NATIONAL INFORMATIVE INVENTORY REPORT 2022

PORTUGAL

SUBMISSION UNDER THE NEC DIRECTIVE (EU) 2016/2284 AND THE UNECE CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR POLLUTION

Amadora,
April, 15th 2022

apa agência portuguesa do ambiente

Technical Reference

Title	PORTUGUESE INFORMATIVE INVENTORY REPORT 1990 – 2020 Submitted under the NEC Directive (EU) 2016/2284 and the UNECE Convention on Long-range Transboundary Air Pollution
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Edition	Portuguese Environmental Agency
Date	April, 15th 2022
Place	Amadora

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Acknowledgements

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

Preface

The United Nations Economic Commission for Europe (UNECE) Convention on Long-Range Transboundary Air Pollution of 1979 (CLRTAP) and related Protocols require Parties to provide each year an update of its inventory for the pollutants concerned, following adopted guidelines for estimating and reporting emission data. The National Emissions Ceiling Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants, defined new obligations in order to align the EU and the Member States with the international commitments under the CLRTAP and, in particular, the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone of 1999, which was revised in 2012 (the 'revised Gothenburg Protocol').

In the case of Portugal, however, the European and international obligations differ in terms of the geographical scope. While for the NEC Directive and for the Gothenburg Protocol the report excludes the emissions of Azores and Madeira Islands, the LRTAP Convention covers the whole national territory.

This report intends to fulfill the reporting obligations under the different Agreements, presenting data both for the whole national territory and for Portugal mainland (without the two Autonomous Regions of Azores and Madeira).

The revised guidelines (ECE/EB.AIR/128), for application in 2015 and subsequent years, include technical changes approved at the thirty-seventh session of the Steering Body to the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) (Geneva, 9–11 September 2013), as well as further changes proposed and agreed to by the Executive Body at its thirty-second session (Geneva, 9–13 December 2013).

The guidelines define the format for reporting emission data (Nomenclature For Reporting/NFR) and offer guidance on how to provide supporting documentation, through an Informative Inventory Report (IIR), which describes the activity data, emission factors, methodologies applied in the calculation, and explanation of the whole process of inventory preparation.

This 2022 Portuguese submission includes inventory emission data provided in the latest version (Revised 18.11.2019) of the templates "NFR14" which accompanies this report. Summary information on condensable component of Particulates is presented in ANNEX F.

This IIR refers to the 2022 Portuguese inventory submission on air pollutant emissions for the period 1990-2020. It includes estimates for carbon monoxide (CO), nitrogen oxides (NO_x), and non-methane volatile organic compounds (NMVOC). Data are also reported for sulphur oxides (SO_x), ammonia (NH_3), particulate matter (TSP, PM_{10}, $PM_{2.5}$ and BC), heavy metals and persistent organic pollutants (POPs).

The report was prepared by the Portuguese Environment Agency (*Agência Portuguesa do Ambiente*), *Ministry of Environment and Climate Action (Ministério do Ambiente e da Ação Climática*), which is the national entity responsible for the overall coordination of the Portuguese inventory of air pollutants emissions.

Table of Contents

EXECUTIVE SUMMARY

1. Introduction

2. Emission Trends

3. Energy (NFR 1)

4. Industrial Processes and Product Use (NFR 2)

5. Agriculture (NFR 3)

6. Waste (NFR 5)

7. Memo itens

8. Recalculations and Improvements

9. Projections

10. Reporting of gridded emissions and LPS

LIST OF ACRONYMS

REFERENCES

ANNEXES

ANNEX A – Completeness and Key Categories

ANNEX B – Energy Balance

ANNEX C – Energy

ANNEX D – Agriculture

ANNEX E – Waste

ANNEX F – Information on Inclusion/Exclusion of the Condensable Component from PM10 and PM2.5 Emission Factors

ANNEX G – Uncertainty Analysis

EXECUTIVE SUMMARY

Updated: March 2022

ES.1 Introduction

The Portuguese inventory of air pollutants aims to cover all substances considered by the international agreements - UNFCCC and CLRTAP - and the EU regulations - (EU) 525/2013 of the European Parliament and of the Council of 21 May 2013, (EU) 749/2014 of 30 June 2014, and the Directive (EU) 2016/2284 of the European Parliament and the Council of 14 December 2016, on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC.

As a Party to the UNECE Convention on Long-Range Transboundary Air Pollution (CLRTAP), and in order to comply with the obligations under the National Emissions Ceiling Directive (Directive (EU) 2016/2284), Portugal is requested to provide each year an update of its inventory of air pollutant emissions, taking into account the most recent adopted Reporting Guidelines for estimating and reporting emission data (Guidelines for reporting emissions and projections data under the Convention on Long-range Transboundary Air Pollution (ECE/EB.AIR/128)).

The UNECE Guidelines require that Parties prepare an Informative Inventory Report (IIR) as part of their annual submission. The IIR should contain information related to methodologies, emission factors, activity data, and should give explanations concerning any recalculations of historical inventories, in order to ensure transparency and enable the inventory review.

This report was prepared in order to comply with the international commitments under the UNECE/CLRTAP and the NECD. It presents a description of the methods, assumptions and background data used in the preparation of the 2022 national inventory submission of air pollutants covered by the CLRTAP and related Protocols. The methodologies applied refer, as far as possible, to the international agreed guidelines such as the EMEP/CORINAIR guidebook or the IPCC Guidelines.

ES.1.1 Pollutants

This report includes estimates for the following gaseous air pollutants: carbon monoxide (CO), nitrogen oxides (NO_x), and non-methane volatile organic compounds (NMVOC). Data are also reported for sulphur oxides (SO_x), ammonia (NH_3), particulate matter (TSP, PM_{10}, $PM_{2.5}$ and BC), heavy metals (HM) and persistent organic pollutants (POP). The period covered is 1990-2020.

ES.1.2 Emission sources

The inventory has been continuously developed and improved in order to include more pollutants and more complete and reliable estimates. Changes in methodology, source coverage or scope of the data were reflected in the estimation of the emissions for all years in the period considered, i.e., the inventory is internally consistent.

The report is generally structured in accordance with the format approved by the UNECE instances, and includes the following source sectors: energy production and transformation, combustion in industry, domestic, agriculture, fisheries, institutional and commerce sectors, transportation (road, rail, maritime and air), industrial production and industrial and non-industrial use of solvents, waste production (urban, industrial and hospitals solid wastes, and domestic and industrial waste water treatment), agriculture and animal husbandry emissions, as well as emissions from forest.

ES.1.3 Time coverage

Emissions are estimated for each civil year from 1990 to 2020.

ES.2 Geographical coverage

Emissions from Madeira and Azores Archipelagos are not covered by NECD as established in its Article 2.2.

On the other hand, the CLRTAP´s geographical coverage refers to “the area within which, coordinated by the international centers of EMEP, monitoring is carried out." Since its adoption in 1984, this definition has been referred to in all protocols to the LRTAP Convention. With the ratification or accession of Parties to the EMEP Protocol, the geographical scope of EMEP has become larger and the EMEP grid was modified three times until now, once in the late 1990s, another time in 2008 and then again in 2013.

The most recent Guidelines for reporting emissions and projections data under the Convention on Long-range Transboundary Air Pollution (ECE/EB.AIR/128)), adopted in 2013, considers a new “EMEP grid” with changes in the grid projection type (polar-stereographic vs latitude-longitude), and increasing the grid resolution (from 50 x 50 km2 to a finer scale – 0.1° × 0.1°). This new grid includes the two Portuguese Archipelagos of Madeira and Azores.

This report includes information both for the whole national territory and for Portugal Mainland considering that:

- the geographical scope of NECD refers only to the Portuguese Mainland;
- the CLRTAP emissions 2010 ceiling’s and the 2020 reduction commitments, as the 2012 amended Gothenburg Protocol, consider only the Mainland (when the amendment of the Gothenburg Protocol was adopted in 2012, the EMEP grid in use was the 2008 EMEP grid that excluded the Portuguese Islands);
- the CLRTAP reporting refers presently to the new grid covering the two Portuguese Autonomous regions of Azores and Madeira.

The reported data in Annex I emissions reporting template (NFR tables) differ between the submissions. The NFR tables submitted under the NECD refer to Portugal Mainland, while the reporting tables submitted under CLRTAP refer to the present EMEP domain, i.e. the whole Portuguese territory.

ES.3 Differences between NECD/ CLRTAP and UNFCCC/ European Commission Monitoring Mechanism reporting

There are some differences in data submitted to the UNECE/CLRTAP Secretariat and the UNFCCC Secretariat and the EU Commission under MMR (EU 525/2013) concerning SO2, NOx, NMVOC and CO emissions, which refer to:

- geographical coverage: UNFCCC and UNECE/ CLRTAP refer to the national territory, while the NECD/ UE and the 2012 amended Gothenburg Protocol exclude Madeira and Azores Autonomous Regions;
- Aviation: there are differences in the emissions between the NIR and the IIR which result from the difference in terms of coverage. While NIR covers domestic LTOs and cruise emissions in all territory (including islands), IIR covers only LTO in the continental mainland area, either domestic or international LTO;

- Navigation: differences refer to the different coverage between NIR and IIR. While NIR covers domestic movements in all territory, IIR does not cover emissions in the islands of Madeira and Azores. The separation of navigation emissions between mainland continental area and islands was determined according with the number of domestic docks in the seaports from mainland and islands.

ES.4 Summary of emissions trends

Following the guidance of the international methodological Guidelines/Guidebook, the main sources of air pollutants are now divided in the four following sectors: Energy, Industrial Processes and Product Use (IPPU), Agriculture and Waste. Wildfires and natural biogenic emissions are reported as memo items. The sources of air pollutants are discussed in detail in the sectoral chapters 3 to 7 of this report.

The next tables present the national total and Mainland emission data for the period covered by this report. A deeper analysis of the sectoral emission trends is presented in chapter 2.

Table ES. 1: Total emissions (National territory)

Pollutant	Unit	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	% change 1990-2020
NOx	kt	260.1	297.0	300.6	283.1	203.8	170.2	163.2	166.4	160.7	154.6	135.0	-48.1
NMVOC	kt	249.4	239.3	237.8	195.8	158.2	146.1	143.7	145.8	146.1	148.4	159.6	-36.0
SOx	kt	317.9	322.0	295.0	189.9	63.1	45.8	45.8	47.3	45.2	44.3	38.3	-88.0
NH3	kt	76.8	72.4	76.6	64.5	58.9	59.2	59.7	60.4	60.5	61.9	63.3	-17.6
PM2.5	kt	69.4	67.9	71.0	62.2	53.0	49.6	49.1	49.2	48.9	48.9	47.3	-31.8
PM10	kt	86.9	87.5	90.2	80.2	71.9	61.0	61.6	61.2	61.2	61.7	61.2	-29.6
TSP	kt	129.1	139.4	151.9	141.1	128.4	101.3	105.2	102.8	103.8	104.8	104.6	-19.0
BC	kt	9.2	10.0	11.4	9.6	8.5	7.0	6.9	6.9	6.7	6.6	5.6	-39.4
CO	kt	797.3	827.3	682.7	522.8	402.1	324.1	310.6	326.7	284.8	294.3	262.3	-67.1
Pb	t	570.3	789.7	34.6	31.6	28.6	25.6	25.1	25.6	26.2	25.3	23.1	-95.9
Cd	t	2.4	2.5	2.7	2.4	2.0	2.0	1.9	1.9	1.9	1.8	1.8	-24.9
Hg	t	2.2	2.4	2.3	1.8	1.6	1.4	1.3	1.4	1.3	1.3	1.2	-43.8
As	t	3.3	3.7	3.9	3.9	2.1	2.2	2.0	2.1	2.0	1.6	1.4	-58.4
Cr	t	12.0	13.2	13.0	12.3	8.8	7.7	7.1	7.4	7.0	6.9	6.6	-45.3
Cu	t	26.3	32.4	42.5	45.0	35.9	29.4	29.2	29.6	29.3	29.7	25.5	-3.2
Ni	t	111.4	115.6	106.4	104.5	45.7	23.0	21.9	21.8	20.6	21.0	19.8	-82.3
Se	t	1.9	2.5	2.9	3.2	3.4	3.4	3.3	3.4	3.7	3.4	3.2	65.3
Zn	t	57.9	59.2	62.3	61.5	55.0	54.2	54.1	55.2	55.3	53.6	51.5	-11.1
DIOX	g I-TEQ	550.5	547.7	351.6	66.0	49.3	47.7	48.7	51.3	55.3	57.3	70.7	-87.2
PAHs	t	25.3	23.6	22.7	19.2	15.3	13.9	13.8	14.6	15.5	17.4	23.0	-9.0
HCB	kg	60.4	75.7	100.8	1.7	1.4	1.7	1.9	2.0	2.4	2.4	1.3	-97.9
PCB	kg	1059.1	854.0	794.5	670.1	322.6	85.9	84.0	95.8	91.9	89.4	90.0	-91.5

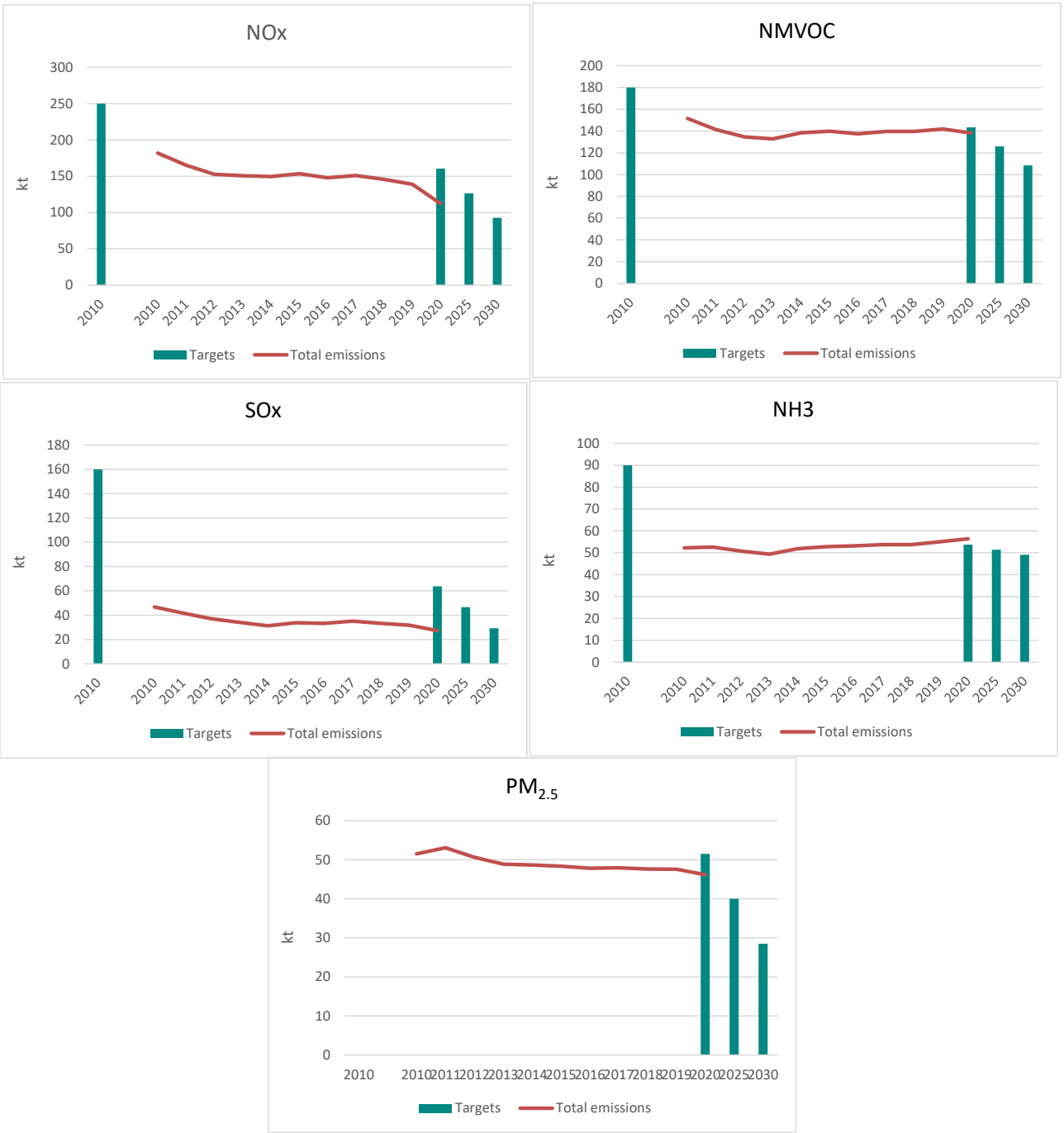
Table ES. 2 Total emissions (Mainland)

Pollutant	Unit	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	% change 1990-2020
NOx	kt	246.8	281.1	281.1	259.4	182.0	153.4	148.1	151.1	145.7	139.1	121.7	-50.7
NMVOC	kt	241.2	230.5	228.1	187.3	151.5	139.8	137.5	139.6	139.7	141.9	152.4	-36.8
SOx	kt	309.5	312.0	282.1	172.5	46.8	33.7	33.2	35.2	33.3	31.7	27.2	-91.2
NH3	kt	71.4	66.9	69.7	57.8	52.2	52.8	53.2	53.7	53.7	55.0	56.4	-21.0
PM2.5	kt	68.2	66.6	69.6	60.6	51.5	48.4	47.8	47.9	47.6	47.6	46.2	-32.3
PM10	kt	85.2	85.6	88.3	78.1	69.8	59.5	60.0	59.6	59.6	60.0	59.7	-29.9
TSP	kt	126.5	136.6	149.0	138.1	125.1	99.3	103.0	100.7	101.7	102.7	102.5	-19.0
BC	kt	8.9	9.5	10.9	9.2	8.1	6.7	6.6	6.6	6.4	6.3	5.4	-39.9
CO	kt	783.3	807.6	665.9	507.6	391.6	316.8	303.6	319.7	278.3	287.5	256.6	-67.2
Pb	t	558.4	764.3	32.5	29.4	26.2	24.4	23.9	24.4	25.2	24.1	22.1	-96.1
Cd	t	2.4	2.5	2.7	2.4	2.0	1.9	1.9	1.9	1.9	1.8	1.8	-25.6
Hg	t	2.2	2.4	2.3	1.8	1.6	1.3	1.3	1.4	1.3	1.3	1.2	-44.4
As	t	3.2	3.6	3.8	3.7	2.0	2.1	1.8	2.0	1.9	1.5	1.3	-61.1
Cr	t	11.8	12.9	12.6	11.7	8.2	7.3	6.7	6.9	6.5	6.4	6.2	-47.6
Cu	t	25.8	31.4	41.2	43.3	34.5	28.2	28.1	28.4	28.1	28.4	24.4	-5.3
Ni	t	107.5	111.1	100.2	96.0	37.5	16.7	15.4	15.5	14.4	14.6	14.1	-86.9
Se	t	1.9	2.4	2.9	3.2	3.4	3.4	3.3	3.4	3.6	3.4	3.1	65.6
Zn	t	57.3	58.4	61.3	60.1	53.8	53.2	53.1	54.2	54.3	52.5	50.6	-11.7
DIOX	g I-TEQ	549.4	546.5	350.1	64.4	48.3	45.6	46.5	48.7	53.0	54.7	67.0	-87.8
PAHs	t	25.1	23.4	22.5	19.1	15.2	13.7	13.7	14.4	15.4	17.2	22.8	-8.9
HCB	kg	60.4	75.6	100.7	1.6	1.4	1.7	1.9	2.0	2.3	2.3	1.3	-97.9
PCB	kg	1010.5	815.7	760.0	643.7	309.8	84.3	83.0	94.7	90.9	88.7	89.2	-91.2

ES.5 Assessment of Compliance with National Ceilings

National emissions for compliance - without the emissions from the Azores and Madeira Islands - are presented in the following figure, together with the emission ceilings set by the NEC Directive and the 2012 ammended Gothemburg Protocol (after 2020).

As the figures below show, according to the most recent estimates, Portugal is in non-compliance for NH3 for 2020, which is a significant change from previous submissions.



Notes:
The 'National Total for Compliance (NECD)' includes the 'National Total (based on fuel sold)' (NFR tables´ row 141) minus the sectors 3B + 3D for NOx and NMVOC (only from 2020 onwards and for the year 2005 as a basis for emission reduction commitment calculations), according to the NEC Directive, Article 4/3(d).

Figure ES. 1: National emissions for NECD compliance (Mainland Portugal)

The achieved emission reductions for NOx in 2020 compared with 2005 were 55.2% and 53.1%, respectively under the scope of the NECD and of CLRTAP. Both figures ensure compliance with the reduction commitments for 2020 (36% for NOx).

The achieved emissions reductions of NMVOC in 2020 compared with 2005 were 21% and 18.6% respectively under the scope of the NECD and of CLRTAP. These figures were below the emission reduction commitments for 2020 (18% for NMVOC). However, the CLRTAP commitment is accomplished with a very small margin of achievement.

The emission reduction achieved for SO2 in 2020 compared with 2005 attaining a reduction of 134 %, which represents the highest verified and complies largely with the reduction commitment (63% for SO2).

Also for PM2.5, the emissions in 2020 compared with 2005, allow compliance with the commitment (15% for PM2.5).

The NH3 emissions in 2020 compared with 2005 were above the expected and place Portugal non-compliant with the NH3 commitment (7% for NH3). The 2020 emissions (56.4 kton) represent a reduction of 2.2%, 4.8% above the expected reduction commitment.

This situation was not expected since the previous emission values reported and the projected values indicated otherwise. The increase in NH3 emissions relates mainly to a significant increase in the number of animals in 3B4 category, which was only identified after the latest statistical update made available in mid-2021 with 2019 data. Previous available statistics referred to 2016.

ES.6 Information on projections

No updated projections are provided in this submission. An update on emission projections is foreseen for next year in accordance with the directive requirements.

The estimation of emissions for 2020, 2030, 2040 and 2050 refer to the 2021 submission and is based on a methodological approach consistent with the National Inventory System (SNIERPA) and the evolution scenarios of the Portuguese economy as outlined in the scope of work developed for the Portuguese Roadmap for Carbon Neutrality 2050 (RNC2050).

According to the previous emission estimates, reduction commitments for all pollutants covered by the NEC Directive were expected to be achieved.

However, in the case of NH3 emissions, the latest estimates for the year 2020 indicate a deviation from the the previous projection exercise, leeding to the non-compliance of Portugal concerning this pollutant in 2020. This unexpected situation is due to an upward tendency in activity data for the 3B4g category, revealed in the latest update of the national statistics regarding the number of animals included in the 3B4g category, which was made available in mid-2021.

Regarding the 2030 targets, the fulfilment of national targets will require the implementation of additional measures to reduce PM2.5 emissions, mainly oriented to the industrial sector, and addressing solvent use to ensure no deviations for the NMVOC reduction target in 2030.

Further measures to address the agriculture sector need to be implemented in order to turn the evolution of NH3 emissions back on track.

ES.7 Future developments

Future improvements are defined under the Methodological Development Plan (PDM), which is settled each year in the context of the National Inventory System (SNIERPA) and is developed under the responsibility of

APA in cooperation with the sectoral Focal Points. The PDM pretends to reflect the results of the various review processes, as the UNFCCC, the UNECE/CLRTAP and EC/NEC reviews, the annual inventory compilation process (all experts and entities involved can make proposals for methodological development), and generally the results of the application procedures of Quality Control and Quality Assurance which have been defined under the Control and Quality Assurance System.

A detailed explanation of the sectoral future improvements is presented in each source specific sub-chapter.

A synthesis of the main development priorities are:

- development of country specific excreta factors from excreta analyzes in facilities;
- analysis of implementation of BATs provided under Commission's Implementing Decision (EU) 2017/302 of 15 February 2017 in IPPC facilities;
- collection of information from facilities in articulation with the Environmental Licensing/PRTR.
- further development of country specific emissions factors for combustion in energy industries;
- development of the uncertainty analysis;
- several other developments described in the sector chapters.

1 Introduction

Table of Contents

1 Introduction 1-1

1.1 Background information on air emission inventories 1-3

1.1.1 History of national inventories 1-3

1.2 Institutional arrangements for inventory preparation 1-5

1.2.1 Institutional arrangements in place 1-5

1.3 Inventory Preparation Process 1-8

1.3.1 Responsibility 1-8

1.3.2 Overview of inventory planning 1-8

1.3.3 Calculation, data archiving and documentation system 1-10

1.4 Geographic and sectoral coverage 1-11

1.5 Time coverage 1-11

1.6 General overview of methodologies and data sources used 1-11

1.7 Key source categories 1-14

1.8 Information on QA/QC 1-18

1.9 General uncertainty assessment 1-18

1.9.1 Method used 1-19

1.9.2 Data sources 1-19

1.9.3 Uncertainty results 1-20

1.10 Overview of the completeness 1-21

List of Figures

Figure 1-1: SNIERPA's main elements relations 1-6

Figure 1-2: Main bodies of the national system (SNIERPA) 1-7

Figure 1-3: Electronic System Structure of the estimation and reporting system 1-10

List of Tables

Table 1.1: Calendar for the inventory process 1-9

Table 1.2: Main data sources used in the Portuguese inventory 1-13

Table 1.3: Key category analysis of 2020 inventory 1-15

Table 1.4: Rating definitions 1-19

Table 1.5: Emission quality data ratings and calculated uncertainties by main NFR source categories 1-20

Table 1.6: Emission quality data rResult of overall uncertainty for the main pollutants (NOx, NMVOC, SO2; NH3 and CO) 1-21

1 Introduction

Updated: April 2022

1.1 Background information on air emission inventories

1.1.1 History of national inventories

Air emission inventories in Portugal were only initiated in the late eighties/ early nineties of last century, when the first estimates of NO_x, SO_x and VOC emissions from combustion where 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 program. A major breakthrough occurred during the CORINAIR90 inventory realized during 1992 and 1993 by General-Directorate of Environment (DGA, presently the Portuguese Environment Agency - APA). This inventory exercise, aiming also 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 duels, production processes, use of solvents, agriculture, urban and industrial wastes 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 conventions UNFCCC and CLRTAP, 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), has result in substantial improvement of the methodologies that are used in the inventory, particularly for agriculture and wastes, and that were included at 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 subjected to a review made by an international team. The second and third communications was 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 from 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 (1990-2018), 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 (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 Tier2 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 (Pereira et al,2002) for the quantification of carbon sinks in Portugal, 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);
- Sectorial 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 (IA,2004);
- Methodological Development Programme (PDM) under the implementation of the National Inventory System;
- UNFCCC reviews, in particular the in-depth review (September/October 2004), and the centralised review (October 2005);
- UNFCCC in-depth review of the Initial Report in May 2007, which fixed the Assigned Amount for the first commitment period;
- CLRTAP stage 3 in-depth review realised from 6-10 October 2008;
- Consistency reports under the EC MMD (Dec. 280/2004/EC);
- 2012 technical review of the greenhouse gas emission inventory of Portugal under Decision 406/2009/EC;
- UNFCCC in-depth review of the 2012 GHG inventory (24-29 September);
- UNECE/CLRTAP stage 3 review (June 2013);
- UNFCCC centralized reviews of the GHG inventories (2013-2016);
- 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;
- Effort Sharing Decision (ESD) review of the 2016-2020 GHG inventories;
- UNFCCC centralized reviews of the GHG inventories (2020);
- 2019, 2020 and 2021 Reviews of national air pollution inventory data pursuant to the Directive (EU) 2016/2284 (NECD).

The inventory covers several gaseous air pollutants, such as GHGs emissions (not covered in this report), carbon monoxide (CO), nitrogen oxides (NO_x), sulphur oxides (SO_x), non-methane volatile organic compounds (NMVOC), ammonia (NH_3), Particulate Matter, Heavy Metals and POPs.

Emissions are estimated for each civil year from 1990 to 2020.

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 air traffic and navigation realized

between places in territorial Portugal, including movements between mainland and islands, are also include in national emission 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 industrial and non-industrial use of solvents, waste production (urban, industrial and hospitals solid wastes, and domestic and industrial waste water treatment), agriculture, animal husbandry emissions, as well as emissions from forest fires and natural biogenic emissions (memo items).

1.2 Institutional arrangements for inventory preparation

1.2.1 Institutional arrangements in place

A new legal national arrangement has been adopted (Council of Ministers Resolution no. 20/2015) in order to take into account the recent developments at international level relating to the UNFCCC and the Kyoto Protocol, and the new 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 and repealing Decision No 280/2004/EC, and the Commission Implementing Regulation (EU) 749/2014 of 30 June 2014 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) No 525/2013 of the European Parliament and of the Council, and the requirements under the CLRTAP and the NECD.

This national system for the inventory (SNIERPA) contains a set of legal, institutional and procedural arrangements that aim at ensuring the accurate estimation of emissions by sources and removals by sinks of air pollutants, as well as the communication and archiving of all relevant information.

The principal objective of the SNIERPA is to prepare in a timely manner the National Inventory of Emissions by Sources and Removals by Sinks of Air Pollutants (INERPA), in accordance with the directives defined at international and EC levels, in order to make easier and more cost-effective the tasks of inventory planning, implementation and management.

SNIERPA defines the entities relevant for its implementation, based on the principle of institutional cooperation. This clear allocation of responsibilities is essential to ensure that the inventory takes place within the defined deadlines and complies with international requirements.

The new 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.

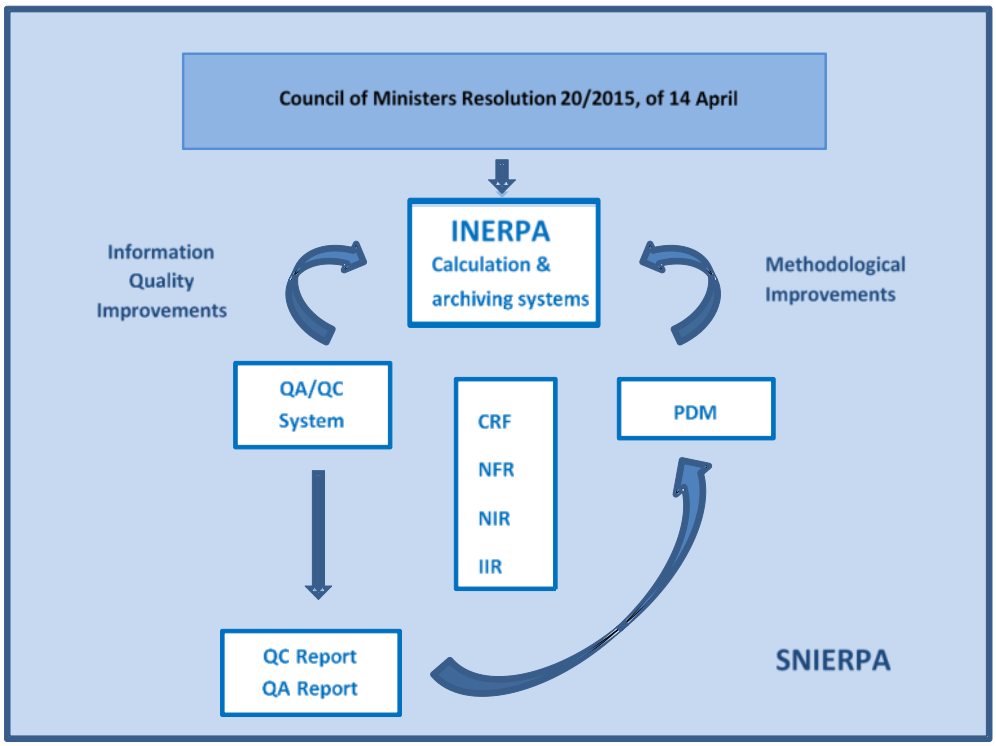


Figure 1-1: SNIERPA's main elements relations

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 sectorial Focal Points;
iii) the Entities Involved.

APA is the Responsible Body for: 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. The Climate Change Department (DCLIMA) 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 CRF tables and the preparation of the NIR, the response to the review processes and data archiving and documentation.

The sectorial Focal Points work with APA/DCLIMA in the preparation of INERPA, and are responsible for fostering intra and inter-sectorial cooperation to ensure a more efficient use of resources. Their main task includes coordinating the work and participation of the relevant sectorial 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 sectorial quality assurance and methodological development. They are also responsible for the production of statistical information and data publication that are used in the inventory estimates.

The involved entities are public or private bodies which generate or hold information which is relevant to the 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 new 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 next figure presents the main entities that make part of the national system.

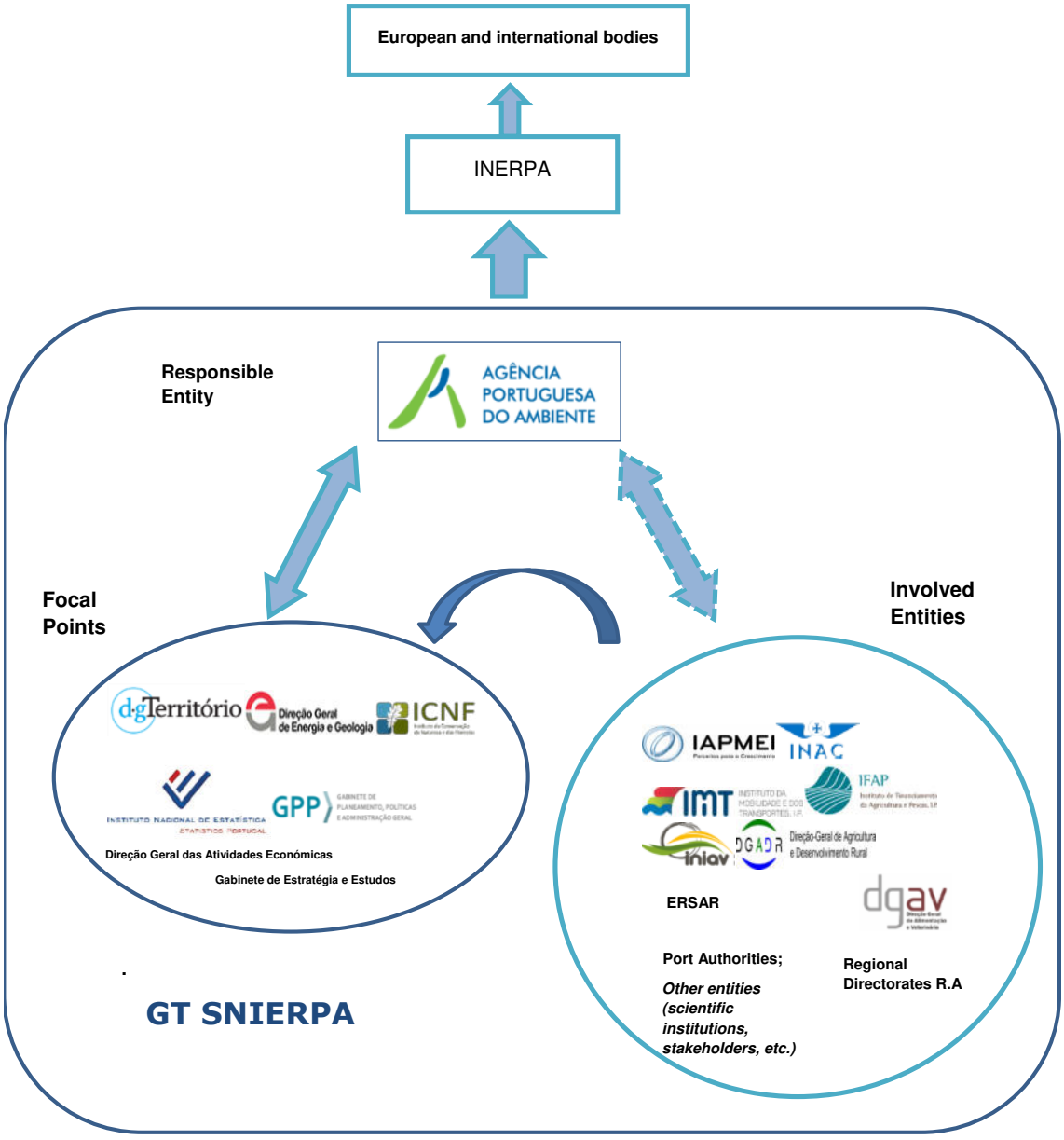


Figure 1-2: Main bodies of the national system (SNIERPA)

For the sake of efficiency, the Portuguese national system, has been broadened to include a wider group of air pollutants than just GHG not covered by the Montreal Protocol, allowing for improvements in information quality, as well as an optimisation of human and material resources applied to the preparation of the inventory.

The RCM (Council of Ministers Resolution 20/2015, of 14 April) also includes a procedure for the official consideration of the inventory, defining, in its article 12, that the final approval of INERPA is the responsibility of APA, after hearing the focal points (FP) and the involved entities (IE).

1.3 Inventory Preparation Process

1.3.1 Responsibility

APA is the national entity responsible for the overall coordination of the Portuguese inventory of air pollutants emissions. According to these attributions, APA makes an annual compilation of the Portuguese Inventory of air emissions which includes Greenhouse Gas (GHGs) 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 the APA.

The designated representative is:

Agência Portuguesa do Ambiente, I.P. (Portuguese Environmental Agency)

DCLIMA (Climate Change Department)

Address: Rua da Murgueira, 9/9A, 2610-124 Amadora, Portugal

Telephone: +351 21 472 82 00

Fax: + 351 21 471 90 74

Head of Department: Eduardo Santos – eduardo.santos@apambiente.pt

1.3.2 Overview of inventory planning

All the participating organizations represented in SNIERPA support the annual production of the national inventories and the fulfillment 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. Each issue identified is attributed a priority, considering its importance from the key categories assessment, the level of uncertainty associated and the economic and technical resources available.

Each year, typically in June according to the agreed calendar of INERPA, APA, 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 1.1: Calendar for the inventory process

Date	Task	Process	Tasks
May - June	- Elaboration of QA/QC plan - Definition/update of inventory development priorities (PDM)	Inventory Planning	- setting of quality objectives - 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 - 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 - 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 - collection of activity data and EFs update - implementation of methodological improvements - estimation of emissions/ removals - aplication of QA/QC checks - uncertainty and KC assessment - archiving of information - 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 - implementation of corrections and late data updates
14 February	*Official consideration/approval of the NFR submission to UNECE [CLRTAP]*	*Approval*	*Approval by President of APA*
15 February	*Official NFR submission to NECD [EU] and UNECE [CLRTAP]*	*Reporting*	-
	- Revision of CRF submission - Preparation of NIR and IIR - Circulation of NIR and IIR comments among FP and/or IE	Inventory Verification/ Improvement	- aplication of QA/QC checks - 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 APA*
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 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 and Kyoto Protocol]*	*Reporting*	-
8/27 May	*Resubmission (if needed) of CRF and NIR (final version) to the EC and UNFCCC [UNFCCC and Kyoto Protocol]*	*Reporting*	-

1.3.3 Calculation, data archiving and documentation system

The emissions calculations are performed by APA/DCLIMA. However many other institutions and agencies contributed to the inventory process, providing activity data, sectorial 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 the figure below.

The information received from the several data suppliers is stored in its original format (paper or magnetic). 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 at APA to answer to the various international obligations and national needs. At present, the different demands refer to: UNFCCC (CRF format); UNECE/CLRTAP (NFR format); NECD Directive (NFR format); as well 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.

Particular attention is paid to the archiving and storing of all inventory data and supporting information. 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.

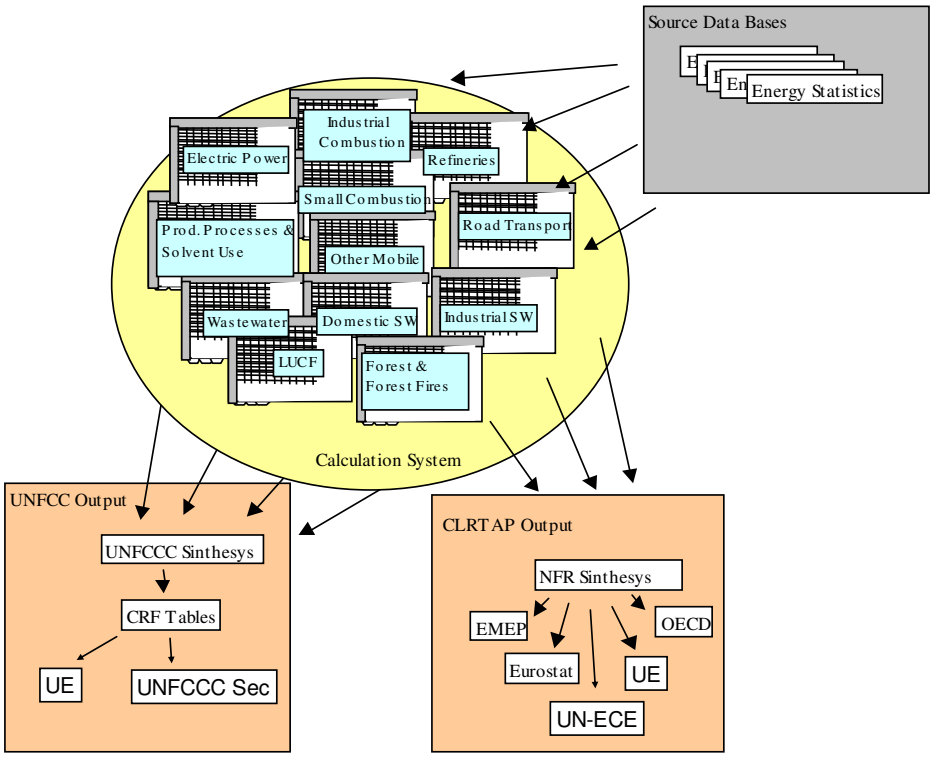


Figure 1-3: Electronic System Structure of the estimation and reporting system

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 APA premises where the inventory team key is located. All data are backed up daily. Hence, the present system existing in APA 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 Geographic and sectoral coverage

The CLRTAP reporting refer presently to the new EMEP grid which covers the whole national territory.

The geographical scope of NEC Directive refer only to the Portuguese Mainland, and consequently Annex I Emissions reporting template exclude the emissions of the Azores and Madeira.

Emissions from international maritime traffic and aircraft emissions beyond the landing and take-off cycle are not included.

1.5 Time coverage

Emissions are estimated for each civil year from 1990 to 2020.

1.6 General overview of methodologies and data sources used

The inventory is compiled, to the extent as possible, in accordance with the recommended methodologies from the EMEP/CORINAIR guidebook or the IPCC Guidelines. The most recent methodological guidance – EMEP/EEA air pollutant emission inventory guidebook – 2019 and the 2006 IPCC Guidelines - have been implemented to the extent of possible for the compilation of the Portuguese inventory.

The national inventory system for air pollutants has been continuously developed and improved in order to include more pollutants and more complete and reliable estimates.

Default methods and emission factors used and the choice between Tier 1 and Tier 2 approaches, were dictated, case by case, by the availability of proper background information, from national circumstances and the availability of resources.

Table 1.2 gives an overview of the institutions and data sources providing data for the compilation of the Portuguese emission inventories.

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, maritime and aviation, such as the number of vehicles, harbour statistics and aircraft landing and take-off cycles are provided to the APA, within the SNIERPA arrangements, from different national entities, such as the Institute of Mobility and Transports (IMT), the National Civil Aviation (ANAC), the National Ports and different sectoral associations.

For the more recent years, data collected at APA under the European Emissions Trading Scheme (ETS) on production data, fuel consumption, fuel energy content and emission factors are also used in the inventory compilation.

Data sources for the industrial sector are diverse and include: annual production data from the IAPI (INE), ETS data, data collected from the National Pollutant Release and Transfer Register under the EC Regulation no.166/2006, are used to develop emission factors 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.

The collection of data under the Large Combustion Plant Directive, the E-PRTR Regulation and Regulation (EU) No. 517/2014 on fluorinated greenhouse gases is also under the responsibility of APA and directly available to the inventory team.

Data sources for the agriculture sector, rely to a great extent 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/INCF, 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 the APA via the Integrated System for Electronic Registry on Waste (SIRER) in the SILIAMB electronic platform.

Table 1.2: 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) Large Combustion Plants (LCP) EDP Sustainability Annual Reports Energy Balance - General Directorate for Geology and Energy (DGEG) Autonomous Government of Azores National Statistical Institute (INE) European Emissions Trading Scheme - APA
1A2 - Manufacturing Industries and Construction		LPS, LCP, EPER/PCIP Energy Balance (DGEG) European Emissions Trading Scheme - APA
1A3 – Transport	Airport movements Vehicle sales Fuel sales Vehicle inspection data / Port movements	ANAC ACAP Energy Balance (DGEG) IMT
1A4 – Other Sectors	Fuel sales Equipments and fuel used	Energy Balance (DGEG) Survey on Energy Consumption in the Residential Sector (DGEG)
1A5 – Other	Fuel sales	Energy Balance (DGEG)
1 B – Fugitive Emissions from Fuels		Energy Balance and statistical yearbooks (DGEG) GALP
2 – IPPU		
2A - Mineral industry		LPS, LCP CIMPOR, SECIL Energy Balance (DGEG) Portuguese Association of Producers of Bitumen Materials (APORBET) European Asphalt Pavement Association (EAPA) Technology Centre for Ceramics and Glass (CTCV) European Emissions Trading Scheme - APA
2B - Chemical industry		Energy Balance (DGEG) LCP INE
2C - Metal industry		Energy Balance (DGEG) LCP INE SN
2D - Non-energy products from fuels and solvent use		Energy Balance (DGEG) Gen-Dir for Economic Activities (DGAE) INE
2F - Product uses as ODS substitutes		INE APIRAC Data from Industry Importers EDP, REN Fluorinated Gas Reporting (APA)
2G - Other product manufacture and use		LCP Energy Balance (DGEG)
3 – Agriculture		
	Agriculture survey, Animal and Crop production, Fertilizer consumption	GPP IFAP INE APA
4 – Land Use, Land Use Change and Forestry		
	Biomass increment, Burnt area, Harvest Land use area, LUC Biomass increment	ICNF COS cartography (DGT) ISA
5 – Waste		
5A – Solid Waste Disposal on Land	Amount of Waste (Municipal) Amount of Waste (Industrial)	APA APA-INE
5B – Biological Treatment	Amount of Waste	APA
5C – Waste Incineration	Amount of Waste	APA
5D – Wastewater Handling	Industrial Production, Protein consumption	APA INE

1.7 Key source categories

Key source analysis to the 2020 Portuguese inventory estimates was conducted using Approach 1 for both level and trend assessments, as described in the EEA Guidebook and IPCC Guidelines.

The assessment was undertaken for 2020 for all pollutants at the NFR14 code level. The pollutant-specific key categories were identified using a predetermined cumulative emissions threshold. Key categories are those which, when summed together in descending order of magnitude, cumulatively add up to 80 % of the total level.

The results of the key category analysis for each pollutant are presented in the table below, which show the contribution of the KC identified to the national total (%) and the Tier 1 identification criteria (level (L1)/trend (T1)).

The importance of combustion sources is shown by the predominance of categories identified as key under the Energy sector (categories under 1.A) for the majority of pollutants (exception for NH_3). NH_3 emissions are generated in the agriculture sector which represent more than 80% of total NH_3 emissions in 2020. The Residential stationary sources (1A4bi) are related to a great extent to particulate, dioxins/furans and PAHs emissions.

For NMVOC, key categories refer in majority to the IPPU sector (NFR 2), in particular 2.D.3.a Domestic solvent use, 2.D.3.d Coating applications and 2.D.3.g Chemical products or 2.H.1 Pulp and paper industry. Glass production (2.A.3) is responsible for the large majority of Se emissions (76.5%) and a significant source for other HM emissions. Iron and steel production is also an important source of HM emissions in namelly, Pb, Cd and Zn emissions. Waste incineration sources (5.C) and Public electricity and heat production (1.A.1.a) generate the majority of HCBs emissions. PCBs emissions are related principally (76%) to Industrial waste incineration (5.C.1.b.i) .

Table 1.3: Key category analysis of 2020 inventory

NFR sectors			Main Pollutants (from 1990)				Particulate Matter (from 2000)				Other (from 1990)
			NOx (as NO_2)	NMVOC	SOx (as SO_2)	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
NFR Code	Longname		kt	kt	kt	kt	kt	kt	kt	kt	kt
1A1a	Public electricity and heat production	ENERGY	9.9% (L1, T1)		29.5% (L1, T1)		0.8% (T1)	0.7% (T1)	0.5% (T1)		
1A1b	Petroleum refining	ENERGY			0.7% (T1)						
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	ENERGY									
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	ENERGY	3.9% (L1, T1)	1.6% (L1)	24.3% (L1, T1)	2.7% (T1)		2% (L1)		3.4% (L1)	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	ENERGY								1.5% (T1)	
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	ENERGY	11.4% (L1, T1)	5.2% (L1, T1)	14.3% (L1, T1)		8.6% (L1, T1)	6.6% (L1, T1)	13.4% (L1, T1)	8.1% (L1, T1)	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	ENERGY	3.1% (L1)		1.7% (T1)					4.5% (L1)	
1A3ai(i)	International aviation LTO (civil)	ENERGY								4.6% (L1, T1)	
1A3bi	Road transport: Passenger cars	ENERGY	17.5% (L1, T1)	2.3% (L1, T1)		0.9% (T1)	2.1% (L1, T1)	1.6% (T1)		13.3% (L1, T1)	14.3% (L1, T1)
1A3bii	Road transport: Light duty vehicles	ENERGY	11.2% (L1, T1)				2.3% (L1, T1)	1.8% (L1, T1)		13.9% (L1)	
1A3biii	Road transport: Heavy duty vehicles and buses	ENERGY	9.9% (L1, T1)				0.5% (T1)	0.4% (T1)	0.2% (T1)	2.8% (T1)	
1A3biv	Road transport: Mopeds & motorcycles	ENERGY		1.3% (T1)							3.2% (L1, T1)
1A3bv	Road transport: Gasoline evaporation	ENERGY		2.9% (L1, T1)							
1A3bvi	Road transport: Automobile tyre and brake wear	ENERGY						2% (L1, T1)			
1A3dii	National navigation (shipping)	ENERGY	3.2% (L1)								
1A4ai	Commercial/institutional: Stationary	ENERGY									
1A4bi	Residential: Stationary	ENERGY	2.5% (L1)	8.8% (L1, T1)		3% (T1)	38.7% (L1, T1)	30.7% (L1, T1)	18.8% (L1, T1)	32.1% (L1, T1)	38.7% (L1, T1)
1A4ci	Agriculture/Forestry/Fishing: Stationary	ENERGY									
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	ENERGY								3% (L1, T1)	
1B2aiv	Fugitive emissions oil: Refining / storage	ENERGY			6.9% (L1, T1)						11.7% (L1, T1)
1B2av	Distribution of oil products	ENERGY		2.4% (L1)							
1B2d	Other fugitive emissions from energy production	ENERGY									
2A2	Lime production	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)						3.1% (L1, T1)	4.7% (L1, T1)		
2A3	Glass production	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)									
2A5a	Quarrying and mining of minerals other than coal	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)						5.1% (L1, T1)	6.1% (L1, T1)		
2A5b	Construction and demolition	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)						3.3% (L1, T1)	6.4% (L1, T1)		
2B10a	Chemical industry: Other (please specify in the IIR)	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)				5.9% (L1, T1)	12.6% (L1, T1)	9.8% (L1, T1)	12% (L1, T1)		3.2% (L1)
2C1	Iron and steel production	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)									
2D3a	Domestic solvent use including fungicides	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)		16.9% (L1, T1)							
2D3b	Road paving with asphalt	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)							2.9% (L1)		
2D3d	Coating applications	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)		11.5% (L1, T1)							
2D3g	Chemical products	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)		11.1% (L1, T1)							
2D3i	Other solvent use (please specify in the IIR)	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)		6.5% (L1, T1)							
2G	Other product use (please specify in the IIR)	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)									
2H1	Pulp and paper industry	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)	3.7% (L1, T1)	4.9% (L1, T1)	10.6% (L1, T1)		14% (L1, T1)	13.1% (L1, T1)	8.7% (L1, T1)		
2I	Wood processing	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)							3.5% (L1, T1)		
2K	Consumption of POPs and heavy metals (e.g. electrical and scientific equipment)	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)									
3B1a	Manure management - Dairy cattle	AGRICULTURE		1.6% (L1)		8.3% (L1)					
3B1b	Manure management - Non-dairy cattle	AGRICULTURE				3.5% (L1)					
3B2	Manure management - Sheep	AGRICULTURE				0.7% (T1)					
3B3	Manure management - Swine	AGRICULTURE				9.6% (L1, T1)					
3B4gi	Manure mangement - Laying hens	AGRICULTURE				3.5% (T1)			2.7% (L1, T1)		
3B4gii	Manure mangement - Broilers	AGRICULTURE		2.5% (L1)		8.5% (L1, T1)					
3B4h	Manure management - Other animals (please specify in IIR)	AGRICULTURE				0.6% (T1)					
3Da1	Inorganic N-fertilizers (includes also urea application)	AGRICULTURE	3.1% (L1)			8.4% (L1, T1)					
3Da2a	Animal manure applied to soils	AGRICULTURE		2.7% (L1)		19.9% (L1, T1)					
3Da3	Urine and dung deposited by grazing animals	AGRICULTURE	2.9% (L1, T1)			16.1% (L1, T1)					
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	AGRICULTURE						0.8% (T1)			
3F	Field burning of agricultural residues	AGRICULTURE					3.7% (L1)	3% (L1)	1.8% (L1)		11.2% (L1, T1)
5C1bi	Industrial waste incineration	WASTE									
5C1biii	Clinical waste incineration	WASTE									
	TOTAL		**82.3**	**82.2**	**88.0**	**91.6**	**83.3**	**84.0**	**81.7**	**87.2**	**82.3**

NFR sectors			Priority Heavy Metals (from 1990)			Additional Heavy Metals (from 1990, voluntary reporting)					
			Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
NFR Code	Longname		t	t	t	t	t	t	t	t	t
1A1a	Public electricity and heat production	ENERGY			6.8% (L1)	23.1% (L1, T1)	8% (L1, T1)	2.2% (T1)	27.6% (L1, T1)	2.2% (T1)	
1A1b	Petroleum refining	ENERGY							1.5% (T1)		
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	ENERGY		0.8% (T1)		0.7% (T1)					
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	ENERGY		6.5% (L1)	36.5% (L1, T1)				10.1% (L1)		16.4% (L1, T1)
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	ENERGY		1.6% (T1)	2.2% (T1)						
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	ENERGY	7.3% (L1, T1)		4.7% (L1, T1)	21% (L1, T1)	43% (L1, T1)	6.8% (L1)	19.8% (L1, T1)	13.7% (L1, T1)	2.5% (T1)
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	ENERGY		1% (T1)	2.7% (T1)	1.6% (T1)	0.6% (T1)		0.7% (T1)		
1A3ai(i)	International aviation LTO (civil)	ENERGY									
1A3bi	Road transport: Passenger cars	ENERGY	23.4% (L1, T1)								
1A3bii	Road transport: Light duty vehicles	ENERGY									
1A3biii	Road transport: Heavy duty vehicles and buses	ENERGY									
1A3biv	Road transport: Mopeds & motorcycles	ENERGY						1.5% (T1)			
1A3bv	Road transport: Gasoline evaporation	ENERGY									
1A3bvi	Road transport: Automobile tyre and brake wear	ENERGY	6.9% (L1, T1)				9% (L1, T1)	50.6% (L1, T1)			10.1% (L1, T1)
1A3dii	National navigation (shipping)	ENERGY							7.7% (L1, T1)		
1A4ai	Commercial/institutional: Stationary	ENERGY						2.4% (T1)			
1A4bi	Residential: Stationary	ENERGY		23.5% (L1, T1)			11.4% (L1)				32.4% (L1, T1)
1A4ci	Agriculture/Forestry/Fishing: Stationary	ENERGY				3.7% (L1)			8.1% (L1, T1)		
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	ENERGY									
1B2aiv	Fugitive emissions oil: Refining / storage	ENERGY			4.5% (L1, T1)		4% (T1)				
1B2av	Distribution of oil products	ENERGY									
1B2d	Other fugitive emissions from energy production	ENERGY			7% (L1, T1)						
2A2	Lime production	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)									
2A3	Glass production	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)	21.3% (L1, T1)	10.8% (L1, T1)		34.1% (L1, T1)	9.1% (L1, T1)			76.5% (L1, T1)	
2A5a	Quarrying and mining of minerals other than coal	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)									
2A5b	Construction and demolition	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)									
2B10a	Chemical industry: Other (please specify in the IIR)	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)									
2C1	Iron and steel production	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)	24.8% (L1, T1)	24.5% (L1, T1)	9.1% (L1, T1)				7.8% (L1, T1)		15.4% (L1, T1)
2D3a	Domestic solvent use including fungicides	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)			4.7% (L1)						
2D3b	Road paving with asphalt	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)									
2D3d	Coating applications	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)									
2D3g	Chemical products	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)									
2D3i	Other solvent use (please specify in the IIR)	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)									
2G	Other product use (please specify in the IIR)	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)		8.1% (L1, T1)				28.9% (L1, T1)			8.3% (L1, T1)
2H1	Pulp and paper industry	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)									
2I	Wood processing	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)									
2K	Consumption of POPs and heavy metals (e.g. electrical and scientific equipment)	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)			8.5% (L1)						
3B1a	Manure management - Dairy cattle	AGRICULTURE									
3B1b	Manure management - Non-dairy cattle	AGRICULTURE									
3B2	Manure management - Sheep	AGRICULTURE									
3B3	Manure management - Swine	AGRICULTURE									
3B4gi	Manure mangement - Laying hens	AGRICULTURE									
3B4gii	Manure mangement - Broilers	AGRICULTURE									
3B4h	Manure management - Other animals (please specify in IIR)	AGRICULTURE									
3Da1	Inorganic N-fertilizers (includes also urea application)	AGRICULTURE									
3Da2a	Animal manure applied to soils	AGRICULTURE									
3Da3	Urine and dung deposited by grazing animals	AGRICULTURE									
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	AGRICULTURE									
3F	Field burning of agricultural residues	AGRICULTURE		11.9% (L1)							
5C1bi	Industrial waste incineration	WASTE									
5C1biii	Clinical waste incineration	WASTE			1% (T1)						
	TOTAL		83.7	88.7	87.7	84.2	85.1	92.4	83.3	92.4	85.1

NFR sectors			POPs (1) (from 1990)								
			PCDD/ PCDF (dioxins/ furans)	PAHs					HCB	PCBs
				benzo(a) pyrene	benzo(b) fluoranthene	benzo(k) fluoranthene	Indeno (1,2,3-cd) pyrene	Total 1-4		
NFR Code	Longname		g I-TEQ	t	t	t	t	t	kg	kg
1A1a	Public electricity and heat production	ENERGY							18.6% (L1, T1)	
1A1b	Petroleum refining									
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals									
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print									
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco									
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals									
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)									
1A3ai(i)	International aviation LTO (civil)									
1A3bi	Road transport: Passenger cars									
1A3bii	Road transport: Light duty vehicles									
1A3biii	Road transport: Heavy duty vehicles and buses									
1A3biv	Road transport: Mopeds & motorcycles									
1A3bv	Road transport: Gasoline evaporation									
1A3bvi	Road transport: Automobile tyre and brake wear									
1A3dii	National navigation (shipping)									
1A4ai	Commercial/institutional: Stationary									
1A4bi	Residential: Stationary		27.9% (L1, T1)					38.2% (L1, T1)	12.7% (L1, T1)	
1A4ci	Agriculture/Forestry/Fishing: Stationary									
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery									
1B2aiv	Fugitive emissions oil: Refining / storage									
1B2av	Distribution of oil products									
1B2d	Other fugitive emissions from energy production									
2A2	Lime production	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)								
2A3	Glass production									
2A5a	Quarrying and mining of minerals other than coal									
2A5b	Construction and demolition									
2B10a	Chemical industry: Other (please specify in the IIR)									
2C1	Iron and steel production		9.4% (L1)							
2D3a	Domestic solvent use including fungicides									
2D3b	Road paving with asphalt									
2D3d	Coating applications									
2D3g	Chemical products									
2D3i	Other solvent use (please specify in the IIR)		32.4% (L1, T1)					45.8% (L1, T1)		
2G	Other product use (please specify in the IIR)									
2H1	Pulp and paper industry									
2I	Wood processing									
2K	Consumption of POPs and heavy metals (e.g. electrical and scientific equipment)									17.7% (L1, T1)
3B1a	Manure management - Dairy cattle	AGRICULTURE								
3B1b	Manure management - Non-dairy cattle									
3B2	Manure management - Sheep									
3B3	Manure management - Swine									
3B4gi	Manure mangement - Laying hens									
3B4gii	Manure mangement - Broilers									
3B4h	Manure management - Other animals (please specify in IIR)									
3Da1	Inorganic N-fertilizers (includes also urea application)									
3Da2a	Animal manure applied to soils									
3Da3	Urine and dung deposited by grazing animals									
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products									
3F	Field burning of agricultural residues									
5C1bi	Industrial waste incineration	WASTE	13% (L1)							75.8% (L1, T1)
5C1biii	Clinical waste incineration		4.3% (T1)						59.1% (L1, T1)	
	TOTAL		87.0					84.0	90.4	93.5

1.8 Information on QA/QC

APA is the national entity responsible for the Quality Assurance and Quality Control (QA\QC) System of the inventory (Figure 1-2).

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, namely QC1.

Each Involved Entity (IE) within SNIERPA contributing with data to the inventory is responsible for the quality of their own data. A request for information on the specific QC or QA procedures is to be sent to IEs in order to document such procedures, its results and also the uncertainty calculations.

A QA/QC coordinator is designated 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 SCGQ is composed of a Quality Control and Quality Assurance Programme and a Procedures Manual. The first schedules the application of the general (QC1) and specific (QC2) Quality Control as well as Quality Assurance (QA) procedures, described in detail in the Manual. The procedures were defined according to Good Practice and Uncertainty Management Guide (IPCC, 2000 and 2006) and adapted to the INERPA characteristics.

Quality Control tier 1 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 NIR and NFR tables. Documentation and archiving procedures include checks on information handling which should enable the recalculation of the inventory. QC tier 2 procedures, on the other hand, include technical verifications of emission factors, activity data, and comparison of results among different approaches.

Both QC1 and QC2 procedures are to be applied by the inventory team during the inventory calculation and compilation following a yearly defined QA/QC plan.

The sectorial 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, APA 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.

The results of quality control of national submissions under the European Regulation No 525/2013 on a CO_2 Monitoring Mechanism (MMR), e.g. completeness checks, consistency checks, and the issues raised during the annual review process of the UNFCCC or the reviews in the context of the European Effort Sharing Decision (ESD) and the National Emission Ceiling Directive (NECD), constitute additional processes of technical verification and represent valuable sources of error detection and methodological improvement.

1.9 General uncertainty assessment

The 2022 submission includes for the first time an uncertainty assessment, which comprises a qualitative and a quantitative uncertainty analysis for the main pollutants (SO_2, NOx, NMVOC, NH_3 and $PM_{2.5}$).

1.9.1 Method used

The methodology used for the assessment of uncertainty followed the guidance from the "EMEP/EEA air pollutant emission inventory guidebook 2019 (EEA 2019)".

The Tier 1 methodology was applied for SO_2, NOx, NMVOC, NH_3, and $PM_{2.5}$, by using the error propagation method. In this approach, the uncertainties for a specific source category are estimated and combined to an overall uncertainty of each pollutant.

More detailed information can be found in Annex G of this report.

1.9.2 Data sources

In order to estimate the overall uncertainty, the uncertainty of activity data and emission factor, has to be quantified.

For this first uncertainty analysis exercise, the indicative error ranges in activity data proposed by the EMEP/EEA air pollutant emission inventory guidebook 2019 (EEA 2019) (Chapter 5/ Table 2-1) are used. Nevertheless, for some sectors/categories and whenever possible, the uncertainties of activity data are based on the GHG uncertainty analysis.

Uncertainties of emission factors are based on the qualitative ratings following the EMEP/EEA air pollutant emission inventory guidebook 2019 (EEA 2019). Therefore the arithmetic mean value of the proposed upper and lower emission factor uncertainty was calculated and used for the calculation of the overall combined uncertainty.

The quality of estimates has been rated using qualitative indicators as suggested in Chapter 5 (Table 2-2) of the EMEP/EEA air pollutant emission inventory guidebook 2019 (EEA 2019). The definition of the ratings is given in Table 1.4, the ratings for the emission estimates are presented in Table 1.5.

Table 1.4: Rating definitions

Rating	Definition	Typical Error Range
A	An estimate based on a large number of measurements made at a large number of facilities or individual sources across a comprehensive range of operating conditions that fully represent the sector	10 to 30%
B	An estimate based on a large number of measurements made at a large number of facilities or individual sources across a range of operating conditions that represent a large part of the sector	20 to 60%
C	An estimate based on a number of measurements made at a small number of representative facilities or individual sources across a smaller range of operating conditions, or an engineering judgement based on a number of relevant facts. An estimate based on a large number of measurements across a range of conditions for a source which is complex and/or variable.	50 to 200%
D	An estimate based on single measurements, or an engineering calculation derived from a number of relevant facts. An estimate based on a large number of measurements across a range of conditions for a source which is particularly complex and/or variable	100 to 300%
E	An estimate based on an engineering calculation derived from assumptions only An estimate based on a limited number of measurements for a source which is particularly complex and/or variable.	Order of magnitude
Calc	Quantitative uncertainty assessment based on sectoral analysis	*

1.9.3 Uncertainty results

The quantitative uncertainty assessment was performed with the Approach 1 according to (EEA 2019) for the air pollutants SO_2, NOx, NMVOC, NH_3, and $PM_{2.5}$ in the year 2020 and the respective level and trend uncertainties. The basis for this assessment is the qualitative rating and sector quantitative data as presented in Table 1.5.

Table 1.5: Emission quality data ratings and calculated uncertainties by main NFR source categories

NFR	Description	NOx (as NO_2)	NMVOC	SOx (as SO_2)	NH3	PM2.5
1A1a	Public electricity and heat production	A	C	A	E	C
1A1b	Petroleum refining	B	C	A	-	C
1A2*	Stationary combustion	B	C	A	E	C
1A2*	Mobile Combustion	B	C	A	E	C
1A3a	Civil Aviation	D	D	B	-	D
1A3b	Road transport	C	C	A	E	C
1A3c	Railways	D	D	B	E	D
1A3d	National navigation	D	D	B	-	D
1A4a	Commercial/institutional	C	C	A	E	D
1A4b	Residential	C	C	A	E	D
1A4c	Agriculture/Forestry/Fishing	C	C	A	E	D
1A5	Other	D	D	B	-	D
1B2	Fugitive emissions from energy production	C	C	C	E	D
2A	Mineral Products	-	C	-	C	C
2B	Chemical industry	B/C	C	C	B/C	C
2C	Metal production	C	C	C	-	C
2D	Solvent Use	-	B/C	-	C	C
2G	Other product manufacture and use	C	C	C	C	C
2H	Other Processes	C	C	B	-	C
3B	Manure management	D	D	-	D	E
3D	Agricultural Soils	D	D	-	D	E
3F	Field burning of agricultural residues	D	D	D	D	E
5A	Solid waste disposal on land	**Calc**	**Calc**	**Calc**	**Calc**	**Calc**
5B	Biological treatment of waste	-	-	-	**Calc**	-
5C	Waste incineration	**Calc**	**Calc**	**Calc**	**Calc**	**Calc**
5D	Wastewater handling	-	**Calc**	-	-	-
5E	Other waste	-	-	-	-	**Calc**

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

The high levels of the overall uncertainty estimated for each pollutant are considered to be related in part to the uncertainty assessment approach followed, which was based in majority on default range values for uncertainty of AD and EF. This exercise should be improved in the future using more specific uncertainty values.

Table 1.6: Emission quality data rResult of overall uncertainty for the main pollutants (NOx, NMVOC, SO2; NH3 and CO)

Pollutant	Unit	Emissions 2020	Level uncertainty 2020 (%)	Trend uncertainty 2020 (%)
NOx	kt	121.7	33.7	0.6
NMVOC	kt	152.4	30.9	3.2
SO_2	kt	27.2	16.6	0.0
NH_3	kt	56.4	77.3	7.9
$PM_{2.5}$	kt	46.2	91.6	5.5

A more detailed presentation of the uncertainties on sectoral leval per pollutant is given in Annex G of this report.

1.10 Overview of the completeness

The national inventory comprehends emissions occurring in the whole Portuguese territory, i.e., mainland Portugal and the two autonomous regions of Madeira and Azores Islands. Emissions from air traffic and navigation realized between places in territorial Portugal, including movements between mainland and islands, are also include in national emission total.

The inventory covers several air pollutants: GHGs emissions (not covered in this report), carbon monoxide (CO), nitrogen oxides (NO_x), sulphur oxides (SO_x), non-methane volatile organic compounds (NMVOC), ammonia (NH_3), Particulate Matter, Heavy Metals and POPs.

An effort has been done in the late years in order to extend the scope of the inventory in terms of substances and the source categories covered. The situation has been continuously improved, however, some pollutants/categories are still not quantified.

Table A-1 included in ANNEX A: COMPLETENESS AND KEY CATEGORIES, indicates the source categories/pollutants emissions reported as “NE” (Not Estimated). These situations result, in the majority of cases, from a lack of methodological guidance (e.g. non-availability of EF). In other cases, they may correspond to areas where further work is needed at national level, and consequently they have or will be considered in the methodological development programme (PDM) for future inventory improvement.

Table A-2 specifies the emission sources estimated but included elsewhere in the inventory instead of under the expected source category. This table is accompanied by information where, in the inventory, the emissions for the displaced source category have been included.

2 Emission Trends

Table of Contents

2 Emission Trends 2-1

List of Figures

Figure 2-1: Hydraulic index and SO_2 emissions from Public Electricity and Heat Production 2-3

Figure 2-2: Main pollutants and particulate matter - total emissions 2-4

Figure 2-3: Percentage variation of main pollutant emissions: 1990-2020 period 2-4

Figure 2-4: Heavy metals total emissions 2-6

Figure 2-5: Percentage variation of HM emissions: 1990-2020 period 2-7

Figure 2-6: Persistent organic pollutant total emissions 2-8

Figure 2-7: Percentage variation of POP emissions: 1990-2020 period 2-8

List of Tables

Table 2.1: Main pollutants and particulate matter total emissions 2-5

Table 2.2: Heavy metals total emissions 2-7

Table 2.3: Persistent organic pollutant total emissions 2-9

2 Emission Trends

Updated: March 2022

SO_x emissions are generated in majority in the energy sector (87.5% of total emissions in 2020) which is a major consumer of fossil fuels. Within this sector, the combustion in manufacturing industries, with approximately 39% of national total emissions in 2020, and the energy industries, representing 31% of national total emissions in 2020, followed by the fugitive emissions from refining (~11% of national total emissions in 2020), represent the major sources.

The variation of SO_x emissions in the period 1990-2020 registered an overall trend variation of -88% for the same period, that resulted from the significant decrease of most of sub-categories: energy industries –94%, manufacturing industries –79%, transport -91% and combustion of other sectors -91%.

In the past, oil and coal represented the biggest share of the fuel mix used in thermal electrical production in the country. The situation changed along the years with the implementation of several measures that had a positive effect in the emissions levels, such as the introduction of natural gas (1997), the installation of new combined cycle thermoelectric plants using natural gas (1999), the progressive installation of co-generation units, the amelioration of energetic and technologic efficiency of industrial processes, or the introduction of stricter laws regulating the quality of fuels, e.g. for residual fuel oil (Decree-Law 281/2000 of 10th November). The introduction of natural gas and its increasing use since 1997 was a major step in the control of SO_x emissions. In 2020, natural gas represented the main fuel used in electric thermal generation.

Until the early 2000's, SO_x emissions presented a significant inter-annual variation which was related to the pronounced fluctuations of hydroelectric power generation that is highly dependent on annual variations in precipitation (see figure below). This relation was broken particularly in the late years, after the implementation of new desulphurization systems in two Large Point Source Energy Plants in Mainland Portugal. As a consequence, SO_x emissions from the energy industries registered a strong reduction since 2007 (approx. -89% in 2020 as compared to 2007).

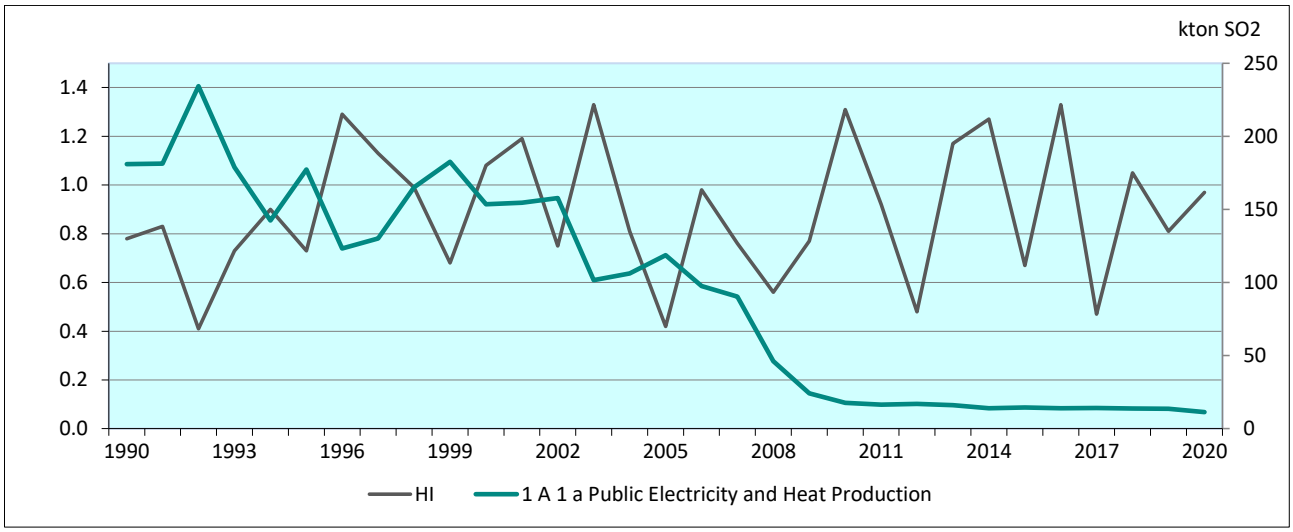
This reduction also reflects the increasing relevance of renewable energy in the energy produced in Portugal in latest years.

The decline in emissions in electricity production in 2020 compared to the previous year (-17% SOx) is the result of the 55% reduction in the use of coal in thermal production in view of the closure of the two Portuguese coal plants until the end of 2021, and the greater proportion of the renewable domestic production in 2020, due in particular to a more favourable hydraulic availability (IH = 0.97) and a higher hydroelectric production (+33%), and an increase of biomass use in electricity production (+29%). The use of NG in energy production rose 4% in 2020 compared to 2019.

In 2020 there was a general decrease of emissions as compared to 2019 for most of the categories as a result of the COVID-19 pandemic outbreak on the national economy and the population activity.

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).

Emissions related to the energy sector present the larger reductions due to the reduced consumption of petroleum products. The primary energy consumption decreased by 8% in 2020 compared to 2019. The decrease of emissions was also associated with the reduction in the refining of fuels and the drop in fugitive emissions, namely in road transport.



Note: HI = 1 corresponds to the average hydrologic availability.
Source: EDP; REN.

Figure 2-1: Hydraulic index and SO_2 emissions from Public Electricity and Heat Production

Energy is also the major responsible sector for emissions of NO_x and CO, representing, respectively, approx. 87% and 84% of 2020 national total emissions. Its contribution for NMVOC emissions is also significant, together with Industrial Processes and Products Use.

Within energy, transportation is responsible for the major share of NO_x, CO and NMVOC emissions: approx. 44% for NO_x, 23% for CO and 8% for NMVOC of 2020 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, limited the growth of these emissions or even its decrease. In fact, the situation started to change in the last years, as transport emissions growth has first stabilised and even started to decline in the most recent years. The emissions variation registered in the transport road sector in the period 1990-2020 for CO, NMVOC and NO_x emissions are, respectively, -89%, -87% and -45%.

Other sectors (commercial/institutional, residential and agriculture/ forestry) within energy, also amount for a significant share of CO: approx. 40% of 2020 totals.

NH_3 is primarily generated in biological systems, such as agriculture soil (45% of 2020 national totals), manure management systems (38% of 2020 national totals), chemical industry and decomposition of municipal wastes. Road transport represents a smaller amount of emissions with 1.1% of 2020 national total, but has grown significantly since 1990 (~1000%). The overall evolution of ammonia in the period analysed is downwards with a -18% variation between 1990 and 2020.

A significant share of particulate matter is generated in other sectors (residential) which represents approximately 39% of 2020 national total PM2.5 emissions and in combustion in manufacturing industry (~13%), and the estimates show overwhole negative trends since 1990 for TSP (-19%), PM10 (-30%), PM2.5 (-32%) and BC (-40%).

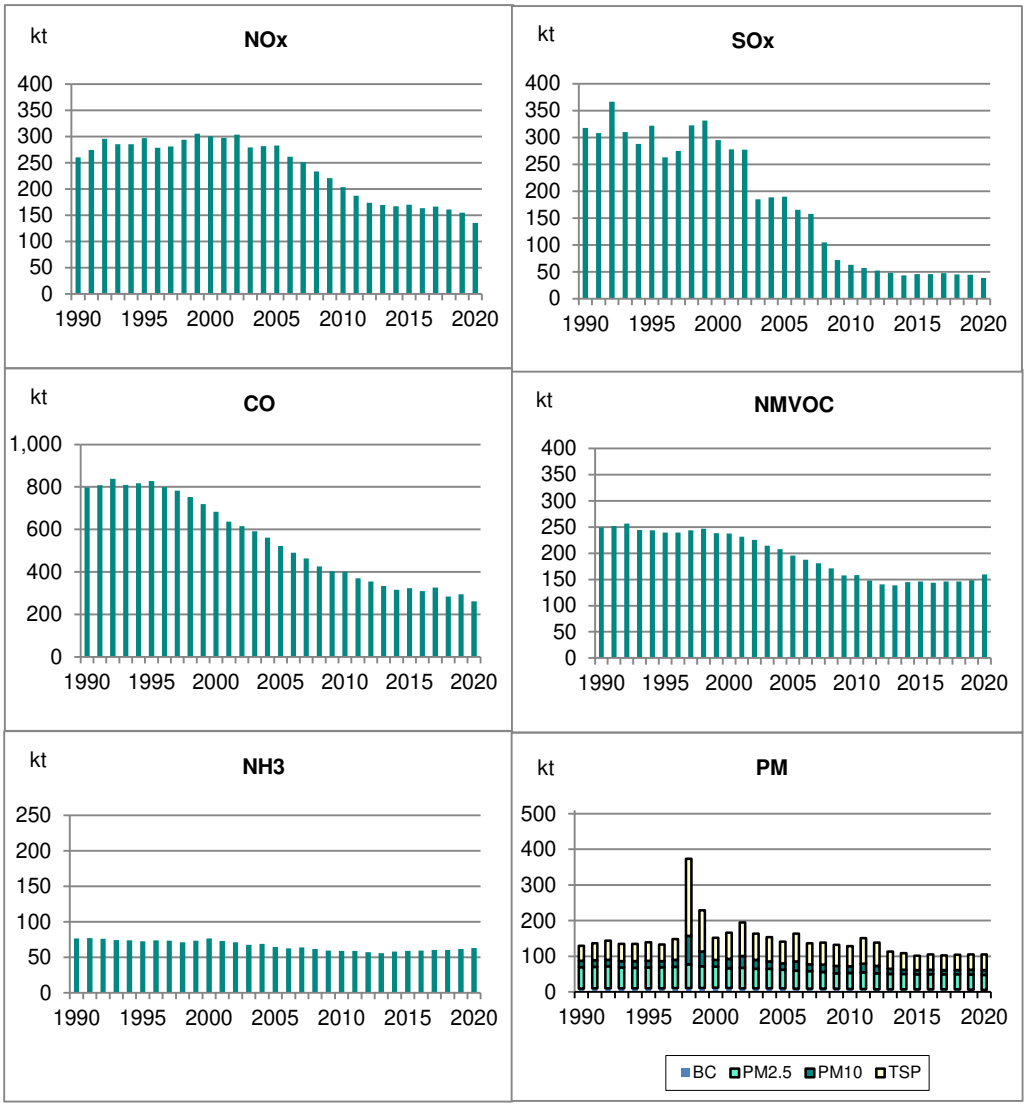


Figure 2-2: Main pollutants and particulate matter - total emissions

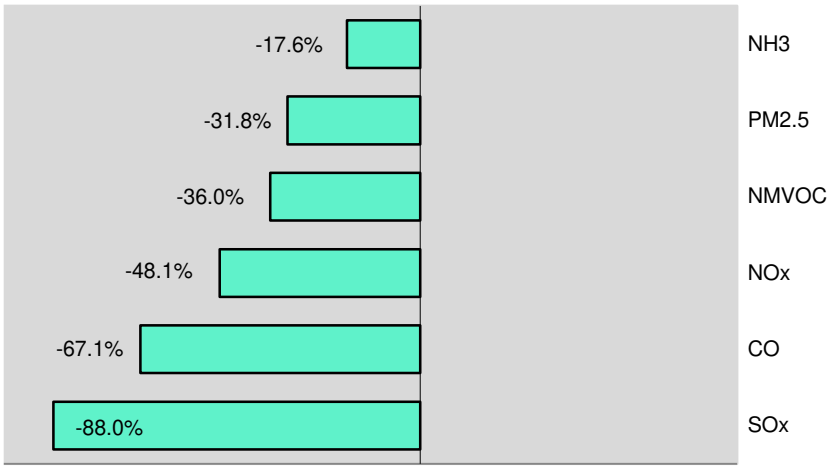


Figure 2-3: Percentage variation of main pollutant emissions: 1990-2020 period

Table 2.1: Main pollutants and particulate matter total emissions

	NOx	NMVOC	SOx	NH3	PM2.5	PM10	TSP	BC	CO
	kt	kt	kt	kt	kt	kt	kt	kt	kt
1990	260.1	249.4	317.9	76.8	69.4	86.9	129.1	9.2	797.3
1991	274.4	251.5	308.2	76.9	70.4	88.6	136.5	9.4	808.5
1992	295.6	256.7	366.7	76.0	71.6	90.1	143.3	9.6	838.2
1993	285.6	244.2	309.7	74.5	67.8	86.2	134.9	9.5	809.6
1994	285.5	243.7	288.2	73.8	67.3	86.0	134.7	9.8	817.3
1995	297.0	239.3	322.0	72.4	67.9	87.5	139.4	10.0	827.3
1996	278.9	239.3	262.9	74.0	68.9	86.0	132.7	10.2	799.1
1997	281.2	243.6	275.1	73.4	70.3	90.1	148.3	10.5	781.9
1998	294.2	246.8	322.3	71.4	77.6	157.3	373.7	10.9	751.9
1999	305.8	238.2	331.2	73.7	72.2	112.9	228.9	11.0	718.7
2000	300.6	237.8	295.0	76.6	71.0	90.2	151.9	11.4	682.7
2001	297.9	231.3	277.9	73.2	66.8	92.4	166.3	10.7	636.2
2002	303.5	225.2	277.0	71.2	67.1	100.4	194.7	10.3	615.0
2003	279.0	214.3	185.2	67.5	64.2	89.3	163.6	9.9	591.0
2004	281.5	207.4	188.6	68.9	64.6	85.7	153.7	9.9	561.5
2005	283.1	195.8	189.9	64.5	62.2	80.2	141.1	9.6	522.8
2006	261.6	187.6	165.1	62.7	59.1	85.6	163.6	9.3	490.1
2007	251.3	180.7	157.7	64.0	58.2	77.1	136.6	9.1	464.2
2008	233.4	171.3	104.4	62.0	55.5	76.3	138.0	8.8	425.3
2009	220.7	157.8	72.0	59.5	52.0	72.7	131.8	8.6	402.7
2010	203.8	158.2	63.1	58.9	53.0	71.9	128.4	8.5	402.1
2011	186.9	147.7	57.1	59.2	54.5	78.9	150.4	7.9	369.5
2012	173.6	140.8	52.4	57.4	52.0	72.8	137.9	7.4	355.2
2013	169.7	138.7	48.1	55.9	50.2	64.5	113.4	7.1	334.4
2014	167.3	144.7	43.6	58.2	49.9	61.7	108.4	7.0	316.6
2015	170.2	146.1	45.8	59.2	49.6	61.0	101.3	7.0	324.1
2016	163.2	143.7	45.8	59.7	49.1	61.6	105.2	6.9	310.6
2017	166.4	145.8	47.3	60.4	49.2	61.2	102.8	6.9	326.7
2018	160.7	146.1	45.2	60.5	48.9	61.2	103.8	6.7	284.8
2019	154.6	148.4	44.3	61.9	48.9	61.7	104.8	6.6	294.3
2020	135.0	159.6	38.3	63.3	47.3	61.2	104.6	5.6	262.3

Emissions of heavy metals refer in majority to energy-related sources and associated with fuel combustion. They are directly related to the type of fuel used (and its HM content) in power and heat generating facilities and in industrial facilities.

With the exception of selenium, all pollutants present downward trends from 1990 to 2020.

The lead emissions registered from 1990 to 2020 a decreasing trend, with a reduction of approx. 96% which are mainly related with the reductions of emissions in road transport emissions and are explained by the phased out of use of leaded petrol within the EU context.

Nickel (Ni) and mercury (Hg) registered significant reductions since 1990, respectively 82% and 44%, that are related to the amelioration of the fuels used and the fuel mix used in public power and heat generating facilities and in industrial facilities.

Copper emissions which are largely associated with road transportation whichrepresent more than 50% of national total copper emissions in 2020, shows a decreasing tendency in the period 1990-2020. Zinc emissions are related to category 2.C.1 Iron and Steel (15% of total emissions) and to Combustion in industry (22%); the remaining part are related to energy categories, in particular 1.A.4.b.i (residential combustion) (32%).

Selenium emissions are principally related to the evolution of glass production sector (2.A.3) representing 77% of the total emissions in 2020, show an overall increasing trend of 65% from 1990 to 2020.

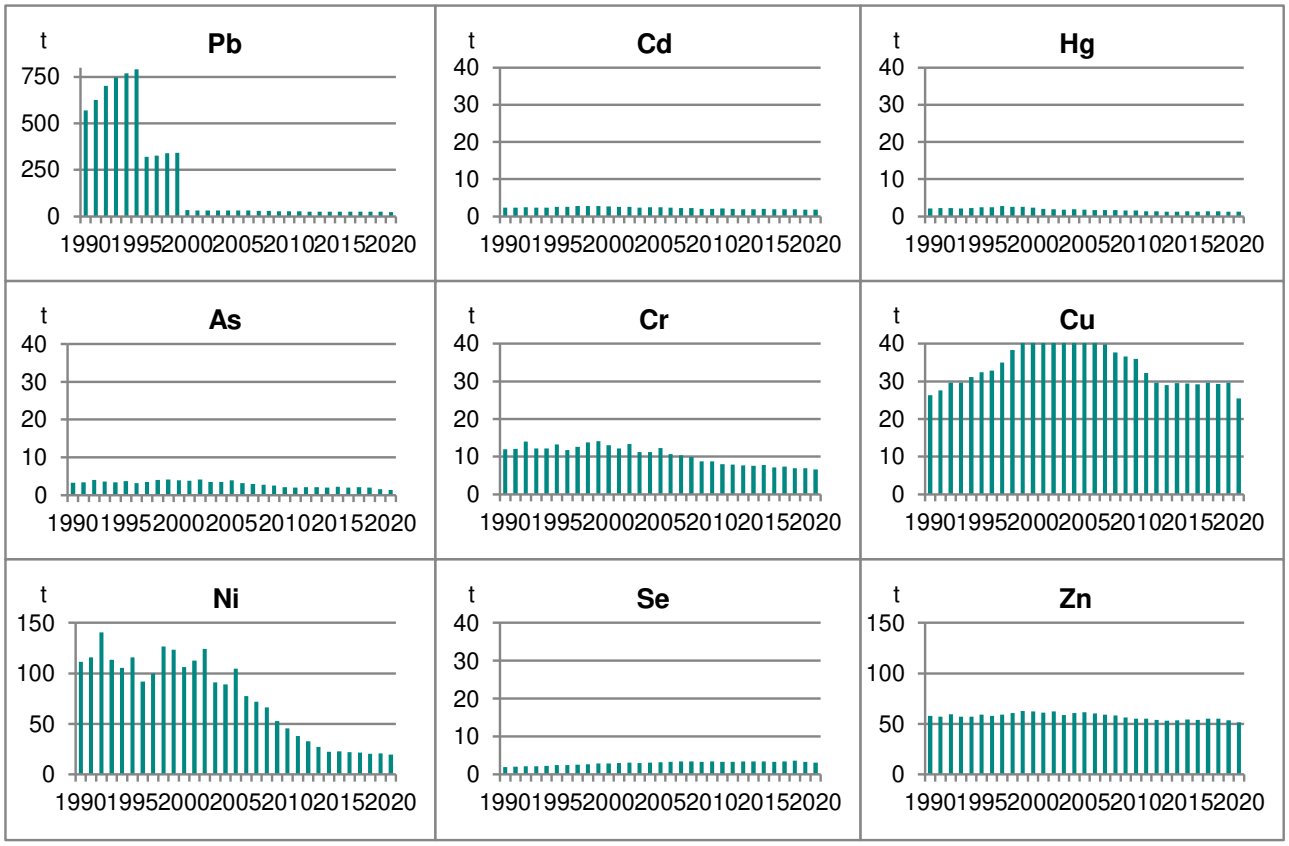


Figure 2-4: Heavy metals total emissions

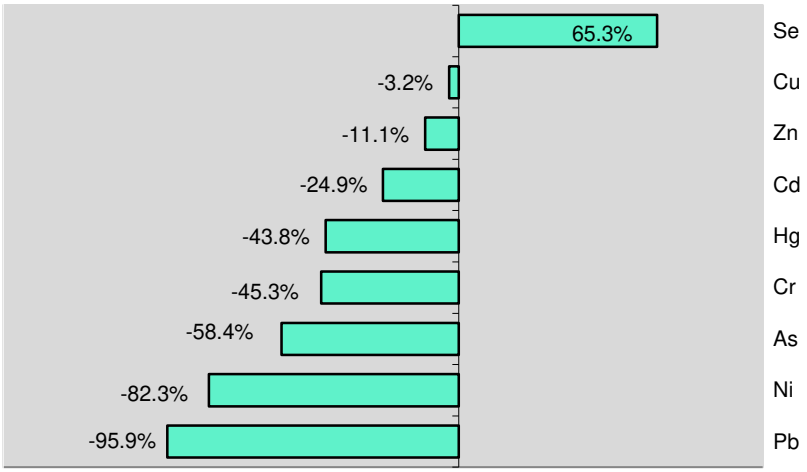


Figure 2-5: Percentage variation of HM emissions: 1990-2020 period

Table 2.2: Heavy metals total emissions

	Pb t	Cd t	Hg t	As t	Cr t	Cu t	Ni t	Se t	Zn t
1990	570.3	2.4	2.2	3.3	12.0	26.3	111.4	1.9	57.9
1991	625.6	2.4	2.2	3.4	12.1	27.6	115.8	2.1	57.0
1992	702.1	2.4	2.2	4.1	14.0	29.6	140.5	2.2	59.4
1993	746.0	2.3	2.2	3.6	12.2	29.7	113.4	2.2	57.3
1994	768.3	2.4	2.3	3.4	12.1	31.1	105.4	2.3	57.0
1995	789.7	2.5	2.4	3.7	13.2	32.4	115.6	2.5	59.2
1996	320.8	2.6	2.5	3.2	11.7	32.9	91.7	2.5	57.9
1997	327.1	2.8	2.8	3.5	12.6	35.0	99.9	2.6	59.1
1998	338.7	2.8	2.6	4.0	13.8	38.3	126.4	2.7	60.8
1999	341.7	2.7	2.5	4.2	14.1	40.4	123.2	2.9	62.7
2000	34.6	2.7	2.3	3.9	13.0	42.5	106.4	2.9	62.3
2001	32.0	2.6	2.0	3.9	12.1	43.7	112.4	3.0	61.3
2002	32.3	2.5	2.0	4.2	13.3	45.3	124.0	3.1	62.1
2003	31.7	2.4	1.8	3.5	11.2	44.1	91.1	3.1	58.9
2004	32.0	2.4	1.9	3.6	11.2	45.5	89.0	3.2	60.6
2005	31.6	2.4	1.8	3.9	12.3	45.0	104.5	3.2	61.5
2006	31.3	2.4	1.8	3.2	10.7	40.7	77.7	3.3	60.2
2007	30.8	2.3	1.7	3.0	10.3	39.8	71.8	3.4	59.2
2008	30.4	2.2	1.7	2.7	9.9	37.7	66.4	3.4	58.4
2009	28.4	2.1	1.6	2.6	8.8	36.6	52.6	3.3	56.4
2010	28.6	2.0	1.6	2.1	8.8	35.9	45.7	3.4	55.0
2011	27.9	2.1	1.4	2.0	8.0	32.2	37.9	3.3	55.2
2012	26.3	2.0	1.4	2.2	7.8	29.7	32.7	3.4	53.8
2013	25.8	1.9	1.3	2.1	7.7	29.0	27.2	3.4	53.2
2014	26.1	1.9	1.3	2.0	7.5	29.6	22.4	3.5	53.5
2015	25.6	2.0	1.4	2.2	7.7	29.4	23.0	3.4	54.2
2016	25.1	1.9	1.3	2.0	7.1	29.2	21.9	3.3	54.1
2017	25.6	1.9	1.4	2.1	7.4	29.6	21.8	3.4	55.2
2018	26.2	1.9	1.3	2.0	7.0	29.3	20.6	3.7	55.3
2019	25.3	1.8	1.3	1.6	6.9	29.7	21.0	3.4	53.6
2020	23.1	1.8	1.2	1.4	6.6	25.5	19.8	3.2	51.5

Main sources of dioxines emissions refer to the incineration of waste (17 % of 2020 national total emissions), the combustion in the residential sector (28 % of 2020 national total emissions) and the use of solvent and other product in different activities (32 % of 2020 national total emissions). These emissions registered an overall decrease of -88 %) in the period 1990-2020. Polycyclic aromatic hydrocarbons (PAH) emissions are related in majority to the residential – stationary sector (1.A.4.b.i) and the use of solvent and other product. HCBs emissions occur in energy industries (1.A.1), the combustion in the residential sector – stationary sector (1.A.4.b.i) and waste incineration sources (5.C) and. Polychlorobiphenyls (PCB) estimated emissions are related to the consumption of POPs and heavy metals (2.K) and in majority to the incineration of industrial waste (5.C).

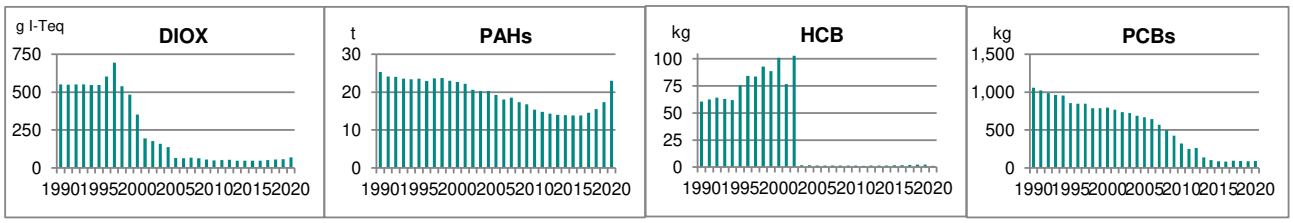


Figure 2-6: Persistent organic pollutant total emissions

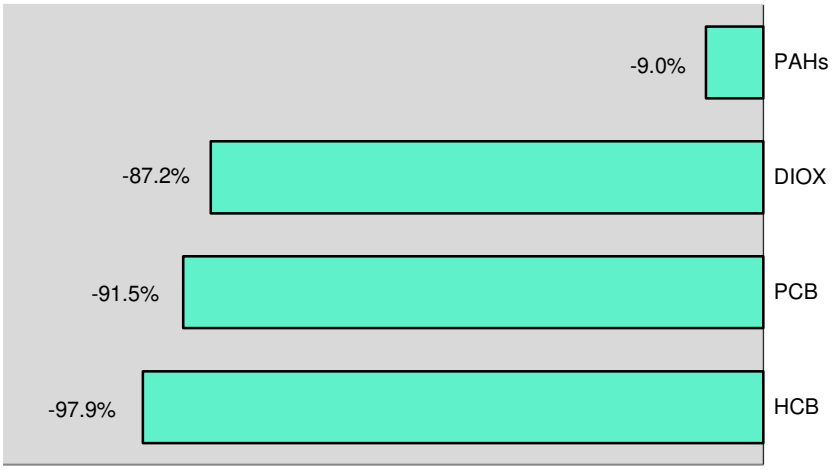


Figure 2-7: Percentage variation of POP emissions: 1990-2020 period

Table 2.3: Persistent organic pollutant total emissions

	DIOX g I-TEQ	PAHs t	HCB kg	PCB kg
1990	550.5	25.3	60.4	1,059.1
1991	548.4	24.1	62.4	1,021.9
1992	549.8	24.0	64.2	985.7
1993	549.8	23.6	63.1	963.9
1994	546.8	23.4	61.9	953.7
1995	547.7	23.6	75.7	854.0
1996	603.4	22.9	84.2	847.4
1997	693.1	23.6	83.7	847.8
1998	538.3	23.7	92.8	788.8
1999	483.6	23.0	88.7	787.5
2000	351.6	22.7	100.8	794.5
2001	194.2	22.2	76.6	769.5
2002	176.5	20.6	102.7	735.1
2003	159.7	20.3	1.7	724.6
2004	137.4	20.3	1.7	686.4
2005	66.0	19.2	1.7	670.1
2006	63.1	18.0	1.6	643.1
2007	66.7	18.5	1.6	570.2
2008	63.8	17.4	1.6	496.7
2009	55.2	16.8	1.7	424.2
2010	49.3	15.3	1.4	322.6
2011	51.4	14.8	1.4	251.0
2012	53.3	14.3	1.5	261.8
2013	48.3	14.0	1.5	139.9
2014	48.1	13.9	1.6	105.3
2015	47.7	13.9	1.7	85.9
2016	48.7	13.8	1.9	84.0
2017	51.3	14.6	2.0	95.8
2018	55.3	15.5	2.4	91.9
2019	57.3	17.4	2.4	89.4
2020	70.7	23.0	1.3	90.0

3 Energy (NFR Sector 1)

Table of Contents

3 Energy (NFR Sector 1) 3-1

3.1 International Bunkers Fuels 3-10

3.1.1 International aviation bunkers 3-10

3.1.2 International marine bunkers 3-11

3.2 Energy Industries (NFR 1.A.1) 3-12

3.2.1 Public Electricity and Heat Production (NFR 1.A.1.a) 3-12

3.2.2 Petroleum Refining (NFR 1.A.1.b) 3-28

3.2.3 Other Energy Industries (NFR 1.A.1.c) 3-32

3.3 Manufacturing Industries and Construction (NFR 1.A.2) 3-36

3.3.1 Methodology 3-36

3.3.2 Activity data 3-39

3.3.3 Emission Factors 3-56

3.3.4 Recalculations 3-69

3.3.5 Further Improvements 3-69

3.4 Transport (NFR 1.A.3) 3-70

3.4.1 Civil Aviation (NFR 1.A.3.a) 3-70

3.4.2 Road Transportation (NFR 1.A.3.b) 3-81

3.4.3 Railways (NFR 1.A.3.c) 3-94

3.4.4 Water Borne Navigation (NFR 1.A.3.d) 3-97

3.5 Small Combustion (NFR 1.A.4) 3-103

3.5.1 Category description 3-103

3.5.2 Methodology 3-104

3.5.3 Activity Data 3-107

3.5.4 Emission Factors 3-116
3.5.5 Category-specific QA/QC and Verification 3-121
3.5.6 Recalculations 3-124
3.5.7 Further Improvements 3-124
3.6 Other (including Military) (NFR 1.A.5) 3-126
3.6.1 Military Aviation (NFR 1.A.5.b) 3-126
3.7 Fugitive Emissions from Solid Fuels (NFR 1.B.1) 3-128
3.7.1 Coal Mining and Handling (NFR 1.B.1.a) 3-128
3.7.2 Solid fuels: Solid fuel transformation (NFR 1.B.1.b) 3-130
3.8 Fugitive Emissions from Oil Production and Refining (NFR 1.B.2.a) 3-132
3.8.1 Category description 3-132
3.8.2 Refining and Storage (NFR 1.B.2.a.iv) 3-134
3.8.3 Distribution of Oil Products (1.B.2.a.v) 3-145
3.9 Fugitive Emissions from Natural Gas (NFR 1.B.2.b.) 3-153
3.9.1 Category description 3-153
3.9.2 Methodology 3-153
3.9.3 Emission Factors 3-154
3.9.4 Activity data 3-155
3.9.5 Recalculations 3-156
3.9.6 Further Improvements 3-156
3.10 Venting and Flaring in Oil Industry (1.B.2.c) 3-157
3.10.1 Category description 3-157
3.10.2 Methodology 3-157
3.10.3 Emission Factors 3-158
3.10.4 Activity data 3-159
3.10.5 Recalculations 3-159
3.10.6 Further Improvements 3-159

List of Figures

Figure 3-1: International navigation and aviation bunkers 3-10
Figure 3-2: International aviation bunkers 3-11
Figure 3-3: International marine bunkers 3-11
Figure 3-4: Implied Emission Factors for NOx estimated on monitoring by type of Plant 3-18

Figure 3-5: Trends of sulphur content by fuel type 3-19
Figure 3-6: Trends of fuel consumption per fuel type 3-22
Figure 3-7: Trends of fuel consumption in Azores and Madeira Archipelagos 3-23
Figure 3-8: Trends in consumption of fuels in non-public co-generation plants 3-24
Figure 3-9: Comparison of total fuel consumption in large power plants, between values used in the inventory (INERPA) and in the Energy Balance 3-25
Figure 3-10: Comparison of fuel consumption between DGEG energy balance and IEA energy statistics.. 3-26
Figure 3-11: Trends of sulphur content 3-30
Figure 3-12: Fuel consumption 3-31
Figure 3-13: Net Calorific Value (NCV) expressed in MJ/kg by fuel type 3-31
Figure 3-14: Coking coal consumption in the coke plant 3-34
Figure 3-15: Consumption of fuels in co-generation in city gas production 3-35
Figure 3-16: Distribution of Large Point Sources in Portugal mainland 3-40
Figure 3-17: General procedure for emissions estimates 3-41
Figure 3-18: Total Energy Consumption in Manufacturing Industries and Construction 3-44
Figure 3-19: Share of energy consumption by source & Emissions intensity 3-45
Figure 3-20: Share of energy consumption by source & Greenhouse gases emissions intensity 3-46
Figure 3-21: Share of energy consumption by source & Greenhouse gases emissions intensity 3-47
Figure 3-22: Share of energy consumption by source & Greenhouse gases emissions intensity 3-48
Figure 3-23: Share of energy consumption by source & Greenhouse gases emissions intensity 3-49
Figure 3-24: Share of energy consumption by source & Greenhouse gases emissions intensity 3-50
Figure 3-25: Comparison of total LPS consumption in Paper Pulp units with the reported consumption in the EB for the sector “Paper pulp and paper production” 3-52
Figure 3-26: Comparison of total LPS consumption in Petrochemical units with the reported consumption in the EB for the sector “Chemical and Plastics” 3-53
Figure 3-27: Comparison of total LPS consumption in Cement Plant with the reported consumption in the EB for the sector “Cement and Lime” (Due to confidentiality issues y axis values are not shown) 3-54
Figure 3-28: Total paper pulp production: Kraft and sulphide paper pulp 3-55
Figure 3-29: Ceramic Production by type of ceramic 3-56
Figure 3-30: Glass production by glass type (excluding flat glass production) 3-56
Figure 3-31: Decision tree for emissions from aviation (EMEP/EEA, 2019) 3-70
Figure 3-32: Decision tree for LTOCycle emission calculation 3-72
Figure 3-33: Decision tree for distinction between domestic and international emissions 3-79
Figure 3-34: Total Fuel consumption of Aviation Gasoline and Jet Fuel 3-80

Figure 3-35: Road Transportation contribution (%) of main pollutants, particulate matter and CO in total national emissions in 2020 3-82
Figure 3-36: Fuel and lubricant consumption from Road Transportation sector (TJ) 3-86
Figure 3-37: Number of Passenger Cars by fuel type 3-90
Figure 3-38: Kilometers travelled by vehicle type (vkm) 3-91
Figure 3-39: Consumption of diesel oil in the railway transport sector 3-95
Figure 3-40: Generic methodology flowchart 3-97
Figure 3-41: Ship fleet 3-100
Figure 3-42: Split in Thermal Uses for Commercial/Institutional Sector 3-107
Figure 3-43: Split in Thermal Uses for Residential Sector 3-108
Figure 3-44: Split in appliances/technologies for Residential Sector –Wood Burning 3-108
Figure 3-45: Split in Thermal Uses for Agriculture Sector – Diesel 3-109
Figure 3-46: Diesel consumption in 1A4cii- split by engine technology (TJ) 3-110
Figure 3-47: Gasoline consumption in 1A4cii- split by engine technology (TJ) 3-110
Figure 3-48: Fuel consumption by engine type (t) 3-112
Figure 3-49: Energy consumption in Comercial/Institutional sector - by Fuel, Source and Final Use 3-113
Figure 3-50: Energy consumption in Residential sector - by Fuel, Source and Final Use 3-114
Figure 3-51: Energy consumption in Agriculture sector - by Fuel, Source and Final Use 3-115
Figure 3-52: Energy consumption in the Fishing sector - by Fuel, Source and Final Use 3-116
Figure 3-53: Sulphur Content in Liquid Fuels used in Sector 1.A.4 3-119
Figure 3-54: NOx emissions factor for diesel and fuel oil combustion in shipping vessels 3-120
Figure 3-55: Energy consumption comparison between Inventory, National Energy Balance and EUROSTAT data by sector 3-122
Figure 3-56: Energy consumption comparison between National Energy Balance and Inventory data by fuel type 3-124
Figure 3-57: Energy Consumption in Military aviation 3-127
Figure 3-58: Amount of coal extracted from mines in Portugal 3-129
Figure 3-59: Coke production in the coke plant 3-131
Figure 3-60: Total amount of crude in Marine Terminals 3-133
Figure 3-61: Fresh feed in the Fluid Catalytic Cracking Unit 3-136
Figure 3-62: Fresh feed in the Platforming Units 3-138
Figure 3-63: Wastewater treated 3-139
Figure 3-64: Sulphur input in Claus Units (Index related to 1990 value) 3-141
Figure 3-65: Total throughput in Lisbon, Porto and Sines refineries 3-144
Figure 3-66: Products loaded at terminal dispatch stations of refineries and depots 3-146

Figure 3-67: Liquids transports from Refineries and Depots 3-147
Figure 3-68: Throughput in depots 3-150
Figure 3-69: Fuel Sales at Service Stations 3-151
Figure 3-70: Fugitive Emissions from Natural Gas 3-153
Figure 3-71: Natural Gas transported by High, Medium and Low Pressure Networks 3-156
Figure 3-72: Total consumption of flare gas in Portuguese refineries and Low Heating Value 3-159

List of Tables

Table 3-1: Large Point Sources in the sector of Public Electricity and Heat Production 3-13
Table 3-2: Electricity Power Plants in the Azores and Madeira 3-15
Table 3-3: Emission Factors for energy production sector. Ozone Precursors and other pollutants 3-18
Table 3-4: Emission Factors for energy production sector. Particulate Matter 3-18
Table 3-5: Emission Factors for energy production sector. Heavy Metals (g/t) 3-19
Table 3-6: Emission Factors for energy production sector. Dioxins/Furans and PAHs 3-19
Table 3-7: Emission Factors for thermo-electricity production in Azores and Madeira. Ozone Precursors and other pollutants 3-20
Table 3-8: Emission Factors for thermo-electricity production in Azores and Madeira. Particulate Matter and BC 3-20
Table 3-9: Emission Factors for thermo-electricity production in Azores and Madeira. Heavy Metals 3-20
Table 3-10: Emission Factors for non public co-generation self producers. Ozone Precursors gases and other pollutants 3-21
Table 3-11: Emission Factors for non public co-generation self producers. Particulate Matter 3-21
Table 3-12: Emission Factors for non public co-generation self producers. Heavy Metals 3-21
Table 3-13: Emissions factors of Dioxins/Furans and PAH for for non public co-generation self producers .. 3-21
Table 3-14: Low Heating Value per fuel type 3-22
Table 3-15: LHV per fuel type 3-23
Table 3-16: LHV per fuel type used for non-public co-generation plants estimates 3-24
Table 3-17: Emission Factors for combustion sources in Petroleum Refining 3-29
Table 3-18: Coke oven emission factors from coke production in the period 1990-2001 3-33
Table 3-19: Emission Factors used for city gas production 3-34
Table 3-20: NCV/LHV per fuel type for city gas production 3-35
Table 3-21: Incorporation rate of biodiesel (% toe/toe) 3-38
Table 3-22: Structure of the Portuguese Energy Balance. Sectoral categories 3-42

Table 3-23: Structure of the Portuguese Energy Balance. Fuel categories 3-42

Table 3-24: Definition of Sectors in accordance with CAE 3-43

Table 3-25: Total Paper Pulp Production (Kraft and sulphide paper pulp) 3-55

Table 3-26: Ceramic Production according to type of ceramic (kt) 3-55

Table 3-27: Glass production by glass type (kt/yr) excluding flat glass production 3-56

Table 3-28: Default emissions factors of ozone precursor gases for combustion equipments in the Manufacturing Industry 3-57

Table 3-29: Default sulphur content of fuels for combustion equipments in the Manufacturing Industry 3-58

Table 3-30: Default emissions factors of Particulate Matter for combustion equipments in the Manufacturing Industry 3-58

Table 3-31: Default emissions factors of Heavy Metals for combustion equipments in Manufacturing Industry 3-59

Table 3-32: Default emissions factors of Dioxins/Furans and PAH for combustion equipments in Manufacturing Industry 3-59

Table 3-33: Emission factors of Ozone precursor gases in the extractive industry 3-60

Table 3-34: Sulphur content in fuels used in the extractive industry (%S) 3-60

Table 3-35: Emission factors of Particulate Matter in the extractive industry 3-60

Table 3-36: Emission factors of Heavy Metals in the extractive industry 3-61

Table 3-37: Emission factors of Dioxins/Furans and PAH in the extractive industry 3-61

Table 3-38: Emission factors for Ozone Precursor gases in the building and construction industry 3-61

Table 3-39: Sulphur content in the fuels used in the building and construction industry (%S) 3-62

Table 3-40: Emission factors for Particulate Matter in the building and construction industry 3-62

Table 3-41: Emission factors for Heavy Metals in the building and construction industry 3-62

Table 3-42: Emission factors from sinter production and pig iron production in LPS units in iron and steel sector (Integrated iron and steel facility) 3-63

Table 3-43: Emission factors from combustion in LPS units in iron and steel sector 3-63

Table 3-44: Emission factors used in LPS units in the Paper Pulp Industry: Ozone precursors from combustion – Energy Approach – International EF sources 3-64

Table 3-45: Emission factors used in LPS units in the Paper Pulp Industry: Ozone precursors from combustion – Production Approach – International EF sources 3-64

Table 3-46: Emission factors used in LPS units in the Paper Pulp Industry: Ozone precursors from combustion – Production Approach and Energy Approach – Plant specific EF 3-64

Table 3-47: Emission factors used in LPS units in the Paper Pulp Industry: sulphur oxides (SO_x) emissions – Mass Balance – International EF sources 3-65

Table 3-48: Emission factors used in LPS units in the Paper Pulp Industry: sulphur oxides (SOx) emissions – Production Approach – International EF sources 3-65

Table 3-49: Emission factors used in LPS units in the Paper Pulp Industry: Particulate Matter – Energy Approach – International EF sources 3-65

Table 3-50: Emission factors used in LPS units in the Paper Pulp Industry: Particulate Matter – Production Approach – International EF sources 3-66

Table 3-51: Emission factors used in LPS units in the Paper Pulp Industry: Particulate Matter – Production Approach and Energy Approach – Plant specific EF 3-66

Table 3-52: Emission factors used in LPS units in the Paper Pulp Industry: Particulate Matter – Fraction of PM10, PM2.5 and BC – International EF sources 3-66

Table 3-53: Emission factors used in LPS units in the Paper Pulp Industry: Heavy Metals – International EF sources 3-67

Table 3-54: Emission factors used in LPS units in the Paper Pulp Industry: Dioxins/Furans and PAH – International EF sources 3-67

Table 3-55: Emission Factors for ceramic production using the Production Approach: Indirect Ozone Precursor gases and SO_x 3-68

Table 3-56: Emission Factors for ceramic production using the Production Approach: Particulate Matter 3-68

Table 3-57: Emissions factors for most common aircraft movements in national airports 3-74

Table 3-58: Airport based LTO emission factors (kg/movement) 3-75

Table 3-59: Cruise emissions and fuel consumption 3-77

Table 3-60: Heavy Metals fuel dependent emission factors 3-78

Table 3-61: LTO_{Cycle} per airport 3-79

Table 3-62: Main pollutants and particulate matter emissions from road transport (t) 3-81

Table 3-63: Heavy metals emissions from road transport (kg) 3-81

Table 3-64: Persistent organic pollutant emissions from road transport (kg) 3-82

Table 3-65: Monthly average ambient temperatures (ºC) and relative air humidity (%) 3-84

Table 3-66: Fuel specifications 3-84

Table 3-67: Sulphur content in petrol and diesel (ppm wt) 3-84

Table 3-68: Heavy metal content in fuel (ppm/wt) 3-85

Table 3-69: Reid Vapour Pressure (kPa) 3-85

Table 3-70: Incorporation rate of Biodiesel in Diesel (%) 3-86

Table 3-71: Incorporation rate of Bioethanol in Petrol (%) 3-86

Table 3-72: COPERT 5 segments 3-87

Table 3-73: Technology classification according to first registry year 3-88

Table 3-74: Vehicle fleet synthesis 3-89

Table 3-75: Assumed mileage percentage driven by driving mode and vehicle type for 2020 3-92

Table 3-76: Assumed vehicle speeds by driving mode and vehicle type. 3-92

Table 3-77: Low Heating Value (LHV) in Railways 3-94

Table 3-78: Emission factors in Railways 3-95
Table 3-79: Low Heating Value (LHV) for navigation 3-98
Table 3-80: Emission factors for navigation 3-98
Table 3-81: Consumption factors 3-99
Table 3-82: Ship docks 3-99
Table 3-83: Total fuel sales (ton) 3-100
Table 3-84: Estimated fuel consumption (ton) 3-100
Table 3-85: Estimated fuel consumption after top-down calibration (ton) 3-101
Table 3-86: Spatial allocation of fuel consumption in mainland territory (ton) 3-101
Table 3-87: Criteria employed in the tugs fuel consumption estimation 3-101
Table 3-88: Ship type classification for tugs fuel consumption estimation 3-101
Table 3-89: Subcategories considered and coverage of estimated pollutants 3-103
Table 3-90: Methodological approaches and main source of emissions for each sub-category 3-104
Table 3-91: Share of Engine Types by Number of Ships, Gross Tonnage and Total Power Instaled – Diesel Engines 3-111
Table 3-92: Emissions factors for Category 1.A.4.a.i – Commercial/Institutional: Stationary 3-117
Table 3-93: Emissions factors for Category 1.A.4.c.i – Agriculture / Forestry / Fishing: Stationary 3-117
Table 3-94: Emissions factors for Category 1.A.4.b.i – Residential: Stationary 3-118
Table 3-95: Emissions factors for Category 1.A.4.c.ii – Off-road vehicles and other machinery 3-118
Table 3-96: Emissions factors for Category 1.A.4.c.ii – National Fishing 3-119
Table 3-97: Emission factors – Military Aviation 3-126
Table 3-98: Emission Factors for coal extraction and processing 3-129
Table 3-99: Emission Factors for fugitive air emissions from coke production 3-130
Table 3-100: Emission Factors 3-132
Table 3-101: Emission Factors for FCC Units in refineries 3-136
Table 3-102: Emission Factors for Continuous Catalyst Regeneration (Platforming) in Refineries 3-137
Table 3-103: NMVOC emission factor for Oil-Water Separators 3-139
Table 3-104: Type of tanks classes distinguished in TANKS4.0 model and percentage of tanks per tank type in Porto and Sines refineries in 2005 (%) 3-143
Table 3-105: Types of losses from tanks for storage of organic compounds and petroleum products 3-143
Table 3-106: NMVOC IEF trend from storage and tank in refineries 3-143
Table 3-107: NMVOC emission factors 3-146
Table 3-108: NMVOC emission factor 3-147
Table 3-109: Type of tanks classes distinguished in TANKS4.0 model 3-149

Table 3-110: Types of losses from tanks for storage of organic compounds and petroleum products 3-149
Table 3-111: NMVOC IEF trend from storage and tank in depots..... 3-149
Table 3-112: Filling Underground Tank (Stage I) NMVOC Emission Factors 3-151
Table 3-113: Vehicle Refuelling Operations (Stage II) NMVOC Emission Factors 3-151
Table 3-114: Ajustment Factor for Natural Gas Leaks..... 3-155
Table 3-115: Characteristics of natural gas 3-155
Table 3-116: Emission Factors for flaring in refineries..... 3-158

3 Energy (NFR Sector 1)

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Updated: March 2022

3.1 International Bunkers Fuels

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

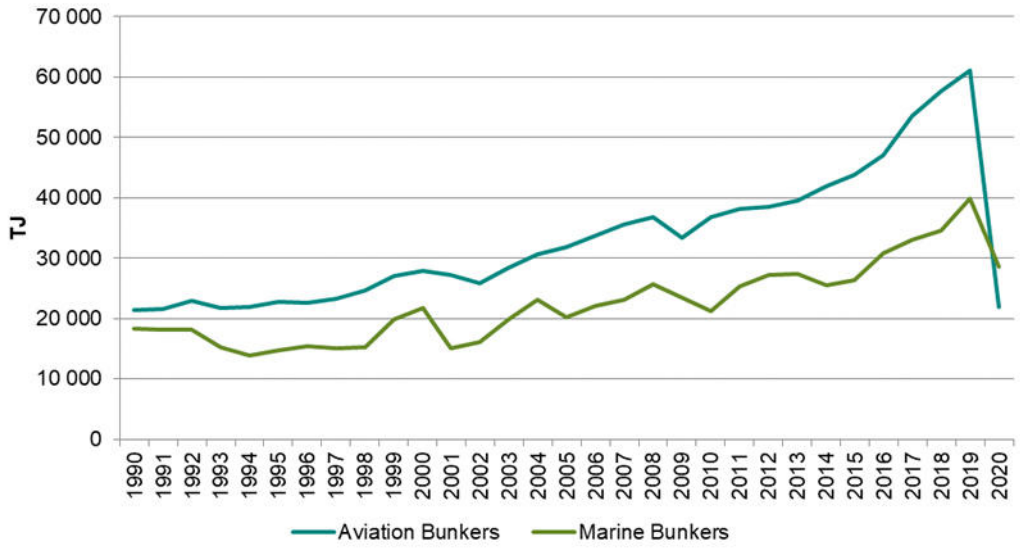


Figure 3-1: International navigation and aviation bunkers

3.1.1 International aviation bunkers

The majority of jet fuel is used for international aviation. In 2020 the quantity of jet fuel for international aviation was about 86% 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 as presented in the figure below.

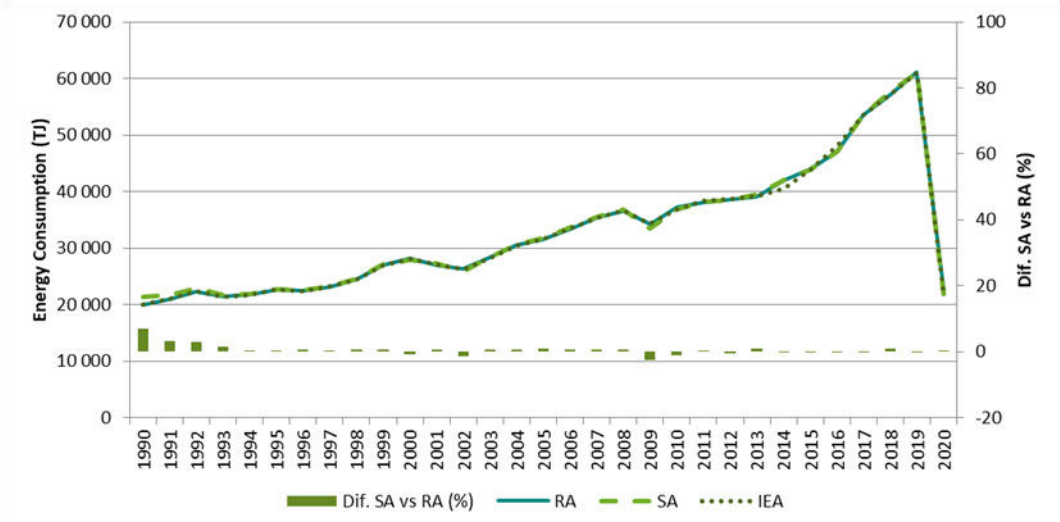


Figure 3-2: International aviation bunkers

3.1.2 International marine bunkers

In 2020 the energy consumption for international navigation was about 92% 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.

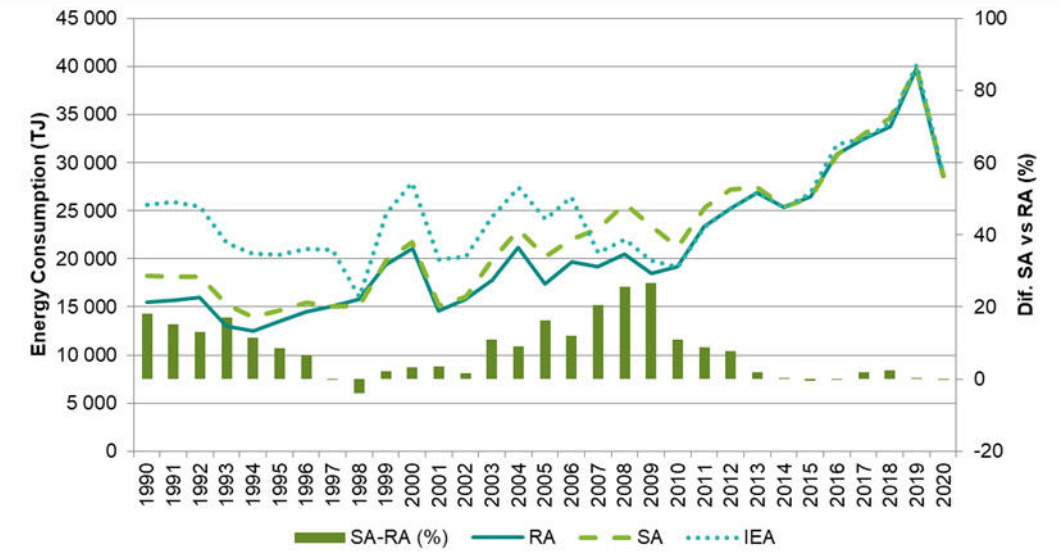


Figure 3-3: International marine bunkers

3.2 Energy Industries (NFR 1.A.1)

3.2.1 Public Electricity and Heat Production (NFR 1.A.1.a)

3.2.1.1 Category description

Until 1950 electric energy production in Portugal was based in small power plant units using coal as energy source. In the nineteen fifties increase in the demand for industry consumers cause 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[1] 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 Revised 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[2].

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.

3.2.1.1.1 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 19 units at present. Power plants and installed power are listed in Table 3.1 together with their main relevant characteristics.

[1] TER – Termoeléctrica do Carregado

[2] 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-producer 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 3-1: 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	HC + FO + GO + LPG	628 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	Working	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 along the 1990-2005 period, 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 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 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.

3.2.1.1.2 Desulphurization in Large Point Source Energy Plants in Mainland Portugal

Even though this source produces CO_2 emissions it also implies a SO_2 emission reduction. Because of this the inclusion of a chapter describing the methodology used for determining emission from desulphurization was considered relevant in this report.

From the information gathered only two plants in Portugal implement this king of abatement system: Pêgo and Sines. Both plants use hard coal and fuel oil in the combustion processes. The abatement equipments operate since 2008 (for both plants).

In a wet flue gas desulphurization the SO_2 emissions are absorbed by lime, forming CO_2 and plaster (gypsum + H_20) as by-products:

$$SO_2 + H_2O \rightarrow H_2SO_3$$
$$CaCO_3 + H_2SO_3 \rightarrow CaSO_3 + CO_2 + H_2O$$
$$CaSO_3 + 1/2O_2 + 2H_2O \rightarrow CaSO_4.2H_2O$$

These equations show that the wet flue gas desulphurization reduces the SO_2 emissions but increment de CO_2 emissions.

Since there is no NRF category specific for desulphurization, total reduction in SO_2 emissions were included together with combustion emissions.

3.2.1.1.3 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 3.2.

Table 3-2: 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

* HC - hard-coal; LIG - Lignite; FO - fuel-oil; GO - Diesel oil; NG - Natural Gas; WW – Wood Waste

3.2.1.1.4 Non public co-generation Energy Producers

Apart from *Barreiro, Soporgen*, *Energin, Fisigen* and Carriço power plant units, already discussed as Large Point Sources, production of electricity by co-generation process in smaller private owned units started after 1993. Some of these units, 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.

3.2.1.2 Methodology

3.2.1.2.1 Thermo-electricity Power Plants

Emissions of sulphur oxides were estimated using the following mass balance equation:

$$SOx_{(u,f,y)} = 2 * Fuel_{Cons(u,f,y)} * CF_{(f)} * S_{(u,f,y)} * 10^{-2} * (1- AshRet_{(u,f)} * 10^{-2})$$

Where:

$SOx_{(u,f,y)}$ - Sulphur oxide emission estimated from consumption of fuel f in power plant u in year y (t);

$Fuel_{Cons(u,f,y)}$ - Consumption of fuel f in power plant u in year y (any unit in agreement with CF);

$S_{(u,f,y)}$ - Sulphur content of fuel f, specific of each power plant and year (% mass);

$CF_{(f)}$ - Factor to convert FuelCons from original units into metric t. Equals 1 except to natural gas where it refers to density (t/original unit);

$AshRet_{(u,f)}$ - Sulphur retention in ash (% mass).

For the remaining pollutants, emission estimates were based on the application of emission factors, either to energy consumption (GJ/yr) or to fuel consumption expressed in mass (t/yr).

In the first case, when activity data is expressed in energy units, the following equation is 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).

Presently for most pollutants, EF is independent of year and power plant. The only exception is NO_x where there are for some units some information concerning annual variations of the emission factors.

For emissions of Heavy Metals the following equation was used instead:

$$HM_{p(u,f,y)} = Fuel_{Cons(u,f,y)} * EF_{HM\ (u,f,y,p)} * 10^{-6} * (1- AshRet_{(u,f,p)} * 10^{-2})$$

Where:

$HM_{p\ (u,f,y)}$ - Heavy Metal p emission estimated from consumption of fuel f in power plant u in year y (t);

$Fuel_{Cons(u,f,y)}$ - Consumption of fuel f in power plant u in year y (t);

$EF_{HM\ (u,f,y,p)}$ - Emission Factor for heavy metal p from fuel f in power plant u and in year y (g/t);

$AshRet_{(u,f,p)}$ - Retention of Heavy Metal p in ash from fuel f under burning conditions in power plant u (% mass).

3.2.1.2.2 Desulphurization in Large Point Source Energy Plants in Mainland Portugal

In the desulphurization processes it's 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:

$$CO_2\ Emission_{(u,y)} = CaCO_{3Cons(u,y)} * CO_2Ratio * 10^{-3}$$

$$SO_2\ Removal_{(u,y)} = CaCO_{3Cons(u,y)} * SO_2Ratio * 10^{-3}$$

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 y(t);

$CaCO_{3Cons(u,y)}$ – Consumption of $CaCO_3$ in power plant u in year y(t);

CO_2Ratio –Ratio between CO_2 emitted and $CaCO_3$ consumption;

SO_2Ratio – Ratio between the SO_2 removed and $CaCO_3$ consumption;

Since both these energy plants are 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 plant 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. Because of this the SO_2 ration is plant specific and varies 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 desulphurization equipment will be subtracted to the total SO_2 emissions.

3.2.1.3 Emission Factors

3.2.1.3.1 Large Point Source Energy Plants

Emission factors presented in 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 Guidelines (IPCC,1997; IPCC, 2006);
- IPCC Good Practice Guidebook (IPCC, 2000);
- EMEP/ CORINAIR Emission Factor Handbook (EEA, 2002; EEA, 2009);
- EMEP/EEA air pollutant emission inventory guidebook 2016 (EEA, 2016)
- AP-42 (USEPA, 1996; USEPA, 1996b; USEPA, 1998; USEPA, 1998b; USEPA, 1998c).

Emissions of Nitrogen Oxides (NO_x) and Particulate Material (PM) are related to both fuel type and burning conditions (burning device and control equipment) and are therefore specific of each power plant and change over years. The range of emission factors for each fuel type is also presented in the figure below and Tables 3.3 to 3.6. For most units (*Sines*, *Pêgo*, Carregado, Barreiro, Setúbal, *Turbogas and TER*) emission factors reflect actual monitoring data under *Autocontrolo* program.

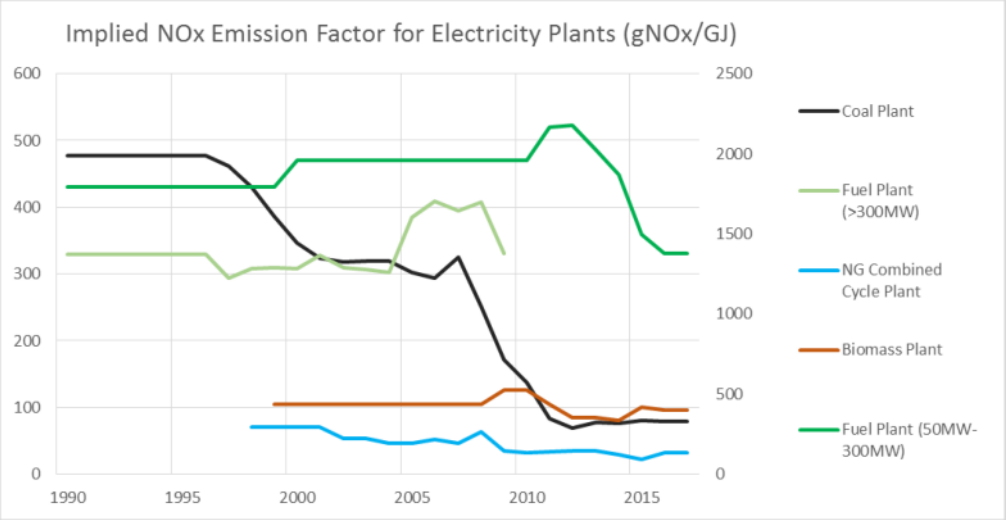


Figure 3-4: Implied Emission Factors for NOx estimated on monitoring by type of Plant

The IEFs of all series have values in the main axis (left) with the exception of the IEF of the Fuel Plant series (50MW-300MW) which has values in the secondary axis (right).

Table 3-3: Emission Factors for energy production sector. Ozone Precursors and other pollutants

Fuel	NOx	NMVOC	CO	AshRet(S)
	g/GJ	g/GJ	g/GJ	%
Lignite	244	1.5	16	5
Fuel-oil	142	3.0	15	0
Diesel (GT)	398	4.0	15	0
Diesel (Engine)	942	2.0	15	0

Table 3-4: Emission Factors for energy production sector. Particulate Matter

Fuel	PM	PM10	PM2.5	BC
	g/GJ	%	%	% of PM2.5
Lignite	9.3	67	29	-
Hard Coal	1.4 – 40.1	67	29	2.2
Fuel-oil	0.26 – 69 (a)	63	41	5.6
Orimulsion	1.03	63	63	5.6
Natural Gas	0.82 – 2.54	100	100	2.5
LPG	11.2	100	100	2.5
Biomass	23.2	74	65	3.3
Diesel (GT)[3]	30	100	100	33.5
Diesel (Engine)	30	82.2	77.3	33.5

(a) as function of Sulphur content (USEPA) and control equipment

[3] Mainly used in Gas Turbine plants

Table 3-5: Emission Factors for energy production sector. Heavy Metals (g/t)

Fuel	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
Lignite	4.00E-03	6.00E-02	4.00E-02	3.00E-02	2.00E-02	4.00E-02	0.00E+00	1.00E-01
Hard Coal	6.50E-03	1.25E-01	1.65E-01	1.20E-01	2.05E-01	2.15E-01	2.00E-02	6.65E-01
Fuel-oil	6.84E-01	5.07E-01	5.56E-01	1.70E+00	7.41E-01	2.69E+01	6.84E-02	1.90E+00
Orimulsion	6.84E-01	5.07E-01	5.56E-01	1.70E+00	7.41E-01	2.69E+01	6.84E-02	1.90E+00
Natural Gas a)	1.76E-05	4.18E-03	3.20E-06	2.24E-05	1.36E-05	3.36E-05	3.84E-07	4.64E-04
LPG	1.76E-05	4.18E-03	3.20E-06	2.24E-05	1.36E-05	3.36E-05	3.84E-07	4.64E-04
Diesel (GT)	3.96E-02	1.69E-02	6.38E-02	2.61E-01	6.50E-01	6.00E-02	3.66E-02	4.33E-01
Diesel (Engine)	3.96E-02	1.69E-02	6.38E-02	2.61E-01	6.50E-01	6.00E-02	3.66E-02	4.33E-01
Biomass	1.47E-02	1.00E-01	4.27E-02	5.00E-04	1.00E-01	6.03E-03	2.30E-02	2.00E+00

a) g/km^3

Table 3-6: Emission Factors for energy production sector. Dioxins/Furans and PAHs

Fuel	DioxFur microg TEQ/TJ	PAH µg/GJ	PCBs µg/GJ	HCB µg/GJ
Lignite	10	67.8	0.003	6.7
Hard Coal	10	69.4	0.003	6.7
Fuel-oil	3	15.9	-	-
Orimulsion	3	15.9	-	-
Natural Gas	1	3.1	-	-
LPG	-	3.1	-	-
Biomass	50	1.2	3.5	5
Diesel (GT)	1	6.9	-	-
Diesel (Engine)	1	6.9	-	-

Source: UNEP (2005), EEA (EMEP/CORINAIR), US-EPA AP-42
Note: PAH is defined as Benzo[b]fluoranthene, Benzo[k]fluoranthene, Benzo[a]pyrene and Indeno[1,2,3-cd]pyrene

Average sulphur content for each fuel type has evolved along the 1990-2017 time series as shown in the figure below for the most important fuel types and power plants.

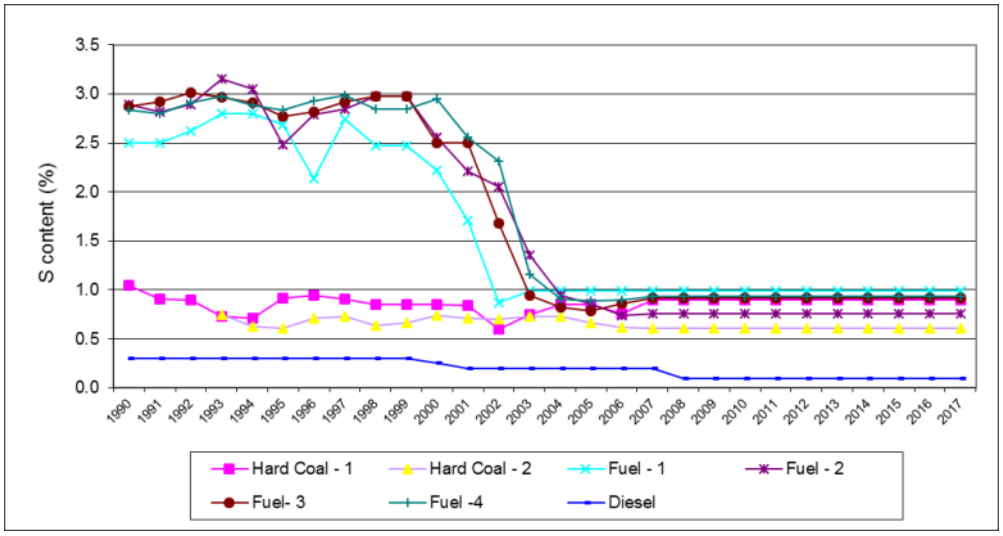


Figure 3-5: Trends of sulphur content by fuel type[4]

[4] Power plants are denominated by number and not by name due to confidentiality constrains

3.2.1.3.2 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 Guidelines (IPCC, 2006);
- IPCC Good Practice Guidebook (IPCC, 2000);
- EMEP/ CORINAIR Emission Factor Handbook (EEA, 2002);
- EMEP/EEA air pollutant emission inventory guidebook 2016 (EEA, 2016)
- AP-42 (USEPA, 1996; USEPA, 1996b; USEPA, 1998; USEPA, 1998b; USEPA, 1998c).

The emission factors that were used in the inventory are shown from Table 3.7 to Table 3.9 for the public power plants belonging to the public system in Azores and Madeira, and from Table 3.10 to Table 3.12 for the non public co-generation self producers[5].

Table 3-7: Emission Factors for thermo-electricity production in Azores and Madeira. Ozone Precursors and other pollutants

Region	Fuel	NO_x g/GJ	NMVOC g/GJ	CO g/GJ
Azores	Fuel-oil	180	3	15
Azores	Diesel oil	1 300	2	15
Madeira	Fuel-oil	180	3	15
Madeira	Diesel oil	1 300	2	15
Madeira	LPG	90	2.5	17

Table 3-8: Emission Factors for thermo-electricity production in Azores and Madeira. Particulate Matter and BC

Region	Fuel	PM g/GJ	PM_{10} %	$PM_{2.5}$ %	BC % $PM_{2.5}$
Azores	Fuel-oil	30	82.2	77.3	33.5
Azores	Diesel oil	30	82.2	77.3	33.5
Madeira	Fuel-oil	30	82.2	77.3	33.5
Madeira	Diesel oil	30	82.2	77.3	33.5
Madeira	LPG	11.2	100	100	2.5

Table 3-9: Emission Factors for thermo-electricity production in Azores and Madeira. Heavy Metals

Fuel	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
	g/t							
Fuel-oil	6.84E-01	5.07E-01	5.56E-01	1.70E+00	7.41E-01	2.69E+01	6.84E-02	1.90E+00
Diesel-oil	3.96E-02	1.69E-02	6.38E-02	2.61E-01	6.50E-01	6.00E-02	3.66E-02	4.33E-01
LPG	1.76E-05	4.18E-03	3.20E-06	2.24E-05	1.36E-05	3.36E-05	3.84E-07	2.00E+00

[5] Power producers as main activity only.

Table 3-10: Emission Factors for non public co-generation self producers. Ozone Precursors gases and other pollutants

Fuel	NO_x	NMVOC	CO	S
	g/GJ	g/GJ	g/GJ	%
LPG	80	2.5	20	0.01
Fuel –oil	180	3	15	2.84-2.6
Diesel oil	580	50	15	0.3-0.2
Natural Gas	100	5	13	0.0007

Table 3-11: Emission Factors for non public co-generation self producers. Particulate Matter

Fuel	PM	PM_{10}	$PM_{2.5}$	BC
	g/GJ	%	%	% $PM_{2.5}$
LPG	6.9	100	100	2.5
Fuel –oil	37-88 [(a)]	71	52	5.6
Diesel oil	81.6	91.1	88.6	33.5
Natural Gas	0.8	100	100	2.5

(a) According to sulphur content

Table 3-12: Emission Factors for non public co-generation self producers. Heavy Metals

Fuel	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
	g/t							
LPG	1.76E-05	4.18E-03	3.20E-06	2.24E-05	1.36E-05	3.36E-05	3.84E-07	4.64E-04
Fuel -oil	6.84E-01	5.07E-01	5.56E-01	1.70E+00	7.41E-01	2.69E+01	6.84E-02	1.90E+00
Diesel oil	3.96E-02	1.69E-02	6.38E-02	2.61E-01	6.50E-01	6.00E-02	3.66E-02	4.33E-01
Natural Gas a)	1.76E-05	4.18E-03	3.20E-06	2.24E-05	1.36E-05	3.36E-05	3.84E-07	4.64E-04

a) g/km^3

Table 3-13: Emissions factors of Dioxins/Furans and PAH for for non public co-generation self producers

Fuel	DioxFur	PAH
	microg TEQ/TJ	µg/GJ
LPG	0	3.1
Fuel –oil	3	15.9
Diesel oil	1	6.9
Natural Gas	1	3.1

Source: UNEP (2005), EEA (EMEP/CORINAIR), US-EPA AP-42
Note: PAH is defined as Benzo[b]fluoranthene, Benzo[k]fluoranthene, Benzo[a]pyrene and Indeno[1,2,3-cd]pyrene

3.2.1.4 Activity Data

Activity data has different origins according to specific energy plants.

3.2.1.4.1 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*)[6];

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

- 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[7] for that specific year from where consumption of fuels in energy units are calculated from:

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

or

Energy (GJ) = Consumption (Nm3/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 3-14: 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 - 41.61)	MJ/kg
Orimulsion	28.00	MJ/kg
Diesel oil	43.30	MJ/kg
Natural Gas	38.16 (36.02 - 39.16)	MJ/kNm^3
LPG	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.

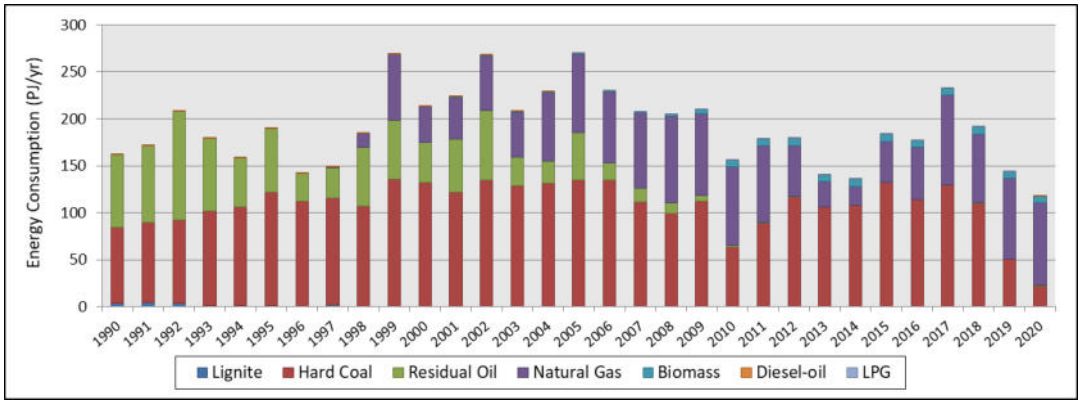


Figure 3-6: Trends of fuel consumption per fuel type

[7] 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.

Not visible in the graph is the increase in biomass consumption (wood waste) from 2000 to 2020 (mostly in the last 5 years). 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 2012 due to Barreiro power plant deactivation.

3.2.1.4.2 Desulphurization in Large Point Source Energy Plants n Mainland Portugal

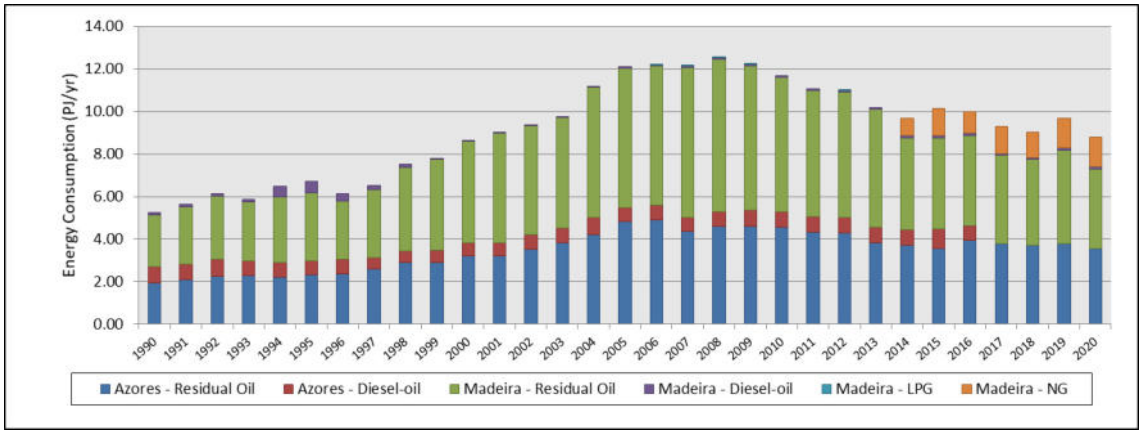
Values for the total lime consumed for desulphurization in each plant were obtained in the EU-ETS. For confidential reason, there are only two plants in Portugal that use this king of abatement system, the $CaCO_3$ consumption cannot by reported.

3.2.1.4.3 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 3-7: Trends of fuel consumption in Azores and Madeira Archipelagos

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

Table 3-15: 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

3.2.1.4.4 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.

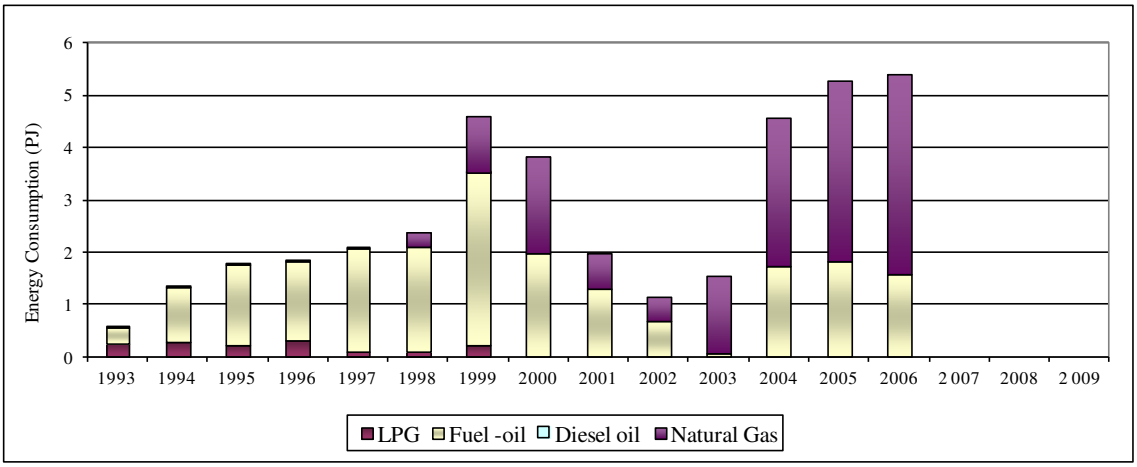


Figure 3-8: Trends in consumption of fuels in non-public co-generation plants

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 (CRF 1A2), the emission inventory maintains its completeness.

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

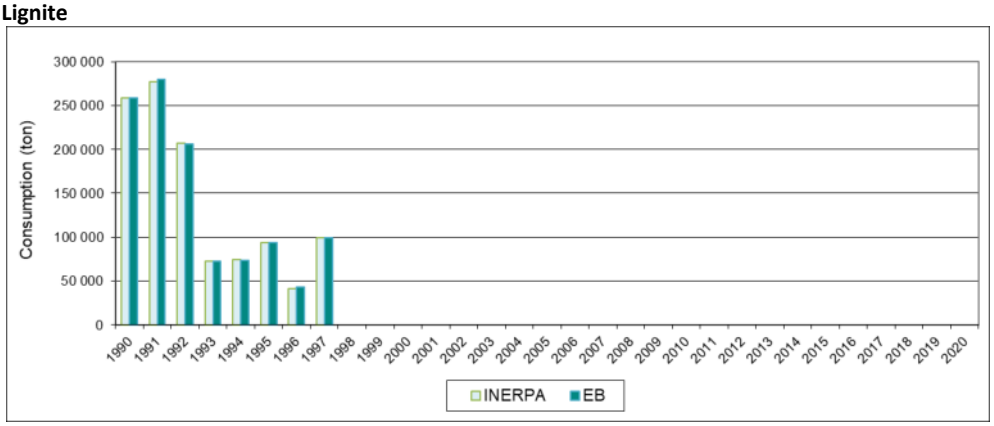
Table 3-16: LHV per fuel type used for non-public co-generation plants estimates

Fuel	LHV (MJkg)
LPG	49.76
Fuel -oil	40.00
Diesel oil	42.60
Natural Gas	38.72 (MJ/Nm^3)

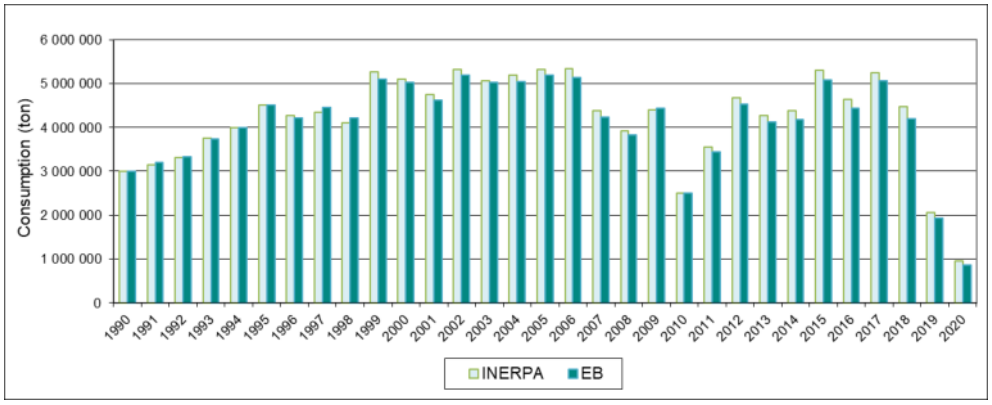
3.2.1.4.5 Comparison of LPS data vs. National Statistics

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 next figure. Generally, there is an 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.

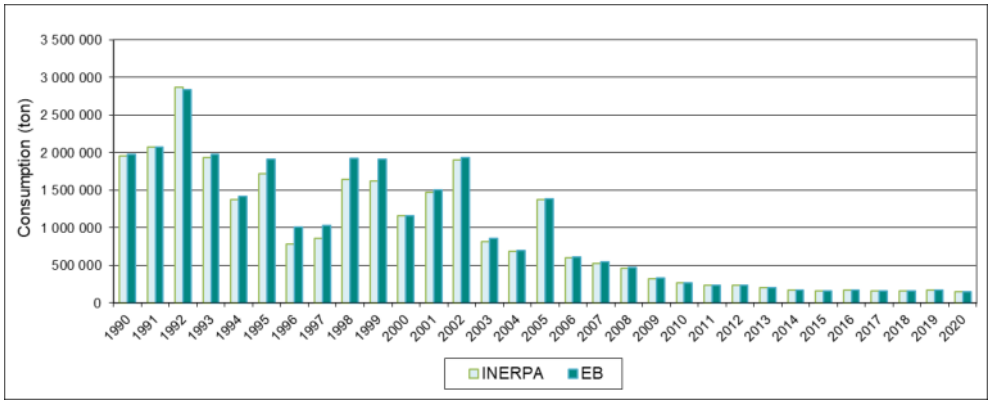
Lignite



Hard Coal



Residual Fuel Oil



Natural Gas

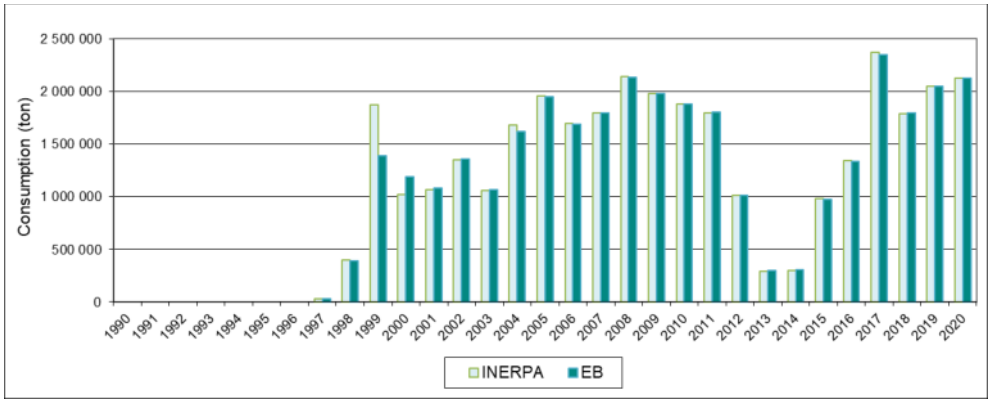


Figure 3-9: Comparison of total fuel consumption in large power plants, between values used in the inventory (INERPA) and in the Energy Balance

3.2.1.4.6 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. Unfortunably 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 fuels 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 2018, is shown in the figure below.

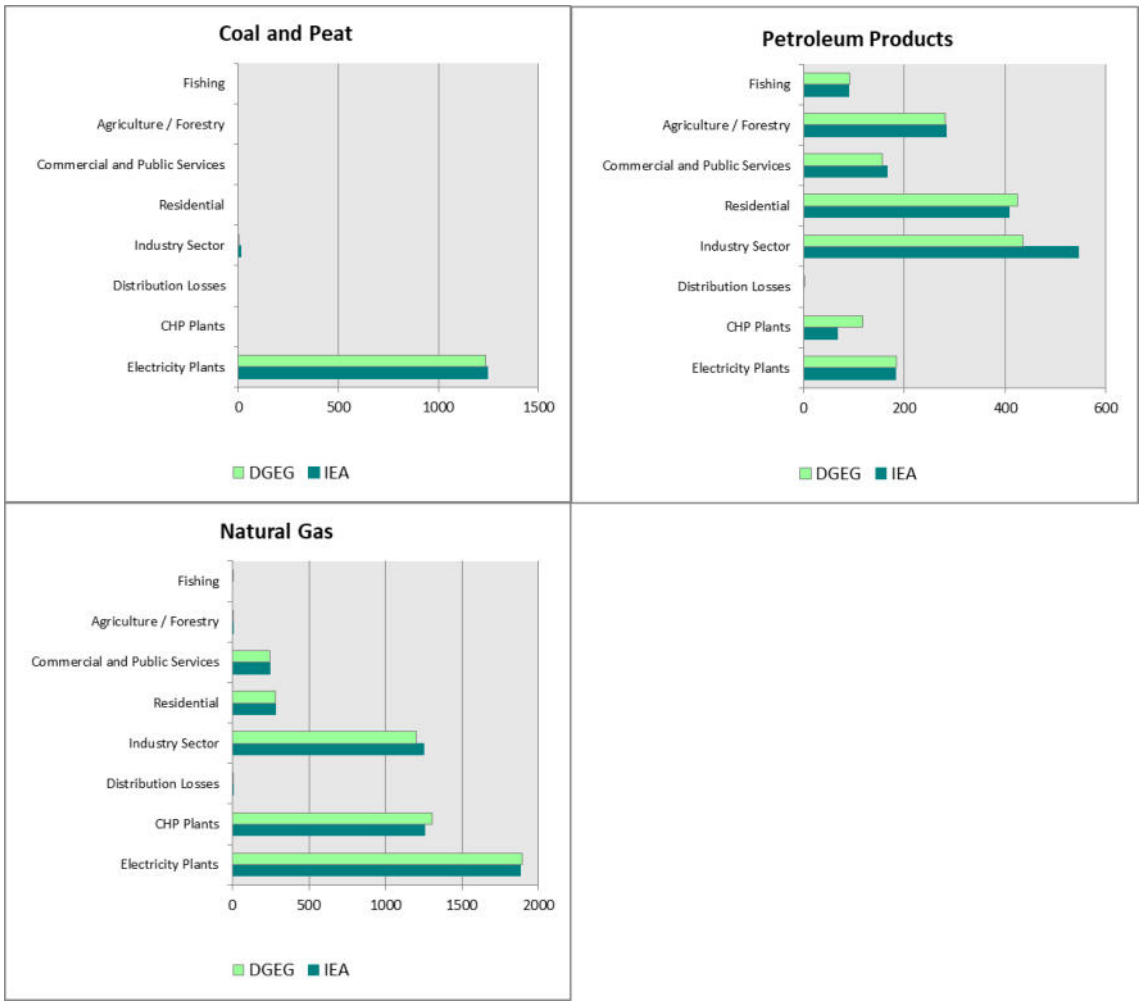


Figure 3-10: Comparison of fuel consumption between DGEG energy balance and IEA energy statistics

For natural gas and coal and peat the differences between the two data sources are very small. The consumption of petroleum products shows discrepancies for five of the eight analyzed sectors: CHP Plants, Industry, Commercial and Public Services, Fishing and Distribution Losses.

These differences are greater for CHP Plants and Industry which may imply a problem in the fuel consumption classification. Upon our contact DGEG reported that there were compilation errors in the information sent to IEA, which may explain the differences found between the two data sources.

3.2.1.5 Recalculations

In the 2022 submission, there were no major recalculations for 1.A.1.a sub-category.

3.2.1.6 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[8] has set to streamline data collection for the inventories and for the EU-ETS[9]. In the same sense on-going efforts should be maintained for the compatibilization of data acquisition by 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.

[8] European Commission.
[9] European CO2 trading scheme.

3.2.2 Petroleum Refining (NFR 1.A.1.b)

3.2.2.1 Category description

In 1990 there were three oil refining plants in Portugal: Porto, Lisbon and Sines. In 1993, the Lisbon unit was closed and only two units remain in operation ever since.

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 (desulphurization). This refinery unit has also units for the production of oils, lubricants and aromatics (Benzene, Hexane, toluene, xilene, etc).

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

The nowadays closed refinery at 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, only emissions resulting from combustion in boilers and furnaces are included in this source sector. Process fugitive emissions, including combustion emissions realized in the FCC unit are included in NFR 1.B.2.a.iv.

SO_x and NMVOC emissions do also result from sulphur that is removed from intermediate or final products, mostly to respect 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 Emissions from Flaring and Venting (NFR 1.B.2.c).

3.2.2.2 Methodology

A bottom-up sectoral Tier 2 approach was used to estimate emissions of all pollutants from combustion in refineries, either in boilers or process furnaces. Emissions were estimated individually for each combustion equipment when discrimination was possible.

For all pollutants except sulphur oxides (SO_x), 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)

For heavy metals, the emission factor unit is mg/GJ and for PCDD/PCDF and PCBs the emission factor unit is ng I-TEQ/GJ, and the previous equation is adjusted to the emission factor unit. For Black Carbon (BC) the emission factor is a % of $PM_{2.5}$.

Sulphur oxides emissions from combustion are estimated from fuel consumption quantities and sulphur content from:

$$SOx_{(e,f)} = 2 \times Fuel_{Cons(e,f)} \times S_{(e,f)} \times 10^{-2} \times (1 - AshRet_{(e,f)} \times 10^{-2})$$

Where:

$SOx_{(e,f)}$: Sulphur oxide emission estimated from consumption of fuel f in combustion equipment e (t)

$Fuel_{Cons\ (e,f)}$: Consumption of fuel f in combustion equipment e (t)

$S_{(e,f)}$: Sulphur content of fuel (% mass)

$AshRet_{(e,f)}$: Sulphur retention in ash (% mass)

It was assumed no ash retention for all fuels and combustion equipment in the refinery process.

3.2.2.3 Emission Factors

The same set of emission factors was used for all three refineries and was obtained from "EMEP/EEA emission inventory guidebook 2016".

Table 3-17: Emission Factors for combustion sources in Petroleum Refining

Pollutant	Unit	Fuel Oil[a]	Refinery Gas[b]	Liquified Petroleum Gases[c]	Gas Oil[d]	Natural Gas[c]	Refinery Feedstock[a]
NOx	g/GJ	142	63	89	942	89	142
NMVOC	g/GJ	2.3	2.58	2.6	37.1	2.6	2.3
NH3	g/GJ	NE	NE	NE	NE	NE	NE
PM2.5	g/GJ	9	0.89	0.89	21.7	0.89	9
PM10	g/GJ	15	0.89	0.89	22.4	0.89	15
TSP	g/GJ	20	0.89	0.89	28.1	0.89	20
BC	%PM2.5	5.6	18.4	2.5	78	2.5	5.6
CO	g/GJ	6	12.1	39	130	39	6
Pb	mg/GJ	4.6	1.79	0.0015	4.07	0.0015	4.6
Cd	mg/GJ	1.2	0.712	0.00025	1.36	0.00025	1.2
Hg	mg/GJ	0.3	0.086	0.1	1.36	0.1	0.3
As	mg/GJ	3.98	0.343	0.12	1.81	0.12	3.98
Cr	mg/GJ	14.8	2.74	0.00076	1.36	0.00076	14.8
Cu	mg/GJ	11.9	2.22	0.000076	2.72	0.000076	11.9
Ni	mg/GJ	1030	3.6	0.00051	1.36	0.00051	1030
Se	mg/GJ	2.1	0.42	0.0112	6.79	0.0112	2.1
Zn	mg/GJ	49.3	25.5	0.0015	1.81	0.0015	49.3
PCDD/PCDF	ng I-TEQ/GJ	2.5	NE	0.5	0.99	0.5	2.5
Benzo(a)pyrene	µg/GJ	NE	0.669	0.56	0.11	0.56	NE
Benzo(b)fluoranthene	µg/GJ	3.7	1.14	0.84	0.49	0.84	3.7
Benzo(k)fluoranthene	µg/GJ	NE	0.631	0.84	0.096	0.84	NE
Indeno(1,2,3-cd)pyrene	µg/GJ	NE	0.631	0.84	0.18	0.84	NE
HCB	µg/GJ	NE	NE	NE	0.22	NE	NE
PCBs	ng I-TEQ/GJ	NE	NE	NE	0.13	NE	NE

(a) EMEP/EEA emission inventory guidebook 2016 – Table 4-4 (Tier 2)
(b) EMEP/EEA emission inventory guidebook 2016 – Table 4-2 (Tier 1)
(c) EMEP/EEA emission inventory guidebook 2016 – Table 3-4 (Tier 1)
(d) EMEP/EEA emission inventory guidebook 2016 – Table 4-8 (Tier 2)

Sulphur composition of fuels was reported for each year and for each pollutant directly from refineries under the LCP directive. Weighted average values from 1990 onwards are reported in the next figure. For fuel oil there is almost a continuous decrease from 1998 to 2005 and a stabilization from 2005 onwards.

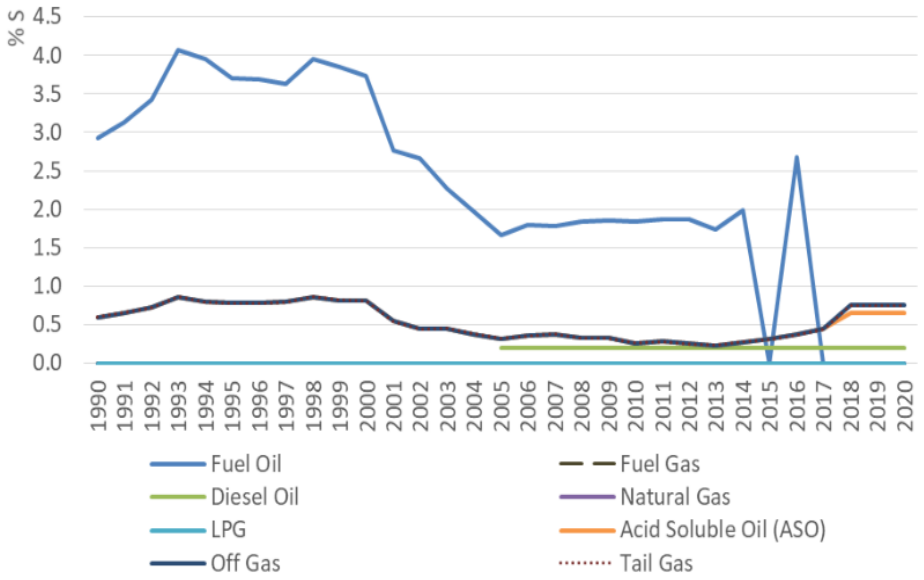


Figure 3-11: Trends of sulphur content

3.2.2.4 Activity Data

Emissions from this source sector include combustion air pollutants resulting from boilers and furnaces.

The refinery units consume self-produced residual fuel oil, fuel gas, liquefied petroleum gases (LPG), diesel oil, natural gas, acid soluble oil (ASO), tail gas and offgas.

The amounts of fuel consumption from 1990 to 2004 in boilers and furnaces are collected directly from individual units under the Large Combustion Plants (LCP) directive and may be observed in the next figure. From 2005 onwards, data source is EU-ETS. The use of natural gas is becoming more relevant from 2008 onwards 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.

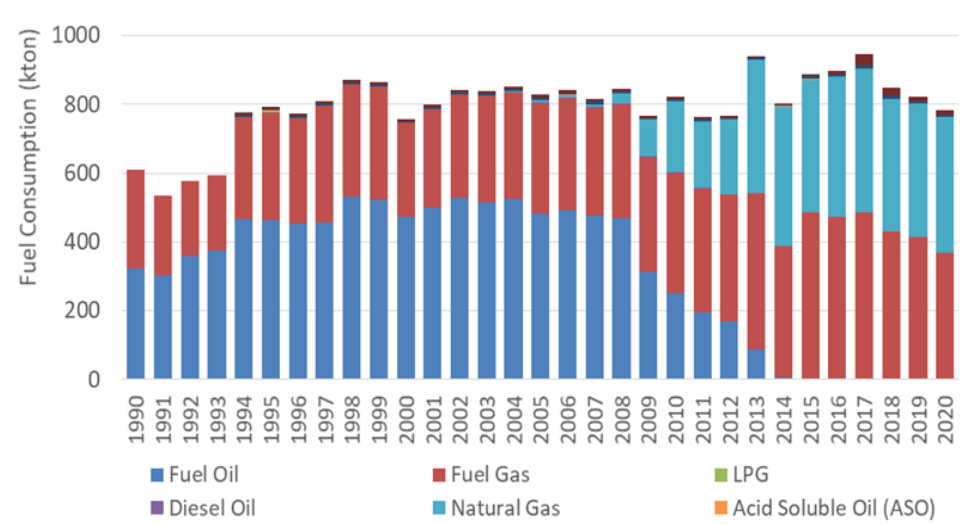


Figure 3-12: Fuel consumption

Consumption expressed in energy was calculated with the following time series of Low Heating 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 the plants. In 2016 there is no fuel oil consumption.

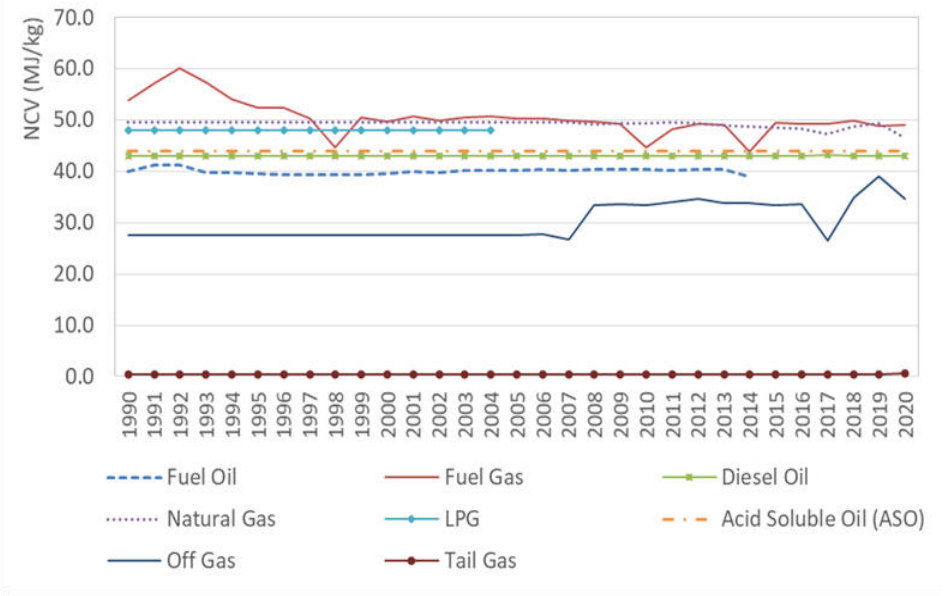


Figure 3-13: Net Calorific Value (NCV) expressed in MJ/kg by fuel type

3.2.2.5 Recalculations

No recalculations were made.

3.2.2.6 Further Improvements

No further improvements are expected.

3.2.3 Other Energy Industries (NFR 1.A.1.c)

3.2.3.1 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 in the Iron and Steel section 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 being 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.

3.2.3.2 Methodology

Metallurgical coke production

Metallurgical coke production is considered to be an energy transformation of fossil fuel and leads to air emissions. These emissions were estimated based on a Tier 2 approach of the 2019 EMEP Guidebook, according to the following equation:

$$Emi_p = EF_p \times Coal_{Cons} \times 10^{-3}$$

Where:

Emi_p: Air emissions of pollutant p (t)

EF_p: Emission factor of pollutant p (kg/t coal)

$Coal_{Cons}$: Quantity of coal consumed (t)

City Gas Production

Sulphur oxides emissions from combustion were estimated from fuel consumption quantities and considering its sulphur content as:

$$SOx_{(y)} = 2 \times Fuel_{Cons(y)} \times S$$

Where:

$SOx_{(y)}$: Sulphur oxide emission estimated from consumption of fuel in year y (t)

$Fuel_{Cons(y)}$: Consumption of fuel f in city gas production (t)

S: Sulphur fraction of fuel f in city gas production (0..1)

For emissions of Heavy Metals, the following equation was used, when data available:

$$HM_{p(u,f,y)} = Fuel_{Cons(f,y)} \times CF_{(f)} \times EF_{HM(f,y,p)} \times 10^{-6} \times (1 - AshRet_{(f,p)} \times 10^{-2})$$

Where:

$HM_{p(f,y)}$: Heavy Metal p emission from consumption of fuel f in year y (t)

$Fuel_{Cons(f,y)}$: Consumption of fuel f in year y (any unit in agreement with CF)

$EF_{HM(f,y,p)}$: Emission Factor for heavy metal p from fuel f and in year y (g/t)

$CF_{(f,)}$: Factor to convert $Fuel_{Cons}$ from original units into metric t. Equals 1 except to natural gas where it refers to density (t/original unit)

$AshRet_{(f,p)}$: Retention of Heavy Metal p in ash from fuel f under burning conditions (% mass).

For all pollutants other than sulphur oxides (SO_x) and Heavy Metals, the following equation was applied to estimate emissions:

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

Where:

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

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

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

3.2.3.3 Emission Factors

Metallurgical coke production

Emissions factors for coke production were taken from table 5.2 of section 5.4.3 of chapter 1.A.1 Energy Industries of 2019 EMEP Guidebook and are listed in the table below.

Table 3-18: Coke oven emission factors from coke production in the period 1990-2001

Pollutant	Coke oven (byproduct recovery)	
	Unit	EF
SOx	g/t coal	420
NOx	g/t coal	820
NMVOC	g/t coal	47
CO	g/t coal	340
TSP	g/t coal	1914
PM_{10}	g/t coal	1864
$PM_{2.5}$	g/t coal	1176
BC	% of $PM_{2.5}$	48
Pb	mg/t coal	2.2
Cd	mg/t coal	0.1
Hg	mg/t coal	NE
As	mg/t coal	1.6
Cr	mg/t coal	3.6
Cu	mg/t coal	1.7
Ni	mg/t coal	0.9
Se	mg/t coal	1.8
Zn	mg/t coal	7.6
PCDD/ PCDF	ng I-TEQ/ton coal	738
Benzo(α)pyrene	mg/t coal	8.2
Benzo(β)fluoranthene	mg/t coal	0.1
Benzo(k)fluoranthene	mg/t coal	0.03
Indeno(1,2,3-cd)pyrene	mg/t coal	0.02

City Gas Production

Emissions factors for combustion of fuel in the city gas factory were set from EMEP/CORINAIR and AP-42 and are listed in the table below.

Table 3-19: Emission Factors used for city gas production

Source	City Gas Production			Unit
Fuel	FO	Naphta	NG a)	
SO_x	2.6-2.9	0.1	0.0007	% S
NO_x	160	160	100	g/GJ
NMVOC	3.0	3.0	5.0	
CO	15	15	13	
PST	85	6.5	0.8	
PM_{10}	86.0	50.0	100	% PST
$PM_{2.5}$	56.0	12.0	100	
PM_1	36.0	8.0	100	
Cd	6.84E-01	2.55E-01	1.76E-05	g/t
Hg	5.07E-01	0.00E+00	4.18E-03	
Ar	5.56E-01	0.00E+00	3.20E-06	
Cr	1.70E+00	5.00E-02	2.24E-05	
Cu	7.41E-01	1.10E+00	1.36E-05	
Ni	2.69E+01	2.85E-01	3.36E-05	
Se	6.84E-02	3.00E-02	3.84E-07	

a) Heavy Metais - g/km³

3.2.3.4 Activity Data

Metallurgical coke production

Annual coking coal consumption was obtained from DGEG (Coke plant Balance) from 1990 to 2001 and is presented in the figure below. From 2002 onwards, there is no coke production in the iron and steel industry in Portugal.

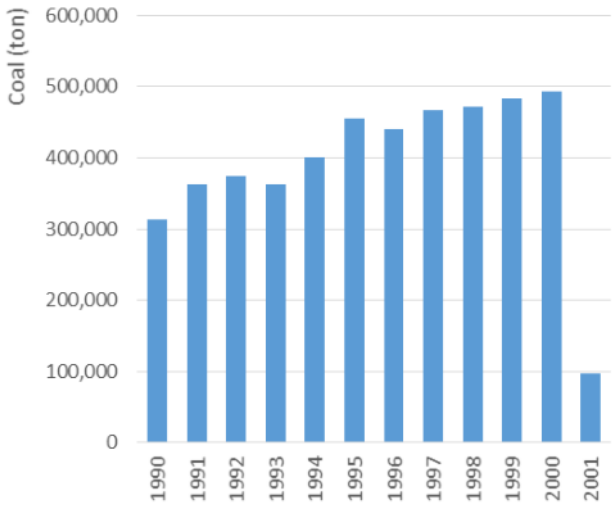


Figure 3-14: Coking coal consumption in the coke plant

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[10]. The available time series is presented in the figure below.

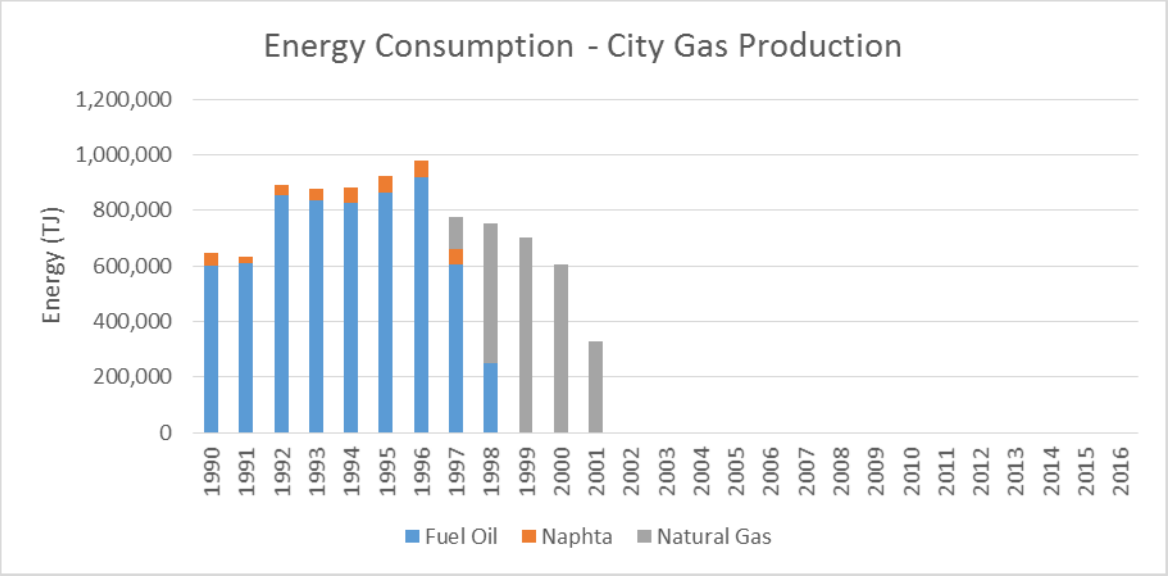


Figure 3-15: Consumption of fuels in co-generation in city gas production

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.

Table 3-20: NCV/LHV per fuel type for city gas production

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

3.2.3.5 Recalculations

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

3.2.3.6 Further Improvements

No further improvements are expected.

[10] 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.

3.3 Manufacturing Industries and Construction (NFR 1.A.2)

Emissions covered in this source category are those resulting from combustion activities in manufacturing industry and building and construction industry. Excluded are the process emissions from cement and glass industries, which are covered under production processes (Chapters 4.2.1 and 4.2.4, respectively). The following sub-source categories are reported individually: Iron and Steel, Metallurgic industry, Chemicals, Pulp and Paper, Food Processing, Beverages and Tobacco, Textile, Ceramic, Glass and glass products, Cement, Clothing, shoes and leather industry, Wood, Rubber, Metal Equipment and Machines, Extractive industry, Construction and building and Other Transformation Industry.

Total emissions for this sub-sector are 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[11].

The consumption of liquid fuels considered in the estimation of emissions of the Manufacturing Industry is based on information from the Energy Balance, which aggregates fuel consumption by industrial sector taking into account the purchases of fuel made by each economic activity code. Even in sectors where consumption data are collected under EU-ETS, there is no disaggregation by source, and all the consumption of a certain fuel is associated with an installation. It is thus impossible to distinguish between mobile and stationary sources. Thus emissions of category 1.A.2.g vii are included in category 1.A.2.g viii.

3.3.1 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.

Emissions of SO_x are directly related to the sulphur content of the fuel[12]. Estimates for SO_x were calculated assuming that there were no abatement technologies. The following equation applies:

$$Emi_{SOx} = 2 * \sum_f \sum_s \sum_t [S_{(f,s,t)} /100 * Fuel_{Cons(f,s,t)} * (1- AshRet_{(f,t)} * 10^{-2})]$$

Where:

Emi_{SOx} - Total emissions of SO_x (t/yr);

$S_{(f,s,t)}$- Sulphur content of fuel f in sector activity s and technology/ combustion equipment t(%);

$Fuel_{Consumption\ (f,s,t)}$ – Quantity of fuel that was consumed for each particular fuel f, for sector activity s and technology/ combustion equipment t (t/yr);

$AshRet_{(u,f,p)}$ - Retention of sulphur in ash from fuel f in equipment t (% mass).

For the other pollutants either the energy approach or the production approach may be used.

When the energy consumption approach is used the equation is:

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

Where:

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

[11] Only when the co-generation activity is reported to the energy balance as referring to the manufacturing industry. When economic activity is referred as Energy Production then emissions are included in source category CRF 1a1a (See chapter 3.2.A.1 for further explanations).
[12] For some activities SOx emissions may also be estimated using the production approach, as presented below.

$EF_{(p,f,s,t)}$ - 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 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 CO2 in kt);

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

Production – Production activity rate (t/yr).

For determination of emissions of Heavy Metals the following equation was used:

$$HM_{p(f,y)} = Fuel_{Cons(f,y)} * CF_{(f)} * EF_{HM\,(f,y,p)} * 10^{-6} * (1 - AshRet_{(f,p)} * 10^{-2})$$

Where:

$HM_{p\,(f,y)}$ - Heavy Metal p emission estimated from consumption of fuel f in year y (t);

$Fuel_{Cons(f,y)}$ - Consumption of fuel f in year y (any unit in agreement with CF);

$EF_{HM\,(f,y,p)}$ - Emission Factor for heavy metal p from fuel f in year y (g/t);

$CF_{(f,)}$ - Factor to convert FuelCons from original units into metric t. Equals 1 except to natural gas where it refers to density (t/original unit);

$AshRet_{(u,f,p)}$ - Retention of Heavy Metal p in ash from fuel f under burning conditions in refinery u (% mass).

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 now have biodiesel. This new approach for obtaining biodiesel results from the fact that from 2006 forward 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 these steps[13]:

- 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;

[13] 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.

- 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 which industrial sector, the total gas oil consumed (heating gas oil + gas oil with biodiesel removed) and the total biodiesel consumed (biodiesel from gas oil +pure biodiesel purchased directly by the industrial unit).

The table below represents the incorporation rate derived for the period 2006-2020.

Table 3-21: Incorporation rate of biodiesel (% toe/toe)

	2006	2007	2008	2009	2010	2011	2012	2013
Incorporation rate	1.31	2.50	2.43	4.16	6.03	6.25	6.20	6.05
	2014	2015	2016	2017	2018	2019	2020	
Incorporation rate	5.93	6.81	5.15	5.10	5.48	5.41	5.56	

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.

3.3.1.1 Paper and Pulp Production

Emissions of SO_x, NO_x, CO, 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).

3.3.1.2 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). Process emissions from decarbonising limestone and dolomite are also quantified and reported in this category.

3.3.1.3 Lime Production

Emissions of SO_x, NO_x, NMVOC and CO from combustion processes in furnaces in the Lime 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. Process emissions from decarbonising limestone and dolomite are quantified in IPPU chapter 4.2.2 and reported in NRF sector 2.A.2.

Both this activity and Clinker production are included in the energy balance Cement sector.

3.3.1.4 Ceramic Industry

Emissions of SO_x, NO_x, NMVOC and CH_4 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.

3.3.1.5 Glass Production

Similarly to ceramic industry, emission 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. Carbon dioxide emissions from glass production comprehend both oxidation of carbon, that are estimated using the general emission factors based on energy consumption, and decarbonizing or materials, which are included in production process and reported in IPPU chapter 4.2.3.

3.3.1.6 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 sake, activity data and emission factors for this source are discussed in IPPU chapter 4.4.1.

3.3.2 Activity data

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

3.3.2.1 Combustion Data

Data on fuel consumption for the Larger Point Sources (LPS) were obtained from several sources:

- 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;
- from EU-ETS, since the 2009 inventory.

Presently LPS comprehend one iron and steel industry, one petrochemical unit, one carbon black industrial plant, eight paper pulp plants (in most cases divided in differente fiscal entities) and six cement plants (covering all clinker producing units).

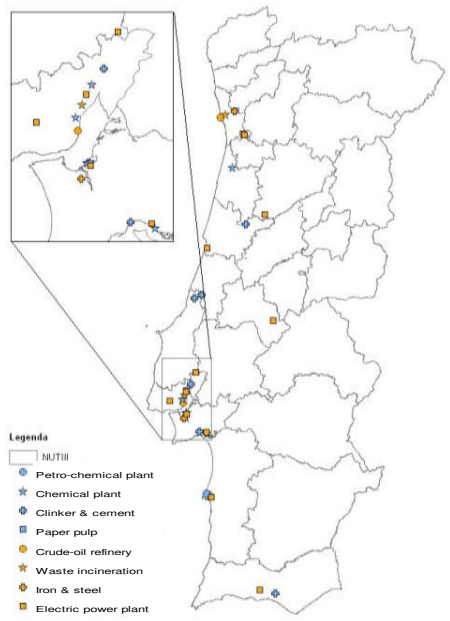


Figure 3-16: Distribution of Large Point Sources in Portugal mainland[14]

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 Figure 3.17 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);

$Cons_{LPS(u,f,e)}$ – 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/Nm3);

$LHV_{EB(f,s)}$ – 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/Nkm3);

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

$LHV_{AREA(f,s,e)}$ - 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/Nm3)[15].

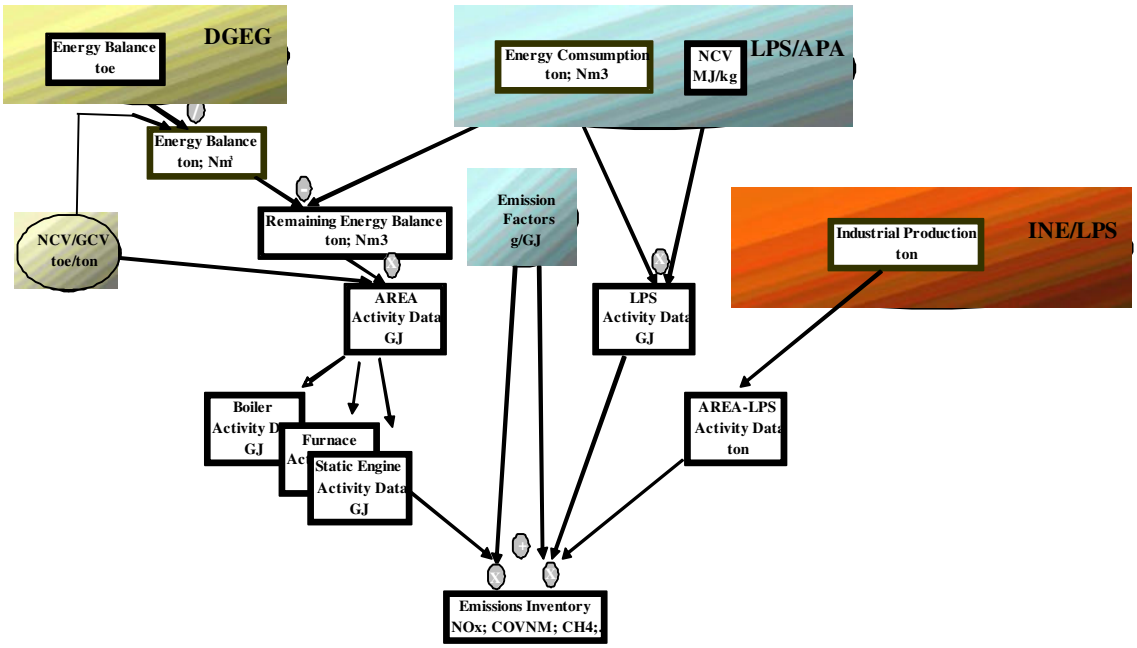


Figure 3-17: General procedure for emissions estimates

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.

3.3.2.1.1 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 sheet for 2020 is presented in ANNEX B.

[15] In most cases similar values to Energy Balance are used

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

Primary	Imports
	Indigenous Production
	Stock variations
	Exports
	Foreign ships
	Foreign aircraft
	Primary Energy Consumption
For production of secondary energy sources	Briqettes
	Coke
	Crude oil products
	City gas
	Petro-chemical
	Electricity
Consumption in the Energy sector	Refineries (own consumption)
	Refineries (losses)
	Coquerie
	Electric Power Plants
	Hidropower pumping
	City gas
	Mining Industry
	Transport and distribution (losses)
Feedstocks	
Corrections	

Co-generation	Electric producers
	Barreiro power plant
	Crude oil refineries
	City gas
	Agriculture
	Food and Beverages
	Textile
	Paper pulp and paper
	Chemical and Plastics
	Ceramic
	Glass
	Cement
	Metalurgy
	Iron and steel
	Cloth, shoes, leather
	Wood
	Rubber
	Equipment
	Other Manufacturing Industries
	Extractive
	Services

Final Consumption	**Agriculture**	
	Fisheries	
	Mining Industry	
	Manufacturing Industry	Food and Beverages
		Textile
		Paper pulp and paper
		Chemical and Plastics
		Ceramic
		Glass
		Cement
		Metalurgy
		Iron and steel
		Cloth, shoes, leather
		Wood
		Rubber
		Equipment
		Other Manufacturing Industries
	Construction and Publick Works	
	Transport	National airplanes
		National ships
		Railways
		road
	Domestic	
	Services	

Table 3-23: Structure of the Portuguese Energy Balance. Fuel categories

Coal	Imported coal
	National coal
	coal coke
Oil	Intermediate refinery products
	LPG
	Gasoline
	Kerosene
	Jets
	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

Non Energ Products	Lubricants
	Asphalts
	Parafin
	Solvents
	Propylene
Electricity	Hydro-electricity
	Wind and Geothermal
	Thermo-electricity

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 3-24: Definition of Sectors in accordance with CAE

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&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

3.3.2.2 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.

Figure 3-22, represents 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) - All main installations 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 size 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.

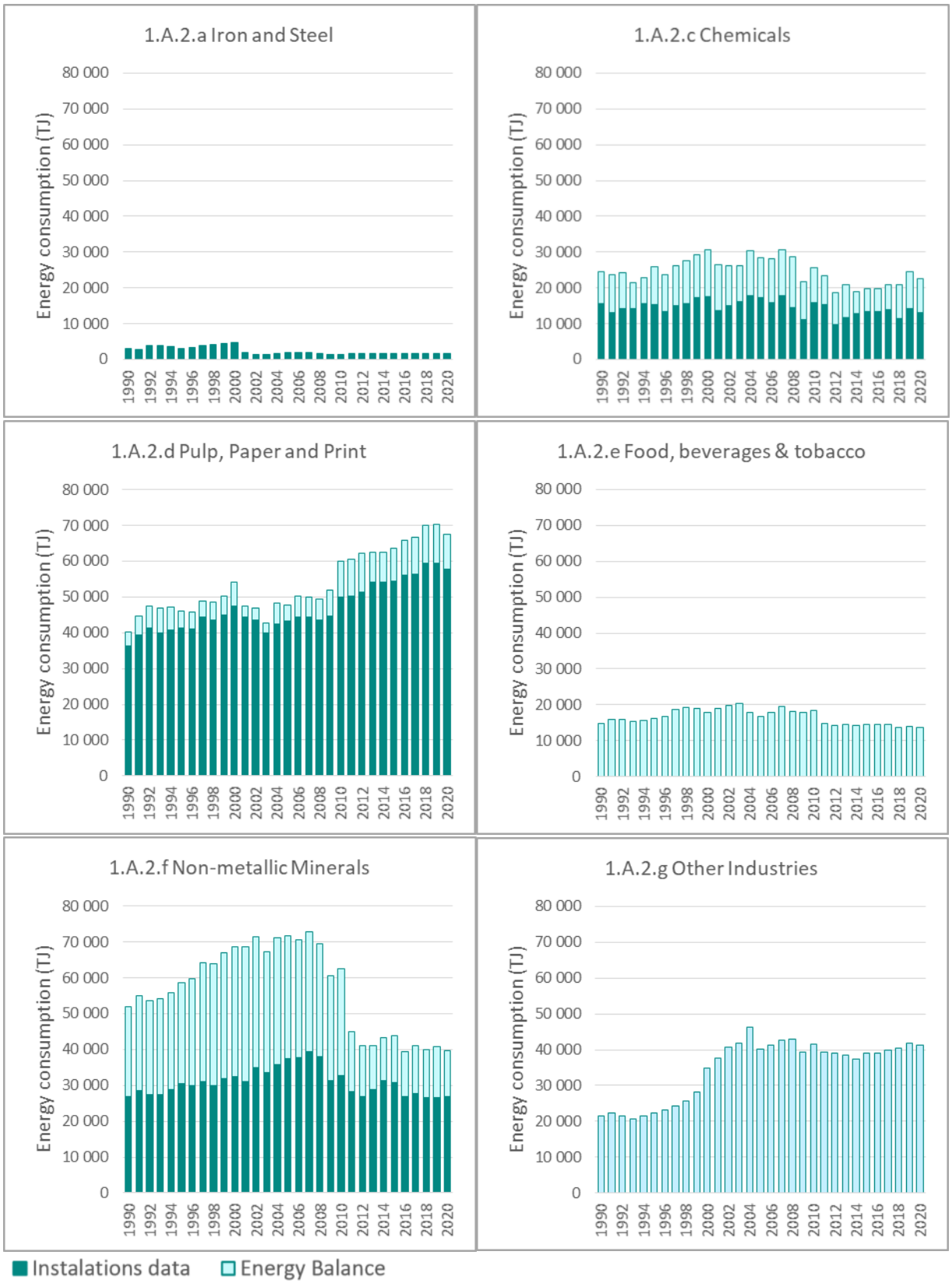
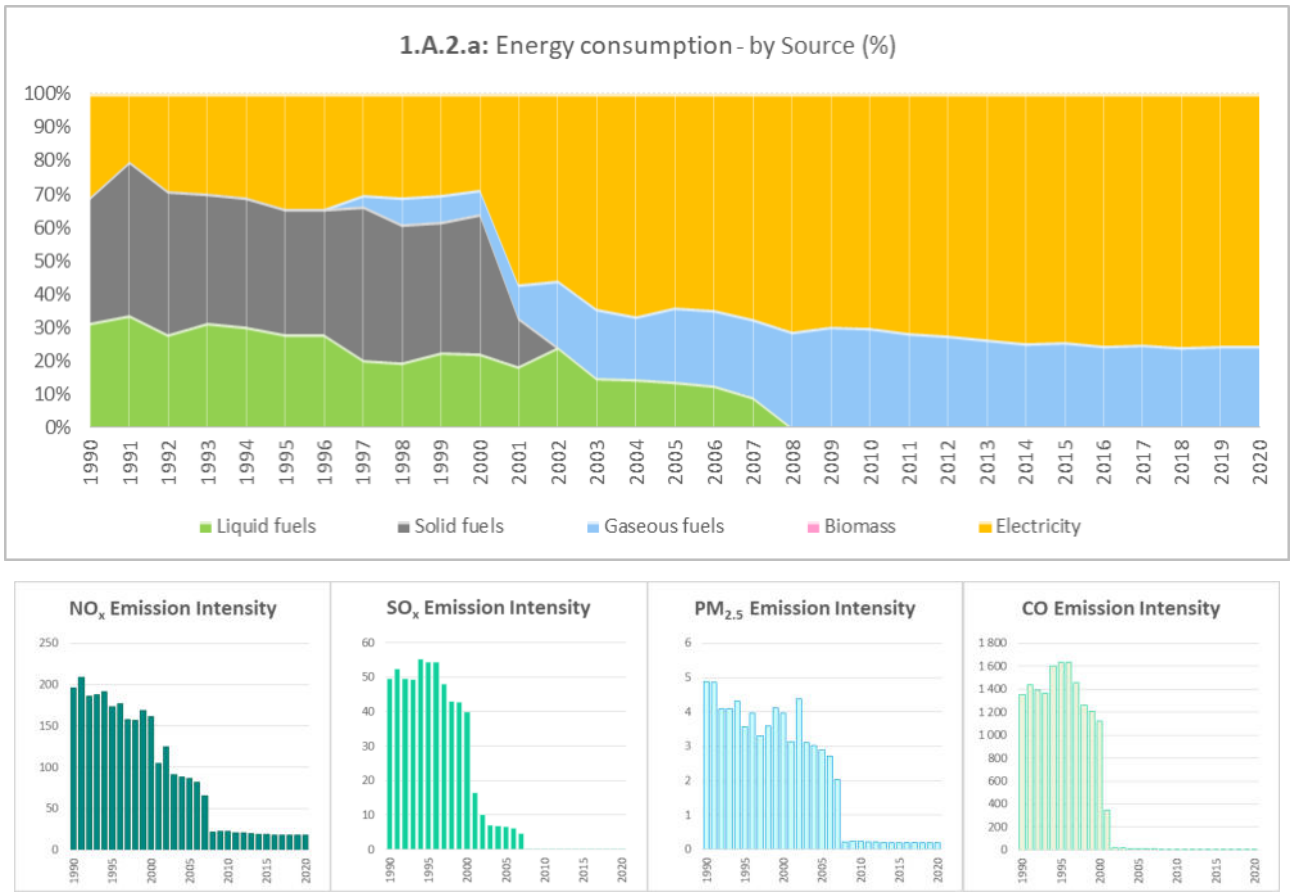


Figure 3-18: Total Energy Consumption in Manufacturing Industries and Construction

3.3.2.2.1 Iron and Steel Industry (CRF 1.A.2.a)

There are two distinct periods in the 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, pig iron production and BOF steel production). And after 2001, when the two plants only produced steel using the electric arc furnace and scrap an metallic foils as raw materials. This change has also caused substantial changes in the contribution of fuels, with the disappearance 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, becoming the main source of energy after 2002.



Emission Intensity [ton of pollutant emission/TJ of Energy consumption] is estimated considering the total emissions (NO_X, SO_X, $PM_{2.5}$ and CO) reported in category *1.A.2.a Iron and Steel* in relation to the total energy consumed (fossil fuels, biomass and electricity)

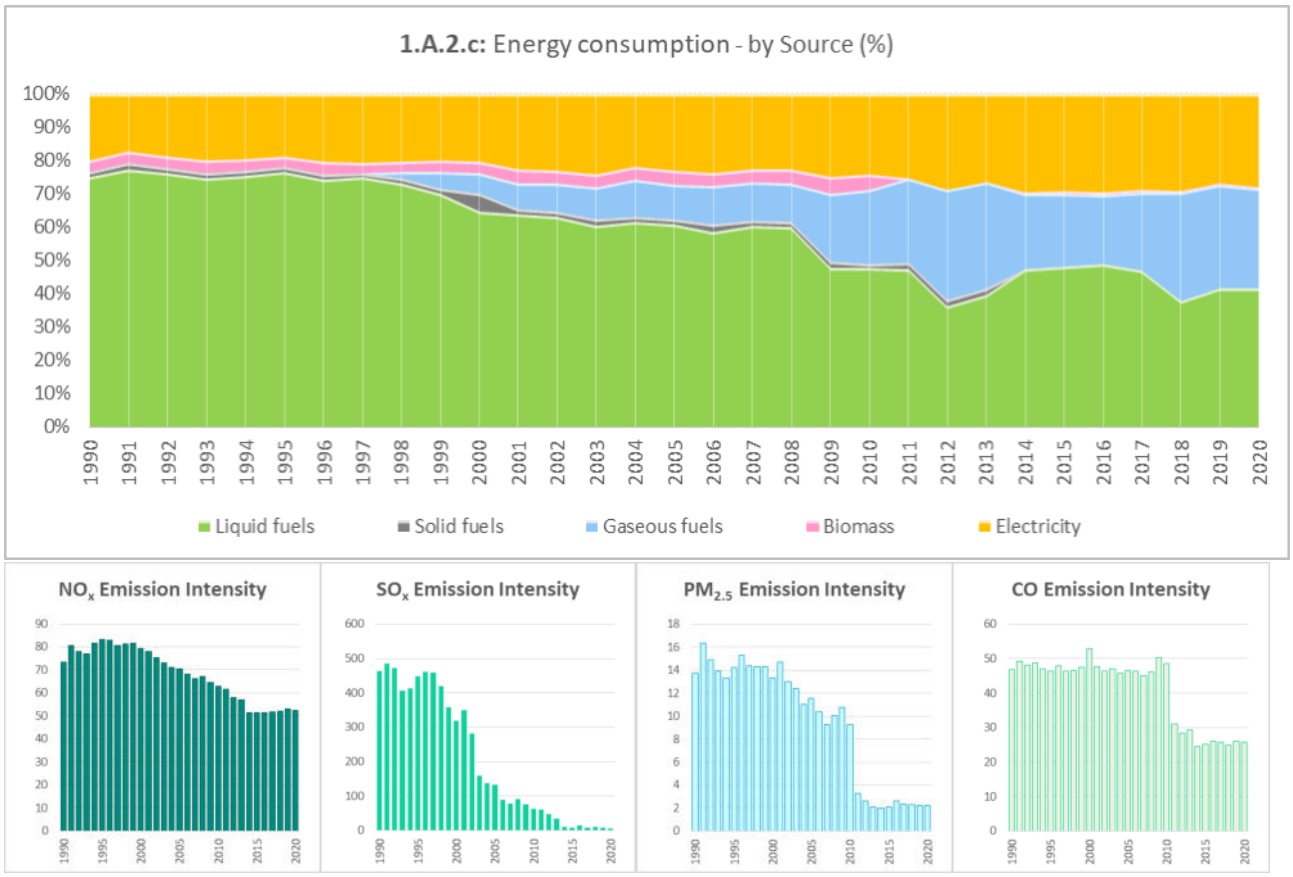
Figure 3-19: Share of energy consumption by source & Emissions intensity

The higher levels of intensity emission of NO_X, SO_2 and CO between 1990 and 2001 are mainly due to the production of Sinter. Although the majority of pollutant emissions from sinter production are reported in category 2.C.1, the guidebook suggests that NO_X, SO_2 and CO emissions are assigned to a combustion activity. Another factor that explains the downward trend in emissions intensity is related to the replacement of fuel oil by natural gas in rolling mills, with the greatest impact between 2007 and 2008 when fuel oil consumption stopped.

3.3.2.2.2 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.



Emission Intensity [ton of pollutant emission/TJ of Energy consumption] is estimated considering the total emissions (NO_X, SO_X, $PM_{2.5}$ and CO) reported in category *1.A.2.c Chemicals* in relation to the total energy consumed (fossil fuels, biomass and electricity)

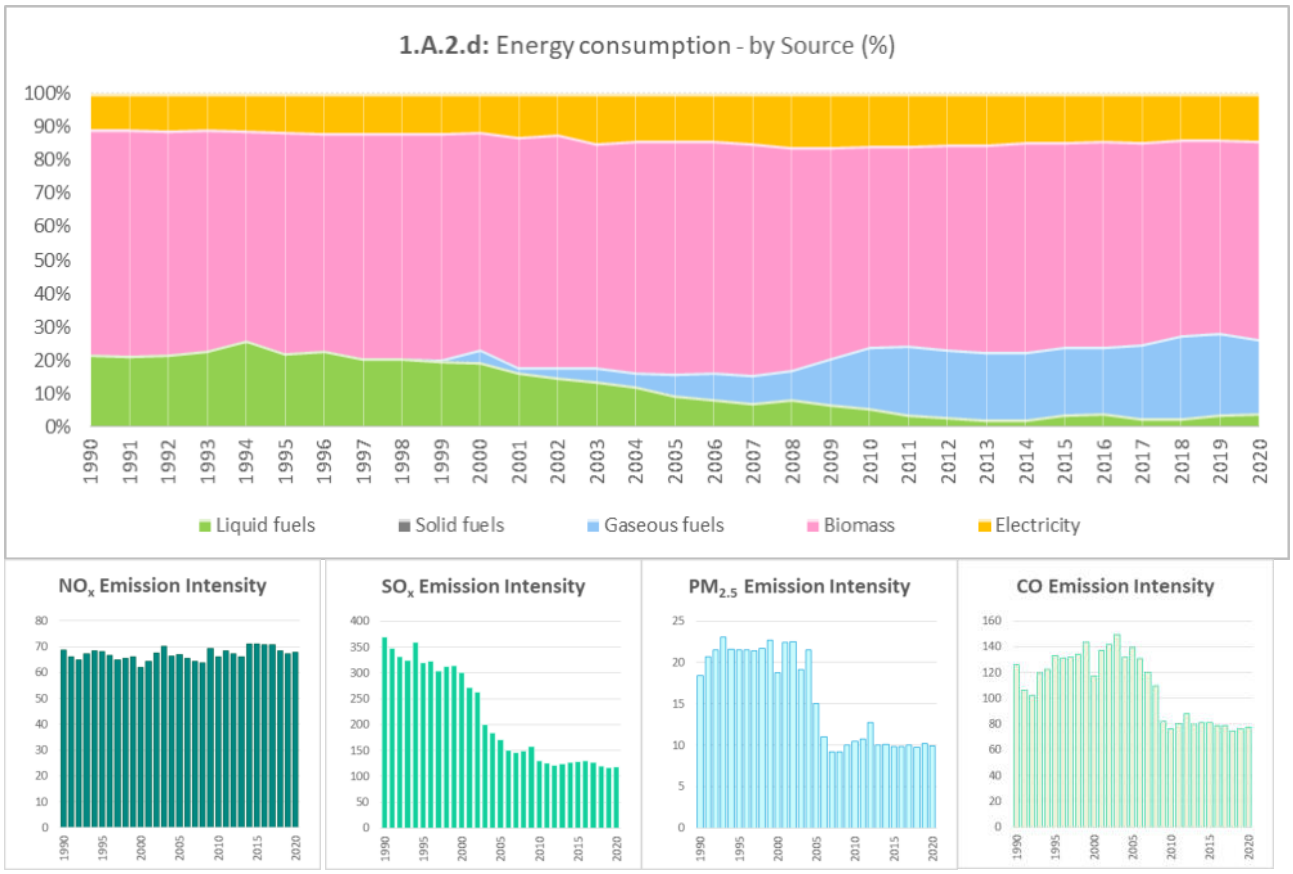
Figure 3-20: Share of energy consumption by source & Greenhouse gases emissions intensity

The trend towards a reduction in the intensity of NO_X and SO_2 emissions that occurred after 2000 is essentially due to the change in consumption between residual fuel oil and natural gas. The impact is felt especially in SO_2 emissions, because there is a big difference between the sulfur content of fuel oil and natural gas.

With regard to PM2.5 and CO emissions, the consumption of Wood and Wood products is of primary importance. The apparent drop in the consumption of biomass that took place in 2011 had a significant impact on the total emissions of these pollutants.

3.3.2.2.3 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 fueloil and natural gas. These last two with 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.



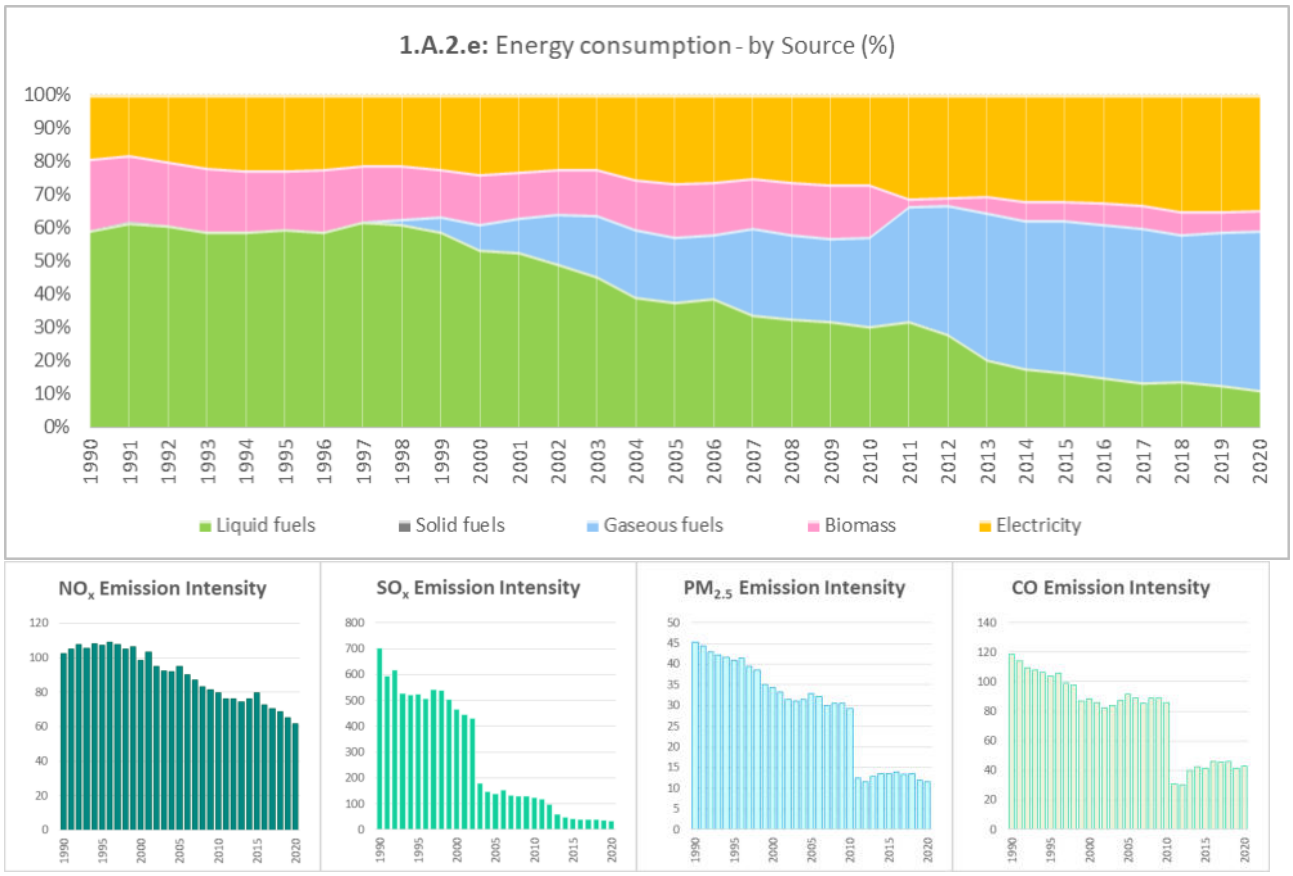
Emission Intensity [ton of pollutant emission/TJ of Energy consumption] is estimated considering the total emissions (NO_x, SO_x, $PM_{2.5}$ and CO) reported in category *1.A.2.d Pulp, Paper and Print* in relation to the total energy consumed (fossil fuels, biomass and electricity)

Figure 3-21: Share of energy consumption by source & Greenhouse gases emissions intensity

In the Pulp and Paper subsector, facility-specific data is used to estimate emissions. In this way, sharp reductions in the intensity of PM2.5 emissions in 2005 and CO in 2009 are related to the introduction of technology that reduces emissions in Pulp plants. With regard to the intensity of SO_2 emissions, the downward trend between 2000 and 2010 concerns first the reduction in the sulfur content of fuel oil, and subsequently the replacement of fuel oil consumption by natural gas.

3.3.2.2.4 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 is twice as high as in 1990, and is now responsible for around 30% of total energy consumption.



Emission Intensity [ton of pollutant emission/TJ of Energy consumption] is estimated considering the total emissions (NO_X, SO_X, $PM_{2.5}$ and CO) reported in category *1.A.2.e Food Processing, Beverages and Tobacco* in relation to the total energy consumed (fossil fuels, biomass and electricity)

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

The transition from petroleum-based fuels (fuel oil and diesel oil) to natural gas is the driver of the trend towards reducing NO_X Emission Intensity. This transition is also responsible for the downward trend seen in other pollutants. However, occasional episodes are responsible for abrupt breaks in the trend. With regard to the intensity of SO_2 emissions, the sharp drop in 2003 is related to the new legal limit in the sulfur content of fuel oil. In the case of the intensity of PM2.5 and CO emissions, the decrease seen in 2011 and 2012 is due to the particularly low values of biomass consumption in this sector.

3.3.2.2.5 Non-metallic Minerals

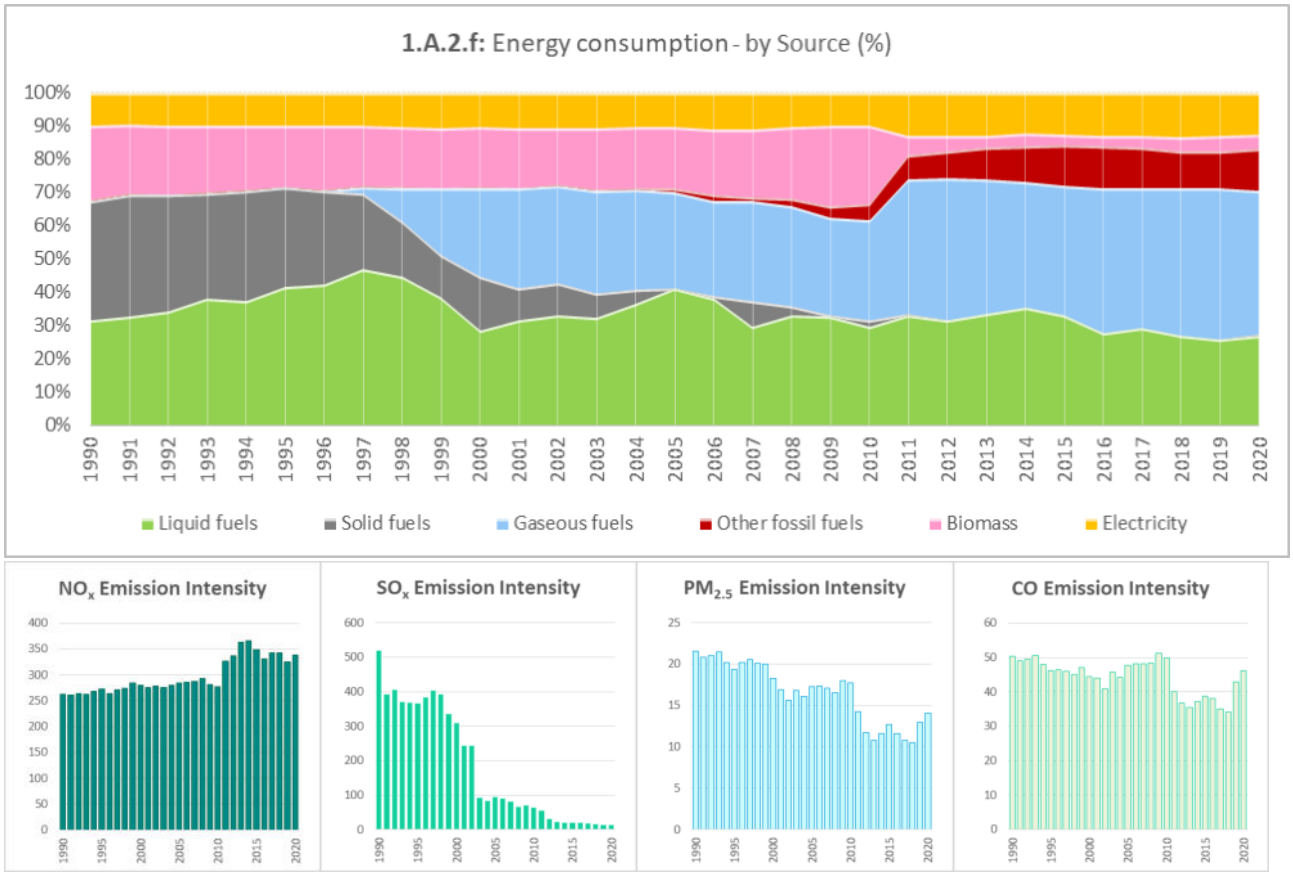
Category 1.A.2.f Non-Metallic Minerals enfolds emissions from fuel combustion in cement, lime, glass and bricks & tiles industries.

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. The cement industry underwent a different transition, with the substitution of coal for petroleum coke between 1998 and 2005, and subsequently an

increase in the share of consumption of Natural Gas, which is currently equivalent to 50% of the energy consumed, with coke a represent about 30%.

More recently, combustion of industrial waste, used tires and other waste started in cement plants. Thus increasing the share of "Other fossil fuels" in the subcategory to around 10%.



Emission Intensity [ton of pollutant emission/TJ of Energy consumption] is estimated considering the total emissions (NO_x, SO_x, $PM_{2.5}$ and CO) reported in category *1.A.2.f Non-metallic Minerals* in relation to the total energy consumed (fossil fuels, biomass and electricity)

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

Most of the NO_X emissions in this subcategory come from the Cement Industry and the Glass Industry, these emissions are estimated by Installation and with emission factors dependent on the production of Clinker and Glass. Thus, the jump in the intensity of NO_x emissions in 2011 is not related to production methods but to the significant drop in energy consumption of biomass seen in the Ceramics Industry.

With regard to the intensity of SO_2 emissions, the downward trend between 2000 and 2010 concerns first the reduction in the sulfur content of fuel oil, and subsequently the replacement of fuel oil consumption by natural gas. The increase in the intensity of SOx emissions seen since 2007 is mainly due to the consumption of petroleum coke in the Ceramics Industry.

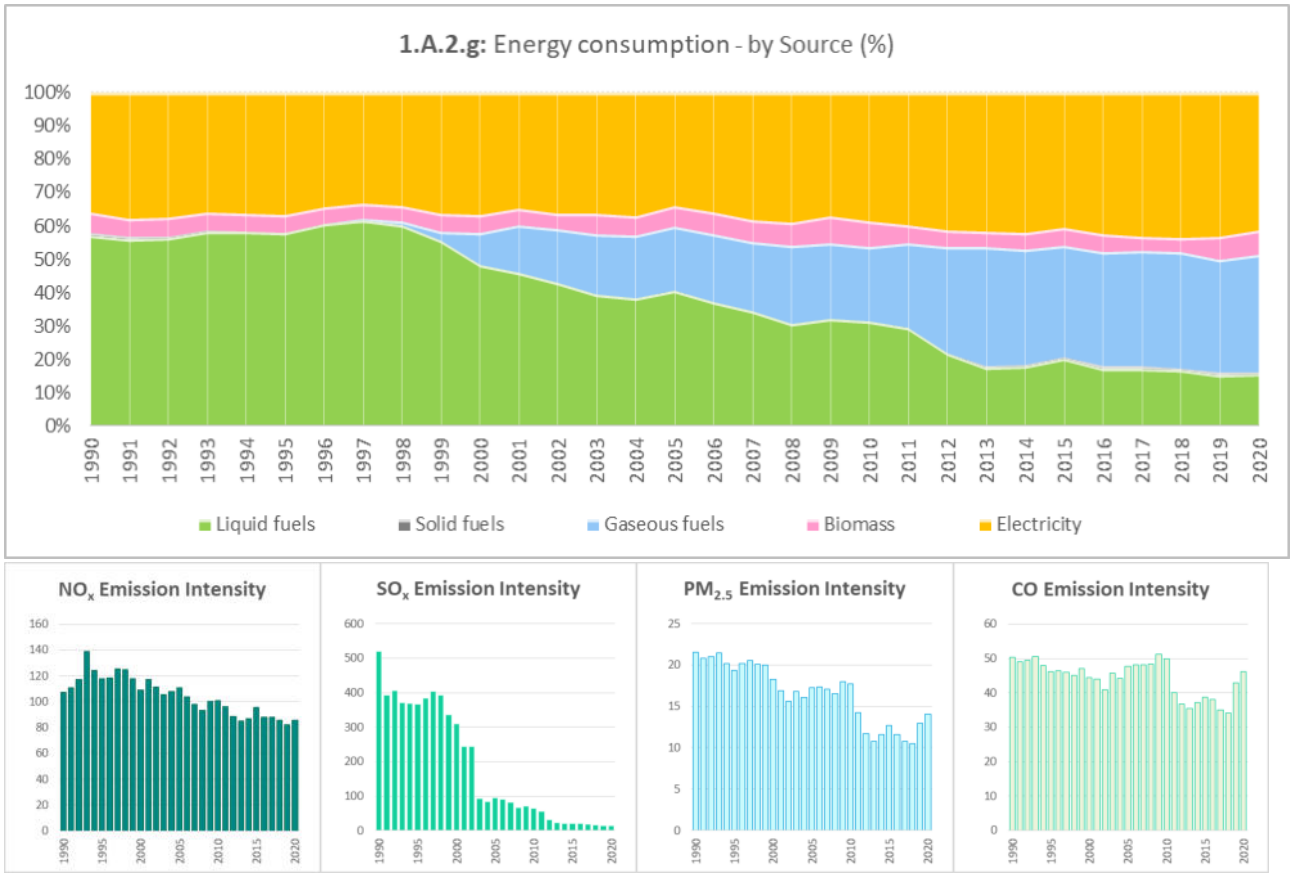
$PM_{2.5}$ emissions originate predominantly in the Ceramics Industry, and are associated with the combustion of wood and wood products. The variations in the emission intensity along the time series are related to the variations in the energy consumption of biomass.

The main sources of CO emissions in the subcategory are the Cement Industry, in which estimates are made by installation based on the production of Clinker and Industria Cerâmica whose emissions result mainly from the combustion of biomass. When analyzing the trend in the intensity of CO emissions, we can see that the drop in energy consumption that occurs in 2011 has a significant impact.

3.3.2.2.6 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.



Emission Intensity [ton of pollutant emission/TJ of Energy consumption] is estimated considering the total emissions (NO_X, SO_X, $PM_{2.5}$ and CO) reported in category *1.A.2.g Other Industries* in relation to the total energy consumed (fossil fuels, biomass and electricity)

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

The transition from petroleum-based fuels (fuel oil and diesel oil) to natural gas is the driver of the trend towards reducing NOX Emission Intensity. This transition is also responsible for the downward trend seen in other pollutants. However, occasional episodes are responsible for abrupt breaks in the trend. With regard to the intensity of SO2 emissions, the sharp drop in 2003 is related to the new legal limit in the sulfur content of fuel oil. In the case of the intensity of PM2.5 and CO emissions, the decrease seen in 2011 and 2012 is due to the particularly low values of biomass consumption in Textile Industry.

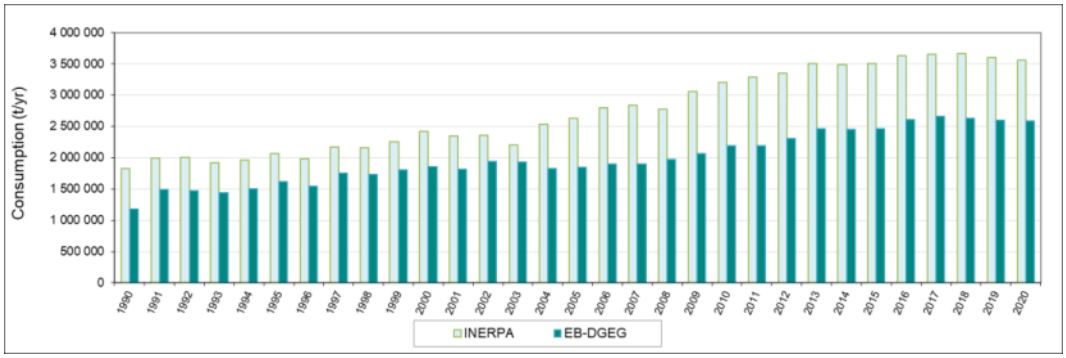
3.3.2.2.7 Comparison of LPS data vs. Energy Balance

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-

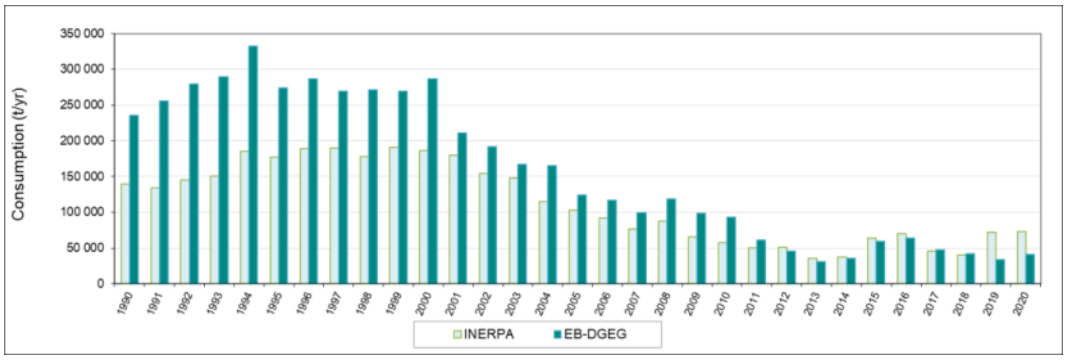
down approach (EB) with a bottom-up approach (LPS data). The following figures present the comparison done for sectors: (1) Paper Pulp; (2) Chemical Manufacturing; (3) Cement Industry and (4) Iron and Steel Plants.

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).

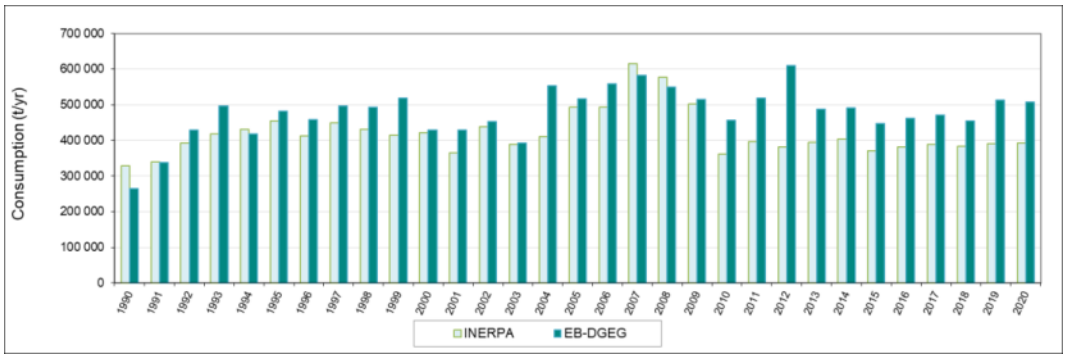
Black Liquor



Residual Fuel Oil



Biomass



Natural Gas

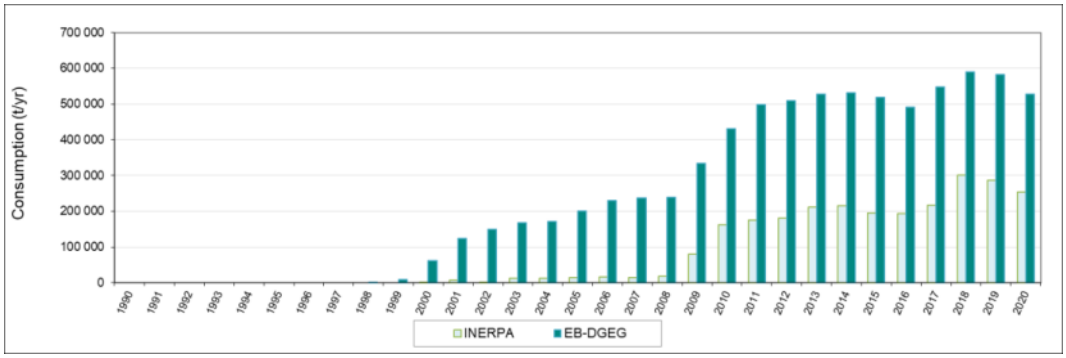


Figure 3-25: Comparison of total LPS consumption in Paper Pulp units with the reported consumption in the EB for the sector "Paper pulp and paper production"

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. It´s important to point out that in 2007 and 2008 the total

Biomass considered in INERPA is slight superior to that reported in the EB. Careful estimations were made not double count the emissions.

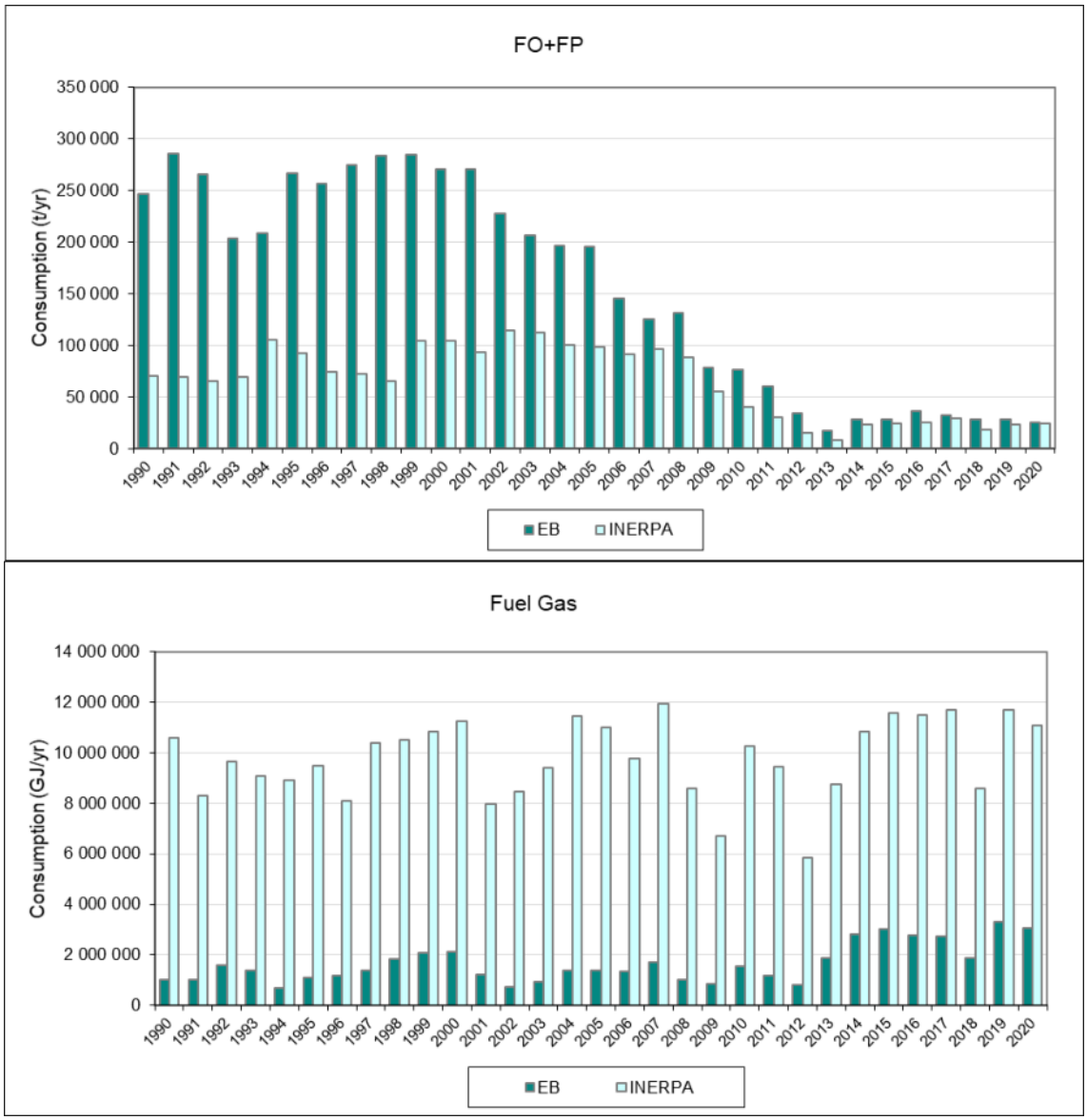


Figure 3-26: Comparison of total LPS consumption in Petrochemical units with the reported consumption in the EB for the sector "Chemical and Plastics"[16]

For the Petrochemical industry the comparison shows that the share of LPS in the consumption of residual fuel oil[17] is about 50 % until 2005. The two values show a tendency to converge in the later years. Also importante to note that in 2012 LPS values surpasse energy balance data by 8 %. Consumption of fuel gas as 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.

[16] Units in the vertical axis are not indicated due to confidenciality issues.

[17] 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.

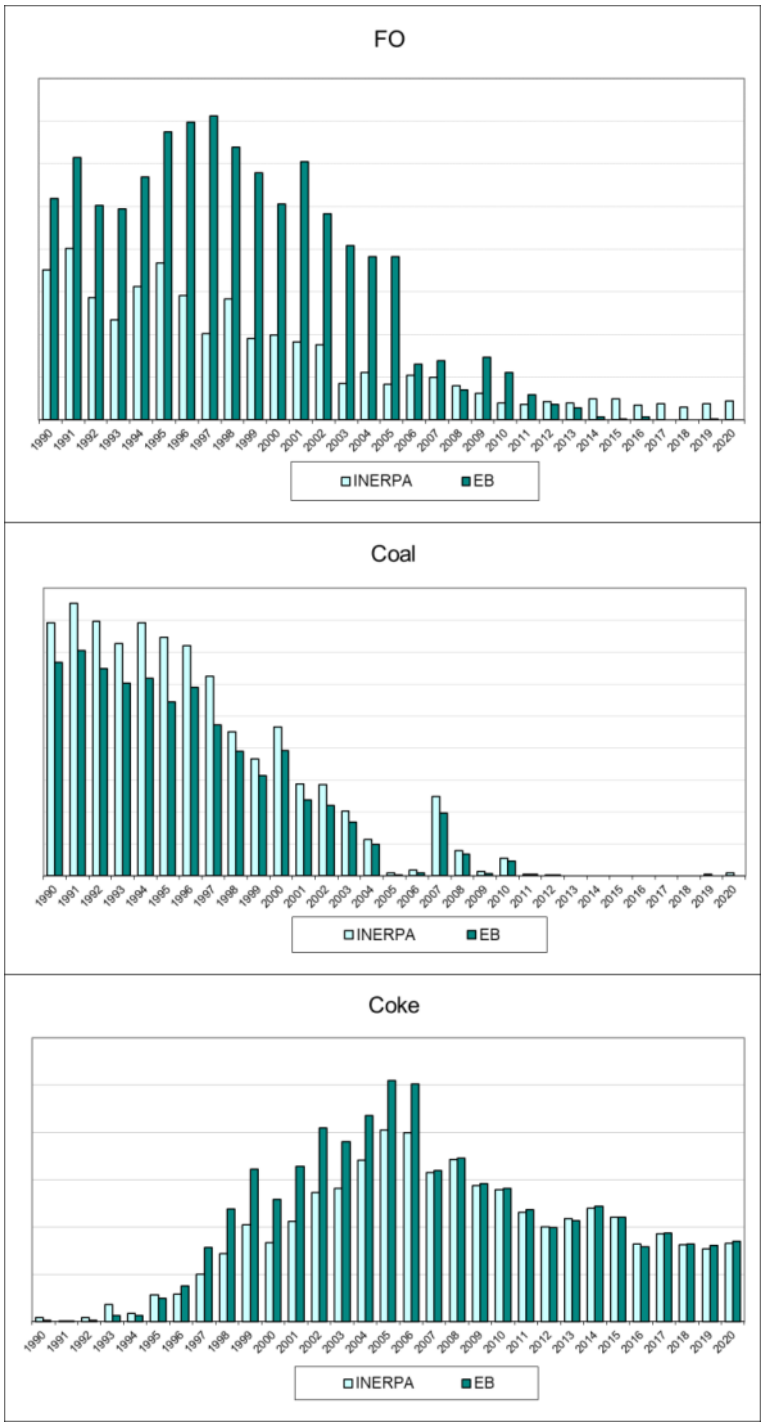


Figure 3-27: Comparison of total LPS consumption in Cement Plant with the reported consumption in the EB for the sector "Cement and Lime" (Due to confidentiality issues y axis values are not shown)

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.

3.3.2.3 Production Data

The production activity rates that were used to estimate of air emissions (production approach) are present in next tables. 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 IIR.

Total production of paper pulp is reported in Table 3.70. 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 3-25: Total Paper Pulp Production (Kraft and sulphide paper pulp)

Product	Unit	1990	2005	2018	2019	2020
Pulp Production	kt	1,398	2,010	2,773	2,754	2,683

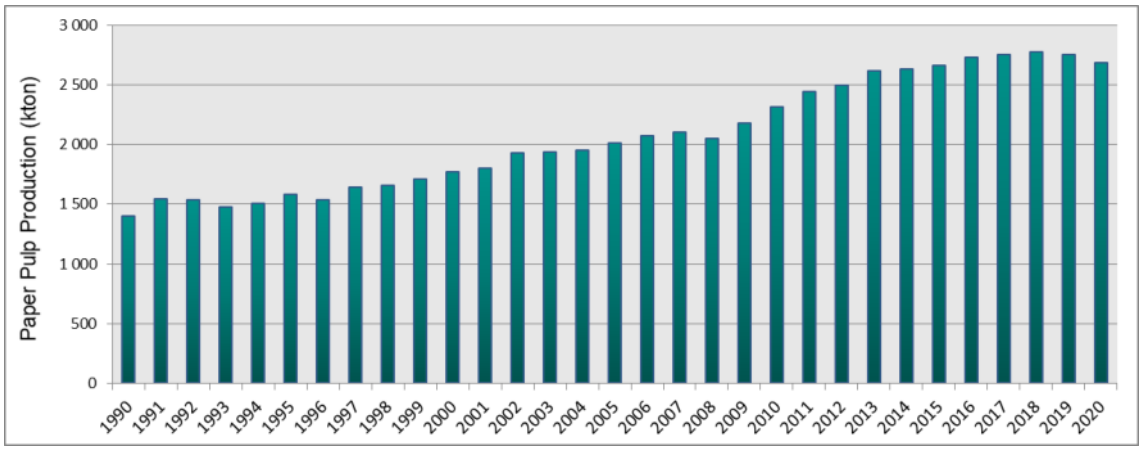


Figure 3-28: Total paper pulp production: Kraft and sulphide paper pulp

Clinker production values cannot be shown in this reported because of confidentiality issues.

Data on annual manufacturing of ceramic products is available from 1990 to 2020 from INE statistical database. The time series for total production is shown in Table 3.71 and Figure 3.54, according to type of ceramic.

Table 3-26: Ceramic Production according to type of ceramic (kt)

Product	Unit	1990	2005	2018	2019	2020
Bricks & roof tiles	kt	2,290	3,923	1,659	1,815	1,731
Tiles & other const	kt	478	1,327	999	927	811
Refractory	kt	31	100	16	19	15
Other ceramic	kt	104	278	395	376	319

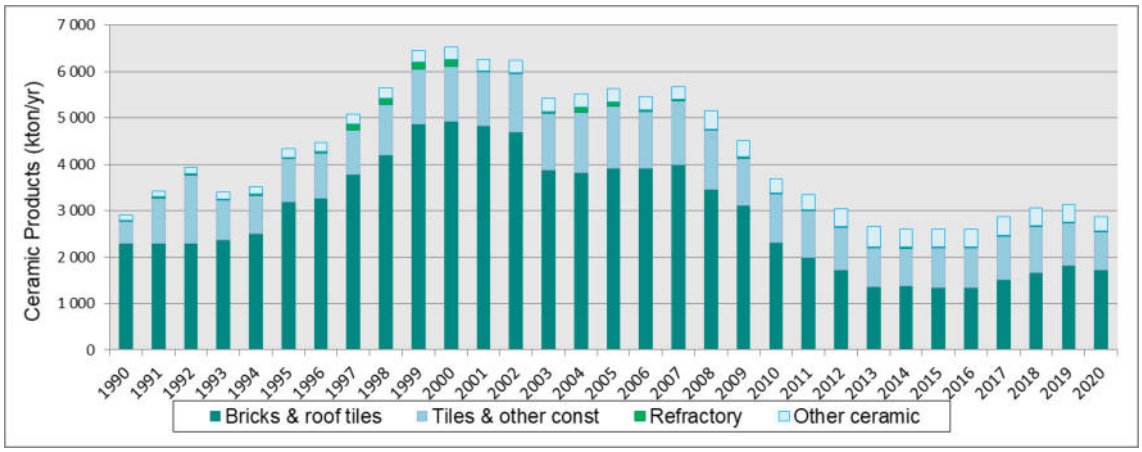


Figure 3-29: Ceramic Production by type of ceramic

The production values for container glass and lead crystal glass are presented in Figure 3.55 and in Table 3.73, 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.A.5. Because of confidentiality concerns the production of flat glass may not be published in IIR.

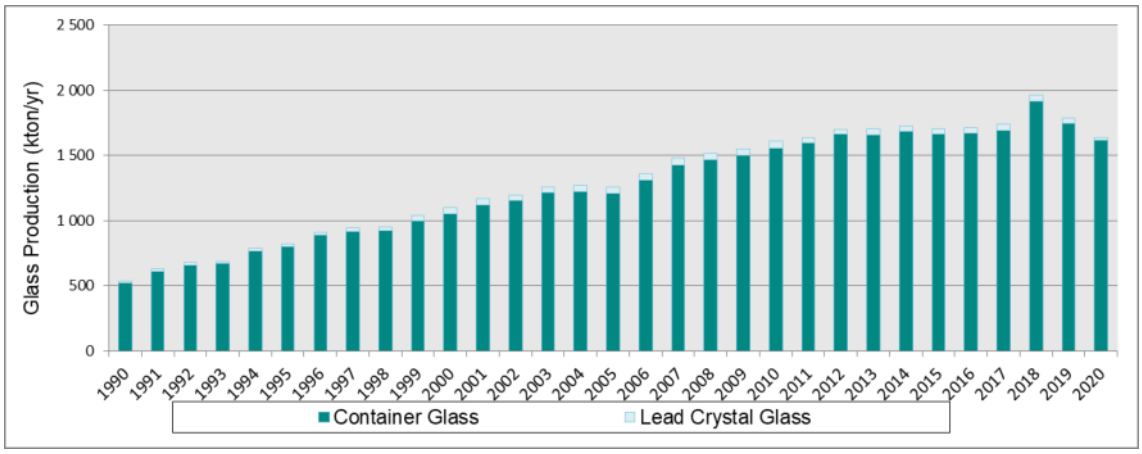


Figure 3-30: Glass production by glass type (excluding flat glass production)

Table 3-27: Glass production by glass type (kt/yr) excluding flat glass production

Product	Unit	1990	2005	2018	2019	2020
Container Glass	kt	508	1,201	1,916	1,743	1,615
Lead Crystal Glass	kt	16	45	46	43	25

Sinter is reported in Industrial Processes chapter 4.4.1 – Iron and Steel Production. Lime production in iron and steel integrated facility is addressed in Industrial Processes chapter 4.2.2 – Iron and Steel Production.

3.3.3 Emission Factors

The emissions factors that were used are dependent, in the majority of 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:

- EMEP/CORINAIR Emission Inventory Guidebook - 3rd edition (EEA, 2002);

- EMEP/EEA Air Pollutant Emission Inventory Guidebook – 2009 (EEA, 2009);
- EMEP/EEA air pollutant emission inventory guidebook 2013 (EEA, 2013)
- EMEP/EEA air pollutant emission inventory guidebook 2016 (EEA, 2016)
- IPCC Guidelines (IPCC, 1997; IPCC, 2006);
- US EPA AP-42 and EIIP (USEPA, 1996; USEPA, 1996b; USEPA, 1998; USEPA, 1998b; USEPA, 1998c);
- Stockholm Convention Toolkit (UNEP) for Dioxins/Furans and PAH.

Also, some EF for Total Particulate Matter were established from monitoring data collected in industrial plants in Portugal.

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 specific methodologies and emission factors available in the bibliography or either because country specific emission factors were developed from national studies and monitoring data. They are presented in the subsequent tables.

Table 3-28: Default emissions factors of ozone precursor gases for combustion equipments in the Manufacturing Industry

Equipment	Fuel		Code	NO_x (g/GJ)	NMVOC (g/GJ)	CO (g/GJ)
Boilers	Steam Coal	S	102	180	20	200
	Brown Coal/Lignite	S	105	180	20	200
	Coke from Coal	S	107	180	20	200
	LPG	L	303	74	23	29
	Gasoline	L	208	83	0.18	2.6
	City Gas	G	308	74	23	29
	Coke Oven Gas	S	304	74	23	29
	Blast Furnace Gas	S	305	74	23	29
	Fuel Gas, Hydrogen	G	399	74	23	29
	Biomass Wood	B	111	91	156	435
	Kerosene	L	206	83	0.18	2.6
	Diesel Oil	L	204	83	0.18	2.6
	Residual Fuel Oil	L	203	100	15	40
	Natural Gas	G	301	73	0.36	24
	Biodiesel	B	223	83	0.18	2.6
Static Engines	Gasoline	L	208	942	50	130
	Gas Oil	L	204	942	50	130
	Biogas	B	204	135	89	56
	Biodiesel	B	223	942	50	130

Table 3-29: Default sulphur content of fuels for combustion equipments in the Manufacturing Industry

Fuel		NAPFUE	Unit	1990	1995	2000	2001	2005	2019
Steam Coal	S	102	%	0.65	0.65	0.65	0.65	0.65	0.65
Brown Coal/Lignite	S	105	%	0.65	0.65	0.65	0.65	0.65	0.65
Coke from Coal	S	107	%	1.0	1.0	1.0	1.0	1.0	1.0
LPG	L	303	%	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016
Gasoline	L	208	%	0.100	0.100	0.015	0.015	0.005	0.005
City Gas	G	308	g S/Nm3	0.0	0.0	0.0	0.0	0.0	0.0
Coke Oven Gas	S	304	g S/Nm3	7.05	7.05	7.05	7.05	7.05	7.05
Blast Furnace Gas	S	305	g S/Nm3	0.045	0.045	0.045	0.045	0.045	0.045
Fuel Gas, Hydrogen	G	399	%	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016
Biomass Wood	B	111	%	0.03	0.03	0.03	0.03	0.03	0.03
Biogas	B	309	%	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016
Kerosene	L	206	%	0.15	0.03	0.03	0.03	0.03	0.03
Diesel Oil	L	204	%	0.30	0.30	0.20	0.20	0.20	0.20
Residual Fuel Oil	L	203	%	2.84	2.26	2.26	2.26	1.00	1.00
Natural Gas	G	301	g S/Nm3	0.01	0.01	0.01	0.01	0.01	0.01
Biodiesel	B	223	%	0.0	0.0	0.0	0.0	0.0	0.0

Table 3-30: Default emissions factors of Particulate Matter for combustion equipments in the Manufacturing Industry

Equipment	Fuel		Code	TSP (g/GJ)	PM_{10} (%TSP)	$PM_{2.5}$ (%TSP)	BC (%$PM_{2.5}$)
Boilers	Steam Coal	S	102	80	20	20	6.4
	Brown Coal/Lignite	S	105	80	35	10	6.4
	Coke from Coal	S	107	80	20	20	6.4
	LPG	L	303	0.8	100	100	4
	Gasoline	L	208	9.5	0.0	0.0	0.0
	City Gas	G	308	0.8	100	100	4
	Coke Oven Gas	S	304	0.8	100	100	4
	Blast Furnace Gas	S	305	0.8	100	100	4
	Fuel Gas, Hydrogen	G	399	0.8	100	100	4
	Biomass Wood	B	111	93	90	76	28
	Kerosene	L	206	9.5	50	12	56
	Diesel Oil	L	204	9.5	50	12	56
	Residual Fuel Oil [(a)]	L	203	Formula	86	56	56
	Natural Gas	G	301	0.5	100	100	4
	Biodiesel	B	223	9.5	50	12	56
Static Engines	Gasoline	L	208	30	100	100	56
	Gas Oil	L	204	30	100	100	56
	Biogas	B	309	2	100	100	4
	Biodiesel	B	223	30	100	100	56

(a) Decreasing function of sulphur content (USEPA)

Table 3-31: Default emissions factors of Heavy Metals for combustion equipments in Manufacturing Industry

Equipment	Fuel		NAPFUE	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
				g/t							
Boilers	Steam Coal	S	102	5.2E-02	1.7E-01	4.5E-01	3.6E-01	4.7E-01	7.2E-01	2.7E-01	1.3E+00
	Brown Coal/Lignite	S	105	4.0E-03	6.0E-02	4.0E-02	3.0E-02	2.0E-02	4.0E-02	0.0E+00	1.0E-01
	Coke from Coal	S	107	5.2E-02	1.7E-01	4.5E-01	3.6E-01	4.7E-01	7.2E-01	2.7E-01	1.3E+00
	LPG	L	303	1.8E-05	4.2E-03	3.2E-06	2.2E-05	1.4E-05	3.4E-05	3.8E-07	4.6E-04
	City Gas a)	G	308	1.8E-05	4.2E-03	3.2E-06	2.2E-05	1.4E-05	3.4E-05	3.8E-07	4.6E-04
	Coke Oven Gas a)	S	304	1.8E-05	4.2E-03	3.2E-06	2.2E-05	1.4E-05	3.4E-05	3.8E-07	4.6E-04
	Blast Furnace Gas a)	S	305	1.8E-05	4.2E-03	3.2E-06	2.2E-05	1.4E-05	3.4E-05	3.8E-07	4.6E-04
	Fuel Gas, Hydrogen	G	399	1.8E-05	4.2E-03	3.2E-06	2.2E-05	1.4E-05	3.4E-05	3.8E-07	4.6E-04
	Biomass Wood	B	111	1.5E-02	1.0E-01	4.3E-02	5.0E-04	1.0E-01	6.0E-03	2.3E-02	2.0E+00
	Kerosene	L	206	2.6E-01	0.0E+00	0.0E+00	5.0E-02	1.1E+00	2.9E-01	3.0E-02	3.0E+00
	Diesel Oil	L	204	4.0E-02	1.7E-02	6.4E-02	2.6E-01	6.5E-01	6.0E-02	3.7E-02	4.3E-01
	Residual Fuel Oil	L	203	6.8E-01	5.1E-01	5.6E-01	1.7E+00	7.4E-01	2.7E+01	6.8E-02	1.9E+00
	Natural Gas a)	G	301	1.8E-05	4.2E-03	3.2E-06	2.2E-05	1.4E-05	3.4E-05	3.8E-07	4.6E-04
	Biodiesel	B	223	4.0E-02	1.7E-02	6.4E-02	2.6E-01	6.5E-01	6.0E-02	3.7E-02	4.3E-01
Static Engines	Gasoline	L	208	2.6E-01	0.0E+00	0.0E+00	5.0E-02	1.1E+00	2.9E-01	3.0E-02	3.0E+00
	Gas Oil	L	204	4.0E-02	1.7E-02	6.4E-02	2.6E-01	6.5E-01	6.0E-02	3.7E-02	4.3E-01
	Biogas	B	309	1.8E-05	4.2E-03	3.2E-06	2.2E-05	1.4E-05	3.4E-05	3.8E-07	4.6E-04
	Biodiesel	B	223	4.0E-02	1.7E-02	6.4E-02	2.6E-01	6.5E-01	6.0E-02	3.7E-02	4.3E-01

a) g/km³

Table 3-32: Default emissions factors of Dioxins/Furans and PAH for combustion equipments in Manufacturing Industry

Equipment	Fuel		NAPFUE	DioxFur	PAH	PCB	HCB
				microg TEQ/TJ	mg/GJ	µg/GJ	µg/GJ
Boilers	Steam Coal	S	102	10.0	146	170	0.06
	Brown Coal/Lignite	S	105	10.0	146	170	0.06
	Coke from Coal	S	107	0.0	146	170	0.06
	LPG	L	303	0.0	5.8	0.0	0.0
	City Gas	G	308	0.5	5.8	0.0	0.0
	Coke Oven Gas	S	304	0.0	5.8	0.0	0.0
	Blast Furnace Gas	S	305	0.0	5.8	0.0	0.0
	Fuel Gas, Hydrogen	G	399	0.0	0.0	0.0	0.0
	Biomass Wood	B	111	50.0	35	0.06	5
	Kerosene	L	206	0.0	20.1	0.0	0.0
	Diesel Oil	L	204	0.5	20.1	0.0	0.0
	Residual Fuel Oil	L	203	2.5	20.1	0.0	0.0
	Natural Gas	G	301	0.5	5.8	0.0	0.0
	Biodiesel	B	223	0.5	20.1	0.0	0.0
Static Engines	Gasoline	L	208	0.0	20.1	0.0	0.0
	Gas Oil	L	204	0.5	20.1	0.0	0.0
	Biogas	B	309	0.5	5.8	0.0	0.0
	Biodiesel	B	223	0.5	20.1	0.0	0.0

Source: UNEP (2005), EEA (EMEP/CORINAIR), US-EPA AP-42

Note: PAH is defined as Benzo[b]fluoranthene, Benzo[k]fluoranthene, Benzo[a]pyrene and Indeno[1,2,3-cd]pyrene

Table 3-33: Emission factors of Ozone precursor gases in the extractive industry

Equipment	Fuel		NAPFUE	NO_x (g/GJ)	NMVOC (g/GJ)	CO (g/GJ)
Boilers	LPG	L	303	65	2.5	29
	Gasoline	L	208	60	1	66
	Kerosene	L	206	60	1	66
	Diesel Oil	L	204	60	1	66
	Residual Oil	L	203	160	3	66
	Natural Gas	G	301	67	5	29
	Lignite	S	105	200	190	931
	Biodiesel	B	223	60	1	66
Static Engines	Gasoline	L	208	1300	100	66
	Gas Oil	L	204	1100	100	66
	Biodiesel	B	223	1100	100	66

Table 3-34: Sulphur content in fuels used in the extractive industry (%S)

Year	LPG	Lead Gasoline	Unlead Gasoline	Kerosene	Gas Oil	Residual Oil	Natural Gas	Lignite	Biodiesel
1990	0.0016	0.10	0.100	0.15	0.30	2.84	0.0007	0.65	0
1995	0.0016	0.10	0.100	0.15	0.30	2.26	0.0007	0.65	0
2000	0.0016	0.10	0.050	0.15	0.25	2.26	0.0007	0.65	0
2005	0.0016	0.02	0.005	0.15	0.20	1.00	0.0007	0.65	0
2010	0.0016	0.02	0.005	0.15	0.10	1.00	0.0007	0.65	0
2015	0.0016	0.02	0.005	0.15	0.10	1.00	0.0007	0.65	0
2016	0.0016	0.02	0.005	0.15	0.10	1.00	0.0007	0.65	0
2017	0.0016	0.02	0.005	0.15	0.10	1.00	0.0007	0.65	0

Table 3-35: Emission factors of Particulate Matter in the extractive industry

Equipment	Fuel	Code		TSP (g/GJ)	PM_{10} (% TSP)	$PM_{2.5}$ (% TSP)	BC (%$PM_{2.5}$)
Boilers	LPG	L	303	3	100	100	4
	Gasoline	L	208	43	100	100	56
	Kerosene	L	206	7	50	12	56
	Gas Oil	L	204	6.5-133.3	50	12	56
	Residual Oil	L	203	53.0-88.9	86	56	56
	Natural Gas	G	301	1	100	100	4
	Lignite	S	105	1 166	35	10	6.4
	Biodiesel	B	223	6.5-133.3	50	12	56
Static Engines	Gasoline	L	208	43	100	100	56
	Gas Oil	L	204	133	100	100	56
	Biodiesel	B	223	133	100	100	56

Table 3-36: Emission factors of Heavy Metals in the extractive industry

Equipment	Fuel		Code	Cd	Hg	Ar	Cr	Cu	Ni	Se	Zn
				g/t							
Boilers	LPG	L	303	1.8E-05	4.2E-03	3.2E-06	2.2E-05	1.4E-05	3.4E-05	3.8E-07	4.6E-04
	Gasoline	L	208	2.6E-01	0.0E+00	0.0E+00	5.0E-02	1.1E+00	2.9E-01	3.0E-02	3.0E+00
	Kerosene	L	206	4.0E-02	1.7E-02	6.4E-02	2.6E-01	6.5E-01	6.0E-02	3.7E-02	4.3E-01
	Gas Oil	L	204	4.0E-02	1.7E-02	6.4E-02	2.6E-01	6.5E-01	6.0E-02	3.7E-02	4.3E-01
	Residual Oil	L	203	6.8E-01	5.1E-01	5.6E-01	1.7E+00	7.4E-01	2.7E+01	6.8E-02	1.9E+00
	Natural Gas a)	G	301	1.8E-05	4.2E-03	3.2E-06	2.2E-05	1.4E-05	3.4E-05	3.8E-07	4.6E-04
	Lignite	S	105	4.0E-03	6.0E-02	4.0E-02	3.0E-02	2.0E-02	4.0E-02	0.0E+00	1.0E-01
	Biodiesel	B	223	4.0E-02	1.7E-02	6.4E-02	2.6E-01	6.5E-01	6.0E-02	3.7E-02	4.3E-01
Static Engines	Gasoline	L	208	2.6E-01	0.0E+00	0.0E+00	5.0E-02	1.1E+00	2.9E-01	3.0E-02	3.0E+00
	Gas Oil	L	204	4.0E-02	1.7E-02	6.4E-02	2.6E-01	6.5E-01	6.0E-02	3.7E-02	4.3E-01
	Biodiesel	B	223	4.0E-02	1.7E-02	6.4E-02	2.6E-01	6.5E-01	6.0E-02	3.7E-02	4.3E-01

a) g/km^3

Table 3-37: Emission factors of Dioxins/Furans and PAH in the extractive industry

Equipment	Fuel		Code	DioxFur	PAH	PCB	HCB
				microg TEQ/TJ	mg/GJ	µg/GJ	µg/GJ
Boilers	LPG	L	303	0.0	5.8	0.0	0.0
	Gasoline	L	208	0.0	20.1	0.0	0.0
	Kerosene	L	206	0.0	20.1	0.0	0.0
	Gas Oil	L	204	0.5	20.1	0.0	0.0
	Residual Oil	L	203	2.5	20.1	0.0	0.0
	Natural Gas	G	301	0.5	5.8	0.0	0.0
	Lignite	S	105	0.0	146	170	1
	Biodiesel	B	223	0.5	20.1	0.0	0.0
Static Engines	Gasoline	L	208	0.0	20.1	0.0	0.0
	Gas Oil	L	204	0.5	20.1	0.0	0.0
	Biodiesel	B	223	0.5	20.1	0.0	0.0

Source: UNEP (2005), EEA (EMEP/CORINAIR), US-EPA AP-42
Note: PAH is defined as Benzo[b]fluoranthene, Benzo[k]fluoranthene, Benzo[a]pyrene and Indeno[1,2,3-cd]pyrene

Table 3-38: Emission factors for Ozone Precursor gases in the building and construction industry

Fuel		NAPFUE	NO_x	NMVOC	CO
			g/GJ	g/GJ	g/GJ
Residual Oil	L	203	513	25	66
Gas Oil	L	204	513	25	66
Kerosene	L	206	513	25	66
Motor Gasoline	L	208	513	25	66
LPG	L	303	513	25	66
Natural Gas	G	301	74	23	29
Biodiesel	B	223	513	25	66

Table 3-39: Sulphur content in the fuels used in the building and construction industry (%S)

Year	LPG	Motor Gasoline	Kerosene	Gas Oil	Residual Oil	Natural Gas	Biodiesel
1990	0.0016	0.10	0.15	0.30	2.84	0.0007	0.0
1991	0.0016	0.10	0.15	0.30	2.60	0.0007	0.0
1992	0.0016	0.10	0.15	0.30	2.60	0.0007	0.0
1993	0.0016	0.10	0.15	0.30	2.60	0.0007	0.0
1994	0.0016	0.10	0.15	0.30	2.60	0.0007	0.0
1995	0.0016	0.10	0.15	0.20	2.60	0.0007	0.0
1996	0.0016	0.10	0.15	0.05	2.60	0.0007	0.0
1997	0.0016	0.10	0.15	0.05	2.60	0.0007	0.0
1998	0.0016	0.10	0.15	0.05	2.60	0.0007	0.0
1999	0.0016	0.10	0.15	0.05	2.60	0.0007	0.0
2000	0.0016	0.10	0.15	0.05	2.60	0.0007	0.0
2001	0.0016	0.02	0.15	0.05	2.60	0.0007	0.0
2002	0.0016	0.02	0.15	0.04	2.60	0.0007	0.0
2003	0.0016	0.02	0.15	0.04	1.00	0.0007	0.0
2004	0.0016	0.02	0.15	0.04	1.00	0.0007	0.0
2005	0.0016	0.02	0.15	0.01	1.00	0.0007	0.0
2006	0.0016	0.02	0.15	0.01	1.00	0.0007	0.0
2007	0.0016	0.02	0.15	0.01	1.00	0.0007	0.0
2008	0.0016	0.02	0.15	0.01	1.00	0.0007	0.0
2009	0.0016	0.02	0.15	0.01	1.00	0.0007	0.0
2010	0.0016	0.02	0.15	0.01	1.00	0.0007	0.0
2011	0.0016	0.02	0.15	0.01	1.00	0.0007	0.0
2012	0.0016	0.02	0.15	0.01	1.00	0.0007	0.0
2013	0.0016	0.02	0.15	0.01	1.00	0.0007	0.0

Table 3-40: Emission factors for Particulate Matter in the building and construction industry

Fuel		NAPFUE	TSP	PM_{10}	$PM_{2.5}$	BC
			g/GJ	% TSP	% TSP	% PM2.5
Residual Oil	L	203	20.0	100	100	56
Gas Oil	L	204	20.0	100	100	56
Kerosene	L	206	20.0	100	100	56
Motor Gasoline	L	208	20.0	100	100	56
LPG	L	303	20.0	100	100	56
Natural Gas	G	301	0.8	100	100	4
Biodiesel	B	223	20.0	100	100	56

Table 3-41: Emission factors for Heavy Metals in the building and construction industry

Fuel	Technology	Table	Source
Gas Oil	Default - T1	**3.4**	GB 2016 - Combustion in Industries
Fuel Oil	Default - T1	**3.4**	GB 2016 - Combustion in Industries
Natural Gas	Default - T1	**3.3**	GB 2016 - Combustion in Industries
Liquefied Petroleum Gases (LPG)	Default - T1	**3.3**	GB 2016 - Combustion in Industries
Gasoline	Default - T1	**3.4**	GB 2016 - Combustion in Industries
Other Kerosene	Default - T1	**3.4**	GB 2016 - Combustion in Industries
Wood products	Default - T1	**3.4**	GB 2016 - Combustion in Industries
Biofuels	Default - T1	**3.4**	GB 2016 - Combustion in Industries

Other specific emission factors were used for some industrial units, some of them obtained from direct measurements in Large Point Sources (LPS) or 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 Large Point Sources (LPS).

Table 3-42: Emission factors from sinter production and pig iron production in LPS units in iron and steel sector (Integrated iron and steel facility)

Pollutant	Sinter		Blastfurnace	
	EF	Unit	EF	Unit
NOx (as NO2)	558	g/ton sinter	8	g/ton pig iron
SOx (as SO2)	463	g/ton sinter	38	g/ton pig iron
NH3	NE	-	NE	g/ton pig iron
CO	18 000	g/ton sinter	27	g/ton pig iron
Source: Tables 3-7 and 3-8, Vol. 1.A.2, 2016 EMEP Guidebook				

Table 3-43: Emission factors from combustion in LPS units in iron and steel sector

Pollutant	Fuel				Unit
	Fuel Oil	Coke Oven Gas / Blast Furnace Gas	Coal Tar / Residual Fuel Oil	Natural Gas / LPG / Diesel	
NOx (as NO2)	513	48	398	74	g/GJ
NMVOC	25	1,6	0,19	23	g/GJ
SOx (as SO2)	47	0,281	46,5	0,67	g/GJ
NH3	NE	NE	NE	NE	-
PM2.5	20	0,2	1,95	0,78	g/GJ
PM10	20	0,2	1,95	0,78	g/GJ
TSP	20	0,2	1,95	0,78	g/GJ
BC	56	2,5	33,5	4	% of PM2.5
CO	66	4,8	1,49	29	g/GJ
Pb	0,08	0,0015	0,0069	0,011	mg/GJ
Cd	0,006	0,00025	0,0012	0,0009	mg/GJ
Hg	0,12	0,1	0,053	0,54	mg/GJ
As	0,03	0,12	0,0023	0,1	mg/GJ
Cr	0,2	0,00076	0,28	0,013	mg/GJ
Cu	0,22	0,000076	0,17	0,0026	mg/GJ
Ni	0,008	0,00051	0,0023	0,013	mg/GJ
Se	0,11	0,0112	0,0023	0,058	mg/GJ
Zn	29	0,0015	0,44	0,73	mg/GJ
PCDD/ PCDF (dioxins/ furans)	1,4	NE	NE	0,52	g I-TEQ
Benzo(a) pyrene	1,9	0,56	NE	0,72	µg/GJ
Benzo(b) fluoranthene	15	1,58	NE	2,9	µg/GJ
Benzo(k) fluoranthene	1,7	1,11	NE	1,1	µg/GJ
Indeno (1,2,3-cd) pyrene	1,5	8,36	NE	1,08	µg/GJ
Total PAH's	20,1	11,61	0	5,8	µg/GJ
HCB	NE	NE	NE	NE	-
PCBs	NE	NE	NE	NE	-
Source: Tables 3-3, 3-4, 3-7 and 3-8, Vol. 1.A.2, 2016 EMEP Guidebook					

In the 2012 inventory, for 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. The EF used for this industrial sector (LPS estimation only) can be found in the next tables.

Table 3-44: Emission factors used in LPS units in the Paper Pulp Industry: Ozone precursors from combustion – Energy Approach – International EF sources

Equipment	Fuel	NAPFUE		NOx EF (g/GJ)	NMVOC EF (g/GJ)	CO EF (g/GJ)
Auxiliary Boilers	Residual Oil	L	203	170 - 210	2.3	15.1
	Natural Gas	G	301	70.0	2.0	20.0
Biomass Boilers	Wood Waste	B	111	153.5	7.3	150
	Residual Oil	L	203	-	2.3	15.1
	Natural Gas	G	301	-	1.5	-
	LPG	L	303	-	1.5	-
Recovery Boilers	Residual Oil	L	203	-	-	15.1
	Natural Gas	G	301	-	-	-
	Gas Oil	L	204	-	-	-
	Bisulfite Liquor	B	215	-	-	150.0
	Black Liquor	B	215	-	-	-
	Methanol	B	111	-	-	-
Flare	LPG	L	303	90	3.0	30.0
Lime Kiln	Gasified Biomass	B	111	-	-	-
	Residual Oil	L	203	-	-	-
	Natural Gas	G	301	-	-	-
	Gas Oil	L	204	-	-	-
	NCG	B	111	-	-	-
	Tall-oil	B	111	-	-	-
Static Engine	Gas Oil	L	204	1 450.0	37.1	385.0
Gas Turbine	Natural Gas	G	301	153.0	1.0	39.2

Table 3-45: Emission factors used in LPS units in the Paper Pulp Industry: Ozone precursors from combustion – Production Approach – International EF sources

Equipment	NOx EF (kg/t pulp)	NMVOC EF (kg/t pulp)
Recovery Boilers	2.0 (i)	0.2 - 0.75
Lime Kiln	-	0.096
(i) Only for Bisulfite.		

Table 3-46: Emission factors used in LPS units in the Paper Pulp Industry: Ozone precursors from combustion – Production Approach and Energy Approach – Plant specific EF

Equipment	Approach	NOx		CO	
		EF	Unit	EF	Unit
Auxiliary Boilers	Energy	91.2	g/GJ	86.7	g/GJ
Biomass Boilers	Energy	63.17 - 180.5	g/GJ	53.73 – 1 294.0	g/GJ
Recovery Boilers	Production	0.33 - 1.17	kg/t pulp	0.05 - 2.59	kg/t pulp
Lime Kiln	Production	0.12 - 0.22	kg/t pulp	0.01 - 0.07	kg/t pulp

Table 3-47: Emission factors used in LPS units in the Paper Pulp Industry: sulphur oxides (SO_x) emissions – Mass Balance – International EF sources

Equipment	Fuel	NAPFUE		SOx %
Auxiliary Boilers	Residual Oil	L	203	0.9 - 3.5
	Natural Gas	G	301	0
Biomass Boilers	Wood Waste	B	111	0.03
	Residual Oil	L	203	0.9 - 3.5
	Natural Gas	G	301	0
	LPG	L	303	0
Recovery Boilers	Residual Oil	L	203	-
	Natural Gas	G	301	-
	Gas Oil	L	204	-
	Bisulfite Liquor	B	215	-
	Black Liquor	B	215	-
	Methanol	B	111	-
Flare	LPG	L	303	0
Lime Kiln	Gasified Biomass	B	111	-
	Residual Oil	L	203	-
	Natural Gas	G	301	-
	Gas Oil	L	204	-
	NCG	B	111	-
	Tall-oil	B	111	-
Static Engine	Gas Oil	L	204	0.3
Gas Turbine	Natural Gas	G	301	0

Table 3-48: Emission factors used in LPS units in the Paper Pulp Industry: sulphur oxides (SOx) emissions – Production Approach – International EF sources

Equipment	SOx EF (kg/t pulp)
Recovery Boilers	3.5 - 4.5
Lime Kiln	0.15

Table 3-49: Emission factors used in LPS units in the Paper Pulp Industry: Particulate Matter – Energy Approach – International EF sources

Equipment	Fuel	NAPFUE		TSP g/GJ
Auxiliary Boilers	Residual Oil	L	203	20.0
	Natural Gas	G	301	0.5
Biomass Boilers	Wood Waste	B	111	35.0
	Residual Oil	L	203	-
	Natural Gas	G	301	-
	LPG	L	303	-
Recovery Boilers	Residual Oil	L	203	-
	Natural Gas	G	301	-
	Gas Oil	L	204	-
	Bisulfite Liquor	B	215	-
	Black Liquor	B	215	-
	Methanol	B	111	-
Flare	LPG	L	303	0.5
Lime Kiln	Gasified Biomass	B	111	-
	Residual Oil	L	203	-
	Natural Gas	G	301	-
	Gas Oil	L	204	-
	NCG	B	111	-
	Tall-oil	B	111	-
Static Engine	Gas Oil	L	204	28.1
Gas Turbine	Natural Gas	G	301	0.91

Table 3-50: Emission factors used in LPS units in the Paper Pulp Industry: Particulate Matter – Production Approach – International EF sources

Equipment	NOx EF (kg/t pulp)
Recovery Boilers	1.0 (i)
(i) Only for Bisulfite.	

Table 3-51: Emission factors used in LPS units in the Paper Pulp Industry: Particulate Matter – Production Approach and Energy Approach – Plant specific EF

Equipment	Approach	NOx EF	Unit
Biomass Boilers	Energy	10.1 - 405.8	g/GJ
Recovery Boilers	Production	0.1 - 1.48	kg/t pulp
Lime Kiln	Production	0.01 - 0.04	kg/t pulp

Table 3-52: Emission factors used in LPS units in the Paper Pulp Industry: Particulate Matter – Fraction of PM10, PM2.5 and BC – International EF sources

Equipment	Fuel	NAPFUE		PM10 %	PM2.5 %	BC % PM2.5
Auxiliary Boilers	Residual Oil	L	203	75.0	45.0	56.0
	Natural Gas	G	301	100.0	100.0	4.0
Biomass Boilers	Wood Waste	B	111	71.4	34.3	28.0
	Residual Oil	L	203	75.0	45.0	56.0
	Natural Gas	G	301	100.0	100.0	4.0
	LPG	L	303	100.0	100.0	4.0
Recovery Boilers	Residual Oil	L	203	93.5	67.0	56.0
	Natural Gas	G	301	93.5	53.8	4.0
	Gas Oil	L	204	93.5	53.8	56.0
	Bisulfite Liquor	B	215	93.5	67.0	28.0
	Black Liquor	B	215	93.5	53.8	28.0
	Methanol	B	111	93.5	53.8	28.0
Flare	LPG	L	303	100.0	100.0	4.0
Lime Kiln	Gasified Biomass	B	111	98.3	96.0	28.0
	Residual Oil	L	203	98.3	96.0	56.0
	Natural Gas	G	301	98.3	96.0	4.0
	Gas Oil	L	204	88.5	83.0	56.0
	NCG	B	111	88.5	83.0	28.0
	Tall-oil	B	111	98.3	96.0	28.0
Static Engine	Gas Oil	L	204	79.7	77.2	56.0
Gas Turbine	Natural Gas	G	301	100.0	100.0	4.0

Table 3-53: Emission factors used in LPS units in the Paper Pulp Industry: Heavy Metals – International EF sources

Fuel	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
	g/t								
Wood	5.00E-02	1.47E-02	1.00E-01	4.27E-02	5.00E-04	1.00E-01	6.03E-03	2.30E-02	2.00E+00
Gasified Biomass	5.00E-02	1.47E-02	1.00E-01	4.27E-02	5.00E-04	1.00E-01	6.03E-03	2.30E-02	2.00E+00
Residual Oil	9.31E-01	6.84E-01	5.07E-01	5.56E-01	1.70E+00	7.41E-01	2.69E+01	6.84E-02	1.90E+00
Natural Gas	8.00E-03	1.76E-02	4.16E-03	3.20E-03	2.24E-02	1.36E-02	3.36E-02	3.84E-04	4.64E-01
Gas Oil	5.93E-01	3.96E-02	1.69E-02	6.38E-02	2.61E-01	6.50E-01	6.00E-02	3.66E-02	4.33E-01
Bisulfite Liquor	5.00E-02	1.47E-02	1.00E-01	4.27E-02	5.00E-04	1.00E-01	6.03E-03	2.30E-02	2.00E+00
Black Liquor	5.00E-02	1.47E-02	1.00E-01	4.27E-02	5.00E-04	1.00E-01	6.03E-03	2.30E-02	2.00E+00
Methanol	9.52E-03	2.09E-02	4.95E-03	3.81E-03	2.67E-02	1.62E-02	4.00E-02	4.57E-04	5.52E-01
NCG	8.00E-03	1.76E-02	4.16E-03	3.20E-03	2.24E-02	1.36E-02	3.36E-02	3.84E-04	4.64E-01
LPG	9.52E-03	2.09E-02	4.95E-03	3.81E-03	2.67E-02	1.62E-02	4.00E-02	4.57E-04	5.52E-01
Tall-oil	5.00E-02	1.47E-02	1.00E-01	4.27E-02	5.00E-04	1.00E-01	6.03E-03	2.30E-02	2.00E+00
(i) Except for Natural Gas ana NCG which is g/km3									

Table 3-54: Emission factors used in LPS units in the Paper Pulp Industry: Dioxins/Furans and PAH – International EF sources

Equipment	Fuel	NAPFUE		DioxFur ng TEQ/GJ	PAH mg/GJ
Auxiliary Boilers	Residual Oil	L	203	2.5	0.007
	Natural Gas	G	301	2.0	0.003
Biomass Boilers	Wood Waste	B	111	50.0	1.53
	Residual Oil	L	203	2.5	0.007
	Natural Gas	G	301	0.5	0.003
	LPG	L	303	0.5	0.003
Recovery Boilers	Residual Oil	L	203	2.5	0.007
	Natural Gas	G	301	0.5	0.003
	Gas Oil	L	204	0	0.91
	Bisulfite Liquor	B	215	0	0
	Black Liquor	B	215	0	0
	Methanol	B	111	0	0
Flare	LPG	L	303	2	0.003
Lime Kiln	Gasified Biomass	B	111	50	1.53
	Residual Oil	L	203	2.5	0.007
	Natural Gas	G	301	0.5	0.003
	Gas Oil	L	204	0	0.91
	NCG	B	111	0	0
	Tall-oil	B	111	0	0
Static Engine	Gas Oil	L	204	0	0.90
Gas Turbine	Natural Gas	G	301	0.5	0.003

For the cement 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 Data chapter for more explanations). Most emission factors result from plant specific emission factors developed from monitoring at each installation.

Table 3-55: Emission Factors for ceramic production using the Production Approach: Indirect Ozone Precursor gases and SO_x

Fuel		NAPFUE		NO_x (kg/t)	SOx (kg/t)	NMVOC (kg/t)
Bricks and roof tiles [a]	LPG	L	303	0.45	1.50	0.03
	Residual Oil	L	203	0.45	1.13	0.03
	Natural Gas	G	301	0.45	1.50	0.03
	Biomass Wood	B	111	0.47	0.39	0.09
Tiles & other construction materials [a]	LPG	L	303	0.27	0.01	0.22
	Residual Oil	L	203	0.27	62.48	0.22
	Natural Gas	G	301	0.27	0.05	0.22
	Biomass Wood	B	111	0.27	0.14	0.22
Refractory [b]	LPG	L	303	0.87	3.80	0.03
	Residual Oil	L	203	0.87	3.80	0.03
	Natural Gas	G	301	0.87	3.80	0.03
	Biomass Wood	B	111	0.87	3.80	0.09
Other Ceramic [c]	LPG	L	303	0.27	0.01	0.22
	Residual Oil	L	203	0.27	62.48	0.22
	Natural Gas	G	301	0.27	0.05	0.22
	Biomass Wood	B	111	0.27	0.14	0.22

Source: (a) USEPA (1997); (b) USEPA (1995f); (c) USEPA (1996c)

Table 3-56: Emission Factors for ceramic production using the Production Approach: Particulate Matter

Fuel		Code		TSP (kg/t)	PM_{10} (% TSP)	$PM_{2.5}$ (% TSP)	BC (%$PM_{2.5}$)
Bricks and roof tiles [a]	LPG	L	303	0.14	100	100	4.0
	Residual Oil	L	203	0.14	88	88	56.0
	Natural Gas	G	301	0.14	100	100	4.0
	Biomass Wood	B	111	0.13	62	62	28.0
Tiles & other construction materials [a]	LPG	L	303	11	27	27	4.0
	Residual Oil	L	203	11	27	27	56.0
	Natural Gas	G	301	11	27	27	4.0
	Biomass Wood	B	111	11	27	27	28.0
Refractory [b]	LPG	L	303	68	25	25	4.0
	Residual Oil	L	203	68	25	25	56.0
	Natural Gas	G	301	68	25	25	4.0
	Biomass Wood	B	111	68	25	25	28.0
Other Ceramic [c]	LPG	L	303	11	27	27	4.0
	Residual Oil	L	203	11	27	27	56.0
	Natural Gas	G	301	11	27	27	4.0
	Biomass Wood	B	111	11	27	27	28.0

Source: (a) USEPA (1997); (b) USEPA (1995f); (c) USEPA (1996c)

Emission factors for sinter in iron and steel integrated plan are reported in Industrial Processes chapter 4.4.1 – Iron and Steel Production.

3.3.4 Recalculations

In 2022 submission there were no significant recalculations in category 1.A.2. However, minor adjustments were made to some of the methodologies used. Namely:

- Update of 1990-2004 glass production activity data, with impact on NOx; COVNM and SOx emissions
- Correction of the consumption of Biomass in the Pulp and Paper Industry, for the year 2019
- Correction of the consumption of Natural Gas in the Lime Production Industry, for the year 2019
- Update of the methodology for calculating CO emissions in the lime production sector. The production approach was implemented to estimate CO emissions for the entire time series.

3.3.5 Further Improvements

The most important improvement in this sector is the continuing streamline with EU-ETS and DGEG's energy balance, mainly for sectors like Chemical industry. Also efforts should be made to expand the estimation and use of plant specific emission factors with data from Self-Control Program (*Programa Autocontrolo).*

It was also identified the need to improve the data sets related to the consumption of biomass, heating oil and the incorporation of biofuels.

3.4 Transport (NFR 1.A.3)

3.4.1 Civil Aviation (NFR 1.A.3.a)

3.4.1.1 Category description

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 Other Mobile Sources.

3.4.1.2 Methodology

The method to estimate emissions from jet fuel consumption is a Tier 3 method according with 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.

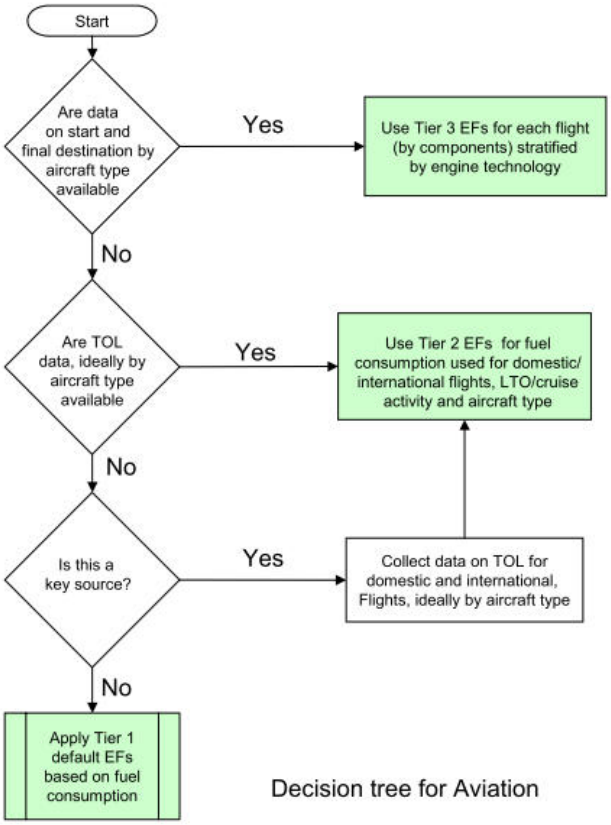


Figure 3-31: Decision tree for emissions from aviation (EMEP/EEA, 2019)

The method to estimate emissions from aviation gasoline is a Tier 1 method which is based primarily in energy statistics.

The choice of methods allows the harmonization between inventories covering greenhouse gas emissions and inventories covering air pollutants.

The IIR covers LTO emissions from either domestic or international flights. Cruise emissions, realized above 3000 ft, although excluded from the IIR coverage are reported as memo item.

Emissions and consumption are estimated for each airport allowing spatial allocation for mainland and islands.

The model developed by the inventory team at the Portuguese environmental Agency, provides the necessary disaggregation to fulfill the report needs of the IIR.

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.

3.4.1.2.1 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:

$$Emission_{LTO(p,d,a,y)} = Emission_{Arrival(p,d,s,y)} + Emission_{Departure(p,d,a,y)}$$

$$Emission_{Arrival(p,d,a,y)} = N_{Arrival(d,a,y)} \times EF_{Arrival(p,a)} \times 10^{-3}$$

$$Emission_{Departure(p,d,a,y)} = N_{Departure(d,a,y)} \times EF_{Departure(p,a)} \times 10^{-3}$$

Figure below outlines the process whereby LTO_{Cycle} emissions are estimated.

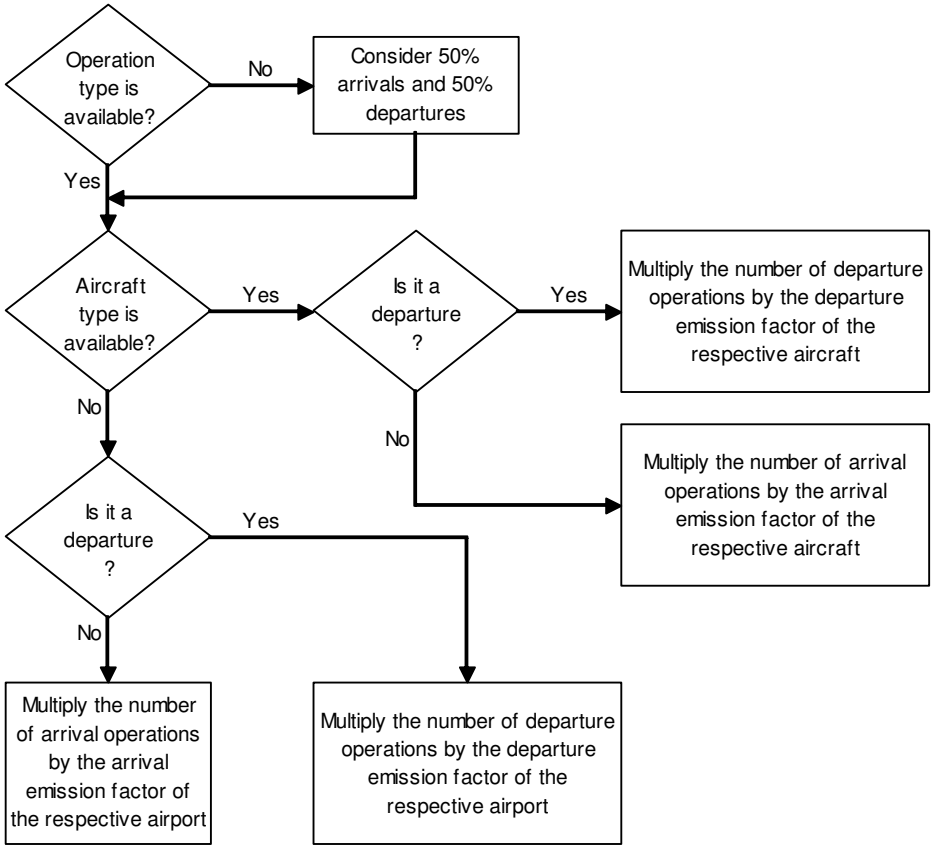


Figure 3-32: Decision tree for LTOCycle emission calculation

3.4.1.2.2 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:

$Emission_{cruise(p,d,a,s,y)}$ – 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)

$N_{LTO(d,a,s,y)}$ – number domestic LTO from origin/destiny d in airport a performed by aircraft type s during year y

$EF_{cruise(p,d,a,s,t,y)}$ – 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.

3.4.1.3 Emission Factors

3.4.1.3.1 LTO

3.4.1.3.1.1 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 3-57: Emissions factors for most common aircraft movements in national airports

Aircraft	Take-off (kg/movement)					Land (kg/movement)				
	FC	HC	CO	NOx	PM	FC	HC	CO	NOx	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

3.4.1.3.1.2 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 3-58: Airport based LTO emission factors (kg/movement)

Airport	Operation	Parameter	1990	1995	2000	2005	2010	2015	2018	2019	2020
Lisboa (LIS)	Take-off	Fuel Consumption	670.2	608.9	567.4	452.6	451.6	468.4	484.2	471.9	453.3
		VOC	16.4	14.9	15.2	9.3	2.8	2.3	2.3	2.3	2.5
		CO	37.1	33.7	35.4	21.5	13.8	12.8	13.3	13.2	13.7
		NOx	26.3	23.9	23.6	16.2	15.9	17.1	18.3	17.0	16.1
		PM_{10}	6.2	5.6	5.2	4.2	4.2	4.4	4.5	4.4	4.2
	Landing	Fuel Consumption	291.0	264.4	240.2	204.2	206.6	223.7	213.0	207.0	194.7
		VOC	7.0	6.4	6.0	4.4	1.5	1.2	1.2	1.2	1.3
		CO	17.8	16.2	16.3	11.1	7.0	6.5	6.4	6.4	6.4
		NOx	4.9	4.4	4.3	3.3	3.4	3.8	3.7	3.5	3.3
		PM_{10}	3.1	2.8	2.6	2.2	2.2	2.4	2.3	2.2	2.1
Porto (OPO)	Take-off	Fuel Consumption	530.0	481.5	401.1	374.4	427.6	358.1	364.0	354.3	374.0
		VOC	8.2	7.5	6.5	4.1	3.3	2.6	2.3	2.2	2.2
		CO	26.3	23.9	23.0	13.7	12.8	10.7	10.9	10.7	11.2
		NOx	19.1	17.3	15.0	11.9	14.7	11.9	11.8	11.9	12.5
		PM_{10}	4.9	4.5	3.7	3.5	4.0	3.3	3.4	3.3	3.5
	Landing	Fuel Consumption	236.2	214.6	181.3	172.9	191.7	171.1	164.6	162.5	170.8
		VOC	3.7	3.3	2.9	2.2	1.6	1.4	1.2	1.3	1.3
		CO	12.7	11.5	11.1	7.2	6.3	5.8	5.5	5.7	6.0
		NOx	3.8	3.5	3.0	2.6	3.2	2.8	2.6	2.7	2.9
		PM_{10}	2.5	2.3	1.9	1.9	2.1	1.8	1.8	1.7	1.8
Faro (FAO)	Take-off	Fuel Consumption	514.8	467.7	443.6	348.7	339.1	263.5	280.7	265.6	245.8
		VOC	5.3	4.8	4.9	3.0	2.4	2.1	1.8	2.0	2.1
		CO	19.2	17.4	17.2	12.2	11.0	8.5	8.3	8.4	8.0
		NOx	17.4	15.8	16.0	11.0	10.0	7.7	8.0	7.6	7.2
		PM_{10}	4.8	4.3	4.1	3.2	3.1	2.4	2.6	2.5	2.3
	Landing	Fuel Consumption	231.8	210.6	198.9	158.2	161.1	139.3	134.2	130.1	119.1
		VOC	2.7	2.5	2.5	1.7	1.4	1.4	1.2	1.3	1.5
		CO	10.0	9.1	9.0	6.5	5.9	5.0	4.7	4.8	4.8
		NOx	3.5	3.2	3.1	2.3	2.4	2.0	1.9	1.8	1.7
		PM_{10}	2.5	2.3	2.1	1.7	1.7	1.5	1.4	1.4	1.3
Santa Maria (SMA)	Take-off	Fuel Consumption	424.1	385.3	328.4	393.3	446.6	335.2	257.9	259.2	157.2
		VOC	9.2	8.3	9.8	7.6	5.2	2.0	2.1	2.6	0.9
		CO	23.1	21.0	22.2	19.1	17.6	10.2	10.4	12.5	4.9
		NOx	16.3	14.8	12.0	16.0	20.0	12.4	10.0	9.8	4.1
		PM_{10}	3.9	3.6	3.0	3.7	4.2	3.1	2.4	2.4	1.4
	Landing	Fuel Consumption	216.1	196.3	169.9	196.1	223.3	178.3	137.7	130.2	91.9
		VOC	4.6	4.1	4.9	3.4	2.6	1.3	1.3	1.5	0.8
		CO	13.2	12.0	12.4	10.7	9.8	6.6	6.8	7.2	4.1
		NOx	3.6	3.2	2.6	3.6	4.3	3.3	2.5	2.2	1.1
		PM_{10}	2.3	2.1	1.8	2.1	2.4	1.9	1.5	1.4	0.9
Ponta Delgada (PDL)	Take-off	Fuel Consumption	616.3	559.9	895.0	403.0	475.3	525.1	406.9	393.7	362.6
		VOC	7.7	7.0	10.1	3.8	2.7	2.3	1.8	1.9	1.2
		CO	19.5	17.7	24.2	12.4	12.6	13.7	11.3	11.6	8.9
		NOx	20.4	18.6	31.5	13.0	15.9	20.3	14.8	15.6	11.3
		PM_{10}	5.7	5.2	8.3	3.8	4.4	4.9	3.8	3.7	3.4
	Landing	Fuel Consumption	285.0	258.9	414.5	175.7	202.8	243.4	184.5	173.8	164.0
		VOC	4.4	4.0	7.6	1.8	1.3	1.1	1.0	0.9	0.7
		CO	11.2	10.2	16.4	6.2	6.3	6.5	5.8	5.5	4.9
		NOx	4.1	3.7	6.3	2.6	3.1	4.3	3.0	2.9	2.4
		PM_{10}	3.1	2.8	4.5	1.9	2.2	2.6	2.0	1.9	1.8

Airport	Operation	Parameter	1990	1995	2000	2005	2010	2015	2018	2019	2020
Horta (HOR)	Take-off	Fuel Consumption	457.9	416.0	783.6	287.9	405.3	263.2	418.7	350.4	437.9
		VOC	3.8	3.5	1.8	4.8	3.6	1.0	1.1	1.2	1.8
		CO	13.0	11.8	15.6	10.6	10.7	6.6	9.0	7.9	10.1
		NOx	14.4	13.1	25.7	8.5	13.1	8.9	14.3	11.6	14.9
		PM_{10}	4.3	3.9	7.3	2.7	3.8	2.5	3.9	3.3	4.1
	Landing	Fuel Consumption	219.8	199.6	337.9	146.4	194.9	163.8	211.3	182.6	185.3
		VOC	1.8	1.7	0.7	2.1	1.9	0.7	0.6	0.8	1.0
		CO	6.8	6.2	6.7	5.6	5.7	4.6	4.9	4.7	5.0
		NOx	3.2	2.9	5.3	2.0	2.9	2.5	3.3	2.8	2.9
		PM_{10}	2.4	2.2	3.7	1.6	2.1	1.8	2.3	2.0	2.0
Flores (FLW)	Take-off	Fuel Consumption	422.4	383.8	299.1	359.5	343.4	380.6	582.4	412.7	615.5
		VOC	5.3	4.8	4.3	5.3	3.9	1.0	1.2	1.0	1.3
		CO	14.2	12.9	9.3	11.8	9.5	7.4	11.3	8.6	12.1
		NOx	13.0	11.8	8.9	10.8	10.6	12.2	19.6	13.6	20.9
		PM_{10}	4.0	3.6	2.8	3.4	3.2	3.6	5.5	3.9	5.8
	Landing	Fuel Consumption	227.7	206.8	164.9	170.2	176.2	210.6	284.4	209.5	278.7
		VOC	2.2	2.0	1.9	2.6	1.9	0.7	0.6	0.6	0.6
		CO	7.5	6.8	5.1	6.6	5.0	4.3	5.7	4.7	5.7
		NOx	3.4	3.1	2.4	2.4	2.4	3.0	4.5	3.0	4.4
		PM_{10}	2.5	2.3	1.8	1.9	1.9	2.3	3.1	2.3	3.0
Funchal (FNC)	Take-off	Fuel Consumption	623.5	566.5	465.6	466.6	469.7	448.7	462.9	401.4	410.7
		VOC	5.9	5.4	4.5	2.7	1.7	1.4	1.4	1.4	1.4
		CO	20.2	18.3	15.1	13.0	12.1	10.6	10.1	9.5	9.5
		NOx	19.3	17.6	14.0	15.2	14.6	14.0	14.6	12.6	13.2
		PM_{10}	5.8	5.2	4.3	4.3	4.4	4.2	4.3	3.7	3.8
	Landing	Fuel Consumption	280.8	255.1	210.8	206.3	209.3	205.1	211.5	182.1	179.5
		VOC	2.9	2.7	2.2	1.5	0.9	0.8	0.7	0.8	0.9
		CO	10.3	9.4	7.9	6.5	5.7	5.2	4.9	4.8	4.8
		NOx	4.0	3.7	2.9	3.2	3.2	3.1	3.2	2.8	2.8
		PM_{10}	3.0	2.7	2.3	2.2	2.3	2.2	2.3	2.0	1.9
Porto Santo (PXO)	Take-off	Fuel Consumption	561.0	509.6	534.2	438.3	447.3	443.3	498.4	489.1	366.2
		VOC	7.9	7.2	4.8	6.7	2.8	1.5	1.3	2.0	1.1
		CO	25.0	22.7	15.8	19.3	14.1	12.2	10.7	13.4	8.0
		NOx	18.6	16.9	18.4	16.0	13.9	13.7	15.9	15.7	10.8
		PM_{10}	5.2	4.7	4.9	4.1	4.2	4.1	4.6	4.5	3.4
	Landing	Fuel Consumption	277.8	252.4	238.5	196.3	207.6	218.0	232.0	226.5	174.0
		VOC	3.2	2.9	2.3	2.8	1.2	0.7	0.6	0.6	0.7
		CO	12.0	10.9	8.1	8.8	6.6	6.1	5.0	5.0	4.3
		NOx	4.1	3.7	4.0	3.2	3.1	3.3	3.6	3.5	2.5
		PM_{10}	3.0	2.7	2.6	2.1	2.2	2.4	2.5	2.5	1.9
Terceira (TER)	Take-off	Fuel Consumption	958.6	870.9	743.3	847.6	623.2	702.0	748.7	700.9	484.7
		VOC	7.4	6.7	5.7	8.9	5.5	2.6	4.1	3.5	1.9
		CO	28.2	25.6	21.8	29.0	18.7	17.2	23.0	20.1	12.1
		NOx	39.1	35.6	30.3	36.8	23.4	29.1	30.9	32.3	17.5
		PM_{10}	9.0	8.1	7.0	7.9	5.8	6.6	7.0	6.5	4.5
	Landing	Fuel Consumption	391.8	355.9	303.8	338.7	262.6	287.7	306.7	286.3	219.5
		VOC	3.0	2.7	2.3	3.3	2.3	1.1	1.8	1.6	1.1
		CO	11.8	10.7	9.1	11.9	8.5	7.0	9.9	8.8	6.3
		NOx	6.9	6.3	5.4	6.4	4.6	5.3	5.7	5.7	3.6
		PM_{10}	4.3	3.9	3.3	3.7	2.9	3.1	3.3	3.1	2.4

3.4.1.3.2 Cruise Emissions

3.4.1.3.2.1 Aircraft Based Cruise Emissions

Cruise emissions were estimated from EMEP/CORINAR 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 3-59: Cruise emissions and fuel consumption

Aircraft	Distance (km)	Fuel Consumption (kg)	NOX (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

3.4.1.3.2.2 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.

3.4.1.3.3 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. The table 5 in ANNEX C shows the correspondence between aircrafts and representative aircrafts for LTO and cruise emissions factors.

3.4.1.3.4 Fuel dependent emission factors

Fuel dependent emission factors were set for SO_2 (0.04%) and heavy metals. The LHV for Aviation Gasoline (44 Mj/kg) and Jet Fuel (43 MJ/kg) were obtained from the national energy authority (DGEG).

Table 3-60: Heavy Metals fuel dependent emission factors

Fuel	Aviation Gasoline			Jet Fuel		
Pollutant	**Value**	**Unit**	**Reference**	**Value**	**Unit**	**Reference**
Pb	0.6	g/l	1A3a EMEP/EEA Guidebook 2019 Annex 2	0.0016	g/t	1A3b EMEP/EEA Guidebook 2019 table 3-78
Cd	0,0002	g/t	1A3b EMEP/EEA Guidebook 2019 table 3-78	0.0002		
Hg	0,0087			0.0087		
As	0,0003			0.0003		
Cr	0,0063			0.0063		
Cu	0,0045			0.0045		
Ni	0,0023			0.0023		
Se	0,0002			0.0002		
Zn	0,033			0.033		

3.4.1.4 Activity Data

3.4.1.4.1 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 2020 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 3-61: LTO_{Cycle} per airport

Region	Airport Code	1990	1995	2000	2005	2010	2015	2018	2019	2020
Mainland	LIS	30 862	34 932	56 073	68 168	73 783	84 385	110 371	112 367	45 980
	OPO	11 574	13 348	23 280	25 910	28 502	35 248	46 997	49 753	22 317
	FAO	11 252	13 067	18 243	20 397	22 359	22 330	30 406	31 510	12 560
	TOTAL	**53 688**	**61 347**	**97 596**	**114 475**	**124 643**	**141 963**	**187 774**	**193 629**	**80 856**

Region	Airport Code	1990	1995	2000	2005	2010	2015	2018	2019	2020
Islands	FNC	6 475	9 460	12 040	15 952	12 697	12 442	13 376	13 031	6 180
	TER	3 801	4 049	4 501	4 875	4 988	4 755	5 862	6 031	3 819
	PDL	2 954	3 382	4 134	7 196	8 182	8 499	12 048	12 712	8 111
	PXO	2 403	4 243	3 788	3 688	2 325	2 103	2 033	1 708	1 093
	HOR	1 237	1 542	1 756	2 964	2 919	2 331	2 866	2 940	2 107
	SMA	634	893	1 557	1 649	1 275	1 073	1 327	1 561	1 203
	FLW	281	357	552	1 101	1 136	1 002	1 456	1 524	1 104
	TOTAL	**17 785**	**23 924**	**28 327**	**37 425**	**33 521**	**32 204**	**38 966**	**39 505**	**23 616**

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.

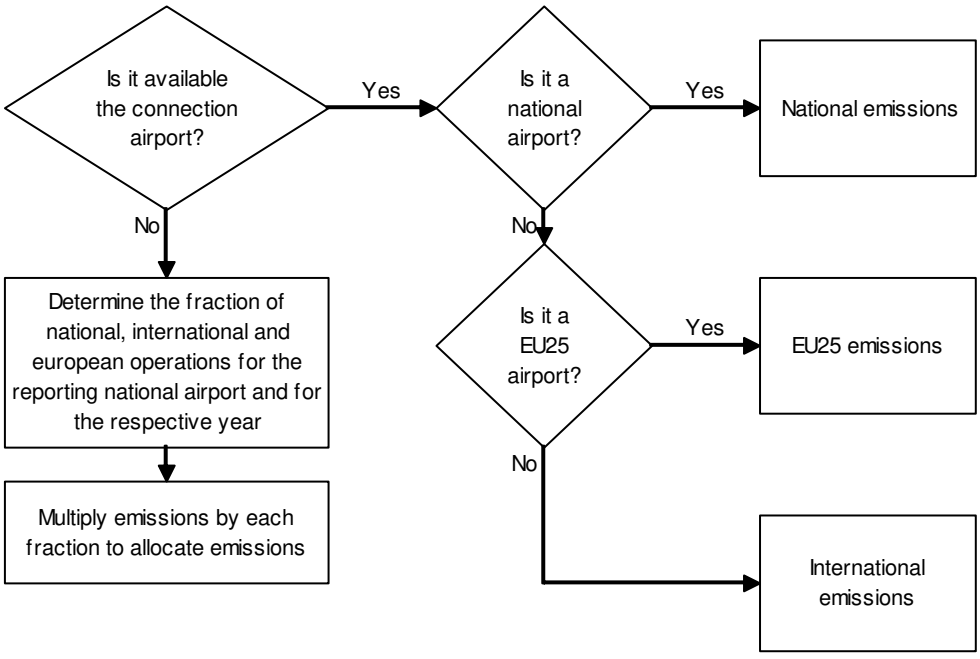
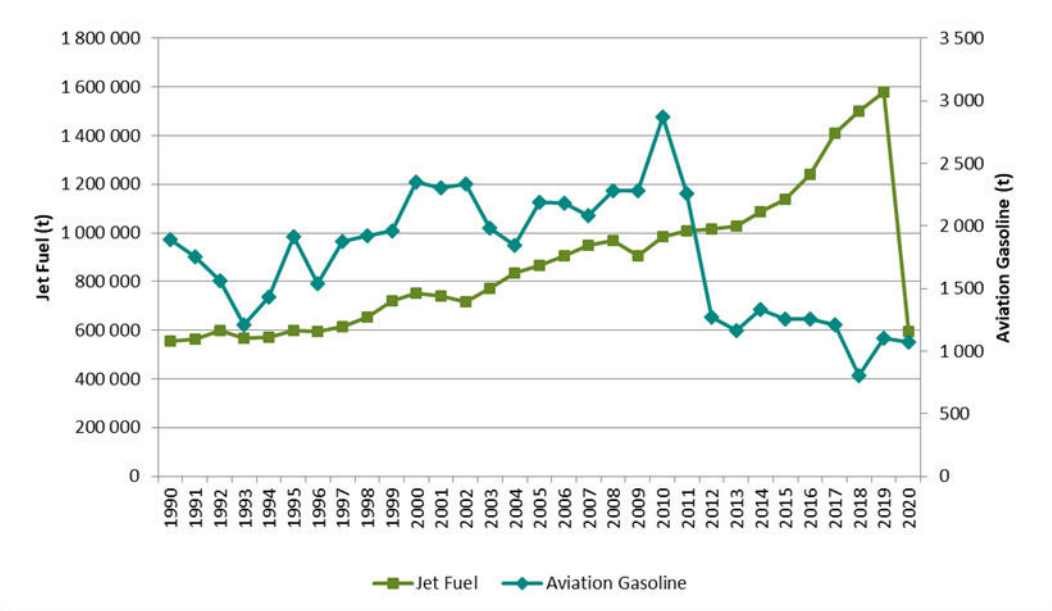


Figure 3-33: Decision tree for distinction between domestic and international emissions

3.4.1.4.2 Fuel Consumption

Fuel consumption is available from fuel sales statistics from DGEG for main territory and islands and is presented in the figure below and ANNEX C. 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 3-34: Total Fuel consumption of Aviation Gasoline and Jet Fuel

3.4.1.5 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.

3.4.1.6 Recalculations

No recalculations were made.

3.4.1.7 Further Improvements

We plan to include the estimation of PM 2.5 cruise emission in a future submission.

3.4.2 Road Transportation (NFR 1.A.3.b)

3.4.2.1 Category description

Road transportation is one of the most important emission sources of pollutants associated with trans-boundary, regional and, particularly, local air problems, comprehending nitrogen oxides (NO_x), carbon monoxide (CO), non-methane volatile organic compounds (NMVOC), particulate matter and heavy metals.

Table 3-62: Main pollutants and particulate matter emissions from road transport (t)

Pollutant	1990	1995	2000	2005	2010	2015	2018	2019	2020
NOx	95 751	111 957	128 646	110 790	93 794	71 354	66 684	64 417	52 283
NMVOC	93 880	91 436	67 686	40 713	25 678	18 141	15 250	14 825	11 875
SOx	13 407	12 921	5 856	597	108	91	97	100	84
NH_3	62	639	1 463	1 792	1 351	1 000	883	879	686
$PM_{2.5}$	6 117	7 547	8 623	7 483	6 586	4 756	4 235	4 084	3 312
PM_{10}	6 697	8 331	9 718	8 559	7 664	5 660	5 168	5 048	4 130
CO	487 469	484 835	366 445	230 632	141 784	92 607	75 531	72 584	55 844

The introduction of catalytic converters has reduced significantly the carbon monoxide (CO) emissions and incresed the ammonia (NH3) emissions.

In addition to the exhaust emissions, Road Transportation sector also includes evaporative NMVOC emissions from gasoline vehicles and emissions of particulate matter (PM) from tyre and brake wear and road abrasion.

Table 3-63: Heavy metals emissions from road transport (kg)

Pollutant	1990	1995	2000	2005	2010	2015	2018	2019	2020
Pb - 1A3b	554 567.50	766 395.54	16 384.03	14 463.37	11 440.43	8 759.00	8 598.79	8 868.53	7 402.18
Pb - 2G	0.22	0.28	0.36	0.37	0.38	0.34	0.35	0.36	0.30
Cd - 1A3b	14.15	13.44	14.68	12.99	12.91	10.86	11.29	11.73	10.10
Cd - 2G	30.32	37.82	49.09	50.24	51.82	46.29	48.02	49.14	41.58
Hg - 1A3b	21.40	28.65	38.19	37.88	33.41	27.80	29.21	30.09	25.39
Hg - 2G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
As - 1A3b	15.09	20.15	27.61	26.43	26.25	21.43	21.84	22.50	19.09
As - 2G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cr - 1A3b	525.13	675.63	912.39	869.76	865.71	707.91	723.36	745.98	633.54
Cr - 2G	127.68	159.23	206.71	211.53	218.18	194.92	202.19	206.92	175.07
Cu - 1A3b	11 631.54	14 541.49	19 281.93	18 206.16	18 200.92	14 868.73	15 173.37	15 657.29	13 311.31
Cu - 2G	5 173.57	6 452.29	8 376.08	8 571.56	8 840.99	7 898.37	8 192.89	8 384.39	7 094.12
Ni - 1A3b	133.08	139.46	164.29	149.31	148.33	123.04	126.84	131.41	112.51
Ni - 2G	212.06	264.48	343.33	351.35	362.39	323.75	335.82	343.67	290.79
Se - 1A3b	17.88	18.70	22.28	20.65	20.49	17.28	17.89	18.52	15.86
Se - 2G	30.19	37.65	48.88	50.02	51.59	46.09	47.81	48.93	41.40
Zn - 1A3b	4 622.76	5 740.58	7 657.02	7 383.17	7 333.81	6 113.96	6 271.52	6 467.89	5 499.85
Zn - 2G	2 993.75	3 733.70	4 846.93	4 960.04	5 115.95	4 570.50	4 740.93	4 851.74	4 105.11

Heavy metals emissions from road transport include emissions from lubricants use as energy in two-stroke engines (reported in 1A3b) and from lubricants that enters accidentally in the four-stroke engines combustion chambers (reported in 2G).

Table 3-64: Persistent organic pollutant emissions from road transport (kg)

Pollutant	1990	1995	2000	2005	2010	2015	2018	2019	2020
Dioxins/Furans	0.0009	0.0014	0.0027	0.0031	0.0035	0.0027	0.0023	0.0022	0.0018
PAH's	169	232	353	388	438	401	428	436	370
HCB	0.0007	0.0013	0.0026	0.0030	0.0034	0.0027	0.0023	0.0022	0.0018
PCB's	0.0002	0.0003	0.0006	0.0006	0.0007	0.0005	0.0005	0.0004	0.0004

The 2020 Road Transportation contribution of main pollutants, particulate matter and CO in total national emissions is represented in the next Figure.

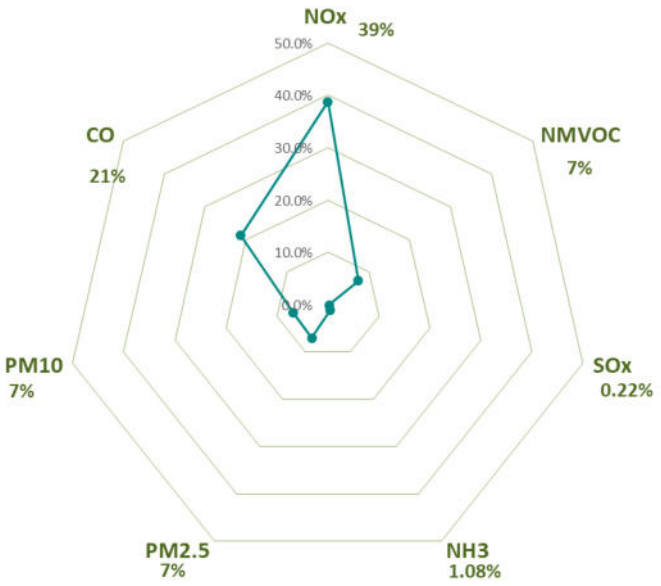


Figure 3-35: Road Transportation contribution (%) of main pollutants, particulate matter and CO in total national emissions in 2020

3.4.2.2 Methodology

Emissions from Road Transportation, estimated using the COPERT 5[18] (Version 5.4.36 - October 2020) includes the following type of emissions:

- Exhaust Emissions from Fuel (1A3bi, 1A3bii, 1A3biii, 1A3biv) - NOx, NMVOC, SOx, NH_3, CO, $PM_{2.5}$, PM_{10}, TSP, BC, heavy metals, dioxins/furans, PAH's, HCB and PCB's;
- Exhaust Emissions from Lubricants use in two-stroke engines (1A3biv) – heavy metals;
- Emissions from Lubricants use in four-stroke engines (2G) – heavy metals;
- Gasoline Evaporation Emissions (1A3bv) – NMVOC;
- Automobile Tyre and Brake Wear Emissions (1A3bvi) - PM2.5, PM10, TSP, BC, PAH's[19] and heavy metals.
- Automobile Road Abrasion (1A3bvii) - $PM_{2.5}$, PM_{10}, TSP and BC.

[18] https://www.emisia.com/utilities/copert/
[19] The estimate of PAHs emissions in 1A3bvi follows the methodology described in the EMEP/EEA Guidebook 2019 and does not use Copert 5 software.

For the calculation of these emissions, beyond COPERT V 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 V adjust the blend type and share and the annual distance travelled (mean activity).

The separation between Mainland and the archipelagos of Azores and Madeira takes into account data from the regional energy balance of these two Autonomous Regions.

Estimated emissions from Road Transportation are based in Tier 2 method for CO_2 emissions and Tier 3 for non-CO_2 emissions.

3.4.2.3 Emission Factors

Emissions factors for Exhaust Emissions, Gasoline Evaporation, Automobile Tyre and Brake Wear and Road Surface Wear were determined using COPERT V.

For the estimation of PAHs emissions in 1A3bvi the emission factors described in table 3-10, of the 1A3bvi EMEP/EEA Guidebook 2019, were applied.

3.4.2.3.1 Implied Emission Factors

The Implied Emission Factors based on energy (t/TJ and kg/TJ) and distance (mg/km) were determined for different Vehicle Category, Fuel, Segment and Euro Standard and are presented in ANNEX C.

3.4.2.4 Activity Data and Input Variables

3.4.2.4.1 Environmental information

The **monthly average ambient minimum and maximum temperatures** and **monthly average relative air humidity** were inputted into COPERT V. 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 concern to modeled historical data from 1971 to 2000. The same values were used for all years in analysis.

Table 3-65: 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/)

3.4.2.4.2 Trip Characteristics

According to COPERT V 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.

3.4.2.4.3 Fuel Characteristics and Specifications

Some fuel specifications used, like energy content, density, H:C and O:C ratio, were default COPERT V values set accordingly with EMEP/EEA Guidebook 2019.

Table 3-66: 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 3-67: Sulphur content in petrol and diesel (ppm wt)

Fuel	1990-1999
Leaded Petrol	1000

Fuel	1990-1995	1996-2001	2002-2004	2005-2008	2008-2020
Unleaded Petrol	1000	500	150	50	10

Fuel	1990-1994	1995	1996-2000	2001-2004	2005-2008	2009-2020
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).

The **Heavy Metal content** in fuels used were COPERT V default that correspond to the EMEP/EEA Guidebook 2019 indications except for the Lead content for gasoline that were set with the Portuguese Legislation values.

Table 3-68: Heavy metal content in fuel (ppm/wt)

Fuel	Pb	Cd	Cu	Cr	Ni	Se	Zn	Hg	As
Petrol	401.3[1] 150.5[2] 6.7[3]	0.0002	0.0045	0.0063	0.0023	0.0002	0.033	0.0087	0.0003
Diesel	0.0005	0.0001	0.0057	0.0085	0.0002	0.0001	0.018	0.0053	0.0001
LPG	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	0.0000	0.0000
CNG	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	0.0000	0.0000
Biodiesel	0.0005	0.0001	0.0057	0.0085	0.0002	0.0001	0.018	0.0053	0.0001
Bioethanol	0.0016	0.0002	0.0045	0.0063	0.0023	0.0002	0.033	0.0087	0.0003

Source: EMEP/EEA Guidebook 2019 and National Legislation (Portaria 125/89, Portaria 1489/95, Decreto-Lei nº 104/2000, Decreto-Lei 235/2004, DecretoL-Lei 142/2010 and Decreto-Lei 214-E/2015)
[1] 1990-1995
[2] 1996-1999
[3] 2000-2020

Monthly values of fuel volatility (RVP - Reid Vapour Pressure) were established from Portuguese Legislation.

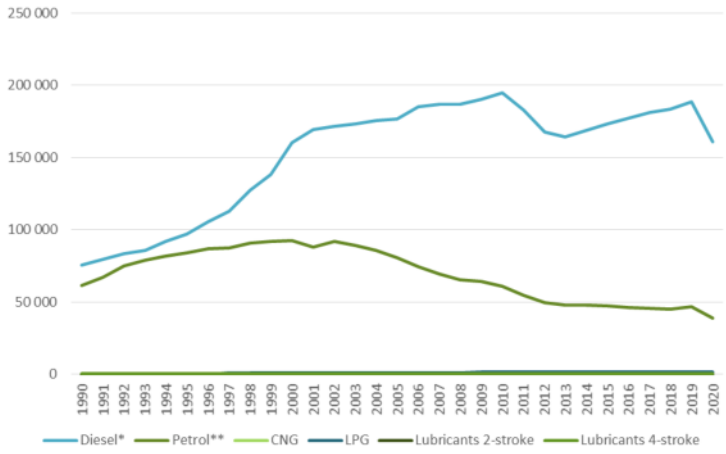
Table 3-69: Reid Vapour Pressure (kPa)

Month	1990 to 1995	1996 to 1999	2000 to 2020
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

Source: National Legislation (Portaria 125/89, Portaria 1489/95, Decreto-Lei n.º 104/2000, Decreto-Lei 235/2004, Decreto-Lei 142/2010 and Decreto-Lei 214-E/2015).

3.4.2.4.4 Energy Consumption

Fuel consumption from Road Transportation sector is available from the energy balances from DGEG while the lubricant consumption is calculated by COPERT V. Fuel and lubricant consumption is presented in the following figure and in ANNEX C.



* includes incorporation of Biodiesel
** includes incorporation of Bioethanol

Figure 3-36: 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 consider 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 Consumption (NFR 2.G).

In Portugal the incorporation of Biodiesel in Diesel starts in 2006 and the incorporation of Bioethanol in Petrol starts in 2013. The incorporation rates in the Road Transportation Sector are presented in the next tables.

Table 3-70: Incorporation rate of Biodiesel in Diesel (%)

2006	2007	2008	2009	2010	2011	2012	2013
1.31%	2.50%	2.43%	4.16%	6.03%	6.25%	6.20%	6.05%
2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	
5.93%	6.81%	5.15%	5.10%	5.48%	5.41%	5.56%	

Source: (DGEG)

Table 3-71: Incorporation rate of Bioethanol in Petrol (%)

2012	2013	2014	2015	2016	2017	2018	2019	2020
0.09%	0.16%	0.16%	1.73%	1.89%	0.28%	0.56%	0.77%	0.73%

Source: (DGEG)

3.4.2.4.5 Vehicle Fleet

The active fleet of Passenger Cars, Light Commercial Vehicles, Heavy Duty Trucks and Buses, for the period between 2003 and 2020, was obtain from data from the national vehicle inspection centers 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 consider 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.

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 3-72: COPERT 5 segments

COPERT 5 Vehicle Category	COPERT 5 Vehicle Segment	Fuel	Weight (kg)	Cylinder Power (cm³)
Passenger Cars	Mini	Petrol Petrol Hibrid Diesel 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 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 present in table below.

Table 3-73: 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	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	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	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	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	2021	...
Light Commercial Vehicles - N1-II/N1-III	Petrol	Conventional	...	1994
		Euro 1	1995	1998
		Euro 2	1999	2001

Vehicle Category	Fuel	Euro Standard	First Registry year	
			from	to
		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	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	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 3-74: Vehicle fleet synthesis

Vehicle Category	1990	1995	2000	2005	2010	2015	2018	2019	2020
Passenger Cars	1 552 912	2 516 415	3 546 152	3 962 031	4 386 247	4 611 618	5 036 041	5 148 616	4 995 153
Light Commercial Vehicles	290 461	591 822	960 125	1 177 894	1 255 037	1 210 303	1 221 505	1 227 758	1 214 454
Heavy Duty Trucks	52 054	79 076	108 924	115 517	107 452	90 323	96 714	102 466	102 497
Buses	6 209	8 405	11 946	13 851	14 666	14 255	15 331	15 325	14 608
L-Category	900 822	774 282	673 994	487 589	497 024	527 431	615 826	660 662	691 044
Total	**2 802 458**	**3 970 000**	**5 301 141**	**5 756 882**	**6 260 426**	**6 453 930**	**6 985 417**	**7 154 827**	**7 017 756**

Detailed information regarding vehicle fleet, with information of Vehicle Category, Fuel, Segment and Euro Standard is presented in ANNEX C.

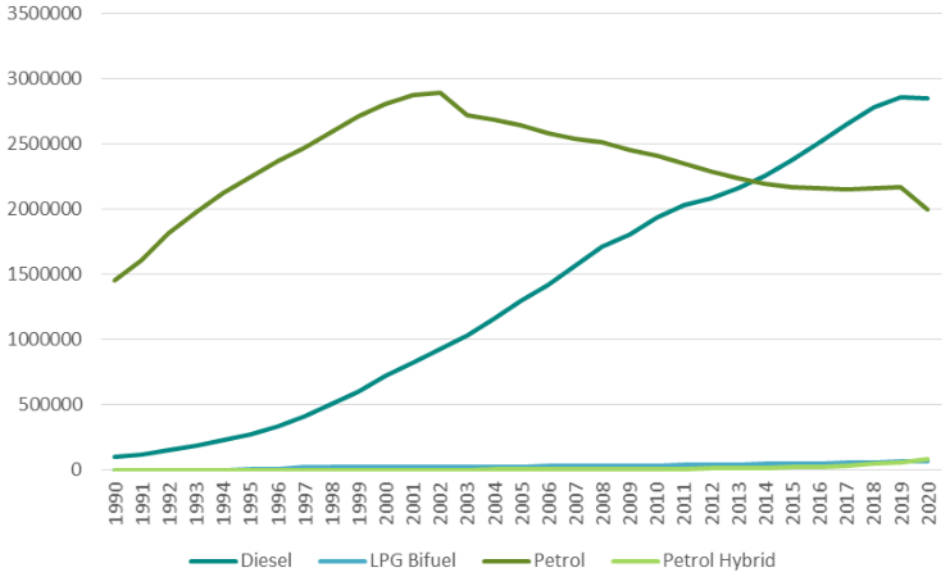


Figure 3-37: Number of Passenger Cars by fuel type

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.

3.4.2.4.6 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, taking into account 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 2020 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 taking into account its age.

For Mopeds and Motorcycles the average distance travelled was obtained by the TRACCS Project (http://traccs.emisia.com/index.php).

Total road traffic activity has increased 71% between 1990 and 2020.

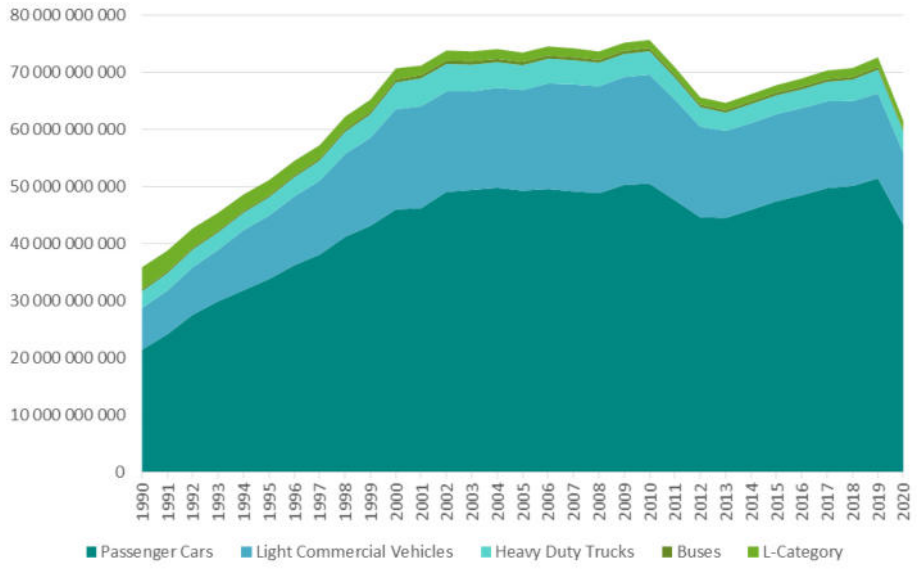


Figure 3-38: Kilometers travelled by vehicle type (vkm)

Detailed information on total activity, for the period between 1990 and 2020, regarding different Vehicle Categories, Fuel types, Segments and Euro Standard is presented in ANNEX C.

3.4.2.4.7 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 3-75: Assumed mileage percentage driven by driving mode and vehicle type for 2020

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 3-76: 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

3.4.2.5 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.

3.4.2.6 Recalculations

The major changes between submissions result from the update of activity data, namely:

- Revision of the stock and distances travelled data from 2003 to 2019;
- Revision of the share of FAME in Biodiesel from 2014 to 2019.

3.4.2.7 Further Improvements

We are planning to update the latest version of COPERT in a future submission.

3.4.3 Railways (NFR 1.A.3.c)

3.4.3.1 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.

3.4.3.2 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 Carbon Dioxide emissions (kg CO_2/GJ)

C_{Fossil} - % 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)

3.4.3.3 Emission Factors

Emission factors, expressed in kg/t of fuel, were set from available proposed emission factors in EMEP/CORINAIR Handbook (EEA, 2002; EEA, 2019), IPCC 2006 Guidelines (IPCC, 2006) and MEET project, and are presented in next table.

Table 3-77: Low Heating Value (LHV) in Railways

Fuel		NAPFUE	LHV
			MJ/kg
Coal	S	102	31.0
Coke	S	108	29.4
Diesel-oil	L	204	42.6
Biodiesel	B	223	37.0

Table 3-78: Emission factors in Railways

Fuel	Technology	Table	Source
Gas Oil / Diesel	Diesel locomotives	**3.1**	GB2019 - 1A3c Railways
Other bituminous Coal	Standard boilers> 50KWth <1MWth	**3.20**	GB2016 - Small Combustion
Coking Coal	Standard boilers >50KWth <1MWth	**3.20**	GB2016 - Small Combustion

3.4.3.4 Activity Data

Consumption of fuel in the railway transport sector is available by fuel type from 1990 to 2020 from the energy balance produced by General-Directorate of Geology and Energy (DGEG) and are presented in ANNEX C. Besides some very small use of coal and coke until 1996, and biodiesel since 2006, 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 fugire below.

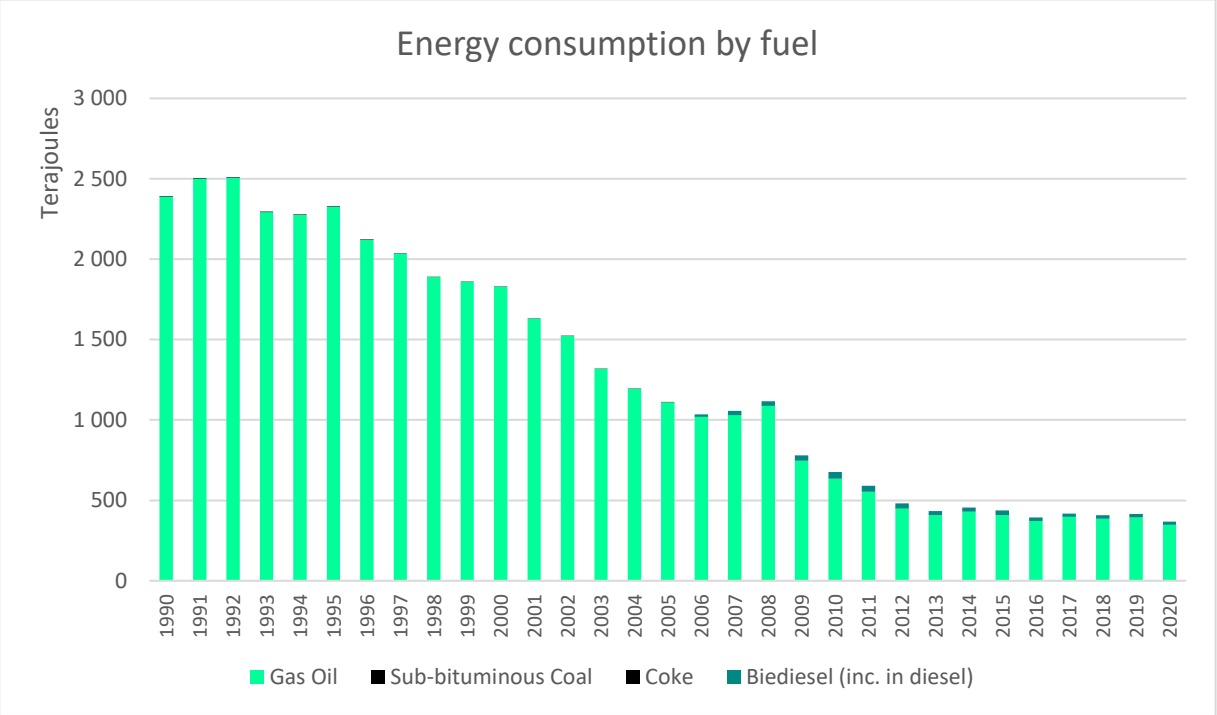


Figure 3-39: Consumption of diesel oil in the railway transport sector

3.4.3.5 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.

3.4.3.6 Recalculations

There are no significant recalculations for this category.

[20] Gas oil represents no less than 98.4 % of total annual use of combustible energy.

3.4.3.7 Further Improvements

There are two issues to be clarified regarding energy consumption in the rail sector. One associated with the lack of consistency in diesel consumption, namely the consumption reported in the energy balance in 2008. And the other issue regarding the allocation of coal consumption in small locomotives for tourist purposes.

In both cases, efforts continued to be made to see this matter resolved with the national authority responsible for producing the energy balance, with the aim of resolving inconsistencies and correctly allocating energy consumption and emissions in turn.

3.4.4 Water Borne Navigation (NFR 1.A.3.d)

3.4.4.1 Category description

This sector refers to domestic ship transport between Portuguese ports including traffic to the Azores and Madeira islands. Emissions are primarily estimated for all territory then emissions from islands are subtracted according with the domestic distance travelled allocated to each seaport.

3.4.4.2 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:

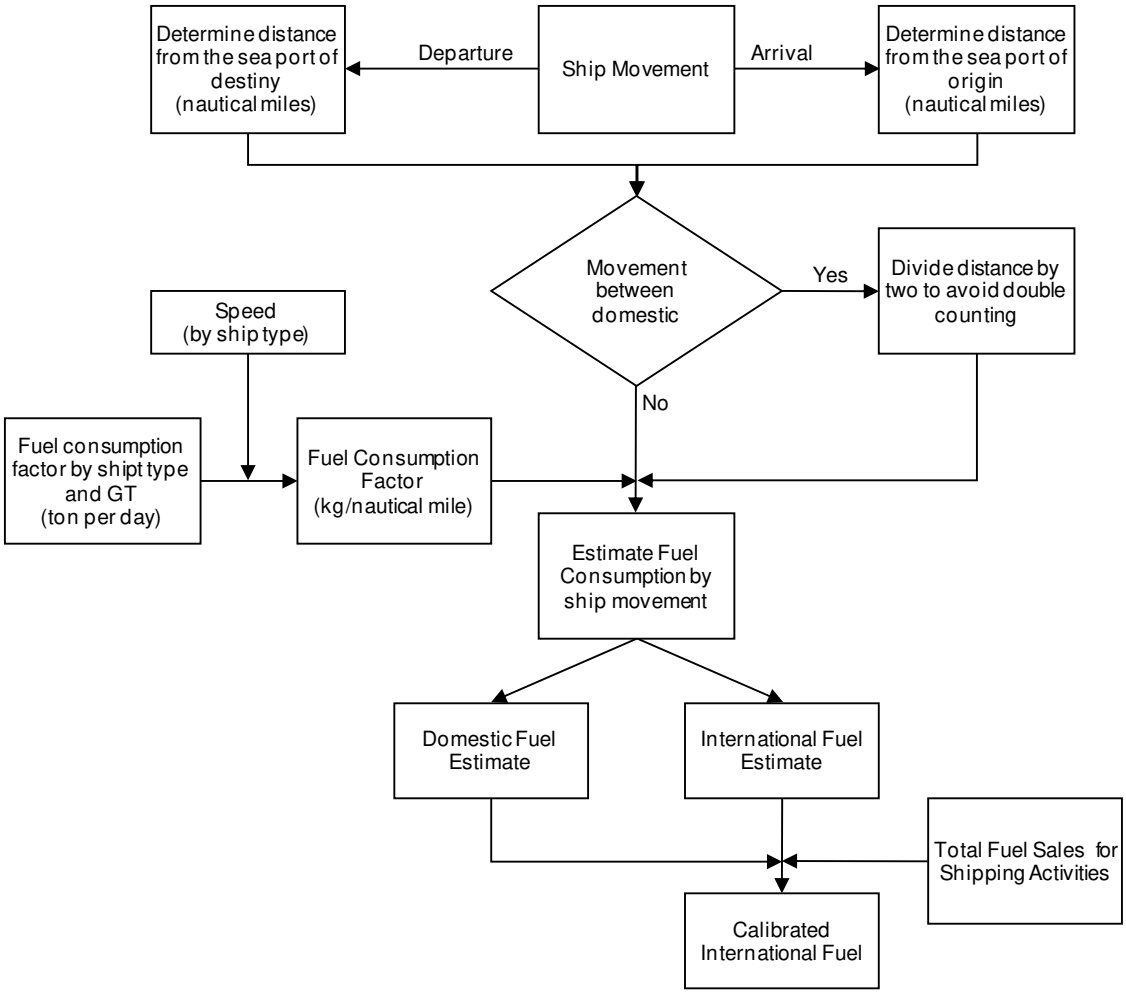


Figure 3-40: Generic methodology flowchart

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.

International Inland Waterways (1.A.3.d1(ii)) is considered almost as negligible in Portugal, on the other hand our National Energy Balance don't have the separation between inland and sea or costal navigation. Therefore, all emissions related with International Inland Waterways are included in International Maritime Navigation (1.A.3.di(i)).

3.4.4.3 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 emission factors were obtained from EMEP/EEA Air Pollutant Inventory Guidebook 2019.

Table 3-79: Low Heating Value (LHV) for navigation

Fuel		NAPFUE	LHV
			MJ/kg
Gas-oil	L	204	42.60
Residual Fuel-oil	L	203	40.00

Source: DGEG

Table 3-80: Emission factors for navigation

Fuel	Residual Fuel-oil			Gas Oil		
Pollutant	Value	Unit	Reference	Value	Unit	Reference
SO_x	54 [1] 30 [2]	kg/t	Guidebook 2019	10 [3] 4 [4] 2 [5]	kg/t	Guidebook 2019
NMVOC	2.7	kg/t	Guidebook 2019	2.8	kg/t	Guidebook 2019
CO	7.4	kg/t	Guidebook 2019	7.4	kg/t	Guidebook 2019
TSP	6.2	kg/t	Guidebook 2019	1.5	kg/t	Guidebook 2019
PM_{10}	6.2	kg/t	Guidebook 2019	1.5	kg/t	Guidebook 2019
$PM_{2.5}$	5.6	kg/t	Guidebook 2019	1.4	kg/t	Guidebook 2019

[1] Until year 2006, inclusive;
[2] After year 2007;
[3] Until year 2000, inclusive;
[4] Between year 2001 and 2007;
[5] After year 2008
Source: EMEP/EEA Guidebook 2019

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 3-81: 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)

The Tier 2 emission factors for the NOx estimates are described in section 3.3 of the 1.A.3.d EMEP/EEA Guidebook 2019. This estimate applies emission factors that consider the engine requirements that aim the reduction of NOx emissions, as well as a replacement rate for older vessels.

3.4.4.4 Activity Data

3.4.4.4.1 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 2020. The number of movements and the distances travelled for the period 1991-1994 and 1996-1999 were estimated according with a trend line 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 3-82: Ship docks

Sea Port	Location	Unit	1990	1995	2000	2005	2010	2015	2018	2019	2020
Aveiro	Mainland	docks	876	1 098	1 009	1 028	961	1 025	1 129	1 066	990
Caniçal	Madeira	docks	76	76	76	178	390	241	250	252	246
Faro	Mainland	docks	163	163	163	32	12	85	39	29	46
Figueira da Foz	Mainland	docks	315	297	307	321	476	496	480	469	484
Funchal	Madeira	docks	1 063	1 063	1 063	948	758	664	667	757	382
Leixões	Mainland	docks	2 742	2 896	3 050	2 814	2 612	2 735	2 551	2 583	2 477
Lisboa	Mainland	docks	5 586	4 993	3 869	3 474	3 129	2 605	2 402	2 595	1 661
Ponta Delgada	Azores	docks	1 080	1 080	1 080	1 078	1 035	831	855	827	684
Portimão	Mainland	docks	34	34	37	42	136	70	103	74	4
Porto Santo	Madeira	docks	402	402	402	400	392	348	357	390	318
Setúbal	Mainland	docks	1 453	1 453	1 699	1 592	1 632	1 627	1 516	1 532	1 598
Sines	Mainland	docks	1 038	979	808	1 124	1 632	2 173	2 103	2 117	1 989
Viana do Castelo	Mainland	docks	254	293	348	214	179	198	184	195	202

3.4.4.4.2 Ship Fleet

The fleet from the figure below refers to all ships that docked in national seaports irrespective of domestic or international movements.

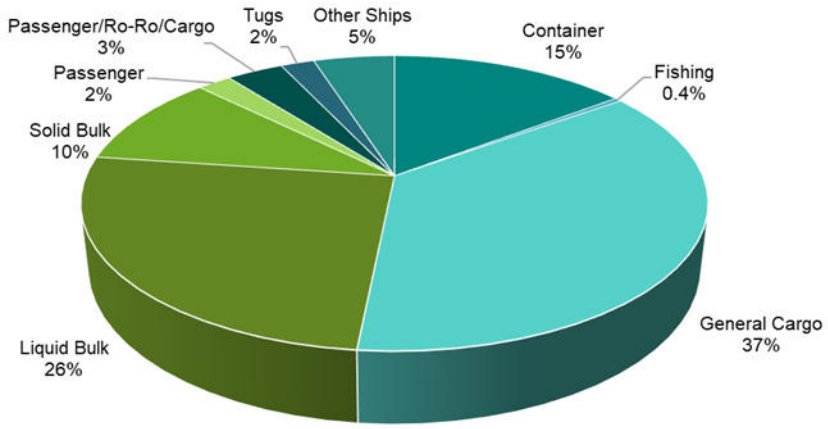


Figure 3-41: Ship fleet

3.4.4.4.3 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 3-83: Total fuel sales (ton)

Fuel Sales		NAPFUE	1990	1995	2000	2005	2010	2015	2018	2019	2020
Gas-oil	L	204	126 903	141 272	125 554	110 197	94 064	139 277	176 346	181 216	157 452
Residual Fuel-oil	L	203	407 823	290 920	475 743	457 115	506 320	603 295	763 796	894 060	613 084

Source: DGEG

Table 3-84: Estimated fuel consumption (ton)

Fuel	Region	1990	1995	2000	2005	2010	2015	2018	2019	2020
Residual Fuel-oil	Domestic	61 244	53 023	46 988	48 804	53 458	65 968	61 305	62 927	47 037
Residual Fuel-oil	International	431 554	448 716	430 253	411 428	515 738	805 707	802 684	764 680	782 099
Residual Fuel-oil	**Total**	**492 797**	**501 739**	**477 242**	**460 233**	**569 196**	**871 676**	**863 989**	**827 607**	**829 136**
Gas-oil	Domestic	23 132	20 027	17 748	18 434	20 192	24 917	23 156	23 768	17 766
Gas-oil	International	163 002	169 485	162 511	155 401	194 799	304 324	303 182	288 827	295 407
Gas-oil	**Total**	**186 135**	**189 512**	**180 259**	**173 835**	**214 991**	**329 241**	**326 338**	**312 595**	**313 173**

Table 3-85: Estimated fuel consumption after top-down calibration (ton)

Fuel	Region	1990	1995	2000	2005	2010	2015	2018	2019	2020
Residual Fuel-oil	Domestic	61 244	53 023	46 988	48 804	53 458	65 968	61 305	62 927	47 037
Residual Fuel-oil	International	346 579	237 897	428 754	408 311	452 862	537 327	702 491	831 133	566 047
Residual Fuel-oil	**Total**	**407 823**	**290 920**	**475 743**	**457 115**	**506 320**	**603 295**	**763 796**	**894 060**	**613 084**
Gas-oil	Domestic	23 132	20 027	17 748	18 434	20 192	24 917	23 156	23 768	17 766
Gas-oil	International	103 770	121 244	107 806	91 763	73 872	114 360	153 190	157 448	139 685
Gas-oil	**Total**	**126 903**	**141 272**	**125 554**	**110 197**	**94 064**	**139 277**	**176 346**	**181 216**	**157 452**

Emissions are primarily estimated for all territory and only then occurs the process of spatial allocation whereby emissions from mainland and islands are separated according with the domestic distance travelled allocated to each seaport. The result of spatial allocation of fuel consumption is presented in the next table.

Table 3-86: Spatial allocation of fuel consumption in mainland territory (ton)

Fuel	Region	1990	1995	2000	2005	2010	2015	2018	2019	2020
Residual Fuel-oil	Domestic	37 315	32 306	28 629	29 736	32 571	40 194	37 352	38 340	28 659
Residual Fuel-oil	International	317 684	218 063	393 008	374 269	415 105	492 528	643 922	761 839	518 853
Residual Fuel-oil	**Total**	**354 999**	**250 369**	**421 637**	**404 004**	**447 676**	**532 721**	**681 274**	**800 179**	**547 512**
Gas-oil	Domestic	14 094	12 202	10 814	11 231	12 302	15 182	14 108	14 482	10 825
Gas-oil	International	95 119	111 136	98 818	84 113	67 713	104 825	140 418	144 321	128 039
Gas-oil	**Total**	**109 213**	**123 338**	**109 631**	**95 344**	**80 016**	**120 007**	**154 527**	**158 802**	**138 864**

The decrease in the amount of liquid fuels consumed in 2011 is related with the slightly drop in the number of docks, in some of the major ports in Portugal, and the reduction of National distance travelled.

3.4.4.4.3.1 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 manoeuvring ship in a seaport following the criteria shown in the Table 3.148. Specific tug fuel consumption factors were supplied by DGRM.

Table 3-87: 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 3-88: 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.

3.4.4.5 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.

3.4.4.6 Recalculations

No recalculations were made.

3.4.4.7 Further Improvements

We plan to review, for the next submission, the emission factor for navigation in accordance with the December 2021 update of the EMEP/EEA 2019 air pollutant emission inventory guidebook.

3.5 Small Combustion (NFR 1.A.4)

3.5.1 Category description

This source category refers to combustion in stationary and mobile sources (off-road equipment) that occur in commercial/institutional, residential, and agriculture/forestry/fishing activity sectors. The following stationary combustion equipment were included in this sector: boilers, co-generation equipment, machines and static engines. Also included in 1.A.4 are emissions from fisheries bunkers and off-road vehicles used in agriculture/forestry sector (both will have their own sub chapter below).

The table below summarizes the subcategories considered as well as the coverage of the estimated pollutants for each of the subcategories.

Table 3-89: Subcategories considered and coverage of estimated pollutants

NFR Code	Categories	Pollutant coverage	Source Category
1A4a	**Commercial/institutional:**		
1A4ai	Stationary	All CLRTAP pollutants	Commercial, services and institutional Railways - stationary
1A4aii	Mobile	All CLRTAP pollutants (ii)	Commercial mobile
1A4b	**Residential**		
1A4bi	Stationary	All CLRTAP pollutants	Domestic combustion
1A4bii	Household and gardening	All CLRTAP pollutants (ii)	House and garden machinery
1A4c	**Agriculture/Forestry/Fishing**		
1A4ci	Stationary	All CLRTAP pollutants (i)	Stationary combustion
1A4cii	Off-road vehicles and other machinery	All CLRTAP pollutants (ii)	Tractors and mobile machinery
1A4ciii	National fishing	All CLRTAP pollutants (i)	Fishing Vessels

(i) NH3 is not estimated
(ii) Hg, As, PCDD/PCDF, benzo(k) fluoranthene, Indeno (1,2,3-cd) pyrene, HCB and PCBs are not estimated

3.5.2 Methodology

The table below summarizes the methodological approaches adopted and the main source of emissions for each sub-category.

Table 3-90: Methodological approaches and main source of emissions for each sub-category

Categories	Method Approach	Main source of emissions
1A4ai - Commercial/institutional: Stationary	**TIER 2** - Technology-specific [a] **TIER 1** - Energy consumption	Combustion of diesel and natural gas in Commercial and Public plants for space heating
1A4aii - Commercial/institutional: Mobile	**TIER 1** - Energy consumption	Combustion of gasoline and other kerosene in commercial sector
1A4bi - Residential: Stationary	**TIER 2** - Technology-specific [a] **TIER 1** - Energy consumption	Combustion of wood and LPG in households for space heating, water heating and cooking
1A4bii - Residential: Household and gardening	**TIER 1** - Energy consumption	Combustion of gasoline and other kerosene in household mobile appliances
1A4ci - Agriculture/Forestry/Fishing: Stationary	**TIER 2** - Technology-specific [a] **TIER 1** - Energy consumption	Combustion of diesel for heating purposes
1A4cii - Agriculture/Forestry/Fishing: Off-road vehicles and machinery	**TIER 2** - Technology-specific [b] **TIER 1** - Energy consumption	Combustion of diesel in tractors and other agricultural machinery
1A4ciii - Agriculture/Forestry/Fishing: National fishing	**TIER 2** - Technology-specific [b] **TIER 1** - Energy consumption	Combustion of diesel in deep sea and coastal fishing vessels
(a) Tier 2 was applied based on the thermal uses of each sub-sector, taking into account the fuel consumption in each appliance. (b) Tier 2 was used only to estimate NOx and PMs emissions from this sub-sector.		

The paragraphs below are intended to explain the different methodologies used to estimate the different sub-sectors and pollutants.

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

[21] Tables 3.36, 3.37and 3.38 of EMEP/EEA Guidebook – 1A4 Small Combustion 2016

- 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 3.2.3.4.3.1 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 the emissions factors of the EMEP/EEA Guidebook, 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 3.2.4.4 Emission Factors.

Regarding mobile sources, as mentioned earlier, this submission is the first time that a Tier 2 is applied for the NOx estimation. One of the main limitations identified to date was the unavailability of information to break down fuel consumption by type motorization (fishing boats) or technology stage (tractors).

During the NECD 2020 review, it was suggested by the experts review team that information from the EMEP 2019 Guidebook be used to split the activity data by technology.

In the case of NOx emissions from tractors and other agricultural machines, the methodology described in section 3.3 of the 2019 EMEP / EEA Guidebook (Non-road mobile sources and machinery chapter) was used. Regarding NOx emissions from fishing vessels, the methodology used can be found in section 3.3 of the 2019 EMEP / EEA Guidebook (1.A.3.d Navigation chapter).

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:

$$E_i = \sum_j \sum_k EF_{i,j,k} \times A_{j,k}$$

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:

$$E_{pollutant} = AR_{fuelconsumption} \times EF_{pollutant}$$

[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

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.

General Approach for SOx emission of Liquid Fuels Combustion

Emissions of SO_x are directly related to the fuel content of the fuel, and were estimated from:

$$Emi_{SOx(s)} = 2 * \sum_f \sum_t [S_{(f,s,t,y)} /100 * Fuel_{Cons(f,s,t)}]$$

Where:

$Emi_{SOx(s)}$ - Total emissions of SOx from sub-sector s (t/yr);

$S_{(f,s,t)}$- Sulphur content of fuel f used in sub-sector s and equipment t in year y (%);

$Fuel_{Cons(f,s,t)}$ – Fuel consumption for each particular fuel and in each equipment of technology t (t/yr).

General Approach for Tier 2 NOx emission from mobile sources

The Tier 2 approach for NOx emissions from category 1.A.4.c uses the general equation:

$$Emi_{NOx} = \sum_j \sum_t FC_{j,t} \times EF_{NOx,j,k}$$

Where:

Emi_{NOx} – annual NOx emission

$FC_{j,t}$ - fuel consumption of fuel type j by technology type t

$EF_{i,k,j}$ – average emission factor for NOx for fuel type j for technology type t,

j – fuel type (diesel, petrol, bunker fuel oil, marine diesel oil)

t (off-road equipment technology) < 1981, 1981–1990, 1991–Stage I, Stage I, Stage II, Stage IIIA, Stage IIIB, Stage IV, Stage V)

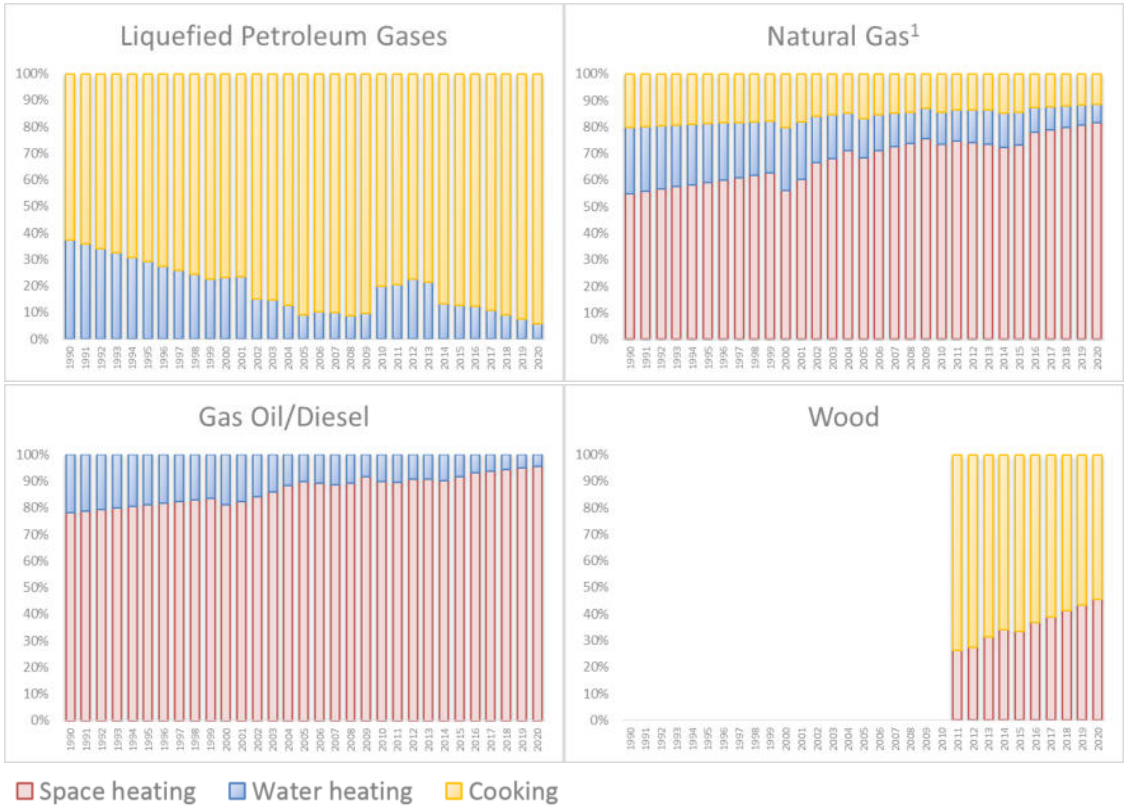
t (vessel engine type): High-speed diesel, Medium-speed diesel, Slow-speed diesel

3.5.3 Activity Data

3.5.3.1 Technology Split (stationary sources)

As explained in the previous point the technological split was made based on two different sources - IIASA GAINS Model and JRC-IDEES Database.

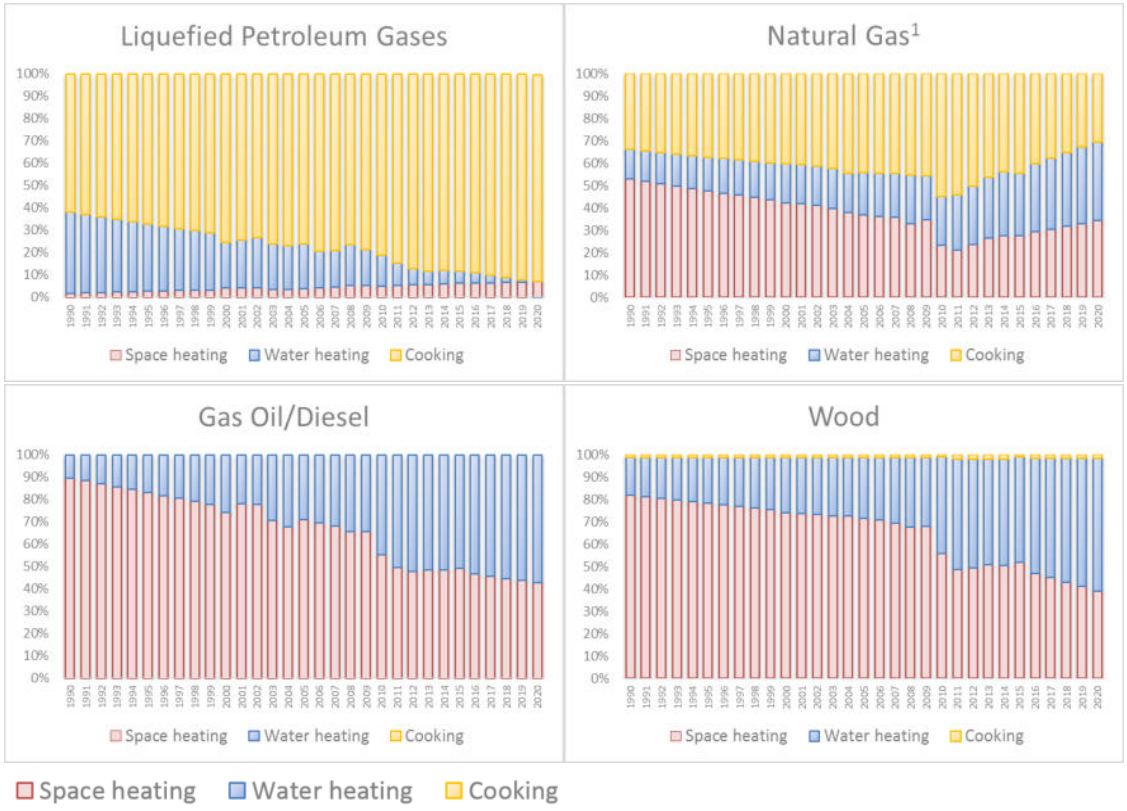
Commercial and Institutional sector is characterized, on one hand, by the heating needs supplied by Diesel and Natural Gas in small plants of heat generation and on the other hand, by the consumption of LPG and Solid Biomass in the Catering sector.



1 Include Gas Work Gas

Figure 3-42: Split in Thermal Uses for Commercial/Institutional Sector

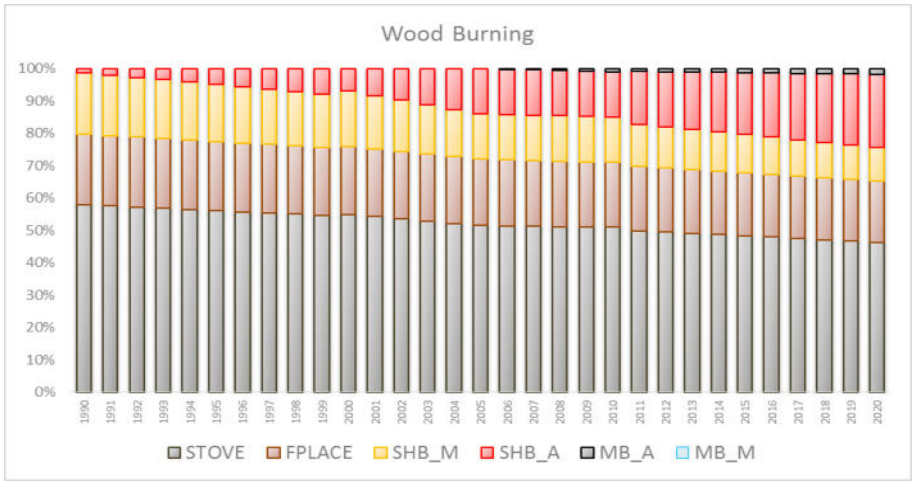
In the residential sector, the main fuels consumed are LPG and solid Biomass. Between the two are covered the three types of thermal uses. Since LPG is preferentially used in stoves intended for cooking, and the wood is burned in stoves, boilers and fireplaces for the purpose of space heating. Another 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 Include Gas Work Gas

Figure 3-43: 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 3-44: 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 (1.A.4.c ii) to the category Agriculture/Forestry/Fishing: Stationary (1.A.4.c i). Assuming that these allocated emissions refer to heating and pumping activities by stationary sources in agriculture.

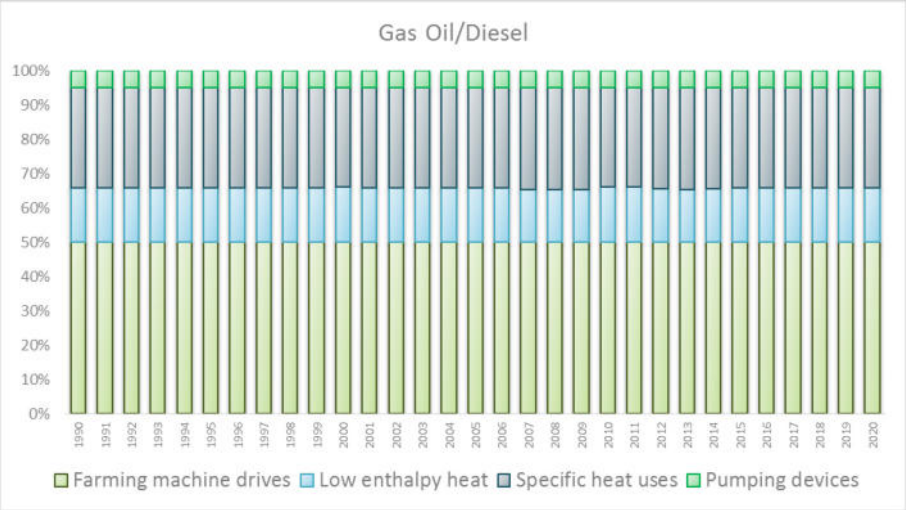


Figure 3-45: Split in Thermal Uses for Agriculture Sector – Diesel

3.5.3.2 Technology Split (mobile sources)

AGRICULTURE: Off-road vehicles and other machinery

In order to apply the tier 2 methodology to estimate NOx emissions (key-category) for tractors and other agricultural machinery, suggested in the EMEP Guidebook 2019 section 3.3 of the Non-road mobile sources and machinery volume, it was necessary to obtain information regarding fuel consumption disaggregated by technology.

Data on the estimated lifetime of different machines included in Appendix C of the guidelines referred to above was used to build a picture of the age profiles for the different categories and technologies. In combination with the information from the percentage split of total fuel consumption as a function of engine age are given for diesel machinery and for gasoline two-stroke and four-stroke machinery (available in tables 3.3 and 3.4 GB2019 - Non-road mobile sources and machinery) it was possible to split the total fuel consumption into engine technology layers for each inventory year.

The figures below represent the split of diesel and gasoline consumption by technology for the time series (1990-2020) considered in the estimate of the Portuguese inventory.

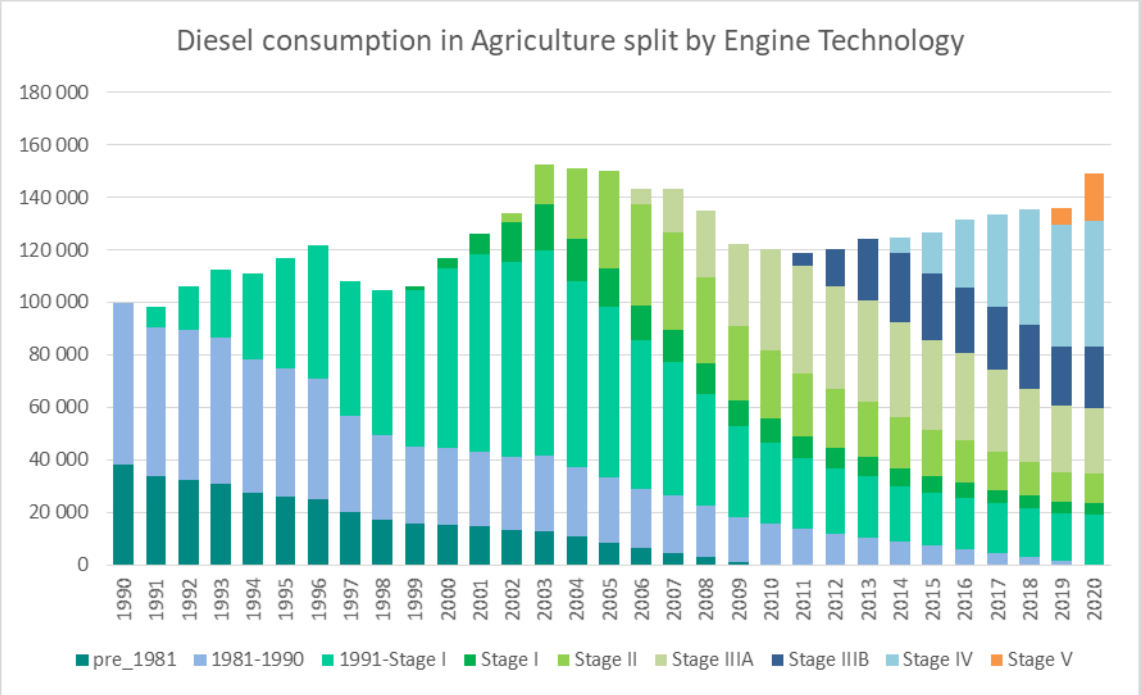


Figure 3-46: Diesel consumption in 1A4cii- split by engine technology (TJ)

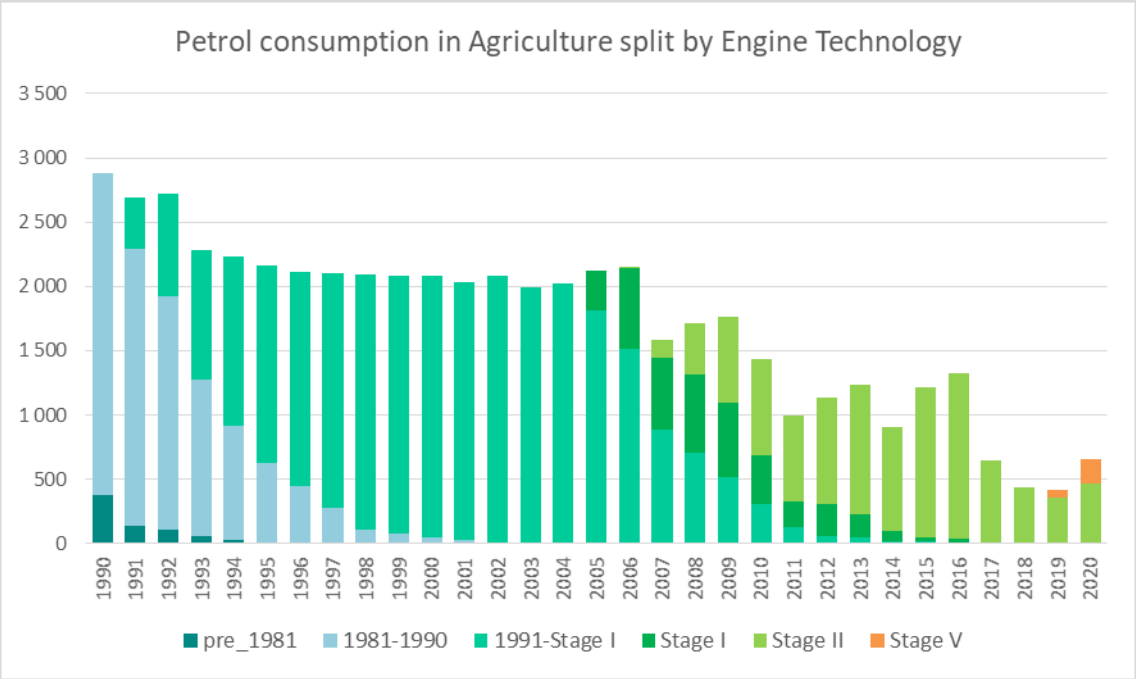


Figure 3-47: Gasoline consumption in 1A4cii- split by engine technology (TJ)

PORTUGUESE FISHING FLEET CHARACTERIZATION

Similar to the previous category, there is a need to disaggregate fuel consumption by type of technology (in this case by type of engine) in order to apply a methodology for estimating NOx tier 2 emissions for the category of fishing boats.

Fishing Fleet classification by engine type was made considering the implicit values of Gross Tonnage and Propulsion Power Instlated for the period 2011 to 2018. For this, the source of information was the "Annual Report: Portuguese Fishing Fleet" produced by the Directorate-General for Natural Resources, Safety and Maritime Services.

The criteria for classification by engine type were chosen by the inventory team, taking into account additional information published in the Annual Report of the Portuguese Fleet: 2015-2018. Also for this classification, the length of the vessel and the type of fishing technique used were considered. More disaggregated data can be found in ANNEX C - Small combustion (NFR 1.A.4).

In the table below is a compilation of the results related to the share of each parameter considered. Representing the share of each type of engine in the total of vessels, the share of each type of engine considering the total Gross Tonnage of the Portuguese fleet, and the share of each type of engine considering the propelling power of all motorized fishing vessels in Portugal.

Table 3-91: Share of Engine Types by Number of Ships, Gross Tonnage and Total Power Instaled – Diesel Engines

ENGINE TYPE	2011	2012	2013	2014	2015	2016	2017	2018
Share of engine type by total Ships								
High-speed Diesel Engine	72%	71%	71%	70%	71%	67%	66%	66%
Medium-speed Diesel Engine	28%	28%	28%	29%	29%	33%	34%	33%
Slow-speed Diesel Engine	1%	1%	1%	1%	0%	1%	1%	0%
Share of engine type by total Gross Tonnage								
High-speed Diesel Engine	6%	6%	6%	6%	6%	6%	6%	6%
Medium-speed Diesel Engine	56%	58%	57%	56%	59%	58%	56%	60%
Slow-speed Diesel Engine	38%	37%	37%	38%	35%	36%	38%	34%
Share of engine type by total Propulsion Power kW								
High-speed Diesel Engine	27%	26%	26%	26%	28%	25%	25%	26%
Medium-speed Diesel Engine	60%	61%	61%	61%	62%	63%	62%	63%
Slow-speed Diesel Engine	13%	12%	13%	13%	11%	12%	13%	11%

For the distribution of diesel consumption in fishing vessels, the Share of engine type by total propulsion power kW was considered, assuming the relationship of proportionality between power and fuel consumption. As the information collected only covers the period 2011 to 2018, it was assumed that between 1990 and 2010 the share is equal to the share of 2011.

In the exceptional case of fuel oil consumption recorded in the energy balance as associated with fishing activity (only significant in 1994), this consumption was considered to occur in "medium-speed engines".

The figure below represents the distribution of fuel consumption by type of engine considered for fishing vessels used to estimate NOx emissions.

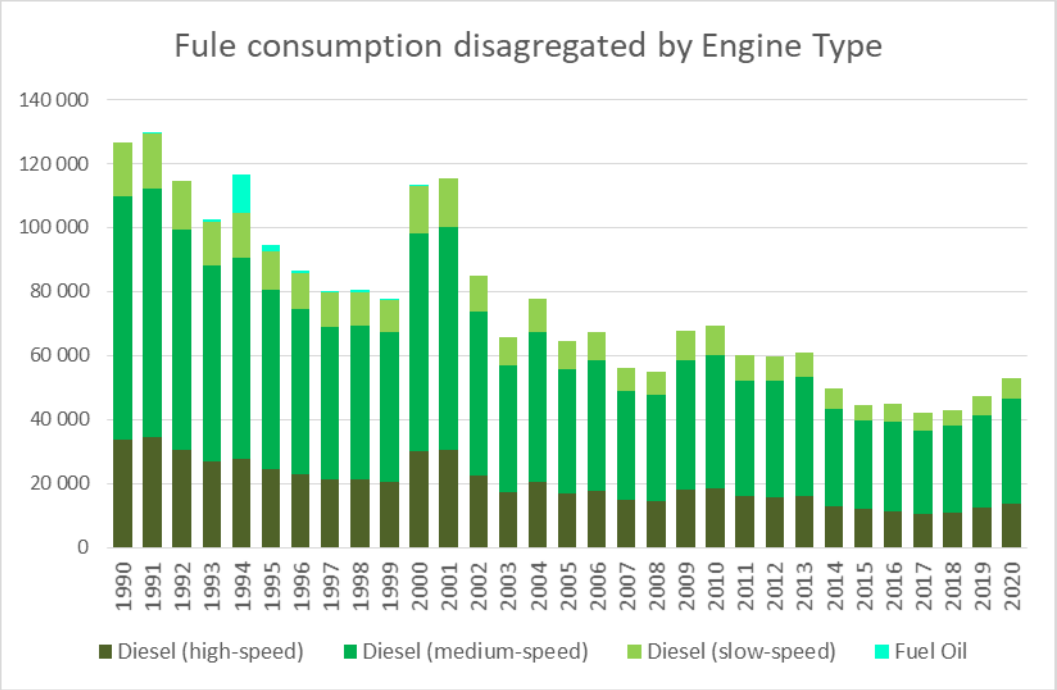


Figure 3-48: Fuel consumption by engine type (t)

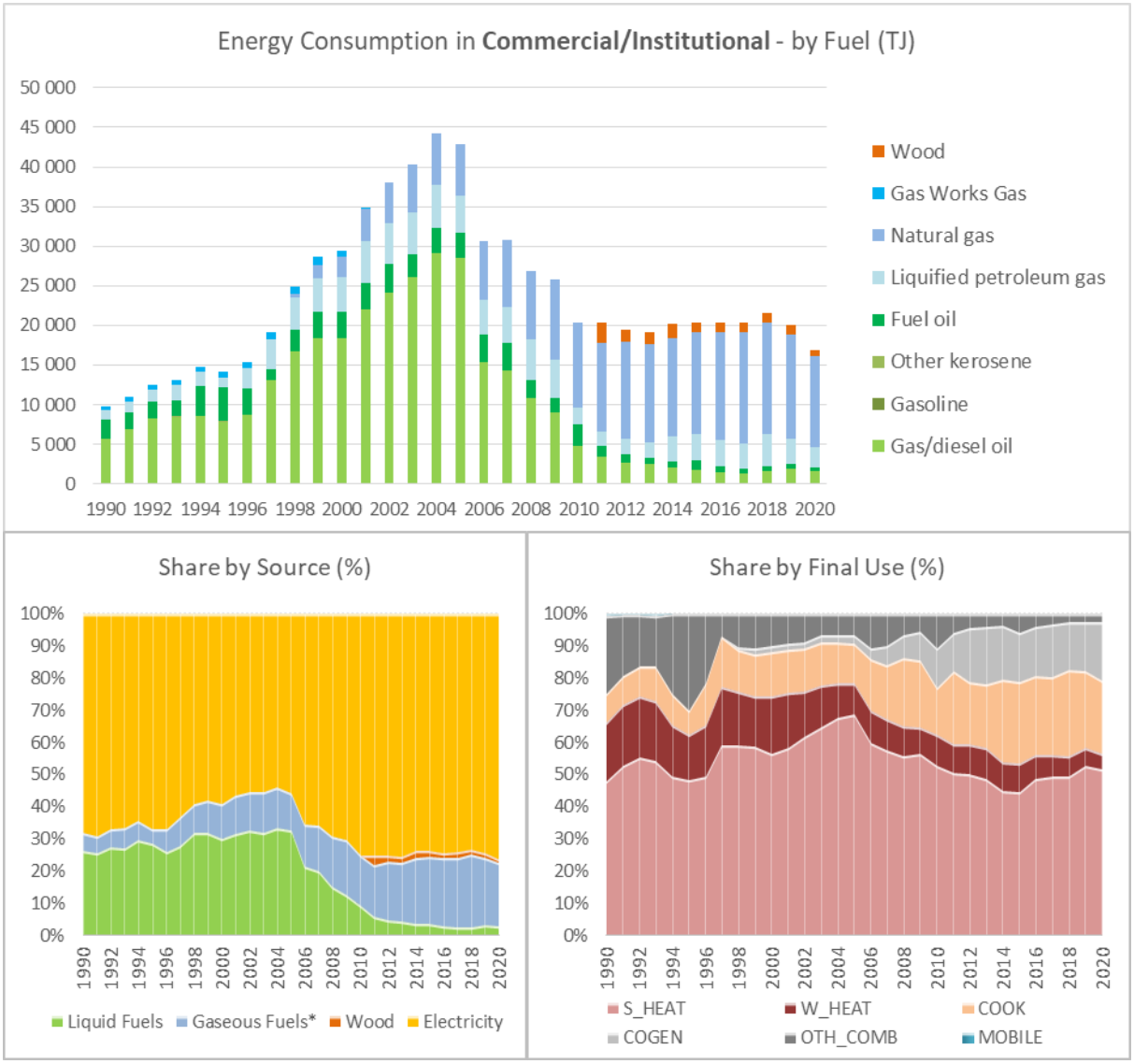
3.5.3.3 Energy Consumption

Data on fuel consumption was obtained from the annual energy balances compiled by DGEG and are presented in the following figures and ANNEX C: ENERGY (NFR 1).

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.



a) S_HEAT: Space Heating; W_HEAT: Water Heating; COOK: Cooking; COGEN: Cogeneration; OTH_COMB: Other Combustion

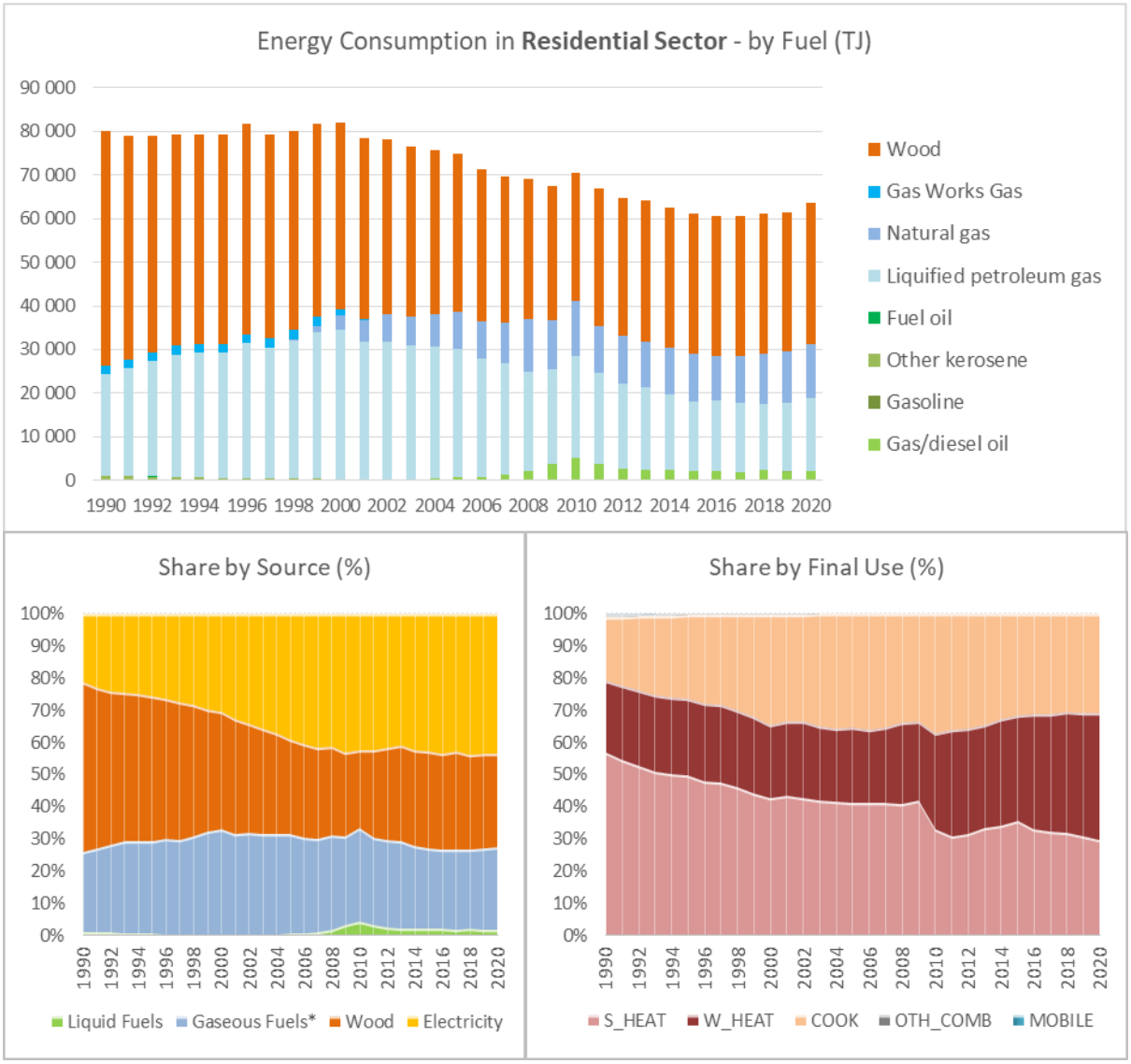
Figure 3-49: Energy consumption in Comercial/Institutional sector - by Fuel, Source and Final Use

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.

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 done a lot thanks to electrification of the same, this statement 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.



a) 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

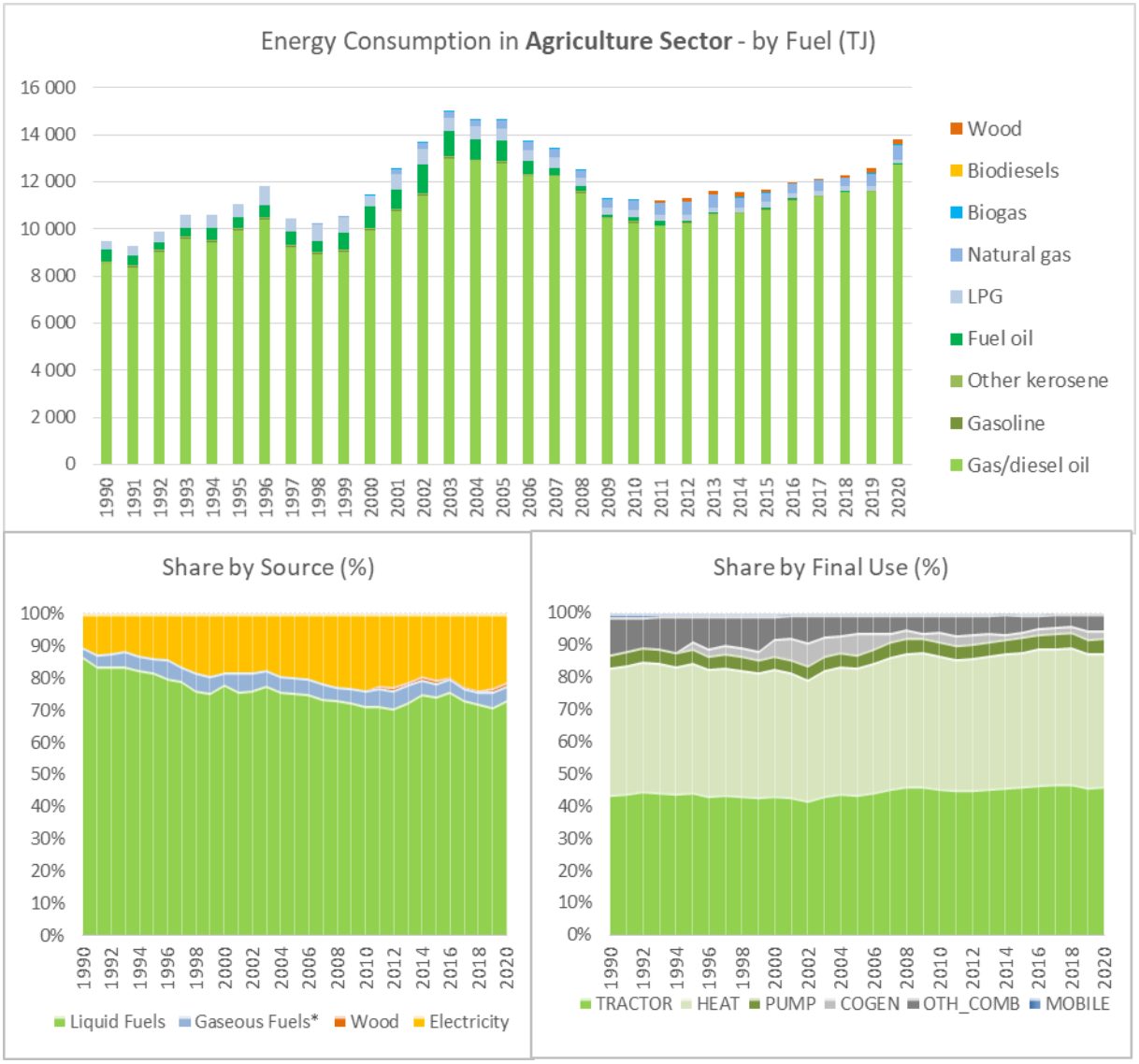
Also Natural Gas has some highlight in the consumption of this sector, having gained market share through solutions that cover the entire spectrum of thermal solutions (space heating, water heating and cooking).

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.

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.



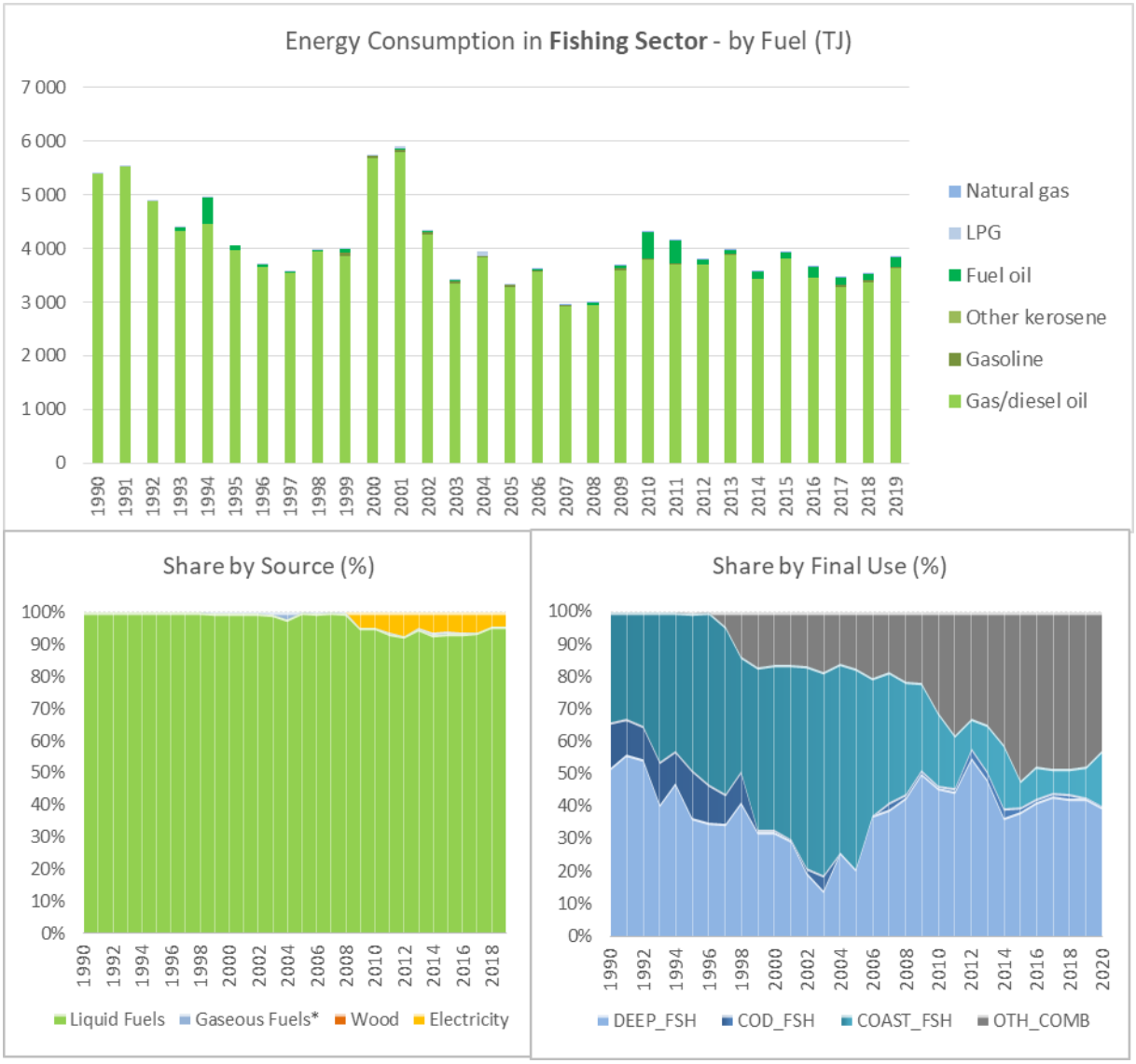
a) Gaseous Fuels* include Natural Gas, Gas Work Gas and Liquefied Petroleum Gases
b) TRACTOR: Mobile machinery; HEAT: Heat uses; PUMP: Pumping devices; COGEN: Cogeneration; OTH_COMB: Other Combustion

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

As regards the general consumption trend, two slight consistency breaks are identified between 1997 and 1998 and then between 2002 and 2005. It was clarified by our national Energy Authority, that until 2002 colored gas oil (Agricultural diesel) was used as fuel for use in agriculture, but also in coastal fishing and other stationary equipment (such as heating boilers). In 2003, "colored and marked diesel for heating" was introduced on the internal market, separating the consumption of these two fuels. This alteration could be at the origin of the apparent series break, in particular in 2003 and 2004.

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.



a) DEEP_FSH: Deep Sea Fishing; COD_FSH: Cod Fishing; COAST_FSH: Coastal Fishing; OTH_COMB: Other Combustion

Figure 3-52: Energy consumption in the Fishing sector - by Fuel, Source and Final Use

3.5.4 Emission Factors

This section lists the emission factors used in the Small Combustion category estimates (NFR 1.A.4). In general for this sector, default emission factors present in the most recent version of the EMEP / EEA Guidebook are used. However, in this section you can also consult the sulfur contents of the liquid fuels used to estimate SOx emissions in the Small Combustion category, and the methodology used to determine the evolution of the emission factor used to estimate the NOx emissions for the National Fishing sub-category. (NFR 1.A.4.ciii).

Table 3-92: Emissions factors for Category 1.A.4.a.i – Commercial/Institutional: Stationary

Fuel	Technology	Final use	Table[1]
Liquefied Petroleum Gases	Medium Boilers	Water heating	**3.27**
	Stove, Hobs and Ovens	Cooking	**3.26**
Natural Gas & Gas Work Gas	Medium Boilers	Space heating; Water heating	**3.27**
	Heat Pump	Space heating; Space cooling	**3.26**
	Stove, Hobs and Ovens	Cooking	**3.26**
	Gas Turbines	Small Cogeneration	**3.28**
Gas Oil	Medium Boilers	Space heating; Water heating	**3.25**
Wood and Wood Waste	Medium Boilers	Space heating	**3.48**
	Ovens	Cooking	**3.46**
Fuel Oil	Boilers (>50KWth <1MWth)	Other Combustion	**3.24**
	Boilers (>1MWth <50MWth)	Small Cogeneration	**3.25**
Gasoline	-	Other Combustion	**3.9**
Other Kerosene	-	Other Combustion	**3.9**

[1] Source: EMEP/EEA Guidebook - 1A4 Small Combustion - Version 2019

Table 3-93: Emissions factors for Category 1.A.4.c.i – Agriculture / Forestry / Fishing: Stationary

Fuel	Technology	Final use	Table[1]
Gas Oil	Boilers (>50KWth <1MWth)	Heat uses	**3.24**
	Reciprocating engines	Pumping devices	**3.31**
	-	Other Combustion	**3.9**
Liquefied Petroleum Gases	Boilers (>1MWth <50MWth)	Other Combustion	**3.27**
Natural Gas & Gas Work Gas	Boilers (>1MWth <50MWth)	Other Combustion	**3.27**
	Gas Turbines	Small Cogeneration	**3.28**
Wood Waste	Medium boilers (>50kWth)	Other Combustion	**3.48**
Fuel Oil	Boilers (>50KWth <1MWth)	Other Combustion	**3.24**
	Boilers (>1MWth <50MWth)	Small Cogeneration	**3.25**
Gasoline	-	Other Combustion	**3.9**
Other Kerosene	-	Other Combustion	**3.9**

[1] Source: EMEP/EEA Guidebook - 1A4 Small Combustion - Version 2019

Table 3-94: Emissions factors for Category 1.A.4.b.i – Residential: Stationary

Fuel	Technology	Final use	Table[1]
Liquefied Petroleum Gases	LPG Heaters	Space heating	**3.13**
	Condensing boilers	Water heating	**3.16**
	Stove, Hobs and Ovens	Cooking	**3.16**
Natural Gas & Gas Work Gas	Small Boilers	Space heating	**3.13**
	Condensing boilers	Water heating	**3.16**
	Stove, Hobs and Ovens	Cooking	**3.16**
Gas Oil	Small Boilers	Space heating; Water heating	**3.18**
Wood and Wood Waste	Conventional stoves	Space heating; Cooking	**3.40**
	Open fireplaces	Space heating; Cooking	**3.39**
	Conventional boilers (< 50 kWth)	Space heating; Water heating	**3.43**
	Pellet stoves and boilers	Space heating; Water heating	**3.44**
	Automatic Boilers (<1MW)	Space heating; Water heating	**3.48**
	Manual Boilers (<1MW)	Space heating; Water heating	**3.47**
Fuel Oil	-	Other Combustion	**3.5**
Gasoline	-	Other Combustion	**3.5**
Other Kerosene	-	Other Combustion	**3.5**

[1] Source: EMEP/EEA Guidebook - 1A4 Small Combustion - Version 2019

Table 3-95: Emissions factors for Category 1.A.4.c.ii – Off-road vehicles and other machinery

Fuel	Technology	Final use	Table[1]
Gas Oil	Tractors, Harvesters, Others	Farming machine drives	**3.1**
Gasoline & Other Kerosene	Four and Two Stroke motors	Mobile equipments	**3.1**
Gasoline & Other Kerosene	Four and Two Stroke motors	Household and gardening	**3.1**
Gasoline & Other Kerosene	Four and Two Stroke motors	Mobile equipments	**3.1**

[1] Source: EMEP/EEA Guidebook - 1A4 Non road mobile machinery - Version 2019

Table 3-96: Emissions factors for Category 1.A.4.c.ii – National Fishing

Fuel	Technology	Final use	Table[1]
Gas Oil	Fishing Vessels	Deep Sea, Cod and Coastal Fishing	**3.2 & 3.4**[2]
Thick Fuel Oil	Fishing Vessels	Deep Sea Fishing	**3.1 & 3.4**[2]
Thin Fuel Oil	Fishing Vessels	Deep Sea Fishing	**3.1 & 3.4**[2]

[1] Source: EMEP/EEA Guidebook 2019 - 1A3d Navigation - Shipping (Oct.2020)
[2] Table 3.4 used to estimate Tier 2 emissions from NOx, TSP, PM10 and PM2.5

SULPHUR CONTENT ON LIQUID FUELS

The values of the sulphur contents considered in the SO_2 estimates from combustion of liquid fuels can be found in the ANNEX C: ENERGY (NFR 1).

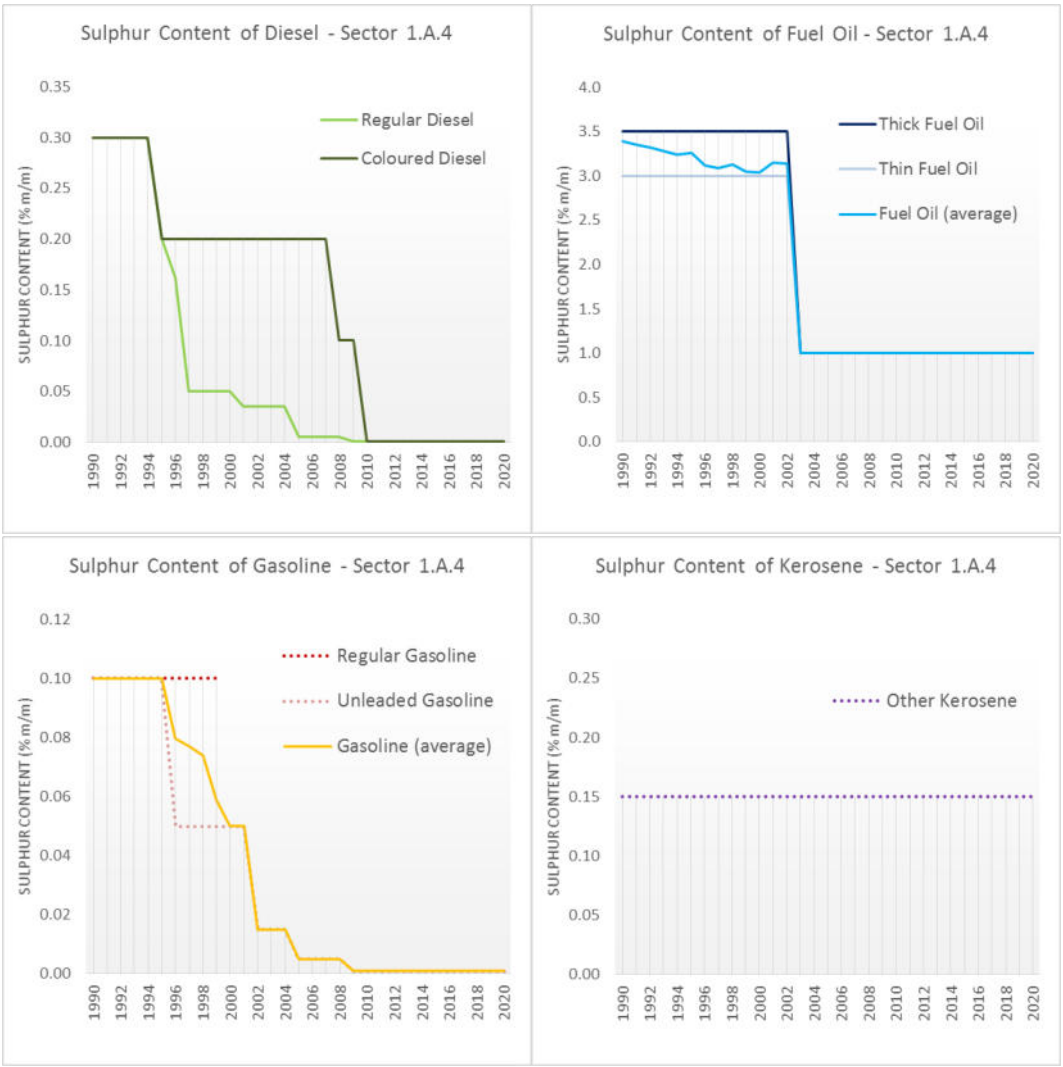


Figure 3-53: Sulphur Content in Liquid Fuels used in Sector 1.A.4

NOx EMISSIONS FACTOR FOR NATIONAL FISHING (1.A.4.ciii)

The determination of the NOx emission factor for the combustion of liquid fuels in fishing vessels followed the methodological guidelines described in volume 1.A.3.d Navigation (shipping) of the 2019 Guidebook EMPE/EEA. In particular section - 3.3.2 Tier 2 engine and fuel-specific emission factors.

The following assumptions were extracted from the Guidebook chapter mentioned above:

- The emission factors for 2000 are representative of the fleet before application of IMO NOx Technical Code;
- A new engine meeting the requirements of the NOx Technical Code has roughly 17% lower NOx emissions than a pre-2000 engine;
- The approximate life cycle for a marine engine is assumed to be 25 years, which is equivalent to an annual replacement rate of 4%.

Considering the three points above, the emission factors used to estimate NOx emissions have been divided into two approaches:

- Before 2000, the annual EFs are considered equal to the EFs of the year 2000, as this is representative of the fleet before application of IMO NOx Technical Code;
- From 2001 onwards, annual EFs are estimated using the following equation:

$$NOx\ EF_{YEARy} = NOx\ EF_{2000} \times RepRate \times ReqReduction \times Time$$

Where:

$NOx\ EF_{YEAR}$ – NOx Emission Factor for a given year y

$NOx\ EF_{2000}$ – NOx Emission Factor for the year 2000 (table 3-4, vol. Navigaton Shipping, GB 2019)

RepRate – Annual replacement rate (4%)

ReqReduction – Engine meeting requirements reduction of emissions (17%)

Time – Years since the year 2000 for a given year y, (YEARy - 2000)-1

The table compiling the annual NOx emission factors for diesel and fuel oil used to estimate combustion emissions from fishing vessels can be found in ANNEX C: ENERGY (NFR 1).

The figure below shows the summary of FE NOx taking into account the vessel's engine type.

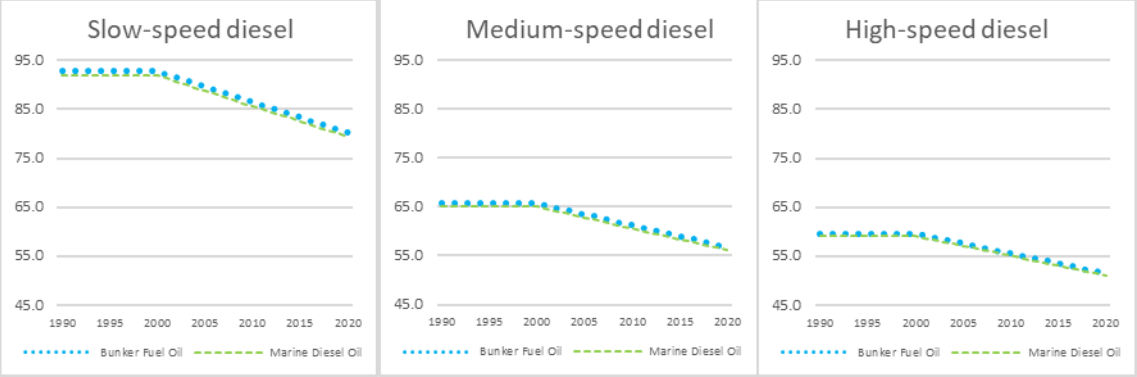


Figure 3-54: NOx emissions factor for diesel and fuel oil combustion in shipping vessels

3.5.5 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)

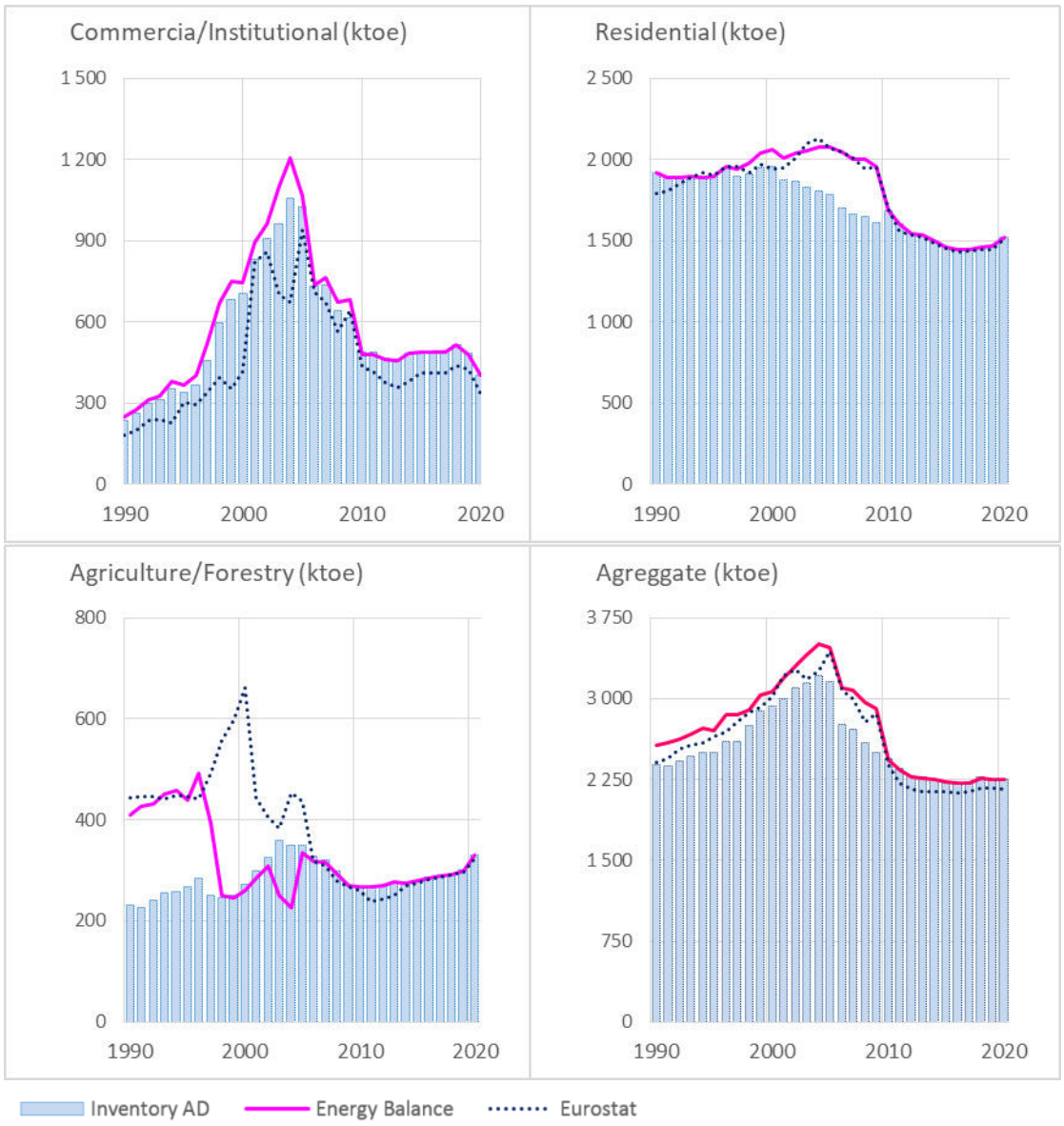


Figure 3-55: Energy consumption comparison between Inventory, National Energy Balance and EUROSTAT data by sector

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 these gasoline consumption now estimated and reported in CRF 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 these gasoline consumption now estimated and reported in CRF 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.

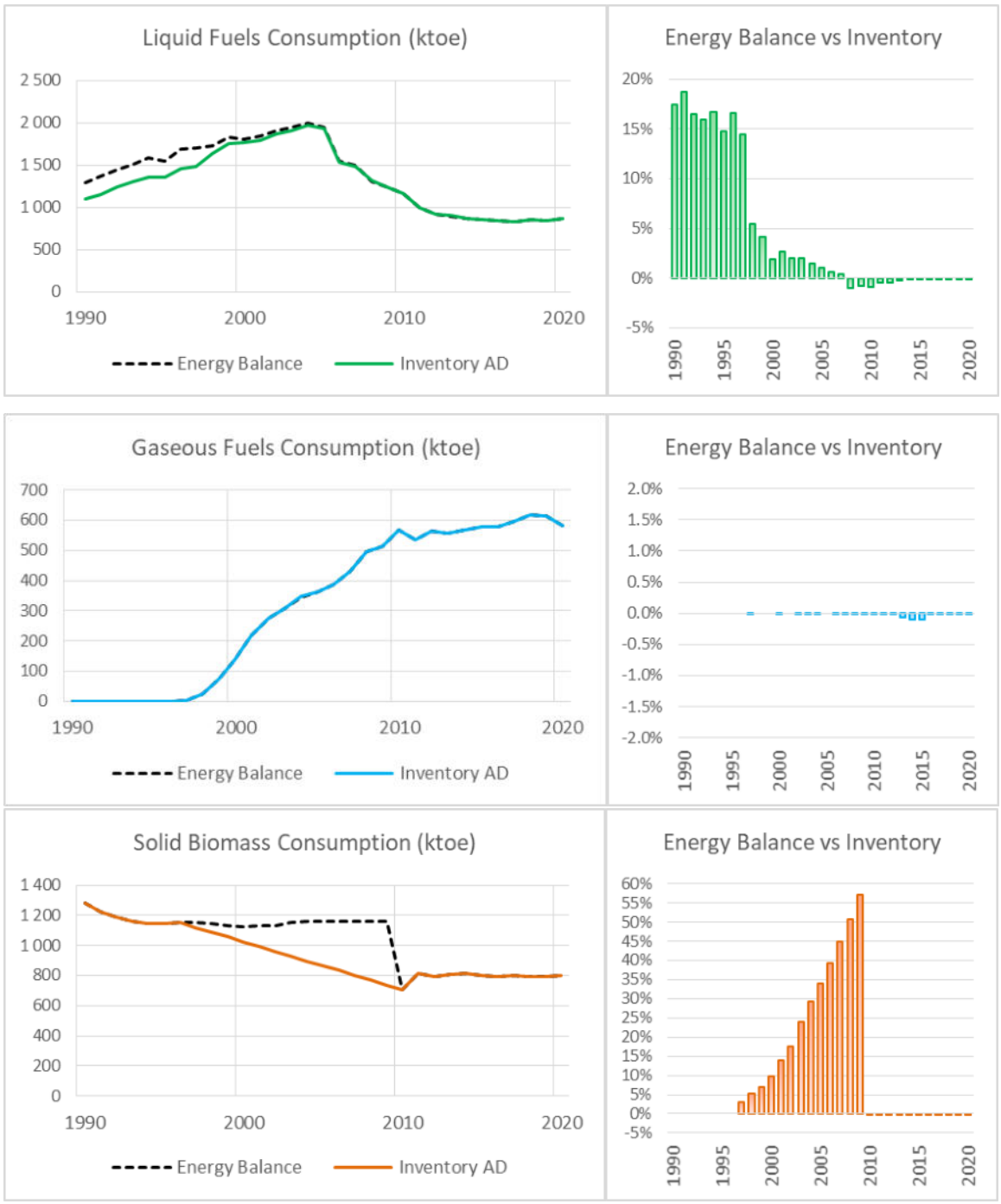


Figure 3-56: Energy consumption comparison between National Energy Balance and Inventory data by fuel type

3.5.6 Recalculations

No recalculations were made.

3.5.7 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;

- Separate the consumption of diesel for heating proposes from normal diesel, as these two fuels have different limits of sulphur content in national legislation. Such changes could lead to increased SO2 emissions, particularly in commercial / institutional combustion (1A4ci). This task should involve the constitution of a series of consumption of diesel for heating, as well as the attempt to separate this consumption by appliance;

- Despite the great effort made during the last 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.

3.6 Other (including Military) (NFR 1.A.5)

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.

3.6.1 Military Aviation (NFR 1.A.5.b)

3.6.1.1 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.

3.6.1.2 Emission Factors

The emission factors used to estimate emissions were obtained from IPCC and EMEP/EEA default emission factors.

Table 3-97: Emission factors – Military Aviation

Fuel	Jet Fuel		
Pollutant	Value	Unit	Reference
NO_x	300	kg/TJ	IPCC reference manual 1996
NMVOC	50		
CO	100		
SOx	19		
Pb	0.0016	g/ton	1A3b EMEP/EEA Guidebook 2019 table 3-78
Cd	0.0002		
Hg	0.0087		
As	0.0003		
Cr	0.0063		
Cu	0.0045		
Ni	0.0023		
Se	0.0002		
Zn	0.033		

For Particulate Matter, since there is no Tier 1 EF in 1A3b EMEP/EEA Guidebook 2019, we have applied the implied emission factor for 1A3ai(i) - International aviation LTO (civil) to the Energy Consumption in Military aviation.

3.6.1.3 Activity data

The following figure 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.

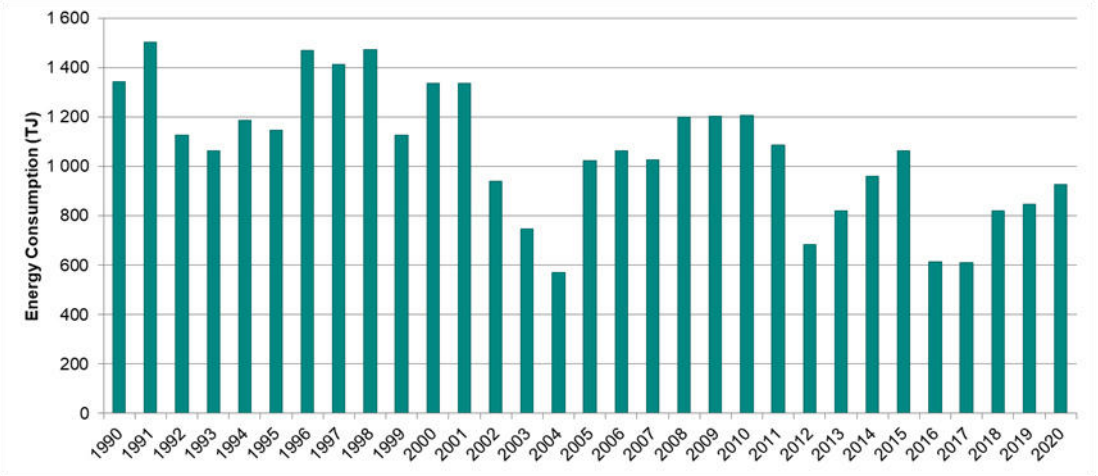


Figure 3-57: Energy Consumption in Military aviation

The fluctuations in Jet Fuel consumption is related to budget availability and the frequency of training and missions of the military aviation activities.

3.6.1.4 Recalculations

Following a recommendation (PT-1A5b-2021-0001) raised during the 2021 NECD review, related with the estimation of PM_{10} in this category, we have included the estimates of $PM_{2.5}$, PM_{10} and TSP by applying the implied emission factor for 1A3ai(i) - International aviation LTO (civil).

3.6.1.5 Further Improvements

No further improvements are planned for this sector.

3.7 Fugitive Emissions from Solid Fuels (NFR 1.B.1)

3.7.1 Coal Mining and Handling (NFR 1.B.1.a)

3.7.1.1 Category description

Coal contains some fraction of CO_2 and CH_4 trapped in its structure that it is usually emitted to atmosphere during and after extraction of coal from mines to open air. 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 methane still entrapped in coal after it is extracted and stored at surface in piles, or from crushing and drying operations applied to modified and ameliorate coal characteristics. In underground mines, post-mining emissions may occur in fact during extraction if degasification systems are installed but, nevertheless, total emissions remain more or less unaffected.

However, the extraction and treatment of coal is also responsible for non-methane volatile organic compounds (NMVOC), particulate matter.

Since 1990 in Portugal there was extraction of coal at only two coal mines, but both were latter closed down in 1992 and 1994 and did not resume activity since. Both mines - *Pejão* and *S. Pedro da Cova* - 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 Oporto (*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 below). Both mines (Pejão and S. Pedro da Cova) are of the underground type.

Emissions of carbon dioxide and sulphur oxides may occur from mining activity when burning of coal deposits occurs or when flaring is used to control air emissions or recover energy. Because the occurrence of coal burning on-site or flaring is unknown for both Portuguese mines, emissions of these pollutants from this source are not included in the inventory.

Emissions of methane from abandoned mines may still continue after mine closure, even if mines are sealed.

Emissions from fuel combustion for coal extraction are included under category 1.A.1.c.1.

3.7.1.2 Methodology

For all pollutants, emissions were estimated according to EMEP 2019 Guidebook:

$$Emi = EF \times Coal_U \times 10^{-3}$$

Where:

Emi: Emissions (t)

EF: Emission factor (kg/t of coal)

$Coal_U$: Coal extracted from underground mines (t of coal)

3.7.1.3 Emission Factors

The emission factors applied were taken from Table 3-1 of chapter 1.B.1.a Fugitive emissions from solid fuels: Coal mining and handling" of EMEP/EEA emission inventory guidebook 2019 (Tier 1) and are listed in the table below:

Table 3-98: Emission Factors for coal extraction and processing

Parameter	Emission Factor	Unit
NMVOC	0.8	Kg/t of coal
TSP	0.089	Kg/t of coal
PM10	0.042	Kg/t of coal
PM2.5	0.005	Kg/t of coal

3.7.1.4 Activity data

The quantity of extracted coal has decreased towards the final closure of both mines in 1994, as may be seen in next figure. Statistical information on the amount of coal extracted was obtained from Geological Resources reports from DGEG.

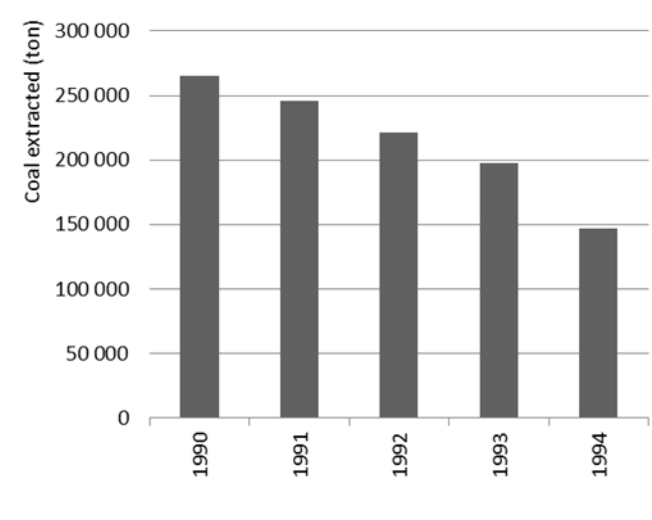


Figure 3-58: Amount of coal extracted from mines in Portugal

3.7.1.5 Recalculations

No recalculations were made.

3.7.1.6 Further Improvement

No further improvements are expected.

3.7.2 Solid fuels: Solid fuel transformation (NFR 1.B.1.b)

3.7.2.1 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 fugitive air emissions from coke production in the coke plant.

3.7.2.2 Methodology

Fugitive air emissions from coke production were estimated based on a Tier 1 production approach of the 2019 EMEP Guidebook, according to the following equation:

$$Emi = EF \times Coke_{Prod} \times 10^{-3}$$

Where:

Emi: Fugitive emissions (t)

EF: Emission factor (kg/t coke)

$Coke_{Prod}$: Quantity of coke produced (t)

3.7.2.3 Emission Factors

Emission factors for fugitive air emissions from coke production in the period 1990-2001 were taken from Table 3-1 of chapter 1.B.1.b Fugitive emissions from solid fuels: solid fuel transformation of the 2019 EMEP Guidebook and are provided in the table below.

Table 3-99: Emission Factors for fugitive air emissions from coke production

Pollutant	Fugitive emissions	
	Unit	EF
SOx	g/t coke	0.8
NOx	g/t coke	0.9
NMVOC	g/t coke	7.7
CO	g/t coke	460
TSP	g/t coke	347
PM_{10}	g/t coke	146
$PM_{2.5}$	g/t coke	61
BC	% of $PM_{2.5}$	49
Pb	g/t coke	0.38
Cd	g/t coke	0.007
Hg	g/t coke	0.012
As	g/t coke	0.013
Cr	g/t coke	0.17
Cu	g/t coke	0.048
Ni	g/t coke	0.12
Se	g/t coke	0.016
Zn	g/t coke	0.22
PCDD/ PCDF	ng I-TEQ/ton coke	3
Benzo(α)pyrene	g/t coke	0.16
Benzo(β)fluoranthene	g/t coke	0.2
Benzo(k)fluoranthene	g/t coke	0.1
Indeno(1,2,3-cd)pyrene	g/t coke	0.07
Source: EMEP/EEA guidebook 2019, Vol. 1.B.1.b, Table 3-1		

3.7.2.4 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.

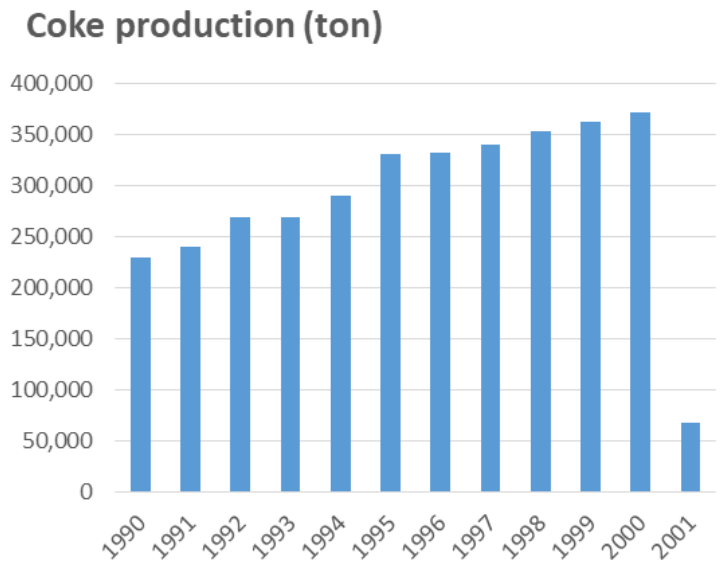


Figure 3-59: Coke production in the coke plant

3.1.1.1 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.

3.7.2.5 Recalculations

No recalculations were made.

3.7.2.6 Further Improvement

No further improvements are planned for this sector.

3.8 Fugitive Emissions from Oil Production and Refining (NFR 1.B.2.a)

3.8.1 Category description

Extraction and production of crude oil did never occur in the Portuguese territory. Therefore, fugitive emissions comprehend only 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.

3.8.1.1 Fugitive emissions from oil: Exploration, production, transport (NFR 1.B.2.a.i)

Emissions from this category result from transport of Crude/Marine Terminals.

There is no oil exploration nor crude oil production in Portugal.

3.8.1.1.1 Category description

Emissions from this source consist mainly of volatile organic compounds 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.

3.8.1.1.2 Methodology

NMVOC emissions were estimated according to the following equation:

$$Emis_{NMVOC} = \frac{(Crude_{cons} \times EF_{NMVOC})}{1000}$$

Where:

$Emis_{NMVOC}$: NMVOC emissions (kt)

$Crude_{cons}$: Crude consumption in refineries (t)

EF_{NMVOC}: NMVOC emission factor (kg/t crude)

3.8.1.1.3 Emission Factors

Table 3-100: Emission Factors

Parameter	Unit	Emission Factor	Source
NMVOC	Kg/t crude	0.2	Table 3-1 of chapter "1.B.2.a.i Oil – Exploration, production, transport; and 1.B.2.b Natural gas" of "EMEP/EEA air pollutant emission inventory guidebook 2016"

3.8.1.1.4 Activity data

Activity Data reported under this subcategory concerns crude that arrives in marine terminals, before being consumed in the refineries.

In the period 1990-2004, data on crude received was obtained from DGEG. From 2005 onwards, data was obtained from refineries.

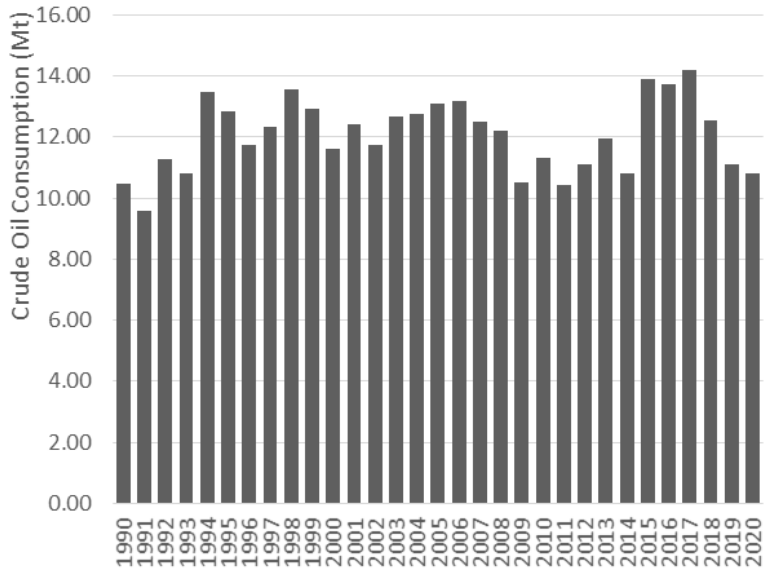


Figure 3-60: Total amount of crude in Marine Terminals

3.8.1.1.5 Recalculations

No recalculations were made.

3.8.1.1.6 Further Improvement

No further improvements are planned for this sector.

3.8.2 Refining and Storage (NFR 1.B.2.a.iv)

3.8.2.1 Category description

In 1990 there were three oil refining plants in Portugal, located in Porto, Lisbon and Sines. After 1993, the Lisbon unit was closed for all activity and only two units remain now operating.

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;
  - Polymerisation of small molecules combined in bigger molecules with different characteristics. Alkylation has similar objectives;
  - 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 methane 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. Catalytic processes

[23] Sometimes only these emissions are referred as fugitive emissions from refineries.

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.

Finally sulphur oxide is emitted to the atmosphere when sulphur that is present in the tail gas of the refining process is not recovered in the Claus units and transformed into elemental sulphur, either because the normal recovery efficiency is actually not hundredth % by design, or because the Claus unit was not at all operating and the sulphur flux had to be oxidized to SO_2 in the tail gas incinerator before being released to atmosphere.

3.8.2.2 Fluid Catalytic Cracking (FCC)

3.8.2.2.1 Methodology

NO_x, CO, NMVOC, SO_x, NH_3, TSP, PM_{10} and $PM_{2.5}$ emissions were estimated according to the following:

$$Emi_p = Fresh\ Feed \times EF_p \times 10^{-3}$$

Where:

Emi_p: Emission of pollutant "p" (t)

Fresh Feed: Fresh Feed of Fluid catalytic cracking unit (m^3)

EF_p: Emission factor for pollutant "p" (kg/m^3)

Black Carbon (BC) emissions were estimated according to the following equation:

$$Emi_{BC} = Emi_{PM2.5} \times EF_{BC}$$

Where:

Emi_{BC}: Black Carbon emissions (t)

$Emi_{PM2.5}$: $PM_{2.5}$ emissions (t)

EF_{BC}: Black Carbon emission factor (% $PM_{2.5}$)

Pb, Cd, Hg, As, Cr, Cu, Ni, Se and Zn emissions were estimated according to the following equation:

$$Emi_p = Fresh\ Feed \times EF_p \times 10^{-6}$$

Where:

Emi_p: Emission of pollutant "p" (t)

Fresh Feed: Fresh Feed of Fluid catalytic cracking unit (m^3)

EF_p: Emission factor pollutant "p" (g/m^3)

3.8.2.2.2 Emission Factors

Emission factors were taken from Table 3-2 of chapter 1.B.2 of 2016 EMEP Guidebook and are listed below.

Table 3-101: Emission Factors for FCC Units in refineries

Pollutant	Unit	EF
NO_x	Kg/m^3 fresh feed	0.2
CO	Kg/m^3 fresh feed	39
NMVOC	Kg/m^3 fresh feed	0.63
SO_x	Kg/m^3 fresh feed	1.4
NH_3	Kg/m^3 fresh feed	0.16
TSP	Kg/m^3 fresh feed	0.7
PM_{10}	Kg/m^3 fresh feed	0.55
$PM_{2.5}$	Kg/m^3 fresh feed	0.24
BC	% $PM_{2.5}$	0.13
Pb	g/m^3 fresh feed	0.32
Cd	g/m^3 fresh feed	0.063
Hg	g/m^3 fresh feed	0.07
As	g/m^3 fresh feed	0.014
Cr	g/m^3 fresh feed	0.33
Cu	g/m^3 fresh feed	0.14
Ni	g/m^3 fresh feed	0.61
Se	g/m^3 fresh feed	0.014
Zn	g/m^3 fresh feed	0.12
Benzo(α)pyrene	mg/m^3 fresh feed	0.71
Benzo(β)fluoranthene	mg/m^3 fresh feed	1.2
Benzo(k)fluoranthene	mg/m^3 fresh feed	0.82
Indeno(1,2,3-cd)pyrene	mg/m^3 fresh feed	0.62

3.8.2.2.3 Activity Data

The activity data considered was the fresh feed (m^3) in the fluid catalytic cracking unit of one of the refineries. Since there are only two refineries in Portugal and the FCC unit started in 1994, we present the activity data as an index related to the 1994 fresh feed value.

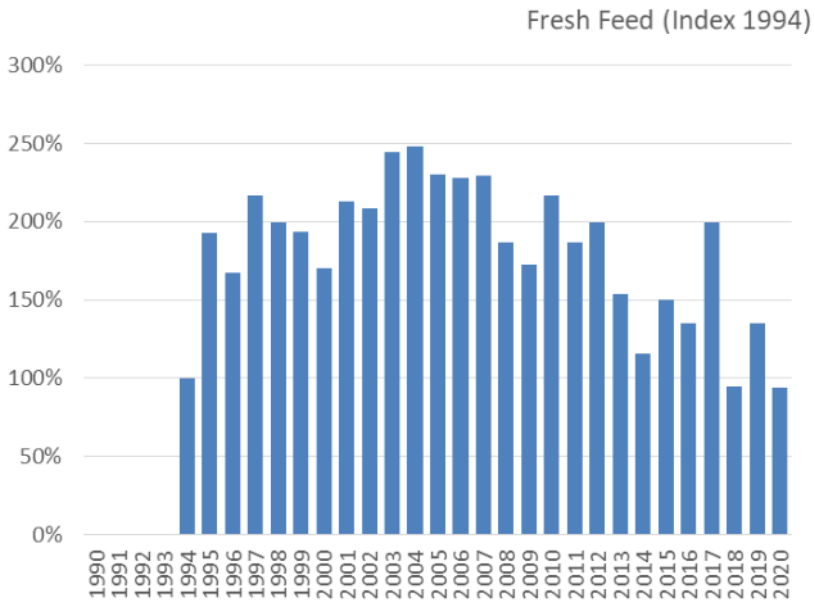


Figure 3-61: Fresh feed in the Fluid Catalytic Cracking Unit

3.8.2.2.4 Recalculations

No recalculations were made.

3.8.2.2.5 Further Improvements

No further improvements are planned for this sector.

3.8.2.3 Platforming/Continuous Catalyst Regenerators (CCR)

3.8.2.3.1 Methodology

CO and SO_x emissions were estimated according to the following equation:

$$Emi_p = Fresh\ Feed \times EF_p \times 10^{-6}$$

Where:

Emi_p: Emissions of pollutant "p" (t)

Fresh Feed: Fresh Feed of Continuous Catalyst Regeneration unit (m^3)

EF_p: Emission factor pollutant "p" (g/m^3)

PCDD/F emissions were estimated according to the following equation:

$$Emi_p = Fresh\ Feed \times EF_p \times 10^{-6}$$

Where:

Emi_p: Emission of pollutant "p" (g I-TEQ)

Fresh Feed: Fresh Feed of Continuous Catalyst Regeneration unit (m^3)

EF_p: Emission factor pollutant "p" (µg I-TEQ/m^3)

3.8.2.3.2 Emission Factors

Emission factors from Table 3-3 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016 are listed below.

Table 3-102: Emission Factors for Continuous Catalyst Regeneration (Platforming) in Refineries

Pollutant	Unit	EF
CO	g/m^3 fresh feed	42
SO_x	g/m^3 fresh feed	4
PCDD/F	µg I-teq/m^3 fresh feed	0.019

3.8.2.3.3 Activity Data

The activity data considered was the fresh feed (m^3) in the platforming units of the refineries. Since there are only two refineries in Portugal, we present the activity data as an index related to the 1990 fresh feed value.

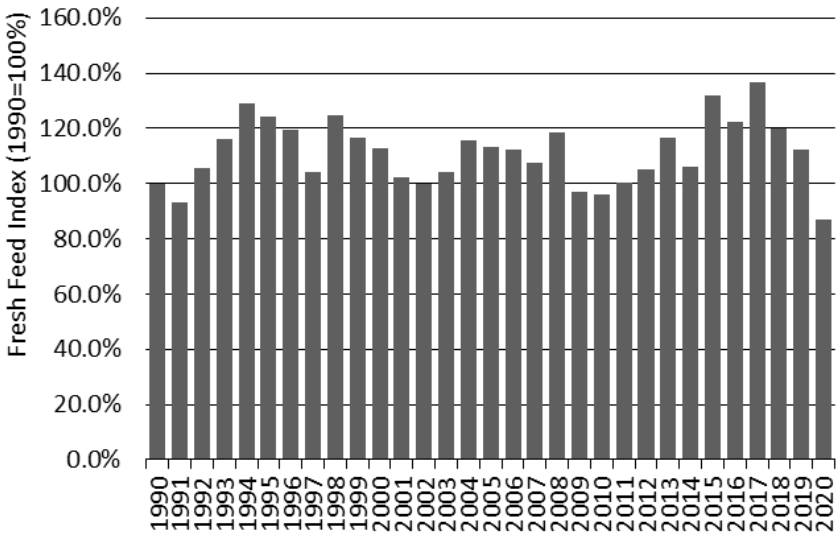


Figure 3-62: Fresh feed in the Platforming Units

3.8.2.3.4 Recalculations

No recalculations were made.

3.8.2.3.5 Further Improvements

No further improvements are planned for this sector.

3.8.2.4 Asphalt Blowing in Refineries

Emissions related to Asphalt blowing in refineries are estimated and reported in NFR 2.D.3.g in IPPU sector.

3.8.2.5 Oil-Water Separators

3.8.2.5.1 Methodology

From 2005 onwards, NMVOC emissions were estimated according to the following equation:

$$Emi_{NMVOC} = V_{Wastewater} \times EF_{NMVOC} \times 10^{-3}$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

$V_{Wastewater}$: Volume of wastewater treated (m^3)

EF_{NMVOC}: NMVOC emission factor (kg/m^3)

In the period 1990-1994, NMVOC emissions were estimated according to the following equation:

$$Emi_{NMVOC,y} = Emi_{NMVOC,2005} \times \frac{Crude_{cons,y}}{Crude_{cons,2005}}$$

Where:

$Emi_{NMVOC,y}$: NMVOC emissions in year "y" (t)

$Emi_{NMVOC,2005}$: NMVOC emissions in year 2005 (t)

$Crude_{cons,y}$: Crude consumption in year "y" (t)

$Crude_{cons,2005}$: Crude consumption in year 2005 (t)

3.8.2.5.2 Emission Factors

Table 3-103: NMVOC emission factor for Oil-Water Separators

Pollutant	Unit	EF	Source
NMVOC	kg/m^3 wastewater	4x10^{-3}	Table 8 of Concawe report no. 4/17 (Concawe 2017)

3.8.2.5.3 Activity Data

Emissions from oil-water separators consider wastewater treated as activity data. From 2005 onwards, data on wastewater treated was obtained from Annual Environmental Reports and publication and from security and environment databooks. In the period 1990-2014, wastewater treated was estimated based on crude input trend in refineries.

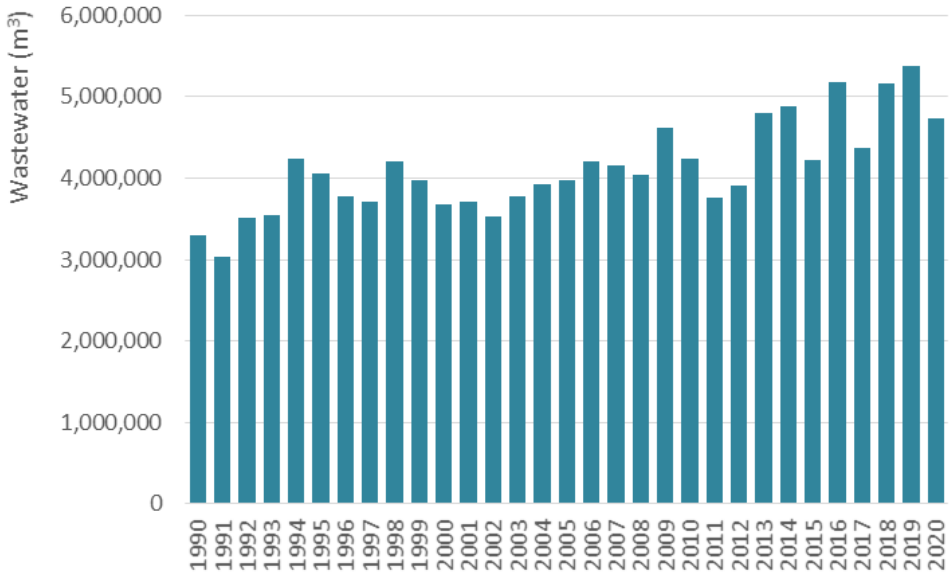


Figure 3-63: Wastewater treated

3.8.2.5.4 Recalculations

No recalculations were made.

3.8.2.5.5 Further Improvements

No further improvements are expected.

3.8.2.6 Sulphur Recovery Units

3.8.2.6.1 Methodology

Emissions of SO_x were estimated annually according to the following equation:

$$Emi_{SO2} = Emi_{Claus\ Units} + Emi_{Absorption\ Towers} + Emi_{Incinerators}$$

Where:

Emi_{SOx}: SO_x emissions in the Refineries (t SO_x)

$Emi_{Claus\ Units}$: SOx emissions in Claus Units due to the inefficiency of the process (t SO_x)

$Emi_{Absoption\ Towers}$: SOx emissions in the Absorption Towers before the Incinerator (t SO_x)

$Emi_{Incinerators}$: SOx emissions related to Tail Gas burning in the Incinerator (t SO_x)

Emissions of SOx in Claus Units were estimated according to the following equation:

$$\boldsymbol{Emi_{Claus\ Unit} = \frac{M_{SO2}}{M_S} \times \left[S_{input} \times \left(100\% - Effic_{Claus\ Unit}\right)\right]}$$

Where:

$Emi_{Claus\ Unit}$: SO_x emissions in the the Claus Unit (t SO_x)

M_{SO2}: SO_2 molar mass (g/mol)

M_S: S molar mass (g/mol)

S_{input}: Sulphur input in the Claus unit (t S)

$Effic_{Claus\ Unit}$: Efficiency of the Claus Unit (%)

Emissions of SOx in the Absorption Tower were estimated according to the following equation:

$$Emi_{Absorption\ Tower} = \frac{M_{SO2}}{M_S} \times \left[S_{input} \times \left(100\% - Effic_{Absorption\ Tower}\right)\right]$$

Where:

$Emi_{Absorption\ Tower}$: SO_x emissions in the the Absorption Tower (t SO_x)

M_{SO2}: SO_2 molar mass (g/mol)

M_S: S molar mass (g/mol)

S_{input}: Sulphur input in the Absorption Tower (t S)

$Effic_{Absorption\ Tower}$: Efficiency of the Absorption Tower (%)

Emissions of SOx related to the tail gas burning in the incinerator were estimated according to the following equation:

$$Emi_{Incinerator} = \frac{M_{SO2}}{M_S} \times \left[S_{input} \times \left(100\% - Effic_{Incinerator}\right)\right]$$

Where:

$Emi_{Incinerator}$: SO_x emissions in the the Incinerator (t SO_x)

M_{SO2}: SO_2 molar mass (g/mol)

M_S: S molar mass (g/mol)

S_{input}: Sulphur input in the Incinerator (t S)

$Effic_{Incinerator}$: Efficiency of the Incinerator (%)

3.8.2.6.2 Emission Factors

Sulphur Claus Recovery units' efficiency lies between 94.8-98.0%. According to the performance evaluation of one of the Refineries, the absorption towers efficiency is 99.98% and the recovery efficiency in the incinerator is 99.92%.

3.8.2.6.3 Activity Data

Total Sulphur recovered in the refineries was available from the balance of petroleum products in annual publications from DGEG, from 1990 to 2004. From 2005 onwards, data was obtained from refineries publication "Data Book de Segurança, Saúde e Ambiente".

From 1996 onwards, sulphur recovery has been increasing, expressing the technology changes set by the auto-oil program. From 2013 onwards, there is a new Sulphur recovery unit in one of the refineries, leading to an increase in the Sulphur recovered.

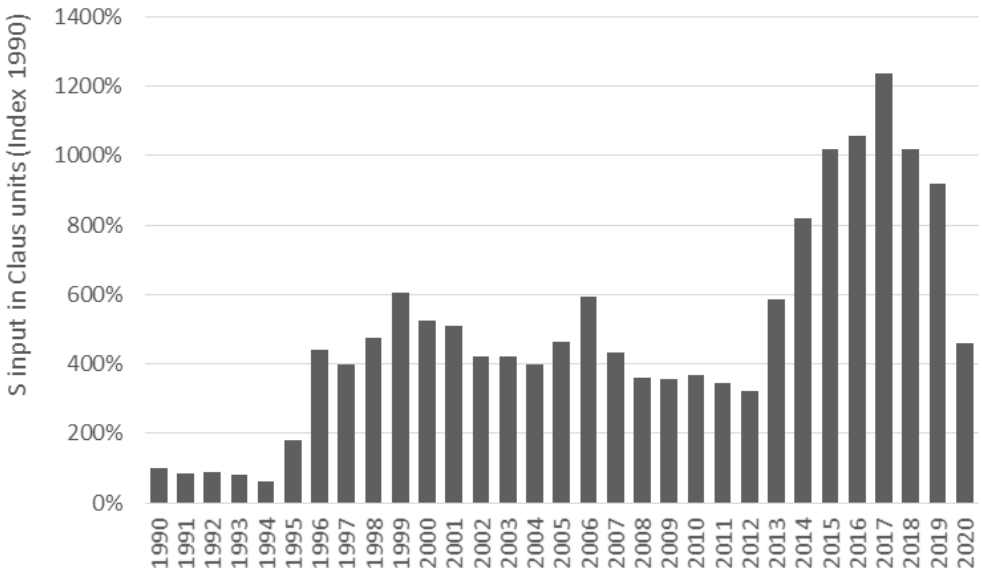


Figure 3-64: Sulphur input in Claus Units (Index related to 1990 value)

3.8.2.6.4 Recalculations

No recalculations were made.

3.8.2.6.5 Further Improvements

No further improvements are planned for this sector.

3.8.2.7 Storage/Tanks

3.8.2.7.1 Methodology

For one of the refineries there are estimates, relying on TANKS 4.0 model, available from 2003 onwards. For the period 1990-2002, emissions are estimated based on throughput trend.

For the other refinery there are estimates, relying on TANKS 4.0 model, available only for year 2005 and from 2017 onwards. For the remaining years, emissions are estimated based on throughout trend.

Emissions relying on the TANKS 4.0 model were estimated according to the following equation:

$$Emi_{NMVOC} = EF_{(y)} \text{ X Throughput X } 10^{-6}$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

EF(y): Emission factor for each tank, considering site information, liquid characterization, and tank specific information (kg/t throughput)

Throughput: Specific liquid throughput in each tank (t)

Emissions for the years for which there is no data in TANKS 4.0 model, NMVOC emissions are estimated as:

$$Emi_{NMVOC,y} = Emis_{NMVOC,y\ TANKS} \times \frac{Throughput_y}{Throughput_{y\ TANKS}}$$

Where:

$Emi_{NMVOC,y}$: NMVOC emissions in year "y" (t)

$Emi_{NMVOC,y\ TANKS}$: NMVOC emissions in the last year for which there is data reported in TANKS 4.0 model. For Sines Refinery is year 2003 and for Porto Refinery is year 2005

$Throughput_y$: Throughput in year "y" (t)

$Throughput_{y\ TANKS}$: Throughput in the last year for which there is data reported in TANKS 4.0 model. For Sines Refinery is year 2003 and for Porto Refinery is year 2005 (t)

3.8.2.7.2 Emission Factors

TANKS4.0 program was designed to estimate air emissions from organic liquids in storage tanks, according to the methodology proposed in "Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources" (AP-42), Section 7.1, Organic Liquid Storage Tanks (USEPA, 1997).

Determination of emission factors for Porto and Sines refineries were performed for each tank, considering the following detailed information:

- Site information: meteorological data such as the daily average ambient temperature, the annual average minimum and maximum temperatures, the annual average wind speed, the annual average solar insolation factor, and the atmospheric pressure;
- Liquid characterization: For individual substances the model requires chemical *nomenclature*, average liquid temperature, vapour pressure (psia) at liquid surface temperature, and liquid and vapour molecular weights. For mixtures, the information may be as detailed as the mixture name, average, minimum and maximum liquid surface temperatures, bulk temperature, vapour pressure (psia) at liquid surface temperature, and liquid and vapour molecular weights;
- Tank information is slightly different according to tank type, but in general terms comprehends: shell and roof colour and condition, height, diameter, average and maximum liquid height, working volume, turnover rate and net output, heating conditions and pressure and vacuum settings and the existence and type of seals[24].

[24] This list is intended as presenting an overview. For precise description please consult USEPA (1997) or USEPA (2000).

Emissions were determined relying on methodologies that vary according to each tank type. The possible type of tanks, a very short description of their characteristics and the number of tanks by type in 2005 at Porto and Sines refineries are presented in the table below.

Table 3-104: Type of tanks classes distinguished in TANKS4.0 model and percentage of tanks per tank type in Porto and Sines refineries in 2005 (%)

Tank Type	Description	Porto	Sines (a)
External Floating Roof Tank	Cylindrical steel shell equipped with a roof that floats on the surface of the stored liquid	55	170
Horizontal Tank	Above-ground or underground storage with the axis parallel to the foundation	4	0
Internal Floating Roof Tank	Permanent fixed roof and a floating deck	30	58
Vertical Fixed Roof Tank	Cylindrical shells with permanently affixed roofs; the tank axis is perpendicular to the foundation. The fixed roof may be dome-shaped or cone shaped	206	235
Domed External Floating Roof.	External floating roof tank that has been retrofit with a domed fixed roof	0	0

(a) Inventory covers only tanks for storage of liquids with Vapour Pressure above 27kPa

TANKS4.0 methodology differentiates the following emissions, according to the cause of release:

Table 3-105: Types of losses from tanks for storage of organic compounds and petroleum products

Tank	Loss	Description
Fixed Roof	Breathing	Expulsion of vapour from a tank through vapour expansion and contraction, which are the results of changes in temperature and barometric pressure
	Working	Combined loss from filling and emptying. Evaporation during filling operations is a result of an increase in the liquid level in the tank. As the liquid level increases, the pressure inside the tank exceeds the relief pressure and vapours are expelled from the tank. Evaporative loss during emptying occurs when air drawn into the tank during liquid removal becomes saturated with organic vapour and expands, thus exceeding the capacity of the vapour space.
Floating Roof	Rim Seal	The majority of rim seal vapour losses have been found to be wind induced.
	Withdrawal	Occur as the liquid level, and thus the floating roof, is lowered. Some liquid remains on the inner tank wall surface and evaporates.
	Deck Fitting	Deck fittings can be a source of evaporative loss when they require openings in the deck, such as: access hatches, gauges, rim vents, deck drains, guide-poles, columns, wells, vacuum breakers and ladders.
Internal Floating	Deck Seam	Seams may not be completely vapour tight if the deck is not welded

Table 3-106: NMVOC IEF trend from storage and tank in refineries

Pollutant	Unit	1990	1995	2000	2005	2010	2018	2019	2020
NMVOC	kg/t throughput	31.8	31.2	31.0	30.6	34.8	14.8	17.9	19.2

3.8.2.7.3 Activity Data

Total throughput in each refinery was used to estimate NMVOC emissions from storage and tanks. Total throughput represents not only crude oil entered into the refinery but also other petroleum products that are imported or moved between refineries.

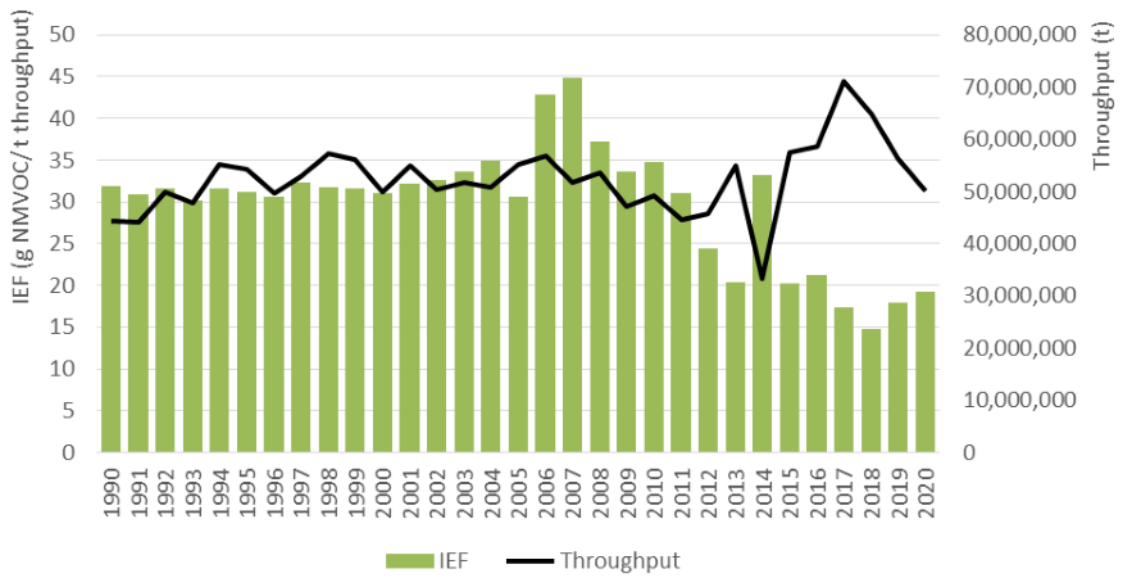


Figure 3-65: Total throughput in Lisbon, Porto and Sines refineries

3.8.2.7.4 Recalculations

No recalculations were made.

3.8.2.7.5 Further Improvements

In the future, we intend to revise all activity data based on data provided by the refineries as input to TANKS software.

3.8.3 Distribution of Oil Products (1.B.2.a.v)

This sub-source sector includes emissions of volatile organic compounds resulting from distribution of refinery products, mainly gasoline:

- (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.

3.8.3.1 Terminal Dispatch Stations

3.8.3.1.1 Methodology

For gasoline, crude oil, jet naphtha, jet kerosene, distillate oil and residual oil, emissions are estimated according to the following equation:

$$Emi_{NMVOC} = V_{liquid} \times EF_{NMVOC}$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

V_{liquid}: Volume of the liquid loaded in the terminal dispatch (L)

EF_{NMVOC}: NMVOC emission factor (t NMVOC/L liquid loaded)

For other liquids (LPG, heptane, hexane, toluene, xylene, white spirit and solvents) emissions are estimated according to the following equation:

$$Emi_{NMVOC} = V_{liquid} \times \left(\frac{0.0004535924}{3785.412}\right) \times 12.46 \times \frac{S \times P \times M}{T}$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

V_{liquid}: Volume of the liquid loaded in the terminal dispatch (L)

S: Saturation factor of the liquid loaded

P: True vapour pressure of liquid loaded (psi)

M: Molecular weight of vapours (lb/lb-mole)

T: Temperature of bulk liquid loaded (R)

3.8.3.1.2 Emission Factors

NMVOC emission factors applied were taken from Table 5.2-5 of chapter 5.2 Transportation and marketing of Petroleum Products of USEPA AP-42 and are listed in the table below.

Table 3-107: NMVOC emission factors

Liquid loaded	Type of loading	Unit	EF
Fuel oil	Submerged loading – dedicated normal service	t/L	$1X10^{-11}$
Gasoline	Submerged loading – dedicated normal service	t/L	$5.9x10^{-7}$
Jet Kerosene	Submerged loading – dedicated normal service	t/L	$1.9x10^{-9}$
Gasoil	Submerged loading – dedicated normal service	t/L	$1.7x10^{-9}$

3.8.3.1.3 Activity Data

The amounts of liquids loaded at terminal dispatch stations of refineries and depots were collected for year 2005. For the remaining period data has been estimated based on products processed in the refineries trend.

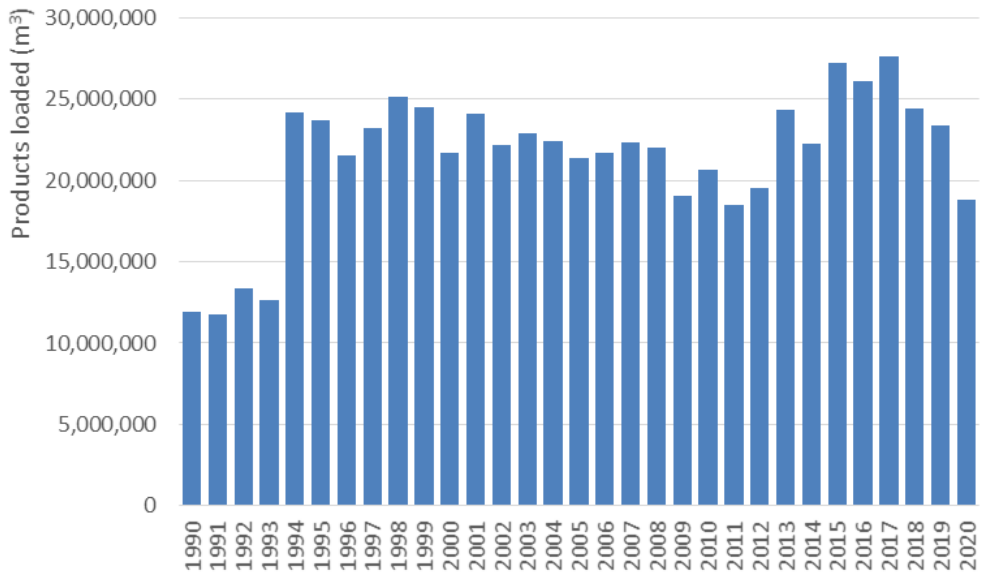


Figure 3-66: Products loaded at terminal dispatch stations of refineries and depots

3.8.3.1.4 Recalculations

No recalculations were made.

3.8.3.1.5 Further Improvements

No further improvements are expected.

3.8.3.2 Transport of oil products

3.8.3.2.1 Methodology

The most relevant emissions of transport of oil products are related to gasoline transport.

NMVOC emissions are estimated according to the following equation:

$$Emi_{NMVOC} = V_{liquid} \times EF_{NMVOC}$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

V_{liquid}: Volume of the liquid transported (L)

EF_{NMVOC}: NMVOC emission factor (t NMVOC/L liquid)

3.8.3.2.2 Emission Factors

NMVOC emission factor related to gasoline transport was taken from Table 5.2-5 of chapter 5.2 Transportation and marketing of Petroleum Products of USEPA AP-42 and is indicated in the table below.

Table 3-108: NMVOC emission factor

Liquid Transported	Type of Transport	Unit	EF
Gasoline	Transit Losses-Loaded with Product-Extreme	t/L	$4.5x10^{-9}$

3.8.3.2.3 Activity Data

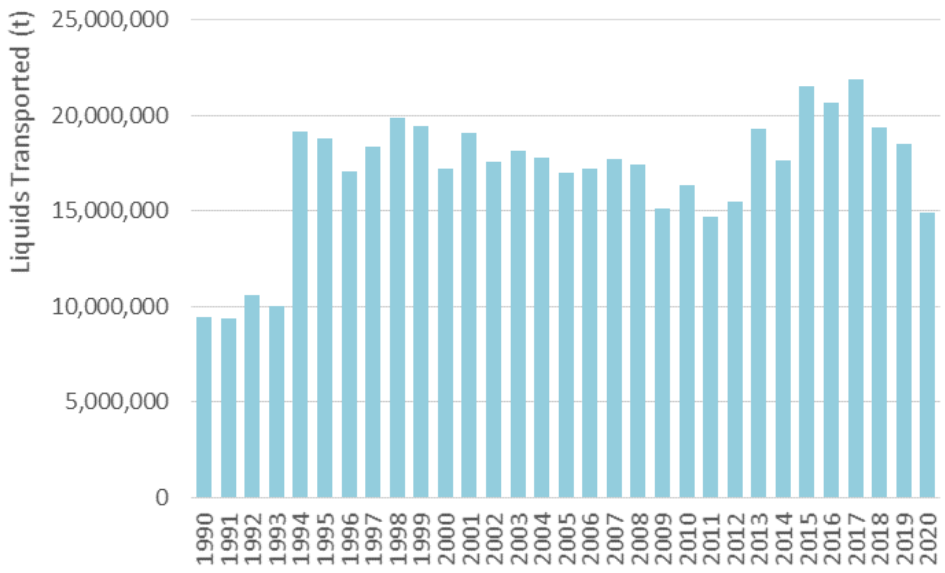


Figure 3-67: Liquids transports from Refineries and Depots

3.8.3.2.4 Recalculations

No recalculations were made.

3.8.3.2.5 Further Improvements

No further improvements are expected.

3.8.3.3 Storage of oil products in Depots

3.8.3.3.1 Methodology

There are estimates, relying on the TANKS 4.0 model, available only for year 2005. For the remaining period, emissions are estimated based on throughout trend.

Emissions relying on the TANKS 4.0 model were estimated according to the following equation:

$$Emi_{NMVOC} = EF_{(y)} \text{ X Throughput X } 10^{-6}$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

EF(y): Emission factor for each tank, considering site information, liquid characterization, and tank specific information (kg/t throughput)

Throughput: Specific liquid throughput in each tank (t)

Emissions for the years for which there is no data in TANKS 4.0 model, NMVOC emissions were estimated according to the following equation:

$$Emi_{NMVOC,y} = Emi_{NMVOC,2005} \times \frac{Throughput_y}{Throughput_{2005}}$$

Where:

$Emi_{NMVOC,y}$: NMVOC emissions in year "y" (t)

$Emi_{NMVOC,2005}$: NMVOC emissions in year 2005

$Throughput_y$: Throughput in year "y" (t)

$Throughput_{2005}$: Throughput in year 2005 (t)

3.8.3.3.2 Emission Factors

TANKS4.0 program was designed to estimate air emissions from organic liquids in storage tanks, according to the methodology proposed in "Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources" (AP-42), Section 7.1, Organic Liquid Storage Tanks (USEPA, 1997).

Determination of emission factors were performed for each tank, considering the following detailed information:

- Site information: meteorological data such as the daily average ambient temperature, the annual average minimum and maximum temperatures, the annual average wind speed, the annual average solar insolation factor, and the atmospheric pressure;
- Liquid characterization: For individual substances the model requires chemical nomenclature, average liquid temperature, vapour pressure (psia) at liquid surface temperature, and liquid and vapour molecular weights. For mixtures, the information may be as detailed as the mixture name, average, minimum and maximum liquid surface temperatures, bulk temperature, vapour pressure (psia) at liquid surface temperature, and liquid and vapour molecular weights;
- Tank information is slightly different according to tank type, but in general terms comprehends: shell and roof colour and condition, height, diameter, average and maximum liquid height,

working volume, turnover rate and net output, heating conditions and pressure and vacuum settings and the existence and type of seals[25].

Emissions were determined relying on methodologies that vary according to each tank type. The possible type of tanks and a very short description of their characteristics are presented in the table below.

Table 3-109: Type of tanks classes distinguished in TANKS4.0 model

Tank Type	Description
External Floating Roof Tank	Cylindrical steel shell equipped with a roof that floats on the surface of the stored liquid
Horizontal Tank	Above-ground or underground storage with the axis parallel to the foundation
Internal Floating Roof Tank	Permanent fixed roof and a floating deck
Vertical Fixed Roof Tank	Cylindrical shells with permanently affixed roofs; the tank axis is perpendicular to the foundation. The fixed roof may be dome-shaped or cone shaped
Domed External Floating Roof.	External floating roof tank that has been retrofit with a domed fixed roof

(a) Inventory covers only tanks for storage of liquids with Vapour Pressure above 27kPa

TANKS4.0 methodology differentiates the following emissions, according to the cause of release:

Table 3-110: Types of losses from tanks for storage of organic compounds and petroleum products

Tank	Loss	Description
Fixed Roof	Breathing	Expulsion of vapour from a tank through vapour expansion and contraction, which are the results of changes in temperature and barometric pressure
	Working	Combined loss from filling and emptying. Evaporation during filling operations is a result of an increase in the liquid level in the tank. As the liquid level increases, the pressure inside the tank exceeds the relief pressure and vapours are expelled from the tank. Evaporative loss during emptying occurs when air drawn into the tank during liquid removal becomes saturated with organic vapour and expands, thus exceeding the capacity of the vapour space.
Floating Roof	Rim Seal	The majority of rim seal vapour losses have been found to be wind induced.
	Withdrawal	Occur as the liquid level, and thus the floating roof, is lowered. Some liquid remains on the inner tank wall surface and evaporates.
	Deck Fitting	Deck fittings can be a source of evaporative loss when they require openings in the deck, such as: access hatches, gauges, rim vents, deck drains, guide-poles, columns, wells, vacuum breakers and ladders.
Internal Floating	Deck Seam	Seams may not be completely vapour tight if the deck is not welded

Table 3-111: NMVOC IEF trend from storage and tank in depots

Pollutant	Unit	1990	1995	2000	2005	2010	2018	2019	2020
NMVOC	kg/t throughput	37.5	22.1	22.1	22.1	22.1	22.1	22.1	22.1

[25] This list is intended as presenting an overview. For precise description please consult USEPA (1997) or USEPA (2000).

3.8.3.3.3 Activity Data

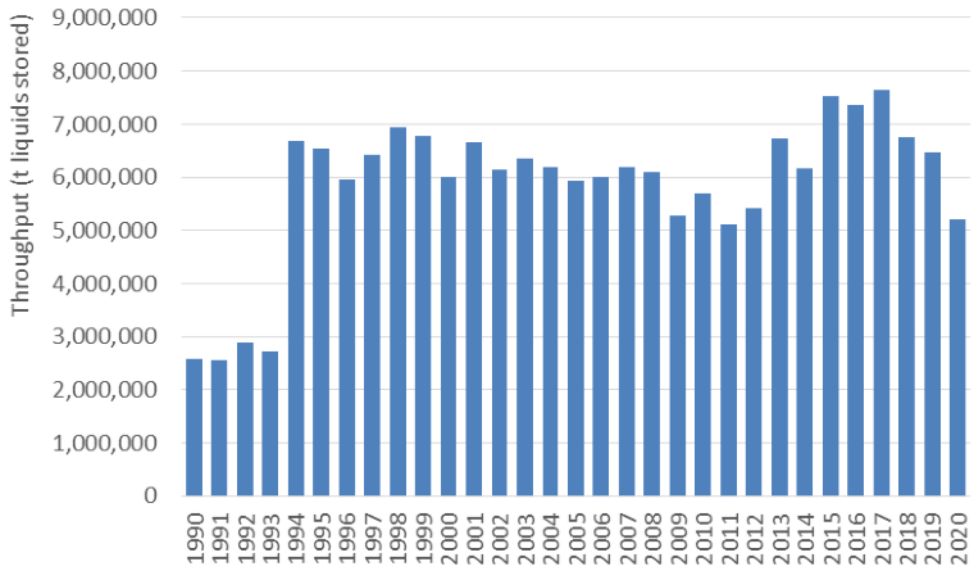


Figure 3-68: Throughput in depots

3.8.3.3.4 Recalculations

No recalculations were made.

3.8.3.3.5 Further Improvements

No further improvements are expected.

3.8.3.4 Service Stations

3.8.3.4.1 Methodology

According to National Ordinance No 646/97, 11th August, it is assumed that since 2005 it is used "bottom loading with vapour return" (Stage IB) for latter recovering (VRU) or destruction (VDU). Before 2005 it is not known the type of filling used and it is assumed that 50% of the service stations had vapour return and 50% hadn't the Stage IB in place.

Before 2005, emissions from Filling Underground Tanks (FUT) were estimated are based on the following:

$$E_{FUT} = V_{StageIB} \times TVP \times EF_{StageIB} + V_{other} \times TVP \times EF_{other}$$

Where:

E_{FUT}: Emissions Filling Underground Tanks (kg)

TVP: True Vapour Pressure (kPa)

$V_{StageIB}$: Gasoline throughput at Service Stations with Stage IB (m^3)

$EF_{StageIB}$: Emission Factor for FUT at Service Stations with Stage IB (kg/m^3/kPa TVP)

V_{ohter}: Gasoline throughput at Service Stations without Stage IB (m^3)

EF_{other}: Emission Factor for FUT at Service Stations without Stage IB (kg/m^3/kPa TVP)

Since 2005, the emissions estimates are based on:

$$E_{FUT} = V_{StageIB} \times EF_{StageIB}$$

Where:

E_{FUT}: Emissions Filling Underground Tanks (kg)

$V_{StageIB}$: Gasoline throughput at Service Stations with Stage IB (m^3)

$EF_{StageIB}$: Emission Factor for FUT at Service Stations with Stage IB (kg/m^3/Kpa TVP)

3.8.3.4.2 Emission Factors

Emission factors for "Filling Underground Tanks" were obtained from "Concawe – Air pollutant emission estimation methods for EPER and PRTR reporting by refineries (revised) – report no. 9/05R – Appendix 3 – Table A3.1".

Table 3-112: Filling Underground Tank (Stage I) NMVOC Emission Factors

Filling Underground Tank	Emission Factor (kg/m^3/kPa TVP)
Without Stage IB	$2.44E^{-02}$
With Stage IB	$1.1E^{-03}$

The NMVOC emission factor source for "Underground Tank Breathing and Emptying" is "Concawe – Air pollutant emission estimation methods for EPER and PRTR reporting by refineries (revised) – report no. 9/05R – Appendix 3 – Table A3.1" (=$3.30E^{-03}$ kg/m^3/kPa TVP).

Table 3-113: Vehicle Refuelling Operations (Stage II) NMVOC Emission Factors

Vehicle Refuelling Operations	Emission Factor (kg/m^3/kPa TVP)
Drips and Minor Spillage	$2.20E^{-03}$
Refuelling with no emission controls in operations (without Stage II measures)	$3.67E^{-02}$

3.8.3.4.3 Activity data

Data on gasoline sales was obtained from DGEG Energy Balance for the entire period.

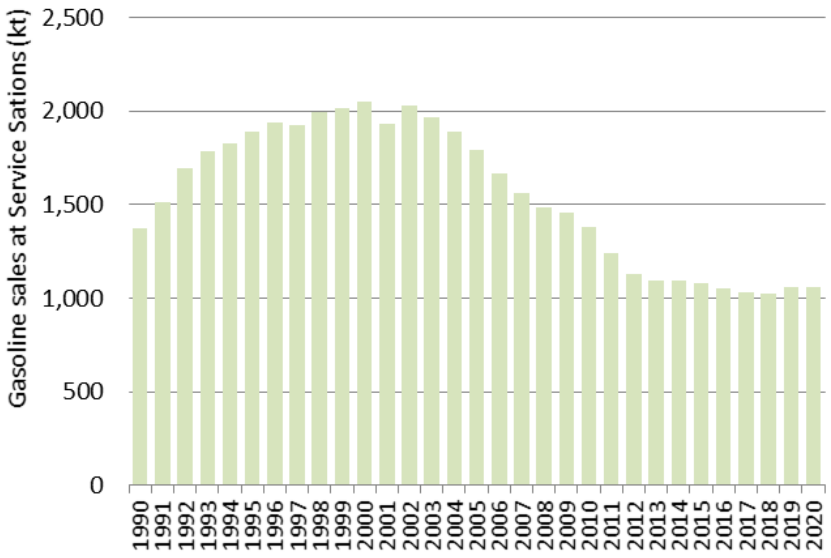


Figure 3-69: Fuel Sales at Service Stations

3.8.3.4.4 Recalculations

Data on gasoline sales was updated for 2019.

3.8.3.4.5 Further Improvements

Efforts should be addressed in order to verify stage II implementation in service stations in Portugal.

3.9 Fugitive Emissions from Natural Gas (NFR 1.B.2.b.)

3.9.1 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 became more widespread and its 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 occurs 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.

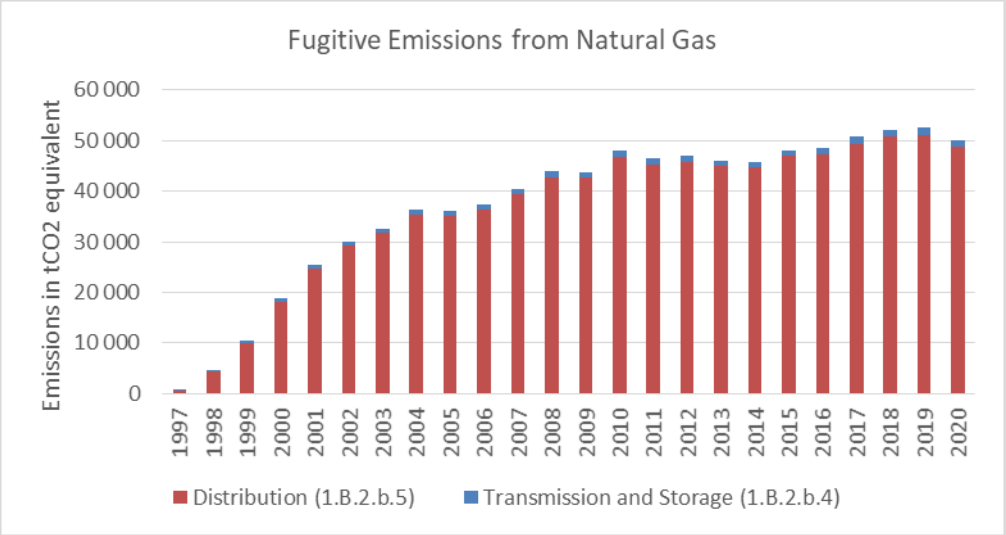


Figure 3-70: Fugitive Emissions from Natural Gas

3.9.2 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 NFR

1.B.2.b - Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other).

Losses of natural gas through leaks are estimated through adjustment factors published by ERSE - National regulatory body of the Natural Gas market. The NMVOC emissions are estimated taking into account the composition of Natural Gas imported by Portugal.

Transmission and Storage

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 NMVOC Fugitive Emissions = NG Transmission Network HP Leaks * % of NMVOC in National NG

Distribution

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 NMVOC Fugitive Emissions = NG Transmission Distribution Leaks * % of NMVOC in National NG

3.9.3 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.

Table 3-114: 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 3-115: Characteristics of natural gas

Pollutants	Unit	Value	Unit	Value
Methane	mole %	90.05	mass %	80.62
Ethane (COVNM)	mole %	6.45	mass %	10.82
Propane (COVNM)	mole %	1.74	mass %	4.29
i-butane (COVNM)	mole %	0.23	mass %	0.76
n-butane (COVNM)	mole %	0.27	mass %	0.87
i-pentane (COVNM)	mole %	0.02	mass %	0.08
n-pentane (COVNM)	mole %	0.01	mass %	0.04
n-hexane (COVNM)	mole %	0.01	mass %	0.05
Nitrogen	mole %	0.58	mass %	0.91
CO_2	mole %	0.63	mass %	1.55

3.9.4 Activity data

According to the above explained methodology, activity data comprehends:

- natural gas imports, obtained from the DGEG's Energy Balances;
- consumption of Natural Gas.

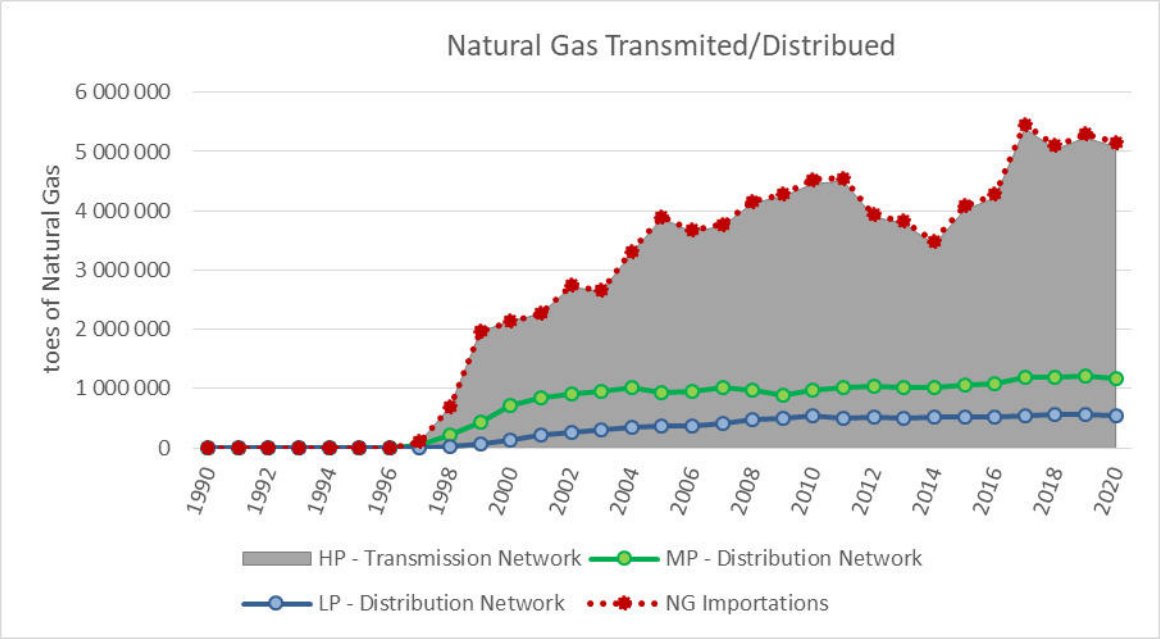


Figure 3-71: Natural Gas transported by High, Medium and Low Pressure Networks

3.9.5 Recalculations

There are no significant recalculations for this category.

3.9.6 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.

3.10 Venting and Flaring in Oil Industry (1.B.2.c)

3.10.1 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 and CO.

3.10.2 Methodology

Air emissions in flaring, resulting from combustion of gas collected from leaks and blowdown system, and were estimated either from the quantity of gas flared or total feed to refinery.

NMVOC emissions were estimated according to the following equation:

$$Emi_{(p,y)} = EF_{(p)} \times Flare_{GAS(y)} \times m_{(p,y)}/m_{(gas,y)} \times 10^{-3}$$

Where:

$Emi_{(p,y)}$: Emission of pollutant p in year y (t/yr)

$EF_{(p)}$: Emission factor (Kg/t gas)

$Flare_{GAS(y)}$: Quantity of gas flared in year y (t/yr)

$m_{(p,y)}/m_{(gas,y)}$: Mass fraction of pollutant p in year y.

CO and NO_x emissions were estimated according to the following equation:

$$Emi_{(p,y)} = EF_{(p)} \times Flare_{Gas(y)} \times NCV_{Gas} \times 10^{-3}$$

Where:

$Emi_{(p,y)}$: Emission of pollutant p in year y (t/yr)

$EF_{(p)}$: Emission factor of pollutant p (kg/GJ gas)

$Flare_{Gas(y)}$: Quantity of gas flared in year y (t/yr)

NCV_{Gas}: Net calorific value of the gas flared (GJ/t)

SO_x emissions are estimated according to the following equation:

$$Emi_{SOx} = EF_{SOx} \times S_{(m/m)} \times Flare_{GAS(y)} \times 10^{-3}$$

Where:

Emi_{SOx}: Emission of pollutant p in year y (t/yr)

EF_{SOx}: Emission factor (Kg/t gas)

$S_{(m/m)}$: Sulphur content of the gas flared (kg S/kg gas)

$Flare_{GAS(y)}$: Quantity of gas flared in year y (t/yr)

Heavy Metals, PAHs, TSP, PM_{10} and $PM_{2.5}$ emissions are estimated according to the following equation:

$$Emi_{(p,y)} = EF_{(p)} \times Flare_{Gas(y)} \times NCV_{Gas} \times 10^{-6}$$

Where:

$Emi_{(p,y)}$: Emission of pollutant p in year y (t/yr)

$EF_{(p)}$: Emission factor of pollutant p (g/GJ gas)

$Flare_{Gas(y)}$: Quantity of gas flared in year y (t/yr)

NCV_{Gas}: Net calorific value of the gas flared (GJ/t)

3.10.3 Emission Factors

Emission factors were set from "Concawe – Air pollutant emission estimation methods for E-PRTR reporting by refineries – report no. 4/17 (2017 Edition)" as presented in the next table. Sulphur content was obtained from the refineries.

Table 3-116: Emission Factors for flaring in refineries

Pollutant	EF Unit	EF	Source
NMVOC	kg/t gas	5	Chapter 13.2.1.1. (Flare Stream Details Known) of "Concawe - Air pollutant emission estimation methods for E-PRTR reporting by refineries – report no. 4/17 (2017 Edition)"
CO	kg/GJ gas	0.133	Chapter 8.2.2.1. (Flare Stream Details Known) of "Concawe - Air pollutant emission estimation methods for E-PRTR reporting by refineries – report no. 4/17 (2017 Edition)"
NO_x	kg/GJ gas	29.2×10^{-2}	Chapter 14.6.1.1. (Flare Stream Details Known) of "Concawe - Air pollutant emission estimation methods for E-PRTR reporting by refineries – report no. 4/17 (2017 Edition)"
SO_x	kg/t gas	2×10^{3}	Chapter 16.1 of "Concawe - Air pollutant emission estimation methods for E-PRTR reporting by refineries – report no. 4/17 (2017 Edition)"
As	g/GJ gas	3.52×10^{-4}	Chapters 18.2 and 18.1 of "Concawe - Air pollutant emission estimation methods for E-PRTR reporting by refineries – report no. 4/17 (2017 Edition)"
Cd	g/GJ gas	2.19×10^{-3}	Chapters 19.2 and 19.1 of "Concawe - Air pollutant emission estimation methods for E-PRTR reporting by refineries – report no. 4/17 (2017 Edition)"
Cr	g/GJ gas	6.69×10^{-3}	Chapters 20.2 and 20.1 of "Concawe - Air pollutant emission estimation methods for E-PRTR reporting by refineries – report no. 4/17 (2017 Edition)"
Cu	g/GJ gas	3.29×10^{-3}	Chapters 21.2 and 21.1 of "Concawe - Air pollutant emission estimation methods for E-PRTR reporting by refineries – report no. 4/17 (2017 Edition)"
Hg	g/GJ gas	3.72×10^{-4}	Chapters 22.2 and 22.1 of "Concawe - Air pollutant emission estimation methods for E-PRTR reporting by refineries – report no. 4/17 (2017 Edition)"
Ni	g/GJ gas	7.37×10^{-3}	Chapters 23.2 and 23.1 of "Concawe - Air pollutant emission estimation methods for E-PRTR reporting by refineries – report no. 4/17 (2017 Edition)"
Pb	g/GJ gas	1.61×10^{-3}	Chapters 24.2 and 24.1 of "Concawe - Air pollutant emission estimation methods for E-PRTR reporting by refineries – report no. 4/17 (2017 Edition)"
Zn	g/GJ gas	1.70×10^{-2}	Chapters 25.2 and 25.1 of "Concawe - Air pollutant emission estimation methods for E-PRTR reporting by refineries – report no. 4/17 (2017 Edition)"
Benzo(α)pyrene	g/GJ gas	6.688×10^{-7}	Chapters 28.2 and 28.1.2.2 of "Concawe - Air pollutant emission estimation methods for E-PRTR reporting by refineries – report no. 4/17 (2017 Edition)"
Benzo(β)fluoranthene	g/GJ gas	1.137×10^{-6}	Chapters 28.2 and 28.1.2.2 of "Concawe - Air pollutant emission estimation methods for E-PRTR reporting by refineries – report no. 4/17 (2017 Edition)"
Benzo(k)fluoranthene	g/GJ gas	6.306×10^{-7}	Chapters 28.2 and 28.1.2.2 of "Concawe - Air pollutant emission estimation methods for E-PRTR reporting by refineries – report no. 4/17 (2017 Edition)"
Indeno(1,2,3-cd)pyrene	g/GJ gas	6.306×10^{-7}	Chapters 28.2 and 28.1.2.2 of "Concawe - Air pollutant emission estimation methods for E-PRTR reporting by refineries – report no. 4/17 (2017 Edition)"
TSP[26]	g/GJ gas	8.90×10^{-1}	Chapters 30.2 and 30.1 of "Concawe - Air pollutant emission estimation methods for E-PRTR reporting by refineries – report no. 4/17 (2017 Edition)"
PM_{10}	g/GJ gas	8.90×10^{-1}	Chapters 30.2 and 30.1 of "Concawe - Air pollutant emission estimation methods for E-PRTR reporting by refineries – report no. 4/17 (2017 Edition)"
$PM_{2.5}$[27]	g/GJ gas	8.90×10^{-1}	Chapters 30.2 and 30.1 of "Concawe - Air pollutant emission estimation methods for E-PRTR reporting by refineries – report no. 4/17 (2017 Edition)"

[26] In Concawe there is only the emission factor for PM10. We assume that TSP=PM_{10}=$PM_{2.5}$.

[27] In Concawe there is only the emission factor for PM10. We assume that TSP=PM_{10}=$PM_{2.5}$.

3.10.4 Activity data

For the period 1990-2004, total flare gas consumed in the three units and Low Heating Value was made available from PETROGAL. From 2005 onwards, data is obtained from EU-ETS.

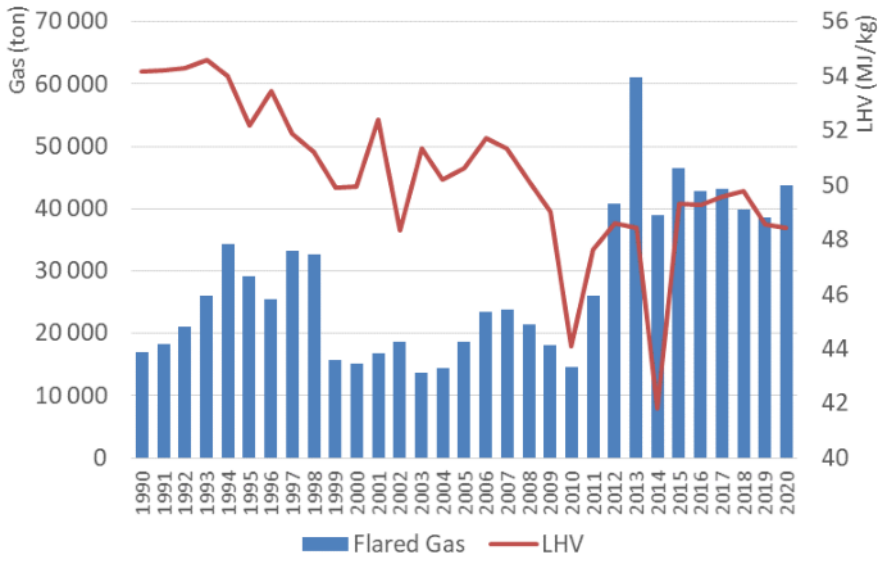


Figure 3-72: Total consumption of flare gas in Portuguese refineries and Low Heating Value

3.10.5 Recalculations

No recalculations were made.

3.10.6 Further Improvements

No further improvements are expected for this sector.

4 Industrial Processes and Product Use (NFR Sector 2)

Table of Contents

4 Industrial Processes and Product Use (NFR Sector 2) 4-1

4.1 Overview of the sector 4-12

4.2 Mineral Industry (NFR 2.A) 4-15

4.2.1 Cement Production (NFR 2.A.1) 4-15

4.2.2 Lime Production in dedicated plants (NFR 2.A.2) 4-17

4.2.3 Lime Production in Iron and Steel (CRF 2.A.2) 4-21

4.2.4 Glass Production (NFR 2.A.3) 4-24

4.2.5 Glass Wool Production (NFR 2.A.3) 4-27

4.2.6 Quarrying and mining of minerals other than coal (NFR 2.A.5.a) 4-29

4.2.7 Construction and Demolition (NFR 2.A.5.b) 4-31

4.2.8 Storage, handling and transport of mineral products (NFR 2.A.5.c) 4-35

4.3 Chemical Industry (NFR 2.B) 4-37

4.3.1 Ammonia Production (NFR 2.B.1 – SNAP 040403) 4-37

4.3.2 Nitric Acid Production (NFR 2.B.2 – SNAP 040402) 4-39

4.3.3 Adipic Acid Production (NFR 2.B.3 – SNAP 040521) 4-40

4.3.4 Calcium Carbide Production (NFR 2.B.5 – SNAP 040412) 4-40

4.3.5 Titanium Dioxide Production (NFR 2.B.6 – SNAP 040410) 4-40

4.3.6 Other Chemical Industry - Sulphuric Acid Production (NFR 2.B.10.a – SNAP 040401) 4-43

4.3.7 Other Chemical Industry - Ammonium Sulphate Production (NFR 2.B.10.a – SNAP 040404) 4-45

4.3.8 Other Chemical Industry - Explosives Manufacturing (NFR 2.B.10.a – SNAP 040622) 4-47

4.3.9 Other Chemical Industry - Ammonium Nitrate Production (NFR 2.B.10.a – SNAP 040405) .. 4-48

4.3.10 Other Chemical Industry - Ammonium Phosphates Production (NFR 2.B.10.a – SNAP 040406) 4-50

4.3.11 Other Chemical Industry - NPK Fertilisers Production (NFR 2.B.10.a – SNAP 040407) 4-51

4.3.12 Other Chemical Industry - Urea Production (NFR 2.B.10.a – SNAP 040408) 4-53
4.3.13 Other Chemical Industry - Carbon Black Production (NFR 2.B.10.a – SNAP 040409) 4-55
4.3.14 Other Chemical Industry - Graphite Production (NFR 2.B.10.a – SNAP 040411) 4-56
4.3.15 Other Chemical Industry - Chlorine Production (NFR 2.B.10.a – SNAP 040413) 4-56
4.3.16 Other Chemical Industry - Phosphate Fertilisers Production (NFR 2.B.10.a – SNAP 040414) 4-56
4.3.17 Other Chemical Industry - Ethylene Production (NFR 2.B.10.a – SNAP 040501) 4-57
4.3.18 Other Chemical Industry - 1,2-Dichloroethane + Vinylchloride Production (balanced process) (NFR 2.B.10.a – SNAP 040505) 4-59
4.3.19 Other Chemical Industry - Polyethylene Low Density Production (NFR 2.B.10.a – SNAP 040506) 4-60
4.3.20 Other Chemical Industry - Polyethylene High Density Production (NFR 2.B.10.a – SNAP 040507) 4-62
4.3.21 Other Chemical Industry - Polypropylene Production (NFR 2.B.10.a – SNAP 040509) 4-63
4.3.22 Other Chemical Industry - Polystyrene Production (NFR 2.B.10.a – SNAP 040511) 4-64
4.3.23 Other Chemical Industry - Formaldehyde Production (NFR 2.B.10.a – SNAP 040517) 4-66
4.3.24 Other Chemical Industry - Phthalic Anhydride Production (NFR 2.B.10.a – SNAP 040519) 4-67
4.4 Metal Industry (NFR 2.C) 4-69
4.4.1 Iron and Steel Production (NFR 2.C.1) 4-69
4.4.2 Ferroalloys Production (NFR 2.C.2 – SNAP 040302) 4-78
4.4.3 Aluminium Production (NFR 2.C.3 – SNAP 040301; 030310) 4-78
4.4.4 Magnesium Production (NFR 2.C.4) 4-81
4.4.5 Lead Production (NFR 2.C.5 – SNAP 040309b) 4-81
4.4.6 Zinc Production (NFR 2.C.6 – SNAP 040309c) 4-83
4.4.7 Copper Production (NFR 2.C.7.a – SNAP 040309a) 4-83
4.4.8 Nickel Production (NFR 2.C.7.b – SNAP 040305) 4-86
4.4.9 Other Metal Production (NFR 2.C.7.c – SNAP 040309z) 4-86
4.4.10 Storage, Handling and Transport of Metal Products (NFR 2.C.7.d – SNAP 041000) 4-86
4.5 Solvent and other Product Use (2.D.3.a – 2.D.3.h) 4-88
4.5.1 Domestic solvent use including fungicides (NFR 2.D.3.a – SNAP 060408; 060411) 4-88
4.5.2 Road Paving with Asphalt (NFR 2.D.3.b – SNAP 040611) 4-93
4.5.3 Asphalt Roofing (NFR 2.D.3.c – SNAP 040610) 4-97
4.5.4 Coating applications - Manufacture of automobiles (NFR 2.D.3.d - SNAP 060101) 4-99
4.5.5 Coating applications - Car Repairing (NFR 2.D.3.d - SNAP 060102) 4-101

4.5.6 Coating applications - Construction and buildings (NFR 2.D.3.d - SNAP 060103) 4-103
4.5.7 Coating applications - Domestic Use (NFR 2.D.3.d - SNAP 060104) 4-105
4.5.8 Coating applications - Coil Coating (NFR 2.D.3.d - SNAP 060105) 4-106
4.5.9 Coating applications - Boat Building (NFR 2.D.3.d - SNAP 060106) 4-108
4.5.10 Coating applications - Wood (NFR 2.D.3.d - SNAP 060107) 4-108
4.5.11 Coating applications - Truck/Van coating (NFR 2.D.3.d - SNAP 060108) 4-110
4.5.12 Coating applications - Truck cabin coating (NFR 2.D.3.d - SNAP 060108) 4-111
4.5.13 Coating applications - Bus coating (NFR 2.D.3.d - SNAP 060108) 4-113
4.5.14 Coating applications - Wire coating (NFR 2.D.3.d - SNAP 060108) 4-114
4.5.15 Coating applications - Leather finishing (NFR 2.D.3.d - SNAP 060108) 4-114
4.5.16 Coating applications - Other Industrial Applications (NFR 2.D.3.d - SNAP 060108) 4-115
4.5.17 Degreasing (NFR 2.D.3.e – SNAP 060201; 060203; 060204) 4-117
4.5.18 Dry cleaning (NFR 2.D.3.f – SNAP 060202) 4-121
4.5.19 Chemical Products - Polyester processing (NFR 2.D.3.g - SNAP 060301) 4-123
4.5.20 Chemical Products - Polyvinylchloride processing (NFR 2.D.3.g - SNAP 060302) 4-124
4.5.21 Chemical Products - Polyurethane foam processing (NFR 2.D.3.g - SNAP 060303) 4-126
4.5.22 Chemical Products - Polystyrene foam processing (NFR 2.D.3.g - SNAP 060304) 4-127
4.5.23 Chemical Products - Rubber processing (NFR 2.D.3.g - SNAP 060305) 4-128
4.5.24 Chemical Products - Pharmaceutical Products Manufacturing (NFR 2.D.3.g – SNAP 060306)4-130
4.5.25 Chemical Products - Paints, Inks and Glues Manufacturing (NFR 2.D.3.g - SNAP 060307; 060308; 060309) 4-131
4.5.26 Chemical Products - Asphalt Blowing (NFR 2.D.3.g – SNAP 060310) 4-134
4.5.27 Chemical Products - Adhesive, Magnetic Tapes, Films and Photographs Manufacturing (NFR 2.D.3.g – SNAP 060311) 4-135
4.5.28 Chemical Products - Manufacture of Shoes (NFR 2.D.3.g) 4-137
4.5.29 Chemical Products - Leather Tanning (NFR 2.D.3.g - SNAP 060313) 4-138
4.5.30 Chemical Products - Tyre Production (NFR 2.D.3.g - SNAP 060314) 4-140
4.5.31 Printing Industry (NFR 2.D.3.h – SNAP 060403) 4-141
4.6 Other Solvent and other Product Use (2.D.3.i – 2.G) 4-148
4.6.1 Glass Wool Induction (NFR 2.D.3.i – SNAP 060401) 4-148
4.6.2 Mineral Wool Induction (NFR 2.D.3.i – SNAP 060402) 4-148
4.6.3 Fat, Edible and Non-Edible Oil Extraction (NFR 2.D.3.i – SNAP 060404) 4-149
4.6.4 Application of glues and adhesives (NFR 2.D.3.i – SNAP 060405) 4-151

4.6.5 Preservation of Wood (NFR 2.D.3.i – SNAP 060406) 4-153
4.6.6 Underseal Treatment and Conservation of Vehicles (NFR 2.D.3.i – SNAP 060407) 4-156
4.6.7 Vehicles Dewaxing (NFR 2.D.3.i – SNAP 060409) 4-157
4.6.8 Use of Fireworks (NFR 2.G – SNAP 060601) 4-159
4.6.9 Use of Tobacco (NFR 2.G – SNAP 060602) 4-161
4.6.10 Use of Shoes (NFR 2.G - SNAP 060603) 4-164
4.6.11 Lubricants consumption (NFR 2.G – SNAP 060604) 4-166
4.7 Other Industry Production (2.H) 4-168
4.7.1 Wood Chipboard Production (NFR 2.H.1 – SNAP 040601) 4-168
4.7.2 Paper pulp production (NFR 2.H.1 – SNAP 040602; 040603; 040604) 4-169
4.7.3 Food Manufacturing (NFR 2.H.2 – SNAP 040605; 040625; 040626; 040627) 4-170
4.7.4 Drink Manufacturing (NFR 2.H.2 – SNAP 040606; 040607; 040608) 4-173
4.7.5 Wood Processing (2.I – SNAP 040620) 4-181
4.7.6 Consumption of persistent organic pollutants and heavy metals (NFR 2.K – SNAP 060502; 060504; 060507) 4-183

List of Figures

Figure 4-1: Total clinker production in Portugal 4-16
Figure 4-2: Clinker production data – comparison of approaches 4-17
Figure 4-3: Lime production from different sources 4-19
Figure 4-4: Lime production 4-20
Figure 4-5: Lime production in dedicated plants – comparison of approaches 4-20
Figure 4-6: Lime production and steel production from BOF in Iron and Steel 4-23
Figure 4-7: Lime production in Iron and Steel 4-23
Figure 4-8: Glass production 4-26
Figure 4-9: Cullet incorporation by type of glass 4-26
Figure 4-10: Gross Domestic Product and Extractive Industry Gross Value Added 4-30
Figure 4-11: Quarrying and mining of minerals other than coal 4-30
Figure 4-12: Houses/apartments construction 4-33
Figure 4-13: Non-residential construction 4-33
Figure 4-14: Roads construction 4-34
Figure 4-15: Mineral products stored, handled and transported 4-36
Figure 4-16: Trend in Ammonia production 4-38

Figure 4-17: Trend in Nitric Acid production 4-40
Figure 4-18: Titanium Dioxide Production 4-42
Figure 4-19: Trend in total sulphuric acid production, including sulphur recovery 4-44
Figure 4-20: Ammonium Sulphate production (Index 1990=100%) 4-46
Figure 4-21: Explosives production 4-47
Figure 4-22: Ammonium Nitrate production (1990=100%) 4-49
Figure 4-23: Ammonium Phosphates (Index 1990=100%) 4-51
Figure 4-24: NPK Fertilisers production (Index 1990=100%) 4-52
Figure 4-25: Trend in Urea production 4-54
Figure 4-26: Carbon Black production 4-56
Figure 4-27: Trend in Ethylene production 4-58
Figure 4-28: Ethylene production data – comparison of approaches 4-58
Figure 4-29: VCM production 4-60
Figure 4-30: Polyethylene Low-Density (PELD) trend (1990=100%) 4-61
Figure 4-31: Polyethylene High-Density (PEHD) trend (1990=100%) 4-62
Figure 4-32: Polypropylene trend (1990=100%) 4-64
Figure 4-33: Polystyrene trend (1990=100%) 4-65
Figure 4-34: Formaldehyde trend (1990=100%) 4-66
Figure 4-35: Phthalic Anhydride production trend (1990=100%) 4-68
Figure 4-36: Integrated iron and steel facility – production of steel and intermediate products (1990-2001) 4-76
Figure 4-37: Steel production by process 4-77
Figure 4-38: Crude steel production in Portugal – comparison of approaches 4-78
Figure 4-39: Secondary Aluminium production (Index 1990=100%) 4-80
Figure 4-40: Secondary Lead production data (Index 1990=100%) 4-83
Figure 4-41: Secondary Copper production (Index 1990=100%) 4-85
Figure 4-42: Metal products handled (Index 1990=100%) 4-87
Figure 4-43: Iberian Peninsula 2.D.3.a total solvent VOC emissions (Source: ESIG inventory) 4-90
Figure 4-44: Total corrected Iberian Peninsula 2.D.3.a solvent VOC emissions 4-91
Figure 4-45: Implied NMVOC emission factor 4-92
Figure 4-46: Portuguese population 4-92
Figure 4-47: Asphalt in road paving, by type 4-95

Figure 4-48: Total consumption of bitumen in the construction sector according to sales from DGEG Energy Balance and sum of values of asphalt used according to the inventory 4-96
Figure 4-49: Main recalculations in road paving sector 4-97
Figure 4-50: Asphalt roofing materials production, imports, exports and apparent consumption 4-99
Figure 4-51: Number of cars manufactured 4-100
Figure 4-52: Paint production for car repairing 4-102
Figure 4-53: Paint production for construction and buildings 4-104
Figure 4-54: Paints consumption in domestic use 4-106
Figure 4-55: Coil coatings application 4-108
Figure 4-56: Primers, enamels and varnishes use in wood 4-110
Figure 4-57: Number of vehicles manufactured 4-111
Figure 4-58: Number of truck cabins manufactured 4-112
Figure 4-59: Number of public transportation vehicles manufactured 4-113
Figure 4-60: Leather production 4-115
Figure 4-61: Paint applied in Other Industrial Applications 4-116
Figure 4-62: Degreasing substances consumption – total territory 4-119
Figure 4-63: Recalculations in NMVOC for degreasing – 2.D.3.e sector and national total NMVOC emissions 4-120
Figure 4-64: Annual consumption of PER – total territory 4-122
Figure 4-65: Polyester production 4-124
Figure 4-66: PVC production 4-125
Figure 4-67: Polyurethane Production (Index 1990=100) 4-126
Figure 4-68: Polystyrene Foam Production (Index 1990=100) 4-128
Figure 4-69: Rubber processed – total territory 4-129
Figure 4-70: Pharmaceutical products produced – total territory 4-130
Figure 4-71: Paints Manufacturing – total territory 4-132
Figure 4-72: Inks manufacturing – total territory 4-133
Figure 4-73: Glues Manufacturing – total territory 4-133
Figure 4-74: Asphalt produced in the Asphalt Blowing Units (Index related to 1990 value) 4-135
Figure 4-75: Adhesive, magnetic tapes, films and photographs production 4-136
Figure 4-76: Shoes Manufactured – total territory 4-137
Figure 4-77: Shoes Manufactured – comparison of approaches 4-138
Figure 4-78: Leather production – total territory 4-139

Figure 4-79: Tyre Production – Total territory 4-141
Figure 4-80: Abated NMVOC emissions by printing technology 4-145
Figure 4-81: Apparent ink consumption in Portugal 4-145
Figure 4-82: Share of ink consumption by printing technology 4-146
Figure 4-83: Recalculations in activity data for the printing sector 4-147
Figure 4-84: Recalculations in NMVOC for printing – 2.D.3.h sector and national total NMVOC emissions... 4-147
Figure 4-85: Mineral Wool produced 4-149
Figure 4-86: Seeds/grains consumption 4-150
Figure 4-87: Glues and adhesives apparent consumption 4-152
Figure 4-88: Wood Preservative applied by type – total territory 4-156
Figure 4-89: Annual vehicles sales – Total Territory 4-158
Figure 4-90: Use of Fireworks (Apparent Consumption) 4-160
Figure 4-91: Tobacco apparent consumption – Total territory 4-163
Figure 4-92: Apparent consumption of shoes (x1000 pairs of shoes) – Total territory 4-165
Figure 4-93: Lubricants consumption in engines other than two-stroke 4-167
Figure 4-94: Total production of paper pulp 4-170
Figure 4-95: Food manufacturing by food product – Total territory 4-172
Figure 4-96: Barley Malting 4-178
Figure 4-97: Hop Processing 4-178
Figure 4-98: Fermentation, Casking and Maturation 4-178
Figure 4-99: Red Wine 4-179
Figure 4-100: White Wine 4-179
Figure 4-101: Beer 4-179
Figure 4-102: Spirits 4-180
Figure 4-103: Wood Processing (t wood products processed) 4-181
Figure 4-104: PCB contaminated fluid leaks 4-184

List of Tables

Table 4-1: Total Main Pollutants and PM2.5 emissions from IPPU sector 4-12
Table 4-2: Emission Factors for Cement Production 4-16
Table 4-3: Emission Factors for lime production in dedicated plants 4-19
Table 4-4: Emission Factors for lime production in Iron and Steel 4-22

Table 4-5: Emission Factors considered 4-25
Table 4-6: Emission Factors considered 4-27
Table 4-7: Abatement efficiencies considered 4-28
Table 4-8: Recalculations in glass wool production emissions for 2019 4-28
Table 4-9: Emission Factors 4-29
Table 4-10: Emission Factors 4-32
Table 4-11: Affected Area (m^2) 4-32
Table 4-12: Duration of construction (year) 4-32
Table 4-13: Control Efficiency 4-32
Table 4-14: Emission Factors considered 4-35
Table 4-15: Emission Factors 4-38
Table 4-16: Default emission factor 4-42
Table 4-17: Emission factors 4-46
Table 4-18: Emission factors 4-47
Table 4-19: Solids formation operations 4-48
Table 4-20: Neutralizer and Evaporator 4-49
Table 4-21: Emission factors 4-50
Table 4-22: Emission factors 4-52
Table 4-23: Emission factors 4-54
Table 4-24: Emission Factors for Carbon Black process emissions 4-55
Table 4-25: Emission factor 4-57
Table 4-26: Emission factor 4-59
Table 4-27: Emission factors 4-61
Table 4-28: Emission factors 4-62
Table 4-29: Emission factors 4-63
Table 4-30: Emission factors 4-65
Table 4-31: Emission factors 4-66
Table 4-32: Emission factors 4-67
Table 4-33: Emission streams for iron and steel industry 4-72
Table 4-34: Sinter and pig iron production emission factors in the period 1990-2001 4-73
Table 4-35: Basic Oxygen Furnace and Electric Arc Furnace emission factors 4-74
Table 4-36: Pot oven and rolling mills emission factors 4-74
Table 4-37: Emission factors 4-80

Table 4-38: Abatement technologies efficiencies 4-80
Table 4-39: Emission factors 4-82
Table 4-40: Abatement technologies efficiencies 4-82
Table 4-41: Emission factors 4-85
Table 4-42: Abatement technologies efficiencies 4-85
Table 4-43: Emission factors 4-87
Table 4-44: Mapping table: REACH to NFR (2.D.3.a - Domestic solvent use including fungicides) 4-89
Table 4-45: Correction factors for solvent VOC emissions 4-90
Table 4-46: Tier 1 Hg emission factor 4-92
Table 4-47: Emission factors for road paving with asphalt 4-95
Table 4-48: Emission Factors 4-98
Table 4-49: Default emission factor 4-100
Table 4-50: Abatement technology 4-100
Table 4-51: % Efficiency of the abatement technology mix 4-100
Table 4-52: Final emission factor 4-100
Table 4-53: Default emission factor 4-101
Table 4-54: Abatement technology 4-101
Table 4-55: % Efficiency of the abatement technology mix 4-102
Table 4-56: Final emission factor 4-102
Table 4-57: Default emission factor 4-103
Table 4-58: Abatement technology 4-103
Table 4-59: Share of each abatement technology over time 4-104
Table 4-60: Final emission factor 4-104
Table 4-61: Default emission factor 4-105
Table 4-62: Abatement technology 4-105
Table 4-63: Share of each abatement technology over time 4-105
Table 4-64: Final emission factor 4-105
Table 4-65: Default emission factor 4-107
Table 4-66: Abatement technology efficiency 4-107
Table 4-67: Share of each abatement technology over time 4-107
Table 4-68: Final emission factor 4-107
Table 4-69: Default emission factor 4-109
Table 4-70: Abatement technology 4-109

Table 4-71: Share of each abatement technology over time 4-109
Table 4-72: Final emission factor 4-109
Table 4-73: Default emission factor 4-111
Table 4-74: Default emission factor 4-112
Table 4-75: Default emission factor 4-113
Table 4-76: Default emission factor 4-114
Table 4-77: Abatement technology 4-114
Table 4-78: Control strategy 4-115
Table 4-79: Final emission factor 4-115
Table 4-80: Default emission factor (Tier 1) 4-116
Table 4-81: Mapping table: REACH to NFR (2.D.3.e - Degreasing) 4-118
Table 4-82: Emission Factors 4-122
Table 4-83: % of Open Circuit and Closed Circuit equipments 4-122
Table 4-84: NMVOC polyester processing emission factor 4-123
Table 4-85: Emission factors 4-125
Table 4-86: NMVOC foam processing emission factor 4-126
Table 4-87: NMVOC foam processing emission factor 4-127
Table 4-88: NMVOC rubber processing emission factor 4-129
Table 4-89: NMVOC pharmaceutical products manufacturing emission factor 4-130
Table 4-90: Emission Factors 4-132
Table 4-91: NMVOC Abatement technology (Source: EMEP/EEA, 2019) 4-132
Table 4-92: NMVOC Control strategy (Source: IIASA, 2009) 4-132
Table 4-93: NMVOC final emission factor 4-132
Table 4-94: Emission Factors for Asphalt Blowing 4-134
Table 4-95: Emission factors 4-136
Table 4-96: Emission Factors 4-137
Table 4-97: Mass vs area leather conversion factor 4-139
Table 4-98: Emission Factor 4-139
Table 4-99: NMVOC default emission factor 4-140
Table 4-100: Tyre weight by vehicle type 4-140
Table 4-101: NMVOC emission factors for printing industry, by technology 4-143
Table 4-102: NMVOC abatement techniques considered for printing industry, by technology 4-144
Table 4-103: Default emission factor 4-149

Table 4-104: Default emission factors 4-150
Table 4-105: NMVOC default emission factor 4-152
Table 4-106: NMVOC abatement efficiencies 4-152
Table 4-107: Share of NMVOC Abatement Technologies 4-152
Table 4-108: Share of each type of wood preservative 4-154
Table 4-109: Amount of wood preservative (kg) used per m^3 of wood preserved 4-154
Table 4-110: Tier 2 emission factors 4-155
Table 4-111: Waterborne Preservative Abatement Technologies Efficiencies 4-155
Table 4-112: Creosote Preservative Abatement Technologies Efficiencies 4-155
Table 4-113: Creosote Preservative Abatement Technologies Efficiencies 4-155
Table 4-114: Default emission factor 4-157
Table 4-115: Default emission factor 4-158
Table 4-116: Default emission factors 4-160
Table 4-117: Default emission factors 4-163
Table 4-118: Default emission factor 4-165
Table 4-119: Efficiency of abatement technologies 4-165
Table 4-120: Wood Chipboard Production 4-168
Table 4-121: Emission Factors for paper pulp production (non-combustion) 4-169
Table 4-122: Emission Factors for food industry 4-172
Table 4-123: NMVOC emission Factors for drink industry 4-177
Table 4-124: Emission Factor for Wood Processing 4-181
Table 4-125: Emission Factors 4-184

4 Industrial Processes and Product Use (NFR Sector 2)

Rita Silva

Updated: March 2022

4.1 Overview of the sector

Industrial Processes and Product Use (IPPU) sector generates air pollutants from the chemical and physical transformation of raw materials in the industrial transformation processes, excluding emissions that result from combustion processes aiming for energy production[1]. Air pollutants also result from product use, like domestic solvent use, tobacco use or vehicles dewaxing.

Industrial processes, either involving combustion or not, may result in the release of acidifying gases NO_x, NMVOC and SO_x. This sector is also a relevant source of particulate matter (TSP, PM_{10}, $PM_{2.5}$ and PM_1) and local air pollutants such CO and Heavy Metals.

The table below presents total main pollutants and $PM_{2.5}$ emissions from IPPU, for Portugal Mainland (without the Island of Azores and Madeira, for NECD compliance) and for the whole Portuguese territory (for CLRTAP compliance).

Table 4-1: Total Main Pollutants and PM2.5 emissions from IPPU sector

Source /Gas	1990	2005	2018	2019	2020	Δ 2020-2019	Δ 2020-2005	Δ 2020-1990	Importance in total emissions from PT in 2020
	Kt					%			%
NOx									
Portugal	3.18	4.79	5.90	5.83	5.77	-1.0%	20.5%	81.3%	4.3%
Mainland	3.18	4.79	5.90	5.83	5.77	-1.0%	20.5%	81.2%	5.1%
NMVOC									
Portugal	83.69	92.01	71.84	74.33	89.42	20.3%	-2.8%	6.8%	56.0%
Mainland	80.26	88.59	69.11	71.65	85.88	19.9%	-3.1%	7.0%	62.2%
SOx									
Portugal	12.61	12.55	5.74	5.50	5.23	-4.9%	-58.3%	-58.5%	13.7%
Mainland	12.61	12.55	5.74	5.50	5.23	-4.9%	-58.3%	-58.5%	19.2%
NH3									
Portugal	5.46	5.52	3.20	3.44	3.82	10.9%	-30.8%	-30.0%	6.0%
Mainland	5.46	5.51	3.20	3.44	3.81	10.9%	-30.8%	-30.1%	6.8%
PM2.5									
Portugal	12.07	14.71	13.64	13.86	14.65	5.7%	-0.4%	21.4%	31.0%
Mainland	12.01	14.62	13.58	13.80	14.58	5.7%	-0.2%	21.4%	31.6%

The majority of air pollutants in IPPU sector is released as NMVOC and particulate matter.

[1] Emissions of 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.

The year of 2020 was globally marked by the strong negative impact of the COVID-19 pandemic on national economy, which led to a strong contraction in the vast majority of the economic activity branches, leading in some cases to almost total paralysis. The impact was also significantly negative in manufacturing industries, especially petroleum products, vehicle manufacturing and, less expressively, food industries. Gas and marine diesel kept presenting the highest value of sales, followed by Other parts and accessories for motor vehicles, tractors and vehicles for special uses (Source: National Statistics - "Industrial Production Statistics 2020").

Recalculations

2.A.2 (Lime production in Iron and Steel): 1990-2009 and 2018-2019 lime production data were revised;

2.A.3 (Glass Wool production): abatement techniques were introduced in glass wool production's estimates; activity data was reported in NFR 2.A.3 for the first time (due to a compilation error, it was not being reported);

2.A.5.a (Quarrying and mining of minerals other than coal 2019): 2019 activity data was updated;

2.A.5.b (Construction and Demolition): 2019 activity data was updated;

2.B.1 (Ammonia Production): emission factors were updated to a Tier 2 (Partial Oxidation process) based on 2019 EMEP Guidebook for 1990-2008;

2.B.6 (Titanium Dioxide Production): 2019 activity data was updated;

2.B.8 (Petrochemical and Carbon Black Production): 2019 activity data was updated for minor categories;

2.B.10.a (Chemical Industry): 2019 activity data was updated for minor categories;;

2.C.1 (Iron and Steel Production): PAH emissions from Pig Iron production in the Blast furnace were reported for this first time for 1990-2001, following a compilation error;

2.D.3.a (Domestic Solvent Use): 2018-2019 activity data were updated according to ESIG;

2.D.3.b (Road Paving with asphalt): activity data was corrected for the whole time series, due to a compilation error; emission factors were updated to a Tier 2 based on 2019 EMEP Guidebook for the whole time series; BC emissions were estimated for the first time for the whole time series;

2.D.3.c (Asphalt Roofing): 2014-2019 data on sold production were updated according to EUROSTAT database;

2.D.3.d (Coating Applications - Paint Aplication for Domestic Use): Activity data in 2002-2003 and 2011-2019 were updated, due to a compilation error;

2.D.3.d (Coating Applications – Other Industrial Paint aplications): 2019 data was updated;

2.D.3.e (Degreasing): methodological revision of the sector for the whole time series;

2.D.3.g (Chemical Products – Glues Manufacturing): Activity data in 1991-2019 were updated, due to a compilation error;

2.D.3.g (Chemical Products - Adhesives, Magnetic Tapes, Films and Photographs Manufacturing): 2019 activity data was updated;

2.D.3.g (Chemical Products – Shoes Manufacturing): Activity data in 2012-2019 were updated;

2.D.3.h (Printing): methodological revision of the sector for the whole time series;

2.D.3.i (Glass Wool Induction): NMVOC emissions were removed for the whole time series, due to double counting with NMVOC emissions from Glass Wool production NFR 2.A.3;

2.D.3.i (Preservation of Wood): 2019 data was updated;

2.D.3.i (Lubricants consumption): Two-stroke engines lubricants consumption data were updated for 1994-2019;

2.H.2 (Food Manufacturing): TSP, $PM_{2.5}$ and BC estimates were updated to NE for the whole time series according to a 2021 NECD Review recomendation;

Several minor sub-categories: Update on surrogate data such as Gross Domestic Product (GDP) and Gross Value Added (GVA) for 2019.

4.2 Mineral Industry (NFR 2.A)

4.2.1 Cement Production (NFR 2.A.1)

4.2.1.1 Category description

There are six cement production plants operating in Portugal, mostly dedicated to Portland cement production[2] and almost all localized in the south 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[3].

Although emissions may result from both fuel and raw material, they are reported in the Energy sector (CRF 1.A.2.f) for simplicity sake.

4.2.1.2 Methodology

For all pollutants except black carbon, the methodology applied for emissions estimates is:

Equation 4-1: Emissions from clinker production for all pollutants except black carbon

$$Emi = AD \times EF \times 10^{-3}$$

Where:

Emi: Total emission of each pollutant (t)

AD: Clinker Production (t)

EF: Emission Factor of each pollutant (kg/t of clinker)

For black carbon, there are emission factors by fuel type (solid, liquid, gaseous, biomass). We use a weighted BC emission factor based on the annual percentage of consumption of each type of fuel. The methodology used is:

Equation 4-2: Black carbon emissions from clinker production

$$Emi_{BC} = \%\ Fuel_y \times E_{PM2.5} \times EF_y$$

Where:

Emi_{BC}: Total emission of black carbon (t) related to fuel y (liquid, solid, gaseous, biomass)

$\%\ Fuel_y$: Fuel (%) y (liquid, solid, gaseous, biomass)

$E_{PM2.5}$: Emissions of $PM_{2.5}$ (t)

EF_y: Emission Factor (kg/t of clinker) related to fuel y (liquid, solid, gaseous, biomass)

[2] 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. There are also in Portugal smaller additional cement plants but that do not produce clinker.

[3] One calciner is a false pre-calciner.

4.2.1.3 Emission Factors

The emission factors applied are listed in the table below:

Table 4-2: Emission Factors for Cement Production

Pollutant	Unit	Emission Factor	Source
SOx	kg/t clinker	[0.050 – 4.100]	Plant Specific (Monitoring Data)
NOx	kg/t clinker	[1.106 – 3.700]	Plant Specific (Monitoring Data)
NMVOC	kg/t clinker	[0.007 – 0.098]	Plant Specific (Monitoring Data)
NH3	kg/t clinker	[0.005 – 1.041]	Plant Specific (Monitoring Data)
PM2.5	kg/t clinker	[0.014 – 0.309]	Plant Specific (Monitoring Data)
PM10	kg/t clinker	[0.014 – 0.309]	Plant Specific (Monitoring Data)
TSP	kg/t clinker	[0.014 – 0.309]	Plant Specific (Monitoring Data)
BC	% of $PM_{2.5}$	[1.6 – 19.6]	Tables 3-2 to 3-7 Chapter 1.A.1 2019 EMEP Guidebook
CO	kg/t clinker	[0.06 – 1.80]]	Plant Specific (Monitoring Data)
Pb	kg/t clinker	[$3.00x10^{-5}$ – $1.51x10^{-3}$]	Plant Specific (Monitoring Data)
Cd	kg/t clinker	0.008	Table 3-24 of Chapter 1.A.2 of 2019 EMEP Guidebook
Hg	kg/t clinker	[$1.87x10^{-6}$ – $2.52x10^{-5}$]	Plant Specific (Monitoring Data)
As	kg/t clinker	[$2.24x10^{-7}$ – $5.57x10^{-4}$]	Plant Specific (Monitoring Data)
Cr	kg/t clinker	[$1.49x10^{-5}$ – $1.58x10^{-3}$]	Plant Specific (Monitoring Data)
Cu	kg/t clinker	[$2.82x10^{-5}$ – $2.60x10^{-3}$]	Plant Specific (Monitoring Data)
Ni	kg/t clinker	[$6.38x10^{-7}$ – $1.88x10^{-3}$]	Plant Specific (Monitoring Data)
Se	kg/t clinker	[$7.50x10^{-5}$ – 1.00 $x10^{-4}$]	Plant Specific (Monitoring Data)
Zn	kg/t clinker	[$2.69x10^{-5}$ – $8.77x10^{-4}$]	Plant Specific (Monitoring Data)
PCDD/PCDF	kg/t clinker	[$1.64x10^{-12}$ – $2.38x10^{-11}$]	Plant Specific (Monitoring Data)
Benzo(a)pyrene	kg/t clinker	NE	-
Benzo(b)fluoranthene	kg/t clinker	NE	-
Benzo(k)fluoranthene	kg/t clinker	NE	-
Indeno(1,2,3-cd)pyrene	kg/t clinker	NE	-
HCB	kg/t clinker	NE	-
PCBs	kg/t clinker	NE	-

4.2.1.4 Activity Data

Clinker production data was obtained directly from each facility for the whole time series and may be observed in the next figure.

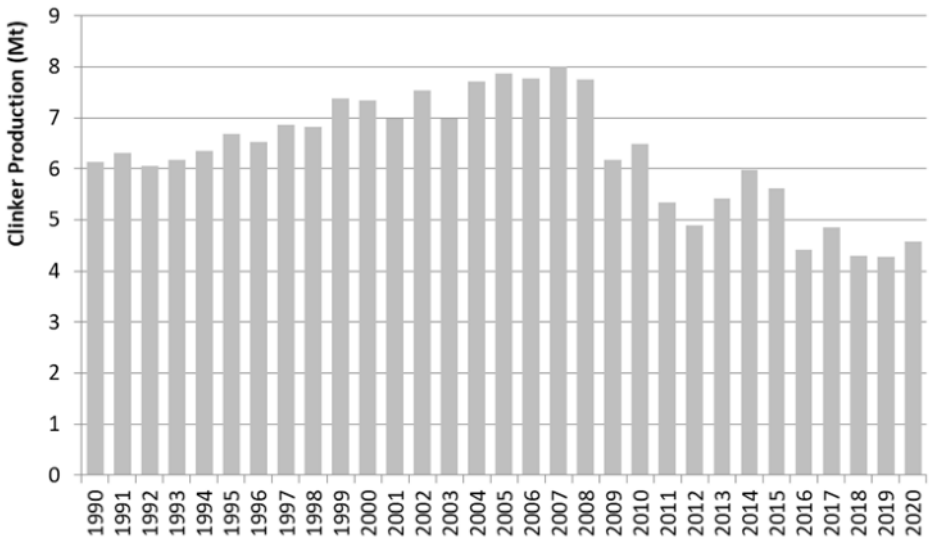


Figure 4-1: Total clinker production in Portugal

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. From 2015 onwards, 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.

4.2.1.5 Category specific QA/QC and verification

Emissions estimates were based on a bottom-up approach with collection of plant specific clinker production data, used for the inventory compilation. A comparison was made using a top-down approach based on clinker production data obtained from national production statistics (INE/IAPI) from 1992 onwards. There are slight differences using the two different approaches but, generally, data is consistent.

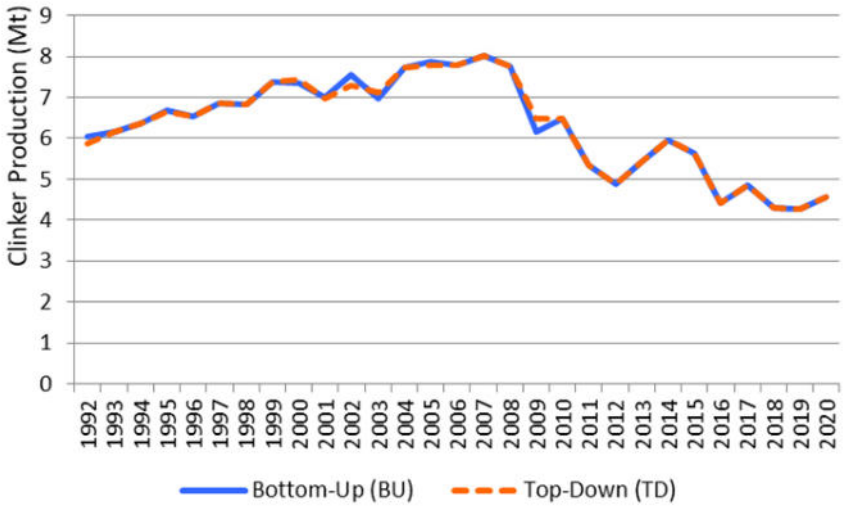


Figure 4-2: Clinker production data – comparison of approaches

4.2.1.6 Recalculations

No recalculations were made.

4.2.1.7 Further Improvements

In the future, we intend to revise plant specific emission factors based on updated monitoring data.

4.2.2 Lime Production in dedicated plants (NFR 2.A.2)

4.2.2.1 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 sea shells could be also used) releasing carbon dioxide and leaving lime (CaO) or magnesia (MgO) as valuable products.

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 building, 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 in Portugal.

4.2.2.2 Methodology

Atmospheric emissions in lime production include particulate emissions from the calcining of the limestone/dolomite and emissions of air pollutants generated during fuel combustion in kilns. These emissions are not very significant on a global or even regional scale. However, lime works can be an important emission source of air pollutants on a local scale.

In section 3.2.2 of chapter 2.A.2 of the 2019 EMEP Guidebook, process emission factors are provided for particulate fractions only. This does not imply that there are no process emissions for other pollutants, but since it is very difficult to separate process and combustion emissions and it is expected the majority of emissions for other pollutants (NOx, SOx, NMVOC, CO, Cd, Hg and Pb) to be due to the combustion of fuels. Combustion-related emissions from lime production are addressed in the Energy sector (chapter 1.A.2) and reported in category 1.A.2.f. Emissions of other heavy metals are assumed to be negligible.

For all pollutants, the methodology applied for emissions estimates was based on a Tier 2 approach from chapter 2.A.2 of 2019 EMEP Guidebook, according to the following equation:

Equation 4-3: Emissions from lime production

$$Emi = AD \times EF \times 10^{-3}$$

Where:

Emi: Total emission of each pollutant (t)

AD: Lime Production (t)

EF: Emission Factor of each pollutant (kg/t of lime)

4.2.2.3 Emission Factors

Tier 2 – uncontrolled - emission factors applied were taken from Table 3.2 of chapter 2.A.2 of 2019 EMEP Guidebook and are listed in the table below:

Table 4-3: Emission Factors for lime production in dedicated plants

Pollutant	Unit	Emission Factor
TSP	kg/t lime	9
PM10	kg/t lime	3.5
PM2.5	kg/t lime	0.7
BC	% of $PM_{2.5}$	0.46

4.2.2.4 Activity Data

National lime production was collected from National Statistics (INE) IAPI industrial survey for the period 1990 to 2009. From 2010 onwards, lime production was collected from E-PRTR.

In order to ensure time series consistency of the activity data used, we collected national lime production from National Statistics for the whole time series and compared it with lime production collected from the E-PRTR (figure below). However, from E-PRTR 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.

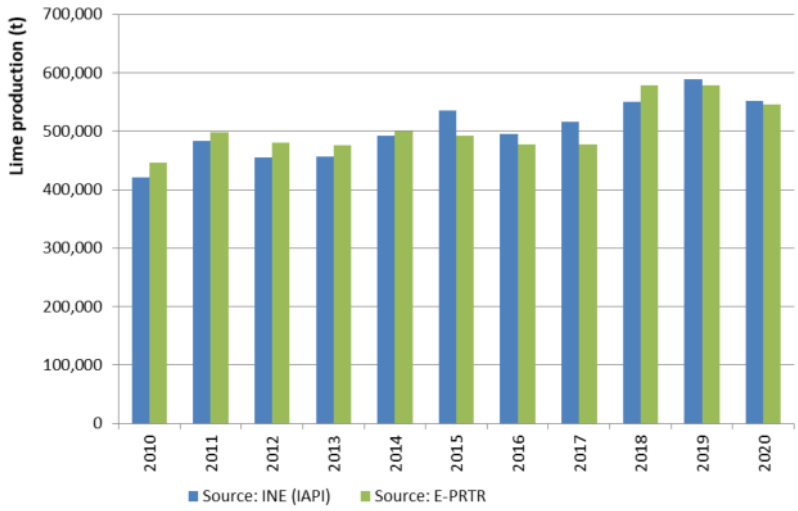


Figure 4-3: Lime production from different sources

Given the relative consistency between the two sets of data, we decided to use:

. from 1990 to 2009 - Lime production from National Statistics (INE) IAPI industrial survey;

. from 2010 onwards - Lime production from E-PRTR.

From 1990 to 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.

From 2010 onwards, for each lime production plant, it was gathered information on lime production by type of lime, based on E-PRTR.

Lime production is presented in the figure below for the whole time series.

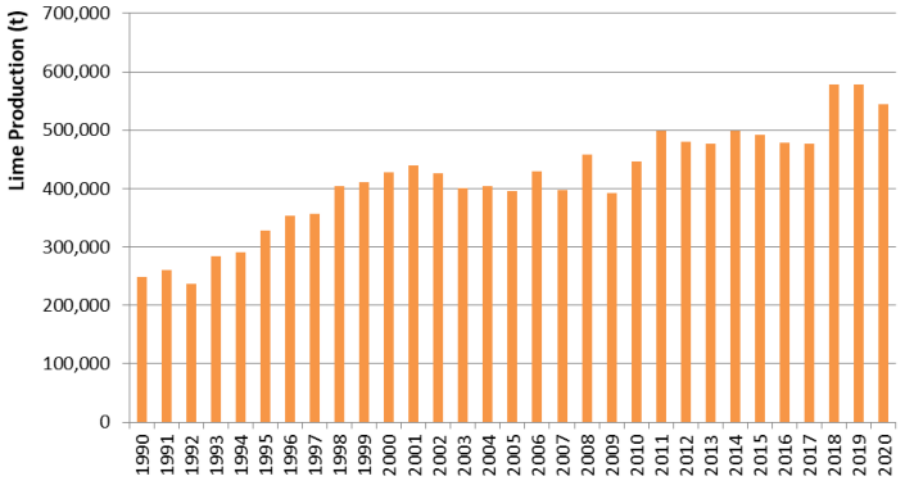


Figure 4-4: Lime production

In the end of the second quarter of 2008, one facility terminated operation, 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, however, it was on a pilot phase and, therefore, working intermittently. Formally, this facility only started fully operating in early 2018, hence the increase in lime production from 2017 to 2018.

4.2.2.5 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.

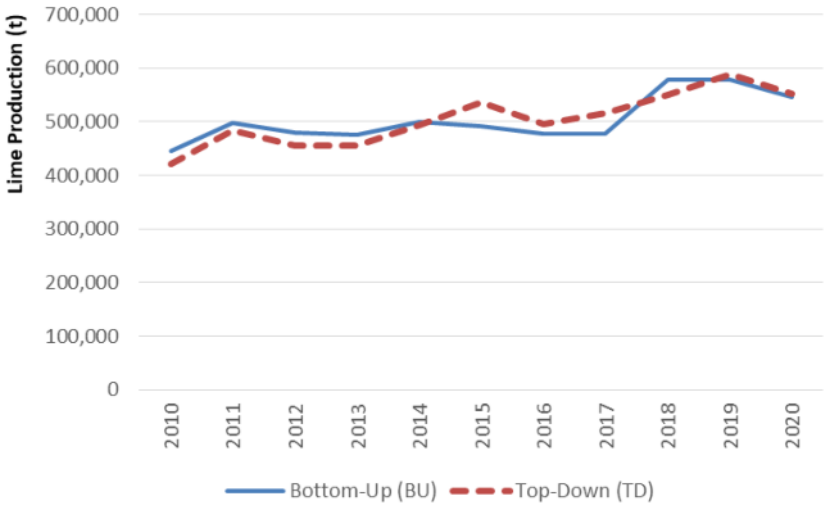


Figure 4-5: Lime production in dedicated plants – comparison of approaches

Following QA/QC procedures to the sector, lime production data from 1990 to 2009 was updated to values from National Statistics (INE), in order to improve time series consistency. This update affects particulate emissions estimates.

Further QA/QC procedures to the sector identified a compilation error regarding 2018 and 2019 lime production values for one facility.

These updates affect particulate and black carbon emissions estimates.

4.2.2.6 Recalculations

The update of lime production data in 1990-2009 resulted in an annual decrease of about 3.8% in particulate and black carbon emissions for those years.

The update of lime production data in 2018-2019 resulted in an annual increase of about 15% in particulate and black carbon emissions for those years.

4.2.2.7 Further Improvements

In the future, we intend to revise plant specific emission factors based on updated monitoring data.

4.2.3 Lime Production in Iron and Steel (CRF 2.A.2)

4.2.3.1 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 4.2.2, 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 4.4.1 – Iron and Steel Production (2.C.1).

Atmosferic pollutants from lime production in Iron and Steel were estimated and reported for the first time in the 2021 submission.

4.2.3.2 Methodology

For all pollutants except black carbon, the methodology applied for emissions estimates was based on a Tier 2 approach from chapter 2.A.2 of 2019 EMEP Guidebook, according to the following equation:

Equation 4-4: Emissions from lime production

$$Emi = AD \times EF \times 10^{-3}$$

Where:

Emi: Total emission of each pollutant (t)

AD: Lime Production (t)

EF: Emission Factor of each pollutant (kg/t of lime)

4.2.3.3 Emission Factors

Tier 2 – uncontrolled - emission factors applied were taken from Table 3.2 of chapter 2.A.2 of 2019 EMEP Guidebook and are listed in the table below:

Table 4-4: Emission Factors for lime production in Iron and Steel

Pollutant	Unit	Emission Factor
TSP	kg/t lime	9
PM10	kg/t lime	3.5
PM2.5	kg/t lime	0.7
BC	% of $PM_{2.5}$	0.46

4.2.3.4 Activity Data

Lime production data in the iron and steel industry was available from information received from the industry for the period 1991-1994.

Regarding the missing years of lime production data, upon a new contact, the integrated iron and steel facility indicated that does not possess such information due to company restructuration in 2001 and consequent loss of old data. 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.

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 4-5: 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.

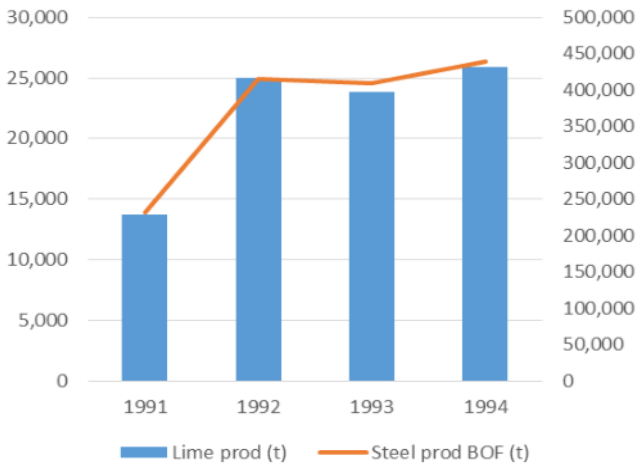


Figure 4-6: Lime production and steel production from BOF in Iron and Steel

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.

All lime produced in that iron and steel plant was high calcium lime (no production of hydrated lime) and can be observed in the figure below.

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 4.2.2 above (Lime production in dedicated plants).

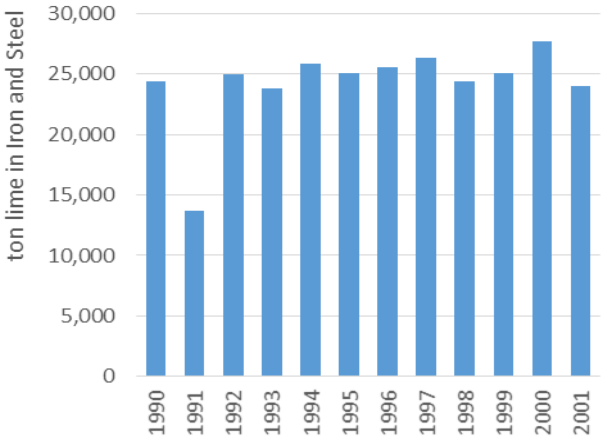


Figure 4-7: Lime production in Iron and Steel

4.2.3.5 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.

4.2.3.6 Recalculations

No recalculations were made.

4.2.3.7 Further Improvements

No further improvements are planned.

4.2.4 Glass Production (NFR 2.A.3)

4.2.4.1 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 carbon dioxide 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 were already considered 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[4].

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).

4.2.4.2 Methodology

For all pollutants except black carbon, the methodology applied for emissions estimates was:

Equation 4-6: Emissions from glass production

$$Emission_{(x,y)} = EF_{(x,y)} * Glass_{PROD,y} * 10^{-3}$$

Where:

$Emission_{(t,y)}$: Annual emission of pollutant x from production of specific glass type y (t)

$EF_{(x,y)}$: Emission factor of pollutant x from production of specific glass y (kg_x/t_y)

$Glass_{PROD,Y}$: Production of specific glass y (t)

4.2.4.3 Emission Factors

Combustion emission factors (reported in category 1.A.2.f) presented in the table below were taken from USEPA AP-42 – Chapter 11.15 – Table 11.15-2 (VOC emission factor).

Process emission factors (reported in category 2.A.3) were taken from Tables 3.2, 3.3 and 3.6 respectively for flat, container and lead crystal glass production of chapter 2.A.3 from 2019 EMEP Guidelines.

[4] They were not used to derive the country specific emission factors for instance.

Table 4-5: Emission Factors considered

Parameter	Unit	Reported in NFR sector	Flat Glass	Container Glass	Crystal Glass
NMVOC	kg/t Glass	1 A 2 f	0.1	4.5	4.7
SOx	kg/t Glass	1 A 2 f	1.5	1.7	2.8
NOx	kg/t Glass	1 A 2 f	4.0	3.1	4.3
CO	kg/t Glass	1 A 2 f	0.1	0.1	0.1
TSP	g/t Glass	2 A 3	130	280	10
PM_{10}	g/t Glass	2 A 3	120	250	9
$PM_{2.5}$	g/t Glass	2 A 3	100	220	8
BC	% of $PM_{2.5}$	2 A 3	0.062	0.062	0.062
Pb	g/t Glass	2 A 3	0.4	2.9	10
Cd	g/t Glass	2 A 3	0.068	0.12	-
Hg	g/t Glass	2 A 3	0.003	NE	NE
As	g/t Glass	2 A 3	0.08	0.29	-
Cr	g/t Glass	2 A 3	0.08	0.37	-
Cu	g/t Glass	2 A 3	0.007	NE	NE
Ni	g/t Glass	2 A 3	0.74	0.24	-
Se	g/t Glass	2 A 3	0.15	1.5	-
Zn	g/t Glass	2 A 3	0.37	NE	NE

NMVOC, NOx and CO emissions are assumed to be generated from combustion activities and, therefore, reported in NFR sector 1.A.2.f. SOx emissions, although also emitted from the glass industry process, are also reported under chapter 1.A.2.f in order to avoid the risk of double counting of emissions as much as possible, according to the guidance of 2019 EMEP Guidebook. All other pollutants are reported in NFR sector 2.A.3.

4.2.4.4 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. From 2009 onwards there is no Flat Glass production in Portugal.

Crystal Glass production data was obtained from AIC (Crystal Glass National Association).

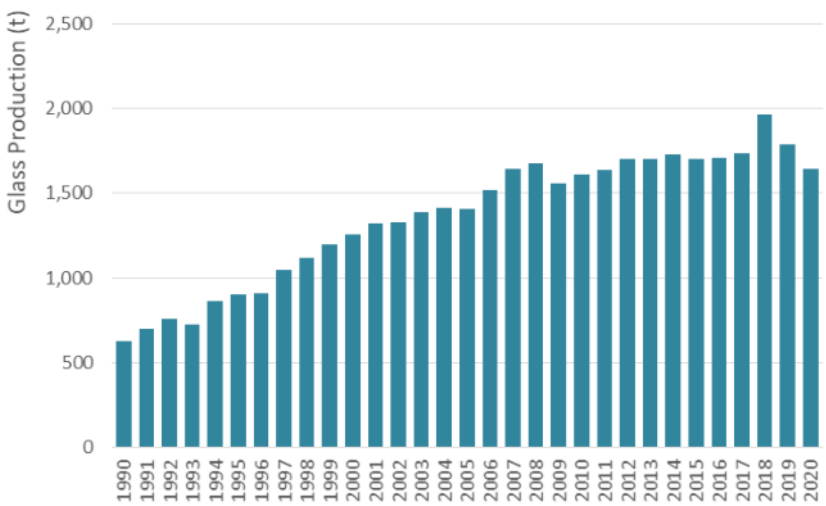


Figure 4-8: Glass production

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.

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.

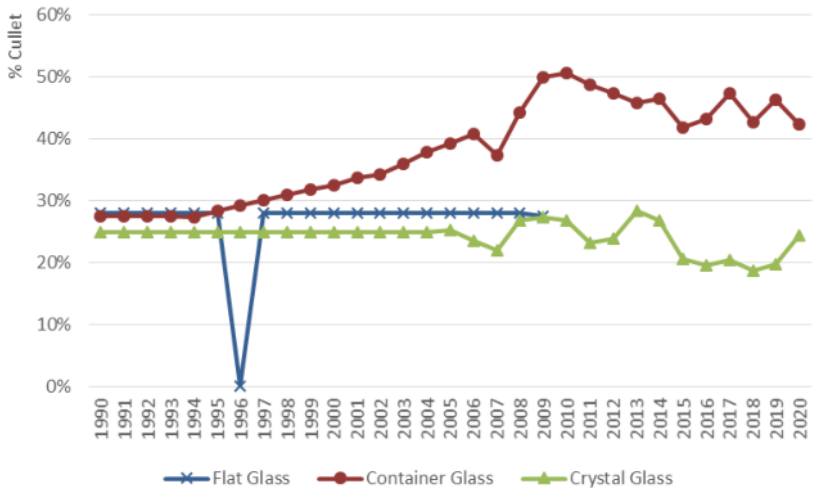


Figure 4-9: Cullet incorporation by type of glass

4.2.4.5 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.

4.2.4.6 Recalculations

No recalculations were made.

4.2.4.7 Further Improvements

No further improvements are planned.

4.2.5 Glass Wool Production (NFR 2.A.3)

4.2.5.1 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, as one facility entered in operation in 2019. 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 products usually contain a proportion of phenol-resin-based binder. The binder solution is applied to the fibres in the forming area and is cross-linked and dried in the curing oven. The forming area waste gas will contain particulate matter, phenol, formaldehyde and ammonia. The particulate matter consists of both organic and inorganic material, often with a very small particle size. Lower levels of VOC and amines may also be detected if they are included in the binder system.

This chapter estimates emissions from both melting and after melting treatment regarding glass wool production, according to the 2019 EMEP Guidelines.

4.2.5.2 Methodology

For all pollutants except black carbon, the methodology applied for emissions estimates was:

Equation 4-7: Emissions from glass wool production

$$Emission_{(x)} = Glass_{PROD} \times EF_{(x)} \times (1-\eta_{abat}) \times 10^{-6}$$

Where:

$Emission_{(x)}$: Annual emission of pollutant x from glass wool production (t)

$Glass_{PROD}$: Glass wool production (t)

$EF_{(x)}$: Emission factor of pollutant x from glass wool production (g_x/t)

η_{abat} : Abatement efficiency (%)

4.2.5.3 Emission Factors

Tier 2 emission factors applied for melting and the after melting treatment were taken from Table 3.5 of chapter 2.A.3 from 2019 EMEP Guidelines and are listed in the table below.

Table 4-6: Emission Factors considered

Parameter	Unit	EF
NMVOC	g/t Glass	500
NH_3	g/t Glass	1400
TSP	g/t Glass	670
PM_{10}	g/t Glass	590
$PM_{2.5}$	g/t Glass	520
BC	% of $PM_{2.5}$	2

Abatement efficiencies considered for melting and the after melting treatment were taken directly from the facility's environmental permit, since there is no specific information for Glass Wool production in chapter 2.A.3 from 2019 EMEP Guidelines. Abatement efficiencies applied are listed in the table below.

Table 4-7: Abatement efficiencies considered

Abatement technology	Parameter	Unit	Efficiency
Wet scrubber	NMVOC	%	80
Wet scrubber	NH_3	%	80
Wet scrubber	TSP	%	95
Wet scrubber + Fabric filter	PM_{10}	%	95
Wet scrubber + Fabric filter	$PM_{2.5}$	%	95
Wet scrubber + Fabric filter	BC	% of $PM_{2.5}$	-

4.2.5.4 Activity Data

Glass wool production data was obtained directly from the facility and the Environmental Annual Reports.

Due to confidentiality constraints (there is only one facility in Portugal), we don't present glass wool production data.

4.2.5.5 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, we realized glass wool production data was not being reported as activity data in NFR tables, due to a compilation error. This correction does not affect emissions because these values were already being used, they were just not being correctly reported in the NFR tables.

Further analysis of the facility's environmental permit, we found a number of existing add-on technologies to reduce the emissions of specific pollutants, as indicated in the table above. Therefore, the inventory compiled the corresponding abatement efficiencies in order to reduce the emissions from this activity. These reductions were included for the first time in this submission.

4.2.5.6 Recalculations

Add-on technologies and corresponding abatement efficiencies were introduced for the first time in this submission. Recalculations occurred in 2019 (the first year in operation) and resulted in a general significant decrease of emissions, as presented in the table below.

Table 4-8: Recalculations in glass wool production emissions for 2019

Recalculated data	Previous submission	Latest submission	Difference	Difference
	ton	ton	ton	%
NMVOC	2.97	0.557	-2.42	-81.2%
NH_3	8.32	1.561	-6.76	-81.2%
TSP	3.98	0.187	-3.80	-95.3%
PM_{10}	3.51	0.164	-3.34	-95.3%
$PM_{2.5}$	3.09	0.145	-2.95	-95.3%
BC	0.06	0.003	-0.06	-95.3%

4.2.5.7 Further Improvements

No further improvements are planned.

4.2.6 Quarrying and mining of minerals other than coal (NFR 2.A.5.a)

4.2.6.1 Category description

This chapter discusses the quarrying and mining of minerals other than coal and results in emissions of particulates (TSP, PM_{10} and $PM_{2.5}$).

These minerals are divided in four major categories, according to their composition and use:

- Aggregates in the Construction, Cement and Lime Industries (Crushed Limestone, sand and siliceous crushed stone);
- Industrial Minerals (Clay, sand, limestone for manufacturing industry and kaolin);
- Ornamental Rocks (Granite, Marble, Limestone, stone for soothing and rustic stone);
- Metallic Minerals (Copper, Zinc, Lead, Tungsten and Tin).

4.2.6.2 Methodology

Currently Portugal does not possess the disaggregated activity data required in the spreadsheet available in the 2019 EMEP Guidebook in order to move to a Tier 2 methodology.

Particulate matter emissions are estimated based on a Tier 1 methodology, according to chapter "2.A.5.a Quarrying and mining of minerals other than coal" from EMEP/EEA guidebook 2019:

Equation 4-8: Particulate matter emissions from quarrying and mining of minerals

$$Emission = AR \times EF \times 1 \times 10^{-6}$$

Where:

Emission: Particulate matter (TSP, PM_{10} or $PM_{2.5}$) emissions (t)

AR: Activity rate for the quarrying/mining (t)

EF: Emission factor (g/t)

4.2.6.3 Emission Factors

The following emission factors were considered in the estimates:

Table 4-9: Emission Factors

Parameter	Unit	EF	Source
TSP	g/t	102	EMEP/EEA guidebook 2019, Volume "2.A.5.a Quarrying and mining of minerals other than coal", table 3.1
PM_{10}	g/t	50	EMEP/EEA guidebook 2019, Volume "2.A.5.a Quarrying and mining of minerals other than coal", table 3.1
$PM_{2.5}$	g/t	5	EMEP/EEA guidebook 2019, Volume "2.A.5.a Quarrying and mining of minerals other than coal", table 3.1

4.2.6.4 Activity Data

Currently, Portugal does not possess the disaggregated activity data required in the spreadsheet available in the 2019 EMEP Guidebook in order to move to a Tier 2 methodology. Obtaining such information will require a great amount of time and several contacts with sectoral authorities in the matter. However, considering that this is a key category, we intend to engage contacts in order to assess the information available in the country.

From 2007 onwards, data on quarrying and mining of minerals other than coal was obtained from Geology and Energy National Authority (DGEG). From 1995-2006, data has been estimated based on 2007 value and on 1995-2006 extractive industry GVA (Gross Value Added) trend obtained from INE. Given that there are no extractive industry GVA for the periods 1990-1994 and 2016, we used the GDP (Gross Domestic Product) trend, obtained also from INE, to estimate minerals extraction values in these periods.

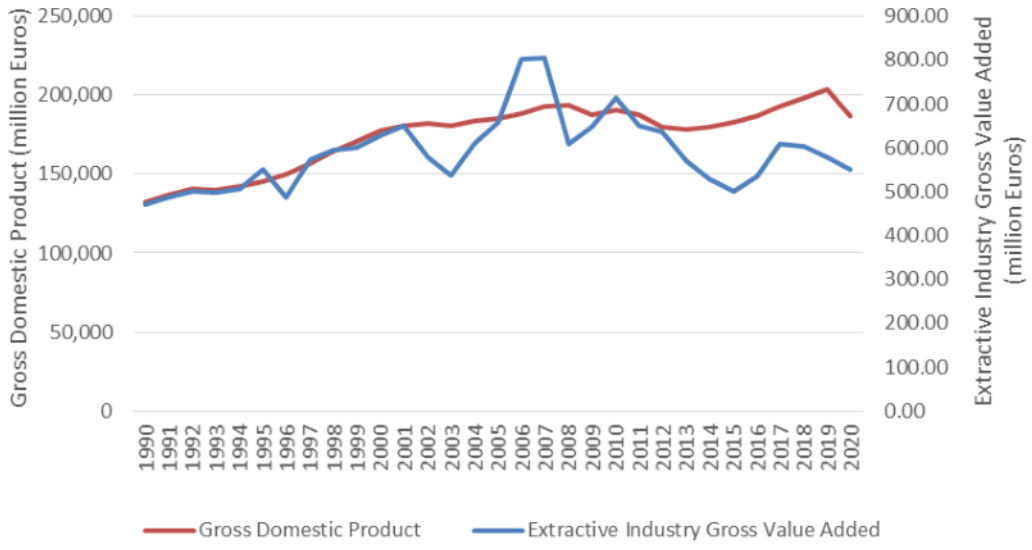


Figure 4-10: Gross Domestic Product and Extractive Industry Gross Value Added

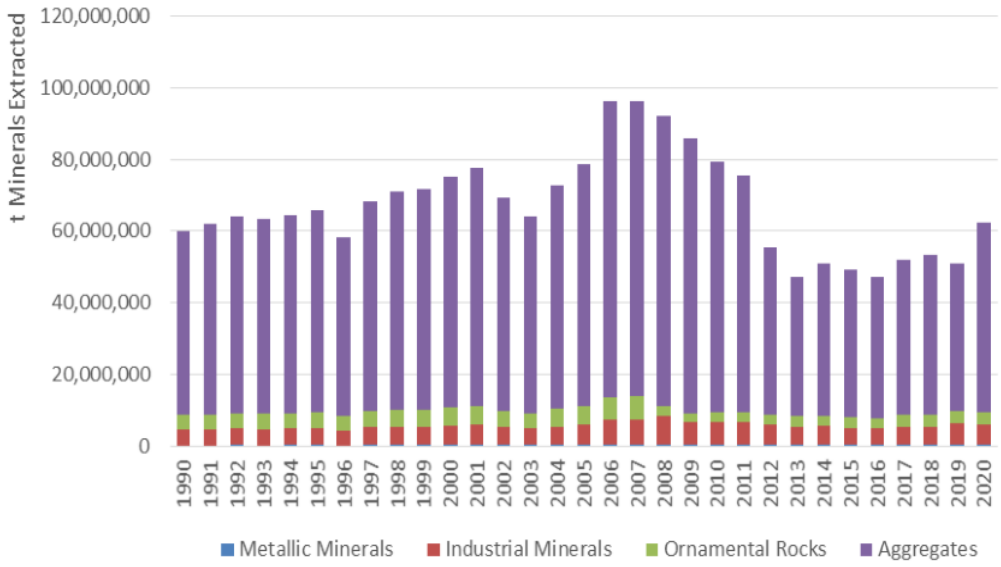


Figure 4-11: Quarrying and mining of minerals other than coal

4.2.6.5 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.

4.2.6.6 Recalculations

2019 activity data was updated.

4.2.6.7 Further Improvements

We intend to contact DGEG in order to obtain consistent data on quarrying and mining of minerals other than coal in the 1990-2006 period.

Following a 2021 NECD Review question, Portugal was not able to present revised estimates using a Tier 2 methodology. Further analysis to the spreadsheet available in the 2019 EMEP Guidebook showed the importance of possessing relatively disaggregated activity data for this category. At the moment, the inventory team does not possess such information at national level and foresees that obtaining such information will require a great amount of time and several contacts with sectoral authorities in the matter. Therefore, for the time being, Portugal is unable to apply a higher tier methodology. However, considering that this is a key category, we intend to engage contacts in order to assess the information available in the country, and further evaluate the possibility of moving to a higher tier. We hope to report on the progress in future submissions.

4.2.7 Construction and Demolition (NFR 2.A.5.b)

4.2.7.1 Category description

The construction of infrastructures and buildings constitutes a relevant source of fugitive particulate matter emissions. These activities may emit other pollutants as well, such as NO_x, soot, CO_2 and NMVOC. All combustion and product use emissions are estimated in NFR 1.A.2.g.viii. This chapter only considers fugitive particulate matter emissions (TSP, PM_{10} and $PM_{2.5}$).

4.2.7.2 Methodology

We use a Tier 1 methodology to estimate particulate matter emissions, as proposed in chapter "2.A.5.b Construction and demolition" from EMEP/EEA guidebook 2016:

Equation 4-9: Particulate matter emissions

$$Emission = AD \times A_{affected} \times \frac{EF}{1000} \times d \times (1 - CE) \times \frac{24}{PE} \times \frac{S}{9\%}$$

Where:

Emission: Particulate matter emissions (t)

AD: Activity data (n. º)

$A_{affected}$: Area affected by construction activity (m^2)

EF: Emission factor (kg/[m^2.year])

d: Duration of construction (year)

CE: Efficiency of emission control measures (dimensionless)

PE: Thornthwaite precipitation-evaporation index (dimensionless)

S: Soil silt content (%)

4.2.7.3 Emission Factors

The following emission factors were considered in the estimates:

Table 4-10: Emission Factors

Source Category	Parameter	Unit	EF	Source
Construction of houses and apartments	TSP	Kg/[m^2.year]	1	EMEP/EEA guidebook 2016, Volume "2.A.5.b Construction and demolition", table 3.2
	PM_{10}	Kg/[m^2.year]	0.3	EMEP/EEA guidebook 2016, Volume "2.A.5.b Construction and demolition", table 3.2
	$PM_{2.5}$	Kg/[m^2.year]	0.03	EMEP/EEA guidebook 2016, Volume "2.A.5.b Construction and demolition", table 3.2
Non-residential construction	TSP	Kg/[m^2.year]	3.3	EMEP/EEA guidebook 2016, Volume "2.A.5.b Construction and demolition", table 3.3
	PM_{10}	Kg/[m^2.year]	1	EMEP/EEA guidebook 2016, Volume "2.A.5.b Construction and demolition", table 3.3
	$PM_{2.5}$	Kg/[m^2.year]	0.1	EMEP/EEA guidebook 2016, Volume "2.A.5.b Construction and demolition", table 3.3
Road construction	TSP	Kg/[m^2.year]	7.7	EMEP/EEA guidebook 2016, Volume "2.A.5.b Construction and demolition", table 3.4
	PM_{10}	Kg/[m^2.year]	2.3	EMEP/EEA guidebook 2016, Volume "2.A.5.b Construction and demolition", table 3.4
	$PM_{2.5}$	Kg/[m^2.year]	0.23	EMEP/EEA guidebook 2016, Volume "2.A.5.b Construction and demolition", table 3.4

Table 4-11: Affected Area (m^2)

Source Category	Footprint Area (m^2)	Conversion factor	Affected Area (m^2)	Source
Construction of houses and apartments	106.06	1.6	169.70	National construction statistics
Non-residential construction	575.21	1.25	719.01	National construction statistics
Road construction	-	-	36000 m^2/km road	EMEP/EEA guidebook 2016, Volume "2.A.5.b Construction and demolition", page 12

Table 4-12: Duration of construction (year)

Source Category	Duration of construction (year)	Source
Construction of houses and apartments	0.625	EMEP/EEA guidebook 2016, Volume "2.A.5.b Construction and demolition", page 8
Non-residential construction	0.83	EMEP/EEA guidebook 2016, Volume "2.A.5.b Construction and demolition", page 8
Road construction	1	EMEP/EEA guidebook 2016, Volume "2.A.5.b Construction and demolition", page 8

Table 4-13: Control Efficiency

Source Category	Control Efficiency	Source
Construction of houses and apartments	0	EMEP/EEA guidebook 2016, Volume "2.A.5.b Construction and demolition", pages 8-9
Non-residential construction	0.5	EMEP/EEA guidebook 2016, Volume "2.A.5.b Construction and demolition", pages 8-9
Road construction	0.5	EMEP/EEA guidebook 2016, Volume "2.A.5.b Construction and demolition", pages 8-9

The Thornthwaite precipitation-evaporation index (PE=53.56) was estimated based on the monthly precipitation (Pi) and mean temperature (Ti) of Lisbon for the period 1981-2010, according to:

Equation 4-10: Thornthwaite precipitation-evaporation index

$$PE\ index = 3.16 \times \sum_{i=1}^{12} \left(\frac{P_i}{1.8 \times T_i + 22}\right)^{\frac{10}{9}}$$

The soil silt content (S) was considered equal to 20%, as assumed for Germany (EMEP/EEA guidebook 2016, Volume "2.A.5.b Construction and demolition", page 10).

4.2.7.4 Activity Data

From 2003 onwards, data on the number of new houses/apartments constructed and non-residential construction for each year was obtained from INE. In the period 1990-2002, data was estimated based on the average 2003-2007 values and on GDP trend, also from INE.

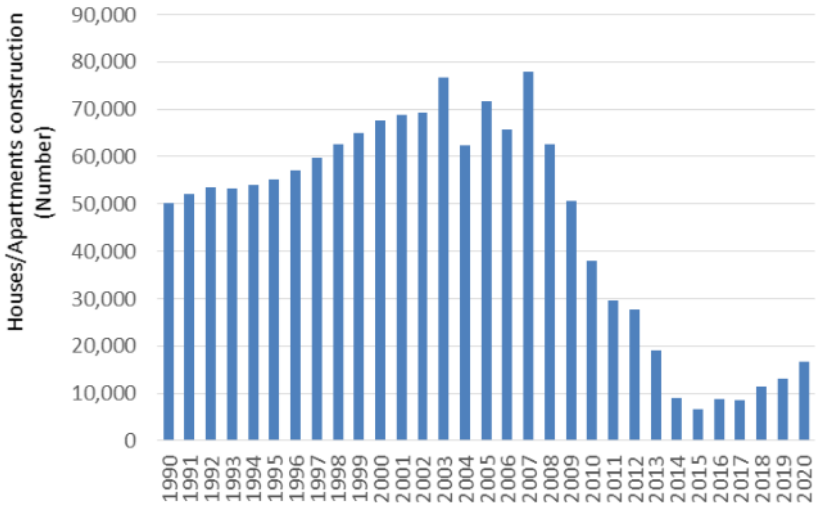


Figure 4-12: Houses/apartments construction

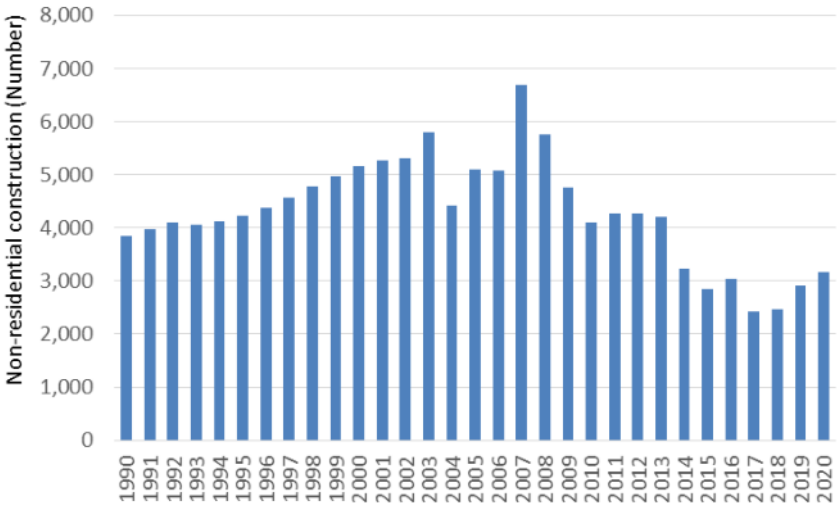


Figure 4-13: Non-residential construction

The figure below presents the national road extension (left axis) and the extension of new roads constructed (right axis).

The extension of new roads constructed each year was estimated based on the evolution of the extension of national roads, obtained from INE and the Institute of Mobility and Transport (IMT). In the period 1991-1994 the data was estimated based on the interpolation of 1990 and 1995 total road extension data.

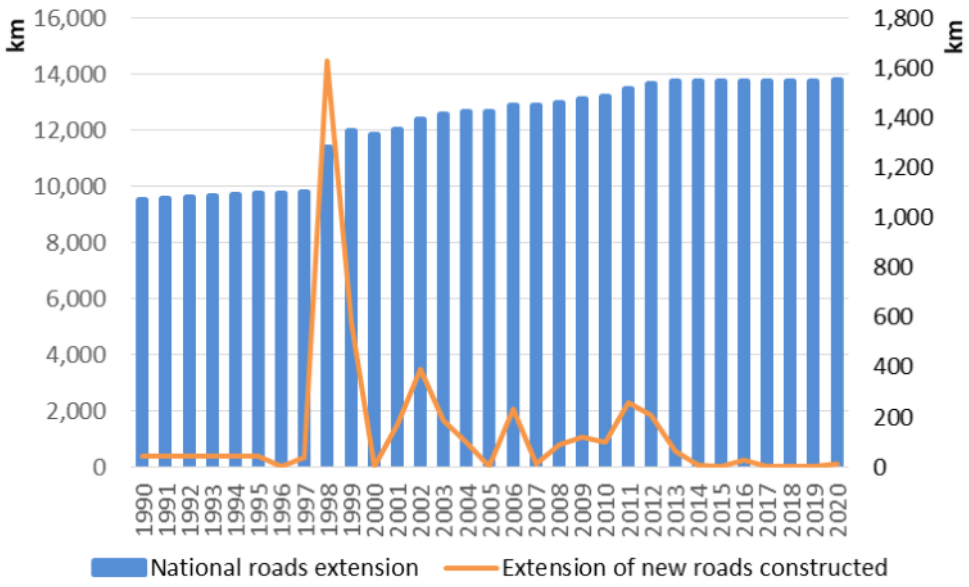


Figure 4-14: Roads construction

Following a request from the inventory team, in 2019 submission INE and IMT revised the national series regarding the annual construction of new roads in the period 2009-onwards.

In the period 1990-2008 data was also revised based on a thorough research in INE database.

Concerning the figure above, the high increase in road construction in years 1998 and 1999 is due to the opening of the *1998 Lisbon World Exposition*, a World Trade Fair which brought massive investment to Portugal´s infrastructure at many levels, namely, road infrastructure.

4.2.7.5 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.

4.2.7.6 Recalculations

2019 data on the number of new houses/apartments constructed and non-residential construction was revised by INE.

4.2.7.7 Further Improvements

We intend to contact national authorities in order to obtain better estimates on houses/apartments and non-residential construction for the period 1990-2002.

4.2.8 Storage, handling and transport of mineral products (NFR 2.A.5.c)

4.2.8.1 Category description

This chapter addresses emissions from storage, handling and transport of mineral products. These activities result mainly in emissions of particulates (TSP, PM_{10} and $PM_{2.5}$).

4.2.8.2 Methodology

We use a Tier 2 methodology (uncontrolled) to estimate separate particulate matter emissions from storage, handling and transport of mineral products, as proposed in chapter "2.A.5.c Storage, handling and transport of mineral products" from EMEP/EEA guidebook 2016:

Equation 4-11: Particulate matter emissions

$$Emission = AR \times EF \times 1 \times 10^{-6}$$

Where:

Emission: Particulate matter emissions (t)

AR: Activity rate for storage, handling and transport of mineral products (t)

EF: Emission factor (g/t)

4.2.8.3 Emission Factors

The following emission factors were considered in the estimates:

Table 4-14: Emission Factors considered

Technologies/ Practices	Parameter	Unit	EF	Source
Handling - Uncontrolled	TSP	g/t	12	EMEP/EEA guidebook 2019, Volume "2.A.5.c Storage, handling and transport of mineral products", table 3.4
	PM_{10}	g/t	6	EMEP/EEA guidebook 2019, Volume "2.A.5.c Storage, handling and transport of mineral products", table 3.4
	$PM_{2.5}$	g/t	0.6	EMEP/EEA guidebook 2019, Volume "2.A.5.c Storage, handling and transport of mineral products", table 3.4

4.2.8.4 Activity Data

We assumed that the amount of minerals stored, handled and transported is equal to the sum of minerals extracted (quarried and mined) and minerals imported (minerals exported are also stored, handled and transported in the national territory).

At present only handling related emissions are considered in the inventory due to lack of AD on storage related emissions (storage areas).

As explained in category 2.A.5.a, data on quarrying and mining of minerals other than coal was obtained from DGEG for the period 2007-2015. From 1995-2007, data has been estimated based on 2007 value and on 1995-2006 extractive industry gross value added trend. Given that there are no extractive industry gross value added for the periods 1990-1994 and 2016, we used the gross domestic product trend to estimate minerals extraction values in these periods.

From 1995 onwards, data on imports was obtained from EUROSTAT. From 1990 to 1994, data on imports was based on 1995 imports value and on 1990-1994 data on minerals extracted.

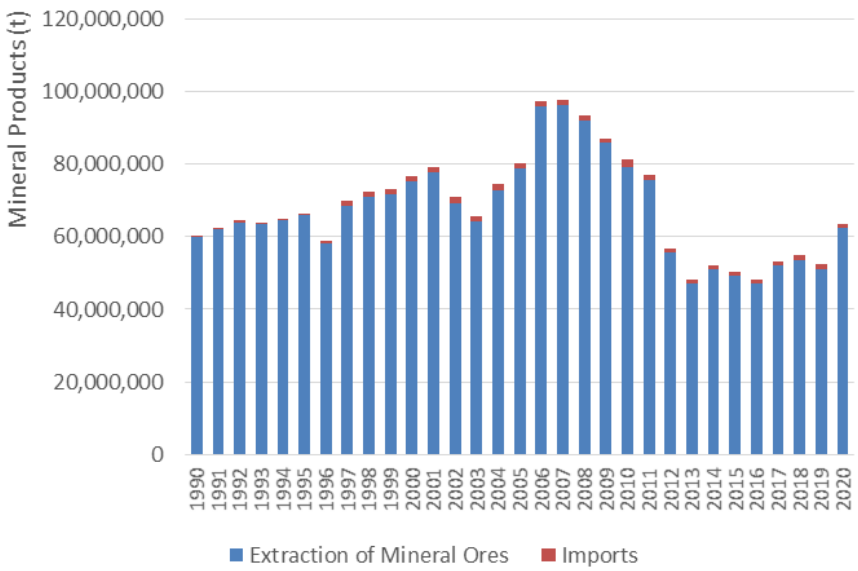


Figure 4-15: Mineral products stored, handled and transported

4.2.8.5 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.

4.2.8.6 Recalculations

No recalculations were made.

4.2.8.7 Further Improvements

We intend to investigate and collect information on storage areas in order to estimate, in the future, storage related emissions based on emission factors proposed in tables 3.2 or 3.3 of chapter 2.A.5.c of "EMEP/EEA air pollutant emission inventory guidebook 2019".

4.3 Chemical Industry (NFR 2.B)

4.3.1 Ammonia Production (NFR 2.B.1 – SNAP 040403)

4.3.1.1 Category description

In 1990 there were two plants producing ammonia in Portugal, but one of the plants has stopped activity already in the beginning of that year. From 1991-2008, there was only one plant producing ammonia. In 2009, this plant was closed and the ammonia production has been relocated to India.

Ammonia is synthesized from nitrogen and hydrogen, by the following reaction:

Equation 4-12: 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 are 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 4-13: Chemical conversion equation

$$2CH_n + O_2 \rightarrow 2CO + nH_2$$

Emissions result from the process, either from escape of ammonia (NH_3) or either from release of products from feedstock (CO and NOx).

4.3.1.2 Methodology

Emissions estimates for all pollutants are based on a Tier 2 methodology from the 2019 EMEP Guidelines, according to the following equation:

Equation 4-14: Emissions from ammonia production

$$Emission_{(p)} = EF_{(p)} * AP * 10^{-3}$$

Where:

$Emission_{(p)}$: Annual emission of pollutant p (t)

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

AP : Annual ammonia production (t)

4.3.1.3 Emission Factors

Considering that from 1990 to 2008 ammonia was produced by partial oxidation, Tier 2 emission factors applied were taken from Table 3.8 of Chapter 2.B Chemical Industry of the 2019 EMEP Guidelines and are listed in the table below.

Table 4-15: Emission Factors

Parameter	Unit	EF
NOx	kg/t NH_3	1
CO	kg/t NH_3	0.1
NH_3	kg/t NH_3	0.01

4.3.1.4 Activity Data

In 1990 there were two plants producing ammonia in Portugal, but one of the plants has stopped activity already in the beginning of that year. From 1991-2008, there was only one plant producing ammonia. In 2009, this plant was closed and the ammonia production has been relocated to India.

For the period 1990-2008, ammonia production data was obtained from the facilities. From 2009 onwards there is no ammonia production. This data is consistent with national statistics ammonia production data.

Due to confidentiality constraints, ammonia production is 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.

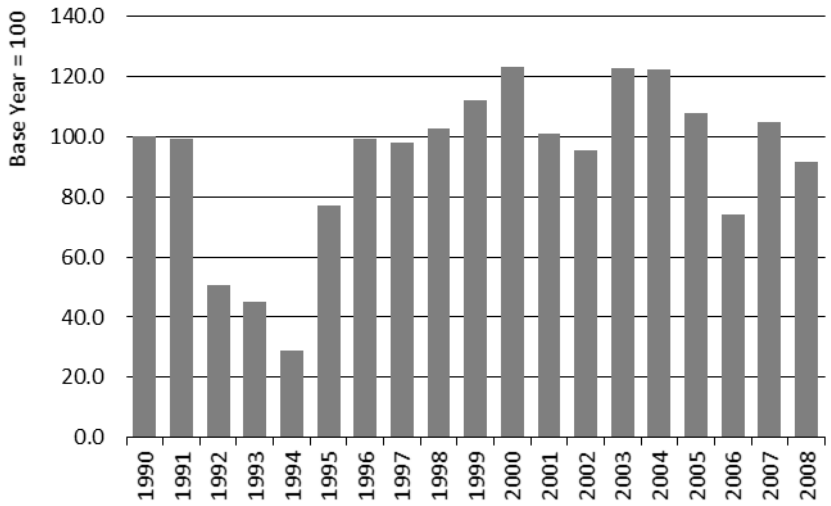


Figure 4-16: Trend in Ammonia production

4.3.1.5 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. Data on ammonia production is consistent with national statistics ammonia production data.

Following QA/QC procedures to the sector, considering ammonia was produced by partial oxidation, emission factors for ammonia production were updated to a Tier 2 according to Table 3.8 of chapter 2.B Chemical Industry of the 2019 EMEP Guidelines. According to the guidelines, NOx and CO Tier 1 emission factors (Table 3.2) previously applied are equal to the ones of Tier 2.

Following a 2021 NECD Review question, Portugal updated CO notation key to 'NO' (not occurring) from 2009 onwards, given there is no ammonia production in that period.

4.3.1.6 Recalculations

Recalculations resulted from the update of NH_3 emission factor for ammonia production, from 1990 to 2008. Given that ammonia was produced by partial oxidation, according to Table 3.8 of chapter 2.B Chemical Industry of the 2019 EMEP Guidelines, Tier 2 NH_3 emission factor is considered Not Estimated. Tier 1 NH_3 emission factor previously applied was 0.01 kg/ton NH_3.

Recalculations were found to be below the threshold of significance (between 0.001 and 0.005%).

4.3.1.7 Further Improvements

No further improvements are planned.

4.3.2 Nitric Acid Production (NFR 2.B.2 – SNAP 040402)

4.3.2.1 Category description

Currently, three industrial plants produce nitric acid in Portugal. In all units, weak nitric acid (60 %) is produced from ammonia, using catalytic (Platinum-rhodium alloy catalysts) oxidation of ammonia with air to NO_2 at "dual-pressure" medium/high (M/H), 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 in operation. This facility, however, was closed during 2011 and was replaced by a new facility, which began operating in 2010.

Nitric Acid production results in air emissions primarily of NO_x (NO and NO_2), trace amounts of HNO_3 acid mist, ammonia (NH_3) and Nitrous Oxide (N_2O). The great majority of emissions are conveyed in the tail gas from the absorption tower. Emissions of NO_x are controlled by catalytic reduction.

4.3.2.2 Methodology

NH_3 and NOx emissions are estimated based on a Tier 3 approach according the following equation:

Equation 4-15: Emissions from nitric acid production

$$Emission_{(p,y)} = EF_{(p)} * ActivityRate_{(y)} * 10^{-3}$$

Where:

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

$ActivityRate_{(y)}$: Production of Nitric Acid in year y (t)

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

4.3.2.3 Emission Factors

NOx and NH_3 emission factors applied are Tier 3 based on monitoring data from the facilities. In effect, these EF are based on continuous monitoring system data and emissions are currently monitored by the plants. Due to confidentiality constraints it is not possible to publish the chosen emission factors.

4.3.2.4 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 year 2010 and was replaced by a new facility.

Due to confidentiality constraints (a limited number of existing production facilities), the activity data used to estimate emissions from this sub-source sector is presented in the figure below in relation to production in 1990 (trends).

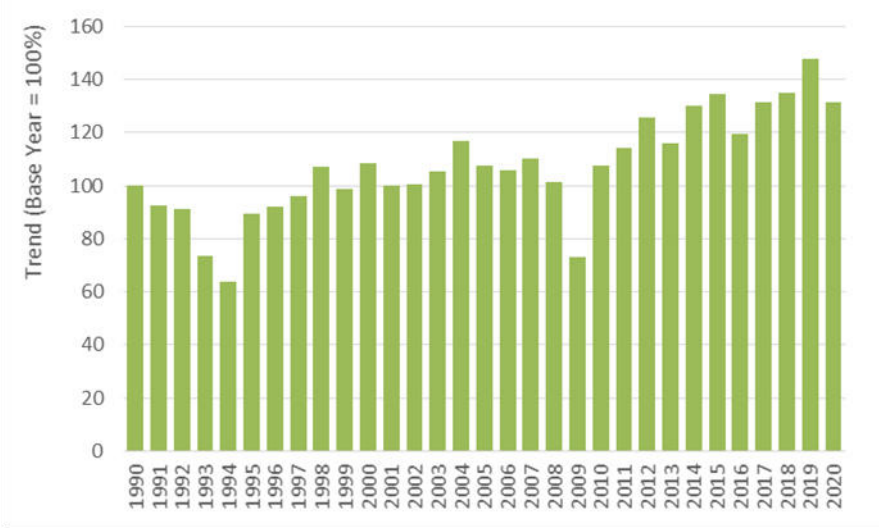


Figure 4-17: Trend in Nitric Acid production

4.3.2.5 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.

4.3.2.6 Recalculations

No recalculations were made.

4.3.2.7 Further Improvements

In the future, we intend to revise plant specific NOx and NH_3 emission factors based on updated monitoring data.

4.3.3 Adipic Acid Production (NFR 2.B.3 – SNAP 040521)

There is no adipic acid production in Portugal, only imports and exports.

4.3.4 Calcium Carbide Production (NFR 2.B.5 – SNAP 040412)

There is no Calcium Carbide production in Portugal, only imports and exports.

4.3.5 Titanium Dioxide Production (NFR 2.B.6 – SNAP 040410)

4.3.5.1 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 titanium dioxide 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.

4.3.5.2 Methodology

Emissions from Titanium Dioxide production were estimated in accordance with EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2016).

Equation 4-16: Titanium Dioxide production data

$$AD_y = AD \times \%_y$$

Where:

AD_y: Titanium Dioxide production (t) using a specific technology/practice (chloride or sulphate process)

AD: Titanium Dioxide national total production (t)

$\%_y$: Share (%) of titanium dioxide production using a specific technology/practice (chloride or sulphate process)

For all pollutants, except for Black Carbon (BC):

Equation 4-17: Emissions from titanium dioxide production

$$Emis_{x,y} = AD_y \times \frac{EF_{x,y}}{1000}$$

Where:

$Emi_{x,y}$: Emissions of pollutant "x" using a specific technology "y" (t)

AD_y: Titanium Dioxide production data using a specific technology "y" (t)

EF_x: Emission factor of pollutant "x" for a given technology "y" (kg/t Titanium Dioxide)

For BC:

Equation 4-18: Black carbon emissions from titanium dioxide production

$$Emis_{BC} = Emis_{PM2.5} \times EF_{BC}$$

Where:

$Emis_{BC}$: BC emissions (t)

$Emis_{PM2.5}$: $PM_{2.5}$ emissions (t)

EF_{BC}: BC emission factor (% $PM_{2.5}$)

4.3.5.3 Emission Factors

The emission factors used are listed in the table below. According to Section 3.2.2 (page 14) of chapter "2.B Chemical Industry" of EMEP/EEA air pollutant emission inventory guidebook 2016, "as a default distribution between TSP, PM10 and PM2.5, PM10 and PM2.5 can be assumed to be 0.8 × TSP and 0.6 × TSP".

Table 4-16: Default emission factor

Tehcnology/Practice	Pollutant	Unit	EF	Source
Chloride Process	SO_x	Kg/t	1.14	Table 3.19 of chapter "2.B Chemical Industry" of EMEP/EEA air pollutant emission inventory guidebook 2016
	NO_x	Kg/t	0.1	
	CO	Kg/t	159	
	TSP	Kg/t	0.2	
	PM_{10}	Kg/t	0.16	Section 3.2.2 (page 14) of chapter "2.B Chemical Industry" of EMEP/EEA air pollutant emission inventory guidebook 2016
	$PM_{2.5}$	Kg/t	0.12	Section 3.2.2 (page 14) of chapter "2.B Chemical Industry" of EMEP/EEA air pollutant emission inventory guidebook 2016
	BC	% $PM_{2.5}$	1.8	Table 3.1 of chapter "2.B Chemical Industry" of EMEP/EEA air pollutant emission inventory guidebook 2016
Sulphate Process	SO_x	Kg/t	3.97	Table 3.20 of chapter "2.B Chemical Industry" of EMEP/EEA air pollutant emission inventory guidebook 2016
	NO_x	Kg/t	0.108	
	TSP	Kg/t	0.3	
	PM_{10}	Kg/t	0.24	Section 3.2.2 (page 14) of chapter "2.B Chemical Industry" of EMEP/EEA air pollutant emission inventory guidebook 2016
	$PM_{2.5}$	Kg/t	0.18	Section 3.2.2 (page 14) of chapter "2.B Chemical Industry" of EMEP/EEA air pollutant emission inventory guidebook 2016
	BC	% $PM_{2.5}$	1.8	Table 3.1 of chapter "2.B Chemical Industry" of EMEP/EEA air pollutant emission inventory guidebook 2016

4.3.5.4 Activity Data

From 2014 onwards, there is Titanium Dioxide production according to EUROSTAT data.

There is no information on the type of process used in Portugal (Chloride or Sulphate process). Given so, we have considered the share proposed in the BREF document of “Large Volume Inorganic Chemicals – Solids and Others” (Chloride Process = 30% and Sulphate Process = 70% of the total Titanium Dioxide Production).

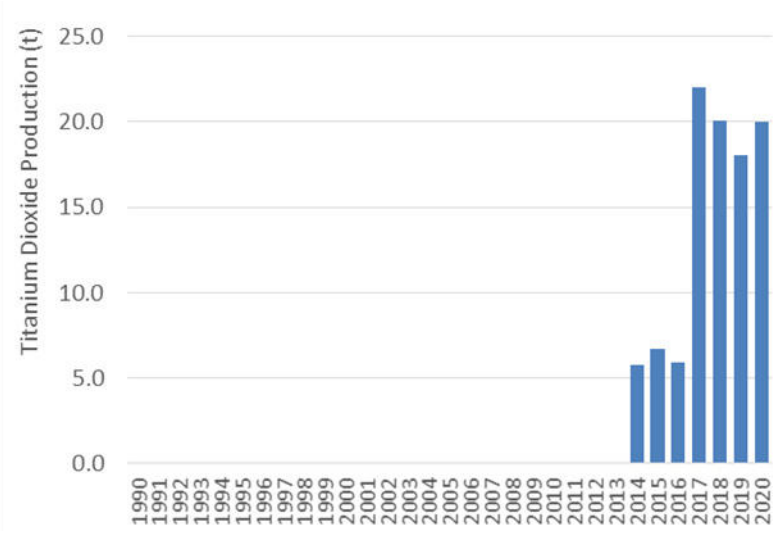


Figure 4-18: Titanium Dioxide Production

4.3.5.5 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.

4.3.5.6 Recalculations

2019 activity data was updated according to EUROSTAT.

4.3.5.7 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.

4.3.6 Other Chemical Industry - Sulphuric Acid Production (NFR 2.B.10.a – SNAP 040401)

4.3.6.1 Category description

In 1990 in Portugal there were two industrial units producing sulphuric acid from mineral processing and two additional industrial plants producing H_2SO_4 by recovery of sulphur. In 1990 and 1991, both industrial plants producing sulphuric acid from pyrites were closed and thereafter only sulphur recovery process remained active. In 2008, emissions of SO_x from sulphuric acid production resulted from recovery of sulphur - and abatement of air emission - in an ammonia industrial plant that used a high sulphur content raw material - Vacuum Residual Fuel oil (VRF) - as feedstock. In 2009, the only facility that produced ammonia in Portugal was closed and the production was relocated to India.

Production of sulphuric acid (Contact Process) comprehends a first step, where SO_2 is formed from oxidation of elemental sulphur with air, followed by conversion to SO_3, in a catalytic converter, and finally the absorption of this gas in a strong acid solution.

In the case of sulphur recovery units, a flux of hydrogen sulphide, coming from the partial oxidation of the feedstock, is converted into H_2SO_4, also by air oxidation, but without previous conversion to elemental sulphur. The process then proceeds in a similar fashion to sulphuric acid production. Although emissions of SO_x from recovery of sulphur occur in the Claus unit and in the flare, all are reported in the same source category (NFR 2.B.10.a – Other Chemical Industry) in NFR tables. For reporting of acidification emissions, in NFR reporting format, only emissions in the Claus unit are reported in 2.B.10.a, while emissions in the flare – a lesser source however – are reported in 1.B.2.c – Flaring in chemical industries.

4.3.6.2 Methodology

In the case of sulphur recovery with sulphuric acid production, total SOx emissions are estimated from the knowledge of sulphur content in original feedstock, considering the recovery efficiency and assuming that all sulphur in feedstock is recovered or goes to atmosphere[5]:

Equation 4-19: SO_2 emissions from sulphuric acid production

$$Emi_{SOx(y)} = 2 * Feedstock_{(y)} * S_{Feed(y)} * 10^{-2} – 32/98 * Prod_{H2SO4\,(y)}$$

Where:

$EmiSOx_{(y)}$: Emission of Sulphur oxides[6] (t)

$FeedStock_{(y)}$: Annual consumption of feedstock (t)

$S_{Feed(y)}$: Sulphur content of feedstock (%)

$Prod_{H2SO4\,(y)}$: Production of Sulphuric acid from Sulphur recovery in year y (t)

[5] For the time being this procedure is only feasible for two years: 1990 and 1993. For the remaining years the average emission factor (kg SOx/kg S in VRF) for 1990 and 1993 was used to estimate emissions.

[6] In fact, this emissions include also H_2S and other Sulphur compounds, but it is assumed that they are converted to SO_x in atmosphere.

4.3.6.3 Emission Factors

Due to confidentiality constraints, the emission factors for sulphuric acid are not published.

4.3.6.4 Activity Data

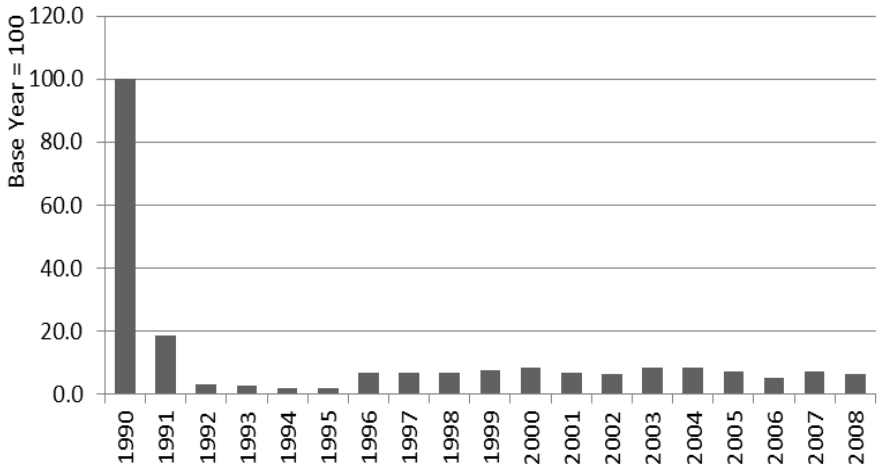


Figure 4-19: Trend in total sulphuric acid production, including sulphur recovery

The amount of sulphur recovered and transformed into sulphuric acid is only available for a limited number of years (1990, 1993 and 1995). The remaining time series was estimated from consumption of VRF and ammonia production in the following mode:

- Consumption of feedstock VRF, and its sulphur content, was available from the only industrial plant in Portugal also for a limited number of years – 1990 till 1994 – but a strong linear relation between feedstock consumption and ammonia production could be established from available data[7];
- Production of ammonia in Portugal is available from the only existing facility for the period 1990-2008. From 2009 onwards there is no ammonia production since the facility was stopped and the production relocated to India;
- Finally a linear relation was also set between VRF consumption and the quantity of H_2SO_4 that was recovered.

4.3.6.5 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.

4.3.6.6 Recalculations

No recalculations were made.

4.3.6.7 Further Improvements

Specific issues to improve comprehend the revision of the different reporting placement for SOx emissions from flaring in Sulphur recovery.

[7] For confidentiality reasons original data and relation may not be reported in IIR

4.3.7 Other Chemical Industry - Ammonium Sulphate Production (NFR 2.B.10.a – SNAP 040404)

4.3.7.1 Category description

Ammonium sulfate is commonly used as fertilizer. In Portugal, Ammonium sulfate is synthetically manufactured through reaction of ammonia with sulphuric acid. This chapter addresses emissions estimates from the production of ammonium sulphate.

4.3.7.2 Methodology

Emissions from TSP, PM_{10} and $PM_{2.5}$ were estimated according to the following equation:

Equation 4-20: Emissions from ammonium sulphate production

$$Emi_x = AD \times \frac{EF_x}{1000}$$

Where:

Emi_x: Emissions of pollutant "x" (t)

AD: Ammonium Sulphate production data (t Ammonium Sulphate)

EF_x: Emission factor of pollutant "x" (kg/t Ammonium Sulphate)

For BC:

Equation 4-21: Black carbon emissions from ammonium sulphate production

$$Emi_{BC} = Emis_{PM2.5} \times EF_{BC}$$

Where:

Emi_{BC}: BC emissions (t)

$Emis_{PM2.5}$: $PM_{2.5}$ emissions (t)

EF_{BC}: BC emission factor (% $PM_{2.5}$)

4.3.7.3 Emission Factors

Upon a regional survey carried out in a national fertilizer production compound, it was learned that ammonia sulphate production process used rotary dryers and wet scrubbers as emissions control equipments. For this reason, we considered TSP emission factor from Table 8.4 of chapter "8.4 Ammonium Sulphate" of USEPA AP-42 to be the most adequate EF given national circumstances.

There are no emission factors for PM10, PM2.5 and BC from ammonia sulphate production in USEPA AP-42 or in 2019 EMEP Guidebook.

According to Section 3.2.2 (page 14) of chapter "2.B Chemical Industry" of 2019 EMEP Guidebook, when EF is only available for TSP, "as a default distribution between TSP, PM10 and PM2.5, PM10 and PM2.5 can be assumed to be 0.8 × TSP and 0.6 × TSP". Therefore, we applied this principle to the TSP emission factor used from USEPA.

BC emission factor was taken from Table 3.1 from chapter "2.B Chemical Industry" of 2019 EMEP Guidebook, which is, according to that guidebook, applicable for 'general' chemical industry and may be combined with process specific emissions of PM2.5. Therefore, we also applied this principle.

The emission factors used are listed in the table below.

Table 4-17: Emission factors

Pollutant	Unit	EF	Source
TSP	Kg/t	0.02	Table 8.4-1 of chapter "8.4 Ammonium Sulphate" of USEPA AP-42 emission factors
PM_{10}	Kg/t	0.016	Section 3.2.2 (page 14) of chapter "2.B Chemical Industry" of EMEP/EEA air pollutant emission inventory guidebook 2019
$PM_{2.5}$	Kg/t	0.012	Section 3.2.2 (page 14) of chapter "2.B Chemical Industry" of EMEP/EEA air pollutant emission inventory guidebook 2019
BC	% $PM_{2.5}$	1.8	Table 3.1 of chapter "2.B Chemical Industry" of EMEP/EEA air pollutant emission inventory guidebook 2019

4.3.7.4 Activity Data

From 1995 onwards, ammonium sulphate production was obtained from INE. In the period 1990-1994, data has been estimated based on 1995 production value and on GDP trend.

Due to confidentiality constraints (there is only one ammonium sulphate production plant in Portugal), the activity data is presented as an index value (1990=100%).

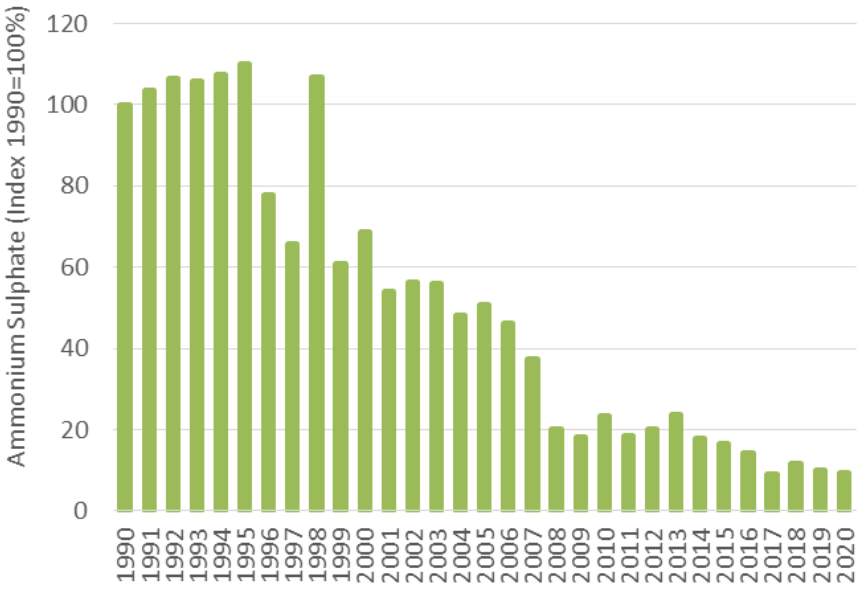


Figure 4-20: Ammonium Sulphate production (Index 1990=100%)

4.3.7.5 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.

4.3.7.6 Recalculations

No recalculations were made.

4.3.7.7 Further Improvements

Efforts will be made in order to obtain plant specific production data in the period 1990-1994.

4.3.8 Other Chemical Industry - Explosives Manufacturing (NFR 2.B.10.a – SNAP 040622)

4.3.8.1 Category description

This chapter addresses emissions estimates from the production of explosives.

4.3.8.2 Methodology

Emissions were estimated according to the following equation:

Equation 4-22: Emissions from explosives manufacturing

$$Emi_x = AD \times \frac{EF_x}{1000}$$

Where:

Emi_x: Emissions of pollutant "x" (t)

AD: Explosives production data (t)

EF_x: Emission factor of pollutant "x" (kg/t explosives)

4.3.8.3 Emission Factors

SO_x and NO_x emission factors used were taken from USEPA AP-42 and are listed in the table below.

Table 4-18: Emission factors

Pollutant	Type of Explosive	Unit	EF	Source
SOx	Smokeless Powder	kg/t Explosive	34.7	Table 6.3-2 of chapter 6.3 Explosives of USEPA AP-42
	Dynamite and Nitroglycerine	kg/t Explosive	34.7	
	Nitrocellulose	kg/t Explosive	34,7	
	TNT	kg/t Explosive	36.5	
NOx	Smokeless Powder	kg/t Explosive	14.0	
	Dynamite and Nitroglycerine	kg/t Explosive	14.0	
	Nitrocellulose	kg/t Explosive	14.0	
	TNT	kg/t Explosive	78.5	

4.3.8.4 Activity Data

Activity data was obtained from INE for the whole time series.

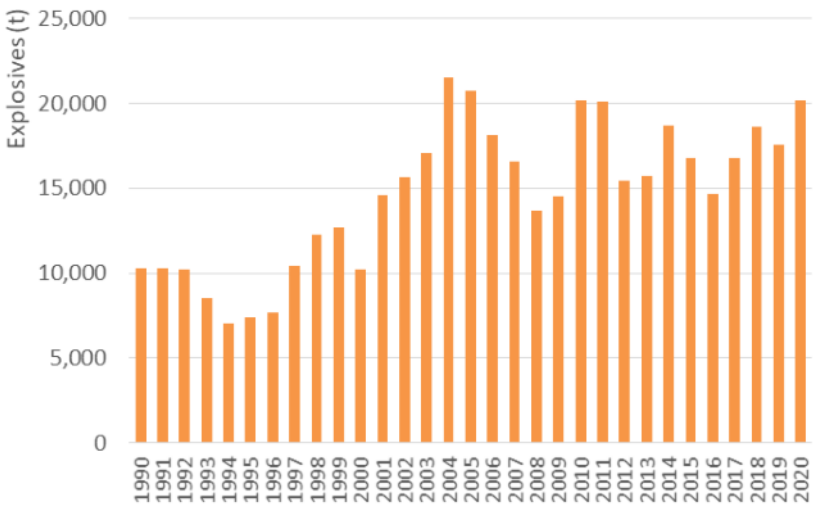


Figure 4-21: Explosives production

4.3.8.5 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.

4.3.8.6 Recalculations

No recalculations were made.

4.3.8.7 Further Improvements

No further improvements are expected.

4.3.9 Other Chemical Industry - Ammonium Nitrate Production (NFR 2.B.10.a – SNAP 040405)

4.3.9.1 Category description

This chapter addresses emissions estimates from the production of ammonium nitrate.

4.3.9.2 Methodology

Emissions from Ammonium Nitrate production were estimated according to the following equation:

Equation 4-23: Emissions from ammonium nitrate production

$$Emi_x = AD \times \frac{EF_x}{1000}$$

Where:

Emi_x: Emissions of pollutant "x" (t)

AD: Ammonium Nitrate production data (t)

EF_x: Emission factor of pollutant "x" (kg/t Ammonium Nitrate)

4.3.9.3 Emission Factors

The emission factors used are listed in the tables below.

Table 4-19: Solids formation operations

Pollutant	Unit	EF	Source
NH3	Kg/t Ammonium Nitrate	1.4	Plant Specific data
TSP	Kg/t Ammonium Nitrate	2.5	Plant Specific Data
PM_{10}	Kg/t Ammonium Nitrate	2.0	Chapter 8.3 Ammonium Nitrate of USEPA AP-42
$PM_{2.5}$	Kg/t Ammonium Nitrate	2.0	Chapter 8.3 Ammonium Nitrate of USEPA AP-42

Table 4-20: Neutralizer and Evaporator

Pollutant	Unit	EF	Source
NH3	Kg/t Ammonium Nitrate	2.0	Chapter 8.3 Ammonium Nitrate of USEPA AP-42
TSP	Kg/t Ammonium Nitrate	2.4	Chapter 8.3 Ammonium Nitrate of USEPA AP-42
PM_{10}	Kg/t Ammonium Nitrate	2.4	Expert Judgement
$PM_{2.5}$	Kg/t Ammonium Nitrate	2.4	Expert Judgement

4.3.9.4 Activity Data

From 1992 onwards, ammonium sulphate production was obtained from INE. In the period 1990-1991, data has been estimated based on 1992 production value and on GDP trend.

Due to confidentiality constraints, ammonium nitrate production is presented as an index value related to 1990 production.

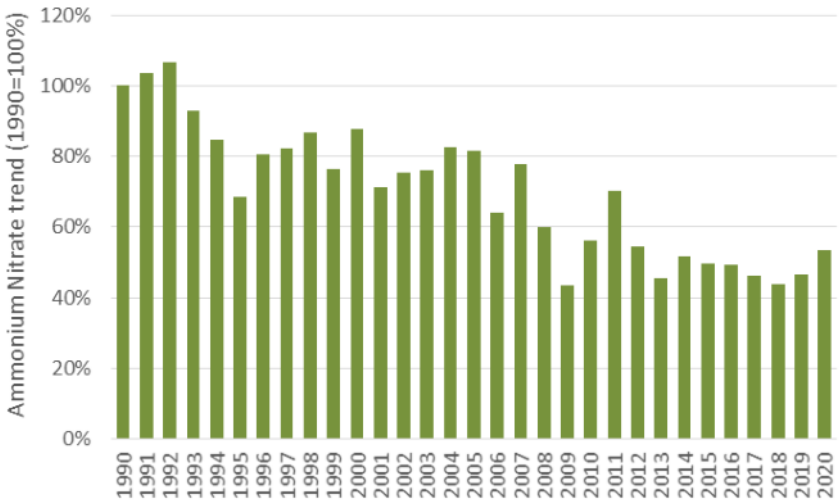


Figure 4-22: Ammonium Nitrate production (1990=100%)

4.3.9.5 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.

4.3.9.6 Recalculations

No recalculations were made.

4.3.9.7 Further Improvements

No further improvements are expected.

4.3.10 Other Chemical Industry - Ammonium Phosphates Production (NFR 2.B.10.a – SNAP 040406)

4.3.10.1 Category description

This chapter addresses emissions estimates from the production of ammonium phosphates.

4.3.10.2 Methodology

Emissions from Ammonium Phosphates production were estimated in accordance with EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2016).

Emissions from TSP, PM_{10} and $PM_{2.5}$ were estimated according to the following equation:

Equation 4-24: Emissions from ammonium phosphates production

$$Emi_x = AD \times \frac{EF_x}{1000}$$

Where:

Emi_x: Emissions of pollutant "x" (t)

AD: Ammonium Phosphates production data (t)

EF_x: Emission factor of pollutant "x" (kg/t Ammonium Phosphates)

For BC:

Equation 4-25: Black carbon emissions from ammonium phosphates production

$$Emi_{BC} = Emis_{PM2.5} \times EF_{BC}$$

Where:

Emi_{BC}: BC emissions (t)

$Emis_{PM2.5}$: $PM_{2.5}$ emissions (t)

EF_{BC}: BC emission factor (% $PM_{2.5}$)

4.3.10.3 Emission Factors

The emission factors used are listed in the table below.

Table 4-21: Emission factors

Pollutant	Unit	EF	Source
TSP	g/t Ammonium Phosphates	300	Table 3.28 of chapter "2.B Chemical Industry" of EMEP/EEA air pollutant emission inventory guidebook 2016
PM_{10}	g/t Ammonium Phosphates	240	
$PM_{2.5}$	g/t Ammonium Phosphates	180	
BC	% $PM_{2.5}$	1.8	Table 3.1 of chapter "2.B Chemical Industry" of EMEP/EEA air pollutant emission inventory guidebook 2016

4.3.10.4 Activity Data

From 1992 onwards, ammonium phosphates production was obtained from INE. In the period 1990-1991, data was estimated based on 1992 ammonium phosphates production and on GDP trend.

Due to confidentiality constraints, data is presented as an index value related to year 1990 production.

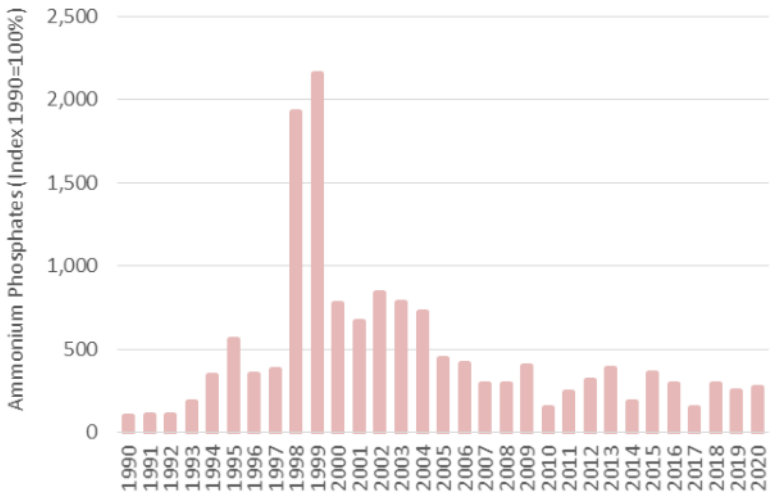


Figure 4-23: Ammonium Phosphates (Index 1990=100%)

4.3.10.5 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.

4.3.10.6 Recalculations

No recalculations were made.

4.3.10.7 Further Improvements

No further improvements are planned for this sector.

4.3.11 Other Chemical Industry - NPK Fertilisers Production (NFR 2.B.10.a – SNAP 040407)

4.3.11.1 Category description

This chapter addresses emissions estimates from the production of NPK fertilisers.

4.3.11.2 Methodology

Emissions from NPK Fertilisers production were estimated in accordance with EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2016).

Emissions from NH_3, TSP, PM_{10} and $PM_{2.5}$ were estimated according to the following equation:

Equation 4-26: Emissions from NPK Fertilisers production

$$Emi_x = AD \times \frac{EF_x}{1000}$$

Where:

Emi_x: Emissions of pollutant "x" (t)

AD: NPK Fertilisers production data (t)

EF_x: Emission factor of pollutant "x" (kg/t NPK Fertilisers)

Emissions from BC were estimated according to the following equation:

Equation 4-27: Black carbon emissions from NPK Fertilisers production

$$Emi_{BC} = Emis_{PM2.5} \times EF_{BC}$$

Where:

Emi_{BC}: BC emissions (t)

$Emis_{PM2.5}$: $PM_{2.5}$ emissions (t)

EF_{BC}: BC emission factor (% $PM_{2.5}$)

4.3.11.3 Emission Factors

The emission factors used are listed in the table below.

Table 4-22: Emission factors

Pollutant	Unit	EF	Source
NH_3	Kg/t NPK Fertilisers	1.84	Plant specific monitoring data
TSP	Kg/t NPK Fertilisers	4.22	Plant specific monitoring data
PM_{10}	Kg/t NPK Fertilisers	3.43	Expert Judgement
$PM_{2.5}$	Kg/t NPK Fertilisers	3.41	Expert Judgement
BC	% $PM_{2.5}$	1.8	Table 3.1 of chapter "2.B Chemical Industry" of EMEP/EEA air pollutant emission inventory guidebook 2016

4.3.11.4 Activity Data

From 1992 onwards, NPK fertilisers' production was obtained from national statistics. In the period 1990-1991, data was estimated based on 1992 NPK fertilisers production and on gross domestic product trend.

Due to confidentiality constraints, data is presented as an index value related to year 1990 production.

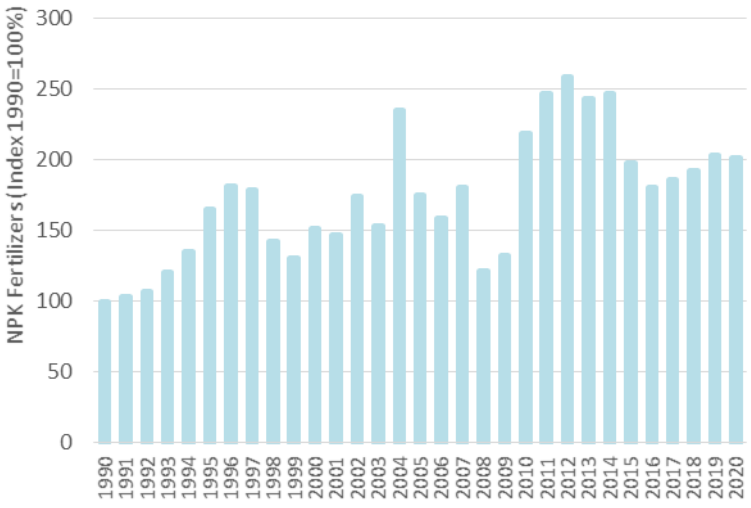


Figure 4-24: NPK Fertilisers production (Index 1990=100%)

4.3.11.5 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.

4.3.11.6 Recalculations

No recalculations were made.

4.3.11.7 Further Improvements

Efforts will be made in order to update plant specific emission factors based on monitoring data.

4.3.12 Other Chemical Industry - Urea Production (NFR 2.B.10.a – SNAP 040408)

4.3.12.1 Category description

This chapter addresses emissions estimates from the production of urea. Urea is produced commercially from synthetic ammonia and carbon dioxide.

4.3.12.2 Methodology

Emissions from urea production were estimated in accordance with EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2016).

Emissions from NH_3, TSP, PM_{10} and $PM_{2.5}$ were estimated according to the following equation:

Equation 4-28: Emissions from Urea production

$$Emi_x = AD \times \frac{EF_x}{1000}$$

Where:

Emi_x: Emissions of pollutant "x" (t)

AD: Urea production data (t)

EF_x: Emission factor of pollutant "x" (kg/t Urea)

Emissions from BC were estimated according to the following equation:

Equation 4-29: Black carbon emissions from Urea production

$$Emi_{BC} = Emis_{PM2.5} \times EF_{BC}$$

Where:

Emi_{BC}: BC emissions (t)

$Emis_{PM2.5}$: $PM_{2.5}$ emissions (t)

EF_{BC}: BC emission factor (% $PM_{2.5}$)

4.3.12.3 Emission Factors

The emission factors used are listed in the table below.

Table 4-23: Emission factors

Pollutant	Unit	EF	Source
NH_3	Kg/t Urea	2.5	Table 3.29 of chapter "2.B Chemical Industry" of EMEP/EEA air pollutant emission inventory guidebook 2016
TSP	Kg/t Urea	1.5	
PM_{10}	Kg/t Urea	1.2	
$PM_{2.5}$	Kg/t Urea	0.9	
BC	% $PM_{2.5}$	2	

4.3.12.4 Activity Data

In the periods 1992-2008 and from 2010 onwards, urea production was obtained from INE. In year 2009, data was obtained from EUROSTAT due to lack of information in INE. In the period 1990-1991, data was estimated based on 1992 production and on GDP trend for this period.

Due to confidentiality constraints, data is presented as an index value related to year 1990 production.

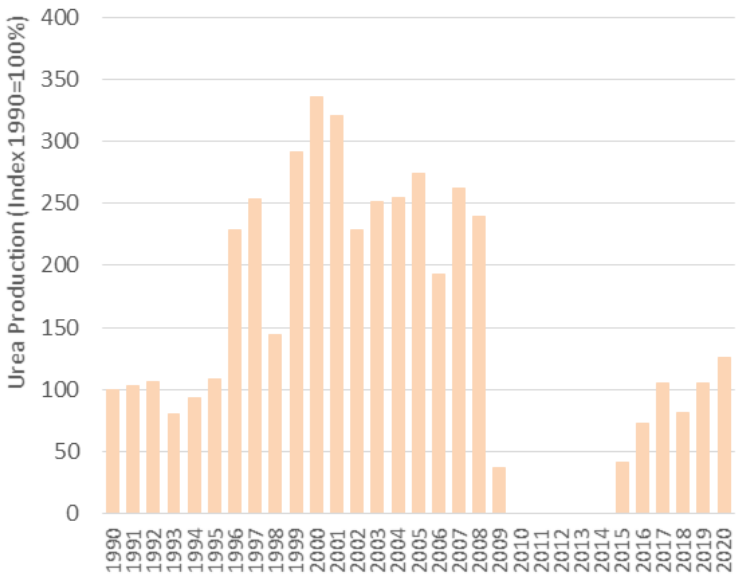


Figure 4-25: Trend in Urea production

There is no urea production in Portugal in the period 2010-2014.

4.3.12.5 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.

4.3.12.6 Recalculations

No recalculations were made.

4.3.12.7 Further Improvements

Efforts will be made in order to obtain plant specific urea production data.

4.3.13 Other Chemical Industry - Carbon Black Production (NFR 2.B.10.a – SNAP 040409)

4.3.13.1 Category description

This chapter addresses emissions estimates from the production of carbon black.

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 ceased in 2013.

4.3.13.2 Methodology

For this sub-sector emissions estimates are extensively based on the use of emission factors multiplied by quantity of material produced:

Equation 4-30: Emissions from black carbon production

$$Emission_{(p,y)} = EF_{(p)} * ActivityRate_{(y)} * 10^{-3}$$

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)

4.3.13.3 Emission Factors

In the period 2009-2012, carbon black industrial unit was subjected to a detailed inventory exercise. Consequently, emission factors were established for carbon black unit and emission estimates were extended for the rest of the time series using carbon black production as indicator of activity rate. Carbon Gas emissions include also emissions suffering partial combustion.

Table 4-24: Emission Factors for Carbon Black process emissions

Pollutant	EF (kg/t carbon black)	Source
NOx	9.390	EMEP Guidebook 2016
CO	1.160	Instalation Data
NMVOCs	0.540	Instalation Data
SOx	10.96	Sulphur Balance Approach
TSP	0.148	Instalation Data
PM10	0.133	Instalation Data
PM2.5	0.130	Instalation Data
BC	0.013	EMEP Guidebook 2016

4.3.13.4 Activity Data

Due to confidentiality constraints, data is presented as an index value related to year 1990 production.

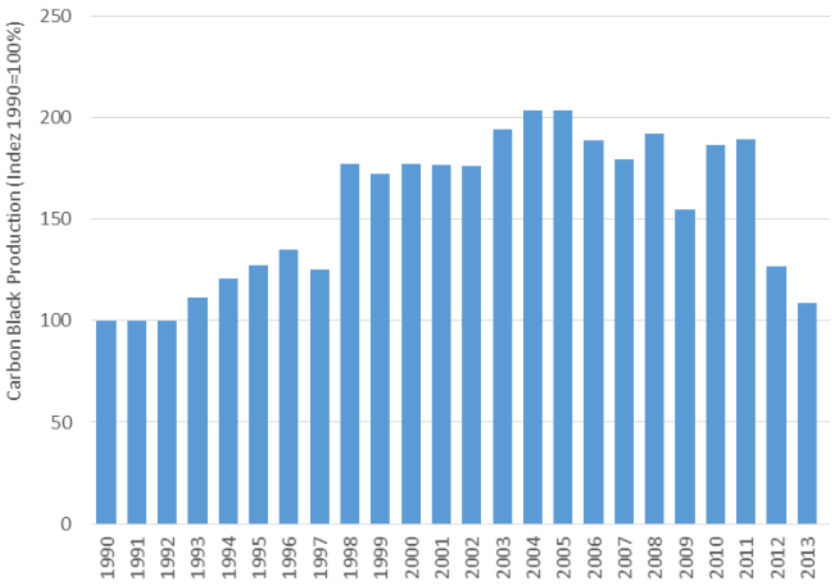


Figure 4-26: Carbon Black production

4.3.13.5 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.

4.3.13.6 Recalculations

No recalculations were made.

4.3.13.7 Further Improvements

No further improvements are expected.

4.3.14 Other Chemical Industry - Graphite Production (NFR 2.B.10.a – SNAP 040411)

There is no relevant activity on graphite production in Portugal. In INE there is only data in year 2000. Furthermore, there are no emission factors for this category in the EMEP/EEA air pollutant emission inventory guidebook 2016.

4.3.15 Other Chemical Industry - Chlorine Production (NFR 2.B.10.a – SNAP 040413)

There is only one plant producing chlorine in Portugal by the membrane cell electrolysis process. There are no emission factors for this process in the EMEP/EEA air pollutant emission inventory guidebook 2016.

4.3.16 Other Chemical Industry - Phosphate Fertilisers Production (NFR 2.B.10.a – SNAP 040414)

Considered in “NPK Fertilisers” in chapter 4.3.11 (SNAP 040407).

4.3.17 Other Chemical Industry - Ethylene Production (NFR 2.B.10.a – SNAP 040501)

4.3.17.1 Category description

This chapter addresses emissions estimates from the production of ethylene.

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 Poly Ethylene (LDPE) and High Density Poly Ethylene (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 NMVOC emissions.

4.3.17.2 Methodology

NMVOC emissions were estimated according to:

Equation 4-31: NMVOC emissions from ethylene production

$$Emi_{NMVOC} = AD \times \frac{EF_{NMVOC}}{1000}$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

AD: Ethylene production data (t)

EF_{NMVOC}: Emission factor of NMVOC (kg/t Ethylene)

4.3.17.3 Emission Factors

NMVOC emission factor was taken from EMEP Guidebook 2019 and is indicated in the table below.

Table 4-25: Emission factor

Pollutant	Unit	EF	Source
NMVOC	kg/t ethylene	0.6	Table 3.36 of chapter "2.B. Chemical Industry" of "EMEP/EEA emission inventory guidebook 2019".

4.3.17.4 Activity Data

There is only one plant producing ethylene in Portugal. Activity data was obtained directly from the facility 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 was due to an interruption in the production lines.

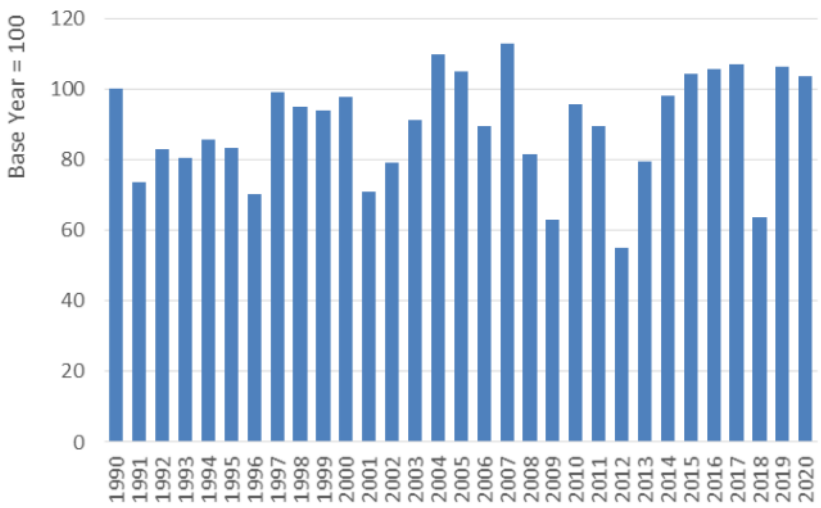


Figure 4-27: Trend in Ethylene production

4.3.17.5 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.

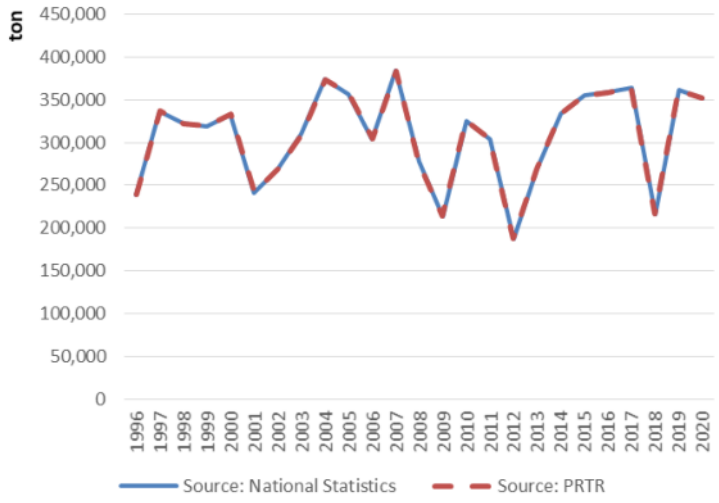


Figure 4-28: Ethylene production data – comparison of approaches

4.3.17.6 Recalculations

No recalculations were made.

4.3.17.7 Further Improvements

In the future, we intend to revise the emission factors based on monitoring data.

4.3.18 Other Chemical Industry - 1,2-Dichloroethane + Vinylchloride Production (balanced process) (NFR 2.B.10.a – SNAP 040505)

4.3.18.1 Category description

This chapter addresses emissions estimates from the production of vinylchloride.

We consider that vinyl chloride monomer (VCM) is produced from ethylene by a balanced process, as follows:

Equation 4-32: Chemical conversion equations

$$2C_2H_4 + Cl_2 + \frac{1}{2}O_2 \rightarrow 2CH_2CHCl + H_2O \qquad (Ethylene\ Dichloride - VCM\ Reaction)$$

$$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O \qquad (Feedstock\ Oxidation\ Reaction)$$

4.3.18.2 Methodology

NMVOC emissions were estimated according to the following equation:

Equation 4-33: Emissions from vinylchloride production

$$Emi_x = AD \times \frac{EF_x}{1000}$$

Where:

Emi_x: Emissions of pollutant "x" (t)

AD: VCM production data (t)

EF_x: Emission factor of pollutant "x" (kg/t VCM)

4.3.18.3 Emission Factors

NMVOC emission factor was taken from EMEP Guidebook 2016 and is indicated in the table below.

Table 4-26: Emission factor

Pollutant	Unit	EF	Source
NMVOC	kg/t VCM	2.5	Table 3.38 of chapter "2.B. Chemical Industry" of "EMEP/EEA emission inventory guidebook 2016".

4.3.18.4 Activity Data

Activity data for year 1990 is from INE. From 1991 onwards, data is estimated based on GDP trend. Due to confidentiality constraints, VCM production is presented as a trend related to 1990 production.

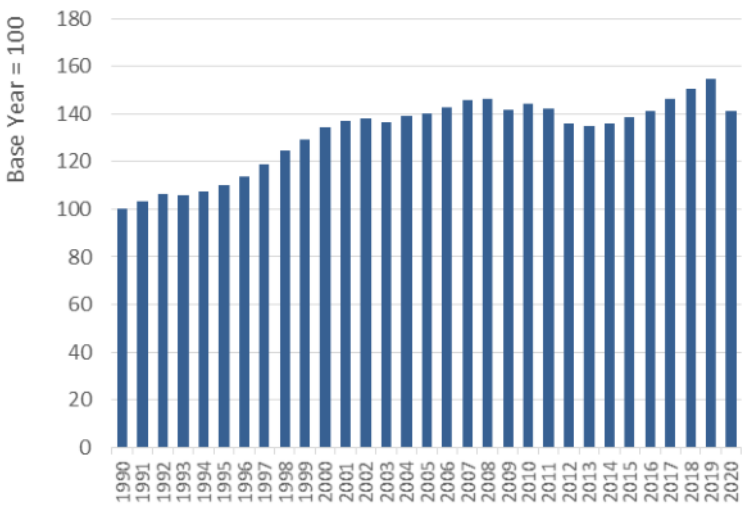


Figure 4-29: VCM production

4.3.18.5 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.

4.3.18.6 Recalculations

Recalculations occurred in 2019 upon activity data update.

4.3.18.7 Further Improvements

In the future, we intend to contact Chemical sector associations in order to obtain better quality information related to VCM production in Portugal.

4.3.19 Other Chemical Industry - Polyethylene Low Density Production (NFR 2.B.10.a – SNAP 040506)

4.3.19.1 Category description

This chapter addresses emissions estimates from the production of low density polyethylene (PELD).

4.3.19.2 Methodology

Emissions were estimated according to the following equation:

Equation 4-34: Emissions from PELD production

$$Emi_x = AD \times \frac{EF_x}{1000}$$

Where:

Emi_x: Emissions of pollutant "x" (t)

AD: PELD production data (t)

EF_x : Emission factor of pollutant "x" (kg/t PELD)

4.3.19.3 Emission Factors

TSP and NMVOC emission factors were taken from EMEP Guidebook 2016 and are indicated in the table below.

Table 4-27: Emission factors

Pollutant	Unit	EF	Source
NMVOC	Kg/t PELD	2.4	Table 3.39 of chapter "2.B. Chemical Industry" of "EMEP/EEA emission inventory guidebook 2016"
TSP	Kg/t PELD	0.031	Table 3.39 of chapter "2.B. Chemical Industry" of "EMEP/EEA emission inventory guidebook 2016"

4.3.19.4 Activity Data

Activity data was obtained from INE. Due to confidentiality constraints, Low-density polyethylene production is presented as a trend related to 1990 production.

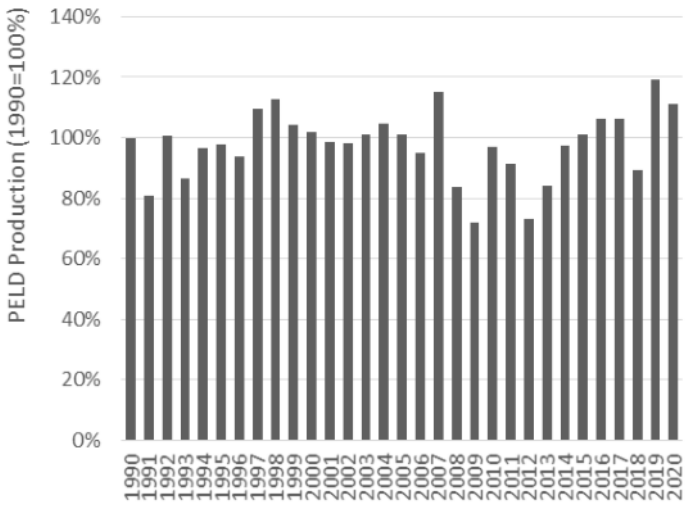


Figure 4-30: Polyethylene Low-Density (PELD) trend (1990=100%)

4.3.19.5 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.

4.3.19.6 Recalculations

2019 activity data was updated according to INE.

4.3.19.7 Further Improvements

No further improvements are expected.

4.3.20 Other Chemical Industry - Polyethylene High Density Production (NFR 2.B.10.a – SNAP 040507)

4.3.20.1 Category description

This chapter addresses emissions estimates from the production of high density polyethylene (PEHD).

4.3.20.2 Methodology

Emissions were estimated according to the following equation:

Equation 4-35: Emissions from PEHD production

$$Emi_x = AD \times \frac{EF_x}{1000}$$

Where:

Emi_x: Emissions of pollutant "x" (t)

AD: PEHD production data (t)

EF_x: Emission factor of pollutant "x" (kg/t PEHD)

4.3.20.3 Emission Factors

TSP and NMVOC emission factors were taken from EMEP Guidebook 2016 and are indicated in the table below.

Table 4-28: Emission factors

Pollutant	Unit	EF	Source
NMVOC	Kg/t PEHD	2.3	Table 3.40 of chapter "2.B. Chemical Industry" of "EMEP/EEA emission inventory guidebook 2016"
TSP	Kg/t PEHD	0.097	Table 3.40 of chapter "2.B. Chemical Industry" of "EMEP/EEA emission inventory guidebook 2016"

4.3.20.4 Activity Data

Activity data was obtained from INE. Due to confidentiality constraints, polyethylene high-density production is presented as a trend related to 1990 production.

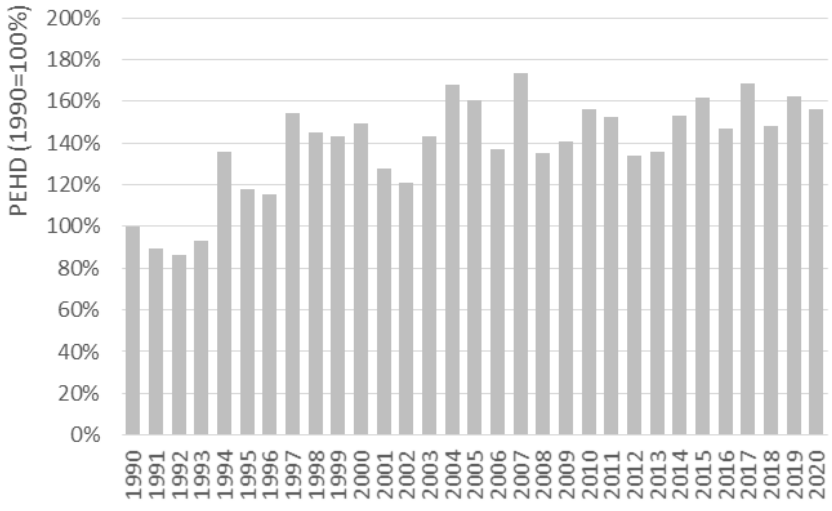


Figure 4-31: Polyethylene High-Density (PEHD) trend (1990=100%)

4.3.20.5 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.

4.3.20.6 Recalculations

2019 activity data was updated according to INE.

4.3.20.7 Further Improvements

No further improvements are expected.

4.3.21 Other Chemical Industry - Polypropylene Production (NFR 2.B.10.a – SNAP 040509)

4.3.21.1 Category description

This chapter addresses emissions estimates from the production of polypropylene (PP).

4.3.21.2 Methodology

Emissions were estimated according to the following equation:

Equation 4-36: Emissions from polypropylene production

$$Emi_x = AD \times \frac{EF_x}{1000}$$

Where:

Emi_x: Emissions of pollutant "x" (t)

AD: Polypropylene production data (t)

EF_x : Emission factor of pollutant "x" (kg/t Polypropylene)

4.3.21.3 Emission Factors

TSP and NMVOC emission factors were taken from EMEP Guidebook 2016 and are indicated in the table below.

Table 4-29: Emission factors

Pollutant	Unit	EF	Source
NMVOC	kg/t Polypropylene	4.0	Table 3.43 of chapter "2.B. Chemical Industry" of "EMEP/EEA emission inventory guidebook 2016"
TSP	kg/t Polypropylene	1.5	Table 3.43 of chapter "2.B. Chemical Industry" of "EMEP/EEA emission inventory guidebook 2016"

4.3.21.4 Activity Data

Activity data was obtained from INE. Due to confidentiality constraints, polypropylene production is presented as a trend related to 1990 production.

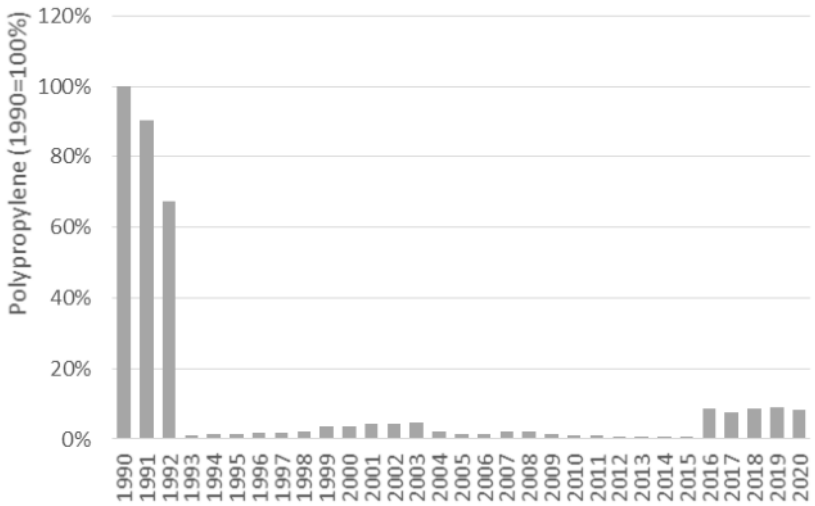


Figure 4-32: Polypropylene trend (1990=100%)

4.3.21.5 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.

4.3.21.6 Recalculations

2019 activity data was updated.

4.3.21.7 Further Improvements

No further improvements are expected.

4.3.22 Other Chemical Industry - Polystyrene Production (NFR 2.B.10.a – SNAP 040511)

4.3.22.1 Category description

This chapter addresses emissions estimates from the production of polystyrene.

4.3.22.2 Methodology

Emissions were estimated according to the following equation:

Equation 4-37: Emissions from polystyrene production

$$Emi_x = AD \times \frac{EF_x}{1000}$$

Where:

Emi_x: Emissions of pollutant "x" (t)

AD: Polystyrene production data (t)

EF_x : Emission factor of pollutant "x" (kg/t Polystyrene)

4.3.22.3 Emission Factors

TSP and NMVOC emission factors were taken from EMEP Guidebook 2016 and are indicated in the table below.

Table 4-30: Emission factors

Pollutant	Unit	EF	Source
NMVOC	kg/t Polystyrene	0.12	Table 3.45 of chapter "2.B. Chemical Industry" of "EMEP/EEA emission inventory guidebook 2016"
TSP	kg/t Polystyrene	0.004	Table 3.45 of chapter "2.B. Chemical Industry" of "EMEP/EEA emission inventory guidebook 2016"

4.3.22.4 Activity Data

From 1992 onwards, activity data was obtained from INE. In the period 1990-1991, data was estimated based on 1992 production and on GDP trend. Due to confidentiality constraints, polystyrene production is presented as a trend related to 1990 production.

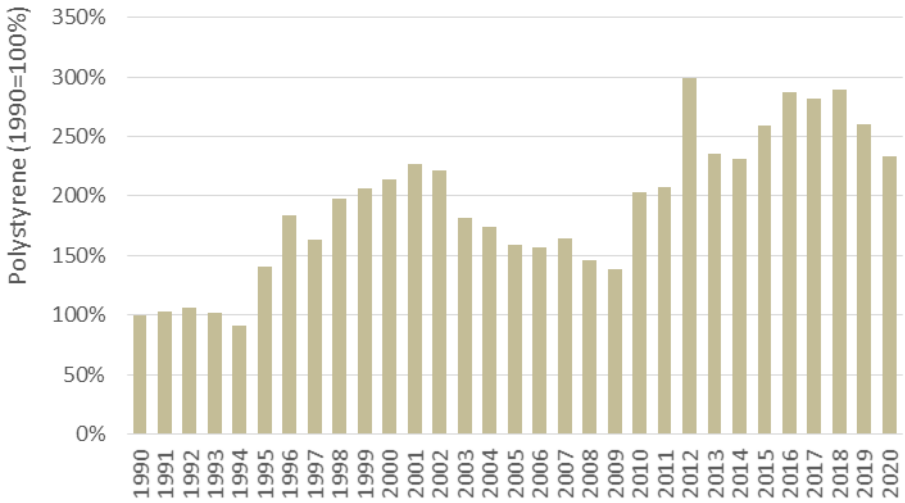


Figure 4-33: Polystyrene trend (1990=100%)

4.3.22.5 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.

4.3.22.6 Recalculations

No recalculations were made.

4.3.22.7 Further Improvements

No further improvements are expected.

4.3.23 Other Chemical Industry - Formaldehyde Production (NFR 2.B.10.a – SNAP 040517)

4.3.23.1 Category description

This chapter addresses emissions estimates from the production of formaldehyde.

4.3.23.2 Methodology

Emissions were estimated according to the following equation:

Equation 4-38: Emissions from formaldehyde production

$$Emi_x = AD \times \frac{EF_x}{1000}$$

Where:

Emi_x: Emissions of pollutant "x" (t)

AD: Formaldehyde production data (t)

EF_x : Emission factor of pollutant "x" (kg/t Formaldehyde)

4.3.23.3 Emission Factors

CO, TSP and NMVOC emission factors were taken from EMEP Guidebook 2016 and are indicated in the table below.

Table 4-31: Emission factors

Pollutant	Unit	EF	Source
NMVOC	kg/t Formaldehyde	7	Table 3.53 of chapter "2.B. Chemical Industry" of "EMEP/EEA emission inventory guidebook 2016"
TSP	kg/t Formaldehyde	0.004	Table 3.53 of chapter "2.B. Chemical Industry" of "EMEP/EEA emission inventory guidebook 2016"
CO	kg/t Formaldehyde	12	Table 3.53 of chapter "2.B. Chemical Industry" of "EMEP/EEA emission inventory guidebook 2016"

4.3.23.4 Activity Data

Activity data was obtained from INE. Due to confidentiality constraints, formaldehyde production is presented as a trend related to 1990 production.

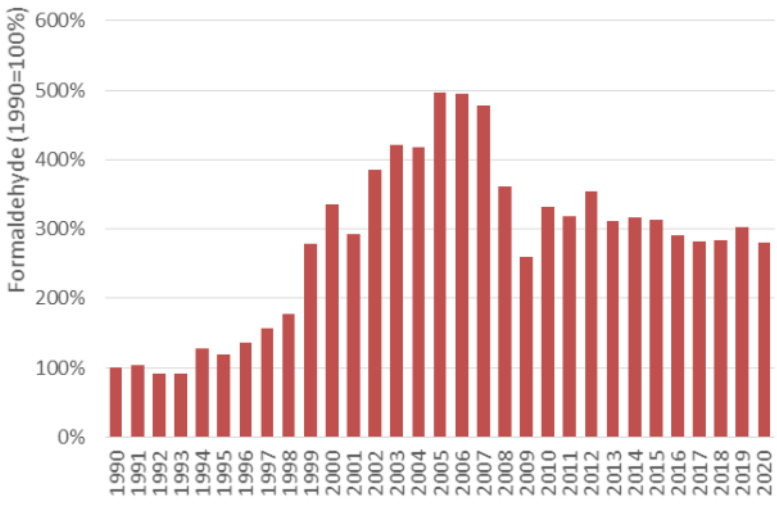


Figure 4-34: Formaldehyde trend (1990=100%)

4.3.23.5 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.

4.3.23.6 Recalculations

No recalculations were made.

4.3.23.7 Further Improvements

No further improvements are expected.

4.3.24 Other Chemical Industry - Phthalic Anhydride Production (NFR 2.B.10.a – SNAP 040519)

4.3.24.1 Category description

This chapter addresses emissions estimates from the production of phthalic anhydride.

4.3.24.2 Methodology

Emissions were estimated according to the following equation:

Equation 4-39: Emissions from phthalic anhydride production

$$Emi_x = AD \times \frac{EF_x}{1000}$$

Where:

Emi_x: Emissions of pollutant "x" (t)

AD: Phthalic anhydride production data (t)

EF_x : Emission factor of pollutant "x" (kg/t Phthalic anhydride)

4.3.24.3 Emission Factors

Emission factors were taken from USEPA AP-42 and are indicated in the table below.

Table 4-32: Emission factors

Pollutant	Unit	EF	Source
SOx	kg/t Phthalic Anhydride	4.7	Table 6.5-1 of chapter 6.5 Phthalic Anhydride of USEPA AP-42
NMVOC	kg/t Phthalic Anhydride	1.2	Table 6.5-1 of chapter 6.5 Phthalic Anhydride of USEPA AP-42
CO	kg/t Phthalic Anhydride	151.0	Table 6.5-1 of chapter 6.5 Phthalic Anhydride of USEPA AP-42
TSP	kg/t Phthalic Anhydride	120.4	Table 6.5-1 of chapter 6.5 Phthalic Anhydride of USEPA AP-42

4.3.24.4 Activity Data

From 2015 onwards, activity data was obtained from INE. In the period 1990-2014, data was estimated based on 2015 production and on GDP trend. Due to confidentiality constraints, phthalic anhydride production is presented as a trend related to 1990 production.

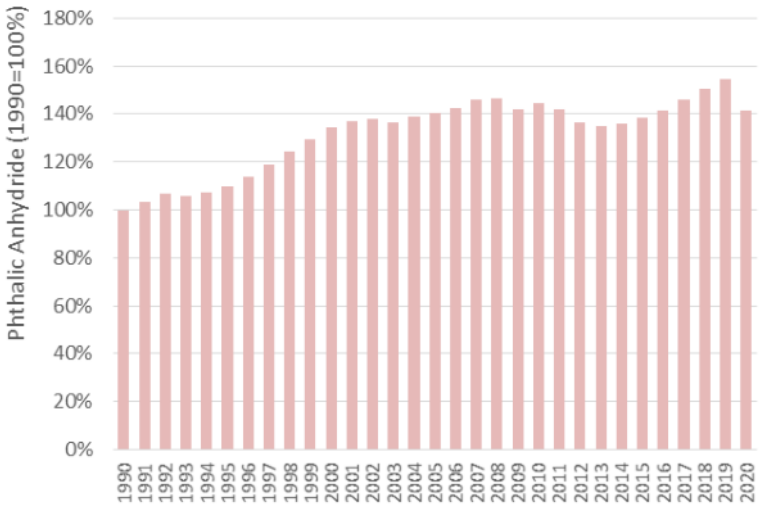


Figure 4-35: Phthalic Anhydride production trend (1990=100%)

4.3.24.5 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.

4.3.24.6 Recalculations

2019 activity data was updated.

4.3.24.7 Further Improvements

In the future, we intend to contact Chemical sector associations in order to obtain better quality information related to Phthalic Anhydride production in Portugal.

4.4 Metal Industry (NFR 2.C)

4.4.1 Iron and Steel Production (NFR 2.C.1)

4.4.1.1 Category description

The iron and steel industry is a highly material and energy-intensive industry. More than half of the mass input becomes outputs in the form of off-gases and solid wastes or by-products. The contribution of this sector to the total emissions to air is considerable for a number of pollutants, especially for some heavy metals and polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/F).

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 2019 EMEP Guidebook, metallurgical coke production is considered to be 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). 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 emissions from various pollutants from oxidation of the coke breeze and other inputs. These emissions are reported and addressed in this chapter.

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), resulting in air emissions of carbon monoxide (CO), carbon dioxide (CO2) and NMVOCs. 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 2019 EMEP Guidebook, 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.

According to the 2019 EMEP Guidebook, all emissions of NOx, SOx and CO are assumed to originate from the combustion activities in the blast furnace; these emissions are included in source category 1.A.2.a. 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. 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 2019 EMEP Guidebook, 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.

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Emissions of carbon may occur as CO and NMVOC but it is assumed that they are subsequently converted in atmosphere in CO_2. Some carbon may remain in pig iron after initial reducing in BF and partly may be emitted from oxidation in the BOF. Also EAF furnaces may result in carbon emission but from consumption of graphite anodes in the process.

Other pollutants may be emitted during steel production as result of its presence (or presence of its precursors) in original ore or in the material used to produce coke. That is the case of SO_x and heavy metals. But because combustion occurs with contact, emissions are modified - increase or decrease - by contact of combustion gases with products and emissions cannot be estimated by mass balance alone.

NO_x is formed from reaction of atmospheric nitrogen at high temperatures, which may result from fuel combustion or from high temperature generated at production processes.

Finally, particulate materials result from handling and storage of materials, such as coal, ore, coke and scrap, crushers and screening in raw materials preparation and finishing operations in products such as teeming into ingots and scarfing. Particulate matter results also from BF during casting and oxygen blow in BOF. Particulate materials are mostly composed of iron, sulphur and other metal oxides.

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 4-33: Emission streams for iron and steel industry

Process/Activity description	Reporting period	Emission stream	NRF Code Report
Coke production	1990-2001	Combustion	1A1c
		Fugitive emissions	1B1b
Lime production	1990-2001	Process	2A2
Sinter production	1990-2001	Process	2C1d
Cogeneration	1990-2001	Combustion	1A2a
Ironmaking	1990-2001	Process	2C1b
Steelmaking: BOF	1990-2001	Process	2C1a
Steelmaking: EAF	1990-onwards	Process	2C1a
Rolling mills, pot ovens and reheating ovens	1990-onwards	Combustion	1A2a
Other machinery operation (a)	1990-onwards	Combustion	1A2gvii

(a) Consumption of fuels in other iron and steel related activities such as blowtorches, emergency generators, lift trucks operation, etc.

4.4.1.2 Methodology

Since there are different processes and different data sources available depending on the years, distinguished methodologies were used throughout the time series.

Process emissions for sinter, pig iron and steel production were estimated according to a product approach methodology.

Equation 4-40: Emissions from sinter, pig iron and steel production

$$Emi_p = AD \times EF_p$$

Where:

Emi: Emissions for pollutant p (t)

AD: Sinter, pig iron or steel production (t)

EF: Emission factor for pollutant p ($t/t_{production}$)

Process emissions from sinter, pig iron and steel production are reported in source code 2.C.1.

Emissions from coke production are estimated and reported in category 1.A.1.c – Manufacture of solid fuels. Fugitive emissions from coke production are estimated and reported under category 1.B.1.b – Solid fuel transformation.

4.4.1.3 Emission Factors

Emission factors for processes related to Iron and Steel Production are provided in the tables below.

Table 4-34: Sinter and pig iron production emission factors in the period 1990-2001

Pollutant	Sinter production (a)		Pig iron production (b)	
	Unit	EF	Unit	EF
SOx	g/t sinter	NE	g/t pig iron	NE
NOx	g/t sinter	NE	g/t pig iron	NE
NMVOC	g/t sinter	138	g/t pig iron	NE
CO	g/t sinter	NE	g/t pig iron	NE
TSP	g/t sinter	200	g/t pig iron	50
PM_{10}	g/t sinter	100	g/t pig iron	40
$PM_{2.5}$	g/t sinter	80	g/t pig iron	25
BC	% of $PM_{2.5}$	0.17	% $PM_{2.5}$	2.4
Pb	g/t sinter	3.5	g/t pig iron	0.00049
Cd	g/t sinter	0.004	g/t pig iron	8.1 E -7
Hg	g/t sinter	0.049	g/t pig iron	0.00019
As	g/t sinter	0.018	g/t pig iron	0.000024
Cr	g/t sinter	0.016	g/t pig iron	0.00024
Cu	g/t sinter	0.033	g/t pig iron	0.015
Ni	g/t sinter	0.09	g/t pig iron	NE
Se	g/t sinter	0.02	g/t pig iron	NE
Zn	g/t sinter	0.06	mg/t pig iron	0.73
PCB	mg/t sinter	0.09	mg/t pig iron	2.5
HCB	mg/t sinter	0.03	mg/t pig iron	NE
PCDD/ PCDF	ng I-TEQ/ton sinter	8.0	µg I-TEQ/t pig iron	0.002
Benzo(α)pyrene	g/t sinter	NE	g/t pig iron	NE
Benzo(β)fluoranthene	g/t sinter	NE	g/t pig iron	NE
Benzo(k)fluoranthene	g/t sinter	NE	g/t pig iron	NE
Indeno(1,2,3-cd)pyrene	g/t sinter	NE	g/t pig iron	NE
Total PAH	g/t sinter	0.3	g/t pig iron	2.5

Emission factors for Sinter and Pig Iron production are taken from Tables 3-2 and 3-11 from Vol. 2.C.1 of the 2019 EMEP Guidebook, respectively.

Table 4-35: Basic Oxygen Furnace and Electric Arc Furnace emission factors

Pollutant	BOF production (a)		EAF production (b)	
	Unit	EF	Unit	EF
SOx	g/t steel	NE	g/t steel	60
NOx	g/t steel	10	g/t steel	130
NMVOC	g/t steel	NE	g/t steel	46
CO	g/t steel	3500	g/t steel	1700
TSP	g/t steel	35	g/t steel	30
PM_{10}	g/t steel	32	g/t steel	24
$PM_{2.5}$	g/t steel	28	g/t steel	21
BC	% $PM_{2.5}$	0.36	% $PM_{2.5}$	0.36
Pb	g/t steel	4	g/t steel	2.6
Cd	g/t steel	0.067	g/t steel	0.2
Hg	g/t steel	0.0014	g/t steel	0.05
As	g/t steel	0.4	g/t steel	0.015
Cr	g/t steel	2.3	g/t steel	0.1
Cu	g/t steel	0.02	g/t steel	0.02
Ni	g/t steel	0.13	g/t steel	0.7
Se	g/t steel	0.003	g/t steel	3.6
Zn	g/t steel	4	mg/t steel	2.5
PCB	mg/t steel	2.5	mg/t steel	NE
HCB	mg/t steel	NE	mg/t steel	NE
PCDD/ PCDF	µg I-TEQ/t steel	0.69	µg I-TEQ/t steel	3
Benzo(α)pyrene	g/t steel	NE	g/t steel	NE
Benzo(β)fluoranthene	g/t steel	NE	g/t steel	NE
Benzo(k)fluoranthene	g/t steel	NE	g/t steel	NE
Indeno(1,2,3-cd)pyrene	g/t steel	NE	g/t steel	NE
Total PAH	g/t sinter	0.01	g/t steel	0.48
(a) Source: EMEP/EEA guidebook 2019, Vol. 2.C.1, Table 3-14 (b) Source: EMEP/EEA guidebook 2019, Vol. 2.C.1, Table 3-15				

Table 4-36: Pot oven and rolling mills emission factors

Pollutant	Unit	EF (a)	Pollutant	Unit	EF (a)
SOx	g/GJ	47	Cr	g/GJ	0.2
NOx	g/GJ	513	Cu	g/GJ	0.22
NMVOC	g/GJ	25	Se	g/GJ	0.11
CO	g/GJ	66	Zn	g/GJ	29
TSP	g/GJ	20	PCB	g/GJ	NE
PM_{10}	g/GJ	20	HCB	g/GJ	NE
$PM_{2.5}$	g/GJ	20	PCDD/F	µg I-TEQ/GJ	1.4
BC	% $PM_{2.5}$	56	Benzo(α)pyrene	g/GJ	1.9
Pb	g/GJ	0.08	Benzo(β)fluoranthene	g/GJ	15
Cd	g/GJ	0.006	Benzo(k)fluoranthene	g/GJ	1.7
Hg	g/GJ	0.12	Indeno(1,2,3-cd)pyrene	g/GJ	1.5
As	g/GJ	0.03	Total 4 PAHs	g/GJ	20.1
Source: EMEP/EEA guidebook 2019, Vol. 1.A.2, Table 3-4					

From 2002 onwards there is only secondary steel production. Therefore, in this period there are only emission factors related to electric arc furnace, pot oven and rolling mills.

4.4.1.4 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 4-41: 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 4-42: 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.

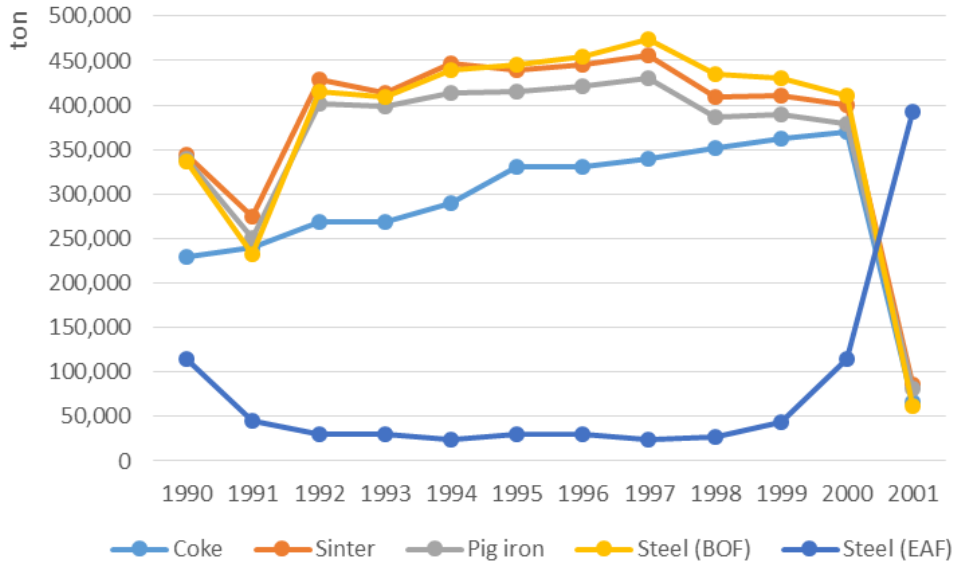


Figure 4-36: Integrated iron and steel facility – production of steel and intermediate products (1990-2001)

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.

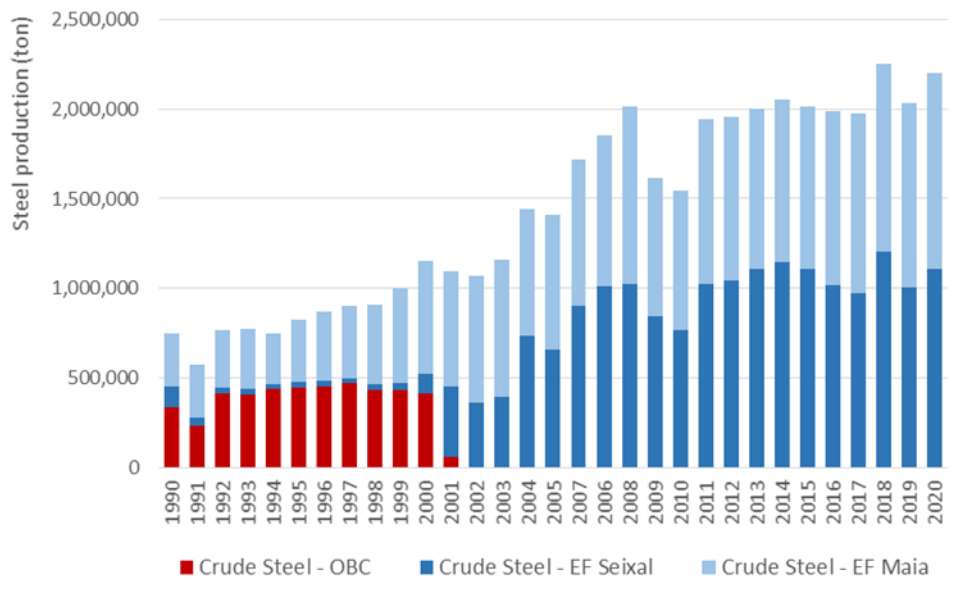
From 2002 to 2005:

- Annual steel production from EAF was estimated based on Equation 4-42;
- 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 national steel production by process for the whole time series.



I&S: Integrated Iron and Steel facility

Figure 4-37: 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).

4.4.1.5 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.

PAH process emissions from pig iron in the blast furnace were reported for the first time in this submission for the perios 1990 to 2001. Following QA/QC procedures, we realized that they were being estimated, however, due to a compilation error, were not being reported.

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.

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.viii”, since this could be a misallocation from the energy balance.

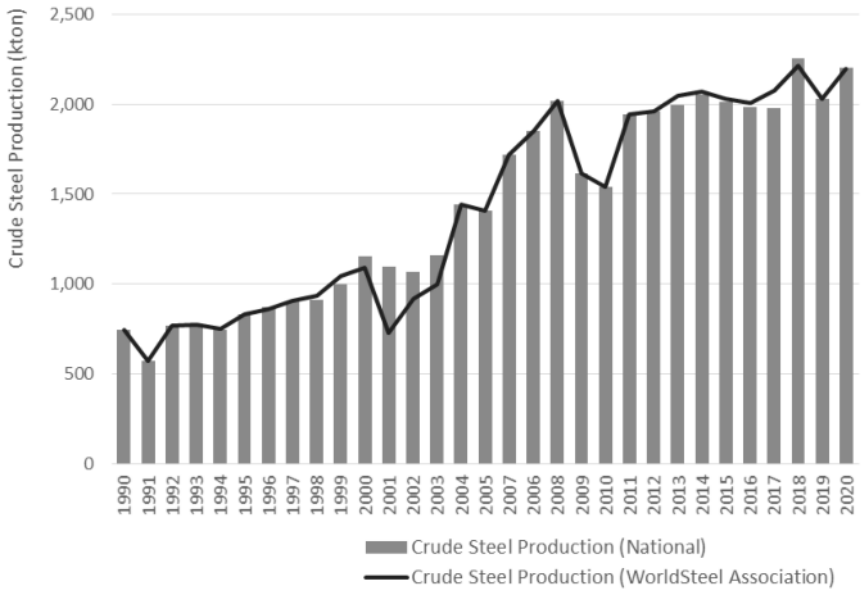


Figure 4-38: Crude steel production in Portugal – comparison of approaches

4.4.1.6 Recalculations

PAH process emissions from pig iron production in the blast furnace were reported for the first time in this submission.

4.4.1.7 Further Improvements

No further improvements are planned for this sector.

4.4.2 Ferroalloys Production (NFR 2.C.2 – SNAP 040302)

Concerning ferroalloys production, following a 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 TSP, PM_{10}, $PM_{2.5}$ and BC estimates were made. Available activity data (from 2011-2014, 2017-2019) were obtained from national statistics and Eurostat. Tier 1 emission factors were applied according to the 2019 EMEP/EEA Guidebook (Table 3.1 of chapter "2.C.2 - Ferroalloys production").

These estimates were found to be well below the threshold of significance (between 0.0024t and 0.12t).

Therefore, and given the scarcity of the activity data in order to assess a timeline, we will report 2.C.2 as Not Estimated.

4.4.3 Aluminium Production (NFR 2.C.3 – SNAP 040301; 030310)

4.4.3.1 Category description

This chapter addresses emissions estimates from the production of aluminium. In Portugal, according to information received from the General Directorate of Economic Activities (DGAE), there is only secondary aluminium production from ingots.

4.4.3.2 Methodology

Emissions from Aluminium production were estimated in accordance with the 2019 EMEP Guidebook.

Emissions of TSP, PM_{10} and $PM_{2.5}$ were estimated according to the following equation:

Equation 4-43: Particulate matter emissions from aluminium production

$$Emi_x = AD \times \frac{EF_x}{1000} \times (100\% - \eta_{abatement})$$

Where:

Emi_x: Emissions of pollutant "x" (t)

AD: Aluminium production (t)

EF_x: Emission factor of pollutant "x" (kg/t Aluminium)

$\eta_{abatement}$: Abatement technology efficiency (%)

For BC:

Equation 4-44: Black carbon emissions from aluminium production

$$Emi_{BC} = Emis_{PM2.5} \times EF_{BC}$$

Where:

Emi_{BC}: Black Carbon emissions (t)

$Emi_{PM2.5}$: $PM_{2.5}$ emissions (t)

EF_{BC}: Black Carbon emission factor (% $PM_{2.5}$)

For PCDD/F (Dioxins and Furans):

Equation 4-45: PCDD/F (Dioxins and Furans) emissions from aluminium production

$$Emi_{PCDD/F} = AD \times \frac{EF_{PCDD/F}}{1 \times 10^6}$$

Where:

$Emi_{PCDD/F}$: Emissions of dioxins and furans (g I-TEQ)

AD: Aluminium production (t)

EF_x: Emission factor of dioxins and furans (µg I-TEQ/t Aluminium)

HCB emissions result from the use of hexachloroethane (HCE) in secondary aluminium production. According to legislation regarding the phasing-out of the use of HCE in the non-ferrous metal industry (which includes the secondary aluminium industry), the use of that substance by the aluminium industry in Portugal was prohibited since 2002. Therefore, from 2003 onwards, HCB emissions are reported as NA. For the period 1990-2002, no data on national emissions of HCB in secondary aluminium industries is available.

From 1990 to 2002, HCB emissions were estimated according to the following equation:

Equation 4-46: HCB emissions from aluminium production – 1990-2002

$$Emi_{HCB} = AD \times \frac{EF_{HCB}}{1000}$$

Where:

Emi_{HCB}: Emissions of HCB (kg)

AD: Aluminium production (t)

EF_{HCB}: Emission factor of HCB (g/t Aluminium)

4.4.3.3 Emission Factors

Emission factors and abatement technologies were taken from EMEP guidebook 2019 and are listed in the tables below.

Table 4-37: Emission factors

Pollutant	Unit	EF	Source
TSP	kg/t Aluminium	2	Table 3.4 of chapter "2.C.3 Aluminium Production" of EMEP/EEA air pollutant emission inventory guidebook 2016
PM_{10}	kg/t Aluminium	1.4	
$PM_{2.5}$	kg/t Aluminium	0.55	
BC	% $PM_{2.5}$	2.3%	
PCDD/F	µg I-TEQ/t Aluminium	35	
HCB	g/t Aluminium	5	

Table 4-38: Abatement technologies efficiencies

Pollutant	Unit	EF	Abatement Technology	Source
TSP	%	98.1%	Coated Fabric Filter	Table 3.5 of chapter "2.C.3 Aluminium Production" of EMEP/EEA air pollutant emission inventory guidebook 2016
PM_{10}	%	99.9%		
$PM_{2.5}$	%	99.6%		

Data on abatement technologies was selected based on expert judgement. This data will be improved in future submissions based on plant specific data.

4.4.3.4 Activity Data

There is only secondary aluminium production in Portugal.

From 1992 onwards, data on secondary aluminium production was obtained from INE. In the period 1990-1991, data was estimated based on 1992 production and on GDP trend.

Due to confidentiality constraints data, is presented as an index value related to 1990 production.

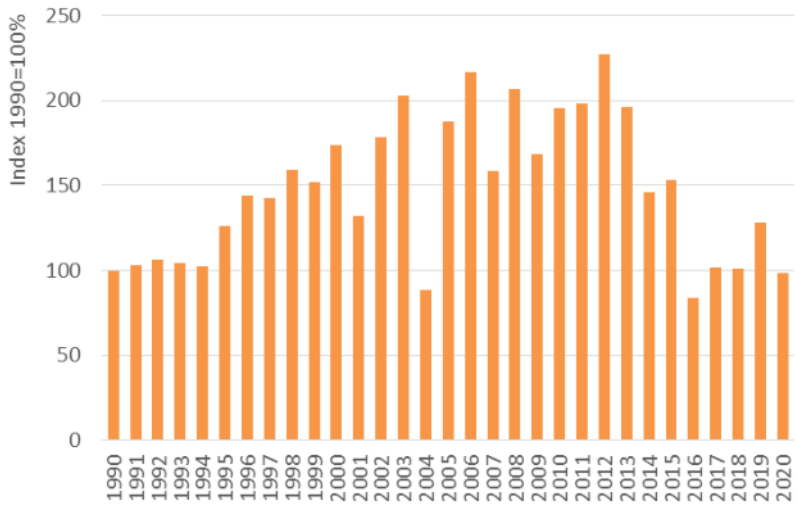


Figure 4-39: Secondary Aluminium production (Index 1990=100%)

4.4.3.5 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.

4.4.3.6 Recalculations

No recalculations were made.

4.4.3.7 Further Improvements

Efforts will be made in order to obtain plant specific data on abatement technologies.

4.4.4 Magnesium Production (NFR 2.C.4)

According to INE, there is no magnesium production in Portugal.

4.4.5 Lead Production (NFR 2.C.5 – SNAP 040309b)

4.4.5.1 Category description

This chapter addresses emissions estimates from the production of lead.

4.4.5.2 Methodology

Emissions from lead production were estimated based on a Tier 2 methodology in accordance with EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2019).

Emissions of TSP, PM_{10} and $PM_{2.5}$ were estimated according to the following equation:

Equation 4-47: Particulate matter emissions from lead production

$$Emi_x = AD \times \frac{EF_x}{1 \times 10^6} \times (100\% - \eta_{abatement})$$

Where:

Emi_x: Emissions of pollutant "x" (t)

AD: Lead production (t)

EF_x: Emission factor of pollutant "x" (g/t Lead)

$\eta_{abatement}$: Abatement technology efficiency (%)

For SO_x, Pb, Cd, As and Zn:

Equation 4-48: SO_x, Pb, Cd, As and Zn emissions from lead production

$$Emi_x = AD \times \frac{EF_x}{1 \times 10^6}$$

Where:

Emi_x: Emissions of pollutant "x" (t)

AD: Lead production (t)

EF_x: Emission factor of pollutant "x" (kg/t Lead)

For PCDD/F (Dioxins and Furans):

Equation 4-49: PCDD/F (Dioxins and Furans) emissions from lead production

$$Emi_{PCDD/F} = AD \times \frac{EF_{PCDD/F}}{1 \times 10^6}$$

Where:

$Emi_{PCDD/F}$: Emissions of dioxins and furans (g I-TEQ)

AD: Lead production (t)

EF_x: Emission factor of dioxins and furans (µg I-TEQ/t Lead)

For PCB:

Equation 4-50: PCB emissions from lead production

$$Emi_{HCB} = AD \times \frac{EF_{HCB}}{1000}$$

Where:

Emi_{HCB}: Emissions of PCB (kg)

AD: Lead production (t)

EF_{PCB}: Emission factor of PCB (µg/t Lead)

4.4.5.3 Emission Factors

Emission factors and abatement technologies considered are listed in the tables below.

Table 4-39: Emission factors

Pollutant	Unit	EF	Source
SO_x	g/t Lead	5000	Table 3.5 of chapter "2.C.5 Lead Production" of EMEP/EEA air pollutant emission inventory guidebook 2019
Pb	g/t Lead	1.1	
TSP	g/t Lead	20	
PM_{10}	g/t Lead	16	
$PM_{2.5}$	g/t Lead	8	
Cd	g/t Lead	0.05	
As	g/t Lead	0.3	
Zn	g/t Lead	0.05	
PCDD/F	µg I-TEQ/t Lead	2.6	
PCB	µg/t Lead	3.2	

Table 4-40: Abatement technologies efficiencies

Pollutant	Unit	EF	Abatement Technology	Source
TSP	%	98.1%	Coated Fabric Filter	Table 3.6 of chapter "2.C.5 Lead Production" of EMEP/EEA air pollutant emission inventory guidebook 2019
PM_{10}	%	99.9%		
$PM_{2.5}$	%	99.6%		

4.4.5.4 Activity Data

There is only secondary Lead production in Portugal.

In the period 1990-1991, data has been estimated based on 1992 production and on GDP trend. In the period 1992-2005 and in 2017, data on secondary Lead production was obtained from INE.

Due to lack of information in INE and EUROSTAT, in the period 2006-2007 data has been estimated based on the interpolation of 2005 and 2008 production data.

In the period 2008-2015, data on secondary Lead production was obtained from EUROSTAT. In 2016, data has been estimated based on 2015 production and on GDP trend.

Due to confidentiality constraints data is presented as an index value related to 1990 production.

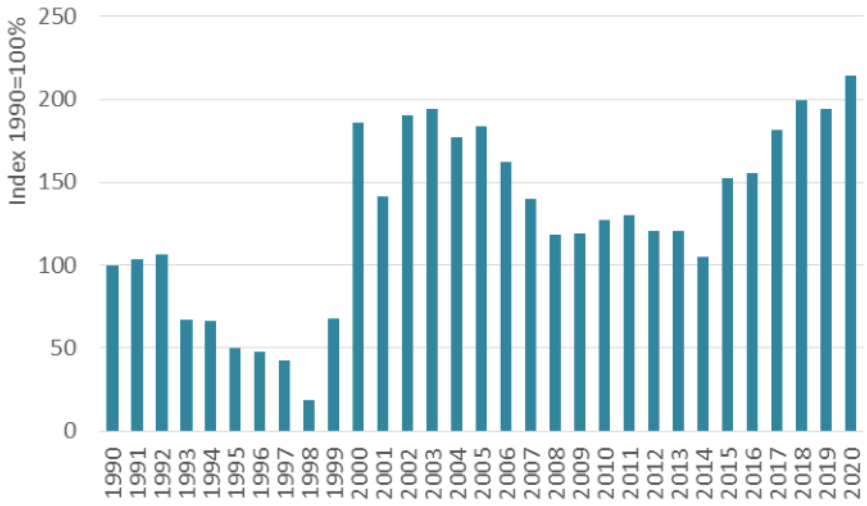


Figure 4-40: Secondary Lead production data (Index 1990=100%)

4.4.5.5 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.

4.4.5.6 Recalculations

No recalculations were made.

4.4.5.7 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.

4.4.6 Zinc Production (NFR 2.C.6 – SNAP 040309c)

According to INE, there is no zinc production in Portugal.

4.4.7 Copper Production (NFR 2.C.7.a – SNAP 040309a)

4.4.7.1 Category description

This chapter addresses emissions estimates from the production of copper.

4.4.7.2 Methodology

Emissions from Copper production were estimated based on a Tier 2 methodology in accordance with EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2019).

Emissions of TSP, PM_{10} and $PM_{2.5}$ were estimated according to the following equation:

Equation 4-51: Particulate matter emissions from copper production

$$Emi_x = AD \times \frac{EF_x}{1 \times 10^6} \times (100\% - \eta_{abatement})$$

Where:

Emi_x: Emissions of pollutant "x" (t)

AD: Copper production (t)

EF_x: Emission factor of pollutant "x" (g/t Copper)

$\eta_{abatement}$: Abatement technology efficiency (%)

For SO_x, Pb, Cd, As and Zn:

Equation 4-52: SO_x, Pb, Cd, As and Zn emissions from copper production

$$Emi_x = AD \times \frac{EF_x}{1 \times 10^6}$$

Where:

Emi_x: Emissions of pollutant "x" (t)

AD: Copper production (t)

EF_x: Emission factor of pollutant "x" (kg/t Copper)

For PCDD/F (Dioxins and Furans):

Equation 4-53: PCDD/F (Dioxins and Furans) emissions from Copper production

$$Emi_{PCDD/F} = AD \times \frac{EF_{PCDD/F}}{1 \times 10^6}$$

Where:

$Emi_{PCDD/F}$: Emissions of dioxins and furans (g I-TEQ)

AD: Copper production (t)

EF_x: Emission factor of dioxins and furans (µg I-TEQ/t Copper)

For PCB:

Equation 4-54: PCB emissions from Copper production

$$Emi_{HCB} = AD \times \frac{EF_{HCB}}{1000}$$

Where:

Emi_{HCB}: Emissions of PCB (kg)

AD: Copper production (t)

EF_{PCB}: Emission factor of PCB (µg/t Copper)

4.4.7.3 Emission Factors

Emission factors and abatement technologies considered are listed in the tables below.

Table 4-41: Emission factors

Pollutant	Unit	EF	Source
SO_x	g/t Copper	1320	Table 3.3 of chapter "2.C.7.a Copper Production" of EMEP/EEA air pollutant emission inventory guidebook 2019
Pb	g/t Copper	24	
TSP	g/t Copper	320	
PM_{10}	g/t Copper	250	
$PM_{2.5}$	g/t Copper	190	
BC	%PM2.5	0.1%	
Cd	g/t Copper	2.3	
As	g/t Copper	2	
Cu	g/t Copper	28	
Ni	g/t Copper	0.13	
PCDD/F	µg I-TEQ/t Copper	50	
PCB	µg/t Copper	3.7	

Table 4-42: Abatement technologies efficiencies

Abatement Technology	Pollutant	Unit	EF	Source
Coated Fabric Filter	TSP	%	98.1%	Table 3.4 of chapter "2.C.7.a Copper Production" of EMEP/EEA air pollutant emission inventory guidebook 2019
	PM_{10}	%	99.9%	
	$PM_{2.5}$	%	99.6%	

4.4.7.4 Activity Data

There is only secondary Copper production in Portugal.

In the period 1990-1992, data was estimated based on 1993 production and on GDP trend. In the period 1993-2007 and in 2017, data on secondary Copper production was obtained from INE.

Following a 2018 UNFCCC In-country Review, due to lack of consistent information in INE and EUROSTAT, in the period 2005-2007 data has been estimated based on the interpolation of 2004 and 2008 production data. Furthermore, 2014 data has been estimated based on the interpolation of 2013 and 2015 production data.

From 2008 onwards, data was obtained from EUROSTAT.

Due to confidentiality constraints data is presented as an index value related to 1990 production.

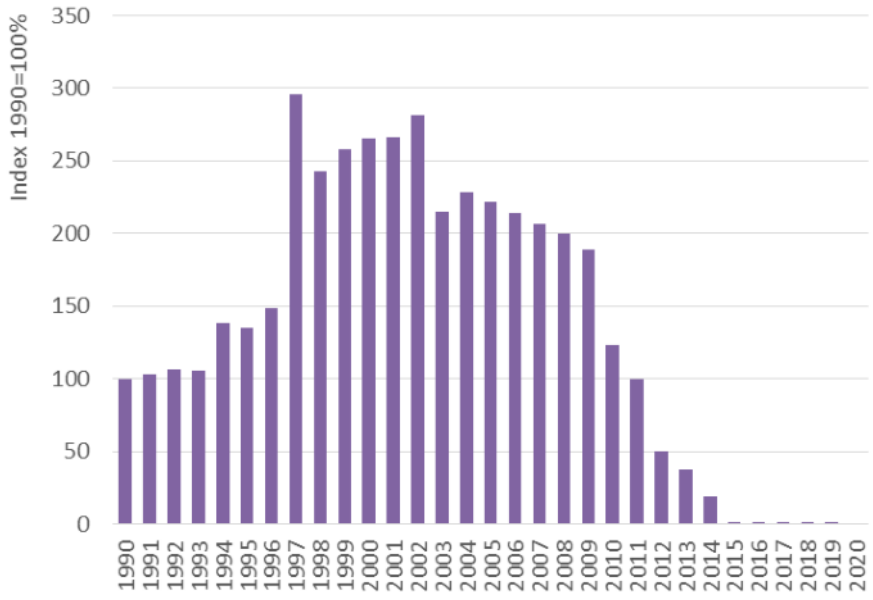


Figure 4-41: Secondary Copper production (Index 1990=100%)

4.4.7.5 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.

4.4.7.6 Recalculations

No recalculations were made.

4.4.7.7 Further Improvements

Efforts will be made in order to obtain plant specific data.

4.4.8 Nickel Production (NFR 2.C.7.b – SNAP 040305)

According to INE, there is no nickel production in Portugal.

4.4.9 Other Metal Production (NFR 2.C.7.c – SNAP 040309z)

There is no other metal production in Portugal.

4.4.10 Storage, Handling and Transport of Metal Products (NFR 2.C.7.d – SNAP 041000)

4.4.10.1 Category description

This chapter addresses emissions estimates from the production of Storage, Handling and Transport of Metal Products, specifically the ones produced in Portugal – iron, aluminium, copper and lead.

4.4.10.2 Methodology

Emissions from Handling of Metal Products were estimated based in a Tier 2 methodology in accordance with EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2019).

Emissions of TSP, PM_{10} and $PM_{2.5}$ were estimated according to the following equation:

Equation 4-55: Particulate matter emissions from other metal production

$$Emi_x = AD \times \frac{EF_x}{1 \times 10^6}$$

Where:

Emi_x: Emissions of pollutant "x" (t)

AD: Metal products handled (t Metal Products)

EF_x: Emission factor of pollutant "x" (g/t Metal Products)

Emissions from storage of metal products are not estimated due to lack of information on the areas used to store metal products.

4.4.10.3 Emission Factors

Emission factors applied are listed in the table below.

Table 4-43: Emission factors

Pollutant	Practice	Abatement Technology	Unit	EF	Source
TSP	Handling	Uncontrolled	g/t metal products	4	Table 3.4 of chapter "2.C.7.d Storage, handling and transport of metal products" of EMEP/EEA air pollutant emission inventory guidebook 2019
PM_{10}			g/t metal products	2	
$PM_{2.5}$			g/t metal products	0.2	

4.4.10.4 Activity Data

Activity Data used for this category´s estimates is indicated in iron, aluminium, copper and lead's activity data sub-chapters. Due to confidentiality constraints, data is presented as an index value related to 1990 production.

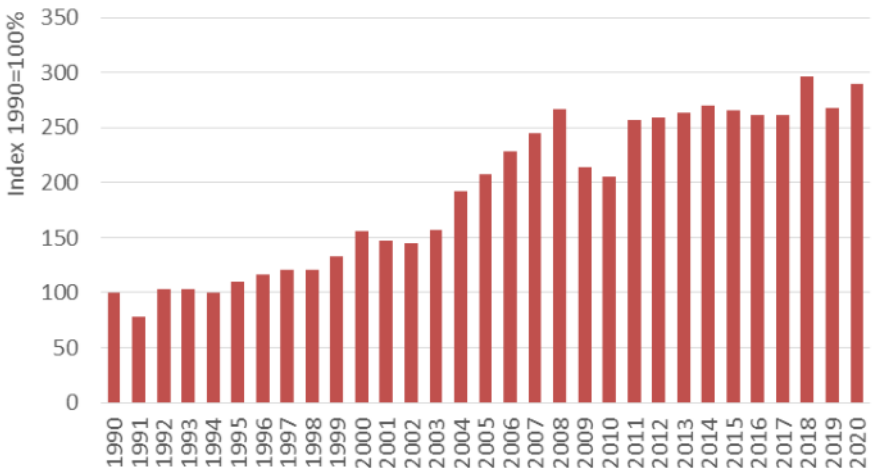


Figure 4-42: Metal products handled (Index 1990=100%)

4.4.10.5 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.

4.4.10.6 Recalculations

No recalculations were made.

4.4.10.7 Further Improvements

Efforts will be made in order to obtain plant specific data on the areas used to store metal products. This improvement will allow the estimate of emissions from storage of metal products.

4.5 Solvent and other Product Use (2.D.3.a – 2.D.3.h)

4.5.1 Domestic solvent use including fungicides (NFR 2.D.3.a – SNAP 060408; 060411)

4.5.1.1 Category description

This chapter addresses emissions estimates from domestic solvent use (other than paint application). Solvents are used in a large number of products sold for public use. These include:

- Household products (aerosol and non-aerosol);
- Cosmetics and toiletries; Products for the maintenance or improvement of personal appearance, health or hygiene;
- Household products; Products used to maintain or improve the appearance of household durables;
- Construction/Do-It-Yourself; Products used to improve the appearance or the structure of buildings such as adhesives and paint remover;
- Car care products (aerosol and non-aerosol); Products used for improving the appearance of vehicles to maintain vehicles or winter products such as antifreeze;
- Pharmaceutical products;
- Pesticides such as garden herbicides and insecticides and household insecticide sprays may be considered as consumer products. Most agrochemicals, however, are produced for agricultural use and fall outside the scope of this section.

Emissions result from the evaporation of the NMVOC contained in products during their use. For most products, all NMVOC will be emitted to the atmosphere. However, in some products, NMVOC will be lost mainly in wastewater.

4.5.1.2 Methodology

Domestic solvent use results in NMVOC and Hg emissions.

NMVOC emissions were estimated using a Tier 2a approach from 2019 EMEP guidebook. Due to lack of national data on used amount of product or solvent content of products, this methodology was based on data supplied by European Solvents Industry Group (ESIG), which allowed us to estimate a per capita implicit emission factor.

Equation 4-56: NMVOC emissions from Domestic solvent use

$$Emi\ NMVOC = Population \times IEF_{NMVOC\ IB}/1000$$

Where:

Emi_{NMVOC}: National emissions of NMVOC (t)

Population: Portuguese inhabitants

$IEF_{NMVOC\ IB}$: Implied NMVOC emission factor for Iberian Peninsula (kg/capita)

Hg emissions were estimated using a Tier 1 approach, according to the following equation:

Equation 4-57: Hg emissions from Domestic solvent use

$$Emi\ Hg = Population \times EF_{Hg}/1000$$

Where:

Emi_{Hg}: Emissions of Hg (t)

Population: Portuguese inhabitants

EF_{Hg}: Hg emission factor (kg/capita)

4.5.1.3 Emission Factors

Due to lack of national data on used amount of product or solvent content of products, and following guidance from 2019 EMEP Guidebook, activity data was obtained from ESIG and consisted of solvent VOC emissions by REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) end-use sector.

Since categories using the REACH sector classification are different from the NFR classifications used, a conversion was made using the distribution percentages from the table below:

Table 4-44: Mapping table: REACH to NFR (2.D.3.a - Domestic solvent use including fungicides)

REACH end-use sector	Unit	2.D.3.a
Agrochemical uses	ton	100%
Blowing Agents	ton	-
De-Icing	ton	50%
Binder and Release Agents	ton	-
Cleaning Industrial + Leather treatment	ton	-
Cleaning-Professional Consumer	ton	100%
Coatings-Industrial + adhesives, inks	ton	-
Coatings-Professional/Consumer + Thinners, paint industry	ton	30%
Functional Solvents (inc. solvents used in chemical processes, e.g. process aids, intermediates, extraction, dewaxing agents)	ton	-
Metal working/rolling oils/Lubricant uses	ton	-
Oil field chemicals-drilling-mining-extraction	ton	-
Polymers Processing (inc.rubber-tyre production)+ Industrial resins, synthetic rubber, process	ton	-
Road and construction	ton	-
Use as Fuel/Combustion + Fuel additives	ton	-
Water Treatment	ton	-
Other consumer uses (household,aerosols,cosmetics)	ton	100%
Pharmaceuticals manufacturing	ton	-
Others-please specify below	ton	-
Chlorinated Solvents (not ventilated by sector)	ton	-
Source: Table A1.1 - Annex 1, Chapter 2.D.3.a Domestic solvent use including fungicides - Guidebook EMEP/EEA 2019		

Data concerning Portugal solvent VOC emissions was only available for 2015 to 2020. Data on solvent VOC emissions was available for Iberian Peninsula (Portugal+Spain) for years 2008, 2009, 2013 and 2015-2020, as shown in the figure below. 2020 Iberian Peninsula 2.D.3.a total solvent VOC emissions are highly up due to ethanol consumption triggered by the COVID pandemic.

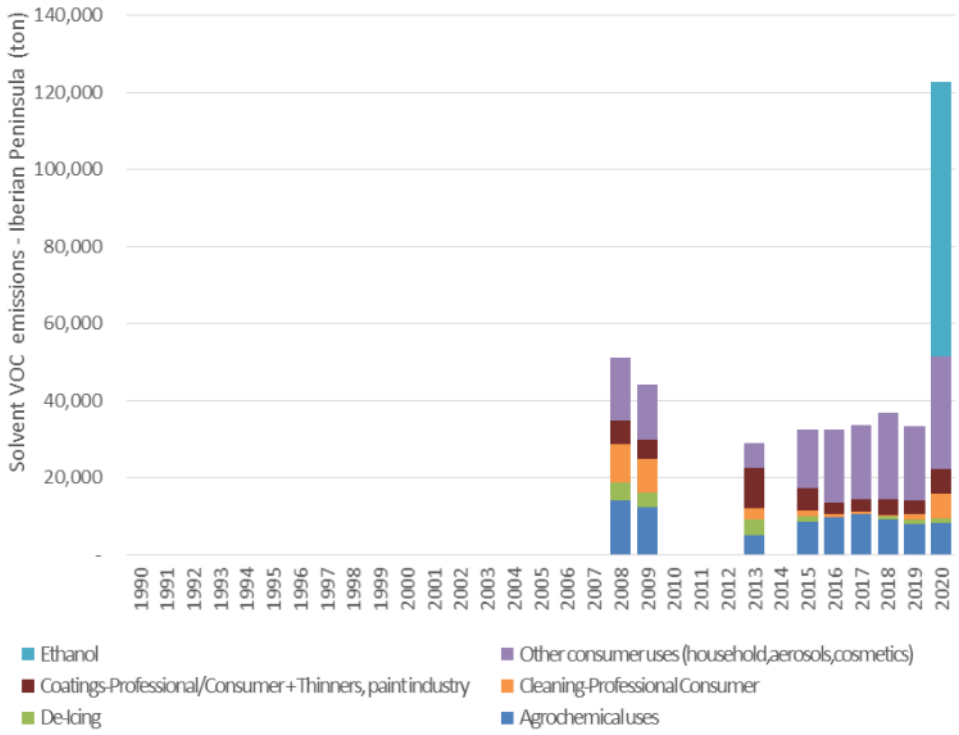


Figure 4-43: Iberian Peninsula 2.D.3.a total solvent VOC emissions (Source: ESIG inventory)

Correction factors C (for the non-solvent emissions) and F (solvent fraction not considered in ESIG methodology) were also applied to total Iberian Peninsula solvent VOC emissions, in order to include emissions from non-solvent product components, as well as emissions from missing solvents producers not included in the ESIG inventory. The correction factors are listed in the table below:

Table 4-45: Correction factors for solvent VOC emissions

Factor	Value
Correction factor for the non-solvent NMVOC emissions – C	1.11
Fraction of solvents not considered in the ESIG methodology - F	1.11
Source: GB 2016 - 2D3a - 3.2.3 Special case of Tier 2a	

Thus, total corrected Iberian Peninsula solvent VOC emissions were estimated according to the following equation:

Equation 4-58: Total corrected Iberian Peninsula solvent VOC emissions

$$Emi_{NMVOC\ IB\ CORR} = Emi_{NMVOC\ IB} \times C \times F$$

Where:

$Emi_{NMVOC\ IB\ CORR}$: Total corrected Iberian Peninsula solvent VOC emissions (t)

Emi_{NMVOC}: Total Iberian Peninsula solvent VOC emissions (t)

C: Correction factor for the non-solvent emissions

F: Correction factor for solvent fraction not considered in ESIG methodology

Total corrected Iberian Peninsula 2.D.3.a solvent VOC emissions are presentedin the figure below. 2020 emissions are highly up due to ethanol consumption triggered by the COVID pandemic.

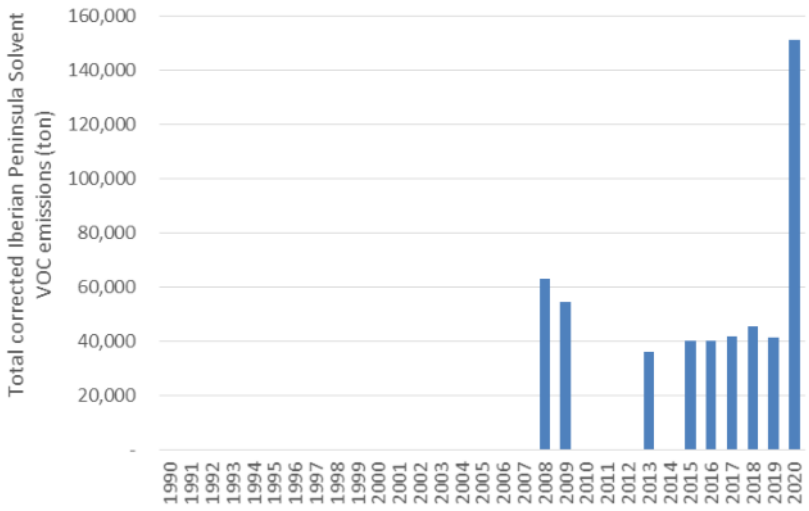


Figure 4-44: Total corrected Iberian Peninsula 2.D.3.a solvent VOC emissions

Although data for 2015 to 2020 were available and dissagregated for Portugal, the Inventory team came to the conclusion that it would be more correct to estimate an implicit emission factor for the entire Iberian Peninsula instead of a Portuguese IEF. Such decision was based on the analysis of the ESIG data for the two countries. According to these data, the IEF per capita obtained for Portugal was 6 times lower than the estimated IEF for Spain. Given the social, cultural and economic similarities between Portugal and Spain, this result seems to be unrealistic and may be explained by ESIG's difficulty in separating data between the two Iberian countries. To overcome this limitation, extrapolations and interpolations were used to estimate IEF for the entire time series.

Therefore, the implied NMVOC emission factor for the entire Iberian Peninsula was estimated according to the following equation:

Equation 4-59: Implied NMVOC emission factor for Domestic solvent use

$$IEF_{INMVOC\,IB} = \frac{Emi_{NMVOC_{IB\,CORR}}}{Population_{IP}}\ X\ 1000$$

Where:

IEF_{NMVOC}: Implied NMVOC emission factor for Iberian Peninsula (kg/capita)

Emi_{NMVOC}: Total corrected NMVOC emissions for Iberian Peninsula (t)

Population: Iberian Peninsula inhabitants

The implied NMVOC emission factors for the entire Iberian Peninsula is presented in the figure below. The dark green bars indicate the years for which ESIG information was available. Due to lack of information:

- from 1900 to 2007, implied NMVOC emission factor was assumed equal to year 2008 (first year with available data);
- from 2008 to 2009, 2013 and 2015-onwards, implied NMVOC emission factor were estimated according to the equation above;
- for the missing years from 2010 to 2012 and 2014, implied NMVOC emission factor was estimated based on the average of available years.

Implied NMVOC emission factor is presented in the figure below. 2020 emission factor is highly up due to ethanol consumption triggered by the COVID pandemic.

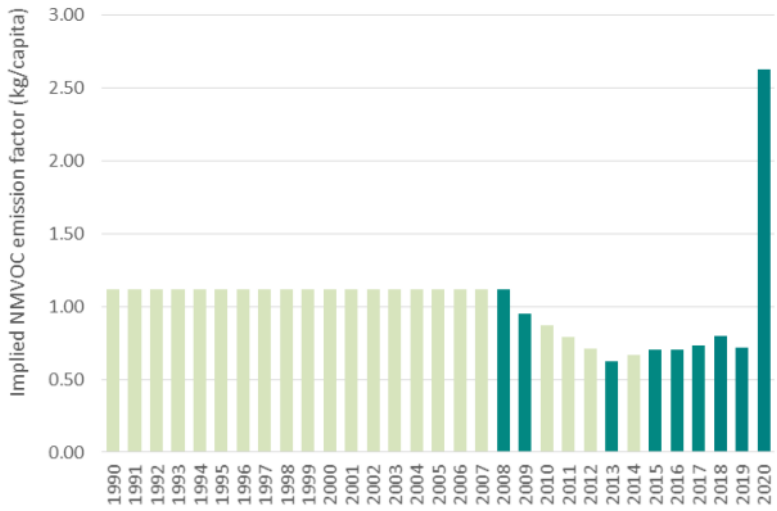


Figure 4-45: Implied NMVOC emission factor

Hg emission factor is listed in the table below.

Table 4-46: Tier 1 Hg emission factor

Description	Unit	Value	Source
Fluorescent tubes	mg/capita	5.6	Table 3.6 of volume "2.D.3.a Domestic solvent use including fungicides" of EMEP/EEA guidebook 2016

4.5.1.4 Activity Data

The number of national inhabitants was obtained from INE and is presented in the figure below. This activity data intends to fulfil different obligations between CLRTAP and NECD submissions. The NFR tables submitted under the NECD refer to Portugal Mainland (without the Island of Azores and Madeira) - greens bars -, while the reporting tables submitted under CLRTAP refer to the present EMEP domain, i.e. the whole Portuguese territory – blue bars.

Spain's population was obtained from EUROSTAT for the whole time series.

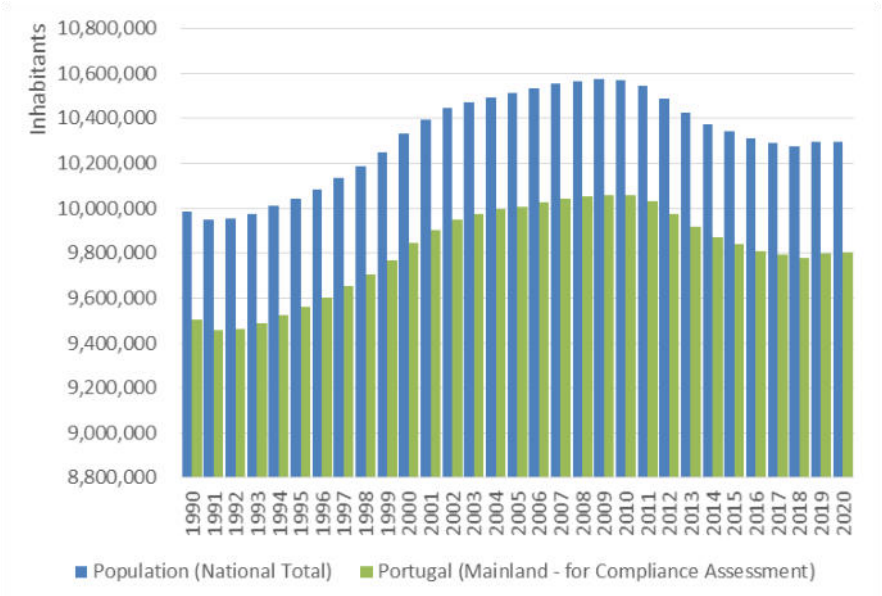


Figure 4-46: Portuguese population

4.5.1.5 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.

4.5.1.6 Recalculations

Update of 2018 and 2019 solvent VOC emissions for Iberian Peninsula (Portugal+Spain), according to ESIG data.

Update of 2018 and 2019 Spain population, according to EUROSTAT.

4.5.1.7 Further Improvements

In the future, we intend to apply this methodology to other sub-categories in sector 2.D.3 based on ESIG data, whenever possible.

4.5.2 Road Paving with Asphalt (NFR 2.D.3.b – SNAP 040611)

4.5.2.1 Category description

Emissions 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 production of asphalt emulsions and cold asphalt mixtures are not included in the inventory estimates, being assumed that they are negligible.

Road pavement with asphalt is done by the application of several layers over road bed. 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 hotmix or as coldmixes: 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 (150-160 Celsius degrees)[8]. Cold mix plants also involve mixing aggregate materials with an asphalt binder, but now the binder is an asphalt emulsion or is a 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[9]. Cure may result from water evaporation alone or from the formation of chemical ionic bonds between aggregate materials (anionic and 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 diluent 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

[8]That are needed to fluidize the asphalt cement.

[9] And also a solvent in several emulsion types.

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).

Emissions during fabrication of asphalt concretes are estimated only for hot mix asphalt and comprehend NMVOC and particulate matter that escape mostly from the drier. Other pollutants are also emitted but they result mostly from combustion of fuels and are considered in the Energy chapter (1.A.2)[10]. Emission estimates for hot-mix asphalt are only made for NMVOC and PM, while emission of other pollutants are covered in emission estimates made for Energy in Manufacturing Industries and Construction (1.A.2) using fuel combustion in building and construction activity[11].

Emissions during production of emulsions, cutback binders and cold mix asphalt concretes are not estimated and assumed negligible[12].

4.5.2.2 Methodology

NMVOC and particulate matter emissions from road paving with asphalt were estimated based on a Tier 2 methodology of 2019 EMEP Guidebook, according to the following equation:

$$Emi_p = AD \times EF_p$$

Where:

Emi_p: Emissions of pollutant p (t)

AD: Asphalt used in Road Paving, by type (t)

EF_p: Emission factor of pollutant p (g/Mg asphalt)

According to the 2019 EMEP Guidebook, for road paving with asphalt, NOx, CO and SOx emission factors are not given in the chapter 2.D.3.b. It is assumed that these emissions originate from combustion activities. Although other available methodologies allow the calculation of emissions of several other pollutants from Hot mix asphalt production, in order to avoid double counting – and because fuel consumption in this activity could not be individualized from total fuel use in construction and building – only emissions of NMVOC and PM were estimated. Although double counting could nevertheless be made for these pollutants, it was considered that the production process results in specific emissions of these pollutants, which would be under-estimated if they would be estimated solely from fuel combustion. Particulate matter is enhanced by manipulation of aggregate materials and some NMVOC result not from incomplete combustion of fuel but also from partial evaporation of bitumen components.

4.5.2.3 Emission Factors

Tier 2 emission factors from Tables 3.2, 3.3 and 3.4 of chapter 2.D.3.b of 2019 EMEP Guidebook were applied in order to estimate emissions from hotmix and cutback asphalts.

[10] To avoid double counting and because from statistical information is not possible to separate fuel use in this particular activity sector.

[11] It is not possible to distinguish fuel combustion in hot mix production activity.

[12] Some emissions do occur in fact during mixing and stockpiling operations. However, because the methodology is based on mass balance, these emissions are in fact quantified under application of asphalt.

Table 4-47: Emission factors for road paving with asphalt

Parameter	Unit	Hotmix - Batch mix	Hotmix - Drum mix	Cutback asphalt
NMVOC	g/Mg asphalt	16	15	30000
TSP	g/Mg asphalt	15000	13000	-
PM10	g/Mg asphalt	2000	3000	-
PM2.5	g/Mg asphalt	100	700	-
BC	% of PM2.5	5.7	2.5	-

4.5.2.4 Activity Data

In Portugal, asphalt used in road paving is the sum of the following: Hot mix, emulsions and cutback asphalt.

From 1991 onwards, data on hot mix asphalt production is obtained from the publication "Asphalt in Figures", available from EAPA (European Asphalt Pavement Association). Bitumen in hot mix asphalt was estimated considering that it equals 5 % of hot mix asphalt. Emissions of Hot Mix Production depend if the equipment is batch or continuous. Disagregation of Hot Mix production per equipment was done by expert judgement (PTEN, 2002), assuming a constant proportion of 46 % continuous and 54 % batch.

Total emulsions applied in road paving were also obtained from EAPA from 1997 onwards. For previous years, use of emulsions was estimated from the total quantity of asphalt materials applied as road pavement, also from EAPA, and considering a % of that bitumen that are emulsions. It was also assumed that this % was zero in 1990 and has increased to 19 % in 1996.

Cutback asphalt is seldom used in Portugal and it is sold only by two companies, according to information gathered at APORBET, the Portuguese Association of Producers of Bitumen Materials. Annual consumption were assumed equal to anual sales.

Asphalt used in road paving is presented in the figure below, by type.

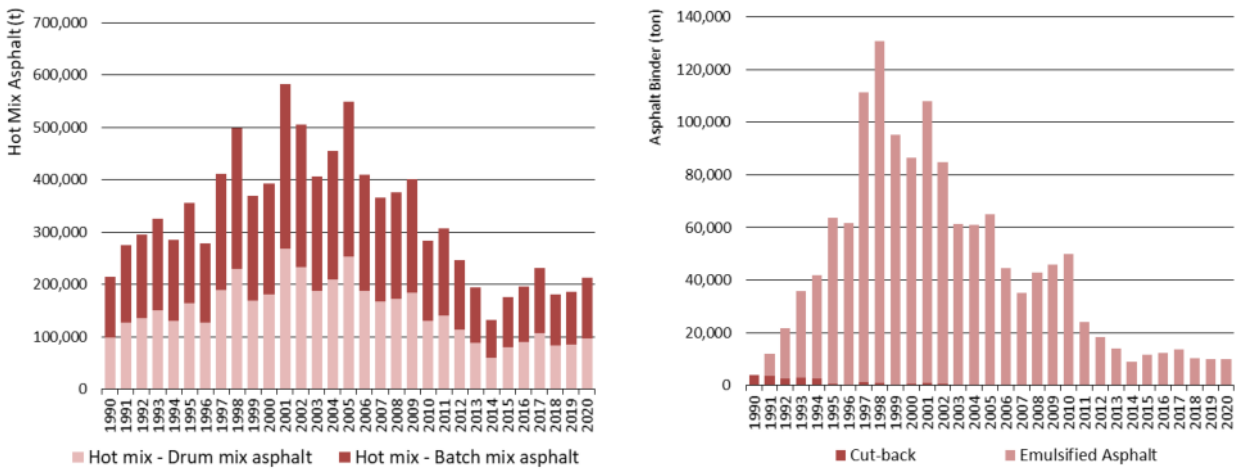


Figure 4-47: Asphalt in road paving, by type

Emissions of Mainland Portugal represent 94.4 % of the total territory. This share has been estimated based on asphalt consumption on construction and public works.

4.5.2.5 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.

Bitumen apparent consumption data for the whole time series was collected from the Energy Balance, published by DGEG, and it is presented in the figure below. Although this time series was not used in the inventory, it is nevertheless used for the verification that the estimates made for each asphalt materials, which are explained in the section above, are coherent with bitumen apparent consumption.

Following QA/QC procedures within the scope of NECD review recomendations to the sector, a compilation error was detected and activity data regarding asphalt used was revised.

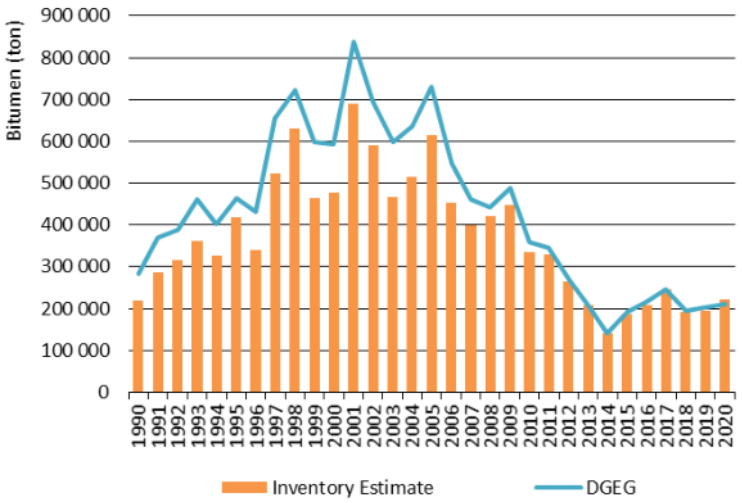


Figure 4-48: Total consumption of bitumen in the construction sector according to sales from DGEG Energy Balance and sum of values of asphalt used according to the inventory

4.5.2.6 Recalculations

Following QA/QC procedures within the scope of NECD review recomendations to the sector, a compilation error was detected and activity data regarding asphalt used was revised.

Following a 2021 NECD review recomendation, Portugal revised EFs for both batch and continuous processes, applying a Tier 2 EF for these processes from the EMEP 2019 Guidebook. Previous estimates were based in EFs from the USEPA (2000).

Also following a 2021 NECD review question, BC emissions were estimated for the first time for both batch and continuous processes, according to a Tier 2 methodology from the EMEP 2019 Guidebook. According to the Guidebook, there is no available EF for BC for cutback asphalt.

Main recalculations to the sector are presented in the figures below.

Figure 4-49: Main recalculations in road paving sector

4.5.2.7 Further Improvements

No further improvements are planned.

4.5.3 Asphalt Roofing (NFR 2.D.3.c – SNAP 040610)

4.5.3.1 Category description

This chapter addresses emissions estimates from the asphalt roofing industry.

4.5.3.2 Methodology

For all pollutants, emission were estimated based on a Tier 1 methodology according to the following equation:

Equation 4-60: Emissions from Asphalt Roofing

$$Emix = (Prod + Imp - Exp) \times \frac{EFx}{10^6}$$

Where:

Emi_x: Emissions of pollutant "x" (t)

Prod: National production of Asphalt roofing products (t)

Imp: Imports of Asphalt roofing products (t)

Exp: Exports of Asphalt roofing products (t)

EF_x: Emission factor of pollutant "x" (g/t of asphalt roofing products)

4.5.3.3 Emission Factors

Tier 1 emission factors applied were taken from Table 3.1 of chapter 2.D.3.c Asphalt roofing of 2019 EMEP Guidebook and are listed in the table below.

Table 4-48: Emission Factors

Pollutant	Unit	EF
CO	g/t shingle	9.5
NMVOC	g/t shingle	130
TSP	g/t shingle	1600
PM_{10}	g/t shingle	400
$PM_{2.5}$	g/t shingle	80
BC	g/t shingle	0.013

4.5.3.4 Activity Data

Asphalt roofing materials national production was obtained from INE in the periods 1992-2007 and from 2011 onwards. In the period 1990-1991, data has been estimated based on 1992 production and on GDP trend. In the period 2008-2010, due to statistical inconsistencies, data has been estimated based on 2007 production and on GDP trend. Originally, part of the data was reported in "kg" unit and the other part in "m^2" of shingle. For the conversion, we have considered that usually a shingle has 1.1 lb_m/ft^2 (1.1x4.86 kg/m^2).

From 1995 onwards, imports and exports data were obtained from EUROSTAT database. In the period 1990-1994, imports and exports data have been estimated based on 1995 data and on GDP trend.

Asphalt roofing materials data is presented in the figure below. 2020 data are relatively lower due to the COVID pandemic.

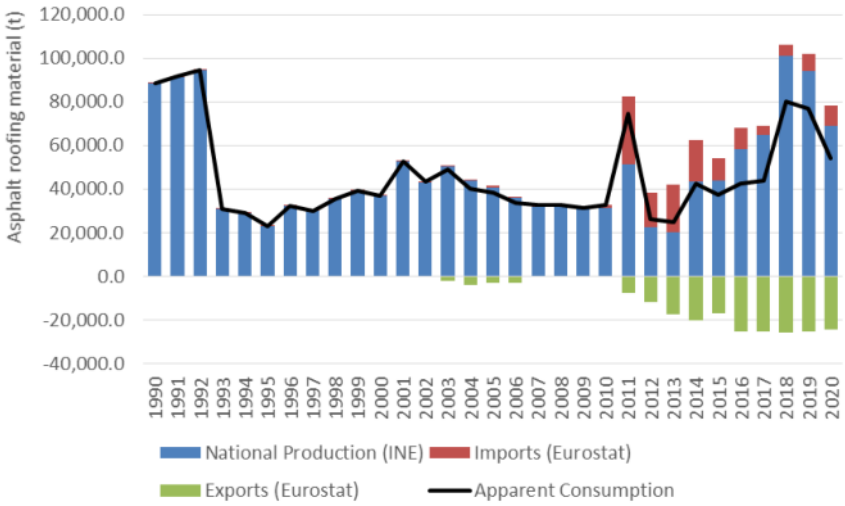


Figure 4-50: Asphalt roofing materials production, imports, exports and apparent consumption

Emissions of Mainland Portugal represent 94.4 % of the total territory. This share has been estimated based on asphalt consumption on construction and public works.

4.5.3.5 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.

4.5.3.6 Recalculations

2014-2019 data on asphalt roofing materials national production were updated according to EUROSTAT database.

4.5.3.7 Further Improvements

Efforts will be made to better understand the reasons behind the sharp decrease (INE) in asphalt roofing materials from 1992 to 1993.

4.5.4 Coating applications - Manufacture of automobiles (NFR 2.D.3.d - SNAP 060101)

4.5.4.1 Category description

This chapter addresses emissions estimates from coating application on automobile manufacturing.

4.5.4.2 Methodology

NMVOC emissions were estimated according to:

Equation 4-61: NMVOC emissions from coating applications in the manufacture of automobiles

$$Emi_{NMVOC} = AD \times \frac{EF_{NMVOC}}{1000} \times (100\% - Eff_{Abat\ Techn})$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

AD: Number of cars manufactured

EF_{NMVOC}: NMVOC emission factor (kg NMVOC/car)

$Eff_{Abat\ Techn}$: Efficiency of Abatement Technology Mix (%)

4.5.4.3 Emission Factors

The following parameters were chosen to estimate emissions for coating application on car manufacturing.

Table 4-49: Default emission factor

Subsector	Unit	NMVOC	Source
Manufacture of automobiles: Car coating	kg/car	8	Table 3-6 of chapter "2.D.3.d Coating applications" of "EMEP/EEA air pollutant emission inventory guidebook 2016"

Table 4-50: Abatement technology

Abatement Technology	Unit	Efficiency
Water-based primer; solvent-based	%	10
Solvent-based primer; water-based basecoat	%	40
Water-based primer and basecoat	%	50
Add on: incinerator on drying oven	%	10
Add on: Incinerator on drying oven; activated carbon adsorption on spray booth & thermal incineration	%	40

Source: (EMEP/EEA, 2016)

Table 4-51: % Efficiency of the abatement technology mix

Technology	Unit	1990	1995	2000	2005	2010-onwards
Manufacture of automobiles-Vehicles-Process modification and substitution	% Efficiency of Abatement technology mix	0.0	22.5	45.0	67.5	90.0

Table 4-52: Final emission factor

Parameter	Unit	1990	1995	2000	2005	2010-onwards
Final EF Car coating	kg/car	8.0	6.2	4.4	2.6	0.8

4.5.4.4 Activity Data

From 1992 onwards, number of vehicles was obtained from INE. In the period 1990-1991, data has been estimated based on 1992 production and on GDP trend. 2020 data on automobiles manufactured are relatively lower due to the COVID pandemic.

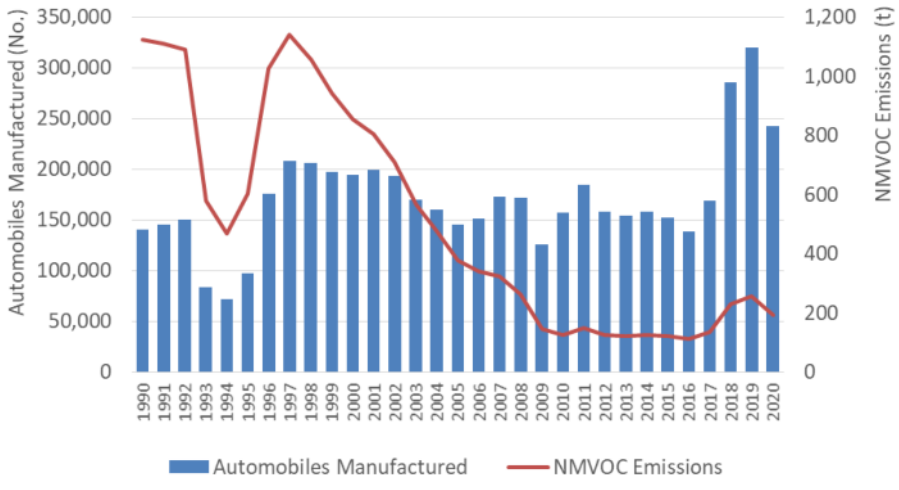


Figure 4-51: Number of cars manufactured

4.5.4.5 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.

4.5.4.6 Recalculations

No recalculations were made.

4.5.4.7 Further Improvements

No further improvements are expected.

4.5.5 Coating applications - Car Repairing (NFR 2.D.3.d - SNAP 060102)

4.5.5.1 Category description

This chapter addresses emissions estimates from coating application on car repairing.

4.5.5.2 Methodology

NMVOC emissions were estimated according to:

Equation 4-62: NMVOC emissions from coating applications on car repairing

$$Emi_{NMVOC} = AD \times \frac{EF_{NMVOC}}{1000} \times (100\% - Eff_{Abat\ Techn})$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

AD: Paint consumption (t)

EF_{NMVOC}: NMVOC emission factor (kg NMVOC/t paint)

$Eff_{Abat\ Techn}$: Efficiency of Abatement Technology Mix (%)

4.5.5.3 Emission Factors

The following parameters were chosen to estimate emissions for coating application on car repairing.

Table 4-53: Default emission factor

SNAP	Unit	NMVOC	Source
Coating Applications: Car Repairing	kg/t paint	720	Table 3-7 of chapter "2.D.3.d Coating applications" of "EMEP/EEA air pollutant emission inventory guidebook 2016"

Table 4-54: Abatement technology

Abatement Technology	Unit	Efficiency
No abatement technology	%	0
Conventional primer; high solid surfacer; conventional topcoat(s); basic cleaning agent	%	8
Conventional primer; high solid surfacer; improved topcoat(s); better cleaning agent	%	60
Conventional primer; very high solid surfacer; improved topcoat(s); better cleaning agent	%	70
Source: (Table 3-19 of chapter "2.D.3.d Coating applications" of "EMEP/EEA air pollutant emission inventory guidebook 2016")		

Table 4-55: % Efficiency of the abatement technology mix

SNAP	Unit	1990	1995	2000	2005	2010	2018	2019	2020
Coating Applications: Car Repairing	% Efficiency of abatement technology mix	0.0	17.0	34.0	49.5	65.0	69.0	69.5	70.0

Table 4-56: Final emission factor

Parameter	Unit	1990	1995	2000	2005	2010	2018	2019	2020
Final EF Car coating	kg/t paint	720	598	475	364	252	223	220	216

4.5.5.4 Activity Data

In the period 1990-2006, data on paint production for car repairing was obtained from INE. From 2007 onwards, data has been estimated based on synthetic polymers paints production trend also from INE.

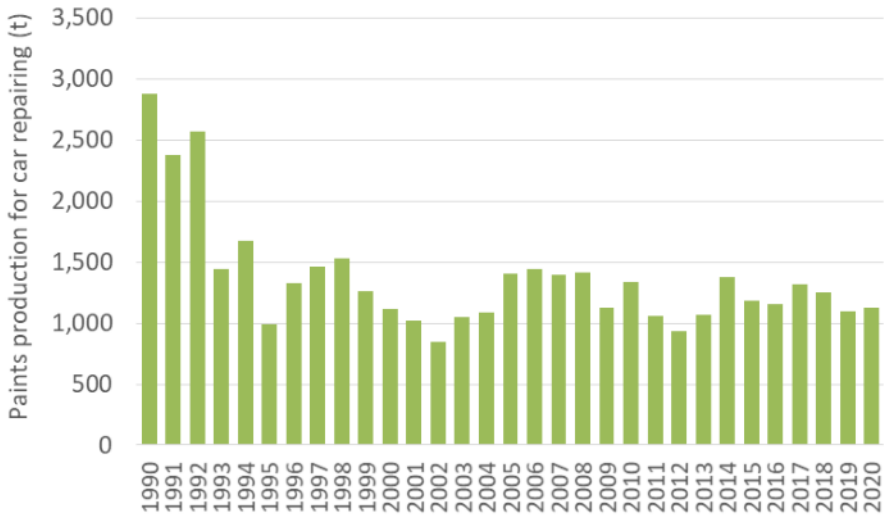


Figure 4-52: Paint production for car repairing

4.5.5.5 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.

4.5.5.6 Recalculations

No recalculations were made.

4.5.5.7 Further Improvements

No further improvements are expected.

4.5.6 Coating applications - Construction and buildings (NFR 2.D.3.d - SNAP 060103)

4.5.6.1 Category description

This chapter addresses emissions estimates from coating application on construction and buildings.

4.5.6.2 Methodology

Emissions were estimated according to:

Equation 4-63: NMVOC emissions from coating applications in construction and buildings

$$Emi_{NMVOC} = AD \times \frac{EF_{NMVOC}}{1000} \times (100\% - Eff_{Abat\ Techn})$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

AD: Paint consumption (t)

EF_{NMVOC}: NMVOC emission factor (kg NMVOC/t paint)

$Eff_{Abat\ Techn}$: Efficiency of Abatement Technology Mix (%)

4.5.6.3 Emission Factors

The following parameters were chosen to estimate emissions for coating application on construction and buildings.

Table 4-57: Default emission factor

SNAP	Unit	NMVOC	Source
Construction and buildings	g/kg paint	230	Table 3-4 of chapter "2.D.3.d Coating applications" of "EMEP/EEA air pollutant emission inventory guidebook 2016"

Table 4-58: Abatement technology

Abatement Technology	Efficiency	Source
Substitution with dispersion/emulsion (2-3 wt-% solvent)	39	Table 3-17 of chapter "2.D.3.d Coating applications" of "EMEP/EEA air pollutant emission inventory guidebook 2016
Substitution with water-based paints (efficiency 80%)	26	
Substitution with high solids paints (efficiency 40-60%)	4	
Substitution with dispersion/emulsion and water-based paints	65	
Substitution with dispersion/emulsion and high solids paints	43	
Substitution with dispersion/emulsion, water-based and high solids paints	70	

Table 4-59: Share of each abatement technology over time

Technology	Unit	1990	1995	2000	2005	2010	2018	2019	2020
Substitution with dispersion/emulsion (2-3 wt-% solvent)	%	0	0	100	50	0	0	0	0
Substitution with water-based paints (efficiency 80%)	%	0	100	0	0	0	0	0	0
Substitution with high solids paints (efficiency 40-60%)	%	100	0	0	0	0	0	0	0
Substitution with dispersion/emulsion and water-based paints	%	0	0	0	0	0	0	0	0
Substitution with dispersion/emulsion and high solids paints	%	0	0	0	0	0	0	0	0
Substitution with dispersion/emulsion, water-based and high solids paints	%	0	0	0	50	100	100	100	100
Source: Expert judgement									

Table 4-60: Final emission factor

Parameter	Unit	1990	1995	2000	2005	2010-onwards
Final EF	kg/t paint	221	170	140	105	69

4.5.6.4 Activity Data

In the period 1990-2003, data on paint production for construction of buildings was obtained from INE. From 2004 onwards, data has been estimated based on synthetic polymers paints production trend, also from INE.

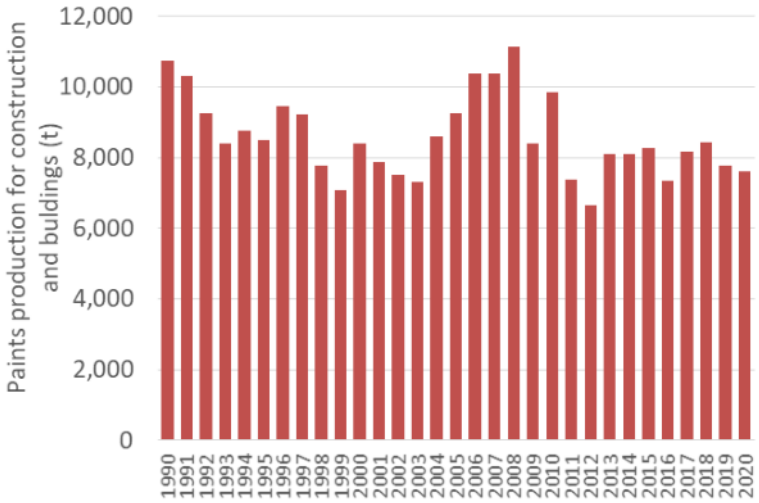


Figure 4-53: Paint production for construction and buildings

4.5.6.5 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.

4.5.6.6 Recalculations

No recalculations were made.

4.5.6.7 Further Improvements

No further improvements are expected.

4.5.7 Coating applications - Domestic Use (NFR 2.D.3.d - SNAP 060104)

4.5.7.1 Category description

This chapter addresses emissions estimates from domestic use of coating application.

4.5.7.2 Methodology

NMVOC emissions from the domestic use of coating applications were estimated according to:

Equation 4-64: NMVOC emissions from Domestic use of coating applications

$$Emi_{NMVOC} = AD \times \frac{EF_{NMVOC}}{1000} \times (100\% - Eff_{Abat\ Techn})$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

AD: Paint consumption (t)

EF_{NMVOC}: NMVOC emission factor (kg NMVOC/t paint)

$Eff_{Abat\ Techn}$: Efficiency of Abatement Technology Mix (%)

4.5.7.3 Emission Factors

The following parameters were chosen to estimate emissions for domestic use of coating application.

Table 4-61: Default emission factor

SNAP	Unit	NMVOC	Source
Domestic application (except 060107)	g/kg paint	230	Table 3-5 of chapter "2.D.3.d Coating applications" of "EMEP/EEA air pollutant emission inventory guidebook 2016"

Table 4-62: Abatement technology

Abatement Technology	Efficiency	Source
Substitution with dispersion/emulsion (2-3 wt-% solvent)	39	Table 3-17 of chapter "2.D.3.d Coating applications" of "EMEP/EEA air pollutant emission inventory guidebook 2016
Substitution with water-based paints (efficiency 80%)	26	
Substitution with high solids paints (efficiency 40-60%)	4	
Substitution with dispersion/emulsion and water-based paints	65	
Substitution with dispersion/emulsion and high solids paints	43	
Substitution with dispersion/emulsion, water-based and high solids paints	70	

Table 4-63: Share of each abatement technology over time

Technology	Unit	1990	1995	2000	2005	2010-onwards
Substitution with dispersion/emulsion (2-3 wt-% solvent)	%	0	0	100	50	0
Substitution with water-based paints (efficiency 80%)	%	0	100	0	0	0
Substitution with high solids paints (efficiency 40-60%)	%	100	0	0	0	0
Substitution with dispersion/emulsion and water-based paints	%	0	0	0	0	0
Substitution with dispersion/emulsion and high solids paints	%	0	0	0	0	0
Substitution with dispersion/emulsion, water-based and high solids paints	%	0	0	0	50	100

Table 4-64: Final emission factor

Parameter	Unit	1990	1995	2000	2005	2010-onwards
Final EF	g/kg paint applied	221	170	140	105	69

4.5.7.4 Activity Data

Data not considered in the other subcategories of "Coating Applications" is considered in Domestic Use. Paint application for domestic use was obtained from national statistics for the periods 1994 to 2001 and 2004 to 2010. The missing years were estimated based on GDP trend.

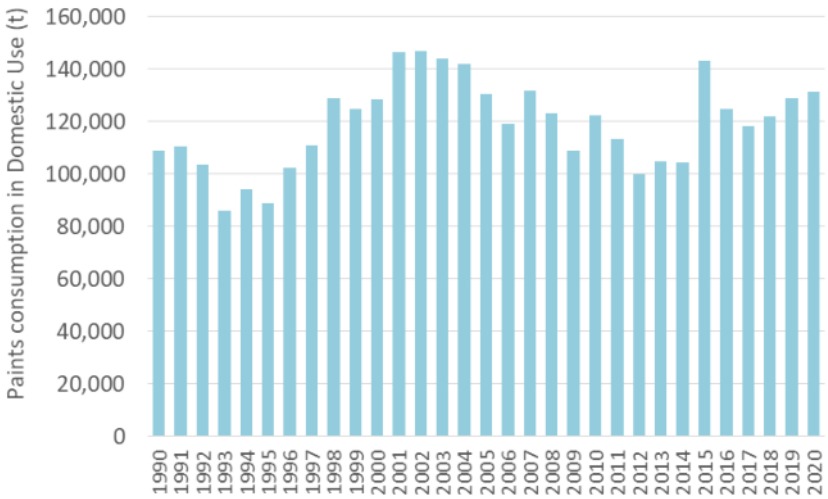


Figure 4-54: Paints consumption in domestic use

4.5.7.5 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, 2002-2003 and 2001-2018 activity data due to a compilation error.

4.5.7.6 Recalculations

Following QA/QC procedures to the sector, 2002-2003 and 2001-2018 activity data due to a compilation error.

4.5.7.7 Further Improvements

No further improvements are expected.

4.5.8 Coating applications - Coil Coating (NFR 2.D.3.d - SNAP 060105)

4.5.8.1 Category description

This chapter addresses emissions estimates from coil coating application.

4.5.8.2 Methodology

NMVOC emissions from coil coating applications were estimated according to:

Equation 4-65: NMVOC emissions from coil coating application

$$Emi_{NMVOC} = AD \times \frac{EF_{NMVOC}}{1000} \times (100\% - Eff_{Abat\ Techn})$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

AD: Coil coatings application (t)

EF_{NMVOC}: NMVOC emission factor (kg NMVOC/t coil coating)

$Eff_{Abat\ Techn}$: Efficiency of Abatement Technology Mix (%)

4.5.8.3 Emission Factors

The following parameters were chosen to estimate emissions for coil coating application.

Table 4-65: Default emission factor

SNAP	Unit	NMVOC	Source
Coil Coating	Kg/t coil coating	480	Table 3-8 of chapter "2.D.3.d Coating applications" of "EMEP/EEA air pollutant emission inventory guidebook 2016"

Table 4-66: Abatement technology efficiency

Abatement Technology	Efficiency	Source
No abatement technology	0%	Table 3-20 of chapter "2.D.3.d Coating applications" of "EMEP/EEA air pollutant emission inventory guidebook 2016")
Coil coating line with water-based coatings (10% wt-% solvent content)	75%	Table 3-20 of chapter "2.D.3.d Coating applications" of "EMEP/EEA air pollutant emission inventory guidebook 2016")
Coil coating line with powder coating systems (solvent free)	100%	Table 3-20 of chapter "2.D.3.d Coating applications" of "EMEP/EEA air pollutant emission inventory guidebook 2016")

Table 4-67: Share of each abatement technology over time

Technology	Unit	1990	1995	2000	2005	2010	2018	2019	2020
No abatement technology	%	30.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0
Coil coating line with water-based coatings (10% wt-% solvent content)	%	50.0	50.0	50.0	31.0	12.0	6.4	5.7	5.0
Coil coating line with powder coating systems (solvent free)	%	20.0	35.0	50.0	69.0	88.0	93.6	94.3	95.0

Table 4-68: Final emission factor

Parameter	Unit	1990	1995	2000	2005	2010	2018	2019	2020
Final EF	Kg/t coil coating	204	132	60	37.2	14.4	7.7	6.8	6.0

4.5.8.4 Activity Data

In the period 1992-2003, data on coil coating was obtained from INE (IAPI). In the period 1990-1991, data has been estimated based on GDP trend.

From 2004 onwards, data has been estimated based on total paints production trend.

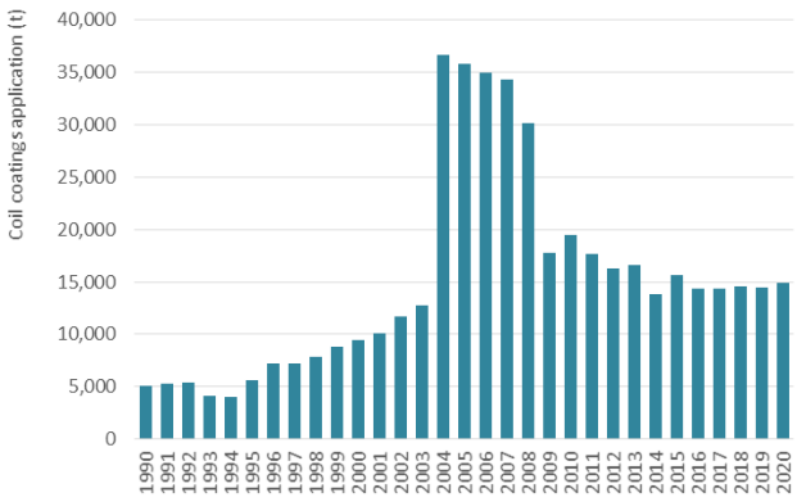


Figure 4-55: Coil coatings application

4.5.8.5 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.

4.5.8.6 Recalculations

No recalculations were made.

4.5.8.7 Further Improvements

No further improvements are expected.

4.5.9 Coating applications - Boat Building (NFR 2.D.3.d - SNAP 060106)

There is no national statistics data in m^2 in order to apply the default emission factor proposed in table 3-15 of 2019 EMEP Guidebook. Thus, emissions of this category are included in SNAP 060104 (Domestic Use except 060107), which is the category where we estimate all the emissions that are not possible to account separately.

4.5.10 Coating applications - Wood (NFR 2.D.3.d - SNAP 060107)

4.5.10.1 Category description

This chapter addresses emissions estimates from wood coating application.

4.5.10.2 Methodology

NMVOC emissions from wood coating applications were estimated according to:

Equation 4-66: NMVOC emissions from wood coating application

$$Emi_{NMVOC} = AD \times \frac{EF_{NMVOC}}{1000} \times (100\% - Eff_{Abat\ Techn})$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

AD: Paint consumption (t primers, enamels and varnishes applied in wood)

EF_{NMVOC}: NMVOC emission factor (kg NMVOC/t primers, enamels and varnishes applied in wood)

$Eff_{Abat\ Techn}$: Efficiency of Abatement Technology Mix (%)

4.5.10.3 Emission Factors

The following parameters were chosen to estimate emissions for wood coating application.

Table 4-69: Default emission factor

SNAP	Unit	NMVOC	Source
Wood	kg/t material applied	800	Table 3-9 of chapter "2.D.3.d Coating applications" of "EMEP/EEA air pollutant emission inventory guidebook 2016"

Table 4-70: Abatement technology

Abatement Technology	Unit	Efficiency
Uncontrolled	%	0
Medium solids system (55% solvent content)	%	31
High solids system (20% solvent content)	%	75
Very high solids system (5% solvent content)	%	94
Add-on: Thermal oxidation	%	76
Source: (EMEP/EEA, 2016)		

Table 4-71: Share of each abatement technology over time

Technology	Unit	1990	1995	2000	2005	2010-onwards
Uncontrolled	%	13.99	13.99	13.99	13.74	4.37
Medium solids system (55% solvent content)	%	0.00	0.00	0.00	0.00	0.00
High solids system (20% solvent content)	%	38.13	38.13	38.13	38.38	47.75
Very high solids system (5% solvent content)	%	47.88	47.88	47.88	47.88	47.88
Add-on: Thermal oxidation	%	0.00	0.00	0.00	0.00	0.00

Table 4-72: Final emission factor

Parameter	Unit	1990	1995	2000	2005	2010-onwards
Final EF	g/kg material applied	211.2	211.2	211.2	209.7	153.4

4.5.10.4 Activity Data

In the period 1990-2003, data on primers, enamels and varnishes use in wood were obtained from INE (IAPI). From 2004 onwards, data has been estimated based on synthetic polymers paints production trend, also from INE.

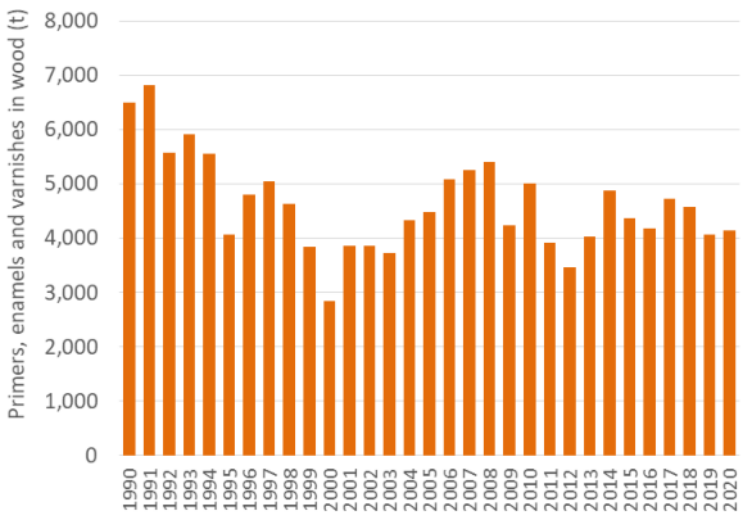


Figure 4-56: Primers, enamels and varnishes use in wood

4.5.10.5 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.

4.5.10.6 Recalculations

No recalculations were made.

4.5.10.7 Further Improvements

No further improvements are expected.

4.5.11 Coating applications - Truck/Van coating (NFR 2.D.3.d - SNAP 060108)

4.5.11.1 Category description

This chapter addresses emissions estimates from coating application in trucks and vans.

4.5.11.2 Methodology

NMVOC emissions from truck/van coating applications were estimated according to:

Equation 4-67: NMVOC emissions from truck/van coating application

$$Emi_{NMVOC} = AD \times \frac{EF_{NMVOC}}{1000}$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

AD: Number of cars manufactured

EF_{NMVOC}: NMVOC emission factor (kg NMVOC/vehicle)

4.5.11.3 Emission Factors

NMVOC emission factor was taken from EMEP Guidebook 2016 and is indicated in the table below.

Table 4-73: Default emission factor

Subsector	Unit	NMVOC	Source
Truck/Van coating	kg/vehicle	28	Table 3-10 of chapter "2.D.3.d Coating applications" of "EMEP/EEA air pollutant emission inventory guidebook 2016"

4.5.11.4 Activity Data

From 1992 onwards, the number of trucks/vans assembled each year was obtained from INE (IAPI). In the period 1990-1991, data has been estimated based on GDP trend.

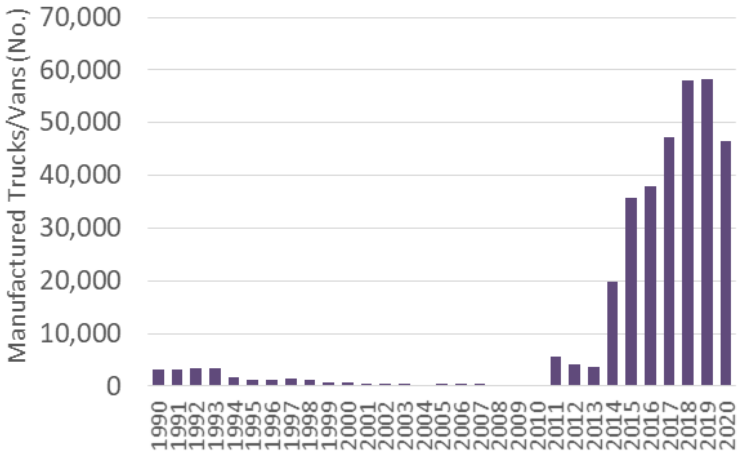


Figure 4-57: Number of vehicles manufactured

4.5.11.5 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.

4.5.11.6 Recalculations

No recalculations were made.

4.5.11.7 Further Improvements

No further improvements are expected.

4.5.12 Coating applications - Truck cabin coating (NFR 2.D.3.d - SNAP 060108)

4.5.12.1 Category description

This chapter addresses emissions estimates from Truck cabin coating.

4.5.12.2 Methodology

NMVOC emissions from truck cabin coating applications were estimated according to:

Equation 4-68: NMVOC emissions from truck cabin coating application

$$Emi_{NMVOC} = AD \times \frac{EF_{NMVOC}}{1000}$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

AD: Number of cars manufactured

EF_{NMVOC}: NMVOC emission factor (kg NMVOC/vehicle)

4.5.12.3 Emission Factors

NMVOC emission factor was taken from EMEP Guidebook 2016 and is indicated in the table below.

Table 4-74: Default emission factor

Subsector	Unit	NMVOC	Source
Truck Cabin coating	kg/vehicle	8	Table 3-11 of chapter "2.D.3.d Coating applications" of "EMEP/EEA air pollutant emission inventory guidebook 2016"

4.5.12.4 Activity Data

The number of truck cabins assembled each year was obtained from INE (IAPI) from 1992 onwards. In the period 1990-1991, data has been estimated based on GDP trend. 2020 data are relatively lower due to the COVID pandemic.

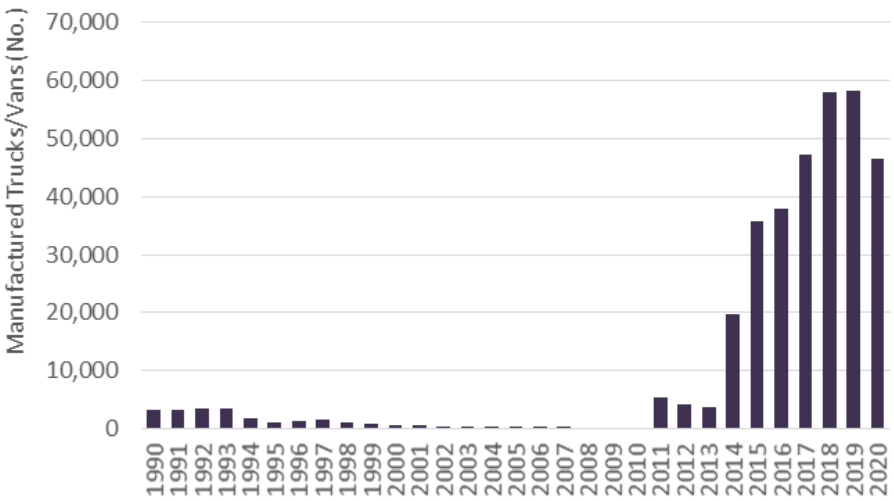


Figure 4-58: Number of truck cabins manufactured

4.5.12.5 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.

4.5.12.6 Recalculations

No recalculations were made.

4.5.12.7 Further Improvements

No further improvements are expected.

4.5.13 Coating applications - Bus coating (NFR 2.D.3.d - SNAP 060108)

4.5.13.1 Category description

This chapter addresses emissions estimates from bus coating.

4.5.13.2 Methodology

NMVOC emissions from bus coating applications were estimated according to:

Equation 4-69: NMVOC emissions from truck bus coating application

$$Emi_{NMVOC} = AD \times \frac{EF_{NMVOC}}{1000}$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

AD: Public transportation vehicles manufactured

EF_{NMVOC}: NMVOC emission factor (kg NMVOC/vehicle)

4.5.13.3 Emission Factors

NMVOC emission factor was taken from EMEP Guidebook 2016 and is indicated in the table below.

Table 4-75: Default emission factor

Subsector	Unit	NMVOC	Source
Bus Coating	kg/vehicle	150	Table 3-12 of chapter "2.D.3.d Coating applications" of "EMEP/EEA air pollutant emission inventory guidebook 2016"

4.5.13.4 Activity Data

From 1992 onwards, the number of public transportation vehicles assembled each year was obtained from INE (IAPI). In the period 1990-1991, data has been estimated based on GDP trend.

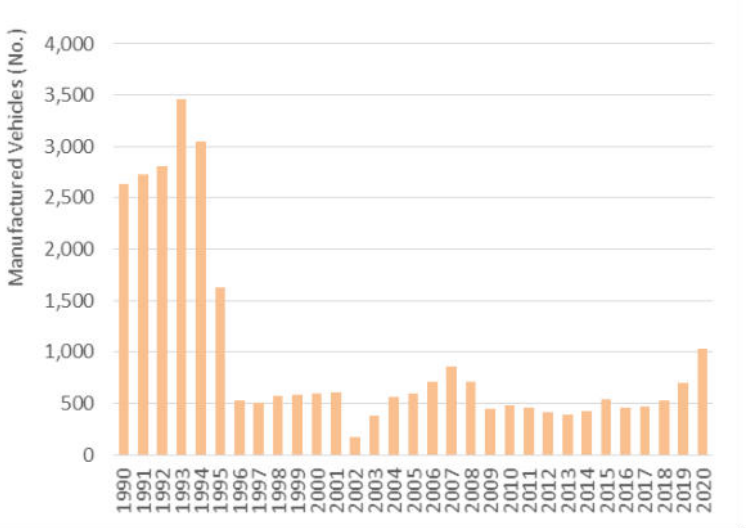


Figure 4-59: Number of public transportation vehicles manufactured

4.5.13.5 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.

4.5.13.6 Recalculations

No recalculations were made.

4.5.13.7 Further Improvements

No further improvements are expected.

4.5.14 Coating applications - Wire coating (NFR 2.D.3.d - SNAP 060108)

There is no national statistics data in kg of wire in order to apply the default emission factor proposed in table 3-13 of the 2019 EMEP Guidebook. Thus, emissions of this category are included in SNAP 060108 (Other Industrial coating applications) and we have applied the Tier 1 emission factor proposed in table 3-2 of the 2019 EMEP Guidebook (400 g NMVOC/kg paint applied).

4.5.15 Coating applications - Leather finishing (NFR 2.D.3.d - SNAP 060108)

4.5.15.1 Category description

This chapter addresses emissions estimates from leather finishing.

4.5.15.2 Methodology

NMVOC emissions from leather coating applications were estimated according to:

Equation 4-70: NMVOC emissions from leather finishing

$$Emi_{NMVOC} = AD \times \frac{EF_{NMVOC}}{1000} \times (100\% - Eff_{Abat\ Techn})$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

AD: Leather production (t)

EF_{NMVOC}: NMVOC emission factor (kg NMVOC/t leather)

$Eff_{Abat\ Techn}$: Efficiency of Abatement Technology Mix (%)

4.5.15.3 Emission Factors

The following parameters were chosen to estimate emissions for leather finishing.

Table 4-76: Default emission factor

SNAP	Unit	NMVOC
Industrial coating application: leather finishing	kg/t leather	200
Source: (EMEP/EEA, 2016)		

Table 4-77: Abatement technology

Abatement Technology	Unit	Efficiency
Use of water based products (30 wt-% solvent content)	%	65
Add on: Thermal oxidation	%	81
Add on: Biofiltration	%	81
Uncontroled	%	0
Source: (EMEP/EEA, 2016)		

Table 4-78: Control strategy

Technology	Unit	1990	1995	2000	2005	2010	2015-onwards
Use of water based products (30 wt-% solvent content)	%	0	0	0	10	30	50
Add on: Thermal oxidation	%	0	0	0	0	0	0
Add on: Biofiltration	%	0	0	0	0	5	5
Uncontroled	%	100	100	100	90	65	45

Table 4-79: Final emission factor

Parameter	Unit	1990	1995	2000	2005	2010	2015-onwards
Final EF leather finishing	kg/t leather	200.0	200.0	200.0	187.0	152.9	126.9

4.5.15.4 Activity Data

From 1992 onwards, leather production data was obtained from INE (IAPI). In the period 1990-1991, data has been estimated based on GDP trend.

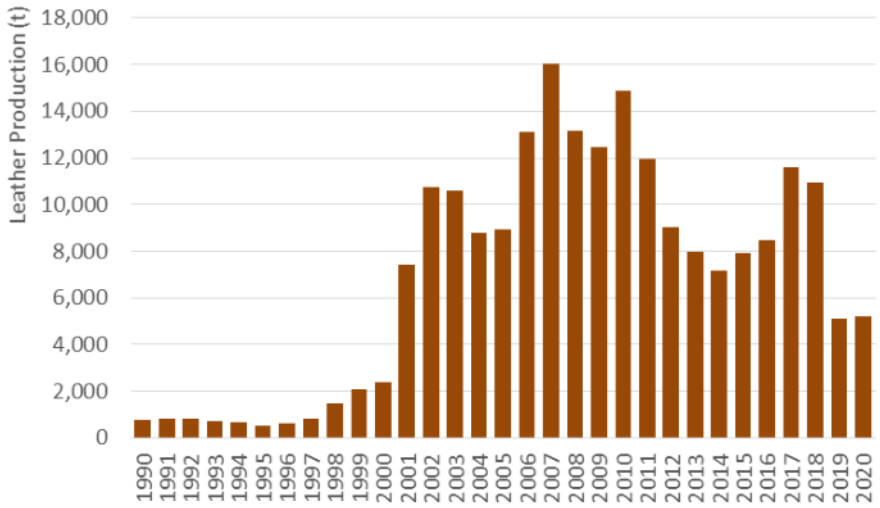


Figure 4-60: Leather production

4.5.15.5 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.

4.5.15.6 Recalculations

No recalculations were made.

4.5.15.7 Further Improvements

No further improvements are expected.

4.5.16 Coating applications - Other Industrial Applications (NFR 2.D.3.d - SNAP 060108)

4.5.16.1 Category description

This chapter addresses emissions estimates from coating in other industrial applications, like metal, plastic, paper, leather and glass substrates which are not covered by any of the other categories already described.

4.5.16.2 Methodology

Other industrial coating applications is estimated based on a Tier 1 approach in accordance to 2019 EMEP Guidebook. NMVOC emissions were estimated according to the following equation:

Equation 4-71: NMVOC emissions from other industrial coating applications

$$Emi_{NMVOC} = AD \times \frac{EF_{NMVOC}}{1000} \times (100\% - Eff_{Abat\ Techn})$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

AD: Paint applied production (t)

EF_{NMVOC}: NMVOC emission factor (kg NMVOC/t paint)

$Eff_{Abat\ Techn}$: Efficiency of Abatement Technology Mix (%)

4.5.16.3 Emission Factors

NMVOC emission factor was taken from EMEP Guidebook 2016 and is indicated in the table below.

Table 4-80: Default emission factor (Tier 1)

SNAP	Unit	NMVOC	Source
Industrial coating application	kg/t paint applied	400	Table 3-2 of chapter "2.D.3.d Coating applications" of "EMEP/EEA air pollutant emission inventory guidebook 2016"

4.5.16.4 Activity Data

In the period 1995-2010, data was obtained from INE (IAPI). In the period 1990-1994 and from 2011 onwards, data has been estimated based on GDP trend.

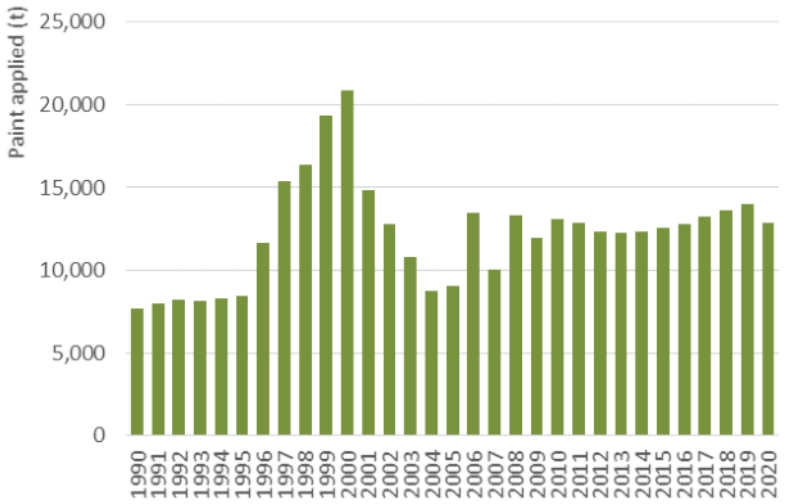


Figure 4-61: Paint applied in Other Industrial Applications

4.5.16.5 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.

4.5.16.6 Recalculations

2019 activity data was updated.

4.5.16.7 Further Improvements

No further improvements are expected.

4.5.17 Degreasing (NFR 2.D.3.e – SNAP 060201; 060203; 060204)

4.5.17.1 Category description

Solvent degreasing refers to operation processes, usually performed within industrial activities, where solvents are used as degreasers to clean products and materials from water insoluble substances (fats), such as oil, grease, wax or tars. This cleaning procedure usually preceeds the application of other treatment processes and occurs mainly in metal industry, plastics products manufacturing, rubber[13], textiles, glass, paper and fiberglass, etc. Usually solvents used to achieve degreasing are petroleum distillates, chlorinated hydrocarbons, ketones and alcohols, and the cleaning process is usually done in tanks, which may have some form of emissions control (solvent recovery).

Emissions result from the evaporation of the NMVOC contained in organic degreasing solvents, during their use. For most products, all NMVOC will be emitted to the atmosphere. However, in some products, NMVOC will be lost mainly in wastewater.

4.5.17.2 Methodology

NMVOC emissions from degreasing were estimated based on a Tier 2a approach of chapter 2.D.3.a of 2019 EMEP Guidelines (section 3.2.3). Due to lack of national data on used amount of degreasing products or solvent content of degreasing products, this methodology was based on data supplied by European Solvents Industry Group (ESIG).

NMVOC emissions from degreasing were estimated according to the following equation:

Equation 4-72: NMVOC emissions from degreasing

$$Emi_{NMVOC} = Deg_{consump} \times (100\% - \eta_{abatement})$$

Where:

Emi_{NMVOC}: NMVOC emissions from degreasing (t)

$Deg_{consump}$: Consumption of degreasing substances (t)

$\eta_{abatement}$: Abatement efficiency (%)

4.5.17.3 Emission Factors

Activity data / Penetration of different techniques

As a result of the wide range of activities for which metal cleaning is used, it is very difficult to get a reliable picture of the penetration of the different techniques in Portugal. Due to lack of national data, and following guidance from 2019 EMEP Guidebook, data was obtained from ESIG inventory. Data supplied from ESIG is categorized using REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) sector classification.

[13] Emissions from degreasing in this industry are included under rubber processing.

For the degreasing category, a one-to-one link (100%) between REACH *Cleaning Industrial + Leather treatment* sector and NRF 2.D.3.e is assumed, according to the table below:

Table 4-81: Mapping table: REACH to NFR (2.D.3.e - Degreasing)

REACH end-use sector	Unit	2.D.3.e
Cleaning Industrial + Leather treatment	ton	100%
Source: Table A1.1 - Annex 1, Chapter 2.D.3.a Domestic solvent use including fungicides - EMEP/EEA Guidebook 2019		

Therefore, we consider all data from ESIG "Cleaning Industrial + Leather treatment" can be used for the degreasing sector.

Abatement technologies

Due to lack of data regarding abatement techniques that may occur in the country, we considered the following:

. from 1990 to 1999, prior to the publication of the Solvents Emissions Directive 1999/13/EC, (11th March), we assumed no abatement technologies for degreasing activity were implemented in the country. It was assumed a conservative approach of 0% abatement efficiency, hence, all degreasing substances used were emited as NMVOC;

. from 2011 onwards, with no available information regarding abatement techniques in place in the country or their penetration rate, further research was made on air quality legislation in place. The National Emission Ceilings (NEC) Directive 2001/81/EC (23rd October) stated that by the year 2010 at the latest, Member States should limit their annual national emissions of pollutants such as volatile organic compounds (VOC) to amounts not greater than the emission ceilings laid down in Annex I. Therefore, from 2011 onwards we assumed 30% abatement efficiency, according to ESIG technical paper (2015);

. from 2000 to 2010, with no available information regarding abatement techniques in place in the country or their penetration rate, further research was made on air quality legislation in place. Upon the publication of the Solvents Emissions Directive 1999/13/EC, (11th March), Member States were required to limit emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations, such as industrial degreasing. Also, the National Emission Ceilings (NEC) Directive 2001/81/EC (23rd October), stated that, by the year 2010 at the latest, Member States should limit their annual national emissions of pollutants such as volatile organic compounds (VOC) to amounts not greater than the emission ceilings laid down in Annex I. As a Member State, Portugal had to comply with these European commitments, however, there is no national data on the progress of these Directives. Therefore, from 2000 to 2010 we assumed a linear growing trend between 0% and 30% abatement efficiencies.

4.5.17.4 Activity Data

From 2008 onwards, data concerning consumption of degreasing substances was available from ESIG. From 1990 to 2007, the splicing technique "overlap" (section 5.3.1.1 of the 2006 IPCC Guidelines) was used in order to estimate degreasing substances consumption, using surrogate data from EUROSTAT, according to the following equation:

Equation 4-73: Consumption of degreasing substances – 1990-2007

$$Deg_{consump,y} = App_{consump,y} \times \frac{Deg_{\text{consump},2008-2020}}{App\ \text{consump}_{2008-2020}}$$

Where:

$Deg_{consump,y}$: Consumption of degreasing substances in year y (t)

$App_{consump,y}$: Apparent consumption of degreasing substances (EUROSTAT) in year y (t)

$Deg_{consump,2008-2020}$: Average consumption of degreasing substances in period 2008-2020 (t)

$App_{consump,2008-2020}$: Average apparent consumption of degreasing substances (EUROSTAT) in period 2008-2020 (t)

Apparent consumption data on degreasing substances was estimated from sold production, imports and exports from EUROSTAT for the whole time series, according to the following equation:

Equation 4-74: Apparent consumption substances in degreasing

$$App_{consump} = Sold\ Prod + Imp - Exp$$

Where:

$App_{consump}$: Apparent consumption of metal degreasing substances (t)

Sold Prod: Sold production of metal degreasing substances (t)

Imp: Imports of metal degreasing substances (t)

Exp: Exports of metal degreasing substances (t)

According to chapter 2.D.3.e of the 2019 EMEP Guidebook (section 2.3), the most common cleaning organic solvents are methylene chloride, trichloroethylene; tetrachloroethylene and xylenes. Previous estimates were made based on xylenes consumption, however, we found that a Portuguese facility was using p-xylene as feedstock for terephthalic acid (PTA) production. Therefore, we only used trichloroethylene; tetrachloroethylene values from EUROSTAT.

A comparison between degreasing substances data from EUROSTAT and those considered in the inventory is presented in the figure below for the whole time series.

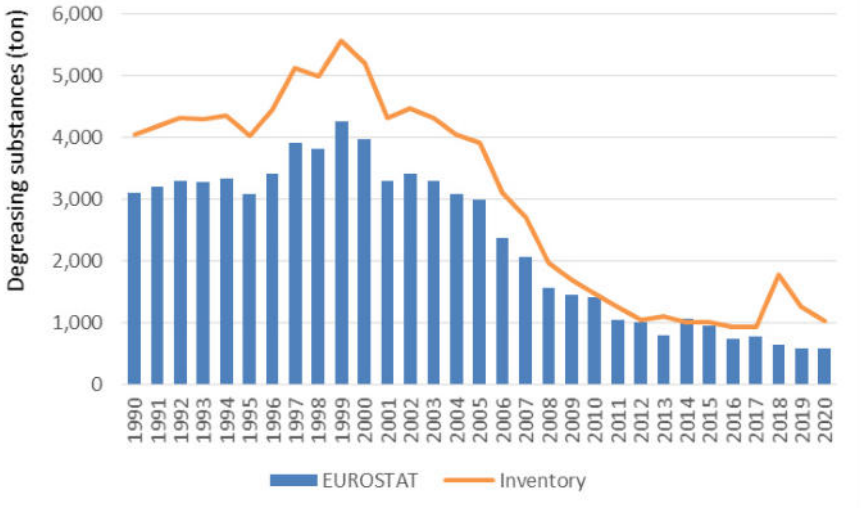


Figure 4-62: Degreasing substances consumption – total territory

Emissions of Mainland Portugal represent 100.0% of the total territory. This share has been estimated based on fuel sold to "Chemical Industry" (1.A.2.c).

4.5.17.5 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.

In previous submissions, we were considering the following substances as metal industry degreasing solvents: p-xylene, o-xylene, m-xylene and Dichloromethane.

Folowing QA/QC procedures to degreasing activity data, we found p-xylene is the isomer with the greatest demand (about 98%) for the production of terephthalic acid (PTA) or dimethylterephthalate (DMT). Further research showed there is a Portuguese facility consuming large amounts of this isomer in order to produce PTA. Therefore, we considered revising activity data for this category.

4.5.17.6 Recalculations

Previous NECD reviews recomended that Portugal moved to a Tier 2 methodology, given that degreasing is a key category for NMVOC.

Previous methodology was a Tier 1 based on xylene consumption as degreasing substance. National xylene consumption trend in the last years increased significantly due to terephthalic acid (PTA) production frm ne facility.

Degreasing methodology update resulted in recalculations in NMVOC emissions as showed in the figure below - 2.D.3.e sector in tons (left) and national total NMVOC emissions in % (right). We consider this methodology to be more in line with national circumstances regarding the NMVOC emissions trend over the years.

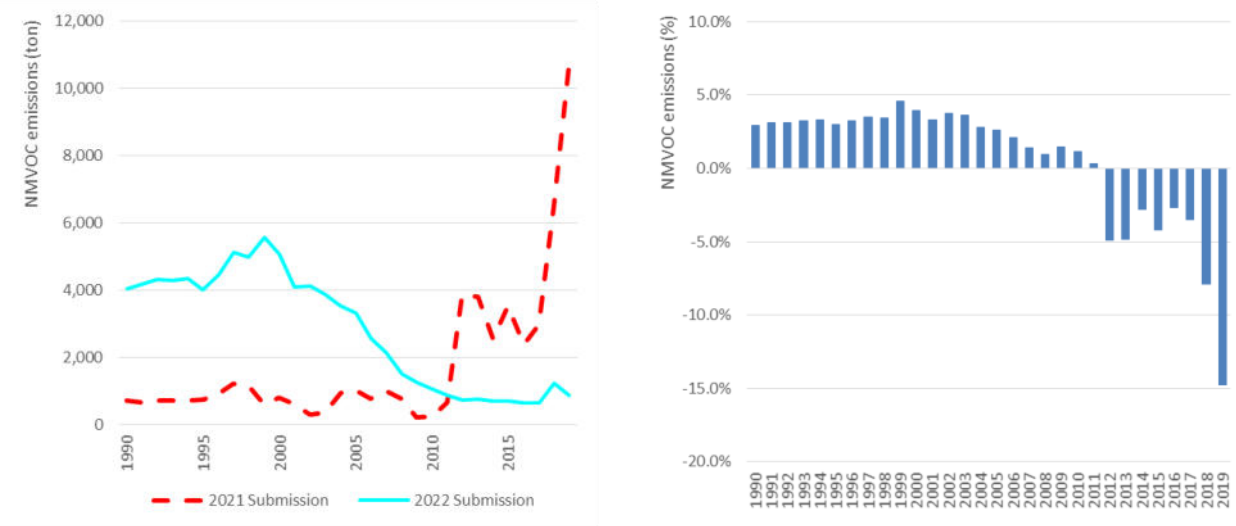


Figure 4-63: Recalculations in NMVOC for degreasing – 2.D.3.e sector and national total NMVOC emissions

4.5.17.7 Further Improvements

According to the 2019 EMEP Guidelines, in order to apply a Tier 2 approach, an insight into the penetration of the different technologies is necessary, as well as abatement techniques that may occur in the country. Following further research, Portugal was unable to collect national data concerning degreasing sector.

For the time being, Portugal will apply the revised methodology presented in this submission, based on ESIG data for the country.

4.5.18 Dry cleaning (NFR 2.D.3.f – SNAP 060202)

4.5.18.1 Category description

In essence, dry cleaning seeks to remove contamination or dirt from cloths, textile, furs, leather, down leathers, textiles or other objects made of fibers, using chlorinated organic solvents, predominantly tetrachloroethylene (PER).

4.5.18.2 Methodology

There is no available stratified data regarding the different solvents used or amount of textiles treated in dry cleaning or abatement techniques that may occur in the country. We assumed that PER is the only solvent used in Portugal for dry-cleaning. NMVOC emissions from dry cleaning were estimated based on a Tier 1 approach from chapter 2.D.3.f of 2019 EMEP Guidelines.

Apparent consumption of PER was estimated according to the following equation:

Equation 4-75: PER apparent consumption

App Cons = Production + Imports - Exports

Where:

App Cons: Apparent consumption of Perchloroethylene (t)

Production: National production of Perchloroethylene (t)

Imports: Imports of Perchloroethylene (t)

Exports: Exports of Perchloroethylene (t)

NMVOC emissions were estimated according to the following equation:

Equation 4-76: NMVOC emissions

$$Emi_{NMVOC} = PER_{Cons} \times (EF_{OC} \times \%_{OC} + EF_{CC} \times \%_{CC})$$

Where:

Emi_{NMVOC}: NMVOC emissions

PER_{Cons}: Percloroethylene apparent consumption (t)

EF_{OC}: Open circuit equipment emission factor

$\%_{OC}$: % of Open circuit equipments

EF_{CC}: Closed circuit equipment emission factor

$\%_{CC}$: % of Closed circuit equipments

4.5.18.3 Emission Factors

The following parameters by type of equipment were chosen to estimate emissions for dry cleaning. According to Section 3.2 (Page 6) of chapter "2.D.3.f Dry cleaning" of the 2019 EMEP Guidebook, solvent emissions directly from the cleaning machine into the air represent about 80% of the solvent consumption (i.e. 80% of solvent used for the replacement of lost solvent) for an open-circuit equipment and little more than 40% for a closed-circuit machine.

Table 4-82: Emission Factors

Type of Equipment	Unit	Emission Factor	Source
Open Circuit	Kg NMVOC/ kg PER	0.8	Section 3.2 (Page 6) of chapter "2.D.3.f Dry cleaning" of "EMEP guidebook 2019"
Closed Circuit	Kg NMVOC/ kg PER	0.4	

Also according to Section 3.2 (Page 6) of that chapter, open-circuit equipment is no longer used within the EU, following the European Solvents Directive coming into force. Therefore, we assumed that, from 1999 onwards, there are only closed circuit equipments in dry cleaners in Portugal.

Table 4-83: % of Open Circuit and Closed Circuit equipments

Type of Equipment	1990	1995	1999 onwards
Open Circuit	50	22	0
Closed Circuit	50	78	100
Source: INE			

4.5.18.4 Activity Data

There is no national statistical information available concerning consumption of solvents or amount of textiles treated in dry cleaning activity, because such activity is not included under IAIT and IAPI industrial surveys. Therefore, it was assumed that:

. PER[14] is the only solvent used in Portugal for dry-cleaning;

. all PER consumed in Portugal is used in dry-cleaning[15] activity and

. all PER used is imported (no national production).

From 1995 onwards, annual apparent consumption of PER was estimated from EUROSTAT data on imports and exports of PER. In the period 1990-1994, data was estimated based on 1995 apparent consumption and on GDP trend.

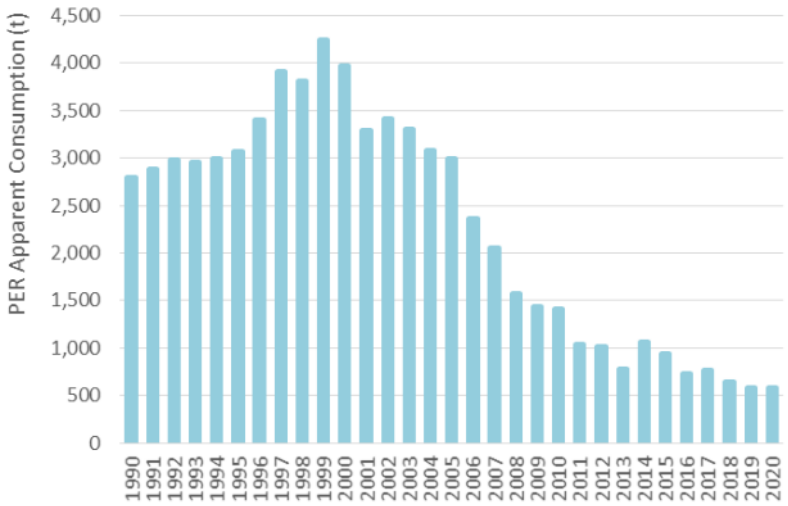


Figure 4-64: Annual consumption of PER – total territory

[14] Other organic solvents may be also used in dry-cleaning, such as trichloroethylene, 1,1,1-trichloroethane(methyl chloroform), cichloromethane (methylene chloride), R113 (tri-chloro-trifluoroethane) and aliphatic hydrocarbon solvents C10 to C13.

[15] There is no reference to PER consumption in other industrial activities according to IAIT and IAPI industrial surveys from INE.

Emissions of Mainland Portugal represent 95.1% of the total territory. This share has been estimated based on the population.

4.5.18.5 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.

4.5.18.6 Recalculations

No recalculations were made.

4.5.18.7 Further Improvements

Portugal participated in a capacity building project for Air emission inventories relating to NMVOC emissions, and has flagged this category as priority in order to get support to move to a higher Tier methodology. We intend to contact regional authorities on the matter in order to assess and collect the available data for the sector. We hope to report on the progress in future submissions.

4.5.19 Chemical Products - Polyester processing (NFR 2.D.3.g - SNAP 060301)

4.5.19.1 Category description

This chapter addresses emissions estimates from polyester processing.

4.5.19.2 Methodology

Emissions from polyester processing were estimated using a Tier 2 approach in accordance with the 2019 EMEP Guidebook. NMVOC emissions were estimated based on the quantity of polyester produced according to the following equation:

Equation 4-77: NMVOC emissions from polyester processing

$$Emi_{NMVOC} = EF_{NMVOC} \times Proc_{POLYESTER} \times 10^{-3}$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

EF_{NMVOC}: NMVOC emission factor (g/kg monomer used)

$Proc_{POLYESTER}$: Quantity of monomer used (t)

4.5.19.3 Emission Factors

The technology specific emission factor was obtained from the 2019 EMEP Guidebook. The emission factor was assumed constant for the whole time series.

Table 4-84: NMVOC polyester processing emission factor

SNAP	Unit	NMVOC	Source
Polyester processing	g/kg monomer used	50	Table 3-2 of chapter "2.D.3.g Chemical Products" of 2019 EMEP Guidebook

4.5.19.4 Activity Data

Data on polyester production is available from Eurostat in the periods 2000-2002 and from 2008 onwards. In the periods 1990-1999 and 2003-2007, data has been estimated based on gross domestic product trend.

Polyester production is presented in the figure below. The decrease in polyester production from 2008 to 2011 can be explained due to an economic recession period.

Figure 4-65: Polyester production

4.5.19.5 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.

4.5.19.6 Recalculations

No recalculations were made.

4.5.19.7 Further Improvements

In the future, we intend to collect information on abatement techniques.

4.5.20 Chemical Products - Polyvinylchloride processing (NFR 2.D.3.g - SNAP 060302)

4.5.20.1 Category description

This chapter addresses emissions estimates from polyvinylchloride processing.

4.5.20.2 Methodology

Emissions from polyvinylchloride processing were estimated based on a Tier 2 approach in accordance with the 2019 EMEP Guidebook.

Emissions were estimated according to the following equation:

Equation 4-78: Emissions from Polyvinylchloride processing

$$Emi_x = AD \times \frac{EF_x}{1000}$$

Where:

Emi_x: Emissions of pollutant "x" (t)

AD: PVC production data (t PVC)

EF_x: Emission factor of pollutant "x" (kg/t PVC)

4.5.20.3 Emission Factors

Emission factors were taken from EMEP Guidebook 2019 and are listed in the table below.

Table 4-85: Emission factors

Pollutant	Material	Unit	EF	Source
NMVOC	S-PVC	Kg/t product	0.096	2019 EMEP Guidebook, Volume 2.B Chemical Industry (Table 3.41)
NMVOC	E-PVC	Kg/t product	0.813	2019 EMEP Guidebook, Volume 2.B Chemical Industry (Table 3.42)
TSP	S-PVC/E-PVC	Kg/t product	0.263	2019 EMEP Guidebook, Volume 2.B Chemical Industry (Table 3.41 and Table 3.42)
PM10	S-PVC/E-PVC	Kg/t product	0.100	2019 EMEP Guidebook, Volume 2.B Chemical Industry (Table 3.41 and Table 3.42)
PM2.5	S-PVC/E-PVC	Kg/t product	0.005	2019 EMEP Guidebook, Volume 2.B Chemical Industry (Table 3.41 and Table 3.42)

4.5.20.4 Activity Data

Data on polyvinylchloride production is available from the IAPI industrial surveys from INE.

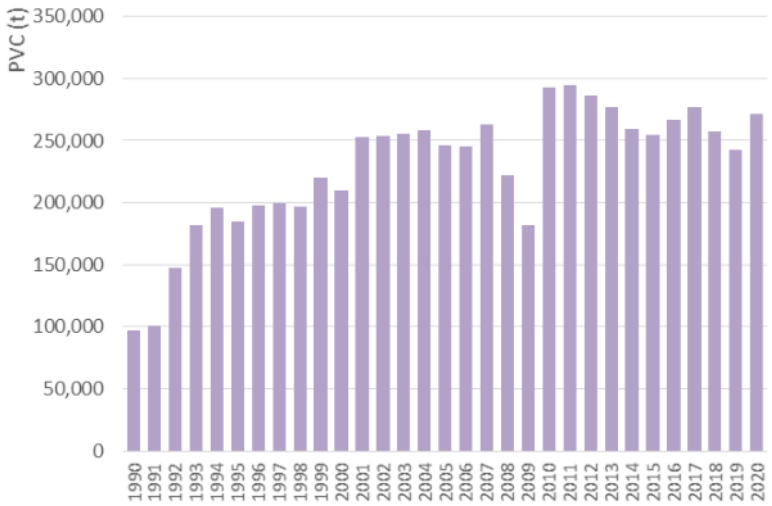


Figure 4-66: PVC production

4.5.20.5 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.

4.5.20.6 Recalculation

No recalculations were made.

4.5.20.7 Further Improvements

No further improvements are planned for this sector.

4.5.21 Chemical Products - Polyurethane foam processing (NFR 2.D.3.g - SNAP 060303)

4.5.21.1 Category description

This chapter addresses emissions estimates from polyurethane foam processing.

4.5.21.2 Methodology

Emissions from polyurethane foam processing were estimated in accordance with the 2019 EMEP Guidebook. NMVOC emissions were estimated from the quantity of foam processed according to a Tier 2 approach:

Equation 4-79: NMVOC emissions from Polyurethane foam processing

$$Emi_{NMVOC} = EF_{NMVOC} \times Prod_{FOAM} \times 10^{-3}$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

EF_{NMVOC}: NMVOC emission factor (g/kg foam processed)

$Prod_{FOAM}$: Quantity of foam produced (t)

4.5.21.3 Emission Factors

The technology specific emission factor was obtained from the 2019 EMEP Guidebook.

Table 4-86: NMVOC foam processing emission factor

SNAP	Unit	NMVOC	Source
Polyurethane foam processing	g/kg foam processed	120	Table 3-3 of chapter 2.D.3.g Chemical Products of the 2019 EMEP Guidebook

4.5.21.4 Activity Data

In the period 1992-onwards, data on polyurethane production is available from the IAPI industrial surveys from INE. The 1990-1991 production values were estimated based on GVA trend for the chemical and fibres sector and on the 1992 national survey value.

Due to confidentiality constraints, the activity data is presented in index (1990 year = 100).

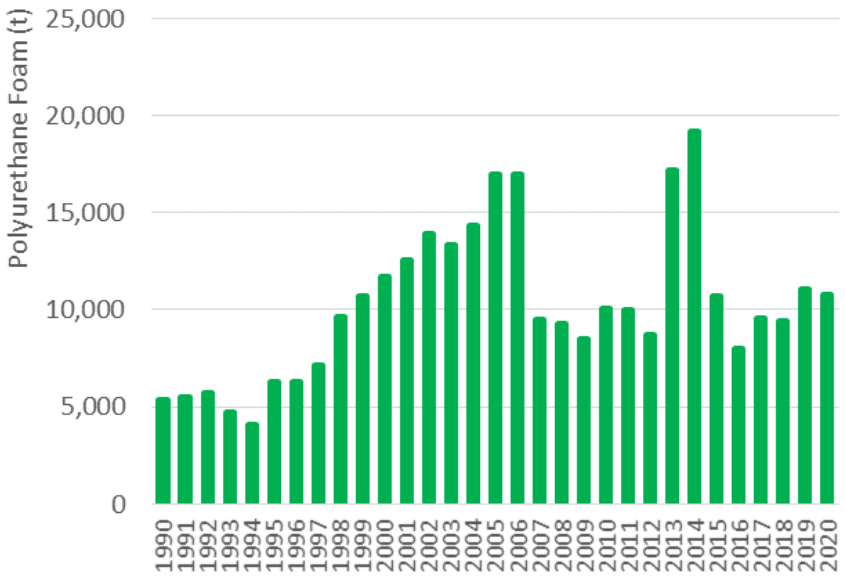


Figure 4-67: Polyurethane Production (Index 1990=100)

4.5.21.5 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.

4.5.21.6 Recalculations

No recalculations were made.

4.5.21.7 Further Improvements

No further improvements are planned for this sector.

4.5.22 Chemical Products - Polystyrene foam processing (NFR 2.D.3.g - SNAP 060304)

4.5.22.1 Category description

This chapter addresses emissions estimates from polystyrene foam processing.

4.5.22.2 Methodology

Emissions from polystyrene foam processing were estimated in accordance with the 2019 EMEP Guidebook.

Emissions were estimated from the quantity of foam produced according to Tier 2 approach:

Equation 4-80: NMVOC emissions from Polyurethane foam processing

$$Emi_{NMVOC} = EF_{NMVOC} \times Prod_{FOAM} \times 10^{-3}$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

EF_{NMVOC}: NMVOC emission factor (g/kg foam processed)

$Prod_{FOAM}$: Quantity of foam produced (t)

4.5.22.3 Emission Factors

The technology specific emission factor was obtained from 2019 EMEP Guidebook. The emission factor was assumed constant for the whole time series.

Table 4-87: NMVOC foam processing emission factor

SNAP	Unit	NMVOC	Source
Polystyrene foam processing	g/kg foam processed	60	Table 3-4 of chapter 2.D.3.g Chemical Products of 2019 EMEP Guidebook

4.5.22.4 Activity Data

Data on polystyrene foam production is available from the IAPI industrial surveys from INE in the period 1995-onwards. The 1990-1994 production values were estimated based on gross value added trend for the chemical and fibres sector and on the 1995 national survey value.

Due to confidentiality constraints, the activity data is presented in index (1990 year = 100).

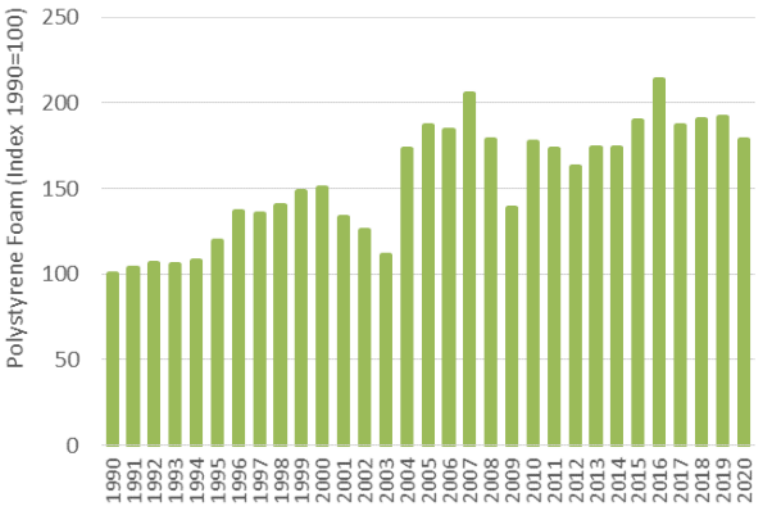


Figure 4-68: Polystyrene Foam Production (Index 1990=100)

4.5.22.5 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.

4.5.22.6 Recalculations

No recalculations were made.

4.5.22.7 Further Improvements

No further improvements are planned for this sector.

4.5.23 Chemical Products - Rubber processing (NFR 2.D.3.g - SNAP 060305)

4.5.23.1 Category description

This chapter addresses emissions estimates from rubber processing.

4.5.23.2 Methodology

Emissions from rubber processing was estimated based on a Tier 2 approach in accordance with the 2019 EMEP Guidebook. Rubber processed for tyre production is not included in this sector.

NMVOC emissions were estimated from the quantity of rubber processed according to:

Equation 4-81: NMVOC emissions from rubber processing

$$Emi_{NMVOC(y)} = EF_{NMVOC} \times Prod_{RUBBER} \times 10^{-3}$$

Where:

$Emi_{NMVOC(y)}$: NMVOC emissions (t)

EF_{NMVOC}: NMVOC emission factor (g/kg rubber produced)

$Prod_{RUBBER}$: Quantity of rubber produced (t)

4.5.23.3 Emission Factors

The emission factor used for rubber processing was obtained from the 2019 EMEP Guidebook.

Table 4-88: NMVOC rubber processing emission factor

SNAP	Unit	NMVOC	Source
Rubber processing	g/kg rubber produced	8	Table 3-5 of chapter "2.D.3.g Chemical Products" of 2019 EMEP Guidebook

4.5.23.4 Activity Data

From 1992 onwards, production data of rubber artefacts was available from IAPI industrial surveys from INE. For the period 1990-1991, statistical enquiries were completely different and data was not comparable with the one obtained from 1992 onwards. Thus, for the period 1990-1991, rubber processed values were based on GVA trend for rubber industry in 1990-1991 period and on 1992 rubber production data.

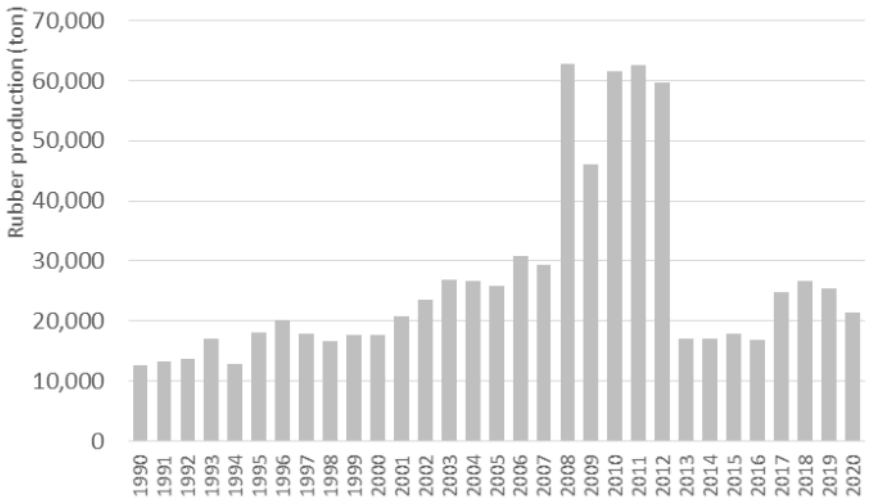


Figure 4-69: Rubber processed – total territory

Emissions of Mainland Portugal represent 100.0% of the total territory. This share has been estimated based on fuel sold to "Chemical Industry" (1.A.2.c).

4.5.23.5 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.

4.5.23.6 Recalculations

No recalculations were made.

4.5.23.7 Further Improvements

Activity data in the period 2008-2012 will be analysed with INE in order to understand the reasons behind the relevant increase of rubber production in this period.

4.5.24 Chemical Products - Pharmaceutical Products Manufacturing (NFR 2.D.3.g – SNAP 060306)

4.5.24.1 Category description

This chapter addresses emissions estimates from pharmaceutical products manufacturing.

4.5.24.2 Methodology

There is no available stratified data regarding the types or amounts of solvents used in pharmaceutical products manufacturing or abatement techniques that may occur in the country. NMVOC emissions from this category were estimated using a Tier 1 approach based on the quantity of pharmaceutical products produced, in accordance with the 2019 EMEP Guidebook:

Equation 4-82: NMVOC emissions from Pharmaceutical Products Manufacturing

$$Emi_{NMVOC} = EF_{NMVOC} \times Pharm_{prod} \times 10^{-6}$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

EF_{NMVOC}: NMVOC emission factor (g/kg product)

$Pharm_{prod}$: Quantity of pharmaceutical products produced (kg)

4.5.24.3 Emission Factors

The emission factor used for pharmaceutical products manufacturing was obtained from Table 3-1 of chapter 2.D.3.g Chemical Products of the 2019 EMEP Guidebook.

Table 4-89: NMVOC pharmaceutical products manufacturing emission factor

SNAP	Unit	NMVOC
Chemical Products Use	g/kg product	10

4.5.24.4 Activity Data

For the period 2008-2011, pharmaceutical products manufacturing data was obtained from EUROSTAT. For the 1990-2007 period, data was estimated based on GVA trend for pharmaceutical industry and on 2008 production data. For the 2012-2015 period, data was estimated based on GVA trend for pharmaceutical industry and on 2011 production data. For 2016 onwards, data was estimated based on GDP trend.

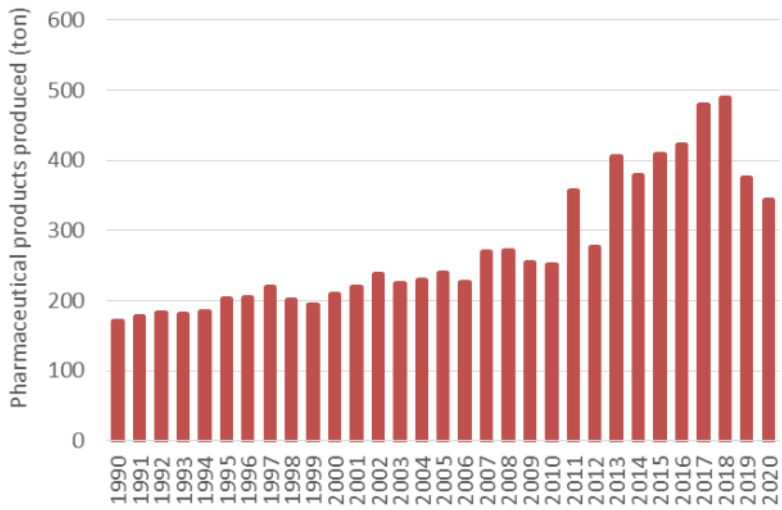


Figure 4-70: Pharmaceutical products produced – total territory

Emissions of Mainland Portugal represent 100.0% of the total territory. This share has been estimated based on fuel sold to "Chemical Industry" (1.A.2.c).

4.5.24.5 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.

4.5.24.6 Recalculations

2019 activity data has been updated.

4.5.24.7 Further Improvements

In the future, we intend to make efforts in order to collect more reliable national statistics data for the whole time series. We will further investigate on available information on solvents amounts used in pharmaceutical products manufacturing.

4.5.25 Chemical Products - Paints, Inks and Glues Manufacturing (NFR 2.D.3.g - SNAP 060307; 060308; 060309)

4.5.25.1 Category description

This chapter addresses emissions estimates from Paints, Inks and Glues Manufacturing.

4.5.25.2 Methodology

Emissions from paints, inks and glue manufacturing were estimated based on a Tier 2 approach in accordance with the 2019 EMEP Guidebook. Emissions were estimated based on the quantity of Paints, Inks and Glues produced according to the following equation:

Equation 4-83: Emissions from Paints, Inks and Glues Manufacturing

$$Emi_{(p)} = EF \times ProductManuf_{(p)} \times 10^{-3}$$

Where:

$Emi_{(p)}$: Emissions from manufacturing of product p (t)

EF: Emission factor for production of paints, inks and glue (g/kg product)

$ProductManuf_{(p)}$: Quantity of product p manufactured (t)

p: product (paint, ink, glue)

4.5.25.3 Emission Factors

Paints and inks manufacturing related TSP emission factor was obtained from chapter "6.4 Paint and Varnish" of USEPA AP-42.

NMVOC default emission factor and Abatement technologies were taken from 2019 EMEP Guidebook. Control strategies were obtained from GAINS model developed by IIASA (http://gains.iiasa.ac.at) and applied in the following manner:

Equation 4-84: NMVOC emission factor for Paints, Inks and Glues Manufacturing

$$EF_{NMVOC(y)} = \sum_{t} \left(\frac{CS_{(t,y)}}{100} \times \left(1 - \frac{AT_{(t)}}{100}\right) \times EF_{NMVOC(default)} \right)$$

Where:

EF_{NMVOC}: NMVOC emission factor (t)

$CS_{(t)}$: Control strategy, share of Abatement technology t (%)

$AT_{(t)}$: Efficiency of Abatement technology t (%)

t: Abatement technology

$EF_{NMVOC(default)}$: Default NMVOC emission factor

Table 4-90: Emission Factors

SNAP	Unit	Pollutant	EF	Source
Paints, Inks and Glues Manufacturing	g/kg product	NMVOC	11	Table 3-11 of chapter "2D3g Chemical Products" of 2019 EMEP Guidebook
Paints and Inks Manufacturing	g/kg product	TSP	10	USEPA AP-42

Table 4-91: NMVOC Abatement technology (Source: EMEP/EEA, 2019)

Abatement Technology	Unit	Efficiency
Use of good practices	%	27

Table 4-92: NMVOC Control strategy (Source: IIASA, 2009)

Technology	Unit	1990	1995	2000	2005	2010 onwards
Use of good practices	%	0	0	0	50	100
No control	%	100	100	100	50	0

Table 4-93: NMVOC final emission factor

Parameter	Unit	1990	1995	2000	2005	2010 onwards
Final EF	g/kg product	11.0	11.0	11.0	9.5	8.0

4.5.25.4 Activity Data

From 1992 onwards, production of paints was obtained from IAPI (INE industrial survey). In the period 1990-1991, data has been estimated based on GDP trend and on 1992 paints production data.

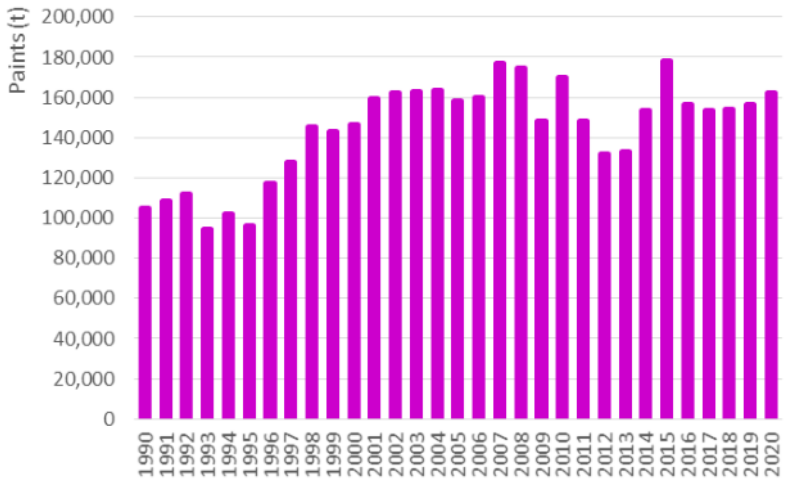


Figure 4-71: Paints Manufacturing – total territory

From 1994 onwards, production of inks was available from IAPI (INE industrial survey). In the period 1990-1993, data has been estimated based on GDP trend and on 1994 inks production data.

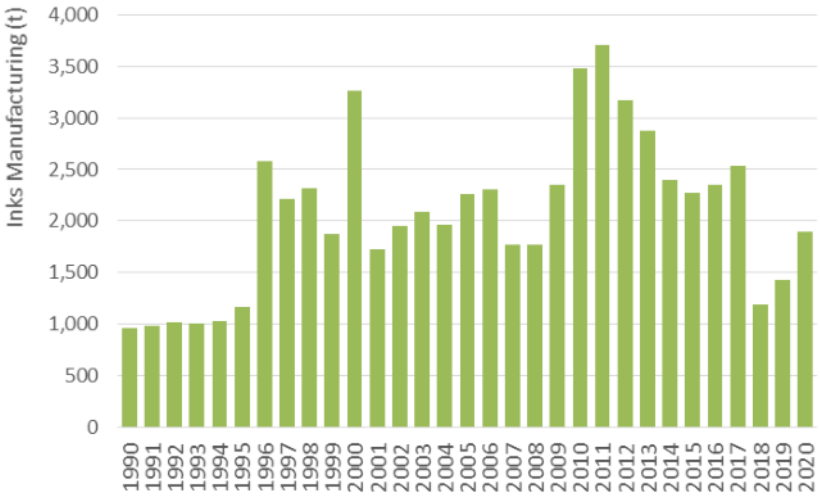


Figure 4-72: Inks manufacturing – total territory

Data on glues manufacturing was available from IAPI (INE industrial survey) for the whole time series.

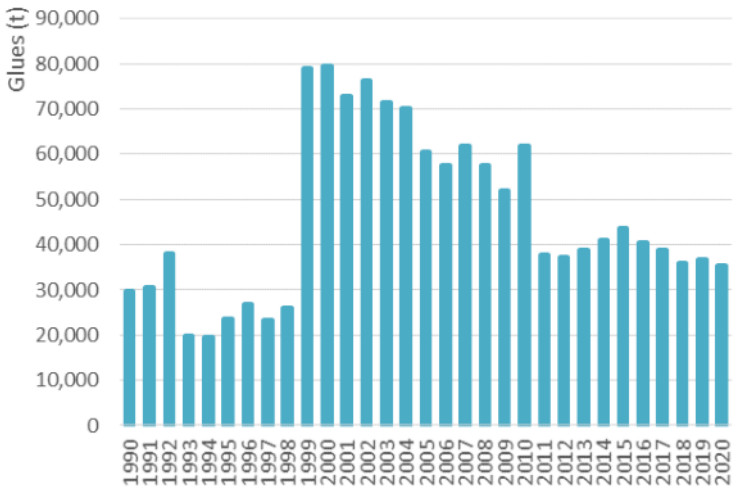


Figure 4-73: Glues Manufacturing – total territory

Emissions of Mainland Portugal represent 100.0% of the total territory. This share has been estimated based on fuel sold to "Chemical Industry" (1.A.2.c).

4.5.25.5 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.

4.5.25.6 Recalculations

Data on glues manufacturing was revised from 1991 onwards due to a compilation error.

4.5.25.7 Further Improvements

No further improvements are planned.

4.5.26 Chemical Products - Asphalt Blowing (NFR 2.D.3.g – SNAP 060310)

4.5.26.1 Category description

This chapter addresses emissions estimates from asphalt blowing.

4.5.26.2 Methodology

Emissions related to asphalt blowing were estimated based on a Tier 2 approach in accordance with the 2019 EMEP Guidebook.

Currently, we assume that, in Portugal, asphalt blowing only occurs in refineries.

Emissions were estimated from the amount of asphalt produced in the asphalt blowing units of each refinery, according to:

Equation 4-85: Emissions from asphalt blowing

$$Emi_{pol(y)} = EF_{pol(y)} \times Asphalt_{prod} \times 10^{-6}$$

Where:

$Emi_{pol(y)}$: Pollutant "y" emissions (t)

$EF_{pol(y)}$: Pollutant "y" emission factor (g/t asphalt)

$Asphalt_{prod}$: Amount of asphalt produced in asphalt blowing units (t)

4.5.26.3 Emission Factors

Emission factors applied were taken from table 3-8 of chapter 2D3g of 2019 EMEP Guidebook and are listed in the table below.

Table 4-94: Emission Factors for Asphalt Blowing

Pollutant	Unit	EF
NMVOC	g/t asphalt	27200
TSP	g/t asphalt	400
Cd	g/t asphalt	0.0001
As	g/t asphalt	0.0005
Cr	g/t asphalt	0.006
Ni	g/t asphalt	0.05
Se	g/t asphalt	0.0005
PAH	g/t asphalt	2.55

4.5.26.4 Activity Data

The activity data considered was the amount of asphalt produced in the asphalt blowing units of each refinery. Since there are only two refineries in Portugal, we present the activity data as an index related to the 1990 value.

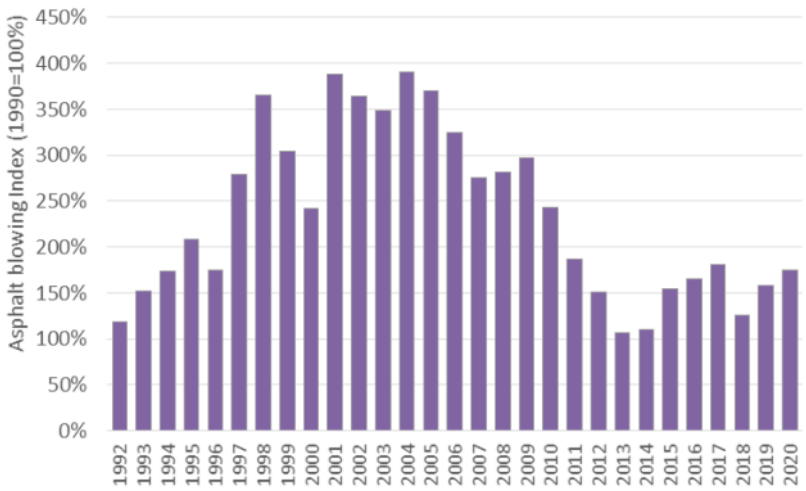


Figure 4-74: Asphalt produced in the Asphalt Blowing Units (Index related to 1990 value)

Emissions of Mainland Portugal represent 100.0% of the total territory. This share has been estimated based on fuel sold to "Chemical Industry" (1.A.2.c).

4.5.26.5 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.

4.5.26.6 Recalculations

No recalculations were made.

4.5.26.7 Further Improvements

In the future, we intend to investigate whether there is asphalt blowing activity in facilities other than refineries.

4.5.27 Chemical Products - Adhesive, Magnetic Tapes, Films and Photographs Manufacturing (NFR 2.D.3.g – SNAP 060311)

4.5.27.1 Category description

This chapter addresses emissions estimates from adhesive, magnetic tapes, films and photographs manufacturing.

4.5.27.2 Methodology

NMVOC emissions resulting from this activity were estimated according to a Tier 1 approach from the 2019 EMEP Guidebook:

Equation 4-86: NMVOC emissions

$$Emi_{NMVOC} = AD \times \frac{EF_{NMVOC}}{1000}$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

AD: Production data (t)

EF_{NMVOC}: NMVOC emission factor (kg/t)

4.5.27.3 Emission Factors

NMVOC emission factor was taken from EMEP Guidebook 2019 and is listed in the table below.

Table 4-95: Emission factors

Parameter	Unit	EF	Source
NMVOC	Kg/t product	10	Table 3-1 of chapter "2.D.3.g Chemical Products" of the 2019 EMEP Guidebook

4.5.27.4 Activity Data

From 1995 onwards, activity data on adhesive, magnetic tapes, films and photographs was obtained from EUROSTAT. In the period 1990-1994, data has been estimated based on 1995 production data and on GDP trend.

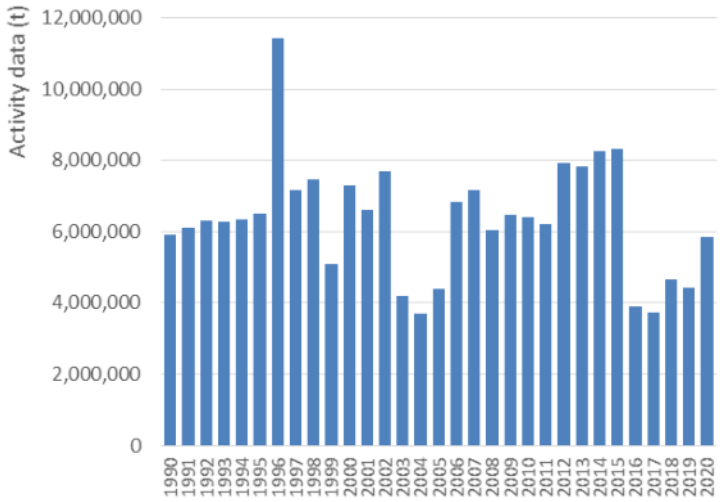


Figure 4-75: Adhesive, magnetic tapes, films and photographs production

4.5.27.5 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.

4.5.27.6 Recalculation

2019 activity data was revised based on EUROSTAT database.

4.5.27.7 Further Improvements

Portugal participated in a capacity building project for Air emission inventories relating to NMVOC emissions, and flagged this category as priority in order to get support to move to a higher Tier methodology. We intend to contact national authorities on the matter in order to assess and collect the available data for the sector. We hope to report on the progress in future submissions.

4.5.28 Chemical Products - Manufacture of Shoes (NFR 2.D.3.g)

4.5.28.1 Category description

This chapter addresses emissions estimates from shoes manufacturing.

4.5.28.2 Methodology

NMVOC emissions from shoes manufacturing were estimated based on a Tier 2 approach in accordance with the 2019 EMEP Guidebook.

Equation 4-87: NMVOC emissions from Manufacture of Shoes

$$Emi_{NMVOC} = EF_{NMVOC} \times Shoes_{Manufactured} \times 10^{-3}$$

Where:

Emi_{NMVOC}: NMVOC emissions from manufacture of shoes (t)

EF_{NMVOC}: Emission factor for manufacture of shoes (kg/pair of shoes)

$Shoes_{Manufactured}$: Quantity of shoes manufactured (pair of shoes)

4.5.28.3 Emission Factors

NMVOC default emission factor was taken from table 3-13 of chapter 2.D.3.g Chemical Products of the 2019 EMEP Guidebook.

Table 4-96: Emission Factors

SNAP	Unit	Pollutant	EF
Manufacture of Shoes	kg/pair of shoes	NMVOC	0.045

4.5.28.4 Activity Data

From 1995 onwards, production data on manufacture of shoes was available from EUROSTAT. In the period 1990-1994, data has been estimated based on GDP trend and on 1995 manufacture of shoes production value.

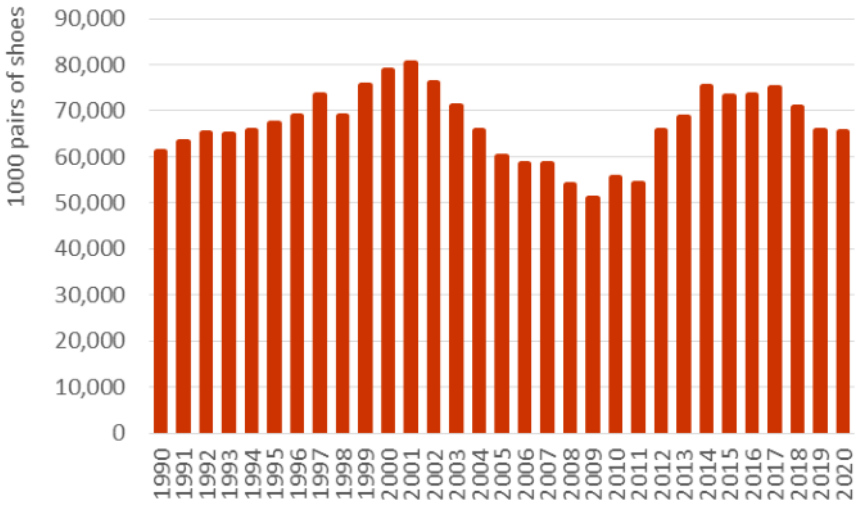


Figure 4-76: Shoes Manufactured – total territory

Emissions of Mainland Portugal represent 100% of the total territory. This share has been estimated based on fuel sold to "Chemical Industry" (1.A.2.c).

4.5.28.5 Category specific QA/QC and verification

Emissions estimates were based on shoe manufacturing data from EUROSTAT. A comparison was made using shoe manufacturing data obtained from national production statistics (IAPI). There are slight differences using the two different approaches but, generally, data is consistent.

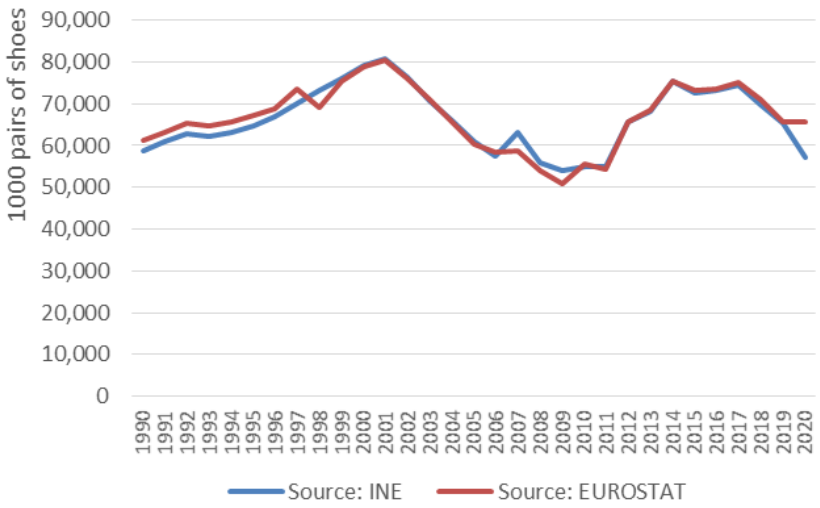


Figure 4-77: Shoes Manufactured – comparison of approaches

4.5.28.6 Recalculations

2012-2019 sold production data has been updated based on EUROSTAT database.

4.5.28.7 Further Improvements

In the future, we intend to contact sectoral associations in order to collect data on abatement techniques.

4.5.29 Chemical Products - Leather Tanning (NFR 2.D.3.g - SNAP 060313)

4.5.29.1 Category description

This chapter addresses emissions estimates from leather tanning.

4.5.29.2 Methodology

NH_3 emissions from leather tanning were estimated basec on a Tier 2 approach in accordance with the 2019 EMEP Guidebook.

Equation 4-88: NH_3 emissions from Leather Tanning

$$Emi_{NH3} = EF_{NH3} \times Leather_{Prod} \times 10^{-6}$$

Where:

Emi_{NH3}: NH_3 emissions (t)

EF_{NH3}: NH_3 emission factor (g/kg raw hid)

$Leather_{Prod}$: Leather Produced (kg raw hid)

4.5.29.3 Emission Factors

Leather production data is reported in EUROSTAT in two different units (kg and m^2). Thus, it was necessary to estimate a factor for the conversion of leather m^2 in kg of leather. Mass vs area leather conversion factor was estimated assuming that usually a cow piece of leather has 4 m^2 and weighs 40 kg.

Table 4-97: Mass vs area leather conversion factor

Parameter	Unit	EF	Source
Mass vs area leather conversion factor	Kg/m^2	10	Expert judgment

NH_3 default emission factor was taken from table 3-14 of chapter 2.D.3.g Chemical Products of the 2019 EMEP Guidebook.

Table 4-98: Emission Factor

SNAP	Unit	Pollutant	EF
Leather Tanning	g/kg raw hid	NH_3	0.68

4.5.29.4 Activity Data

From 2008 onwards, leather production data was available from EUROSTAT. In the period 1990-2007, data has been estimated based on textile and leather industry GVA trend and on 2008 leather production value. Leather production is presented in the figure below.

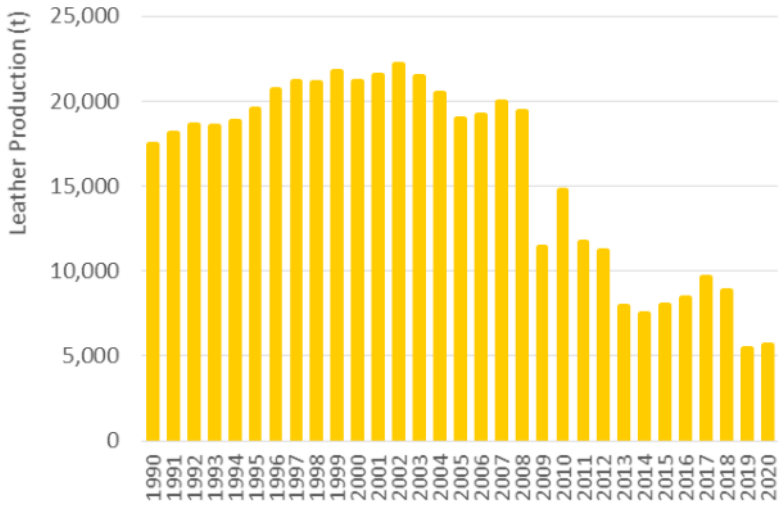


Figure 4-78: Leather production – total territory

Emissions of Mainland Portugal represent 100% of the total territory. This share has been estimated based on fuel sold to "Chemical Industry" (1.A.2.c).

4.5.29.5 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.

4.5.29.6 Recalculations

2008-2019 leather production data has been updated based on EUROSTAT database.

4.5.29.7 Further Improvements

Efforts will be made to compile national statistics data on leather production for the 1990-2007 period.

4.5.30 Chemical Products - Tyre Production (NFR 2.D.3.g - SNAP 060314)

4.5.30.1 Category description

This chapter addresses emissions estimates from manufacture of tyres.

4.5.30.2 Methodology

Emissions from tyre manufacturing were estimated based on a Tier 2 approach in accordance with the 2019 EMEP Guidebook. NMVOC emissions result from the solvents used to treat the tyre rubber and were estimated according to:

Equation 4-89: NMVOC emissions from tyre production

$$Emi_{NMVOC} = EF_{NMVOC} \times Tyres_{prod} \times 10^{-6}$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

EF_{NMVOC}: NMVOC emission factor (g/kg tyres)

$Tyres_{prod}$: Tyres produced (kg)

4.5.30.3 Emission Factors

NMVOC emission factor applied is indicated in the table below:

Table 4-99: NMVOC default emission factor

SNAP	Unit	NMVOC	Source
Tyre production	g/kg tyres	10	Table 3-6 of chapter "2.D.3.g Chemical Products" of the 2019 EMEP Guidebook

4.5.30.4 Activity Data

Regarding activity data, we considered production of new tyres as well as retreaded tyres. For this category we did not consider the following items: tyre's inner tubes, rubber straps and profiles. For simplicity sake, we also considered that the amount of solvents required to treat the rubber used in tyre production is the same for new tyres and retreaded tyres.

Production data concerning tyres (in total number of tyres by vehicle type) was available from the IAIT and IAPI industrial surveys from INE for the whole time series. Given that the emission factor unit is in g/kg tyres, we estimated tyre production in kg based on tyre weight by vehicle type (light, duty, machinery, motorcycles). Information on sverage tyre weight by vehicle was available from VALORPNEU (corporation with the purpose of organizing and managing the national used tyre collection and final disposal system) and is indicated in the table below:

Table 4-100: Tyre weight by vehicle type

Tyre type	Unit	Tyre Weight
Light duty vehicle	kg	8.58
Heavy duty vehicle	kg	60.83
Machinery	kg	60.83
Motorcycle	kg	3.51
Source: VALORPNEU, 2019		

Total tyre production by vehicle type is presented in the figure below. There is a relevant decrease in tyre production from 2007 to 2009, possibly due to the country's economic recession. 2020 data on tyre production are relatively lower due to the COVID pandemic.

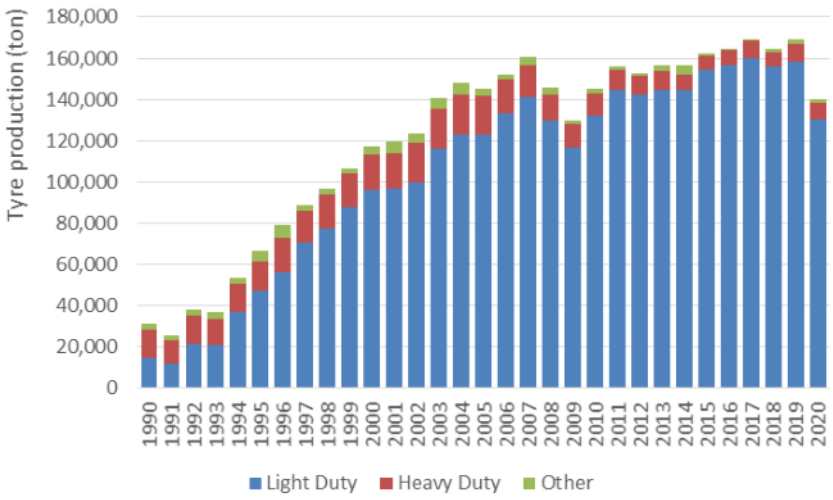


Figure 4-79: Tyre Production – Total territory

Emissions of Mainland Portugal represent 100% of the total territory. This share has been estimated based on fuel sold to "Chemical Industry" (1.A.2.c).

4.5.30.5 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.

4.5.30.6 Recalculations

No recalculations were made.

4.5.30.7 Further Improvements

In the future, we intend to contact sectoral associations in order to collect data on abatement techniques.

4.5.31 Printing Industry (NFR 2.D.3.h – SNAP 060403)

4.5.31.1 Category description

Printing involves the application of an ink to several materials by presses, the most common of which is paper, but also cardboard, wood, plastics and metallic artefacts are subjected to this process. Emissions are very dependent of the printing technology because it (i.e., the type of press equipment) dictates the types of inks and coatings – and its solvent content - that can be used and defines, to a large extent, the emissions and the control techniques that are applicable (USEPA, 1985).

Emissions to air arise primarily from the organic solvents contained in inks. Solvents used in cleaning and dampening solutions (commonly isopropanol) are also important sources of VOC emissions. Solvents driven off through evaporation from the inks may be discharged untreated, recovered or destroyed via thermal oxidation (EGTEI, 2005).

According to BREF document on *Surface Treatment Using Organic Solvents including Wood and Wood Products Preservation with Chemicals*, 2020, offset is currently the most widely used printing process for an extensive range of products such as books, newspapers, stationery, corrugated board, posters, etc., due to its versatility, speed, quality, and cost-effectiveness achieved by a series of developments in plates and extending their service life, improved materials allowing higher quality and ease of use with photosetting.

Depending on the type of printing process, substrate or products printed, the offset process is further divided into subprocesses: sheetfed offset; heatset web offset; coldset offset.

Offset inks used in sheetfed and coldset offset dry through adsorption into the paper and by oxidation. With glossy paper especially, adsorption happens too slowly for modern fast printing presses. Modern high-speed webfed offset presses, which print onto non-adsorbent paper, are therefore equipped with forced hot air drying systems; these offset printing processes are called 'heatset'.

The new building approach was followed by an increased use of modern office technology such as photocopying machines, computers, video display terminals (VDT), laser, matrix, and ink jet printers, carbon paper and carbonless copy paper. At home or in the office, printers and photocopiers are also sources of NMVOC such as benzene, toluene, ethylbenzene, xylenes, and styrene, formaldehyde and acetaldehyde, which derive at least in part from the toner powder that undergoes heating during the printing process (Lee et al, 2001; Leovic et al, 1996; Leovic et al, 1998). Although the absolute emission levels of photocopies, laser and matrix printer copies, and carbonless copy paper are low, large numbers of fresh copies can contribute substantially to office NMVOC concentration, thus reducing the indoor air quality, in particular in the microenvironment of paper handling. It is likely that NMVOC concentration gradients are present in copying rooms with low to no natural ventilation and in rooms in which copies are stored and used.

In Portugal, with the exception of a small number of licensed IPPC industrial printing facilities, the vast majority are small and medium printing companies, which also handle the creation of the image and all the processes involved before the actual printing takes place, along with the binding and finishing. Also, the vast majority of commercial firms do their own printing in-house. Furthermore, there are many street printing shops based on photocopying and inkjet and digital printing. This configuration is mainly related to the activity carried out, since the physical proximity required by the customer, the quick response and the low "time-to-market" of a good part of the sector's products are fundamental aspects in many of the market requests.

NMVOC emissions from printing result from the evaporation of solvents that are components of the ink or that are added (dilution) just prior to printing activities. Emissions may also result from the use of cleaning products and dampeners. Emissions may occur during drying at air or at ovens (heat set).

According to the 2019 EMEP Guidebook, the following printing technologies are considered the main sources of NMVOC emissions in the printing industry: heat set offset printing; publication gravure and rotogravure and flexography. In Portugal, with the exception of a small number of IPPC printing facilities, the vast majority are small and medium printing companies, using mostly offset and digital printing with tonners and cartridges – considered in the inventory as "Other publication". These small and medium companies are not subject to any environmental permit and therefore are "off the grid" and impossible to track and account. Given there are no available EFs for these types of technologies in the Guidelines or in the BREF, we considered NMVOC emissions from these technologies negligible.

4.5.31.2 Methodology

NMVOC emissions from printing were estimated based on a Tier 2 methodology of chapter 2.D.3.h of the 2019 EMEP Guidebook, according to the following equation:

Equation 4-90: NMVOC emissions from printing

$$Emi_{NMVOC} = \mathrm{Ink}_{consump,tech} \times EF_{tech} \times (100\% - \eta_{abatement})$$

Where:

Emi_{NMVOC}: NMVOC emissions from printing (t)

$Ink_{consump)}$: Printing ink consumption, by printing technology (t)

EF_{tech}: NMVOC emission factor for ink, by printing technology (t/t ink)

$\eta_{abatement}$: Abatement efficiency, by printing technology (%)

4.5.31.3 Emission Factors

Emission Factors

Tier 2 NMVOC emission factors by printing technology were taken from Tables 3-2, 3-3, 3-4 and 3-6 of chapter 2.D.3.h of 2019 EMEP Guidelines and are indicated in the table below.

The EMEP Guidebook considers the main printing techniques responsible for most of NMVOC emissions in printing industry to be: heatset offset, publication gravure, flexography and rotogravure. Considering the printing market, as well as printing facilities in the scope of E-PRTR, we consider there are no large flexography facilities in Portugal. In addiction, as already mentioned in the section above, we consider "Other Publication" uses mostly offset and digital printing with tonners and cartridges. Given there are no available EFs for these types of technologies in the EMEP Guidebook or in the BREF, and according to further contacts with the Guidebook's authors, we consider NMVOC emissions from these technologies negligible.

Table 4-101: NMVOC emission factors for printing industry, by technology

Printing technology	Unit	Emission Factor
Heat set offset	g NMVOC/kg ink	730
Publication gravure	g NMVOC/kg ink	300
Other publication	g NMVOC/kg ink	-
Packaging, small flexography	g NMVOC/kg ink	900
Packaging, Rotogravure	g NMVOC/kg ink	800

Abatement techniques

Due to lack of data regarding abatement techniques that may occur in the country, we considered the following:

. from 1990 to 1999, prior to the publication of the Solvents Emissions Directive 1999/13/EC, (11th March), we assumed no abatement techniques for printing activity were implemented in the country. It was assumed a conservative approach of 0% abatement efficiency;

. from 2007 onwards, information regarding abatement techniques in place in the country was collected from E-PRTR (facilities operating above legally applicable solvents consumption thresholds) and sectoral association APIGRAF;

. from 2000 to 2006, with no available information regarding abatement techniques in place in the country or their penetration rate, further research was made on air quality legislation in place. Upon the publication of the Solvents Emissions Directive 1999/13/EC, (11th March), Member States were required to limit emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations, such as printing. Also, the National Emission Ceilings (NEC) Directive 2001/81/EC (23rd October), stated that Member States should limit their annual national emissions of pollutants such as volatile organic compounds (VOC) to amounts not greater than the emission ceilings laid down in Annex I. As a Member State, Portugal had to comply with these European commitments, however, there is no national data on the progress of these Directives. Therefore, from 2000 to 2006 we assumed a growing trend on abatement efficiencies taking into account the two periods above mentioned.

Abatement techniques considered for printing industry by technology are presented in the table below.

Table 4-102: NMVOC abatement techniques considered for printing industry, by technology

Printing Technology	Abatement techniques	Fugitive emission input	Secondary measure	1990-1999	2000	2001	2002	2003	2004	2005	2006	2007-onwards
Heat set offset	No abatement	-	-	100%	87.5%	75.0%	62.5%	50.0%	37.5%	25.0%	12.5%	0%
	Reduced Isopropanol consump	30%	-	0%	13%	25%	38%	50%	63%	75%	88%	0%
	Reduced Isopropanol consump	25%	-	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Isopropanol impregnation	45%	Thermal Incineration	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Reduced Isopropanol consump	30%	Thermal Incineration	0%	0%	0%	0%	0%	0%	0%	0%	100
	Reduced Isopropanol consump	25%	Thermal Incineration	0%	0%	0%	0%	0%	0%	0%	0%	0%
Publication gravure	No abatement	-	-	100%	0%	0%	0%	0%	0%	0%	0%	0%
	Activated carbon adsorption	10%	-	0%	100%	100%	100%	100%	100%	100%	100%	100
	Activated carbon adsorption	10%	-	0%	0%	0%	0%	0%	0%	0%	0%	0%
Packaging, small flexography	No abatement	-	-	100%	87.5%	75.0%	62.5%	50.0%	37.5%	25.0%	12.5%	0%
	Conventional solvent prod	-	Incineration	0%	6%	11%	17%	23%	28%	34%	39%	45%
	Water-based prod	-	-	0%	7%	14%	21%	28%	34%	41%	48%	55%
	UV curing inks	-	-	0%	0%	0%	0%	0%	0%	0%	0%	0%
Packaging, rotogravure	No abatement	-	-	100%	87.5%	75.0%	62.5%	50.0%	37.5%	25.0%	12.5%	0%
	60% replaced by 2 comp. adhesives	-	-	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Conventional solvent prod	-	Incineration	0%	12%	24%	36%	48%	59%	71%	83%	95%
	Conventional solvent prod	-	Absorption and solvent recovery	0%	1%	1%	2%	3%	3%	4%	4%	5%
	60% replaced by 2 comp. adhesives	-	Incineration	0%	0%	0%	0%	0%	0%	0%	0%	0%
	60% replaced by 2 comp. adhesives	-	Absorption and solvent recovery	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Water-based products	-	-	0%	0%	0%	0%	0%	0%	0%	0%	0%

Abated NMVOC emissions by printing technology are presented in the next figure. A comparison is made regarding total NMVOC emissions from printing industry if no abatement techniques were in place (red dashed line).

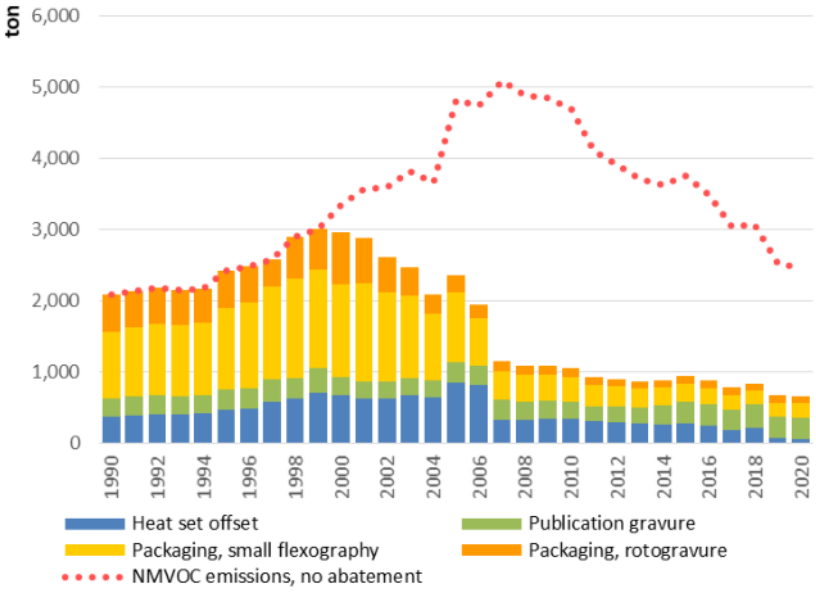


Figure 4-80: Abated NMVOC emissions by printing technology

4.5.31.4 Activity Data

Apparent printing ink consumption data was estimated from sold production, imports and exports from EUROSTAT database for the whole time series, according to the following equation:

Equation 4-91: Apparent printing ink consumption

$$App_{consump} = Sold\ Prod + Imp - Exp$$

Where:

$App_{consump}$: Apparent printing ink consumption (t)

Sold Prod: Sold production of printing ink (t)

Imp: Imports of printing ink (t)

Exp: Exports of printing ink (t)

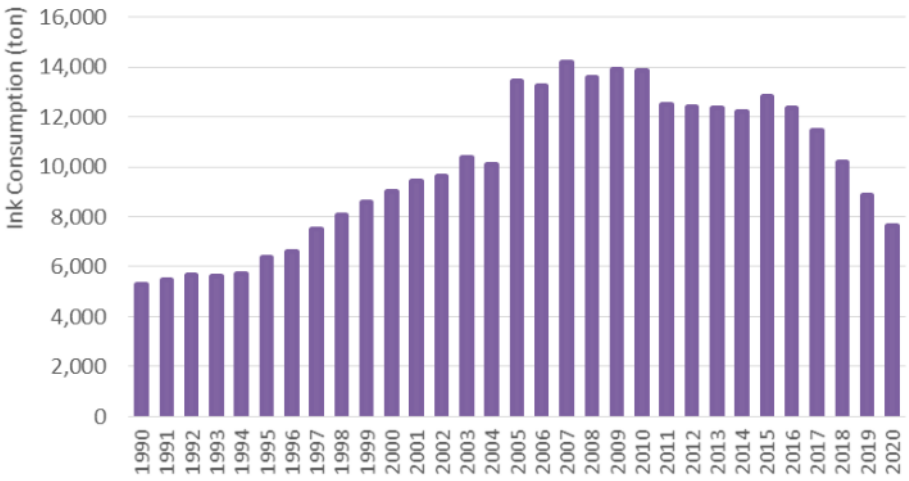


Figure 4-81: Apparent ink consumption in Portugal

Due to lack of data regarding printing technologies that may occur in the country as well as their penetration rate, we considered the following:

. from 1990 to 2006, information regarding printing technologies and their penetration rate in the country was collected from national statistics and several publications from sectoral associations such as EuPIa, APTintas and APIGRAF. Direct contact was made with some facilities and expert judgement was also applied;

. from 2007 onwards, information regarding printing technologies in the country was collected from E-PRTR (facilities operating above legally applicable solvents consumption thresholds) and sectoral association APIGRAF.

The share of ink consumed in the printing industry by printing technology is presented in the figure below.

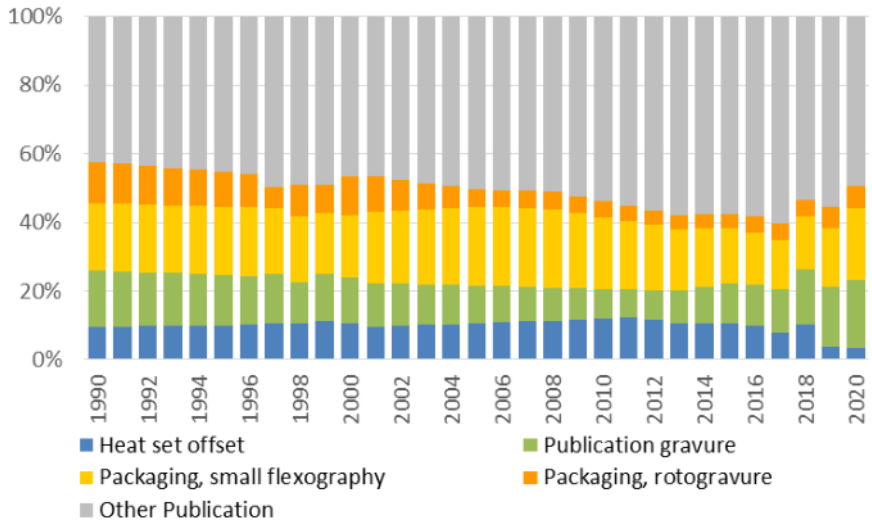


Figure 4-82: Share of ink consumption by printing technology

4.5.31.5 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.

4.5.31.6 Recalculations

Previous NECD reviews recomended that Portugal updated NMVOC estimation methodology to a Tier 2, given that printing is a key category for this pollutant.

Previous methodology was a Tier 1 based on total printing ink consumption, however, available information for several years was missing. Therefore, activity data was revised for the whole time series, in order to obtain a more reliable and complete data set on printing ink consumption. Comparison in activity data considered between submissions is presented in the figure below.

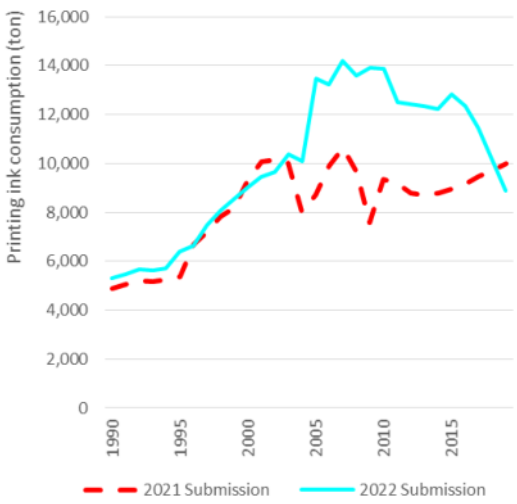


Figure 4-83: Recalculations in activity data for the printing sector

Printing methodology update resulted in significant recalculations in NMVOC emissions as showed in the figures below - 2.D.3.h sector in ktons (left) and national total NMVOC emissions in % (right). We consider this methodology to be more in line with national circumstances regarding the NMVOC emissions trend over the years.

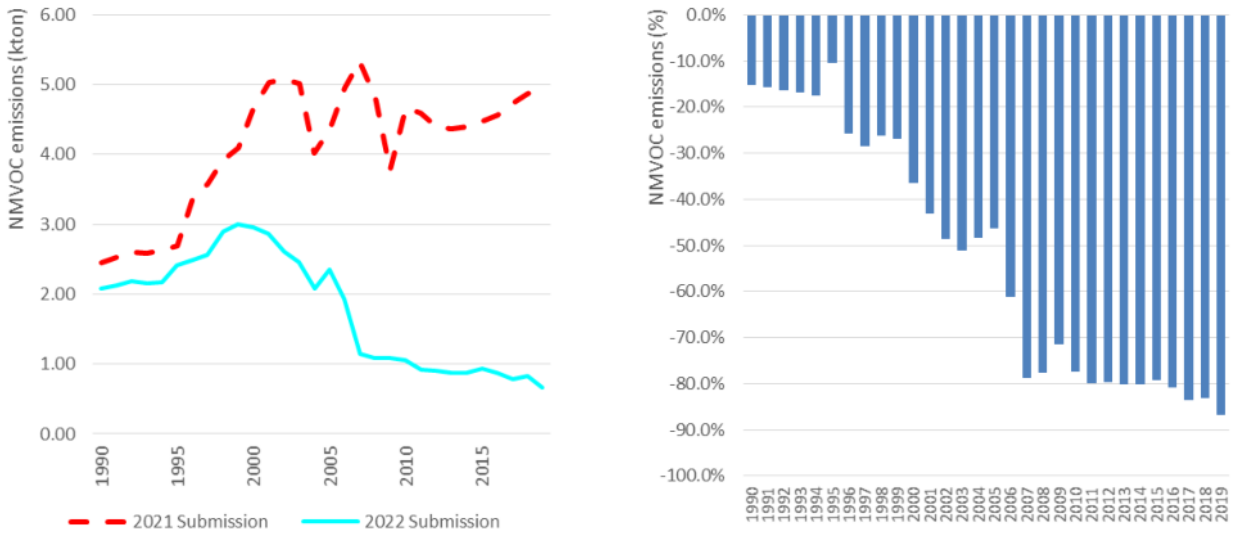


Figure 4-84: Recalculations in NMVOC for printing – 2.D.3.h sector and national total NMVOC emissions

4.5.31.7 Further Improvements

No further improvements are planned.

4.6 Other Solvent and other Product Use (2.D.3.i – 2.G)

4.6.1 Glass Wool Induction (NFR 2.D.3.i – SNAP 060401)

4.6.1.1 Category description

In Portugal, there is currently one glass wool production facility, which began operation in 2019. NMVOC emissions arise from the solvent applied to the glass wool, after cullet and sodium carbonate fusion in the oven.

Following QA/QC activities on glass production sectors in the last submission and further 2019 EMEP Guidelines consultation, we found that the NMVOC emissions described for the production of glass wool (sub-chapter 3.3.2.4 of chapter 2.A.3 of the 2019 EMEP Guidelines), estimated in chapter 4.2.5 of the IIR, might also be related to the application of the binder - solvent applied to the glass wool, after cullet and sodium carbonate fusion in the oven. Therefore, we might be double counting NMVOC emissions, since we were estimating them in chapter 4.2.5 Glass Wool Production and in the present chapter.

After consultation with the 2019 EMEP Guidelines authors, they replied that they would take a further look at this issue in order to determine the need to correct the EMEP Guidebook on this point. Furthermore, they advised us, for the time being, to use only one of the NMVOC emission factors to avoid this double counting issue.

Therefore, for the time being and until new version of the EMEP Guidelines, as advised by the authors, emissions from Glass Wool Induction will be considered Included Elsewhere (IE), in NFR 2.A.3, for the reasons explained above.

4.6.2 Mineral Wool Induction (NFR 2.D.3.i – SNAP 060402)

4.6.2.1 Category description

In Portugal, there are 2 facilites producing rock wool from basalt. NMVOC emissions arise from the solvent applied to the mineral wool, after basalt fusion in the oven.

4.6.2.2 Methodology

Emissions from mineral wool induction were estimated based on a Tier 2 approach in accordance with the 2019 EMEP Guidebook. NMVOC emissions were estimated based on mineral wool production according to:

Equation 4-92: NMVOC emissions from mineral wool production

$$Emi_{NMVOC} = EF_{NMVOC} \times Mineral\ Wool_{prod} \times 10^{-6}$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

EF_{NMVOC}: NMVOC emission factor (g/t mineral wool)

$Mineral\ Wool_{prod}$: Mineral Wool produced (t)

4.6.2.3 Emission Factors

NMVOC emission factor was taken from the 2019 EMEP Guidebook and is listed in the table below.

Table 4-103: Default emission factor

SNAP	Unit	NMVOC	Source
Mineral Wool Induction	g/t mineral wool	300	Table 3-3 of chapter "2.D.3.i, 2.G Other solvent and product use" of the 2019 EMEP Guidebook

4.6.2.4 Activity Data

In the period 1990-2004, data on rockwool production was obtained from INE. From 2005 onwards, rockwool production was provided the facilities.

Due to confidentiality constraints (reduced number of companies), data on mineral wool production is presented as an index value related to 1990 production (assumed 1990 production value is equal to 100%).

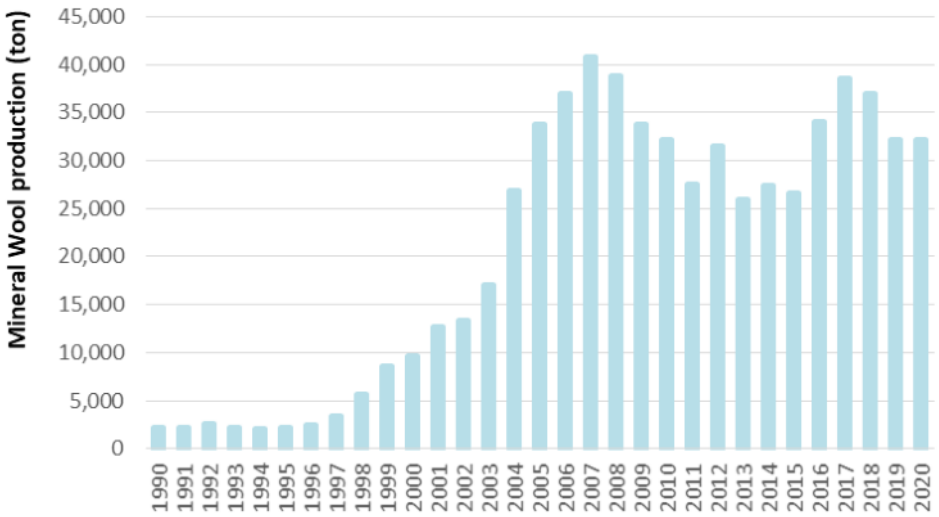


Figure 4-85: Mineral Wool produced

4.6.2.5 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.

4.6.2.6 Recalculations

No recalculations were made.

4.6.2.7 Further Improvements

No further improvements are planned.

4.6.3 Fat, Edible and Non-Edible Oil Extraction (NFR 2.D.3.i – SNAP 060404)

4.6.3.1 Category description

This chapter addresses emissions estimates from Fat, Edible and Non-Edible Oil Extraction. According to National Statistics data, there are only two plants extracting fat, edible and non-edible oil in Portugal from sunflower, rapeseed and soy.

NMVOC emissions are mainly related to the use of hexane as solvent in the oils extraction. Particle emissions are related to the seeds/grains handling inside the facilities.

4.6.3.2 Methodology

Emissions from fat, edible and non-edible oil extraction were estimated based on a Tier 2 approach in accordance with EMEP Guidebook 2019.

Emissions were estimated from the mass of seeds/grains consumed, according to the following equation:

Equation 4-93: Emission from fat, edible and non-edible oil extraction

$$Emi_{Polx} = EF_{Polx} \times Seeds_{cons} \times 10^{-3}$$

Where:

Emi_{Polx}: Emissions of pollutant "x" (t)

EF_{Polx}: Emission factor of pollutant "x" (kg/t of seed)

$Seeds_{cons}$: Seeds/grains consumption (t)

4.6.3.3 Emission Factors

Emission factors applied were taken from EMEP Guidebook 2019 and are listed below.

Table 4-104: Default emission factors

Pollutant	Unit	EF	Source
NMVOC	kg/t seed	1.57	Table 3-4 of chapter "2.D.3.i, 2.G Other solvent and product use" of EMEP Guidebook 2019
TSP	kg/t seed	1.10	
PM_{10}	kg/t seed	0.90	
$PM_{2.5}$	kg/t seed	0.60	

4.6.3.4 Activity Data

It was not possible to obtain seeds/grains consumption from INE for the entire time series. However, we have contacted one edible oil extraction plant and verified that the mass of oil extracted is similar to the mass of seeds/grains consumed in its production. Thus, we have estimated the seeds/grains consumption based on fat, edible and non-edible oil extraction values from INE.

Due to confidentiality constraints (reduced number of companies), data on seeds/grains consumption is presented as an index value related to 1990 production (assumed that 1990 production value is equal to 100%).

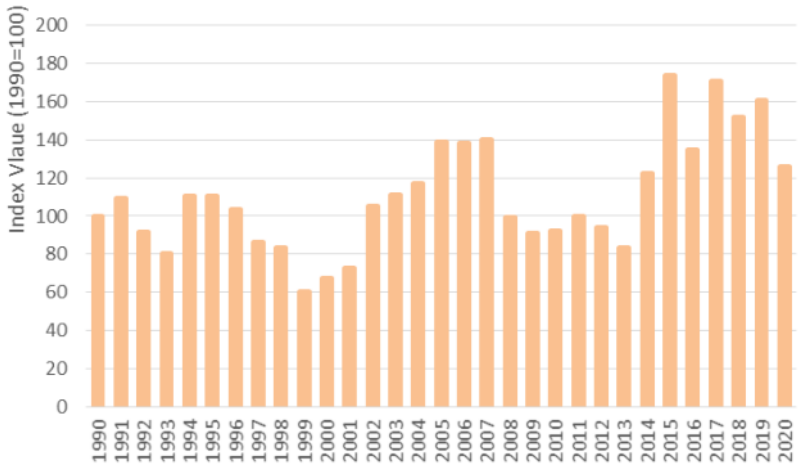


Figure 4-86: Seeds/grains consumption

Emissions of Mainland Portugal represent 91.2% of the total territory. This share has been estimated based on fuel sold to "Other Industry" (1.A.2.g).

4.6.3.5 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.

4.6.3.6 Recalculations

No recalculations were made.

4.6.3.7 Further Improvements

No further improvements are expected.

4.6.4 Application of glues and adhesives (NFR 2.D.3.i – SNAP 060405)

4.6.4.1 Category description

This chapter addresses emissions estimates from the application of glues and adhesives.

4.6.4.2 Methodology

NMVOC emissions from glues and adhesives were estimated based on a Tier 2 approach in accordance with 2019 EMEP air pollutant emission inventory guidebook.

Apparent consumption of glues and adhesives is obtained according to the following equation:

Equation 4-94: Glues and adhesives apparent consumption

App Cons = Production + Imports - Exports

Where:

App Cons: Apparent consumption of glues and adhesives (t)

Production: National production of glues and adhesives (t)

Imports: Imports of glues and adhesives (t)

Exports: Exports of glues and adhesives (t)

NMVOC emissions were estimated according to the following equation:

Equation 4-95: NMVOC emissions

$$EmiNMVOC = \sum_{Abat\ Techn\ i} \frac{[App\ Cons \times EF \times Share_{Abat\ Techn\ i} \times (100\% - Effic_{Abat\ Techn\ i})]}{1000}$$

Where:

EmiNMVOC: NMVOC emissions (t)

App Cons: Apparent consumption of glues and adhesives (t)

EF: Tier 2 NMVOC emission factor (kg/t adhesives)

Share $_{Abat\ Techn\ i}$: Share of each abatement technology "i" (%)

Effic $_{Abat\ Techn\ i}$: Efficiency of each abatement technology "i" (%)

4.6.4.3 Emission Factors

The following parameters were chosen to estimate emissions for the application of glues and adhesives.

Table 4-105: NMVOC default emission factor

SNAP	Unit	NMVOC	Source
Application of glues and adhesives	kg/t adhesives	522	Table 3-11 of chapter "2.D.3.i, 2.G Other solvent and product use" of "EMEP/EEA air pollutant emission inventory guidebook 2019"

Table 4-106: NMVOC abatement efficiencies

Abatement Technology	Efficiency	Source
Traditional solvent based adhesives (65% solvent, 35% solid) with activated carbon adsorption or condensation	76%	Table 3-22 of chapter "2.D.3.i, 2.G Other solvent and product use" of "EMEP/EEA air pollutant emission inventory guidebook 2019"
Emulsions (2% solvent, 50% solid) without secondary abatement	98%	

Table 4-107: Share of NMVOC Abatement Technologies

Abatement Technology	Share	Source
Traditional solvent based adhesives (65% solvent, 35% solid) with activated carbon adsorption or condensation	80%	Expert Judgement
Emulsions (2% solvent, 50% solid) without secondary abatement	20%	

4.6.4.4 Activity Data

Activity data regarding glues and adhesives consumption was obtained from EUROSTAT.

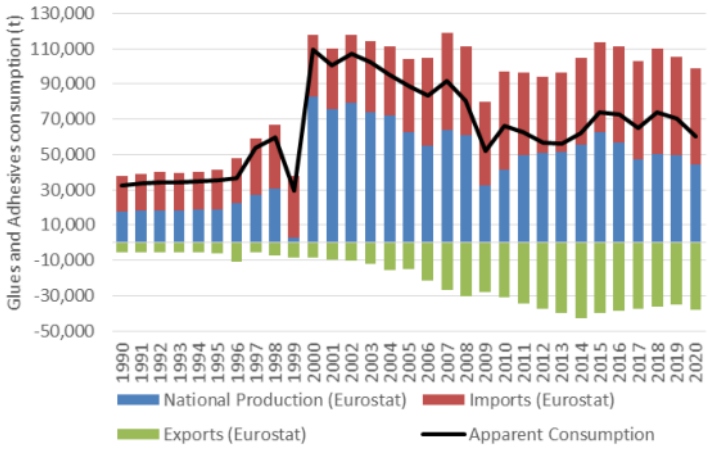


Figure 4-87: Glues and adhesives apparent consumption

4.6.4.5 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.

4.6.4.6 Recalculations

No recalculations were made.

4.6.4.7 Further Improvements

Portugal participated in a capacity building project for Air emission inventories relating to NMVOC emissions, and flagged this category as priority in order to get support to move to a higher Tier methodology. We intend to contact national authorities on the matter in order to assess and collect the available data for the sector. We hope to report on the progress in future submissions.

4.6.5 Preservation of Wood (NFR 2.D.3.i – SNAP 060406)

4.6.5.1 Category description

Preservation of wood, against weathering, fungi and insect attack, is applied to wood furniture, artefacts and building and construction materials. It is usually done by impregnation or immersion of timber in organic solvent based preservatives (light organic solvent-based preservatives LOSP, composed of hydrocarbon vehicle – usually white spirit – carrying a pesticide active ingredient), creosote or water based preservatives (inorganic solutions of Cu, Cr or As in water).

4.6.5.2 Methodology

Emissions from preservation of wood were estimated based on a Tier 2 approach in accordance with the 2019 EMEP Guidebook.

Apparent consumption of treated wood was estimated according to the following equation:

Equation 4-96: Treated wood apparent consumption

App Cons = Production + Imports - Exports

Where:

App Cons: Apparent consumption of treated wood (m^3)

Production: National production of treated wood (m^3)

Imports: Imports of treated wood (m^3)

Exports: Exports of treated wood (m^3)

Wood preservatives consumption were estimated according to the following equation:

Equation 4-97: Wood preservatives consumption

$$Wood\ Pres_x = App\ Cons \times \%Wood\ Pres_x \times {}^{m\ wood\ pres_x}/_{m^3 wood}$$

Where:

Wood $Pres_x$: Mass (kg) of wood preservative of type "x" (waterborne preservative, creosote preservative or solvent borne preservative)

App Cons: Apparent consumption of treated wood (m^3)

%Wood $Pres_x$: Share of wood preservative of type "x" (%).

m wood $pres_x/m^3$ wood: mass of preservative of type "x" needed to preserve 1 m^3 of wood (kg/m^3)

According to the document "Wood Preservation with chemicals – Best Available Technics", the share of wood preservative is 71% waterborne preservative, 18% solvent borne preservative and 11% creosote preservative.

According to the 2019 EMEP Guidebook, for creosote type wood preservative, 1 m^3 of wood requires 75 kg of creosote. For solvent borne and water borne preservative, 1 m^3 of wood requires 24 kg of wood preservative.

NMVOC emissions were estimated according to the following equation:

Equation 4-98: NMVOC emissions

$$NMVOC_{wood\ Pres\ x} = \frac{m\ Wood\ Pres_x \times EF\ Wood\ Pres_x \times (100\% - Eff_{Abat\ Techn})}{1 \times 10^6}$$

Where:

$NMVOC_{Wood\ Pres\ x}$: NMVOC emissions related to wood preservative "x" (t)

m $Wood\ Pres_x$: Mass of wood preservative "x" (kg)

EF $Wood\ Pres_x$: NMVOC emission factor related to wood preservative "x" (g NMVOC/kg wood preservative)

$Eff_{Abat\ Techn}$: Efficiency of abatement technology (%)

PCDD/F emissions were estimated according to the following equation:

Equation 4-99: PCDD/F emissions

$$PCDD/F_{wood\ Pres\ x} = \frac{m\ Wood\ Pres_x \times EF\ Wood\ Pres_x}{1000}$$

Where:

$PCDD/F_{Wood\ Pres\ x}$: PCDD/F emissions related to wood preservative "x" (g TEQ)

m $Wood\ Pres_x$: Mass of wood preservative "x" (kg)

EF $Wood\ Pres_x$: PCDD/F emission factor related to wood preservative "x" (mg TEQ/kg wood preservative)

Benzo(α)pyrene, Benzo(β)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene emissions were estimated according to the following equation:

Equation 4-100: Other emissions

$$Emissions_{Creosote} = \frac{m_{Creosote} \times EF_{Creosote}}{1 \times 10^6}$$

Where:

$Emissions_{Creosote}$: Emissions related to creosote preservative (t)

$m_{Creosote}$: Mass of Creosote Preservative (kg of Creosote)

$EF_{Creosote}$: Emission factor related to Creosote Preservative (g/kg of Creosote)

4.6.5.3 Emission Factors

The following parameters were chosen to estimate emissions for preservation of wood.

Table 4-108: Share of each type of wood preservative

Wood Preservative Type	Share (%)	Source
Waterborne Preservative	71%	Expert Judgement based on document "Wood Preservation with Chemicals – Best Available Technics"
Creosote Preservative	11%	
Solvent-Borne Preservative	18%	

Table 4-109: Amount of wood preservative (kg) used per m^3 of wood preserved

Wood Preservative Type	Kg/m^3	Source
Waterborne Preservative	24	Page 16 of chapter "2.D.3.i, 2.G Other solvent and product use" of 2019 EMEP Guidebook
Creosote Preservative	75	
Solvent-Borne Preservative	24	

Table 4-110: Tier 2 emission factors

Wood Preservative Type	Pollutant	Unit	EF	Source
Waterborne Preservative	NMVOC	g/kg preservative	5	Table 3-7 of chapter "2.D.3.i, 2.G Other solvent and product use" of 2019 EMEP Guidebook
Solvent-Borne Preservative	NMVOC	g/kg preservative	945	Table 3-6 of chapter "2.D.3.i, 2.G Other solvent and product use" of 2019 EMEP Guidebook
Creosote Preservative	NMVOC	g/kg creosote	105	Table 3-5 of chapter "2.D.3.i, 2.G Other solvent and product use" of 2019 EMEP Guidebook
	Benzo(α)pyrene	mg/kg creosote	1.05	
	Benzo(β)fluoranthene	mg/kg creosote	0.53	
	Benzo(k)fluoranthene	mg/kg creosote	0.53	
	Indeno(1,2,3-cd)pyrene	mg/kg creosote	0.53	
General	PCDD/F	g TEQ/t PCP	0.0016	Table 3-8 of chapter "2.D.3.i, 2.G Other solvent and product use" of 2019 EMEP Guidebook

Table 4-111: Waterborne Preservative Abatement Technologies Efficiencies

Abatement Technology	Pollutant	Efficiency	Source
100% water based preservatives. Improved application technique. (Vaccuum impregnation system).	NMVOC	40%	Table 3-19 of chapter "2.D.3.i, 2.G Other solvent and product use" of of 2019 EMEP Guidebook

Table 4-112: Creosote Preservative Abatement Technologies Efficiencies

Abatement Technology	Pollutant	Efficiency	Source
Solvent management plan. Good housekeeping – type controls.	NMVOC	3%	Table 3-17 of chapter "2.D.3.i, 2.G Other solvent and product use" of 2019 EMEP Guidebook
Enclosure of drying and other áreas and venting through end-of-pipe controls such as condensation or incineration	NMVOC	67%	
Average (Considered for estimates)	**NMVOC**	**35%**	

Table 4-113: Creosote Preservative Abatement Technologies Efficiencies

Abatement Technology	Pollutant	Efficiency	Source
Solvent management plan; good housekeeping – type controls	NMVOC	5%	Table 3-18 of chapter "2.D.3.i, 2.G Other solvent and product use" of 2019 EMEP Guidebook
Enclosure of drying and other áreas and venting through end-of-pipe controls such as condensation or incineration	NMVOC	69%	
100% solvent based preservatives. Improved application technique. (Vacuum impregnation system)	NMVOC	16.2%	
Process optimization.100% more concentrated solvent based preservatives. Improved application technique. (Vacuum impregnation system)	NMVOC	44.4%	
Average (considered for estimates)	**NMVOC**	**33.7%**	

4.6.5.4 Activity Data

From 1995 onwards, production, imports and exports of treated wood were obtained from EUROSTAT. Data in the period 1990-1994 has been estimated based on 1995 values and on GDP. The apparent consumption of treated wood was split by type of wood preservative applied, considering the document "Wood Preservation with chemicals – Best available technics".

The correspondence between m^3 of treated wood and kg of wood preservative applied has been done using the values proposed in page 16 of chapter "2.D.3.i, 2.G - Other solvent and product use" of 2019 EMEP Guidebook.

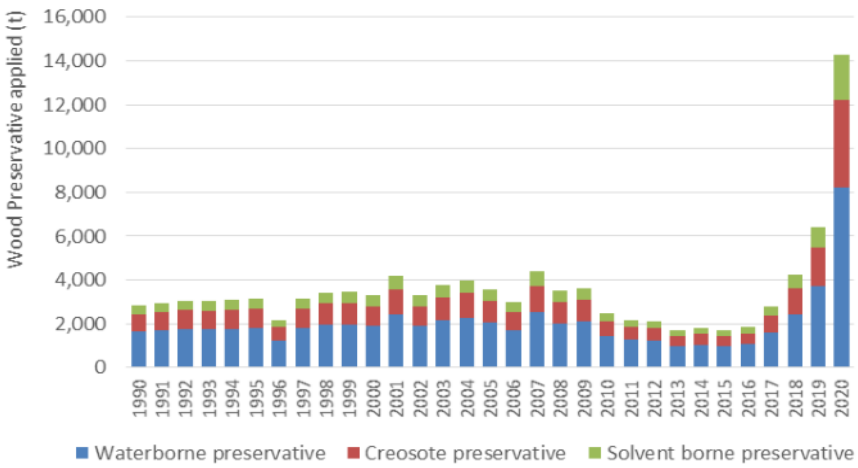


Figure 4-88: Wood Preservative applied by type – total territory

Emissions of Mainland Portugal represent 91.2% of the total territory. This share has been estimated based on fuel sold to "Other Industry" (1.A.2.g).

4.6.5.5 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.

4.6.5.6 Recalculations

2019 activity data was revised based on EUROSTAT database.

4.6.5.7 Further Improvements

Contacts will be made with sectoral associations in order to obtain data on share of each type of wood preservative and abatement technologies applied in Portugal.

4.6.6 Underseal Treatment and Conservation of Vehicles (NFR 2.D.3.i – SNAP 060407)

4.6.6.1 Category description

This chapter addresses emissions estimates from Underseal Treatment and Conservation of Vehicles.

4.6.6.2 Methodology

NMVOC emissions from Underseal Treatment and Conservation of Vehicles were estimated based on a Tier 2 approach in accordance with the 2019 EMEP Guidebook. Emissions were estimated according to the following equation:

Equation 4-101: NMVOC emissions

$$Emi_{NMVOC} = \frac{Population \times EF_{NMVOC}}{1000}$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

Population: National population

EF_{NMVOC}: NMVOC emission factor (kg/person)

4.6.6.3 Emission Factors

NMVOC emission factor was taken from EMEP Guidebook 2019 and is listed in the table below.

Table 4-114: Default emission factor

SNAP	Unit	NMVOC	Source
Underseal treatment and conservation of vehicles	kg/person	0.2	Table 3-10 of chapter "2.D.3.i, 2.G Other solvent and product use" of 2019 EMEP Guidebook

4.6.6.4 Activity Data

National population data was obtained from INE.

Emissions of Mainland Portugal represent 91.2% of the total territory. This share has been estimated based on fuel sold to "Other Industry" (1.A.2.g).

4.6.6.5 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.

4.6.6.6 Recalculations

No recalculations were made.

4.6.6.7 Further Improvements

No further improvements are expected.

4.6.7 Vehicles Dewaxing (NFR 2.D.3.i – SNAP 060409)

4.6.7.1 Category description

This chapter addresses emissions estimates from Vehicles Dewaxing.

4.6.7.2 Methodology

NMVOC emissions from vehicle dewaxing were estimated based on a Tier 2 approach in accordance with the 2019 EMEP Guidebook. NMVOC emissions from vehicle dewaxing were estimated according to the following equation:

Equation 4-102: NMVOC emissions from vehicle dewaxing

$$Emi_{NMVOC} = \frac{Vehicles_{Sales} \times EF_{NMVOC}}{1000}$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

$Use_{Fireworks}$: Vehicles sales (Number of vehicles)

EF_{NMVOC}: NMVOC emission factor (kg/car)

4.6.7.3 Emission Factors

NMVOC emission factor was taken from EMEP Guidebook 2019 and is listed in the table below.

Table 4-115: Default emission factor

SNAP	Unit	NMVOC	Source
Vehicles dewaxing	kg/car	1	Table 3-9 of chapter "2.D.3.i, 2.G Other solvent and product use" of 2019 EMEP Guidebook

4.6.7.4 Activity Data

According to EMEP Guidebook 2019, in continental Europe it may apply only to those vehicles transported over longer distances. We assume all national vehicles sales concern vehicles transported over long distances. National vehicles sales data was obtained from Portuguese Automobile Association (ACAP) for the whole time series. 2020 sales are relatively lower due to the COVID pandemic.

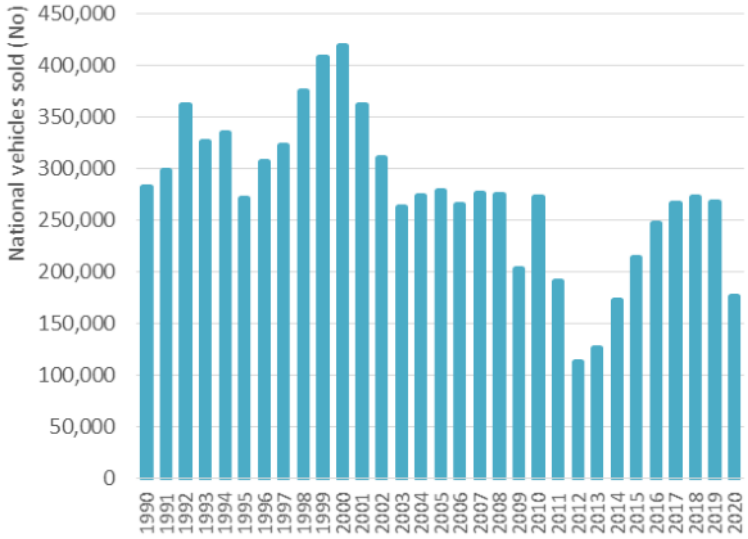


Figure 4-89: Annual vehicles sales – Total Territory

Emissions of Mainland Portugal represent 91.2% of the total territory. This share has been estimated based on fuel sold to "Other Industry" (1.A.2.g).

4.6.7.5 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.

4.6.7.6 Recalculations

No recalculations were made.

4.6.7.7 Further Improvements

No further improvements are expected.

4.6.8 Use of Fireworks (NFR 2.G – SNAP 060601)

4.6.8.1 Category description

This chapter addresses emissions estimates from the Use of Fireworks.

4.6.8.2 Methodology

Emissions from the use of fireworks were estimated based on a Tier 2 approach in accordance with 2019 EMEP Guidebook. Fireworks apparent consumption was estimated according to the following equation:

Equation 4-103: Fireworks apparent consumption

App Cons = Production + Imports - Exports

Where:

App Cons: Apparent consumption of fireworks (t)

Production: National production of fireworks (t)

Imports: Imports of fireworks (t)

Exports: Exports of fireworks (t)

Emissions for all pollutants except NMVOC were estimated according to the following equation:

Equation 4-104: Emissions from tobacco consumption

$$Emip = \frac{Use_{Fireworks} \times EF}{1 \times 10^6}$$

Where:

Emi_P: Emissions of pollutant p (t)

$Use_{Fireworks}$: Product used in Fireworks (t)

EF: Emission factor (g/t product)

NMVOC emissions were estimated according to the following equation:

Equation 4-105: NMVOC emissions from tobacco consumption

$$Emi_{NMVOC} = \frac{Use_{Fireworks} \times EF_{NMVOC}}{1000}$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

$Use_{Fireworks}$: Product used in Fireworks (t)

EF: Emission factor (kg/t product)

4.6.8.3 Emission Factors

NMVOC emission factor was taken from Table 3-13 of chapter “2.D.3.i, 2.G Other solvent and product use” of EMEP Guidebook 2019. All other emission factors were taken from Table 3-14 of chapter “2.D.3.i, 2.G Other solvent and product use” of EMEP Guidebook 2019 and are listed in the table below.

Table 4-116: Default emission factors

Pollutant	Unit	EF
SO_2	g/t product	3020
NO_x	g/t product	260
NMVOC	kg/t product	342
CO	g/t product	7150
Pb	g/t product	784
TSP	g/t product	109.83
PM_{10}	g/t product	99.92
$PM_{2.5}$	g/t product	51.94
Cd	g/t product	1.48
Hg	g/t product	0.057
As	g/t product	1.33
Cr	g/t product	15.6
Cu	g/t product	444
Ni	g/t product	30
Zn	g/t product	260

4.6.8.4 Activity Data

From 1996 onwards, fireworks production data was obtained from EUROSTAT. In the period 1990-1995, data was estimated based on GDP trend and on 1996 production value.

From 1995 onwards, fireworks exports and imports data were obtained from EUROSTAT. In the period 1990-1994, data was estimated based on GDP trend and on 1995 exports/imports data values.

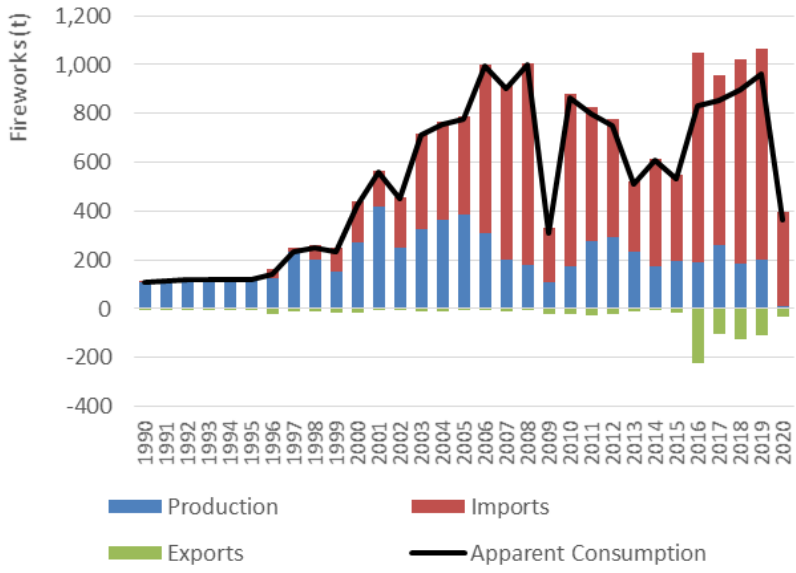


Figure 4-90: Use of Fireworks (Apparent Consumption)

From the figure above it's possible to verify that a substantial part of the use of fireworks is based on imports. 2020 data are relatively lower due to the COVID pandemic.

Emissions of Mainland Portugal represent 95.1% of the total territory. This share has been estimated based on the population (data used also to spatial allocation).

4.6.8.5 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.

4.6.8.6 Recalculations

No recalculations were made.

4.6.8.7 Further Improvements

No further improvements are expected.

4.6.9 Use of Tobacco (NFR 2.G – SNAP 060602)

4.6.9.1 Category description

This chapter addresses emissions estimates from the Use of Tobacco.

4.6.9.2 Methodology

Emissions from the use of tobacco were estimated based on a Tier 2 approach in accordance with EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2019).

Tobacco apparent consumption was estimated according to the following equation:

Equation 4-106: Tobacco apparent consumption

App Cons = Production + Imports - Exports

Where:

App Cons: Apparent consumption of tobacco (t)

Production: National production of tobacco (t)

Imports: Imports of tobacco (t)

Exports: Exports of tobacco (t)

NO_x, NMVOC, CO, NH_3, TSP, PM_{10} and $PM_{2.5}$ emissions from tobacco consumption were estimated according to the following equation:

Equation 4-107: Emissions from tobacco consumption

$$Emi = \frac{Apparent\ Consumption_{Tobacco} \times EF}{1000}$$

Where:

Emi: Pollutant emissions (t)

Apparent $Consumption_{Tobacco}$: Apparent consumption of tobacco (t)

EF: Emission factor (kg/t tobacco)

Cd, Cu, Ni, Zn, Benzo(α)pyrene, Benzo(β)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene were estimated according to the following equation:

Equation 4-108: Emissions from tobacco consumption

$$Emi = \frac{Apparent\ Consumption_{Tobacco} \times EF}{1 \times 10^6}$$

Where:

Emi: Pollutant emissions (t)

Apparent $Consumption_{Tobacco}$: Apparent consumption of tobacco (t)

EF: Emission factor (g/t tobacco)

PCDD/F (Dioxines and Furanes) were estimated according to the following equation:

Equation 4-109: Dioxines and Furanes' emissions from tobacco consumption

$$Emi = \frac{Apparent\ Consumption_{Tobacco} \times EF}{1 \times 10^6}$$

Where:

Emi: Pollutant emissions (g I-teq)

Apparent $Consumption_{Tobacco}$: Apparent consumption of tobacco (t)

EF: Emission factor (µg I-teq/t tobacco)

Black Carbon was estimated according to the following equation:

Equation 4-110: Black carbon emissions from tobacco consumption

$$Emi_{Black\ Carbon} = Emi_{PM2.5} \times \%_{Black\ Carbon}$$

Where:

$Emi_{Black\ Carbon}$: Black Carbon emissions (t)

$Emi_{PM2.5}$: $PM_{2.5}$ emissions (t)

$\%_{Black\ Carbon}$: % of Black Carbon in $PM_{2.5}$ emissions (% $PM_{2.5}$)

4.6.9.3 Emission Factors

Emission factors were taken from Table 3-15 of chapter "2.D.3.i, 2.G Other solvent and product use" of EMEP Guidebook 2019 and are listed in the table below.

Table 4-117: Default emission factors

Pollutant	Unit	EF
NO_x	kg/t tobacco	1.8
NMVOC	kg/t tobacco	4.84
CO	kg/t tobacco	55.1
NH3	kg/t tobacco	4.15
TSP	kg/t tobacco	27
PM_{10}	kg/t tobacco	27
$PM_{2.5}$	kg/t tobacco	27
BC	% PM2.5	0.45
Cd	g/t tobacco	5.4
Cu	g/t tobacco	5.4
Ni	g/t tobacco	2.7
Zn	g/t tobacco	2.7
PCDD/F	µg I-teq/t tobacco	0.1
Benzo(α)pyrene	g/t tobacco	0.111
Benzo(β)fluoranthene	g/t tobacco	0.045
Benzo(k)fluoranthene	g/t tobacco	0.045
Indeno(1,2,3-cd)pyrene	g/t tobacco	0.045

4.6.9.4 Activity Data

From 1992 onwards, tobacco production has been obtained from INE. In the period 1990-1991 it was estimated based on 1992 tobacco production and on GDP trend.

Imports and exports data has been obtained from EUROSTAT in the period 1995-2016. In the period 1990-1994 it was estimated based on 1995 imports/exports values and on GDP trend. In 2016 imports/exports data was estimated based on 2015 value and on GDP trend.

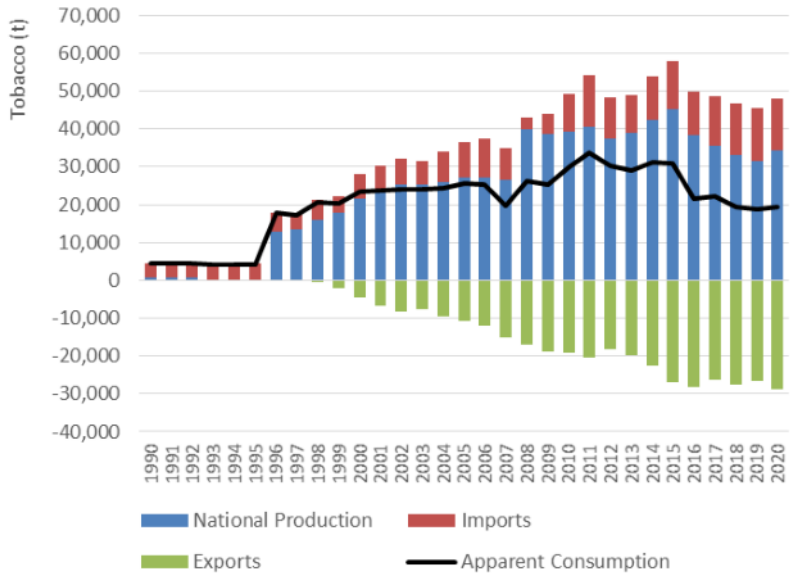


Figure 4-91: Tobacco apparent consumption – Total territory

The apparent consumption increase from 1995 to 1996 is due to cigars national production substantial increase in this period.

Tobacco exports are more relevant than the imports from 2007 onwards, which led to a slight decrease in tobacco apparent consumption in the period 2014-2016, despite the national production increase from 2014 to 2015.

Emissions of Mainland Portugal represent 95.1% of the total territory. This share has been estimated based on the population (data used also to spatial allocation).

4.6.9.5 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.

4.6.9.6 Recalculations

No recalculations were made.

4.6.9.7 Further Improvements

No further improvements are expected.

4.6.10 Use of Shoes (NFR 2.G - SNAP 060603)

4.6.10.1 Category description

This chapter addresses emissions estimates from the use of shoes.

4.6.10.2 Methodology

NMVOC emissions from the use of shoes were estimated based on a Tier 2 approach in accordance with EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2019).

Shoes apparent consumption was estimated according to the following equation:

Equation 4-111: Shoes apparent consumption

App Cons = Production + Imports - Exports

Where:

App Cons: Apparent consumption of shoes (pair of shoes)

Production: National production of shoes (pair of shoes)

Imports: Imports of shoes (pair of shoes)

Exports: Exports of shoes (pair of shoes)

NMVOC emissions from the use of shoes were estimated according to the following equation:

Equation 4-112: NMVOC emissions from the use of shoes

$$Emi_{NMVOC} = \frac{Apparent\ Consumption_{Shoes} \times EF}{1 \times 10^{6}} \times (100\% - Eff_{Abat.\ Techn.})$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

$Apparent\ Consumption_{Shoes}$: Apparent consumption of shoes (pair of shoes)

EF: Emission factor (g/pair of shoes)

$Eff_{Abat.\ Techn.}$: Efficiency of Abatement Technologies (%)

4.6.10.3 Emission Factors

The following parameters were chosen to estimate emissions for the use of shoes.

Table 4-118: Default emission factor

SNAP	Unit	NMVOC	Source
Use of shoes	g/pair of shoes	60	Table 3-16 of chapter "2.D.3.i, 2.G Other solvent and product use" of "EMEP/EEA air pollutant emission inventory guidebook 2019"

Table 4-119: Efficiency of abatement technologies

Abatement Technology	Efficiency	Source
90% solvent based/10% water based adhesives, Incineration	71%	Table 3-22 of chapter "2.D.3.i, 2.G Other solvent and product use" of "EMEP/EEA air pollutant emission inventory guidebook 2019"
90% solvent based/10% water based adhesives, Biofiltration	71%	
60% solvent based/40% water based, good housekeeping, No secondary end-of-pipe device	48%	
60% solvent based/40% water based, good housekeeping, Incineration	85%	
60% solvent based/40% water based, good housekeeping, Biofiltration	85%	
60% solvent based/40% water based, good housekeeping/automatic application, No secondary end-of-pipe device	62%	
Average	**70%**	-

It was considered an average value of 70% as abatement efficiency (average of the proposed efficiencies).

4.6.10.4 Activity Data

Shoes production, imports and exports data has been obtained from EUROSTAT in the period 1995-2016. In the period 1990-1994 it was estimated based on 1995 values and on GDP trend.

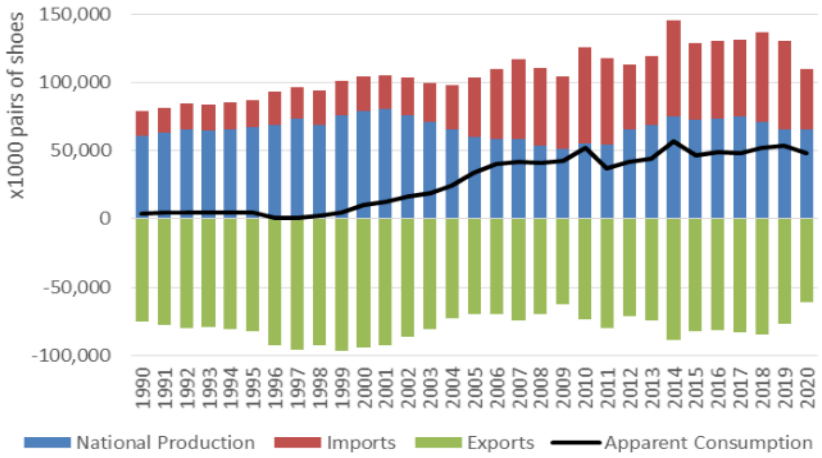


Figure 4-92: Apparent consumption of shoes (x1000 pairs of shoes) – Total territory

Shoes exports in Portugal are more relevant than imports, and thus the apparent consumption values are lower than the national production values. 2020 numbers are relatively lower due to the COVID pandemic.

Emissions of Mainland Portugal represent 95.1% of the total territory. This share has been estimated based on the population (data used also to spatial allocation).

4.6.10.5 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.

4.6.10.6 Recalculations

No recalculations were made.

4.6.10.7 Further Improvements

Efforts will be made in order to obtain a better characterization of abatement technologies share over time.

4.6.11 Lubricants consumption (NFR 2.G – SNAP 060604)

4.6.11.1 Category description

This chapter addresses emissions estimates from lubricants use.

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.

4.6.11.2 Methodology

Lubricants accounted for in this category can be estimated according to the following:

Equation 4-113: 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 (NFR 1.A.3.b) chapter.

NMVOC emissions from this sector were estimated using a Tier 2 approach.

Equation 4-114: NMVOC emissions from lubricants consumption

$$EmiNMVOC_i = AD \times EF_{NMVOC}/10^6$$

Where:

Emi_{NMVOC}: Emissions of NMVOC associated to the use of lubricants in engines other than two-stroke (t)

AD: Consumption of Lubricants except in two-stroke engines in Road Transportation (t)

EF_{NMVOC}: Emission factor associated to the use of lubricants (g/t product)

Emissions from 2G also include heavy metals emissions from lubricants that enter accidentally in the four-stroke engines combustion chambers in road transportation. The methodology used for this estimations is described in Road Transportation (1.A.3.b) chapter.

4.6.11.3 Emission Factors

Emission factor used for NMVOC was 28,000 g/t product, according to table 3-16 of volume "2.D.3.i, 2G Other solvent and product use" of EMEP/EEA guidebook 2016.

4.6.11.4 Activity Data

Total lubricants consumption was obtained from the energy balance (DGEG). Lubricants consumption in two-stroke engines were estimated by COPERT V.

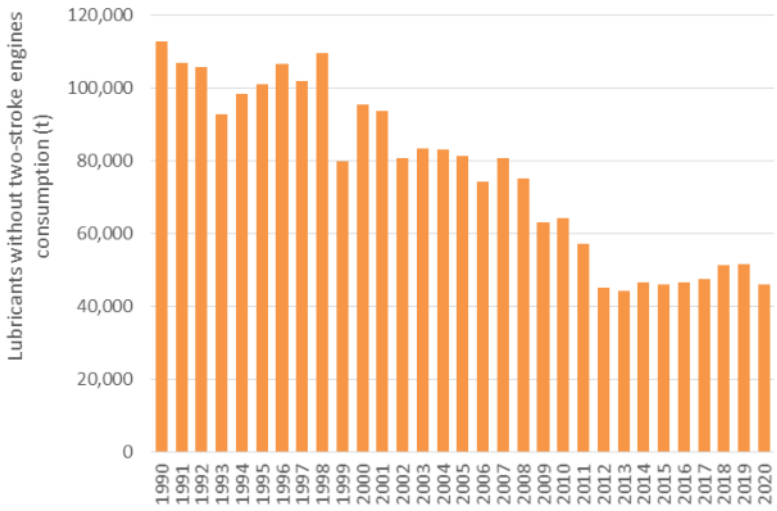


Figure 4-93: Lubricants consumption in engines other than two-stroke

4.6.11.5 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.

4.6.11.6 Recalculations

Two-stroke engines lubricants consumption data were updated for the period 1994 to 2019.

4.6.11.7 Further Improvements

No further improvements are expected.

4.7 Other Industry Production (2.H)

4.7.1 Wood Chipboard Production (NFR 2.H.1 – SNAP 040601)

4.7.1.1 Category description

This chapter addresses emissions estimates from Wood Chipboard Production. Chipboard manufacturing involves solvent emission but it is included in this source sector.

4.7.1.2 Methodology

Emissions were estimated by the use of emission factors multiplied by the quantity of material produced:

Equation 4-115: Emissions from wood chipboard production

$$Emi_{NMVOC} = EF_{NMVOC} \times ActivityRate_{(y)} \times 10^{-3}$$

Where:

Emi_{NMVOC}: Annual NMVOC emissions (t)

EF_{NMVOC}: Emission factor (kg/t)

ActivityRate: Indicator of activity in the production process (t)

4.7.1.3 Emission Factors

Emission factor used for estimating NMVOC emissions was 0.9 kg/t, taken from Table 18.1 of Corinair90 Default Emission Factor Handbook.

4.7.1.4 Activity Data

Information about activity data for this sector is still scarce and limited to 1990, 2001-2007 and from 2010 onwards, from INE. For the period 1991-2000 and 2008-2009 data has been interpolated based on GDP trend.

Due to inconsistencies between the units in which the data is provided to INE in the periods 1992-2007 and from 2008 onwards, we have considered only the data from 2008 onwards and did a retropolation for the period 1990-2007 based on 2008 value and on GDP trend.

4.7.1.5 Uncertainty Assessment

Table 4-120: Wood Chipboard Production

Parameter	U (%)
AD Combined Uncertainty	10%
EF Combined Uncertainty	51%

4.7.1.6 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.

4.7.1.7 Recalculations

No recalculations were made.

4.7.1.8 Further Improvements

In the future, we intend to improve consistency and completeness of activity data.

4.7.2 Paper pulp production (NFR 2.H.1 – SNAP 040602; 040603; 040604)

4.7.2.1 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.

4.7.2.2 Methodology

Emissions for each pollutant are estimated according to the following equation:

Equation 4-116: Emissions from Pulp and Paper Industry

$$Emission_{(p)} = EF_{(p)} * Pulp_{PROD} * 10^{-3}$$

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)

4.7.2.3 Emission Factors

The following emission 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 4-121: Emission Factors for paper pulp production (non-combustion)

Process	SO_x	NO_x	NMVOC	TSP	PM_{10} (%)	$PM_{2.5}$ (%)	PM_1 (%)
Kraft	0.31	1.95	2.74	3.5	88.5	73	40
Sulphide	35.5	NA	NA	NA	NA	NA	NA

4.7.2.4 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). Since 2010, 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 from 1990 onwards.

The following figure presents total production of paper pulp.

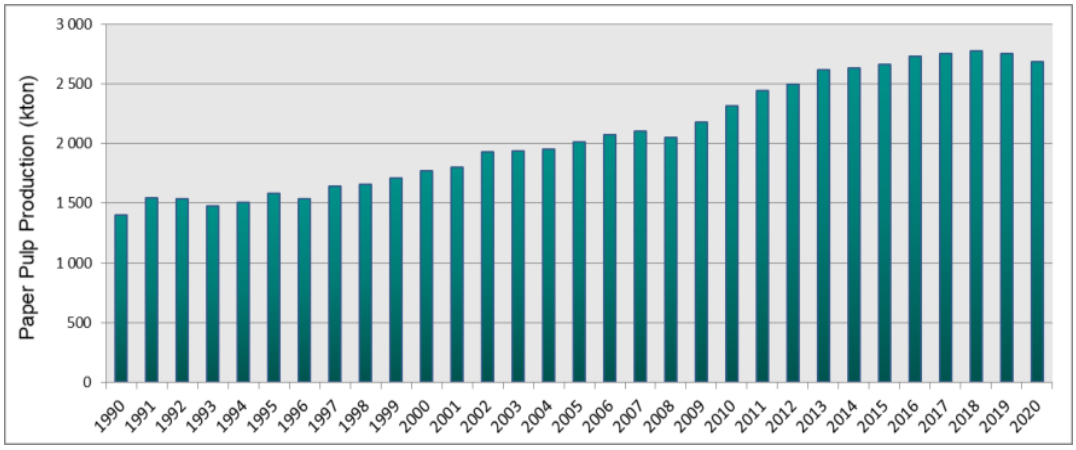


Figure 4-94: Total production of paper pulp

4.7.2.5 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.

4.7.2.6 Recalculations

No recalculations were made.

4.7.2.7 Further Improvements

No further improvements are planned.

4.7.3 Food Manufacturing (NFR 2.H.2 – SNAP 040605; 040625; 040626; 040627)

4.7.3.1 Category description

Emissions from food manufacturing include all processes in the food production chain, which occur after the slaughtering of animals and the harvesting of crops. Emissions occur primarily from the following sources:

- Animal rendering;
- Fish meal processing;
- Grain drying;
- Handling of agricultural products;
- The cooking of meat, fish and poultry, releasing mainly fats and oils and their degradation products;
- The processing of sugar beet and cane and the subsequent refining of sugar;

[16] Specific information for sulphide pulping can not be delivered because presently there is only one plant operating which raised confidential constraints.

- The processing of fats and oils to produce margarine and solid cooking fat;
- The baking of bread, cakes, biscuits and breakfast cereals;
- The processing of meat and vegetable by-products to produce animal feeds;
- The roasting of coffee beans.

4.7.3.2 Methodology

Emissions were estimated according to a Tier 2 methodology from 2019 EMEP Guidebook.

Regarding activities in the food industry, it was assumed that abatement equipment reduces the NMVOC emissions by 90%, according to page 25 section "3.3.3 Abatement" of chapter 2.H.2 of the Guidebook.

NMVOC emissions from food industry were estimated using the following equation:

Equation 4-117: Emissions from Food Industry

$$Emi_{NMVOC} = AD \times EF \times (1 - \eta_{abatement}) \times 10^{-3}$$

Where:

Emi_{NMVOC}: Annual NMVOC emissions (t)

AD: Activity Data (t of product)

$\eta_{abatement}$: Abatement Technology efficiency (=0.9)

PM_{10} emissions from Handling of agricultural products (grains, soya) were estimated using the following equation:

Equation 4-118: PM_{10} emissions from Food Industry

$$Emissions = AD \times EF \times 10^{-6}$$

Where:

Emissions - Emissions (t)

AD - Activity Data (t product)

EF - Emission factor (g/t product)

For PM_{10} there are no specific abatement techniques.

4.7.3.3 Emission Factors

Emission factors were obtained from chapter 2.H.2 Food and beverages industry of 2019 EMEP Guidebook and are listed in the table below.

Table 4-122: Emission Factors for food industry

Product	Pollutant	Unit	EF	Source
Animal rendering	NMVOC	Kg/t meat	0.33	Table 3-2 of chapter "2.H.2 Food and beverages industry" of 2019 EMEP Guidebook
Fish meal processing	NMVOC	Kg/t fish	1	Table 3-3 of chapter "2.H.2 Food and beverages industry" of 2019 EMEP Guidebook
Grain Drying	NMVOC	Kg/t grain dried	1.3	Table 3-4 of chapter "2.H.2 Food and beverages industry" of 2019 EMEP Guidebook
Handling of agricultural products (grains, soya)	PM_{10}	g/t	24	Table 3-10 of chapter "2.H.2 Food and beverages industry" of 2019 EMEP Guidebook
White Bread	NMVOC	Kg/t bread	4.5	Table 3-14 of chapter "2.H.2 Food and beverages industry" of 2019 EMEP Guidebook
Wholemeal Bread	NMVOC	Kg/t bread	3	Table 3-16 of chapter "2.H.2 Food and beverages industry" of 2019 EMEP Guidebook
Cakes, biscuits and breakfast cereals	NMVOC	Kg/t product	1	Table 3-18 of chapter "2.H.2 Food and beverages industry" of 2019 EMEP Guidebook
Meat, fish and poultry	NMVOC	Kg/t product	0.3	Table 3-19 of chapter "2.H.2 Food and beverages industry" of 2019 EMEP Guidebook
Sugar	NMVOC	Kg/t sugar	10	Table 3-20 of chapter "2.H.2 Food and beverages industry" of 2019 EMEP Guidebook
Margarine and solid cooking fats	NMVOC	Kg/t product	10	Table 3-21 of chapter "2.H.2 Food and beverages industry" of 2019 EMEP Guidebook
Animal feed	NMVOC	Kg/t feed	1	Table 3-22 of chapter "2.H.2 Food and beverages industry" of 2019 EMEP Guidebook
Coffee roasting	NMVOC	Kg/t beans	0.55	Table 3-23 of chapter "2.H.2 Food and beverages industry" of 2019 EMEP Guidebook

4.7.3.4 Activity Data

From 1992 onwards, activity data for this sector was obtained from National Statistics (INE). In the period 1990-1991, data has been estimated based on 1992 activity data values and on GDP.

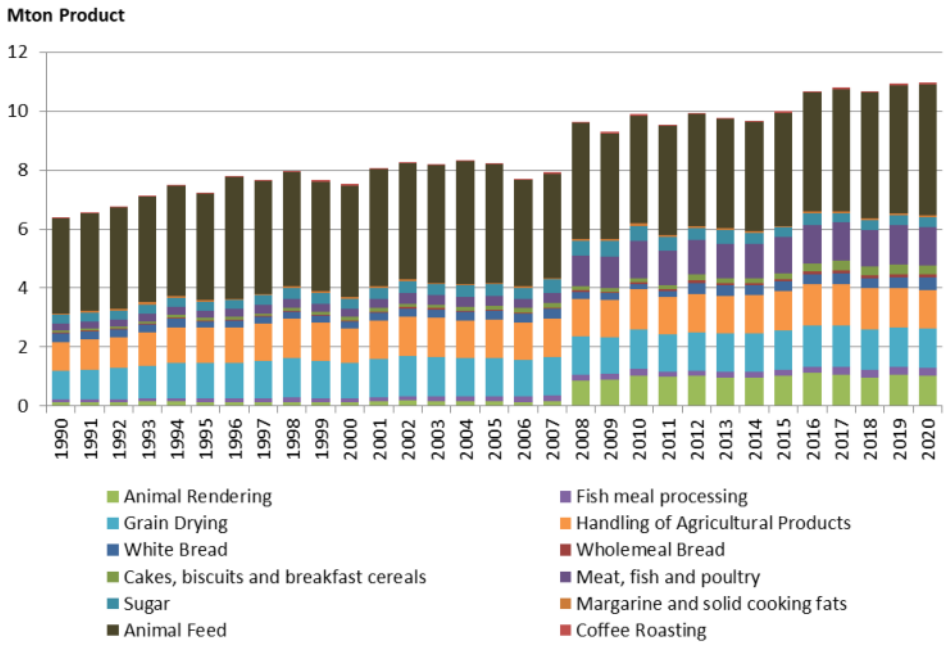


Figure 4-95: Food manufacturing by food product – Total territory

Emissions of Mainland Portugal represent 91.6% of the total territory. This share has been estimated based on the amounts of fuel sold to the food industry (data used also to spatial allocation).

4.7.3.5 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.

4.7.3.6 Recalculations

Following a 2021 NECD Review question, further analysis to Table 3-10 of chapter 2H2 of the Guidebook showed that for Handling of agricultural products (grains, soya) there is only emission factor for PM_{10}, and that TSP, $PM_{2.5}$ and BC are considered "Not estimated". Therefore, TSP, $PM_{2.5}$ and BC emissions were reviewed and corrected to Not Estimated.

Recalculations in Handling of agricultural products (grains, soya) resulted in a decrease in TSP, $PM_{2.5}$ and BC emissions.

4.7.3.7 Further Improvements

No further improvements are planned.

4.7.4 Drink Manufacturing (NFR 2.H.2 – SNAP 040606; 040607; 040608)

4.7.4.1 Category description

NMVOC emissions from drink manufacturing include the production of alcoholic beverages, especially wine, beer and spirits. Emissions occur primarily from the following sources:

- Barley malting;
- Hop processing;
- Fermentation;
- Casking;
- Maturation;
- Red wine;
- White wine;
- Beer;
- Spirits.

4.7.4.2 Methodology

NMVOC emissions from drink manufacturing were estimated according to a Tier 2 methodology from chapter 2.H.2 of the 2019 EMEP Guidebook.

Barley Malting

Emissions from barley malting were estimated according to the following equations:

Equation 4-119: Mass of beer

$$m_{Beer} = V_{Beer} \times \frac{100\ l\ Beer}{1\ hl\ Beer} \times d_{Beer}$$

Where:

m_{Beer}: Mass of Beer (t)

V_{Beer}: Volume of Beer (hl)

d_{Beer}: Density of Beer ($1x10^{-3}$ t/l)

Equation 4-120: Mass of barley

$$m_{Barley} = m_{Beer} \times \frac{0.15\ t\ Barley}{1\ t\ Beer}$$

Where:

m_{Barley}: Mass of Barley (t)

m_{Beer}: Mass of Beer (t)

Equation 4-121: Emissions from barley malting

$$Emissions = \frac{m_{Barley} \times EF \times (1 - \eta_{abatement})}{1000}$$

Where:

Emissions: NMVOC emissions (t)

m_{Barley}: Mass of Barley (t)

EF: Emission factor (kg/t barley)

$\eta_{abatement}$: Abatement Technology efficiency (0.9)

Hop Processing

Emissions from hop processing were estimated according to the following equations:

Equation 4-122: Mass of beer

$$m_{Beer} = V_{Beer} \times \frac{100\ l\ Beer}{1\ hl\ Beer} \times d_{Beer}$$

Where:

m_{Beer}: Mass of Beer (t)

V_{Beer}: Volume of Beer (hl)

d_{Beer}: Density of Beer ($1x10^{-3}$ t/l)

Equation 4-123: Emissions from hop processing

$$Emissions = \frac{m_{Beer} \times EF \times (1 - \eta_{abatement})}{1 \times 10^6}$$

Where:

Emissions: NMVOC emissions (t)

m_{Beer}: Mass of Beer (t)

EF: Emission factor (g/t beer)

$\eta_{abatement}$: Abatement Technology efficiency (0.9)

Fermentation, Casking and Maturation

Emissions from fermentation, casking and maturation were estimated according to the following equations:

Equation 4-124: Volume of alcohol in drinks

$$V_{alcohol\ in\ drink\ x} = \frac{V_{drink\ x}}{10} \times \%\ (v/v)_{alcohol\ in\ drink\ x}$$

Where:

$V_{alcohol\ in\ drink\ x}$: Volume of alcohol ($m^3$) in drink x (red wine, white wine, beer and spirits)

$V_{drink\ x}$: Volume of drink x (red wine, white wine, beer and spirits) (hl)

$\%\ (v/v)_{alcohol\ in\ drink\ x}$: Percentage of alcohol by volume in drink x (red wine, white wine, beer and spirits) (%)

By expert judgement we have considered the following percentages:

- Red wine = 13%;
- White wine = 12%;
- Beer = 4%;
- Spirits = 40%.

Equation 4-125: Mass of alcohol in drinks

$$m_{alcohol\ in\ drink\ x} = V_{alcohol\ in\ drink\ x} \times d_{alcohol}$$

Where:

$m_{alcohol}$: Mass of alcohol (t) in drink x (red wine, white wine, beer and spirits)

$V_{alcohol}$: Volume of alcohol (m^3) in drink x (red wine, white wine, beer and spirits)

$d_{alcohol}$: Density of alcohol/ethanol (789 kg/m^3)

Equation 4-126: Total mass of alcohol in drinks

$$m_{alcohol} = m_{alcohol\ in\ red\ wine} + m_{alcohol\ in\ white\ wine} + m_{alcohol\ in\ beer} + m_{alcohol\ in\ spirits}$$

Where:

$m_{alcohol}$: Mass of alcohol (t) in all drinks categories (red wine, white wine, beer and spirits)

$m_{alcohol\ in\ red\ wine}$: Mass of alcohol (t) in red wine

$m_{alcohol\ in\ white\ wine}$: Mass of alcohol (t) in white wine

$m_{alcohol\ in\ beer}$: Mass of alcohol (t) in beer

$m_{alcohol\ in\ spirits}$: Mass of alcohol (t) in spirits

Equation 4-127: Emissions from fermentation, casking and maturation

$$Emissions = \frac{m_{Alcohol} \times EF \times (1 - \eta_{abatement})}{1000}$$

Where:

Emissions: Total NMVOC emissions (t)

$m_{Alcohol}$: Mass of Alcohol (t)

EF: Emission factor (kg/t alcohol)

$\eta_{abatement}$: Abatement Technology efficiency (0.9)

Red Wine, White Wine and Beer

Emissions from red wine, white wine and beer were estimated according to the following equation:

Equation 4-128: Emissions from red wine, white wine and beer

$$Emissions = \frac{V_{drink\ x} \times EF \times (1 - \eta_{abatement})}{1000}$$

Where:

Emissions: Total NMVOC emissions (t)

$V_{drink\ x}$: Volume (hl) of drink x (red wine, white wine, beer)

EF: Emission factor (kg/hl drink x)

$\eta_{abatement}$: Abatement Technology efficiency (0.9)

Spirits

Emissions from spirits were estimated according to the following equations:

Equation 4-129: Volume of alcohol in spirits

$$V_{alcohol\ in\ spirits} = v_{spirits} \times \%\ (v/v)_{alcohol\ in\ spirits}$$

Where:

$V_{alcohol\ in\ spirits}$: Volume of alcohol in spirits (hl)

$V_{spirits}$: Volume of spirits (hl)

$\%\ (v/v)_{alcohol\ in\ spirits}$: Percentage of alcohol by volume in spirits (%)

Equation 4-130: Emissions from spirits

$$Emissions = \frac{v_{Alcohol\ in\ spirits} \times EF \times (1 - \eta_{abatement})}{1000}$$

Where:

Emissions: Total NMVOC emissions (t)

$V_{alcohol\ in\ spirits}$: Volume of alcohol in spirits (hl)

EF: Emission factor (kg/hl alcohol in spirits)

$\eta_{abatement}$: Abatement Technology efficiency (0.9)

4.7.4.3 Emission Factors

NMVOC emission factors were obtained from chapter 2.H.2 of the 2019 EMEP Guidebook and are listed in the table below.

Table 4-123: NMVOC emission Factors for drink industry

Product	Unit	NMVOC EF	Source
Barley Malting	g/t barley	0.55	Table 3-5 of chapter "2.H.2 Food and beverages industry" of 2019 EMEP Guidebook
Hop Processing	g/t beer	7.8	Table 3-6 of chapter "2.H.2 Food and beverages industry" of 2019 EMEP Guidebook
Fermentation	Kg/t alcohol	2	Table 3-7 of chapter "2.H.2 Food and beverages industry" of 2019 EMEP Guidebook
Casking	Kg/t alcohol	0.5	Table 3-8 of chapter "2.H.2 Food and beverages industry" of 2019 EMEP Guidebook
Maturation	Kg/t alcohol	20	Table 3-9 of chapter "2.H.2 Food and beverages industry" of 2019 EMEP Guidebook
Red Wine	Kg/hl wine	0.080	Table 3-25 of chapter "2.H.2 Food and beverages industry" of 2019 EMEP Guidebook
White Wine	Kg/hl wine	0.035	Table 3-26 of chapter "2.H.2 Food and beverages industry" of 2019 EMEP Guidebook
Beer	Kg/hl beer	0.035	Table 3-27 of chapter "2.H.2 Food and beverages industry" of 2019 EMEP Guidebook
Spirits	Kg/hl alcohol	15	Table 3-28 of chapter "2.H.2 Food and beverages industry" of 2019 EMEP Guidebook

The following additional assumptions were made, for estimates purposes:

- 0.15 t of barley are required to produce 1 t of beer (page 9 of chapter "2.H.2 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016");
- Spirits have 40% alcohol by volume (page 9 of chapter "2.H.2 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016");
- Red wine has on average 13% alcohol by volume (expert judgement);
- White wine has on average 12% alcohol by volume (expert judgement);
- Beer has on average 4% alcohol by volume (page 9 of chapter "2.H.2 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016");
- Alcohol (ethanol) has a density of 789 kg/m3 (page 9 of chapter "2.H.2 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016").

For the activities in the beverages industry, it is assumed that abatement equipment reduces the emissions by 90% (page 25 of chapter "2.H.2 Food and beverages industry" of 2019 EMEP Guidebook).

4.7.4.4 Activity Data

From 1992 onwards, data on beverages production was obtained from INE. In the period 1990-1991, data was estimated based on 1992 beverages production and on GDP.

Emissions of Mainland Portugal represent 91.6% of the total territory. This share has been estimated based on the amounts of fuel sold to the food industry (data used also to spatial allocation). Below we present beverages production on total territory.

Barley Malting

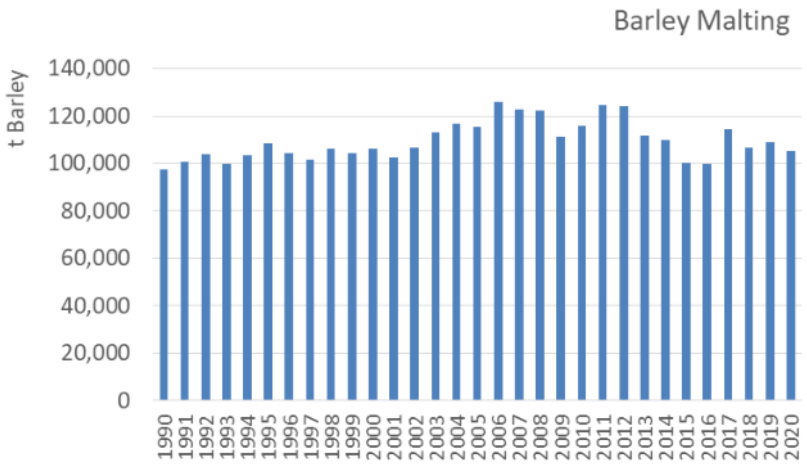


Figure 4-96: Barley Malting

Hop Processing

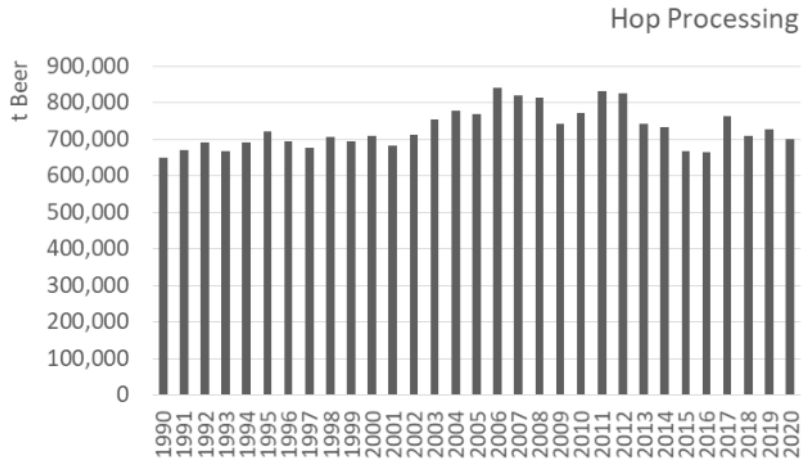


Figure 4-97: Hop Processing

Fermentation, Casking and Maturation

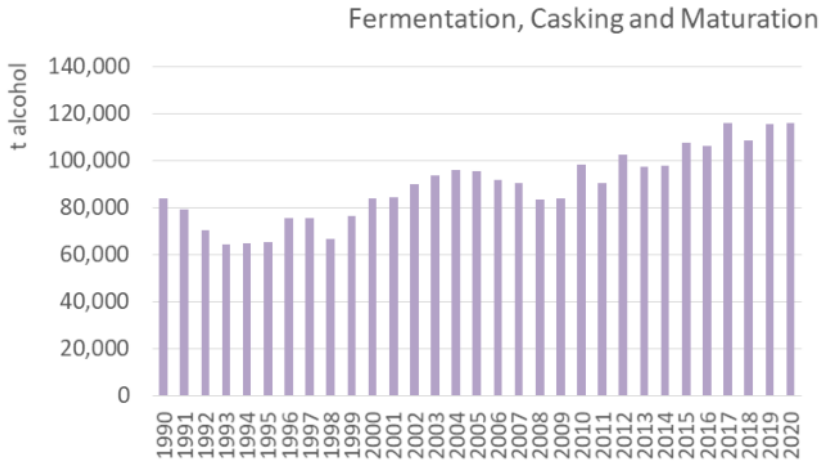


Figure 4-98: Fermentation, Casking and Maturation

Red Wine, White Wine, Beer

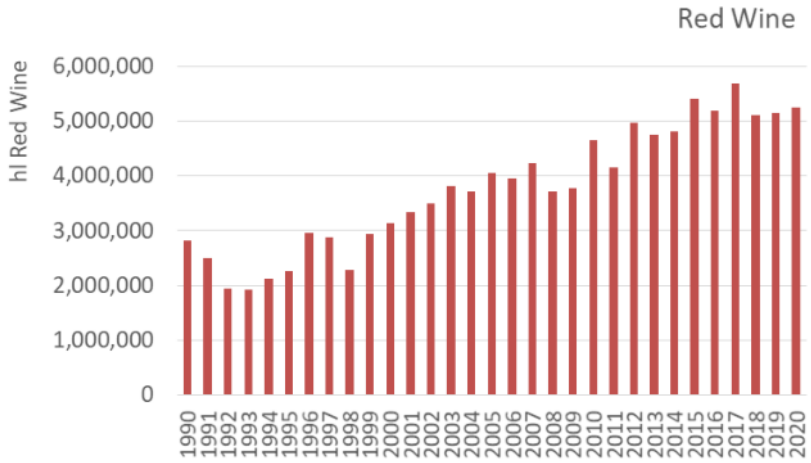


Figure 4-99: Red Wine

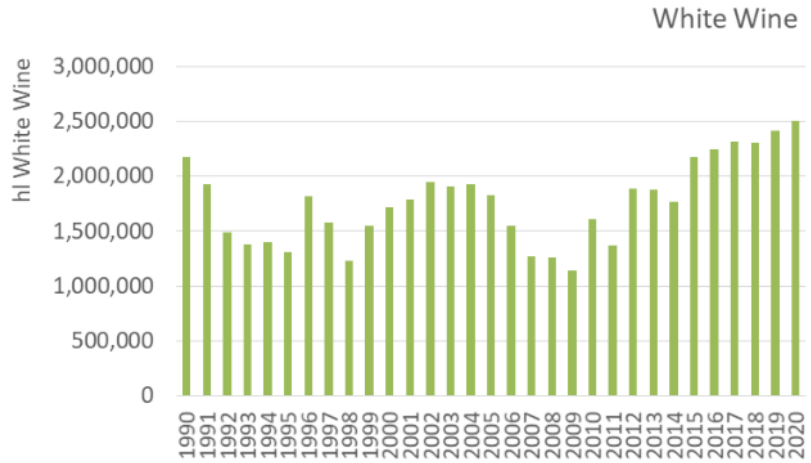


Figure 4-100: White Wine

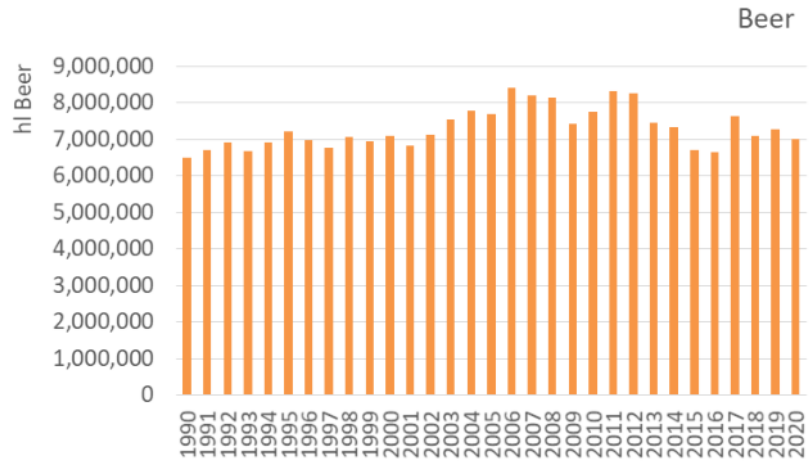


Figure 4-101: Beer

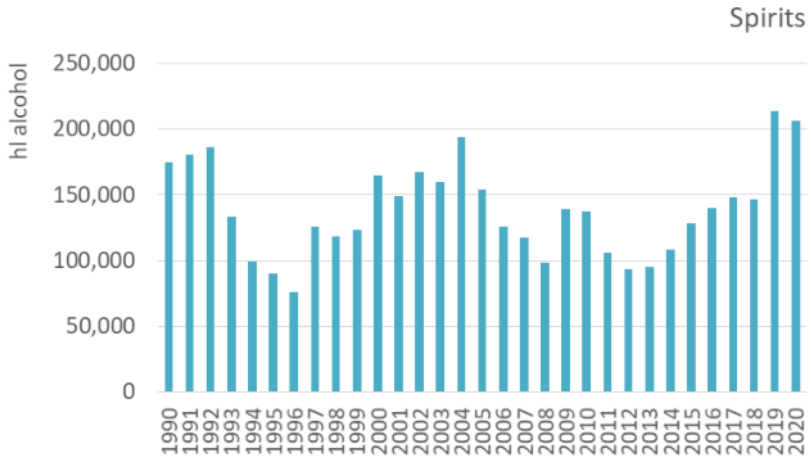


Figure 4-102: Spirits

4.7.4.5 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.

4.7.4.6 Recalculations

No recalculations were made.

4.7.4.7 Further Improvements

No further improvements are planned.

4.7.5 Wood Processing (2.I – SNAP 040620)

4.7.5.1 Category description

This category includes the estimation of emissions of particulate matter generated from the processing of wood. This includes the manufacture of plywood, reconstituted wood products and engineered wood products.

4.7.5.2 Methodology

TSP emissions were estimated according to a Tier 1 methodology through the following equation:

Equation 4-131: Emissions from Wood Processing

$$Emissions = \frac{Wood\ Products_{Production} \times EF_{TSP}}{1000}$$

Where:

Emissions: TSP emissions (t)

Wood $Products_{Production}$: National production of Wood Products (t)

EF_{TSP}: TSP emission factor (kg/t wood product)

4.7.5.3 Emission Factors

TSP emission factor were obtained from chapter "2.I Wood Processing" of "EMEP/EEA air pollutant emission inventory guidebook 2016" and are indicated in the table below.

Table 4-124: Emission Factor for Wood Processing

Parameter	Unit	EF	Source
TSP	kg/t wood	1	Table 3.1 of chapter "2.I Wood processing" of EMEP/EEA guidebook 2016

4.7.5.4 Activity Data

From 1992 onwards, data on processed wood products has been obtained from INE. In the period 1990-1991, data has been estimated based on 1992 processed wood production data and on GDP.

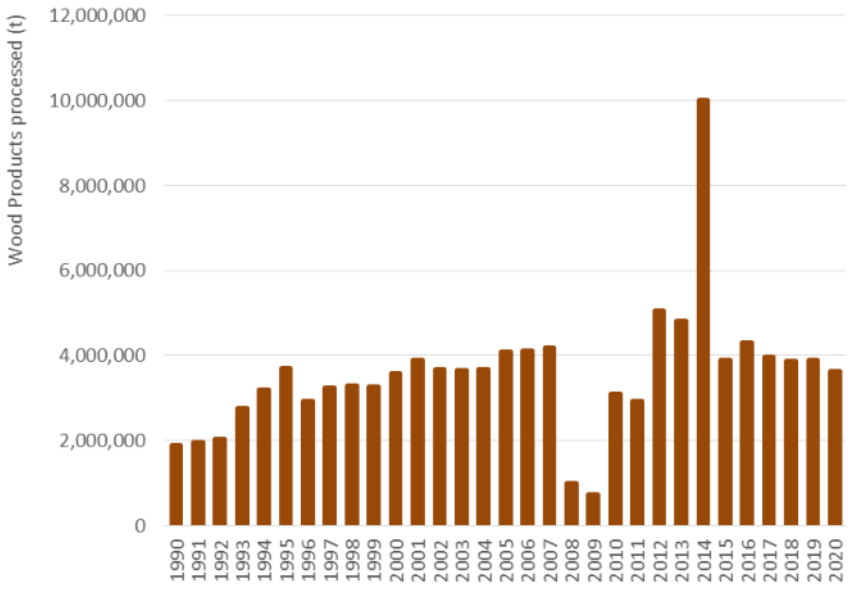


Figure 4-103: Wood Processing (t wood products processed)

4.7.5.5 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.

4.7.5.6 Recalculations

No recalculations were made.

4.7.5.7 Further Improvements

No further improvements are expected.

4.7.6 Consumption of persistent organic pollutants and heavy metals (NFR 2.K – SNAP 060502; 060504; 060507)

4.7.6.1 Category description

The major source of PCBs arises from leaks of dielectric fluid from large electrical transformers and capacitors that are in poor condition. Fragmentising operations are other relevant sources of PCBs.

Mercury (Hg) emissions arise mainly from the use of batteries, measuring and control equipment, electrical equipment and lighting.

4.7.6.2 Methodology

Hg emissions were estimated using a Tier 1 methodology through the following equation:

Equation 4-132: Hg emissions

$$Emi_{Hg} = EF * Population * 10^{-6}$$

Where:

Emi_{Hg}: Emissions of Hg (t)

Population: National population (inhabitants)

EF: Hg emission factor (g/capita)

Regarding PCB´s emissions, prior to the 2019 submission, Tier 1 methodology suggested by the EMEP / EEA guidebook 2016 was also used throughout the time series, as described above. However, in the late 80's, following a EU legislation, a National PCB Decontamination Plan was created in order to oversee the decontamination and phasing out of these fluids and equipment containing them. Therefore, we considered that estimating PCB emissions maintaining such an approach would fail to characterize Portuguese PCB emissions.

Thus, we decided to adopt a hybrid approach that intends to better portray the efforts made for the decontamination and phasing out of the fluids in Portugal, as well as the equipment that contained them.

Our hybrid approach is based on two main assumptions:

1. The Guidebook EMEP / EEA Tier 1 methodology is adequate to portray the emissions occurring in 1990 because at that date few decontamination efforts had been carried out since fluid disposal activities began in 1989;

2. The PCB emissions estimated for category 2K are directly related to the amount of contaminated fluid present in the equipment.

Resuming, we considered 1990's PCB estimated emissions as a reference and, for the remaining time series, PCB emissions were estimated by relating the amount of contaminated fluid existing in a given year to the amount of contaminated fluid that existed in 1990.

For 1990, PCB emissions were estimated using a Tier 1 methodology according to EMEP/EEA air pollutant emission inventory guidebook 2016:

Equation 4-133: PCB emissions in 1990

$$Emi_{PCB\ 1990} = EF\ X\ Population_{1990}\ X\ 10^{-3}$$

Where:

$Emi_{PCB\ 1990}$: Emissions of PCB in year 1990 (kg)

Population: National population in year 1990 (inhabitants)

EF: PCB emission factor (g/capita)

From 1991 onwards, PCB emissions were estimated according to:

Equation 4-134: PCB emissions from 1991 onwards

$$Emi_{PCB\ y} = Emi_{PCB\ 1990} \times (M_y/M_{1990})$$

Where:

$Emi_{PCB\ y}$: Emissions of PCB in year y (kg)

$Emi_{PCB\ 1990}$: Emission of PCB in year 1990 (kg)

M_y: Amount of fluid contaminated with PCB in year y (kg)

M_{1990}: Amount of fluid contaminated with PCB in year 1990 (kg)

4.7.6.3 Emission Factors

The emission factors applied are listed in the table below.

Table 4-125: Emission Factors

Parameter	Unit	EF	Source
Hg	g/capita	0.01	Table 3.1 of chapter "2.K Consumption of persistent organic pollutants and heavy metals" of EMEP/EEA guidebook 2016
PCB	g PCB/ per capita	0.1	Table 3.1 of chapter "2.K Consumption of persistent organic pollutants and heavy metals" of EMEP/EEA guidebook 2016

4.7.6.4 Activity Data

For Hg emissions estimates, national population data was obtained from INE.

For PCB emissions estimates, PCB contaminated fluid were obtained from "PCB National Inventory", obtained from APA. This inventory was created in order to fulfil National PCB Decontamination Plan's requirements.

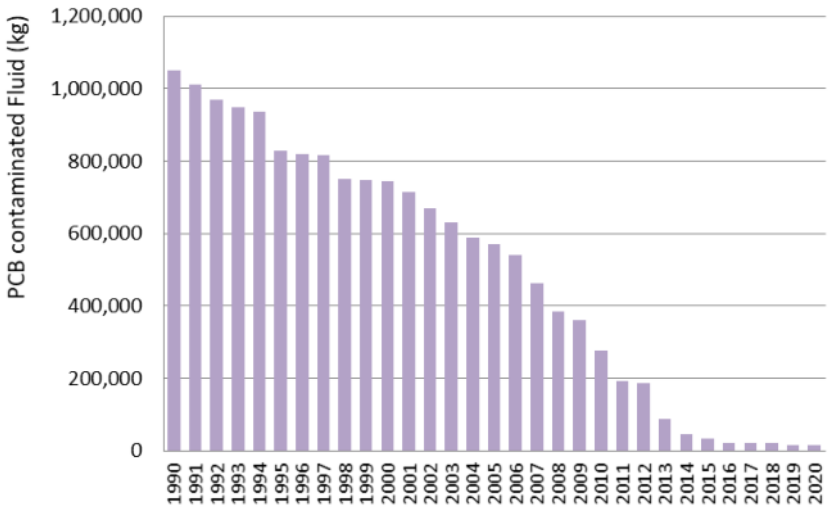


Figure 4-104: PCB contaminated fluid leaks

4.7.6.5 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.

4.7.6.6 Recalculations

No recalculations were made.

4.7.6.7 Further Improvements

No further improvements are planned.

5 Agriculture (NFR Sector 3)

Table of Contents

5 Agriculture (NFR Sector 3) 5-1

5.1 Overview of the sector 5-5

5.2 Manure Management (NFR 3B) 5-9

5.2.1 Methodology 5-9

5.2.2 Activity Data 5-10

5.2.3 Parameters 5-14

5.2.4 Emission Factors 5-21

5.2.5 Uncertainties 5-23

5.2.6 QA/QC and verification 5-23

5.2.7 Recalculations 5-25

5.2.8 Further improvements 5-25

5.3 Crop Production and Agricultural Soils (NFR 3D) 5-25

5.3.1 Synthetic N_fertilizers (NFR 3Da1) 5-26

5.3.2 Animal manure applied to soil (NFR 3Da2a) 5-30

5.3.3 Other organic fertilizers applied to soil (NFR 3Da2b and NFR 3Da2c) 5-31

5.3.4 Urine and dung deposited by grazing animals (NFR 3Da3) 5-33

5.3.5 Cultivated crops and farm level agricultural operations (NFR 3De) 5-33

5.3.6 Use of pesticides (NFR 3Df) 5-34

5.3.7 Uncertainties 5-35

5.3.8 QA/QC and verification 5-35

5.3.9 Recalculations 5-36

5.3.10 Further improvements 5-37

5.4 Field Burning of Agriculture Residues (NFR 3F) 5-37

5.4.1 Methodology 5-38

5.4.2 Activity data 5-38

5.4.3 Emission Factors 5-40
5.4.4 Uncertainties 5-41
5.4.5 QA/QC and verification 5-42
5.4.6 Recalculations 5-42
5.4.7 Further improvements 5-42

List of Figures

Figure 5-1: NH_3 emissions (kt) from agriculture –Trends (Portugal and Mainland) 5-5
Figure 5-2: NH_3 emissions (kt) by source category in 1990 and in 2020 (Portugal and Mainland) 5-6
Figure 5-3: Comparative share (%) of NH_3 emissions by source category in 1990 and in 2020 (Portugal and Mainland) 5-7
Figure 5-4: Contribution (%) of agricultural emissions of air pollutants other than NH_3, in total national emissions 5-8
Figure 5-5: Evolution pattern growth for sheep (a) and goats (b) 5-12
Figure 5-6: Lambs and Kids: average carcass weight at slaughtering 5-12
Figure 5-7: Livestock numbers: comparison between National Statistics and FAO database 5-24
Figure 5-8: Manure management emission estimates. Differences between 2021 and 2022 submissions 5-25
Figure 5-9: Climate regions presentation 5-27
Figure 5-10: Alkaline, Neutral and Acid soils representation at Portugal mainland 5-28
Figure 5-11: Application of sewage sludge (t $dm.yr^{-1}$) and quantities of N (t N) applied in agriculture soils .. 5-32
Figure 5-12: Data bases comparison of inorganic N fertilizers (t $N.yr^{-1}$) 5-35
Figure 5-13: Crop production and agricultural soils NH_3 emissions. Differences between submissions (2021 and 2022) 5-36
Figure 5-14: Rice cultivation areas (ha) in Portugal 5-39
Figure 5-15: Annual biomass burnt (t dm /yr) for the time series 5-40
Figure 5-16: Amount of biomass burnt (kt dm). Differences between 2021 and 2022 submissions 5-42

List of Tables

Table 5-1: Total Main Pollutants and PM2.5 emissions from Agriculture sector 5-8
Table 5-2: Emissions from Manure Management (3B), kt 5-9
Table 5-3: Methods, Activity Data, Parameters and Emission factors used by pollutant (NFR 3B) 5-10
Table 5-4: Livestock population (thousands) 5-13
Table 5-5: Nitrogen excretion rates (Nex) of dairy cows in the time series 5-14

Table 5-6: Nitrogen excretion rates (Nex) of non-dairy cattle in the time series 5-15

Table 5-7: Nitrogen excretion rates (Nex) of all livestock other than cattle 5-16

Table 5-8: Share (%) of each Manure Management System per animal type in 1990 and 2020 5-18

Table 5-9: Proportion of N excreted on building, yard and grazing (%) 5-19

Table 5-10: Proportion of housed livestock managed on liquid/slurry and solid manure systems (%) 5-19

Table 5-11: Average amount of straw used in animal bedding-solid manure management systems and N content of straw 5-20

Table 5-12: Cattle specific parameters 5-20

Table 5-13: All animal categories other than cattle, specific parameters 5-21

Table 5-14: Emission factors used for calculation of the NH_3-N emissions from manure management. EF as proportion of TAN (volatilization rates) 5-22

Table 5-15: Emission factors to calculate the NO-N emissions from manure management. EF as proportion of TAN 5-22

Table 5-16: NMVOC emission factors for cattle (kg NMVOC.MJ feed intake^{-1}) 5-23

Table 5-17: NMVOC emission factors for all other animal categories other than cattle (kg NMVOC.kg VS excreted^{-1}) 5-23

Table 5-18: Emissions from Crop Production and Agricultural Soils (NFR 3D), kt 5-26

Table 5-19: Pollutant emitted by sub sources of category 3D 5-26

Table 5-20: Proportion (%) of the agricultural land in each emission region 5-28

Table 5-21: Nitrogen amount (kt.yr^{-1}) by type of fertilizer and emission region in 2020 5-29

Table 5-22: Nitrogen amount (kt.yr^{-1}) by type of fertilizer 5-30

Table 5-23: NH_3 emission factors (kg NH_3 . kg N applied^{-1}) 5-30

Table 5-24: Crop area (ha) 5-33

Table 5-25: NMVOC, PM2.5, PM10 and TSP emission factors (kg.ha-1) 5-34

Table 5-26: Quantities sold (kg a.s^{-1}) - Clopyralid and Chlorothalonil 5-34

Table 5-27: Impurity factors (mg.kg^{-1}) - Clopyralid and Chlorothalonil 5-35

Table 5-28: Emission estimates from Field Burning of agriculture residues (3F), kt 5-37

Table 5-29: Pollutant emission estimates from field burning of agricultural crop residues 5-38

Table 5-30: Activity data and parameters used to estimate emissions from field burning of crop residues, 2020 5-39

Table 5-31: Emission factors for field burning agriculture residues, by pollutant and crop (Kg.kg dm burnt-^{1}). Main pollutant and CO 5-40

Table 5-32: Emission factors for field burning agriculture residues, by pollutant and crop (Kg.kg dm burnt^{-1}). Particulate Matter 5-41

Table 5-33: Emission factors for field burning agriculture residues, by pollutant and crop - POPs 5-41

Table 5-34: Emission factors for field burning agriculture residues, by pollutant and crop (mKg.kg dm burnt^{-1}). Heavy metals 5-41

List of Equations

Equation 5-1: Annual Consumption of inorganic N fertilizers 5-29

Equation 5-2: NH_3 emissions from sewage sludge applied to soils 5-31

Equation 5-3: NH_3 emissions from MSW compost applied to soils 5-32

Equation 5-4: Emissions from cultivated crops 5-33

Equation 5-5: HCB Emissions from pesticides 5-34

Equation 5-6: Estimation of GHG emissions from field burning of crop residues 5-38

5 Agriculture (NFR Sector 3)

Tiago Seabra

Updated: March 2022

5.1 Overview of the sector

Agriculture activities generate the largest part of NH_3 national emissions. In 2020, NH_3 emissions from the agriculture sector were 52.73 kt, corresponding to 82.3% of the national[1] NH_3 emissions. From 1990 to 2020, NH_3 agriculture emissions decreased 9.49%. From 2005 to 2020 there is an increase of 6.07% in agriculture NH_3 emissions. The complete time series trend is shown in figure below.

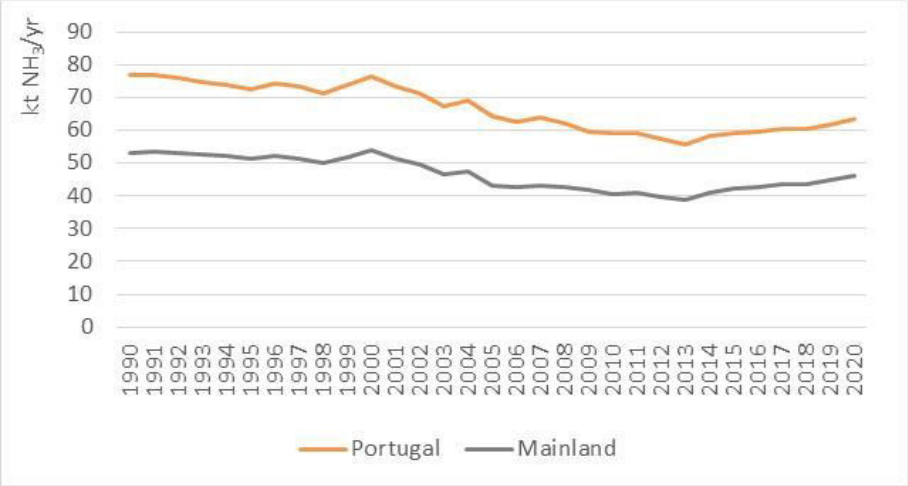


Figure 5-1: NH_3 emissions (kt) from agriculture –Trends (Portugal and Mainland)

Overall, NH_3 emissions from agriculture presented reductions between 1990 and 2020 in almost all source categories with the exception of 3B4g (Poultry). The next figure shows the ammonia emissions in the years 1990 and 2020 by category of emission source.

[1] See Preface of this Informative Inventory Report..

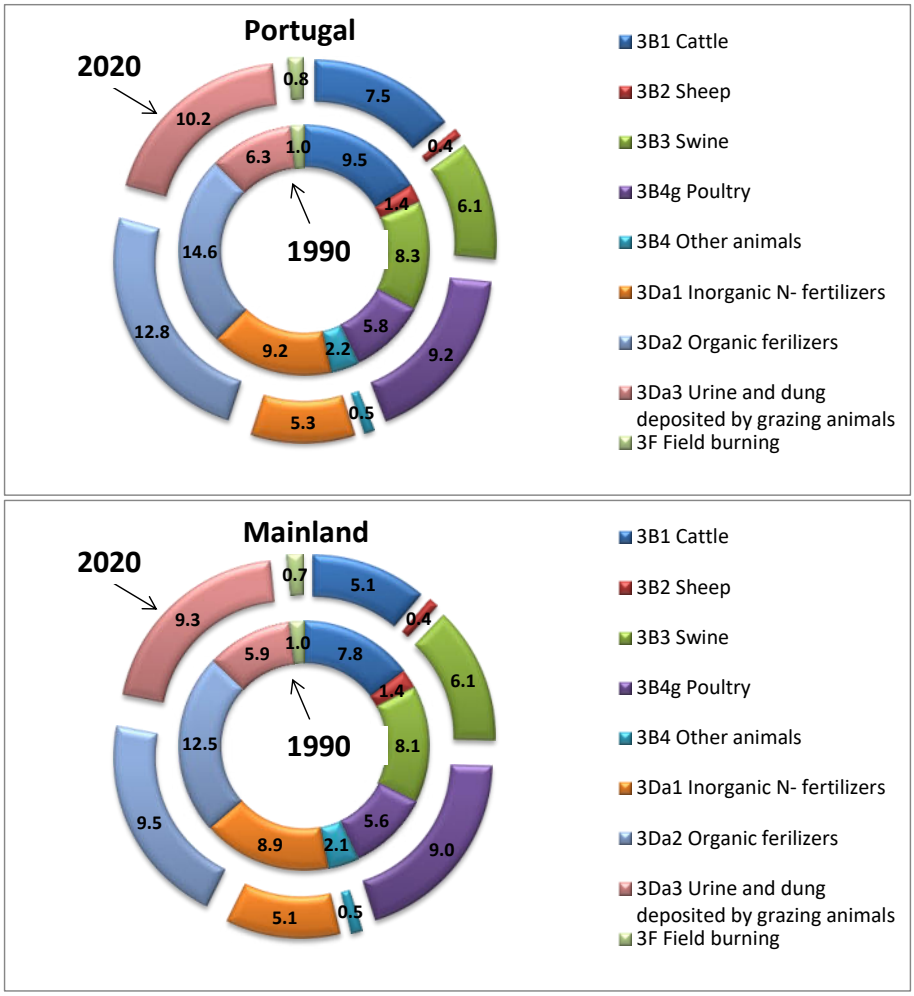


Figure 5-2: NH_3 emissions (kt) by source category in 1990 and in 2020 (Portugal and Mainland)

The most significant reductions are linked to a decrease in the number of animals in 3B1 (cattle) and 3B2 (sheeps and goats). The reduction in cattle is related mainly with dairy cows and changes to the milk quota scheme under the Common Agricultural Policy (CAP). Extensive production systems have been supported in the context of CAP through measures, either in the 1st or in the 2nd pillar, which promote the maintenance or improvement of permanent pastures that are directly grazed by cattle (other than dairy cows), sheep or goats. The result is a greater percentage of animals in pasture and consequently more NH_3 emissions from urine and dung deposited in pasture and less from managed manure and applied to the soil.

The only increase in NH_3 emissions is related to a relevant increase in the number of animals in 3B4g (Poultry).

The relative importance of each Source (NFR codes) of NH_3 emissions from agriculture, in 1990 and 2020, is presented in figure below.

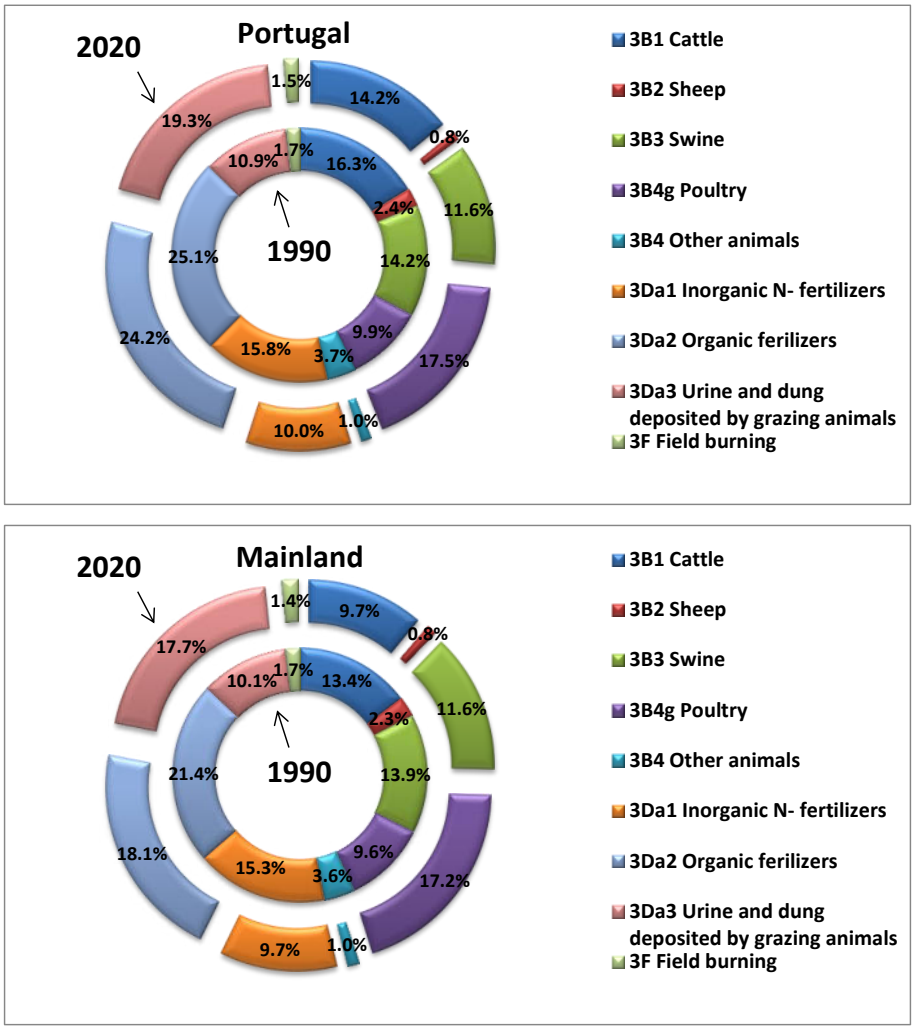


Figure 5-3: Comparative share (%) of NH_3 emissions by source category in 1990 and in 2020 (Portugal and Mainland)

Besides NH_3 emissions, the Portuguese Inventory includes also other pollutant emissions estimates related with agricultural activity that are summarized as follow:

- From Manure Management (3B): NOx[2], NMVOC, $PM_{2.5}$, PM_{10}, TSP;
- From Crop Production and Agricultural Soils (3D): NOx, NMVOC, $PM_{2.5}$, PM_{10}, TSP;
- From Field Burning of Agricultural Residues (3F): NOx, NMVOC, SOx[3], $PM_{2.5}$, PM_{10}, TSP,BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCDD/F and PAHs;
- From Use of Pesticides (3D.f): HCB.

The contribution of agriculture emissions of NO_X, SO_X, NMVOC, $PM_{2.5}$, PM_{10} and TSP in total national emissions of these pollutants is represented in the next Figure for the year 2020.

[2] Reported as NO_2
[3] Reported as SO_2

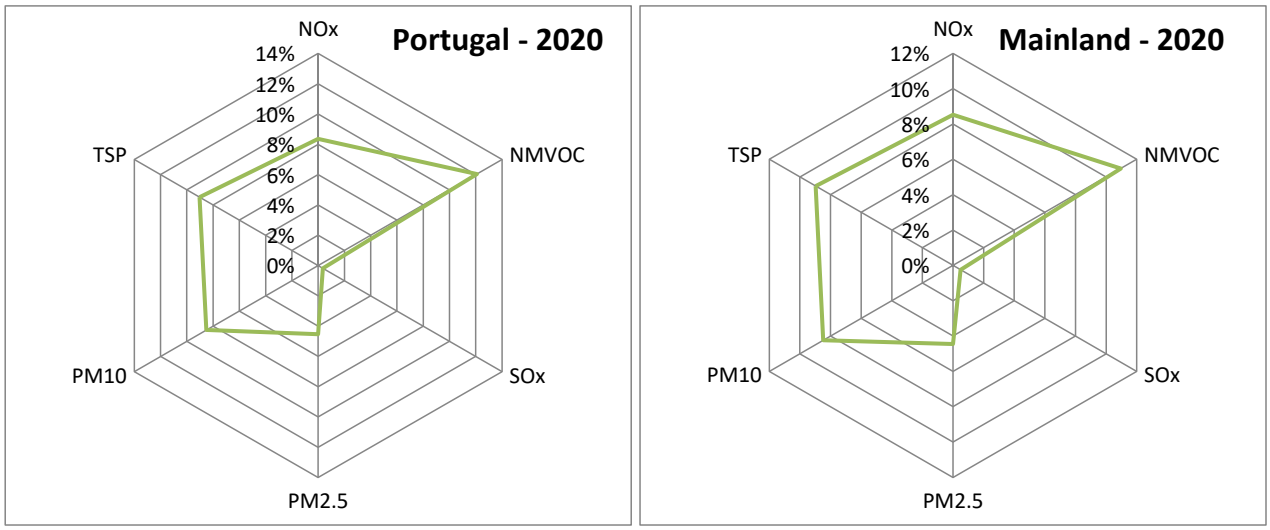


Figure 5-4: Contribution (%) of agricultural emissions of air pollutants other than NH_3, in total national emissions

In the case of Portugal, the European and international obligations differ in terms of the geographical scope[4]. While for the NEC Directive and for the Gothenburg Protocol the report exclude the emissions of Azores and Madeira Islands, the LRTAP Convention covers the whole national territory. In the table below are presented the total emissions estimates of main pollutants and $PM_{2.5}$ reported under the framework of the LRTAP Convention (Portugal) and under the framework of the NEC Directive and the Gothenburg Protocol (Mainland).

Table 5-1: Total Main Pollutants and PM2.5 emissions from Agriculture sector

Pollutant	1990	2005	2018	2019	2020	Δ 2020-2019	Δ 2020-2005	Δ 2020-1990	% of total emissions from PT in 2020
	Kt					%			
NO_X									
Portugal	12.85	10.40	10.81	11.18	11.29	0.98%	8.57%	-12.16%	8.36%
Mainland	12.11	9.56	9.90	10.24	10.37	1.27%	8.44%	-14.39%	8.52%
NMVOC									
Portugal	21.72	16.84	17.46	18.58	19.30	3.87%	14.63%	-11.12%	12.09%
Mainland	19.73	14.51	15.04	16.07	16.69	3.89%	15.06%	-15.39%	10.95%
SO_X									
Portugal	0.19	0.13	0.14	0.14	0.14	-1.64%	5.78%	-24.11%	0.37%
Mainland	0.18	0.13	0.14	0.14	0.14	-1.65%	4.10%	-25.69%	0.50%
NH_3									
Portugal	58.26	49.71	50.42	51.48	52.73	2.43%	6.07%	-9.49%	83.33%
Mainland	53.27	43.17	43.72	44.69	45.96	2.84%	6.45%	-13.73%	81.48%
$PM_{2.5}$									
Portugal	2.74	1.85	2.10	2.16	2.14	-0.90%	15.44%	-21.82%	4.53%
Mainland	2.68	1.79	2.02	2.07	2.05	-0.88%	14.50%	-23.24%	4.45%

The percentages, by NFR code, of the national emissions that correspond to mainland territory are presented in the table D-5 of ANNEX D: Agriculture for the time series.

[4] See Preface of this Informative Inventory Report

Recalculations

The major changes between last year submission and this year submission result from the following actions:

- the revision of National Statistics on livestock numbers from 2017 onwards (NFR 3B);
- the update of Daily volatile solids excreted (VS), following methodological development plan (NFR 3B);
- Update in "Other NP & NPK" fertilizers consumption National Statistics time series for the period 2003-2008 (NFR 3D);
- Update in "Other N" fertilizers consumption National Statistics time series for the period 2011-2013, years 2016 and 2019 (NFR 3D);
- Update in Calcium Ammonium Nitrate (CAN) fertilizers methodology; Since there is no reliable data for the period 2008-2014, we start using the average of the period 2015-2019; For the other periods we used National Statistics (NFR 3D);
- Update in Ammonium Nitrate National Statistics in 2019 (NFR 3D);
- Update in Ammonium Sulphate National Statistics in 2018-2019 period (NFR 3D);
- Update in N content of sludge applied to soils from 2018 onwards (NFR 3D);
- National statistics updates on Biomass Burnt from 2016 onwards (NFR 3F).

5.2 Manure Management (NFR 3B)

5.2.1 Methodology

For all 3B sub source categories, were estimated emissions for pollutants recommended in *EMEP/EEA air pollutant emission inventory guidebook 2019* (EMEP/EEA, Guidebook 2019): NH_3, NOx[5], NMVOC and $PM_{2.5}$.

Table 5-2: Emissions from Manure Management (3B), kt

Pollutant	1990	2005	2018	2019	2020	Δ 2020-2019	Δ 2020-2005	Δ 2020-1990	% of Agriculture emissions from PT in 2020
	Kt					%			
NO_X									
Portugal	0.74	0.59	0.62	0.68	0.72	6.26%	21.82%	-2.24%	6.41%
Mainland	0.69	0.54	0.57	0.63	0.67	6.54%	24.98%	-2.59%	6.48%
NMVOC									
Portugal	12.66	9.83	10.26	11.03	11.57	4.94%	17.79%	-8.59%	59.97%
Mainland	11.45	8.43	8.94	9.71	10.23	5.35%	21.31%	-10.69%	61.28%
SO_X									
Portugal	0.00	0.00	0.00	0.00	0.00	0.00%	0.00%	0.00%	0.00%
Mainland	0.00	0.00	0.00	0.00	0.00	0.00%	0.00%	0.00%	0.00%
NH_3									
Portugal	27.11	21.77	21.74	22.92	23.75	3.62%	9.11%	-12.39%	45.05%
Mainland	24.98	18.91	19.16	20.34	21.23	4.37%	12.26%	-15.02%	46.19%
$PM_{2.5}$									
Portugal	0.38	0.27	0.31	0.36	0.39	8.65%	42.43%	2.60%	18.04%
Mainland	0.34	0.24	0.28	0.33	0.36	9.31%	49.62%	3.70%	17.42%

[5] Reported as NO_2

Methodologies, activity data, parameters and emission factors used for the calculation of each pollutant emissions are summarized in the table below.

Table 5-3: Methods, Activity Data, Parameters and Emission factors used by pollutant (NFR 3B)

Pollutant	Method	Activity data	Parameters	Emission factor
NH_3	Tier 2	NS	CS ; D	D
NOx	Tier 2	NS	CS ; D	D
NMVOC	Tier 2	NS	CS ; D	D
$PM_{2.5}$	Tier 1	NS	-	D
PM_{10}	Tier 1	NS	-	D
TSP	Tier 1	NS	-	D
NS- National Statistics; CS – Country specific; D – Default tier 1 or tier 2 from the Guidebook				

For NH_3 and NO_X emissions estimates, Portugal used the Tier 2 mass flow approach described in the EMEP/EEA Guidebook 2019, chapter 3B – Manure management[6]. From the N-flow calculation process were obtained NH_3 emission estimates from manure management systems which occur from livestock housing, yards, storage, on field application and grazing. In the same process are also calculated NO_X emissions from manure storage and the net amount of Nitrogen returned to soil from manure (after N losses from emissions during building, yard, storage, manure application and from leaching of solid manure storage) which is used in the calculations of NO_X emissions in chapter 3D – Crop production and agricultural soils. The same calculations were done for the net return of N during grazing which is also used to estimate NO_X emissions in chapter 3D.

Emission estimates are done separately for each animal category (NFR 3B1a, 3B1b, 3B2, 3B4d, 3B4e, 3B4f, 3B4h, 3B4gi, 3B4gii, 3B4giii and 3B4giv).

For NMVOC emission estimates were used the calculation algorithms (cattle and all other animals) recommended by the EMEP/EEA Guidebook 2019 (pg.28 to 30), which covers different sources of emissions from: silage store and feed, livestock housing, manure storage, manure application to soil and grazing animals.

PM emissions were estimate using a Tier 1 methodology: $Emi_{PM(i)}=EF_{(i)}*N_{(i)}$, where $EF_{(i)}$ is the emission factor for the specific animal category i and $N_{(i)}$ is the number of animals of the category i that are presented within the year. PM emissions are originated mainly from feed.

5.2.2 Activity Data

General census on agriculture[7] and animal husbandry activities are made every 10 years by the National Statistical Institute (INE) in accordance with EU 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[8].

[6] Calculations were done based on the excel spreadsheet provided in the Appendix B of chapter 3B –Manure management of the Guidebook 2013 with the updates of the Guidebook 2016 and Guidebook 2019

[7] In portuguese Recenseamento Geral Agrícola (RGA 1989 and RGA 1999), Recenseamento Agrícola (RA 2009).

[8] Methodology - Agriculture - Eurostat (europa.eu) > Structure of agricultural holdings > *National methodological reports* > FFS National Methodology report 2010 > Portugal

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[9] to 3 years. The complete National Methodological Report of 2013 and 2016[10] FSS is also available to the public at Eurostat website (same link).

Annually livestock numbers[11] 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 2020 for cattle, swine, sheep and goats, disaggregated per region[12], age and sex.

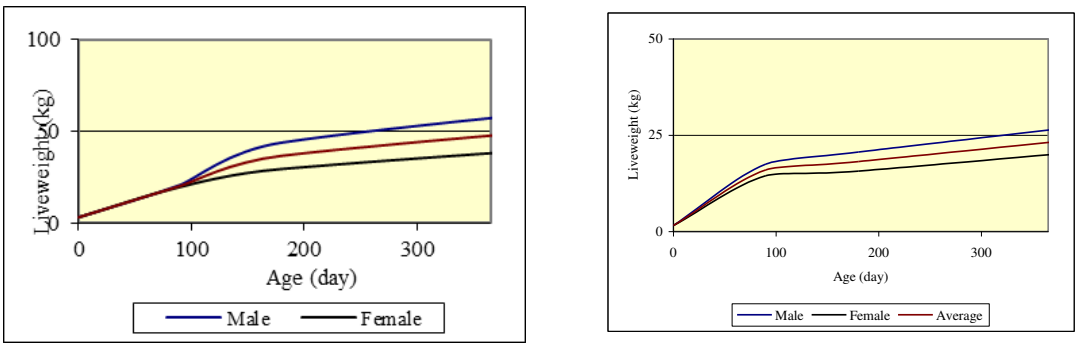
All original figures in statistical database represent the annual average population.

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[13] for both species, Figure 5-5, using the weight at slaughter as published by INE, which values are presented in Figure 5-6. Resultant average ages vary from 107 to 134 days for lambs and 69 to 104 days for kids.

[9] Regulation (EC) nº 1166/2008, on Farm Structure Surveys and the Survey on Agricultural Production methods, repealing Regulation (EEC) nº 571/88.
[10] Methodology - Agriculture - Eurostat (europa.eu) Structure of agricultural holdings > *National methodological reports* > FFS National Methodology report 2013 > Portugal and FFS National Methodology report 2016 >Portugal.
[11] Regulation (EC) nº 1165/2008, concerning livestock and meat statistics and repealing Council Directives 93/23/EEC, 93/24/EEC and 93/25/EEC,
[12] 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.
[13] Set up from the information on existing breeds in Portugal, complemented by information of Jarrige (1988) related with growth patterns.



(a) (b)

Figure 5-5: Evolution pattern growth for sheep (a) and goats (b)

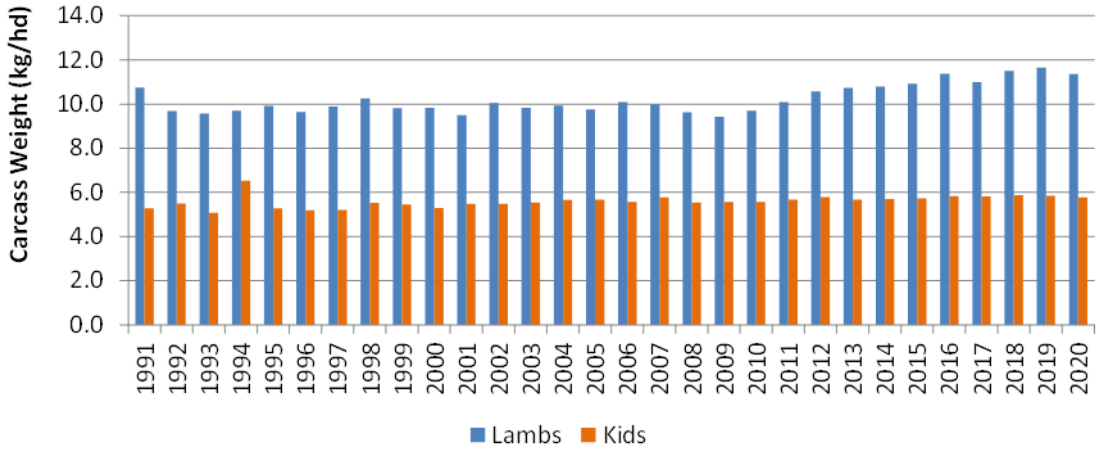


Figure 5-6: Lambs and Kids: average carcass weight at slaughtering

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, poultry and rabbits (reproductive females) is established from the results of the Agricultural Census and the Farm Structure Survey. 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 the next table is presented the annual livestock numbers (1990, 1995, 2000, 2005, 2010, 2015 and the three last years) that are activity data for emission estimates from manure management. In a consistent way same activity data are used to estimate CH_4 emissions and N_2O emissions from: manure management (3B), urine and dung deposited by grazing animals (3Da2) and animal manure applied to soil (3Da3). The complete time series data is included in the table D.1 of ANNEX D: Agriculture.

In a consistent way the same activity data were used for the UNFCCC and UNECE/CLRTAP emission inventory.

Table 5-4: Livestock population (thousands)

Animal class	Sub-class	1990	1995	2000	2005	2010	2015	2018	2019	2020
Dairy cattle	Dairy cows	394	383	353	290	255	235	237	235	233
Non-dairy cattle	Beef calves (<1 yr)	46	60	67	104	114	112	112	109	107
	Calves M.Rep. (<1 yr)	186	162	144	136	123	152	165	172	175
	Calves F Rep. (<1 yr)	177	158	174	183	171	209	224	232	236
	Males 1-2 yrs	112	103	82	81	66	58	75	70	70
	Beef Fem. 1-2 yrs	18	22	17	17	20	15	14	15	16
	Females rep. 1-2 yrs	111	109	127	135	137	148	163	158	157
	Steers (>2 yrs)	38	33	26	25	38	37	53	60	62
	Heifers Beef (>2 yrs)	4	10	6	9	12	15	15	14	12
	Heifers rep. (>2 yrs)	45	52	67	94	110	96	95	98	98
	Non-dairy cows	242	273	345	397	438	461	487	492	497
Swine	Swinelets (<20 kg)	727	726	663	574	597	713	738	771	797
	Fatt. Swines (20-50 kg)	662	660	585	467	448	485	471	469	453
	Fatt. Swines (50-80 kg)	525	525	483	368	360	380	378	381	387
	Fatt. Swines (80-110 kg)	218	198	174	214	244	285	311	312	319
	Fatt. Swines (> 110 kg)	44	44	38	41	36	30	34	34	45
	Boars (>50 kg)	26	26	20	12	7	6	5	5	5
	Sows, pregnant	210	211	195	191	179	162	162	163	163
	Sows, non-pregnant	124	132	124	68	66	71	72	73	72
Sheep	Ewes	2 292	2 339	2 410	2 293	1 915	1 620	1 666	1 648	1 635
	Other Ovine	663	817	734	234	192	237	373	385	412
	Lambs	307	278	319	322	277	194	189	185	180
Goats	Does	614	517	460	380	356	324	285	273	264
	Other Caprine	149	151	129	57	40	39	36	38	38
	kids	47	41	33	26	29	20	18	18	17
Equidae	Horses	33	48	58	52	38	30	30	30	30
	Asses & Mules	118	103	69	40	22	11	13	12	11
Poultry	Hens, reproductive	3 421	3 271	2 644	3 056	3 453	2 920	3 306	3 767	4 109
	Hens eggs	7 539	7 745	9 060	7 349	7 867	6 710	8 038	9 556	10 533
	Broilers	18 524	18 813	24 374	18 686	19 207	19 395	27 398	30 702	32 904
	Turkeys	1 149	945	1 208	798	1 445	785	1 160	1 505	1 735
	Other poultry	1 571	1 551	1 622	1 376	1 522	1 284	2 300	2 823	3 172
Other	Rabbits[1]	475	401	336	289	255	148	128	148	162

[1]Female reproductive

5.2.3 Parameters

5.2.3.1 Nitrogen excretion rates

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[14] (CBPA).

The following sections 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 below.

Table 5-5: 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	7 233	115.5
2010	7 886	117.0
2015	8 287	118.0
2018	8 392	118.2
2019	8 310	118.0
2020	8 561	118.6

The 2020 Nex value of 118.6 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[15] considering an average weight of 600 kg per dairy cow), but is close to those used by other countries.

b) Non - dairy Cattle Nex

The Nex estimates for non-dairy cattle subcategories were calculated using IPCC 2006 equations 10.31, 10.32 and 10.33[16]. The values 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 in the framework of the UNFCCC inventory emissions (chapter 5.2.3 of the Portuguese National Inventory Report (NIR) 1990-2020). The percent crude

[14] 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)
[15] Volume 4, chapter 10, page10.59
[16] Volume 4, chapter 10, pages 10.58 and 10.59

protein in the representative diets were estimated by the expert[17] of the INIAV[18] on Chemical and Nutritive evaluation of Animal Feed, considering the proportion and the data of the different feed constituents of each diet. In the table below are presented the weighted average values of Nex by subcategory of non-dairy cattle, for the time series.

Table 5-6: 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	2018	2019	2020
Beef calves (<1 yr)	85.8	86.9	106.5	115.5	117.0	118.0	118.2	118.0	118.6
Calves M.Rep. (<1 yr)	25.0	25.0	24.8	24.3	23.7	23.4	23.4	23.4	23.4
Calves F Rep. (<1 yr)	25.0	25.0	27.1	32.5	37.8	41.0	41.0	41.0	41.0
Males 1-2 yrs	25.0	25.0	27.1	32.5	37.8	44.8	44.8	44.8	44.8
Beef Fem. 1-2 yrs	40.0	40.0	42.6	49.1	55.5	59.4	59.4	59.4	59.4
Females rep. 1-2 yrs	40.0	40.0	41.7	45.9	50.0	52.5	52.5	52.5	52.5
Steers (>2 yrs)	40.0	40.0	41.8	46.5	51.1	53.9	53.9	53.9	53.9
Heifers Beef (>2 yrs)	41.0	41.0	47.7	64.4	81.1	91.1	91.1	91.1	91.1
Heifers rep. (>2 yrs)	55.0	55.0	55.7	57.6	59.4	60.5	60.5	60.5	60.5
Non-dairy cows	55.0	55.0	55.7	57.6	59.4	60.5	60.5	60.5	60.5

The average Nex, weighted by the 2020 non-dairy cattle population is 55.4 kg. hd^{-1}. $year^{-1}$, which is higher but close of the default value for Western Europe[19] (considering the average weight of 443.4 kg of the non-dairy cattle population in 2020).

c) Nex for all livestock other than cattle

The following table 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[20] 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 be low, when in comparison to IPCC default, but it has similarities to those used by other parties.

[17] Engª Teresa Dentinho-Chemical and Nutritive evaluation of animal feed, 2018.
[18] National Institute for Agriculture and Veterinary Research
[19] Table 10.19 of IPCC 2006, volume 4, chapter 10, page 10.59. Default Nex of the EMEP/EEA Guidebook 2019 are taken from IPCC 2006
[20] Volume 4, chapter 10, page 10.57

Table 5-7: Nitrogen excretion rates (Nex) of all livestock other than cattle

Animal type	Sub category	Nex			
		Country specific (kg N.hd^{-1}.yr^{-1})	IPCC default[21]		
			Typical animal mass (average) (kg)	Kg N (1000 kg animal mass)$^{-1}$.day^{-1}	Kg N hd^{-1}.yr^{-1}
Swine	Swinelets (<20 kg)	0.00	65	0.51	12.10
	Fatt. Swines (20-50 kg)	9.00			
	Fatt. Swines (50-80 kg)	13.00			
	Fatt. Swines (80-110 kg)				
	Fatt. Swines (> 110 kg)				
	Boars (>50 kg)	18.0	205	0.42	31.43
	Sows, pregnant	20.0			
	Sows, non-pregnant	42.0			
Sheep	Ewes	9.17	54	0.85	16.75
	Other Ovine	6.60			
	Lambs	0.00			
Goats	Does	7.00	30	1.28	14.02
	Other Caprine	6.60			
	kids	0.00			
Equidae	Horses	44.0	550	0.26	52.20
	Asses & Mules	22.0	245		23.25
Poultry	Hens, reproductive	0.34	1.8	0.96	0.63
	Hens eggs	0.80			
	Broilers	0.45	0.9	1.10	0.36
	Turkeys	1.40	6.8	0.74	1.84
	Other poultry	0.45	2.7	0.83	0.82
Other	Rabbits[1]	9.00	-	-	8.10
[1]Per female cage					

Values for Swinelets (< 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 2020, is presented in the table D-2 of the ANNEX D: Agriculture.

The proportion of total ammoniacal-N (TAN) used to calculate NH_3 emissions (N-flow method) was obtained from Table 3.9[22] of EMEP/EEA Guidebook 2019 for each animal type excretion.

[21] Default Nex of the EMEP/EEA Guidebook 2019 are taken from table 10.19, Chapter 10 of IPCC 2006
[22] Page 31 of Chapter 3B Manure Management of the EMEP/EEA Guidebook 2019

5.2.3.2 Manure Management Systems

Expert guess[23], 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.

The 2009 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[24] 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 has changed is unknown, a linear evolution between year 1990 and the target year of 2010 was assumed.

Since the results of 2019 Agriculture Census (RA19) have been published during year 2021, the update related to manure management systems in use on the farms will be considered in future submissions. Thus, for 2020 we assume the 2010 distribution.

The values for the fraction of manure handled in each MMS in 1990 and in 2020 are presented in the table below.

[23] Information received from Eng. Carlos Pereira, from the Ministry of Agriculture in 3, March 2005, and in 7, October 2009, following update.
[24] Information treated, discussed and validated on the Working group involving national experts from the relevant national entities (GPP, INIAV, DGAV, DGADR and IFAP) of the Portuguese Agriculture Ministry, September 2017 (Documento nº 1/2017/GT SNIERPA Agricultura). The working group is coordinated by GPP which is the inventory National Focal Point for agriculture sector as explained in chapter 1.2 - Institutional arrangements for inventory preparation..

Table 5-8: Share (%) of each Manure Management System per animal type in 1990 and 2020

Animal Type	1990					2020				
	Lagoon system	Tanks/ Earthen pond	Solid storage	Pasture/ range/ paddock	Total	Lagoon system	Tanks/ Earthen pond	Solid storage	Pasture/ range/ paddock	**Total**
Dairy cows	-	35.0	35.0	30.0	**100.0**	12.0	25.0	24.0	39.0	**100.0**
Non-dairy cows	-	-	-	100.0	**100.0**	-	1.0	6.0	93.0	**100.0**
Other cattle		-		30.0	**100.0**	-		12.0		**100.0**
Ewes		-		80.0	**100.0**	-		9.0		**100.0**
Other ovine	-	-	20.0	80.0	**100.0**	-	-	9.0	91.0	**100.0**
Does	-	-	20.0	80.0	**100.0**	-	-	11.0	89.0	**100.0**
Other caprine	-	-	20.0	80.0	**100.0**	-	-	11.0	89.0	**100.0**
Sows	80.0	15.0	3.0	2.0	**100.0**	85.0	6.0	1.0	8.0	**100.0**
Other swine	80.0	15.0	3.0	2.0	**100.0**	85.0	8.0	2.0	5.0	**100.0**
Hens	-	-	100.0	-	**100.0**	-	-	100.0	-	**100.0**
Broilers	-	-	99.9	0.1	**100.0**	-	-	96.0	4.0	**100.0**
Turkeys	-	-	100.0	-	**100.0**	-	-	99.9	0.1	**100.0**
Other poultry	-	-	100.0	-	**100.0**	-	10.0	90.0	-	**100.0**
Rabbits	-	-	100.0	-	**100.0**	-	-	100.0	-	**100.0**
Equidae	-	-	60.0	40.0	**100.0**	-	-	11.0	89.0	**100.0**

Based on the same information are presented in table 5-9 the proportion of N excreted on building, yard and grazing and in table 5-10 the proportion of housed livestock managed on liquid/slurry and solid manure systems, for 1990 and 2020.

Table 5-9: Proportion of N excreted on building, yard and grazing (%)

Animal type	1990			2020		
	Building	Yard	Grazing	Building	Yard	Grazing
Dairy Cows	52.50	17.50	30.00	45.75	15.25	39.0
Non-dairy cows	0.00	0.00	100.00	6.30	0.70	93.00
Other cattle	63.00	7.00	30.00	12.60	1.40	86.00
Ewes	20.00	0.00	80.00	9.00	0.00	91.00
Other ovine	20.00	0.00	80.00	9.00	0.00	91.00
Does	20.00	0.00	80.00	11.00	0.00	89.00
Other caprine	20.00	0.00	80.00	11.00	0.00	89.00
Sows	98.00	0.00	2.00	92.00	0.00	8.00
Other Swine	98.00	0.00	2.00	95.00	0.00	5.00
Hens	100.00	0.00	0.00	100.00	0.00	0.00
Broilers	99.90	0.00	0.10	96.00	0.00	4.00
Turkeys	100.00	0.00	0.00	99.90	0.00	0.10
Other poultry	100.00	0.00	0.00	100.00	0.00	0.00
Rabbits	100.00	0.00	0.00	100.00	0.00	0.00
Equidae	60.00	0.00	40.00	11.00	0.00	89.00

Table 5-10: Proportion of housed livestock managed on liquid/slurry and solid manure systems (%)

Animal type	1990		2020	
	Liquid/slurry	Solid	Liquid/slurry	Solid
Dairy Cows	50.00	50.00	64.21	35.79
Non-dairy cows	-	-	10.32	89.68
Other cattle	0.00	100.00	10.32	89.68
Ewes	0.00	100.00	0.00	100.00
Other ovine	0.00	100.00	0.00	100.00
Does	0.00	100.00	0.00	100.00
Other caprine	0.00	100.00	0.00	100.00
Sows	96.94	3.06	98.91	1.09
Other Swine	96.94	3.06	97.89	2.11
Hens	0.00	100.00	0.00	100.00
Broilers	0.00	100.00	0.00	100.00
Turkeys	0.00	100.00	0.00	100.00
Other poultry	0.00	100.00	10.00	90.00
Rabbits	0.00	100.00	0.00	100.00
Equidae	0.00	100.00	0.00	100.00

5.2.3.3 Other Parameters

The amounts of straw used and the N inputs from animal bedding were based on the default values of table 3.7[25] of EMEP/EEA Guidebook 2019, and are shown in table below.

[25] Page 25 of Chapter 3B Manure Management

Table 5-11: 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	1461.10	5.84
Other cattle	216.42	0.87
Sheep & goats	30.97	0.12
Sows	564.19	2.26
Other swine	192.03	0.77
Horses & asses	279.80	1.12

Specific parameters related to NMVOC emissions estimates are presented in table 5-12: Cattle and in table 5-13: Other animal categories than cattle.

The values of gross energy (Mj . hd^{-1} . yr^{-1}) for cattle categories and volatile solid excretion for all other animal categories than cattle, are the same as those calculated (Tier 2) and reported in the UNFCCC inventory emissions, sources categories enteric fermentation (CRF 3A) and manure management (CRF 3Ba). Dairy cows in Portugal are predominantly stalled with a feed diet based on maize silage (40%), and hay/straw (10%) as raw feed and compound feed (50%) in a dry matter base. For other cattle it was assumed the same $Frac_{silage}$. For all livestock categories other than cattle the $Frac_{silage}$ was considered as zero.

Table 5-12: Cattle specific parameters

	1990	1995	2000	2005	2010	2015	2018	2019	2020
Dairy cattle									
GE (MJ.hd^{-1}.yr^{-1})	82 918	83 465	96 905	105 142	109 817	112 950	113 915	114 008	115 783
$Frac_{Silage}$	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
$Frac_{Silage_Store}$	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Housed days.yr^{-1}	192	185	179	173	167	167	167	167	167
Non dairy cattle									
GE (MJ.hd^{-1}.yr^{-1})	55 221	56 213	56 388	55 025	54 810	53 151	53 409	53 463	53 509
$Frac_{Silage}$	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
$Frac_{Silage_Store}$	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Housed days.yr^{-1}	77	66	50	40	30	30	30	30	30

Table 5-13: All animal categories other than cattle, specific parameters

	1990	1995	2000	2005	2010	2015	2018	2019	2020
Sows									
VS (kg dm.hd^{-1}.yr^{-1})	230.62	232.95	233.82	211.33	212.77	219.17	219.62	219.56	219.54
Housed days.yr^{-1}	358	352	347	341	336	336	336	336	336
Other swine									
VS (kg dm.hd^{-1}.yr^{-1})	83.47	82.81	82.32	83.70	83.25	80.93	81.18	80.15	80.14
Housed days.yr^{-1}	358	355	352	349	347	347	347	347	347
Sheep									
VS (kg dm.hd^{-1}.yr^{-1})	183.54	186.82	184.21	175.11	174.65	178.98	182.78	183.24	184.14
Housed days.yr^{-1}	73	63	53	43	33	33	33	33	33
Goats									
VS (kg dm.hd^{-1}.yr^{-1})	170.48	168.62	169.66	174.68	174.74	176.33	175.92	175.32	175.00
Housed days.yr^{-1}	73	65	57	48	40	40	40	40	40
Horses									
VS (kg dm.hd^{-1}.yr^{-1})	627.80	627.80	627.80	627.80	627.80	627.80	627.80	627.80	627.80
Housed days.yr^{-1}	219	174	130	85	40	40	40	40	40
Mules & asses									
VS (kg dm.hd^{-1}.yr^{-1})	343.10	343.10	343.10	343.10	343.10	343.10	343.10	343.10	343.10
Housed days.yr^{-1}	219	174	130	85	40	40	40	40	40
Hens									
VS (kg dm.hd^{-1}.yr^{-1})	14.99	14.99	15.02	14.99	14.99	14.99	15.00	15.00	15.00
Housed days.yr^{-1}	365	365	365	365	365	365	365	365	365
Broilers									
VS (kg dm.hd^{-1}.yr^{-1})	6.54	6.54	6.54	6.54	6.54	6.54	6.54	6.54	6.54
Housed days.yr^{-1}	365	361	358	354	350	350	350	350	350
Turkeys									
VS (kg dm.hd^{-1}.yr^{-1})	29.28	29.28	29.28	29.28	29.28	29.28	29.28	29.28	29.28
Housed days.yr^{-1}	365	365	365	365	365	365	365	365	365
Other poultry									
VS (kg dm.hd^{-1}.yr^{-1})	14.76	14.76	14.76	14.76	14.76	14.76	14.76	14.76	14.76
Housed days.yr^{-1}	365	365	365	365	365	365	365	365	365
Rabbits*									
VS (kg dm.hd^{-1}.yr^{-1})	52.79	52.79	52.79	52.79	52.79	52.79	52.79	52.79	52.79
Housed days.yr^{-1}	365	365	365	365	365	365	365	365	365
* per female cage									

Also relevant to the calculation of NMVOC emissions from manure store and manure application, are the estimated NH_3 emissions (tier 2) from livestock housing, manure store and manure application, which are presented, for all animal categories, in the table D-3 of the ANNEX D: Agriculture.

5.2.4 Emission Factors

The emission factors used to estimate **ammonia emissions** from manure management were obtained from table 3.9[26] of EMEP/EEA Guidebook 2019.

Ammonia emissions following manure application and from grazing animals are calculated in this source category but reported in the agricultural soils source category (3D).

[26] Page 31, chapter 3B-Manure management

Table 5-14: Emission factors used for calculation of the NH_3-N emissions from manure management. EF as proportion of TAN (volatilization rates)

Animal type	Manure type	EF housing	EF yard	EF storage	EF application	EF grazing
Dairy cattle	Slurry	0.24	0.30	0.25	0.55	0.14
	Solid	0.08		0.32	0.68	
Other cattle	Slurry	0.24	0.53	0.25	0.55	0.14
	Solid	0.08		0.32	0.68	
Sows	Slurry	0.35	-	0.11	0.29	0.31
	Solid	0.24		0.29	0.45	
Other swine	Slurry	0.27	0.53	0.11	0.40	0.20#
	Solid	0.23		0.29	0.45	
Sheep & Goats	Solid	0.22	0.75	0.32	0.90	0.09
Horses & Asses	Solid	0.22	-	0.35	0.90	0.35
Hens	Slurry	0.41	-	0.14	0.69	-
	Solid	0.20		0.08	0.45	
Broilers	Solid	0.21	-	0.3	0.38	-
Turkeys	Solid	0.35	-	0.24	0.54	-
Other poultry	Solid	0.24 - 0.57	-	0.16 - 0.24	0.45 - 0.54	-
Rabbits*	Solid	0.21	-	0.3	0.38	-
*Not available, assumed the same EFs for broilers; # IPCC 2006 table 11.3						

Emission factors used to estimate **nitric oxide emissions** from manure management were obtained from table 3.10[27] of EMEP/EEA Guidebook 2019.

Table 5-15: Emission factors to calculate the NO-N emissions from manure management. EF as proportion of TAN

EF storage	
Slurry	Solid
0.0001	0.0100

In a consistent way the storage N_2O-N emission factors derivate (kg N/kg TAN) from the ones that were used in the UNFCCC emission inventory. For the same reason the N fraction leached from solid storage of manure also used in the UNFCCC emission inventory was inserted in the N-flow calculations (step 10)[28].

The N_2 storage emissions were also calculated using the emission factors of the same table 3.10 of the EMEP/EEA Guidebook 2019.

Emission factors used to estimate **NMVOC emissions** from this source category were those of the EMEP/EEA Guidebook 2019, table 3.11[29] for cattle and table 3.12[30] for all other animal categories than cattle.

There are no available NMVOC emission factors for manure stored and for manure applications to soil. Emissions from these two sources are estimated as fraction of those from livestock housing, as recommended by the methodology of the EMEP/EEA Guidebook 2019[31]. The fraction is assumed to be the same ratio as for NH_3 emission (equations 52 and 53 for cattle categories; equations 58 and 59 for all livestock categories other than cattle).

NMVOC emissions following manure application and from grazing animals are calculated in this source category but reported in the agricultural soils source category (3D).

[27] Page 32, chapter 3B-Manure management
[28] Page 26, chapter 3B-Manure management of the EMEP/EEA Guidebook 2019
[29] Page 32, chapter 3B-Manure management
[30] Page 33, chapter 3B-Manure management
[31] Pages 28 to 30, chapter 3B-Manure management

Table 5-16: NMVOC emission factors for cattle (kg NMVOC.MJ feed intake^{-1})

Animal type	EF silage feed	EF house	EF grazing
Dairy cattle	0.0002002	0.0000353	0.0000069
Other cattle	0.0002002	0.0000353	0.0000069

Table 5-17: NMVOC emission factors for all other animal categories other than cattle (kg NMVOC.kg VS excreted^{-1})

Animal type	EF silage feed	EF house	EF grazing
Sows	-	0.00170300	-
Other swine	-	0.00704200	-
Sheep & Goats	0.01076000	0.00161400	0.00002349
Horses & Asses	0.01076000	0.00161400	0.00002349
Hens	-	0.00568400	-
Broilers	-	0.00914700	-
Turkeys	-	0.00568400	-
Other poultry	-	0.00568400	-
Rabbits	-	0.00161400	-

Emission factors used to estimate **particulate emissions** from animal husbandry were the default Tier 1 values from table 3.5[32] of EMEP/EEA Guidebook 2019.

5.2.5 Uncertainties

To be provided in the future.

5.2.6 QA/QC and verification

For this source category QA/QC procedures were focused in the livestock data obtained from INE. Two quality assessments of 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 1990-2019 (2020 not available) and the results are presented in the Figure 5-7 for cattle, swine and sheep.

[32] Page 19 , chapter 3B-Manure management

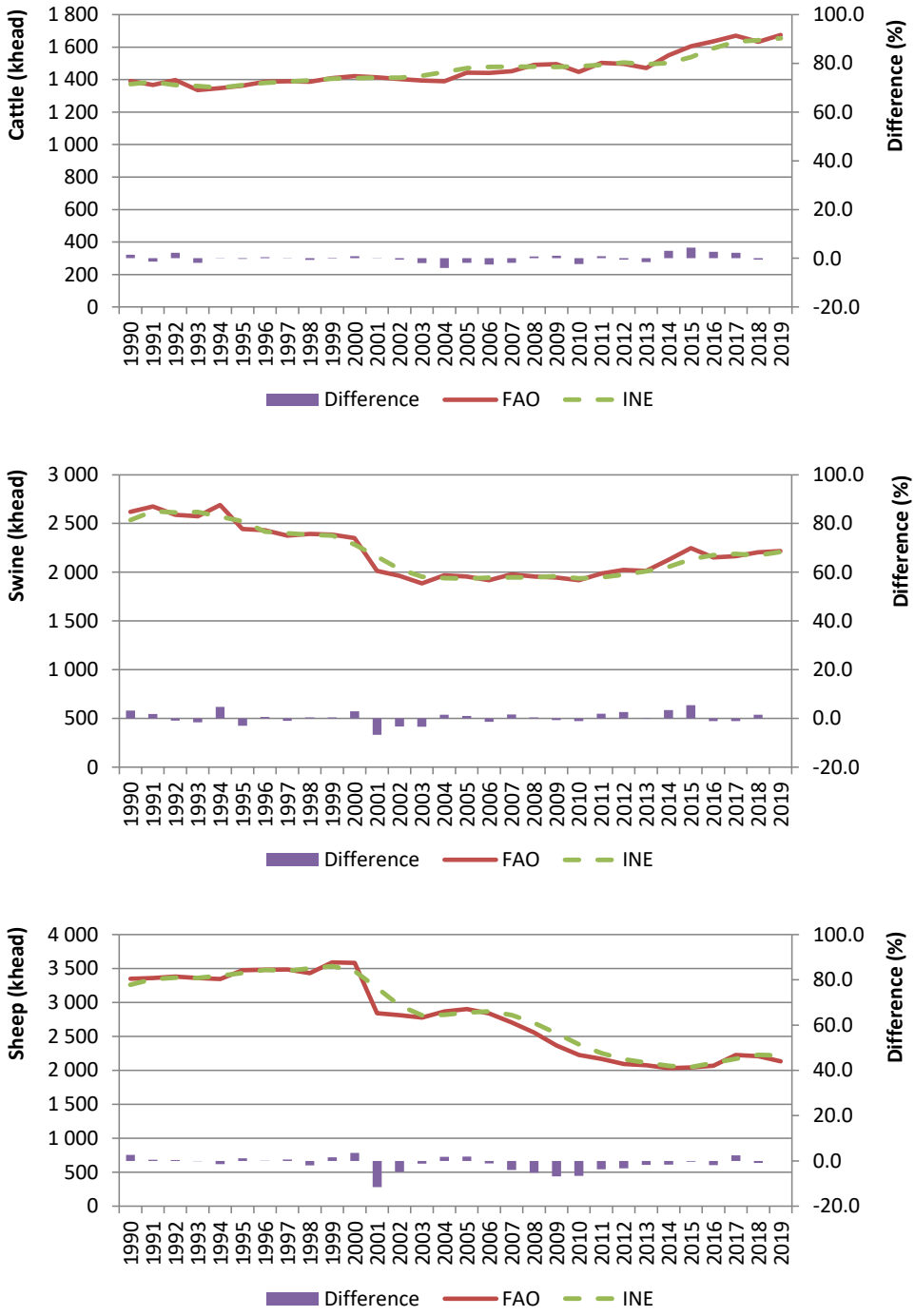


Figure 5-7: Livestock numbers: comparison between National Statistics and FAO database

FAO and INE livestock numbers have a good adhesion for all species.

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 Recalculations

Differences between 2021 and 2022 submissions are mainly due to:

- the revision of National Statistics on livestock numbers from 2017 onwards;
- the update of Daily volatile solids excreted (VS), following methodological development plan.

Other minor corrections were done as a result of internal QA/QC procedures which had no significant impact.

The differences on NH_3 emissions estimates between last year submission and this year submission are represented in the next figure.

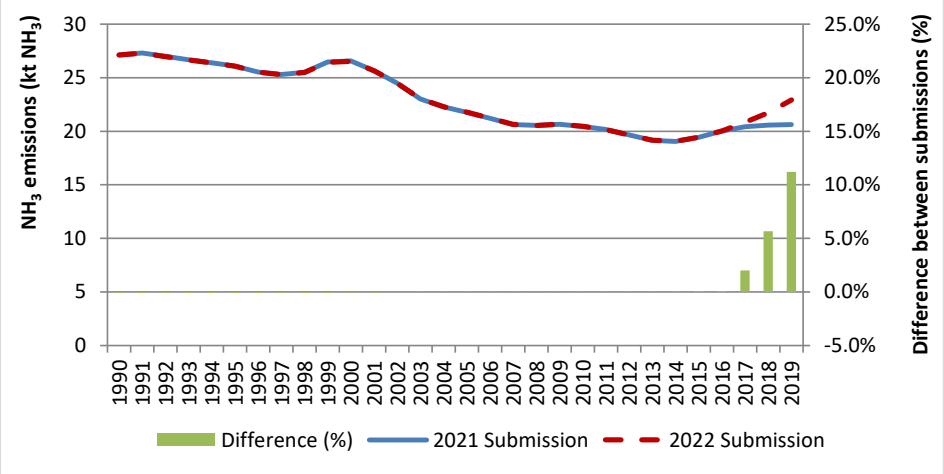


Figure 5-8: Manure management emission estimates. Differences between 2021 and 2022 submissions

5.2.8 Further improvements

It is planned to continue the improvement of the characterization of the manure management systems framed by the new national law[33] related with livestock farming. Further efforts will be done to obtain more detailed information exploring new sources of information.

5.3 Crop Production and Agricultural Soils (NFR 3D)

For the source category 3D, the Portuguese inventory includes emission estimates of the pollutants recommended in EMEP/EEA, Guidebook 2019: NH_3, NOx[34], NMVOC and $PM_{2.5}$.

[33] Decree-Law nº 81/2013
[34] Reported as NO_2

Table 5-18: Emissions from Crop Production and Agricultural Soils (NFR 3D), kt

Pollutant	1990	2005	2018	2019	2020	Δ 2020-2019	Δ 2020-2005	Δ 2020-1990	% of Agriculture emissions from PT in 2020
	Kt					%			
NO_x									
Portugal	10.93	8.98	9.29	9.58	9.67	0.91%	7.64%	-11.55%	85.65%
Mainland	10.26	8.22	8.45	8.73	8.83	1.24%	7.46%	-13.90%	85.17%
NMVOC									
Portugal	6.04	4.78	4.69	5.00	5.23	4.55%	9.36%	-13.37%	27.10%
Mainland	5.30	3.89	3.66	3.90	4.05	4.01%	4.20%	-23.53%	24.27%
NH_3									
Portugal	30.13	27.26	27.91	27.77	28.21	1.61%	3.49%	-6.38%	53.50%
Mainland	27.29	23.59	23.81	23.59	23.99	1.71%	1.69%	-12.09%	52.20%
$PM_{2.5}$									
Portugal	0.06	0.04	0.02	0.02	0.02	-0.67%	-48.17%	-70.64%	0.86%
Mainland	0.06	0.03	0.02	0.02	0.02	-0.67%	-48.03%	-70.65%	0.87%

Table 5-19: Pollutant emitted by sub sources of category 3D

NFR code	Source	Pollutant emissions
3Da1	Synthetic N_fertilizers	NH_3; NOx
3Da2a	Animal manure applied to soil	NH_3; NOx; NMVOC
3Da2b	Other organic fertilizer applied to soil	NH_3; NOx
3Da3	Urine and dung deposited by grazing animals	NH_3; NMVOC
3De	Cultivated crops	NMVOC
3Dc	Farm level agricultural operations	$PM_{2.5}$;PM_{10};TSP

Detailed information about methods, activity data and emission factors used are given in each sub source category chapter.

5.3.1 Synthetic N_fertilizers (NFR 3Da1)

5.3.1.1 Methodology

The **ammonia emissions** estimates from synthetic N_fertilizers are based on the tier 2 methodology of the EMEP/EEA Guidebook 2019, which provides different emission factors by type of fertilizer and emission region (table 3.2 of chapter 3D – Crop production and agricultural soils), considering the soil pH and the climate zone as defined in table 10.14[35] of IPCC 2006.

[35] Volume 4, chapter 10, page 10.38

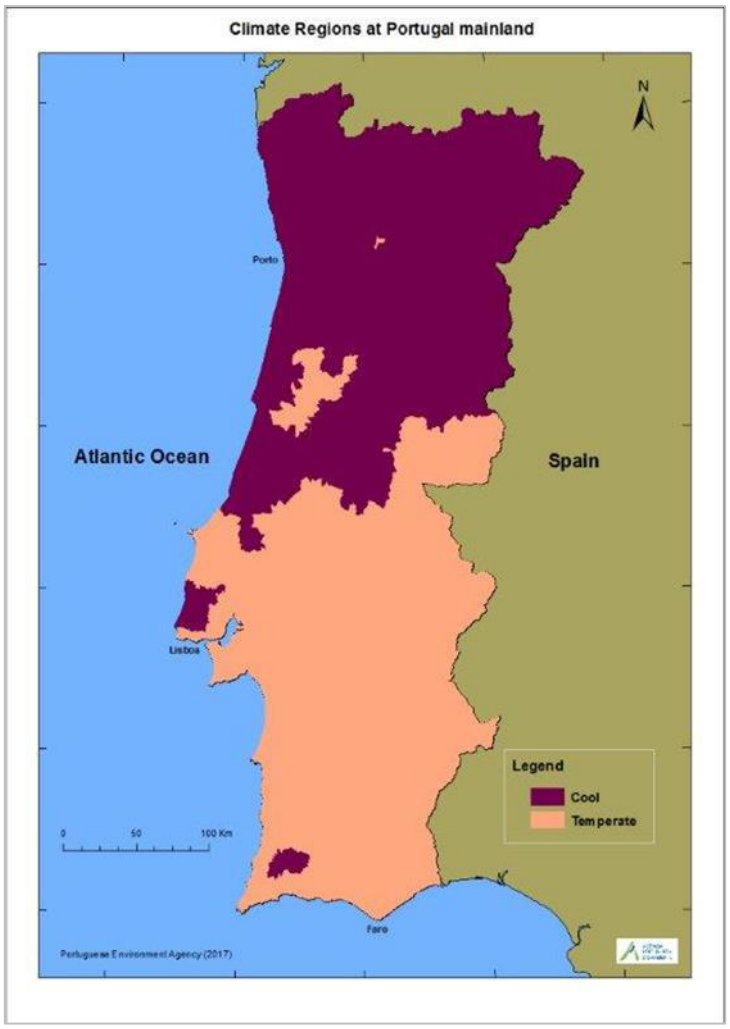


Figure 5-9: Climate regions presentation

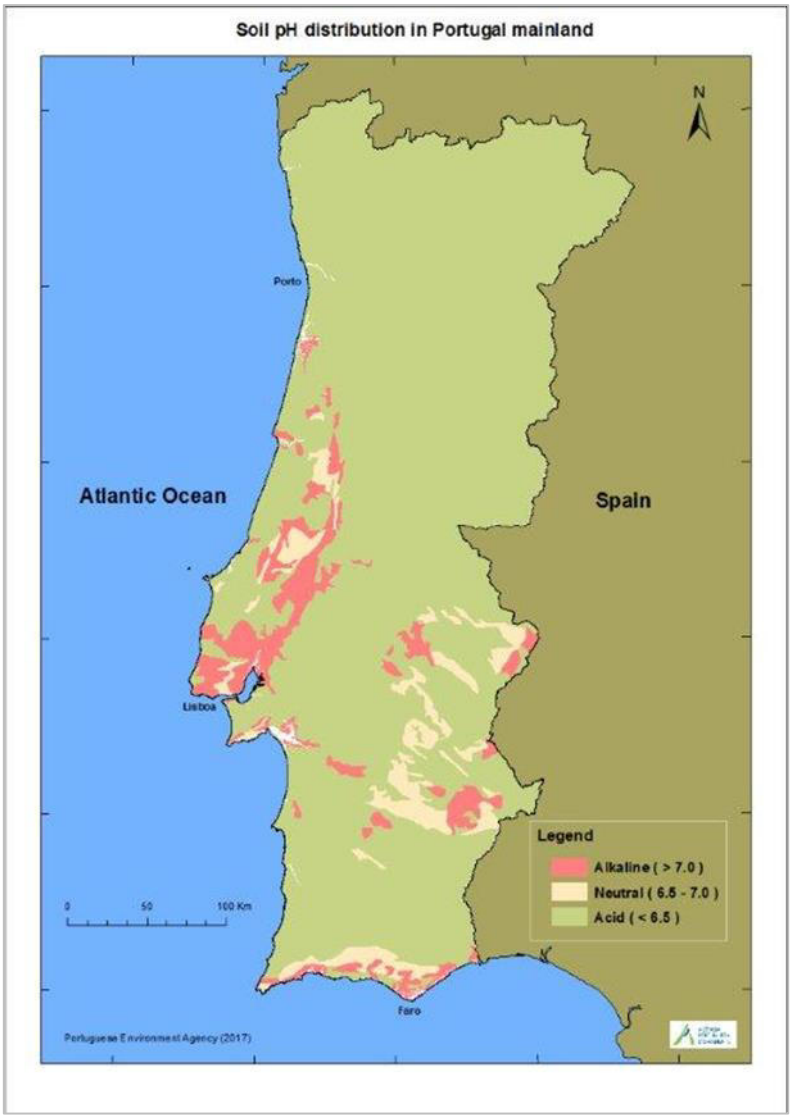


Figure 5-10: Alkaline, Neutral and Acid soils representation at Portugal mainland

The proportion of the agricultural land in the different emissions regions that result from the combination of the areas within each climate zone (cool and temperate) in which the soil pH is above (high) or below[36] 7.0 (normal) is presented in the next table.

Table 5-20: Proportion (%) of the agricultural land in each emission region

Emission regions Description	Code	Agricultural land (%)
Normal Cool	NC	37.73
Normal temperate	NT	31.28
High Cool	HC	3.31
High Temperate	HT	27.68

The amount of each N fertilizer type applied in each emission region was estimate through the equation (3)[37], of tier 2 methodology of the EMEP/EEA Guidebook 2019, chapter 3D – Crop production and agricultural soils. In table below are presented the calculation results for the year 2020.

[36] Below or equal 7.0. Includes Neutral and Acid soils
[37] Page 14, chapter 3D Crop production and agricultural soils

Table 5-21: Nitrogen amount (kt.yr^{-1}) by type of fertilizer and emission region in 2020

Type of fertilizer	Emission regions			
	NC	NT	HC	HT
Ammonium nitrate (AN)	0.15	0.10	0.01	0.10
Ammonium phosphate (MAP & DAP)	0.74	0.50	0.04	0.52
Ammonium sulfate (AS)	0.23	0.16	0.01	0.16
Calcium ammonia nitrate (CAN)	8.90	6.02	0.45	6.20
Urea	6.26	4.24	0.32	4.36
Other NP & NPK	11.50	7.78	0.59	8.01
Other N	15.67	10.61	0.80	10.92
Total	**43.45**	**29.41**	**2.22**	**30.27**

The **nitric oxide emissions** estimates from inorganic N-fertilizers application were calculated with a Tier 1 method (no Tier 2 available). Nitric oxide emissions from this source category were obtained with the amount of the N content of the fertilizer multiplied by the default emission factor.

5.3.1.2 Activity data

There are no available records of statistical information concerning the annual quantity of nitrogen used to agricultural soils or even available statistical information concerning sales of inorganic N fertilizers. However, following the need to respond 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[38] and ADP[39], 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[40] and international market information data. The fertilizer consumption data reported by INE are obtained by the following methodology:

Equation 5-1: 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) this 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.

[38] 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).
[39] ADP, Adubos de Portugal, S.A., is the main producer of fertilizers in Portugal, and responsible for about 75% of fertilizer sales (INE,2004)
[40] IAPI – Annual Survey of Industrial Production made by INE to the Manufacturing Industry.

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 quantity of inorganic fertilizers in the period 1995-2002, (158 500 t N.yr^{-1}) was applied for all lacking years (1990-1994).

The complete time series of the annual consumption of the N-fertilizers type is included in the ANNEX D: Agriculture. Table below presents the same activity data only for a few years of the time series.

In a consistent way the same activity data were used for UNFCCC and for UNECE/CLRTAP emission inventory.

Table 5-22: Nitrogen amount (kt.yr^{-1}) by type of fertilizer

Type of fertilizer	1990	1995	2000	2005	2010	2015	2018	2019	2020
Ammonium nitrate (AN)	0.00	0.00	0.00	0.00	4.01	0.67	0.01	0.02	0.36
Ammonium phosphate (MAP & DAP)	13.28	16.75	11.83	0.00	0.54	0.58	2.50	1.59	1.79
Ammonium sulfate (AS)	17.72	25.40	14.47	10.30	3.06	1.80	0.69	2.51	0.56
Calcium ammonia nitrate (CAN)	46.13	40.67	45.72	29.68	34.99	17.89	19.93	19.61	21.57
Urea	13.35	7.06	20.52	11.85	13.85	30.52	21.82	13.84	15.18
Other NP & NPK	49.54	40.76	57.74	39.94	24.90	27.97	23.91	28.30	27.88
Other N	18.49	15.18	19.72	10.90	18.90	38.48	32.52	39.63	38.00
Total	**158.50**	**145.82**	**170.01**	**102.66**	**100.25**	**117.91**	**102.58**	**101.28**	**105.95**

5.3.1.3 Emission Factors

The emission factors used to **estimate ammonia emissions** from synthetic N-fertilizers were obtained from table 3.2 of the EMEP/EEA Guidebook 2019, of chapter 3D – Crop production and agricultural soils, and are presented in the table below.

Table 5-23: NH_3 emission factors (kg NH_3 . kg N applied^{-1})

Type of fertilizer	Emission regions			
	NC	NT	HC	HT
Ammonium nitrate (AN)	0.015	0.016	0.032	0.033
Ammonium phosphate (MAP & DAP)	0.050	0.051	0.091	0.094
Ammonium sulfate (AS)	0.090	0.092	0.165	0.170
Calcium ammonia nitrate (CAN)	0.008	0.008	0.017	0.017
Urea	0.155	0.159	0.164	0.168
Other NP & NPK	0.050	0.067	0.091	0.094
Other N	0.010	0.014	0.019	0.020

The emission factor used to estimate **nitric oxide emissions** from synthetic N-fertilizers was the default value of 0.04 kg NO_2. kg N applied^{-1} (table 3.1 of the EMEP/EEA Guidebook 2019, chapter 3D - Crop production and agricultural soils).

5.3.2 Animal manure applied to soil (NFR 3Da2a)

5.3.2.1 Methodology and activity data

NH_3, NO_X and NMVOC emissions from animal manure applied to soil were calculated using the same methodologies and activity data described for the source category 3B - Manure management as it was already highlighted there.

5.3.2.2 Emission factors

The **NH_3 emission factors** used for manure applied to soil were the ones referred in Table 5-14 of this Report – EF application - for each animal type.

The **emission factor** used to estimate **NO_X** emissions from manure applied to soil was the default value of 0.04 kg NO_2. kg N applied (table 3.1 of the EMEP/EEA Guidebook 2019, of the chapter 3D – crop production and agricultural soils).

There are no available **NMVOC emission factors** for manure stored and manure applications to soil. Emissions from these two sources are estimated as fraction of those from livestock housing, as recommended by the methodology of the EMEP/EEA Guidebook 2019, pages 28-30, chapter 3B – Manure Management. The fraction is assumed to be the same ratio as for NH_3 emission (Chapter 3B - equations 52 and 53[41] for cattle categories; equations 58 and 59[42] for all livestock categories other than cattle).

5.3.3 Other organic fertilizers applied to soil (NFR 3Da2b and NFR 3Da2c)

5.3.3.1 Sewage sludge applied to soils (NFR 3Da2b)

NH_3 emissions from sewage sludge applied to soils (Emi_{NH3}) was estimated by:

Equation 5-2: NH_3 emissions from sewage sludge applied to soils

$$Emi_{NH3} = SS * NSSF * EFss$$

Where:

SS: quantity of sewage sludge spread on agricultural lands (ton.yr-1)

NSSF: nitrogen fraction of sewage sludge (% of dry solids)

EFss: NH_3 emission factor for sewage sludge (kg NH_3 . Kg N applied^{-1})

The **emission factor** used to estimate **ammonia** emissions is from table 3.1 of the EMEP/EEA Guidebook 2019, chapter 3D – crop production and agricultural soils, 0.13 kg NH_3 . Kg N applied^{-1} to soil from sewage sludge.

NO_X emissions from sewage sludge application were estimate with the tier 1 methodology which consists by multiplying the N amount of sewage sludge applied to soil (SS * NSSF) by the **emission factor** of 0.04 kg NO_2. kg N applied^{-1} to soil from sewage sludge. The NO_X emission factor is from table 3.1 and Annexe A2 (A2.3) of EMEP/EEA Guidebook 2019, chapter 3D – crop production and agricultural soils.

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 Decree-Law n.º 276/2009 which establishes the use of sewage sludge on agricultural soils, transposing for the internal legal order the EU Directive no. 86/278/EEC, of 12 June. 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).

[41] Page 29
[42] Page 30

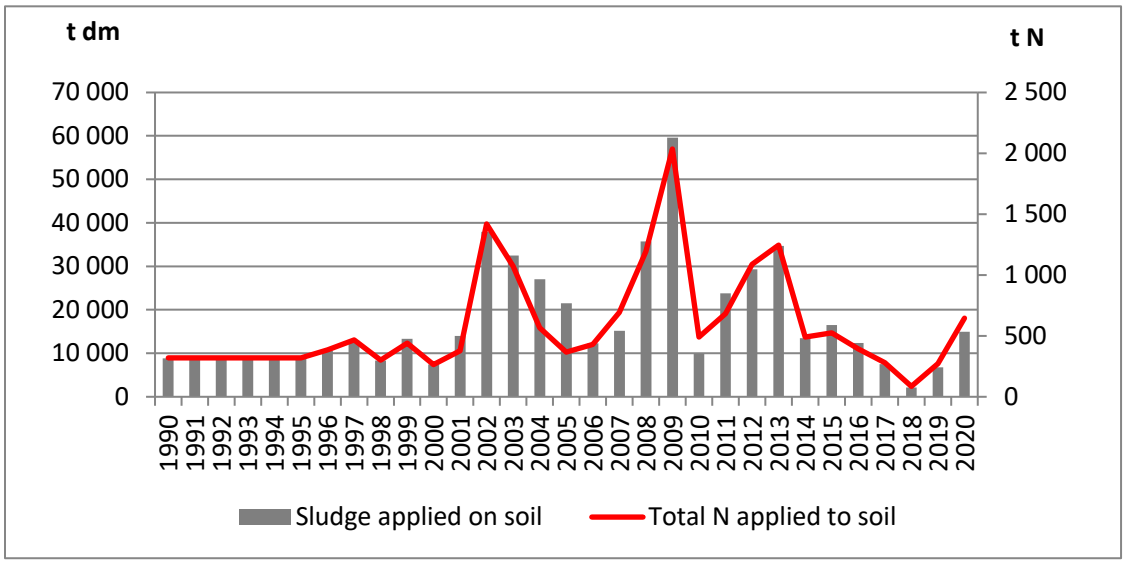


Figure 5-11: Application of sewage sludge (t dm.yr^{-1}) and quantities of N (t N) applied in agriculture soils

5.3.3.2 Compost from municipal solid waste applied to soil (NFR 3Da2c)

NH_3 emissions from MSW compost applied to soils ($EmiNH_3$) was estimated by:

Equation 5-3: NH_3 emissions from MSW compost applied to soils

$$Emi_{NH3} = MSW * NMSWF * EF_{MSW}$$

Where:

MSW: quantity of compost from Municipal Solid Waste spread on agricultural lands (ton.yr^{-1})

NMSWF: nitrogen fraction of compost (%)

EF_{MSW}: NH_3 emission factor for MSW compost (kg NH_3.Kg N applied^{-1})

The **emission factor** used to estimate **ammonia** emissions is from table 3.1 of EMEP/EEA Guidebook 2019, of chapter 3D – Crop production and agricultural soils and is equal to 0.08 kg NH_3. Kg N applied^{-1}to soil from MSW compost.

NO_X emissions from MSW compost application were estimate with the tier 1 methodology which consists by multiplying the N amount of compost applied to soil (MSW * NMSWF) by the **emission factor** of 0.04 kg NO_2. kg N applied^{-1} to soil from compost. The NO_X emission factor is from table 3-1 of EMEP/EEA Guidebook 2019, chapter 3D – crop production and agricultural soils.

The compost resulting from biological treatment of municipal solid waste (MSW) was only recognized as a fertilizer from June 2015 (Decree Law 103/2015). The decree establishes quality standards and control measures including the monitoring of the compost applied to agricultural soils. Therefore, the accounting of this type of N amendment begins in 2015 and emissions, NH_3 and NO_X, are estimated since then.

In 2020 a total amount of 65 928 t of MSW compost was applied to agricultural soils which corresponds to the N amount application of 1 319 t.

5.3.4 Urine and dung deposited by grazing animals (NFR 3Da3)

5.3.4.1 Methodology and activity data

NH_3, NO_X and NMVOC emissions from urine and dung deposited by grazing animals were calculated using the same methodologies and activity data described for the source category 3B - Manure Management as it was already highlighted there.

5.3.4.2 Emission factors

The **NH_3 emission factors** used for urine and dung deposited by grazing animals were the ones referred in table 5-14 of this Report – EF grazing - for each animal type.

The **NMVOC emission factors** for urine and dung deposited by grazing animals were the ones referred in table 5-16 and table 5-17 of this Report – EF grazing - for each animal type.

The **emission factor** used to estimate **nitric oxide** emissions from N returned to soil from urine and dung deposited on soils by grazing animals was the default value of 0.04 kg NO_2. kg N applied^{-1} (table 3.1 of EMEP/EEA Guidebook 2019, chapter 3D- Crop production and agricultural soils).

5.3.5 Cultivated crops and farm level agricultural operations (NFR 3De)

5.3.5.1 Methodology and activity data

In this source category the Portuguese inventory includes the NMVOC emissions estimates from crop process and $PM_{2.5}$, PM_{10} and TSP emissions estimates from soil cultivation and crop harvesting.

The methodology used was a Tier 1 (EMEP/EEA Guidebook 2019) for all the above pollutants mentioned.

Equation 5-4: Emissions from cultivated crops

$$Emi_{pollutant} = AR_{area} * EF_{pollutant}$$

Where:

$Emi_{pollutant}$: amount of pollutant emitted (kg)

AR_{area}: area covered by crop (ha)

$EF_{pollutant}$: emission factor of pollutant (kg.ha^{-1})

The same activity data were considered for NMVOC and PM emissions estimates, i.e, the crop area covered with grain cereals and forage (hay) which are presented in the table below.

Table 5-24: Crop area (ha)

	1990	1995	2000	2005	2010	2015	2018	2019	2020
Crop area (ha)	1 048 641	865 276	742 494	593 994	475 618	369 644	325 954	309 948	307 868

5.3.5.2 Emission factors

Emission factors used are from table 3.1 of the EMEP/EEA Guidebook 2019, chapter 3D – Crop production and agricultural soils, and are shown in the next table.

Table 5-25: NMVOC, PM2.5, PM10 and TSP emission factors (kg.ha-1)

NMVOC	$PM_{2.5}$	PM_{10}	TSP
0.86	0.06	1.56	1.56

5.3.6 Use of pesticides (NFR 3Df)

5.3.6.1 Methodology

As of the October 2018 Guidebook version update, estimates of pesticide emissions containing HCB impurities should be reported. The estimates of HCB emissions were done with the available tier 1 default approach of the EMEP/EEA Guidebook 2019, based in the following equation:

Equation 5-5: HCB Emissions from pesticides

$$E_{pest} = \sum (AD_{pest_i} * IF_{pest_i})$$

Where:

E_{pest}: total HCB emission of active substances (in kg $a.s^{-1}$)

AD_{pest_i}: mass of individual active substances applied (kg $a.s.^{-1}$)

IF_{pest_i}: HCB impurity factor of individual active substances ($mg.kg^{-1}$)

5.3.6.2 Activity data

From the National Authority responsible for the management and authorization of plant protection products[43], information has been received that the active substances in use in Portugal are clopyralid and chlorothalonil. From the same source were also received the quantities sold (kg s.a.) of these products from 2012 onwards, which are presented in the table below.

Table 5-26: Quantities sold (kg $a.s^{-1}$) - Clopyralid and Chlorothalonil

Year	Clopyralid	Chlorothalonil
2012	12.57	5 360.61
2013	4.57	7 139.72
2014	43.20	9 829.00
2015	0.00	11 371.00
2016	82.00	16 644.00
2017	75.00	16 221.00
2018	74.80	19 019.00
2019	95.40	27 308.50
2020	42.00	0.00

Before 2012, there are no records or other sources of information on the quantities sold in Portugal for both active substances.

Clopyralid was not used in the EU before 2010[44], so from 1990 to 2009 the quantities sold are zero and in the years 2010 and 2011 the value of 2012 was adopted to complete the time series.

Also, in the case of chlorothalonil, since there are no other sources of information, the value of 2012 was assumed to complete the time series. According to DGAV/Ministry of Agriculture, there are no sales of

[43] Engª Miriam Cavaco-Head of the Division of Management and Authorization of Plant Protection Products of DGAV/Ministry of Agriculture
[44] Table 4 , Chapter 3.D.f of the EMEP/EEA Guidebook 2019

Chlorothalonil from 2020 onwards because this active substance was not approved from May 2019 onwards and withdrawn from the market from November 2019 onwards.

5.3.6.3 Impurity factors

The impurity factors used are the default ones from table 4 of chapter 3.D.f of the EMEP/EEA Guidebook 2019 that are shown in the next table.

Table 5-27: Impurity factors (mg.kg^{-1}) - Clopyralid and Chlorothalonil

	Clopyralid	Chlorothalonil
All years	2.5	--
1990 -1999	--	300
2000 onwards	--	40

5.3.7 Uncertainties

To be provided in the future.

5.3.8 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 (http://www.fao.org/faostat/en/#data/RFN) and of IFA[45] (https://www.ifastat.org/databases/plant-nutrition) for the period 2002 – 2018. For previous years (1990-2001) FAO database archive has no data registers. In both databases (FAO and IFA) 2018 is the last year available. Comparison results are shown in Figure below.

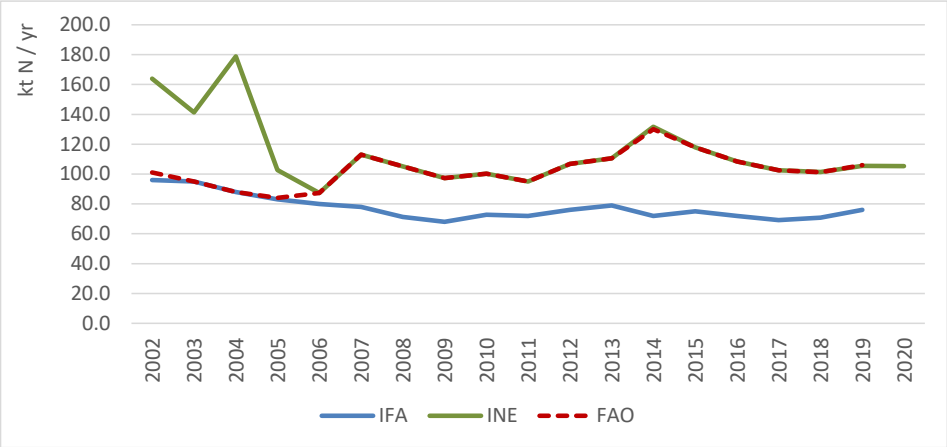


Figure 5-12: Data bases comparison of inorganic N fertilizers (t N.yr^{-1})

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*" values

[45] International Fertilizers Association

were produced, for instance if consumption in forestry areas is accounted. Until this issue is completely clarified 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.

QA/QC also included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

5.3.9 Recalculations

Differences between 2021 and 2022 submissions are mainly due to:

- Update in "Other NP & NPK" fertilizers consumption National Statistics time series for the period 2003-2008;
- Update in "Other N" fertilizers consumption National Statistics time series for the period 2011-2013, years 2016 and 2019;
- Update in Calcium Ammonium Nitrate (CAN) fertilizers methodology; Since there is no reliable data for the period 2008-2014, we start using the average of the period 2015-2019; For the other periods we used National Statistics;
- Update in Ammonium Nitrate National Statistics in 2019;
- Update in Ammonium Sulphate National Statistics in 2018-2019 period;
- Update in N content of sludge applied to soils from 2018 onwards.

Other minor corrections were done as a result of internal QA/QC procedures which had no significant impact.

For NH_3 emissions the graphical representation of the differences between submissions is shown in the figure below.

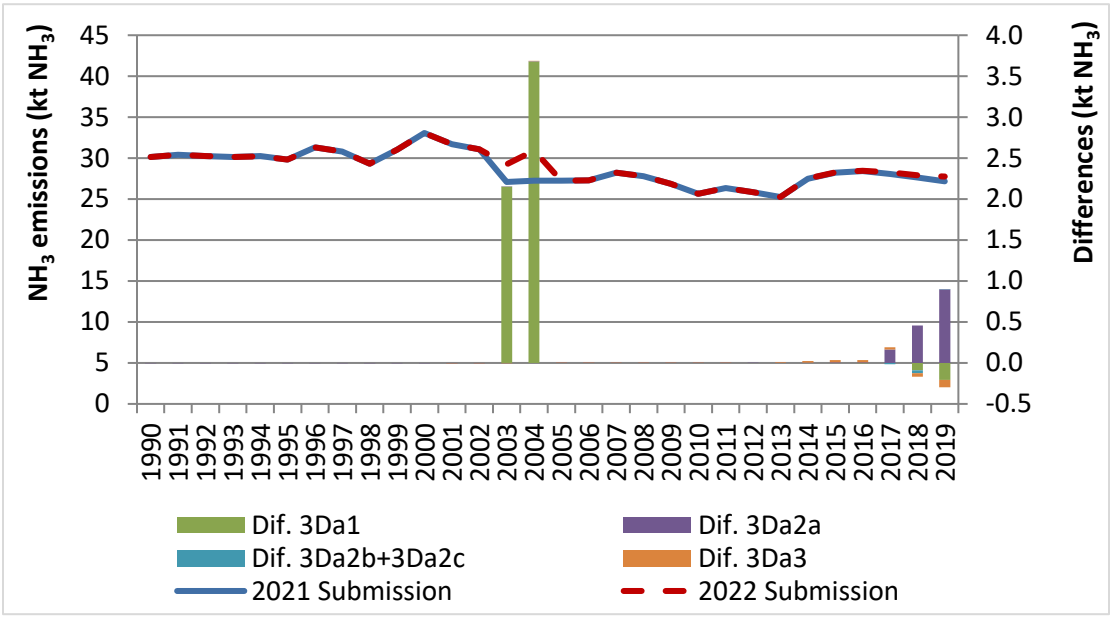


Figure 5-13: Crop production and agricultural soils NH_3 emissions. Differences between submissions (2021 and 2022)

5.3.10 Further improvements

As referred in the sources category NFR 3B - manure management, it is planned to continue the improvement of the characterization of the manure management systems framed by the new national law[46] 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 emissions from manure applied to soil and from urine and dung deposited on pasture, range and paddock by grazing animals.

5.4 Field Burning of Agriculture Residues (NFR 3F)

In-site burning of agricultural residues is still practiced nowadays in Portugal, being however forbidden by law-decree from july to September, when normally forest fires occur.

In the source category 3F, the Portuguese inventory includes emission estimates of the pollutants: NH_3, NOx[47], NMVOC, SO_X[48] and $PM_{2.5}$.

Table 5-28: Emission estimates from Field Burning of agriculture residues (3F), kt

Pollutant	1990	2005	2018	2019	2020	Δ 2020-2019	Δ 2020-2005	Δ 2020-1990	% of Agriculture emissions from PT in 2020
	Kt					%			
NO_X									
Portugal	1.18	0.82	0.91	0.92	0.90	-2.23%	9.18%	-24.09%	7.94%
Mainland	1.16	0.81	0.88	0.89	0.87	-2.24%	7.45%	-25.67%	8.35%
NMVOC									
Portugal	3.02	2.23	2.50	2.55	2.49	-2.08%	12.02%	-17.26%	12.93%
Mainland	2.98	2.19	2.43	2.46	2.41	-2.09%	10.24%	-18.99%	14.45%
SO_x									
Portugal	0.19	0.13	0.14	0.14	0.14	-1.64%	5.78%	-24.11%	1.25%
Mainland	0.18	0.13	0.14	0.14	0.14	-1.65%	4.10%	-25.69%	1.31%
NH_3									
Portugal	1.01	0.68	0.78	0.79	0.77	-2.74%	11.93%	-24.48%	1.45%
Mainland	1.00	0.67	0.76	0.76	0.74	-2.75%	10.15%	-26.06%	1.61%
$PM_{2.5}$									
Portugal	2.30	1.55	1.77	1.79	1.74	-2.80%	12.17%	-24.48%	81.10%
Mainland	2.27	1.52	1.72	1.73	1.68	-2.81%	10.39%	-26.06%	81.71%

Besides the main pollutants and $PM_{2.5}$, the Portuguese inventory also includes, in the source category 3F, the emission estimates of the pollutants described in the table below.

[46] Decree-Law nº 81/2013
[47] Reported as NO_2
[48] Reported as SO_2

Table 5-29: Pollutant emission estimates from field burning of agricultural crop residues

	Pollutants
Main pollutants	NH_3, NOx, NMVOC, SOx
Particulate Matter	PM2.5, PM10, TSP
Other	CO
Heavy Metals	Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn
POP's	PCDD/PCDF, Benzo(a)pyrene,Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indenol (1,2,3-cd)pyrene

5.4.1 Methodology

Emissions of in-site burning of agriculture residues were estimated based on equation 2.27[49] from the IPCC 2006 which is summarized in the following equation:

Equation 5-6: 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, $g.kg\ dm\ burnt^{-1}$

5.4.2 Activity data

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.

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[50] limits. In these situations, the practice of burning crop residues is forbidden[51] for reasons of conservation of natural habitats and animal species since 2000 until nowadays.

Outside the Natura 2000 network during the time period 2002-2008[52] all rice cultivation areas subjected to "Techniques of Integrated Production and Protection[53]" had the same burnt residues restrictions. 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.

[49] Volume 4, chapter 2, pg 2.42
[50] 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). http://www.icnf.pt/portal/naturaclas/rn2000
[51] National Laws: DL 140/99 artº 11º (revised by DL 49/2005); RCM 177/2008 artº 21º; RCM 182/2008 artº 8º.
[52] From 2009 onwards the limitation of residues burnt was removed (Circular / DSPFSV/ 08 from Directorate General of Agriculture and Rural Development -DGADR)
[53] "Modos de proteção e produção integrada" in the original in Portuguese.

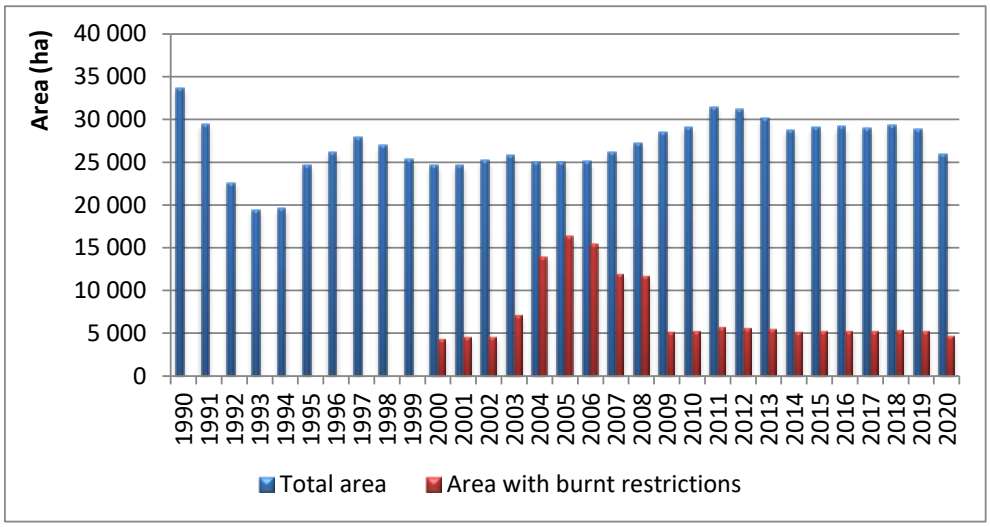


Figure 5-14: Rice cultivation areas (ha) in Portugal

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 2009 Agricultural Census (RA09) which included a set of questions about some agricultural practice.

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 of cereal crops (rice included) was estimated using the IPCC 2006 methodology, i.e., the regression equations in table 11.2[54] . The amounts of pruning material produced for each of the permanent crops are country specific[55] values.

Activity data and parameters used to estimate emissions from cereal and permanent crops residues burnt on field are summarized in table below for 2019. Combustion factors used for cereals are the default values from Table 2.6 of IPCC 2006[56]. For pruning material from permanent crops, the combustion factor considered was made equal to 1, following the recommendation of the EMEP/EEA Guidebook 2019.

In a consistent way the same activity data were used for UNFCCC and for UNECE/CLRTAP emission inventory.

Table 5-30: Activity data and parameters used to estimate emissions from field burning of crop residues, 2020

Crop	Area burnt* (kha)	Biomass available for combustion (t dm.ha^{-1})	Combustion factor
Wheat	0.30	4.12	0.90
Barley	0.22	2.97	0.90
Maize	1.02	8.98	0.80
Rice	16.56	6.35	0.80
Other cereals	0.66	2.06	0.90
Orchards	10.79	2.06	1.00
Vineyards	90.47	1.19	1.00
Olive grove	246.64	0.27	1.00
*Area where the on field burning practice of crop residues occurs			

[54] Volume 4. chapter 11, page 11.17
[55] Dias, J.J. Mestre (2002), "Utilização da biomassa: avaliação dos resíduos e utilização de pellets em caldeiras domésticas".
[56] Volume 4, chapter 2, page 2.49

In the next figure is shown the annual biomass burnt for the period 1990-2020.

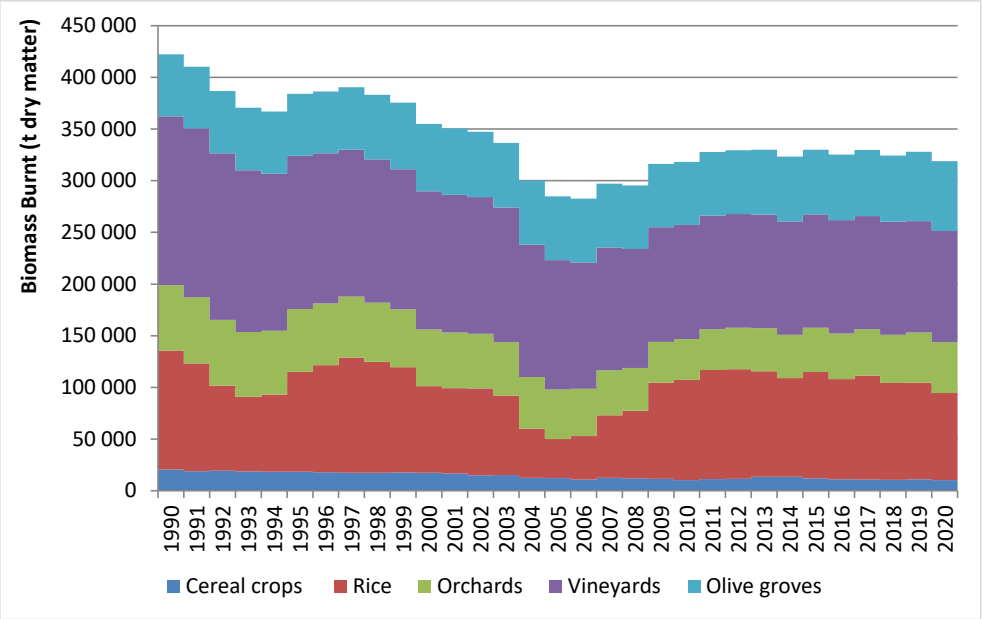


Figure 5-15: Annual biomass burnt (t dm /yr) for the time series

5.4.3 Emission Factors

The emission factors used to estimate NOx, NMVOC, SOx, NH_3 and CO emissions from on field burning agricultural residues are presented in Table 5-31.

For $PM_{2.5}$, PM_{10}, TSP and BC emission estimates were used the emission factors presented in table 5-32.

Table 5-31: Emission factors for field burning agriculture residues, by pollutant and crop (Kg.kg dm burnt-^{1}). Main pollutant and CO

Crop	NOx	NMVOC	SOx	NH_3	CO
Wheat	0.0023	0.0005	0.0005	0.0024	0.0667
Barley	0.0027	0.0117	0.0001	0.0024	0.0987
Maize	0.0018	0.0045	0.0002	0.0024	0.0388
Rice	0.0024	0.0063	0.0003	0.0024	0.0589
Other cereals	0.0023#	0.0005#	0.0005#	0.0024#	0.0667#
Orchards	0.0030”	0.0007»	0.0005#	0.0024#	0.1070”
Vineyards	0.0030”	0.0006»	0.0005#	0.0024#	0.1070”
Olive grove	0.0030”	0.0140»	0.0005#	0.0024#	0.1070”

Sources: Wheat, barley, maize and rice values from tables 3-3, 3-4, 3-5 and 3-6, respectively, of EMEP/EEA guidebook 2019; chapter 3F; #Table 3-1 of EMEP/EEA guidebook 2019; chapter 3F; » Table 2.5-5 AP_ 42 USEPA ;“Table 2.5 of IPCC guidelines 2006

Table 5-32: Emission factors for field burning agriculture residues, by pollutant and crop (Kg.kg dm burnt^{-1}). Particulate Matter

Crop	$PM_{2.5}$	PM_{10}	TSP	BC
Wheat	0.0054	0.0057	0.0058	0.0005
Barley	0.0074	0.0077	0.0078	0.0012
Maize	0.0060	0.0062	0.0063	0.00075
Rice	0.0055	0.0058	0.0058	0.0005
Other cereals	0.0054#	0.0057#	0.0058#	0.0005#
Orchards	0.0054#	0.0057#	0.0058#	0.0005#
Vineyards	0.0054#	0.0057#	0.0058#	0.0005#
Olive grove	0.0054#	0.0057#	0.0058#	0.0005#

Sources: Wheat, barley, maize and rice values from tables 3-3, 3-4, 3-5 and 3-6, respectively, of EMEP/EEA guidebook 2019; chapter 3F; #Table 3-1 of EMEP/EEA guidebook 2019; chapter 3F

For all other pollutant emission estimates, the emission factors used are those presented in the following two tables.

Table 5-33: Emission factors for field burning agriculture residues, by pollutant and crop - POPs

Crop	PCDD/PCDF (µg I -TEQ t^{-1})	Benzo(a)pyrene (mg / kg dm)	Benzo(b) fluoranthene (mg / kg dm	Benzo(k) fluoranthene (mg / kg dm	Indeno(1,2,3-cd) pyrene (mg / kg dm)
Wheat	0.5000#	0.393	1.097	0.468	0.336
Barley	0.5000#	0.771	2.398	0.601	0.298
Maize	0.5000#	7.162	3.495	2.138	2.415
Rice	0.5000#	0.072	0.120	0.088	0.055
Other cereals	0.5000#	0.393#	1.097#	0.468#	0.336#
Orchards	0.5000#	0.393#	1.097#	0.468#	0.336#
Vineyards	0.5000#	0.393#	1.097#	0.468#	0.336#
Olive grove	0.5000#	0.393#	1.097#	0.468#	0.336#

Sources: Wheat, barley, maize and rice values from tables 3-3, 3-4, 3-5 and 3-6 , respectively, of EMEP/EEA guidebook 2019; chapter 3F; #Table 3-1 of EMEP/EEA guidebook 2019

Table 5-34: Emission factors for field burning agriculture residues, by pollutant and crop (mKg.kg dm burnt^{-1}). Heavy metals

Crop	Pb	Cd	Hg	As	Cr	Ni	Se	Zn	Cu
Wheat	0.1100	0.8800	0.1400	0.0064	0.0800	0.0520	0.0200	0.5600	0.0730
Barley	0.0036	0.2400	0.0960	0.0064#	0.1400	0.0110	0.0390	0.4900	0.0036
Maize	0.0070	0.0360	0.0280	0.0130	0.1000	0.0360	0.0280	0.8400	0.0540
Rice	0.0720	0.1600	0.0330	0.0910	0.1000	0.0450	0.0480	0.9200	0.0880
Other cereals	0.1100#	0.8800#	0.1400#	0.0064#	0.0800#	0.05200#	0.0200#	0.5600#	0.0730#
Orchards	0.1100#	0.8800#	0.1400#	0.0064#	0.0800#	0.05200#	0.0200#	0.5600#	0.0730#
Vineyards	0.1100#	0.8800#	0.1400#	0.0064#	0.0800#	0.05200#	0.0200#	0.5600#	0.0730#
Olive grove	0.1100#	0.8800#	0.1400#	0.0064#	0.0800#	0.05200#	0.0200#	0.5600#	0.0730#

Sources: Wheat, barley, maize and rice values from tables 3-3, 3-4, 3-5 and 3-6 , respectively, of EMEP/EEA guidebook 2019; chapter 3F; #Table 3-1 of EMEP/EEA guidebook 2019

5.4.4 Uncertainties

To be provided in the future.

5.4.5 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.

5.4.6 Recalculations

Recalculations were made from 2016 onwards, based on national statistics updates on Biomass Burnt.

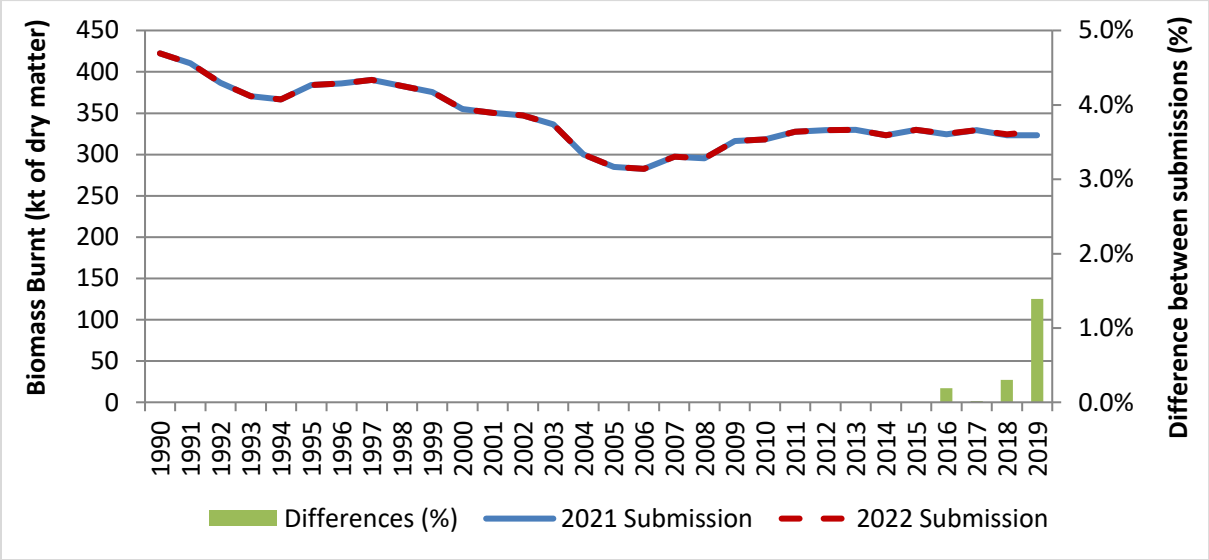


Figure 5-16: Amount of biomass burnt (kt dm). Differences between 2021 and 2022 submissions

5.4.7 Further improvements

No specific improvements are planned.

6 Waste (NFR Sector 5)

Table of Contents

6 Waste (NFR Sector 5) 6-1

6.1 Overview 6-3

6.2 Solid Waste Disposal on Land (NFR 5.A) 6-5

6.2.1 NMVOC emissions 6-5

6.2.2 NH3 emissions from Solid Waste Disposal Sites (SWDS) 6-15

6.2.3 Emissions from landfill gas and other biogas burning (NFR 5.A) 6-15

6.2.4 NH3 emissions from Biological Treatment of Waste - Composting (NFR 5.B.1) and Anaerobic Digestion (NFR 5.B.2) 6-18

6.2.5 Waste Incineration (NFR 5.C) 6-19

6.2.6 Cremation (NFR 5.C.1.b.v) 6-25

6.2.7 Wastewater Handling (NFR 5.D) 6-26

6.2.8 Emissions from Other Waste: car and house fires (NFR 5.E) 6-35

6.3 Recalculations 6-37

6.4 Further improvements 6-37

List of Figures

Figure 6-1: Share of the waste sector as a percentage of total emissions in 2020 6-4

Figure 6-2: Population served by waste collection systems 6-7

Figure 6-3: Municipal waste 6-7

Figure 6-4: Waste treatment by final destination 6-9

Figure 6-5: Quantities of fermentable industrial waste disposed to SWDS 6-12

Figure 6-6: Total industrial waste by treatment types 6-13

Figure 6-7: Emissions of CH4 and NH3 6-15

Figure 6-8: Quantities of municipal waste composted/ Digested and related NH3 emissions 6-18

Figure 6-9: Quantities of combusted industrial waste 6-20
Figure 6-10: Quantities of healthcare waste incinerated 6-21
Figure 6-11: Quantities of Municipal Solid Waste incinerated 6-22
Figure 6-12: NMVOC emissions 6-29
Figure 6-13: NH3 emissions and % population served by latrines 6-29
Figure 6-14: Industrial Wastewater discharges, expressed in 1000 m3, from major groups of industrial activity 6-35
Figure 6-15: Total industrial wastewater discharge and NMVOC emissions 6-35
Figure 6-16: Number of fire occurrences 6-36

List of Tables

Table 6-1: Parameters used in Lo calculation 6-9
Table 6-2: Municipal waste composition disposed to SWDS and DOC 6-10
Table 6-3: Industrial organic waste composition and DOC 6-14
Table 6-4: Activity data, emission factors and emissions resulting from landfill gas and biogas combusted . 6-16
Table 6-5: Ammonia emission factors for compost production 6-18
Table 6-6: Ammonia emission factors for anaerobic digestion at biogas facilities 6-18
Table 6-7: Emission factors of CLRTAP gases for incineration of Industrial Waste 6-23
Table 6-8: Emission factors of CLRTAP gases from incineration of healthcare wastes: until 2004 6-23
Table 6-9: Emission factors of CLRTAP gases from incineration of healthcare wastes: after 2005 6-24
Table 6-10: Emission factors of CLRTAP gases from incineration of MSW 6-24
Table 6-11: Number of human corpses cremated 6-25
Table 6-12: Emission factors of CLRTAP gases for cremation 6-26
Table 6-13: Percentage of population by wastewater handling system 6-28
Table 6-14: Data and parameters used calculation of NH3 emissions from wastewater 6-30
Table 6-15: Sources of Information used to define the time-series of industrial production (1/2) 6-32
Table 6-16: Sources of Information used to define the time-series of industrial production (2/2) 6-33
Table 6-17: Coefficients used to estimate volumes of industrial wastewater production 6-34
Table 6-18: Emission factors 6-36

6 Waste (NFR Sector 5)

Teresa Costa Pereira

Updated: March 2022

6.1 Overview

Waste management of industrial and municipal wastes are sources of air pollutant emissions, such as SO_2, NO_x, CO, NMVOC, particulate matter, heavy metals and POPs.

The inventory covers emissions resulting from waste disposal on land, composting/digestion, waste incineration and cremation, treatment of liquid wastes, and sludge spreading.

Waste disposal on land, e.g. landfills that are significant sources of GHG (not included in this report), produce also NMVOC and NH_3 emissions (smaller amounts).

Wastewater treatment systems are also potential sources of NMVOC and NH_3.

Municipal solid wastes (MSW) and hazardous wastes incineration originates emissions of several pollutants, which depend on the type of incinerators, the degree of abatement techniques used and the composition of the waste combusted.

The inventory includes estimates for Particulates and Heavy Metals emissions from the incineration of municipal solid wastes (MSW) and healthcare hazardous wastes. Furthermore, these source categories are also relevant in terms of Dioxins and Furans, PAHs and PCBs emissions.

The Guidelines determines emissions from incineration with energy recovery to be reported in the energy sector (sub-category 1A1a Public electricity and heat production).

Incineration of municipal solid wastes (MSW) in Portugal is done in four modern units (two in Portugal Mainland) where energy is recovered, and thus these emissions are accounted for in the energy sector. The incineration of healthcare waste occurs without energy recovery and 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.

This sector includes also the incineration of industrial waste that occurs in industrial waste units without energy recovery.

Emissions from biogas combustion are also accounted and reported in the energy sector when there is energy recovery or in the waste sector when biogas is flared (without energy recovery).

The inventory includes also three other source categories: cremation of human corpses, sludge spreading (reported under agriculture category NFR 3Da2b) and car fires and building fires.

ANNEX E: WASTE (NRF 5) refers to underlying data used in the sector estimates.

The next figure presents the contribution of the waste sector to the total emissions by substance.

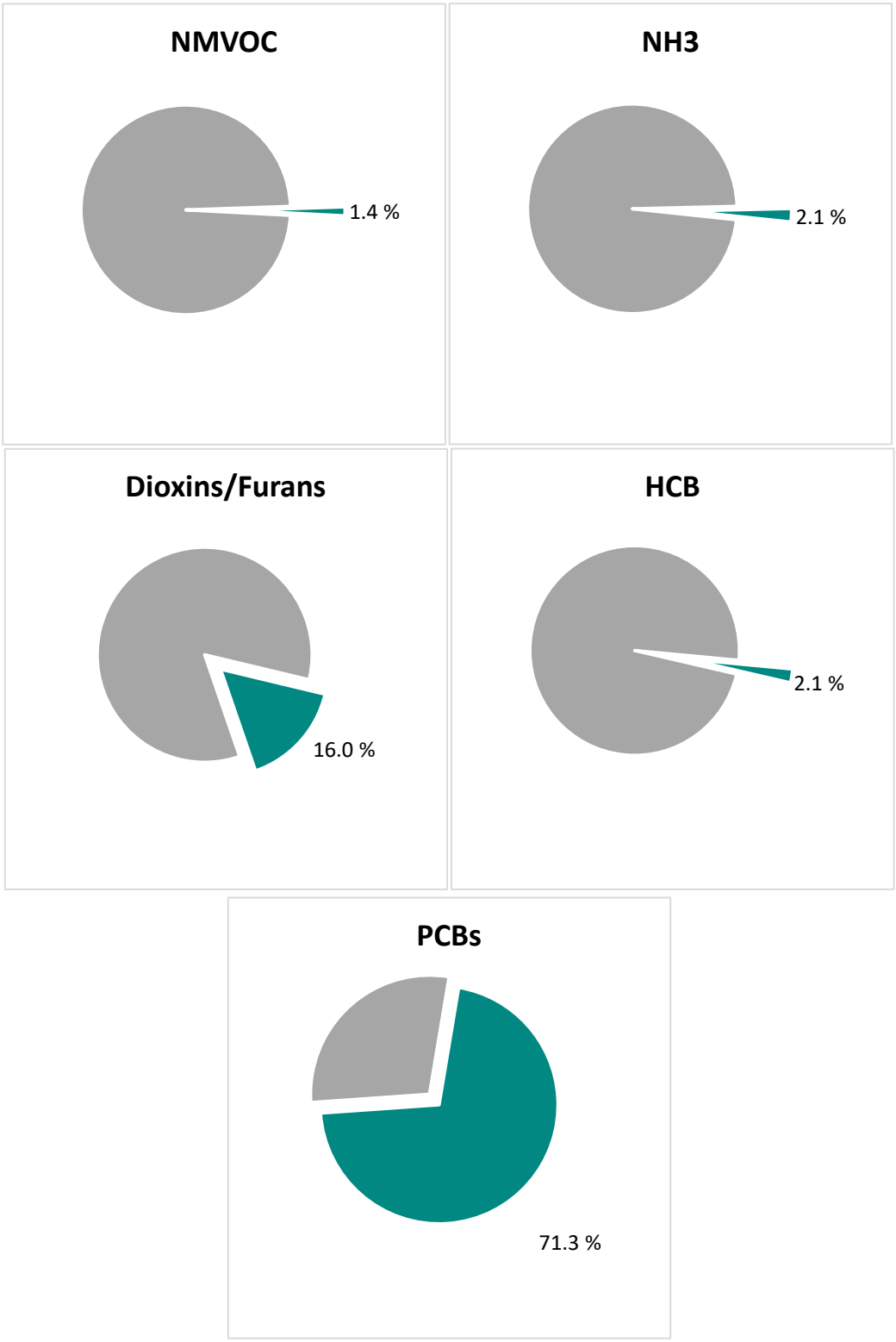


Figure 6-1: Share of the waste sector as a percentage of total emissions in 2020

6.2 Solid Waste Disposal on Land (NFR 5.A)

6.2.1 NMVOC emissions

6.2.1.1 Methodology

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 and 3.5 and a single-phase approach based on bulk waste (MSW). Emissions from industrial waste are estimated in a similar way.

NMVOC emissions are calculated using an emission factor of 0.01 t NMVOC/ t methane produced which is equivalent to 5.65g NMVOC/ m^3 landfill gas (Passant, 1993).

6.2.1.2 Activity data and parameters

SWDS include solid municipal waste (household, garden, commercial-services wastes) and industrial wastes.

6.2.1.2.1 Municipal waste

6.2.1.2.1.1 Quantities of waste landfilled

Until 2020 the Decree-Law no. 178/2006 amended and republished in the Decree-Law no. 73/2011) defined the legal obligations related to the Waste Registry for: waste producers, management waste operators (municipal and non-municipal), waste carriers, integrated and individual management schemes for waste streams, whether covered or not by the extended producer responsibility, and waste brokers and dealers.

At present the National legislation refers to the Annex I of DL 102-D/2020.

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 the 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, in order to assess compliance with legal obligations, targets and to determine the waste management tax.

In terms of municipal waste, the data is reported in the Municipal Waste Register Map (MRRU), 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 collection and/or treatment systems from Portugal Mainland and from the Autonomous Region of Madeira. Information from the Autonomous Region of Azores is collected under the framework of SNIERPA (National System Inventory).

Since the end of 2010, the management of MSW in Portuguese mainland has been under the responsibility of 23 entities, named "Municipal Waste Management Systems – SGRU" (12 multi-municipal and 11 inter-municipal systems). 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.

For 1994, and 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.

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.

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 A: COMPLETENESS AND KEY CATEGORIES). 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 (6.2.1.2.1.3-Other parameters) of the waste deposited at SWDS.

Before 1994, data on landfill wastes had to be estimated based on expert judgement 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 wastes production was estimated for each municipality as follows:

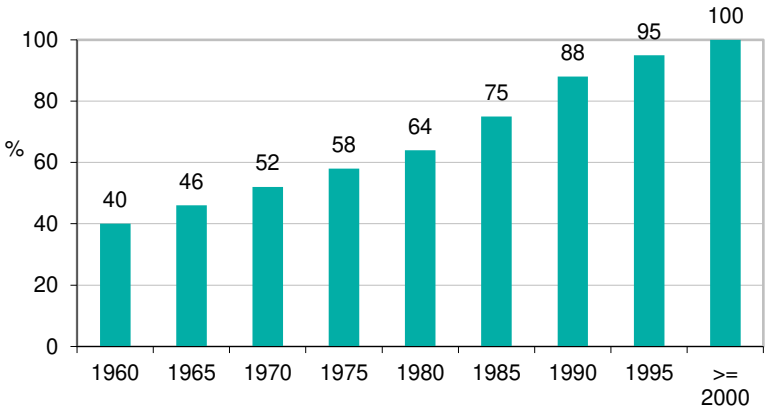
[Population (inhabitants) * Annual amount of municipal waste generated per capita (t/inhabitant/year)]

Population data for resident population is available from periodical census made by the National Statistical Office (INE). Available years are: 1960, 1970, 1981, 1991, 2001, and 2011. Data for intermediate years were estimated, by interpolation, for each municipality.

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:

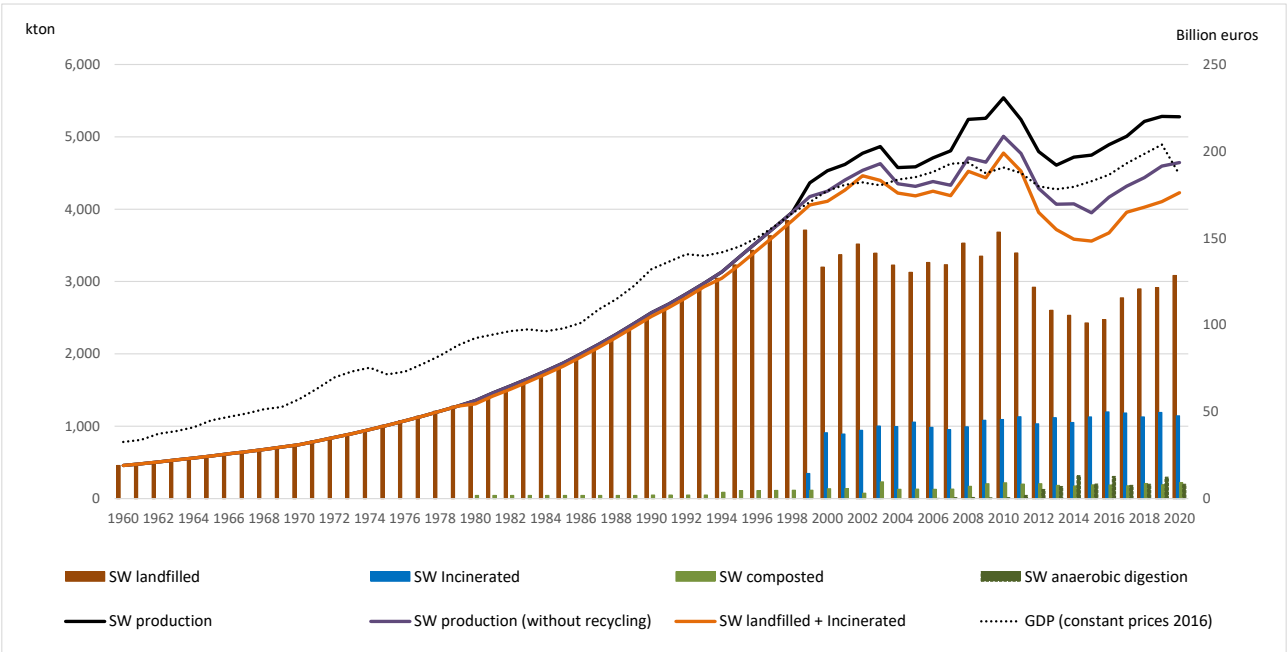
Waste disposed to SWDS = [Population * Annual amount of municipal waste generated per capita * % of Population served by waste collection] – Quantity of incinerated waste – Quantity of composted/digested waste



Source: APA

Figure 6-2: Population served by waste collection systems

The next figure presents the trends of SW generation amounts and the quantities of waste per type of final disposal.



Source: APA, include estimates.

Figure 6-3: Municipal waste

The production of municipal waste increased strongly along the years, driven by changes in consumption patterns and life style associated with the steady economic growth registered in particular in the years following the Portuguese accession to the EU in 1986.

After a peak around the year 2010, total municipal solid waste (MSW) production presented a decreasing tendency, resulting from prevention policies, but mostly due to the economic crisis effect on consumption. Since 2014, however, an inversion of this tendency is registered.

In 2020, 5.28 million tons (t) of municipal waste were produced in Portugal, 0.05% less than in 2019.

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 Portugalbefore the pandemic crisis, contributing both to the Portuguese economic development and to the growth of municipal waste generation.

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).

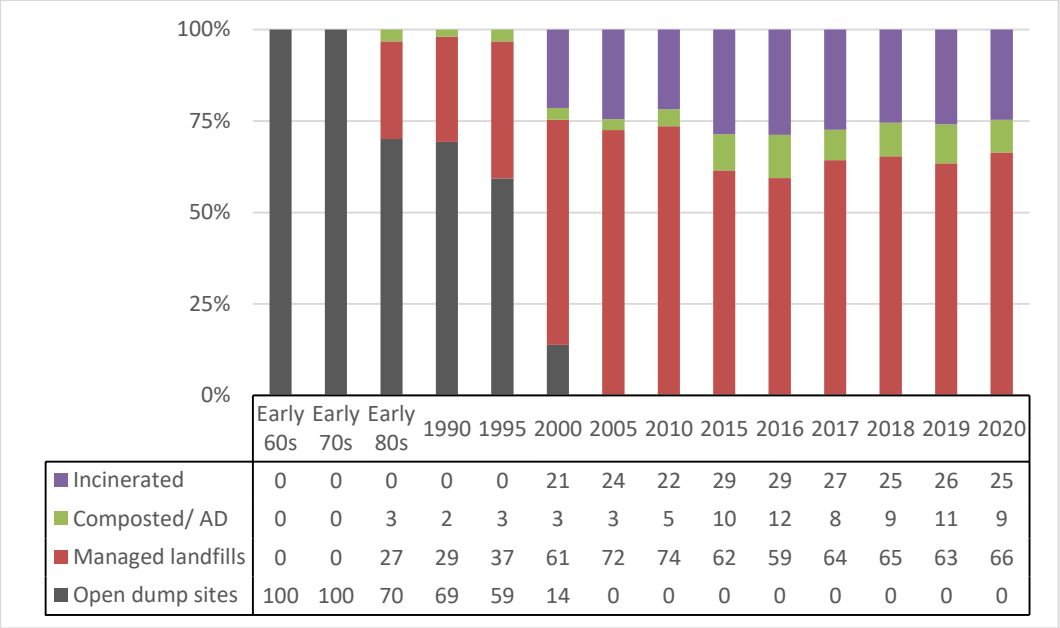
The Portuguese MSW production per capita in 2020 corresponded to approx. 513 kg/year above the EU28 average per capita MSW production (http://ec.europa.eu/eurostat/statistics-explained/index.php/Municipal_waste_statistics).

The share of treatment for the first years of the time series was calculated having as a basis the Quercus survey. Since 1999 data is collected from Municipal Waste Management Systems. As shown in the next figure there was a significant effort at national level to deactivate and closure all uncontrolled dumping sites. This effort was concluded in 2002 when all uncontrolled dumping sites had been closed.

Until the late ‘90s, landfilling remained almost exclusively the main waste treatment operation. In 1999/2000, with the start of operation of two MSW incineration units in Mainland Portugal, another one in 2001/2002 in the Autonomous Region of Madeira, and more recently, at the end of 2015, one more in the Autonomous Region of Açores, 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 tendentially decreasing since 2010, with the exception of 2020 due to the to 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.

This trend has been accompanied by the growth of importance of Mechanical and Biological Treatment (MBT) as well as Sorting units as foreseen in the Municipal Solid waste Strategic Plan (PERSU, PERSU II, PERSU 2020) 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 has been growing in importance. 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.



Note: The figure below, 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 screening.

Source: APA estimates.

Figure 6-4: Waste treatment by final destination

6.2.1.2.1.2 Methane generation

The parameters used in the calculation are mainly IPCC default values.

Table 6-1: Parameters used in Lo calculation

Parameter	Explanation	Value considered
MCF	IPCC defaults	Managed landfills = 1.0 Unmanaged/Uncategorised = 0.6
DOC	National estimate	Variable on waste composition
DOCF	2006 IPCC default (including lignin C)	0.5
F	2006 IPCC default	0.5

The estimation of Degradable Organic Carbon (DOC), presented in the following table, was based on national information on the waste composition.

Table 6-2: Municipal waste composition disposed to SWDS and DOC

Fermentable fractions	DOC content	Early 60s	Early 70s	Early 80s	Early 90s	Mid 90s	2000	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
		Percentage of wet weight																
Paper/cardboard	40	17.0	17.0	17.0	21.1	22.7	26.4	13.7	12.9	12.3	13.6	13.7	13.3	10.0	9.4	9.8	7.7	6.3
Glass	-	2.5	2.5	2.5	4.4	5.1	7.4	3.7	3.6	4.0	4.5	4.4	4.3	3.2	3.2	3.3	3.1	3.3
Plastics	-	3.0	3.0	3.0	9.2	11.7	11.1	10.8	10.5	10.2	10.8	10.8	10.8	12.5	14.1	14.1	13.5	12.1
Metal	-	3.0	3.0	3.0	2.8	2.7	2.8	2.0	1.8	1.6	1.9	1.9	1.8	1.6	1.6	1.7	1.5	1.4
Food waste	15	40.9	40.9	40.9	36.5	34.8	26.5	42.8	43.0	40.9	36.6	37.5	36.7	31.8	30.3	31.6	31.5	32.0
Textiles	24	5.5	5.5	5.5	3.8	3.1	2.6	6.0	6.4	6.7	7.1	7.4	7.8	8.1	8.1	8.1	8.1	8.1
Non-food fermentable materials	20	18.7	18.7	18.7	18.7	18.7	17.4	14.3	14.3	14.3	14.3	14.3	14.3	14.6	14.6	14.6	14.6	14.6
Wood	43	0.3	0.3	0.3	0.3	0.3	0.5	1.5	1.0	1.1	1.1	1.0	1.2	0.7	1.1	0.9	0.9	0.7
Other	-	9.1	9.1	9.1	3.2	0.9	5.4	5.3	6.5	8.9	10.3	9.1	9.8	17.6	17.7	15.9	19.1	21.6
DOC	**-**	**18.1**	**18.1**	**18.1**	**18.7**	**18.9**	**18.9**	**16.8**	**16.4**	**16.0**	**15.9**	**16.1**	**16.1**	**13.9**	**13.6**	**13.9**	**13.0**	**12.5**

Note:
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: 2006 IPCC defaults.

6.2.1.2.1.3 Other parameters

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 $t_{1/2}$) as follows: k = ln2 / $t_{1/2}$. 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 0.07 refer to the average conditions of the overall SWDS.

6.2.1.2.2 Industrial waste

6.2.1.2.2.1 Quantities of waste landfilled

Industrial wastes considered refer only to the fermentable part of industrial waste.

Data for the period 1960-1998 have been revised for this submission on the following of a recommendation from the UNFCCC.

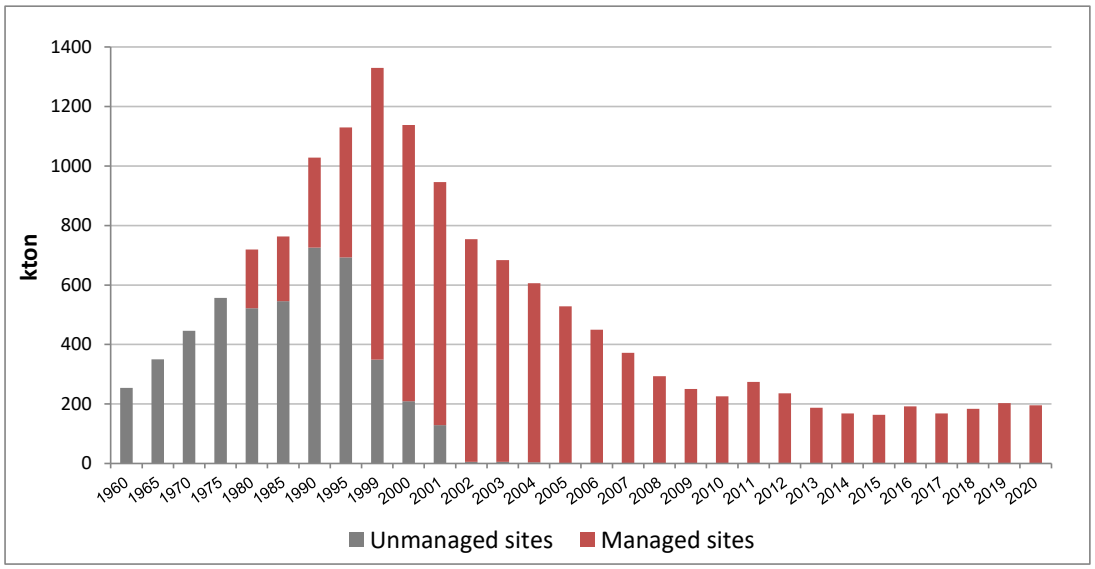
Until the 2021 submission, data estimated for the period 1960-1998 were based on expert judgment. For the years 1960-1990 a growth rate of 1.5% per year was considered, and for the following years (1990-1998), 2% per year. The basis for these assumptions was difficult to track down as no full registry of the rationale behind could be found. Therefore, in the absence of historical data on solid waste disposal, the evolution of the national Gross Domestic Product (GDP) was used as the driver to estimate the historical time series on industrial waste disposal for the period 1960 to 1998. This indicator is considered to be the most appropriate as it is the longer and consistent time series available.

Data for 1999 refer to the first set of available data on industrial waste disposal that was collected via an annual registry of industrial declarations received from the regional environment directorates (CCDR). The historical time series were then estimated based on the GDP evolution for the period 1960-1999.

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 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).

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.

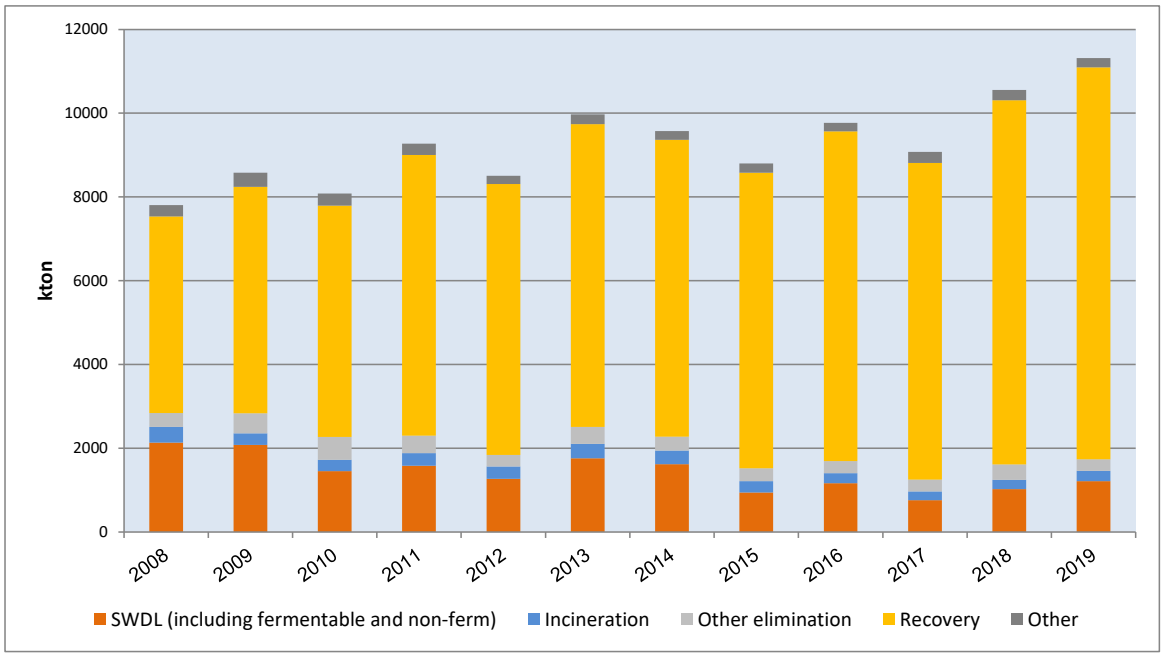


Source: APA

Figure 6-5: 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 wastes treatment types since 2008. From 2008 to 2019 as the total amount of industrial waste increased from 7.81 Mt in 2008 to 11.32 Mt in 2019, the amount disposed in SWDS decreased from 2.14 Mt in 2008 to 1.21 Mt in 2019 as the recovery of waste increased from 4.69 Mt in 2008 to 9.36 Mt in 2019. Data for 2020 not yet available.



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 6-6: Total industrial waste by treatment types

6.2.1.2.2.2 Methane generation

The parameters used in the calculations are basically the same as the ones presented for municipal waste, excepted for DOCm. Data for this parameter varies according to the available information on industrial waste composition and includes estimates based on interpolation and average of last available data for missing years.

Available data on industrial waste production is based on APA´s data which refer to annual registries from industrial units declarations. This information is classified according to the European Waste Catalogue list (EWC) and is disaggregated by type of treatment. From this database a selection was made (by expert judgment) in order to consider the EWC categories referring to organic origin. Each one of these categories was classified according to a group and was assigned with a DOC value, also defined by expert guess.

Until 2003 the inventory considered data from the waste registries at a disaggregated level of 6 digits of the European Waste List Decision - 2000/532/EC, by treatment/destiny type; no statistical treatment were made to consider the non-responses. 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) in order to extrapolate the information to the universe of enterprises for each economic branch. The extrapolation is made however at a more aggregated level.

Data considered for the years 2008 onwards, refer to the EWCStat 4.0 categories that are considered as organic waste. These data are presented in the next table.

Table 6-3: 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
								ton						
Health care and biological wastes (05)	0.15	wet waste		98			1	2					7,886	8,586
Paper and cardboard (07.2)	0.40	wet waste		778,422			58,383	278,007					2,320	3,449
Wood 07.5)	0.43	wet waste		155,142			64,044	14,566					20,551	13,947
Textiles (07.6)	0.24	wet waste		63,384			326,329	38,530					30,227	21,777
Waste of food preparation and products (09.1)	0.15	wet waste		19,209			56,455	158,286					14,485	10,604
Garden waste, park waste or other non-food organic putrescibles (09	0.20	wet waste		77,269			208,965	172,135					22,441	6,782
Household and similar wastes (10.1)	0.18	wet waste		-			-	-					70,432	63,690
Mixed and undifferentiated materials (10.21, 10.22)	0.23	wet waste		-			-	-					17,736	16,444
Screening waste (10.3)	0.11	wet waste		-			-	-					6	14
Sludge (03.2, 03.3, 11)	0.13	wet waste		236,280			39,759	22,687					107,577	105,235
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**	**250,527**
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**

Waste groups (EWC-Stat/Version 4)	DOC (0..1)	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
								ton					
Health care and biological wastes (05)	0.15	wet waste	9,605	10,702	27,109	3,882	813	656	486	495	94	90	*87*
Paper and cardboard (07.2)	0.40	wet waste	1,325	1,178	797	385	314	206	349	287	300	284	*273*
Wood 07.5)	0.43	wet waste	6,965	5,326	3,394	1,190	593	869	1,003	3,273	4,037	2,864	*2,761*
Textiles (07.6)	0.24	wet waste	23,218	21,022	14,708	14,288	13,609	12,156	14,618	12,939	14,790	18,299	*17,641*
Waste of food preparation and products (09.1)	0.15	wet waste	9,788	8,887	11,186	10,320	10,871	5,919	4,860	3,464	4,291	4,036	*3,890*
Garden waste, park waste or other non-food organic putrescibles (09	0.20	wet waste	6,127	10,349	6,035	3,601	4,615	6,980	4,138	3,909	4,631	5,508	*5,310*
Household and similar wastes (10.1)	0.18	wet waste	43,978	96,329	49,762	35,743	32,135	29,435	26,085	30,682	36,906	40,151	*38,707*
Mixed and undifferentiated materials (10.21, 10.22)	0.23	wet waste	16,644	15,563	10,639	10,108	10,513	10,836	11,235	11,099	17,408	27,544	*26,553*
Screening waste (10.3)	0.11	wet waste	0	0	336	3,579	99	382	368	278	709	1,010	*974*
Sludge (03.2, 03.3, 11)	0.13	wet waste	107,934	104,565	111,771	104,594	92,752	96,621	127,717	102,307	100,284	103,190	*99,478*
Total fermentable waste disposed on land	-		**225,583**	**273,921**	**235,735**	**187,689**	**166,314**	**164,059**	**190,858**	**168,734**	**183,448**	**202,976**	***195,675***
DOC (weighted average)	-		**0.171**	**0.171**	**0.160**	**0.156**	**0.157**	**0.157**	**0.152**	**0.160**	**0.165**	**0.168**	***0.168***

Notes:
a) DOC values: IPCC 2006.
b) Data on italics: estimates. Emission factors and other parameters

Both data sets, before 2003 and after 2008, refer to substance oriented waste groups. The waste categories considered have been slightly revised for the 2018 submission in order to take account of more specific guidance from IPCC 2006 on DOC defaults. This was the case of previously reported category “paper and textiles”, which is now considered in two different categories.

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 (% 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 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 inerts 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.

6.2.2 NH3 emissions from Solid Waste Disposal Sites (SWDS)

NH_3 emissions are calculated on the basis of CH_4 emission values (calculated under UNFCCC), using the NH_3/CH_4 ratio proposed by Eggleston (1992), i.e. 0.0073 kg NH_3/kg CH_4.

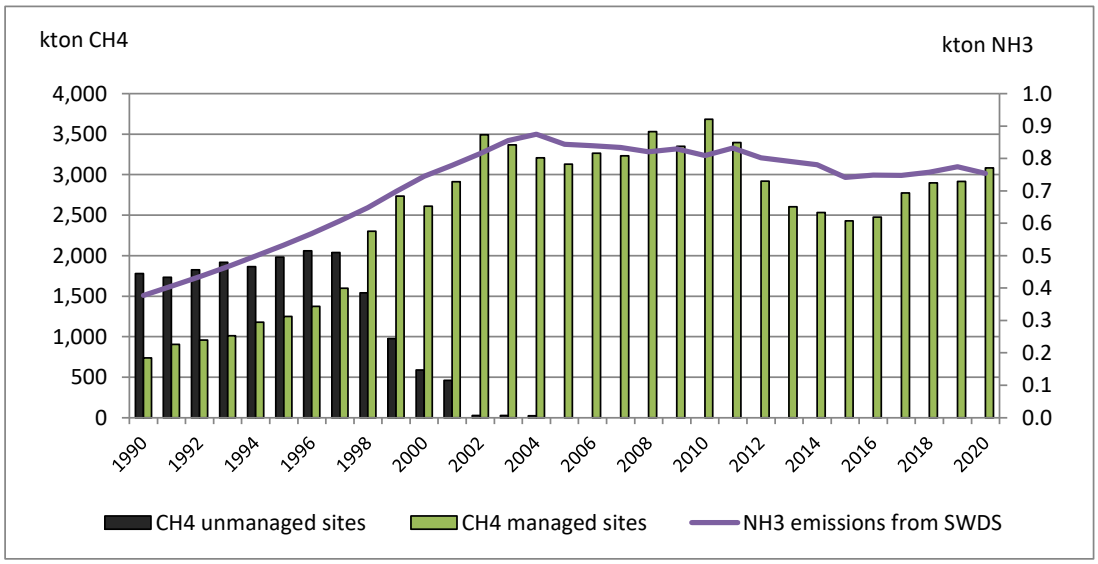


Figure 6-7: Emissions of CH4 and NH3

6.2.3 Emissions from landfill gas and other biogas burning (NFR 5.A)

The capture and burning of landfill gas and biogas (e.g. from sewage sludge) is used for energy purposes or flaring (without energy recovery). Both situations are accounted in this category.

6.2.3.1 Methodology

Emissions from the combustion of landfill gas and biogas with and without energy recovery have been estimated using emission factors based on the energy or the mass of the biogas consumed (combusted).

6.2.3.2 Activity data and parameters

Table 6-4: Activity data, emission factors and emissions resulting from landfill gas and biogas combusted

Quantities of landfill gas and biogas combusted			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	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	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
	Flaring b)	GJ	-	-	-	-	-	266,085	440,544	420,404	416,178	356,085	287,131	60,069	*58,012*	*55,954*	*53,896*	30,104	71,515	15,139	22,987	37,915	56,837

Emission factors			
	NOx	g/GJ	74
	NMVOC	g/GJ	23
	CO	g/GJ	29
	SOx	g/GJ	0.67
	TSP	g/GJ	0.78
	PM10	g/GJ	0.78
	PM2.5	g/GJ	0.78
	BC	% PM2.5	4
	Pb	mg/GJ	0.011
	Cd	mg/GJ	0.0009
	Hg	mg/GJ	0.54
	As	mg/GJ	0.1
	Cr	mg/GJ	0.013
	Cu	mg/GJ	0.0026
	Ni	mg/GJ	0.013
	Se	mg/GJ	0.058
	Zn	mg/GJ	0.73
	DioxFur	nano g TEQ/GJ	0.52
	PAHs	microg/GJ	5.8

(cont.)

Emissions with energy recovery (CRF 1A1a)			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	NOx	ton	2.814	2.076	2.236	1.824	10.845	25.369	21.833	43.069	61.125	65.119	84.805	128.236	163.968	191.300	215.736	218.627	208.297	226.307	217.437	212.783	218.766
	NMVOC	ton	0.875	0.645	0.695	0.567	3.371	7.885	6.786	13.386	18.998	20.240	26.358	39.857	50.963	59.458	67.053	67.952	64.741	70.339	67.582	66.135	67.995
	CO	ton	1.103	0.814	0.876	0.715	4.250	9.942	8.556	16.878	23.954	25.519	33.234	50.255	64.258	74.969	84.545	85.678	81.630	88.688	85.212	83.388	85.733
	SOx	ton	0.025	0.019	0.020	0.017	0.098	0.230	0.198	0.390	0.553	0.590	0.768	1.161	1.485	1.732	1.953	1.979	1.886	2.049	1.969	1.927	1.981
	TSP	ton	0.030	0.022	0.024	0.019	0.114	0.267	0.230	0.454	0.644	0.686	0.894	1.352	1.728	2.016	2.274	2.304	2.196	2.385	2.292	2.243	2.306
	PM10	ton	0.030	0.022	0.024	0.019	0.114	0.267	0.230	0.454	0.644	0.686	0.894	1.352	1.728	2.016	2.274	2.304	2.196	2.385	2.292	2.243	2.306
	PM2.5	ton	0.030	0.022	0.024	0.019	0.114	0.267	0.230	0.454	0.644	0.686	0.894	1.352	1.728	2.016	2.274	2.304	2.196	2.385	2.292	2.243	2.306
	BC	ton	0.001	0.001	0.001	0.001	0.005	0.011	0.009	0.018	0.026	0.027	0.036	0.054	0.069	0.081	0.091	0.092	0.088	0.095	0.092	0.090	0.092
	Pb	ton	0.000000	0.000000	0.000000	0.000000	0.000002	0.000004	0.000003	0.000006	0.000009	0.000011	0.000014	0.000018	0.000023	0.000026	0.000028	0.000033	0.000029	0.000030	0.000029	0.000028	0.000028
	Cd	ton	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000001	0.000001	0.000001	0.000002	0.000002	0.000002	0.000002	0.000003	0.000002	0.000002	0.000002	0.000002	0.000002
	Hg	ton	0.000021	0.000015	0.000016	0.000013	0.000079	0.000185	0.000171	0.000290	0.000425	0.000523	0.000681	0.000901	0.001108	0.001261	0.001391	0.001611	0.001416	0.001480	0.001403	0.001364	0.001394
	As	ton	0.000004	0.000003	0.000003	0.000002	0.000015	0.000034	0.000032	0.000054	0.000079	0.000097	0.000126	0.000167	0.000205	0.000234	0.000258	0.000298	0.000262	0.000274	0.000260	0.000253	0.000258
	Cr	ton	0.000000	0.000000	0.000000	0.000000	0.000002	0.000004	0.000004	0.000007	0.000010	0.000013	0.000016	0.000022	0.000027	0.000030	0.000033	0.000039	0.000034	0.000036	0.000034	0.000033	0.000034
	Cu	ton	0.000000	0.000000	0.000000	0.000000	0.000000	0.000001	0.000001	0.000001	0.000002	0.000003	0.000003	0.000004	0.000005	0.000006	0.000007	0.000008	0.000007	0.000007	0.000007	0.000007	0.000007
	Ni	ton	0.000000	0.000000	0.000000	0.000000	0.000002	0.000004	0.000004	0.000007	0.000010	0.000013	0.000016	0.000022	0.000027	0.000030	0.000033	0.000039	0.000034	0.000036	0.000034	0.000033	0.000034
	Se	ton	0.000002	0.000002	0.000002	0.000001	0.000009	0.000020	0.000018	0.000031	0.000046	0.000056	0.000073	0.000097	0.000119	0.000135	0.000149	0.000173	0.000152	0.000159	0.000151	0.000146	0.000150
	Zn	ton	0.000028	0.000020	0.000022	0.000018	0.000107	0.000250	0.000232	0.000392	0.000575	0.000707	0.000921	0.001218	0.001498	0.001705	0.001880	0.002178	0.001914	0.002001	0.001897	0.001844	0.001884
	DioxFur	g I-TEQ	0.000020	0.000015	0.000016	0.000013	0.000076	0.000178	0.000165	0.000279	0.000409	0.000504	0.000656	0.000868	0.001067	0.001214	0.001339	0.001552	0.001363	0.001425	0.001351	0.001313	0.001342
	PAHs	ton	0.000000	0.000000	0.000000	0.000000	0.000001	0.000002	0.000002	0.000003	0.000005	0.000006	0.000007	0.000010	0.000012	0.000014	0.000015	0.000017	0.000015	0.000016	0.000015	0.000015	0.000015
Emissions without energy recovery (CRF 5A)			**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
	NOx	ton	-	-	-	-	-	19.690	32.600	31.110	30.797	26.350	21.248	4.445	4.293	4.141	3.988	2.228	5.292	1.120	1.701	2.806	4.206
	NMVOC	ton	-	-	-	-	-	6.120	10.133	9.669	9.572	8.190	6.604	1.382	1.334	1.287	1.240	0.692	1.645	0.348	0.529	0.872	1.307
	CO	ton	-	-	-	-	-	7.716	12.776	12.192	12.069	10.326	8.327	1.742	1.682	1.623	1.563	0.873	2.074	0.439	0.667	1.100	1.648
	SOx	ton	-	-	-	-	-	0.178	0.295	0.282	0.279	0.239	0.192	0.040	0.039	0.037	0.036	0.020	0.048	0.010	0.015	0.025	0.038
	TSP	ton	-	-	-	-	-	0.208	0.344	0.328	0.325	0.278	0.224	0.047	0.045	0.044	0.042	0.023	0.056	0.012	0.018	0.030	0.044
	PM10	ton	-	-	-	-	-	0.0016	0.0027	0.0026	0.0025	0.0022	0.0017	0.0004	0.0004	0.0003	0.0003	0.0002	0.0004	0.0001	0.0001	0.0002	0.0003
	PM2.5	ton	-	-	-	-	-	0.0016	0.0027	0.0026	0.0025	0.0022	0.0017	0.0004	0.0004	0.0003	0.0003	0.0002	0.0004	0.0001	0.0001	0.0002	0.0003
	BC	ton	-	-	-	-	-	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Pb	ton	-	-	-	-	-	0.000003	0.000005	0.000005	0.000005	0.000004	0.000003	0.000001	0.000001	0.000001	0.000001	0.000000	0.000001	0.000000	0.000000	0.000000	0.000001
	Cd	ton	-	-	-	-	-	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	Hg	ton	-	-	-	-	-	0.000144	0.000238	0.000227	0.000225	0.000192	0.000155	0.000032	0.000031	0.000030	0.000029	0.000016	0.000039	0.000008	0.000012	0.000020	0.000031
	As	ton	-	-	-	-	-	0.000027	0.000044	0.000042	0.000042	0.000036	0.000029	0.000006	0.000006	0.000006	0.000005	0.000003	0.000007	0.000002	0.000002	0.000004	0.000006
	Cr	ton	-	-	-	-	-	0.000003	0.000006	0.000005	0.000005	0.000005	0.000004	0.000001	0.000001	0.000001	0.000001	0.000000	0.000001	0.000000	0.000000	0.000000	0.000001
	Cu	ton	-	-	-	-	-	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	Ni	ton	-	-	-	-	-	0.000003	0.000006	0.000005	0.000005	0.000005	0.000004	0.000001	0.000001	0.000001	0.000001	0.000000	0.000001	0.000000	0.000000	0.000000	0.000001
	Se	ton	-	-	-	-	-	0.000015	0.000026	0.000024	0.000024	0.000021	0.000017	0.000003	0.000003	0.000003	0.000003	0.000002	0.000004	0.000001	0.000001	0.000002	0.000003
	Zn	ton	-	-	-	-	-	0.000194	0.000322	0.000307	0.000304	0.000260	0.000210	0.000044	0.000042	0.000041	0.000039	0.000022	0.000052	0.000011	0.000017	0.000028	0.000041
	DioxFur	g I-TEQ	-	-	-	-	-	0.000138	0.000229	0.000219	0.000216	0.000185	0.000149	0.000031	0.000030	0.000029	0.000028	0.000016	0.000037	0.000008	0.000012	0.000020	0.000030
	PAHs	ton	-	-	-	-	-	0.0000015	0.0000026	0.0000024	0.0000024	0.0000021	0.0000017	0.0000003	0.0000003	0.0000003	0.0000003	0.0000002	0.0000004	0.0000001	0.0000001	0.0000002	0.0000003

Notes:
DGEG data
Data refer to landfill gas flared without energy recovery. APA data.

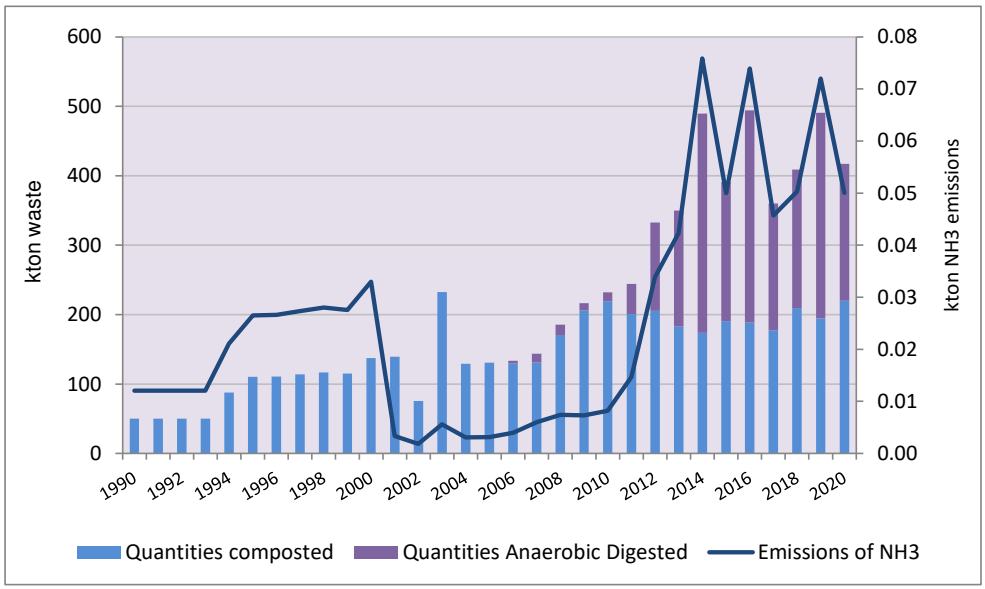
6.2.4 NH3 emissions from Biological Treatment of Waste - Composting (NFR 5.B.1) and Anaerobic Digestion (NFR 5.B.2)

6.2.4.1 Methodology

Emission estimates follow Tier 2 approach for composting indicated in the 2016 Guidebook.

6.2.4.2 Activity data

The activity level for past years is based on estimated data as previously explained (section 6.2.1.1.2.1.1 - Quantities of waste landfilled). Data for recent years refer to data collected from management systems.



Source:APA

Figure 6-8: Quantities of municipal waste composted/ Digested and related NH3 emissions

6.2.4.3 Emission factors

Emission factors for compost reflect change in treatment technology. Until 1999 NH3 emissions from domestic composting of organic waste were estimated to be without control; after 2000 it was assumed the existence of emission control with bio-filters.

Table 6-5: Ammonia emission factors for compost production

	EF g NH3/ton SW	Source
Uncontrolled	240	2019 EEA Guidebook (Tier 2 default)
Biofilter	24	2019 EEA Guidebook (Tier 2 default)

The Tier 1 approach estimates the emissions from anaerobic digestion from the total annual amount of N in feedstock, and an EF NH3-N related to N in feedstock.

Table 6-6: Ammonia emission factors for anaerobic digestion at biogas facilities

	Value	Source
EF (kg NH3-N per kg N in feedstock)	0.0275	2019 EEA Guidebook (Tier 1)
N content of fresh matter (kg kg–1) in Municipal organic waste	0.0068	2019 EEA Guidebook (Tier 1)

6.2.5 Waste Incineration (NFR 5.C)

Waste incineration originates emissions of several pollutants. The inventory includes estimates for SO_2, NO_x, NMVOC, CO, NH_3, Particulates and Heavy Metals emissions from the incineration of waste. Furthermore, these sources are also relevant in terms of Dioxins and Furans, PAHs, HCB and PCBs emissions.

The IPCC GPG determines that emissions from incineration with energy recovery should be reported in the energy sector (sub-category 1A1a Public electricity and heat production).

Incineration of municipal waste (MSW) in Portugal takes place in four modern units (two in Portugal Mainland) where energy is recovered, and thus these emissions are accounted for in the energy sector. The incineration of healthcare waste occurs without energy recovery and 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.

This category includes also emissions from the incineration of industrial waste in industrial units. The emissions from cremation are also quantified.

Open burning of waste (NFR 5C2) is prohibited in Portugal and are reported as 'not occurring (NO)'. Any emissions resulting from the open burning of wood and other plant material are considered in the agricultural sector.

6.2.5.1 Methodology

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.

$$\text{Non-}CO_2 \text{ emissions (Gg/yr)} = \sum_i (IW_i * EF_i) * 10^{-6}$$

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)

6.2.5.2 Activity data

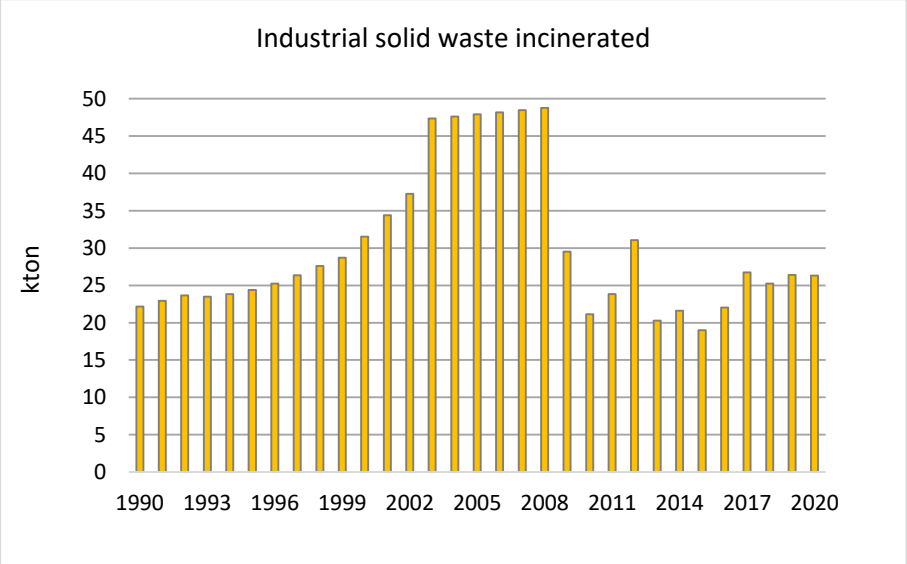
6.2.5.2.1 Industrial waste incineration (NFR 5.C.1.b.i)

Data refer to incineration of industrial waste in industrial units collected in APA. 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) 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 6-9: Quantities of combusted industrial waste

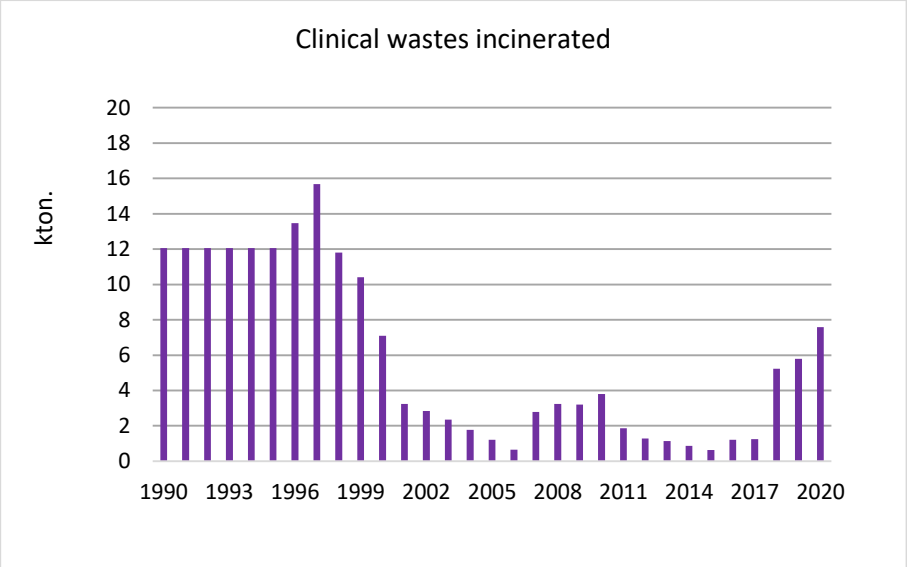
The fluctuations on the amounts of industrial waste incineration, as shown in the previous figure, results, at least partially, from the variation of fluxes to other treatments (landfilling, shipping abroad and recycling) as a consequence of the annual waste market demand.

6.2.5.2.1.1 Hazardous Waste Incineration (NFR 5.C.1.b.ii)

Emissions from hazardous waste incineration are included in 5C1bi Industrial waste incineration and are reported as 'included elsewhere (IE)'.

6.2.5.2.1.2 Healthcare waste (NFR 5.C.1.b.iii)

Data on healthcare waste incinerated refers to data declared in registry maps of public and private healthcare units (for human and animal), research centres and other units (e.g. piercings, tattoos). The quantities of healthcare waste incinerated decreased strongly in the years 2000s as shown in the next figure. Twenty-five incinerators were closed in recent years in Mainland Portugal, and only 1 remaining healthcare waste incinerator is operating since 2004. This infrastructure is nowadays closed.



Note: Data for 2020 are still not available. Data refer to estimates assuming a 30% increase of healthcare waste due to the Covid19 pandemic.
Sources: APA; DGS.

Figure 6-10: Quantities of healthcare waste incinerated

At present, there are two healthcare incinerators in Portugal: the "Centro Integrado de Gestão de Resíduos (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 medicine waste, animal by-products and other type of wastes that need destruction by incineration.

In the CIVTRHI, he 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.

6.2.5.2.1.3 Sewage sludge incineration (NFR 5.C.1.b.iv)

Emissions from sewage sludge incineration are included in 5C1bi Industrial waste incineration and in 1A1a MSW incineration with energy recovery, and are reported as 'included elsewhere (IE)'.

6.2.5.2.1.4 Municipal waste (accounted in NFR 1.A.1.a)

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. These units are dedicated to the incineration of MSW which includes domestic and commercial waste. (Figure 6.10).

The emissions from MSW incineration occur with energy recovery and are therefore accounted in the energy sector (category 1A1a).

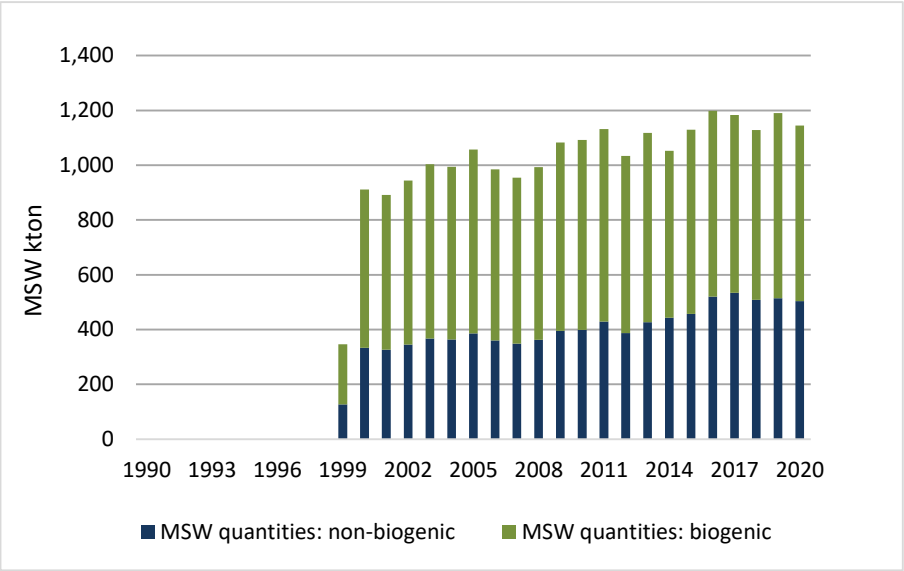


Figure 6-11: Quantities of Municipal Solid Waste incinerated

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 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 NO_x, 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.

6.2.5.2.2 Emission factors

Emission factors applied are either country-specific, being obtained from monitoring data in incineration units, or obtained from references US/AP42 or EMEP/CORINAIR.

Table 6-7: Emission factors of CLRTAP gases for incineration of Industrial Waste

Pollutants	Unit	EF	Source
SOx	kg/ton MSW	0.047	2019 EEA Guidebook (Tier 1 default EF)
NOx	kg/ton MSW	0.87	2019 EEA Guidebook (Tier 1 default EF)
NMVOC	kg/ton MSW	7.4	2019 EEA Guidebook (Tier 1 default EF)
CO	kg/ton MSW	0.07	2019 EEA Guidebook (Tier 1 default EF)
PST	kg/ton MSW	0.01	2019 EEA Guidebook (Tier 1 default EF)
PM10	kg/ton MSW	0.007	2019 EEA Guidebook (Tier 1 default EF)
PM2.5	kg/ton MSW	0.004	2019 EEA Guidebook (Tier 1 default EF)
BC	% of PM2.5	3.5	2019 EEA Guidebook (Tier 1 default EF)
Pb	g/ton MSW	1.3	2019 EEA Guidebook (Tier 1 default EF)
As	g/ton MSW	0.016	2019 EEA Guidebook (Tier 1 default EF)
Cd	g/ton MSW	0.1	2019 EEA Guidebook (Tier 1 default EF)
Cr	g/ton MSW	0.13	AP-42. Chp 2.1 (Refuse Combustion) a)
Hg	g/ton MSW	0.056	2019 EEA Guidebook (Tier 1 default EF)
Ni	g/ton MSW	0.14	2019 EEA Guidebook (Tier 1 default EF)
PCDD/ Fs	g TEQ/ton MSW	0.00035	2019 EEA Guidebook (Tier 1 default EF)
Total PAHs	g/ton MSW	0.02	2019 EEA Guidebook (Tier 1 default EF)
HCB	g/ton MSW	0.002	2019 EEA Guidebook (Tier 1 default EF)
PCB	g/ton MSW	2.59	EIIP: chapter 16 Open burning municipal waste; table 16.4-1; EF source: EPA, 1997

Notes:
a) Mass Burn Waterwall Combustor (MW/WW) with Eletrostatic Prec. And Semi-wet scrubber (same as Spray Dryier) SD/ESP

Table 6-8: Emission factors of CLRTAP gases from incineration of healthcare wastes: until 2004

Pollutants	Unit	EF	Source
SOx	kg/ton W	1.09	2019 EEA Guidebook (Tier 2, Uncontroled)
NOx	kg/ton W	1.78	2019 EEA Guidebook (Tier 2, Uncontroled)
COVNM	kg/ton W	0.7	2019 EEA Guidebook (Tier 2, Uncontroled)
CO	kg/ton W	1.48	2019 EEA Guidebook (Tier 2, Uncontroled)
NH3	kg/ton W	0.0043	Country measured data
Pb	kg/ton W	0.0364	2019 EEA Guidebook (Tier 2, Uncontroled)
PST	kg/ton W	2.33	2019 EEA Guidebook (Tier 2, Uncontroled)
PM10	% PST	65	2019 EEA Guidebook (Tier 2, Uncontroled)
PM2.5	% PST	43.3	2019 EEA Guidebook (Tier 2, Uncontroled)
BC	% PST	2.3	2019 EEA Guidebook (Tier 2, Uncontroled)
Cd	kg/ton W	0.00274	2019 EEA Guidebook (Tier 2, Uncontroled)
Hg	kg/ton W	0.0537	2019 EEA Guidebook (Tier 2, Uncontroled)
As	kg/ton W	0.000121	2019 EEA Guidebook (Tier 2, Uncontroled)
Cr	kg/ton W	0.000388	2019 EEA Guidebook (Tier 2, Uncontroled)
Cu	kg/ton W	0.0006	2007 guid CR, Plant type: controlled air; Abatem: uncontrolled; refª USEPA1998
Ni	kg/ton W	0.000295	2019 EEA Guidebook (Tier 2, Uncontroled)
DioxFur	g I-TEQ/ton W	0.04	2019 EEA Guidebook (Tier 2, Uncontroled)
PAH	g/ton W	0.00004	2019 EEA Guidebook (Tier 2, Uncontroled)
PCB	g/ton W	0.0233	2019 EEA Guidebook (Tier 2, Uncontroled)
HCB	g/ton W	0.1	2019 EEA Guidebook (Tier 2, Uncontroled)

Table 6-9: Emission factors of CLRTAP gases from incineration of healthcare wastes: after 2005

Pollutants	Unit	EF	Efficiency	Source
SOx	kg/ton W	0.0872	92.0%	2019 EEA Guidebook (Tier 2, Controled by various types of abatement)
NOx	kg/ton W	1.78	-	2019 EEA Guidebook (Tier 2, Uncontroled)
COVNM	kg/ton W	0.7	-	2019 EEA Guidebook (Tier 2, Uncontroled)
CO	kg/ton W	1.48	-	2019 EEA Guidebook (Tier 2, Uncontroled)
NH3	kg/ton W	0.0043	-	Country measured data
Pb	kg/ton W	0.002002	94.5%	2019 EEA Guidebook (Tier 2, Controled by various types of abatement)
PST	kg/ton W	0.233	90.0%	2019 EEA Guidebook (Tier 2, Controled by various types of abatement)
PM10	% PST	65	-	-
PM2.5	% PST	43.3	-	-
BC	% PST	2.3	-	-
Cd	kg/ton W	0.0001096	96.0%	2019 EEA Guidebook (Tier 2, Controled by various types of abatement)
Hg	kg/ton W	0.001611	97.0%	2019 EEA Guidebook (Tier 2, Controled by various types of abatement)
As	kg/ton W	0.00000121	99.0%	2019 EEA Guidebook (Tier 2, Controled by various types of abatement)
Cr	kg/ton W	0.00001552	96.0%	2019 EEA Guidebook (Tier 2, Controled by various types of abatement)
Cu	kg/ton W	0.000246	59.0%	2019 EEA Guidebook (Tier 2, Controled by various types of abatement)
Ni	kg/ton W	0.000295	-	2019 EEA Guidebook (Tier 2, Uncontroled)
DioxFur	g I-TEQ/ton W	0.0004	99.0%	2019 EEA Guidebook (Tier 2, Batch type conversion, good APC)
PAH	g/ton W	0.00004	-	2019 EEA Guidebook (Tier 2, Uncontroled)
PCB	g/ton W	0.0233	-	2019 EEA Guidebook (Tier 2, Uncontroled)
HCB	g/ton W	0.1	-	2019 EEA Guidebook (Tier 2, Uncontroled)

Table 6-10: Emission factors of CLRTAP gases from incineration of MSW

Pollutants	Unit	EF	Source
SOx	kg/ton MSW	[0.0152 - 0.0743]	Plant Specific (Monitoring Data)
NOx	kg/ton MSW	[0.444 - 1.2069]	Plant Specific (Monitoring Data)
COVNM	kg/ton MSW	[0.0006 - 0.0059]	Plant Specific (Monitoring Data); 2016 EEA Guidebook (Tier 1); Nielsen et al. (2010)
CO	kg/ton MSW	[0.0075 - 0.0708]	Plant Specific (Monitoring Data)
NH3	kg/ton MSW	[0.0013 - 0.0354]	Plant Specific (Monitoring Data)
Pb	kg/ton MSW	[0.00002 - 0.00029]	Plant Specific (Monitoring Data)
PST	kg/ton MSW	[0.00124 - 0.01736]	Plant Specific (Monitoring Data)
PM10	kg/ton MSW	[0.00124 - 0.01736]	
PM2.5	kg/ton MSW	[0.00124 - 0.01736]	
BC	% of PM2.5	3.5	2019 EEA Guidebook (Olmez et al. (1988))
Cd	kg/ton MSW	[0.0000007 - 0.0000117]	Plant Specific (Monitoring Data)
Hg	kg/ton MSW	[0.0000072 - 0.000033]	Plant Specific (Monitoring Data)
As	g/ton MSW	[0.00056 - 0.0154]	Plant Specific (Monitoring Data)
Cr	g/ton MSW	[0.00942 - 0.19362]	Plant Specific (Monitoring Data)
Cu	g/ton MSW	[0.0137 - 0.48019]	Plant Specific (Monitoring Data)
Ni	g/ton MSW	[0.0216 - 0.25218]	Plant Specific (Monitoring Data)
Se	g/ton MSW	0.0117	2019 Guidebook (Tier 1); Nielsen et al. (2010)
Zn	g/ton MSW	0.0245	2019 Guidebook (Tier 1); Nielsen et al. (2010)
DioxFur	g I-TEQ/ton MSW	[0.00000003 - 0.0000122]	Plant Specific (Monitoring Data)
PAH	g/ton MSW	0.0000474	2019 Guidebook (Tier 1); Nielsen et al. (2010)
HCB	g/ton MSW	0.0000452	2019 Guidebook (Tier 1); Nielsen et al. (2010)
PCB	g/ton MSW	0.0000000034	2019 Guidebook (Tier 1); Nielsen et al. (2010)

6.2.6 Cremation (NFR 5.C.1.b.v)

This category includes the cremation of human corpses.

The inventory covers also the co-incineration of animal carcasses and by-products in cement plants (included in NFR 1A2f). Quantities of animal by-products are also incinerated in other facilities and included in industrial waste incineration (5C1bi).

The contribution of crematoria to national emissions is generally comparatively small for all pollutants except for heavy metals (HM). Other potential emissions are: dioxins and furans and polycyclic aromatic hydrocarbons (PAHs).Emission estimates follow the simpler methodology (tier 1 default) indicated in 2016 EEA Guidebook, based on activity data multiplied by default emission factors.

6.2.6.1 Activity data

The importance of cremation has been steadily growing and represents at present 18% of funeral types.

Table 6-11: Number of human corpses cremated

Year	Number of corpses	Year	Number of corpses	Year	Number of corpses
1990	131	2000	1,706	2010	8,752
1991	250	2001	2,053	2011	9,849
1992	268	2002	2,446	2012	12,117
1993	517	2003	3,085	2013	12,589
1994	593	2004	3,441	2014	13,433
1995	677	2005	4,110	2015	15,438
1996	744	2006	4,492	2016	17,396
1997	912	2007	5,323	2017	18,913
1998	1,124	2008	6,889	2018	20,625
1999	1,541	2009	7,750	2019	21,100
-	-	-	-	2020	27,430

Note: 2019 and 2020 are estimates.
Source: Servilusa/ Associação Portuguesa dos Profissionais do Sector Funerário

Table 6-12: Emission factors of CLRTAP gases for cremation

Pollutants	Unit	EF	Source
SOx	kg/body	0.113	2019 EEA Guidebook, Tier 1 default
NOx	kg/body	0.825	2019 EEA Guidebook, Tier 1 default
COVNM	kg/body	0.013	2019 EEA Guidebook, Tier 1 default
CO	kg/body	0.14	2019 EEA Guidebook, Tier 1 default
Pb	mg/body	30.03	2019 EEA Guidebook, Tier 1 default
PST	g/body	38.56	2019 EEA Guidebook, Tier 1 default
Cd	mg/body	5.03	2019 EEA Guidebook, Tier 1 default
Hg	g/body	1.49	2019 EEA Guidebook, Tier 1 default
As	mg/body	13.61	2019 EEA Guidebook, Tier 1 default
Cr	mg/body	13.56	2019 EEA Guidebook, Tier 1 default
Cu	mg/body	12.43	2019 EEA Guidebook, Tier 1 default
Ni	mg/body	17.33	2019 EEA Guidebook, Tier 1 default
Se	mg/body	19.78	2019 EEA Guidebook, Tier 1 default
Zn	mg/body	160.12	2019 EEA Guidebook, Tier 1 default
PCDD/ PCDF (DioxFur)	µg/body	0.027	2019 EEA Guidebook, Tier 1 default
benzo(a)pyrene	µg/body	13.2	2019 EEA Guidebook, Tier 1 default
benzo(b)fluoranthene	µg/body	7.21	2019 EEA Guidebook, Tier 1 default
benzo(k)fluoranthene	µg/body	6.44	2019 EEA Guidebook, Tier 1 default
indeno(1,2,3-cd)pyrene	µg/body	6.99	2019 EEA Guidebook, Tier 1 default
PCB	mg/body	0.41	2019 EEA Guidebook, Tier 1 default
HCB	mg/body	0.15	2019 EEA Guidebook, Tier 1 default

6.2.7 Wastewater Handling (NFR 5.D)

6.2.7.1 Domestic Wastewater

Wastewater treatment systems types determine the level of air pollution emissions.

Until the 2018 submission, the accounting of this category was based exclusively 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 for wastewater handling systems 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.

As a consequence of the restructuration of the National Water Authority, the INSAAR, the national data base for wastewater treatment systems was deactivated and the last available year from this survey is the year 2009. Until the 2018 submission, data used for the period 2010-2016 referred to the latest available year of this survey (2009).

In order to overcome this situation, data on wastewater treatment types for this period was revised, based on new data collected for 2015 from Águas de Portugal (AdP Group) and other main WW treatment plants information registered by APA.

AdP Group is a Portuguese state-owned company that operates in the water sector. AdP Group companies operates in mainland Portugal and in the fields of water supply and wastewater sanitation, namely the

capture, treatment and distribution of water for public consumption and the collection, transport, treatment and disposal of urban and industrial wastewater, including their recycling and reuse.

AdP´s universe represents approximately 60% of WW Treatment in Portugal. Together with other large WW treatment plants (> 50 000 inhab. eq.), managed by municipal entities, data on WW treatment for 2015 is considered to represent around 70% of Portuguese population.

For the remaining share of the Portuguese population, two sets of data were considered for WW handling system types: one in mainland Portugal and the other referring to the Autonomous Regions of Madeira and Azores.

The next table shows the evolution of the total population by wastewater handling system.

For the period 1990-2009, data corresponds to previous set of data used in the preceding submissions, and thus refers to wastewater sanitation surveys from the National Water Authority.

For the years after 2010, data considered includes the 3 sets of information:

- the AdP´s universe representing, together with other major WW treatment, approximately 70% of population served;
- the Autonomous Regions (islands of Madeira and Açores) which represents around 5% of population;
- other systems in mainland Portugal, amounting for the remaining share of population.

Table 6-13: Percentage of population by wastewater handling system

Wastewater handling systems		1990	1994	1999	2000	2005	2010	2015	2016	2017	2018	2019	2020
		% population											
Population without sewerage		**38.5**	**31.6**	**21.2**	**22.3**	**27.5**	**21.2**	**16.1**	**16.0**	**16.0**	**15.9**	**15.8**	**15.6**
1.1-	% Pop: without sewerage (latrines)	37.0	23.4	6.4	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2-	% Pop: individual treatment (private septic tanks)	1.5	8.2	14.8	16.9	27.5	21.2	16.1	16.0	16.0	15.9	15.8	15.6
Population with sewerage		**43.3**	**47.4**	**36.8**	**31.9**	**7.5**	**7.1**	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**	**1.4**
2.1-	% de Pop: with discharge into the ocean, without treatment	6.5	6.5	6.5	5.6	1.0	1.1	0.4	0.4	0.4	0.4	0.4	0.3
2.2-	% de Pop: with discharge into inland waters, without treatment	36.8	40.8	30.3	25.9	4.0	1.1	0.2	0.2	0.2	0.2	0.2	0.2
2.3-	% de Pop: with discharge into soil, without treatment	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.4-	% de Pop: unknown disposal	0.0	0.0	0.0	0.4	2.4	4.9	0.9	0.9	0.9	0.9	0.9	0.9
3-	**% Pop: with treatment**	**18.2**	**21.1**	**42.0**	**45.8**	**65.0**	**71.7**	**82.4**	**82.4**	**82.5**	**82.6**	**82.8**	**83.0**
3.1-	**% Pop: colective septic tanks**	2.2	2.3	5.0	5.0	5.0	2.7	0.7	0.7	0.7	0.7	0.7	0.7
3.2-	**% Pop: with preliminary treatment**	0.0	0.0	0.0	0.5	3.0	6.9	1.8	1.8	1.8	1.1	1.1	1.1
3.3-	**% Pop: with primary treatment**	5.2	5.2	9.0	8.5	6.0	2.9	10.1	10.1	10.1	9.5	9.4	9.4
3.4-	**% Pop: with secondary and tertiary treatment**	**10.8**	**13.6**	**28.0**	**31.8**	**51.0**	**59.3**	**69.7**	**69.8**	**69.8**	**71.3**	**71.5**	**71.8**
3.4.1-	Biodisks with anaerobic sludge digestion	1.1	1.4	2.0	1.7	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
3.4.2-	Biodisks without anaerobic sludge digestion	0.0	0.0	0.0	0.1	0.8	0.2	0.2	0.2	0.2	0.2	0.2	0.2
3.4.3-	Activated sludge with anaerobic sludge digestion	1.4	2.0	4.6	6.9	18.5	18.3	30.8	30.9	30.9	30.9	30.9	30.8
3.4.4-	Activated sludge without anaerobic sludge digestion	1.4	2.0	4.6	5.8	11.7	14.4	18.4	18.5	18.5	18.5	18.7	18.9
3.4.5-	Laguning, with anaerobic pond	1.7	1.9	3.6	3.0	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3.4.6-	Laguning, without anaerobic pond	0.6	0.6	1.2	1.9	5.3	4.2	4.2	4.2	4.2	4.3	4.3	4.3
3.4.7-	Percolation beds with anaerobic sludge digestion	3.6	4.6	8.8	8.0	3.7	2.8	2.5	2.5	2.5	2.5	2.5	2.5
3.4.8-	Percolation beds without anaerobic sludge digestion	0.0	0.0	0.0	0.7	3.9	1.9	2.5	2.5	2.6	2.6	2.5	2.5
3.4.9-	Imhoff Tank	0.6	0.3	0.1	0.3	1.3	0.8	0.3	0.3	0.3	0.3	0.3	0.3
3.4.10-	Oxidation ponds with anaerobic sludge digestion	0.0	0.0	0.0	0.1	0.6	0.6	0.4	0.4	0.4	0.4	0.4	0.4
3.4.11-	Oxidation ponds without anaerobic sludge digestion	0.3	0.4	1.6	1.6	1.5	1.3	0.6	0.5	0.5	0.5	0.5	0.5
3.4.12-	Other treatment with anaerobic sludge digestion	0.0	0.0	0.0	0.4	2.3	2.1	0.0	0.0	0.0	0.0	0.0	0.0
3.4.13-	Other treatment without anaerobic sludge digestion	0.0	0.3	1.6	1.4	0.2	1.4	9.4	9.5	9.5	10.9	10.9	10.9
3.4.14-	With unspecified treatment	0.0	0.0	0.0	0.1	0.8	10.8	0.0	0.0	0.0	0.0	0.0	0.0

Source: APA.

6.2.7.1.1 NMVOC emissions from wastewater (Human Sewage)

6.2.7.1.1.1 Methodology, activity data and parameters

Total population for each year was multiplied by a default emission factor for NMVOC of 15 mg/m3 waste water proposed by the 2019 EEA Guidebook:

$$NMVOC = Population * 15\ mg/10^3\ l\ wastewater * 125\ l/inhabitant.day * 365$$

The daily human sewage production average (125 l/inh.day) was taken from “Regulamento Geral dos Sistemas Públicos e Prediais de Distribuição de Água e Drenagem de Águas Residuais” (Decree-law 23/95 23rd August).

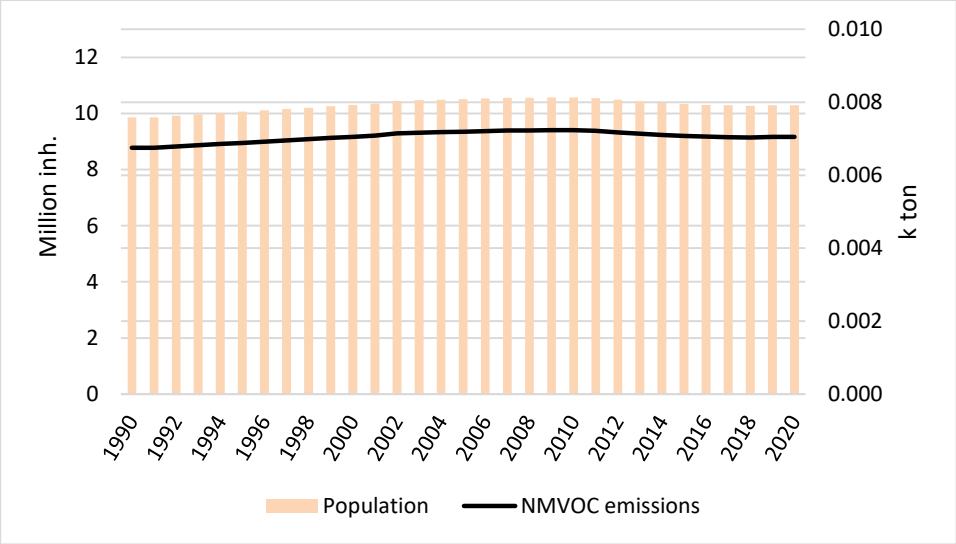


Figure 6-12: NMVOC emissions

6.2.7.1.2 NH3 emissions from Wastewater Handling (WWH)

NH3 emissions result mainly from the decomposition of urea and uric acid contained in human excreta. The estimates considered the population served by latrines.

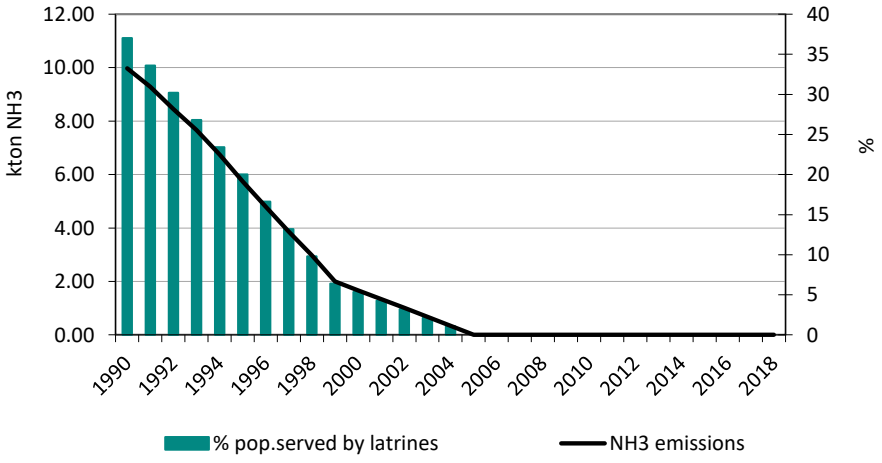


Figure 6-13: NH3 emissions and % population served by latrines

6.2.7.1.2.1 Methodology

Emissions were calculated, as follows:

$$NH_3(S) = (Protein * F_{NPR} * F_{NON\text{-}CON} * EF * Pop - N_{SLUDGE}) * Stor * 17/14$$

Where:

$NH3_{(s)}$ - NH3 emissions from human sewage (kg NH_3-N/yr);

Protein - annual per capita protein intake (kg/person/yr);

F_{NPR} - fraction of nitrogen in protein (0.16 kg N/kg protein - IPCC default);

$F_{NON-CON}$ - Fraction of non-consumed protein added to the wastewater (0.2);

EF - emissions factor (0.3 kg NH_3-N/kg sewage-N produced);

Pop - number of inhabitants in country;

N_{SLUDGE} – nitrogen applied in agriculture soils, kg N/yr;

Stor - % population served by latrines;

17/14 is the molecular weight ratio of NH_3 to N.

6.2.7.1.2.2 Activity data

Activity data results of protein intake, according to national data from National Statistical Office (INE) (please see next table), multiplied by total population, from the INE Census for the years 1981, 1991, 2001, and 2011; intermediate years have been estimated by interpolation. Data on annual per capita protein intake refer to the "Balança Alimentar Portuguesa - BAP" which is updated every five years. The latest data that come available in 2017 refer to the 2012-2016 period. Other parameters used in the estimations are based on the 2006 IPCC defaults.

Table 6-14: Data and parameters used calculation of NH3 emissions from wastewater

Parameter	Year	INE data (kg/person/year)
Annual per capita protein intake	1990	39.24
	1991	40.19
	1992	40.52
	1993	41.17
	1994	41.35
	1995	40.92
	1996	41.06
	1997	41.39
	1998	42.74
	1999	43.84
	2000	43.51
	2001	43.62
	2002	43.87
	2003	43.65
	2004	43.65
	2005	43.22
	2006	44.02
	2007	45.19
	2008	46.03
	2009	46.03
	2010	45.73
	2011	44.79
	2012	44.24
	2013	43.84
	2014	44.35
	2015	45.26
	2016	45.59
	2017	46.57
	2018	47.60
	2019	48.62
	2020	48.80
Fraction of nitrogen in protein	16%	2006 IPCC default
Fraction of non-consumed	20%	Expert judgement

INE (2021), Portuguese Food Balance Sheet (BAP) - 2016 - 2020

6.2.7.1.2.3 Emission factors

The EF proposed by EMEP/CORINAIR (EEA, 2002) was used: 0.3 kg NH_3-N/kg sewage-N produced, which is based on the assumption that during storage for one year, approximately 30% of nitrogen is emitted as NH_3 in an evaporation process.

6.2.7.2 Industrial Wastewater

6.2.7.2.1 NMVOC emissions

6.2.7.2.1.1 Methodology, activity data and parameters

Emissions were calculated on the basis of an emission factor value of 0.15 mg NMVOC/m3 wastewater, and the quantities of wastewater discharged in m3 for each industry sector considered.

EF = 0.15 mg/m^3 wastewater * volumes of wastewater produced

Data on industrial discharges and handling systems types are scattered and difficult to obtain. The approach used in the Portuguese inventory estimates the volumes of industrial wastewater production using statistical production data on industries (IndPROD, t product/yr) multiplied by discharge coefficients (m3/t product).

For each industrial sector identified, several statistical information sources - although obtained from the same institution - had to be used to establish the full time series from 1990 to 2017. Nevertheless, efforts were made to guarantee that the consistency in time series was not impaired by the use of different origins of information.

As regards the sources of information:

- Preference was given to statistical information publicly available from the webpage of the National Statistical Institute (INE) - http://www.ine.pt/prodserv. The use of these data guarantees the absence of confidential issues and usually comprehends the full time-series. It was not possible to use this data for all sectors because the level of disaggregation was seldom compatible with the needs of the inventory;
- The National Statistical Institute (INE) makes periodical annual surveys on industrial production. Unfortunately the survey that was executed until 1991, the IAIT survey, uses a different methodology, than the one that was used in the IAPI survey, that is being used since 1992.
- The IAIT survey was based on an inquiry to each industrial facility, used the Economic Activity Class code rev.1 (CAE rev 1) and a set of specific codes for products and materials. The IAPI survey uses the new revision of the CAE system (CAE rev2), and products and materials use a common code system (PRODCOM) in connection with CAE code. In opposition to the IAIT survey, the IAPI collected data for each company (headquarters). These two surveys are delivered to the APA for inventory purposes, but with the compromise that confidential data could not be published;
- Refining of crude oil and petroleum products was establish from the DGEG's Energy Balance and Galp´s Reports, which data is available annually from 1990 till 2019;
- Production of paper pulp was available directly from the individual industrial plants, for the all period.

The next tables present the building blocks of the activity data time series from the available information. Gaps in mid years were estimated by linear interpolation. In a similar mode, linear extrapolation was used to estimate data for years 1990-1991 and 2001 till 2009, whenever they were not available. All constructed time series were checked against the occurrence of inconsistencies that could appear due to the use of different sources of information1. The checking of the time series was based on graph plotting of the data, and basically the aim was to detected unexpected sudden changes in the magnitude of the time series from 1991 till 1992, when IAIT was changed to IAPI. In some situations the beginning years when IAPI was started had to be discarded, because a sudden and temporary drop from IAIT values was observable and after some years they rise again and continue with a trend compatible with that that existed in IAIT. It was assumed that an adaptation period to the new industrial survey lead to a temporary underestimation of industrial production statistics.

Table 6-15: Sources of Information used to define the time-series of industrial production (1/2)

Industry	IAIT CAE rev1	IAPI PRODCOM	Infoline	Note
Slaughter House			1990-2020	Cattle, sheep, goats and horses
Slaughter House, swine			1990-2020	
Slaughter House, Poultry			1990-2020	Broilers, Turkeys, ducks, quails, ostrich, guinea-fowl, geese, pheasants, partridge and pigeons
Meat Packing	311120	15130-1513013-151301190200	-	
Milk processing	3112		1994-2020	
Cheese	3112	15510	-	
Other dairy products	3112		1994-2020	Cream, yugurt, powder milk, ice-creams
Fruit and vegetables conservation	3114		1994-2020	
Tomato juice			1994-2020	
Fruit Juices	3131+3132		1994-2020	
Fish processing and canning	3114	15200	-	
Olive oil production		15412	-	
Olive oil processing	31152	15420113	-	
Edible oils	31152	1541; 1542	-	Only Olive oil
Margarine	31154	1543	-	
Grains milling and processing	3116	156; 15860	-	
Sugar processing	3118	15830	-	
Yeast			1993-2020	
Ethanol	313110	159101070; 1592011	-	
Spirits Distillation	3131+3132	1591010-159101070+1592012	-	
Wine Cellars	3131+3132	15930; 15950	2001-2020	
Beer	3133	1596010	-	
Mineral water and similars			1993-2020	

1 It must be stressed though, that all information sources were produced by the National Statistical Institute (INE). Only methodological procedures for data collection change according to years.

Table 6-16: Sources of Information used to define the time-series of industrial production (2/2)

Industry	IAIT CAE rev1	IAPI PRODCOM	Infoline	Note
Wool production		171002021	-	
Wool processing		171002027;1710042; 1710053	-	
Synthetic fibres processing	321130	171003031; 171003039;171005231/32/33/39/91/92/93/99;1710055	171003039+171005231/32/33/39/91/92/93/99+1710055	
Artificial fibres processing	321130	171003050;1710054/55	-	
Cotton fibres processing	321130	1710043; 171004553; 171004555; 171004557; 1720020; 173001023	-	
Leather industry		19101; 19102	-	
Cork processing	162902250; 162902290; 162902320; 162902350; 162902380	-	-	
Cork granulation	162902320; 162902350; 162902380	-	-	
Kraft pulping			-	LPS Data
Acid sulphite pulping			-	LPS Data
Kraft paper	3412	2112022; 2112023	-	
Wafer board and Strand board	33 (code 15460)	20202	-	
Chorine and alkalis		241301111; 2413015; 2413022	-	
Inorganic acids		2413014-241301453-241301475-241301477	-	
Cyclic Hydrocarbons		2414312; 2414314	-	
Aliphatic Hydrocarbons		2414311	-	
Synthetic fertilizers		2415	-	Original units is kg N, kg P2O5 and K2O and were converted to ton of fertilizer
Pesticides	3512	242	-	
Polymers	351312	24160-2416058	-	
Synthetic rubber		2417	-	
Artificial fibres production		2470023; 247003070	-	
Polyester fibres production		247001130; 247001315; 247001350	-	
Acrylic fibres production		247001150	-	
Paints, varnishes and lacquers	3521	24301	-	
Pharmaceutical products			1998-2020	
Soaps		2451131	-	
detergents		2451120/32	-	
Petroleum refining			-	DGEG EBs and Galp Reports: 1990-2020

The following table shows the discharge coefficients that were used to estimate the volumes of wastewater produced by industrial sector, having as a basis the coefficients available in Cartaxo et al (1985).

Table 6-17: Coefficients used to estimate volumes of industrial wastewater production

Portuguese classification	IPCC industrial branches	Production Unit (PU)	Discharge (m3/PU)
Slaughter House	Meat & Poultry	ton	6
Slaughter House, swine	Meat & Poultry	ton	6
Slaughter House, Poultry	Meat & Poultry	ton	9
Meat Packing	Meat & Poultry	ton	10
Milk processing	Dairy Products	m3	1
Cheese	Dairy Products	m3 milk	8
Other dairy products	Dairy Products	m3 milk	5
Fruit and vegetables conservat	Vegetables, Fruits & Juices	ton	15
Tomato juice	Vegetables, Fruits & Juices	ton	100
Fruit Juices	Vegetables, Fruits & Juices	ton	9
Fish processing and canning	Fish Processing	ton	35
Olive oil production	-	ton olives	1
Olive oil processing	-	ton	6
Edible oils	Vegetable Oils	ton	3
Margarine	Dairy Products	ton	25
Grains milling and processing	Starch Production	ton	3
Sugar processing	Sugar Refining	ton	8
Yeast	-	ton	120
Ethanol	Alcohol Refining	m3	17
Spirits Distillation	Wine & Vinegar	m3	8
Wine Cellars	Wine & Vinegar	ton grapes	2
Beer	Beer & Malt	m3	5
Mineral water and similars	Vegetables, Fruits & Juices	ton	8
Wool production	Textiles (Natural)	ton	44
Wool processing	Textiles (Natural)	ton	537
Synthetic fibres processing	Textiles (Natural)	ton	155
Artificial fibres processing	Textiles (Natural)	ton	42
Cotton fibres processing	Textiles (Natural)	ton	317
Leather industry	-	ton	85
Cork processing	-	ton	1
Cork granulation	-	ton	1
Kraft pulping	Pulp & Paper (Combined)	ton	140
Acid sulphite pulping	Pulp & Paper (Combined)	ton	270
Kraft paper	Pulp & Paper (Combined)	ton	14
Wafer board and Strand board	-	ton	1
Chorine and alkalis	-	ton ClNa	28
Inorganic acids	-	ton	100
Cyclic Hydrocarbons	Organic Chemicals	ton	190
Aliphatic Hydrocarbons	Organic Chemicals	ton	190
Synthetic fertilizers	-	ton	15
Pesticides	Drugs & Medicines	ton	4
Polymers	Plastics & Resins	ton	15
Synthetic rubber	Plastics & Resins	ton	15
Artificial fibres production	Plastics & Resins	ton	300
Polyester fibres production	Plastics & Resins	ton	348
Acrylic fibres production	Plastics & Resins	ton	65
Paints, varnishes and lacquers	Paints	ton	0
Pharmaceutical products	-	employe	0
Soaps	Soap & Detergents	ton	4
Detergents	Soap & Detergents	ton	3
Petroleum refining	Petroleum Refineries	ton	2

Total wastewater load aggregated per industrial group is presented in the figure below, showing the predominant importance of wastewater loads from the industry of wood and wood derivatives and from the organic industry.

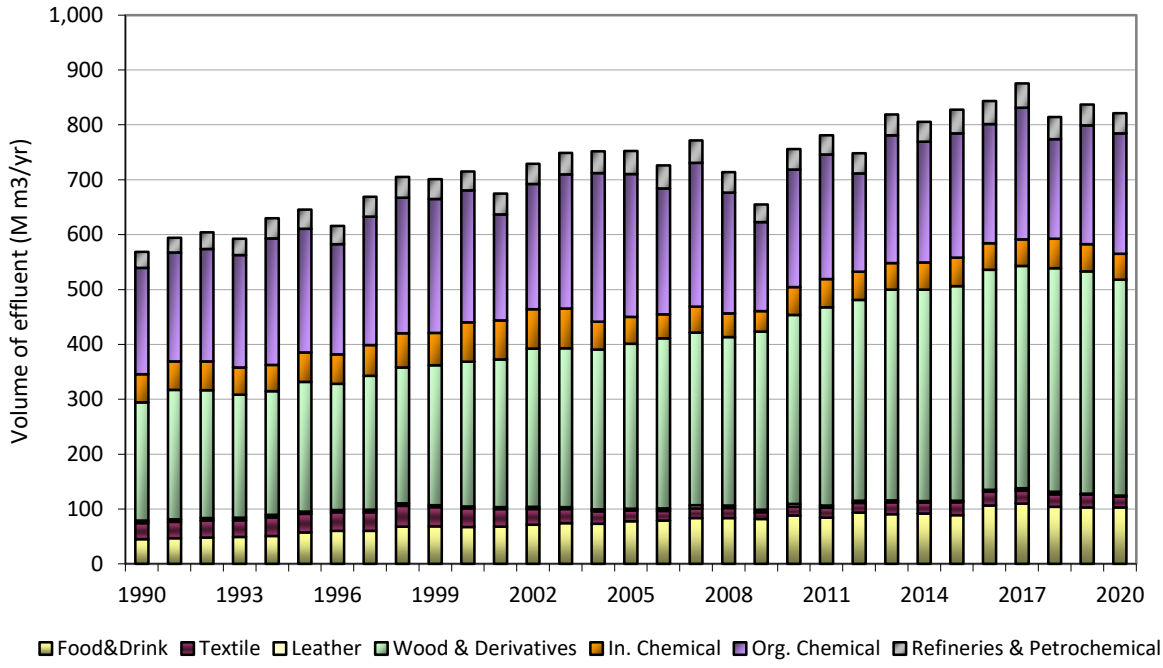


Figure 6-14: Industrial Wastewater discharges, expressed in 1000 m3, from major groups of industrial activity

The next figure presents the estimated total volumes of industrial wastewater produced and the related NMVOC emissions during the period analysed.

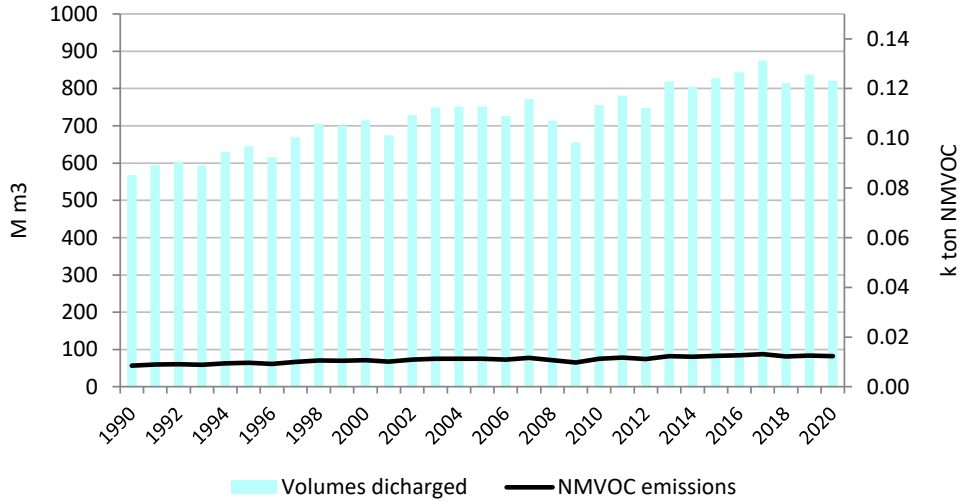


Figure 6-15: Total industrial wastewater discharge and NMVOC emissions

6.2.8 Emissions from Other Waste: car and house fires (NFR 5.E)

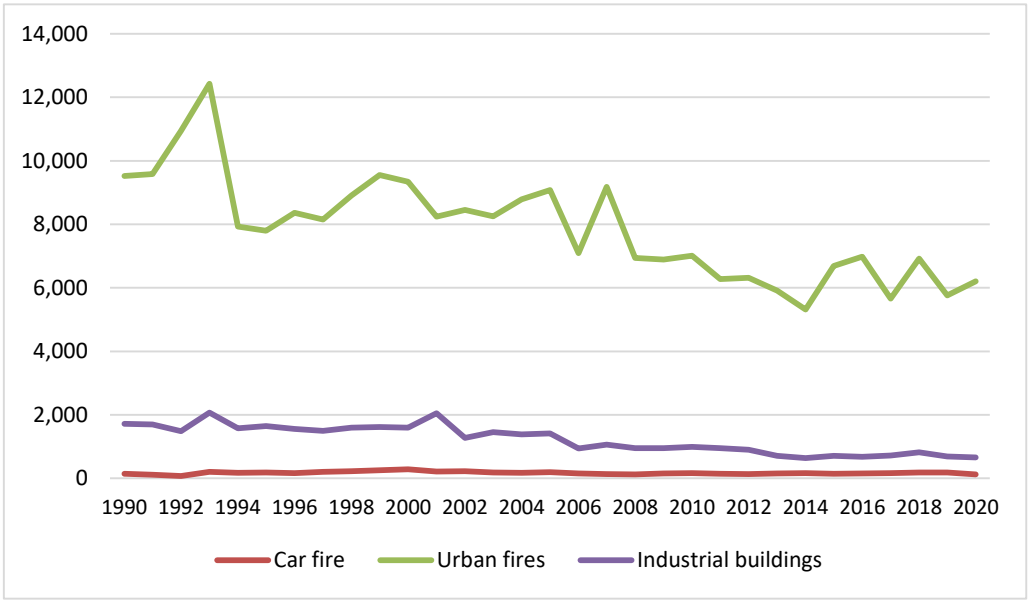
This category includes mostly unwanted fires in cars and various types of houses.

Emissions from fires include emissions of particulates, heavy metals and main pollutants such as NOx, SO2, CO and non-methane volatile organic compounds (NMVOC).

6.2.8.1 Methodology, activity data and emission factors

Emissions were calculated on the basis of emission factors proposed in the 2016 EMEP/EEA Guidebook, for occurrences referring to car fires, and residential (assumed as undetached house) and industrial buildings.

Acitivity data refer to the National Authority for Emergency and Civil Protection (Autoridade Nacional de Emergência e Proteção Civil (ANEPC)), which is responsible for the coordination and execution of policies for preventing and responding to major accidents and disasters. For the City of Lisbon the source of data is the Regiment of Firefighters of Lisbon.



Source: National Authority for Emergency and Civil Protection (Autoridade Nacional de Emergência e Proteção Civil (ANEPC)); Municipality of Lisbon/Regiment of Firefighters Lisbon.

Figure 6-16: Number of fire occurrences

Table 6-18: Emission factors

		Car Fires		House Fires		Industrial Fires	
	Unit	Value	Reference	Value	Reference	Value	Reference
TSP	kg/fire	2.3	Aasestad (2007)	61.62	Aasestad (2007)	27.23	Aasestad (2007)
PM10	kg/fire	2.3	Aasestad (2007)	61.62	Aasestad (2007)	27.23	Aasestad (2007)
PM2.5	kg/fire	2.3	Aasestad (2007)	61.62	Aasestad (2007)	27.23	Aasestad (2007)
Pb	g/fire			0.18	Aasestad (2007)	0.08	Aasestad (2007)
Cd	g/fire			0.36	Aasestad (2007)	0.16	Aasestad (2007)
Hg	g/fire			0.36	Aasestad (2007)	0.16	Aasestad (2007)
As	g/fire			0.58	Aasestad (2007)	0.25	Aasestad (2007)
Cr	g/fire			0.55	Aasestad (2007)	0.24	Aasestad (2007)
Cu	g/fire			1.28	Aasestad (2007)	0.57	Aasestad (2007)
DioxFur	mg/fire	0.048	Hansen (2000)	0.62	Aasestad (2007)	0.27	Aasestad (2007)

6.3 Recalculations

Changes in this submission refer to:

- Industrial Waste Amounts

  A major revision referring to activity data on industrial waste was made for this submission in order to respond to a UNFCCC recommendation urging Portugal to provide information that supports the industrial waste growth rates used to estimate the historical time series on the amount of industrial waste for the period 1960-1998.

  Previous assumptions on annual growth rates used to estimate AD for the years 1960-1998 were based on expert judgement. The basis for these assumptions established several years ago was however difficult to track down as no full registry of the rationale behind could be found. Therefore, in the absence of historical data on solid waste disposal, an approach based on the evolution of Portuguese GDP was used for this submission. This indicator is considered to be the most appropriate as it is the most complete and consistent time series available.

  This change impacted the CH4 and COVNM and NH3 emission estimates for the whole reporting period due to the FOD methodology (5.A), emissions related to the incineration of Industrial waste (5.C.1) concerning the years 1990-1998.

- Domestic wastewater (5.D.1)
  - revision of per capita protein intake (years 2012-2019);
  - agricultural recovery of sludge
    - AD and total N concentration: revision of 2018-2019 years based on the average values of 2017 and 2020 years;
    - NH3 from sewage sludge that volatilizes as NH3 and NOx (FracGASM): revision according to EMEP/EEA GB2019 (table 3.1 chapter 3 D).

- Industrial wastewater (5.D.2)

  Revision of AD for some industrial sectors (years 2018-2019).

6.4 Further improvements

Despite the efforts done in the revisions and data update related to wastewater treatment systems for this submission, the work should continue to extend the analysis to other sub-sectors.

7 Memo Items

Table of Contents

7 Memo Items 7-1

7.1 Wildfires (NFR 11.B) 7-3

7.1.1 Activity data and parameters 7-3

7.1.2 Methodology 7-5

7.2 NMVOC Biogenic Emissions (NFR 11.C) 7-7

7.2.1 Overview 7-7

7.2.2 Methodology 7-7

7.2.3 Emission Factors 7-8

7.2.4 Activity Data 7-13

7.2.5 Recalculations 7-14

7.2.6 Further Improvements 7-15

List of Figures

Figure 7-1: Wildfires: annual area burnt (1000 hectares) 7-4

Figure 7-2: Time variable Ɛ for Cork Oak (adapted from Silva et al, 1999) 7-11

Figure 7-3: Cosine modelling of daily evolution of air temperatures in January and July in Madeira Island region. Obtained for average minimum and maximum monthly temperatures in 1951-1980 (INMG) 7-14

Figure 7-4: Pattern of evolution of PAR (mmol/m2/s) according to month and hour of day (Nunes, 1996) .. 7-14

List of Tables

Table 7-1: Combustion Factors per Biomass Component used in the Estimation of Fire Emissions 7-5

Table 7-2: Average Carbon Stocks (BABG) in Above Ground Living Biomass and Litter per Land Use Type . 7-6

Table 7-3: Meteorological independent parameters used to determine foliage emission factors 7-9

Table 7-4: Specie and country specific equations for ɣ 7-11

Table 7-5: Emission Factors of NMVOC for biogenic emissions from agricultural areas, except olives, orchards and vine 7-12

Table 7-6: Forest Area per tree species (ha) 7-13

7 Memo Items

Updated: March 2021

7.1 Wildfires (NFR 11.B)

Forest fires are the main disturbance to forests in Portugal and have a substantial impact on the Portuguese forest. The level of disturbances on a forest varies with the type and severity of the fire, the conditions under which they occur and the characteristics of the ecosystem. Different tree species have different strategies to cope with the effects of fire and the actual mortality caused by fires depend on the ecosystem types or climatic zones.

Forest fires are highly correlated to weather conditions, both within each year (about 90% of the fires take place during period June-September, usually the hotter and drier months of the year), and between years (years with hot and dry summers have much higher burnt areas than years with mild and wet summers).

7.1.1 Activity data and parameters

7.1.1.1 Estimation of Burnt Areas

The main source of burnt areas are the fire reports issued every year by the National Forest Authority, currently the Institute for Nature Conservation and Forestry. The reports are derived from satellite imagery and the results cover all burnt areas, divided by forest, shrubland and agriculture.

ICNF reports provide also annual burnt area per forest type, comparing annual forest fire cartography with the NFI plots. For other land uses only the total aggregated area is presented. To estimate the burnt areas per other land use type the following assumptions were made:

1. No burnt areas in the categories: irrigated crops, rice paddies

2. Agriculture burnt area reported in fire statistics distributed proportionally to reported area per land-use type, for all other cropland and grassland types

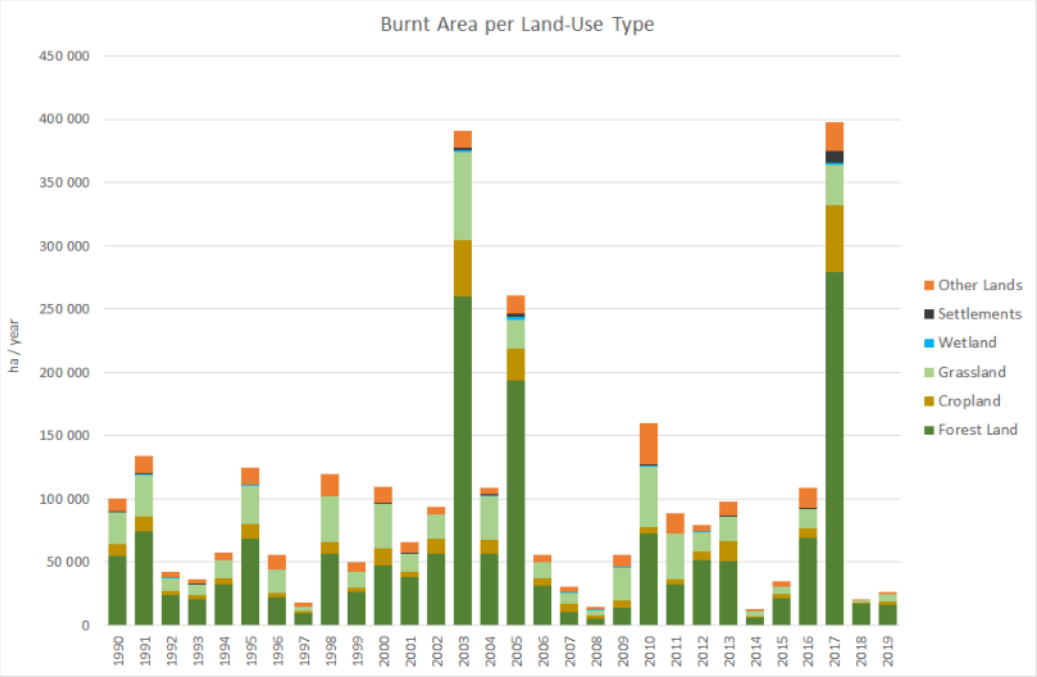


Figure 7-1: Wildfires: annual area burnt (1000 hectares)

7.1.1.2 Estimation of Biomass Loss due to Fires

The estimates consider the above ground biomass for forest trees, the undergrowth cover, and biomass from litter existing in forest land.

Schrubland ("matos") is also considered in the inventory, despite the fact that it is generally non-managed land. This submission considers also the biomass burning in croplands and grasslands.

The loss of biomass during forest fires was estimated by multiplying the above ground biomass in each land-use with 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, small branches, litter and understory shrubs (woody vegetation under the canopy of species that do not reach 5m at maturity). The basis for this calculation is the biomass values presented in next table.

As there were no values on combustion factors for these land-use types, a conservative approach was taken and the combustion factor was assumed to be 100%, which is very likely an overestimation.

A summary of the values used in estimating biomass loss due to fires is presented in the next table.

Table 7-1: 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 %	Litter %	Shrubs %	AG Biomass %
Pinus pinaster	7%	11%	88%	58%	75%	72%	-
Quercus suber	13%	21%	88%	58%	75%	72%	-
Eucalyptus spp.	9%	7%	88%	58%	75%	72%	-
Quercus rotundifolia	16%	27%	88%	58%	75%	72%	-
Quercus spp.	21%	54%	88%	58%	75%	72%	-
Other broadleaves	21%	54%	88%	58%	75%	72%	-
Pinus pinea	5%	8%	88%	58%	75%	72%	-
Other coniferous	8%	12%	88%	58%	75%	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	-	-	-	-	75%	72%	-
Other	-	-	-	-	-	-	-

7.1.2 Methodology

The estimates of non-CO_2 gas emissions are based on the IPCC 2006 Guidelines methodology, which are based on ratios to carbon released during combustion (L_{Direct}).

The carbon trace gas emissions (CO and NMVOC) are calculated using direct ratios to total carbon. Total suspended particles (TSP) have also been estimated applying a direct ratios to total carbon. To estimate nitrogen trace gas releases (NO_x), the total carbon released is first multiplied by the N/C ration (0.01) to get the total nitrogen released; the emissions of NO_x are then calculated multiplying the total N released by the NO_x emissions ratios to the total N released.

Emission ratios:

IPCC 2006 - CO: 0.06; NOx: 0.121

AP-42 - NMVOC: 0.0068, TSP: 0.0085

Emission estimation:

Emissions NMVOC (expressed as CH4) = L_{Direct} * emission ratio * 16/12

Emissions CO = L_{Direct} * emission ratio * 28/12

Emissions TSP = L_{Direct} * emission ratio

Emissions NOx = L_{Direct} * ratio N/C (0.01) * emission ratio * 46/14

7.1.2.1 Carbon losses due to wildfires

The annual carbon loss in living biomass resulting from wildfires was estimated based on direct carbon loss, and was calculated as follows:

$$L_{Direct} = \sum A_{burnt,j} \times B_{ABG,j} \times (B_{leafs,j} \times BCF_{leafs,j} + B_{branches,j} \times BCF_{branches,j})$$

Where:

L_{Direct}: Annual carbon loss (Gg C)

j: Forest type *j* or crop type or grassland or scrubland

$A_{burnt,j}$: Area burnt (kha)

B_{ABG}: Average C stock in above ground biomass (Gg C.kha^{-1})

B_{leafs}: % of leaf's biomass in above ground biomass (%)

BCF_{leafs}: Combustion factor of leafs (%)

$B_{branches}$: % of small branches' biomass in above ground biomass (%)

$BCF_{branches}$: Combustion factor of small branches (%)

In the case of cropland, grassland the combustion factor for above ground biomass is considered to be 100 %, assuming that all the biomass is burnt. For schrubland the combustion factor considered is 72 %.

Other carbon losses, called here indirect, can be estimated on the basis of tree mortality, as a consequence of fires. However, as the accounting of these losses only affects CO_2 emissions from non-salvaged wood, they have not been considered in this submission (only in UNFCCC submission).

Emissions of air pollutants depend on the fuel type and fuel loading, among other factors.

In this submission, the estimates consider the tree species burnt and their respective biomass volumes and dry matter content.

Table 7-2: Average Carbon Stocks (BABG) in Above Ground Living Biomass and Litter per Land Use Type

Average Carbon Stocks per Landuse Type	Above Ground Biomass			Litter	Notes
	1995 *GgC/1.000ha*	2005 *GgC/1.000ha*	2010 *GgC/1.000ha*	All years *GgC/1.000ha*	
Pinus pinaster	28.29	26.74	26.74	2.96	(1); (8)
Quercus suber	20.67	20.04	20.04	2.04	(1); (8)
Eucalyptus spp.	16.72	17.97	17.97	1.85	(1); (8)
Quercus rotundifolia	9.47	8.37	8.37	2.04	(1); (8)
Quercus spp.	15.45	15.87	15.87	1.85	(1); (8)
Other broadleaves	20.40	30.79	30.79	1.85	(1); (8)
Pinus pinea	25.40	18.79	18.79	2.41	(1); (8)
Other coniferous	8.70	14.51	14.51	2.96	(1); (8)
Rainfed annual crops	0.31	0.31	0.31	0.33	(4)
Irrigated annual crops (except rice)	0.31	0.31	0.31	0.33	(4)
Rice padies	0.31	0.31	0.31	0.33	(4)
Vineyards	3.34	3.34	3.34	0.33	(5); (6)
Olive groves	7.85	7.85	7.85	0.33	(5); (6)
Other permanent crops	8.46	8.46	8.46	0.33	(5); (6)
All grasslands	0.53	0.53	0.53	0.41	(2)
Wetlands	0.00	0.00	0.00	0.00	(9)
Settlements	0.00	0.00	0.00	0.00	(9)
Shrubland	8.78	8.78	8.78	4.96	(3)
Other	1.05	1.05	1.05	2.07	(7)

(1) Living biomass calculated from NFI4 (1995), NFI5 (2005) and NFI6 (2010). NFI6 data will be available in 2013; NIR 2013
(2) Calculated from EMEP/EEA emission inventory guidebook 2009, Chapter 11b Forest fires, Table 2-1 "Grassland vegetated
(3) Calculated from Rosa 2009 "Estimativa das emissões de gases com efeito de estufa"
(4) Calculated from EMEP/EEA emission inventory guidebook 2009, Chapter 11b Forest fires, Table 2-1 "Grassland vegetated
(5) Litter calculated from EMEP/EEA emission inventory guidebook 2009, Chapter 11b Forest fires, Table 2-1 "Non-forest class
(6) Living biomass from NIR Spain 2012, Tabla 7.3.3, page 7.59
(7) Calculated from EMEP/EEA emission inventory guidebook 2009, Chapter 11b Forest fires, Table 2-1 "Sparsely vegetated ar
(8) Litter values from expert judgement based on Rosa 2009 "Estimativa das emissões de gases com efeito de estufa", Quad
(9) No values were found in literature; assumed = 0

7.2 NMVOC Biogenic Emissions (NFR 11.C)

7.2.1 Overview

Emissions of Volatile Organic Compounds occur from plant foliage, either in forest or in agricultural lands, and are commonly called biogenic emissions. Usually in emission inventories a distinction is made for emissions of Isoprene, monoterpenes (α-pinene, β-pinene, limonene, etc.) and OVOC (Other Volatile Organic Compounds, mostly oxygenated compounds such as alcohols, aldehydes, etc). This separation pretends to distinguish compounds with different importance in ozone formation, which is apparently higher for isoprene than for terpenes (Simpson et 1, 1995).

Biogenic emissions are highly dependent on the vegetation specie and also on climatic conditions. Temperature affects almost all species. Light affects mostly isoprene emissions, but terpene emissions are also affected for a few species.

In Portugal, besides emissions from foliage, the emission inventory considers also monoterpene emissions resulting from resin-tapping. In fact, when coniferous live tissues are damaged, the exposed resin channels result in increased terpene emission. This process is artificially increased by resin-tapping that is practiced to obtain resin-derivatives. In Portugal resin tapping is common in maritime pine (*Pinus pinaster*) during the spring-autumn period and is done by extraction of part of the bark in the tree trunk. The majority of emissions comprehend α-pinene and β-pinene.

7.2.2 Methodology

7.2.2.1 Vegetation foliage

Emission of NMVOC from vegetation foliage are estimated separately for isoprenes, monoterpenes and Other Volatile Organic Compounds (OVOC), and using emission factors that are regional specific, at NUT 3 level, using the general equation:

$$Emi_NMVOC_{(s,t)} = \sum_n [(EF_Iso_{(s,n)} + EF_Mono_{(s,n)} + EF_OVOC_{(s,n)}) * Veget_{AREA(s,n)}] * 10^{-6}$$

Where:

$Emi_NMVOC_{(s,t)}$: Emissions of NMVOC resulting from crop or tree species, added over all national territory, in year t (t/yr)

$EF_Iso_{(s,n)}$: Isoprene emission factor for specie s at territorial unit n (g/ha/yr)

$EF_Mono_{(s,n)}$: Total monoterpene emission factor for specie s at territorial unit n (g/ha/yr)

$EF_OVOC_{(s,n)}$: Emission factor of Other Volatile Organic Compounds for specie s at territorial unit n (g/ha/yr)

$Veget_{AREA(s,n,t)}$: Area occupied by crop or tree specie s in territorial unit n during year t (ha)

The determination of emission factors varies in complexity with VOC compound and specie, as explained next.

7.2.2.2 Resin-tapping

VOC emissions from resin-tapping of maritime pine emissions are estimated using the number of tapped trees as activity data, according to the methodology proposed by (Pio & Valente, 1998):

$$Resin_NMVOC_{(s)} = \sum_n [(EF_tapping_{(n)} * N_{tappedtrees(n)}] * 10^{-3}$$

Where:

$Resin_NMVOC_{(s)}$: Emissions of NMVOC resulting from resin tapping in Maritime pine, added over all national territory, in year t (t/yr)

$EF_Tapping_{(n)}$: VOC emission factor for resin tapping at territorial unit n (mg/tree/yr)

$N_{tappedtrees(n)}$: Number of trees subjected to resin-tapping in territorial unit n (millions)

7.2.3 Emission Factors

Two different situations exist in what concern the determination of emission factors.

7.2.3.1 Forest areas and permanent crops

For forest areas, and also for permanent crops such as olive trees, vineyards and orchards, emission factors are fixed from the specie/ecosystem characteristics, foliar density and tacking into account the influence of abiotic factors - light and temperature. This procedure follows the methodology proposed by Guenther (1995) after Tingey et al (1980, 1991), and which is reproduced in EMEP/CORINAIR (EEA, 2002). Final emission factor is therefore determined from the following adapted equation:

$$EF_{(s,n,t,c)} = D_{(s)} * \varepsilon_{(s,c)} * \gamma_{(n,t,c)} * 10 / CC_{(s)}$$

Where:

$EF_{(s,n,t,c)}$: Emission factor (g/ha/yr) for compound c

$CC_{(s)}$: Carbon content of compound c

$D_{(s)}$: Foliar density (kg dm/m^2) for each specific species, averaged over the vegetation period

$\varepsilon_{(s,c)}$: Specie or ecosystem dependent emission factor (µgC/g dm/yr) at standard conditions (PAR flux of 1000 µgmol/m2/s and leaf temperature of 303.15 K). Varies with each specific compound

$\gamma_{(n,t,c)}$: Non-dimensional adjustment factor accounting for the influence of light (PAR) and leaf temperature. This parameter changes in time, according to meteorological conditions, and it is function of each particular compound

PAR: Photosynthetically active radiation (400-700 nm), typically about 45-50% of total global radiation (mmol-photons/m^2/s)

Values for D and Ɛ were set from available bibliographic references and are presented in next Table 7.3. For deciduous species D is zero during the coldest period, which is also presented in Table 7.3 [1]:

Carbon content was determined from the chemical formula of Isoprene (C_5H_8) and terpenes ($C_{10}H_{12}$), which value is 88% for both compounds. This same percentage was considered also for OVOC.

1 During this period emissions from foliage are obviously zero.

Table 7-3: Meteorological independent parameters used to determine foliage emission factors

Tree Specie		D		Vegetation Period	ε					
		kd dm/m2			µgC/g dm/h @standart L,T					
					Isoprene		Monoterpenes		OVOC	
Maritime pine	Pinus pinaster	700	Veldt (1989); Guenther et al (1994); Nunes (1996)	Evergreen	0	-	2.25	Pio et al, 1999	1.5	Guenther et al, 1994
Umbrella pine	P. Pinea	400	same as Other Coniferous	Evergreen	0	-	6	EMEP/CORINAIR-B1101 (EEA,2002)	1.5	
Other coniferous	-	400	(Ortiz and Dory, 1990 in Simpson,1995)	Evergreen	0	-	1.08	Simpson et al 1998. Average for Cupressus, P. halepensis, Pseudotsuga, P. sylvestris	1.5	
Gum tree	Eucalyptus sp.	300	(Nunes,1996); Nunes & Pio (1999)	Evergreen	32	Nunes & Pio (1999)	1.5	Nunes & Pio (1999)	1.5	
Cork oak	Quercus suber	200	Intermediate value between Forest area Mediterranean Oak (300) Simpson et al (1995) and Monte Hueco (100) from Ortiz and Dory (1990)	Evergreen	0	-	varies along year according to Table 7.4		1.5	
Holm oak	Quercus rotundifolia	200	Intermediate value between Forest area Mediterranean Oak (300) Simpson et al (1995) and Monte Hueco (100) from Ortiz and Dory (1990)	Evergreen	0	-	17	Luchetta, Simon and Torres (Average value)	1.5	
Oaks	Quercus sp.	400	Guenther et al (1994)	Apr-Sept	40	Guenther et al (1994)	0.35	Luchetta et al, 1999(Average Q. robur and Q. petrae)	1.5	
Chetnut	Castanea sativa	375	Guenther et al (1994)	Apr-Sept	0	-	8.71	(Luchetta et al,1999)	1.5	
Other broadleaves	-	418	Guenther et al (1994) in Geron, Guenther et Pierce (1994). Average: Acacia, Betula, Celtis, Fraxinus, Juniperus, Platanus, Populus, Prunus, Salix, Ulmus and Olea)	Mixed Evergreen and Deciduous	12.8	Guenther et al (1994) in Geron, Guenther et Pierce (1994). Average: Acacia, Betula, Celtis, Fraxinus, Juniperus, Platanus, Populus, Prunus, Salix, Ulmus and Olea)	0.6	Guenther et al (1994) in Geron, Guenther et Pierce (1994). Average: Acacia, Betula, Celtis, Fraxinus, Juniperus, Platanus, Populus, Prunus, Salix, Ulmus and Olea)	1.5	

Tree Specie		D	Vegetation Period	ε					
		kd dm/m2		µgC/g dm/h @standart L,T					
				Isoprene		Monoterpenes		OVOC	
Mixed broadleaves/ coniferous	-	380	Average other species	Mixed Evergreen and Deciduous	-	Average other species	-	Average other species	1.5
Bush (Matos)	-	200	Ortiz & Dory (1990) in Simpson et al, 1999 (Garrigue)	Evergreen	8	Ortiz & Dory (1990) in Simpson et al, 1999 (Garrigue)	0.65	Ortiz & Dory (1990) in Simpson et al, 1999 (Garrigue)	1.5
Olive Tree	Olea europaea	200	(Ortiz and Dory, 1990 in Simpson,1995)	Evergreen	0	-	1.6	(Ortiz and Dory, 1990 in Simpson,1995)	1.5
Orchards/ Vine	-	200		Mixed Evergreen and Deciduous	0	-	1.6		1.5

Values for ɣ are estimated according to empirical equations that are functions of both VOC compound and vegetation specie. For Isoprene emissions the general set of equations were used, function of light and temperature, following Guenther et al (1993).

$$\gamma = C_L * C_T$$

C_L, the light dependence factor is determined according to:

Where:

$$C_L = \frac{0.0027 * 1.066 * Q}{\sqrt{1 + (0.027 * Q)}}$$

Q: Flux of PAR (mmol/m^2/s)

C_T, the temperature dependence is determined according to:

$$C_T = \frac{\exp\left[\frac{95\,000 * (T - Ts)}{R * T * Ts}\right]}{1 + \exp\left[\frac{230\,000 * (T - 314)}{R * T * Ts}\right]}$$

Where:

T: Leaf temperature (K) and T_s is standard temperature (303 K)

R: Ideal gas constant (=8.314 J/K/mol)

For monoterpenes Guenther et al (1993) proposed the general formulation:

$$\gamma = \exp [\beta * (T-T_s)]$$

Where:

B: Constant, assumed 0.09 K^{-1} (Guenther et al, 1993)

T: Leaf temperature (K)

T_s: Standard temperature (303 K)

This same equation was used for OVOC following recommendations in Geron et al (1999) and in the EMEP/CORINAIR (Chapter B1101) (EEA, 2002).

For some species however, this general formulation was not used but it is replaced by country specific equations. This is particularly the case for cork and Holm oaks, where monoterpene emissions are also function of light[2]. These equations are summarized in the next table.

Table 7-4: Specie and country specific equations for γ

Specie	Compound	Equation	Reference
P. Pinaster	Monoterpernes	γ = exp[0.138 * (T-30)]	Pio et al (1999)
Eucalyptus	Monoterpenes	γ = exp[0.07 * (T-30)]	Nunes (1996)
Cork Oak	Isoprene	γ = {CL*CT + exp[□* (T-Ts)]}	Silva et al (1999); CL*CT is Guenther's model. B parameter changes during the year, and the considered variation is in Figure 9.2
Holm Oak	Isoprene	γ = {CL*CT + exp[0.09* (T-Ts)]}	-

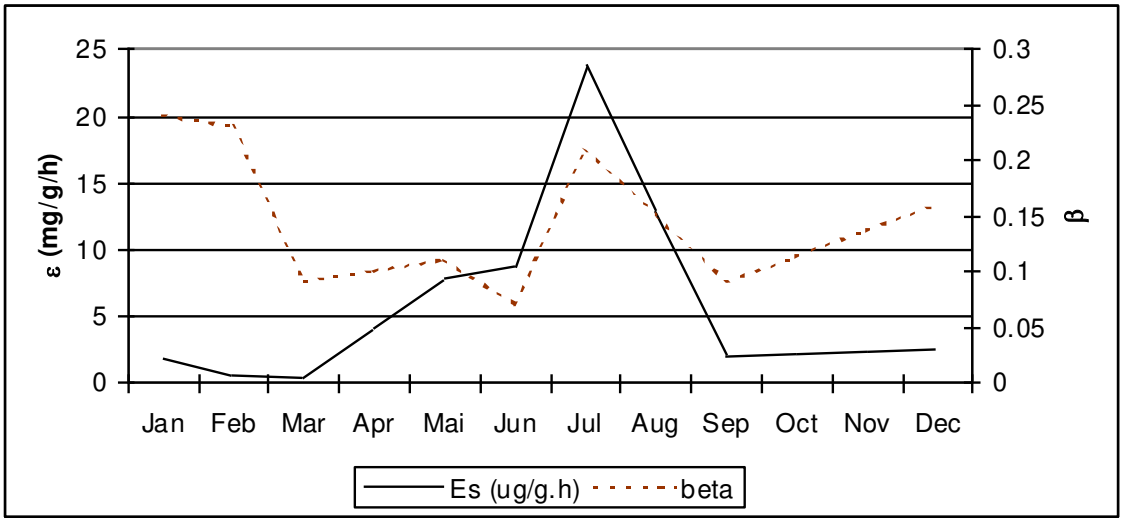


Figure 7-2: Time variable Ɛ for Cork Oak (adapted from Silva et al, 1999)

2 This dependence is however distinct from the emission dependence of isoprenes for oak (Quercus robur) and Gum (eucalyptus globulus), for example, because it still occurs during darkness. Hence there is a need for a mixed emission model (Silva et al, 1999)

The ɣ parameter was determined for each tree specie (s) for each territorial unit, n (NUT 3 level) from climatic data for a typical day of 12 hours for each month of the year according to the following equation:

$$ɣ_{(n,s)} = \sum_{m,h} \{ ɣ [PAR_{(n,m,h)}, T_{(n,m,h)}, s]\}$$

Where:

$ɣ [PAR_{(n,m,h)}, T_{(n,m,h)}, s]$: ɣ estimate for a specific hour h of a typical day a particular month m, calculated according to the specific equation for tree specie s

$PAR_{(n,m,h)}, T_{(n,m,h)}$: Photosynthetically active radiation of hour h of month m in territorial unit n

$T_{(n,m,h)}$: Leaf temperature of hour h of month m in territorial unit n

7.2.3.2 Other agricultural areas and grasslands

For other agricultural areas and grasslands, the emission factor is simply a constant value that is not a function of climatic conditions and hence not specific of each territorial area and that is expressed in mg C/m^2h. The considered values in the Portuguese inventory, from (Veldt, 1991; Veldt, 1998), are presented in the next table.

Table 7-5: Emission Factors of NMVOC for biogenic emissions from agricultural areas, except olives, orchards and vine

Crop	Isoprene	Monoterpene	OVOC	NMVOC
		µgC/m2/h		µg/m2/h
Arable Land	8	20	12	45
Rice	8	20	12	45
Grassland	8	20	12	45
Market Gardening	8	20	12	45

Source: Veldt, 1991 ; Veldt, 1998

7.2.3.3 Resin-tapping

The emission factor for resin-tapping, per tree in extraction, follows the equation proposed by Pio & Valente (1998), for each particular condition:

$$\log10[EF_tapping_{(m,h)}] = 0.631 + 0.06 * T$$

Where:

$EF_tapping_{(m,h)}$: VOC emission rate from resin-tapping (mg VOC/hr/tree) for a specific time

T: Air temperature (ºC)

The annual emission factor for each territorial unit was obtained by the addition of the emission factors for each hourly period in a year:

$$EF_tapping_{(n)} = \sum_{m,h} \{EF_Tapping_{(m,h)}\}$$

7.2.4 Activity Data

Basic activity data is the area for each crop or plant species. This information was available from AFN for years 1990 and 1995 and was interpolated and extrapolated[3] for the remaining time-series. Foliage areas for each tree specie were obtained according to the following equation:

$$Foliage_Area_{(n,s)} = Pure_{(n,s)} + 0.75 * Dominant_{(n,s)} + 0.25 * Dominated_{(n,s)} + Dispersed_{(n,s)}$$

Where:

$Foliage_Area_{(n,s)}$: Total area covered by foliage of tree specie s in territorial unit n (ha)

$Pure_{(n,s)}$: Land area occupied by pure strands of specie s in territorial unit n (ha)

$Dominant_{(n,s)}$: Land area occupied by mixed strands where specie s is dominant, in territorial unit n (ha)

$Dominated_{(n,s)}$: Land area occupied by mixed strands where specie s is non-dominant, in territorial unit n (ha)

$Dispersed_{(n,s)}$: Dispersed arboreal areas inter-mixed in non-forest areas forming small woodland areas (Bosquetes) (ha)

Table 7-6: Forest Area per tree species (ha)

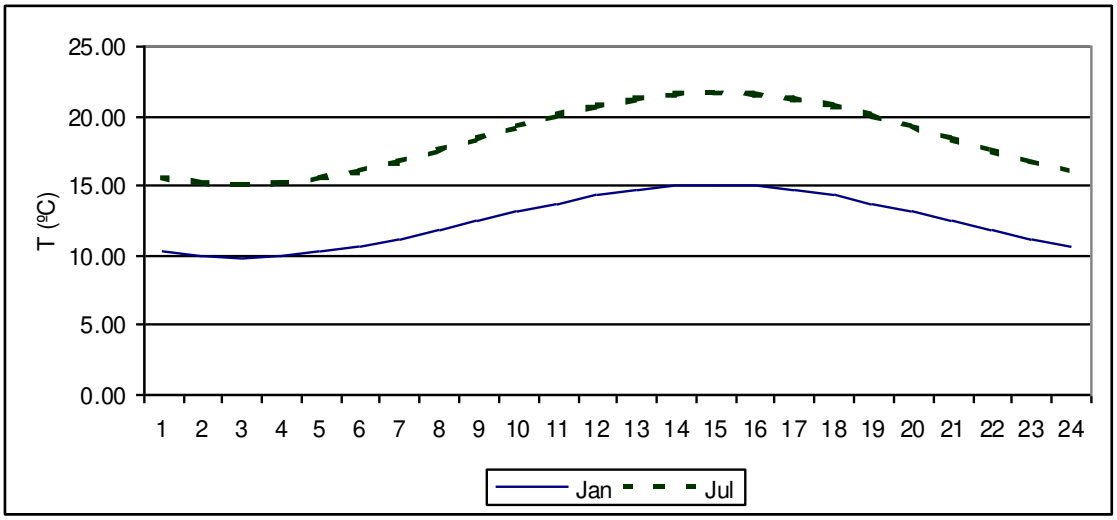
specie	1990	1995	2000	2005	Last year
Pinus pinaster	1,069,000	976,069	974,015	741,741	741,741
P. Pinea	35,000	77,650	83,559	102,143	77,650
Other conifer	69,000	27,358	29,440	46,499	70,992
Quercus suber	693,000	712,813	728,693	851,958	851,958
Q. Rotundifolia	462,000	461,577	465,295	420,244	420,244
Other oaks	123,000	130,899	130,078	117,900	117,900
Castanea sativa	37,000	40,579	40,324	28,200	28,200
Eucalyptus sp.	554,000	672,149	677,599	678,741	678,741
Other broadleaves	98,000	102,037	106,994	131,373	131,373
Mixed, other	0	0	0	0	0
Bushlands (Matos)	1,734,822	2,054,571	2,054,571	2,054,571	2,054,571
Olive groves	337,189	333,144	369,162	376,524	343,219
Orchards and vineyards	428,506	406,712	378,054	379,680	307,578
Arable land	2,349,298	2,140,174	1,692,107	1,240,701	833,209
Rice	33,824	21,726	23,859	21,938	29,120
Pasture	857,733	1,024,373	1,389,845	1,768,616	1,786,434
Market gardening	31,980	27,825	21,608	21,408	16,943
Resin tapping (Mtree)	35	35	35	35	35

For the determination of emissions from resin-tapping the number of pine trees under extraction must be known. Pio & Valente (1998) estimated that this number is about 35 million trees in the 1980-1990 period. After 1990 the same authors believe that there has been a decrease in the number of trees explored, but no statistical information is available.

For the calculation of the emission factors it is necessary, as mentioned before, the knowledge of PAR and leaf temperature. These were set for each hour of the day and each month according to the following information.

A time series of 30 years (1951-1980) of average minimum and maximum air temperature, for each month and territorial unit, were used to establish a typical evolution of daily temperature, for each month of the year and each territorial unit. A cosine function was considered with a peak of air temperature occurring at 15.00 (2 PM). In the following figure there is an example for the daily evolution of air temperatures in January and July for Madeira Island.

3 Linear interpolation



Source: INMG

Figure 7-3: Cosine modelling of daily evolution of air temperatures in January and July in Madeira Island region. Obtained for average minimum and maximum monthly temperatures in 1951-1980 (INMG)

However, the information concerning PAR is scarce and some simplifications and assumptions had to be made. The pattern of monthly and daily variation of PAR was set by UA (Nunes, 1996) in Aveiro region, in central coastal Portugal, from a full year of measurements of total radiation (W/m2) in the meteorology monitoring station of Cacia. Average hourly total radiation was converted in PAR (mmol-photons/m^2/s) by multiplication of 0.45, the local conversion factor (Pinho, 1995 in Nunes, 1996) and assuming an average wavelength of 550 nm. The annual monthly-hourly pattern of PAR in Cacia is presented in the figure below.

PAR values for Cacia were corrected for each territorial unit proportionally to the relation of insolation in each specific region and in original Cacia station.

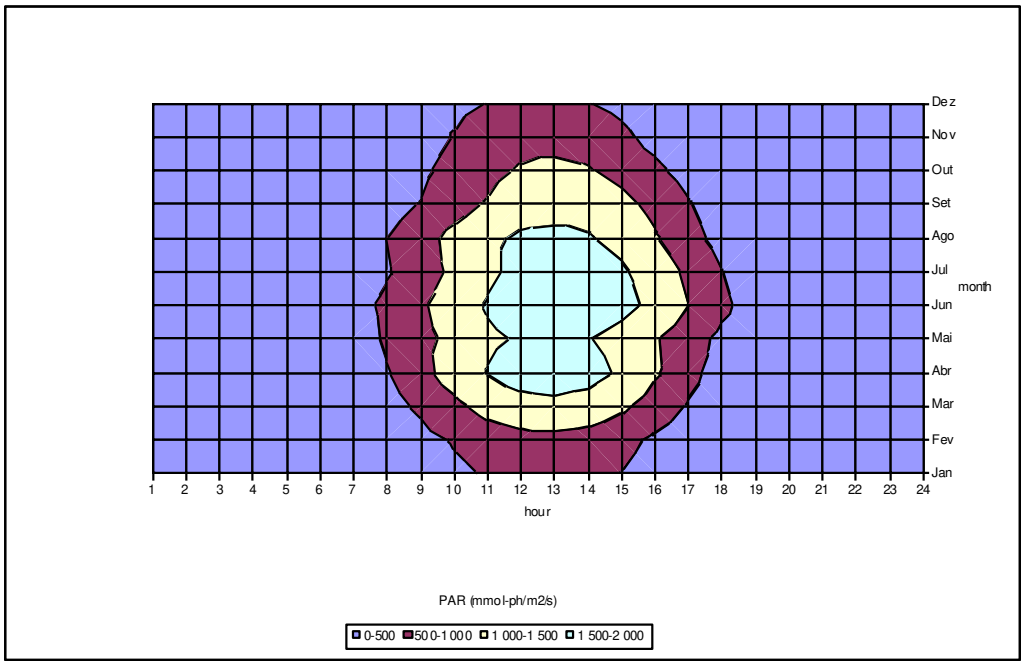


Figure 7-4: Pattern of evolution of PAR (mmol/m2/s) according to month and hour of day (Nunes, 1996)

7.2.5 Recalculations

No changes were made to this category since the submission of last year.

7.2.6 Further Improvements

This category is foreseen to be revised in the near future in order to better harmonise and reflect the developments made in the last years related to the quantification of Land Use categories, and improvements in the methologies.

An improvement in information concerning resin extraction may ameliorate the estimates of VOC emissions from resin-tapping in Maritime pine.

8 Recalculations and Improvements

Table of Contents

8 Recalculations and Improvements 8-1

8.1 Overview of the review process 8-2

8.2 Overview recalculations 8-16

8.2.1 Recalculations Energy sector (NFR 1) 8-16

8.2.2 Recalculations Industrial Processes sector (NFR 2) 8-16

8.2.3 Recalculations Agriculture sector (NFR 3) 8-17

8.2.4 Recalculations Waste sector (NFR 5) 8-18

List of Figures

Figure 8-1: Recalculations for main pollutants and particulate matter for 1990-2019 (absolute difference between 2022 and 2021 submissions) 8-19

Figure 8-2: Sectoral contribution in recalculations: Main pollutants and particulate matter (% contribution to the total emissions of each pollutant in 2019) 8-20

Figure 8-3: Recalculations for heavy metals for 1990-2019 (absolute difference between 2022 and 2021 submissions) 8-21

Figure 8-4: Sectoral contribution in recalculations: Heavy Metals (% contribution to the total emissions of each pollutant in 2019) 8-22

Figure 8-5: Recalculations for Dioxines, PAHs, HCB and PCB for 1990-2019 (absolute difference between 2022 and 2021 submissions) 8-23

Figure 8-6: Sectoral contribution in recalculations: PCB, HCB, Dioxines and PAHs (% contribution to the total emissions of each pollutant in 2019) 8-23

List of Tables

Table 8-1: Reporting on implementation of NECD recommendations 8-3

8 Recalculations and Improvements

Updated: March 2022

8.1 Overview of the review process

The next table presents the status of implementation of recommendations included in the Final Review Report 2021 on the Review of National Air Pollutant Emission Inventory Data 2021 under Directive 2016/2284 (National Emission reduction Commitments Directive). It includes findings issued from the last 2021 NECD Review and previous NECD Reviews whenever not yet fully implemented.

Table 8-1: Reporting on implementation of NECD recommendations

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE, TC or UPTC	MS response / Status of implementation	Chapter/section in the IIR
PT-0A-2020-0001	No	0A National Total - National Total for the Entire Territory - Based on Fuel Sold/Fuel Used, SO2, NOX, NH3, NMVOC, PM2.5, BaP, PAHs, PCBs, HCB, Cd, Hg, Pb, PCDD/F, PM10, CO, BC, 1990-2018	The TERT noted that the methods used for the assessment of the uncertainty are not described transparently in the IIR. Portugal does not perform an overall uncertainty analysis for the inventory related to the pollutants covered under the NECD. The 2020 review noted that the IIR (page 1-17) stated that the uncertainty analysis is currently performed only for the direct GHG. Portugal has currently no concrete plans in place to include a quantitative uncertainty analysis. The TERT recommends that further information on the methods used to quantify uncertainties are presented in the IIR transparently in accordance with the "Recommended Structure for Informative Inventory Report" (Annex II_v2018 to the revised 2014 reporting guidelines). The TERT noted that no information on uncertainty was provided for BC, PM10 and CO. The TERT recommends that the guidance given in "Part A 5 Uncertainties 2019" of the 2019 EMEP/EEA Guidebook is used to assess the uncertainty by pollutant and sector. The TERT further recommends that the methods used for the assessment of the uncertainty are described in the IIR transparently along with a summary of uncertainties by pollutant and sector as requested in the "Recommended Structure for Informative Inventory Report" (Annex II_v2018 to the revised 2014 reporting guidelines).	No	Portugal is preparing a first evaluation of uncertainties concerning the 5 pollutants with reduction targets. In the case we cannot complete the work in time for the 15 March IIR submission 2022, we intend to deliver this evaluation in time for the 2022 NECD review.	-
PT-1A1a-2019-0001	Yes	1A1a Public Electricity and Heat Production, Cd, Hg, Pb, 2005, 2017	For NFR 1A1a Public Electricity and Heat Production and pollutants Cd, Hg, Pb in all years the TERT noted that implementation of an installation approach to emission estimates has not been completed and that	No	Addressing. As explained during the review, the transition to the estimation of emissions through	3.2.1.3 Emission factors

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE, TC or UPTC	MS response / Status of implementation	Chapter/section in the IIR
			there may be an over- or under-estimate of emissions. This was raised during the 2019 and 2020 NECD inventory review. In response to a question raised during the review Portugal explained that this issue is due to challenges in restructuring the emission inventory to use installation-specific information. The TERT noted that the issue is below the threshold of significance for a technical correction. The TERT recommends that 1A1a should be a high priority for use of installation-specific information and that a plan is agreed with a clear timetable for delivery of the improvement.		monitoring is very time consuming, and it was not possible to make this methodological improvement in time to include it in the 2022 submission.	
PT-1A2f-2020-0001	No	1A2f Stationary Combustion in Manufacturing Industries and Construction: Non-Metallic Minerals, PCBs, 2017, 2018	For category 1A2f Stationary Combustion in Manufacturing Industries and Construction: Non-Metallic Minerals and pollutant PCB for year 2018 the TERT noted an increase in emissions. This was raised during the 2020 NECD inventory review. In response to a question raised during the review Portugal has indicated that the issue is due to reported consumption of coke in the glass industry, but activity data remains provisional. Portugal has sought clarification of the energy balance but proposes to re-allocate emissions by assigning coke use to another activity in the 2022 submission. The TERT noted that the issue is below the threshold of significance for a technical correction. The TERT recommends that Portugal seeks resolution of the activity data and, if appropriate, re-allocate coke use or, to describe the reason for the increase in 2018 in the IIR for the 2022 submission to address the issue.	No	Implemented. The inconsistency has been corrected. The sporadic consumption of coke in this category has been removed from the inventory.	
PT-1A2f-2021-0001	Yes	1A2f Stationary Combustion in Manufacturing Industries and Construction: Non-Metallic Minerals, BC, 2011-2014	For 1A2f Stationary Combustion in Manufacturing Industries and Construction: Non-Metallic Minerals and pollutant BC for years 2011-2014 the TERT noted that the emission trend is not consistent with the PM2.5 emission trend.. There may be an over-estimate of BC emissions. The TERT recommends that	No	Implemented. The inconsistent BC emission estimates were related to the emissions from the ceramics sector, in particular due to a drop in the consumption of biomass from 2011. The	

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE, TC or UPTC	MS response / Status of implementation	Chapter/section in the IIR
			Portugal reviews the methodology for BC estimates in 1A2f and corrects this error for the 2022 submission.		methodology has been revised for the 2022 submission and the inconsistency has been corrected	
PT-1A3ai(ii)-2017-0001	No	1A3ai(ii) International Aviation Cruise (Civil); PM2.5; 1990-2018	For 1A3ai(ii) International Aviation Cruise (Civil) and 1A3aii(ii) Domestic Aviation Cruise (Civil), PM2.5, all years, the TERT noted that emissions are reported as 'NE'. This was raised during the 2017, 2018 and 2019 NECD inventory review. In response to a question raised during the review Portugal explained the several resource-based barriers preventing changes to the emissions calculations to facilitate emissions of these pollutants for these categories to be estimated. The TERT noted that the issue is related to non-mandatory categories. The TERT recommends that Portugal continue to make efforts to improve the completeness of the emissions inventory by including PM2.5, PM10, BC emissions from 1A3ai(ii) and 1A3aii(ii).	No	Not Implemented So far it was not possible to include PM 2.5 Cruise emissions due to time and resource constrains and priority inventory work. We plan to include these emissions in a future submission	3.4.1 Civil Aviation (NFR 1.A.3.a)/ 3.4.1.7 Further Improvements
PT-1A4bii-2021-0001	No	1A4bii Residential: Household and Gardening (Mobile), PM2.5, 1990-2019	For 1A4bii Residential: Household and Gardening (Mobile), all years, the TERT noted that the BC estimates are larger than the PM2.5 estimates. In response to a question raised during the review, Portugal explained that this was due to an error in the calculation file. Portugal provided revised estimates for all years and stated that it will be included in the next submission. The TERT agreed with the revised estimate provided by Portugal. The TERT recommends that Portugal include the revised estimate in its 2022 NFR and IIR submission.	No	Implemented.	
PT-1A5b-2021-0001	Yes	1A5b Other, Mobile (Including Military, Land Based and Recreational Boats), PM10, 1990-2019	For 1A5b Other, Mobile (Including Military, Land Based and Recreational Boats), PM10, all years, the TERT noted that emissions are reported with 'NE'. In response to a question raised during the review Portugal explained that the only source of emissions in 1A5b in Portugal is from jet fuel consumption in military aviation, for which there is no Tier 1 fuel	No	Implemented We have included the estimates of $PM_{2.5}$, PM_{10} and TSP by applying the implied emission factor for 1A3ai(i) - International aviation LTO (civil) to the Energy Consumption in Military aviation.	Military Aviation (NFR 1.A.5.b)/ 3.6.1.2 Emission Factors Military Aviation (NFR 1.A.5.b)/

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE, TC or UPTC	MS response / Status of implementation	Chapter/section in the IIR
			consumption-based emission factor for PM10 in the EMEP/EEA Guidebook, and Portugal does not have the data required for a Tier 2 estimate due to confidentiality issues. The TERT notes that despite a Tier 1 PM10 EF not being provided in the 2019 EMEP/EEA Guidebook, an implied emission factor from civil aviation could be estimated using the activity data and emissions reported by Portugal for 1A3ai(i), to be applied to activity data for Portugal's military flights. The TERT acknowledges that the characteristics of military planes can be quite different to civil aviation, but also that much of military aviation activity includes freight and personnel movement between airports, which would involve planes similar to civil aviation. The TERT noted that the issue is below the threshold of significance for a technical correction. The TERT recommends that Portugal includes this explanation for transparency in the next IIR submission and continue to make efforts to improve the completeness of the NECD inventory.			3.6.1.4 Recalculations
PT-1B2b-2017-0001	No	1B2b Fugitive Emissions from Natural Gas (Exploration, Production, Processing, Transmission, Storage, Distribution and Other), SO2, NMVOC, 1990-2018	For category 1B2b Fugitive Emissions from Natural Gas (Exploration, Production, Processing, Transmission, Storage, Distribution and Other) and pollutants NMVOC and SOX the TERT noted that the 2020 submission has corrected NMVOC emissions but SOX emissions remain unreported (IIR Table 8.1). This was raised during the 2017, 2018 and 2019 NECD review. The TERT noted that the SOX issue is below the threshold of significance for a technical correction. The 2020 review noted that the IIR states (page 8-6) that the issue has been included in the list of improvements. The TERT reiterates the recommendation that Portugal includes SOX emissions for category 1B2b in future submissions.	No	Addressing. No progress has been made in the collection of information that allows the determination of the sulfur content in Natural Gas.	

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE, TC or UPTC	MS response / Status of implementation	Chapter/section in the IIR
PT-2A5a-2021-0001	Yes	2A5a Quarrying and Mining of Minerals Other Than Coal, PM10, 2000, 2005, 2019	The TERT notes with reference to 2A5a Quarrying and mining of minerals other than coal for PM10 for 2000, 2005 and 2019 that a Tier 1 method is used for a key category. The TERT notes that using a Tier 1 method is not best practice, and could result in an over and/or underestimate of emissions. This over/underestimate may have an impact on total emissions that is above the threshold of significance. Portugal has not provided a revised estimate which has been accepted by the TERT. It is currently not possible for the TERT to provide a numerical emission estimate based on a Tier 2 method, and therefore the issue will be flagged as Potential Technical Correction, and will be assessed as a high priority item in future reviews. The TERT recommends that Portugal should calculate PM10 and other particles emissions from 2A5a Quarrying and mining of minerals other than coal using a Tier 2 or Tier 3 method for inclusion in next years' inventory submission.	UPTC	Not implemented. Portugal was not able to present revised estimates using a Tier 2 methodology. Further analysis to the spreadsheet available in the 2019 EMEP Guidebook showed the importance of possessing relatively disaggregated activity data for this category. At the moment, the inventory team does not possess such information at national level and foresees that obtaining such information will require a great amount of time and several contacts with sectoral authorities in the matter. Therefore, for the time being, Portugal is unable to apply a higher tier methodology. However, considering that this is a key category, we intend to engage contacts in order to assess the information available in the country, and further evaluate the possibility of moving to a higher tier. We hope to report on the progress in future submissions.	Section 4.2.6.7
PT-2B1-2021-0001	Yes	2B1 Ammonia Production, CO, 2009-2019 No	For 2B1 Ammonia Production for CO for 2009-2019 the TERT noted that there is a lack of transparency regarding the notation key used. Portugal used 'NA' while for the period no production is occurring. This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Portugal explained that it will update the notation key to 'NO' from 2009 onwards in its next submission. The TERT recommends that Portugal implements this in its next submission.	No	Implemented. Portugal updated CO notation key to 'NO' (not occurring) from 2009 onwards, given there is no ammonia production in that period.	NFR Tables
PT-2B1-2021-0002	Yes	2B1 Ammonia Production, NOx, NH_3, 1990-2008	For 2B1 Ammonia production and NO_X and NH_3 for 1990-2008, the TERT noted that there is a lack of transparency regarding the future improvement that Portugal planned on moving from Tier 1 to a Tier 2 emission factors. This does not relate to an over- or	No	Implemented. Portugal updated and NOx, CO and NH_3 emission factors to a Tier 2 according to	Section 4.3.1.3

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE, TC or UPTC	MS response / Status of implementation	Chapter/section in the IIR
			under-estimate of emissions. In its IIR such an improvement has been stated (p. 4-39). In response to questions raised during the review, Portugal explained that his improvement was identified earlier in 2021, following an improvement in GHG emissions for this category but that they could not proceed with the update of air pollutant emissions due to lack of time. The TERT recommends that Portugal includes this improvement in its next submission.		chapter 2.B of the 2019 EMEP Guidebook, for 1990-2008, for this submission.	
PT-2B10a-2021-0001	Yes	2B10a Chemical Industry: Other, PM2.5, PM10, BC, TSP, 2000, 2005, 2019	For 2B10a Chemical industry: Other for PM2.5, PM10, BC, TSP for 2000, 2005, 2019 the TERT noted that there is a lack of transparency regarding the use of a lower EF than the one from the 2019 EMEP/EEA Guidebook (for uncontrolled process). This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Portugal explained that as a result of a regional survey it was found that ammonia sulphate production process uses rotary dryers and wet scrubbers as emissions control equipment and for this reason, Portugal considered the emission factor from Table 8.4 of chapter '8.4 Ammonium Sulphate' of USEPA AP-42 to be the most adequate EF given national circumstances. The TERT recommends that Portugal include this explanation for the choice of the emission factor in its next IIR.	No	Implemented. Portugal clarified the choice of the emission factor for ammonia sulphate production in this submission.	Section 4.3.7.3
PT-2D3b-2021-0001	No	2D3b Road Paving With Asphalt, PM2.5, PM10, BC, TSP, 2000, 2005, 2019	For 2D3b Road Paving with Asphalt for the years 2000, 2005 and 2019 and for TSP, PM10 and PM2.5 emissions the TERT noted that Portugal used EFs from the USEPA (2000) (IIR p. 4-97) for both batch processes and continuous processes while the EMEP 2019 Guidebook includes a Tier 2 EF for these processes which are slightly lower than those used by Portugal. In response to a question raised during the review Portugal provided a comparison of the EF with those from the EMEP 2019 GB. The TERT noted that	No	Implemented. Portugal updated particulate matter emission factors for those from the EMEP 2019 Guidebook for the whole time series for this submission.	Section 4.5.2.3

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE, TC or UPTC	MS response / Status of implementation	Chapter/section in the IIR
			the issue is below the threshold of significance for a technical correction. The TERT recommends that Portugal uses the EF from the EMEP 2019 Guidebook in its next submission or provides a clear justification for using other country specific EF.			
PT-2D3b-2021-0002	Yes	2D3b Road Paving With Asphalt, BC, 2000, 2005, 2019	For 2D3b Road Paving with Asphalt for BC for 2000, 2005 and 2019 the TERT noted that there may be an under-estimate of emissions as emissions are not estimated ('NE'). The TERT noted that Portugal estimates emissions of PM2.5 of this category and that the 2019 EMEP/EEA Guidebook provides a EF for BC (to be calculated as % of PM2.5 emissions). In response to a question raised during the review, Portugal provided a revised estimate for years 2000, 2005 and 2019 and stated that it will be included in the next submission. The TERT agreed with the revised estimate provided by Portugal. The TERT recommends that Portugal includes the revised estimate in its 2022 NFR and IIR submission.	RE	Implemented. BC emissions were estimated for the first time for the whole time series in this submissions for both batch and continuous processes, according to a Tier 2 methodology from the EMEP 2019 Guidebook.	Section 4.5.2
PT-2D3g-2017-0001	Yes	2D3g Chemical Products; NMVOC; 1990-2018	For 2D3g Chemical Products for NMVOC for 1990-2019 the TERT noted that Portugal did partly implement the recommendation (https://emrt-necd.eionet.europa.eu/2020/PT-2D3g-2017-0001) for tyres. However, the other issues raised were not addressed, but were included in the list of improvements (p. 8-8 of the IIR). No concrete timetable is given for these improvements. The TERT notes that this was already raised during the 2017, 2018, 2019 and 2020 NECD inventory review. In response to a question raised during the review Portugal explained that (1) regarding asphalt blowing, it is attempting to establish sectoral contacts in order to clarify if there is asphalt blowing activity in facilities other than refineries, and that they hope to report on the progress in the next IIR submission; (2) regarding adhesive, magnetic tapes, films and photographs	No	Addressing. Regarding asphalt blowing, Portugal is attempting to establish sectoral contacts in order to clarify if there is asphalt blowing activity in facilities other than refineries, however, has not received a reply so far. We hope to report on the progress in the next IIR submission. Regarding adhesive, magnetic tapes, films and photographs manufacturing, due to unavailability of stratified data at national level, NMVOC emissions from this category are estimated based on a Tier 1 approach for the time being. In order to overcome the lack of data, Portugal participated in a capacity	Asphalt Blowing: Section 4.5.26.7 Adhesive, Magnetic Tapes, Films and Photographs

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE, TC or UPTC	MS response / Status of implementation	Chapter/section in the IIR
			manufacturing, NMVOC emissions from this category were estimated based on a Tier 1 approach. In order to overcome the lack of data for a Tier 2 approach, Portugal is attempting to organise VC meetings with the regional entities responsible for the solvents management plans and the environmental licensing under this domain and hopes to be able to get some results and sound information regarding this category in order to improve the estimates of this sector or report on the progress in time for the 2022 submission. The TERT is unable to determine whether the issue is below the threshold of significance for a technical correction. The TERT recommends that Portugal includes all realized improvements in its next submission and reports the improvements not yet realized in an improvement plan featuring a time schedule.		building project for Air emission inventories relating to NMVOC emissions, and flagged this category as priority in order to get support to move to a higher Tier methodology. We intend to contact national authorities on the matter in order to assess and collect the available data for the sector. We hope to report on the progress in future submissions.	Manufacturing: Section 4.5.27.7
PT-2D3i-2017-0002	Yes	2D3i Other Solvent Use; NMVOC; 1990-2018	For 2D3i Other Solvent Use for NMVOC for 1990-2019 the TERT noted that there is a lack of transparency regarding the implementation of recommendation PT-2D3i-2017-0002. This does not relate to an over- or under-estimate of emissions. This was raised during the 2017, 2018, 2019 and 2020 NECD inventory review. In response to a question raised during the review, Portugal explained that due to the unavailability of stratified data at national level regarding the different abatement technologies, Portugal still has not been able to provide a revised estimate for NMVOC emissions from this category. But in order to overcome the lack of data, Portugal is attempting to organise VC meetings with the regional entities responsible for the solvents management plans and the environmental licensing under this domain. Furthermore, Portugal is currently participating in a capacity building project for Air emission inventories relating to NMVOC emissions	No	Not implemented. Regarding application of glues and adhesives, due to unavailability of stratified data at national level, NMVOC emissions from this category were estimated based on a Tier 1 approach for the time being. In order to overcome the lack of data, Portugal participated in a capacity building project for Air emission inventories relating to NMVOC emissions, and flagged this category as priority in order to get support to move to a higher Tier methodology. We intend to contact national authorities on the matter in order to assess and collect the available data for the sector.	Section 4.6.4

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE, TC or UPTC	MS response / Status of implementation	Chapter/section in the IIR
			and hopes to obtain some guidance from that project in order to improve the estimating methodology used. The TERT recommends that Portugal improves the emission estimate based on these actions and includes the improved estimates in its next IIR and describes transparently the method, AD and EF used.			
PT-2D3e-2019-0001	Yes	2D3e Degreasing, NMVOC, 1990-2018	The TERT notes with reference to NMVOC emissions for 2D3e Degreasing for 1990-2019 that a Tier 1 method is used for a key category. The TERT notes that using a Tier 1 method is not best practice, and could result in an over and/or underestimate of emissions. This over/underestimate may have an impact on total emissions that is above the threshold of significance. Portugal has not provided a revised estimate which has been accepted by the TERT. It is currently not possible for the TERT to provide a numerical emission estimate based on a Tier 2 method, and therefore the issue will be flagged as Potential Technical Correction, and will be assessed as a high priority item in future reviews. The TERT recommends that Portugal should calculate NMVOC emissions from 2D3e Degreasing using a Tier 2 or Tier 3 method for inclusion in next years' inventory submission.	UPTC	Implemented. Portugal updated NMVOC estimates from degreasing according to a Tier 2a approach based on chapter 2.D.3.a of 2019 EMEP Guidebook (section 3.2.3) for the whole time series for this submission.	Section 4.5.17
PT-2D3h-2019-0001	Yes	2D3h Printing, NMVOC, 1990-2018	The TERT notes with reference to 2D3h Printing and NMVOC emissions for 1990-2019 that a Tier 1 method is used for a key category. The TERT notes that using a Tier 1 method is not best practice, and could result in an over and/or underestimate of emissions. This over/underestimate may have an impact on total emissions that is above the threshold of significance. The MS has not provided a revised estimate which has been accepted by the TERT. It is currently not possible for the TERT to provide a numerical emission estimate based on a	UPTC	Implemented. Portugal updated NMVOC estimates from printing according to a Tier 2 approach based on chapter 2.D.3.h of 2019 EMEP Guidebook for the whole time series for this submission.	Section 4.5.31

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE, TC or UPTC	MS response / Status of implementation	Chapter/section in the IIR
			Tier 2 method, and therefore the issue will be flagged as Potential Technical Correction, and will be assessed as a high priority item in future reviews. The TERT recommends that Portugal should calculate NMVOC emissions from 2D3h Printing using a Tier 2 or Tier 3 method for inclusion in next years' inventory submission.			
PT-3Da1-2021-0001	No	3Da1 Inorganic N-Fertilizers, NOX, 1990-2019	For category 3Da1 Inorganic N-Fertilizers, pollutant NOX and for all years, the TERT noted that Portugal does not estimate emissions from soils with a pH status < 6.5 on the basis of a statement in the 2019 EMEP/EEA Guidebook which states that 'In agricultural soils, where pH is likely to be maintained above 5.0, nitrification is considered to be the dominant pathway of 'NO' emission'. However, the TERT is of the view that this does not preclude emissions of NOX at lower pH status and that it is merely a statement of the dominant loss pathway when pH status is above 5.0. In response to a question raised during the review, Portugal provided a revised estimate for all years. The TERT agreed with the revised estimate provided by Portugal. The TERT recommends that Portugal include the revised estimate in its 2022 NFR and IIR submission.	No	Implemented.	Section 5.3.1 5.3.1 Synthetic N_fertilizers (NFR 3Da1)
PT-5B2-2021-0001	No	5B2 Biological Treatment of Waste - Anaerobic Digestion at Biogas Facilities, NH3, 2006-2019	For 5B2 (Anaerobic Digestion at Biogas Facilities) and NH3 emissions and years 2006-2019 the TERT noted that there is a lack of transparency regarding the use of manure as a feedstock for this source. This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Portugal explained that anaerobic digestion of manure, based on the last available General Agricultural Census of 2009, does not occur. Additionally, Portugal answered that the 2019 General Agricultural Census was not	No	Data on the use of manure as feedstock in biogas facilities will be addressed in a near future submission.	

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE, TC or UPTC	MS response / Status of implementation	Chapter/section in the IIR
			available for the 2021 submission but will surely be available for the 2022 submission. The TERT recommends that Portugal includes information from the 2019 General Agricultural Census on the use of anaerobic digestion in the IIR and updates the NH3 emissions for this source as part of the 2022 submission.			
PT-5C1bv-2021-0001	No	5C1bv Cremation, SO2, NOX, NMVOC, PM2.5, BaP, PAHs, PCBs, HCB, Cd, Hg, Pb, PCDD/F, PM10, CO, BC, TSP, 1990-2019	For 5C1bv Cremation the TERT noted that there is a lack of transparency regarding the incineration of animal carcasses (or parts of those). This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Portugal explained that the emissions from incineration of animal carcasses are included in the inventory (cement production and industrial waste incineration) and that a reference to this accounting will be added to the 2022 submission. The TERT recommends that Portugal explains in the 2022 submission of the IIR how the emissions of incineration of animal carcasses is considered in the inventory.	No	Explanation included in the IIR 2022. The inventory covers also the co-incineration of animal carcasses and by-products in cement plants (included in NFR 1A2f). Quantities of animal by-products are also incinerated in other facilities and included in industrial waste incineration (5C1bi).	Sub-chapter 6.2.6 - Cremation (NFR 5.C.1.b.v)
PT-LPS-GEN-2021-0001	-	General, 2019	The TERT noted that in 2019, the longitude and latitude coordinates '40.684589211, -8.5897715084' was assigned to both LPS 'Nagivator Pulp Cacia, S.A.' and 'Central Termoeléctrica a Biomassa de Cacia'. The TERT agrees with this approach and recommends that Portugal updates its LPS data accordingly for the next submission.	No	Not implemented During the Review, Portugal advised that the two facilities are located in the same industrial complex, and the coordinates reported refer to the geographical centre of the industrial area. Portugal further advised that they intend to obtain geo-referenced information by stack and report this information in the next LPS submission. This correction will be implemented at the time of the next LPS submission.	

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE, TC or UPTC	MS response / Status of implementation	Chapter/section in the IIR
PT-LPS-A-2021-0001	-	A Public Power, NOX, 2019	The TERT noted that that for the year 2019, NOX emissions are not reported for the 2LPS with the GNFR code A_PublicPower and name 'ARTLANT PTA, SA'. The TERT would generally expect emissions of this pollutant to occur at levels above the reporting threshold from LPS for this GNFR. In response to a question Portugal indicated that the reason for not reporting NOX emissions for this installation is a compilation error, and provided 2019 NOX emission values of 0 kt for the stack of height class 1, and 0.4997 kt for the stack of height class 2. The TERT confirms that there is no further deadline for submissions (other than 01-May-2025), but for users of the data (e.g. modelers, scientists) it would be of value to have access to the corrected data sooner. In this context, the TERT recommends that Portugal ensures that this issue does not recur in the LPS data submission in 2025 and encourages Portugal to provide a corrected version of the current dataset as soon as possible.	-	Not Implemented. This correction will be implemented at the time of the next LPS submission.	
PT-GRID-GEN-2020-0001		General, SO2, NOX, NH3, NMVOC, PM2.5, 2015	The TERT notes with reference to Annex V submitted in 2021, there is a potential lack of appropriate distributions for the gridded emissions and the category F_RoadTransport, which is a key sector for most of the pollutants. This issue was flagged previously during the 2020 NECD inventory review and will therefore be flagged as a priority recommendation. This does not relate to an over- or under-estimate of emissions but does relate to an inaccurate representation of the distribution of emissions. The TERT recommends that Portugal makes improvements to the gridding methods for the next submission and follow best practice for this sector, which is to use traffic data by vehicle types for all major roads.	No	The distribution of Rural and Urban Road Transport emissions according to the road network is a highly resource demanding work that needs the use of a GIS together with data on traffic per road. The availability of these traffic studies is seen, in particular, as one major difficulty concerning this issue. As next steps, we intend to work with other institutions that have additional information and technical capacity to improve the distribution of emissions in the F_RoadTransport category in time to be included in the next gridded emissions submission.	

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE, TC or UPTC	MS response / Status of implementation	Chapter/section in the IIR
PT-GRID-G-2021-0001	-	G Shipping, SO2, NOX, NH3, NMVOC, PM2.5, PAHs, PCBs, HCB, Cd, Hg, PCDD/F, PM10, CO, 2019	The TERT notes with reference to Annex V submitted in 2021 that there is an issue with the gridded data allocated to the sea territory, which does not follow best practice as it appears that Portugal has not allocated emissions to the sea territory. The TERT recommends that Portugal ensure that the gridded data submission provide a complete set of emissions (for as far as located within the EMEP grid), including offshore sources such as domestic shipping and fishing for G_Shipping and I_OffRoad categories, respectively. For these type of sources that are located in the sea, Portugal should make use of the shapefile 'Grid for the whole new EMEP domain' (located at the end of the list in https://www.ceip.at/the-emep-grid/grid-definiton). The TERT recommends that Portugal submits a revised estimate of the 2019 gridded data after addressing this issue.	-	Portugal will consider reviewing this methodology in the next Grid Emissions submission in 2025	

8.2 Overview recalculations

Recalculations and changes in this submission result from updates of background information and to revisions aiming to follow recommendations issued from the NECD reviews, and other inventory review processes under the UNFCCC and the EC. Other recalculations refer to changes resulting from the internal application of QA/QC procedures.

The recalculations performed are summarized as follows:

8.2.1 Recalculations Energy sector (NFR 1)

Manufacturing Industries and Construction (NFR 1.A.2)

In this submission, recalculations in category 1.A.2 were due to minor adjustments listed below:

- Update of 1990-2004 glass production activity data, with impact on NOx, COVNM and SOx emissions;
- Correction of the consumption of Biomass in the Pulp and Paper Industry, for the year 2019
- Correction of the consumption of Natural Gas in the Lime Production Industry for the year 2019;
- Update of the methodology for estimating CO emissions in the lime production sector. The production approach was implemented to estimate CO emissions for the entire time series.

Road Transportation (NFR 1.A.3.b)

The major changes between submissions result from the update of activity data, namely:

- Revision of the stock and distances travelled data from 2003 to 2019;
- Revision of the share of FAME in Biodiesel from 2014 to 2019.

Military Aviation (NFR 1.A.5.b)

Following a recommendation (PT-1A5b-2021-0001) raised during the 2021 NECD review, related with the estimation of PM10 in this category, we have included the estimates of PM2.5, PM10 and TSP by applying the implied emission factor for 1A3ai(i) - International aviation LTO (civil).

Fugitive emission from Oil Production and Refining - Distribution of Oil Products (NFR 1.B.2.a.v)

Data on gasoline sales was updated for 2019.

8.2.2 Recalculations Industrial Processes sector (NFR 2)

The major changes between submissions result from the following actions:

- 2.A.2 (Lime production in Iron and Steel): 1990-2009 and 2018-2019 lime production data were revised;
- 2.A.3 (Glass Wool production): abatement techniques were introduced in glass wool production's estimates; activity data was reported in NFR 2.A.3 for the first time (due to a compilation error, it was not being reported);
- 2.A.5.a (Quarrying and mining of minerals other than coal 2019): 2019 activity data was updated;
- 2.A.5.b (Construction and Demolition): 2019 activity data was updated;
- 2.B.1 (Ammonia Production): emission factors were updated to a Tier 2 (Partial Oxidation process) based on 2019 EMEP Guidebook for 1990-2008;
- 2.B.6 (Titanium Dioxide Production): 2019 activity data was updated;

- 2.B.8 (Petrochemical and Carbon Black Production): 2019 activity data was updated for minor categories;
- 2.B.10.a (Chemical Industry): 2019 activity data was updated for minor categories;;
- 2.C.1 (Iron and Steel Production): PAH emissions from Pig Iron production in the Blast furnace were reported for this first time for 1990-2001, following a compilation error;
- 2.D.3.a (Domestic Solvent Use): 2018-2019 activity data were updated according to ESIG;
- 2.D.3.b (Road Paving with asphalt): activity data was corrected for the whole time series, due to a compilation error; emission factors were updated to a Tier 2 based on 2019 EMEP Guidebook for the whole time series; BC emissions were estimated for the first time for the whole time series;
- 2.D.3.c (Asphalt Roofing): 2014-2019 data on sold production were updated according to EUROSTAT database;
- 2.D.3.d (Coating Applications - Paint Application for Domestic Use): Activity data in 2002-2003 and 2011-2019 were updated, due to a compilation error;
- 2.D.3.d (Coating Applications – Other Industrial Paint applications): 2019 data was updated;
- 2.D.3.e (Degreasing): methodological revision of the sector for the whole time series;
- 2.D.3.g (Chemical Products – Glues Manufacturing): Activity data in 1991-2019 were updated, due to a compilation error;
- 2.D.3.g (Chemical Products - Adhesives, Magnetic Tapes, Films and Photographs Manufacturing): 2019 activity data was updated;
- 2.D.3.g (Chemical Products – Shoes Manufacturing): Activity data in 2012-2019 were updated;
- 2.D.3.h (Printing): methodological revision of the sector for the whole time series;
- 2.D.3.i (Glass Wool Induction): NMVOC emissions were removed for the whole time series, due to double counting with NMVOC emissions from Glass Wool production NFR 2.A.3;
- 2.D.3.i (Preservation of Wood): 2019 data was updated;
- 2.D.3.i (Lubricants consumption): Two-stroke engines lubricants consumption data were updated for 1994-2019;
- 2.H.2 (Food Manufacturing): TSP, PM2.5 and BC estimates were updated to NE for the whole time series according to a 2021 NECD Review recommendation;
- Several minor sub-categories: Update on surrogate data such as Gross Domestic Product (GDP) and Gross Value Added (GVA) for 2019.

8.2.3 Recalculations Agriculture sector (NFR 3)

The major changes between last year submission and this year submission result from the following actions:

- the revision of National Statistics on livestock numbers from 2017 onwards (NFR 3B);
- the update of Daily volatile solids excreted (VS), following methodological development plan (NFR 3B);
- Update in “Other NP & NPK” fertilizers consumption National Statistics time series for the period 2003-2008 (NFR 3D);
- Update in “Other N” fertilizers consumption National Statistics time series for the period 2011-2013, years 2016 and 2019 (NFR 3D);
- Update in Calcium Ammonium Nitrate (CAN) fertilizers methodology; Since there is no reliable data for the period 2008-2014, we start using the average of the period 2015-2019; For the other periods we used National Statistics (NFR 3D);
- Update in Ammonium Nitrate National Statistics in 2019 (NFR 3D);

- Update in Ammonium Sulphate National Statistics in 2018-2019 period (NFR 3D);
- Update in N content of sludge applied to soils from 2018 onwards (NFR 3D); National statistics updates on Biomass Burnt from 2016 onwards (NFR 3F).

8.2.4 Recalculations Waste sector (NFR 5)

Revisions since last submission include:

- Industrial Waste Amounts

  A major revision referring to activity data on industrial waste was made for this submission in order to respond to a UNFCCC recommendation urging Portugal to provide information that supports the industrial waste growth rates used to estimate the historical time series on the amount of industrial waste for the period 1960-1998.

  Previous assumptions on annual growth rates used to estimate AD for the years 1960-1998 were based on expert judgement. The basis for these assumptions established several years ago was however difficult to track down as no full registry of the rationale behind could be found. Therefore, in the absence of historical data on solid waste disposal, an approach based on the evolution of Portuguese GDP was used for this submission. This indicator is considered to be the most appropriate as it is the most complete and consistent time series available.

  This change impacted the CH4, and COVNM and NH3 emission estimates for the whole reporting period due to the FOD methodology (5.A), and emissions related to the incineration of Industrial waste (5.C.1) concerning the years 1990-1998.

- Domestic wastewater (5.D.1)
  - revision of per capita protein intake (years 2012-2019);
  - agricultural recovery of sludge:
    - AD and total N concentration: revision of 2018-2019 years based on the average values of 2017 and 2020 years;
    - NH3 from sewage sludge that volatilizes as NH3 and NOx (FracGASM): revision according to EMEP/EEA GB2019 (table 3.1 chapter 3 D).

- Industrial wastewater (5.D.2)

  Revision of AD for some industrial sectors (years 2018-2019).

The recalculations of emission levels are presented in the following figures which show the absolute differences between the latest submission (2022) and the previous submission (2021) for National Total (Mainland + Madeira and Azores Islands).

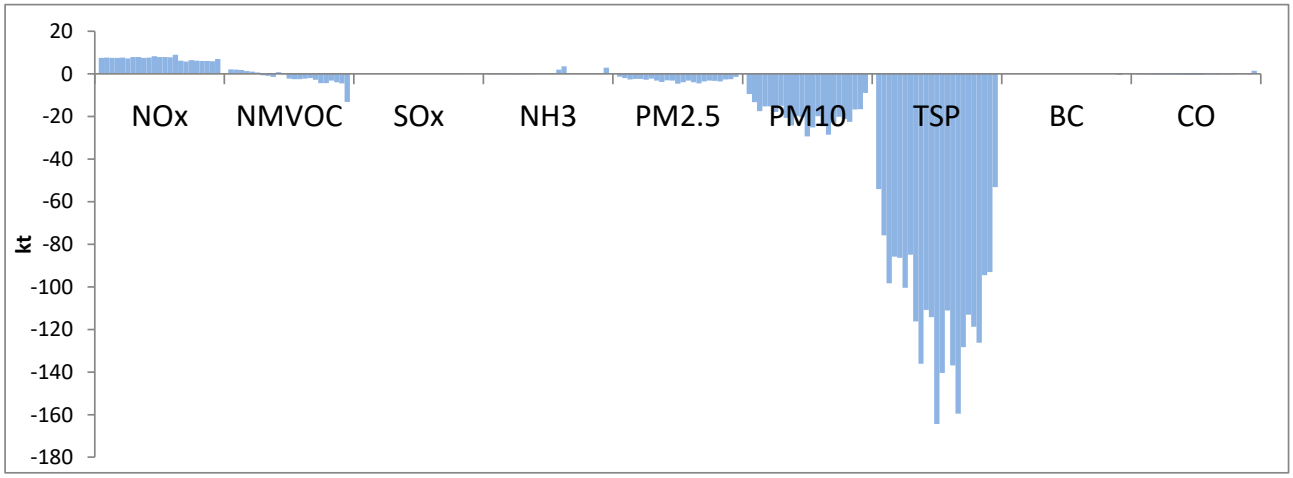


Figure 8-1: Recalculations for main pollutants and particulate matter for 1990-2019 (absolute difference between 2022 and 2021 submissions)

The impact of the recalculation in each sector for the 2019 year and for every pollutant is presented in the next figures, which show the impact of the recalculation of the categories in total recalculation of each pollutant, calculated as: 100 x [(LS-PS)/Total recalculation (LS)], where LS = latest submission and PS = previous submission).

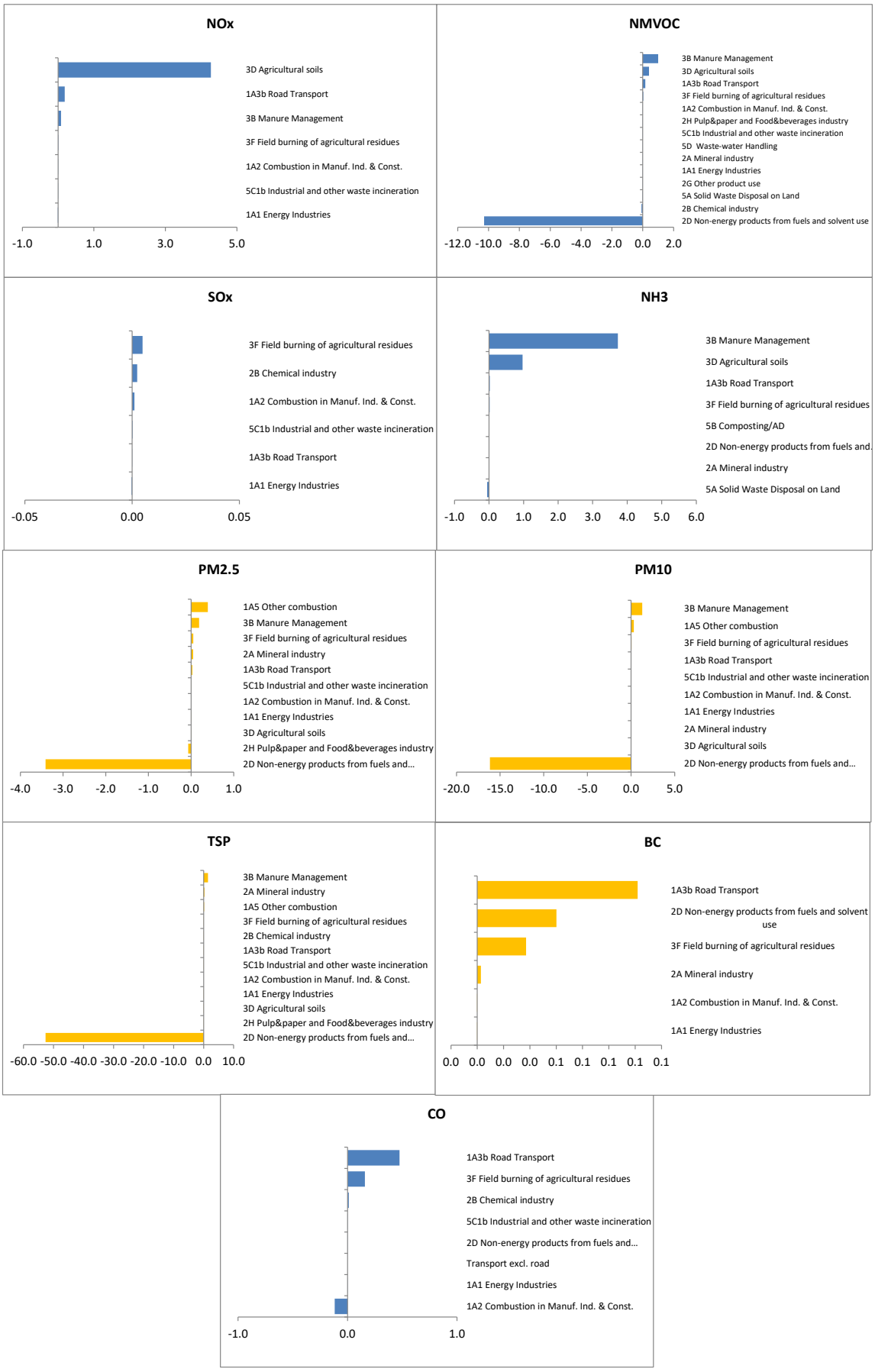


Figure 8-2: Sectoral contribution in recalculations: Main pollutants and particulate matter (% contribution to the total emissions of each pollutant in 2019)

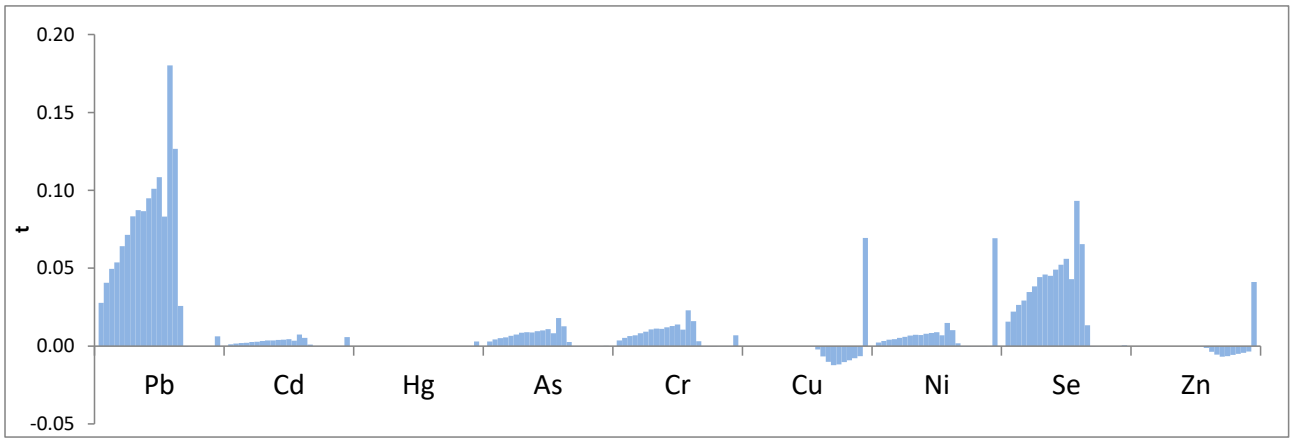


Figure 8-3: Recalculations for heavy metals for 1990-2019 (absolute difference between 2022 and 2021 submissions)

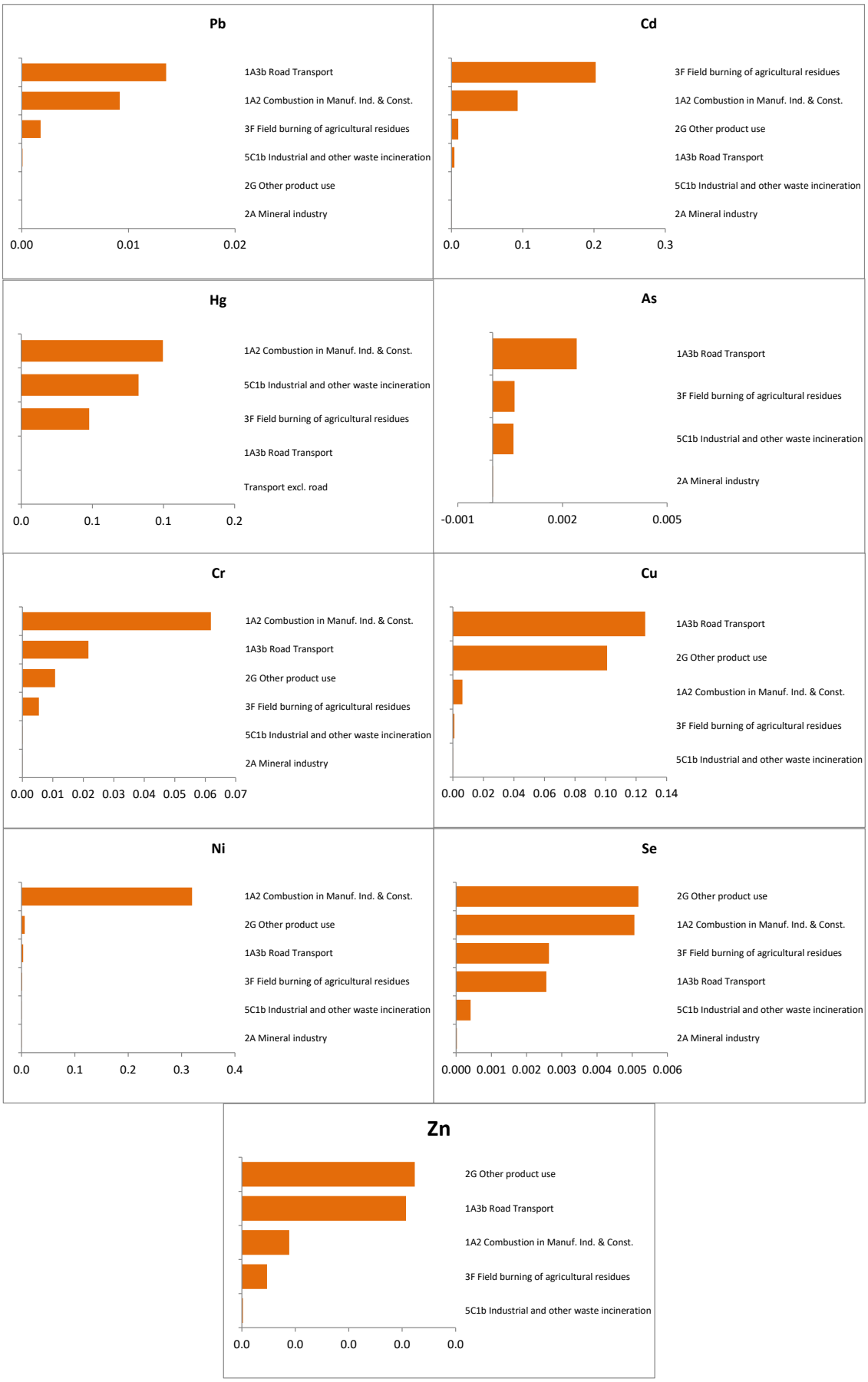


Figure 8-4: Sectoral contribution in recalculations: Heavy Metals (% contribution to the total emissions of each pollutant in 2019)

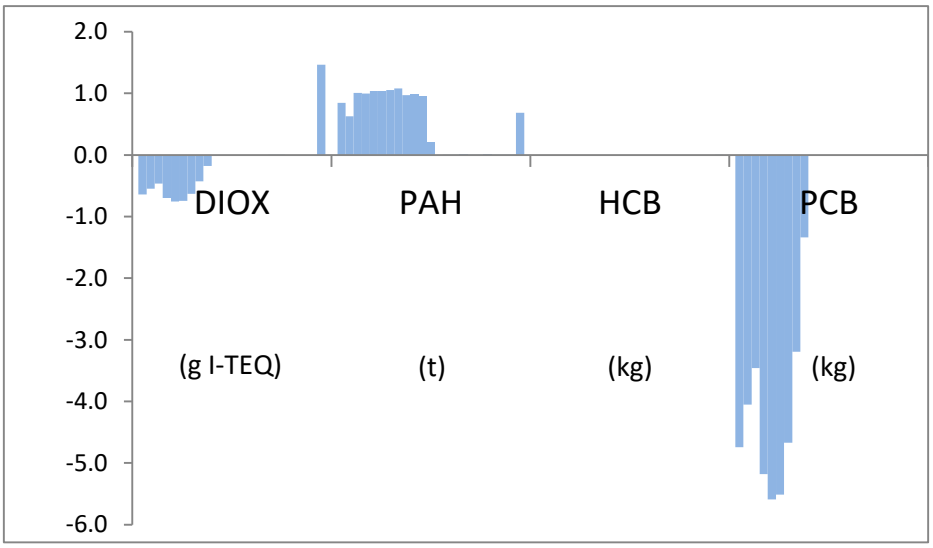


Figure 8-5: Recalculations for Dioxines, PAHs, HCB and PCB for 1990-2019 (absolute difference between 2022 and 2021 submissions)

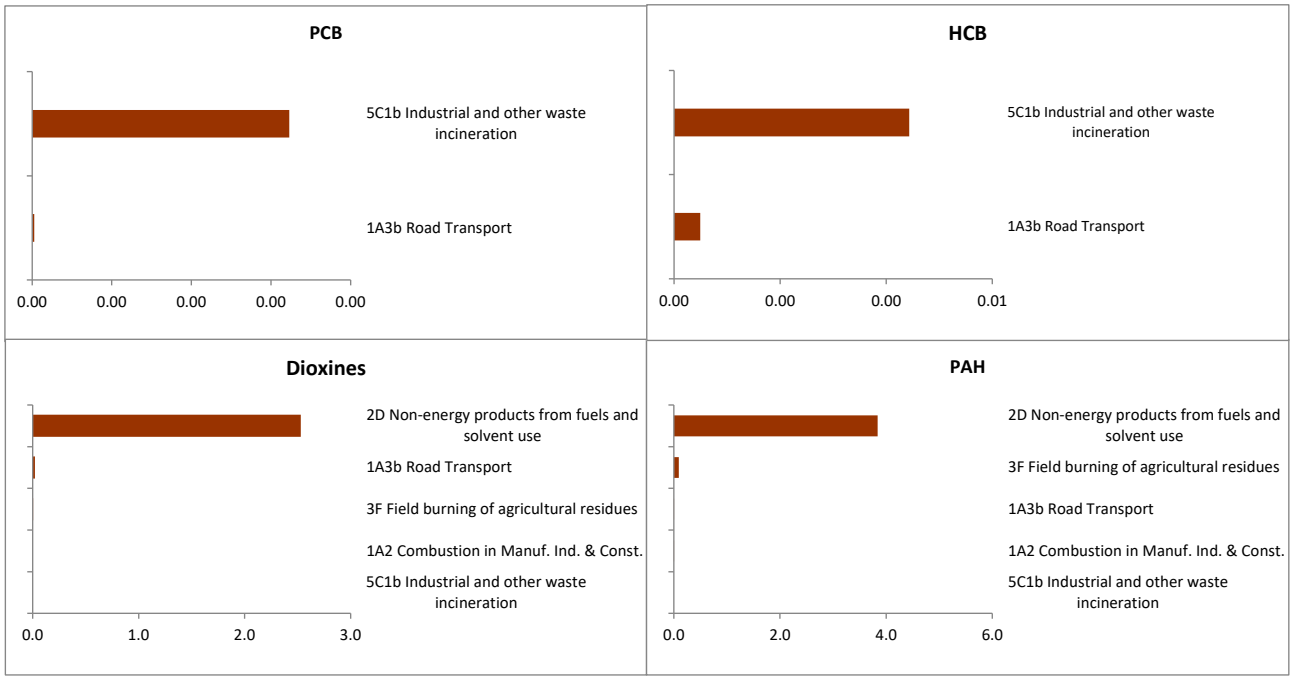


Figure 8-6: Sectoral contribution in recalculations: PCB, HCB, Dioxines and PAHs (% contribution to the total emissions of each pollutant in 2019)

9 Projections

Table of Contents

9 Projections 9-1

9.1 Introduction 9-4

9.2 General methodological approach 9-5

9.3 Emission projections by sector 9-8

9.3.1 Energy industries: electricity production and refining (NFR 1A1) 9-8

9.3.2 Transport (NFR 1A3a, 1A3b, 1A3c, 1A3d) 9-10

9.3.3 Commercial/Institutional, Residential, and Agriculture/Forestry/Fishing – small combustion (NFR 1A4) 9-14

9.3.4 Fugitive Emissions (NFR 1B) 9-16

9.3.5 Industry and Construction (NFR 1A2, 2B, 2C, 2H) 9-17

9.3.6 Solvent use (NFR 2D, 2G) 9-20

9.3.7 Agriculture (NFR 3B, 3D, 3F) and Forest Fires (NFR 11C) 9-22

9.3.8 Waste (NFR 5A, 5B, 5C, 5D, 5E) 9-26

9.4 Carbon neutrality impacts on atmospheric emissions 9-29

9.5 Carbon neutrality impacts on national emission reduction commitments 9-32

List of Figures

Figure 9-1: Methodological approach adopted for the projection of air pollutant emissions under the scope of the RNC2050 9-8

Figure 9-2: Projected emissions of the main atmospheric pollutants in the electricity and heat production sector (NFR 1A1a), by fuel (kt) 9-10

Figure 9-3: Demand evolution trend by transport mode (Index compared to 2010) 9-11

Figure 9-4: Demand satisfaction in the passenger car and heavy duty vehicles categories (Mpkm and Mtkm) 9-12

Figure 9-5: Projected emissions of the main atmospheric pollutants in the transport sector (NFR 1A3) (kt). 9-13

Figure 9-6: Final energy consumption in the Commercial/Institutional (NFR 1A4ai) and Residential (NFR 1A4bi) (PJ) 9-14

Figure 9-7: Combustion emissions of the main atmospheric pollutants in the Commercial/Institutional (NFR 1A4ai), Residential (NFR 1A4bi) and Agriculture/Forestry/Fishing (NFR 1A4cii) sectors (kt) 9-16

Figure 9-8: Projected NMVOC fugitive emissions accounted in NFR 1B (kt) 9-17

Figure 9-9: Projection of energy demand and materials demand in the industrial sub-sectors (Index 2015 = 100) 9-18

Figure 9-10: Projected emissions of the main atmospheric pollutants in the industrial sub-sectors (NFR 1A2 and NFR 2A,B,C,H,I,J,K,L) (kt) 9-20

Figure 9-11: Projected solvent use NMVOC emissions accounted in NFR 2D, 2G (kt) 9-21

Figure 9-12: Activity data considered in the waste sector: trends of population (left) and evolution of municipal solid waste production (right) 9-27

Figure 9-13: Composition of municipal solid waste in 2016 and 2050 (%) 9-27

Figure 9-14: Total amount of municipal solid waste projected by final destination (kt) 9-28

Figure 9-15: Projected evolution of organic industrial waste deposition in landfill (kt) 9-28

Figure 9-16: Historic and projected atmospheric emissions by sector 9-32

List of Tables

Table 9-1: Energy consumption in the power sector (NFR 1A1a) and total amount of crude processed in the refining sector (NFR 1A1b) (PJ) 9-9

Table 9-2: Emissions of the main atmospheric pollutants in the energy industries sector (NFR 1A1) 9-10

Table 9-3: Emissions of the main atmospheric pollutants in the transport sector (NFR 1A3) (kt) 9-13

Table 9-4: Combustion emissions of the main atmospheric pollutants in the Commercial/Institutional (NFR 1A4ai), Residential (NFR 1A4bi) and Agriculture/Forestry/Fishing (NFR 1A4cii) 9-15

Table 9-5: Selected activity variables to estimate fugitive emissions (NFR 1B) 9-16

Table 9-6: NMVOC fugitive emissions accounted in NFR 1B (kt) 9-17

Table 9-7: Final energy consumption in the industry and construction sector (without cogeneration) (NFR 1A2) (PJ) 9-18

Table 9-8: Final energy consumption in cogeneration from industrial sector I (NFR 1A2) (PJ) 9-18

Table 9-9: Emissions of the main atmospheric pollutants in the industrial sector (NFR 1A2 and NFR 2A,B,C,H,I,J,K,L) (kt) 9-19

Table 9-10: Selected activity variables to estimate solvent use emissions (NFR 2D, 2G) 9-21

Table 9-11: NMVOC emissions in the solvent use sector (NFR 2D, 2G) (kt) 9-21

Table 9-12: Main sectorial variables of plant production in the agricultural sector 9-22

Table 9-13: Main sectorial variables of animal production in the agricultural sector 9-23

Table 9-14: Summary of the main sectorial activity variables of the agriculture sector 9-23

Table 9-15: Activity data selected to estimate emissions from forest fires 9-24

Table 9-16: Emissions of the main atmospheric pollutants in the agriculture sector (NFR 3B, 3D, 3F) 9-25

Table 9-17: NH_3 emissions in the agriculture sector (NFR 3B, 3D, 3F) (kt) 9-25

Table 9-18: Emissions of the main atmospheric pollutants in the forest sector (NFR 11B) 9-26

Table 9-19: Emissions of the main atmospheric pollutants in the waste sector (NFR 5A, B, C, D, E) 9-29

Table 9-20: Atmospheric emissions, projections and percentage reductions compared to 2005 by sector 9-31

Table 9-21: Assessment of compliance of the national emission reduction commitments in 2020 and 2030, with regards to 2005 9-33

9 Projections

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Updated: March 2021

9.1 Introduction

The estimation of emissions of acidifying and eutrophic gases (NO_x, NMVOC, NH_3), ozone precursors (NO_x and NMVOC), particles (PM_{10}, $PM_{2.5}$, TSP), heavy metals and persistent organic pollutants, for 2020, 2030, 2040 and 2050 is based on a methodological approach consistent with the National Inventory System (SNIERPA) and the evolution scenarios of the Portuguese economy outlined in the scope of the Portuguese Roadmap for Carbon Neutrality 2050 (RNC2050).

During the twenty-second session of the Conference of the Parties (COP 22) Portugal publically affirmed its commitment to attain net zero GHG emissions, by the end of the first half of the century. To do so the RNC2050 roadmap was developed (in 2018) to assess conceivable pathways, integrating all socioeconomic sectors, to achieve zero net carbon emissions by 2050. The RNC2050 was approved by the Portuguese Government with the publication of the Resolution of the Council of Ministers 107/2019, and its Technical Report — Long-term Strategy for Carbon Neutrality of the Portuguese Economy by 2050 — is available online[1].

The effects of carbon neutrality trajectories, and correspondent solutions, on air pollutant emissions in Portugal were performed, additionally to the RNC2050, and those results are the main focus of the present chapter. The estimation of atmospheric emissions is based on assumptions made within the scope of the RNC2050 and on the projection of activity variables. The estimates of air pollutant emissions, until 2050, were based on the projection of activity variables. These, in turn, result from the energy services and materials demand scenarios, to accommodate the considered paths of evolution of the Portuguese economy.

In the scope of the RNC2050, three distinct socio-economic evolution scenarios were considered, namely: Yellow Jersey (YJ), Pack (P), and Off Track (OT), with a cycling analogy, reflecting distinct economic activity and climate action levels. For the purpose of this projection report, the macroeconomic Pack (P) scenario "with neutrality" — corresponding to a WAM scenario in Climate Policy — was selected as the scenario With Measures (WM), in the context of the NEC Directive[2], since it was assumed that the respective measures will be adopted under Climate framework. In this sense, the WAM scenario for Air Pollution Policy will be considered and adopted under the NAPCP (National Air Pollution Control Programme) for further reductions, taking into account the national emission reduction commitments applicable from 2020 to 2029 and from 2030 onwards.

[1] https://unfccc.int/sites/default/files/resource/RNC2050_EN_PT%20Long%20Term%20Strategy.pdf

[2] The EU Directive 2016/2284, on the reduction of national emissions of certain atmospheric pollutants, is referred in short, within this section, as the NEC Directive

9.2 General methodological approach

The bottom-up linear optimization energy system TIMES model was selected as a modelling tool for the development of decarbonisation scenarios for the energy system. The goal of the model is the satisfaction of the energy services demand at the minimum total system cost, subject to technological, physical and policy constraints. To do so, the model makes simultaneous choices regarding technology investment, primary energy supply and energy trade.

The technological peer-reviewed model TIMES_PT was used to evaluate the future penetration of different cost-effective technological options in each of the three storylines/scenarios. The TIMES_PT model represents the whole Portuguese energy system and its possible long-term developments. It takes an integrated energy system, from services demand (in industry, residential/commercial/services, transport, and agriculture sectors), to supply sectors (power and heat production), to decide over a portfolio of energy technologies, following cost-effective criteria.

The detailed analysis of the basic assumptions taken into account for the prospective analysis until 2050 can be consulted in the Technical Report "Roadmap for Carbon Neutrality 2050", as well as in the respective Sectoral Technical Reports[3]. Some of the assumptions taken into account in the prospective analysis until 2050 are systematized below, by activity sector:

- Power sector:
  - In all scenarios, the end of production of thermal power plants is considered in the following terms: coal power plants in Pego and Sines between 2025-2029; Ribatejo natural gas combined cycle plant between 2036-2039; combined cycle power plants from Lares and Pego between 2041-2044;
  - All scenarios are modeled using the RCP4.5[4] climate scenario, therefore considering a gradual reduction in water availability until 2050;
- Buildings:
  - In the P scenario there is a reduction in urban housing (and a slight increase in rural dwellings); an increase in multi-apartment buildings due to urban pressure and to increased tourism in large cities; a reduction in the average housing area due to higher house pricing, real estate pressure and greater house modularity;
  - In this scenario, an improvement in the thermal comfort inside the houses is considered, both in heating and cooling seasons;
- Transports and Mobility:
  - In the P scenario, a greater demand for passengers and goods mobility is assumed, due to greater equity in access to mobility services and economic activity growth; as well as, moderate evolution of "mobility-as-a-service" systems with predominance of classic public transport and soft modes; and

[3] https://descarbonizar2050.pt/documentos/; https://unfccc.int/process/the-paris-agreement/long-term-strategies; https://ec.europa.eu/info/energy-climate-change-environment/overall-targets/long-term-strategies_en.

[4] The RCP4.5 scenario describes a climatic future, depending on the amount of GHG emitted in the coming years, leading to a radiative forcing, in the year 2100, of 4.5W/m^2. This scenario corresponds to an increase in the average temperature of the planet of 1.4° C (in a range between 0.9° C and 2° C) until 2065, and of 1.8° C until the end of the century.

technological developments, including autonomous mobility, very much allocated to a structure centered on individual use;

- Agriculture:
  - In the P scenario, there is a greater demand for plant-based and organic food products; moderate growth in productivity of agricultural production factors; maintenance of the composition of the system of direct payments to producers, more oriented to the environment, climate change and land use.
- Land Use:
  - In the P scenario, there is a trend to decrease the average annual burnt area due to forest fires, as a result of improved land use management; the burnt areas will mostly be reforested with production species (cork, maritime pine and eucalyptus), with less loss of forest area for scrub (deforestation) and a considerable increase in forest productivity, with forest expansion limited to production species;
- Waste:
  - The P scenario is characterized by the development and application of new technologies that, however, do not change either the production structures or the ways of life of the populations. There is a gradual increase in the selective waste collection of recyclables, including bio-waste, reaching the target of 65% in 2030; a relative reduction of biodegradable urban waste disposal on landfill; and a reduction in the production of urban waste per capita (reaching 421 kg/person.year, in 2050);

The followed methodological approach is consistent with national submissions on this subject, namely, with the Portuguese Informative Inventory Report (IIR), in particular regarding specific emission factors (EF) by fuel type, process emission factors, territorial coverage (only for mainland Portugal, excluding Madeira and Açores groups of islands) and other approach boundaries (i.e. aviation emissions accountability). For instance, the estimation of air pollutant emissions in the power sector resulted from the application of implicit emission factors, by type of fuel, according to the projection of energy consumption. Regarding the refining activity, this was estimated according to the evolution of the amount of crude processed in the refineries, in future scenarios. An adaptation was made for emission factors to be used taking into account the level of technological detail of the TIMES_PT model.

Regarding the emission factors used, the following sector specificities were also taken into account:

- In order to ensure adequate adherence to the national methodology, industry estimates were based on the calculation of implicit emission factors, taking into account the available dataset from IIR (2018 submission). Implicit emission factors are expressed as the amount of pollutant emitted by energy consumed (fuel-based), or the amount of pollutant emitted by quantity of produced product (activity-based), associated with each technology and fuel used. These EF reflect the national real operating conditions, ac-counting for technologies that have already been installed to reduce air pollution. For NMVOC, emissions are dominated by non-energy sources, such as fugitive emissions and process emissions from industry. Regarding this, some additional control and abatement measures were taken into account, namely measures with a mitigation potential in the area of industrial use of solvents, and

in the distribution of oil products, simulating the implementation of the Stage II and IB controls at service stations[5];

- In the case of road transport sector, EF used (based on the national IIR) consider current technological conditions (i.e. vehicles stock euro standards shares). These EF were adjusted to future conditions, reflecting technological and fuel evolution. The emission projection considered TIMES_PT modelling outputs of fleet composition and demand satisfaction. Cold start emissions and evaporative emissions were not included. Non-exhaust emissions (including tyre, brake, and road wear) were accounted, using the EMEP/EEA Air Pollutant Emission Inventory Guidebook[6] (2016 edition) EF. For railways, estimates were activity–based and, in the case of shipping and aviation subsectors, the calculations were fuel consumption based;
- In residential/commercial/services sector, EMEP/EEA Guidebook (2016 edition) EF were used, as well others, reflecting emission control and efficiency improvement technologies, to be implemented until 2050. The impacts of approved standards (as the so called Ecodesign Directive, referring to Directive 2009/125/EC) for improved technology efficiency and air pollutant emissions, for PM and NMVOC, were additionally included by considering reductions in emission factors correspondent to new wood burning domestic appliances, beyond 2030;
- In the case of agriculture and forestry sectors, its evolution assumed different assumptions, aligned with the socioeconomic scenarios storylines. Emissions from this sector resulted from areas occupied by temporary and permanent crops and livestock, as well as from the respective vegetable and animal production, and areas occupied by pastures and other uses of agricultural soils. EF were compiled from the EMEP/EEA Guidebook (2016 edition) and from the IIR (2018 submission);
- For the waste sector, the methodology adopted for emissions projections considered the physical quantities of municipal solid waste (MSW) and domestic wastewater annually generated, and the correspondent resident population evolution. Air pollutant emissions from MSW incineration were also estimated and allocated under the energy production sector, in coherence with national inventory approach. The quantification of industrial waste was based on the projections of industrial production, by activity sector.

Recently, a revision of air pollutant emissions estimates was carried out, considering the recent updates in the IIR, submitted in 2020, which brought significant changes, namely for the emissions of non-methane volatile organic compounds (NMVOC). In the current section the updated version of estimates is presented, being the historical data presented based on the submission version of the IIR carried out in 2020 (with emissions data up to the year 2018).

Figure 9-1 summarizes the adopted methodology.

[5] IIASA GAINS Europe Greenhouse Gas - Air Pollution Interactions and Synergies - Control Strategies. 2018, Available at: https://gains.iiasa.ac.at/models/gains_models3.html.

[6] The EMEP/EEA Air pollutant Emission Inventory Guidebook is, in this section, referred in short as EMEP/EEA Guidebook.

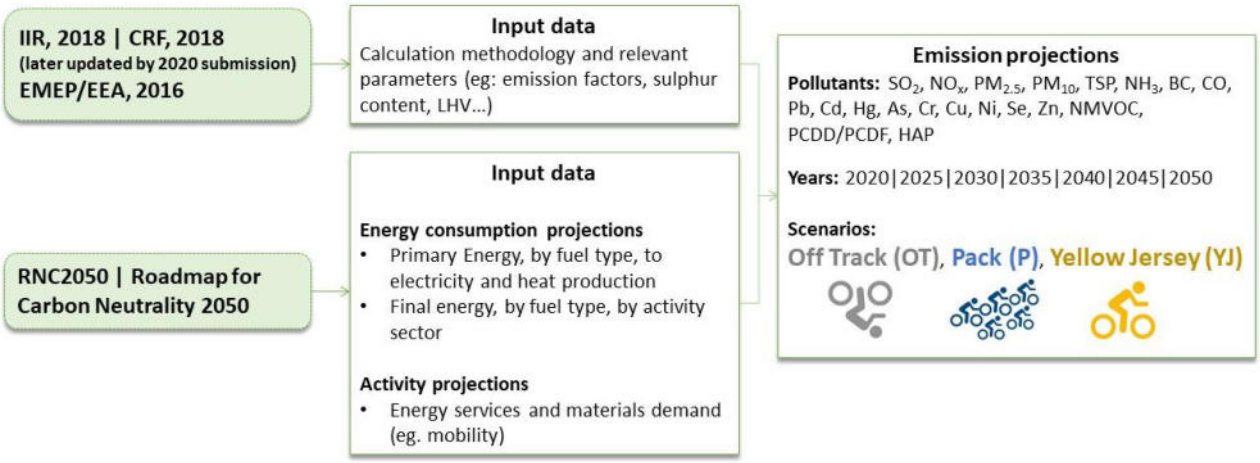

Figure 9-1: Methodological approach adopted for the projection of air pollutant emissions under the scope of the RNC2050

As previously referred, the projected emissions analysis will be focused on the Pack (P) scenario, representing the With Measures (WM) scenario, in the context of the NEC Directive. It is assumed that the respective measures will be adopted under Climate framework. In this sense, the WAM scenario for Air Pollution Policy will be considered and adopted under the NAPCP (National Air Pollution Control Programme) for further reductions, taking into account the national emission reduction commitments applicable from 2020 to 2029 and from 2030 onwards.

9.3 Emission projections by sector

9.3.1 Energy industries: electricity production and refining (NFR 1A1)

9.3.1.1 Methodology and activity variables

The estimation of air pollutant emissions in the power sector resulted from the application of implicit emission factors, by type of fuel, according to the projection of the activity variables, such as energy consumption, until 2050, for each scenario generated by the TIMES_PT model.

The estimates of air pollutants emissions were made according to the following methodological approach:

- power sector (NFR 1A1a): application of implicit emission factors based on the evolution of the energy consumed, by fuel type, between 2015 and 2050;
- refining sector (NFR 1A1b): application of an implicit emission factor, according to the quantity of crude processed, between 2015 and 2050.

Energy consumption, projected for the centralized electricity production, is shown in Table 9-1 (excluding renewable sources that do not emit pollutants), by fuel type. This scenario responds to a greater demand for electricity. Also in Table 9-1 is represented the total amount of crude processed, projected until 2050.

Table 9-1: Energy consumption in the power sector (NFR 1A1a) and total amount of crude processed in the refining sector (NFR 1A1b) (PJ)

	Historical data			Projection				Trend	Unit
	2005	2010	2015	2020	2030	2040	2050		
Power sector									
Coal	137	67	123	116	0	0	0		PJ
Petroleum Products	57	0	11	9	6	2	0		PJ
Natural Gas	72	85	32	22	7	0	0		PJ
Biogas	0	1	2	3	2	0	0		PJ
Biomass	1	6	8	8	16	4	0		PJ
Waste	9	8	4	4	7	4	4		PJ
Geothermal	0	1	1	2	2	1	0		PJ
Total	**275**	**168**	**181**	**164**	**40**	**12**	**4**		PJ
Refining sector									
Crude processed	560	535	588	588	498	202	69		PJ

The objective of achieving carbon neutrality will require a shift in the paradigm of the energy supply structure, together with a significant increase in energy efficiency.

Carbon neutrality will require a massive use of endogenous renewable energy resources with positive consequences on the energy bill and reduced energy dependence. After 2030, endogenous resources are expected to surpass the import of petroleum products, which currently represent the largest primary energy source in the country (> 40%), mainly needed for transport sector. Natural gas and coal will also suffer a considerable decline, especially coal, which will practically cease to exist in the national energy system.

9.3.1.2 Emissions

Pollutant emissions in the power sector, presented in Table 9-2, show a significant decrease, compared to 2005, mainly due to the introduction of electricity production from renewable sources.

The power sector is one of the major vectors of national decarbonisation due to the cost-effective potential of renewable energy in Portugal, corresponding also to a strong reduction in all atmospheric pollutants emissions until 2050.

NO_x and SO_x emissions (Table 9-2) are sharply reduced, 91% and 99%, respectively, due to the reduction in the consumption of coal and petroleum products. Figure 9-2 represents the main pollutants emission trends within the power sector (NFR 1A1a). There is a slight increase in some pollutants' emissions, such as NMVOC, CO, PM, in 2030, due to the transitory increase of biomass consumption.

Table 9-2: Emissions of the main atmospheric pollutants in the energy industries sector (NFR 1A1)

Pollutant	Historical data			Projection				Trend	Δ2020-2005	Δ2030-2005
	2005	2010	2015	2020	2030	2040	2050		(%)	(%)
NOx (as NO2) (kt)	70.32	19.23	16.48	13.02	6.04	2.36	1.30		-81%	-91%
NMVOC (kt)	1.00	1.65	1.70	1.66	2.33	0.58	0.02		66%	133%
SOx (as SO2) (kt)	118.61	8.68	3.27	2.27	1.34	0.39	0.04		-98%	-99%
PM2.5 (kt)	1.05	0.34	0.21	0.21	0.27	0.07	0.01		-80%	-75%
CO (kt)	3.35	5.35	6.52	6.26	8.13	2.17	0.15		87%	143%
NH3 (kt)	0.01	0.01	0.01	0.01	0.02	0.01	0.01		7%	73%
BC (kt)	0.02	0.02	0.01	0.01	0.01	0.00	0.00		-53%	-43%
Pb (t)	1.42	0.72	1.19	2.62	0.19	0.07	0.04		84%	-86%
Zn (t)	8.61	5.43	6.60	6.00	4.34	1.16	0.10		-30%	-50%
PCDD/ PCDF (g I-TEQ)	1.65	1.09	1.82	1.60	0.90	0.29	0.11		-3%	-45%

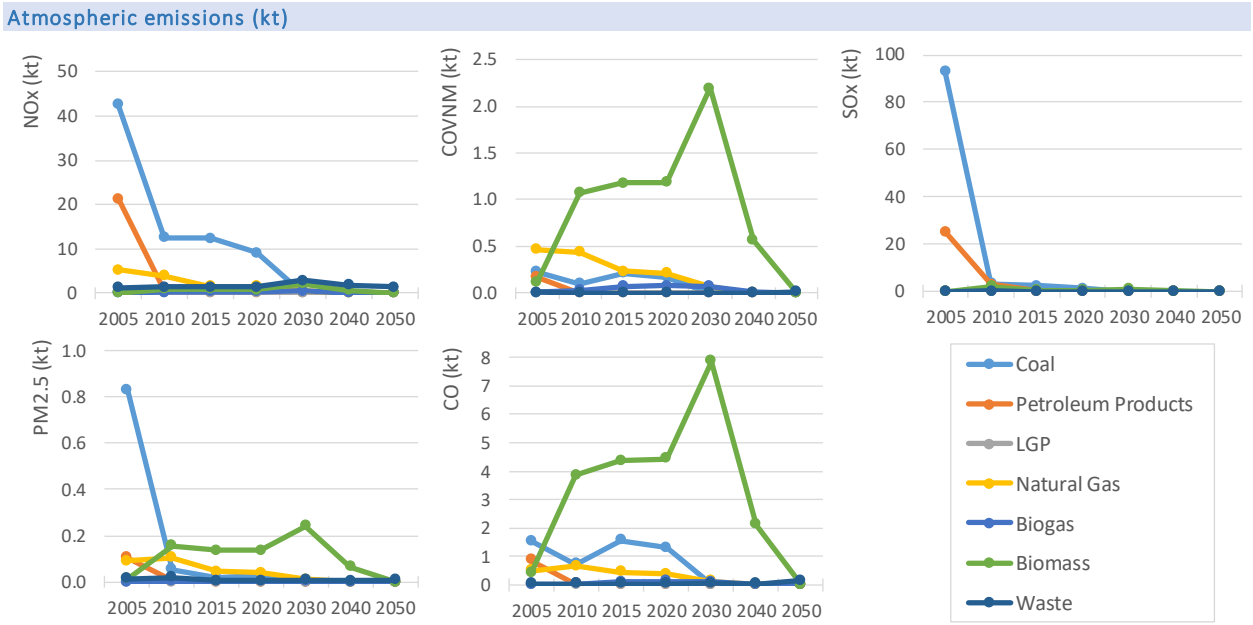

Figure 9-2: Projected emissions of the main atmospheric pollutants in the electricity and heat production sector (NFR 1A1a), by fuel (kt)

9.3.2 Transport (NFR 1A3a, 1A3b, 1A3c, 1A3d)

9.3.2.1 Methodology and activity variables

The transport sector has a significant weight in GHG emissions (about a quarter of total national GHG emissions) and NO_x (50% in 2015). In the last decades this sector showed the greatest growth, being the road transport segment the major contributor. It is also the sector with the highest energy intensity and the greatest indirect contribution to primary energy import and energy dependence.

In the decarbonisation effort context, the mobility sector will have significant changes, especially in the next two decades. An increase in the mobility demand is expected, in all modes, as well as the following aspects:

- passenger mobility: the main driver for the decarbonisation of passenger mobility is the replacement of combustion engines with electric traction provided by batteries and/or hydrogen, together with more intensive use of public transport. From 2040 onwards, there will also be a generalization of shared and/or autonomous electric light passenger transport;
- heavy duty vehicles: in addition to the growing electrification, new fuels (H_2) or new technologies (dynamic charging systems) will be introduced in 2050. The implementation of these solutions will

depend on the development of basic infrastructures, whose investment and operating costs are still subject to a high degree of uncertainty.

The projected technological change to satisfy mobility brings efficiency improvements, with a reduction in the energy intensity of the sector, between 2005 and 2050, of 76% (energy consumed per passenger.kilometer) and 83% (energy consumed per ton of goods transported).

Fossil fuels are gradually replaced by electricity and hydrogen, with an increase of soft modes in short distance mobility. Electrification is preponderant in most transport modes in the trajectory for carbon neutrality, reaching values in the order of 70% of the total energy consumption of transport in 2050. Electrification is thus an enhancer of energy efficiency in transport, propagating this effect throughout the energy system and contributing to a positive impact in the reduction of air pollutants.

With regard to activity variables, the generation of mobility demand (Figure 9-3) was carried out considering the relationships between the different key variables (socioeconomic indicators) and the sector's activity. The different relationships by transport mode were determined using multiple linear regressions selected from the relationship between historical activity data (2000-2015 period) and the referred indicators.

The calculation of emissions from road transport was done using emission factors (Gg of pollutant / PJ), which vary according to the type of vehicles that guarantee demand satisfaction and the fuel used (Figure 9-4), according with the results obtained with TIMES_PT model.

With regard to the road transport, an adaptation was made to the emission factors to be used taking into account the level of technological detail of the TIMES_PT model. Thus, the implicit emission factors took into account the age and respective Euro standard of the national car fleet in 2016, as well as the mileage of each vehicle category. The evolution of the age of the car fleet took into account the historical evolution of these indicators and the average lifetime. The introduction of new Euro “VII” and “VIII” standards was considered from 2025 and 2030, respectively. Given the high uncertainty of the effective reduction in the level of emissions of these standards, a reduction between 25% and 35% was estimated compared to the emission levels of the Euro VI standard.

In the case of abrasion emissions associated to tyre, brake and road surface wear (NFR codes: 1A3bvi - Road transport: Automobile tyre and brake wear and 1A3bvii - Road transport: Automobile road abrasion), the respective mileage was taken into account.

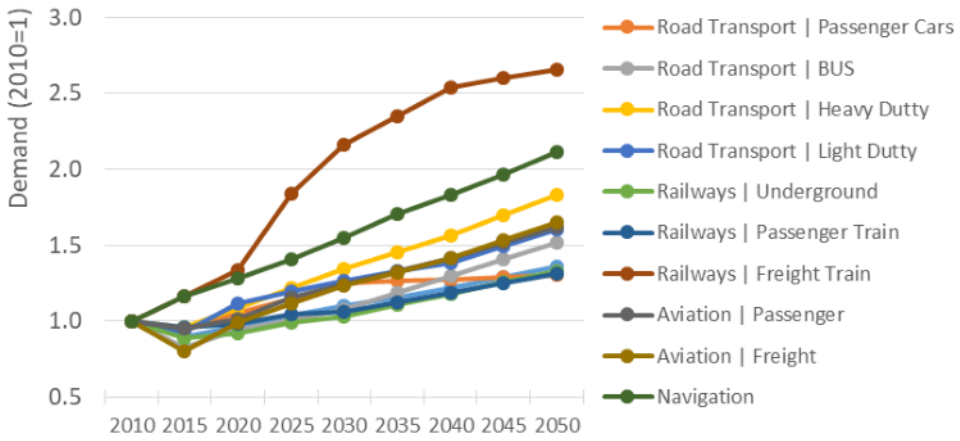

Figure 9-3: Demand evolution trend by transport mode (Index compared to 2010)

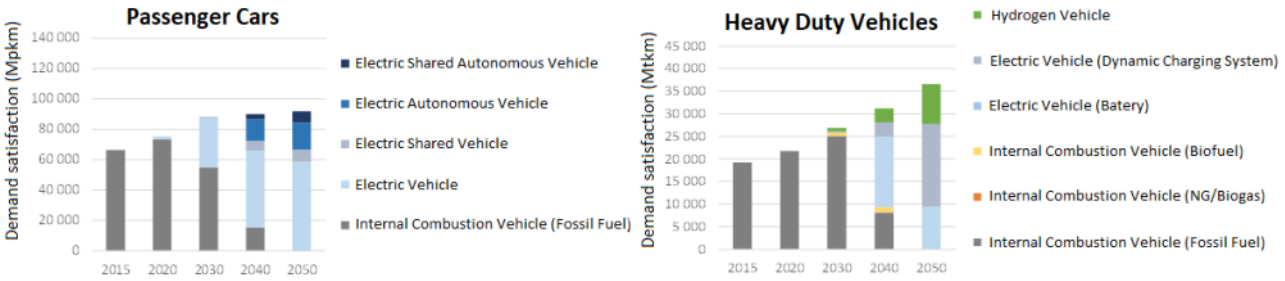

Figure 9-4: Demand satisfaction in the passenger car and heavy duty vehicles categories (Mpkm and Mtkm)

The calculation of emissions from the aviation sector was based on implicit emission factors, taking into account the evolution of consumption of biofuels and electricity. The activity variables in this case were the projection of flight movements (take-off and landing cycles - LTO) of the aircraft, whose flights had origin or destination airports in the territory of mainland Portugal.

In relation to the railway transport, the emissions estimate took into account the demand for energy from transport carried out by diesel trains. This sector excludes the energy consumption of electric traction locomotives, which are considered in the energy sector.

Finally, emissions from the shipping sector were estimated based on the implicit emission factors by fuel type.

9.3.2.2 Emissions

The projected emissions of the main air pollutants in the transport sector are presented in Table 9-3 and in Figure 9-5.

For most air pollutants there is a significant reduction in emissions, in the road transport sector, from 2030 onwards, which is more notable for NO_x and CO. The electrification of the sector has a decisive influence on the reduction of these emissions. The adoption of shared mobility models, which are cost-effective by 2050, contributes to the reduction of energy intensity, having a positive effect on the reduction of GHG and atmospheric pollutants. Efficiency gains through electric mobility, compared to fossil fuels, are also important.

In the road transport, Road transport sector reaches, in 2050, a 100% emissions reduction compared to 2005 for most pollutants. This is not the case for particulate matter, due to abrasion contribution (tyre, brake and surface wear), which will remain.

The shipping sector is the highest SO_x emissions contributor. This subsector is the least decarbonized, with demand growing over time and, in 2030, still satisfied by a high proportion of maritime diesel that, in the following years, gives rise to the use of liquefied natural gas and biofuels (in the medium-long distance) and electricity (in short distance, in particular in inland waterways).

Table 9-3: Emissions of the main atmospheric pollutants in the transport sector (NFR 1A3) (kt)

Pollutant/ NFR		Historical data			Projection				Trend	Δ2020-2005 (%)	Δ2030-2005 (%)
		2005	2010	2015	2020	2030	2040	2050			
NOx (as NO2) (kt)	Road Transport (NFR 1A3b)	99.6	83.8	65.0	59.9	18.4	3.0	0.0		-40%	-82%
	Aviation, Navigation, Railways (NFR 1A3a,c,d,e)	7.3	7.3	8.3	7.9	8.3	6.8	5.6		9%	13%
	Total	**106.9**	**91.1**	**73.3**	**67.8**	**26.7**	**9.8**	**5.6**		**-37%**	**-75%**
NMVOC (kt)	Road Transport (NFR 1A3b)	38.3	24.1	17.4	15.0	9.4	1.3	0.0		-61%	-75%
	Aviation, Navigation, Railways (NFR 1A3a,c,d,e)	0.6	0.6	0.5	0.5	0.4	0.3	0.3		-28%	-36%
	Total	**39.0**	**24.6**	**17.9**	**15.5**	**9.8**	**1.6**	**0.3**		**-60%**	**-75%**
SOx (as SO2) (kt)	Road Transport (NFR 1A3b)	0.6	0.1	0.1	0.1	0.1	0.0	0.0		-84%	-91%
	Aviation, Navigation, Railways (NFR 1A3a,c,d,e)	1.8	1.1	1.3	1.3	1.6	1.5	1.2		-29%	-11%
	Total	**2.4**	**1.2**	**1.4**	**1.4**	**1.7**	**1.5**	**1.2**		**-42%**	**-30%**
PM2.5 (kt)	Road Transport (NFR 1A3b)	6.6	5.8	4.2	4.2	2.3	1.6	1.3		-37%	-66%
	Aviation, Navigation, Railways (NFR 1A3a,c,d,e)	1.1	1.2	1.4	1.2	0.9	0.6	0.5		4%	-25%
	Total	**7.7**	**7.0**	**5.6**	**5.4**	**3.1**	**2.2**	**1.8**		**-31%**	**-60%**
CO (kt)	Road Transport (NFR 1A3b)	217.7	132.3	86.9	71.3	25.8	2.3	0.0		-67%	-88%
	Aviation, Navigation, Railways (NFR 1A3a,c,d,e)	3.4	3.5	3.4	3.0	2.3	1.5	1.2		-12%	-33%
	Total	**221.1**	**135.7**	**90.3**	**74.3**	**28.1**	**3.8**	**1.2**		**-66%**	**-87%**
BC (kt)	Road Transport (NFR 1A3b)	3.5	3.2	2.3	1.1	0.2	0.0	0.0		-69%	-94%
	Aviation, Navigation, Railways (NFR 1A3a,c,d,e)	0.5	0.5	0.6	0.5	0.3	0.2	0.2		9%	-27%
	Total	**3.9**	**3.7**	**2.9**	**1.6**	**0.6**	**0.2**	**0.2**		**-60%**	**-86%**
NH3 (kt)	Road Transport (NFR 1A3b)	1.7	1.3	1.0	0.9	0.6	0.1	0.0		-45%	-67%
	Aviation, Navigation, Railways (NFR 1A3a,c,d,e)	0.0	0.0	0.0	0.0	0.0	0.0	0.0		-100%	-100%
	Total	**1.7**	**1.3**	**1.0**	**0.9**	**0.6**	**0.1**	**0.0**		**-45%**	**-67%**

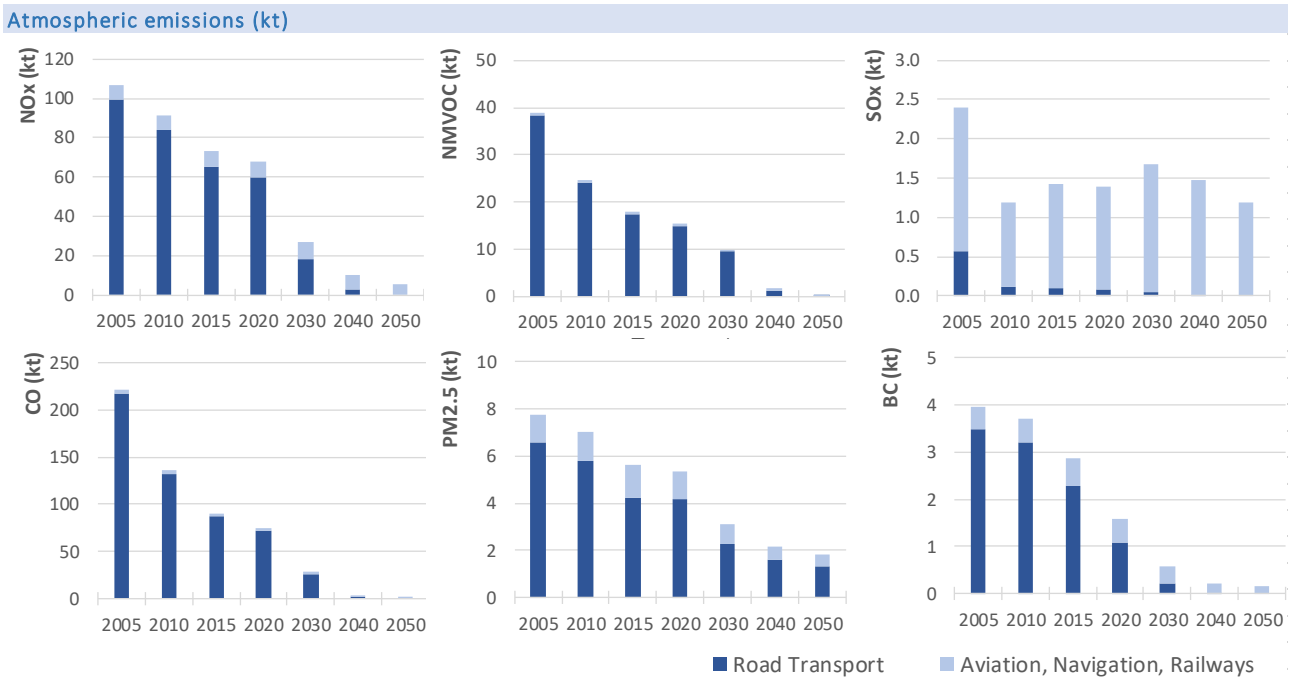

Figure 9-5: Projected emissions of the main atmospheric pollutants in the transport sector (NFR 1A3) (kt)

9.3.3 Commercial/Institutional, Residential, and Agriculture/Forestry/Fishing – small combustion (NFR 1A4)

9.3.3.1 Methodology and activity variables

Buildings, both residential and services, are major energy consumers and are currently responsible for around 30% of final energy consumption in Portugal. Energy consumption in service buildings is used for heating and cooling, lighting, refrigeration and cooking, among others.

The estimation of emissions from stationary combustion sources associated with the commercial/institutional, residential and agriculture/forestry/fishing sectors was based on the methodology and EF contained in IIR 2018 (APA, 2020) and in the EMEP/EEA Guidebook (EEA, 2016).

In order to maintain a similarity with the IIR reporting model, the combustion emissions from non-road mobile machinery in the agriculture/forestry/fishing were included.

Regarding the emissions associated to the use of biomass for heating, in the tertiary and residential sectors, the implementation of the Ecodesign Directive was accounted, applying a reduction in the emission factors of $PM_{2.5}$ and NMVOC from 2030 onwards.

The activity variable used for the emissions estimates was the final energy consumption, by type of energy used in these sectors (NFR 1A4), according to the results obtained through the TIMES_PT model, which are shown in Figure 9-6.

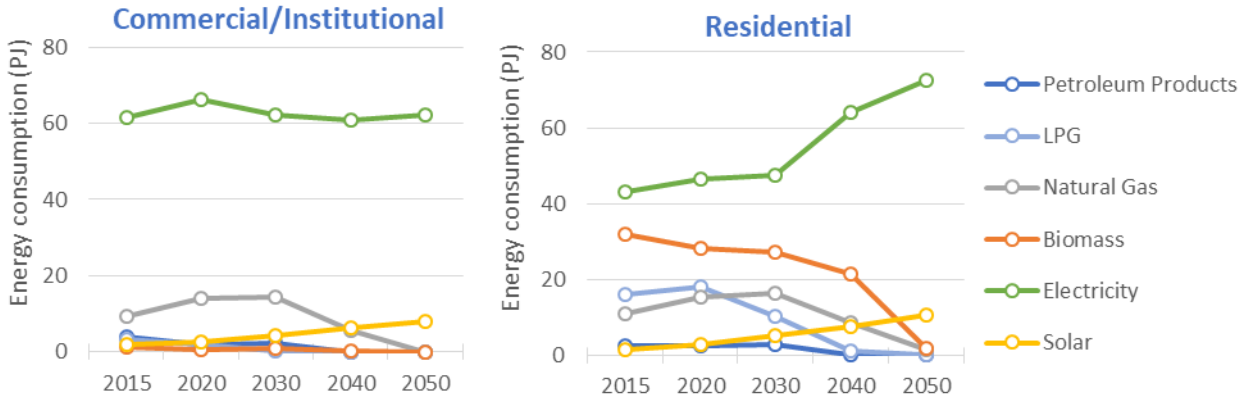

Figure 9-6: Final energy consumption in the Commercial/Institutional (NFR 1A4ai) and Residential (NFR 1A4bi) (PJ)

In a long-term perspective of final energy consumption (Figure 9-6), the following aspects stand out:

- a similar trend is obtained, for distinct sectors, towards the electrification of all end uses, with electricity already being the main energy vector in the case of service buildings;
- natural gas remains an option in homes until 2040, nearly disappearing in the 2040-50s;
- the options for using biomass follow the same trend, nearly disappearing in the 2040-50s, but maintaining still relevant expression for space heating;
- thermal solar energy use, for water heating and heat pumps for air conditioning, is the cost-effective option, with the greatest potential in order to achieve decarbonisation in buildings.

The projected values also show the possibility of a decrease in energy consumption per m^2 in residential buildings in 2050 compared to 2015 (of 7%), also justified by the adoption of high performance electrical equipment such as LEDs for lighting and class A +++ equipments.

9.3.3.2 Emissions

In all pollutants under analysis there is a global reduction in emissions in 2050, due to the decrease in the consumption of more polluting fossil fuels (Table 9-4 and Figure 9-7). The increased use of electricity and renewable energy sources, such as thermal solar energy in buildings, has a positive impact in reducing emissions of air pollutants.

The largest percentage reductions in emissions occur in the tertiary sector, followed by the residential sector. With regard to NO_x, the emissions in the commercial sector essentially derive from the use of petroleum products and natural gas, while in the residential sector, they are due to the more significant use of LPG and biomass. In 2050, CO and PM emissions are almost exclusively due to the consumption of biomass in the residential sector.

Regarding particulate matter, the decrease in the consumption of biomass in the domestic sector is reflected in the reduction of emissions of this pollutant. It should be noted that in the case of $PM_{2.5}$ and NMVOC, resulting from the combustion of biomass for heating, the application of the Ecodesign Directive was considered, resulting in a greater limitation of emissions from 2030 onwards.

Table 9-4: Combustion emissions of the main atmospheric pollutants in the Commercial/Institutional (NFR 1A4ai), Residential (NFR 1A4bi) and Agriculture/Forestry/Fishing (NFR 1A4cii)

Pollutant/ NFR		Historical data			Projection				Trend	Δ2020-2005	Δ2030-2005
		2005	2010	2015	2020	2030	2040	2050		(%)	(%)
NOx (as NO2) (kt)	Comm./Inst. (NFR 1A4ai)	3.7	1.3	1.2	1.1	1.1	0.2	0.0		-70%	-70%
	Residential (NFR 1A4bi)	3.7	3.6	3.2	3.6	3.2	1.9	0.2		-4%	-14%
	Agri./Forest./Fish. (NFR 1A4cii)	4.8	3.8	4.1	4.1	4.2	4.1	4.1		-14%	-13%
	Total	**12.3**	**8.8**	**8.4**	**8.9**	**8.5**	**6.2**	**4.2**		**-28%**	**-30%**
NMVOC (kt)	Comm./Inst. (NFR 1A4ai)	0.5	0.1	0.2	0.2	0.2	0.0	0.0		-59%	-62%
	Residential (NFR 1A4bi)	17.4	14.0	14.3	11.6	7.0	5.5	0.4		-33%	-60%
	Agri./Forest./Fish. (NFR 1A4cii)	0.5	0.4	0.4	0.3	0.3	0.3	0.3		-37%	-36%
	Total	**18.4**	**14.6**	**15.0**	**12.2**	**7.5**	**5.9**	**0.8**		**-34%**	**-59%**
SOx (as SO2) (kt)	Comm./Inst. (NFR 1A4ai)	1.5	1.1	0.6	0.1	0.1	0.0	0.0		-93%	-93%
	Residential (NFR 1A4bi)	0.4	0.3	0.4	0.2	0.2	0.0	0.0		-57%	-54%
	Agri./Forest./Fish. (NFR 1A4cii)	0.0	0.0	0.0	0.6	0.7	0.6	0.6		4831%	4901%
	Total	**1.9**	**1.4**	**0.9**	**0.9**	**1.0**	**0.6**	**0.6**		**-51%**	**-50%**
PM2.5 (kt)	Comm./Inst. (NFR 1A4ai)	0.1	0.0	0.1	0.1	0.1	0.0	0.0		-9%	17%
	Residential (NFR 1A4bi)	22.4	18.1	18.6	15.8	11.0	8.7	0.7		-30%	-51%
	Agri./Forest./Fish. (NFR 1A4cii)	0.3	0.2	0.2	0.2	0.2	0.2	0.2		-9%	-8%
	Total	**22.8**	**18.4**	**18.9**	**16.1**	**11.3**	**8.9**	**0.9**		**-29%**	**-50%**
BC (kt)	Comm./Inst. (NFR 1A4ai)	0.0	0.0	0.0	0.0	0.0	0.0	0.0		13857%	17034%
	Residential (NFR 1A4bi)	2.2	1.8	1.8	0.8	0.7	0.6	0.0		-66%	-67%
	Agri./Forest./Fish. (NFR 1A4cii)	0.2	0.1	0.1	0.1	0.1	0.1	0.1		-14%	-13%
	Total	**2.4**	**1.9**	**2.0**	**0.9**	**0.9**	**0.7**	**0.2**		**-61%**	**-62%**
CO (kt)	Comm./Inst. (NFR 1A4ai)	0.9	0.5	0.9	2.9	3.8	1.0	0.0		217%	316%
	Residential (NFR 1A4bi)	126.0	101.9	103.6	113.7	109.6	86.4	6.8		-10%	-13%
	Agri./Forest./Fish. (NFR 1A4cii)	3.2	2.4	2.3	0.9	0.9	0.9	0.9		-72%	-71%
	Total	**130.1**	**104.7**	**106.8**	**117.5**	**114.2**	**88.4**	**7.7**		**-10%**	**-12%**
NH3 (kt)	Comm./Inst. (NFR 1A4ai)										
	Residential (NFR 1A4bi)	2.3	1.8	1.9	2.3	2.6	0.0	0.0		3%	14%
	Agri./Forest./Fish. (NFR 1A4cii)										
	Total	**2.3**	**1.8**	**1.9**	**2.3**	**2.6**	**0.0**	**0.0**		**3%**	**14%**

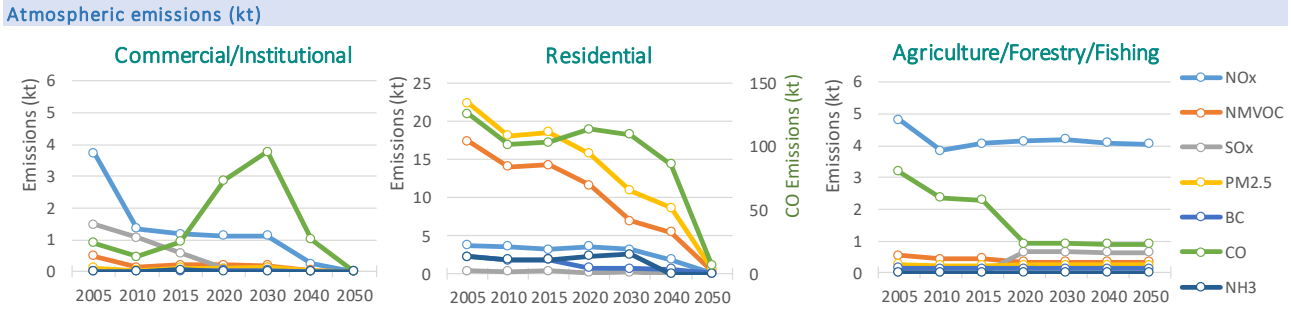

Figure 9-7: Combustion emissions of the main atmospheric pollutants in the Commercial/Institutional (NFR 1A4ai), Residential (NFR 1A4bi) and Agriculture/Forestry/Fishing (NFR 1A4cii) sectors (kt)

9.3.4 Fugitive Emissions (NFR 1B)

9.3.4.1 Methodology and activity variables

This sector includes fugitive emissions mainly from NMVOC resulting from activities such as crude oil transportation, refuelling, loading and unloading at refineries, storage in tanks, and fuel distribution at gas stations.

The estimation of fugitive emissions resulted from the application of implicit emission factors, in order to guarantee the consistency of the historical emission data with the projection of the future scenario. Therefore, these emission factors were based:

- on quantities of processed crude, to estimate NFR related to refining operations (FIG);
- on gasoline and diesel consumption, in the road transport, to estimate NFR related to fugitive emissions in gas stations (FIG).

To determine emissions in this sector, a set of additional control strategies for NFR 1B2av (in the subsector related to the distribution of gasoline in gas stations) was also considered[7]. These estimates took into account the application of the fugitive emission control measure 'Stage II and IB at gas station', with an estimated 73% removal potential for NMVOC, covering 60% of gas stations in Portugal in 2030, and 100% up to 2050.

Table 9-5: Selected activity variables to estimate fugitive emissions (NFR 1B)

	Historical data	Projection				Trend	Unit
	2015	2020	2030	2040	2050		
Crude processed	588	588	498	202	69		PJ
Gasoline and diesel consumption in Road Transport	199	209	134	36	0		PJ

[7] Selection of emission control strategies, for Portugal, based on the GAINS Model - Greenhouse gas Air pollution INteractions and Synergies. It was applied in the emission calculations that translates a maximum mitigation potential for 2030, for the pollutant NMVOC, in the Maximum Technically Possible Reduction Scenario (MTFR) calculated for the case 'CEP_post2014_CLE'. Source: http://gains.iiasa.ac.at/models/gains_models3.html.

9.3.4.2 Emissions

Table 9-6 and Figure 9-8 summarize the obtained results, regarding fugitive emissions from NMVOC derived from oil production and refining. NMVOC emissions follow the downward trend of activity variables (from the quantity of processed crude and gasoline/diesel distribution to supply the road transport sector) on which its projection was based. The overall reduction of this sector's NMVOC is of 39%, in 2030 compared to 2005.

Table 9-6: NMVOC fugitive emissions accounted in NFR 1B (kt)

NFR	Historical data			Projection				Trend	Δ2020-2005	Δ2030-2005
	2005	2010	2015	2020	2030	2040	2050		(%)	(%)
Fugitive emissions oil: Exploration, production, transport (NFR 1B2ai)	2.6	2.3	2.8	2.8	2.4	1.0	0.3		6%	-10%
Fugitive emissions oil: Refining/storage (NFR 1B2aiv)	2.9	2.9	2.0	2.0	1.7	0.7	0.2		-32%	-43%
Distribution of oil products (NFR 1B2av)	5.4	4.5	4.5	4.6	2.6	0.9	0.3		-15%	-52%
Venting and flaring (oil, gas) (NFR 1B2c)	0.1	0.0	0.1	0.1	0.1	0.0	0.0		138%	102%
Total	**11.0**	**9.7**	**9.4**	**9.5**	**6.7**	**2.6**	**0.9**		**-14%**	**-39%**

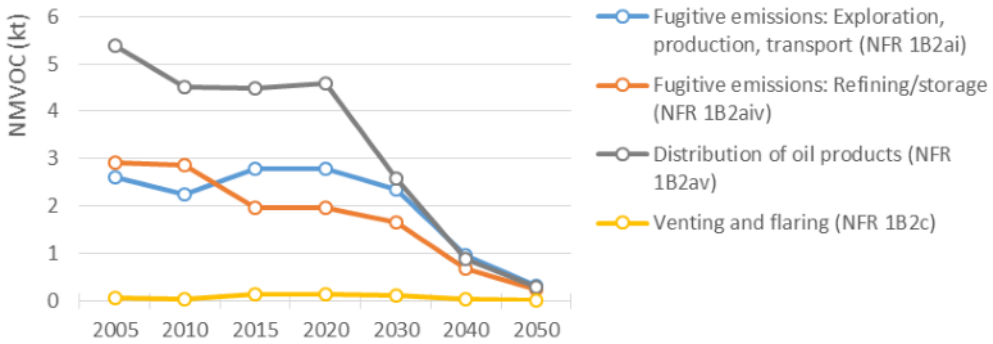

Figure 9-8: Projected NMVOC fugitive emissions accounted in NFR 1B (kt)

9.3.5 Industry and Construction (NFR 1A2, 2B, 2C, 2H)

9.3.5.1 Methodology and activity variables

Emissions from the industry and construction sector result from combustion and industrial processes. The estimation of air pollutant emissions from the industry and construction sector resulted from the application of implicit emission factors (by type of fuel, or according to the expected evolution of demand for certain products), in order to guarantee the consistency of the historic emission data with the projection of the future scenario.

Distinct methodologies were used to calculate emissions in this sector, depending on their origin:

(i) to estimate combustion emissions, determined in the IIR by energy approach, fuel consumption data per sector was used as activity variable;
(ii) to estimate combustion emissions, determined in the IIR by production approach, total amount of products, produced per sector, was used as activity variable;
(iii) to estimate process emissions, the approach was the same as in (ii), by using the quantities produced or projected demand, within each industrial sub-sector.

NFR 1A2, presented in this section, also includes emissions resulting from cogeneration in the industrial sector.

The activity variables used are represented in Table 9-7 and Table 9-8. The evolution of demand for materials is especially important with regard to emissions based on the production approach, while final energy consumptions were used to estimate emissions associated with combustion in the industry (Figure 9-9).

Table 9-7: Final energy consumption in the industry and construction sector (without cogeneration) (NFR 1A2) (PJ)

Fuel	Historical data			Projection				Trend	Unit
	2005	2010	2015	2020	2030	2040	2050		
Coal	0.7	2.1	0.6	0.3	0.4	0.4	0.4		PJ
Fuel oil	50.8	26.5	19.1	15.1	0.0	0.0	0.0		PJ
Gasoline/ Diesel	15.8	12.2	10.8	8.1	0.2	0.1	0.1		PJ
LPG	6.2	3.8	3.8	4.7	0.1	0.1	0.1		PJ
Natural Gas	39.7	41.4	41.8	50.4	67.7	39.7	28.8		PJ
Biomass	22.9	24.2	11.8	3.6	14.2	23.4	16.1		PJ
Industrial waste	1.4	2.3	3.9	6.0	10.6	0.0	0.0		PJ
Total	137.4	112.4	91.9	88.1	93.2	63.6	45.5		PJ

Table 9-8: Final energy consumption in cogeneration from industrial sector I (NFR 1A2) (PJ)

Fuel	Historical data			Projection				Trend	Unit
	2005	2010	2015	2020	2030	2040	2050		
Fuel oil	8.9	14.1	0.0	1.7	0.0	0.0	0.0		PJ
Diesel	0.0	0.0	0.0	0.0	0.0	0.0	0.0		PJ
Natural Gas	17.8	17.4	24.2	26.8	2.0	9.2	0.0		PJ
Black liquor	30.6	11.4	40.8	40.8	42.1	52.1	49.7		PJ
Biogas	0.1	0.0	0.0	0.0	0.0	0.0	1.0		PJ
Biomass	7.5	6.0	0.0	0.8	0.0	4.3	3.8		PJ
Total	65.0	49.0	65.0	70.1	44.1	65.6	54.5		PJ

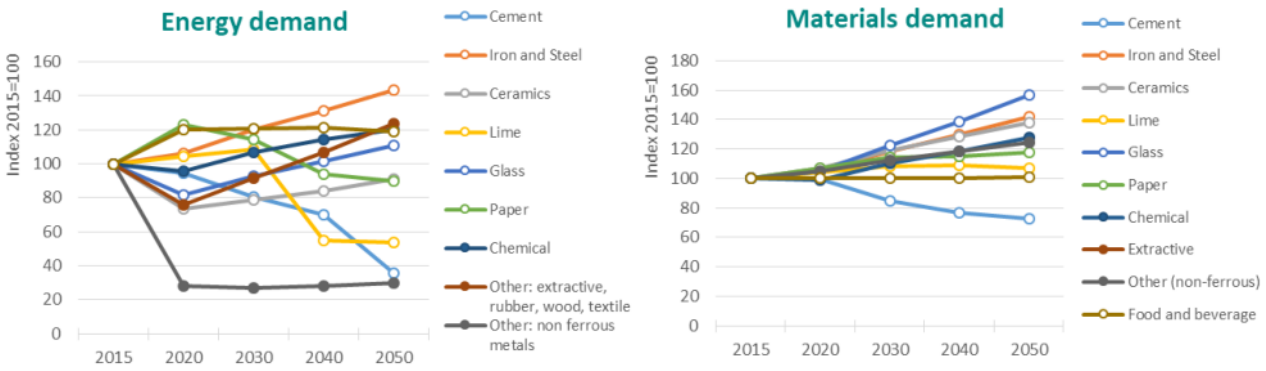

Figure 9-9: Projection of energy demand and materials demand in the industrial sub-sectors (Index 2015 = 100)

The scenario projected for the industrial sector will imply profound changes. By 2030 the consumption of petroleum products, mainly associated to petroleum coke, consumed by the cement industry, will be replaced by other forms of energy, namely waste (vegetables and others), which will increase 3.5 times compared to current values.

Natural gas appears as a transition fuel, increasing its consumption until 2030 and declining from that date onwards, as some processes are being electrified, particularly in the less energy intensive sectors, and the thermal solar energy gains prominence for the production of low/medium temperature heat. Options, such

as the use of electric ovens and the increase in robotisation, will drive electricity consumption to a level two times higher than the current level in the sector.

These factors, combined with the circularity of the economy, allow, in addition to the decarbonisation process, significant gains in energy efficiency in the industry, resulting in a reduction in the energy intensity of the sector of 52% in 2050, compared to the 2015 levels.

9.3.5.2 Emissions

Table 9-9 and Figure 9-10 summarize the obtained results, in terms of combustion and process emissions for the main atmospheric pollutants.

In general, between 2005 and 2050, there is a decrease in NO_x and SO_x emissions, due to the reduction in the consumption of fuel oil, gasoline/diesel and natural gas in the industrial sector, but an increase of NMVOC and PM due to the contribution of process emissions and biomass consumption.

In the subsectors where emission reductions are achieved, these are due to changes in fuels (for less polluting alternatives), efficiency improvements and decreasing/constant demands (between 2005 and 2050). Subsectors such as paper and glass production, which stand out in NO_x, NMVOC and SO_x emissions, show growing demands, up to 2050, and a respective emission increase, mainly due to the contribution of process emissions.

Table 9-9: Emissions of the main atmospheric pollutants in the industrial sector (NFR 1A2 and NFR 2A,B,C,H,I,J,K,L) (kt)

Pollutant	Emission type	Historical data			Projection				Trend	Δ2020-2005 (%)	Δ2030-2005 (%)
		2005	2010	2015	2020	2030	2040	2050			
NOx (as NO2) (kt)	Combustion (a)	44	37	33	25	21	20	19		-43%	-51%
	Process (b)	5	5	6	6	6	6	7		26%	35%
	Total	**48**	**42**	**38**	**31**	**28**	**26**	**26**		**-36%**	**-42%**
NMVOC (kt)	Combustion (a)	11	13	12	11	12	14	15		-4%	6%
	Process (b)	10	10	11	12	13	13	13		19%	27%
	Total	**21**	**23**	**23**	**23**	**25**	**27**	**29**		**7%**	**16%**
SOx (as SO2) (kt)	Combustion (a)	32	25	17	14	12	14	14		-56%	-62%
	Process (b)	13	6	5	6	6	6	6		-54%	-51%
	Total	**44**	**31**	**23**	**20**	**18**	**20**	**21**		**-55%**	**-59%**
PM2.5 (kt)	Combustion (a)	11	8	6	6	6	7	7		-47%	-44%
	Process (b)	15	14	14	14	16	16	17		-2%	8%
	Total	**25**	**22**	**20**	**20**	**22**	**23**	**24**		**-21%**	**-14%**
CO (kt)	Combustion (a)	34	29	19	14	13	13	12		-58%	-61%
	Process (b)	12	11	12	12	13	14	15		-2%	9%
	Total	**46**	**41**	**31**	**26**	**26**	**28**	**28**		**-44%**	**-43%**
BC (kt)	Combustion (a)	2.1	1.7	1.2	0.8	0.7	0.9	0.8		-61%	-65%
	Process (b)	0.0	0.0	0.0	0.0	0.0	0.0	0.0		-13%	-4%
	Total	**2.1**	**1.7**	**1.2**	**0.8**	**0.7**	**0.9**	**0.9**		**-60%**	**-64%**
NH3 (kt)	Combustion (a)	3.0	3.0	2.4	2.0	2.0	2.6	2.4		-35%	-33%
	Process (b)	5.4	3.5	3.3	3.3	3.6	3.9	4.2		-39%	-33%
	Total	**8.4**	**6.6**	**5.7**	**5.2**	**5.7**	**6.5**	**6.6**		**-38%**	**-33%**

(a) Combustion emissions: NFR 1A2; (b) Process emissions: NFR 2A,B,C,H,I,J,K,L

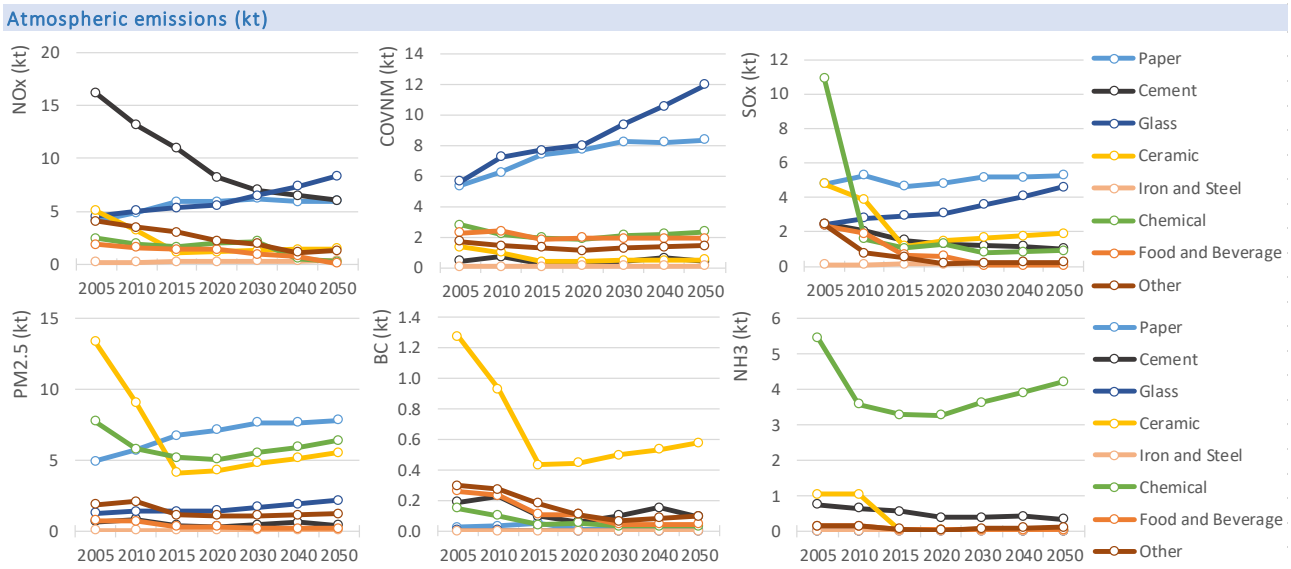

Figure 9-10: Projected emissions of the main atmospheric pollutants in the industrial sub-sectors (NFR 1A2 and NFR 2A,B,C,H,I,J,K,L) (kt)

9.3.6 Solvent use (NFR 2D, 2G)

9.3.6.1 Methodology and activity variables

With regard to emissions associated with the use of solvents and other products at domestic and industrial level (such as application of paints, varnishes, glues, degreasers), the projections were made based on the extrapolation of the emissions verified in 2015 (APA, 2018) taking into account the drivers evolution trend (projected production levels and population evolution) to which the emission subsectors are associated. In this way the estimated emissions took into account the existing control measures. Table 9-10 shows the evolution trend of the referred activity variables.

This is one of the sectors that contributes the most to NMVOC emissions from anthropogenic origin. Regarding the emissions estimation of this pollutant, an additional set of control strategies was also considered[8]. A set of measures was selected to be applied to NFR 2D3a (domestic solvent use including fungicides) and NFR 2D3i (in the fraction of industrial application of glues and adhesives)[9], as having effects from the year 2030 onwards (with a maximum implementation of 70% in 2030), until 2050 (with an implementation of 100% of the emission reduction capacity after 2030).

[8] Measures listed for Portugal, in the GAINS Model - Greenhouse gas Air pollution INteractions and Synergies. Maximum Technically Possible Reduction Scenario (MTFR) calculated for the scenario 'CEP_post2014_CLE'. Source: http://gains.iiasa.ac.at/models/gains_models3.html.

[9] The considered measures assume a maximum mitigation potential for 2030 in the emission of NMVOC, and are as follows: i) NFR 2D3a Domestic use of solvents (other than paint): Inclusion of product reformulation measures at stage 1, stage 2, stage 3, with NMVOC removal efficiencies of 10%, 28% and 60%, respectively, with a respective coverage of 30%, 50% and 20%; ii) NFR 2D3i Other solvent use/Subsector Industrial application of adhesives (traditional): Inclusion of measures: M1) Emulsions, water-based dispersion paints; M2) Hot melts or UV cross-linking acrylates or electron beam curing systems (solids content 100%); M3) Incineration with NMVOC removal efficiencies of 98% (M1), 100% (M2) and 76% (M3), with a coverage of 76% of installations (M1), 13% (M2), 11% (M3).

Table 9-10: Selected activity variables to estimate solvent use emissions (NFR 2D, 2G)

Activity variables	Historical data	Projection				Trend	Unit
	2015	2020	2030	2040	2050		
Products demand							
Paper	2	2	3	3	3		Mt
Other chemicals	15	15	17	18	19		PJ
Other industries	28	28	33	38	44		PJ
Other manufacturing industries	19	17	11	7	4		PJ
Resident population							
Population	10 358	10 249	10 005	9 668	9 173		Thousands of inhabitants

9.3.6.2 Emissions

Table 9-11 and Figure 9-11 summarize the obtained results, in terms of NMVOC emissions from solvents use (pollutant with greater relevance in this sector). In general, the total NMVOC emissions show a reduction of about 33%, between 2005 and 2030. There is a slight rise in emissions between 2040 and 2050, due to an increase in industry demand.

Table 9-11: NMVOC emissions in the solvent use sector (NFR 2D, 2G) (kt)

NFR	Historical data			Projection				Trend	Δ2020-2005	Δ2030-2005
	2005	2010	2015	2020	2030	2040	2050		(%)	(%)
Domestic solvent use including fungicides (2D3a)	11.2	8.8	6.9	6.8	5.3	4.6	4.4		-39%	-52%
Road paving with asphalt (2D3b)	2.1	1.0	0.6	0.6	0.4	0.2	0.1		-73%	-83%
Asphalt roofing (2D3c)	0.005	0.004	0.005	0.005	0.003	0.002	0.001		5%	-34%
Coating applications (2D3d)	22.1	17.4	18.5	16.9	18.0	18.8	19.7		-23%	-19%
Degreasing (2D3e)	1.0	0.3	3.5	2.4	2.3	2.2	2.1		132%	127%
Dry cleaning (2D3f)	1.1	0.5	0.4	0.3	0.3	0.3	0.2		-76%	-76%
Chemical products (2D3g)	24.2	20.0	17.6	16.6	16.6	16.9	17.5		-32%	-31%
Printing (2D3h)	4.0	4.3	4.1	4.4	4.7	4.7	4.8		10%	18%
Other solvent use* (2D3i)	11.2	8.9	9.6	9.4	5.4	2.7	2.6		-16%	-52%
Other product use** (2G)	3.1	3.0	2.3	1.1	1.0	0.9	0.8		-64%	-69%
Total NMVOC (kt)	**80.1**	**64.1**	**63.4**	**58.5**	**53.9**	**51.4**	**52.3**		**-27%**	**-33%**

* Glass Wool Induction, Mineral Wool Induction, Fat, Edible and Non-Edible Oil Extraction, Application of glues and adhesives, Preservation of

** Use of Fireworks, Use of Tobacco, Use of Shoes, Lubricants consumption.

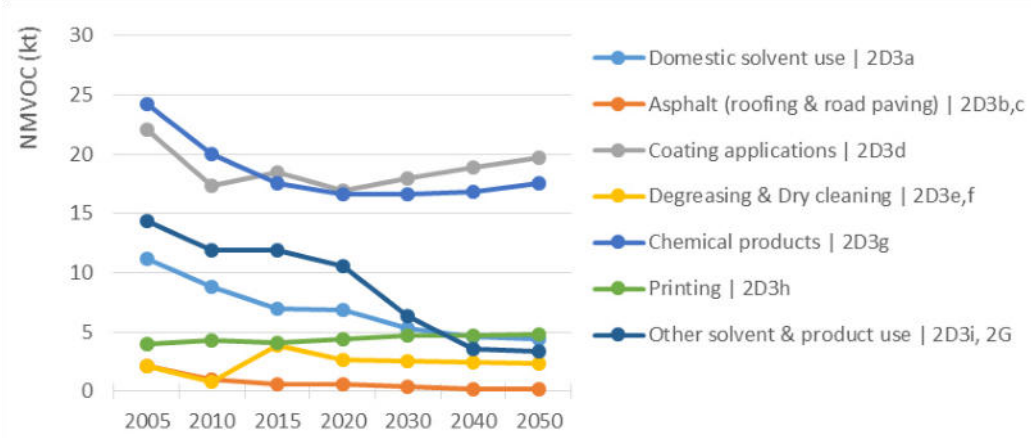

Figure 9-11: Projected solvent use NMVOC emissions accounted in NFR 2D, 2G (kt)

9.3.7 Agriculture (NFR 3B, 3D, 3F) and Forest Fires (NFR 11C)

9.3.7.1 Methodology and activity variables

Emissions from the agriculture sector result from areas occupied by temporary and permanent crops and livestock, as well as from the respective vegetable and animal production, and areas occupied by pastures and other uses of agricultural soils. For the calculation of atmospheric emissions, emission factors from IIR (APA, 2018) and EMEP/EEA Guidebook (EEA, 2016) were used.

The main evolution trend observed in the last decade, for crops and pastures production, is projected to be maintained, with a later stabilization (Table 9-12), characterized by:

(i) reduction in the area occupied by rainfed and irrigated cereal crops, followed by productivity gains;
(ii) increase in the areas occupied by vegetables and permanent irrigated crops, followed by productivity gains in nuts;
(iii) slightly negative evolution of the areas occupied by temporary forage crops and permanent pastures.

Table 9-12: Main sectorial variables of plant production in the agricultural sector

Agricultural area (expressed in 10^3 ha)	Historical data			Projection			Δ2030-2005 (%)	Δ2050-2005 (%)
	2005	2010	2015	2020	2030	2050		
Temporary crops	**881**	**746**	**716**	**641**	**588**	**545**	**-33%**	**-38%**
Grain Cereals[1)]	409	304	269	257	303	303	-26%	-26%
Temporary forage crops[2)]	335	336	330	269	184	167	-45%	-50%
Other temporary crops[3)]	137	106	117	114	101	75	-26%	-45%
Permanent Crops	**697**	**651**	**670**	**678**	**682**	**682**	**-2%**	**-2%**
Orchards	145	128	716	143	147	147	1%	1%
Wine yard	204	180	179	179	179	179	-12%	-12%
Olive groves	348	343	351	356	356	356	2%	2%
Area occupied by temporary and permanent crops	**1 578**	**1 397**	**1 387**	**1 319**	**1 270**	**1 227**	**-20%**	**-22%**
Permanent Pastures (PP)	**ND**	**ND**	**ND**	**1 200**	**924**	**904**	**ND**	**ND**
Enhanced PP	ND	ND	ND	50	180	200	ND	ND
Other PP	ND	ND	ND	1 150	744	704	ND	ND

1) Includes Wheat, Rice, Grain Maize and other Cereals
2) Includes forage maize, and other temporary meadows and forage crops
3) Includes dried legumes for grain, potatoes, industrial crops and horticultural crops

Greater efficiency is expected in the use of general intermediate production factors, and fertilizers in particular, followed by a moderate expansion of agricultural technologies and practices associated with precision agriculture, conservation (or regenerative) agriculture, permanent pastures plants rich in legumes and organic production.

A reduction in the dairy cattle is assumed (Table 9-13) resulting from the decreasing trend in domestic demand for milk and dairy products, and the loss of economic viability of the farms, partly offset by average productivity gains.

The evolution of non-dairy cattle is characterized by the maintenance of livestock from extensive and mixed production farms, and by a reduction in the number of farms based on intensive production systems, either by factors inherent to the reduction of tariff protections in the EU, or by an internal food demand increasingly oriented towards products of vegetable origin and white meats.

An increase in the number of sheep and goats is expected (table below), as a result of the increase in support of its production systems, associated with their role in preventing rural fires, and a maintenance of the evolution trends of the last ten years for swine and poultry livestock.

Table 9-13: Main sectorial variables of animal production in the agricultural sector

Animal livestock (thousands)	Historical data			Projection			Δ2030-2005 (%)	Δ2050-2005 (%)
	2005	2010	2015	2020	2030	2050		
Dairy cattle	290	255	235	238	199	199	-31%	-31%
Non-dairy cattle	397	438	461	474	453	453	14%	14%
Other cattle	522	539	564	586	560	560	7%	7%
Sheep and Goats	497	421	365	362	379	379	-24%	-24%
Swine	632	630	686	699	825	825	31%	31%
Poultry	771	824	779	855	878	878	14%	14%
Total	**3 108**	**3 107**	**3 090**	**3 255**	**3 304**	**3 304**	**6%**	**6%**

An increasing rate of diffusion of precision animal husbandry is projected, and of mitigation and carbon sequestration measures, associated with both animal feed, effluent management and permanent pastures. A set of decarbonisation measures for agricultural and livestock activities, and circularity, were also considered, with an impact on:

(i) the reduction of emissions, associated with the digestibility of animal feed, the management of livestock effluents and precision agriculture;
(ii) the increase in carbon sequestration associated with conservation and preservation (or regenerative) plant and animal production systems;
(iii) the promotion of circularity related with organic production and precision and conservation agriculture.

The summary of the main activity data trends, considered in the agriculture sector, are shown in Table 9-14.

Table 9-14: Summary of the main sectorial activity variables of the agriculture sector

Activity data	Historical data			Projection			Trend	Δ2020-2005 (%)	Δ2030-2005 (%)
	2005	2010	2015	2020	2030	2050			
Areas occupied by temporary and permanent crops (thousands of ha)	1 578	1 397	1 387	1 319	1 270	1 227		-16%	-20%
Areas occupied by enhanced permanent pastures (thousands of ha)	ND	ND	ND	50	180	200		ND	ND
Areas related to precision agriculture and conservation (thousands of ha)	ND	ND	ND	120	170	210		ND	ND
Non-dairy cattle livestock (thousands)	1 209	1 232	1 260	1 298	1 212	1 212		7%	0%
Other livestock (thousands)	1 900	1 875	1 830	1 917	2 083	2 083		1%	10%

With regard to forest and land use, these have a fundamental role in the trajectories of carbon neutrality due to their function of CO_2 sequestration. The evolution of the Portuguese forest over the next decades is determined by three main factors:

(i) decrease in the average annual burnt area;
(ii) increase in the national forest area, as a result of the investment in new forest areas and in the reforestation of burnt areas;
(iii) increase in the average annual productivity associated with forest settlements.

Regarding forest fires, the air pollutants emissions were determined from the projected burnt areas, represented in Table 9-15.

Table 9-15: Activity data selected to estimate emissions from forest fires

Activity variable	Historical data	Projection				Trend	Δ2020-2015	Δ2030-2015
	2015	2020	2030	2040	2050		(%)	(%)
Burnt area (ha)	68 800	155 266	91 484	89 278	87 206		**126%**	**33%**

9.3.7.2 Emissions

The emission sources within this sector derive from: manure management (NFR 3B), crop production and agricultural soils (including the use of fertilizers) (NFR 3D), and field burning of agriculture residues (NFR 3F).

The projected emissions for the pollutants with the greatest relevance in this sector are shown in Table 9-16. In general, there is a trend towards emission reduction, between 2005 and 2030, being the exception for SO_x and NMVOC.

Agriculture activities generate the largest part of NH_3 national emissions. In 2018, NH_3 from agriculture sector were 82% of the national emissions. Concerning the importance of NH_3 in this sector, Table 9-17 provides the NH_3 emissions projection disaggregated by each NFR. For this pollutant, there is a 12% reduction in emissions between 2005 and 2030. NH_3 emissions show a slight reduction in the long-term horizon, both in the manure management component (NFR 3B, mainly due to the reduction of dairy and non-dairy cattle livestock), and in the reduction of urine and dung deposited by grazing animals (NFR 3Da3) component. In contrast, until 2030, once compared to 2005, there is an increase of this pollutant emissions in the portion related to fertilizer application to the soils.

Table 9-16: Emissions of the main atmospheric pollutants in the agriculture sector (NFR 3B, 3D, 3F)

Pollutant	NFR	Historical data			Projection				Trend	Δ2020-2005	Δ2030-2005
		2005	2010	2015	2020	2030	2040	2050		(%)	(%)
NOx (as NO2) (kt)	Manure management (NFR 3B)	0.5	0.4	0.4	0.4	0.3	0.3	0.3		-25%	-36%
	Crop production and agricultural soils (NFR 3D)	2.6	2.5	2.8	1.7	1.6	1.6	1.6		-34%	-38%
	Field burning of agriculture residues (NFR 3F)	0.8	0.9	0.9	1.0	0.9	0.9	0.9		18%	18%
	Total	**3.9**	**3.9**	**4.1**	**3.0**	**2.9**	**2.8**	**2.8**		**-22%**	**-26%**
NMVOC (kt)	Manure management (NFR 3B)	7.0	6.6	6.2	7.5	7.5	7.4	7.2		7%	7%
	Crop production and agricultural soils (NFR 3D)	3.6	3.4	3.2	4.4	4.3	4.2	4.2		22%	21%
	Field burning of agriculture residues (NFR 3F)	2.2	2.4	2.5	1.6	1.6	1.5	1.5		-27%	-29%
	Total	**12.8**	**12.4**	**11.8**	**13.4**	**13.4**	**13.1**	**12.9**		**5%**	**5%**
SOx (as SO2) (kt)	Manure management (NFR 3B)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Crop production and agricultural soils (NFR 3D)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Field burning of agriculture residues (NFR 3F)	0.13	0.13	0.14	0.15	0.15	0.15	0.15		14%	14%
	Total	**0.13**	**0.13**	**0.14**	**0.15**	**0.15**	**0.15**	**0.15**		**14%**	**14%**
PM2.5 (kt)	Manure management (NFR 3B)	0.24	0.27	0.21	0.43	0.41	0.41	0.41		80%	72%
	Crop production and agricultural soils (NFR 3D)	0.03	0.03	0.02	0.02	0.02	0.02	0.02		-40%	-47%
	Field burning of agriculture residues (NFR 3F)	1.52	1.70	1.75	0.95	0.95	0.94	0.93		-37%	-38%
	Total	**1.79**	**2.00**	**1.98**	**1.41**	**1.38**	**1.36**	**1.35**		**-22%**	**-23%**
NH3 (kt)	Manure management (NFR 3B)	19.5	18.5	17.6	16.4	16.5	16.5	16.6		-16%	-15%
	Crop production and agricultural soils (NFR 3D)	20.6	18.7	21.1	19.7	18.8	18.6	18.6		-4%	-9%
	Field burning of agriculture residues (NFR 3F)	0.7	0.7	0.8	0.8	0.8	0.8	0.8		22%	20%
	Total	**40.8**	**37.9**	**39.4**	**37.0**	**36.0**	**35.9**	**35.9**		**-9%**	**-12%**
CO (kt)	Manure management (NFR 3B)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Crop production and agricultural soils (NFR 3D)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Field burning of agriculture residues (NFR 3F)	27.5	28.2	28.8	31.3	31.2	30.9	30.7		14%	14%
	Total	**27.5**	**28.2**	**28.8**	**31.3**	**31.2**	**30.9**	**30.7**		**14%**	**14%**

NA: Not applicable

Table 9-17: NH_3 emissions in the agriculture sector (NFR 3B, 3D, 3F) (kt)

NFR		Historical data			Projection				Trend	Δ2020-2005	Δ2030-2005
		2005	2010	2015	2020	2030	2040	2050		(%)	(%)
3B1a	Manure management - Dairy cattle	3.99	3.26	3.04	2.46	2.13	2.19	2.26		-38%	-47%
3B1b	Manure management - Non-dairy cattle	2.07	1.73	1.84	1.47	1.40	1.40	1.40		-29%	-32%
3B2	Manure management - Sheep	0.68	0.44	0.37	0.38	0.39	0.39	0.39		-44%	-43%
3B3	Manure management - Swine	5.56	5.43	5.80	5.80	6.34	6.34	6.34		4%	14%
3B4d	Manure management - Goats	0.10	0.08	0.07	0.07	0.08	0.08	0.08		-32%	-18%
3B4e	Manure management - Horses	0.13	0.05	0.04	0.05	0.01	0.01	0.01		-63%	-90%
3B4f	Manure management - Mules and asses	0.11	0.03	0.02	0.01	0.00	0.00	0.00		-92%	-99%
3B4gi	Manure mangement - Laying hens	2.78	3.03	2.58	2.54	2.34	2.34	2.34		-9%	-16%
3B4gii	Manure mangement - Broilers	2.70	2.76	2.79	3.12	3.29	3.29	3.29		16%	22%
3B4giii	Manure mangement - Turkeys	0.48	0.87	0.47	0.48	0.45	0.45	0.45		0%	-5%
3B4giv	Manure management - Other poultry	0.25	0.27	0.23	0.00	0.00	0.00	0.00		-100%	-100%
3B4h	Manure management - Other animals	0.62	0.55	0.32	0.04	0.01	0.01	0.01		-94%	-98%
	NFR 3B Total	**19.5**	**18.5**	**17.6**	**16.4**	**16.5**	**16.5**	**16.6**		-16%	-15%
3Da1	Inorganic N-fertilizers (includes also urea application)	6.1	4.9	7.5	9.0	7.7	7.1	6.0		47%	27%
3Da2a	Animal manure applied to soils	9.7	8.9	8.7	10.2	9.9	10.0	10.1		5%	2%
3Da2b	Sewage sludge applied to soils	0.0	0.1	0.1	0.0	0.0	0.0	0.0		15%	15%
3Da2c	Other organic fertilisers applied to soils (incl. compost)	NA	NA	0.1	0.1	0.7	1.1	2.0		NA	NA
3Da3	Urine and dung deposited by grazing animals	4.8	4.8	4.7	0.4	0.4	0.4	0.4		-91%	-93%
	NFR 3D Total	**20.6**	**18.7**	**21.1**	**19.7**	**18.8**	**18.6**	**18.6**		-4%	-9%
3F	Field burning of agricultural residues	0.7	0.7	0.8	0.8	0.8	0.8	0.8		22%	20%
	NFR 3F Total	**0.7**	**0.7**	**0.8**	**0.8**	**0.8**	**0.8**	**0.8**		22%	20%
NH3 Total Emissions (kt)		**40.8**	**37.9**	**39.4**	**37.0**	**36.0**	**35.9**	**35.9**		-9%	-12%

Table 9-18 shows the forest fires emissions projections for the main air pollutants. For the forest sub-sector, projected emissions are slightly higher than in 2015, due to an increase in the burnt area, with relevance in the case of CO emissions.

Table 9-18: Emissions of the main atmospheric pollutants in the forest sector (NFR 11B)

Pollutant	Historical data			Projection				Trend	Δ2020-2005	Δ2030-2005
	2005	2010	2015	2020	2030	2040	2050		(%)	(%)
NOx (as NO2) (kt)	8.4	2.9	1.4	3.3	1.9	1.9	1.8		-61%	-77%
NMVOC (kt)	44.2	15.5	7.4	17.2	10.1	9.9	9.7		-61%	-77%
SOx (as SO2) (kt)	3.4	1.2	0.6	1.3	0.8	0.8	0.7		-61%	-77%
PM2.5 (kt)	9.5	3.3	1.6	3.7	2.2	2.1	2.1		-61%	-77%
NH3 (kt)	3.8	1.3	0.6	1.5	0.9	0.8	0.8		-61%	-77%
CO (kt)	294.4	103.4	49.3	114.6	67.5	65.9	64.4		-61%	-77%

9.3.8 Waste (NFR 5A, 5B, 5C, 5D, 5E)

9.3.8.1 Methodology and activity variables

The waste sector includes emissions from waste and wastewater treatment systems, whether urban or industrial.

This sector has an important contribution of GHG emissions associated with organic matter anaerobic decomposition processes, which is found in solid waste and wastewater. Decarbonisation in this sector therefore relies on reducing the weight of methane emissions from anaerobic fermentation processes.

The methodology adopted to estimate emissions from the waste sector considers the activity variables of each specific segment (physical quantity of waste and wastewater generated) and the emission factors of the different processes in question.

One of the fundamental vectors, which determines the magnitude of activity data and, consequently, emissions in the waste sector, is the resident population, which generates waste and wastewater. Given the importance that the touristic activity has been gaining at national level (accounted for about 42 million of overnight stays in the year 2017) this was considered in addition to the statistics of the resident population (Figure 9-12).

In the case of industrial waste and wastewater (only organic waste and effluents are included in the calculation scope), the evolution of activity data for each economic sector follows the respective annual rate of change of activity, in line with the values used at other modelling sectors (in particular those for energy/industry).

In the definition of the projection scenario, a set of policies and measures was taken into account, which would influence emissions evolution over time. In this sense, a series of documents framing the waste and wastewater policy was considered, in the form of plans/strategies/regimes/commitments[10]. Finally, the quantities related to the production of waste, the composition of the waste and its disaggregation by final destination were determined by scenario. The projected evolution of municipal solid waste production is represented in Figure 9-12.

[10] https://descarbonizar2050.pt/documentos/

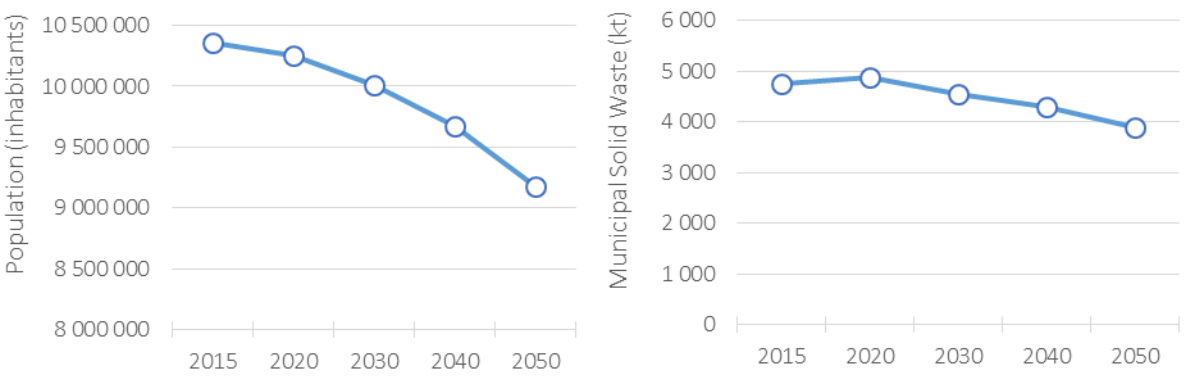

Figure 9-12: Activity data considered in the waste sector: trends of population (left) and evolution of municipal solid waste production (right)

In terms of the evolution of the composition of urban waste, until 2050, a trend compatible with the fulfilment of the goal for reuse and recycling (2035 = 65%) was assumed, with a consequent increase in the quantities of separate recollection. Measures to encourage circular economy and, in particular, the production of bio-waste were also considered. Figure 9-13 represents the evolution in the composition of municipal waste solid waste, in 2016 and projected to 2050.

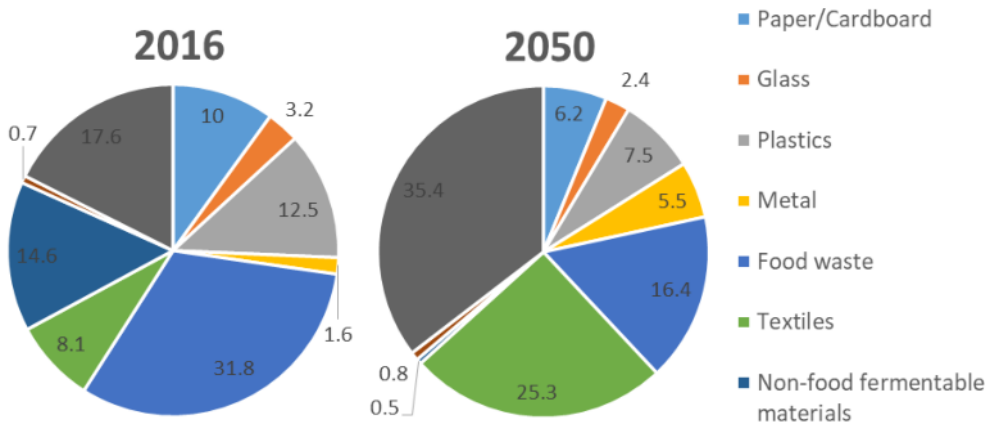

Figure 9-13: Composition of municipal solid waste in 2016 and 2050 (%)

The quantities of urban waste produced were distributed among three types of final destinations, represented in Figure 9-14:

i) controlled landfill deposition;
ii) biological treatment (composting and anaerobic digestion with biogas valorisation);
iii) incineration with energy recovery.

In order to estimate the impact of policies and measures to encourage circular economy, food waste reduction, and restriction to landfill deposition, in the future evolution of the deposition of municipal solid waste, in the scenario of carbon neutrality, factors such as the optimization of solutions to reduce production, and increase reuse, were considered.

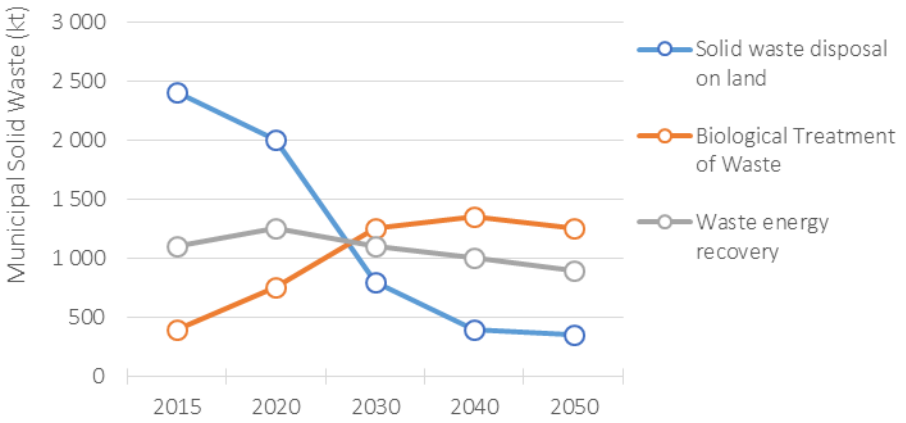

Figure 9-14: Total amount of municipal solid waste projected by final destination (kt)

Regarding industrial waste, and concerning the landfill final destination of industrial waste, only the organic fraction is taken into account in the methodological approach. Its projected quantities, until 2050, are shown in Figure 9-15. The incineration component, without energy recovery from industrial waste, relates to the incineration conducted in industrial environment, and has a relatively small expression in the context of the sector.

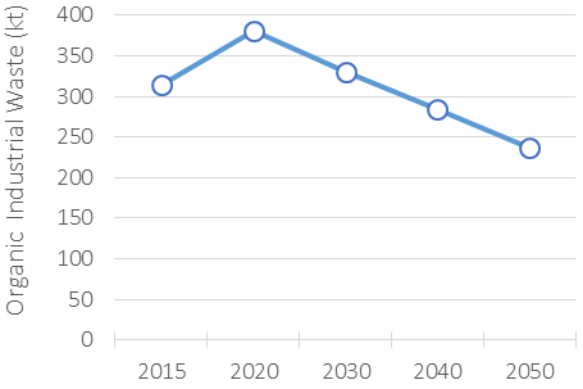

Figure 9-15: Projected evolution of organic industrial waste deposition in landfill (kt)

9.3.8.2 Emissions

Table 9-19 summarizes the projected emissions from this sector. It should be noted that emissions related to incineration, with energy recovery, are excluded, being directly accounted in the energy sector.

The waste sector includes mainly activities not related to combustion processes, such as disposal on land and wastewater treatment, resulting in a greater global representativeness in terms of NMVOC and NH_3 emissions. Concerning these two pollutants, it is possible to observe a reduction over time, of 38% and 35% respectively, until 2030, which is due to the expected phasing-out of landfill deposition of urban waste.

This source category is also relevant in terms of dioxins and furans (28% in 2018), HCB (36% in 2018) and PCB (72% in 2018) emissions.

On the contrary, emissions from industrial waste incineration source (without energy recovery) show an increase related to a projected scenario of economic and industrial activity growth.

Table 9-19: Emissions of the main atmospheric pollutants in the waste sector (NFR 5A, B, C, D, E)

Pollutant	NFR	Historical data			Projection				Trend	Δ2020-2005 (%)	Δ2030-2005 (%)
		2005	2010	2015	2020	2030	2040	2050			
NOx (as NO2) (kt)	Industrial waste incineration (NFR 5C1bi)	**0.04**	**0.02**	**0.02**	**0.02**	**0.02**	**0.03**	**0.03**		**-51%**	**-43%**
NMVOC (kt)	Solid waste disposal on land (NFR 5A)	2.07	2.08	1.95	1.79	1.28	0.82	0.54		-13%	-38%
	Industrial waste incineration (NFR 5C1bi)	0.34	0.15	0.14	0.17	0.20	0.22	0.25		-51%	-43%
	Domestic wastewater handling (NFR 5D1)	0.01	0.01	0.01	0.01	0.01	0.01	0.01		-3%	-5%
	Industrial wastewater handling (NFR 5D2)	0.01	0.01	0.01	0.01	0.01	0.02	0.02		18%	39%
	NMVOC Total (kt)	**2.42**	**2.24**	**2.10**	**1.98**	**1.50**	**1.06**	**0.82**		**-18%**	**-38%**
SOx (as SO2) (kt)	Industrial waste incineration (NFR 5C1bi)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**		**-51%**	**-43%**
PM2.5 (kt)	Other waste* (NFR 5E)	**0.60**	**0.46**	**0.43**	**0.41**	**0.37**	**0.34**	**0.32**		**-31%**	**-38%**
NH3 (kt)	Solid waste disposal on land (NFR 5A)	1.65	1.44	1.21	1.14	0.82	0.52	0.34		-30%	-50%
	Composting (NFR 5B1)	0.00	0.01	0.00	0.00	0.01	0.02	0.02		54%	238%
	Anaerobic digestion at biogas facilities (NFR 5B2)	0.00	0.00	0.05	0.11	0.23	0.28	0.24		ND	ND
	NH3 Total (kt)	**1.65**	**1.45**	**1.26**	**1.26**	**1.06**	**0.81**	**0.61**		**-24%**	**-35%**
PCDD/PCDF (dioxins/ furans) (g I-TEQ)	Industrial waste incineration (NFR 5C1bi)	16.07	7.11	6.39	7.43	7.69	7.95	8.21		-54%	-52%
	Clinical waste incineration (NFR 5C1biii)**	*48.67*	*137.02*	*25.12*	43.88	42.83	41.39	39.27		-10%	-12%
	Other waste* (NFR 5E)	6.02	4.62	4.34	4.13	3.72	3.43	3.23		-31%	-38%
	PCDD/PCDF Total (g I-TEQ)	**70.76**	**148.75**	**35.85**	**55.44**	**54.25**	**52.77**	**50.71**		**-22%**	**-23%**
HCB (kg)	Industrial waste incineration (NFR 5C1bi)	**0.09**	**0.04**	**0.04**	**0.05**	**0.05**	**0.06**	**0.07**		**-51%**	**-43%**
PCB (kg)	Industrial waste incineration (NFR 5C1bi)	**124.30**	**54.81**	**49.25**	**61.26**	**71.22**	**81.17**	**91.13**		**-51%**	**-43%**

*landfill gas and other biogas burning (without energy recovery)

**Clinical waste incineration source projections were made based on historical data, reported in the 2018 IIR submission (highlighted in gray and italics). In the 2020 IIR submission these values were revised downwards (reduction of about 99%).

9.4 Carbon neutrality impacts on atmospheric emissions

This section highlights the potential for reducing air pollutant emissions, projected up to 2050, by pollutant and sector, for the Pack (P) decarbonising scenario developed under the scope of the RNC2050. Within the scope of the new NEC Directive[11], the year 2020 and 2030 assumes relevance as they are the two time horizons to comply emission reduction targets, by pollutant.

With regard to the main pollutants, the largest percentage of emission reductions is obtained (in 2030 compared to 2005) for SO_x, NO_x and CO (85%, 71% and 51% respectively, for Pack scenario) due to the reduction in fossil fuel consumption and the transition to the use of renewable energy sources (Table 9-20 and Figure 9-16). The smallest reductions are obtained for NH_3 and NMVOC (of 15% and 36% respectively).

The activity sectors with greater emission percentage reduction, until 2030, are power sector, commercial/services, and transports (Table 9-20). Underlying these results are the trajectories of renewable electricity production, ensured by endogenous resources, as well as the electrification which is transversal to many sectors of final consumption, especially in transports. In commercial/services buildings, a significant role is due to solar energy.

In particular, the transport sector (mainly in the road transport component) reduces 75% of NO_x emissions and 87% of CO emissions by 2030. These percentages rise to 92% and 98%, respectively, by 2050. The reductions achieved in 2030 depend strongly on the penetration of electric vehicles, which will unfold in 2020-2030. In 2050 it is projected to achieve the complete electrification of the of the road transport sector.

The considerable increase in the efficiency of the economy, allowing to respond to growing demands, but through less energy intensity, is also reflected on pollutant emissions of the transport sector. This sector is a

[11] The EU Directive 2016/2284, on the reduction of national emissions of certain atmospheric pollutants, is referred in short, within this section, as the NEC Directive

major driver of this efficiency, with consumption reductions of over 60% due essentially to the most efficient electric mobility. The aspect of increasing shared mobility is also an example of this.

In contrast, the agriculture sector in 2030 stands out for reaching an emission increase for some pollutants, such as CO, NMVOC and SO_x.

The industrial sector is one of the least cost-effective in reducing GHG, which is also true for air pollutants. In this sector, a significant reduction in combustion emissions is obtained, which is not the case for a significant part of process emissions, particularly in the subsectors responsible for the largest emissions (such as cement, paper and glass). Significant reductions in emissions from various sectors, highlight the contribution of the industrial sector, already in 2030, which will increase its relative weight in national emissions, becoming, in the case of NO_x, SO_x, $PM_{2.5}$ and NMVOC, dominant within this time horizon. This change emphasizes the industrial sector as a target when selecting mitigating and air pollution control measures.

Most NMVOC are emitted by the industrial sector (55% in 2005 and 66% in 2030), and within this sector, this is the pollutant with the lowest percentage emission reduction (22%).

With regard to the main air pollutants, the smallest emission reduction is achieved for the pollutant NH_3 (of 15% in 2030). NH_3 is a secondary particulate precursor, reacting in the atmosphere to form particulate compounds, or condensing into pre-existing particles to produce inorganic secondary particles. The agriculture sector is its dominant source (80% in 2018 and 76% in 2030, compared to the total national emissions), gaining relevance in the context of the national reduction commitments, of the new NEC Directive. The emission reduction achieved for this pollutant and sector is 12% in the Pack scenario, in 2030.

Table 9-20: Atmospheric emissions, projections and percentage reductions compared to 2005 by sector

Pollutant	Activity Sector	Historic emissions			Projected emissions				Trend	Δ2020-2005 (%)	Δ2030-2005 (%)
		2005	2010	2015	2020	2030	2040	2050			
NOx (as NO2) (kt)	Energy	71	20	17	14	7	3	1		-80%	-90%
	Industry	48	42	38	31	28	26	26		-36%	-42%
	Commerce/Services	18	15	13	9	9	6	4		-51%	-52%
	Transports	107	91	73	68	27	10	6		-36%	-75%
	Agriculture	4	4	4	3	3	3	3		-22%	-26%
	Waste	0	0	0	0	0	0	0		-70%	-65%
	Total	**248**	**172**	**146**	**125**	**73**	**48**	**40**		**-50%**	**-71%**
NMVOC (kt)	Energy	12	11	11	11	9	3	1		-7%	-24%
	Industry	102	87	87	81	79	78	81		-20%	-22%
	Commerce/Services	19	15	15	12	7	6	1		-36%	-60%
	Transports	39	25	18	15	10	2	0		-60%	-75%
	Agriculture	13	12	12	13	13	13	13		5%	5%
	Waste	2	2	2	2	2	1	1		-18%	-38%
	Total	**187**	**153**	**145**	**136**	**120**	**103**	**97**		**-27%**	**-36%**
SOx (as SO2) (kt)	Energy	123	12	8	7	6	2	1		-94%	-95%
	Industry	44	31	23	20	18	20	21		-55%	-59%
	Commerce/Services	2.6	1.7	1.0	0.9	1.0	0.6	0.6		-64%	-63%
	Transports	2.4	1.2	1.4	1.4	1.7	1.5	1.2		-42%	-30%
	Agriculture	0.1	0.1	0.1	0.1	0.1	0.1	0.1		14%	14%
	Waste	0.0	0.0	0.0	0.0	0.0	0.0	0.0		-63%	-57%
	Total	**172**	**47**	**34**	**30**	**27**	**25**	**23**		**-83%**	**-85%**
PM2.5 (kt)	Energy	2	1	1	1	1	0	0		-66%	-66%
	Industry	31	26	23	22	23	24	25		-28%	-25%
	Commerce/Services	23	19	19	16	11	9	1		-30%	-51%
	Transports	8	7	6	5	3	2	2		-31%	-60%
	Agriculture	2	2	2	1	1	1	1		-22%	-23%
	Waste	1	0	0	0	0	0	0		-31%	-38%
	Total	**66**	**55**	**50**	**46**	**40**	**37**	**29**		**-30%**	**-39%**
NH3 (kt)	Energy	0	1	1	1	1	1	0		172%	156%
	Industry	9	7	6	5	6	7	7		-38%	-33%
	Commerce/Services	2	2	2	2.3	2.6	0.0	0.0		3%	14%
	Transports	2	1	1	1	1	0	0		-45%	-67%
	Agriculture	41	38	39	37	36	36	36		-9%	-12%
	Waste	2	1	1	1	1	1	1		-24%	-35%
	Total	**55**	**50**	**50**	**48**	**47**	**44**	**43**		**-13%**	**-15%**
CO (kt)	Energy	78	76	56	55	50	19	6		-29%	-36%
	Industry	47	42	32	27	27	28	28		-43%	-43%
	Commerce/Services	132	106	108	117	114	88	8		-11%	-13%
	Transports	221	136	90	74	28	4	1		-66%	-87%
	Agriculture	28	28	29	31	31	31	31		14%	14%
	Waste	0	0	0	0	0	0	0		-88%	-86%
	Total	**506**	**388**	**315**	**305**	**250**	**170**	**73**		**-40%**	**-51%**

Figure 9-16: Historic and projected atmospheric emissions by sector

9.5 Carbon neutrality impacts on national emission reduction commitments

The EU Directive 2016/2284, on the reduction of national emissions of certain atmospheric pollutants, also referred as the new NEC Directive – sets national emission reduction commitments for each EU Member State for the period 2020 to 2029, and for 2030 onwards, targeting five air pollutants responsible for significant negative impacts on human health and the environment: SO_2, NO_x, NMVOC, NH_3 and fine particulate matter $PM_{2.5}$.

Table 9-21 shows the expected state of compliance for the national emission reduction commitments, as established in the new NEC Directive, in 2020 and 2030, compared to 2005. It shows that reductions in

emissions of atmospheric pollutants, obtained under the scope of the trajectory outlined by the RNC2050, are not sufficient to achieve the national reduction commitment for $PM_{2.5}$, in the 2030 time horizon.

In 2030, $PM_{2.5}$ are mainly emitted by the industrial sector (58%), with a relevant contribution from process emissions, and also having a significant contribution from the commercial/services sector (in which the relative weight of biomass combustion for heating rises in the 2030 time horizon). It should be noted that, in this sector, an additional reduction of $PM_{2,5}$ emissions was considered, resulting from the adoption of the Ecodesign Directive, even though this will not be sufficient to achieve the necessary emissions reduction.

With regard to NMVOC and NH_3, despite national emission reduction commitments being fulfilled, they are by a small margin in relation to the correspondent emission ceiling (less than 1%).

The main NMVOC emitter in 2030 is the industrial sector (66%). It should be noted that, within this sector, an additional emission reduction was considered as a result of the adoption of control strategies, namely measures with mitigation potential in the area of industrial solvents use. Within this sector, it was not possible to achieve a significant reduction in process emissions, as opposed to combustion emissions, particularly in the subsectors responsible for the highest NMVOC and $PM_{2.5}$ contributions (such as chemistry, paints, and solvents in the NMVOC case, and ceramics and chemistry in the $PM_{2.5}$ case). In the long term, the industrial sector acquires the largest weight in national emissions, especially due to the fraction of process emissions, in a growing product demand trend and considering current technological limitations, which do not allow for significant reductions.

In the case of NH_3, the obtained emission reduction made it possible to meet all emission ceilings, however, after 2030, projections were quite close to the national emission reduction commitment. The agriculture sector is the dominant source of NH_3,accounting for 76% of emissions in 2030.

In 2020, the reduction commitments for the pollutants under the NEC Directive are expected to be achieved. Regarding the 2030 time horizon, to comply with national targets will require the implementation of additional measures to reduce $PM_{2.5}$ emissions, mainly oriented to the industrial sector, and also for the agriculture sector, targeting NH_3, and solvent use to address VOCNM, to ensure no deviation in 2030.

Table 9-21: Assessment of compliance of the national emission reduction commitments in 2020 and 2030, with regards to 2005

Pollutant	Parameter/ Unit	Historic Emission	NEC		Emission Projection		NEC Compliance		Distance to target	
		2005	[2020; 2029]	≥2030	[2020; 2029]	≥2030	[2020; 2029]	≥2030	[2020; 2029]	≥2030
NO_x*	Emissions (kt)	245	157	91	123	71	Yes	Yes	-34 kt	-20 kt
	Δ/2005 (%)	NA	-36%	-63%	-50%	-71%			-14%	-8%
COVNM*	Emissions (kt)	176	144	109	124	108	Yes	Yes	-21 kt	-1 kt
	Δ/2005 (%)	NA	-18%	-38%	-30%	-39%			-12%	-0.5%
SO_2	Emissions (kt)	172	64	29	30	27	Yes	Yes	-34 kt	-3 kt
	Δ/2005 (%)	NA	-63%	-83%	-83%	-85%			-20%	-1.5%
NH_3	Emissions (kt)	55	52	47	48	47	Yes	Yes	-3 kt	0 kt
	Δ/2005 (%)	NA	-7%	-15%	-13%	-15%			-6%	-0.2%
$PM_{2.5}$	Emissions (kt)	66	56	31	46	40	Yes	No	-10 kt	9 kt
	Δ/2005 (%)	NA	-15%	-53%	-30%	-39%			-15%	14%

Legend: NEC: National Emission Ceiling; NA: non-applicable; Yes: NEC compliance; No: NEC non-compliance; *according to NECD Article 4, Point 3(d), emissions of NOx and NMVOC from activities of NFR categories 3B (manure management) and 3D (agricultural soils) are not accounted for the purpose of complying

10 Reporting of gridded emissions and LPS

Table of Contents

10 Reporting of gridded emissions and LPS 10-1

10.1 Background information 10-3

10.2 Gridded emissions data 10-3

10.2.1 The EMEP Grid 10-3

10.2.2 Methods and data for disaggregation of emission data 10-5

10.2.3 EMEP grid results 10-21

10.2.4 Improvements since last submission 10-26

10.2.5 Planned improvements 10-26

10.3 Large Point Sources (LPS) 10-27

10.3.1 Reported LPS 10-27

10.3.2 Methodological issues 10-28

10.3.3 Improvements since last submission 10-29

10.3.4 Planned improvements 10-29

List of Figures

Figure 10-1: Portuguese EMEP grid 10-4

Figure 10-2: Emissions by pollutant and source type 10-5

Figure 10-3: Point sources 10-6

Figure 10-4: Line sources 10-7

Figure 10-5: Portuguese EMEP grid and Municipalities 10-8

Figure 10-6: NOx gridded emissions 10-21

Figure 10-7: NMVOC gridded emissions 10-22

Figure 10-8: SOx gridded emissions 10-23

Figure 10-9: NH_3 gridded emissions 10-24

Figure 10-10: PM2.5 gridded emissions 10-25

Figure 10-11: LPS in 2019 10-28

List of Tables

Table 10-1: List of GNFR classes, corresponding NFR categories and geographical datasets used in emission gridding 10-10

10 Reporting of gridded emissions and LPS

Updated: May 2021

This section has been updated for the 2021 submission (due on 1 May) and refers to the inventory year of 2019 (NFR tables V2.0) resubmitted on the 15th March 2021.

Gridded emissions include LPS emissions so full consistency between grid and LPS reporting is ensured.

This chapter includes a description of data and methods used as well as the results of the grid emissions exercise for the year 2019.

10.1 Background information

In December 2013, the Executive Body for the Convention on Long-range Transboundary Air Pollution adopted new Guidelines for Reporting Emissions and Projections Data (ECE/EB.AIR/125), which include the requirement of four-year reporting of gridded emissions and LPS from 2017 onwards, for the year x-2.

Previous reporting of gridded emissions was last updated in 2017, referring to year 2015.

The reporting follows the latest Guidance from the EMEP/EEA 2019 Guidebook and the latest Reporting Guidelines. The EMEP grid of 0.1 x 0.1 degrees was used and all substances referred in paragraph 7 of the reporting Guidelines were included: SOx, NOx, NH_3, NMVOCs, CO, PM2.5, PM10, Cd, Pb, Hg, PAHs, PCDD/F, PCBs and HCB. Gridded data is reported using NFR2014 reporting table: ANNEX V - Template file for gridded sector data for each of the relevant aggregated Gridding NFR sectors (GNFR).

The reporting also includes emissions from Large Point Sources (LPS) with information on the location and altitude at which they occur. LPS data is submitted using the NFR2014 reporting table: ANNEX VI - Template for LPS data for each relevant aggregated Gridding NFR sectors (GNFR).

10.2 Gridded emissions data

10.2.1 The EMEP Grid

The EMEP grid refers to a 0.1 x 0.1 degrees latitude-longitude projection in the geographic coordinate World Geodetic System (WGS) latest revision, WGS 84.

As shown in the figure below, under the EMEP domain, Portugal's geographical area is covered by 1151 grid cells, which do not include the occidental group of the Azores islands - Corvo and Flores. These two islands are not covered by the EMEP Grid and therefore are excluded from this reporting. Emission data estimated by Portugal within the geographic scope of EMEP were spatially allocated in the EMEP Grid.

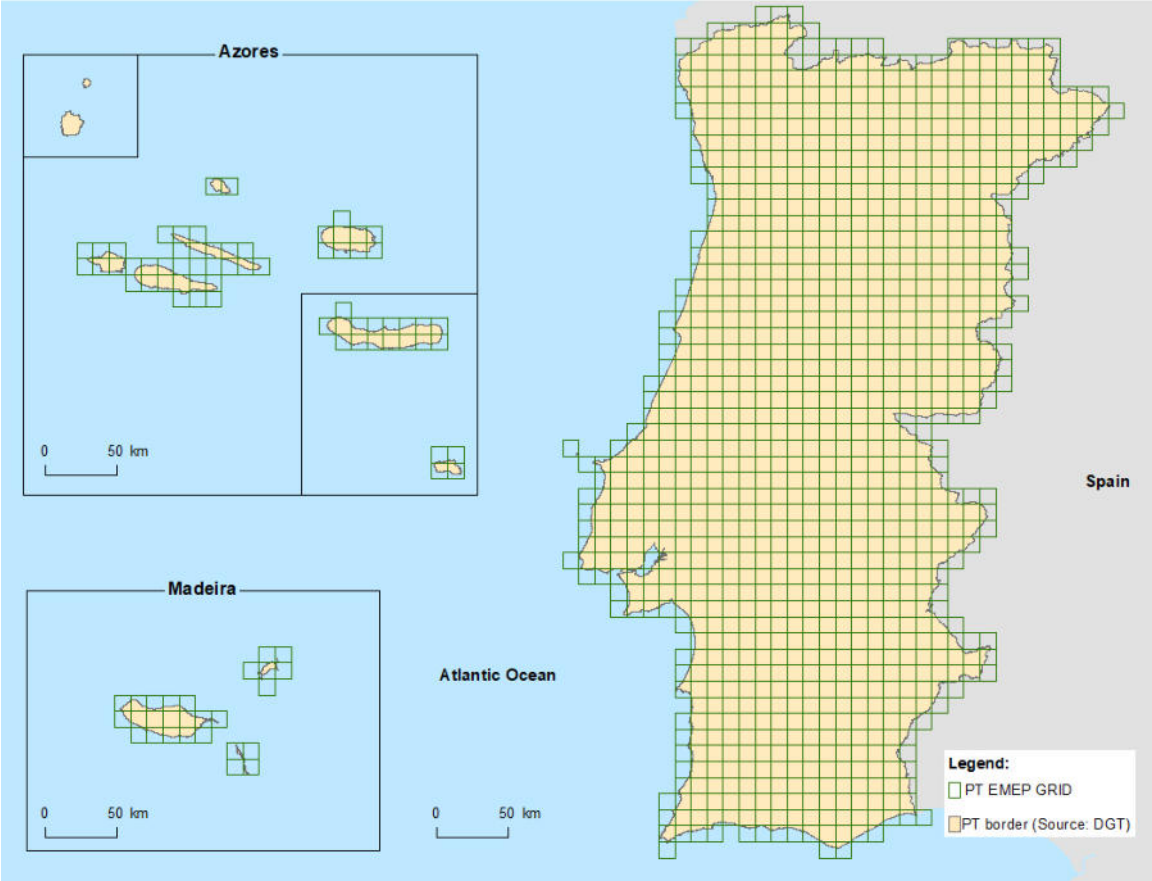

Figure 10-1: Portuguese EMEP grid

In order to spatially disaggregate emissions, Portugal downloaded country specific EMEP ESRI shapefile with the grid definition, as well as the grid definition tables in excel file, which contain specific data for the country, from the CEIP website (https://www.ceip.at/the-emep-grid/grid-definiton).

10.2.2 Methods and data for disaggregation of emission data

The spatial disaggregation of emission data consists on the attribution of an air pollutant emission amount to a geographic location.

This chapter describes the approach used for the allocation of national emissions to the EMEP Grid, which include the use of a GIS based method and surrogate data.

This chapter begins with a general description of how the different types of sources were used for the distribution of emissions. In the following sections, more details are given about the different methodologies used for each sector of activity / NFR category.

10.2.2.1 Source Types - Methodological Overview

The Portuguese emission inventory includes point, line and area sources.

As the figure below shows, there is a considerable heterogeneity among pollutants regarding the coverage of source types, reflecting the diversity of the activities involved and their spatial distribution.

In the case of SOx for instance, emissions are mostly associated to stationary combustion plants and are accounted, in general, as individual sources.

NOx and BC emissions, which are largely related to transport and mobile sources, present a bigger share of line sources as compared to other pollutants.

The importance of area sources concerning NH_3 emissions reflect their association with the agriculture sector, where diffuse emissions are predominant.

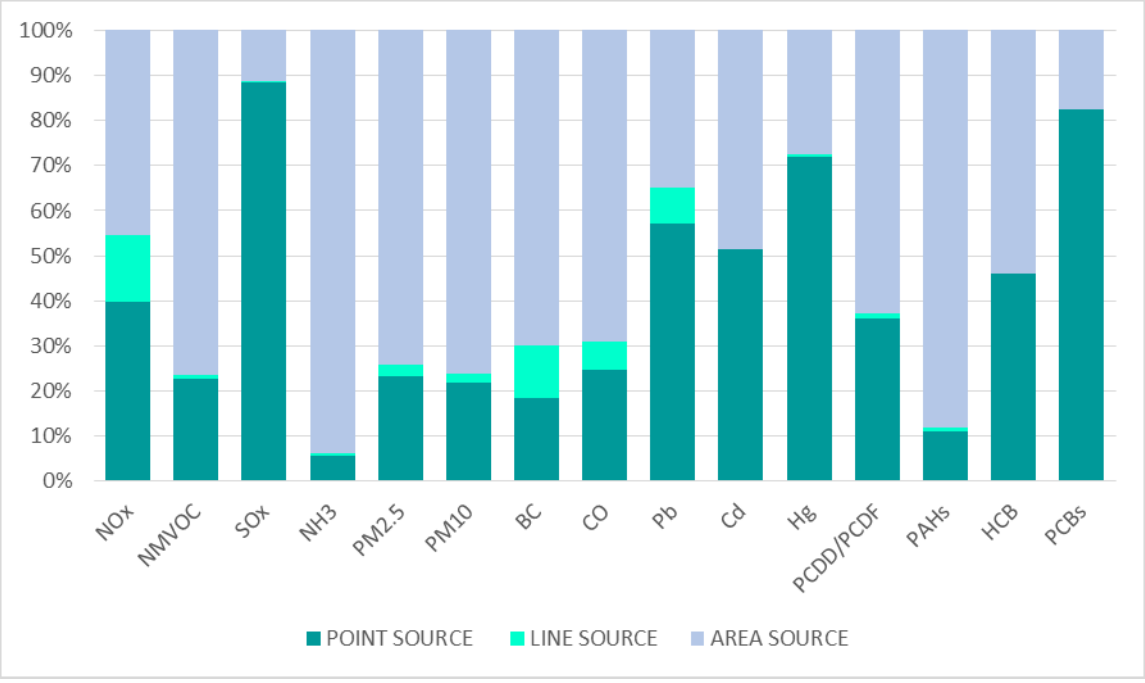

Figure 10-2: Emissions by pollutant and source type

POINT SOURCES

In the case of point sources, emissions are allocated to the geographical coordinates of the individual plants and other facilities included in the national inventory. When gridded, the emission is spatially allocated to the grid cell containing the point or points.

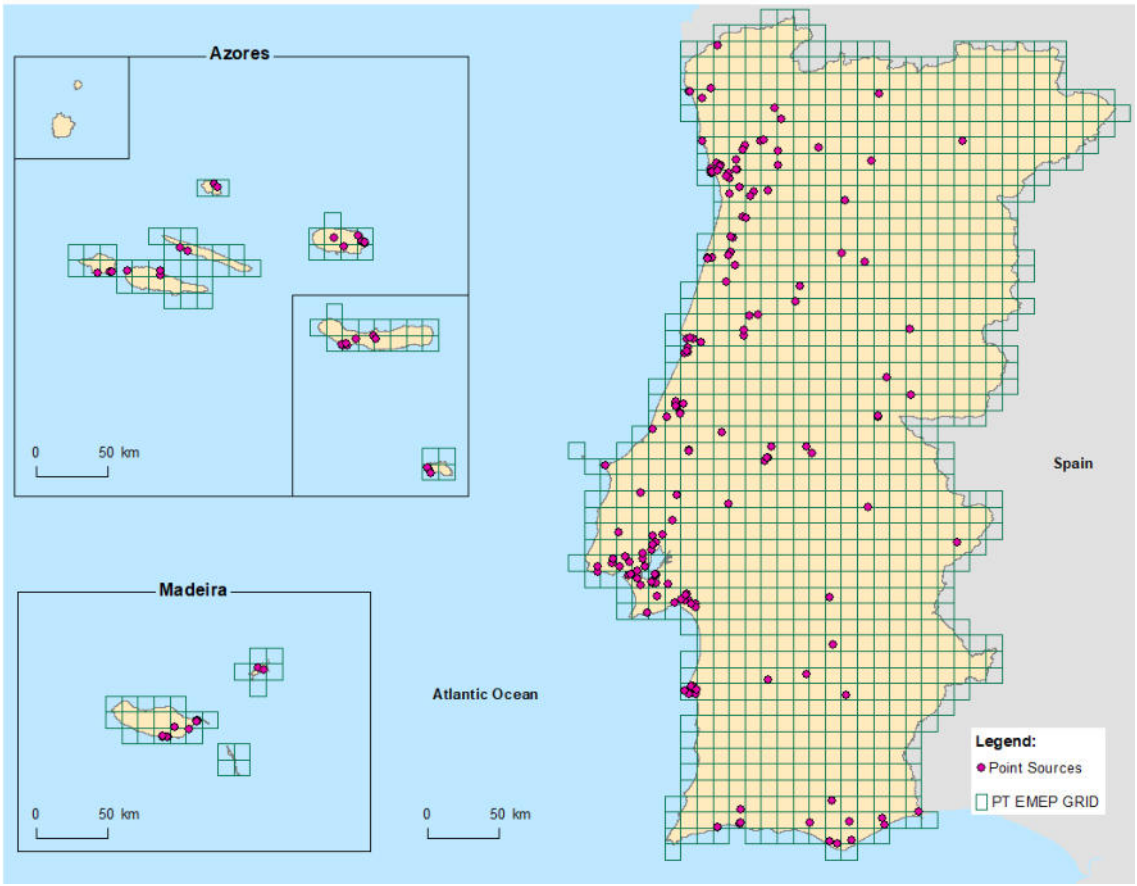

Figure 10-3: Point sources

In point sources it is possible to identify two types of approach used to distribute emissions from one category.

There are cases in which the national inventory produces individual estimates for each point source considering specific information from the installation, such as activity data and monitored emissions, assuming a bottom-up approach (e.g. emissions from Aviation LTOs are estimated based on the movements of each airport).

On the other hand, there are cases in which the estimates were made at national level, using information for the total territory, and are distributed by point sources using proxy data representative of that activity, assuming a top-down approach (e.g. emissions from National fishing are estimated at national level, considering the fuel consumption of this sector of activity, and are then spatially distributed considering the amount of fish caught in each fishing port).

LINE SOURCES

The information used to report spatial emissions included also line sources (e.g. highways and railways), as shown in the figure below.

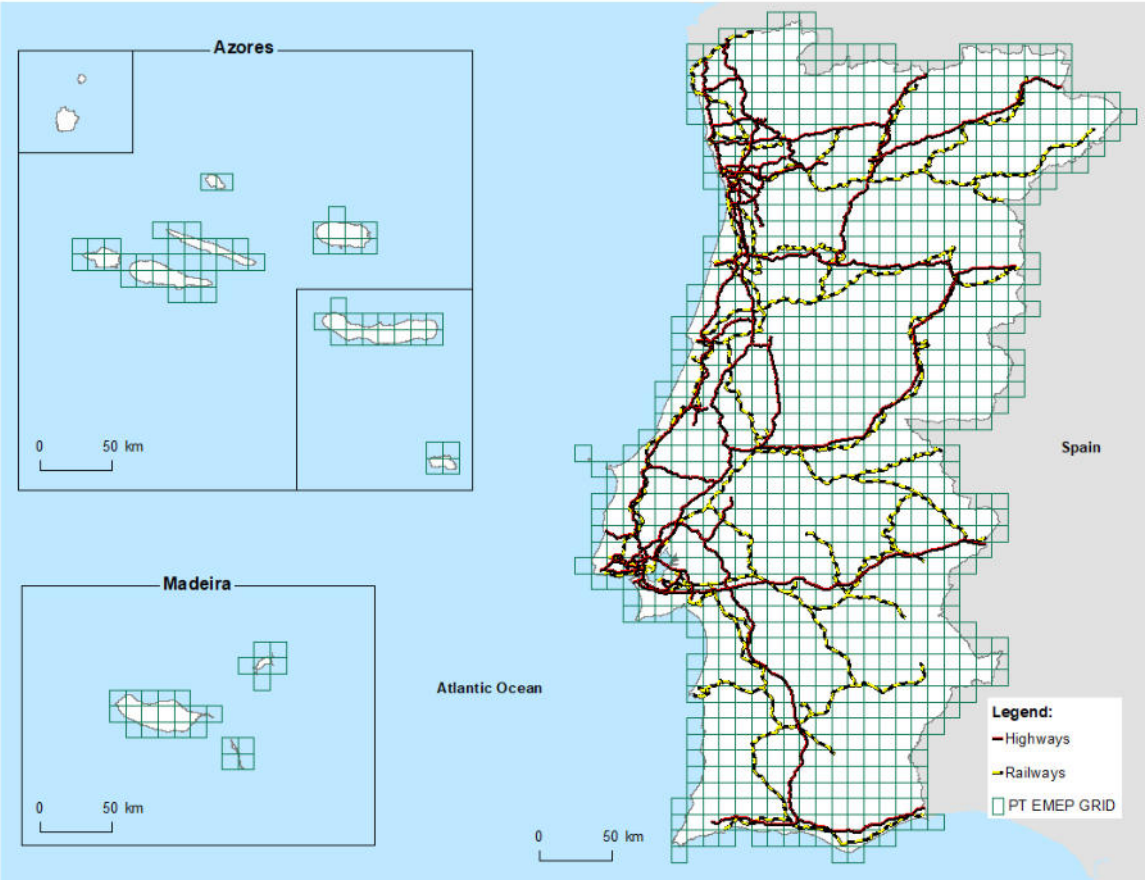

Figure 10-4: Line sources

The national inventory estimates emissions for mobile sources using data aggregated at the national level, such as fuel consumption and activity, but does not consider the routes of these vehicles in its estimates. This aspect makes it difficult to find methodologies that distribute emissions from mobile sources in a correct and balanced way.

In cases where we have information on traffic in each section of a line source, it is possible to apply a weighted distribution approach, thus allowing an approximation to the geographic location of these emissions.

AREA SOURCES

Emissions from area sources are distributed on the basis of several datasets with different levels of spatial disaggregation, e.g. national statistical data, Land Use cover.

The most current disaggregation level used is the territorial unit – *Concelho* (Municipality), which is the designation of a territory associated with one municipal administrative authority. There are 308 municipalities in Portugal: 278 in Portugal Mainland, 19 in the Autonomous Region of Azores and 11 in the Autonomous Region of Madeira, as shown in the figure below.

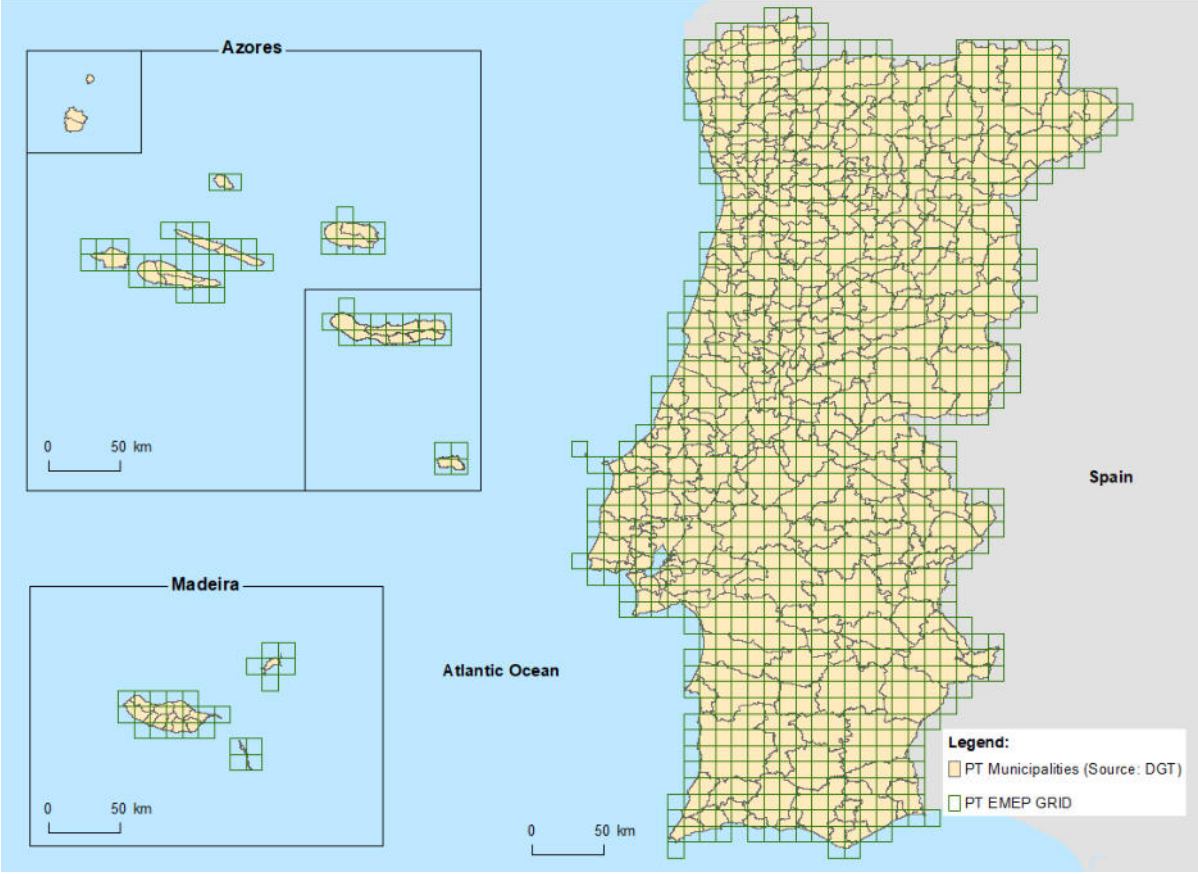

Figure 10-5: Portuguese EMEP grid and Municipalities

The reason this level of disaggregation is the most used to distribute emissions is related to the availability of regionalized data. These are, as a general rule, the highest level of disaggregation in which it is possible to have a complete coverage of the national territory while ensuring statistical consistency between territorial units.

Regarding the methodology used for this type of sources, as a general rule, the estimation of emissions from these categories is made at the national level, therefore it is necessary to adopt a top-down approach to perform the distribution of emissions.

Accordingly, allocation parameters were selected in order to portray the activity level of a certain category in each municipality. Emissions are distributed based on the chosen parameters and we obtain emissions for each category distributed by the 308 municipalities' area.

In these cases, a spatial correlation between each municipality area and the area of each grid cell was established in order to obtain the gridded emissions.

COMPILATION OF DIFFERENT SOURCE DATASETS

A GIS software (ArcGIS 10.6.1) was used in order to spatially allocate the different data sources, in the form of shapefiles, to each grid cell of the EMEP Grid shapefile. Finally, all the different spatial datasets (point, line, area) were combined together into a unique gridded dataset according to the reporting guidelines: the EMEP grid (0.1° x 0.1° longitude/latitude).

Table 10.1 lists the GNFR – Code, the corresponding NFR sectors used for reporting the 2021 gridded emission data, as well as the corresponding geographical information used in the spatial emission disaggregation.

Table 10-1: List of GNFR classes, corresponding NFR categories and geographical datasets used in emission gridding

GNFR	NFR code	Name	Source type			Spatial Allocation Parameter	Data Source
			Point	Area	Line		
A_PublicPower	1A1a	Public electricity and heat production	×			Location of industrial facilities	E-PRTR coordinates
B_Industry	1A1b	Petroleum refining	×			Location of industrial facilities	E-PRTR coordinates
	1A2 & 2A, 2B, 2C, 2H	Large Point Sources: Combustion and Process	×			Location of industrial facilities	E-PRTR coordinates
	1A2 & 2A, 2B, 2C, 2H	Diffuse Emissions: Combustion and Process		×		Fuel sales by municipality and economic sector	DGEG – Energy statistics
	2D3b	Road paving with asphalt		×		Total sales of asphalt by municipality in the construction and public works sector	DGEG – Energy statistics
	2I & 2D3c	Wood processing & Asphalt roofing		×		Population by municipality	INE – National statistics
	2K	Consumption of POPs and heavy metals		×		Fuel sales by municipality in the electronic material production sector	DGEG – Energy statistics
C_OtherStationaryComb	1A4ai & 1A4ci	Commercial / Institutional: Stationary Agriculture/Forestry/Fishing: Stationary		×		Fuel sales by municipality and economic sector	DGEG – Energy statistics
	1A4bi	Residential: Stationary combustion		×		Population by municipality	INE – National statistics
D_Fugitive	1B2ai	Fugitive emissions oil: Exploration, production, transport	×			Location of Marine terminals for unloading crude oil	Plants coordinates
	1B2aiv & 1B2c	Refining and storage & Venting and flaring (oil)	×			Location of refining and storage facilities	E-PRTR coordinates / Plants coordinates
	1B2b	Distribution of natural gas		×		Total natural gas sales by municipality	DGEG – Energy statistics
	1B2d	Geothermal Plants	×			Location of Geothermal plants facilities	Plants coordinates
E_Solvents	2D3 & 2G	Solvent use and other applications		×		Population by municipality	INE – National statistics
F_RoadTransport	1A3b	Road transport		×	×	Urban and rural population and population density Highway segments length and traffic	INE IMT
G_Shipping	1A3dii	National navigation (shipping)	×			Domestic ship movements in national seaports	IMT Ports authorities

GNFR	NFR code	Name	Source type			Spatial Allocation Parameter	Data Source
			Point	Area	Line		
H_Aviation	1A3ai(i) & 1A3aii(i)	Aviation LTO (civil)	×			Domestic and international aircraft movement in national airports	ANAC
I_Offroad	1A3c	Railways			×	Rail network	IMT – Transport statistics
	1A4cii	Offroad Mobile combustion		×		Total marked diesel sales by municipality	DGEG – Energy statistics
	1A4ciii	National fishing	×			Fish landings by seaports locations	INE – National statistics
	1A5b	Military aviation	×			Domestic LTO in civil aviation	ANAC
J_Waste	5A	Solid waste disposal on land	×	×		Landfills location/ quantities of waste deposited on land per municipality	MRRU-MIRR-estimates / APA
	5B	Composting and anaerobic digestion	×			Installations location	MRRU / APA
	5C	Waste incineration	×			Installations location	MIRR / APA Servilusa
	5D1	Domestic wastewater handling		×		Population by municipality	INE – National statistics
	5D2	Industrial wastewater handling		×		Fuel sales by municipality and economic sector	DGEG
	5E	Other waste (fires in urban areas)		×		Population in urban areas	INE – National statistics
K_AgriLivestock	3B	Manure management		×		Livestock population per municipality	Agricultural Census / INE
L_AgriOther	3D & 3F	Crop production & agricultural soils		×		Crop areas & livestock population per municipality	
N_Natural	11B	Forest fires		×		Burnt Areas map Land use map	ICNF DGT

10.2.2.2 [A_PublicPower]

NFR categories:

- Public electricity and heat production (1A1a)

Point sources - Public electricity and heat production

Emissions from Public electricity and heat production facilities were obtained using plant-specific emissions and activity statistics obtained from E-PRTR and EU-ETS. For that reason, this category is reported as point source and spatial disaggregation of emissions was made according to the geographic coordinates of the facilities.

This category includes also emissions accounted on the basis of 2019 amounts of waste incinerated by MSW incineration unit and biogas combusted for energy purposes in landfills. Data reported under MRRU/APA. The spatial disaggregation of emissions was made according to the geographic coordinates of the installations.

The approach used to distribute emissions for this category can be considered a Tier 3.

10.2.2.3 [B_Industry]

NFR categories:

Manufacturing Industry - Combustion

- Petroleum refining (1A1b)
- Iron and steel (1A2a)
- Chemicals (1A2c)
- Pulp, paper and print (1A2d)
- Food, beverages and tobacco (1A2e)
- Non-metallic minerals (1A2f)
- Other manufacturing industry (1A2gviii)

Industrial Processes and Product Use

- Cement production (2A1)
- Lime production (2A2)
- Glass production (2A3)
- Quarrying and mining (2A5a)
- Construction and demolition (2A5b)
- Nitric acid production (2B2)
- Titanium dioxide production (2B6)
- Other chemical industry (2B10a)
- Iron and steel production (2C1)
- Aluminium production (2C3)
- Road paving with asphalt (2D3b)
- Asphalt roofing (2D3c)
- Pulp and paper industry (2H1),
- Food and beverages industry (2H2)
- Wood processing (2I)

Point sources - Industrial Installations:

In emissions' estimates, the Inventory considers diversified information disaggregated by installation, such as activity data obtained from the EU-ETS system (fuel and raw material consumption or production data) or emission data obtained from the E-PRTR. In such cases, where it is possible to estimate emissions for a given installation, these were considered point sources and their geographic position was used for spatial allocation.

The approach used to distribute emissions for this category can be considered a Tier 3.

Area sources - Industrial Activity (Combustion):

Point sources considered in B_Industry do not cover all the industrial activity that occurs in Portugal. In those cases where the sources we consider do not fully cover the sector, or in cases where there is no point information for a category, the allocation parameter used was fuel sales by industrial sector and by municipality, since it is possible to establish a relationship between emissions and fuel consumption that occurred in each municipality.

Considering the strong relationship between fuel sales and combustion emissions in the industry, this approach is considered a Tier 2.

Area sources - Industrial Activity (Process):

In the case of emissions resulting from industrial processes whose activity is not covered by specific information from industrial installations, it was considered that, although there is no direct relationship between energy consumption and process emissions, the use of fuel sales allocation parameter by industry sector and by municipality allows to infer the activity level of a municipality and to consider its contribution to the national total.

In this way, emissions resulting from these categories are distributed among the 308 municipalities considering the level of activity that occurs in each one, taking into account energy consumption.

As previously mentioned, energy consumption and process emissions sometimes do not have a direct relationship. However, energy consumption allows inferring the geographical distribution of an industrial sector, which is why it is considered a valid distribution factor and, in our understanding, with higher quality than simple distribution by population. Therefore, we consider this approach a Tier 2.

There are still two categories - Asphalt roofing and Wood Processing - whose emissions' distribution was made considering the population of each municipality, as there was no information on fuel sales that would allow the level of activity of each municipality to be weighed. This approach can be considered a tier 1.

10.2.2.4 [C_OtherStationaryComb]

NFR categories:

Other Stationary Combustion

- Commercial / Institutional (1A4ai)
- Residential (1A4bi)
- Agriculture / Forestry / Fishing (1A4ci)

Area sources – Commercial / Institutional & Agriculture / Forestry / Fishing

Without specific information for these sectors, we considered that fuel sales by municipality were the best allocation parameter for these economic activities. Distribution of emissions was made by municipality and then by the grid cell.

Considering the strong relationship between fuel sales and stationary combustion emissions, this approach could be considered a Tier 2, lacking modelled estimates for population density for be considered a Tier 3.

Area sources – Residential

In this case, with biomass combustion being one of the main sources of emissions in this category, and taking into account that there is no biomass sales information by municipality, the inventory considered that the distribution of emissions by resident population in each municipality was the best alternative.

This choice of parameter has a clear limitation because it assumes that the entire population of the country has the same energy consumption habits in the residential sector. However, considering the weighting of the distribution by the population, this approach can be considered a Tier 2.

10.2.2.5 [D_Fugitive]

NFR categories:

Fugitive Emissions

- Fugitive emissions Oil (1B2a)
- Fugitive emissions Natural Gas (1B2b)
- Venting and Flaring (1B2c)
- Other fugitive emissions: Geothermal (1B2d)

Point sources – Fugitive emissions from oil refining and storage:

Fugitive emissions from storage units were obtained using TANKS 4.0.9d software and storage units' specific activity data. For that reason, this category is reported as point source and spatial disaggregation of emissions was made according to the geographic coordinates of storage units.

The approach used to distribute emissions for this category can be considered a Tier 3.

Point sources – Venting and Flaring

Fugitive emissions from Venting and Flaring are considered only to occur in refineries, hence, plant specific activity statistics were used to estimate emissions. These were considered point sources and their geographic position was used for spatial allocation. The approach used to distribute emissions for this category can be considered a Tier 3.

Point sources – Geothermal Plants

Fugitive emissions from geothermal power plants were estimated considering the amount of electrical energy produced individually by each power plant, thus allowing the distribution of NH_3 and Hg emissions through point sources. The approach used to distribute emissions for this category can be considered a Tier 3.

Area sources – Distribution of Oil products and Natural Gas

Oil products - In this category, the main emissions of atmospheric pollutants result from the escape of NMVOCs during the supply of vehicles at the filling stations. Thus, in order to distribute these emissions, gas deliveries in filling stations by municipality were used as spatial allocation parameter.

Natural Gas - Currently, we do not have spatial information on leakage rates along the distribution network. Considering that according to the methodology employed in the inventory, most fugitive emissions associated with natural gas transport occur in the distribution networks, we consider that the total deliveries of natural gas by municipalities is a good parameter to distribute these emissions.

The approaches used to distribute emissions from these two categories can be considered a Tier 1.

10.2.2.6 [E_Solvents]

NFR categories:

Other solvent and product use

- Domestic solvent use including fungicides (2D3a)
- Coating applications (2D3d)
- Degreasing (2D3e)
- Dry cleaning (2D3f)
- Chemical products (2D3g)
- Printing (2D3h)
- Other solvent use (2D3i)
- Other applications (2G)

Area source – Solvent use and other product use

Activity data on the use of solvents and other products is only available at national level, making it impossible to obtain information on the level of consumption and use of these products in a more dissagregated level. Thus, we consider that the distribution of the Portuguese population among the different municipalities could be a reasonable allocation parameter, assuming that the level of activity is related to the population.

The approach used to distribute emissions in this category can be considered a Tier 1.

10.2.2.7 [F_RoadTransport]

NFR Sources:

- Passenger cars (1A3bi)
- Light duty vehicles (1A3bii)
- Heavy duty vehicles and buses (1A3biii)
- Mopeds & motorcycles (1A3biv)
- Gasoline evaporation (1A3bv)
- Automobile tyre and brake wear (1A3bvi)
- Automobile road abrasion (1A3bvii)

Emissions from the road transport sector were estimated using the COPERT 5 software (methodology described in section 3.4.2), that allows the separation of emissions in different driving modes:

- Urban mode - associated with circulation within localities, with lower circulation speeds (below 50 km/h) and more frequent stops and starts;
- Rural mode - associated with circulation on national and regional roads, where the speed limit is higher (usually greater than 50 km/h), and less frequent stops;
- Highway mode - associated with circulation on roads reserved for light and heavy vehicles and motorcycles, where the maximum speed limits are greater than 80 km/h, with longer trips and less variations in circulation speed.

Line source – Highway emissions

Highway emission totals were distributed along the highway network, according to the average annual daily traffic and the length of each highway segment, provided by the Institute for Mobility and Transportation (IMT).

The approach used to distribute emissions for this category can be considered a Tier 2.

Area source - Urban [Peak & Off-Peak] and Rural emissions

For urban and rural modes, where the road network is more dense and complex, it was not possible to find information on traffic count/flow for all roads with national coverage and guarantee an ideal weighted distribution of emissions.

Our approach used criteria such as population and population density to replicate the different traffic intensities of these two modes of circulation. Population data were disaggregated into civil parishes (*freguesia*), which allowed to divide the Portuguese territory and population into 3092 polygons.

Civil parishes are classified into urban and rural using a classification criteria from Statitics Portugal (INE): with a population density greater than 300 inhabitants/km^2 are classified as urban and with less than 300 inhabitants/km^2 are classified as rural.

This classification criteria allows a weighted distribution of total urban and rural emissions into urban and rural civil parishes, according to the corresponding population.

Despite the fact that this allocation considers that each civil parish has only one mode of circulation (urban or rural), emissions are subsequently aggregated in municipalities areas creating a more balanced distribution of these two modes of circulation.

Although this methodology goes further than separating emissions based only on population, as it does not consider the road network, the approach used to distribute emissions for this category can be considered a Tier 1.

10.2.2.8 [G_Shipping]

NFR categories:

- National navigation (shipping) (1A3dii)

Point source

Emissions allocation to each national seaport was based on the methodology described in section 3.4.4 Water Borne Navigation, according to detailed data on domestic ship movements provided by the Institute for Mobility and Transportation (IMT) and Ports authorities. The approach used to distribute emissions for this category can be considered a Tier 2.

10.2.2.9 [H_Aviation]

NFR categories:

- International aviation LTO (civil) (1A3ai(i))
- Domestic aviation LTO (civil) (1A3aii(i))

Point source

Landing and Take-Off emissions allocation to national airports was based on the methodology described in section 3.4.1 Civil Aviation, according to detailed data on domestic and international aircraft movement provided by Portuguese Civil Aviation Authority (ANAC). The approach used to distribute emissions for this category can be considered a Tier 2.

10.2.2.10 [I_Offroad]

NFR categories:

Non road mobile machinery

- Mobile combustion in Industries (1A2gvii)
- Commercial/Institutional: Mobile (1A4aii)
- Residential: Household and gardening (1A4bii)
- Off-road vehicles and other machinery (1A4cii)

Other off-road sources

- Railways (1A3c)
- National fishing (1A4aiii)
- Military aviation (1A5b)

Line source – Railways emissions

Railways emission totals were distributed according to the length of national railways (2019 data), courtesy of IMT. Currently in Portugal, practically the entire railway network is electrified, however, diesel locomotives continue to operate on these same lines, making it impossible to fine-tune the location of these emissions. The approach used to distribute emissions in this category can be considered a Tier 1.

Area source – Off-road vehicles and other machinery

Emissions from this category are essentially the result of diesel combustion in agricultural machinery. This equipment is supplied with marked diesel, subsidized by the government. Thus, in order to distribute emissions in this category, marked diesel deliveries by municipality were considered as allocation parameters. The approach used to distribute emissions in this category can be considered a Tier 3.

Point source – National fishing

Emissions from National fishing were distributed based on tons of fish landings at national seaports in 2019, provided by National statistics. The approach used to distribute emissions in this category can be considered a Tier 2.

Point source – Military Aviation

Emissions from military aviation were allocated to national airport location according to the ratio of domestic Landing and Take-Off in civil aviation, provided by ANAC. The approach used to distribute emissions in this category can be considered a Tier 1.

10.2.2.11 [J_Waste]

NFR categories:

Biological treatment of waste

- Solid waste disposal on land (SWDL) (5A)
- Biogas combusted without energy recovery in landfills (5A)
- Composting and Anaerobic digestion at biogas facilities (5B)

Waste water handling

- Domestic wastewater (5D1)
- Industrial wastewater (5D2)

Waste incineration

- Industrial waste incineration (5C1bi)
- Hazardous waste incineration (5C1bii); Sewage sludge incineration (5C1biv) Included in 5C1bi
- Clinical waste incineration (5C1biii)
- Cremation (5C1bv)

Other waste

- Car and house fires in urban areas (5E)

Point Source /Area Source - Solid waste disposal on land (SWDL)

NMVOC and NH_3 emissions are estimated on the basis of CH_4 emissions calculated under the UNFCCC.

In more recent years, distribution of CH_4 emissions has been done according to the geographical location of landfills and the accumulated quantities of municipal and industrial waste disposed in landfills reported by management systems and waste operators to APA.

Emissions from municipal solid waste for historical years are allocated as area sources, based on estimated quantities of waste deposited on land (in open dumps and landfills) by municipality since 1960. Emissions from industrial waste disposal were based on the same distribution as urban waste.

Data on recovered methane gas has been considered at landfill level.

Particulate emissions (PM2.5 and PM10) are based on the annual deposition of waste deposited in landfills.

The approach used to distribute emissions for this category can be considered as a Tier 3.

Point Source – Biogas combusted without energy recovery in landfills

Emissions are estimated based on data from landfills (MRRU/APA). The approach used to distribute emissions for this category can be considered a Tier 3.

Point Source – Composting and Anaerobic digestion at biogas facilities

Emissions are based on the quantities of waste treated in each facility and distributed according to the geographical location of the installations. The approach used to distribute emissions for this category can be considered a Tier 3.

Point Source – Industrial waste incineration

Emissions are estimated based on quantities of industrial waste incinerated without energy recovery (reported under MIRR/APA) by installation. The spatial disaggregation refers to the geographic coordinates of the installations. The approach used to distribute emissions for this category can be considered a Tier 3.

Area Source – Hazardous waste incineration & Sewage sludge incineration

Included in Industrial waste incineration

Point Source – Clinical waste incineration

Emissions are estimated based on the quantities of clinical waste incinerated (reported under MIRR/APA). The spatial disaggregation refers to the geographic coordinates of the incineration units. The approach used to distribute emissions for this category can be considered a Tier 3.

Point Source – Cremation

Distribution of emissions are based on the number of human corpses cremated by crematorium according to georeferencing, courtesy of Servilusa. The approach used to distribute emissions for this category can be considered a Tier 3.

Point Source – Domestic wastewater handling

The NMVOC, NH_3 and N2O emissions are distributed as source areas according to the population by Municipality (INE). The approach used to distribute emissions for this category can be considered a Tier 1.

Area Source – Industrial wastewater handling

Distribution of emissions are based on the Fuel sales by municipality and economic sector (DGEG data).

The approach used to distribute emissions for this category can be considered a Tier 1 since there is no direct relationship between energy consumption and industrial wastewater handling types and associated emissions.

Area Source – Other waste: Car and house fires in urban areas

Emissions are estimated based on the annual occurrences (car fires, urban fires and industrial buildings), collected from the Civil Protection National Authority and the Lisbon City Hall Fire Brigade. Aggregated data on the number of occurrences were spatially allocated by population in urban areas (population density 300 inh./km^2). The approach used to distribute emissions for this category can be considered a Tier 1.

10.2.2.12 [K_AgriLivestock]

NFR categories:

Manure management

- Dairy cattle (3B1a)
- Non-dairy cattle (3B1b)
- Sheep (3B2)
- Swine (3B3)
- Goats (3B4d)
- Horses (3B4e)
- Mules & Asses (3B4f)
- Laying hens (3B4gi)
- Broilers (3B4gii)
- Turkeys (3B4giii)
- Other poultry (3B4giv)
- Other animals (3B4h)

Area Source

Emissions from manure management were distributed based on data from the last agricultural census provided by INE (Statitics Portugal/Instituto Nacional de Estatística), on the number of animals per municipality, disaggregated by animal species. Unfortunately, due to the situation described in the DISCLAIMER inserted at the beginning of the Agriculture chapter of this report (chapter 5), the data from 2019 Agricultural Census were not known in time to be used in this year inventory submission. Hence, data from the last available agriculture census, 2009, was used.

The approach used to distribute emissions in this category can be considered a Tier 2.

10.2.2.13 [L_AgriOther]

NFR categories:

Crop production and agricultural soils

- Inorganic N-fertilizers (3Da1)
- Animal manure applied to soils (3Da2a)
- Sewage sludge applied to soils (3Da2b)
- Other organic fertilizers applied to soils (3Da2c)
- Urine & dung deposited by grazing animals (3Da3)
- Farm-level agricultural operations (3Dc)
- Cultivated crops (3De)
- Use of pesticides (3Df)
- Field burning of agricultural residues (3F)

Area Source

Emissions from sources related to application of inorganic N- fertilizer, sewage sludge, other organic fertilizers, animal manure as well urine and dung deposited by grazing animals, were distributed based on data from the last agricultural census provided by INE, on cropland areas and the number of animals per municipality, disaggregated by annual and permanent crops and by animal species, taking into account the proportion of animals on pasture when distributing emissions from manure. The approach used to distribute emissions in these categories can be considered a Tier 2.

Emissions from field burning of agricultural residues were distributed based on data from the last agricultural census provided by INE, on cereals and orchards areas per municipality. The approach used to distribute emissions in this category can be considered a Tier 2.

Emissions from agricultural operations, cultivated crops and use of pesticides, were distributed based on data from the last agricultural census provided by INE, on annual and permanent crops areas per municipality. The approach used to distribute emissions in this category can be considered a Tier 2.

As referred in the GNFR K_Livestock, data from 2019 Agricultural Census were not known in time to be used in this year inventory submission. Hence, data from the last available agriculture census, 2009, was used.

10.2.2.14 [N_Natural]

NFR categories:

"Memo" Items

- Forest Fires (11B)

Area Source

Total national forest fires'emissions per land-use type were estimated in the inventory and dissagregated using 2010 Land Use and 2019 burnt areas cartography.

Cartography of 2019 burnt areas was obtained from the Institute for Nature Conservation and Forest/ Instituto da Conservação da Natureza e das Florestas, I.P. (ICNF). Cartography of 2010 Land Use was obtained from the General Directorate for spatial planning / Direção Geral do Território (DGT). In order to obtain previous land use percentage of burnt areas, burnt areas, as well as land use and EMEP Grid shapefiles were crossed in ArcGIS software.

Total national forest fires'emissions per land-use type were then allocated to the EMEP grid based on the percentages of burnt area of each land use in the grid over total burnt area of that land-use.

The approach used to distribute emissions in this category can be considered a Tier 2.

10.2.3 EMEP grid results

The figure below presents NOx gridded emissions for Portugal.

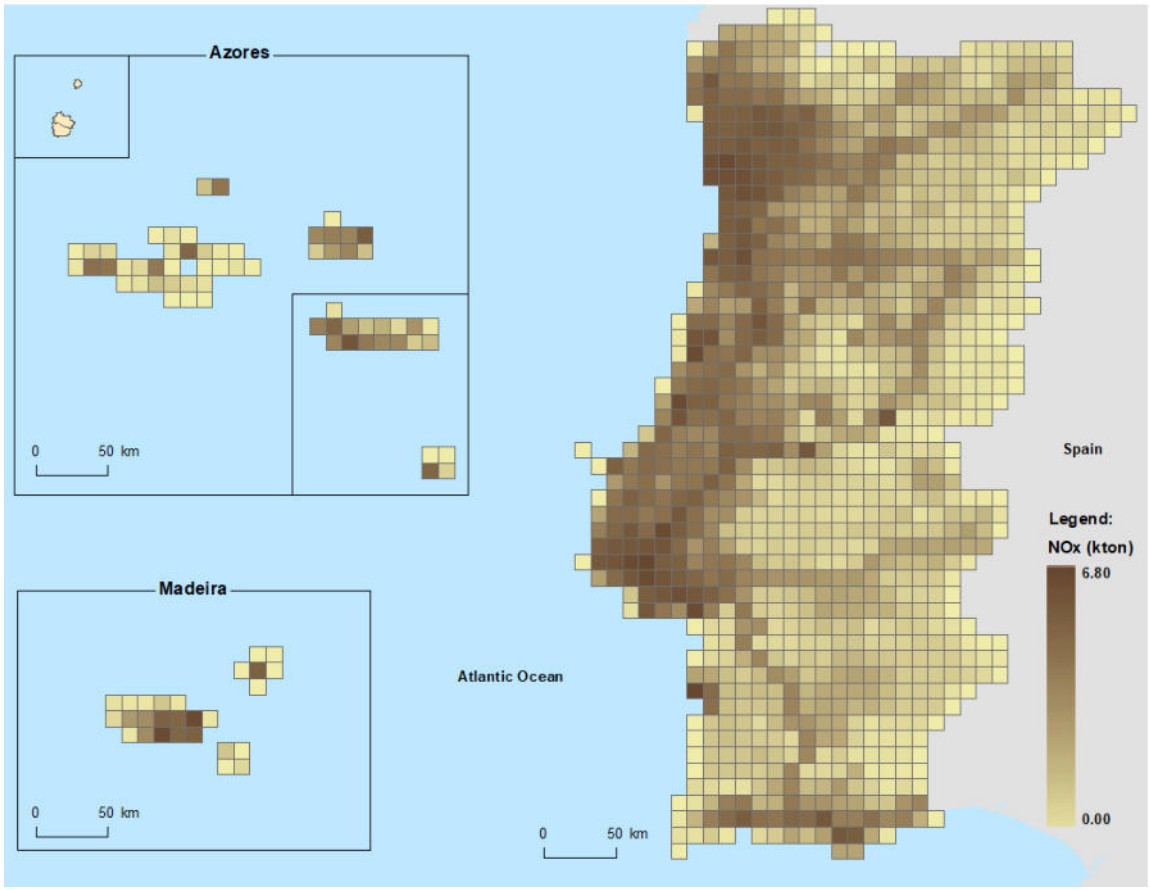

Figure 10-6: NOx gridded emissions

NOx emissions are predominantely associated with road transport sources, energy and manufacturing industries, and shipping. NOx gridded emissions presented in the figure above are the combination of emissions from combustion plants accounted individually, as well as emissions from road transport in motorways, estimated linearly, and diffuse emissions from other sectors, estimated as area sources.

The concentration of major industrial areas and agglomerations in the litoral part of the territory determines the higher intensity of emissions in those regions.

The figure below presents NMVOC gridded emissions for Portugal.

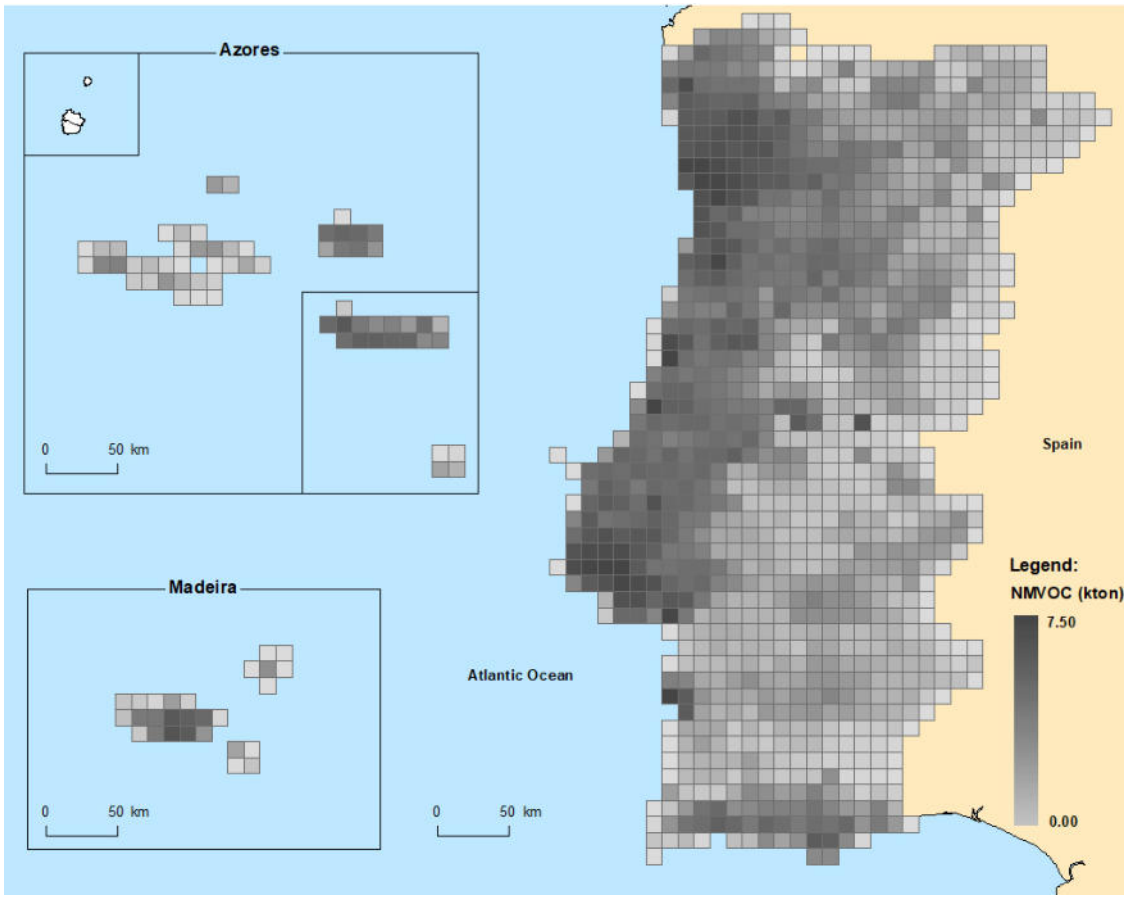

Figure 10-7: NMVOC gridded emissions

NMVOC emissions are associated not only with the use of solvents, but also to stationary combustion in the residential sector and some industries, as well as fuel related fugitive sources. Since these are generally diffuse sources that are too numerous or small to be quantified individually, NMVOC gridded emissions refer mainly to area sources that are distributed according to proxy statistics as population.

NMVOC gridded emissions presented in the figure reflect the high concentration of the population in the coastal areas and a dilution of activities in the interior part of the territory, as a reflection of the abandonment of the rural areas.

The figure below presents SOx gridded emissions for Portugal.

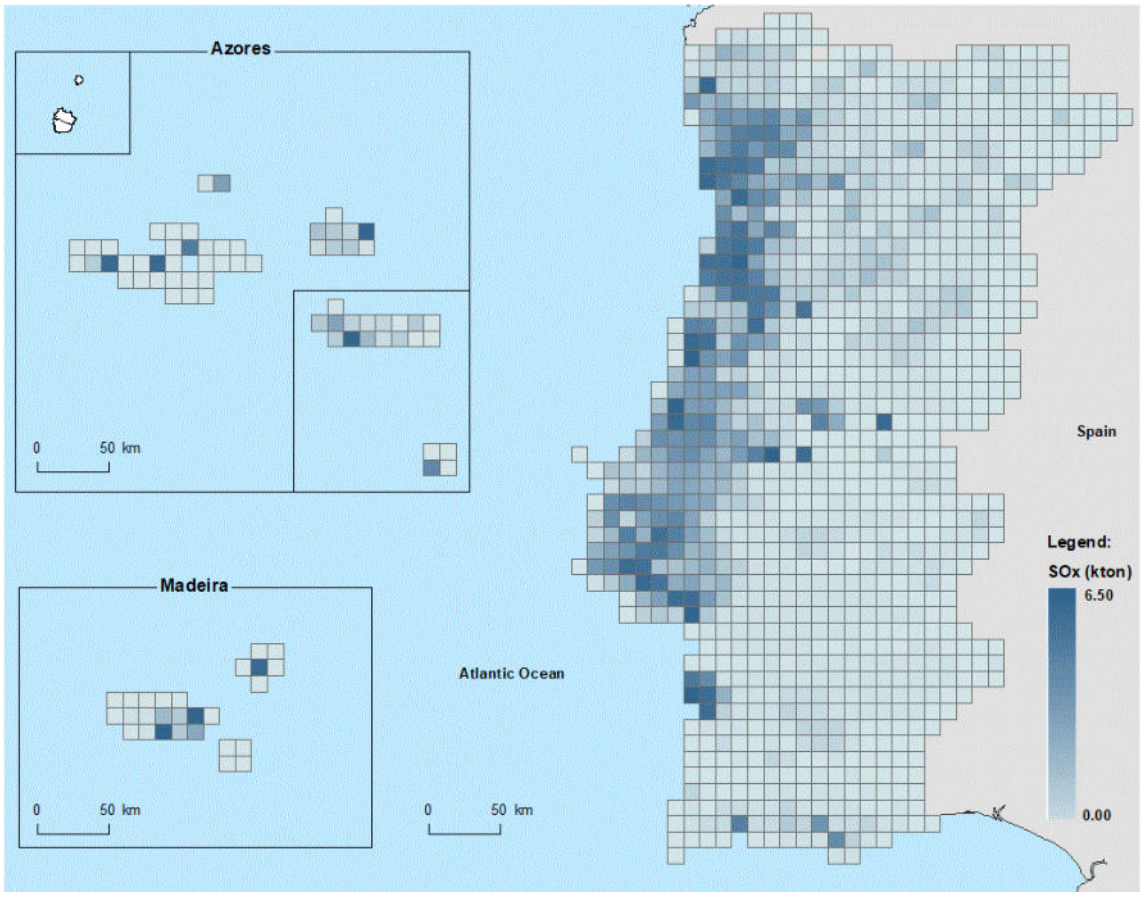

Figure 10-8: SOx gridded emissions

SOx emissions are primarily related to fuel combustion in energy and manufacturing industries, which refer generally to large emittors and are accounted separately as point sources in the inventory. The spacial disaggregation of non-point sources are accounted as diffuse sources using statistical datasets.

The figure below presents NH_3 gridded emissions for Portugal.

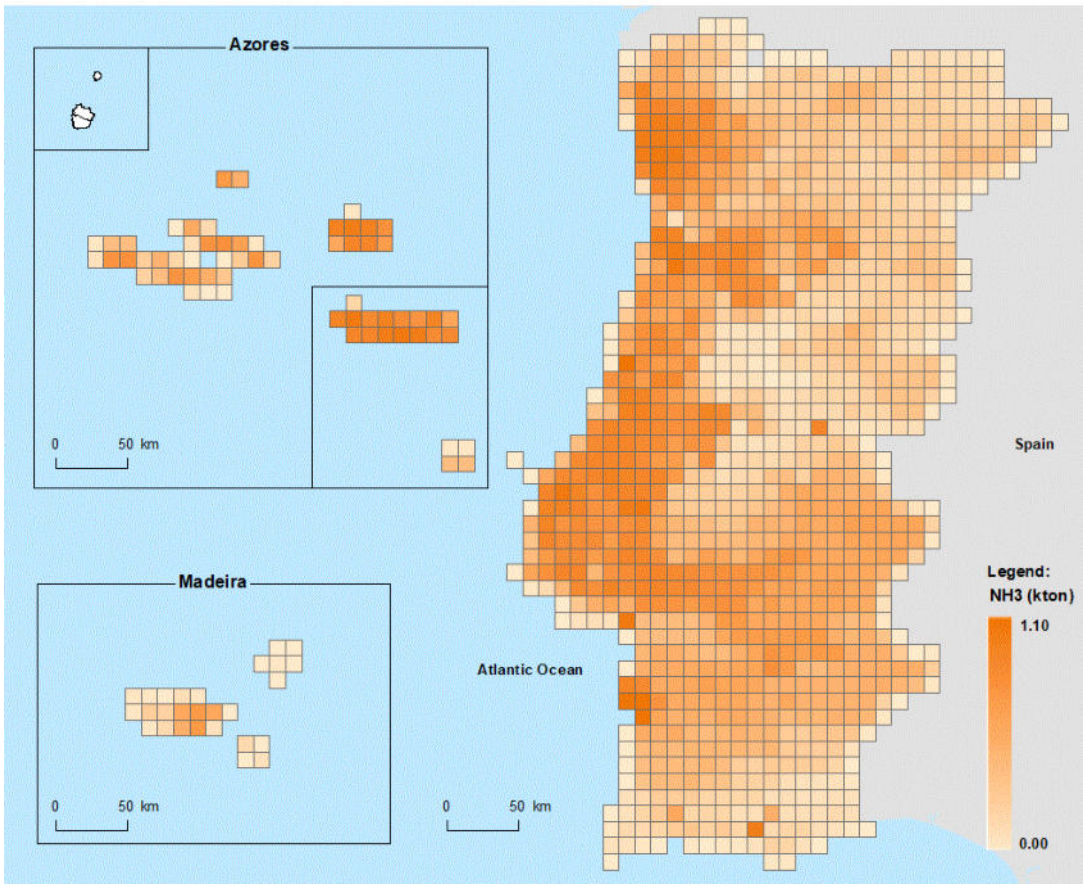

Figure 10-9: NH_3 gridded emissions

NH_3 emissions are related mostly to the agriculture sector, which are characterized by diffuse sources.

As the figure shows, there is a predominance of emissions in the litoral areas, where there is a concentration of intensive rearing of poultry and pigs and also of intensive dairy cattle production. Non-dairy cattle stay mainly on pasture (extensive production) and the major animal concentration is located mostly in the south.

There are a few point sources contributing to the distribution of these emissions, in particular the pulp and paper sector.

The figure below presents PM2.5 gridded emissions for Portugal.

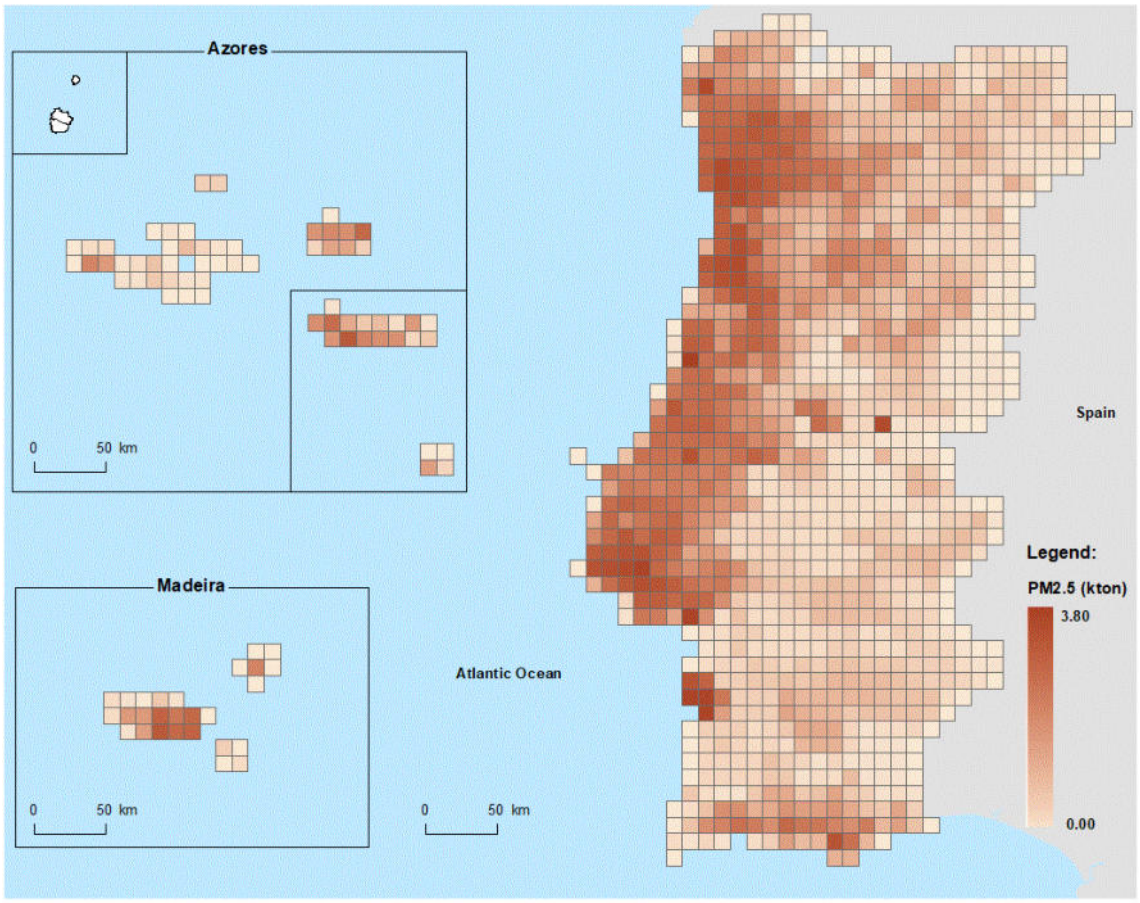

Figure 10-10: PM2.5 gridded emissions

Particulate emissions (PM2.5) are related primarly to combustion in the residential sector and in industry (e.g. pulp, chemical).

PM2.5 gridded emissions presented in the figure were accounted essentially as area sources, on the basis of population, and reflect the high concentration of the main cities and activities in the coastal areas. A significant share of PM2.5 emissions are also associated with industries and refer to point sources considered individually in the inventory.

10.2.4 Improvements since last submission

Following the recommendations issued from the 2020 NECD review, this submission includes:

- An improvement of transparency regarding the IIR grid chapter with more detailed descriptions of the methodological aspects and on data used to grid emissions and the respective results.

10.2.5 Planned improvements

There are some areas where methodological improvements concerning the distribution of emissions could be foreseen, either by using more specific point source data or more closely related proxy datasets to allocate the emissions.

Furthermore, on the following of the 2020 NECD review, where the TERT recommended to intersect the road network with the grid cells and allocate the emissions to the relevant grid cells proportionally, we intend to investigate the possibility of integrating the national road network with a population-based traffic intensity for the urban and rural emissions.

These improvements are however highly demanding in resources which, in conjunction with several other priorities and ongoing inventory developments, makes it difficult or not possible to establish at present a time plan for their implementation in the near future.

10.3 Large Point Sources (LPS)

LPS are defined as facilities or installations whose emissions (of at least one of 14 pollutants) exceed the threshold values given in Table 1 of the Guidelines for Reporting Emissions and Projections Data (ECE/EB.AIR.125). These thresholds refer to the list of pollutants in Regulation (EC) No. 166/2006 concerning the establishment of a European Pollutant Release and Transfer Register.

As indicated in the Reporting Guidelines, reported LPS data should, as far as possible, be consistent with emissions data reported under relevant EU legislation (e.g. the European Pollutant Release and Transfer Register (E-PRTR)).

Information provided in this section refers to point sources considered individually in the Portuguese inventory and located in Portugal mainland. The units considered include point sources for which annual measurements emissions are available or for which plant-specific emission factors could be calculated.

The criteria used does not correspond, however, to the Reporting Guidelines LPS definition mentioned above due to several reasons, such as: differences in the methodologies used, differences concerning the universe of installations considered by the inventory and the E-PRTR reporting, differences due to concerns regarding the representativeness of analytical measurements (in cases of point monitoring) and also resource constraints.

10.3.1 Reported LPS

In 2019, 53 emitting point sources (in Mainland Portugal) are considered individually in the Portuguese emissions inventory. Point sources emitting in earlier years but not in 2019 are not accounted in this total.

The criteria used does not correspond to the Reporting Guidelines LPS definition mentioned above and the number of facilities considered differs considerably from the Portuguese reporting under E-PRTR which considers a larger number of installations in particular concerning the E-PRTR categories: 7.(a) Intensive livestock production and aquaculture, and 5.(d) Waste and waste water management.

Several reasons explain the differences such as the methodological approaches used.

The Agriculture sector of the National Inventories does not account for Point Sources individually, as both IPCC and EMEP/EEA guidance recommend the use of animal population data from official national statistics. Furthermore, for the gridding of ammonia emissions, the EMEP/Guidebook 2019 refers that “disaggregation is normally based on livestock census data”. Since E-PRTR reporting criteria differs from the scope and definitions of the national emission inventories, data from point sources are not used in the accounting of the agriculture sector and the LPS submission does not include these sources.

Concerning the Waste sector, the Portuguese National Inventory accounts emissions from waste deposition in landfills following the recommended IPCC Guidance, i.e. based on FOD method that considers a long historical time series (since 1960). Due to methodological consistency (e.g. E-PRTR reporting considers active disposal SWDS), emissions from Landfills reported under E-PRTR are not considered individually in the inventory and have not been included in the LPS submission.

Differences also relate to the universe of installations considered by the inventory and the E-PRTR reporting as is the case of Solvent Use. The E-PRTR considers installations above a certain capacity threshold whereas the Portuguese inventory relies on a top-down approach aiming to cover the national total of solvent use.

As a general rule, point sources currently considered in the Portuguese inventory include facilities for which annual measurements emissions are available or for which plant-specific emission factors could be calculated. In some cases, data used refer exclusively to the annual fuel consumption at plant level.

Also, due to concerns related to the representativeness of the analytical measurements (in cases of point monitoring) part of these data are not considered in the inventory.

Furthermore, the use of point specific data in the Portuguese inventory is also limited by resource constraints and this is one of the reasons explaining a more reduced number of individual point sources considered.

Portuguese LPS in 2019 considered in this reporting are presented in the next figure.

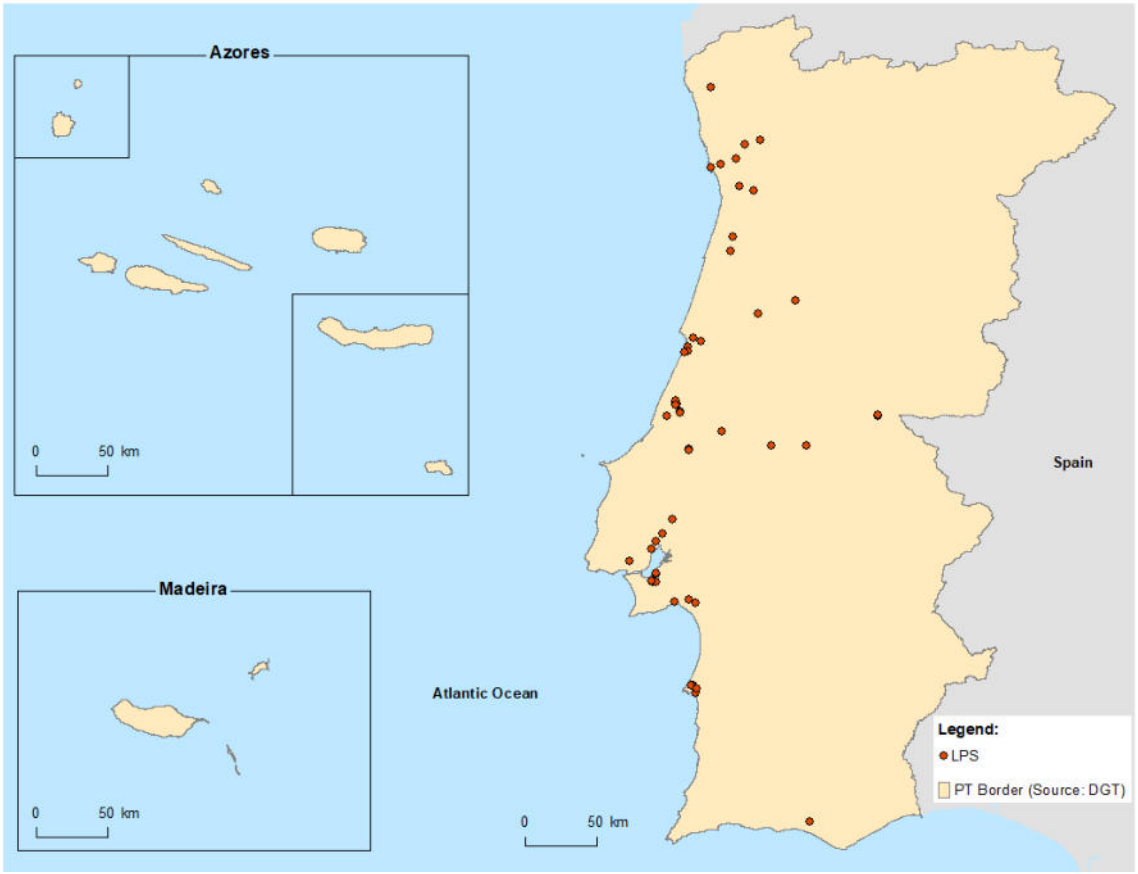

Figure 10-11: LPS in 2019

10.3.2 Methodological issues

Each facility considered is classified according to a GNFR code following the correspondence of SNAP-NFR-GNFR coding (mapping table available at the CEIP´s webpage). Information on stack heights has been collected from different sources such as LCP reporting, Environmental Permits, etc.

10.3.2.1 Consistency with the emission inventory

LPS reporting is fully consistent with the national emission inventory as point sources emissions are an integral part of the emission inventory. As explained in the energy section (e.g. 3.3.2 Activity data of Manufacturing Industries and Construction (NFR 1.A.2)), fuel consumed by LPS is subtracted from the energy balance data compiled annually by DGEG, and the remaining fuel quantities are considered as area sources for each industrial sector and fuel.

10.3.2.2 Consistency with PRTR data

As already referred, there are differences between LPS and E-PRTR reporting.

Differences concern the universe of installations considered by the inventory and the E-PRTR, in particular in agriculture and waste sectors, due to the use of diverse methodological approaches.

Differences include also the situations where the E-PRTR data are based on estimates and not on analytical measurements. The underlying rational for the inventory to consider E-PRTR data is the availability of annual measurements based on continuous monitoring. In the case of point measurements, there are sometimes concerns about the representativeness of the measurements, and data may not be used.

Differences result also from the shortage of resources to extend the compilation and the analysis of new point source data, or to update the information concerning part of the LPS already considered.

10.3.3 Improvements since last submission

Following the recommendations issued from the 2020 NECD review, this submission includes:

- An improvement of the LPS section with a description of the methodological aspects and on the completeness of the reporting ;
- Correction of facility coordinates for some facilities;
- Inclusion of LPS exclusively for Mainland Portugal (previous report included the Portuguese Azores and Madeira Islands that are not covered by the NECD);
- Integration of revised estimates for some pollutants and facilities included in LPS reporting.

10.3.4 Planned improvements

Portugal aims to continue the effort of including more point data in the national emissions inventory based on the information reported by E-PRTR and LCP facilities in order to ensure a better consistency between LPS and E-PRTR emissions as required by the reporting guidelines.

This implies, however, a substantial effort of harmonization of data collected under the different schemes, such as: the European Directive on Large Combustion Plants, E-PRTR and EU-ETS. Furthermore, in the case of point monitoring (not continuous), there is a need to evaluate the representativeness of the measurements in comparison to the international guidance proposed. Due to resource constraints, this objective is however an ongoing process that is being implemented as far as possible, according to the resources available and the existence of other priorities.

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
AVG	Aviation Gasoline	Gasolina de Aviação
AN	Ammonium Nitrate	Nitrato de Amónio
ANA	Airports and Air Navigation	Aeroportos e Navegação Aérea
ANAC	Portuguesa 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 Betuminous 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-amônio
CCDR-LVT	Lisbon and Tagus Valley Coordination and Regional Development Comission	Comissão de Coordenação e Desenvolvimento Regional de Lisboa e Vale do Tejo
CELPA	Portuguese Paper Industry Association	Associação da Indústria Papeleira
CFC	Clorofluorcarbons	Clorofluorcarbonetos
CH4	Methane	Metano
CITEPA	Interprofessional Technical Center 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 Cálcio0
CO	Carbon Monoxide	Monóxido de Carbono
CO2	Carbon Dioxide	Dióxido de Carbono ou anidrido carbónico
COD	Chemical Oxygen Demand	Carência Química de Oxigénio
CONCAWE	-	-
Concelho	Portuguese territorial unit under the responsibility of a municipal authority	-
CORINAIR	Core Inventory Air Emissions	Inventário de Emissões Atmosféricas
CRF	Common Reporting Format	-
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

Acronym	English	Portuguese
DGAE (ex DGE)	General Directorate for Economic Activities	Direcção Geral das Actividades Económicas
DGAV	General Directorate for Food and Veterenary	Direção geral de Alimentação e Veterinária
DGEG (ex DGGE)	General Directorate for Energy and Geology	Direcção Geral de Energia e Geologia
DGF	General Directorate of Forests	Direcção-Geral das Florestas
AFN	National Forestry Authority	Autoridade Florestal Nacional
DGTT	General Directorate of Terrestrial Transportation	Direcção Geral dos Transportes Terrestres
Distrito	Portuguese territorial unit comprehending several concelhos 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 Longrange 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
FCT-UNL	Faculty of Science and Technology of New University of Lisbon	Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa
FOD	First Order Decay	Decaimento de Primeira Ordem
FSN	Nitrogen in Synthetic Fertilizers	-
GASA	Analysis Group of Ambiental 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	Agricultre and Food Planning and Policies Office (changed to GPP)	Gabinete de Planeamento e Política Agro-Alimentar
GWP	Global Warming Potential	-
H2S	Hydrogen Sulfide	Sulfureto de Hidrogénio
HCFC	Hydroclorofluorcarbons	-
HDPE	High Density Poly Ethylene	-
HDV	Heavy Duty Vehicles	Veículos Pesados de Mercadorias
HFC	Hydrofluorcarbons	-
IA	Institute for The Environment	Instituto 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	
ICNF (ex-AFN)	National Institute for Nature conservation and Forests	Instituto da Conservação da Natureza e das Florestas

Acronym	English	Portuguese
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
IMT (ex.IMTT, DGV)	Institute for Mobility and Transportation	Instituto da Mobilidade e dos Transportes
INAG	National Water Institute	Instituto da Água
INE	Statistics Portugal/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-UNL	Technical Superior Institute - Lisbon Technical University	Instituto Superior Técnico - Universidade Técnica de Lisboa
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	Liquified Natural Gas	Gás Natural Liquefeito
LOSP	Light Organic Solvent-based Preservatives	-
LQARS	Agriculture Quimical Laboratoy 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	Ministério da Agricultura, Desenvolvimento Rural e Pescas
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	Ministério do Ambiente e Ordenamento do Território
MCF	Methane Conversion Factor	Factor de Conversão de Metano
MCOTA	Ministry of Urban Affairs, Land Use Planning and Environment	Ministério das Cidades, Ordenamento do Território e Ambiente
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

Acronym	English	Portuguese
NAPFUE	CORINAIR Fuel Nomenclature	
NATO	North Atlantic Treaty Organisation	Organização do Tratado do Atlântico Norte
NAVE	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)
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	Florestal Action Program	Programa de Acção Florestal
PAH	Polycyclic Aromatic Hydrocarbons	Hidrocarbonetos Aromáticos Policíclicos
PCI	Low Heating Value (LHV)	Poder Calorífico Inferior
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 Hidrocarbons	-
PM1	Particles with Aerodynamic Diameter smaller than 1 micrometer	Partículas cujo diâmetro aerodinâmico é inferior a 1 micrómetro
PM10	Particles with Aerodynamic Diameter smaller than 10 micrometers	Partículas cujo diâmetro aerodinâmico é inferior a 10 micrómetros
PM2.5	Particles with Aerodynamic Diameter smaller than 2.5 micrometers	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
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 Remotions 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
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)

Acronym	English	Portuguese
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 Resíduais
ZA	Agricultural Zone	Zona Agrária

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Annex A: Completeness and Key categories

Updated: March 2022

Table A-1: Completeness table- Not Estimated (NE)

NFR Code	Longname	Main Pollutants				Particulate Matter				Other	Priority Heavy Metals			Additional Heavy Metals						POPs			
		NOx (as NO_2)	NMVOC	SOx (as SO_2)	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	Dioxines /furans	PAHs/ Total	HCB	PCBs
1A1b	Petroleum refining				NE																		
1A2a	**Stationary combustion in manufacturing industries and construction: Iron and steel**				**NE**																		
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)																						NE
1A3ai(i)	**International aviation LTO (civil)**				**NE**																		
1A3aii(i)	Domestic aviation LTO (civil)				NE																		
1A3bv	**Road transport: Gasoline evaporation**																		**NE**	**NE**	**NE**		**NE**
1A3bvi	Road transport: Automobile tyre and brake wear									NE			NE							NE			NE
1A3bvii	**Road transport: Automobile road abrasion**									**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**		**NE**	**NE**		**NE**
1A3dii	National navigation (shipping)																			NE			
1A4aii	**Commercial/institutional: Mobile**				**NE**								**NE**	**NE**						**NE**		**NE**	**NE**
1A4bii	Residential: Household and gardening (mobile)												NE	NE						NE		NE	NE
1A4cii	**Agriculture/Forestry/Fishing: Off-road vehicles and other machinery**												**NE**	**NE**						**NE**		**NE**	**NE**
1A4ciii	Agriculture/Forestry/Fishing: National fishing				NE																NE		
1A5b	**Other, Mobile (including military, land based and recreational boats)**								**NE**											**NE**	**NE**		
1B1a	Fugitive emission from solid fuels: Coal mining and handling				NE					NE	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE		
1B1b	**Fugitive emission from solid fuels: Solid fuel transformation**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**		**NE**	**NE**		
1B1c	Other fugitive emissions from solid fuels	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE				
1B2av	**Distribution of oil products**			**NE**															**NE**				
1B2b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution an			NE																NE			
1B2c	**Venting and flaring (oil, gas, combined oil and gas)**				**NE**				**NE**									**NE**		**NE**			
1B2d	Other fugitive emissions from energy production	NE	NE	NE		NE	NE	NE	NE	NE	NE	NE			NE	NE	NE	NE	NE	NE	NE	NE	NE
2A1	**Cement production**																			**NE**	**NE**		
2A2	Lime production	NE	NE	NE						NE	NE	NE	NE										
2A3	**Glass production**												**NE**			**NE**			**NE**	**NE**	**NE**		
2B1	Ammonia production		NE	NE		NE																	
2B2	**Nitric acid production**					**NE**																	
2B7	Soda ash production					NE	NE	NE															
2B10a	**Chemical industry: Other (please specify in the IIR)**										**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
2C1	Iron and steel production				NE													NE				NE		
2C2	**Ferroalloys production**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**		
2C3	**Aluminium production**	**NE**	**NE**	**NE**	**NE**					**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**		**NE**	**NE**	
2C5	**lead production**	**NE**	**NE**		**NE**				**NE**	**NE**			**NE**		**NE**	**NE**	**NE**	**NE**			**NE**	**NE**	
2C7a	Copper production	NE	NE		NE																		
2D3a	**Domestic solvent use including fungicides**					**NE**																	
2D3b	Road paving with asphalt	NE		NE															NE	NE	NE		
2D3c	**Asphalt roofing**	**NE**									**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	
2D3e	Degreasing					NE																	
2D3f	**Dry cleaning**					**NE**																	
2D3g	Chemical products	NE		NE					NE	NE	NE		NE			NE			NE	NE		NE	NE
2D3h	**Printing**					**NE**			**NE**														
2D3i	Other solvent use (please specify in the IIR)	NE		NE	NE				NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE			NE	NE
2G	**Other product use (please specify in the IIR)**																					**NE**	**NE**

For the majority of categories No Estimation of emissions (NE) is due to unavailability of Emission Factor

Table A-1: Completeness table - Not Estimated (NE)

NFR Code	Longname	Main Pollutants				Particulate Matter				Other	Priority Heavy Metals			Additional Heavy Metals						POPs			
		NOx (as NO_2)	NMVOC	SOx (as SO_2)	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	Dioxines /furans	PAHs/ Total	HCB	PCBs
2H1	Pulp and paper industry				NE				NE												NE		
2H2	**Food and beverages industry**					**NE**		**NE**	**NE**														
2I	Wood processing	NE	NE	NE	NE	NE	NE		NE	NE				NE		NE							
2K	**Consumption of POPs and heavy metals (e.g. electrical and scientific equipment)**										**NE**	**NE**		**NE**	**NE**	**NE**	**NE**	**NE**	**NE**			**NE**	
5B1	Biological treatment of waste - Composting	NE	NE	NE		NE	NE	NE	NE	NE													
5B2	**Biological treatment of waste - Anaerobic digestion at biogas facilities**	**NE**	**NE**	**NE**		**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**		**NE**					**NE**	**NE**	**NE**	**NE**
5C1bi	Industrial waste incineration				NE											NE		NE	NE				
5C1bii	**Hazardous waste incineration**				**NE**											**NE**		**NE**	**NE**				
5C1biii	Clinical waste incineration																	NE	NE				
5C1biv	**Sewage sludge incineration**				**NE**											**NE**		**NE**	**NE**				
5C1bv	Cremation								NE														
5D1	**Domestic wastewater handling**					**NE**	**NE**	**NE**	**NE**		**NE**	**NE**	**NE**		**NE**				**NE**	**NE**	**NE**	**NE**	**NE**
5D2	Industrial wastewater handling				NE	NE	NE	NE	NE		NE	NE											
5E	**Other waste (please specify in IIR)**	**NE**	**NE**	**NE**																		**NE**	**NE**

For the majority of categories No Estimation of emissions (NE) is due to unavailability of Emission Factor

Table A-2: Completeness table – Included Elsewhere (IE)

NFR Code	Longname	Main Pollutants				Particulate Matter				Other	Priority Heavy Metals			Additional Heavy Metals						POPs			
		NOx (as NO_2)	NMVOC	SOx (as SO_2)	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	Dioxines /furans	PAHs/ Total	HCB	PCBs
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1A3di(ii)	International inland waterways	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1A5a	Other stationary (including military)	IE	IE	IE		IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE		
2A1	Cement production	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE				
2A3	Glass production	IE		IE						IE													
2B10b	Storage, handling and transport of chemical products (please specify in the IIR)	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
3De	Cultivated crops					IE	IE	IE															
5C1bii	Hazardous waste incineration	IE	IE	IE		IE	IE	IE	IE	IE	IE	IE	IE	IE	IE		IE			IE	IE	IE	IE
5C1biv	Sewage sludge incineration	IE	IE	IE		IE	IE	IE	IE	IE	IE	IE	IE	IE	IE		IE			IE	IE	IE	IE

Allocation by NFR code	Allocation by party	Explanation
1A2b - Stationary combustion in manufacturing industries and construction: Non-ferrous metals	1A2gviii - Stationary combustion in manufacturing industries and construction: Other	Not possible to separate the Non-Ferrous Metals data from Metalurgic Industries data in Energy Balance
1A3di(ii) - International inland waterways	1A3di(i) International maritime navigation	International inland waterways is considered almost negligible in Portugal and our National Energy Balance dont't have the separation for inland waterways.
1A5a - Other stationary (including military)	1.A.4.a.i Commercial/institutional	No information to disaggregate fuel consumption.
2A1 - Cement production	1A2f - 3.4 Manufacturing Industries and Construction	Emissions related with combustion in cement kilns
2A3 - Glass production	1A2f - 3.4 Manufacturing Industries and Construction	Emissions related with combustion in glass kilns
2B10b - Storage, handling and transport of chemical products (please specify in the IIR)	2B10a - Chemical industry: Other	All default Tier 1 emission factors for the chemical industry also include storage and handling in production
3De - Cultivated crops	3Dc - Farm-level agricultural operations including storage, handling and transport of agricultural products	No EF available
5C1bii - Hazardous waste incineration	5C1bi - Industrial waste incineration	No specific EF available.
5C1biv - Sewage sludge incineration	5C1bi - Industrial waste incineration	No specific EF available.

Table A-3: Key category analysis of 2020 inventory

NOx **Level Assessment**

NFR	Sectors	% total 2020	Cumulative total	Key category
1A3bi	Road transport: Passenger cars	17.47	17.5	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	11.39	28.9	x
1A3bii	Road transport: Light duty vehicles	11.24	40.1	x
1A1a	Public electricity and heat production	9.95	50.0	x
1A3biii	Road transport: Heavy duty vehicles and buses	9.89	59.9	x
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	3.95	63.9	x
2H1	Pulp and paper industry	3.74	67.6	x
1A3dii	National navigation (shipping)	3.19	70.8	x
3Da1	Inorganic N-fertilizers (includes also urea application)	3.12	73.9	x
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	3.10	77.1	x
3Da3	Urine and dung deposited by grazing animals	2.87	79.9	x
1A4bi	Residential: Stationary	2.55	82.5	x
1A4ciii	Agriculture/Forestry/Fishing: National fishing	2.26	84.7	
1A1b	Petroleum refining	2.16	86.9	
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	1.48	88.4	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	1.45	89.8	
1A4ci	Agriculture/Forestry/Fishing: Stationary	1.25	91.1	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	1.22	92.3	
1A3ai(i)	International aviation LTO (civil)	1.14	93.4	
3Da2a	Animal manure applied to soils	1.11	94.5	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.96	95.5	
1A4ai	Commercial/institutional: Stationary	0.72	96.2	
3F	Field burning of agricultural residues	0.66	96.9	
1A3aii(i)	Domestic aviation LTO (civil)	0.61	97.5	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.46	98.0	
1A3c	Railways	0.34	98.3	
2C1	Iron and steel production	0.21	98.5	
2B10a	Chemical industry: Other (please specify in the IIR)	0.21	98.7	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.21	98.9	
3B4gii	Manure mangement - Broilers	0.19	99.1	
3B4gi	Manure mangement - Laying hens	0.13	99.2	
1A3biv	Road transport: Mopeds & motorcycles	0.12	99.4	
1B2aiv	Fugitive emissions oil: Refining / storage	0.12	99.5	
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.10	99.6	
2B2	Nitric acid production	0.09	99.7	
3B1b	Manure management - Non-dairy cattle	0.08	99.7	
3B1a	Manure management - Dairy cattle	0.05	99.8	
3Da2c	Other organic fertilisers applied to soils (including compost)	0.04	99.8	
3B4giii	Manure mangement - Turkeys	0.03	99.9	
2G	Other product use (please specify in the IIR)	0.03	99.9	
3Da2b	Sewage sludge applied to soils	0.02	99.9	
5C1bi	Industrial waste incineration	0.02	99.9	
5C1bv	Cremation	0.02	99.9	
3B2	Manure management - Sheep	0.01	99.9	
3B4h	Manure management - Other animals (please specify in IIR)	0.01	100.0	
3B4giv	Manure management - Other poultry	0.01	100.0	
5C1biii	Clinical waste incineration	0.01	100.0	
3B3	Manure management - Swine	0.01	100.0	

NOx **Trend Assessment (1990-2020)**

NFR	Sectors	1990	Last year	Trend assess.	% cont. to trend	Cumulative total	Key category
1A1a	Public electricity and heat production	83.47	13.43	0.11	35.79	35.8	x
1A3biii	Road transport: Heavy duty vehicles and buses	43.08	13.36	0.03	10.77	46.6	x
1A3bii	Road transport: Light duty vehicles	14.00	15.18	0.03	9.46	56.0	x
1A2f	Stationary combustion in manufacturing industries and	15.13	15.38	0.03	9.01	65.0	x
2H1	Pulp and paper industry	2.50	5.05	0.01	4.50	69.5	x
1A2d	Stationary combustion in manufacturing industries and	3.10	5.33	0.01	4.46	74.0	x
1A3bi	Road transport: Passenger cars	38.37	23.58	0.01	4.39	78.4	x
3Da3	Urine and dung deposited by grazing animals	2.61	3.87	0.01	3.01	81.4	x
1A1b	Petroleum refining	2.80	2.92	0.01	1.75	83.1	
1A2gviii	Stationary combustion in manufacturing industries and	5.39	4.19	0.01	1.67	84.8	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	8.48	3.05	0.01	1.62	86.4	
1A4bi	Residential: Stationary	4.16	3.44	0.00	1.53	88.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.93	1.69	0.00	1.45	89.4	
1A3c	Railways	2.94	0.45	0.00	1.28	90.7	
3Da1	Inorganic N-fertilizers (includes also urea application)	6.34	4.21	0.00	1.10	91.8	
1A3ai(i)	International aviation LTO (civil)	1.24	1.54	0.00	1.07	92.9	
1A3dii	National navigation (shipping)	6.75	4.31	0.00	0.97	93.8	
1A2gvii	Mobile Combustion in manufacturing industries and cor	2.71	2.00	0.00	0.71	94.5	
1A4ai	Commercial/institutional: Stationary	0.90	0.98	0.00	0.61	95.1	
3Da2a	Animal manure applied to soils	1.96	1.50	0.00	0.58	95.7	
1A2c	Stationary combustion in manufacturing industries and	2.24	1.65	0.00	0.58	96.3	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.27	0.62	0.00	0.58	96.9	
1A3aii(i)	Domestic aviation LTO (civil)	0.72	0.82	0.00	0.53	97.4	
1A2a	Stationary combustion in manufacturing industries and	0.91	0.13	0.00	0.41	97.8	
1A2e	Stationary combustion in manufacturing industries and	1.90	1.30	0.00	0.38	98.2	
3F	Field burning of agricultural residues	1.18	0.90	0.00	0.34	98.5	
2C1	Iron and steel production	0.06	0.29	0.00	0.31	98.8	
2B10a	Chemical industry: Other (please specify in the IIR)	0.13	0.28	0.00	0.25	99.1	
3B4gii	Manure mangement - Broilers	0.15	0.26	0.00	0.22	99.3	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	3.46	1.95	0.00	0.19	99.5	
3B4gi	Manure mangement - Laying hens	0.13	0.18	0.00	0.13	99.6	
1A5b	Other, Mobile (including military, land based and recrea	0.40	0.28	0.00	0.08	99.7	
3B1b	Manure management - Non-dairy cattle	0.13	0.11	0.00	0.05	99.8	
2G	Other product use (please specify in the IIR)	0.01	0.03	0.00	0.04	99.8	
3B4giii	Manure mangement - Turkeys	0.02	0.04	0.00	0.03	99.8	
5C1bv	Cremation	0.00	0.02	0.00	0.03	99.9	
3Da2b	Sewage sludge applied to soils	0.01	0.03	0.00	0.02	99.9	
5C1bi	Industrial waste incineration	0.02	0.02	0.00	0.02	99.9	
3B4giv	Manure management - Other poultry	0.01	0.02	0.00	0.02	99.9	
2B2	Nitric acid production	0.25	0.12	0.00	0.01	99.9	
3B2	Manure management - Sheep	0.06	0.02	0.00	0.01	99.9	
3B4h	Manure management - Other animals (please specify ir	0.06	0.02	0.00	0.01	100.0	
3B4f	Manure management - Mules and asses	0.02	0.00	0.00	0.01	100.0	
3B1a	Manure management - Dairy cattle	0.13	0.07	0.00	0.01	100.0	
1A4bii	Residential: Household and gardening (mobile)	0.01	0.00	0.00	0.01	100.0	
1A4aii	Commercial/institutional: Mobile	0.01	0.00	0.00	0.01	100.0	
1A3biv	Road transport: Mopeds & motorcycles	0.30	0.16	0.00	0.01	100.0	
3B4d	Manure management - Goats	0.01	0.00	0.00	0.00	100.0	
5C1biii	Clinical waste incineration	0.02	0.01	0.00	0.00	100.0	
3B4e	Manure management - Horses	0.01	0.00	0.00	0.00	100.0	
3B3	Manure management - Swine	0.01	0.01	0.00	0.00	100.0	

NMVOC **Level Assessment**

NFR	Sectors	%total 2020	Cumulative total	Key category
2D3a	Domestic solvent use including fungicides	16.93	16.9	x
2D3d	Coating applications	11.51	28.4	x
2D3g	Chemical products	11.14	39.6	x
1A4bi	Residential: Stationary	8.82	48.4	x
2D3i	Other solvent use (please specify in the IIR)	6.53	54.9	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	5.16	60.1	x
2H1	Pulp and paper industry	4.93	65.0	x
1A3bv	Road transport: Gasoline evaporation	2.92	67.9	x
3Da2a	Animal manure applied to soils	2.74	70.7	x
3B4gii	Manure mangement - Broilers	2.52	73.2	x
1B2av	Distribution of oil products	2.44	75.6	x
1A3bi	Road transport: Passenger cars	2.31	78.0	x
3B1a	Manure management - Dairy cattle	1.63	79.6	x
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	1.56	81.1	x
3F	Field burning of agricultural residues	1.56	82.7	
2G	Other product use (please specify in the IIR)	1.48	84.2	
1B2ai	Fugitive emissions oil: Exploration, production, transport	1.36	85.5	
1A3biv	Road transport: Mopeds & motorcycles	1.33	86.9	
2H2	Food and beverages industry	1.27	88.1	
2B10a	Chemical industry: Other (please specify in the IIR)	1.16	89.3	
5A	Biological treatment of waste - Solid waste disposal on land	1.14	90.4	
1A1a	Public electricity and heat production	1.05	91.5	
3B4gi	Manure mangement - Laying hens	1.03	92.5	
3B1b	Manure management - Non-dairy cattle	1.01	93.5	
1B2aiv	Fugitive emissions oil: Refining / storage	0.93	94.5	
1A3bii	Road transport: Light duty vehicles	0.59	95.0	
3B3	Manure management - Swine	0.47	95.5	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.46	96.0	
2D3e	Degreasing	0.44	96.4	
2D3h	Printing	0.41	96.8	
3Da3	Urine and dung deposited by grazing animals	0.37	97.2	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.34	97.5	
1A3biii	Road transport: Heavy duty vehicles and buses	0.28	97.8	
3B4giii	Manure mangement - Turkeys	0.26	98.1	
3B4giv	Manure management - Other poultry	0.22	98.3	
3De	Cultivated crops	0.17	98.5	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.16	98.6	
2D3f	Dry cleaning	0.14	98.8	
5C1bi	Industrial waste incineration	0.12	98.9	
1A3ai(i)	International aviation LTO (civil)	0.12	99.0	
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.12	99.1	
1A3dii	National navigation (shipping)	0.11	99.2	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.09	99.3	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.08	99.4	
3B2	Manure management - Sheep	0.08	99.5	
1A4ai	Commercial/institutional: Stationary	0.08	99.6	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.07	99.6	
2C1	Iron and steel production	0.06	99.7	
1A1b	Petroleum refining	0.06	99.8	
1A3aii(i)	Domestic aviation LTO (civil)	0.05	99.8	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.05	99.9	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.03	99.9	
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.03	99.9	
1A3c	Railways	0.03	99.9	
3B4h	Manure management - Other animals (please specify in IIR)	0.02	100.0	
3B4d	Manure management - Goats	0.01	100.0	
5D2	Industrial wastewater handling	0.01	100.0	
1A4bii	Residential: Household and gardening (mobile)	0.01	100.0	
3B4e	Manure management - Horses	0.00	100.0	
5D1	Domestic wastewater handling	0.00	100.0	

NMVOC **Trend Assessment (1990-2020)**

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
1A3bi	Road transport: Passenger cars	41.90	3.69	0.09	18.16	18.2	x
2D3a	Domestic solvent use including fungicides	11.16	27.02	0.08	15.60	33.8	x
1A3biv	Road transport: Mopeds & motorcycles	28.82	2.12	0.07	12.81	46.6	x
2D3g	Chemical products	12.19	17.78	0.04	7.84	54.4	x
2D3i	Other solvent use (please specify in the IIR)	6.22	10.43	0.03	5.06	59.5	x
1A2f	Stationary combustion in manufacturing industries and	3.14	8.24	0.02	4.89	64.4	x
1A3bv	Road transport: Gasoline evaporation	16.86	4.66	0.02	4.81	69.2	x
2H1	Pulp and paper industry	4.12	7.87	0.02	4.11	73.3	x
1A4bi	Residential: Stationary	29.36	14.08	0.02	3.70	77.0	x
2D3d	Coating applications	35.82	18.38	0.02	3.57	80.5	x
3B4gii	Manure mangement - Broilers	2.36	4.02	0.01	1.97	82.5	
1A3biii	Road transport: Heavy duty vehicles and buses	3.79	0.45	0.01	1.55	84.1	
2D3e	Degreasing	4.05	0.71	0.01	1.48	85.5	
1A2d	Stationary combustion in manufacturing industries and	1.30	2.50	0.01	1.31	86.8	
1A1a	Public electricity and heat production	0.37	1.68	0.01	1.13	88.0	
3Da2a	Animal manure applied to soils	4.72	4.37	0.01	1.06	89.0	
5A	Biological treatment of waste - Solid waste disposal on	0.98	1.81	0.00	0.93	90.0	
2H2	Food and beverages industry	1.47	2.03	0.00	0.85	90.8	
2B10a	Chemical industry: Other (please specify in the IIR)	1.41	1.85	0.00	0.74	91.6	
3B4gi	Manure mangement - Laying hens	1.23	1.65	0.00	0.67	92.2	
2D3f	Dry cleaning	1.68	0.23	0.00	0.66	92.9	
1B2ai	Fugitive emissions oil: Exploration, production, transpo	2.09	2.16	0.00	0.65	93.5	
1B2av	Distribution of oil products	4.86	3.90	0.00	0.62	94.2	
2D3h	Printing	2.08	0.65	0.00	0.53	94.7	
1A3bii	Road transport: Light duty vehicles	2.51	0.94	0.00	0.52	95.2	
1A4bii	Residential: Household and gardening (mobile)	0.99	0.01	0.00	0.49	95.7	
3F	Field burning of agricultural residues	3.02	2.49	0.00	0.44	96.2	
1B2aiv	Fugitive emissions oil: Refining / storage	1.43	1.48	0.00	0.44	96.6	
3B1b	Manure management - Non-dairy cattle	3.12	1.61	0.00	0.31	96.9	
1A3ai(i)	International aviation LTO (civil)	0.82	0.19	0.00	0.26	97.2	
3Da3	Urine and dung deposited by grazing animals	0.42	0.60	0.00	0.26	97.4	
3De	Cultivated crops	0.90	0.26	0.00	0.25	97.7	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.41	0.54	0.00	0.22	97.9	
1A2e	Stationary combustion in manufacturing industries and	0.80	0.25	0.00	0.21	98.1	
2G	Other product use (please specify in the IIR)	3.29	2.36	0.00	0.20	98.3	
3B4giii	Manure mangement - Turkeys	0.28	0.42	0.00	0.19	98.5	
3B4giv	Manure management - Other poultry	0.17	0.34	0.00	0.18	98.7	
3B1a	Manure management - Dairy cattle	3.77	2.60	0.00	0.15	98.8	
1A2c	Stationary combustion in manufacturing industries and	0.33	0.07	0.00	0.11	98.9	
1A3aii(i)	Domestic aviation LTO (civil)	0.32	0.08	0.00	0.10	99.0	
1A3c	Railways	0.26	0.04	0.00	0.10	99.1	
3B2	Manure management - Sheep	0.39	0.12	0.00	0.10	99.2	
1A2gviii	Stationary combustion in manufacturing industries and	0.96	0.73	0.00	0.09	99.3	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.05	0.13	0.00	0.08	99.4	
5C1bi	Industrial waste incineration	0.16	0.19	0.00	0.07	99.5	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.35	0.15	0.00	0.06	99.5	
2D3b	Road paving with asphalt	0.13	0.00	0.00	0.06	99.6	
3B3	Manure management - Swine	1.06	0.75	0.00	0.06	99.6	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.07	0.12	0.00	0.06	99.7	
2C1	Iron and steel production	0.07	0.10	0.00	0.05	99.7	
1A1b	Petroleum refining	0.06	0.09	0.00	0.04	99.8	
3B4f	Manure management - Mules and asses	0.07	0.00	0.00	0.04	99.8	
1A4ai	Commercial/institutional: Stationary	0.12	0.12	0.00	0.03	99.9	
3B4d	Manure management - Goats	0.09	0.02	0.00	0.03	99.9	
1A3dii	National navigation (shipping)	0.23	0.18	0.00	0.02	99.9	
3B4h	Manure management - Other animals (please specify ir	0.09	0.03	0.00	0.02	99.9	
1A2gvii	Mobile Combustion in manufacturing industries and cor	0.25	0.18	0.00	0.02	99.9	
1A4aii	Commercial/institutional: Mobile	0.03	0.00	0.00	0.02	100.0	

SOx **Level Assessment**

NFR	Sectors	% total 2020	Cumulative total	Key category
1A1a	Public electricity and heat production	29.45	29.5	x
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	24.33	53.8	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	14.27	68.0	x
2H1	Pulp and paper industry	10.58	78.6	x
1B2aiv	Fugitive emissions oil: Refining / storage	6.89	85.5	x
1A3dii	National navigation (shipping)	3.78	89.3	
2B10a	Chemical industry: Other (please specify in the IIR)	2.37	91.7	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	1.80	93.5	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	1.69	95.2	
1A4bi	Residential: Stationary	0.96	96.1	
1A1b	Petroleum refining	0.70	96.8	
1A4ai	Commercial/institutional: Stationary	0.61	97.4	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.54	98.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.37	98.3	
3F	Field burning of agricultural residues	0.37	98.7	
2C5	Lead production	0.36	99.1	
2C1	Iron and steel production	0.35	99.4	
1A3bi	Road transport: Passenger cars	0.13	99.5	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.12	99.7	
1A3ai(i)	International aviation LTO (civil)	0.12	99.8	
1A3aii(i)	Domestic aviation LTO (civil)	0.06	99.8	
1A3bii	Road transport: Light duty vehicles	0.05	99.9	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.05	99.9	
1A3biii	Road transport: Heavy duty vehicles and buses	0.04	100.0	
5C1bv	Cremation	0.01	100.0	
5C1bi	Industrial waste incineration	0.00	100.0	

SOx **Trend Assessment (1990-2020)**

NFR	Sectors	1990	Last year	Trend assess.	% cont. to trend	Cumulative total	Key category
1A1a	Public electricity and heat production	180.93	11.28	0.03	26.80	26.8	x
1A2d	Stationary combustion in manufacturing industries and	16.64	9.31	0.02	18.62	45.4	x
1A2f	Stationary combustion in manufacturing industries and	8.04	5.47	0.01	11.46	56.9	x
2H1	Pulp and paper industry	4.55	4.05	0.01	8.93	65.8	x
1B2aiv	Fugitive emissions oil: Refining / storage	0.34	2.64	0.01	6.61	72.4	x
1A2gviii	Stationary combustion in manufacturing industries and	26.05	0.65	0.01	6.35	78.8	x
1A1b	Petroleum refining	18.80	0.27	0.01	5.09	83.9	x
1A2c	Stationary combustion in manufacturing industries and	14.19	0.21	0.00	3.83	87.7	
1A3dii	National navigation (shipping)	3.54	1.45	0.00	2.60	90.3	
1A2e	Stationary combustion in manufacturing industries and	12.99	0.69	0.00	2.23	92.5	
1A3biii	Road transport: Heavy duty vehicles and buses	6.43	0.01	0.00	1.94	94.4	
1A3bii	Road transport: Light duty vehicles	3.45	0.02	0.00	1.01	95.5	
1A3bi	Road transport: Passenger cars	3.32	0.05	0.00	0.89	96.3	
1A4ai	Commercial/institutional: Stationary	4.81	0.23	0.00	0.88	97.2	
1A4bi	Residential: Stationary	0.77	0.37	0.00	0.70	97.9	
2C1	Iron and steel production	0.02	0.13	0.00	0.33	98.3	
2C5	Lead production	0.06	0.14	0.00	0.33	98.6	
3F	Field burning of agricultural residues	0.19	0.14	0.00	0.30	98.9	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.76	0.00	0.00	0.23	99.1	
1A2gvii	Mobile Combustion in manufacturing industries and cor	0.44	0.00	0.00	0.13	99.2	
2B10a	Chemical industry: Other (please specify in the IIR)	7.96	0.91	0.00	0.13	99.4	
1A3ai(i)	International aviation LTO (civil)	0.03	0.04	0.00	0.10	99.5	
1A3c	Railways	0.34	0.00	0.00	0.10	99.6	
1A4ci	Agriculture/Forestry/Fishing: Stationary	1.52	0.14	0.00	0.10	99.7	
1A2a	Stationary combustion in manufacturing industries and	0.23	0.00	0.00	0.07	99.8	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.15	0.04	0.00	0.07	99.8	
1A3biv	Road transport: Mopeds & motorcycles	0.21	0.00	0.00	0.06	99.9	
1A3aii(i)	Domestic aviation LTO (civil)	0.02	0.02	0.00	0.05	99.9	
1A5b	Other, Mobile (including military, land based and recrea	0.03	0.02	0.00	0.04	100.0	
5C1bv	Cremation	0.00	0.00	0.00	0.01	100.0	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.01	0.00	0.00	0.00	100.0	
1A4bii	Residential: Household and gardening (mobile)	0.01	0.00	0.00	0.00	100.0	
5C1bi	Industrial waste incineration	0.00	0.00	0.00	0.00	100.0	
2G	Other product use (please specify in the IIR)	0.00	0.00	0.00	0.00	100.0	
5C1biii	Clinical waste incineration	0.01	0.00	0.00	0.00	100.0	

NH3 **Level Assessment**

NFR	Sectors	% total 2020	Cumulative total	Key category
3Da2a	Animal manure applied to soils	19.87	19.9	x
3Da3	Urine and dung deposited by grazing animals	16.05	35.9	x
3B3	Manure management - Swine	9.64	45.6	x
3B4gii	Manure mangement - Broilers	8.53	54.1	x
3Da1	Inorganic N-fertilizers (includes also urea application)	8.36	62.5	x
3B1a	Manure management - Dairy cattle	8.30	70.8	x
2B10a	Chemical industry: Other (please specify in the IIR)	5.89	76.6	x
3B1b	Manure management - Non-dairy cattle	3.50	80.1	x
3B4gi	Manure mangement - Laying hens	3.48	83.6	
1A4bi	Residential: Stationary	2.96	86.6	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	2.72	89.3	
5A	Biological treatment of waste - Solid waste disposal on land	1.79	91.1	
3B4giii	Manure mangement - Turkeys	1.65	92.7	
3F	Field burning of agricultural residues	1.21	94.0	
1A3bi	Road transport: Passenger cars	0.94	94.9	
3B4giv	Manure management - Other poultry	0.90	95.8	
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	0.80	96.6	
3B2	Manure management - Sheep	0.70	97.3	
1B2d	Other fugitive emissions from energy production	0.64	97.9	
3B4h	Manure management - Other animals (please specify in IIR)	0.63	98.6	
1B2aiv	Fugitive emissions oil: Refining / storage	0.20	98.8	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.20	99.0	
3Da2c	Other organic fertilisers applied to soils (including compost)	0.17	99.1	
3Da2b	Sewage sludge applied to soils	0.13	99.3	
2G	Other product use (please specify in the IIR)	0.13	99.4	
3B4d	Manure management - Goats	0.10	99.5	
1A3biii	Road transport: Heavy duty vehicles and buses	0.09	99.6	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.07	99.7	
5B2	Biological treatment of waste - Anaerobic digestion at biogas facilities	0.07	99.7	
3B4e	Manure management - Horses	0.07	99.8	
1A3bii	Road transport: Light duty vehicles	0.05	99.8	
1A4ai	Commercial/institutional: Stationary	0.05	99.9	
3B4f	Manure management - Mules and asses	0.03	99.9	
1A1a	Public electricity and heat production	0.02	99.9	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.01	100.0	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.01	100.0	
2B2	Nitric acid production	0.01	100.0	
5B1	Biological treatment of waste - Composting	0.01	100.0	
2A3	Glass production	0.01	100.0	
2D3g	Chemical products	0.01	100.0	
1A3biv	Road transport: Mopeds & motorcycles	0.00	100.0	

NH3 **Trend Assessment (1990-2020)**

NFR	Sectors	1990	Last year	Trend assess.	% cont. to trend	Cumulative total	Key category
3Da3	Urine and dung deposited by grazing animals	6.33	10.16	0.06	23.98	24.0	x
3B4gii	Manure mangement - Broilers	3.16	5.40	0.04	13.56	37.5	x
3Da1	Inorganic N-fertilizers (includes also urea application)	9.20	5.29	0.03	11.14	48.7	x
1A4bi	Residential: Stationary	3.81	1.87	0.02	6.17	54.8	x
3B4gi	Manure mangement - Laying hens	1.61	2.20	0.01	4.24	59.1	x
1A2d	Stationary combustion in manufacturing industries and	1.13	1.72	0.01	3.82	62.9	x
2B10a	Chemical industry: Other (please specify in the IIR)	5.42	3.73	0.01	3.61	66.5	x
3B3	Manure management - Swine	8.28	6.10	0.01	3.50	70.0	x
3B2	Manure management - Sheep	1.37	0.44	0.01	3.34	73.4	x
3Da2a	Animal manure applied to soils	14.56	12.57	0.01	2.81	76.2	x
1A3bi	Road transport: Passenger cars	0.04	0.60	0.01	2.74	78.9	x
3B4h	Manure management - Other animals (please specify ir	1.16	0.40	0.01	2.72	81.6	x
3B1a	Manure management - Dairy cattle	7.01	5.25	0.01	2.53	84.2	
3B4giii	Manure mangement - Turkeys	0.69	1.04	0.01	2.30	86.4	
3B4f	Manure management - Mules and asses	0.56	0.02	0.01	2.16	88.6	
5A	Biological treatment of waste - Solid waste disposal on	0.87	1.13	0.01	2.02	90.6	
1B2d	Other fugitive emissions from energy production	0.01	0.41	0.01	1.94	92.6	
1A2f	Stationary combustion in manufacturing industries and	1.03	0.51	0.00	1.68	94.3	
3B4giv	Manure management - Other poultry	0.31	0.57	0.00	1.52	95.8	
3B4d	Manure management - Goats	0.28	0.06	0.00	0.82	96.6	
3B1b	Manure management - Non-dairy cattle	2.51	2.21	0.00	0.70	97.3	
3B4e	Manure management - Horses	0.16	0.04	0.00	0.41	97.7	
1A2e	Stationary combustion in manufacturing industries and	0.15	0.05	0.00	0.36	98.1	
3F	Field burning of agricultural residues	1.01	0.77	0.00	0.34	98.4	
2G	Other product use (please specify in the IIR)	0.02	0.08	0.00	0.32	98.7	
3Da2b	Sewage sludge applied to soils	0.04	0.08	0.00	0.24	98.9	
1A3biii	Road transport: Heavy duty vehicles and buses	0.01	0.05	0.00	0.23	99.2	
5B2	Biological treatment of waste - Anaerobic digestion at b	NO	0.04	0.00	0.22	99.4	
1A2gviii	Stationary combustion in manufacturing industries and	0.11	0.12	0.00	0.17	99.6	
1A4ai	Commercial/institutional: Stationary	NO	0.03	0.00	0.14	99.7	
1A2c	Stationary combustion in manufacturing industries and	0.04	0.01	0.00	0.12	99.8	
1A3bii	Road transport: Light duty vehicles	0.01	0.03	0.00	0.12	99.9	
2D3g	Chemical products	0.01	0.00	0.00	0.03	100.0	
5B1	Biological treatment of waste - Composting	0.01	0.01	0.00	0.02	100.0	
1A3biv	Road transport: Mopeds & motorcycles	0.00	0.00	0.00	0.00	100.0	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.00	0.00	0.00	0.00	100.0	

PM2.5 **Level Assessment**

NFR	Sectors	%total 2020	Cumulative total	Key category
1A4bi	Residential: Stationary	38.71	38.7	x
2H1	Pulp and paper industry	14.00	52.7	x
2B10a	Chemical industry: Other (please specify in the IIR)	12.55	65.3	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	8.56	73.8	x
3F	Field burning of agricultural residues	3.67	77.5	x
1A3bii	Road transport: Light duty vehicles	2.29	79.8	x
1A3bi	Road transport: Passenger cars	2.07	81.9	x
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	1.65	83.5	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	1.46	85.0	
1A3bvi	Road transport: Automobile tyre and brake wear	1.39	86.4	
1A3ai(i)	International aviation LTO (civil)	1.13	87.5	
2G	Other product use (please specify in the IIR)	1.10	88.6	
5E	Other waste (please specify in IIR)	0.85	89.4	
2A2	Lime production	0.81	90.2	
1A1a	Public electricity and heat production	0.81	91.0	
2A3	Glass production	0.75	91.8	
2A5a	Quarrying and mining of minerals other than coal	0.66	92.5	
1A3bvii	Road transport: Automobile road abrasion	0.66	93.1	
1A3dii	National navigation (shipping)	0.61	93.7	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.60	94.3	
1A3aii(i)	Domestic aviation LTO (civil)	0.60	94.9	
1A3biii	Road transport: Heavy duty vehicles and buses	0.52	95.4	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.51	96.0	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.45	96.4	
2A5b	Construction and demolition	0.42	96.8	
1B2aiv	Fugitive emissions oil: Refining / storage	0.40	97.2	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.36	97.6	
2D3i	Other solvent use (please specify in the IIR)	0.32	97.9	
3B4giii	Manure mangement - Turkeys	0.26	98.2	
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.24	98.4	
2D3b	Road paving with asphalt	0.17	98.6	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.15	98.7	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.15	98.9	
1A4ai	Commercial/institutional: Stationary	0.14	99.0	
3B4giv	Manure management - Other poultry	0.13	99.1	
3B4gii	Manure mangement - Broilers	0.13	99.3	
3B1a	Manure management - Dairy cattle	0.12	99.4	
2C1	Iron and steel production	0.10	99.5	
3B4gi	Manure mangement - Laying hens	0.09	99.6	
1A3biv	Road transport: Mopeds & motorcycles	0.08	99.7	
2A5c	Storage, handling and transport of mineral products	0.08	99.8	
1A1b	Petroleum refining	0.08	99.8	
3B1b	Manure management - Non-dairy cattle	0.05	99.9	
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	0.04	99.9	
1A3c	Railways	0.03	99.9	
3B3	Manure management - Swine	0.02	100.0	
2D3c	Asphalt roofing	0.01	100.0	
3B2	Manure management - Sheep	0.01	100.0	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.00	100.0	

PM2.5 **Trend Assessment (1990-2020)**

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
1A4bi	Residential: Stationary	37.53	18.30	0.10	33.11	33.1	x
2H1	Pulp and paper industry	3.27	6.62	0.06	19.99	53.1	x
1A2f	Stationary combustion in manufacturing industries and	2.83	4.05	0.03	9.65	62.8	x
1A3biii	Road transport: Heavy duty vehicles and buses	1.90	0.24	0.02	4.79	67.6	x
2B10a	Chemical industry: Other (please specify in the IIR)	7.30	5.94	0.01	4.36	71.9	x
1A1a	Public electricity and heat production	1.68	0.38	0.01	3.48	75.4	x
1A3bi	Road transport: Passenger cars	0.63	0.98	0.01	2.51	77.9	x
1A3bii	Road transport: Light duty vehicles	2.32	1.08	0.01	2.27	80.2	x
2G	Other product use (please specify in the IIR)	0.12	0.52	0.01	2.01	82.2	
1A3biv	Road transport: Mopeds & motorcycles	0.61	0.04	0.01	1.71	83.9	
1A3bvi	Road transport: Automobile tyre and brake wear	0.47	0.66	0.00	1.53	85.4	
1A2e	Stationary combustion in manufacturing industries and	0.84	0.24	0.00	1.49	86.9	
2A3	Glass production	0.12	0.36	0.00	1.24	88.1	
1A3ai(i)	International aviation LTO (civil)	0.39	0.54	0.00	1.23	89.4	
2A2	Lime production	0.19	0.38	0.00	1.15	90.5	
1A2c	Stationary combustion in manufacturing industries and	0.42	0.07	0.00	0.99	91.5	
1A2d	Stationary combustion in manufacturing industries and	0.83	0.78	0.00	0.98	92.5	
1A3bvii	Road transport: Automobile road abrasion	0.19	0.31	0.00	0.83	93.3	
3F	Field burning of agricultural residues	2.30	1.74	0.00	0.77	94.1	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.19	0.29	0.00	0.71	94.8	
1A3aii(i)	Domestic aviation LTO (civil)	0.23	0.28	0.00	0.56	95.4	
2A5b	Construction and demolition	0.46	0.20	0.00	0.52	95.9	
2A5a	Quarrying and mining of minerals other than coal	0.30	0.31	0.00	0.49	96.4	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.10	0.17	0.00	0.48	96.8	
2D3i	Other solvent use (please specify in the IIR)	0.12	0.15	0.00	0.32	97.2	
3B4giii	Manure mangement - Turkeys	0.08	0.12	0.00	0.30	97.5	
1A1b	Petroleum refining	0.13	0.04	0.00	0.24	97.7	
1A4ai	Commercial/institutional: Stationary	0.02	0.07	0.00	0.23	97.9	
1A2gviii	Stationary combustion in manufacturing industries and	1.08	0.69	0.00	0.22	98.1	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.17	0.07	0.00	0.20	98.3	
3B4giv	Manure management - Other poultry	0.03	0.06	0.00	0.19	98.5	
1A3c	Railways	0.08	0.01	0.00	0.18	98.7	
3B4gii	Manure mangement - Broilers	0.04	0.06	0.00	0.16	98.9	
1A3dii	National navigation (shipping)	0.38	0.29	0.00	0.15	99.0	
5E	Other waste (please specify in IIR)	0.63	0.40	0.00	0.14	99.2	
2D3b	Road paving with asphalt	0.08	0.08	0.00	0.11	99.3	
3Dc	Farm-level agricultural operations including storage, har	0.06	0.02	0.00	0.11	99.4	
3B4gi	Manure mangement - Laying hens	0.03	0.04	0.00	0.10	99.5	
3B1a	Manure management - Dairy cattle	0.11	0.06	0.00	0.09	99.6	
1A2a	Stationary combustion in manufacturing industries and	0.02	0.00	0.00	0.06	99.6	
2A5c	Storage, handling and transport of mineral products	0.04	0.04	0.00	0.06	99.7	
1A4bii	Residential: Household and gardening (mobile)	0.02	0.00	0.00	0.05	99.8	
2C1	Iron and steel production	0.05	0.05	0.00	0.04	99.8	
1A2gvii	Mobile Combustion in manufacturing industries and cor	0.16	0.11	0.00	0.04	99.8	
5C1biii	Clinical waste incineration	0.01	0.00	0.00	0.03	99.9	
3B1b	Manure management - Non-dairy cattle	0.04	0.02	0.00	0.02	99.9	
3B2	Manure management - Sheep	0.01	0.00	0.00	0.02	99.9	
3B4f	Manure management - Mules and asses	0.01	0.00	0.00	0.02	99.9	
1A5b	Other, Mobile (including military, land based and recrea	0.30	0.21	0.00	0.02	100.0	
3B4d	Manure management - Goats	0.00	0.00	0.00	0.01	100.0	
3B4e	Manure management - Horses	0.00	0.00	0.00	0.01	100.0	

PM10 **Level Assessment**

NFR	Sectors	% total 2020	Cumulative total	Key category
1A4bi	Residential: Stationary	30.67	30.7	x
2H1	Pulp and paper industry	13.12	43.8	x
2B10a	Chemical industry: Other (please specify in the IIR)	9.81	53.6	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	6.63	60.2	x
2A5a	Quarrying and mining of minerals other than coal	5.09	65.3	x
2A5b	Construction and demolition	3.28	68.6	x
2A2	Lime production	3.12	71.7	x
3F	Field burning of agricultural residues	2.99	74.7	x
1A3bvi	Road transport: Automobile tyre and brake wear	1.98	76.7	x
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	1.97	78.7	x
1A3bii	Road transport: Light duty vehicles	1.77	80.4	x
1A3bi	Road transport: Passenger cars	1.60	82.0	
3B4giii	Manure mangement - Turkeys	1.47	83.5	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	1.27	84.8	
3B4gii	Manure mangement - Broilers	0.99	85.8	
3B4gi	Manure mangement - Laying hens	0.96	86.7	
1A3bvii	Road transport: Automobile road abrasion	0.94	87.7	
1A3ai(i)	International aviation LTO (civil)	0.87	88.5	
2D3b	Road paving with asphalt	0.85	89.4	
2G	Other product use (please specify in the IIR)	0.85	90.2	
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	0.79	91.0	
3B4giv	Manure management - Other poultry	0.73	91.8	
1B2aiv	Fugitive emissions oil: Refining / storage	0.71	92.5	
1A1a	Public electricity and heat production	0.68	93.1	
2A3	Glass production	0.66	93.8	
5E	Other waste (please specify in IIR)	0.66	94.5	
2A5c	Storage, handling and transport of mineral products	0.62	95.1	
1A3dii	National navigation (shipping)	0.52	95.6	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.48	96.1	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.47	96.5	
1A3aii(i)	Domestic aviation LTO (civil)	0.46	97.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.40	97.4	
2D3i	Other solvent use (please specify in the IIR)	0.37	97.8	
3B3	Manure management - Swine	0.36	98.1	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.34	98.5	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.34	98.8	
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.19	99.0	
3B1a	Manure management - Dairy cattle	0.15	99.2	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.13	99.3	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.13	99.4	
1A4ai	Commercial/institutional: Stationary	0.11	99.5	
2C1	Iron and steel production	0.09	99.6	
1A3biv	Road transport: Mopeds & motorcycles	0.06	99.7	
1A1b	Petroleum refining	0.06	99.7	
3B1b	Manure management - Non-dairy cattle	0.06	99.8	
2H2	Food and beverages industry	0.05	99.9	
2D3g	Chemical products	0.04	99.9	
2D3c	Asphalt roofing	0.04	99.9	
1A3c	Railways	0.02	100.0	
3B2	Manure management - Sheep	0.02	100.0	

PM10 **Trend Assessment (1990-2020)**

NFR	Sectors	1990	Last year	Trend assess.	% cont. to trend	Cumulative total	Key category
1A4bi	Residential: Stationary	38.49	18.76	0.10	26.98	27.0	x
2H1	Pulp and paper industry	3.97	8.03	0.06	16.95	43.9	x
1A2f	Stationary combustion in manufacturing industries and	2.84	4.06	0.02	6.67	50.6	x
1A1a	Public electricity and heat production	3.11	0.41	0.02	5.75	56.4	x
2A5b	Construction and demolition	4.61	2.01	0.01	4.03	60.4	x
2A2	Lime production	0.95	1.91	0.01	4.00	64.4	x
1A3biii	Road transport: Heavy duty vehicles and buses	1.90	0.24	0.01	3.55	67.9	x
2A5a	Quarrying and mining of minerals other than coal	3.00	3.12	0.01	3.25	71.2	x
2B10a	Chemical industry: Other (please specify in the IIR)	7.37	6.00	0.01	2.65	73.8	x
3Dc	Farm-level agricultural operations including storage, hai	1.64	0.48	0.01	2.17	76.0	x
1A3bvi	Road transport: Automobile tyre and brake wear	0.89	1.21	0.01	1.89	77.9	x
1A3bii	Road transport: Light duty vehicles	2.32	1.08	0.01	1.79	79.7	x
1A3bi	Road transport: Passenger cars	0.63	0.98	0.01	1.74	81.4	x
3B4giii	Manure mangement - Turkeys	0.60	0.90	0.01	1.55	83.0	
1A2e	Stationary combustion in manufacturing industries and	1.06	0.29	0.01	1.48	84.5	
2G	Other product use (please specify in the IIR)	0.12	0.52	0.01	1.42	85.9	
1A3biv	Road transport: Mopeds & motorcycles	0.61	0.04	0.00	1.26	87.1	
3B4gii	Manure mangement - Broilers	0.37	0.61	0.00	1.12	88.3	
1A3bvii	Road transport: Automobile road abrasion	0.35	0.58	0.00	1.07	89.3	
1A2c	Stationary combustion in manufacturing industries and	0.57	0.08	0.00	1.03	90.4	
2A3	Glass production	0.14	0.40	0.00	0.99	91.3	
3B4giv	Manure management - Other poultry	0.22	0.44	0.00	0.94	92.3	
3B4gi	Manure mangement - Laying hens	0.44	0.59	0.00	0.90	93.2	
1A3ai(i)	International aviation LTO (civil)	0.39	0.54	0.00	0.84	94.0	
1A2d	Stationary combustion in manufacturing industries and	1.39	1.20	0.00	0.72	94.7	
1A2gviii	Stationary combustion in manufacturing industries and	1.40	0.78	0.00	0.68	95.4	
2D3b	Road paving with asphalt	0.53	0.52	0.00	0.49	95.9	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.19	0.29	0.00	0.49	96.4	
2A5c	Storage, handling and transport of mineral products	0.36	0.38	0.00	0.41	96.8	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.12	0.21	0.00	0.40	97.2	
3F	Field burning of agricultural residues	2.42	1.83	0.00	0.40	97.6	
1A3aii(i)	Domestic aviation LTO (civil)	0.23	0.28	0.00	0.38	98.0	
1A1b	Petroleum refining	0.21	0.04	0.00	0.35	98.3	
2D3i	Other solvent use (please specify in the IIR)	0.18	0.23	0.00	0.33	98.7	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.19	0.08	0.00	0.18	98.8	
1A4ai	Commercial/institutional: Stationary	0.02	0.07	0.00	0.16	99.0	
5E	Other waste (please specify in IIR)	0.63	0.40	0.00	0.15	99.2	
1A3c	Railways	0.08	0.01	0.00	0.14	99.3	
3B1a	Manure management - Dairy cattle	0.17	0.09	0.00	0.11	99.4	
1A3dii	National navigation (shipping)	0.41	0.32	0.00	0.09	99.5	
2D3g	Chemical products	0.01	0.03	0.00	0.07	99.6	
3B3	Manure management - Swine	0.29	0.22	0.00	0.05	99.6	
3B2	Manure management - Sheep	0.04	0.01	0.00	0.05	99.7	
2H2	Food and beverages industry	0.02	0.03	0.00	0.05	99.7	
1A2a	Stationary combustion in manufacturing industries and	0.02	0.00	0.00	0.05	99.8	
5C1biii	Clinical waste incineration	0.02	0.00	0.00	0.04	99.8	
1A4bii	Residential: Household and gardening (mobile)	0.02	0.00	0.00	0.04	99.8	
3B1b	Manure management - Non-dairy cattle	0.06	0.03	0.00	0.03	99.9	
3B4f	Manure management - Mules and asses	0.01	0.00	0.00	0.03	99.9	
1A2gvii	Mobile Combustion in manufacturing industries and cor	0.16	0.11	0.00	0.02	99.9	
3B4d	Manure management - Goats	0.01	0.00	0.00	0.02	99.9	
2C1	Iron and steel production	0.07	0.05	0.00	0.01	99.9	
3B4h	Manure management - Other animals (please specify ir	0.01	0.00	0.00	0.01	99.9	
2C7d	Storage, handling and transport of metal products (plea	0.00	0.00	0.00	0.01	100.0	
2D3c	Asphalt roofing	0.04	0.02	0.00	0.01	100.0	
1A5b	Other, Mobile (including military, land based and recrea	0.30	0.21	0.00	0.01	100.0	

TSP Level Assessment

NFR	Sectors	% total 2020	Cumulative total	Key category
1A4bi	Residential: Stationary	18.83	18.8	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	13.36	32.2	x
2B10a	Chemical industry: Other (please specify in the IIR)	12.01	44.2	x
2H1	Pulp and paper industry	8.67	52.9	x
2A5b	Construction and demolition	6.37	59.2	x
2A5a	Quarrying and mining of minerals other than coal	6.08	65.3	x
2A2	Lime production	4.69	70.0	x
2I	Wood processing	3.49	73.5	x
2D3b	Road paving with asphalt	2.86	76.4	x
3B4gi	Manure mangement - Laying hens	2.66	79.0	x
3F	Field burning of agricultural residues	1.77	80.8	x
2D3g	Chemical products	1.71	82.5	
1A3bvi	Road transport: Automobile tyre and brake wear	1.54	84.0	
3B3	Manure management - Swine	1.38	85.4	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	1.28	86.7	
3B4gii	Manure mangement - Broilers	1.16	87.9	
1A3bvii	Road transport: Automobile road abrasion	1.10	89.0	
1A3bii	Road transport: Light duty vehicles	1.03	90.0	
1A3bi	Road transport: Passenger cars	0.94	90.9	
3B4giii	Manure mangement - Turkeys	0.86	91.8	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.81	92.6	
2A5c	Storage, handling and transport of mineral products	0.73	93.3	
1B2aiv	Fugitive emissions oil: Refining / storage	0.53	93.9	
1A3ai(i)	International aviation LTO (civil)	0.51	94.4	
2G	Other product use (please specify in the IIR)	0.50	94.9	
1A1a	Public electricity and heat production	0.48	95.3	
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	0.46	95.8	
2A3	Glass production	0.43	96.2	
3B4giv	Manure management - Other poultry	0.42	96.7	
5E	Other waste (please specify in IIR)	0.38	97.0	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.31	97.4	
1A3dii	National navigation (shipping)	0.30	97.7	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.27	97.9	
1A3aii(i)	Domestic aviation LTO (civil)	0.27	98.2	
2D3i	Other solvent use (please specify in the IIR)	0.27	98.5	
1A3biii	Road transport: Heavy duty vehicles and buses	0.23	98.7	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.20	98.9	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.20	99.1	
3B1a	Manure management - Dairy cattle	0.19	99.3	
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.11	99.4	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.09	99.5	
2D3c	Asphalt roofing	0.08	99.6	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.08	99.7	
3B1b	Manure management - Non-dairy cattle	0.07	99.7	
1A4ai	Commercial/institutional: Stationary	0.06	99.8	
2C1	Iron and steel production	0.06	99.9	
1A3biv	Road transport: Mopeds & motorcycles	0.04	99.9	
1A1b	Petroleum refining	0.04	99.9	
3B2	Manure management - Sheep	0.03	100.0	
1A3c	Railways	0.01	100.0	
2C7d	Storage, handling and transport of metal products (please specify in the IIR)	0.01	100.0	

TSP Trend Assessment (1990-2020)

NFR	Sectors	1990	Last year	Trend assess.	% cont. to trend	Cumulative total	Key category
1A4bi	Residential: Stationary	40.41	19.70	0.10	23.17	23.2	x
1A2f	Stationary combustion in manufacturing industries and	9.21	13.98	0.05	11.59	34.8	x
2A5b	Construction and demolition	15.37	6.66	0.04	10.29	45.0	x
2H1	Pulp and paper industry	4.48	9.07	0.04	9.67	54.7	x
1A1a	Public electricity and heat production	4.68	0.50	0.03	5.85	60.6	x
2A2	Lime production	2.45	4.91	0.02	5.19	65.8	x
2B10a	Chemical industry: Other (please specify in the IIR)	12.35	12.56	0.02	4.55	70.3	x
2I	Wood processing	1.91	3.65	0.02	3.74	74.0	x
2A5a	Quarrying and mining of minerals other than coal	6.12	6.36	0.01	2.49	76.5	x
1A3biii	Road transport: Heavy duty vehicles and buses	1.90	0.24	0.01	2.31	78.8	x
3B4gi	Manure mangement - Laying hens	2.08	2.78	0.01	1.95	80.8	x
2D3g	Chemical products	1.13	1.79	0.01	1.56	82.3	
3Dc	Farm-level agricultural operations including storage, har	1.64	0.48	0.01	1.50	83.8	
1A3bii	Road transport: Light duty vehicles	2.32	1.08	0.01	1.42	85.3	
1A3bvi	Road transport: Automobile tyre and brake wear	1.16	1.61	0.01	1.19	86.5	
1A2e	Stationary combustion in manufacturing industries and	1.20	0.32	0.00	1.15	87.6	
3B4gii	Manure mangement - Broilers	0.74	1.21	0.00	1.09	88.7	
1A3bvii	Road transport: Automobile road abrasion	0.70	1.15	0.00	1.04	89.7	
2D3b	Road paving with asphalt	3.01	2.99	0.00	0.98	90.7	
1A3bi	Road transport: Passenger cars	0.63	0.98	0.00	0.84	91.5	
1A2c	Stationary combustion in manufacturing industries and	0.69	0.09	0.00	0.82	92.4	
1A3biv	Road transport: Mopeds & motorcycles	0.61	0.04	0.00	0.80	93.2	
1A2gviii	Stationary combustion in manufacturing industries and	1.60	0.85	0.00	0.79	94.0	
2G	Other product use (please specify in the IIR)	0.12	0.52	0.00	0.76	94.7	
3B4giii	Manure mangement - Turkeys	0.60	0.90	0.00	0.74	95.5	
2A3	Glass production	0.16	0.45	0.00	0.58	96.0	
3B4giv	Manure management - Other poultry	0.22	0.44	0.00	0.47	96.5	
1A3ai(i)	International aviation LTO (civil)	0.39	0.54	0.00	0.39	96.9	
1A1b	Petroleum refining	0.27	0.04	0.00	0.32	97.2	
2A5c	Storage, handling and transport of mineral products	0.73	0.76	0.00	0.31	97.5	
3F	Field burning of agricultural residues	2.46	1.85	0.00	0.24	97.8	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.19	0.29	0.00	0.23	98.0	
5E	Other waste (please specify in IIR)	0.63	0.40	0.00	0.20	98.2	
3B1a	Manure management - Dairy cattle	0.38	0.20	0.00	0.20	98.4	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.12	0.21	0.00	0.20	98.6	
2D3i	Other solvent use (please specify in the IIR)	0.22	0.28	0.00	0.18	98.8	
1A3aii(i)	Domestic aviation LTO (civil)	0.23	0.28	0.00	0.17	98.9	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.19	0.08	0.00	0.13	99.1	
3B3	Manure management - Swine	1.87	1.45	0.00	0.13	99.2	
1A3c	Railways	0.09	0.01	0.00	0.10	99.3	
1A4ai	Commercial/institutional: Stationary	0.02	0.07	0.00	0.09	99.4	
3B2	Manure management - Sheep	0.09	0.03	0.00	0.08	99.5	
1A2d	Stationary combustion in manufacturing industries and	1.60	1.34	0.00	0.07	99.5	
1A5b	Other, Mobile (including military, land based and recrea	0.30	0.21	0.00	0.06	99.6	
3B1b	Manure management - Non-dairy cattle	0.14	0.08	0.00	0.06	99.7	
2D3c	Asphalt roofing	0.14	0.09	0.00	0.05	99.7	
2C1	Iron and steel production	0.11	0.07	0.00	0.04	99.8	
5C1biii	Clinical waste incineration	0.03	0.00	0.00	0.04	99.8	
3B4f	Manure management - Mules and asses	0.02	0.00	0.00	0.03	99.8	
1A3dii	National navigation (shipping)	0.41	0.32	0.00	0.03	99.9	
1A2a	Stationary combustion in manufacturing industries and	0.02	0.00	0.00	0.03	99.9	
3B4d	Manure management - Goats	0.02	0.00	0.00	0.02	99.9	
1A4bii	Residential: Household and gardening (mobile)	0.02	0.00	0.00	0.02	99.9	
1A2gvii	Mobile Combustion in manufacturing industries and cor	0.16	0.11	0.00	0.02	100.0	
3B4h	Manure management - Other animals (please specify ir	0.02	0.01	0.00	0.02	100.0	
2C7d	Storage, handling and transport of metal products (plea	0.00	0.01	0.00	0.01	100.0	
3B4e	Manure management - Horses	0.01	0.00	0.00	0.01	100.0	

BC Level Assessment

NFR	Sectors	% total 2020	Cumulative total	Key category
1A4bi	Residential: Stationary	32.08	32.1	x
1A3bii	Road transport: Light duty vehicles	13.92	46.0	x
1A3bi	Road transport: Passenger cars	13.35	59.4	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	8.14	67.5	x
1A3ai(i)	International aviation LTO (civil)	4.59	72.1	x
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	4.50	76.6	x
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	3.36	79.9	x
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	2.97	82.9	x
3F	Field burning of agricultural residues	2.89	85.8	
1A3biii	Road transport: Heavy duty vehicles and buses	2.83	88.6	
1A3aii(i)	Domestic aviation LTO (civil)	2.41	91.1	
1A4ci	Agriculture/Forestry/Fishing: Stationary	1.83	92.9	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	1.50	94.4	
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	1.27	95.6	
1A3bvi	Road transport: Automobile tyre and brake wear	1.22	96.9	
1A3dii	National navigation (shipping)	0.77	97.6	
2B10a	Chemical industry: Other (please specify in the IIR)	0.53	98.2	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.39	98.6	
1A1a	Public electricity and heat production	0.37	98.9	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.26	99.2	
1A4ai	Commercial/institutional: Stationary	0.23	99.4	
1A3bvii	Road transport: Automobile road abrasion	0.22	99.6	
1A3biv	Road transport: Mopeds & motorcycles	0.12	99.8	
2D3b	Road paving with asphalt	0.08	99.8	
1A1b	Petroleum refining	0.07	99.9	
2G	Other product use (please specify in the IIR)	0.04	100.0	
2A2	Lime production	0.03	100.0	
1A4bii	Residential: Household and gardening (mobile)	0.01	100.0	

BC Trend Assessment (1990-2020)

NFR	Sectors	1990	Last year	Trend assess.	% cont. to trend	Cumulative total	Key category
1A3bi	Road transport: Passenger cars	0.33	0.75	0.06	20.96	21.0	x
1A4bi	Residential: Stationary	3.76	1.80	0.05	18.06	39.0	x
1A3biii	Road transport: Heavy duty vehicles and buses	0.95	0.16	0.04	15.85	54.9	x
1A2f	Stationary combustion in manufacturing industries and	0.24	0.46	0.03	11.81	66.7	x
1A3ai(i)	International aviation LTO (civil)	0.19	0.26	0.02	5.48	72.2	x
1A2e	Stationary combustion in manufacturing industries and	0.32	0.08	0.01	4.23	76.4	x
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.11	0.17	0.01	3.77	80.2	x
1A2c	Stationary combustion in manufacturing industries and	0.16	0.01	0.01	3.06	83.2	
1A3aii(i)	Domestic aviation LTO (civil)	0.11	0.14	0.01	2.57	85.8	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.07	0.10	0.01	2.23	88.0	
1A3biv	Road transport: Mopeds & motorcycles	0.09	0.01	0.01	1.83	89.9	
1A2gviii	Stationary combustion in manufacturing industries and	0.49	0.25	0.00	1.69	91.5	
1A3bvi	Road transport: Automobile tyre and brake wear	0.05	0.07	0.00	1.53	93.1	
3F	Field burning of agricultural residues	0.21	0.16	0.00	1.24	94.3	
1A2d	Stationary combustion in manufacturing industries and	0.28	0.19	0.00	0.83	95.1	
2B10a	Chemical industry: Other (please specify in the IIR)	0.02	0.03	0.00	0.77	95.9	
1A4bii	Residential: Household and gardening (mobile)	0.03	0.00	0.00	0.69	96.6	
1A1a	Public electricity and heat production	0.06	0.02	0.00	0.50	97.1	
1A4ai	Commercial/institutional: Stationary	0.00	0.01	0.00	0.50	97.6	
1A2gvii	Mobile Combustion in manufacturing industries and cor	0.10	0.07	0.00	0.49	98.1	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.05	0.02	0.00	0.37	98.5	
1A3dii	National navigation (shipping)	0.06	0.04	0.00	0.35	98.8	
1A3bii	Road transport: Light duty vehicles	1.28	0.78	0.00	0.32	99.1	
1A3bvii	Road transport: Automobile road abrasion	0.01	0.01	0.00	0.29	99.4	
1A2a	Stationary combustion in manufacturing industries and	0.01	0.00	0.00	0.28	99.7	
2G	Other product use (please specify in the IIR)	0.00	0.00	0.00	0.08	99.8	
1A1b	Petroleum refining	0.01	0.00	0.00	0.07	99.9	
2D3b	Road paving with asphalt	0.00	0.00	0.00	0.07	99.9	
2A2	Lime production	0.00	0.00	0.00	0.05	100.0	
5C1biii	Clinical waste incineration	0.00	0.00	0.00	0.01	100.0	

CO **Level Assessment**

NFR	Sectors	%total 2020	Cumulative total	Key category
1A4bi	Residential: Stationary	38.74	38.7	x
1A3bi	Road transport: Passenger cars	14.32	53.1	x
1B2aiv	Fugitive emissions oil: Refining / storage	11.72	64.8	x
3F	Field burning of agricultural residues	11.24	76.0	x
2B10a	Chemical industry: Other (please specify in the IIR)	3.19	79.2	x
1A3biv	Road transport: Mopeds & motorcycles	3.18	82.4	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	2.73	85.1	
1A3bii	Road transport: Light duty vehicles	2.45	87.6	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	2.32	89.9	
1A1a	Public electricity and heat production	1.86	91.8	
2C1	Iron and steel production	1.43	93.2	
1A3biii	Road transport: Heavy duty vehicles and buses	1.34	94.5	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.86	95.4	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.85	96.2	
1A3ai(i)	International aviation LTO (civil)	0.75	97.0	
2G	Other product use (please specify in the IIR)	0.41	97.4	
1A1b	Petroleum refining	0.38	97.8	
1A3aii(i)	Domestic aviation LTO (civil)	0.35	98.1	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.34	98.5	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.31	98.8	
1A4ai	Commercial/institutional: Stationary	0.25	99.0	
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.22	99.3	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.19	99.4	
1A3dii	National navigation (shipping)	0.18	99.6	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.15	99.8	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.11	99.9	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.04	99.9	
1A3c	Railways	0.04	99.9	
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.02	100.0	
1A4aii	Commercial/institutional: Mobile	0.02	100.0	

CO **Trend Assessment (1990-2020)**

NFR	Sectors	1990	Last year	Trend assess.	% cont. to trend	Cumulative total	Key category
1A3bi	Road transport: Passenger cars	390.91	37.56	0.11	42.18	42.2	x
1A4bi	Residential: Stationary	213.27	101.63	0.04	14.57	56.8	x
1B2aiv	Fugitive emissions oil: Refining / storage	0.14	30.75	0.04	14.23	71.0	x
3F	Field burning of agricultural residues	38.63	29.48	0.02	7.77	78.7	x
1A3biv	Road transport: Mopeds & motorcycles	59.88	8.33	0.01	5.27	84.0	x
2B10a	Chemical industry: Other (please specify in the IIR)	5.44	8.36	0.01	3.04	87.1	
1A2d	Stationary combustion in manufacturing industries and	5.67	6.10	0.01	1.96	89.0	
1A1a	Public electricity and heat production	2.11	4.89	0.01	1.94	91.0	
2C1	Iron and steel production	1.87	3.74	0.00	1.45	92.4	
1A2f	Stationary combustion in manufacturing industries and	13.80	7.17	0.00	1.22	93.6	
1A2a	Stationary combustion in manufacturing industries and	6.28	0.05	0.00	0.93	94.6	
1A3bii	Road transport: Light duty vehicles	25.31	6.44	0.00	0.87	95.4	
1A2gviii	Stationary combustion in manufacturing industries and	2.54	2.26	0.00	0.66	96.1	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	3.36	2.22	0.00	0.52	96.6	
2G	Other product use (please specify in the IIR)	0.24	1.07	0.00	0.46	97.1	
1A1b	Petroleum refining	0.25	0.98	0.00	0.42	97.5	
1A3ai(i)	International aviation LTO (civil)	3.30	1.98	0.00	0.41	97.9	
1A4bii	Residential: Household and gardening (mobile)	2.70	0.03	0.00	0.40	98.3	
1A4ai	Commercial/institutional: Stationary	0.21	0.66	0.00	0.27	98.6	
1A3aii(i)	Domestic aviation LTO (civil)	1.52	0.92	0.00	0.20	98.8	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.23	0.49	0.00	0.19	99.0	
1A4aii	Commercial/institutional: Mobile	1.31	0.04	0.00	0.18	99.1	
1A2c	Stationary combustion in manufacturing industries and	1.43	0.81	0.00	0.16	99.3	
1A2gvii	Mobile Combustion in manufacturing industries and cor	0.80	0.59	0.00	0.15	99.5	
1A3dii	National navigation (shipping)	0.62	0.48	0.00	0.13	99.6	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.12	0.28	0.00	0.11	99.7	
1A3biii	Road transport: Heavy duty vehicles and buses	11.38	3.52	0.00	0.11	99.8	
1A2e	Stationary combustion in manufacturing industries and	2.19	0.90	0.00	0.08	99.9	
1A3c	Railways	0.60	0.09	0.00	0.05	99.9	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.94	0.39	0.00	0.04	100.0	
1A5b	Other, Mobile (including military, land based and recrea	0.13	0.09	0.00	0.02	100.0	
5C1biii	Clinical waste incineration	0.02	0.01	0.00	0.00	100.0	
5C1bv	Cremation	0.00	0.00	0.00	0.00	100.0	

Pb **Level Assessment**

NFR	Sectors	% total 2020	Cumulative total	Key category
2C1	Iron and steel production	24.786	24.8	x
1A3bi	Road transport: Passenger cars	23.372	48.2	x
2A3	Glass production	21.338	69.5	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	7.317	76.8	x
1A3bvi	Road transport: Automobile tyre and brake wear	6.909	83.7	x
1A4bi	Residential: Stationary	3.807	87.5	
1A3ai(i)	International aviation LTO (civil)	2.567	90.1	
1A1a	Public electricity and heat production	1.778	91.9	
1A3biv	Road transport: Mopeds & motorcycles	1.691	93.6	
2G	Other product use (please specify in the IIR)	1.243	94.8	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	1.194	96.0	
1A3aii(i)	Domestic aviation LTO (civil)	1.147	97.1	
1B2aiv	Fugitive emissions oil: Refining / storage	1.088	98.2	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.351	98.6	
1A4ai	Commercial/institutional: Stationary	0.212	98.8	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.185	99.0	
5C1bi	Industrial waste incineration	0.148	99.1	
1A1b	Petroleum refining	0.144	99.3	
3F	Field burning of agricultural residues	0.134	99.4	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.134	99.5	
2C5	Lead production	0.130	99.7	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.083	99.8	
5C1biii	Clinical waste incineration	0.066	99.8	
1A3bii	Road transport: Light duty vehicles	0.062	99.9	
1A3dii	National navigation (shipping)	0.047	99.9	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.030	100.0	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.015	100.0	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.011	100.0	
5E	Other waste (please specify in IIR)	0.005	100.0	
5C1bv	Cremation	0.004	100.0	
2C7a	Copper production	0.002	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.002	100.0	

Pb **Trend Assessment (1990-2020)**

NFR	Sectors	1990	Last year	Trend assess.	% cont. to trend	Cumulative total	Key category
1A3bi	Road transport: Passenger cars	492.695	5.400	0.03	43.75	43.7	x
2C1	Iron and steel production	3.614	5.727	0.01	16.77	60.5	x
2A3	Glass production	1.702	4.930	0.01	14.61	75.1	x
1A2f	Stationary combustion in manufacturing industries and	2.194	1.691	0.00	4.81	79.9	x
1A3bvi	Road transport: Automobile tyre and brake wear	1.259	1.596	0.00	4.64	84.6	x
1A3biv	Road transport: Mopeds & motorcycles	41.599	0.391	0.00	3.89	88.5	
1A4bi	Residential: Stationary	1.453	0.880	0.00	2.47	90.9	
1A3bii	Road transport: Light duty vehicles	19.014	0.014	0.00	2.27	93.2	
1A3ai(i)	International aviation LTO (civil)	1.047	0.593	0.00	1.65	94.9	
1A1a	Public electricity and heat production	1.024	0.411	0.00	1.11	96.0	
2G	Other product use (please specify in the IIR)	0.087	0.287	0.00	0.85	96.8	
1A2d	Stationary combustion in manufacturing industries and	0.361	0.276	0.00	0.79	97.6	
1B2aiv	Fugitive emissions oil: Refining / storage	NO	0.251	0.00	0.76	98.4	
1A3aii(i)	Domestic aviation LTO (civil)	0.468	0.265	0.00	0.74	99.1	
1A4ai	Commercial/institutional: Stationary	0.002	0.049	0.00	0.15	99.2	
5C1bi	Industrial waste incineration	0.029	0.034	0.00	0.10	99.3	
1A1b	Petroleum refining	0.087	0.033	0.00	0.09	99.4	
1A2gviii	Stationary combustion in manufacturing industries and	1.265	0.081	0.00	0.09	99.5	
2C5	Lead production	0.014	0.030	0.00	0.09	99.6	
3F	Field burning of agricultural residues	0.041	0.031	0.00	0.09	99.7	
1A2e	Stationary combustion in manufacturing industries and	0.449	0.043	0.00	0.07	99.8	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.003	0.019	0.00	0.06	99.8	
1A2c	Stationary combustion in manufacturing industries and	0.318	0.031	0.00	0.05	99.9	
1A3dii	National navigation (shipping)	0.014	0.011	0.00	0.03	99.9	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.308	0.003	0.00	0.03	99.9	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.016	0.007	0.00	0.02	100.0	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.001	0.003	0.00	0.01	100.0	
5C1biii	Clinical waste incineration	0.439	0.015	0.00	0.01	100.0	
1A4bii	Residential: Household and gardening (mobile)	0.056	0.000	0.00	0.01	100.0	
2C7a	Copper production	0.055	0.000	0.00	0.01	100.0	
5E	Other waste (please specify in IIR)	0.002	0.001	0.00	0.00	100.0	
5C1bv	Cremation	0.000	0.001	0.00	0.00	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.001	0.000	0.00	0.00	100.0	

Cd **Level Assessment**

NFR	Sectors	%total 2020	Cumulative total	Key category
2C1	Iron and steel production	24.497	24.5	x
1A4bi	Residential: Stationary	23.550	48.0	x
3F	Field burning of agricultural residues	11.871	59.9	x
2A3	Glass production	10.779	70.7	x
2G	Other product use (please specify in the IIR)	8.133	78.8	x
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	6.542	85.4	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	3.019	88.4	
1B2aiv	Fugitive emissions oil: Refining / storage	2.752	91.1	
1A1a	Public electricity and heat production	2.655	93.8	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	1.555	95.4	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.977	96.3	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.839	97.2	
1A1b	Petroleum refining	0.729	97.9	
1A4ai	Commercial/institutional: Stationary	0.575	98.5	
1A3bvi	Road transport: Automobile tyre and brake wear	0.419	98.9	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.258	99.1	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.201	99.3	
5C1bi	Industrial waste incineration	0.146	99.5	
5E	Other waste (please specify in IIR)	0.130	99.6	
1A3biv	Road transport: Mopeds & motorcycles	0.125	99.8	
2C5	Lead production	0.076	99.8	
1A3dii	National navigation (shipping)	0.062	99.9	
5C1biii	Clinical waste incineration	0.046	99.9	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.029	100.0	
1A3bi	Road transport: Passenger cars	0.014	100.0	
5C1bv	Cremation	0.008	100.0	
1A3c	Railways	0.005	100.0	
2C7a	Copper production	0.003	100.0	
1A3bii	Road transport: Light duty vehicles	0.002	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.002	100.0	
2D3g	Chemical products	0.001	100.0	
1A3ai(i)	International aviation LTO (civil)	0.001	100.0	
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.001	100.0	
1A3aii(i)	Domestic aviation LTO (civil)	0.000	100.0	

Cd **Trend Assessment (1990-2020)**

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
2C1	Iron and steel production	0.106	0.441	0.15	26.62	26.6	x
1A2gviii	Stationary combustion in manufacturing industries and	0.294	0.018	0.08	14.95	41.6	x
2A3	Glass production	0.068	0.194	0.06	10.51	52.1	x
2G	Other product use (please specify in the IIR)	0.054	0.146	0.04	7.80	59.9	x
1A4bi	Residential: Stationary	0.699	0.424	0.04	7.48	67.4	x
1A2e	Stationary combustion in manufacturing industries and	0.158	0.028	0.04	6.70	74.1	x
1A2c	Stationary combustion in manufacturing industries and	0.135	0.015	0.04	6.38	80.4	x
1A1a	Public electricity and heat production	0.179	0.048	0.04	6.37	86.8	
1B2aiv	Fugitive emissions oil: Refining / storage	NO	0.049	0.02	3.65	90.5	
1A2f	Stationary combustion in manufacturing industries and	0.124	0.054	0.02	2.87	93.3	
1A2d	Stationary combustion in manufacturing industries and	0.193	0.118	0.01	1.99	95.3	
5C1biii	Clinical waste incineration	0.033	0.001	0.01	1.77	97.1	
1A4ai	Commercial/institutional: Stationary	0.001	0.010	0.00	0.72	97.8	
1A1b	Petroleum refining	0.026	0.013	0.00	0.50	98.3	
2C7a	Copper production	0.005	0.000	0.00	0.29	98.6	
1A3biv	Road transport: Mopeds & motorcycles	0.008	0.002	0.00	0.28	98.9	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.000	0.004	0.00	0.24	99.1	
1A3bvi	Road transport: Automobile tyre and brake wear	0.006	0.008	0.00	0.24	99.3	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.002	0.005	0.00	0.23	99.6	
3F	Field burning of agricultural residues	0.281	0.213	0.00	0.17	99.8	
5C1bi	Industrial waste incineration	0.002	0.003	0.00	0.07	99.8	
2C5	Lead production	0.001	0.001	0.00	0.07	99.9	
5E	Other waste (please specify in IIR)	0.004	0.002	0.00	0.03	99.9	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.001	0.001	0.00	0.03	100.0	
1A3c	Railways	0.001	0.000	0.00	0.02	100.0	
5C1bv	Cremation	0.000	0.000	0.00	0.01	100.0	
1A3bi	Road transport: Passenger cars	0.000	0.000	0.00	0.00	100.0	
1A3dii	National navigation (shipping)	0.001	0.001	0.00	0.00	100.0	

Hg **Level Assessment**

NFR	Sectors	%total 2020	Cumulative total	Key category
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	36.466	36.5	x
2C1	Iron and steel production	9.050	45.5	x
2K	Consumption of POPs and heavy metals (e.g. electrical and scientific equipment)	8.463	54.0	x
1B2d	Other fugitive emissions from energy production	6.985	61.0	x
1A1a	Public electricity and heat production	6.761	67.7	x
2D3a	Domestic solvent use including fungicides	4.739	72.5	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	4.663	77.1	x
1B2aiv	Fugitive emissions oil: Refining / storage	4.518	81.6	x
5C1bv	Cremation	3.359	85.0	
3F	Field burning of agricultural residues	2.859	87.9	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	2.742	90.6	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	2.238	92.8	
1A4bi	Residential: Stationary	1.758	94.6	
1A3bi	Road transport: Passenger cars	1.342	95.9	
5C1biii	Clinical waste incineration	1.004	96.9	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.527	97.5	
1A3bii	Road transport: Light duty vehicles	0.380	97.9	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.379	98.2	
1A3biii	Road transport: Heavy duty vehicles and buses	0.323	98.6	
1A4ai	Commercial/institutional: Stationary	0.319	98.9	
1A1b	Petroleum refining	0.295	99.2	
5E	Other waste (please specify in IIR)	0.192	99.4	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.131	99.5	
1A3dii	National navigation (shipping)	0.121	99.6	
5C1bi	Industrial waste incineration	0.121	99.7	
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.078	99.8	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.065	99.9	
1A3biv	Road transport: Mopeds & motorcycles	0.042	99.9	
1A3ai(i)	International aviation LTO (civil)	0.040	100.0	
1A3aii(i)	Domestic aviation LTO (civil)	0.021	100.0	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.015	100.0	
5A	Biological treatment of waste - Solid waste disposal on land	0.003	100.0	
2G	Other product use (please specify in the IIR)	0.002	100.0	

Hg **Trend Assessment (1990-2020)**

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
5C1biii	Clinical waste incineration	0.647	0.012	0.16	27.98	28.0	x
1A2d	Stationary combustion in manufacturing industries and	0.334	0.444	0.12	20.38	48.4	x
1A2gviii	Stationary combustion in manufacturing industries and	0.240	0.033	0.05	8.07	56.4	x
2C1	Iron and steel production	0.038	0.110	0.04	7.08	63.5	x
1B2d	Other fugitive emissions from energy production	0.002	0.085	0.04	6.69	70.2	x
1A2f	Stationary combustion in manufacturing industries and	0.207	0.057	0.03	4.76	74.9	x
1B2aiv	Fugitive emissions oil: Refining / storage	NO	0.055	0.03	4.38	79.3	x
1A2e	Stationary combustion in manufacturing industries and	0.145	0.027	0.03	4.32	83.7	x
1A2c	Stationary combustion in manufacturing industries and	0.103	0.005	0.02	4.22	87.9	
2K	Consumption of POPs and heavy metals (e.g. electrica	0.100	0.103	0.02	3.74	91.6	
5C1bv	Cremation	0.000	0.041	0.02	3.25	94.9	
2D3a	Domestic solvent use including fungicides	0.056	0.058	0.01	2.09	96.9	
1A3bi	Road transport: Passenger cars	0.011	0.016	0.00	0.79	97.7	
3F	Field burning of agricultural residues	0.046	0.035	0.00	0.72	98.5	
1A1a	Public electricity and heat production	0.153	0.082	0.00	0.31	98.8	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.004	0.006	0.00	0.31	99.1	
1A4bi	Residential: Stationary	0.033	0.021	0.00	0.24	99.3	
1A3bii	Road transport: Light duty vehicles	0.003	0.005	0.00	0.22	99.5	
5C1bi	Industrial waste incineration	0.001	0.001	0.00	0.06	99.6	
1A3biii	Road transport: Heavy duty vehicles and buses	0.006	0.004	0.00	0.06	99.7	
1A4ai	Commercial/institutional: Stationary	0.008	0.004	0.00	0.06	99.7	
1A2a	Stationary combustion in manufacturing industries and	0.000	0.001	0.00	0.06	99.8	
1A1b	Petroleum refining	0.005	0.004	0.00	0.05	99.8	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.000	0.001	0.00	0.05	99.9	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.004	0.002	0.00	0.04	99.9	
1A3dii	National navigation (shipping)	0.002	0.001	0.00	0.03	99.9	
1A3ai(i)	International aviation LTO (civil)	0.000	0.000	0.00	0.02	100.0	
5E	Other waste (please specify in IIR)	0.004	0.002	0.00	0.02	100.0	
1A3aii(i)	Domestic aviation LTO (civil)	0.000	0.000	0.00	0.01	100.0	
1A5b	Other, Mobile (including military, land based and recrea	0.000	0.000	0.00	0.00	100.0	
2G	Other product use (please specify in the IIR)	0.000	0.000	0.00	0.00	100.0	
1A3biv	Road transport: Mopeds & motorcycles	0.001	0.001	0.00	0.00	100.0	

As **Level Assessment**

NFR	Sectors	% total 2020	Cumulative total	Key category
2A3	Glass production	34.089	34.1	x
1A1a	Public electricity and heat production	23.126	57.2	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	20.963	78.2	x
1A4ci	Agriculture/Forestry/Fishing: Stationary	3.686	81.9	x
1A4ai	Commercial/institutional: Stationary	3.113	85.0	
2C1	Iron and steel production	2.404	87.4	
1A3dii	National navigation (shipping)	2.379	89.8	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	1.684	91.4	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	1.594	93.0	
1A3bvi	Road transport: Automobile tyre and brake wear	1.346	94.4	
1B2aiv	Fugitive emissions oil: Refining / storage	0.800	95.2	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.742	95.9	
1A4bi	Residential: Stationary	0.703	96.6	
1A1b	Petroleum refining	0.687	97.3	
3F	Field burning of agricultural residues	0.670	98.0	
2C5	Lead production	0.595	98.6	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	0.422	99.0	
1B2d	Other fugitive emissions from energy production	0.351	99.4	
5E	Other waste (please specify in IIR)	0.274	99.6	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.154	99.8	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.054	99.8	
2G	Other product use (please specify in the IIR)	0.035	99.9	
5C1bi	Industrial waste incineration	0.031	99.9	
1A3bi	Road transport: Passenger cars	0.030	99.9	
5C1bv	Cremation	0.027	100.0	
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.013	100.0	
2D3g	Chemical products	0.007	100.0	
1A3bii	Road transport: Light duty vehicles	0.006	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.005	100.0	
2C7a	Copper production	0.003	100.0	
1A3biv	Road transport: Mopeds & motorcycles	0.001	100.0	
1A3ai(i)	International aviation LTO (civil)	0.001	100.0	
5C1biii	Clinical waste incineration	0.001	100.0	

As **Trend Assessment (1990-2020)**

NFR	Sectors	1990	Last year	Trend assess.	% cont. to trend	Cumulative total	Key category
2A3	Glass production	0.158	0.468	0.12	32.79	32.8	x
1A1a	Public electricity and heat production	1.647	0.318	0.11	29.87	62.7	x
1A2f	Stationary combustion in manufacturing industries and	0.408	0.288	0.04	9.65	72.3	x
1A2gviii	Stationary combustion in manufacturing industries and	0.254	0.022	0.03	6.81	79.1	x
1A2c	Stationary combustion in manufacturing industries and	0.124	0.010	0.01	3.38	82.5	x
1A2e	Stationary combustion in manufacturing industries and	0.139	0.023	0.01	2.83	85.3	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.040	0.051	0.01	2.76	88.1	
2C1	Iron and steel production	0.147	0.033	0.01	2.29	90.4	
1A4ai	Commercial/institutional: Stationary	0.160	0.043	0.01	1.95	92.3	
1A2d	Stationary combustion in manufacturing industries and	0.054	0.006	0.00	1.34	93.7	
1A3dii	National navigation (shipping)	0.043	0.033	0.00	1.22	94.9	
1A1b	Petroleum refining	0.056	0.009	0.00	1.14	96.0	
1A3bvi	Road transport: Automobile tyre and brake wear	0.014	0.018	0.00	1.01	97.0	
1B2aiv	Fugitive emissions oil: Refining / storage	NO	0.011	0.00	0.89	97.9	
2C5	Lead production	0.004	0.008	0.00	0.54	98.5	
1B2d	Other fugitive emissions from energy production	0.000	0.005	0.00	0.39	98.8	
1A4bi	Residential: Stationary	0.013	0.010	0.00	0.34	99.2	
3F	Field burning of agricultural residues	0.012	0.009	0.00	0.33	99.5	
2C7a	Copper production	0.005	0.000	0.00	0.15	99.7	
5E	Other waste (please specify in IIR)	0.006	0.004	0.00	0.10	99.8	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.000	0.001	0.00	0.05	99.8	
5C1biii	Clinical waste incineration	0.001	0.000	0.00	0.05	99.9	
2G	Other product use (please specify in the IIR)	0.000	0.000	0.00	0.03	99.9	
5C1bv	Cremation	0.000	0.000	0.00	0.03	99.9	
5C1bi	Industrial waste incineration	0.000	0.000	0.00	0.02	100.0	
1A3bi	Road transport: Passenger cars	0.000	0.000	0.00	0.02	100.0	
2D3g	Chemical products	0.000	0.000	0.00	0.01	100.0	
1A2a	Stationary combustion in manufacturing industries and	0.000	0.000	0.00	0.01	100.0	
1A3bii	Road transport: Light duty vehicles	0.000	0.000	0.00	0.00	100.0	

Cr **Level Assessment**

NFR	Sectors	% total 2020	Cumulative total	Key category
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	42.969	43.0	x
1A4bi	Residential: Stationary	11.428	54.4	x
2A3	Glass production	9.111	63.5	x
1A3bvi	Road transport: Automobile tyre and brake wear	8.994	72.5	x
1A1a	Public electricity and heat production	8.002	80.5	x
1B2aiv	Fugitive emissions oil: Refining / storage	3.951	84.5	
2C1	Iron and steel production	3.358	87.8	
2G	Other product use (please specify in the IIR)	2.756	90.6	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	2.096	92.7	
1A4ci	Agriculture/Forestry/Fishing: Stationary	1.774	94.4	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.942	95.4	
1A1b	Petroleum refining	0.803	96.2	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.663	96.8	
1A4ai	Commercial/institutional: Stationary	0.585	97.4	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.551	98.0	
1A3dii	National navigation (shipping)	0.530	98.5	
3F	Field burning of agricultural residues	0.417	98.9	
1A3bi	Road transport: Passenger cars	0.305	99.2	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.216	99.5	
1A3biv	Road transport: Mopeds & motorcycles	0.149	99.6	
1A3bii	Road transport: Light duty vehicles	0.113	99.7	
1A3biii	Road transport: Heavy duty vehicles and buses	0.096	99.8	
5E	Other waste (please specify in IIR)	0.054	99.9	
5C1bi	Industrial waste incineration	0.052	99.9	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.040	100.0	
2D3g	Chemical products	0.017	100.0	
1A3c	Railways	0.007	100.0	
5C1bv	Cremation	0.006	100.0	
1A3ai(i)	International aviation LTO (civil)	0.005	100.0	
1A3aii(i)	Domestic aviation LTO (civil)	0.003	100.0	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.002	100.0	
5C1biii	Clinical waste incineration	0.002	100.0	
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.001	100.0	

Cr **Trend Assessment (1990-2020)**

NFR	Sectors	1990	Last year	Trend assess.	% cont. to trend	Cumulative total	Key category
1A1a	Public electricity and heat production	3.864	0.525	0.13	29.71	29.7	x
1A2f	Stationary combustion in manufacturing industries and	2.793	2.819	0.11	24.19	53.9	x
2A3	Glass production	0.199	0.598	0.04	9.15	63.0	x
1A2gviii	Stationary combustion in manufacturing industries and	0.734	0.036	0.03	6.83	69.9	x
1A3bvi	Road transport: Automobile tyre and brake wear	0.468	0.590	0.03	6.26	76.1	x
1B2aiv	Fugitive emissions oil: Refining / storage	NO	0.259	0.02	4.85	81.0	x
2C1	Iron and steel production	0.822	0.220	0.02	4.28	85.3	
1A2e	Stationary combustion in manufacturing industries and	0.386	0.062	0.01	2.80	88.1	
1A2c	Stationary combustion in manufacturing industries and	0.349	0.043	0.01	2.76	90.8	
2G	Other product use (please specify in the IIR)	0.129	0.181	0.01	2.06	92.9	
1A2d	Stationary combustion in manufacturing industries and	0.403	0.138	0.01	1.55	94.4	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.071	0.116	0.01	1.45	95.9	
1A1b	Petroleum refining	0.233	0.053	0.01	1.40	97.3	
1A4bi	Residential: Stationary	1.238	0.750	0.01	1.37	98.6	
1A3bi	Road transport: Passenger cars	0.009	0.020	0.00	0.28	98.9	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.006	0.014	0.00	0.20	99.1	
1A3dii	National navigation (shipping)	0.045	0.035	0.00	0.19	99.3	
1A3biv	Road transport: Mopeds & motorcycles	0.034	0.010	0.00	0.17	99.5	
3F	Field burning of agricultural residues	0.036	0.027	0.00	0.14	99.6	
1A4ai	Commercial/institutional: Stationary	0.080	0.038	0.00	0.10	99.7	
1A3bii	Road transport: Light duty vehicles	0.005	0.007	0.00	0.09	99.8	
5C1biii	Clinical waste incineration	0.005	0.000	0.00	0.05	99.9	
5C1bi	Industrial waste incineration	0.003	0.003	0.00	0.03	99.9	
1A3biii	Road transport: Heavy duty vehicles and buses	0.009	0.006	0.00	0.02	99.9	
1A3c	Railways	0.003	0.000	0.00	0.02	99.9	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.006	0.003	0.00	0.02	100.0	
2D3g	Chemical products	0.001	0.001	0.00	0.01	100.0	
5E	Other waste (please specify in IIR)	0.006	0.004	0.00	0.01	100.0	
5C1bv	Cremation	0.000	0.000	0.00	0.01	100.0	

Cu **Level Assessment**

NFR	Sectors	% total 2020	Cumulative total	Key category
1A3bvi	Road transport: Automobile tyre and brake wear	50.620	50.6	x
2G	Other product use (please specify in the IIR)	28.867	79.5	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	6.849	86.3	x
1A4ci	Agriculture/Forestry/Fishing: Stationary	2.776	89.1	
1A4ai	Commercial/institutional: Stationary	2.427	91.5	
1A1a	Public electricity and heat production	2.151	93.7	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	1.833	95.5	
1A3biv	Road transport: Mopeds & motorcycles	1.493	97.0	
1A4bi	Residential: Stationary	0.767	97.8	
1B2aiv	Fugitive emissions oil: Refining / storage	0.431	98.2	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.322	98.5	
1A3dii	National navigation (shipping)	0.292	98.8	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.183	99.0	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.173	99.2	
2C1	Iron and steel production	0.173	99.4	
1A1b	Petroleum refining	0.167	99.5	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.152	99.7	
3F	Field burning of agricultural residues	0.096	99.8	
1A3c	Railways	0.058	99.8	
1A3bi	Road transport: Passenger cars	0.053	99.9	
5E	Other waste (please specify in IIR)	0.033	99.9	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.027	99.9	
1A3bii	Road transport: Light duty vehicles	0.019	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.017	100.0	
5C1biii	Clinical waste incineration	0.007	100.0	
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.007	100.0	
2C7a	Copper production	0.002	100.0	
5C1bv	Cremation	0.001	100.0	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.001	100.0	
1A3ai(i)	International aviation LTO (civil)	0.001	100.0	
1A3aii(i)	Domestic aviation LTO (civil)	0.001	100.0	

Cu **Trend Assessment (1990-2020)**

NFR	Sectors	1990	Last year	Trend assess.	% cont. to trend	Cumulative total	Key category
1A3bvi	Road transport: Automobile tyre and brake wear	10.244	12.908	0.11	26.51	26.5	x
2G	Other product use (please specify in the IIR)	5.246	7.361	0.09	20.24	46.8	x
1A4ai	Commercial/institutional: Stationary	2.402	0.619	0.06	15.14	61.9	x
1A1a	Public electricity and heat production	2.154	0.548	0.06	13.63	75.5	x
1A3biv	Road transport: Mopeds & motorcycles	1.371	0.381	0.04	8.40	83.9	x
1A2f	Stationary combustion in manufacturing industries and	2.159	1.747	0.01	3.05	87.0	
1A2gviii	Stationary combustion in manufacturing industries and	0.379	0.082	0.01	2.53	89.5	
1A2e	Stationary combustion in manufacturing industries and	0.215	0.044	0.01	1.45	91.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.574	0.708	0.01	1.35	92.3	
1A2c	Stationary combustion in manufacturing industries and	0.192	0.039	0.01	1.31	93.6	
1A1b	Petroleum refining	0.187	0.043	0.01	1.23	94.8	
1A4bi	Residential: Stationary	0.323	0.195	0.00	1.04	95.9	
1B2aiv	Fugitive emissions oil: Refining / storage	NO	0.110	0.00	0.98	96.9	
1A2d	Stationary combustion in manufacturing industries and	0.392	0.467	0.00	0.78	97.6	
1A3c	Railways	0.095	0.015	0.00	0.69	98.3	
2C7a	Copper production	0.065	0.001	0.00	0.55	98.9	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.111	0.047	0.00	0.54	99.4	
1A3dii	National navigation (shipping)	0.097	0.074	0.00	0.17	99.6	
2C1	Iron and steel production	0.031	0.044	0.00	0.12	99.7	
1A3bi	Road transport: Passenger cars	0.006	0.014	0.00	0.07	99.8	
3F	Field burning of agricultural residues	0.032	0.024	0.00	0.06	99.8	
5C1biii	Clinical waste incineration	0.007	0.002	0.00	0.05	99.9	
5E	Other waste (please specify in IIR)	0.013	0.008	0.00	0.04	99.9	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.003	0.007	0.00	0.04	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.006	0.004	0.00	0.02	100.0	
1A3bii	Road transport: Light duty vehicles	0.003	0.005	0.00	0.01	100.0	
1A2gvii	Mobile Combustion in manufacturing industries and cor	0.001	0.002	0.00	0.00	100.0	
5C1bv	Cremation	0.000	0.000	0.00	0.00	100.0	
1A2a	Stationary combustion in manufacturing industries and	0.000	0.000	0.00	0.00	100.0	

Ni **Level Assessment**

NFR	Sectors	% total 2020	Cumulative total	Key category
1A1a	Public electricity and heat production	27.608	27.6	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	19.824	47.4	x
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	10.124	57.6	x
1A4ci	Agriculture/Forestry/Fishing: Stationary	8.149	65.7	x
2C1	Iron and steel production	7.803	73.5	x
1A3dii	National navigation (shipping)	7.707	81.2	x
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	4.265	85.5	
1A4ai	Commercial/institutional: Stationary	3.116	88.6	
1B2aiv	Fugitive emissions oil: Refining / storage	2.425	91.0	
2A3	Glass production	1.962	93.0	
2G	Other product use (please specify in the IIR)	1.791	94.8	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	1.657	96.4	
1A1b	Petroleum refining	1.499	97.9	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.658	98.6	
1A3bvi	Road transport: Automobile tyre and brake wear	0.477	99.1	
1A4bi	Residential: Stationary	0.331	99.4	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.268	99.7	
3F	Field burning of agricultural residues	0.080	99.7	
1A3biv	Road transport: Mopeds & motorcycles	0.080	99.8	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.079	99.9	
2D3g	Chemical products	0.048	99.9	
5C1bi	Industrial waste incineration	0.019	100.0	
5C1biii	Clinical waste incineration	0.011	100.0	
1A3bi	Road transport: Passenger cars	0.011	100.0	
1A3c	Railways	0.003	100.0	
5C1bv	Cremation	0.002	100.0	
1A3bii	Road transport: Light duty vehicles	0.001	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.001	100.0	
1A3ai(i)	International aviation LTO (civil)	0.001	100.0	
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.000	100.0	

Ni **Trend Assessment (1990-2020)**

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
1A1a	Public electricity and heat production	55.847	5.456	0.04	23.95	23.9	x
1A2f	Stationary combustion in manufacturing industries and	6.002	3.917	0.03	15.34	39.3	x
1A1b	Petroleum refining	13.302	0.296	0.02	11.10	50.4	x
1A2gviii	Stationary combustion in manufacturing industries and	11.262	0.130	0.02	10.05	60.4	x
2C1	Iron and steel production	0.361	1.542	0.01	7.95	68.4	x
1A4ci	Agriculture/Forestry/Fishing: Stationary	1.092	1.610	0.01	7.62	76.0	x
1A3dii	National navigation (shipping)	1.983	1.523	0.01	6.30	82.3	x
1A2d	Stationary combustion in manufacturing industries and	6.351	2.001	0.01	4.70	87.0	
1A2c	Stationary combustion in manufacturing industries and	5.529	0.328	0.01	3.51	90.5	
1B2aiv	Fugitive emissions oil: Refining / storage	NO	0.479	0.00	2.58	93.1	
2A3	Glass production	0.192	0.388	0.00	1.90	95.0	
2G	Other product use (please specify in the IIR)	0.227	0.354	0.00	1.69	96.7	
1A2e	Stationary combustion in manufacturing industries and	5.995	0.843	0.00	1.19	97.9	
1A4ai	Commercial/institutional: Stationary	2.402	0.616	0.00	1.02	98.9	
1A3bvi	Road transport: Automobile tyre and brake wear	0.073	0.094	0.00	0.44	99.3	
1A4bi	Residential: Stationary	0.108	0.065	0.00	0.25	99.6	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.127	0.053	0.00	0.16	99.7	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.007	0.016	0.00	0.08	99.8	
3F	Field burning of agricultural residues	0.021	0.016	0.00	0.07	99.9	
2D3g	Chemical products	0.005	0.009	0.00	0.05	99.9	
1A3biv	Road transport: Mopeds & motorcycles	0.056	0.016	0.00	0.03	100.0	
5C1bi	Industrial waste incineration	0.003	0.004	0.00	0.02	100.0	
1A3bi	Road transport: Passenger cars	0.003	0.002	0.00	0.01	100.0	
5C1biii	Clinical waste incineration	0.004	0.002	0.00	0.01	100.0	
5C1bv	Cremation	0.000	0.000	0.00	0.00	100.0	
1A3bii	Road transport: Light duty vehicles	0.000	0.000	0.00	0.00	100.0	
1A3ai(i)	International aviation LTO (civil)	0.000	0.000	0.00	0.00	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.000	0.000	0.00	0.00	100.0	
1A3c	Railways	0.004	0.001	0.00	0.00	100.0	

Se **Level Assessment**

NFR	Sectors	% total 2020	Cumulative total	Key category
2A3	Glass production	76.481	76.5	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	13.700	90.2	x
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	3.099	93.3	
1A1a	Public electricity and heat production	2.170	95.5	
2G	Other product use (please specify in the IIR)	1.307	96.8	
1A4bi	Residential: Stationary	0.524	97.3	
1A3bvi	Road transport: Automobile tyre and brake wear	0.414	97.7	
1A3dii	National navigation (shipping)	0.368	98.1	
1B2aiv	Fugitive emissions oil: Refining / storage	0.347	98.4	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.341	98.8	
3F	Field burning of agricultural residues	0.278	99.0	
1A1b	Petroleum refining	0.263	99.3	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.240	99.5	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.167	99.7	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.157	99.9	
1A3biv	Road transport: Mopeds & motorcycles	0.070	99.9	
1A4ai	Commercial/institutional: Stationary	0.017	99.9	
5C1bv	Cremation	0.017	100.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.013	100.0	
1A3bi	Road transport: Passenger cars	0.011	100.0	
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.003	100.0	
2D3g	Chemical products	0.003	100.0	
1A3bii	Road transport: Light duty vehicles	0.003	100.0	
1A3c	Railways	0.003	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.002	100.0	
1A3ai(i)	International aviation LTO (civil)	0.000	100.0	

Se **Trend Assessment (1990-2020)**

NFR	Sectors	1990	Last year	Trend assess.	% cont. to trend	Cumulative total	Key category
2A3	Glass production	0.791	2.423	0.58	49.92	49.9	x
1A2f	Stationary combustion in manufacturing industries and	0.603	0.434	0.29	25.20	75.1	x
1A1a	Public electricity and heat production	0.201	0.069	0.14	11.79	86.9	x
1A2gviii	Stationary combustion in manufacturing industries and	0.041	0.011	0.03	2.55	89.5	
1A1b	Petroleum refining	0.034	0.008	0.02	2.11	91.6	
1A2c	Stationary combustion in manufacturing industries and	0.029	0.008	0.02	1.83	93.4	
1A2e	Stationary combustion in manufacturing industries and	0.024	0.005	0.02	1.52	94.9	
1A4bi	Residential: Stationary	0.027	0.017	0.01	1.27	96.2	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.013	0.005	0.01	0.70	96.9	
1A3dii	National navigation (shipping)	0.015	0.012	0.01	0.60	97.5	
1A3biv	Road transport: Mopeds & motorcycles	0.008	0.002	0.01	0.49	98.0	
1B2aiv	Fugitive emissions oil: Refining / storage	NO	0.011	0.01	0.49	98.5	
3F	Field burning of agricultural residues	0.012	0.009	0.01	0.47	98.9	
1A2d	Stationary combustion in manufacturing industries and	0.066	0.098	0.01	0.46	99.4	
2G	Other product use (please specify in the IIR)	0.030	0.041	0.00	0.38	99.8	
1A3bvi	Road transport: Automobile tyre and brake wear	0.009	0.013	0.00	0.11	99.9	
1A3c	Railways	0.001	0.000	0.00	0.04	99.9	
5C1bv	Cremation	0.000	0.001	0.00	0.02	100.0	
1A4ai	Commercial/institutional: Stationary	0.000	0.001	0.00	0.02	100.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.000	0.000	0.00	0.01	100.0	
1A2a	Stationary combustion in manufacturing industries and	0.000	0.000	0.00	0.01	100.0	

Zn **Level Assessment**

NFR	Sectors	% total 2020	Cumulative total	Key category
1A4bi	Residential: Stationary	32.403	32.4	x
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	16.426	48.8	x
2C1	Iron and steel production	15.404	64.2	x
1A3bvi	Road transport: Automobile tyre and brake wear	10.083	74.3	x
2G	Other product use (please specify in the IIR)	8.260	82.6	x
1A1a	Public electricity and heat production	7.759	90.3	
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	2.491	92.8	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	1.642	94.5	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	1.038	95.5	
1A1b	Petroleum refining	0.914	96.4	
1A4ai	Commercial/institutional: Stationary	0.815	97.2	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.770	98.0	
1A3biv	Road transport: Mopeds & motorcycles	0.431	98.4	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.416	98.9	
3F	Field burning of agricultural residues	0.410	99.3	
1B2aiv	Fugitive emissions oil: Refining / storage	0.183	99.4	
1A3dii	National navigation (shipping)	0.151	99.6	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.123	99.7	
1A3bi	Road transport: Passenger cars	0.113	99.8	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.070	99.9	
1A3bii	Road transport: Light duty vehicles	0.031	99.9	
1A3biii	Road transport: Heavy duty vehicles and buses	0.026	100.0	
1A3c	Railways	0.017	100.0	
5C1bv	Cremation	0.009	100.0	
1A3ai(i)	International aviation LTO (civil)	0.004	100.0	
2C5	Lead production	0.003	100.0	
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.002	100.0	
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.002	100.0	
1A3aii(i)	Domestic aviation LTO (civil)	0.002	100.0	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.001	100.0	

Zn **Trend Assessment (1990-2020)**

NFR	Sectors	1990	Last year	Trend assess.	% cont. to trend	Cumulative total	Key category
1A4bi	Residential: Stationary	27.549	16.681	0.13	28.67	28.7	x
2C1	Iron and steel production	2.866	7.930	0.09	19.74	48.4	x
1A2d	Stationary combustion in manufacturing industries and	4.749	8.456	0.07	15.53	63.9	x
1A2f	Stationary combustion in manufacturing industries and	3.596	1.282	0.03	7.02	71.0	x
1A3bvi	Road transport: Automobile tyre and brake wear	3.752	5.190	0.03	6.80	77.8	x
2G	Other product use (please specify in the IIR)	3.034	4.252	0.03	5.70	83.5	x
1A1a	Public electricity and heat production	5.926	3.994	0.02	4.68	88.1	
1A2e	Stationary combustion in manufacturing industries and	1.082	0.397	0.01	2.07	90.2	
1A3biv	Road transport: Mopeds & motorcycles	0.797	0.222	0.01	1.78	92.0	
1A1b	Petroleum refining	1.029	0.470	0.01	1.63	93.6	
1A2c	Stationary combustion in manufacturing industries and	1.098	0.535	0.01	1.62	95.3	
1A2gviii	Stationary combustion in manufacturing industries and	1.447	0.845	0.01	1.62	96.9	
1A4ai	Commercial/institutional: Stationary	0.080	0.419	0.01	1.28	98.2	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.061	0.214	0.00	0.59	98.7	
1B2aiv	Fugitive emissions oil: Refining / storage	NO	0.094	0.00	0.35	99.1	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.152	0.064	0.00	0.26	99.4	
1A3c	Railways	0.056	0.009	0.00	0.15	99.5	
3F	Field burning of agricultural residues	0.280	0.211	0.00	0.14	99.6	
1A2a	Stationary combustion in manufacturing industries and	0.032	0.001	0.00	0.10	99.7	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.016	0.036	0.00	0.08	99.8	
1A3bi	Road transport: Passenger cars	0.043	0.058	0.00	0.07	99.9	
1A3dii	National navigation (shipping)	0.101	0.078	0.00	0.04	99.9	
1A3bii	Road transport: Light duty vehicles	0.012	0.016	0.00	0.02	100.0	
5C1bv	Cremation	0.000	0.004	0.00	0.02	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.019	0.013	0.00	0.01	100.0	
2C5	Lead production	0.001	0.001	0.00	0.00	100.0	
1A3ai(i)	International aviation LTO (civil)	0.001	0.002	0.00	0.00	100.0	
1A2gvii	Mobile Combustion in manufacturing industries and cor	0.001	0.001	0.00	0.00	100.0	
1A3aii(i)	Domestic aviation LTO (civil)	0.001	0.001	0.00	0.00	100.0	
1A5b	Other, Mobile (including military, land based and recrea	0.001	0.001	0.00	0.00	100.0	

Diox **Level Assessment**

NFR	Sectors	% total 2020	Cumulative total	Key category
2D3i	Other solvent use (please specify in the IIR)	32.39	32.4	x
1A4bi	Residential: Stationary	27.90	60.3	x
5C1bi	Industrial waste incineration	13.02	73.3	x
2C1	Iron and steel production	9.35	82.7	x
5E	Other waste (please specify in IIR)	5.71	88.4	
5C1biii	Clinical waste incineration	4.29	92.7	
1A1a	Public electricity and heat production	2.55	95.2	
1A3bi	Road transport: Passenger cars	1.68	96.9	
1A3bii	Road transport: Light duty vehicles	0.67	97.6	
2C3	Aluminium production	0.55	98.1	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	0.51	98.6	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.26	98.9	
3F	Field burning of agricultural residues	0.23	99.1	
1A3biii	Road transport: Heavy duty vehicles and buses	0.17	99.3	
1A4ai	Commercial/institutional: Stationary	0.15	99.4	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.13	99.6	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.10	99.7	
2C5	Lead production	0.10	99.8	
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	0.09	99.9	
1B2aiv	Fugitive emissions oil: Refining / storage	0.08	99.9	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.02	99.9	
1A3biv	Road transport: Mopeds & motorcycles	0.02	100.0	
1A1b	Petroleum refining	0.01	100.0	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.01	100.0	

Diox **Trend Assessment (1990-2020)**

NFR	Sectors	1990	Last year	Trend assess.	% cont. to trend	Cumulative total	Key category
5C1biii	Clinical waste incineration	482.30	3.03	0.11	49.92	49.9	x
2D3i	Other solvent use (please specify in the IIR)	4.58	22.88	0.04	18.91	68.8	x
1A4bi	Residential: Stationary	40.05	19.71	0.03	12.36	81.2	x
5C1bi	Industrial waste incineration	7.76	9.20	0.01	6.96	88.1	
2C1	Iron and steel production	4.21	6.61	0.01	5.15	93.3	
5E	Other waste (please specify in IIR)	6.38	4.03	0.01	2.73	96.0	
1A1a	Public electricity and heat production	1.05	1.80	0.00	1.41	97.4	
1A3bi	Road transport: Passenger cars	0.61	1.19	0.00	0.94	98.4	
1A3bii	Road transport: Light duty vehicles	0.03	0.48	0.00	0.40	98.8	
2C3	Aluminium production	0.40	0.39	0.00	0.29	99.1	
1A2d	Stationary combustion in manufacturing industries and	0.28	0.36	0.00	0.28	99.3	
1A2gviii	Stationary combustion in manufacturing industries and	0.20	0.18	0.00	0.13	99.5	
3F	Field burning of agricultural residues	0.21	0.16	0.00	0.11	99.6	
1A3biii	Road transport: Heavy duty vehicles and buses	0.21	0.12	0.00	0.08	99.7	
1A4ai	Commercial/institutional: Stationary	0.08	0.11	0.00	0.08	99.7	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.05	0.09	0.00	0.07	99.8	
2C5	Lead production	0.03	0.07	0.00	0.06	99.9	
1B2aiv	Fugitive emissions oil: Refining / storage	0.06	0.05	0.00	0.04	99.9	
1A2e	Stationary combustion in manufacturing industries and	0.22	0.07	0.00	0.04	99.9	
1A2f	Stationary combustion in manufacturing industries and	0.64	0.06	0.00	0.02	100.0	
2C7a	Copper production	0.12	0.00	0.00	0.01	100.0	
1A3biv	Road transport: Mopeds & motorcycles	0.04	0.01	0.00	0.01	100.0	
1A1b	Petroleum refining	0.03	0.01	0.00	0.01	100.0	
1A2c	Stationary combustion in manufacturing industries and	0.07	0.01	0.00	0.00	100.0	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.02	0.01	0.00	0.00	100.0	

Total PAH Level Assessment

NFR	Sectors	% total 2020	Cumulative total	Key category
2D3i	Other solvent use (please specify in the IIR)	45.77	45.8	x
1A4bi	Residential: Stationary	38.19	84.0	x
2C1	Iron and steel production	4.60	88.6	
3F	Field burning of agricultural residues	2.88	91.4	
2D3g	Chemical products	2.10	93.5	
1A2gviii	Stationary combustion in manufacturing industries and constructic	1.32	94.9	
1A3bi	Road transport: Passenger cars	0.95	95.8	
1A2e	Stationary combustion in manufacturing industries and constructic	0.62	96.4	
1A3dii	National navigation (shipping)	0.56	97.0	
1A2f	Stationary combustion in manufacturing industries and constructic	0.54	97.5	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.50	98.0	
1A2d	Stationary combustion in manufacturing industries and constructic	0.47	98.5	
1A3bii	Road transport: Light duty vehicles	0.37	98.9	
1A4ai	Commercial/institutional: Stationary	0.35	99.2	
1A2c	Stationary combustion in manufacturing industries and constructic	0.27	99.5	
1A3biii	Road transport: Heavy duty vehicles and buses	0.24	99.8	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machiner	0.05	99.8	
1A1a	Public electricity and heat production	0.05	99.9	
1A2a	Stationary combustion in manufacturing industries and constructic	0.04	99.9	
1A3bvi	Road transport: Automobile tyre and brake wear	0.04	99.9	
2G	Other product use (please specify in the IIR)	0.02	100.0	
1A2gvii	Mobile Combustion in manufacturing industries and construction: (	0.02	100.0	
1B2aiv	Fugitive emissions oil: Refining / storage	0.01	100.0	
1A3biv	Road transport: Mopeds & motorcycles	0.01	100.0	

Total PAH Trend Assessment (1990-2020)

NFR	Sectors	1990	Last year	Trend assess.	% cont. to trend	Cumulative total	Key category
2D3i	Other solvent use (please specify in the IIR)	2.11	10.52	0.34	46.76	46.8	x
1A4bi	Residential: Stationary	18.35	8.78	0.31	43.00	89.8	x
1A2f	Stationary combustion in manufacturing industries and	0.59	0.12	0.02	2.23	92.0	
2D3g	Chemical products	0.28	0.48	0.01	1.26	93.3	
1A2gviii	Stationary combustion in manufacturing industries and	0.58	0.30	0.01	1.20	94.5	
1A2e	Stationary combustion in manufacturing industries and	0.35	0.14	0.01	0.95	95.4	
1A2c	Stationary combustion in manufacturing industries and	0.24	0.06	0.01	0.86	96.3	
1A3bi	Road transport: Passenger cars	0.07	0.22	0.01	0.86	97.1	
3F	Field burning of agricultural residues	0.85	0.66	0.00	0.61	97.7	
1A4ai	Commercial/institutional: Stationary	0.21	0.08	0.00	0.59	98.3	
2C1	Iron and steel production	1.05	1.06	0.00	0.57	98.9	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.07	0.11	0.00	0.29	99.2	
1A3bii	Road transport: Light duty vehicles	0.05	0.09	0.00	0.23	99.4	
1A2d	Stationary combustion in manufacturing industries and	0.09	0.11	0.00	0.15	99.6	
1A3dii	National navigation (shipping)	0.17	0.13	0.00	0.13	99.7	
1A2a	Stationary combustion in manufacturing industries and	0.03	0.01	0.00	0.08	99.8	
1A3biii	Road transport: Heavy duty vehicles and buses	0.05	0.06	0.00	0.08	99.9	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.01	0.01	0.00	0.02	99.9	
1A1a	Public electricity and heat production	0.01	0.01	0.00	0.02	99.9	
2G	Other product use (please specify in the IIR)	0.00	0.00	0.00	0.02	99.9	
1A3c	Railways	0.00	0.00	0.00	0.02	100.0	
1A3bvi	Road transport: Automobile tyre and brake wear	0.01	0.01	0.00	0.02	100.0	
1B2aiv	Fugitive emissions oil: Refining / storage	NO	0.00	0.00	0.01	100.0	
1A3biv	Road transport: Mopeds & motorcycles	0.00	0.00	0.00	0.01	100.0	
1A2gvii	Mobile Combustion in manufacturing industries and cor	0.01	0.00	0.00	0.01	100.0	

HCB Level Assessment

NFR	Sectors	% total 2020	Cumulative total	Key category
5C1biii	Clinical waste incineration	59.10	59.1	x
1A1a	Public electricity and heat production	18.59	77.7	x
1A4bi	Residential: Stationary	12.70	90.4	x
5C1bi	Industrial waste incineration	4.10	94.5	
1A2d	Stationary combustion in manufacturing industries and constructic	2.39	96.9	
1A2gviii	Stationary combustion in manufacturing industries and constructic	1.33	98.2	
1A2e	Stationary combustion in manufacturing industries and constructic	0.50	98.7	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.33	99.0	
5C1bv	Cremation	0.32	99.4	
1A4ai	Commercial/institutional: Stationary	0.30	99.7	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.12	99.8	
1A3bi	Road transport: Passenger cars	0.09	99.9	
1A2c	Stationary combustion in manufacturing industries and constructic	0.08	99.9	
1A3bii	Road transport: Light duty vehicles	0.04	100.0	
3Df	Use of pesticides	0.01	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.01	100.0	
1A3biv	Road transport: Mopeds & motorcycles	0.00	100.0	
1A1b	Petroleum refining	0.00	100.0	

HCB Trend Assessment (1990-2020)

NFR	Sectors	1990	Last year	Trend assess.	% cont. to trend	Cumulative total	Key category
5C1biii	Clinical waste incineration	1.21	0.76	0.01	57.65	57.6	x
1A1a	Public electricity and heat production	0.57	0.24	0.00	17.82	75.5	x
1A4bi	Residential: Stationary	0.27	0.16	0.00	12.37	87.8	x
5C1bi	Industrial waste incineration	0.04	0.05	0.00	4.06	91.9	
3Df	Use of pesticides	1.61	0.00	0.00	2.68	94.6	
1A2d	Stationary combustion in manufacturing industries and	0.03	0.03	0.00	2.37	96.9	
1A2gviii	Stationary combustion in manufacturing industries and	0.02	0.02	0.00	1.31	98.3	
1A2e	Stationary combustion in manufacturing industries and	0.02	0.01	0.00	0.47	98.7	
5C1bv	Cremation	0.00	0.00	0.00	0.32	99.1	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.01	0.00	0.00	0.32	99.4	
1A4ai	Commercial/institutional: Stationary	NO	0.00	0.00	0.31	99.7	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.00	0.00	0.00	0.12	99.8	
1A3bi	Road transport: Passenger cars	0.00	0.00	0.00	0.09	99.9	
1A2c	Stationary combustion in manufacturing industries and	0.01	0.00	0.00	0.07	100.0	
1A3bii	Road transport: Light duty vehicles	0.00	0.00	0.00	0.04	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.00	0.00	0.00	0.01	100.0	

PCBs **Level Assessment**

NFR	Sectors	% total 2020	Cumulative total	Key category
5C1bi	Industrial waste incineration	75.78	75.8	x
2K	Consumption of POPs and heavy metals (e.g. electrical and scien	17.72	93.5	x
2C1	Iron and steel production	6.12	99.6	
5C1biii	Clinical waste incineration	0.20	99.8	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.092	99.9	
1A2gviii	Stationary combustion in manufacturing industries and constructic	0.04	99.9	
1A1a	Public electricity and heat production	0.03	100.0	
5C1bv	Cremation	0.01	100.0	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.01	100.0	
1A4bi	Residential: Stationary	0.002	100.0	
1A2d	Stationary combustion in manufacturing industries and constructic	0.00	100.0	

PCBs **Trend Assessment (1990-2020)**

NFR	Sectors	1990	Last year	Trend assess.	% cont. to trend	Cumulative total	Key category
2K	Consumption of POPs and heavy metals (e.g. electrica	998.32	15.95	0.07	50.00	50.0	x
5C1bi	Industrial waste incineration	57.55	68.22	0.06	45.95	95.9	x
2C1	Iron and steel production	2.74	5.51	0.00	3.83	99.8	
5C1biii	Clinical waste incineration	0.28	0.18	0.00	0.11	99.9	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.06	0.08	0.00	0.06	99.9	
1A2gviii	Stationary combustion in manufacturing industries and	0.10	0.04	0.00	0.02	100.0	
1A1a	Public electricity and heat production	0.00	0.03	0.00	0.02	100.0	
5C1bv	Cremation	0.00	0.01	0.00	0.01	100.0	
1A2c	Stationary combustion in manufacturing industries and	0.07	0.00	0.00	0.00	100.0	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.02	0.01	0.00	0.00	100.0	

Annex B: Energy Balance

Updated: March 2022

Table B-1: Energy Balance Sheet for 2020

BALANÇO ENERGÉTICO tep 2020 provisório		Hulha e Antracite 1	Coque de Carvão 2	Total de Carvão 3 = 1 + 2	Petróleo Bruto 4	Refugos e Produtos Intermédios 5	GPL 6	Gasolinas 7	Petróleos 8	Jets 9	Gasóleo 10	Fuelóleo 11	Nafta 12	Coque de Petróleo 13	Total de Petróleo Energético 14 = 4 a 13	Lubrificantes 15	Asfaltos 16	Parafinas 17	Solventes 18	Outros 19	Total de Petróleo Não Energético 20 = 15 a 19	Total de Petróleo 21= 14 + 20	Gás Natural 22
IMPORTAÇÕES	01	3 924	7 430	**11 354**	11 015 837	898 844	833 972	203 161	317	2 041	946 536	246 119	209 770	240 365	**14 596 962**	38 269	116 386	3 580	4 164		**162 399**	**14 759 361**	**5 154 080**
PRODUÇÃO DOMÉSTICA	02																						
VARIAÇÃO DE "STOCKS"	03	- 604 233	1 651	**- 602 582**	- 192 237	- 32 036	15 939	- 11 506	19	- 39 750	63 186	- 5 485	- 4 528	- 34 840	**- 241 238**	- 3 083	2 002	- 82	- 1 094	10 741	**8 484**	**- 232 754**	**- 37 445**
SAÍDAS	04	48 195	28	**48 223**		153 800	37 765	1 330 206		524 093	1 468 904	2 069 082	578 650		**6 162 500**	129 675	79 946	4 149	10 534	110 283	**334 587**	**6 497 087**	
Exportações	*04.01*	*48 195*	*28*	*48 223*		*153 800*	*37 765*	*1 330 206*		*1 018*	*1 326 644*	*1 528 281*	*578 650*		*4 956 364*	*129 175*	*79 946*	*4 149*	*10 534*	*110 283*	*334 087*	*5 290 451*	
Transportes Marítimos Internacionais	*04.02*										*142 260*	*540 801*			*683 061*	*500*					*500*	*683 561*	
Aviação Internacional	*04.03*									*523 075*					*523 075*							*523 075*	
CONSUMO DE ENERGIA PRIMÁRIA	05	559 962	5 751	**565 713**	11 208 074	777 080	780 268	-1 115 539	298	- 482 302	- 585 554	-1 817 478	- 364 352	275 205	**8 675 700**	- 88 323	34 438	- 487	- 5 276	- 121 024	**- 180 672**	**8 495 028**	**5 191 525**
PARA NOVAS FORMAS DE ENERGIA	06	556 078		**556 078**	11 219 363	229 615	- 94 443	-2 052 106	- 228	- 604 306	-5 123 941	-2 068 115	- 889 297		**616 542**	- 137 335	- 176 526	- 6 183	- 12 558	- 125 658	**- 458 260**	**158 282**	**3 399 328**
Briquetes	*06.01*																						
Coque	*06.02*																						
Produtos de Petróleo	*06.03*				*11 219 363*	*341 764*	*- 177 500*	*-2 052 106*	*- 228*	*- 604 306*	*-5 140 572*	*-2 307 900*	*- 998 710*		*279 805*	*- 137 335*	*- 176 526*	*- 6 183*	*- 12 558*	*- 125 658*	*- 458 260*	*- 178 455*	
Hidrogénio	*06.04*																						*185 891*
Petroquímica	*06.05*					*- 123 718*	*83 057*						*109 413*		*68 752*							*68 752*	
Eletricidade	*06.06*	*556 078*		*556 078*							*16 607*	*142 814*			*159 421*							*159 421*	*1 962 779*
Cogeração	*06.07*					*11 569*					*24*	*96 971*			*108 564*							*108 564*	*1 250 658*
Produção de Eletricidade	*06.07.01*										*24*	*41 830*			*41 854*							*41 854*	
Refinação de Petróleo	*06.07.02*					*11 569*									*11 569*							*11 569*	*439 542*
Gás de Cidade	*06.07.03*																						
Agricultura	*06.07.04*																						*7 571*
Alimentação, bebidas e tabaco	*06.07.05*											*10 866*			*10 866*							*10 866*	*76 441*
Têxteis	*06.07.06*																						*125 449*
Papel e Artigos de Papel	*06.07.07*											*21 402*			*21 402*							*21 402*	*346 722*
Químicas e Plásticos	*06.07.08*											*22 873*			*22 873*							*22 873*	*119 461*
Cerâmicas	*06.07.09*																						*25 073*
Vidro e Artigos de Vidro	*06.07.10*																						
Cimento e Cal	*06.07.11*																						*3 310*
Metalúrgicas	*06.07.12*																						
Siderurgia	*06.07.13*																						
Vestuário, Calçado e Curtumes	*06.07.14*																						*7 432*
Madeira e Artigos de Madeira	*06.07.15*																						
Borracha	*06.07.16*																						*10 588*
Metálo-eletro-mecânicas	*06.07.17*																						*1 986*
Outras Indústrias Transformadoras	*06.07.18*																						*2 066*
Indústrias Extrativas	*06.07.19*																						*14 416*
Serviços	*06.07.20*																						*70 601*

BALANÇO ENERGÉTICO tep 2020 provisório		Hulha e Antracite 1	Coque de Carvão 2	Total de Carvão 3 = 1 + 2	Petróleo Bruto 4	Refugos e Produtos Intermédios 5	GPL 6	Gasolinas 7	Petróleos 8	Jets 9	Gasóleo 10	Fuelóleo 11	Nafta 12	Coque de Petróleo 13	Total de Petróleo Energético 14 = 4 a 13	Lubrificantes 15	Asfaltos 16	Parafinas 17	Solventes 18	Outros 19	Total de Petróleo Não Energético 20 = 15 a 19	Total de Petróleo 21= 14 + 20	Gás Natural 22
CONSUMO DO SECTOR ENERGÉTICO	07				- 11 289	547 465	765		73		434	114 331	1 223		**653 002**	3 187	533		88	182	**3 990**	**656 992**	**94 122**
Consumo Próprio da Refinação	*07.01*					*506 381*	*765*				*252*	*113 502*			*620 900*	*28*					*28*	*620 928*	*87 135*
Perdas da Refinação	*07.02*				*- 11 289*	*41 084*			*73*			*829*	*1 223*		*31 920*	*1 677*	*533*		*88*		*2 298*	*34 218*	
Coquerie e outras não especificadas	*07.03*																						
Centrais Elétricas	*07.04*															*1 482*					*1 482*	*1 482*	
Bombagem Hidroeléctrica	*07.05*																						
Extração de Carvão, Petróleo e GN	*07.06*																						
Perdas de Transporte e Distribuição	*07.07*										*182*				*182*					*182*	*182*	*364*	*6 987*
CONSUMO COMO MATÉRIA PRIMA	08						*354 355*						*523 722*		*878 077*							*878 077*	
DISPONÍVEL PARA CONSUMO FINAL	09	3 884	5 751	**9 635**			519 591	936 567	453	122 004	4 537 953	136 306		275 205	**6 528 079**	45 825	210 431	5 696	7 194	4 452	**273 598**	**6 801 677**	**1 698 075**
ACERTOS		11	- 64	- 53			- 27 943	7 462	- 31	13 993	23 422	21 964		2 533	41 400	- 699	- 3 459	143	1 456	- 1 997	- 4 556	36 844	- 16 218
CONSUMO FINAL	10	3 873	5 815	**9 688**			547 534	929 105	484	108 011	4 514 531	114 342		272 672	**6 486 679**	46 524	213 890	5 553	5 738	6 449	**278 154**	**6 764 833**	**1 714 293**
AGRICULTURA E PESCAS	10.01						4 359	510	326		392 072	6 482			**403 749**	448					**448**	**404 197**	6 924
Agricultura	*10.01.01*						*4 359*	*367*	*326*		*304 000*	*567*			*309 619*	*252*					*252*	*309 871*	*6 916*
Pescas	*10.01.02*							*143*			*88 072*	*5 915*			*94 130*	*196*					*196*	*94 326*	*8*
INDÚSTRIAS EXTRATIVAS	10.02						1 093				28 094	1 106			**30 293**	1 345					**1 345**	**31 638**	**1 553**
INDÚSTRIAS TRANSFORMADORAS	10.03	3 873	5 815	**9 688**			44 472	907	23		72 097	40 643		272 672	**430 814**	11 689	6 829	5 544	5 628	6 449	**36 139**	**466 953**	**1 176 786**
Alimentação, bebidas e tabaco	*10.03.01*						*15 876*				*11 241*	*18 674*			*45 791*	*181*					*181*	*45 972*	*164 626*
Têxteis	*10.03.02*						*1 555*				*158*	*1 444*			*3 157*	*841*					*841*	*3 998*	*123 711*
Papel e Artigos de Papel	*10.03.03*						*716*		*3*		*3 345*	*18 098*			*22 162*	*611*			*2 859*	*2 867*	*6 337*	*28 499*	*142 055*
Químicas e Plásticos	*10.03.04*						*2 236*		*1*		*1 869*	*1 245*			*5 351*	*4 609*	*6 829*	*4 533*	*2 679*	*3 582*	*22 232*	*27 583*	*144 183*
Cerâmicas	*10.03.05*						*2 341*				*1 167*			*12 350*	*15 858*	*87*					*87*	*15 945*	*188 594*
Vidro e Artigos de Vidro	*10.03.06*						*81*				*278*				*359*	*207*					*207*	*566*	*192 594*
Cimento e Cal	*10.03.07*						*399*		*18*		*15 482*			*260 322*	*276 221*	*301*					*301*	*276 522*	*51 644*
Metalúrgicas	*10.03.08*		*3 663*	*3 663*			*1 167*				*420*				*1 587*	*419*			*2*		*421*	*2 008*	*22 957*
Siderurgia	*10.03.09*	*3 719*	*1 922*	*5 641*			*17*				*1 449*				*1 466*	*326*			*10*		*336*	*1 802*	*51 694*
Vestuário, Calçado e Curtumes	*10.03.10*						*1 954*				*265*	*113*			*2 332*	*23*					*23*	*2 355*	*11 526*
Madeira e Artigos de Madeira	*10.03.11*						*1 072*				*4 534*	*91*			*5 697*	*303*		*720*			*1 023*	*6 720*	*9 614*
Borracha	*10.03.12*						*194*				*79*				*273*	*1 346*		*279*	*1*		*1 626*	*1 899*	*8 465*
Metálo-eletro-mecânicas	*10.03.13*		*4*	*4*			*14 762*	*907*	*1*		*7 411*				*23 081*	*2 342*		*1*	*77*		*2 420*	*25 501*	*55 330*
Outras Indústrias Transformadoras	*10.03.14*	*154*	*226*	*380*			*2 102*				*24 399*	*978*			*27 479*	*93*		*11*			*104*	*27 583*	*9 793*
CONSTRUÇÃO E OBRAS PÚBLICAS	10.04						8 017		1		70 287	10 824			**89 129**	1 303	207 061		110		**208 474**	**297 603**	**17 467**
TRANSPORTES	10.05						30 792	927 688	34	85 860	3 861 330	44 939			**4 950 643**	31 383					**31 383**	**4 982 026**	**15 310**
Aviação Nacional	*10.05.01*							*1 127*		*85 860*					*86 987*							*86 987*	
Transportes Marítimos Nacionais	*10.05.02*										*17 947*	*44 939*			*62 886*	*42*					*42*	*62 928*	
Caminho de Ferro	*10.05.03*										*8 788*				*8 788*							*8 788*	
Rodoviários	*10.05.04*						*30 792*	*926 561*	*34*		*3 834 595*				*4 791 982*	*31 341*					*31 341*	*4 823 323*	*15 310*
SETOR DOMÉSTICO	10.06						396 513		46		52 094				**448 653**							**448 653**	**294 561**
SERVIÇOS	10.07						62 288		54	22 151	38 557	10 348			**133 398**	356		9			**365**	**133 763**	**201 692**

BALANÇO ENERGÉTICO tep 2020 provisório		Gases Incond. de Petroquímica 23	Hidrogénio 24	Gases e Outros Derivados 25 = 23 + 24	Hidro-eletricidade 26	Eólica 27	Foto-voltaica 28	Geo-térmica 29	Termo-eletricidade 30	Total de Eletricidade 31	Calor 32	Resíduos não Renováveis 33	Solar Térmico 34	Lenhas e Resíduos Vegetais 35	Resíduos Sólidos Urbanos 36	Licores Sulfitivos 37	Outros Renováveis 38	Biogás 39	Biocombustíveis 40	Bombas de Calor 41	Renováveis Sem Eletricidade 42 = 34 a 41	TOTAL GERAL 43=3+21+22+25 +31+32+33+42
IMPORTAÇÕES	01									**649 568**		47 948		32 538			36 846		18 540		**87 924**	20 710 235
PRODUÇÃO DOMÉSTICA	02				1 172 400	1 057 685	147 541	18 677		**2 396 302**		141 496	100 692	1 841 841	113 161	1 035 801	18 414	82 780	300 232	625 888	**4 118 809**	**6 656 607**
VARIAÇÃO DE "STOCKS"	03																		2 461		**2 461**	**- 870 320**
SAÍDAS	04									**524 329**				314 527					62 049		**376 576**	**7 446 215**
Exportações	04.01									*524 329*				*314 527*					*62 049*		*376 576*	*6 239 579*
Transportes Marítimos Internacionais	04.02																					*683 561*
Aviação Internacional	04.03																					*523 075*
CONSUMO DE ENERGIA PRIMÁRIA	05				*1 172 400*	*1 057 685*	*147 541*	*18 677*		**2 521 541**		189 444	100 692	1 559 852	113 161	1 035 801	55 260	82 780	254 262	625 888	**3 827 696**	**20 790 947**
PARA NOVAS FORMAS DE ENERGIA	06				*1 172 400*	*1 057 685*	*147 541*	*18 677*	-2 168 430	**-2 168 430**	**-1 336 425**	93 101		603 885	113 161	1 035 801		75 707	253 233		**2 081 787**	**2 783 721**
Briquetes	06.01																					
Coque	06.02																					
Produtos de Petróleo	06.03		*157 429*	*157 429*															*253 233*		*253 233*	*232 207*
Hidrogénio	06.04		*- 157 429*	*- 157 429*																		*28 462*
Petroquímica	06.05	*- 73 157*		*- 73 157*																		*- 4 405*
Eletricidade	06.06				*1 172 400*	*1 057 685*	*147 541*	*18 677*	*-1 552 141*	*-1 552 141*		*86 066*		*456 183*	*113 161*			*70 610*				639 954	*1 852 157*
Cogeração	06.07	*73 157*		*73 157*					*- 616 289*	*- 616 289*	*-1 336 425*	*7 035*		*147 702*		*1 035 801*		*5 097*			*1 188 600*	*675 303*
Produção de Eletricidade	06.07.01								*- 16 600*	*- 16 600*	*- 931*											*24 323*
Refinação de Petróleo	06.07.02								*- 138 134*	*- 138 134*	*- 207 807*											*105 170*
Gás de Cidade	06.07.03																					
Agricultura	06.07.04								*- 3 191*	*- 3 191*	*- 2 913*							*432*			*432*	*1 899*
Alimentação, bebidas e tabaco	06.07.05								*- 22 750*	*- 22 750*	*- 47 368*											*17 189*
Têxteis	06.07.06								*- 50 089*	*- 50 089*	*- 41 775*											*33 585*
Papel e Artigos de Papel	06.07.07								*- 281 740*	*- 281 740*	*- 870 361*			*130 714*		*1 035 801*		*44*			*1 166 559*	*382 582*
Químicas e Plásticos	06.07.08	*73 157*		*73 157*					*- 48 906*	*- 48 906*	*- 99 064*	*5 827*										*73 348*
Cerâmicas	06.07.09								*- 8 505*	*- 8 505*	*- 12 063*											*4 505*
Vidro e Artigos de Vidro	06.07.10																					
Cimento e Cal	06.07.11								*- 1 381*	*- 1 381*	*- 1 028*											*901*
Metalúrgicas	06.07.12																					
Siderurgia	06.07.13																					
Vestuário, Calçado e Curtumes	06.07.14								*- 3 078*	*- 3 078*	*- 1 841*											*2 513*
Madeira e Artigos de Madeira	06.07.15								*- 3 355*	*- 3 355*	*- 11 248*			*16 988*							*16 988*	*2 385*
Borracha	06.07.16								*- 3 454*	*- 3 454*	*- 5 905*	*1 208*										*2 437*
Metálo-eletro-mecânicas	06.07.17								*- 848*	*- 848*	*- 741*											*397*
Outras Indústrias Transformadoras	06.07.18								*- 1 647*	*- 1 647*	*- 920*							*2 368*			*2 368*	*1 867*
Indústrias Extrativas	06.07.19								*- 4 253*	*- 4 253*	*- 7 877*											*2 286*
Serviços	06.07.20								*- 28 355*	*- 28 355*	*- 24 583*							*2 253*			*2 253*	*19 916*

BALANÇO ENERGÉTICO tep 2020 provisório		Gases Incond. de Petroquímica 23	Hidrogénio 24	Gases e Outros Derivados 25 = 23 + 24	Hidro-eletricidade 26	Eólica 27	Foto-voltaica 28	Geo-térmica 29	Termo-eletricidade 30	Total de Eletricidade 31	Calor 32	Resíduos não Renováveis 33	Solar Térmico 34	Lenhas e Resíduos Vegetais 35	Resíduos Sólidos Urbanos 36	Licores Sulfitivos 37	Outros Renováveis 38	Biogás 39	Biocombustíveis 40	Bombas de Calor 41	Renováveis Sem Eletricidade 42 = 34 a 41	TOTAL GERAL 43=3+21+22+25 +31+32+33+42
CONSUMO DO SECTOR ENERGÉTICO	07									**704 297**	**207 807**											**1 663 218**
Consumo Próprio da Refinação	07.01									*58 573*	*207 807*											*974 443*
Perdas da Refinação	07.02																					*34 218*
Coquerie e outras não especificadas	07.03																					
Centrais Elétricas	07.04									*89 683*												*91 165*
Bombagem Hidroeléctrica	07.05									*170 894*												*170 894*
Extração de Carvão, Petróleo e GN	07.06																					
Perdas de Transporte e Distribuição	07.07									*385 147*												*392 498*
CONSUMO COMO MATÉRIA PRIMA	08																					*878 077*
DISPONÍVEL PARA CONSUMO FINAL	09									**3 985 674**	**1 128 618**	96 343	100 692	955 967			55 260	7 073	1 029	625 888	**1 745 909**	**15 465 931**
ACERTOS										- 58									- 384		- 384	20 131
CONSUMO FINAL	10									**3 985 732**	**1 128 618**	96 343	100 692	955 967			55 260	7 073	1 413	625 888	**1 746 293**	**15 445 800**
AGRICULTURA E PESCAS	10.01									**92 038**	**2 913**			**5 127**							**5 127**	**511 199**
Agricultura	10.01.01									*87 800*	*2 913*			*5 127*							*5 127*	*412 627*
Pescas	10.01.02									*4 238*												*98 572*
INDÚSTRIAS EXTRATIVAS	10.02									**42 315**	**7 877**											**83 383**
INDÚSTRIAS TRANSFORMADORAS	10.03									**1 314 921**	**1 093 429**	**96 343**		**154 129**			53 935	7 073	255		**215 392**	**4 373 512**
Alimentação, bebidas e tabaco	10.03.01									*173 844*	*47 368*			*30 606*				*1 458*			*32 064*	*463 874*
Têxteis	10.03.02									*66 128*	*41 775*			*10 816*							*10 816*	*246 428*
Papel e Artigos de Papel	10.03.03									*264 485*	*870 361*			*21 737*				*5 615*			*27 352*	*1 332 752*
Químicas e Plásticos	10.03.04									*209 800*	*99 064*	*116*		*4 644*					*255*		*4 899*	*485 645*
Cerâmicas	10.03.05									*35 529*	*12 063*			*19 805*							*19 805*	*271 936*
Vidro e Artigos de Vidro	10.03.06									*44 507*												*237 667*
Cimento e Cal	10.03.07									*57 533*	*1 028*	*96 227*		*13 608*			*53 935*				*67 543*	*550 497*
Metalúrgicas	10.03.08									*20 757*				*3*							*3*	*49 388*
Siderurgia	10.03.09									*130 037*												*189 174*
Vestuário, Calçado e Curtumes	10.03.10									*24 172*	*1 841*			*3 399*							*3 399*	*43 293*
Madeira e Artigos de Madeira	10.03.11									*73 499*	*11 248*			*46 945*							*46 945*	*148 026*
Borracha	10.03.12									*19 715*	*5 905*			*267*							*267*	*36 251*
Metálo-eletro-mecânicas	10.03.13									*140 728*	*741*			*228*							*228*	*222 532*
Outras Indústrias Transformadoras	10.03.14									*54 187*	*2 035*			*2 071*							*2 071*	*96 049*
CONSTRUÇÃO E OBRAS PÚBLICAS	10.04									40 722												**355 792**
TRANSPORTES	10.05									36 481									1 158		**1 158**	**5 034 975**
Aviação Nacional	10.05.01																					*86 987*
Transportes Marítimos Nacionais	10.05.02																					*62 928*
Caminho de Ferro	10.05.03									*35 589*												*44 377*
Rodoviários	10.05.04									*892*									*1 158*		*1 158*	*4 840 683*
SETOR DOMÉSTICO	10.06									**1 178 355**			54 884	*778 102*						255 115	**1 088 101**	**3 009 670**
SERVIÇOS	10.07									**1 280 900**	**24 399**		45 808	18 609			1 325			370 773	**436 515**	**2 077 269**

Annex C: Energy (NFR 1.A.3, 1.A.4 and 1.A.5)

Transport (NFR 1.A.3)

Table C-1: Activity data for NFR 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	2002	2003	2004	2005
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	2 334	1 985	1 847	2 192
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	715 095	770 040	835 208	865 857

Fuel Sales		NAPFUE	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Aviation Gasoline	L	209	2 179	2 086	2 280	2 280	2 869	2 258	1 268	1 168	1 333	1 257	1 256	1 211	804	1 101	1 072
Jet Fuel	L	207	907 189	949 650	969 349	907 530	985 343	1 006 836	1 015 897	1 027 228	1 086 001	1 139 567	1 239 311	1 409 602	1 501 383	1 580 683	592 926

Table C-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
AC11	Rockwell Commander	L AvG	L1P	C150	DHO

Code	Aircraft Name	Fuel Type	Description	Representative	
				LTO	Cruise
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
C208	Cessna 208 Caravan	L JeK	L1T	C208	C208
C210	Cessna 210 Centurion	L AvG	L1P	C150	DHO

Code	Aircraft Name	Fuel Type	Description	Representative	
				LTO	Cruise
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
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

Code	Aircraft Name	Fuel Type	Description	Representative	
				LTO	Cruise
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
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

Code	Aircraft Name	Fuel Type	Description	Representative	
				LTO	Cruise
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 C-3: Road transportation energy based implied emission factors (t/TJ) for 2020 for Main Pollutants, Particulate Matter and CO

				Main Pollutants				Particulate Matter				Other
				NOx (as NO_2)	NMVOC	SOx (as SO_2)	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
Category	Fuel	Segment	Euro Standard	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ
Passenger Cars	Petrol	Mini	Euro 4	0.029	0.1353	0.0004	0.0124	0.006	0.011	0.016	0.0005	0.4539
Passenger Cars	Petrol	Mini	Euro 5	0.019	0.1124	0.0004	0.0060	0.006	0.011	0.017	0.0006	0.4413
Passenger Cars	Petrol	Mini	Euro 6 a/b/c	0.019	0.1063	0.0004	0.0058	0.006	0.011	0.017	0.0006	0.4125
Passenger Cars	Petrol	Mini	Euro 6 d-temp	0.019	0.1508	0.0004	0.0057	0.006	0.011	0.016	0.0005	0.4116
Passenger Cars	Petrol	Small	PRE ECE - ECE 15/04	0.777	1.1826	0.0004	0.0007	0.005	0.009	0.014	0.0005	5.8104
Passenger Cars	Petrol	Small	Euro 1	0.202	0.4488	0.0004	0.0299	0.006	0.010	0.014	0.0006	2.0109
Passenger Cars	Petrol	Small	Euro 2	0.098	0.3025	0.0004	0.0390	0.006	0.010	0.015	0.0006	1.1362
Passenger Cars	Petrol	Small	Euro 3	0.043	0.1760	0.0004	0.0108	0.005	0.009	0.014	0.0005	1.0770
Passenger Cars	Petrol	Small	Euro 4	0.024	0.1228	0.0004	0.0105	0.005	0.009	0.014	0.0005	0.3818
Passenger Cars	Petrol	Small	Euro 5	0.016	0.1009	0.0004	0.0051	0.005	0.009	0.014	0.0005	0.3712
Passenger Cars	Petrol	Small	Euro 6 a/b/c	0.016	0.0786	0.0004	0.0049	0.005	0.009	0.014	0.0005	0.3473
Passenger Cars	Petrol	Small	Euro 6 d-temp	0.016	0.0733	0.0004	0.0048	0.005	0.009	0.014	0.0004	0.3474
Passenger Cars	Petrol	Medium	PRE ECE - ECE 15/04	0.819	1.0208	0.0004	0.0006	0.004	0.008	0.011	0.0005	4.9028
Passenger Cars	Petrol	Medium	Euro 1	0.171	0.2832	0.0004	0.0254	0.005	0.008	0.012	0.0005	1.5837
Passenger Cars	Petrol	Medium	Euro 2	0.087	0.1713	0.0004	0.0348	0.005	0.009	0.013	0.0006	0.9148
Passenger Cars	Petrol	Medium	Euro 3	0.036	0.0967	0.0004	0.0091	0.004	0.008	0.012	0.0004	0.8349
Passenger Cars	Petrol	Medium	Euro 4	0.021	0.0691	0.0004	0.0090	0.004	0.008	0.012	0.0004	0.3058
Passenger Cars	Petrol	Medium	Euro 5	0.014	0.0628	0.0004	0.0043	0.005	0.008	0.012	0.0004	0.2965
Passenger Cars	Petrol	Medium	Euro 6 a/b/c	0.014	0.0553	0.0004	0.0042	0.005	0.008	0.012	0.0004	0.2759
Passenger Cars	Petrol	Medium	Euro 6 d-temp	0.014	0.0526	0.0004	0.0041	0.004	0.008	0.012	0.0004	0.2759
Passenger Cars	Petrol	Large-SUV-Executive	PRE ECE - ECE 15/04	0.763	0.9721	0.0004	0.0005	0.004	0.006	0.009	0.0004	4.2069
Passenger Cars	Petrol	Large-SUV-Executive	Euro 1	0.126	0.1855	0.0004	0.0197	0.004	0.006	0.009	0.0004	1.0509
Passenger Cars	Petrol	Large-SUV-Executive	Euro 2	0.059	0.1056	0.0004	0.0254	0.004	0.006	0.009	0.0004	0.5428
Passenger Cars	Petrol	Large-SUV-Executive	Euro 3	0.028	0.0709	0.0004	0.0078	0.004	0.007	0.010	0.0003	0.5897
Passenger Cars	Petrol	Large-SUV-Executive	Euro 4	0.014	0.0435	0.0004	0.0066	0.003	0.006	0.009	0.0003	0.1940
Passenger Cars	Petrol	Large-SUV-Executive	Euro 5	0.009	0.0386	0.0004	0.0032	0.003	0.006	0.009	0.0003	0.1872
Passenger Cars	Petrol	Large-SUV-Executive	Euro 6 a/b/c	0.009	0.0334	0.0004	0.0031	0.003	0.006	0.009	0.0003	0.1721
Passenger Cars	Petrol	Large-SUV-Executive	Euro 6 d-temp	0.009	0.0367	0.0004	0.0030	0.003	0.006	0.008	0.0003	0.1720
Passenger Cars	Petrol Hybrid	All Segments	Euro 4	0.014	0.1029	0.0004	0.0148	0.007	0.013	0.019	0.0006	0.2437
Passenger Cars	Petrol Hybrid	All Segments	Euro 5	0.012	0.0640	0.0004	0.0143	0.007	0.013	0.019	0.0007	0.1908
Passenger Cars	Petrol Hybrid	All Segments	Euro 6 a/b/c	0.013	0.0725	0.0004	0.0144	0.007	0.013	0.019	0.0007	0.2172
Passenger Cars	Petrol Hybrid	All Segments	Euro 6 d-temp	0.014	0.0735	0.0004	0.0144	0.007	0.012	0.019	0.0006	0.2239
Passenger Cars	Diesel	Mini	Euro 4	0.431	0.0099	0.0004	0.0006	0.030	0.037	0.044	0.0203	0.0634
Passenger Cars	Diesel	Mini	Euro 5	0.392	0.0008	0.0004	0.0011	0.009	0.016	0.023	0.0010	0.0237
Passenger Cars	Diesel	Mini	Euro 6 a/b/c	0.354	0.0008	0.0004	0.0042	0.009	0.015	0.023	0.0009	0.0226
Passenger Cars	Diesel	Mini	Euro 6 d-temp	0.043	0.0008	0.0004	0.0042	0.009	0.015	0.023	0.0009	0.0146
Passenger Cars	Diesel	Small	Conventional	0.205	0.0578	0.0004	0.0003	0.098	0.102	0.106	0.0522	0.2368
Passenger Cars	Diesel	Small	Euro 1	0.295	0.0232	0.0004	0.0004	0.049	0.053	0.058	0.0310	0.2014
Passenger Cars	Diesel	Small	Euro 2	0.315	0.0154	0.0004	0.0004	0.031	0.035	0.040	0.0216	0.1427
Passenger Cars	Diesel	Small	Euro 3	0.353	0.0089	0.0004	0.0004	0.025	0.029	0.035	0.0175	0.0420
Passenger Cars	Diesel	Small	Euro 4	0.290	0.0067	0.0004	0.0004	0.020	0.025	0.030	0.0137	0.0427
Passenger Cars	Diesel	Small	Euro 5	0.264	0.0005	0.0004	0.0008	0.006	0.011	0.016	0.0007	0.0159
Passenger Cars	Diesel	Small	Euro 6 a/b/c	0.238	0.0005	0.0004	0.0028	0.006	0.010	0.015	0.0006	0.0152
Passenger Cars	Diesel	Small	Euro 6 d-temp	0.029	0.0005	0.0004	0.0028	0.006	0.010	0.015	0.0006	0.0098
Passenger Cars	Diesel	Medium	Conventional	0.205	0.0578	0.0004	0.0003	0.098	0.102	0.106	0.0522	0.2368

				Main Pollutants				Particulate Matter				Other
				NOx (as NO_2)	NMVOC	SOx (as SO_2)	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
Category	Fuel	Segment	Euro Standard	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ
Passenger Cars	Diesel	Medium	Euro 1	0.295	0.0232	0.0004	0.0004	0.049	0.053	0.058	0.0310	0.2014
Passenger Cars	Diesel	Medium	Euro 2	0.315	0.0154	0.0004	0.0004	0.031	0.035	0.040	0.0216	0.1427
Passenger Cars	Diesel	Medium	Euro 3	0.353	0.0089	0.0004	0.0004	0.025	0.029	0.035	0.0175	0.0420
Passenger Cars	Diesel	Medium	Euro 4	0.290	0.0067	0.0004	0.0004	0.020	0.025	0.030	0.0137	0.0427
Passenger Cars	Diesel	Medium	Euro 5	0.264	0.0005	0.0004	0.0008	0.006	0.011	0.016	0.0007	0.0159
Passenger Cars	Diesel	Medium	Euro 6 a/b/c	0.238	0.0005	0.0004	0.0028	0.006	0.010	0.015	0.0006	0.0152
Passenger Cars	Diesel	Medium	Euro 6 d-temp	0.029	0.0005	0.0004	0.0028	0.006	0.010	0.015	0.0006	0.0098
Passenger Cars	Diesel	Large-SUV-Executive	Conventional	0.320	0.0578	0.0004	0.0003	0.098	0.102	0.106	0.0522	0.2368
Passenger Cars	Diesel	Large-SUV-Executive	Euro 1	0.220	0.0259	0.0004	0.0003	0.036	0.040	0.043	0.0232	0.1506
Passenger Cars	Diesel	Large-SUV-Executive	Euro 2	0.243	0.0348	0.0004	0.0003	0.024	0.027	0.031	0.0166	0.1101
Passenger Cars	Diesel	Large-SUV-Executive	Euro 3	0.257	0.0142	0.0004	0.0003	0.018	0.021	0.025	0.0127	0.0306
Passenger Cars	Diesel	Large-SUV-Executive	Euro 4	0.211	0.0048	0.0004	0.0003	0.015	0.018	0.022	0.0099	0.0311
Passenger Cars	Diesel	Large-SUV-Executive	Euro 5	0.192	0.0004	0.0004	0.0006	0.005	0.008	0.011	0.0005	0.0116
Passenger Cars	Diesel	Large-SUV-Executive	Euro 6 a/b/c	0.173	0.0004	0.0004	0.0021	0.004	0.007	0.011	0.0004	0.0111
Passenger Cars	Diesel	Large-SUV-Executive	Euro 6 d-temp	0.021	0.0004	0.0004	0.0021	0.004	0.007	0.011	0.0004	0.0072
Passenger Cars	LPG Bifuel	All Segments	Conventional	0.856	0.4182	-	-	0.005	0.009	0.014	0.0006	3.7458
Passenger Cars	LPG Bifuel	All Segments	Euro 1	0.163	0.3225	-	-	0.005	0.009	0.013	0.0006	1.7237
Passenger Cars	LPG Bifuel	All Segments	Euro 2	0.074	0.1507	-	-	0.005	0.009	0.013	0.0006	1.1977
Passenger Cars	LPG Bifuel	All Segments	Euro 3	0.038	0.0513	-	-	0.005	0.008	0.013	0.0004	0.8884
Passenger Cars	LPG Bifuel	All Segments	Euro 4	0.022	0.0254	-	-	0.005	0.008	0.013	0.0004	0.3299
Passenger Cars	LPG Bifuel	All Segments	Euro 5	0.018	0.0254	-	-	0.005	0.008	0.013	0.0004	0.3299
Passenger Cars	LPG Bifuel	All Segments	Euro 6 a/b/c	0.018	0.0254	-	-	0.005	0.008	0.013	0.0004	0.3299
Passenger Cars	LPG Bifuel	All Segments	Euro 6 d-temp	0.018	0.0254	-	-	0.005	0.008	0.013	0.0004	0.3299
Light Commercial Vehicles	Petrol	N1-I	Conventional	0.810	1.1615	0.0004	0.0005	0.005	0.009	0.013	0.0006	8.6492
Light Commercial Vehicles	Petrol	N1-I	Euro 1	0.255	0.3635	0.0004	0.0301	0.008	0.013	0.019	0.0008	6.1685
Light Commercial Vehicles	Petrol	N1-I	Euro 2	0.081	0.1242	0.0004	0.0391	0.008	0.013	0.019	0.0008	3.1733
Light Commercial Vehicles	Petrol	N1-I	Euro 3	0.045	0.0704	0.0004	0.0109	0.007	0.013	0.019	0.0007	2.5103
Light Commercial Vehicles	Petrol	N1-I	Euro 4	0.020	0.0513	0.0004	0.0104	0.007	0.012	0.018	0.0006	0.8905
Light Commercial Vehicles	Petrol	N1-I	Euro 5	0.007	0.0534	0.0004	0.0050	0.007	0.013	0.018	0.0007	0.4895
Light Commercial Vehicles	Petrol	N1-I	Euro 6 a/b/c	0.007	0.0454	0.0004	0.0049	0.007	0.013	0.018	0.0007	0.4897
Light Commercial Vehicles	Petrol	N1-I	Euro 6 d-temp	0.007	0.0373	0.0004	0.0048	0.007	0.012	0.018	0.0006	0.4899
Light Commercial Vehicles	Petrol	N1-II & N1-III	Conventional	0.710	1.1063	0.0004	0.0005	0.005	0.008	0.012	0.0005	7.5753
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 1	0.124	0.1740	0.0004	0.0155	0.004	0.007	0.010	0.0004	2.4638
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 2	0.051	0.0872	0.0004	0.0204	0.004	0.007	0.010	0.0004	1.6232
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 3	0.029	0.0725	0.0004	0.0056	0.004	0.006	0.010	0.0003	1.3900
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 4	0.014	0.0371	0.0004	0.0056	0.004	0.006	0.010	0.0003	0.5823
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 5	0.010	0.0401	0.0004	0.0037	0.005	0.009	0.013	0.0005	0.5889
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 6 a/b/c	0.012	0.0533	0.0004	0.0042	0.006	0.011	0.016	0.0006	0.7008
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 6 d-temp	0.012	0.0420	0.0004	0.0042	0.006	0.010	0.015	0.0006	0.7012
Light Commercial Vehicles	Diesel	N1-I	Conventional	0.678	0.0492	0.0004	0.0003	0.124	0.129	0.134	0.0657	0.4703
Light Commercial Vehicles	Diesel	N1-I	Euro 1	0.533	0.0628	0.0004	0.0004	0.062	0.068	0.074	0.0393	0.2730
Light Commercial Vehicles	Diesel	N1-I	Euro 2	0.517	0.0631	0.0004	0.0004	0.060	0.066	0.072	0.0434	0.2645
Light Commercial Vehicles	Diesel	N1-I	Euro 3	0.460	0.0420	0.0004	0.0004	0.045	0.051	0.058	0.0330	0.2300
Light Commercial Vehicles	Diesel	N1-I	Euro 4	0.373	0.0156	0.0004	0.0004	0.027	0.033	0.039	0.0179	0.1823
Light Commercial Vehicles	Diesel	N1-I	Euro 5	0.699	0.0001	0.0004	0.0008	0.008	0.014	0.020	0.0008	0.0001
Light Commercial Vehicles	Diesel	N1-I	Euro 6 a/b/c	0.565	0.0001	0.0004	0.0028	0.008	0.014	0.020	0.0008	0.0001
Light Commercial Vehicles	Diesel	N1-I	Euro 6 d-temp	0.202	0.0001	0.0004	0.0028	0.008	0.014	0.020	0.0008	0.0001
Light Commercial Vehicles	Diesel	N1-II & N1-III	Conventional	0.491	0.0356	0.0004	0.0002	0.090	0.093	0.097	0.0476	0.3406
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 1	0.349	0.0411	0.0004	0.0003	0.041	0.045	0.049	0.0258	0.1789

				Main Pollutants				Particulate Matter				Other
				NOx (as NO_2)	NMVOC	SOx (as SO_2)	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
Category	Fuel	Segment	Euro Standard	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 2	0.349	0.0427	0.0004	0.0003	0.041	0.045	0.049	0.0294	0.1789
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 3	0.294	0.0268	0.0004	0.0003	0.029	0.033	0.037	0.0210	0.1467
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 4	0.238	0.0099	0.0004	0.0003	0.017	0.021	0.025	0.0114	0.1163
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 5	0.492	0.0001	0.0004	0.0005	0.005	0.009	0.014	0.0005	0.0001
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 6 a/b/c	0.397	0.0001	0.0004	0.0020	0.005	0.009	0.014	0.0005	0.0001
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 6 d-temp	0.142	0.0001	0.0004	0.0020	0.005	0.009	0.014	0.0005	0.0001
Heavy Duty Trucks	Diesel	<=20 t	Conventional	1.011	0.1189	0.0004	0.0004	0.048	0.053	0.059	0.0217	0.3019
Heavy Duty Trucks	Diesel	<=20 t	Euro I	0.740	0.0431	0.0004	0.0004	0.035	0.040	0.047	0.0191	0.1636
Heavy Duty Trucks	Diesel	<=20 t	Euro II	0.832	0.0290	0.0004	0.0004	0.023	0.028	0.035	0.0111	0.1436
Heavy Duty Trucks	Diesel	<=20 t	Euro III	0.638	0.0251	0.0004	0.0004	0.021	0.026	0.032	0.0108	0.1687
Heavy Duty Trucks	Diesel	<=20 t	Euro IV	0.458	0.0042	0.0004	0.0004	0.010	0.015	0.022	0.0031	0.0842
Heavy Duty Trucks	Diesel	<=20 t	Euro V	0.416	0.0039	0.0004	0.0015	0.011	0.016	0.023	0.0037	0.1388
Heavy Duty Trucks	Diesel	<=20 t	Euro VI A/B/C	0.035	0.0027	0.0004	0.0012	0.007	0.012	0.019	0.0005	0.0155
Heavy Duty Trucks	Diesel	<=20 t	Euro VI D/E	0.035	0.0027	0.0004	0.0012	0.007	0.012	0.019	0.0005	0.0156
Heavy Duty Trucks	Diesel	20 - 28 t	Conventional	0.914	0.0456	0.0004	0.0002	0.039	0.043	0.047	0.0180	0.1902
Heavy Duty Trucks	Diesel	20 - 28 t	Euro I	0.752	0.0454	0.0004	0.0003	0.036	0.040	0.044	0.0207	0.1794
Heavy Duty Trucks	Diesel	20 - 28 t	Euro II	0.833	0.0306	0.0004	0.0003	0.022	0.026	0.031	0.0120	0.1604
Heavy Duty Trucks	Diesel	20 - 28 t	Euro III	0.639	0.0276	0.0004	0.0003	0.020	0.023	0.028	0.0110	0.1765
Heavy Duty Trucks	Diesel	20 - 28 t	Euro IV	0.456	0.0046	0.0004	0.0003	0.008	0.012	0.017	0.0030	0.0837
Heavy Duty Trucks	Diesel	20 - 28 t	Euro V	0.394	0.0041	0.0004	0.0011	0.009	0.013	0.018	0.0036	0.1344
Heavy Duty Trucks	Diesel	20 - 28 t	Euro VI A/B/C	0.032	0.0028	0.0004	0.0009	0.005	0.009	0.014	0.0004	0.0167
Heavy Duty Trucks	Diesel	20 - 28 t	Euro VI D/E	0.032	0.0028	0.0004	0.0009	0.005	0.009	0.014	0.0004	0.0167
Heavy Duty Trucks	Diesel	>28 t	Conventional	0.938	0.0405	0.0004	0.0002	0.040	0.043	0.047	0.0184	0.1909
Heavy Duty Trucks	Diesel	>28 t	Euro I	0.752	0.0418	0.0004	0.0002	0.037	0.041	0.046	0.0218	0.1909
Heavy Duty Trucks	Diesel	>28 t	Euro II	0.809	0.0270	0.0004	0.0002	0.023	0.027	0.032	0.0126	0.1679
Heavy Duty Trucks	Diesel	>28 t	Euro III	0.648	0.0243	0.0004	0.0002	0.019	0.023	0.027	0.0108	0.1836
Heavy Duty Trucks	Diesel	>28 t	Euro IV	0.471	0.0045	0.0004	0.0002	0.008	0.011	0.016	0.0030	0.0817
Heavy Duty Trucks	Diesel	>28 t	Euro V	0.364	0.0040	0.0004	0.0009	0.008	0.012	0.016	0.0036	0.1383
Heavy Duty Trucks	Diesel	>28 t	Euro VI A/B/C	0.026	0.0027	0.0004	0.0008	0.004	0.008	0.012	0.0004	0.0138
Heavy Duty Trucks	Diesel	>28 t	Euro VI D/E	0.026	0.0027	0.0004	0.0008	0.004	0.008	0.012	0.0004	0.0138
Buses	Diesel	Urban Buses	Conventional	0.947	0.1548	0.0004	0.0001	0.062	0.065	0.067	0.0300	0.3966
Buses	Diesel	Urban Buses	Euro I	0.746	0.0515	0.0004	0.0001	0.035	0.038	0.041	0.0211	0.2120
Buses	Diesel	Urban Buses	Euro II	0.838	0.0366	0.0004	0.0001	0.019	0.022	0.025	0.0108	0.2144
Buses	Diesel	Urban Buses	Euro III	0.789	0.0327	0.0004	0.0001	0.018	0.021	0.024	0.0106	0.2133
Buses	Diesel	Urban Buses	Euro IV	0.520	0.0054	0.0004	0.0002	0.008	0.011	0.014	0.0033	0.1117
Buses	Diesel	Urban Buses	Euro V	0.588	0.0045	0.0004	0.0006	0.008	0.011	0.015	0.0038	0.2160
Buses	Diesel	Urban Buses	Euro VI A/B/C	0.031	0.0031	0.0004	0.0005	0.004	0.007	0.010	0.0003	0.0222
Buses	Diesel	Urban Buses	Euro VI D/E	0.031	0.0031	0.0004	0.0005	0.004	0.007	0.010	0.0003	0.0222
Buses	Diesel	Coaches	Conventional	0.945	0.0414	0.0004	0.0003	0.037	0.041	0.046	0.0166	0.1697
Buses	Diesel	Coaches	Euro I	0.782	0.0438	0.0004	0.0003	0.032	0.036	0.042	0.0182	0.1599
Buses	Diesel	Coaches	Euro II	0.861	0.0299	0.0004	0.0003	0.020	0.024	0.030	0.0105	0.1411
Buses	Diesel	Coaches	Euro III	0.655	0.0284	0.0004	0.0003	0.019	0.023	0.028	0.0103	0.1616
Buses	Diesel	Coaches	Euro IV	0.468	0.0045	0.0004	0.0003	0.008	0.012	0.018	0.0030	0.0840
Buses	Diesel	Coaches	Euro V	0.298	0.0040	0.0004	0.0011	0.009	0.013	0.018	0.0036	0.1267
Buses	Diesel	Coaches	Euro VI A/B/C	0.020	0.0029	0.0004	0.0009	0.005	0.009	0.014	0.0004	0.0169
Buses	CNG	Urban CNG Buses	Euro I	0.619	0.0075	-	0.0375	0.003	0.005	0.007	0.0001	0.3153
Buses	CNG	Urban CNG Buses	Euro III	0.458	0.0009	-	0.0458	0.003	0.006	0.008	0.0002	0.0458
Buses	CNG	Urban CNG Buses	EEV	0.208	0.0108	-	0.0426	0.003	0.005	0.007	0.0001	0.0541
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Conventional	0.049	8.1300	0.0004	0.0009	0.159	0.165	0.170	0.0311	12.8082

				Main Pollutants				Particulate Matter				Other
				NOx (as NO_2)	NMVOC	SOx (as SO_2)	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
Category	Fuel	Segment	Euro Standard	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ	t/TJ
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 1	0.198	4.5299	0.0004	0.0011	0.057	0.064	0.070	0.0055	5.0478
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 2	0.188	3.5474	0.0004	0.0011	0.036	0.043	0.049	0.0063	3.0943
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 3	0.190	2.4425	0.0004	0.0011	0.028	0.035	0.041	0.0046	2.0129
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 4	0.191	2.3411	0.0004	0.0011	0.028	0.035	0.041	0.0047	2.0236
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Conventional	0.049	8.1300	0.0004	0.0009	0.159	0.165	0.170	0.0158	12.8082
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 1	0.241	1.6549	0.0004	0.0011	0.051	0.058	0.064	0.0094	7.3522
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 2	0.188	1.5472	0.0004	0.0011	0.015	0.022	0.028	0.0021	4.6414
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 3	0.513	2.5932	0.0004	0.0013	0.019	0.028	0.035	0.0028	4.3273
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 4	0.060	0.9839	0.0004	0.0014	0.012	0.020	0.028	0.0012	2.9976
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Conventional	0.021	7.2012	0.0004	0.0013	0.134	0.137	0.141	0.0133	13.5743
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 1	0.034	2.9461	0.0004	0.0014	0.061	0.064	0.068	0.0117	9.7803
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 2	0.039	1.7155	0.0004	0.0014	0.033	0.036	0.040	0.0060	7.7665
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 3	0.073	1.5745	0.0004	0.0022	0.020	0.025	0.031	0.0032	8.0551
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 4	0.062	1.6360	0.0004	0.0022	0.019	0.024	0.030	0.0031	9.5059
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Conventional	0.256	1.0967	0.0004	0.0013	0.017	0.020	0.024	0.0023	13.3088
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 1	0.330	1.0745	0.0004	0.0016	0.021	0.025	0.029	0.0045	13.0358
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 2	0.363	0.6342	0.0004	0.0020	0.010	0.015	0.020	0.0017	5.8404
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 3	0.100	0.2217	0.0004	0.0023	0.012	0.017	0.023	0.0019	1.8969
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 4	0.033	0.2043	0.0004	0.0020	0.011	0.015	0.021	0.0017	1.7990
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Conventional	0.240	1.3360	0.0004	0.0010	0.013	0.015	0.017	0.0017	12.4437
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 1	0.220	0.8570	0.0004	0.0010	0.013	0.016	0.018	0.0028	7.2121
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 2	0.111	0.5594	0.0004	0.0011	0.006	0.009	0.012	0.0010	3.5889
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 3	0.030	0.1686	0.0004	0.0008	0.004	0.006	0.008	0.0007	0.2489
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 4	0.016	0.1270	0.0004	0.0010	0.005	0.007	0.010	0.0008	0.1937
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Conventional	0.132	1.4631	0.0004	0.0009	0.011	0.013	0.015	0.0015	10.8465
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 1	0.146	0.8327	0.0004	0.0009	0.012	0.014	0.016	0.0025	6.3689
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 2	0.163	0.4838	0.0004	0.0009	0.005	0.007	0.009	0.0008	2.9135
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 3	0.030	0.2148	0.0004	0.0008	0.004	0.006	0.008	0.0007	0.2489
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 4	0.015	0.1672	0.0004	0.0010	0.005	0.007	0.010	0.0008	0.1933

Table C-4: Road transportation energy based implied emission factors (kg/TJ) for 2020 for Heavy Metals

				Priority Heavy Metals			Additional Heavy Metals					
				Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
Category	Fuel	Segment	Euro Standard	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ
Passenger Cars	Petrol	Mini	Euro 4	0.159	0.00034	0.00019	0.00011	0.0046	0.121	0.0026	0.00037	0.059
Passenger Cars	Petrol	Mini	Euro 5	0.159	0.00034	0.00020	0.00011	0.0046	0.121	0.0026	0.00037	0.059
Passenger Cars	Petrol	Mini	Euro 6 a/b/c	0.159	0.00032	0.00020	0.00011	0.0045	0.118	0.0025	0.00035	0.057
Passenger Cars	Petrol	Mini	Euro 6 d-temp	0.159	0.00031	0.00019	0.00011	0.0045	0.116	0.0024	0.00034	0.056
Passenger Cars	Petrol	Small	PRE ECE - ECE 15/04	0.154	0.00027	0.00019	0.00009	0.0038	0.098	0.0021	0.00030	0.048
Passenger Cars	Petrol	Small	Euro 1	0.157	0.00029	0.00019	0.00010	0.0040	0.104	0.0022	0.00032	0.051
Passenger Cars	Petrol	Small	Euro 2	0.157	0.00029	0.00019	0.00010	0.0040	0.105	0.0023	0.00032	0.051
Passenger Cars	Petrol	Small	Euro 3	0.157	0.00029	0.00019	0.00010	0.0040	0.104	0.0023	0.00032	0.051
Passenger Cars	Petrol	Small	Euro 4	0.157	0.00028	0.00019	0.00009	0.0039	0.101	0.0022	0.00031	0.049
Passenger Cars	Petrol	Small	Euro 5	0.157	0.00028	0.00020	0.00009	0.0039	0.102	0.0022	0.00031	0.049
Passenger Cars	Petrol	Small	Euro 6 a/b/c	0.158	0.00027	0.00020	0.00009	0.0039	0.099	0.0021	0.00030	0.048
Passenger Cars	Petrol	Small	Euro 6 d-temp	0.158	0.00026	0.00020	0.00009	0.0038	0.098	0.0021	0.00029	0.048
Passenger Cars	Petrol	Medium	PRE ECE - ECE 15/04	0.153	0.00023	0.00019	0.00008	0.0032	0.082	0.0018	0.00025	0.040
Passenger Cars	Petrol	Medium	Euro 1	0.156	0.00025	0.00020	0.00008	0.0034	0.088	0.0019	0.00027	0.043
Passenger Cars	Petrol	Medium	Euro 2	0.157	0.00026	0.00020	0.00009	0.0036	0.092	0.0020	0.00028	0.045
Passenger Cars	Petrol	Medium	Euro 3	0.157	0.00025	0.00020	0.00008	0.0034	0.088	0.0019	0.00027	0.043
Passenger Cars	Petrol	Medium	Euro 4	0.157	0.00024	0.00020	0.00008	0.0034	0.087	0.0019	0.00026	0.042
Passenger Cars	Petrol	Medium	Euro 5	0.157	0.00024	0.00020	0.00008	0.0034	0.087	0.0019	0.00026	0.042
Passenger Cars	Petrol	Medium	Euro 6 a/b/c	0.157	0.00023	0.00020	0.00008	0.0033	0.085	0.0018	0.00025	0.041
Passenger Cars	Petrol	Medium	Euro 6 d-temp	0.157	0.00023	0.00020	0.00008	0.0033	0.084	0.0018	0.00025	0.041
Passenger Cars	Petrol	Large-SUV-Executive	PRE ECE - ECE 15/04	0.152	0.00018	0.00019	0.00006	0.0026	0.065	0.0014	0.00020	0.032
Passenger Cars	Petrol	Large-SUV-Executive	Euro 1	0.155	0.00019	0.00020	0.00006	0.0027	0.068	0.0015	0.00021	0.034
Passenger Cars	Petrol	Large-SUV-Executive	Euro 2	0.155	0.00019	0.00020	0.00006	0.0027	0.068	0.0015	0.00021	0.033
Passenger Cars	Petrol	Large-SUV-Executive	Euro 3	0.156	0.00021	0.00020	0.00007	0.0029	0.075	0.0016	0.00023	0.037
Passenger Cars	Petrol	Large-SUV-Executive	Euro 4	0.155	0.00018	0.00020	0.00006	0.0025	0.064	0.0014	0.00019	0.031
Passenger Cars	Petrol	Large-SUV-Executive	Euro 5	0.155	0.00018	0.00020	0.00006	0.0025	0.064	0.0014	0.00019	0.031
Passenger Cars	Petrol	Large-SUV-Executive	Euro 6 a/b/c	0.155	0.00017	0.00020	0.00006	0.0025	0.062	0.0013	0.00019	0.030
Passenger Cars	Petrol	Large-SUV-Executive	Euro 6 d-temp	0.155	0.00017	0.00020	0.00006	0.0024	0.061	0.0013	0.00018	0.030
Passenger Cars	Petrol Hybrid	All Segments	Euro 4	0.161	0.00039	0.00020	0.00013	0.0054	0.142	0.0031	0.00043	0.069
Passenger Cars	Petrol Hybrid	All Segments	Euro 5	0.160	0.00038	0.00020	0.00012	0.0053	0.138	0.0030	0.00042	0.067
Passenger Cars	Petrol Hybrid	All Segments	Euro 6 a/b/c	0.161	0.00037	0.00020	0.00013	0.0053	0.137	0.0029	0.00041	0.066
Passenger Cars	Petrol Hybrid	All Segments	Euro 6 d-temp	0.161	0.00036	0.00020	0.00013	0.0053	0.136	0.0028	0.00040	0.066
Passenger Cars	Diesel	Mini	Euro 4	0.012	0.00047	0.00011	0.00014	0.0064	0.169	0.0036	0.00051	0.082
Passenger Cars	Diesel	Mini	Euro 5	0.012	0.00047	0.00011	0.00014	0.0064	0.169	0.0036	0.00051	0.082
Passenger Cars	Diesel	Mini	Euro 6 a/b/c	0.012	0.00044	0.00011	0.00014	0.0063	0.164	0.0034	0.00048	0.079
Passenger Cars	Diesel	Mini	Euro 6 d-temp	0.012	0.00043	0.00011	0.00014	0.0062	0.162	0.0033	0.00047	0.078
Passenger Cars	Diesel	Small	Conventional	0.007	0.00025	0.00011	0.00008	0.0035	0.090	0.0019	0.00028	0.044
Passenger Cars	Diesel	Small	Euro 1	0.008	0.00031	0.00011	0.00009	0.0043	0.111	0.0024	0.00034	0.054
Passenger Cars	Diesel	Small	Euro 2	0.008	0.00030	0.00011	0.00009	0.0041	0.107	0.0023	0.00033	0.052
Passenger Cars	Diesel	Small	Euro 3	0.008	0.00032	0.00011	0.00010	0.0044	0.114	0.0024	0.00035	0.055
Passenger Cars	Diesel	Small	Euro 4	0.008	0.00032	0.00011	0.00010	0.0044	0.114	0.0024	0.00035	0.055
Passenger Cars	Diesel	Small	Euro 5	0.008	0.00032	0.00011	0.00010	0.0044	0.114	0.0024	0.00035	0.055
Passenger Cars	Diesel	Small	Euro 6 a/b/c	0.008	0.00030	0.00011	0.00010	0.0043	0.110	0.0023	0.00033	0.053
Passenger Cars	Diesel	Small	Euro 6 d-temp	0.008	0.00029	0.00011	0.00010	0.0043	0.109	0.0022	0.00032	0.052
Passenger Cars	Diesel	Medium	Conventional	0.007	0.00025	0.00011	0.00008	0.0035	0.090	0.0019	0.00028	0.044
Passenger Cars	Diesel	Medium	Euro 1	0.008	0.00031	0.00011	0.00009	0.0043	0.111	0.0024	0.00034	0.054

				Priority Heavy Metals			Additional Heavy Metals					
				Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
Category	Fuel	Segment	Euro Standard	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ
Passenger Cars	Diesel	Medium	Euro 2	0.008	0.00030	0.00011	0.00009	0.0041	0.107	0.0023	0.00033	0.052
Passenger Cars	Diesel	Medium	Euro 3	0.008	0.00032	0.00011	0.00010	0.0044	0.114	0.0024	0.00035	0.055
Passenger Cars	Diesel	Medium	Euro 4	0.008	0.00032	0.00011	0.00010	0.0044	0.114	0.0024	0.00035	0.055
Passenger Cars	Diesel	Medium	Euro 5	0.008	0.00032	0.00011	0.00010	0.0044	0.114	0.0024	0.00035	0.055
Passenger Cars	Diesel	Medium	Euro 6 a/b/c	0.008	0.00030	0.00011	0.00010	0.0043	0.110	0.0023	0.00033	0.053
Passenger Cars	Diesel	Medium	Euro 6 d-temp	0.008	0.00029	0.00011	0.00010	0.0043	0.109	0.0022	0.00032	0.052
Passenger Cars	Diesel	Large-SUV-Executive	Conventional	0.007	0.00025	0.00011	0.00008	0.0035	0.090	0.0019	0.00028	0.044
Passenger Cars	Diesel	Large-SUV-Executive	Euro 1	0.006	0.00023	0.00011	0.00007	0.0032	0.083	0.0018	0.00025	0.040
Passenger Cars	Diesel	Large-SUV-Executive	Euro 2	0.006	0.00023	0.00011	0.00007	0.0032	0.083	0.0018	0.00025	0.040
Passenger Cars	Diesel	Large-SUV-Executive	Euro 3	0.006	0.00023	0.00011	0.00007	0.0032	0.083	0.0018	0.00025	0.040
Passenger Cars	Diesel	Large-SUV-Executive	Euro 4	0.006	0.00023	0.00011	0.00007	0.0032	0.083	0.0018	0.00025	0.040
Passenger Cars	Diesel	Large-SUV-Executive	Euro 5	0.006	0.00023	0.00011	0.00007	0.0032	0.083	0.0018	0.00025	0.040
Passenger Cars	Diesel	Large-SUV-Executive	Euro 6 a/b/c	0.006	0.00022	0.00011	0.00007	0.0032	0.080	0.0017	0.00024	0.039
Passenger Cars	Diesel	Large-SUV-Executive	Euro 6 d-temp	0.006	0.00021	0.00011	0.00007	0.0031	0.079	0.0016	0.00023	0.038
Passenger Cars	LPG Bifuel	All Segments	Conventional	0.007	0.00027	-	0.00008	0.0037	0.099	0.0021	0.00030	0.047
Passenger Cars	LPG Bifuel	All Segments	Euro 1	0.007	0.00026	-	0.00008	0.0035	0.093	0.0020	0.00028	0.045
Passenger Cars	LPG Bifuel	All Segments	Euro 2	0.007	0.00026	-	0.00008	0.0035	0.093	0.0020	0.00028	0.045
Passenger Cars	LPG Bifuel	All Segments	Euro 3	0.007	0.00026	-	0.00008	0.0035	0.093	0.0020	0.00028	0.045
Passenger Cars	LPG Bifuel	All Segments	Euro 4	0.007	0.00026	-	0.00008	0.0035	0.093	0.0020	0.00028	0.045
Passenger Cars	LPG Bifuel	All Segments	Euro 5	0.007	0.00026	-	0.00008	0.0035	0.093	0.0020	0.00028	0.045
Passenger Cars	LPG Bifuel	All Segments	Euro 6 a/b/c	0.007	0.00024	-	0.00008	0.0034	0.091	0.0019	0.00027	0.044
Passenger Cars	LPG Bifuel	All Segments	Euro 6 d-temp	0.007	0.00024	-	0.00008	0.0034	0.090	0.0018	0.00026	0.043
Light Commercial Vehicles	Petrol	N1-I	Conventional	0.155	0.00022	0.00019	0.00010	0.0040	0.098	0.0018	0.00025	0.046
Light Commercial Vehicles	Petrol	N1-I	Euro 1	0.162	0.00031	0.00019	0.00015	0.0056	0.139	0.0025	0.00036	0.066
Light Commercial Vehicles	Petrol	N1-I	Euro 2	0.162	0.00031	0.00020	0.00015	0.0056	0.140	0.0025	0.00036	0.066
Light Commercial Vehicles	Petrol	N1-I	Euro 3	0.162	0.00031	0.00020	0.00015	0.0056	0.139	0.0025	0.00035	0.065
Light Commercial Vehicles	Petrol	N1-I	Euro 4	0.162	0.00030	0.00020	0.00014	0.0054	0.134	0.0024	0.00034	0.063
Light Commercial Vehicles	Petrol	N1-I	Euro 5	0.162	0.00030	0.00020	0.00014	0.0054	0.134	0.0024	0.00034	0.063
Light Commercial Vehicles	Petrol	N1-I	Euro 6 a/b/c	0.162	0.00029	0.00020	0.00014	0.0053	0.132	0.0023	0.00033	0.062
Light Commercial Vehicles	Petrol	N1-I	Euro 6 d-temp	0.162	0.00028	0.00020	0.00014	0.0053	0.131	0.0023	0.00032	0.061
Light Commercial Vehicles	Petrol	N1-II & N1-III	Conventional	0.154	0.00019	0.00019	0.00009	0.0035	0.085	0.0016	0.00022	0.041
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 1	0.156	0.00016	0.00020	0.00008	0.0030	0.072	0.0013	0.00019	0.034
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 2	0.156	0.00016	0.00020	0.00008	0.0030	0.072	0.0013	0.00019	0.034
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 3	0.156	0.00016	0.00020	0.00008	0.0030	0.072	0.0013	0.00019	0.034
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 4	0.157	0.00016	0.00020	0.00008	0.0030	0.072	0.0013	0.00019	0.034
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 5	0.135	0.00022	0.00016	0.00010	0.0039	0.096	0.0017	0.00025	0.045
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 6 a/b/c	0.160	0.00025	0.00020	0.00012	0.0046	0.113	0.0020	0.00028	0.053
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 6 d-temp	0.160	0.00024	0.00020	0.00012	0.0046	0.112	0.0020	0.00028	0.052
Light Commercial Vehicles	Diesel	N1-I	Conventional	0.010	0.00027	0.00011	0.00012	0.0049	0.120	0.0021	0.00031	0.056
Light Commercial Vehicles	Diesel	N1-I	Euro 1	0.013	0.00033	0.00011	0.00015	0.0059	0.147	0.0026	0.00038	0.069
Light Commercial Vehicles	Diesel	N1-I	Euro 2	0.012	0.00032	0.00011	0.00014	0.0057	0.142	0.0025	0.00036	0.067
Light Commercial Vehicles	Diesel	N1-I	Euro 3	0.013	0.00034	0.00011	0.00015	0.0061	0.151	0.0027	0.00039	0.071
Light Commercial Vehicles	Diesel	N1-I	Euro 4	0.013	0.00034	0.00011	0.00015	0.0061	0.151	0.0027	0.00039	0.071
Light Commercial Vehicles	Diesel	N1-I	Euro 5	0.013	0.00034	0.00011	0.00015	0.0061	0.151	0.0027	0.00039	0.071
Light Commercial Vehicles	Diesel	N1-I	Euro 6 a/b/c	0.013	0.00032	0.00011	0.00015	0.0060	0.147	0.0026	0.00037	0.069
Light Commercial Vehicles	Diesel	N1-I	Euro 6 d-temp	0.013	0.00031	0.00011	0.00015	0.0060	0.146	0.0025	0.00036	0.068
Light Commercial Vehicles	Diesel	N1-II & N1-III	Conventional	0.007	0.00019	0.00011	0.00009	0.0036	0.087	0.0016	0.00022	0.041
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 1	0.008	0.00022	0.00011	0.00010	0.0039	0.096	0.0017	0.00025	0.045
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 2	0.008	0.00022	0.00011	0.00010	0.0039	0.096	0.0017	0.00025	0.045
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 3	0.008	0.00022	0.00011	0.00010	0.0039	0.096	0.0017	0.00025	0.045

				Priority Heavy Metals			Additional Heavy Metals					
				Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
Category	Fuel	Segment	Euro Standard	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 4	0.008	0.00022	0.00011	0.00010	0.0039	0.096	0.0017	0.00025	0.045
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 5	0.009	0.00023	0.00011	0.00010	0.0042	0.104	0.0019	0.00027	0.049
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 6 a/b/c	0.009	0.00022	0.00011	0.00010	0.0042	0.102	0.0018	0.00025	0.048
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 6 d-temp	0.009	0.00022	0.00011	0.00010	0.0042	0.101	0.0017	0.00025	0.047
Heavy Duty Trucks	Diesel	<=20 t	Conventional	0.009	0.00013	0.00011	0.00010	0.0038	0.087	0.0011	0.00014	0.031
Heavy Duty Trucks	Diesel	<=20 t	Euro I	0.010	0.00014	0.00011	0.00012	0.0043	0.099	0.0013	0.00016	0.035
Heavy Duty Trucks	Diesel	<=20 t	Euro II	0.010	0.00015	0.00011	0.00012	0.0044	0.100	0.0013	0.00017	0.036
Heavy Duty Trucks	Diesel	<=20 t	Euro III	0.009	0.00013	0.00011	0.00011	0.0039	0.089	0.0011	0.00015	0.035
Heavy Duty Trucks	Diesel	<=20 t	Euro IV	0.009	0.00014	0.00011	0.00011	0.0040	0.091	0.0012	0.00016	0.037
Heavy Duty Trucks	Diesel	<=20 t	Euro V	0.010	0.00014	0.00011	0.00011	0.0041	0.094	0.0012	0.00017	0.038
Heavy Duty Trucks	Diesel	<=20 t	Euro VI A/B/C	0.009	0.00014	0.00011	0.00011	0.0041	0.093	0.0012	0.00017	0.038
Heavy Duty Trucks	Diesel	<=20 t	Euro VI D/E	0.009	0.00014	0.00011	0.00011	0.0041	0.092	0.0012	0.00017	0.038
Heavy Duty Trucks	Diesel	20 - 28 t	Conventional	0.006	0.00008	0.00011	0.00007	0.0025	0.056	0.0007	0.00010	0.023
Heavy Duty Trucks	Diesel	20 - 28 t	Euro I	0.007	0.00010	0.00011	0.00008	0.0029	0.065	0.0008	0.00012	0.027
Heavy Duty Trucks	Diesel	20 - 28 t	Euro II	0.007	0.00010	0.00011	0.00008	0.0030	0.067	0.0009	0.00012	0.028
Heavy Duty Trucks	Diesel	20 - 28 t	Euro III	0.007	0.00010	0.00011	0.00008	0.0029	0.064	0.0008	0.00012	0.027
Heavy Duty Trucks	Diesel	20 - 28 t	Euro IV	0.007	0.00010	0.00011	0.00008	0.0030	0.067	0.0009	0.00012	0.028
Heavy Duty Trucks	Diesel	20 - 28 t	Euro V	0.007	0.00010	0.00011	0.00008	0.0031	0.069	0.0009	0.00012	0.028
Heavy Duty Trucks	Diesel	20 - 28 t	Euro VI A/B/C	0.007	0.00010	0.00011	0.00008	0.0030	0.068	0.0009	0.00012	0.028
Heavy Duty Trucks	Diesel	20 - 28 t	Euro VI D/E	0.007	0.00010	0.00011	0.00008	0.0030	0.068	0.0009	0.00012	0.028
Heavy Duty Trucks	Diesel	>28 t	Conventional	0.005	0.00007	0.00011	0.00006	0.0021	0.046	0.0006	0.00010	0.025
Heavy Duty Trucks	Diesel	>28 t	Euro I	0.005	0.00008	0.00011	0.00007	0.0024	0.052	0.0007	0.00011	0.029
Heavy Duty Trucks	Diesel	>28 t	Euro II	0.005	0.00008	0.00011	0.00007	0.0024	0.053	0.0007	0.00011	0.028
Heavy Duty Trucks	Diesel	>28 t	Euro III	0.005	0.00008	0.00011	0.00007	0.0024	0.052	0.0007	0.00011	0.028
Heavy Duty Trucks	Diesel	>28 t	Euro IV	0.006	0.00009	0.00011	0.00007	0.0026	0.058	0.0008	0.00011	0.025
Heavy Duty Trucks	Diesel	>28 t	Euro V	0.006	0.00009	0.00011	0.00007	0.0027	0.060	0.0008	0.00011	0.025
Heavy Duty Trucks	Diesel	>28 t	Euro VI A/B/C	0.006	0.00009	0.00011	0.00007	0.0027	0.059	0.0008	0.00011	0.025
Heavy Duty Trucks	Diesel	>28 t	Euro VI D/E	0.006	0.00009	0.00011	0.00007	0.0027	0.059	0.0008	0.00011	0.025
Buses	Diesel	Urban Buses	Conventional	0.006	0.00020	0.00011	0.00007	0.0031	0.078	0.0015	0.00020	0.031
Buses	Diesel	Urban Buses	Euro I	0.007	0.00022	0.00011	0.00008	0.0034	0.087	0.0017	0.00023	0.035
Buses	Diesel	Urban Buses	Euro II	0.007	0.00023	0.00011	0.00008	0.0036	0.091	0.0018	0.00024	0.037
Buses	Diesel	Urban Buses	Euro III	0.007	0.00023	0.00011	0.00008	0.0036	0.090	0.0018	0.00024	0.036
Buses	Diesel	Urban Buses	Euro IV	0.008	0.00026	0.00011	0.00009	0.0040	0.103	0.0020	0.00027	0.041
Buses	Diesel	Urban Buses	Euro V	0.008	0.00026	0.00011	0.00009	0.0040	0.101	0.0020	0.00027	0.041
Buses	Diesel	Urban Buses	Euro VI A/B/C	0.007	0.00015	0.00011	0.00008	0.0034	0.079	0.0012	0.00016	0.029
Buses	Diesel	Urban Buses	Euro VI D/E	0.007	0.00015	0.00011	0.00008	0.0034	0.079	0.0012	0.00016	0.029
Buses	Diesel	Coaches	Conventional	0.006	0.00012	0.00011	0.00007	0.0028	0.065	0.0010	0.00013	0.027
Buses	Diesel	Coaches	Euro I	0.006	0.00012	0.00011	0.00008	0.0029	0.068	0.0010	0.00014	0.029
Buses	Diesel	Coaches	Euro II	0.006	0.00012	0.00011	0.00008	0.0029	0.067	0.0010	0.00014	0.030
Buses	Diesel	Coaches	Euro III	0.006	0.00012	0.00011	0.00008	0.0029	0.067	0.0010	0.00014	0.030
Buses	Diesel	Coaches	Euro IV	0.006	0.00012	0.00011	0.00008	0.0029	0.067	0.0010	0.00015	0.030
Buses	Diesel	Coaches	Euro V	0.006	0.00012	0.00011	0.00007	0.0028	0.064	0.0010	0.00014	0.028
Buses	Diesel	Coaches	Euro VI A/B/C	0.006	0.00011	0.00011	0.00007	0.0027	0.062	0.0009	0.00013	0.028
Buses	CNG	Urban CNG Buses	Euro I	0.005	0.00017	-	0.00006	0.0025	0.066	0.0013	0.00017	0.025
Buses	CNG	Urban CNG Buses	Euro III	0.006	0.00020	-	0.00007	0.0030	0.080	0.0016	0.00021	0.030
Buses	CNG	Urban CNG Buses	EEV	0.006	0.00019	-	0.00006	0.0028	0.075	0.0015	0.00019	0.028
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Conventional	0.157	0.00411	0.00019	0.00016	0.0221	0.799	0.0291	0.00413	0.436
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 1	0.161	0.00518	0.00019	0.00020	0.0278	1.007	0.0367	0.00520	0.549
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 2	0.162	0.00522	0.00019	0.00020	0.0280	1.014	0.0370	0.00523	0.553
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 3	0.164	0.00528	0.00019	0.00020	0.0283	1.026	0.0374	0.00530	0.560

				Priority Heavy Metals			Additional Heavy Metals					
				Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
Category	Fuel	Segment	Euro Standard	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 4	0.165	0.00531	0.00019	0.00020	0.0285	1.031	0.0376	0.00533	0.563
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Conventional	0.157	0.00411	0.00019	0.00016	0.0221	0.799	0.0291	0.00413	0.436
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 1	0.161	0.00518	0.00019	0.00020	0.0278	1.007	0.0367	0.00520	0.549
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 2	0.162	0.00522	0.00019	0.00020	0.0280	1.014	0.0370	0.00523	0.553
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 3	0.167	0.00633	0.00019	0.00024	0.0339	1.230	0.0448	0.00635	0.671
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 4	0.169	0.00650	0.00019	0.00024	0.0349	1.264	0.0461	0.00652	0.690
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Conventional	0.153	0.00307	0.00019	0.00008	0.0153	0.570	0.0217	0.00308	0.320
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 1	0.155	0.00335	0.00019	0.00009	0.0167	0.623	0.0236	0.00336	0.350
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 2	0.155	0.00336	0.00019	0.00009	0.0168	0.625	0.0237	0.00337	0.351
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 3	0.159	0.00529	0.00019	0.00014	0.0263	0.983	0.0373	0.00530	0.552
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 4	0.159	0.00513	0.00019	0.00013	0.0255	0.953	0.0362	0.00514	0.535
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Conventional	0.155	0.00017	0.00019	0.00008	0.0032	0.077	0.0014	0.00019	0.034
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 1	0.157	0.00020	0.00019	0.00010	0.0038	0.094	0.0017	0.00023	0.042
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 2	0.159	0.00024	0.00019	0.00012	0.0046	0.113	0.0020	0.00027	0.050
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 3	0.161	0.00028	0.00019	0.00014	0.0052	0.129	0.0023	0.00031	0.058
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 4	0.160	0.00025	0.00019	0.00012	0.0046	0.114	0.0020	0.00028	0.051
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Conventional	0.153	0.00012	0.00019	0.00006	0.0023	0.056	0.0010	0.00014	0.025
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 1	0.154	0.00013	0.00019	0.00007	0.0025	0.059	0.0011	0.00015	0.027
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 2	0.155	0.00014	0.00019	0.00007	0.0027	0.065	0.0012	0.00016	0.029
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 3	0.154	0.00010	0.00019	0.00005	0.0019	0.046	0.0008	0.00011	0.021
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 4	0.154	0.00012	0.00019	0.00006	0.0023	0.054	0.0010	0.00013	0.025
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Conventional	0.152	0.00011	0.00019	0.00006	0.0021	0.049	0.0009	0.00012	0.022
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 1	0.153	0.00012	0.00019	0.00006	0.0022	0.052	0.0009	0.00013	0.024
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 2	0.153	0.00012	0.00019	0.00006	0.0022	0.052	0.0009	0.00013	0.024
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 3	0.153	0.00010	0.00019	0.00005	0.0019	0.046	0.0008	0.00011	0.021
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 4	0.154	0.00012	0.00019	0.00006	0.0023	0.054	0.0010	0.00013	0.025

Table C-5: Road transportation distance based implied emission factor (mg/km) for 2020 for Main Pollutants, Particulate Matter and CO

				Main Pollutants				Particulate Matter				Other
				NOx (as NO_2)	NMVOC	SOx (as SO_2)	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
Category	Fuel	Segment	Euro Standard	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km
Passenger Cars	Petrol	Mini	Euro 4	65.72	310.01	1.03	28.51	13.73	24.28	37.05	1.23	1 040.22
Passenger Cars	Petrol	Mini	Euro 5	43.21	257.39	1.03	13.77	14.60	25.15	37.92	1.36	1 010.33
Passenger Cars	Petrol	Mini	Euro 6 a/b/c	43.21	243.40	1.03	13.25	14.52	25.08	37.85	1.35	944.24
Passenger Cars	Petrol	Mini	Euro 6 d-temp	43.21	345.81	1.03	12.97	13.60	24.15	36.93	1.21	944.24
Passenger Cars	Petrol	Small	PRE ECE - ECE 15/04	2 192.18	3 337.53	1.24	2.00	15.08	25.63	38.40	1.53	16 398.87
Passenger Cars	Petrol	Small	Euro 1	536.46	1 191.84	1.18	79.47	15.08	25.63	38.40	1.68	5 340.43
Passenger Cars	Petrol	Small	Euro 2	258.76	797.97	1.18	102.98	15.08	25.63	38.40	1.68	2 997.01
Passenger Cars	Petrol	Small	Euro 3	113.06	465.77	1.18	28.70	13.73	24.28	37.05	1.23	2 849.88
Passenger Cars	Petrol	Small	Euro 4	65.72	334.55	1.22	28.55	13.73	24.28	37.05	1.23	1 040.22
Passenger Cars	Petrol	Small	Euro 5	43.21	274.59	1.22	13.83	14.60	25.15	37.92	1.36	1 010.33
Passenger Cars	Petrol	Small	Euro 6 a/b/c	43.21	213.66	1.22	13.41	14.52	25.08	37.85	1.35	944.24
Passenger Cars	Petrol	Small	Euro 6 d-temp	43.21	199.24	1.22	13.07	13.60	24.15	36.93	1.21	944.24
Passenger Cars	Petrol	Medium	PRE ECE - ECE 15/04	2 757.47	3 439.13	1.48	2.00	15.08	25.63	38.40	1.53	16 516.45
Passenger Cars	Petrol	Medium	Euro 1	536.75	890.51	1.41	79.80	15.08	25.63	38.40	1.68	4 979.94
Passenger Cars	Petrol	Medium	Euro 2	258.97	512.53	1.34	104.09	15.08	25.63	38.40	1.68	2 737.46
Passenger Cars	Petrol	Medium	Euro 3	113.15	304.22	1.41	28.75	13.73	24.28	37.05	1.23	2 626.38
Passenger Cars	Petrol	Medium	Euro 4	65.77	220.30	1.43	28.55	13.73	24.28	37.05	1.23	975.33
Passenger Cars	Petrol	Medium	Euro 5	43.26	200.20	1.43	13.84	14.60	25.15	37.92	1.36	945.44
Passenger Cars	Petrol	Medium	Euro 6 a/b/c	43.26	176.34	1.43	13.43	14.52	25.08	37.85	1.35	879.35
Passenger Cars	Petrol	Medium	Euro 6 d-temp	43.26	167.74	1.43	13.11	13.60	24.15	36.93	1.21	879.35
Passenger Cars	Petrol	Large-SUV-Executive	PRE ECE - ECE 15/04	3 237.60	4 128.68	1.87	2.00	15.08	25.63	38.40	1.49	17 869.70
Passenger Cars	Petrol	Large-SUV-Executive	Euro 1	511.42	750.83	1.82	79.58	15.08	25.63	38.40	1.68	4 253.98
Passenger Cars	Petrol	Large-SUV-Executive	Euro 2	240.73	430.75	1.83	103.63	15.08	25.63	38.40	1.68	2 214.77
Passenger Cars	Petrol	Large-SUV-Executive	Euro 3	105.04	261.69	1.66	28.71	13.73	24.28	37.05	1.23	2 176.28
Passenger Cars	Petrol	Large-SUV-Executive	Euro 4	61.21	189.47	1.96	28.54	13.73	24.28	37.05	1.23	844.66
Passenger Cars	Petrol	Large-SUV-Executive	Euro 5	38.70	167.90	1.96	13.78	14.60	25.15	37.92	1.36	814.77
Passenger Cars	Petrol	Large-SUV-Executive	Euro 6 a/b/c	38.70	145.44	1.96	13.38	14.52	25.08	37.85	1.35	748.67
Passenger Cars	Petrol	Large-SUV-Executive	Euro 6 d-temp	38.70	159.72	1.96	13.05	13.60	24.15	36.93	1.21	748.67
Passenger Cars	Petrol Hybrid	All Segments	Euro 4	27.85	199.68	0.87	28.72	13.73	24.28	37.05	1.23	472.85
Passenger Cars	Petrol Hybrid	All Segments	Euro 5	24.86	127.91	0.90	28.67	14.60	25.15	37.92	1.36	381.61
Passenger Cars	Petrol Hybrid	All Segments	Euro 6 a/b/c	26.28	142.78	0.89	28.35	14.52	25.08	37.85	1.35	428.10
Passenger Cars	Petrol Hybrid	All Segments	Euro 6 d-temp	26.73	144.13	0.88	28.20	13.60	24.15	36.93	1.21	439.06
Passenger Cars	Diesel	Mini	Euro 4	713.59	16.38	0.69	1.00	49.98	60.53	73.30	33.59	105.11
Passenger Cars	Diesel	Mini	Euro 5	649.64	1.34	0.69	1.90	15.47	26.02	38.79	1.64	39.21
Passenger Cars	Diesel	Mini	Euro 6 a/b/c	586.08	1.29	0.69	7.00	14.64	25.19	37.96	1.47	37.45
Passenger Cars	Diesel	Mini	Euro 6 d-temp	71.15	1.29	0.69	7.00	14.64	25.19	37.96	1.47	24.21
Passenger Cars	Diesel	Small	Conventional	636.98	179.10	1.29	1.00	305.15	315.70	328.47	161.97	734.21
Passenger Cars	Diesel	Small	Euro 1	744.22	58.51	1.06	1.00	123.04	133.59	146.36	78.38	508.93
Passenger Cars	Diesel	Small	Euro 2	820.44	40.16	1.09	1.00	81.59	92.14	104.91	56.26	372.16
Passenger Cars	Diesel	Small	Euro 3	868.04	22.01	1.03	1.00	61.97	72.52	85.29	43.04	103.39
Passenger Cars	Diesel	Small	Euro 4	713.59	16.38	1.03	1.00	49.98	60.53	73.30	33.59	105.11
Passenger Cars	Diesel	Small	Euro 5	649.64	1.34	1.03	1.90	15.47	26.02	38.79	1.64	39.21
Passenger Cars	Diesel	Small	Euro 6 a/b/c	586.08	1.29	1.03	7.00	14.65	25.20	37.97	1.47	37.45
Passenger Cars	Diesel	Small	Euro 6 d-temp	71.15	1.29	1.03	7.00	14.65	25.20	37.97	1.47	24.21
Passenger Cars	Diesel	Medium	Conventional	636.98	179.10	1.29	1.00	305.15	315.70	328.47	161.97	734.21

				Main Pollutants				Particulate Matter				Other
				NOx (as NO_2)	NMVOC	SOx (as SO_2)	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
Category	Fuel	Segment	Euro Standard	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km
Passenger Cars	Diesel	Medium	Euro 1	744.22	58.51	1.06	1.00	123.04	133.59	146.36	78.38	508.93
Passenger Cars	Diesel	Medium	Euro 2	820.44	40.16	1.09	1.00	81.59	92.14	104.91	56.26	372.16
Passenger Cars	Diesel	Medium	Euro 3	868.04	22.01	1.03	1.00	61.97	72.52	85.29	43.04	103.39
Passenger Cars	Diesel	Medium	Euro 4	713.59	16.38	1.03	1.00	49.98	60.53	73.30	33.59	105.11
Passenger Cars	Diesel	Medium	Euro 5	649.64	1.34	1.03	1.90	15.47	26.02	38.79	1.64	39.21
Passenger Cars	Diesel	Medium	Euro 6 a/b/c	586.08	1.29	1.03	7.00	14.65	25.20	37.97	1.47	37.45
Passenger Cars	Diesel	Medium	Euro 6 d-temp	71.15	1.29	1.03	7.00	14.65	25.20	37.97	1.47	24.21
Passenger Cars	Diesel	Large-SUV-Executive	Conventional	992.97	179.10	1.29	1.00	305.15	315.70	328.47	161.97	734.21
Passenger Cars	Diesel	Large-SUV-Executive	Euro 1	744.22	87.66	1.41	1.00	123.04	133.59	146.36	78.38	508.93
Passenger Cars	Diesel	Large-SUV-Executive	Euro 2	820.44	117.66	1.41	1.00	81.59	92.14	104.91	56.26	372.16
Passenger Cars	Diesel	Large-SUV-Executive	Euro 3	868.04	47.98	1.41	1.00	61.97	72.52	85.29	43.04	103.39
Passenger Cars	Diesel	Large-SUV-Executive	Euro 4	713.59	16.38	1.41	1.00	49.98	60.53	73.30	33.59	105.11
Passenger Cars	Diesel	Large-SUV-Executive	Euro 5	649.64	1.34	1.41	1.90	15.47	26.02	38.79	1.64	39.21
Passenger Cars	Diesel	Large-SUV-Executive	Euro 6 a/b/c	586.08	1.29	1.41	7.00	14.65	25.20	37.97	1.47	37.45
Passenger Cars	Diesel	Large-SUV-Executive	Euro 6 d-temp	71.15	1.29	1.41	7.00	14.65	25.20	37.97	1.47	24.21
Passenger Cars	LPG Bifuel	All Segments	Conventional	2 397.09	1 170.82	-	-	15.08	25.63	38.40	1.56	10 487.22
Passenger Cars	LPG Bifuel	All Segments	Euro 1	482.18	953.22	-	-	15.08	25.63	38.40	1.68	5 095.52
Passenger Cars	LPG Bifuel	All Segments	Euro 2	217.46	445.61	-	-	15.08	25.63	38.40	1.68	3 540.46
Passenger Cars	LPG Bifuel	All Segments	Euro 3	113.15	151.61	-	-	13.73	24.28	37.05	1.23	2 626.38
Passenger Cars	LPG Bifuel	All Segments	Euro 4	65.77	75.23	-	-	13.73	24.28	37.05	1.23	975.33
Passenger Cars	LPG Bifuel	All Segments	Euro 5	53.95	75.23	-	-	13.73	24.28	37.05	1.23	975.33
Passenger Cars	LPG Bifuel	All Segments	Euro 6 a/b/c	53.95	75.23	-	-	13.73	24.28	37.05	1.23	975.33
Passenger Cars	LPG Bifuel	All Segments	Euro 6 d-temp	53.95	75.23	-	-	13.73	24.28	37.05	1.23	975.33
Light Commercial Vehicles	Petrol	N1-I	Conventional	3 053.39	4 377.84	1.66	2.00	19.96	34.53	50.35	2.08	32 598.84
Light Commercial Vehicles	Petrol	N1-I	Euro 1	672.21	959.37	1.18	79.43	19.96	34.53	50.35	2.21	16 279.94
Light Commercial Vehicles	Petrol	N1-I	Euro 2	214.27	327.14	1.18	103.05	19.96	34.53	50.35	2.21	8 357.05
Light Commercial Vehicles	Petrol	N1-I	Euro 3	119.74	186.43	1.19	28.80	18.62	33.19	49.01	1.76	6 644.93
Light Commercial Vehicles	Petrol	N1-I	Euro 4	54.92	140.64	1.23	28.63	18.62	33.19	49.01	1.76	2 442.90
Light Commercial Vehicles	Petrol	N1-I	Euro 5	19.15	146.64	1.23	13.80	20.05	34.62	50.45	1.97	1 343.13
Light Commercial Vehicles	Petrol	N1-I	Euro 6 a/b/c	19.15	124.40	1.23	13.41	20.05	34.62	50.45	1.97	1 343.13
Light Commercial Vehicles	Petrol	N1-I	Euro 6 d-temp	19.15	102.30	1.23	13.17	18.49	33.06	48.88	1.74	1 343.13
Light Commercial Vehicles	Petrol	N1-II & N1-III	Conventional	3 053.39	4 761.23	1.89	2.00	19.96	34.53	50.35	2.03	32 598.84
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 1	635.55	890.88	2.30	79.39	19.96	34.53	50.35	2.21	12 615.06
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 2	259.18	446.35	2.30	104.51	19.96	34.53	50.35	2.21	8 305.56
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 3	145.94	371.08	2.30	28.43	18.62	33.19	49.01	1.76	7 114.72
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 4	72.63	189.85	2.30	28.61	18.62	33.19	49.01	1.76	2 977.33
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 5	32.14	128.70	1.21	12.00	16.85	29.09	42.38	1.66	1 889.77
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 6 a/b/c	38.26	170.92	1.44	13.47	20.05	34.62	50.45	1.97	2 249.37
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 6 d-temp	38.26	134.63	1.44	13.33	18.76	33.33	49.16	1.78	2 249.37
Light Commercial Vehicles	Diesel	N1-I	Conventional	2 101.82	152.64	1.29	1.00	384.85	399.43	415.25	203.64	1 458.40
Light Commercial Vehicles	Diesel	N1-I	Euro 1	1 347.79	158.67	1.06	1.00	157.16	171.73	187.55	99.37	689.94
Light Commercial Vehicles	Diesel	N1-I	Euro 2	1 347.79	164.69	1.09	1.00	157.16	171.73	187.55	113.33	689.94
Light Commercial Vehicles	Diesel	N1-I	Euro 3	1 132.14	103.35	1.03	1.00	111.06	125.64	141.46	81.14	565.75
Light Commercial Vehicles	Diesel	N1-I	Euro 4	916.50	38.35	1.03	1.00	66.36	80.94	96.76	44.12	448.46
Light Commercial Vehicles	Diesel	N1-I	Euro 5	1 719.03	0.23	1.03	1.90	18.97	33.54	49.37	1.88	0.30
Light Commercial Vehicles	Diesel	N1-I	Euro 6 a/b/c	1 390.36	0.23	1.03	7.00	18.97	33.54	49.37	1.88	0.30
Light Commercial Vehicles	Diesel	N1-I	Euro 6 d-temp	496.87	0.23	1.03	7.00	18.97	33.54	49.37	1.88	0.17
Light Commercial Vehicles	Diesel	N1-II & N1-III	Conventional	2 101.82	152.64	1.79	1.00	384.85	399.43	415.25	203.64	1 458.40
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 1	1 347.79	158.67	1.61	1.00	157.16	171.73	187.55	99.37	689.94

				Main Pollutants				Particulate Matter				Other
				NOx (as NO_2)	NMVOC	SOx (as SO_2)	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
Category	Fuel	Segment	Euro Standard	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 2	1 347.79	164.69	1.61	1.00	157.16	171.73	187.55	113.33	689.94
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 3	1 132.14	103.35	1.61	1.00	111.06	125.64	141.46	81.14	565.75
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 4	916.50	38.35	1.61	1.00	66.36	80.94	96.76	44.12	448.46
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 5	1 751.71	0.25	1.49	1.90	18.97	33.54	49.37	1.88	0.36
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 6 a/b/c	1 415.22	0.25	1.49	7.00	18.97	33.54	49.37	1.88	0.36
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 6 d-temp	504.33	0.25	1.49	7.00	18.97	33.54	49.37	1.88	0.36
Heavy Duty Trucks	Diesel	<=20 t	Conventional	8 204.11	964.99	3.39	2.90	388.77	428.05	476.82	175.83	2 449.39
Heavy Duty Trucks	Diesel	<=20 t	Euro I	5 295.98	308.46	2.99	2.90	248.59	287.94	336.86	136.56	1 171.73
Heavy Duty Trucks	Diesel	<=20 t	Euro II	5 888.90	205.44	2.96	2.90	159.61	199.23	248.77	78.40	1 016.92
Heavy Duty Trucks	Diesel	<=20 t	Euro III	5 073.06	199.39	3.32	2.90	163.52	204.23	256.19	85.56	1 342.74
Heavy Duty Trucks	Diesel	<=20 t	Euro IV	3 534.97	32.25	3.22	2.90	73.91	114.96	167.69	23.74	650.25
Heavy Duty Trucks	Diesel	<=20 t	Euro V	3 127.58	29.39	3.14	11.00	79.97	121.25	174.47	27.98	1 044.12
Heavy Duty Trucks	Diesel	<=20 t	Euro VI A/B/C	262.80	20.27	3.17	9.00	50.96	92.34	145.79	4.01	117.89
Heavy Duty Trucks	Diesel	<=20 t	Euro VI D/E	265.88	20.50	3.20	9.00	51.03	92.43	145.92	4.02	119.37
Heavy Duty Trucks	Diesel	20 - 28 t	Conventional	11 452.86	571.62	5.23	2.90	492.71	534.27	588.11	225.95	2 382.28
Heavy Duty Trucks	Diesel	20 - 28 t	Euro I	8 191.60	494.17	4.55	2.90	389.17	430.72	484.56	225.37	1 954.95
Heavy Duty Trucks	Diesel	20 - 28 t	Euro II	8 814.75	323.92	4.42	2.90	237.08	278.63	332.48	126.51	1 697.70
Heavy Duty Trucks	Diesel	20 - 28 t	Euro III	7 022.02	303.24	4.59	2.90	216.25	257.80	311.63	121.39	1 940.17
Heavy Duty Trucks	Diesel	20 - 28 t	Euro IV	4 827.33	48.32	4.42	2.90	85.53	127.08	180.91	31.76	886.42
Heavy Duty Trucks	Diesel	20 - 28 t	Euro V	4 064.31	42.25	4.31	11.00	92.95	134.50	188.33	37.33	1 386.90
Heavy Duty Trucks	Diesel	20 - 28 t	Euro VI A/B/C	339.24	29.29	4.37	9.00	52.50	94.06	147.89	4.24	175.25
Heavy Duty Trucks	Diesel	20 - 28 t	Euro VI D/E	339.05	29.28	4.37	9.00	52.50	94.05	147.89	4.24	174.79
Heavy Duty Trucks	Diesel	>28 t	Conventional	14 314.38	618.98	6.37	2.90	611.29	657.58	721.95	281.41	2 914.88
Heavy Duty Trucks	Diesel	>28 t	Euro I	10 262.07	570.46	5.69	2.90	510.60	557.71	623.90	297.85	2 603.05
Heavy Duty Trucks	Diesel	>28 t	Euro II	10 919.85	364.59	5.64	2.90	313.22	359.99	425.41	169.96	2 266.38
Heavy Duty Trucks	Diesel	>28 t	Euro III	8 804.26	330.66	5.67	2.90	260.88	307.46	372.46	146.22	2 492.70
Heavy Duty Trucks	Diesel	>28 t	Euro IV	5 731.29	54.91	5.08	2.90	92.75	134.84	189.89	36.42	994.41
Heavy Duty Trucks	Diesel	>28 t	Euro V	4 305.36	47.37	4.94	11.00	99.53	141.08	194.92	42.27	1 635.18
Heavy Duty Trucks	Diesel	>28 t	Euro VI A/B/C	312.15	32.66	4.96	9.00	52.91	94.46	148.30	4.30	164.35
Heavy Duty Trucks	Diesel	>28 t	Euro VI D/E	312.07	32.67	4.96	9.00	52.91	94.46	148.29	4.30	164.17
Buses	Diesel	Urban Buses	Conventional	21 468.63	3 508.60	9.46	2.90	1 408.08	1 464.45	1 518.27	679.11	8 986.00
Buses	Diesel	Urban Buses	Euro I	15 063.47	1 038.84	8.43	2.90	709.28	766.52	822.28	426.50	4 279.43
Buses	Diesel	Urban Buses	Euro II	16 222.98	708.77	8.08	2.90	375.29	432.60	488.52	209.32	4 148.86
Buses	Diesel	Urban Buses	Euro III	15 317.45	635.38	8.11	2.90	347.21	404.35	459.86	205.69	4 141.32
Buses	Diesel	Urban Buses	Euro IV	8 890.38	92.27	7.15	2.90	130.18	187.37	243.02	57.23	1 912.24
Buses	Diesel	Urban Buses	Euro V	10 217.00	77.80	7.25	11.00	142.09	199.37	255.22	66.04	3 750.96
Buses	Diesel	Urban Buses	Euro VI A/B/C	576.00	57.12	7.68	9.00	68.65	126.19	182.61	5.44	409.02
Buses	Diesel	Urban Buses	Euro VI D/E	575.51	57.08	7.68	9.00	68.66	126.21	182.64	5.44	408.84
Buses	Diesel	Coaches	Conventional	9 318.44	408.48	4.12	2.90	363.07	400.26	450.70	163.24	1 673.03
Buses	Diesel	Coaches	Euro I	7 360.92	412.79	3.93	2.90	302.25	340.16	392.22	170.93	1 506.02
Buses	Diesel	Coaches	Euro II	8 151.77	282.93	3.95	2.90	192.68	230.80	283.30	99.48	1 335.96
Buses	Diesel	Coaches	Euro III	6 228.25	270.31	3.97	2.90	180.43	218.57	271.12	98.29	1 537.37
Buses	Diesel	Coaches	Euro IV	4 432.35	42.63	3.96	2.90	79.06	117.32	170.14	28.87	796.52
Buses	Diesel	Coaches	Euro V	2 984.02	40.33	4.18	11.00	87.84	126.03	178.71	35.54	1 267.72
Buses	Diesel	Coaches	Euro VI A/B/C	200.35	28.89	4.22	9.00	49.32	87.65	140.61	4.00	170.56
Buses	CNG	Urban CNG Buses	Euro I	16 500.00	200.00	-	1 000.00	74.97	130.33	181.92	3.37	8 400.00
Buses	CNG	Urban CNG Buses	Euro III	10 000.00	20.00	-	1 000.00	64.97	120.33	171.92	3.37	1 000.00
Buses	CNG	Urban CNG Buses	EEV	4 878.54	253.27	-	1 000.00	68.42	123.79	175.38	3.37	1 270.51
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Conventional	56.00	9 330.74	0.49	1.00	182.72	188.89	194.57	35.74	14 700.00

				Main Pollutants				Particulate Matter				Other
				NOx (as NO_2)	NMVOC	SOx (as SO_2)	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
Category	Fuel	Segment	Euro Standard	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 1	180.00	4 128.10	0.39	1.00	51.72	57.89	63.57	5.04	4 600.00
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 2	170.00	3 210.05	0.39	1.00	32.72	38.89	44.57	5.74	2 800.00
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 3	170.00	2 184.11	0.39	1.00	24.72	30.89	36.57	4.14	1 800.00
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 4	170.00	2 082.36	0.39	1.00	24.72	30.89	36.57	4.14	1 800.00
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Conventional	56.00	9 330.74	0.49	1.00	182.72	188.89	194.57	18.14	14 700.00
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 1	220.00	1 508.10	0.39	1.00	46.72	52.89	58.57	8.54	6 700.00
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 2	170.00	1 400.05	0.39	1.00	13.72	19.89	25.57	1.94	4 200.00
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 3	382.78	1 934.52	0.33	1.00	14.47	20.64	26.33	2.09	3 228.09
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 4	43.28	714.21	0.32	1.00	8.37	14.55	20.23	0.87	2 176.00
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Conventional	31.66	11 035.93	0.67	2.00	205.49	210.23	215.51	20.46	20 802.83
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 1	47.10	4 134.21	0.62	2.00	85.49	90.23	95.51	16.46	13 724.42
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 2	54.61	2 398.24	0.62	2.00	45.49	50.23	55.51	8.46	10 857.32
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 3	65.26	1 399.96	0.39	2.00	17.49	22.23	27.51	2.86	7 162.22
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 4	56.96	1 500.45	0.41	2.00	17.49	22.23	27.51	2.86	8 718.35
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Conventional	380.23	1 628.72	0.66	2.00	25.49	30.23	35.51	3.46	19 764.38
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 1	401.94	1 308.03	0.54	2.00	25.49	30.23	35.51	5.46	15 869.67
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 2	367.72	642.14	0.45	2.00	10.49	15.23	20.51	1.71	5 913.93
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 3	88.54	195.45	0.39	2.00	10.49	15.23	20.51	1.71	1 672.53
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 4	32.59	204.10	0.45	2.00	10.49	15.23	20.51	1.71	1 797.56
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Conventional	489.69	2 723.82	0.90	2.00	25.49	30.23	35.51	3.46	25 370.21
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 1	424.91	1 652.97	0.86	2.00	25.49	30.23	35.51	5.46	13 910.85
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 2	195.57	989.09	0.79	2.00	10.49	15.23	20.51	1.71	6 345.98
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 3	75.92	420.60	1.12	2.00	10.49	15.23	20.51	1.71	621.06
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 4	32.89	265.88	0.94	2.00	10.49	15.23	20.51	1.71	405.49
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Conventional	307.90	3 422.25	1.03	2.00	25.49	30.23	35.51	3.46	25 370.21
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 1	319.10	1 818.86	0.97	2.00	25.49	30.23	35.51	5.46	13 910.85
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 2	354.33	1 053.69	0.97	2.00	10.49	15.23	20.51	1.71	6 345.98
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 3	74.65	535.82	1.11	2.00	10.49	15.23	20.51	1.71	621.06
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 4	31.32	350.82	0.94	2.00	10.49	15.23	20.51	1.71	405.49

Table C-6: Road transportation distance based implied emission factor (mg/km) for 2020 for Heavy Metals

				Priority Heavy Metals			Additional Heavy Metals					
				Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
Category	Fuel	Segment	Euro Standard	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km
Passenger Cars	Petrol	Mini	Euro 4	0.364	0.0008	0.00045	0.00025	0.011	0.276	0.0059	0.0008	0.134
Passenger Cars	Petrol	Mini	Euro 5	0.364	0.0008	0.00045	0.00025	0.011	0.276	0.0059	0.0008	0.134
Passenger Cars	Petrol	Mini	Euro 6 a/b/c	0.364	0.0007	0.00045	0.00025	0.010	0.270	0.0057	0.0008	0.131
Passenger Cars	Petrol	Mini	Euro 6 d-temp	0.364	0.0007	0.00045	0.00025	0.010	0.267	0.0056	0.0008	0.129
Passenger Cars	Petrol	Small	PRE ECE - ECE 15/04	0.435	0.0008	0.00054	0.00025	0.011	0.276	0.0060	0.0008	0.135
Passenger Cars	Petrol	Small	Euro 1	0.416	0.0008	0.00051	0.00025	0.011	0.276	0.0060	0.0008	0.135
Passenger Cars	Petrol	Small	Euro 2	0.414	0.0008	0.00051	0.00025	0.011	0.276	0.0060	0.0008	0.135
Passenger Cars	Petrol	Small	Euro 3	0.416	0.0008	0.00052	0.00025	0.011	0.276	0.0060	0.0008	0.135
Passenger Cars	Petrol	Small	Euro 4	0.429	0.0008	0.00053	0.00025	0.011	0.276	0.0060	0.0008	0.135
Passenger Cars	Petrol	Small	Euro 5	0.429	0.0008	0.00053	0.00025	0.011	0.276	0.0060	0.0008	0.135
Passenger Cars	Petrol	Small	Euro 6 a/b/c	0.429	0.0007	0.00053	0.00025	0.010	0.270	0.0057	0.0008	0.131
Passenger Cars	Petrol	Small	Euro 6 d-temp	0.429	0.0007	0.00053	0.00025	0.010	0.267	0.0056	0.0008	0.129
Passenger Cars	Petrol	Medium	PRE ECE - ECE 15/04	0.517	0.0008	0.00065	0.00026	0.011	0.276	0.0060	0.0008	0.135
Passenger Cars	Petrol	Medium	Euro 1	0.492	0.0008	0.00061	0.00026	0.011	0.276	0.0060	0.0008	0.135
Passenger Cars	Petrol	Medium	Euro 2	0.469	0.0008	0.00058	0.00025	0.011	0.276	0.0060	0.0008	0.135
Passenger Cars	Petrol	Medium	Euro 3	0.493	0.0008	0.00061	0.00026	0.011	0.276	0.0060	0.0008	0.135
Passenger Cars	Petrol	Medium	Euro 4	0.499	0.0008	0.00062	0.00026	0.011	0.276	0.0060	0.0008	0.135
Passenger Cars	Petrol	Medium	Euro 5	0.499	0.0008	0.00062	0.00026	0.011	0.276	0.0060	0.0008	0.135
Passenger Cars	Petrol	Medium	Euro 6 a/b/c	0.499	0.0007	0.00062	0.00026	0.011	0.270	0.0057	0.0008	0.131
Passenger Cars	Petrol	Medium	Euro 6 d-temp	0.499	0.0007	0.00062	0.00026	0.010	0.267	0.0056	0.0008	0.130
Passenger Cars	Petrol	Large-SUV-Executive	PRE ECE - ECE 15/04	0.644	0.0008	0.00081	0.00026	0.011	0.276	0.0060	0.0008	0.136
Passenger Cars	Petrol	Large-SUV-Executive	Euro 1	0.628	0.0008	0.00079	0.00026	0.011	0.276	0.0060	0.0008	0.136
Passenger Cars	Petrol	Large-SUV-Executive	Euro 2	0.633	0.0008	0.00080	0.00026	0.011	0.276	0.0060	0.0008	0.136
Passenger Cars	Petrol	Large-SUV-Executive	Euro 3	0.575	0.0008	0.00072	0.00026	0.011	0.276	0.0060	0.0008	0.135
Passenger Cars	Petrol	Large-SUV-Executive	Euro 4	0.675	0.0008	0.00085	0.00026	0.011	0.276	0.0060	0.0008	0.136
Passenger Cars	Petrol	Large-SUV-Executive	Euro 5	0.675	0.0008	0.00085	0.00026	0.011	0.276	0.0060	0.0008	0.136
Passenger Cars	Petrol	Large-SUV-Executive	Euro 6 a/b/c	0.675	0.0007	0.00085	0.00026	0.011	0.270	0.0058	0.0008	0.132
Passenger Cars	Petrol	Large-SUV-Executive	Euro 6 d-temp	0.675	0.0007	0.00085	0.00026	0.011	0.267	0.0057	0.0008	0.131
Passenger Cars	Petrol Hybrid	All Segments	Euro 4	0.311	0.0008	0.00038	0.00025	0.011	0.276	0.0059	0.0008	0.134
Passenger Cars	Petrol Hybrid	All Segments	Euro 5	0.321	0.0008	0.00039	0.00025	0.011	0.276	0.0059	0.0008	0.134
Passenger Cars	Petrol Hybrid	All Segments	Euro 6 a/b/c	0.316	0.0007	0.00039	0.00025	0.010	0.270	0.0057	0.0008	0.130
Passenger Cars	Petrol Hybrid	All Segments	Euro 6 d-temp	0.315	0.0007	0.00038	0.00025	0.010	0.267	0.0055	0.0008	0.129
Passenger Cars	Diesel	Mini	Euro 4	0.020	0.0008	0.00018	0.00024	0.011	0.279	0.0060	0.0009	0.135
Passenger Cars	Diesel	Mini	Euro 5	0.020	0.0008	0.00018	0.00024	0.011	0.279	0.0060	0.0009	0.135
Passenger Cars	Diesel	Mini	Euro 6 a/b/c	0.020	0.0007	0.00018	0.00024	0.010	0.271	0.0056	0.0008	0.130
Passenger Cars	Diesel	Mini	Euro 6 d-temp	0.020	0.0007	0.00018	0.00024	0.010	0.268	0.0055	0.0008	0.129
Passenger Cars	Diesel	Small	Conventional	0.020	0.0008	0.00034	0.00024	0.011	0.279	0.0060	0.0009	0.136
Passenger Cars	Diesel	Small	Euro 1	0.020	0.0008	0.00028	0.00024	0.011	0.279	0.0060	0.0009	0.135
Passenger Cars	Diesel	Small	Euro 2	0.020	0.0008	0.00029	0.00024	0.011	0.279	0.0060	0.0009	0.135
Passenger Cars	Diesel	Small	Euro 3	0.020	0.0008	0.00027	0.00024	0.011	0.279	0.0060	0.0009	0.135
Passenger Cars	Diesel	Small	Euro 4	0.020	0.0008	0.00027	0.00024	0.011	0.279	0.0060	0.0009	0.135
Passenger Cars	Diesel	Small	Euro 5	0.020	0.0008	0.00027	0.00024	0.011	0.279	0.0060	0.0009	0.135
Passenger Cars	Diesel	Small	Euro 6 a/b/c	0.020	0.0007	0.00027	0.00024	0.011	0.271	0.0056	0.0008	0.131
Passenger Cars	Diesel	Small	Euro 6 d-temp	0.020	0.0007	0.00027	0.00024	0.010	0.268	0.0055	0.0008	0.129
Passenger Cars	Diesel	Medium	Conventional	0.020	0.0008	0.00034	0.00024	0.011	0.279	0.0060	0.0009	0.136
Passenger Cars	Diesel	Medium	Euro 1	0.020	0.0008	0.00028	0.00024	0.011	0.279	0.0060	0.0009	0.135

				Priority Heavy Metals			Additional Heavy Metals					
				Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
Category	Fuel	Segment	Euro Standard	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km
Passenger Cars	Diesel	Medium	Euro 2	0.020	0.0008	0.00029	0.00024	0.011	0.279	0.0060	0.0009	0.135
Passenger Cars	Diesel	Medium	Euro 3	0.020	0.0008	0.00027	0.00024	0.011	0.279	0.0060	0.0009	0.135
Passenger Cars	Diesel	Medium	Euro 4	0.020	0.0008	0.00027	0.00024	0.011	0.279	0.0060	0.0009	0.135
Passenger Cars	Diesel	Medium	Euro 5	0.020	0.0008	0.00027	0.00024	0.011	0.279	0.0060	0.0009	0.135
Passenger Cars	Diesel	Medium	Euro 6 a/b/c	0.020	0.0007	0.00027	0.00024	0.011	0.271	0.0056	0.0008	0.131
Passenger Cars	Diesel	Medium	Euro 6 d-temp	0.020	0.0007	0.00027	0.00024	0.010	0.268	0.0055	0.0008	0.129
Passenger Cars	Diesel	Large-SUV-Executive	Conventional	0.020	0.0008	0.00034	0.00024	0.011	0.279	0.0060	0.0009	0.136
Passenger Cars	Diesel	Large-SUV-Executive	Euro 1	0.020	0.0008	0.00038	0.00024	0.011	0.280	0.0060	0.0009	0.136
Passenger Cars	Diesel	Large-SUV-Executive	Euro 2	0.020	0.0008	0.00038	0.00024	0.011	0.280	0.0060	0.0009	0.136
Passenger Cars	Diesel	Large-SUV-Executive	Euro 3	0.020	0.0008	0.00038	0.00024	0.011	0.280	0.0060	0.0009	0.136
Passenger Cars	Diesel	Large-SUV-Executive	Euro 4	0.020	0.0008	0.00038	0.00024	0.011	0.280	0.0060	0.0009	0.136
Passenger Cars	Diesel	Large-SUV-Executive	Euro 5	0.020	0.0008	0.00038	0.00024	0.011	0.280	0.0060	0.0009	0.136
Passenger Cars	Diesel	Large-SUV-Executive	Euro 6 a/b/c	0.020	0.0007	0.00038	0.00024	0.011	0.271	0.0056	0.0008	0.131
Passenger Cars	Diesel	Large-SUV-Executive	Euro 6 d-temp	0.020	0.0007	0.00038	0.00024	0.011	0.268	0.0055	0.0008	0.129
Passenger Cars	LPG Bifuel	All Segments	Conventional	0.020	0.0008	-	0.00023	0.010	0.276	0.0058	0.0008	0.133
Passenger Cars	LPG Bifuel	All Segments	Euro 1	0.020	0.0008	-	0.00023	0.010	0.276	0.0058	0.0008	0.133
Passenger Cars	LPG Bifuel	All Segments	Euro 2	0.020	0.0008	-	0.00023	0.010	0.276	0.0058	0.0008	0.133
Passenger Cars	LPG Bifuel	All Segments	Euro 3	0.020	0.0008	-	0.00023	0.010	0.276	0.0058	0.0008	0.133
Passenger Cars	LPG Bifuel	All Segments	Euro 4	0.020	0.0008	-	0.00023	0.010	0.276	0.0058	0.0008	0.133
Passenger Cars	LPG Bifuel	All Segments	Euro 5	0.020	0.0008	-	0.00023	0.010	0.276	0.0058	0.0008	0.133
Passenger Cars	LPG Bifuel	All Segments	Euro 6 a/b/c	0.020	0.0007	-	0.00023	0.010	0.269	0.0056	0.0008	0.129
Passenger Cars	LPG Bifuel	All Segments	Euro 6 d-temp	0.020	0.0007	-	0.00023	0.010	0.267	0.0054	0.0008	0.127
Light Commercial Vehicles	Petrol	N1-I	Conventional	0.586	0.0008	0.00072	0.00039	0.015	0.368	0.0067	0.0009	0.174
Light Commercial Vehicles	Petrol	N1-I	Euro 1	0.427	0.0008	0.00051	0.00038	0.015	0.368	0.0066	0.0009	0.173
Light Commercial Vehicles	Petrol	N1-I	Euro 2	0.426	0.0008	0.00051	0.00038	0.015	0.368	0.0066	0.0009	0.173
Light Commercial Vehicles	Petrol	N1-I	Euro 3	0.429	0.0008	0.00052	0.00038	0.015	0.368	0.0066	0.0009	0.173
Light Commercial Vehicles	Petrol	N1-I	Euro 4	0.444	0.0008	0.00054	0.00038	0.015	0.368	0.0066	0.0009	0.173
Light Commercial Vehicles	Petrol	N1-I	Euro 5	0.444	0.0008	0.00054	0.00038	0.015	0.368	0.0066	0.0009	0.173
Light Commercial Vehicles	Petrol	N1-I	Euro 6 a/b/c	0.444	0.0008	0.00054	0.00038	0.015	0.361	0.0064	0.0009	0.169
Light Commercial Vehicles	Petrol	N1-I	Euro 6 d-temp	0.444	0.0008	0.00054	0.00038	0.015	0.358	0.0063	0.0009	0.168
Light Commercial Vehicles	Petrol	N1-II & N1-III	Conventional	0.664	0.0008	0.00082	0.00039	0.015	0.368	0.0067	0.0009	0.174
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 1	0.801	0.0008	0.00100	0.00040	0.015	0.368	0.0068	0.0009	0.175
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 2	0.801	0.0008	0.00100	0.00040	0.015	0.368	0.0068	0.0009	0.175
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 3	0.801	0.0008	0.00100	0.00040	0.015	0.368	0.0068	0.0009	0.175
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 4	0.801	0.0008	0.00100	0.00040	0.015	0.368	0.0068	0.0009	0.175
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 5	0.432	0.0007	0.00053	0.00033	0.013	0.309	0.0056	0.0008	0.146
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 6 a/b/c	0.514	0.0008	0.00063	0.00039	0.015	0.361	0.0064	0.0009	0.170
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 6 d-temp	0.514	0.0008	0.00063	0.00039	0.015	0.358	0.0063	0.0009	0.168
Light Commercial Vehicles	Diesel	N1-I	Conventional	0.032	0.0008	0.00034	0.00037	0.015	0.371	0.0066	0.0010	0.174
Light Commercial Vehicles	Diesel	N1-I	Euro 1	0.032	0.0008	0.00028	0.00037	0.015	0.371	0.0066	0.0010	0.174
Light Commercial Vehicles	Diesel	N1-I	Euro 2	0.032	0.0008	0.00029	0.00037	0.015	0.371	0.0066	0.0010	0.174
Light Commercial Vehicles	Diesel	N1-I	Euro 3	0.032	0.0008	0.00027	0.00037	0.015	0.371	0.0066	0.0010	0.174
Light Commercial Vehicles	Diesel	N1-I	Euro 4	0.032	0.0008	0.00027	0.00037	0.015	0.371	0.0066	0.0010	0.174
Light Commercial Vehicles	Diesel	N1-I	Euro 5	0.032	0.0008	0.00027	0.00037	0.015	0.371	0.0066	0.0010	0.174
Light Commercial Vehicles	Diesel	N1-I	Euro 6 a/b/c	0.032	0.0008	0.00027	0.00037	0.015	0.363	0.0063	0.0009	0.169
Light Commercial Vehicles	Diesel	N1-I	Euro 6 d-temp	0.032	0.0008	0.00027	0.00037	0.015	0.359	0.0062	0.0009	0.167
Light Commercial Vehicles	Diesel	N1-II & N1-III	Conventional	0.032	0.0008	0.00048	0.00038	0.015	0.371	0.0066	0.0010	0.175
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 1	0.032	0.0008	0.00043	0.00037	0.015	0.371	0.0066	0.0010	0.174
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 2	0.032	0.0008	0.00043	0.00037	0.015	0.371	0.0066	0.0010	0.174
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 3	0.032	0.0008	0.00043	0.00037	0.015	0.371	0.0066	0.0010	0.174

				Priority Heavy Metals			Additional Heavy Metals					
				Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
Category	Fuel	Segment	Euro Standard	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 4	0.032	0.0008	0.00043	0.00037	0.015	0.371	0.0066	0.0010	0.174
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 5	0.032	0.0008	0.00040	0.00037	0.015	0.371	0.0066	0.0010	0.174
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 6 a/b/c	0.032	0.0008	0.00040	0.00037	0.015	0.363	0.0063	0.0009	0.170
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 6 d-temp	0.032	0.0008	0.00040	0.00037	0.015	0.359	0.0062	0.0009	0.168
Heavy Duty Trucks	Diesel	<=20 t	Conventional	0.071	0.0010	0.00090	0.00083	0.031	0.706	0.0090	0.0012	0.252
Heavy Duty Trucks	Diesel	<=20 t	Euro I	0.071	0.0010	0.00080	0.00082	0.031	0.705	0.0090	0.0012	0.252
Heavy Duty Trucks	Diesel	<=20 t	Euro II	0.071	0.0010	0.00079	0.00083	0.031	0.706	0.0091	0.0012	0.257
Heavy Duty Trucks	Diesel	<=20 t	Euro III	0.072	0.0010	0.00088	0.00084	0.031	0.706	0.0091	0.0012	0.276
Heavy Duty Trucks	Diesel	<=20 t	Euro IV	0.072	0.0010	0.00086	0.00084	0.031	0.706	0.0092	0.0012	0.282
Heavy Duty Trucks	Diesel	<=20 t	Euro V	0.072	0.0010	0.00084	0.00084	0.031	0.706	0.0092	0.0013	0.286
Heavy Duty Trucks	Diesel	<=20 t	Euro VI A/B/C	0.072	0.0010	0.00084	0.00084	0.031	0.706	0.0092	0.0013	0.288
Heavy Duty Trucks	Diesel	<=20 t	Euro VI D/E	0.072	0.0010	0.00085	0.00084	0.031	0.706	0.0092	0.0013	0.288
Heavy Duty Trucks	Diesel	20 - 28 t	Conventional	0.072	0.0011	0.00139	0.00085	0.032	0.707	0.0092	0.0013	0.293
Heavy Duty Trucks	Diesel	20 - 28 t	Euro I	0.072	0.0011	0.00121	0.00085	0.032	0.707	0.0092	0.0013	0.292
Heavy Duty Trucks	Diesel	20 - 28 t	Euro II	0.072	0.0011	0.00118	0.00085	0.032	0.707	0.0092	0.0013	0.292
Heavy Duty Trucks	Diesel	20 - 28 t	Euro III	0.072	0.0011	0.00122	0.00085	0.032	0.707	0.0092	0.0013	0.292
Heavy Duty Trucks	Diesel	20 - 28 t	Euro IV	0.072	0.0011	0.00118	0.00085	0.032	0.707	0.0092	0.0013	0.292
Heavy Duty Trucks	Diesel	20 - 28 t	Euro V	0.072	0.0011	0.00115	0.00085	0.032	0.707	0.0092	0.0013	0.292
Heavy Duty Trucks	Diesel	20 - 28 t	Euro VI A/B/C	0.072	0.0011	0.00116	0.00085	0.032	0.707	0.0092	0.0013	0.292
Heavy Duty Trucks	Diesel	20 - 28 t	Euro VI D/E	0.072	0.0011	0.00116	0.00085	0.032	0.707	0.0092	0.0013	0.292
Heavy Duty Trucks	Diesel	>28 t	Conventional	0.074	0.0011	0.00170	0.00090	0.033	0.709	0.0096	0.0015	0.376
Heavy Duty Trucks	Diesel	>28 t	Euro I	0.074	0.0011	0.00152	0.00091	0.032	0.709	0.0096	0.0015	0.390
Heavy Duty Trucks	Diesel	>28 t	Euro II	0.074	0.0011	0.00150	0.00090	0.032	0.709	0.0096	0.0015	0.384
Heavy Duty Trucks	Diesel	>28 t	Euro III	0.074	0.0011	0.00151	0.00090	0.032	0.709	0.0096	0.0015	0.380
Heavy Duty Trucks	Diesel	>28 t	Euro IV	0.072	0.0011	0.00135	0.00086	0.032	0.707	0.0093	0.0013	0.302
Heavy Duty Trucks	Diesel	>28 t	Euro V	0.072	0.0011	0.00131	0.00085	0.032	0.707	0.0092	0.0013	0.292
Heavy Duty Trucks	Diesel	>28 t	Euro VI A/B/C	0.072	0.0011	0.00132	0.00085	0.032	0.707	0.0092	0.0013	0.292
Heavy Duty Trucks	Diesel	>28 t	Euro VI D/E	0.072	0.0011	0.00132	0.00085	0.032	0.707	0.0092	0.0013	0.292
Buses	Diesel	Urban Buses	Conventional	0.132	0.0045	0.00252	0.00155	0.070	1.757	0.0346	0.0046	0.691
Buses	Diesel	Urban Buses	Euro I	0.133	0.0045	0.00224	0.00155	0.070	1.757	0.0347	0.0047	0.705
Buses	Diesel	Urban Buses	Euro II	0.133	0.0045	0.00215	0.00155	0.069	1.757	0.0347	0.0047	0.706
Buses	Diesel	Urban Buses	Euro III	0.133	0.0045	0.00216	0.00155	0.069	1.757	0.0347	0.0047	0.703
Buses	Diesel	Urban Buses	Euro IV	0.133	0.0045	0.00190	0.00154	0.069	1.757	0.0347	0.0047	0.703
Buses	Diesel	Urban Buses	Euro V	0.133	0.0045	0.00193	0.00154	0.069	1.757	0.0347	0.0047	0.705
Buses	Diesel	Urban Buses	Euro VI A/B/C	0.133	0.0027	0.00204	0.00155	0.062	1.459	0.0225	0.0030	0.538
Buses	Diesel	Urban Buses	Euro VI D/E	0.133	0.0027	0.00204	0.00155	0.062	1.459	0.0225	0.0030	0.538
Buses	Diesel	Coaches	Conventional	0.060	0.0012	0.00110	0.00071	0.028	0.636	0.0096	0.0013	0.265
Buses	Diesel	Coaches	Euro I	0.060	0.0012	0.00105	0.00071	0.028	0.636	0.0097	0.0014	0.278
Buses	Diesel	Coaches	Euro II	0.060	0.0012	0.00105	0.00072	0.028	0.636	0.0097	0.0014	0.281
Buses	Diesel	Coaches	Euro III	0.060	0.0012	0.00106	0.00072	0.028	0.636	0.0097	0.0014	0.282
Buses	Diesel	Coaches	Euro IV	0.060	0.0012	0.00105	0.00072	0.028	0.637	0.0097	0.0014	0.284
Buses	Diesel	Coaches	Euro V	0.060	0.0012	0.00111	0.00072	0.028	0.637	0.0097	0.0014	0.283
Buses	Diesel	Coaches	Euro VI A/B/C	0.060	0.0011	0.00112	0.00072	0.028	0.628	0.0094	0.0013	0.280
Buses	CNG	Urban CNG Buses	Euro I	0.132	0.0044	-	0.00149	0.066	1.754	0.0345	0.0045	0.665
Buses	CNG	Urban CNG Buses	Euro III	0.132	0.0044	-	0.00149	0.066	1.754	0.0345	0.0045	0.665
Buses	CNG	Urban CNG Buses	EEV	0.132	0.0044	-	0.00149	0.066	1.754	0.0345	0.0045	0.665
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Conventional	0.180	0.0047	0.00021	0.00018	0.025	0.917	0.0335	0.0047	0.501
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Euro 1	0.147	0.0047	0.00017	0.00018	0.025	0.917	0.0334	0.0047	0.501
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Euro 2	0.147	0.0047	0.00017	0.00018	0.025	0.917	0.0334	0.0047	0.501
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Euro 3	0.147	0.0047	0.00017	0.00018	0.025	0.917	0.0334	0.0047	0.501

				Priority Heavy Metals			Additional Heavy Metals					
				Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
Category	Fuel	Segment	Euro Standard	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 4	0.147	0.0047	0.00017	0.00018	0.025	0.917	0.0334	0.0047	0.501
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Conventional	0.180	0.0047	0.00021	0.00018	0.025	0.917	0.0335	0.0047	0.501
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 1	0.147	0.0047	0.00017	0.00018	0.025	0.917	0.0334	0.0047	0.501
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 2	0.147	0.0047	0.00017	0.00018	0.025	0.917	0.0334	0.0047	0.501
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 3	0.125	0.0047	0.00014	0.00018	0.025	0.917	0.0334	0.0047	0.501
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 4	0.122	0.0047	0.00014	0.00018	0.025	0.917	0.0334	0.0047	0.501
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Conventional	0.234	0.0047	0.00029	0.00012	0.023	0.874	0.0332	0.0047	0.491
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 1	0.217	0.0047	0.00027	0.00012	0.023	0.874	0.0332	0.0047	0.491
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 2	0.217	0.0047	0.00027	0.00012	0.023	0.874	0.0332	0.0047	0.491
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 3	0.141	0.0047	0.00017	0.00012	0.023	0.874	0.0332	0.0047	0.491
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 4	0.146	0.0047	0.00018	0.00012	0.023	0.874	0.0332	0.0047	0.491
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Conventional	0.230	0.0002	0.00029	0.00012	0.005	0.114	0.0020	0.0003	0.051
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 1	0.191	0.0002	0.00024	0.00012	0.005	0.114	0.0020	0.0003	0.051
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 2	0.161	0.0002	0.00020	0.00012	0.005	0.114	0.0020	0.0003	0.051
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 3	0.142	0.0002	0.00017	0.00012	0.005	0.114	0.0020	0.0003	0.051
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 4	0.159	0.0002	0.00019	0.00012	0.005	0.114	0.0020	0.0003	0.051
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Conventional	0.312	0.0003	0.00039	0.00013	0.005	0.114	0.0021	0.0003	0.052
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 1	0.297	0.0003	0.00037	0.00013	0.005	0.114	0.0021	0.0003	0.052
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 2	0.274	0.0002	0.00034	0.00013	0.005	0.114	0.0020	0.0003	0.051
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 3	0.383	0.0003	0.00049	0.00013	0.005	0.114	0.0021	0.0003	0.052
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 4	0.323	0.0003	0.00041	0.00013	0.005	0.114	0.0021	0.0003	0.052
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Conventional	0.355	0.0003	0.00045	0.00013	0.005	0.114	0.0021	0.0003	0.052
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 1	0.334	0.0003	0.00042	0.00013	0.005	0.114	0.0021	0.0003	0.052
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 2	0.334	0.0003	0.00042	0.00013	0.005	0.114	0.0021	0.0003	0.052
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 3	0.383	0.0003	0.00049	0.00013	0.005	0.114	0.0021	0.0003	0.052
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 4	0.323	0.0003	0.00041	0.00013	0.005	0.114	0.0021	0.0003	0.052

Table C-7: Fuel and lubricant consumption from road transport sector (TJ)

Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
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
Petrol**	61 131.89	67 292.71	75 053.58	79 027.71	81 635.79	84 280.67	86 727.50	87 424.17	90 989.75	91 945.40	92 733.15
CNG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	29.78
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
Lubricants 2-stroke	74.00	69.02	63.91	58.09	52.45	48.08	44.03	40.06	37.50	34.16	31.08
Lubricants 4-stroke	279.29	293.10	313.09	323.29	337.25	348.32	365.54	377.74	404.48	419.58	452.18

Fuel	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Diesel*	169 398.15	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
Petrol**	88 217.65	92 096.09	89 286.60	85 921.39	80 634.47	74 586.03	69 599.91	65 277.91	64 029.05	60 751.90
CNG	197.04	304.13	397.29	391.52	440.00	437.06	483.91	505.81	502.58	526.74
LPG	996.03	975.81	942.26	867.96	963.02	1 028.40	1 068.05	1 189.80	1 394.20	1 331.70
Lubricants 2-stroke	26.04	25.49	22.43	20.55	19.31	18.61	18.28	17.44	18.44	19.68
Lubricants 4-stroke	452.05	466.09	463.36	465.48	462.73	469.99	466.55	462.39	473.03	477.28

Fuel	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Diesel*	182 938.79	167 871.09	164 487.36	168 842.84	173 023.45	177 089.50	181 287.35	183 537.84	188 472.36	160 595.31
Petrol**	54 696.56	49 789.07	48 030.83	48 013.34	47 473.14	46 243.71	45 359.65	45 073.02	46 684.33	38 764.30
CNG	528.29	503.17	520.13	552.16	592.14	583.14	616.92	672.94	733.02	641.00
LPG	1 385.83	1 465.38	1 537.39	1 541.87	1 647.00	1 720.61	1 700.22	1 668.86	1 709.89	1 289.20
Lubricants 2-stroke	18.71	17.47	17.67	17.97	18.61	20.58	20.66	21.02	22.58	20.54
Lubricants 4-stroke	446.33	413.05	407.23	417.08	426.39	433.77	440.52	442.29	452.63	382.97

* includes incorporation of Biodiesel
** includes incorporation of Bioethanol

Table C-8: Vehicle fleet.

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2015	2018	2019	2020
Passenger Cars	Petrol	Mini	Euro 4	0	0	0	0	32 145	29 767	30 580	30 676	30 563
Passenger Cars	Petrol	Mini	Euro 5	0	0	0	0	0	20 992	16 860	17 375	17 709
Passenger Cars	Petrol	Mini	Euro 6 a/b/c	0	0	0	0	0	11 646	54 124	48 662	42 311
Passenger Cars	Petrol	Mini	Euro 6 d-temp	0	0	0	0	0	0	0	18 260	23 887
Passenger Cars	Petrol	Small	PRE ECE - ECE 15/04	1 314 342	1 510 432	1 147 073	678 906	381 268	233 461	178 658	162 932	123 289
Passenger Cars	Petrol	Small	Euro 1	0	544 032	695 574	555 115	427 631	303 928	231 988	208 270	168 994
Passenger Cars	Petrol	Small	Euro 2	0	0	574 509	510 073	478 939	417 071	360 753	336 759	251 758
Passenger Cars	Petrol	Small	Euro 3	0	0	0	364 643	336 001	327 523	314 075	305 966	266 156
Passenger Cars	Petrol	Small	Euro 4	0	0	0	0	174 241	159 967	160 814	159 689	157 782
Passenger Cars	Petrol	Small	Euro 5	0	0	0	0	0	82 554	69 646	70 645	70 921
Passenger Cars	Petrol	Small	Euro 6 a/b/c	0	0	0	0	0	35 274	186 960	178 038	164 239
Passenger Cars	Petrol	Small	Euro 6 d-temp	0	0	0	0	0	0	0	64 875	107 678
Passenger Cars	Petrol	Medium	PRE ECE - ECE 15/04	49 005	55 651	41 937	25 475	17 040	11 835	9 575	8 797	7 992
Passenger Cars	Petrol	Medium	Euro 1	0	42 397	66 756	72 893	57 398	40 698	31 900	29 110	25 646
Passenger Cars	Petrol	Medium	Euro 2	0	0	185 430	167 393	160 952	141 023	123 324	115 583	105 243
Passenger Cars	Petrol	Medium	Euro 3	0	0	0	180 661	167 216	163 184	156 514	152 327	145 679
Passenger Cars	Petrol	Medium	Euro 4	0	0	0	0	89 578	82 307	83 165	82 558	81 630
Passenger Cars	Petrol	Medium	Euro 5	0	0	0	0	0	19 221	25 051	25 632	25 922
Passenger Cars	Petrol	Medium	Euro 6 a/b/c	0	0	0	0	0	4 863	37 644	43 343	53 454
Passenger Cars	Petrol	Medium	Euro 6 d-temp	0	0	0	0	0	0	0	24 941	39 050
Passenger Cars	Petrol	Large-SUV-Executive	PRE ECE - ECE 15/04	91 320	76 145	48 942	24 497	20 759	17 246	14 580	13 570	13 466
Passenger Cars	Petrol	Large-SUV-Executive	Euro 1	0	17 144	21 751	17 101	14 858	11 861	10 189	9 695	9 324
Passenger Cars	Petrol	Large-SUV-Executive	Euro 2	0	0	26 680	28 162	29 249	26 723	24 832	23 933	22 778
Passenger Cars	Petrol	Large-SUV-Executive	Euro 3	0	0	0	16 474	16 639	16 853	16 471	16 154	15 549
Passenger Cars	Petrol	Large-SUV-Executive	Euro 4	0	0	0	0	7 206	6 153	7 755	7 850	7 790
Passenger Cars	Petrol	Large-SUV-Executive	Euro 5	0	0	0	0	0	4 003	2 663	2 893	3 056
Passenger Cars	Petrol	Large-SUV-Executive	Euro 6 a/b/c	0	0	0	0	0	1 419	7 619	11 933	13 826
Passenger Cars	Petrol	Large-SUV-Executive	Euro 6 d-temp	0	0	0	0	0	0	0	2 049	3 317
Passenger Cars	Petrol Hybrid	All Segments	Euro 4	0	0	0	1 227	7 601	7 699	7 768	7 711	7 567
Passenger Cars	Petrol Hybrid	All Segments	Euro 5	0	0	0	0	0	6 682	9 007	10 956	11 708
Passenger Cars	Petrol Hybrid	All Segments	Euro 6 a/b/c	0	0	0	0	0	4 088	26 794	26 794	26 794
Passenger Cars	Petrol Hybrid	All Segments	Euro 6 d-temp	0	0	0	0	0	0	0	13 181	35 873
Passenger Cars	Diesel	Mini	Euro 4	0	0	0	0	6 055	6 282	7 610	7 926	8 176
Passenger Cars	Diesel	Mini	Euro 5	0	0	0	0	0	2 571	3 190	3 478	3 641
Passenger Cars	Diesel	Mini	Euro 6 a/b/c	0	0	0	0	0	0	2 852	2 852	2 852
Passenger Cars	Diesel	Mini	Euro 6 d-temp	0	0	0	0	0	0	0	10	10
Passenger Cars	Diesel	Small	Conventional	31 145	52 304	50 885	43 369	29 400	19 428	14 546	13 077	10 837
Passenger Cars	Diesel	Small	Euro 1	0	33 346	43 841	42 456	34 746	28 085	23 650	22 032	19 927
Passenger Cars	Diesel	Small	Euro 2	0	0	37 486	37 250	35 885	33 745	31 757	30 548	29 102
Passenger Cars	Diesel	Small	Euro 3	0	0	0	71 323	71 133	72 403	71 489	70 077	68 067
Passenger Cars	Diesel	Small	Euro 4	0	0	0	0	50 792	51 113	53 555	53 835	53 663
Passenger Cars	Diesel	Small	Euro 5	0	0	0	0	0	24 667	27 699	29 157	29 899
Passenger Cars	Diesel	Small	Euro 6 a/b/c	0	0	0	0	0	5 889	70 562	70 562	70 562
Passenger Cars	Diesel	Small	Euro 6 d-temp	0	0	0	0	0	0	0	14 590	14 590
Passenger Cars	Diesel	Medium	Conventional	9 902	26 450	26 190	24 159	18 657	12 999	9 790	8 669	7 440
Passenger Cars	Diesel	Medium	Euro 1	0	49 845	72 530	74 093	68 423	58 530	50 191	46 801	42 311
Passenger Cars	Diesel	Medium	Euro 2	0	0	144 097	143 182	144 836	137 124	129 212	124 804	118 534
Passenger Cars	Diesel	Medium	Euro 3	0	0	0	285 107	283 682	280 755	274 275	268 890	261 511

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2015	2018	2019	2020
Passenger Cars	Diesel	Medium	Euro 4	0	0	0	0	388 526	389 210	394 477	391 130	386 220
Passenger Cars	Diesel	Medium	Euro 5	0	0	0	0	0	247 219	279 863	299 230	308 500
Passenger Cars	Diesel	Medium	Euro 6 a/b/c	0	0	0	0	0	95 659	312 257	312 257	312 257
Passenger Cars	Diesel	Medium	Euro 6 d-temp	0	0	0	0	0	0	0	57 512	89 456
Passenger Cars	Diesel	Large-SUV-Executive	Conventional	57 173	70 532	65 192	57 821	50 984	43 722	39 296	37 413	35 003
Passenger Cars	Diesel	Large-SUV-Executive	Euro 1	0	37 787	65 106	67 426	64 727	57 454	51 985	49 676	46 680
Passenger Cars	Diesel	Large-SUV-Executive	Euro 2	0	0	211 246	209 863	209 622	195 252	183 261	177 237	168 253
Passenger Cars	Diesel	Large-SUV-Executive	Euro 3	0	0	0	238 066	236 996	235 335	231 447	227 520	221 328
Passenger Cars	Diesel	Large-SUV-Executive	Euro 4	0	0	0	0	239 424	238 400	250 788	250 218	247 082
Passenger Cars	Diesel	Large-SUV-Executive	Euro 5	0	0	0	0	0	107 912	121 934	126 949	129 076
Passenger Cars	Diesel	Large-SUV-Executive	Euro 6 a/b/c	0	0	0	0	0	31 759	141 208	141 208	141 208
Passenger Cars	Diesel	Large-SUV-Executive	Euro 6 d-temp	0	0	0	0	0	0	0	17 852	26 068
Passenger Cars	LPG Bifuel	All Segments	Conventional	25	164	4 561	4 477	5 671	7 562	8 243	8 243	8 243
Passenger Cars	LPG Bifuel	All Segments	Euro 1	0	186	7 066	6 937	8 788	11 718	12 770	12 770	12 770
Passenger Cars	LPG Bifuel	All Segments	Euro 2	0	0	9 300	9 129	11 566	15 421	16 806	16 806	16 806
Passenger Cars	LPG Bifuel	All Segments	Euro 3	0	0	0	4 753	6 021	8 028	8 750	8 750	8 750
Passenger Cars	LPG Bifuel	All Segments	Euro 4	0	0	0	0	1 592	1 585	1 620	1 620	1 620
Passenger Cars	LPG Bifuel	All Segments	Euro 5	0	0	0	0	0	3 750	4 329	4 329	4 329
Passenger Cars	LPG Bifuel	All Segments	Euro 6 a/b/c	0	0	0	0	0	0	2 725	2 725	2 725
Passenger Cars	LPG Bifuel	All Segments	Euro 6 d-temp	0	0	0	0	0	0	4 595	6 706	6 706
Light Commercial Vehicles	Petrol	N1-I	Conventional	35 580	35 948	30 761	21 038	13 153	9 754	8 290	7 791	6 950
Light Commercial Vehicles	Petrol	N1-I	Euro 1	0	461	919	832	533	322	229	209	174
Light Commercial Vehicles	Petrol	N1-I	Euro 2	0	0	230	214	190	178	136	125	137
Light Commercial Vehicles	Petrol	N1-I	Euro 3	0	0	0	402	480	431	391	372	356
Light Commercial Vehicles	Petrol	N1-I	Euro 4	0	0	0	0	11	13	15	18	22
Light Commercial Vehicles	Petrol	N1-I	Euro 5	0	0	0	0	0	4	8	10	11
Light Commercial Vehicles	Petrol	N1-I	Euro 6 a/b/c	0	0	0	0	0	0	6	6	9
Light Commercial Vehicles	Petrol	N1-I	Euro 6 d-temp	0	0	0	0	0	0	2	4	6
Light Commercial Vehicles	Petrol	N1-II & N1-III	Conventional	2 219	2 473	2 179	1 742	1 398	1 256	1 172	1 075	1 083
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 1	0	295	366	347	362	287	256	243	218
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 2	0	0	31	232	276	264	245	229	222
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 3	0	0	0	25	57	67	81	72	74
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 4	0	0	0	0	4	13	20	31	27
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 5	0	0	0	0	0	1	2	6	8
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 6 a/b/c	0	0	0	0	0	0	4	4	6
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 6 d-temp	0	0	0	0	0	0	1	2	3
Light Commercial Vehicles	Diesel	N1-I	Conventional	46 471	161 742	160 307	141 339	97 499	65 074	49 462	43 927	38 400
Light Commercial Vehicles	Diesel	N1-I	Euro 1	0	28 452	107 939	104 661	89 788	73 461	61 751	56 930	51 569
Light Commercial Vehicles	Diesel	N1-I	Euro 2	0	0	143 654	142 123	132 054	118 382	107 440	101 958	95 766
Light Commercial Vehicles	Diesel	N1-I	Euro 3	0	0	0	162 955	167 534	157 942	150 433	145 646	140 055
Light Commercial Vehicles	Diesel	N1-I	Euro 4	0	0	0	0	103 686	105 451	103 027	101 449	99 106
Light Commercial Vehicles	Diesel	N1-I	Euro 5	0	0	0	0	0	24 562	25 164	25 118	24 769
Light Commercial Vehicles	Diesel	N1-I	Euro 6 a/b/c	0	0	0	0	0	5 651	14 333	14 593	14 652
Light Commercial Vehicles	Diesel	N1-I	Euro 6 d-temp	0	0	0	0	0	0	3 910	5 561	6 101
Light Commercial Vehicles	Diesel	N1-II & N1-III	Conventional	206 191	344 266	327 430	278 575	215 732	171 559	155 201	149 929	142 347
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 1	0	18 185	69 030	66 784	57 996	49 677	46 474	45 339	43 353
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 2	0	0	117 279	115 764	110 477	98 946	94 382	92 104	88 942
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 3	0	0	0	140 861	139 846	129 441	124 855	122 547	119 229
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 4	0	0	0	0	123 961	142 123	139 958	138 984	136 731
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 5	0	0	0	0	0	36 262	39 239	39 526	40 528
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 6 a/b/c	0	0	0	0	0	19 182	67 910	70 193	72 021
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 6 d-temp	0	0	0	0	0	0	27 108	63 757	91 579

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2015	2018	2019	2020
Heavy Duty Trucks	Diesel	<=20 t	Conventional	33 568	43 785	40 420	31 480	19 438	11 275	9 248	8 609	7 774
Heavy Duty Trucks	Diesel	<=20 t	Euro I	0	4 239	6 243	6 151	5 165	3 752	3 310	3 160	2 877
Heavy Duty Trucks	Diesel	<=20 t	Euro II	0	0	13 333	16 183	16 090	12 678	12 433	11 853	11 036
Heavy Duty Trucks	Diesel	<=20 t	Euro III	0	0	0	7 035	12 220	13 128	14 880	14 296	13 348
Heavy Duty Trucks	Diesel	<=20 t	Euro IV	0	0	0	0	11 343	11 241	11 597	11 414	11 007
Heavy Duty Trucks	Diesel	<=20 t	Euro V	0	0	0	0	2 702	9 139	10 225	10 620	10 692
Heavy Duty Trucks	Diesel	<=20 t	Euro VI A/B/C	0	0	0	0	0	4 197	16 137	19 869	19 452
Heavy Duty Trucks	Diesel	<=20 t	Euro VI D/E	0	0	0	0	0	0	0	4 070	8 121
Heavy Duty Trucks	Diesel	20 - 28 t	Conventional	8 891	11 108	10 189	7 840	4 246	2 198	1 667	1 549	1 375
Heavy Duty Trucks	Diesel	20 - 28 t	Euro I	0	989	1 523	1 538	1 236	823	703	671	632
Heavy Duty Trucks	Diesel	20 - 28 t	Euro II	0	0	3 451	4 258	4 040	3 124	2 860	2 783	2 694
Heavy Duty Trucks	Diesel	20 - 28 t	Euro III	0	0	0	1 401	1 919	2 087	2 325	2 377	2 395
Heavy Duty Trucks	Diesel	20 - 28 t	Euro IV	0	0	0	0	815	876	1 113	1 179	1 243
Heavy Duty Trucks	Diesel	20 - 28 t	Euro V	0	0	0	0	168	462	676	770	831
Heavy Duty Trucks	Diesel	20 - 28 t	Euro VI A/B/C	0	0	0	0	0	183	722	755	806
Heavy Duty Trucks	Diesel	20 - 28 t	Euro VI D/E	0	0	0	0	0	0	0	205	409
Heavy Duty Trucks	Diesel	>28 t	Conventional	9 595	15 044	13 400	8 321	3 000	1 014	596	525	451
Heavy Duty Trucks	Diesel	>28 t	Euro I	0	3 911	6 194	5 752	2 985	1 248	817	721	617
Heavy Duty Trucks	Diesel	>28 t	Euro II	0	0	14 171	17 551	12 378	6 098	3 337	2 943	2 614
Heavy Duty Trucks	Diesel	>28 t	Euro III	0	0	0	8 007	8 529	5 942	2 680	2 475	2 213
Heavy Duty Trucks	Diesel	>28 t	Euro IV	0	0	0	0	1 088	644	711	729	773
Heavy Duty Trucks	Diesel	>28 t	Euro V	0	0	0	0	90	137	180	194	216
Heavy Duty Trucks	Diesel	>28 t	Euro VI A/B/C	0	0	0	0	0	77	497	505	534
Heavy Duty Trucks	Diesel	>28 t	Euro VI D/E	0	0	0	0	0	0	0	194	387
Buses	Diesel	Urban Buses	Conventional	5 458	6 603	6 238	5 265	2 875	1 351	844	702	509
Buses	Diesel	Urban Buses	Euro I	0	806	1 299	1 233	1 422	1 012	671	541	418
Buses	Diesel	Urban Buses	Euro II	0	0	2 991	3 515	3 650	3 477	3 018	2 729	2 315
Buses	Diesel	Urban Buses	Euro III	0	0	0	2 231	2 898	3 377	3 739	3 657	3 352
Buses	Diesel	Urban Buses	Euro IV	0	0	0	0	1 698	1 840	2 291	2 389	2 300
Buses	Diesel	Urban Buses	Euro V	0	0	0	0	395	1 084	1 242	1 297	1 315
Buses	Diesel	Urban Buses	Euro VI A/B/C	0	0	0	0	0	433	1 611	1 621	1 614
Buses	Diesel	Urban Buses	Euro VI D/E	0	0	0	0	0	0	0	344	686
Buses	Diesel	Coaches	Conventional	751	898	847	719	429	203	123	101	75
Buses	Diesel	Coaches	Euro I	0	98	168	170	221	170	114	90	69
Buses	Diesel	Coaches	Euro II	0	0	402	460	491	499	447	403	341
Buses	Diesel	Coaches	Euro III	0	0	0	214	270	364	456	458	429
Buses	Diesel	Coaches	Euro IV	0	0	0	0	136	154	228	248	245
Buses	Diesel	Coaches	Euro V	0	0	0	0	38	108	134	143	148
Buses	Diesel	Coaches	Euro VI A/B/C	0	0	0	0	0	42	149	149	147
Buses	CNG	Urban CNG Buses	Euro I	0	0	0	0	0	1	1	1	1
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	44	36	28
Buses	CNG	Urban CNG Buses	EEV	0	0	0	0	90	89	219	416	616
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Conventional	417 346	341 022	264 699	143 902	103 233	94 731	86 372	90 404	92 462
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 1	0	0	0	9 163	7 145	5 651	4 659	4 328	3 997
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 2	0	0	0	12 202	13 388	9 407	8 319	7 882	7 446
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 3	0	0	0	0	17 922	26 070	29 096	26 632	24 215
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 4	0	0	0	0	0	0	1 355	2 756	3 575
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Conventional	417 346	341 022	264 699	143 902	103 233	94 731	86 372	90 404	92 462
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 1	0	0	0	9 163	7 145	5 651	4 659	4 328	3 997
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 2	0	0	0	12 202	13 388	9 407	8 319	7 882	7 446
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 3	0	0	0	0	17 922	26 070	29 096	26 632	24 215

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2015	2018	2019	2020
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 4	0	0	0	0	0	0	1 355	2 756	3 575
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Conventional	14 753	20 578	31 798	14 218	29 622	28 748	31 774	31 363	31 658
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 1	0	0	0	10 200	14 985	14 535	17 746	18 439	17 893
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 2	0	0	0	6 158	12 526	12 961	14 834	17 102	16 731
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 3	0	0	0	0	20 774	56 563	72 547	74 752	76 040
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 4	0	0	0	0	0	0	23 550	37 006	50 302
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Conventional	7 869	10 975	17 591	9 473	8 375	5 565	5 673	5 600	5 652
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 1	0	0	0	6 796	4 237	2 814	3 168	3 292	3 195
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 2	0	0	0	4 103	3 541	2 509	2 649	3 053	2 987
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 3	0	0	0	0	5 873	10 950	12 953	13 347	13 577
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 4	0	0	0	0	0	0	4 205	6 607	8 981
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Conventional	26 481	36 936	54 811	27 567	22 198	14 564	15 074	14 879	15 019
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 1	0	0	0	19 777	11 229	7 364	8 419	8 748	8 489
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 2	0	0	0	11 940	9 387	6 566	7 037	8 113	7 937
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 3	0	0	0	0	15 567	28 656	34 417	35 464	36 074
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 4	0	0	0	0	0	0	11 172	17 556	23 864
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Conventional	17 027	23 749	40 396	21 773	21 039	16 289	18 022	17 789	17 956
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 1	0	0	0	15 620	10 643	8 236	10 065	10 459	10 149
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 2	0	0	0	9 430	8 897	7 344	8 414	9 700	9 490
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 3	0	0	0	0	14 755	32 049	41 148	42 399	43 129
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 4	0	0	0	0	0	0	13 357	20 990	28 531

Table C-9: Total activity (vkm)

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2015	2018	2019	2020
Passenger Cars	Petrol	Mini	Euro 4	0	0	0	0	228 193 530	219 645 580	209 177 507	210 941 746	180 198 181
Passenger Cars	Petrol	Mini	Euro 5	0	0	0	0	0	88 641 737	115 041 391	120 400 125	108 480 772
Passenger Cars	Petrol	Mini	Euro 6 a/b/c	0	0	0	0	0	71 294 870	293 510 905	278 974 280	212 667 511
Passenger Cars	Petrol	Mini	Euro 6 d-temp	0	0	0	0	0	0	0	55 316 520	63 062 608
Passenger Cars	Petrol	Small	PRE ECE - ECE 15/04	17 125 833 850	18 394 897 297	11 320 013 132	5 371 235 806	2 217 769 743	1 034 153 601	665 727 762	594 333 619	386 713 390
Passenger Cars	Petrol	Small	Euro 1	0	8 146 858 929	9 118 043 165	5 965 624 611	3 568 225 438	2 035 991 225	1 345 218 266	1 192 896 188	820 068 427
Passenger Cars	Petrol	Small	Euro 2	0	0	7 429 049 450	6 009 381 933	4 479 512 588	3 165 872 196	2 407 949 189	2 228 912 882	1 418 272 806
Passenger Cars	Petrol	Small	Euro 3	0	0	0	4 259 975 306	3 347 283 942	2 712 243 430	2 311 643 432	2 237 708 205	1 663 837 689
Passenger Cars	Petrol	Small	Euro 4	0	0	0	0	1 267 858 946	1 286 269 441	1 201 997 319	1 195 690 357	1 015 614 891
Passenger Cars	Petrol	Small	Euro 5	0	0	0	0	0	491 106 888	525 802 914	533 065 880	469 004 223
Passenger Cars	Petrol	Small	Euro 6 a/b/c	0	0	0	0	0	258 234 330	1 448 649 154	1 463 629 965	1 247 225 976
Passenger Cars	Petrol	Small	Euro 6 d-temp	0	0	0	0	0	0	0	507 289 176	733 772 524
Passenger Cars	Petrol	Medium	PRE ECE - ECE 15/04	647 706 668	801 045 899	523 555 566	256 208 075	121 495 284	62 065 131	42 670 347	38 257 984	29 079 086
Passenger Cars	Petrol	Medium	Euro 1	0	483 078 813	968 477 300	882 871 580	534 857 422	301 050 319	204 988 352	184 497 382	137 879 420
Passenger Cars	Petrol	Medium	Euro 2	0	0	2 163 334 787	2 315 129 564	1 739 647 207	1 237 831 363	952 490 926	884 804 016	684 296 509
Passenger Cars	Petrol	Medium	Euro 3	0	0	0	2 042 557 081	1 829 490 211	1 467 784 735	1 253 357 213	1 217 563 857	994 493 813
Passenger Cars	Petrol	Medium	Euro 4	0	0	0	0	661 004 063	677 219 220	626 220 302	624 624 650	530 497 873
Passenger Cars	Petrol	Medium	Euro 5	0	0	0	0	0	124 594 476	183 400 764	194 873 920	170 023 199
Passenger Cars	Petrol	Medium	Euro 6 a/b/c	0	0	0	0	0	34 568 814	313 047 249	371 013 159	406 438 487
Passenger Cars	Petrol	Medium	Euro 6 d-temp	0	0	0	0	0	0	0	224 813 682	306 751 117
Passenger Cars	Petrol	Large-SUV-Executive	PRE ECE - ECE 15/04	1 435 416 132	1 107 249 937	593 083 083	224 603 041	129 622 660	77 290 870	56 173 422	52 406 809	40 917 854
Passenger Cars	Petrol	Large-SUV-Executive	Euro 1	0	309 160 334	375 169 313	233 729 068	144 130 316	86 737 845	62 347 316	58 934 217	46 686 684
Passenger Cars	Petrol	Large-SUV-Executive	Euro 2	0	0	439 839 070	430 801 528	319 432 190	223 029 091	179 231 887	174 293 989	138 217 503
Passenger Cars	Petrol	Large-SUV-Executive	Euro 3	0	0	0	239 491 337	193 268 382	147 542 071	124 847 095	121 752 240	98 690 015
Passenger Cars	Petrol	Large-SUV-Executive	Euro 4	0	0	0	0	58 383 096	51 116 186	57 763 780	57 342 875	48 388 927
Passenger Cars	Petrol	Large-SUV-Executive	Euro 5	0	0	0	0	0	22 577 594	18 806 738	21 516 169	19 538 711
Passenger Cars	Petrol	Large-SUV-Executive	Euro 6 a/b/c	0	0	0	0	0	10 714 637	54 108 226	101 617 913	100 161 838
Passenger Cars	Petrol	Large-SUV-Executive	Euro 6 d-temp	0	0	0	0	0	0	0	13 394 778	18 897 104
Passenger Cars	Petrol Hybrid	All Segments	Euro 4	0	0	0	19 281 603	95 927 499	88 521 658	79 426 757	79 403 281	66 964 994
Passenger Cars	Petrol Hybrid	All Segments	Euro 5	0	0	0	0	0	96 528 098	142 796 770	177 788 958	157 446 120
Passenger Cars	Petrol Hybrid	All Segments	Euro 6 a/b/c	0	0	0	0	0	54 025 073	279 834 771	290 787 771	268 859 488
Passenger Cars	Petrol Hybrid	All Segments	Euro 6 d-temp	0	0	0	0	0	0	0	132 270 564	313 717 528
Passenger Cars	Diesel	Mini	Euro 4	0	0	0	0	53 646 231	63 266 119	69 524 014	71 178 943	60 880 730
Passenger Cars	Diesel	Mini	Euro 5	0	0	0	0	0	20 581 249	31 878 943	33 039 994	28 604 170
Passenger Cars	Diesel	Mini	Euro 6 a/b/c	0	0	0	0	0	0	17 042 460	20 272 683	20 695 802
Passenger Cars	Diesel	Mini	Euro 6 d-temp	0	0	0	0	0	0	0	59 442	50 958
Passenger Cars	Diesel	Small	Conventional	749 769 632	751 935 607	639 873 832	428 657 160	264 698 000	137 608 536	94 079 134	82 580 032	57 807 258
Passenger Cars	Diesel	Small	Euro 1	0	656 417 686	815 251 740	581 109 875	435 429 780	279 172 609	220 105 664	199 362 033	151 334 808
Passenger Cars	Diesel	Small	Euro 2	0	0	793 038 909	639 106 609	515 790 625	385 764 671	332 385 663	313 431 118	250 547 504
Passenger Cars	Diesel	Small	Euro 3	0	0	0	1 109 336 664	1 067 001 843	833 631 843	757 677 711	725 867 886	590 978 047
Passenger Cars	Diesel	Small	Euro 4	0	0	0	0	723 736 371	627 981 566	591 586 643	582 045 246	485 731 378
Passenger Cars	Diesel	Small	Euro 5	0	0	0	0	0	334 728 484	377 090 257	457 654 058	370 825 537
Passenger Cars	Diesel	Small	Euro 6 a/b/c	0	0	0	0	0	87 555 635	1 082 823 360	1 050 107 066	908 464 827
Passenger Cars	Diesel	Small	Euro 6 d-temp	0	0	0	0	0	0	0	225 950 315	193 699 099
Passenger Cars	Diesel	Medium	Conventional	231 464 098	465 355 004	413 596 261	302 278 116	211 938 472	112 142 535	74 707 894	63 650 405	45 423 204
Passenger Cars	Diesel	Medium	Euro 1	0	906 179 150	1 363 273 321	1 067 096 805	894 418 189	587 129 000	462 468 777	418 131 397	316 700 766
Passenger Cars	Diesel	Medium	Euro 2	0	0	2 801 853 826	2 480 878 478	2 200 872 576	1 644 330 876	1 444 778 028	1 364 381 972	1 092 094 052
Passenger Cars	Diesel	Medium	Euro 3	0	0	0	4 634 679 403	4 729 685 705	3 600 291 872	3 270 971 877	3 133 409 882	2 561 530 848

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2015	2018	2019	2020
Passenger Cars	Diesel	Medium	Euro 4	0	0	0	0	5 561 278 888	5 297 750 016	4 794 740 317	4 671 930 393	3 860 038 392
Passenger Cars	Diesel	Medium	Euro 5	0	0	0	0	0	3 379 502 664	4 241 789 441	4 569 829 926	3 770 299 079
Passenger Cars	Diesel	Medium	Euro 6 a/b/c	0	0	0	0	0	1 240 682 227	3 878 138 976	3 965 207 182	3 768 875 644
Passenger Cars	Diesel	Medium	Euro 6 d-temp	0	0	0	0	0	0	0	681 418 770	908 614 674
Passenger Cars	Diesel	Large-SUV-Executive	Conventional	1 275 652 831	1 249 562 825	1 076 434 895	760 276 388	618 023 803	415 200 704	343 768 464	318 008 863	249 272 891
Passenger Cars	Diesel	Large-SUV-Executive	Euro 1	0	525 297 686	1 486 207 309	1 126 013 661	947 789 335	638 429 298	525 519 495	487 008 840	380 198 306
Passenger Cars	Diesel	Large-SUV-Executive	Euro 2	0	0	3 302 677 687	4 020 260 947	3 191 781 076	2 266 626 054	1 942 818 555	1 825 812 576	1 444 595 001
Passenger Cars	Diesel	Large-SUV-Executive	Euro 3	0	0	0	3 533 745 747	4 444 508 965	3 200 862 501	2 896 425 843	2 770 816 351	2 264 366 184
Passenger Cars	Diesel	Large-SUV-Executive	Euro 4	0	0	0	0	3 234 382 832	3 786 726 528	3 413 722 172	3 316 156 140	2 734 739 059
Passenger Cars	Diesel	Large-SUV-Executive	Euro 5	0	0	0	0	0	1 505 425 508	2 110 638 597	2 105 179 492	1 708 084 635
Passenger Cars	Diesel	Large-SUV-Executive	Euro 6 a/b/c	0	0	0	0	0	275 125 484	1 392 089 718	1 610 620 622	1 628 909 899
Passenger Cars	Diesel	Large-SUV-Executive	Euro 6 d-temp	0	0	0	0	0	0	0	145 145 459	181 693 310
Passenger Cars	LPG Bifuel	All Segments	Conventional	362 577	1 126 869	31 780 936	23 681 573	26 008 189	28 565 833	24 573 478	24 857 853	25 377 269
Passenger Cars	LPG Bifuel	All Segments	Euro 1	0	3 809 484	172 693 428	123 288 812	129 664 047	151 638 011	134 718 081	133 770 719	96 032 988
Passenger Cars	LPG Bifuel	All Segments	Euro 2	0	0	169 310 734	118 453 061	176 295 946	194 957 482	165 034 652	161 345 294	119 994 322
Passenger Cars	LPG Bifuel	All Segments	Euro 3	0	0	0	76 012 654	105 882 345	114 465 748	93 619 716	89 522 522	65 847 920
Passenger Cars	LPG Bifuel	All Segments	Euro 4	0	0	0	0	28 497 324	24 965 501	19 365 376	18 848 907	13 778 506
Passenger Cars	LPG Bifuel	All Segments	Euro 5	0	0	0	0	0	48 481 518	52 676 009	51 855 451	37 094 002
Passenger Cars	LPG Bifuel	All Segments	Euro 6 a/b/c	0	0	0	0	0	0	27 235 987	28 633 781	23 873 397
Passenger Cars	LPG Bifuel	All Segments	Euro 6 d-temp	0	0	0	0	0	0	48 613 309	70 896 844	55 450 888
Light Commercial Vehicles	Petrol	N1-I	Conventional	554 508 903	405 650 294	245 961 594	123 190 269	53 343 531	29 257 989	21 202 324	19 458 729	14 733 860
Light Commercial Vehicles	Petrol	N1-I	Euro 1	0	10 712 231	15 538 703	10 674 702	5 094 035	2 253 982	1 424 837	1 203 085	871 504
Light Commercial Vehicles	Petrol	N1-I	Euro 2	0	0	4 564 072	3 058 330	1 995 932	1 430 711	975 160	844 596	775 599
Light Commercial Vehicles	Petrol	N1-I	Euro 3	0	0	0	5 484 582	5 239 165	3 841 519	3 178 560	3 152 131	2 486 708
Light Commercial Vehicles	Petrol	N1-I	Euro 4	0	0	0	0	204 424	142 965	139 879	161 077	165 228
Light Commercial Vehicles	Petrol	N1-I	Euro 5	0	0	0	0	0	37 398	70 850	73 360	70 061
Light Commercial Vehicles	Petrol	N1-I	Euro 6 a/b/c	0	0	0	0	0	0	57 936	52 920	64 380
Light Commercial Vehicles	Petrol	N1-I	Euro 6 d-temp	0	0	0	0	0	0	20 041	40 602	51 149
Light Commercial Vehicles	Petrol	N1-II & N1-III	Conventional	33 743 420	33 146 961	21 623 720	13 467 563	6 664 393	4 016 308	3 133 774	2 831 572	2 290 393
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 1	0	6 570 042	5 723 388	4 020 820	3 287 346	1 953 874	1 500 220	1 408 576	1 054 363
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 2	0	0	754 726	3 418 524	3 078 536	2 580 687	2 074 918	1 897 810	1 647 867
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 3	0	0	0	459 337	383 777	367 334	386 029	319 334	268 391
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 4	0	0	0	0	37 371	123 795	189 092	282 802	204 893
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 5	0	0	0	0	0	14 779	22 550	79 482	85 907
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 6 a/b/c	0	0	0	0	0	0	35 164	31 811	38 904
Light Commercial Vehicles	Petrol	N1-II & N1-III	Euro 6 d-temp	0	0	0	0	0	0	15 218	30 831	39 663
Light Commercial Vehicles	Diesel	N1-I	Conventional	1 181 067 318	3 176 988 775	2 361 020 984	1 564 373 901	1 011 556 500	545 423 648	387 708 480	336 025 641	249 505 721
Light Commercial Vehicles	Diesel	N1-I	Euro 1	0	743 450 566	2 195 272 425	1 544 860 085	1 161 239 680	707 879 190	536 629 065	479 556 148	363 257 533
Light Commercial Vehicles	Diesel	N1-I	Euro 2	0	0	3 448 672 545	2 421 074 703	2 008 833 766	1 358 625 191	1 119 931 869	1 030 392 527	808 055 423
Light Commercial Vehicles	Diesel	N1-I	Euro 3	0	0	0	3 033 051 790	2 959 675 786	2 136 476 299	1 853 056 183	1 741 677 018	1 398 871 212
Light Commercial Vehicles	Diesel	N1-I	Euro 4	0	0	0	0	2 079 241 095	1 706 608 205	1 521 522 645	1 450 561 114	1 179 580 379
Light Commercial Vehicles	Diesel	N1-I	Euro 5	0	0	0	0	0	482 477 097	459 566 193	445 361 398	366 227 120
Light Commercial Vehicles	Diesel	N1-I	Euro 6 a/b/c	0	0	0	0	0	111 331 895	264 098 589	265 512 897	233 612 511
Light Commercial Vehicles	Diesel	N1-I	Euro 6 d-temp	0	0	0	0	0	0	71 759 286	101 523 722	97 274 770
Light Commercial Vehicles	Diesel	N1-II & N1-III	Conventional	5 532 090 794	6 186 948 457	4 606 898 176	2 980 822 412	2 074 380 379	1 269 604 318	1 052 736 243	990 472 379	788 141 976
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 1	0	552 858 098	1 558 493 080	1 070 612 373	805 684 009	515 083 629	433 028 201	409 555 010	326 391 797
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 2	0	0	3 049 019 874	2 006 056 562	1 668 175 364	1 109 095 043	957 403 155	904 607 008	727 454 880
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 3	0	0	0	2 829 305 839	2 589 394 253	1 783 709 314	1 545 751 318	1 466 789 791	1 186 004 954
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 4	0	0	0	0	2 612 651 696	2 420 813 668	2 192 596 833	2 110 208 267	1 725 691 291
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 5	0	0	0	0	0	680 116 803	735 160 995	733 275 290	632 557 205
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 6 a/b/c	0	0	0	0	0	358 475 332	1 213 351 012	1 231 382 054	1 106 968 859
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 6 d-temp	0	0	0	0	0	0	477 356 517	1 119 928 495	1 338 408 067

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2015	2018	2019	2020
Heavy Duty Trucks	Diesel	<=20 t	Conventional	1 238 478 247	1 166 279 618	905 165 352	516 579 016	279 343 088	120 358 840	89 070 122	80 749 022	59 961 729
Heavy Duty Trucks	Diesel	<=20 t	Euro I	0	116 615 712	213 287 144	158 426 379	110 672 725	56 547 587	43 663 108	39 335 808	29 393 677
Heavy Duty Trucks	Diesel	<=20 t	Euro II	0	0	514 267 500	569 781 790	462 542 879	244 486 375	210 215 114	189 996 360	144 991 209
Heavy Duty Trucks	Diesel	<=20 t	Euro III	0	0	0	244 326 540	640 379 800	522 494 571	564 568 407	509 567 622	392 462 386
Heavy Duty Trucks	Diesel	<=20 t	Euro IV	0	0	0	0	725 479 144	683 934 003	611 829 375	585 513 222	467 406 292
Heavy Duty Trucks	Diesel	<=20 t	Euro V	0	0	0	0	166 828 708	637 271 757	690 902 914	687 545 591	573 345 297
Heavy Duty Trucks	Diesel	<=20 t	Euro VI A/B/C	0	0	0	0	0	242 317 962	1 016 079 030	1 307 656 449	1 133 115 837
Heavy Duty Trucks	Diesel	<=20 t	Euro VI D/E	0	0	0	0	0	0	0	244 169 033	417 635 065
Heavy Duty Trucks	Diesel	20 - 28 t	Conventional	473 796 395	432 071 138	330 358 147	181 130 471	89 832 074	32 409 760	21 461 349	20 176 419	14 281 653
Heavy Duty Trucks	Diesel	20 - 28 t	Euro I	0	37 269 801	72 582 131	55 883 431	35 014 781	16 231 168	12 522 729	11 057 133	8 583 170
Heavy Duty Trucks	Diesel	20 - 28 t	Euro II	0	0	161 059 419	187 796 546	142 853 073	72 226 919	56 967 889	52 764 333	41 422 086
Heavy Duty Trucks	Diesel	20 - 28 t	Euro III	0	0	0	56 432 722	86 212 065	71 756 594	69 074 263	68 665 290	58 794 603
Heavy Duty Trucks	Diesel	20 - 28 t	Euro IV	0	0	0	0	28 664 348	35 395 725	43 673 970	46 028 505	39 823 617
Heavy Duty Trucks	Diesel	20 - 28 t	Euro V	0	0	0	0	5 732 656	18 917 129	34 141 961	38 786 151	34 416 160
Heavy Duty Trucks	Diesel	20 - 28 t	Euro VI A/B/C	0	0	0	0	0	4 569 385	23 425 351	26 589 771	26 471 922
Heavy Duty Trucks	Diesel	20 - 28 t	Euro VI D/E	0	0	0	0	0	0	0	5 836 128	9 981 802
Heavy Duty Trucks	Diesel	>28 t	Conventional	1 197 276 692	1 119 474 323	626 125 246	224 999 910	66 945 189	15 242 406	8 173 335	6 943 014	4 847 195
Heavy Duty Trucks	Diesel	>28 t	Euro I	0	324 449 813	488 999 953	229 951 663	86 490 660	24 491 292	14 043 442	11 508 218	8 226 574
Heavy Duty Trucks	Diesel	>28 t	Euro II	0	0	1 364 979 327	1 253 923 604	476 304 820	155 918 089	71 146 551	60 222 727	42 974 320
Heavy Duty Trucks	Diesel	>28 t	Euro III	0	0	0	653 350 969	668 661 636	317 369 390	114 384 136	100 825 731	74 348 369
Heavy Duty Trucks	Diesel	>28 t	Euro IV	0	0	0	0	44 476 889	28 041 527	28 494 133	29 015 361	25 108 762
Heavy Duty Trucks	Diesel	>28 t	Euro V	0	0	0	0	3 071 066	5 903 711	9 068 308	9 708 807	8 850 828
Heavy Duty Trucks	Diesel	>28 t	Euro VI A/B/C	0	0	0	0	0	1 936 275	15 674 005	16 609 729	16 076 948
Heavy Duty Trucks	Diesel	>28 t	Euro VI D/E	0	0	0	0	0	0	0	5 522 970	9 444 883
Buses	Diesel	Urban Buses	Conventional	303 457 923	242 503 352	181 742 508	113 013 363	53 479 559	17 788 769	9 467 587	7 694 801	4 566 364
Buses	Diesel	Urban Buses	Euro I	0	36 901 003	68 417 240	46 762 520	42 018 890	17 350 783	10 041 288	7 577 617	5 033 287
Buses	Diesel	Urban Buses	Euro II	0	0	174 824 178	165 449 718	134 689 591	86 369 113	59 780 452	48 663 767	33 324 838
Buses	Diesel	Urban Buses	Euro III	0	0	0	119 422 639	123 964 867	110 331 962	107 053 356	97 812 855	71 825 432
Buses	Diesel	Urban Buses	Euro IV	0	0	0	0	61 531 186	69 605 785	82 096 031	81 237 290	65 099 990
Buses	Diesel	Urban Buses	Euro V	0	0	0	0	11 342 174	45 374 720	52 585 425	53 271 096	43 028 046
Buses	Diesel	Urban Buses	Euro VI A/B/C	0	0	0	0	0	14 870 481	57 156 950	61 663 849	54 282 285
Buses	Diesel	Urban Buses	Euro VI D/E	0	0	0	0	0	0	0	9 145 123	15 636 143
Buses	Diesel	Coaches	Conventional	50 778 103	39 210 953	28 471 011	17 610 700	8 801 824	2 931 372	1 514 628	1 212 179	730 135
Buses	Diesel	Coaches	Euro I	0	6 132 435	10 780 418	7 528 153	7 109 584	2 995 359	1 772 260	1 302 568	849 692
Buses	Diesel	Coaches	Euro II	0	0	29 740 834	26 727 271	21 598 581	13 909 841	9 619 869	7 739 143	5 269 181
Buses	Diesel	Coaches	Euro III	0	0	0	15 747 127	15 228 660	14 186 176	14 990 591	13 979 265	10 451 213
Buses	Diesel	Coaches	Euro IV	0	0	0	0	7 547 365	8 743 287	11 247 457	11 272 439	9 170 738
Buses	Diesel	Coaches	Euro V	0	0	0	0	1 625 677	6 740 589	7 933 026	8 023 431	6 478 425
Buses	Diesel	Coaches	Euro VI A/B/C	0	0	0	0	0	2 017 209	7 699 592	8 192 835	7 051 521
Buses	CNG	Urban CNG Buses	Euro I	0	0	0	0	0	53 124	41 242	28 076	15 882
Buses	CNG	Urban CNG Buses	Euro II	0	0	1 204 723	7 750 076	3 580 913	2 569 834	0	0	0
Buses	CNG	Urban CNG Buses	Euro III	0	0	0	11 374 676	5 731 529	6 665 605	6 619 024	3 586 812	1 558 739
Buses	CNG	Urban CNG Buses	EEV	0	0	0	0	13 332 265	16 252 861	22 456 610	27 850 717	25 831 661
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Conventional	1 668 421 253	1 058 438 881	647 678 322	272 108 647	137 175 779	92 514 134	69 826 937	71 045 081	60 740 922
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 1	0	0	0	38 241 873	18 519 089	9 465 329	5 984 012	5 270 763	3 969 232
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 2	0	0	0	48 728 495	42 656 522	19 372 830	13 135 684	11 797 242	9 090 083
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 3	0	0	0	0	66 177 506	73 796 485	75 824 134	65 036 357	47 943 898
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 4	0	0	0	0	0	0	2 634 963	7 713 216	9 759 571
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Conventional	1 668 421 253	1 058 438 881	647 678 322	272 108 647	137 175 779	92 514 134	69 826 937	71 045 081	60 740 922
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 1	0	0	0	38 241 873	18 519 089	9 465 329	5 984 012	5 270 763	3 969 232
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 2	0	0	0	48 728 495	42 656 522	19 372 830	13 135 684	11 797 242	9 090 083
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 3	0	0	0	0	66 177 506	73 796 485	75 824 134	65 036 357	47 943 898

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2015	2018	2019	2020
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 4	0	0	0	0	0	0	2 634 963	7 713 216	9 759 571
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Conventional	58 977 967	63 868 476	77 804 885	26 885 247	39 361 647	28 075 248	25 687 504	24 646 994	20 797 042
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 1	0	0	0	42 569 803	38 839 544	24 345 878	22 792 932	22 455 546	17 768 695
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 2	0	0	0	24 591 876	39 910 038	26 691 958	23 422 856	25 597 112	20 425 219
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 3	0	0	0	0	76 708 599	160 113 179	189 057 377	182 547 226	150 553 543
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 4	0	0	0	0	0	0	62 179 918	110 955 623	138 464 550
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Conventional	68 832 672	74 533 847	94 180 982	39 194 820	24 350 581	11 891 777	10 035 255	9 629 417	8 124 299
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 1	0	0	0	64 275 012	24 924 588	10 688 904	9 236 189	9 089 807	7 181 442
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 2	0	0	0	34 257 782	25 368 094	11 604 180	9 389 108	10 263 152	8 187 171
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 3	0	0	0	0	43 921 393	73 981 674	79 345 376	78 045 525	65 381 562
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 4	0	0	0	0	0	0	25 282 743	43 211 607	52 705 585
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Conventional	231 637 816	250 841 202	293 454 254	114 059 284	64 541 396	31 121 625	26 665 157	25 585 018	21 588 613
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 1	0	0	0	187 046 337	66 055 746	27 971 958	24 545 288	24 154 808	19 080 833
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 2	0	0	0	99 692 399	67 249 448	30 367 894	24 941 923	27 273 159	21 754 797
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 3	0	0	0	0	116 418 241	193 609 028	210 826 049	207 372 930	173 718 382
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 4	0	0	0	0	0	0	67 172 128	114 821 095	140 047 442
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Conventional	148 940 640	161 285 134	216 277 354	90 086 437	61 171 567	34 807 755	31 880 023	30 588 876	25 810 316
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 1	0	0	0	147 730 383	62 608 540	31 284 227	29 344 141	28 879 188	22 812 037
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 2	0	0	0	78 735 286	63 739 037	33 966 161	29 822 558	32 608 115	26 011 468
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 3	0	0	0	0	110 345 676	216 533 212	252 057 712	247 924 793	207 692 524
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 4	0	0	0	0	0	0	80 309 534	137 280 404	167 436 036

Table C-10: Activity data for NFR 1.A.3.c: Fuel consumption from railways (TJ)

Fuel	Technology	unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
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
	Sub-bituminous Coal	TJ	1	0	1	0	1	0	0	0	1	1	1	1	1	1	1	1
	Coke	TJ	0	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-

Fuel	Technology	unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Railways	Gas Oil	TJ	1 035	1 056	1 115	779	676	590	481	434	456	437	393	418	408	415	368	-
	Sub-bituminous Coal	TJ	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-	-
	Coke	TJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Small combustion (NFR 1.A.4)

Table C-11: Activity data for NFR 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
Liquefied Petroleum Gases	Medium Boilers	TJ	447	490	539	616	577	370	706	995	957	960	1 025	1 230	779	779	682	435
	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
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
	Heat Pump	TJ	-	-	-	-	-	-	-	-	-	-	11	11	12	15	15	16
	Stove, Hobs and Ovens	TJ	102	111	104	125	124	138	146	145	265	424	612	660	729	826	873	966
	Gas Turbines	TJ	-	-	-	-	-	-	-	-	-	255	281	480	567	677	735	748
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
Wood and Wood Waste	Medium Boilers	TJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Ovens	TJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fuel Oil	Medium Boilers[1]	TJ	-	-	-	-	-	-	-	-	231	363	333	246	208	166	241	251
	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

Fuel	Technology	unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Liquefied Petroleum Gases	Medium Boilers	TJ	453	450	457	460	430	395	431	421	421	428	418	344	376	240	151	-
	Stove, Hobs and Ovens	TJ	3 896	4 037	4 686	4 343	1 716	1 532	1 488	1 538	2 714	2 956	2 917	2 833	3 737	2 972	2 457	-
Natural Gas & Gas Work Gas	Medium Boilers	TJ	5 538	5 999	6 073	7 213	7 457	7 666	8 002	7 804	7 733	8 254	9 149	9 287	9 480	8 972	7 403	-
	Heat Pump	TJ	19	24	26	29	37	37	44	51	68	95	73	77	82	81	69	-
	Stove, Hobs and Ovens	TJ	1 017	1 047	1 015	1 087	1 255	1 215	1 269	1 235	1 335	1 394	1 339	1 324	1 315	1 211	972	-
	Gas Turbines	TJ	815	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	-
Gas Oil	Medium Boilers	TJ	15 348	14 266	10 912	8 971	4 858	3 366	2 720	2 506	2 081	1 749	1 413	1 282	1 614	1 971	1 614	-
Wood and Wood Waste	Medium Boilers	TJ	-	-	-	-	-	665	400	458	598	433	452	525	520	499	353	-
	Ovens	TJ	-	-	-	-	-	1 870	1 065	1 005	1 158	860	775	821	745	655	426	-
Fuel Oil	Medium Boilers[1]	TJ	247	436	455	444	465	194	179	76	-	-	-	-	-	-	-	-
	Medium Boilers[2]	TJ	3 294	3 125	1 765	1 462	2 208	1 191	851	775	773	1 219	806	706	598	496	433	-

Table C-12: Activity data for NFR 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
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
	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
	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
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
	Condensing boilers	TJ	253	264	276	296	291	291	305	321	407	589	769	899	1 089	1 190	1 320	1 572
	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
Gas Oil	Small Boilers	TJ	158	211	286	205	190	201	133	92	106	144	90	82	120	235	474	839
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
	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
	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
	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
	Automatic Boilers	TJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	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	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Liquefied Petroleum Gases	LPG Heaters	TJ	1 147	1 160	1 179	1 185	1 169	1 090	1 077	1 069	1 049	1 033	1 006	1 026	1 008	1 067	1 126	-
	Condensing boilers	TJ	4 476	4 205	4 180	3 484	3 179	2 081	1 430	1 173	997	836	746	546	336	155	163	-
	Stove, Hobs and Ovens	TJ	21 452	20 052	17 420	17 127	18 867	17 702	17 016	16 706	15 125	14 020	14 315	14 372	13 907	14 513	15 312	-
Natural Gas & Gas Work Gas	Small Boilers	TJ	3 063	3 308	3 916	3 847	2 906	2 281	2 554	2 755	2 999	3 025	3 000	3 218	3 650	3 947	4 231	-
	Condensing boilers	TJ	1 655	1 813	2 603	2 170	2 759	2 693	2 835	2 829	3 101	3 091	3 110	3 326	3 763	4 059	4 341	-
	Stove, Hobs and Ovens	TJ	3 794	4 129	5 405	5 086	6 907	5 877	5 451	4 831	4 752	4 933	4 139	3 996	4 069	3 937	3 761	-
Gas Oil	Small Boilers	TJ	829	1 438	2 138	3 717	5 218	3 671	2 729	2 517	2 406	2 232	2 281	1 976	2 347	2 017	2 181	-
Wood and Wood Waste	Conventional stoves	TJ	17 929	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	-
	Open fireplaces	TJ	7 116	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	-
	Conventional boilers	TJ	4 884	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	-
	Pellet stoves and boilers	TJ	4 884	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	-
	Automatic Boilers	TJ	70	134	193	247	296	275	307	346	376	407	439	471	503	533	578	-
	Manual Boilers	TJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fuel Oil	-	TJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other Kerosene	-	TJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table C-13: Activity data for NFR 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
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
	Reciprocating engines	TJ	425	419	451	479	473	498	520	461	446	452	498	538	572	650	643	639
	-	TJ	6	0	1	1	1	17	2	151	539	565	854	872	641	548	511	540
LPG	Medium Boilers	TJ	527	382	290	345	485	167	260	267	198	410	347	147	419	370	327	128
Natural Gas & Gas Work Gas	Medium Boilers	TJ	-	-	-	-	-	-	-	-	0	0	5	84	129	136	139	160
	Gas Turbines	TJ	-	-	-	-	-	-	-	-	-	-	9	138	162	163	168	195
Wood Waste	Medium boilers	TJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fuel Oil	Medium Boilers[1]	TJ	-	-	-	-	5	261	253	285	280	278	567	689	814	738	635	740
	Medium Boilers[2]	TJ	529	382	294	353	488	179	265	272	202	451	332	133	426	374	236	122
Other Kerosene	-	TJ	93	82	72	55	53	51	49	49	49	49	49	47	50	47	49	55

Fuel	Technology	unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Gas Oil	Medium Boilers	TJ	5 496	5 495	5 184	4 697	4 620	4 553	4 618	4 766	4 791	4 865	5 044	5 121	5 199	5 212	5 728	-
	Reciprocating engines	TJ	611	611	576	522	513	506	513	530	532	541	560	569	578	579	636	-
	-	TJ	692	518	590	717	845	1 132	1 155	1 288	1 312	1 917	1 542	1 490	1 541	1 635	1 432	-
LPG	Medium Boilers	TJ	79	110	57	102	155	173	47	34	36	54	38	32	24	12	24	-
Natural Gas & Gas Work Gas	Medium Boilers	TJ	175	215	142	214	147	199	216	292	315	247	205	242	154	262	290	-
	Gas Turbines	TJ	173	169	179	179	304	316	322	313	146	181	209	213	239	291	335	-
Wood Waste	Medium boilers	TJ	-	-	-	-	-	100	159	129	202	130	60	60	60	215	215	-
Fuel Oil	Medium Boilers[1]	TJ	496	183	149	-	-	-	-	-	-	-	-	-	-	-	-	-
	Medium Boilers[2]	TJ	86	108	99	151	628	590	145	105	165	165	225	174	153	191	271	-
Other Kerosene	-	TJ	56	32	39	45	39	30	33	30	25	26	21	23	12	10	14	-

Table C-14: Activity data for NFR 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
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
	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
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
	Agriculture: 4-Stroke	TJ	35	36	48	45	45	45	45	44	47	105	99	93	87	81	75	68
Other Kerosene	Commercial: mobile	TJ	74	33	64	74	24	13	13	15	21	14	4	7	9	7	7	6
	Residential: mobile	TJ	184	174	145	123	119	82	76	76	76	76	76	76	76	90	89	50

Fuel	Technology	unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Gas Oil	Medium Boilers	TJ	5 496	5 495	5 184	4 697	4 620	4 553	4 618	4 766	4 791	4 865	5 044	5 121	5 199	5 212	5 728	-
	Reciprocating engines	TJ	611	611	576	522	513	506	513	530	532	541	560	569	578	579	636	-
	-	TJ	692	518	590	717	845	1 132	1 155	1 288	1 312	1 917	1 542	1 490	1 541	1 635	1 432	-
LPG	Medium Boilers	TJ	79	110	57	102	155	173	47	34	36	54	38	32	24	12	24	-
Natural Gas & Gas Work Gas	Medium Boilers	TJ	175	215	142	214	147	199	216	292	315	247	205	242	154	262	290	-
	Gas Turbines	TJ	173	169	179	179	304	316	322	313	146	181	209	213	239	291	335	-
Wood Waste	Medium boilers	TJ	-	-	-	-	-	100	159	129	202	130	60	60	60	215	215	-
Fuel Oil	Medium Boilers[1]	TJ	496	183	149	-	-	-	-	-	-	-	-	-	-	-	-	-
	Medium Boilers[2]	TJ	86	108	99	151	628	590	145	105	165	165	225	174	153	191	271	-
Other Kerosene	-	TJ	56	32	39	45	39	30	33	30	25	26	21	23	12	10	14	-

Table C-15: Portuguese Active Fishing Fleet (2011-2018)

			Number of Ships								Gross Tonnage (total)								Propulsion Power kW (total)							
VESSEL_LENGTH	FISHING_TECHNIQUE	ENGINE_TYPE	2011	2012	2013	2014	2015	2016	2017	2018	2011	2012	2013	2014	2015	2016	2017	2018	2011	2012	2013	2014	2015	2016	2017	2018
VL0010	DFN	HSD	469	302	307	408	232	423	396	402	704	492	505	549	393	569	547	531	10,274	7,784	7,718	8,677	6,067	9,134	8,797	8,680
VL0010	DRB	MSD	57	42	41	44	44	43	36	39	156	124	125	136	137	135	107	122	2,404	1,828	1,810	1,963	1,962	1,912	1,523	1,722
VL0010	DTS	MSD	5	5	5	5	5	5	5	4	51	51	51	51	51	51	51	40	285	285	285	285	285	285	285	230
VL0010	FPO	MSD	129	143	158	163	161	305	331	316	367	397	456	456	471	814	880	829	4,981	5,471	6,097	6,302	6,403	12,155	13,350	13,339
VL0010	HOK	HSD	185	172	161	146	146	137	135	133	176	169	153	137	135	135	132	128	3,665	3,413	3,148	2,877	2,830	2,914	2,983	2,987
VL0010	MGO	MSD	32	31	32	31	29	33	33	30	80	77	81	82	87	100	96	90	1,101	1,068	1,111	1,095	1,065	1,262	1,196	1,108
VL0010	PGP	HSD	1,797	1,867	1,849	1,701	1,840	1,508	1,485	1,461	3,153	3,264	3,251	3,227	3,331	2,850	2,793	2,767	48,220	48,927	48,734	47,670	49,672	42,787	42,549	42,961
VL0010	PMP	HSD	57	64	60	45	47	31	31	36	121	145	127	97	93	75	84	94	2,039	2,484	2,194	1,594	1,620	1,149	1,217	1,419
VL0010	PS	MSD	26	25	24	24	23	24	20	21	111	100	105	109	114	120	98	108	1,181	1,031	1,006	1,060	1,130	1,123	1,006	1,069
VL0010	TBB	MSD	65	57	44	52	43	16	15	14	136	131	99	118	108	50	56	56	2,237	2,010	1,599	1,857	1,607	651	645	608
VL1012	DFN	MSD	24	32	27	25	22	21	20	18	211	300	241	228	204	197	206	165	1,623	2,304	1,882	1,758	1,571	1,522	1,638	1,478
VL1012	DRB	MSD	21	23	22	24	23	24	24	22	177	193	179	197	192	198	204	183	1,497	1,662	1,558	1,696	1,592	1,666	1,737	1,588
VL1012	FPO	MSD	49	48	50	52	54	56	52	56	424	412	443	456	474	483	455	480	3,507	3,309	3,489	3,755	3,851	3,946	3,540	3,821
VL1012	HOK	MSD	14	12	12	12	10	5	6	5	132	108	96	96	85	45	55	45	1,274	938	914	927	813	361	493	361
VL1012	MGO	MSD	7	6	5	5	6	8	9	9	42	37	29	29	35	47	54	54	310	266	221	221	266	354	398	398
VL1012	PGP	MSD	13	13	13	10	11	13	14	10	117	117	115	95	99	125	112	96	872	1,042	1,022	784	812	1,169	976	810
VL1012	PS	MSD	27	25	27	28	30	30	30	28	248	230	247	254	266	266	266	248	2,107	1,988	2,105	2,157	2,275	2,268	2,241	2,111
VL1012	TBB	MSD	8	8	8	10	7	10	9	9	73	73	73	87	61	88	76	76	443	443	443	523	396	511	461	461
VP1218	DFN	MSD	71	68	66	63	84	50	77	50	1,558	1,518	1,503	1,402	2,039	1,093	1,935	1,098	8,466	8,188	7,771	7,235	10,696	5,737	10,194	5,967
VP1218	DRB	MSD	14	14	15	15	13	13	14	13	207	207	212	222	192	193	218	214	1,320	1,286	1,381	1,366	1,246	1,222	1,332	1,227
VP1218	DTS	MSD	8	9	8	9	10	7	8	8	286	315	274	293	330	267	292	292	1,412	1,584	1,405	1,640	1,865	1,224	1,395	1,395
VP1218	FPO	MSD	51	51	58	57	45	63	50	60	1,039	1,089	1,283	1,158	766	1,399	925	1,289	6,232	6,175	7,224	6,762	4,637	7,623	5,183	7,016
VP1218	HOK	MSD	24	26	21	23	22	21	20	22	671	659	544	565	566	564	536	572	3,411	3,604	3,004	3,172	3,055	2,941	2,650	2,883
VP1218	PGP	MSD	38	37	34	37	27	33	19	31	914	899	795	976	686	837	439	840	4,958	4,868	4,454	5,186	3,702	4,573	2,525	4,545
VP1218	PS	MSD	37	36	38	34	36	37	36	36	737	711	757	694	718	744	725	716	4,809	4,877	5,199	4,827	5,022	4,965	4,833	4,741
VL1824	DFN	MSD	26	26	26	27	28	25	31	24	1,772	1,772	1,772	1,807	1,921	1,763	2,183	1,713	6,215	6,217	6,217	6,438	6,649	5,824	7,095	5,503
VL1824	DTS	MSD	8	8	7	7	7	7	8	9	924	924	839	839	839	839	878	928	2,644	2,644	2,372	2,372	2,372	2,372	2,468	2,633
VL1824	FPO	MSD	7	7	7	7	7	7	1	6	501	501	501	501	501	414	89	379	1,666	1,666	1,666	1,666	1,666	1,723	268	1,495
VL1824	HOK	MSD	26	24	24	22	21	19	17	16	2,292	2,088	2,088	2,008	1,829	1,618	1,464	1,430	6,862	6,001	6,001	5,640	5,274	4,652	4,146	3,974
VL1824	PS	MSD	52	51	51	51	51	52	53	53	2,922	2,856	2,856	2,856	2,886	2,937	2,985	2,985	14,847	14,497	14,494	14,529	14,670	14,916	15,289	15,329
VL2440	DTS	MSD	66	65	67	67	59	59	57	59	14,354	14,351	14,650	14,751	12,495	12,536	12,085	12,309	34,876	35,288	36,417	36,326	30,603	30,608	29,360	29,863
VL2440	FPO	MSD	2	2	2	2	2	2	2	1	391	391	391	391	391	391	391	224	915	915	915	915	915	915	915	456
VL2440	HOK	MSD	35	36	32	29	25	28	28	29	8,402	8,600	7,260	6,510	5,793	6,394	6,394	6,744	16,683	16,849	14,348	12,765	11,099	12,345	12,345	12,941
VL2440	PS	MSD	18	18	18	18	19	20	20	21	1,512	1,471	1,489	1,490	1,583	1,693	1,693	1,796	6,221	6,156	6,261	6,261	6,581	7,296	7,343	7,659
VL40XX	DTS	SSD	13	12	12	12	10	11	12	10	25,089	23,099	23,099	23,099	18,656	19,692	21,357	17,441	27,717	25,069	25,069	25,069	20,394	22,273	24,443	19,588
VL40XX	HOK	SSD	5	5	5	5	4	5	5	5	2,910	2,910	2,910	2,910	2,412	2,938	2,938	2,938	4,169	4,169	4,169	4,169	3,281	4,181	4,181	4,181

VESSEL LENGTH: VL0010: Vessel between 0 meters and 10 meters in length / VL1012: Vessel between 10 meters and 12 meters in length / VL1218: Vessel between 12 meters and 18 meters in length / VL1824: Vessel between 18 meters and 24 meters in length. / VL2440: Vessel between 24 meters and 40 meters in length. / VL40XX: Vessel greater than 40 meters in length.

FISHING TECHNIQUE: DFN: Drift and/or fixed netters / DRB: Dredgers / DTS: Demersal trawlers and/or demersal seiners / FPO: Vessels using pots and/or traps / HOK: Vessels using hooks / MGO: Vessel using other active gears / MGP: Vessels using polyvalent active gears only / PG: Vessels using passive gears only for vessels < 12m / PGO: Vessels using other passive gears / PGP: Vessels using polyvalent passive gears only / PMP: Vessels using active and passive gears / PS: Purse seiners / TM: Pelagic trawlers / TBB: Beam trawlers

ENGINE TYPE: HSD: High-speed diesel Engine / MSD: Medium-speed diesel Engine / SSD: Slow-speed diesel Engine

Table C-16: Emission Factor for NFR 1.A.4: Sulphur Content in Small Combustion (% m/m)

Fuel	Technology	unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Diesel	Regular Diesel	%	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.04	0.035	0.035	0.035	0.005
	Coloured Diesel	%	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Diesel for Heating	%	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Fuel oil	Thick Fuel Oil	%	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1.0	1.0	1.0
	Thin Fuel Oil	%	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	1.0	1.0	1.0
	Fuel Oil (average)	%	3.4	3.4	3.3	3.3	3.2	3.3	3.1	3.1	3.1	3.1	3.0	3.1	3.1	1.0	1.0	1.0
Gasoline	Reguler Gasoline	%	0.1	0.1	0.1	0.1	0.1	0.1	0.10	0.10	0.10	0.10	-	-	-	-	-	-
	Unleaded Gasoline	%	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.05	0.05	0.05	0.05	0.02	0.02	0.02	0.01
	Gasoline (average)	%	0.1	0.1	0.1	0.1	0.1	0.1	0.08	0.08	0.07	0.06	0.05	0.05	0.02	0.02	0.02	0.01
Other Kerosene	-	%	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

Fuel	Technology	unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Diesel	Regular Diesel	%	0.005	0.005	0.005	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	Coloured Diesel	%	0.2	0.2	0.1	0.1	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	Diesel for Heating	%	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Fuel oil	Thick Fuel Oil	%	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Thin Fuel Oil	%	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Fuel Oil (average)	%	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Gasoline	Reguler Gasoline	%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Unleaded Gasoline	%	0.01	0.01	0.01	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	Gasoline (average)	%	0.01	0.01	0.01	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Other Kerosene	-	%	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

Other Mobile (NFR 1.A.5)

Table C-17: Activity data for NFR 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
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

Fuel Sales		NAPFUE	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Jet Fuel	L	207	1 064	1 026	1 200	1 205	1 208	1 086	683	822	961	1 065	614	612	821	847	927

Annex D: Agriculture

Updated: March 2022

Table D-1: Livestock numbers (thousand)

Type		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	Dairy cows	394	388	381	383	382	383	380	379	375	369
Non-dairy cattle	Beef calfs (<1 yr)	46	52	53	53	58	60	64	64	65	66
	Calfs M.Rep. (<1 yr)	186	185	182	176	167	162	155	151	149	149
	Calfs F Rep. (<1 yr)	177	178	178	174	164	158	152	152	155	165
	Males 1-2 yrs	112	114	114	108	103	103	105	101	95	86
	Beef Fem. 1-2 yrs	18	19	20	22	22	22	24	24	24	20
	Females rep. 1-2 yrs	111	115	112	109	106	109	112	109	108	116
	Steers (>2 yrs)	38	38	36	37	35	33	33	31	31	29
	Heifers Beef (>2 yrs)	4	5	7	9	10	10	9	9	9	7
	Heifers rep. (>2 yrs)	45	46	45	48	50	52	51	50	52	60
	non-dairy cows	242	245	238	241	252	273	296	316	332	338
Swine	Piglets (<20 kg)	727	756	756	750	735	726	703	701	695	691
	Fatt. Pigs (20-50 kg)	662	675	660	671	668	660	633	631	633	623
	Fatt. Pigs (50-80 kg)	525	545	544	539	532	525	505	496	492	498
	Fatt. Pigs (80-110	218	227	226	225	210	198	179	177	174	176
	Fatt. Pigs (> 110 kg)	44	46	46	47	45	44	40	39	38	38
	Boars (>50 kg)	26	28	27	28	28	26	24	23	23	22
	Sows, pregnant	210	219	218	220	216	211	204	204	202	201
	Sows, non-pregnant	124	131	135	136	134	132	127	128	127	127
Sheep	Ewes	2 292	2 293	2 257	2 268	2 303	2 339	2 376	2 368	2 367	2 388
	Other Ovine	663	725	789	794	811	817	813	802	834	840
	Lambs	307	326	320	300	279	278	292	297	301	307
Goats	Does	614	588	556	538	528	517	509	498	485	472
	Other Caprine	149	156	166	160	153	151	147	151	154	151
	kids	47	49	47	44	45	41	41	36	37	36
Horses	Horses	33	38	40	42	44	48	52	54	56	57
Asses	Asses and Mules.	118	116	114	114	109	103	96	90	82	75
Poultry	Hens, reproductive	3 421	3 300	3 116	2 941	2 947	3 271	3 477	3 390	2 982	2 636
	Hens eggs	7 539	7 695	7 932	8 159	8 143	7 745	7 392	7 322	7 859	8 627
	Broilers	18 524	18 812	19 243	19 674	19 530	18 813	18 355	18 733	20 538	22 936
	Turkeys	1 149	1 122	1 082	1 041	996	945	936	972	1 061	1 158
	Other poultry	1 571	1 559	1 542	1 525	1 528	1 551	1 552	1 509	1 494	1 552
Other	Rabbits*	475	464	447	430	415	401	384	363	346	338

Table D-1: Livestock numbers (thousand)

Type		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cattle	Dairy cows	353	331	311	297	294	290	284	275	269	263
Non-dairy cattle	Beef calfs (<1 yr)	67	72	75	82	91	104	108	108	108	109
	Calfs M.Rep. (<1 yr)	144	140	137	141	140	136	131	129	127	123
	Calfs F Rep. (<1 yr)	174	180	186	186	187	183	180	178	174	169
	Males 1-2 yrs	82	81	80	80	79	81	77	75	73	72
	Beef Fem. 1-2 yrs	17	14	14	15	16	17	17	16	17	18
	Females rep. 1-2 yrs	127	135	136	133	135	135	139	139	141	142
	Steers (>2 yrs)	26	24	23	23	23	25	28	31	33	34
	Heifers Beef (>2 yrs)	6	6	8	8	8	9	9	9	9	10
	Heifers rep. (>2 yrs)	67	77	80	86	90	94	96	96	97	102
	non-dairy cows	345	352	362	371	382	397	411	425	432	436
Swine	Piglets (<20 kg)	663	626	591	571	570	574	583	590	592	602
	Fatt. Pigs (20-50 kg)	585	535	493	471	467	467	466	468	464	460
	Fatt. Pigs (50-80 kg)	483	446	402	374	373	368	362	356	357	362
	Fatt. Pigs (80-110	174	184	197	208	213	214	221	222	227	237
	Fatt. Pigs (> 110 kg)	38	43	42	43	40	41	43	44	44	40
	Boars (>50 kg)	20	19	17	16	14	12	12	11	10	8
	Sows, pregnant	195	197	196	198	194	191	189	185	183	181
	Sows, non-pregnant	124	111	91	73	67	68	70	71	70	69
Sheep	Ewes	2 410	2 388	2 328	2 282	2 273	2 293	2 275	2 225	2 137	2 030
	Other Ovine	734	505	299	204	216	234	267	250	226	206
	Lambs	319	320	330	324	329	322	328	340	337	307
Goats	Does	460	440	417	392	382	380	380	373	365	358
	Other Caprine	129	91	62	48	52	57	65	59	52	44
	kids	33	30	29	28	28	26	25	28	30	31
Horses	Horses	58	59	59	58	56	52	49	47	46	42
Asses	Asses and Mules.	69	63	57	51	45	40	36	33	29	26
Poultry	Hens, reproductive	2 644	2 780	3 019	3 206	3 253	3 056	2 800	2 717	2 877	3 218
	Hens eggs	9 060	9 089	8 739	8 440	7 942	7 349	6 830	6 490	6 758	7 341
	Broilers	24 374	24 259	22 590	20 921	19 620	18 686	17 885	16 848	16 780	17 915
	Turkeys	1 208	1 201	1 139	1 077	963	798	799	1 017	1 318	1 485
	Other poultry	1 622	1 634	1 588	1 542	1 471	1 376	1 322	1 332	1 414	1 504
Other	Rabbits*	336	332	325	318	306	289	270	254	251	255

Table D-1: Livestock numbers (thousand)

Type		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Dairy cattle	Dairy cows	255	247	241	236	233	235	238	240	237	235	233
Non-dairy cattle	Beef calfs (<1 yr)	114	120	125	119	113	112	114	114	112	109	107
	Calfs M.Rep. (<1 yr)	123	128	136	136	142	152	162	166	165	172	175
	Calfs F Rep. (<1 yr)	171	179	190	191	198	209	221	226	224	232	236
	Males 1-2 yrs	66	60	55	54	53	58	67	74	75	70	70
	Beef Fem. 1-2 yrs	20	19	20	19	17	15	14	14	14	15	16
	Females rep. 1-2 yrs	137	132	131	135	139	148	159	165	163	158	157
	Steers (>2 yrs)	38	41	44	42	39	37	38	45	53	60	62
	Heifers Beef (>2 yrs)	12	13	14	14	15	15	14	15	15	14	12
	Heifers rep. (>2 yrs)	110	111	110	105	103	96	92	90	95	98	98
	non-dairy cows	438	440	442	443	450	461	474	483	487	492	497
Swine	Piglets (<20 kg)	597	614	634	658	681	713	729	739	738	771	797
	Fatt. Pigs (20-50 kg)	448	446	455	464	472	485	490	488	471	469	453
	Fatt. Pigs (50-80 kg)	360	362	366	366	369	380	387	385	378	381	387
	Fatt. Pigs (80-110	244	251	255	263	273	285	294	301	311	312	319
	Fatt. Pigs (> 110 kg)	36	30	27	25	28	30	33	33	34	34	45
	Boars (>50 kg)	7	6	5	5	5	6	5	6	5	5	5
	Sows, pregnant	179	172	166	159	159	162	164	163	162	163	163
	Sows, non-pregnant	66	66	66	68	69	71	72	73	72	73	72
Sheep	Ewes	1 915	1 811	1 735	1 683	1 638	1 620	1 639	1 659	1 666	1 648	1 635
	Other Ovine	192	179	160	192	215	237	267	318	373	385	412
	Lambs	277	264	267	237	213	194	202	196	189	185	180
Goats	Does	356	353	349	342	333	324	311	298	285	273	264
	Other Caprine	40	38	35	37	38	39	36	35	36	38	38
	kids	29	29	28	26	24	20	20	19	18	18	17
Horses	Horses	38	36	34	33	32	30	30	29	30	30	30
Asses	Asses and Mules.	22	21	20	18	13	11	10	13	13	12	11
Poultry	Hens, reproductive	3 453	3 542	3 396	3 179	3 047	2 920	2 890	2 979	3 306	3 767	4 109
	Hens eggs	7 867	7 883	7 475	7 138	6 857	6 710	6 607	7 090	8 038	9 556	10 533
	Broilers	19 207	19 452	18 650	17 847	18 096	19 395	21 745	24 413	27 398	30 702	32 904
	Turkeys	1 445	1 331	1 144	956	836	785	800	926	1 160	1 505	1 735
	Other poultry	1 522	1 460	1 319	1 178	1 167	1 284	1 530	1 869	2 300	2 823	3 172
Other	Rabbits*	255	243	218	193	170	148	128	121	128	148	162

Table D-2: 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	2001	2002	2003	2004	2005
Dairy cattle	33 850	33 196	32 476	31 322	32 165	33 282	33 824	34 052	34 384	36 952	37 590	36 125	35 826	33 363	33 086	33 467
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	54 038	55 641	57 404	59 212	61 310
Sheep	25 391	25 809	25 910	26 037	26 474	26 837	27 154	27 006	27 213	27 444	26 943	25 236	23 318	22 269	22 275	22 567
Goats	5 279	5 149	4 983	4 824	4 703	4 614	4 535	4 480	4 409	4 301	4 077	3 678	3 327	3 060	3 016	3 041
Horses	1 447	1 666	1 750	1 842	1 953	2 094	2 272	2 396	2 485	2 527	2 563	2 582	2 596	2 567	2 449	2 273
Asses & Mules	2 599	2 560	2 513	2 499	2 393	2 273	2 104	1 969	1 812	1 658	1 517	1 383	1 247	1 115	983	880
Swine	26 055	27 093	27 064	27 217	26 701	26 132	24 977	24 816	24 653	24 618	23 786	22 485	20 858	19 650	19 285	19 190
Poultry	17 846	18 016	18 273	18 525	18 387	17 795	17 364	17 480	18 701	20 440	21 536	21 550	20 492	19 458	18 299	17 064
Rabbits*	4 273	4 172	4 022	3 872	3 733	3 605	3 452	3 263	3 113	3 041	3 023	2 984	2 923	2 862	2 754	2 599
Total	**160 176**	**161 970**	**160 591**	**159 739**	**160 397**	**162 145**	**162 899**	**163 855**	**166 248**	**171 755**	**173 334**	**170 061**	**166 226**	**161 748**	**161 359**	**162 391**

Type	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Dairy cattle	32 919	31 822	31 289	30 783	29 845	28 894	28 329	27 689	27 532	27 760	27 982	28 173	28 053	27 772	27 671
Non-dairy cattle	62 868	64 220	65 270	66 149	67 256	68 282	69 532	70 408	71 033	72 758	75 474	77 877	79 004	80 049	80 703
Sheep	22 623	22 056	21 089	19 977	18 826	17 794	16 970	16 697	16 444	16 414	16 793	17 309	17 736	17 651	17 712
Goats	3 094	3 004	2 898	2 793	2 758	2 717	2 670	2 637	2 581	2 528	2 416	2 320	2 234	2 164	2 102
Horses	2 141	2 083	2 009	1 833	1 672	1 569	1 511	1 437	1 393	1 335	1 311	1 276	1 302	1 311	1 317
Asses & Mules	785	726	645	565	491	455	433	389	293	242	230	277	295	266	237
Swine	19 248	19 183	19 131	19 114	18 836	18 696	18 703	18 820	19 133	19 739	20 104	20 184	20 032	20 084	20 217
Poultry	16 177	15 721	16 417	17 785	18 818	18 784	17 721	16 691	16 361	16 765	17 863	19 807	22 543	26 119	28 486
Rabbits*	2 429	2 290	2 256	2 294	2 295	2 184	1 962	1 741	1 531	1 334	1 149	1 088	1 150	1 336	1 459
Total	**162 285**	**161 105**	**161 005**	**161 293**	**160 797**	**159 375**	**157 831**	**156 509**	**156 302**	**158 875**	**163 322**	**168 311**	**172 349**	**176 751**	**179 905**

*Per female cage

Table D-3: NH_3 emissions from housing, manure storage and manure application ($kg.hd^{-1}.yr^{-1}$)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Dairy cattle																
housing (slurry and solid)	5.25	5.24	5.22	5.01	5.16	5.33	5.47	5.51	5.63	6.15	6.53	6.70	7.05	6.88	6.88	7.07
storage (slurry and solid)	12.52	12.39	12.26	11.65	11.95	12.28	12.53	12.56	12.75	13.93	14.74	15.04	15.76	15.25	15.15	15.47
application (slurry and solid)	11.49	11.42	11.35	10.83	11.15	11.50	11.77	11.85	12.07	13.22	14.04	14.37	15.11	14.69	14.65	15.01
Non-dairy cattle																
housing (slurry and solid)	0.52	0.52	0.51	0.51	0.50	0.49	0.47	0.45	0.43	0.43	0.43	0.43	0.42	0.42	0.41	0.40
storage (slurry and solid)	2.05	2.02	1.98	1.96	1.90	1.84	1.78	1.69	1.61	1.59	1.59	1.58	1.55	1.52	1.47	1.44
application (slurry and solid)	1.27	1.26	1.25	1.24	1.21	1.18	1.15	1.10	1.05	1.04	1.05	1.05	1.04	1.02	0.99	0.97
Sows																
housing (slurry and solid)	8.13	8.13	8.16	8.14	8.12	8.10	8.08	8.06	8.05	8.03	8.02	7.81	7.53	7.21	7.12	7.13
storage (slurry and solid)	1.85	1.85	1.85	1.84	1.84	1.83	1.82	1.82	1.81	1.81	1.80	1.75	1.69	1.61	1.59	1.59
application (slurry and solid)	4.11	4.11	4.13	4.12	4.11	4.10	4.09	4.08	4.08	4.07	4.06	3.96	3.82	3.66	3.61	3.61
Other swine																
housing (slurry and solid)	1.69	1.69	1.68	1.68	1.68	1.67	1.66	1.65	1.64	1.65	1.65	1.65	1.65	1.65	1.65	1.64
storage (slurry and solid)	0.55	0.55	0.55	0.55	0.55	0.54	0.54	0.54	0.53	0.53	0.54	0.54	0.54	0.54	0.53	0.53
application (slurry and solid)	1.69	1.69	1.68	1.68	1.68	1.67	1.66	1.65	1.64	1.65	1.65	1.66	1.66	1.65	1.65	1.64
Sheep																
housing (slurry and solid)	0.20	0.19	0.18	0.18	0.18	0.17	0.17	0.16	0.16	0.15	0.15	0.14	0.14	0.13	0.13	0.12
storage (slurry and solid)	0.21	0.21	0.20	0.20	0.19	0.19	0.18	0.18	0.17	0.16	0.16	0.15	0.15	0.15	0.14	0.13
application (slurry and solid)	0.20	0.19	0.18	0.18	0.18	0.17	0.17	0.16	0.16	0.15	0.15	0.14	0.14	0.13	0.13	0.12
Goats																
housing (slurry and solid)	0.17	0.17	0.17	0.16	0.16	0.15	0.15	0.15	0.14	0.14	0.14	0.13	0.13	0.12	0.12	0.12
storage (slurry and solid)	0.17	0.17	0.17	0.16	0.16	0.16	0.15	0.15	0.15	0.14	0.14	0.14	0.13	0.13	0.13	0.12
application (slurry and solid)	0.16	0.16	0.15	0.15	0.15	0.14	0.14	0.14	0.14	0.13	0.13	0.13	0.12	0.12	0.12	0.11
Horses																
housing (slurry and solid)	2.58	2.53	2.44	2.36	2.28	2.21	2.16	2.08	2.00	1.92	1.82	1.73	1.63	1.52	1.41	1.28
storage (slurry and solid)	2.16	2.18	2.16	2.12	2.11	2.09	2.08	2.05	2.02	1.96	1.90	1.83	1.75	1.66	1.56	1.43
application (slurry and solid)	1.80	1.82	1.80	1.78	1.76	1.75	1.75	1.72	1.69	1.65	1.60	1.54	1.48	1.40	1.31	1.21
Mules & asses																
housing (slurry and solid)	2.58	2.53	2.44	2.36	2.28	2.21	2.16	2.08	2.00	1.92	1.82	1.73	1.63	1.52	1.41	1.28
storage (slurry and solid)	2.16	2.18	2.16	2.12	2.11	2.09	2.08	2.05	2.02	1.96	1.90	1.83	1.75	1.66	1.56	1.43
application (slurry and solid)	1.80	1.82	1.80	1.78	1.76	1.75	1.75	1.72	1.69	1.65	1.60	1.54	1.48	1.40	1.31	1.21
Hens																
housing (slurry and solid)	0.11	0.11	0.11	0.12	0.12	0.11	0.11	0.11	0.11	0.12	0.12	0.12	0.12	0.11	0.11	0.11

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
storage (slurry and solid)	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	0.04	0.04	0.04
application (slurry and solid)	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.13	0.12	0.12	0.12
Broilers																
housing (slurry and solid)	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
storage (slurry and solid)	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
application (slurry and solid)	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	0.04	0.04	0.04
Turkeys																
housing (slurry and solid)	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
storage (slurry and solid)	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
application (slurry and solid)	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Other poultry																
housing (slurry and solid)	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.14	0.14	0.14
storage (slurry and solid)	0.05	0.05	0.05	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
application (slurry and solid)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Rabbits																
housing (slurry and solid)	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
storage (slurry and solid)	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
application (slurry and solid)	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58

Table D-4: NH_3 emissions from housing, manure storage and manure application ($kg.hd^{-1}.yr^{-1}$)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Dairy cattle															
housing (slurry and solid)	7.08	7.07	7.11	7.13	7.13	7.13	7.17	7.15	7.19	7.18	7.15	7.15	7.20	7.19	7.22
storage (slurry and solid)	15.39	15.26	15.25	15.19	15.09	15.10	15.18	15.13	15.22	15.21	15.14	15.13	15.24	15.22	15.30
application (slurry and solid)	14.99	14.92	14.96	14.96	14.92	14.93	15.01	14.96	15.05	15.04	14.97	14.97	15.07	15.05	15.13
Non-dairy cattle															
housing (slurry and solid)	0.39	0.38	0.37	0.35	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34
storage (slurry and solid)	1.40	1.34	1.29	1.24	1.18	1.18	1.18	1.20	1.19	1.18	1.18	1.19	1.20	1.21	1.21
application (slurry and solid)	0.95	0.92	0.89	0.86	0.82	0.82	0.82	0.83	0.83	0.82	0.82	0.83	0.84	0.84	0.84
Sows															
housing (slurry and solid)	7.15	7.18	7.16	7.13	7.07	7.12	7.17	7.25	7.27	7.29	7.29	7.31	7.30	7.30	7.30
storage (slurry and solid)	1.59	1.59	1.59	1.58	1.56	1.57	1.59	1.60	1.61	1.61	1.61	1.62	1.62	1.62	1.62
application (slurry and solid)	3.63	3.64	3.64	3.62	3.59	3.62	3.64	3.68	3.69	3.70	3.70	3.71	3.71	3.71	3.71

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Other swine															
housing (slurry and solid)	1.63	1.61	1.61	1.60	1.60	1.59	1.57	1.56	1.55	1.55	1.55	1.54	1.54	1.52	1.51
storage (slurry and solid)	0.53	0.52	0.52	0.52	0.52	0.51	0.51	0.50	0.50	0.50	0.50	0.50	0.50	0.49	0.49
application (slurry and solid)	1.63	1.62	1.62	1.61	1.61	1.59	1.58	1.57	1.56	1.55	1.55	1.55	1.55	1.52	1.52
Sheep															
housing (slurry and solid)	0.12	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
storage (slurry and solid)	0.13	0.12	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
application (slurry and solid)	0.12	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Goats															
housing (slurry and solid)	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
storage (slurry and solid)	0.12	0.11	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
application (slurry and solid)	0.11	0.11	0.10	0.10	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Horses															
housing (slurry and solid)	1.16	1.03	0.90	0.77	0.63	0.63	0.63	0.64	0.66	0.67	0.67	0.66	0.65	0.66	0.67
storage (slurry and solid)	1.31	1.18	1.05	0.90	0.75	0.75	0.75	0.76	0.79	0.80	0.80	0.78	0.78	0.79	0.80
application (slurry and solid)	1.11	1.00	0.88	0.76	0.63	0.64	0.64	0.64	0.66	0.68	0.68	0.66	0.66	0.67	0.68
Mules & asses															
housing (slurry and solid)	1.16	1.03	0.90	0.77	0.63	0.63	0.63	0.64	0.66	0.67	0.67	0.66	0.65	0.66	0.67
storage (slurry and solid)	1.31	1.18	1.05	0.90	0.75	0.75	0.75	0.76	0.79	0.80	0.80	0.78	0.78	0.79	0.80
application (slurry and solid)	1.11	1.00	0.88	0.76	0.63	0.64	0.64	0.64	0.66	0.68	0.68	0.66	0.66	0.67	0.68
Hens															
housing (slurry and solid)	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
storage (slurry and solid)	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	0.04	0.04
application (slurry and solid)	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Broilers															
housing (slurry and solid)	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
storage (slurry and solid)	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
application (slurry and solid)	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	0.04	0.04
Turkeys															
housing (slurry and solid)	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
storage (slurry and solid)	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
application (slurry and solid)	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Other poultry															
housing (slurry and solid)	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
storage (slurry and solid)	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	0.04	0.04
application (slurry and solid)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Rabbits															
housing (slurry and solid)	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
storage (slurry and solid)	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
application (slurry and solid)	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58

Table D-5: Nitrogen amount consumption (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	2001	2002	2003	2004	2005
Ammonium nitrate (AN)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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	10 521	12 038	9 097	1 920	-
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	10 917	11 575	10 310	10 273	10 298
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	38 776	42 505	35 892	43 305	29 682
Urea	13 347	13 347	13 347	13 347	13 347	7 058	14 072	15 262	7 752	14 514	20 524	17 527	10 066	9 235	8 203	11 849
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	59 095	69 986	61 915	96 642	39 937
Other N	18 488	18 488	18 488	18 488	18 488	15 180	16 258	20 295	19 604	18 435	19 725	20 675	17 731	14 959	18 508	10 897
Total	**158 500**	**158 500**	**158 500**	**158 500**	**158 500**	**145 815**	**168 229**	**164 288**	**149 303**	**148 944**	**170 009**	**157 511**	**163 902**	**141 408**	**178 851**	**102 663**

Type	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Ammonium nitrate (AN)	-	-	-	4 295	4 009	4 182	3 696	7 700	4 635	670	850	406	6	20	359
Ammonium phosphate (MAP&DAP)	-	-	-	1 013	539	209	1 371	2 042	1 172	576	1 942	2 457	2 496	1 594	1 793
Ammonium sulphate (AS)	4 221	5 864	2 541	1 951	3 057	-	-	-	1 202	1 805	1 912	1 711	688	2 507	556
Calcium ammonia nitrate (CAN)	19 206	34 634	26 751	27 179	34 989	23 487	17 620	25 380	18 553	17 889	21 764	16 521	19 931	19 608	21 569
Urea	20 447	21 976	26 008	24 064	13 854	22 193	20 883	15 567	25 402	30 518	30 203	25 846	21 816	13 840	15 176
Other NK & NPK	33 758	41 105	28 972	16 086	24 905	24 943	17 193	24 568	31 865	27 969	24 887	24 798	23 910	28 300	27 876
Other N	9 759	9 426	20 859	22 705	18 896	20 074	46 101	35 387	48 814	38 480	26 883	30 845	32 519	39 631	38 000
Total	**87 391**	**113 005**	**105 131**	**97 293**	**100 249**	**95 088**	**106 864**	**110 643**	**131 643**	**117 906**	**108 440**	**102 584**	**101 365**	**105 499**	**105 330**

Table D-6: Share (%) of the National emissions corresponding to the mainland territory

NFR code	Description	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
3 B 1 a	Manure management – Dairy cattle	78.68	77.75	78.74	78.50	78.10	77.86	77.39	76.39	74.73	71.99	71.73	69.51	67.56	67.71	67.68	65.96
3 B 1 b	Manure management – Non - Dairy cattle	92.39	90.63	90.64	90.18	90.43	90.02	90.11	89.73	90.53	89.83	89.12	89.09	89.66	90.01	90.12	89.63
3 B 2	Manure management – Sheep	99.58	99.59	99.58	99.58	99.60	99.60	99.60	99.59	99.58	99.66	99.50	99.54	99.61	99.60	99.65	99.62
3 B 3	Manure management – Swine	97.57	97.64	97.67	97.73	97.55	97.53	97.47	97.37	97.19	96.44	96.27	95.83	95.88	95.71	95.63	96.42
3 B 4 d	Manure management – Goats	97.11	97.02	96.98	96.83	96.81	97.02	96.90	97.03	96.75	97.16	96.62	96.32	96.38	96.62	96.60	96.63
3 B 4 e	Manure management –Horses	88.00	88.00	88.00	88.00	88.00	88.65	89.76	90.56	90.93	91.20	91.53	91.53	93.10	92.98	92.31	93.75
3 B 4 f	Manure management – Mules & asses	97.00	97.00	97.00	97.00	97.00	96.98	96.99	97.30	97.51	97.69	98.41	98.25	98.04	97.73	97.44	97.14
3 B 4 g i	Manure management – Laying hens	96.24	96.16	96.08	96.00	96.13	96.27	96.92	97.59	96.82	96.13	95.83	95.53	95.21	94.90	95.36	95.93
3 B 4 g ii	Manure management – Broilers	96.47	96.22	95.98	95.75	95.64	95.51	95.36	95.23	96.31	97.13	97.21	97.30	97.40	97.52	97.17	96.80
3 B 4 g iii	Manure management – Turkeys	99.73	99.71	99.68	99.66	99.60	99.53	99.63	99.71	99.73	99.74	99.75	99.75	99.75	99.75	99.60	99.33
3 B 4 g iv	Manure management – Other poultry	98.87	98.83	98.79	98.75	98.71	98.68	98.59	98.50	98.54	98.58	98.58	98.58	98.58	98.59	98.48	98.36
3 B 4 h	Manure management – Other animals	98.65	98.46	98.25	98.03	97.77	97.49	97.98	98.55	98.72	98.90	98.89	98.88	98.87	98.86	98.60	98.28
3 D a 1	Inorganic N_Fertilizers	96.86	96.89	96.86	96.81	96.85	96.79	96.80	96.71	96.67	96.74	96.75	96.71	96.67	96.62	96.60	96.58
3 D a 2 a	Animal manure applied to soil	85.54	84.19	84.69	84.34	84.27	83.94	83.75	83.06	82.63	80.91	80.43	79.30	78.61	78.86	78.90	77.80
3 D a 2 b	Sewage sludge applied to soil	96.86	96.89	96.86	96.81	96.85	96.79	96.80	96.71	96.67	96.74	96.75	96.71	96.67	96.62	96.60	96.58
3 D a 2 c	Other organic fertilizers applied to soil	96.86	96.89	96.86	96.81	96.85	96.79	96.80	96.71	96.67	96.74	96.75	96.71	96.67	96.62	96.60	96.58
3 D a 3	Urine & dung deposited by grazing animals	92.91	92.52	92.66	92.55	92.50	92.52	92.60	92.57	92.46	92.00	91.88	91.44	91.46	91.48	91.35	91.31
3 D c	Farm level agricultural operations	96.86	96.89	96.86	96.81	96.85	96.79	96.80	96.71	96.67	96.74	96.75	96.71	96.67	96.62	96.60	96.58
3 D e	Cultivated crops	96.86	96.89	96.86	96.81	96.85	96.79	96.80	96.71	96.67	96.74	96.75	96.71	96.67	96.62	96.60	96.58
3D f	Use of pesticides	96.86	96.89	96.86	96.81	96.85	96.79	96.80	96.71	96.67	96.74	96.75	96.71	96.67	96.62	96.60	96.58
3 F	Field burning of agricultural residues	98.74	98.80	98.76	98.72	98.67	98.65	98.62	98.65	98.45	98.57	98.55	98.44	98.45	98.35	98.35	98.23

Table D-6: Share (%) of the National emissions corresponding to the mainland territory

NFR code	Description	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
3 B 1 a	Manure management – Dairy cattle	65.19	65.06	64.91	63.53	62.55	62.40	61.18	61.47	61.97	62.55	62.34	61.92	61.28	61.11	60.52
3 B 1 b	Manure management – Non - Dairy cattle	89.39	89.27	89.03	88.46	88.16	88.22	87.58	87.76	88.25	88.17	88.56	88.56	88.24	88.42	88.05
3 B 2	Manure management – Sheep	99.65	99.67	99.73	99.66	99.64	99.63	99.62	99.66	99.66	99.66	99.69	99.73	99.73	99.73	99.69
3 B 3	Manure management – Swine	96.45	96.92	96.73	97.07	96.92	97.38	97.68	98.31	98.45	98.44	98.51	98.43	98.32	98.27	100.00
3 B 4 d	Manure management – Goats	96.37	97.27	97.46	97.41	96.42	96.61	96.78	96.98	96.34	96.25	96.25	95.88	95.50	95.89	95.51
3 B 4 e	Manure management –Horses	93.62	93.48	92.68	94.44	94.29	94.44	93.94	93.55	93.75	93.10	93.34	94.28	95.21	96.12	100.00
3 B 4 f	Manure management – Mules & asses	96.88	96.55	96.00	95.00	95.00	95.00	94.44	93.33	100.00	100.00	98.10	98.10	98.10	96.57	100.00
3 B 4 g i	Manure management – Laying hens	95.95	95.98	96.43	96.78	96.82	96.87	96.93	96.99	96.95	96.91	96.87	97.35	97.69	97.94	97.94
3 B 4 g ii	Manure management – Broilers	96.08	95.24	96.35	97.20	97.12	97.03	96.94	96.84	97.09	97.29	97.45	97.56	97.65	97.72	97.72
3 B 4 g iii	Manure management – Turkeys	99.72	99.88	99.76	99.65	99.66	99.67	99.68	99.69	99.71	99.72	99.73	99.83	99.89	99.92	99.92
3 B 4 g iv	Manure management – Other poultry	98.42	98.47	98.52	98.57	98.53	98.49	98.43	98.36	98.75	99.01	99.20	99.47	99.63	99.75	99.75
3 B 4 h	Manure management – Other animals	98.18	98.07	97.75	97.47	97.47	97.49	97.50	97.52	97.57	97.64	97.74	97.68	97.63	97.60	97.60
3 D a 1	Inorganic N_Fertilizers	96.48	96.38	96.48	96.57	96.57	96.57	96.57	96.60	96.60	96.60	96.47	96.47	96.47	96.84	96.84
3 D a 2 a	Animal manure applied to soil	77.29	77.16	76.97	75.99	75.35	75.31	74.38	74.62	75.11	75.36	75.45	75.24	74.76	74.76	74.28
3 D a 2 b	Sewage sludge applied to soil	96.48	96.38	96.48	96.57	96.57	96.57	96.57	96.60	96.60	96.60	96.47	96.47	96.47	96.84	96.84
3 D a 2 c	Other organic fertilizers applied to soil	96.48	96.38	96.48	96.57	96.57	96.57	96.57	96.60	96.60	96.60	96.47	96.47	96.47	96.84	96.84
3 D a 3	Urine & dung deposited by grazing animals	91.08	91.17	90.93	90.80	90.43	90.53	90.18	90.15	91.20	91.17	90.97	90.99	90.91	90.87	91.97
3 D c	Farm level agricultural operations	96.48	96.38	96.48	96.57	96.57	96.57	96.57	96.60	96.60	96.60	96.47	96.47	96.47	96.84	96.84
3 D e	Cultivated crops	96.48	96.38	96.48	96.57	96.57	96.57	96.57	96.60	96.60	96.60	96.47	96.47	96.47	96.84	96.84
3D f	Use of pesticides	96.48	96.38	96.48	96.57	96.57	96.57	96.57	96.60	96.60	96.60	96.47	96.47	96.47	96.84	96.84
3 F	Field burning of agricultural residues	98.18	98.04	98.13	98.05	97.97	97.92	97.94	97.45	97.45	97.36	97.21	97.14	97.13	96.68	96.67

Annex E: Waste (NFR 5)

Updated: March 2022

Annex Table 1: National population, waste generation per capita, and municipal waste generation

Year	Population		Annual per capita generation rate		Pop. served by waste collection syst.	Municipal waste generation									
						TOTAL		*of which:*							
								Open dump sites		Managed landfills		Composting/Anaerobic digestion		Incinerated	
	National Total	Mainland	National Total	Mainland		National Total	Mainland	National Total	Mainland	National Total	Mainland	National Total	Mainland	National Total	Mainland
	inhabitants		kg/inh/year		% pop.	Kton									
1960	8,889,197	8,292,784	51.5	51.3	40	457.8	425.5	457.8	425.5	0.0	0.0	0.0	0.0	0.0	0.0
1961	8,861,388	8,271,002	54.4	54.2	41	482.4	448.5	482.4	448.5	0.0	0.0	0.0	0.0	0.0	0.0
1962	8,833,580	8,249,219	57.5	57.3	42	507.8	472.4	507.8	472.4	0.0	0.0	0.0	0.0	0.0	0.0
1963	8,805,771	8,227,437	60.7	60.4	44	534.1	497.1	534.1	497.1	0.0	0.0	0.0	0.0	0.0	0.0
1964	8,777,962	8,205,654	64.0	63.7	45	561.4	522.8	561.4	522.8	0.0	0.0	0.0	0.0	0.0	0.0
1965	8,750,154	8,183,872	67.4	67.1	46	589.6	549.4	589.6	549.4	0.0	0.0	0.0	0.0	0.0	0.0
1966	8,722,345	8,162,090	70.9	70.7	47	618.8	576.9	618.8	576.9	0.0	0.0	0.0	0.0	0.0	0.0
1967	8,694,536	8,140,307	74.7	74.4	48	649.1	605.4	649.1	605.4	0.0	0.0	0.0	0.0	0.0	0.0
1968	8,666,727	8,118,525	78.5	78.2	50	680.4	635.0	680.4	635.0	0.0	0.0	0.0	0.0	0.0	0.0
1969	8,638,919	8,096,742	82.5	82.2	51	712.8	665.6	712.8	665.6	0.0	0.0	0.0	0.0	0.0	0.0
1970	8,611,110	8,074,960	86.7	86.3	52	746.3	697.2	746.3	697.2	0.0	0.0	0.0	0.0	0.0	0.0
1971	8,722,192	8,189,669	91.1	90.8	53	794.5	743.3	794.5	743.3	0.0	0.0	0.0	0.0	0.0	0.0
1972	8,833,274	8,304,378	95.7	95.4	54	845.2	791.9	845.2	791.9	0.0	0.0	0.0	0.0	0.0	0.0
1973	8,944,357	8,419,087	100.5	100.1	56	898.5	842.9	898.5	842.9	0.0	0.0	0.0	0.0	0.0	0.0
1974	9,055,439	8,533,796	105.4	105.1	57	954.5	896.6	954.5	896.6	0.0	0.0	0.0	0.0	0.0	0.0
1975	9,166,521	8,648,505	110.5	110.2	58	1,013.4	953.1	1,013.4	953.1	0.0	0.0	0.0	0.0	0.0	0.0
1976	9,277,603	8,763,215	115.9	115.5	59	1,075.1	1,012.5	1,075.1	1,012.5	0.0	0.0	0.0	0.0	0.0	0.0
1977	9,388,685	8,877,924	121.4	121.1	60	1,140.0	1,074.9	1,140.0	1,074.9	0.0	0.0	0.0	0.0	0.0	0.0
1978	9,499,767	8,992,633	127.2	126.8	62	1,208.1	1,140.4	1,208.1	1,140.4	0.0	0.0	0.0	0.0	0.0	0.0
1979	9,610,850	9,107,342	133.1	132.8	63	1,279.5	1,209.2	1,279.5	1,209.2	0.0	0.0	0.0	0.0	0.0	0.0
1980	9,721,932	9,222,051	139.3	138.9	64	1,354.4	1,281.4	949.2	876.2	360.5	360.5	44.7	44.7	0.0	0.0
1981	9,833,014	9,336,760	148.7	148.3	66	1,462.0	1,384.7	1,021.1	943.8	396.2	396.2	44.7	44.7	0.0	0.0
1982	9,836,427	9,340,677	158.4	158.0	68	1,558.2	1,475.9	1,088.1	1,005.8	425.4	425.4	44.7	44.7	0.0	0.0
1983	9,839,841	9,344,593	168.6	168.2	71	1,658.9	1,571.5	1,158.2	1,070.8	456.0	456.0	44.7	44.7	0.0	0.0
1984	9,843,254	9,348,510	179.3	178.8	73	1,764.5	1,671.7	1,231.7	1,138.9	488.1	488.1	44.7	44.7	0.0	0.0
1985	9,846,667	9,352,426	190.4	190.0	75	1,875.0	1,776.6	1,308.6	1,210.2	521.7	521.7	44.7	44.7	0.0	0.0
1986	9,850,081	9,356,343	203.2	202.7	78	2,001.1	1,896.3	1,396.3	1,291.5	560.1	560.1	44.7	44.7	0.0	0.0
1987	9,853,494	9,360,260	216.5	216.0	80	2,133.2	2,021.7	1,488.2	1,376.7	600.3	600.3	44.7	44.7	0.0	0.0
1988	9,856,907	9,364,176	230.5	229.9	83	2,271.7	2,153.2	1,584.5	1,466.0	642.5	642.5	44.7	44.7	0.0	0.0
1989	9,860,320	9,368,093	245.1	244.5	85	2,416.8	2,290.9	1,685.4	1,559.5	686.7	686.7	44.7	44.7	0.0	0.0

(cont.)

Year	Population		Annual per capita generation rate		Pop. served by waste collection syst.	Municipal waste generation									
						TOTAL		*of which:* Open dump sites		Managed landfills		Composting/Anaerobic digestion		Incinerated	
	National Total	Mainland	National Total	Mainland		National Total	Mainland	National Total	Mainland	National Total	Mainland	National Total	Mainland	National Total	Mainland
	inhabitants		kg/inh/year		% pop.	kton									
1990	9,863,734	9,372,009	260.4	259.8	88	2,568.7	2,435.2	1,779.3	1,645.7	739.2	739.2	50.3	50.3	0.0	0.0
1991	9,867,147	9,375,926	272.7	272.1	89	2,690.9	2,551.3	1,734.5	1,594.9	906.1	906.1	50.3	50.3	0.0	0.0
1992	9,916,044	9,425,268	285.5	284.9	91	2,831.4	2,685.5	1,824.4	1,678.6	956.7	956.7	50.3	50.3	0.0	0.0
1993	9,964,941	9,474,609	298.9	298.3	92	2,978.4	2,826.1	1,918.6	1,766.3	1,009.6	1,009.6	50.3	50.3	0.0	0.0
1994	10,013,838	9,523,951	312.8	312.2	93	3,132.3	2,973.3	1,865.1	1,726.1	1,179.4	1,159.3	87.8	87.8	0.0	0.0
1995	10,062,735	9,573,293	332.0	331.7	95	3,341.2	3,175.2	1,982.4	1,837.7	1,248.5	1,227.2	110.4	110.4	0.0	0.0
1996	10,111,632	9,622,635	350.4	350.2	96	3,542.8	3,370.2	2,058.3	1,908.3	1,373.6	1,351.1	110.8	110.8	0.0	0.0
1997	10,160,529	9,671,976	368.9	369.0	97	3,748.6	3,569.1	2,038.6	1,883.1	1,596.1	1,572.2	113.8	113.8	0.0	0.0
1998	10,209,426	9,721,318	387.8	388.0	98	3,958.7	3,772.1	1,539.9	1,380.2	2,302.1	2,275.2	116.8	116.8	0.0	0.0
1999	10,258,323	9,770,660	425.3	425.3	99	4,363.2	4,155.8	975.1	905.8	2,736.9	2,626.7	114.9	100.4	346.4	346.4
2000	10,307,220	9,820,001	439.5	437.7	100	4,530.3	4,298.0	588.8	520.5	2,610.5	2,484.7	137.4	123.3	911.1	911.1
2001	10,356,117	9,869,343	446.0	421.9	100	4,618.5	4,164.3	460.1	445.0	2,912.1	2,700.9	139.2	126.7	891.7	891.6
2002	10,444,592	9,950,051	457.0	433.6	100	4,772.8	4,314.0	27.8	0.0	3,490.6	3,337.0	75.5	62.2	943.9	914.7
2003	10,473,050	9,975,209	464.6	438.5	100	4,865.7	4,374.3	25.9	0.0	3,367.4	3,248.4	232.5	232.5	1,003.4	893.3
2004	10,494,672	9,993,865	435.9	430.2	100	4,575.0	4,299.4	22.3	0.0	3,206.1	3,087.1	129.0	127.5	994.2	876.8
2005	10,511,988	10,008,242	436.3	431.1	100	4,586.4	4,314.7	0.0	0.0	3,128.4	2,998.7	130.7	129.5	1,057.0	937.1
2006	10,532,588	10,025,838	447.1	440.5	100	4,708.9	4,416.6	0.0	0.0	3,264.5	3,142.7	133.3	131.9	984.4	861.4
2007	10,553,339	10,043,520	455.4	454.3	100	4,806.4	4,563.2	0.0	0.0	3,233.3	3,113.7	143.5	142.3	954.5	832.1
2008	10,563,014	10,051,206	496.3	496.5	100	5,242.4	4,990.6	0.0	0.0	3,530.2	3,403.6	185.3	183.9	993.0	869.3
2009	10,573,479	10,059,864	497.2	495.2	100	5,256.9	4,981.4	0.0	0.0	3,351.1	3,200.7	216.2	214.8	1,082.6	958.9
2010	10,572,721	10,057,999	524.0	471.1	100	5,540.3	4,738.7	0.0	0.0	3,682.6	3,542.2	232.1	232.1	1,092.2	964.3
2011	10,542,398	10,030,968	497.0	496.5	100	5,239.6	4,980.0	0.0	0.0	3,395.3	3,255.0	244.1	244.1	1,131.5	1,012.2
2012	10,487,289	9,976,649	457.4	453.8	100	4,797.1	4,527.6	0.0	0.0	2,920.9	2,788.3	332.7	332.7	1,034.3	919.3
2013	10,427,301	9,918,548	441.9	439.8	100	4,607.4	4,362.4	0.0	0.0	2,601.9	2,491.3	349.7	343.9	1,117.8	1,019.5
2014	10,374,822	9,869,783	454.9	453.3	100	4,720.0	4,473.8	0.0	0.0	2,532.1	2,425.6	489.6	483.1	1,051.9	948.8
2015	10,341,330	9,839,140	459.1	457.9	100	4,747.2	4,505.8	0.0	0.0	2,429.0	2,335.9	390.8	377.4	1,129.2	1,020.7
2016	10,309,573	9,809,414	474.4	473.0	100	4,891.0	4,640.0	0.0	0.0	2,474.3	2,375.6	494.3	477.4	1,198.8	1,070.1
2017	10,291,027	9,792,797	486.5	483.5	100	5,006.5	4,735.1	0.0	0.0	2,775.2	2,672.4	360.0	339.9	1,183.3	1,034.8
2018	10,276,617	9,779,826	507.3	505.6	100	5,213.1	4,944.7	0.0	0.0	2,897.7	2,803.5	408.9	388.4	1,128.8	981.0
2019	10,295,909	9,798,859	513.0	511.0	100	5,281.4	5,006.8	0.0	0.0	2,915.3	2,816.8	490.8	468.3	1,190.2	1,040.4
2020	10,298,252	9,802,128	512.5	510.8	100	5,277.5	5,006.8	0.0	0.0	3,082.6	2,983.5	417.1	394.6	1,144.4	999.9

Notes:

Sources: INE; APA (include estimates); Quercus Study

Annex Table 2: Fermentable industrial waste disposal

Year	National Total			Mainland		Year	National Total			Mainland	
	Industrial SWDL	managed landfills		Industrial SWDL	managed landfills		Industrial SWDL	managed landfills		Industrial SWDL	managed landfills
	kton	%		kton	%		kton	%		kton	%
1960	254.2	0		236.2	0	1990	1,028.0	29		973.5	31
1961	263.3	0		244.8	0	1991	1,062.6	34		1006.4	36
1962	291.0	0		270.7	0	1992	1,095.9	34		1038.4	36
1963	302.1	0		281.2	0	1993	1,088.3	34		1031.7	36
1964	320.4	0		298.4	0	1994	1,104.5	39		1046.9	40
1965	350.6	0		326.7	0	1995	1,130.0	39		1072.0	40
1966	366.6	0		341.7	0	1996	1,169.6	40		1110.8	41
1967	381.8	0		356.1	0	1997	1,221.1	44		1160.8	46
1968	401.1	0		374.4	0	1998	1,279.8	60		1217.7	62
1969	410.9	0		383.7	0	1999	1,329.8	74		1265.5	74
1970	445.7	0		416.4	0	2000	1,137.8	82		1068.8	83
1971	492.5	0		460.8	0	2001	945.9	86		882.4	86
1972	543.6	0		509.3	0	2002	753.9	99		715.1	100
1973	570.4	0		535.1	0	2003	684.2	99		655.0	100
1974	587.0	0		551.4	0	2004	606.1	99		579.6	100
1975	557.1	0		524.0	0	2005	528.0	100		506.1	100
1976	569.8	0		536.6	0	2006	449.9	100		433.1	100
1977	604.1	0		569.6	0	2007	371.8	100		358.0	100
1978	641.4	0		605.4	0	2008	293.7	100		283.1	100
1979	686.9	0		649.2	0	2009	250.5	100		239.3	100
1980	719.6	28		679.5	29	2010	225.6	100		217.0	100
1981	735.3	28		695.2	30	2011	273.9	100		262.6	100
1982	751.2	28		710.4	30	2012	235.7	100		225.0	100
1983	758.5	28		717.4	30	2013	187.7	100		179.7	100
1984	750.6	28		710.1	30	2014	168.4	100		161.4	100
1985	762.9	29		721.8	30	2015	164.1	100		157.8	100
1986	788.2	29		746.0	30	2016	192.2	100		184.5	100
1987	848.3	29		803.0	30	2017	168.7	100		162.5	100
1988	893.6	29		846.1	30	2018	183.4	100		177.5	100
1989	953.1	29		902.5	31	2019	203.0	100		196.1	100
-	-	-		-	-	2020	195.7	100		189.4	100

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)

Annex Table 3: Quantities of waste incinerated

Year	Clinical waste quantities incinerated		Industrial solid waste incinerated		MSW quantities incinerated	
	National total	of which in Mainland	National total	of which in Mainland	National total	of which in Mainland
	kton	%	kton	%	kton	%
1990	*12.1*	100	*22*	*95*	-	-
1991	*12.1*	100	*23*	*95*	-	-
1992	*12.1*	100	*24*	*95*	-	-
1993	*12.1*	100	*23*	*95*	-	-
1994	*12.1*	100	*24*	*95*	-	-
1995	12.1	100	*24*	*95*	-	-
1996	13.5	100	*25*	*95*	-	-
1997	15.7	100	*26*	*95*	-	-
1998	11.8	100	*28*	*95*	-	-
1999	10.4	100	29	*95*	346	100
2000	7.1	100	*32*	*94*	911	100
2001	3.2	100	*34*	*93*	892	100
2002	2.8	100	37	*95*	944	97
2003	2.3	100	47	*96*	1003	89
2004	*1.8*	100	48	*96*	994	88
2005	*1.2*	100	48	*96*	1057	89
2006	0.7	100	48	*96*	984	88
2007	2.8	100	48	*96*	955	87
2008	3.2	100	49	*96*	993	88
2009	3.2	100	30	*95*	1083	89
2010	3.8	100	21	*96*	1092	88
2011	1.9	100	24	*96*	1132	89
2012	1.3	100	31	*95*	1034	89
2013	1.1	100	20	*96*	1118	91
2014	0.9	100	22	*96*	1052	90
2015	0.6	100	19	*96*	1129	90
2016	1.2	100	22	96	1199	89
2017	1.3	100	27	96	1183	87
2018	5.2	100	25	97	1129	87
2019	5.8	100	26	97	1190	87
2020	*7.6*	100	26	97	1144	87

Note: Estimates in italics. Clinical data for 2020 are still not available; data refer to estimates assuming a 30% increase of clinical waste due to the Covid19 pandemic.
Sources: APA; DGS

Annex F: Information on inclusion/exclusion of the condensable component from PM_{10} and $PM_{2.5}$ emission factors

Updated: March 2022

Table F-1: Inclusion/exclusion of the condensable component from PM_{10} and $PM_{2.5}$ emission factors

NFR Code	Source/Sector name	PM emissions: the condensable component is		EF reference and comments
		included	excluded	
1A1a	Public electricity and heat production	unknown	unknown	Monitoring data from Plants (Gravimetric method - EN 13284-1)
1A1b	Petroleum refining		✓	EMEP/EEA Guidebook 2019
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	unclear	unclear	EMEP/EEA Guidebook 2019
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	unknown	unknown	Monitoring data from Plants (Gravimetric method - EN 13284-1)
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	unclear	unclear	EMEP/EEA Guidebook 2019
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	unclear	unclear	EMEP/EEA Guidebook 2019
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	unclear	unclear	EMEP/EEA Guidebook 2019
1A3ai(i)	International aviation LTO (civil)	unknown	unknown	ICAO Emission Factor Databank
1A3aii(i)	Domestic aviation LTO (civil)	unknown	unknown	ICAO Emission Factor Databank
1A3bi	Road transport: Passenger cars	✓		COPERT V
1A3bii	Road transport: Light duty vehicles	✓		COPERT V
1A3biii	Road transport: Heavy duty vehicles and buses	✓		COPERT V
1A3biv	Road transport: Mopeds & motorcycles	✓		COPERT V
1A3bvi	Road transport: Automobile tyre and brake wear	✓		COPERT V
1A3bvii	Road transport: Automobile road abrasion	✓		COPERT V
1A3c	Railways	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
1A3dii	National navigation (shipping)	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
1A4ai	Commercial/institutional: Stationary	✓		EMEP/EEA Guidebook 2019
1A4bi	Residential: Stationary	✓		EMEP/EEA Guidebook 2019
1A4ci	Agriculture/Forestry/Fishing: Stationary	✓		EMEP/EEA Guidebook 2019
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	✓		EMEP/EEA Guidebook 2019
1A4ciii	Agriculture/Forestry/Fishing: National fishing	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
1B2aiv	Fugitive emissions oil: Refining / storage	not mentioned	not mentioned	EMEP/EEA Guidebook 2019

NFR Code	Source/Sector name	PM emissions: the condensable component is		EF reference and comments
		included	excluded	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	unknown	unknown	Concawe - Air pollutant emission estimation methods for E-PRTR
2A1	Cement production	unknown	unknown	Monitoring data from Plants (Gravimetric method - EN 13284-1)
2A2	Lime production	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
2A3	Glass production	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
2A5a	Quarrying and mining of minerals other than coal	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
2A5b	Construction and demolition	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
2A5c	Storage, handling and transport of mineral products	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
2B6	Titanium dioxide production	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
2B10a	Chemical industry: Other (please specify in the IIR)	not mentioned	not mentioned	USEPA AP-42; EMEP/EEA Guidebook 2019; Plant specific monitoring data
2C1	Iron and steel production		✓	EMEP/EEA Guidebook 2019
2C3	Aluminium production		✓	EMEP/EEA Guidebook 2019
2C5	Lead production		✓	EMEP/EEA Guidebook 2019
2C7a	Copper production		✓	EMEP/EEA Guidebook 2019
2C7d	Storage, handling and transport of metal products (please specify in the IIR)	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
2D3b	Road paving with asphalt		✓	EMEP/EEA Guidebook 2019
2D3c	Asphalt roofing	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
2D3g	Chemical products	unknown	unknown	USEPA AP-42; EMEP/EEA Guidebook 2019
2D3i	Other solvent use (please specify in the IIR)	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
2G	Other product use (please specify in the IIR)	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
2H1	Pulp and paper industry	unknown	unknown	Monitoring data from Plants (Gravimetric method - EN 13284-1)
3B1a	Manure management - Dairy cattle	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
3B1b	Manure management - Non-dairy cattle	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
3B2	Manure management - Sheep	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
3B3	Manure management - Swine	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
3B4d	Manure management - Goats	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
3B4e	Manure management - Horses	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
3B4f	Manure management - Mules and asses	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
3B4gi	Manure mangement - Laying hens	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
3B4gii	Manure mangement - Broilers	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
3B4giii	Manure mangement - Turkeys	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
3B4giv	Manure management - Other poultry	not mentioned	not mentioned	EMEP/EEA Guidebook 2019

NFR Code	Source/Sector name	PM emissions: the condensable component is		EF reference and comments
		included	excluded	
3B4h	Manure management - Other animals (please specify in IIR)	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
3F	Field burning of agricultural residues	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
5A	Biological treatment of waste - Solid waste disposal on land	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
5C1bi	Industrial waste incineration	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
5C1biii	Clinical waste incineration	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
5C1bv	Cremation	not mentioned	not mentioned	EMEP/EEA Guidebook 2019
5E	Other waste (please specify in IIR)	not mentioned	not mentioned	Aasestad (2007)

Annex G: Uncertainty Analysis

Updated: April 2022

G.1 Methodology

G.1.1 Qualitative assessment

A qualitative assessment was performed on sectoral level for all pollutants. The relevant sectors of each pollutant were classified in different quality groups from A to E (see Table 1.2) following the EMEP/EEA air pollutant emission inventory guidebook 2019 (EEA 2019). Table G-1 presents a definition and default error ranges for each quality group.

Table G-1: Emission quality data ratings and calculated uncertainties by main NFR source categories

NFR	Description	NOx (as NO_2)	NMVOC	SOx (as SO_2)	NH3	PM2.5
1A1a	Public electricity and heat production	A	C	A	E	C
1A1b	Petroleum refining	B	C	A	-	C
1A2*	Stationary combustion	B	C	A	E	C
1A2*	Mobile Combustion	B	C	A	E	C
1A3a	Civil Aviation	D	D	B	-	D
1A3b	Road transport	C	C	A	E	C
1A3c	Railways	D	D	B	E	D
1A3d	National navigation	D	D	B	-	D
1A4a	Commercial/institutional	C	C	A	E	D
1A4b	Residential	C	C	A	E	D
1A4c	Agriculture/Forestry/Fishing	C	C	A	E	D
1A5	Other	D	D	B	-	D
1B2	Fugitive emissions from energy production	C	C	C	E	D
2A	Mineral Products	-	C	-	C	C
2B	Chemical industry	B/C	C	C	B/C	C
2C	Metal production	C	C	C	-	C
2D	Solvent Use	-	B/C	-	C	C
2G	Other product manufacture and use	C	C	C	C	C
2H	Other Processes	C	C	B	-	C
3B	Manure management	D	D	-	D	E
3D	Agricultural Soils	D	D	-	D	E
3F	Field burning of agricultural residues	D	D	D	D	E
5A	Solid waste disposal on land	**Calc**	**Calc**	**Calc**	**Calc**	**Calc**
5B	Biological treatment of waste	-	-	-	**Calc**	-
5C	Waste incineration	**Calc**	**Calc**	**Calc**	**Calc**	**Calc**
5D	Wastewater handling	-	**Calc**	-	-	-
5E	Other waste	-	-	-	-	**Calc**

G.1.2 Quantitative uncertainty assessment

G.1.2.1 Waste sector

The uncertainty of activity data for solid waste disposed on land result from the combined uncertainty of municipal and industrial solid waste. 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 considering AD = MSWT (Total Municipal Solid Waste produced) * MSWF (Fraction of MSWT sent to SWDS), applying the proposed values from IPCC 2006. A combined uncertainty of 14% was estimated for the quantities disposed in managed SWDS in 2020. The uncertainty of activity data for the calculation of emissions from Industrial Waste Production is consider to have a lower accuracy than MSW; the uncertainty considered in 2020 for the deposition on land of industrial solid wastes was about 18%.

Composting and anaerobic digestion refer to municipal waste and the same level of uncertainty (14% in 2020) was estimated as for the quantities disposed in managed SWDS.

For industrial incineration (without energy recovery) an uncertainty of 20% was estimated for the activity data 2020.

For healthcare waste an uncertainty of 20% for 2020 AD (higher than previous years) was considered, since 2020 data are still based on assumptions (30% increase due to Covid-19).

The uncertainty of the number of human cremations (non-official data) has been set to 5%, in particular de more recent years which are based on estimates.

For domestic waste water handling the activity data, expressed in human water consumption, was estimated from population and an average daily human water consumption. Assuming a 5% for human population and 5% for water consumption, a final 7% error was set.

In the case of industrial waste-water systems, the uncertainty value was estimated for each industrial sector separately combining the uncertainty of average water consumption by unit produced and the uncertainty in the production activity data, assuming an uncertainty of production data of 20% if data was obtained from National Statistics and 50% if it was interpolated. The uncertainty related to water consumption by sector was considered as 50%, since they refer to an ancient data source (Cartaxo et al, 1985).

The total number of accidental fires refer to official sources, but there is great uncertainty about the magnitude of the fires. The uncertainty considered has been set to 25%.

Table G-2: Uncertainties for activity data in the waste sector

NFR	Description	Activity data uncertainty (%)
5A	Biological treatment of waste - Solid waste disposal on land	13
5B1	Biological treatment of waste - Composting	14
5B2	Biological treatment of waste - AD	14
5C1bi	Industrial waste incineration	20
5C1biii	Clinical waste incineration	20
5C1bv	Cremation	5
5D1	Domestic wastewater handling	7
5D2	Industrial wastewater handling	34
5E	Other Waste: car and house fires	25

Table G-3: Estimated uncertainty rates for emission factors

NFR	Description	NOx (%)	NMVOC (%)	SOx (%)	NH3 (%)	PM2.5 (%)
5A	Biological treatment of waste - Solid waste disposal on land	39	60	40	60	242
5B1	Biological treatment of waste - Composting	-	-	-	126	-
5B2	Biological treatment of waste - AD	-	-	-	89	-
5C1bi	Industrial waste incineration	495	495	495	-	1245
5C1biii	Clinical waste incineration	55	79	37	200	1000
5C1bv	Cremation	495	495	495	-	495
5D1	Domestic wastewater handling	-	150	-	-	-
5D2	Industrial wastewater handling	-	150	-	-	-
5E	Other Waste: car and house fires	-	-	-	-	87

G.2 Detailed Results

Table G-4: Uncertainty estimation of NOx emissions 1990 and 2020

Pollutant	NFR	Base year emissions (ton)	Year 2020 emissions (ton)	AD uncertainty (%)	EF uncertainty (%)	Combined uncertainty_ 1 (%)	Combined uncertainty_ 2 (%)	Type A Sensitivity (%)	Type B Sensitivity (%)	Unc introduced by EF Unc	Unc introduced by AD Unc	Uncertainty introduced
NOx	1A1a	78.02	6.12	1%	20%	20%	0.01%	13.07%	2.48%	2.61%	0.04%	0.07%
NOx	1A1b	2.80	2.92	1%	40%	40%	0.01%	0.62%	1.18%	0.25%	0.02%	0.00%
NOx	1A2a	0.91	0.13	2%	40%	40%	0.00%	0.13%	0.05%	0.05%	0.00%	0.00%
NOx	1A2c	2.24	1.65	2%	40%	40%	0.00%	0.22%	0.67%	0.09%	0.02%	0.00%
NOx	1A2d	3.10	5.33	2%	40%	40%	0.03%	1.54%	2.16%	0.62%	0.06%	0.00%
NOx	1A2e	1.90	1.30	5%	40%	40%	0.00%	0.15%	0.53%	0.06%	0.04%	0.00%
NOx	1A2f	15.13	15.38	2%	40%	40%	0.26%	3.21%	6.23%	1.28%	0.18%	0.02%
NOx	1A2gvii	2.71	2.00	10%	40%	41%	0.00%	0.27%	0.81%	0.11%	0.11%	0.00%
NOx	1A2gviii	5.39	4.19	5%	40%	40%	0.02%	0.62%	1.70%	0.25%	0.12%	0.00%
NOx	1A3ai(i)	1.15	1.47	2%	200%	200%	0.06%	0.37%	0.60%	0.73%	0.02%	0.01%
NOx	1A3aii(i)	0.31	0.27	2%	200%	200%	0.00%	0.05%	0.11%	0.09%	0.00%	0.00%
NOx	1A3bi	37.63	22.66	2%	125%	125%	5.41%	1.66%	9.18%	2.07%	0.26%	0.04%
NOx	1A3bii	13.73	14.58	2%	125%	125%	2.24%	3.16%	5.91%	3.95%	0.17%	0.16%
NOx	1A3biii	42.25	12.83	2%	125%	125%	1.74%	3.24%	5.20%	4.05%	0.15%	0.16%
NOx	1A3biv	0.30	0.16	2%	125%	125%	0.00%	0.00%	0.06%	0.00%	0.00%	0.00%
NOx	1A3c	2.94	0.46	2%	200%	200%	0.01%	0.40%	0.18%	0.81%	0.01%	0.01%
NOx	1A3dii	4.11	2.63	2%	200%	200%	0.19%	0.24%	1.06%	0.49%	0.03%	0.00%
NOx	1A4ai	0.87	0.94	10%	125%	125%	0.01%	0.21%	0.38%	0.26%	0.05%	0.00%
NOx	1A4aii	0.01	0.00	25%	125%	127%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NOx	1A4bi	4.06	3.37	10%	125%	125%	0.12%	0.55%	1.37%	0.69%	0.19%	0.01%
NOx	1A4bii	0.01	0.00	25%	125%	127%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NOx	1A4ci	0.87	1.59	10%	125%	125%	0.03%	0.47%	0.64%	0.59%	0.09%	0.00%
NOx	1A4cii	3.21	1.83	10%	125%	125%	0.04%	0.10%	0.74%	0.12%	0.10%	0.00%
NOx	1A4ciii	7.00	2.86	10%	125%	125%	0.09%	0.24%	1.16%	0.30%	0.16%	0.00%
NOx	1A5b	0.16	0.11	10%	200%	200%	0.00%	0.01%	0.04%	0.03%	0.01%	0.00%
NOx	1B2aiv	NE	0.16	1%	125%	125%	0.00%	--	--	--	--	--

Pollutant	NFR	Base year emissions (ton)	Year 2020 emissions (ton)	AD uncertainty (%)	EF uncertainty (%)	Combined uncertainty_ 1 (%)	Combined uncertainty_ 2 (%)	Type A Sensitivity (%)	Type B Sensitivity (%)	Unc introduced by EF Unc	Unc introduced by AD Unc	Uncertainty introduced
NOx	1B2c	0.27	0.62	1%	125%	125%	0.00%	0.20%	0.25%	0.25%	0.00%	0.00%
NOx	2B2	0.25	0.12	1%	40%	40%	0.00%	0.00%	0.05%	0.00%	0.00%	0.00%
NOx	2B10a	0.13	0.28	20%	125%	127%	0.00%	0.09%	0.11%	0.11%	0.03%	0.00%
NOx	2C1	0.06	0.29	1%	125%	125%	0.00%	0.10%	0.12%	0.13%	0.00%	0.00%
NOx	2G	0.01	0.03	20%	125%	127%	0.00%	0.01%	0.01%	0.01%	0.00%	0.00%
NOx	2H1	2.50	5.05	10%	125%	125%	0.27%	1.55%	2.05%	1.94%	0.29%	0.04%
NOx	3B1a	0.10	0.04	1%	200%	200%	0.00%	0.00%	0.02%	0.00%	0.00%	0.00%
NOx	3B1b	0.12	0.09	1%	200%	200%	0.00%	0.01%	0.04%	0.03%	0.00%	0.00%
NOx	3B2	0.06	0.02	1%	200%	200%	0.00%	0.00%	0.01%	0.01%	0.00%	0.00%
NOx	3B3	0.01	0.01	1%	200%	200%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NOx	3B4d	0.01	0.00	1%	200%	200%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NOx	3B4e	0.00	0.00	1%	200%	200%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NOx	3B4f	0.02	0.00	1%	200%	200%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%
NOx	3B4gi	0.13	0.18	1%	200%	200%	0.00%	0.05%	0.07%	0.09%	0.00%	0.00%
NOx	3B4gii	0.15	0.25	1%	200%	200%	0.00%	0.07%	0.10%	0.15%	0.00%	0.00%
NOx	3B4giii	0.02	0.04	1%	200%	200%	0.00%	0.01%	0.01%	0.02%	0.00%	0.00%
NOx	3B4giv	0.01	0.02	1%	200%	200%	0.00%	0.01%	0.01%	0.01%	0.00%	0.00%
NOx	3B4h	0.05	0.02	1%	200%	200%	0.00%	0.00%	0.01%	0.01%	0.00%	0.00%
NOx	3Da1	6.14	4.08	1%	200%	200%	0.45%	0.43%	1.65%	0.85%	0.02%	0.01%
NOx	3Da2a	1.68	1.12	1%	200%	200%	0.03%	0.12%	0.45%	0.23%	0.01%	0.00%
NOx	3Da2b	0.01	0.02	1%	200%	200%	0.00%	0.01%	0.01%	0.02%	0.00%	0.00%
NOx	3Da2c	NA	0.05	1%	200%	200%	0.00%	--	--	--	--	--
NOx	3Da3	2.43	3.56	1%	200%	200%	0.34%	0.96%	1.44%	1.92%	0.02%	0.04%
NOx	3F	1.16	0.87	1%	200%	200%	0.02%	0.12%	0.35%	0.24%	0.00%	0.00%
NOx	5A	NA	0.00	13%	39%	41%	0.00%	--	--	--	--	--
NOx	5C1bi	0.02	0.02	20%	495%	495%	0.00%	0.01%	0.01%	0.03%	0.00%	0.00%
NOx	5C1biii	0.02	0.01	20%	55%	58%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
NOx	5C1bv	0.00	0.02	5%	495%	495%	0.00%	0.01%	0.01%	0.04%	0.00%	0.00%
NOx	**TOTAL**	**246.80**	**121.75**	**1%**	**34%**	**34%**	**11.38%**	**-**	**-**	**-**	**-**	**0.56%**

Table G-5: Uncertainty estimation of NMVOCs emissions 1990 and 2020

Pollutant	NFR	Base year emissions (ton)	Year 2020 emissions (ton)	AD uncertainty (%)	EF uncertainty (%)	Combined uncertainty_1 (%)	Combined uncertainty_2 (%)	Type A Sensitivity (%)	Type B Sensitivity (%)	Unc introduced by EF Unc	Unc introduced by AD Unc	Uncertainty introduced
NMVOC	1A1a	0.36	1.65	1%	125%	125%	0.02%	0.59%	0.68%	0.74%	0.01%	0.01%
NMVOC	1A1b	0.06	0.09	1%	125%	125%	0.00%	0.02%	0.04%	0.03%	0.00%	0.00%
NMVOC	1A2a	0.04	0.04	2%	125%	125%	0.00%	0.01%	0.02%	0.01%	0.00%	0.00%
NMVOC	1A2c	0.33	0.07	2%	125%	125%	0.00%	0.06%	0.03%	0.07%	0.00%	0.00%
NMVOC	1A2d	1.30	2.50	2%	125%	125%	0.04%	0.69%	1.03%	0.87%	0.03%	0.01%
NMVOC	1A2e	0.80	0.25	5%	125%	125%	0.00%	0.11%	0.10%	0.13%	0.01%	0.00%
NMVOC	1A2f	3.14	8.24	2%	125%	125%	0.46%	2.59%	3.41%	3.24%	0.10%	0.10%
NMVOC	1A2gvii	0.25	0.18	10%	125%	125%	0.00%	0.01%	0.08%	0.01%	0.01%	0.00%
NMVOC	1A2gviii	0.96	0.73	5%	125%	125%	0.00%	0.05%	0.30%	0.06%	0.02%	0.00%
NMVOC	1A3ai(i)	0.78	0.17	2%	200%	200%	0.00%	0.13%	0.07%	0.27%	0.00%	0.00%
NMVOC	1A3aii(i)	0.16	0.03	2%	200%	200%	0.00%	0.03%	0.01%	0.06%	0.00%	0.00%
NMVOC	1A3bi	41.09	3.54	2%	125%	125%	0.08%	9.27%	1.47%	11.59%	0.04%	1.34%
NMVOC	1A3bii	2.46	0.91	2%	125%	125%	0.01%	0.27%	0.38%	0.33%	0.01%	0.00%
NMVOC	1A3biii	3.72	0.44	2%	125%	125%	0.00%	0.79%	0.18%	0.99%	0.01%	0.01%
NMVOC	1A3biv	28.27	2.04	2%	125%	125%	0.03%	6.55%	0.85%	8.18%	0.02%	0.67%
NMVOC	1A3bv	16.54	4.48	2%	125%	125%	0.14%	2.47%	1.86%	3.09%	0.05%	0.10%
NMVOC	1A3c	0.26	0.04	2%	200%	200%	0.00%	0.05%	0.02%	0.10%	0.00%	0.00%
NMVOC	1A3dii	0.14	0.11	2%	200%	200%	0.00%	0.01%	0.04%	0.02%	0.00%	0.00%
NMVOC	1A4ai	0.12	0.12	10%	125%	125%	0.00%	0.02%	0.05%	0.02%	0.01%	0.00%
NMVOC	1A4aii	0.03	0.00	25%	125%	127%	0.00%	0.01%	0.00%	0.01%	0.00%	0.00%
NMVOC	1A4bi	29.16	13.98	10%	125%	125%	1.32%	1.84%	5.79%	2.30%	0.82%	0.06%
NMVOC	1A4bii	0.99	0.01	25%	125%	127%	0.00%	0.25%	0.00%	0.32%	0.00%	0.00%
NMVOC	1A4ci	0.06	0.11	10%	125%	125%	0.00%	0.03%	0.05%	0.04%	0.01%	0.00%
NMVOC	1A4cii	0.38	0.51	10%	125%	125%	0.00%	0.11%	0.21%	0.14%	0.03%	0.00%
NMVOC	1A4ciii	0.29	0.14	10%	125%	125%	0.00%	0.02%	0.06%	0.02%	0.01%	0.00%
NMVOC	1A5b	0.03	0.02	1%	200%	200%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
NMVOC	1B2ai	2.09	2.16	1%	125%	125%	0.03%	0.35%	0.90%	0.44%	0.01%	0.00%

Pollutant	NFR	Base year emissions (ton)	Year 2020 emissions (ton)	AD uncertainty (%)	EF uncertainty (%)	Combined uncertainty_1 (%)	Combined uncertainty_2 (%)	Type A Sensitivity (%)	Type B Sensitivity (%)	Unc introduced by EF Unc	Unc introduced by AD Unc	Uncertainty introduced
NMVOC	1B2aiv	1.43	1.48	1%	125%	125%	0.01%	0.24%	0.61%	0.30%	0.01%	0.00%
NMVOC	1B2av	4.63	3.70	1%	125%	125%	0.09%	0.32%	1.53%	0.40%	0.02%	0.00%
NMVOC	1B2b	NE	0.00	5%	125%	125%	0.00%	--	--	--	--	--
NMVOC	1B2c	0.05	0.13	1%	125%	125%	0.00%	0.04%	0.05%	0.05%	0.00%	0.00%
NMVOC	2A3	IE	0.00	1%	125%	125%	0.00%	--	--	--	--	--
NMVOC	2B10a	1.41	1.85	20%	150%	151%	0.03%	0.40%	0.77%	0.60%	0.22%	0.00%
NMVOC	2C1	0.07	0.10	1%	125%	125%	0.00%	0.02%	0.04%	0.03%	0.00%	0.00%
NMVOC	2D3a	10.63	25.72	20%	20%	28%	0.23%	7.87%	10.66%	1.57%	3.02%	0.12%
NMVOC	2D3b	0.12	0.00	20%	125%	127%	0.00%	0.03%	0.00%	0.04%	0.00%	0.00%
NMVOC	2D3c	0.01	0.01	20%	150%	151%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NMVOC	2D3d	34.07	17.48	20%	125%	127%	2.11%	1.67%	7.25%	2.09%	2.05%	0.09%
NMVOC	2D3e	4.05	0.71	20%	20%	28%	0.00%	0.77%	0.29%	0.15%	0.08%	0.00%
NMVOC	2D3f	1.59	0.22	20%	150%	151%	0.00%	0.33%	0.09%	0.49%	0.03%	0.00%
NMVOC	2D3g	12.19	17.78	20%	150%	151%	3.12%	4.18%	7.37%	6.27%	2.09%	0.44%
NMVOC	2D3h	1.89	0.59	20%	125%	127%	0.00%	0.25%	0.25%	0.31%	0.07%	0.00%
NMVOC	2D3i	5.67	9.51	20%	125%	127%	0.62%	2.46%	3.94%	3.07%	1.11%	0.11%
NMVOC	2G	3.13	2.25	20%	125%	127%	0.03%	0.11%	0.93%	0.14%	0.26%	0.00%
NMVOC	2H1	4.07	7.80	10%	125%	125%	0.41%	2.17%	3.23%	2.71%	0.46%	0.08%
NMVOC	2H2	1.35	1.86	20%	125%	127%	0.02%	0.42%	0.77%	0.52%	0.22%	0.00%
NMVOC	3B1a	2.96	1.57	1%	200%	200%	0.04%	0.12%	0.65%	0.25%	0.01%	0.00%
NMVOC	3B1b	2.89	1.42	1%	200%	200%	0.03%	0.17%	0.59%	0.34%	0.01%	0.00%
NMVOC	3B2	0.39	0.12	1%	200%	200%	0.00%	0.05%	0.05%	0.10%	0.00%	0.00%
NMVOC	3B3	1.03	0.75	1%	200%	200%	0.01%	0.04%	0.31%	0.08%	0.00%	0.00%
NMVOC	3B4d	0.09	0.02	1%	200%	200%	0.00%	0.01%	0.01%	0.03%	0.00%	0.00%
NMVOC	3B4e	0.03	0.01	1%	200%	200%	0.00%	0.01%	0.00%	0.01%	0.00%	0.00%
NMVOC	3B4f	0.07	0.00	1%	200%	200%	0.00%	0.02%	0.00%	0.04%	0.00%	0.00%
NMVOC	3B4gi	1.19	1.61	1%	200%	200%	0.04%	0.36%	0.67%	0.72%	0.01%	0.01%
NMVOC	3B4gii	2.27	3.93	1%	200%	200%	0.27%	1.03%	1.63%	2.07%	0.02%	0.04%

Pollutant	NFR	Base year emissions (ton)	Year 2020 emissions (ton)	AD uncertainty (%)	EF uncertainty (%)	Combined uncertainty_1 (%)	Combined uncertainty_2 (%)	Type A Sensitivity (%)	Type B Sensitivity (%)	Unc introduced by EF Unc	Unc introduced by AD Unc	Uncertainty introduced
NMVOC	3B4giii	0.28	0.42	1%	200%	200%	0.00%	0.10%	0.17%	0.20%	0.00%	0.00%
NMVOC	3B4giv	0.17	0.34	1%	200%	200%	0.00%	0.10%	0.14%	0.20%	0.00%	0.00%
NMVOC	3B4h	0.08	0.03	1%	200%	200%	0.00%	0.01%	0.01%	0.02%	0.00%	0.00%
NMVOC	3Da2a	4.04	3.25	1%	200%	200%	0.18%	0.29%	1.35%	0.58%	0.02%	0.00%
NMVOC	3Da3	0.39	0.55	1%	200%	200%	0.01%	0.13%	0.23%	0.25%	0.00%	0.00%
NMVOC	3De	0.87	0.26	1%	200%	200%	0.00%	0.12%	0.11%	0.24%	0.00%	0.00%
NMVOC	3F	2.98	2.41	1%	200%	200%	0.10%	0.22%	1.00%	0.44%	0.01%	0.00%
NMVOC	5A	0.94	1.74	13%	60%	61%	0.00%	0.47%	0.72%	0.28%	0.13%	0.00%
NMVOC	5C1bi	0.16	0.19	20%	495%	495%	0.00%	0.04%	0.08%	0.18%	0.02%	0.00%
NMVOC	5C1biii	0.01	0.01	20%	79%	81%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NMVOC	5C1bv	0.00	0.00	5%	495%	495%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NMVOC	5D1	0.01	0.01	7%	150%	150%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NMVOC	5D2	0.01	0.01	34%	150%	154%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NMVOC	**TOTAL**	**241.25**	**152.40**	**5%**	**30%**	**31%**	**9.53%**	-	-	-	-	**3.19%**

Table G-6: Uncertainty estimation of SO_2 emissions 1990 and 2020

Pollutant	NFR	Base year emissions (ton)	Year 2020 emissions (ton)	AD uncertainty (%)	EF uncertainty (%)	Combined uncertainty_1 (%)	Combined uncertainty_2 (%)	Type A Sensitivity (%)	Type B Sensitivity (%)	Unc introduced by EF Unc	Unc introduced by AD Unc	Uncertainty introduced
SO2	1A1a	174.63	0.85	1%	20%	20%	0.00%	4.66%	0.28%	0.93%	0.00%	0.01%
SO2	1A1b	18.80	0.27	1%	20%	20%	0.00%	0.45%	0.09%	0.09%	0.00%	0.00%
SO2	1A2a	0.23	0.00	2%	20%	20%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%
SO2	1A2c	14.19	0.21	2%	20%	20%	0.00%	0.34%	0.07%	0.07%	0.00%	0.00%
SO2	1A2d	16.64	9.31	2%	20%	20%	0.47%	2.53%	3.01%	0.51%	0.09%	0.00%
SO2	1A2e	12.99	0.69	5%	20%	21%	0.00%	0.15%	0.22%	0.03%	0.02%	0.00%
SO2	1A2f	8.04	5.47	2%	20%	20%	0.16%	1.54%	1.77%	0.31%	0.05%	0.00%
SO2	1A2gvii	0.44	0.00	10%	20%	22%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%
SO2	1A2gviii	26.05	0.65	5%	20%	21%	0.00%	0.53%	0.21%	0.11%	0.01%	0.00%
SO2	1A3ai(i)	0.03	0.04	2%	40%	40%	0.00%	0.01%	0.01%	0.01%	0.00%	0.00%
SO2	1A3aii(i)	0.01	0.01	2%	40%	40%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
SO2	1A3bi	3.26	0.05	2%	20%	20%	0.00%	0.08%	0.02%	0.02%	0.00%	0.00%
SO2	1A3bii	3.38	0.02	2%	20%	20%	0.00%	0.09%	0.01%	0.02%	0.00%	0.00%
SO2	1A3biii	6.31	0.01	2%	20%	20%	0.00%	0.17%	0.00%	0.03%	0.00%	0.00%
SO2	1A3biv	0.20	0.00	2%	20%	20%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%
SO2	1A3c	0.34	0.00	2%	40%	40%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%
SO2	1A3dii	2.16	0.88	2%	40%	40%	0.02%	0.22%	0.28%	0.09%	0.01%	0.00%
SO2	1A4ai	4.62	0.21	10%	20%	22%	0.00%	0.06%	0.07%	0.01%	0.01%	0.00%
SO2	1A4aii	0.01	0.00	25%	20%	32%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
SO2	1A4bi	0.77	0.37	10%	20%	22%	0.00%	0.10%	0.12%	0.02%	0.02%	0.00%
SO2	1A4bii	0.01	0.00	25%	20%	32%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
SO2	1A4ci	1.48	0.14	10%	20%	22%	0.00%	0.00%	0.05%	0.00%	0.01%	0.00%
SO2	1A4cii	0.01	0.00	10%	20%	22%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
SO2	1A4ciii	0.63	0.00	10%	20%	22%	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%
SO2	1A5b	0.01	0.01	1%	40%	40%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
SO2	1B2aiv	0.34	2.64	1%	125%	125%	1.46%	0.84%	0.85%	1.05%	0.01%	0.01%
SO2	1B2c	0.15	0.04	1%	125%	125%	0.00%	0.01%	0.01%	0.01%	0.00%	0.00%

Pollutant	NFR	Base year emissions (ton)	Year 2020 emissions (ton)	AD uncertainty (%)	EF uncertainty (%)	Combined uncertainty_1 (%)	Combined uncertainty_2 (%)	Type A Sensitivity (%)	Type B Sensitivity (%)	Unc introduced by EF Unc	Unc introduced by AD Unc	Uncertainty introduced
SO2	2B6	NO	0.00	20%	125%	127%	0.00%	--	--	--	--	--
SO2	2B10a	7.96	0.91	20%	150%	151%	0.25%	0.07%	0.29%	0.10%	0.08%	0.00%
SO2	2C1	0.02	0.13	1%	125%	125%	0.00%	0.04%	0.04%	0.05%	0.00%	0.00%
SO2	2C5	0.06	0.14	20%	150%	151%	0.01%	0.04%	0.04%	0.06%	0.01%	0.00%
SO2	2C7a	0.00	0.00	20%	150%	151%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
SO2	2G	0.00	0.00	20%	125%	127%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
SO2	2H1	4.55	4.05	1%	40%	40%	0.35%	1.18%	1.31%	0.47%	0.02%	0.00%
SO2	3F	0.18	0.14	1%	200%	200%	0.01%	0.04%	0.04%	0.08%	0.00%	0.00%
SO2	5A	NA	0.00	13%	40%	42%	0.00%	--	--	--	--	--
SO2	5C1bi	0.00	0.00	20%	495%	495%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
SO2	5C1biii	0.01	0.00	20%	37%	42%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
SO2	5C1bv	0.00	0.00	5%	495%	495%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
SO2	**TOTAL**	**309.52**	**27.24**	**1%**	**17%**	**17%**	**2.76%**	**-**	**-**	**-**	**-**	**0.03%**

Table G-7: Uncertainty estimation of NH_3 emissions 1990 and 2020

Pollutant	NFR	Base year emissions (ton)	Year 2020 emissions (ton)	AD uncertainty (%)	EF uncertainty (%)	Combined uncertainty_1 (%)	Combined uncertainty_2 (%)	Type A Sensitivity (%)	Type B Sensitivity (%)	Unc introduced by EF Unc	Unc introduced by AD Unc	Uncertainty introduced
NH3	1A1a	NE	0.01	1%	1000%	1000%	0.00%	--	--	--	--	--
NH3	1A2c	0.04	0.01	2%	1000%	1000%	0.00%	0.03%	0.01%	0.33%	0.00%	0.00%
NH3	1A2d	1.13	1.72	2%	1000%	1000%	9.28%	1.16%	2.41%	11.56%	0.07%	1.34%
NH3	1A2e	0.15	0.05	5%	1000%	1000%	0.01%	0.10%	0.07%	0.96%	0.00%	0.01%
NH3	1A2f	1.03	0.51	2%	1000%	1000%	0.80%	0.43%	0.71%	4.35%	0.02%	0.19%
NH3	1A2gvii	0.00	0.00	10%	1000%	1000%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NH3	1A2gviii	0.11	0.12	5%	1000%	1000%	0.05%	0.05%	0.17%	0.54%	0.01%	0.00%
NH3	1A3bi	0.04	0.57	2%	1000%	1000%	1.04%	0.76%	0.80%	7.60%	0.02%	0.58%
NH3	1A3bii	0.01	0.03	2%	1000%	1000%	0.00%	0.03%	0.04%	0.33%	0.00%	0.00%
NH3	1A3biii	0.01	0.05	2%	1000%	1000%	0.01%	0.06%	0.07%	0.63%	0.00%	0.00%
NH3	1A3biv	0.00	0.00	2%	1000%	1000%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%
NH3	1A3c	0.00	0.00	2%	1000%	1000%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NH3	1A4ai	NO	0.03	10%	1000%	1000%	0.00%	--	--	--	--	--
NH3	1A4bi	3.79	1.86	10%	1000%	1000%	10.87%	1.58%	2.60%	15.82%	0.37%	2.50%
NH3	1A4bii	0.00	0.00	25%	1000%	1000%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NH3	1A4ci	NO	0.01	10%	1000%	1000%	0.00%	--	--	--	--	--
NH3	1A4cii	0.00	0.00	10%	1000%	1000%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%
NH3	1B2aiv	NA	0.13	1%	1000%	1000%	0.05%	--	--	--	--	--
NH3	1B2d	0.01	0.41	5%	1000%	1000%	0.52%	0.56%	0.57%	5.59%	0.04%	0.31%
NH3	2A3	IE	0.00	1%	125%	125%	0.00%	--	--	--	--	--
NH3	2B2	0.01	0.01	1%	40%	40%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
NH3	2B10a	5.42	3.73	20%	150%	151%	1.00%	0.78%	5.21%	1.17%	1.47%	0.04%
NH3	2D3g	0.01	0.00	20%	150%	151%	0.00%	0.01%	0.01%	0.01%	0.00%	0.00%
NH3	2G	0.02	0.08	20%	125%	127%	0.00%	0.09%	0.11%	0.11%	0.03%	0.00%
NH3	3B1a	5.51	3.18	1%	200%	200%	1.27%	1.64%	4.45%	3.28%	0.06%	0.11%
NH3	3B1b	2.32	1.95	1%	200%	200%	0.48%	0.16%	2.73%	0.33%	0.04%	0.00%
NH3	3B2	1.37	0.44	1%	200%	200%	0.02%	0.89%	0.62%	1.78%	0.01%	0.03%

Pollutant	NFR	Base year emissions (ton)	Year 2020 emissions (ton)	AD uncertainty (%)	EF uncertainty (%)	Combined uncertainty_1 (%)	Combined uncertainty_2 (%)	Type A Sensitivity (%)	Type B Sensitivity (%)	Unc introduced by EF Unc	Unc introduced by AD Unc	Uncertainty introduced
NH3	3B3	8.08	6.10	1%	200%	200%	4.68%	0.39%	8.54%	0.77%	0.12%	0.01%
NH3	3B4d	0.27	0.06	1%	200%	200%	0.00%	0.22%	0.09%	0.43%	0.00%	0.00%
NH3	3B4e	0.14	0.04	1%	200%	200%	0.00%	0.09%	0.06%	0.18%	0.00%	0.00%
NH3	3B4f	0.54	0.02	1%	200%	200%	0.00%	0.58%	0.02%	1.15%	0.00%	0.01%
NH3	3B4gi	1.55	2.16	1%	200%	200%	0.59%	1.30%	3.02%	2.61%	0.04%	0.07%
NH3	3B4gii	3.05	5.28	1%	200%	200%	3.50%	4.01%	7.39%	8.02%	0.10%	0.64%
NH3	3B4giii	0.69	1.04	1%	200%	200%	0.14%	0.70%	1.46%	1.39%	0.02%	0.02%
NH3	3B4giv	0.31	0.57	1%	200%	200%	0.04%	0.45%	0.80%	0.91%	0.01%	0.01%
NH3	3B4h	1.14	0.39	1%	200%	200%	0.02%	0.72%	0.54%	1.45%	0.01%	0.02%
NH3	3Da1	8.91	5.12	1%	200%	200%	3.30%	2.68%	7.17%	5.36%	0.10%	0.29%
NH3	3Da2a	12.45	9.34	1%	200%	200%	10.97%	0.69%	13.08%	1.37%	0.18%	0.02%
NH3	3Da2b	0.04	0.08	1%	200%	200%	0.00%	0.07%	0.11%	0.14%	0.00%	0.00%
NH3	3Da2c	NA	0.10	1%	200%	200%	0.00%	--	--	--	--	--
NH3	3Da3	5.89	9.34	1%	200%	200%	10.98%	6.57%	13.08%	13.14%	0.18%	1.73%
NH3	3F	1.00	0.74	1%	200%	200%	0.07%	0.07%	1.04%	0.14%	0.01%	0.00%
NH3	5A	0.83	1.08	13%	60%	61%	0.01%	0.59%	1.51%	0.35%	0.28%	0.00%
NH3	5B1	0.01	0.00	14%	126%	127%	0.00%	0.01%	0.01%	0.01%	0.00%	0.00%
NH3	5B2	NO	0.04	14%	89%	91%	0.00%	--	--	--	--	--
NH3	5C1biii	0.00	0.00	20%	200%	201%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NH3	**TOTAL**	**71.44**	**56.41**	**1%**	**77%**	**77%**	**59.69%**	**-**	**-**	**-**	**-**	**7.93%**

Table G-8: Uncertainty estimation of $PM_{2.5}$ emissions 1990 and 2020

Pollutant	NFR	Base year emissions (ton)	Year 2020 emissions (ton)	AD uncertainty (%)	EF uncertainty (%)	Combined uncertainty_1 (%)	Combined uncertainty_2 (%)	Type A Sensitivity (%)	Type B Sensitivity (%)	Unc introduced by EF Unc	Unc introduced by AD Unc	Uncertainty introduced
PM2.5	1A1a	1.56	0.19	1%	125%	125%	0.00%	1.26%	0.29%	1.58%	0.00%	0.02%
PM2.5	1A1b	0.13	0.04	1%	125%	125%	0.00%	0.08%	0.05%	0.10%	0.00%	0.00%
PM2.5	1A2a	0.02	0.00	2%	125%	125%	0.00%	0.02%	0.00%	0.03%	0.00%	0.00%
PM2.5	1A2c	0.42	0.07	2%	125%	125%	0.00%	0.32%	0.10%	0.39%	0.00%	0.00%
PM2.5	1A2d	0.83	0.78	2%	125%	125%	0.04%	0.32%	1.14%	0.40%	0.03%	0.00%
PM2.5	1A2e	0.84	0.24	5%	125%	125%	0.00%	0.48%	0.36%	0.60%	0.03%	0.00%
PM2.5	1A2f	2.83	4.05	2%	125%	125%	1.20%	3.12%	5.94%	3.91%	0.17%	0.15%
PM2.5	1A2gvii	0.16	0.11	10%	125%	125%	0.00%	0.01%	0.17%	0.02%	0.02%	0.00%
PM2.5	1A2gviii	1.08	0.69	5%	125%	125%	0.03%	0.07%	1.01%	0.08%	0.07%	0.00%
PM2.5	1A3ai(i)	0.36	0.51	2%	200%	200%	0.05%	0.39%	0.75%	0.79%	0.02%	0.01%
PM2.5	1A3aii(i)	0.10	0.09	2%	200%	200%	0.00%	0.04%	0.14%	0.08%	0.00%	0.00%
PM2.5	1A3bi	0.61	0.94	2%	125%	125%	0.06%	0.77%	1.38%	0.96%	0.04%	0.01%
PM2.5	1A3bii	2.28	1.04	2%	125%	125%	0.08%	0.74%	1.52%	0.92%	0.04%	0.01%
PM2.5	1A3biii	1.87	0.23	2%	125%	125%	0.00%	1.51%	0.34%	1.89%	0.01%	0.04%
PM2.5	1A3biv	0.60	0.04	2%	125%	125%	0.00%	0.54%	0.06%	0.67%	0.00%	0.00%
PM2.5	1A3bvi	0.46	0.63	2%	125%	125%	0.03%	0.47%	0.92%	0.58%	0.03%	0.00%
PM2.5	1A3bvii	0.19	0.30	2%	125%	125%	0.01%	0.25%	0.44%	0.32%	0.01%	0.00%
PM2.5	1A3c	0.08	0.01	2%	200%	200%	0.00%	0.06%	0.02%	0.12%	0.00%	0.00%
PM2.5	1A3dii	0.23	0.18	2%	200%	200%	0.01%	0.03%	0.26%	0.06%	0.01%	0.00%
PM2.5	1A4ai	0.02	0.07	10%	200%	200%	0.00%	0.07%	0.10%	0.15%	0.01%	0.00%
PM2.5	1A4aii	0.00	0.00	25%	200%	202%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
PM2.5	1A4bi	37.26	18.18	10%	200%	200%	62.06%	10.30%	26.65%	20.60%	3.77%	4.39%
PM2.5	1A4bii	0.02	0.00	25%	200%	202%	0.00%	0.02%	0.00%	0.03%	0.00%	0.00%
PM2.5	1A4ci	0.09	0.16	10%	200%	200%	0.00%	0.15%	0.24%	0.29%	0.03%	0.00%
PM2.5	1A4cii	0.18	0.27	10%	200%	200%	0.01%	0.22%	0.39%	0.43%	0.06%	0.00%
PM2.5	1A4ciii	0.14	0.07	10%	200%	200%	0.00%	0.04%	0.10%	0.08%	0.01%	0.00%
PM2.5	1A5b	0.12	0.08	1%	200%	200%	0.00%	0.00%	0.12%	0.01%	0.00%	0.00%

Pollutant	NFR	Base year emissions (ton)	Year 2020 emissions (ton)	AD uncertainty (%)	EF uncertainty (%)	Combined uncertainty_1 (%)	Combined uncertainty_2 (%)	Type A Sensitivity (%)	Type B Sensitivity (%)	Unc introduced by EF Unc	Unc introduced by AD Unc	Uncertainty introduced
PM2.5	1B2aiv	NE	0.19	1%	200%	200%	0.01%	--	--	--	--	--
PM2.5	1B2c	0.00	0.00	1%	200%	200%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
PM2.5	2A2	0.19	0.38	1%	125%	125%	0.01%	0.37%	0.56%	0.46%	0.01%	0.00%
PM2.5	2A3	0.12	0.36	1%	125%	125%	0.01%	0.40%	0.52%	0.50%	0.01%	0.00%
PM2.5	2A5a	0.29	0.30	20%	150%	151%	0.01%	0.15%	0.43%	0.23%	0.12%	0.00%
PM2.5	2A5b	0.44	0.19	20%	150%	151%	0.00%	0.16%	0.28%	0.23%	0.08%	0.00%
PM2.5	2A5c	0.03	0.04	20%	125%	127%	0.00%	0.02%	0.05%	0.02%	0.02%	0.00%
PM2.5	2B6	NO	0.00	20%	125%	127%	0.00%	--	--	--	--	--
PM2.5	2B10a	7.30	5.94	20%	150%	151%	3.78%	1.45%	8.70%	2.17%	2.46%	0.11%
PM2.5	2C1	0.05	0.05	1%	125%	125%	0.00%	0.01%	0.07%	0.02%	0.00%	0.00%
PM2.5	2C3	0.00	0.00	20%	150%	151%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
PM2.5	2C5	0.00	0.00	20%	150%	151%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
PM2.5	2C7a	0.00	0.00	20%	150%	151%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
PM2.5	2C7d	0.00	0.00	20%	125%	127%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
PM2.5	2D3b	0.08	0.08	20%	125%	127%	0.00%	0.04%	0.12%	0.05%	0.03%	0.00%
PM2.5	2D3c	0.01	0.00	20%	150%	151%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
PM2.5	2D3g	0.00	0.00	20%	150%	151%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
PM2.5	2D3i	0.11	0.14	20%	125%	127%	0.00%	0.09%	0.20%	0.12%	0.06%	0.00%
PM2.5	2G	0.11	0.50	20%	125%	127%	0.02%	0.62%	0.73%	0.77%	0.21%	0.01%
PM2.5	2H1	3.27	6.62	1%	125%	125%	3.21%	6.45%	9.71%	8.07%	0.14%	0.65%
PM2.5	3B1a	0.09	0.04	1%	1000%	1000%	0.01%	0.04%	0.05%	0.37%	0.00%	0.00%
PM2.5	3B1b	0.04	0.02	1%	1000%	1000%	0.00%	0.01%	0.03%	0.08%	0.00%	0.00%
PM2.5	3B2	0.01	0.00	1%	1000%	1000%	0.00%	0.01%	0.01%	0.07%	0.00%	0.00%
PM2.5	3B3	0.01	0.01	1%	1000%	1000%	0.00%	0.00%	0.01%	0.02%	0.00%	0.00%
PM2.5	3B4d	0.00	0.00	1%	1000%	1000%	0.00%	0.00%	0.00%	0.02%	0.00%	0.00%
PM2.5	3B4e	0.00	0.00	1%	1000%	1000%	0.00%	0.00%	0.00%	0.02%	0.00%	0.00%
PM2.5	3B4f	0.01	0.00	1%	1000%	1000%	0.00%	0.01%	0.00%	0.07%	0.00%	0.00%
PM2.5	3B4gi	0.03	0.04	1%	1000%	1000%	0.01%	0.03%	0.06%	0.32%	0.00%	0.00%

Pollutant	NFR	Base year emissions (ton)	Year 2020 emissions (ton)	AD uncertainty (%)	EF uncertainty (%)	Combined uncertainty_1 (%)	Combined uncertainty_2 (%)	Type A Sensitivity (%)	Type B Sensitivity (%)	Unc introduced by EF Unc	Unc introduced by AD Unc	Uncertainty introduced
PM2.5	3B4gii	0.04	0.06	1%	1000%	1000%	0.02%	0.05%	0.09%	0.51%	0.00%	0.00%
PM2.5	3B4giii	0.08	0.12	1%	1000%	1000%	0.07%	0.10%	0.18%	0.98%	0.00%	0.01%
PM2.5	3B4giv	0.03	0.06	1%	1000%	1000%	0.02%	0.06%	0.09%	0.62%	0.00%	0.00%
PM2.5	3B4h	0.00	0.00	1%	1000%	1000%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
PM2.5	3Dc	0.06	0.02	1%	1000%	1000%	0.00%	0.03%	0.03%	0.34%	0.00%	0.00%
PM2.5	3F	2.27	1.68	1%	1000%	1000%	13.20%	0.21%	2.46%	2.06%	0.03%	0.04%
PM2.5	5A	0.00	0.00	13%	242%	242%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
PM2.5	5C1bi	0.00	0.00	20%	1245%	1245%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
PM2.5	5C1biii	0.01	0.00	20%	1000%	1000%	0.00%	0.01%	0.00%	0.11%	0.00%	0.00%
PM2.5	5C1bv	0.00	0.00	5%	495%	495%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%
PM2.5	5E	0.63	0.40	25%	87%	90%	0.01%	0.04%	0.59%	0.04%	0.21%	0.00%
PM2.5	**TOTAL**	**68.21**	**46.20**	**5%**	**92%**	**92%**	**83.98%**	-	-	-	-	**5.48%**