 | 5.33 | 5.59 | 5.80 | 5.95 | 6.06 | 6.35 |
| CL5 | 0.86 | 1.46 | 2.34 | 3.50 | 4.80 | 6.02 | 7.00 | 7.68 | 8.10 | 8.36 | 8.51 | 8.59 | 8.64 | 8.66 | 8.67 | 8.68 | 8.69 | 8.69 | 8.69 | 8.69 | 8.69 |
| CL6 | 1.79 | 2.30 | 2.88 | 3.53 | 4.21 | 4.89 | 5.53 | 6.11 | 6.62 | 7.03 | 7.36 | 7.62 | 7.82 | 7.97 | 8.09 | 8.17 | 8.23 | 8.27 | 8.31 | 8.33 | 8.39 |
| **BGB** | **age of orchard** | | | | | | | | | | | | | | | | | | | | |
| **C Stock** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** | **50** |
| CL4 | 0.34 | 0.45 | 0.59 | 0.76 | 0.96 | 1.19 | 1.45 | 1.72 | 1.98 | 2.24 | 2.47 | 2.66 | 2.83 | 2.97 | 3.07 | 3.16 | 3.22 | 3.27 | 3.30 | 3.33 | 3.40 |
| CL5 | 0.14 | 0.27 | 0.49 | 0.81 | 1.17 | 1.47 | 1.68 | 1.80 | 1.86 | 1.89 | 1.90 | 1.91 | 1.91 | 1.92 | 1.92 | 1.92 | 1.92 | 1.92 | 1.92 | 1.92 | 1.92 |
| CL6 | 0.79 | 1.04 | 1.34 | 1.68 | 2.06 | 2.45 | 2.83 | 3.19 | 3.50 | 3.76 | 3.97 | 4.14 | 4.27 | 4.36 | 4.43 | 4.48 | 4.52 | 4.55 | 4.57 | 4.58 | 4.62 |
| unit:tC/ha | | | | | | | | | | | | | | | | | | | | | |

***Table 6-8: Carbon Stock Annual Gains in Above and Below Ground Biomass in Permanent Crops, according to age after plantation***

| AGB | age of orchard | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C Stock Gains | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 50 |
| CL4 | 0.18 | 0.07 | 0.09 | 0.14 | 0.17 | 0.24 | 0.29 | 0.38 | 0.44 | 0.50 | 0.54 | 0.55 | 0.52 | 0.48 | 0.41 | 0.33 | 0.26 | 0.21 | 0.15 | 0.11 | 0.01 |
| CL5 | 0.86 | 0.60 | 0.88 | 1.16 | 1.30 | 1.22 | 0.98 | 0.68 | 0.42 | 0.26 | 0.15 | 0.08 | 0.05 | 0.02 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| CL6 | 1.79 | 0.51 | 0.58 | 0.65 | 0.68 | 0.68 | 0.64 | 0.58 | 0.51 | 0.41 | 0.33 | 0.26 | 0.20 | 0.15 | 0.12 | 0.08 | 0.06 | 0.04 | 0.04 | 0.02 | 0.00 |
| **BGB** | **age of orchard** | | | | | | | | | | | | | | | | | | | | |
| **C Stock Gains** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** | **50** |
| CL4 | 0.34 | 0.11 | 0.14 | 0.17 | 0.20 | 0.23 | 0.26 | 0.27 | 0.26 | 0.26 | 0.23 | 0.19 | 0.17 | 0.14 | 0.10 | 0.09 | 0.06 | 0.05 | 0.03 | 0.03 | 0.00 |
| CL5 | 0.14 | 0.13 | 0.22 | 0.32 | 0.36 | 0.30 | 0.21 | 0.12 | 0.06 | 0.03 | 0.01 | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CL6 | 0.79 | 0.25 | 0.30 | 0.34 | 0.38 | 0.39 | 0.38 | 0.36 | 0.31 | 0.26 | 0.21 | 0.17 | 0.13 | 0.09 | 0.07 | 0.05 | 0.04 | 0.03 | 0.02 | 0.01 | 0.00 |
| unit:tC/ha/y | | | | | | | | | | | | | | | | | | | | | |

[5] https://webgate.ec.europa.eu/life/publicWebsite/project/LIFE15-PRE-IT-000001/mediterranean-network-for-reporting-emissions-and-removals-in-cropland-and-grassland

The "Above Ground Biomass" mentioned above relates to the total biomass after pruning. In addition to those, gains and losses in biomass related to pruning were also considered, with the assumption that biomass removed in each year by pruning is equal to an equivalent growth in the same year. It is also assumed that pruning growth and losses do not affect below ground biomass. The values used are shown in Table 6-9.

***Table 6-9: Carbon Stock Annual Gains and Losses related to pruning of Above Ground Biomass in Permanent crops, according to age after plantation***

| AGB | age of orchard | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pruning Gains | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 50 |
| CL4 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 |
| CL5 | 0.35 | 0.46 | 0.59 | 0.74 | 0.91 | 1.07 | 1.24 | 1.39 | 1.52 | 1.63 | 1.72 | 1.79 | 1.84 | 1.88 | 1.90 | 1.93 | 1.94 | 1.95 | 1.96 | 1.98 | 1.96 |
| CL6 | 0.42 | 0.52 | 0.63 | 0.74 | 0.86 | 0.97 | 1.08 | 1.17 | 1.25 | 1.32 | 1.38 | 1.43 | 1.46 | 1.49 | 1.52 | 1.53 | 1.55 | 1.55 | 1.56 | 1.58 | 1.56 |
| AGB | age of orchard | | | | | | | | | | | | | | | | | | | | |
| Pruning Losses | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 50 |
| CL4 | -0.45 | -0.45 | -0.45 | -0.45 | -0.45 | -0.45 | -0.45 | -0.45 | -0.45 | -0.45 | -0.45 | -0.45 | -0.45 | -0.45 | -0.45 | -0.45 | -0.45 | -0.45 | -0.45 | -0.45 | -0.45 |
| CL5 | -0.35 | -0.46 | -0.59 | -0.74 | -0.91 | -1.07 | -1.24 | -1.39 | -1.52 | -1.63 | -1.72 | -1.79 | -1.84 | -1.88 | -1.90 | -1.93 | -1.94 | -1.95 | -1.96 | -1.98 | -1.96 |
| CL6 | -0.42 | -0.52 | -0.63 | -0.74 | -0.86 | -0.97 | -1.08 | -1.17 | -1.25 | -1.32 | -1.38 | -1.43 | -1.46 | -1.49 | -1.52 | -1.53 | -1.55 | -1.55 | -1.56 | -1.58 | -1.56 |
| unit:tC/ha/y | | | | | | | | | | | | | | | | | | | | | |

For land-use conversions involving permanent crops, biomass carbon stock losses are estimated using the annually updated average biomass carbon stock of the category in the year of conversion. This approach is consistent with the methodology applied for forest land when age-specific spatial information is not available.

#### 6.1.2.1.3 Shrublands (GL2)

For estimating Above Ground Biomass, the model proposed by Olson (1963) and adjusted for Portugal by Rosa (2009) was used.

***Equation 6-7: Estimation of Above Ground Living Biomass in Shrubland***

$$AGB_s = 18.86 \times (1 - e^{-0.23t}) \times CF_s$$

**Where:**

$AGB_s$ = Average Above Ground Biomass of shrubs (t C/ha)

$t$ = time in years

$CF_s$ = Carbon Fraction for shrubs (tC $tDM^{-1}$)

The IPCC 2006 default value for Carbon Fraction was used (47%). A constant Root-to-Shoot factor of 0.563 was used to estimate below ground biomass. The application of the equation above resulted in the Carbon Stocks referred to in Table 6-10, and in the Carbon Stock Gains referred to in

Table 6-11.

***Table 6-10: Above and Below Ground Biomass in Shrublands, according to age***

| AGB | age of shrubland | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C Stock | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 50 |
| GL2 | 1.82 | 3.27 | 4.42 | 5.33 | 6.06 | 6.63 | 7.09 | 7.46 | 7.75 | 7.98 | 8.16 | 8.30 | 8.42 | 8.51 | 8.58 | 8.64 | 8.69 | 8.72 | 8.75 | 8.78 | 8.86 |
| BGB | age of shrubland | | | | | | | | | | | | | | | | | | | | |
| C Stock | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 50 |
| GL2 | 1.03 | 1.84 | 2.49 | 3.00 | 3.41 | 3.74 | 3.99 | 4.20 | 4.36 | 4.49 | 4.59 | 4.67 | 4.74 | 4.79 | 4.83 | 4.86 | 4.89 | 4.91 | 4.93 | 4.94 | 4.99 |
| unit:tC/ha/y | | | | | | | | | | | | | | | | | | | | | |

***Table 6-11: Carbon stock annual gains in Above and Below Ground Biomass in Shrublands, according to age***

| AGB | age of shrubland | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C Stock Gains | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 50 |
| GL2 | 1.821 | 1.447 | 1.150 | 0.914 | 0.726 | 0.577 | 0.458 | 0.364 | 0.289 | 0.230 | 0.183 | 0.145 | 0.115 | 0.092 | 0.073 | 0.058 | 0.046 | 0.036 | 0.029 | 0.023 | 0.003 |
| BGB | age of shrubland | | | | | | | | | | | | | | | | | | | | |
| C Stock Gains | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 50 |
| GL2 | 1.025 | 0.815 | 0.647 | 0.514 | 0.409 | 0.325 | 0.258 | 0.205 | 0.163 | 0.129 | 0.103 | 0.082 | 0.065 | 0.052 | 0.041 | 0.033 | 0.026 | 0.021 | 0.016 | 0.013 | 0.002 |
| unit:tC/ha/y | | | | | | | | | | | | | | | | | | | | | |

For land-use conversions involving shrublands, biomass carbon stocks losses are estimated using the annually updated average biomass carbon stock of the category in the year of conversion. This approach is used when age-specific information for individual land-use polygons is not available.

#### 6.1.2.1.4 Annual Crops (CL1-CL3), Pastures (GL1) and Other Wetlands (WT2)

Data of biomass stocks was obtained from the *EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019*, (Chapter 11B, Table 2.1). Values for CL1-CL3 were taken from the category "Grassland vegetated by annual grasses and forbs", for GL1 from "Grassland vegetated by perennial grasses and forbs" and for WT2 from "Inland and coastal marshes". Data on biomass was converted to Carbon Stocks by using the default IPCC 2006 value of 47%.

Default values for Root-to-Shoot from *IPCC 2006 Guidelines* (Vol 4, 11, Table 11.2) were used, with the value for CL1-CL3 taken from "Grains", and the values for GL1 and WT2 from "Perennial grasses".

For annual crops and pastures, the assumption was made that this biomass is renewed annually, which means that stocks, annual gains and annual losses all share the same value. For Other Wetlands it was assumed that the biomass took the default 20 years period to accumulate and, hence, gains and losses equal 1/20 of the total stock, in wetlands under 20 years, and are zero after 20 years.

***Table 6-12: Above and Below Ground Biomass and Annual Carbon Stock Gains and Losses in Annual Crops, Pastures and Other Wetlands.***

| tC | AGB | | | BGB | | |
|---|---|---|---|---|---|---|
| | Stock | Gains | Losses | Stock | Gains | Losses |
| CL1 | 0.31 | 0.31 | -0.31 | 0.07 | 0.07 | -0.07 |
| CL2 | 0.31 | 0.31 | -0.31 | 0.07 | 0.07 | -0.07 |
| CL3 | 0.31 | 0.31 | -0.31 | 0.07 | 0.07 | -0.07 |
| GL1 | 0.26 | 0.26 | -0.26 | 0.21 | 0.21 | -0.21 |
| WT2 <20 years | | 0.11 | | | 0.08 | |
| WT2 >20 years | 2.11 | | | 1.68 | | |
| unit:tC/ha/y | | | | | | |

#### 6.1.2.1.5 Other land uses (WT1, ST1, OL1, OO1)

For other land-uses no country specific or literature values were found. It is assumed that biomass stocks are zero.

### 6.1.2.2 Litter

Litter data are not available from the NFIs or from any other official data source. As an alternative, "typical" litter C stocks were based on Rosa (2009), who used these values to estimate fire emissions from litter. This information was complemented, for non-forest land-uses, with default data from the *EMEP/EEA Emission Inventory Guidebook 2019* (Chapter 11B Table 2-1). Constant litter Carbon Stocks were assumed for land remaining in the same land use, and changes in litter Carbon Stocks were estimated only in cases of land-use change. The values used are shown in Table 6-13.

***Table 6-13: Litter Carbon Stocks at maturity by land-use***

| Litter C Stock | |
|---|---|
| **FL1** | 3.0 |
| **FL2** | 2.4 |
| **FL3** | 3.0 |
| **FL4** | 1.9 |
| **FL5** | 2.0 |
| **FL6** | 2.0 |
| **FL7** | 1.9 |
| **FL8** | 1.9 |
| **CL1** | 0.3 |
| **CL2** | 0.3 |
| **CL3** | 0.3 |
| **CL4** | 0.3 |
| **CL5** | 0.3 |
| **CL6** | 0.3 |
| **GL1** | 0.4 |
| **GL2** | 1.1 |
| **WT1** | 0.0 |
| **WT2** | 0.0 |
| **ST1** | 0.0 |
| **OL1** | 0.0 |
| **OO1** | 0.0 |
| **unit** | tC/ha |

Litter emission/sequestration factors were then calculated for all land-use transitions based on the difference in average litter Carbon Stocks between land-use and an assumed conversion period, as shown in Equation 6-8. A default conversion period of 20 years was applied for all land-use transitions, except land converted to Settlements, where carbon losses from litter are assumed to occur entirely in the year of conversion, in accordance with the *2006 IPCC Guidelines*.

***Equation 6-8: Estimation of Litter emission factors for all land use-changes***

$$LEF_{x \to y} = \frac{ALC_y - ALC_x}{T}$$

**Where:**

$LEF_{x \to y}$ = Litter Emission Factor for Land-use Change from x to y (tC ha$^{-1}$ yr$^{-1}$)

$ALC_y$ = Average Litter Carbon Stock in Land Use y (tC ha$^{-1}$)

$ALC_x$ = Average Litter Carbon Stock in Land Use x (tC ha$^{-1}$).

$T$ = Conversion period (yr); a default value of 20 years is applied for most land-use transitions, while 1 year is used for conversions to Settlements.

The resulting annual emission and sequestration factors for litter associated with land-use changes are presented in

Table 6-14.

***Table 6-14: Annual emission/sequestration factors for Litter***

| Litter EF | | to | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FL1 | FL2 | FL3 | FL4 | FL5 | FL6 | FL7 | FL8 | CL1 | CL2 | CL3 | CL4 | CL5 | CL6 | GL1 | GL2 | WT1 | WT2 | ST1* | OL1 | OO1 |
| from | FL1 | 0.00 | -0.03 | 0.00 | -0.06 | -0.05 | -0.05 | -0.06 | -0.06 | -0.14 | -0.14 | -0.14 | -0.14 | -0.14 | -0.14 | -0.13 | -0.10 | -0.15 | -0.15 | -3.00 | -0.15 | -0.15 |
| | FL2 | 0.03 | 0.00 | 0.03 | -0.03 | -0.02 | -0.02 | -0.03 | -0.03 | -0.11 | -0.11 | -0.11 | -0.11 | -0.11 | -0.11 | -0.10 | -0.07 | -0.12 | -0.12 | -2.40 | -0.12 | -0.12 |
| | FL3 | 0.00 | -0.03 | 0.00 | -0.06 | -0.05 | -0.05 | -0.06 | -0.06 | -0.14 | -0.14 | -0.14 | -0.14 | -0.14 | -0.14 | -0.13 | -0.10 | -0.15 | -0.15 | -3.00 | -0.15 | -0.15 |
| | FL4 | 0.06 | 0.03 | 0.06 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | -0.08 | -0.08 | -0.08 | -0.08 | -0.08 | -0.08 | -0.08 | -0.04 | -0.10 | -0.10 | -1.90 | -0.10 | -0.10 |
| | FL5 | 0.05 | 0.02 | 0.05 | -0.01 | 0.00 | 0.00 | -0.01 | -0.01 | -0.09 | -0.09 | -0.09 | -0.09 | -0.09 | -0.09 | -0.08 | -0.05 | -0.10 | -0.10 | -2.00 | -0.10 | -0.10 |
| | FL6 | 0.05 | 0.02 | 0.05 | -0.01 | 0.00 | 0.00 | -0.01 | -0.01 | -0.09 | -0.09 | -0.09 | -0.09 | -0.09 | -0.09 | -0.08 | -0.05 | -0.10 | -0.10 | -2.00 | -0.10 | -0.10 |
| | FL7 | 0.06 | 0.03 | 0.06 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | -0.08 | -0.08 | -0.08 | -0.08 | -0.08 | -0.08 | -0.08 | -0.04 | -0.10 | -0.10 | -1.90 | -0.10 | -0.10 |
| | FL8 | 0.06 | 0.03 | 0.06 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | -0.08 | -0.08 | -0.08 | -0.08 | -0.08 | -0.08 | -0.08 | -0.04 | -0.10 | -0.10 | -1.90 | -0.10 | -0.10 |
| | CL1 | 0.14 | 0.11 | 0.14 | 0.08 | 0.09 | 0.09 | 0.08 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.04 | -0.02 | -0.02 | -0.30 | -0.02 | -0.02 |
| | CL2 | 0.14 | 0.11 | 0.14 | 0.08 | 0.09 | 0.09 | 0.08 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.04 | -0.02 | -0.02 | -0.30 | -0.02 | -0.02 |
| | CL3 | 0.14 | 0.11 | 0.14 | 0.08 | 0.09 | 0.09 | 0.08 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.04 | -0.02 | -0.02 | -0.30 | -0.02 | -0.02 |
| | CL4 | 0.14 | 0.11 | 0.14 | 0.08 | 0.09 | 0.09 | 0.08 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.04 | -0.02 | -0.02 | -0.30 | -0.02 | -0.02 |
| | CL5 | 0.14 | 0.11 | 0.14 | 0.08 | 0.09 | 0.09 | 0.08 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.04 | -0.02 | -0.02 | -0.30 | -0.02 | -0.02 |
| | CL6 | 0.14 | 0.11 | 0.14 | 0.08 | 0.09 | 0.09 | 0.08 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.04 | -0.02 | -0.02 | -0.30 | -0.02 | -0.02 |
| | GL1 | 0.13 | 0.10 | 0.13 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | -0.01 | -0.01 | -0.01 | -0.01 | -0.01 | -0.01 | 0.00 | 0.04 | -0.02 | -0.02 | -0.40 | -0.02 | -0.02 |
| | GL2 | 0.10 | 0.07 | 0.10 | 0.04 | 0.05 | 0.05 | 0.04 | 0.04 | -0.04 | -0.04 | -0.04 | -0.04 | -0.04 | -0.04 | -0.04 | 0.00 | -0.06 | -0.06 | -1.10 | -0.06 | -0.06 |
| | WT1 | 0.15 | 0.12 | 0.15 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | WT2 | 0.15 | 0.12 | 0.15 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | ST1 | 0.15 | 0.12 | 0.15 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | OL1 | 0.15 | 0.12 | 0.15 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | OO1 | 0.15 | 0.12 | 0.15 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **unit** tC/ha/year | | | | | | | | | | | | | | | | | | | | | | |
| Conversion period of 20 years assumed for all transitions, except to ST1* where it is 1 year. | | | | | | | | | | | | | | | | | | | | | | |

### 6.1.2.3 Soil C Stock data

Data for soils and soil emission factors are derived from measurements obtained from three data sets: Measurements made over the ICP Forests grid (1995 and 2005); Project Biosoil (1999); LUCAS soil assessment (2009).

Within the framework of the NFI6, the inclusion of a soil inventory module, including soil organic carbon assessment, was foreseen during the planning phase. However, this module has not yet been implemented and no soil data from NFI were available for use in the present inventory submission. Consequently, soil carbon estimates continue to rely on the existing datasets, consistent with the *2006 IPCC Guidelines*.

Measurements were conducted in forest areas over the ICP Forest Sampling Grid in 1995 and repeated for the same plots in 2005. An additional project carried out in 1999 expanded the ICP Forests grid to agriculture and grassland plots. LUCAS was a project conducted by EUROSTAT that collected soil samples across Europe, including Portugal. Samples were collected at 0–20 cm depth for all sites, and at 20–40 cm depth for a subset of plots. A summary of the number of plots by land use and soil depth is presented in Table 6-15.

***Table 6-15: Number of sample plots per land-use and soil depth***

| No. Plots C(0-20cm) (measured) | Source | | | | Total |
|---|---|---|---|---|---|
| | LUCAS | ICP/Biosoil | | | |
| Legenda KP | 2009 | 1995/99 | 2005 | Total | |
| 01. Pinus pinaster | 54 | 41 | 12 | 53 | **107** |
| 02. Quercus suber | 57 | 42 | 37 | 79 | **136** |
| 03. Eucalyptus | 46 | 21 | 8 | 29 | **75** |
| 04. Quercus rotundifolia | 30 | 25 | 23 | 48 | **78** |
| 05. Other quercus | 10 | 4 | 4 | 8 | **18** |
| 06. Other broadleaves | 5 | 19 | 17 | 36 | **41** |
| 07. Pinus pinea + 08. Other coniferous | 4 | 2 | 1 | 3 | **7** |
| 09. Rain-fed crops | 78 | 21 | | 21 | **99** |
| 10. Irrigated crops + 11. Rice | 22 | 26 | | 26 | **48** |
| 12. Vineyards | 22 | 14 | | 14 | **36** |
| 13. Olive | 39 | 12 | | 12 | **51** |
| 14. Other permanent | 11 | 11 | | 11 | **22** |
| 15. Grassland | 42 | 18 | | 18 | **60** |
| 17. Settlements | 7 | | | | **7** |
| 18. Shrubland | 36 | 5 | 1 | 6 | **42** |
| Total | 463 | 261 | 103 | 364 | 828 |

| No. Plots C(20-40cm) (measured) | Source | | | | Total |
|---|---|---|---|---|---|
| | LUCAS | ICP/Biosoil | | | |
| Legenda KP | 2009 | 1995/99 | 2005 | Total | |
| 01. Pinus pinaster | 0 | 1 | 12 | 13 | **13** |
| 02. Quercus suber | 0 | 3 | 35 | 38 | **38** |
| 03. Eucalyptus | 0 | | 8 | 8 | **8** |
| 04. Quercus rotundifolia | 0 | | 21 | 21 | **21** |
| 05. Other quercus | 0 | | 4 | 4 | **4** |
| 06. Other broadleaves | 0 | 1 | 17 | 18 | **18** |
| 07. Pinus pinea + 08. Other coniferous | 0 | 1 | 1 | 2 | **2** |
| 09. Rain-fed crops | 0 | 21 | | 21 | **21** |
| 10. Irrigated crops + 11. Rice | 0 | 25 | | 25 | **25** |
| 12. Vineyards | 0 | 14 | | 14 | **14** |
| 13. Olive | 0 | 12 | | 12 | **12** |
| 14. Other permanent | 0 | 11 | | 11 | **11** |
| 15. Grassland | 0 | 15 | | 15 | **15** |
| 17. Settlements | 0 | | | | |
| 18. Shrubland | 0 | 5 | 1 | 6 | **6** |
| Total | 0 | 109 | 99 | 208 | 208 |

***Table 6-16: Average C Stock measured per land-use and soil depth***

| Average C (0-20cm) ton/ha (measured) | Source | | | | Total Average |
|---|---|---|---|---|---|
| | LUCAS | ICP/Biosoil | | | |
| Legenda KP | 2009 | 1995/99 | 2005 | Average | |
| 01. Pinus pinaster | **70** | 73 | 72 | **72** | **71** |
| 02. Quercus suber | **46** | 43 | 40 | **41** | **43** |
| 03. Eucalyptus | **75** | 41 | 41 | **41** | **62** |
| 04. Quercus rotundifolia | **41** | 43 | 45 | **44** | **43** |
| 05. Other quercus | **58** | 51 | 52 | **52** | **55** |
| 06. Other broadleaves | **71** | 66 | 63 | **64** | **65** |
| 07. Pinus pinea + 08. Other coniferous | **74** | 25 | 64 | **38** | **58** |
| 09. Rain-fed crops | **40** | 27 | | **27** | **37** |
| 10. Irrigated crops + 11. Rice | **39** | 39 | | **39** | **39** |
| 12. Vineyards | **36** | 24 | | **24** | **31** |
| 13. Olive | **49** | 33 | | **33** | **45** |
| 14. Other permanent | **44** | 26 | | **26** | **35** |
| 15. Grassland | **43** | 30 | | **30** | **39** |
| 17. Settlements | **55** | | | | **55** |
| 18. Shrubland | **70** | 52 | 88 | **58** | **68** |
| Média global | **52** | 44 | 50 | **46** | **49** |

| Average C (0-40cm) ton/ha (measured) | Source | | | | |
|---|---|---|---|---|---|
| | LUCAS | ICP/Biosoil | | | |
| Legenda KP | 20-40cm | 0-20cm | 20-40cm | 0-40cm | 40/20cm |
| 01. Pinus pinaster | | 77 | 45 | **122** | 59% |
| 02. Quercus suber | | 38 | 15 | **53** | 40% |
| 03. Eucalyptus | | 41 | 26 | **67** | 63% |
| 04. Quercus rotundifolia | | 44 | 15 | **59** | 35% |
| 05. Other quercus | | 52 | 39 | **91** | 74% |
| 06. Other broadleaves | | 60 | 45 | **105** | 75% |
| 07. Pinus pinea + 08. Other coniferous | | 46 | 28 | **74** | 62% |
| 09. Rain-fed crops | | 27 | 19 | **46** | 71% |
| 10. Irrigated crops + 11. Rice | | 37 | 28 | **65** | 74% |
| 12. Vineyards | | 24 | 16 | **40** | 69% |
| 13. Olive | | 33 | 20 | **53** | 61% |
| 14. Other permanent | | 26 | 16 | **42** | 61% |
| 15. Grassland | | 33 | 18 | **51** | 54% |
| 17. Settlements | | | | | |
| 18. Shrubland | | 58 | 33 | **91** | 58% |
| Grand Total | | 41 | 24 | **64** | 58% |

For the 208 plots where both 0–20 cm and 20–40 cm measurements were available, the ratio between carbon stocks at the two depths was calculated and used to estimate missing values for plots where only 0–20 cm samples were collected. Given the relatively limited number of plots and the lack of detailed land-use history for individual sites, these data were used only to characterize the average carbon stock in each land-use.

For categories with a low number of data points or no national data, the following assumptions were applied: for Settlements (ST1), soil carbon stocks were assumed to decrease by 20% relative to the preceding land-use category prior to conversion, consistent with the *2006 IPCC Guidelines*; for Flooded Areas (WT1) and Oceans (OO1) a Carbon Stock of zero was assumed; for Other Wetlands (WT2), default values of *2006 IPCC Guidelines* for Wetland Soils in Warm Temperate Climates (Vol 4, Chapter 2, Table 2.3) were applied; for Other land (OL1) the default values from IPCC 2006 Guidelines for Sandy Soils in Warm Temperate Climates, representing average for Dry and Moist (Vol 4, Chapter 2, Table 2.3) were used. The values used are presented in Table 6-17.

***Table 6-17: Average Soil C Stock 0-40 cm per land-use***

| Soil C Stock | |
|---|---|
| **FL1** | 113.0 |
| **FL2** | 93.0 |
| **FL3** | 93.0 |
| **FL4** | 98.0 |
| **FL5** | 66.0 |
| **FL6** | 65.0 |
| **FL7** | 89.0 |
| **FL8** | 107.0 |
| **CL1** | 59.0 |
| **CL2** | 64.0 |
| **CL3** | 64.0 |
| **CL4** | 51.0 |
| **CL5** | 71.0 |
| **CL6** | 56.0 |
| **GL1** | 61.0 |
| **GL2** | 107.0 |
| **WT1** | 0.0 |
| **WT2** | 88.0 |
| **OL1** | 27.0 |
| **OO1** | 0.0 |
| **unit** | tC/ha |

Soil emission/sequestration factors were calculated for all possible land-use changes based on the differences in average soil carbon stocks between land uses, assuming a 20-year conversion period, as shown in Equation 6-9. An exception applies to transitions to Settlements (ST1), for which soil Carbon Stocks were assumed to be 80% of the preceding land-use stock, reflecting a 20% loss upon conversion in accordance with the *2006 IPCC Guidelines*.

***Equation 6-9: Estimation of Soil emission factors***

$$SEF_{x \to y} = \frac{ASC_y - ASC_x}{20}$$

**Where:**

$SEF_{x \to y}$ = Soil Emission Factor for Land-use Change from x to y (tC ha$^{-1}$ yr$^{-1}$)

$ASC_y$ = Average Soil Carbon Stock in Land Use y (tC ha$^{-1}$)

$ASC_x$ = Average Soil Carbon Stock in Land Use x (tC ha$^{-1}$)

The resulting annual soil emission and sequestration factors for all land-use transitions are presented in Table 6-18.

***Table 6-18: Annual emission/sequestration factors for Soil***

| Soil EF | | to | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FL1 | FL2 | FL3 | FL4 | FL5 | FL6 | FL7 | FL8 | CL1 | CL2 | CL3 | CL4 | CL5 | CL6 | GL1 | GL2 | WT1 | WT2 | ST1* | OL1 | OO1 |
| from | FL1 | 0.00 | -1.00 | -1.00 | -0.75 | -2.35 | -2.40 | -1.20 | -0.30 | -2.70 | -2.45 | -2.45 | -3.10 | -2.10 | -2.85 | -2.60 | -0.30 | -5.65 | -1.25 | -1.13 | -4.30 | -5.65 |
| | FL2 | 1.00 | 0.00 | 0.00 | 0.25 | -1.35 | -1.40 | -0.20 | 0.70 | -1.70 | -1.45 | -1.45 | -2.10 | -1.10 | -1.85 | -1.60 | 0.70 | -4.65 | -0.25 | -0.93 | -3.30 | -4.65 |
| | FL3 | 1.00 | 0.00 | 0.00 | 0.25 | -1.35 | -1.40 | -0.20 | 0.70 | -1.70 | -1.45 | -1.45 | -2.10 | -1.10 | -1.85 | -1.60 | 0.70 | -4.65 | -0.25 | -0.93 | -3.30 | -4.65 |
| | FL4 | 0.75 | -0.25 | -0.25 | 0.00 | -1.60 | -1.65 | -0.45 | 0.45 | -1.95 | -1.70 | -1.70 | -2.35 | -1.35 | -2.10 | -1.85 | 0.45 | -4.90 | -0.50 | -0.98 | -3.55 | -4.90 |
| | FL5 | 2.35 | 1.35 | 1.35 | 1.60 | 0.00 | -0.05 | 1.15 | 2.05 | -0.35 | -0.10 | -0.10 | -0.75 | 0.25 | -0.50 | -0.25 | 2.05 | -3.30 | 1.10 | -0.66 | -1.95 | -3.30 |
| | FL6 | 2.40 | 1.40 | 1.40 | 1.65 | 0.05 | 0.00 | 1.20 | 2.10 | -0.30 | -0.05 | -0.05 | -0.70 | 0.30 | -0.45 | -0.20 | 2.10 | -3.25 | 1.15 | -0.65 | -1.90 | -3.25 |
| | FL7 | 1.20 | 0.20 | 0.20 | 0.45 | -1.15 | -1.20 | 0.00 | 0.90 | -1.50 | -1.25 | -1.25 | -1.90 | -0.90 | -1.65 | -1.40 | 0.90 | -4.45 | -0.05 | -0.89 | -3.10 | -4.45 |
| | FL8 | 0.30 | -0.70 | -0.70 | -0.45 | -2.05 | -2.10 | -0.90 | 0.00 | -2.40 | -2.15 | -2.15 | -2.80 | -1.80 | -2.55 | -2.30 | 0.00 | -5.35 | -0.95 | -1.07 | -4.00 | -5.35 |
| | CL1 | 2.70 | 1.70 | 1.70 | 1.95 | 0.35 | 0.30 | 1.50 | 2.40 | 0.00 | 0.25 | 0.25 | -0.40 | 0.60 | -0.15 | 0.10 | 2.40 | -2.95 | 1.45 | -0.59 | -1.60 | -2.95 |
| | CL2 | 2.45 | 1.45 | 1.45 | 1.70 | 0.10 | 0.05 | 1.25 | 2.15 | -0.25 | 0.00 | 0.00 | -0.65 | 0.35 | -0.40 | -0.15 | 2.15 | -3.20 | 1.20 | -0.64 | -1.85 | -3.20 |
| | CL3 | 2.45 | 1.45 | 1.45 | 1.70 | 0.10 | 0.05 | 1.25 | 2.15 | -0.25 | 0.00 | 0.00 | -0.65 | 0.35 | -0.40 | -0.15 | 2.15 | -3.20 | 1.20 | -0.64 | -1.85 | -3.20 |
| | CL4 | 3.10 | 2.10 | 2.10 | 2.35 | 0.75 | 0.70 | 1.90 | 2.80 | 0.40 | 0.65 | 0.65 | 0.00 | 1.00 | 0.25 | 0.50 | 2.80 | -2.55 | 1.85 | -0.51 | -1.20 | -2.55 |
| | CL5 | 2.10 | 1.10 | 1.10 | 1.35 | -0.25 | -0.30 | 0.90 | 1.80 | -0.60 | -0.35 | -0.35 | -1.00 | 0.00 | -0.75 | -0.50 | 1.80 | -3.55 | 0.85 | -0.71 | -2.20 | -3.55 |
| | CL6 | 2.85 | 1.85 | 1.85 | 2.10 | 0.50 | 0.45 | 1.65 | 2.55 | 0.15 | 0.40 | 0.40 | -0.25 | 0.75 | 0.00 | 0.25 | 2.55 | -2.80 | 1.60 | -0.56 | -1.45 | -2.80 |
| | GL1 | 2.60 | 1.60 | 1.60 | 1.85 | 0.25 | 0.20 | 1.40 | 2.30 | -0.10 | 0.15 | 0.15 | -0.50 | 0.50 | -0.25 | 0.00 | 2.30 | -3.05 | 1.35 | -0.61 | -1.70 | -3.05 |
| | GL2 | 0.30 | -0.70 | -0.70 | -0.45 | -2.05 | -2.10 | -0.90 | 0.00 | -2.40 | -2.15 | -2.15 | -2.80 | -1.80 | -2.55 | -2.30 | 0.00 | -5.35 | -0.95 | -1.07 | -4.00 | -5.35 |
| | WT1 | 5.65 | 4.65 | 4.65 | 4.90 | 3.30 | 3.25 | 4.45 | 5.35 | 2.95 | 3.20 | 3.20 | 2.55 | 3.55 | 2.80 | 3.05 | 5.35 | 0.00 | 4.40 | 0.00 | 1.35 | 0.00 |
| | WT2 | 1.25 | 0.25 | 0.25 | 0.50 | -1.10 | -1.15 | 0.05 | 0.95 | -1.45 | -1.20 | -1.20 | -1.85 | -0.85 | -1.60 | -1.35 | 0.95 | -4.40 | 0.00 | -0.88 | -3.05 | -4.40 |
| | ST1 | 1.30 | 0.30 | 0.30 | 0.55 | -1.05 | -1.10 | 0.10 | 1.00 | -1.40 | -1.15 | -1.15 | -1.80 | -0.80 | -1.55 | -1.30 | 1.00 | -4.35 | 0.05 | 0.00 | -3.00 | -4.35 |
| | OL1 | 4.30 | 3.30 | 3.30 | 3.55 | 1.95 | 1.90 | 3.10 | 4.00 | 1.60 | 1.85 | 1.85 | 1.20 | 2.20 | 1.45 | 1.70 | 4.00 | -1.35 | 3.05 | -0.27 | 0.00 | -1.35 |
| | OO1 | 5.65 | 4.65 | 4.65 | 4.90 | 3.30 | 3.25 | 4.45 | 5.35 | 2.95 | 3.20 | 3.20 | 2.55 | 3.55 | 2.80 | 3.05 | 5.35 | 0.00 | 4.40 | 0.00 | 1.35 | 0.00 |

**unit** tC/ha/year

*Transitions to Settlements (ST1) assume a 20% loss of soil carbon relative to the preceding land use, consistent with the 2006 IPCC Guidelines.

### 6.1.2.4 Other Dead Organic Matter

Emissions and removals from the dead wood (DW) pool are not explicitly calculated but are implicitly included in the estimates of losses from living biomass and therefore reported under the notation key "included elsewhere" (IE).

The two main sources of dead wood in Portuguese forests are harvesting residues and fire-induced tree mortality. Harvesting residues are included in losses from living biomass, where carbon losses are calculated for the loss of carbon from the entire tree in the year of harvest, including stems, stumps, roots and coarse wood debris. For fire events, emissions are estimated as direct and indirect fire emissions. Direct emissions correspond to biomass combusted during the fire. Indirect emissions reflect post-fire tree mortality and are estimated using the same approach as for harvesting, including both above and below-ground biomass. Other potential sources of dead wood are considered negligible or are implicitly included within these two processes and are therefore not reported separately.

By attributing all carbon losses to the year of harvest or post-fire mortality, the inventory implicitly captures the carbon transfers and delayed emissions that would otherwise occur through the DW pool over time. While this approach may result in a slight overestimation of emissions in the year of harvest or burn and an underestimation in subsequent years, these effects tend to balance out over time. The applied methodology is consistent with the *2006 IPCC Guidelines* and ensures that all major DW components are accounted for, avoids double counting, and provides a transparent, traceable methodology through the use of the IE notation.

## 6.2 Forest Land (CFR 4.A)

The areas of forest land have increased since 1990 but have stabilized over the last decade. Considering only the scope of CRT Table 4.A emissions and removals, forest land was responsible for an average net sequestration of -2 794 $ktCO_{2eq}$ in the period 1990-2024, and a value of -1 311 $ktCO_{2eq}$ in 2024. Considering also the effect of other emission sources, most notably CRT 4(V) biomass burning, these values are significantly reduced to an average net sequestration was -969 $ktCO_{2eq}$ in the period 1990-2024, and an emission of 448 $ktCO_{2eq}$ in 2024.

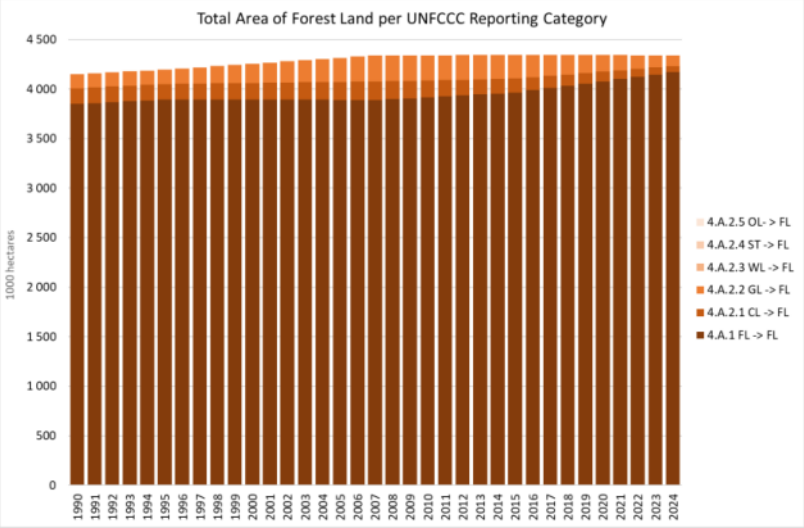



***Figure 6-13: Areas of Forest Land per UNFCCC reporting category***

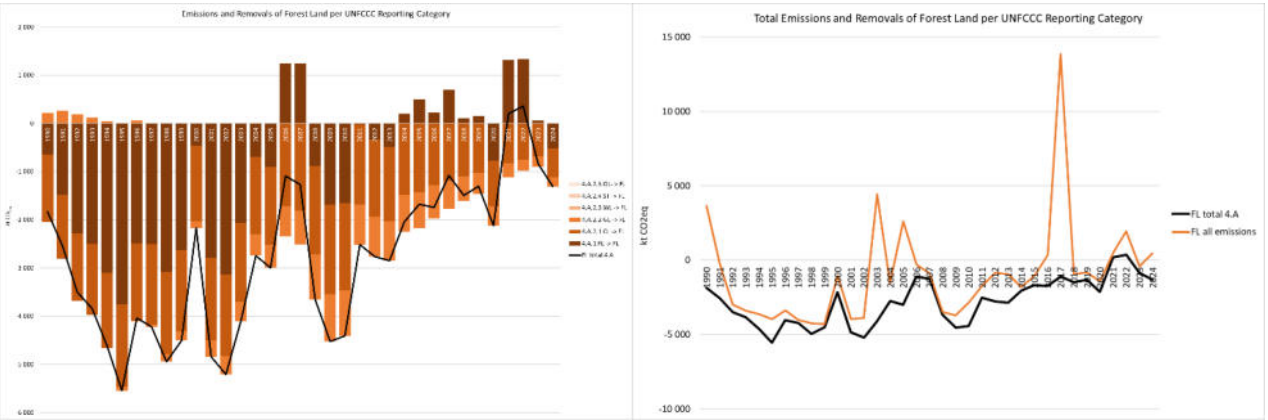



***Figure 6-14: Total emissions and removals in Forest Land***

## 6.2.1 Forest Land remaining Forest Land

### 6.2.1.1 Area

Area estimates for forest land remaining forest land were made following the methodology outlined in section 0

Higher tier methods are applied where data and methodological capacity are available. However, Tier 1 approaches are still used for some key categories due to the lack of sufficiently detailed country-specific data and nationally derived emission factors for several carbon pools and land-use categories. The implementation of higher-tier methods in line with the decision trees of the *2006 IPCC Guidelines* would require the development of disaggregated national datasets by land use, land-use transition and management practices, including country-specific estimates of carbon stocks and stock changes. These improvements would require the establishment of new data collection systems, periodic data collection and significant financial and human resources, which are not currently available. Therefore, it has not been possible to apply higher-tier methods for all key categories. In accordance with paragraph 23 of the MPGs (Decision 18/CMA.1), the use of Tier 1 methods is considered an interim solution, and these categories are prioritized for future methodological improvement.

Representation of Land-Areas and Land-Use Changes.

Land-use changes between different forest types (conversion of one type of forest into another) have been estimated and included in this category.

### 6.2.1.2 Living Biomass

#### 6.2.1.2.1 Gains in Living Biomass

Gains in living biomass refer to trees only and were estimated using Equation 6-10. Estimates were made for each forest type (8 forest types considered; see Table 6-3).

***Equation 6-10: Estimation of Above Ground Biomass Gains in Forest Land Remaining Forest Land***

$$AGBG_{RY_i} = \sum_{FT_f} AFF_{f,RY_i} \times MAI_f \times BCEF_f \times CF_f$$

***Equation 6-11: Estimation of Below Ground Biomass Gains in Forest Land Remaining Forest Land***

$$BGBG_{RY_i} = \sum_{FT_f} AFF_{f,RY_i} \times MAI_f \times BCEF_f \times RTS_f \times CF_f$$

**Where:**

$AGBG_{RY_i}$= Above Ground Biomass Gains in Reporting Year i (tC $yr^{-1}$)

$BGBG_{RY_i}$= Below Ground Biomass Gains in Reporting Year i (tC $yr^{-1}$)

$\sum_{FT_f}$ = Sum for all forest types

$AFF_{f,RY_i}$= Area of forest land remaining forest land of type f in reporting year i (ha)

$MAI_f$= Mean Annual Increment of forest species f ($m^3$ $ha^{-1}$ $yr^{-1}$)

$BCEF_f$= Biomass Conversion and Expansion Factor of forest species f (tDM $m^{-3}$)

$RTS_f$= Root-to-Shoot Factor of forest species f

$CF_f$= Carbon Fraction of forest species f (tC $tDM^{-1}$)

Gains in living biomass from understory vegetation (non-tree woody vegetation, grasses, ferns, mosses) were not estimated. It is assumed that gains and losses in this vegetation type are equivalent or that any gains or losses are marginal compared to the estimates from trees. This assumption is considered conservative given the annual vegetation cycles (for annual species gains and losses should be equivalent) and management practices (shrub biomass is reduced as a fire management practice, and removals from lands with growing vegetation tend to offset emissions from lands under shrub vegetation control).

#### 6.2.1.2.2 Losses in Living Biomass

Losses of living biomass were categorised in different types / origins of loss, and the corresponding emissions are estimated using different approaches according to loss type. Table 6-19 provides a summary of the types of losses considered in the reporting and how they were allocated to UNFCCC Categories “forest land remaining forest land” and “land converted to forest”.

***Table 6-19: Summary of types of losses in Living Biomass considered in the estimations of emissions and removals in Forest Land***

| Type of C loss | Definition / data sources | Allocation L->FL and FL<->FL |
|---|---|---|
| Industrial harvest | Industry wood consumption; estimates include the loss of biomass from the entire tree (AG and BG biomass) at the year of harvest<br>**Source**: UNECE-FAO database; Regional Forest Authorities | Allocated according to total carbon stock in each land-use transition |
| Salvaged wood from forest fires | It is assumed that all salvaged wood is included in "industrial harvest" | NA |
| Forest conversion | Losses from converting one forest type into another forest type (change in dominant species); estimated based on loss of standing volume of previous forest type; estimates include the loss of biomass from the entire tree (AG and BG biomass) at the year of conversion<br>**Source:** COS (for areas) and NFI/calculated for average caron stock in each land-use conversion | L->FL = not applicable<br>FL<->FL = based on land-use change areas in reporting year |
| Conversion to forest (afforestation) | Losses from converting a non-forest land-use type into a forest type; estimated based on loss of living biomass of previous land-use type<br>**Source:** COS (for areas) and please refer to the descriptions in other land-uses for average carbon stocks lost | L->FL = allocation based on area per previous land-use per new forest type<br>FL->FL = not applicable |
| Other Harvest | Wood uses for un-declared purposes (small industry or households) and non-industrial thinning; estimates include the loss of biomass from the entire tree (AG and BG biomass) at the year of harvest<br>**Source**: Calculated | Allocated according to total carbon stock in each land-use transition |
| Natural mortality (non-fire related) | It is assumed that natural mortality is included in "Other Harvest" | NA |
| Non-salvaged wood | Wood lost as a result of forest fires that was not salvaged for industrial use; estimates include the loss of biomass from the entire tree (AG and BG biomass) at the year of fire<br>**Source:** calculated per forest species as total loss of wood – industrial wood consumption (zero when industrial wood > total wood loss due to fires) | Reported as "fire emissions" not as "losses"<br>L->FL = allocation based on area per forest type<br>FL->FL = allocation based on area per forest type |
| Deforestation | Losses from converting one forest type into another land-use; estimated based on loss of average living biomass carbon stock of the previous forest type; estimates include the loss of biomass from the entire tree (AG and BG biomass) at the year of deforestation<br>**Source:** COS (for areas) and NFI/calculation for average carbon stocks | Reported as "losses" from FL->L in the respective land-use and not as Forest land emissions |

Losses in living biomass refer to harvesting and conversion between different forest types. Additional losses in living biomass due to forest fires are reported in CRT Table 4(IV).

Emissions from industrial harvesting were estimated from domestic industrial wood consumption statistics as contained in the UNECE/FAO TIMBER database[6]. Data from the Timber Database is available for hardwoods and conifers only. Data from the Azores and Madeira is available by species and was allocated to the respective forest type. The remaining hardwoods volume is fully allocated to FL4 "Eucalyptus" and the remaining softwoods volume is fully allocated to FL1 "Maritime pine", as these are the main tree species used by industry in Portugal.

[6] Database containing data of domestic production, imports and exports of wood removals and forest products, data refers to 1964-2023, last updated in November 2024.

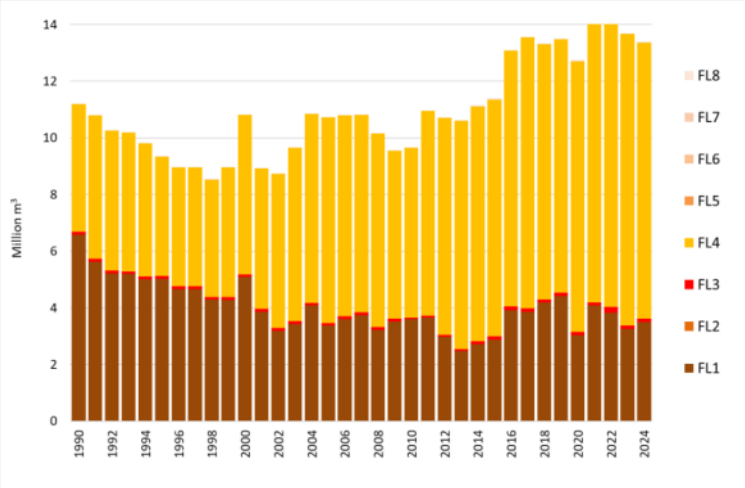



***Figure 6-15: Industrial Harvest per forest type***

Emissions from salvaged wood are considered included in industrial harvesting. Emissions from non-salvaged wood (i.e. additional wood losses to those already included in industrial harvesting) are included as fire emissions in CRT.4(IV).

Emissions from forest conversion are associated with changes in species, which may happen following final felling followed by a reforestation using a different species or by more subtle changes in dominant species (which lead to a change in forest type classification). Forest conversions are not deforestation (because a forest type is followed by another forest type), but the emissions from conversion are calculated in a similar manner as deforestation, i.e., it consists on the emission of all the living biomass carbon present in the previous forest type.

Emissions from conversions to forest (i.e. land converted to forest or afforestation) include the emissions related to the loss of carbon present in the previous land-use.

Finally, emissions from natural mortality are considered to be included in “other harvest”.

“Other harvest” was included to ensure consistency between annual stock changes and total biomass stocks observed in successive NFIs. This variable represents biomass losses not captured by industrial roundwood statistics, including non-industrial removals and natural mortality. As no official statistics are available for this component, the corresponding volumes were derived numerically so that the net change in biomass stocks over each NFI interval is consistent with the balance of estimated gains and losses for the same period This additional harvesting component is assumed to be constant within each interval between consecutive NFIs (1989–1995; 1996–2005; 2006–2015). For years after 2015, values cannot be updated until results from a new NFI become available; therefore, the average value for the period 1990–2015 for each forest type is applied.

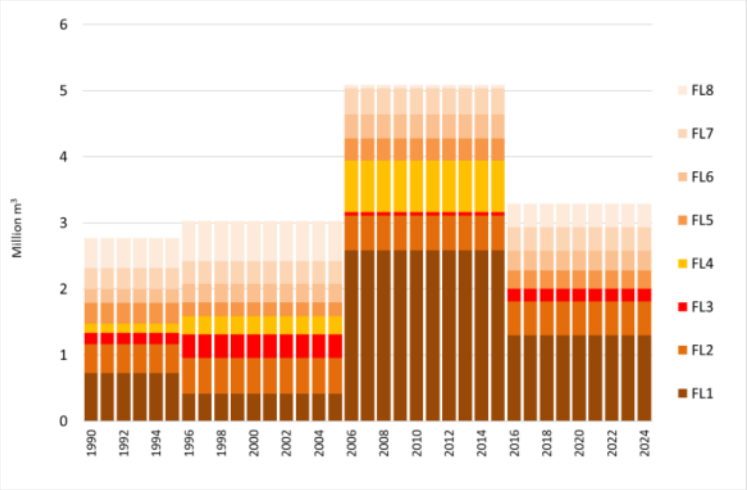



***Figure 6-16: "Other Harvest" per forest type***

Losses in living biomass from understory vegetation (non-tree woody vegetation, grasses, ferns, mosses) are not estimated. It is assumed that gains and losses in this vegetation type are equivalent or that any gains or losses have a marginal influence in the final estimates. This assumption is considered conservative given the annual vegetation cycles (for annual species gains and losses should be equivalent) and management practices (shrubs biomass is reduced as a fire management practice, and removals from lands with growing vegetation tend to offset emissions from lands under shrub vegetation control).

***Equation 6-12: Estimation of losses in living biomass in Forest Land remaining Forest Land***

$$LBL_{RY_i} = LBLH_{RY_i} + LBLOWU_{RY_i} + LBLFC_{RY_i}$$

$$LBLH_{RY_i} = \sum_{FS_y} (HARV_{y,RY_i} \times BEF_y \times (1 + RTS_y) \times CF_y$$

$$LBLOWU_{RY_i} = \sum_{FS_y} (OWU_{y,RY_i} \times BEF_y \times (1 + RTS_y) \times CF_y$$

$$LBLFC_{RY_i} = \sum_{f \to x} AFC_{f \to x,RY_i} \times (AGB_f + BGB_f)$$

**Where:**

$LBL_{RY_i}$ = Living Biomass Losses in Reporting Year i (tC)

$LBLH_{RY_i}$ = Living Biomass Losses from Industrial Harvesting in Reporting Year i (tC)

$LBLOWU_{RY_i}$ = Living Biomass Losses from Other Wood Use in Reporting Year i (tC)

$LBLFC_{RY_i}$ = Living Biomass Losses from Forest Conversion in Reporting Year i (tC)

$\sum_{FS_y}$ = Sum for all forest species

$\sum_{f \to x}$ = Sum for all conversions between forest types

$HARV_{y,RY_i}$ = Volume of industrial harvesting of forest species y in reporting year i ($m^3$)

$OWU_{y,RY_i}$ = Volume of other wood use harvesting of forest species y in reporting year i ($m^3$)

$AFC_{f \to x,RY_i}$ = Area of forest land type f converted into type x in reporting year i (ha)

$AGB_f$ = Average Above Ground Biomass of forest type f ($tC\ ha^{-1}$)

$BGB_f$ = Average Below Ground Biomass of forest type f ($tC\ ha^{-1}$)

$BCEF_y$= Biomass Conversion and Expansion Factor of forest species y (tDM $m^{-3}$)

$RTS_y$= Root-to-Shoot Factor of forest species y

$CF_y$= Carbon Fraction of forest species y (tC $tDM^{-1}$)

#### 6.2.1.3 Dead Organic Matter

The annual emission/sequestration factors of

Table 6-14 combined with the relevant area estimates were used to estimate emissions and removals in the litter pool. Dead wood is accounted for within other pools, as it primarily results from harvesting residues, which are reported as losses in living biomass (including the emission of the whole tree), and dead trees from fire, which are reported as indirect fire emissions (including the emission of the whole tree). Other dead wood sources are considered negligible compared to these two sources or included in harvesting and are not reported separately.

#### 6.2.1.4 Mineral Soils

The annual emission/sequestration factors of Table 6-18 combined with the relevant area estimates were used to estimate emissions and removals in this pool.

### 6.2.2 Land converted to Forest

#### 6.2.2.1 Area

Area estimates for land converted to forest land were made following the methodology outlined in section 0

Higher tier methods are applied where data and methodological capacity are available. However, Tier 1 approaches are still used for some key categories due to the lack of sufficiently detailed country-specific data and nationally derived emission factors for several carbon pools and land-use categories. The implementation of higher-tier methods in line with the decision trees of the *2006 IPCC Guidelines* would require the development of disaggregated national datasets by land use, land-use transition and management practices, including country-specific estimates of carbon stocks and stock changes. These improvements would require the establishment of new data collection systems, periodic data collection and significant financial and human resources, which are not currently available. Therefore, it has not been possible to apply higher-tier methods for all key categories. In accordance with paragraph 23 of the MPGs (Decision 18/CMA.1), the use of Tier 1 methods is considered an interim solution, and these categories are prioritized for future methodological improvement.

Representation of Land-Areas and Land-Use Changes.

#### 6.2.2.2 Living Biomass

##### 6.2.2.2.1 Gains in Living Biomass

Equation 6-10 and Equation 6-11 was also used to estimate gains in living biomass for land converted to forests, the only difference being the area estimates, which should now refer to “Area converted to forest land of type f in reporting year i”. The remaining parameters were kept unchanged for the two reporting categories.

#### 6.2.2.2.2 Losses in Living Biomass

Losses in living biomass in land converted to forest were estimated as the sum of emissions from industrial harvesting and other wood use, and emissions from the elimination of the vegetation of the former land use.

The industrial harvesting under lands converted to forest was estimated based on the total carbon stock share of the area of "land converted to FLx" and the total carbon stock of the "total FLx area" in the respective year; the remaining industrial wood consumption was assumed to come from forest land remaining forest land. A similar approach was used for allocating "other harvest" to "land converted to FLx".

### 6.2.2.3 Dead Organic matter

The annual emission/sequestration factors of

Table 6-14 combined with the relevant area estimates were used to estimate emissions and removals in this pool.

### 6.2.2.4 Mineral Soils

The annual emission/sequestration factors of Table 6-18 combined with the relevant area estimates were used to estimate emissions and removals in this pool.

## 6.3 Cropland (CRT 4.B)

The area of cropland has been reduced since 1990, mostly for conversion to grasslands, forest land and other land. However, this decline has been accompanied by a significant expansion of permanent crop areas, driven both by the conversion of non-cropland and the replacement of annual crops.

Considering only the scope of CRT Table 4.B emissions and removals, cropland was responsible for an average net-emission of 349 $ktCO_{2eq}$ in the period 1990-2024, and a value of 289 $ktCO_{2eq}$ in 2024. Considering also the effect of other emission sources (namely, CRT 4 (IV) biomass burning), these values are significantly raised to an average net-emission of 519 $ktCO_{2eq}$ in the period 1990-2024, and 397 $ktCO_{2eq}$ in 2024.

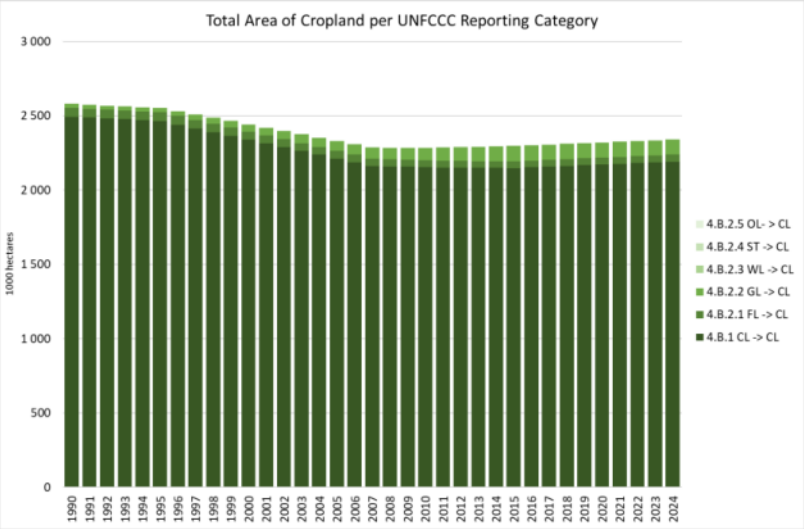



***Figure 6-17: Areas of Cropland per UNFCCC reporting category***

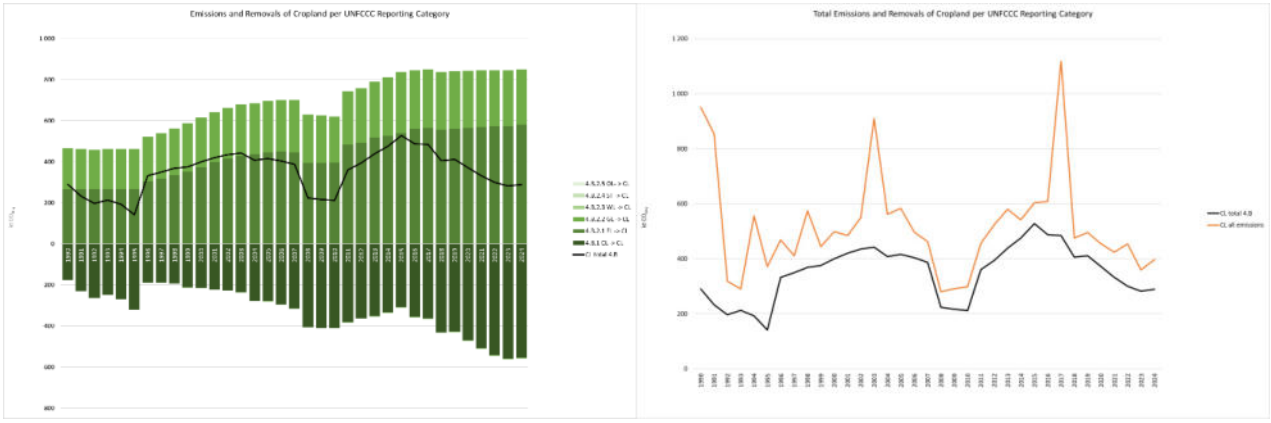



***Figure 6-18: Total emissions and removals in Cropland***

### 6.3.1 Cropland remaining Cropland

#### 6.3.1.1 Area

Area estimates for cropland remaining cropland were made following the methodology outlined in section 0

Higher tier methods are applied where data and methodological capacity are available. However, Tier 1 approaches are still used for some key categories due to the lack of sufficiently detailed country-specific data and nationally derived emission factors for several carbon pools and land-use categories. The implementation of higher-tier methods in line with the decision trees of the *2006 IPCC Guidelines* would require the development of disaggregated national datasets by land use, land-use transition and management practices, including country-specific estimates of carbon stocks and stock changes. These improvements would require the establishment of new data collection systems, periodic data collection and significant financial and human resources, which are not currently available. Therefore, it has not been possible to apply higher-tier methods for all key categories. In accordance with paragraph 23 of the MPGs (Decision 18/CMA.1), the use of Tier 1 methods is considered an interim solution, and these categories are prioritized for future methodological improvement.

Representation of Land-Areas and Land-Use Changes.

Land-use changes between different cropland types (conversion of one type of cropland into another) have been estimated and included in this category.

#### 6.3.1.2 Living Biomass

##### 6.3.1.2.1 Gains in Living Biomass

For cropland remaining cropland (4.B.1), the assumption of no net change in living biomass applies exclusively to annual crops (CL1–CL3), where annual biomass growth is assumed to be fully removed within the same year. For permanent crops (CL4–CL6), biomass carbon stock changes are explicitly estimated.

Gains in living biomass arise from:

(i) conversions between cropland sub-categories, particularly conversion to perennial crops;
(ii) post-fire recovery of burned perennial crop areas; and
(iii) biomass increments in perennial crops remaining in the same land-use category.

For annual crops, all gains associated with land-use change are assumed to occur in the year in which the land-use change takes place. For perennial crops established following land-use conversion, biomass carbon accumulation is distributed over a 20-year transition period, consistent with IPCC guidance for perennial systems. For perennial crops remaining in the same land-use subcategory, biomass dynamics are represented by applying a net annual increment under mature stand conditions, as described in 6.1.2.1.2.

##### 6.3.1.2.2 Losses in Living Biomass

For cropland remaining cropland, the same default assumption of no net changes in living biomass applies to annual crops (CL1–CL3). For permanent crops (CL4–CL6), losses in living biomass arise from conversions to other cropland sub-categories and are calculated using the average biomass carbon stock of the perennial crop category in the year of conversion. Losses associated with pruning are accounted for within the annual biomass balance of perennial crops and do not result in additional net emissions. All losses are assumed to occur in the year when the land-use change occurs. Losses from fires are reported separately under CRT 4(IV), in accordance with IPCC reporting guidance.

#### 6.3.1.3 Dead Organic matter

The annual emission/sequestration factors of

Table 6-14 combined with the relevant area estimates were used to estimate emissions and removals in this pool.

#### 6.3.1.4 Mineral Soils

The annual emission/sequestration factors of Table 6-18 combined with the relevant area estimates were used to estimate emissions and removals in this pool. Changes in management practices within the same cropland type are not explicitly accounted for due to the absence of consistent national data. Consequently, SOC stock changes are estimated only when transitions occur between different cropland types. Where land remains in the same cropland type, no significant net change in soil carbon stocks is assumed.

### 6.3.2 Land converted to Cropland

#### 6.3.2.1 Area

Area estimates for Land Converted to Cropland were made following the methodology outlined in section 0

Higher tier methods are applied where data and methodological capacity are available. However, Tier 1 approaches are still used for some key categories due to the lack of sufficiently detailed country-specific data and nationally derived emission factors for several carbon pools and land-use categories. The implementation of higher-tier methods in line with the decision trees of the *2006 IPCC Guidelines* would require the development of disaggregated national datasets by land use, land-use transition and management practices, including country-specific estimates of carbon stocks and stock changes. These improvements would require the establishment of new data collection systems, periodic data collection and significant financial and human resources, which are not currently available. Therefore, it has not been possible to apply higher-tier methods for all key categories. In accordance with paragraph 23 of the MPGs (Decision 18/CMA.1), the use of Tier 1 methods is considered an interim solution, and these categories are prioritized for future methodological improvement.

Representation of Land-Areas and Land-Use Changes.

#### 6.3.2.2 Living Biomass

##### 6.3.2.2.1 Gains in Living Biomass

Gains in living biomass in land converted to cropland result in particular from the conversion to perennial crops (vineyards, olive groves, other permanent crops), according to the unit values and transition periods presented in section 6.1.2.1.2 Permanent Crops (CL4-CL6). All gains are assumed to occur in the year when the land-use change occurs (for annual crops) or over a 20 years period (for perennial crops).

##### 6.3.2.2.2 Losses in Living Biomass

Losses in living biomass in land converted to cropland result from the loss of the vegetation of the previous land use. All losses are assumed to occur in the year when the land-use change occurs. Losses from fires are reported as fire emissions in CRT 4(IV).

#### 6.3.2.3 Dead Organic matter

The annual emission/sequestration factors of

Table 6-14 combined with the relevant area estimates were used to estimate emissions and removals in this pool.

#### 6.3.2.4 Mineral Soils

The annual emission/sequestration factors of Table 6-18 combined with the relevant area estimates were used to estimate emissions and removals in this pool.

## 6.4 Grassland (CRT 4.C)

Grassland areas have decreased since 1990. The conversion from agriculture to grasslands usually results in an increased sequestration, while the conversions from forest land result in increased emissions.

Considering only the scope of CRT Table 4.C emissions and removals, grassland was responsible for an average net sequestration of -2 099 $ktCO_{2eq}$ in the period 1990-2024, and a value of -1 582 $ktCO_{2eq}$ in 2024. Considering also the effect of other emission sources (most notably CRT 4.(IV) Biomass burning), these values are significantly reduced to an average net sequestration of -846 $ktCO_{2eq}$ in the period 1990-2024, and -742 $ktCO_{2eq}$ in 2024.

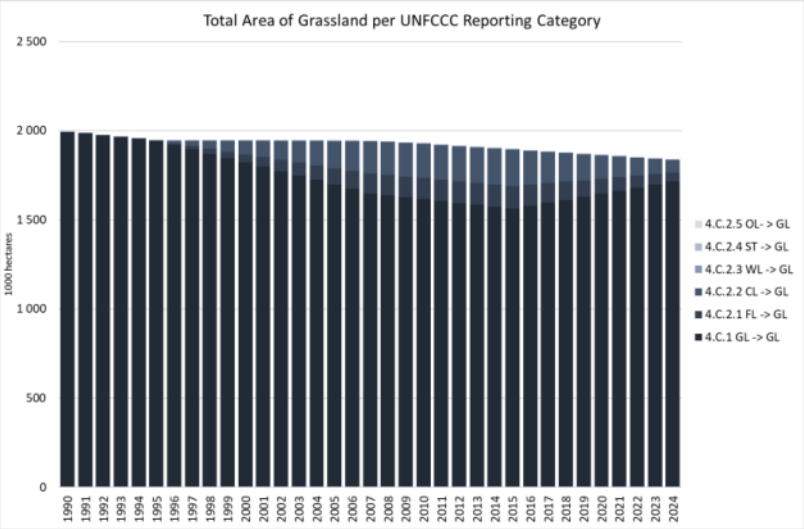



***Figure 6-19: Areas of Grassland per reporting category (1000 ha)***

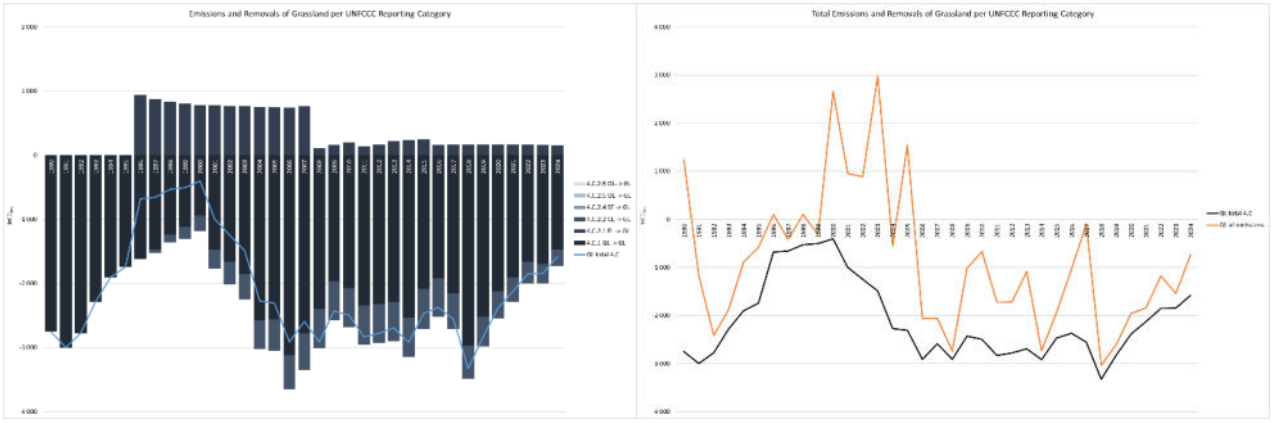



***Figure 6-20: Total emissions and removals in Grassland***

### 6.4.2 Grassland remaining Grassland

#### 6.4.2.1 Area

Area estimates for grassland remaining grassland were made following the methodology outlined in section 0

Higher tier methods are applied where data and methodological capacity are available. However, Tier 1 approaches are still used for some key categories due to the lack of sufficiently detailed country-specific data and nationally derived emission factors for several carbon pools and land-use categories. The implementation of higher-tier methods in line with the decision trees of the *2006 IPCC Guidelines* would require the development of disaggregated national datasets by land use, land-use transition and management practices, including country-specific estimates of carbon stocks and stock changes. These improvements would require the establishment of new data collection systems, periodic data collection and significant financial and human resources, which are not currently available. Therefore, it has not been possible to apply higher-tier methods for all key categories. In accordance with paragraph 23 of the MPGs (Decision 18/CMA.1), the use of Tier 1 methods is considered an interim solution, and these categories are prioritized for future methodological improvement.

Representation of Land-Areas and Land-Use Changes.

#### 6.4.2.2 Living Biomass

##### 6.4.2.2.1 Gains in Living Biomass

For grassland remaining grassland (4.C.1) the assumption of no net change in living biomass applies exclusively to All Grasslands (GL1), where annual biomass growth is assumed to be fully removed within the same year. For Shrublands (GL2), biomass carbon stock changes are explicitly estimated.

Gains in living biomass result mainly from:

(i) conversion between grassland types, in particular conversion to shrublands;
(ii) post-fire recovery of burned shrublands[7]
(iii) biomass increments in shrublands remaining in the same land-use category.

For All Grasslands converted to Shrublands (GL1->GL2), biomass carbon accumulation is distributed over a 20-year transition period, consistent with IPCC guidance for perennial systems. For Shrublands remaining in the same land-use subcategory, biomass dynamics are represented by applying a net annual increment under mature stand conditions, as described in 6.1.2.1.3.

##### 6.4.2.2.2 Losses in Living Biomass

For grasslands remaining grasslands, the same default assumption of no net-changes in living biomass for All Grassland (GL1) subcategory. Therefore, losses in living biomass in grassland remaining grassland result only from the conversion between grassland types, in particular conversion from Shrublands to All Grasslands (GL2->GL1). All losses are assumed to occur in the year when the land-use change occurs. Losses from fires are reported separately under CRT 4(IV), in accordance with IPCC reporting guidance.

[7] Fire emissions in CRT.4(IV) assume the loss of the full carbon stock of shrublands in affected areas. The assumption is that, if no land-use change occurs after the fire, this is followed by natural recovery of the burned areas with the same species.

#### 6.4.2.3 Dead Organic matter

The annual emission/sequestration factors of

Table 6-14 combined with the relevant area estimates were used to estimate emissions and removals in this pool.

#### 6.4.2.4 Mineral Soils

The annual emission/sequestration factors of Table 6-18 combined with the relevant area estimates were used to estimate emissions and removals in this pool.

### 6.4.3 Land converted to Grassland

#### 6.4.3.1 Area

Area estimates for land converted to grassland were made following the methodology outlined in section 0

Higher tier methods are applied where data and methodological capacity are available. However, Tier 1 approaches are still used for some key categories due to the lack of sufficiently detailed country-specific data and nationally derived emission factors for several carbon pools and land-use categories. The implementation of higher-tier methods in line with the decision trees of the *2006 IPCC Guidelines* would require the development of disaggregated national datasets by land use, land-use transition and management practices, including country-specific estimates of carbon stocks and stock changes. These improvements would require the establishment of new data collection systems, periodic data collection and significant financial and human resources, which are not currently available. Therefore, it has not been possible to apply higher-tier methods for all key categories. In accordance with paragraph 23 of the MPGs (Decision 18/CMA.1), the use of Tier 1 methods is considered an interim solution, and these categories are prioritized for future methodological improvement.

Representation of Land-Areas and Land-Use Changes.

#### 6.4.3.2 Living Biomass

##### 6.4.3.2.1 Gains in Living Biomass

Gains in living biomass in land converted to grassland result from the establishment and growth of grassland or shrubland vegetation. For grassland category GL1 (pastures), gains are assumed to occur in the year of conversion. For GL2 (shrublands), biomass accumulation occurs over a longer period following conversion. Gains are estimated using the unit values presented in Section 6.1.2.1.3 (Shrublands), with biomass increasing over a 20-year period after conversion.

##### 6.4.3.2.2 Losses in Living Biomass

Losses in living biomass in land converted to grassland result from the loss of the vegetation of the previous land use. All losses are assumed to occur in the year when the land-use change occurs. Losses from fires are reported as fire emissions in CRT 4(IV).

#### 6.4.3.3 Dead Organic matter

The annual emission/sequestration factors of

Table 6-14 combined with the relevant area estimates were used to estimate emissions and removals in this pool.

#### 6.4.3.4 Mineral Soils

The annual emission/sequestration factors of Table 6-18 combined with the relevant area estimates were used to estimate emissions and removals in this pool.

## 6.5 Wetlands (CRT 4.D)

The area of wetlands has been increasing over time, mostly due to the construction of artificial reservoirs, which are included in this land use category. An on-going programme to increase the water storage and hydro-electricity production capacity will likely maintain this trend in the future. As expected under these trends, wetlands are a net-source of emissions, although not a very significant one.

Considering only the scope of CRT Table 4.D emissions and removals, wetlands were responsible for an average net-emission of 470 $ktCO_{2eq}$ in the period 1990-2024, and a value of 294 $ktCO_{2eq}$ in 2024. Considering also the effect of other emission sources, these values present a small increase, with an average net-emission of 501 $ktCO_{2eq}$ in the period 1990-2024, and 311 $ktCO_{2eq}$ in 2024.

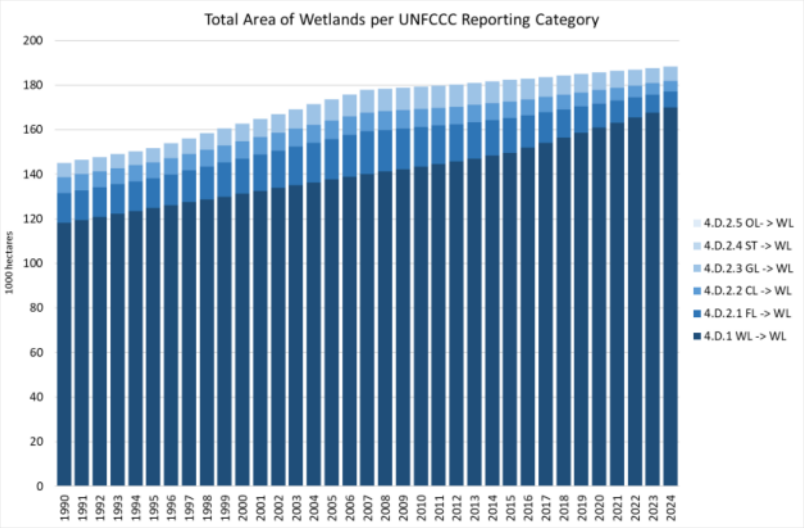



***Figure 6-21: Areas of Wetlands per reporting category (1000 ha)***

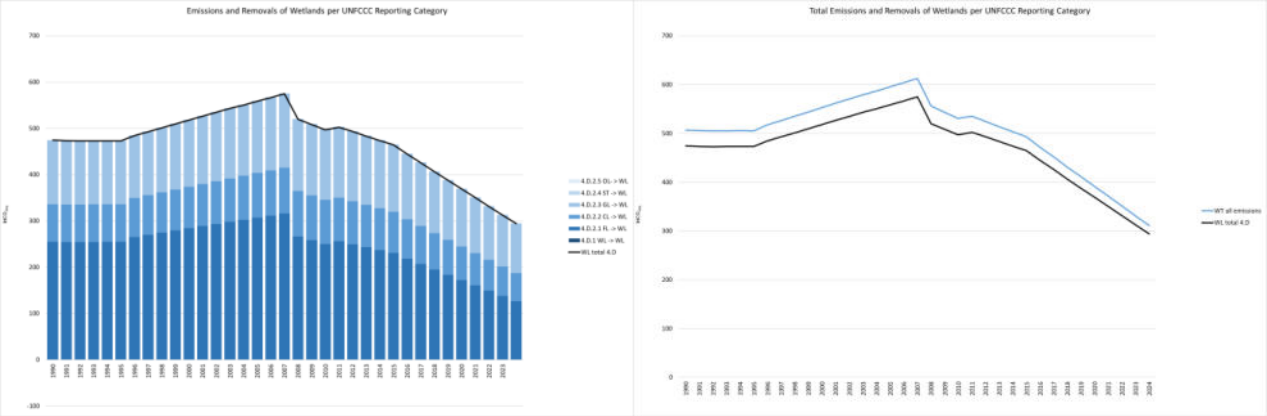



***Figure 6-22: Total emissions and removals in Wetlands***

### 6.5.1 Wetlands remaining Wetlands

#### 6.5.1.1 Area

Area estimates for wetlands remaining wetlands were made following the methodology outlined in section 0

Higher tier methods are applied where data and methodological capacity are available. However, Tier 1 approaches are still used for some key categories due to the lack of sufficiently detailed country-specific data and nationally derived emission factors for several carbon pools and land-use categories. The implementation of higher-tier methods in line with the decision trees of the *2006 IPCC Guidelines* would require the development of disaggregated national datasets by land use, land-use transition and management practices, including country-specific estimates of carbon stocks and stock changes. These improvements would require the establishment of new data collection systems, periodic data collection and significant financial and human resources, which are not currently available. Therefore, it has not been possible to apply higher-tier methods for all key categories. In accordance with paragraph 23 of the MPGs (Decision 18/CMA.1), the use of Tier 1 methods is considered an interim solution, and these categories are prioritized for future methodological improvement.

Representation of Land-Areas and Land-Use Changes.

#### 6.5.1.2 Living Biomass

##### 6.5.1.2.1 Gains in Living Biomass

The default assumption of no net change in living biomass was applied to wetlands remaining in the same subcategory for more than 20 years, namely Flooded Areas remaining Flooded Areas (WT1) and Other Wetlands remaining Other Wetlands (WT2).

Gains in living biomass in wetlands remaining wetlands result only from conversions between wetland subcategories (e.g., WT1 to WT2) and are estimated using the values presented in Table 6-12 for Other Wetlands (WT2), multiplied by the relevant areas. For WT1 (Flooded Areas), gains in living biomass are assumed to be zero. All gains are assumed to occur over a 20-year period.

##### 6.5.1.2.2 Losses in Living Biomass

Losses in living biomass in wetlands remaining wetlands result from conversions between wetland subcategories, in particular from WT2 to WT1, due to the loss of vegetation associated with inundation. All losses are assumed to occur in the year when the land-use change occurs.

#### 6.5.1.3 Dead Organic matter

The annual emission/sequestration factors of

Table 6-14 combined with the relevant area estimates were used to estimate emissions and removals in this pool.

#### 6.5.1.4 Mineral Soils

The annual emission/sequestration factors of Table 6-18 combined with the relevant area estimates were used to estimate emissions and removals in this pool.

### 6.5.2 Land converted to Wetlands

#### 6.5.2.1 Area

Area estimates for land converted to wetlands were made following the methodology outlined in section 0

Higher tier methods are applied where data and methodological capacity are available. However, Tier 1 approaches are still used for some key categories due to the lack of sufficiently detailed country-specific data and nationally derived emission factors for several carbon pools and land-use categories. The implementation of higher-tier methods in line with the decision trees of the *2006 IPCC Guidelines* would require the development of disaggregated national datasets by land use, land-use transition and management practices, including country-specific estimates of carbon stocks and stock changes. These improvements would require the establishment of new data collection systems, periodic data collection and significant financial and human resources, which are not currently available. Therefore, it has not been possible to apply higher-tier methods for all key categories. In accordance with paragraph 23 of the MPGs (Decision 18/CMA.1), the use of Tier 1 methods is considered an interim solution, and these categories are prioritized for future methodological improvement.

Representation of Land-Areas and Land-Use Changes.

#### 6.5.2.2 Living Biomass

##### 6.5.2.2.1 Gains in Living Biomass

Gains in living biomass in land converted to wetlands result from the growth vegetation. For wetlands category WT2 (Other Wetlands), gains are assumed to occur over a 20-year period. For WT1 (Flooded Areas), gains in living biomass are assumed to be zero.

##### 6.5.2.2.2 Losses in Living Biomass

Losses in living biomass in land converted to wetlands result from the loss of the vegetation of the previous land use. All losses are assumed to occur in the year when the land-use change occurs. Losses from fires are reported as fire emissions in CRT 4(IV).

#### 6.5.2.3 Dead Organic matter

The annual emission/sequestration factors of

Table 6-14 combined with the relevant area estimates were used to estimate emissions and removals in this pool.

#### 6.5.2.4 Mineral Soils

The annual emission/sequestration factors of Table 6-18 combined with the relevant area estimates were used to estimate emissions and removals in this pool.

## 6.6 Settlements (CFR 4.E)

Over the past decades Portugal has witnessed an enormous growth in the building of infrastructure and urban expansion. As consequence, the areas under settlements have increased since 1990. As expected under these trends, settlements are a net-source of emissions.

Considering only the scope of CRT Table 4.E emissions and removals, settlements were responsible for an average net-emission of 584 $ktCO_{2eq}$ in the period 1990-2024, and a value of 291 $ktCO_{2eq}$ in 2024. Considering also the effect of other emission sources, the values are similar, with an average net-emission of 611 $ktCO_{2eq}$ in the period 1990-2024, and 307 $ktCO_{2eq}$ in 2024.

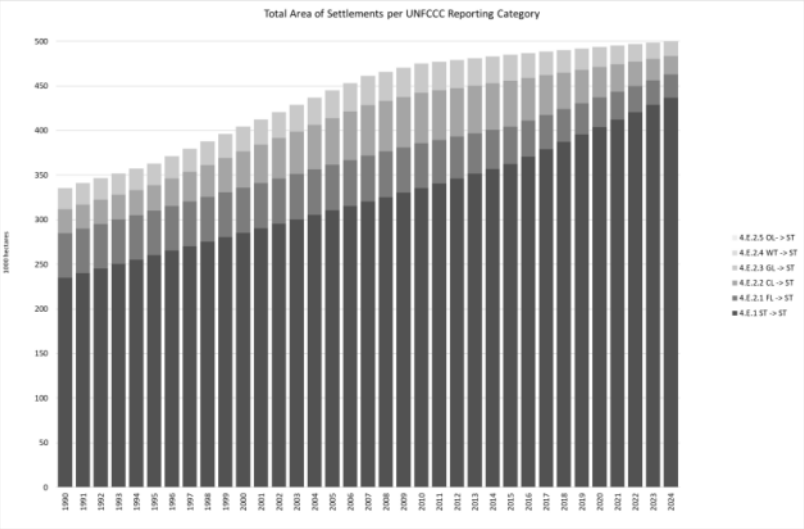



***Figure 6-23: Areas of Settlements per reporting category***

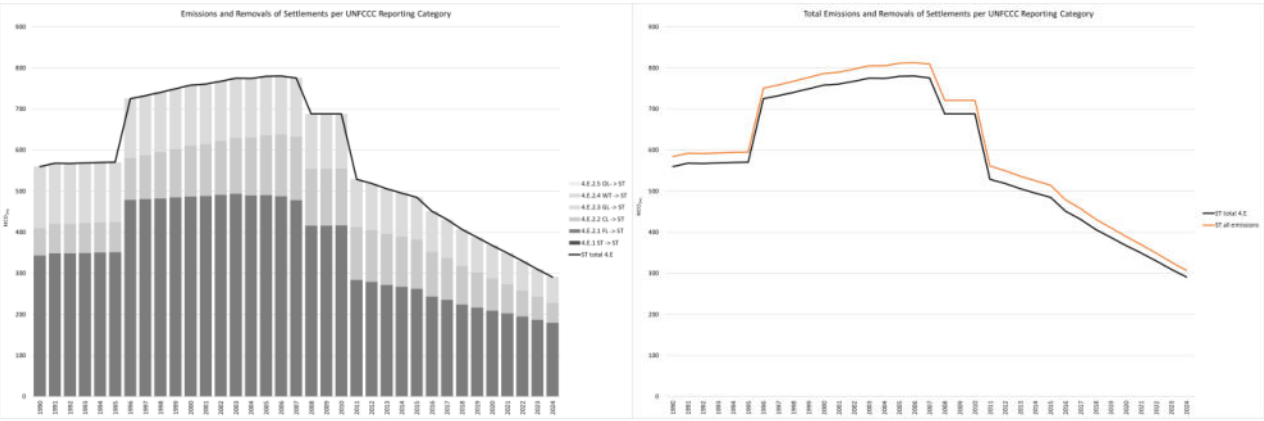



***Figure 6-24: Total emissions and removals in Settlements***

### 6.6.1 Settlements remaining Settlements

Area estimates for settlements remaining settlements were made following the methodology outlined in section 0

Higher tier methods are applied where data and methodological capacity are available. However, Tier 1 approaches are still used for some key categories due to the lack of sufficiently detailed country-specific data and nationally derived emission factors for several carbon pools and land-use categories. The

implementation of higher-tier methods in line with the decision trees of the *2006 IPCC Guidelines* would require the development of disaggregated national datasets by land use, land-use transition and management practices, including country-specific estimates of carbon stocks and stock changes. These improvements would require the establishment of new data collection systems, periodic data collection and significant financial and human resources, which are not currently available. Therefore, it has not been possible to apply higher-tier methods for all key categories. In accordance with paragraph 23 of the MPGs (Decision 18/CMA.1), the use of Tier 1 methods is considered an interim solution, and these categories are prioritized for future methodological improvement.

Representation of Land-Areas and Land-Use Changes.

The default assumption of no net-changes was used for all pools in settlements in that category for over 20 years. Therefore, all gains and losses in settlements remaining settlements were considered zero.

### 6.6.2 Land converted to Settlements

#### 6.6.2.1 Area

Area estimates for land converted to settlements were made following the methodology outlined in section 0

Higher tier methods are applied where data and methodological capacity are available. However, Tier 1 approaches are still used for some key categories due to the lack of sufficiently detailed country-specific data and nationally derived emission factors for several carbon pools and land-use categories. The implementation of higher-tier methods in line with the decision trees of the *2006 IPCC Guidelines* would require the development of disaggregated national datasets by land use, land-use transition and management practices, including country-specific estimates of carbon stocks and stock changes. These improvements would require the establishment of new data collection systems, periodic data collection and significant financial and human resources, which are not currently available. Therefore, it has not been possible to apply higher-tier methods for all key categories. In accordance with paragraph 23 of the MPGs (Decision 18/CMA.1), the use of Tier 1 methods is considered an interim solution, and these categories are prioritized for future methodological improvement.

Representation of Land-Areas and Land-Use Changes.

#### 6.6.2.2 Living Biomass

##### 6.6.2.2.1 Gains in Living Biomass

Gains in living biomass are estimated to be zero.

##### 6.6.2.2.2 Losses in Living Biomass

Losses in living biomass in land converted to settlements result from the loss of the vegetation of the previous land use. All losses are assumed to occur in the year when the land-use change occurs.

#### 6.6.2.3 Dead Organic matter

The annual emission/sequestration factors of

Table 6-14 combined with the relevant area estimates were used to estimate emissions and removals in this pool. In accordance with the *2006 IPCC Guidelines*, carbon losses from dead organic matter for land converted to settlements are assumed to occur entirely in the year of conversion.

#### 6.6.2.4 Mineral Soils

For land converted to settlements, soil carbon stocks were assumed to decrease by 20% relative to the preceding land use, in accordance with the *2006 IPCC Guidelines*. The annual emission/sequestration factors of Table 6-18 combined with the relevant area estimates were used to estimate emissions and removals in this pool.

## 6.7 Other Land (CRT 4.F)

The category other land is a residual land-use class with little expression in national area totals.

Since there are no reported conversion to “other land” and we assume stabilised carbon stocks in lands over 20 years, the emissions from this category are assumed to be zero.

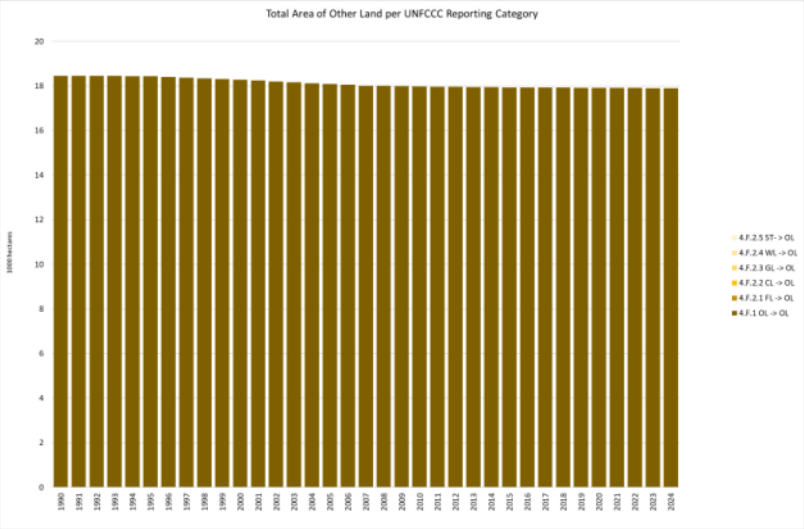



***Figure 6-25: Areas of Other Land per reporting category***

## 6.8 Harvested Wood Products (CRT 4.G)

Emissions and removals from harvested wood products (HWP) are estimated using the Production Approach, as defined in the *2006 IPCC Guidelines* (Volume 4, Chapter 12). Under this approach, carbon stocks are tracked for products originating from domestically harvested wood, accounting for production, imports and exports. The HWP pool has acted as a net carbon sink throughout the period 1990–2024, with an average removal of approximately -623 $ktCO_{2eq}$ per year.

Activity data for production, imports and exports of wood products were obtained primarily from the UNECE database for the period 1970–2022. For years where UNECE data were unavailable, FAOSTAT data were used to ensure completeness of the time series, including the years 1961–1963 and 2023.

In accordance with IPCC guidance, the time series was extended back to 1900 to properly initialize the HWP carbon pool. For the period prior to the availability of official production statistics, inflows were estimated using the methodology described in the *2006 IPCC Guidelines* (Volume 4, Chapter 12, Equation 12.6), which provides a procedure for reconstructing historical inputs based on available data. The production of HWP originating from domestic harvest was estimated using IPCC Equation 12.4. Carbon stocks were then estimated using first-order decay functions with product-specific half-lives. Product grades considered were wood pulp (half-live of 2 years); wood panels (half-live of 25 years) and sawn wood (half-live 35 years). The results are presented in Figure 6-29.

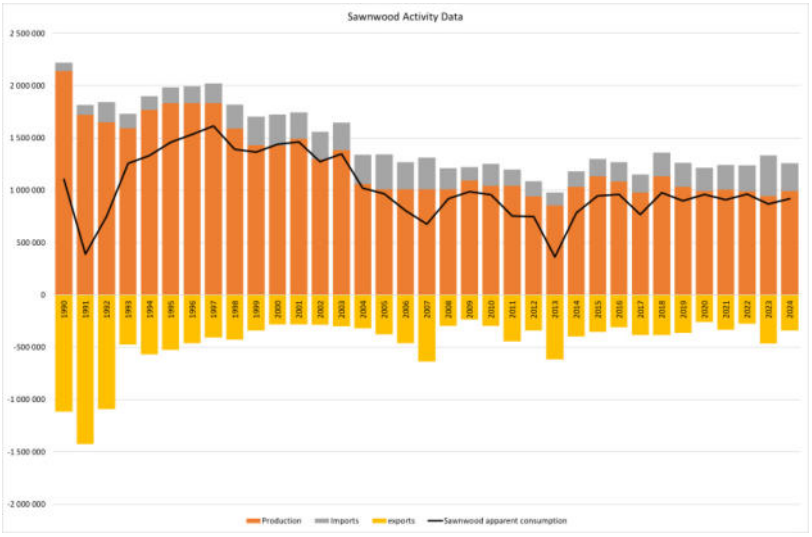



*Figure 6-26: Reported activity data for Harvested Wood Products – Sawnwood*

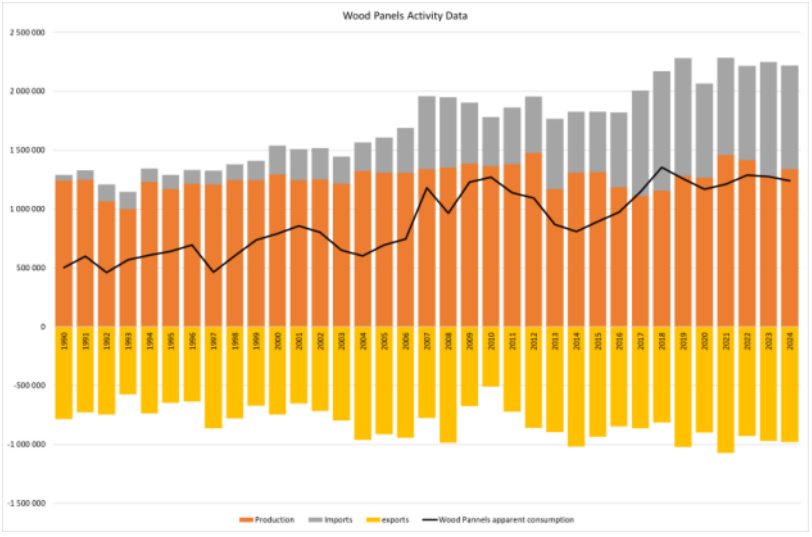



*Figure 6-27: Reported activity data for Harvested Wood Products – Wood Panels*

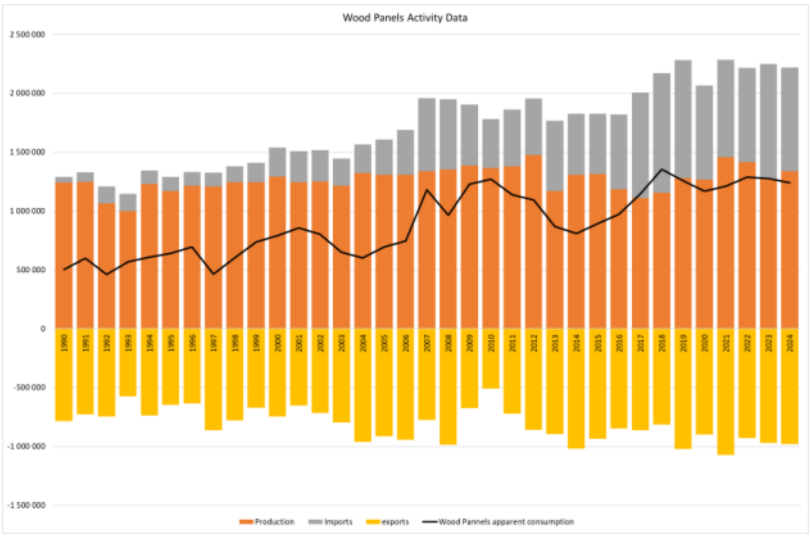



*Figure 6-28: Reported activity data for Harvested Wood Products – Paper and Paper board*

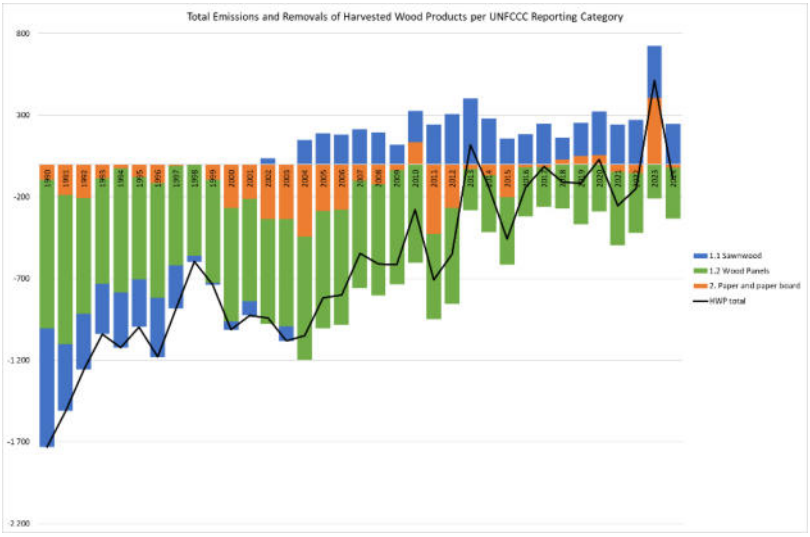



***Figure 6-29: Evolution of carbon stocks and carbon stock changes in Harvested Wood Products***

## 6.9 Direct $N_2O$ Emissions from N-Inputs to Managed Soils (CRT 4(I))

Emissions are estimated together with N fertilization and are reported under the Agriculture sector, as it is not possible to disaggregate nitrogen inputs by land-use category.

## 6.10 Emissions and Removals from Drainage and Rewetting and other Management of Organic and Mineral soils (CRT 4(II))

The source is considered negligible and is reported as "Not Occurring". Annex G: Identification of Organic Soils in Portugal presents the information that supports that assessment.

## 6.11 Direct and Indirect $N_2O$ emissions from N Mineralization/Immobilization associated with Loss/Gain of Soil Organic Matter resulting from change of LU or management of Mineral Soils (CRT 4(III))

### 6.11.1 Activity Data

For the purposes of estimating this category, only the areas associated with land-use transitions where mineral soil C is being lost were considered (i.e. land-use transitions with negative soil emission factors; see Table 6-18).

Therefore, the areas reported in CRT Table 4(III) are areas where mineralization is occurring (Figure 6-30). These may be smaller from those reported for in CRT Table 4.1, because some land-use transitions result in carbon gains and, consequently, do not contribute to this category.

In accordance with IPCC guidance, emissions from "cropland remaining cropland" are reported under CRT 3.D.1.5, whereas all N mineralization occurring in other land-use categories is reported under CRT 4(III).

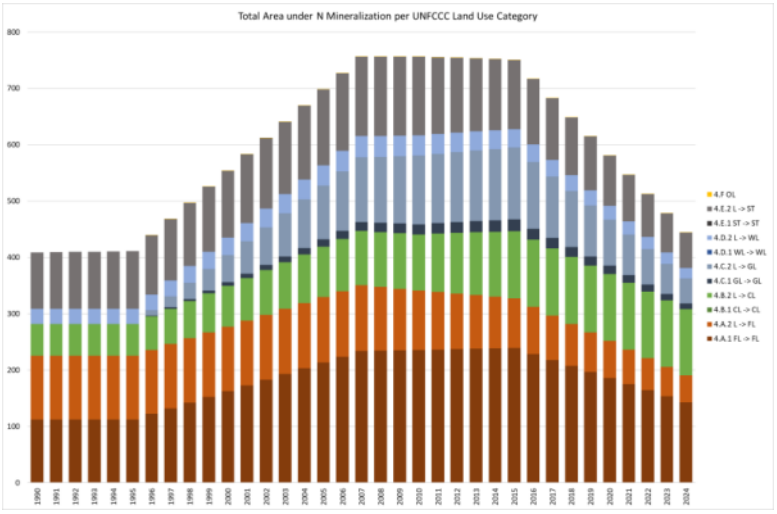



*Figure 6-30: Total Area under N Mineralization (kha)*

## 6.11.2 Emission estimation

Emissions of $N_2O$ associated with land-use change were estimated from the mineralization of soil nitrogen resulting from losses of soil organic carbon. Emissions were calculated for areas where soil carbon loss occurs following conversion between land-use categories.

*Equation 6-13: $N_2O$ emissions from managed soils*

$$N_2O - N_{CLoss} = EF_1 \times \Delta C_{LCMineral} \times \frac{1}{C:N\ ratio} \times 10^{-6}$$

**Where:**

$N_2O$-$N_{CLoss}$ = $N_2O$ emissions associated with a Soil Carbon Loss, Gg $N_2O$-N.yr$^{-1}$

$EF_1$ = IPCC default emission factor for $N_2O$ emissions from mineralized nitrogen (kg $N_2O$-N per kg N). The default value applied is 0.01 kg $N_2O$-N kg$^{-1}$ N (*IPCC 2006 Guidelines*, Table 11.1)

$\Delta C_{LCMineral}$ = C emissions from land-use change

C:N = Carbon-to-nitrogen ratio of soil organic matter

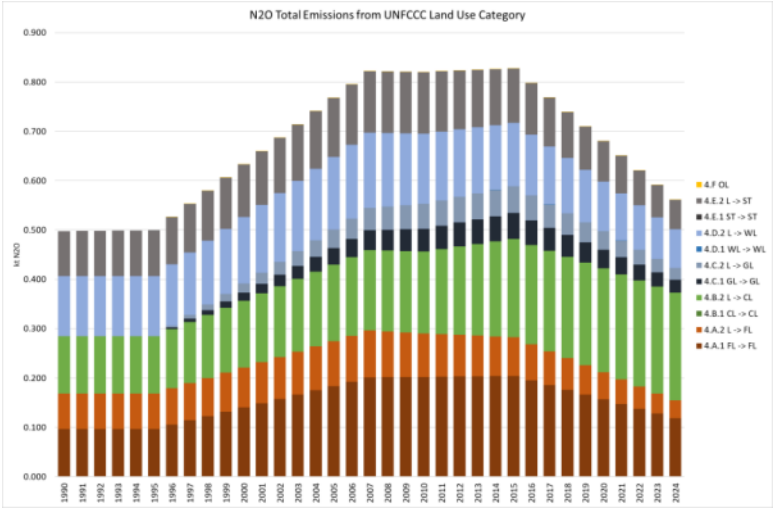



*Figure 6-31: $N_2O$ Emissions from areas under N Mineralization (kt $N_2O$)*

## 6.12 Emissions from Biomass Burning (CRT 4(IV))

Forest fire emissions are estimated as the sum of:

- Direct $CO_2$ emissions, i.e., $CO_2$ emissions that occur during the fire
- Direct non-$CO_2$ emissions, i.e., $CH_4$ and $N_2O$ emissions that occur during the fire
- Indirect $CO_2$ emissions, i.e., $CO_2$ emissions that occur after the fire as a consequence of fire-induced tree mortality

The following pools and gases are included in the estimations of fire emissions:

- Direct emissions ($CO_2$)
    - Living biomass – AGB: Included (forests, shrublands, permanent crops)
    - Living biomass – AGB: Not included (annual crops, pastures, wetlands)
    - Living biomass – BGB: Not included
- Direct emissions ($CH_4$ and $N_2O$)
    - Living biomass – AGB: Included (forests, shrublands, permanent crops, annual crops, pastures, wetlands)
    - Living biomass – BGB: Not included
- Indirect emissions ($CO_2$)
    - Living biomass – AGB: Included (forests, if above emissions from industrial harvest)
    - Living biomass – AGB: Included (shrublands, permanent crops)
    - Living biomass – BGB: Included (forests, if above emissions from industrial harvest and shrublands, permanent crops)

Litter and deadwood are considered to be in balance after 20 years and no gains or losses are included from that pool.

### 6.12.1 Estimation of Burned Areas

Annual burned area data were obtained from official fire reports and burned area maps produced by the Institute for Nature Conservation and Forestry (ICNF). Burned area by land-use category was estimated by spatially overlaying annual fire maps with the land-use distribution from COS maps. This ensures consistency between fire activity data and the land representation system used in the inventory.

For the Autonomous Region of Madeira, burned areas were provided by the regional authority and reported in two categories: “burned forest” and “burned shrubland.” Allocation to forest types was performed proportionally according to the forest-type distribution in total forest area. No forest fires have been recorded in the Autonomous Region of the Azores.

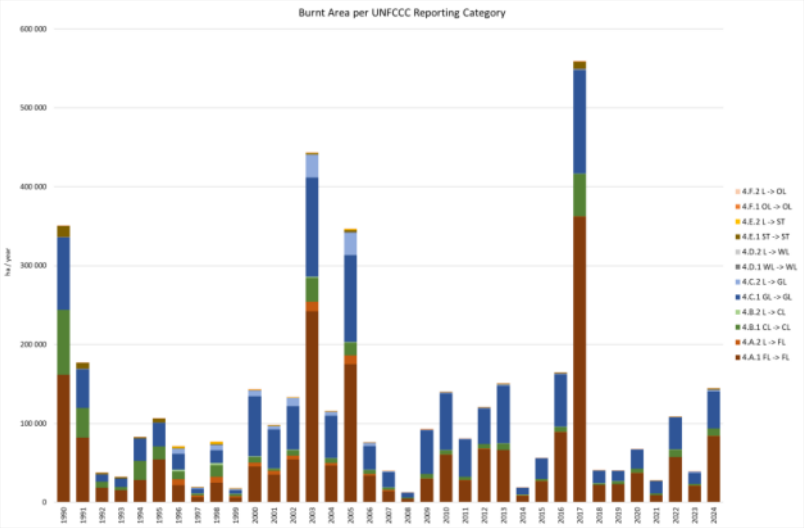



***Figure 6-32: Burned areas per reporting category (ha)***

## 6.12.2 Estimation of Biomass Loss due to Fires

The loss of biomass during forest fires was estimated by multiplying the above ground biomass in each land-use by its combustion factor. According to Rosa (2009) forest fire emissions are much more related to biomass of smaller sizes than to total biomass, as they tend to present much higher combustion factors. An estimation of the finer particles present in forest was made identifying the following components: leaves and small branches.

In cases where no reliable combustion factors were available, a conservative approach was taken and the combustion factor was assumed to be 100%. This assumption considers that 100% of all dead trees (including roots) is oxidised during a fire. This approach is needed as there is no information to adequately characterize gains and losses of this pool. The consequence is an overestimation of emissions in the year of fire, but also an underestimation of emissions in the following years. However, it should be noted that all emissions are reported and the approach is consistent over the entire time series (i.e., the system does not consistently bias results in relation to present versus future emissions).

A summary of the values used in estimating biomass loss due to fires is presented in Table 6-20.

***Table 6-20: Combustion factors per biomass component used in the estimation of Fire Emissions***

| | Share of AG Tree Biomass | | Combustion Factor | | | |
|---|---|---|---|---|---|---|
| Land-use Type | Leaves | Small branches | Leaves | Small branches | Shrubs | AG Biomass |
| | % | % | % | % | % | % |
| Pinus pinaster | 14% | 22% | 88% | 58% | 72% | - |
| Pinus pinea | 20% | 33% | 88% | 58% | 72% | - |
| Other coniferous | 33% | 42% | 88% | 58% | 72% | - |
| Eucalyptus spp. | 19% | 14% | 88% | 58% | 72% | - |
| Quercus suber | 2% | 3% | 88% | 58% | 72% | - |
| Quercus rotundifolia | 3% | 4% | 88% | 58% | 72% | - |
| Quercus spp. | 6% | 14% | 88% | 58% | 72% | - |
| Other broadleaves | 3% | 7% | 88% | 58% | 72% | - |
| Rainfed annual crops | - | - | - | - | - | 100% |
| Irrigated annual crops | - | - | - | - | - | - |
| Rice padies | - | - | - | - | - | - |
| Vineyards | - | - | - | - | - | 100% |
| Olive groves | - | - | - | - | - | 100% |
| Other permanent crops | - | - | - | - | - | 100% |
| All grasslands | - | - | - | - | - | 100% |
| Wetlands | - | - | - | - | - | - |
| Settlements | - | - | - | - | - | - |
| Shrubland | - | - | - | - | 72% | - |
| Other | - | - | - | - | - | - |

### 6.12.3 Direct $CO_2$ Emissions from Fires

Direct $CO_2$ emissions from fires were estimated using the following equation:

***Equation 6-14: Estimation of Direct $CO_2$ Emissions from Fires***

$$E_{CO2} = \sum_x BA_x \times BLF_x \times Cf \times CtoCO2$$

**Where:**

$E_{CO2}$ = Emissions of $CO_2$ ($tCO_2$)

$BA_x$ = Burned area of land-use *x* (ha)

$BLF_x$ = Biomass Loss due to fires in land-use *x* (tdm/ha), derived from average biomass stocks and combustion-related parameters

$C_f$= Carbon fraction of Dry Matter (%)

$CtoCO2$ = Stoichiometric conversion from Carbon to $CO_2$ (44/12)

### 6.12.4 Direct $CH_4$ Emissions from Fires

Direct $CH_4$ emissions from fires were estimated using the following equation:

***Equation 6-15: Estimation of Direct $CH_4$ emissions from Fires***

$$E_{CH4} = \sum_x BA_x \times BLF_x \times Cf \times EF_{CH4}$$

**Where:**

$E_{CH4}$ = Emissions of $CH_4$ ($tCH_4$)

$BA_x$ = Burned area of land-use *x* (ha)

$BLF_x$ = Biomass Loss due to fires in land-use *x* (tdm/ha), derived from average biomass stocks and combustion-related parameters

$C_f$= Carbon fraction of Dry Matter (%)

$EF_{CH4}$ = Emission factor for $CH_4$ expressed per unit of carbon emitted (t $CH_4$ per t C). A value of 0.015 t $CH_4$ $t^{-1}$ C was applied (*EMEP/EEA Emission Inventory Guidebook 2019*, Chapter 11.B, Table 3.3)

### 6.12.5 Direct $N_2O$ Emissions from Fires

Direct $N_2O$ emissions from fires were estimated using the following equation:

***Equation 6-16: Estimation of Direct $N_2O$ emissions from Fires***

$$E_{N2O} = \sum_x BA_x \times BLF_x \times Cf \times EF_{N2O}$$

**Where:**

$E_{N2O}$ = Emissions of $N_2O$ (t $N_2O$)

$BA_x$ = Burned area of land-use x (ha)

$BLF_x$ = Biomass Loss due to fires in land-use x (tdm/ha), derived from average biomass stocks and combustion-related parameters

$C_f$= Carbon fraction of Dry Matter (%)

$EF_{N2O}$ = Emission factor for $N_2O$ expressed per unit of carbon emitted (t $N_2O$ per t C). A value of 0.0004 t $N_2O$ $t^{-1}$ C was applied (*EMEP/EEA Emission Inventory Guidebook 2019*, Chapter 11.B, Table 3.3).

### 6.12.6 Indirect $CO_2$ Emissions from Fires

Indirect emissions are defined as emissions occurring after the fire due to tree mortality caused by the disturbance. They are estimated following the flow described in Figure 6-33.

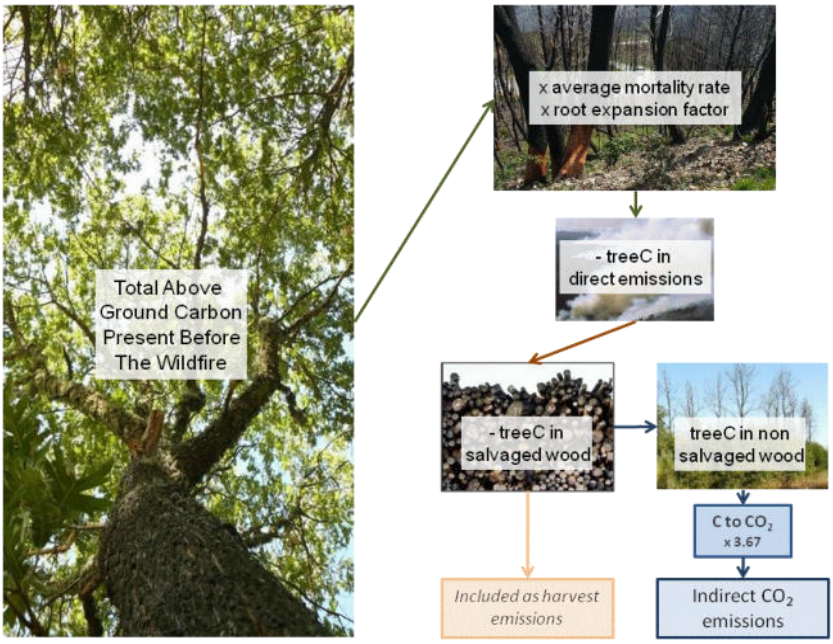



***Figure 6-33: Estimation of Indirect Fire emissions***

Post-fire mortality rates were estimated based on expert judgement, as presented in Table 6-21.

***Table 6-21: Fire mortality rates***

| Land-use Type | Mortality % |
|---|---|
| Pinus pinaster | 70% |
| Pinus pinea | 30% |
| Other coniferous | 70% |
| Eucalyptus spp. | 50% |
| Quercus suber | 30% |
| Quercus rotundifolia | 10% |
| Quercus spp. | 30% |
| Other broadleaves | 30% |
| Shrublands | 90% |

Salvage logging is accounted for under “losses from industrial harvest.” Therefore, indirect emissions are estimated only where total biomass loss due to mortality exceeds the carbon already accounted for as direct fire emissions and industrial harvest.

Results of fire emission estimates are presented in the following figure.

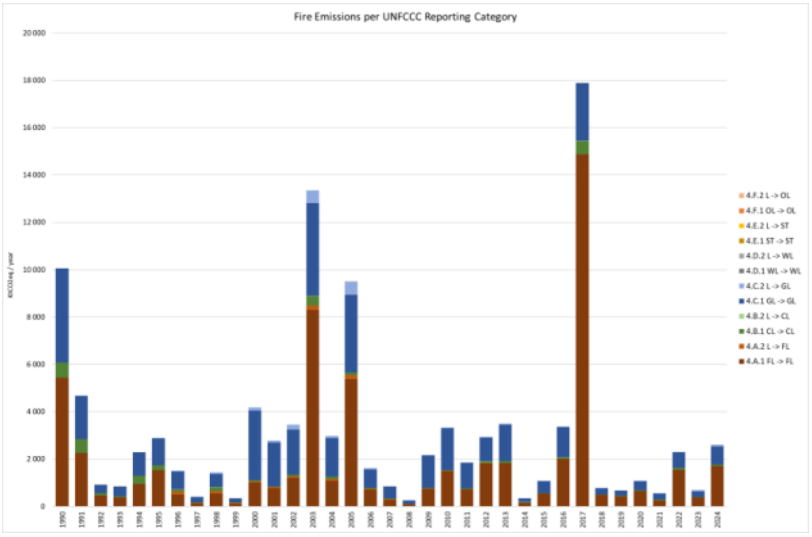



***Figure 6-34: Total emissions from biomass burning per land-use category***

## 6.13 Uncertainty Assessment

Portugal made in 2022 an extensive recalculation of the LULUCF sector. Unfortunately, it was still not possible to revise and present in this submission the uncertainty estimates for LULUCF.

## 6.14 QA/QC

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification, and the information provided in this report.

Where applicable cross-checks and consistency checks between data submitted for the UNFCCC and KP reporting were also made.

Particular attention was given to the consistent application of the 20 years conversion period and the "since 1990" in both the UNFCCC and KP reporting.

Issues detected by and recommendations made by the Joint Research Centre were also considered, following the QA/QC procedures implemented by JRC in the compilation of the inventory submission for the EU.

Finally, issues detected by and recommendations made by the Expert Review Teams in previous UNFCCC reviews were also considered and, where possible, corrected.

## 6.15 Recalculations and Data Improvements

The major changes between submissions result from the following actions:

- **4.A Forestland:**
  - Harvest data updated using the latest values from the UNECE/FAO Forest Products Production and Trade Database (version updated in November 2024).
  - Harvest data revised to correct data entry errors identified in previous submissions.

- **4.C Grassland:**
  - A typographical error in the GL1 fuel load value was corrected.
  - Emission factor of Indirect $N_2O$ emission was updated in accordance with the *2006 IPCC Guidelines*.

- **4.E Settlements:**
  - A 20% reduction in soil organic carbon was applied for conversions to settlements, following the *2006 IPCC Guidelines*.
  - Emission factor of $N_2O$ emissions was corrected to align with the default values provided in the *2006 IPCC Guidelines*.
  - The full loss of dead organic matter (DOM) was applied in the year of conversion to settlements, in accordance with the *2006 IPCC Guidelines*.

- **4.G Harvested wood products:**
  - Data updated with the latest values from UNECE/FAO Database Forest Products Production and Trade (version updated November 2024).
  - Extension of HWP time series to 1900. Revised HWP estimates were developed by extending the time series back to 1900, in accordance with the *2006 IPCC Guidelines*, applying the recommended methodology for estimating carbon pool inputs prior to the availability of official production data.

- **4(IV) Biomass Burning:**
  - Data for 2021-2024 updated based on ICNF Fire Maps overlapped with COS maps, making data consistent with the rest of the time series.
  - Data for the Autonomous Region of Madeira was revised based on information provided by the Local Government.

The impact of these recalculations in the final totals is presented in

Figure 6-35.

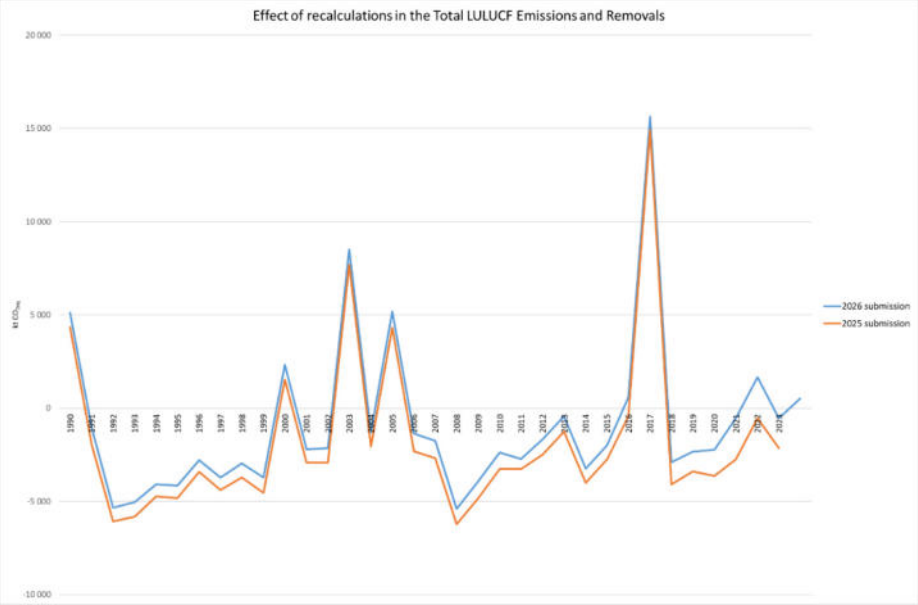



***Figure 6-35: Effect of recalculations in the LULUCF emissions and removals***

## 6.16 Further Developments

Portugal continues to undertake significant efforts to improve the methodological level of the LULUCF inventory, aiming at the progressive implementation of higher-tier approaches and ensuring more complete, transparent and accurate reporting of emissions and removals.

Planned improvements include a revision of soil emission and sequestration factors, taking into account newly available data from the LUCAS Soil survey. These data are expected to support a more robust characterization of soil carbon dynamics across land-use categories.

A new national land-use map (Carta de Uso e Ocupação do Solo – COS 2023) has recently been released. The integration of this dataset into the inventory is planned for future submissions. However, its incorporation requires methodological harmonisation with previous COS versions to ensure consistency of the land-use time series and compatibility with the currently applied land-representation system, but this process has not yet been completed.

The results of the next National Forest Inventory (NFI) are also expected to support future improvements in the estimation of forest area, biomass stocks and growth parameters. At the time of this submission, the NFI data are still under preparation and therefore could not yet be incorporated.

# 7 Waste (CRF Sector 5)

## Table of Contents


7 Waste (CRF Sector 5) ..... 7-1

7.1 Overview of the sector ..... 7-6

7.1.1 Emission trends ..... 7-6

7.1.2 General evolution of the waste sector and data trends ..... 7-10

7.1.3 Data sources on solid waste ..... 7-13

7.1.4 Recalculations ..... 7-14

7.2 Solid Waste Disposal (CRF 5.A) ..... 7-15

7.2.1 Category description ..... 7-15

7.2.2 Methodological issues ..... 7-16

7.2.3 Uncertainty assessment ..... 7-25

7.2.4 Category specific QA/QC and verification ..... 7-26

7.2.5 Category specific recalculations ..... 7-26

7.2.6 Category specific planned improvements ..... 7-26

7.3 Biological Treatment of Solid Waste (CRF 5.B) ..... 7-27

7.3.1 Category description ..... 7-27

7.3.2 Methodological issues ..... 7-28

7.3.3 Uncertainty assessment ..... 7-29

7.3.4 Category specific QA/QC and verification ..... 7-29

7.3.5 Category specific recalculations ..... 7-29

7.3.6 Category specific planned improvements ..... 7-29

7.4 Waste Incineration (CRF 5.C) ..... 7-30

7.4.1 Category description ..... 7-30

7.4.2 Methodological issues ..... 7-31

7.4.3 Uncertainty Assessment ..... 7-38

7.4.4 Category specific QA/QC and verification ..... 7-38
7.4.5 Category specific recalculations ..... 7-39
7.4.6 Category specific planned improvements ..... 7-39
7.5 Wastewater Treatment and Discharge (CRF 5.D) ..... 7-40
7.5.1 Category description ..... 7-40
7.5.2 Methodological issues ..... 7-41
7.5.3 Uncertainty assessment ..... 7-63
7.5.4 Category specific QA/QC and verification ..... 7-64
7.5.5 Category specific recalculations ..... 7-65
7.5.6 Category specific planned improvements ..... 7-65
7.6 Biogas burning without energy recovery (CRF 5.E) ..... 7-66
7.6.1 Category description ..... 7-66
7.6.2 Methodological issues ..... 7-66
7.6.3 Uncertainty Assessment ..... 7-67
7.6.4 Category specific QA/QC and verification ..... 7-67
7.6.5 Category specific recalculations ..... 7-67
7.6.6 Category specific planned improvements ..... 7-67

## List of Figures

Figure 7-1: Greenhouse gas emissions from the waste sector in 2024 ..... 7-7
Figure 7-2: Emissions of direct GHG from waste in percentage of national total by gas (last year available) 7-7
Figure 7-3: Emission trends of GHG from waste by gas ..... 7-9
Figure 7-4: Emission trends of GHG from waste by sub-category ..... 7-10
Figure 7-5: Municipal waste ..... 7-11
Figure 7-6: Municipal waste treatment by final destination. ..... 7-13
Figure 7-7:Recalculations between 2025 and 2026 submissions in Waste Sector. ..... 7-15
Figure 7-9: Population served by waste collection systems ..... 7-17
Figure 7-10: Quantities of fermentable industrial waste disposed to SWDS ..... 7-19
Figure 7-11: Total industrial waste by treatment types ..... 7-19
Figure 7-12: Geographical location of Landfills and climatic conditions ..... 7-23
Figure 7-13: Quantities of CH4 combusted (SWDS) ..... 7-25
Figure 7-14: Quantities of waste Composted/ Digested and related emissions ..... 7-28

Figure 7-15: Incineration of Municipal Solid Waste: quantities incinerated (kt) and related emissions (kt CO2e) (accounted in CRF 1Aa) ..... 7-33

Figure 7-16: Incineration of Healthcare Waste: quantities incinerated (kt) and related emissions (kt CO2e) 7-35

Figure 7-17: Quantities of combusted industrial waste ..... 7-36

Figure 7-18: Comparison between MSW incineration data used in the inventory and EB data ..... 7-39

Figure 7-19: CH4 emissions from urban wastewater handling systems ..... 7-42

Figure 7-20: Wastewater and sludge $BOD_5$ produced according to handling systems and related CH4 emissions ..... 7-47

Figure 7-21: Direct, indirect and sludge treatment CH4 emissions from industrial wastewater handling systems ..... 7-49

Figure 7-22: Organic load aggregated by industrial sector and treatment type in 2018 ..... 7-51

Figure 7-23: Industrial Wastewater organic load, expressed in COD, from major industrial sectors ..... 7-51

Figure 7-24: Wastewater and sludge COD produced according to handling systems and related CH4 emissions ..... 7-52

Figure 7-25: Urban wastewater N load per wastewater handling systems and related N2O emissions ..... 7-55

Figure 7-26: N2O emissions from urban wastewater handling systems ..... 7-55

Figure 7-27: Industrial wastewater N load and related N2O emissions ..... 7-60

Figure 7-28: Direct, indirect and sludge treatment N2O emissions from industrial waste water handling systems ..... 7-60

Figure 7-29: Nitrogen load aggregated by industrial sector and treatment type in 2018 ..... 7-62

Figure 7-30: Industrial Wastewater nitrogen load from major groups of industrial activity ..... 7-63

## List of Tables

Table 7-1: Key categories in the Waste sector (CRF 5) and methodologies used in emission estimates ..... 7-6

Table 7-2: Total Greenhouse Gas Emissions from Waste Mt $CO_2$eq. ..... 7-8

Table 7-3: Calculation methods and types of emission factors for emissions on Solid Waste Disposal on Land ..... 7-15

Table 7-4: $CH_4$ emissions from solid waste disposal on land (kt CO2e.) ..... 7-16

Table 7-5: Estimated average annual growing rates for the period 1970-1998 ..... 7-18

Table 7-6: Municipal waste composition disposed to SWDS and DOC ..... 7-20

Table 7-7: Industrial organic waste composition and DOC ..... 7-22

Table 7-8: Parameters used in Lo calculation ..... 7-22

Table 7-9: CH4 in landfill gas ..... 7-24

Table 7-10: Emissions from Biological Treatment of Solid Waste (ktCO2e) ..... 7-27

Table 7-11: Calculation methods and types of emission factors for emissions on Solid Waste Disposal on Land ..... 7-27

Table 7-12: Default emission factors for CH4 and N2O emissions from biological treatment (wet weight basis) ..... 7-28

Table 7-13: Emissions from Waste Incineration (ktCO2e)..... 7-30

Table 7-14: Calculation methods and types of emission factors for emissions on Solid Waste Disposal on Land ..... 7-31

Table 7-15: Base table for MSW C content estimation ..... 7-33

Table 7-16: CO2 Implied Emission Factors for CRF 1Aa ..... 7-34

Table 7-17: Parameters considered: healthcare waste..... 7-35

Table 7-18: Parameters considered. ..... 7-36

Table 7-19: Emissions factors of GHG and precursors gases from incineration of MSW ..... 7-37

Table 7-20: Emissions factors of GHG and precursors gases from incineration of healthcare wastes: until 2004 ..... 7-37

Table 7-21: Emissions factors of GHG and precursors gases from incineration of healthcare wastes: after 2005 ..... 7-38

Table 7-22: Emissions factors of GHG and precursors gases for Industrial solid waste incineration ..... 7-38

Table 7-23: Calculation methods and types of emission factors for emissions on wastewater treatment and discharge ..... 7-40

Table 7-24: Emissions from Wastewater Treatment and Discharge (ktCO2e)..... 7-41

Table 7-25: Percentage of population by wastewater handling system ..... 7-46

Table 7-26: Fraction of organic load (BOD) removed by type of treatment - $TOW_{REM}$ ..... 7-48

Table 7-27: Estimation of Sludge production ($S_{mass}$) from amount of BOD-removed by type of treatment 7-48

Table 7-28: Methane Conversion Factors (MCF) by type of treatment and discharge pathway (Direct emissions)..... 7-48

Table 7-29: Default emission factors for CH4 and N2O emissions from biological treatment (wet weight basis) ..... 7-49

Table 7-30: Percentage of industrial wastewater by handling system ..... 7-52

Table 7-31: Fraction of organic load (BOD) removed by type of treatment - $TOW_{REM}$ ..... 7-53

Table 7-32: Estimation of Sludge production (Smass) from amount of BOD-removed by type of treatment 7-53

Table 7-33: Methane Conversion Factors (MCF) by type of treatment and discharge pathway..... 7-54

Table 7-34: Data and parameters used calculation of N2O emissions from wastewater..... 7-58

Table 7-35: Wastewater treatment Nitrogen removal fractions ($N_{REM}$) by treatment type ..... 7-59

Table 7-36: Emission factors for domestic and industrial wastewater (kg N2O-N/kg N) ..... 7-59

Table 7-37: Activity data, emission factors and related emissions of biogas combusted..... 7-67

# List of Equations

Equation 7-1: $CO_2$ emissions from MSW and industrial waste incineration ..... 7-31
Equation 7-2: $CO_2$ emissions from healthcare waste incineration ..... 7-31
Equation 7-3: Non-$CO_2$ emissions from waste incineration ..... 7-37
Equation 7-4: Total organics in domestic wastewater prior to treatment ..... 7-42
Equation 7-5: Total organics per wastewater handling system type ..... 7-42
Equation 7-6: Total organics in treated wastewater effluent ..... 7-43
Equation 7-7: Organic component removed as sludge from aerobic treatment plants ..... 7-43
Equation 7-8: Organic component removed as sludge from septic systems ..... 7-43
Equation 7-9: Emission Factors per wastewater handling system type ..... 7-44
Equation 7-10: Total $CH_4$ emissions from wastewater handling ..... 7-44
Equation 7-11: Total organics in industrial wastewater before treatment per handling system type ..... 7-50
Equation 7-12: Total Nitrogen in domestic wastewater ..... 7-56
Equation 7-13: Total Nitrogen in domestic wastewater by treatment pathway ..... 7-56
Equation 7-14: Total Nitrogen in domestic wastewater effluent ..... 7-56
Equation 7-15: N2O emissions from domestic wastewater treatment plants/discharge pathway ..... 7-57
Equation 7-16: N2O emissions from domestic wastewater effluent ..... 7-57
Equation 7-17: Total nitrogen in wastewater before treatment by type of treatment ..... 7-61
Equation 7-18: N2O emissions from industrial wastewater in treatment plants ..... 7-61
Equation 7-19: N2O emissions from industrial wastewater effluent ..... 7-61

# 7 Waste (CRF Sector 5)

*Teresa Costa Pereira*

*Updated: March 2026*

Portugal implemented for the EU submission of March 2024 the methodological approach proposed by the 2019 IPCC Refinements, which represents a major change compared with the 2006 IPCC Guidance for the Wastewater Treatment sub-sector.

The main revision refers to the N2O emissions, which underwent a profound change leading to a greater importance. In fact, while in the previous guidelines (IPCC, 2006) N2O emissions in WWTPs were considered almost negligible, with this approach, N2O emissions have a bigger importance.

CH4 emissions also recorded a significant revision and include now the emissions that occur after the discharge of wastewater into the water environment, where previously only N2O emissions were accounted for in this path.

The change in the estimation methodology and the consideration of some emission factors substantially changed the level of emissions associated with this subsector in relation to previous submissions.

## 7.1 Overview of the sector

***Key categories***

The key categories related to the waste sector are summarised in table below.

***Table 7-1: Key categories in the Waste sector (CRF 5) and methodologies used in emission estimates***

| IPCC category | Gas | Criteria | Method |
|---|---|---|---|
| **5.A Solid waste disposal** | $CH_4$ | L 1-2,T 1-2 | T2 |
| **5.D Wastewater treatment and discharge** | $CH_4$ | L 1-2,T 1-2 | T2 |
| **5.D Wastewater treatment and discharge** | $N_2O$ | L 1-2,T 1-2 | T2 |

### 7.1.1 Emission trends

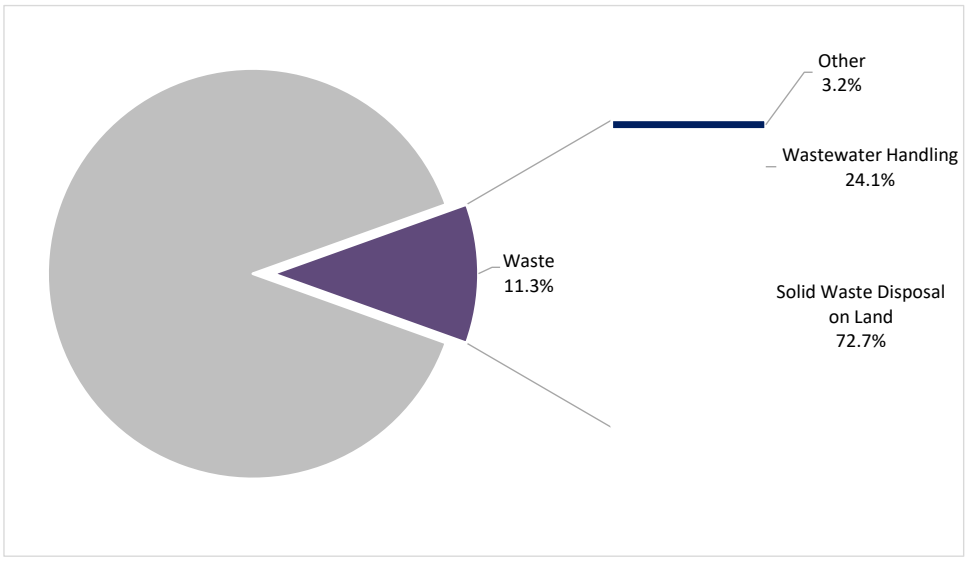
Waste management of municipal and industrial wastes are sources of GHG emissions. The inventory covers emissions resulting from landfilling, composting of organic waste, wastewater treatment, waste incineration and combustion of biogas.

Wastewater can also be a source of CH4 and N2O emissions.

The most important gas produced is CH4, resulting from the anaerobic decomposition of organic waste disposed on land and from handling of wastewater treatment under anaerobic conditions. N2O emissions are related with wastewater treatment and discharge of nitrogen into waterways.

CO2 emissions in the waste sector are associated with incineration of waste containing fossil carbon, e.g. plastics. CO2 emissions from biogenic origin are accounted as an information item.

Waste and wastewater treatment can also produce emissions of NMVOCs, NOx, CO as well as NH3 which are also estimated.




Note: Percentages may not sum 100% due to rounding

***Figure 7-1: Greenhouse gas emissions from the waste sector in 2024***

Emissions generated from waste activities are estimated, in 2024, as 5.6 Mt CO2e, representing 11.3 % of total GHG emissions. The biggest sub-category within the sector refers to waste disposed on land (CRF 5A) – 4.1 Mt CO2e - corresponding to approx. 73 % of the sector´ emissions. Wastewater Handling (CRF 5D) contributes to most of the remaining emissions, with 24% of the sector emissions. Additionally, biological treatment of waste and waste incineration without energy recovery (which occur in health care and industrial waste units), classified as disposal operation D10, represent minor shares of the sector emissions with 1.7% and 1.5%, respectively.

Waste incineration with energy recovery, classified as recovery operation R1, includes Municipal waste incineration units (waste-to-energy facilities) and industrial plants (cement plants) reported under Energy sector 1A. Emissions from biogas combustion with energy recovery are also reported in CRF 1A1a.

Other waste treatment (CRF 5E) includes emissions from biogas burning without energy recovery.

The contribution of each greenhouse gas emissions from this sector to the national emissions, expressed in $CO_2$eq, in 2024 is: $CH_4$ emissions 47.8%; $N_2O$ emissions 23.9% and $CO_2$ emissions 0.1 %, as the next figure shows.

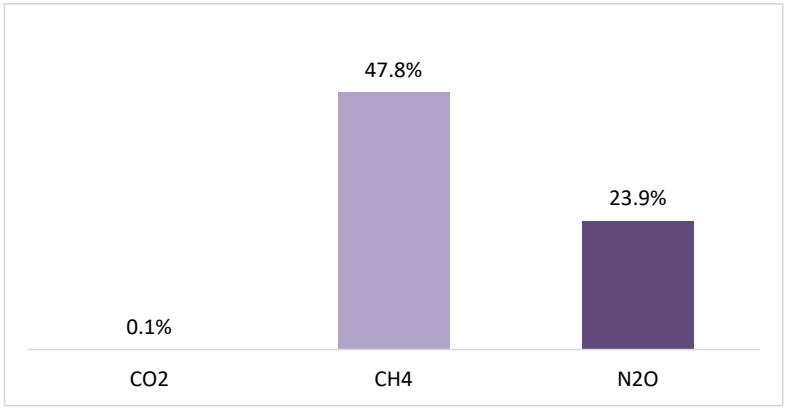



***Figure 7-2: Emissions of direct GHG from waste in percentage of national total by gas (last year available)***

*Table 7-2: Total Greenhouse Gas Emissions from Waste Mt $CO_2$eq.*

| | Source /Gas | 1990 | 2005 | 2021 | 2023 | 2024 | Δ 2024-2023 | Δ 2024-2005 | Δ 2024-1990 |
|---|---|---|---|---|---|---|---|---|---|
| | | kt $CO_2$ eq. | | | | | % | | |
| **5.A** | **Solid waste disposal** | | | | | | | | |
| | $CH_4$ | 2,944.82 | 5,326.92 | 4,126.77 | 4,078.66 | 4,076.80 | 0.0 | -23.5 | 38.4 |
| **5.B** | **Biological treatment of solid waste** | | | | | | | | |
| | $CH_4$ | 5.63 | 14.64 | 51.30 | 54.66 | 64.39 | 17.8 | 339.8 | 1043.9 |
| | $N_2O$ | 3.20 | 8.31 | 23.14 | 25.31 | 29.52 | 16.6 | 255.0 | 823.4 |
| **5.C** | **Incineration of waste (without energy recovery)** | | | | | | | | |
| | $CO_2$ | 6.96 | 11.64 | 36.52 | 37.39 | 38.05 | 1.8 | 226.8 | 446.7 |
| | $CH_4$ | 38.02 | 31.26 | 30.07 | 30.43 | 30.34 | -0.3 | -2.9 | -20.2 |
| | $N_2O$ | 20.52 | 17.48 | 16.28 | 16.47 | 16.45 | -0.2 | -5.9 | -19.9 |
| **5.D** | **Wastewater treatment** | | | | | | | | |
| | CH4 | 1,156.96 | 850.03 | 592.98 | 579.25 | 575.38 | -0.7 | -32.3 | -50.3 |
| | $N_2O$ | 253.23 | 504.00 | 735.16 | 756.06 | 778.48 | 3.0 | 54.5 | 207.4 |
| **5.E** | **Other (biogas burning)** | | | | | | | | |
| | $CH_4$ | NO | 0.0075 | 0.0009 | 0.0009 | 0.0016 | 77.7 | -78.0 | - |
| | $N_2O$ | NO | 0.0071 | 0.0009 | 0.0009 | 0.0016 | 77.7 | -78.0 | - |
| **Total** | $CO_2$ | 6.96 | 11.64 | 36.52 | 37.39 | 38.05 | 1.8 | 226.8 | 446.7 |
| | $CH_4$ | 4,145.44 | 6,222.85 | 4,801.13 | 4,743.00 | 4,746.92 | 0.1 | -23.7 | 14.5 |
| | $N_2O$ | 276.95 | 529.80 | 774.58 | 797.84 | 824.44 | 3.3 | 55.6 | 197.7 |
| **Total** | **All gases** | **4,429.35** | **6,764.30** | **5,612.23** | **5,578.23** | **5,609.41** | 0.6 | -17.1 | 26.6 |
| **1.A.1.a** | **Incineration of waste (with energy recovery)** | | | | | | | | |
| | $CO_2$ | 0.00 | 331.67 | 432.84 | 401.46 | 513.24 | 27.8 | 54.7 | - |
| | $CH_4$ | 0.00 | 6.94 | 6.07 | 7.04 | 8.32 | 18.1 | 19.9 | - |
| | $N_2O$ | 0.00 | 14.01 | 13.96 | 12.95 | 16.53 | 27.6 | 17.9 | - |

Note: Totals may not sum due to independent rounding. Emissions values are presented in $CO_2$eq mass units using IPCC AR5 GWP values ($CH_4$ - 28; $N_2O$ - 265).

In the period 1990-2024 GHG emissions from waste activities recorded a variation +27%. The sector registered a stronger growth until the mid-years 2000´s, recording an increase of more than 50% until 2004.

The evolution of the emissions in the sector is primarily related to the CH4 emissions generated in Municipal Solid Waste landfilling, representing 59% of the sector emissions in 2024. This increase is strongly related to the growth of waste generation driven by the change in consumption patterns associated with the steady economic growth in the following years after the Portuguese accession to the EU in 1986. Another factor relates to the geographical distribution change of the Portuguese population, registering a significant increase of the population living in urban centres since 1960. This trend was accompanied by the development of waste collection systems: the population served by waste collection systems is estimated to have increased from 40% in 1960 to 100% in 2000 (Figure 7-8).

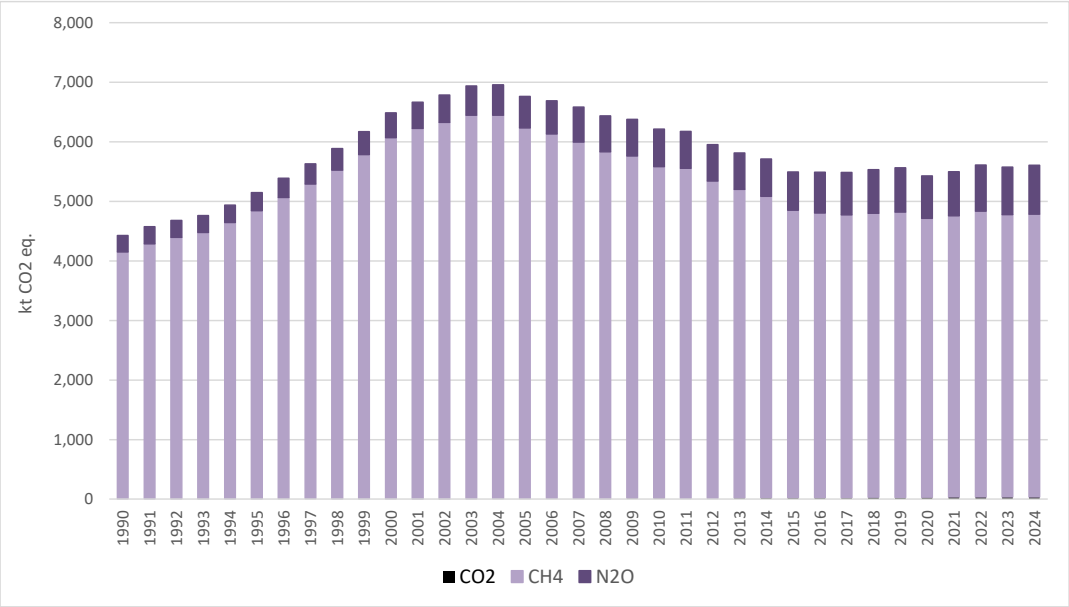



***Figure 7-3: Emission trends of GHG from waste by gas***

In the mid of 2000, emissions started to decrease, due in particular to the increasing importance of biogas burning that can occur with and without energy recovery. Landfill gas with energy recovery is burned in several units which produce and sell electricity to the grid.

Also, the quantities of separate collected waste, which have more than doubled since 1999, have deviate waste flows from SWDS and incineration units, and contributed to this trend.

The start of operation of two incineration units dedicated to MSW incineration in Portugal Mainland (1999), another incineration unit in the Autonomous Region of Madeira in 2001/2002, and more recently, at the end of 2015, one more in the Autonomous Region of Azores, also contribute to the sectoral trend. The emissions from MSW incineration occur with energy recovery and are therefore accounted in the energy sector (category 1A1a).

Emissions from biogas combustion are also accounted and are reported in the energy sector when there is energy recovery or in the waste sector when biogas is flared (without energy recovery).

The emissions are estimated to increase since 2015 (2.1% variation from 2015-2024) namely as a result to the increase of WWTP with tertiary treatment (N removal).

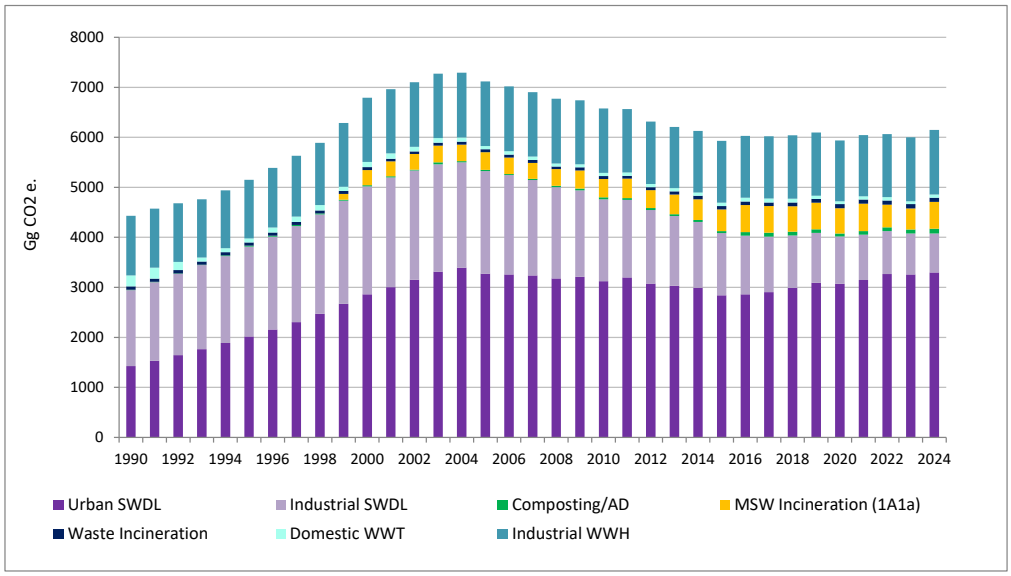



***Figure 7-4: Emission trends of GHG from waste by sub-category***

### 7.1.2 General evolution of the waste sector and data trends

In the last three decades there has been a significant evolution in the management of municipal waste (MSW) systems. Leaving from a predominantly municipal management logic, in the period prior to 1995, the situation has evolved towards a multi-municipal management through the creation of multi-municipal systems and inter-municipal management of MSW.

Since the end of 2010, the treatment of MSW in Portuguese mainland has been under the responsibility of 23 entities, named as "Municipal Waste Management Systems – SGRU" (11 multi-municipal (private group) and 12 inter-municipal systems (majority public capital)). In the Autonomous Region of Azores, municipality authorities are the responsible entities for the management of MSW, and in the Autonomous Region of Madeira, this responsibility is shared between municipalities and the Regional Government.

The policy of management of municipal waste in Portugal has been defined through specific strategic plans for this sector.

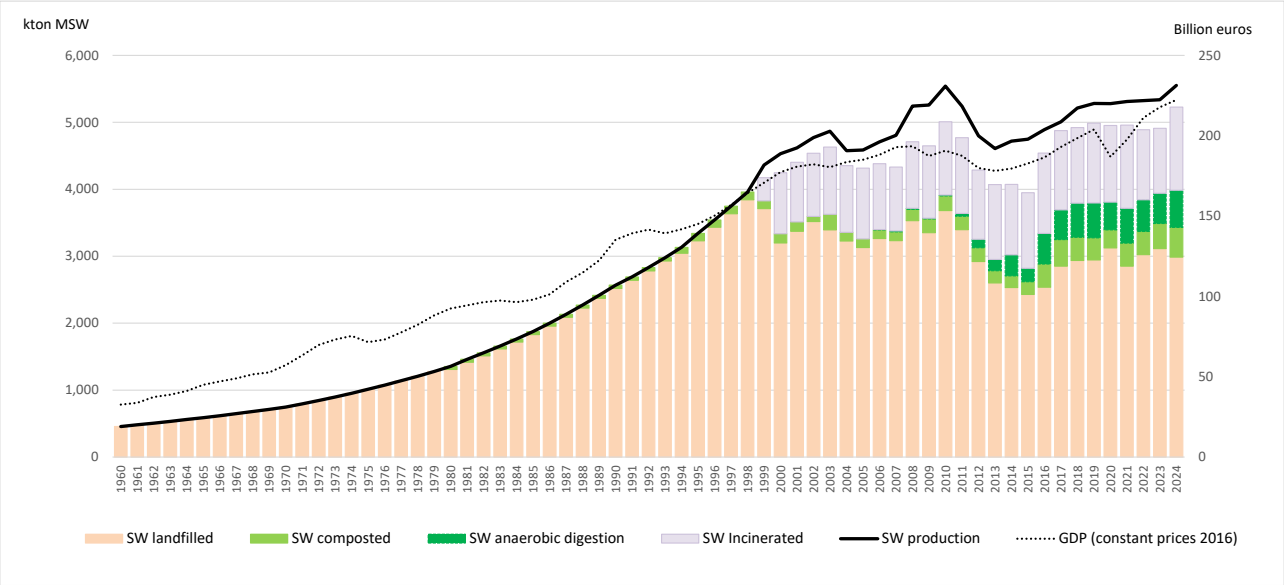
The first Strategic Plan on Municipal Solid Waste (PERSU - "*Plano Estratégico dos Resíduos Sólidos Urbanos*"), approved in 1997, settled the main axis of action in this domain: the deactivation and closure of all uncontrolled dumping sites which occurred in 2002, the construction of environmentally sound management infrastructures and the development of separate collection.

In a second phase, after the construction of the adequate infrastructures for waste treatment, the Strategic Plan for Municipal Solid Waste, PERSU II (2007-2016), foreseen the construction of mechanical and biological treatment and recovery organic units, with a view to the recovery and recycling of the biodegradable waste fraction and their diversion from landfill, as well as the reinforcement of the equipment for the recovery of the multi-material fraction of waste.

In 2014, a new Strategic Plan for Municipal Solid Waste (PERSU 2020) covering the period 2014-2020 was approved. One of the main measures of this Plan is the promotion of the use of waste as a resource, giving priority to the upstream activity of the chain of value and the integration of the Municipal Waste Prevention Program. Furthermore, it supports a significant increase in separate collection and recycling and promotes the progressive elimination of direct landfilling.

Recognising that the level of ambition set by the new European targets for landfill disposal, preparation for reuse and recycling of municipal waste, recycling of packaging and plastic reduction, pose highly complex challenges for Portugal, it has become imperative to take measures to realign the strategic lines that enable it to contribute to fulfilling its commitments. So, with that need in mind, PERSU 2020+ was approved in 2019, which is a strategic reflection and an adjustment to the measures contained in the PERSU 2020, which projects the interventions to be developed up to the year 2025. In 2023, PERSU 2030 was published. The PERSU 2030 is fourth-generation document that aims to ensure the application of the national municipal waste management policy, guiding the involved stakeholders in implementing actions that allow the country to align with policies and strategies at the European Union level. It contributes to waste prevention, increased preparation for reuse, recycling, and other forms of municipal waste recovery, with a consequent reduction in the consumption of primary raw materials, making a significant contribution to decarbonization and environmental improvement.

The figure below presents the trends of SW generation amounts and the quantities of waste per type of final disposal.




Source: APA, include estimates

***Figure 7-5: Municipal waste***

Waste generation registered an expressive growth during the 1990s, in association with the development of household income and the growth of urbanization recorded in the country during those years.

After the peak around the year 2010, total municipal solid waste (MSW) production presented mostly a decreasing tendency, resulting from prevention policies, but mostly due to the economic crisis effect on consumption.

In 2020, the GDP growing tendency verified since 2014 was broken due to the economic downturn caused by the COVID-19 viral pandemic. The shutdown measures to contain the pandemic have plunged the national economy into recession, with a registered downfall of 8.4% in GDP (2019/2020 variation).

With the exception of 2020 due to the pandemic crisis, Portugal registered since 2014 a growing trend of municipal waste production. This increase is believed to be related with an improvement of the economic situation of Portugal until 2019, seeming to indicate that the goal of decoupling waste production from economic growth is not being fulfilled.

Among the factors that explain these tendencies, is the remarkable growth of tourist inbound in Portugal before the pandemic crisis, contributing both to the Portuguese economic development and to the growth of municipal waste generation.

The resumption of economic activity in the 3 latest years, influenced all the national reality and, consequently, the waste sector.

In 2024, 5,550 thousand tons (t) of municipal waste were produced in Portugal, representing a 4.0% increase when comparing to 2023.

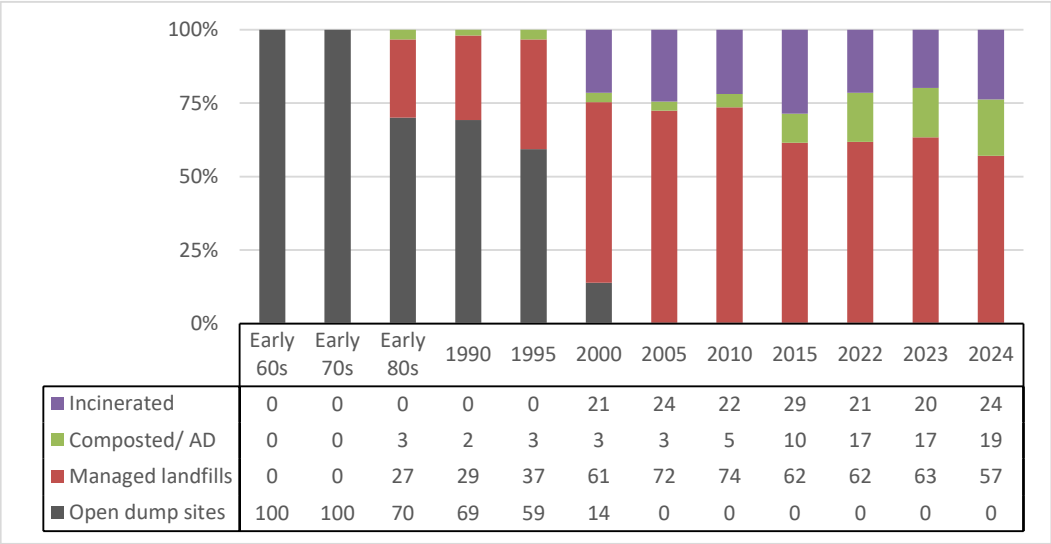
The Portuguese MSW production per capita in 2024 corresponded to approx. 519 kg/year above the EU27 average per capita MSW production in 2023 (http://ec.europa.eu/eurostat/statistics-explained/index.php/Municipal_waste_statistics).

Until the late '90s, landfilling remained almost exclusively the main waste treatment practice.

In 1999/2000, with the start of operation of two MSW incineration units in Mainland Portugal, in 2001/2002 one more in the Autonomous Region of Madeira, and at the end of 2015 another one in the Autonomous Region of Azores, waste started to be diverted from SWDS. All MSW incineration occur with energy recovery.

Although landfilling remains the main final destination for municipal waste, the disposal of waste in landfills have been progressively decreasing since 2010, with the exception of 2020 due to the pandemic crisis. In 2020, APA, together with ERSAR and DGS issued *Guidelines and Recommendations for waste management in pandemic situation of COVID-19*, that recommended, during a period of time, that SGRU should send mixed waste, directly and without any prior sorting, preferably for incineration, or to landfill when not possible to use incineration capacity or when the geographical location of the waste production would justify it. It was also recommended the closure of the mechanical treatment of mixed waste in order to reduce the exposure of workers.

The diversion of waste disposal from landfills has been accompanied by the growth of importance of Mechanical and Biological treatment as well as sorting units as foreseen in the Municipal Solid waste Strategic Plans (PERSUs) and the National Plan for Waste Management (PGNR 2014-2020). The number of waste management infrastructures for biological treatment have grown expressively in the last decade, with the aim to increase the direct diversion of biodegradable waste from landfills and increase recycling. As a consequence, composting/AD has been growing in importance (exception for 2020). These measures have contributed also to an increase in multi-material recycling and the organic recovery and recycling of waste, with a consequent decrease of biodegradable waste in landfills.




| | Early 60s | Early 70s | Early 80s | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Incinerated | 0 | 0 | 0 | 0 | 0 | 21 | 24 | 22 | 29 | 21 | 20 | 24 |
| Composted/ AD | 0 | 0 | 3 | 2 | 3 | 3 | 3 | 5 | 10 | 17 | 17 | 19 |
| Managed landfills | 0 | 0 | 27 | 29 | 37 | 61 | 72 | 74 | 62 | 62 | 63 | 57 |
| Open dump sites | 100 | 100 | 70 | 69 | 59 | 14 | 0 | 0 | 0 | 0 | 0 | 0 |

Note: The figure refers to the final destination of waste, which includes the "direct disposal of waste" and the "indirect disposal" of additional amounts of waste, understanding the latter as rejected amounts from the previous handling processes, such as mechanical treatment and sorting.
Source: APA estimates

***Figure 7-6: Municipal waste treatment by final destination.***

### 7.1.3 Data sources on solid waste

From 1999 onwards, data on MSW is available for the majority of management systems, including generation amounts, final disposal and, to a less extent, waste composition.

For previous years, information on municipal waste was not collected on a regular basis, and most information was available from:

- PERSU - "*Plano Estratégico dos Resíduos Sólidos Urbanos*" (Strategic Plan on Municipal Solid Waste), which was approved by the Government in 1997. This plan includes data from annual municipal registries;

- a study performed by Quercus (1995) – "*Caracterização dos Resíduos Sólidos Urbanos e Inventariação dos Locais de Deposição em Portugal*" (Characterization of Municipal Solid Waste and Survey of Disposal Sites in Portugal). The study of Quercus (1995) considered open dump sites, managed landfills, composting and incineration units, covering aspects as the quantities of waste treated or landfilled and other characteristics (opening and closure year of operation, waste composition, existence of flaring equipment, etc). Data was based on a survey performed in 1994, which enabled the calculation of per capita generation rates for 1994, based on the amounts of waste collected and the population served by waste collection.

Since 1999, the information refers to data effectively collected and reported by the waste management systems, which details the different treatments: landfilling, incineration, composting/anaerobic digestion, and material recycling.

At present the National legislation refers to the DL 102-D/2020, which approves the general waste management regime (in annex I), the legal regime for the disposal of waste in landfills (in annex II) and amends the management regime for specific waste flows, transposing Directives (EU) 2018/849, 2018/850, 2018/851 and 2018/ 852.

Waste management policies have evolved towards the sustainable management of materials to protect, preserve and improve the quality of the environment, ensure the rational use of natural resources, and promote the principles of the circular economy.

The National entity responsible for the definition, implementation and supervising the waste policies is APA, I.P. through its Waste Department, which is also responsible for the verification, validation and treatment of the information collected via the Integrated System for Electronic Registry on Waste (SIRER) in the SILiAmb electronic platform.

The operators should upload on different registration maps the information regarding generation, trade, recovery and disposal of waste, including the origin of waste, the quantities generated and treated, the classification and the destiny of the waste.

The data collected is of the utmost relevance for a proper monitoring of the national reality in terms of waste. This information is the basis for an adequate national waste planning and for the assessment of the national policies implemented, including the possible need to reformulate them.

In addition, the information reported also allows close monitoring of the performance of those involved in the waste sector, whether waste producers, treatment operators and municipal or multi-municipal waste collection and/or treatment systems, to assess compliance with legal obligations, targets and to determine the waste management tax.

In terms of municipal waste, the data is reported in MRRU (Municipal Waste Registration Form), allowing the registration of quantities of municipal waste generated in each municipality and their treatment (landfilling, incineration, composting, recycling). Information on waste composition is also collected (the Ordinance 851/2009 defines the methodology for municipal waste characterization). At present, MRRU is filled in by municipal or multi-municipal waste treatment systems from Portugal Mainland and from Autonomous Region of Madeira. Information for the Autonomous Region of Azores is collected under the framework of SNIERPA (National Inventory System). The MIRR is also fill in by waste producers/operators from Portugal Mainland and the Autonomous Region of Madeira.

As regards industrial waste treatment, the first set of data available was collected via an annual registry of industrial declarations received from the regional environment directorates (CCDR).

Data from 2008 onwards refer to data collected via SIRER (Integrated System for Electronic Registry on Waste), available from 2008 to 2011 through the SIRAPA platform, and since 2012 via the SILiAmb electronic platform. After data collection and the respective validation at APA, I.P., data is handled by the INE (National Statistical Office) in order to extrapolate the information to the universe of enterprises for each economic branch, due to the different scope required by the national legislation on waste registration and the Waste Statistics Regulation (Regulation (EC) no. 2150/2002).

### 7.1.4 Recalculations

Changes in this submission refer to:

- Biological treatment of solid waste (5.B): CH4 and N2O emissions:
  Revision of activity data for 2023

- Domestic Wastewater Handling (5.D.1): N2O emissions
  - revision issued from 2025 ESR Review recommendation for N2O affecting all the years: Fnon-con value changed from 1.09 to Fnon-con=1, to accommodate the fact that in Portugal sinks are generally not equipped with "food waste disposal systems";

- protein intake: annual per capita protein intake time series has been revised based on the Portuguese Food Balance (INE).

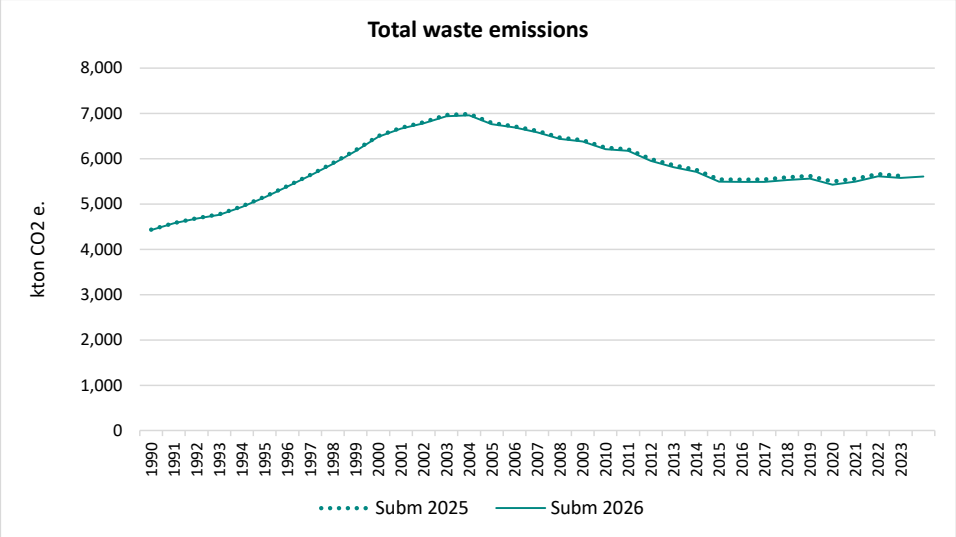



***Figure 7-7:Recalculations between 2025 and 2026 submissions in Waste Sector.***

## 7.2 Solid Waste Disposal (CRF 5.A)

### 7.2.1 Category description

Decomposition of organic waste does not occur instantaneously after disposal on land, but rather over a long period of time, and CH4 is emitted at a diminishing rate. Different factors affect the generation of CH4: Waste disposal practices (degree of control of disposal sites – in general, controlled placement of waste favours anaerobic activity and consequently landfill gas formation, but the gas can be recovered and be either flared or used for energy purposes); Waste composition (quantities of degradable materials is one major element influencing biogas production); and Physical factors (e.g. moisture content and temperature).

Solid waste disposal sites (SWDS), which include both managed landfills and open dump sites, can also produce directly significant amounts of CO2. In fact, the decomposition of organic materials originates landfill gas or biogas consisting of approximately 50 % CH4 and 50 % CO2 by volume. However, this carbon dioxide results in its major part from oxidation of biomass materials and does not contribute hence to ultimate CO2. Additionally, a much smaller percentage of landfill gas is composed of NMVOC and NH3.

SWDS include municipal waste (household, garden, commercial-services wastes) and industrial wastes.

The source category solid waste disposal on land (SWDL) is a key category for CH4, both in terms of level and trend.

***Table 7-3: Calculation methods and types of emission factors for emissions on Solid Waste Disposal on Land***

| Source | Emissions reported | Methods | Activity Data | Emission Factors |
|---|---|---|---|---|
| 5.A.1 Managed Waste Disposal | CH4 | Tier 2 | National data | CS, D |
| 5.A.2 Unmanaged Waste Disposal | CH4 | Tier 2 | National data | CS, D |

The table below presents the estimates of $CH_4$ emission from solid waste disposal on land.

*Table 7-4: $CH_4$ emissions from solid waste disposal on land (kt CO2e.)*

| Source | 1990 | 2000 | 2005 | 2010 | 2015 | 2020 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|
| **Municipal solid waste** | **1,426.0** | **2,862.3** | **3,275.1** | **3,122.1** | **2,840.9** | **3,069.7** | **3,258.7** | **3,296.2** |
| - managed disposal sites | 410.5 | 1,429.3 | 2,200.2 | 2,364.7 | 2,307.1 | 2,693.5 | 2,953.8 | 3,011.9 |
| - unmanaged disposal sites | 1,015.5 | 1,433.0 | 1,074.9 | 757.5 | 533.8 | 376.2 | 304.9 | 284.3 |
| **Industrial solid waste** | **1,518.8** | **2,155.3** | **2,051.8** | **1,639.1** | **1,242.4** | **948.8** | **820.0** | **780.6** |
| - managed disposal sites | 382.7 | 975.2 | 1,189.6 | 1,031.5 | 814.2 | 647.0 | 575.4 | 552.5 |
| - unmanaged disposal sites | 1,136.0 | 1,180.2 | 862.2 | 607.6 | 428.2 | 301.7 | 244.6 | 228.0 |
| **Total** | **2,944.8** | **5,017.7** | **5,326.9** | **4,761.2** | **4,083.2** | **4,018.4** | **4,078.7** | **4,076.8** |

Note: Totals may not sum due to independent rounding

$CH_4$ emissions from SWDL which represent the great majority (73%) of the emissions of the sector have grown almost 90% until 2004 and register a declining trend (-23% from 2005-2024) since then.

## 7.2.2 Methodological issues

### 7.2.2.1 Methods

Methane emissions are calculated on the basis of the First Order Decay Method (Tier 2), following the guidance from the 2006 IPCC Guidelines (Volume 5/ Chapter 3 on Solid Waste Disposal). The IPCC Waste Model was applied using Equations 3.2, 3.4, 3.5 and 3.6 and a single-phase approach based on bulk waste.

Parameter values used are:

- total amount of waste disposed;
- fraction of Degradable Organic Carbon (DOC);
- fraction of DOC dissimilated (DOCF);
- fraction of methane in landfill gas (F);
- methane correction factor (MCF);
- methane generation rate constant (k);
- landfill gas recovered (R);
- oxidation factor (OX).

### 7.2.2.2 Activity data and parameters

The use of the FOD method requires building a data time series for several decades in the past concerning waste quantities, composition and disposal practices. According to IPCC (2000, 2006), it is good practice to estimate historical data if such data are not available, when this is a key source category (ANNEX G). The extent of the time series has been set to 30 years, in order to follow the guidance from IPCC (2000, 2006) which recommends to consider data on solid waste disposal (amount, composition) for 3 to 5 half-lives of the waste deposited at SWDS.

#### 7.2.2.2.1 Quantities of waste landfilled: municipal waste

The first studies available with information on municipal waste refer to PERSU (1997) and a study performed by Quercus (1995) with data from a survey performed in 1994, which enabled the calculation of per capita generation rates for 1994, based on the amounts of waste collected and the population served by waste collection.

Before 1994, data on landfill wastes had to be estimated based on expert judgment for waste generation growth rates. For the period 1960-1980 it was considered a per capita waste generation growth rate of 2.5% per year; for the following years (1980-1994) 3% per year. These assumptions were based on scarce information for municipal solid wastes quantities in Portugal mainland, which indicated a tendency of 3% in the period (1980-1985).

Therefore, for the period 1960-1994, municipal solid waste production was estimated for each municipality as follows:

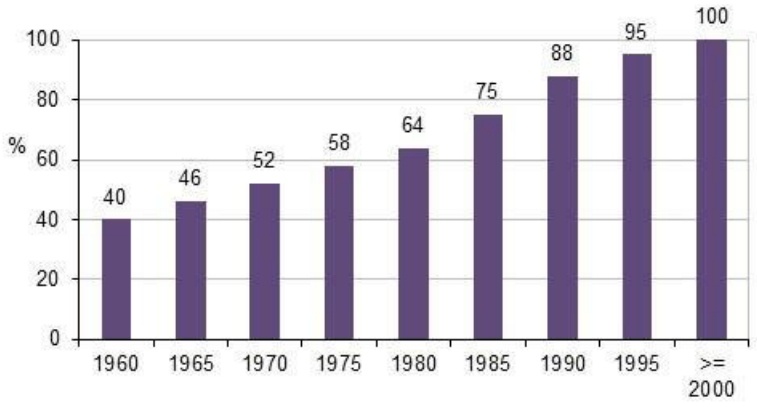
[Population (inhabitants) * Annual amount of municipal waste generated per capita (t/inhabitant/year)]

Population data for resident population is available from periodical census made by the National Statistical Office (INE). Available years for the years concerned are: 1960, 1970, 1981, 1991, 2001, 2011 and 2021. Population data for intermediate years were estimated, by interpolation, for each municipality.

Since 1999, data on MSW are collected from management systems operators. The quantities of MSW production between 1994 and 1999 were estimated by interpolation.

To take into account the fact that part of the population (rural areas) was not served by an organised waste collection and waste disposal system, values of annual production were multiplied by the percentage of population served by waste collection in each municipality. After 2000, it was assumed that all the population of the country is served by waste collecting systems (100%). The total amount of waste disposed to SWDS was then calculated based on this estimated value minus the amounts of waste incinerated and composted or digested:

Waste disposed to SWDS = [Population * Annual amount of municipal waste generated per capita * Percentage of Population served by waste collection] – Quantity of incinerated waste – Quantity of composted/digested waste




Source: APA

***Figure 7-8: Population served by waste collection systems***

### 7.2.2.2.2 Quantities of waste landfilled: industrial waste

Industrial wastes considered refer only to the fermentable part of industrial waste.

The first set of data on industrial waste disposal refer to the year 1999. This data was collected via an annual registry of industrial declarations received from the regional environment directorates (CCDR).

Historical data on industrial production was collected from INE (National Statistical Office) for the economic sectors responsible for most of organic waste generated and deposited in land (food and beverage, pulp and paper, wood and cork, textile, clothing, leather) aiming to establish annual growing rates that could indicate the evolution of industrial waste production.

An annual average growing rate was determined for the period 1970-1998 for each of these sectors and for a category "Other" aggregating the remaining activities generating organic waste. These growing rates were applied to the whole period 1960-1998 to estimate the annual organic industrial waste quantities deposited on land.

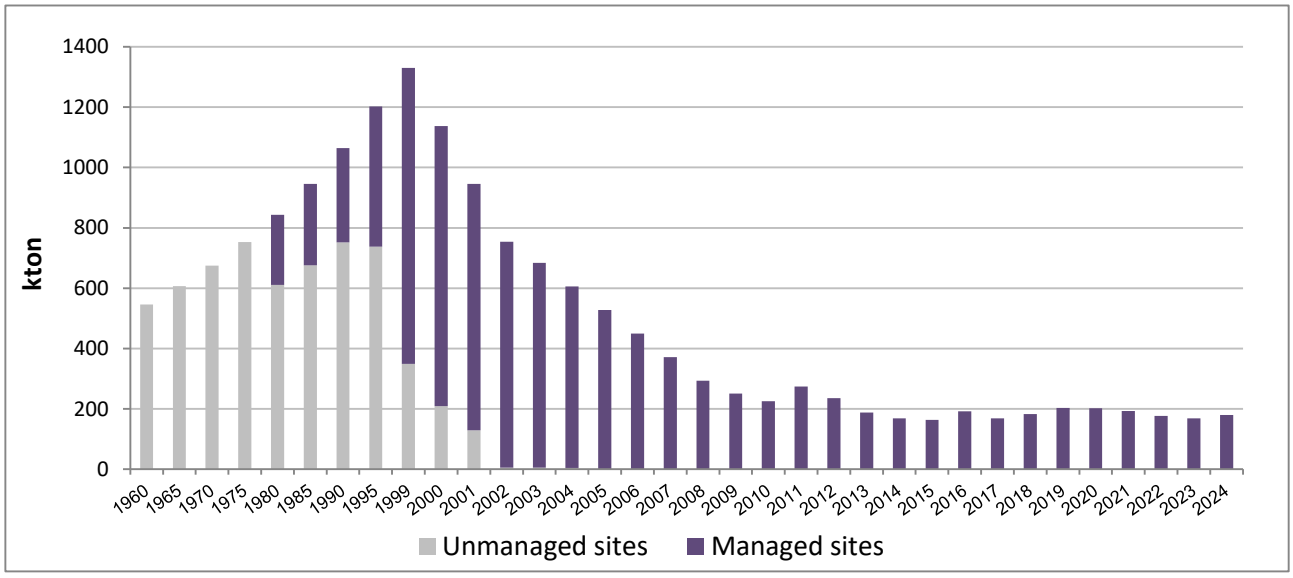
***Table 7-5: Estimated average annual growing rates for the period 1970-1998***

| Activity sectors | Industrial organic waste deposited on land in 1999 | | Growing rates Annual average 1970-1998 |
|---|---|---|---|
| | (ton) | (%) | (%) |
| Food, beverage and tobacco | 908,745 | 68% | 1.8% |
| Textile, clothing, leather and leather products | 228,810 | 17% | 5.0% |
| Wood, pulp, paper and cardboard industry and its articles and printing | 117,493 | 9% | 2.6% |
| Other | 74,756 | 6% | 5.0% |
| **TOTAL** | **1,329,803** | **100%** | **2.6%** |

Data for the years 1999, 2002 and 2003 refer to the annual registries data. The years 2000 and 2001 refer to estimates based on the interpolation of 1999 and 2002 data, and the 2004-2007 period to an interpolation of 2003 and 2008 data.

Data from 2008 onwards refer to data collected via SIRER (Integrated System for Electronic Registry on Waste), first in SIRAPA (2008-2011) and, since 2012, in the SILiAMB electronic platform. After data collection and the respective validation at APA, I.P., data is handled by the INE (National Statistical Office) according to the organisation of the information required by the Waste Statistics Regulation (Regulation (EC) no. 2150/2002).

As there is no available information concerning industrial waste treatment for the earlier years, it was assumed that all estimated waste produced have followed the municipal disposal pattern between uncontrolled and controlled SWDS.

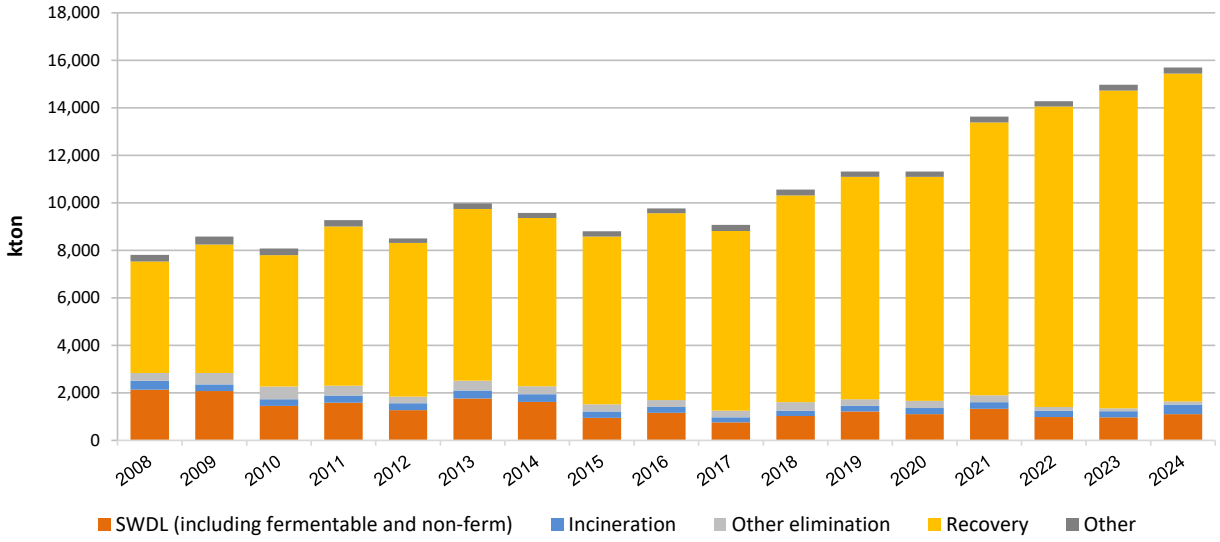


Source: APA

***Figure 7-9: Quantities of fermentable industrial waste disposed to SWDS***

The fluctuations of industrial waste amounts disposed in landfills, as shown in the figure above, are due among other factors to waste diversion from landfill to other treatment methods or destinations, such as shipping abroad and recycling.

Next figure presents the evolution of all industrial waste treatment types since 2008. From 2008 to 2024 as the total amount of industrial waste increased from 7.81 Mt in 2008 to 15.70 Mt in 2024, the amount disposed in SWDS decreased from 2.14 Mt in 2008 to 1.10 Mt in 2024 as the recovery of waste increased from 4.69 Mt in 2008 to 13.80 Mt in 2024.




Notes:
Other elimination - includes biological and physio-chemical treatment not specified.
Recovery – includes regeneration, and recycling etc.
Other – storage before other treatments.
Source: APA/INE.

***Figure 7-10: Total industrial waste by treatment types***

#### 7.2.2.2.3 Waste composition: municipal waste

Waste composition is one of the key parameters that influences the estimation of emissions from SWDS, which depend on the fraction of Degradable Organic Carbon (DOC) in the waste.

Data on waste composition are scarce for the previous years of the time series. Nowadays, data refer to the information collected from all waste management systems, while for the first years data referred to studies which were based in more restricted information. Nevertheless, the first studies included all waste fractions.

The estimation of Degradable Organic Carbon (DOC), presented in the following table, was based on national information on the composition of waste disposed in SWDS.

***Table 7-6: Municipal waste composition disposed to SWDS and DOC***

| Fractions | DOC content | 1960-1980 | Early 90s | Mid 90s | 2000 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022-2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Percentage of wet weight | | | | | | | | | | | | | | | | |
| Paper/cardboard | 40 | 19.9 | 24.7 | 26.6 | 30.8 | 14.9 | 14.1 | 13.8 | 15.3 | 15.2 | 15.0 | 11.5 | 10.6 | 9.6 | 8.7 | 8.4 | 8.2 | 7.9 |
| Glass | - | 2.9 | 5.1 | 6.0 | 8.6 | 4.0 | 3.9 | 4.4 | 5.0 | 4.9 | 4.8 | 4.0 | 3.9 | 3.8 | 3.7 | 3.5 | 3.4 | 3.3 |
| Plastics | - | 3.5 | 10.8 | 13.7 | 12.9 | 11.7 | 11.5 | 11.4 | 12.1 | 12.0 | 12.1 | 15.4 | 15.7 | 15.9 | 16.1 | 15.5 | 14.9 | 14.4 |
| Metal | - | 3.5 | 3.3 | 3.2 | 3.2 | 2.2 | 2.0 | 1.8 | 2.1 | 2.1 | 2.1 | 1.8 | 1.8 | 1.8 | 1.9 | 1.8 | 1.7 | 1.7 |
| Food waste | 15 | 47.9 | 42.8 | 40.8 | 30.9 | 46.6 | 47.0 | 45.8 | 41.1 | 41.8 | 41.4 | 31.5 | 31.1 | 30.7 | 30.3 | 29.1 | 27.8 | 26.6 |
| Textiles | 24 | 6.4 | 4.4 | 3.6 | 3.0 | 4.2 | 3.9 | 3.9 | 5.6 | 4.3 | 3.9 | 7.3 | 7.3 | 7.3 | 7.3 | 8.3 | 9.3 | 10.3 |
| Nappies | 24 | 0.0 | 0.0 | 0.0 | 3.8 | 5.3 | 6.1 | 6.4 | 6.7 | 7.0 | 6.5 | 15.7 | 17.3 | 18.8 | 20.3 | 21.2 | 22.1 | 23.0 |
| Non-food fermentable materials | 20 | 4.7 | 4.7 | 4.7 | 3.7 | 2.3 | 1.9 | 1.9 | 1.5 | 2.1 | 2.2 | 6.8 | 6.9 | 7.0 | 7.1 | 7.3 | 7.6 | 7.9 |
| Wood | 43 | 0.4 | 0.4 | 0.4 | 0.6 | 1.6 | 1.1 | 1.3 | 1.2 | 1.1 | 1.4 | 0.7 | 0.8 | 0.9 | 1.0 | 0.9 | 0.9 | 0.9 |
| Other | - | 10.7 | 3.8 | 1.1 | 2.5 | 7.2 | 8.5 | 9.2 | 9.3 | 9.3 | 10.6 | 5.4 | 4.8 | 4.2 | 3.7 | 3.8 | 3.9 | 4.1 |
| | | | | | | | | | | | | | | | | | | |
| DOC | - | 17.8 | 18.5 | 18.7 | 19.6 | 16.4 | 15.9 | 15.8 | 16.0 | 16.0 | 15.7 | 16.5 | 16.5 | 16.5 | 16.5 | 16.7 | 16.9 | 17.1 |

Notes:
Data on waste composition: Early 60s, 70s and 80s data refer to Fernandes, A Pastor (1982), "RSU do Continente - um Guia para Orientação e Inform. Das Autarquias", LNETI. Early 90s: estimates from interpolation. Mid-90s: data refer to 1994; DGA. 2000 and since 2010: APA
DOC content: IPCC defaults.

#### 7.2.2.2.4 Waste composition: industrial waste

Data on DOC varies according to the available information on industrial waste composition and includes estimates based on interpolation for missing years.

Until 2003 the inventory considered data from the waste registries at a disaggregated level of 6 digits of the European Waste List (LoW) Decision - 2000/532/EC, by treatment/destiny type. Based on these categories, a selection was done in order to consider the categories containing fermentable waste, and each of the categories selected was classified according to a group/DOC value.

Since 2008, data refer to the National Waste Registry that collects data via the SIRER's Integrated Waste Registration Map – MIRR at SIRAPA (2008-2011) and SILiAmb electronic platform (since 2012). Data provided by waste operators under this registry are treated subsequently by the INE (National Statistical Institute).

Both data sets, before 2003 and after 2008, are reported according to the European Waste list (LoW) and refer to substance oriented waste groups. Based on these categories, a selection was done in order to consider the categories containing fermentable waste, and each of the selected categories was classified according to a group/DOC value: paper, textiles, garden and other non-food organic putrescible waste, food waste, wood or straw, etc.

In both data sets, the transposition of the information between the European list of waste (LoW) and the EWC Stat classifications is done according to the stipulated in annex III of the waste statistics regulation (Reg. 849/2010, annex III), and thus consistency is consider to exist among waste groups.

Data presented in Table 7-7: Industrial organic waste composition and DOC, are reported according to EWC-Stat Rev 4 categories, which is a substance-oriented waste statistical nomenclature.

The fraction "mixed and undifferentiated materials" refer to Mixed packaging which includes essentially composite packaging and mixed packaging, respectively, category 15 01 05 and 15 01 06 of the European list of waste (LoW). The DOC value was established considering equal proportions for each of these waste sub-types, and assuming the average composition (percentage of weight) for composite packaging as: 75% cardboard, 20% polyethylene and 5% aluminium (http://www.protegeoqueebom.pt/2010/02/18/embalagens-de-cartao-para-liquidos/); and mixed packaging as 20% for each fraction: paper, glass, plastic, metal and wood.

For the new category "Screening waste", the DOC value was estimated on the basis of the composition of rejected waste disposed into landfills, considering two thirds of the fractions as inert materials and one third as biogenic.

Total amounts of organic industrial waste and associated DOC values refer to estimates based on interpolation for the years: 2000, 2001 (interpolation of 1999 and 2002 data); and 2004-2007 (interpolation of 2003 and 2008 data). The amounts of waste for the previous decades (1960-1998) were calculated considering annual growth rates as explained previously. Since 2008, data are provided by the waste operators and reported in the National Waste Registry.

DOC values used in the calculations resulted from weighted averages based on the quantities reported for each EWC category considered and the respective assigned DOC and refer to disposal on land.

***Table 7-7: Industrial organic waste composition and DOC***

| Waste groups (EWC-Stat/Version 4) | DOC (0..1) | Unit | *1960-99* | 1999 | 2000 | *2001* | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | ton | | | | | | | |
| Health care and biological wastes (05) | 0.15 | wet waste | | 98 | | | 1 | 2 | | | | | 7,886 | 8,586 | 9,605 |
| Paper and cardboard (07.2) | 0.40 | wet waste | | 778,422 | | | 58,383 | 278,007 | | | | | 2,320 | 3,449 | 1,325 |
| Wood 07.5) | 0.43 | wet waste | | 155,142 | | | 64,044 | 14,566 | | | | | 20,551 | 13,947 | 6,965 |
| Textiles (07.6) | 0.24 | wet waste | | 63,384 | | | 326,329 | 38,530 | | | | | 30,227 | 21,777 | 23,218 |
| Waste of food preparation and products (09.1) | 0.15 | wet waste | | 19,209 | | | 56,455 | 158,286 | | | | | 14,485 | 10,604 | 9,788 |
| Garden waste, park waste or other non-food organic putrescibles (09.2) | 0.20 | wet waste | | 77,269 | | | 208,965 | 172,135 | | | | | 22,441 | 6,782 | 6,127 |
| Household and similar wastes (10.1) | 0.18 | wet waste | | - | | | - | - | | | | | 70,432 | 63,690 | 43,978 |
| Mixed and undifferentiated materials (10.21, 10.22) | 0.23 | wet waste | | - | | | - | - | | | | | 17,736 | 16,444 | 16,644 |
| Screening waste (10.3) | 0.11 | wet waste | | - | | | - | - | | | | | 6 | 14 | 0 |
| Sludge (03.2, 03.3, 11) | 0.13 | wet waste | | 236,280 | | | 39,759 | 22,687 | | | | | 107,577 | 105,255 | 107,934 |
| **Total fermentable waste disposed on land** | - | | *estimates* | **1,329,803** | ***1,137,848*** | ***945,893*** | **753,937** | **684,214** | ***606,103*** | ***527,993*** | ***449,882*** | ***371,772*** | **293,661** | **250,547** | **225,583** |
| **DOC (weighted average)** | - | | ***0.332*** | **0.332** | ***0.303*** | ***0.274*** | **0.245** | **0.274** | ***0.257*** | ***0.240*** | ***0.223*** | ***0.205*** | **0.188** | **0.181** | **0.171** |

| Waste groups (EWC-Stat/Version 4) | DOC (0..1) | Unit | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | ton | | | | | | | |
| Health care and biological wastes (05) | 0.15 | wet waste | 10,702 | 27,109 | 3,882 | 813 | 656 | 486 | 495 | 94 | 90 | 91 | 667 | 84 | 941 | 469 |
| Paper and cardboard (07.2) | 0.40 | wet waste | 1,178 | 797 | 385 | 314 | 206 | 349 | 287 | 300 | 284 | 337 | 231 | 486 | 151 | 1,809 |
| Wood 07.5) | 0.43 | wet waste | 5,326 | 3,394 | 1,190 | 593 | 869 | 1,003 | 3,273 | 4,037 | 2,864 | 1,361 | 2,080 | 1,526 | 556 | 598 |
| Textiles (07.6) | 0.24 | wet waste | 21,022 | 14,708 | 14,288 | 13,609 | 12,156 | 14,618 | 12,939 | 14,790 | 18,299 | 14,353 | 13,375 | 13,283 | 9,414 | 5,319 |
| Waste of food preparation and products (09.1) | 0.15 | wet waste | 8,887 | 11,186 | 10,320 | 10,871 | 5,919 | 4,860 | 3,464 | 4,291 | 4,036 | 5,386 | 4,378 | 2,797 | 4,201 | 3,772 |
| Garden waste, park waste or other non-food organic putrescibles (09.2) | 0.20 | wet waste | 10,349 | 6,035 | 3,601 | 4,615 | 6,980 | 4,138 | 3,909 | 4,631 | 5,508 | 7,313 | 5,738 | 4,236 | 4,694 | 5,039 |
| Household and similar wastes (10.1) | 0.18 | wet waste | 96,329 | 49,762 | 35,743 | 32,135 | 29,435 | 26,085 | 30,682 | 36,906 | 40,151 | 46,378 | 45,172 | 49,436 | 57,275 | 35,768 |
| Mixed and undifferentiated materials (10.21, 10.22) | 0.23 | wet waste | 15,563 | 10,639 | 10,108 | 10,513 | 10,836 | 11,235 | 11,099 | 17,408 | 27,544 | 24,741 | 27,704 | 27,878 | 20,179 | 19,604 |
| Screening waste (10.3) | 0.11 | wet waste | 0 | 336 | 3,579 | 99 | 382 | 368 | 278 | 709 | 1,010 | 430 | 93 | 697 | 1,597 | 3,955 |
| Sludge (03.2, 03.3, 11) | 0.13 | wet waste | 104,565 | 111,771 | 104,594 | 94,875 | 96,621 | 129,040 | 102,307 | 100,284 | 103,190 | 101,755 | 93,829 | 76,212 | 69,835 | 54,272 |
| **Total fermentable waste disposed on land** | - | | **273,921** | **235,735** | **187,689** | **168,437** | **164,059** | **192,181** | **168,734** | **183,448** | **202,977** | **202,144** | **193,266** | **176,636** | **168,843** | **130,604** |
| **DOC (weighted average)** | - | | **0.171** | **0.160** | **0.156** | **0.157** | **0.157** | **0.152** | **0.160** | **0.165** | **0.168** | **0.165** | **0.168** | **0.172** | **0.167** | **0.170** |

Notes:
a) DOC values: IPCC 2006.
b) Data on italics: estimates. Emission factors and other parameters

Other parameters used in the calculation rely on some IPCC default values and apply both to municipal and industrial waste.

***Table 7-8: Parameters used in Lo calculation***

| Parameter | Explanation | Value considered |
|---|---|---|
| MCF | IPCC defaults | Managed landfills = 1.0 Unmanaged = 0.6 |
| DOCF | 2006 IPCC default (including lignin C) | 0.5 |
| F | 2006 IPCC default | 0.5 |

The MCF value (0.6) for unmanaged landfilling assumes that half of unmanaged SWDS refer to a deeper depth (>5 m waste) and the other half to shallow SWDS (<5m waste).

#### 7.2.2.2.5 Methane generation rate constant (k)

The value of landfill gas generation rate constant (k) depends on several factors as the composition of the waste and the conditions of the SWDS (e.g. climatic conditions).

This parameter is related to the time taken for the DOCm (Degradable Organic Matter) in waste to decay to half its initial mass (´half life´ or t1/2) as follows: k = ln2 / t1/2. The k value considered was 0.07 (half life of about 10 years), which represents a higher decay rate compared to the k default value proposed by the IPCC 2000 (0.05 - half life of about 14 years).

The k value used was estimated as a function of the national climatic conditions, using a Geographic Information System. A geographic database with the universe Landfill Sites (SWDS) licensed in Portugal was crossed with cartography on the following climatological variables: a) Annual Potential Evapotranspiration (PET); 2) Mean Annual Temperature (MAT); 3) Mean Annual Precipitation (MAP) (from IPMA). Each SWDS was classified according to the climatic conditions and a corresponding k value, based on the recommended default methane generation rate (k) values from 2006 IPCC (Table 3.3, Chapter 3: SWD). The figure below

presents the geographical location of landfill sites and their climatological conditions, considered as dry or wet, on the basis of the MAP/PET index.

The 0.07 refers to the average conditions of the overall SWDS.

***Figure 7-11: Geographical location of Landfills and climatic conditions***

### 7.2.2.2.6 Landfill gas recovered (R)

Data on landfill gas recovered and combusted is flared or used for energy purposes. The first quantities of biogas consumed for energy purposes reported by DGEG (the national energy authority) refer to 2004. This situation is related to the fact that the great majority of landfills have been implemented in the late 90s or the early 2000s. However, flaring (without energy recovery) started before. In order to account with this practice, the APA launched a questionnaire in 2012 with the aim of collecting the total amount of landfill gas combusted either in flaring (without energy recovery) or used for energy purposes. This inquiry was focused on the more recent years (since 2005) in order not to overload the waste systems managers.

As regards the coverage of the APA´s questionnaire, it considered all Municipal SWDS, which totalled in 2012, 34 landfill sites in exploration (receiving waste) in Mainland, plus 3 closed landfill sites which do not receive waste anymore (but burn biogas).

Since 2015, data on biogas is collected from management systems in a specific form included in MRRU (Municipal Waste Registration Form), at APA, I.P.

At present there are 32 MSW landfills in exploration in Mainland, 26 of which use biogas for energy recover. In the two Autonomous Regions there are 6 landfills in exploration (4 in the Azores, and 2 in Madeira (1 of them for emergency situations)).

CH4 recovered in flares and valorised for energy purposes is estimated on the basis of average biogas flows (continuous measurement) and the number of hours of burning. The concentration of CH4 in biogas used in the estimates of the CH4 quantities refer to monitoring plans (quarterly measurements) measuring the biogas quality (generally CH4, CO2, O2, N2, H2S) at the entrance of the flares or the biogas energy recovery system.

The annual quantities of biogas burnt (in flares and energy recovering units) reported by each landfill (in cubic meters) were converted into CH4 amounts considering the CH4 percentages in biogas (based on measurements) reported by management systems.

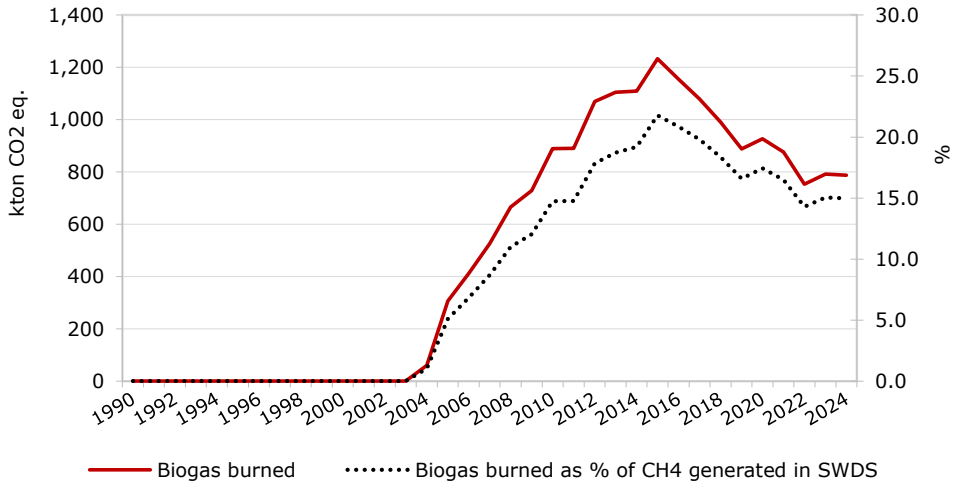
***Table 7-9: CH4 in landfill gas***

| | | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Average share of CH4 | % | 54 | 51 | 53 | 52 | 52 | 52 | 54 | 51 | 50 | 50 |

| | | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average share of CH4 | % | 49 | 48 | 52 | 51 | 51 | 48 | 48 | 48 | 45 | 49 | 45 |

Source: APA.

As next figure shows, after 2015, the quantities of biogas recovered have been progressively decreasing since most landfills have already reached their maximum biogas production as they have been operating for a long period of time and are reaching their limit capacity, and also due to the diversion of biogenic waste from landfills for other alternative destinations.




Source: APA and DGEG data.

***Figure 7-12: Quantities of CH4 combusted (SWDS)***

The fraction of methane in landfill gas (F) value used was based in the IPCC (0.5) default for the whole time series. Data presented in Table 7-9 refer exclusively to landfill sites that burnt biogas for energy purposes or flaring and do not probably represent the whole landfill sites situations. Figures reported in Table 7-9 are weighted averages calculated from data reported by landfills that were used in the calculation of the CH4 amounts recovered/burnt.

In what concerns the oxidation factor (OX), the IPCC default value – zero - was used for unmanaged SWDS. For landfill sites, which are considered as well-managed SWDS, it was used 0.1 for OX, as recommended in GPG (IPCC, 2006). The OX factor was applied after subtraction of CH4 recovered.

## 7.2.3 Uncertainty assessment

### 7.2.3.1 Municipal Solid Wastes

The uncertainty of activity data for Municipal Solid Wastes is considered high for past years as data was estimated for each year from population and per capita waste production ratio and mostly because of the low accuracy in the back cast establishment of past solid wastes disposal since 1960. The situation changed in more recent years, where data refer to data collected by waste management systems. Different uncertainty values were considered for different periods applying equation 3.2; AD = MSWT (Total Municipal Solid Waste produced) * MSWF (Fraction of MSWT sent to SWDS), using the proposed values from IPCC 2006. A combined uncertainty of 14% was estimated for the quantities disposed in managed SWDS in 2021. The uncertainty of the emission factor was estimated using a combination of equation 3.2 and 3.1. The default values proposed IPCC 2006 were used to calculate uncertainties for each parameter: DOC (approx. 15%), DOCF (20%), MCF (10%), F (5%) and k (28.6%). An overall error of 25 % was estimated for CH4 EF in 2021.

### 7.2.3.2 Industrial Wastes

The activity data for the calculation of emissions from Industrial Waste Production has a lower accuracy than Municipal Solid Wastes, because the time trend since 1960 was established with poor information only collected after 1999. The uncertainty considered in 2021 for the deposition on land of industrial solid wastes was about 18%.

Uncertainty in the determination of the emission factor follows the rules of error propagation and were set from the default values proposed in the 2006 IPCC. The calculated uncertainties in 2021 for the parameters

are: DOC (29%), DOCF (20%), MCF (10%), F (5%) and k (28.6%). An overall error of 43 % was estimated for CH4 EF in 2021.

### 7.2.4 Category specific QA/QC and verification

#### 7.2.4.1 General QC 1

General QC 1 procedures were applied following the guidance from 2006 IPCC Guidelines (Volume 1/Table 6.1) in particular:

- Checks on data units, calculation procedures, and file links;
- Check for consistency in data between source categories;
- Verification of uncertainties estimates;
- Undertake completeness checks;
- Comparison of estimates to previous estimates.
- An analysis of emission trends and of IEF was performed to detect unusual trends in order to identify potential underlying problems.

#### 7.2.4.2 QC2 procedures

Activity level parameters were compared with 2006 IPCC Guidelines default values.

National emission rates and implied emissions factors (IEF) were compared with other countries, in particular those with similar natural, demographic and economic conditions.

### 7.2.5 Category specific recalculations

No changes have been done in this submission.

### 7.2.6 Category specific planned improvements

No further improvements are foreseen in the near future.

## 7.3 Biological Treatment of Solid Waste (CRF 5.B)

### 7.3.1 Category description

This category refers to composting and anaerobic digestion of municipal organic waste and composting of non-MSW (e.g. industrial organic waste, garden and park waste).

The emissions from home composting are not included, as emissions are at present considered negligible. The registering of domestic and/or community composting recycling of biowaste began in 2024, and accounts 28 952 t for 2024, corresponding approximately to 5 kton kt CO2 eq., which is far below the threshold of significance.

After the period 1995-2002, characterized by a significant increase in MSW deposition capacity in landfills and incineration with energy recovery, the country has been investing in organic recovery infrastructures (Municipal Waste Management Systems – SGRU) to meet the objectives of the Directive Landfills. In 2002, in Mainland Portugal, there were 5 composting units, while in 2024, the number rose to 29 organic recovery units distributed throughout the country. Out of these, 21 units refer to mechanical and biological treatment and 8 to recovery organic units (biological treatment infrastructures for waste from selective collection). Regarding the type of treatment implemented, 15 installations carry out composting, while in the remaining installations anaerobic digestion followed by composting is carried out to stabilize the digestate.

Facilities with a capacity exceeding 75 tons/day for biological treatment activity (composting) (category 5.3 b) i) of Annex I) are covered by the regime of industrial emissions applicable to the prevention and integrated control of pollution (IPCC), established by the Decree-Law No. 127/2013, of 30 August. The inventory included for the first time in this submission the information reported under this regime from 6 facilities.

Anaerobic digestion started in 2006.

The table below presents the estimates of $CH_4$ emission from the biological treatment of solid waste.

***Table 7-10: Emissions from Biological Treatment of Solid Waste (ktCO2e)***

| Source | 1990 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2024 |
|---|---|---|---|---|---|---|---|---|
| CH4 | 5.6 | 15.4 | 14.6 | 24.8 | 27.2 | 40.5 | 54.7 | 64.4 |
| N2O | 3.2 | 8.7 | 8.3 | 13.9 | 12.9 | 17.7 | 25.3 | 29.5 |
| **Total** | **8.8** | **24.1** | **23.0** | **38.8** | **40.1** | **58.1** | **80.0** | **93.9** |

Note: Totals may not sum due to independent rounding

The source category Biological Treatment has been identified as a key category for CH4, both in terms of level and trend.

***Table 7-11: Calculation methods and types of emission factors for emissions on Solid Waste Disposal on Land***

| Source | Emissions reported | Methods | Activity Data | Emission Factors |
|---|---|---|---|---|
| 5.B Biological treat. of solid waste | CH4 | Tier 1 | National data | D |

## 7.3.2 Methodological issues

### 7.3.2.1 Methods

The emissions were estimated using the IPCC default (Tier 1) methodology (IPCC 2006), which is the product of the mass of organic waste treated by biological treatment and an emission factor. When CH4 recovery occurs the amounts should be subtracted. As the CH4 emission factor used for anaerobic digestion refer to the IPCC defaults which account for CH4 recovery, the estimates do not consider biogas recovery in biological treatment systems (anaerobic digestion).

Due to lack of data, in particular for the years until 2008, some assumptions were made in order to estimate the amounts that are effectively subject to composting, i.e. the quantities that are forwarded to biological treatment minus the amounts rejected afterwards. For the latest years, the rejections from composting represent approximately 55% of the total quantities sent to composting. This percentage was used to estimate the activity level for the past years. Data for the latest years refer to data collected from management systems, which separates entrances and rejections from biological treatment. The time series shown in the next figure presents some fluctuations which are the result of systems functioning interruptions what occurred for instance in 2002, when a composting system did not function in that year.

### 7.3.2.2 Activity Data

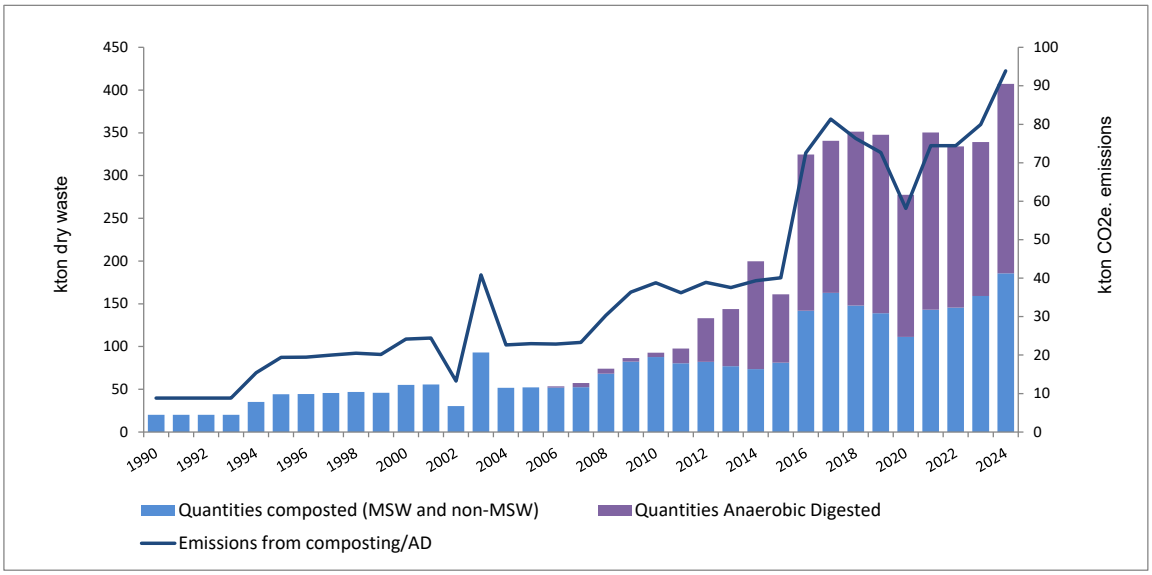



***Figure 7-13: Quantities of waste Composted/ Digested and related emissions (dry weight)***

### 7.3.2.3 Emission Factors

***Table 7-12: Default emission factors for CH4 and N2O emissions from biological treatment (dry weight basis)***

| | CH4 (g/kg waste treated) | N2O (g/kg waste treated) |
|---|---|---|
| Composting | 10 | 0.6 |
| Anaerobic digestion | 2 | Assumed negligible |

Note: Default emission factors for CH4 for anaerobic digestion already account for CH4 recovery.
Source: IPCC 2006 GL

### 7.3.3 Uncertainty assessment

The accuracy of the activity data on biological treatment of waste is considered to be lower for the previous years of the time series when information on waste collection and disposal was scarce. Even for the more recent years, there is still some uncertainty concerning the quantification of the amounts that are effectively subject to composting. In fact, there are considerable amounts of waste that are rejected after being forwarded to organic valorisation facilities. These amounts are well known for the latest years, but information is difficult to obtain for previous years. The uncertainties estimated for the activity data varies from approx. 150% (1990) to 14% (2021). The uncertainties of the emissions factors were based on range variations considered in the 2006 IPCC for default emission factors for composting and anaerobic digestion, resulting in 109% for CH4. The uncertainty value considered for EF for N2O emissions from composting is 112.5%.

### 7.3.4 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification, and the information provided in this report.

### 7.3.5 Category specific recalculations

- Biological treatment of solid waste (5.B): CH4 and N2O emissions:
  Revision of activity data for 2023

### 7.3.6 Category specific planned improvements

No revisions are foreseen in the near future.

## 7.4 Waste Incineration (CRF 5.C)

### 7.4.1 Category description

Waste incineration in Portugal includes combustion of municipal, healthcare and industrial wastes.

Relevant gases emitted include CO2, CH4 and N2O. CO2 emissions are dependent to a large extent on the amount of fossil carbon in the waste burned. The non-CO2 emissions are more dependent on the technology and conditions during the incineration process.

Waste incineration with energy recovery includes municipal incineration units (waste-to-energy facilities) and industrial plants (cement plants).

Incineration of municipal solid waste (MSW) takes place in four modern units where energy is recovered, and thus, according to the IPCC Guidelines, these emissions are accounted for in the energy sector (sub-category 1A1a Public electricity and heat production). Emissions from incineration of industrial waste with energy recovery occurring in some industrial plants (cement units) are reported in Energy sector 1A2.

The incineration of other waste, such as healthcare or industrial waste that occurs without energy recovery, is therefore allocated to the waste sector. Nevertheless, as the methodology applies for both situations (with and without energy recover), in order to avoid a double description, it is presented only once in this sub-section.

Emissions have been estimated for the non-biogenic and biogenic component of the waste. Emissions from the non-biogenic component have been reported under public electricity and heat production – other fuels. Non-CO2 emissions from the biogenic part are accounted under public electricity and heat production – biomass, and the CO2 emissions are reported as a memo item from solid biomass use.

***Table 7-13: Emissions from Waste Incineration (ktCO2e)***

| Source/ Gas | | 1990 | 2000 | 2005 | 2010 | 2015 | 2020 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|
| **Incineration without energy recovery (CRF 5C)** | | | | | | | | | |
| **Industrial solid wastes** | | **3.3** | **3.7** | **12.8** | **15.8** | **24.6** | **31.1** | **346.8** | **35.4** |
| | CO2 | 2.5 | 2.6 | 11.2 | 15.1 | 23.9 | 30.2 | 36.0 | 34.7 |
| | CH4 | 0.2 | 0.2 | 0.3 | 0.1 | 0.2 | 0.2 | 0.1 | 0.1 |
| | N2O | 0.6 | 0.8 | 1.3 | 0.6 | 0.7 | 0.7 | 0.6 | 0.6 |
| **Healthcare waste** | | **4.7** | **2.8** | **0.5** | **1.5** | **0.2** | **3.5** | **1.4** | **3.5** |
| | CO2 | 4.4 | 2.6 | 0.4 | 1.4 | 0.2 | 3.3 | 1.3 | 3.3 |
| | CH4 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 |
| | N2O | 0.2 | 0.1 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | 0.1 |
| **Open Burning of Waste/Agriculture residues** | | **57.5** | **50.9** | **47.1** | **42.3** | **43.1** | **45.1** | **46.1** | **45.9** |
| | CH4 | 37.7 | 33.4 | 30.9 | 27.7 | 28.3 | 29.6 | 30.2 | 30.1 |
| | N2O | 19.8 | 17.5 | 16.2 | 14.5 | 14.8 | 15.5 | 15.8 | 15.8 |
| **Total** | CO2 | 7.0 | 5.2 | 11.6 | 16.5 | 24.2 | 33.5 | 37.4 | 38.0 |
| | CH4 | 38.0 | 33.7 | 31.3 | 27.9 | 28.4 | 29.8 | 30.4 | 30.3 |
| | N2O | 20.5 | 18.4 | 17.5 | 15.1 | 15.3 | 16.3 | 16.5 | 16.4 |
| **Total** | **All gases** | **65.5** | **57.3** | **60.4** | **59.5** | **67.9** | **79.6** | **84.3** | **84.8** |
| | | | | | | | | | |
| **MSW incineration (CRF 1A1a)** | | - | **303.8** | **352.6** | **365.7** | **434.0** | **507.3** | **421.3** | **537.9** |
| | CO2: Non-biogenic | - | 285.9 | 331.7 | 342.7 | 412.6 | 485.6 | 401.5 | 513.2 |
| | *CO2: Biogenic (memorandum item)* | - | 332.7 | 386.0 | 398.8 | 343.1 | 234.5 | 180.2 | 230.4 |
| | CH4 | - | 5.9 | 6.9 | 8.5 | 6.5 | 6.6 | 7.0 | 8.2 |
| | N2O | - | 12.1 | 14.0 | 14.5 | 15.0 | 15.2 | 12.9 | 16.5 |

The source category has been identified as a key category for CO2, in terms of level.

***Table 7-14: Calculation methods and types of emission factors for emissions on Solid Waste Disposal on Land***

| Source | Emissions reported | Methods | Activity Data | Emission Factors |
|---|---|---|---|---|
| 5.C Incineration and open burning of waste | CH4 | Tier 2a | National data | D |

## 7.4.2 Methodological issues

### 7.4.2.1 CO2 emissions

#### 7.4.2.1.1 Methods

CO2 emissions from waste incineration have been estimated using Tier 2a which requires the use of country-specific data on waste composition and default data on other parameters (equation 5.2 from 2006 IPCC).

For MSW and industrial waste incineration, CO2 emissions were calculated on the basis of waste composition as following:

***Equation 7-1: $CO_2$ emissions from MSW and industrial waste incineration***

$$CO2\ emissions\ (Gg/yr) = MSW * \Sigma_j ( WFj * dmj * CF_j * FCF_j * OF_j ) * 44 / 12 )$$

**Where:**

j - component of the MSW incinerated (such as paper, wood, plastics);

MSW - total amount of municipal solid waste as wet weight incinerated (Gg/yr);

WFj - fraction of waste type/material of component j in the MSW (as wet weight incinerated);

dmj - dry matter content in the component j of the MSW incinerated, (fraction);

$CF_j$ - Fraction of carbon in the dry matter (i.e., carbon content) of component j;

$FCF_j$ - Fraction of fossil carbon in the total carbon of component j;

$OF_j$ - oxidation factor, (fraction);

44/12 = conversion factor from C to CO2.

For healthcare wastes, the method applied is based on the total amount of waste combusted (based on equation 5.1 from 2006 IPCC), as follows:

***Equation 7-2: $CO_2$ emissions from healthcare waste incineration***

$$CO2\ emissions\ (Gg/yr) = (SW * CF * FCF * OF * 44 / 12 )$$

**Where:**

SW - amount of waste incinerated (Gg/yr);

CF - fraction of carbon content;

FCF - fraction of fossil carbon;

OF – oxidation factor (fraction).

#### 7.4.2.1.2 Activity data, emission factors and other parameters

##### 7.4.2.1.2.1 Municipal Solid Waste

In 1999, two incineration units, Valorsul and Lipor started to operate in an experimental regime, respectively in April and August 1999. Their industrial exploration started at the end of the same year or early January 2000. In 2001/2002, another unit started operating in the Autonomous regions of Madeira, and more recently, at the end of 2015, one more in the Autonomous Region of Azores. These units are dedicated to the incineration of MSW which includes domestic and commercial waste.

All the incineration units considered are modern units using best available technologies, either concerning the abatement technologies or the incineration techniques used, which aim at the optimization of the combustion process, and consequently the minimisation of atmospheric pollutants.

The incineration process used refers to continuous mass burning with heat recovery for steam and electricity production. The waste is burnt in a combustion grate at approximately 1000ºC. During the waste incineration process, high temperature gases are released. These gases remain at least 2 seconds in the combustion chambers at a minimum temperature of 850ºC. After the passage in the recovery boiler, the produced steam is used for electric power generation; the cooled gases suffer several treatment processes to remove NOx, acid gases, dioxins, furans, heavy metals and particulates.

Abatement technologies used include:

- NOx reduction system based on the ammonia or urea injection in the combustion chamber;
- semi-dry treatment process, consisting of a reactor, were spray fine droplets of an alkaline reagent (calcium hydroxide) are introduced to neutralise the acid gases;
- activated carbon injection to remove dioxins, furans and heavy metals;
- fabric filter for particulate removal.
- Emissions associated with the components of fossil origin – plastics, synthetic fibres, and synthetic rubber – are accounted for in the net emissions, which include also the non-CO2 emissions from the combustion of organic materials (e.g. food waste, paper). CO2 emissions from the biogenic component are only reported as a memo item.

2006 IPCC considers good practice to make a distinction between composition of waste incinerated and the composition of waste delivered to other waste management systems. Accordingly, CO2 emissions estimates consider the composition of waste incinerated.

The fossil C content in MSW was calculated from the weighted average of the C content in plastics and textiles (fossil carbon) and the respective fractions of incinerated waste weight. The total C content of MSW, which includes the biogenic and non-biogenic (fossil) components, results from the weighted average of the different waste fractions and the respective total C content. The % of fossil carbon in waste was then obtained dividing the fossil C component by the total C content in MSW.

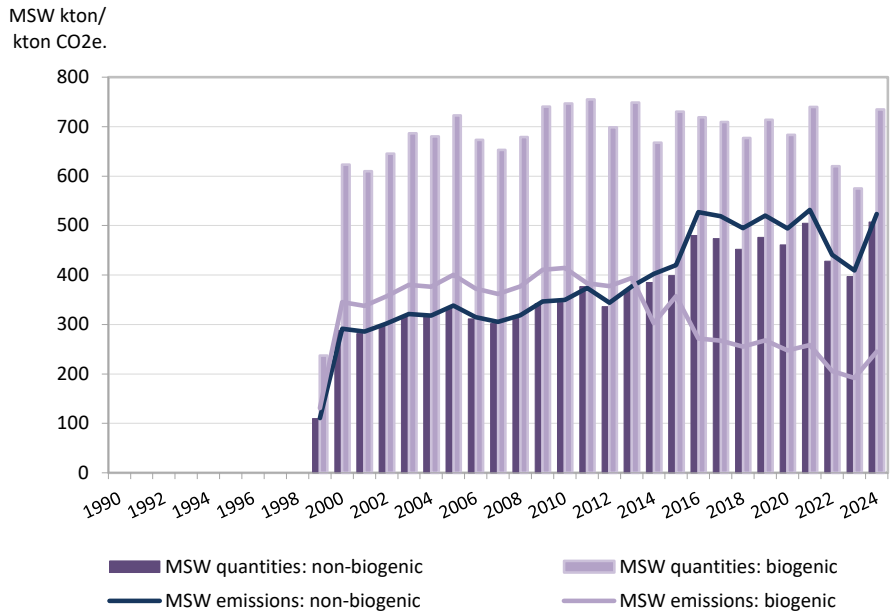
Information used for the calculation is presented in the table below.

***Table 7-15: Base table for MSW C content estimation***

| | Dry matter content | Carbon content | Fossil carbon | Waste composition (% of wet weight) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | (% of wet weight) | (% of dry matter) | (% of total C) | < 1999 | 1999 | 2000 | 2010 | 2011 | 2012 | 2013 | 2014 |
| Paper/ Card | 90 | 46 | 1 | - | 14.3 | 14.3 | 14.3 | 15.6 | 15.6 | 14.5 | 13.6 |
| Glass | 100 | NA | NA | - | 4.7 | 4.7 | 4.7 | 5.7 | 5.7 | 5.1 | 5.1 |
| Plastics | 100 | 75 | 100 | - | 10.0 | 10.0 | 10.0 | 10.7 | 10.7 | 10.7 | 12.3 |
| Metals | 100 | NA | NA | - | 2.0 | 2.0 | 2.0 | 1.9 | 1.9 | 1.8 | 2.1 |
| Food waste | 40 | 38 | - | - | 42.2 | 42.2 | 42.2 | 39.6 | 39.6 | 40.5 | 38.8 |
| Textiles | 80 | 50 | 20 | - | 8.5 | 8.5 | 8.5 | 5.1 | 6.2 | 7.0 | 7.7 |
| Nappies | 40 | 70 | 10 | - | 7.3 | 7.3 | 7.3 | 7.1 | 8.7 | 8.7 | 8.7 |
| Non-food fermentable materials | 40 | 49 | 0 | - | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 |
| Wood | 85 | 50 | - | - | 0.7 | 0.7 | 0.7 | 1.1 | 1.1 | 0.8 | 0.5 |
| Other | 90 | 3 | 100 | - | 3.2 | 3.2 | 3.2 | 6.3 | 3.5 | 3.9 | 4.1 |
| C content in Plastics,Textiles, etc (1) | | | | | 8.6 | 8.6 | 8.6 | 8.8 | 8.9 | 9.0 | 10.2 |
| **Total C of waste (2)** | - | - | - | - | **27.1** | **27.1** | **27.1** | **26.5** | **27.4** | **27.3** | **28.0** |
| **% non-biogenic C in waste (1)/(2) * 100** | - | - | - | - | **31.6** | **31.6** | **31.6** | **33.3** | **32.5** | **33.1** | **36.6** |

| | Dry matter content | Carbon content | Fossil carbon | Waste composition (% of wet weight) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | (% of wet weight) | (% of dry matter) | (% of total C) | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022-2024 |
| Paper/ Card | 90 | 46 | 1 | 15.3 | 15.1 | 14.8 | 14.5 | 14.2 | 12.2 | 10.3 | 8.4 |
| Glass | 100 | NA | NA | 5.1 | 5.2 | 5.0 | 4.9 | 4.8 | 4.8 | 4.9 | 4.9 |
| Plastics | 100 | 75 | 100 | 12.1 | 14.6 | 14.6 | 14.5 | 14.5 | 14.3 | 14.0 | 13.8 |
| Metals | 100 | NA | NA | 2.1 | 2.3 | 2.3 | 2.4 | 2.5 | 2.3 | 2.2 | 2.1 |
| Food waste | 40 | 38 | - | 39.7 | 37.0 | 37.6 | 38.3 | 38.9 | 40.3 | 41.7 | 43.1 |
| Textiles | 80 | 50 | 20 | 6.4 | 5.0 | 5.1 | 5.2 | 5.4 | 5.3 | 5.3 | 5.2 |
| Nappies | 40 | 70 | 10 | 9.5 | 10.2 | 9.9 | 9.6 | 9.3 | 10.5 | 11.7 | 12.9 |
| Non-food fermentable materials | 40 | 49 | 0 | 7.0 | 7.0 | 6.4 | 5.7 | 5.1 | 5.2 | 5.3 | 5.3 |
| Wood | 85 | 50 | - | 0.4 | 0.7 | 1.1 | 1.5 | 1.9 | 1.5 | 1.2 | 0.8 |
| Other | 90 | 3 | 100 | 2.6 | 2.9 | 3.1 | 3.3 | 3.5 | 3.5 | 3.4 | 3.4 |
| C content in Plastics,Textiles, etc (1) | | | | 10.0 | 11.8 | 11.8 | 11.7 | 11.7 | 11.6 | 11.4 | 11.3 |
| **Total C of waste (2)** | - | - | - | **28.2** | **29.4** | **29.4** | **29.3** | **29.3** | **28.7** | **28.2** | **27.6** |
| **% non-biogenic C in waste (1)/(2) * 100** | - | - | - | **35.3** | **40.0** | **40.0** | **40.0** | **40.0** | **40.3** | **40.5** | **40.8** |

The emissions from MSW incineration occur with energy recovery and are therefore accounted in the energy sector (category 1A1a).




Source: APA

***Figure 7-14: Incineration of Municipal Solid Waste: quantities incinerated (kt) and related emissions (kt CO2e) (accounted in CRF 1Aa)***

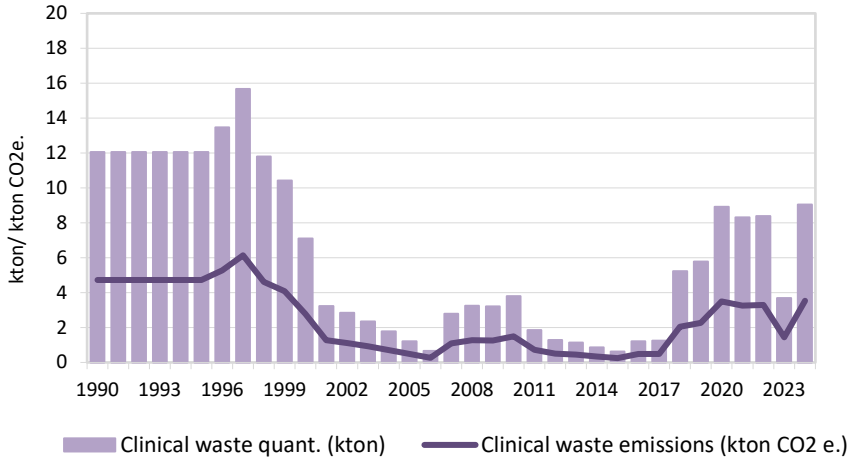
The emissions result from the combustion of two fuel types: biogenic and non-biogenic, which are reported, in CRF Table 1.A(a), respectively as "Biomass" and "Other Fossil Fuels". In the case of "Biomass", emissions refer to combustion in Electricity Production units, Municipal waste incineration and Biogas burning. For "Other Fossil Fuels", the emissions refer exclusively to Municipal waste incineration.

***Table 7-16: CO2 Implied Emission Factors for CRF 1Aa***

| | Biomass | | | | | Other Fuels | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Energy (GJ) | | CO2 emissions (kt) | | CO2 IEF (t/TJ) | Energy (GJ) | | CO2 emissions (kt) | | CO2 IEF (t/TJ) |
| | Elect.Ind. | MSW and Biogas comb | Elect.Ind. | MSW and Biogas comb | | Elect.Ind. | MSW and Biogas comb | Elect.Ind. | MSW and Biogas comb | |
| 1990 | - | - | - | - | - | - | - | - | - | - |
| 1991 | - | - | - | - | - | - | - | - | - | - |
| 1992 | - | - | - | - | - | - | - | - | - | - |
| 1993 | - | - | - | - | - | - | - | - | - | - |
| 1994 | - | - | - | - | - | - | - | - | - | - |
| 1995 | - | - | - | - | - | - | - | - | - | - |
| 1996 | - | - | - | - | - | - | - | - | - | - |
| 1997 | - | - | - | - | - | - | - | - | - | - |
| 1998 | - | - | - | - | - | - | - | - | - | - |
| 1999 | 85,550 | 1,834,096 | 9.6 | 235.2 | 127.5 | - | 847,636 | - | 108.7 | 128.2 |
| 2000 | 146,796 | 4,806,249 | 16.4 | 620.7 | 128.6 | - | 2,203,654 | - | 285.9 | 129.7 |
| 2001 | 316,477 | 4,692,569 | 35.4 | 606.9 | 128.2 | - | 2,155,727 | - | 279.8 | 129.8 |
| 2002 | 555,142 | 4,942,430 | 62.2 | 642.5 | 128.2 | - | 2,270,203 | - | 296.2 | 130.5 |
| 2003 | 699,691 | 5,275,477 | 78.4 | 682.6 | 127.4 | - | 2,426,696 | - | 314.8 | 129.7 |
| 2004 | 746,413 | 5,384,982 | 83.6 | 683.0 | 125.0 | - | 2,420,964 | - | 311.9 | 128.9 |
| 2005 | 716,680 | 5,984,878 | 80.3 | 736.4 | 121.9 | - | 2,607,503 | - | 331.7 | 127.2 |
| 2006 | 877,250 | 5,558,097 | 98.3 | 685.6 | 121.8 | - | 2,422,051 | - | 308.9 | 127.5 |
| 2007 | 896,657 | 5,591,236 | 100.4 | 677.4 | 119.9 | - | 2,335,900 | - | 299.5 | 128.2 |
| 2008 | 1,883,843 | 7,400,333 | 211.0 | 717.1 | 100.0 | - | 3,056,314 | - | 311.6 | 101.9 |
| 2009 | 3,970,991 | 7,628,034 | 444.8 | 787.9 | 106.3 | - | 3,077,767 | - | 339.7 | 110.4 |
| 2010 | 6,769,919 | 8,169,397 | 758.2 | 810.4 | 105.0 | - | 3,192,739 | - | 342.7 | 107.3 |
| 2011 | 7,127,005 | 8,029,970 | 798.2 | 825.3 | 107.1 | - | 3,174,200 | - | 366.4 | 115.4 |
| 2012 | 7,116,139 | 7,496,090 | 791.7 | 812.8 | 109.8 | - | 2,619,677 | - | 337.2 | 128.7 |
| 2013 | 7,239,303 | 8,417,937 | 804.2 | 875.6 | 107.3 | - | 3,003,250 | - | 369.4 | 123.0 |
| 2014 | 7,775,008 | 7,243,550 | 870.2 | 825.3 | 112.9 | - | 2,691,138 | - | 394.7 | 146.7 |
| 2015 | 7,693,786 | 8,011,037 | 861.7 | 918.5 | 113.4 | - | 2,744,659 | - | 412.6 | 150.3 |
| 2016 | 7,242,135 | 7,545,762 | 811.1 | 919.2 | 117.0 | - | 3,287,600 | - | 518.1 | 157.6 |
| 2017 | 7,196,037 | 6,926,154 | 806.0 | 914.5 | 121.8 | - | 2,793,151 | - | 510.5 | 182.8 |
| 2018 | 7,729,334 | 6,932,088 | 865.7 | 870.4 | 118.4 | - | 2,891,491 | - | 486.1 | 168.1 |
| 2019 | 7,543,471 | 6,385,741 | 844.9 | 905.0 | 125.6 | - | 2,574,594 | - | 511.6 | 198.7 |
| 2020 | 7,352,946 | 7,291,573 | 823.5 | 861.0 | 115.0 | - | 3,176,166 | - | 485.6 | 152.9 |
| 2021 | 6,637,851 | 9,834,689 | 743.4 | 912.3 | 100.5 | - | 4,855,172 | - | 521.1 | 107.3 |
| 2022 | 7,062,610 | 6,834,052 | 791.0 | 769.9 | 112.3 | - | 2,912,083 | - | 432.8 | 148.6 |
| 2023 | 7,088,059 | 7,455,810 | 793.9 | 721.1 | 104.2 | - | 3,383,685 | - | 401.5 | 118.6 |
| 2024 | 6,049,628 | 8,337,047 | 677.6 | 881.8 | 108.4 | - | 4,008,155 | - | 513.2 | 128.0 |

#### 7.4.2.1.2.2 Healthcare waste

Data on healthcare waste incinerated refers to data declared in registry maps of public and private healthcare units (for human and animal), research centers and other units (e.g. piercings, tattoos). The quantities of healthcare waste incinerated decreased strongly in the years 2000 as shown in the previous figure. Twenty-five public incinerators were closed in recent years in Mainland Portugal, and only one healthcare waste incinerator operated from 2004 after suffered two main requalification processes, the most significant occurred in 2004. This infrastructure is nowadays closed.




Sources: APA; DGS.

***Figure 7-15: Incineration of Healthcare Waste: quantities incinerated (kt) and related emissions (kt CO2e)***

Currently, there are two healthcare incinerators in Portugal: the "Centro Integrado de Gestão de Resíduos da Chamusca (CIGR)", and the "Centro Integrado De Valorização E Tratamento De Resíduos Hospitalares E Industriais (CIVTRH). With this two units, Portugal is now able to treat all group IV healthcare wastes, as well as drug residues, animal by-products and other residues that need destruction by incineration.

In the CIVTRHI, the thermic treatment process includes 2 phases. At a first stage, designated as pyrolysis, the waste is burnt in oxygen deficit conditions at temperatures from 650ºC to 800ºC. The resulting gases get into a second combustion chamber or thermal reactor where the gases suffer a new combustion reaching higher temperatures (minimum 1100ºC) during at least 2 seconds. These gases are then conducted into a boiler where they are cooled. After that, the gases suffer a dry treatment chemical process, in a contact reactor, through the direct injection of ammonia, lime and activated carbon in the gas flux. At the end, the gas is conducted into filters where the particulate matter is trapped.

The parameters considered for healthcare waste are presented in the following table.

***Table 7-17: Parameters considered: healthcare waste***

| | Unit | Healthcare waste |
|---|---|---|
| C content of waste | % | 40 a) |
| Fossil carbon in waste | % total C | 25 a) |

Note: a) 2006 IPCC default (wet basis).

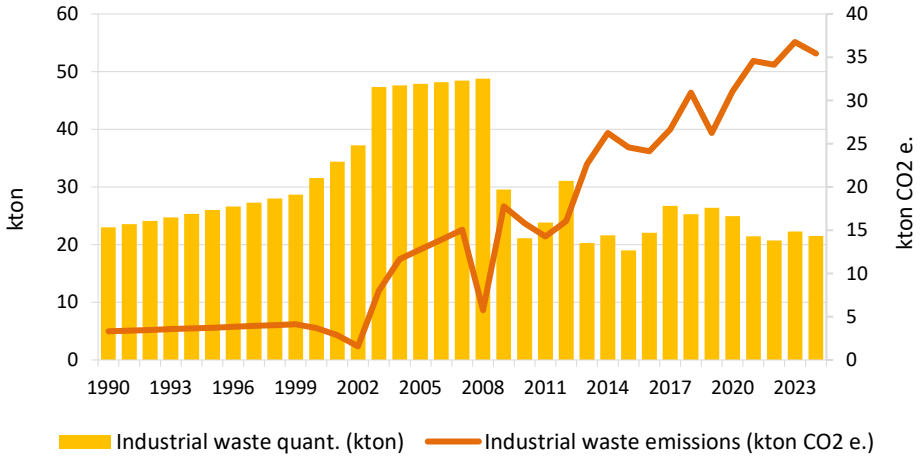
The oxidation factor in percentage of carbon input considered is 100% (IPCC default).

#### 7.4.2.1.2.3 Industrial Waste

Data refer to incineration of industrial solid waste in industrial units collected in APA, which includes hazardous and sewage sludge waste. Data for the years 1999, 2002 and 2003 refer to industrial units declarations. Data for the period 1990-98 are based on the same assumptions used for Industrial Solid Waste Disposed on Land: a per year growth rate of 2%. Data for the years 1999, 2002 and 2003 refer to the annual registries data. The years 2000 and 2001 refer to estimates based on the interpolation of 1999 and 2002 data, and the 2004-2007 period to an interpolation of 2003 and 2008 data.

Data from 2008 onwards refer to data collected via SIRER (Integrated System for Electronic Registry on Waste), first (2008-2011) in the SIRAPA platform and since 2012 in the SILiAmb electronic platform. After data collection and the respective validation at APA, I.P., data is handled by the INE (National Statistical

Office) in order to extrapolate the information to the universe of enterprises for each economic branch, due to the different scope required by the national legislation on waste registration and the Waste Statistics Regulation (Regulation (EC) no. 2150/2002).




Source: APA (include estimates).

***Figure 7-16: Quantities of combusted industrial waste***

The significant fluctuations on the amounts of industrial waste incineration, as shown in the previous figure, results, at least partially, from the variation of fluxes to other treatments or destinations (landfilling, export (e.g. hazardous waste) and recycling) because of the annual waste market demand.

Despite the reduction in quantities of industrial waste incinerated, the emissions raised in more recent years due to the growth of the fossil carbon content fraction of waste incinerated.

***Table 7-18: Parameters considered.***

| | Unit | Industrial Solid Waste | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1990 | 1995 | 2000 | 2005 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| C content of waste | % | 0.14 | 0.14 | 0.16 | 0.21 | 0.21 | 0.38 | 0.38 | 0.34 | 0.32 | 0.42 | 0.44 |
| Fraction of fossil carbon in waste | % total C | 0.21 | 0.21 | 0.14 | 0.30 | 0.11 | 0.41 | 0.51 | 0.46 | 0.42 | 0.70 | 0.74 |
| Efficiency of combustion a) | % | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

| | Unit | Industrial Solid Waste | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
| C content of waste | % | 0.45 | 0.43 | 0.42 | 0.45 | 0.42 | 0.45 | 0.49 | 0.50 | 0.50 | 0.50 |
| Fraction of fossil carbon in waste | % total C | 0.76 | 0.68 | 0.63 | 0.73 | 0.63 | 0.74 | 0.88 | 0.89 | 0.89 | 0.89 |
| Efficiency of combustion a) | % | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Note:

a) IPCC default.

The parameters presented in the previous table (C content and % total C) are national estimates based on the background data on industrial waste production. This information is classified according to the European Waste Catalogue list (EWC) and is disaggregated by treatment type. Each one of the EWC categories were classified according to a group and were assigned with an estimated fraction of C content and a fraction of fossil carbon in waste, which has been defined by expert judgment. The values considered resulted from weighted averages based on quantities reported for each of the EWC categories and the respective assigned C content and fraction of fossil C.

### 7.4.2.2 Non-CO2 emissions

Non-CO2 emissions are dependent in particularly on the technology and conditions during the incineration process. The completeness of combustion (temperature, oxygen, residence time) is especially relevant for the CH4 emissions. The N2O emissions are mainly determined by technology, combustion temperature and waste composition.

#### 7.4.2.2.1 Methods

Emissions were estimated as the product of the mass of total waste combusted and an emission factor for the pollutant emitted per unit mass of waste incinerated.

***Equation 7-3: Non-$CO_2$ emissions from waste incineration***

$$\text{Non-}CO_2 \text{ emissions (Gg/yr)} = \Sigma_i \left( IW_i * EF_i \right) * 10^{-6}$$

**Where:**

$IW_i$ - amount of incinerated waste of type i (Gg/yr);

$EF_i$ - aggregate pollutant emission factor for waste type i (kg pollutant/Gg);

i – waste type (MSW, Industrial waste, healthcare waste).

#### 7.4.2.2.2 Emission factors

Emission factors applied are either country-specific (Tier 2), being obtained from monitoring data in incineration units, or obtained from references US/AP42 or EMEP/CORINAIR (EEA,2016) (Tier 1).

The CH4 emission factor considered follows the guidance from 2006 IPCC that says that for continuous incineration of MSW and industrial waste, it is good practice to apply the CH4 emission factors for Stationary Combustion (Volume 2, Chapter 2).

For N2O emissions the default emission factor from table 5.6 of volume 5: waste of the 2006 IPCC was used.

***Table 7-19: Emissions factors of GHG and precursors gases from incineration of MSW***

| Pollutants | Unit | EF | Source |
|---|---|---|---|
| LHV | MJ/kg | [4.3867 - 11.3083] | Plant Specific (Monitoring Data) |
| CH4 | g/GJ | 30.0 | 2006 IPCC |
| N2O | kg/ton MSW | 0.05 | 2006 IPCC |
| SOx | kg/ton MSW | [0.0152 - 0.0835] | Plant Specific (Monitoring Data) |
| NOx | kg/ton MSW | [0.444 - 1.2793] | Plant Specific (Monitoring Data) |
| COVNM | kg/ton MSW | [0.0006 - 0.0059] | Plant Specific (Monitoring Data); 2023 EEA Guidebook (Tier 1); Nielsen et al. (2010) |
| CO | kg/ton MSW | [0.0075 - 0.0999] | Plant Specific (Monitoring Data) |

***Table 7-20: Emissions factors of GHG and precursors gases from incineration of healthcare wastes: until 2004***

| Pollutants | Unit | EF | Source |
|---|---|---|---|
| LHV | MJ/kg W | 13.82 | Country Study (Environmental Impact Assessment) |
| CH4 | g/GJ | 30.00 | 2006 IPCC |
| N2O | kg/ton W | 0.05 | 2006 IPCC |
| SOx | kg/ton W | 1.09 | 2023 EEA Guidebook (Tier 2, Uncontroled) |
| NOx | kg/ton W | 1.78 | 2023 EEA Guidebook (Tier 2, Uncontroled) |
| COVNM | kg/ton W | 0.70 | 2023 EEA Guidebook (Tier 2, Uncontroled) |
| CO | kg/ton W | 1.48 | 2023 EEA Guidebook (Tier 2, Uncontroled) |

***Table 7-21: Emissions factors of GHG and precursors gases from incineration of healthcare wastes: after 2005***

| Pollutants | Unit | EF | Source |
|---|---|---|---|
| LHV | MJ/kg W | 13.82 | Country Study (Environmental Impact Assessment) |
| CH4 | g/GJ | 30.00 | 2006 IPCC |
| N2O | kg/ton W | 0.05 | 2006 IPCC |
| SOx | kg/ton W | 0.09 | 2019 EEA Guidebook (Tier 2, Controled by various types of abatement) |
| NOx | kg/ton W | 1.78 | 2023 EEA Guidebook (Tier 2, Uncontroled) |
| COVNM | kg/ton W | 0.70 | 2023 EEA Guidebook (Tier 2, Uncontroled) |
| CO | kg/ton W | 1.48 | 2023 EEA Guidebook (Tier 2, Uncontroled) |

***Table 7-22: Emissions factors of GHG and precursors gases for Industrial solid waste incineration***

| Pollutants | Unit | EF | Source |
|---|---|---|---|
| LHV | MJ/kg | 7.82 | PROET study |
| CH4 | g/GJ | 30.00 | 2006 IPCC |
| N2O | kg/ton MSW | 0.10 | Corinair 3rd version. Activity 090201. No NOx abatement |
| SOx | kg/ton MSW | 0.05 | 2023 EEA Guidebook (Tier 1 default EF) |
| NOx | kg/ton MSW | 0.87 | 2023 EEA Guidebook (Tier 1 default EF) |
| NMVOC | kg/ton MSW | 7.40 | 2023 EEA Guidebook (Tier 1 default EF) |
| CO | kg/ton MSW | 0.07 | 2023 EEA Guidebook (Tier 1 default EF) |

#### 7.4.2.2.2.1 Open Burning of Waste

Following the 2022 NECD review, Portugal reallocated emissions from residues burning of vineyard, olive trees or orchard, previously reported in the agriculture sector, to category 5C2.

In order to avoid repetition, the methodological description of this issue is considered in the category 3F chapter where emissions from in place field burning (e.g. stubble burning) are included.

### 7.4.3 Uncertainty Assessment

The accuracy of activity data considered for incineration of MSW was 5%. The uncertainty for CO2 emission factor was estimated on the basis of the value ranges proposed by the 2006 IPCC for the fossil carbon fraction in % of total carbon for the different fractions of waste incinerated. The estimated uncertainty for 2021 resulting from the application of equation 3.2 is 30%.

For healthcare wastes an uncertainty of 30% for the years 1990 and 10% since 2006 was considered for the activity data. For industrial incineration (without energy recovery) an uncertainty of approx. 190% was estimated for the activity data for the early 1990s and 18% for the latest years.

The uncertainty of CO2 emission factors was set as 10% for hospital wastes and 250% for industrial wastes, which expresses the uncertainty in carbon content and the additional uncertainty in the fraction of the incinerated carbon that has fossil origin. For N2O and CH4 emission factors a 100% uncertainty was considered.

### 7.4.4 Category specific QA/QC and verification

#### 7.4.4.1 General QC 1

General QC 1 procedures were applied following the guidance from the IPCC GPG (IPCC 2000, Table 8.1) in particular:

- Checks on data units, calculation procedures, and data field relationships
- Check for consistency in data between source categories
- Verification of uncertainties estimates
- Undertake completeness checks

- Comparison of estimates to previous estimates.

An analysis of emission trends and of IEF was performed to detect unusual trends in order to identify potential underlying problems.

#### 7.4.4.2 QC2 procedures

National emission rates and implied emissions factors (IEF) were compared with other countries, in particular those with similar natural, demographic and economic conditions.

The AD for waste incineration related to energy production used by the inventory was compared with DGEG energy balance available data.

Energy content (NCV) data have been revised on the basis of annual data from the incineration units. Previously, a constant value was used for the whole period which referred to a study done in the past. This revision increased however the difference between the values considered by DGEG and the values considered by the inventory.

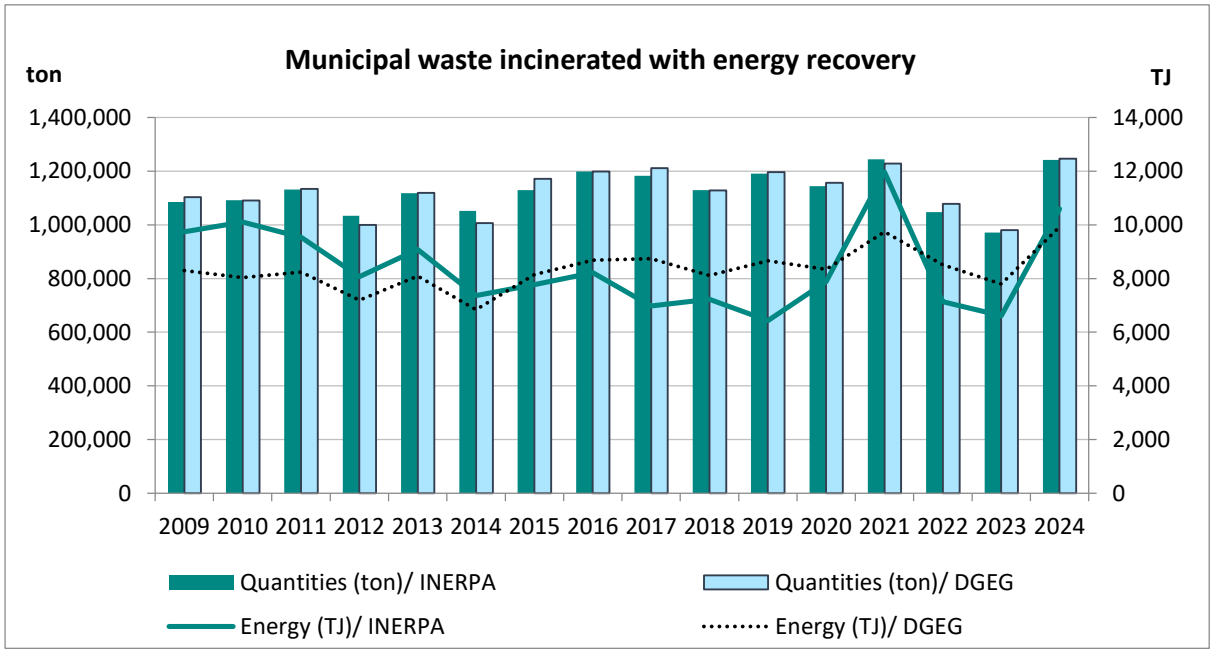



***Figure 7-17: Comparison between MSW incineration data used in the inventory and EB data***

### 7.4.5 Category specific recalculations

No changes has have been done in this category.

### 7.4.6 Category specific planned improvements

No improvements are foreseen.

## 7.5 Wastewater Treatment and Discharge (CRF 5.D)

Taking advantage of the momentum of the National Energy and Climate Plan and the 2060 Carbon Neutrality Roadmap revisions, the wastewater sector was revisited for 2024 submission considering the new guidance provided by the 2019 IPCC Refinements which proposes significant changes regarding the sub-sector 5.D and the paper prepared by Hans Oonk "Application of the 2019 Refinement" circulated under the framework of an Effort Sharing Decision (ESD) Webinar in 2021.

A new set of information on all public urban WWTPs in operation in Portugal was used. This includes data on two differentiated groups: UWWTP treating a load of 2,000 population equivalent (p.e.) and above, and less of 2,000 p.e., referring to the type of technology and some other particularities that were used. This information enabled, among others, the estimate of the average weight of industrial effluents in relation to domestic effluents.

New information related to industrial loads after treatment discharged into the natural environment was also considered in this submission. This information refers to data for 2018 with the characterization of existing treatment typologies for each industrial WWTP collected within the framework of APA licensing and monitoring activities.

The IPCC's methodological guidelines for the wastewater sector have undergone a major revision, following the IPCC 2019 Refinements.

The main change refers to N2O emissions, which underwent a profound change towards greater importance. In fact, while in the previous guidelines (IPCC, 2006) N2O emissions in WWTPs were considered almost negligible, in this review, due to the evolution of scientific knowledge on this subject, N2O emissions have a bigger importance.

CH4 emissions also recorded a significant revision to consider the emissions that occur after the discharge of wastewater into the water environment, where previously only N2O emissions were accounted for.

Another important change concerns the treatment of WWTP sludge which, until now, was included in the same calculation sequence, and which now has an autonomous treatment, with the liquid and solid phases of the process being clearly separated.

The changes in the calculation methodologies and the consideration of some emission factors substantially changed the estimates associated with GHG emissions from this subsector in relation to previous submissions.

### 7.5.1 Category description

Wastewater treatment processes can produce CH4 emissions when treated or disposed anaerobically, and N2O emissions. CO2 emissions from wastewater are not considered as these are of biogenic origin and should not be included in the national total emissions.

***Table 7-23: Calculation methods and types of emission factors for emissions on wastewater treatment and discharge***

| Source | Emissions reported | Methods | Activity Data | Emission Factors |
|---|---|---|---|---|
| 5.D.1 Domestic wastewater | CH4 | Tier 2 | National data | CS, D |
| | N2O | Tier 1 | National data | D |
| 5.D.2 Industrial wastewater | CH4 | Tier 2 | National data | CS, D |
| | N2O | Tier 2 | National data | D |

Emissions estimates from wastewater treatment decreased 2.3 % in the period 1990-2023.

***Table 7-24: Emissions from Wastewater Treatment and Discharge (ktCO2e)***

| Gas/Source | 1990 | 2000 | 2005 | 2010 | 2015 | 2020 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|
| **CH4** | **1,157.0** | **1,000.6** | **850.0** | **753.6** | **688.9** | **594.1** | **579.3** | **575.4** |
| Domestic wastewater | 963.1 | 908.8 | 797.1 | 699.6 | 631.8 | 547.2 | 532.8 | 525.3 |
| Industrial wastewater | 193.9 | 91.8 | 53.0 | 54.0 | 57.2 | 46.8 | 46.4 | 50.1 |
| **N2O** | **253.2** | **386.9** | **504.0** | **600.1** | **616.4** | **678.9** | **756.1** | **778.5** |
| Domestic wastewater | 226.1 | 372.8 | 493.6 | 588.9 | 604.0 | 669.5 | 745.3 | 767.3 |
| Industrial wastewater | 27.1 | 14.1 | 10.4 | 11.2 | 12.3 | 9.4 | 10.7 | 11.1 |
| **Total** | **1,410.2** | **1,387.5** | **1,354.0** | **1,353.7** | **1,305.3** | **1,273.0** | **1,335.3** | **1,353.9** |

## 7.5.2 Methodological issues

Sewage can be disposed on land or discharged into aquatic environments (e.g. rivers and estuaries), either directly without treatment or after treatment in septic systems or wastewater treatment facilities.

The inventory considers both direct emissions from treatment plants and indirect emissions from wastewater after disposal of effluent into aquatic environments.

In accordance with good practice, which recommends treating the wastewater treatment system and onsite sludge treatment system as separate pathways, the emissions from the sludge treatment are accounted for separately.

Some WWTP do not compost, nor anaerobically digest sludge. They simply dewater or dry the sludge. The emissions considered under this category refer exclusively to composting and anaerobic digestion of sludge.

Regarding the agriculture recovery of sludge, information is reported to the Regional Directorates for Agriculture and Fisheries (DRAP), under Decree-Law no. 276/2009, of 2 October, which revoked the previous Decree-Law no. 118/2006 of 21 June transposing the Council Directive 86/278/EEC, of 12 June, and establishes the regime for the use of sewage sludge in agricultural soils.

### 7.5.2.1 Urban Wastewater CH4 emissions

CH4 emissions from urban wastewater handling systems reduced globally since 1990, as a result of the progressive implementation of public WWT (reducing direct emissions) and the consequent reduction of organic load discharges into the environment (indirect emissions). The increase of emissions related to sludge treatment (composting and anaerobic digestion) presents a growing trend in result of the increase of sludge amounts generated in WWTP.

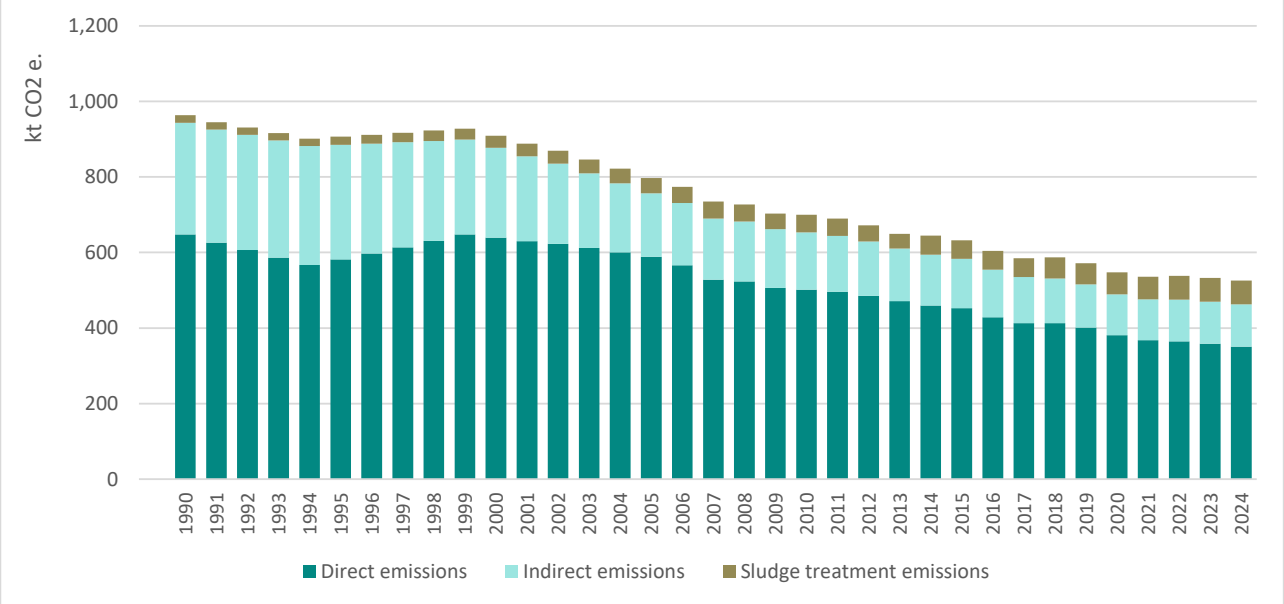



***Figure 7-18: CH4 emissions from urban wastewater handling systems***

#### 7.5.2.1.1 Methods

The inventory follows the good practice proposed by the IPCC regarding the separate accounting of wastewater treatment system and onsite sludge treatment system.

##### 7.5.2.1.1.1 Determination of the total amount of organic material originated in each wastewater handling system and discharged

The main factor determining the CH4 generation potential of wastewater is the amount of degradable organic component (DC) of the wastewater stream, which is expressed in terms of either $BOD_5$ (recommended for domestic wastewater and sludge), or COD (more appropriate for industrial waste streams).

Total organics in domestic wastewater (TOW) is a function of human population and the amount of degradable organic component generated per person.

***Equation 7-4: Total organics in domestic wastewater prior to treatment***

$$TOW_{dom} = P * D_{dom}$$

**Where:**

$TOW_{dom}$ - total domestic/commercial organics in wastewater in kg $BOD_5$/yr;

P - population in 1000 persons;

$D_{dom}$ - domestic/commercial degradable organic component in kg $BOD_5$/1000 persons/yr.

The total organics by wastewater handling system i ($TOW_i$ ) is calculated as a percentage of population served by wastewater handling system.

***Equation 7-5: Total organics per wastewater handling system type***

$$TOW_i = TOW_{dom} * U_i * I_i$$

**Where:**

$TOW_i$ – Total organics per wastewater handling system in kg $BOD_5$/

$TOW_{dom}$ - - total domestic/commercial organics in wastewater in kg $BOD_5$/yr

$U_i$ – fraction of population served by each treatment/discharge pathway or system type i;

$I_i$ – correction factor for additional industrial BOD co-discharged into wastewater handling system (variable between 1.25-1.35 for collected and 1.00 for uncollected wastewater).

The estimation of total organics in treated effluent discharged was calculated using the following equation.

***Equation 7-6: Total organics in treated wastewater effluent***

$$TOW_{EFFtreat} = \Sigma_i [TOW_i * (1- TOW_{REM,i}]$$

$TOW_{EFFtreat}$ - total organics in the treated wastewater effluent discharged to aquatic environments, kg BOD/yr.
$TOW_i$ - total organics by wastewater handling system type i, kg BOD/yr.

$TOW_{REM,i}$ - fraction of total wastewater organics removed during wastewater treatment per treatment type *i*.

Organic removal include loss to sludge and biological decomposition. The organic component removed as sludge was calculated for aerobic treatment and septic systems.

***Equation 7-7: Organic component removed as sludge from aerobic treatment plants***

$$S_{aerobic} = S_{mass} * K_{rem} * 1000$$

**Where:**

$S_{aerobic}$ – organic component removed from wastewater (in the form of sludge) in kg BOD/yr

$S_{mass}$ – amount of raw sludge removed from wastewater treatment as dry mass in t d.m./ yr

$K_{rem}$ – sludge factor, kg BOD/kg sludge

***Equation 7-8: Organic component removed as sludge from septic systems***

$$S_{septic} = TOW_{septic} * F * 0.5$$

**Where:**

$S_{septic}$ – organic component removed from wastewater (in the form of sludge), kg BOD/yr

$TOW_{septic}$ – total organics in wastewater in septic systems, kg BOD/yr

F – fraction of population managing their septic tank in compliance with the sludge removal instruction of their septic system

0.5 - fraction of organics in wastewater removed in sludge when septic tank is managed in accordance with sludge removal instructions

#### 7.5.2.1.1.2 Estimation of emission factors

The emission factor for each wastewater depends on the maximum $CH_4$ producing potential of each waste type (Bo) and $CH_4$ conversion factors (MCF) for the different wastewater treatment systems existing in a country.

***Equation 7-9: Emission Factors per wastewater handling system type***

$$EF_i = B_o \times MCF_i$$

**Where:**

$EF_i$ - emission factor (kg $CH_4$ /kg DC) for wastewater handling system type i;

$B_o$ - maximum methane producing capacity (kg $CH_4$/kg $BOD_5$);

$MCF_i$ - methane correction factors of each wastewater system i.

Maximum CH4 producing capacity ($B_o$) is the maximum amount of $CH_4$ that can be generated from a given quantity of wastewater.

Methane Correction Factor (MCF) is an estimate of the fraction of DC that will ultimately degrade anaerobically. The MCF varies between 0 for a completely aerobic system to 1.0 for a completely anaerobic system.

#### 7.5.2.1.1.3 Calculation of emissions

Emissions are a function of total organics generated and an emission factor characterizing the extent of $CH_4$ generation for each wastewater handling system. Total emissions are calculated as the sum of emissions from the different handling systems. $CH_4$ that is recovered and flared or used for energy should be subtracted from emissions, as it is not emitted into the atmosphere.

***Equation 7-10: Total $CH_4$ emissions from wastewater handling***

$$CH4\ emissions = \Sigma_i [(TOW_i - S_i) * EF_i - R_i]$$

**Where:**

CH4 emissions - Total $CH_4$ emissions from wastewater handling in kg $CH_4$/yr;

$TOW_i$ - total organics in wastewater for type i, kg $BOD_5$/yr;

$S_i$ - organic component removed from wastewater (in the form of sludge) from treatment/discharge pathway or system, i, kg BOD/yr;

$EF_i$ - emission factor for treatment/discharge pathway or system I, kg $CH_4$/kg DC;

$R_i$ - amount of CH4 recovered or flared from treatment/discharge pathway or system, i, kg CH4.

### 7.5.2.1.2 Activity data and parameters

Total organic content of domestic sewage ($TOW_{dom}$) was determined multiplying the total population for each year by a per capita wastewater $BOD_5$ production rate. National population data is from the census from National Statistical Office (INE) for the years 1981, 1991, 2001, 2011 and 2021, and intermediate years have been estimated by interpolation. Population data since 2021 refer to estimates from INE. For this submission population includes foreign tourists, calculated as the number of sleeps that foreign tourists spend in hotels or other types of tourist accommodation divided by 365 days (please see next figure).

The $BOD_5$ factor considered was 60 g $BOD_5$/cap/day, which is the figure considered in the Council Directive 91/271/CEE, 21st May, and in the new Directive 2024/3019, 27th November, referring to urban wastewater treatment.

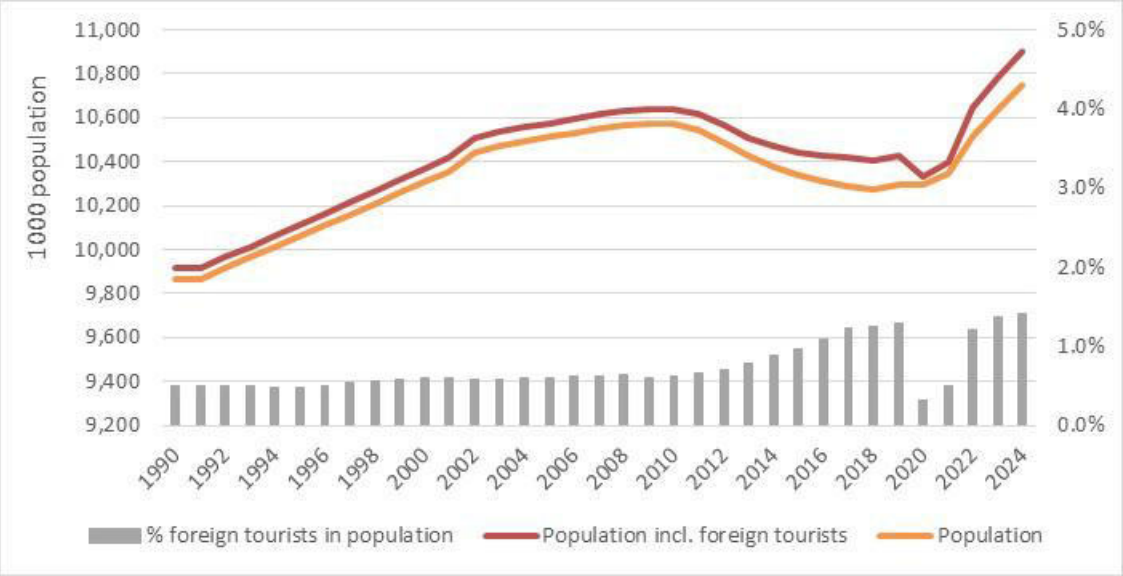



***Figure 7-19: Resident population and foreign tourists***

Population served by wastewater handling system

The previous submission was based on data trends for the public urban wastewater handling systems and types of treatment compiled by APA (previously INAG/ Water Institute which was integrated in the APA), which refer to:

- from 1990 to 1999, data are based on a compilation study, performed by ex-INAG, of all surveys and inventories done in the past concerning sanitation and wastewater treatment infrastructures. Data from this study refer to 1990, 1994 and 1999;
- from 2005 onwards, data is based on a database (INSAAR – "*Inventário Nacional de Sistemas de Abastecimento de Água e de Águas Residuais*"/ National survey on water supply and wastewater treatment systems) which was implemented and was managed by ex-INAG. From 2000 to 2004, data used in the calculations are interpolations based on the 1999 and 2005 figures.

Following the restructuration of the National Water Authority, the INSAAR, the national data base for water supply and wastewater treatment systems was deactivated and the last available year from this survey is the year 2009.

For the more recent years, data was collected for 2015 from Águas de Portugal (AdP Group) and other main urban wastewater treatment plants (> 50 000 inhab. eq.) information registered by APA.

For the 2024 submission, new sets of data referring to the Urban WWTP with an influent load ≥2000 p.e. reported under the urban wastewater directive were considered. And data on smaller Urban WWTP (influent load <2000 p.e.) based on the information from APA/Water Resources Department, were also considered.

The next table shows the evolution of the total population by wastewater handling system.

***Table 7-25: Percentage of population by wastewater handling system***

| | 1990 | 1994 | 1999 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | % population | | | | | | | | | | | | | | | |
| Discharge to marine/ inland waters | 33.4% | 45.8% | 31.3% | 27.8% | 10.3% | 6.9% | 3.5% | 2.8% | 2.1% | 1.4% | 0.7% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Septic tank: discharge to inland waters | 3.6% | 3.4% | 7.1% | 6.9% | 6.0% | 4.1% | 2.3% | 1.9% | 1.5% | 1.1% | 0.8% | 0.4% | 0.4% | 0.4% | 0.4% | 0.4% |
| Septic tank: discharge to soil | 37.0% | 23.4% | 9.0% | 7.6% | 0.9% | 0.6% | 0.3% | 0.3% | 0.2% | 0.2% | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% |
| Primary treatment | 8.5% | 7.6% | 12.8% | 13.0% | 14.0% | 11.9% | 9.9% | 9.4% | 9.0% | 8.6% | 8.2% | 7.8% | 7.8% | 7.8% | 7.8% | 7.8% |
| Secondary treatment | 11.1% | 11.1% | 24.4% | 29.3% | 53.7% | 58.7% | 63.8% | 64.8% | 65.8% | 66.8% | 67.9% | 68.9% | 68.8% | 68.7% | 68.6% | 68.5% |
| Tertiary treatment | 2.8% | 5.1% | 8.0% | 8.8% | 12.7% | 15.2% | 17.7% | 18.2% | 18.7% | 19.2% | 19.6% | 20.1% | 20.3% | 20.5% | 20.7% | 20.8% |
| Anaerobic shallow lagoon (< 2m) | 1.9% | 1.6% | 2.6% | 2.3% | 1.0% | 1.1% | 1.1% | 1.1% | 1.1% | 1.2% | 1.2% | 1.2% | 1.1% | 1.1% | 1.1% | 1.0% |
| Anaerobic deep lagoon (> 2m) | 1.9% | 1.6% | 2.6% | 2.3% | 1.0% | 1.1% | 1.1% | 1.1% | 1.1% | 1.2% | 1.2% | 1.2% | 1.1% | 1.1% | 1.1% | 1.0% |
| Macrophyte lagoon | 0.0% | 0.4% | 2.3% | 1.9% | 0.3% | 0.3% | 0.3% | 0.3% | 0.4% | 0.4% | 0.4% | 0.4% | 0.4% | 0.4% | 0.4% | 0.4% |

Source: APA; include estimates.

For the period 1990-2009, data corresponds to the previous set of data used in the preceding submissions and thus refers to wastewater sanitation surveys from the National Water Authority. Treatment types for these previous years were aggregated to consider the stratification and default parameters proposed by the 2019 Refinement guidelines.

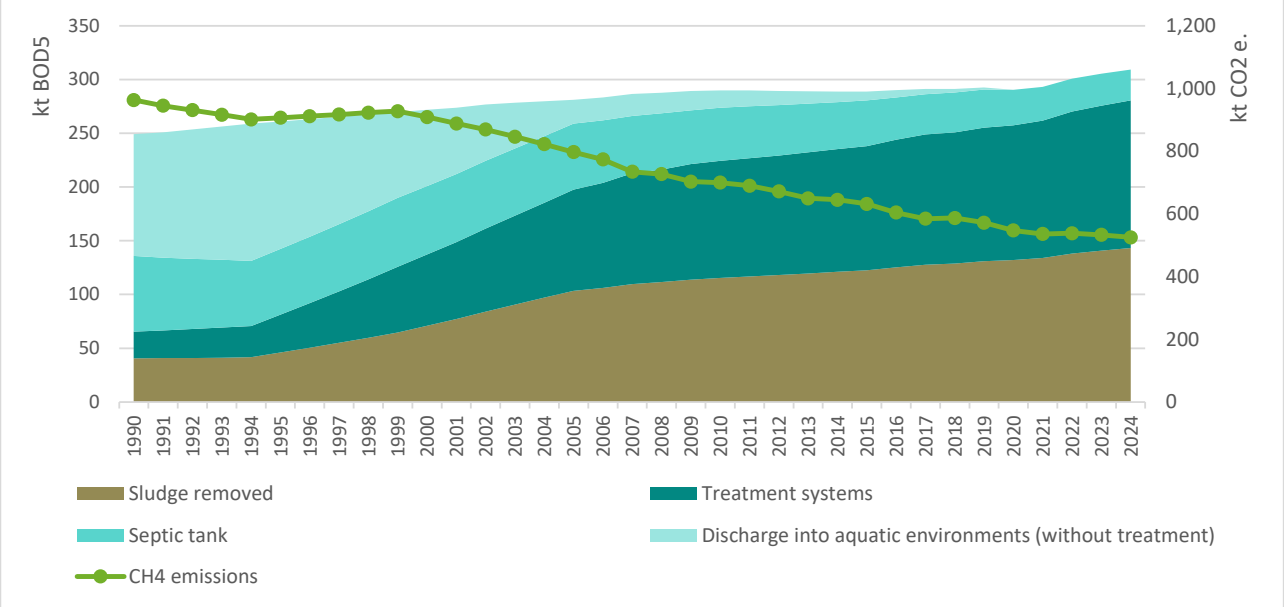
For 2020, the systematized information on all public WWTPs in operation in Portugal (two differentiated groups with load greater and above and less than 2,000 population equivalent) was used. This data, which include among others, information on the nominal and used treatment capacity and the treatment technology, was worked to assemble a matrix of WWT typologies.

Information on wastewater handling systems for the period 2010-2019 was estimated by interpolation.

Wastewater treated in urban WWTPs has two main origins: domestic wastewater and non-domestic wastewater, mainly related to industrial facilities that drain their effluents into municipal collectors, according to criteria established in specific municipal regulations regarding discharge limit values per pollutant.

Data available on public WWTPs, which includes a fraction of wastewater of industrial origin, allowed the estimation of the average weight of industrial effluents in relation to domestic effluents.

This submission considers a correction factor for additional industrial BOD discharged into treatment/discharge pathway or system, based on the information collected from the Urban WWTP for 2020: 1.35. The default value 1.25 was considered for the base year. A linear interpolation was used for the intermediate years. The default 1.00 was considered for uncollected wastewater.




Notes:
Discharge into aquatic environments: without treatment.
Septic tank: include individual and collective systems.
Treatment systems: include primary, secondary (centralised, aerobic treatment plants), Anaerobic lagoons, and Macrophyte lagoons.
Sludge removed in WW handling systems.
Source: APA (estimates).

***Figure 7-20: Wastewater and sludge $BOD_5$ produced according to handling systems and related CH4 emissions***

Sludge is produced in all the primary, secondary, and tertiary stages of treatment.

The information available on sludge refers generally to the amount of sludge having undergone some treatment such as composting, anaerobic digestion or other types of treatment, and not to the mass of sludge removed from the WWTP. Furthermore, there is a considerable amount of uncertainty in terms of sludge characteristics, e.g. water and organic matter content. To overcome these limitations, the amount of organic component (TOW) removed as sludge was estimated following the guidance proposed by the 2019 IPCC Refinement and the corrections proposed in the paper presented in a ESD Webinar paper (Hans Onke, 2021).

The calculation of the amount of TOW removed as sludge (in BOD) and the mass of sludge generated and treated ($S_{mass}$) have been estimated using the factors presented in the tables below.

***Table 7-26: Fraction of organic load (BOD) removed by type of treatment - $TOW_{REM}$***

| Treatment type | $TOW_{REM}$ |
|---|---|
| Discharge to marine/ inland waters | 0 |
| Septic tank: discharge to inland waters | 0.625 |
| Septic tank: discharge to soil | 0.625 |
| Primary treatment | 0.40 |
| Secondary treatment | 0.85 |
| Tertiary treatment | 0.90 |
| Anaerobic shallow lagoon (< 2m) | 0.50 |
| Anaerobic deep lagoon (> 2m) | 0.50 |
| Macrophyte lagoon | 0.80 |

Source: Based in 2019 IPCC Refinement (Table 6.6B); anaerobic lagoons: https://www.climate-policy-watcher.org/industrial-wastes/anaerobic-lagoon.html; macrophyte lagoons. Revista da UIIPS – Unidade de Investigação do Instituto Politécnico de Santarém, Vol. VI, N. º 3, 2018, pp. 83-97, Miguel Macário et all, "Constructed wetlands as an alternative to conventional wastewater treatment systems". https://revistas.rcaap.pt/uiips/

***Table 7-27: Estimation of Sludge production ($S_{mass}$) from amount of BOD-removed by type of treatment***

| Treatment type | kg sludge (dry mass) produced per kg TOW removed |
|---|---|
| Discharge to marine/ inland waters | 0 |
| Septic tank: discharge to inland waters | 2 |
| Septic tank: discharge to soil | 2 |
| Primary treatment | 2 |
| Aerobic treatment plants with primary treatment (mixed primary and secondary sludge, untreated or treated aerobically) | 1.25 |
| Aerobic treatment plants with primary treatment and anaerobic sludge digestion (mixed primary and secondary sludge, treated anaerobically) | 1 |

Source: ESD Webinar paper (Hans Onke, 2021, Application of the 2019 Refinement).

For $K_{rem}$, a value of 0.5 has been used for all types of sludge.

Parameters: Bo - The default IPCC value for Bo 0.6 kg CH4/kg $BOD_5$ was used .

Parameters: MCF - The next table present the MCF factors used for each wastewater treatment system considered and data set used.

***Table 7-28: Methane Conversion Factors (MCF) by type of treatment and discharge pathway (Direct emissions)***

| Treatment type | MCF |
|---|---|
| Discharge to marine/ inland waters | 0 |
| Septic tank: discharge to inland waters | 0.5 |
| Septic tank: discharge to soil | 0.5 |
| Primary treatment | 0 |
| Secondary treatment | 0.03 |
| Tertiary treatment | 0.03 |
| Anaerobic shallow lagoon (< 2m) | 0.2 |
| Anaerobic deep lagoon (> 2m) | 0.8 |
| Macrophyte lagoon | 0.1 |

Source: 2019 IPCC Refinement defaults (Table 6.3) and for Macrophyte lagoon: Table 6.4 Ch.6: Constructed Wetlands for WW Treatment/ 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands.

The MCF value applied to quantify indirect CH4 emissions is 0.11.

Emission factors used for the biological treatment (composting and anaerobic digestion) of sludge are presented in the next table and refer to a dry weight basis.

***Table 7-29: Default emission factors for CH4 and N2O emissions from biological treatment (wet weight basis)***

| | CH4 (g/kg sludge treated) | N2O (g/kg sludge treated) |
|---|---|---|
| Composting | 10 | 0.6 |
| Anaerobic digestion | 2 | Assumed negligible |

Source: 2015 corrigenda of the IPCC 2006 GL (IPCC TFI, 31 July 2015 as published at http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html).

No quantities of CH4 recovered or flared from treatment systems has been considered. The emission factor relating to anaerobic digestion treatment already includes the recovery of CH4.

### 7.5.2.2 Industrial Wastewater Handling CH4 emissions

In the methodology used until the 2024 inventory, industrial wastewater was accounted separately from domestic wastewater, whether it was treated in private/industrial WWTPs, or whether it was sent to collectors and treated in public WWTPs.

The methodology used before encompassed all industrial wastewater generated, do not considering where the treatment took place.

From now on, industrial wastewater will be limited to effluents treated exclusively in industrial WWTPs.

While until now, all calculations relied on the characterization data (e.g. COD loads) prior to treatment, which was calculated based on industrial activity indicators and COD load generation factors by type of industry, from now on, data available relates to loads, after treatment, discharged into the natural environment. This information refers to data for each industrial WWTP within the framework of APA licensing and monitoring activities, with the characterization of existing treatment typologies.

The pulp and paper sector represents approximately 90% of COD load in 2018. CH4 emissions from industrial wastewater handling systems reduced since 1990, mainly as a result of the decrease of the organic load from pulp and paper industry (Figure 7-23).

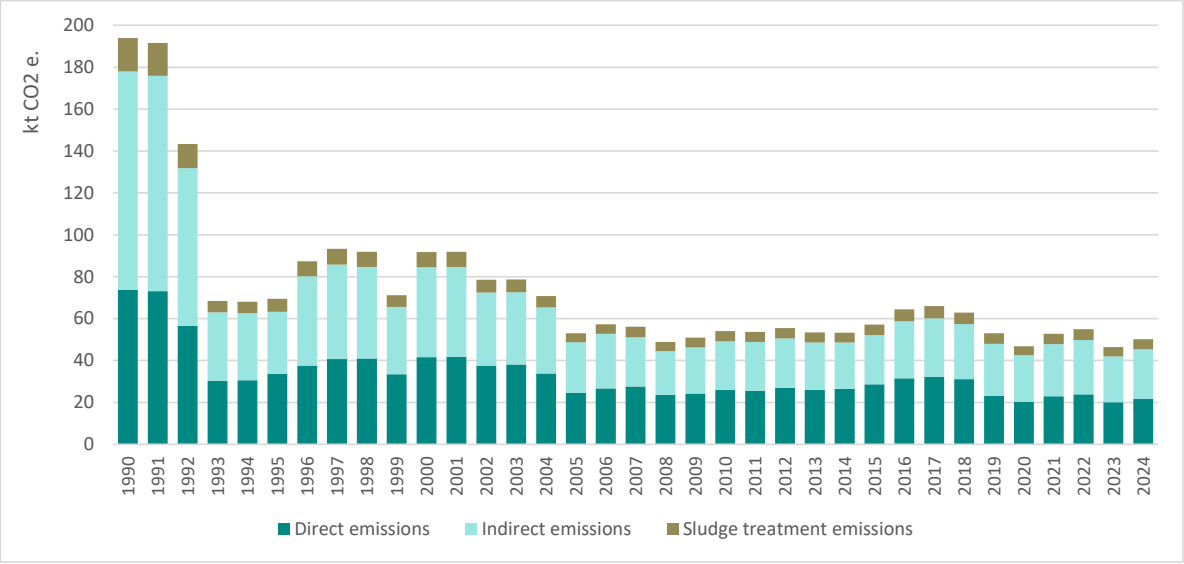



***Figure 7-21: Direct, indirect and sludge treatment CH4 emissions from industrial wastewater handling systems***

#### 7.5.2.2.1 Methods

The present methodology uses data relating to reported and discharged loads into the natural environment, after treatment, available in a database for each industrial WWTP within the framework of APA licensing and monitoring activities, which also includes the characterization of treatment typologies. This information refers to 2018.

Since the methodological approach proposed by the 2019 IPCC Refinement to account for direct emissions from WWTP is based on the total load before treatment, it was necessary to estimate the total organics in wastewater prior to treatment using the following equation.

***Equation 7-11: Total organics in industrial wastewater before treatment per handling system type***

$$TOW_i = TOW_{EFFLUENT\ IND\ i} / (1- TOW_{REM,i})$$

$TOW_i$ - total organics in industrial wastewater per handling system, kg BOD/yr.

$TOW_{EFFLUENT\ IND\ i}$ - total organics in the treated industrial wastewater effluent discharged to aquatic environments per treatment type, kg BOD/yr.

$TOW_{REM,i}$ - fraction of total industrial wastewater organics removed during wastewater treatment per treatment type *i*. (Table 7-26)

Organic removal include loss to sludge and biological decomposition. The organic component removed as sludge was calculated for aerobic treatment.

Emissions from treatment plants (direct emissions) and from wastewater after disposal of effluent into aquatic environments (indirect emissions) are accounted for using Equation 7-10: Total $CH_4$ emissions from wastewater handling.

#### 7.5.2.2.2 Activity data

The accounting of the emissions from industrial wastewater handling relied on the use of the information available related to loads, after treatment, discharged into the natural environment. This information refers to data for each industrial WWTP within the framework of APA licensing and monitoring activities, with the characterization of existing treatment typologies by economic branch for the year 2018.

The information for the year 2018 for each WWTP was classified according to the economic sector and the typology of treatment and aggregated into the following main classes:

- Pulp and paper
- Textile
- Food and drink
- Other

And the following treatment/handling types:

- Without treatment
- Primary
- Secondary (excluding anaerobic lagoons)
- Secondary (Anaerobic lagoons)
- Tertiary

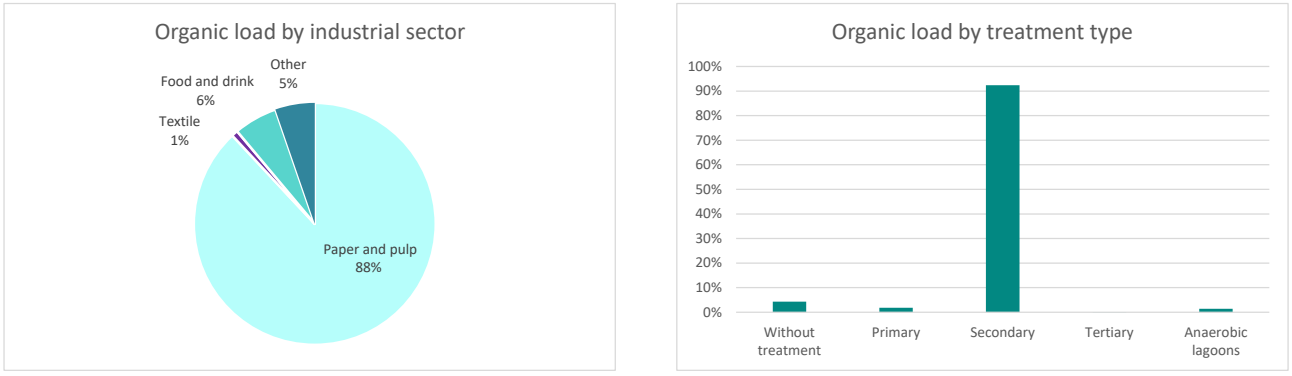



***Figure 7-22: Organic load aggregated by industrial sector and treatment type in 2018***

The evolution of organic load since 1990 was estimated diversely according to the information available for the different industrial sectors.

For the pulp and paper industry, the total annual organic load discharged concerning the period 1990-2018 was estimated based on data collected from the individual units on the organic load discharged by unit of pulp and paper produced (kg CQO/t pulp and paper).

The evolution of the annual organic wastewater load for the other sectors was based on the estimated annual organic loads, as estimated in the previous submissions[1]. The previous methodology was based on statistics of industrial activity from the National Statistical Office (in particular, industrial production data) for a range of relevant economic sectors, and a set of pollution coefficients[2] (expressed in an amount of COD generated per unit of production - kg COD per ton of product produced), in relation to the total organic load for 2018.

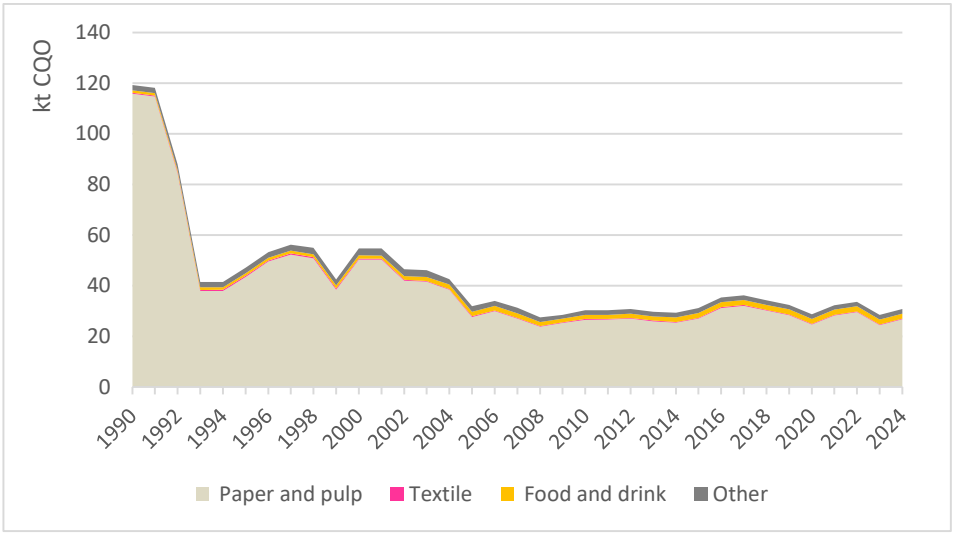



***Figure 7-23: Industrial Wastewater organic load, expressed in COD, from major industrial sectors***

The very high weight of pollutant loads in treated effluents relating to the pulp and paper sector in relation to the total (around 90% in the case of COD load in 2018), and the better knowledge of the evolution of this sector over time, has driven the over whole trend of the industrial effluents rejected in natural environments.

[1] Portugal. 2023 National Inventory Report (NIR) (https://unfccc-int.translate.goog/documents/627602?_x_tr_sl=en&_x_tr_tl=pt&_x_tr_hl=pt-PT&_x_tr_pto=sc )

[2] The pollution coefficients that were used result from a study specifically done for the estimate of the loads from the Portuguese Industry (Cartaxo et al, 1985).

***Table 7-30: Percentage of industrial wastewater by handling system***

| Wastewater handling System | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Discharge without treatment | 2.1% | 3.4% | 3.0% | 4.1% | 1.4% | 1.0% | 0.7% | 0.7% | 0.7% | 0.6% | 0.6% |
| Primary treatment | 5.2% | 6.1% | 6.3% | 5.2% | 0.8% | 0.8% | 0.5% | 0.5% | 0.5% | 0.5% | 0.4% |
| Secondary treatment | 92.2% | 89.5% | 89.5% | 89.5% | 96.7% | 96.9% | 98.3% | 98.3% | 98.3% | 98.4% | 98.5% |
| Tertiary treatment | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% |
| Anaerobic shallow lagoon (< 2m) | 0.2% | 0.5% | 0.6% | 0.6% | 0.5% | 0.7% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% |
| Anaerobic deep lagoon (> 2m) | 0.2% | 0.5% | 0.6% | 0.6% | 0.5% | 0.7% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% |
| Total | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

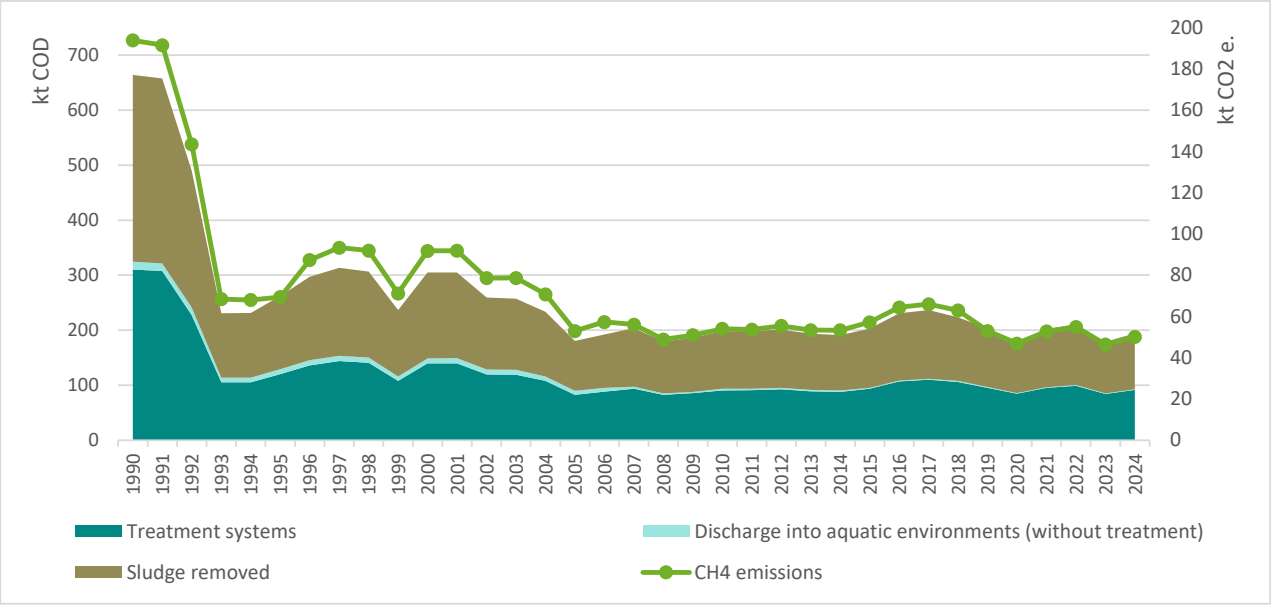



***Figure 7-24: Wastewater and sludge COD produced according to handling systems and related CH4 emissions***

The amount of organic component (TOW) removed as sludge was estimated following the guidance proposed by the 2019 IPCC Refinement and the proposed corrections considered in a ESD Webinar paper (Hans Onke, 2021).

The calculation of the amount of TOW removed as sludge (in BOD) and the mass of sludge generated and treated ($S_{mass}$) have been estimated using the factors presented in the tables below.

***Table 7-31: Fraction of organic load (BOD) removed by type of treatment - $TOW_{REM}$***

| Treatment type | $TOW_{REM}$ |
|---|---|
| Discharge to marine/ inland waters (without treatment) | 0 |
| Primary treatment | 0.40 |
| Secondary treatment | 0.85 |
| Tertiary treatment | 0.90 |
| Anaerobic shallow lagoon (< 2m) | 0.50 |
| Anaerobic deep lagoon (> 2m) | 0.50 |

Source: Based in 2019 IPCC Refinement (Table 6.6B); anaerobic lagoons: https://www.climate-policy-watcher.org/industrial-wastes/anaerobic-lagoon.html.

***Table 7-32: Estimation of Sludge production (Smass) from amount of BOD-removed by type of treatment***

| Treatment type | kg sludge (dry mass) produced per kg TOW removed |
|---|---|
| Discharge to marine/ inland waters (without treatment) | 0 |
| Primary treatment | 0.84 |
| Aerobic treatment plants with primary treatment (mixed primary and secondary sludge untreated or treated aerobically) | 0.52 |
| Aerobic treatment plants with primary treatment and anaerobic sludge digestion (mixed primary and secondary sludge untreated or treated anaerobically) | 0.52 |
| Anaerobic lagoon (< and > 2m) | 0 |

Source: ESD Webinar paper (Hans Onke, 2021, Application of the 2019 Refinement).

For $K_{rem}$, a value of 1.2 has been used for all types of sludge.

Data on sludge final disposal was based on information about the pulp and paper sector which, as already mentioned, represents the great majority of organic load and sludge generated. According to the information collected under the industrial licensing and monitoring in APA, the main sludge destiny is nowadays incineration with energy recovery after drying internally in the plants, instead of disposal in composting. Based on the recent information collected a value of 20% was considered for the fraction of industrial sludge composted.

#### 7.5.2.2.3 Emission factors and other parameters

##### 7.5.2.2.3.1 Wastewater handling systems types

In the absence of comprehensive information on treatment systems in the past, the information on the treatment types by sector had to be estimated specifically for the inventory using information collected from:

- EPER data. At the time that the inventory was compiled the EPER data was available for 2000 and partially for 2004. Information for the following sectors was available: paper pulp production; crude oil refining; slaughterhouses and meat processing; pig farms; olive oil extraction; fish canning and processing and chemical industry;
- Covenants of Environmental Adaptation. These were voluntary agreements between the Environmental Ministry, other ministries responsible for the permits of specific industrial sectors (Ministry of Economy or the Ministry of Agriculture, Rural Development and Fisheries) and several industrial associations in representation of the industrial units. The agreements were established between March 1997 and February 1998 with the objective to define a time schedule to reach the complete respect of legal constrains concerning the water, air, wastes and noise. The contract involved the elaboration of an *Assessment of the*

*Environmental State*[3] and a *Specific Plan of Elaboration*[4]. Eighteen sectors were involved: textile; dairy; stone quarrying and processing; vegetable oils; chemical industry; graphics and paper transformation; shoe making; rubber; ceramics; cork; wood and wood products; paper and card; electric and electronic equipment production; naval industry; crop protection industry; paint and varnishes, glues and adhesives and tomato processing. There was a specific agreement with the sector of extraction of olive oil;

- Information for individual plants or industrial associations, such as the paper pulp production industry and the oil refineries;
- Information collected from the Environmental Permits attributed to operators of installations covered by the IPCC Directive.

For each specific industrial sector the share of use of each specific treatment system was aggregated according to the following classes presented in Table 7-30: Percentage of industrial wastewater by handling system.

#### 7.5.2.2.3.2 Methane Production Potential

The parameter Bo, representing the maximum Methane Production Potential, was assumed constant and common to all sectors and treatment systems, and set to 0.25 kg CH4/kg COD, the default value from IPCC.

#### 7.5.2.2.3.3 Methane Correction Factor

MCF values used to account for direct emissions were established from the latest guidelines available (IPCC, 2019), and are presented in the next table.

***Table 7-33: Methane Conversion Factors (MCF) by type of treatment and discharge pathway***

| Treatment type | MCF |
|---|---|
| Discharge to marine/ inland waters (without treatment) | 0 |
| Primary treatment | 0 |
| Secondary treatment | 0.03 |
| Tertiary treatment | 0.03 |
| Anaerobic shallow lagoon (< 2m) | 0.2 |
| Anaerobic deep lagoon (> 2m) | 0.8 |

Source: 2019 IPCC Refinement defaults (Table 6.8).

The MCF value applied to quantify indirect CH4 emissions is 0.11.

### 7.5.2.3 Urban Wastewater N2O emissions

N2O can occur as direct emissions from treatment plants or from indirect emissions from wastewater after disposal of effluent into aquatic environments. N2O can be generated during all these stages through nitrification/denitrification of the nitrogen in faeces, urine, and other liquid wastes, which are typically in the form of urea and proteins. In general, temperature, pH, $BOD_5$, and nitrogen concentration influence $N_2O$ production from human sewage.

According to the 2006 IPCC guidance, direct emissions from wastewater treatment plants, predominantly associated with advanced centralized wastewater treatment plants with nitrification/denitrification steps,

[3] Caracterização da Situação Ambiental, *in the original Portuguese nomenclature.*
[4] Plano Específico de Adaptação, *in the original Portuguese nomenclature.*

were considered a minor source. The 2019 IPCC Refinement, which integrates the evolution of scientific knowledge on this subject, has revised this perception and accordingly these emissions have been reviewed and became of greater importance. The inventory considers also, as previously, indirect N2O emissions. Emissions from wastewater treatment that is discharged into aquatic environments are consider in this section, and those resulting from disposal of sludge in agriculture soils are included in the agriculture sector. N2O emissions from biological treatment (composting) of sludge are also accounted.

N2O emissions from municipal wastewater handling systems grew substantially since 1990, due to the strong investment in wastewater collection infrastructures and centralized treatment systems, and the consequent increase in emissions related to centralized treatment facilities when compared with N2O emissions from no treatment or primary treatment.

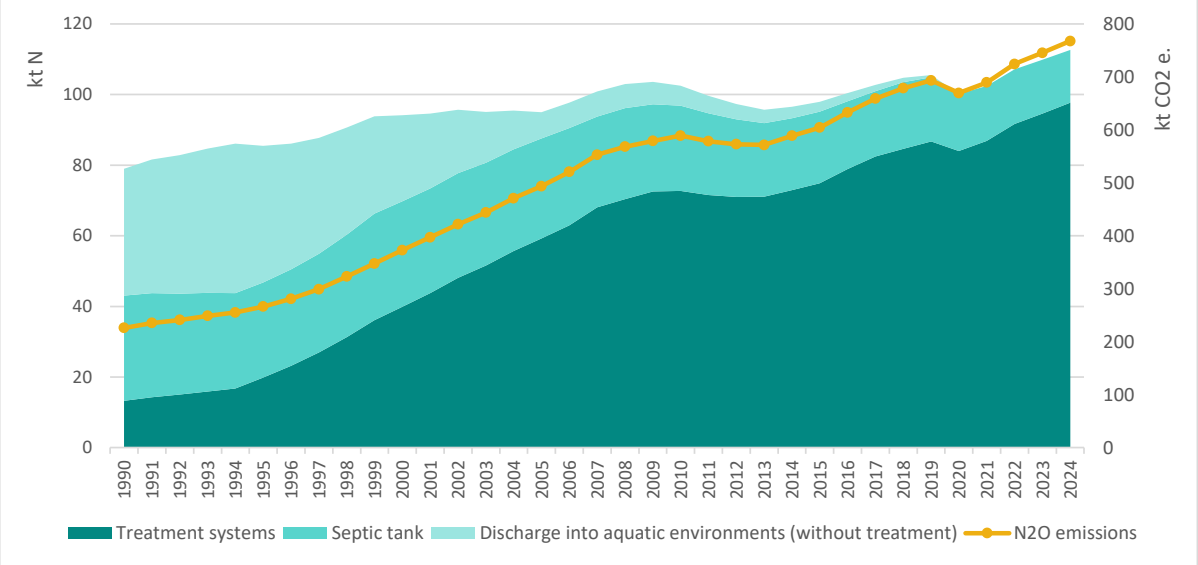



***Figure 7-25: Urban wastewater N load per wastewater handling systems and related N2O emissions***

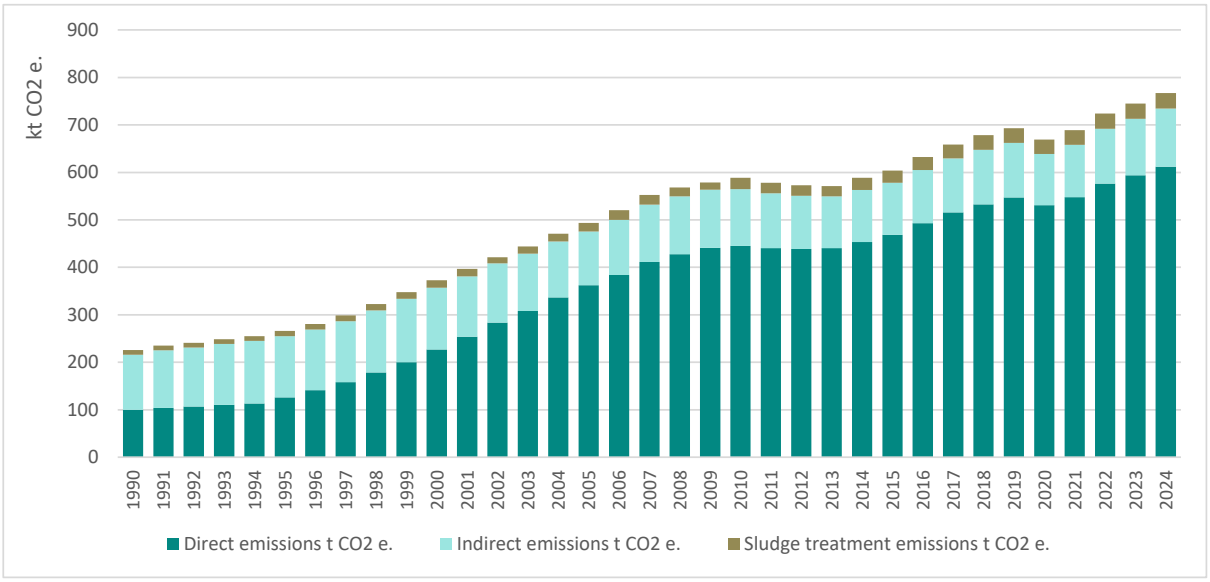



***Figure 7-26: N2O emissions from urban wastewater handling systems***

#### 7.5.2.3.1 Methods

This category accounts for direct N2O emissions from wastewater treatment plants/discharge pathways and indirect emissions from wastewater after disposal of untreated or treated effluent into water bodies. N2O emissions from biological treatment (sludge composting) are also accounted here. (please see previous figure)

Emissions of N2O from wastewater were estimated considering that the amount of protein consumed by population determines the quantity of nitrogen contained in sewage and considering the account of N removal with sewage sludge, the non-consumed protein and the industrial and commercial sources discharged into the sewer system. The application of this $F_{IND-COM}$ is only applied to collected (sewered) wastewater (excluding septic tanks and latrines).

The approach followed the guidance from IPCC (2019), as follows:

***Equation 7-12: Total Nitrogen in domestic wastewater***

$$TN_{DOM} = P * Protein * F_{NPR} * F_{NON-CON} * N_{HH}$$

**Where:**

$TN_{DOM}$ = total annual amount of nitrogen in domestic wastewater, kg N/yr

P - population in 1000 persons;

Protein = annual per capita protein consumption, kg protein/person/yr;

$F_{NPR}$ = fraction of nitrogen in protein

$F_{NON-CON}$ = factor for nitrogen in non-consumed protein disposed in sewer system, kg N/kg N

$N_{HH}$ = additional nitrogen from household products added to the wastewater, kg N/kg N

***Equation 7-13: Total Nitrogen in domestic wastewater by treatment pathway***

$$TN_{DOM\ i} = TN_{DOM} * U_i * F_{IND-COM}$$

**Where:**

$TN_{DOM\ i}$= total annual amount of nitrogen in domestic wastewater for treatment pathway i, kg N/yr

$TN_{DOM}$ = total annual amount of nitrogen in domestic wastewater, kg N/yr

$U_i$ – fraction of population served by each treatment/discharge pathway or system type i;

$F_{IND-COM}$ = factor for industrial and commercial co-discharged protein into the sewer system, kg N/kg N; this factor is only applied to collected (sewered) wastewater (excluding septic tanks and latrines).

***Equation 7-14: Total Nitrogen in domestic wastewater effluent***

$$N_{EFFLUENT,DOM} = \sum TN_{DOM}\ i * (1 - N_{REM}\ i)$$

**Where:**

$N_{EFFLUENT,DOM}$ = total nitrogen in the wastewater effluent discharged to aquatic environments in inventory year, kg N/yr

$TN_{DOM}$ i= total nitrogen in domestic wastewater by treatment pathway, kg N/yr.

i = each wastewater treatment type used in inventory year

$N_{REM}$ = fraction of total wastewater nitrogen removed during wastewater treatment per treatment type i. Pathways for N removal include transfer to sludge and N loss to the atmosphere.

Emissions from nitrification and denitrification at centralised wastewater treatment plants have been estimated as follows:

***Equation 7-15: N2O emissions from domestic wastewater treatment plants/discharge pathway***

$$N2O_{PLANTS\text{-}DOM} = \sum_i (T_{PLANT} * EF_{PLANT}) * TN_{DOM} * 44/28$$

**Where:**

$N2O_{PLANTS\text{-}DOM}$ – $N_2O$ emissions from domestic WWTP (kg $N_2O$/yr);

$TN_{DOM}$ – total annual amount of nitrogen in domestic wastewater, kg N/yr

$T_{PLANT}$ – fraction of population served by each treatment/discharge pathway;

$EF_{PLANT}$ – emission factor per treatment/discharge pathway kg N2O-N/kg N

***Equation 7-16: N2O emissions from domestic wastewater effluent***

$$N2O_{EFFLUENT\text{-}DOM} = N_{EFFLUENT,DOM} * EF_{EFFLUENT} \times 44/28$$

**Where:**

$N2O_{EFFLUENT\text{-}DOM}$ – $N_2O$ emissions from domestic sewage (kg $N_2O$/yr);

$N_{EFFLUENT,DOM}$ – nitrogen in the effluent discharged to aquatic environments (kg N/yr);

$EF_{EFFLUENT}$ – emission factor for N2O emissions from discharged wastewater (kg $N_2O$-N/kg sewage-N produced);

44/28 is the molecular weight ratio of $N_2O$-N into $N_2O$.

#### 7.5.2.3.2 Activity data and parameters

The fraction of population served by modern centralized WWT plants is presented in Table 7-25.

Portuguese population refer to National Statistical Office (INE) Census for the years 1981, 1991, 2001, 2011and 2021; intermediate years have been estimated by interpolation. Population data include also foreign tourists, calculated as the number of sleeps that foreign tourists spend in hotels or other types of tourist accommodation divided by 365 days.

Data on annual per capita protein intake refer to the "*Balança Alimentar Portuguesa – BAP*" which is updated every five years. The latest data refer to the 2020-2024 period, but all the time series has been revised by INE. Other parameters used in the estimations are based on the IPCC defaults.

***Table 7-34: Data and parameters used calculation of N2O emissions from wastewater***

| Parameter | Year | INE data (kg/person/year) |
|---|---|---|
| Annual per capita protein intake | 1990 | 40.15 |
| | 1991 | 41.32 |
| | 1992 | 41.57 |
| | 1993 | 42.16 |
| | 1994 | 42.45 |
| | 1995 | 41.90 |
| | 1996 | 41.98 |
| | 1997 | 42.52 |
| | 1998 | 43.65 |
| | 1999 | 44.93 |
| | 2000 | 44.82 |
| | 2001 | 44.79 |
| | 2002 | 44.90 |
| | 2003 | 44.46 |
| | 2004 | 44.53 |
| | 2005 | 44.20 |
| | 2006 | 45.22 |
| | 2007 | 46.32 |
| | 2008 | 47.19 |
| | 2009 | 47.34 |
| | 2010 | 46.87 |
| | 2011 | 45.66 |
| | 2012 | 44.79 |
| | 2013 | 44.17 |
| | 2014 | 44.71 |
| | 2015 | 45.44 |
| | 2016 | 46.54 |
| | 2017 | 47.56 |
| | 2018 | 48.58 |
| | 2019 | 48.76 |
| | 2020 | 46.65 |
| | 2021 | 47.30 |
| | 2022 | 48.25 |
| | 2023 | 48.73 |
| | 2024 | 49.35 |
| Fraction of nitrogen in protein ($F_{NPR}$ ) | 0.16 | IPCC default |
| Fraction of non-consumed protein ($F_{NON-CON}$) | 1.00 | IPCC default |
| Additional nitrogen from household products ($N_{HH}$) | 1.08 | IPCC default |
| Factor for industrial and commercial co-discharged protein ($F_{IND-COM}$) | 1.25 | IPCC default |

Source: INE (2025), Portuguese Food Balance Sheet (BAP).

***Table 7-35: Wastewater treatment Nitrogen removal fractions ($N_{REM}$) by treatment type***

| Treatment type and discharge pathway or system | NREM |
|---|---|
| Discharge to marine/ inland waters | 0 |
| Septic tank: discharge to inland waters | 0.15 |
| Septic tank: discharge to soil | 0.68 |
| Primary treatment | 0.10 |
| Secondary treatment | 0.40 |
| Tertiary treatment | 0.80 |
| Anaerobic shallow lagoon (< 2m) | 0.30 |
| Anaerobic deep lagoon (> 2m) | 0.30 |
| Macrophyte lagoon | 0.45 |

Source: Based in 2019 IPCC Refinement (Table 6.10C). ); anaerobic lagoons: https://www.climate-policy-watcher.org/industrial-wastes/anaerobic-lagoon.html; macrophyte lagoons. Revista da UIIPS – Unidade de Investigação do Instituto Politécnico de Santarém, Vol. VI, N. º 3, 2018, pp. 83-97, Miguel Macário et all, "Constructed wetlands as an alternative to conventional wastewater treatment systems". https://revistas.rcaap.pt/uiips/

***Table 7-36: Emission factors for domestic and industrial wastewater (kg N2O-N/kg N)***

| Treatment type and discharge pathway or system | EF |
|---|---|
| Discharge to marine/ inland waters | 0 |
| Septic tank: discharge to inland waters | 0 |
| Septic tank: discharge to soil | 0.0045 |
| Primary treatment | 0 |
| Secondary treatment | 0.016 |
| Tertiary treatment | 0.016 |
| Anaerobic shallow lagoon (< 2m) | 0 |
| Anaerobic deep lagoon (> 2m) | 0 |
| Macrophyte lagoon | 0.0079 |

Source: Based in 2019 IPCC Refinement (Table 6.8A); Macrophyte lagoon: Horizontal subsurface flow (HSSF) from 6.3.1.2 Ch.6: Constructed Wetlands for WW Treatment

The emission factor for wastewater disposal in aquatic environments is 0.005 kg N2O-N/kg N.

N2O emissions from sludge refer to the aerobic treatment of sludge on agriculture land (included in chapter 5) and composting (EF presented in Table 7-29).

### 7.5.2.4 Industrial Wastewater N2O emissions

As mentioned previously, the emissions considered here refer exclusively to industrial wastewater treated on site. Industrial effluents released into municipal WWTP are accounted in urban wastewater.

N2O emissions from industrial wastewater handling systems decreased since 1990, due to the reduction of the nitrogen load from industry.

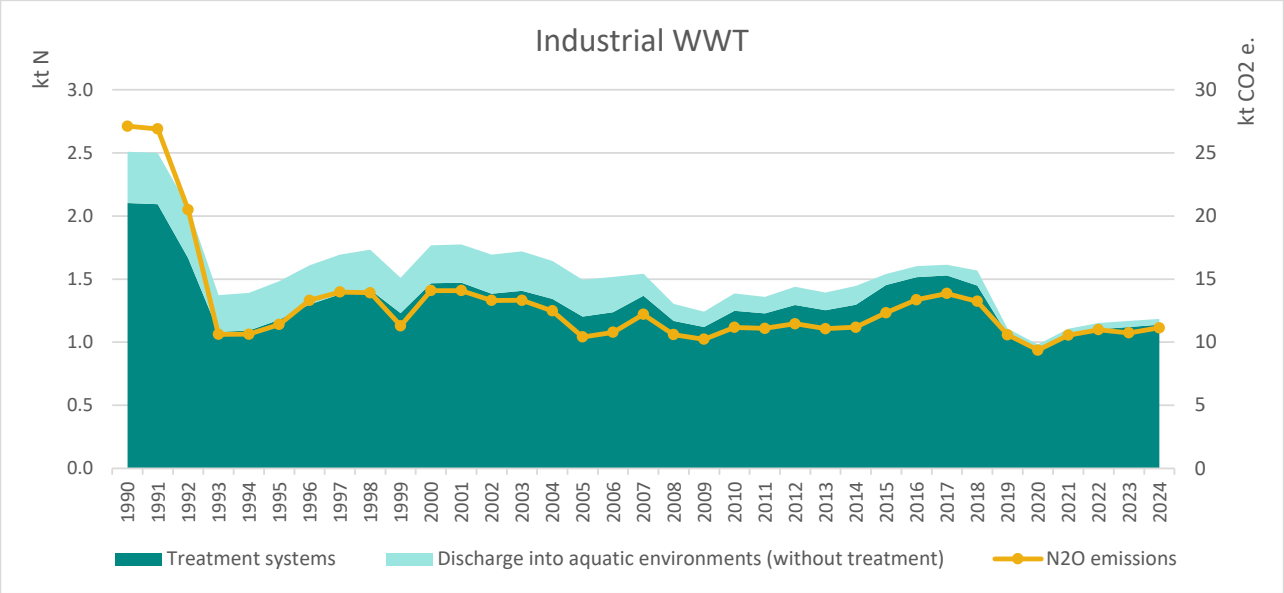



***Figure 7-27: Industrial wastewater N load and related N2O emissions***

This category accounts for direct N2O emissions from wastewater treatment plants/discharge pathways and indirect emissions from wastewater after disposal of untreated or treated effluent into natural environment. N2O emissions from biological treatment (sludge composting and anaerobic digestion) are also accounted here.

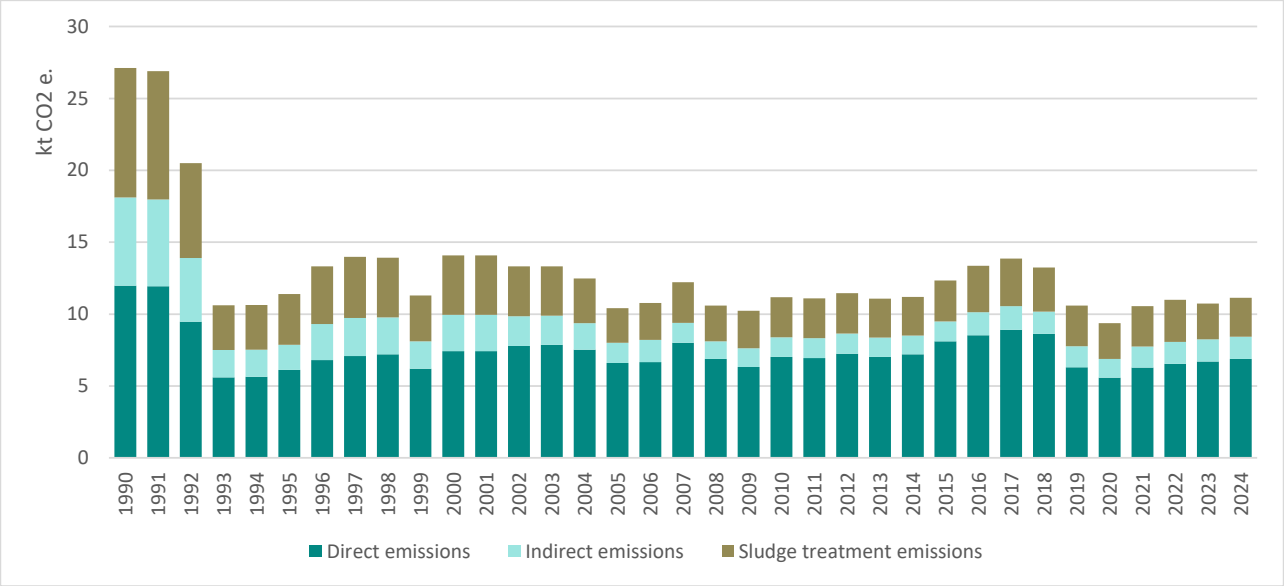



***Figure 7-28: Direct, indirect and sludge treatment N2O emissions from industrial waste water handling systems***

#### 7.5.2.4.1 Methods

The accounting of these emissions relied on the use of the information available related to loads, after treatment, discharged into the natural environment. This information refers to data for each industrial WWTP within the framework of APA licensing and monitoring activities, with the characterization of existing treatment typologies.

Since the information refer to the nitrogen load after treatment in each industrial WWTP, the total load before treatment needed to be estimated to account for emissions from WWTP. The methodology proposed in the 2019 IPCC Refinement (equation 6.14 (NEW) was used as follows:

***Equation 7-17: Total nitrogen in wastewater before treatment by type of treatment***

$$TN_{IND\,i} = \sum_i N_{EFFLUENT\,i} / (1 - N_{REM\,i})$$

Where:

$TN_{IND\,I}$ – total nitrogen wastewater before treatment by type of treatment

$N_{EFFLUENT\,I}$ – total amount of nitrogen in industrial wastewater effluent by treatment type

$N_{REM\,I}$ – fraction of total wastewater nitrogen removed by treatment type (please see Table 7-355)

i - treatment type (please see Table 7-30)

***Equation 7-18: N2O emissions from industrial wastewater in treatment plants***

$$N2O\ Plants_{IND} = \sum_i (TN_{IND\,i} * EF_i) * 44/28$$

Where:

$N2O\ Plants_{IND}$ – N2O emissions from industrial wastewater treatment plants

$TN_{IND\,I}$ – total nitrogen wastewater before treatment by type of treatment

$EF_i$- emission factor for treatment/discharge (please see Table 7-366)

The indirect emissions from wastewater after disposal of untreated or treated effluent into natural environment was calculated as follows:

***Equation 7-19: N2O emissions from industrial wastewater effluent***

$$N2O\ Effluent_{IND} = N_{EFFLUENT} * EF * 44/28$$

Where:

$N2O\ Effluent_{IND}$ – N2O emissions from industrial wastewater effluent

$N_{EFFLUENT}$– total amount of nitrogen in industrial wastewater effluent discharged to aquatic environment

EF - emission factor for N2O from wastewater discharged to aquatic environment (0.005 kg N2O-N/kg N)

N2O emissions from sludge treatment refer to the aerobic treatment of sludge on agriculture land (included in chapter 5) and composting (EF presented in Table 7-29).

#### 7.5.2.4.2 Activity data and parameters

The accounting of these emissions relied on the use of the information available related to loads, after treatment, discharged into the natural environment. This information refers to data for each industrial WWTP within the framework of APA licensing and monitoring activities, with the characterization of existing treatment typologies by economic branch for the year 2018.

The information for the year 2018 for each WWTP was classified according to the economic sector and the typology of treatment and aggregated into the following main classes:

- Paper and pulp
- Textile
- Food and drink
- Other

And the following treatment/handling types:

- Without treatment
- Primary
- Secondary (excluding anaerobic lagoons)
- Secondary (Anaerobic lagoons)
- Tertiary

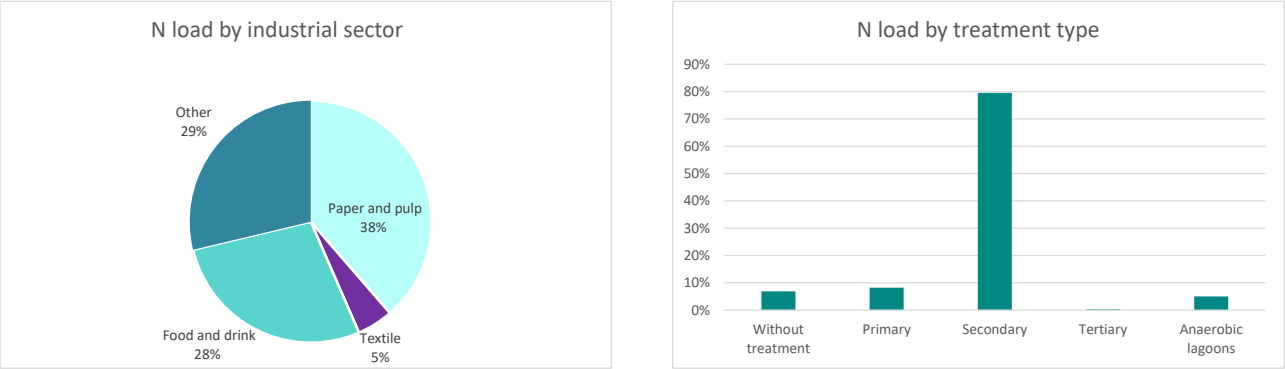



***Figure 7-29: Nitrogen load aggregated by industrial sector and treatment type in 2018***

The evolution of organic load since 1990 was estimated diversely according to the information available for the different industrial sectors.

For the pulp and paper industry, the total annual nitrogen load discharged for the period 1990-2018 was based on the evolution of the organic load discharged by unit of pulp and paper produced (kg CQO/t pulp and paper) in the same period, using the data collected from the paper and pulp plants.

The evolution of the annual organic wastewater load for the other sectors was based on the estimated annual organic loads, as estimated in the previous submissions[5]. The previous methodology was based on statistics of industrial activity from the National Statistical Office (in particular, industrial production data) for a range

[5] Portugal. 2023 National Inventory Report (NIR) (https://unfccc-int.translate.goog/documents/627602?_x_tr_sl=en&_x_tr_tl=pt&_x_tr_hl=pt-PT&_x_tr_pto=sc )

of relevant economic sectors, and a set of pollution coefficients[6] (expressed in an amount of COD generated per unit of production - kg COD per ton of product produced), in relation to the total organic load for 2018.

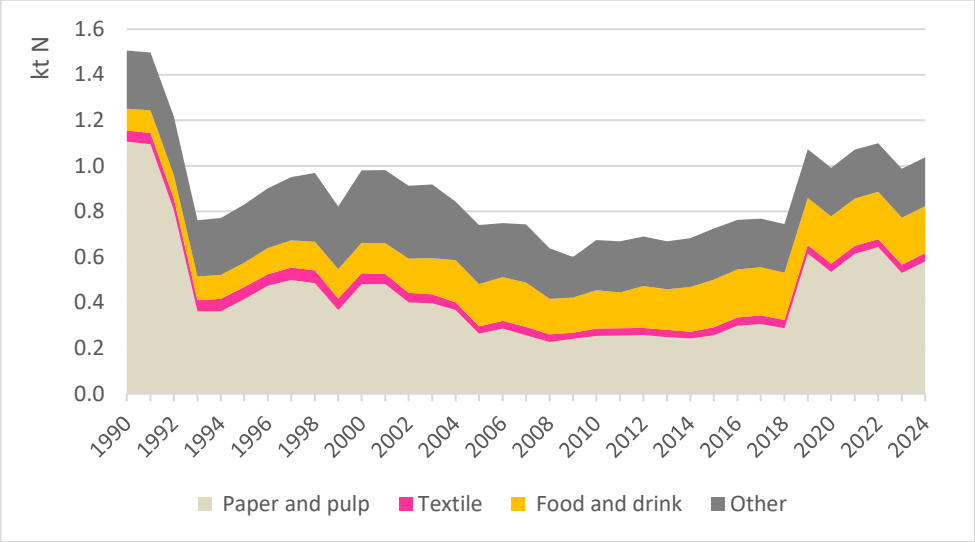



***Figure 7-30: Industrial Wastewater nitrogen load from major groups of industrial activity***

Please refer to Table 7-30: Percentage of industrial wastewater by handling system.

The Nitrogen removal fraction per treatment/handling type ($N_{REM}$) and EF used in the different pathways are presented in 7.5.2.4.

Based on the information collected concerning the pulp and paper sector as mentioned in section 7.5.2.2.2, which represents most of the sludge generated, a value of 20% was considered for the fraction of industrial sludge composted.

### 7.5.3 Uncertainty assessment

For urban wastewater treatment the activity data, expressed in organic load to wastewater systems, was estimated from population, $BOD_5$ per capita production, and the degree of utilisation of each type of treatment. The error associated with these variables needs to be incorporated in the determination of the final uncertainty value. Assuming the default uncertainties proposed in 2006 IPCC, 5% for human population and 30% for $BOD_5$ per capita, and 50% for the degree of utilisation of each type of treatment, a final 59% error was set for this activity.

Concerning the methane emission factor, the uncertainty of this parameter includes an error for the Maximum Methane Producing Capacity (Bo), for which the GPG default of 30% was used, and the error determination in the fraction of water treated anaerobically (MCF). For urban water the uncertainty in this last fraction was estimated to vary from 47% in 1990 to as 26% in 2021, considering the percentage of individual septic tanks and the lack of knowledge of in which conditions they operate.

As regards domestic wastewater handling N2O emissions, the activity data (N load in effluent) was estimated from the population, the protein consumption per capita, the fraction of N in protein, the factor to adjust for non-consumed protein and the quantity of N in sludge subtracted to the effluent. The error associated with these variables were set from the default range values or uncertainties proposed in 2006 IPCC: 5% for human

[6] The pollution coefficients that were used result from a study specifically done for the estimate of the loads from the Portuguese Industry (Cartaxo et al, 1985).

population, 10% for the protein intake, 6.3% for the fraction of N in protein, 9% for the factor to adjust for non-consumed protein, and 20% for the factor related to industrial and commercial co-discharged protein into the sewer system. The quantity of N in sludge subtracted to the effluent is considered to be very uncertain due to scarce data on sludge amounts produced and the respective content in N, and a value of 100% was considered.

Equation 3.2 was applied to estimate the overall error for the activity data which is estimated as 25% in 2021. The uncertainty considered for the emission factor (kg N2O-N/kg-N) was set from the default range values proposed in 2006 IPCC and is approx. 2500%.

In the case of industrial waste-water systems the available information is much scarcer. The uncertainty value was estimated for each industrial sector separately for the COD load and the uncertainty in the production activity data:

- the uncertainty in load was estimated for each available coefficient of pollution from the range of COD concentration values presented in the original documentation document (Cartaxo et al, 1985). Uncertainty values range from 11%, for the dairy industry, up to 100%;
- the uncertainty of production data is 20% if data was obtained from National Statistics and 50% if was interpolated.

The uncertainty considering all industrial activities, according to their production, varied between 21 and 33%, according to years.

For industrial wastewater treatment, also the uncertainty in the methane emission factor also changes with time and considers:

- the uncertainty in Bo, the maximum methane generation potential, is 30% according to the GP;
- the error of the allocation of each specific treatment system, established from the % of unknown situations, adds 20% to the error for the known cases;
- the uncertainty in MCF for each specific treatment system, set from the GP, and varying from 10% for Secondary Treatment, well managed, to 50% for the no treatment situation.

Finally the error was determined for each industry and propagated accordingly. The final uncertainty for the methane emission factor varies in time from 16% to 37%.

### 7.5.4 Category specific QA/QC and verification

#### 7.5.4.1 General QC 1

General QC 1 procedures were applied following the guidance from the IPCC GPG (IPCC 2000, Table 8.1) in particular:

- Checks on data units, calculation procedures, and data field relationships;
- Check for consistency in data between source categories;
- Verification of uncertainties estimates;
- Undertake completeness checks;
- Comparison of estimates to previous estimates.

### 7.5.5 Category specific recalculations

Changes in this submission refer to:

- Domestic Wastewater Handling (5.D.1): N2O emissions
  - revision issued from 2025 ESR Review recommendation for N2O affecting all the years: Fnon-con value changed from 1.09 to Fnon-con=1, to accommodate the fact that in Portugal sinks are generally not equipped with "food waste disposal systems";
  - protein intake: annual per capita protein intake time series has been revised based on the Portuguese Food Balance (INE).

### 7.5.6 Category specific planned improvements

The accounting of industrial WWT relies on loads, after treatment, discharged by industrial units into the natural environment. This information refers to a database for 2018 for each industrial WWTP which aggregates data from APA licensing and monitoring activities. In the absence of historical data series, which would guarantee the coherence of the National Inventory since 1990, estimations with some uncertainties have been made. Efforts should be made to improve the accuracy of the approach followed.

A revision of the uncertainty analysis of this sector should be done in accordance with the methodological revisions made in the 2024 submission.

## 7.6 Biogas burning without energy recovery (CRF 5.E)

### 7.6.1 Category description

The capture and burning of landfill gas and biogas (e.g. from sewage sludge) is used for energy purposes or flaring (without energy recovery). The resulting $CO_2$ from the combustion of landfill gas and biogas of biogenic origin, only needs to be reported as a memo item when there is energy recovery. $CH_4$ and $N_2O$ emissions from the combustion of landfill gas and biogas captured need to be estimated and should be included in the energy sector when there is energy recovery, or in the waste sector when is flared.

For practical reasons all information related to the estimates of emissions from biogas combustion (with and without energy recovery) is presented here. However, the emissions related to energy recovery situations are accounted in sector 1A1a, and the emissions resulting from flaring are considered in category 5E.

The inventory considers landfill gas recovery values since 2000. However, in particular flaring (without energy recovery) started before. In order to account with this practice, a questionnaire was launched by APA in 2012 with the aim of collecting the total amount of landfill gas combusted either in flaring (without energy recovery) or used for energy purposes. This inquiry was focused on the more recent years (since 2005) in order not to overload the waste systems managers.

This questionnaire considered all Municipal SWDS, which totalled in 2012, 34 landfill sites in exploration (receiving waste) in Mainland, plus 3 closed landfill sites which do not receive waste anymore (but burn biogas).

Since 2015, data on biogas is collected from management systems in a specific form included in MRRU (Municipal Waste Registration Form), at APA, I.P.

At present there are 32 MSW landfills in exploration in Mainland, 26 of which use biogas for energy recover. In the two Autonomous Regions there are 6 landfills in exploration (4 in the Azores, and 2 in Madeira (1 of them for emergency situations)).

CH4 recovered in flares and valorised for energy purposes is estimated on the basis of average biogas flows (continuous measurement) and the number of hours of burning. The concentration of CH4 in biogas used in the estimates of the CH4 quantities refer to monitoring plans (quarterly measurements) measuring the biogas quality (generally CH4, CO2, O2, N2, H2S) at the entrance of the flares or the biogas energy recovery system.

### 7.6.2 Methodological issues

#### 7.6.2.1 Methods

Emissions from the combustion of landfill gas and biogas with and without energy recovery have been estimated using emission factors based on the energy of the biogas consumed (combusted).

***Table 7-37: Activity data, emission factors and related emissions of biogas combusted***

| Quantities of landfill gas and biogas combusted | | | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Electrical production a) | GJ | 38,031 | 28,056 | 30,216 | 24,647 | 146,555 | 342,822 | 317,318 | 536,868 | 787,149 | 968,432 | 1,261,021 | 1,668,286 | |
| | Flaring b) | GJ | - | - | - | - | - | 266,085 | 440,544 | 420,404 | 416,178 | 356,085 | 287,131 | 60,069 | |
| **Quantities of landfill gas and biogas combusted** | | | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2023** | **2024** |
| | Electrical production a) | GJ | 2,051,425 | 2,335,114 | 2,575,738 | 2,984,082 | 2,621,564 | 2,741,127 | 2,598,224 | 2,525,505 | 2,581,348 | 2,716,054 | 2,614,589 | 2,553,019 | 2,529,430 |
| | Flaring b) | GJ | *58,012* | *55,954* | *53,896* | 30,104 | 71,515 | 15,139 | 22,987 | 37,915 | 56,837 | 2,143 | 33,388 | 33,006 | 58,647 |

| Emission factors | | | |
|---|---|---|---|
| | CO2 | kg/GJ | 54.6 |
| | CH4 | g/GJ | 1 |
| | N2O | g/GJ | 0.1 |
| | NOx | g/GJ | 74 |
| | NMVOC | g/GJ | 23 |
| | CO | g/GJ | 29 |
| | SOx | g/GJ | 0.67 |

| Emissions with energy recovery (CRF 1A1a) | | | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CO2 c) | kton | 2.1 | 1.5 | 1.6 | 1.3 | 8.0 | 18.7 | 17.3 | 29.3 | 43.0 | 52.9 | 68.9 | 91.1 | |
| | CH4 | ton | 0.038 | 0.028 | 0.030 | 0.025 | 0.147 | 0.343 | 0.295 | 0.582 | 0.826 | 0.880 | 1.146 | 1.733 | |
| | N2O | ton | 0.004 | 0.003 | 0.003 | 0.002 | 0.015 | 0.034 | 0.030 | 0.058 | 0.083 | 0.088 | 0.115 | 0.173 | |
| **Emissions with energy recovery (CRF 1A1a)** | | | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2023** | **2024** |
| | CO2 c) | kton | *91.1* | *112.0* | *127.5* | 140.6 | 162.9 | 143.1 | 149.7 | 141.9 | 137.9 | 140.9 | 148.3 | 142.8 | 139.4 |
| | CH4 | ton | *1.733* | *2.216* | *2.585* | 2.923 | 2.954 | 2.815 | 3.058 | 2.938 | 2.875 | 2.956 | 3.137 | 2.975 | 2.940 |
| | N2O | ton | *0.173* | *0.222* | *0.259* | 0.292 | 0.295 | 0.281 | 0.306 | 0.294 | 0.288 | 0.296 | 0.314 | 0.298 | 0.294 |

| Emissions without energy recovery (CRF 5E) | | | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CO2 d) | kton | - | - | - | - | - | - | - | - | - | - | - | - | |
| | CH4 | ton | - | - | - | - | - | 0.266 | 0.441 | 0.420 | 0.416 | 0.356 | 0.287 | 0.060 | |
| | N2O | ton | - | - | - | - | - | 0.027 | 0.044 | 0.042 | 0.042 | 0.036 | 0.029 | 0.006 | |
| **Emissions without energy recovery (CRF 5E)** | | | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2023** | **2024** |
| | CO2 d) | kton | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | CH4 | ton | *0.058* | *0.056* | *0.054* | 0.030 | 0.072 | 0.015 | 0.023 | 0.038 | 0.057 | 0.002 | 0.033 | 0.033 | 0.059 |
| | N2O | ton | *0.006* | *0.006* | *0.005* | 0.003 | 0.007 | 0.002 | 0.002 | 0.004 | 0.006 | 0.0002 | 0.0033 | 0.0033 | 0.0059 |

Notes:
a) Includes landfill biogas and other (e.g. sludge treatment plants) with energy recovery. Data refer mostly to DGEG data.
b) Data refer to landfill gas flared without energy recovery. APA data.
c) Memorandum item.
d) According to the guidelines, CO2 emissions from source categories "Solid waste disposal on land and Waste incineration" should only be included if they derive from non-biological or inorganic waste sources.

### 7.6.3 Uncertainty Assessment

CH4 and N2O emissions from biogas flaring reported in category 5E refer to data collected from a direct enquiry to landfill management systems and refer to measured data. The uncertainty value for quantities of biogas flared was set at 5 %, which is in accordance to the values considered for LPS data in category 1A1a (biogas burning with energy recovery).

The uncertainty associated with CH4 and N2O emission factors was set to 150 % and 1000 %, respectively.

### 7.6.4 Category specific QA/QC and verification

General CQ1 procedures were applied.

### 7.6.5 Category specific recalculations

No recalculations have been made since last submission.

### 7.6.6 Category specific planned improvements

Not foreseen.

# 8 Other (CRT 6)

Portugal does not report any emissions under Other sector.

# 9 Indirect $CO_2$ and Nitrous Oxide emissions

*Updated: March 2026*

Indirect $CO_2$ emissions represented 264 kt in 2024 (considering also solvent use and road paving emissions) and 0.5% of total emissions, decreasing about 10% from year 1990. The two most relevant sectors are Industrial Processes (CRT 2) and Energy (CRT 1), with respectively, 68% and 32% of indirect $CO_2$ emissions.

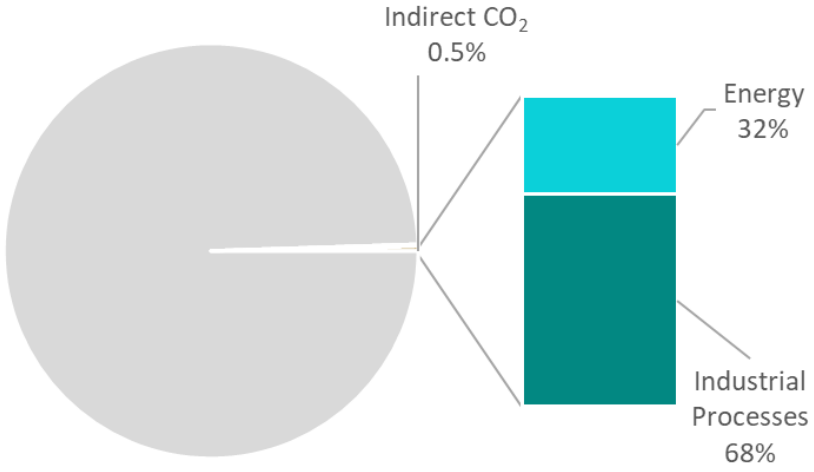



***Figure 9-1: Indirect $CO_2$ emissions in 2024***

In 2024, the most relevant category to indirect $CO_2$ emissions remained 2D3a, representing 45% of the total (from which 99% NMVOC and 1% CO), followed by 1B2a (18% of indirect $CO_2$ emissions, from which 73% CO and 27% NMVOC), 1A2f (12% of indirect $CO_2$ emissions, from which 60% NMVOC; 32% CO; 8% $CH_4$), 2H2 (11% of indirect $CO_2$ emissions, from which 100% NMVOC) and 2B8 (8% of indirect $CO_2$ emissions, from which 87% NMVOC and 13% CO).

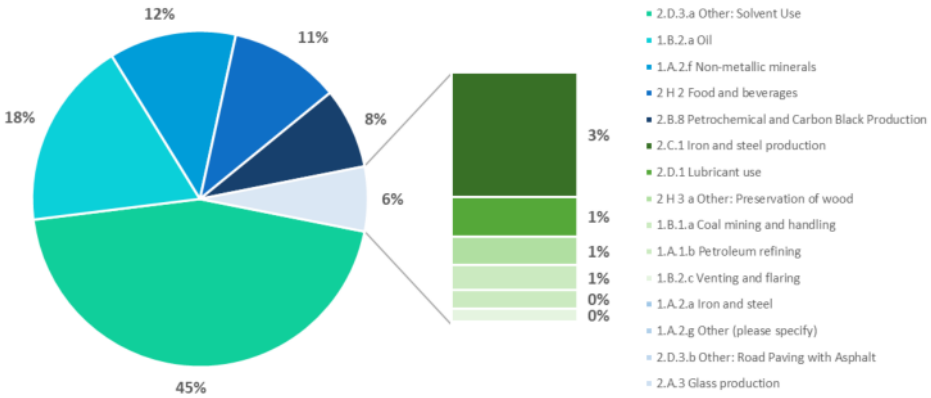



***Figure 9-2: Indirect $CO_2$ emissions by CRT category in 2024***

In order to ensure consistency with Portugal's reporting under the first commitment period of the Kyoto Protocol, indirect $CO_2$ emissions from solvent use and road paving with asphalt are reported in category 2D3a and 2D3b of the CRT tables. For other sources of indirect $CO_2$, the emissions are reported in CRT Table 6.

In the calculation of indirect $CO_2$ emissions, only fossil carbon has been considered.

Indirect $CO_2$ emissions due to atmospheric oxidation of NMVOC, $CH_4$ and CO emissions are calculated using the equation below:

***Equation 9-1: Indirect $CO_2$ emissions***

$$Emissions_{CO_2} = \left[Emissions_{NMVOC} \times 0.60 \times \frac{44}{12}\right] + \left[Emissions_{CH_4} \times \frac{44}{16}\right] + \left[Emissions_{CO} \times \frac{44}{28}\right]$$

According to the information provided by box 7.2 of Volume 1: General Guidance and Reporting of 2006 IPCC Guidelines, the carbon fraction of NMVOC is assumed to be 60% by mass.

$CH_4$ estimates, methodologies and emission factors are presented in this document.

NMVOC and CO emissions are reported under the United Nations Economic Commission for Europe's Convention on Long-Range Transboundary Air Pollution and the European Union National Emissions Ceilings Directive. Methodologies and emission factors used in the estimates are presented in the Portuguese Informative Inventory Report.

The following table indicates which CRT categories contribute to $CO_2$ indirect emissions and where these emissions are reported (CRT Table 6 or in the sectorial tables).

***Table 9-1: CRT categories and description of $CO_2$ Indirect emissions***

| CRT category | Description | Indirect $CO_2$ | NMVOC | $CH_4$ | CO | Reported in: |
|---|---|---|---|---|---|---|
| 1.A.1.b | Petroleum Refining | √ | √ | √ | √ | Table 6 |
| 1.A.1.c.i | Manufacture of Solid Fuels | √ | √ | √ | √ | Table 6 |
| 1.A.2.a | Iron and Steel | √ | √ | √ | √ | Table 6 |
| 1.A.2.f | Non-metallic Minerals | √ | √ | √ | √ | Table 6 |
| 1.A.2.g | Iron and Steel | √ | √ | √ | √ | Table 6 |
| 1.B.1.a.1.i | Underground Mines – Mining Activities | √ | √ | √ | | Table 6 |
| 1.B.1.a.1.ii | Underground Mines – Post-Mining Activities | √ | | √ | | Table 6 |
| 1.B.1.a.1.iii | Abandoned Underground Mines | √ | | √ | | Table 6 |
| 1.B.1.b | Solid Fuel Transformation | √ | √ | √ | √ | Table 6 |
| 1.B.2.a.3 | Fugitive Emissions – Oil – Transport | √ | √ | √ | | Table 6 |
| 1.B.2.a.4 | Fugitive Emissions – Oil – Refining/Storage | √ | √ | √ | √ | Table 6 |
| 1.B.2.a.5 | Fugitive Emissions – Oil – Distribution of Oil Products | √ | √ | | | Table 6 |
| 1.B.2.c.2.i | Flaring - Oil | √ | √ | √ | √ | Table 6 |
| 2.B.1 | Ammonia | √ | | | √ | Table 6 |
| 2.B.6 | Titanium Dioxide | √ | | | √ | Table 6 |
| 2.B.8.b | Ethylene | √ | √ | √ | | Table 6 |
| 2.B.8.f | Carbon Black | √ | √ | | √ | Table 6 |
| 2.B.8.g.i | Low-Density Polyethylene (PEBD) | √ | √ | | | Table 6 |
| 2.B.8.g.ii | High-Density Polyethylene (PEAD) | √ | √ | | | Table 6 |
| 2.B.8.g.iii | Polypropylene | √ | √ | | | Table 6 |
| 2.B.8.g.iv | Polystyrene | √ | √ | | | Table 6 |
| 2.B.8.g.v | Formaldehyde | √ | √ | | √ | Table 6 |
| 2.B.8.g.vi | Phthalic Anhydride | √ | √ | | √ | Table 6 |
| **2.B.8.g.vii** | **Polyamide Fiber** | √ | √ | | | CRT Table2(I).A-Hs1 |
| **2.B.8.g.viii** | **Polyester Fiber** | √ | √ | | | CRT Table2(I).A-Hs1 |
| **2.B.8.g.ix** | **Polystyrene Fiber** | √ | √ | | | CRT Table2(I).A-Hs1 |
| **2.B.8.g.x** | **Polypropylene Fiber** | √ | √ | | | CRT Table2(I).A-Hs1 |
| **2.B.8.g.xi** | **Polyvinylchloride Fiber** | √ | √ | | | CRT Table2(I).A-Hs1 |
| **2.B.8.g.xii** | **Acrylic Fiber** | √ | √ | | | CRT Table2(I).A-Hs1 |
| **2.B.8.g.xiii** | **Acrylonitrile Fiber** | √ | √ | | | CRT Table2(I).A-Hs1 |
| **2.B.8.g.xiv** | **Polyvinylchloride** | √ | √ | | | CRT Table2(I).A-Hs1 |
| **2.B.8.g.xv** | **Polyurethane Foam** | √ | √ | | | CRT Table2(I).A-Hs1 |
| 2.C.1.a | Steel | √ | √ | √ | √ | Table 6 |
| 2.C.1.b | Pig Iron | √ | | | √ | Table 6 |
| 2.C.1.d | Sinter | √ | √ | √ | √ | Table 6 |
| **2.D.3.a** | **Solvent Use** | **√** | **√** | | **√** | CRT Table2(I).A-Hs2 |
| **2.D.3.b** | **Road Paving with Asphalt and Alphalt Blowing in Refineries** | **√** | **√** | **√** | | CRT Table2(I).A-Hs2 |
| 2.H.2 | Food and Beverages | √ | √ | | | Table 6 |
| 2.H.3.a | Chipboard Production | √ | √ | | | Table 6 |

# 10 Recalculations and Improvements

## Table of Contents

10 Recalculations and Improvements ..... 1
10.1 Overview of the review process ..... 2
10.2 Overview recalculations ..... 12
10.2.1 Recalculations Energy sector (CRT 1) ..... 13
10.2.2 Recalculations Industrial Processes sector (CRT 2) ..... 13
10.2.3 Recalculations Agriculture sector (CRT 3) ..... 14
10.2.4 Recalculations LULUCF sector (CRT 4) ..... 15
10.2.5 Recalculations Waste sector (CRT 5) ..... 15

## List of Tables

Table 10-1: Reporting on implementation of UNFCCC recommendations and adjustments ..... 3
Table 10-2: Synthesis of the recalculations made for the 2025 inventory submission by CRT category and their implications to the emissions level in 1990 and 2023 ..... 12

# 10 Recalculations and Improvements

*Updated: March 2026*

This section presents an overview of responses to the reviews and information on recalculations made in this submission. Recalculations made result mostly from recommendations issued from the last EU and UNFCCC reviews reports and updates of activity data.

## 10.1 Overview of the review process

Table 10-1 presents the status of implementation of recommendations included in the UNFCCC 2022 report on the individual review of the greenhouse gas inventory.

***Table 10-1: Reporting on implementation of UNFCCC recommendations and adjustments***

| CRF category / issue | Review recommendation | Review report / paragraph | MS response / status of implementation | Reason for non-implementation | Chapter/section in the NIR |
|---|---|---|---|---|---|
| Uncertainty analysis (G.13, 2020) Transparency | Report thorough work to quantify the assumptions used when defining the uncertainty of parameters for the LULUCF sector, including the key assumptions, choice of methods and detailed results, in accordance with the 2006 IPCC Guidelines (vol. 1, chap. 3.5). | G.5 | To be developped in the future. | - | - |
| Inventory planning | In the previous annual review report, the ERT noted that the Party reported in its NIR (p.1-24) that future inventory Not an issue/problem improvements are defined for each sector by the relevant inventory compiler and collated in a methodological development plan, which is updated and agreed every year. However, the NIR does not include the likely implementation dates of those improvement activities or the expected scope of the work involved. In table 10-1 of its NIR, Portugal stated that it is addressing this issue. During the review, Portugal presented several examples of improvements regarding the expected scope of the work involved. It also noted that the likely implementation dates for improvements are often difficult to establish, in particular where improvement activities depend on data or input from external entities. To enhance the transparency of the list of Portugal's planned inventory improvement activities, the ERT encourages the Party to provide in its NIR more detail on the processes involved in the methodological development plan, including the likely implementation dates of the improvement activities and the expected scope of the work involved. | G.7 | Continuous improvement. | Portugal has been trying to progressively be more transparent and specific concerning the information given in NIR sub-chapters "further improvements". However, we acknowledge some difficulties in providing details on the planning of methodological developments, especially as regards likely implementation dates of the improvement activities, particularly when improvement activities depend on data and inputs from external entities. Furthermore, the increasing external demands often oblige, a small inventory team like the Portuguese, to redefine priorities when issues and activities not foreseen in our working plan occur. Nevertheless, we´ll try to continue the effort to be more detailed on this subject in the following NIRs, in particular as regards the processes involved in the methodological development plan. | - |

| CRF category / issue | Review recommendation | Review report / paragraph | MS response / status of implementation | Reason for non-implementation | Chapter/section in the NIR |
|---|---|---|---|---|---|
| Fuel combustion – reference approach – all fuels – CO2 (E.1, 2020) (E.1, 2018) (E.1, 2016) (E.1, 2015) (25, 2014) Convention reporting adherence | Improve the consistency between the energy balance and the data available for large point sources in order to reduce the differences between the reference and sectoral approaches. | E.1 | Continuous improvement. | Every year the inventory team tries to improve consistency between energy balance data and large point sources, but some issues remain to be resolved, and new issues arise. In the last submissions an effort was made to substantially reduce the differences, which are for several years of the time series below 2%. | 3.12 Reference Approach |
| Feedstocks, reductants and other non-energy use of fuels – gaseous, liquid and solid fuels – CO2 (E.4, 2020) (E.5, 2018) (E.22, 2016) (E.22, 2015) Convention reporting adherence | Carry out QC checks for non-energy use of fuels, as prescribed in the 2006 IPCC Guidelines (vol. 3, chap. 1.4). | E.2 | Not implemented. | This recommendation was not considered a priority in the annual tasks to improve the reporting of the GHG inventory. And for that reason, the information requested in the NIR was not included. To be considered in a future submission. | |
| 1.A.1 Energy industries – all fuels – CO2 (E.8, 2020) (E.10, 2018) (E.26, 2016) (E.26, 2015) Accuracy | Develop a country-specific CO2 EF for natural gas and provide further information on the reasons for not deriving country-specific CO2 EFs for other fuels (hard coal and fuel oil) that are identified as key. | E.5 | Addressing. | The national specific emission factor for Natural Gas was estimated. In the case of Fuel Oil it will not be possible to make such an estimate because there is no specific national information for this fuel. In the case of the Hard coal, practically all coal-burning facilities monitor the carbon content of | |

| CRF category / issue | Review recommendation | Review report / paragraph | MS response / status of implementation | Reason for non-implementation | Chapter/section in the NIR |
|---|---|---|---|---|---|
| | | | | burned fuel, so most emissions are estimated using TIER 3 methods using facility-specific EF. | |
| 1.A.2 Manufacturing industries and construction – biomass – CO2, CH4 and N2O (E.30, 2020) Consistency | Analyse the differences between the previous methodology and the new methodology introduced in 2011 to enhance consistency and recalculate biomass consumption for before 2011, if necessary. | E.6 | Not implemented. | Revisions to the series of biomass fuel consumption in category 1.A.2 (manufacturing industries and construction), will have to be coordinated with and at the same time with energy statistics and industrial operator reporting entities. Although foreseen in the methodological developing plan of the inventory, it was not possible to implement this recommendation until now due to the implementation of several other inventory improvements and also due to limited resources related not only to the inventory but also to other entities. | |
| 1.A.2.f Non-metallic minerals – all fuels – CO2, CH4 and N2O (E.16, 2020) (E.25, 2018) (E.37, 2016) (E.37, 2015) Transparency | Include explanations for the introduction of industrial waste and the rate of biogenic and fossil fuel use in the NIR. | E.9 | Not implemented. | Brief explanations regarding the industrial waste considered were included in the NIR. However, the framework for the introduction of industrial waste in the sector is missing, as well as the rates of fossil and biogenic fuels used, information that we intend to include in a future submission. | 3.4.2.3.6 Non-Metallic Minerals |

| CRF category / issue | Review recommendation | Review report / paragraph | MS response / status of implementation | Reason for non-implementation | Chapter/section in the NIR |
|---|---|---|---|---|---|
| 1.A.3.b Road transportation – liquid fuels – CO2 (E.17, 2020) (E.27, 2018) (E.16, 2016) (E.16, 2015) (44, 2014) Accuracy | Continue with the efforts to develop country-specific CO2 EFs for gasoline and diesel oil, and investigate the possibility of obtaining a country-specific CO2 EF for gasoline and diesel oil reported under the EU ETS. | E.12 | Addressing. | Although it has not yet been possible to develop National CO2 EFs, contacts have been initiated with national Refineries with the aim of obtaining the carbon content of fuels. We are also looking into the possibility to analyze the carbon content in the fuel samples collected under the Fuel Quality Directive. | 3.5.2 Road Transportation (CRF 1.A.3.b)/ 3.5.2.8 Further Improvements |
| 1.A.3.e.ii Other (other transportation) – gaseous, liquid and solid fuels – CO2, CH4 and N2O (E.21, 2020) (E.31, 2018) (E.21, 2016) (E.21, 2015) (49, 2014) Comparability | Report the AD and emissions from ground activities at airports under the other transportation category, explain what type of consumption is included under the item “Serviços” in the energy balance and report the fuel consumption and the associated emission estimates under the appropriate category. | E.16 | Addressing. | It is not possible to separate the fuel consumption related to ground activities in airports | 3.5.5 Other Mobile Sources (CRF 1.A.3.e) |
| 1.B.2.d Other (oil, natural gas and other emissions from energy production) – CO2 (E.27, 2020) (E.38, 2018) (E.46, 2016) (E.46, 2015) Transparency | Provide detailed information on the flows and operating regimes for geothermal energy production, and on how the CO2 EFs are derived. | E.22 | Not implemented. | This recommendation was not considered a priority in the annual tasks to improve the reporting of the GHG inventory. And for that reason, the information requested in the NIR was not included. To consider in a future submission. | |
| 2. General (IPPU) – (I.2, 2020) (I.2, 2018) (I.2, 2016) (I.2, 2015) (54, | Include information in the NIR on specific QA/QC activities for industrial processes, for example for limestone and dolomite use and for glass production (reported under other mineral products), for which this information is not currently included. | I.2 | Addressing. This issue has already been addressed for some categories (Cement, Iron and Steel, Lime in Dedicated Plants, Ethylene | This issue has not yet been fully concluded, as it is an on-going and time-consuming process. | Section 4.2.2.6 Section 4.2.3.6 Section 4.3.2.6 Section 4.3.2.4 |

| CRF category / issue | Review recommendation | Review report / paragraph | MS response / status of implementation | Reason for non-implementation | Chapter/section in the NIR |
|---|---|---|---|---|---|
| 2014) (39, 2013) Transparency | | | production sectors and Ammonia Production). | | Section 4.3.10.6<br>Section 4.4.2.6 |
| 2. General (IPPU) – (I.4, 2020) (I.37, 2018) Transparency | Include explanations of the checks performed to ensure time-series consistency for cement production, lime production from dedicated plants, other process uses of carbonates and lead production, where two data sources are used throughout the time series. These explanations can be included in the category-specific QC section. | I.3 | Addressing.<br>Portugal improved time-series consistency for cement, lime and glass and Rockwool production. | This recommendation was not considered a priority in the annual tasks to improve the reporting of the GHG inventory. And for that reason, the information requested in the NIR was not included. To consider in a future submission. | Section 4.2.2.2<br>Section 4.2.3.4<br>Section 4.2.7.4<br>Section 4.2.13.4 |
| 2.A.2 Lime production – CO2 (I.10, 2020) (I.38, 2018) Transparency | Check whether there are data transcription errors and confirm the correctness of the data with the facilities when large inter-annual changes in the IEFs are observed, in particular for 2009–2015. | I.6 | Addressing.<br>The Party will check the CO2 IEF variability and contact the other lime production facilities in order to report information in the NIR. | Improving time-series consistency is an on going and time-consuming process and it has not been concluded yet. | Section 4.2.3.3 |
| 2.A.4 Other process uses of carbonates – CO2 (I.14, 2020) (I.40, 2018) Accuracy | Work with the data provider (the EU ETS) to improve the quality of raw material data (e.g. by contacting facilities to check for reporting errors) and use raw material data for the years for which data from the ceramics industry were collected under the EU ETS as the AD for backcasting, instead of using estimated fuel consumption data collected directly from facilities. | I.11 | Not implemented. | Concerning ceramics sector, it was only since 2012 that this activity was included in EU-ETS system. Currently, there are still a significant number of ceramics facilities that are not included in EU-ETS (circa 30%). We have contacted ceramics sectoral associations, which were not able to provide us with national production data. | |
| 2.D.3 Other (non-energy products from fuels and solvent use) – CO2 (I.35, 2020) Comparability | Report all indirect CO2 emissions from solvent use as indirect CO2 emissions in CRF table 6 only, without reporting those emissions in CRF tables 2(I)s2 and 2(I).A-Hs2. In addition, specify and explain in the NIR the activities leading to the indirect CO2 emissions reported in CRF table 6. | I.16 | Not implemented. | The report of indirect emissions was agreed several years ago, among EU countries with the aim of ensure consistency between KP commitment periods(CP). When indirect CO2 emissions are reported in table 6, they are separated from the national total and appear in the new lines for national total with and without indirect emissions. But if indirect CO2 emissions are reported in table 2.D.3, they are part of the national total in the summary tables. Countries, like Portugal, that reported indirect CO2 emissions in inventory submissions before 2015 (CP 1) in | Section 4.2.8.1<br>Section 4.3.1<br>Section 4.2.3.1<br>Section 4.3.7.1<br>Section 4.3.10.1<br>Section 4.3.11.1<br>Section 4.3.14.1<br>Section 4.3.15<br>Section 4.3.19<br>Section 4.4.2.1<br>Section 4.5.1<br>Section 4.5.4 |

| CRF category / issue | Review recommendation | Review report / paragraph | MS response / status of implementation | Reason for non-implementation | Chapter/section in the NIR |
|---|---|---|---|---|---|
| | | | | previous CRF table 3 (Sectoral report for solvents and other products use) should continue reporting these emissions. For this reason it was recommended and agreed to report these indirect CO2 emissions in CRF table 2(I) under "2D Non-energy products from fuels and solvent use" which includes a predefined drop down list in the CRF reporter under 2D3 Other for "solvent use" and for "asphalt roofing" and "road paving with asphalt". The rationale was then to ensure the highest consistency with 2006 IPCC Guidelines and with the previous inventory submissions. We understand that this reporting may not be totally in line with the 2006 IPCC Guidelines. However, in order to comply with such Guidelines, there should be EU consensus and coherence of reporting among all the Member States. If Portugal were to comply with the 2006 IPCC Guidelines, it would not be complying with other Member States reporting on this matter. Nevertheless, the inventory team has made an effort to improve the transparency of the reporting of the indirect emissions by further clarifying in the appropriate sections of the 2022 March NIR submission. We have also attached in ANNEX J of the 15th March NIR submission the paper "WG1_190216_indirect emissions.docx" which includes further explanation to the approaches taken by Portugal and all other EU MS. | Section 4.5.5.1<br>Section 4.9.1<br>Section 4.9.3<br>Section 4.9.4<br>Section 4.9.5<br>ANNEX I |
| 2.B.1 Ammonia production – CO2 | The Party reported in its NIR (pp.4-56–4-60) that category 2.B.1 (ammonia production) was estimated using a tier 1 approach and default EFs from the 2006 IPCC Guidelines. Furthermore, in its NIR (section 4.3.2.3, p.4-58), Portugal noted that according to the 2006 IPCC Guidelines, it is good practice to use the average EF for partial oxidation (which is the process used to produce ammonia in Portugal) when no information is available on the fuel type used in the process. Portugal used the total fuel requirement of 42.5 GJ/t NH and CO EF of 3.273 t CO /t NH ) sourced from the 2006 IPCC Guidelines (vol. 3, chap. 3.2.2.2, table 3.1). The use of this EF leads to an overestimation | I.24 | Not implemented. | As good practice, Portugal acknowledges and pursues the application of Tier 2 methodologies or higher for Key Categories as much as technically possible. However, Portugal does not possess specific information from the ammonia production facilities such as fuel requirement and its carbon content and carbon oxidation factor, given the facilities informed that they did not possess such old data due to company restructuration, since they have long since terminated ammonia production. Therefore, no further improvements are planned to update to a higher tier approach as no activity data is available. | Section 4.3.1.1 |

| CRF category / issue | Review recommendation | Review report / paragraph | MS response / status of implementation | Reason for non-implementation | Chapter/section in the NIR |
|---|---|---|---|---|---|
| | of emissions for this category. During the review, the Party clarified that it has contacted the ammonia production facilities and was informed that they do not possess data related to feedstock consumption for 1990–2009, as the facilities have been restructured and the records are no longer available. Category 2.B.1 is a key category and so a tier 2 or 3 method should be used to estimate emissions. The ERT considers that, even though the Party correctly applied a tier 1 approach, owing to the absence of suitable time-series-consistent AD for estimation of emissions using a higher-tier method, it is not in line with the 2006 IPCC Guidelines.<br>The ERT encourages the Party to use a higher-tier approach for estimating emissions for key category 2.B.1 (ammonia production). | | | | |
| 3.B Manure management – CH4, N2O | The Party reported in NIR section 5.3.3 (p.5-36) that, since no new data on the fraction of manure handled in each MMS are available, the 2010 distribution was assumed for 2019. The values for the fraction of manure handled in each MMS in 1990 and in 2020 are presented in NIR table 5-22. The ERT requested the Party to provide values and data sources for the fraction of manure handled in each MMS in 2010 and further clarify data sources of 2020 values in table 5-22. During the review, the Party clarified that the statement in the NIR should have referred to 2020 rather than 2019. Portugal's general agriculture census for 2009 included for the first time a question for farmers related to the type of MMS in use on their farm. On the basis of that information and on the information from the national animal registration database about the number of livestock produced in pasture mode, the trend for 1990–2010 was updated in September 2017 for cattle (dairy cows, non-dairy cows and other cattle), sheep (ewes and other ovines), goats (does and other caprine) and Equidae (horses, mules and asses). The Party indicated that it is in the process of analysing data from the general agriculture census for 2019 in order to update data related to MMS in use on farms in the country and plans to include the results of the analysis in its next annual submission. | A.11 | Addressing. | The Party considers that compiling the results from the 2019 Agriculture Census (RA19), provided by INE (National Statistics Institute), would allow for a more accurate estimation of emissions from 3B Manure Management. However, upon further investigation, the Party identified several outliers in the data provided, which would lead to inconsistencies in the time series of estimates. This problem has already been reported to INE. We intend to work with the data provider in order to make the necessary corrections. | |

| CRF category / issue | Review recommendation | Review report / paragraph | MS response / status of implementation | Reason for non-implementation | Chapter/section in the NIR |
|---|---|---|---|---|---|
| | The Party also stated that it plans to correct the annual percentage share of each MMS for 2011–2020 and is developing a file to be updated annually by the operators with data related to MMS on farms. The ERT noted that application of the outdated shares for MMS for 2013–2019 did not lead to an underestimation for inclusion in a 'Saturday paper'.<br>The ERT recommends that the Party update the fraction of manure handled in each MMS using the results of the 2019 national agricultural census in the next annual submission. | | | | |
| 4. General (LULUCF) – (L.4, 2020) (L.13, 2018) Convention reporting adherence | Carry out a significance analysis to determine which carbon pools and subcategories are significant in each key category on the basis of the 2006 IPCC Guidelines (vol. 1, chap. 4.2, and vol. 4, chap. 1.3), and provide in the NIR detailed information on the results of this analysis. | L.4 | Implemented.<br>The results of this analysis, including the criteria applied and the identification of significant pools and subcategories, are now documented in the NID. | | NID 2026, Section 6.1. Overview of the sector LULUCF |
| 4.A Forest land – CO2 (L.13, 2020) (L.21, 2018) Transparency | Include detailed information on the differences between the NFIs and the land-use map of the Portuguese Directorate-General for Territory for the forest land area, along with a justification for these differences and the reasons that led to the choice of the data source for the forest land area. | L.12 | Implemented.<br>The NID has been updated to include detailed information on the differences between the NFIs and the land-use map with respect to forest land area. | | NID 2026, Section 6.1.1. Representation of Land-Areas and Land-Use Changes |
| 4.A Forest land – CO2 (L.15, 2020) (L.23, 2018) Accuracy | Provide detailed information on the scope and phases of the NFI6 in the NIR, including any updates with regard to the module/phase on the evaluation of SOC. | L.14 | Implemented.<br>The NID was updated to clarify the scope of NFI6 with regard to soil data. Although a soil module, including SOC assessment, was foreseen in the planning of NFI6, it has not been conducted within the period covered by the current submission. Consequently, soil estimates continue to rely on existing datasets consistent with the 2006 IPCC Guidelines. | | NID 2026, Section 6.1.2.3. Soil C Stock Data |

| CRF category / issue | Review recommendation | Review report / paragraph | MS response / status of implementation | Reason for non-implementation | Chapter/section in the NIR |
|---|---|---|---|---|---|
| 4.A.2 Land converted to forest land – CO2 (L.21, 2020) (L.8, 2018) (L.12, 2016) (L.12, 2015) (95, 2014) Accuracy | Develop further the sampling and estimation system and the application of the sampling system when developing carbon stock change estimates for mineral soils. | L.20 | Not implemented. | Further development of the sampling and estimation system for mineral soil carbon stock change estimates was not possible for the present submission. The inclusion of new data from the LUCAS Soil project is being planned. | |
| 4.B.1 Cropland remaining cropland – CO2 (L.23, 2020) (L.27, 2018) Transparency | Do not consider below-ground biomass in annual crops, in line with the IPCC default assumption (2006 IPCC Guidelines, vol. 4, chap. 5, p.5.10). | L.22 | Not implemented. | Below-ground biomass for annual crops is currently included. Revising the treatment of below-ground biomass for annual crops would require a recalculation of the full time series, which could not be undertaken within the timeframe of the present submission. The issue will be considered in future methodological updates. | |

## 10.2 Overview recalculations

The table below presents in a tabular form a synthesis of the main recalculations made in this submission and the implications in 1990 and 2023 emission levels.

***Table 10-2: Synthesis of the recalculations made for the 2025 inventory submission by CRT category and their implications to the emissions level in 1990 and 2023***

| CRF Category | Implication To the CRF category (Gg CO2eq.) | | Implication to the Total Emissions without LULUCF & Indirect $CO_2$ emissions (%) | |
|---|---|---|---|---|
| | in 1990 | in 2023 | in 1990 | in 2023 |
| **Total** | **778.88** | **1,588.53** | **1.32** | **2.99** |
| **1. Energy** | 0.00 | -38.35 | 0.00 | -0.07 |
| A. Fuel combustion activities | 0.00 | -38.08 | 0.00 | -0.07 |
| 1. Energy industries | 0.00 | 15.67 | 0.00 | 0.03 |
| 2. Manufacturing industries and construction | 0.00 | -36.76 | 0.00 | -0.07 |
| 3. Transport | 0.00 | 0.00 | 0.00 | 0.00 |
| 4. Other sectors | 0.00 | -16.99 | 0.00 | -0.03 |
| 5. Other | 0.00 | 0.00 | 0.00 | 0.00 |
| B. Fugitive Emissions from Fuels | 0.00 | -0.27 | 0.00 | 0.00 |
| 1. Solid fuels | 0.00 | 0.00 | 0.00 | 0.00 |
| 2. Oil and natural gas | 0.00 | -0.27 | 0.00 | 0.00 |
| C. CO2 transport and storage | 0.00 | 0.00 | 0.00 | 0.00 |
| **2. Industrial Processes and Product Use** | -20.20 | 35.35 | -0.03 | 0.07 |
| A. Mineral industry | -23.26 | -0.21 | -0.04 | 0.00 |
| B. Chemical industry | 0.12 | -0.18 | 0.00 | 0.00 |
| C. Metal industry | 0.12 | 0.00 | 0.00 | 0.00 |
| D. Non-energy products from fuels and solvent use | 2.81 | -0.22 | 0.00 | 0.00 |
| F. F-gases | 0.00 | 48.71 | 0.00 | 0.09 |
| G. Other product manufacture and use | 0.00 | -12.75 | 0.00 | -0.02 |
| H. Other | 0.01 | 0.00 | 0.00 | 0.00 |
| **3. Agriculture** | 19.83 | 29.93 | 0.03 | 0.06 |
| A. Enteric fermentation | 0.00 | 0.00 | 0.00 | 0.00 |
| B. Manure management | 0.00 | -0.19 | 0.00 | 0.00 |
| C. Rice cultivation | 0.00 | 1.80 | 0.00 | 0.00 |
| D. Agricultural soils | 19.83 | 14.97 | 0.03 | 0.03 |
| E. Prescribed burning of savannahs | 0.00 | 0.00 | 0.00 | 0.00 |
| F. Field burning of agricultural residues | 0.00 | -0.19 | 0.00 | 0.00 |
| G. Liming | 0.00 | 0.00 | 0.00 | 0.00 |
| H. Urea application | 0.00 | 12.47 | 0.00 | 0.02 |
| I. Other carbon-containing fertilizer | 0.00 | 1.07 | 0.00 | 0.00 |
| J. Other | 0.00 | 0.00 | 0.00 | 0.00 |
| **4. Land Use, Land-use Change and Forestry** | 784.32 | 1,607.36 | n.a | n.a |
| A. Forest land | -35.10 | 586.76 | n.a | n.a |
| B. Cropland | -0.26 | -4.22 | n.a | n.a |
| C. Grassland | 26.79 | 1.28 | n.a | n.a |
| D. Wetlands | -0.28 | -1.02 | n.a | n.a |
| E. Settlements | 397.51 | 247.24 | n.a | n.a |
| F. Other land | 0.00 | 0.00 | n.a | n.a |
| G. Harvested wood products | 395.66 | 777.32 | n.a | n.a |
| H. Other | 0.00 | 0.00 | n.a | n.a |
| **5. Waste** | -5.08 | -45.76 | -0.01 | -0.09 |
| A. Solid waste disposal | 0.00 | 0.00 | 0.00 | 0.00 |
| B. Biological treatment of solid waste | 0.00 | 1.71 | 0.00 | 0.00 |
| C. Incineration and open burning of waste | 0.00 | 0.00 | 0.00 | 0.00 |
| D. Waste water treatment and discharge | -5.08 | -47.47 | -0.01 | -0.09 |
| E. Other | 0.00 | 0.00 | 0.00 | 0.00 |

### 10.2.1 Recalculations Energy sector (CRT 1)

Energy Industries (CRT 1.A.1)

Recalculations refer to the revision of natural gas consumption following the publication of an updated Energy Balance for 2023.

Manufacturing Industries (CRT 1.A.2)

The major changes between submissions result from the following actions:

- the revision of fuel consumption data following the publication of an updated National Energy Balance for 2023;
- the revision of 2023 biodiesel incorporation rate;
- the correction of an outlier in ceramics production in 2021-2023 provided by the National Statistics Office.

Civil aviation (CRT 1.A.3.a)

The changes between submissions result from the correction to the 2021 activity data due to a compilation error detected.

Railways (CRT 1.A.3.c)

The changes between submissions result from the update of Energy Balances data provided by DGEG and the incorporation rate of biodiesel, between years 2018 and 2023.

Other Sectors (NFR 1.A.4)

Changes between submissions result from the update of the 2021 and 2022 Energy Balances data provided by DGEG.

### 10.2.2 Recalculations Industrial Processes sector (CRT 2)

The major changes between submissions result from the following actions:

- 2.A.3 (Glass Production): Correction of compilation error in CO2 emissions in 2022-2023, found during QA/QC procedures to Glass production sector;
- 2.A.4.a (Other Uses of Carbonates in Ceramics): Update of 2023 activity data on electricity consumption in ceramics sector, according to 2023 Energy Balance update from data provider DGEG;
- 2.A.4.b (Other Uses of Soda Ash): Update of 2022-2023 activity data as a result of the updates in 2.A.3 e 2.A.4.a (see above);
- 2.A.4.d (Carbonates in Fertilizers): Update of activity data time series according to QA/QC analysis by the data provider (National Statistics Office - INE), following a recommendation from the 2025 ESD Review;
- 2.C.5 (Lead Production): Minor activity data updates in 1990-1991 according to GVA trend on basic metal industries;
- 2.C.7 (Copper Production): Minor activity data updates in 1990-1992 according to GVA trend on basic metal industries;
- 2.D.1 (Lubricants use): Update of 2023 activity data on lubricants consumption according to 2023 Energy Balance update from data provider DGEG;
- 2.D.3.a (Solvent Use): Activity data update for some sub-categories (please consult IIR 2026);
- 2.F.1.a (Commercial Refrigeration): Update of assembly methodology assumptions and activity data for the whole time series, following a recommendation from the 2025 ESD Review;

- 2.F.1.b (Domestic refrigeration): Minor recalculations in R-134a emissions in the period 2002-2023 due to the revision of total annual classic accommodations as main residence in Portugal, during QA/QC procedures to national statistics database;
- 2.F.1.c (Industrial refrigeration): revision and update on the industrial refrigeration equipment assembled in Portugal in 2010-2023 according to GDP trend, following a recommendation from the 2025 ESD Review; following further analysis to the national F-gases reporting tool (FGF) from 2013 onwards, PFC activity data and respective emissions (C2F6 and C3F8) were eliminated from this category;
- 2.F.1.d (Transport refrigeration): 2006-2023 activity data update in assembly according to GDP trend, following a recommendation from the 2025 ESD Review; update on assembly and operation F-gas fluids and share assumptions for the whole time series, based on the national F-gases reporting tool (FGF);
- 2.F.1.e (Mobile air-conditioning): update on assembled vehicles in Portugal in 2023, according to sectoral vehicle association ACAP;
- 2.F.1.f (Stationary Air Conditioning): Activity data update in 2002-2023 regarding fluid stocks in operation phase, following sectoral QA/QC activities;
- Foam Blowing (2F2): Update of assembly methodology assumptions and activity data for open cell foams in 2023, according to the most recent F-gas Regulation;
- Fire Protection (2F3): Update of methodology assumptions and activity data for the whole time series, following a recommendation from the 2025 ESD Review;
- 2.F.4 (Other Aerosols): Minor activity data updates in 2022-2023; following a question from the 2026 ESD review, assembly amounts of HFC-134a in 2.F.4.b were updated from 2018 onwards according to EU F-gas Regulation;
- 2.G.1.a (Electrical Equipment manufacturing): Update of assembly methodology assumptions and activity data for assembly phase for the whole time series following QA/QC procedures to the category and contacts with the data provider;
- 2.G.1.b (Electrical Equipment operation): Update of 2011-2023 activity data following QA/QC procedures to the category and contacts with the data provider;
- 2.G.3.b (N2O from Product Uses): Population data update in 2022-2023 according to INE;
- Several minor sub-categories: Update on surrogate data such as Gross Domestic Product (GDP) and Gross Value Added (GVA) for 1990-1994 and 2022-2023.

### 10.2.3 Recalculations Agriculture sector (CRT 3)

Changes between submissions are due to the:

- Agricultural soils (3D): Update of the "Volatilized N from agricultural inputs of N" and "Leaching and run off" activity data from 2020 onwards; update of 2019 and 2023 CAN activity data;
- Urea application (3H): Update of 2023 Urea activity data;
- Other carbon-containing fertilizers (3I): Update of 2019 and 2023 CAN activity data;
- Rice Cultivation: updated 2023 rice cultivation area (ha).

### 10.2.4 Recalculations LULUCF sector (CRT 4)

The major changes between submissions result from the following actions:

- 4.A Forestland:
  - Harvest data updated using the latest values from the UNECE/FAO Forest Products Production and Trade Database (version updated in November 2024).
  - Harvest data revised to correct data entry errors identified in previous submissions.
- 4.C Grassland:
  - A typographical error in the GL1 fuel load value was corrected.
  - Emission factor of Indirect $N_2O$ emission was updated in accordance with the 2006 IPCC Guidelines.
- 4.E Settlements:
  - A 20% reduction in soil organic carbon was applied for conversions to settlements, following the 2006 IPCC Guidelines.
  - Emission factor of $N_2O$ emissions was corrected to align with the default values provided in the 2006 IPCC Guidelines.
  - The full loss of dead organic matter (DOM) was applied in the year of conversion to settlements, in accordance with the 2006 IPCC Guidelines.
- 4.G Harvested wood products:
  - Data updated with the latest values from UNECE/FAO Database Forest Products Production and Trade (version updated November 2024).
  - Extension of HWP time series to 1900. Revised HWP estimates were developed by extending the time series back to 1900, in accordance with the 2006 IPCC Guidelines, applying the recommended methodology for estimating carbon pool inputs prior to the availability of official production data.
- 4(IV) Biomass Burning:
  - Data for 2021-2024 updated based on ICNF Fire Maps overlapped with COS maps, making data consistent with the rest of the time series.
  - Data for the Autonomous Region of Madeira was revised based on information provided by the Local Government.

### 10.2.5 Recalculations Waste sector (CRT 5)

Changes in this submission refer to:

- Biological treatment of solid waste (5.B): CH4 and N2O emissions:
  Revision of activity data for 2023

- Domestic Wastewater Handling (5.D.1): N2O emissions
  - revision issued from 2025 ESR Review recommendation for N2O affecting all the years: Fnon-con value changed from 1.09 to Fnon-con=1, to accommodate the fact that in Portugal sinks are generally not equipped with "food waste disposal systems";
  - protein intake: annual per capita protein intake time series has been revised based on the Portuguese Food Balance (INE).

# LIST OF ACRONYMS

| Acronym | English | Portuguese |
|---|---|---|
| ABS | Acrylonitrile Butadiene Styrene | Acrilo Nitrilo Butadieno Estireno |
| AC | Air Conditioning | Ar condicionado |
| ACAP | Portuguese Association of Automobile Business | Associação do Comércio Automóvel de Portugal |
| ADP | ADP fertilizers (national fertilizer industry) | ADP fertilizantes |
| AG | Aviation Gasoline | Gasolina de Aviação |
| AN | Ammonium Nitrate | Nitrato de Amónio |
| ANA | Airports and Air Navigation | Aeroportos e Navegação Aérea |
| ANAC | Portuguese Civil Aviation Authority | Autoridade Nacional da Aviação Civil |
| ANAM | Madeira Island Airports and Air Navigation | Aeroportos e Navegação Aérea da Madeira |
| ANECRA | National Association of Companies of Automobile Business and Reparation | Associação Nacional das Empresas do Comércio e da Reparação Automóvel |
| APED | Portuguese Association of Distribution Companies | Associação Portuguesa de Empresas de Distribuição |
| APIRAC | National Association of Industry of Refrigeration and Air Conditioning | Associação Portuguesa dos Industriais da Refrigeração e Ar Condicionado |
| APORBET | Portuguese Association of Bituminous Mixes Producers | Associação Portuguesa de Fabricantes de Misturas Betuminosas |
| AS | Ammonium Sulphate | Sulfato de Amónia |
| ASN | Ammonium Sulphate Nitrate | Sulfonitrato de Amónia |
| BAT | Best Available Technologies | - |
| BOD | Biochemical Oxygen Demand | Carência Bioquímica de Oxigénio |
| BOF | Basic Oxygen Furnace | - |
| CAFE | Clean Air For Europe | - |
| CAN | Calcium Ammonium Nitrate | Nitrato de Cálcio-amónio |
| CCDR-LVT | Lisbon and Tagus Valley Coordination and Regional Development Commission | Comissão de Coordenação e Desenvolvimento Regional de Lisboa e Vale do Tejo |
| CELPA | Portuguese Paper Industry Association | Associação da Indústria Papeleira |
| CFC | Chlorofluorocarbons | Clorofluorcarbonetos |
| CH4 | Methane | Metano |
| CITEPA | Interprofessional Technical Centre of Studies of Atmospheric Pollution | Centre Interprofessionnel Technique d'Études de la Pollution Atmosphérique |
| CKD | Cement Kiln Dust | - |
| CMN | Calcium Magnesium Nitrate | - |
| CN | Calcium Nitrate | Nitrato de Cálcio |
| CO | Carbon Monoxide | Monóxido de Carbono |
| CO2 | Carbon Dioxide | Dióxido de Carbono ou anidrido carbónico |
| CO2e | Carbon dioxide equivalent | Dióxido de carbono equivalente |
| COD | Chemical Oxygen Demand | Carência Química de Oxigénio |
| CONCAWE | European Oil Company Organisation for Environment, Health and Safety | Organização para o Meio Ambiente, Saúde e Segurança das Empresas Europeias de Petróleo |

| Acronym | English | Portuguese |
|---|---|---|
| Concelho | Portuguese territorial unit under the responsibility of a municipal authority | - |
| CORINAIR | Core Inventory Air Emissions | Inventário de Emissões Atmosféricas |
| CRT | Common Reporting Tables | - |
| CTCV | Technological Centre for Ceramics and Glass | Centro Tecnológico da Cerâmica e do Vidro |
| DAP | Di-ammonium phosphate | - |
| DBH | Diameter at Breast Height | Diâmetro à Altura do Peito (DAP) |
| DC | Degradable Organic Component | Fracção Orgânica Degradável |
| DGA | General Directorate of Environment | Direcção Geral do Ambiente |
| DGADR | General Directorate for Agriculture and Rural Development | Direção Geral de Agricultura e do Desenvolvimento Rural |
| DGAE (ex DGE) | General Directorate for Economic Activities | Direcção Geral das Actividades Económicas |
| DGAV | General Directorate for Food and Veterinary | Direção geral de Alimentação e Veterinária |
| DGEG (ex DGEG) | General Directorate for Energy and Geology | Direcção Geral de Energia e Geologia |
| DGF | General Directorate of Forests | Direcção-Geral das Florestas |
| DGRF | General Directorate for Forestry Resources | Direcção Geral dos Recursos Florestais |
| DGTT | General Directorate of Terrestrial Transportation | Direcção Geral dos Transportes Terrestres |
| Distrito | Portuguese territorial unit comprehending several counties but not coincident with a region which is NUT II. | - |
| DOC | Degradable Organic Carbon | Carbono Orgânico Degradável |
| DOCF | Degradable Organic Carbon Dissimilated | - |
| DRAOT | Regional Directorate of Environment and Land Use Planning | Direcção Regional do Ambiente e Ordenamento do Território |
| EAF | Electric Arc Furnace | Forno Arco Eléctrico |
| EAPA | European Asphalt Pavement Association | - |
| EF | Emission Factors | Factores de Emissão |
| EMEP | Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe | - |
| EPER | European Pollutant Emission Register | Registo Europeu de Emissões Poluentes |
| E-PRTR | European Pollutant Release and Transfer Register | - |
| FAEED | Federal Aviation Administration Aircraft Engine Emission Database | - |
| FAM | Animal Manure Nitrogen Applied to Soils | - |
| FAO | Food and Agriculture Organization of the United Nations | - |
| FCC | Fluidized-bed Catalytic Cracking | Cracking catalítico de leito fluidizado |
| FCR | Fixation in Crop Residues | - |
| FCT-UNL | Faculty of Science and Technology of New University of Lisbon | Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa |
| FGR | Annual amount of nitrogen in animal excreta (faeces and urine) deposited directly in soil during grazing in pasture and adjusted to account for the amount that volatilises as NH3 | - |
| FOD | First Order Decay | Decaimento de Primeira Ordem |

| Acronym | English | Portuguese |
|---|---|---|
| FSN | Nitrogen in Synthetic Fertilizers | - |
| GASA | Analysis Group of Ambient Systems | Grupo de Análises de Sistemas Ambientais |
| GCV | Gross Calorific Value | - |
| GHG | Green House Gases | Gases Com Efeito de Estufa |
| GHV | Gross Heating Value | Poder Calorífico Superior |
| GIC | Large Combustion Plants (LCP) | Grandes Instalações de Combustão |
| GPG | Good Practice Guidance | - |
| GPP | Planning and Policies Office | Gabinete de Planeamento e Políticas |
| GPPAA | Agriculture and Food Planning and Policies Office (changed to GPP) | Gabinete de Planeamento e Política Agro-Alimentar |
| GWP | Global Warming Potential | - |
| H2S | Hydrogen Sulphide | Sulfureto de Hidrogénio |
| HCFC | Hydrochlorofluorocarbons | - |
| HDPE | High Density Poly Ethylene | - |
| HDV | Heavy Duty Vehicles | Veículos Pesados de Mercadorias |
| HFC | Hydrofluorocarbons | - |
| APA | Portuguese Environmental Agency | Agência Portuguesa do Ambiente |
| IAIT | Annual Survey to Manufacturing Industry | Inquérito Anual à Indústria Transformadora |
| IAPI | Annual Survey to Industrial Production | Inquérito Anual à Produção Industrial |
| ICAO | International Civil Aviation Organization | |
| IEF | Implied Emission Factors | Factores de Emissão Implícitos |
| IEP | Portuguese Road Institute | Instituto de Estradas de Portugal |
| IFA | International Fertilizer Industry Association | |
| IFADAP | Institute for Financing and Support of Development of Agriculture and Fisheries | Instituto de Financiamento e Apoio ao Desenvolvimento da Agricultura e das Pescas |
| IFRAA | Forestry Inventory of the Autonomous Region of Azores | Inventário Florestal da Região Autónoma dos Açores |
| IFRAM | Forestry Inventory of the Autonomous Region of Madeira | Inventário Florestal da Região Autónoma da Madeira |
| IMT (ex. IMTT, DGV) | Institute for Mobility and Transportation | Instituto da Mobilidade e dos Transportes |
| INAG | National Water Institute | Instituto da Água |
| INE | National Statistics Institute | Instituto Nacional de Estatística |
| INIAV | National Institute for Agriculture and Veterinary Research | Instituto Nacional de Investigação Agrária e Veterinária |
| INR | National Wastes Institute | Instituto Nacional de Resíduos |
| INRA | National Institute for Agronomic Investigation (France) | Institut National de la Recherche Agronomique (França) |
| INRB | National Institute of Biological Resources (changed to INIAV) | Instituto Nacional de Recursos Biológicos |
| IPCC | Intergovernmental Panel on Climate Change | - |
| IPMA | Portuguese Sea and Atmosphere Institute | Instituto Português do Mar e da Atmosfera |
| ISP | Portuguese Insurance Institute | Instituto de Seguros de Portugal |
| IST-UTL | Technical Superior Institute – Lisbon Technical University | Instituto Superior Técnico – Universidade Técnica de Lisboa |

| Acronym | English | Portuguese |
|---|---|---|
| JP | Jet Fuel | - |
| LCP | Large Combustion Plants (the same as GIC) | o mesmo que GIC |
| LDPE | Low Density Poly Ethylene | Polietileno de Baixa Densidade (PEBD) |
| LDV | Light Duty Vehicles | Veículos Ligeiros de Mercadorias |
| LNG | Liquefied Natural Gas | Gás Natural Liquefeito |
| LOSP | Light Organic Solvent-based Preservatives | - |
| LQARS | Agriculture Chemical Laboratory Rebelo da Silva (integrated in INIAV) | Laboratório Químico Agrícola Rebelo da Silva |
| LPS | Large Point Sources (Corinair definition) | Grandes Fontes Poluidoras |
| LRTAP | Long-range Transboundary Air Pollution | Poluição Atmosférica Transfronteiras a Longa Distância |
| LTO | Landing and Take-off | Aterragens e Descolagens |
| LUCF | Land-use Change and Forestry | Alteração do Uso do Solo e Florestas |
| LULUCF | Land Use, Land-use Change and Forestry | Uso do Solo, Alteração do Uso do Solo e Florestas |
| MA | Ministry of Environment | Ministério do Ambiente |
| MAC | Mobile Air-conditioning systems | - |
| MADRP | Ministry of Agriculture, Rural Development and Fisheries (changed to MAMAOT) | Ministério da Agricultura, Desenvolvimento Rural e Pescas (changed to MAMAOT) |
| MAM | Ministry of Agriculture and Sea | Ministério da Agricultura e do Mar |
| MAMAOT | Ministry for Agriculture, Sea, Environment and Land Use Planning (changed to MAM) | Ministério da Agricultura, do Mar, do Ambiente e do Ordenamento do Território |
| MAOT | Ministry of Environment and Land Use Planning (changed to MAMAOT) | Ministério do Ambiente e Ordenamento do Território (changed to MAMAOT) |
| MCF | Methane Conversion Factor | Factor de Conversão de Metano |
| MCOTA | Ministry of Urban Affairs, Land Use Planning and Environment (older name of Ministry of Environment) | Ministério das Cidades, Ordenamento do Território e Ambiente (older name of Ministry of Environment) |
| MDI | Metered Dose Inhalers | - |
| MEET | Methodologies For Estimating Air Pollutant Emissions From Transport | - |
| MMS | Manure Management Systems | Sistema de Gestão de Estrumes |
| MSW | Municipal Solid Wastes | Resíduos Sólidos Municipais |
| MTBE | Methyl Tertiary Butyl Ether | Metil-Ter-Butil-Éter |
| Na2S | Sodium Sulphide | Sulfureto de Sódio |
| NaOH | Sodium Hydroxide | Hidróxido de Sódio |
| NAPFUE | Corinair Fuel Nomenclature | |
| NATO | North Atlantic Treaty Organisation | Organização do Tratado do Atlântico Norte |
| NAV | National Entity responsible for air traffic | Navegação Aérea |
| NCV | Net Calorific Value | - |
| NFI | National Forestry Inventories | Inventário Florestal Nacional |
| NFR | New Format Reporting | - |
| NH3 | Ammoniac | Amoníaco |
| NMVOC | Non Methane Volatile Organic Compounds | Compostos Orgânicos Voláteis Não Metânicos (COVNM) |

| Acronym | English | Portuguese |
|---|---|---|
| NOx | Nitrogen Oxides (NO + NO2) | Óxidos de Azoto (NO+NO2) |
| NPK | Nitrogen, Phosphorus and Potassium | Nitrogénio, Fósforo e Potássio |
| NSS | Normal Super Phosphates | Superfosfatos simples |
| NUTS (0..III) | Nomenclature of Territorial Units for Statistics | Nomenclatura de Unidades Territoriais para fins estatísticos |
| OD | Origin - Destiny | Origem - Destino |
| ODS | Ozone Depleting Substances | - |
| OECD | Organization for Economic Co-operation and Development | Organização para a Cooperação e Desenvolvimento Económico (OCDE) |
| OX | Oxidation Factor | Factor de Oxidação |
| PAF | Forestry Action Program | Programa de Acção Florestal |
| PAH | Polycyclic Aromatic Hydrocarbons | Hidrocarbonetos Aromáticos Policíclicos |
| PCI | Low Heating Value (LHV) | Poder Calorífico Inferior |
| PDM | Methodological Development Plan | Plano de Desenvolvimento Metodológico |
| PEN | National Energetic Program | Plano Energético Nacional |
| PER | Perchloro-ethylene | Percloroetileno |
| PERSU | Strategic Plan on Municipal Solid Wastes | Plano Estratégico dos Resíduos Sólidos Urbanos |
| PETROGAL | Portuguese Petroleum Company | Empresa de Petróleos de Portugal |
| PFC | Perfluorinated Hydrocarbons | - |
| PM1 | Particles with Aerodynamic Diameter smaller than 1 micrometre | Partículas cujo diâmetro aerodinâmico é inferior a 1 micrómetro |
| PM10 | Particles with Aerodynamic Diameter smaller than 10 micrometres | Partículas cujo diâmetro aerodinâmico é inferior a 10 micrómetros |
| PM2.5 | Particles with Aerodynamic Diameter smaller than 2.5 micrometres | Partículas cujo diâmetro aerodinâmico é inferior a 2.5 micrómetros |
| PNAC | National Climate Change Program | Programa Nacional para as Alterações Climáticas |
| PNPA | National Plan for Environmental Policy | Plano Nacional da Política de Ambiente |
| PP | Poly Propylene | Polipropileno |
| PS | Poly Styrene | Poliestireno |
| PTEN | National Emission Ceilings Program | Programa para os Tectos de Emissão Nacional |
| PVC | Poly Vinyl Chloride | Cloreto de Polivinil |
| RA | Agricultural Region | Região Agrária |
| RCM | Council Minister´s Resolution | Resolução do Conselho de Ministros |
| REN | National Electric System | Rede Eléctrica Nacional |
| RVP | Reid Vapour Pressure | Pressão de Vapor de Reid |
| SF6 | Sulphur Hexafluoride | Hexafluoreto de Enxofre |
| SNIERPA | National System of Inventories of Emissions and Removals of Atmospheric Pollutants | Sistema Nacional de Inventários de Emissões e Remoções de Poluentes Atmosféricos |
| SOx | Sulphur Oxides | Óxidos de Enxofre |
| SW | Solid Wastes | Resíduos Sólidos |
| SWDS | Solid Waste Disposal Sites | Locais para Deposição de Resíduos Sólidos |

| Acronym | English | Portuguese |
|---|---|---|
| TANKS | Software designed to estimate air emissions from organic liquids in storage tanks (USEPA, September 27, 2001) | Software criado para a estimativa de emissões atmosféricas a partir de líquidos orgânicos em tanques de armazenamento (USEPA, 27 de Setembro de 2001) |
| TNT | Trinitrotoluene | Trinitrotolueno |
| TOE | Tons of oil equivalent | Toneladas Equivalentes de Petróleo (TEP) |
| TOW | Total Organic Waste | Resíduo Orgânico Total |
| TRANSGÁS | Portuguese Company of Natural Gas | Sociedade Portuguesa de Gás Natural (Empresa) |
| TSP | Total Suspended Particles | Partículas Totais em Suspensão |
| TSS | Triple Super Phosphates | Superfosfatos Triplos |
| UNECE | United Nations Economic Commission for Europe | - |
| UNFCCC | United Nations Framework Convention on Climate Change | Convenção Quadro das Nações Unidas para as Alterações Climáticas |
| USEPA | United States Environmental Protection Agency | Agência de Protecção Ambiental dos Estados Unidos da América |
| VCM | Vinyl Chloride Monomer | Monómero de Cloreto de Vinilo |
| VOC | Volatile Organic Compounds | Compostos Orgânicos Voláteis |
| VRF | Vacuum Residual Fuel Oil | Resíduo de Alto Vácuo |
| WWH | Wastewater Handling | Tratamento de Águas Residuais |
| ZA | Agricultural Zone | Zona Agrária |

# REFERENCES

ACAP. Estatísticas do Sector Automóvel. Associação do Comércio Automóvel de Portugal.

AFN (1982, 1995, 2005) – National Forestry Inventories.

AFN, 2009a. Série temporal de dados de área ardida. Autoridade Florestal Nacional, Lisboa (Conceição Ferreira, com. pessoal).

AFN, 2009b. Volume cortado 2004-2006 para coníferas e não coníferas. Autoridade Florestal Nacional, Lisboa (Conceição Ferreira, com. pessoal).

AFN (2010). Inventário Florestal Nacional de Portugal Continental IFN5 2005-2006.

Almeida, Domingos, 2006. Manual de Culturas Hortícolas, Volume I e II.

ANA, 2003. Estatísticas do Tráfego Aéreo 2002. ANA – Aeroportos de Portugal.

APED, 1999. Anuário da Distribuição Portuguesa 1999.

BEMA - 1997, Biogenic Emissions in the Mediterranean Area, Atmospheric Environment, Special issue 31-S1,1-256

BHF - Centro Federal de Investigação Florestal (2000) - Estado das Florestas na Europa. Relatório de Síntese de ONU/CEE e CE, Genebra e Bruxelas.

Bossard, M., Feranec, J. & J. Otahel, 2000. CORINE land cover technical guide – Addendum 2000. EEA Technical Report nº 40. Environmental European Agency. Copenhagen

Büttner, G., G. Feranec and G. Jaffrain, 2006. CORINE Land Cover nomenclature illustrated guide - addendum 2006, available online athttp://www.igeo.pt/gdr/en/index.php?princ=Projects/CLC2006&sessao=m_projectos

Caetano, M., A. Araújo, A. Nunes, V. Nunes and M. Pereira, 2009a. Accuracy assessment of the CORINE Land Cover 2006 map of Continental Portugal, Technical Report, Instituto Geográfico Português, available online at http://www.igeo.pt/gdr/en/index.php?princ=Projects/CLC2006&sessao=m_projectos (last accessed 5 April 2011).

Caetano, M., A. Nunes and V. Nunes, 2007. Manual de apoio à produção do CLC2006 para Portugal Continental, Technical report, Instituto Geográfico Português.

Caetano, M. e Pereira, M. 2007. Proposta de trabalhos para o Instituto Geográfico Português no estudo piloto para definição da metodologia a adoptar por Portugal para prestação de informação no âmbito do sector LULUCF da UNFCCC e do Protocolo de Quioto, relatório técnico, Instituto Geográfico Português.

Caetano, M., Araújo, A. e Nunes, V. 2008a. Proposta de conversão da nomenclatura da COS'90 para a da COS2007 - Relatório final (versão 6.0), relatório técnico, Instituto Geográfico Português.

Caetano, M., Carrão H. & M. Painho, 2005. Alterações da ocupação do solo em Portugal Continental: 1985 - 2000, Instituto do Ambiente, Lisboa.

Caetano, M., M. Pereira, H. Carrão, A. Araújo, A. Nunes and V. Nunes, 2008. Cartografia temática de ocupação/uso do solo do Instituto Geográfico Português. Mapping - Revista Internacional de Ciencias de la Tierra Nº 126, pp. 78-87.

Caetano, M., Nunes, V and Pereira, M. 2009c. Land Use and Land Cover Map of Continental Portugal for 2007 (COS2007): project presentation and technical specifications development. 3rd Workshop of the EARSeL Special Interest Group on Land Use and Land Cover, 25 - 27 November 2009, Bonn, Germany, in press.

Caetano, M., Nunes, V. and Nunes, A. 2009b. CORINE Land Cover 2006 for Continental Portugal, technical report, Instituto Geográfico Português.

Caetano, M., Nunes, V. e Araújo, A. 2009a. Manual da COS2007 - Carta de Uso e Ocupação do Solo de Portugal Continental para 2007 (versão preliminar 2.16), relatório técnico, Instituto Geográfico Português.

Caetano, M., Pereira, M., Carrão, H., Araújo, A., Nunes, A. e Nunes, V. 2008b. Cartografia temática de ocupação/uso do solo do Instituto Geográfico Português. Mapping - Revista Internacional de Ciencias de la Tierra, nº 126, pp. 78-87.

Carreira, 2002. Fluorocarbonetos – Actividade 2001, AIR LIQUIDE

Cartaxo et al, 1985. Determinação das cargas poluidoras brutas produzidas pelos sectores de actividade industrial em Portugal Continental. Ministério do Equipamento Social. Direcção-geral dos Recursos e Aproveitamentos Hidráulicos. Direcção de Serviços de Controle da Poluição.

Carvalho, M.J. e G. Basch (1995): Effects of traditional and no-tillage on physical and chemical properties of a Vertisol. Proceedings of the EC-Workshop - II - on no-tillage crop production in the West-European Countries, Silsoe, May 1995, 2, 17 – 23, F. Tebrügge, A. Böhrnsen (ed.), Wissenschaftlicher Fachverlag, Giessen.

Carvalho, J., 2000. Crescimento, Produção e Ecologia de Povoamentos de Quercus pyrenaica Wild em Portugal Continental. PhD Thesis. Universidade de Trás-os-Montes e Alto Douro, Vila Real, Portugal.

Carvalho, M., Basch, G., Brandão, M., Santos, F., Figo, M. (2002). A sementeira directa e os residuos das culturas no aumento do teor de matéria orgânica do solo e na desposta da cultura de trigo à adubação azotada. Proceedings of 1º Congresso Nacional de Mobilização de Conservação do Solo, APOSOLO, Évora.

Carvalho, M., Basch, G., Calado, J.M.G., Barros, J.F.C. (2012). Long Term Effects of Tillage System and Crop Residue Management on Soil Carbon Content of a Luvisol under Rainfed Mediterranean Conditions. Special Issue Striving for Sustainable High Productivity through Improved Soil and Crop Management. Revista Científica de la Facultad de Agronomía, Universidad de la República, y del Instituto Nacional de Investigación Agropecuaria. ISSN 1510-0839

CEC, 1992. CORINAIR Inventory. Default Emission Factors Handbook. 2nd ed. Comission of the European Comission.

Coelho, M. B. & Godinho, J. M., 2002. SUBER DATA 2 - Base de dados de sobreiro - Manual para o utilizador. Publicações GIMREF, RT8/2002. Departamento de Engenharia Florestal, Instituto Superior de Agronomia, Lisboa.

Correia, A., Faias, S., Tomé, M., Evangelista, M., Freire, J., Carvalho, P.O. (2008) Ajustamento simultâneo de equações de biomassa de Pinheiro Manso no Sul de Portugal. Silva Lusintana 16 (2): 197-205

COSTA, J. B. (1985) – Caracterização e constituição do solo, 3ª Ed. FCGulbenkian, Lisboa.

CPPE, 2000 - Companhia Portuguesa de Produção de Electricidade, 2001. Relatório de Ambiente 2000.

Cunha, P. P., Lemos de Sousa, M. J., Pinto de Jesus, A., Rodrigues, C. F., Telles Antunes. M. e Tomás (2012) - *Coal in Portugal: Geology, Petrology and Geochemistry*.

de VRIES, W., G.J. REINDS, M. KERKVOORDE, (2000) - Intensive monitoring of forest ecosystems in Europe, Technical Report 2000 / UN/ECE & EC Forest Intensive.

Dias, J.J. Mestre (2002) - Utilização da biomassa: avaliação dos resíduos e utilização de pellets em caldeiras domésticas.

DGE, 2003. Energy in Portugal. The 1990s. Direcção-Geral de Energia. Statistical Division (Eurostat file nº 200245501003).

DGRF, 2006. Manual de instruções para a realização do trabalho de fotointerpretação – 5º Inventário Florestal Nacional. Direcção Geral dos Recursos Florestais, Lisboa, Portugal (publicação interna).

Direcção-Geral das Florestas, 2001. Inventário Florestal Nacional – Portugal Continental – 3ª Revisão, 1995-1998, Relatório Final

Direcção-Geral de Energia, 1989. Informação Energia nº14. Direcção de Serviços e Planeamento e Assuntos Económicos e Divisão de Estatística.

Direcção-Geral de Energia, 1990. Informação Energia nº15. Direcção de Serviços e Planeamento e Assuntos Económicos e Divisão de Estatística.

Direcção-Geral de Energia, 1991. Informação Energia nº16. Direcção de Serviços e Planeamento e Assuntos Económicos e Divisão de Estatística.

Direcção-Geral de Energia, 1992. Informação Energia nº17. Direcção de Serviços e Planeamento e Assuntos Económicos e Divisão de Estatística.

Direcção-Geral de Energia, 1993. Informação Energia nº18. Direcção de Serviços e Planeamento e Assuntos Económicos e Divisão de Estatística.

Direcção-Geral de Energia, 1994. Informação Energia nº19. Direcção de Serviços e Planeamento e Assuntos Económicos e Divisão de Estatística.

Direcção-Geral de Energia, 1995. Informação Energia nº20. Direcção de Serviços e Planeamento e Assuntos Económicos e Divisão de Estatística.

Direcção-Geral de Energia, 1996. Informação Energia nº21. Direcção de Serviços e Planeamento e Assuntos Económicos e Divisão de Estatística.

Direcção-Geral de Energia, 1997. Informação Energia nº22. Direcção de Serviços e Planeamento e Assuntos Económicos e Divisão de Estatística.

Direcção-Geral de Energia, 1998. Informação Energia nº23. Direcção de Serviços e Planeamento e Assuntos Económicos e Divisão de Estatística.

Direcção-Geral de Energia, 1999. Informação Energia nº24. Direcção de Serviços e Planeamento e Assuntos Económicos e Divisão de Estatística.

Direcção-Geral de Energia, 2000. Informação Energia nº25. Direcção de Serviços e Planeamento e Assuntos Económicos e Divisão de Estatística.

Direcção-Geral de Energia, 2001. Informação Energia nº26. Direcção de Serviços e Planeamento e Assuntos Económicos e Divisão de Estatística.

Direcção-Geral de Energia, 2026. Balanços Energéticos - Séries Temporais 1990-2024.

Direcção-Geral de Energia, 2003. Energy in Portugal. The 1990s. Statistical Division (Eurostat file nº 200245501003).

EAPA, 2024. Asphalt in Figures. European Asphalt Pavement Association. Breukelen. The Netherlands.

EDP - Electricidade de Portugal, 2000. Relatório de Ambiente 1999.

EDP - Electricidade de Portugal, 2001. Relatório de Ambiente 2000.

EDP - Electricidade de Portugal, 2002. Emissões Atmosféricas das Centrais do SEP - Previsões para 2002.

EDP-Electricidade de Portugal, 2002. Relatório de Ambiente 2001.

EDP-Electricidade de Portugal, 2003. Relatório de Ambiente 2002 - Ambiente e Sociedade.

EDP-Electricidade de Portugal, 2004. Relatório de Ambiente 2003 - Ambiente e Sociedade.

EEA, 2002. EMEP/CORINAIR Emission Inventory Guidebook - 3rd edition October 2002 UPDATE Technical report No 30, Environment European Agency.

EEA, 2002b. CORINE Land Cover Update. I&LC2000 Project. Technical Guidelines. Compenhagen

Eggleston H.S., 1992, An Improved UK Ammonia Emission Inventory. In Proceedings of a workshop: Ammonia Emissions in Europe: emission coefficients and abatement costs, Laxenburg, Austria, February 4-6 1991, Klasssen G., ed., IIASA, Laxenburg, Austria, pp. 95-107.

EMEP/CORINAIR, 1996. Atmospheric Emission Inventory Guidebook (first edition). EMEP Task Force on Emission Inventories. European Environment Agency. Copenhagen.

EMEP/EEA Emission Inventory Guidebook (2009), Chapter 11b forest fires.

EMEP/EEA Emission Inventory Guidebook (2013).

EMEP/EEA air pollutant emission inventory guidebook (2016)

EMEP/EEA air pollutant emission inventory guidebook (2019)

EMEP/EEA air pollutant emission inventory guidebook (2023)

EPA, 2001. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-1999

EPA, 2002. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2000

European Commission, 1994. Corinair. Technical annexes. Volume 2. Default Emission Factors Handbook. Directorate-General Environment, Nuclear Safety and Civil Protection. 327 pp

FAA, Federal Aviation Administration Aircraft Engine Emission User Guide and Database (AEE-110). Office of Environment and Energy within the Federal Aviation Administration

Faias, S., 2009. Analysis of Biomass Expansion Factors for the Most Important Species in Portugal. Master thesis. Instituto Superior de Agronomia, Universidade Técnica de Lisboa, Lisboa, Portugal.

Faias, S.P. (2009) Analysis of Biomass Expansion Factors for the most important tree species in Portugal. Dissertação para obtenção do Grau de Mestre em Engenharia Florestal e dos Recusrsos Naturais, Instituto Superior de Agronomia.

FAO, 2001. Lecture Notes on the Major Soils of the World. FAO Agriculture Department. Rome (http://www.fao.org/docrep)

Fresenius, W., Schneider, W. Bohnke, B., Poppinghaus, K. (editors), *Waste Water Technology: Origin, Treatment, and Analysis of Waste Water*, Deutsche GesellSchaft fur Technische Zusammenarbeit, Springer-Verlag, Berlin, Heidelberg, 1989.

GDR (Grupo de Detecção Remota) 2009. CLC2006 - CORINE Land Cover 2006 for Continental Portugal. Available online at: http://www.igeo.pt/gdr/en/projects/clc2006/ (last accessed 15 January 2010).

Geron, C.D., A.B. Guenther and T.E. Pierce - 1994, An Improved Model for Estimating Emissions of Volatile Organic Compounds from Forests in the Eastern United States, J. Geophys. Res. 99 (D6) 12773-12791.

Gonçalves, J. 2008a. Conversões de coordenadas com o programa PROJ – Método de conversão com grelhas. Primeiras Jornadas de Software Aberto para Sistemas de Informação Geográfica SASIG I, 20 – 22 Outubro 2008, Águeda, Portugal. Disponível online em: http://gfoss.sigaberto.org/wp-content/uploads/2008/11/sasig2008.pdf (último acesso em 23 Outubro 2009).

Gonçalves, J. 2008b. Grelhas no formato NTv2. Disponível online em: http://www.fc.up.pt/pessoas/jagoncal/coordenadas/parte1.htm (último acesso em 23 Outubro 2009).

GT SNIERPA 3.3/3.4 (Grupo de Trabalho do SNIERPA para o Artigo 3, Parágrafos 3 e 4, do Protocolo de Quioto) 2008. Acta da reunião de 12 de Fevereiro de 2008, meeting minutes, Agência Portuguesa do Ambiente.

GT SNIERPA 3.3/3.4 (Grupo de Trabalho do SNIERPA para o Artigo 3, Parágrafos 3 e 4, do Protocolo de Quioto) 2007a. Acta da reunião bilateral APA-IGP de 17 de Dezembro de 2007 (versão preliminar), meeting minutes, Agência Portuguesa do Ambiente.

GT SNIERPA 3.3/3.4 (Grupo de Trabalho do SNIERPA para o Artigo 3, Parágrafos 3 e 4, do Protocolo de Quioto) 2007b. Acta da reunião de 27 de Setembro de 2007 (versão preliminar), meeting minutes, Agência Portuguesa do Ambiente.

GT SNIERPA 3.3/3.4 (Grupo de Trabalho do SNIERPA para o Artigo 3, Parágrafos 3 e 4, do Protocolo de Quioto) 2007c. Acta da reunião de 17 de Julho de 2007, meeting minutes, Agência Portuguesa do Ambiente.

GT SNIERPA 3.3/3.4 (Grupo de Trabalho do SNIERPA para o Artigo 3, Parágrafos 3 e 4, do Protocolo de Quioto) 2009. Acta da reunião de 15 de Julho de 2009, Agência Portuguesa do Ambiente.

GT SNIERPA 3.3/3.4 (Grupo de Trabalho do SNIERPA para o Artigo 3, Parágrafos 3 e 4, do Protocolo de Quioto) 2008a. Acta da reunião de 12 de Fevereiro de 2008, Agência Portuguesa do Ambiente.

GT SNIERPA 3.3/3.4 (Grupo de Trabalho do SNIERPA para o Artigo 3, Parágrafos 3 e 4, do Protocolo de Quioto) 2008b. Acta da reunião de 27 de Outubro de 2008, Agência Portuguesa do Ambiente.

Guenther, A., Nicholas Hewitt, N., David Erickson, Ray Fall, Chris Geron, Tom Graedel, Peter Harley, Lee Klinger, Manuel Lerdau, W.A. McKay, Tom Pierce, Bob Scholes, Rainer Steinbrecher, Raja Tallamraju, John Taylor and Pat Zimmerman - 1995, A Global Model of Natural Volatile Organic Compound Emissions, J. Geophys. Res., 100(D5), 8873-8892.

Guenther, A., Zimmerman, P.R., Harley, P. And Wildermuth, M. - 1994, Natural Volatile Organic Compound Emission rate estimates for U.S. Woodland landscapes, Atmos. Environ., 28, 1197-1210

IA (Instituto do Ambiente) 2006. Portuguese initial report under the Kyoto Protocol - Report to facilitate the calculation of the assigned amount pursuant to Article 3, paragraphs 7 and 8, of the Kyoto Protocol (submission to the UNFCCC Secretariat), technical report.

IA (Instituto do Ambiente) 2006. Portuguese initial report under the Kyoto Protocol - Report to facilitate the calculation of the assigned amount pursuant to Article 3, paragraphs 7 and 8, of the Kyoto Protocol (submission to the UNFCCC Secretariat), technical report.

ICAO, 1989. ICAO Engine Exhaust Emission Databank. ICAO Committee on Aviation Environmental Protection Working Group 3 meeting, Mariehamn, Aland. October 10-13, 1989.

ICNF (2001-2012). Informação sobre áreas ardidas e ocorrências de 2001 a 2012. http://www.icnf.pt/portal/florestas/dfci/relat/rel-if

IGP (Instituto Geográfico Português) 2002. Área coberta pela Carta de Ocupação do Solo - COS'90. Available online at: http://www.igeo.pt/produtos/CEGIG/cos_cartograma.htm (last accessed 15 January 2010).

INCM (Imprensa Nacional – Casa da Moeda) 2005. Resolução do Conselho de Ministros n.º 68/2005, de 17 de Março. Diário da República, série I-B, n.º 54. Available online at: http://dre.pt/pdf1sdip/2005/03/054B00/23712374.PDF (last accessed 9 April 2008).

INRA, 1984. Alimentation de Los Animales Monogastricos. Cerdo, Conejo, Aves. Ed. Mundi-Prensa, Madrid, 1985

IPCC (The Intergovernmental Panel on Climate Change) 2003. Good practice guidance for land use, land-use change and forestry, Institute for Global Environmental Strategies. Available online at: http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_contents.htm

IPCC (The Intergovernmental Panel on Climate Change) 2003. Good practice guidance for land use, land-use change and forestry, Institute for Global Environmental Strategies. Available online at: http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_contents.htm (last accessed 9 April 2008).

IPCC, 1995. IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2 - Workbook. United Nations Environment Programme (UNEP), the Organization for Economic Co-operation and Development (OECD), the International Energy Agency (IEA) and the Intergovernmental Panel on Climate Change (IPCC).

IPCC, 1995b. IPCC Guidelines for National Greenhouse Gas Inventories. Volume 3 - Reference Manual. United Nations Environment Programme (UNEP), the Organization for Economic Co-operation and Development (OECD), the International Energy Agency (IEA) and the Intergovernmental Panel on Climate Change (IPCC).

IPCC, 1997. Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2 - Workbook. The Intergovernmental Panel on Climate Change (IPCC), the Organization for Economic Co-operation and Development (OECD) and the International Energy Agency (IEA).

IPCC, 1997b. Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 3 - Reference Manual. The Intergovernmental Panel on Climate Change (IPCC), the Organization for Economic Co-operation and Development (OECD) and the International Energy Agency (IEA).

IPCC, 2000. Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. The Intergovernmental Panel on Climate Change (IPCC).

IPCC, 2003. Good Practice Guidance for Land Use, Land-Use Change and Forestry. The Intergovernmental Panel on Climate Change (IPCC).

IPCC (2006). Guidelines for National Greenhouse Gas Inventories.

IPCC (2019). 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

IPCC/OECD, 1994. IPCC Draft Guidelines for National Greenhouse Gas Inventories. Volume 2 - Workbook. IPCC/OECD Joint Programme.

IPCC/OECD, 1994b. IPCC Draft Guidelines for National Greenhouse Gas Inventories. Volume 3 - Reference Manual. IPCC/OECD Joint Programme.

ISR, Departamento de Engenharia Electrotécnica e de Computadores, Universidade de Coimbra, 24 de Marco de 2006. EFIPRE Eficiência Energética e Integração Sustentada de PRE-Biogás.

Jarrige, R., 1988. Alimentation des Bovins, Ovins et Caprins, INRA, Parisa.

Kauppi, P.E., K. Mielikainen & K. Kuusela (1992) - Biomass and carbon budget of European forests, 1971, Science 256:70-74.

LQARS, 2000. Manual de Fertilização das Culturas. Laboratório Químico Agrícola Rebelo da Silva, Lisboa.

Luchetta, L., V. Simon and L. Torres - 1999 (confirmar data), Estimation of the Yeraly Emission of non-methanic Volatile Organic Compounds (VOCs) from the Forest Ecosystem in France.

Luz, A., Nunes, A. e Caetano, M. 2008. Proposta metodológica para a correcção das distorções geométricas da COS'90: resultados preliminares. X Encontro de Utilizadores de Informação Geográfica (ESIG 2008), 14 - 16 Maio 2008, Oeiras, Portugal, in press.

MADRP/DGPC (MINISTÉRIO DA AGRICULTURA, DO DESENVOLVIMENTORURAL E PESCAS/ DIRECÇÃO-GERAL DE PROTECÇÃO DAS CULTURAS), 2006. Requisitos Mínimos para o Exercício da Produção Integrada.

Martins, A. A. A. (1992) – Génese e evolução de solos derivados de granitos / Estudo de uma climo-sequência no norte de Portugal, Tese PhD em Engenharia Agrícola, UTAD, Vila Real.

McDonald, P., Edwards, R.A., Greenhalgh, J.F.D. Et C.A. Morgan, 2002. Animal Nutrition. Prentice Hall, Harlow.

Menegon, G., Pivotti, F. & G. Xiccato, 1985. Fundamentos de Tecnologia Agrária. 2º Volume. Publicações Europa-América.

Ministerio de Medio Ambiente, y Medio Rural y Marino (2011) - Inventario de emisiones de gases de efecto invernadero de España años 1990-2009. Comunicación a la comisión europea.

Montero, G., Ruiz-Peinado, R. Muñoz, M (2005) Producción de biomasa y fijación de CO2 por los bosques españoles. INIA 220: 25-36.

Montero, G., Ruiz-Peinado, R., & Muñoz, M., 2005. Producción de biomassa y fijación de CO2 por los bosques españoles. In Coléccion Monografías INIA. Serie Forestal nº13. Instituto Nacional de Investigaciones Agrarias, Ministerio de Agricultura, Madrid, Espanha.

Mueller-Edzards, C., W. de Vries & J.W. (1997) - Ten years of monitoring forest condition in Europe -, Technical Background Report / UN/ECE & EC: 211-224, Geneva – Brussels.

Nery, F. 2007. Sobre a avaliação da conformidade da Carta de Ocupação do Solo de 1990, relatório de projecto, Projecto MUBISPI [POCTI/42351/GEO/2001].

Nery, F. e Marrecas, P. 2003. Avaliação de qualidade da Carta de Ocupação do Solo de Portugal Continental de 1990, relatório de projecto, Projecto MUBISPI [POCTI/42351/GEO/2001].

Nunes, T.V. - 1996, Biogenic Emissions of non-methane hydrocarbons. Contribution to the evaluation of VOC emission rates by portuguese ecosystems (in Portuguese). Ph. Thesis, University of Aveiro, Portugal.

Nunes, T.V. And C.A. Pio - 1999, Emission of Volatile Organic Compounds from Portuguese Eucalyptus Forests.

Oliveira, Arlinda Leal Franco de (1967) - Estudo da matéria orgânica nas unidades de solos cartografados em Portugal (a sul do rio Tejo), Sec. Est. Agricultura / DGSFA, Lisboa.

Olson, J.S. (1963). Energy storage and the balance of producers and decomposers in ecological systems. Ecology 44 (2): 322-331. Quoted in Rosa (2009).

Painho, M. & M. Caetano, 2006. Cartografia de ocupação do solo. Portugal continental 1985-2000 CORINE Land Cover 2000, Instituto do Ambiente, Amadora, available at: http://www.igeo.pt/gdr/index.php?princ=PROJECTOS/CLC2000&sessao=m_projectos

Páscoa, F., 1987. Estrutura, Crescimento e Produção em Povoamentos de Pinheiro Bravo. Um Modelo de Simulação. PhD Thesis. Instituto Superior de Agronomia, Universidade Técnica de Lisboa, Lisboa, Portugal.

Patrício, Maria S.F. 2006. Análise da potencialidade produtiva do castanheiro em Portugal. PhD Thesis. Departamento de Engenharia Florestal, Instituto Superior de Agronomia, Lisboa, Portugal.

Pereira et al, 2002. Quantificação dos Sumidouros Terrestres de Carbono em Portugal Continental. Universidade Técnica de Lisboa - Instituto Superior de Economia.

Pereira, M., Luz, A. and Caetano, M. 2008. Pilot study for defining Portugal's reporting methodology under the UNFCCC and the Kyoto Protocol, in the LULUCF sector (Final report of work package WP10 - Portuguese Geographic Institute), technical report, Instituto Geográfico Português.

Pereira, Mª Conceição and Caetano, M., 2008. Pilot study for defining Portugal´s reporting methodology under the UNFCCC and the Kyoto Protocol, in the LULUCF sector, IGP.

Pereira, T. C., Seabra, T., Maciel, H. & Torres, P., 2009. Portuguese National Inventory Report on Greenhouse Gases, 1990-2007 Submitted under the United Nations Framework Convention on Climate Change and the Kyoto Protocol. Portuguese Environmental Agency. Amadora.

Pereira, J., Figueiredo, N., Goufo,P., Carneiro, J., Morais,R., Carranca, C., Coutinho, J and Trindade, H , 2013 – Effects of elevated temperatura and atmospheric carbón dioxide concentration on the emissions of methane and nitrous oxide from Portuguese flooded rice fields – Atmospheric Environment 80 (2013)464-471.

Pio, C.A. And A.A. Valente - 1998, Atmospheric Fluxes and Concentrations of Monoterpenes in Resin-Tapped Pine Forests, Atmosph. Env. Vol 32 nº 4, 683-691.

Pio, C.A., Nunes, T.V. And A.R. Valente - 1999 (Confirmar data), Emission of Volatile Organic Compounds from Portuguese Maritime Pine Forests, Universidade de Aveiro, Portugal.

PNAC, 2003. Medidas Adicionais Visando o Cumprimento do Protocolo de Quioto, Documento de trabalho.

PNALE, 2004. Plano Nacional de Atribuição de Licenças de Emissão de CO2 (PNALE) 2005-2007, Grupo de Trabalho PNALE.

PTEN, 2002. Programa para os Tectos de Emissão Nacional - Estudos de Base - Cenário de Referência, Departamento de Ciências e Engenharia do Ambiente da Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa - Instituto do Ambiente - Centro de Estudos em Economia da Energia, dos Transportes e Ambiente.

Razquin, M. C., O Porco e a sua alimentação razional, Biblioteca Agrícola Litexa, Lisboa, 1975.

REN-Rede Eléctrica Nacional, 2003. Emissões Atmosféricas das Centrais do SEN - Previsões para 2003.

Rosa, I (2009). Estimativa das emissões de gases com efeito de estufa resultantes de fogos de vegetação em Portugal. Dissertação para a obtenção do Grau de Mestre em Engenharia Florestal e Gestão dos Recursos Naturais. Instituto Superior de Agronomia.

Rosário, L. (2009) - Referências para a avaliação do sequestro de carbono nos solos portugueses com base na rede ICP Forest e LQARS.

Rosário, L.; Ferreira, C; Avelar, T.; Paulino, J. e Pina, A: (2010) - Bases para a avaliação do sequestro e sinks de carbono orgânico total nos solos florestais e agrícolas Portugueses – Dados da Rede ICP Forest (1995), LQARS (1999) e Projecto BioSoil (2005).

Sánchez-González, M. S., Tomé, M. & Montero, G., 2005. Modelling height and diameter growth of dominant cork oak trees in Spain. Annals of Forest Science, 62:633-643.

Schulze, E.D. (ed) (2000) - Carbon and nitrogen cycling in Europe forest, Ecological Studies 142, in press, Springer Verlag, Hiedelberg.

Seixas, J., V. Gois, F. Ferreira, R. Diniz, F. Moura, P. Torres, C. Furtado, S. Martinho, P. Matos, S. Fava, M. Remédio e J. Gonçalves, 2000. Emissão e Controlo de Gases com Efeito de Estufa em Portugal. Ministério do Ambiente e Ordenamento do Território, GASA-DCEA-FCT, Março 2000.

Silva, P., T. Nunes, C. Campos, M. Mariz and C.Pio - 1999, Emissões de Compostos Orgânicos Voláteis pela Floresta de Sobreiro em Portugal, 6ª Conferência Nacional sobre a Qualidade do Ambiente, 627-637, 1999.

Silva, T.P., Pereira, J.M.C., Paúl, J.C.P, Santos, M.T.N., Vasconcelos, M.J.P. (2006) Estimativa de emissões atmosféricas originadas por fogos rurais em Portugal. Silva Lusitana 14 (2): 239-263.

Simpson - 1996, Inventorying Biogenic VOC Emissions in Europe, EMEP MSC-W, Norwegian Meterorological Institute, Oslo.

Simpson, D., Alex Guenther, C. Nicholas Hewitt and Rainer Steinbrecher - 1995. Biogenic Emissions in Europe. 1. Estimates and Uncertainties, J. Geophys. Res., 100 (D11), 22875-22890.

Simpson, D., Wilfried Winiwarter, Gynnar Borjesson, Steve Cinderby, Antonio Ferreiro, Alex Guenther, C. Nicholas Hewitt, Robert Janson, M. Aslam K. Khalil, Susan Owen, Tom E. Pierce, Hans Puxbaum, Martha Shearer, Ute Skiba, Rainer Steinbrecher, Leonor Tarrasón and Mats H. Oquist - 1999. Inventorying emissions from nature in Europe, J. Geophys. Res., 104 (D7), 8113-8152.

Soares, P., Oliveira, T. & Tomé, M., 2006. O Modelo Globulus 3.0. Publicações GIMREF, RC2/2006. Departamento de Engenharia Florestal, Instituto Superior de Agronomia, Lisboa, Portugal.

Spain (2012). National Inventory Report (2012 submission).

Teixeira, R., Domingos, T., Canaveira, P., Avelar, T., Basch, G., Belo, C.C., Calouro, F., Crespo, D., Ferreira, V.G., Martins, C. (2008b). Carbon sequestration in biodiverse sown grasslands. Options méditerranéennes – Sustainable Mediterranean Grasslands and Their Multi-Functions, A-79: 123-126.

Teixeira, R., Domingos, T., Costa, A.P.S.V., Oliveira, R., Farropas, L., Calouro, F., Barradas, A.M., Carneiro, J.P.B.G. (2008a). The dynamics of soil organic matter accumulation in Portuguese grasslands soils. Options méditerranéennes – Sustainable Mediterranean Grasslands and Their Multi-Functions, A-79: 41-44.

Teixeira, Ricardo et al., 2009. Soil organic carbon stocks in Portuguese cropland soils, IST/LQARS.

Teixeira, R. (2010). Sustainable Land Uses and Carbon Sequestration: the Case of Sown Biodiverse Permanent Pastures Rich in Legumes. Ph.D. Thesis in Environmental Engineering. Instituto Superior Técnico, Technical University of Lisbon, Lisbon.

Tomé, M., 2004. Modelo de crescimento e produção para a gestão do montado de sobro em Portugal. Relatório final do projecto POCTI/AGR/35172/99. Publicações GIMREF, RFP1/2005. Departamento de Engenharia Florestal, Instituto Superior de Agronomia, Lisboa, Portugal.

Tomé, M., Barreiro, S. Cortiçada, A., Paulo, J., Meyer, A. Ramos, T., Malico, P. (2007) Inventário Florestal 2005-2005. Áreas, volumes e biomassas dos povoamentos florestais. Resultados nacionais e por NUT's II e III. Publicações GIMREF PT 8

Tomé, M., Barreiro, S., Cortiçada, A., Paulo, J. A., Meyer, A. V., Ramos, T. & Malico, P., 2007. Inventário Florestal 2005-2006. Áreas, Volumes e Biomassas dos Povoamentos Florestais. Resultados Nacionais e por NUT's II e III. Publicações GIMREF, PT 8/2007, Centro de Estudos Florestais, Instituto Superior de Agronomia, Lisboa, Portugal.

Tomé, Margarida et al., 2009. Carbon Stock Changes in Portuguese Eucalyptus, ISA.

USEPA, 1979. AP-42, Compilation of Air Pollutant Emission Factors, Section 4.5, Final Section, "Asphalt Paving Operations", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1980. AP-42 Supplement 10 for Compilation of Air Pollutant Emission Factors, Third Edition. Research Triangle Park, North Carolina: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, February, 1980.

USEPA, 1980b. AP-42, Compilation of Air Pollutant Emission Factors, Section 13.3, Final Section, "Explosive Detonation", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1981. AP-42, Compilation of Air Pollutant Emission Factors, Section 4.1, Final Section, "Dry Cleaning", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1981b. AP-42, Compilation of Air Pollutant Emission Factors, Section 4.9.1, Final Section, "General Graphic Arts", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1981c. AP-42, Compilation of Air Pollutant Emission Factors, Section 4.9.1, Final Section, "Publication Gravure Printing", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1983. AP-42, Compilation of Air Pollutant Emission Factors, Section 6.5, Final Section, "Phthalic Anhydride", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1983b. AP-42, Compilation of Air Pollutant Emission Factors, Section 6.5, Final Section, "Explosives", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1983c. AP-42, Compilation of Air Pollutant Emission Factors, Section 6.4, Final Section, "Paint and Varnishes", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1986. AP-42, Compilation of Air Pollutant Emission Factors, Section 11.15, Final Section, "Glass Manufacturing", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1986b. AP-42, Compilation of Air Pollutant Emission Factors, Section 12.3, Final Section, "Primary Copper Smelting", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1986c. AP-42, Compilation of Air Pollutant Emission Factors, Section 12.4, Final Section, "Ferroalloy Production", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1986d. AP-42, Compilation of Air Pollutant Emission Factors, Section 12.5, Final Section, "Iron and Steel Production", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1986e. AP-42, Compilation of Air Pollutant Emission Factors, Section 12.8, Final Section, "Secondary Aluminum Operations", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1990. AP-42, Compilation of Air Pollutant Emission Factors, Section 10.2, Final Section, "Chemical Wood Pulping", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1991. AP-42, Compilation of Air Pollutant Emission Factors, Section 6.6.3, Final Section, "Polystyrene", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1991b. AP-42, Compilation of Air Pollutant Emission Factors, Section 6.6.4, Final Section, "Polypropylene", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1991c. AP-42, Compilation of Air Pollutant Emission Factors, Section 6.6.1, Final Section, "Poly vinyl Chloride", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1991d. AP-42, Compilation of Air Pollutant Emission Factors, Section 6.7, Final Section, "Printing Ink", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1991e. AP-42, Compilation of Air Pollutant Emission Factors, Section 13.5, Final Section, "Industrial Flares", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1992. AP-42, Compilation of Air Pollutant Emission Factors, Section 2.5, Final Section, "Open Burning", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1993. AP-42, Compilation of Air Pollutant Emission Factors, Section 8.1, Final Section, "Synthetic Ammonia", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1993b. AP-42, Compilation of Air Pollutant Emission Factors, Section 8.10, Final Section, "Sulphuric Acid", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1993c. AP-42, Compilation of Air Pollutant Emission Factors, Section 8.2, Final Section, "Urea", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1993d. AP-42, Compilation of Air Pollutant Emission Factors, Section 8.3, Final Section, "Ammonium Nitrate", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1993e. AP-42, Compilation of Air Pollutant Emission Factors, Section 8.5.1, Final Section, "Normal Superphosphates", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1993f. AP-42, Compilation of Air Pollutant Emission Factors, Section 8.5.2, Final Section, "Triple Superphosphates", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1993g. AP-42, Compilation of Air Pollutant Emission Factors, Section 8.5.3, Final Section, "Ammonium Phosphate", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1993h. AP-42, Compilation of Air Pollutant Emission Factors, Section 8.13, Final Section, "Sulfur Recovery", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1995. AP-42, Compilation of Air Pollutant Emission Factors, Section 11.6, Final Section, "Portland Cement Manufacturing", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1995b. AP-42, Compilation of Air Pollutant Emission Factors, Section 12.13, Final Section, "Steel Foundries", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1995c. AP-42, Compilation of Air Pollutant Emission Factors, Section 5.1, Final Section, "Petroleum Refining", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1995d. AP-42, Compilation of Air Pollutant Emission Factors, Section 5.3, Final Section, "Natural Gas Processing", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1995e. AP-42, Compilation of Air Pollutant Emission Factors, Section 6.2, Final Section, "Adipic Acid", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1995f. AP-42, Compilation of Air Pollutant Emission Factors, Section 11.5, Final Section, "Refractory Manufacturing", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1995g. AP-42, Compilation of Air Pollutant Emission Factors, Section 9.11.1, Final Section, "Vegetable Oil Processing", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1995h. AP-42, Compilation of Air Pollutant Emission Factors, Section 9.5.2, Final Section, "Meat Smokehouses", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1995i. AP-42, Compilation of Air Pollutant Emission Factors, Section 9.12.2, Final Section, "Wines and Brandy", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1995j. AP-42, Compilation of Air Pollutant Emission Factors, Section 9.13.1, Final Section, "Fish Processing", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1995k. AP-42, Compilation of Air Pollutant Emission Factors, Section 9.13.2, Final Section, "Coffee Roasting", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1996. AP-42, Compilation of Air Pollutant Emission Factors, Section 1.2, Final Section, "Anthracite Coal Combustion", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York,USA.

USEPA, 1996b. AP-42, Compilation of Air Pollutant Emission Factors, Section 8.4, Final Section, "Ammonium Sulphate", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York,USA.

USEPA, 1996b. AP-42, Compilation of Air Pollutant Emission Factors, Section 1.5, Final Section, "Liquified Petroleum Gas Combustion", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1996c. AP-42, Compilation of Air Pollutant Emission Factors, Section 11.6, Final Section, "Ceramic Products Manufacturing", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1996d. AP-42, Compilation of Air Pollutant Emission Factors, Section 8.4, Final Section, "Ammonium Sulfate", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1996e. AP-42, Compilation of Air Pollutant Emission Factors, Section 9.12.1, Final Section, "Malt Beverages", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1997. AP-42, Compilation of Air Pollutant Emission Factors, Section 11.3, Final Section, "Bricks and Related Clay Products", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1997b. AP-42, Compilation of Air Pollutant Emission Factors, Section 7.1, Final Section, "Organic Liquids Storage Tanks", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1997c. AP-42, Compilation of Air Pollutant Emission Factors, Section 9.5.1, Final Section, "Meat Packing Houses", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1997d. AP-42, Compilation of Air Pollutant Emission Factors, Section 9.9.6, Final Section, "Bread Backing", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1997e. AP-42, Compilation of Air Pollutant Emission Factors, Section 9.12.3, Final Section, "Destilled Spirits", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1998. AP-42, Compilation of Air Pollutant Emission Factors, Section 1.1, Final Section, "Bituminous And Subbituminous Coal Combustion", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1998b. AP-42, Compilation of Air Pollutant Emission Factors, Section 1.3, Final Section, "Fuel Oil Combustion", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1998c. AP-42, Compilation of Air Pollutant Emission Factors, Section 1.4, Final Section, "Natural Gas Combustion", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1998d. AP-42, Compilation of Air Pollutant Emission Factors, Section 11.17, Final Section, "Lime Manufacturing", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1998e. AP-42, Compilation of Air Pollutant Emission Factors, Section 8.8, Final Section, "Nitric Acid", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1998f. AP-42, Compilation of Air Pollutant Emission Factors, Section 9.9.1, Final Section, "Grain Elevators and Processes", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 1999. USER'S GUIDE to TANKS. Storage Tank Emissions Calculation Software. Version 4.0

USEPA, 2000. AP-42, Compilation of Air Pollutant Emission Factors, Section 11.1, Final Section, "Hot Mix Asphalt Plants", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 2000d. AP-42, Compilation of Air Pollutant Emission Factors, Section 12.2, Final Section, "Coke Production", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 2001. EIIP, Volume III, Chapter 11, Revised Final,"Gasoline Marketing (Stage I and Stage II)", U.S. Environmental Protection Agency, Emissions Inventory Branch, Eastern Research Group, USA.

USEPA, 2001b. EIIP, Volume III, Chapter 12, Revised Final,"Marine Vessel Loading, Ballasting, and Transit", U.S. Environmental Protection Agency, Emissions Inventory Branch, Eastern Research Group, USA.

USEPA, 2001c. EIIP, Volume III, Chapter 17, Revised Final,"Asphalt Paving", U.S. Environmental Protection Agency, Emissions Inventory Branch, Eastern Research Group, USA.

USEPA, 2003. AP-42, Compilation of Air Pollutant Emission Factors, Section 1.6, Final Section, "Wood Residue Combustion in Boilers", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 2003b. AP-42, Compilation of Air Pollutant Emission Factors, Section 9.9.1, Final Section, "Grain Elevators and Processes", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

USEPA, 2004. AP-42, Compilation of Air Pollutant Emission Factors, Section 11.1, Final Section, "Hot Mix Asphalt Plants", U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, New York, USA.

Valente A.J.R., Nunes, T.V. And C.A. Pio - 1996, Emission of Volatile Organic Compounds by the Portuguese coniferous forests in Portugal (in Portuguese), 5ª Conferência Nacional sobre a Qualidade do Ambiente, 771-782, University of Algarve, Portugal.

Vanmechelen, L., R. Groenemans & E. van Ranst (1997) - Forest soil conditions in Europe. Results of a large-scale soil survey, Forest Soil Co-ordinating Centre / UN-ECE & EC, Geneva & Brussels.

Veldt, C - 1988, Inventorying natural VOC emissions for the CORINAIR project. In Corinair Defaukt Emission Factor handbook, Technical Annexes Volume 2, European Comission EUR 12586/2, 101-128

Veldt, C. - 1991, The use of biogenic VOC measurements in emissions inventories, Apeldoorn, The Netherlands, MT-TNO Report 91-323

Veldt, C. -1989, Leaf biomass data for the estimation of biogenic VOC emissions, Apeldoorn, The Netherlands, MT-TNO Report 89-306

Vivancos, A.D. 1997. Tratado de Fertilización. Ediciones Mundi-Prensa. Madrid

http://www.igeo.pt/produtos/CEGIG/COS.htm – consulted in March 2022

http://www.iea.org/stats/balancetable.asp?COUNTRY_CODE=PT – consulted in March 2022

http://www.ine.pt/ - consulted in January 2022

faostat.fao.org/ - consulted in November 2021

# Annex A: **Energy Balance**

*Updated: March 2026*

***Table A-1: Energy Balance Sheet for 2024***

| BALANÇO ENERGÉTICO tep<br>2024 provisório | | Hulha e Antracite<br>1 | Coque de Carvão<br>2 | **Total de Carvão**<br>3 = 1 + 2 | Petróleo Bruto<br>4 | Refugos e Produtos Intermédios<br>5 | GPL<br>6 | Gasolinas<br>7 | Petróleos<br>8 | Jets<br>9 | Gasóleo<br>10 | Fuelóleo<br>11 | Nafta<br>12 | Coque de Petróleo<br>13 | **Total de Petróleo Energético**<br>14 = 4 a 13 | Lubrificantes<br>15 | Asfaltos<br>16 | Parafinas<br>17 | Solventes<br>18 | Outros<br>19 | **Total de Petróleo Não Energético**<br>20 = 15 a 19 | **Total de Petróleo**<br>21= 14 + 20 | **Gás Natural**<br>22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **IMPORTAÇÕES** | 01 | 1 635 | 4 686 | **6 321** | 10 844 455 | 1 381 044 | 428 467 | 312 018 | 227 | 475 275 | 1 274 487 | 243 854 | 41 855 | 313 353 | **15 315 035** | 36 224 | 174 273 | 2 817 | 3 155 | 19 467 | **235 936** | **15 550 971** | **3 125 759** |
| **PRODUÇÃO DOMÉSTICA** | 02 | | | | | | | | | | | | | | | | | | | | | | |
| **VARIAÇÃO DE "STOCKS"** | 03 | 59 | - 568 | **- 509** | - 6 145 | - 121 418 | - 548 | 29 900 | 13 | - 27 663 | - 19 116 | 101 003 | - 9 504 | 53 130 | **- 348** | 301 | - 4 424 | 377 | - 245 | - 1 643 | **- 5 634** | **- 5 982** | **- 33 167** |
| **SAÍDAS** | 04 | | 368 | **368** | | 4 312 | 57 893 | 1 790 809 | | 1 694 595 | 893 915 | 1 615 346 | 1 062 511 | | **7 119 381** | 10 065 | 8 537 | 23 | 13 | 115 002 | **133 640** | **7 253 021** | |
| *Exportações* | *04.01* | | *368* | *368* | | *4 312* | *57 893* | *1 790 809* | | *23 394* | *739 898* | *1 200 822* | *1 062 511* | | *4 879 639* | *8 642* | *8 537* | *23* | *13* | *115 002* | *132 217* | *5 011 856* | |
| *Transportes Marítimos Internacionais* | *04.02* | | | | | | | | | | *154 017* | *414 524* | | | *568 541* | *1 423* | | | | | *1 423* | *569 964* | |
| *Aviação Internacional* | *04.03* | | | | | | | | | *1 671 201* | | | | | *1 671 201* | | | | | | | *1 671 201* | |
| **CONSUMO DE ENERGIA PRIMÁRIA** | 05 | 1 576 | 4 886 | **6 462** | 10 850 600 | 1 498 150 | 371 122 | -1 508 691 | 214 | -1 191 657 | 399 688 | -1 472 495 | -1 011 152 | 260 223 | **8 196 002** | 25 858 | 170 160 | 2 417 | 3 387 | - 93 892 | **107 930** | **8 303 932** | **3 158 926** |
| **PARA NOVAS FORMAS DE ENERGIA** | 06 | | | | 10 844 103 | 979 157 | - 127 910 | -2 802 925 | | -1 399 830 | -4 678 109 | -1 715 568 | -1 023 039 | | **75 879** | - 19 261 | | | | - 104 101 | **- 123 362** | **- 47 483** | **1 375 578** |
| *Briquetes* | *06.01* | | | | | | | | | | | | | | | | | | | | | | |
| *Coque* | *06.02* | | | | | | | | | | | | | | | | | | | | | | |
| *Produtos de Petróleo* | *06.03* | | | | *10 844 103* | *964 891* | *- 128 376* | *-2 802 925* | | *-1 399 830* | *-4 695 514* | *-1 938 995* | *-1 027 047* | | *- 183 693* | *- 19 261* | | | | *- 104 101* | *- 123 362* | *- 307 055* | |
| *Hidrogénio* | *06.04* | | | | | | | | | | | | | | | | | | | | | | *215 204* |
| *Petroquímica* | *06.05* | | | | | *- 4 312* | *466* | | | | | | *4 008* | | *162* | | | | | | | *162* | |
| *Eletricidade* | *06.06* | | | | | | | | | | *17 387* | *162 468* | | | *179 855* | | | | | | | *179 855* | *594 391* |
| *Cogeração* | *06.07* | | | | | *18 578* | | | | | *18* | *60 959* | | | *79 555* | | | | | | | *79 555* | *565 983* |
| *Produção de Eletricidade* | *06.07.01* | | | | | | | | | | *18* | *38 631* | | | *38 649* | | | | | | | *38 649* | |
| *Refinação de Petróleo* | *06.07.02* | | | | | *18 578* | | | | | | | | | *18 578* | | | | | | | *18 578* | *212 375* |
| *Gás de Cidade* | *06.07.03* | | | | | | | | | | | | | | | | | | | | | | |
| *Agricultura* | *06.07.04* | | | | | | | | | | | | | | | | | | | | | | *4 549* |
| *Alimentação, bebidas e tabaco* | *06.07.05* | | | | | | | | | | | *7 395* | | | *7 395* | | | | | | | *7 395* | *31 734* |
| *Têxteis* | *06.07.06* | | | | | | | | | | | | | | | | | | | | | | *31 876* |
| *Papel e Artigos de Papel* | *06.07.07* | | | | | | | | | | | *14 622* | | | *14 622* | | | | | | | *14 622* | *191 067* |
| *Químicas e Plásticos* | *06.07.08* | | | | | | | | | | | *311* | | | *311* | | | | | | | *311* | *45 222* |
| *Cerâmicas* | *06.07.09* | | | | | | | | | | | | | | | | | | | | | | *1 573* |
| *Vidro e Artigos de Vidro* | *06.07.10* | | | | | | | | | | | | | | | | | | | | | | |
| *Cimento e Cal* | *06.07.11* | | | | | | | | | | | | | | | | | | | | | | |
| *Metalúrgicas* | *06.07.12* | | | | | | | | | | | | | | | | | | | | | | |
| *Siderurgia* | *06.07.13* | | | | | | | | | | | | | | | | | | | | | | |
| *Vestuário, Calçado e Curtumes* | *06.07.14* | | | | | | | | | | | | | | | | | | | | | | *5 646* |
| *Madeira e Artigos de Madeira* | *06.07.15* | | | | | | | | | | | | | | | | | | | | | | |
| *Borracha* | *06.07.16* | | | | | | | | | | | | | | | | | | | | | | |
| *Metálo-eletro-mecânicas* | *06.07.17* | | | | | | | | | | | | | | | | | | | | | | |
| *Outras Indústrias Transformadoras* | *06.07.18* | | | | | | | | | | | | | | | | | | | | | | |
| *Indústrias Extrativas* | *06.07.19* | | | | | | | | | | | | | | | | | | | | | | *8 049* |
| *Serviços* | *06.07.20* | | | | | | | | | | | | | | | | | | | | | | *33 892* |

| BALANÇO ENERGÉTICO<br>tep<br><br>2024 provisório | | Hulha e Antracite<br><br>1 | Coque de Carvão<br><br>2 | **Total de Carvão**<br><br>3 = 1 + 2 | Petróleo Bruto<br><br>4 | Refugos e Produtos Intermédios<br><br>5 | GPL<br><br>6 | Gasolinas<br><br>7 | Petróleos<br><br>8 | Jets<br><br>9 | Gasóleo<br><br>10 | Fuelóleo<br><br>11 | Nafta<br><br>12 | Coque de Petróleo<br><br>13 | **Total de Petróleo Energético**<br><br>14 = 4 a 13 | Lubrificantes<br><br>15 | Asfaltos<br><br>16 | Parafinas<br><br>17 | Solventes<br><br>18 | Outros<br><br>19 | **Total de Petróleo Não Energético**<br><br>20 = 15 a 19 | **Total de Petróleo**<br><br>21= 14 + 20 | **Gás Natural**<br><br>22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CONSUMO DO SECTOR ENERGÉTICO** | 07 | | | | 6 497 | 518 993 | 232 | | | | 55 | 142 201 | 164 | | **668 142** | 1 909 | | | | | **1 909** | **670 051** | **104 355** |
| *Consumo Próprio da Refinação* | *07.01* | | | | | *473 542* | | | | | *55* | *141 314* | | | *614 911* | *176* | | | | | *176* | *615 087* | *99 322* |
| *Perdas da Refinação* | *07.02* | | | | *6 497* | *45 451* | *232* | | | | | *887* | *164* | | *53 231* | | | | | | | *53 231* | |
| *Coquerie e outras não especificadas* | *07.03* | | | | | | | | | | | | | | | | | | | | | | |
| *Centrais Elétricas* | *07.04* | | | | | | | | | | | | | | | *1 733* | | | | | *1 733* | *1 733* | |
| *Bombagem Hidroeléctrica* | *07.05* | | | | | | | | | | | | | | | | | | | | | | |
| *Extração de Carvão, Petróleo e GN* | *07.06* | | | | | | | | | | | | | | | | | | | | | | |
| *Perdas de Transporte e Distribuição* | *07.07* | | | | | | | | | | | | | | | | | | | | | | *5 033* |
| **CONSUMO COMO MATÉRIA PRIMA** | 08 | | | | | | *842* | | | | | | *11 723* | | *12 565* | | | | | | | *12 565* | *56 350* |
| **DISPONÍVEL PARA CONSUMO FINAL** | 09 | 1 576 | 4 886 | **6 462** | | | 497 958 | 1 294 234 | 214 | 208 173 | 5 077 742 | 100 872 | | 260 223 | **7 439 416** | 43 210 | 170 160 | 2 417 | 3 387 | 10 209 | **229 383** | **7 668 799** | **1 622 643** |
| ACERTOS | | 32 | 20 | 52 | | | 3 696 | - 11 006 | 86 | 12 557 | - 2 434 | - 15 787 | | 2 920 | - 9 968 | 412 | - 6 303 | - 8 | 310 | - 774 | - 6 363 | - 16 331 | 5 211 |
| **CONSUMO FINAL** | 10 | 1 544 | 4 866 | **6 410** | | | 494 262 | 1 305 240 | 128 | 195 616 | 5 080 176 | 116 659 | | 257 303 | **7 449 384** | 42 798 | 176 463 | 2 425 | 3 077 | 10 983 | **235 746** | **7 685 130** | **1 617 432** |
| **AGRICULTURA E PESCAS** | 10.01 | | | | | | 4 109 | 387 | 100 | | 403 883 | | | | **408 479** | 371 | | | | | **371** | **408 850** | 5 055 |
| *Agricultura* | *10.01.01* | | | | | | *4 109* | *202* | *100* | | *321 209* | | | | *325 620* | *147* | | | | | *147* | *325 767* | *5 049* |
| *Pescas* | *10.01.02* | | | | | | | *185* | | | *82 674* | | | | *82 859* | *224* | | | | | *224* | *83 083* | *6* |
| **INDÚSTRIAS EXTRATIVAS** | 10.02 | | | | | | 921 | | | | 30 926 | 1 186 | | | **33 033** | 1 328 | | | | | **1 328** | **34 361** | **2 873** |
| **INDÚSTRIAS TRANSFORMADORAS** | 10.03 | 1 544 | 4 866 | **6 410** | | | 48 704 | 1 390 | 5 | | 40 081 | 18 613 | | 257 303 | **366 096** | 10 943 | 1 228 | 2 425 | 2 611 | 10 983 | **28 190** | **394 286** | **1 072 241** |
| *Alimentação, bebidas e tabaco* | *10.03.01* | | | | | | *17 956* | | | | *9 125* | *7 361* | | | *34 442* | *138* | | | | | *138* | *34 580* | *180 823* |
| *Têxteis* | *10.03.02* | | | | | | *2 788* | | | | *4* | *1 064* | | | *3 856* | *910* | | | | | *910* | *4 766* | *104 947* |
| *Papel e Artigos de Papel* | *10.03.03* | | | | | | *745* | | *1* | | *3 251* | *8 829* | | | *12 826* | *675* | | *11* | *1 653* | *2 898* | *5 237* | *18 063* | *128 448* |
| *Químicas e Plásticos* | *10.03.04* | | | | | | *2 139* | | *1* | | *1 724* | *128* | | | *3 992* | *3 437* | *1 228* | *1 849* | *860* | *8 085* | *15 459* | *19 451* | *107 006* |
| *Cerâmicas* | *10.03.05* | | | | | | *2 424* | | | | *792* | | | *10 877* | *14 093* | *74* | | | | | *74* | *14 167* | *163 815* |
| *Vidro e Artigos de Vidro* | *10.03.06* | | | | | | *204* | | | | *72* | | | | *276* | *161* | | | | | *161* | *437* | *185 565* |
| *Cimento e Cal* | *10.03.07* | | | | | | *478* | | *2* | | *12 955* | *214* | | *246 426* | *260 075* | *271* | | | | | *271* | *260 346* | *33 672* |
| *Metalúrgicas* | *10.03.08* | *1* | *2 498* | *2 499* | | | *1 398* | | | | *327* | | | | *1 725* | *358* | | | *2* | | *360* | *2 085* | *19 164* |
| *Siderurgia* | *10.03.09* | *1 441* | *2 315* | *3 756* | | | | | | | *1 022* | | | | *1 022* | *290* | | | *8* | | *298* | *1 320* | *53 977* |
| *Vestuário, Calçado e Curtumes* | *10.03.10* | | | | | | *1 883* | | | | *7* | *74* | | | *1 964* | *29* | | | | | *29* | *1 993* | *9 596* |
| *Madeira e Artigos de Madeira* | *10.03.11* | | | | | | *994* | | | | *3 869* | | | | *4 863* | *403* | | *2* | | | *405* | *5 268* | *7 293* |
| *Borracha* | *10.03.12* | | | | | | *592* | | | | *64* | | | | *656* | *1 665* | | *546* | *1* | | *2 212* | *2 868* | *8 302* |
| *Metálo-eletro-mecânicas* | *10.03.13* | *4* | *10* | *14* | | | *13 703* | *1 390* | *1* | | *6 728* | | | | *21 822* | *2 378* | | | *87* | | *2 465* | *24 287* | *55 774* |
| *Outras Indústrias Transformadoras* | *10.03.14* | *98* | *43* | *141* | | | *3 400* | | | | *141* | *943* | | | *4 484* | *154* | | *17* | | | *171* | *4 655* | *13 859* |
| **CONSTRUÇÃO E OBRAS PÚBLICAS** | 10.04 | | | | | | 11 008 | 2 | | | 65 186 | 14 066 | | | **90 262** | 1 018 | 175 235 | | 266 | | **176 519** | **266 781** | **26 408** |
| **TRANSPORTES** | 10.05 | | | | | | 58 473 | 1 303 245 | | 177 473 | 4 456 428 | 68 604 | | | **6 064 223** | 28 896 | | | | | **28 896** | **6 093 119** | **35 913** |
| *Aviação Nacional* | *10.05.01* | | | | | | | *1 242* | | *177 473* | | | | | *178 715* | *238* | | | | | *238* | *178 953* | |
| *Transportes Marítimos Nacionais* | *10.05.02* | | | | | | | | | | *39 101* | *68 604* | | | *107 705* | *295* | | | | | *295* | *108 000* | |
| *Caminho de Ferro* | *10.05.03* | | | | | | | | | | *8 125* | | | | *8 125* | *24* | | | | | *24* | *8 149* | |
| *Rodoviários* | *10.05.04* | | | | | | *58 473* | *1 302 003* | | | *4 409 202* | | | | *5 769 678* | *28 339* | | | | | *28 339* | *5 798 017* | *35 913* |
| **SETOR DOMÉSTICO** | 10.06 | | | | | | 297 377 | | 1 | | 37 945 | | | | **335 323** | 1 | | | | | **1** | **335 324** | **254 926** |
| **SERVIÇOS** | 10.07 | | | | | | 73 670 | 216 | 22 | 18 143 | 45 727 | 14 190 | | | **151 968** | 241 | | | 200 | | **441** | **152 409** | **220 016** |

| BALANÇO ENERGÉTICO<br>tep<br><br>2024 provisório | | Gases Incond. de Petroquímica<br><br>23 | Hidrogénio<br><br>24 | Gases e Outros Derivados<br><br>25 = 23 + 24 | Hidro-eletricidade<br><br>26 | Eólica<br><br>27 | Foto-voltaica<br><br>28 | Geo-térmica<br><br>29 | Termo-eletricidade<br><br>30 | Total de Eletricidade<br><br>31 | Calor<br><br>32 | Resíduos não Renováveis<br><br>33 | Solar Térmico<br><br>34 | Lenhas e Resíduos Vegetais<br><br>35 | Resíduos Sólidos Urbanos<br><br>36 | Licores Sulfitivos<br><br>37 | Outros Renováveis<br><br>38 | Biogás<br><br>39 | Biocombustíveis<br><br>40 | Bombas de Calor<br><br>41 | Renováveis Sem Eletricidade<br><br>42 = 34 a 41 | TOTAL GERAL<br><br>43=3+21+22+25+31+32+33+42 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **IMPORTAÇÕES** | 01 | | | | | | | | | **1 234 655** | | 21 066 | | 45 432 | | | 13 119 | | 171 357 | | **229 908** | 20 168 680 |
| **PRODUÇÃO DOMÉSTICA** | 02 | | | | 1 599 109 | 1 240 031 | 609 652 | 17 363 | | **3 466 155** | | 172 225 | 113 292 | 1 977 572 | 140 280 | 1 049 116 | 31 163 | 87 628 | 265 398 | 714 765 | **4 379 214** | **8 017 594** |
| **VARIAÇÃO DE "STOCKS"** | 03 | | | | | | | | | | | | | | | | | | - 3 640 | | **- 3 640** | **- 43 298** |
| **SAÍDAS** | 04 | | | | | | | | | **334 664** | | | | 241 907 | | | | | 53 125 | | **295 032** | **7 883 085** |
| *Exportações* | *04.01* | | | | | | | | | *334 664* | | | | *241 907* | | | | | *53 125* | | *295 032* | *5 641 920* |
| *Transportes Marítimos Internacionais* | *04.02* | | | | | | | | | | | | | | | | | | | | | *569 964* |
| *Aviação Internacional* | *04.03* | | | | | | | | | | | | | | | | | | | | | *1 671 201* |
| **CONSUMO DE ENERGIA PRIMÁRIA** | 05 | | | | *1 599 109* | *1 240 031* | *609 652* | *17 363* | | **4 366 146** | | 193 291 | 113 292 | 1 781 097 | 140 280 | 1 049 116 | 44 282 | 87 628 | 387 270 | 714 765 | **4 317 730** | **20 346 487** |
| **PARA NOVAS FORMAS DE ENERGIA** | 06 | | | | *1 599 109* | *1 240 031* | *609 652* | *17 363* | - 927 620 | **- 927 620** | **-1 100 832** | 100 726 | | 681 481 | 140 280 | 1 049 116 | | 72 807 | 384 900 | | **2 328 584** | **1 728 953** |
| *Briquetes* | *06.01* | | | | | | | | | | | | | | | | | | | | | |
| *Coque* | *06.02* | | | | | | | | | | | | | | | | | | | | | |
| *Produtos de Petróleo* | *06.03* | | *183 531* | *183 531* | | | | | | | | | | | | | | | *384 900* | | *384 900* | *261 376* |
| *Hidrogénio* | *06.04* | | *- 183 531* | *- 183 531* | | | | | | | | | | | | | | | | | | *31 673* |
| *Petroquímica* | *06.05* | *- 2 891* | | *- 2 891* | | | | | | | | | | | | | | | | | | *- 2 729* |
| *Eletricidade* | *06.06* | | | | *1 599 109* | *1 240 031* | *609 652* | *17 363* | *- 575 254* | *- 575 254* | | *96 680* | | *413 067* | *140 280* | | | *64 527* | | | 617 874 | *913 546* |
| *Cogeração* | *06.07* | *2 891* | | *2 891* | | | | | *- 352 366* | *- 352 366* | *-1 100 832* | *4 046* | | *268 414* | | *1 049 116* | | *8 280* | | | *1 325 810* | *525 085* |
| *Produção de Eletricidade* | *06.07.01* | | | | | | | | *- 16 594* | *- 16 594* | *- 1 305* | | | | | | | | | | | *20 750* |
| *Refinação de Petróleo* | *06.07.02* | | | | | | | | *- 71 336* | *- 71 336* | *- 127 010* | | | | | | | | | | | *32 607* |
| *Gás de Cidade* | *06.07.03* | | | | | | | | | | | | | | | | | | | | | |
| *Agricultura* | *06.07.04* | | | | | | | | *- 2 000* | *- 2 000* | *- 1 820* | | | | | | | *379* | | | *379* | *1 108* |
| *Alimentação, bebidas e tabaco* | *06.07.05* | | | | | | | | *- 7 003* | *- 7 003* | *- 26 451* | | | | | | | | | | | *5 675* |
| *Têxteis* | *06.07.06* | | | | | | | | *- 13 003* | *- 13 003* | *- 11 251* | | | | | | | | | | | *7 622* |
| *Papel e Artigos de Papel* | *06.07.07* | | | | | | | | *- 206 173* | *- 206 173* | *- 873 776* | | | *223 692* | | *1 049 116* | | *2 773* | | | *1 275 581* | *401 321* |
| *Químicas e Plásticos* | *06.07.08* | *2 891* | | *2 891* | | | | | *- 7 417* | *- 7 417* | *- 15 582* | *4 046* | | | | | | | | | | *29 471* |
| *Cerâmicas* | *06.07.09* | | | | | | | | *- 605* | *- 605* | *- 685* | | | | | | | | | | | *283* |
| *Vidro e Artigos de Vidro* | *06.07.10* | | | | | | | | | | | | | | | | | | | | | |
| *Cimento e Cal* | *06.07.11* | | | | | | | | | | | | | | | | | | | | | |
| *Metalúrgicas* | *06.07.12* | | | | | | | | | | | | | | | | | | | | | |
| *Siderurgia* | *06.07.13* | | | | | | | | | | | | | | | | | | | | | |
| *Vestuário, Calçado e Curtumes* | *06.07.14* | | | | | | | | *- 2 347* | *- 2 347* | *- 1 429* | | | | | | | | | | | *1 870* |
| *Madeira e Artigos de Madeira* | *06.07.15* | | | | | | | | *- 7 962* | *- 7 962* | *- 23 868* | | | *44 722* | | | | | | | *44 722* | *12 892* |
| *Borracha* | *06.07.16* | | | | | | | | | | | | | | | | | | | | | |
| *Metálo-eletro-mecânicas* | *06.07.17* | | | | | | | | | | | | | | | | | | | | | |
| *Outras Indústrias Transformadoras* | *06.07.18* | | | | | | | | *- 748* | *- 748* | *- 25* | | | | | | | *2 280* | | | *2 280* | *1 507* |
| *Indústrias Extrativas* | *06.07.19* | | | | | | | | *- 2 257* | *- 2 257* | *- 5 344* | | | | | | | | | | | *448* |
| *Serviços* | *06.07.20* | | | | | | | | *- 14 923* | *- 14 923* | *- 12 286* | | | | | | | *2 848* | | | *2 848* | *9 531* |

| BALANÇO ENERGÉTICO tep<br>2024 provisório | | Gases Incond. de Petroquímica<br>23 | Hidrogénio<br>24 | Gases e Outros Derivados<br>25 = 23 + 24 | Hidro-eletricidade<br>26 | Eólica<br>27 | Foto-voltaica<br>28 | Geo-térmica<br>29 | Termo-eletricidade<br>30 | Total de Eletricidade<br>31 | Calor<br>32 | Resíduos não Renováveis<br>33 | Solar Térmico<br>34 | Lenhas e Resíduos Vegetais<br>35 | Resíduos Sólidos Urbanos<br>36 | Licores Sulfitivos<br>37 | Outros Renováveis<br>38 | Biogás<br>39 | Biocombustíveis<br>40 | Bombas de Calor<br>41 | Renováveis Sem Eletricidade<br>42 = 34 a 41 | TOTAL GERAL<br>43=3+21+22+25 +31+32+33+42 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CONSUMO DO SECTOR ENERGÉTICO** | 07 | | | | | | | | | **945 237** | **127 010** | | | | | | | | | | | **1 846 653** |
| *Consumo Próprio da Refinação* | *07.01* | | | | | | | | | *53 179* | *127 010* | | | | | | | | | | | *894 598* |
| *Perdas da Refinação* | *07.02* | | | | | | | | | | | | | | | | | | | | | *53 231* |
| *Coquerie e outras não especificadas* | *07.03* | | | | | | | | | | | | | | | | | | | | | |
| *Centrais Elétricas* | *07.04* | | | | | | | | | *54 615* | | | | | | | | | | | | *56 348* |
| *Bombagem Hidroeléctrica* | *07.05* | | | | | | | | | *408 135* | | | | | | | | | | | | *408 135* |
| *Extração de Carvão, Petróleo e GN* | *07.06* | | | | | | | | | | | | | | | | | | | | | |
| *Perdas de Transporte e Distribuição* | *07.07* | | | | | | | | | *429 308* | | | | | | | | | | | | *434 341* |
| **CONSUMO COMO MATÉRIA PRIMA** | 08 | | | | | | | | | | | | | | | | | | | | | *68 915* |
| **DISPONÍVEL PARA CONSUMO FINAL** | 09 | | | | | | | | | **4 348 529** | **973 822** | 92 565 | 113 292 | 1 099 616 | | | 44 282 | 14 821 | 2 370 | 714 765 | **1 989 146** | **16 701 966** |
| ACERTOS | | | | | | | | | | 24 | | | | | | | | | 200 | | 200 | - 10 844 |
| **CONSUMO FINAL** | 10 | | | | | | | | | **4 348 505** | **973 822** | 92 565 | 113 292 | 1 099 616 | | | 44 282 | 14 821 | 2 170 | 714 765 | **1 988 946** | **16 712 810** |
| **AGRICULTURA E PESCAS** | 10.01 | | | | | | | | | **95 802** | **1 820** | | | **2 698** | | | | | | | **2 698** | **514 225** |
| *Agricultura* | *10.01.01* | | | | | | | | | *88 533* | *1 820* | | | *2 698* | | | | | | | *2 698* | *423 867* |
| *Pescas* | *10.01.02* | | | | | | | | | *7 269* | | | | | | | | | | | | *90 358* |
| **INDÚSTRIAS EXTRATIVAS** | 10.02 | | | | | | | | | **48 949** | **5 344** | | | | | | | | | | | **91 527** |
| **INDÚSTRIAS TRANSFORMADORAS** | 10.03 | | | | | | | | | **1 403 356** | **954 556** | **92 565** | | **297 475** | | | 42 173 | 14 821 | 187 | | **354 656** | **4 278 070** |
| *Alimentação, bebidas e tabaco* | *10.03.01* | | | | | | | | | *190 615* | *26 451* | | | *22 500* | | | | *2 583* | | | *25 083* | *457 552* |
| *Têxteis* | *10.03.02* | | | | | | | | | *73 301* | *11 251* | | | *17 860* | | | | | | | *17 860* | *212 125* |
| *Papel e Artigos de Papel* | *10.03.03* | | | | | | | | | *266 513* | *873 776* | | | *136 101* | | | *5 895* | *12 238* | | | *154 234* | *1 441 034* |
| *Químicas e Plásticos* | *10.03.04* | | | | | | | | | *210 593* | *15 582* | *163* | | *7 734* | | | | | *187* | | *7 921* | *360 716* |
| *Cerâmicas* | *10.03.05* | | | | | | | | | *41 577* | *685* | | | *25 404* | | | | | | | *25 404* | *245 648* |
| *Vidro e Artigos de Vidro* | *10.03.06* | | | | | | | | | *50 674* | | | | | | | | | | | | *236 676* |
| *Cimento e Cal* | *10.03.07* | | | | | | | | | *61 758* | | *92 402* | | *37 505* | | | *36 278* | | | | *73 783* | *521 961* |
| *Metalúrgicas* | *10.03.08* | | | | | | | | | *29 554* | | | | *13* | | | | | | | *13* | *53 315* |
| *Siderurgia* | *10.03.09* | | | | | | | | | *107 861* | | | | | | | | | | | | *166 914* |
| *Vestuário, Calçado e Curtumes* | *10.03.10* | | | | | | | | | *28 356* | *1 429* | | | *2 693* | | | | | | | *2 693* | *44 067* |
| *Madeira e Artigos de Madeira* | *10.03.11* | | | | | | | | | *81 922* | *23 868* | | | *46 142* | | | | | | | *46 142* | *164 493* |
| *Borracha* | *10.03.12* | | | | | | | | | *29 761* | | | | *52* | | | | | | | *52* | *40 983* |
| *Metálo-eletro-mecânicas* | *10.03.13* | | | | | | | | | *177 135* | | | | *505* | | | | | | | *505* | *257 715* |
| *Outras Indústrias Transformadoras* | *10.03.14* | | | | | | | | | *53 736* | *1 514* | | | *966* | | | | | | | *966* | *74 871* |
| **CONSTRUÇÃO E OBRAS PÚBLICAS** | 10.04 | | | | | | | | | 32 909 | | | | 2 | | | | | | | **2** | **326 100** |
| **TRANSPORTES** | 10.05 | | | | | | | | | 75 757 | | | | | | | | | 1 983 | | **1 983** | **6 206 772** |
| *Aviação Nacional* | *10.05.01* | | | | | | | | | | | | | | | | | | | | | *178 953* |
| *Transportes Marítimos Nacionais* | *10.05.02* | | | | | | | | | | | | | | | | | | | | | *108 000* |
| *Caminho de Ferro* | *10.05.03* | | | | | | | | | *43 132* | | | | | | | | | | | | *51 281* |
| *Rodoviários* | *10.05.04* | | | | | | | | | *32 625* | | | | | | | | | *1 983* | | *1 983* | *5 868 538* |
| **SETOR DOMÉSTICO** | 10.06 | | | | | | | | | **1 270 033** | | | 69 169 | *771 576* | | | | | | 238 875 | **1 079 620** | **2 939 903** |
| **SERVIÇOS** | 10.07 | | | | | | | | | **1 421 699** | **12 102** | | 44 123 | 27 865 | | | 2 109 | | | 475 890 | **549 987** | **2 356 213** |

# Annex B: **Energy (CRT 1.A.3, 1.A.4 and 1.A.5)**

## Transport (CRT 1.A.3)

*Updated: March 2025*

***Table B-1: Activity data for CRT 1.A.3.a: Fuel consumption from Aviation sector (t)***

| Fuel Sales | | NAPFUE | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aviation Gasoline | L | 209 | 1 893 | 1 751 | 1 560 | 1 212 | 1 435 | 1 914 | 1 540 | 1 876 | 1 925 | 1 964 | 2 353 | 2 304 |
| Jet Fuel | L | 207 | 554 471 | 564 264 | 596 977 | 565 406 | 572 457 | 599 465 | 595 172 | 613 723 | 654 021 | 720 960 | 752 932 | 741 541 |

| Fuel Sales | | NAPFUE | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aviation Gasoline | L | 209 | 2 334 | 1 985 | 1 847 | 2 192 | 2 179 | 2 086 | 2 280 | 2 280 | 2 869 | 2 258 | 1 268 |
| Jet Fuel | L | 207 | 715 095 | 770 040 | 835 208 | 865 857 | 907 189 | 949 650 | 969 349 | 907 530 | 985 343 | 1 006 836 | 1 015 897 |

| Fuel Sales | | NAPFUE | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aviation Gasoline | L | 209 | 1 168 | 1 333 | 1 257 | 1 256 | 1 211 | 804 | 1 101 | 1 072 | 1 183 | 1 607 | 1 436 |
| Jet Fuel | L | 207 | 1 027 228 | 1 086 001 | 1 139 567 | 1 239 311 | 1 409 602 | 1 501 383 | 1 580 683 | 592 926 | 758 571 | 1 488 691 | 1 717 389 |

***Table B-2: Aircraft type and representative aircraft for LTO and cruise emission factors***

| Code | Aircraft Name | Fuel Type | Description | Representative | |
|---|---|---|---|---|---|
| | | | | LTO | Cruise |
| 100 | Fokker 100 | L JeK | L2J | 100 | 100 |
| 146 | BAe 146 all pax models | L JeK | L4J | 146 | 146 |
| 310 | Airbus A310 all pax models | L JeK | L2J | 310 | 310 |
| 319 | Airbus A319 | L JeK | L2J | 319 | 320 |
| 320 | Airbus A320-100/200 | L JeK | L2J | 321 | 320 |
| 321 | Airbus A321-100/200 | L JeK | L2J | 321 | 320 |
| 330 | Airbus A330 all models | L JeK | L2J | 330 | 330 |
| 332 | Airbus A330-200 | L JeK | L2J | 330 | 330 |
| 333 | Airbus A330-300 | L JeK | L2J | 330 | 330 |
| 340 | Airbus A340 all models | L JeK | L4J | 342 | 340 |
| 342 | Airbus A340-200 | L JeK | L4J | 342 | 340 |
| 343 | Airbus A340-300 | L JeK | L4J | 343 | 340 |
| 346 | Airbus A340-600 | L JeK | L4J | 346 | 340 |
| 707 | Boeing 707/720 all pax models | L JeK | L4J | 707 | 340 |
| 717 | Boeing 717 | L JeK | L2J | 717 | NA |
| 727 | Boeing 727 all pax models | L JeK | L3J | 727 | 727 |
| 731 | Boeing 737-100 pax | L JeK | L2J | 731 | 731 |
| 735 | Boeing 737-500 pax | L JeK | L2J | 735 | 734 |
| 736 | Boeing 737-600 pax | L JeK | L2J | 736 | 734 |
| 737 | Boeing 737 all pax models | L JeK | L2J | 731 | 731 |
| 739 | Boeing 737-900 pax | L JeK | L2J | 739 | 734 |
| 741 | Boeing 747-100 pax | L JeK | L4J | 741 | 741 |
| 747 | Boeing 747 all pax models | L JeK | L4J | 747 | 741 |
| 753 | Boeing 757-300 pax | L JeK | L2J | 752 | 757 |
| 757 | Boeing 757 all pax models | L JeK | L2J | 752 | 757 |
| 764 | Boeing 767-400 pax | L JeK | L2J | 764 | 767 |
| 767 | Boeing 767 all pax models | L JeK | L2J | 767 | 767 |
| 772 | Boeing 777-200 pax | L JeK | L2J | 772 | 777 |
| 773 | Boeing 777-300 pax | L JeK | L2J | 773 | 777 |
| 777 | Boeing 777 all pax models | L JeK | L2J | 772 | 777 |
| 14F | BAe 146 Freighter (-100/200/300QT & QC) | L JeK | L4J | 146 | 146 |
| 31F | Airbus A310 Freighter | L JeK | L2J | 310 | 310 |
| 31X | Airbus A310-200 Freighter | L JeK | L2J | 312 | 310 |
| 32S | Airbus A318/319/320/321 | L JeK | L2J | 320 | 320 |
| 70F | Boeing 707 Freighter | L JeK | L4J | 70F | 340 |
| 70M | Boeing 707 Combi | L JeK | L4J | 707 | 340 |
| 72F | Boeing 727 Freighter (-100/200) | L JeK | L3J | 72F | 727 |
| 72M | Boeing 727 Combi | L JeK | L3J | 727 | 727 |
| 72S | Boeing 727-200 Advanced pax | L JeK | L3J | 722 | 727 |
| 72X | Boeing 727-100 Freighter | L JeK | L3J | 721 | 727 |
| 73F | Boeing 737 all Freighter models | L JeK | L2J | 731 | 731 |
| 73H | Boeing 737-800 (winglets) pax | L JeK | L2J | 73H | 734 |
| 73M | Boeing 737-200 Combi | L JeK | L2J | 732 | 731 |
| 73W | Boeing 737-700 (winglets) pax | L JeK | L2J | 73W | 734 |
| 73Y | Boeing 737-300 Freighter | L JeK | L2J | 733 | 731 |
| 74C | Boeing 747-200 Combi | L JeK | L4J | 742 | 741 |
| 74F | Boeing 747 all Freighter models | L JeK | L4J | 74F | 741 |
| 74J | Boeing 747-400 (Domestic) pax | L JeK | L4J | 744 | 74J |
| 74M | Boeing 747 all Combi models | L JeK | L4J | 747 | 741 |
| 74U | Boeing 747-300 / 747-200 SUD Freighter | L JeK | L4J | 743 | 741 |
| 75F | Boeing 757 Freighter | L JeK | L2J | 75F | 757 |
| 75M | Boeing 757 Mixed Configuration | L JeK | L2J | 752 | 757 |
| 76F | Boeing 767 all Freighter models | L JeK | L2J | 767 | 767 |
| 76X | Boeing 767-200 Freighter | L JeK | L2J | 762 | 767 |
| 76Y | Boeing 767-300 Freighter | L JeK | L2J | 763 | 767 |
| A109 | Agusta A-109 | L JeK | H2T | S61 | NA |
| A26 | Antonov AN-26 | L JeK | L2T | A26 | AN6 |
| A32 | Antonov AN-32 | L JeK | L2T | A32 | NA |
| A4F | Antonov AN-124 Ruslan | L JeK | L4J | A4F | 340 |
| A660 | Ayres Turbo Thrush (S-2R-T660) | L JeK | L1T | C208 | C208 |
| AA5 | Gulfstream American AA-5 Traveler | L AvG | L1P | AA5 | DHO |
| AB3 | Airbus Industrie A300 pax | L JeK | L2J | AB3 | 310 |
| AB4 | Airbus Industrie A300B2/B4/C4 pax | L JeK | L2J | AB4 | 310 |
| AB6 | Airbus Industrie A300-600 pax | L JeK | L2J | AB6 | 310 |
| ABB | Airbus Industrie A300-600ST Beluga Freighter | L JeK | L2J | AB6 | 310 |
| ABF | Airbus Industrie A300 Freighter | L JeK | L2J | AB3 | 310 |

| Code | Aircraft Name | Fuel Type | Description | Representative | |
|---|---|---|---|---|---|
| | | | | LTO | Cruise |
| AC11 | Rockwell Commander | L AvG | L1P | C150 | DHO |
| ACD | Gulfstream/Rockwell (Aero) Commander/Turbo Commander | L JeK | L2T | ACD | NA |
| ACT | Gulfstream/Rockwell (Aero) Turbo Commander | L JeK | L2T | ACT | NA |
| AEST | Aerostar 600 | L AvG | L2P | AEST | DHO |
| AJET | Dassault Alpha Jet | L JeK | L2J | FA10 | S20 |
| ALO3 | Aerospatiale Alouette 3 | L JeK | H1T | ALO3 | NA |
| AN4 | Antonov AN-24 | L JeK | L2T | AN4 | NA |
| AN6 | Antonov AN-26 / AN-30 /AN-32 | L JeK | L2T | A26 | AN6 |
| AN7 | Antonov AN-72 / AN-74 | L JeK | L2J | AN7 | F27 |
| ANF | Antonov AN-12 | L JeK | L4T | ANF | NA |
| APH | Eurocopter (Aerospatiale) SA330 Puma / AS332 Super Puma | L JeK | H2T | S61 | NA |
| ARJ | Avro RJ70 / RJ85 / RJ100 Avroliner | L JeK | L4J | ARJ | 146 |
| AS32 | Aerospatiale Super Puma | L JeK | H2T | S61 | NA |
| AS50 | Aerospatiale Fennec (AS-550) | L JeK | H1T | S61 | NA |
| AS65 | Aerospatiale Dolphin (AS-366) | L JeK | H2T | AS65 | NA |
| ASTR | IAI Gulfstream G100 | L JeK | L2J | WWP | S20 |
| AT3 | AIDC AT-3 Tzu-Chung | L JeK | L2J | AT3 | NA |
| AT43 | Aerospatiale/Alenia ATR 42-300 / 320 | L JeK | L2T | ATR | AT42 |
| AT5 | Aerospatiale/Alenia ATR 42-500 | L JeK | L2T | ATR | AT42 |
| AT5T | Air Tractor AT-502 | L JeK | L1T | C208 | C208 |
| AT7 | Aerospatiale/Alenia ATR 72 | L JeK | L2T | ATR | AT7 |
| AT8T | Air Tractor AT-802 Fire Boss | L JeK | L1T | C208 | NA |
| ATP | British Aerospace ATP | L JeK | L2T | ATR | AT42 |
| ATR | Aerospatiale/Alenia ATR 42/ ATR 72 | L JeK | L2T | ATR | AT42 |
| B06 | Agusta AB-206 LongRanger | L JeK | H1T | S61 | NA |
| B11 | British Aerospace (BAC) One Eleven / RomBAC One Eleven | L JeK | L2J | B11 | B11 |
| B12 | British Aerospace (BAC) One Eleven 200 | L JeK | L2J | B12 | B11 |
| B200 | Beech 200 Super King Air | L JeK | L2T | BE20 | BE20 |
| B350 | Beech Super King Air 350 | L JeK | L2T | BE30 | B350 |
| B36T | Allison 36 Turbine Bonanza | L JeK | L1T | C208 | C208 |
| B412 | Bell 412 | LJeK | H1T | BH2 | NA |
| B72 | Boeing 720B pax | L JeK | L4J | B72 | NA |
| B735 | Boeing 737-500 | L JeK | L2J | 735 | 734 |
| B74R | Boeing 747SR | LJeK | L4J | 74V | 741 |
| B74S | Boeing 747SP | L JeK | L4J | B74S | 741 |
| BE1 | Beechcraft 1900/1900C/1900D | L JeK | L2T | BE1 | BE1 |
| BE10 | Beech King Air 100 | L JeK | L2T | BE10 | B350 |
| BE18 | Beech 18 | L AvG | L2P | BE18 | DHO |
| BE19 | Beech 19 Sport | L AvG | L1P | BE19 | DHO |
| BE2 | Beechcraft twin piston engines | L AvG | L2P | BE55 | DHO |
| BE20 | Beech Huron | L JeK | L2T | BE20 | BE20 |
| BE30 | Beech Super King Air 300 | L JeK | L2T | BE30 | B350 |
| BE33 | Beech Bonanza 33 | L AvG | L1P | BE33 | DHO |
| BE35 | Beech Bonanza 35 | L AvG | L1P | BE33 | DHO |
| BE36 | Beech Bonanza 36 | L AvG | L1P | BE33 | DHO |
| BE4 | Beech Beechjet | L JeK | L2J | BE40 | LOH |
| BE40 | Beech Beechjet | L JeK | L2J | BE40 | LOH |
| BE55 | Beech Baron | L AvG | L2P | BE55 | DHO |
| BE58 | Beech Baron 58 | L AvG | L2P | BE55 | DHO |
| BE76 | Beech Duchess | L AvG | L2P | BE55 | DHO |
| BE95 | Beech 95 Travel Air | LJeK | L2T | BE10 | B350 |
| BE9L | Beech King Air 90 | L JeK | L2T | BE10 | B350 |
| BEC | Beechcraft light aircraft | L AvG | L1P | BE19 | DHO |
| BEH | Beechcraft 1900D | L JeK | L2T | BE1 | BE1 |
| BEP | Beechcraft light aircraft - single engine | L AvG | L1P | BE19 | DHO |
| BES | Beechcfrat 1900/1900C | L JeK | L2T | BE1 | BE1 |
| BET | Beechcraft light aircraft - twin turboprop engine | L JeK | L2T | BE20 | BE1 |
| BH2 | Bell Helicopters | L JeK | H1T | BH2 | NA |
| BNI | Pilatus Britten-Norman BN-2A/B Islander | L AvG | L2P | BNI | DHO |
| C130 | Lockheed Hercules | L JeK | L4T | C130 | LOH |
| C150 | Cessna 150 | L AvG | L1P | C150 | DHO |
| C160 | Transall C-160 | L JeK | L2T | C160 | NA |
| C17 | Boeing Globemaster 3 | L JeK | L4J | C17 | NA |
| C172 | Cessna 172 Mescalero | L AvG | L1P | C150 | DHO |
| C177 | Cessna 177 Cardinal | L AvG | L1P | C150 | DHO |
| C182 | Cessna 182 Skylane | L AvG | L1P | C150 | DHO |
| C185 | Cessna 185 Skywagon | L AvG | L1P | C150 | DHO |
| C206 | Cessna 206 Stationair | L AvG | L1P | C150 | DHO |

| Code | Aircraft Name | Fuel Type | Description | Representative | |
|---|---|---|---|---|---|
| | | | | LTO | Cruise |
| C208 | Cessna 208 Caravan | L JeK | L1T | C208 | C208 |
| C210 | Cessna 210 Centurion | L AvG | L1P | C150 | DHO |
| C303 | Cessna T303 Crusader | L AvG | L2P | C404 | DHO |
| C310 | Cessna 310 | L AvG | L2P | C337 | DHO |
| C337 | Cessna 337 Super Skymaster | L AvG | L2P | C337 | DHO |
| C402 | Cessna 402 Businessliner | L AvG | L2P | C404 | DHO |
| C404 | Cessna 402 Titan | L AvG | L2P | C404 | DHO |
| C414 | Cessna 414 Chancellor | L AvG | L2P | C404 | DHO |
| C421 | Cessna 421 Executive Commuter | L AvG | L2P | C404 | DHO |
| C425 | Cessna 425 Conquest | L JeK | L2T | C425 | NA |
| C441 | Cessna 441 Conquest | L JeK | L2T | C441 | NA |
| C500 | Cessna 500 Citation | L JeK | L2J | C500 | DHO |
| C501 | Cessna 501 Citation 1SP | L JeK | L2J | C500 | DHO |
| C510 | Cessna Citation Muatang | LJeK | L2J | C500 | DHO |
| C525 | Cessna 525 Citation | L JeK | L2J | C500 | DHO |
| C550 | Cessna 550 Citation 2 | L JeK | L2J | C550 | DHO |
| C551 | Cessna 551 Citation 2SP | L JeK | L2J | C551 | DHO |
| C560 | Cessna 560 Citation 5 | L JeK | L2J | C560 | S20 |
| C56X | Cessna 560XL Citation Excel | L JeK | L2J | C560 | S20 |
| C650 | Cessna 650 Citation 3 | L JeK | L2J | C680 | SH6 |
| C680 | Cessna 680 Citation Sovereign | L JeK | L2J | C680 | SH6 |
| C750 | Cessna 750 Citation 10 | L JeK | L2J | C750 | F50 |
| CCJ | Canadair Challenger | L JeK | L2J | CCJ | AN6 |
| CCX | Canadair Global Express | L JeK | L2J | CR7 | FRJ |
| CL30 | BD-100 Challenge | LJeK | L2J | CL30 | NA |
| CL4 | Canadair CL-44 | L JeK | L4T | CL4 | F28 |
| CN2 | Cessna light aircraft - twin piston engines | L AvG | L2P | C404 | DHO |
| CNA | Cessna light aircraft | 0 | 0 | C150 | DHO |
| CNJ | Cessna Citation | L JeK | L2J | C500 | DHO |
| CNT | Cessna light aircraft - twin turboprop engines | L JeK | L2T | CNT | NA |
| CRJ | Canadair Regional Jet | L JeK | L2J | CR1 | FRJ |
| CRV | Aerospatiale (Sud Aviation) Se.210 Caravelle | L JeK | L2J | CRV | D94 |
| CS2 | CASA / IPTN 212 Aviocar | L JeK | L2T | CS2 | NA |
| CS5 | CASA / IPTN CN-235 | L JeK | L2T | CS5 | NA |
| CVF | Convair CV-240 / 440 / 580 / 600 / 640 Freighter | L JeK | L2T | CVF | NA |
| CVR | Convair CV-240 / 440 / 580 / 600 / 640 pax | L JeK | L2T | CVR | NA |
| CVY | Convair CV-580 / 600 / 640 Freighter | L JeK | L2T | CVY | BE1 |
| D10 | Douglas DC-10 pax | L JeK | L3J | D10 | D10 |
| D1F | Douglas DC-10 all Freighters | L JeK | L3J | D10 | D10 |
| D1X | Douglas DC-10-10 Freighter | L JeK | L3J | D11 | D10 |
| D28 | Fairchild Dornier Do.228 | L JeK | L2T | D28 | BE20 |
| D38 | Fairchild Dornier Do.328 | L JeK | L2T | FRJ | FRJ |
| D8F | Douglas DC-8 all Freighters | L JeK | L4J | D8T | 340 |
| D8L | Douglas DC-8-62 pax | L JeK | L4J | D8X | 340 |
| D8M | Douglas DC-8 all Combi models | L JeK | L4J | DC8 | 340 |
| D8T | Douglas DC-8-50 Freighter | L JeK | L4J | D8T | 340 |
| D8Y | Douglas DC-8-71 / 72 / 73 Freighters | L JeK | L4J | D8Y | 340 |
| D9F | Douglas DC-9 all Freighters | L JeK | L2J | D9F | D91 |
| DC3T | Douglas DC-3 | L JeK | L2T | DC3T | NA |
| DC8 | Douglas DC-8 all pax models | L JeK | L4J | DC8 | 340 |
| DC9 | Douglas DC-9 all pax models | L JeK | L2J | DC9 | D91 |
| DF3 | Dassault (Breguet Mystere) Falcon 50 / 900 | L JeK | L3J | FA50 | F50 |
| DFL | Dassault (Breguet Mystere) Falcon | 0 | 0 | FA10 | S20 |
| DH1 | De Havilland Canada DHC-8-100 Dash 8 / 8Q | L JeK | L2T | DH8 | DH8 |
| DH3 | De Havilland Canada DHC-8-300 Dash 8 / 8Q | L JeK | L2T | DH8 | DH8 |
| DH4 | De Havilland Canada DHC-8-400 Dash 8Q | L JeK | L2T | DH8 | DH8 |
| DH7 | De Havilland Canada DHC-7 Dash 7 | L JeK | L4T | DH7 | DH7 |
| DH8 | De Havilland Canada DHC-8 Dash 8 all models | L JeK | L2T | DH8 | DH8 |
| DHB | De Havilland Canada DHC-2 Beaver / Turbo Beaver | L AvG | L1P | DHB | DHO |
| DHO | De Havilland Canada DHC-3 Otter / Turbo Otter | L AvG | L1P | DHB | DHO |
| DHP | De Havilland Canada DHC-2 Beaver | L AvG | L1P | DHB | DHO |
| DHR | De Havilland Canada DHC-2 Turbo-Beaver | L AvG | L1P | DHB | DHO |
| DHS | De Havilland Canada DHC-3 Otter | L AvG | L1P | DHB | DHO |
| DHT | De Havilland Canada DHC-6 Twin Otter | L JeK | L2T | DHT | B350 |
| DR40 | Robin DN-400 | L AvG | L1P | C150 | DHO |
| E121 | Embraer 121 Xingu | L JeK | L2T | E121 | B350 |
| E3CF | Boeing Sentry | L JeK | L4J | E3CF | NA |
| E70 | Embraer 170 | L JeK | L2J | EMJ | FRJ |

| Code | Aircraft Name | Fuel Type | Description | Representative | |
|---|---|---|---|---|---|
| | | | | LTO | Cruise |
| EM2 | Embraer EMB.120 Brasilia | L JeK | L2T | EM2 | NA |
| EMB | Embraer EMB.110 Bandeirnate | L JeK | L2T | EMB | EMB |
| EMJ | Embraer 170/190 | L JeK | L2J | EMJ | FRJ |
| ER3 | Embraer RJ135 | L JeK | L2J | ERJ | ERJ |
| ER4 | Embraer RJ145 Amazon | L JeK | L2J | ERJ | ERJ |
| ERJ | Embraer RJ135 / RJ140 / RJ145 | L JeK | L2J | ERJ | ERJ |
| F16 | Lockheed F-16 Fighting Falcon | L JeK | L1J | F16 | NA |
| F27 | Fairchild FH.227 | L JeK | L2T | FK7 | NA |
| F28 | Fokker F.28 Fellowship 3000 | L JeK | L2J | F24 | F28 |
| F2TH | Dassault Falcon 2000 | L JeK | L2J | F2TH | NA |
| F406 | Cessna F406 Caravan 2 | L JeK | L2T | F406 | F406 |
| F50 | Fokker 50 | L JeK | L2T | F50 | F50 |
| F70 | Fokker 70 | L JeK | L2J | F70 | NA |
| F900 | Dassault Falcon 900 | L JeK | L3J | F900 | F50 |
| FA10 | Dassault Falcon 10 | L JeK | L2J | FA10 | S20 |
| FA20 | Dassault Falcon 20 | L JeK | L2J | FA20 | S20 |
| FA50 | Dassault Falcon 50 | L JeK | L3J | FA50 | F50 |
| FRJ | Fairchild Dornier 328JET | L JeK | L2J | FRJ | FRJ |
| GALX | IAI Galaxi | L JeK | L2J | WWP | S20 |
| GLF2 | Grumman Gulfstream 2 | L JeK | L2J | GLF3 | NA |
| GLF3 | Grumman Gulfstream 3 | L JeK | L2J | GLF3 | NA |
| GLF4 | Grumman Gulfstream 4 | L JeK | L2J | GLF4 | NA |
| GLF5 | Grumman Gulfstream 5 | L JeK | L2J | GLF5 | NA |
| GRG | Grumman G.21 Goose | L AvG | A2P | GRG | B350 |
| GRJ | Gulfstream Aerospace G-1159 Gulfstream II / III / IV / V | L JeK | L2J | GLF3 | NA |
| GRS | Gulfstream Aerospace G-159 Gulfstream I | L JeK | L2T | GRS | NA |
| H25 | British Aerospace (Hawker Siddeley) HS-125 | L JeK | L2J | H25 | S20 |
| H25B | British Aerospace (Hawker Siddeley) HS-125 | L JeK | L2J | H25 | S20 |
| H60 | Sikorsky Black Hawk | L JeK | H2T | S61 | NA |
| HS7 | Hawker Siddeley HS.748 | L JeK | L2T | HS7 | FRJ |
| IL6 | Ilyushin IL62 | L JeK | L4J | IL6 | 340 |
| IL7 | Ilyushin IL76 | L JeK | L4J | IL7 | 340 |
| IL8 | Ilyushin IL18 | L JeK | L4T | IL8 | NA |
| IL9 | Ilyushin IL96 pax | L JeK | L4J | IL9 | 340 |
| ILW | Ilyushin IL86 | L JeK | L4J | ILW | 340 |
| J31 | British Aerospace Jetstream 31 | L JeK | L2T | J31 | J31 |
| J41 | British Aerospace Jetstream 41 | L JeK | L2T | J41 | J41 |
| L10 | Lockheed L-1011 Tristar pax | L JeK | L3J | L10 | D10 |
| L11 | Lockheed L-1011 1 / 50 / 100 / 150 / 200 / 250 Tristar pax | L JeK | L3J | L10 | D10 |
| L1F | Lockheed L-1011 Tristar Freighter | L JeK | L3J | L10 | D10 |
| L29 | Aero (2) L-29 Delfin | L JeK | L1J | F16 | NA |
| L4T | LET 410 | L JeK | L2T | L4T | NA |
| LJ31 | Learjet 31 | L JeK | L2J | LJ31 | S20 |
| LJ35 | Learjet 35 | L JeK | L2J | LJ35 | S20 |
| LJ40 | Learjet 40 | LJeK | L2J | LJ35 | S20 |
| LJ45 | Learjet 45 | L JeK | L2J | LJ35 | S20 |
| LJ60 | Learjet 60 | L JeK | L2J | LJ35 | S20 |
| LOE | Lockheed L-188 Electra pax | L JeK | L4T | LOE | NA |
| LOF | Lockheed L-188 Electra Freighter | L JeK | L4T | LOF | NA |
| LOH | Lockheed L-182 / 282 / 382 (L-100) Hercules | L JeK | L4T | C130 | LOH |
| LOM | Lockheed L-188 Electra Mixed Configuration | L JeK | L4T | LOM | NA |
| LRJ | Gates Learjet | L JeK | L2J | LJ23 | S20 |
| LYNX | Westland Lynx | L JeK | H2T | S61 | NA |
| M11 | McDonnell Douglas MD11 pax | L JeK | L3J | M11 | D10 |
| M1F | McDonnell Douglas MD11 Freighter | L JeK | L3J | M11 | D10 |
| M1M | McDonnell Douglas MD11 Mixed Configuration | L JeK | L3J | M11 | D10 |
| M20P | Mooney M-20 | L AvG | L1P | M20P | DHO |
| M20T | Mooney TLS | L AvG | L1P | M20P | DHO |
| M80 | McDonnell Douglas MD80 | L JeK | L2J | M81 | M82 |
| M82 | McDonnell Douglas MD82 | L JeK | L2J | M82 | M82 |
| M83 | McDonnell Douglas MD83 | L JeK | L2J | M83 | M82 |
| M88 | McDonnell Douglas MD88 | L JeK | L2J | M88 | M82 |
| M90 | McDonnell Douglas MD90 | L JeK | L2J | M90 | M82 |
| MBH | Eurocopter (MBB) Bo.105 | L JeK | H2T | S61 | NA |
| MIH | MIL Mi-8 / Mi-17 / Mi-171 / Mil-172 | L JeK | H2T | S61 | NA |
| MU2 | Mitsubishi Mu-2 | L JeK | L2T | MU2 | NA |
| ND2 | Aerospatiale (Nord) 262 | L JeK | L2T | ND2 | NA |
| NDC | Aerospatiale SN.601 Corvette | L JeK | L2J | NDC | DHO |

| Code | Aircraft Name | Fuel Type | Description | Representative | |
|---|---|---|---|---|---|
| | | | | LTO | Cruise |
| P180 | Piaggio P-180 Avanti | L JeK | L2T | P180 | B350 |
| P28A | Piper Archer 2 | L AvG | L1P | P28A | DHO |
| PA18 | Piper Super Club | L AvG | L1P | PA18 | DHO |
| PA2 | Piper light aircraft - twin piston engines | L AvG | L2P | PA31 | DHO |
| PA24 | Piper Comanche | L AvG | L1P | PA24 | DHO |
| PA27 | Piper Aztec | L AvG | L1P | PA27 | DHO |
| PA3 | Piper Twin Comanche | L AvG | L2P | PA31 | DHO |
| PA31 | Piper Navajo | L AvG | L2P | PA31 | DHO |
| PA32 | Piper Saratoga | L AvG | L1P | PA32 | DHO |
| PA34 | Piper Seneca | L AvG | L2P | PA44 | DHO |
| PA44 | Piper Seminole | L AvG | L2P | PA44 | DHO |
| PA46 | Piper Malibu | L AvG | L1P | PA46 | DHO |
| PAG | Piper light aircraft | L AvG | L1P | P28A | DHO |
| PAT4 | Piper T-1040 | L JeK | L2T | PAT4 | SWM |
| PL2 | Pilatus PC-12 | L JeK | L1T | PL2 | C208 |
| PL6 | Pilatus PC-6 Turbo Porter | L JeK | L1T | PL6 | C208 |
| PN6 | Partenavia P.68 | L AvG | L2P | PN6 | DHO |
| PUMA | Aerospatile Puma | L JeK | H2T | S61 | NA |
| S05F | Siai-Marchetti S-205-20F | L AvG | L1P | C150 | DHO |
| S20 | Saab 2000 | L JeK | L2T | S20 | S20 |
| S58 | Sikorsky S-58T | L JeK | H1T | S58 | NA |
| S58P | Sikorsky S-58 | L AvG | H1P | S61 | NA |
| S61 | Sikorsky S-61 | L JeK | H2T | S61 | NA |
| S76 | Sikorsky S-76 | L JeK | H2T | S61 | NA |
| SA3 | Stits Playboy | L AvG | L1P | SA3 | DHO |
| SBR1 | North American Sabreliner | L JeK | L2J | SBR1 | NA |
| SF3 | Saab SF340A/B | L JeK | L2T | SF3 | SF3 |
| SH3 | Shorts SD.330 | L JeK | L2T | SH3 | SH3 |
| SH6 | Shorts SD.360 | L JeK | L2T | SH6 | SH6 |
| SHB | Shorts SC-5 Belfast | L JeK | L4T | SHB | NA |
| SR20 | Cirrus SR-20 | L AvG | L1P | C150 | DHO |
| SR22 | Cirrus SR-22 | L AvG | L1P | C150 | DHO |
| SSC | Aerospatiale/BAC Concorde | L JeK | L4J | SSC | NA |
| SW2 | Swearingen Merlin 2 | L JeK | L2T | SW2 | NA |
| SW3 | Swearingen Merlin 3 | L JeK | L2T | SW3 | SHS |
| SW4 | Swearingen Merlin 4 | L JeK | L2T | SW4 | NA |
| SWM | Fairchild (Swearingen) SA26 / SA226 / SA227 Metro / Merlin / Expediter | L JeK | L2T | PA31 | SWM |
| T20 | Tupolev Tu-204 / Tu-214 | L JeK | L2J | T20 | NA |
| TBM | Grumman Avenger | L AvG | L1P | C150 | NA |
| TBM7 | Socata TBM-700 | L JeK | L1T | TBM7 | C208 |
| TOBA | Socata Tobago | L AvG | L1P | C150 | DHO |
| TRIN | Scata Pashosh | L AvG | L1P | C150 | DHO |
| TU3 | Tupolev Tu134 | L JeK | L2J | TU3 | NA |
| TU5 | Tupolev Tu154 | L JeK | L3J | TU5 | 727 |
| VC10 | Bac VC-10 | L JeK | L4J | VC10 | NA |
| VCV | Vickers Viscount | L JeK | L4T | VCV | NA |
| WG30 | Westland WG-30 | L JeK | H2T | S61 | NA |
| WWP | Israel Aircraft Industries 1124 Westwind | L JeK | L2J | WWP | S20 |
| YK2 | Yakovlev Yak 42 | L JeK | L3J | YK2 | NA |
| YK4 | Yakovlev Yak 40 | L JeK | L3J | YK4 | NA |
| YK5 | Yakovlev Yak 50 | L AvG | L1P | C150 | DHO |

***Table B-3: Road transportation energy based implied emission factors (t/TJ) for 2023***

| Category | Fuel | Segment | Euro Standard | CO2 fossil* t/TJ | CO2 bio t/TJ | CH4 t/TJ | N2O t/TJ |
|---|---|---|---|---|---|---|---|
| Passenger Cars | Petrol | Mini | Euro 4 | 70.86 | 1.27 | 0.00869 | 0.00090 |
| Passenger Cars | Petrol | Mini | Euro 5 | 70.93 | 1.27 | 0.00870 | 0.00060 |
| Passenger Cars | Petrol | Mini | Euro 6 a/b/c | 70.99 | 1.27 | 0.00131 | 0.00055 |
| Passenger Cars | Petrol | Mini | Euro 6 d-temp | 71.03 | 1.27 | 0.00131 | 0.00053 |
| Passenger Cars | Petrol | Mini | Euro 6 d/e | 71.15 | 1.27 | 0.00131 | 0.00051 |
| Passenger Cars | Petrol | Small | PRE ECE - ECE 15/04 | 69.66 | 1.25 | 0.04061 | 0.00288 |
| Passenger Cars | Petrol | Small | Euro 1 | 70.35 | 1.26 | 0.00968 | 0.00489 |
| Passenger Cars | Petrol | Small | Euro 2 | 70.47 | 1.26 | 0.01424 | 0.00284 |
| Passenger Cars | Petrol | Small | Euro 3 | 70.74 | 1.26 | 0.01033 | 0.00107 |
| Passenger Cars | Petrol | Small | Euro 4 | 70.84 | 1.27 | 0.00731 | 0.00076 |
| Passenger Cars | Petrol | Small | Euro 5 | 70.90 | 1.27 | 0.00732 | 0.00051 |
| Passenger Cars | Petrol | Small | Euro 6 a/b/c | 70.95 | 1.27 | 0.00110 | 0.00048 |
| Passenger Cars | Petrol | Small | Euro 6 d-temp | 71.03 | 1.27 | 0.00110 | 0.00047 |
| Passenger Cars | Petrol | Small | Euro 6 d/e | 71.11 | 1.27 | 0.00110 | 0.00044 |
| Passenger Cars | Petrol | Medium | PRE ECE - ECE 15/04 | 69.79 | 1.25 | 0.03400 | 0.00241 |
| Passenger Cars | Petrol | Medium | Euro 1 | 70.92 | 1.27 | 0.00818 | 0.00419 |
| Passenger Cars | Petrol | Medium | Euro 2 | 70.96 | 1.27 | 0.01256 | 0.00255 |
| Passenger Cars | Petrol | Medium | Euro 3 | 71.01 | 1.27 | 0.00869 | 0.00091 |
| Passenger Cars | Petrol | Medium | Euro 4 | 71.02 | 1.27 | 0.00625 | 0.00065 |
| Passenger Cars | Petrol | Medium | Euro 5 | 71.03 | 1.27 | 0.00625 | 0.00044 |
| Passenger Cars | Petrol | Medium | Euro 6 a/b/c | 71.04 | 1.27 | 0.00094 | 0.00041 |
| Passenger Cars | Petrol | Medium | Euro 6 d-temp | 71.07 | 1.27 | 0.00094 | 0.00039 |
| Passenger Cars | Petrol | Medium | Euro 6 d/e | 71.09 | 1.27 | 0.00094 | 0.00036 |
| Passenger Cars | Petrol | Large-SUV-Executive | PRE ECE - ECE 15/04 | 69.60 | 1.25 | 0.02705 | 0.00192 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 1 | 70.95 | 1.27 | 0.00635 | 0.00321 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 2 | 70.98 | 1.27 | 0.00921 | 0.00185 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 3 | 71.01 | 1.27 | 0.00741 | 0.00077 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 4 | 71.03 | 1.27 | 0.00458 | 0.00048 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 5 | 71.04 | 1.27 | 0.00458 | 0.00032 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 6 a/b/c | 71.05 | 1.27 | 0.00069 | 0.00030 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 6 d-temp | 71.05 | 1.27 | 0.00069 | 0.00028 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 6 d/e | 71.07 | 1.27 | 0.00069 | 0.00026 |
| Passenger Cars | Petrol Hybrid | All Segments | Euro 4 | 71.02 | 1.27 | 0.01031 | 0.00110 |
| Passenger Cars | Petrol Hybrid | All Segments | Euro 5 | 71.11 | 1.27 | 0.00997 | 0.00083 |
| Passenger Cars | Petrol Hybrid | All Segments | Euro 6 a/b/c | 71.07 | 1.27 | 0.00711 | 0.00051 |
| Passenger Cars | Petrol Hybrid | All Segments | Euro 6 d-temp | 71.07 | 1.27 | 0.00746 | 0.00046 |
| Passenger Cars | Petrol Hybrid | All Segments | Euro 6 d/e | 71.10 | 1.27 | 0.00736 | 0.00043 |
| Passenger Cars | Diesel | Mini | Euro 4 | 70.39 | 4.24 | 0.00066 | 0.00489 |
| Passenger Cars | Diesel | Mini | Euro 5 | 70.39 | 4.24 | 0.00041 | 0.00489 |
| Passenger Cars | Diesel | Mini | Euro 6 a/b/c | 70.44 | 4.24 | 0.00033 | 0.00397 |
| Passenger Cars | Diesel | Mini | Euro 6 d-temp | 70.43 | 4.24 | 0.00005 | 0.00397 |
| Passenger Cars | Diesel | Small | Conventional | 70.26 | 4.24 | 0.00525 | - |
| Passenger Cars | Diesel | Small | Euro 1 | 70.29 | 4.24 | 0.00405 | 0.00098 |
| Passenger Cars | Diesel | Small | Euro 2 | 70.29 | 4.24 | 0.00162 | 0.00183 |
| Passenger Cars | Diesel | Small | Euro 3 | 70.30 | 4.24 | 0.00122 | 0.00329 |
| Passenger Cars | Diesel | Small | Euro 4 | 70.30 | 4.24 | 0.00045 | 0.00329 |
| Passenger Cars | Diesel | Small | Euro 5 | 70.30 | 4.24 | 0.00003 | 0.00329 |

| Category | Fuel | Segment | Euro Standard | CO2 fossil* t/TJ | CO2 bio t/TJ | CH4 t/TJ | N2O t/TJ |
|---|---|---|---|---|---|---|---|
| Passenger Cars | Diesel | Small | Euro 6 a/b/c | 70.35 | 4.24 | 0.00003 | 0.00268 |
| Passenger Cars | Diesel | Small | Euro 6 d-temp | 70.34 | 4.24 | 0.00003 | 0.00268 |
| Passenger Cars | Diesel | Small | Euro 6 d/e | 70.34 | 4.24 | 0.00003 | 0.00268 |
| Passenger Cars | Diesel | Medium | Conventional | 70.26 | 4.24 | 0.00525 | - |
| Passenger Cars | Diesel | Medium | Euro 1 | 70.29 | 4.24 | 0.00405 | 0.00098 |
| Passenger Cars | Diesel | Medium | Euro 2 | 70.29 | 4.24 | 0.00162 | 0.00183 |
| Passenger Cars | Diesel | Medium | Euro 3 | 70.30 | 4.24 | 0.00122 | 0.00329 |
| Passenger Cars | Diesel | Medium | Euro 4 | 70.30 | 4.24 | 0.00045 | 0.00329 |
| Passenger Cars | Diesel | Medium | Euro 5 | 70.30 | 4.24 | 0.00003 | 0.00329 |
| Passenger Cars | Diesel | Medium | Euro 6 a/b/c | 70.35 | 4.24 | 0.00003 | 0.00268 |
| Passenger Cars | Diesel | Medium | Euro 6 d-temp | 70.34 | 4.24 | 0.00003 | 0.00268 |
| Passenger Cars | Diesel | Medium | Euro 6 d/e | 70.34 | 4.24 | 0.00003 | 0.00268 |
| Passenger Cars | Diesel | Large-SUV-Executive | Conventional | 70.26 | 4.24 | 0.00525 | - |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 1 | 70.25 | 4.24 | 0.00303 | 0.00073 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 2 | 70.25 | 4.24 | 0.00125 | 0.00142 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 3 | 70.25 | 4.24 | 0.00089 | 0.00240 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 4 | 70.25 | 4.24 | 0.00033 | 0.00240 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 5 | 70.25 | 4.24 | 0.00002 | 0.00240 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 6 a/b/c | 70.30 | 4.24 | 0.00002 | 0.00195 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 6 d-temp | 70.30 | 4.24 | 0.00002 | 0.00195 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 6 d/e | 70.29 | 4.24 | 0.00002 | 0.00195 |
| Passenger Cars | LPG Bifuel | All Segments | Conventional | 65.09 | - | 0.01875 | - |
| Passenger Cars | LPG Bifuel | All Segments | Euro 1 | 65.09 | - | 0.01776 | 0.00687 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 2 | 65.09 | - | 0.01050 | 0.00348 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 3 | 65.09 | - | 0.00894 | 0.00145 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 4 | 65.09 | - | 0.00861 | 0.00145 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 5 | 65.09 | - | 0.00861 | 0.00041 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 6 a/b/c | 65.07 | - | 0.00779 | 0.00038 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 6 d-temp | 65.08 | - | 0.00836 | 0.00041 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 6 d/e | 58.44 | - | 0.00765 | 0.00038 |
| Light Commercial Vehicles | Petrol | N1-I | Conventional | 69.68 | 1.25 | 0.02879 | 0.00204 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 1 | 70.87 | 1.27 | 0.00818 | 0.00413 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 2 | 70.92 | 1.27 | 0.01257 | 0.00252 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 3 | 71.01 | 1.27 | 0.00868 | 0.00092 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 4 | 71.03 | 1.27 | 0.00623 | 0.00065 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 5 | 71.03 | 1.27 | 0.00623 | 0.00043 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 6 a/b/c | 71.08 | 1.27 | 0.00094 | 0.00044 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 6 d-temp | 71.06 | 1.27 | 0.00094 | 0.00039 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 6 d/e | 71.10 | 1.27 | 0.00094 | 0.00037 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Conventional | 69.62 | 1.25 | 0.02662 | 0.00189 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 1 | 70.96 | 1.27 | 0.00503 | 0.00542 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 2 | 71.00 | 1.27 | 0.00735 | 0.00698 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 3 | 70.98 | 1.27 | 0.00534 | 0.00131 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 4 | 71.03 | 1.27 | 0.00365 | 0.00090 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 5 | 71.06 | 1.27 | 0.00582 | 0.00048 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 6 a/b/c | 71.07 | 1.27 | 0.00055 | 0.00044 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 6 d-temp | 71.09 | 1.27 | 0.00055 | 0.00041 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 6 d/e | 71.11 | 1.27 | 0.00055 | 0.00038 |
| Light Commercial Vehicles | Diesel | N1-I | Conventional | 70.26 | 4.24 | 0.00525 | - |

| Category | Fuel | Segment | Euro Standard | CO2 fossil* t/TJ | CO2 bio t/TJ | CH4 t/TJ | N2O t/TJ |
|---|---|---|---|---|---|---|---|
| Light Commercial Vehicles | Diesel | N1-I | Euro 1 | 70.29 | 4.24 | 0.00405 | 0.00098 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 2 | 70.29 | 4.24 | 0.00162 | 0.00183 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 3 | 70.30 | 4.24 | 0.00122 | 0.00329 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 4 | 70.30 | 4.24 | 0.00045 | 0.00329 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 5 | 70.30 | 4.24 | 0.00003 | 0.00329 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 6 a/b/c | 70.35 | 4.24 | 0.00003 | 0.00268 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 6 d-temp | 70.34 | 4.24 | 0.00003 | 0.00268 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 6 d/e | 70.34 | 4.24 | 0.00003 | 0.00268 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Conventional | 70.22 | 4.24 | 0.00380 | - |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 1 | 70.23 | 4.24 | 0.00265 | 0.00064 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 2 | 70.23 | 4.24 | 0.00109 | 0.00124 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 3 | 70.23 | 4.24 | 0.00078 | 0.00210 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 4 | 70.23 | 4.24 | 0.00029 | 0.00210 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 5 | 70.24 | 4.24 | 0.00000 | 0.00227 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 6 a/b/c | 70.29 | 4.24 | 0.00000 | 0.00185 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 6 d-temp | 70.29 | 4.24 | 0.00000 | 0.00185 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 6 d/e | 70.28 | 4.24 | 0.00000 | 0.00185 |
| Heavy Duty Trucks | Diesel | <=20 t | Conventional | 70.17 | 4.24 | 0.00887 | 0.00372 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro I | 70.18 | 4.24 | 0.01063 | 0.00098 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro II | 70.18 | 4.24 | 0.00827 | 0.00094 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro III | 70.17 | 4.24 | 0.00857 | 0.00053 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro IV | 70.50 | 4.24 | 0.00058 | 0.00147 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro V | 70.51 | 4.24 | 0.00061 | 0.00436 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro VI A/B/C | 70.43 | 4.24 | 0.00062 | 0.00435 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro VI D/E | 70.43 | 4.24 | 0.00062 | 0.00436 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Conventional | 70.15 | 4.24 | 0.00862 | 0.00239 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro I | 70.15 | 4.24 | 0.00992 | 0.00080 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro II | 70.15 | 4.24 | 0.00775 | 0.00078 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro III | 70.15 | 4.24 | 0.00705 | 0.00041 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro IV | 70.49 | 4.24 | 0.00046 | 0.00111 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro V | 70.49 | 4.24 | 0.00047 | 0.00325 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro VI A/B/C | 70.41 | 4.24 | 0.00046 | 0.00321 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro VI D/E | 70.42 | 4.24 | 0.00046 | 0.00321 |
| Heavy Duty Trucks | Diesel | >28 t | Conventional | 70.14 | 4.24 | 0.00709 | 0.00197 |
| Heavy Duty Trucks | Diesel | >28 t | Euro I | 70.14 | 4.24 | 0.00794 | 0.00102 |
| Heavy Duty Trucks | Diesel | >28 t | Euro II | 70.14 | 4.24 | 0.00614 | 0.00101 |
| Heavy Duty Trucks | Diesel | >28 t | Euro III | 70.14 | 4.24 | 0.00577 | 0.00057 |
| Heavy Duty Trucks | Diesel | >28 t | Euro IV | 70.48 | 4.24 | 0.00040 | 0.00150 |
| Heavy Duty Trucks | Diesel | >28 t | Euro V | 70.48 | 4.24 | 0.00041 | 0.00435 |
| Heavy Duty Trucks | Diesel | >28 t | Euro VI A/B/C | 70.40 | 4.24 | 0.00041 | 0.00432 |
| Heavy Duty Trucks | Diesel | >28 t | Euro VI D/E | 70.58 | 4.24 | 0.00041 | 0.00432 |
| Buses | Diesel | Urban Buses | Conventional | 70.22 | 4.24 | 0.00767 | 0.00131 |
| Buses | Diesel | Urban Buses | Euro I | 70.24 | 4.24 | 0.00873 | 0.00060 |
| Buses | Diesel | Urban Buses | Euro II | 70.25 | 4.24 | 0.00598 | 0.00063 |
| Buses | Diesel | Urban Buses | Euro III | 70.24 | 4.24 | 0.00527 | 0.00031 |
| Buses | Diesel | Urban Buses | Euro IV | 70.59 | 4.24 | 0.00030 | 0.00074 |
| Buses | Diesel | Urban Buses | Euro V | 70.59 | 4.24 | 0.00030 | 0.00188 |
| Buses | Diesel | Urban Buses | Euro VI A/B/C | 70.47 | 4.24 | 0.00027 | 0.00213 |
| Buses | Diesel | Urban Buses | Euro VI D/E | 70.47 | 4.24 | 0.00027 | 0.00210 |

| Category | Fuel | Segment | Euro Standard | CO2 fossil* t/TJ | CO2 bio t/TJ | CH4 t/TJ | N2O t/TJ |
|---|---|---|---|---|---|---|---|
| Buses | Diesel | Coaches | Conventional | 70.17 | 4.24 | 0.00753 | 0.00300 |
| Buses | Diesel | Coaches | Euro I | 70.17 | 4.24 | 0.00798 | 0.00085 |
| Buses | Diesel | Coaches | Euro II | 70.17 | 4.24 | 0.00518 | 0.00080 |
| Buses | Diesel | Coaches | Euro III | 70.17 | 4.24 | 0.00466 | 0.00047 |
| Buses | Diesel | Coaches | Euro IV | 70.50 | 4.24 | 0.00024 | 0.00134 |
| Buses | Diesel | Coaches | Euro V | 70.50 | 4.24 | 0.00023 | 0.00371 |
| Buses | Diesel | Coaches | Euro VI A/B/C | 70.42 | 4.24 | 0.00022 | 0.00339 |
| Buses | Diesel | Coaches | Euro VI D/E | 70.60 | 4.24 | 0.00022 | 0.00339 |
| Buses | CNG | Urban CNG Buses | Euro III | 57.27 | - | 0.05861 | 0.00462 |
| Buses | CNG | Urban CNG Buses | EEV | 57.27 | - | 0.04174 | 0.00430 |
| L-Category | Petrol | Mopeds 2-stroke <50 cm³ | Conventional | 70.71 | 1.22 | 0.19140 | 0.00087 |
| L-Category | Petrol | Mopeds 2-stroke <50 cm³ | Euro 1 | 71.79 | 1.22 | 0.04811 | 0.00110 |
| L-Category | Petrol | Mopeds 2-stroke <50 cm³ | Euro 2 | 72.28 | 1.23 | 0.02664 | 0.00111 |
| L-Category | Petrol | Mopeds 2-stroke <50 cm³ | Euro 3 | 73.59 | 1.24 | 0.02645 | 0.00134 |
| L-Category | Petrol | Mopeds 2-stroke <50 cm³ | Euro 4 | 74.24 | 1.25 | 0.02723 | 0.00138 |
| L-Category | Petrol | Mopeds 2-stroke <50 cm³ | Euro 5 | 74.09 | 1.25 | 0.02717 | 0.00138 |
| L-Category | Petrol | Mopeds 4-stroke <50 cm³ | Conventional | 70.71 | 1.22 | 0.19140 | 0.00087 |
| L-Category | Petrol | Mopeds 4-stroke <50 cm³ | Euro 1 | 71.79 | 1.22 | 0.04811 | 0.00110 |
| L-Category | Petrol | Mopeds 4-stroke <50 cm³ | Euro 2 | 72.28 | 1.23 | 0.02664 | 0.00111 |
| L-Category | Petrol | Mopeds 4-stroke <50 cm³ | Euro 3 | 73.59 | 1.24 | 0.02645 | 0.00134 |
| L-Category | Petrol | Mopeds 4-stroke <50 cm³ | Euro 4 | 74.24 | 1.25 | 0.02723 | 0.00138 |
| L-Category | Petrol | Mopeds 4-stroke <50 cm³ | Euro 5 | 74.09 | 1.25 | 0.02717 | 0.00138 |
| L-Category | Petrol | Motorcycles 2-stroke >50 cm³ | Conventional | 71.21 | 1.24 | 0.09806 | 0.00131 |
| L-Category | Petrol | Motorcycles 2-stroke >50 cm³ | Euro 1 | 71.85 | 1.25 | 0.07156 | 0.00143 |
| L-Category | Petrol | Motorcycles 2-stroke >50 cm³ | Euro 2 | 72.11 | 1.25 | 0.02173 | 0.00143 |
| L-Category | Petrol | Motorcycles 2-stroke >50 cm³ | Euro 3 | 73.34 | 1.25 | 0.01392 | 0.00225 |
| L-Category | Petrol | Motorcycles 2-stroke >50 cm³ | Euro 4 | 73.67 | 1.26 | 0.01350 | 0.00218 |
| L-Category | Petrol | Motorcycles 2-stroke >50 cm³ | Euro 5 | 73.62 | 1.26 | 0.01349 | 0.00218 |
| L-Category | Petrol | Motorcycles 4-stroke <250 cm³ | Conventional | 70.20 | 1.26 | 0.13479 | 0.00135 |
| L-Category | Petrol | Motorcycles 4-stroke <250 cm³ | Euro 1 | 70.36 | 1.26 | 0.11460 | 0.00164 |
| L-Category | Petrol | Motorcycles 4-stroke <250 cm³ | Euro 2 | 70.39 | 1.26 | 0.11069 | 0.00198 |
| L-Category | Petrol | Motorcycles 4-stroke <250 cm³ | Euro 3 | 70.58 | 1.26 | 0.06079 | 0.00227 |
| L-Category | Petrol | Motorcycles 4-stroke <250 cm³ | Euro 4 | 70.77 | 1.27 | 0.05367 | 0.00200 |
| L-Category | Petrol | Motorcycles 4-stroke <250 cm³ | Euro 5 | 70.74 | 1.26 | 0.00767 | 0.00205 |
| L-Category | Petrol | Motorcycles 4-stroke 250 - 750 cm³ | Conventional | 70.10 | 1.25 | 0.09819 | 0.00098 |
| L-Category | Petrol | Motorcycles 4-stroke 250 - 750 cm³ | Euro 1 | 70.37 | 1.26 | 0.08128 | 0.00104 |
| L-Category | Petrol | Motorcycles 4-stroke 250 - 750 cm³ | Euro 2 | 70.44 | 1.26 | 0.07750 | 0.00113 |
| L-Category | Petrol | Motorcycles 4-stroke 250 - 750 cm³ | Euro 3 | 70.67 | 1.27 | 0.02562 | 0.00080 |
| L-Category | Petrol | Motorcycles 4-stroke 250 - 750 cm³ | Euro 4 | 70.72 | 1.27 | 0.03054 | 0.00096 |
| L-Category | Petrol | Motorcycles 4-stroke 250 - 750 cm³ | Euro 5 | 70.58 | 1.26 | 0.00971 | 0.00133 |
| L-Category | Petrol | Motorcycles 4-stroke >750 cm³ | Conventional | 69.78 | 1.25 | 0.08561 | 0.00086 |
| L-Category | Petrol | Motorcycles 4-stroke >750 cm³ | Euro 1 | 70.12 | 1.26 | 0.05068 | 0.00092 |
| L-Category | Petrol | Motorcycles 4-stroke >750 cm³ | Euro 2 | 70.27 | 1.26 | 0.03860 | 0.00092 |
| L-Category | Petrol | Motorcycles 4-stroke >750 cm³ | Euro 3 | 70.56 | 1.26 | 0.01490 | 0.00080 |
| L-Category | Petrol | Motorcycles 4-stroke >750 cm³ | Euro 4 | 70.61 | 1.26 | 0.01773 | 0.00095 |
| L-Category | Petrol | Motorcycles 4-stroke >750 cm³ | Euro 5 | 70.62 | 1.26 | 0.00542 | 0.00094 |

*includes lubricants and SCR emissions

***Table B-4: Road transportation distance based implied emission factor for 2023 (g/km and mg/km)***

| Category | Fuel | Segment | Euro Standard | CO2 fossil* g/km | CO2 bio g/km | CH4 mg/km | N2O mg/km |
|---|---|---|---|---|---|---|---|
| Passenger Cars | Petrol | Mini | Euro 4 | 162.41 | 2.90 | 19.918 | 2.07 |
| Passenger Cars | Petrol | Mini | Euro 5 | 162.41 | 2.90 | 19.918 | 1.38 |
| Passenger Cars | Petrol | Mini | Euro 6 a/b/c | 162.40 | 2.90 | 2.994 | 1.27 |
| Passenger Cars | Petrol | Mini | Euro 6 d-temp | 162.39 | 2.90 | 2.994 | 1.22 |
| Passenger Cars | Petrol | Mini | Euro 6 d/e | 162.38 | 2.90 | 2.994 | 1.17 |
| Passenger Cars | Petrol | Small | PRE ECE - ECE 15/04 | 195.89 | 3.50 | 114.216 | 8.10 |
| Passenger Cars | Petrol | Small | Euro 1 | 186.97 | 3.34 | 25.723 | 12.99 |
| Passenger Cars | Petrol | Small | Euro 2 | 186.00 | 3.32 | 37.588 | 7.51 |
| Passenger Cars | Petrol | Small | Euro 3 | 187.26 | 3.35 | 27.335 | 2.84 |
| Passenger Cars | Petrol | Small | Euro 4 | 193.04 | 3.45 | 19.918 | 2.08 |
| Passenger Cars | Petrol | Small | Euro 5 | 193.04 | 3.45 | 19.918 | 1.40 |
| Passenger Cars | Petrol | Small | Euro 6 a/b/c | 193.03 | 3.45 | 2.994 | 1.29 |
| Passenger Cars | Petrol | Small | Euro 6 d-temp | 193.02 | 3.45 | 2.994 | 1.29 |
| Passenger Cars | Petrol | Small | Euro 6 d/e | 193.00 | 3.45 | 2.994 | 1.18 |
| Passenger Cars | Petrol | Medium | PRE ECE - ECE 15/04 | 234.48 | 4.19 | 114.216 | 8.10 |
| Passenger Cars | Petrol | Medium | Euro 1 | 222.96 | 3.99 | 25.723 | 13.16 |
| Passenger Cars | Petrol | Medium | Euro 2 | 212.30 | 3.80 | 37.588 | 7.64 |
| Passenger Cars | Petrol | Medium | Euro 3 | 223.34 | 3.99 | 27.335 | 2.87 |
| Passenger Cars | Petrol | Medium | Euro 4 | 226.50 | 4.05 | 19.918 | 2.08 |
| Passenger Cars | Petrol | Medium | Euro 5 | 226.50 | 4.05 | 19.918 | 1.40 |
| Passenger Cars | Petrol | Medium | Euro 6 a/b/c | 226.49 | 4.05 | 2.994 | 1.30 |
| Passenger Cars | Petrol | Medium | Euro 6 d-temp | 226.48 | 4.05 | 2.994 | 1.25 |
| Passenger Cars | Petrol | Medium | Euro 6 d/e | 226.46 | 4.05 | 2.994 | 1.16 |
| Passenger Cars | Petrol | Large-SUV-Executive | PRE ECE - ECE 15/04 | 293.87 | 5.26 | 114.216 | 8.10 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 1 | 287.18 | 5.14 | 25.723 | 12.99 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 2 | 289.60 | 5.18 | 37.588 | 7.56 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 3 | 262.04 | 4.69 | 27.335 | 2.84 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 4 | 309.17 | 5.53 | 19.918 | 2.07 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 5 | 309.17 | 5.53 | 19.918 | 1.40 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 6 a/b/c | 309.16 | 5.53 | 2.994 | 1.30 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 6 d-temp | 309.15 | 5.53 | 2.994 | 1.22 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 6 d/e | 309.14 | 5.53 | 2.994 | 1.14 |
| Passenger Cars | Petrol Hybrid | All Segments | Euro 4 | 137.17 | 2.45 | 19.918 | 2.13 |
| Passenger Cars | Petrol Hybrid | All Segments | Euro 5 | 142.09 | 2.54 | 19.918 | 1.65 |
| Passenger Cars | Petrol Hybrid | All Segments | Euro 6 a/b/c | 216.74 | 3.88 | 19.918 | 1.42 |
| Passenger Cars | Petrol Hybrid | All Segments | Euro 6 d-temp | 205.88 | 3.68 | 19.918 | 1.24 |
| Passenger Cars | Petrol Hybrid | All Segments | Euro 6 d/e | 209.48 | 3.75 | 19.918 | 1.17 |
| Passenger Cars | Diesel | Mini | Euro 4 | 116.67 | 7.03 | 1.100 | 8.10 |
| Passenger Cars | Diesel | Mini | Euro 5 | 116.67 | 7.03 | 0.687 | 8.10 |
| Passenger Cars | Diesel | Mini | Euro 6 a/b/c | 116.75 | 7.03 | 0.552 | 6.58 |
| Passenger Cars | Diesel | Mini | Euro 6 d-temp | 116.74 | 7.03 | 0.075 | 6.58 |
| Passenger Cars | Diesel | Small | Conventional | 217.85 | 13.16 | 16.270 | - |
| Passenger Cars | Diesel | Small | Euro 1 | 177.63 | 10.72 | 10.231 | 2.48 |
| Passenger Cars | Diesel | Small | Euro 2 | 183.34 | 11.07 | 4.219 | 4.78 |
| Passenger Cars | Diesel | Small | Euro 3 | 172.89 | 10.44 | 3.000 | 8.10 |
| Passenger Cars | Diesel | Small | Euro 4 | 172.89 | 10.44 | 1.100 | 8.10 |
| Passenger Cars | Diesel | Small | Euro 5 | 172.89 | 10.44 | 0.075 | 8.10 |

| Category | Fuel | Segment | Euro Standard | CO2 fossil* g/km | CO2 bio g/km | CH4 mg/km | N2O mg/km |
|---|---|---|---|---|---|---|---|
| Passenger Cars | Diesel | Small | Euro 6 a/b/c | 173.03 | 10.44 | 0.075 | 6.58 |
| Passenger Cars | Diesel | Small | Euro 6 d-temp | 173.01 | 10.44 | 0.075 | 6.58 |
| Passenger Cars | Diesel | Small | Euro 6 d/e | 172.99 | 10.44 | 0.075 | 6.58 |
| Passenger Cars | Diesel | Medium | Conventional | 217.85 | 13.16 | 16.270 | - |
| Passenger Cars | Diesel | Medium | Euro 1 | 177.63 | 10.72 | 10.231 | 2.48 |
| Passenger Cars | Diesel | Medium | Euro 2 | 183.34 | 11.07 | 4.219 | 4.78 |
| Passenger Cars | Diesel | Medium | Euro 3 | 172.89 | 10.44 | 3.000 | 8.10 |
| Passenger Cars | Diesel | Medium | Euro 4 | 172.89 | 10.44 | 1.100 | 8.10 |
| Passenger Cars | Diesel | Medium | Euro 5 | 172.89 | 10.44 | 0.075 | 8.10 |
| Passenger Cars | Diesel | Medium | Euro 6 a/b/c | 173.03 | 10.44 | 0.075 | 6.58 |
| Passenger Cars | Diesel | Medium | Euro 6 d-temp | 173.01 | 10.44 | 0.075 | 6.58 |
| Passenger Cars | Diesel | Medium | Euro 6 d/e | 172.99 | 10.44 | 0.075 | 6.58 |
| Passenger Cars | Diesel | Large-SUV-Executive | Conventional | 217.85 | 13.16 | 16.270 | - |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 1 | 237.44 | 14.34 | 10.231 | 2.48 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 2 | 237.44 | 14.34 | 4.219 | 4.78 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 3 | 237.44 | 14.34 | 3.000 | 8.10 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 4 | 237.44 | 14.34 | 1.100 | 8.10 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 5 | 237.44 | 14.34 | 0.075 | 8.10 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 6 a/b/c | 237.62 | 14.34 | 0.075 | 6.58 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 6 d-temp | 237.61 | 14.34 | 0.075 | 6.58 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 6 d/e | 237.59 | 14.34 | 0.075 | 6.58 |
| Passenger Cars | LPG Bifuel | All Segments | Conventional | 182.25 | - | 52.506 | - |
| Passenger Cars | LPG Bifuel | All Segments | Euro 1 | 192.40 | - | 52.506 | 20.30 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 6 d-temp | 192.40 | - | 31.052 | 10.29 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 3 | 192.40 | - | 26.424 | 4.28 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 4 | 192.40 | - | 25.444 | 4.28 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 5 | 192.40 | - | 25.444 | 1.22 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 6 a/b/c | 206.39 | - | 24.616 | 1.22 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 6 d-temp | 192.21 | - | 24.616 | 1.22 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 6 d/e | 169.22 | - | 22.107 | 1.09 |
| Light Commercial Vehicles | Petrol | N1-I | Conventional | 276.47 | 4.95 | 114.216 | 8.10 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 1 | 222.96 | 3.99 | 25.723 | 12.99 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 2 | 212.13 | 3.79 | 37.588 | 7.54 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 3 | 223.73 | 4.00 | 27.335 | 2.89 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 4 | 227.03 | 4.06 | 19.918 | 2.09 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 5 | 227.03 | 4.06 | 19.918 | 1.38 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 6 a/b/c | 227.02 | 4.06 | 2.994 | 1.39 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 6 d-temp | 227.01 | 4.06 | 2.994 | 1.24 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 6 d/e | 227.00 | 4.06 | 2.994 | 1.18 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Conventional | 298.68 | 5.34 | 114.216 | 8.10 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 1 | 363.23 | 6.50 | 25.723 | 27.76 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 2 | 363.23 | 6.50 | 37.588 | 35.71 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 3 | 363.23 | 6.50 | 27.335 | 6.70 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 4 | 363.23 | 6.50 | 18.690 | 4.58 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 5 | 228.07 | 4.08 | 18.690 | 1.53 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 6 a/b/c | 228.06 | 4.08 | 1.766 | 1.40 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 6 d-temp | 228.05 | 4.08 | 1.766 | 1.30 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 6 d/e | 228.04 | 4.08 | 1.766 | 1.21 |
| Light Commercial Vehicles | Diesel | N1-I | Conventional | 217.85 | 13.16 | 16.270 | - |

| Category | Fuel | Segment | Euro Standard | CO2 fossil* g/km | CO2 bio g/km | CH4 mg/km | N2O mg/km |
|---|---|---|---|---|---|---|---|
| Light Commercial Vehicles | Diesel | N1-I | Euro 1 | 177.63 | 10.72 | 10.231 | 2.48 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 2 | 183.34 | 11.07 | 4.219 | 4.78 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 3 | 172.89 | 10.44 | 3.000 | 8.10 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 4 | 172.89 | 10.44 | 1.100 | 8.10 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 5 | 172.89 | 10.44 | 0.075 | 8.10 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 6 a/b/c | 173.03 | 10.44 | 0.075 | 6.58 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 6 d-temp | 173.01 | 10.44 | 0.075 | 6.58 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 6 d/e | 172.99 | 10.44 | 0.075 | 6.58 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Conventional | 300.67 | 18.17 | 16.270 | - |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 1 | 270.85 | 16.37 | 10.231 | 2.48 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 2 | 270.85 | 16.37 | 4.219 | 4.78 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 3 | 270.85 | 16.37 | 3.000 | 8.10 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 4 | 270.85 | 16.37 | 1.100 | 8.10 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 5 | 250.27 | 15.12 | 0.008 | 8.10 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 6 a/b/c | 250.47 | 15.12 | 0.008 | 6.58 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 6 d-temp | 250.45 | 15.12 | 0.008 | 6.58 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 6 d/e | 250.44 | 15.12 | 0.008 | 6.58 |
| Heavy Duty Trucks | Diesel | <=20 t | Conventional | 565.36 | 34.19 | 71.454 | 30.00 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro I | 501.35 | 30.32 | 75.949 | 7.00 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro II | 493.80 | 29.86 | 58.192 | 6.62 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro III | 558.25 | 33.76 | 68.202 | 4.23 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro IV | 544.23 | 32.76 | 4.493 | 11.35 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro V | 530.19 | 31.91 | 4.623 | 32.78 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro VI A/B/C | 534.82 | 32.23 | 4.684 | 33.04 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro VI D/E | 535.90 | 32.29 | 4.718 | 33.14 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Conventional | 878.74 | 53.16 | 108.037 | 30.00 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro I | 764.06 | 46.22 | 108.037 | 8.75 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro II | 742.74 | 44.93 | 82.096 | 8.28 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro III | 771.24 | 46.65 | 77.493 | 4.53 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro IV | 746.47 | 44.94 | 4.819 | 11.77 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro V | 727.41 | 43.79 | 4.819 | 33.50 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro VI A/B/C | 736.99 | 44.42 | 4.819 | 33.60 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro VI D/E | 736.04 | 44.36 | 4.819 | 33.60 |
| Heavy Duty Trucks | Diesel | >28 t | Conventional | 1 068.43 | 64.64 | 108.037 | 30.00 |
| Heavy Duty Trucks | Diesel | >28 t | Euro I | 954.00 | 57.72 | 108.037 | 13.93 |
| Heavy Duty Trucks | Diesel | >28 t | Euro II | 938.16 | 56.76 | 82.096 | 13.51 |
| Heavy Duty Trucks | Diesel | >28 t | Euro III | 942.14 | 57.00 | 77.493 | 7.69 |
| Heavy Duty Trucks | Diesel | >28 t | Euro IV | 853.78 | 51.40 | 4.819 | 18.21 |
| Heavy Duty Trucks | Diesel | >28 t | Euro V | 833.19 | 50.16 | 4.819 | 51.37 |
| Heavy Duty Trucks | Diesel | >28 t | Euro VI A/B/C | 837.15 | 50.46 | 4.819 | 51.40 |
| Heavy Duty Trucks | Diesel | >28 t | Euro VI D/E | 839.32 | 50.46 | 4.819 | 51.40 |
| Buses | Diesel | Urban Buses | Conventional | 1 602.14 | 96.82 | 175.000 | 30.00 |
| Buses | Diesel | Urban Buses | Euro I | 1 407.74 | 85.05 | 175.000 | 12.00 |
| Buses | Diesel | Urban Buses | Euro II | 1 335.94 | 80.70 | 113.750 | 12.00 |
| Buses | Diesel | Urban Buses | Euro III | 1 376.02 | 83.13 | 103.250 | 6.00 |
| Buses | Diesel | Urban Buses | Euro IV | 1 215.84 | 73.09 | 5.250 | 12.80 |
| Buses | Diesel | Urban Buses | Euro V | 1 243.57 | 74.76 | 5.250 | 33.20 |
| Buses | Diesel | Urban Buses | Euro VI A/B/C | 1 372.18 | 82.63 | 5.250 | 41.50 |
| Buses | Diesel | Urban Buses | Euro VI D/E | 1 388.96 | 83.64 | 5.250 | 41.50 |

| Category | Fuel | Segment | Euro Standard | CO2 fossil* g/km | CO2 bio g/km | CH4 mg/km | N2O mg/km |
|---|---|---|---|---|---|---|---|
| Buses | Diesel | Coaches | Conventional | 701.77 | 42.44 | 75.287 | 30.00 |
| Buses | Diesel | Coaches | Euro I | 661.72 | 40.02 | 75.287 | 8.06 |
| Buses | Diesel | Coaches | Euro II | 663.11 | 40.10 | 48.936 | 7.59 |
| Buses | Diesel | Coaches | Euro III | 669.22 | 40.47 | 44.419 | 4.53 |
| Buses | Diesel | Coaches | Euro IV | 668.20 | 40.22 | 2.259 | 12.67 |
| Buses | Diesel | Coaches | Euro V | 704.58 | 42.41 | 2.259 | 37.09 |
| Buses | Diesel | Coaches | Euro VI A/B/C | 711.54 | 42.88 | 2.259 | 34.29 |
| Buses | Diesel | Coaches | Euro VI D/E | 714.30 | 42.93 | 2.259 | 34.29 |
| Buses | CNG | Urban CNG Buses | Euro III | 1 250.86 | 0.00 | 1 280.000 | 101.00 |
| Buses | CNG | Urban CNG Buses | EEV | 1 344.60 | 0.00 | 980.000 | 101.00 |
| L-Category | Petrol | Mopeds 2-stroke <50 cm³ | Conventional | 80.90 | 1.39 | 219.000 | 1.00 |
| L-Category | Petrol | Mopeds 2-stroke <50 cm³ | Euro 1 | 65.36 | 1.11 | 43.800 | 1.00 |
| L-Category | Petrol | Mopeds 2-stroke <50 cm³ | Euro 2 | 65.36 | 1.11 | 24.090 | 1.00 |
| L-Category | Petrol | Mopeds 2-stroke <50 cm³ | Euro 3 | 54.83 | 0.93 | 19.710 | 1.00 |
| L-Category | Petrol | Mopeds 2-stroke <50 cm³ | Euro 4 | 53.74 | 0.91 | 19.710 | 1.00 |
| L-Category | Petrol | Mopeds 2-stroke <50 cm³ | Euro 5 | 53.74 | 0.91 | 19.710 | 1.00 |
| L-Category | Petrol | Mopeds 4-stroke <50 cm³ | Conventional | 80.90 | 1.39 | 219.000 | 1.00 |
| L-Category | Petrol | Mopeds 4-stroke <50 cm³ | Euro 1 | 65.36 | 1.11 | 43.800 | 1.00 |
| L-Category | Petrol | Mopeds 4-stroke <50 cm³ | Euro 2 | 65.36 | 1.11 | 24.090 | 1.00 |
| L-Category | Petrol | Mopeds 4-stroke <50 cm³ | Euro 3 | 54.83 | 0.93 | 19.710 | 1.00 |
| L-Category | Petrol | Mopeds 4-stroke <50 cm³ | Euro 4 | 53.74 | 0.91 | 19.710 | 1.00 |
| L-Category | Petrol | Mopeds 4-stroke <50 cm³ | Euro 5 | 53.74 | 0.91 | 19.710 | 1.00 |
| L-Category | Petrol | Motorcycles 2-stroke >50 cm³ | Conventional | 108.93 | 1.89 | 150.000 | 2.00 |
| L-Category | Petrol | Motorcycles 2-stroke >50 cm³ | Euro 1 | 100.78 | 1.75 | 100.373 | 2.00 |
| L-Category | Petrol | Motorcycles 2-stroke >50 cm³ | Euro 2 | 100.78 | 1.75 | 30.365 | 2.00 |
| L-Category | Petrol | Motorcycles 2-stroke >50 cm³ | Euro 3 | 65.17 | 1.11 | 12.365 | 2.00 |
| L-Category | Petrol | Motorcycles 2-stroke >50 cm³ | Euro 4 | 67.48 | 1.15 | 12.365 | 2.00 |
| L-Category | Petrol | Motorcycles 2-stroke >50 cm³ | Euro 5 | 67.48 | 1.15 | 12.365 | 2.00 |
| L-Category | Petrol | Motorcycles 4-stroke <250 cm³ | Conventional | 104.15 | 1.86 | 200.000 | 2.00 |
| L-Category | Petrol | Motorcycles 4-stroke <250 cm³ | Euro 1 | 85.64 | 1.53 | 139.477 | 2.00 |
| L-Category | Petrol | Motorcycles 4-stroke <250 cm³ | Euro 2 | 71.26 | 1.27 | 112.059 | 2.00 |
| L-Category | Petrol | Motorcycles 4-stroke <250 cm³ | Euro 3 | 62.22 | 1.11 | 53.590 | 2.00 |
| L-Category | Petrol | Motorcycles 4-stroke <250 cm³ | Euro 4 | 70.67 | 1.26 | 53.590 | 2.00 |
| L-Category | Petrol | Motorcycles 4-stroke <250 cm³ | Euro 5 | 68.87 | 1.23 | 7.468 | 2.00 |
| L-Category | Petrol | Motorcycles 4-stroke 250 - 750 cm³ | Conventional | 142.80 | 2.56 | 200.000 | 2.00 |
| L-Category | Petrol | Motorcycles 4-stroke 250 - 750 cm³ | Euro 1 | 135.70 | 2.43 | 156.731 | 2.00 |
| L-Category | Petrol | Motorcycles 4-stroke 250 - 750 cm³ | Euro 2 | 124.54 | 2.23 | 137.014 | 2.00 |
| L-Category | Petrol | Motorcycles 4-stroke 250 - 750 cm³ | Euro 3 | 176.30 | 3.16 | 63.900 | 2.00 |
| L-Category | Petrol | Motorcycles 4-stroke 250 - 750 cm³ | Euro 4 | 148.00 | 2.65 | 63.900 | 2.00 |
| L-Category | Petrol | Motorcycles 4-stroke 250 - 750 cm³ | Euro 5 | 105.86 | 1.89 | 14.559 | 2.00 |
| L-Category | Petrol | Motorcycles 4-stroke >750 cm³ | Conventional | 163.03 | 2.92 | 200.000 | 2.00 |
| L-Category | Petrol | Motorcycles 4-stroke >750 cm³ | Euro 1 | 153.10 | 2.74 | 110.657 | 2.00 |
| L-Category | Petrol | Motorcycles 4-stroke >750 cm³ | Euro 2 | 153.03 | 2.74 | 84.066 | 2.00 |
| L-Category | Petrol | Motorcycles 4-stroke >750 cm³ | Euro 3 | 176.01 | 3.15 | 37.172 | 2.00 |
| L-Category | Petrol | Motorcycles 4-stroke >750 cm³ | Euro 4 | 148.03 | 2.65 | 37.172 | 2.00 |
| L-Category | Petrol | Motorcycles 4-stroke >750 cm³ | Euro 5 | 150.47 | 2.69 | 11.550 | 2.00 |

*includes lubricants and SCR emissions

***Table B-5: Fuel and lubricant consumption from road transport sector (TJ)***

| Fuel | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Diesel* | 75 778.03 | 79 322.06 | 83 290.83 | 85 747.79 | 92 121.05 | 97 235.69 | 105 415.48 | 112 872.10 | 127 740.58 | 138 050.34 | 160 136.37 | 169 398.15 |
| Petrol** | 60 347.12 | 66 423.71 | 74 078.34 | 78 085.42 | 80 728.89 | 83 406.60 | 85 892.99 | 86 630.38 | 90 224.29 | 91 219.21 | 92 137.42 | 87 678.13 |
| CNG | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 29.78 | 197.04 |
| LPG | 0.98 | 2.56 | 4.51 | 5.03 | 5.40 | 13.28 | 82.77 | 796.75 | 910.55 | 1 097.65 | 1 027.14 | 996.03 |
| Lubricants 2-stroke | 74.32 | 69.27 | 64.09 | 58.23 | 52.56 | 48.17 | 44.10 | 40.11 | 37.53 | 34.18 | 31.10 | 26.05 |

| Fuel | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Diesel* | 171 651.80 | 173 177.29 | 175 597.29 | 176 673.02 | 185 226.47 | 186 797.14 | 186 665.76 | 190 450.08 | 194 527.94 | 182 938.79 | 167 871.09 |
| Petrol** | 91 583.73 | 88 825.13 | 85 489.20 | 80 234.74 | 74 220.55 | 69 259.35 | 64 958.93 | 63 725.12 | 60 464.58 | 54 431.54 | 49 541.07 |
| CNG | 304.13 | 397.29 | 391.52 | 440.00 | 437.06 | 483.91 | 505.81 | 502.58 | 526.74 | 528.29 | 503.17 |
| LPG | 975.81 | 942.26 | 867.96 | 963.02 | 1 028.40 | 1 068.05 | 1 189.80 | 1 394.20 | 1 331.70 | 1 385.83 | 1 465.38 |
| Lubricants 2-stroke | 25.49 | 22.48 | 20.72 | 19.56 | 18.92 | 18.58 | 17.70 | 18.67 | 19.88 | 18.88 | 17.60 |

| Fuel | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Diesel* | 164 487.36 | 168 842.84 | 173 023.45 | 177 089.50 | 181 287.35 | 183 537.84 | 188 589.09 | 160 872.98 | 173 807.88 | 182 311.61 | 190 675.66 |
| Petrol** | 47 779.88 | 47 767.20 | 47 194.66 | 45 972.39 | 45 094.50 | 44 814.51 | 46 439.05 | 38 550.07 | 42 421.98 | 46 685.67 | 51 542.45 |
| CNG | 520.13 | 508.32 | 548.05 | 496.72 | 616.92 | 672.94 | 733.02 | 841.34 | 996.58 | 1 370.26 | 1 427.70 |
| LPG | 1 537.39 | 1 541.87 | 1 647.00 | 1 720.61 | 1 700.22 | 1 668.86 | 1 710.39 | 1 289.37 | 1 451.27 | 1 614.22 | 1 956.83 |
| Lubricants 2-stroke | 17.78 | 18.08 | 18.67 | 20.60 | 20.64 | 20.67 | 21.60 | 19.31 | 22.42 | 25.52 | 28.48 |

* includes incorporation of Biodiesel

** includes incorporation of Biopetrol and excludes petrol evaporation

### *Table B-6: Vehicle fleet*

| Category | Fuel | Segment | Euro Standard | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Passenger Cars | Petrol | Mini | Euro 4 | 0 | 0 | 0 | 0 | 32 145 | 29 767 | 30 563 | 31 689 | 31 736 |
| Passenger Cars | Petrol | Mini | Euro 5 | 0 | 0 | 0 | 0 | 0 | 20 992 | 17 813 | 18 935 | 19 445 |
| Passenger Cars | Petrol | Mini | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 11 646 | 42 537 | 27 077 | 21 444 |
| Passenger Cars | Petrol | Mini | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 23 887 | 23 767 | 26 566 |
| Passenger Cars | Petrol | Mini | Euro 6 d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 11 407.0 | 17 096.0 |
| Passenger Cars | Petrol | Small | PRE ECE - ECE 15/04 | 1 314 342 | 1 510 432 | 1 147 073 | 678 906 | 381 268 | 233 461 | 117 412 | 101 686 | 86 845 |
| Passenger Cars | Petrol | Small | Euro 1 | 0 | 544 032 | 695 574 | 555 115 | 427 631 | 303 928 | 168 994 | 141 874 | 119 143 |
| Passenger Cars | Petrol | Small | Euro 2 | 0 | 0 | 574 509 | 510 073 | 478 939 | 417 071 | 251 758 | 223 839 | 203 601 |
| Passenger Cars | Petrol | Small | Euro 3 | 0 | 0 | 0 | 364 643 | 336 001 | 327 523 | 266 156 | 256 505 | 248 383 |
| Passenger Cars | Petrol | Small | Euro 4 | 0 | 0 | 0 | 0 | 174 241 | 159 967 | 157 782 | 158 719 | 157 676 |
| Passenger Cars | Petrol | Small | Euro 5 | 0 | 0 | 0 | 0 | 0 | 82 554 | 71 190 | 73 452 | 74 350 |
| Passenger Cars | Petrol | Small | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 35 274 | 164 975 | 128 423 | 118 163 |
| Passenger Cars | Petrol | Small | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 107 678 | 107 138 | 128 432 |
| Passenger Cars | Petrol | Small | Euro 6 d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 86 038.0 | 128 949.0 |
| Passenger Cars | Petrol | Medium | PRE ECE - ECE 15/04 | 49 005 | 55 651 | 41 937 | 25 475 | 17 040 | 11 835 | 7 442 | 6 649 | 5 707 |
| Passenger Cars | Petrol | Medium | Euro 1 | 0 | 42 397 | 66 756 | 72 893 | 57 398 | 40 698 | 25 646 | 22 526 | 19 601 |
| Passenger Cars | Petrol | Medium | Euro 2 | 0 | 0 | 185 430 | 167 393 | 160 952 | 141 023 | 105 243 | 94 214 | 86 072 |
| Passenger Cars | Petrol | Medium | Euro 3 | 0 | 0 | 0 | 180 661 | 167 216 | 163 184 | 145 679 | 140 290 | 135 705 |
| Passenger Cars | Petrol | Medium | Euro 4 | 0 | 0 | 0 | 0 | 89 578 | 82 307 | 81 630 | 82 176 | 81 634 |
| Passenger Cars | Petrol | Medium | Euro 5 | 0 | 0 | 0 | 0 | 0 | 19 221 | 26 113 | 27 874 | 28 450 |
| Passenger Cars | Petrol | Medium | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 4 863 | 53 820 | 89 016 | 96 819 |
| Passenger Cars | Petrol | Medium | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 39 050 | 38 730 | 45 687 |
| Passenger Cars | Petrol | Medium | Euro 6 d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 28 147.0 | 42 185.0 |
| Passenger Cars | Petrol | Large-SUV-Executive | PRE ECE - ECE 15/04 | 91 320 | 76 145 | 48 942 | 24 497 | 20 759 | 17 246 | 13 301 | 12 048 | 11 618 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 1 | 0 | 17 144 | 21 751 | 17 101 | 14 858 | 11 861 | 9 324 | 8 903 | 8 604 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 2 | 0 | 0 | 26 680 | 28 162 | 29 249 | 26 723 | 22 778 | 22 322 | 21 562 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 3 | 0 | 0 | 0 | 16 474 | 16 639 | 16 853 | 15 549 | 15 834 | 15 490 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 4 | 0 | 0 | 0 | 0 | 7 206 | 6 153 | 7 790 | 8 862 | 8 892 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 5 | 0 | 0 | 0 | 0 | 0 | 4 003 | 3 143 | 4 137 | 4 372 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 1 419 | 6 177 | 6 877 | 6 339 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 3 317 | 3 300 | 3 931 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 6 d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2 550.0 | 3 822.0 |
| Passenger Cars | Petrol Hybrid | All Segments | Euro 4 | 0 | 0 | 0 | 1 227 | 7 601 | 7 699 | 7 567 | 7 586 | 7 525 |
| Passenger Cars | Petrol Hybrid | All Segments | Euro 5 | 0 | 0 | 0 | 0 | 0 | 6 682 | 11 954 | 12 862 | 14 242 |
| Passenger Cars | Petrol Hybrid | All Segments | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 4 088 | 26 968 | 28 430 | 29 028 |
| Passenger Cars | Petrol Hybrid | All Segments | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 35 873 | 35 873 | 47 219 |
| Passenger Cars | Petrol Hybrid | All Segments | Euro 6 d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 45 384.0 | 68 076.0 |
| Passenger Cars | Diesel | Mini | Euro 4 | 0 | 0 | 0 | 0 | 6 055 | 6 282 | 8 176 | 8 658 | 8 927 |
| Passenger Cars | Diesel | Mini | Euro 5 | 0 | 0 | 0 | 0 | 0 | 2 571 | 3 641 | 4 079 | 4 338 |
| Passenger Cars | Diesel | Mini | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Passenger Cars | Diesel | Mini | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 10 | 10 |
| Passenger Cars | Diesel | Small | Conventional | 31 145 | 52 304 | 50 885 | 43 369 | 29 400 | 19 428 | 10 837 | 9 165 | 7 408 |
| Passenger Cars | Diesel | Small | Euro 1 | 0 | 33 346 | 43 841 | 42 456 | 34 746 | 28 085 | 19 927 | 17 620 | 15 841 |
| Passenger Cars | Diesel | Small | Euro 2 | 0 | 0 | 37 486 | 37 250 | 35 885 | 33 745 | 29 102 | 27 479 | 26 332 |
| Passenger Cars | Diesel | Small | Euro 3 | 0 | 0 | 0 | 71 323 | 71 133 | 72 403 | 68 067 | 67 063 | 65 622 |
| Passenger Cars | Diesel | Small | Euro 4 | 0 | 0 | 0 | 0 | 50 792 | 51 113 | 53 663 | 54 885 | 55 054 |
| Passenger Cars | Diesel | Small | Euro 5 | 0 | 0 | 0 | 0 | 0 | 24 667 | 30 072 | 31 593 | 32 741 |
| Passenger Cars | Diesel | Small | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 5 889 | 13 513 | 13 942 | 14 105 |

| Category | Fuel | Segment | Euro Standard | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Passenger Cars | Diesel | Small | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 21 890 | 21 890 | 25 540 |
| Passenger Cars | Diesel | Small | Euro 6 d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 14 600.0 | 21 900.0 |
| Passenger Cars | Diesel | Medium | Conventional | 9 902 | 26 450 | 26 190 | 24 159 | 18 657 | 12 999 | 7 440 | 6 179 | 5 060 |
| Passenger Cars | Diesel | Medium | Euro 1 | 0 | 49 845 | 72 530 | 74 093 | 68 423 | 58 530 | 42 311 | 37 438 | 33 753 |
| Passenger Cars | Diesel | Medium | Euro 2 | 0 | 0 | 144 097 | 143 182 | 144 836 | 137 124 | 118 534 | 112 195 | 107 479 |
| Passenger Cars | Diesel | Medium | Euro 3 | 0 | 0 | 0 | 285 107 | 283 682 | 280 755 | 261 511 | 255 953 | 250 839 |
| Passenger Cars | Diesel | Medium | Euro 4 | 0 | 0 | 0 | 0 | 388 526 | 389 210 | 386 220 | 386 739 | 384 117 |
| Passenger Cars | Diesel | Medium | Euro 5 | 0 | 0 | 0 | 0 | 0 | 247 219 | 310 544 | 324 224 | 338 921 |
| Passenger Cars | Diesel | Medium | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 95 659 | 395 192 | 419 323 | 427 825 |
| Passenger Cars | Diesel | Medium | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 89 456 | 89 456 | 105 428 |
| Passenger Cars | Diesel | Medium | Euro 6 d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 63 888.0 | 95 832.0 |
| Passenger Cars | Diesel | Large-SUV-Executive | Conventional | 57 173 | 70 532 | 65 192 | 57 821 | 50 984 | 43 722 | 35 003 | 32 982 | 31 154 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 1 | 0 | 37 787 | 65 106 | 67 426 | 64 727 | 57 454 | 46 680 | 44 185 | 41 850 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 2 | 0 | 0 | 211 246 | 209 863 | 209 622 | 195 252 | 168 253 | 161 299 | 155 108 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 3 | 0 | 0 | 0 | 238 066 | 236 996 | 235 335 | 221 328 | 218 853 | 215 129 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 4 | 0 | 0 | 0 | 0 | 239 424 | 238 400 | 247 082 | 251 525 | 250 617 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 5 | 0 | 0 | 0 | 0 | 0 | 107 912 | 129 937 | 138 301 | 142 338 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 31 759 | 130 970 | 140 110 | 142 601 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 26 068 | 26 068 | 30 176 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 6 d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 16 432.0 | 24 648.0 |
| Passenger Cars | LPG Bifuel | All Segments | Conventional | 25 | 164 | 4 561 | 4 477 | 5 671 | 7 562 | 7 828 | 7 828 | 7 828 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 1 | 0 | 186 | 7 066 | 6 937 | 8 788 | 11 718 | 12 128 | 12 128 | 12 128 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 2 | 0 | 0 | 9 300 | 9 129 | 11 566 | 15 421 | 15 961 | 15 961 | 15 961 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 3 | 0 | 0 | 0 | 4 753 | 6 021 | 8 028 | 8 310 | 8 310 | 8 310 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 4 | 0 | 0 | 0 | 0 | 1 592 | 1 585 | 1 595 | 1 595 | 1 595 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 5 | 0 | 0 | 0 | 0 | 0 | 3 750 | 3 724 | 3 724 | 3 724 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 0 | 2 769 | 2 769 | 2 769 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 7 419 | 7 419 | 7 419 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 6 d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2 007.0 | 7 419.0 | 9 530.0 |
| Light Commercial Vehicles | Petrol | N1-I | Conventional | 35 580 | 35 948 | 30 761 | 21 038 | 13 153 | 9 754 | 6 950 | 6 571 | 6 041 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 1 | 0 | 461 | 919 | 832 | 533 | 322 | 174 | 150 | 118 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 2 | 0 | 0 | 230 | 214 | 190 | 178 | 137 | 108 | 109 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 3 | 0 | 0 | 0 | 402 | 480 | 431 | 356 | 331 | 311 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 4 | 0 | 0 | 0 | 0 | 11 | 13 | 22 | 27 | 29 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 5 | 0 | 0 | 0 | 0 | 0 | 4 | 11 | 12 | 14 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 8 | 10 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 125 | 142 | 194 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 6 d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 116.0 | 174.0 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Conventional | 2 219 | 2 731 | 2 435 | 2 000 | 1 609 | 1 422 | 1 209 | 1 207 | 1 196 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 1 | 0 | 38 | 110 | 89 | 151 | 121 | 92 | 83 | 79 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 2 | 0 | 0 | 31 | 232 | 276 | 264 | 222 | 214 | 205 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 3 | 0 | 0 | 0 | 25 | 57 | 67 | 74 | 83 | 80 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 4 | 0 | 0 | 0 | 0 | 4 | 13 | 27 | 39 | 40 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 5 | 0 | 0 | 0 | 0 | 0 | 1 | 8 | 25 | 29 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 14 | 15 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 19 | 25 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 6 d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 16.0 | 24.0 |
| Light Commercial Vehicles | Diesel | N1-I | Conventional | 46 471 | 161 742 | 160 307 | 141 339 | 97 499 | 65 074 | 38 400 | 32 543 | 27 361 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 1 | 0 | 28 452 | 107 939 | 104 661 | 89 788 | 73 461 | 51 569 | 45 329 | 40 588 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 2 | 0 | 0 | 143 654 | 142 123 | 132 054 | 118 382 | 95 766 | 88 620 | 83 381 |

| Category | Fuel | Segment | Euro Standard | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Light Commercial Vehicles | Diesel | N1-I | Euro 3 | 0 | 0 | 0 | 162 955 | 167 534 | 157 942 | 140 055 | 135 116 | 130 693 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 4 | 0 | 0 | 0 | 0 | 103 686 | 105 451 | 99 106 | 98 290 | 96 759 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 5 | 0 | 0 | 0 | 0 | 0 | 24 562 | 24 769 | 25 025 | 24 984 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 5 651 | 14 652 | 15 015 | 15 287 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 7 274 | 7 795 | 9 293 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 6 d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1 080.0 | 1 620.0 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Conventional | 206 191 | 344 266 | 327 430 | 278 575 | 215 732 | 171 559 | 142 347 | 138 082 | 132 794 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 1 | 0 | 18 185 | 104 999 | 101 499 | 92 045 | 79 823 | 69 970 | 68 528 | 66 594 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 2 | 0 | 0 | 81 309 | 117 418 | 109 705 | 99 062 | 89 845 | 88 748 | 86 700 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 3 | 0 | 0 | 0 | 104 492 | 133 051 | 123 906 | 114 960 | 114 277 | 112 434 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 4 | 0 | 0 | 0 | 0 | 97 479 | 117 396 | 113 480 | 115 632 | 115 120 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 5 | 0 | 0 | 0 | 0 | 0 | 36 262 | 40 528 | 42 847 | 43 721 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 19 182 | 72 021 | 76 353 | 78 858 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 76 378 | 81 940 | 103 928 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 6 d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 55 644.0 | 83 466.0 |
| Heavy Duty Trucks | Diesel | <=20 t | Conventional | 33 568 | 43 785 | 40 420 | 31 480 | 19 438 | 11 275 | 7 774 | 7 498 | 6 826 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro I | 0 | 4 239 | 6 243 | 6 151 | 5 165 | 3 752 | 2 877 | 2 771 | 2 575 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro II | 0 | 0 | 13 333 | 16 183 | 16 090 | 12 678 | 11 036 | 10 839 | 10 194 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro III | 0 | 0 | 0 | 7 035 | 12 220 | 13 128 | 13 348 | 13 372 | 12 680 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro IV | 0 | 0 | 0 | 0 | 11 343 | 11 241 | 11 007 | 11 225 | 10 970 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro V | 0 | 0 | 0 | 0 | 2 702 | 9 139 | 10 692 | 10 967 | 11 181 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro VI A/B/C | 0 | 0 | 0 | 0 | 0 | 7 287 | 19 452 | 19 560 | 19 298 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro VI D/E | 0 | 0 | 0 | 0 | 0 | 0 | 8 243 | 16 358 | 20 396 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Conventional | 8 891 | 11 108 | 10 189 | 7 840 | 4 246 | 2 198 | 1 375 | 1 166 | 1 030 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro I | 0 | 989 | 1 523 | 1 538 | 1 236 | 823 | 632 | 557 | 523 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro II | 0 | 0 | 3 451 | 4 258 | 4 040 | 3 124 | 2 694 | 2 536 | 2 468 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro III | 0 | 0 | 0 | 1 401 | 1 919 | 2 087 | 2 395 | 2 480 | 2 536 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro IV | 0 | 0 | 0 | 0 | 815 | 876 | 1 243 | 1 454 | 1 518 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro V | 0 | 0 | 0 | 0 | 168 | 462 | 831 | 1 061 | 1 138 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro VI A/B/C | 0 | 0 | 0 | 0 | 0 | 183 | 806 | 972 | 1 024 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro VI D/E | 0 | 0 | 0 | 0 | 0 | 0 | 377 | 690 | 846 |
| Heavy Duty Trucks | Diesel | >28 t | Conventional | 9 595 | 15 044 | 13 400 | 8 321 | 3 000 | 1 014 | 451 | 333 | 259 |
| Heavy Duty Trucks | Diesel | >28 t | Euro I | 0 | 3 911 | 6 194 | 5 752 | 2 985 | 1 248 | 617 | 505 | 407 |
| Heavy Duty Trucks | Diesel | >28 t | Euro II | 0 | 0 | 14 171 | 17 551 | 12 378 | 6 098 | 2 614 | 2 114 | 1 763 |
| Heavy Duty Trucks | Diesel | >28 t | Euro III | 0 | 0 | 0 | 8 007 | 8 529 | 5 942 | 2 213 | 1 969 | 1 749 |
| Heavy Duty Trucks | Diesel | >28 t | Euro IV | 0 | 0 | 0 | 0 | 1 088 | 644 | 773 | 826 | 870 |
| Heavy Duty Trucks | Diesel | >28 t | Euro V | 0 | 0 | 0 | 0 | 90 | 137 | 216 | 287 | 306 |
| Heavy Duty Trucks | Diesel | >28 t | Euro VI A/B/C | 0 | 0 | 0 | 0 | 0 | 77 | 534 | 586 | 605 |
| Heavy Duty Trucks | Diesel | >28 t | Euro VI D/E | 0 | 0 | 0 | 0 | 0 | 0 | 418 | 857 | 1 077 |
| Buses | Diesel | Urban Buses | Conventional | 5 458 | 6 603 | 6 238 | 5 265 | 2 875 | 1 351 | 509 | 380 | 223 |
| Buses | Diesel | Urban Buses | Euro I | 0 | 806 | 1 299 | 1 233 | 1 422 | 1 012 | 418 | 311 | 194 |
| Buses | Diesel | Urban Buses | Euro II | 0 | 0 | 2 991 | 3 515 | 3 650 | 3 477 | 2 315 | 1 866 | 1 504 |
| Buses | Diesel | Urban Buses | Euro III | 0 | 0 | 0 | 2 231 | 2 898 | 3 377 | 3 352 | 3 080 | 2 862 |
| Buses | Diesel | Urban Buses | Euro IV | 0 | 0 | 0 | 0 | 1 698 | 1 840 | 2 300 | 2 366 | 2 358 |
| Buses | Diesel | Urban Buses | Euro V | 0 | 0 | 0 | 0 | 395 | 1 084 | 1 315 | 1 578 | 1 606 |
| Buses | Diesel | Urban Buses | Euro VI A/B/C | 0 | 0 | 0 | 0 | 0 | 433 | 1 614 | 1 777 | 1 777 |
| Buses | Diesel | Urban Buses | Euro VI D/E | 0 | 0 | 0 | 0 | 0 | 0 | 598 | 1 031 | 1 369 |
| Buses | Diesel | Coaches | Conventional | 751 | 898 | 847 | 719 | 429 | 203 | 75 | 55 | 33 |
| Buses | Diesel | Coaches | Euro I | 0 | 98 | 168 | 170 | 221 | 170 | 69 | 50 | 30 |
| Buses | Diesel | Coaches | Euro II | 0 | 0 | 402 | 460 | 491 | 499 | 341 | 268 | 213 |

| Category | Fuel | Segment | Euro Standard | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Buses | Diesel | Coaches | Euro III | 0 | 0 | 0 | 214 | 270 | 364 | 429 | 407 | 392 |
| Buses | Diesel | Coaches | Euro IV | 0 | 0 | 0 | 0 | 136 | 154 | 245 | 261 | 267 |
| Buses | Diesel | Coaches | Euro V | 0 | 0 | 0 | 0 | 38 | 108 | 148 | 197 | 202 |
| Buses | Diesel | Coaches | Euro VI A/B/C | 0 | 0 | 0 | 0 | 0 | 42 | 147 | 164 | 162 |
| Buses | Diesel | Coaches | Euro VI D/E | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 57.0 | 155.0 | 192.5 |
| Buses | CNG | Urban CNG Buses | Euro I | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| Buses | CNG | Urban CNG Buses | Euro II | 0 | 0 | 1 | 23 | 23 | 16 | 0 | 0 | 0 |
| Buses | CNG | Urban CNG Buses | Euro III | 0 | 0 | 0 | 21 | 30 | 35 | 28 | 19 | 11 |
| Buses | CNG | Urban CNG Buses | EEV | 0 | 0 | 0 | 0 | 90 | 89 | 503 | 842 | 982 |
| L-Category | Petrol | Mopeds 2-stroke <50 cm³ | Conventional | 417 346 | 341 022 | 264 699 | 140 866 | 100 710 | 92 770 | 91 027 | 95 388 | 98 587 |
| L-Category | Petrol | Mopeds 2-stroke <50 cm³ | Euro 1 | 0 | 0 | 0 | 9 163 | 7 145 | 5 651 | 3 997 | 3 258 | 2 926 |
| L-Category | Petrol | Mopeds 2-stroke <50 cm³ | Euro 2 | 0 | 0 | 0 | 15 238 | 15 911 | 11 368 | 8 882 | 8 050 | 7 620 |
| L-Category | Petrol | Mopeds 2-stroke <50 cm³ | Euro 3 | 0 | 0 | 0 | 0 | 17 922 | 26 070 | 24 215 | 19 722 | 16 740 |
| L-Category | Petrol | Mopeds 2-stroke <50 cm³ | Euro 4 | 0 | 0 | 0 | 0 | 0 | 0 | 3 575 | 3 187 | 4 132 |
| L-Category | Petrol | Mopeds 2-stroke <50 cm³ | Euro 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2 133.0 | 3 177.0 |
| L-Category | Petrol | Mopeds 4-stroke <50 cm³ | Conventional | 417 346 | 341 022 | 264 699 | 140 866 | 100 710 | 92 770 | 91 027 | 95 388 | 98 587 |
| L-Category | Petrol | Mopeds 4-stroke <50 cm³ | Euro 1 | 0 | 0 | 0 | 9 163 | 7 145 | 5 651 | 3 997 | 3 258 | 2 926 |
| L-Category | Petrol | Mopeds 4-stroke <50 cm³ | Euro 2 | 0 | 0 | 0 | 15 238 | 15 911 | 11 368 | 8 882 | 8 050 | 7 620 |
| L-Category | Petrol | Mopeds 4-stroke <50 cm³ | Euro 3 | 0 | 0 | 0 | 0 | 17 922 | 26 070 | 24 215 | 19 722 | 16 740 |
| L-Category | Petrol | Mopeds 4-stroke <50 cm³ | Euro 4 | 0 | 0 | 0 | 0 | 0 | 0 | 3 575 | 3 187 | 4 132 |
| L-Category | Petrol | Mopeds 4-stroke <50 cm³ | Euro 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2 133.0 | 3 177.0 |
| L-Category | Petrol | Motorcycles 2-stroke >50 cm³ | Conventional | 14 753 | 20 578 | 31 798 | 14 218 | 29 622 | 28 748 | 31 658 | 33 925 | 33 844 |
| L-Category | Petrol | Motorcycles 2-stroke >50 cm³ | Euro 1 | 0 | 0 | 0 | 10 200 | 14 985 | 14 535 | 17 893 | 18 756 | 18 487 |
| L-Category | Petrol | Motorcycles 2-stroke >50 cm³ | Euro 2 | 0 | 0 | 0 | 6 158 | 12 526 | 12 961 | 16 731 | 16 582 | 16 974 |
| L-Category | Petrol | Motorcycles 2-stroke >50 cm³ | Euro 3 | 0 | 0 | 0 | 0 | 20 774 | 56 563 | 68 407 | 60 846 | 59 971 |
| L-Category | Petrol | Motorcycles 2-stroke >50 cm³ | Euro 4 | 0 | 0 | 0 | 0 | 0 | 0 | 50 302 | 81 246 | 94 669 |
| L-Category | Petrol | Motorcycles 2-stroke >50 cm³ | Euro 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 15 066.0 | 15 171.0 |
| L-Category | Petrol | Motorcycles 4-stroke <250 cm³ | Conventional | 7 869 | 10 975 | 17 591 | 9 473 | 8 375 | 5 565 | 5 652 | 6 057 | 6 042 |
| L-Category | Petrol | Motorcycles 4-stroke <250 cm³ | Euro 1 | 0 | 0 | 0 | 6 796 | 4 237 | 2 814 | 3 195 | 3 349 | 3 301 |
| L-Category | Petrol | Motorcycles 4-stroke <250 cm³ | Euro 2 | 0 | 0 | 0 | 4 103 | 3 541 | 2 509 | 2 987 | 2 961 | 3 031 |
| L-Category | Petrol | Motorcycles 4-stroke <250 cm³ | Euro 3 | 0 | 0 | 0 | 0 | 5 873 | 10 950 | 12 214 | 10 864 | 10 708 |
| L-Category | Petrol | Motorcycles 4-stroke <250 cm³ | Euro 4 | 0 | 0 | 0 | 0 | 0 | 0 | 8 981 | 14 506 | 16 902 |
| L-Category | Petrol | Motorcycles 4-stroke <250 cm³ | Euro 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2 690.0 | 2 709.0 |
| L-Category | Petrol | Motorcycles 4-stroke 250 - 750 cm³ | Conventional | 26 481 | 36 936 | 54 811 | 27 567 | 22 198 | 14 564 | 15 019 | 16 094 | 16 056 |
| L-Category | Petrol | Motorcycles 4-stroke 250 - 750 cm³ | Euro 1 | 0 | 0 | 0 | 19 777 | 11 229 | 7 364 | 8 489 | 8 898 | 8 770 |
| L-Category | Petrol | Motorcycles 4-stroke 250 - 750 cm³ | Euro 2 | 0 | 0 | 0 | 11 940 | 9 387 | 6 566 | 7 937 | 7 867 | 8 053 |
| L-Category | Petrol | Motorcycles 4-stroke 250 - 750 cm³ | Euro 3 | 0 | 0 | 0 | 0 | 15 567 | 28 656 | 32 453 | 28 866 | 28 451 |
| L-Category | Petrol | Motorcycles 4-stroke 250 - 750 cm³ | Euro 4 | 0 | 0 | 0 | 0 | 0 | 0 | 23 864 | 38 544 | 44 912 |
| L-Category | Petrol | Motorcycles 4-stroke 250 - 750 cm³ | Euro 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 7 147.0 | 7 196.0 |
| L-Category | Petrol | Motorcycles 4-stroke >750 cm³ | Conventional | 17 027 | 23 749 | 40 396 | 21 773 | 21 039 | 16 289 | 17 956 | 19 242 | 19 196 |
| L-Category | Petrol | Motorcycles 4-stroke >750 cm³ | Euro 1 | 0 | 0 | 0 | 15 620 | 10 643 | 8 236 | 10 149 | 10 638 | 10 485 |
| L-Category | Petrol | Motorcycles 4-stroke >750 cm³ | Euro 2 | 0 | 0 | 0 | 9 430 | 8 897 | 7 344 | 9 490 | 9 405 | 9 627 |
| L-Category | Petrol | Motorcycles 4-stroke >750 cm³ | Euro 3 | 0 | 0 | 0 | 0 | 14 755 | 32 049 | 38 800 | 34 512 | 34 016 |
| L-Category | Petrol | Motorcycles 4-stroke >750 cm³ | Euro 4 | 0 | 0 | 0 | 0 | 0 | 0 | 28 531 | 46 082 | 53 696 |
| L-Category | Petrol | Motorcycles 4-stroke >750 cm³ | Euro 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 8 545.0 | 8 604.0 |

### *Table B-7: Total activity (vkm)*

| Category | Fuel | Segment | Euro Standard | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Passenger Cars | Petrol | Mini | Euro 4 | 0 | 0 | 0 | 0 | 228 195 540 | 219 320 116 | 174 582 503 | 215 414 430 | 225 784 529 |
| Passenger Cars | Petrol | Mini | Euro 5 | 0 | 0 | 0 | 0 | 0 | 88 510 391 | 105 734 252 | 137 205 507 | 147 465 155 |
| Passenger Cars | Petrol | Mini | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 71 189 228 | 207 290 223 | 198 118 278 | 164 208 911 |
| Passenger Cars | Petrol | Mini | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 182 805 150 | 192 100 541 | 224 726 034 |
| Passenger Cars | Petrol | Mini | Euro 6 d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 150 817 366.5 | 236 563 326.6 |
| Passenger Cars | Petrol | Small | PRE ECE - ECE 15/04 | 17 200 354 377 | 18 427 903 890 | 11 326 526 342 | 5 370 858 097 | 2 217 789 279 | 1 032 621 226 | 362 153 786 | 342 246 122 | 304 624 078 |
| Passenger Cars | Petrol | Small | Euro 1 | 0 | 8 161 477 117 | 9 123 289 426 | 5 965 205 105 | 3 568 256 871 | 2 032 974 360 | 794 511 894 | 728 286 179 | 640 080 458 |
| Passenger Cars | Petrol | Small | Euro 2 | 0 | 0 | 7 433 323 912 | 6 008 959 349 | 4 479 552 049 | 3 161 181 110 | 1 374 073 889 | 1 348 403 823 | 1 283 542 707 |
| Passenger Cars | Petrol | Small | Euro 3 | 0 | 0 | 0 | 4 259 675 742 | 3 347 313 428 | 2 708 224 517 | 1 611 986 012 | 1 720 509 679 | 1 743 629 638 |
| Passenger Cars | Petrol | Small | Euro 4 | 0 | 0 | 0 | 0 | 1 267 870 115 | 1 284 363 489 | 983 964 366 | 1 095 769 378 | 1 139 276 420 |
| Passenger Cars | Petrol | Small | Euro 5 | 0 | 0 | 0 | 0 | 0 | 490 379 182 | 456 124 282 | 519 034 134 | 549 850 359 |
| Passenger Cars | Petrol | Small | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 257 851 687 | 1 213 479 857 | 895 855 880 | 862 677 307 |
| Passenger Cars | Petrol | Small | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 1 032 389 620 | 1 211 887 294 | 1 520 418 867 |
| Passenger Cars | Petrol | Small | Euro 6 d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 950 893 241.9 | 1 491 531 504.5 |
| Passenger Cars | Petrol | Medium | PRE ECE - ECE 15/04 | 650 525 068 | 802 483 243 | 523 856 805 | 256 190 058 | 121 496 354 | 61 973 165 | 27 039 929 | 26 359 132 | 23 737 599 |
| Passenger Cars | Petrol | Medium | Euro 1 | 0 | 483 945 617 | 969 034 534 | 882 809 496 | 534 862 134 | 300 604 232 | 133 582 559 | 128 140 007 | 116 691 927 |
| Passenger Cars | Petrol | Medium | Euro 2 | 0 | 0 | 2 164 579 508 | 2 314 966 763 | 1 739 662 532 | 1 235 997 185 | 662 971 159 | 650 872 692 | 622 321 773 |
| Passenger Cars | Petrol | Medium | Euro 3 | 0 | 0 | 0 | 2 042 413 447 | 1 829 506 327 | 1 465 609 819 | 963 501 504 | 1 021 407 343 | 1 034 045 163 |
| Passenger Cars | Petrol | Medium | Euro 4 | 0 | 0 | 0 | 0 | 661 009 886 | 676 215 739 | 513 965 488 | 574 118 314 | 596 898 487 |
| Passenger Cars | Petrol | Medium | Euro 5 | 0 | 0 | 0 | 0 | 0 | 124 409 856 | 166 007 547 | 197 079 760 | 210 523 727 |
| Passenger Cars | Petrol | Medium | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 34 517 591 | 396 192 460 | 637 658 836 | 725 864 726 |
| Passenger Cars | Petrol | Medium | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 274 094 074 | 346 807 163 | 428 160 108 |
| Passenger Cars | Petrol | Medium | Euro 6 d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 227 738 012.4 | 357 218 929.4 |
| Passenger Cars | Petrol | Large-SUV-Executive | PRE ECE - ECE 15/04 | 1 441 662 132 | 1 109 236 714 | 593 424 326 | 224 587 247 | 129 623 802 | 77 176 343 | 39 327 501 | 38 922 449 | 39 532 917 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 1 | 0 | 309 715 071 | 375 385 175 | 233 712 632 | 144 131 585 | 86 609 319 | 45 231 745 | 46 061 609 | 46 586 055 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 2 | 0 | 0 | 440 092 141 | 430 771 234 | 319 435 004 | 222 698 614 | 133 910 106 | 141 258 169 | 142 802 053 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 3 | 0 | 0 | 0 | 239 474 496 | 193 270 084 | 147 323 448 | 95 614 449 | 105 711 563 | 108 233 543 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 4 | 0 | 0 | 0 | 0 | 58 383 610 | 51 040 443 | 46 880 940 | 59 135 189 | 62 099 997 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 5 | 0 | 0 | 0 | 0 | 0 | 22 544 139 | 19 439 175 | 30 294 468 | 33 504 347 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 10 698 761 | 41 219 675 | 49 845 441 | 48 084 651 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 16 213 393 | 23 927 571 | 29 826 719 |
| Passenger Cars | Petrol | Large-SUV-Executive | Euro 6 d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 14 367 904.1 | 22 538 080.2 |
| Passenger Cars | Petrol Hybrid | All Segments | Euro 4 | 0 | 0 | 0 | 19 280 248 | 95 928 344 | 88 390 490 | 64 878 103 | 71 822 228 | 74 577 954 |
| Passenger Cars | Petrol Hybrid | All Segments | Euro 5 | 0 | 0 | 0 | 0 | 0 | 96 385 065 | 156 086 262 | 176 320 349 | 204 577 282 |
| Passenger Cars | Petrol Hybrid | All Segments | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 53 945 020 | 252 700 086 | 330 906 911 | 353 706 936 |
| Passenger Cars | Petrol Hybrid | All Segments | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 276 961 633 | 334 284 732 | 460 506 877 |
| Passenger Cars | Petrol Hybrid | All Segments | Euro 6 d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 403 905 242.3 | 634 079 550.5 |
| Passenger Cars | Diesel | Mini | Euro 4 | 0 | 0 | 0 | 0 | 53 646 231 | 62 632 915 | 61 293 976 | 64 953 557 | 67 557 246 |
| Passenger Cars | Diesel | Mini | Euro 5 | 0 | 0 | 0 | 0 | 0 | 20 375 260 | 28 798 330 | 32 400 804 | 34 760 233 |
| Passenger Cars | Diesel | Mini | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 574 | 11 244 |
| Passenger Cars | Diesel | Mini | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 51 304 | 80 249 | 80 951 |
| Passenger Cars | Diesel | Small | Conventional | 749 769 632 | 751 935 607 | 639 874 133 | 428 657 162 | 264 698 001 | 136 231 269 | 58 199 643 | 51 531 356 | 42 019 504 |
| Passenger Cars | Diesel | Small | Euro 1 | 0 | 656 417 686 | 815 252 124 | 581 109 877 | 435 429 781 | 276 378 487 | 152 362 040 | 141 571 553 | 128 386 696 |
| Passenger Cars | Diesel | Small | Euro 2 | 0 | 0 | 793 039 282 | 639 106 611 | 515 790 626 | 381 903 713 | 252 248 173 | 248 390 374 | 240 100 692 |
| Passenger Cars | Diesel | Small | Euro 3 | 0 | 0 | 0 | 1 109 336 668 | 1 067 001 845 | 825 288 370 | 594 989 493 | 614 968 543 | 606 930 484 |
| Passenger Cars | Diesel | Small | Euro 4 | 0 | 0 | 0 | 0 | 723 736 373 | 621 696 360 | 489 028 430 | 539 432 586 | 545 821 046 |
| Passenger Cars | Diesel | Small | Euro 5 | 0 | 0 | 0 | 0 | 0 | 331 378 326 | 376 698 027 | 368 389 668 | 385 114 223 |
| Passenger Cars | Diesel | Small | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 86 679 327 | 208 362 750 | 283 189 320 | 289 011 528 |

| Category | Fuel | Segment | Euro Standard | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Passenger Cars | Diesel | Small | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 290 783 779 | 391 418 344 | 460 677 871 |
| Passenger Cars | Diesel | Small | Euro 6 d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 306 317 282.3 | 463 493 666.9 |
| Passenger Cars | Diesel | Medium | Conventional | 231 464 098 | 465 355 004 | 413 596 456 | 302 278 117 | 211 938 472 | 111 020 147 | 45 731 529 | 37 030 079 | 30 591 006 |
| Passenger Cars | Diesel | Medium | Euro 1 | 0 | 906 179 150 | 1 363 273 964 | 1 067 096 808 | 894 418 191 | 581 252 670 | 318 850 470 | 282 041 001 | 256 500 304 |
| Passenger Cars | Diesel | Medium | Euro 2 | 0 | 0 | 2 801 855 147 | 2 480 878 486 | 2 200 872 580 | 1 627 873 453 | 1 099 506 978 | 1 052 406 357 | 1 016 981 390 |
| Passenger Cars | Diesel | Medium | Euro 3 | 0 | 0 | 0 | 4 634 679 417 | 4 729 685 715 | 3 564 258 050 | 2 578 918 030 | 2 542 252 613 | 2 513 244 594 |
| Passenger Cars | Diesel | Medium | Euro 4 | 0 | 0 | 0 | 0 | 5 561 278 899 | 5 244 727 042 | 3 886 239 595 | 3 912 891 826 | 3 920 350 505 |
| Passenger Cars | Diesel | Medium | Euro 5 | 0 | 0 | 0 | 0 | 0 | 3 345 678 630 | 3 824 665 222 | 3 774 573 341 | 3 980 173 251 |
| Passenger Cars | Diesel | Medium | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 1 228 264 755 | 4 644 830 206 | 5 615 062 288 | 5 778 999 968 |
| Passenger Cars | Diesel | Medium | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 883 863 939 | 959 823 785 | 1 141 087 757 |
| Passenger Cars | Diesel | Medium | Euro 6 d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 664 657 950.1 | 1 005 704 765.3 |
| Passenger Cars | Diesel | Large-SUV-Executive | Conventional | 1 275 652 831 | 1 249 562 825 | 1 076 435 402 | 760 276 391 | 618 023 805 | 411 045 133 | 250 964 908 | 236 119 616 | 224 979 512 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 1 | 0 | 525 297 686 | 1 486 208 010 | 1 126 013 665 | 947 789 336 | 632 039 525 | 382 779 020 | 361 932 047 | 345 806 250 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 2 | 0 | 0 | 3 302 679 244 | 4 020 260 959 | 3 191 781 082 | 2 243 940 337 | 1 454 400 636 | 1 391 583 487 | 1 349 874 505 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 3 | 0 | 0 | 0 | 3 533 745 758 | 4 444 508 974 | 3 168 826 401 | 2 279 736 269 | 2 249 087 216 | 2 230 145 460 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 4 | 0 | 0 | 0 | 0 | 3 234 382 838 | 3 748 826 759 | 2 753 301 946 | 2 795 710 903 | 2 809 980 898 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 5 | 0 | 0 | 0 | 0 | 0 | 1 490 358 331 | 1 732 770 499 | 1 742 508 785 | 1 809 050 310 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 272 371 867 | 1 508 476 082 | 1 918 291 113 | 1 969 465 551 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 171 792 490 | 260 485 188 | 304 171 162 |
| Passenger Cars | Diesel | Large-SUV-Executive | Euro 6 d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 114 022 316.4 | 172 529 023.3 |
| Passenger Cars | LPG Bifuel | All Segments | Conventional | 362 577 | 1 126 869 | 31 780 936 | 23 681 573 | 26 008 189 | 28 565 833 | 24 206 954 | 22 379 456 | 26 211 041 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 1 | 0 | 3 809 484 | 172 693 428 | 123 288 812 | 129 664 047 | 151 638 011 | 91 609 755 | 97 571 474 | 114 276 678 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 2 | 0 | 0 | 169 310 734 | 118 453 061 | 176 295 946 | 194 957 482 | 114 462 929 | 129 963 411 | 152 214 436 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 3 | 0 | 0 | 0 | 76 012 654 | 105 882 345 | 114 465 748 | 62 813 849 | 68 756 560 | 80 528 365 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 4 | 0 | 0 | 0 | 0 | 28 497 324 | 24 965 501 | 13 628 135 | 15 251 239 | 17 862 403 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 5 | 0 | 0 | 0 | 0 | 0 | 48 481 518 | 32 049 381 | 37 430 696 | 43 839 203 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 0 | 24 126 751 | 27 305 101 | 31 980 006 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 57 838 401 | 80 098 325 | 93 811 953 |
| Passenger Cars | LPG Bifuel | All Segments | Euro 6 d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 15 455 407.4 | 67 004 135.1 | 100 905 730.7 |
| Light Commercial Vehicles | Petrol | N1-I | Conventional | 556 921 766 | 406 378 166 | 246 103 113 | 123 181 606 | 53 344 001 | 29 214 635 | 14 274 695 | 14 405 657 | 13 859 957 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 1 | 0 | 10 731 452 | 15 547 644 | 10 673 951 | 5 094 080 | 2 250 642 | 844 345 | 747 586 | 617 060 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 2 | 0 | 0 | 4 566 698 | 3 058 115 | 1 995 950 | 1 428 591 | 751 429 | 689 534 | 731 008 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 3 | 0 | 0 | 0 | 5 484 196 | 5 239 211 | 3 835 827 | 2 409 213 | 2 447 461 | 2 405 921 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 4 | 0 | 0 | 0 | 0 | 204 426 | 142 753 | 160 079 | 211 343 | 239 210 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 5 | 0 | 0 | 0 | 0 | 0 | 37 342 | 67 877 | 85 817 | 101 789 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 0 | 87 861 | 92 159 | 116 948 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 1 170 752 | 1 305 661 | 1 867 844 |
| Light Commercial Vehicles | Petrol | N1-I | Euro 6 d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1 254 568.8 | 1 969 512.5 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Conventional | 33 890 249 | 39 024 644 | 25 471 373 | 16 481 586 | 8 515 938 | 5 063 668 | 2 804 033 | 3 046 981 | 3 141 461 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 1 | 0 | 803 808 | 1 903 556 | 1 021 529 | 1 454 023 | 912 161 | 448 306 | 449 951 | 447 151 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 2 | 0 | 0 | 755 160 | 3 418 284 | 3 078 564 | 2 576 863 | 1 596 513 | 1 690 861 | 1 697 847 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 3 | 0 | 0 | 0 | 459 304 | 383 780 | 366 790 | 260 027 | 341 861 | 343 873 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 4 | 0 | 0 | 0 | 0 | 37 372 | 123 612 | 198 507 | 295 308 | 313 941 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 5 | 0 | 0 | 0 | 0 | 0 | 14 758 | 83 230 | 241 501 | 290 323 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 0 | 37 692 | 132 942 | 140 945 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 117 094 | 233 430 | 313 842 |
| Light Commercial Vehicles | Petrol | N1-II & N1-III | Euro 6 d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 225 237.7 | 353 594.4 |
| Light Commercial Vehicles | Diesel | N1-I | Conventional | 1 181 067 318 | 3 176 988 775 | 2 361 022 096 | 1 564 373 905 | 1 011 556 502 | 539 964 730 | 251 199 318 | 221 321 328 | 187 708 976 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 1 | 0 | 743 450 566 | 2 195 273 459 | 1 544 860 090 | 1 161 239 682 | 700 794 322 | 365 723 256 | 334 810 584 | 302 410 911 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 2 | 0 | 0 | 3 448 674 170 | 2 421 074 710 | 2 008 833 770 | 1 345 027 278 | 813 540 349 | 787 159 700 | 747 099 988 |

| Category | Fuel | Segment | Euro Standard | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Light Commercial Vehicles | Diesel | N1-I | Euro 3 | 0 | 0 | 0 | 3 033 051 800 | 2 959 675 792 | 2 115 093 198 | 1 408 366 483 | 1 430 256 812 | 1 395 534 628 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 4 | 0 | 0 | 0 | 0 | 2 079 241 099 | 1 689 527 475 | 1 187 587 145 | 1 252 071 585 | 1 243 340 261 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 5 | 0 | 0 | 0 | 0 | 0 | 477 648 184 | 368 712 999 | 404 031 794 | 406 903 500 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 110 217 621 | 235 198 228 | 284 807 934 | 292 510 474 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 116 764 395 | 147 857 333 | 177 815 004 |
| Light Commercial Vehicles | Diesel | N1-I | Euro 6 d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 25 160 883.5 | 38 071 342.5 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Conventional | 5 532 090 794 | 6 186 948 457 | 4 606 900 348 | 2 980 822 421 | 2 074 380 383 | 1 256 897 377 | 793 491 733 | 800 945 411 | 777 472 853 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 1 | 0 | 552 858 098 | 2 466 076 496 | 1 657 684 171 | 1 310 250 717 | 838 510 855 | 544 697 992 | 555 582 293 | 544 596 874 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 2 | 0 | 0 | 2 141 417 356 | 2 078 131 922 | 1 714 285 137 | 1 137 673 714 | 761 329 463 | 789 351 519 | 777 866 033 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 3 | 0 | 0 | 0 | 2 170 158 553 | 2 581 184 902 | 1 779 861 437 | 1 214 199 889 | 1 268 389 941 | 1 258 841 270 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 4 | 0 | 0 | 0 | 0 | 2 070 184 479 | 2 014 318 600 | 1 472 232 927 | 1 600 947 495 | 1 607 706 396 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 5 | 0 | 0 | 0 | 0 | 0 | 673 309 797 | 636 850 883 | 751 801 535 | 773 801 193 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 6 a/b/c | 0 | 0 | 0 | 0 | 0 | 354 887 502 | 1 114 482 753 | 1 431 853 707 | 1 491 926 579 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 6 d-temp | 0 | 0 | 0 | 0 | 0 | 0 | 1 087 686 522 | 1 654 989 281 | 2 117 637 045 |
| Light Commercial Vehicles | Diesel | N1-II & N1-III | Euro 6 d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1 301 519 660.0 | 1 969 350 586.8 |
| Heavy Duty Trucks | Diesel | <=20 t | Conventional | 1 238 478 247 | 1 166 279 618 | 905 165 778 | 516 579 017 | 279 343 089 | 119 154 218 | 60 368 738 | 56 635 751 | 51 927 104 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro I | 0 | 116 615 712 | 213 287 245 | 158 426 380 | 110 672 725 | 55 981 626 | 29 593 196 | 27 752 726 | 25 945 114 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro II | 0 | 0 | 514 267 742 | 569 781 792 | 462 542 880 | 242 039 412 | 145 975 381 | 138 739 550 | 130 946 422 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro III | 0 | 0 | 0 | 244 326 541 | 640 379 801 | 517 265 141 | 395 126 346 | 387 357 899 | 362 512 463 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro IV | 0 | 0 | 0 | 0 | 725 479 146 | 677 088 792 | 470 578 956 | 475 854 178 | 462 719 770 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro V | 0 | 0 | 0 | 0 | 166 828 709 | 630 893 570 | 577 237 056 | 583 681 547 | 597 547 338 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro VI A/B/C | 0 | 0 | 0 | 0 | 0 | 459 006 658 | 1 140 807 211 | 1 233 444 857 | 1 224 868 549 |
| Heavy Duty Trucks | Diesel | <=20 t | Euro VI D/E | 0 | 0 | 0 | 0 | 0 | 0 | 417 237 067 | 948 618 452 | 1 194 883 925 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Conventional | 473 796 395 | 432 071 138 | 330 358 303 | 181 130 472 | 89 832 074 | 32 085 384 | 14 378 594 | 12 085 383 | 10 765 845 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro I | 0 | 37 269 801 | 72 582 165 | 55 883 431 | 35 014 781 | 16 068 717 | 8 641 431 | 7 437 581 | 7 040 633 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro II | 0 | 0 | 161 059 494 | 187 796 546 | 142 853 073 | 71 504 030 | 41 703 251 | 38 859 998 | 38 146 129 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro III | 0 | 0 | 0 | 56 432 722 | 86 212 066 | 71 038 412 | 59 193 690 | 58 897 942 | 60 760 854 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro IV | 0 | 0 | 0 | 0 | 28 664 348 | 35 041 464 | 40 093 932 | 45 064 294 | 47 449 979 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro V | 0 | 0 | 0 | 0 | 5 732 656 | 18 727 795 | 34 649 770 | 42 592 140 | 46 064 856 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro VI A/B/C | 0 | 0 | 0 | 0 | 0 | 4 523 652 | 26 651 608 | 38 847 333 | 41 300 270 |
| Heavy Duty Trucks | Diesel | 20 - 28 t | Euro VI D/E | 0 | 0 | 0 | 0 | 0 | 0 | 8 287 621 | 14 886 554 | 18 408 523 |
| Heavy Duty Trucks | Diesel | >28 t | Conventional | 1 197 276 692 | 1 119 474 323 | 626 125 542 | 224 999 911 | 66 945 189 | 15 089 851 | 4 880 097 | 3 725 317 | 2 917 797 |
| Heavy Duty Trucks | Diesel | >28 t | Euro I | 0 | 324 449 813 | 489 000 184 | 229 951 663 | 86 490 660 | 24 246 169 | 8 282 414 | 6 531 345 | 5 322 534 |
| Heavy Duty Trucks | Diesel | >28 t | Euro II | 0 | 0 | 1 364 979 970 | 1 253 923 608 | 476 304 821 | 154 357 570 | 43 266 021 | 34 471 426 | 28 973 687 |
| Heavy Duty Trucks | Diesel | >28 t | Euro III | 0 | 0 | 0 | 653 350 971 | 668 661 637 | 314 192 972 | 74 853 031 | 64 644 535 | 56 252 601 |
| Heavy Duty Trucks | Diesel | >28 t | Euro IV | 0 | 0 | 0 | 0 | 44 476 890 | 27 760 871 | 25 279 196 | 27 489 522 | 29 134 269 |
| Heavy Duty Trucks | Diesel | >28 t | Euro V | 0 | 0 | 0 | 0 | 3 071 066 | 5 844 623 | 8 910 905 | 12 376 585 | 13 305 793 |
| Heavy Duty Trucks | Diesel | >28 t | Euro VI A/B/C | 0 | 0 | 0 | 0 | 0 | 1 916 896 | 16 186 076 | 25 976 835 | 27 047 130 |
| Heavy Duty Trucks | Diesel | >28 t | Euro VI D/E | 0 | 0 | 0 | 0 | 0 | 0 | 9 038 647 | 26 380 287 | 33 447 775 |
| Buses | Diesel | Urban Buses | Conventional | 303 457 923 | 242 503 352 | 181 742 593 | 113 013 364 | 53 479 559 | 17 610 728 | 4 597 359 | 3 488 339 | 2 072 120 |
| Buses | Diesel | Urban Buses | Euro I | 0 | 36 901 003 | 68 417 272 | 46 762 520 | 42 018 890 | 17 177 126 | 5 067 452 | 3 620 093 | 2 256 188 |
| Buses | Diesel | Urban Buses | Euro II | 0 | 0 | 174 824 260 | 165 449 718 | 134 689 591 | 85 504 681 | 33 551 041 | 24 709 314 | 20 052 618 |
| Buses | Diesel | Urban Buses | Euro III | 0 | 0 | 0 | 119 422 639 | 123 964 868 | 109 227 695 | 72 312 969 | 62 832 497 | 59 307 942 |
| Buses | Diesel | Urban Buses | Euro IV | 0 | 0 | 0 | 0 | 61 531 186 | 68 909 130 | 65 541 876 | 64 715 204 | 65 622 267 |
| Buses | Diesel | Urban Buses | Euro V | 0 | 0 | 0 | 0 | 11 342 174 | 44 920 583 | 43 320 112 | 51 776 086 | 53 442 549 |
| Buses | Diesel | Urban Buses | Euro VI A/B/C | 0 | 0 | 0 | 0 | 0 | 14 721 648 | 54 650 743 | 61 859 930 | 62 053 840 |
| Buses | Diesel | Urban Buses | Euro VI D/E | 0 | 0 | 0 | 0 | 0 | 0 | 10 994 139 | 21 404 970 | 28 806 512 |
| Buses | Diesel | Coaches | Conventional | 50 778 103 | 39 210 953 | 28 471 024 | 17 610 700 | 8 801 824 | 2 902 033 | 735 091 | 539 016 | 328 162 |
| Buses | Diesel | Coaches | Euro I | 0 | 6 132 435 | 10 780 423 | 7 528 153 | 7 109 584 | 2 965 380 | 855 460 | 610 659 | 366 203 |
| Buses | Diesel | Coaches | Euro II | 0 | 0 | 29 740 848 | 26 727 271 | 21 598 581 | 13 770 623 | 5 304 947 | 3 753 922 | 3 009 356 |

| Category | Fuel | Segment | Euro Standard | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Buses | Diesel | Coaches | Euro III | 0 | 0 | 0 | 15 747 127 | 15 228 660 | 14 044 192 | 10 522 154 | 9 124 061 | 8 867 310 |
| Buses | Diesel | Coaches | Euro IV | 0 | 0 | 0 | 0 | 7 547 365 | 8 655 779 | 9 232 987 | 9 178 821 | 9 467 525 |
| Buses | Diesel | Coaches | Euro V | 0 | 0 | 0 | 0 | 1 625 677 | 6 673 125 | 6 522 400 | 8 175 286 | 8 468 957 |
| Buses | Diesel | Coaches | Euro VI A/B/C | 0 | 0 | 0 | 0 | 0 | 1 997 020 | 7 099 385 | 7 880 912 | 7 856 954 |
| Buses | Diesel | Coaches | Euro VI D/E | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1 442 017.7 | 4 036 812.7 | 5 057 299.6 |
| Buses | CNG | Urban CNG Buses | Euro I | 0 | 0 | 0 | 0 | 0 | 49 169 | 25 180 | 0 | 0 |
| Buses | CNG | Urban CNG Buses | Euro II | 0 | 0 | 1 204 723 | 7 750 076 | 3 580 913 | 2 378 500 | 0 | 0 | 0 |
| Buses | CNG | Urban CNG Buses | Euro III | 0 | 0 | 0 | 11 374 676 | 5 731 529 | 6 169 325 | 2 471 301 | 1 980 366 | 1 004 064 |
| Buses | CNG | Urban CNG Buses | EEV | 0 | 0 | 0 | 0 | 13 332 265 | 15 042 774 | 33 504 515 | 56 515 849 | 59 870 389 |
| L-Category | Petrol | Mopeds 2-stroke <50 cm³ | Conventional | 1 675 681 140 | 1 060 338 074 | 648 050 977 | 266 349 052 | 133 824 401 | 90 464 778 | 57 934 683 | 64 197 831 | 69 441 315 |
| L-Category | Petrol | Mopeds 2-stroke <50 cm³ | Euro 1 | 0 | 0 | 0 | 38 239 184 | 18 519 252 | 9 451 303 | 3 845 535 | 3 168 043 | 2 978 151 |
| L-Category | Petrol | Mopeds 2-stroke <50 cm³ | Euro 2 | 0 | 0 | 0 | 60 848 434 | 50 695 690 | 23 376 634 | 10 505 238 | 9 613 368 | 9 523 742 |
| L-Category | Petrol | Mopeds 2-stroke <50 cm³ | Euro 3 | 0 | 0 | 0 | 0 | 66 178 089 | 73 687 136 | 46 449 779 | 39 381 316 | 34 983 859 |
| L-Category | Petrol | Mopeds 2-stroke <50 cm³ | Euro 4 | 0 | 0 | 0 | 0 | 0 | 0 | 9 455 425 | 9 971 077 | 13 528 223 |
| L-Category | Petrol | Mopeds 2-stroke <50 cm³ | Euro 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5 848 834.2 | 9 117 350.9 |
| L-Category | Petrol | Mopeds 4-stroke <50 cm³ | Conventional | 1 675 681 140 | 1 060 338 074 | 648 050 977 | 266 349 052 | 133 824 401 | 90 464 778 | 57 934 683 | 64 197 831 | 69 441 315 |
| L-Category | Petrol | Mopeds 4-stroke <50 cm³ | Euro 1 | 0 | 0 | 0 | 38 239 184 | 18 519 252 | 9 451 303 | 3 845 535 | 3 168 043 | 2 978 151 |
| L-Category | Petrol | Mopeds 4-stroke <50 cm³ | Euro 2 | 0 | 0 | 0 | 60 848 434 | 50 695 690 | 23 376 634 | 10 505 238 | 9 613 368 | 9 523 742 |
| L-Category | Petrol | Mopeds 4-stroke <50 cm³ | Euro 3 | 0 | 0 | 0 | 0 | 66 178 089 | 73 687 136 | 46 449 779 | 39 381 316 | 34 983 859 |
| L-Category | Petrol | Mopeds 4-stroke <50 cm³ | Euro 4 | 0 | 0 | 0 | 0 | 0 | 0 | 9 455 425 | 9 971 077 | 13 528 223 |
| L-Category | Petrol | Mopeds 4-stroke <50 cm³ | Euro 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5 848 834.2 | 9 117 350.9 |
| L-Category | Petrol | Motorcycles 2-stroke >50 cm³ | Conventional | 59 234 601 | 63 983 077 | 77 849 652 | 26 883 356 | 39 361 994 | 28 033 647 | 20 148 925 | 22 832 132 | 23 838 771 |
| L-Category | Petrol | Motorcycles 2-stroke >50 cm³ | Euro 1 | 0 | 0 | 0 | 42 566 809 | 38 839 887 | 24 309 803 | 17 214 953 | 18 238 127 | 18 813 520 |
| L-Category | Petrol | Motorcycles 2-stroke >50 cm³ | Euro 2 | 0 | 0 | 0 | 24 590 147 | 39 910 390 | 26 652 407 | 19 788 689 | 19 802 343 | 21 214 698 |
| L-Category | Petrol | Motorcycles 2-stroke >50 cm³ | Euro 3 | 0 | 0 | 0 | 0 | 76 709 275 | 159 875 928 | 131 219 908 | 121 498 608 | 125 329 781 |
| L-Category | Petrol | Motorcycles 2-stroke >50 cm³ | Euro 4 | 0 | 0 | 0 | 0 | 0 | 0 | 134 149 454 | 239 877 794 | 292 527 709 |
| L-Category | Petrol | Motorcycles 2-stroke >50 cm³ | Euro 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 41 312 018.9 | 43 537 718.1 |
| L-Category | Petrol | Motorcycles 4-stroke <250 cm³ | Conventional | 69 132 187 | 74 667 586 | 94 235 171 | 39 192 064 | 24 350 795 | 11 874 156 | 7 871 114 | 8 919 691 | 9 312 526 |
| L-Category | Petrol | Motorcycles 4-stroke <250 cm³ | Euro 1 | 0 | 0 | 0 | 64 270 492 | 24 924 807 | 10 673 066 | 6 957 640 | 7 373 774 | 7 607 337 |
| L-Category | Petrol | Motorcycles 4-stroke <250 cm³ | Euro 2 | 0 | 0 | 0 | 34 255 372 | 25 368 317 | 11 586 985 | 7 932 027 | 7 946 668 | 8 512 888 |
| L-Category | Petrol | Motorcycles 4-stroke <250 cm³ | Euro 3 | 0 | 0 | 0 | 0 | 43 921 780 | 73 872 051 | 58 784 507 | 52 698 473 | 54 361 275 |
| L-Category | Petrol | Motorcycles 4-stroke <250 cm³ | Euro 4 | 0 | 0 | 0 | 0 | 0 | 0 | 51 063 073 | 96 920 405 | 118 191 529 |
| L-Category | Petrol | Motorcycles 4-stroke <250 cm³ | Euro 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 16 020 370.4 | 16 885 047.1 |
| L-Category | Petrol | Motorcycles 4-stroke 250 - 750 cm³ | Conventional | 232 645 754 | 251 291 294 | 293 623 099 | 114 051 264 | 64 541 965 | 31 075 510 | 20 915 827 | 23 700 430 | 24 745 092 |
| L-Category | Petrol | Motorcycles 4-stroke 250 - 750 cm³ | Euro 1 | 0 | 0 | 0 | 187 033 184 | 66 056 327 | 27 930 510 | 18 486 200 | 19 591 473 | 20 209 806 |
| L-Category | Petrol | Motorcycles 4-stroke 250 - 750 cm³ | Euro 2 | 0 | 0 | 0 | 99 685 388 | 67 250 041 | 30 322 896 | 21 076 832 | 21 113 285 | 22 618 925 |
| L-Category | Petrol | Motorcycles 4-stroke 250 - 750 cm³ | Euro 3 | 0 | 0 | 0 | 0 | 116 419 266 | 193 322 144 | 156 192 371 | 140 021 550 | 144 435 085 |
| L-Category | Petrol | Motorcycles 4-stroke 250 - 750 cm³ | Euro 4 | 0 | 0 | 0 | 0 | 0 | 0 | 135 683 017 | 257 527 925 | 314 053 694 |
| L-Category | Petrol | Motorcycles 4-stroke 250 - 750 cm³ | Euro 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 42 564 158.9 | 44 852 269.9 |
| L-Category | Petrol | Motorcycles 4-stroke >750 cm³ | Conventional | 149 588 734 | 161 574 533 | 216 401 793 | 90 080 102 | 61 172 106 | 34 756 178 | 25 005 965 | 28 336 255 | 29 585 454 |
| L-Category | Petrol | Motorcycles 4-stroke >750 cm³ | Euro 1 | 0 | 0 | 0 | 147 719 995 | 62 609 092 | 31 237 871 | 22 101 124 | 23 422 577 | 24 161 759 |
| L-Category | Petrol | Motorcycles 4-stroke >750 cm³ | Euro 2 | 0 | 0 | 0 | 78 729 750 | 63 739 598 | 33 915 831 | 25 200 849 | 25 240 936 | 27 041 369 |
| L-Category | Petrol | Motorcycles 4-stroke >750 cm³ | Euro 3 | 0 | 0 | 0 | 0 | 110 346 648 | 216 212 360 | 186 739 715 | 167 408 846 | 172 686 398 |
| L-Category | Petrol | Motorcycles 4-stroke >750 cm³ | Euro 4 | 0 | 0 | 0 | 0 | 0 | 0 | 162 218 076 | 307 892 326 | 375 472 759 |
| L-Category | Petrol | Motorcycles 4-stroke >750 cm³ | Euro 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 889 987 | 53 628 256 |

***Table B-8: Activity data for CRT 1.A.3.c: Fuel consumption from Railways sector (GJ)***

| Fuel | Technology | unit | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Railways | Gas Oil | TJ | 2 390 | 2 502 | 2 507 | 2 293 | 2 276 | 2 326 | 2 119 | 2 036 | 1 889 | 1 859 | 1 829 | 1 630 | 1 522 | 1 317 | 1 193 | 1 110 | 1 021 |
| | Sub-bituminous Coal | TJ | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Coke | TJ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | - | - | - | - | - | - | - | - | - | - |

| Fuel | Technology | unit | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Railways | Gas Oil | TJ | 1 030 | 1 088 | 747 | 635 | 554 | 452 | 408 | 429 | 407 | 373 | 397 | 385 | 393 | 347 | 338 | 293 | 322 |
| | Sub-bituminous Coal | TJ | 1 | 1 | 1 | 1 | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - |
| | Coke | TJ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

# Other Sectors (CRT 1.A.4)

*Updated: March 2026*

***Table B-9: Activity data for CRT 1.A.4.a.i: Fuel consumption in the commercial, services and institutional sector: stationary (TJ)***

| Fuel | Technology | unit | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Liquefied Petroleum Gases | Medium Boilers | TJ | 447 | 490 | 539 | 616 | 577 | 370 | 706 | 995 | 957 | 960 | 1 025 | 1 230 | 779 | 779 | 682 | 435 | 453 |
| | Stove, Hobs and Ovens | TJ | 751 | 883 | 1 042 | 1 282 | 1 294 | 898 | 1 856 | 2 841 | 2 980 | 3 271 | 3 389 | 3 977 | 4 335 | 4 508 | 4 732 | 4 371 | 3 896 |
| Natural Gas & Gas Work Gas | Medium Boilers | TJ | 403 | 446 | 425 | 519 | 525 | 595 | 640 | 649 | 1 209 | 1 976 | 2 443 | 2 980 | 3 867 | 4 521 | 5 005 | 4 809 | 5 538 |
| | Heat Pump | TJ | - | - | - | - | - | - | - | - | - | - | 11 | 11 | 12 | 15 | 15 | 16 | 19 |
| | Stove, Hobs and Ovens | TJ | 102 | 111 | 104 | 125 | 124 | 138 | 146 | 145 | 265 | 424 | 612 | 660 | 729 | 826 | 873 | 966 | 1 017 |
| | Gas Turbines | TJ | - | - | - | - | - | - | - | - | - | 255 | 281 | 480 | 567 | 677 | 735 | 748 | 815 |
| Gas Oil | Medium Boilers | TJ | 5 640 | 6 918 | 8 280 | 8 446 | 8 592 | 7 889 | 8 726 | 13 106 | 16 719 | 18 352 | 18 392 | 21 957 | 24 195 | 26 051 | 29 093 | 28 452 | 15 348 |
| Wood and Wood Waste | Medium Boilers | TJ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Ovens | TJ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Fuel Oil | Medium Boilers[1] | TJ | - | - | - | - | - | - | - | - | 231 | 363 | 333 | 246 | 208 | 166 | 241 | 251 | 247 |
| | Medium Boilers[2] | TJ | 2 367 | 2 073 | 1 978 | 2 058 | 3 663 | 4 267 | 3 297 | 1 333 | 2 559 | 3 022 | 2 933 | 3 203 | 3 326 | 2 741 | 2 912 | 2 932 | 3 294 |

| Fuel | Technology | unit | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Liquefied Petroleum Gases | Medium Boilers | TJ | 450 | 457 | 460 | 430 | 395 | 431 | 421 | 421 | 428 | 418 | 344 | 376 | 253 | 151 | 100 | 76 | 41 | 31 |
| | Stove, Hobs and Ovens | TJ | 4,037 | 4,686 | 4,343 | 1,716 | 1,532 | 1,488 | 1,538 | 2,714 | 2,956 | 2,917 | 2,833 | 3,737 | 3,139 | 2,457 | 2,342 | 3,084 | 5,748 | 3,054 |
| Natural Gas & Gas Work Gas | Medium Boilers | TJ | 5,999 | 6,073 | 7,213 | 7,457 | 7,666 | 8,002 | 7,804 | 7,626 | 7,949 | 8,680 | 9,287 | 9,480 | 8,972 | 7,386 | 8,165 | 8,134 | 7,920 | 8,172 |
| | Heat Pump | TJ | 24 | 26 | 29 | 37 | 37 | 44 | 51 | 67 | 92 | 69 | 77 | 82 | 81 | 69 | 79 | 81 | 82 | 87 |
| | Stove, Hobs and Ovens | TJ | 1,047 | 1,015 | 1,087 | 1,255 | 1,215 | 1,269 | 1,235 | 1,316 | 1,342 | 1,270 | 1,324 | 1,315 | 1,211 | 970 | 1,042 | 1,008 | 952 | 953 |
| | Gas Turbines | TJ | 1,400 | 1,491 | 1,786 | 2,054 | 2,248 | 3,064 | 3,372 | 3,354 | 3,082 | 3,124 | 3,298 | 3,172 | 3,058 | 3,050 | 2,985 | 2,471 | 1,647 | 1,538 |
| Gas Oil | Medium Boilers | TJ | 14,266 | 10,912 | 8,971 | 4,858 | 3,366 | 2,720 | 2,506 | 2,081 | 1,749 | 1,413 | 1,282 | 1,614 | 1,935 | 1,608 | 1,240 | 1,269 | 2,068 | 1,914 |
| Wood and Wood Waste | Medium Boilers | TJ | - | - | - | - | 665 | 400 | 458 | 598 | 433 | 452 | 525 | 520 | 499 | 353 | 451 | 565 | 592 | 628 |
| | Ovens | TJ | - | - | - | - | 1,870 | 1,065 | 1,005 | 1,158 | 860 | 775 | 821 | 745 | 655 | 426 | 498 | 573 | 552 | 538 |
| Fuel Oil | Medium Boilers[1] | TJ | 436 | 455 | 444 | 465 | 194 | 179 | 76 | - | - | - | - | - | - | - | - | - | - | - |
| | Medium Boilers[2] | TJ | 3,125 | 1,765 | 1,462 | 2,208 | 1,191 | 851 | 775 | 773 | 1,219 | 806 | 706 | 598 | 496 | 433 | 356 | 470 | 364 | 594 |

***Table B-10: Activity data for CRT 1.A.4.b.i: Fuel consumption in the residential sector: stationary (TJ)***

| Fuel | Technology | unit | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Liquefied Petroleum Gases | LPG Heaters | TJ | 418 | 483 | 561 | 643 | 702 | 759 | 873 | 898 | 1 000 | 1 116 | 1 405 | 1 329 | 1 328 | 1 072 | 1 031 | 1 140 | 1 147 |
| | Condensing boilers | TJ | 8 535 | 8 690 | 8 954 | 9 152 | 8 949 | 8 691 | 9 005 | 8 362 | 8 418 | 8 505 | 7 022 | 6 822 | 7 146 | 6 175 | 5 950 | 5 850 | 4 476 |
| | Stove, Hobs and Ovens | TJ | 14 506 | 15 540 | 16 865 | 18 175 | 18 757 | 19 251 | 21 111 | 20 777 | 22 208 | 23 866 | 25 919 | 23 426 | 23 092 | 23 297 | 23 049 | 22 322 | 21 452 |
| Natural Gas & Gas Work Gas | Small Boilers | TJ | 1 017 | 1 011 | 1 008 | 1 032 | 967 | 921 | 923 | 925 | 1 118 | 1 545 | 1 867 | 2 122 | 2 537 | 2 627 | 2 890 | 3 098 | 3 063 |
| | Condensing boilers | TJ | 253 | 264 | 276 | 296 | 291 | 291 | 305 | 321 | 407 | 589 | 769 | 899 | 1 089 | 1 190 | 1 320 | 1 572 | 1 655 |
| | Stove, Hobs and Ovens | TJ | 655 | 677 | 701 | 746 | 727 | 720 | 750 | 782 | 983 | 1 413 | 1 771 | 2 064 | 2 539 | 2 830 | 3 408 | 3 724 | 3 794 |
| Gas Oil | Small Boilers | TJ | 158 | 211 | 286 | 205 | 190 | 201 | 133 | 92 | 106 | 144 | 90 | 82 | 120 | 235 | 474 | 839 | 829 |
| Wood and Wood Waste | Conventional stoves | TJ | 31 213 | 29 612 | 28 427 | 27 615 | 27 143 | 26 982 | 26 879 | 25 961 | 25 052 | 24 153 | 23 581 | 22 558 | 21 553 | 20 567 | 19 599 | 18 650 | 17 929 |
| | Open fireplaces | TJ | 11 672 | 11 107 | 10 695 | 10 422 | 10 276 | 10 246 | 10 240 | 9 922 | 9 606 | 9 292 | 9 004 | 8 683 | 8 364 | 8 048 | 7 735 | 7 424 | 7 116 |
| | Conventional boilers | TJ | 10 229 | 9 626 | 9 165 | 8 829 | 8 603 | 8 477 | 8 369 | 8 009 | 7 656 | 7 310 | 7 289 | 6 813 | 6 353 | 5 910 | 5 482 | 5 070 | 4 884 |
| | Pellet stoves and boilers | TJ | 691 | 1 032 | 1 357 | 1 679 | 2 010 | 2 360 | 2 716 | 2 981 | 3 226 | 3 452 | 3 001 | 3 490 | 3 941 | 4 354 | 4 731 | 5 070 | 4 884 |
| | Automatic Boilers | TJ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 70 |
| | Manual Boilers | TJ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Fuel Oil | - | TJ | 64 | 62 | 56 | 51 | 67 | 43 | 43 | 40 | 11 | 4 | 3 | - | - | - | - | - | - |
| Other Kerosene | - | TJ | 610 | 579 | 481 | 408 | 395 | 274 | 253 | 226 | 199 | 172 | 145 | 118 | 72 | - | - | - | - |

| Fuel | Technology | unit | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Liquefied Petroleum Gases | LPG Heaters | TJ | 1,160 | 1,179 | 1,185 | 1,169 | 1,090 | 1,077 | 1,069 | 1,049 | 1,033 | 1,006 | 1,026 | 1,008 | 1,054 | 1,126 | 963 | 884 | 667 | 844 |
| | Condensing boilers | TJ | 4,205 | 4,180 | 3,484 | 3,179 | 2,081 | 1,430 | 1,173 | 997 | 836 | 746 | 546 | 336 | 153 | 163 | 140 | 128 | 97 | 122 |
| | Stove, Hobs and Ovens | TJ | 20,052 | 17,420 | 17,127 | 18,867 | 17,702 | 17,016 | 16,706 | 15,125 | 14,020 | 14,315 | 14,372 | 13,907 | 14,341 | 15,312 | 13,097 | 12,022 | 9,074 | 11,484 |
| Natural Gas & Gas Work Gas | Small Boilers | TJ | 3,308 | 3,916 | 3,847 | 2,906 | 2,281 | 2,554 | 2,755 | 2,999 | 3,025 | 2,963 | 3,218 | 3,650 | 3,947 | 4,248 | 4,285 | 4,131 | 4,013 | 4,199 |
| | Condensing boilers | TJ | 1,813 | 2,603 | 2,170 | 2,759 | 2,693 | 2,835 | 2,829 | 3,101 | 3,091 | 3,072 | 3,326 | 3,763 | 4,059 | 4,358 | 4,386 | 4,220 | 4,092 | 4,274 |
| | Stove, Hobs and Ovens | TJ | 4,129 | 5,405 | 5,086 | 6,907 | 5,877 | 5,451 | 4,831 | 4,752 | 4,933 | 4,088 | 3,996 | 4,069 | 3,937 | 3,776 | 3,376 | 2,866 | 2,432 | 2,200 |
| Gas Oil | Small Boilers | TJ | 1,438 | 2,138 | 3,717 | 5,218 | 3,671 | 2,729 | 2,517 | 2,406 | 2,232 | 2,281 | 1,976 | 2,347 | 1,976 | 2,181 | 2,080 | 1,785 | 978 | 1,589 |
| Wood and Wood Waste | Conventional stoves | TJ | 17,211 | 16,496 | 15,783 | 15,072 | 15,738 | 15,620 | 15,854 | 15,639 | 15,436 | 15,339 | 15,211 | 15,083 | 14,884 | 15,089 | 15,019 | 14,888 | 15,133 | 14,446 |
| | Open fireplaces | TJ | 6,811 | 6,508 | 6,208 | 5,911 | 6,274 | 6,246 | 6,359 | 6,292 | 6,230 | 6,210 | 6,178 | 6,146 | 6,085 | 6,190 | 6,182 | 6,149 | 6,272 | 6,009 |
| | Conventional boilers | TJ | 4,697 | 4,511 | 4,324 | 4,138 | 4,104 | 4,012 | 4,008 | 3,890 | 3,776 | 3,687 | 3,591 | 3,495 | 3,383 | 3,361 | 3,277 | 3,179 | 3,159 | 2,946 |
| | Pellet stoves and boilers | TJ | 4,697 | 4,511 | 4,324 | 4,138 | 5,136 | 5,359 | 5,710 | 5,904 | 6,099 | 6,335 | 6,559 | 6,784 | 6,974 | 7,360 | 7,618 | 7,847 | 8,281 | 8,202 |
| | Automatic Boilers | TJ | 134 | 193 | 247 | 296 | 275 | 307 | 346 | 376 | 407 | 439 | 471 | 503 | 533 | 578 | 613 | 645 | 695 | 702 |
| | Manual Boilers | TJ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Fuel Oil | - | TJ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Other Kerosene | - | TJ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

***Table B-11: Activity data for CRT 1.A.4.c.i: Fuel consumption in agriculture/forestry/fishing: stationary (TJ)***

| Fuel | Technology | unit | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gas Oil | Medium Boilers | TJ | 3 822 | 3 767 | 4 061 | 4 309 | 4 253 | 4 478 | 4 677 | 4 153 | 4 011 | 4 069 | 4 478 | 4 841 | 5 145 | 5 850 | 5 790 | 5 749 | 5 496 |
| | Reciprocating engines | TJ | 425 | 419 | 451 | 479 | 473 | 498 | 520 | 461 | 446 | 452 | 498 | 538 | 572 | 650 | 643 | 639 | 611 |
| | - | TJ | 6 | 0 | 1 | 1 | 1 | 17 | 2 | 151 | 539 | 565 | 854 | 872 | 641 | 548 | 511 | 540 | 692 |
| LPG | Medium Boilers | TJ | 527 | 382 | 290 | 345 | 485 | 167 | 260 | 267 | 198 | 410 | 347 | 147 | 419 | 370 | 327 | 128 | 79 |
| Natural Gas & Gas Work Gas | Medium Boilers | TJ | - | - | - | - | - | - | - | - | 0 | 0 | 5 | 84 | 129 | 136 | 139 | 160 | 175 |
| | Gas Turbines | TJ | - | - | - | - | - | - | - | - | - | - | 9 | 138 | 162 | 163 | 168 | 195 | 173 |
| Wood Waste | Medium boilers | TJ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Fuel Oil | Medium Boilers[1] | TJ | - | - | - | - | 5 | 261 | 253 | 285 | 280 | 278 | 567 | 689 | 814 | 738 | 635 | 740 | 496 |
| | Medium Boilers[2] | TJ | 529 | 382 | 294 | 353 | 488 | 179 | 265 | 272 | 202 | 451 | 332 | 133 | 426 | 374 | 236 | 122 | 86 |
| Other Kerosene | - | TJ | 93 | 82 | 72 | 55 | 53 | 51 | 49 | 49 | 49 | 49 | 49 | 47 | 50 | 47 | 49 | 55 | 56 |

| Fuel | Technology | unit | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gas Oil | Medium Boilers | TJ | 5,495 | 5,184 | 4,697 | 4,620 | 4,553 | 4,618 | 4,766 | 4,791 | 4,865 | 5,044 | 5,121 | 5,199 | 5,375 | 5,728 | 5,891 | 5,736 | 5,882 | 6,052 |
| | Reciprocating engines | TJ | 611 | 576 | 522 | 513 | 506 | 513 | 530 | 532 | 541 | 560 | 569 | 578 | 597 | 636 | 655 | 637 | 654 | 672 |
| | - | TJ | 518 | 590 | 717 | 845 | 1,132 | 1,155 | 1,288 | 1,312 | 1,917 | 1,542 | 1,490 | 1,541 | 1,635 | 1,432 | 1,048 | 1,398 | 1,281 | 1,020 |
| LPG | Medium Boilers | TJ | 110 | 57 | 102 | 155 | 173 | 47 | 34 | 36 | 54 | 38 | 32 | 24 | 12 | 24 | 3 | 1 | - | - |
| Natural Gas & Gas Work Gas | Medium Boilers | TJ | 215 | 142 | 214 | 147 | 199 | 216 | 292 | 199 | 182 | 178 | 242 | 154 | 262 | 290 | 333 | 160 | 149 | 212 |
| | Gas Turbines | TJ | 169 | 179 | 179 | 304 | 316 | 322 | 313 | 146 | 181 | 209 | 213 | 239 | 291 | 335 | 346 | 163 | 229 | 206 |
| Wood Waste | Medium boilers | TJ | - | - | - | - | 100 | 159 | 129 | 202 | 130 | 60 | 60 | 60 | 215 | 215 | 76 | 95 | 105 | 113 |
| Fuel Oil | Medium Boilers[1] | TJ | 183 | 149 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Medium Boilers[2] | TJ | 108 | 99 | 151 | 628 | 590 | 145 | 105 | 165 | 165 | 225 | 174 | 153 | 191 | 271 | 107 | 1 | - | - |
| Other Kerosene | - | TJ | 32 | 39 | 45 | 39 | 30 | 33 | 30 | 25 | 26 | 21 | 23 | 12 | 10 | 14 | 9 | 11 | 11 | 4 |

***Table B-12: Activity data for CRT 1.A.4.a.ii, 1.A.4.b.ii, 1.A.4.c.ii and 1.A.4.c.iii: Fuel consumption: mobile sources (TJ)***

| Fuel | Technology | unit | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gas Oil | Tractors, Others | TJ | 4 247 | 4 186 | 4 512 | 4 787 | 4 726 | 4 975 | 5 197 | 4 614 | 4 456 | 4 521 | 4 975 | 5 379 | 5 717 | 6 500 | 6 433 | 6 388 | 6 107 |
| | Fishing Vessels | TJ | 5 392 | 5 518 | 4 876 | 4 336 | 4 456 | 3 949 | 3 661 | 3 395 | 3 397 | 3 299 | 4 820 | 4 922 | 3 618 | 2 796 | 3 316 | 2 748 | 2 875 |
| Thick Fuel Oil | Fishing Vessels | TJ | - | - | - | - | 207 | 48 | 12 | 11 | 21 | 11 | - | - | - | - | - | - | - |
| Thin Fuel Oil | Fishing Vessels | TJ | - | 3 | - | 41 | 276 | 27 | 16 | 10 | 11 | 6 | 2 | - | - | - | - | - | - |
| Gasoline | Residential: 2-Stroke | TJ | 6 | 8 | 6 | 6 | 6 | 10 | 14 | 15 | 15 | 6 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Agriculture: 4-Stroke | TJ | 35 | 36 | 48 | 45 | 45 | 45 | 45 | 44 | 47 | 105 | 99 | 93 | 87 | 81 | 75 | 68 | 70 |
| Other Kerosene | Commercial: mobile | TJ | 74 | 33 | 64 | 74 | 24 | 13 | 13 | 15 | 21 | 14 | 4 | 7 | 9 | 7 | 7 | 6 | 0 |
| | Residential: mobile | TJ | 184 | 174 | 145 | 123 | 119 | 82 | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 90 | 89 | 50 | 31 |

| Fuel | Technology | unit | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gas Oil | Tractors, Others | TJ | 6,105 | 5,761 | 5,219 | 5,133 | 5,059 | 5,131 | 5,295 | 5,323 | 5,406 | 5,604 | 5,690 | 5,777 | 5,973 | 6,364 | 6,546 | 6,373 | 6,535 | 6,724 |
| | Fishing Vessels | TJ | 2,399 | 2,347 | 2,883 | 2,958 | 2,571 | 2,541 | 2,596 | 2,118 | 1,893 | 1,915 | 1,789 | 1,826 | 2,012 | 2,256 | 2,657 | 2,037 | 2,370 | 2,441 |
| Thick Fuel Oil | Fishing Vessels | TJ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Thin Fuel Oil | Fishing Vessels | TJ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Gasoline | Residential: 2-Stroke | TJ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Agriculture: 4-Stroke | TJ | 63 | 42 | 62 | 45 | 31 | 20 | 36 | 20 | 33 | 42 | 42 | 43 | 15 | 21 | 20 | 18 | 19 | 16 |
| Other Kerosene | Commercial: mobile | TJ | 0 | 1 | 5 | 1 | 2 | 2 | 4 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| | Residential: mobile | TJ | 25 | 29 | 22 | 27 | 27 | 18 | 20 | 11 | 8 | 7 | 7 | 5 | 4 | 4 | 3 | 1 | 1 | 0 |

# Other (Not Else-where specified) (CRT 1.A.5)

*Updated: March 2025*

***Table B-13: Activity data for CRT 1.A.5.b: Energy Consumption in Military aviation (TJ)***

| Fuel Sales | | NAPFUE | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jet Fuel | L | 207 | 1 344 | 1 504 | 1 127 | 1 065 | 1 188 | 1 149 | 1 471 | 1 413 | 1 474 | 1 127 | 1 338 | 1 338 | 939 | 749 | 570 | 1 025 | 1 064 |

| Fuel Sales | | NAPFUE | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jet Fuel | L | 207 | 1 026 | 1 200 | 1 205 | 1 208 | 1 086 | 683 | 822 | 961 | 1 065 | 614 | 612 | 821 | 847 | 927 | 1 020 | 1 252 | 683 |

# Annex C: Agriculture

*Updated: April 2026*

***Table C- 1**: Livestock numbers (thousand)*

| Type | Subtype | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dairy cattle | Dairy cows | 394 | 388 | 381 | 383 | 382 | 383 | 380 | 379 | 375 | 369 | 353 |
| Non-dairy cattle | Beef calfs (<1 yr) | 46 | 52 | 53 | 53 | 58 | 60 | 64 | 64 | 65 | 66 | 67 |
| | Calfs M.Rep. (<1 yr) | 186 | 185 | 182 | 176 | 167 | 162 | 155 | 151 | 149 | 149 | 144 |
| | Calfs F Rep. (<1 yr) | 177 | 178 | 178 | 174 | 164 | 158 | 152 | 152 | 155 | 165 | 174 |
| | Males 1-2 yrs | 112 | 114 | 114 | 108 | 103 | 103 | 105 | 101 | 95 | 86 | 82 |
| | Beef Fem. 1-2 yrs | 18 | 19 | 20 | 22 | 22 | 22 | 24 | 24 | 24 | 20 | 17 |
| | Females rep. 1-2 yrs | 111 | 115 | 112 | 109 | 106 | 109 | 112 | 109 | 108 | 116 | 127 |
| | Steers (>2 yrs) | 38 | 38 | 36 | 37 | 35 | 33 | 33 | 31 | 31 | 29 | 26 |
| | Heifers Beef (>2 yrs) | 4 | 5 | 7 | 9 | 10 | 10 | 9 | 9 | 9 | 7 | 6 |
| | Heifers rep. (>2 yrs) | 45 | 46 | 45 | 48 | 50 | 52 | 51 | 50 | 52 | 60 | 67 |
| | non-dairy cows | 242 | 245 | 238 | 241 | 252 | 273 | 296 | 316 | 332 | 338 | 345 |
| Swine | Piglets (<20 kg) | 727 | 756 | 756 | 750 | 735 | 726 | 703 | 701 | 695 | 691 | 663 |
| | Fat. Pigs (20-50 kg) | 662 | 675 | 660 | 671 | 668 | 660 | 633 | 631 | 633 | 623 | 585 |
| | Fat. Pigs (50-80 kg) | 525 | 545 | 544 | 539 | 532 | 525 | 505 | 496 | 492 | 498 | 483 |
| | Fat. Pigs (80-110 kg) | 218 | 227 | 226 | 225 | 210 | 198 | 179 | 177 | 174 | 176 | 174 |
| | Fat. Pigs (> 110 kg) | 44 | 46 | 46 | 47 | 45 | 44 | 40 | 39 | 38 | 38 | 38 |
| | Boars (>50 kg) | 26 | 28 | 27 | 28 | 28 | 26 | 24 | 23 | 23 | 22 | 20 |
| | Sows, pregnant | 210 | 219 | 218 | 220 | 216 | 211 | 204 | 204 | 202 | 201 | 195 |
| | Sows, non-pregnant | 124 | 131 | 135 | 136 | 134 | 132 | 127 | 128 | 127 | 127 | 124 |
| Sheep | Ewes | 2 292 | 2 293 | 2 257 | 2 268 | 2 303 | 2 339 | 2 376 | 2 368 | 2 367 | 2 388 | 2 410 |
| | Other Ovine | 663 | 725 | 789 | 794 | 811 | 817 | 813 | 802 | 834 | 840 | 734 |
| | Lambs | 307 | 326 | 320 | 300 | 279 | 278 | 292 | 297 | 301 | 307 | 319 |
| Goats | Does | 614 | 588 | 556 | 538 | 528 | 517 | 509 | 498 | 485 | 472 | 460 |
| | Other Caprine | 149 | 156 | 166 | 160 | 153 | 151 | 147 | 151 | 154 | 151 | 129 |
| | kids | 47 | 49 | 47 | 44 | 45 | 41 | 41 | 36 | 37 | 36 | 33 |
| Horses | Horses | 33 | 38 | 40 | 42 | 44 | 48 | 52 | 54 | 56 | 57 | 58 |
| Asses | Asses and Mules. | 118 | 116 | 114 | 114 | 109 | 103 | 96 | 90 | 82 | 75 | 69 |
| Poultry | Hens, reproductive | 3 421 | 3 300 | 3 116 | 2 941 | 2 947 | 3 271 | 3 477 | 3 390 | 2 982 | 2 636 | 2 644 |
| | Hens eggs | 7 539 | 7 695 | 7 932 | 8 159 | 8 143 | 7 745 | 7 392 | 7 322 | 7 859 | 8 627 | 9 060 |
| | Broilers | 18 524 | 18 812 | 19 243 | 19 674 | 19 530 | 18 813 | 18 355 | 18 733 | 20 538 | 22 936 | 24 374 |
| | Turkeys | 1 149 | 1 122 | 1 082 | 1 041 | 996 | 945 | 936 | 972 | 1 061 | 1 158 | 1 208 |
| | Other poultry | 1 571 | 1 559 | 1 542 | 1 525 | 1 528 | 1 551 | 1 552 | 1 509 | 1 494 | 1 552 | 1 622 |
| Other | Rabbits* | 475 | 464 | 447 | 430 | 415 | 401 | 384 | 363 | 346 | 338 | 336 |

| Type | Subtype | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dairy cattle | Dairy cows | 331 | 311 | 297 | 294 | 290 | 284 | 275 | 269 | 263 | 255 | 247 |
| Non-dairy cattle | Beef calfs (<1 yr) | 72 | 75 | 82 | 91 | 104 | 108 | 108 | 108 | 109 | 114 | 120 |
| | Calfs M.Rep. (<1 yr) | 140 | 137 | 141 | 140 | 136 | 131 | 129 | 127 | 123 | 123 | 128 |
| | Calfs F Rep. (<1 yr) | 180 | 186 | 186 | 187 | 183 | 180 | 178 | 174 | 169 | 171 | 179 |
| | Males 1-2 yrs | 81 | 80 | 80 | 79 | 81 | 77 | 75 | 73 | 72 | 66 | 60 |
| | Beef Fem. 1-2 yrs | 14 | 14 | 15 | 16 | 17 | 17 | 16 | 17 | 18 | 20 | 19 |
| | Females rep. 1-2 yrs | 135 | 136 | 133 | 135 | 135 | 139 | 139 | 141 | 142 | 137 | 132 |
| | Steers (>2 yrs) | 24 | 23 | 23 | 23 | 25 | 28 | 31 | 33 | 34 | 38 | 41 |
| | Heifers Beef (>2 yrs) | 6 | 8 | 8 | 8 | 9 | 9 | 9 | 9 | 10 | 12 | 13 |
| | Heifers rep. (>2 yrs) | 77 | 80 | 86 | 90 | 94 | 96 | 96 | 97 | 102 | 110 | 111 |
| | non-dairy cows | 352 | 362 | 371 | 382 | 397 | 411 | 425 | 432 | 436 | 438 | 440 |
| Swine | Piglets (<20 kg) | 626 | 591 | 571 | 570 | 574 | 583 | 590 | 592 | 602 | 597 | 614 |
| | Fat. Pigs (20-50 kg) | 535 | 493 | 471 | 467 | 467 | 466 | 468 | 464 | 460 | 448 | 446 |
| | Fat. Pigs (50-80 kg) | 446 | 402 | 374 | 373 | 368 | 362 | 356 | 357 | 362 | 360 | 362 |
| | Fat. Pigs (80-110 kg) | 184 | 197 | 208 | 213 | 214 | 221 | 222 | 227 | 237 | 244 | 251 |
| | Fat. Pigs (> 110 kg) | 43 | 42 | 43 | 40 | 41 | 43 | 44 | 44 | 40 | 36 | 30 |
| | Boars (>50 kg) | 19 | 17 | 16 | 14 | 12 | 12 | 11 | 10 | 8 | 7 | 6 |
| | Sows, pregnant | 197 | 196 | 198 | 194 | 191 | 189 | 185 | 183 | 181 | 179 | 172 |
| | Sows, non-pregnant | 111 | 91 | 73 | 67 | 68 | 70 | 71 | 70 | 69 | 66 | 66 |
| Sheep | Ewes | 2 388 | 2 328 | 2 282 | 2 273 | 2 293 | 2 275 | 2 225 | 2 137 | 2 030 | 1 915 | 1 811 |
| | Other Ovine | 505 | 299 | 204 | 216 | 234 | 267 | 250 | 226 | 206 | 192 | 179 |
| | Lambs | 320 | 330 | 324 | 329 | 322 | 328 | 340 | 337 | 307 | 277 | 264 |
| Goats | Does | 440 | 417 | 392 | 382 | 380 | 380 | 373 | 365 | 358 | 356 | 353 |
| | Other Caprine | 91 | 62 | 48 | 52 | 57 | 65 | 59 | 52 | 44 | 40 | 38 |
| | kids | 30 | 29 | 28 | 28 | 26 | 25 | 28 | 30 | 31 | 29 | 29 |
| Horses | Horses | 59 | 59 | 59 | 59 | 60 | 62 | 65 | 71 | 82 | 92 | 98 |
| Asses | Asses and Mules. | 63 | 61 | 60 | 61 | 60 | 57 | 53 | 45 | 33 | 24 | 19 |
| Poultry | Hens, reproductive | 2 780 | 3 019 | 3 206 | 3 253 | 3 056 | 2 800 | 2 717 | 2 877 | 3 218 | 3 453 | 3 542 |
| | Hens eggs | 9 089 | 8 739 | 8 440 | 7 942 | 7 349 | 6 830 | 6 490 | 6 758 | 7 341 | 7 867 | 7 883 |
| | Broilers | 24 259 | 22 590 | 20 921 | 19 620 | 18 686 | 17 885 | 16 848 | 16 780 | 17 915 | 19 207 | 19 452 |
| | Turkeys | 1 201 | 1 139 | 1 077 | 963 | 798 | 799 | 1 017 | 1 318 | 1 485 | 1 445 | 1 331 |
| | Other poultry | 1 634 | 1 588 | 1 542 | 1 471 | 1 376 | 1 322 | 1 332 | 1 414 | 1 504 | 1 522 | 1 460 |
| Other | Rabbits* | 332 | 325 | 318 | 306 | 289 | 270 | 254 | 251 | 255 | 255 | 243 |

| Type | Subtype | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dairy cattle | Dairy cows | 241 | 236 | 233 | 235 | 238 | 240 | 237 | 235 | 233 | 232 | 228 | 223 | 218 |
| Non-dairy cattle | Beef calfs (<1 yr) | 125 | 119 | 113 | 112 | 114 | 114 | 112 | 109 | 107 | 102 | 100 | 91 | 85 |
| | Calfs M.Rep. (<1 yr) | 136 | 136 | 142 | 152 | 162 | 166 | 165 | 172 | 175 | 181 | 180 | 179 | 176 |
| | Calfs F Rep. (<1 yr) | 190 | 191 | 198 | 209 | 221 | 226 | 224 | 232 | 236 | 243 | 242 | 241 | 238 |
| | Males 1-2 yrs | 55 | 54 | 53 | 58 | 67 | 74 | 75 | 70 | 70 | 66 | 59 | 53 | 53 |
| | Beef Fem. 1-2 yrs | 20 | 19 | 17 | 15 | 14 | 14 | 14 | 15 | 16 | 16 | 16 | 15 | 15 |
| | Females rep. 1-2 yrs | 131 | 135 | 139 | 148 | 159 | 165 | 163 | 158 | 157 | 155 | 148 | 139 | 133 |
| | Steers (>2 yrs) | 44 | 42 | 39 | 37 | 38 | 45 | 53 | 60 | 62 | 60 | 58 | 52 | 47 |
| | Heifers Beef (>2 yrs) | 14 | 14 | 15 | 15 | 14 | 15 | 15 | 14 | 12 | 11 | 12 | 11 | 11 |
| | Heifers rep. (>2 yrs) | 110 | 105 | 103 | 96 | 92 | 90 | 95 | 98 | 98 | 94 | 88 | 83 | 76 |
| | non-dairy cows | 442 | 443 | 450 | 461 | 474 | 483 | 487 | 492 | 497 | 504 | 503 | 491 | 475 |
| Swine | Piglets (<20 kg) | 634 | 658 | 681 | 713 | 729 | 739 | 738 | 771 | 797 | 815 | 812 | 816 | 814 |
| | Fat. Pigs (20-50 kg) | 455 | 464 | 472 | 485 | 490 | 488 | 471 | 469 | 453 | 440 | 415 | 404 | 389 |
| | Fat. Pigs (50-80 kg) | 366 | 366 | 369 | 380 | 387 | 385 | 378 | 381 | 387 | 394 | 402 | 411 | 412 |
| | Fat. Pigs (80-110 kg) | 255 | 263 | 273 | 285 | 294 | 301 | 311 | 312 | 319 | 309 | 306 | 287 | 298 |
| | Fat. Pigs (> 110 kg) | 27 | 25 | 28 | 30 | 33 | 33 | 34 | 34 | 45 | 51 | 54 | 46 | 44 |
| | Boars (>50 kg) | 5 | 5 | 5 | 6 | 5 | 6 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| | Sows, pregnant | 166 | 159 | 159 | 162 | 164 | 163 | 162 | 163 | 163 | 160 | 156 | 153 | 151 |
| | Sows, non-pregnant | 66 | 68 | 69 | 71 | 72 | 73 | 72 | 73 | 72 | 72 | 73 | 73 | 73 |
| Sheep | Ewes | 1 735 | 1 683 | 1 638 | 1 620 | 1 639 | 1 659 | 1 666 | 1 664 | 1 668 | 1 678 | 1 659 | 1 629 | 1 578 |
| | Other Ovine | 160 | 192 | 215 | 237 | 265 | 314 | 367 | 378 | 406 | 426 | 458 | 469 | 477 |
| | Lambs | 267 | 237 | 213 | 194 | 204 | 200 | 195 | 191 | 186 | 185 | 172 | 162 | 154 |
| Goats | Does | 349 | 342 | 333 | 324 | 323 | 330 | 337 | 333 | 322 | 312 | 307 | 297 | 284 |
| | Other Caprine | 35 | 37 | 38 | 39 | 36 | 36 | 37 | 38 | 38 | 37 | 36 | 36 | 36 |
| | kids | 28 | 26 | 24 | 20 | 20 | 19 | 19 | 19 | 18 | 18 | 19 | 18 | 17 |
| Horses | Horses | 94 | 87 | 82 | 78 | 74 | 72 | 75 | 82 | 85 | 87 | 88 | 90 | 91 |
| Asses | Asses and Mules. | 18 | 17 | 13 | 11 | 10 | 10 | 10 | 9 | 9 | 9 | 9 | 9 | 9 |
| Poultry | Hens, reproductive | 3 396 | 3 179 | 3 047 | 2 920 | 2 890 | 2 979 | 3 306 | 3 767 | 4 117 | 4 280 | 4 311 | 4 169 | 4 136 |
| | Hens eggs | 7 475 | 7 138 | 6 857 | 6 710 | 6 607 | 7 090 | 8 038 | 9 556 | 10 554 | 11 092 | 11 172 | 11 344 | 11 466 |
| | Broilers | 18 650 | 17 847 | 18 096 | 19 395 | 21 745 | 24 413 | 27 398 | 30 702 | 32 968 | 34 162 | 34 409 | 34 475 | 34 673 |
| | Turkeys | 1 144 | 956 | 836 | 785 | 800 | 926 | 1 160 | 1 505 | 1 738 | 1 858 | 1 871 | 1 874 | 1 884 |
| | Other poultry | 1 319 | 1 178 | 1 167 | 1 284 | 1 530 | 1 869 | 2 300 | 2 823 | 3 216 | 3 362 | 3 360 | 3 318 | 3 284 |
| Other | Rabbits* | 218 | 193 | 170 | 148 | 128 | 121 | 128 | 148 | 169 | 190 | 212 | 233 | 255 |

***Table C- 2**: Share (in %) of livestock population (by sub class) living in cool regions – complete time series*

| Type | Subtype | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dairy cattle | Dairy cows | 64.38 | 63.33 | 62.92 | 63.46 | 64.26 | 64.72 | 64.44 | 63.76 | 62.82 | 61.02 | 59.66 |
| Non-dairy cattle | Beef calfs (<1 yr) | 80.12 | 74.76 | 66.13 | 55.54 | 52.34 | 53.55 | 56.50 | 58.77 | 61.34 | 66.31 | 68.07 |
| | Calfs M.Rep. (<1 yr) | 55.75 | 53.88 | 54.31 | 53.16 | 51.95 | 50.28 | 49.54 | 49.68 | 49.21 | 46.14 | 41.41 |
| | Calfs F Rep. (<1 yr) | 55.75 | 54.47 | 55.44 | 54.01 | 53.52 | 52.47 | 52.49 | 51.25 | 49.22 | 45.86 | 43.64 |
| | Males 1-2 yrs | 54.70 | 53.00 | 51.42 | 50.09 | 53.06 | 53.94 | 54.53 | 53.53 | 53.02 | 51.14 | 49.62 |
| | Beef Fem. 1-2 yrs | 50.68 | 43.86 | 44.89 | 44.38 | 48.81 | 46.19 | 44.86 | 44.53 | 43.87 | 40.87 | 35.13 |
| | Females rep. 1-2 yrs | 51.30 | 47.11 | 46.40 | 45.64 | 48.35 | 46.38 | 45.76 | 44.52 | 42.79 | 41.60 | 40.89 |
| | Steers (>2 yrs) | 69.32 | 68.40 | 65.31 | 59.56 | 54.75 | 52.66 | 52.11 | 49.83 | 48.16 | 42.76 | 38.27 |
| | Heifers Beef (>2 yrs) | 43.44 | 46.67 | 50.28 | 51.69 | 57.12 | 59.66 | 65.36 | 61.71 | 58.67 | 54.75 | 49.31 |
| | Heifers rep. (>2 yrs) | 42.16 | 42.68 | 45.22 | 46.78 | 45.52 | 43.30 | 43.91 | 42.91 | 41.68 | 41.03 | 41.93 |
| | non-dairy cows | 43.19 | 41.36 | 38.96 | 36.28 | 34.05 | 33.09 | 32.38 | 32.04 | 31.15 | 29.42 | 28.20 |
| Swine | Piglets (<20 kg) | 47.97 | 48.47 | 48.52 | 47.40 | 46.50 | 46.01 | 45.99 | 46.04 | 45.92 | 45.46 | 44.83 |
| | Fat. Pigs (20-50 kg) | 45.06 | 44.00 | 44.77 | 45.11 | 45.69 | 45.04 | 45.05 | 44.94 | 44.51 | 43.74 | 42.62 |
| | Fat. Pigs (50-80 kg) | 48.49 | 46.83 | 47.58 | 46.38 | 45.85 | 45.19 | 44.90 | 45.29 | 45.48 | 45.48 | 44.45 |
| | Fat. Pigs (80-110 kg) | 47.73 | 45.78 | 46.43 | 44.88 | 44.32 | 43.53 | 43.32 | 43.75 | 44.21 | 44.27 | 42.97 |
| | Fat. Pigs (> 110 kg) | 48.80 | 46.15 | 46.64 | 44.25 | 44.04 | 43.81 | 44.66 | 44.92 | 45.12 | 44.80 | 42.37 |
| | Boars (>50 kg) | 47.15 | 48.31 | 48.04 | 49.46 | 49.41 | 48.66 | 48.19 | 46.58 | 45.47 | 45.33 | 47.91 |
| | Sows, pregnant | 43.45 | 44.26 | 45.74 | 46.54 | 46.60 | 45.88 | 46.13 | 45.84 | 45.81 | 45.56 | 44.65 |
| | Sows, non-pregnant | 47.54 | 49.58 | 50.09 | 48.68 | 46.65 | 45.92 | 46.54 | 46.30 | 46.33 | 45.95 | 44.90 |
| Sheep | Ewes | 31.33 | 31.25 | 31.54 | 32.17 | 32.53 | 32.87 | 33.03 | 33.45 | 33.77 | 33.88 | 33.72 |
| | Other Ovine | 28.94 | 29.69 | 30.30 | 30.73 | 30.34 | 30.04 | 29.38 | 28.63 | 27.61 | 25.87 | 24.47 |
| | Lambs | 31.33 | 31.26 | 31.52 | 32.10 | 32.51 | 32.87 | 33.03 | 33.46 | 33.78 | 33.88 | 33.71 |
| Goats | Does | 56.28 | 56.02 | 55.40 | 55.26 | 55.81 | 56.60 | 57.45 | 57.67 | 57.13 | 56.88 | 55.82 |
| | Other Caprine | 60.90 | 61.70 | 62.44 | 62.06 | 61.12 | 59.92 | 58.62 | 58.62 | 56.71 | 55.33 | 53.69 |
| | kids | 56.28 | 55.96 | 55.38 | 55.26 | 55.92 | 56.61 | 57.37 | 57.66 | 57.13 | 56.89 | 55.90 |
| Horses | Horses | 41.74 | 41.74 | 41.74 | 41.74 | 41.74 | 41.60 | 42.28 | 43.19 | 43.86 | 43.67 | 43.69 |
| Asses | Asses and Mules. | 67.97 | 67.97 | 67.97 | 67.97 | 67.97 | 68.42 | 69.16 | 70.29 | 71.07 | 71.77 | 72.39 |
| Poultry | Hens, reproductive | 76.65 | 76.64 | 76.61 | 76.58 | 76.88 | 77.56 | 78.40 | 79.16 | 79.52 | 79.33 | 78.76 |
| | Hens eggs | 76.65 | 76.64 | 76.61 | 76.58 | 76.86 | 77.42 | 78.33 | 79.28 | 79.54 | 79.24 | 78.75 |
| | Broilers | 72.05 | 71.93 | 71.75 | 71.58 | 70.74 | 69.16 | 67.89 | 67.86 | 68.66 | 69.02 | 69.19 |
| | Turkeys | 56.54 | 57.01 | 57.75 | 58.55 | 59.29 | 59.97 | 60.59 | 61.18 | 60.74 | 59.54 | 59.31 |
| | Other poultry | 67.11 | 67.21 | 67.38 | 67.54 | 66.94 | 65.60 | 64.86 | 65.44 | 65.18 | 62.82 | 60.07 |
| Other | Rabbits* | 80.64 | 80.25 | 79.62 | 78.95 | 79.46 | 81.27 | 83.46 | 84.73 | 84.90 | 85.02 | 85.25 |

| Type | Subtype | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dairy cattle | Dairy cows | 58.11 | 57.36 | 56.34 | 55.72 | 54.50 | 53.35 | 52.15 | 51.71 | 50.71 | 49.54 | 48.43 |
| Non-dairy cattle | Beef calfs (<1 yr) | 69.47 | 67.79 | 59.03 | 52.77 | 47.70 | 49.34 | 48.92 | 48.43 | 47.45 | 46.56 | 45.35 |
| | Calfs M.Rep. (<1 yr) | 35.30 | 32.83 | 32.24 | 32.22 | 29.46 | 26.68 | 24.20 | 24.08 | 24.41 | 25.40 | 25.48 |
| | Calfs F Rep. (<1 yr) | 42.07 | 40.56 | 38.94 | 36.23 | 34.52 | 32.60 | 31.88 | 31.51 | 32.19 | 33.33 | 33.67 |
| | Males 1-2 yrs | 45.58 | 41.97 | 40.26 | 39.88 | 39.94 | 39.40 | 39.09 | 40.43 | 41.31 | 42.70 | 43.33 |
| | Beef Fem. 1-2 yrs | 29.02 | 28.59 | 26.06 | 23.28 | 27.84 | 33.79 | 39.17 | 39.94 | 42.15 | 40.87 | 38.06 |
| | Females rep. 1-2 yrs | 40.68 | 39.73 | 39.16 | 38.70 | 36.75 | 35.55 | 34.52 | 34.59 | 35.43 | 37.18 | 38.83 |
| | Steers (>2 yrs) | 32.85 | 31.67 | 30.32 | 30.77 | 29.90 | 29.66 | 28.82 | 29.37 | 29.68 | 29.26 | 29.00 |
| | Heifers Beef (>2 yrs) | 36.64 | 41.06 | 41.29 | 45.56 | 48.59 | 54.58 | 58.10 | 53.93 | 50.23 | 41.96 | 36.45 |
| | Heifers rep. (>2 yrs) | 42.72 | 40.70 | 39.12 | 36.17 | 35.67 | 35.20 | 35.60 | 34.35 | 32.06 | 31.88 | 32.42 |
| | non-dairy cows | 26.92 | 26.15 | 24.62 | 22.71 | 21.28 | 20.01 | 19.19 | 18.63 | 18.63 | 18.84 | 18.88 |
| Swine | Piglets (<20 kg) | 44.44 | 44.01 | 43.27 | 42.12 | 41.84 | 41.65 | 40.90 | 39.55 | 38.14 | 37.59 | 36.40 |
| | Fat. Pigs (20-50 kg) | 41.41 | 40.13 | 39.27 | 38.05 | 37.70 | 37.99 | 38.43 | 38.15 | 37.23 | 36.66 | 35.58 |
| | Fat. Pigs (50-80 kg) | 42.67 | 40.45 | 38.79 | 38.15 | 37.97 | 37.86 | 37.53 | 36.88 | 36.54 | 36.43 | 35.85 |
| | Fat. Pigs (80-110 kg) | 40.49 | 38.48 | 37.66 | 37.74 | 38.23 | 38.16 | 37.34 | 35.79 | 34.48 | 33.47 | 33.00 |
| | Fat. Pigs (> 110 kg) | 36.85 | 34.06 | 32.14 | 32.57 | 33.11 | 34.90 | 34.65 | 32.27 | 29.25 | 28.10 | 27.27 |
| | Boars (>50 kg) | 50.09 | 50.52 | 50.75 | 51.81 | 52.73 | 51.89 | 49.57 | 50.55 | 49.83 | 48.74 | 44.58 |
| | Sows, pregnant | 42.55 | 40.22 | 39.07 | 38.79 | 39.20 | 39.44 | 39.54 | 39.56 | 39.32 | 38.84 | 38.34 |
| | Sows, non-pregnant | 43.63 | 43.48 | 45.13 | 46.45 | 45.75 | 45.16 | 44.67 | 44.54 | 44.29 | 44.05 | 42.51 |
| Sheep | Ewes | 33.31 | 33.03 | 32.86 | 33.04 | 33.51 | 33.94 | 34.25 | 34.42 | 34.83 | 35.33 | 35.68 |
| | Other Ovine | 23.51 | 23.25 | 24.95 | 24.38 | 24.39 | 25.42 | 26.30 | 26.68 | 26.85 | 28.43 | 28.61 |
| | Lambs | 33.31 | 33.02 | 32.86 | 33.03 | 33.50 | 33.95 | 34.26 | 34.42 | 34.78 | 35.32 | 35.69 |
| Goats | Does | 55.14 | 53.98 | 53.93 | 54.17 | 54.85 | 55.13 | 55.21 | 54.94 | 54.64 | 53.77 | 52.94 |
| | Other Caprine | 55.18 | 57.83 | 62.02 | 62.16 | 62.38 | 60.99 | 60.44 | 59.49 | 59.66 | 58.84 | 55.47 |
| | kids | 55.25 | 53.96 | 53.92 | 54.15 | 54.82 | 55.11 | 55.16 | 54.93 | 54.65 | 53.76 | 52.96 |
| Horses | Horses | 43.82 | 43.74 | 43.19 | 42.64 | 42.77 | 43.07 | 43.80 | 44.31 | 45.42 | 45.80 | 45.24 |
| Asses | Asses and Mules. | 73.12 | 73.77 | 74.00 | 74.11 | 73.92 | 73.91 | 74.10 | 75.00 | 78.06 | 82.71 | 87.96 |
| Poultry | Hens, reproductive | 78.51 | 78.52 | 78.54 | 78.66 | 78.91 | 79.05 | 78.89 | 78.38 | 77.84 | 77.73 | 77.94 |
| | Hens eggs | 78.51 | 78.52 | 78.54 | 78.65 | 78.92 | 79.06 | 78.91 | 78.38 | 77.83 | 77.73 | 77.94 |
| | Broilers | 69.52 | 70.10 | 70.81 | 71.59 | 72.39 | 72.71 | 72.60 | 72.06 | 71.62 | 71.91 | 72.75 |
| | Turkeys | 60.67 | 63.83 | 67.23 | 69.54 | 70.34 | 72.72 | 77.28 | 80.61 | 82.77 | 83.72 | 84.13 |
| | Other poultry | 58.67 | 58.38 | 57.92 | 56.86 | 55.18 | 53.92 | 53.78 | 50.88 | 44.89 | 40.49 | 40.57 |
| Other | Rabbits* | 85.67 | 86.28 | 86.93 | 87.29 | 87.35 | 87.12 | 86.91 | 87.39 | 88.46 | 89.49 | 89.99 |

| Type | Subtype | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dairy cattle | Dairy cows | 47.66 | 47.24 | 46.99 | 47.24 | 47.31 | 47.10 | 46.69 | 46.39 | 46.07 | 45.85 | 45.79 | 45.94 | 46.23 |
| Non-dairy cattle | Beef calfs (<1 yr) | 45.29 | 45.34 | 45.70 | 44.12 | 42.89 | 43.72 | 45.61 | 46.86 | 46.14 | 46.80 | 47.94 | 49.64 | 48.69 |
| | Calfs M.Rep. (<1 yr) | 24.98 | 24.24 | 23.69 | 23.03 | 22.25 | 21.21 | 20.70 | 20.25 | 20.41 | 19.95 | 20.00 | 20.25 | 20.48 |
| | Calfs F Rep. (<1 yr) | 33.25 | 32.69 | 32.12 | 31.82 | 31.03 | 29.80 | 29.42 | 29.39 | 30.15 | 29.69 | 29.74 | 29.96 | 30.41 |
| | Males 1-2 yrs | 43.63 | 44.23 | 44.22 | 42.24 | 37.42 | 34.16 | 33.63 | 34.76 | 34.61 | 34.71 | 35.61 | 38.21 | 36.82 |
| | Beef Fem. 1-2 yrs | 34.41 | 34.01 | 34.19 | 36.47 | 37.10 | 38.49 | 37.25 | 35.19 | 32.67 | 31.33 | 31.30 | 32.66 | 32.66 |
| | Females rep. 1-2 yrs | 38.99 | 38.45 | 37.96 | 36.54 | 34.60 | 32.94 | 32.45 | 32.60 | 32.91 | 33.65 | 35.00 | 37.10 | 37.88 |
| | Steers (>2 yrs) | 28.68 | 27.23 | 25.65 | 23.86 | 23.04 | 21.32 | 19.53 | 18.74 | 18.43 | 19.01 | 19.82 | 21.47 | 23.24 |
| | Heifers Beef (>2 yrs) | 31.85 | 31.09 | 31.95 | 34.67 | 34.89 | 41.48 | 46.69 | 51.12 | 35.54 | 13.37 | 14.85 | 29.27 | 30.51 |
| | Heifers rep. (>2 yrs) | 34.09 | 33.93 | 33.85 | 31.57 | 28.14 | 23.03 | 19.63 | 17.92 | 18.63 | 19.57 | 20.49 | 20.80 | 21.26 |
| | non-dairy cows | 18.79 | 18.84 | 18.81 | 18.78 | 18.69 | 18.68 | 18.71 | 18.61 | 18.53 | 18.37 | 18.39 | 18.54 | 18.67 |
| Swine | Piglets (<20 kg) | 35.60 | 34.48 | 34.58 | 35.39 | 36.27 | 37.17 | 40.42 | 43.38 | 45.65 | 45.46 | 45.80 | 45.75 | 45.88 |
| | Fat. Pigs (20-50 kg) | 34.71 | 33.23 | 32.77 | 32.19 | 32.59 | 32.43 | 36.40 | 39.55 | 43.50 | 43.32 | 43.68 | 43.26 | 43.30 |
| | Fat. Pigs (50-80 kg) | 34.88 | 33.73 | 33.44 | 33.24 | 33.02 | 32.87 | 36.43 | 39.79 | 42.27 | 41.19 | 41.39 | 41.86 | 42.61 |
| | Fat. Pigs (80-110 kg) | 32.46 | 32.18 | 32.02 | 32.36 | 31.85 | 31.95 | 35.03 | 38.45 | 40.43 | 40.32 | 40.06 | 41.09 | 41.45 |
| | Fat. Pigs (> 110 kg) | 25.58 | 25.99 | 28.16 | 29.18 | 28.94 | 29.13 | 27.89 | 24.94 | 20.87 | 20.63 | 20.14 | 21.26 | 22.38 |
| | Boars (>50 kg) | 38.95 | 42.78 | 39.23 | 42.04 | 39.51 | 42.30 | 47.66 | 52.00 | 58.34 | 58.33 | 58.33 | 58.33 | 58.33 |
| | Sows, pregnant | 38.09 | 38.08 | 38.25 | 38.76 | 39.63 | 40.33 | 43.15 | 45.40 | 47.96 | 48.16 | 48.66 | 48.71 | 49.05 |
| | Sows, non-pregnant | 40.86 | 39.34 | 39.17 | 38.96 | 39.11 | 39.07 | 42.59 | 46.38 | 50.39 | 50.32 | 50.73 | 50.44 | 50.98 |
| Sheep | Ewes | 35.82 | 35.86 | 35.46 | 34.64 | 33.63 | 33.03 | 32.50 | 32.14 | 31.93 | 31.77 | 31.65 | 31.51 | 31.46 |
| | Other Ovine | 28.53 | 25.38 | 25.16 | 24.43 | 23.60 | 22.59 | 20.96 | 19.54 | 17.43 | 17.29 | 16.73 | 17.01 | 16.92 |
| | Lambs | 35.83 | 35.85 | 35.49 | 34.58 | 33.63 | 33.05 | 32.51 | 32.13 | 31.93 | 31.76 | 31.64 | 31.50 | 31.45 |
| Goats | Does | 52.63 | 53.04 | 53.41 | 53.18 | 54.56 | 55.89 | 57.55 | 57.58 | 57.68 | 57.28 | 56.99 | 56.90 | 56.86 |
| | Other Caprine | 52.07 | 48.22 | 46.87 | 45.83 | 45.80 | 44.90 | 44.63 | 44.05 | 44.51 | 44.96 | 45.51 | 45.57 | 45.12 |
| | kids | 52.65 | 53.03 | 53.40 | 53.18 | 54.53 | 55.79 | 57.56 | 57.58 | 57.68 | 57.25 | 56.96 | 56.89 | 56.87 |
| Horses | Horses | 44.74 | 44.88 | 45.84 | 45.20 | 43.10 | 41.87 | 41.90 | 43.22 | 41.61 | 39.94 | 38.14 | 39.02 | 39.69 |
| Asses | Asses and Mules. | 87.64 | 86.79 | 88.48 | 86.61 | 85.37 | 80.19 | 82.73 | 84.93 | 87.89 | 87.92 | 87.92 | 87.92 | 87.92 |
| Poultry | Hens, reproductive | 78.51 | 78.99 | 80.10 | 81.91 | 84.52 | 86.88 | 88.77 | 90.17 | 91.01 | 91.43 | 91.43 | 91.43 | 91.43 |
| | Hens eggs | 78.51 | 78.99 | 80.10 | 81.94 | 84.52 | 86.91 | 88.82 | 90.19 | 91.02 | 91.43 | 91.43 | 91.43 | 91.43 |
| | Broilers | 74.27 | 75.87 | 75.95 | 74.61 | 72.35 | 73.10 | 76.03 | 80.50 | 83.08 | 84.29 | 84.29 | 84.29 | 84.29 |
| | Turkeys | 83.79 | 82.97 | 83.10 | 84.77 | 88.02 | 88.85 | 87.93 | 86.37 | 85.77 | 85.57 | 85.57 | 85.57 | 85.57 |
| | Other poultry | 45.60 | 52.02 | 52.47 | 46.54 | 37.08 | 39.91 | 49.81 | 63.04 | 69.80 | 72.84 | 72.88 | 72.95 | 73.02 |
| Other | Rabbits* | 89.96 | 89.90 | 89.56 | 88.81 | 87.47 | 87.16 | 88.15 | 90.01 | 91.33 | 92.29 | 92.97 | 93.53 | 94.00 |

***Table C- 3**: Methane Emission Factors from Manure Management (kg.hd$^{-1}$.year$^{-1}$), by livestock category – complete time series*

| Type | Subtype | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dairy cattle | Dairy cows | 14.62 | 14.81 | 14.91 | 14.59 | 14.98 | 15.44 | 15.88 | 16.18 | 16.65 | 18.11 | 19.18 |
| Non-dairy cattle | Beef calfs (<1 yr) | 0.45 | 0.47 | 0.49 | 0.52 | 0.53 | 0.53 | 0.53 | 0.53 | 0.53 | 0.51 | 0.49 |
| | Calfs M.Rep. (<1 yr) | 1.09 | 1.11 | 1.12 | 1.14 | 1.16 | 1.18 | 1.19 | 1.21 | 1.22 | 1.20 | 1.18 |
| | Calfs F Rep. (<1 yr) | 0.93 | 0.95 | 0.95 | 0.97 | 0.98 | 1.00 | 1.01 | 1.02 | 1.04 | 1.03 | 1.01 |
| | Males 1-2 yrs | 4.15 | 4.14 | 4.12 | 4.10 | 3.97 | 3.89 | 3.82 | 3.78 | 3.74 | 3.61 | 3.47 |
| | Beef Fem. 1-2 yrs | 2.96 | 3.04 | 2.98 | 2.94 | 2.82 | 2.82 | 2.80 | 2.76 | 2.73 | 2.67 | 2.64 |
| | Females rep. 1-2 yrs | 2.99 | 3.03 | 3.00 | 2.97 | 2.88 | 2.87 | 2.83 | 2.81 | 2.79 | 2.71 | 2.62 |
| | Steers (>2 yrs) | 4.22 | 4.19 | 4.22 | 4.33 | 4.40 | 4.39 | 4.34 | 4.33 | 4.30 | 4.37 | 4.40 |
| | Heifers Beef (>2 yrs) | 3.37 | 3.26 | 3.14 | 3.07 | 2.93 | 2.84 | 2.70 | 2.72 | 2.73 | 2.75 | 2.79 |
| | Heifers rep. (>2 yrs) | 3.39 | 3.34 | 3.24 | 3.16 | 3.14 | 3.13 | 3.07 | 3.04 | 3.01 | 2.97 | 2.90 |
| | non-dairy cows | 2.52 | 2.57 | 2.62 | 2.68 | 2.73 | 2.76 | 2.80 | 2.83 | 2.87 | 2.90 | 2.92 |
| Swine | Piglets (<20 kg) | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 | 1.23 |
| | Fat. Pigs (20-50 kg) | 6.87 | 6.89 | 6.88 | 6.87 | 6.87 | 6.88 | 6.88 | 6.89 | 6.90 | 6.91 | 6.94 |
| | Fat. Pigs (50-80 kg) | 10.03 | 10.08 | 10.06 | 10.10 | 10.11 | 10.13 | 10.15 | 10.14 | 10.14 | 10.14 | 10.17 |
| | Fat. Pigs (80-110 kg) | 12.03 | 12.09 | 12.08 | 12.13 | 12.15 | 12.18 | 12.19 | 12.18 | 12.17 | 12.18 | 12.22 |
| | Fat. Pigs (> 110 kg) | 13.21 | 13.31 | 13.30 | 13.38 | 13.39 | 13.41 | 13.38 | 13.38 | 13.38 | 13.39 | 13.48 |
| | Boars (>50 kg) | 13.25 | 13.21 | 13.23 | 13.18 | 13.19 | 13.22 | 13.24 | 13.30 | 13.34 | 13.35 | 13.27 |
| | Sows, pregnant | 12.94 | 12.91 | 12.86 | 12.83 | 12.82 | 12.84 | 12.83 | 12.84 | 12.83 | 12.84 | 12.86 |
| | Sows, non-pregnant | 26.46 | 26.32 | 26.28 | 26.37 | 26.50 | 26.54 | 26.49 | 26.50 | 26.49 | 26.51 | 26.57 |
| Sheep | Sheep | 0.41 | 0.41 | 0.41 | 0.40 | 0.40 | 0.40 | 0.40 | 0.39 | 0.39 | 0.39 | 0.38 |
| Goats | Goats | 0.32 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 |
| Horses | Horses | 3.77 | 3.70 | 3.63 | 3.56 | 3.49 | 3.42 | 3.33 | 3.25 | 3.16 | 3.10 | 3.03 |
| Asses | Asses and Mules. | 1.55 | 1.53 | 1.50 | 1.47 | 1.44 | 1.41 | 1.38 | 1.34 | 1.31 | 1.28 | 1.24 |
| Poultry | Hens, reproductive | 0.10 | 0.10 | 0.10 | 0.10 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 |
| | Hens eggs | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| | Broilers | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| | Turkeys | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 |
| | Other poultry | 0.09 | 0.10 | 0.10 | 0.10 | 0.10 | 0.11 | 0.11 | 0.11 | 0.12 | 0.12 | 0.12 |
| Other | Rabbits* | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.26 | 0.26 | 0.26 | 0.26 | 0.26 |

| Type | Subtype | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dairy cattle | Dairy cows | 19.91 | 21.10 | 20.93 | 21.15 | 22.22 | 22.60 | 22.97 | 23.65 | 24.32 | 24.67 | 24.93 |
| Non-dairy cattle | Beef calfs (<1 yr) | 0.48 | 0.47 | 0.47 | 0.47 | 0.46 | 0.45 | 0.43 | 0.42 | 0.40 | 0.39 | 0.37 |
| | Calfs M.Rep. (<1 yr) | 1.17 | 1.15 | 1.11 | 1.06 | 1.03 | 1.00 | 0.96 | 0.91 | 0.86 | 0.81 | 0.75 |
| | Calfs F Rep. (<1 yr) | 0.99 | 0.97 | 0.95 | 0.93 | 0.91 | 0.88 | 0.85 | 0.82 | 0.79 | 0.75 | 0.71 |
| | Males 1-2 yrs | 3.37 | 3.27 | 3.13 | 2.97 | 2.81 | 2.66 | 2.51 | 2.34 | 2.19 | 2.04 | 1.94 |
| | Beef Fem. 1-2 yrs | 2.61 | 2.51 | 2.43 | 2.35 | 2.20 | 2.05 | 1.91 | 1.81 | 1.71 | 1.63 | 1.60 |
| | Females rep. 1-2 yrs | 2.53 | 2.44 | 2.36 | 2.27 | 2.20 | 2.12 | 2.04 | 1.95 | 1.86 | 1.76 | 1.71 |
| | Steers (>2 yrs) | 4.45 | 4.40 | 4.35 | 4.27 | 4.21 | 4.13 | 4.07 | 3.98 | 3.90 | 3.83 | 3.84 |
| | Heifers Beef (>2 yrs) | 2.93 | 2.81 | 2.76 | 2.65 | 2.57 | 2.45 | 2.36 | 2.37 | 2.36 | 2.40 | 2.45 |
| | Heifers rep. (>2 yrs) | 2.84 | 2.82 | 2.79 | 2.78 | 2.73 | 2.68 | 2.62 | 2.58 | 2.55 | 2.50 | 2.49 |
| | non-dairy cows | 2.94 | 2.96 | 2.98 | 3.01 | 3.04 | 3.06 | 3.07 | 3.08 | 3.09 | 3.09 | 3.07 |
| Swine | Piglets (<20 kg) | 1.23 | 1.23 | 1.23 | 1.23 | 1.23 | 1.23 | 1.24 | 1.24 | 1.24 | 1.24 | 1.25 |
| | Fat. Pigs (20-50 kg) | 6.96 | 6.98 | 7.00 | 7.02 | 7.03 | 7.03 | 7.03 | 7.03 | 7.05 | 7.07 | 7.08 |
| | Fat. Pigs (50-80 kg) | 10.22 | 10.28 | 10.33 | 10.35 | 10.36 | 10.36 | 10.38 | 10.40 | 10.41 | 10.42 | 10.43 |
| | Fat. Pigs (80-110 kg) | 12.30 | 12.37 | 12.40 | 12.40 | 12.39 | 12.40 | 12.42 | 12.48 | 12.52 | 12.56 | 12.57 |
| | Fat. Pigs (> 110 kg) | 13.67 | 13.77 | 13.83 | 13.83 | 13.81 | 13.76 | 13.77 | 13.86 | 13.96 | 14.01 | 14.03 |
| | Boars (>50 kg) | 13.21 | 13.20 | 13.20 | 13.17 | 13.14 | 13.17 | 13.26 | 13.23 | 13.26 | 13.30 | 13.44 |
| | Sows, pregnant | 12.93 | 13.00 | 13.03 | 13.03 | 13.02 | 13.01 | 13.00 | 13.00 | 13.00 | 13.01 | 13.03 |
| | Sows, non-pregnant | 26.64 | 26.64 | 26.53 | 26.44 | 26.48 | 26.51 | 26.53 | 26.53 | 26.54 | 26.55 | 26.65 |
| Sheep | Sheep | 0.37 | 0.36 | 0.35 | 0.35 | 0.34 | 0.34 | 0.33 | 0.33 | 0.33 | 0.32 | 0.32 |
| Goats | Goats | 0.30 | 0.30 | 0.30 | 0.30 | 0.29 | 0.29 | 0.28 | 0.28 | 0.28 | 0.27 | 0.27 |
| Horses | Horses | 2.95 | 2.88 | 2.82 | 2.76 | 2.69 | 2.61 | 2.53 | 2.45 | 2.37 | 2.30 | 2.30 |
| Asses | Asses and Mules. | 1.21 | 1.18 | 1.15 | 1.13 | 1.10 | 1.08 | 1.05 | 1.02 | 0.98 | 0.93 | 0.90 |
| Poultry | Hens, reproductive | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 |
| | Hens eggs | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| | Broilers | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| | Turkeys | 0.20 | 0.19 | 0.19 | 0.18 | 0.18 | 0.18 | 0.17 | 0.17 | 0.17 | 0.16 | 0.16 |
| | Other poultry | 0.13 | 0.13 | 0.13 | 0.14 | 0.14 | 0.14 | 0.15 | 0.15 | 0.16 | 0.17 | 0.17 |
| Other | Rabbits* | 0.26 | 0.26 | 0.26 | 0.26 | 0.26 | 0.26 | 0.26 | 0.25 | 0.25 | 0.25 | 0.25 |

| Type | Subtype | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dairy cattle | Dairy cows | 25.42 | 25.21 | 25.74 | 25.59 | 25.26 | 25.30 | 25.85 | 26.14 | 26.39 | 26.55 | 26.61 | 26.99 | 27.19 |
| Non-dairy cattle | Beef calfs (<1 yr) | 0.35 | 0.33 | 0.32 | 0.33 | 0.33 | 0.33 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 |
| | Calfs M.Rep. (<1 yr) | 0.70 | 0.64 | 0.64 | 0.64 | 0.64 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 |
| | Calfs F Rep. (<1 yr) | 0.67 | 0.63 | 0.63 | 0.63 | 0.63 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.63 |
| | Males 1-2 yrs | 1.84 | 1.74 | 1.74 | 1.75 | 1.79 | 1.81 | 1.82 | 1.81 | 1.81 | 1.81 | 1.80 | 1.78 | 1.79 |
| | Beef Fem. 1-2 yrs | 1.58 | 1.53 | 1.53 | 1.51 | 1.51 | 1.50 | 1.51 | 1.52 | 1.54 | 1.54 | 1.54 | 1.54 | 1.54 |
| | Females rep. 1-2 yrs | 1.66 | 1.62 | 1.62 | 1.63 | 1.65 | 1.66 | 1.66 | 1.66 | 1.66 | 1.65 | 1.64 | 1.63 | 1.62 |
| | Steers (>2 yrs) | 3.85 | 3.87 | 3.90 | 3.92 | 3.94 | 3.96 | 3.99 | 4.00 | 4.01 | 4.00 | 3.98 | 3.96 | 3.93 |
| | Heifers Beef (>2 yrs) | 2.49 | 2.50 | 2.49 | 2.47 | 2.46 | 2.40 | 2.35 | 2.30 | 2.46 | 2.68 | 2.66 | 2.52 | 2.51 |
| | Heifers rep. (>2 yrs) | 2.47 | 2.47 | 2.47 | 2.50 | 2.53 | 2.58 | 2.62 | 2.63 | 2.63 | 2.62 | 2.61 | 2.60 | 2.60 |
| | non-dairy cows | 3.05 | 3.02 | 3.02 | 3.02 | 3.02 | 3.02 | 3.02 | 3.03 | 3.03 | 3.03 | 3.03 | 3.03 | 3.03 |
| Swine | Piglets (<20 kg) | 1.25 | 1.25 | 1.25 | 1.25 | 1.25 | 1.25 | 1.24 | 1.23 | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 |
| | Fat. Pigs (20-50 kg) | 7.10 | 7.12 | 7.13 | 7.14 | 7.13 | 7.14 | 7.07 | 7.02 | 6.95 | 6.95 | 6.95 | 6.95 | 6.95 |
| | Fat. Pigs (50-80 kg) | 10.45 | 10.48 | 10.49 | 10.50 | 10.50 | 10.50 | 10.42 | 10.33 | 10.27 | 10.30 | 10.29 | 10.28 | 10.26 |
| | Fat. Pigs (80-110 kg) | 12.59 | 12.59 | 12.60 | 12.59 | 12.60 | 12.60 | 12.51 | 12.41 | 12.35 | 12.35 | 12.36 | 12.33 | 12.32 |
| | Fat. Pigs (> 110 kg) | 14.09 | 14.08 | 14.00 | 13.97 | 13.98 | 13.97 | 14.01 | 14.11 | 14.24 | 14.25 | 14.27 | 14.23 | 14.19 |
| | Boars (>50 kg) | 13.62 | 13.50 | 13.61 | 13.52 | 13.60 | 13.51 | 13.34 | 13.19 | 12.98 | 12.98 | 12.98 | 12.98 | 12.98 |
| | Sows, pregnant | 13.03 | 13.03 | 13.03 | 13.01 | 12.99 | 12.96 | 12.87 | 12.80 | 12.72 | 12.72 | 12.70 | 12.70 | 12.69 |
| | Sows, non-pregnant | 26.76 | 26.86 | 26.87 | 26.88 | 26.87 | 26.87 | 26.64 | 26.40 | 26.14 | 26.14 | 26.12 | 26.13 | 26.10 |
| Sheep | Sheep | 0.32 | 0.32 | 0.32 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 |
| Goats | Goats | 0.27 | 0.27 | 0.27 | 0.28 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 |
| Horses | Horses | 2.31 | 2.31 | 2.30 | 2.30 | 2.33 | 2.34 | 2.34 | 2.32 | 2.34 | 2.36 | 2.38 | 2.37 | 2.36 |
| Asses | Asses and Mules. | 0.90 | 0.91 | 0.90 | 0.91 | 0.92 | 0.94 | 0.93 | 0.92 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 |
| Poultry | Hens, reproductive | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 |
| | Hens eggs | 0.10 | 0.10 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 |
| | Broilers | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| | Turkeys | 0.16 | 0.17 | 0.17 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 |
| | Other poultry | 0.16 | 0.16 | 0.16 | 0.16 | 0.17 | 0.17 | 0.16 | 0.15 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 |
| Other | Rabbits* | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.26 | 0.25 | 0.25 | 0.25 | 0.24 | 0.24 | 0.24 | 0.24 |

***Table C- 4**: Total Nitrogen in manure produced by livestock in Portugal (t N.yr$^{-1}$)*

| Type | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dairy cattle | 33 850 | 33 196 | 32 476 | 31 322 | 32 165 | 33 282 | 33 824 | 34 052 | 34 384 | 36 952 | 37 589 |
| Non-dairy cattle | 43 438 | 44 308 | 43 599 | 43 602 | 43 888 | 45 511 | 47 217 | 48 392 | 49 477 | 50 775 | 52 298 |
| Sheep | 25 391 | 25 809 | 25 910 | 26 037 | 26 474 | 26 837 | 27 154 | 27 006 | 27 213 | 27 444 | 26 943 |
| Goats | 5 279 | 5 149 | 4 983 | 4 824 | 4 703 | 4 614 | 4 535 | 4 480 | 4 409 | 4 301 | 4 077 |
| Horses | 1 447 | 1 666 | 1 750 | 1 842 | 1 953 | 2 094 | 2 272 | 2 396 | 2 485 | 2 527 | 2 563 |
| Asses & Mules | 2 599 | 2 560 | 2 513 | 2 499 | 2 393 | 2 273 | 2 104 | 1 969 | 1 812 | 1 658 | 1 517 |
| Swine | 26 055 | 27 093 | 27 064 | 27 217 | 26 701 | 26 132 | 24 977 | 24 816 | 24 653 | 24 618 | 23 786 |
| Poultry | 17 846 | 18 016 | 18 273 | 18 525 | 18 387 | 17 795 | 17 364 | 17 480 | 18 701 | 20 440 | 21 536 |
| Rabbits* | 4 273 | 4 172 | 4 022 | 3 872 | 3 733 | 3 605 | 3 452 | 3 263 | 3 113 | 3 041 | 3 023 |
| **Total** | **160 176** | **161 970** | **160 591** | **159 739** | **160 397** | **162 145** | **162 899** | **163 855** | **166 248** | **171 755** | **173 333** |

| Type | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dairy cattle | 36 125 | 35 827 | 33 395 | 33 063 | 33 466 | 32 925 | 31 826 | 31 285 | 30 791 | 29 849 | 28 893 |
| Non-dairy cattle | 54 038 | 55 641 | 57 404 | 33 063 | 61 310 | 62 868 | 64 220 | 65 270 | 66 149 | 67 256 | 68 282 |
| Sheep | 25 236 | 23 318 | 22 269 | 33 063 | 22 567 | 22 623 | 22 056 | 21 089 | 19 977 | 18 826 | 17 794 |
| Goats | 3 678 | 3 327 | 3 060 | 33 063 | 3 041 | 3 094 | 3 004 | 2 898 | 2 793 | 2 758 | 2 717 |
| Horses | 2 597 | 2 611 | 2 611 | 33 063 | 2 640 | 2 713 | 2 845 | 3 139 | 3 623 | 4 063 | 4 297 |
| Asses & Mules | 1 383 | 1 335 | 1 327 | 33 063 | 1 320 | 1 261 | 1 166 | 983 | 726 | 521 | 418 |
| Swine | 22 485 | 20 858 | 19 650 | 33 063 | 19 190 | 19 248 | 19 183 | 19 131 | 19 114 | 18 836 | 18 696 |
| Poultry | 21 550 | 20 492 | 19 458 | 33 063 | 17 064 | 16 177 | 15 721 | 16 417 | 17 785 | 18 818 | 18 784 |
| Rabbits* | 2 984 | 2 923 | 2 862 | 33 063 | 2 599 | 2 429 | 2 290 | 2 256 | 2 294 | 2 295 | 2 184 |
| **Total** | **170 075** | **166 330** | **162 037** | **297 569** | **163 197** | **163 340** | **162 312** | **162 469** | **163 252** | **163 221** | **162 065** |

| Type | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | **2024** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dairy cattle | 28 329 | 27 689 | 27 532 | 27 760 | 27 982 | 28 173 | 28 053 | 27 844 | 27 676 | 27 535 | 27 066 | 26 685 | 26 073 |
| Non-dairy | 69 532 | 70 408 | 71 033 | 72 758 | 75 474 | 77 877 | 79 004 | 80 049 | 80 703 | 80 888 | 79 342 | 76 528 | 73 816 |
| Sheep | 16 970 | 16 697 | 16 444 | 16 414 | 16 782 | 17 281 | 17 696 | 17 760 | 17 981 | 18 200 | 18 230 | 18 030 | 17 622 |
| Goats | 2 670 | 2 637 | 2 581 | 2 528 | 2 499 | 2 549 | 2 601 | 2 578 | 2 499 | 2 428 | 2 383 | 2 312 | 2 221 |
| Horses | 4 151 | 3 828 | 3 608 | 3 417 | 3 256 | 3 183 | 3 300 | 3 608 | 3 725 | 3 828 | 3 887 | 3 975 | 4 019 |
| Asses & Mules | 403 | 374 | 293 | 242 | 213 | 227 | 220 | 205 | 198 | 198 | 198 | 198 | 198 |
| Swine | 18 703 | 18 820 | 19 133 | 19 739 | 20 104 | 20 184 | 20 032 | 20 084 | 20 217 | 20 080 | 19 906 | 19 515 | 19 462 |
| Poultry | 17 721 | 16 691 | 16 361 | 16 765 | 17 863 | 19 807 | 22 543 | 26 119 | 28 586 | 29 846 | 30 080 | 30 123 | 30 298 |
| Rabbits* | 1 962 | 1 741 | 1 531 | 1 334 | 1 149 | 1 088 | 1 150 | 1 336 | 1 524 | 1 714 | 1 906 | 2 098 | 2 291 |
| **Total** | **160 442** | **158 885** | **158 516** | **160 957** | **165 322** | **170 369** | **174 599** | **179 582** | **183 110** | **184 717** | **182 998** | **179 465** | **175 999** |

*Per female cage

***Table C- 5**: Share (%) of livestock population by climate region*

| Animal | Climate Region | Unit | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dairy Cows | Cool | % | 64.4 | 63.3 | 62.9 | 63.5 | 64.3 | 64.7 | 64.4 | 63.8 | 62.8 | 61.0 | 59.7 |
| | Temperate | % | 35.6 | 36.7 | 37.1 | 36.5 | 35.7 | 35.3 | 35.6 | 36.2 | 37.2 | 39.0 | 40.3 |
| | Warm | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Other Cattle | Cool | % | 52.9 | 50.9 | 50.0 | 47.8 | 47.0 | 45.7 | 45.3 | 44.4 | 43.3 | 41.4 | 39.6 |
| | Temperate | % | 47.1 | 49.1 | 50.0 | 52.2 | 53.0 | 54.3 | 54.7 | 55.6 | 56.7 | 58.6 | 60.4 |
| | Warm | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Sheep | Cool | % | 30.8 | 30.9 | 31.2 | 31.8 | 32.0 | 32.2 | 32.2 | 32.3 | 32.3 | 32.0 | 31.8 |
| | Temperate | % | 69.2 | 69.1 | 68.8 | 68.2 | 68.0 | 67.8 | 67.8 | 67.7 | 67.7 | 68.0 | 68.2 |
| | Warm | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Goats | Cool | % | 57.1 | 57.1 | 56.9 | 56.7 | 56.9 | 57.3 | 57.7 | 57.9 | 57.0 | 56.5 | 55.4 |
| | Temperate | % | 42.9 | 42.9 | 43.1 | 43.3 | 43.1 | 42.7 | 42.3 | 42.1 | 43.0 | 43.5 | 44.6 |
| | Warm | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Horses | Cool | % | 41.7 | 41.7 | 41.7 | 41.7 | 41.7 | 41.6 | 42.3 | 43.2 | 43.9 | 43.7 | 43.7 |
| | Temperate | % | 58.3 | 58.3 | 58.3 | 58.3 | 58.3 | 58.4 | 57.7 | 56.8 | 56.1 | 56.3 | 56.3 |
| | Warm | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Mules and Asses | Cool | % | 68.0 | 68.0 | 68.0 | 68.0 | 68.0 | 68.4 | 69.2 | 70.3 | 71.1 | 71.8 | 72.4 |
| | Temperate | % | 32.0 | 32.0 | 32.0 | 32.0 | 32.0 | 31.6 | 30.8 | 29.7 | 28.9 | 28.2 | 27.6 |
| | Warm | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Swine | Cool | % | 46.9 | 46.4 | 47.0 | 46.3 | 46.0 | 45.4 | 45.4 | 45.4 | 45.3 | 44.9 | 44.0 |
| | Temperate | % | 53.1 | 53.6 | 53.0 | 53.7 | 54.0 | 54.6 | 54.6 | 54.6 | 54.7 | 55.1 | 56.0 |
| | Warm | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Poultry | Cool | % | 72.8 | 72.8 | 72.7 | 72.7 | 72.3 | 71.5 | 71.1 | 71.4 | 71.7 | 71.6 | 71.4 |
| | Temperate | % | 27.2 | 27.2 | 27.3 | 27.3 | 27.7 | 28.5 | 28.9 | 28.6 | 28.3 | 28.4 | 28.6 |
| | Warm | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Rabbits | Cool | % | 80.6 | 80.2 | 79.6 | 79.0 | 79.5 | 81.3 | 83.5 | 84.7 | 84.9 | 85.0 | 85.2 |
| | Temperate | % | 19.4 | 19.8 | 20.4 | 21.0 | 20.5 | 18.7 | 16.5 | 15.3 | 15.1 | 15.0 | 14.8 |
| | Warm | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |

| Animal | Climate Region | Unit | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dairy Cows | Cool | % | 58.1 | 57.4 | 56.3 | 55.7 | 54.5 | 53.3 | 52.1 | 51.7 | 50.7 | 49.5 | 48.4 |
| | Temperate | % | 41.9 | 42.6 | 43.7 | 44.3 | 45.5 | 46.7 | 47.9 | 48.3 | 49.3 | 50.5 | 51.6 |
| | Warm | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Other Cattle | Cool | % | 37.8 | 36.4 | 34.6 | 32.9 | 31.3 | 30.2 | 29.4 | 29.0 | 29.0 | 29.5 | 29.6 |
| | Temperate | % | 62.2 | 63.6 | 65.4 | 67.1 | 68.7 | 69.8 | 70.6 | 71.0 | 71.0 | 70.5 | 70.4 |
| | Warm | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Sheep | Cool | % | 31.8 | 32.0 | 32.3 | 32.4 | 32.8 | 33.1 | 33.5 | 33.8 | 34.2 | 34.8 | 35.1 |
| | Temperate | % | 68.2 | 68.0 | 67.7 | 67.6 | 67.2 | 66.9 | 66.5 | 66.2 | 65.8 | 65.2 | 64.9 |
| | Warm | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Goats | Cool | % | 55.1 | 54.4 | 54.8 | 55.1 | 55.8 | 55.9 | 55.9 | 55.5 | 55.2 | 54.2 | 53.2 |
| | Temperate | % | 44.9 | 45.6 | 45.2 | 44.9 | 44.2 | 44.1 | 44.1 | 44.5 | 44.8 | 45.8 | 46.8 |
| | Warm | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Horses | Cool | % | 43.8 | 43.7 | 43.2 | 42.6 | 42.8 | 43.1 | 43.8 | 44.3 | 45.4 | 45.8 | 45.2 |
| | Temperate | % | 56.2 | 56.3 | 56.8 | 57.4 | 57.2 | 56.9 | 56.2 | 55.7 | 54.6 | 54.2 | 54.8 |
| | Warm | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Mules and Asses | Cool | % | 73.1 | 73.8 | 74.0 | 74.1 | 73.9 | 73.9 | 74.1 | 75.0 | 78.1 | 82.7 | 88.0 |
| | Temperate | % | 26.9 | 26.2 | 26.0 | 25.9 | 26.1 | 26.1 | 25.9 | 25.0 | 21.9 | 17.3 | 12.0 |
| | Warm | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Swine | Cool | % | 42.7 | 41.3 | 40.3 | 39.6 | 39.5 | 39.5 | 39.2 | 38.4 | 37.4 | 36.8 | 35.9 |
| | Temperate | % | 57.3 | 58.7 | 59.7 | 60.4 | 60.5 | 60.5 | 60.8 | 61.6 | 62.6 | 63.2 | 64.1 |
| | Warm | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Poultry | Cool | % | 71.5 | 72.1 | 72.7 | 73.3 | 73.8 | 73.9 | 73.9 | 73.5 | 73.0 | 73.0 | 73.6 |
| | Temperate | % | 28.5 | 27.9 | 27.3 | 26.7 | 26.2 | 26.1 | 26.1 | 26.5 | 27.0 | 27.0 | 26.4 |
| | Warm | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Rabbits | Cool | % | 85.7 | 86.3 | 86.9 | 87.3 | 87.3 | 87.1 | 86.9 | 87.4 | 88.5 | 89.5 | 90.0 |
| | Temperate | % | 14.3 | 13.7 | 13.1 | 12.7 | 12.7 | 12.9 | 13.1 | 12.6 | 11.5 | 10.5 | 10.0 |
| | Warm | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **Total** | **%** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

| Animal Type | Climate Region | Unit | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dairy Cows | Cool | % | 47.7 | 47.2 | 47.0 | 47.2 | 47.3 | 47.1 | 46.7 | 46.4 | 46.1 | 45.8 | 45.8 | 45.9 | 46.2 |
| | Temperate | % | 52.3 | 52.8 | 53.0 | 52.8 | 52.7 | 52.9 | 53.3 | 53.6 | 53.9 | 54.2 | 54.2 | 54.1 | 53.8 |
| | Warm | % | 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** | **%** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Other Cattle | Cool | % | 29.5 | 29.1 | 28.8 | 28.1 | 27.1 | 26.2 | 25.8 | 25.5 | 25.4 | 25.1 | 25.4 | 26.1 | 26.3 |
| | Temperate | % | 70.5 | 70.9 | 71.2 | 71.9 | 72.9 | 73.8 | 74.2 | 74.5 | 74.6 | 74.9 | 74.6 | 73.9 | 73.7 |
| | Warm | % | 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** | **%** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Sheep | Cool | % | 35.3 | 34.9 | 34.4 | 33.5 | 32.4 | 31.5 | 30.6 | 30.0 | 29.3 | 29.1 | 28.7 | 28.5 | 28.3 |
| | Temperate | % | 64.7 | 65.1 | 65.6 | 66.5 | 67.6 | 68.5 | 69.4 | 70.0 | 70.7 | 70.9 | 71.3 | 71.5 | 71.7 |
| | Warm | % | 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** | **%** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Goats | Cool | % | 52.6 | 52.6 | 52.8 | 52.4 | 53.7 | 54.9 | 56.3 | 56.3 | 56.4 | 56.0 | 55.9 | 55.7 | 55.6 |
| | Temperate | % | 47.4 | 47.4 | 47.2 | 47.6 | 46.3 | 45.1 | 43.7 | 43.7 | 43.6 | 44.0 | 44.1 | 44.3 | 44.4 |
| | Warm | % | 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** | **%** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Horses | Cool | % | 44.7 | 44.9 | 45.8 | 45.2 | 43.1 | 41.9 | 41.9 | 43.2 | 41.6 | 39.9 | 38.1 | 39.0 | 39.7 |
| | Temperate | % | 55.3 | 55.1 | 54.2 | 54.8 | 56.9 | 58.1 | 58.1 | 56.8 | 58.4 | 60.1 | 61.9 | 61.0 | 60.3 |
| | Warm | % | 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** | **%** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Mules and Asses | Cool | % | 87.6 | 86.8 | 88.5 | 86.6 | 85.4 | 80.2 | 82.7 | 84.9 | 87.9 | 87.9 | 87.9 | 87.9 | 87.9 |
| | Temperate | % | 12.4 | 13.2 | 11.5 | 13.4 | 14.6 | 19.8 | 17.3 | 15.1 | 12.1 | 12.1 | 12.1 | 12.1 | 12.1 |
| | Warm | % | 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** | **%** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Swine | Cool | % | 35.1 | 34.1 | 34.0 | 34.2 | 34.5 | 34.8 | 38.2 | 41.2 | 43.7 | 43.4 | 43.6 | 43.8 | 44.1 |
| | Temperate | % | 64.9 | 65.9 | 66.0 | 65.8 | 65.5 | 65.2 | 61.8 | 58.8 | 56.3 | 56.6 | 56.4 | 56.2 | 55.9 |
| | Warm | % | 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** | **%** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Poultry | Cool | % | 74.9 | 76.2 | 76.6 | 76.0 | 74.6 | 75.6 | 78.4 | 82.3 | 84.6 | 85.6 | 85.6 | 85.7 | 85.7 |
| | Temperate | % | 25.1 | 23.8 | 23.4 | 24.0 | 25.4 | 24.4 | 21.6 | 17.7 | 15.4 | 14.4 | 14.4 | 14.3 | 14.3 |
| | Warm | % | 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** | **%** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Rabbits | Cool | % | 90.0 | 89.9 | 89.6 | 88.8 | 87.5 | 87.2 | 88.1 | 90.0 | 91.3 | 92.3 | 93.0 | 93.5 | 94.0 |
| | Temperate | % | 10.0 | 10.1 | 10.4 | 11.2 | 12.5 | 12.8 | 11.9 | 10.0 | 8.7 | 7.7 | 7.0 | 6.5 | 6.0 |
| | Warm | % | 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** | **%** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

***Table C- 6**: Total amounts of Nitrogen (t N.yr-1) added to managed soils: activity data for direct $N_2O$ emissions*

| Type | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Synthetic Fertilizer | 158 500 | 158 500 | 158 500 | 158 500 | 158 500 | 145 815 | 168 229 | 164 288 | 149 303 | 148 944 | 170 009 |
| Organic Fertilizer (manure) | 61 042 | 61 165 | 60 146 | 59 188 | 58 361 | 57 570 | 56 134 | 55 315 | 55 257 | 56 777 | 56 544 |
| Pasture | 70 561 | 72 040 | 71 938 | 72 349 | 74 080 | 76 943 | 79 672 | 81 674 | 83 773 | 86 541 | 88 030 |
| Crop Residues | 52 286 | 47 184 | 42 267 | 41 066 | 42 574 | 45 918 | 44 590 | 45 328 | 44 732 | 44 427 | 43 941 |
| Organic Fertilizer (other) | 319 | 319 | 319 | 319 | 319 | 319 | 386 | 467 | 301 | 440 | 263 |
| **Total** | **342 708** | **339 208** | **333 171** | **331 423** | **333 834** | **326 566** | **349 010** | **347 071** | **333 365** | **337 128** | **358 786** |

| Type | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Synthetic Fertilizer | 157 511 | 163 902 | 141 408 | 178 851 | 102 663 | 87 391 | 113 005 | 105 131 | 97 293 | 100 249 | 95 088 |
| Organic Fertilizer (manure) | 54 377 | 51 892 | 48 916 | 47 459 | 46 453 | 45 233 | 43 849 | 43 422 | 43 455 | 42 908 | 42 320 |
| Pasture | 87 737 | 87 671 | 87 846 | 89 997 | 92 985 | 95 038 | 96 077 | 96 714 | 97 205 | 97 800 | 97 497 |
| Crop Residues | 43 351 | 42 108 | 42 344 | 40 500 | 39 751 | 38 286 | 38 616 | 38 153 | 37 427 | 36 374 | 41 448 |
| Organic Fertilizer (other) | 377 | 1 419 | 1 072 | 567 | 366 | 429 | 693 | 1 191 | 2 035 | 491 | 682 |
| **Total** | **343 352** | **346 992** | **321 587** | **357 374** | **282 217** | **266 376** | **292 240** | **284 611** | **277 415** | **277 822** | **277 035** |

| Type | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Synthetic Fertilizer | 106 864 | 110 643 | 131 643 | 117 906 | 108 440 | 102 584 | 101 365 | 101 533 | 103 171 | 94 864 | 68 041 | 86 694 | 95 422 |
| Organic Fertilizer (manure) | 41 374 | 40 492 | 40 284 | 40 908 | 41 821 | 43 116 | 44 578 | 46 651 | 48 174 | 48 808 | 48 617 | 48 119 | 47 843 |
| Pasture | 97 472 | 97 430 | 97 443 | 98 898 | 101 656 | 104 369 | 105 868 | 107 104 | 107 922 | 108 337 | 106 841 | 104 007 | 100 914 |
| Crop Residues | 42 604 | 47 747 | 47 938 | 43 796 | 36 912 | 38 844 | 39 588 | 38 781 | 38 998 | 39 631 | 35 350 | 33 654 | 35 136 |
| Organic Fertilizer (other) | 1 087 | 1 246 | 489 | 1 648 | 1 381 | 1 161 | 1 034 | 1 309 | 1 963 | 1 267 | 1 275 | 1 445 | 1 879 |
| **Total** | **289 400** | **297 559** | **317 797** | **303 155** | **290 210** | **290 074** | **292 431** | **295 378** | **300 228** | **292 907** | **260 123** | **273 918** | **281 194** |

***Table C- 7**: Nitrogen consumption amount (t N.yr-1) by type of N fertilizer – time series activity data*

| Type | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ammonium nitrate (AN) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ammonium phosphate (MAP&DAP) | 13 278 | 13 278 | 13 278 | 13 278 | 13 278 | 16 753 | 15 743 | 12 400 | 12 604 | 14 337 | 11 829 |
| Ammonium sulphate (AS) | 17 722 | 17 722 | 17 722 | 17 722 | 17 722 | 25 397 | 26 703 | 20 428 | 19 838 | 12 446 | 14 473 |
| Calcium ammonia nitrate (CAN) | 46 126 | 46 126 | 46 126 | 46 126 | 46 126 | 40 666 | 52 909 | 52 454 | 53 213 | 42 767 | 45 717 |
| Urea | 13 347 | 13 347 | 13 347 | 13 347 | 13 347 | 7 058 | 14 072 | 15 262 | 7 752 | 14 514 | 20 524 |
| Other NK & NPK | 49 540 | 49 540 | 49 540 | 49 540 | 49 540 | 40 762 | 42 544 | 43 449 | 36 292 | 46 446 | 57 742 |
| Other N | 18 488 | 18 488 | 18 488 | 18 488 | 18 488 | 15 180 | 16 258 | 20 295 | 19 604 | 18 435 | 19 725 |
| **Total** | **158 500** | **158 500** | **158 500** | **158 500** | **158 500** | **145 815** | **168 229** | **164 288** | **149 303** | **148 944** | **170 009** |

| Type | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ammonium nitrate (AN) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 295 | 4 009 | 4 182 |
| Ammonium phosphate (MAP&DAP) | 10 521 | 12 038 | 9 097 | 1 920 | 0 | 0 | 0 | 0 | 1 013 | 539 | 209 |
| Ammonium sulphate (AS) | 10 917 | 11 575 | 10 310 | 10 273 | 10 298 | 4 221 | 5 864 | 2 541 | 1 951 | 3 057 | 0 |
| Calcium ammonia nitrate (CAN) | 38 776 | 42 505 | 35 892 | 43 305 | 29 682 | 19 206 | 34 634 | 26 751 | 27 179 | 34 989 | 23 487 |
| Urea | 17 527 | 10 066 | 9 235 | 8 203 | 11 849 | 20 447 | 21 976 | 26 008 | 24 064 | 13 854 | 22 193 |
| Other NK & NPK | 59 095 | 69 986 | 61 915 | 96 642 | 39 937 | 33 758 | 41 105 | 28 972 | 16 086 | 24 905 | 24 943 |
| Other N | 20 675 | 17 731 | 14 959 | 18 508 | 10 897 | 9 759 | 9 426 | 20 859 | 22 705 | 18 896 | 20 074 |
| **Total** | **157 511** | **163 902** | **141 408** | **178 851** | **102 663** | **87 391** | **113 005** | **105 131** | **97 293** | **100 249** | **95 088** |

| Type | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ammonium nitrate (AN) | 3 696 | 7 700 | 4 635 | 670 | 850 | 406 | 6 | 915 | 358 | 737 | 2 267 | 1 134 | 1 328 |
| Ammonium phosphate (MAP&DAP) | 1 371 | 2 042 | 1 172 | 576 | 1 942 | 2 457 | 2 496 | 1 594 | 845 | 2 498 | 1 928 | 827 | 38 |
| Ammonium sulphate (AS) | 0 | 0 | 1 202 | 1 805 | 1 912 | 1 711 | 688 | 2 507 | 880 | 714 | 90 | 1 137 | 0 |
| Calcium ammonia nitrate (CAN) | 17 620 | 25 380 | 18 553 | 17 889 | 21 764 | 16 521 | 19 931 | 20 608 | 21 560 | 13 282 | 9 849 | 17 717 | 11 589 |
| Urea | 20 883 | 15 567 | 25 402 | 30 518 | 30 203 | 25 846 | 21 816 | 13 840 | 13 881 | 11 684 | 4 065 | 13 249 | 18 812 |
| Other NK & NPK | 17 193 | 24 568 | 31 865 | 27 969 | 24 887 | 24 798 | 23 910 | 28 300 | 27 775 | 29 125 | 25 070 | 30 689 | 37 848 |
| Other N | 46 101 | 35 387 | 48 814 | 38 480 | 26 883 | 30 845 | 32 519 | 39 631 | 37 872 | 36 824 | 24 771 | 21 940 | 26 829 |
| **Total** | **106 864** | **110 643** | **131 643** | **117 906** | **108 440** | **102 584** | **101 365** | **107 394** | **103 171** | **94 864** | **68 041** | **86 694** | **95 422** |

# Annex D: Waste Background Data Tables

*Updated: March 2026*

***Table D-1: National population, waste generation per capita, and municipal waste generation (including waste amounts sent to material recycling)***

| Year | Population | Annual per capita generation rate | Pop. served by waste collection syst. | Municipal waste | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Waste generation a) | Final destination | | | | |
| | | | | | Open dump sites | Managed landfills | Composted | Anaerobic digestion | Incinerated |
| | inhabitants | kg/inh/year | % pop. | Kton (wet weight) | | | | | |
| **1960** | 8,889,197 | 51.5 | 40 | 457.8 | 457.8 | 0.0 | 0.0 | 0.0 | 0.0 |
| **1961** | 8,861,388 | 54.4 | 41 | 482.4 | 482.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| **1962** | 8,833,580 | 57.5 | 42 | 507.8 | 507.8 | 0.0 | 0.0 | 0.0 | 0.0 |
| **1963** | 8,805,771 | 60.7 | 44 | 534.1 | 534.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| **1964** | 8,777,962 | 64.0 | 45 | 561.4 | 561.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| **1965** | 8,750,154 | 67.4 | 46 | 589.6 | 589.6 | 0.0 | 0.0 | 0.0 | 0.0 |
| **1966** | 8,722,345 | 70.9 | 47 | 618.8 | 618.8 | 0.0 | 0.0 | 0.0 | 0.0 |
| **1967** | 8,694,536 | 74.7 | 48 | 649.1 | 649.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| **1968** | 8,666,727 | 78.5 | 50 | 680.4 | 680.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| **1969** | 8,638,919 | 82.5 | 51 | 712.8 | 712.8 | 0.0 | 0.0 | 0.0 | 0.0 |
| **1970** | 8,611,110 | 86.7 | 52 | 746.3 | 746.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| **1971** | 8,722,192 | 91.1 | 53 | 794.5 | 794.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| **1972** | 8,833,274 | 95.7 | 54 | 845.2 | 845.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| **1973** | 8,944,357 | 100.5 | 56 | 898.5 | 898.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| **1974** | 9,055,439 | 105.4 | 57 | 954.5 | 954.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| **1975** | 9,166,521 | 110.5 | 58 | 1,013.4 | 1,013.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| **1976** | 9,277,603 | 115.9 | 59 | 1,075.1 | 1,075.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| **1977** | 9,388,685 | 121.4 | 60 | 1,140.0 | 1,140.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **1978** | 9,499,767 | 127.2 | 62 | 1,208.1 | 1,208.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| **1979** | 9,610,850 | 133.1 | 63 | 1,279.5 | 1,279.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| **1980** | 9,721,932 | 139.3 | 64 | 1,354.4 | 949.2 | 360.5 | 44.7 | 0.0 | 0.0 |
| **1981** | 9,833,014 | 148.7 | 66 | 1,462.0 | 1,021.1 | 396.2 | 44.7 | 0.0 | 0.0 |
| **1982** | 9,836,427 | 158.4 | 68 | 1,558.2 | 1,088.1 | 425.4 | 44.7 | 0.0 | 0.0 |
| **1983** | 9,839,841 | 168.6 | 71 | 1,658.9 | 1,158.2 | 456.0 | 44.7 | 0.0 | 0.0 |
| **1984** | 9,843,254 | 179.3 | 73 | 1,764.5 | 1,231.7 | 488.1 | 44.7 | 0.0 | 0.0 |
| **1985** | 9,846,667 | 190.4 | 75 | 1,875.0 | 1,308.6 | 521.7 | 44.7 | 0.0 | 0.0 |
| **1986** | 9,850,081 | 203.2 | 78 | 2,001.1 | 1,396.3 | 560.1 | 44.7 | 0.0 | 0.0 |
| **1987** | 9,853,494 | 216.5 | 80 | 2,133.2 | 1,488.2 | 600.3 | 44.7 | 0.0 | 0.0 |
| **1988** | 9,856,907 | 230.5 | 83 | 2,271.7 | 1,584.5 | 642.5 | 44.7 | 0.0 | 0.0 |
| **1989** | 9,860,320 | 245.1 | 85 | 2,416.8 | 1,685.4 | 686.7 | 44.7 | 0.0 | 0.0 |
| **1990** | 9,863,734 | 260.4 | 88 | 2,568.7 | 1,779.3 | 739.2 | 50.3 | 0.0 | 0.0 |
| **1991** | 9,867,147 | 272.7 | 89 | 2,690.9 | 1,734.5 | 906.1 | 50.3 | 0.0 | 0.0 |
| **1992** | 9,916,044 | 285.5 | 91 | 2,831.4 | 1,824.4 | 956.7 | 50.3 | 0.0 | 0.0 |
| **1993** | 9,964,941 | 298.9 | 92 | 2,978.4 | 1,918.6 | 1,009.6 | 50.3 | 0.0 | 0.0 |
| **1994** | 10,013,838 | 312.8 | 93 | 3,132.3 | 1,865.1 | 1,179.4 | 87.8 | 0.0 | 0.0 |
| **1995** | 10,062,735 | 332.0 | 95 | 3,341.2 | 1,982.4 | 1,248.5 | 110.4 | 0.0 | 0.0 |
| **1996** | 10,111,632 | 350.4 | 96 | 3,542.8 | 2,058.3 | 1,373.6 | 110.8 | 0.0 | 0.0 |
| **1997** | 10,160,529 | 368.9 | 97 | 3,748.6 | 2,038.6 | 1,596.1 | 113.8 | 0.0 | 0.0 |
| **1998** | 10,209,426 | 387.8 | 98 | 3,958.7 | 1,539.9 | 2,302.1 | 116.8 | 0.0 | 0.0 |
| **1999** | 10,258,323 | 425.3 | 99 | 4,363.2 | 975.1 | 2,736.9 | 114.9 | 0.0 | 346.4 |
| **2000** | 10,307,220 | 439.5 | 100 | 4,530.3 | 588.8 | 2,610.5 | 137.4 | 0.0 | 911.1 |
| **2001** | 10,356,117 | 446.0 | 100 | 4,618.5 | 460.1 | 2,912.1 | 139.2 | 0.0 | 891.7 |
| **2002** | 10,444,592 | 457.0 | 100 | 4,772.8 | 27.8 | 3,490.6 | 75.5 | 0.0 | 943.9 |
| **2003** | 10,473,050 | 464.6 | 100 | 4,865.7 | 25.9 | 3,367.4 | 232.5 | 0.0 | 1,003.4 |

| Year | Population | Annual per capita generation rate | Pop. served by waste collection syst. | Municipal waste | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Waste generation a) | Final destination | | | | |
| | | | | | Open dump sites | Managed landfills | Composted | Anaerobic digestion | Incinerated |
| | inhabitants | kg/inh/year | % pop. | Kton (wet weight) | | | | | |
| **2004** | 10,494,672 | 435.9 | 100 | 4,575.0 | 22.3 | 3,206.1 | 129.0 | 0.0 | 994.2 |
| **2005** | 10,511,988 | 436.3 | 100 | 4,586.4 | 0.0 | 3,128.4 | 130.7 | 0.0 | 1,057.0 |
| **2006** | 10,532,588 | 447.1 | 100 | 4,708.9 | 0.0 | 3,264.5 | 129.5 | 3.8 | 984.4 |
| **2007** | 10,553,339 | 455.4 | 100 | 4,806.4 | 0.0 | 3,233.3 | 131.0 | 12.5 | 954.5 |
| **2008** | 10,563,014 | 496.3 | 100 | 5,242.4 | 0.0 | 3,530.2 | 170.7 | 14.6 | 993.0 |
| **2009** | 10,573,479 | 497.2 | 100 | 5,256.9 | 0.0 | 3,351.1 | 205.8 | 10.4 | 1,082.6 |
| **2010** | 10,572,721 | 524.0 | 100 | 5,540.3 | 0.0 | 3,682.6 | 219.2 | 12.9 | 1,092.2 |
| **2011** | 10,542,398 | 497.0 | 100 | 5,239.6 | 0.0 | 3,395.3 | 200.7 | 43.3 | 1,131.5 |
| **2012** | 10,487,289 | 457.4 | 100 | 4,797.1 | 0.0 | 2,920.9 | 205.3 | 127.4 | 1,034.3 |
| **2013** | 10,427,301 | 441.9 | 100 | 4,607.4 | 0.0 | 2,601.9 | 182.6 | 167.1 | 1,117.8 |
| **2014** | 10,374,822 | 454.9 | 100 | 4,720.0 | 0.0 | 2,532.1 | 173.8 | 315.8 | 1,051.9 |
| **2015** | 10,341,330 | 459.1 | 100 | 4,747.2 | 0.0 | 2,429.0 | 190.8 | 200.0 | 1,129.2 |
| **2016** | 10,309,573 | 474.4 | 100 | 4,891.0 | 0.0 | 2,536.4 | 347.0 | 457.0 | 1,198.8 |
| **2017** | 10,291,027 | 486.5 | 100 | 5,006.5 | 0.0 | 2,852.8 | 394.5 | 445.1 | 1,183.3 |
| **2018** | 10,276,617 | 507.3 | 100 | 5,213.1 | 0.0 | 2,935.5 | 347.0 | 508.9 | 1,128.8 |
| **2019** | 10,295,909 | 513.0 | 100 | 5,281.4 | 0.0 | 2,944.4 | 329.3 | 521.8 | 1,190.2 |
| **2020** | 10,298,252 | 512.6 | 100 | 5,278.8 | 0.0 | 3,124.4 | 269.3 | 415.8 | 1,144.4 |
| **2021** | 10,344,802 | 513.4 | 100 | 5,310.5 | 0.0 | 2,851.8 | 344.9 | 518.1 | 1,244.4 |
| **2022** | 10,516,621 | 506.2 | 100 | 5,323.2 | 0.0 | 3,023.8 | 347.2 | 471.4 | 1,047.6 |
| **2023** | 10,639,726 | 501.7 | 100 | 5,338.1 | 0.0 | 3,112.6 | 376.9 | 450.4 | 971.6 |
| **2024** | 10,749,635 | 516.3 | 100 | 5,549.9 | 0.0 | 2,987.1 | 444.8 | 554.1 | 1,242.2 |

Note: a) Includes recycling.
Sources:INE; APA (include estimates); Quercus Study

***Table D-2: MSW waste incinerated (accounted CRT 1A1a)***

| Year | Quantities incinerated | | Emissions | |
|---|---|---|---|---|
| | Biogenic | Non-biogenic | Biogenic | Non-biogenic |
| | Kton (wet weight) | | kton CO2 e. | |
| **< 1999** | - | - | - | - |
| **1999** | 236.9 | 109.5 | 131.2 | 110.9 |
| **2000** | 623.2 | 288.0 | 345.0 | 291.6 |
| **2001** | 609.8 | 281.8 | 337.6 | 285.3 |
| **2002** | 645.6 | 298.4 | 357.4 | 302.0 |
| **2003** | 686.3 | 317.2 | 379.9 | 321.1 |
| **2004** | 679.9 | 314.2 | 376.4 | 318.1 |
| **2005** | 722.9 | 334.1 | 400.3 | 338.3 |
| **2006** | 673.2 | 311.1 | 372.8 | 315.0 |
| **2007** | 652.8 | 301.7 | 361.5 | 305.5 |
| **2008** | 679.1 | 313.9 | 377.1 | 318.3 |
| **2009** | 740.4 | 342.2 | 410.7 | 346.8 |
| **2010** | 747.0 | 345.2 | 414.5 | 350.0 |
| **2011** | 754.9 | 376.6 | 383.2 | 374.0 |
| **2012** | 698.3 | 336.0 | 377.4 | 343.8 |
| **2013** | 748.4 | 369.5 | 393.8 | 376.8 |
| **2014** | 667.2 | 384.7 | 302.7 | 402.1 |
| **2015** | 730.4 | 398.8 | 357.0 | 420.1 |
| **2016** | 718.9 | 480.0 | 271.6 | 527.2 |
| **2017** | 709.6 | 473.6 | 267.3 | 519.1 |
| **2018** | 677.1 | 451.7 | 255.1 | 494.5 |
| **2019** | 714.0 | 476.2 | 268.2 | 520.1 |
| **2020** | 683.5 | 460.9 | 247.5 | 494.3 |
| **2021** | 739.8 | 504.6 | 258.7 | 531.8 |
| **2022** | 619.8 | 427.8 | 206.1 | 441.0 |

| | | | | |
|---|---|---|---|---|
| **2023** | 574.9 | 396.8 | 192.0 | 409.6 |
| **2024** | 735.0 | 507.2 | 245.0 | 523.3 |

Source: APA.

***Table D-3: Fermentable industrial waste disposal***

| Year | Open dump sites | Managed landfills | Year | Open dump sites | Managed landfills | Year | Open dump sites | Managed landfills |
|---|---|---|---|---|---|---|---|---|
| | Kton (wet weight) | | | Kton (wet weight) | | | Kton (wet weight) | |
| **1960** | 546.4 | 0.0 | **1982** | 634.2 | 247.9 | **2004** | 4.2 | 601.9 |
| **1961** | 557.9 | 0.0 | **1983** | 647.7 | 255.0 | **2005** | 0.0 | 528.0 |
| **1962** | 569.6 | 0.0 | **1984** | 661.7 | 262.2 | **2006** | 0.0 | 449.9 |
| **1963** | 581.7 | 0.0 | **1985** | 676.1 | 269.5 | **2007** | 0.0 | 371.8 |
| **1964** | 594.1 | 0.0 | **1986** | 690.9 | 277.1 | **2008** | 0.0 | 293.7 |
| **1965** | 606.8 | 0.0 | **1987** | 706.2 | 284.9 | **2009** | 0.0 | 250.5 |
| **1966** | 619.8 | 0.0 | **1988** | 722.1 | 292.8 | **2010** | 0.0 | 225.6 |
| **1967** | 633.2 | 0.0 | **1989** | 738.4 | 300.9 | **2011** | 0.0 | 273.9 |
| **1968** | 646.8 | 0.0 | **1990** | 752.1 | 312.4 | **2012** | 0.0 | 235.7 |
| **1969** | 660.9 | 0.0 | **1991** | 716.3 | 374.2 | **2013** | 0.0 | 187.7 |
| **1970** | 675.3 | 0.0 | **1992** | 732.9 | 384.3 | **2014** | 0.0 | 168.4 |
| **1971** | 690.1 | 0.0 | **1993** | 750.1 | 394.7 | **2015** | 0.0 | 164.1 |
| **1972** | 705.3 | 0.0 | **1994** | 718.8 | 454.5 | **2016** | 0.0 | 192.2 |
| **1973** | 720.9 | 0.0 | **1995** | 737.9 | 464.7 | **2017** | 0.0 | 168.7 |
| **1974** | 737.0 | 0.0 | **1996** | 739.5 | 493.5 | **2018** | 0.0 | 183.4 |
| **1975** | 753.4 | 0.0 | **1997** | 709.1 | 555.2 | **2019** | 0.0 | 203.0 |
| **1976** | 770.3 | 0.0 | **1998** | 519.6 | 776.9 | **2020** | 0.0 | 202.1 |
| **1977** | 787.7 | 0.0 | **1999** | 349.3 | 980.5 | **2021** | 0.0 | 193.3 |
| **1978** | 787.7 | 0.0 | **2000** | 209.4 | 928.4 | **2022** | 0.0 | 176.6 |
| **1979** | 823.9 | 0.0 | **2001** | 129.1 | 816.8 | **2023** | 0.0 | 168.8 |
| **1980** | 610.8 | 232.0 | **2002** | 5.9 | 748.0 | **2024** | 0.0 | 130.6 |
| **1981** | 621.2 | 241.0 | **2003** | 5.2 | 679.0 | | | |

Notes:
Share between open dump and managed landfills based on disposal of municipal solid wastes.
2002 to 2004: disposal on open dump sites refer to disposal on controlled dump sites.
Source: APA (include estimates)

***Table D-4: Composted waste: Non-Municipal waste***

| | Non-Municipal waste composted waste |
|---|---|
| | Kton (wet weight) |
| **< 2012** | - |
| **2013** | 9.9 |
| **2014** | 9.9 |
| **2015** | 11.9 |
| **2016** | 7.8 |
| **2017** | 12.2 |
| **2018** | 22.8 |
| **2019** | 18.0 |
| **2020** | 8.7 |
| **2021** | 13.0 |
| **2022** | 16.6 |
| **2023** | 21.1 |
| **2024** | 19.3 |

Source: APA

***Table D-5: Quantities of waste incinerated (accounted CRT 5C)***

| Year | Clinical waste quantities incinerated | | Industrial solid waste incinerated | |
|---|---|---|---|---|
| | Quantities | Emissions | Quantities | Emissions |
| | kton | kton CO2 e. | kton | kton CO2 e. |
| **1990** | *12.1* | *4.7* | *23.0* | *3.3* |
| **1991** | *12.1* | *4.7* | *23.5* | *3.4* |
| **1992** | *12.1* | *4.7* | *24.1* | *3.5* |
| **1993** | *12.1* | *4.7* | *24.7* | *3.5* |
| **1994** | *12.1* | *4.7* | *25.3* | *3.6* |
| **1995** | 12.1 | 4.7 | *26.0* | *3.7* |
| **1996** | 13.5 | 5.3 | *26.6* | *3.8* |
| **1997** | 15.7 | 6.1 | *27.3* | *3.9* |
| **1998** | 11.8 | 4.6 | *28.0* | *4.0* |
| **1999** | 10.4 | 4.1 | 28.7 | 4.1 |
| **2000** | 7.1 | 2.8 | *31.5* | *3.7* |
| **2001** | 3.2 | 1.3 | *34.4* | *2.8* |
| **2002** | 2.8 | 1.1 | 37.2 | 1.6 |
| **2003** | 2.3 | 0.9 | 47.3 | 8.0 |
| **2004** | *1.8* | *0.7* | 47.6 | 11.7 |
| **2005** | *1.2* | *0.5* | 47.9 | 12.8 |
| **2006** | 0.7 | 0.3 | 48.2 | 13.9 |
| **2007** | 2.8 | 1.1 | 48.5 | 15.1 |
| **2008** | 3.2 | 1.3 | 48.8 | 5.8 |
| **2009** | 3.2 | 1.3 | 29.5 | 17.8 |
| **2010** | 3.8 | 1.5 | 21.1 | 15.8 |
| **2011** | 1.9 | 0.7 | 23.8 | 14.3 |
| **2012** | 1.3 | 0.5 | 31.1 | 16.0 |
| **2013** | 1.1 | 0.4 | 20.3 | 22.7 |
| **2014** | 0.9 | 0.3 | 21.6 | 26.2 |
| **2015** | 0.6 | 0.2 | 19.0 | 24.6 |
| **2016** | 1.2 | 0.5 | 22.1 | 24.1 |
| **2017** | 1.3 | 0.5 | 26.7 | 26.6 |
| **2018** | 5.2 | 2.0 | 25.3 | 30.9 |
| **2019** | 5.8 | 2.3 | 26.4 | 26.2 |
| **2020** | 8.9 | 3.5 | 25.0 | 31.1 |
| **2021** | 8.3 | 3.3 | 21.5 | 34.6 |
| **2022** | 8.4 | 3.3 | 20.7 | 34.1 |
| **2023** | 3.7 | 1.4 | 22.3 | 36.8 |
| **2024** | 9.0 | 3.5 | 21.5 | 35.4 |

Note: Estimates in italics
Sources: APA; DGS

***Table D-6: Quantities of CH4 recovered and combusted (SWDS)***

| | Biogas burned | Biogas burned | Biogas burned as % of CH4 generated in SWDS |
|---|---|---|---|
| | kton CH4 | kton CO2 eq. | % |
| **1990** | - | - | - |
| **1991** | - | - | - |
| **1992** | - | - | - |
| **1993** | - | - | - |
| **1994** | - | - | - |
| **1995** | - | - | - |
| **1996** | - | - | - |
| **1997** | - | - | - |
| **1998** | - | - | - |
| **1999** | - | - | - |
| **2000** | - | - | - |
| **2001** | - | - | - |
| **2002** | - | - | - |
| **2003** | - | - | - |
| **2004** | 2 | 61 | 1.0 |
| **2005** | 11 | 306 | 5.1 |
| **2006** | 15 | 412 | 6.8 |
| **2007** | 19 | 527 | 8.7 |
| **2008** | 24 | 666 | 11.0 |
| **2009** | 26 | 729 | 12.0 |
| **2010** | 32 | 889 | 14.7 |
| **2011** | 32 | 890 | 14.8 |
| **2012** | 38 | 1,069 | 17.9 |
| **2013** | 39 | 1,104 | 18.7 |
| **2014** | 40 | 1,110 | 19.2 |
| **2015** | 44 | 1,233 | 21.8 |
| **2016** | 41 | 1,155 | 20.9 |
| **2017** | 39 | 1,079 | 19.8 |
| **2018** | 35 | 991 | 18.4 |
| **2019** | 32 | 888 | 16.6 |
| **2020** | 33 | 927 | 17.4 |
| **2021** | 31 | 875 | 16.5 |
| **2022** | 27 | 754 | 14.3 |
| **2023** | 28 | 792 | 15.0 |
| **2024** | 28 | 788 | 15.0 |

Source: APA and DGEG data.

***Table D-7: Population and generated urban wastewater BOD by handling system***

| | Population (1000 inhabitants) | TOTAL | Domestic | | | Industrial co-discharge |
|---|---|---|---|---|---|---|
| | | | Treatment systems | Individual treatment | Without treatment | |
| | | BOD5 (kton/year) | | | | |
| **1990** | 9,913 | 249 | 34 | 93 | 91 | 32 |
| **1991** | 9,916 | 251 | 35 | 89 | 93 | 34 |
| **1992** | 9,965 | 253 | 37 | 86 | 96 | 35 |
| **1993** | 10,014 | 256 | 38 | 83 | 98 | 37 |
| **1994** | 10,063 | 259 | 40 | 79 | 101 | 39 |
| **1995** | 10,112 | 261 | 48 | 80 | 94 | 40 |
| **1996** | 10,163 | 263 | 56 | 81 | 86 | 41 |
| **1997** | 10,215 | 265 | 64 | 81 | 78 | 42 |
| **1998** | 10,267 | 267 | 73 | 82 | 70 | 43 |
| **1999** | 10,319 | 270 | 81 | 82 | 62 | 44 |
| **2000** | 10,371 | 272 | 90 | 82 | 55 | 45 |
| **2001** | 10,419 | 274 | 99 | 81 | 48 | 46 |
| **2002** | 10,506 | 277 | 109 | 81 | 41 | 47 |
| **2003** | 10,535 | 278 | 118 | 80 | 33 | 48 |
| **2004** | 10,558 | 280 | 127 | 79 | 25 | 49 |
| **2005** | 10,575 | 281 | 136 | 79 | 17 | 49 |
| **2006** | 10,597 | 283 | 141 | 75 | 16 | 51 |
| **2007** | 10,620 | 287 | 149 | 68 | 16 | 54 |
| **2008** | 10,630 | 288 | 151 | 67 | 15 | 55 |
| **2009** | 10,638 | 289 | 155 | 64 | 14 | 56 |
| **2010** | 10,639 | 290 | 157 | 63 | 12 | 57 |
| **2011** | 10,614 | 290 | 159 | 63 | 11 | 57 |
| **2012** | 10,562 | 289 | 161 | 61 | 10 | 58 |
| **2013** | 10,511 | 289 | 163 | 58 | 9 | 59 |
| **2014** | 10,467 | 289 | 165 | 57 | 7 | 60 |
| **2015** | 10,442 | 289 | 167 | 55 | 6 | 60 |
| **2016** | 10,424 | 290 | 172 | 51 | 5 | 62 |
| **2017** | 10,419 | 291 | 176 | 49 | 4 | 63 |
| **2018** | 10,408 | 291 | 177 | 49 | 3 | 63 |
| **2019** | 10,430 | 292 | 180 | 47 | 1 | 64 |
| **2020** | 10,332 | 290 | 183 | 44 | 0 | 64 |
| **2021** | 10,396 | 293 | 186 | 41 | 0 | 65 |
| **2022** | 10,645 | 301 | 192 | 41 | 0 | 68 |
| **2023** | 10,787 | 305 | 197 | 39 | 0 | 69 |
| **2024** | 10,904 | 309 | 201 | 38 | 0 | 71 |

Notes:
Population: include foreign tourists.
Source: APA (include estimates).

***Table D-8: Sludge from urban wastewater removed***

| | Sludge removed BOD5 (kton/year) | | |
|---|---|---|---|
| | Treatment Systems | Individual treatment | Without treatment |
| **1990** | 17 | 24 | 0 |
| **1991** | 18 | 23 | 0 |
| **1992** | 19 | 22 | 0 |
| **1993** | 20 | 21 | 0 |
| **1994** | 21 | 20 | 0 |
| **1995** | 26 | 20 | 0 |
| **1996** | 30 | 21 | 0 |
| **1997** | 34 | 21 | 0 |
| **1998** | 39 | 21 | 0 |
| **1999** | 43 | 21 | 0 |
| **2000** | 50 | 21 | 0 |
| **2001** | 56 | 21 | 0 |
| **2002** | 63 | 21 | 0 |
| **2003** | 70 | 21 | 0 |
| **2004** | 76 | 21 | 0 |
| **2005** | 83 | 20 | 0 |
| **2006** | 87 | 19 | 0 |
| **2007** | 92 | 18 | 0 |
| **2008** | 94 | 17 | 0 |
| **2009** | 97 | 17 | 0 |
| **2010** | 99 | 16 | 0 |
| **2011** | 101 | 16 | 0 |
| **2012** | 102 | 16 | 0 |
| **2013** | 105 | 15 | 0 |
| **2014** | 107 | 15 | 0 |
| **2015** | 108 | 14 | 0 |
| **2016** | 112 | 13 | 0 |
| **2017** | 115 | 12 | 0 |
| **2018** | 116 | 12 | 0 |
| **2019** | 119 | 12 | 0 |
| **2020** | 121 | 11 | 0 |
| **2021** | 124 | 10 | 0 |
| **2022** | 128 | 10 | 0 |
| **2023** | 131 | 10 | 0 |
| **2024** | 134 | 10 | 0 |

Source: APA (include estimates).

***Table D-9: Organics from urban wastewater removed and sludge treatment***

| | Organics treated | Organics in treated effluent | Sludge produced | Sludge treatment | |
|---|---|---|---|---|---|
| | | | | Composting | Anaerobic digestion |
| | BOD5 (kton/year) | | (kt dm/year) | (%) | |
| **1990** | 209 | 160 | 90 | 89.9% | 10.1% |
| **1991** | 210 | 162 | 91 | 89.5% | 10.5% |
| **1992** | 212 | 165 | 91 | 89.1% | 10.9% |
| **1993** | 215 | 168 | 92 | 88.7% | 11.3% |
| **1994** | 217 | 170 | 92 | 88.3% | 11.7% |
| **1995** | 215 | 164 | 101 | 86.3% | 13.7% |
| **1996** | 213 | 157 | 112 | 84.2% | 15.8% |
| **1997** | 210 | 150 | 123 | 82.2% | 17.8% |
| **1998** | 208 | 143 | 128 | 80.2% | 19.8% |
| **1999** | 205 | 136 | 143 | 78.1% | 21.9% |
| **2000** | 201 | 129 | 150 | 75.9% | 24.1% |
| **2001** | 196 | 122 | 169 | 73.8% | 26.2% |
| **2002** | 193 | 115 | 207 | 71.6% | 28.4% |
| **2003** | 188 | 107 | 214 | 69.4% | 30.6% |
| **2004** | 183 | 99 | 222 | 67.3% | 32.7% |
| **2005** | 178 | 91 | 229 | 65.1% | 34.9% |
| **2006** | 177 | 89 | 225 | 66.0% | 34.0% |
| **2007** | 177 | 88 | 235 | 66.8% | 33.2% |
| **2008** | 176 | 86 | 259 | 67.7% | 32.3% |
| **2009** | 175 | 84 | 288 | 68.5% | 31.5% |
| **2010** | 174 | 82 | 242 | 69.4% | 30.6% |
| **2011** | 173 | 80 | 258 | 70.2% | 29.8% |
| **2012** | 171 | 78 | 266 | 71.1% | 28.9% |
| **2013** | 169 | 75 | 274 | 72.0% | 28.0% |
| **2014** | 168 | 73 | 256 | 72.8% | 27.2% |
| **2015** | 166 | 71 | 262 | 73.7% | 26.3% |
| **2016** | 165 | 68 | 263 | 74.5% | 25.5% |
| **2017** | 164 | 66 | 263 | 75.4% | 24.6% |
| **2018** | 162 | 64 | 260 | 76.2% | 23.8% |
| **2019** | 161 | 62 | 269 | 77.1% | 22.9% |
| **2020** | 158 | 59 | 280 | 78.0% | 22.0% |
| **2021** | 159 | 59 | 284 | 78.0% | 22.0% |
| **2022** | 163 | 60 | 292 | 78.0% | 22.0% |
| **2023** | 165 | 60 | 297 | 78.0% | 22.0% |
| **2024** | 166 | 61 | 302 | 78.0% | 22.0% |

Source: APA (include estimates).

# Annex E: Key Category Analysis

*Updated: March 2026*

## E.1 Introduction

This chapter provides an analysis of key categories following recommendations of the 2006 IPCC Guidelines. A key category (source or sink) "is one that is prioritised within the national inventory system because its estimate has a significant influence on a country's total inventory of direct greenhouse gases in terms of the absolute level of emissions, the trend in emissions, or both." The aim of defining key categories is the improvement of the inventory´s accuracy. As key categories are the most important sources or removals in terms of their contribution to the absolute level of national emissions, the identification of these categories enables the prioritisation of national efforts and a more efficient use of available resources in order to reach an improvement of national estimates. Information on key categories is also important for the development of policies and measures for emissions reduction.

The methods purposed by the 2006 IPCC Guidelines for performing key category analysis, include:

- Tier 1 approach (level and trend assessments);
- Tier 2 approach (level and trend assessments with uncertainty analysis);
- Qualitative approach.

## E.2 Methodology for key category identification: Portuguese inventory

Having as a basis the 2026 Portuguese inventory estimates (1990-2024), the determination of key categories was conducted using Approach 1 and Approach 2 with and without the LULUCF sector.

In accordance with the recommendations from the last UNFCCC review, the disaggregation level of the key category analysis has been revised in order to follow the guidance from 2006 IPCC.

Level assessment was undertaken for the base year and the latest reported inventory year; the trend assessment was performed for the 1990-2024 period. The analysis performed without LULUCF resulted in the identification of 34 key categories. Including the LULUCF sector in the analysis, 41 categories were identified.

## E.3 Presentation of results

Key category analysis can be very influenced by the definitions of source categories (extent of the split). If a large category is broken into many subcategories, then these subcategories may not have a significant contribution to the total inventory to be considered as a key source. On the opposite, several non-key sources categories may become key source categories if aggregated into a unique source category.

In a general way, the source and removal categories have been split according to the disaggregation level proposed by the 2016 IPCC.

For this submission the analysis was based on the application of Approach 1 and Approach 2 with and without the LULUCF sector as mentioned before.

Without LULUCF, the analysis resulted in the identification of 34 key categories. Including the LULUCF sector 41 categories were identified.

Table E.1 presents a summary of identified key categories for 1990-2024 without LULUCF using both approaches, and the criteria used (level, trend) in the identification. Table E.2 presents a summary of identified key categories for 1990-2024 with LULUCF.

***Table E-1: Overview of key categories (without LULUCF) using Approach 1 and 2 for the base and latest inventory year***

| IPCC CATEGORIES | GHG | Key source Category Flag | Criteria for Identification | Current year emissions (kton CO2 eq.) |
|---|---|---|---|---|
| 1.A.3.b Road Transportation | CO2 | √ | Level 1 and 2, Trend 1 and 2 | 17,044.6 |
| 5.A Solid waste disposal | CH4 | √ | Level 1 and 2, Trend 1 and 2 | 4,076.8 |
| 3.A Enteric fermentation | CH4 | √ | Level 1 and 2, Trend 1 | 3,800.4 |
| 1.A.2 Manufacturing industries and construction - Gaseous fuels | CO2 | √ | Level 1, Trend 1 | 3,457.4 |
| 1.A.4 Combustion Other Sectors - Liquid fuels | CO2 | √ | Level 1, Trend 1 | 2,551.8 |
| 2.A.1 Mineral Industry - Cement production | CO2 | √ | Level 1 and 2, Trend 1 and 2 | 2,265.4 |
| 1.A.1 Energy industries - Gaseous fuels | CO2 | √ | Level 1, Trend 1 | 2,100.2 |
| 1.A.2 Manufacturing industries and construction - Liquid fuels | CO2 | √ | Level 1 and 2, Trend 1 | 1,908.4 |
| 2.F.1 Refrigeration and Air Conditioning | Fgases | √ | Level 1 and 2 | 1,767.4 |
| 1.A.1 Energy industries - Liquid fuels | CO2 | √ | Level 1 and 2, Trend 1 and 2 | 1,639.9 |
| 3.D.1 Direct N2O Emissions From Managed Soils | N2O | √ | Level 1 and 2, Trend 2 | 1,501.6 |
| 1.A.4 Combustion Other Sectors - Gaseous fuels | CO2 | √ | Level 1, Trend 1 | 1,224.4 |
| 1.B.2.a Fugitive emissions - Oil | CO2 | √ | Level 1, Trend 1 | 1,036.7 |
| 3.B Manure Management | CH4 | √ | Level 1 and 2 | 810.6 |
| 5.D Wastewater treatment and discharge | N2O | √ | Level 1 and 2, Trend 1 and 2 | 778.5 |
| 5.D Wastewater treatment and discharge | CH4 | √ | Level 1 and 2, Trend 1 and 2 | 575.4 |
| 1.A.3.a Civil (domestic) aviation | CO2 | √ | Level 1 and 2, Trend 1 and 2 | 567.4 |
| 1.A.1 Energy industries - Other fossil fuels | CO2 | √ | Level 1, Trend 1 | 513.2 |
| 3.D.2 Indirect N2O Emissions From Managed Soils | N2O | √ | Level 1 | 389.8 |
| 2.A.2 Mineral Industry - Lime production | CO2 | √ | Level 1 and 2, Trend 2 | 369.4 |
| 1.A.3.d Domestic navigation - Residual fuel oil | CO2 | √ | Level 1 and 2 | 300.6 |
| 1.A.4 Combustion Other Sectors - Biomass | CH4 | √ | Level 1 | 228.8 |
| 3.B Manure Management | N2O | √ | Level 2 | 199.7 |
| 2.D Non-energy products from fuels and solvent use | CO2 | √ | Level 1 and 2 | 190.2 |
| 1.B.2.c Venting and Flaring | CO2 | √ | Trend 2 | 105.7 |
| 2.C.1 Metal Industry - Iron and Steel production | CO2 | √ | Level 1, Trend 1 and 2 | 65.8 |
| 5.B Biological treatment of solid waste | CH4 | √ | Trend 2 | 64.4 |
| 1.B.2.b Fugitive emissions - Natural Gas | CH4 | √ | Trend 2 | 54.1 |
| 5.C Incineration and open burning of waste | CO2 | √ | Trend 2 | 38.0 |
| 2.B.2 Chemical Industry - Nitric acid production | N2O | √ | Level 1, Trend 1 | 35.9 |
| 1.B.1.Fugitive emissions – Solid Fuels | CH4 | √ | Level 2, Trend 2 | 16.5 |
| 2.B.8 Chemical Industry - Petrochemical and Carbon Black production | CO2 | √ | Level 1, Trend 1 | 14.7 |
| 1.A.2 Manufacturing industries and construction - Solid fuels | CO2 | √ | Level 1, Trend 1 and 2 | 10.7 |
| 1.B.2.a Fugitive emissions - Oil | CH4 | √ | Level 2, Trend 2 | 1.9 |

***Table E-2: Overview of key categories (with LULUCF) using Approach 1 and 2 for the base and latest inventory year***

| | GHG | Key source Category Flag | Criteria for Identification | Current year emissions (kton CO2 eq.) |
|---|---|---|---|---|
| 1.A.3.b Road Transportation | CO2 | √ | Level 1 and 2, Trend 1 and 2 | 17,044.6 |
| 5.A Solid waste disposal | CH4 | √ | Level 1 and 2, Trend 1 and 2 | 4,076.8 |
| 3.A Enteric fermentation | CH4 | √ | Level 1 and 2, Trend 1 and 2 | 3,800.4 |
| 1.A.2 Manufacturing industries and construction - Gaseous fuels | CO2 | √ | Level 1, Trend 1 | 3,457.4 |
| 1.A.4 Combustion Other Sectors - Liquid fuels | CO2 | √ | Level 1, Trend 1 | 2,551.8 |
| 2.A.1 Mineral Industry - Cement production | CO2 | √ | Level 1 and 2, Trend 1 and 2 | 2,265.4 |
| 1.A.1 Energy industries - Gaseous fuels | CO2 | √ | Level 1, Trend 1 | 2,100.2 |
| 1.A.2 Manufacturing industries and construction - Liquid fuels | CO2 | √ | Level 1 and 2, Trend 1 | 1,908.4 |
| 2.F.1 Refrigeration and Air Conditioning | Fgases | √ | Level 1 and 2 | 1,767.4 |
| 1.A.1 Energy industries - Liquid fuels | CO2 | √ | Level 1 and 2, Trend 1 | 1,639.9 |
| 3.D.1 Direct N2O Emissions From Managed Soils | N2O | √ | Level 1 and 2, Trend 1 and 2 | 1,501.6 |
| 1.A.4 Combustion Other Sectors - Gaseous fuels | CO2 | √ | Level 1, Trend 1 | 1,224.4 |
| 4.A.1. Forest land remaining Forest land | CO2 | √ | Level 1 and 2, Trend 1 and 2 | 1,053.5 |
| 1.B.2.a Fugitive emissions - Oil | CO2 | √ | Level 1, Trend 1 | 1,036.7 |
| 4.B.2 Land converted to Cropland | CO2 | √ | Level 1 and 2, Trend 1 | 845.5 |
| 3.B Manure Management | CH4 | √ | Level 1 and 2, Trend 1 and 2 | 810.6 |
| 5.D Wastewater treatment and discharge | N2O | √ | Level 1 and 2, Trend 1 and 2 | 778.5 |
| 5.D Wastewater treatment and discharge | CH4 | √ | Level 1 and 2, Trend 1 and 2 | 575.4 |
| 1.A.3.a Civil (domestic) aviation | CO2 | √ | Level 1 and 2, Trend 1 and 2 | 567.4 |
| 1.A.1 Energy industries - Other fossil fuels | CO2 | √ | Level 1, Trend 1 | 513.2 |
| 3.D.2 Indirect N2O Emissions From Managed Soils | N2O | √ | Level 1, Trend 1 | 389.8 |
| 2.A.2 Mineral Industry - Lime production | CO2 | √ | Level 1 and 2, Trend 1 and 2 | 369.4 |
| 1.A.3.d Domestic navigation - Residual fuel oil | CO2 | √ | Level 1 and 2, Trend 1 and 2 | 300.6 |
| 4.E.2 Land converted to Settlements | CO2 | √ | Level 1 and 2, Trend 1 and 2 | 291.0 |
| 4.D.2 Land converted to Wetlands | CO2 | √ | Level 1, Trend 1 | 290.8 |
| 1.A.2 Manufacturing industries and construction - Other fossil fuels | CO2 | √ | Level 1 | 257.4 |
| 1.A.4 Combustion Other Sectors - Biomass | CH4 | √ | Level 1 | 228.8 |
| 3.B Manure Management | N2O | √ | Level 2, Trend 2 | 199.7 |
| 2.D Non-energy products from fuels and solvent use | CO2 | √ | Level 1 and 2 | 190.2 |
| 4.A.1. Forest land remaining Forest land | CH4 | √ | Level 1 | 116.2 |
| 2.C.1 Metal Industry - Iron and Steel production | CO2 | √ | Level 1 | 65.8 |
| 4.C.1. Grassland remaining Grassland | CH4 | √ | Level 2 | 40.6 |
| 2.B.2 Chemical Industry - Nitric acid production | N2O | √ | Level 1 | 35.9 |
| 1.B.1.Fugitive emissions – Solid Fuels | CH4 | √ | Level 2 | 16.5 |
| 2.B.8 Chemical Industry - Petrochemical and Carbon Black production | CO2 | √ | Level 1 | 14.7 |
| 1.A.2 Manufacturing industries and construction - Solid fuels | CO2 | √ | Level 1 | 10.7 |
| 1.B.2.a Fugitive emissions - Oil | CH4 | √ | Level 2, Trend 2 | 1.9 |
| 4.G. Other (Harvested Wood Products) | CO2 | √ | Level 1, Trend 1 | -88.0 |
| 4.B.1. Cropland remaining Cropland | CO2 | √ | Level 1 and 2, Trend 1 | -513.3 |
| 4.C.1. Grassland remaining Grassland | CO2 | √ | Level 1 and 2, Trend 1 | -754.5 |
| 4.A.2 Land converted to Forest land | CO2 | √ | Level 1 and 2, Trend 1 and 2 | -792.1 |

The following tables E.3 to E.8, present the two approaches without LULUCF categories for the base year and the latest reported inventory year for level assessment and trend assessment for 1990-2024.

Tables E.9 to E.14, present the two approaches with LULUCF categories for the base year and the latest reported inventory year for level assessment and trend assessment for 1990-2024.

### *Table E-3: Level assessment (Approach 1) without LULUCF: 1990*

**Tier 1 Level Assessment (1990)**

| IPCC SOURCE CATEGORIES | GHG | Base year Estimate (kton CO2 eq.) 1990 | Current year Estimate (kton CO2 eq.) 1990 | Level Assess. | Cumulative Total |
|---|---|---|---|---|---|
| 1.A.3.b Road Transportation | CO2 | 10,000 | 10,000 | 0.17 | 0.17 |
| 1.A.1 Energy industries - Liquid fuels | CO2 | 8,354 | 8,354 | 0.14 | 0.31 |
| 1.A.1 Energy industries - Solid fuels | CO2 | 8,011 | 8,011 | 0.14 | 0.45 |
| 1.A.2 Manufacturing industries and construction - Liquid fuels | CO2 | 6,530 | 6,530 | 0.11 | 0.56 |
| 3.A Enteric fermentation | CH4 | 3,942 | 3,942 | 0.07 | 0.63 |
| 1.A.4 Combustion Other Sectors - Liquid fuels | CO2 | 3,463 | 3,463 | 0.06 | 0.69 |
| 2.A.1 Mineral Industry - Cement production | CO2 | 3,176 | 3,176 | 0.05 | 0.74 |
| 5.A Solid waste disposal | CH4 | 2,945 | 2,945 | 0.05 | 0.79 |
| 1.A.2 Manufacturing industries and construction - Solid fuels | CO2 | 2,311 | 2,311 | 0.04 | 0.83 |
| 3.D.1 Direct N2O Emissions From Managed Soils | N2O | 1,600 | 1,600 | 0.03 | 0.86 |
| 5.D Wastewater treatment and discharge | CH4 | 1,157 | 1,157 | 0.02 | 0.88 |
| 3.B Manure Management | CH4 | 907 | 907 | 0.02 | 0.89 |
| 2.B.1 Chemical Industry - Ammonia production | CO2 | 763 | 763 | 0.01 | 0.90 |
| 2.B.8 Chemical Industry - Petrochemical and Carbon Black production | CO2 | 645 | 645 | 0.01 | 0.91 |
| 1.A.4 Combustion Other Sectors - Biomass | CH4 | 476 | 476 | 0.01 | 0.92 |
| 2.B.2 Chemical Industry - Nitric acid production | N2O | 460 | 460 | 0.01 | 0.93 |
| 3.D.2 Indirect N2O Emissions From Managed Soils | N2O | 459 | 459 | 0.01 | 0.94 |
| 2.C.1 Metal Industry - Iron and Steel production | CO2 | 440 | 440 | 0.01 | 0.95 |
| 2.D Non-energy products from fuels and solvent use | CO2 | 279 | 279 | 0.00 | 0.95 |

### *Table E-4: Level assessment (Approach 1) without LULUCF: latest inventory year*

**Tier 1 Level Assessment (2024)**

| IPCC SOURCE CATEGORIES | GHG | Base year Estimate (kton CO2 eq.) 1990 | Current year Estimate (kton CO2 eq.) 2024 | Level Assess. | Cumulative Total |
|---|---|---|---|---|---|
| 1.A.3.b Road Transportation | CO2 | 10,000 | 17,045 | 0.33 | 0.33 |
| 5.A Solid waste disposal | CH4 | 2,945 | 4,077 | 0.08 | 0.41 |
| 3.A Enteric fermentation | CH4 | 3,942 | 3,800 | 0.07 | 0.49 |
| 1.A.2 Manufacturing industries and construction - Gaseous fuels | CO2 | 0 | 3,457 | 0.07 | 0.55 |
| 1.A.4 Combustion Other Sectors - Liquid fuels | CO2 | 3,463 | 2,552 | 0.05 | 0.60 |
| 2.A.1 Mineral Industry - Cement production | CO2 | 3,176 | 2,265 | 0.04 | 0.65 |
| 1.A.1 Energy industries - Gaseous fuels | CO2 | 0 | 2,100 | 0.04 | 0.69 |
| 1.A.2 Manufacturing industries and construction - Liquid fuels | CO2 | 6,530 | 1,908 | 0.04 | 0.72 |
| 2.F.1 Refrigeration and Air Conditioning | Fgases | NA | 1,767 | 0.03 | 0.76 |
| 1.A.1 Energy industries - Liquid fuels | CO2 | 8,354 | 1,640 | 0.03 | 0.79 |
| 3.D.1 Direct N2O Emissions From Managed Soils | N2O | 1,600 | 1,502 | 0.03 | 0.82 |
| 1.A.4 Combustion Other Sectors - Gaseous fuels | CO2 | 0 | 1,224 | 0.02 | 0.84 |
| 1.B.2.a Fugitive emissions - Oil | CO2 | 0 | 1,037 | 0.02 | 0.86 |
| 3.B Manure Management | CH4 | 907 | 811 | 0.02 | 0.88 |
| 5.D Wastewater treatment and discharge | N2O | 253 | 778 | 0.02 | 0.89 |
| 5.D Wastewater treatment and discharge | CH4 | 1,157 | 575 | 0.01 | 0.91 |
| 1.A.3.a Civil (domestic) aviation | CO2 | 178 | 567 | 0.01 | 0.92 |
| 1.A.1 Energy industries - Other fossil fuels | CO2 | 0 | 513 | 0.01 | 0.93 |
| 3.D.2 Indirect N2O Emissions From Managed Soils | N2O | 459 | 390 | 0.01 | 0.93 |
| 2.A.2 Mineral Industry - Lime production | CO2 | 206 | 369 | 0.01 | 0.94 |
| 1.A.3.d Domestic navigation - Residual fuel oil | CO2 | 263 | 301 | 0.01 | 0.95 |

### *Table E-5: Trend assessment (Approach 1) without LULUCF: 1990- latest inventory year*

**Tier 1 Trend Assessment (1990-2024)**

| IPCC SOURCE CATEGORIES | GHG | Base year Estimate (kton CO2 eq.) 1990 | Current year Estimate (kton CO2 eq.) 2024 | Trend Assess. | Contribution to Trend | Cumulative Total |
|---|---|---|---|---|---|---|
| 1.A.3.b Road Transportation | CO2 | 10,000 | 17,045 | 0.12 | 0.19 | 0.19 |
| 1.A.1 Energy industries - Solid fuels | CO2 | 8,011 | 0 | 0.10 | 0.16 | 0.35 |
| 1.A.1 Energy industries - Liquid fuels | CO2 | 8,354 | 1,640 | 0.08 | 0.13 | 0.48 |
| 1.A.2 Manufacturing industries and construction - Liquid fuels | CO2 | 6,530 | 1,908 | 0.05 | 0.09 | 0.57 |
| 1.A.2 Manufacturing industries and construction - Gaseous fuels | CO2 | 0 | 3,457 | 0.05 | 0.08 | 0.65 |
| 1.A.1 Energy industries - Gaseous fuels | CO2 | 0 | 2,100 | 0.03 | 0.05 | 0.70 |
| 1.A.2 Manufacturing industries and construction - Solid fuels | CO2 | 2,311 | 11 | 0.03 | 0.05 | 0.74 |
| 5.A Solid waste disposal | CH4 | 2,945 | 4,077 | 0.02 | 0.03 | 0.78 |
| 1.A.4 Combustion Other Sectors - Gaseous fuels | CO2 | 0 | 1,224 | 0.02 | 0.03 | 0.81 |
| 1.B.2.a Fugitive emissions - Oil | CO2 | 0 | 1,037 | 0.01 | 0.02 | 0.83 |
| 2.B.1 Chemical Industry - Ammonia production | CO2 | 763 | 0 | 0.01 | 0.02 | 0.85 |
| 5.D Wastewater treatment and discharge | N2O | 253 | 778 | 0.01 | 0.01 | 0.86 |
| 2.B.8 Chemical Industry - Petrochemical and Carbon Black production | CO2 | 645 | 15 | 0.01 | 0.01 | 0.87 |
| 1.A.1 Energy industries - Other fossil fuels | CO2 | 0 | 513 | 0.01 | 0.01 | 0.88 |
| 2.A.1 Mineral Industry - Cement production | CO2 | 3,176 | 2,265 | 0.01 | 0.01 | 0.90 |
| 1.A.4 Combustion Other Sectors - Liquid fuels | CO2 | 3,463 | 2,552 | 0.01 | 0.01 | 0.91 |
| 5.D Wastewater treatment and discharge | CH4 | 1,157 | 575 | 0.01 | 0.01 | 0.92 |
| 1.A.3.a Civil (domestic) aviation | CO2 | 178 | 567 | 0.01 | 0.01 | 0.93 |
| 2.B.2 Chemical Industry - Nitric acid production | N2O | 460 | 36 | 0.01 | 0.01 | 0.94 |
| 3.A Enteric fermentation | CH4 | 3,942 | 3,800 | 0.01 | 0.01 | 0.94 |
| 2.C.1 Metal Industry - Iron and Steel production | CO2 | 440 | 66 | 0.00 | 0.01 | 0.95 |

## *Table E-6: Level assessment (Approach 2) without LULUCF: 1990*

**Tier 2 Level Assessment (1990)**

| IPCC SOURCE CATEGORIES | GHG | Base year Estimate (kton CO2 eq.) 1990 | Current year Estimate (kton CO2 eq.) 1990 | Level Assess. | Combined Uncert. % | Level * Uncert. % | Share Level * Uncert. % | Cumulative Total |
|---|---|---|---|---|---|---|---|---|
| 5.A Solid waste disposal | CH4 | 2,945 | 2,945 | 0.05 | 141.38 | 7.08 | 0.34 | 0.34 |
| 3.D.1 Direct N2O Emissions From Managed Soils | N2O | 1,600 | 1,600 | 0.03 | 76.12 | 2.07 | 0.10 | 0.44 |
| 5.D Wastewater treatment and discharge | N2O | 253 | 253 | 0.00 | 447.02 | 1.92 | 0.09 | 0.53 |
| 5.D Wastewater treatment and discharge | CH4 | 1,157 | 1,157 | 0.02 | 53.94 | 1.06 | 0.05 | 0.58 |
| 3.A Enteric fermentation | CH4 | 3,942 | 3,942 | 0.07 | 14.46 | 0.97 | 0.05 | 0.63 |
| 1.A.1 Energy industries - Solid fuels | CO2 | 8,011 | 8,011 | 0.14 | 6.61 | 0.90 | 0.04 | 0.67 |
| 2.A.1 Mineral Industry - Cement production | CO2 | 3,176 | 3,176 | 0.05 | 14.37 | 0.78 | 0.04 | 0.71 |
| 3.B Manure Management | CH4 | 907 | 907 | 0.02 | 47.53 | 0.73 | 0.04 | 0.75 |
| 1.A.3.b Road Transportation | CO2 | 10,000 | 10,000 | 0.17 | 3.89 | 0.66 | 0.03 | 0.78 |
| 2.D Non-energy products from fuels and solvent use | CO2 | 279 | 279 | 0.00 | 134.70 | 0.64 | 0.03 | 0.81 |
| 1.B.2.a Fugitive emissions - Oil | CH4 | 2 | 2 | 0.00 | 16900.53 | 0.55 | 0.03 | 0.84 |
| 1.A.1 Energy industries - Liquid fuels | CO2 | 8,354 | 8,354 | 0.14 | 2.75 | 0.39 | 0.02 | 0.85 |
| 1.A.2 Manufacturing industries and construction - Liquid fuels | CO2 | 6,530 | 6,530 | 0.11 | 2.78 | 0.31 | 0.01 | 0.87 |
| 1.B.1.Fugitive emissions – Solid Fuels | CH4 | 157 | 157 | 0.00 | 100.50 | 0.27 | 0.01 | 0.88 |
| 3.B Manure Management | N2O | 239 | 239 | 0.00 | 61.88 | 0.25 | 0.01 | 0.89 |

## *Table E-7: Level assessment (Approach 2) without LULUCF: latest inventory year*

**Tier 2 Level Assessment (2024)**

| IPCC SOURCE CATEGORIES | GHG | Base year Estimate (kton CO2 eq.) 1990 | Current year Estimate (kton CO2 eq.) 2024 | Level Assess. | Combined Uncert. % | Level * Uncert. % | Share Level * Uncert. % | Cumulative Total |
|---|---|---|---|---|---|---|---|---|
| 5.D Wastewater treatment and discharge | N2O | 253 | 778 | 0.02 | 493.48 | 7.48 | 0.33 | 0.33 |
| 3.D.1 Direct N2O Emissions From Managed Soils | N2O | 1,600 | 1,502 | 0.03 | 81.31 | 2.38 | 0.11 | 0.44 |
| 5.A Solid waste disposal | CH4 | 2,945 | 4,077 | 0.08 | 25.11 | 1.99 | 0.09 | 0.52 |
| 1.B.2.a Fugitive emissions - Oil | CH4 | 2 | 2 | 0.00 | 48797.88 | 1.82 | 0.08 | 0.60 |
| 2.F.1 Refrigeration and Air Conditioning | Fgases | NA | 1,767 | 0.03 | 42.08 | 1.45 | 0.06 | 0.67 |
| 1.A.3.b Road Transportation | CO2 | 10,000 | 17,045 | 0.33 | 3.60 | 1.19 | 0.05 | 0.72 |
| 3.A Enteric fermentation | CH4 | 3,942 | 3,800 | 0.07 | 11.60 | 0.86 | 0.04 | 0.76 |
| 3.B Manure Management | CH4 | 907 | 811 | 0.02 | 50.79 | 0.80 | 0.04 | 0.80 |
| 5.D Wastewater treatment and discharge | CH4 | 1,157 | 575 | 0.01 | 59.16 | 0.66 | 0.03 | 0.82 |
| 2.A.1 Mineral Industry - Cement production | CO2 | 3,176 | 2,265 | 0.04 | 14.88 | 0.66 | 0.03 | 0.85 |
| 1.A.3.a Civil (domestic) aviation | CO2 | 178 | 567 | 0.01 | 36.93 | 0.41 | 0.02 | 0.87 |
| 3.B Manure Management | N2O | 239 | 200 | 0.00 | 67.71 | 0.26 | 0.01 | 0.88 |
| 2.A.2 Mineral Industry - Lime production | CO2 | 206 | 369 | 0.01 | 35.60 | 0.26 | 0.01 | 0.89 |
| 1.A.3.d Domestic navigation - Residual fuel oil | CO2 | 263 | 301 | 0.01 | 38.91 | 0.23 | 0.01 | 0.90 |

## *Table E-8: Trend assessment (Approach 2) without LULUCF: 1990- latest inventory year*

**Tier 2 Trend Assessment (1990-2024)**

| IPCC SOURCE CATEGORIES | GHG | Base year Estimate (kton CO2 eq.) 1990 | Current year Estimate (kton CO2 eq.) 2024 | Trend Assess. | Combined Uncert. % | Level * Uncert. % | Share Level * Uncert. % | Cumulative Total |
|---|---|---|---|---|---|---|---|---|
| 5.D Wastewater treatment and discharge | N2O | 253 | 778 | 0.01 | 493.48 | 3.94 | 0.50 | 0.50 |
| 5.A Solid waste disposal | CH4 | 2,945 | 4,077 | 0.02 | 25.11 | 0.54 | 0.07 | 0.57 |
| 1.A.3.b Road Transportation | CO2 | 10,000 | 17,045 | 0.12 | 3.60 | 0.43 | 0.05 | 0.63 |
| 5.D Wastewater treatment and discharge | CH4 | 1,157 | 575 | 0.01 | 59.16 | 0.37 | 0.05 | 0.67 |
| 1.A.3.a Civil (domestic) aviation | CO2 | 178 | 567 | 0.01 | 36.93 | 0.22 | 0.03 | 0.70 |
| 1.A.2 Manufacturing industries and construction - Solid fuels | CO2 | 2,311 | 11 | 0.03 | 7.16 | 0.21 | 0.03 | 0.73 |
| 1.B.2.a Fugitive emissions - Oil | CH4 | 2 | 2 | 0.00 | 48797.88 | 0.17 | 0.02 | 0.75 |
| 1.B.1.Fugitive emissions – Solid Fuels | CH4 | 157 | 16 | 0.00 | 100.50 | 0.17 | 0.02 | 0.77 |
| 1.A.1 Energy industries - Liquid fuels | CO2 | 8,354 | 1,640 | 0.08 | 1.98 | 0.16 | 0.02 | 0.79 |
| 3.D.1 Direct N2O Emissions From Managed Soils | N2O | 1,600 | 1,502 | 0.00 | 81.31 | 0.12 | 0.02 | 0.81 |
| 5.C Incineration and open burning of waste | CO2 | 7 | 38 | 0.00 | 250.62 | 0.11 | 0.01 | 0.82 |
| 1.B.2.b Fugitive emissions - Natural Gas | CH4 | 0 | 54 | 0.00 | 147.48 | 0.11 | 0.01 | 0.84 |
| 2.A.1 Mineral Industry - Cement production | CO2 | 3,176 | 2,265 | 0.01 | 14.88 | 0.11 | 0.01 | 0.85 |
| 2.A.2 Mineral Industry - Lime production | CO2 | 206 | 369 | 0.00 | 35.60 | 0.10 | 0.01 | 0.86 |
| 5.B Biological treatment of solid waste | CH4 | 6 | 64 | 0.00 | 109.15 | 0.09 | 0.01 | 0.88 |
| 1.B.2.c Venting and Flaring | CO2 | 52 | 106 | 0.00 | 100.00 | 0.09 | 0.01 | 0.89 |
| 2.B.1 Chemical Industry - Ammonia production | CO2 | 763 | 0 | 0.01 | 7.28 | 0.07 | 0.01 | 0.90 |
| 2.C.1 Metal Industry - Iron and Steel production | CO2 | 440 | 66 | 0.00 | 14.14 | 0.06 | 0.01 | 0.90 |

### *Table E-9: Level assessment (Approach 1) with LULUCF: 1990*

**Tier 1 Level Assessment (1990)**

| IPCC SOURCE CATEGORIES | GHG | Base year Estimate (kton CO2 eq.) 1990 | Current year Estimate (kton CO2 eq.) 1990 | Level Assess. | Cumulative Total |
|---|---|---|---|---|---|
| 1.A.3.b Road Transportation | CO2 | 10,000 | 10,000 | 0.14 | 0.14 |
| 1.A.1 Energy industries - Liquid fuels | CO2 | 8,354 | 8,354 | 0.12 | 0.26 |
| 1.A.1 Energy industries - Solid fuels | CO2 | 8,011 | 8,011 | 0.11 | 0.38 |
| 1.A.2 Manufacturing industries and construction - Liquid fuels | CO2 | 6,530 | 6,530 | 0.09 | 0.47 |
| 4.A.1. Forest land remaining Forest land | CO2 | 4,411 | 4,411 | 0.06 | 0.53 |
| 3.A Enteric fermentation | CH4 | 3,942 | 3,942 | 0.06 | 0.59 |
| 1.A.4 Combustion Other Sectors - Liquid fuels | CO2 | 3,463 | 3,463 | 0.05 | 0.64 |
| 2.A.1 Mineral Industry - Cement production | CO2 | 3,176 | 3,176 | 0.05 | 0.69 |
| 5.A Solid waste disposal | CH4 | 2,945 | 2,945 | 0.04 | 0.73 |
| 1.A.2 Manufacturing industries and construction - Solid fuels | CO2 | 2,311 | 2,311 | 0.03 | 0.76 |
| 4.G. Other (Harvested Wood Products) | CO2 | -1,731 | -1,731 | 0.02 | 0.79 |
| 3.D.1 Direct N2O Emissions From Managed Soils | N2O | 1,600 | 1,600 | 0.02 | 0.81 |
| 4.A.2 Land converted to Forest land | CO2 | -1,188 | -1,188 | 0.02 | 0.83 |
| 5.D Wastewater treatment and discharge | CH4 | 1,157 | 1,157 | 0.02 | 0.84 |
| 4.C.1. Grassland remaining Grassland | CO2 | 966 | 966 | 0.01 | 0.86 |
| 3.B Manure Management | CH4 | 907 | 907 | 0.01 | 0.87 |
| 2.B.1 Chemical Industry - Ammonia production | CO2 | 763 | 763 | 0.01 | 0.88 |
| 2.B.8 Chemical Industry - Petrochemical and Carbon Black production | CO2 | 645 | 645 | 0.01 | 0.89 |
| 4.E.2 Land converted to Settlements | CO2 | 560 | 560 | 0.01 | 0.90 |
| 1.A.4 Combustion Other Sectors - Biomass | CH4 | 476 | 476 | 0.01 | 0.90 |
| 4.D.2 Land converted to Wetlands | CO2 | 475 | 475 | 0.01 | 0.91 |
| 4.B.2 Land converted to Cropland | CO2 | 466 | 466 | 0.01 | 0.92 |
| 2.B.2 Chemical Industry - Nitric acid production | N2O | 460 | 460 | 0.01 | 0.92 |
| 3.D.2 Indirect N2O Emissions From Managed Soils | N2O | 459 | 459 | 0.01 | 0.93 |
| 2.C.1 Metal Industry - Iron and Steel production | CO2 | 440 | 440 | 0.01 | 0.94 |
| 4.B.1. Cropland remaining Cropland | CO2 | 385 | 385 | 0.01 | 0.94 |
| 4.A.1. Forest land remaining Forest land | CH4 | 307 | 307 | 0.00 | 0.95 |
| 2.D Non-energy products from fuels and solvent use | CO2 | 279 | 279 | 0.00 | 0.95 |

### *Table E-10: Level assessment (Approach 1) with LULUCF: latest inventory year*

**Tier 1 Level Assessment (2024)**

| IPCC SOURCE CATEGORIES | GHG | Base year Estimate (kton CO2 eq.) 1990 | Current year Estimate (kton CO2 eq.) 2024 | Level Assess. | Cumulative Total |
|---|---|---|---|---|---|
| 1.A.3.b Road Transportation | CO2 | 10,000 | 17,045 | 0.30 | 0.30 |
| 5.A Solid waste disposal | CH4 | 2,945 | 4,077 | 0.07 | 0.37 |
| 3.A Enteric fermentation | CH4 | 3,942 | 3,800 | 0.07 | 0.44 |
| 1.A.2 Manufacturing industries and construction - Gaseous fuels | CO2 | 0 | 3,457 | 0.06 | 0.50 |
| 1.A.4 Combustion Other Sectors - Liquid fuels | CO2 | 3,463 | 2,552 | 0.05 | 0.55 |
| 2.A.1 Mineral Industry - Cement production | CO2 | 3,176 | 2,265 | 0.04 | 0.59 |
| 1.A.1 Energy industries - Gaseous fuels | CO2 | 0 | 2,100 | 0.04 | 0.63 |
| 1.A.2 Manufacturing industries and construction - Liquid fuels | CO2 | 6,530 | 1,908 | 0.03 | 0.66 |
| 2.F.1 Refrigeration and Air Conditioning | Fgase | NA | 1,767 | 0.03 | 0.69 |
| 1.A.1 Energy industries - Liquid fuels | CO2 | 8,354 | 1,640 | 0.03 | 0.72 |
| 3.D.1 Direct N2O Emissions From Managed Soils | N2O | 1,600 | 1,502 | 0.03 | 0.75 |
| 1.A.4 Combustion Other Sectors - Gaseous fuels | CO2 | 0 | 1,224 | 0.02 | 0.77 |
| 4.A.1. Forest land remaining Forest land | CO2 | 4,411 | 1,053 | 0.02 | 0.79 |
| 1.B.2.a Fugitive emissions - Oil | CO2 | 0 | 1,037 | 0.02 | 0.81 |
| 4.B.2 Land converted to Cropland | CO2 | 466 | 846 | 0.01 | 0.82 |
| 3.B Manure Management | CH4 | 907 | 811 | 0.01 | 0.83 |
| 4.A.2 Land converted to Forest land | CO2 | -1,188 | -792 | 0.01 | 0.85 |
| 5.D Wastewater treatment and discharge | N2O | 253 | 778 | 0.01 | 0.86 |
| 4.C.1. Grassland remaining Grassland | CO2 | 966 | -755 | 0.01 | 0.88 |
| 5.D Wastewater treatment and discharge | CH4 | 1,157 | 575 | 0.01 | 0.89 |
| 1.A.3.a Civil (domestic) aviation | CO2 | 178 | 567 | 0.01 | 0.90 |
| 4.B.1. Cropland remaining Cropland | CO2 | 385 | -513 | 0.01 | 0.91 |
| 1.A.1 Energy industries - Other fossil fuels | CO2 | 0 | 513 | 0.01 | 0.91 |
| 3.D.2 Indirect N2O Emissions From Managed Soils | N2O | 459 | 390 | 0.01 | 0.92 |
| 2.A.2 Mineral Industry - Lime production | CO2 | 206 | 369 | 0.01 | 0.93 |
| 1.A.3.d Domestic navigation - Residual fuel oil | CO2 | 263 | 301 | 0.01 | 0.93 |
| 4.E.2 Land converted to Settlements | CO2 | 560 | 291 | 0.01 | 0.94 |
| 4.D.2 Land converted to Wetlands | CO2 | 475 | 291 | 0.01 | 0.94 |
| 1.A.2 Manufacturing industries and construction - Other fossil fuels | CO2 | 12 | 257 | 0.00 | 0.95 |

## *Table E-11: Trend assessment (Approach 1) with LULUCF: 1990- latest inventory year*

**Tier 1 Trend Assessment (1990-2024)**

| IPCC SOURCE CATEGORIES | GHG | Base year Estimate (kton CO2 eq.) 1990 | Current year Estimate (kton CO2 eq.) 2024 | Trend Assess. | Contribution to Trend | Cumulative Total |
|---|---|---|---|---|---|---|
| 1.A.3.b Road Transportation | CO2 | 10,000 | 17,045 | 0.24 | 0.29 | 0.29 |
| 5.A Solid waste disposal | CH4 | 2,945 | 4,077 | 0.06 | 0.07 | 0.36 |
| 3.A Enteric fermentation | CH4 | 3,942 | 3,800 | 0.05 | 0.06 | 0.43 |
| 1.A.2 Manufacturing industries and construction - Gaseous fuels | CO2 | 0 | 3,457 | 0.05 | 0.06 | 0.48 |
| 4.G. Other (Harvested Wood Products) | CO2 | -1,731 | -88 | 0.05 | 0.06 | 0.54 |
| 1.A.4 Combustion Other Sectors - Liquid fuels | CO2 | 3,463 | 2,552 | 0.04 | 0.04 | 0.59 |
| 2.A.1 Mineral Industry - Cement production | CO2 | 3,176 | 2,265 | 0.03 | 0.04 | 0.62 |
| 1.A.1 Energy industries - Gaseous fuels | CO2 | 0 | 2,100 | 0.03 | 0.04 | 0.66 |
| 1.A.2 Manufacturing industries and construction - Liquid fuels | CO2 | 6,530 | 1,908 | 0.03 | 0.03 | 0.69 |
| 1.A.1 Energy industries - Liquid fuels | CO2 | 8,354 | 1,640 | 0.02 | 0.03 | 0.72 |
| 4.A.2 Land converted to Forest land | CO2 | -1,188 | -792 | 0.02 | 0.03 | 0.75 |
| 3.D.1 Direct N2O Emissions From Managed Soils | N2O | 1,600 | 1,502 | 0.02 | 0.03 | 0.77 |
| 1.A.4 Combustion Other Sectors - Gaseous fuels | CO2 | 0 | 1,224 | 0.02 | 0.02 | 0.79 |
| 4.A.1. Forest land remaining Forest land | CO2 | 4,411 | 1,053 | 0.02 | 0.02 | 0.81 |
| 1.B.2.a Fugitive emissions - Oil | CO2 | 0 | 1,037 | 0.01 | 0.02 | 0.83 |
| 4.B.2 Land converted to Cropland | CO2 | 466 | 846 | 0.01 | 0.01 | 0.84 |
| 3.B Manure Management | CH4 | 907 | 811 | 0.01 | 0.01 | 0.86 |
| 5.D Wastewater treatment and discharge | N2O | 253 | 778 | 0.01 | 0.01 | 0.87 |
| 4.C.1. Grassland remaining Grassland | CO2 | 966 | -755 | 0.01 | 0.01 | 0.88 |
| 5.D Wastewater treatment and discharge | CH4 | 1,157 | 575 | 0.01 | 0.01 | 0.89 |
| 1.A.3.a Civil (domestic) aviation | CO2 | 178 | 567 | 0.01 | 0.01 | 0.90 |
| 1.A.1 Energy industries - Other fossil fuels | CO2 | 0 | 513 | 0.01 | 0.01 | 0.91 |
| 4.B.1. Cropland remaining Cropland | CO2 | 385 | -513 | 0.01 | 0.01 | 0.92 |
| 3.D.2 Indirect N2O Emissions From Managed Soils | N2O | 459 | 390 | 0.01 | 0.01 | 0.93 |
| 2.A.2 Mineral Industry - Lime production | CO2 | 206 | 369 | 0.01 | 0.01 | 0.93 |
| 1.A.3.d Domestic navigation - Residual fuel oil | CO2 | 263 | 301 | 0.00 | 0.01 | 0.94 |
| 4.E.2 Land converted to Settlements | CO2 | 560 | 291 | 0.00 | 0.00 | 0.94 |
| 4.D.2 Land converted to Wetlands | CO2 | 475 | 291 | 0.00 | 0.00 | 0.95 |

## *Table E-12: Level assessment (Approach 2) with LULUCF: 1990*

**Tier 2 Level Assessment (1990)**

| IPCC SOURCE CATEGORIES | GHG | Base year Estimate (kton CO2 eq.) 1990 | Current year Estimate (kton CO2 eq.) 1990 | Level Assess. | Combined Uncert. % | Level * Uncert. % | Share Level * Uncert. % | Cumulative Total |
|---|---|---|---|---|---|---|---|---|
| 5.A Solid waste disposal | CH4 | 2,945 | 2,945 | 0.04 | 141.38 | 5.96 | 0.25 | 0.25 |
| 4.E.2 Land converted to Settlements | CO2 | 560 | 560 | 0.01 | 249.08 | 2.00 | 0.08 | 0.34 |
| 4.A.1. Forest land remaining Forest land | CO2 | 4,411 | 4,411 | 0.06 | 29.63 | 1.87 | 0.08 | 0.42 |
| 3.D.1 Direct N2O Emissions From Managed Soils | N2O | 1,600 | 1,600 | 0.02 | 76.12 | 1.74 | 0.07 | 0.49 |
| 5.D Wastewater treatment and discharge | N2O | 253 | 253 | 0.00 | 447.02 | 1.62 | 0.07 | 0.56 |
| 5.D Wastewater treatment and discharge | CH4 | 1,157 | 1,157 | 0.02 | 53.94 | 0.89 | 0.04 | 0.60 |
| 4.B.1. Cropland remaining Cropland | CO2 | 385 | 385 | 0.01 | 148.69 | 0.82 | 0.03 | 0.63 |
| 3.A Enteric fermentation | CH4 | 3,942 | 3,942 | 0.06 | 14.46 | 0.82 | 0.03 | 0.66 |
| 1.A.1 Energy industries - Solid fuels | CO2 | 8,011 | 8,011 | 0.11 | 6.61 | 0.76 | 0.03 | 0.70 |
| 2.A.1 Mineral Industry - Cement production | CO2 | 3,176 | 3,176 | 0.05 | 14.37 | 0.65 | 0.03 | 0.72 |
| 3.B Manure Management | CH4 | 907 | 907 | 0.01 | 47.53 | 0.62 | 0.03 | 0.75 |
| 1.A.3.b Road Transportation | CO2 | 10,000 | 10,000 | 0.14 | 3.89 | 0.56 | 0.02 | 0.77 |
| 2.D Non-energy products from fuels and solvent use | CO2 | 279 | 279 | 0.00 | 134.70 | 0.54 | 0.02 | 0.80 |
| 1.B.2.a Fugitive emissions - Oil | CH4 | 2 | 2 | 0.00 | 16900.53 | 0.46 | 0.02 | 0.82 |
| 1.A.1 Energy industries - Liquid fuels | CO2 | 8,354 | 8,354 | 0.12 | 2.75 | 0.33 | 0.01 | 0.83 |
| 4.C.1. Grassland remaining Grassland | CO2 | 966 | 966 | 0.01 | 23.12 | 0.32 | 0.01 | 0.84 |
| 4.A.2 Land converted to Forest land | CO2 | -1,188 | -1,188 | 0.02 | 16.80 | 0.29 | 0.01 | 0.86 |
| 1.A.2 Manufacturing industries and construction - Liquid fuels | CO2 | 6,530 | 6,530 | 0.09 | 2.78 | 0.26 | 0.01 | 0.87 |
| 4.B.2 Land converted to Cropland | CO2 | 466 | 466 | 0.01 | 35.07 | 0.23 | 0.01 | 0.88 |
| 1.B.1.Fugitive emissions – Solid Fuels | CH4 | 157 | 157 | 0.00 | 100.50 | 0.23 | 0.01 | 0.89 |
| 3.B Manure Management | N2O | 239 | 239 | 0.00 | 61.88 | 0.21 | 0.01 | 0.89 |
| 4.C.1. Grassland remaining Grassland | CH4 | 215 | 215 | 0.00 | 62.05 | 0.19 | 0.01 | 0.90 |

## *Table E-13: Level assessment (Approach 2) with LULUCF: latest inventory year*

**Tier 2 Level Assessment (2024)**

| IPCC SOURCE CATEGORIES | GHG | Base year Estimate (kton CO2 eq.) 1990 | Current year Estimate (kton CO2 eq.) 2024 | Level Assess. | Combined Uncert. % | Level * Uncert. % | Share Level * Uncert. % | Cumulative Total |
|---|---|---|---|---|---|---|---|---|
| 5.D Wastewater treatment and discharge | N2O | 253 | 778 | 0.01 | 493.48 | 6.81 | 0.30 | 0.30 |
| 3.D.1 Direct N2O Emissions From Managed Soils | N2O | 1,600 | 1,502 | 0.03 | 81.31 | 2.16 | 0.09 | 0.39 |
| 5.A Solid waste disposal | CH4 | 2,945 | 4,077 | 0.07 | 25.11 | 1.81 | 0.08 | 0.47 |
| 1.B.2.a Fugitive emissions - Oil | CH4 | 2 | 2 | 0.00 | 48797.88 | 1.65 | 0.07 | 0.54 |
| 2.F.1 Refrigeration and Air Conditioning | Fgases | NA | 1,767 | 0.03 | 42.08 | 1.32 | 0.06 | 0.60 |
| 4.E.2 Land converted to Settlements | CO2 | 560 | 291 | 0.01 | 249.08 | 1.28 | 0.06 | 0.66 |
| 1.A.3.b Road Transportation | CO2 | 10,000 | 17,045 | 0.30 | 3.60 | 1.09 | 0.05 | 0.70 |
| 3.A Enteric fermentation | CH4 | 3,942 | 3,800 | 0.07 | 11.60 | 0.78 | 0.03 | 0.74 |
| 3.B Manure Management | CH4 | 907 | 811 | 0.01 | 50.79 | 0.73 | 0.03 | 0.77 |
| 5.D Wastewater treatment and discharge | CH4 | 1,157 | 575 | 0.01 | 59.16 | 0.60 | 0.03 | 0.80 |
| 2.A.1 Mineral Industry - Cement production | CO2 | 3,176 | 2,265 | 0.04 | 14.88 | 0.60 | 0.03 | 0.82 |
| 4.A.1. Forest land remaining Forest land | CO2 | 4,411 | 1,053 | 0.02 | 29.63 | 0.55 | 0.02 | 0.85 |
| 1.A.3.a Civil (domestic) aviation | CO2 | 178 | 567 | 0.01 | 36.93 | 0.37 | 0.02 | 0.86 |
| 3.B Manure Management | N2O | 239 | 200 | 0.00 | 67.71 | 0.24 | 0.01 | 0.87 |
| 4.A.2 Land converted to Forest land | CO2 | -1,188 | -792 | 0.01 | 16.80 | 0.24 | 0.01 | 0.88 |
| 2.A.2 Mineral Industry - Lime production | CO2 | 206 | 369 | 0.01 | 35.60 | 0.23 | 0.01 | 0.89 |
| 1.A.3.d Domestic navigation - Residual fuel oil | CO2 | 263 | 301 | 0.01 | 38.91 | 0.21 | 0.01 | 0.90 |

## *Table E-14: Trend assessment (Approach 2) with LULUCF: 1990- latest inventory year*

**Tier 2 Trend Assessment (1990-2024)**

| IPCC SOURCE CATEGORIES | GHG | Base year Estimate (kton CO2 eq.) 1990 | Current year Estimate (kton CO2 eq.) 2024 | Trend Assess. | Combined Uncert. % | Level * Uncert. % | Share Level * Uncert. % | Cumulative Total |
|---|---|---|---|---|---|---|---|---|
| 5.D Wastewater treatment and discharge | N2O | 253 | 778 | 0.01 | 493.48 | 5.50 | 0.31 | 0.31 |
| 3.D.1 Direct N2O Emissions From Managed Soils | N2O | 1,600 | 1,502 | 0.02 | 81.31 | 1.75 | 0.10 | 0.41 |
| 5.A Solid waste disposal | CH4 | 2,945 | 4,077 | 0.06 | 25.11 | 1.47 | 0.08 | 0.50 |
| 1.B.2.a Fugitive emissions - Oil | CH4 | 2 | 2 | 0.00 | 48797.88 | 1.34 | 0.08 | 0.57 |
| 4.E.2 Land converted to Settlements | CO2 | 560 | 291 | 0.00 | 249.08 | 1.04 | 0.06 | 0.63 |
| 1.A.3.b Road Transportation | CO2 | 10,000 | 17,045 | 0.24 | 3.60 | 0.88 | 0.05 | 0.68 |
| 3.A Enteric fermentation | CH4 | 3,942 | 3,800 | 0.05 | 11.60 | 0.63 | 0.04 | 0.72 |
| 3.B Manure Management | CH4 | 907 | 811 | 0.01 | 50.79 | 0.59 | 0.03 | 0.75 |
| 5.D Wastewater treatment and discharge | CH4 | 1,157 | 575 | 0.01 | 59.16 | 0.49 | 0.03 | 0.78 |
| 2.A.1 Mineral Industry - Cement production | CO2 | 3,176 | 2,265 | 0.03 | 14.88 | 0.48 | 0.03 | 0.81 |
| 4.A.1. Forest land remaining Forest land | CO2 | 4,411 | 1,053 | 0.02 | 29.63 | 0.45 | 0.03 | 0.83 |
| 4.A.2 Land converted to Forest land | CO2 | -1,188 | -792 | 0.02 | 16.80 | 0.38 | 0.02 | 0.86 |
| 1.A.3.a Civil (domestic) aviation | CO2 | 178 | 567 | 0.01 | 36.93 | 0.30 | 0.02 | 0.87 |
| 3.B Manure Management | N2O | 239 | 200 | 0.00 | 67.71 | 0.19 | 0.01 | 0.88 |
| 2.A.2 Mineral Industry - Lime production | CO2 | 206 | 369 | 0.01 | 35.60 | 0.19 | 0.01 | 0.89 |
| 1.A.3.d Domestic navigation - Residual fuel oil | CO2 | 263 | 301 | 0.00 | 38.91 | 0.17 | 0.01 | 0.90 |

# Annex F: Uncertainty Assessment

*Updated: April 2026*

Uncertainty in the inventory of emissions and removals of GHG results from the natural variability of emission processes, incomplete knowledge of emission sources and definition, errors and gaps in data collection and statistical information, incorrect determination and choice of emission factors and parameter due to errors in original monitoring data, reference studies and expert judgement.

Uncertainty values were defined as the range of 95% confidence interval (IPCC, 1997; IPCC, 2000), meaning that there is a 95 % probability that the actual value of the quantity (activity data, emission factor or emission) is within the interval defined by the confidence limits.

The uncertainty analysis was performed solely for the direct GHG: $CO_2$, $CH_4$, $N_2O$, considering all emissions in $CO_2e$. The uncertainty of all source activities was considered to overall uncertainty including the uncertainty of LULUCF category.

An approach 1 methodology was used to estimate total uncertainty for the inventory, for one individual year and also the uncertainty in trend. Basically this method of classical analysis, which is explained in more detail in IPCC (2000), attributes uncertainty values to activity data and emission factors, for each of the pollutants, and uses error propagation rules to combine uncertainty estimates for each individual source into total uncertainty. In accordance with IPCC (2000) considerations, the uncertainty in Global Warming Potentials (GWP) is not included in uncertainty quantification. The uncertainty values, both for activity data and emission factors, are discussed in the detailed analysis of emission estimates for each individual source sector.

The uncertainty is estimated for individual years, from emission estimates in specific years and uncertainty values for both activity data and implied emission factors, but also for the trend of emissions for each individual category.

***Table F-1: Approach 1 Uncertainty Estimates: 2024***

| IPCC category/Group | Gas | Base year emissions or removals | Year x emissions or removals | Activity data uncertainty (1) | Emission factor / estimation parameter uncertainty (1) | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2) | Uncertainty in trend in national emissions introduced by activity data uncertainty (3) | Uncertainty introduced into the trend in total national emissions | **Comments** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Gg CO2 equivalent** | **Gg CO2 equivalent** | **%** | **%** | **%** | | **%** | **%** | **%** | **%** | **%** | **Key Category (KC)** |
| | | **input data** | **input data** | **input data Note A** | **input data Note A** | $\sqrt{E^2+F^2}$ | $\frac{(G \bullet D)^2}{(\sum D)^2}$ | **Note B** | $\left\lvert\frac{D}{\sum C}\right\rvert$ | **I*F Note C** | **J*E*sqrt(2) Note D** | **K^2 + L^2** | |
| 1.A.1 Energy industries - Liquid fuels | CO2 | 8354.14 | 1639.93 | 1.5 | 1.2 | 1.9357 | 0.0037 | 0.0803 | 0.0256 | 0.0995 | 0.0539 | 0.01281 | KC |
| 1.A.1 Energy industries - Solid fuels | CO2 | 8011.47 | 0.00 | 0.0 | 0.0 | 0.0000 | 0.0000 | 0.1016 | 0.0000 | 0.0000 | 0.0000 | 0.00000 | |
| 1.A.1 Energy industries - Gaseous fuels | CO2 | 0.00 | 2100.21 | 1.1 | 1.4 | 1.8246 | 0.0054 | 0.0328 | 0.0328 | 0.0473 | 0.0519 | 0.00493 | KC |
| 1.A.1 Energy industries - Other fossil fuels | CO2 | 0.00 | 513.24 | 5.0 | 23.2 | 23.7648 | 0.0550 | 0.0080 | 0.0080 | 0.1863 | 0.0567 | 0.03791 | KC |
| 1.A.2 Manufacturing industries and construction - Liquid fuels | CO2 | 6529.64 | 1908.42 | 1.7 | 7.3 | 7.5030 | 0.0758 | 0.0530 | 0.0298 | 0.3879 | 0.0698 | 0.15537 | KC |
| 1.A.2 Manufacturing industries and construction - Solid fuels | CO2 | 2311.40 | 10.68 | 2.6 | 6.6 | 7.0619 | 0.0000 | 0.0292 | 0.0002 | 0.1920 | 0.0006 | 0.03685 | KC |
| 1.A.2 Manufacturing industries and construction - Gaseous fuels | CO2 | 0.01 | 3457.38 | 0.8 | 1.3 | 1.5258 | 0.0103 | 0.0540 | 0.0540 | 0.0709 | 0.0594 | 0.00856 | KC |
| 1.A.2 Manufacturing industries and construction - Other fossil fuels | CO2 | 12.21 | 257.40 | 6.2 | 20.3 | 21.2498 | 0.0111 | 0.0039 | 0.0040 | 0.0786 | 0.0352 | 0.00741 | KC |
| 1.A.3.a Civil (domestic) aviation | CO2 | 177.82 | 567.35 | 36.6 | 5.0 | 36.9014 | 0.1620 | 0.0066 | 0.0089 | 0.0330 | 0.4583 | 0.21109 | KC |
| 1.A.3.b Road Transportation | CO2 | 10000.46 | 17044.63 | 2.4 | 2.7 | 3.6242 | 1.4105 | 0.1391 | 0.2663 | 0.3732 | 0.9175 | 0.98114 | KC |
| 1.A.3.c Railways - Liquid fuels | CO2 | 177.19 | 23.73 | 2.9 | 1.7 | 3.3431 | 0.0000 | 0.0019 | 0.0004 | 0.0032 | 0.0015 | 0.00001 | |
| 1.A.3.d Domestic navigation - Residual fuel oil | CO2 | 262.52 | 300.64 | 38.0 | 5.8 | 38.4636 | 0.0494 | 0.0014 | 0.0047 | 0.0079 | 0.2525 | 0.06384 | KC |
| 1.A.4 Combustion Other Sectors - Liquid fuels | CO2 | 3463.33 | 2551.82 | 1.1 | 0.6 | 1.1966 | 0.0034 | 0.0041 | 0.0399 | 0.0023 | 0.0597 | 0.00357 | KC |
| 1.A.4 Combustion Other Sectors - Gaseous fuels | CO2 | 0.00 | 1224.43 | 0.0 | 0.0 | 0.0534 | 0.0000 | 0.0191 | 0.0191 | 0.0008 | 0.0009 | 0.00000 | KC |
| 1.A.5 Combustion Non-SpecifiedOther - Liquid fuels | CO2 | 96.11 | 54.25 | 5.0 | 5.0 | 7.0711 | 0.0001 | 0.0004 | 0.0008 | 0.0019 | 0.0060 | 0.00004 | |
| 1.B.1.Fugitive emissions – Solid Fuels | CO2 | 2.88 | 0.00 | 3.5 | 100.4 | 100.4988 | 0.0000 | 0.0000 | 0.0000 | 0.0037 | 0.0000 | 0.00001 | |
| 1.B.2.a Fugitive emissions - Oil | CO2 | 0.43 | 1036.73 | 1.4 | 100.0 | 100.0000 | 3.9730 | 0.0162 | 0.0162 | 1.6188 | 0.0315 | 2.62164 | KC |
| 1.B.2.b Fugitive emissions - Natural Gas | CO2 | 0.00 | 0.04 | 0.2 | 146.9 | 146.9498 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.00000 | |
| 1.B.2.c Venting and Flaring | CO2 | 52.49 | 105.70 | 30.0 | 95.4 | 100.0000 | 0.0413 | 0.0010 | 0.0017 | 0.0940 | 0.0701 | 0.01374 | |

| IPCC category/Group | Gas | Base year emissions or removals | Year x emissions or removals | Activity data uncertainty (1) | Emission factor / estimation parameter uncertainty (1) | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2) | Uncertainty in trend in national emissions introduced by activity data uncertainty (3) | Uncertainty introduced into the trend in total national emissions | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Gg CO2 equivalent | Gg CO2 equivalent | % | % | % | | % | % | % | % | % | Key Category (KC) |
| | | input data | input data | input data Note A | input data Note A | $\sqrt{E^2+F^2}$ | $\frac{(G \bullet D)^2}{(\sum D)^2}$ | 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.d Geothermal | CO2 | 0.80 | 35.33 | 3.5 | 29.6 | 29.8060 | 0.0004 | 0.0005 | 0.0006 | 0.0160 | 0.0028 | 0.00026 | |
| 2.A.1 Mineral Industry - Cement production | CO2 | 3176.37 | 2265.39 | 14.1 | 1.3 | 14.1367 | 0.3791 | 0.0049 | 0.0354 | 0.0063 | 0.7046 | 0.49645 | KC |
| 2.A.2 Mineral Industry - Lime production | CO2 | 206.16 | 369.37 | 35.0 | 6.3 | 35.5985 | 0.0639 | 0.0032 | 0.0058 | 0.0199 | 0.2859 | 0.08212 | KC |
| 2.A.3 Mineral Industry - Glass production | CO2 | 68.88 | 144.70 | 5.4 | 2.2 | 5.8310 | 0.0003 | 0.0014 | 0.0023 | 0.0031 | 0.0172 | 0.00031 | |
| 2.A.4 Mineral Industry - Other Process Uses of Carbonates | CO2 | 196.88 | 113.57 | 2.7 | 0.0 | 2.7385 | 0.0000 | 0.0007 | 0.0018 | 0.0000 | 0.0069 | 0.00005 | |
| 2.B.1 Chemical Industry - Ammonia production | CO2 | 763.47 | 0.00 | 2.0 | 7.0 | 7.2801 | 0.0000 | 0.0097 | 0.0000 | 0.0678 | 0.0000 | 0.00460 | |
| 2.B.6 Titanium dioxide production | CO2 | 0.00 | 0.02 | 10.0 | 15.0 | 18.0278 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.00000 | |
| 2.B.8 Chemical Industry - Petrochemical and Carbon Black production | CO2 | 645.20 | 14.66 | 2.3 | 12.0 | 12.2611 | 0.0000 | 0.0080 | 0.0002 | 0.0958 | 0.0008 | 0.00918 | KC |
| 2.C.1 Metal Industry - Iron and Steel production | CO2 | 439.62 | 65.80 | 10.0 | 10.0 | 14.1421 | 0.0003 | 0.0046 | 0.0010 | 0.0455 | 0.0145 | 0.00228 | KC |
| 2.C.5 Lead production | CO2 | 6.75 | 14.99 | 10.0 | 10.0 | 14.1421 | 0.0000 | 0.0001 | 0.0002 | 0.0015 | 0.0033 | 0.00001 | |
| 2.D Non-energy products from fuels and solvent use | CO2 | 278.69 | 190.22 | 9.3 | 132.0 | 132.2891 | 0.2341 | 0.0006 | 0.0030 | 0.0746 | 0.0392 | 0.00711 | KC |
| 3.G Liming | CO2 | 6.49 | 13.43 | 43.3 | 0.0 | 43.3181 | 0.0001 | 0.0001 | 0.0002 | 0.0000 | 0.0128 | 0.00017 | |
| 3.H Urea application & 3.I Other carbon-containing fertilizers | CO2 | 41.95 | 34.50 | 24.1 | 4.5 | 24.5323 | 0.0003 | 0.0000 | 0.0005 | 0.0000 | 0.0184 | 0.00034 | |
| 4.A.1. Forest land remaining Forest land | CO2 | 4411.04 | 1053.49 | 6.9 | 28.8 | 29.6260 | 0.3601 | 0.0395 | 0.0165 | 1.1384 | 0.1601 | 1.32149 | KC |
| 4.A.2 Land converted to Forest land | CO2 | -1188.00 | -792.06 | 4.3 | 16.2 | 16.7955 | 0.0654 | 0.0027 | 0.0124 | 0.0439 | 0.0755 | 0.00762 | KC |
| 4.B.1. Cropland remaining Cropland | CO2 | 384.89 | -513.26 | 2.7 | 148.7 | 148.6925 | 2.1530 | 0.0129 | 0.0080 | 1.9182 | 0.0310 | 3.68034 | KC |
| 4.B.2 Land converted to Cropland | CO2 | 465.60 | 845.53 | 7.7 | 34.2 | 35.0689 | 0.3250 | 0.0073 | 0.0132 | 0.2498 | 0.1431 | 0.08285 | KC |
| 4.C.1. Grassland remaining Grassland | CO2 | 966.32 | -754.51 | 22.5 | 5.3 | 23.1201 | 0.1125 | 0.0240 | 0.0118 | 0.1279 | 0.3750 | 0.15702 | KC |
| 4.C.2 Land converted to Grassland | CO2 | 0.00 | -55.69 | 5.3 | 53.1 | 53.3304 | 0.0033 | 0.0009 | 0.0009 | 0.0462 | 0.0065 | 0.00217 | |

| IPCC category/Group | Gas | Base year emissions or removals | Year x emissions or removals | Activity data uncertainty (1) | Emission factor / estimation parameter uncertainty (1) | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2) | Uncertainty in trend in national emissions introduced by activity data uncertainty (3) | Uncertainty introduced into the trend in total national emissions | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Gg CO2 equivalent | Gg CO2 equivalent | % | % | % | | % | % | % | % | % | Key Category (KC) |
| | | input data | input data | input data Note A | input data Note A | $\sqrt{E^2+F^2}$ | $\frac{(G \bullet D)^2}{(\sum D)^2}$ | Note B | $\left\|\frac{D}{\sum C}\right\|$ | I*F Note C | J*E*sqrt(2) Note D | K^2 + L^2 | |
| 4.D.1. Wetlands remaining Wetlands | CO2 | 0.00 | -0.41 | 22.5 | 0.0 | 22.5000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.00000 | |
| 4.D.2 Land converted to Wetlands | CO2 | 474.63 | 290.75 | 16.0 | 11.1 | 19.4907 | 0.0119 | 0.0015 | 0.0045 | 0.0164 | 0.1030 | 0.01087 | KC |
| 4.E.1. Settlements remaining Settlements | CO2 | 0.00 | 0.02 | 22.5 | 0.0 | 22.5000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.00000 | |
| 4.E.2 Land converted to Settlements | CO2 | 560.02 | 290.99 | 248.8 | 10.9 | 249.0807 | 1.9420 | 0.0026 | 0.0045 | 0.0279 | 1.5997 | 2.55995 | KC |
| 4.G. Other (Harvested Wood Products) | CO2 | -1731.42 | -88.05 | 0.0 | 0.0 | 0.0000 | 0.0000 | 0.0206 | 0.0014 | 0.0000 | 0.0000 | 0.00000 | KC |
| 5.C Incineration and open burning of waste | CO2 | 6.96 | 38.05 | 15.0 | 250.2 | 250.6242 | 0.0336 | 0.0005 | 0.0006 | 0.1266 | 0.0126 | 0.01618 | |
| 1.A.1 Energy industries - Liquid fuels | CH4 | 3.74 | 1.28 | 1.5 | 93.2 | 93.1869 | 0.0000 | 0.0000 | 0.0000 | 0.0026 | 0.0000 | 0.00001 | |
| 1.A.1 Energy industries - Solid fuels | CH4 | 2.94 | 0.00 | 0.0 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.00000 | |
| 1.A.1 Energy industries - Gaseous fuels | CH4 | 0.00 | 1.05 | 1.1 | 37.9 | 37.9621 | 0.0000 | 0.0000 | 0.0000 | 0.0006 | 0.0000 | 0.00000 | |
| 1.A.1 Energy industries - Other fossil fuels | CH4 | 0.00 | 3.37 | 5.0 | 100.5 | 100.6231 | 0.0000 | 0.0001 | 0.0001 | 0.0053 | 0.0004 | 0.00003 | |
| 1.A.1 Energy industries - Biomass | CH4 | 0.00 | 6.82 | 11.9 | 99.8 | 100.4762 | 0.0002 | 0.0001 | 0.0001 | 0.0106 | 0.0018 | 0.00012 | |
| 1.A.2 Manufacturing industries and construction - Liquid fuels | CH4 | 16.10 | 7.85 | 1.7 | 55.1 | 55.1628 | 0.0001 | 0.0001 | 0.0001 | 0.0045 | 0.0003 | 0.00002 | |
| 1.A.2 Manufacturing industries and construction - Solid fuels | CH4 | 1.81 | 0.03 | 2.6 | 122.1 | 122.0917 | 0.0000 | 0.0000 | 0.0000 | 0.0027 | 0.0000 | 0.00001 | |
| 1.A.2 Manufacturing industries and construction - Gaseous fuels | CH4 | 0.00 | 27.25 | 0.8 | 84.4 | 84.3890 | 0.0020 | 0.0004 | 0.0004 | 0.0359 | 0.0005 | 0.00129 | |
| 1.A.2 Manufacturing industries and construction - Other fossil fuels | CH4 | 0.01 | 0.33 | 6.2 | 99.8 | 99.9699 | 0.0000 | 0.0000 | 0.0000 | 0.0005 | 0.0000 | 0.00000 | |
| 1.A.2 Manufacturing industries and construction - Biomass | CH4 | 16.88 | 25.26 | 7.2 | 58.4 | 58.8548 | 0.0008 | 0.0002 | 0.0004 | 0.0105 | 0.0040 | 0.00013 | |
| 1.A.3.a Civil (domestic) aviation | CH4 | 1.10 | 0.63 | 36.6 | 95.9 | 102.5946 | 0.0000 | 0.0000 | 0.0000 | 0.0004 | 0.0005 | 0.00000 | |
| 1.A.3.b Road Transportation | CH4 | 109.21 | 20.91 | 2.4 | 20.3 | 20.4371 | 0.0001 | 0.0011 | 0.0003 | 0.0215 | 0.0011 | 0.00046 | |
| 1.A.3.c Railways - Liquid fuels | CH4 | 0.28 | 0.04 | 2.9 | 141.5 | 141.5298 | 0.0000 | 0.0000 | 0.0000 | 0.0004 | 0.0000 | 0.00000 | |
| 1.A.3.d Domestic navigation - Residual fuel oil | CH4 | 0.67 | 0.77 | 38.0 | 76.9 | 85.7566 | 0.0000 | 0.0000 | 0.0000 | 0.0003 | 0.0006 | 0.00000 | |

| IPCC category/Group | Gas | Base year emissions or removals | Year x emissions or removals | Activity data uncertainty (1) | Emission factor / estimation parameter uncertainty (1) | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2) | Uncertainty in trend in national emissions introduced by activity data uncertainty (3) | Uncertainty introduced into the trend in total national emissions | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Gg CO2 equivalent | Gg CO2 equivalent | % | % | % | | % | % | % | % | % | Key Category (KC) |
| | | input data | input data | input data Note A | input data Note A | $\sqrt{E^2+F^2}$ | $\frac{(G \bullet D)^2}{(\sum D)^2}$ | Note B | $\left\|\frac{D}{\sum C}\right\|$ | I*F Note C | J*E*sqrt(2) Note D | K^2 + L^2 | |
| 1.A.4 Combustion Other Sectors - Liquid fuels | CH4 | 6.67 | 3.76 | 1.1 | 37.8 | 37.8030 | 0.0000 | 0.0000 | 0.0001 | 0.0010 | 0.0001 | 0.00000 | |
| 1.A.4 Combustion Other Sectors - Gaseous fuels | CH4 | 0.00 | 0.60 | 0.0 | 3.7 | 3.6908 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.00000 | |
| 1.A.4 Combustion Other Sectors - Biomass | CH4 | 475.91 | 228.75 | 0.0 | 0.5 | 0.4983 | 0.0000 | 0.0025 | 0.0036 | 0.0012 | 0.0002 | 0.00000 | KC |
| 1.A.5 Combustion Non-SpecifiedOther - Liquid fuels | CH4 | 0.02 | 0.01 | 5.0 | 40.0 | 40.3113 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.00000 | |
| 1.B.1.Fugitive emissions – Solid Fuels | CH4 | 156.91 | 16.47 | 3.5 | 100.4 | 100.4988 | 0.0010 | 0.0017 | 0.0003 | 0.1742 | 0.0013 | 0.03034 | KC |
| 1.B.2.a Fugitive emissions - Oil | CH4 | 1.90 | 1.91 | 29.7 | 50.0 | 58.1719 | 0.0000 | 0.0000 | 0.0000 | 0.0003 | 0.0013 | 0.00000 | KC |
| 1.B.2.b Fugitive emissions - Natural Gas | CH4 | 0.00 | 54.08 | 4.8 | 146.9 | 146.9831 | 0.0234 | 0.0008 | 0.0008 | 0.1241 | 0.0057 | 0.01544 | |
| 1.B.2.c Venting and Flaring | CH4 | 0.57 | 1.57 | 30.0 | 100.0 | 104.4031 | 0.0000 | 0.0000 | 0.0000 | 0.0017 | 0.0010 | 0.00000 | |
| 2.B.8 Chemical Industry - Petrochemical and Carbon Black production | CH4 | 28.59 | 0.00 | 8.1 | 11.6 | 14.1421 | 0.0000 | 0.0004 | 0.0000 | 0.0042 | 0.0000 | 0.00002 | |
| 2.C.1 Metal Industry - Iron and Steel production | CH4 | 0.67 | 0.00 | 0.0 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.00000 | |
| 3.A Enteric fermentation | CH4 | 3941.74 | 3800.43 | 0.3 | 11.7 | 11.6591 | 0.7258 | 0.0093 | 0.0594 | 0.1088 | 0.0244 | 0.01243 | KC |
| 3.B Manure Management | CH4 | 907.34 | 810.59 | 10.1 | 49.5 | 50.5313 | 0.6202 | 0.0011 | 0.0127 | 0.0567 | 0.1803 | 0.03572 | KC |
| 3.C Rice cultivation | CH4 | 149.99 | 159.23 | 10.2 | 63.5 | 64.3410 | 0.0388 | 0.0006 | 0.0025 | 0.0371 | 0.0359 | 0.00266 | |
| 3.F Field burning of agricultural residues | CH4 | 10.25 | 7.24 | 43.6 | 39.1 | 58.5497 | 0.0001 | 0.0000 | 0.0001 | 0.0007 | 0.0070 | 0.00005 | |
| 4.A.1. Forest land remaining Forest land | CH4 | 306.92 | 116.22 | 8.8 | 22.7 | 24.3730 | 0.0030 | 0.0021 | 0.0018 | 0.0473 | 0.0225 | 0.00274 | KC |
| 4.A.2 Land converted to Forest land | CH4 | 0.00 | 0.34 | 8.8 | 13.9 | 16.4724 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.00000 | |
| 4.B.1. Cropland remaining Cropland | CH4 | 55.66 | 5.24 | 12.0 | 24.2 | 27.0394 | 0.0000 | 0.0006 | 0.0001 | 0.0151 | 0.0014 | 0.00023 | |
| 4.B.2 Land converted to Cropland | CH4 | 0.00 | 0.10 | 8.8 | 24.3 | 25.8342 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.00000 | |
| 4.C.1. Grassland remaining Grassland | CH4 | 214.68 | 40.65 | 22.5 | 57.8 | 62.0504 | 0.0024 | 0.0021 | 0.0006 | 0.1208 | 0.0202 | 0.01501 | KC |
| 4.C.2 Land converted to Grassland | CH4 | 0.00 | 3.14 | 11.3 | 28.9 | 31.0284 | 0.0000 | 0.0000 | 0.0000 | 0.0014 | 0.0008 | 0.00000 | |

| IPCC category/Group | Gas | Base year emissions or removals | Year x emissions or removals | Activity data uncertainty (1) | Emission factor / estimation parameter uncertainty (1) | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2) | Uncertainty in trend in national emissions introduced by activity data uncertainty (3) | Uncertainty introduced into the trend in total national emissions | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Gg CO2 equivalent | Gg CO2 equivalent | % | % | % | | % | % | % | % | % | Key Category (KC) |
| | | input data | input data | input data Note A | input data Note A | $\sqrt{E^2+F^2}$ | $\frac{(G \bullet D)^2}{(\sum D)^2}$ | Note B | $\left\|\frac{D}{\sum C}\right\|$ | I*F Note C | J*E*sqrt(2) Note D | K^2 + L^2 | |
| 5.A Solid waste disposal | CH4 | 2944.82 | 4076.80 | 13.4 | 21.1 | 25.0141 | 3.8442 | 0.0263 | 0.0637 | 0.5546 | 1.2111 | 1.77445 | KC |
| 5.B Biological treatment of solid waste | CH4 | 5.63 | 64.39 | 14.1 | 108.2 | 109.1454 | 0.0183 | 0.0009 | 0.0010 | 0.1011 | 0.0201 | 0.01063 | |
| 5.C Incineration and open burning of waste | CH4 | 38.02 | 30.34 | 15.0 | 51.2 | 53.3739 | 0.0010 | 0.0000 | 0.0005 | 0.0004 | 0.0101 | 0.00010 | |
| 5.D Wastewater treatment and discharge | CH4 | 1156.96 | 575.38 | 37.7 | 46.2 | 59.6008 | 0.4347 | 0.0057 | 0.0090 | 0.2630 | 0.4791 | 0.29872 | KC |
| 5.E Other (Biogas burning) | CH4 | 0.00 | 0.002 | 10.0 | 150.0 | 150.3330 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.00000 | |
| 1.A.1 Energy industries - Liquid fuels | N2O | 9.52 | 1.96 | 1.5 | 56.3 | 56.3449 | 0.0000 | 0.0001 | 0.0000 | 0.0051 | 0.0001 | 0.00003 | |
| 1.A.1 Energy industries - Solid fuels | N2O | 33.63 | 0.00 | 0.0 | 0.0 | 0.0000 | 0.0000 | 0.0004 | 0.0000 | 0.0000 | 0.0000 | 0.00000 | |
| 1.A.1 Energy industries - Gaseous fuels | N2O | 0.00 | 21.78 | 1.1 | 1.0 | 1.4938 | 0.0000 | 0.0003 | 0.0003 | 0.0003 | 0.0005 | 0.00000 | |
| 1.A.1 Energy industries - Other fossil fuels | N2O | 0.00 | 6.72 | 5.0 | 100.0 | 100.1249 | 0.0002 | 0.0001 | 0.0001 | 0.0105 | 0.0007 | 0.00011 | |
| 1.A.1 Energy industries - Biomass | N2O | 0.00 | 21.03 | 11.9 | 99.3 | 99.9885 | 0.0016 | 0.0003 | 0.0003 | 0.0326 | 0.0055 | 0.00109 | |
| 1.A.2 Manufacturing industries and construction - Liquid fuels | N2O | 46.13 | 24.57 | 1.7 | 23.3 | 23.3268 | 0.0001 | 0.0002 | 0.0004 | 0.0047 | 0.0009 | 0.00002 | |
| 1.A.2 Manufacturing industries and construction - Solid fuels | N2O | 4.27 | 0.04 | 2.6 | 135.6 | 135.6518 | 0.0000 | 0.0001 | 0.0000 | 0.0073 | 0.0000 | 0.00005 | |
| 1.A.2 Manufacturing industries and construction - Gaseous fuels | N2O | 0.00 | 16.00 | 0.8 | 37.4 | 37.4517 | 0.0001 | 0.0002 | 0.0002 | 0.0094 | 0.0003 | 0.00009 | |
| 1.A.2 Manufacturing industries and construction - Other fossil fuels | N2O | 0.08 | 9.08 | 6.2 | 168.5 | 168.5671 | 0.0009 | 0.0001 | 0.0001 | 0.0237 | 0.0012 | 0.00056 | |
| 1.A.2 Manufacturing industries and construction - Biomass | N2O | 55.05 | 64.79 | 7.2 | 106.4 | 106.5990 | 0.0176 | 0.0003 | 0.0010 | 0.0333 | 0.0103 | 0.00122 | |
| 1.A.3.a Civil (domestic) aviation | N2O | 1.32 | 4.21 | 36.6 | 498.6 | 499.9751 | 0.0016 | 0.0000 | 0.0001 | 0.0244 | 0.0034 | 0.00061 | |
| 1.A.3.b Road Transportation | N2O | 70.05 | 141.00 | 2.4 | 2.7 | 3.6460 | 0.0001 | 0.0013 | 0.0022 | 0.0036 | 0.0076 | 0.00007 | |
| 1.A.3.c Railways - Liquid fuels | N2O | 18.11 | 2.58 | 2.9 | 141.5 | 141.5298 | 0.0000 | 0.0002 | 0.0000 | 0.0268 | 0.0002 | 0.00072 | |
| 1.A.3.d Domestic navigation - Residual fuel oil | N2O | 1.82 | 2.08 | 38.0 | 384.3 | 386.2107 | 0.0002 | 0.0000 | 0.0000 | 0.0036 | 0.0018 | 0.00002 | |
| 1.A.4 Combustion Other Sectors - Liquid fuels | N2O | 51.70 | 63.24 | 1.1 | 110.6 | 110.5734 | 0.0181 | 0.0003 | 0.0010 | 0.0367 | 0.0015 | 0.00135 | |

| IPCC category/Group | Gas | Base year emissions or removals | Year x emissions or removals | Activity data uncertainty (1) | Emission factor / estimation parameter uncertainty (1) | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2) | Uncertainty in trend in national emissions introduced by activity data uncertainty (3) | Uncertainty introduced into the trend in total national emissions | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Gg CO2 equivalent | Gg CO2 equivalent | % | % | % | | % | % | % | % | % | Key Category (KC) |
| | | input data | input data | input data Note A | input data Note A | $\sqrt{E^2+F^2}$ | $\frac{(G \bullet D)^2}{(\sum D)^2}$ | Note B | $\left\|\frac{D}{\sum C}\right\|$ | I*F Note C | J*E*sqrt(2) Note D | K^2 + L^2 | |
| 1.A.4 Combustion Other Sectors - Gaseous fuels | N2O | 0.00 | 5.32 | 0.0 | 0.2 | 0.1719 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.00000 | |
| 1.A.4 Combustion Other Sectors - Biomass | N2O | 141.15 | 81.66 | 0.0 | 0.2 | 0.1973 | 0.0000 | 0.0005 | 0.0013 | 0.0001 | 0.0001 | 0.00000 | |
| 1.A.5 Combustion Non-SpecifiedOther - Liquid fuels | N2O | 0.71 | 0.40 | 5.0 | 50.0 | 50.2494 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.00000 | |
| 1.B.2.c Venting and Flaring | N2O | 2.09 | 2.14 | 0.0 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.00000 | |
| 2.B.2 Chemical Industry - Nitric acid production | N2O | 460.40 | 35.94 | 2.0 | 10.0 | 10.1980 | 0.0000 | 0.0053 | 0.0006 | 0.0528 | 0.0016 | 0.00279 | KC |
| 2.G Other product manufacture and use | N2O | 73.72 | 30.84 | 5.0 | 0.0 | 5.0000 | 0.0000 | 0.0005 | 0.0005 | 0.0000 | 0.0034 | 0.00001 | |
| 3.B Manure Management | N2O | 238.76 | 199.67 | 38.9 | 55.4 | 67.7076 | 0.0676 | 0.0001 | 0.0031 | 0.0049 | 0.1714 | 0.02942 | KC |
| 3.D.1 Direct N2O Emissions From Managed Soils | N2O | 1600.19 | 1501.56 | 20.7 | 80.6 | 83.2372 | 5.7745 | 0.0031 | 0.0235 | 0.2536 | 0.6852 | 0.53384 | KC |
| 3.D.2 Indirect N2O Emissions From Managed Soils | N2O | 458.85 | 389.80 | 94.1 | 119.7 | 152.2107 | 1.3013 | 0.0003 | 0.0061 | 0.0317 | 0.8102 | 0.65744 | KC |
| 3.F Field burning of agricultural residues | N2O | 2.52 | 1.78 | 43.6 | 47.6 | 64.5326 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0017 | 0.00000 | |
| 4.A.1. Forest land remaining Forest land | N2O | 103.13 | 60.77 | 8.8 | 53.8 | 54.5178 | 0.0041 | 0.0004 | 0.0009 | 0.0194 | 0.0118 | 0.00051 | |
| 4.A.2 Land converted to Forest land | N2O | 19.02 | 9.61 | 8.8 | 35.6 | 36.6295 | 0.0000 | 0.0001 | 0.0002 | 0.0032 | 0.0019 | 0.00001 | |
| 4.B.1. Cropland remaining Cropland | N2O | 14.05 | 1.32 | 12.0 | 59.2 | 60.3873 | 0.0000 | 0.0002 | 0.0000 | 0.0093 | 0.0003 | 0.00009 | |
| 4.B.2 Land converted to Cropland | N2O | 30.72 | 57.95 | 8.8 | 43.7 | 44.5616 | 0.0025 | 0.0005 | 0.0009 | 0.0225 | 0.0112 | 0.00063 | |
| 4.C.1. Grassland remaining Grassland | N2O | 54.18 | 17.16 | 22.5 | 103.8 | 106.1803 | 0.0012 | 0.0004 | 0.0003 | 0.0435 | 0.0085 | 0.00197 | |
| 4.C.2 Land converted to Grassland | N2O | 0.00 | 7.04 | 11.3 | 52.0 | 53.1681 | 0.0001 | 0.0001 | 0.0001 | 0.0057 | 0.0018 | 0.00004 | |
| 4.D.1. Wetlands remaining Wetlands | N2O | 0.00 | 0.02 | 0.0 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.00000 | |
| 4.D.2 Land converted to Wetlands | N2O | 32.33 | 20.86 | 0.0 | 0.0 | 0.0000 | 0.0000 | 0.0001 | 0.0003 | 0.0000 | 0.0000 | 0.00000 | |
| 4.E.2 Land converted to Settlements | N2O | 24.16 | 15.84 | 0.0 | 0.0 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0000 | 0.0000 | 0.00000 | |
| 4.F.2 Land converted to Other Land | N2O | 0.00 | 0.00 | 14.3 | 51.4 | 53.3076 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.00000 | |

| IPCC category/Group | Gas | Base year emissions or removals | Year x emissions or removals | Activity data uncertainty (1) | Emission factor / estimation parameter uncertainty (1) | Combined uncertainty | Contribution to variance by category in year x | Type A sensitivity | Type B sensitivity | Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty (2) | Uncertainty in trend in national emissions introduced by activity data uncertainty (3) | Uncertainty introduced into the trend in total national emissions | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Gg CO2 equivalent | Gg CO2 equivalent | % | % | % | | % | % | % | % | % | Key Category (KC) |
| | | input data | input data | input data Note A | input data Note A | $\sqrt{E^2+F^2}$ | $\frac{(G \bullet D)^2}{(\sum D)^2}$ | Note B | $\left\|\frac{D}{\sum C}\right\|$ | I*F Note C | J*E*sqrt(2) Note D | K^2 + L^2 | |
| 5.B Biological treatment of solid waste | N2O | 3.20 | 29.52 | 14.1 | 112.5 | 113.3854 | 0.0041 | 0.0004 | 0.0005 | 0.0473 | 0.0092 | 0.00232 | |
| 5.C Incineration and open burning of waste | N2O | 20.52 | 16.45 | 15.0 | 40.2 | 42.8715 | 0.0002 | 0.0000 | 0.0003 | 0.0001 | 0.0055 | 0.00003 | |
| 5.D Wastewater treatment and discharge | N2O | 253.23 | 778.48 | 16.0 | 493.8 | 494.0140 | 54.6722 | 0.0089 | 0.0122 | 4.4174 | 0.2745 | 19.58877 | KC |
| 5.E Other (Biogas burning) | N2O | 0.00 | 0.002 | 10.0 | 1000.0 | 1000.0500 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.00000 | |
| 2.F.1 Refrigeration and Air Conditioning | Fgases | 0.00 | 1767.40 | 32.9 | 26.2 | 42.0800 | 2.0446 | 0.0276 | 0.0276 | 0.7239 | 1.2851 | 2.17554 | KC |
| 2.F.2 Foam blowing agents | Fgases | 0.00 | 45.86 | 51.5 | 38.4 | 64.2341 | 0.0032 | 0.0007 | 0.0007 | 0.0275 | 0.0521 | 0.00348 | |
| 2.F.3 Fire protection | Fgases | 0.00 | 58.50 | 42.4 | 21.2 | 47.4217 | 0.0028 | 0.0009 | 0.0009 | 0.0194 | 0.0548 | 0.00338 | |
| END | | | | | | | | | | | | | |
| Total | | 64014.01 | 52012.00 | | | | 81.12 | | | | | 37.81 | |
| **Total Uncertainties** | | | | | | Uncertainty in total inventory %: | 9.01 | | | | Trend uncertainty %: | 6.15 | |

1 Totals exclude indirect CO2.

2 Key Categories: refer to 2024 inventory year.

# Annex G: Identification of Organic Soils in Portugal

Portugal currently reports Organic Soils as NO (Not Occurring). This Annex presents the information that supports that assessment.

## G.1 Definition of Organic Soils

The 2006 IPCC Guidelines for National Greenhouse Gas Inventories define organic soils[1] as:

*Organic soils are identified on the basis of criteria 1 and 2, or 1 and 3 listed below (FAO 1998):*

1. *Thickness of organic horizon greater than or equal to 10 cm. A horizon of less than 20 cm must have 12 percent or more organic carbon when mixed to a depth of 20 cm.*
2. *Soils that are never saturated with water for more than a few days must contain more than 20 percent organic carbon by weight (i.e., about 35 percent organic matter).*
3. *Soils are subject to water saturation episodes and has either:*
    a. *At least 12 percent organic carbon by weight (i.e., about 20 percent organic matter) if the soil has no clay; or*
    b. *At least 18 percent organic carbon by weight (i.e., about 30 percent organic matter) if the soil has 60% or more clay; or*
    c. *An intermediate, proportional amount of organic carbon for intermediate amounts of clay.*

The 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories provide a different definition and define organic soils[2] as:

*Organic soils are found in wetlands or have been drained and converted to other land-use types (e.g., Forest Land, Cropland, Grassland, Settlements). Soils having organic material (Histosols) are defined as (WRB, 2015):*

1. *Starting at the soil surface and having a thickness of ≥ 10 cm and directly overlying:*
    a. *Ice, or*
    b. *Continuous rock or technic hard material, or*
    c. *Coarse fragments, the interstices of which are filled with organic material; or*
2. *Starting ≤ 40 cm from the soil surface and having within ≤ 100 cm of the soil surface a combined thickness of either:*
    a. *≥ 60 cm, if ≥ 75% (by volume) of the material consists of moss fibres; or*
    b. *≥ 40 cm in other materials*

*All other types of soils are classified as mineral.*

Portugal does not have a country wide soil map(s) that allow the identification of organic soils using those definitions.

However there are other information sources that provide some insight as to the possible existence of organic soils in Portugal. These are described in the next sections of this annex.

[1] Please refer to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 AFOLU, Chapter 3 Consistent Representation of Lands, Annex 3A.5 Default climate and soil classifications, page 3-37.

[2] Please refer to the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 AFOLU, Chapter 3 Consistent Representation of Lands, Annex 3A.5 Default climate and soil classifications, page 3-45.

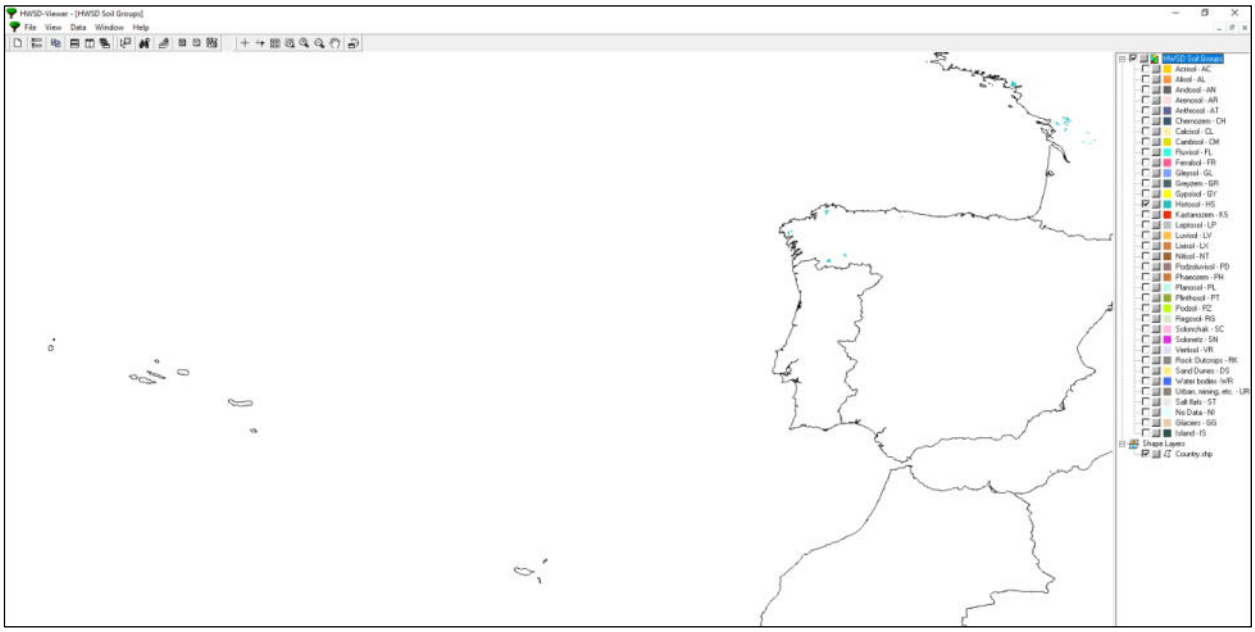
## G.2 FAO / Harmonized World Soil Database

The Harmonized World Soil Database[3] is the result of a collaboration between the FAO with IIASA, ISRIC-World Soil Information, Institute of Soil Science, Chinese Academy of Sciences (ISSCAS), and the Joint Research Centre of the European Commission (JRC).

The database contains over 15 000 different soil mapping units that combines existing regional and national updates of soil information worldwide (SOTER, ESD, Soil Map of China, WISE) with the information contained within the 1:5 000 000 scale FAO-UNESCO Soil Map of the World (FAO, 1971-1981).

The information can be visualized using a Database Viewer[4].

No Histosols can be found in Portugal in that map.



## G.3 JRC – Topsoil Soil Organic Carbon (LUCAS) for EU25

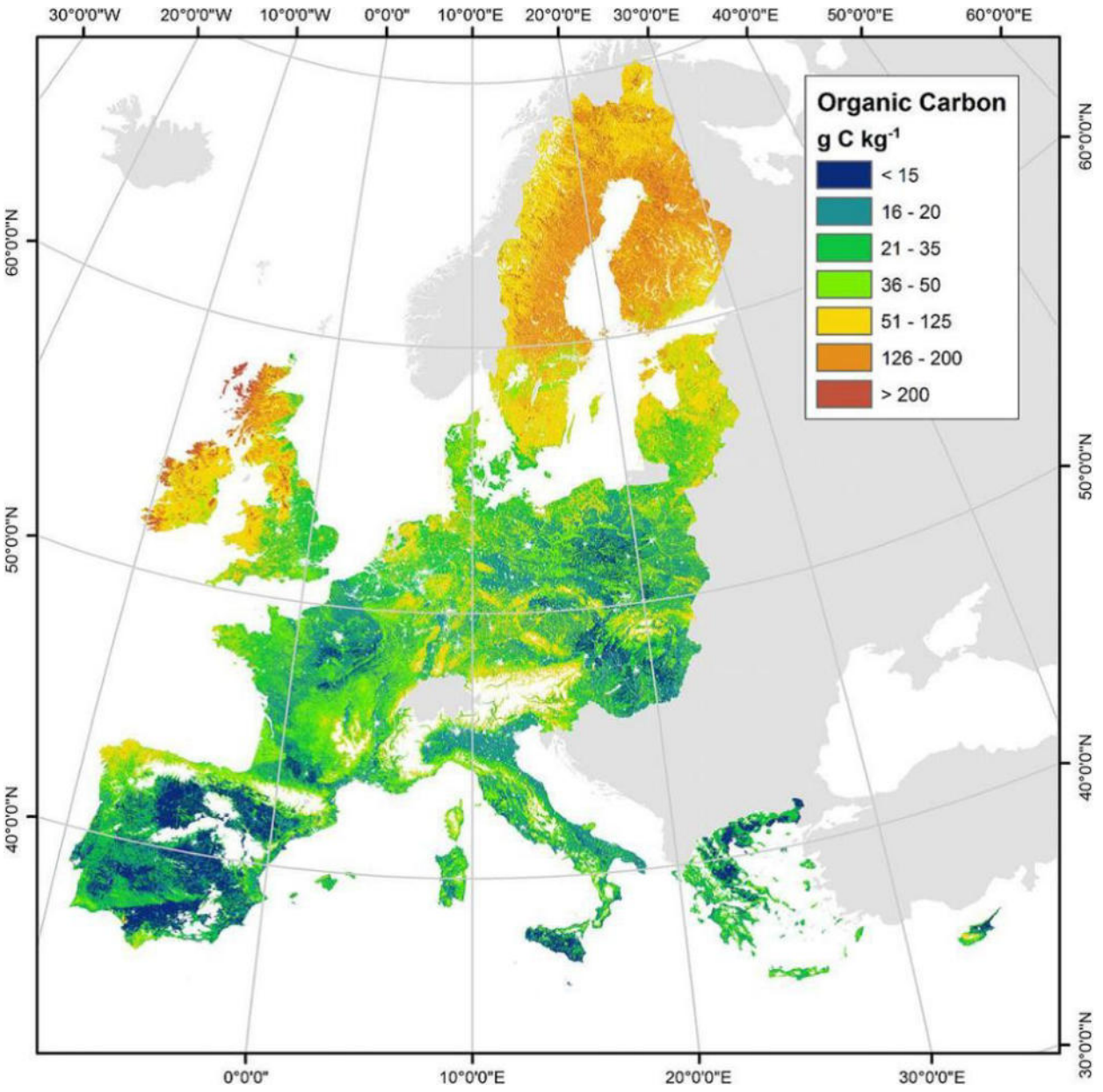
This dataset (2015) was created by the Joint Research Centre of the EU and provides maps for Topsoil Soil Organic Carbon in EU-25 that are based on LUCAS 2009 soil point data through a generalized additive model.

The map of predicted topsoil organic carbon content ($gCkg^{-1}$) was produced by fitting a generalised additive model between organic carbon measurements from the LUCAS survey (dependent variable) and a set of selected environmental covariates; namely slope, land cover, annual accumulated temperature, net primary productivity, latitude and longitude.

The map does not show any areas over 12% C (120 $gCkg^{-1}$) in Portugal.

[3] Available from http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/harmonized-world-soil-database-v12/en/

[4] Harmonized Workd Soil Database Viwer, Version 1.21, March 2012.


30°0'0"W
20°0'0"W
10°0'0"W
0°0'0"
10°0'0"E
20°0'0"E
30°0'0"E
40°0'0"E
50°0'0"E
60°0'0"E
60°0'0"N
50°0'0"N
40°0'0"N
30°0'0"N
Organic Carbon
g C kg-1
< 15
16 - 20
21 - 35
36 - 50
51 - 125
126 - 200
> 200

# Annex H: Activity data for HWP

Consistently with other sectors, CRT Table 4.Gs2 provides activity data only from 1990 onwards. However, emissions and removals from harvested wood products (HWP) depend on the evolution of carbon stocks accumulated over long periods prior to the reporting years, due to the decay characteristics of wood products.

Official data on production, imports and exports of relevant wood product categories were obtained primarily from the UNECE Timber Database for the period 1964–2022. Additional data from FAOSTAT were used to complete the time series for years not covered by UNECE, including the years 1961–1963 and 2023.

In accordance with IPCC guidance, the time series was extended back to 1900 to properly initialize the HWP carbon pool. For the period prior to the availability of official production statistics, inflows were estimated using the methodology described in the 2006 IPCC Guidelines (Volume 4, Chapter 12, Equation 12.6), which provides a procedure for reconstructing historical inputs based on available data. The production of HWP originating from domestic harvest was estimated using IPCC Equation 12.4.

| | | | 1900 | 1901 | 1902 | 1903 | 1904 | 1905 | 1906 | 1907 | 1908 | 1909 | 1910 | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 | 1917 | 1918 | 1919 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Industrial Roundwood | Production | 1.000 m | 1154.43 | 1172.00 | 1189.83 | 1207.93 | 1226.31 | 1244.97 | 1263.91 | 1283.14 | 1302.66 | 1322.48 | 1342.60 | 1363.03 | 1383.77 | 1404.82 | 1426.20 | 1447.89 | 1469.92 | 1492.29 | 1514.99 | 1538.04 |
| | Imports | 1.000 m | 33.88 | 34.39 | 34.92 | 35.45 | 35.99 | 36.53 | 37.09 | 37.65 | 38.23 | 38.81 | 39.40 | 40.00 | 40.61 | 41.22 | 41.85 | 42.49 | 43.13 | 43.79 | 44.46 | 45.13 |
| | Exports | 1.000 m | 78.02 | 79.21 | 80.42 | 81.64 | 82.88 | 84.14 | 85.42 | 86.72 | 88.04 | 89.38 | 90.74 | 92.12 | 93.52 | 94.95 | 96.39 | 97.86 | 99.35 | 100.86 | 102.39 | 103.95 |
| | wood from domestic productio | % | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% |
| Wood Pulp | Production | 1.000 t | 59.58 | 60.48 | 61.41 | 62.34 | 63.29 | 64.25 | 65.23 | 66.22 | 67.23 | 68.25 | 69.29 | 70.34 | 71.41 | 72.50 | 73.60 | 74.72 | 75.86 | 77.01 | 78.19 | 79.38 |
| | Imports | 1.000 t | 5.89 | 5.98 | 6.07 | 6.16 | 6.26 | 6.35 | 6.45 | 6.55 | 6.65 | 6.75 | 6.85 | 6.96 | 7.06 | 7.17 | 7.28 | 7.39 | 7.50 | 7.62 | 7.73 | 7.85 |
| | Exports | 1.000 t | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |
| | pulp from domestic production | % | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% |
| Sawnwood | Production | 1.000 m | 559.26 | 567.77 | 496.45 | 504.00 | 511.67 | 519.45 | 527.36 | 535.38 | 543.52 | 551.79 | 560.19 | 568.71 | 577.37 | 586.15 | 595.07 | 604.12 | 613.31 | 622.64 | 632.12 | 641.74 |
| | Imports | 1.000 m | 8.48 | 8.61 | 12.76 | 12.95 | 13.15 | 13.35 | 13.55 | 13.76 | 13.97 | 14.18 | 14.40 | 14.62 | 14.84 | 15.07 | 15.29 | 15.53 | 15.76 | 16.00 | 16.25 | 16.49 |
| | Exports | 1.000 m | 152.29 | 154.61 | 123.37 | 125.25 | 127.16 | 129.09 | 131.05 | 133.05 | 135.07 | 137.13 | 139.21 | 141.33 | 143.48 | 145.67 | 147.88 | 150.13 | 152.42 | 154.73 | 157.09 | 159.48 |
| Wood panels | Production | 1.000 m | 24.12 | 24.49 | 12.80 | 13.00 | 13.19 | 13.39 | 13.60 | 13.80 | 14.01 | 14.23 | 14.44 | 14.66 | 14.89 | 15.11 | 15.34 | 15.58 | 15.81 | 16.05 | 16.30 | 16.55 |
| | Imports | 1.000 m | 0.19 | 0.19 | 0.21 | 0.21 | 0.21 | 0.21 | 0.22 | 0.22 | 0.22 | 0.23 | 0.23 | 0.24 | 0.24 | 0.24 | 0.25 | 0.25 | 0.25 | 0.26 | 0.26 | 0.27 |
| | Exports | 1.000 m | 7.80 | 7.92 | 1.07 | 1.08 | 1.10 | 1.12 | 1.13 | 1.15 | 1.17 | 1.19 | 1.20 | 1.22 | 1.24 | 1.26 | 1.28 | 1.30 | 1.32 | 1.34 | 1.36 | 1.38 |
| Paper and paperboa | Production | 1.000 t | 14.84 | 15.06 | 48.41 | 49.15 | 49.90 | 50.66 | 51.43 | 52.21 | 53.00 | 53.81 | 54.63 | 55.46 | 56.31 | 57.16 | 58.03 | 58.91 | 59.81 | 60.72 | 61.64 | 62.58 |
| | Imports | 1.000 t | 6.28 | 6.37 | 5.70 | 5.79 | 5.88 | 5.97 | 6.06 | 6.15 | 6.24 | 6.34 | 6.44 | 6.53 | 6.63 | 6.73 | 6.84 | 6.94 | 7.05 | 7.15 | 7.26 | 7.37 |
| | Exports | 1.000 t | 2.36 | 2.39 | 3.57 | 3.62 | 3.68 | 3.73 | 3.79 | 3.85 | 3.91 | 3.97 | 4.03 | 4.09 | 4.15 | 4.21 | 4.28 | 4.34 | 4.41 | 4.48 | 4.54 | 4.61 |

| | | | 1920 | 1921 | 1922 | 1923 | 1924 | 1925 | 1926 | 1927 | 1928 | 1929 | 1930 | 1931 | 1932 | 1933 | 1934 | 1935 | 1936 | 1937 | 1938 | 1939 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Industrial Roundwood | Production | 1.000 m | 1561.44 | 1585.20 | 1609.32 | 1633.80 | 1658.66 | 1683.90 | 1709.52 | 1735.53 | 1761.93 | 1788.74 | 1815.95 | 1843.58 | 1871.63 | 1900.11 | 1929.02 | 1958.37 | 1988.16 | 2018.41 | 2049.12 | 2080.30 |
| | Imports | 1.000 m | 45.82 | 46.52 | 47.23 | 47.94 | 48.67 | 49.41 | 50.17 | 50.93 | 51.70 | 52.49 | 53.29 | 54.10 | 54.92 | 55.76 | 56.61 | 57.47 | 58.34 | 59.23 | 60.13 | 61.05 |
| | Exports | 1.000 m | 105.53 | 107.14 | 108.77 | 110.42 | 112.10 | 113.81 | 115.54 | 117.30 | 119.08 | 120.89 | 122.73 | 124.60 | 126.50 | 128.42 | 130.37 | 132.36 | 134.37 | 136.42 | 138.49 | 140.60 |
| | wood from domestic productio | % | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% |
| Wood Pulp | Production | 1.000 t | 80.58 | 81.81 | 83.05 | 84.32 | 85.60 | 86.90 | 88.23 | 89.57 | 90.93 | 92.31 | 93.72 | 95.14 | 96.59 | 98.06 | 99.55 | 101.07 | 102.61 | 104.17 | 105.75 | 107.36 |
| | Imports | 1.000 t | 7.97 | 8.09 | 8.21 | 8.34 | 8.46 | 8.59 | 8.72 | 8.86 | 8.99 | 9.13 | 9.27 | 9.41 | 9.55 | 9.70 | 9.84 | 9.99 | 10.15 | 10.30 | 10.46 | 10.62 |
| | Exports | 1.000 t | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.07 | 0.07 | 0.07 | 0.07 |
| | pulp from domestic production | % | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% |
| Sawnwood | Production | 1.000 m | 651.50 | 661.41 | 671.47 | 681.69 | 692.06 | 702.59 | 713.28 | 724.13 | 735.15 | 746.34 | 757.69 | 769.22 | 780.92 | 792.80 | 804.87 | 817.11 | 829.54 | 842.16 | 854.98 | 867.99 |
| | Imports | 1.000 m | 16.75 | 17.00 | 17.26 | 17.52 | 17.79 | 18.06 | 18.33 | 18.61 | 18.90 | 19.18 | 19.47 | 19.77 | 20.07 | 20.38 | 20.69 | 21.00 | 21.32 | 21.65 | 21.98 | 22.31 |
| | Exports | 1.000 m | 161.91 | 164.37 | 166.87 | 169.41 | 171.99 | 174.60 | 177.26 | 179.96 | 182.69 | 185.47 | 188.30 | 191.16 | 194.07 | 197.02 | 200.02 | 203.06 | 206.15 | 209.29 | 212.47 | 215.71 |
| Wood panels | Production | 1.000 m | 16.80 | 17.05 | 17.31 | 17.58 | 17.84 | 18.12 | 18.39 | 18.67 | 18.96 | 19.24 | 19.54 | 19.83 | 20.14 | 20.44 | 20.75 | 21.07 | 21.39 | 21.72 | 22.05 | 22.38 |
| | Imports | 1.000 m | 0.27 | 0.27 | 0.28 | 0.28 | 0.29 | 0.29 | 0.29 | 0.30 | 0.30 | 0.31 | 0.31 | 0.32 | 0.32 | 0.33 | 0.33 | 0.34 | 0.34 | 0.35 | 0.35 | 0.36 |
| | Exports | 1.000 m | 1.40 | 1.42 | 1.44 | 1.46 | 1.49 | 1.51 | 1.53 | 1.56 | 1.58 | 1.60 | 1.63 | 1.65 | 1.68 | 1.70 | 1.73 | 1.76 | 1.78 | 1.81 | 1.84 | 1.87 |
| Paper and paperboa | Production | 1.000 t | 63.53 | 64.50 | 65.48 | 66.48 | 67.49 | 68.52 | 69.56 | 70.62 | 71.69 | 72.78 | 73.89 | 75.01 | 76.16 | 77.31 | 78.49 | 79.69 | 80.90 | 82.13 | 83.38 | 84.65 |
| | Imports | 1.000 t | 7.48 | 7.60 | 7.71 | 7.83 | 7.95 | 8.07 | 8.19 | 8.32 | 8.45 | 8.57 | 8.70 | 8.84 | 8.97 | 9.11 | 9.25 | 9.39 | 9.53 | 9.67 | 9.82 | 9.97 |
| | Exports | 1.000 t | 4.68 | 4.76 | 4.83 | 4.90 | 4.98 | 5.05 | 5.13 | 5.21 | 5.29 | 5.37 | 5.45 | 5.53 | 5.61 | 5.70 | 5.79 | 5.88 | 5.96 | 6.06 | 6.15 | 6.24 |

| | | | 1940 | 1941 | 1942 | 1943 | 1944 | 1945 | 1946 | 1947 | 1948 | 1949 | 1950 | 1951 | 1952 | 1953 | 1954 | 1955 | 1956 | 1957 | 1958 | 1959 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Industrial Roundwood | Production | 1.000 m | 2111.95 | 2144.08 | 2176.70 | 2209.82 | 2243.44 | 2277.57 | 2312.23 | 2347.41 | 2383.12 | 2419.38 | 2456.19 | 2493.56 | 2531.50 | 2570.01 | 2609.11 | 2648.81 | 2689.11 | 2730.02 | 2771.56 | 2813.73 |
| | Imports | 1.000 m | 61.97 | 62.92 | 63.87 | 64.85 | 65.83 | 66.84 | 67.85 | 68.88 | 69.93 | 71.00 | 72.08 | 73.17 | 74.29 | 75.42 | 76.56 | 77.73 | 78.91 | 80.11 | 81.33 | 82.57 |
| | Exports | 1.000 m | 142.74 | 144.91 | 147.12 | 149.35 | 151.63 | 153.93 | 156.27 | 158.65 | 161.07 | 163.52 | 166.00 | 168.53 | 171.09 | 173.70 | 176.34 | 179.02 | 181.75 | 184.51 | 187.32 | 190.17 |
| | wood from domestic productio | % | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% | 97% |
| Wood Pulp | Production | 1.000 t | 108.99 | 110.65 | 112.34 | 114.05 | 115.78 | 117.54 | 119.33 | 121.15 | 122.99 | 124.86 | 126.76 | 128.69 | 130.65 | 132.63 | 134.65 | 136.70 | 138.78 | 140.89 | 143.04 | 145.21 |
| | Imports | 1.000 t | 10.78 | 10.94 | 11.11 | 11.28 | 11.45 | 11.62 | 11.80 | 11.98 | 12.16 | 12.35 | 12.54 | 12.73 | 12.92 | 13.12 | 13.32 | 13.52 | 13.72 | 13.93 | 14.14 | 14.36 |
| | Exports | 1.000 t | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 |
| | pulp from domestic production | % | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% | 91% |
| Sawnwood | Production | 1.000 m | 881.19 | 894.60 | 908.21 | 922.03 | 936.06 | 950.30 | 964.76 | 979.43 | 994.34 | 1009.46 | 1024.82 | 1040.42 | 1056.25 | 1072.32 | 1088.63 | 1105.19 | 1122.01 | 1139.08 | 1156.41 | 1174.00 |
| | Imports | 1.000 m | 22.65 | 22.99 | 23.34 | 23.70 | 24.06 | 24.43 | 24.80 | 25.17 | 25.56 | 25.95 | 26.34 | 26.74 | 27.15 | 27.56 | 27.98 | 28.41 | 28.84 | 29.28 | 29.72 | 30.17 |
| | Exports | 1.000 m | 218.99 | 222.32 | 225.70 | 229.14 | 232.62 | 236.16 | 239.75 | 243.40 | 247.10 | 250.86 | 254.68 | 258.56 | 262.49 | 266.48 | 270.54 | 274.65 | 278.83 | 283.08 | 287.38 | 291.75 |
| Wood panels | Production | 1.000 m | 22.72 | 23.07 | 23.42 | 23.77 | 24.14 | 24.50 | 24.88 | 25.25 | 25.64 | 26.03 | 26.43 | 26.83 | 27.24 | 27.65 | 28.07 | 28.50 | 28.93 | 29.37 | 29.82 | 30.27 |
| | Imports | 1.000 m | 0.36 | 0.37 | 0.38 | 0.38 | 0.39 | 0.39 | 0.40 | 0.40 | 0.41 | 0.42 | 0.42 | 0.43 | 0.44 | 0.44 | 0.45 | 0.46 | 0.46 | 0.47 | 0.48 | 0.49 |
| | Exports | 1.000 m | 1.89 | 1.92 | 1.95 | 1.98 | 2.01 | 2.04 | 2.07 | 2.10 | 2.14 | 2.17 | 2.20 | 2.24 | 2.27 | 2.30 | 2.34 | 2.37 | 2.41 | 2.45 | 2.48 | 2.52 |
| Paper and paperboa | Production | 1.000 t | 85.93 | 87.24 | 88.57 | 89.92 | 91.28 | 92.67 | 94.08 | 95.52 | 96.97 | 98.44 | 99.94 | 101.46 | 103.01 | 104.57 | 106.16 | 107.78 | 109.42 | 111.08 | 112.77 | 114.49 |
| | Imports | 1.000 t | 10.12 | 10.28 | 10.43 | 10.59 | 10.75 | 10.92 | 11.08 | 11.25 | 11.42 | 11.60 | 11.77 | 11.95 | 12.13 | 12.32 | 12.51 | 12.70 | 12.89 | 13.09 | 13.28 | 13.49 |
| | Exports | 1.000 t | 6.34 | 6.43 | 6.53 | 6.63 | 6.73 | 6.83 | 6.94 | 7.04 | 7.15 | 7.26 | 7.37 | 7.48 | 7.59 | 7.71 | 7.83 | 7.95 | 8.07 | 8.19 | 8.31 | 8.44 |

| | | | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Industrial Roundwood | Production | 1.000 m | 2856.54 | 2900.00 | 2950.00 | 3200.00 | 3700.00 | 3765.00 | 3895.00 | 3970.00 | 4420.00 | 4860.00 | 5250.00 | 5385.00 | 5530.00 | 5595.00 | 5225.00 | 5056.00 | 4988.00 | 5899.00 | 6300.00 | 6983.00 |
| | Imports | 1.000 m | 83.82 | 85.10 | 69.90 | 76.30 | 88.30 | 111.00 | 91.10 | 133.29 | 132.79 | 185.80 | 160.80 | 253.90 | 248.70 | 411.70 | 317.10 | 334.60 | 354.30 | 504.10 | 249.30 | 171.70 |
| | Exports | 1.000 m | 193.06 | 196.00 | 149.70 | 162.80 | 215.39 | 130.50 | 87.40 | 83.30 | 63.50 | 61.09 | 237.50 | 104.30 | 72.00 | 172.30 | 216.00 | 76.80 | 134.29 | 144.90 | 458.80 | 950.50 |
| | wood from domestic productio | % | 97% | 97% | 98% | 98% | 98% | 97% | 98% | 97% | 97% | 96% | 97% | 95% | 96% | 93% | 94% | 94% | 93% | 92% | 96% | 97% |
| Wood Pulp | Production | 1.000 t | 147.42 | 102.50 | 104.40 | 126.00 | 156.60 | 187.60 | 208.30 | 232.80 | 283.20 | 383.20 | 427.40 | 474.10 | 516.00 | 536.00 | 591.00 | 547.00 | 462.00 | 494.00 | 600.00 | 698.90 |
| | Imports | 1.000 t | 14.58 | 14.80 | 19.20 | 15.00 | 12.90 | 12.10 | 19.20 | 12.70 | 35.20 | 32.60 | 29.40 | 17.10 | 16.70 | 19.39 | 17.89 | 13.80 | 22.70 | 79.30 | 39.00 | 44.59 |
| | Exports | 1.000 t | 0.09 | 0.10 | 0.10 | 0.10 | 0.10 | 0.00 | 0.00 | 0.40 | 234.50 | 303.89 | 340.30 | 291.90 | 459.20 | 464.10 | 363.29 | 264.79 | 359.50 | 317.60 | 290.60 | 346.00 |
| | pulp from domestic production | % | 91% | 87% | 84% | 89% | 92% | 94% | 92% | 95% | 58% | 71% | 75% | 91% | 77% | 79% | 93% | 95% | 82% | 69% | 89% | 89% |
| Sawnwood | Production | 1.000 m | 1191.87 | 1210.00 | 1310.00 | 1310.00 | 1470.00 | 1520.00 | 1575.00 | 1640.00 | 1620.00 | 1685.00 | 1810.00 | 1870.00 | 1990.00 | 2210.00 | 1840.00 | 1600.00 | 1820.00 | 1930.00 | 1970.00 | 2240.00 |
| | Imports | 1.000 m | 30.63 | 31.10 | 22.40 | 23.00 | 22.29 | 21.70 | 31.50 | 31.00 | 33.90 | 37.30 | 34.69 | 37.20 | 37.90 | 37.30 | 46.70 | 27.80 | 12.70 | 18.80 | 11.80 | 8.60 |
| | Exports | 1.000 m | 296.19 | 300.70 | 290.80 | 330.50 | 400.29 | 402.00 | 381.60 | 360.50 | 392.90 | 398.40 | 479.40 | 445.60 | 457.60 | 590.10 | 585.79 | 332.10 | 549.60 | 626.19 | 649.40 | 884.90 |
| Wood panels | Production | 1.000 m | 30.73 | 31.20 | 35.10 | 48.00 | 63.40 | 76.00 | 90.20 | 102.30 | 120.59 | 158.50 | 173.20 | 175.30 | 256.80 | 241.50 | 262.50 | 227.50 | 315.70 | 388.10 | 399.69 | 416.00 |
| | Imports | 1.000 m | 0.49 | 0.50 | 0.10 | 0.10 | 0.50 | 0.60 | 0.90 | 1.30 | 1.30 | 1.70 | 1.90 | 2.10 | 2.10 | 3.50 | 7.60 | 21.10 | 18.50 | 17.44 | 22.54 | 38.70 |
| | Exports | 1.000 m | 2.56 | 2.60 | 5.80 | 15.40 | 20.50 | 26.40 | 24.70 | 39.70 | 47.40 | 69.10 | 82.29 | 103.40 | 103.20 | 82.60 | 36.90 | 45.40 | 46.90 | 34.00 | 101.10 | 193.90 |
| Paper and paperboa | Production | 1.000 t | 116.23 | 118.00 | 119.40 | 117.30 | 39.00 | 152.40 | 156.79 | 154.00 | 168.20 | 215.20 | 219.50 | 236.60 | 228.10 | 253.70 | 310.00 | 357.00 | 336.50 | 449.20 | 438.50 | 492.99 |
| | Imports | 1.000 t | 13.69 | 13.90 | 13.90 | 12.00 | 16.50 | 32.00 | 35.90 | 44.90 | 58.80 | 57.50 | 76.00 | 62.90 | 72.00 | 78.30 | 75.20 | 46.80 | 39.90 | 62.30 | 52.49 | 58.00 |
| | Exports | 1.000 t | 8.57 | 8.70 | 5.70 | 7.00 | 6.20 | 8.90 | 10.50 | 10.70 | 8.00 | 9.80 | 11.70 | 15.00 | 16.70 | 26.40 | 61.90 | 105.90 | 129.10 | 116.90 | 117.00 | 168.00 |

| | | | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Industrial Roundwood | Production | 1.000 m | 7396.00 | 6880.00 | 6643.00 | 7019.00 | 7849.00 | 8792.00 | 9326.00 | 8822.00 | 8839.00 | 9705.00 | 10705.00 | 10309.00 | 9778.00 | 9707.00 | 9319.00 | 8850.00 | 8428.00 | 8428.00 | 7948.00 | 8378.00 |
| | Imports | 1.000 m | 297.60 | 475.49 | 451.00 | 304.80 | 327.60 | 388.00 | 440.00 | 464.00 | 886.00 | 820.00 | 741.40 | 519.10 | 559.40 | 419.86 | 1105.00 | 1632.00 | 1065.00 | 1679.00 | 2121.80 | 1432.00 |
| | Exports | 1.000 m | 621.00 | 283.80 | 243.00 | 181.10 | 339.10 | 619.00 | 481.00 | 533.00 | 447.00 | 534.00 | 402.00 | 429.00 | 549.10 | 361.00 | 629.00 | 778.00 | 452.00 | 627.00 | 572.00 | 543.00 |
| | wood from domestic productio | % | 96% | 93% | 93% | 96% | 96% | 95% | 95% | 95% | 90% | 92% | 93% | 95% | 94% | 96% | 89% | 83% | 88% | 82% | 78% | 85% |
| Wood Pulp | Production | 1.000 t | 645.00 | 685.00 | 870.10 | 950.40 | 988.00 | 1306.00 | 1375.00 | 1408.00 | 1472.00 | 1482.00 | 1449.00 | 1619.00 | 1592.00 | 1520.00 | 1539.00 | 1617.00 | 1595.00 | 1703.00 | 1708.00 | 1755.00 |
| | Imports | 1.000 t | 42.80 | 33.79 | 21.00 | 15.60 | 23.40 | 44.80 | 39.70 | 37.00 | 29.00 | 37.50 | 49.80 | 59.70 | 63.97 | 64.08 | 72.40 | 73.80 | 89.39 | 114.00 | 96.50 | 99.00 |
| | Exports | 1.000 t | 445.40 | 454.80 | 515.00 | 610.90 | 661.90 | 878.60 | 890.00 | 1013.00 | 1017.00 | 1003.09 | 1057.30 | 1092.00 | 1040.95 | 905.53 | 1060.00 | 970.50 | 1009.70 | 1087.00 | 1070.15 | 1145.00 |
| | pulp from domestic production | % | 82% | 87% | 94% | 96% | 93% | 91% | 92% | 91% | 94% | 93% | 89% | 90% | 90% | 91% | 87% | 90% | 87% | 84% | 87% | 86% |
| Sawnwood | Production | 1.000 m | 2270.00 | 1870.00 | 2229.00 | 2360.00 | 2606.00 | 1860.00 | 2070.00 | 2095.00 | 2088.00 | 2140.00 | 2140.00 | 1720.00 | 1650.00 | 1594.00 | 1770.00 | 1831.00 | 1831.00 | 1831.00 | 1590.00 | 1430.00 |
| | Imports | 1.000 m | 12.00 | 34.00 | 36.00 | 17.20 | 17.40 | 18.80 | 27.00 | 34.00 | 64.00 | 70.00 | 80.00 | 96.00 | 194.42 | 136.99 | 131.00 | 153.00 | 162.00 | 190.00 | 230.40 | 273.00 |
| | Exports | 1.000 m | 1024.00 | 787.09 | 881.00 | 896.50 | 1194.09 | 1062.90 | 1168.00 | 1043.00 | 1365.00 | 1405.00 | 1114.00 | 1425.00 | 1091.69 | 473.55 | 568.00 | 525.00 | 460.00 | 407.00 | 428.30 | 339.00 |
| Wood panels | Production | 1.000 m | 472.00 | 493.00 | 471.00 | 522.30 | 495.69 | 657.00 | 776.00 | 827.00 | 851.00 | 1035.00 | 1242.00 | 1246.00 | 1064.00 | 1000.00 | 1230.00 | 1170.09 | 1215.70 | 1208.30 | 1242.90 | 1245.00 |
| | Imports | 1.000 m | 38.24 | 38.40 | 1.20 | 0.60 | 0.70 | 1.10 | 5.00 | 11.00 | 8.00 | 19.00 | 46.80 | 82.30 | 144.35 | 144.85 | 114.00 | 117.90 | 114.20 | 116.60 | 136.09 | 163.00 |
| | Exports | 1.000 m | 172.40 | 147.40 | 120.90 | 241.70 | 319.69 | 430.90 | 511.00 | 560.00 | 569.00 | 628.70 | 786.40 | 728.90 | 747.44 | 576.36 | 738.00 | 647.39 | 635.58 | 862.40 | 778.00 | 671.60 |
| Paper and paperboa | Production | 1.000 t | 463.20 | 484.50 | 527.00 | 592.00 | 670.50 | 706.00 | 589.79 | 627.00 | 681.00 | 740.00 | 780.00 | 877.00 | 959.00 | 878.00 | 949.00 | 1050.00 | 1086.00 | 1114.00 | 1136.00 | 1163.00 |
| | Imports | 1.000 t | 78.40 | 75.59 | 82.00 | 78.70 | 81.59 | 100.60 | 126.30 | 182.50 | 220.00 | 250.60 | 294.60 | 258.39 | 334.21 | 408.44 | 447.00 | 657.70 | 674.50 | 735.70 | 564.20 | 573.00 |
| | Exports | 1.000 t | 147.00 | 146.00 | 161.00 | 194.70 | 214.70 | 216.90 | 204.60 | 174.40 | 208.00 | 238.50 | 289.50 | 336.70 | 332.10 | 456.33 | 601.20 | 583.47 | 631.71 | 721.75 | 642.93 | 683.00 |

| | | | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Industrial Roundwood | Production | 1.000 m | 10231.00 | 8346.00 | 8142.00 | 9073.00 | 10269.00 | 10146.23 | 10204.63 | 10222.88 | 9568.74 | 8964.06 | 9048.36 | 10361.41 | 10110.81 | 10009.58 | 10552.37 | 10799.67 | 12011.40 | 12517.16 | 12045.60 | 12256.20 |
| | Imports | 1.000 m | 1340.42 | 1109.00 | 901.00 | 468.00 | 364.00 | 362.00 | 335.00 | 746.00 | 521.37 | 472.82 | 855.32 | 1716.72 | 1643.96 | 2319.65 | 2599.75 | 2013.56 | 2130.54 | 2042.47 | 2010.07 | 2051.16 |
| | Exports | 1.000 m | 556.92 | 809.00 | 820.00 | 1018.00 | 1009.00 | 1274.00 | 1422.00 | 1526.00 | 1344.71 | 602.37 | 1000.86 | 1125.22 | 1000.30 | 1256.77 | 1036.78 | 318.34 | 298.40 | 510.50 | 500.21 | 429.38 |
| | wood from domestic productio | % | 88% | 87% | 89% | 95% | 96% | 96% | 96% | 92% | 94% | 95% | 90% | 84% | 85% | 79% | 79% | 84% | 85% | 85% | 85% | 85% |
| Wood Pulp | Production | 1.000 t | 1774.00 | 1806.00 | 1929.00 | 1935.00 | 1949.00 | 1990.00 | 2065.00 | 2092.17 | 2021.75 | 2066.63 | 1837.51 | 2265.10 | 2452.03 | 2536.67 | 2625.89 | 2660.90 | 2729.10 | 2752.90 | 2772.90 | 2744.90 |
| | Imports | 1.000 t | 94.23 | 163.00 | 144.50 | 133.00 | 112.00 | 75.98 | 68.00 | 82.43 | 84.71 | 92.31 | 34.78 | 94.49 | 94.74 | 122.16 | 122.87 | 124.95 | 152.30 | 171.75 | 176.39 | 162.08 |
| | Exports | 1.000 t | 969.09 | 980.00 | 962.00 | 961.00 | 933.00 | 762.00 | 1038.04 | 1040.00 | 945.25 | 1149.27 | 830.92 | 1013.36 | 1080.69 | 1165.93 | 1144.19 | 1189.83 | 1238.61 | 1179.16 | 1169.79 | 1255.25 |
| | pulp from domestic production | % | 90% | 84% | 87% | 88% | 90% | 94% | 94% | 93% | 93% | 91% | 97% | 93% | 94% | 92% | 92% | 92% | 91% | 90% | 90% | 90% |
| Sawnwood | Production | 1.000 m | 1427.00 | 1492.00 | 1298.00 | 1383.00 | 1060.00 | 1010.00 | 1010.00 | 1010.81 | 1009.78 | 1093.07 | 1044.85 | 1044.42 | 941.55 | 854.02 | 1034.80 | 1134.25 | 1085.15 | 979.15 | 1135.90 | 1033.93 |
| | Imports | 1.000 m | 297.22 | 252.00 | 262.00 | 263.00 | 280.00 | 333.00 | 258.00 | 302.00 | 202.76 | 129.18 | 208.38 | 154.34 | 146.64 | 126.12 | 145.75 | 167.00 | 185.81 | 171.19 | 225.08 | 229.16 |
| | Exports | 1.000 m | 283.37 | 281.00 | 286.00 | 298.00 | 319.00 | 375.00 | 462.00 | 635.00 | 293.72 | 234.88 | 296.14 | 443.54 | 340.15 | 615.51 | 394.97 | 352.45 | 308.61 | 382.26 | 382.58 | 363.99 |
| Wood panels | Production | 1.000 m | 1293.00 | 1243.00 | 1250.00 | 1215.00 | 1323.00 | 1306.00 | 1306.00 | 1337.08 | 1352.43 | 1385.17 | 1363.46 | 1380.02 | 1474.63 | 1169.15 | 1307.91 | 1312.10 | 1184.32 | 1109.77 | 1153.68 | 1280.45 |
| | Imports | 1.000 m | 246.02 | 264.00 | 268.00 | 231.00 | 242.00 | 301.00 | 381.00 | 620.00 | 597.44 | 517.36 | 416.31 | 480.40 | 478.96 | 595.53 | 517.91 | 514.95 | 636.31 | 897.23 | 1016.68 | 999.71 |
| | Exports | 1.000 m | 747.50 | 652.00 | 715.00 | 796.00 | 963.00 | 914.00 | 943.00 | 776.00 | 984.44 | 674.93 | 509.77 | 721.87 | 859.19 | 896.68 | 1017.44 | 934.61 | 848.96 | 861.75 | 816.24 | 1021.65 |
| Paper and paperboa | Production | 1.000 t | 1290.00 | 1419.00 | 1537.00 | 1530.00 | 1664.00 | 1570.00 | 1644.00 | 1643.76 | 1661.61 | 1633.80 | 1456.47 | 2180.10 | 2120.12 | 2129.03 | 2187.00 | 2220.19 | 2097.40 | 2095.19 | 2060.10 | 2024.50 |
| | Imports | 1.000 t | 643.56 | 642.00 | 668.00 | 696.00 | 783.00 | 757.00 | 736.00 | 836.00 | 777.81 | 804.11 | 802.20 | 820.68 | 765.26 | 788.22 | 788.45 | 894.19 | 848.42 | 877.23 | 890.19 | 886.59 |
| | Exports | 1.000 t | 744.41 | 792.13 | 980.51 | 1172.28 | 1045.16 | 1227.54 | 1079.33 | 1325.32 | 1284.01 | 1360.24 | 962.39 | 1773.60 | 1791.74 | 1843.27 | 1883.94 | 1882.07 | 1916.76 | 1889.33 | 1891.56 | 1892.03 |

| | | | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|
| Industrial Roundwood | Production | 1.000 m | 11031.91 | 12201.41 | 12235.47 | 11221.00 | 11789.20 |
| | Imports | 1.000 m | 2538.25 | 2616.76 | 3130.93 | 3422.38 | 2751.90 |
| | Exports | 1.000 m | 428.29 | 482.93 | 471.31 | 253.49 | 413.08 |
| | wood from domestic productio | % | 81% | 82% | 79% | 76% | 81% |
| Wood Pulp | Production | 1.000 t | 2683.00 | 2809.00 | 2869.00 | 2714.00 | 2763.98 |
| | Imports | 1.000 t | 148.39 | 150.93 | 140.05 | 142.96 | 148.88 |
| | Exports | 1.000 t | 1318.25 | 1293.62 | 1251.57 | 1400.73 | 1303.88 |
| | pulp from domestic production | % | 90% | 91% | 92% | 90% | 91% |
| Sawnwood | Production | 1.000 m | 992.14 | 1005.65 | 988.61 | 945.00 | 993.07 |
| | Imports | 1.000 m | 224.32 | 235.97 | 250.68 | 388.77 | 265.78 |
| | Exports | 1.000 m | 256.64 | 331.27 | 275.99 | 463.04 | 338.19 |
| Wood panels | Production | 1.000 m | 1266.81 | 1457.81 | 1414.61 | 1272.00 | 1338.34 |
| | Imports | 1.000 m | 799.86 | 825.33 | 801.95 | 976.13 | 880.60 |
| | Exports | 1.000 m | 897.90 | 1071.79 | 929.81 | 971.77 | 978.58 |
| Paper and paperboa | Production | 1.000 t | 2115.00 | 2169.00 | 2243.00 | 1830.00 | 2076.30 |
| | Imports | 1.000 t | 821.34 | 929.67 | 948.22 | 813.44 | 879.85 |
| | Exports | 1.000 t | 1744.92 | 1930.21 | 1981.44 | 1594.52 | 1828.62 |

# Annex I: WG1-indirect emissions

Version 19.1.2016

## Guidance related to the reporting of indirect emissions

The initial checks of the 2015 inventories have discovered differences in the ways indirect emissions are reported in GHG inventories across the EU in the new CRT reporter software and revised CRT tables and IPCC Guidance. In addition MS approached WG1 with questions regarding the reporting of indirect emissions. This paper intends to offer some additional guidance related to the reporting of indirect emissions. It provides details on how countries reported information on indirect gases in the 2015 inventories, at the gas level (CO2, N2O) and provides recommendations for submission of the information in 2016. This guidance is also related to the treatment of indirect emissions in the calculation of the assigned amount for the second commitment period under the Kyoto Protocol.

### 1. Indirect CO2 emissions

#### 1.1 Background

The $CO_2$ resulting from the atmospheric oxidation of $CH_4$, CO and NMVOC is referred to as indirect $CO_2$. Indirect CO2 resulting from the oxidation of $CH_4$, CO and NMVOCs produced by fossil fuel combustion are included in the general methodological approach which assumes that all the carbon in the fuel (minus the portion that remains as soot or ash) is oxidized to $CO_2$ whereas actually a fraction of this carbon is initially emitted as CH4, CO or NMVOC.

Other sources of indirect $CO_2$ emissions are not yet captured by the general inventory methodologies. Sources mentioned in the 2006 IPCC Guidelines are:

- Fugitive emissions from energy use, e.g. NMVOC emissions from oil refineries, storage of chemicals at refineries, road traffic evaporative emissions from cars, emissions from gasoline distribution network and refueling of cars, ships and aircrafts, $CH_4$ emissions from natural gas transmission and distribution or coke production.
- Carbon from Non-energy products from fuels and solvent use in IPPU: The production and use of asphalt for road paving and roofing and the use of solvents derived from petroleum and coal are sometimes substantial sources of NMVOC and CO emissions which oxidise to CO2 in the atmosphere. The resulting CO2 input can be estimated from the emissions of these non-CO2 gases.
- AFOLU emissions where non-$CO_2$ gases have been explicitly deducted (Such NMVOC emissions are considered as biogenic in MS reporting and resulting indirect CO2 emissions are not included in MS GHG inventories).

2006 IPCC Guidelines provide a method how the CO2 inputs from the atmospheric oxidation of CH4, CO or NMVOC can be calculated. The basic calculation principles are (2006 IPCC Guidelines, Volume 1, Chapter 7, p. 7.6):

| | | | |
|---|---|---|---|
| From $CH_4$: | $Inputs_{CO2}$ | = | $Emissions_{CH4} \bullet 44/16$ |
| From CO: | $Inputs_{CO2}$ | = | $Emissions_{CO} \bullet 44/28$ |
| From NMVOC: | $Inputs_{CO2}$ | = | $Emissions_{NMVOC} \bullet C \bullet 44/12$ |
| Where C is the fraction carbon in NMVOC by mass (default = 0.6) | | | |

The default fossil carbon content fraction of NMVOC is **60 percent by mass**, based on limited published national analyses of the speciation profile (U.S. EPA, 2002; Austria, 2004; Hungary, 2004; Klein Goldewijk et al., 2005). It may vary between 50 and 70 percent carbon by mass, so having an uncertainty of about ±10 percent (2006 IPCC Guidelines, Volume 3, p. 5.17).

The default fossil C content fraction of NMVOCs **from asphalt production and road paving** is provided with **80%** calculates based on the NMVOC specification provided in the EMEP/CORINAIR Emission Inventory Guidebook (2006 IPCC Guidelines, Volume 3, p. 5.16).

The carbon content in NMVOCs varies as this group includes a large variety of chemically different compounds. 2006 IPCC Guidelines provide for the first time a default factor for the fraction of Carbon in NMVOC (0.6). However, an inventory based on the speciation of the NMVOC compounds and their C content provides more accurate results. Some countries justified the non-estimation of indirect CO2 emissions from NMVOCs in the past with the lack of such default C fraction.

In the calculation of indirect CO2, only fossil carbon should be considered, indirect CO2 should not be calculated for precursors originating from biomass combustion in line with IPCC guidance, nor from other biogenic sources, e.g. agriculture, pulp and paper, food and drink production, wood industry.

### 1.2 UNFCCC legal provisions and IPCC guidance

According to paragraph 29 of the UNFCCC reporting guidelines for GHG inventories (Annex I to decision 24/CP.19) *"Annex I Parties may report indirect $CO_2$ from the atmospheric oxidation of $CH_4$, CO and NMVOCs. For Parties that decide to report indirect $CO_2$ the national totals shall be presented with and without indirect $CO_2$"*.

Para 37(b) the UNFCCC reporting guidelines states: *"Once emissions from a specific category have been reported in a previous submission, emissions from this specific category shall be reported in subsequent GHG inventory submissions."*

Reporting of indirect $CO_2$ emissions is not mandatory ("may" in paragraph 29), however in combination with paragraph 37(b) those countries that included indirect $CO_2$ emissions in the past in their GHG inventories, shall continue to report indirect $CO_2$ emissions in their inventory.

An assessment of the 2015 inventory submissions indicates that 5 MS do not report any indirect $CO_2$ emissions while 23 MS report indirect $CO_2$ emissions. This is not completely clear from the NIRs and the CRT tables because indirect $CO_2$ emissions can be reported combined with direct $CO_2$ emissions. Some MS state in chapter 9 of the NIR that their inventory does not include indirect CO2 emissions, but nevertheless in the IPPU chapter it is explained how indirect CO2 emissions from solvent use were estimated.

The CRT summary table 2 produces two national totals without LULUCF: (1)'Total $CO_2$ equivalent emissions without land use, land-use change and forestry' (2) 'Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry'. In addition summary table 2 includes a separate row for indirect $CO_2$ emissions. Only those indirect $CO_2$ emissions reported in table 6 are part of

the row for indirect $CO_2$ and are deducted from national totals in the row that excludes indirect $CO_2$ emissions.

### 1.3 Where should indirect CO2 emissions be reported in CRT tables?

There are several options where indirect CO2 emissions can be reported in the CRT tables:

1. In the sectoral categories where NMVOC emissions or $CH_4$ emissions occur that lead to indirect $CO_2$ emissions. These are in particular the **source category 2.D.3 Other in IPPU Table 2(I)s2 and 2(I).A-Hs2** where the CRT reporter software contains pre-defined subcategories for solvent use, road paving with asphalt and asphalt roofing. Indirect CO2 emissions could also be included in other source categories and tables, e.g. in table 1.B.2 Oil, natural gas and other emissions from energy production.
2. The new **CRT table 6** cross sectoral report: Indirect emissions of $N_2O$ and $CO_2$. This table only allows reporting at sectoral level (energy, IPPU, agriculture, LULUCF, waste, other) and no distinction of any source categories and the reporting in this table is therefore not very transparent as it only provides information that indirect CO2 emissions have been estimated in some sectors.

2006 IPCC Guidelines recommend the reporting of indirect emissions from solvent use and production and use of asphalt in the IPPU sector under the categories 2.D. Other:

- Volume 3, p. 5.16: The relatively small emissions from production and use of asphalt, including asphalt blowing, should be reported under the subcategory 2D4 'Other' of this source category 2D 'Non-Energy Products from Fuels and Solvent Use'. Emissions from any other non-energy product of fossil fuels not described here should be reported under the subcategory 2D4 'Other' (Volume 3, chapter 5, p. 5.5)

2006 IPCC Guidelines also stress the relationship between the 2.D. categories and the consistency and completeness of emissions from non-energy and feedstock use of fuels:

Non energy product use of fuels and other chemical products resulting in NMVOC and CO emissions (based on table 5.1 of Volume 3, chapter 5, p. 5.6):

| Types of fuels used | Examples of non-energy use |
|---|---|
| Bitumen; road oil and other petroleum diluents | Used in asphalt production for road paving and e.g., in roofing; 2006 IPCC GL, Vol. 3, Ch.5, Section 5.4 |
| White spirit, kerosene, some aromatics | As solvent e.g. for surface coating (paint), dry cleaning; 2006 IPCC GL, Vol. 3, Ch.5, Section 5.5 |

With regard to the verification of completeness of fossil $CO_2$ from non-energy sources 2006 IPCC Guidelines recommend:

- checking that total reported bottom-up calculated $CO_2$ emissions from non-energy use/feedstock sources at different subcategory levels are complete and consistent,

- documenting and reporting how these emissions are allocated in the inventory.

When indirect $CO_2$ emissions are reported in CRT table 6, they appear in a separate line in summary table 2 and the total emissions can be separated in a total with and a total without indirect CO2 emissions.

When indirect $CO_2$ emissions are reported in **IPPU background tables Table 2(I)s2 and 2(I).A-Hs2** or other sectoral tables these emissions are aggregated with other $CO_2$ emissions and are not separated in the national total. This reporting therefore contradicts the requirement that Parties that decide to report indirect $CO_2$ the national totals shall be presented with and without indirect $CO_2$.

However, when indirect $CO_2$ emissions from 2.D.3 Other are reported in CRT table 6, Parties do not follow the reporting guidance provided in 2006 IPCC Guidelines and UNFCCC guidance (paragraph 35 of Annex I to decision 24/CP.19) related to the tracking of the non-energy use: "*Annex I Parties should clearly indicate how feedstocks and non-energy use of fuels have been accounted for in the inventory, under the energy or industrial processes sector, in accordance with the 2006 IPCC Guidelines*."

Thus, thus both options have limitations and there doesn't seem to be a clear solution.

### 1.4 MS reporting in 2015 submission

Table 2 presents an overview of the reporting of MS of indirect CO2 emissions. 7 Member States (BE; CY, GB, GR, MT, HU, SI) did not report indirect CO2 emissions in the 2015 submission.[5] Cyprus, Greece and Hungary had reported indirect CO2 emissions from solvents in previous inventories (e.g. 2014 submission) in Table 3.A-D.

***Table 2 MS reporting of indirect CO2 emissions in 2015 GHG inventories***

| | **2015 submission (for year 2012)** | | | | **2014 submission for year 2012** | |
|---|---|---|---|---|---|---|
| | **Table 2(I)s2 and 2(I).A-Hs2** | | **Table 6** | **Other tables/ categories** | **Table 3 3.A-3.D** | **Table 2(I).A-G (2.A.5 Asphalt Roofing, 2.A.g Road paving with asphalt)** |
| | **2.D.3 Solvent use** | **2.D.3 Road paving with asphalt, asphalt roofing** | | | | |
| AT | 189 kt | IE | NA | | 189 kt | IE |
| BG | 8 kt | IE | NO | | 22 kt | NO |
| CY | NE | NE | Blank cells | | 10 kt | NE |
| CZ | CO2 reported as | NE | indirect CO2 reported for | | 223 kt | NE |

[5] This is not always completely clear, e.g. the Belgian NIR states that no estimation of indirect CO2 from NMVOC from solvents has been carried out, but also states that category 1.A.1c includes indirect CO2 emissions from coke ovens.

| | 2015 submission (for year 2012) | | | | 2014 submission for year 2012 | |
|---|---|---|---|---|---|---|
| | Table 2(I)s2 and 2(I).A-Hs2 | | Table 6 | Other tables/ categories | Table 3 3.A-3.D | Table 2(I).A-G (2.A.5 Asphalt Roofing, 2.A.g Road paving with asphalt) |
| | 2.D.3 Solvent use | 2.D.3 Road paving with asphalt, asphalt roofing | | | | |
| | NO, NMVOC reported | | energy, IPPU and waste<br>2071 kt | | | |
| DE | 1402 kt | NE | NE | | 1436 kt | NA |
| DK | 68 kt | 0.16 kt | indirect CO2 reported for energy, IPPU and waste (sources not included in 2.D.3)<br>465.1 kt | | 63 kt | 1.78 |
| ES | 766 kt | NA | NE | | 771 kt | NA |
| EE | CO2 reported as NO, NMVOC reported | CO2 reported as NO, NMVOC reported | indirect CO2 reported from IPPU<br>14 kt | | 14 kt | NO |
| FI | CO2 reported as NO, NMVOC reported | NO | indirect CO2 reported from energy and IPPU<br>48 kt | 2.B.10 Chemical industry and storage of chemicals, 2.C.7 Iron and steel production, non-ferrous metal production<br>32 kt | 40 kt | 3 kt |

| | 2015 submission (for year 2012) | | | | 2014 submission for year 2012 | |
|---|---|---|---|---|---|---|
| | Table 2(I)s2 and 2(I).A-Hs2 | | Table 6 | Other tables/ categories | Table 3 3.A-3.D | Table 2(I).A-G (2.A.5 Asphalt Roofing, 2.A.g Road paving with asphalt) |
| | 2.D.3 Solvent use | 2.D.3 Road paving with asphalt, asphalt roofing | | | | |
| FR | 622 kt | Not specified in CRT | NMVOC reported, indirect CO2 reported from IPPU 1024 kt | | 1001 kt | NA |
| GR | NE | NO | NE | | 163 kt | NE |
| HR | 41 kt | NA | NA | | 104 kt | NE |
| HU | NE | NE | NE | | 74 kt | NA |
| IE | CO2 reported as NO, NMVOC reported | Not mentioned | indirect CO2 reported from IPPU 64 kt | | 73 kt | NE |
| IT | 1165 kt | NO | NO | | 1001 kt | NE |
| LT | 58 kt | 0.01 kt | NO | 1B2aiv Fugitive emissions oil: refining storage estimated, gasoline evaporation in 1A3bv 0.03 kt | 81 kt | 0.02 kt |
| LU | 14 kt | Not mentioned | NO | | 9 kt | NO |

| | 2015 submission (for year 2012) | | | | 2014 submission for year 2012 | |
|---|---|---|---|---|---|---|
| | Table 2(I)s2 and 2(I).A-Hs2 | | Table 6 | Other tables/ categories | Table 3 3.A-3.D | Table 2(I).A-G (2.A.5 Asphalt Roofing, 2.A.g Road paving with asphalt) |
| | 2.D.3 Solvent use | 2.D.3 Road paving with asphalt, asphalt roofing | | | | |
| LV | CO2 reported as NA, NMVOC reported | 0.13 kt | indirect $CO_2$ reported from IPPU 112 kt | Indirect $CO_2$ from glass fibre production | 49 kt | 0.13 kt |
| NL | CO2 reported as IE, NMVOC reported | Not mentioned | indirect CO2 reported from IPPU 329 kt | | 120 kt | NE |
| PL | 636 kt | Not mentioned | NA | | 636 kt | NA, NO |
| PT | 145 kt | 2 kt | indirect $CO_2$ reported from IPPU 184 kt | indirect $CO_2$ emissions from fires: Indirect emissions are defined as those that not released during the forest fire but are attributed to fires, following tree mortality | 190 kt | 2.8 kt |
| RO | 122 kt | NE | NO | | 128 kt | NE |
| SK | 63 kt | NMVOC reported, but | NO/NE | | 82 kt | NA |

| | 2015 submission (for year 2012) | | | | 2014 submission for year 2012 | |
|---|---|---|---|---|---|---|
| | Table 2(I)s2 and 2(I).A-Hs2 | | Table 6 | Other tables/ categories | Table 3 3.A-3.D | Table 2(I).A-G (2.A.5 Asphalt Roofing, 2.A.g Road paving with asphalt) |
| | 2.D.3 Solvent use | 2.D.3 Road paving with asphalt, asphalt roofing | | | | |
| | | indirect CO2 NE | | | | |
| SE | 184 kt | NMVOC reported, but indirect CO2 reported as NA | Empty cells | | 204 kt | NA |

Source: 2015 GHG inventory submissions to the UNFCCC (CRT and NIR)

Table 2 provides an overview in which tables MS reported indirect CO2 emissions, which notation keys were used and present the quantities reported for the reporting year 2012. The year 2012 was used in order to compare also with the 2014 submission whether the quantities reported changed or remained at similar level.

Table 2 shows that Member States chose the following approaches in the reporting of indirect $CO_2$ emissions:

- 9 Member States reported indirect $CO_2$ emissions in the new CRT table 6:
  - 4 Member States reported indirect $CO_2$ emissions in CRT table 6, but also indirect $CO_2$ emissions in table 2(i)s2 under 2.D.3 Solvent use or asphalt production and use (Denmark, France, Latvia, Portugal). Of these countries, Denmark reported indirect $CO_2$ emissions from solvent use and asphalt production and use which were also reported in previous years in table 2(i)s2 under 2.D.3, whereas additional indirect $CO_2$ emissions that were reported in the 2015 submission for the first time, were reported in table 6. For the other Member States that used both options, it is less clear which emissions were reported in table 6.
  - 5 Member States only used table 6 for the reporting of indirect $CO_2$ emissions (CZ, EE; FI IE, NL). Of these Member States, EE, IE and NL only reported indirect CO2 emissions from IPPU, whereas CZ reported indirect $CO_2$ emissions from energy, IPPU and waste and FI reported indirect CO2 from energy and IPPU sectors. For EE the quantities reported in table 6 are similar to the quantities reported in the 2014 submission in table 3 under solvents use.
- 12 MS (AT, BE, DE, ES, FR, HR, IT, LU, PL, RO, SK, SE) reported indirect $CO_2$ emissions only in table 2(I)s2 under 2.D. Solvent Use, road paving with Asphalt and asphalt roofing. All of these MS

reported indirect $CO_2$ emissions in the 2014 submission in table 3. For two MS (AT and PL), the reported quantities for the year 2012 are identical in the two submissions, for 6 MS, the reported quantities are similar (DE, ES, LU, RO, SK, SE).

- 1 MS reported indirect $CO_2$ emissions in table 2(I)s2 under 2.D. Solvent Use, road paving with Asphalt and asphalt roofing and in table 1.B.2 fugitive emissions from oil under oil refining and gasoline evaporation.
- Only three MS (CZ, FI, LT) reported indirect emissions from the energy sector (fugitive emissions of NMVOC). Reported indirect emissions in the IPPU sector are mostly emissions from solvent use.
- In table 6 all available notation keys and empty cells occur. The reporting of notation keys should be clarified and harmonized.

### 1.5 Recommendations

- Member States which were reporting indirect $CO_2$ emissions in inventory submissions before 2015 in previous CRT table 3 (Sectoral report for solvents and other products use) should continue reporting these emissions. It is recommended to report these indirect $CO_2$ emissions now in CRT table 2(I) under "2D Non-energy products from fuels and solvent use" which includes a predefined drop down lists in the CRT reporter under 2D3 Other for "solvent use".
- Member States which were reporting indirect $CO_2$ emissions in CRT category 2A5 asphalt roofing and 2A6 Road paving with asphalt should continue reporting these emissions. It is recommended to report these indirect $CO_2$ emissions in CRT table 2(I) under "2D Non-energy products from fuels and solvent use" under 2D3 Other which includes a predefined drop down lists in the CRT reporter under 2D3 which includes predefined categories for "asphalt roofing" and "road paving with asphalt".

This approach also ensures the highest possible consistency with the guidance provided in the IPCC 2006 Guidelines related to the reporting of "Non-energy products from fuels and solvent use" and the description of reporting categories under 2D in Volume 1, chapter 8, table 8.2 of the 2006 IPCC Guidelines. This approach is also more transparent than the reporting in table 6 where indirect $CO_2$ emissions are aggregated at sectoral level.

- It is recommended that other indirect $CO_2$ emissions estimated in the energy sector, in the IPPU sector (apart from the categories described above) or in the waste sector, should be reported in table 6. The NIR should describe in more detail the specific sources and methodologies used for the emissions reported in table 6.
- If only indirect $CO_2$ emissions from solvents, or asphalt roofing/ road paving with asphalt are included in the inventory and no other indirect $CO_2$ emissions from the IPPU sector, Table 6 should be filled with the notation key 'IE' in the row for IPPU as some indirect $CO_2$ emissions are included in the IPPU tables.
- If no indirect $CO_2$ emissions are estimated in the energy and waste sectors, the notation key 'NE' seems to be appropriate for Table 6 in the rows for energy and waste because NMVOC inventories, 2006 IPCC Guidelines and the reporting of some MS show that indirect $CO_2$ emissions can occur in these sectors. Therefore NO or NA may not be the appropriate notation keys.
- The information provided in chapter 9 'indirect $CO_2$ and $N_2O$ emission' in the NIR could be improved for some MS, in particular those that report emissions in CRT table 6 should provide information which sources have been estimated.

**Linkages to KP reporting**

- It is recommended to use the row "Total CO2 equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry" in summary table 2 for the calculation of base year emissions and the assigned amount calculation in the initial report to facilitate the calculation of the assigned amount for the 2nd commitment period under the Kyoto Protocol. The reporting guidelines under the Kyoto Protocol do not clearly mention indirect $CO_2$ emissions. However, many countries included indirect $CO_2$ emissions in their KP reporting in the first commitment period which was never raised as a problem and Parties were even encouraged to report indirect $CO_2$ emissions by ERTs. Thus, from the 1st commitment period it can be assumed that indirect $CO_2$ emissions are part of the coverage of emissions under the KP. As this scope has not been changed, it is consistent with the reporting in CP1 to include indirect $CO_2$ emissions in the national total for the purposes of the Kyoto Protocol accounting.

## 2. Indirect N2O emissions

### 2.1 Background

- Indirect $N_2O$ emissions in the agriculture sector address nitrous oxide ($N_2O$) emissions that result from the deposition of the nitrogen emitted as NOx and $NH_3$. $N_2O$ is produced in soils through the biological processes of nitrification and denitrification. One of the main controlling factors in this reaction is the availability of inorganic nitrogen in the soil and therefore deposition of nitrogen resulting from $NO_x$ and ammonia ($NH_3$) will enhance emissions.
- Revised 1996 IPCC Guidelines only estimated indirect $N_2O$ emissions from agricultural sources of nitrogen. The 2006 Guidelines include guidance for estimating $N_2O$ emissions resulting from nitrogen deposition of all anthropogenic sources of $NO_x$ and $NH_3$ (in particular from sources in the energy and IPPU sectors).
- The 2006 IPCC Guidelines, Volume 5, also address indirect $N_2O$ emissions which occur from the release of wastewater effluents into waterways, lakes or the sea.

### 2.2 NFCCC legal provisions and IPCC guidance

**UNFCCC guidelines:**

- Related to indirect $N_2O$ emissions, paragraph 29 of the UNFCCC reporting guidelines for GHG inventories states that the estimates of indirect $N_2O$ from sources other than agriculture and LULUCF should not be included in national totals and "Annex I Parties may report as a memo item indirect $N_2O$ emissions from other than the agriculture and LULUCF sources." Thus, N deposition of $NO_x$ and $NH_3$ from sources in the energy or IPPU sector should be excluded from national totals and included under the memo items in summary table 2. This is technically implemented in the CRT reporter if indirect $N_2O$ emissions are reported in table 6. The indirect emissions reported in this table are those that appear under the memo items in the summary 2 table.
- Indirect $N_2O$ emissions from agriculture and LULUCF sources have been included in the inventory in the past and countries should continue to report these emissions in the agriculture and/ or LULUCF sector. This refers to the following emission sources in the CRT tables and the 2006 IPCC Guidelines:
    - **Indirect $N_2O$ emissions from managed soils in CRT table 3.D.**

- (1) the volatilization of N (as NH3 and NOx) following the application of synthetic and organic N fertilizers and /or urine and dung deposition from grazing animals, and the subsequent deposition of the N as ammonium (NH4+) and oxides of N (NOx) on soils and waters, and
- (2) the leaching and runoff of N from synthetic and organic N fertilizer additions, crop residues, mineralization /immobilization of N associated with loss/gain of soil C in mineral soils through land use change or management practices, and urine and dung deposition from grazing animals, into groundwater, riparian areas and wetlands, rivers and eventually the coastal ocean (2006 IPCC Guidelines, Vol. 1, Chapter 8, p. 8.32).
- These indirect $N_2O$ emissions have already been reported in inventories prior to 2015 (however the categories of N inputs to soils slightly changed with the 2006 IPCC Guidelines).

- **Indirect $N_2O$ Emissions from Manure Management in CRT table 3.B.b**
  - These indirect emissions result from volatile nitrogen losses that occur during manure collection and storage and which are diffused into the surrounding air. Nitrogen losses begin at the point of excretion in houses and other animal production areas and continue through on-site management in storage and treatment systems. Nitrogen is also lost through runoff and leaching into soils from the solid storage of manure at outdoor areas, in feedlots. This reporting category has not been estimated and reported separately in the CRT tables prior to 2015 and the method is new.
- **Indirect $N_2O$ emissions from managed soils in CRT table 4(IV)**
  - Table 3.D.(b) covers indirect $N_2O$ emissions from atmospheric deposition and leaching and run-off from agricultural land areas which includes cropland and grassland areas. Table 4(IV) covers atmospheric deposition and leaching and runoff of N from those land use categories that are not part of agriculture (forest lands, wetlands, settlements, other). This table also covers N mineralization associated with loss of soil organic matter resulting from change of land use or management on mineral soils in all land use categories except for cropland remaining cropland. Footnote 1 of table 4(IV) explains that if the sources of nitrogen (N) cannot be separated between cropland and grasslands and other land use categories, all indirect $N_2O$ emissions should be included in the agriculture sector and reported in table 3.D.(b). This reporting table was not included in the CRT prior to 2015.

**IPCC 2006 Guidelines**

- **Indirect $N_2O$ emissions from sources other than agriculture and LULUCF**
  - Guidance is provided in Volume 1 of 2006 IPCC Guidelines, chapter 7, section 7.3 on estimating $N_2O$ emissions from atmospheric deposition resulting from all categories except agricultural soil management and manure management. Section 7.3 provides information on NOx emissions. Countries may use national methodologies to estimate emissions of $NH_3$ not originating from agriculture. $NH_3$ emissions are also covered in the EMEP/CORINAIR Emission Inventory Guidebook.

- **Indirect $N_2O$ emissions from managed soils**
  - IPCC Guidance is provided in Volume 4 of 2006 IPCC Guidelines, Chapter 11, section 11.2.2 indirect $N_2O$ emissions. The methodology addresses indirect $N_2O$ emissions from managed soils arising from agricultural inputs of N from the following sources:
    - synthetic N fertilisers;
    - organic N applied as fertiliser (e.g., applied animal manure, compost, sewage sludge, rendering waste and other organic amendments);
    - urine and dung N deposited on pasture, range and paddock by grazing animals;
    - N in crop residues (above- and below-ground), including N-fixing crops and forage/pasture renewal returned to soils (FCR); and
    - N mineralisation associated with loss of soil organic matter resulting from change of land use or
    - management on mineral soils.
- **Indirect $N_2O$ emissions from manure management:**
  - IPCC Guidance for volatilization is provided in Volume 4 of 2006 IPCC Guidelines, chapter 10, section 10.5.1 in equations 10.26 and 10.27. The Tier 1 calculation of N volatilisation in forms of $NH_3$ and $NO_x$ from manure management systems is based on multiplication of the amount of nitrogen excreted (from all livestock categories) and managed in each manure management system by a fraction of volatilised nitrogen (see Equation 10.26).
  - IPCC Guidance for leaching is provided in Volume 4 of 2006 IPCC Guidelines, chapter 10, section 10.5.1 in equations 10.28 and 10.29. For the percent of managed manure nitrogen loss due to runoff and leaching during solid and liquid storage of manure ($Frac_{leachMS}$) which is a key parameter for the indirect $N_2O$ emissions from leaching from manure management systems no clear value is provided in the 2006 IPCC Guidelines, but only a range from 1-20%. Thus, when countries do not have a country-specific value for this parameter, it may be difficult to calculate the indirect $N_2O$ emissions from leaching from manure management. However, 11 MS have nevertheless provided estimates for indirect emissions from leaching from manure management, but other MS have not estimated emissions from leaching due to the lack of this default parameter (see Table 3).
  - Pasture losses are considered separately in Chapter 11, Section 11.2, $N_2O$ Emissions from Managed Soils, as are emissions of nitrogen compounds from grazing livestock and are not part of the emissions in this source category.
- **Indirect $N_2O$ emissions from wastewater**
  - The 2006 IPCC Guidelines, Volume 5, also address indirect $N_2O$ emissions which occur from wastewater treatment effluent after this effluent is discharged into waterways, lakes or the sea.
  - The nitrogen in the effluent discharged to aquatic environments is calculated according to the methodology in the 2006 IPCC Guidelines as provided in equation 6.7 of Volume 5, chapter 6 and equation 6.8 where the nitrogen in the effluent is calculated based on the annual per capita protein consumption and multiplied with an EF. This calculation is basically the same as in 1996 IPCC Guidelines for $N_2O$ emissions from human sewage, but with some refinements in the calculation with regard to the addition of non-consumed protein added to the wastewater as well as the addition of industrial and commercial co-discharged protein and the subtraction of N removed with sludge.

- The use of 'indirect' $N_2O$ emissions for these wastewater emissions has not been considered when paragraph 29 of the UNFCCC reporting guidelines was drafted that refers to' indirect $N_2O$ emissions from other than the agriculture and LULUCF sources'. When this para was drafted, experts had in mind the IPCC guidance provided in Volume 1 of the 2006 IPCC Guidelines, chapter 7.3 on atmospheric deposition of nitrogen compounds from NOx and NH3 emissions such as fuel combustion, industrial processes. It was not the intention to exclude $N_2O$ emissions from domestic wastewater that have been estimated in the past inventories before 2015 as well (without using the term 'indirect' for these $N_2O$ emissions). The CRT reporting tables for wastewater also don't make a distinction for direct and indirect emissions and it is recommended to report $N_2O$ emissions from human sewage as before 2015 in CRT table 5.D.

### 2.3 MS reporting in the 2015 submission

Table 3 provides an overview of the reporting of indirect $N_2O$ emissions by Member States.

***Table 3. MS reporting of indirect N2O emissions in 2015 GHG inventories***

| | **Indirect $N_2O$ emissions in table 3.B.(b) Manure management** | | **Indirect $N_2O$ emissions in table 3.D agricultural soils** | | **Indirect $N_2O$ emissions in table 4(IV) managed soils and N mineralization from land use changes** | | **Table 6 indirect $N_2O$ emissions** |
|---|---|---|---|---|---|---|---|
| | Atmos. deposition | N leaching and run-off | Atmos. deposition | N leaching and run-off | Atmos. deposition | N leaching and run-off | |
| **AT** | 0.37 | NO | 0.47 | 0.55 | NO | NO | NA |
| **BE** | 0.61 | NO | 0.58 | 0.27 | IE | IE | NE |
| **BG** | 0.00 | NA | 0.67 | 1.50 | NO | NO | 2.173 (agriculture, other sectors NO,) |
| **CY** | 0.16 | Blank | 0.00 | 0.01 | blank | blank | blank cells |
| **CZ** | 0.83 | 0.50 | 0.92 | 1.47 | 0.02 | NO | 4.46 (energy, IPPU, agriculture, LULUCF, waste reported) |
| **DE** | 3.47 | NO | 5.66 | 10.37 | IE | 0.35 | NE, NO, NA |
| **DK** | 0.47 | 0.00 | 0.51 | 1.10 | IE, NO | IE, NO | 0.78 (energy, IPPU, waste) |

| | Indirect $N_2O$ emissions in table 3.B.(b) Manure management | | Indirect $N_2O$ emissions in table 3.D agricultural soils | | Indirect $N_2O$ emissions in table 4(IV) managed soils and N mineralization from land use changes | | Table 6 indirect $N_2O$ emissions |
|---|---|---|---|---|---|---|---|
| | Atmos. deposition | N leaching and run-off | Atmos. deposition | N leaching and run-off | Atmos. deposition | N leaching and run-off | |
| **ES** | NE[6] | NE | 3.01 | 18.16 | NO | NE | NE |
| **EE** | 0.10 | 0.00 | 0.12 | 0.24 | NE | NE | NO |
| **FI** | 0.30 | 0.01 | 0.15 | 1.13 | NO | 0.01 | 0.65 (energy) |
| **FR** | 4.31 | 0.98 | 6.49 | 10.83 | NO | NO | NO |
| **GB** | 2.37 | 0.03 | 4.56 | 9.15 | IE | IE | 5.80 (from energy, IPPU, waste) |
| **GR** | 0.47 | 0.09 | 1.13 | 1.78 | NO | NO | NE |
| **HR** | 0.31 | NA | 0.31 | 0.65 | IE | IE | NO, NA |
| **HU** | 0.49 | NO | 0.56 | NO | IE | IE | NE |
| **IE** | 0.75 | NE | 0.60 | 1.06 | IE | IE | NE, NO |
| **IT** | 2.86 | IE | 2.39 | 6.14 | NO | NE | 4.42 (energy, IPPU, LULUCF, waste) |
| **LT** | 0.28 | 0.0008 | 0.41 | 0.99 | IE | IE | NE, NO |
| **LU** | 0.06 | NO | 0.06 | 0.09 | NO | NO | NO |
| **LV** | 0.14 | 0.01 | 0.19 | 0.4 | IE | 0.01 | NO, IE |
| **MT** | 0.01 | NE | 0.0038 | 0.01 | IE | IE | NE |
| **NL** | NO | NO | 1.62 | 1.06 | IE | IE | NE, NO |
| **PL** | 2.93 | 0.57 | 2.67 | 5.97 | NO | NO | NA |

[6] Spain indicated that the estimation of these emissions is currently being assessed by the Inventory Team and planned to be implemented in future editions.

| | Indirect $N_2O$ emissions in table 3.B.(b) Manure management | | Indirect $N_2O$ emissions in table 3.D agricultural soils | | Indirect $N_2O$ emissions in table 4(IV) managed soils and N mineralization from land use changes | | Table 6 indirect $N_2O$ emissions |
|---|---|---|---|---|---|---|---|
| | Atmos. deposition | N leaching and run-off | Atmos. deposition | N leaching and run-off | Atmos. deposition | N leaching and run-off | |
| **PT** | 0.28 | 0.02 | 0.39 | 1.01 | IE | IE | NE |
| **RO** | 1.37 | NO | 1.15 | 2.17 | NO | NO | 4.84 (agriculture) |
| **SK** | IE | IE | 0.34 | 1.07 | IE | IE | NO, NE |
| **SI** | 0.09 | NO | 0.13 | 0.22 | NO | NO | NE |
| **SE** | IE | IE | 0.58 | 0.62 | NO | NO | 0.2 (LULUCF) |

- All MS report indirect $N_2O$ emissions from atmospheric deposition and N leaching and run-off in table 3.D for agricultural soils.
- 24 MS provide estimates for indirect $N_2O$ emissions from the atmospheric deposition from manure management, two MS report IE and one MS NO and one NE.
- 11 MS provide estimates for indirect $N_2O$ emissions from leaching and run-off from manure management (3 MS report IE). As explained above no clear default parameter is provided in 2006 IPCC guidelines for the fraction of managed manure nitrogen loss due to runoff and leaching during solid and liquid storage of manure, which explains the lower number of MS providing these emissions.
- Very few MS (only DE, FI, LV) report indirect $N_2O$ emissions in table 4(IV), no MS reports emissions from atmospheric deposition in this table.
- 8 MS report indirect $N_2O$ emissions in table 6.
- Table 6 includes a footnote (2) indicating that Parties may report indirect emissions of $N_2O$ from sources other than agriculture and LULUCF in this table because indirect emissions from these sources are included in agriculture and LULUCF. However, it is possible to report indirect $N_2O$ emissions in table 6 for the sectors agriculture and LULUCF and the corresponding cells are not shaded. 3 MS reported indirect emissions from agricultural sources in this table (BG, CZ and RO) and SE reported indirect $N_2O$ emissions from LULUCF. The NIRs of these countries do not provide clarity of what is included in table 6 as indirect emissions from agriculture or LULUCF. The 2006 IPCC Guidelines, chapter 7.3 mention that the new guidance on additional indirect $N_2O$ emissions includes atmospheric deposition of N compounds from NOx and $NH_3$ sources such as the burning of crop residues and agricultural wastes. This means that there are additional indirect $N_2O$ emissions from agriculture that are not part of the emissions estimated as part of managed soils or manure

management. It seems consistent with the approach in the 2006 IPCC Guidelines to exclude those indirect emissions from national totals and report them in table 6 and as memo item, even when the original N source is from agriculture. The distinction made in paragraph 29 of the UNFCCC reporting guidelines mainly had the intention to keep those indirect $N_2O$ emissions part of the national totals that have been included in the inventory since many years, but exclude the additional indirect $N_2O$ sources that have not been previously reported. From this logic, it makes sense to report indirect $N_2O$ emissions also from agricultural sources in table 6 when these sources are not covered by those emissions reported in table 3.D and 3.B.(b).

### 2.4 Recommendations

- For the agricultural sector, the guidance in the UNFCCC reporting guidelines for GHG inventories seems clear which states that Annex I Parties may report as a memo item only indirect $N_2O$ emissions from other than the agriculture and LULUCF sources. The indirect N2O emissions from agricultural sources should be included in **CRT tables 3.D. and 3.B.b**. in line with the methodologies explained above.
- Atmospheric deposition and leaching and runoff of N from those land use categories that are not part of agriculture (forest lands, wetlands, settlements, other) should be reported in **Table 4(IV)**.
- If agricultural sources cannot be separated from other land uses in **CRT table 4(IV)** all indirect emissions from managed soils should be reported in table 3.D.(b). If this applies it would be very useful when MS would indicate in the documentation box of table 3.D. that indirect emissions from agriculture and LULUCF sources are reported in this table.
- **Table 6** includes a footnote (2) indicating that Parties may report indirect emissions of $N_2O$ from sources other than agriculture and LULUCF in this table because indirect emissions from these sources are included in agriculture and LULUCF. However, it is possible to report indirect $N_2O$ emissions in table 6 for the sectors agriculture and LULUCF and the corresponding cells are not shaded. The indirect $N_2O$ emissions that are requested in specific tables in the agriculture and LULUCF tables should continue to be reported in the CRT tables 3.B(b), 3.D and 4(IV). Only additional indirect $N_2O$ emissions not covered by the methodologies for these categories should be reported in table 6-. MS should clearly explain which sources are covered in this table in chapter 9 'indirect $CO_2$ and $N_2O$ emission' in the NIR.
- Indirect $N_2O$ emissions from **wastewater s**hould continue to be reported in table 5.D as in the years prior to 2015.
- The information provided in chapter 9 'indirect $CO_2$ and $N_2O$ emission' in the NIR could be improved for some MS, in particular those that report emissions in CRT table 6 should provide information which sources have been estimated.
- It is recommended to discuss which notation keys would be preferable in table 6 as a large variety is currently used for the same underlying situation. If no indirect $N_2O$ emissions are estimated in the energy and IPPU sectors, the notation key 'NE' seems to be appropriate for Table 6 because sources of NOx and NH3 do occur in these sectors, however the deposition of these N inputs on lands is mostly not estimated.

**Linkages to KP reporting**

- Indirect emissions of $N_2O$ from sources other than agriculture and LULUCF should be reported in table 6 and excluded from national totals. As paragraph 29 of the UNFCCC Guidelines are very explicit that these emissions should not be part of the national total, it is recommended to calculate the assigned amount only based on the $N_2O$ emissions that are part of the national total emissions in CRT summary 2 table.