NATIONAL INFORMATIVE INVENTORY REPORT

2020

PORTUGAL

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

Amadora,
March, 15th 2020
(revised 7th April)

apa agência portuguesa do ambiente

Technical Reference

Title	PORTUGUESE INFORMATIVE INVENTORY REPORT 1990 – 2018 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	March, 15th 2020 (revised 7th April)
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 exclude the emissions of Azores and Madeira Islands, the LRTAP Convention covers the whole national territory.

This report pretends to fulfil 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 2020 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 2020 Portuguese inventory submission on air pollutant emissions for the period 1990-2018. 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.

Ministry of Environment and Climate Action

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EXECUTIVE SUMMARY

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 2019 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 1990-2018.

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 2018.

ES.2 Geographical coverage

Emissions from Madeira and Azores Archipelagos are not covered by NECD as established in 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 refer only to the Portuguese Mainland;
- the CLRTAP emissions 2010 celling's and the 2020 reduction commitments, as the amended Gothenburg Protocol, considered 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 refer 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 revised 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 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	% change 1990-2018
NOx	kt	252.3	286.0	284.8	270.3	193.2	162.9	156.6	160.2	155.5	-38.4
NMVOC	kt	243.4	235.6	235.1	195.1	160.1	151.7	148.3	150.9	155.2	-36.3
SOx	kt	317.8	322.0	295.0	189.9	63.1	45.8	45.7	47.3	45.3	-85.7
NH3	kt	75.7	70.7	74.7	61.8	56.2	56.0	56.5	57.0	56.1	-25.8
PM2.5	kt	71.0	70.8	74.3	67.0	56.0	51.6	51.3	51.8	51.1	-27.9
PM10	kt	96.6	105.4	110.6	109.0	89.1	70.9	72.7	73.9	71.0	-26.5
TSP	kt	183.3	239.9	266.1	301.1	223.4	154.4	164.7	172.1	157.4	-14.2
BC	kt	8.8	9.3	10.4	9.1	8.0	6.6	6.5	6.5	6.4	-27.6
CO	kt	799.3	828.4	682.1	520.0	399.3	323.3	309.9	326.0	284.5	-64.4
Pb	t	574.6	796.1	43.7	42.5	40.5	39.9	39.5	40.1	43.0	-92.5
Cd	t	2.4	2.6	2.8	2.5	2.1	2.1	2.0	2.0	2.0	-16.7
Hg	t	2.2	2.5	2.4	1.8	1.7	1.4	1.4	1.5	1.4	-35.1
As	t	3.2	3.6	3.7	3.7	1.9	1.9	1.7	1.8	1.7	-47.7
Cr	t	13.3	15.0	15.5	15.2	12.0	11.2	10.6	10.9	11.0	-17.5
Cu	t	26.7	32.9	42.9	45.5	36.4	30.1	29.9	30.3	30.3	13.4
Ni	t	112.4	117.1	108.4	106.9	48.4	25.9	24.8	24.8	23.9	-78.7
Se	t	12.2	17.0	23.4	26.6	30.2	31.7	31.7	32.2	36.2	196.0
Zn	t	64.8	69.0	75.8	76.9	72.9	73.1	73.1	74.5	77.2	19.0
DIOX	g I-TEQ	551.7	549.1	352.1	66.2	49.4	47.7	48.8	51.5	55.4	-90.0
PAHs	t	24.4	22.5	21.7	19.2	15.3	13.8	13.8	14.6	15.6	-36.3
HCB	kg	58.8	74.1	100.5	1.4	1.2	1.7	1.9	2.0	2.4	-96.0
PCB	kg	1063.9	859.5	794.5	670.1	322.6	85.9	84.0	95.8	91.9	-91.4

Table ES. 2 Total emissions (Mainland)

Pollutant	Unit	1990	1995	2000	2005	2010	2015	2016	2017	2018	% change 1990-2018
NOx	kt	239.2	270.8	266.0	248.2	172.0	146.5	141.6	145.4	141.0	-41.1
NMVOC	kt	236.1	227.4	225.3	186.7	152.9	145.1	141.7	144.3	148.4	-37.1
SOx	kt	309.5	312.0	282.1	172.5	46.8	33.7	33.2	35.1	33.5	-89.2
NH3	kt	70.5	65.3	68.0	55.4	49.8	50.0	50.3	50.7	49.9	-29.2
PM2.5	kt	70.0	69.7	73.1	65.7	54.7	50.5	50.2	50.6	50.0	-28.5
PM10	kt	95.1	103.8	108.9	107.1	87.2	69.4	71.1	72.5	69.5	-26.9
TSP	kt	180.9	237.3	263.5	298.3	220.3	152.5	162.5	170.1	155.4	-14.1
BC	kt	8.7	9.1	10.2	8.9	7.7	6.4	6.3	6.3	6.1	-29.0
CO	kt	788.2	810.4	664.5	505.7	387.8	315.0	301.6	318.0	277.1	-64.8
Pb	t	567.6	775.1	43.0	41.7	39.8	39.3	38.9	39.5	42.4	-92.5
Cd	t	2.4	2.5	2.7	2.5	2.1	2.0	2.0	2.0	2.0	-17.4
Hg	t	2.2	2.4	2.4	1.8	1.7	1.4	1.4	1.5	1.4	-35.7
As	t	3.1	3.5	3.6	3.5	1.7	1.8	1.5	1.7	1.5	-50.4
Cr	t	13.0	14.7	15.1	14.6	11.5	10.8	10.2	10.5	10.5	-19.2
Cu	t	26.2	32.1	41.9	44.2	34.9	29.0	28.8	29.2	29.1	11.1
Ni	t	108.5	112.5	102.2	98.4	40.2	19.6	18.3	18.5	17.8	-83.6
Se	t	12.2	17.0	23.4	26.6	30.1	31.7	31.7	32.2	36.2	196.2
Zn	t	64.2	68.2	74.9	75.8	71.6	72.1	72.0	73.4	76.1	18.6
DIOX	g I-TEQ	550.5	547.8	350.6	64.7	48.4	45.7	46.5	48.9	53.2	-90.3
PAHs	t	24.2	22.3	21.5	19.0	15.1	13.7	13.6	14.5	15.4	-36.4
HCB	kg	58.3	73.2	99.7	0.5	0.7	0.8	1.1	1.1	1.6	-97.3
PCB	kg	1015.2	821.2	760.0	643.7	309.8	84.3	83.0	94.7	90.9	-91.0

ES.5 Assessment of Compliance with National Ceilings

National total 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 Gothemburg Protocol (after 2020).

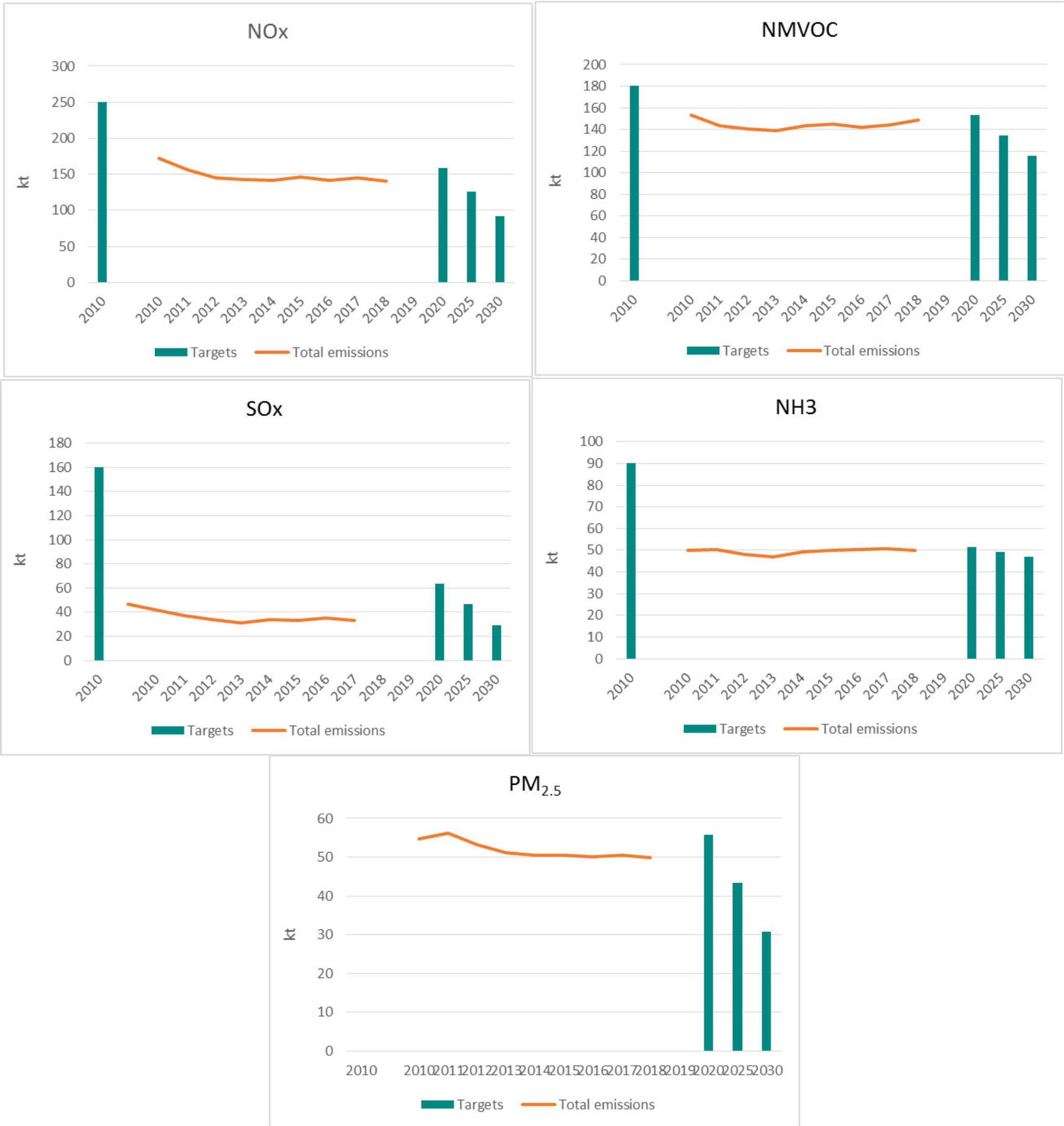

Figure ES. 1: National emissions for compliance (Mainland Portugal)

ES.6 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:

- further development of country specific emissions factors for combustion in energy industries;

- development of the uncertainty analysis.

1 Introduction

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1 Introduction

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);
- Effort Sharing Decision (ESD) review of the 2016 GHG inventory;
- 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;
- 2019 Review 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 2018.

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.

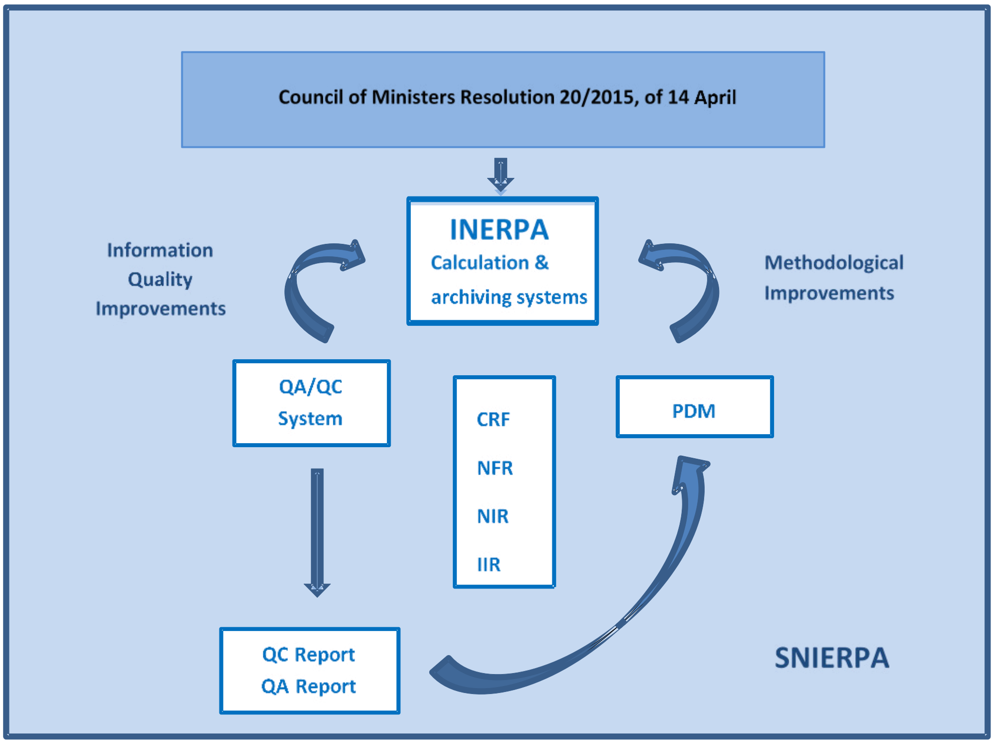

Figure 1-1: SNIERPA's main elements relations

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.

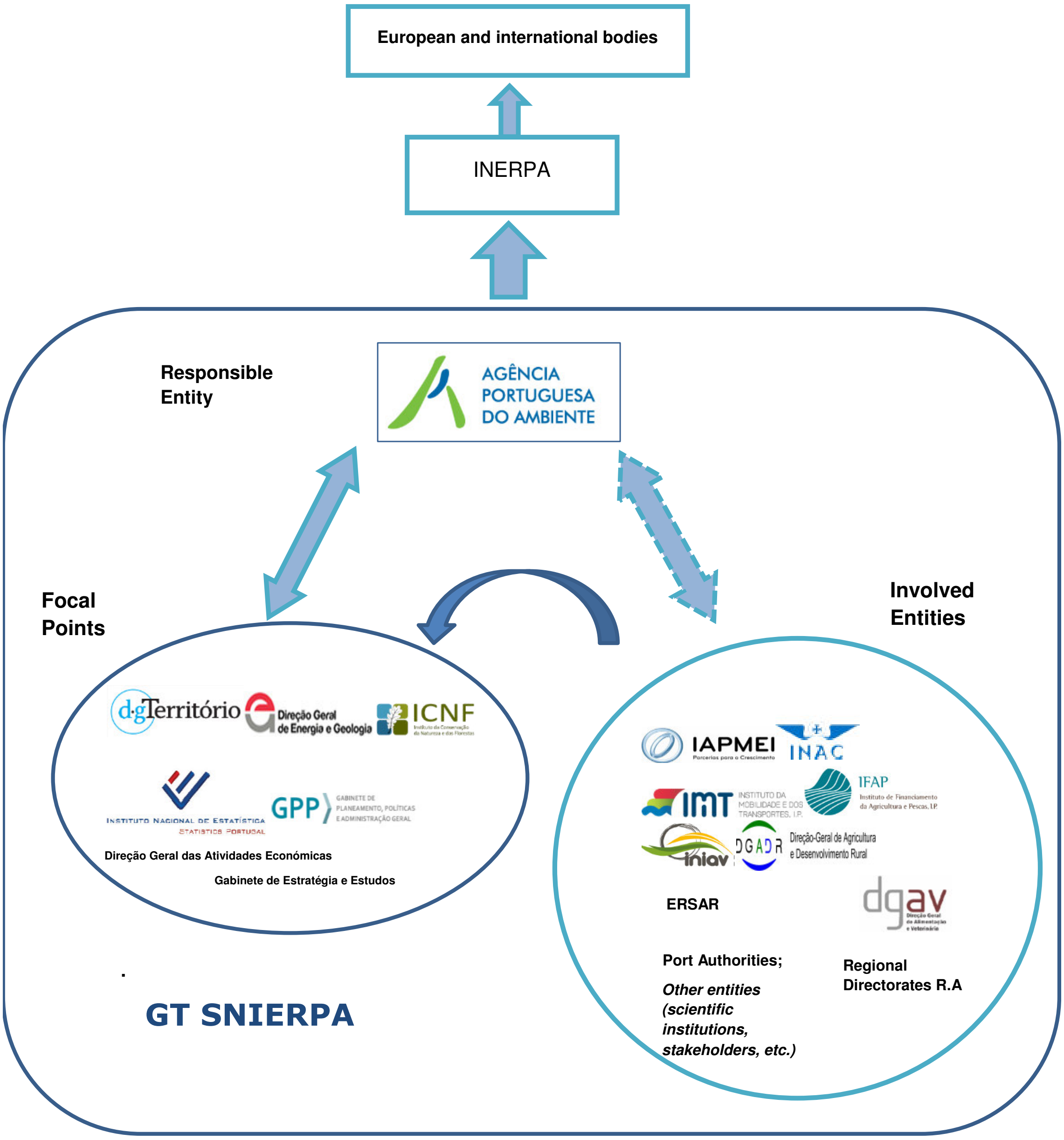

Figure 1-2: Main bodies of the national system (SNIERPA)

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)

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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.

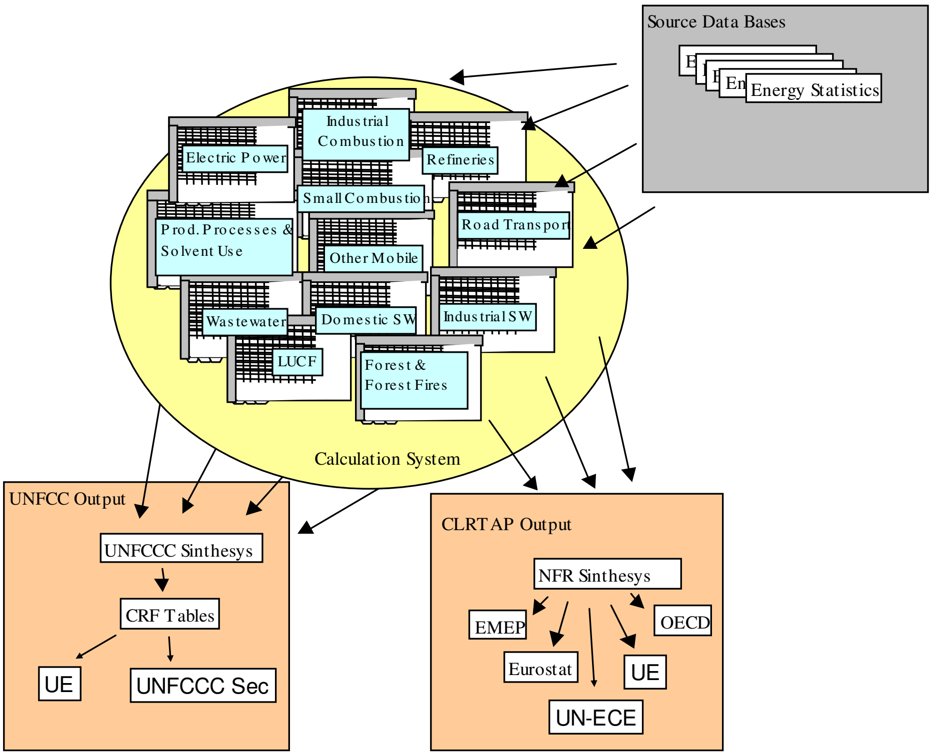

Figure 1-3: Electronic System Structure of the estimation and reporting system

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 2018.

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 – 2016 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		- Large Point Source Surveys (LPS)
		- Large Combustion Plants (LCP)
		- EDP Sustainability Annual Reports
	Fuel sales	- Energy Balance - General Directorate for Geology and Energy (DGEG)
		- Autonomous Gov. 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	Fuel sales	- Energy Balance - General Directorate for Geology and Energy (DGEG)
	Vehicle sales	- ACAP
		- ANECRA
		- Road Institute (IEP)
		- INE
		- General Directorate of Terrestrial Transportation (DGTT)
		- INAC
1A4 – Other Sectors	Fuel sales	- Energy Balance (DGEG)
	Equipments and fuel used	- 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 Enterprise (DGAE)
		- INE
2F - Product uses as ODS substitutes		- INE
		- APIRAC
		- Data from Industry Importers
		- EDP, REN
		- Fluorinated Gas Inquiry (APA)
2G - Other product manufacture and use		- LCP
		- Energy Balance (DGEG)
3 – Agriculture		- GPP
		- ICNF
		- INE: agriculture survey
5 – Land Use, Land Use Change and Forestry	Biomass increment, Burnt area, Harvest	- ICNF
	Land use area, LUC	- COS cartography (DGT)
	Biomass increment	- ISA
5 – Waste		
5A – Solid Waste Disposal on Land	Amount of Waste (Municipal)	APA
	Amount of Waste (Industrial)	APA-INE
5B – Biological Treatment	Amount of Waste	APA
5C – Waste Incineration	Amount of Waste	APA
5D – Wastewater Handling		APA
	Industrial Production, Protein consumption	INE

1.7 Key source categories

Key source analysis to the 2018 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 2018 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 2018. The Residential stationary sources (1A4bi) are related to a great extent to particulate and dioxins/furans emissions.

For NMVOC, key categories refer in majority to the IPPU sector (NFR 2), in particularly 2.D.3.a Domestic solvent use including fungicides, 2.D.3.d Coating applications, 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 and a significant source for other HM emissions. Iron and steel production is also an important source of HM emissions in particular, Zn emissions. The Residential-Stationary sector (1.A.4.b.i) represents the majority of PAHs emissions. The energy industries (1.A.1), the use of pesticides in agriculture soils (3.D.f) and waste incineration sources (5.C) generate the majority of HCBs emissions. The waste sources are related to most of dioxins/furans and PCBs emissions.

Table 1.3: Key category analysis of 2018 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	12.9% (L1, T1)		30.3% (L1, T1)		0.8% (T1)	0.6% (T1)	0.4% (T1)		
1A1b	Petroleum refining				0.9% (T1)						
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals										
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print		3.6% (L1, T1)	1.6% (L1)	21.6% (L1, T1)	3.1% (T1)					
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco										
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals		10.2% (L1, T1)	6.2% (L1, T1)	13.4% (L1, T1)		9.3% (L1, T1)	6.7% (L1, T1)	10.7% (L1, T1)	8.1% (L1, T1)	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)		2.7% (L1)		1.7% (T1)						
1A3ai(i)	International aviation LTO (civil)		2.7% (T1)				2.7% (L1, T1)	2% (L1, T1)		10.5% (L1, T1)	
1A3aii(i)	Domestic aviation LTO (civil)									3.9% (L1, T1)	
1A3bi	Road transport: Passenger cars		18.5% (L1, T1)	3.4% (L1, T1)		1.5% (T1)	2.4% (T1)	1.8% (T1)		14.8% (L1, T1)	18.8% (L1, T1)
1A3bii	Road transport: Light duty vehicles		10.8% (L1, T1)							13.1% (L1)	
1A3biii	Road transport: Heavy duty vehicles and buses		11.5% (L1, T1)				0.7% (T1)	0.5% (T1)	0.2% (T1)	3.5% (L1, T1)	
1A3biv	Road transport: Mopeds & motorcycles			1.6% (L1, T1)							3.7% (L1, T1)
1A3bv	Road transport: Gasoline evaporation			3.9% (L1, T1)							
1A3bvi	Road transport: Automobile tyre and brake wear							1.9% (L1)			
1A3dii	National navigation (shipping)		4.3% (L1)								
1A4ai	Commercial/institutional: Stationary										
1A4bi	Residential: Stationary			9.1% (L1, T1)		3.3% (T1)	35.8% (L1, T1)	26.4% (L1, T1)	12.5% (L1, T1)	28.1% (L1, T1)	35.7% (L1, T1)
1A4ci	Agriculture/Forestry/Fishing: Stationary										
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery		3% (L1)								
1A4ciii	Agriculture/Forestry/Fishing: National fishing		2.2% (T1)								
1B2aiv	Fugitive emissions oil: Refining / storage				10% (L1, T1)						10.9% (L1, T1)
1B2av	Distribution of oil products			2.8% (L1)							
1B2d	Other fugitive emissions from energy production					0.8% (T1)					
2A2	Lime production	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)						2.5% (L1, T1)	2.9% (L1, T1)		
2A3	Glass production						3.1% (L1, T1)	2.3% (L1, T1)			
2A5a	Quarrying and mining of minerals other than coal							3.7% (L1)	3.5% (L1)		
2A5b	Construction and demolition							1.6% (T1)	2.4% (T1)		
2B10a	Chemical industry: Other (please specify in the IIR)					5.6% (L1, T1)	9.4% (L1, T1)	6.9% (L1)	7.4% (L1)		3.1% (L1)
2C1	Iron and steel production										
2D3a	Domestic solvent use including fungicides			4.8% (L1)							
2D3b	Road paving with asphalt						3.1% (L1)	14.2% (L1, T1)	36% (L1, T1)		
2D3d	Coating applications			12.6% (L1, T1)							
2D3e	Degreasing			5.3% (L1, T1)							
2D3g	Chemical products			10.7% (L1, T1)							
2D3h	Printing			3.1% (L1, T1)							
2D3i	Other solvent use (please specify in the IIR)			7.1% (L1, T1)							
2G	Other product use (please specify in the IIR)			1.8% (L1)							
2H1	Pulp and paper industry		3.3% (L1, T1)	5.1% (L1, T1)	10.2% (L1, T1)		13.3% (L1, T1)	11.6% (L1, T1)	5.9% (L1, T1)		
2I	Wood processing								2.5% (L1, T1)		
2K	Consumption of POPs and heavy metals (e.g. electrical and scientific equipment)										
3B1a	Manure management - Dairy cattle	AGRICULTURE				8.7% (L1)					
3B1b	Manure management - Non-dairy cattle					4.1% (L1)					
3B2	Manure management - Sheep					0.7% (T1)					
3B3	Manure management - Swine					10.6% (L1)					
3B4gi	Manure mangement - Laying hens					4.6% (L1)					
3B4gii	Manure mangement - Broilers					6.3% (L1, T1)					
3B4h	Manure management - Other animals (please specify in IIR)					0.4% (T1)					
3Da1	Inorganic N-fertilizers (includes also urea application)					11.6% (L1)					
3Da2a	Animal manure applied to soils			2.2% (L1)		21.6% (L1, T1)					
3Da3	Urine and dung deposited by grazing animals					9.8% (L1, T1)					
3Df	Use of pesticides										
3F	Field burning of agricultural residues						3.4% (L1)	2.6% (L1)			10.4% (L1, T1)
5A	Biological treatment of waste - Solid waste disposal on land	WASTE				2.2% (T1)					
5C1bi	Industrial waste incineration										
5C1biii	Clinical waste incineration										
5E	Other waste (please specify in IIR)										
	TOTAL	(%)	80.7	81.5	85.4	83.1	80.2	80.9	81.3	82.0	82.6

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		6.3% (L1)	14.3% (L1, T1)	53.8% (L1, T1)	8.8% (L1, T1)	4.2% (T1)	27.5% (L1, T1)	0.4% (T1)	8% (L1)
1A1b	Petroleum refining	ENERGY							1.2% (T1)		
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	ENERGY		0.9% (T1)		0.8% (T1)					
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	ENERGY			30.8% (L1, T1)				5.4% (L1)		11.1% (L1, T1)
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	ENERGY		1.5% (T1)		1.6% (T1)					
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	ENERGY			3.8% (T1)	14.4% (L1, T1)	23.2% (L1)	5.6% (L1)	14.2% (L1, T1)	1.1% (T1)	1.6% (T1)
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	ENERGY		0.9% (T1)	1.7% (T1)	1.2% (T1)	0.4% (T1)		0.9% (T1)		
1A3ai(i)	International aviation LTO (civil)	ENERGY									
1A3aii(i)	Domestic aviation LTO (civil)	ENERGY									
1A3bi	Road transport: Passenger cars	ENERGY	14.9% (L1, T1)								
1A3bii	Road transport: Light duty vehicles	ENERGY									
1A3biii	Road transport: Heavy duty vehicles and buses	ENERGY									
1A3biv	Road transport: Mopeds & motorcycles	ENERGY						1.3% (T1)			
1A3bv	Road transport: Gasoline evaporation	ENERGY									
1A3bvi	Road transport: Automobile tyre and brake wear	ENERGY					6% (T1)	47.7% (L1, T1)			7.5% (L1)
1A3dii	National navigation (shipping)	ENERGY							8.3% (L1, T1)		
1A4ai	Commercial/institutional: Stationary	ENERGY				2.8% (T1)		2.2% (T1)			
1A4bi	Residential: Stationary	ENERGY		20.4% (L1, T1)			6.7% (L1, T1)				21.2% (L1, T1)
1A4ci	Agriculture/Forestry/Fishing: Stationary	ENERGY							6.1% (L1)		
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	ENERGY									
1A4ciii	Agriculture/Forestry/Fishing: National fishing	ENERGY									
1B2aiv	Fugitive emissions oil: Refining / storage	ENERGY			3.9% (L1)						
1B2av	Distribution of oil products	ENERGY									
1B2d	Other fugitive emissions from energy production	ENERGY			6.3% (L1, T1)						
2A2	Lime production	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)									
2A3	Glass production	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)	54.5% (L1, T1)	14.4% (L1, T1)	6.9% (L1, T1)	14% (L1, T1)	43% (L1, T1)	3.9% (T1)	15.6% (L1, T1)	97.8% (L1, T1)	27.9% (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)	13.6% (L1, T1)	22.1% (L1, T1)	7.9% (L1, T1)	2% (T1)	2.1% (T1)		6.6% (L1, T1)		10.5% (L1, T1)
2D3a	Domestic solvent use including fungicides	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)			4% (L1)						
2D3b	Road paving with asphalt	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)									
2D3d	Coating applications	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)									
2D3e	Degreasing	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)									
2D3g	Chemical products	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)									
2D3h	Printing	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)		7.5% (L1, T1)				28.2% (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)			7.2% (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									
3Df	Use of pesticides	AGRICULTURE									
3F	Field burning of agricultural residues	AGRICULTURE		10.3% (L1)							
5A	Biological treatment of waste - Solid waste disposal on land	WASTE									
5C1bi	Industrial waste incineration	WASTE									
5C1biii	Clinical waste incineration	WASTE			0.6% (T1)						
5E	Other waste (please specify in IIR)	WASTE									
	TOTAL	(%)	83.1	81.0	81.3	82.2	81.8	81.5	83.8	97.8	86.4

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							34.6% (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)									
1A3aii(i)	Domestic 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		35.5% (L1, T1)					56.5% (L1, T1)		
1A4ci	Agriculture/Forestry/Fishing: Stationary									
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery									
1A4ciii	Agriculture/Forestry/Fishing: National fishing									
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		12.2% (L1)					7% (L1, T1)		
2D3a	Domestic solvent use including fungicides									
2D3b	Road paving with asphalt									
2D3d	Coating applications									
2D3e	Degreasing									
2D3g	Chemical products									
2D3h	Printing									
2D3i	Other solvent use (please specify in the IIR)		12.5% (L1, T1)					20.4% (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)									22.3% (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									
3Df	Use of pesticides								32% (L1)	
3F	Field burning of agricultural residues									
5A	Biological treatment of waste - Solid waste disposal on land	WASTE								
5C1bi	Industrial waste incineration		15.9% (L1, T1)							71.3% (L1, T1)
5C1biii	Clinical waste incineration		3.8% (T1)						22% (L1, T1)	
5E	Other waste (please specify in IIR)		8.2% (L1)							
	TOTAL	(%)	84.3					83.8	88.6	93.6

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

At present, the uncertainty analysis is performed only for the direct GHG. It was not possible until now to extend the assessment to other emission estimates. It is foreseen to be implemented in the future.

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

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2 Emission Trends

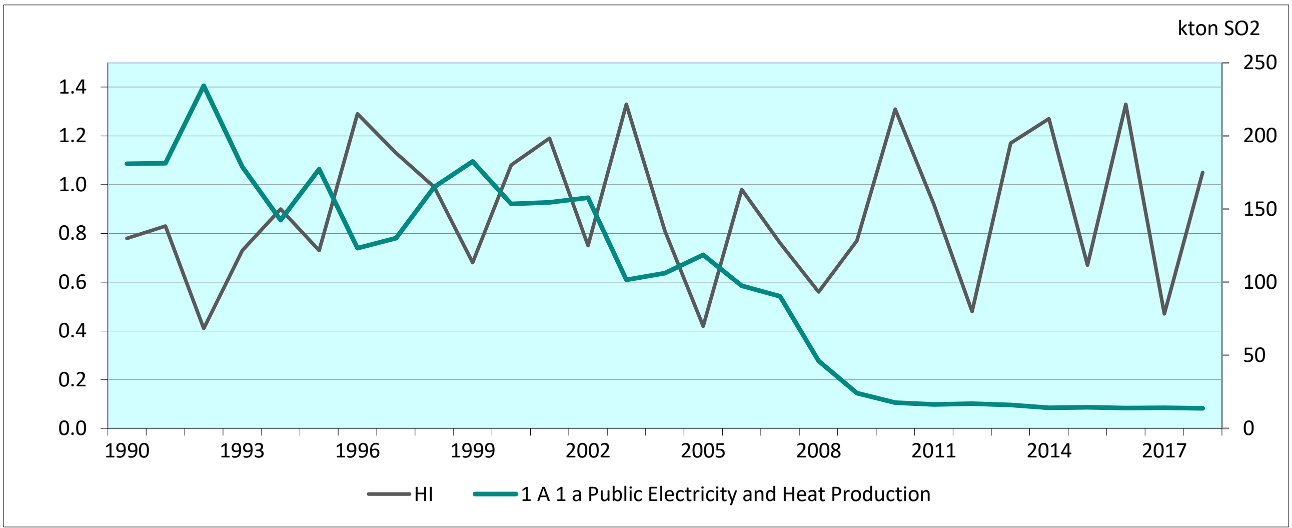
SO_x emissions are generated in majority in the energy sector (~87% of total emissions in 2018) which is a major consumer of fossil fuels. Within this sector, the combustion in manufacturing industries, with approximately 39% of national total emissions in 2018, and fugitive emissions from refining (~10% of national total emissions in 2018) represent the major sources.

The variation of SO_x emissions in the period 1990-2018 registered an overall trend variation of -85.7% for the same period, that resulted from the significant decrease of most of sub-categories: energy industries –93.0%, manufacturing industries –77.0%, transport -87.6% and combustion of other sectors -90.2%.

These tendencies reflect the implementation of important 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).

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. -87% in 2017 as compared to 2007).

2017 year was characterized by a strong decrease of the hydropower production due to an extreme unfavorable year in terms of water availability (HPI = 0.47), contributing to an increase of the use of coal in the electro producer. The year 2018 registered better conditions in terms of water availability (HPI = 1.05) and the increment of the hydropower production and the consequent drop of emissions.



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. 93.4% and 84.8% of 2018 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. 49% for NO_x, 28% for CO and 11% for NMVOC of 2018 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 1990-2018 for NMVOC, CO and NO_x emissions are, respectively, -83%, -85% and -33%.

Other sectors (commercial/institutional, residential and agriculture/ forestry) within energy, also amount for a significant share of CO: approx. 37% of 2018 totals.

NH_3 is primarily generated in biological systems, such as agriculture soil (43% of 2018 national totals), manure management systems (37% of 2018 national totals), chemical industry and decomposition of municipal wastes. Road transport represents a smaller amount of emissions with 1.6% of 2018 national total, but has grown significantly since 1990 (+1000%). The overall evolution of ammonia in the period analysed is downwards with a -26% variation between 1990 and 2018.

A significant share of particulate matter is generated in other sectors (residential) which represents approximately 37% of 2018 national total PM2.5 emissions and in combustion in manufacturing industry (~13%), and the estimates show an over whole negative trend since 1990 for TSP (-14%), and a negative trend for BC (-28%), PM2.5 (-28%) and PM10 (-27%).

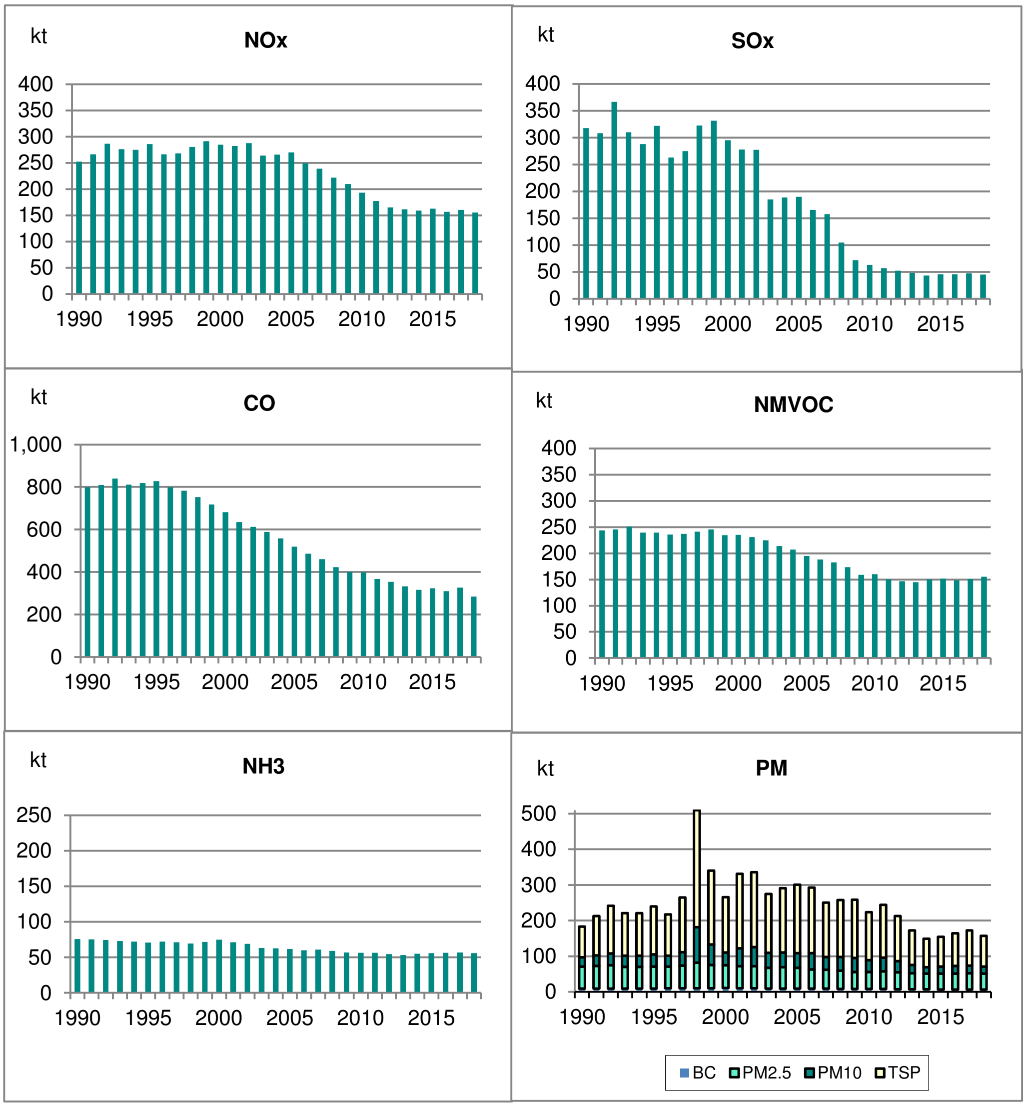


Figure 2-2: Main pollutants and particulate matter - total emissions

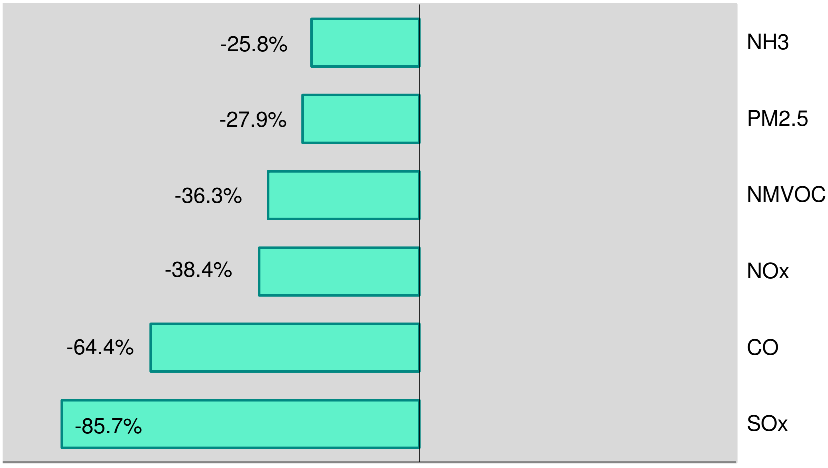


Figure 2-3: Percentage variation of main pollutant emissions: 1990-2018 period

Table 2.1: Main pollutants and particulate matter total emissions

	NOx kt	NMVOC kt	SOx kt	NH3 kt	PM2.5 kt	PM10 kt	TSP kt	BC kt	CO kt
1990	252.3	243.4	317.8	75.7	71.0	96.6	183.3	8.8	799.3
1991	266.4	245.7	308.2	75.3	72.6	102.1	212.6	9.0	810.4
1992	286.8	251.3	366.6	74.5	74.5	107.7	241.7	9.2	839.8
1993	276.3	239.6	309.6	73.0	70.3	101.6	220.7	9.0	811.2
1994	275.2	239.6	288.2	72.2	69.9	101.5	221.1	9.2	818.6
1995	286.0	235.6	322.0	70.7	70.8	105.4	239.9	9.3	828.4
1996	266.2	236.9	262.9	72.1	71.2	101.1	217.5	9.5	799.9
1997	268.0	241.5	275.1	71.4	73.7	110.9	264.5	9.8	782.6
1998	280.6	245.3	322.2	69.4	81.5	181.6	509.7	10.1	752.0
1999	291.5	234.5	331.1	71.7	75.6	132.8	339.8	10.1	718.6
2000	284.8	235.1	295.0	74.7	74.3	110.6	266.1	10.4	682.1
2001	282.4	230.6	277.8	71.2	71.6	121.9	330.8	10.1	634.7
2002	288.0	224.7	277.0	69.1	71.4	125.8	335.5	9.8	613.2
2003	263.9	213.8	185.1	63.2	67.6	109.5	275.0	9.4	588.8
2004	265.7	206.8	188.5	62.8	68.8	110.5	291.0	9.4	559.0
2005	270.3	195.1	189.9	61.8	67.0	109.0	301.1	9.1	520.0
2006	249.5	187.9	165.1	59.9	63.1	108.9	292.4	8.8	486.8
2007	238.9	182.8	157.7	61.1	61.9	97.7	250.2	8.6	461.0
2008	221.7	173.6	104.4	59.0	59.3	97.9	257.2	8.3	422.2
2009	209.9	158.8	72.1	56.6	55.9	95.5	258.4	8.0	399.7
2010	193.2	160.1	63.1	56.2	56.0	89.1	223.4	8.0	399.3
2011	177.5	150.3	57.1	56.5	57.4	95.8	243.9	7.9	367.0
2012	164.9	146.7	52.4	54.6	54.5	86.5	212.9	7.3	353.4
2013	161.5	145.0	48.1	53.1	52.3	75.5	172.6	7.1	333.1
2014	158.9	150.3	43.6	55.2	51.5	69.3	148.6	7.0	315.7
2015	162.9	151.7	45.8	56.0	51.6	70.9	154.4	6.6	323.3
2016	156.6	148.3	45.7	56.5	51.3	72.7	164.7	6.5	309.9
2017	160.2	150.9	47.3	57.0	51.8	73.9	172.1	6.5	326.0
2018	155.5	155.2	45.3	56.1	51.1	71.0	157.4	6.4	284.5

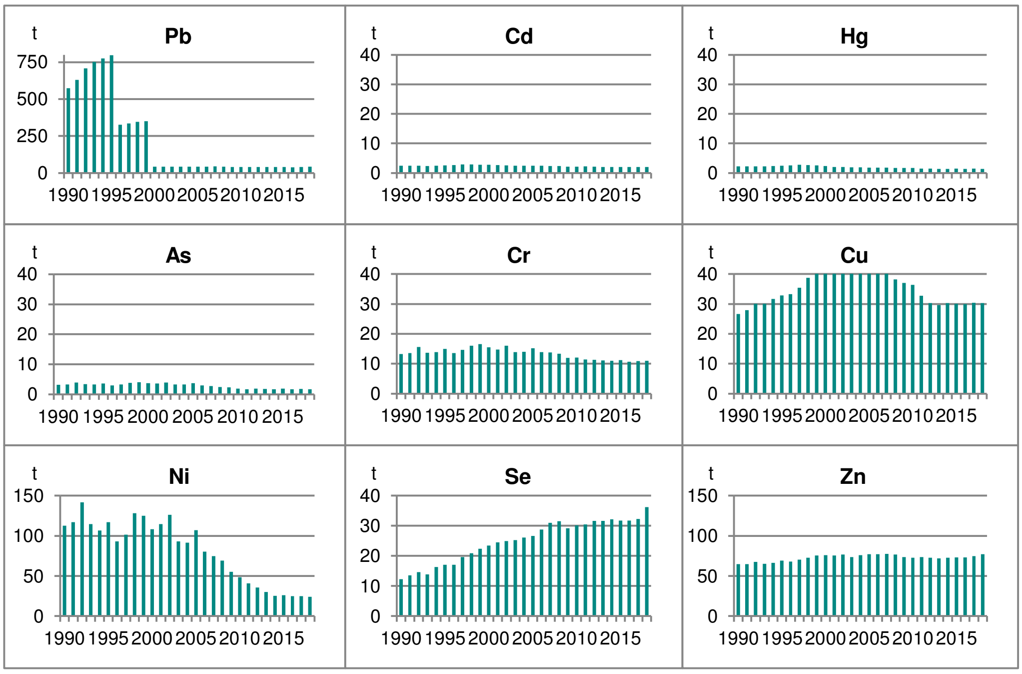


Figure 2-4: Heavy metals total emissions

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.

The upwards or downwards tendencies regarding heavy metals emissions differ from pollutant to pollutant. The lead emissions registered from 1990 to 2018 a decreasing trend, with a reduction of approx. 93% which are mainly related with the reductions of emissions in road transport emissions which are explained by the phased out of use of leaded petrol within the EU context.

Nickel (Ni) and mercury (Hg) registered significant reductions which 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.

Other pollutants present increasing trends in the period 1990-2018. The growth of copper emissions is associated with road transportation, which represents around 50% of national total copper emissions in 2018. Selenium emissions are mostly related to the evolution of glass production sector (2.A.3), and zinc emissions (11%) related to category 2.C.1 Iron and Steel Combustion in industry and the remaining part related to energy categories, in particular 1.A.4.b.i (residential combustion).

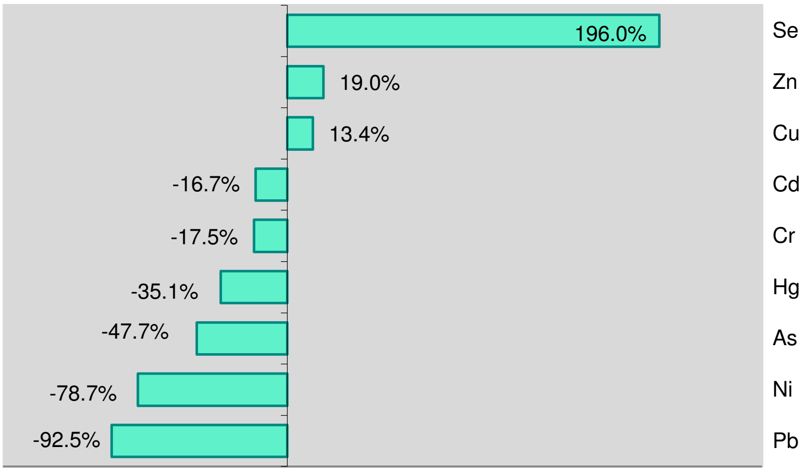


Figure 2-5: Percentage variation of HM emissions: 1990-2018 period

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	574.6	2.4	2.2	3.2	13.3	26.7	112.4	12.2	64.8
1991	630.6	2.4	2.2	3.3	13.5	28.0	116.9	13.5	64.7
1992	707.7	2.5	2.3	3.9	15.6	30.0	141.7	14.6	67.7
1993	751.4	2.4	2.2	3.4	13.7	30.1	114.6	13.9	65.3
1994	774.8	2.4	2.3	3.2	13.9	31.6	106.8	16.3	66.4
1995	796.1	2.6	2.5	3.6	15.0	32.9	117.1	17.0	69.0
1996	327.4	2.7	2.5	3.0	13.5	33.3	93.2	17.1	67.8
1997	334.8	2.8	2.8	3.3	14.7	35.4	101.6	19.6	70.4
1998	347.1	2.9	2.6	3.8	16.0	38.7	128.2	20.9	72.8
1999	350.6	2.8	2.6	4.0	16.5	40.8	125.1	22.4	75.6
2000	43.7	2.8	2.4	3.7	15.5	42.9	108.4	23.4	75.8
2001	41.8	2.7	2.1	3.6	14.8	44.1	114.5	24.4	75.5
2002	42.1	2.6	2.0	4.0	16.0	45.7	126.2	24.9	76.5
2003	42.0	2.5	1.9	3.3	13.9	44.5	93.2	25.2	73.5
2004	42.8	2.5	2.0	3.3	14.0	45.9	91.3	26.1	75.7
2005	42.5	2.5	1.8	3.7	15.2	45.5	106.9	26.6	76.9
2006	43.4	2.5	1.8	3.0	13.8	41.2	80.2	28.8	77.0
2007	44.0	2.4	1.8	2.7	13.7	40.3	74.5	31.0	77.4
2008	43.7	2.3	1.7	2.5	13.4	38.2	69.1	31.5	76.9
2009	40.4	2.2	1.7	2.3	12.0	37.0	55.2	29.2	73.6
2010	40.5	2.1	1.7	1.9	12.0	36.4	48.4	30.2	72.9
2011	40.6	2.2	1.5	1.7	11.4	32.8	40.7	30.4	73.4
2012	40.5	2.1	1.5	1.9	11.3	30.3	35.6	31.6	72.6
2013	40.0	2.0	1.4	1.8	11.1	29.6	30.1	31.6	72.0
2014	40.4	2.0	1.4	1.7	11.0	30.2	25.3	32.1	72.8
2015	39.9	2.1	1.4	1.9	11.2	30.1	25.9	31.7	73.1
2016	39.5	2.0	1.4	1.7	10.6	29.9	24.8	31.7	73.1
2017	40.1	2.0	1.5	1.8	10.9	30.3	24.8	32.2	74.5
2018	43.0	2.0	1.4	1.7	11.0	30.3	23.9	36.2	77.2

Main sources of dioxines emissions refer to the incineration of waste (20 % of 2018 national total emissions) and the combustion in the residential sector (36 % of 2018 national total emissions). These emissions registered an overall decrease of -90 %) in the period 1990-2018. Polycyclic aromatic hydrocarbons (PAH) emissions are related in majority to the residential – stationary sector (1.A.4.b.i). HCBs emissions occur in energy industries (1.A.1), the use of pesticides in agriculture soils (3.D.f) and waste incineration sources (5.C) and. Polychlorobiphenyls (PCB) estimated emissions are related to the consumption of POPs and heavy metals (2.K) and the incineration of industrial waste (5.C).

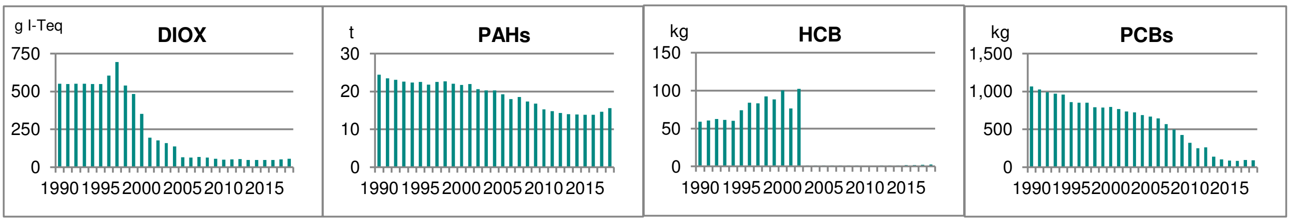


Figure 2-6: Persistent organic pollutant total emissions

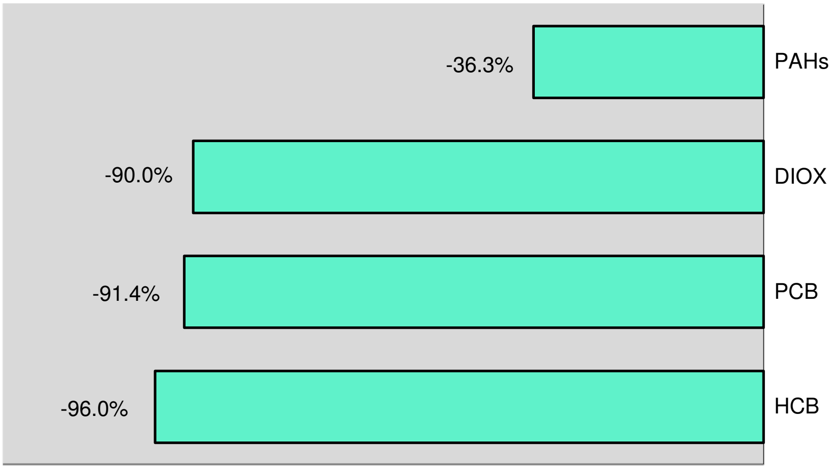


Figure 2-7: Percentage variation of POP emissions: 1990-2018 period

Table 2.3: Persistent organic pollutant total emissions

	DIOX g I-TEQ	PAHs t	HCB kg	PCB kg
1990	551.7	24.4	58.8	1,063.9
1991	549.5	23.5	60.8	1,026.0
1992	550.9	23.0	62.6	989.2
1993	551.2	22.5	61.5	969.1
1994	548.4	22.4	60.3	959.2
1995	549.1	22.5	74.1	859.5
1996	604.6	21.8	84.0	852.1
1997	694.1	22.5	83.5	851.0
1998	539.0	22.7	92.6	790.2
1999	484.1	22.0	88.5	787.5
2000	352.1	21.7	100.5	794.5
2001	194.7	22.0	76.4	769.5
2002	176.9	20.6	102.5	735.1
2003	160.1	20.3	1.5	724.6
2004	137.7	20.3	1.5	686.4
2005	66.2	19.2	1.4	670.1
2006	63.4	18.0	1.4	643.1
2007	66.9	18.5	1.4	570.2
2008	64.0	17.3	1.4	496.7
2009	55.3	16.8	1.4	424.2
2010	49.4	15.3	1.2	322.6
2011	51.5	14.8	1.1	251.0
2012	53.3	14.3	1.5	261.8
2013	48.3	14.0	1.5	139.9
2014	48.2	13.9	1.6	105.3
2015	47.7	13.8	1.7	85.9
2016	48.8	13.8	1.9	84.0
2017	51.5	14.6	2.0	95.8
2018	55.4	15.6	2.4	91.9

3 Energy (NFR 1)

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Rita Silva

3.1 International Bunker Fuels

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

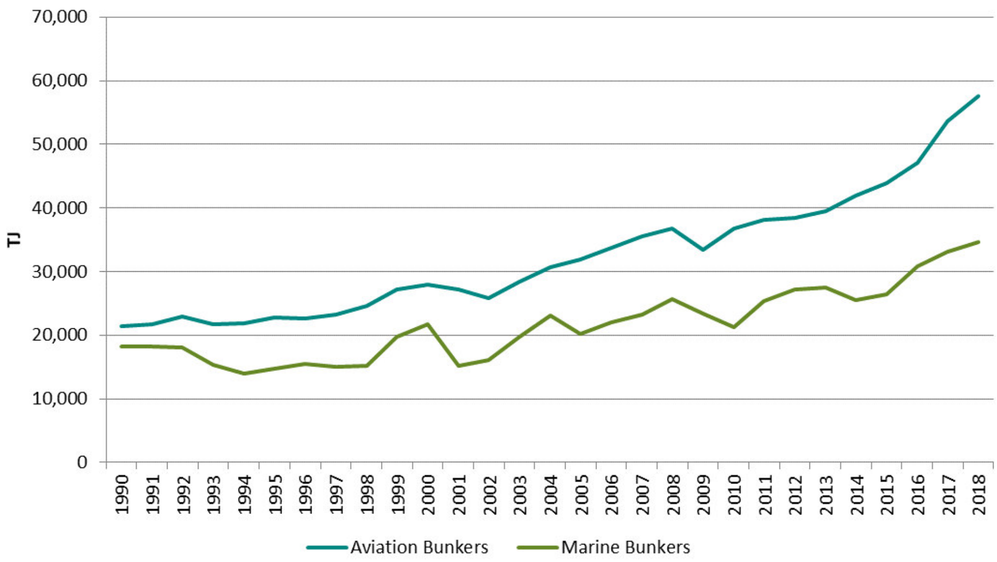


Figure 3-1: International navigation and aviation bunkers

3.1.1 International aviation bunkers

The majority of jet fuel is used for international aviation. In 2018 the quantity of jet fuel for international aviation was about 89% 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.

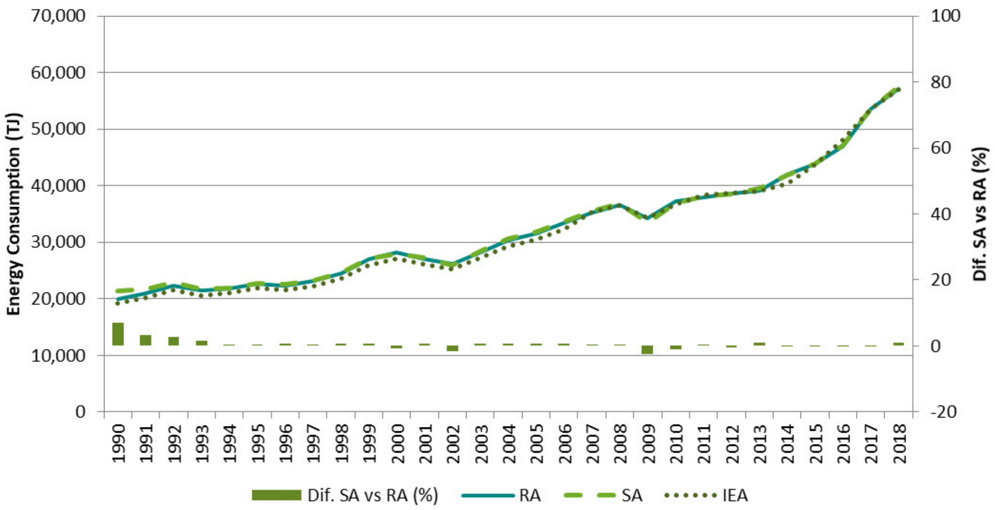


Figure 3-2: International aviation bunkers

3.1.2 International marine bunkers

In 2018 the energy consumption for international navigation was about 91% of the total energy used in marine navigation. This percentage was estimated according with the origin and destiny of the flight as recommended by 2006 IPCC Guidelines.

The international fuel classification used by the national fuel authority (DGEG) is different from the one used in national inventory. DGEG split is 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).

The international navigation energy consumption data from the IEA differ to some extent from the DGEG fuel balance. This discrepancy results from a reporting error to the IEA. 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. DGEG is developing efforts to correct this reporting error.

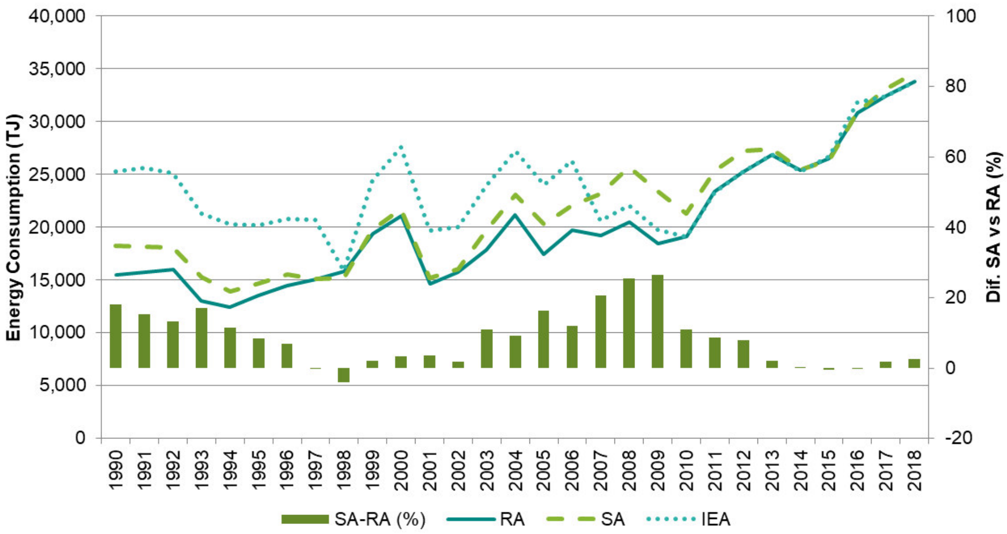


Figure 3-3: International marine bunkers

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.

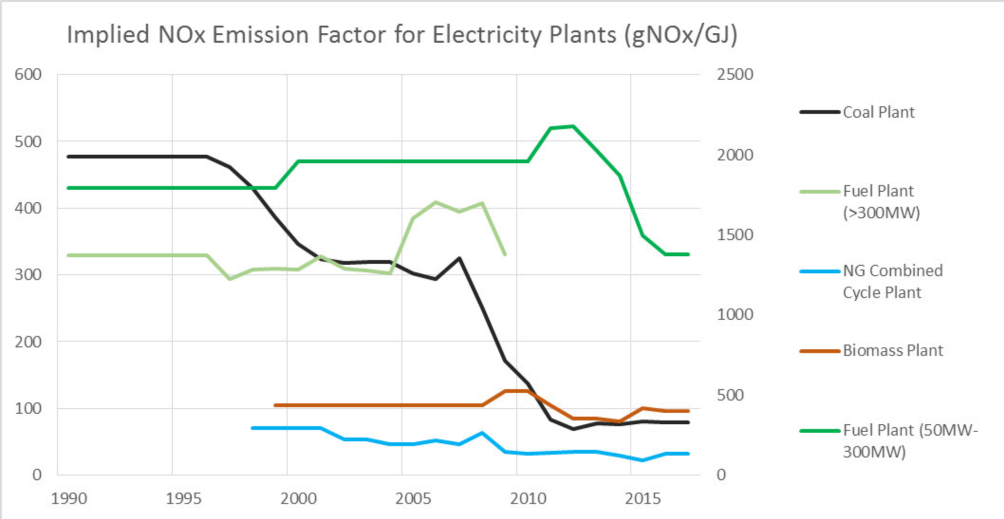


Figure 3-4: Implied Emission Factors for NOx estimated on monitoring by type of Plant

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	As	Cr	Cu	Ni	Se	Zn
Lignite	4.00E-02	3.00E-02	2.00E-02	4.00E-02	0.00E+00	1.00E-01
Hard Coal	1.65E-01	1.20E-01	2.05E-01	2.15E-01	2.00E-02	6.65E-01
Fuel-oil	5.56E-01	1.70E+00	7.41E-01	2.69E+01	6.84E-02	1.90E+00
Orimulsion	5.56E-01	1.70E+00	7.41E-01	2.69E+01	6.84E-02	1.90E+00
Natural Gas a)	3.20E-06	2.24E-05	1.36E-05	3.36E-05	3.84E-07	4.64E-04
LPG	3.20E-06	2.24E-05	1.36E-05	3.36E-05	3.84E-07	4.64E-04
Diesel (GT)	6.38E-02	2.61E-01	6.50E-01	6.00E-02	3.66E-02	4.33E-01
Diesel (Engine)	6.38E-02	2.61E-01	6.50E-01	6.00E-02	3.66E-02	4.33E-01
Biomass	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 (mg/GJ)

Fuel	Pb	Cd	Hg
Lignite	15.00	1.80	2.90
Hard Coal	7.30	0.90	1.40
Fuel-oil	4.56	1.20	0.34
Orimulsion	4.56	1.20	0.34
Natural Gas	0.0015	0.00025	0.10
LPG	0.0015	0.00025	0.10
Diesel	4.07	1.36	1.36
Biomass	20.60	1.76	1.51

EMEP/EEA Guidebook 2016: Energy Industries – Table 3.3

Table 3-7: 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.

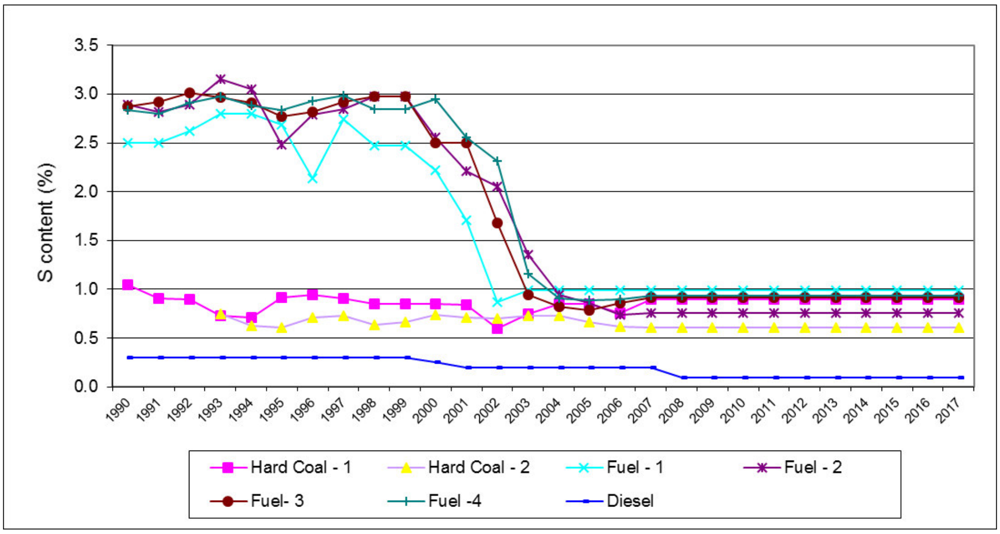


Figure 3-5: Trends of sulphur content by fuel type[4]

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 3-8: 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

[4] Power plants are denominated by number and not by name due to confidentiality constrains
[5] Power producers as main activity only.

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

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 3-10: 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

Table 3-11: Emission Factors for non public co-generation self producers. Ozone Precursors gases and other pollutants

Fuel	NO_x g/GJ	NMVOC g/GJ	CO g/GJ	S %
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 3-12: Emission Factors for non public co-generation self producers. Particulate Matter

Fuel	PM g/GJ	PM_{10} %	$PM_{2.5}$ %	BC % $PM_{2.5}$
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 3-13: 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 3-14: Emissions factors of Dioxins/Furans and PAH for for non public co-generation self producers

Fuel	DioxFur microg TEQ/TJ	PAH 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];
- 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:

$$\text{Energy (GJ)} = \text{Consumption (t/year)} * \text{LHV (MJ/kg)}$$

or

$$\text{Energy (GJ)} = \text{Consumption (Nm3/year)} * \text{LHV (MJ/Nm3)}$$

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.

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

Table 3-15: 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 fugire below.

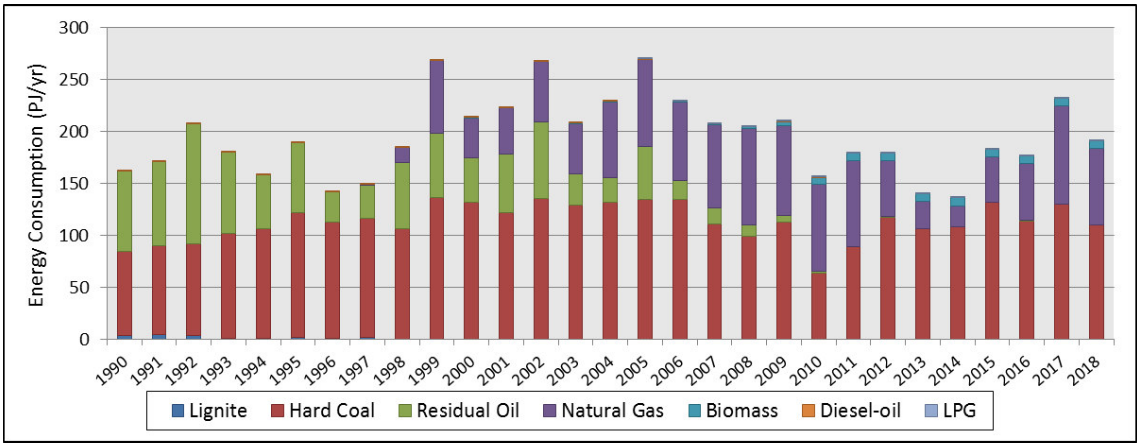


Figure 3-6: Trends of fuel consumption per fuel type

Not visible in the graph is the increase in biomass consumption (wood waste) from 2000 to 2018 (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

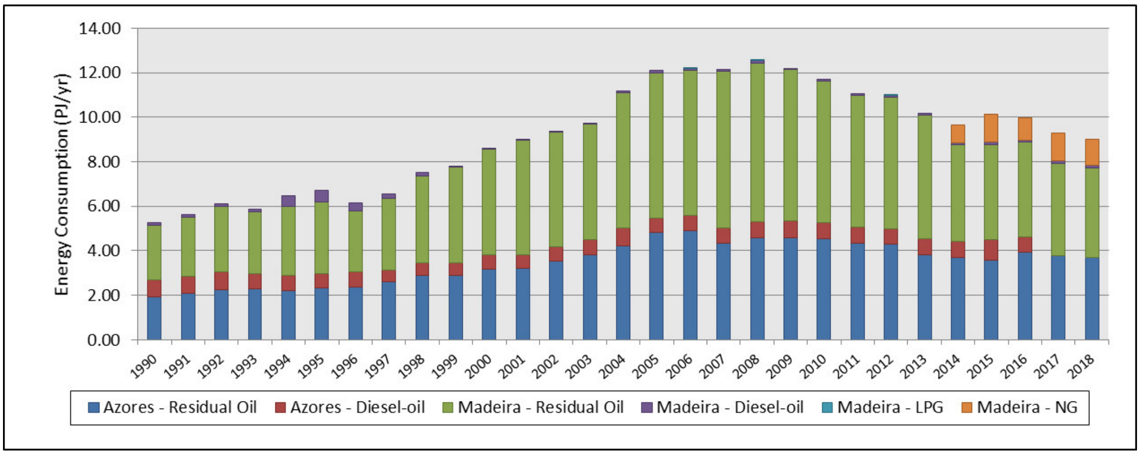
Values for the total lime consumed for desulphurization in each plant were obtained in the EU-ETS. For confidential reason, there are only two plants in Portugal that use this king of abatement system, the $CaCO_3$ consumption cannot by reported.

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 ources:

- 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 3-16: 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.

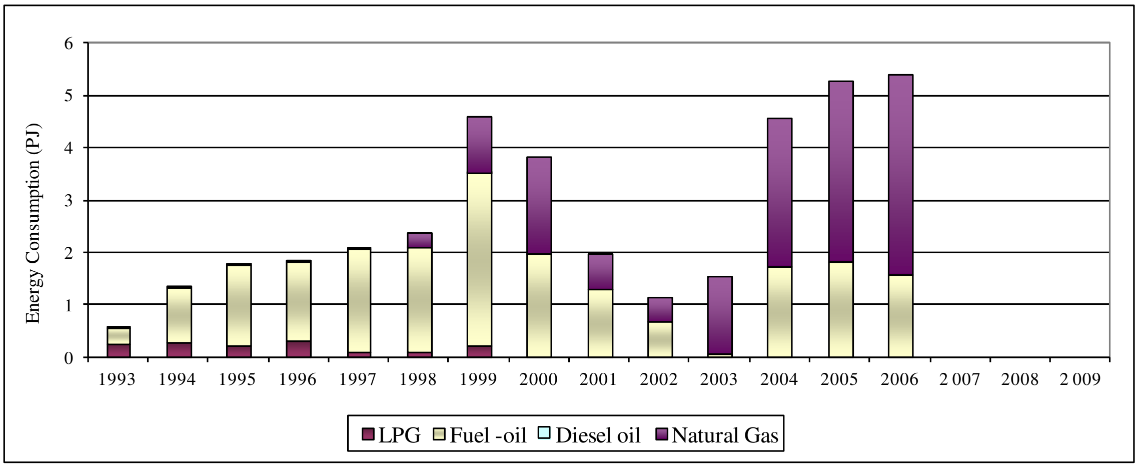


Figure 3-8: Trends in consumption of fuels in non-public co-generation plants

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.

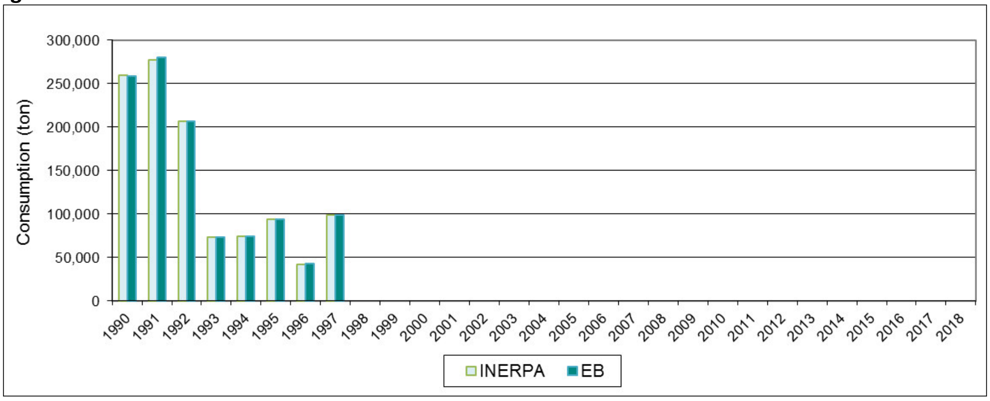
Table 3-17: LHV per fuel type used for non-public co-generation plants estimates

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

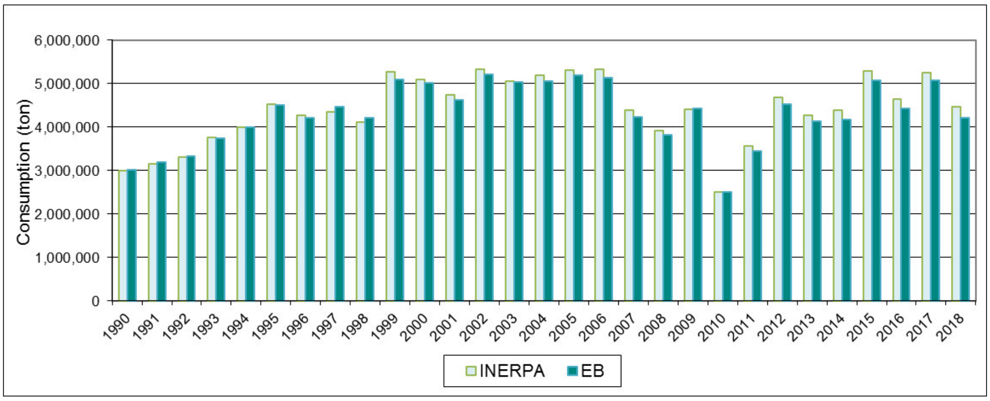
3.2.1.4.5 Comparison of LPS data vs. National Statistics

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.

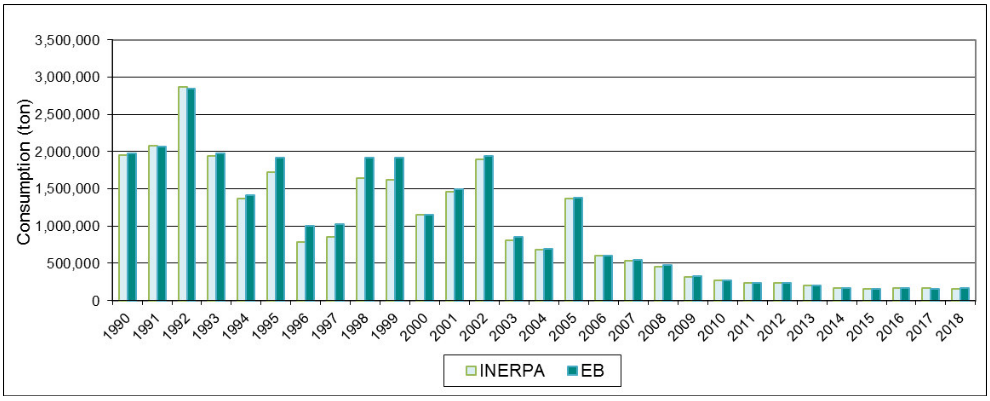
Lignite



Hard Coal



Residual Fuel Oil



Natural Gas

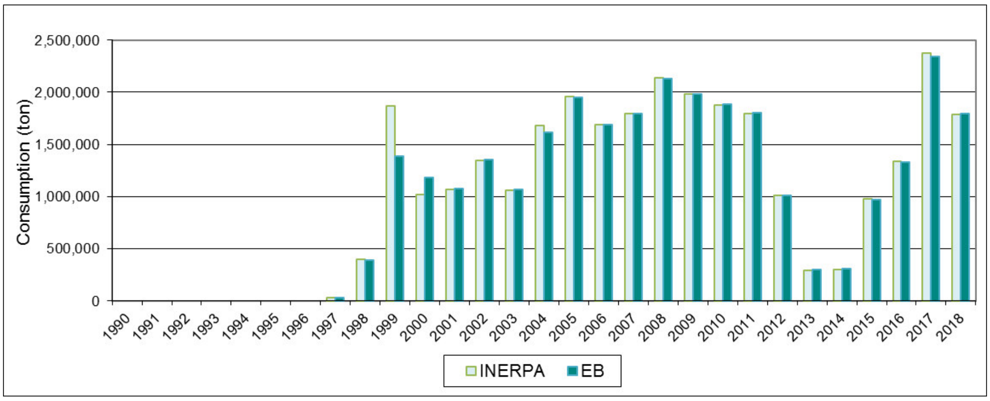


Figure 3-9: Comparison of total fuel consumption in large power plants, between values used in the inventory (INERPA) and in the Energy Balance

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 2016, is shown in the figure below.

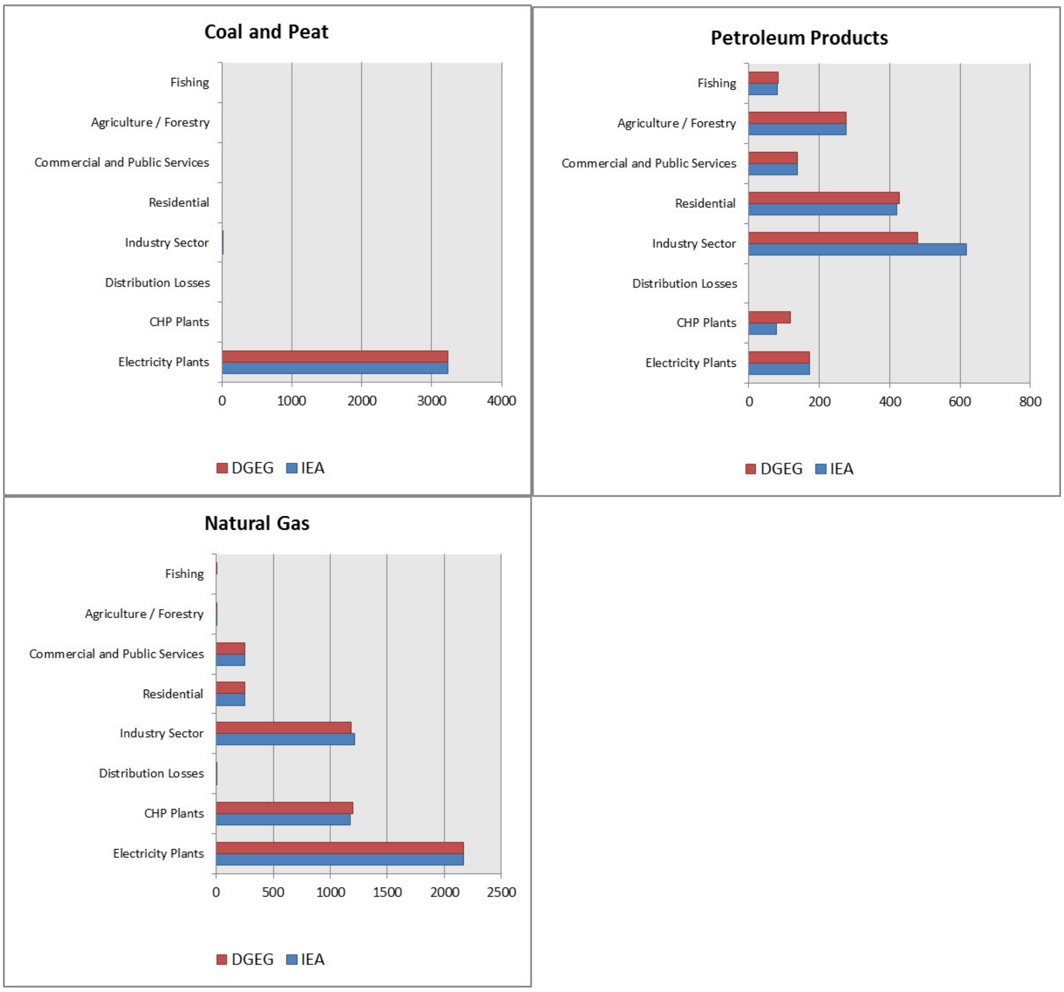


Figure 3-10: Comparison of fuel consumption between DGEG energy balance and IEA energy statistics

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

Pb, Cd and Hg emission factors were updated for the whole time series. During the 2019 edition of Review NECD, it was identified by TERT that the ratio between Cd, Hg, Pb and PM10 emissions for Portugal was significantly higher than the ratio of other member states.

The last submission emission factors were based on the AP-42 guidelines. Portugal considered that these emission factors were outdated update them to the latest version of the Guidebook EMEP / EEA 2016. The figure below summarizes the differences between last submission and the previous year's submission for category 1A1a.

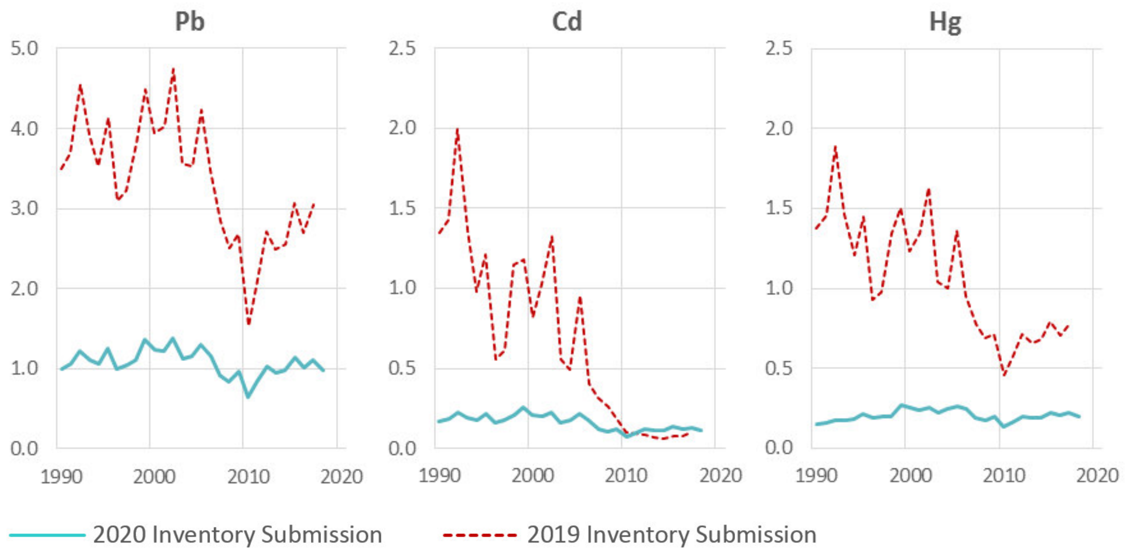


Figure 3-11: Emissions of Pb, Cd and Hg by Inventory version for NFR 1.A.1.a (ton)

The use of the new emission factors resulted in a generalized reduction of emissions for these three pollutants, with the differences in the total emissions of category 1.A.1.a of the series between 1990 and 2017 to be at -67.7% for Lead, -75.6% for Cadmium and -80.8% for Mercury. These recalculations had significant impacts on national totals, in particular for Cadmium and Mercury emissions.

Table 3-18: Recalculated data for category Public Electricity and Heat Production (NFR1A1a)

		Previous submission	Latest submission	Difference	Difference	Impact on total emissions
		1.A.1.a Emissions (t)			%	
1990	Pb	3.50	1.00	-2.50	-71.4	-0.4
2005	Pb	4.23	1.30	-2.93	-69.2	-7.0
2017	Pb	3.04	1.12	-1.93	-63.3	-4.9
1990	Cd	1.35	0.17	-1.18	-87.2	-48.6
2005	Cd	0.96	0.22	-0.74	-77.2	-29.9
2017	Cd	0.10	0.13	0.03	34.8	1.7
1990	Hg	1.38	0.15	-1.22	-89.0	-56.1
2005	Hg	1.36	0.26	-1.10	-80.7	-60.1
2017	Hg	0.78	0.22	-0.55	-71.2	-37.9

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. After 1993, the Lisbon unit was closed for most of its activity and only two units remain now in operation.

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.

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 3-19: 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.

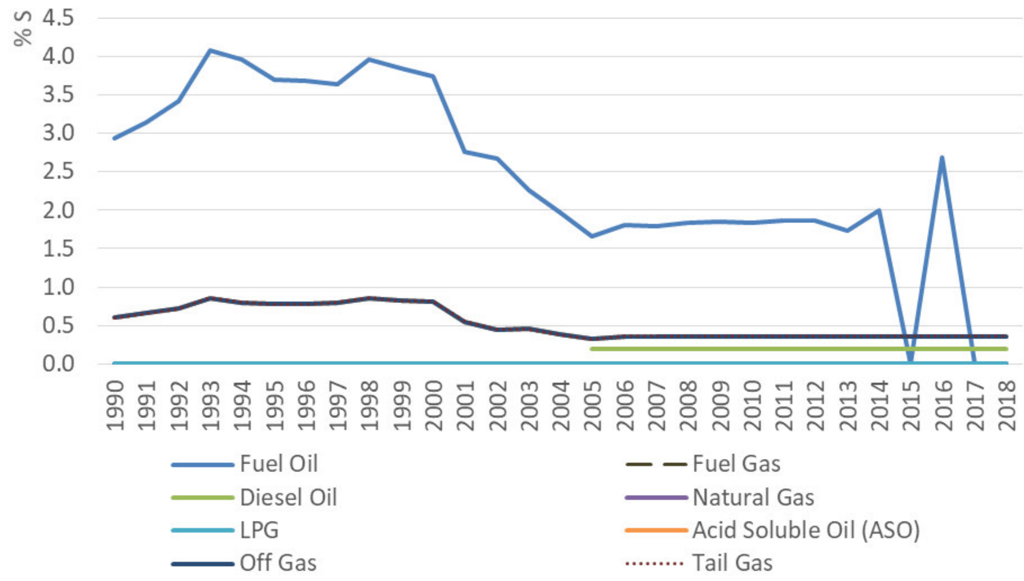


Figure 3-12: Trends of sulphur content

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.

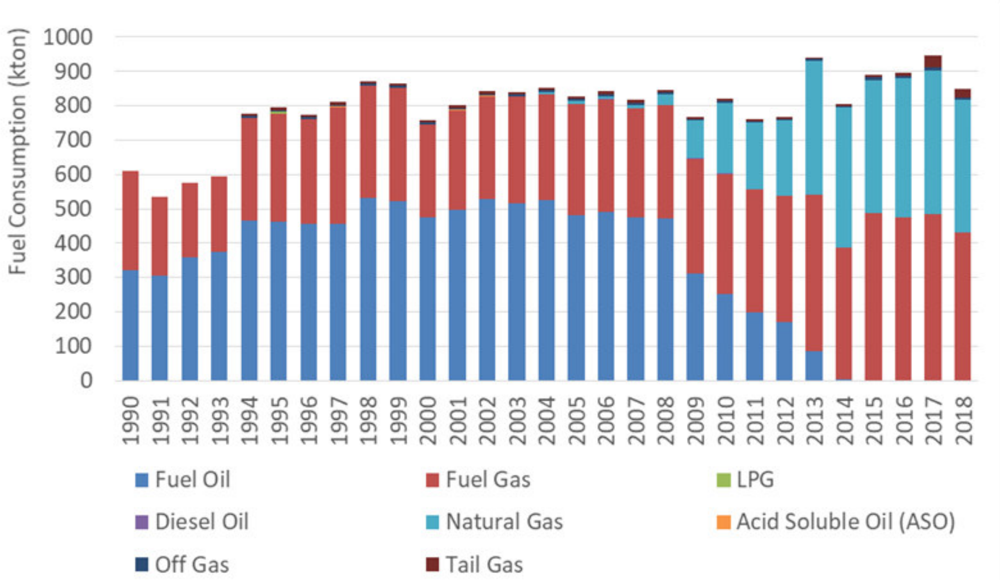


Figure 3-13: Fuel consumption

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.

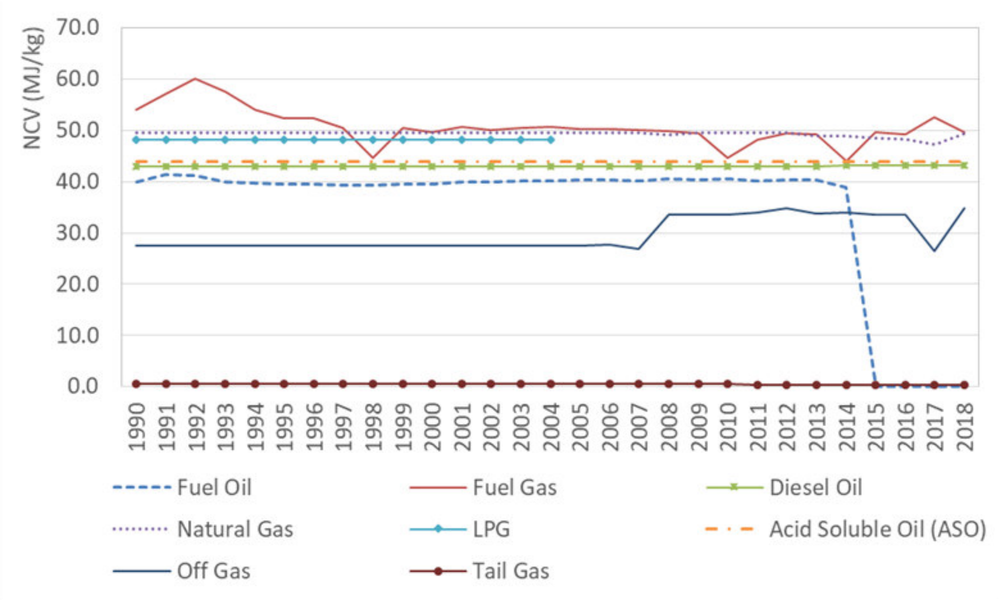


Figure 3-14: Net Calorific Value (NCV) or Low Heating Value (LHV) expressed in MJ/ kg by type of equipment

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 section 4.4.1.1 of the IPPU chapter). Coke gas was the only fuel combustion used as energy source in the coke plant;
- Combustion emissions done for the production of city gas that was consumed in the city of Lisbon. This activity was 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:

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

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:

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

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:

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

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 3-20: 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 3-21: 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/km^3

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.

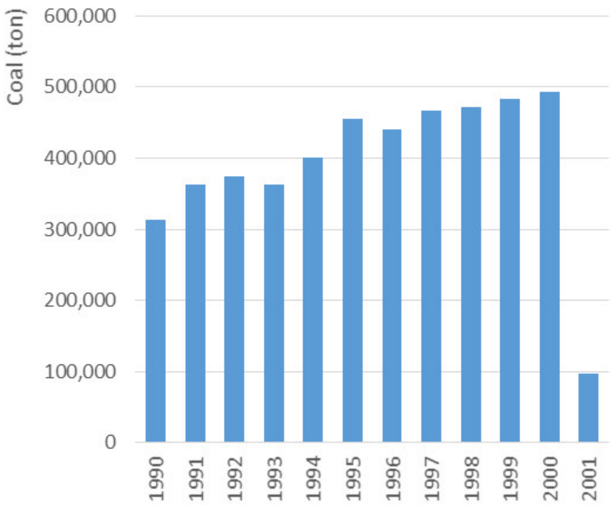


Figure 3-15: Coking coal consumption in the coke plant

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.

[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.

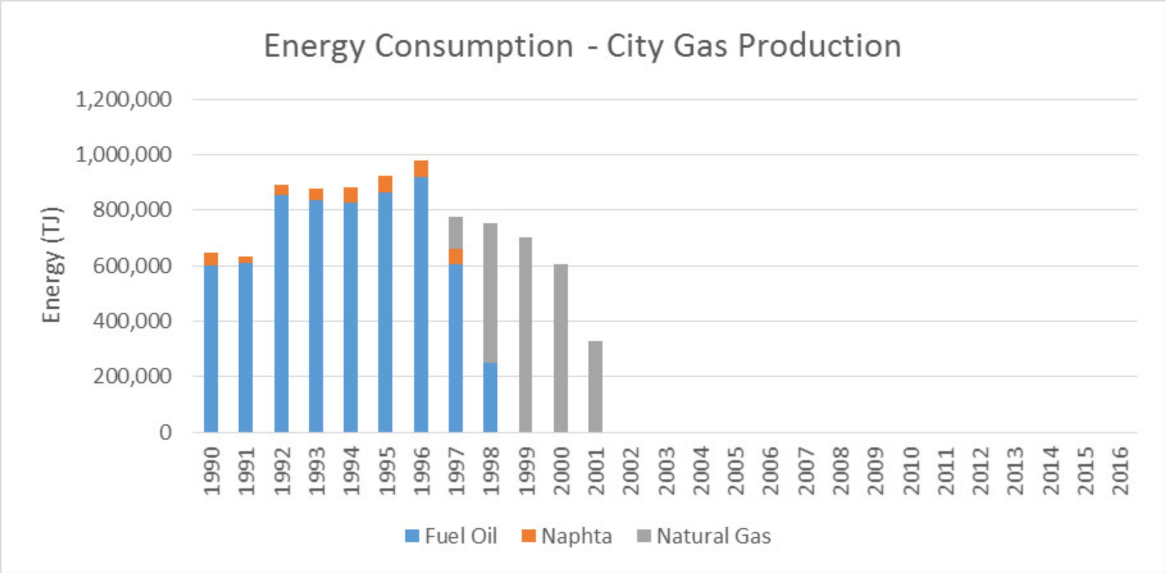


Figure 3-16: Consumption of fuels in co-generation in city gas production

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

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

Table 3-22: 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.

Regarding coke production emissions, there are major differences between submissions, related with methodological developments. We now apply a Tier 2 approach of section 5.4.3 of chapter 1.A.1 Energy Industries of the 2019 EMEP Guidebook, using coal consumption as activity data.

There were also several updates to the emission factors applied to air pollutants. We now use Tier 2 emission factors from 2019 EMEP Guidebook, given that we consider them to be more in line with national circumstances throughout the time series. This resulted in major decrease in emissions from SOx. On the other hand, there are relative increases in emissions from NOx, NMVOC, CO, particulate matter, heavy metals, PCDDs and PAHs. In the figures below it is possible to consult the graphic representation of recalculations for some pollutants for the whole recalculated series (1990-2001).

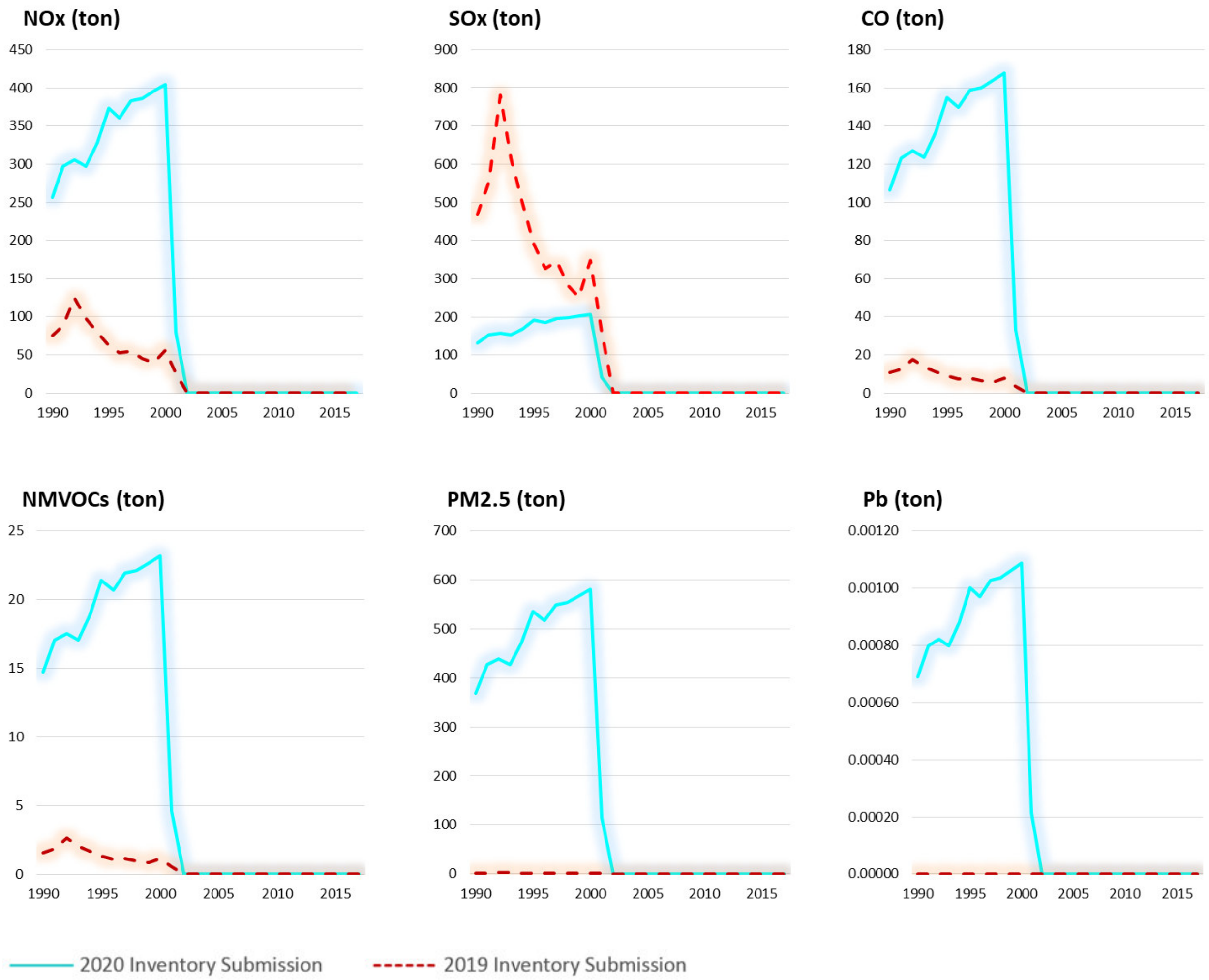


Figure 3-17: Recalculations in emissions from coke production

3.2.3.6 Further Improvements

No further improvements are expected.

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 decarbonising in the cement and glass industries, which are covered under production processes (Chapter 4.2.A). 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´s 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 estimated 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;
- With the pure gas oil and the pure biodiesel values an incorporation rate was derived;

[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.

- 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 2006-2018.

Table 3-23: Incorporation rate of biodiesel (% toe/toe)

	2006	2007	2008	2009	2010	2011	2012
Incorporation rate	1.31	2.50	2.43	4.16	6.03	6.25	6.22
	2013	2014	2015	2016	2017	2018	2019
Incorporation rate	6.05	5.90	6.75	5.14	5.10	5.49	n.a.

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;
- since the 2009 inventory from EU-ETS.

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).

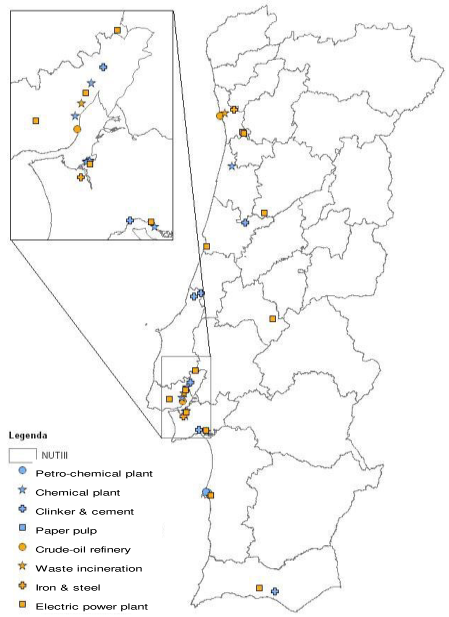


Figure 3-18: Distribution of Large Point Sources in Portugal mainland[14]

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].

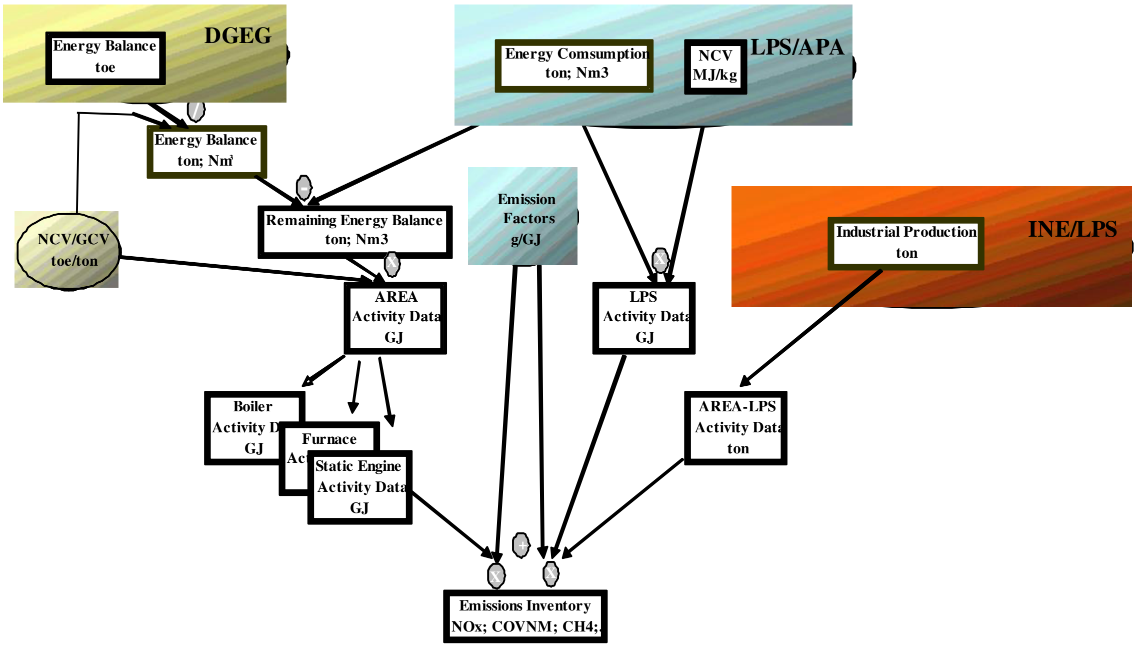


Figure 3-19: General procedure for emissions estimate

Characterization of the combustion equipments was also taken from LPS sources, as well as some characteristics of the fuels. For the non LPS sources, or the remaining energy consumed that are accounted in the energy balances, there is no detailed information about in which equipment combustion takes place, apart from division between co-generation and non co-generation. Hence separation of fuel consumption among boilers, furnaces and engines was made by expert judgment according to each economic sector, and also considering that the original data of fuel consumption in the DGEG's energy balances make a separation between quantities used in co-generation and quantities used without co-generation.

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 2018 is presented in Annex B.

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

Table 3-24: 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 3-25: 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
Electr city	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 3-26: 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

Sub sector	EAC (1977)
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.

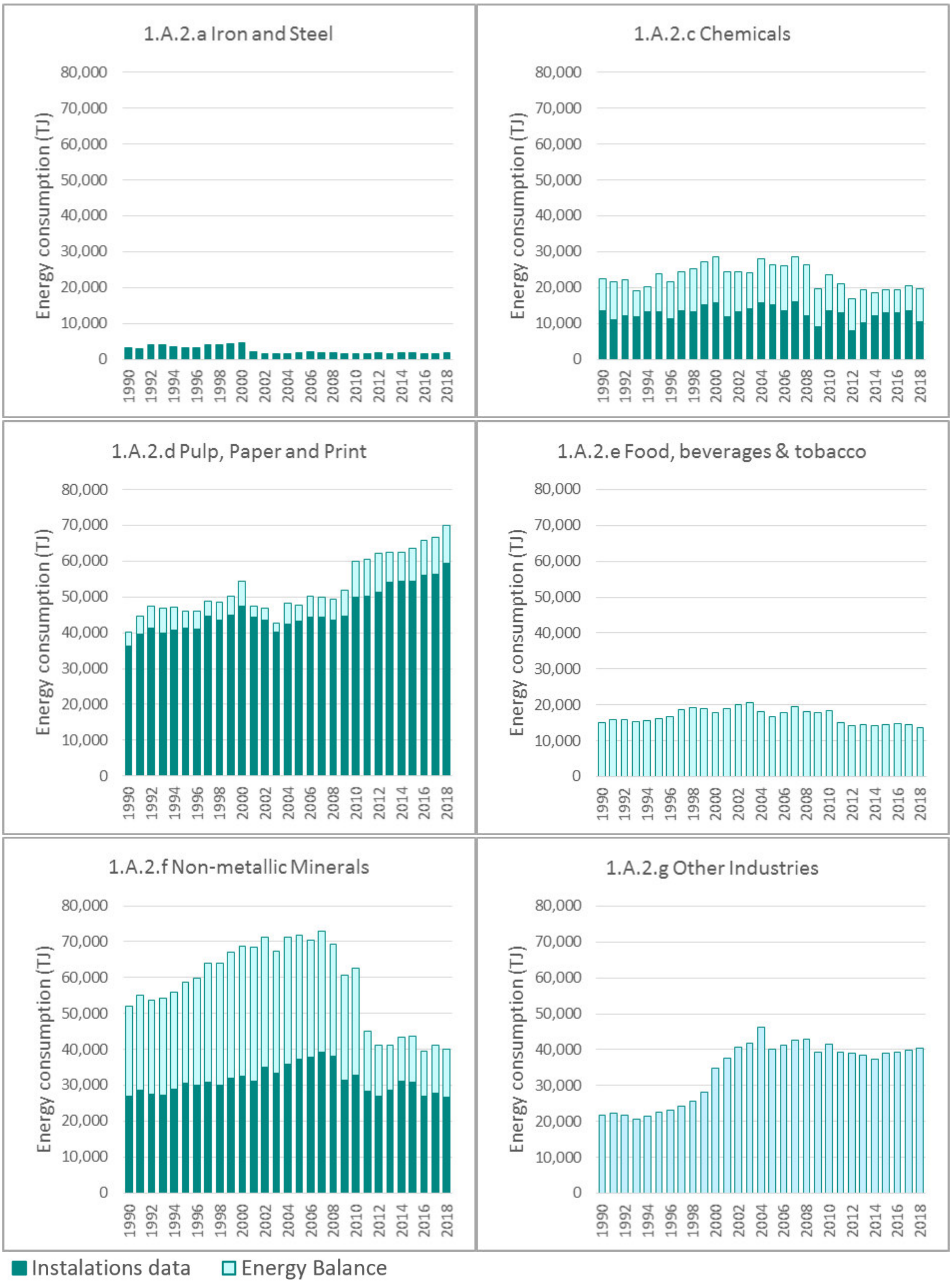
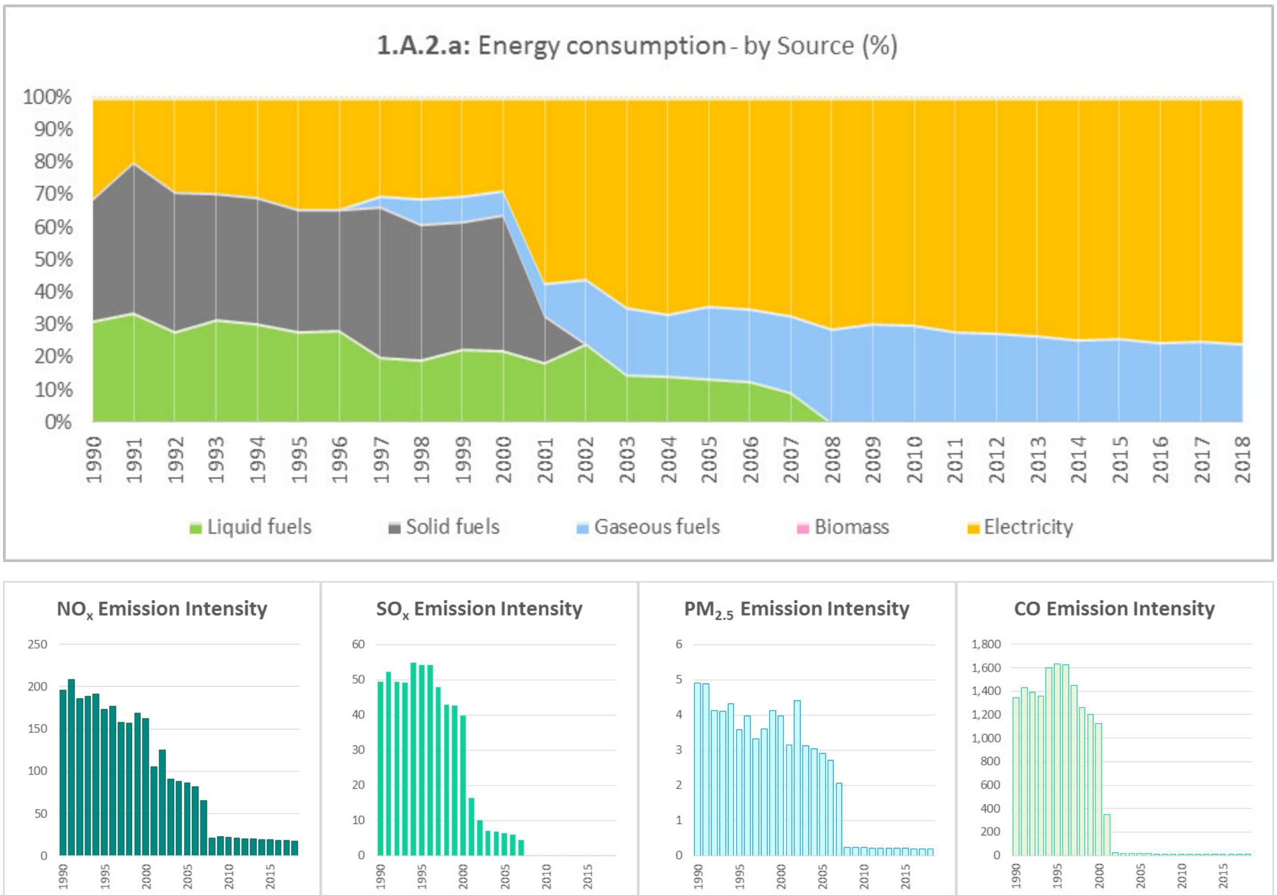


Figure 3-20: Total Energy Consumption in Manufacturing Industries and Construction

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.



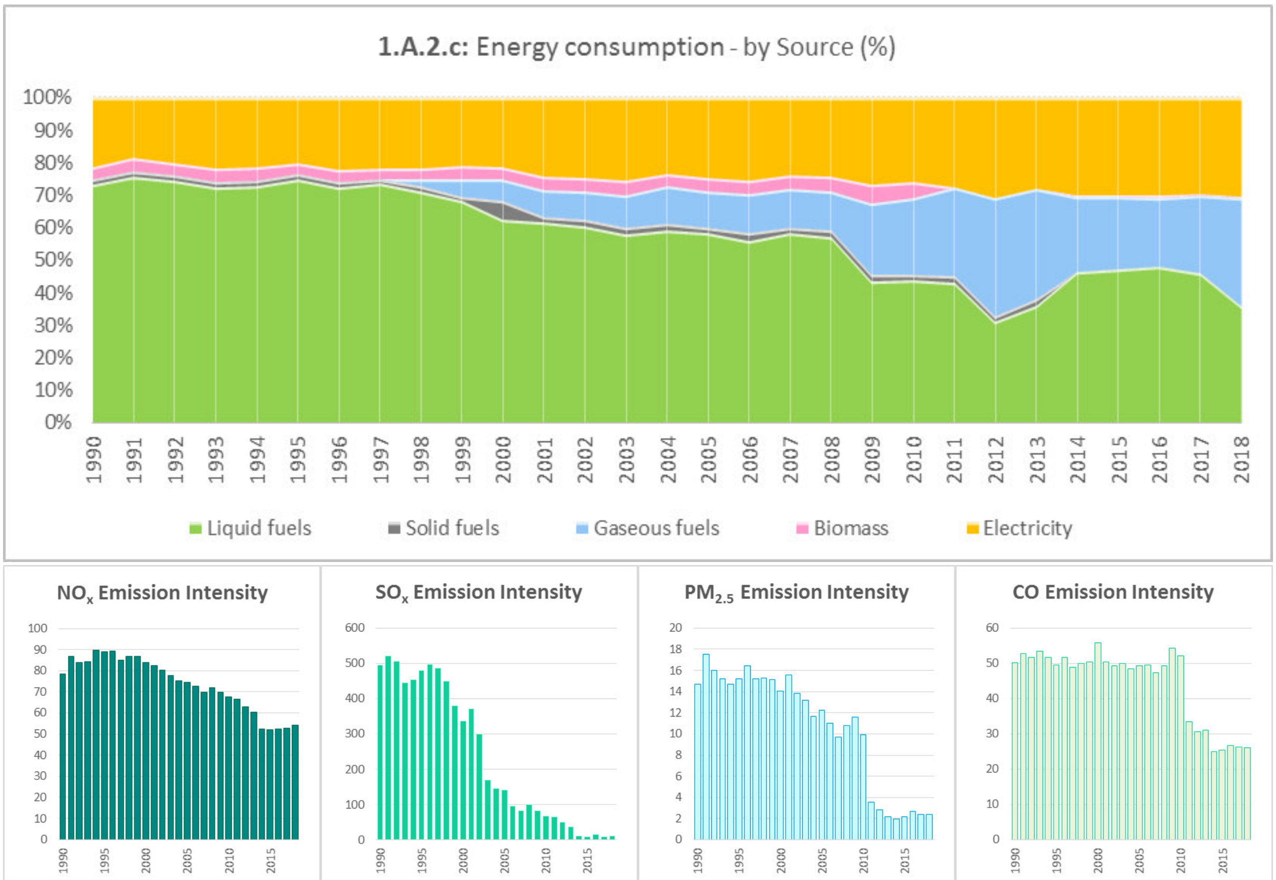
Emission Intensity [ton of pollutant emission/TJ of Energy consumption] is estimated considering the total emissions (NO_X, SO_X, $PM_{2.5}$ and CO) reported in category *1.A.2.a Iron and Steel* in relation to the total energy consumed (fossil fuels, biomass and electricity)

Figure 3-21: 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)

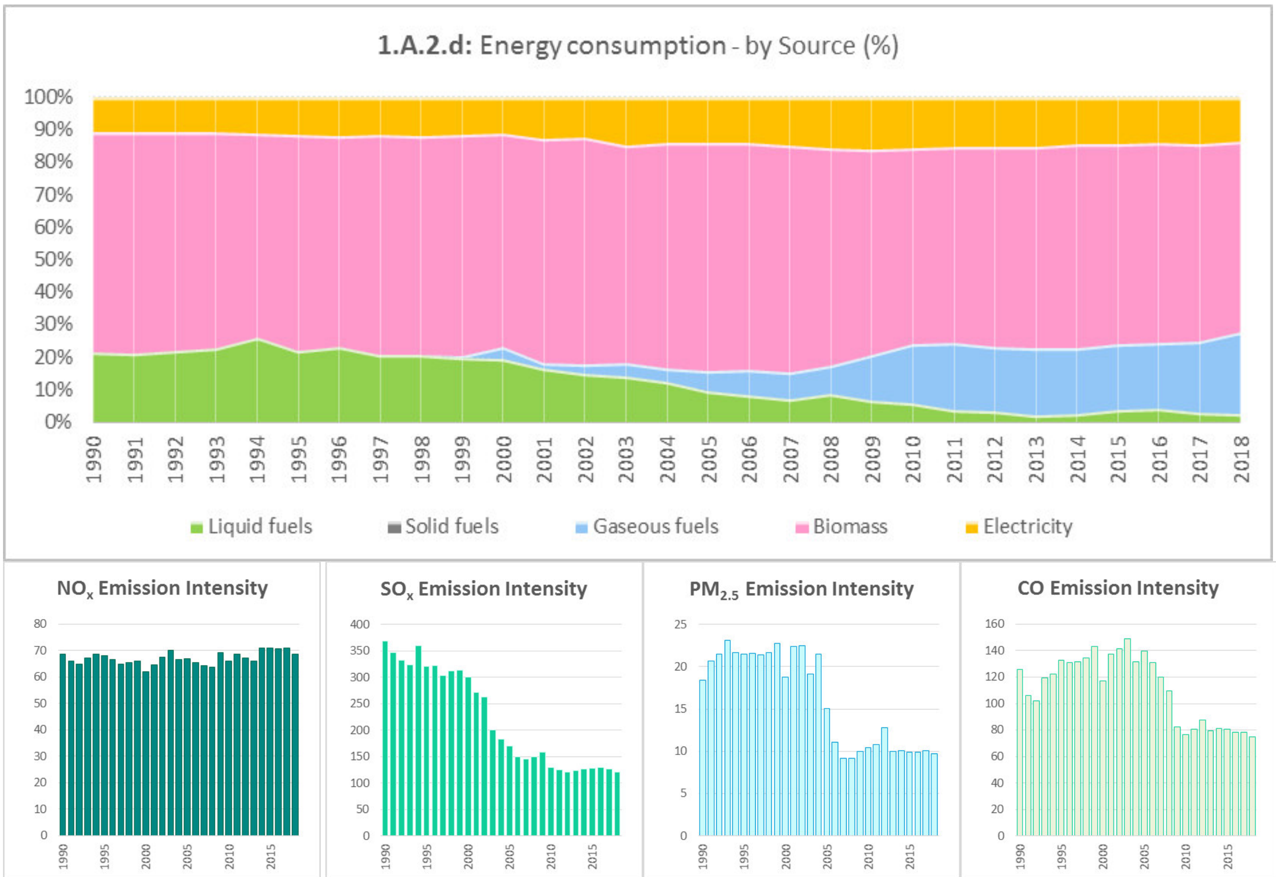
Figure 3-22: Share of energy consumption by source & Greenhouse gases emissions intensity

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.



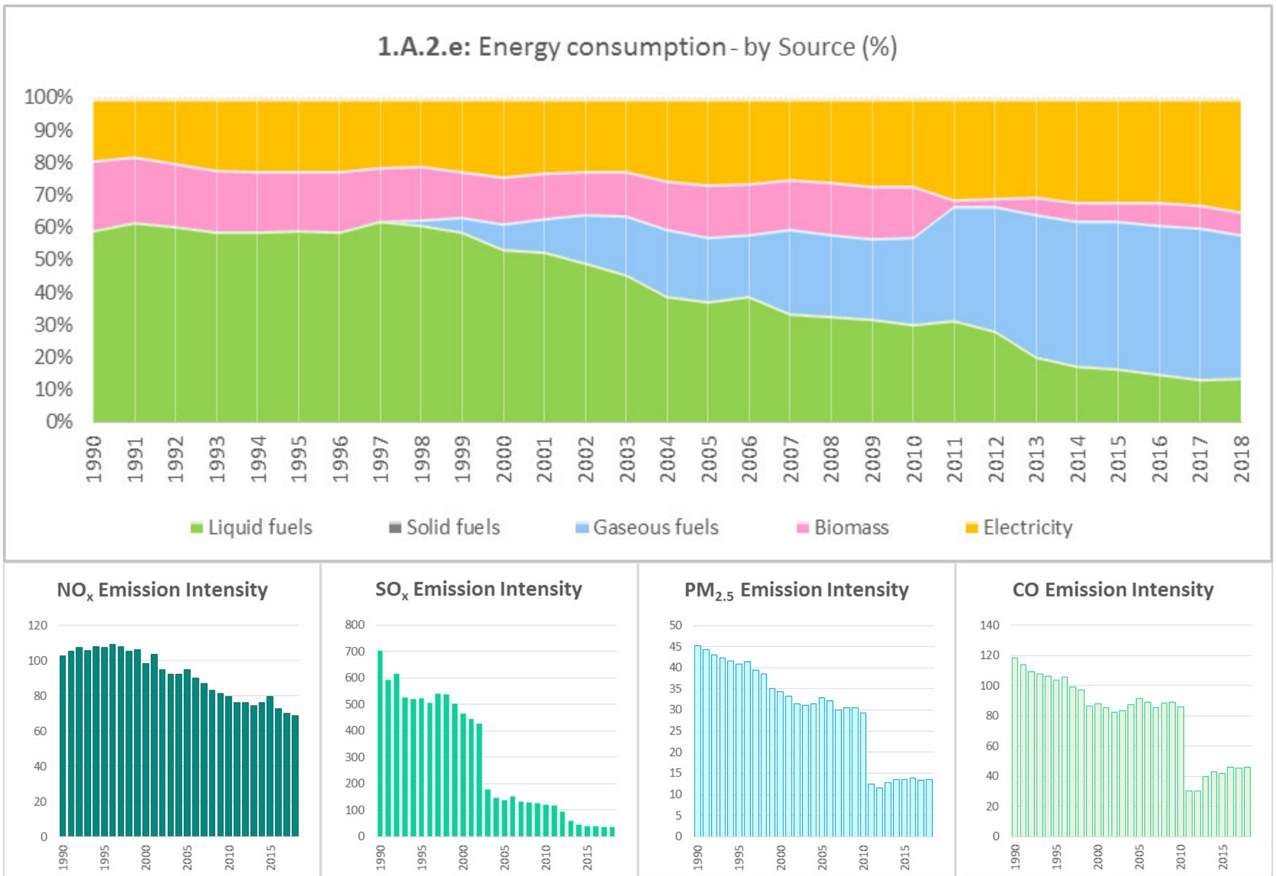
Emission Intensity [ton of pollutant emission/TJ of Energy consumption] is estimated considering the total emissions (NO_x, SO_x, $PM_{2.5}$ and CO) reported in category *1.A.2.d Pulp, Paper and Print* in relation to the total energy consumed (fossil fuels, biomass and electricity)

Figure 3-23: 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 2018 is twice as high as in 1990, and is now responsible for around 30% of total energy consumption.



<u>**Emission Intensity**</u> [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 3-24: 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 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.

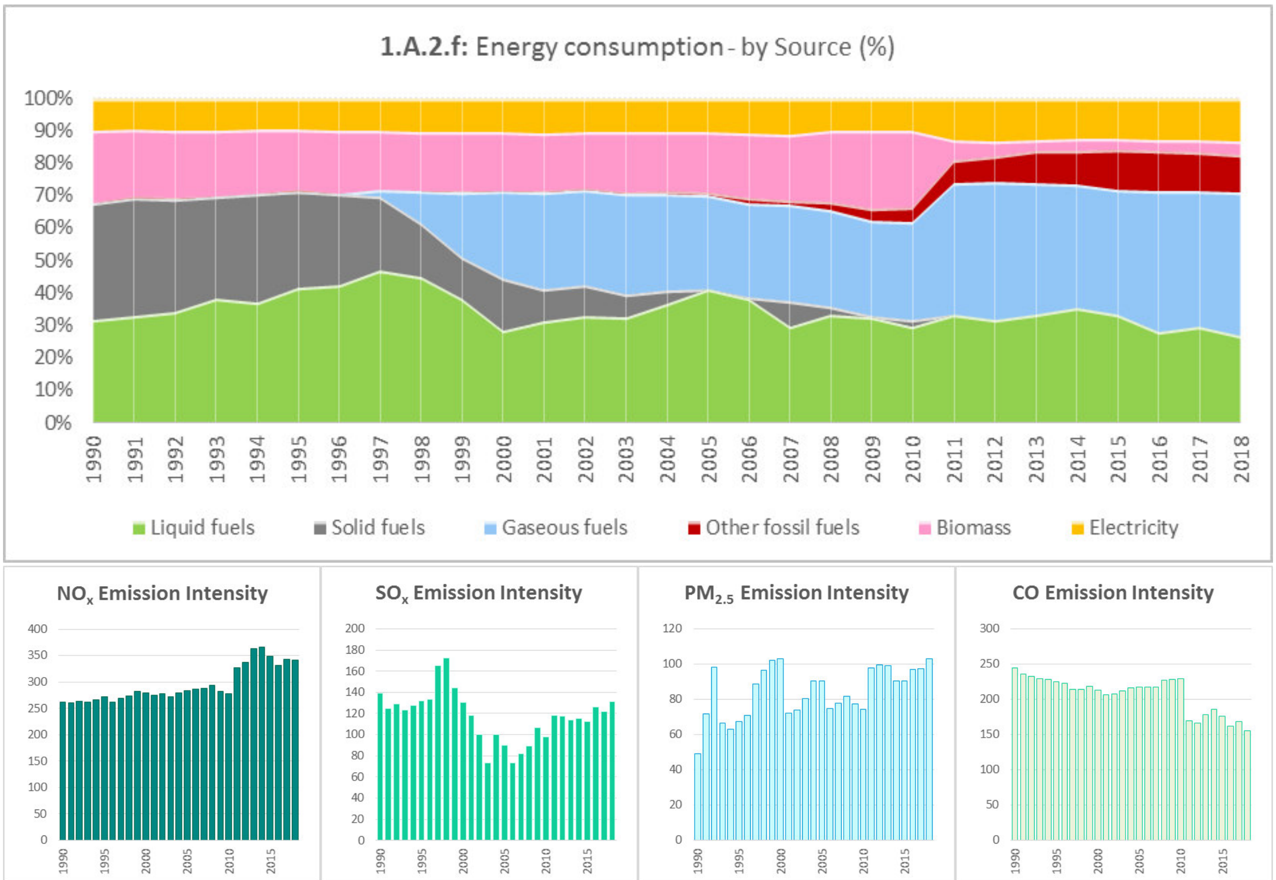
3.3.2.2.5 Non-metallic Minerals

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 3-25: 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.

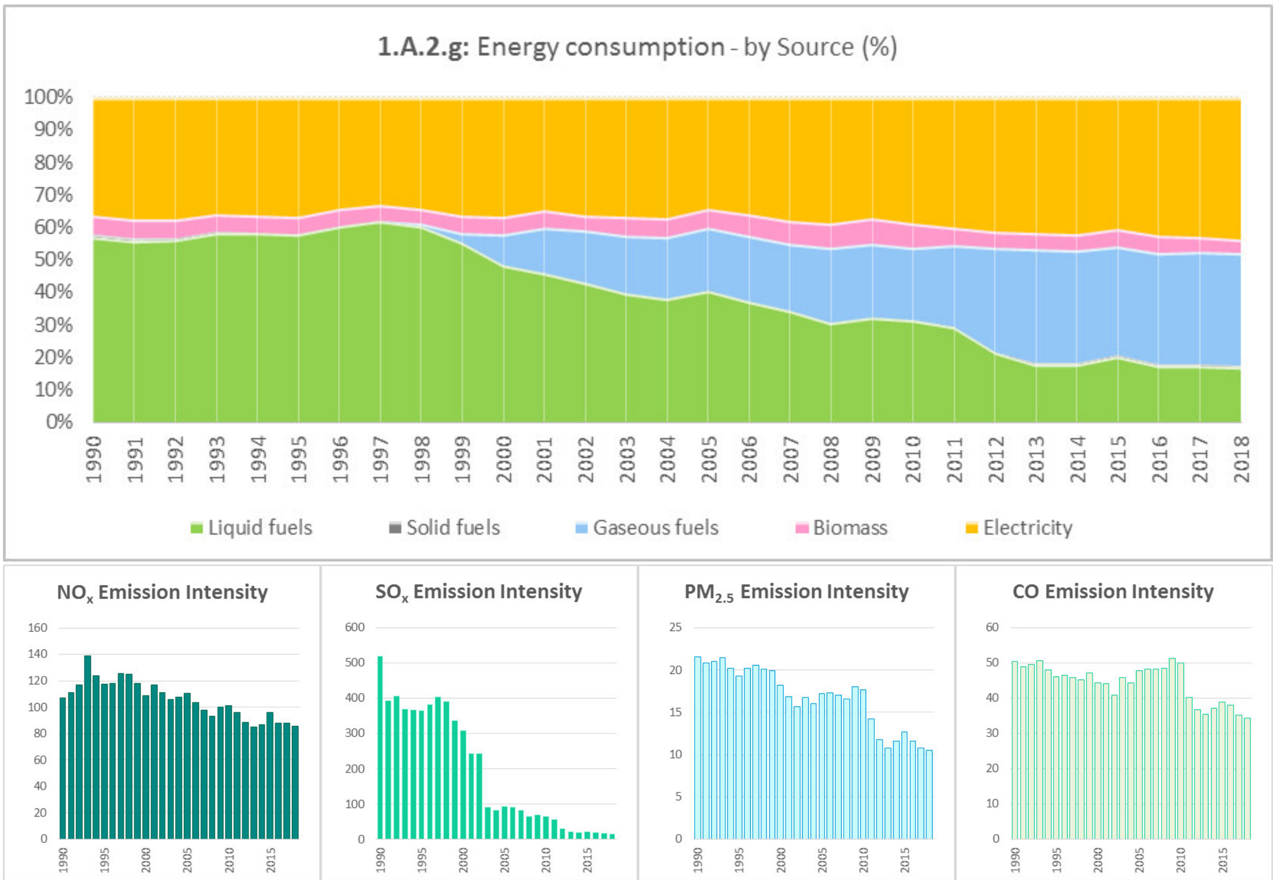
$PM_{2.5}$ emissions originate predominantly in the Ceramics Industry, and are associated with the combustion of wood and wood products. The variations in the emission intensity along the time series are related to the variations in the energy consumption of biomass.

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

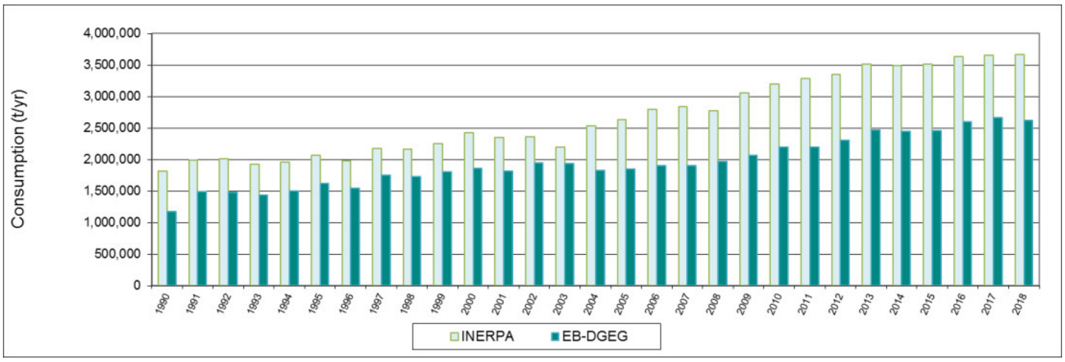
The transition from petroleum-based fuels (fuel oil and diesel oil) to natural gas is the driver of the trend towards reducing NOX Emission Intensity. This transition is also responsible for the downward trend seen in other pollutants. However, occasional episodes are responsible for abrupt breaks in 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

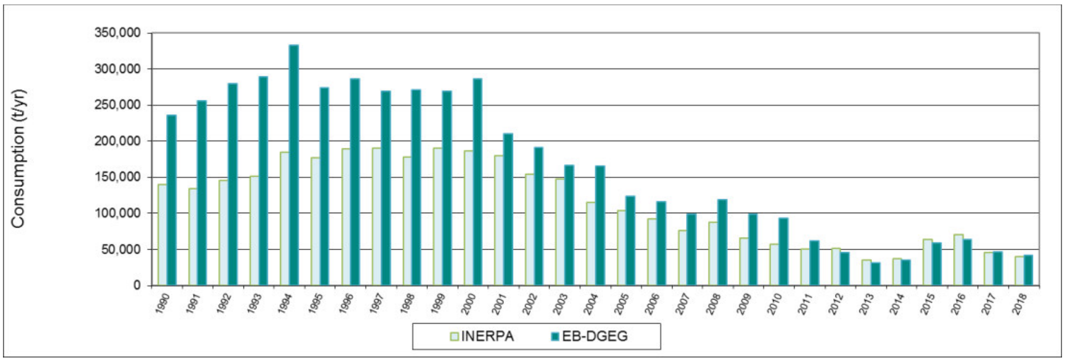
Total consumption in LPS per sector was compared with the correspondent value in the Energy Balance for the most important fuels, in order to verify the applicability of the methodology in use, which mixes a top-down approach (EB) with a bottom-up approach (LPS data). The following figures present the 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).

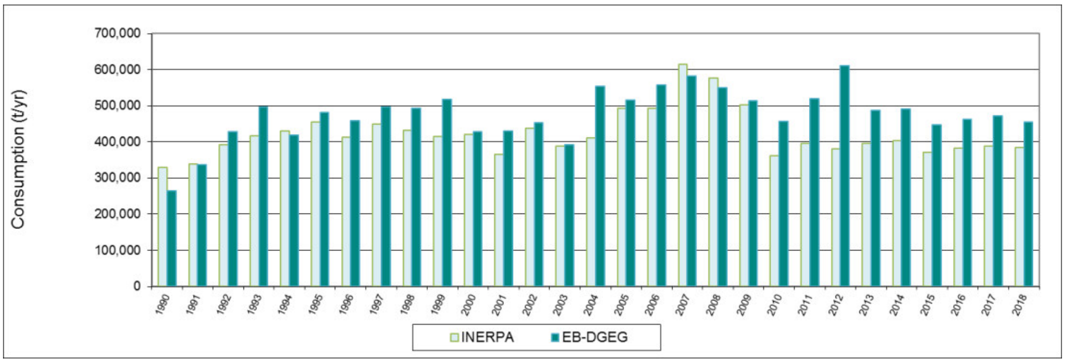
Black Liquor



Residual Fuel Oil



Biomass



Natural Gas

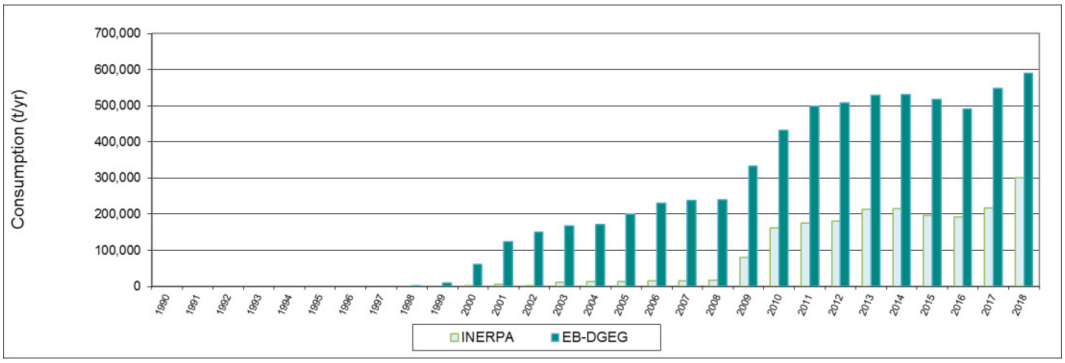


Figure 3-27: Comparison of total LPS consumption in Paper Pulp units with the reported consumption in the EB for the sector "Paper pulp and paper production"

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.

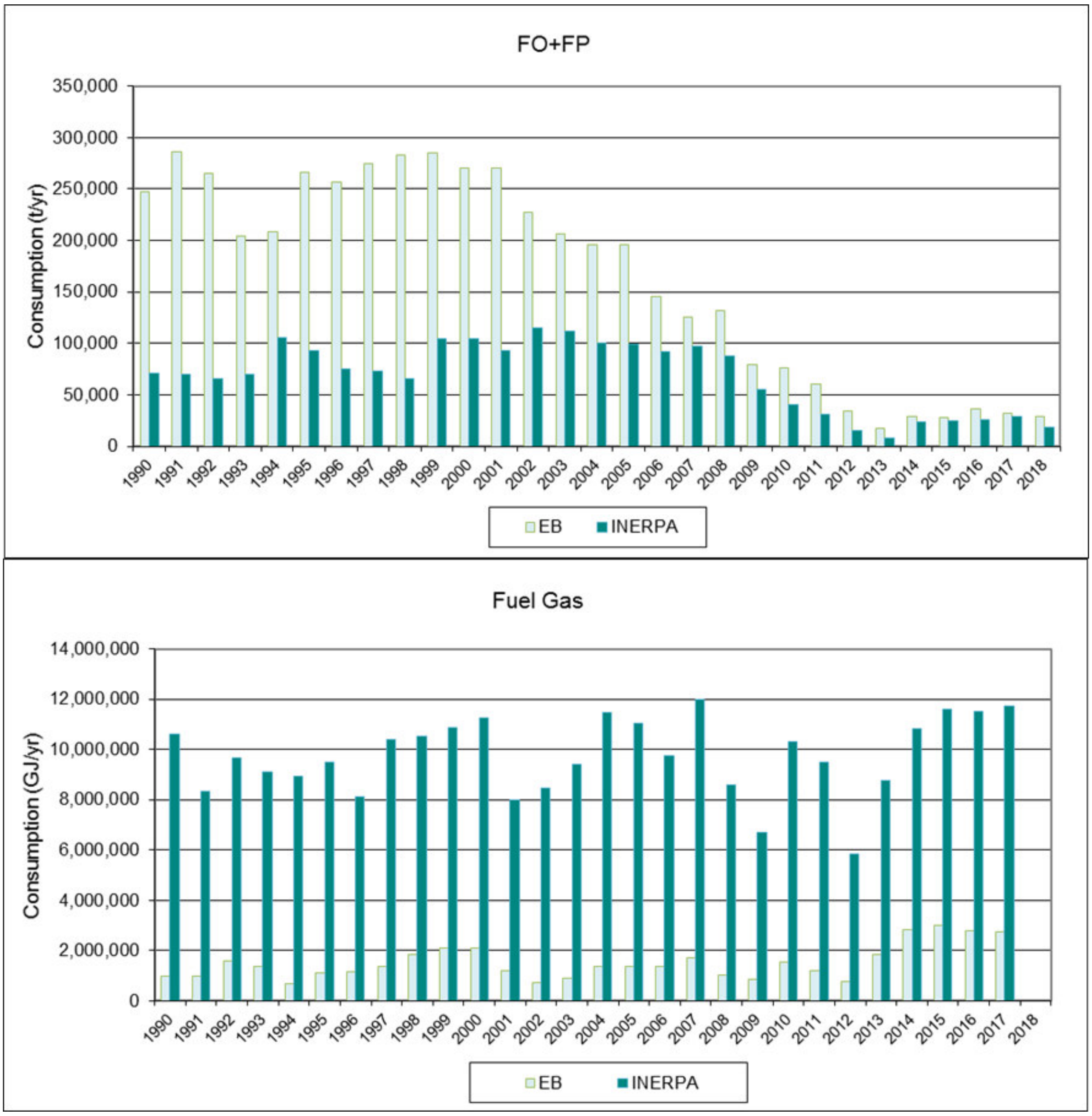


Figure 3-28: Comparison of total LPS consumption in Petrochemical units with the reported consumption in the EB for the sector "Chemical and Plastics" [16]

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 considenciality 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.

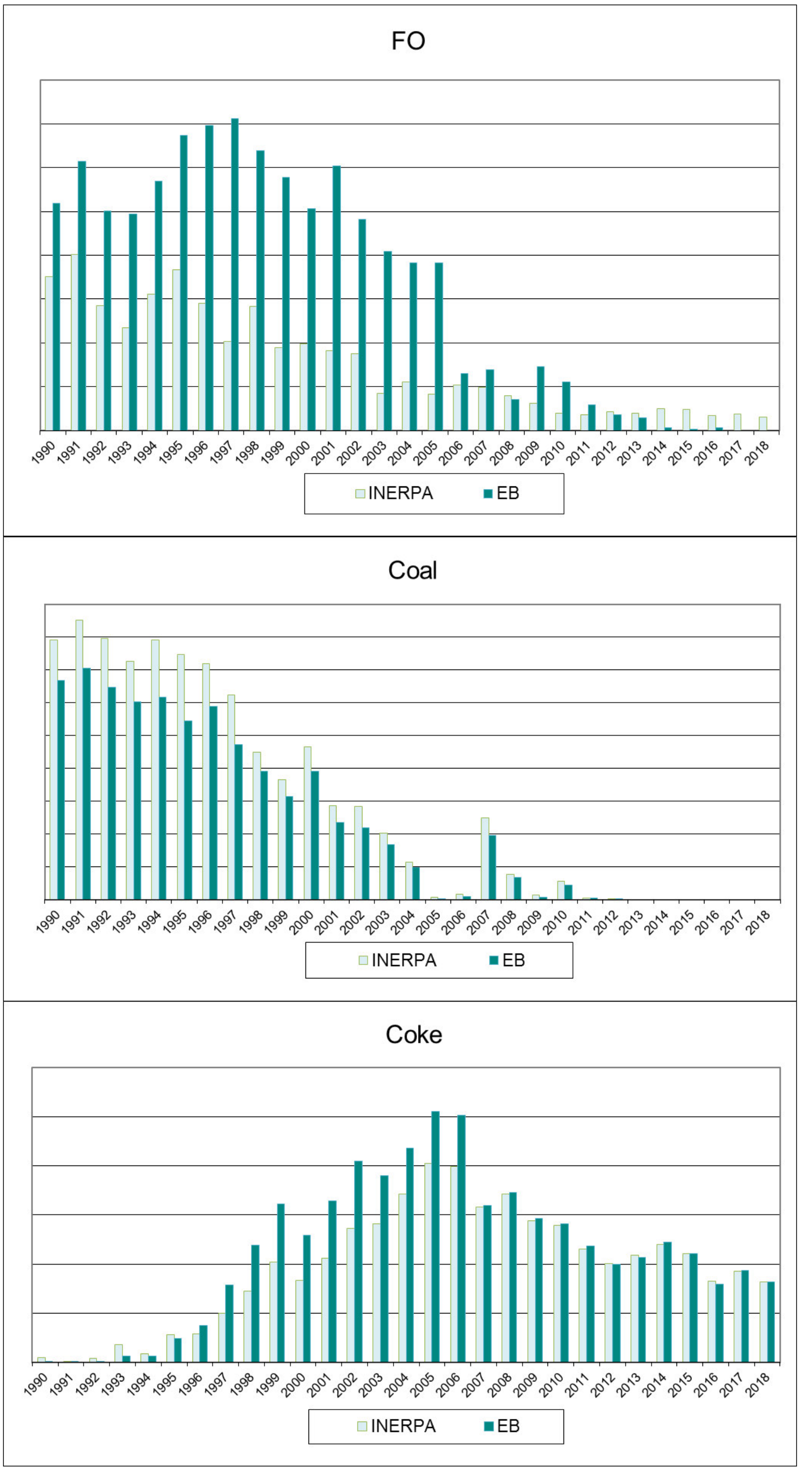


Figure 3-29: Comparison of total LPS consumption in Cement Plant with the reported consumption in the EB for the sector "Cement and Lime" (Due to confidentiality issues y axis values are not shown)

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 3-27: Total Paper Pulp Production (Kraft and sulphide paper pulp)

Product	Unit	1990	2005	2016	2017	2018
Pulp Production	kt	1,398	2,010	2,729	2,754	2,773

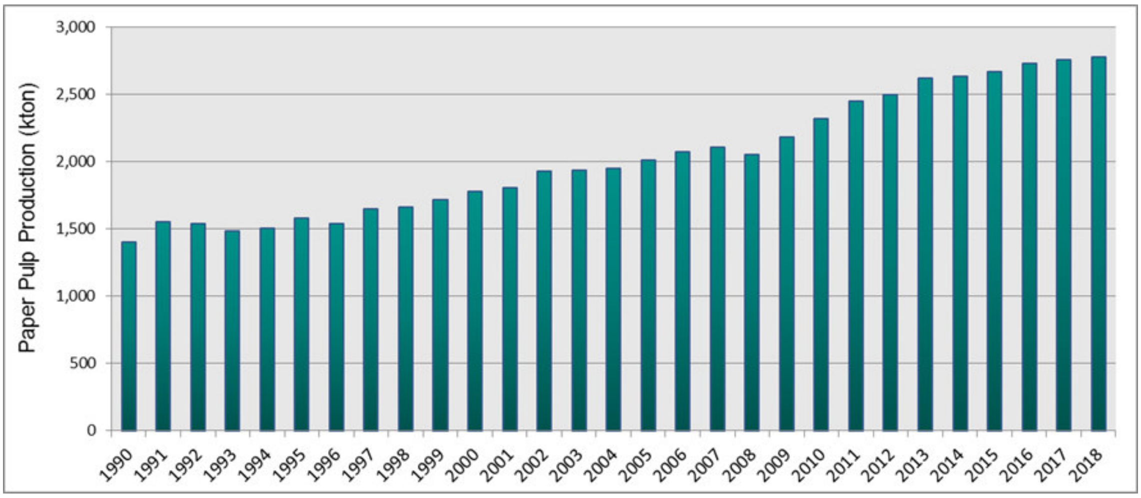


Figure 3-30: Total paper pulp production: Kraft and sulphide paper pulp

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 2018 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 3-28: Ceramic Production according to type of ceramic (kt)

Product	Unit	1990	2005	2016	2017	2018
Bricks & roof tiles	kt	2,290	3,923	1,342	1,521	1,659
Tiles & other const	kt	478	1,327	853	930	999
Refractory	kt	31	100	24	16	16
Other ceramic	kt	104	278	376	397	395

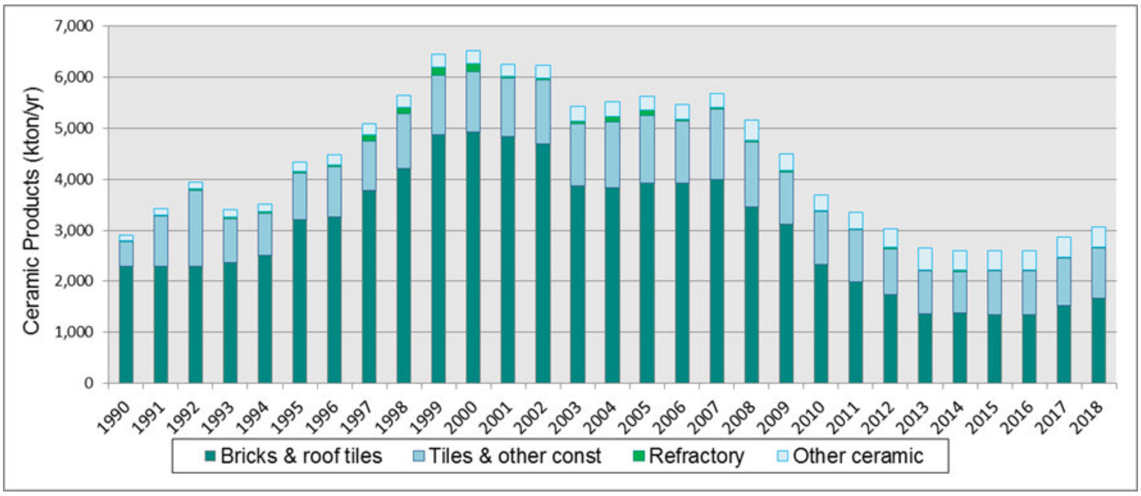


Figure 3-31: Ceramic Production by type of ceramic

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.

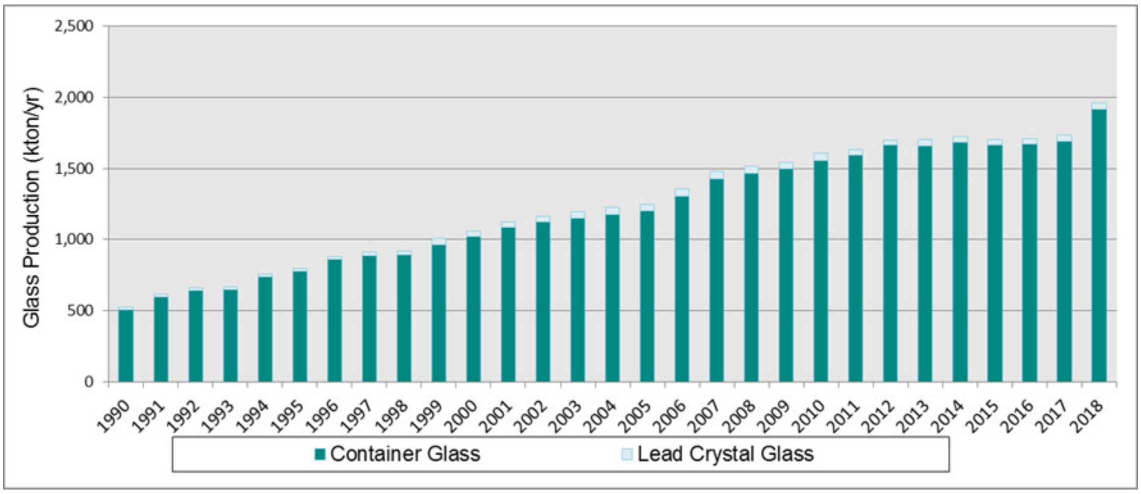


Figure 3-32: Glass production by glass type (excluding flat glass production)

Table 3-29: Glass production by glass type (kt/yr) excluding flat glass production

Product	Unit	1990	2005	2016	2017	2018
Container Glass	kt	508	1,201	1,670	1,693	1,916
Lead Crystal Glass	kt	16	45	42	44	46

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 3-30: 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 3-31: Default sulphur content of fuels for combustion equipments in the Manufacturing Industry

Fuel		NAPFUE	Unit	1990	1995	2000	2001	2005	2018
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 3-32: 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 3-33: Default emissions factors of Heavy Metals for combustion equipments in Manufacturing Industry

Equipment	Fuel		NAPFUE	Cd (g/t)	Hg (g/t)	As (g/t)	Cr (g/t)	Cu (g/t)	Ni (g/t)	Se (g/t)	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/km^3

Table 3-34: Default emissions factors of Dioxins/Furans and PAH for combustion equipments in Manufacturing Industry

Equipment	Fuel		NAPFUE	DioxFur microg TEQ/TJ	PAH mg/GJ	PCB µg/GJ	HCB 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 3-35: 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 3-36: 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
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
2018	0.0016	0.02	0.005	0.15	0.10	1.00	0.0007	0.65	0

Table 3-37: Emission factors of Particulate Matter gases 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 3-38: 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 3-39: Emission factors of Dioxins/Furans and PAH in the extractive industry

Equipment	Fuel		Code	DioxFur microg TEQ/TJ	PAH mg/GJ	PCB µg/GJ	HCB 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 3-40: Emission factors for Ozone Precursor gases in the building and construction industry

Fuel		NAPFUE	NO_x g/GJ	NMVOC g/GJ	CO 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 3-41: 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 3-42: 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 3-43: 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).

Tabela 3-1: 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				

Tabela 3-2: 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 EF	Unit	CO 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 Date 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

The main recalculations in category 1.A.2 are mainly due to the revision of the methodology for estimating emissions made to the subcategory Iron and Steel, and the estimate for the first time of the category Mobile combustion in industry and construction.

The figure below summarizes the differences between last submission and the previous year's submission for key pollutants for sector 1A2.

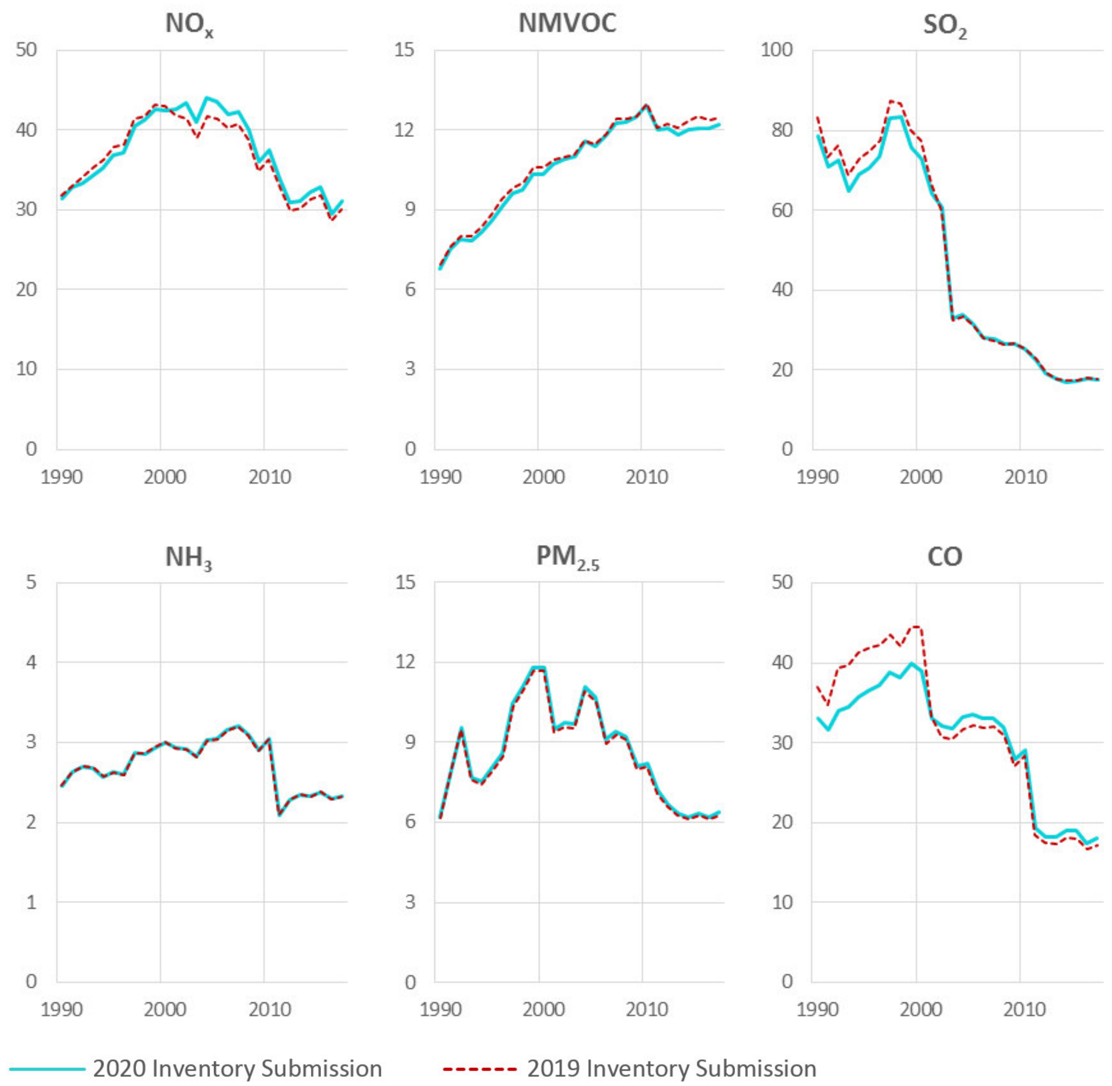


Figure 3-33: Emissions by pollutant and Inventory version for NFR 1A2 (kton)

A relevant trend is the decrease in NO_X, SO_2 and CO emissions between submissions for the period between 1990 and 2001, this change is strongly linked to the revision of the methodology for estimating emissions in the Iron and Steel sector, in particular for the period in that integrated steel production took place in one of the Portuguese steelworks, exactly between 1990 and 2001. For the remaining period of the time series of emissions, the recalculations resulted in an increase in emissions, in particular for NOx and CO. This increase is related to the estimate of emissions from mobile sources in industry and construction, which were previously considered stationary sources.

Regarding the difference between submissions of VOC emissions, there was a reduction in total emissions over the entire time series, particularly in the period 2013-2017. This emission reduction is due to the correction of an error in the estimation of NMVOC emissions in the Lime sector identified during the annual QA / QC checks on spreadsheets.

The increase in total PM2.5 emissions for category 1.A.2 between the last submission and most recent submission is also related to the methodological reviews of Iron and Steel and mobile sources of combustion.

Between submissions, there were no significant recalculations in NH3 emissions.

Table 3-57: Recalculated data for category Manufacturing industries and construction (NFR 1A2)

		Previous submission	Latest submission	Difference	Difference	Impact on total emissions
Year	Pollutant	1.A.2 Emissions (kt)			%	
1990	NOx	31.9	31.3	-0.5	-1.6	-0.2
2005	NOx	41.4	43.6	2.2	5.3	0.9
2017	NOx	30.0	31.0	1.0	3.3	0.7
1990	NMVOC	6.9	6.8	-0.2	-2.3	-0.1
2005	NMVOC	11.4	11.4	-0.1	-0.5	0.0
2017	NMVOC	12.5	12.2	-0.3	-2.1	-0.2
1990	SOX	83.1	78.6	-4.6	-5.5	-1.5
2005	SOX	31.2	31.7	0.5	1.6	0.3
2017	SOX	17.6	17.6	0.0	-0.2	-0.1
1990	NH3	2.5	2.5	0.0	0.0	0.0
2005	NH3	3.0	3.0	0.0	0.0	0.0
2017	NH3	2.3	2.3	0.0	0.2	0.0
1990	PM2.5	6.2	6.2	0.0	0.4	0.0
2005	PM2.5	10.5	10.7	0.2	1.6	0.3
2017	PM2.5	6.3	6.4	0.1	1.4	0.2
1990	CO	37.0	33.0	-4.1	-10.9	-0.5
2005	CO	32.2	33.6	1.4	4.4	0.3
2017	CO	17.2	18.1	0.9	5.2	0.3

Regarding the impact of recalculations in category 1.A.2 on total national emissions, the impact on NOx emissions between 2003 and 2005 should be noted, with an increase in national emissions of close to 1%. Also impacting the total national emissions were the revision of the SOx estimates between 1990 and 2001, achieving an emission reduction of around 1.5%.

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.

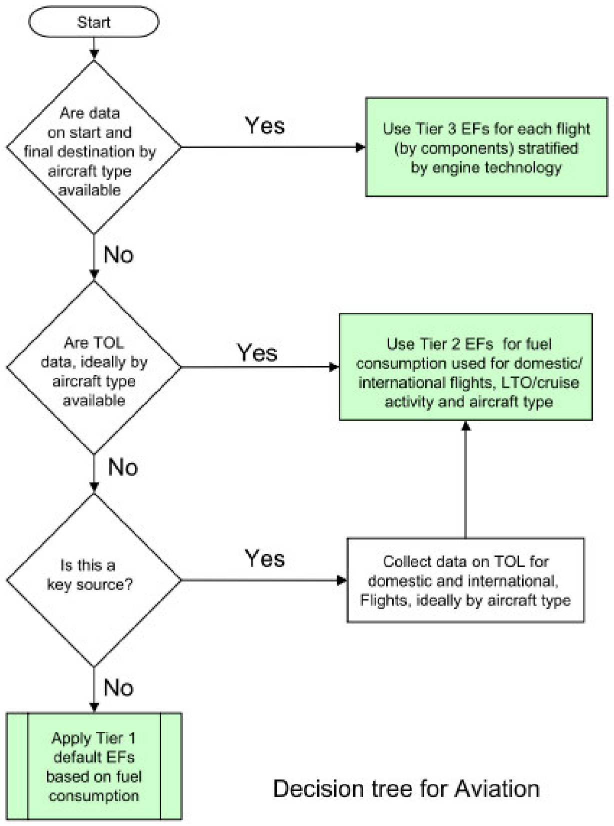


Figure 3-34: Decision tree for emissions from aviation (EMEP/EEA, 2016)

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:

$$\text{Emission}_{LTO(p,d,a,s,y)} = \text{Emission}_{Arrival(p,d,a,s,y)} + \text{Emission}_{Departure(p,d,a,s,y)}$$
$$\text{Emission}_{Arrival(p,d,a,s,y)} = N_{Arrival(d,a,s,y)} \times EF_{Arrival(p,s)} \times 10^{-3}$$
$$\text{Emission}_{Departure(p,d,a,s,y)} = N_{Departure(d,a,s,y)} \times EF_{Departure(p,s)} \times 10^{-3}$$

Where:

$\text{Emission}_{LTO\ (p,d,a,s,y)}$ – Emissions of pollutant p from origin/destiny d in airport a performed by aircraft s during year y (t/yr)

$\text{Emission}_{Arrival(p,d,a,s,y)}$, $\text{Emission}_{Departure(p,d,a,s,y)}$ – 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:

$$\text{Emission}_{LTO(p,d,a,y)} = \text{Emission}_{Arrival(p,d,s,y)} + \text{Emission}_{Departure(p,d,a,y)}$$
$$\text{Emission}_{Arrival(p,d,a,y)} = N_{Arrival(d,a,y)} \times EF_{Arrival(p,a)} \times 10^{-3}$$
$$\text{Emission}_{Departure(p,d,a,y)} = N_{Departure(d,a,y)} \times EF_{Departure(p,a)} \times 10^{-3}$$

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

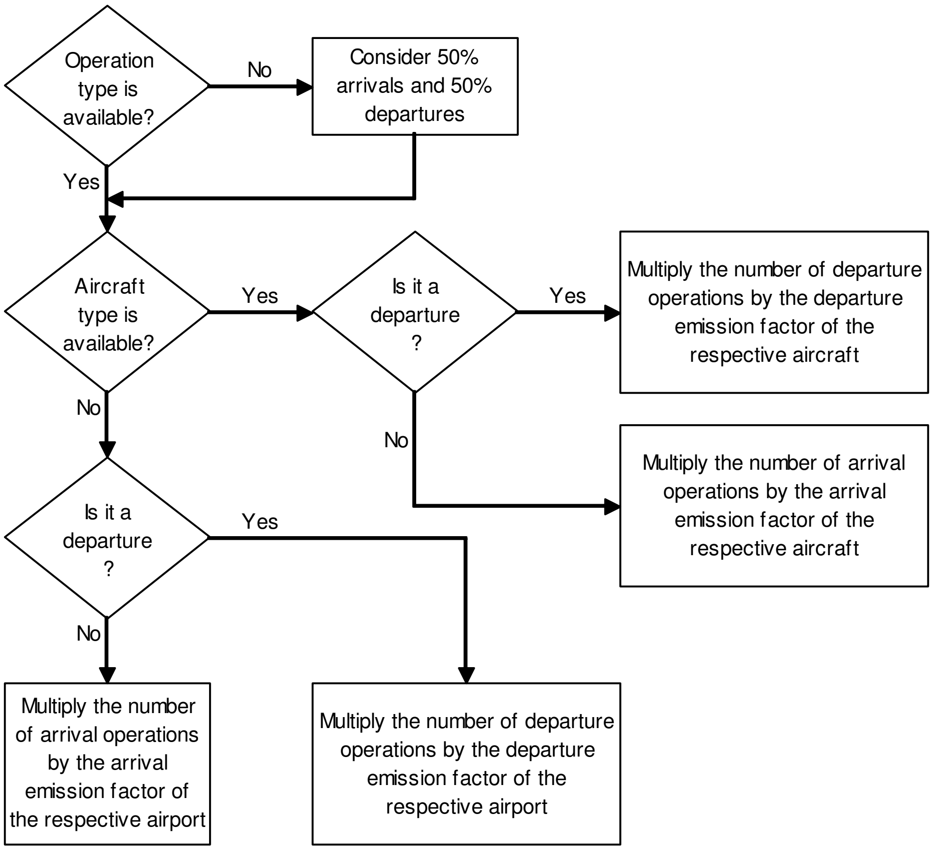


Figure 3-35: Decision tree for LTOCycle emission calculation

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.

$$\text{Emission}_{cruise(p,d,a,s,y)} = N_{LTO(d,a,s,y)} \times EF_{cruise(p,d,s,t,y)} \times 10^{-3}$$

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 3-58: 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 3-59: Airport based LTO emission factors (kg/movement)

Airport	Operation	Parameter	1990	1995	2000	2005	2010	2015	2016	2017	2018
Lisboa (LIS)	Take-off	Fuel Consumption	670.2	608.9	567.4	452.6	451.6	468.4	443.3	484.2	484.2
		VOC	16.4	14.9	15.2	9.3	2.8	2.3	2.4	2.5	2.3
		CO	37.1	33.7	35.4	21.5	13.8	12.8	13.3	13.8	13.3
		NOx	26.3	23.9	23.6	16.2	15.9	17.1	16.3	18.5	18.3
		PM_{10}	6.2	5.6	5.2	4.2	4.2	4.4	4.1	4.5	4.5
	Landing	Fuel Consumption	291.0	264.4	240.2	204.2	206.6	223.7	204.5	208.2	213.0
		VOC	7.0	6.4	6.0	4.4	1.5	1.2	1.3	1.3	1.2
		CO	17.8	16.2	16.3	11.1	7.0	6.5	6.6	6.5	6.4
		NOx	4.9	4.4	4.3	3.3	3.4	3.8	3.5	3.6	3.7
		PM_{10}	3.1	2.8	2.6	2.2	2.2	2.4	2.2	2.2	2.3
Porto (OPO)	Take-off	Fuel Consumption	530.0	481.5	401.1	374.4	427.6	358.1	368.7	377.9	364.0
		VOC	8.2	7.5	6.5	4.1	3.3	2.6	2.3	2.4	2.3
		CO	26.3	23.9	23.0	13.7	12.8	10.7	11.3	11.5	10.9
		NOx	19.1	17.3	15.0	11.9	14.7	11.9	12.1	12.9	11.8
		PM_{10}	4.9	4.5	3.7	3.5	4.0	3.3	3.4	3.5	3.4
	Landing	Fuel Consumption	236.2	214.6	181.3	172.9	191.7	171.1	168.6	176.6	164.6
		VOC	3.7	3.3	2.9	2.2	1.6	1.4	1.2	1.2	1.2
		CO	12.7	11.5	11.1	7.2	6.3	5.8	5.7	5.8	5.5
		NOx	3.8	3.5	3.0	2.6	3.2	2.8	2.6	2.9	2.6
		PM_{10}	2.5	2.3	1.9	1.9	2.1	1.8	1.8	1.9	1.8
Faro (FAO)	Take-off	Fuel Consumption	514.8	467.7	443.6	348.7	339.1	263.5	293.1	289.6	280.7
		VOC	5.3	4.8	4.9	3.0	2.4	2.1	2.0	2.1	1.8
		CO	19.2	17.4	17.2	12.2	11.0	8.5	9.0	9.3	8.3
		NOx	17.4	15.8	16.0	11.0	10.0	7.7	8.7	8.8	8.0
		PM_{10}	4.8	4.3	4.1	3.2	3.1	2.4	2.7	2.7	2.6
	Landing	Fuel Consumption	231.8	210.6	198.9	158.2	161.1	139.3	139.9	139.3	134.2
		VOC	2.7	2.5	2.5	1.7	1.4	1.4	1.2	1.3	1.2
		CO	10.0	9.1	9.0	6.5	5.9	5.0	5.0	5.2	4.7
		NOx	3.5	3.2	3.1	2.3	2.4	2.0	2.1	2.1	1.9
		PM_{10}	2.5	2.3	2.1	1.7	1.7	1.5	1.5	1.5	1.4
Santa Maria (SMA)	Take-off	Fuel Consumption	424.1	385.3	328.4	393.3	446.6	335.2	280.2	305.9	257.9
		VOC	9.2	8.3	9.8	7.6	5.2	2.0	1.8	3.0	2.1
		CO	23.1	21.0	22.2	19.1	17.6	10.2	10.2	14.7	10.4
		NOx	16.3	14.8	12.0	16.0	20.0	12.4	10.4	13.2	10.0
		PM_{10}	3.9	3.6	3.0	3.7	4.2	3.1	2.6	2.8	2.4
	Landing	Fuel Consumption	216.1	196.3	169.9	196.1	223.3	178.3	141.1	149.9	137.7
		VOC	4.6	4.1	4.9	3.4	2.6	1.3	1.0	1.8	1.3
		CO	13.2	12.0	12.4	10.7	9.8	6.6	5.9	9.0	6.8
		NOx	3.6	3.2	2.6	3.6	4.3	3.3	2.4	2.9	2.5
		PM_{10}	2.3	2.1	1.8	2.1	2.4	1.9	1.5	1.6	1.5
Ponta Delgada (PDL)	Take-off	Fuel Consumption	616.3	559.9	895.0	403.0	475.3	525.1	437.5	464.5	406.9
		VOC	7.7	7.0	10.1	3.8	2.7	2.3	2.1	2.1	1.8
		CO	19.5	17.7	24.2	12.4	12.6	13.7	13.3	12.5	11.3
		NOx	20.4	18.6	31.5	13.0	15.9	20.3	15.2	18.1	14.8
		PM_{10}	5.7	5.2	8.3	3.8	4.4	4.9	4.1	4.3	3.8
	Landing	Fuel Consumption	285.0	258.9	414.5	175.7	202.8	243.4	210.1	207.2	184.5
		VOC	4.4	4.0	7.6	1.8	1.3	1.1	1.3	1.0	1.0
		CO	11.2	10.2	16.4	6.2	6.3	6.5	7.5	6.0	5.8
		NOx	4.1	3.7	6.3	2.6	3.1	4.3	3.4	3.7	3.0
		PM_{10}	3.1	2.8	4.5	1.9	2.2	2.6	2.3	2.2	2.0

Airport	Operation	Parameter	1990	1995	2000	2005	2010	2015	2016	2017	2018
Horta (HOR)	Take-off	Fuel Consumption	457.9	416.0	783.6	287.9	405.3	263.2	365.5	339.5	418.7
		VOC	3.8	3.5	1.8	4.8	3.6	1.0	1.4	1.2	1.1
		CO	13.0	11.8	15.6	10.6	10.7	6.6	20.1	9.0	9.0
		NOx	14.4	13.1	25.7	8.5	13.1	8.9	11.9	11.3	14.3
		PM_{10}	4.3	3.9	7.3	2.7	3.8	2.5	3.4	3.2	3.9
	Landing	Fuel Consumption	219.8	199.6	337.9	146.4	194.9	163.8	190.3	166.0	211.3
		VOC	1.8	1.7	0.7	2.1	1.9	0.7	0.7	0.7	0.6
		CO	6.8	6.2	6.7	5.6	5.7	4.6	9.2	5.1	4.9
		NOx	3.2	2.9	5.3	2.0	2.9	2.5	2.8	2.6	3.3
		PM_{10}	2.4	2.2	3.7	1.6	2.1	1.8	2.1	1.8	2.3
Flores (FLW)	Take-off	Fuel Consumption	422.4	383.8	299.1	359.5	343.4	380.6	612.1	631.5	582.4
		VOC	5.3	4.8	4.3	5.3	3.9	1.0	1.3	1.3	1.2
		CO	14.2	12.9	9.3	11.8	9.5	7.4	22.8	12.0	11.3
		NOx	13.0	11.8	8.9	10.8	10.6	12.2	20.5	21.4	19.6
		PM_{10}	4.0	3.6	2.8	3.4	3.2	3.6	5.8	5.9	5.5
	Landing	Fuel Consumption	227.7	206.8	164.9	170.2	176.2	210.6	269.9	289.9	284.4
		VOC	2.2	2.0	1.9	2.6	1.9	0.7	0.5	0.6	0.6
		CO	7.5	6.8	5.1	6.6	5.0	4.3	9.3	5.4	5.7
		NOx	3.4	3.1	2.4	2.4	2.4	3.0	4.4	4.6	4.5
		PM_{10}	2.5	2.3	1.8	1.9	1.9	2.3	2.9	3.2	3.1
Funchal (FNC)	Take-off	Fuel Consumption	623.5	566.5	465.6	466.6	469.7	448.7	459.1	456.4	462.9
		VOC	5.9	5.4	4.5	2.7	1.7	1.4	1.5	1.4	1.4
		CO	20.2	18.3	15.1	13.0	12.1	10.6	11.6	10.3	10.1
		NOx	19.3	17.6	14.0	15.2	14.6	14.0	14.0	14.2	14.6
		PM_{10}	5.8	5.2	4.3	4.3	4.4	4.2	4.3	4.2	4.3
	Landing	Fuel Consumption	280.8	255.1	210.8	206.3	209.3	205.1	206.4	203.7	211.5
		VOC	2.9	2.7	2.2	1.5	0.9	0.8	0.7	0.7	0.7
		CO	10.3	9.4	7.9	6.5	5.7	5.2	5.4	4.9	4.9
		NOx	4.0	3.7	2.9	3.2	3.2	3.1	3.2	3.1	3.2
		PM_{10}	3.0	2.7	2.3	2.2	2.3	2.2	2.2	2.2	2.3
Porto Santo (PXO)	Take-off	Fuel Consumption	561.0	509.6	534.2	438.3	447.3	443.3	454.0	484.1	498.4
		VOC	7.9	7.2	4.8	6.7	2.8	1.5	1.6	1.4	1.3
		CO	25.0	22.7	15.8	19.3	14.1	12.2	12.8	10.8	10.7
		NOx	18.6	16.9	18.4	16.0	13.9	13.7	14.6	16.0	15.9
		PM_{10}	5.2	4.7	4.9	4.1	4.2	4.1	4.2	4.5	4.6
	Landing	Fuel Consumption	277.8	252.4	238.5	196.3	207.6	218.0	212.5	218.7	232.0
		VOC	3.2	2.9	2.3	2.8	1.2	0.7	0.8	0.6	0.6
		CO	12.0	10.9	8.1	8.8	6.6	6.1	5.8	4.9	5.0
		NOx	4.1	3.7	4.0	3.2	3.1	3.3	3.3	3.4	3.6
		PM_{10}	3.0	2.7	2.6	2.1	2.2	2.4	2.3	2.4	2.5
Terceira (TER)	Take-off	Fuel Consumption	958.6	870.9	743.3	847.6	623.2	702.0	597.7	655.0	748.7
		VOC	7.4	6.7	5.7	8.9	5.5	2.6	2.3	3.3	4.1
		CO	28.2	25.6	21.8	29.0	18.7	17.2	15.8	17.2	23.0
		NOx	39.1	35.6	30.3	36.8	23.4	29.1	24.0	29.2	30.9
		PM_{10}	9.0	8.1	7.0	7.9	5.8	6.6	5.6	6.1	7.0
	Landing	Fuel Consumption	391.8	355.9	303.8	338.7	262.6	287.7	257.7	283.7	306.7
		VOC	3.0	2.7	2.3	3.3	2.3	1.1	0.9	1.4	1.8
		CO	11.8	10.7	9.1	11.9	8.5	7.0	6.5	7.6	9.9
		NOx	6.9	6.3	5.4	6.4	4.6	5.3	4.7	5.4	5.7
		PM_{10}	4.3	3.9	3.3	3.7	2.9	3.1	2.8	3.1	3.3

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 3-60: 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 and heavy metals. The LHV were obtained from the national energy authority (DGEG).

Table 3-61: Fuel dependent emission factors

Pollutant	Aviation Gasoline	Jet Fuel
LHV (MJ/kg)	44.0	43.0
SO2 (%)	0.04	0.04
Pb (g/t)	0.45	0.45
Cd (g/t)	0.25	0.25
Cr (g/t)	0.05	0.05
Cu (g/t)	1.10	1.10
Ni (g/t)	0.28	0.28
Se (g/t)	0.03	0.03
Zn (g/t)	3.00	3.00

Source: IPCC; DGEG

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 2018 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 3-62: LTO_{Cycle} per airport

Region	Airport Code	1990	1995	2000	2005	2010	2015	2016	2017	2018
Mainland	LIS	30,862	34,932	56,073	68,168	73,783	84,385	92,741	103,131	110,371
	OPO	11,574	13,348	23,280	25,910	28,502	35,248	39,549	43,544	46,997
	FAO	11,252	13,067	18,243	20,397	22,359	22,330	26,719	29,948	30,406
	TOTAL	**53,688**	**61,347**	**97,596**	**114,475**	**124,643**	**141,963**	**159,009**	**176,623**	**187,774**

Region	Airport Code	1990	1995	2000	2005	2010	2015	2016	2017	2018
Islands	FNC	6,475	9,460	12,040	15,952	12,697	12,442	14,079	14,223	13,376
	TER	3,801	4,049	4,501	4,875	4,988	4,755	5,496	5,992	5,862
	PDL	2,954	3,382	4,134	7,196	8,182	8,499	9,993	11,830	12,048
	PXO	2,403	4,243	3,788	3,688	2,325	2,103	2,394	2,461	2,033
	HOR	1,237	1,542	1,756	2,964	2,919	2,331	2,818	2,873	2,866
	SMA	634	893	1,557	1,649	1,275	1,073	1,292	1,190	1,327
	FLW	281	357	552	1,101	1,136	1,002	1,242	1,386	1,456
	TOTAL	**17,785**	**23,924**	**28,327**	**37,425**	**33,521**	**32,204**	**37,312**	**39,954**	**38,966**

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.

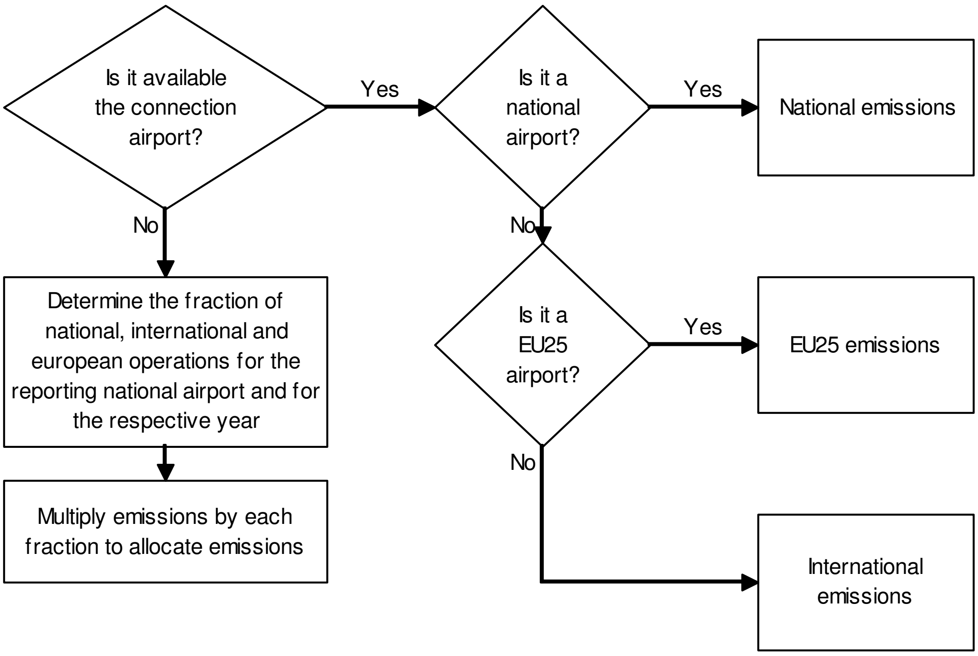
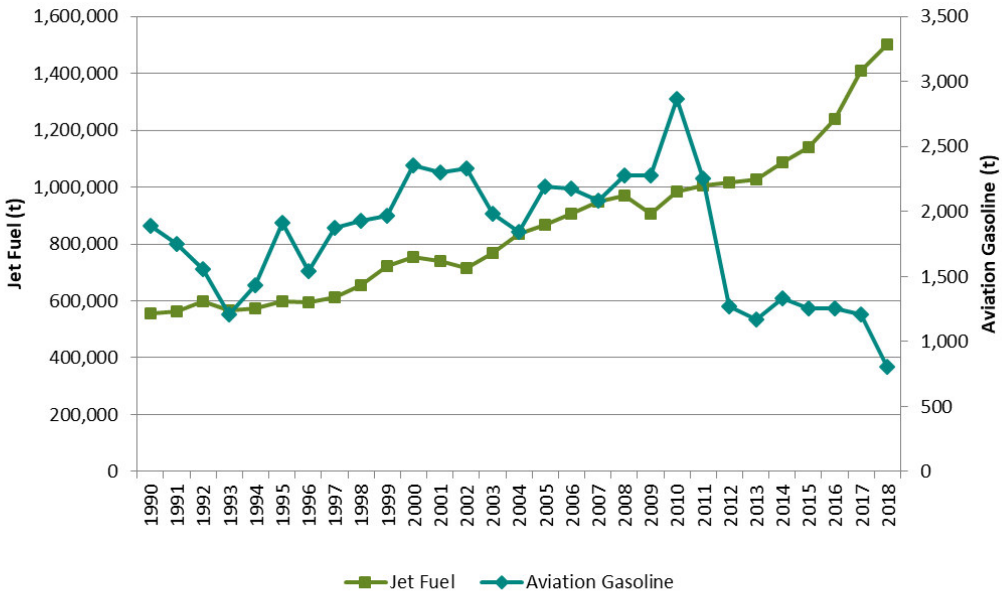


Figure 3-36: Decision tree for distinction between domestic and international emissions

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 3-37: 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 3-63: Main pollutants and particulate matter emissions from road transport (t)

Pollutant	1990	1995	2000	2005	2010	2015	2016	2017	2018
NOx	94,248	107,790	120,882	103,517	87,066	67,272	66,889	65,606	63,592
NMVOC	93,068	91,067	67,109	40,000	25,260	18,329	17,438	16,483	15,621
SOx	13,407	12,921	5,856	597	113	97	99	101	102
NH_3	62	630	1,471	1,778	1,360	1,012	967	925	890
$PM_{2.5}$	5,999	7,211	7,993	6,848	6,014	4,350	4,232	4,087	3,900
PM_{10}	6,575	7,989	9,067	7,899	7,063	5,232	5,126	4,986	4,811
CO	489,065	485,346	365,253	227,380	138,838	91,487	85,774	80,485	75,099

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 surface wear.

Table 3-64: Heavy metals emissions from road transport (kg)

Pollutant	1990	1995	2000	2005	2010	2015	2016	2017	2018
Pb - 1A3b	554,651.20	766,430.61	16,341.03	14,412.83	11,381.10	8,818.05	8,665.27	8,635.06	8,599.29
Pb - 2G	0.22	0.27	0.35	0.36	0.37	0.33	0.34	0.34	0.34
Cd - 1A3b	13.99	13.35	14.46	12.77	12.67	10.71	11.04	10.90	11.07
Cd - 2G	30.03	37.54	48.34	49.26	50.57	45.34	46.17	46.89	47.22
Hg - 1A3b	21.41	28.65	38.20	37.88	36.39	31.17	31.38	31.65	31.90
Hg - 2G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
As - 1A3b	0.59	0.80	1.01	0.96	0.87	0.74	0.74	0.74	0.74
As - 2G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cr - 1A3b	521.69	671.08	896.35	851.19	848.56	696.63	708.02	703.04	712.35
Cr - 2G	126.42	158.07	203.53	207.43	212.93	190.92	194.39	197.41	198.81
Cu - 1A3b	11,547.13	14,438.70	18,929.47	17,801.12	17,725.85	14,516.99	14,771.63	14,638.30	14,837.94
Cu - 2G	5,122.73	6,405.26	8,247.16	8,405.16	8,627.98	7,736.16	7,876.84	7,999.42	8,055.92
Ni - 1A3b	131.82	138.48	161.65	146.46	145.07	120.81	123.80	122.38	124.15
Ni - 2G	209.98	262.55	338.05	344.53	353.66	317.10	322.87	327.89	330.21
Se - 1A3b	17.71	18.57	21.92	20.26	20.09	17.00	17.41	17.33	17.56
Se - 2G	29.89	37.38	48.13	49.05	50.35	45.14	45.97	46.68	47.01
Zn - 1A3b	4,587.21	5,700.51	7,521.12	7,223.46	7,156.74	5,984.31	6,082.81	6,077.25	6,149.80
Zn - 2G	2,964.34	3,706.49	4,772.33	4,863.76	4,992.69	4,476.63	4,558.04	4,628.97	4,661.67

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 3-65: Persistent organic pollutant emissions from road transport (kg)

Pollutant	1990	1995	2000	2005	2010	2015	2016	2017	2018
Dioxins/Furans	0.0014	0.0021	0.0032	0.0033	0.0036	0.0027	0.0026	0.0025	0.0024
PAH's	162	222	332	365	412	379	389	396	397
HCB	0.0007	0.0013	0.0026	0.0029	0.0033	0.0026	0.0025	0.0024	0.0022
PCB's	0.0002	0.0003	0.0005	0.0005	0.0005	0.0004	0.0005	0.0005	0.0004

The 2018 Road Transportation contribution of main pollutants, particulate matter and CO in total national emissions is represented in the next Figure.

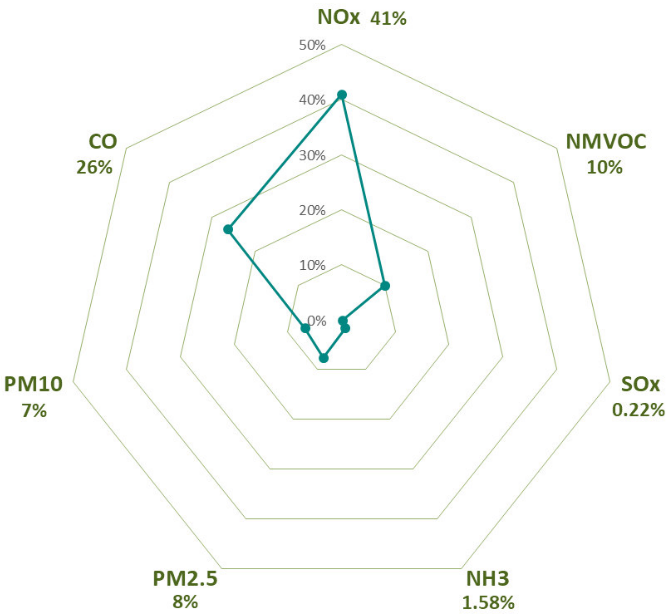


Figure 3-38: Road Transportation contribution (%) of main pollutants, particulate matter and CO in total national emissions in 2018

3.4.2.2 Methodology

Emissions from Road Transportation, estimated using the COPERT V (version 5.2.0 - August 2018) includes the following type of emissions:

- Exhaust Emissions from Fuel (1A3bi, 1A3bii, 1A3biii, 1A3iv) - 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 (1A3bi, 1A3bii, 1A3biii, 1A3iv) – 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) - $PM_{2.5}$, PM_{10}, TSP and heavy metals.
- Automobile Road Abrasion (1A3bvii) - $PM_{2.5}$, PM_{10} and TSP.

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.

3.4.2.3.1 Implied Emission Factors

The Implied Emission Factors based on energy (kg/GJ and g/GJ) 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 3-66: 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 2016, table 3.34) while the average **trip duration** is 0.20 hour.

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 2016.

Table 3-67: 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 3-68: Sulphur content in petrol and diesel (ppm wt)

Fuel	1990-1999
Leaded Petrol	1000

Fuel	1990-1995	1996-2001	2002-2004	2005-2008	2008-2018
Unleaded Petrol	1000	500	150	50	10

Fuel	1990-1994	1995	1996-2000	2001-2004	2005-2008	2009-2018
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 2016 indications except for the Lead content for gasoline that were set with the Portuguese Legislation values.

Table 3-69: 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 2016 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] 2000-2016

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

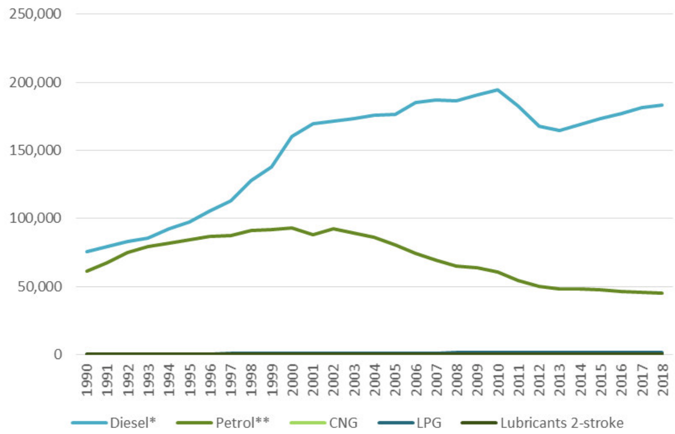
Table 3-70: Reid Vapour Pressure (kPa)

Month	1990 to 1995	1996 to 1999	2000 to 2018
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 3-39: Fuel and lubricant consumption from Road Transportation sector (TJ)

In adition to the "10.05.04 Road Transport" category of the Energy Balance the Road Transportation sector also 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 3-71: Incorporation rate of Biodiesel in Diesel (%).

2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1.31%	2.50%	2.43%	4.16%	6.03%	6.25%	6.22%	6.05%	5.93%	6.75%	5.14%	5.10%	5.49%

Source: (DGEG)

Table 3-72: Incorporation rate of Bioethanol in Petrol (%)

2013	2014	2015	2016	2017	2018
0.16%	0.17%	2.00%	1.95%	0.28%	0.52%

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 2018, 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 3-73: COPERT 5 segments

COPERT 5 Vehicle Category	COPERT 5 Vehicle Segment	Fuel	Weight (kg)	Cylinder Power (cm^3)
Passenger Cars	Mini	Petrol	< 1 400	< 1 000
Passenger Cars	Small		< 1 800	< 1 600
Passenger Cars	Medium	Petrol Hibrid	< 2400	< 1 900
Passenger Cars	Large-SUV-Executive	Diesel LPG Bifuel	> 2400	> 1 900
Light Commercial Vehicles	N1-I	Diesel	< 1 900	-
Light Commercial Vehicles	N1-II	Diesel	1 900 - 2 600	-
Light Commercial Vehicles	N1-III	Diesel	> 2 600	-
Heavy Duty Trucks	>3,5 t	Petrol	-	-
Heavy Duty Trucks	Rigid <=7,5 t	Diesel	<= 7 500	-
Heavy Duty Trucks	Rigid 7,5 - 12 t	Diesel	7 500 - 12 000	-
Heavy Duty Trucks	Rigid 12 - 14 t	Diesel	12 000 - 14 000	-
Heavy Duty Trucks	Rigid 14 - 20 t	Diesel	14 000 - 20 000	-
Heavy Duty Trucks	Rigid 20 - 26 t	Diesel	20 000 - 26 000	-
Heavy Duty Trucks	Rigid 26 - 28 t	Diesel	26 000 - 28 000	-
Heavy Duty Trucks	Rigid 28 - 32 t	Diesel	28 000 - 32 000	-
Heavy Duty Trucks	Rigid >32 t	Diesel	> 32 000	-
Heavy Duty Trucks	Articulated 14 - 20 t	Diesel	< 20 000	-
Heavy Duty Trucks	Articulated 20 - 28 t	Diesel	20 000 - 28 000	-
Heavy Duty Trucks	Articulated 28 - 34 t	Diesel	28 000 - 34 000	-
Heavy Duty Trucks	Articulated 34 - 40 t	Diesel	34 000 - 40 000	-
Heavy Duty Trucks	Articulated 40 - 50 t	Diesel	40 000 - 50 000	-
Heavy Duty Trucks	Articulated 50 - 60 t	Diesel	> 50 000	-
Buses	Urban Buses Midi <=15 t	Diesel	<= 15 000	-
Buses	Urban Buses Standard 15 - 18 t	Diesel	15 000 - 18 000	-
Buses	Urban Buses Articulated >18 t	Diesel	> 18 000	-
Buses	Coaches Standard <=18 t	Diesel	<= 18 000	-
Buses	Coaches Articulated >18 t	Diesel	> 18 000	-
Buses	Urban Biodiesel Buses	Biodiesel	-	-
Buses	Urban CNG Buses	CNG	-	-
L-Category	Mopeds 2-stroke <50 cm^3	Petrol	-	<50
L-Category	Mopeds 4-stroke <50 cm^3	Petrol	-	<50
L-Category	Motorcycles 2-stroke >50 cm^3	Petrol	-	>50
L-Category	Motorcycles 4-stroke <250 cm^3	Petrol	-	<250
L-Category	Motorcycles 4-stroke 250 - 750 cm^3	Petrol	-	250 - 750
L-Category	Motorcycles 4-stroke >750 cm^3	Petrol	-	>750

Vehicle technology were determined according with European and National legislation and the vehicle first registry year as present in table below.

Table 3-74: 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	2015
		Euro 6 up to 2016	2016	2016
		Euro 6 2017-2019	2017	2019
		Euro 6 2020+	2020	...
	Diesel	Conventional	...	1992
		Euro 1	1993	1996
		Euro 2	1997	2000
		Euro 3	2001	2005
		Euro 4	2006	2010
		Euro 5	2011	2015
		Euro 6 up to 2016	2016	2016
		Euro 6 2017-2019	2017	2019
		Euro 6 2020+	2020	...
	LPG Bifuel	Conventional	...	1992
		Euro 1	1993	1996
		Euro 2	1997	2000
		Euro 3	2001	2005
		Euro 4	2006	2010
		Euro 5	2011	2015
		Euro 6	2016	...
Light Commercial Vehicles - N1-I	Petrol / Diesel	Conventional	...	1994
		Euro 1	1995	1997
		Euro 2	1998	2000
		Euro 3	2001	2005
		Euro 4	2006	2010
		Euro 5	2011	2015
		Euro 6 up to 2016	2016	2016
		Euro 6 2017-2019	2017	2019
		Euro 6 2020+	2020	...
Light Commercial Vehicles - N1-II/N1-III	Petrol / Diesel	Conventional	...	1994
		Euro 1	1995	1998
		Euro 2	1999	2001
		Euro 3	2002	2006
		Euro 4	2007	2011
		Euro 5	2012	2016
		Euro 6 up to 2017	2017	2017
		Euro 6 2018-2020	2018	2020
		Euro 6 2021+	2021	...
Heavy Duty Trucks	Diesel	Conventional	...	1993
		Euro I	1994	1996

Vehicle Category	Fuel	Euro Standard	First Registry year	
			from	to
		Euro II	1997	2001
		Euro III	2002	2006
		Euro IV	2007	2009
		Euro V	2010	2013
		Euro VI	2014	…
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	2014	…
	CNG	Euro I	1994	1996
		Euro II	1997	2001
		Euro III	2002	2006
		EEV	2007	2013
		Euro VI	2014	…
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 3-75: Vehicle fleet synthesis

Vehicle Category	1990	1995	2000	2005	2010	2015	2016	2017	2018
Passenger Cars	1,552,912	2,516,415	3,546,152	3,962,031	4,386,247	4,598,202	4,722,796	4,865,200	4,997,897
Light Commercial Vehicles	290,461	591,823	960,125	1,177,894	1,255,037	1,210,303	1,207,593	1,224,576	1,249,810
Heavy Duty Trucks	52,054	79,076	108,924	115,517	107,452	90,323	88,549	90,549	93,003
Buses	6,209	8,405	11,946	13,851	14,666	14,212	14,410	14,643	15,029
L-Category	900,822	774,282	673,994	487,589	497,024	527,431	551,904	592,287	615,826
Total	**2,802,458**	**3,970,001**	**5,301,141**	**5,756,882**	**6,260,426**	**6,440,471**	**6,585,252**	**6,787,255**	**6,971,565**

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

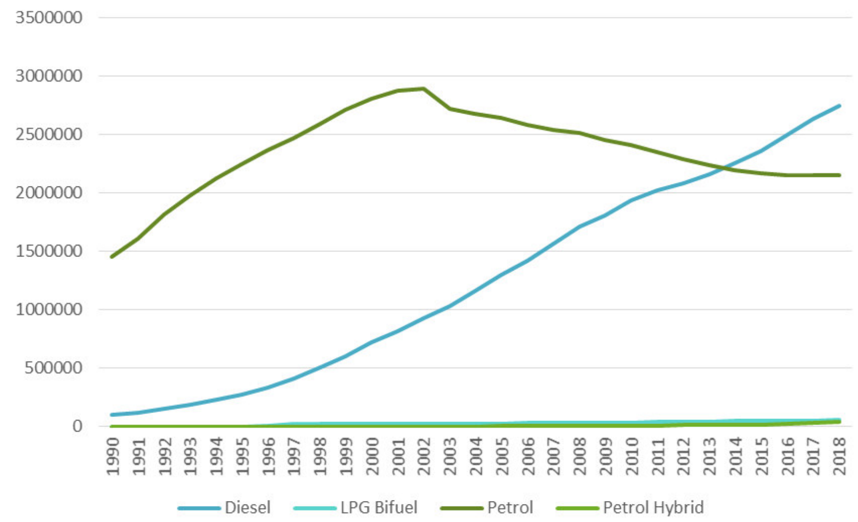


Figure 3-40: Number of Passenger Cars by fuel type

The number of gasoline passenger cars has decreased over the last years. It was observed a decrease in the number of this type of vehicles while diesel passenger cars have increased. After an initial growth, LPG fuelled vehicles have stabilized as a small percentage of passenger cars.

3.4.2.4.6 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 2018 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).

Detailed information on distance travelled, for the period between 1990 and 2018, regarding different Vehicle Categories, Fuel types, Segments and Euro Standard is presented in Annex C.

Total road traffic activity has increased 96% between 1990 and 2018.

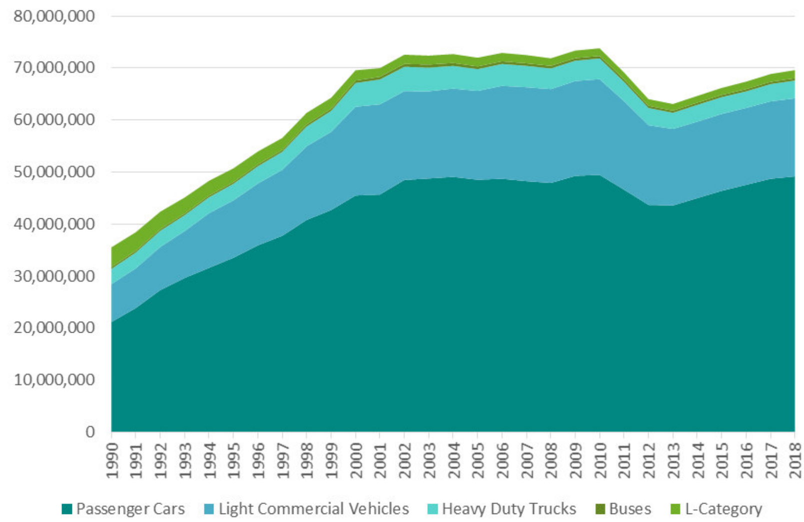


Figure 3-41: Kilometers travelled by vehicle type (vkm x 1000)

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 national authority for terrestrial transportation. 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 3-76: Assumed mileage percentage driven by driving mode and vehicle type for 2018

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 3-77: 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 difference were found.

3.4.2.6 Recalculations

The major changes between submissions result from the following actions:

- Estimation of the CO2 emissions from the fossil part of biofuels, from 2006 to 2018, in accordance with the “note on fossil carbon content in biofuels” developed by the Working Group I – “Annual inventories” under the Climate Change Committee.
- Allocation of petrol consumption, between 1990 and 2011, from 1A4a (Comercial/Institutional) in the Road Transportation sector as described in 3.6 Other Sectors (1A4).
- Allocation of diesel consumption, between 1990 and 1997, from 1A4c (Agriculture) in the Road Transportation sector as described in 3.6 Other Sectors (1A4).
- Correction of a compilation error detected in dioxins emissions.
- Update of activity data::
    - revision of the 2014 and 2017 Energy Balances data provided by DGEG;
    - revision of the stock data from 2014 to 2017;
    - revision of the assumed mileage percentage driven by each driving mode.

3.4.2.7 Further Improvements

No further improvements are planned for this sector.

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, 2016), IPCC 2006 Guidelines (IPCC, 2006) and MEET project, and are presented in next table.

Table 3-78: 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 3-79: 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 2018 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[18]. 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.

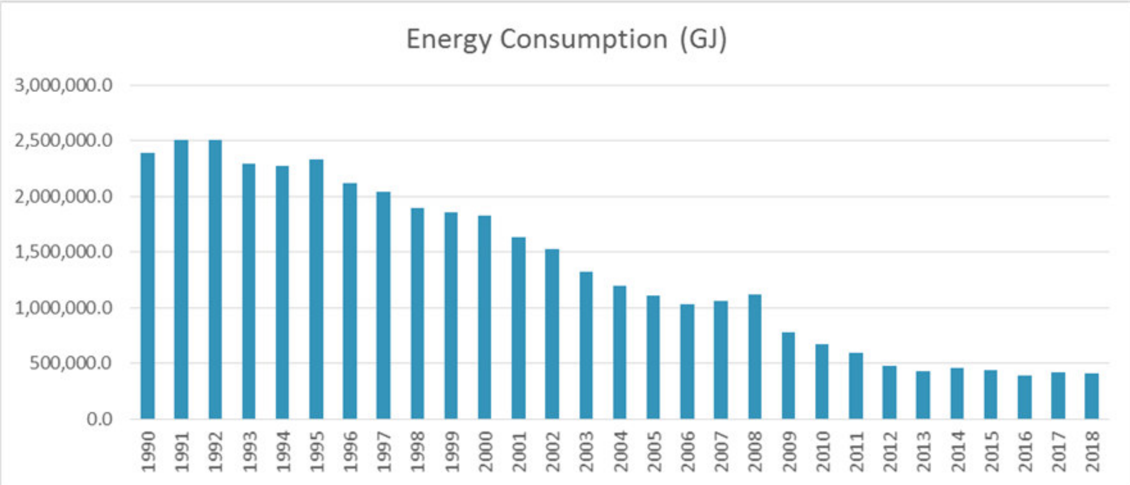


Figure 3-42: Consumption of diesel oil in the railway transport sector

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

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.

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

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:

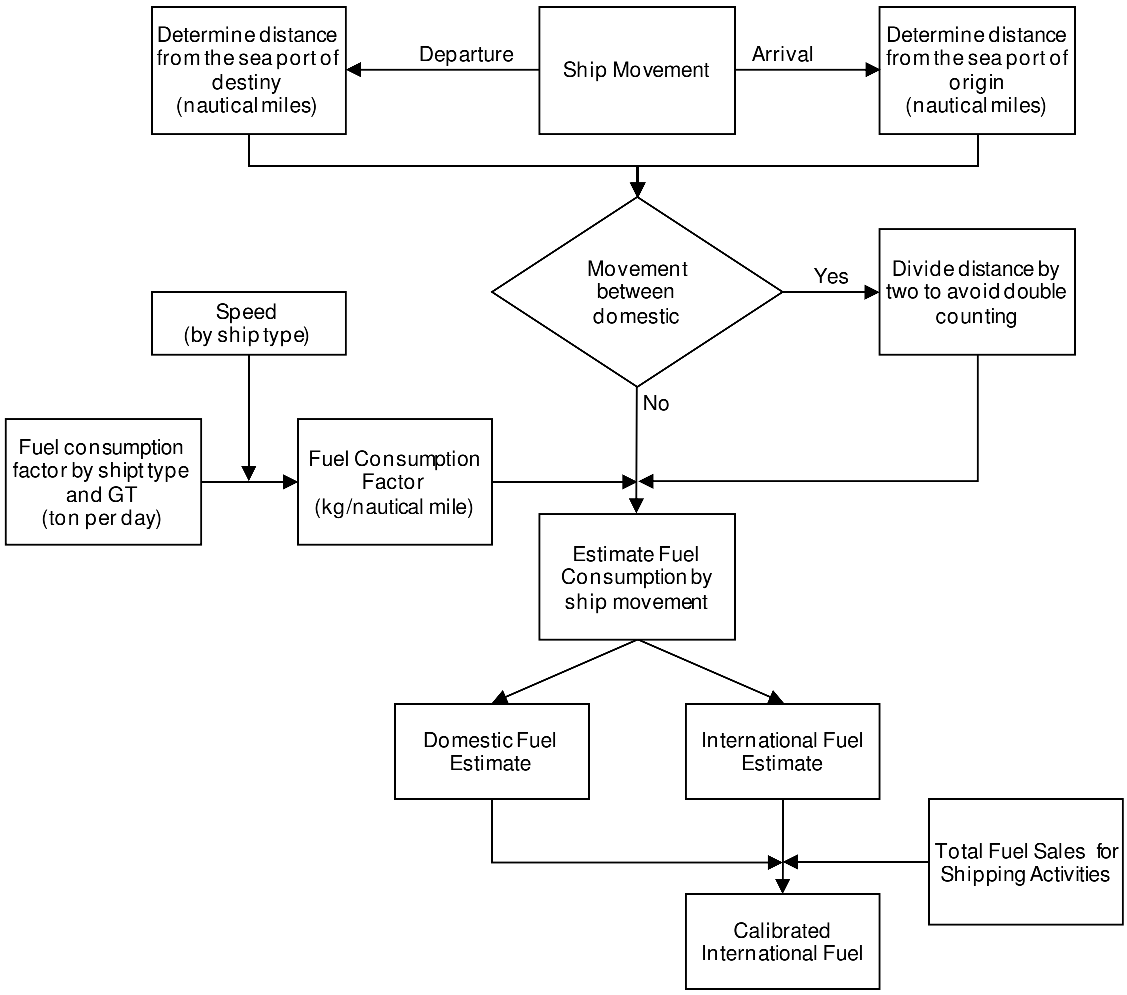


Figure 3-43: Generic methodology flowchart

For each dock (which includes one arrival and one departures) is possible to calculate domestic and international distance and fuel consumtion.

Domestic and international fuel consumption is estimated with a bottom-up approach using the fuel consumption factors and distance travelled by each ship. The fuel consumption factores, in tonne/day, is calculated with the gross tonnage of each ship and coverted to kg/nautical mikes with the ship speed. Detailed ship movements and ships technical information (such as gross tonnage, ship type and speed) is provided by National Seaports.

The international fuel consumption estimated is calibrated with the total fuel sales data from the energy balance provided by the energy authority (DGEG). This top down calibration does not affect the domestic fuel consumption estimated whith the bottom-up approach.

Domestic navigation also takes into account the tugs fuel consumption for each maneuvering.

Since emissions factors vary according with the type of fuel, to distinguish between residual and distillate fuel we consider the fraction of destilate fuel oil and residual fuel oil sold in marine bunkers.

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 2016.

Table 3-80: 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 3-81: Emission factors for navigation

Fuel	Residual Fuel-oil			Gas Oil		
Pollutant	Value	Unit	Reference	Value	Unit	Reference
NO_x	79.3	kg/t	Guidebook 2016	78.5	kg/t	Guidebook 2016
SO_x	54 [1)] 30 [2)]	kg/t	Guidebook 2016	10 [3)] 4 [4)] 2 [5)]	kg/t	Guidebook 2016
NMVOC	2.7	kg/t	Guidebook 2016	2.8	kg/t	Guidebook 2016
CO	7.4	kg/t	Guidebook 2016	7.4	kg/t	Guidebook 2016
TSP	6.2	kg/t	Guidebook 2016	1.5	kg/t	Guidebook 2016
PM_{10}	6.2	kg/t	Guidebook 2016	1.5	kg/t	Guidebook 2016
$PM_{2.5}$	5.6	kg/t	Guidebook 2016	1.4	kg/t	Guidebook 2016

[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 2016

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 3-82: Consumption factors

Ship Type	Consumption at full power (tonne/day)[(a)]
Solid bulk	20.186 + 0.00049 × gt
Liquid bulk	14.685 + 0.00079 × gt
General cargo	9.8197 + 0.00143 × gt
Container	8.0552 + 0.00235 × gt
Passenger/Ro-Ro/Cargo	12.834 + 0.00156 × gt
Passenger	16.904 + 0.00198 × gt
High speed ferry	39.483 + 0.00972 × gt
Inland cargo	9.8197 + 0.00143 × gt
Sail ships	0.4268 + 0.00100 × gt
Tugs	5.6511 + 0.01048 × gt
Fishing	1.9387 + 0.00448 × gt
Other ships	9.7126 + 0.00091 × gt
All ships	16.263 + 0.001 × gt

Legend:
gt – gross tonnage
(a) – a factor of 0.8 was applied to obtain consumption for cruise.
Source: (IPCC 2006)

3.4.4.4 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 2018. 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 3-83: Ship docks

Sea Port	Location	Unit	1990	1995	2000	2005	2010	2015	2016	2017	2018
Aveiro	Mainland	docks	876	1,098	1,009	1,028	961	1,025	1,038	1,069	1,129
Caniçal	Madeira	docks	76	76	76	178	390	241	248	267	250
Faro	Mainland	docks	163	163	163	32	12	85	34	18	39
Figueira da Foz	Mainland	docks	315	297	307	321	476	496	528	501	480
Funchal	Madeira	docks	1,063	1,063	1,063	948	758	664	646	675	667
Leixões	Mainland	docks	2,742	2,896	3,050	2,814	2,612	2,735	2,924	2,654	2,551
Lisboa	Mainland	docks	5,586	4,993	3,869	3,474	3,129	2,605	2,300	2,557	2,402
Ponta Delgada	Azores	docks	1,080	1,080	1,080	1,078	1,035	831	839	850	855
Portimão	Mainland	docks	34	34	37	42	136	70	58	81	103
Porto Santo	Madeira	docks	402	402	402	400	392	348	349	357	357
Setúbal	Mainland	docks	1,453	1,453	1,699	1,592	1,632	1,627	1,659	1,576	1,516
Sines	Mainland	docks	1,038	979	808	1,124	1,632	2,173	2,410	2,218	2,103
Viana do Castelo	Mainland	docks	254	293	348	214	179	198	208	226	184

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.

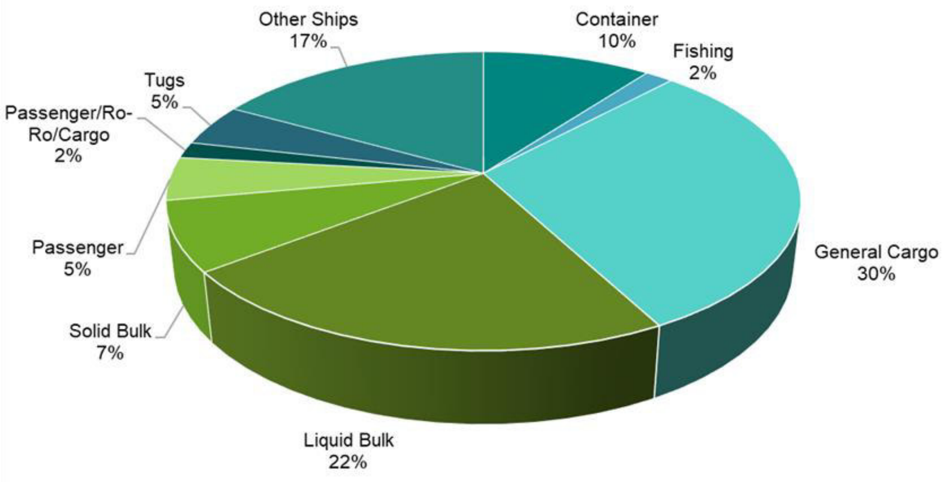


Figure 3-44: Ship fleet

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 3-84: Total fuel sales (ton)

Fuel Sales		NAPFUE	1990	1995	2000	2005	2010	2015	2016	2017	2018
Gas-oil	L	204	126,903	141,272	125,554	110,197	94,064	139,277	126,692	168,171	176,346
Residual Fuel-oil	L	203	407,823	290,920	475,743	457,115	506,320	603,295	722,240	734,789	763,796

Source: DGEG

Table 3-85: Estimated fuel consumption (ton)

Fuel	Region	1990	1995	2000	2005	2010	2015	2016	2017	2018
Residual Fuel-oil	Domestic	61,244	53,023	46,988	48,804	53,458	65,968	61,115	62,568	61,305
Residual Fuel-oil	International	431,554	448,716	430,253	411,428	515,738	805,707	832,495	830,224	802,684
Residual Fuel-oil	Total	492,797	501,739	477,242	460,233	569,196	871,676	893,610	892,793	863,989
Gas-oil	Domestic	23,132	20,027	17,748	18,434	20,192	24,917	23,084	23,633	23,156
Gas-oil	International	163,002	169,485	162,511	155,401	194,799	304,324	314,442	313,584	303,182
Gas-oil	Total	186,135	189,512	180,259	173,835	214,991	329,241	337,526	337,217	326,338

Table 3-86: Estimated fuel consumption after top-down calibration (ton)

Fuel	Region	1990	1995	2000	2005	2010	2015	2016	2017	2018
Residual Fuel-oil	Domestic	61,244	53,023	46,988	48,804	53,458	65,968	61,115	62,568	61,305
Residual Fuel-oil	International	346,579	237,897	428,754	408,311	452,862	537,327	661,125	672,220	702,491
Residual Fuel-oil	**Total**	**407,823**	**290,920**	**475,743**	**457,115**	**506,320**	**603,295**	**722,240**	**734,789**	**763,796**
Gas-oil	Domestic	23,132	20,027	17,748	18,434	20,192	24,917	23,084	23,633	23,156
Gas-oil	International	103,770	121,244	107,806	91,763	73,872	114,360	103,608	144,538	153,190
Gas-oil	**Total**	**126,903**	**141,272**	**125,554**	**110,197**	**94,064**	**139,277**	**126,692**	**168,171**	**176,346**

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 3-87: Spatial allocation of fuel consumption in mainland territory (ton)

Fuel	Region	1990	1995	2000	2005	2010	2015	2016	2017	2018
Residual Fuel-oil	Domestic	37,315	32,306	28,629	29,736	32,571	40,194	37,236	38,122	37,352
Residual Fuel-oil	International	317,684	218,063	393,008	374,269	415,105	492,528	606,005	616,175	643,922
Residual Fuel-oil	**Total**	**354,999**	**250,369**	**421,637**	**404,004**	**447,676**	**532,721**	**643,241**	**654,297**	**681,274**
Gas-oil	Domestic	14,094	12,202	10,814	11,231	12,302	15,182	14,065	14,399	14,108
Gas-oil	International	95,119	111,136	98,818	84,113	67,713	104,825	94,970	132,488	140,418
Gas-oil	**Total**	**109,213**	**123,338**	**109,631**	**95,344**	**80,016**	**120,007**	**109,035**	**146,887**	**154,527**

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 3-88: 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 3-89: 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

No further improvements are planned for this sector.

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 3-90: 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

This category underwent profound methodological changes during this submission. Many of them have been suggested in previous reviews exercises since this category includes key source categories for several air pollutants. The table below summarizes the methodological approaches adopted and the main source of emissions for each sub-category.

Table 3-91: 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 **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 **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 **TIER 1** - Energy consumption	Combustion of diesel for heating purposes
1A4cii - Agriculture/Forestry/Fishing: Off-road vehicles and machinery	**TIER 1** - Energy consumption	Combustion of diesel in tractors and other agricultural machinery
1A4ciii - Agriculture/Forestry/Fishing: National fishing	**TIER 1** - Energy consumption	Combustion of diesel in deep sea and coastal fishing vessels

To apply a TIER 2 methodology its required information on the fuels and technologies used in the sector. While fuel consumption, by this type of fuel, is easily obtained through the National Energy Balance, a consistent time series that correctly characterizes the split technology of this sector is not available.

Previously, the Inventory used as a source of information for the technological split, a survey on energy consumption in the Residential Sector (DGEG), which characterized only the year 2010. Although the information was detailed regarding some of the thermal uses and equipment used, it failed in the task of portraying the time series.

Thus, in order to apply the Tier 2 methodology to these key categories, the Inventory relied on two sources of information:

- Appliance type split according to IIASA GAINS[19] model for years 2000, 2005 and 2010
- Thermal uses split according to JRC-IDEES[20] database between 2000 and 2015

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

[20] 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

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.

Below we describe the methodological approaches considered for the estimation of emissions.

General Approach for Tier 2 Method

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

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

Where:

E_i – annual emission of pollutant *i*

$EF_{i,k,j}$ – default emission factor of pollutant i for appliance type j and fuel k

$A_{j,k}$ – annual consumption of fuel k in appliance type j

General Approach for Tier 1 Method

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

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

Where:

$E_{pollutant}$ – the emission of the specified pollutant

$AR_{fuelconsumption}$ – the activity rate for fuel consumption

$EF_{pollutant}$ – the emission factor for this pollutant

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 (%)

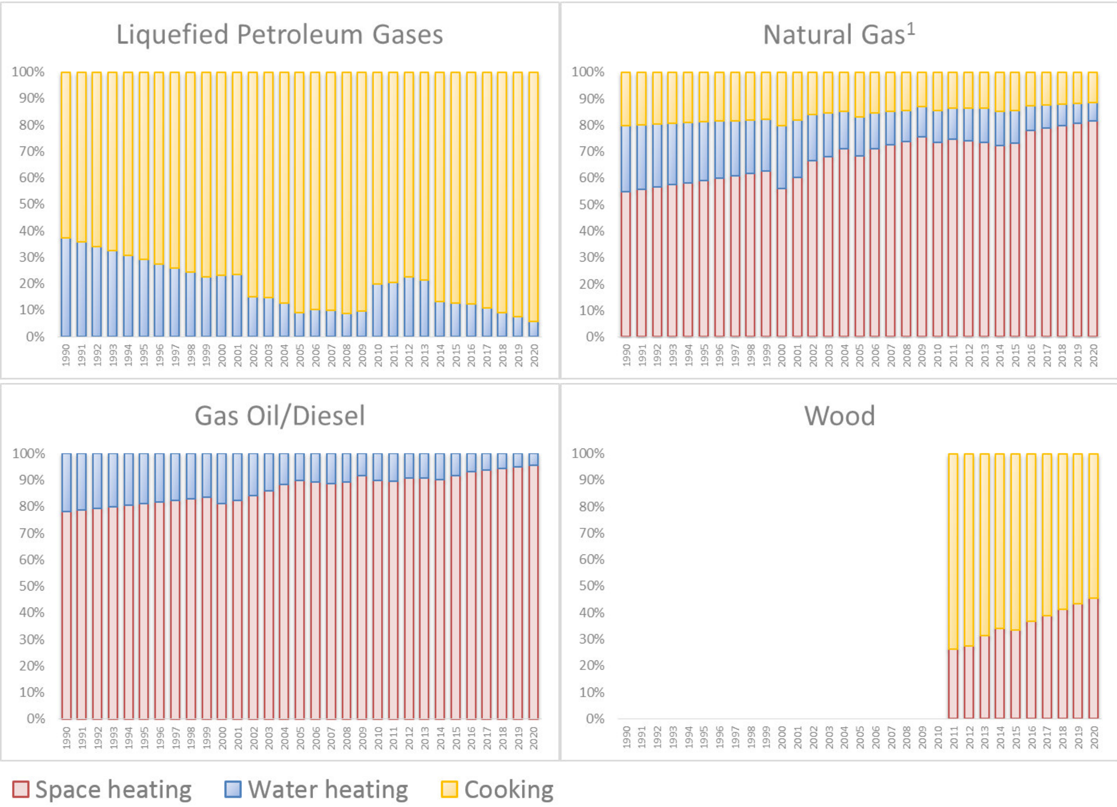
$Fuel_{Cons(f,s,t)}$ – Fuel consumption for each particular fuel and in each equipment of technology t (t/yr)

3.5.3 Activity Data

3.5.3.1 Technology Split

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

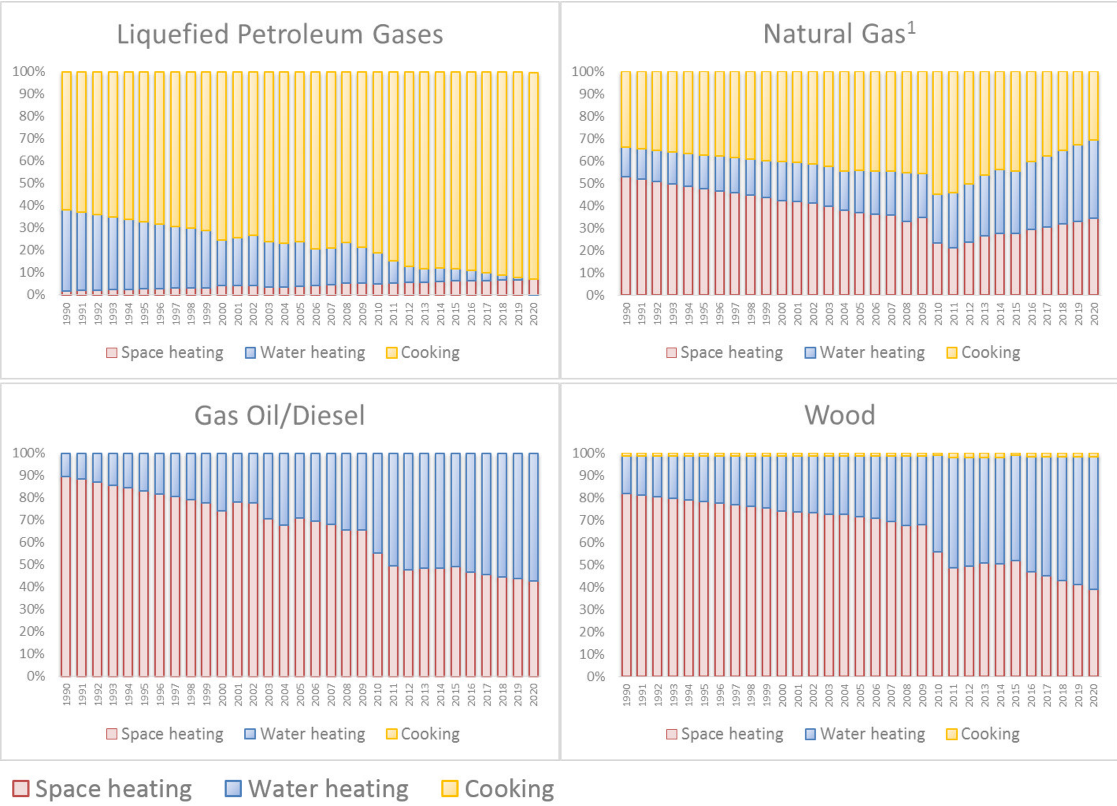
Commercial and Institutional sector, it is characterized on the one hand by the heating needs supplied by Diesel and Natural Gas in small plants of heat generation and by the other side by the consumption of LPG and Solid Biomass in the Food and beverage service activities.



1 Include Gas Work Gas

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

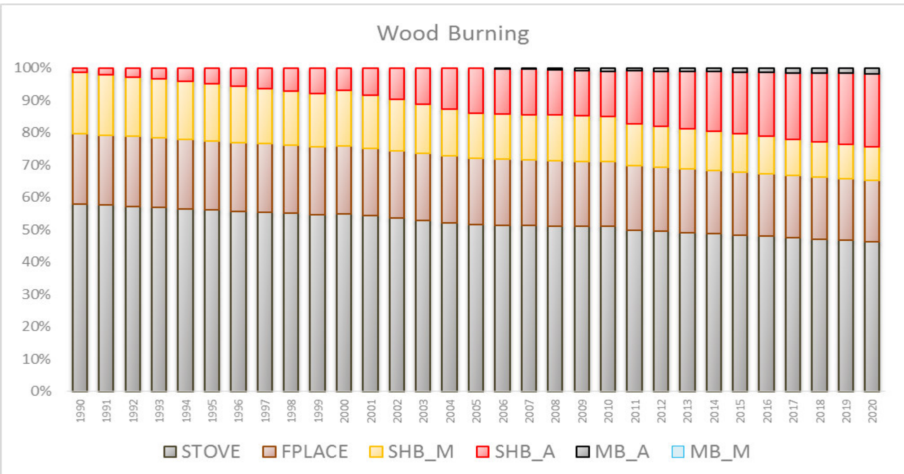
In the residential sector, the main fuels consumed are LPG and solid Biomass. Between the two are covered the three types of thermal uses. Since LPG is preferentially used in stoves intended for cooking, and the wood is burned in stoves, boilers and fireplaces for the purpose of space heating. Another trend observed between these two fuels is the use of wood in the heating of water from 2010, coinciding with the reduction of LPG consumption for this purpose. See figure below.



1 Include Gas Work Gas

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

The figure below shows the split in appliances/tecnhologies considered for the residential combustion of wood. The main trend observed is the replacement of Conventional Stoves with more modern technologies like pellets stoves, pellets boilers and automatic boilers. Even so, the appliances used in Portugal can be considered as traditional since, even in recent years, conventional stoves and boilers as well as open fireplaces represent about 80% of the consumption of wood.



STOVE - Conventional stoves; **FPLACE** - Open fireplaces; **SHB_M** - Conventional boilers
SHB_A - Pellet stoves and boilers; **MB_A** - Automatic Boilers; **MB_M** - Wood combustion

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

The methodological update made this year, allowed to separate more correctly the consumption of Diesel in the Agriculture sector. Until then, it was considered that all Diesel consumed in this sector was attributed to combustion in tractors and other off-road machines.

Using the information from JRC-IDEES Database, we can conclude that this assumption would be incorrect, and diesel consumption of these vehicles represents about 50% of the total diesel consumption of agricultural sector.

This correction in diesel consumption resulted in the allocation of emissions from the category Off-road vehicles and machinery (1A4cii) to the category Agriculture/Forestry/Fishing: Stationary (1A4ci). Assuming that these allocated emissions refer to heating and pumping activities by stationary sources in angriculture.

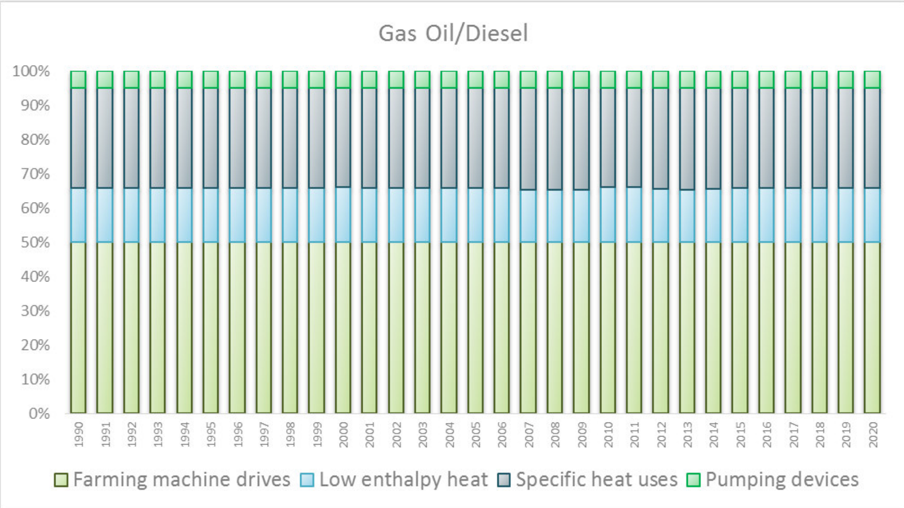


Figure 3-48: Split in Thermal Uses for Agriculture Sector - Diesel

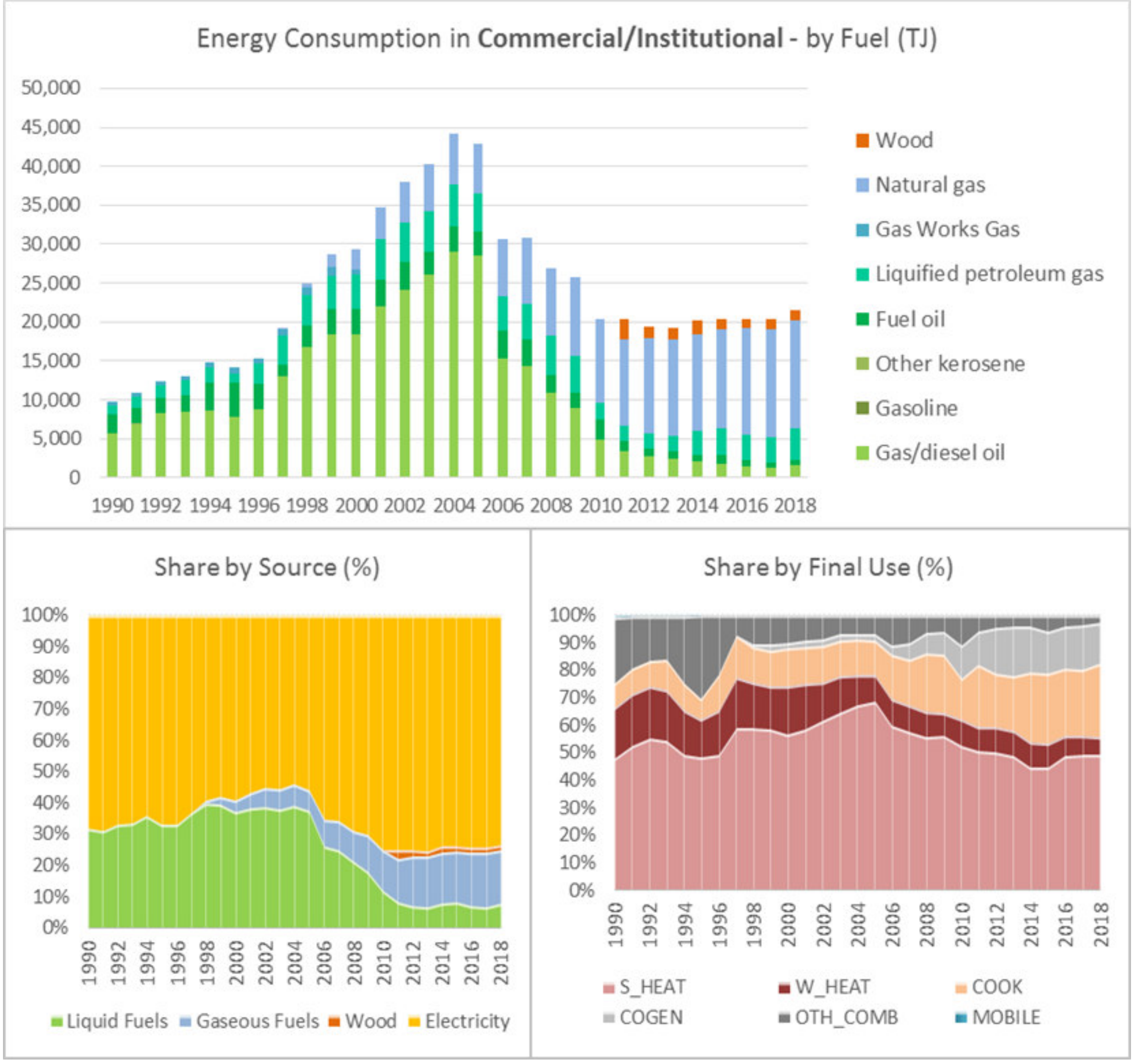
3.5.3.2 Energy Consumption

Data on fuel consumption was obtained from the annual energy balances compiled by DGEG and are presented in the following figures and Annex C.

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

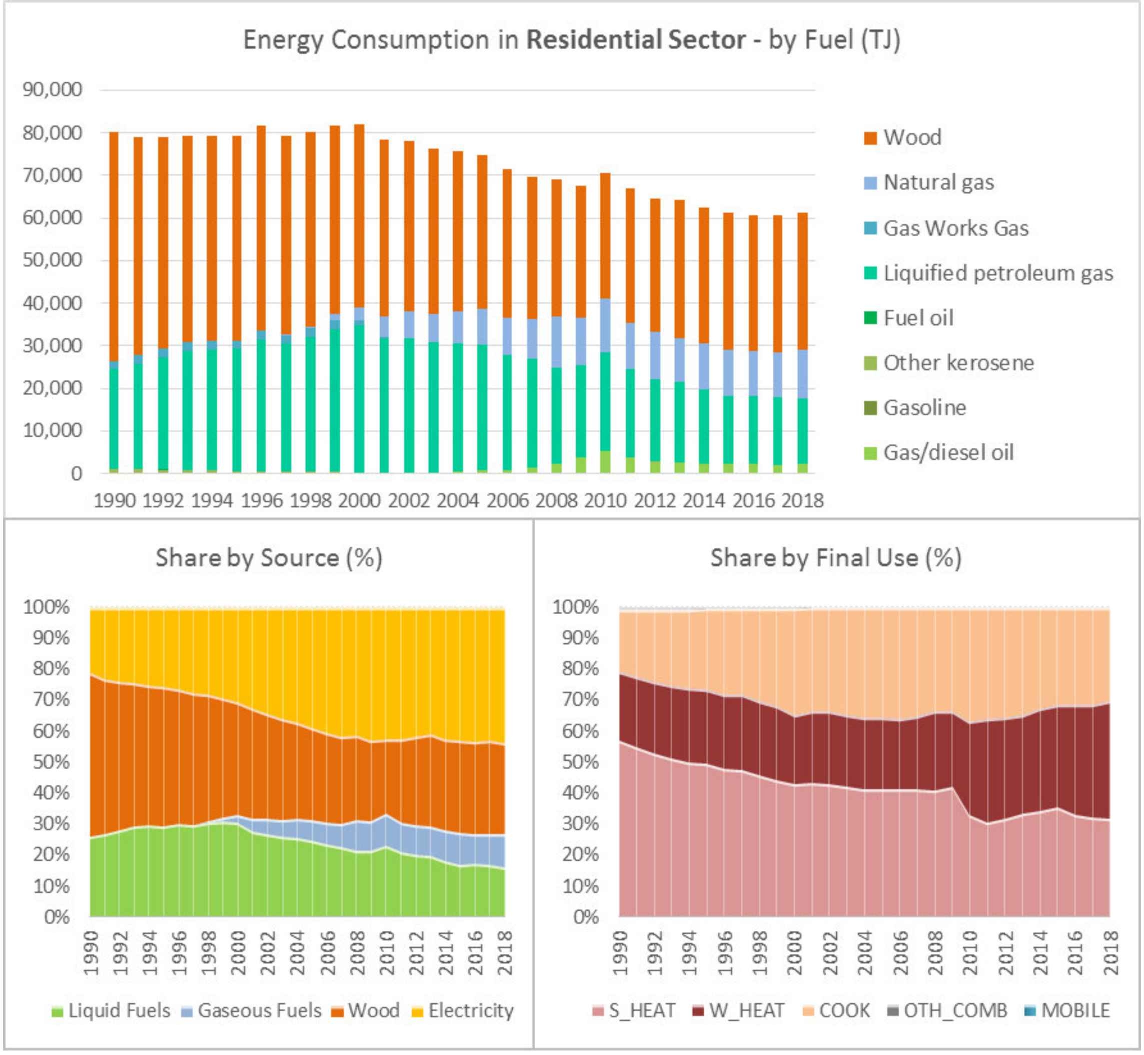
Figure 3-49: Energy consumption in Comercial/Institutional sector - by Fuel, Source and Final Use

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

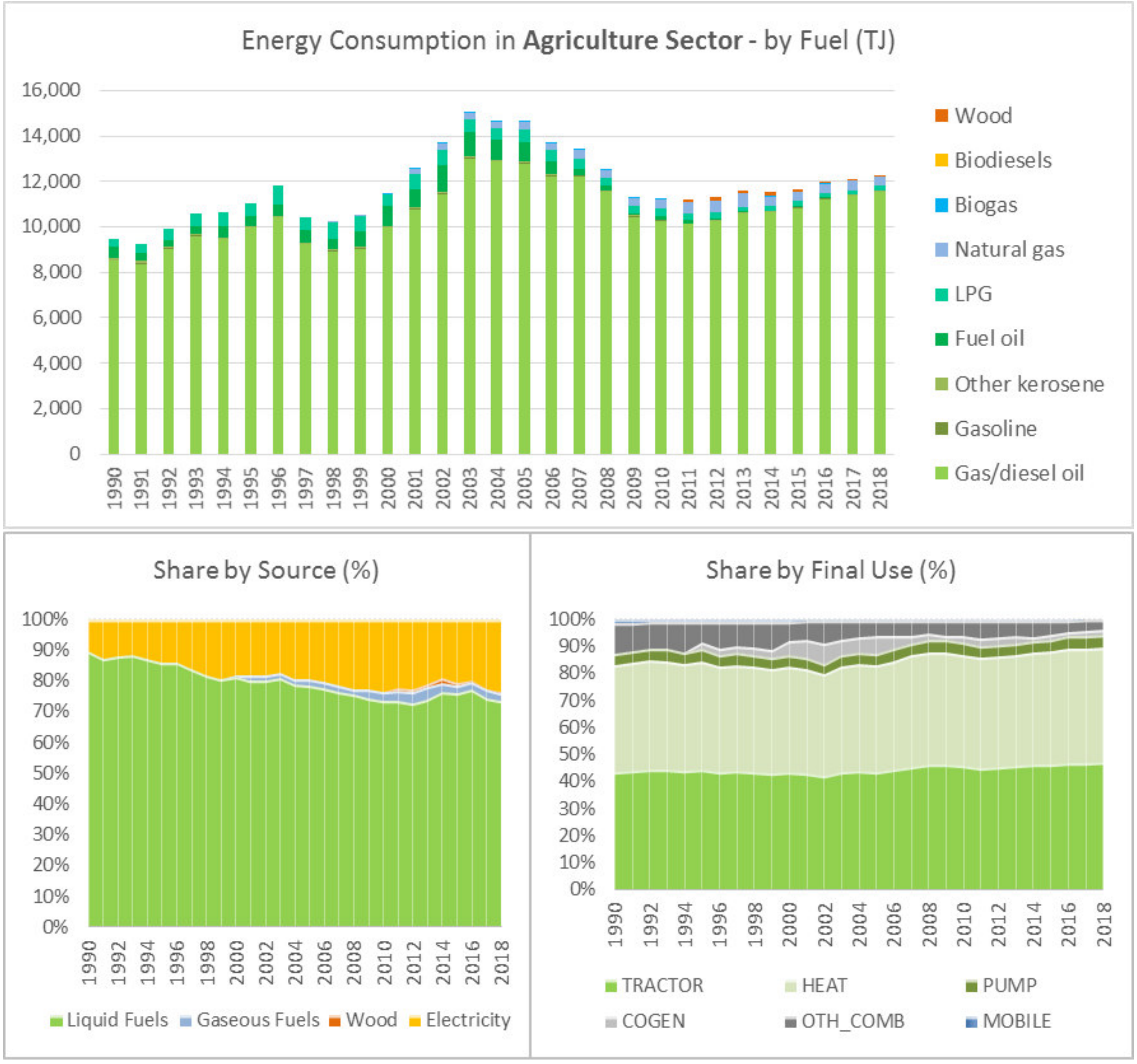
Also Natural Gas has some highlight in the consumption of this sector, having gained market share through solutions that cover the entire spectrum of thermal solutions (space heating, water heating and cooking)

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.



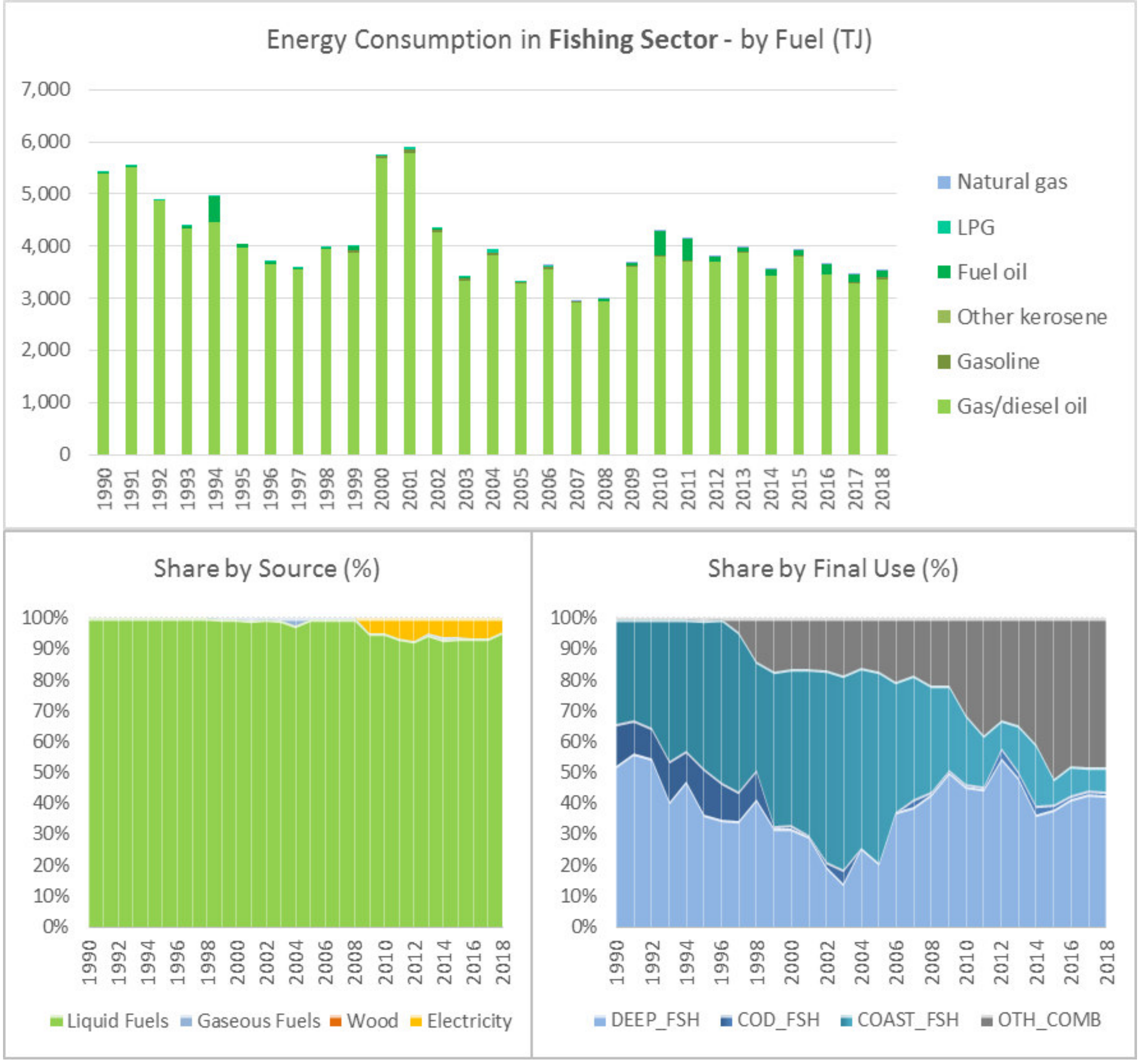
a) Gaseous Fuels* include Natural Gas, Gas Work Gas and Liquefied Petroleum Gases
b) TRACTOR: Mobile machinery; HEAT: Heat uses; PUMP: Pumping devices; COGEN: Cogeneration; OTH_COMB: Other Combustion

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 Fishing sector - by Fuel, Source and Final Use

3.5.4 Emission Factors

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 2016 - 1A4 Small Combustion - Version July 2017

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 2016 - 1A4 Small Combustion - Version July 2017

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 2016 - 1A4 Small Combustion - Version July 2017

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 May 2017

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	**3.1**
Thick Fuel Oil	Fishing Vessels	Deep Sea Fishing	**3.2**
Thin Fuel Oil	Fishing Vessels	Deep Sea Fishing	**3.2**

[1] Source: EMEP/EEA Guidebook 2016 - 1A3d Navigation - Shipping 2016

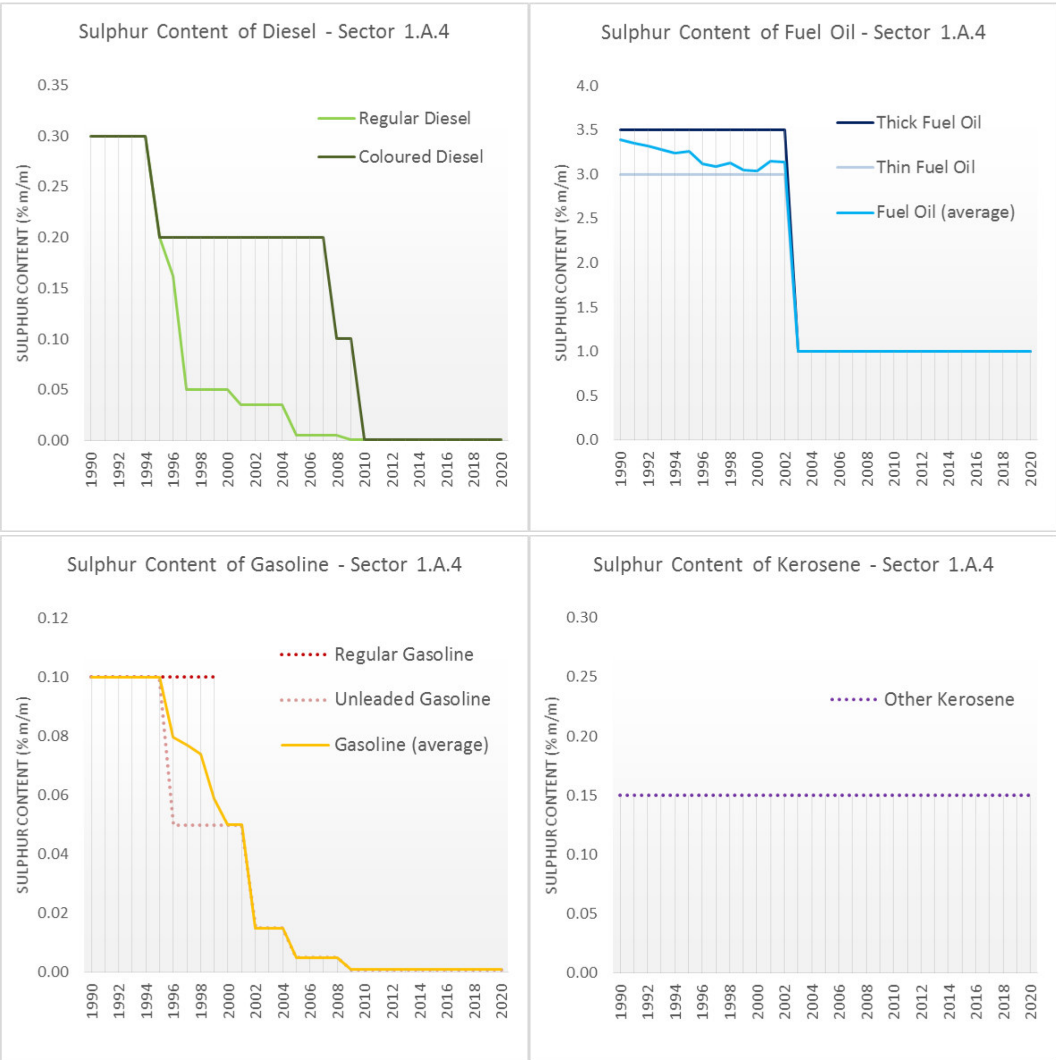


Figure 3-53: Sulphur Content in Liquid Fuels used in Sector 1.A.4

The values of the sulphur contents considered in the SO_2 estimates from combustion of liquid fuels can be found in the Annex C.

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)

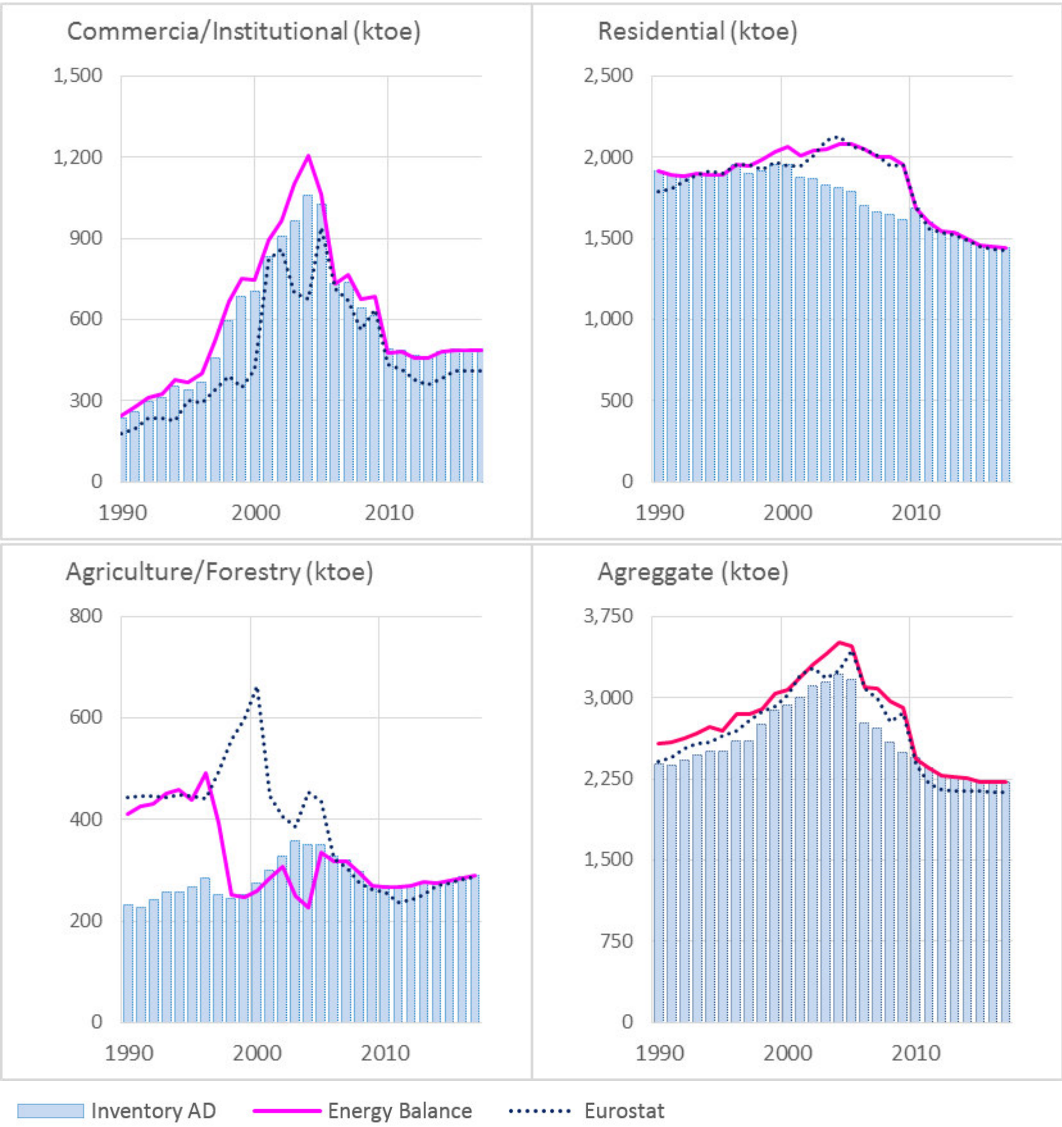


Figure 3-54: Energy consumption comparison between Inventory, National Energy Balance and EUROSTAT data by sector

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.

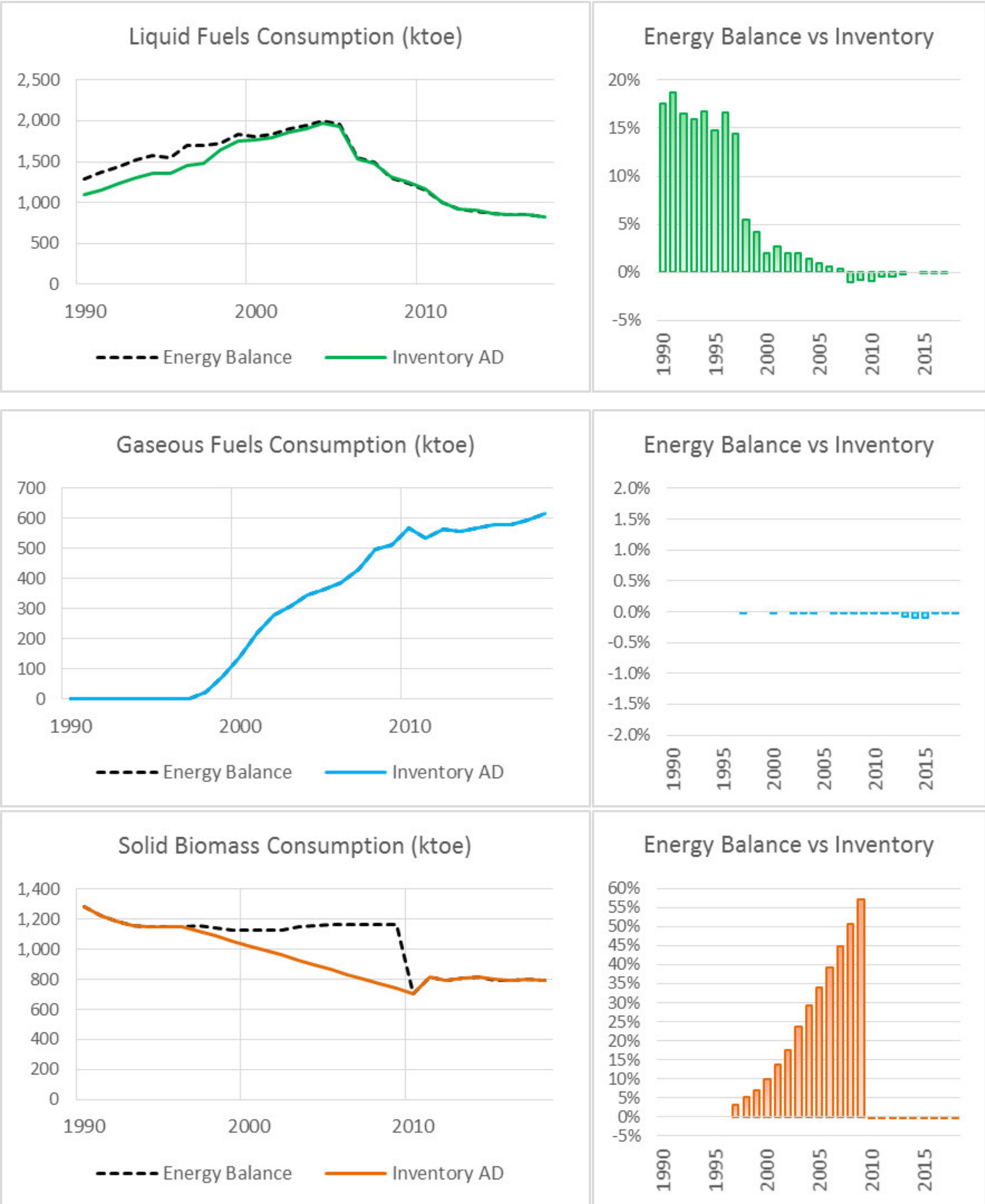


Figure 3-55: Energy consumption comparison between National Energy Balance and Inventory data by fuel type

3.5.6 Recalculations

The main recalculations in category 1A4 are related to the allocation of diesel fuel consumption to the Road Transport sector. Explanations regarding the rationale for this allocation can be found in the previous section on the category's QA / QC.

As expected, the pollutants in which the impact of this allocation can be seen is NOx, which is particularly influenced by the reduction in diesel consumption in this category. Diesel allocation is also responsible for the recalculation of SO2 emissions at the beginning of the period between the years 1990 and 1997, namely due to the correct allocation of agricultural diesel consumption.

It should also be noted that the values for compliance were revised, since the total emissions of category 1A4 were adjusted for the continental territory.

The figure below summarizes the differences between last submission and the previous year's submission for key pollutants for sector 1A4.

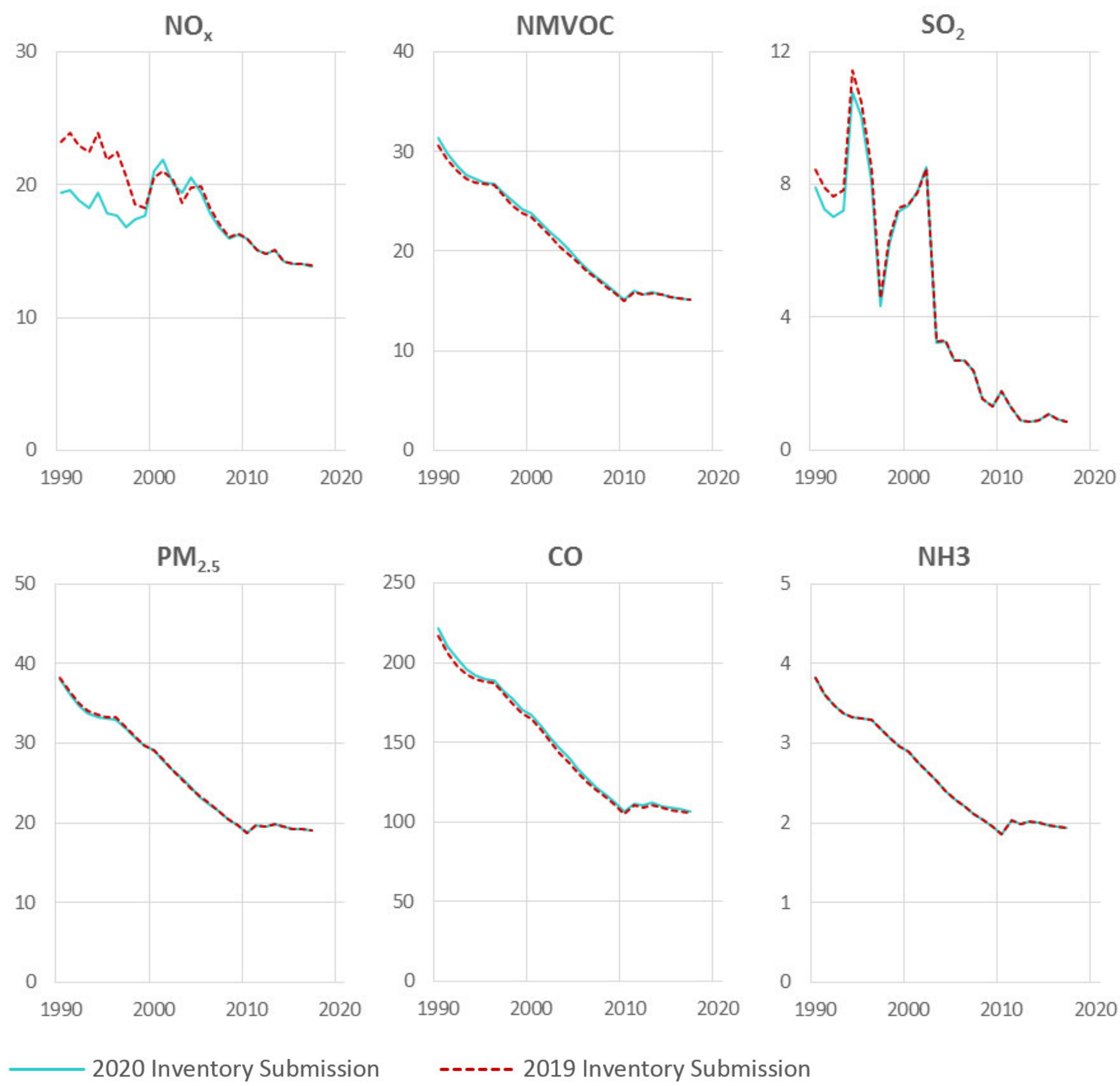


Figure 3-56: Emissions by pollutant and Inventory version for NFR 1A4 (kton)

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 this submission 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 include only military aviation.

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 NFR 1A4 Small Combustion. 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 Good Practice Guidelines, 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 default emission factors and EMEP/CORINAIR.

Table 3-97: Emission factors – Military Aviation

Fuel	Jet Fuel		
Pollutant	Value	Unit	Reference
NO_x	300	kg/TJ	Guidebook
NMVOC	50	kg/TJ	Guidebook
CO	100	kg/TJ	Guidebook
SOx	19	kg/TJ	Guidebook
Pb	0.45	g/ton	Guidebook
Cd	0.3	g/ton	Guidebook
Hg	0.0	g/ton	Guidebook
As	0.0	g/ton	Guidebook
Cr	0.1	g/ton	Guidebook
Cu	1.1	g/ton	Guidebook
Ni	0.3	g/ton	Guidebook
Se	0.0	g/ton	Guidebook
Zn	3.0	g/ton	Guidebook

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.

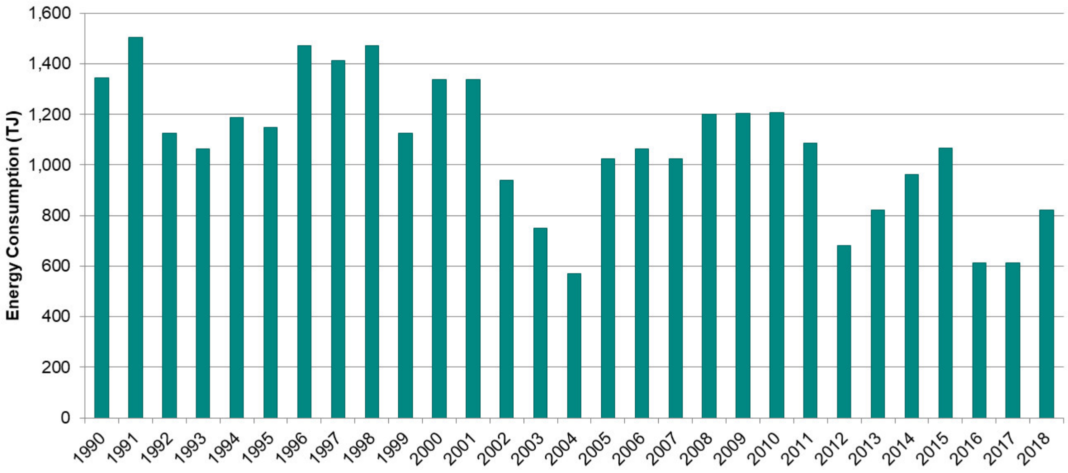


Figure 3-57: Energy Consumption in Military aviation

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

No recalculations were made for this subsector.

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 2016 Guidebook:

$$Emi = EF * Coal_U * 10^{-3}$$

Where:

Emi: Emissions of pollutant x (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 2016 (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 is from Geological Resources reports from DGEG.

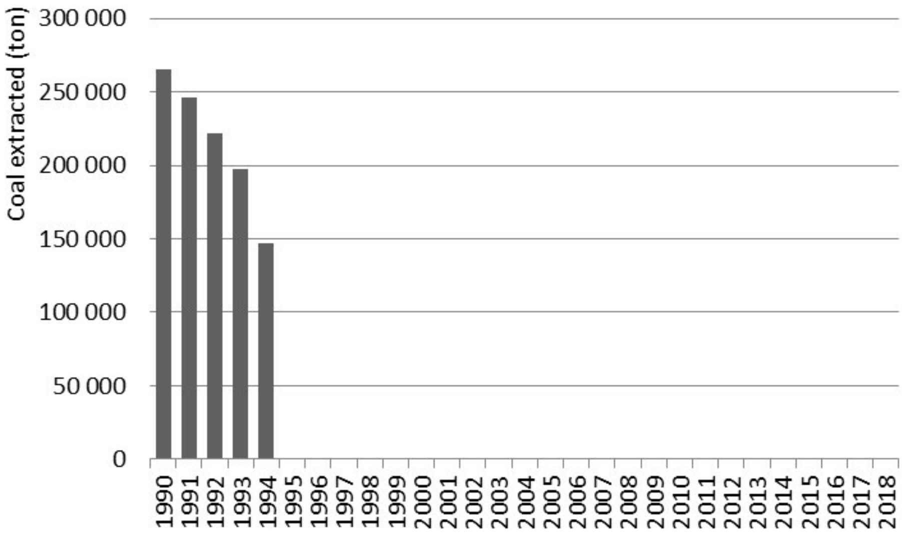


Figure 3-58: Quantities of coal extracted from mines in Portugal

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.

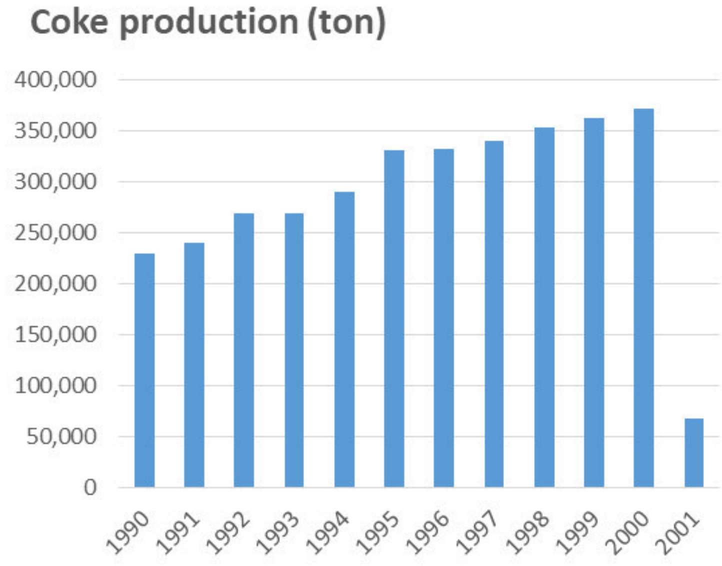


Figure 3-59: Coke production in the coke plant

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

Regarding coke production fugitive emissions, there are major differences between submissions, related with the emission factors applied. In effect, we were using emission factors from AP-42 and for this submission we applied the emission factors from Table 3-1 of chapter 1.B.1.b Fugitive emissions from solid fuels: solid fuel transformation of the 2019 EMEP Guidebook. This resulted in major decreases in emissions from the following air pollutants: SOx, NOx, NMVOC, CO, NH_3 and Particulate Matter. On the other hand, there are slight increases in emissions from heavy metals and PAHs.

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

Data on crude consumption was obtained from refineries from 2005 onwards. In the period 1990-2004, data was obtained from DGEG (General Directorate for Energy and Geology).

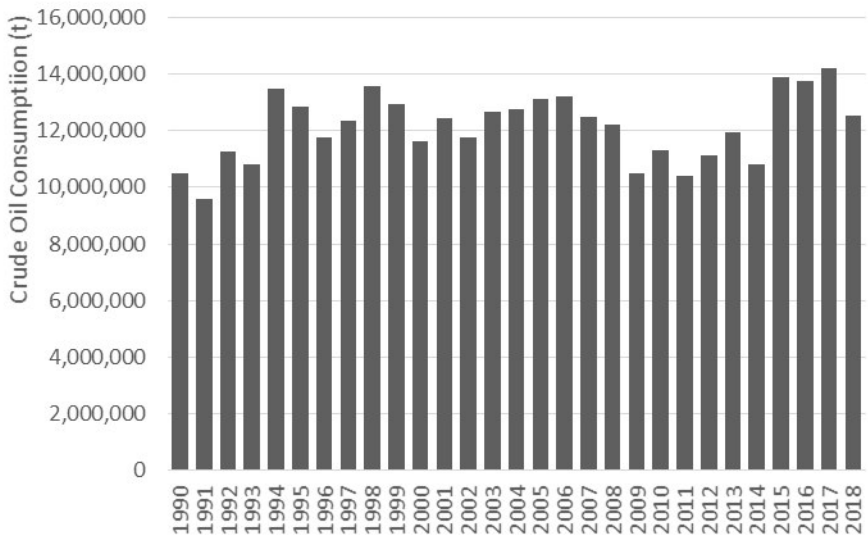


Figure 3-60: Total amount of crude in Marine Terminals

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[21] 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 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:

$$Emi_p = \text{Fresh Feed} \times EF_p \times 10^{-3}$$

Where:

Emi_p: Emission of pollutant “p” (t)

Fresh Feed: Fresh Feed of Fluid catalytic cracking unit (m^3)

[21] Sometimes only these emissions are referred as fugitive emissions from refineries.

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	Source
NO_x	Kg/m^3 fresh feed	0.2	Table 3-2 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016
CO	Kg/m^3 fresh feed	39	Table 3-2 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016
NMVOC	Kg/m^3 fresh feed	0.63	Table 3-2 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016
SO_x	Kg/m^3 fresh feed	1.4	Table 3-2 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016
NH_3	Kg/m^3 fresh feed	0.16	Table 3-2 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016
TSP	Kg/m^3 fresh feed	0.7	Table 3-2 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016
PM_{10}	Kg/m^3 fresh feed	0.55	Table 3-2 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016
$PM_{2.5}$	Kg/m^3 fresh feed	0.24	Table 3-2 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016
BC	% $PM_{2.5}$	0.13	Table 3-2 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016
Pb	g/m^3 fresh feed	0.32	Table 3-2 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016
Cd	g/m^3 fresh feed	0.063	Table 3-2 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016
Hg	g/m^3 fresh feed	0.07	Table 3-2 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016
As	g/m^3 fresh feed	0.014	Table 3-2 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016
Cr	g/m^3 fresh feed	0.33	Table 3-2 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016
Cu	g/m^3 fresh feed	0.14	Table 3-2 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016
Ni	g/m^3 fresh feed	0.61	Table 3-2 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016
Se	g/m^3 fresh feed	0.014	Table 3-2 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016
Zn	g/m^3 fresh feed	0.12	Table 3-2 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016
Benzo(α)pyrene	mg/m^3 fresh feed	0.71	Table 3-2 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016
Benzo(β)fluoranthene	mg/m^3 fresh feed	1.2	Table 3-2 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016
Benzo(k)fluoranthene	mg/m^3 fresh feed	0.82	Table 3-2 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016
Indeno(1,2,3-cd)pyrene	mg/m^3 fresh feed	0.62	Table 3-2 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016

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.

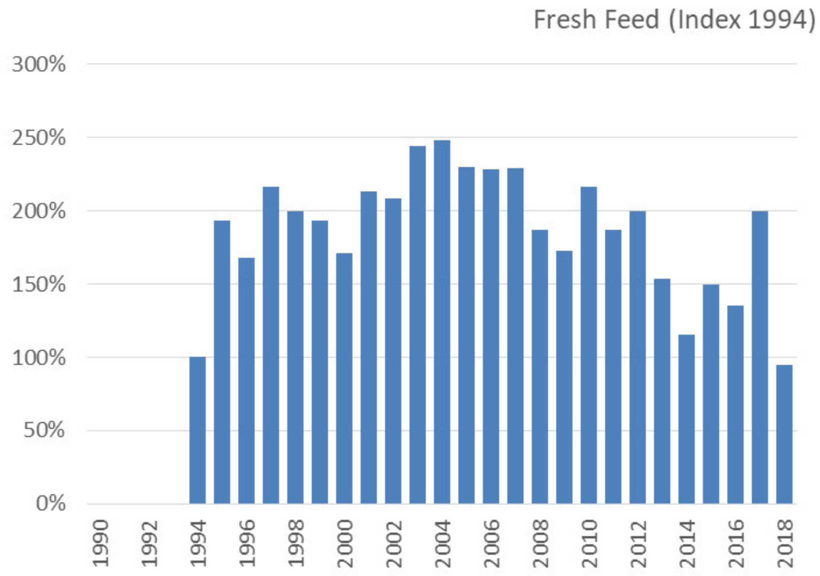


Figure 3-61: Fresh feed in the Fluid Catalytic Cracking Unit

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:

$$Emi_p = \text{Fresh Feed} \times EF_p \times 10^{-6}$$

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:

$$Emi_p = \text{Fresh Feed} \times EF_p \times 10^{-6}$$

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.

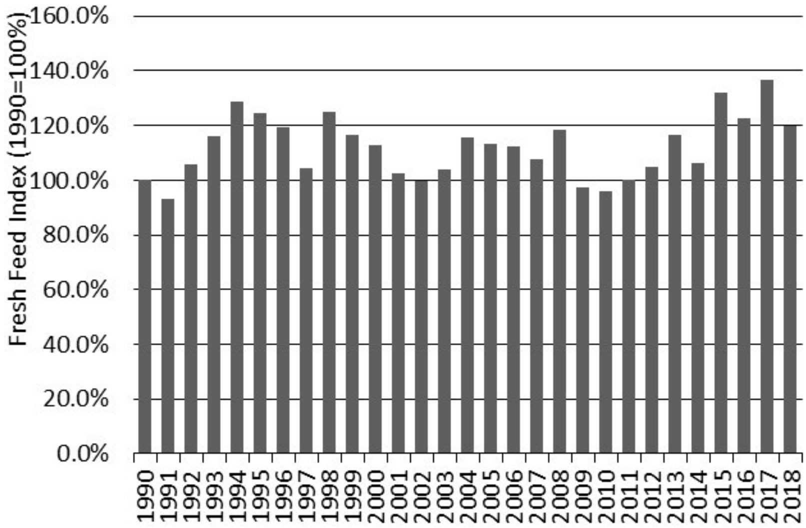


Figure 3-62: Fresh feed in the Platforming Units

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.

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.

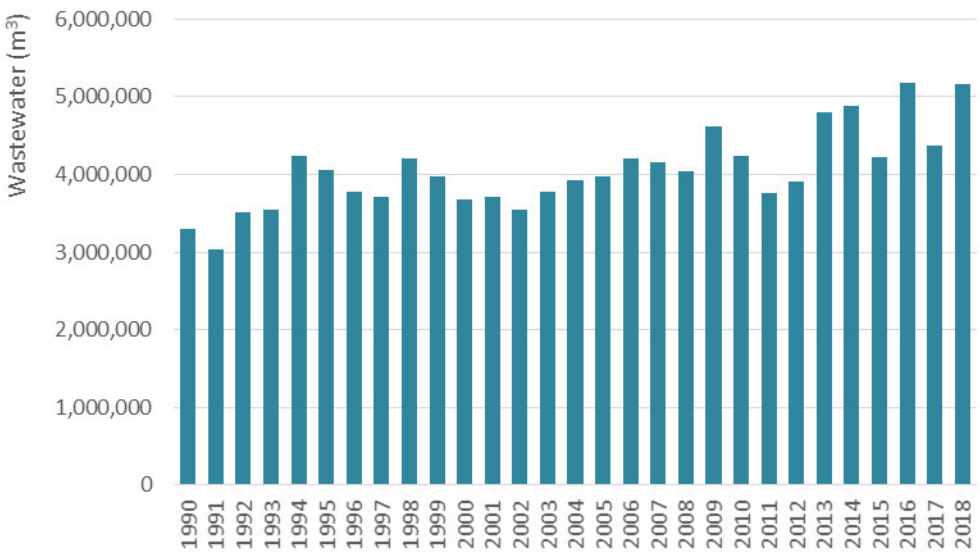


Figure 3-63: Wastewater treated

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:

$$\boldsymbol{Emi_{Claus\ Unit} = \frac{M_{SO2}}{M_S} \times \left[S_{input} \times \ (100\% - Effic_{Claus\ Unit})\right]}$$

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:

$$Emi_{Absorption\ Tower} = \frac{M_{SO2}}{M_S} \times [S_{input} \times (100\% - Effic_{Absorption\ Tower})]$$

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:

$$Emi_{Incinerator} = \frac{M_{SO2}}{M_S} \times [S_{input} \times (100\% - Effic_{Incinerator})]$$

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.

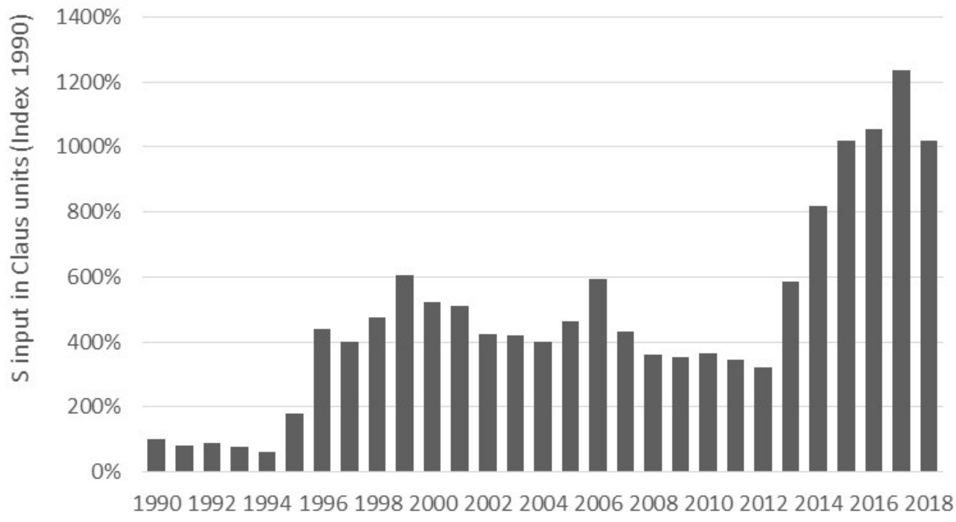


Figure 3-64: Sulphur input in Claus Units (Index related to 1990 value)

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:

$$Emi_{NMVOC} = EF_{(y)} \text{ X } Throughput \text{ X } 10^{-6}$$

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[22].

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.

[22] This list is intended as presenting an overview. For precise description please consult USEPA (1997) or USEPA (2000).

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	2016	2017	2018
NMVOC	kg/t throughput	31.8	31.2	31.0	30.6	34.8	21.2	17.9	14.8

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.

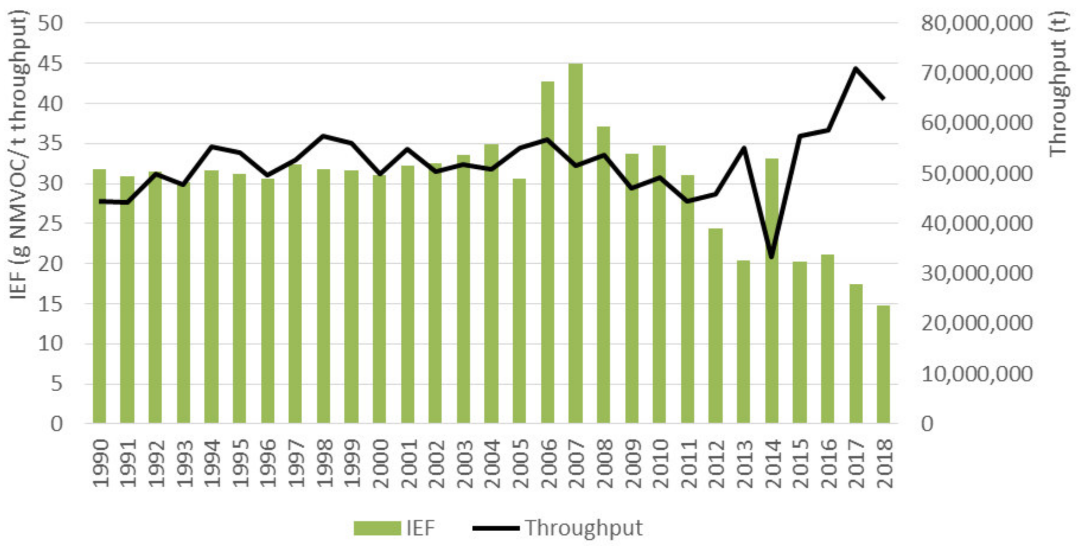


Figure 3-65: Total throughput in Lisbon, Porto and Sines refineries

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.

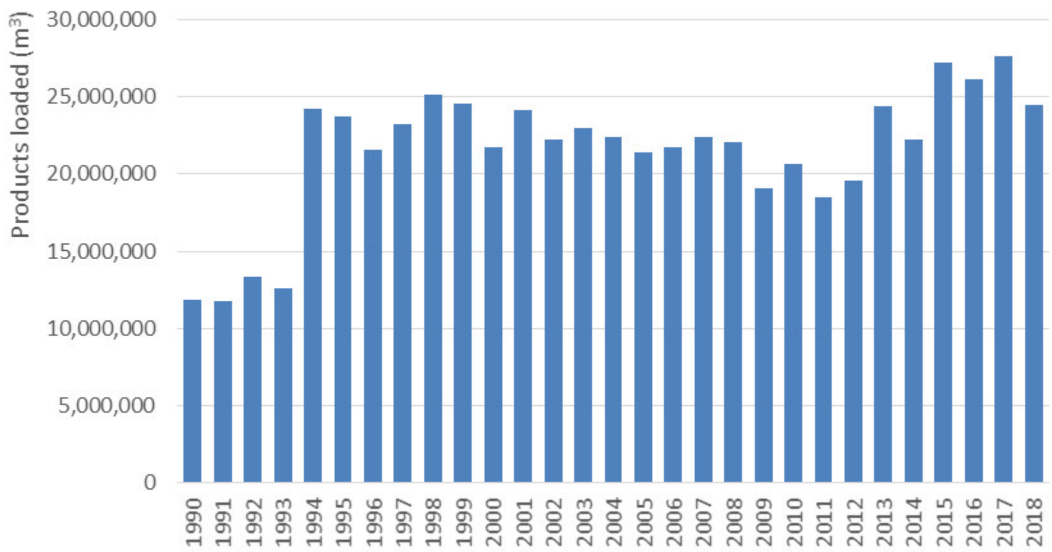


Figure 3-66: Products loaded at terminal dispatch stations of refineries and depots

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

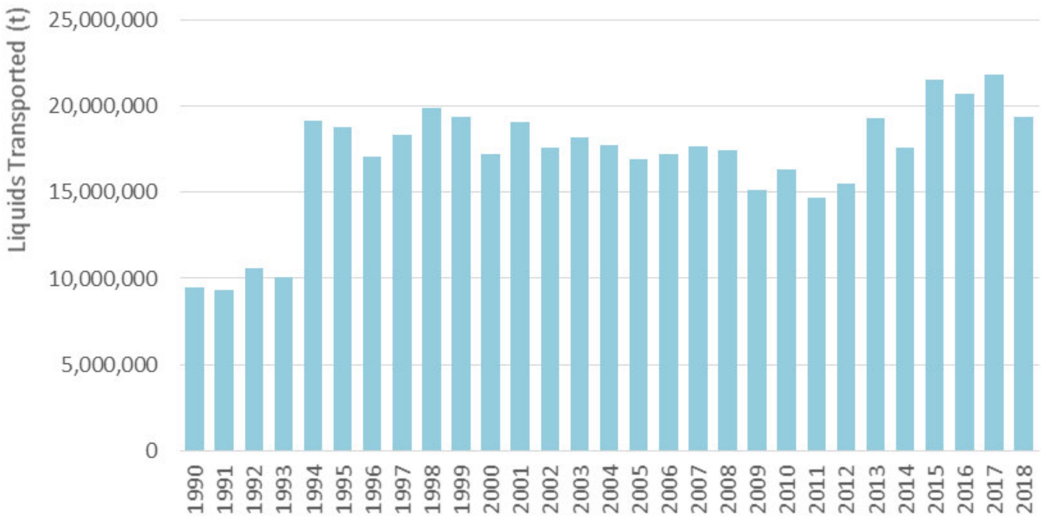


Figure 3-67: Liquids transports from Refineries and Depots

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:

$$Emi_{NMVOC} = EF_{(y)} \text{ X } Throughput \text{ X } 10^{-6}$$

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[23].

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:

[23] This list is intended as presenting an overview. For precise description please consult USEPA (1997) or USEPA (2000).

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	2016	2017	2018
NMVOC	kg/t throughput	37.5	22.1	22.1	22.1	22.1	22.1	22.1	22.1

3.8.3.3.3 Activity Data

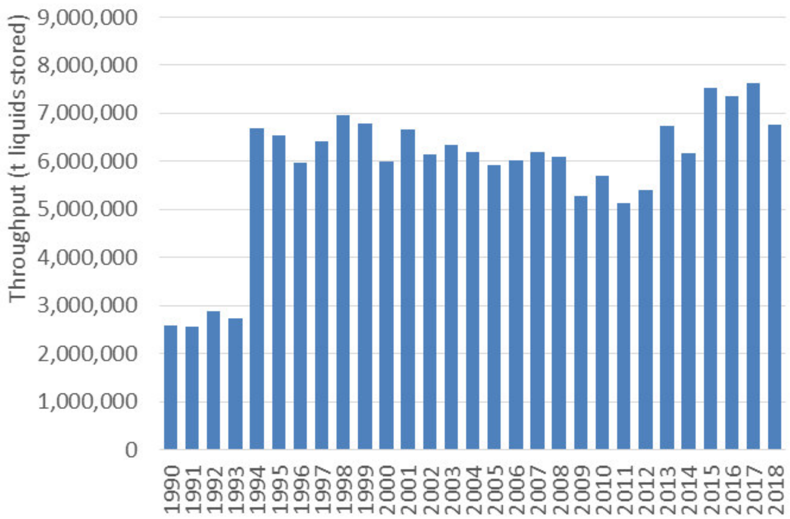


Figure 3-68: Throughput in depots

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/m³/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.

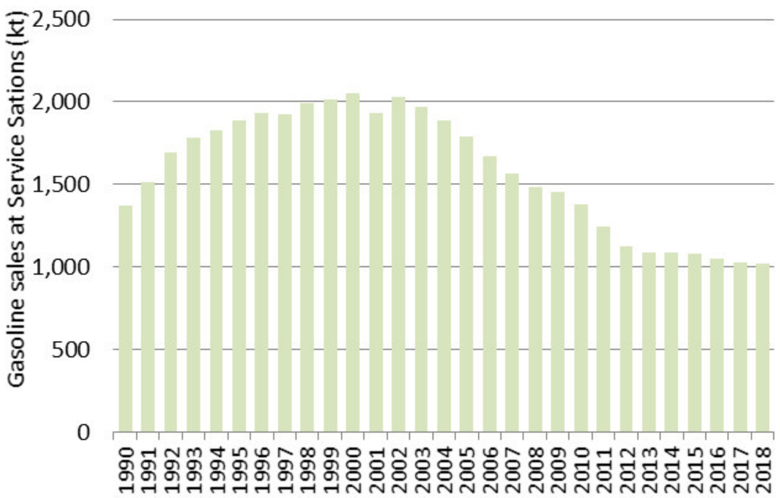


Figure 3-69: Fuel Sales at Service Stations

3.8.3.4.4 Recalculations

No recalculations were made.

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.

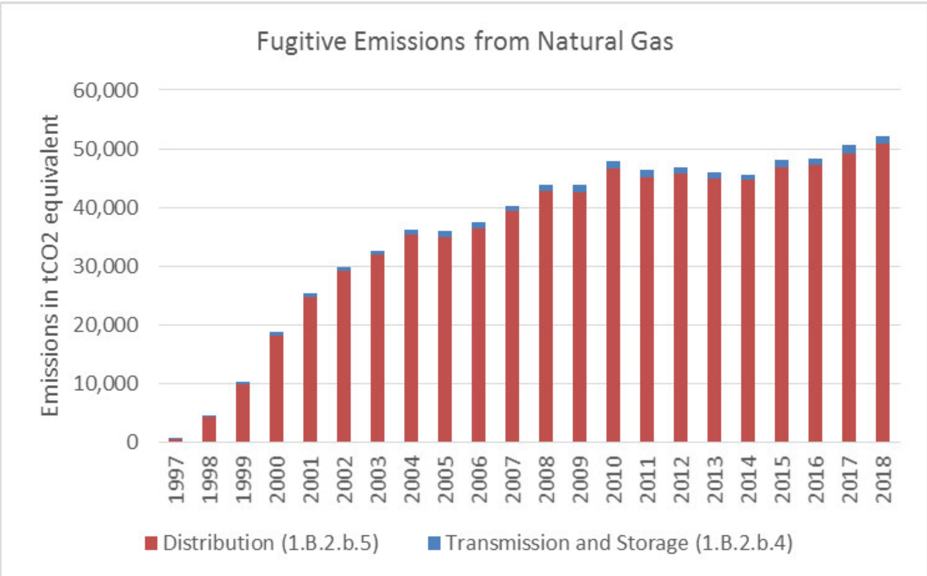


Figure 3-70: Fugitive Emissions from Natural Gas

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:

- importation of natural gas, obtained from the DGEG’s Energy Balances;
- consumption of Natural Gas.

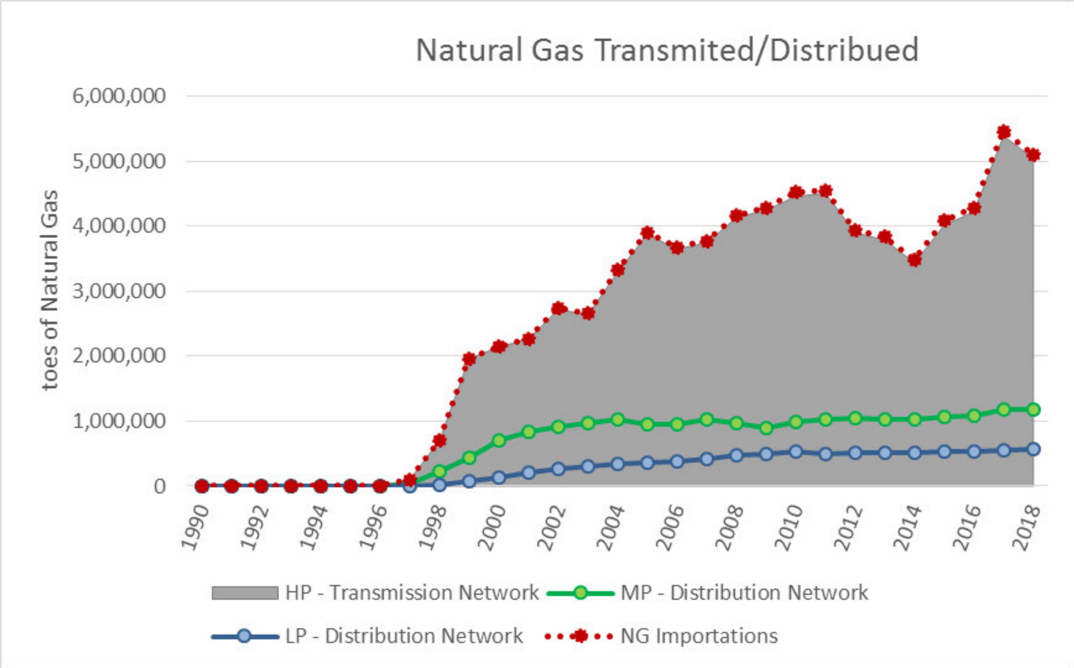


Figure 3-71: Natural Gas transported by High, Medium and Low Pressure Networks

3.9.4.1 Recalculations

There are no significant recalculations for this category.

3.9.4.2 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 Flaring in Oil Industry (1.B.2.c)

3.10.1 Category description

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:

$$Emi_{(p,y)} = EF_{(p)} \text{ X } Flare_{GAS(y)} \text{ X } m_{(p,y)}/m_{(gas,y)} \text{ X } 10^{-3}$$

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:

$$Emi_{SOx} = EF_{SOx} \text{ X } S_{(m/m)} \text{ X } Flare_{GAS(y)} \text{ X } 10^{-3}$$

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[24]	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)"
$PM_{2.5}$[25]	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)"

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.

[24] In Concawe there is only the emission factor for PM10. We assume that TSP=PM_{10}=$PM_{2.5}$.

[25] In Concawe there is only the emission factor for PM10. We assume that TSP=PM_{10}=$PM_{2.5}$.

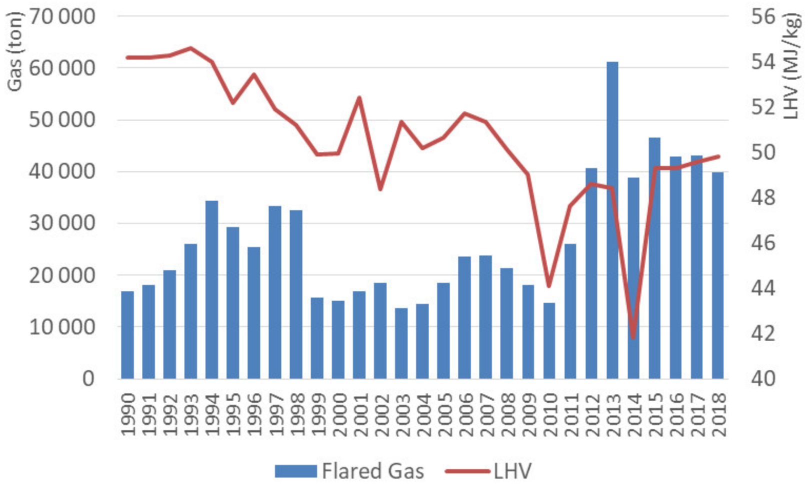


Figure 3-72: Total consumption of flare gas in Portuguese refineries and Low Heating Value

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 2)

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4 Industrial Processes and Product Use (NFR 2)

Rita Silva

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	2016	2017	2018	Δ 2018-2017	Δ 2018-2005	Δ 2018-1990	Importance in total emissions from PT in 2018
			kt				%		%
NOx									
Portugal	3.18	4.79	5.71	5.80	5.90	1.8%	23.2%	85.3%	4.19%
Mainland	3.18	4.79	5.71	5.80	5.90	1.8%	23.2%	85.3%	3.80%
NMVOC									
Portugal	81.41	93.96	75.30	77.68	83.38	7.3%	-11.3%	2.4%	54.07%
Mainland	77.91	90.25	72.36	74.73	80.25	7.4%	-11.1%	3.0%	53.73%
SOx									
Portugal	12.61	12.55	5.47	5.60	5.74	2.5%	-54.2%	-54.5%	17.15%
Mainland	12.61	12.55	5.47	5.60	5.74	2.5%	-54.2%	-54.5%	12.66%
NH3									
Portugal	5.46	5.52	3.40	3.38	3.25	-3.7%	-41.0%	-40.4%	6.52%
Mainland	5.46	5.51	3.39	3.37	3.25	-3.6%	-41.1%	-40.5%	5.80%
PM2.5									
Portugal	14.07	20.39	16.55	16.78	16.42	-2.2%	-19.5%	16.7%	32.71%
Mainland	14.01	20.30	16.48	16.71	16.35	-2.2%	-19.4%	16.7%	32.10%

The majority of air pollutants in IPPU sector is released as NMVOC and particulate matter, which represented circa 54 % and 32 % of national total emissions, respectively.

[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.

In 2018, the industrial processes in Portugal that registered the most significant positive contributions to the growth seen in the total of the industry were the vehicle manufacturing, petroleum products refining and food manufacturing. On the other hand, the activities that contributed negatively were the rubber and plastic products manufacturing, leather products industry and the drink industry.

Recalculations

2.A.1 (Cement production): Cd emission factor was revised to a Tier 2 value according to Table 3-24 of the 2019 EMEP Guidebook, for the whole time series; 2016 and 2017 fuel consumption data were updated;

2.A.2 (Lime production): TSP, PM10 and PM2.5 emission factors were updated according to Table 3.2 of Chapter 2.A.2 of 2019 EMEP Guidebook; NOx, SOx, NMVOC and CO emissions from lime production were removed, given that, according to section 3.2.2 of chapter 2.A.2 of the 2019 EMEP Guidebook, it is expected that they are due to the combustion of fuels;

2.A.5.b (Construction and Demolition): 2017 data on the number of new houses/apartments constructed and non-residential construction was revised by INE; In the period 1990-2002, data on the number of new houses/apartments constructed and non-residential construction was updated for the period 1990-2002 based on the average from 2003-2007 values and on GDP trend, also from INE;

2.A.5.c (Storage, handling and transport of mineral products): A new data series on imports was obtained from EUROSTAT;

2.B.10.a (Polystyrene): 2008 to 2010 activity data were updated based on national statistics;

2.C.1 (Iron and Steel Production): Methodological revision of the sector for the whole time series;

2.C.3 (Aluminium Production): Update on assumptions to reflect Portuguese legislation regarding the use of HCE in aluminium production industry;

2.C.7.d (Storage, Handling and Transport of Metal Products): Activity data were revised for the whole time series upon revision of iron, aluminium, copper and lead's activity data;

2.D.3.a (Domestic solvent use including fungicides): Methodological revision of the sector for the whole time series;

2.D.3.b (Road Paving with Asphalt): 2017-2018 and 2010-2014 asphalt production data were updated based on the Energy Balance;

2.D.3.c (Asphalt Roofing): 2017 data on Imports was updated according to EUROSTAT database;

2.D.3.e (Degreasing): Imports data for the years 2016 and 2017 were updated based on EUROSTAT;

2.D.3.g (Chemical Products - Tyre Production): development of an average tyre weight taking into account the weighting of each type of tyre produced;

2.D.3.g (Chemical Products – Asphalt Blowing): Update of emission factors according to EMEP 2019 Guidebook;

2.D.3.i (Vehicle Dewaxing): National vehicles sales data was updated for the whole time series based on ACAP;

2.G (Other solvent and product use): Use of fireworks - 2017 activity data was updated based on EUROSTAT data; Use of Tobacco - 2008 to 2009 and 2017 imports and exports activity data were updated based on EUROSTAT; Use of Shoes - 2017 imports and exports data were updated based on EUROSTAT; Lubricants use: Lubricant consumption values were updated for 2013, based on the Energy Balance by DGEG;

2.H.2 (Food Manufacturing): PM emissions from sub-category "Handling of agricultural products (grains, soya)" are now estimated under 2.H.2; a compilation error regarding NMVOC emissions was corrected in NFR tables, given that no emissions from this pollutant result from this sub-category;

2.L (Other Production, Consumption, Storage, Transportation or Handling of Bulk Products): following further analysis to chapter 2.L of the 2019 EMEP Guidebook, we concluded that there is no other production, consumption, storage, transportation or handling of bulk products. Therefore, this category will be reported as NO.

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 was:

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)

[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.

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)

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]	Table 3-2 to 3-7 of Chapter 1.A.1 Energy Industries of 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.

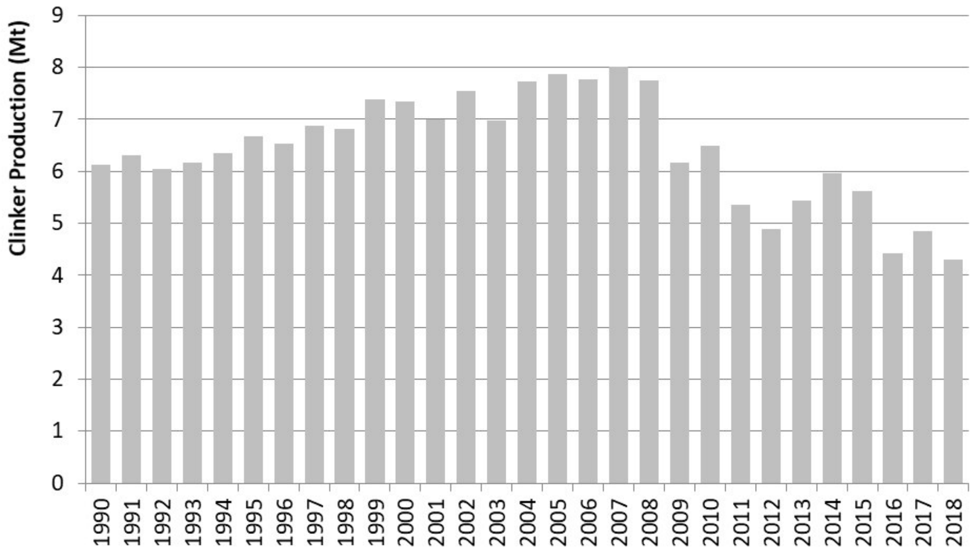


Figure 4-1: Total clinker production in Portugal

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.

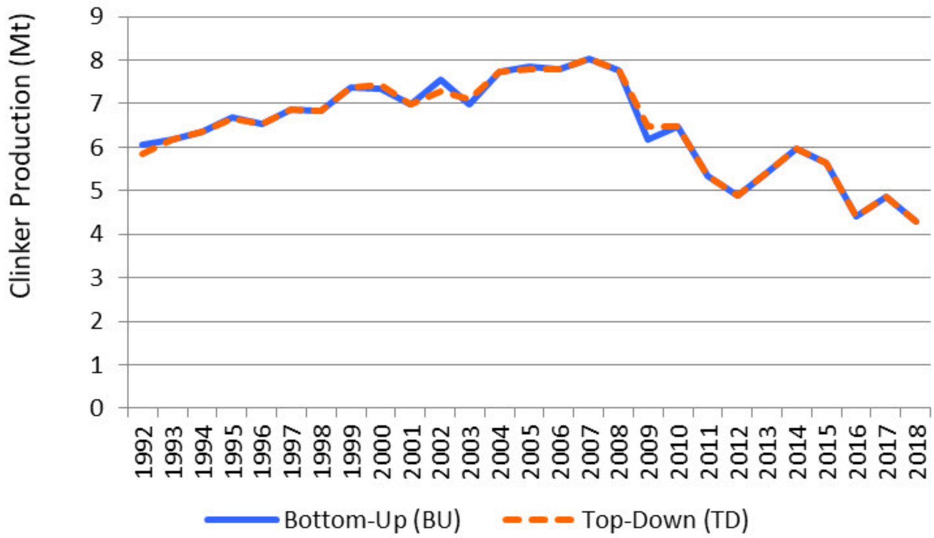


Figure 4-2: Clinker production data – comparison of approaches

4.2.1.6 Recalculations

Following a 2019 NECD recomendation, Cd emission factor was revised to a Tier 2 value according to Table 3-24 of the 2019 EMEP Guidebook, for the whole time series.

2016 and 2017 fuel consumption data were updated.

4.2.1.7 Further Improvements

In future submissions, we intend to revise plant specific emission factors based on updated monitoring data.

4.2.2 Lime Production (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 under ETS in Portugal. During 2017, a new facility began operating and was included in ETS.

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. That is also the case of the production of lime in Kraft paper pulp plants, where quicklime is produced from carbonates in lime kilns and it is used to regenerate green liquor to white liquor.

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. Emission factors for combustion-related emissions are provided in the Energy sector (chapter 1.A.2.f). Emissions of other heavy metals are assumed to be negligible.

For all pollutants, the methodology applied for emissions estimates was:

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

The emission factors applied are listed in the table below:

Table 4-3: Emission Factors for lime production

Pollutant	Unit	Emission Factor	Source
TSP	kg/t lime	9	Table 3.2 of Chapter 2.A.2 of 2019 EMEP Guidebook
PM10	kg/t lime	3.5	Table 3.2 of Chapter 2.A.2 of 2019 EMEP Guidebook
PM2.5	kg/t lime	0.7	Table 3.2 of Chapter 2.A.2 of 2019 EMEP Guidebook
BC	% of $PM_{2.5}$	0.46	Table 3.2 of Chapter 2.A.2 of 2019 EMEP Guidebook

4.2.2.4 Activity Data

From 2010 onwards, lime production was obtained directly from lime production plants. During 2017, a new facility began operating (testing phase) and was included in ETS.

In the period 1990-2009, activity data was estimated based on lime production trend obtained from INE.

Lime production data in the iron and steel industry was available from information received from the industry for the period 1991-1994. For the remaining years, annual lime production, for which data was unavailable, was forecasted using energy consumption as surrogate indicator. From 2002 onwards, production of lime in this unit was interrupted and the production line dismantled. All lime produced in the iron and steel plant was high calcium lime.

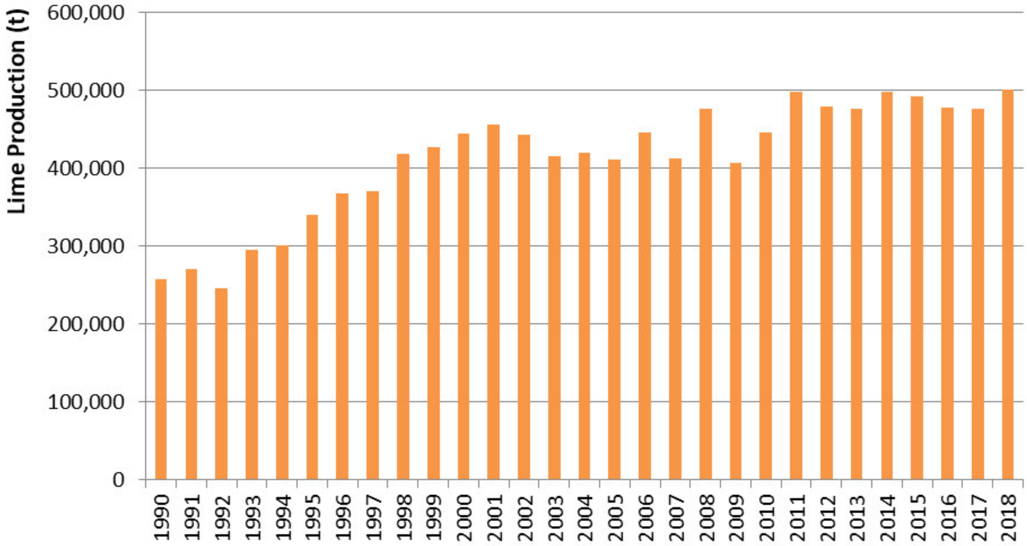


Figure 4-3: $CaCO_3$ consumption and Lime production

In the end of the first quarter of 2017, a new facility began operating and was included in ETS, however, it was on a pilot phase and, therefore, working intermittently. Formally, this facility only started fully operating in early 2018, hence the increase in lime production from 2017 to 2018.

4.2.2.5 Category specific QA/QC and verification

Following QA/QC procedures to the sector, NOx, SOx, NMVOC and CO emissions from lime production were removed, given that, according to section 3.2.2 of chapter 2.A.2 of the 2019 EMEP Guidebook, it is expected that they are due to the combustion of fuels. Process emissions of these pollutants are negligible and therefore are considered Not Estimated (NE) in category 2.A.2.

4.2.2.6 Recalculations

Following a 2019 NECD recommendation, TSP, PM_{10} and $PM_{2.5}$ emission factors were updated according to Table 3.2 of Chapter 2.A.2 of 2019 EMEP Guidebook.

NOx, SOx, NMVOC and CO emissions from lime production were removed, as already explained in section 4.2.2.5 above.

4.2.2.7 Further Improvements

In future submissions, we intend to revise plant specific emission factors based on updated monitoring data.

4.2.3 Glass Production (NFR 2.A.3)

4.2.3.1 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 1A2, 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 (they were not used to derive country specific emission factors, for instance).

4.2.3.2 Methodology

For all pollutants, the methodology applied for emissions estimates was:

Equation 4-4: Emissions from glass production

$$Emission_{(x,y)} = EF_{(x,y)} \text{ X } Glass_{PROD,y} \text{ X } 10^{-3}$$

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)

4.2.3.3 Emission Factors

The following emission factors from USEPA (1986) were considered in the estimates:

Table 4-4: Emission Factors considered

Parameter	Unit	Considered in NFR sector	Flat Glass	Container Glass	Crystal Glass
NMVOC	kg/t Glass	1 A 2 f	0.1 (a)	4.5 (a)	4.7 (a)
SOx	kg/t Glass	1 A 2 f	1.5 (a)	1.7 (a)	2.8 (a)
NOx	kg/t Glass	1 A 2 f	4.0 (a)	3.1 (a)	4.3 (a)
CO	kg/t Glass	1 A 2 f	0.1 (a)	0.1 (a)	0.1 (a)
TSP	kg/t Glass	2 A 3	1.0 (c)	0.7 (c)	8.4 (c)
PM_{10}	% (m/m)	2 A 3	0.95 (d)	0.95 (d)	0.95 (d)
$PM_{2.5}$	% (m/m)	2 A 3	0.91 (d)	0.91 (d)	0.91 (d)
Pb	kg/t Glass	2 A 3	$1.2E^{-02}$ (e)	$1.2E^{-02}$ (e)	$1.0E^{-02}$ (e)
Cd	kg/t Glass	2 A 3	$1.5E^{-04}$ (e)	$1.5E^{-04}$ (e)	$1.5E^{-04}$ (e)
Hg	kg/t Glass	2 A 3	$5.0E^{-05}$ (e)	$5.0E^{-05}$ (e)	$5.0E^{-05}$ (e)
As	kg/t Glass	2 A 3	$1.2E^{-04}$ (e)	$1.2E^{-04}$ (e)	$1.0E^{-04}$ (e)
Cr	kg/t Glass	2 A 3	$2.4E^{-03}$ (e)	$2.4E^{-03}$ (e)	$2.5E^{-03}$ (e)
Cu	kg/t Glass	2 A 3	$6.0E^{-04}$ (e)	$6.0E^{-04}$ (e)	$5.0E^{-04}$ (e)

Parameter	Unit	Considered in NFR sector	Flat Glass	Container Glass	Crystal Glass
Ni	kg/t Glass	2 A 3	1.9E-03 (e)	1.9E-03 (e)	2.0E-03 (e)
Se	kg/t Glass	2 A 3	1.8E-02 (e)	1.8E-02 (e)	2.0E-02 (e)
Zn	kg/t Glass	2 A 3	1.1E-02 (e)	1.1E-02 (e)	1.0E-02 (e)

(a) USEPA AP-42 – Chapter 11.15 – Table 11.15-2 (VOC emission factor);
(b) Assumed 10% of NMVOC emission factor;
(c) USEPA AP-42 – Chapter 11.15 – Table 11.15-1 (Uncontrolled);
(d) USEPA AP-42 – Chapter 11.15 – Table 11.15-3 (particle size distributions);
(e) Emission Factors Manual Parcom-Atmos

NMVOC, SOx, NOx and CO emissions have been reported in NFR sector “1 A 2 f” for consistency purposes with the GHG submission in the CRF Reporter, since it is not possible to add pollutants to the sector “2 A 3”. All the other pollutants are reported in NFR sector “2 A 3”, since they are not reported also in the GHG submission in the CRF Reporter and no consistency between reports need to be assured.

4.2.3.4 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).

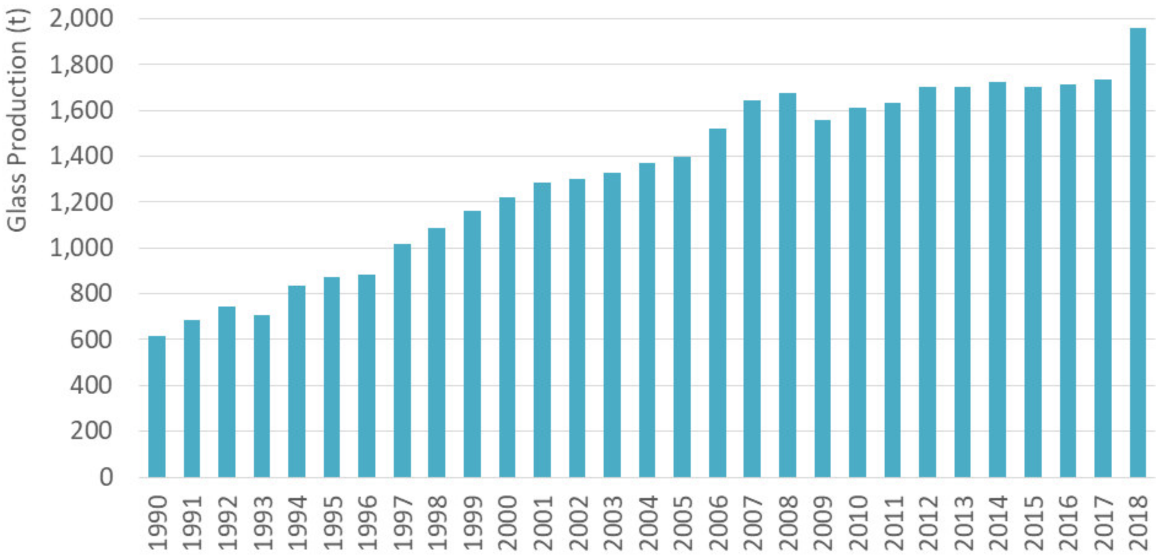


Figure 4-4: Glass production

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 ratio could be checked in the figure below.

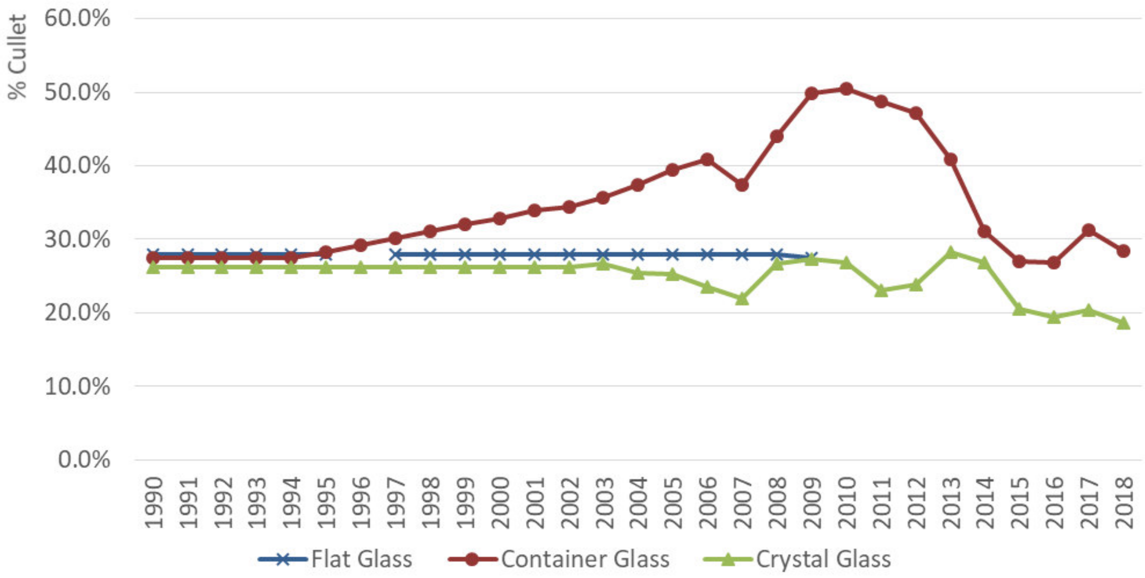


Figure 4-5: Cullet incorporation by type of glass

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 expected.

4.2.4 Quarrying and mining of minerals other than coal (NFR 2.A.5.a)

4.2.4.1 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).

4.2.4.2 Methodology

Particulate matter emissions were estimated based on a Tier 1 methodology, according to chapter 2.A.5.a of 2019 EMEP Guidebook:

Equation 4-5: 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)

4.2.4.3 Emission Factors

The following emission factors were considered in the estimates:

Table 4-5: 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

4.2.4.4 Activity Data

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.

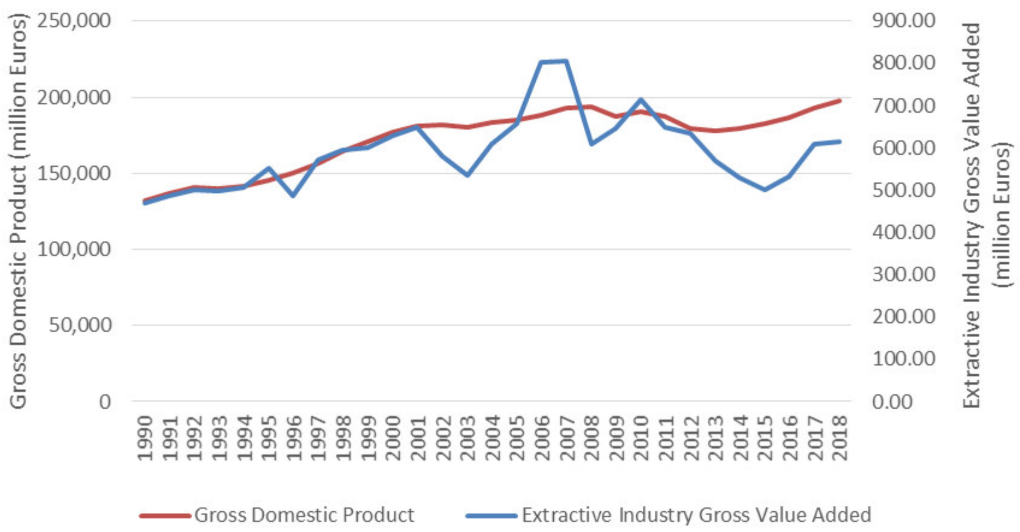


Figure 4-6: Gross Domestic Product and Extractive Industry Gross Value Added

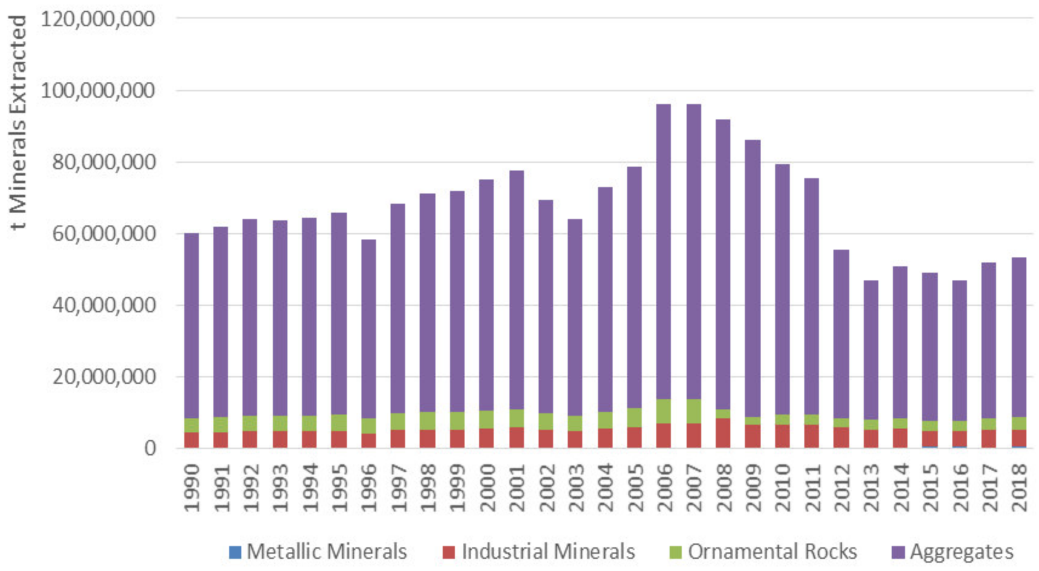


Figure 4-7: Quarrying and mining of minerals other than coal

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

Recalculations regarding activity data were made upon publication of a GDP revised time series, as well as Gross Value Added (GVA) data for 2016 and 2017.

4.2.4.7 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.

4.2.5 Construction and Demolition (NFR 2.A.5.b)

4.2.5.1 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 $PM_{2.5}$).

4.2.5.2 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 4-6: 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 (%)

4.2.5.3 Emission Factors

The following emission factors were considered in the estimates:

Table 4-6: 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 4-7: 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 4-8: 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 4-9: 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 4-7: Thornthwaite precipitation-evaporation index

$$PE\ index = 3.16 \times \sum_{i=1}^{12} (\frac{P_i}{1.8 \times T_i + 22})^{\frac{10}{9}}$$

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).

4.2.5.4 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.

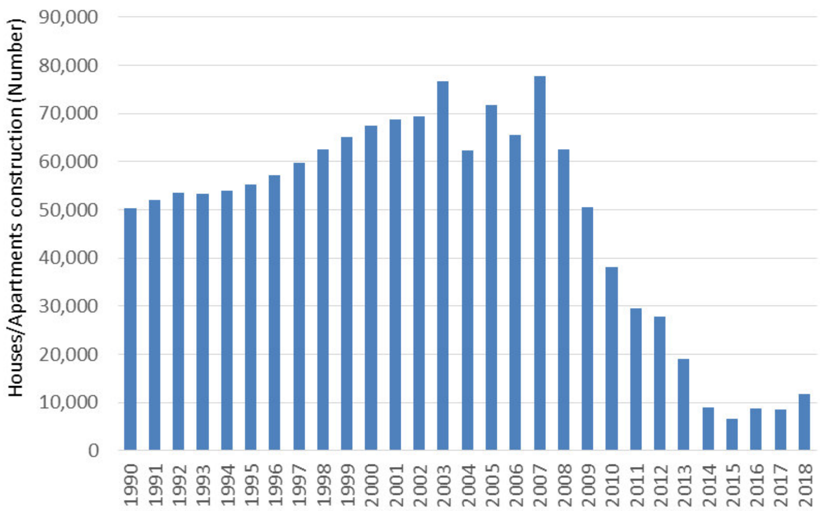


Figure 4-8: Houses/apartments construction

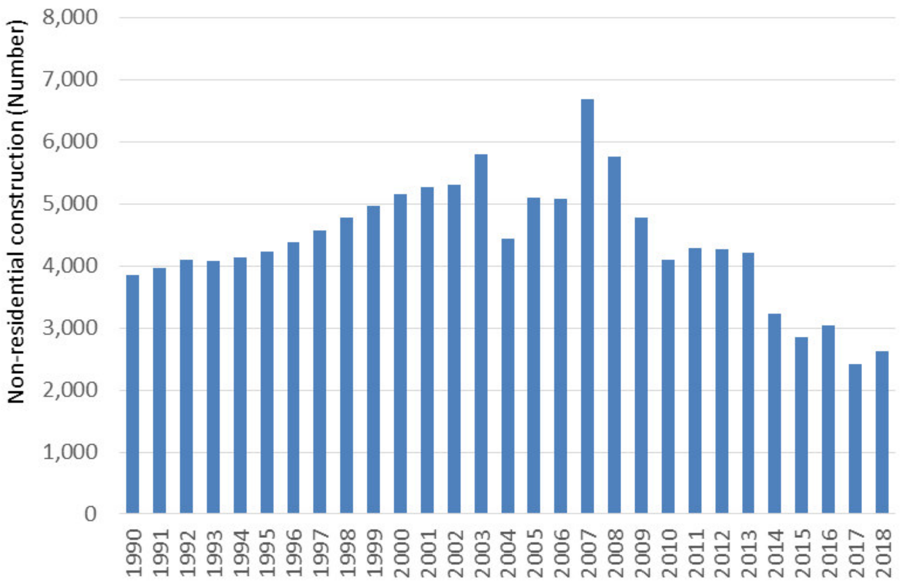


Figure 4-9: Non-residential construction

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.

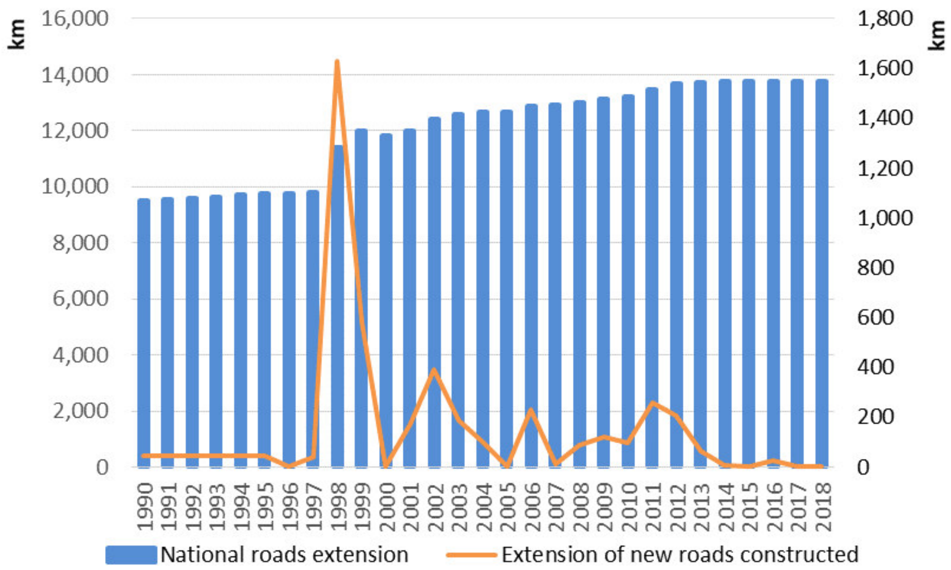


Figure 4-10: Roads construction

Following a request from the inventory team, 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.

4.2.5.5 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.

4.2.5.6 Recalculations

2017 data on the number of new houses/apartments constructed and non-residential construction was revised by INE.

Recalculations were made upon publication of a GDP revised time series, as well as Gross Value Added (GVA) data for 2016 and 2017.

In the period 1990-2002, data on the number of new houses/apartments constructed and non-residential construction was updated for the period 1990-2002 based on the average from 2003-2007 values and on GDP trend, also from INE.

4.2.5.7 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.

4.2.6 Storage, handling and transport of mineral products (NFR 2.A.5.c)

4.2.6.1 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 $PM_{2.5}$).

4.2.6.2 Methodology

We use a Tier 2 methodology (similar to a Tier 1 methodology) 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 4-8: 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)

4.2.6.3 Emission Factors

The following emission factors were considered in the estimates:

Table 4-10: Emission Factors considered

Technologies/ Practices	Parameter	Unit	EF	Source
Handling - Uncontrolled	TSP	g/t	12	EMEP/EEA guidebook 2016, Volume "2.A.5.c Storage, handling and transport of mineral products", table 3.4
	PM_{10}	g/t	6	EMEP/EEA guidebook 2016, 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 2016, Volume "2.A.5.c Storage, handling and transport of mineral products", table 3.4

4.2.6.4 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.

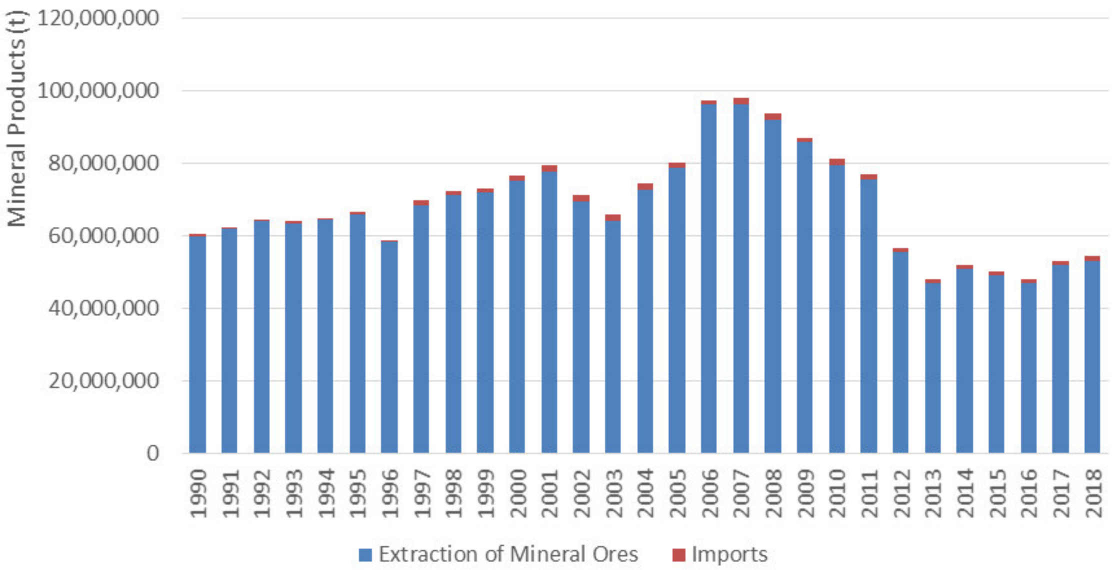


Figure 4-11: Mineral products stored, handled and transported

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

Following QA/QC procedures to the sector, a new data series on imports was obtained from EUROSTAT, given that the latter series concerned the total national imports instead of mineral imports. From 1990 to 1994, data on imports was based on 1995 imports value and on 1990-1994 data on minerals extracted.

Activity data series from category 2.A.5.a (data on quarrying and mining of minerals other than coal) was updated upon publication of a GDP revised time series, as well as Gross Value Added (GVA) data for 2016 and 2017 (please consult section 4.2.4.6).

4.2.6.7 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 and 3.3 of chapter 2.A.5.c of "EMEP/EEA air pollutant emission inventory guidebook 2016".

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 4-9: 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 is obtained from partial oxidation of heavy hydrocarbons.

Gasification of heavy hydrocarbons follows the reaction:

Equation 4-10: 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 NMVOC).

4.3.1.2 Methodology

Emissions estimates for all pollutants are estimated by the use of emission factors multiplied by the quantity of material manufactured:

Equation 4-11: Emissions from ammonia production

$$Emission_{(p,y)} = EF_{(p)} \times ActivityRate_{(y)} \times 10^{-3}$$

Where:

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

$ActivityRate_{(y)}$: Ammonia produced in year y (t)

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

4.3.1.3 Emission Factors

Due to confidentiality constraints it is not possible to publish the applied emission factors.

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.

Due to confidentiality constraints, it is not possible to present any absolute information concerning activity data for this source activity, neither ammonia nor urea production.

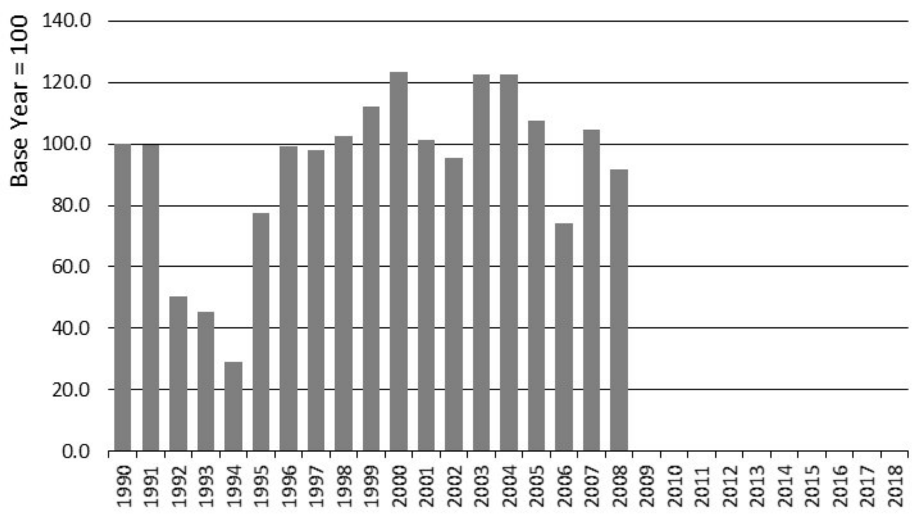


Figure 4-12: Trend in Ammonia production

The overall trend in the amount of ammonia produced in the period may be depicted in the figure above, from where it is evident the significant inter-annual changes in the period 1991-1996. The reason for the low emission values in the period 1992-1994 is the NH_3 production decrease in this period. According to information provided by the facility, in this period there were technical problems that led to several interruptions in the production.

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.

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.

4.3.1.6 Recalculations

No recalculations were made.

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

There are only three industrial plants producing nitric acid in Portugal, located in Estarreja, Alverca and Lavradio. In all, weak nitric acid (60 %) is produced from ammonia, using catalytic (Platinum-rhodium alloy catalysts) oxidation of ammonia with air to NO_2 at medium pressure, and subsequent absorption with water to form nitric acid in a dual-stage process.

Nitric Acid manufacture 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. Ammonia emissions from Nitric Acid are not estimated in the inventory, due to the absence of applicable emission factors or monitoring data.

4.3.2.2 Methodology

Emissions for all pollutants are estimated using the following equation:

Equation 4-12: Emissions from nitric acid production

$$Emission_{(p,y)} = EF_{(p)} \times ActivityRate_{(y)} \times 10^{-3}$$

Where:

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

$ActivityRate_{(y)}$: Production of Nitric Acid in year y (t)

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

4.3.2.3 Emission Factors

Due to confidentiality constraints it is not possible to publish the chosen emission factors. They were estimated based on monitoring data from the facilities.

4.3.2.4 Activity Data

Activity data is obtained directly from the facilities. One of the plants was closed during year 2010 and 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 cannot be presented here in actual figures, but only in relation to production in 1990 (trends).

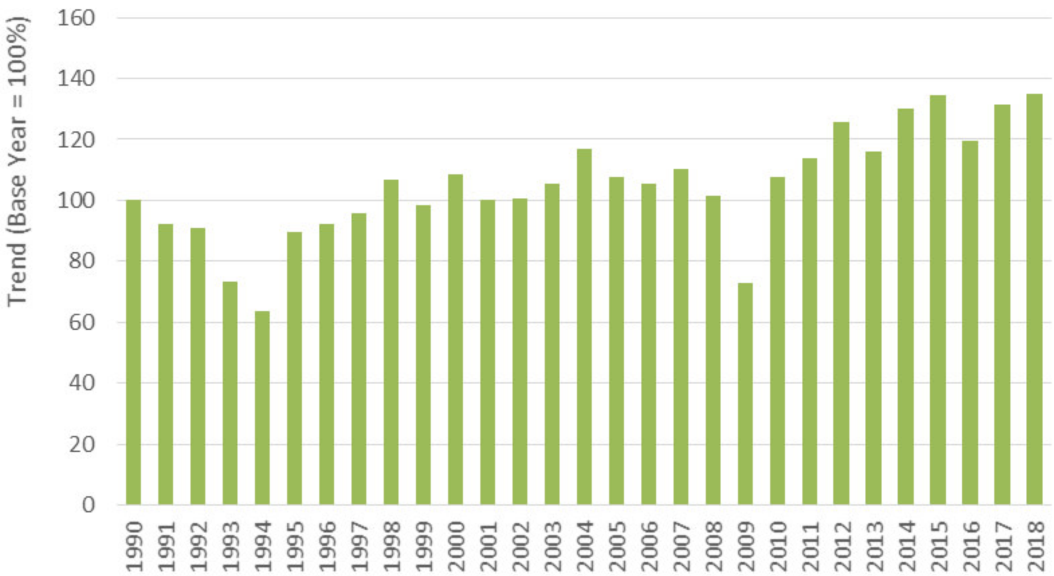


Figure 4-13: Trend in Nitric Acid production

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

No further improvements are planned for this sector.

4.3.3 Adipic Acid Production (NFR 2.B.3 – SNAP 040521)

According to the information provided by the Portuguese Economy Ministry, there is no adipic acid production in Portugal, only imports and exports.

4.3.4 Calcium Carbide Production (NFR 2.B.5 – SNAP 040412)

According to information provided by the Portuguese Economy Ministry, 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 (TiO2). TiO2 pigments are made from one of two chemical processes: the chloride route, which leads to TiO2 products by reacting titanium ores with chlorine gas; and the sulphate route, which leads to TiO2 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 4-13: 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 4-14: 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 4-15: 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 4-11: 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).

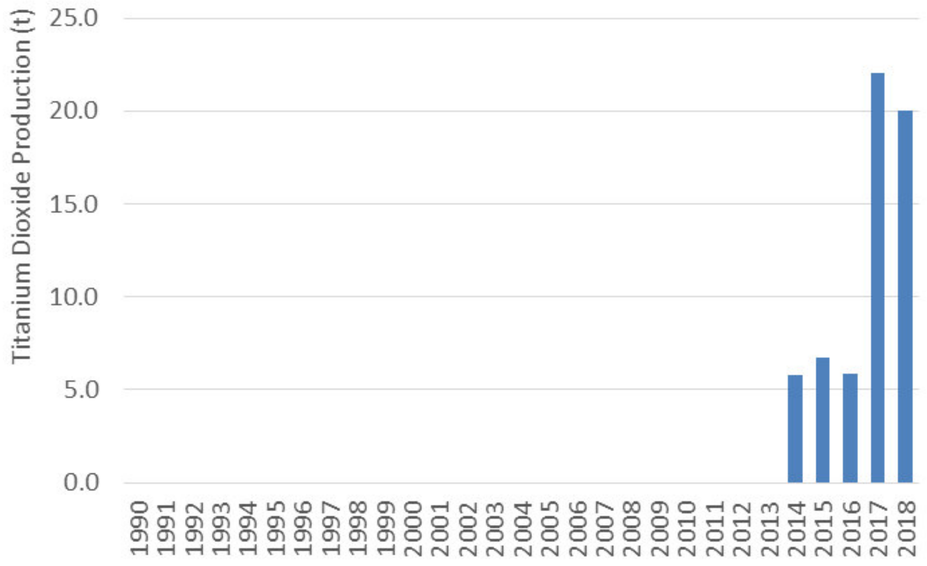


Figure 4-14: Titanium Dioxide Production

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

No recalculations were made.

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 Sulphuric Acid (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 uses 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[4]:

Equation 4-16: SO_2 emissions from sulphuric acid production

$$Emi_{SOx(y)} = 2 \text{ X } Feedstock_{(y)} \text{ X } S_{Feed(y)} \text{ X } 10^{-2} - 32/98 \text{ X } Prod_{H2SO4\,(y)}$$

Where:

$EmiSOx_{(y)}$: Emission of Sulphur oxides[5] (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)

4.3.6.3 Emission Factors

Due to confidentiality constraints, the emission factors for sulphuric acid are not published.

[4] 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.

[5] 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.

4.3.6.4 Activity Data

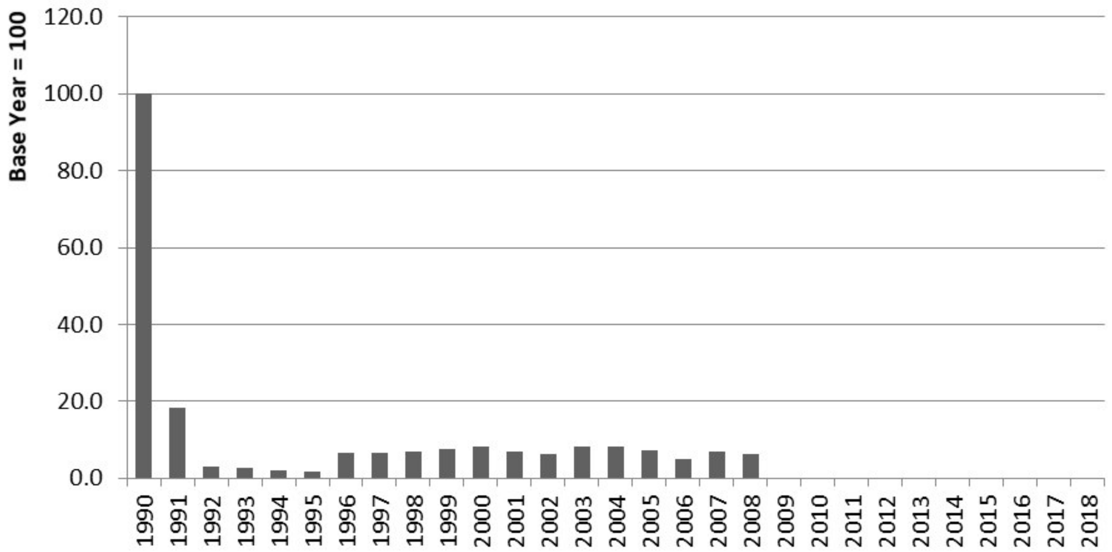


Figure 4-15: Trend in total sulphuric acid production, including sulphur recovery

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[6];
- 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.

[6] For confidentiality reasons original data and relation may not be reported in IIR

4.3.7 Ammonium Sulphate (NFR 2.B.10.a – SNAP 040404)

4.3.7.1 Category description

This chapter addresses emissions estimates from the production of ammonium sulphate.

4.3.7.2 Methodology

Emissions from Ammonium Sulphate 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 4-17: 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 4-18: 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

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 4-12: 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 2016
$PM_{2.5}$	Kg/t	0.012	Section 3.2.2 (page 14) of chapter "2.B Chemical Industry" of EMEP/EEA air pollutant emission inventory guidebook 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

4.3.7.4 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%).

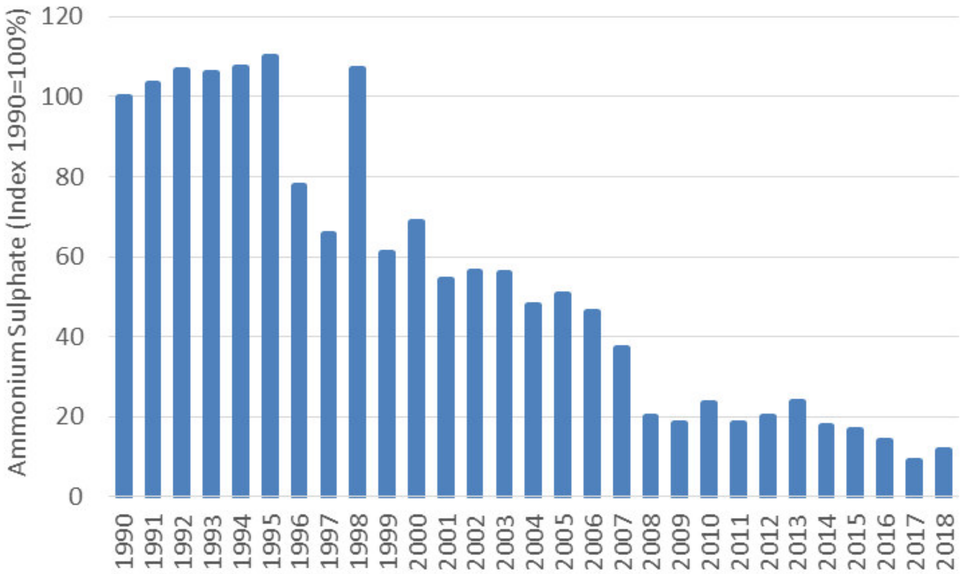


Figure 4-16: Ammonium Sulphate production (Index 1990=100%)

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

1990 to 1994 activity data were updated upon publication of a GDP revised time series.

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 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 4-19: 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 4-13: 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.

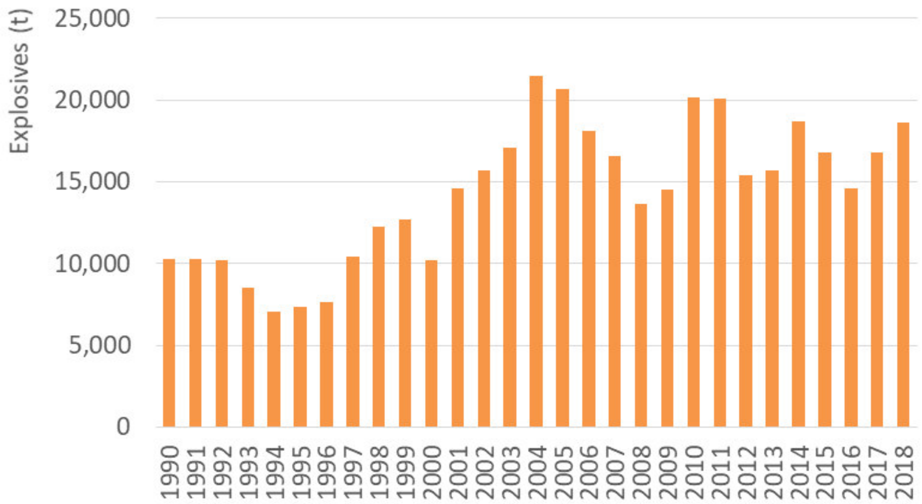


Figure 4-17: Explosives production

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 Ammonium Nitrate (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 4-20: 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 4-14: 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 4-15: 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.

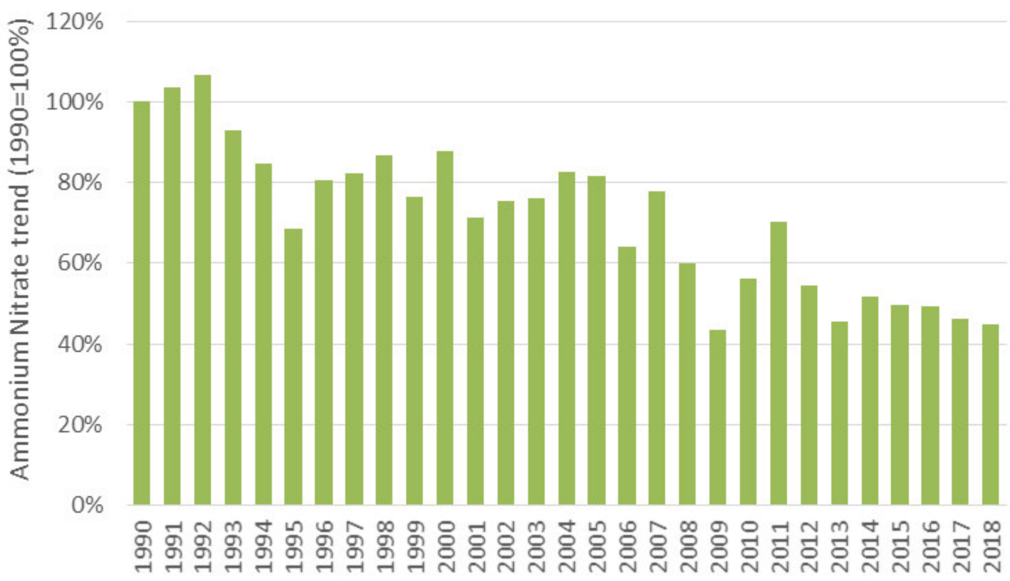


Figure 4-18: Ammonium Nitrate production (1990=100%)

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

1990 and 1991 activity data were updated upon publication of a GDP revised time series.

4.3.9.7 Further Improvements

No further improvements are expected.

4.3.10 Ammonium Phosphates (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 4-21: 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 4-22: 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 4-16: 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.

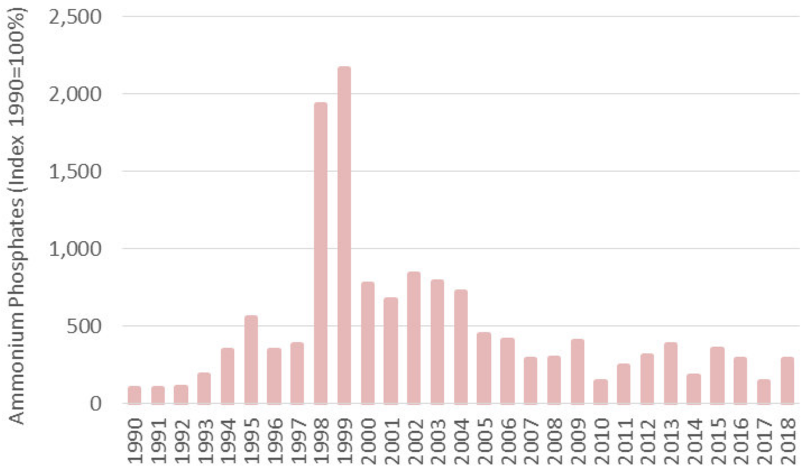


Figure 4-19: Ammonium Phosphates (Index 1990=100%)

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

1990 and 1991 activity data were updated upon publication of a GDP revised time series.

4.3.10.7 Further Improvements

No further improvements are planned for this sector.

4.3.11 NPK Fertilisers (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 4-23: 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)

For BC:

Equation 4-24: 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 4-17: 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.

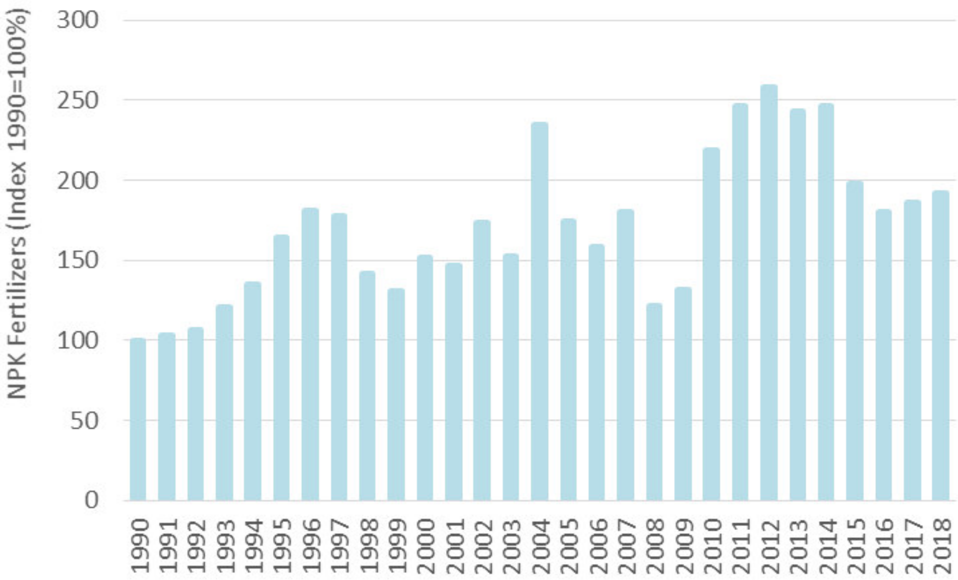


Figure 4-20: NPK Fertilisers production (Index 1990=100%)

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

1990 and 1991 activity data were updated upon publication of a GDP revised time series.

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 Urea (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 4-25: 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)

For BC:

Equation 4-26: 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 4-18: 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.

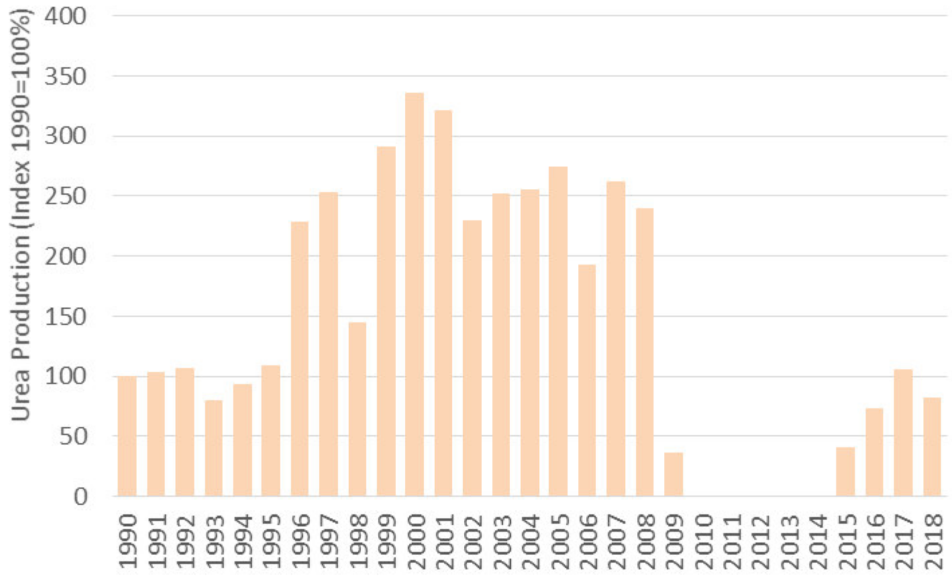


Figure 4-21: Trend in Urea production

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

1990 and 1991 activity data were updated upon publication of a GDP revised time series.

4.3.12.7 Further Improvements

Efforts will be made in order to obtain plant specific urea production data.

4.3.13 Carbon Black (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 4-27: Emissions from black carbon production

$$Emission_{(p,y)} = EF_{(p)} \times ActivityRate_{(y)} \times 10^{-3}$$

Where:

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

$EF_{(p)}$: Emission factor (kg/t)

$ActivityRate_{(y)}$: Indicator of activity in the production process. Quantity of product produced per year is used as a general rule for this emission source sector (t)

4.3.13.3 Emission Factors

In the same way, the carbon black industrial unit was subjected, also for period 2009-2012, 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 4-19: 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.

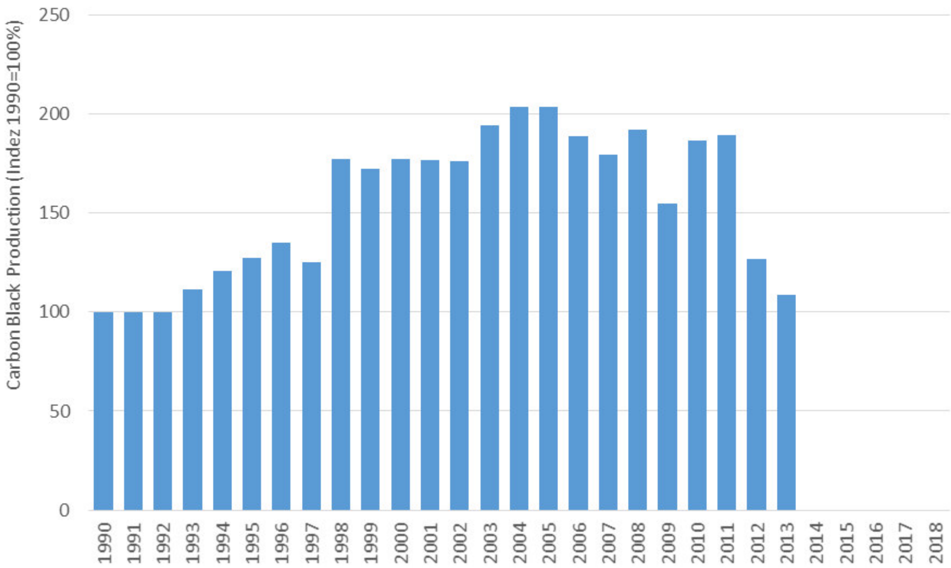


Figure 4-22: Carbon Black production

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 Graphite (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.

There are no emission factors for this category in the EMEP/EEA air pollutant emission inventory guidebook 2016.

4.3.15 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.

Efforts will be made in order to obtain plant specific emissions data.

4.3.16 Phosphate Fertilisers (NFR 2.B.10.a – SNAP 040414)

Considered in “NPK Fertilisers” in chapter 4.3.11 (SNAP 040407).

4.3.17 Ethylene (NFR 2.B.10.a – SNAP 040501)

4.3.17.1 Category description

This chapter addresses emissions estimates from the production of ethylene.

4.3.17.2 Methodology

Emissions were estimated according to:

Equation 4-28: CO_2 and CH_4 emissions from ethylene production

$$Emi_x = AD \times \frac{EF_x}{1000}$$

Where:

Emi_x: Emissions of pollutant “x” (t)

AD: Ethylene production data (t)

EF_x: Emission factor of pollutant "x" (kg/t Ethylene)

4.3.17.3 Emission Factors

NMVOC emission factor was taken from EMEP Guidebook 2016 and is indicated in the table below.

Table 4-20: 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 2016".

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, ethylene production is presented as a trend related to 1990 production.

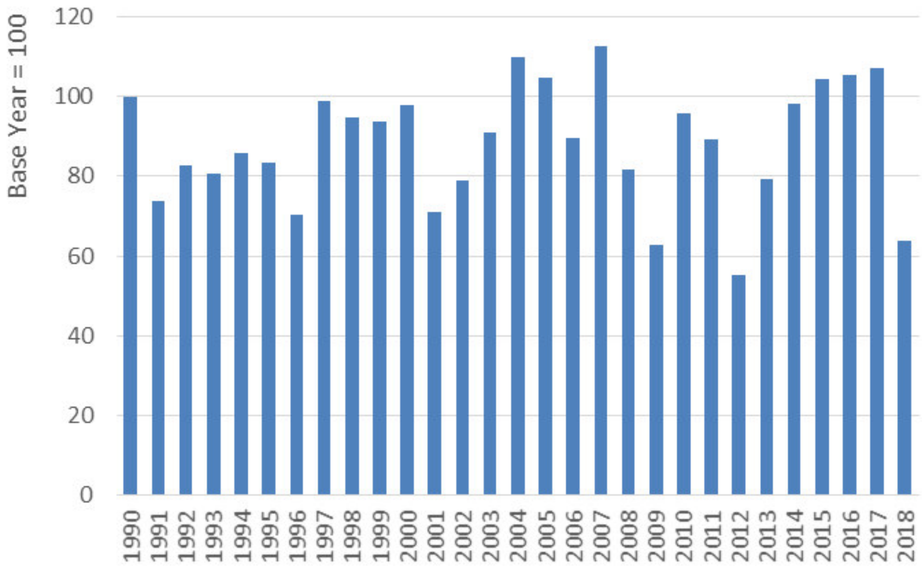


Figure 4-23: Trend in Ethylene production

4.3.17.5 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.

4.3.17.6 Recalculations

No recalculations were made.

4.3.17.7 Further Improvements

In the future, we intend to introduce emission factors updates based on monitoring data.

4.3.18 1,2-Dichloroethane + Vinylchloride (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 4-29: 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 4-30: 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 4-21: 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.

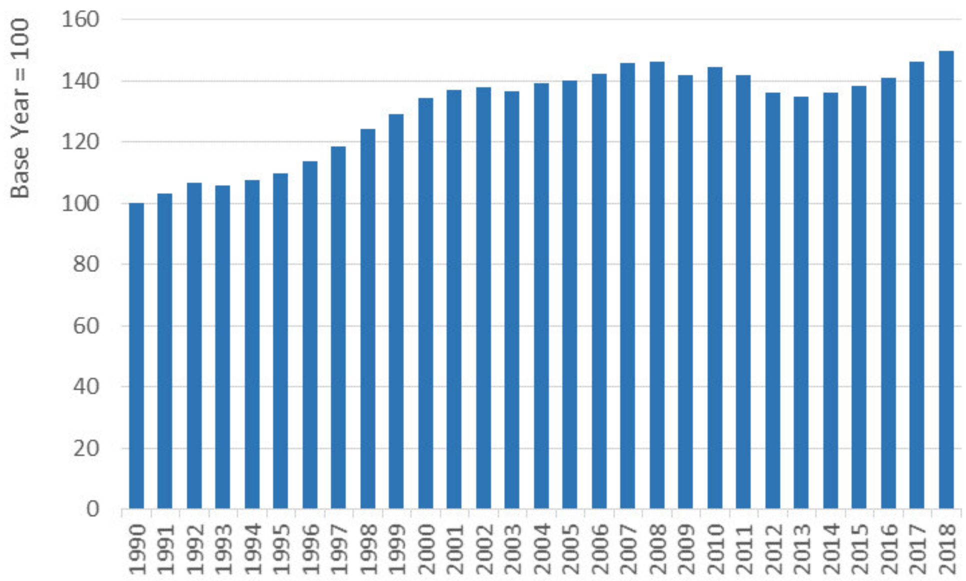


Figure 4-24: VCM production

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 in activity data were made upon publication of a GDP revised time series.

4.3.18.7 Further Improvements

Chemical sector associations will be contacted in order to obtain better quality information related to VCM production in Portugal.

4.3.19 Polyethylene Low Density (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 4-31: 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 4-22: 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

Due to confidentiality constraints, Low-density polyethylene production is presented as a trend related to 1990 production.

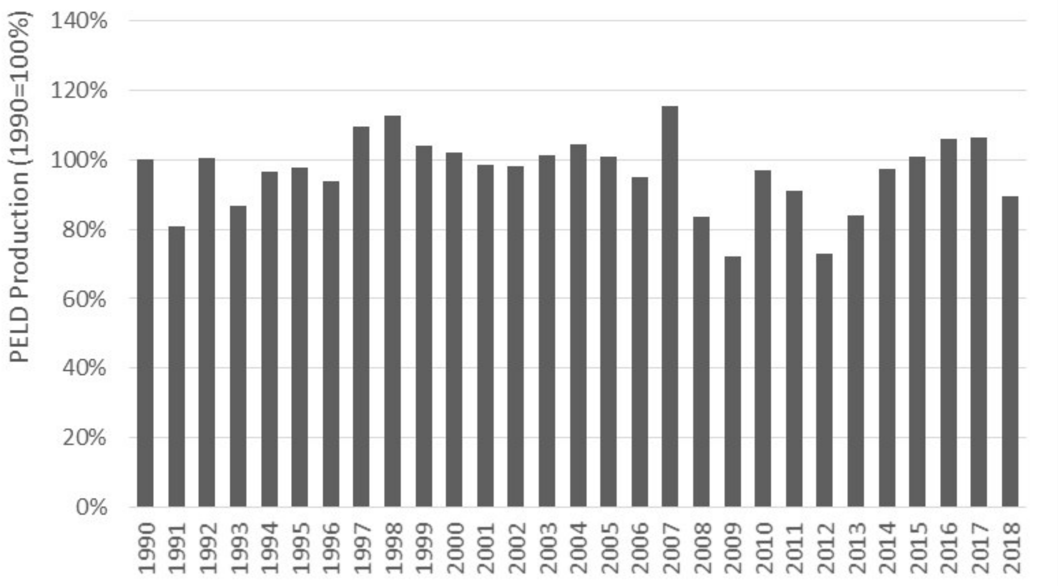


Figure 4-25: Polyethylene Low-Density (PELD) trend (1990=100%)

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

No recalculations were made.

4.3.19.7 Further Improvements

No further improvements are expected.

4.3.20 Polyethylene High Density (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 4-32: 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 4-23: 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

Due to confidentiality constraints, polyethylene high-density production is presented as a trend related to 1990 production.

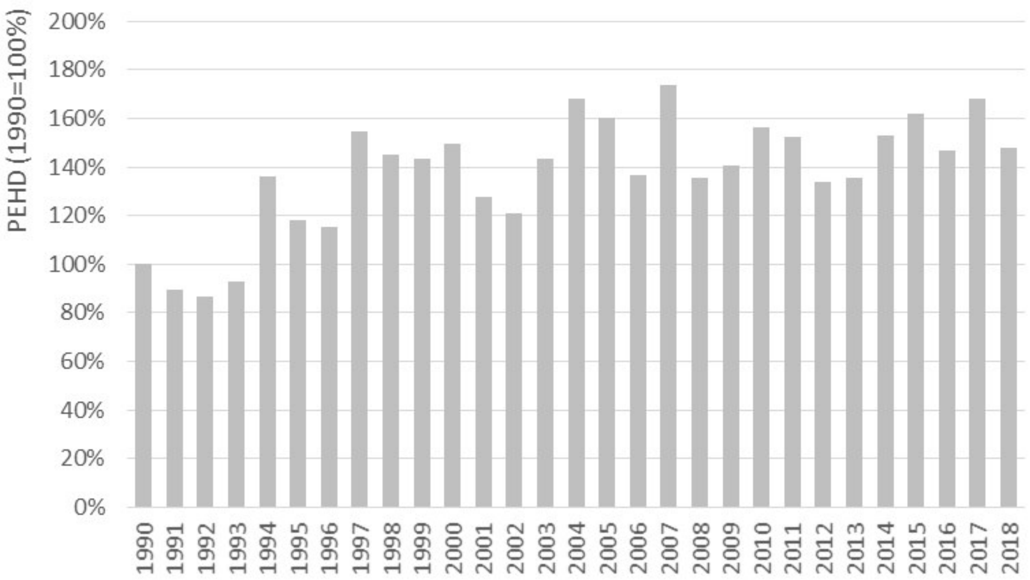


Figure 4-26: Polyethylene High-Density (PEHD) trend (1990=100%)

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

No recalculations were made.

4.3.20.7 Further Improvements

No further improvements are expected.

4.3.21 Polypropylene (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 4-33: 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 4-24: 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.

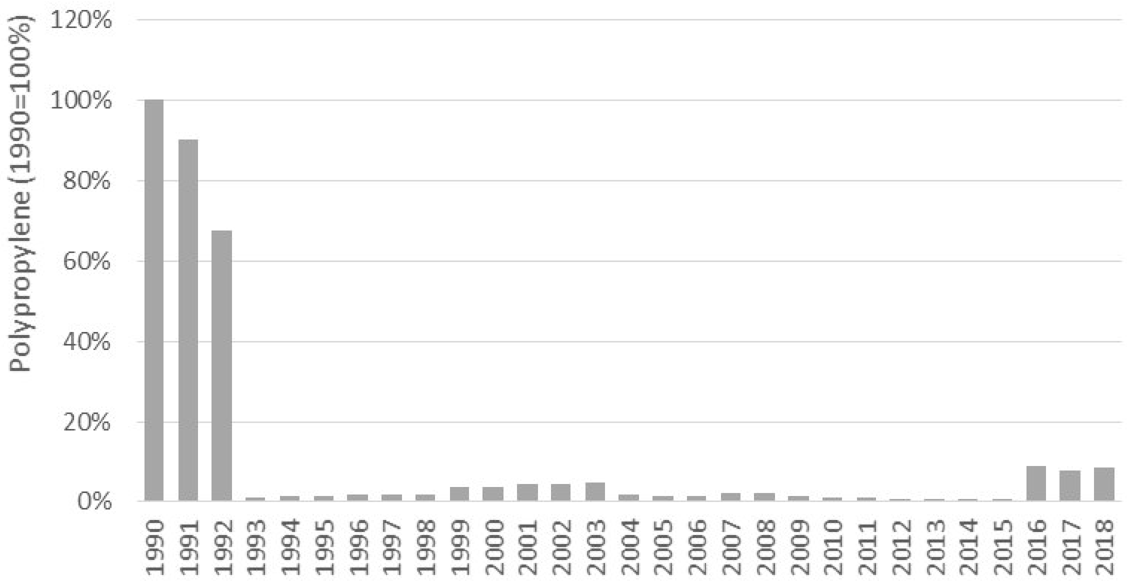


Figure 4-27: Polypropylene trend (1990=100%)

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

No recalculations were made.

4.3.21.7 Further Improvements

No further improvements are expected.

4.3.22 Polystyrene (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 4-34: 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 4-25: 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.

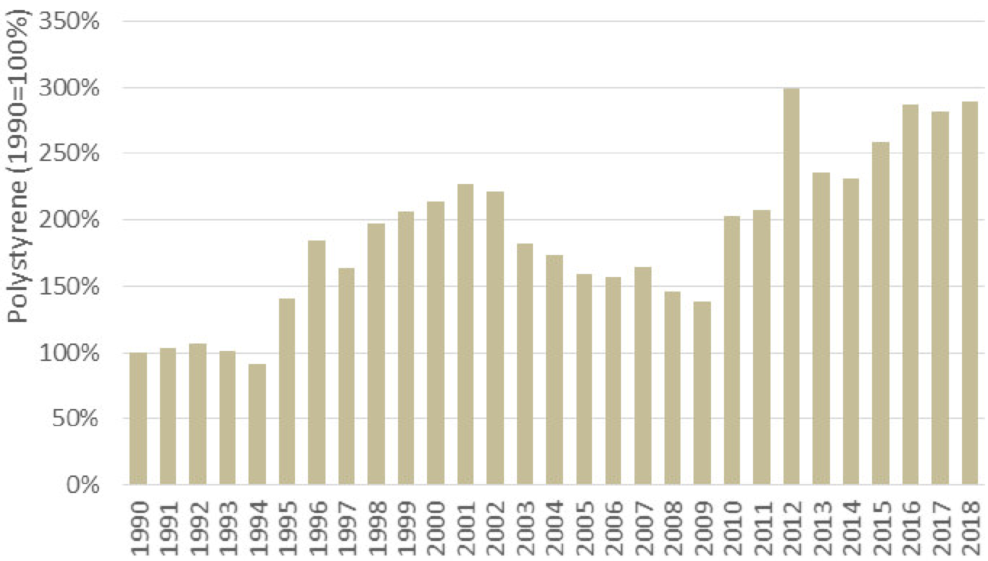


Figure 4-28: Polystyrene trend (1990=100%)

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

2008 to 2010 activity data were updated based on national statistics.

4.3.22.7 Further Improvements

No further improvements are expected.

4.3.23 Formaldehyde (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 4-35: 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 4-26: 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.

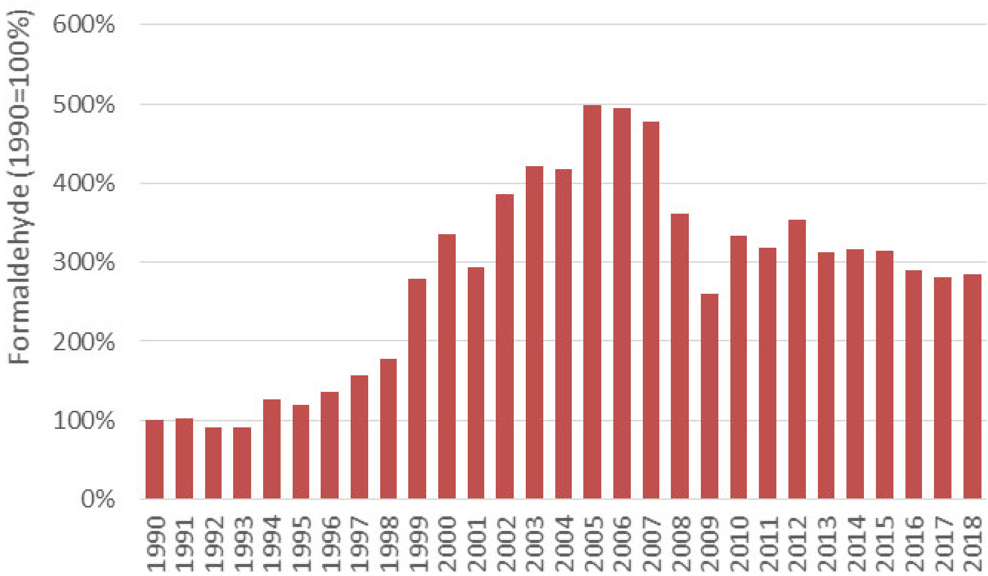


Figure 4-29: Formaldehyde trend (1990=100%)

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 Phthalic Anhydride (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 4-36: 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 4-27: 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.

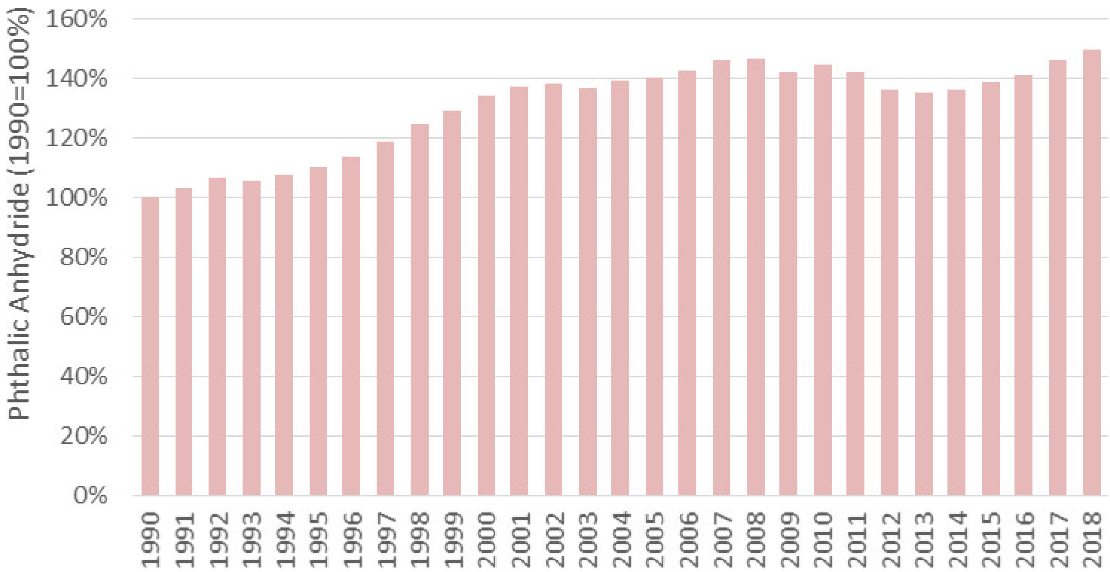


Figure 4-30: Phthalic Anhydride production trend (1990=100%)

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

Recalculations in activity data were made upon publication of a GDP revised time series.

4.3.24.7 Further Improvements

No further improvements are expected.

4.4 Metal Production (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.

Emissions of carbon may occur as CO and NMVOC but it is assumed that they are subsequently converted in atmosphere in carbon dioxide. 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 4-28: 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 product approach methodology.

Equation 4-37: Emissions from sinter, pig iron and steel production

$$Emi_p = Act \times EF_p$$

Where:

Emi: Emissions for pollutant p (t)

Act: 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

Emissions factors for processes related to Iron and Steel Production are provided in the tables below.

Table 4-29: 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

Pollutant	Sinter production (a)		Pig iron production (b)	
	Unit	EF	Unit	EF
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
(a) Source: EMEP/EEA guidebook 2019, Vol. 2.C.1, Table 3-2				
(b) Source: EMEP/EEA guidebook 2019, Vol. 2.C.1, Table 3-11				

Table 4-30: 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 4-31: Pot oven and rolling mills emission factors

Pollutant	Unit	EF (a)
SOx	g/GJ	47
NOx	g/GJ	513
NMVOC	g/GJ	25
CO	g/GJ	66
TSP	g/GJ	20
PM_{10}	g/GJ	20
$PM_{2.5}$	g/GJ	20
BC	% $PM_{2.5}$	56

Pollutant	Unit	EF (a)
Pb	g/GJ	0.08
Cd	g/GJ	0.006
Hg	g/GJ	0.12
As	g/GJ	0.03
Cr	g/GJ	0.2
Cu	g/GJ	0.22
Ni	g/GJ	0.008
Se	g/GJ	0.11
Zn	g/GJ	29
PCB	g/GJ	NE
HCB	g/GJ	NE
PCDD/F	µg I-TEQ/GJ	1.4
Benzo(α)pyrene	g/GJ	1.9
Benzo(β)fluoranthene	g/GJ	15
Benzo(k)fluoranthene	g/GJ	1.7
Indeno(1,2,3-cd)pyrene	g/GJ	1.5
Total 4 PAHs	g/GJ	20.1
(a) 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 4-38: 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 4-39: 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.

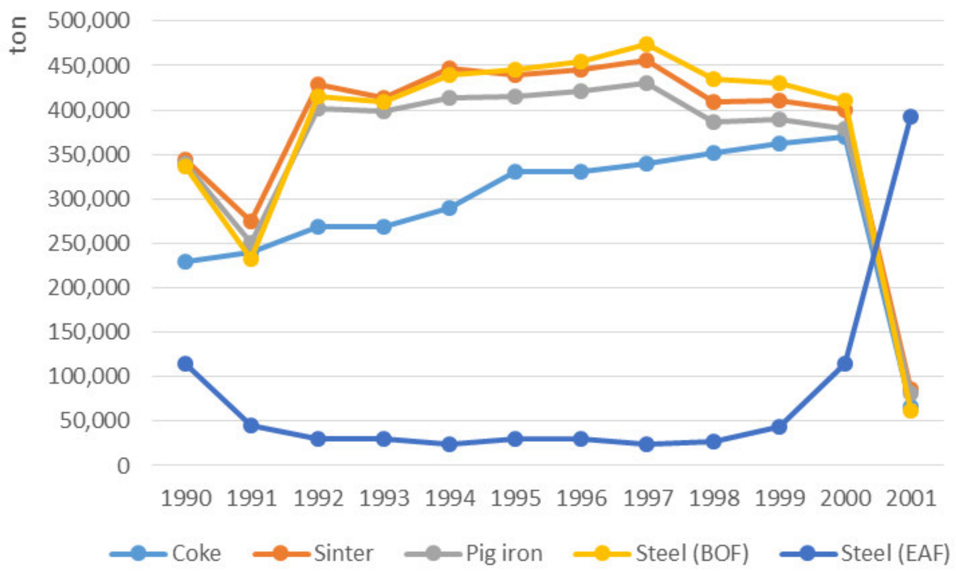


Figure 4-31: Integrated iron and steel facility – production of steel and intermediate products (1990-2001)

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.

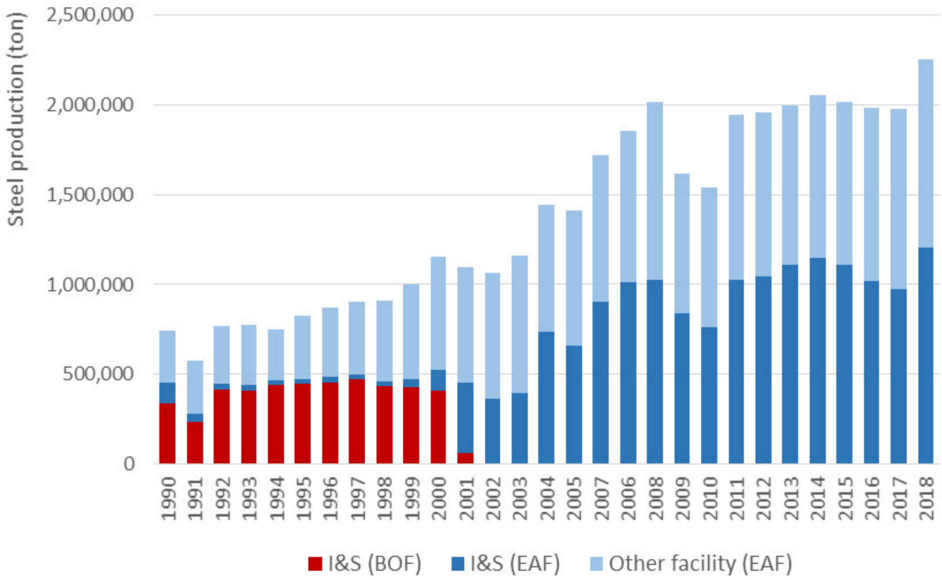
From 2002 to 2005:

- Annual steel production from EAF was estimated based on Equation 4-39;
- 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, from 1990 to 2018.



I&S: Integrated Iron and Steel facility

Figure 4-32: 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.

Emissions estimates were based on a bottom-up approach with collection of plant specific crude steel production data. A comparison was made using a top-down approach based on crude steel production data obtained from the WorldSteel Association. There are slight differences using the two different approaches but, generally, data is consistent.

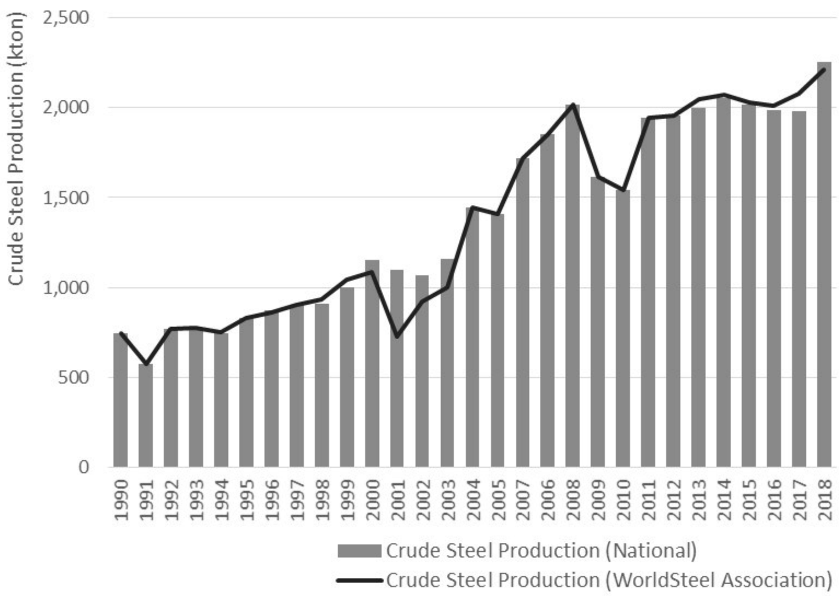


Figure 4-33: Crude steel production in Portugal – comparison of approaches

Data received from the two plants is also cross-checked with data obtained from the energy balance. Part of the differences (fuel consumption data in the national energy balance and in the EU ETS) is considered under source “1.A.2.a”. The differences related to other fuels are reported under source “1.A.2.g.i”, since this could be a misallocation from the energy balance.

4.4.1.6 Recalculations

Following considerable recommendations that resulted from CRLTAP, as well as from UNFCCC reviews, Iron and Steel sector underwent some major methodological changes for this submission. These changes resulted in significant recalculations:

- Regarding activity data, there are slight differences between submissions, as shown in the figures below. Concerning sinter production, we were using coke consumption and now we use pig iron production as surrogate data, given that all sinter produced was used to produce pig iron in the blast furnace. Concerning pig iron production, we now obtained pig iron production data from the Worldsteel Association for the whole time series (1990-2001). We also revised annual total steel production from BOF as well as from EAF from 1990-2001, based on activity data from the Worldsteel Association.

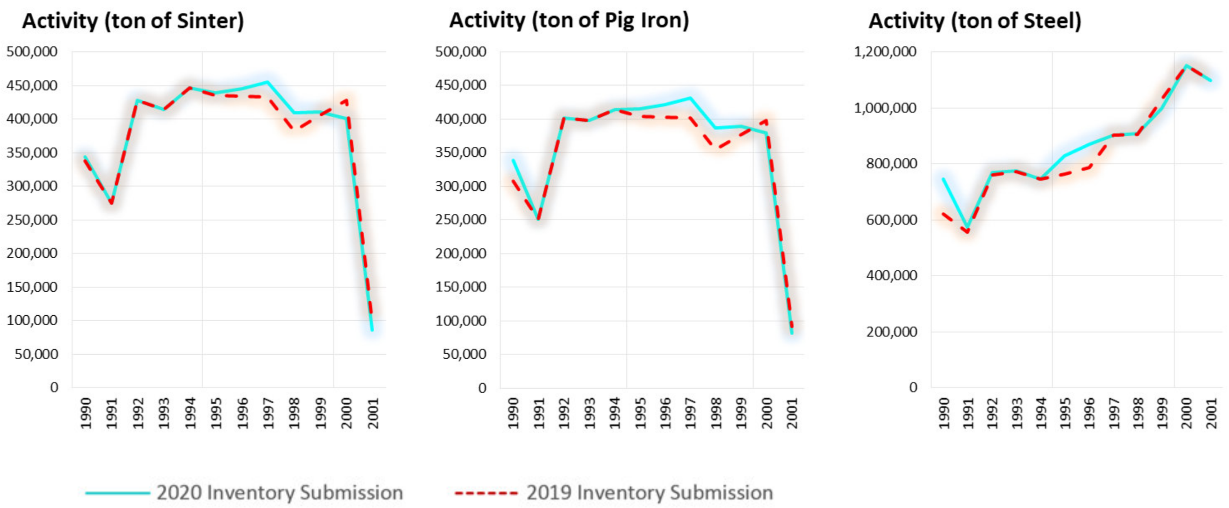


Figure 4-34: Recalculations for activity data in iron and steel sector

- Concerning allocation issues, throrough reading of the chapter 2.C.1 of EMEP/EEA guidebook 2019 indicated that all emissions of NOx, SOx and CO are assumed to originate from the combustion activities in the blast furnace, hence these emissions were allocated from 2.C.1 to source category 1.A.2.a, as shown in the figures below.

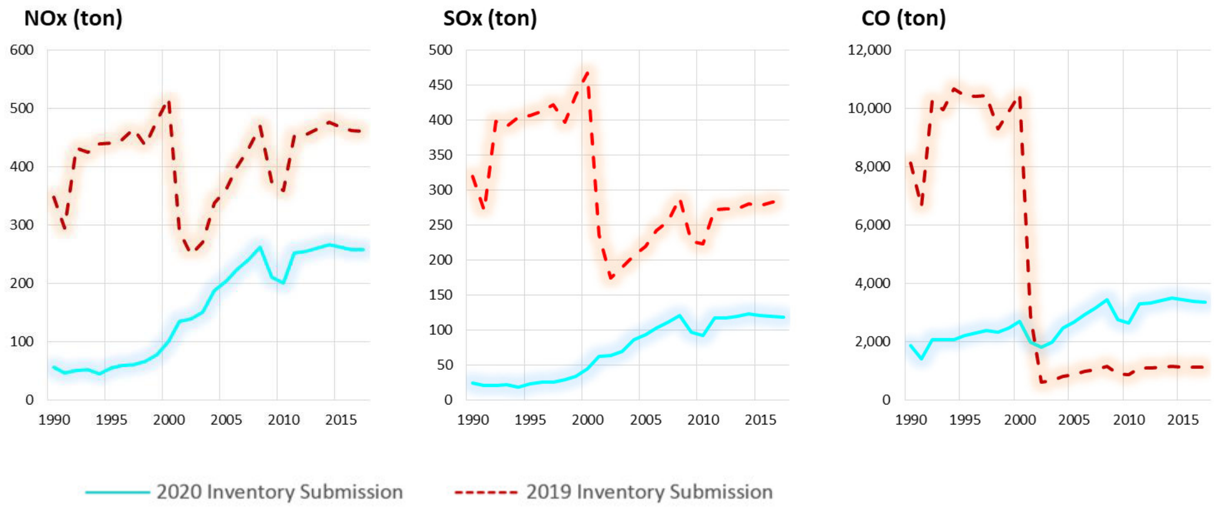


Figure 4-35: Recalculations for combustion emissions in iron and steel sector

- Still regarding allocation issues, we were considering energy consumption related to the production of coke and its by-products, and the energetic use of these fuels from 1990 to 2001 as combustion-related emissions and, therefore, they were being reported in 1.A.2.a (Manufacturing industries and construction – Iron and Steel). However, according to the EMEP/EEA guidebook 2019, all carbon used in ironmaking and steelmaking processes should be considered process-related IPPU emissions. Hence, for this submission, all carbon materials were taken into account as process emissions for pig iron and steel production and, therefore, allocated to 2.C.1.
- There were several updates to the emission factors applied to air pollutants. We now use mainly Tier 2 emission factors from EMEP/EEA guidebook 2019, given that we consider them to be more in line with national circumstances throughout the time series.

4.4.1.7 Further Improvements

In the future, we intend to further analyse and, if possible, gather information regarding carbon content in raw materials and in steel produced, in order to obtain a more accurate and consistent time series of activity data and emissions.

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 and 2018) 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, 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 4-40: 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 4-41: 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 4-42: 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 4-43: 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 4-32: 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 2019
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 4-33: 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 2019
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.

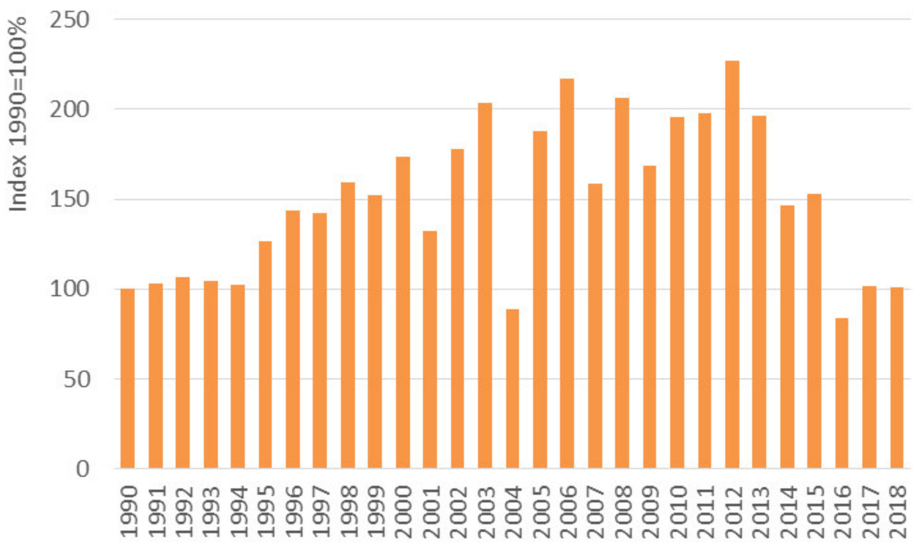


Figure 4-36: Secondary Aluminium production (Index 1990=100%)

4.4.3.5 Category specific QA/QC and verification

Following general QA/QC procedures to atmosferic pollutants, a high level of HCB emissions was identified for this category. After thorough analysis we found that, according to legislation relating to the phasing-out of the use of HCE in the non-ferrous metal industry, the use of that substance by the aluminium industry in Portugal was prohibited sincehmm 2002. Therefore, from 2003 onwards, HCB emissions are reported as NA.

4.4.3.6 Recalculations

Following QA/QC procedures already discussed in the item above, recalculations concern HCB emissions in the period from 2003 onwards. As shown in the table below, in terms of impact on Portugal mainland, recalculations in this sector were responsible for a decrease of total HCB emissions of about 18 000% in 2003 and 5 386% in 2017.

Table 4-34: Recalculated data for HCB emissions from secondary aluminium production: Portugal Mainland - for Compliance Assessment

Recalculated data *NFR 2.C.3*	**Previous submission (March 2020)**	**Latest submission (April 2020)**	**Difference**	**Difference**	**Impact on total emissions**
Year	**kg**			**%**	
2003	115.1	0.0	-115.1	*-100%*	*-17 950*
2005	106.5	0.0	-106.5	*-100%*	*-20 185%*
2015	86.8	0.0	-86.8	*-100%*	*-10 797%*
2016	47.5	0.0	-47.5	*-100%*	*-4 414%*
2017	57.6	0.0	-57.6	*-100%*	*-5 386%*

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 in accordance with EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2016).

Emissions of TSP, PM_{10} and $PM_{2.5}$ were estimated according to the following equation:

Equation 4-44: 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 4-45: 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 4-46: 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 4-47: 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 used are listed in the tables below.

Table 4-35: 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 2016
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 4-36: 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 2016
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.

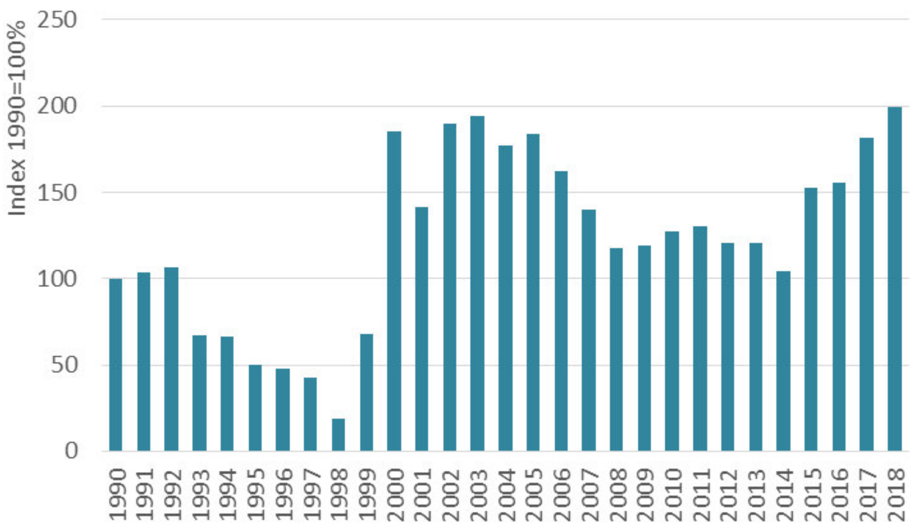


Figure 4-37: Secondary Lead production data (Index 1990=100%)

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

1990 and 1991 activity data were revised upon publication of a GDP revised time series.

4.4.5.7 Further Improvements

Efforts will be made to obtain National Statistics data or plant specific data for the entire period.

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 in accordance with EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2016).

Emissions of TSP, PM_{10} and $PM_{2.5}$ were estimated according to the following equation:

Equation 4-48: 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 4-49: 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 4-50: 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 4-51: 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 used are listed in the tables below.

Table 4-37: 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 2016
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 4-38: 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 2016
	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.

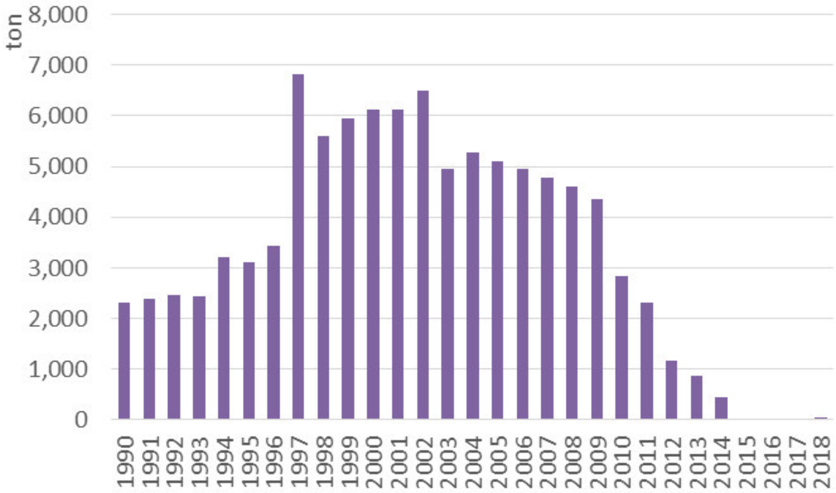


Figure 4-38: Secondary Copper production (Index 1990=100%)

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

1990 to 1992 activity data were revised upon publication of a GDP revised time series.

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 in accordance with EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2016).

Emissions of TSP, PM_{10} and $PM_{2.5}$ were estimated according to the following equation:

Equation 4-52: 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 4-39: 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 2016
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.

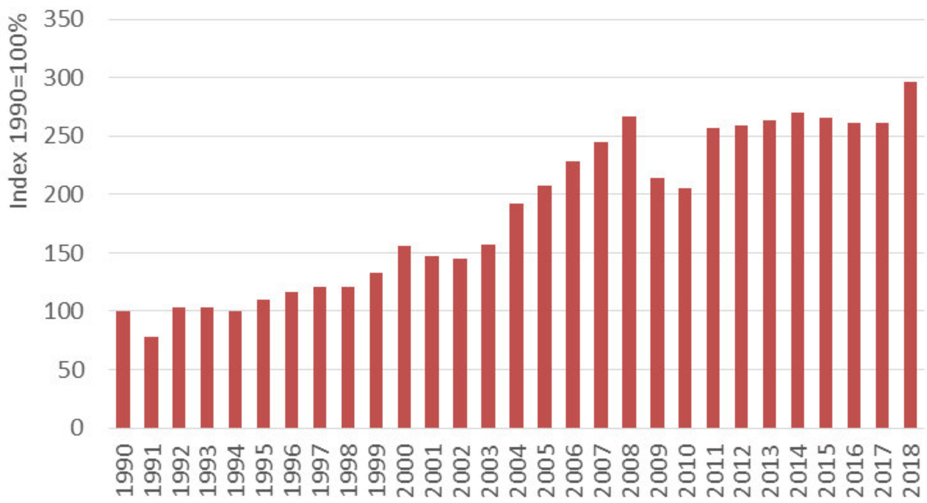


Figure 4-39: Metal products handled (Index 1990=100%)

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

Activity data were revised for the whole time series upon revision of iron, aluminium, copper and lead's activity data.

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 Other Solvent and Product Use (2.D – 2.L)

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 NMVOCs contained in products during their use. For most products, all of the NMVOC will be emitted to the atmosphere. However, in some products, the 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 2016 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 4-53: 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 4-54: 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 2016 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 4-40: 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	-

REACH end-use sector	Unit	2.D.3.a
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		

However, data concerning Portugal solvent VOC emissions was only available for 2015 to 2017. Furthermore, data on solvent VOC emissions was only available for Iberian Peninsula (Portugal+Spain) and for years 2008, 2009, 2013 and 2015, as shown in the figure below.

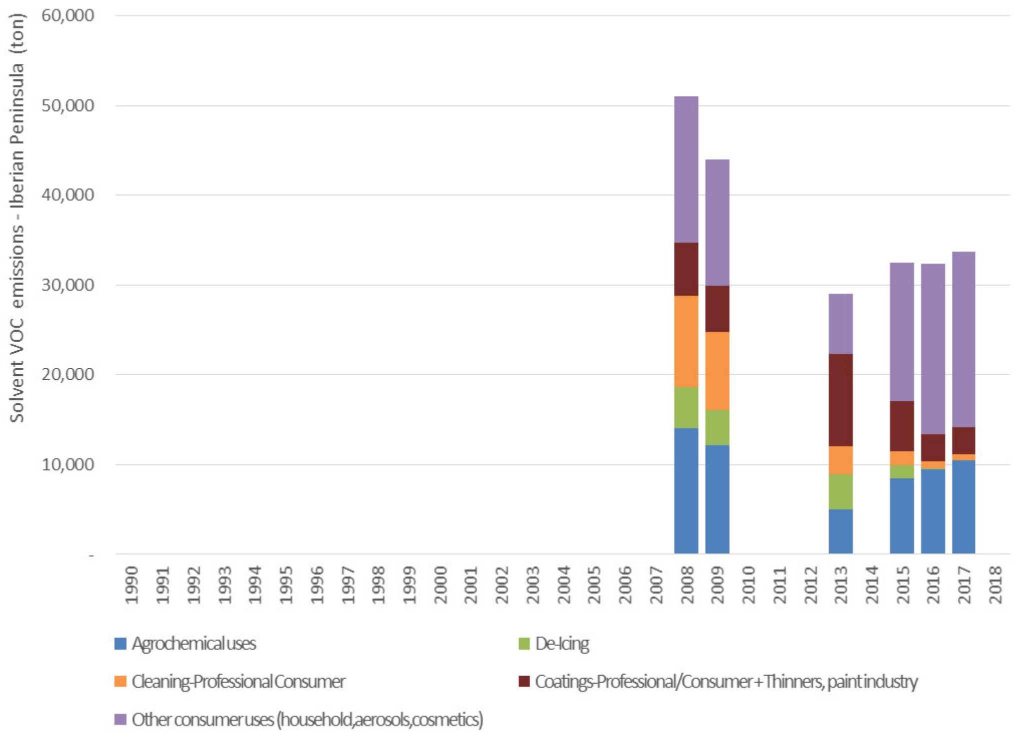


Figure 4-40: Iberian Peninsula 2.D.3.a total solvent VOC emissions (Source: ESIG inventory)

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 4-41: 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 4-55: 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

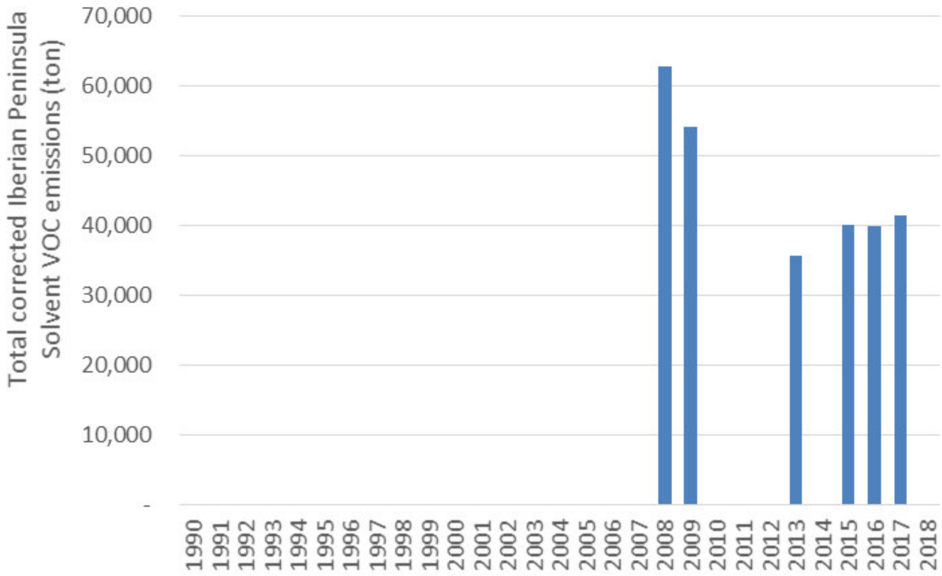


Figure 4-41: Total corrected Iberian Peninsula 2.D.3.a solvent VOC emissions

Although data for 2015 to 2017 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 4-56: 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 onwards, the missing years were estimated based on the average of available years;
- 2018 implied NMVOC emission factor was assumed equal to year 2017.

Figure 4-42: Implied NMVOC emission factor

Hg emission factor is listed in the table below.

Table 4-42: 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 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.

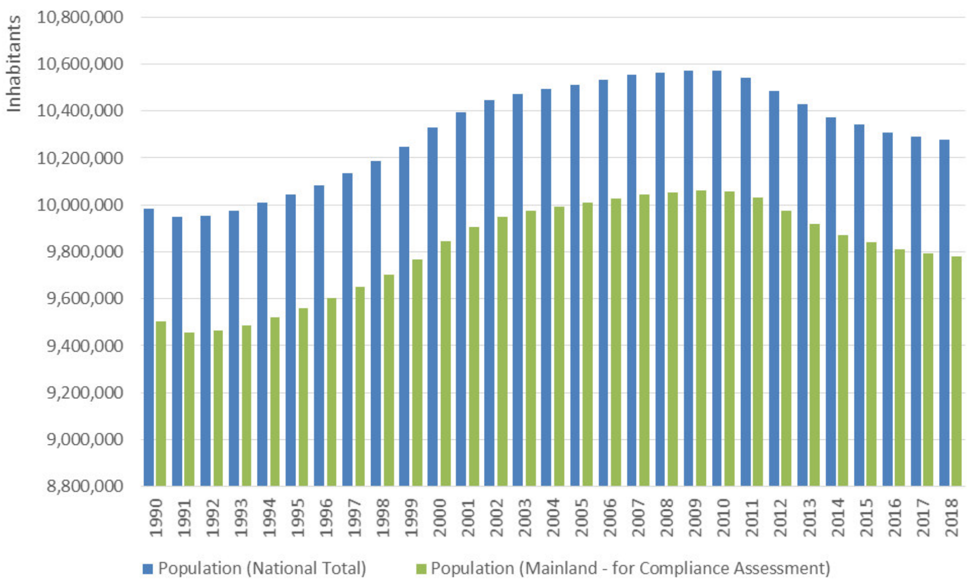


Figure 4-43: Portuguese population

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

Following a 2018 NECD Review recommendation, in order to apply a Tier 2 methodology for domestic solvent use, this key category sector underwent some major methodological changes.

In order to use a higher tier methodology, it was necessary to obtain information that is not currently available in Portugal. Chapter 2D3a of the EMEP/EEA air pollutant emission inventory guidebook 2016 mentions European Solvents Industry Group (ESIG) as a potential source of data regarding the amount of solvents used by country, in case the national activity data are not available. Therefore, the Inventory team contacted this entity directly, in order to request detailed data on the consumption of solvents in the national territory. The information received from ESIG had, however, significant limitations, as already described in activity data section.

Concerning the emission factor, before we were using Tier 2 emission factors from table 3.5, Volume 2.D.3.a from 2016 EMEP Guidebook. These emission factors were being applied incorrectly, given that they are reported in g/person and we were using them in national population (per capita). For this submission, we estimated an implied NMVOC emission factor for Iberian Peninsula, which we considered more suitable to national circumstances, as already explained in emission factors section.

Recalculations occurred for this category for the whole time series, resulting in a general decrease of NMVOC emissions. As shown in the table below, in domestic solvent use sector there was a decrease in NMVOC emissions of about 54.6% in 1990 and of 70.3% in 2017. In terms of impact on Portugal mainland, methodological changes to this sector were responsible for a decrease of total NMVOC emissions of about 5.4% in 1990 and 11.8% in 2017.

Table 4-43: Recalculated data for NMVOC emissions from domestic solvent use: Portugal Mainland - for Compliance Assessment

Recalculated data *NFR 2.D.3.a*	Previous submission	Latest submission	Difference	Difference	Impact on total emissions
Year	kton			%	
1990	23.40	10.63	-12.77	*-54.58*	*-5.41*
2005	24.64	11.19	-13.45	*-54.58*	*-7.20*
2015	24.22	6.94	-17.28	*-71.35*	*-11.91*
2016	24.15	6.91	-17.24	*-71.40*	*-12.17*
2017	24.11	7.16	-16.95	*-70.29*	*-11.75*

Overall, concerning domestic solvent use sector, in the figure below it is possible to observe the graphic representation of the recalculations on NMVOC emissions for the whole recalculated series (1990-2017).

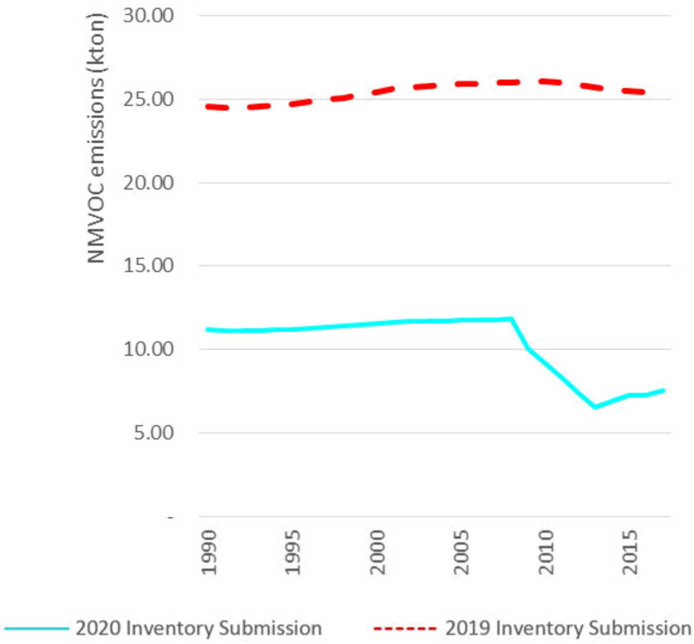


Figure 4-44: Recalculations in domestic solvent use

4.5.1.7 Further Improvements

In the future, we intend to apply this methodology to other sub-categories in sector 2.D.3, whenever possible.

4.5.2 Road Paving with Asphalt (NFR 2.D.3.b – SNAP 040611)

4.5.2.1 Category description

Emission estimates reported in this source category include emissions occurring from paving road surfaces with asphalt materials as well as emissions occurring during operation of hot mix asphalt plants. Emissions from 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)[7]. 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[8]. 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 HAP. 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 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 Material that escape mostly from the drier. Other pollutants are also emitted but they result mostly from combustion of fuels and are considered in chapter Energy (1A2)[9]. Emission estimates for hot-mix are only made here for pollutants NMVOC and PM, while emission of other pollutants are covered in emission estimates made for Energy in Manufacturing Industries and Construction (1A2) using fuel combustion in building and construction activity[10].

[7]That are needed to fluidize the asphalt cement.

[8] And also a solvent in several emulsion types.

[9] To avoid duplication of emissions and because from statistical information is not possible to separate fuel use in this particular activity sector.

[10] It is not possible to distinguish fuel combustion in hot mix production activity.

Emissions during production of emulsions, cutback binders and cold mix asphalt concretes are not estimated and assumed negligible[11].

It was still not possible to distinguish the part of asphalt materials that is used in road pavement and other uses, such as building isolation or asphalt roofing, and therefore all emissions from production of asphalts – except emissions from fuel combustion – are included in this source category.

4.5.2.2 Methodology

Ultimate carbon dioxide emissions are calculated assuming that solvents are 100% composed of VOC (USEPA, 2001) and that emitted VOC have on average 60% of carbon[12]:

Equation 4-57: Ultimate carbon dioxide emissions

$$Emi_{CO2} = 44 / 12 \text{ X } 0.60 \text{ X } Emi_{NMVOC}$$

Different methodologies were used to estimate emissions of NMVOC during asphalt application or from asphalt production.

Application of Asphalt Concretes and Liquefied Asphalts

Calculation of NMVOC emissions during application of asphalt materials is done solely for cutback asphalts and emulsion asphalts. Emissions from application of hot mix asphalts are not quantified and are assumed negligible.

Non methane emissions of volatile organic compounds from liquefied asphalt are dependent on the quantity of distillate or solvent that is added to bitumen and on the rapidity of the curing process, which in itself is a function of the distillate that is used. The following equation was used to estimate emissions from this source, and were adapted from (USEPA, 1997; USEPA, 2001):

Equation 4-58: NMVOC emissions from Asphalt Concretes and Liquefied Asphalts

$$Emi_{NMVOC} = Cure_{FC} \text{ X } Binder \text{ X } d_{Bin}^{-1} \text{ X } SLV_{Fac} \text{ X } d_{SLV}$$

Where:

Emi_{NMVOC}: Emissions of NMVOC from asphalt application (t)

Binder: Total quantity of asphalt binder used in road paving (t)

SLV_{Fac}: Fraction of distillate (solvent) in asphalt (m^3/m^3)

d_{Slv}: density of solvent added to liquefied asphalt (kg/l)

d_{BIN}: density of bitumen binder mixture (kg/l)

$Cure_{FC}$: Factor dependent on cure (% of total distillate that evaporates as emission) (l/l)

[11] 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.

[12] Normal carbon content for medium linear simple hydrocarbons.

Hot Mix Asphalt Production

For calculation of hot mix production emissions, emission calculation is based on total product:

Equation 4-59: NMVOC emissions fromHot Mix Asphalt Production

$$Emi_{(p)} = Hotmix_{Batch} \text{ X } EF_{(p)} + Hotmix_{Drum} \text{ X } EF_{(p)}$$

Where:

$Emi_{(p,y)}$: Total emissions for pollutant p occurring from Hot mix asphalt production (t)

$Hotmix_{Batch}$ and $Hotmix_{Drum}$: Production of Hot mix asphalt, respectively in discontinuous (batch) and continuous (drum) plants (t)

$EF_{(p)}$ and $EF_{(p)}$: Emission Factors for pollutant p used respectively in discontinuous (batch) and continuous (drum) plants (t/t)

Although 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 here. Although double counting could nevertheless be made for these pollutants, it was considered that the production process results in specific emissions of these two 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

The following parameters were chosen to estimate emissions for application of emulsified and cutback asphalts. These values were chosen according to recommendations in AP-42, EMEP/CORINAIR or industrial expert guess.

Table 4-44: Emission Parameters for road paving with asphalt

Parameter	Cutback	Emulsions
SLV_{Fac}	25 %	3 %
d_{SLV}	0.95 kg/l	0.85 kg/l
d_{Bin}	0.95 kg/l	0.85 kg/l
Cure type	Medium Cure (MC)	-
$Cure_{FC}$	0.75 kg/kg	1 kg/kg

Emission factors used to estimate NMVOC and PM emissions from hot mix plants are from USEPA (2000) and are presented in table below.

Table 4-45: Emission Parameters for Hot Mix asphalt production

Pollutant	Continuous	Batch	Unit EF
PM	14	16	kg/t
PM10	23	14	%
PM2.5	5.5	1	%
NMVOC	32.0	22.1	g/t

Source: USEPA (2000)

4.5.2.4 Activity Data

The total quantity of bitumen sold to construction and building economic sector is available from the Energy Balance and was collected by DGEG based on surveys[13], 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 subsequently explained, are coherent with total sale statistics.

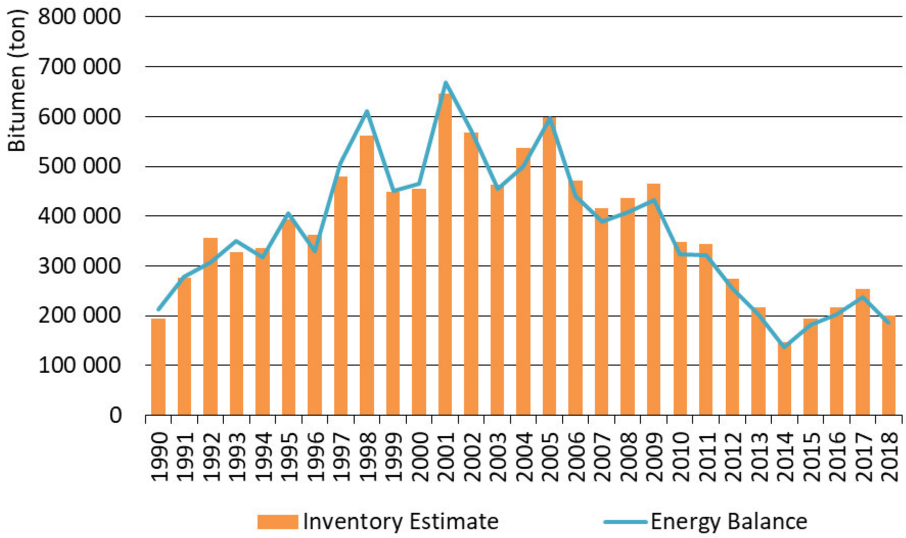


Figure 4-45: Total consumption of bitumen in the construction sector according to sales from DGEG Energy Balance and sum of values of asphalt used according to the inventory

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 sales were assumed equal to annual consumption and may be seen in the table below and figure above. Total emulsions applied are available from EAPA for 1997 and beyond. 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 is emulsions. It was also assumed that this % was zero in 1990 and has increased to 19 % in 1996. From 1991 onwards, data on hot mix concrete asphalt production is obtained from EAPA. Bitumen in hot mix asphalt was estimated considering that it equals 5 % of hot mix asphalt. Although this last figure is not necessary for the inventory it was nevertheless estimated in order to verify if total bitumen sales, from DGEG, match the sum of individual estimates. Total production of hot mix concrete asphalts is presented in the figure below.

[13] Original data from DGE is in toe and was converted to ton by factor 0.96 toe/ton, energy conversion factor used by DGE

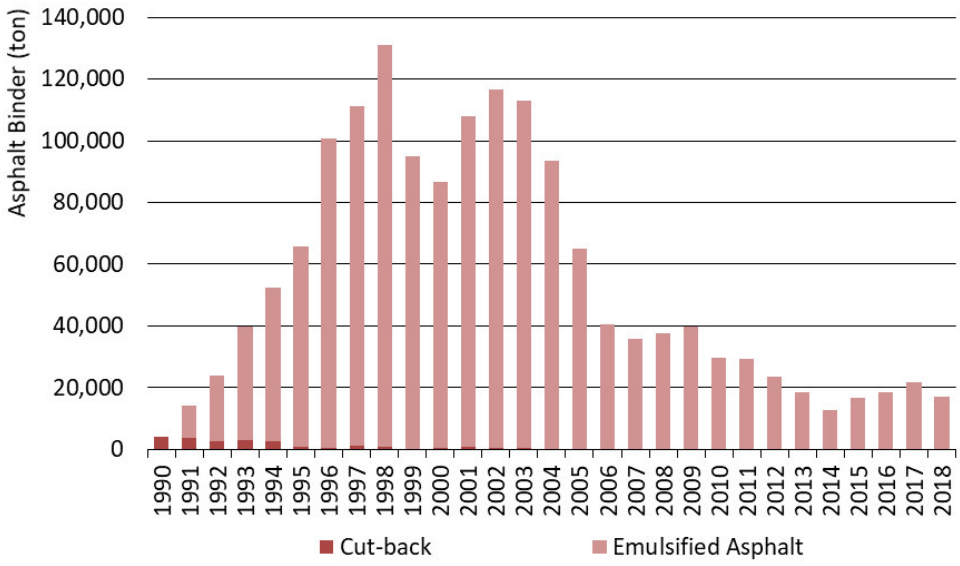


Figure 4-46: Asphalt binders (cutback and emulsified asphalts) consumed in Portugal

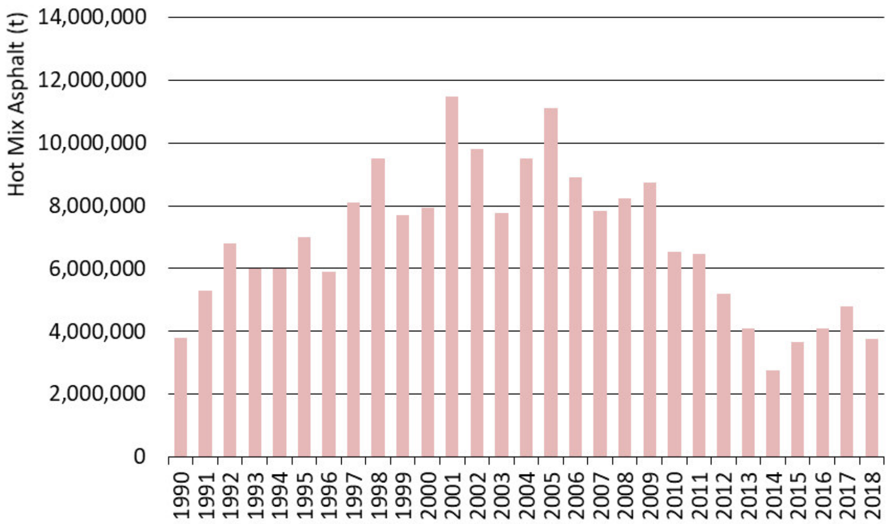


Figure 4-47: Hotmix Asphalt production

Emissions of Hot Mix Production depend if the equipment is batch or continuous. Desegregation of Hot Mix production per equipment was done assuming a constant proportion of 46 % continuous equipment and 54 % batch, which is an expert guess (PTEN, 2002).

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.

4.5.2.6 Recalculations

2017-2018 and 2010-2014 asphalt production data were updated based on the Energy Balance.

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 on 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

Emission factors applied are listed in the table below.

Table 4-46: Emission Factors (Tier 1)

Pollutant	Unit	Emission Factor	Source
CO	g/t shingle	9.5	Table 3.1 of chapter 2.D.3.c Asphalt roofing of EMEP/EEA air pollutant emission inventory guidebook 2016
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 has been estimated based on 1995 data and on GDP trend.

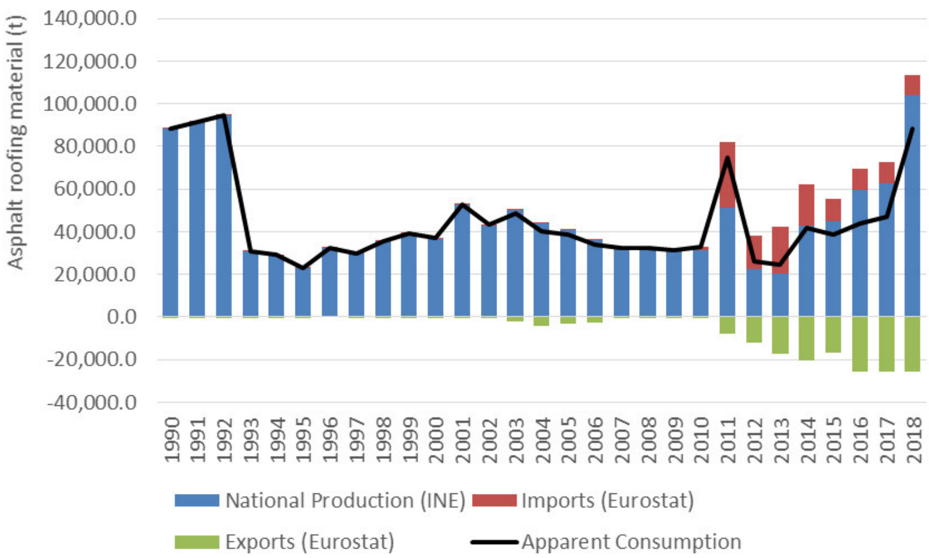


Figure 4-48: Asphalt roofing materials production, imports, exports and apparent consumption

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

1990 to 1994 activity data were updated upon publication of a GDP revised time series.

2017 data on Imports was 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 4-47: 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 4-48: 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 4-49: % Efficiency of the abatement technology mix

Technology	Unit	1990	1995	2000	2005	2010	2016	2017	2018
Manufacture of automobiles-Vehicles-Process modification and substitution	% Efficiency of Abatement technology mix	0.0	22.5	45.0	67.5	90.0	90.0	90.0	90.0

Table 4-50: Final emission factor

Parameter	Unit	1990	1995	2000	2005	2010	2016	2017	2018
Final EF Car coating	kg/car	8.0	6.2	4.4	2.6	0.8	0.8	0.8	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.

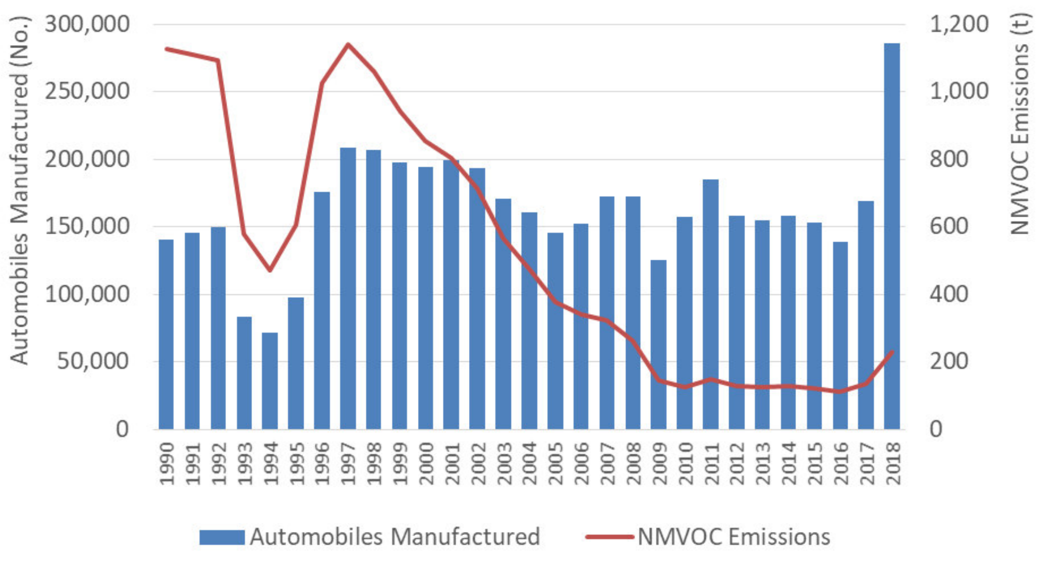


Figure 4-49: Number of cars manufactured

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

1990 and 1991 activity data were updated upon publication of a GDP revised time series.

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 4-51: 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 4-52: 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 4-53: % Efficiency of the abatement technology mix

SNAP	Unit	1990	1995	2000	2005	2010	2016	2017	2018
Coating Applications: Car Repairing	% Efficiency of abatement technology mix	0.0	17.0	34.0	49.5	65.0	68.0	68.5	69.0

Table 4-54: Final emission factor

Parameter	Unit	1990	1995	2000	2005	2010	2016	2017	2018
Final EF Car coating	kg/t paint	720	598	475	364	252	230	227	223

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.

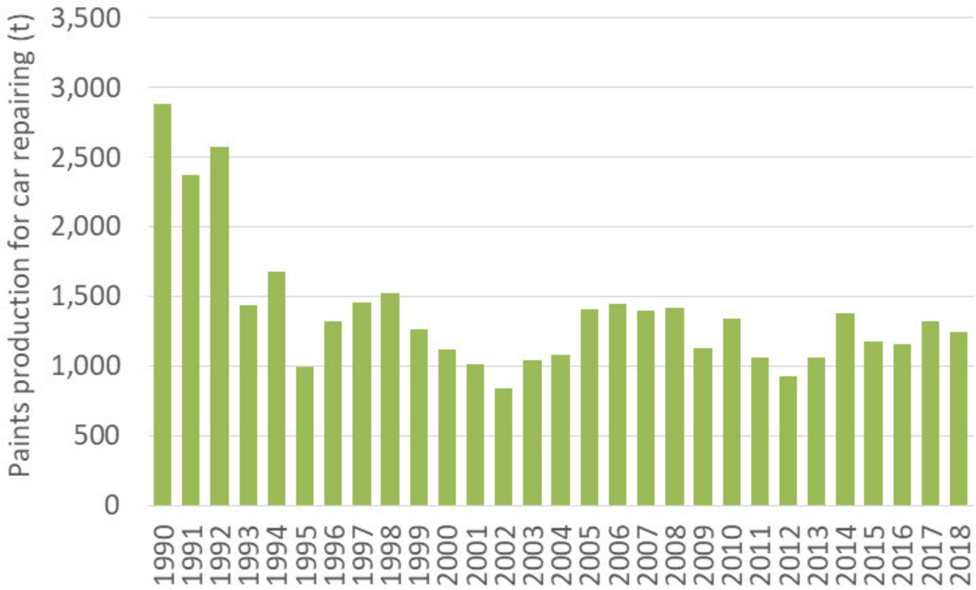


Figure 4-50: Paint production for car repairing

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 4-55: 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 4-56: 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 4-57: Share of each abatement technology over time

Technology	Unit	1990	1995	2000	2005	2010	2016	2017	2018
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

Table 4-58: Final emission factor

Parameter	Unit	1990	1995	2000	2005	2010	2016	2017	2018
Final EF	kg/t paint	221	170	140	105	69	69	69	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.

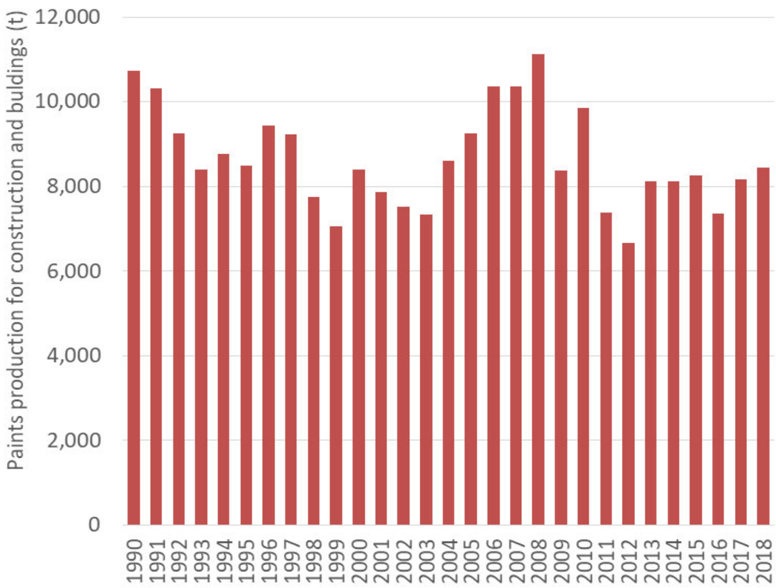


Figure 4-51: Paint production for construction and buildings

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 4-59: 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 4-60: 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 4-61: Share of each abatement technology over time

Technology	Unit	1990	1995	2000	2005	2010	2016	2017	2018
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

Table 4-62: Final emission factor

Parameter	Unit	1990	1995	2000	2005	2010	2016	2017	2018
Final EF	g/kg paint applied	221	170	140	105	69	69	69	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.

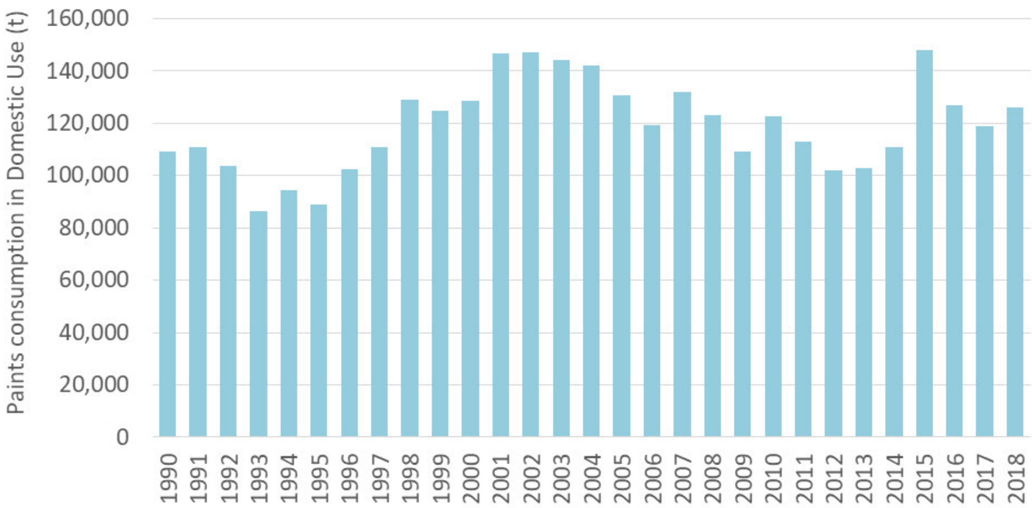


Figure 4-52: Paints consumption in domestic use

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.

4.5.7.6 Recalculations

Activity data in the periods 1990 to 1993, 2002 to 2003 and 2011 onwards were updated upon publication of a GDP revised time series.

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 4-63: 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 4-64: 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 4-65: Share of each abatement technology over time

Technology	Unit	1990	1995	2000	2005	2010	2016	2017	2018
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	7.8	7.1	6.4
Coil coating line with powder coating systems (solvent free)	%	20.0	35.0	50.0	69.0	88.0	92.2	92.9	93.6

Table 4-66: Final emission factor

Parameter	Unit	1990	1995	2000	2005	2010	2016	2017	2018
Final EF	Kg/t coil coating	204	132	60	37.2	14.4	9.4	8.5	7.7

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.

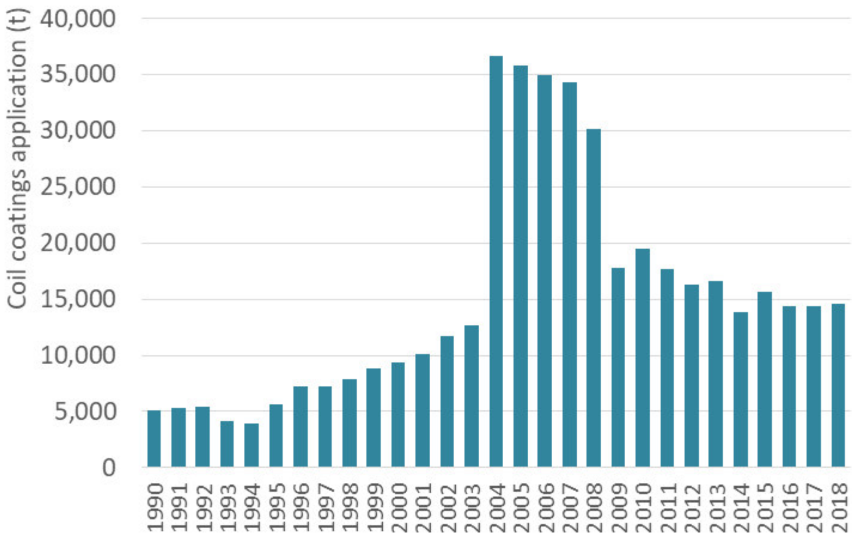


Figure 4-53: Coil coatings application

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

1990 and 1991 activity data were updated upon publication of a GDP revised time series.

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 EMEP/EEA air pollutant emission inventory guidebook 2016. 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 4-67: 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 4-68: 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 4-69: Share of each abatement technology over time

Technology	Unit	1990	1995	2000	2005	2010	2016	2017	2018
Uncontrolled	%	13.99	13.99	13.99	13.74	4.37	4.37	4.37	4.37
Medium solids system (55% solvent content)	%	0.00	0.00	0.00	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	47.75	47.75	47.75
Very high solids system (5% solvent content)	%	47.88	47.88	47.88	47.88	47.88	47.88	47.88	47.88
Add-on: Thermal oxidation	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4-70: Final emission factor

Parameter	Unit	1990	1995	2000	2005	2010	2016	2017	2018
Final EF	g/kg material applied	211.2	211.2	211.2	209.7	153.4	153.4	153.4	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.

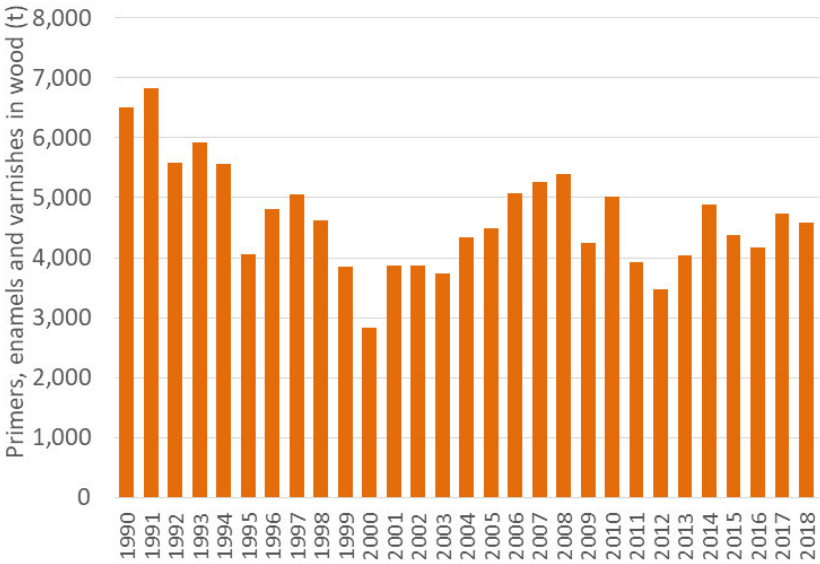


Figure 4-54: Primers, enamels and varnishes use in wood

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 4-71: 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.

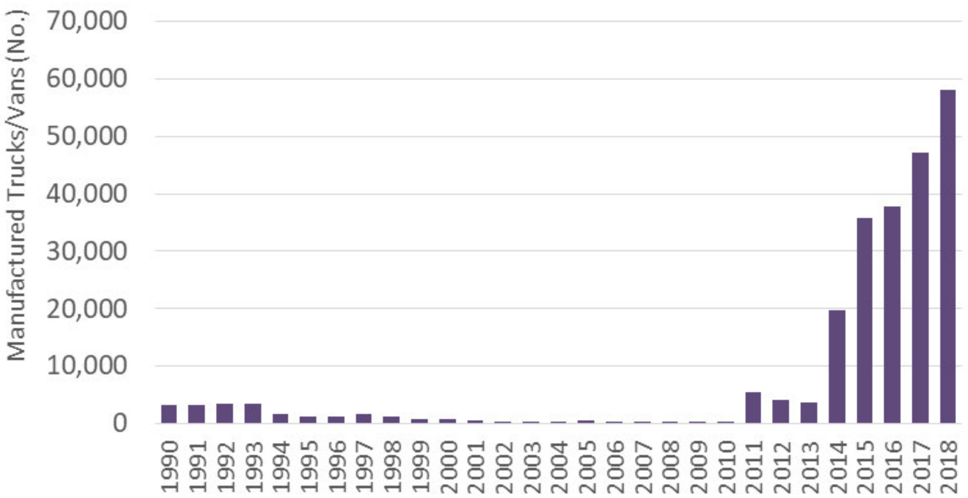


Figure 4-55: Number of vehicles manufactured

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

1990 and 1991 activity data were updated upon publication of a GDP revised time series.

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 4-72: 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.

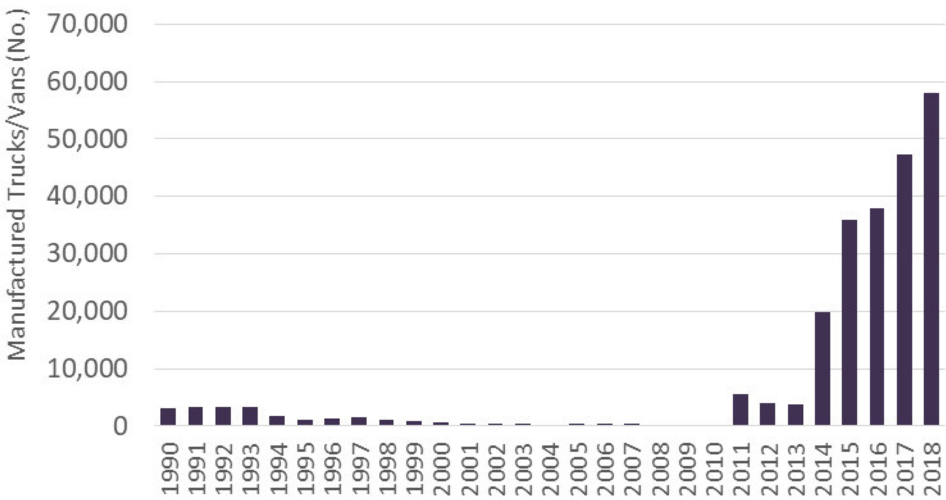


Figure 4-56: Number of truck cabins manufactured

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

1990 and 1991 activity data were updated upon publication of a GDP revised time series.

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 4-73: 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.

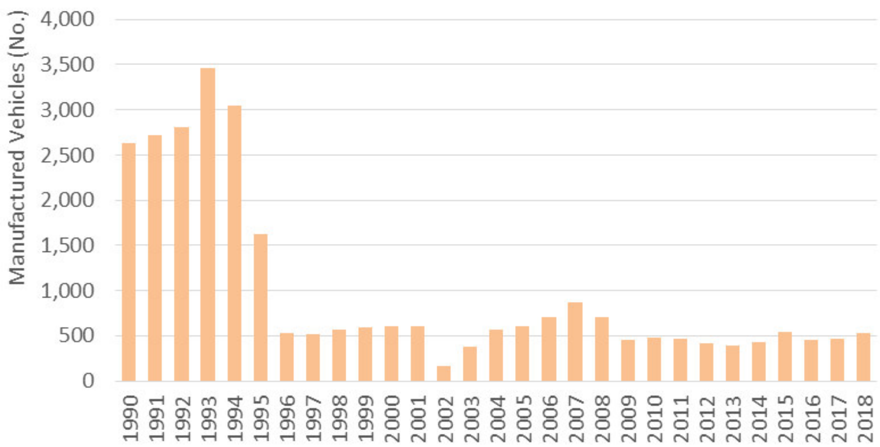


Figure 4-57: Number of public transportation vehicles manufactured

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

1990 and 1991 activity data were updated upon publication of a GDP revised time series.

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 EMEP/EEA air pollutant emission inventory guidebook 2016. 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 EMEP/EEA air pollutant emission inventory guidebook 2016 (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 4-74: Default emission factor

SNAP	Unit	NMVOC
Industrial coating application: leather finishing	kg/t leather	200

Source: (EMEP/EEA, 2016)

Table 4-75: 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 4-76: Control strategy

Technology	Unit	1990	1995	2000	2005	2010	2016	2017	2018
Use of water based products (30 wt-% solvent content)	%	0	0	0	10	30	50	50	50
Add on: Thermal oxidation	%	0	0	0	0	0	0	0	0
Add on: Biofiltration	%	0	0	0	0	5	5	5	5
Uncontroled	%	100	100	100	90	65	45	45	45

Table 4-77: Final emission factor

Parameter	Unit	1990	1995	2000	2005	2010	2016	2017	2018
Final EF leather finishing	kg/t leather	200.0	200.0	200.0	187.0	152.9	126.9	126.9	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.

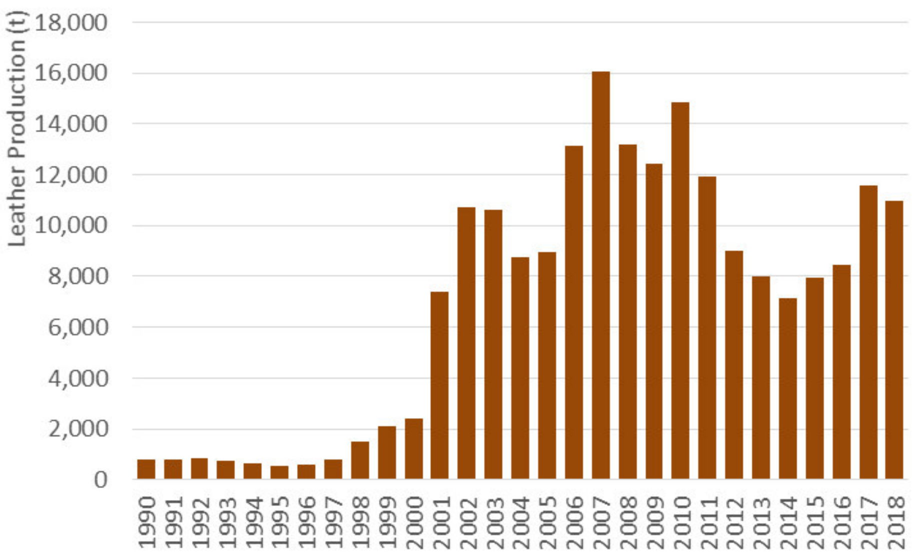


Figure 4-58: Leather production

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

1990 and 1991 activity data were updated upon publication of a GDP revised time series.

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

NMVOC emissions from other industrial coating applications were estimated according to:

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 4-78: 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.

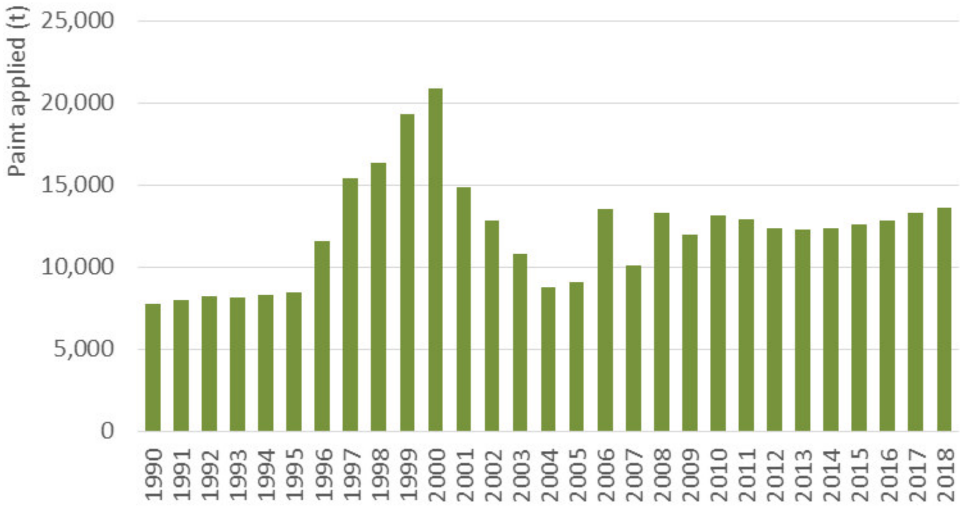


Figure 4-59: Paint applied in Other Industrial Applications

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

Activity data in the periods 1990 to 1994 and 2001 onwards were updated upon publication of a GDP revised time series.

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

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 preceeds normally the application of other treatment processes and occurs mainly in metal industry, plastics products manufacturing, rubber[14], 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).

[14] Emissions from degreasing in this industry are included under rubber processing.

4.5.17.2 Methodology

NMVOC emissions from degreasing treatments were estimated according to:

Equation 4-72: NMVOC emissions from degreasing

$$Emi_{NMVOC} = (Prod + Imp - Exp) \times \frac{EF}{1000}$$

Where:

Emi_{NMVOC}: NMVOC emissions (t)

Prod: National production (t) of metal degreasing substances (o-xylene, m-xylene, p-xylene, dichloromethane and trichloroethylene)

Imp: Imports of metal degreasing substances (t)

Exp: Exports of metal degreasing substances (t)

EF: Emission factor (kg NMVOC/t of metal degreasing substance)

4.5.17.3 Emission Factors

NMVOC emission factor was taken from EMEP Guidebook 2016 and is indicated in the table below.

Table 4-79: Emission Factor

SNAP	Unit	Emission Factor	Source
Degreasing	kg NMVOC/ t cleaning product	460	Table 3-1 of chapter "2.D.3.e - Degreasing " of "EMEP/EEA air pollutant emission inventory guidebook 2016"

4.5.17.4 Activity Data

From 1995 onwards, national production of metal degreasing substances was obtained from INE (IAPI) and data on imports and exports was obtained from EUROSTAT. For the period 1990-1994, both national production and imports/exports data were estimated based on 1995 value and on GDP trend for this period.

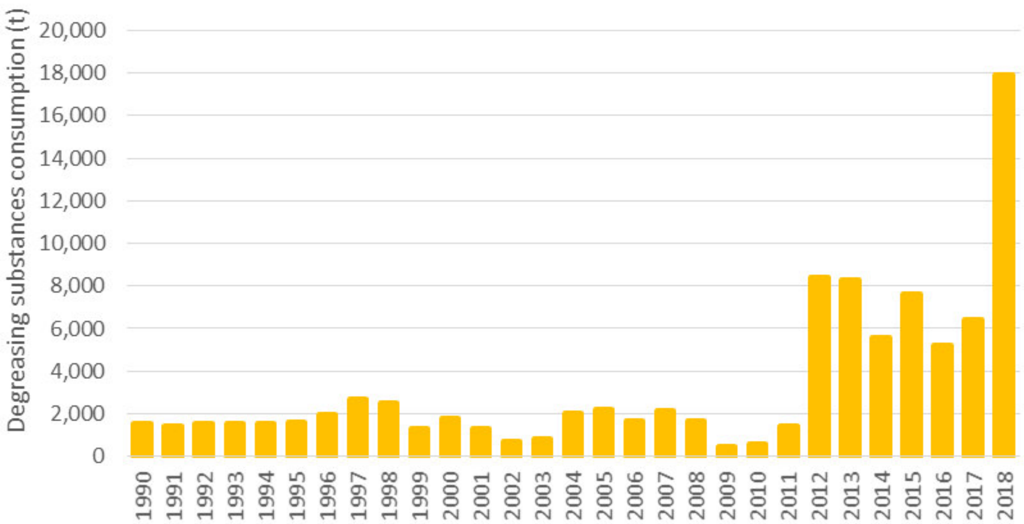


Figure 4-60: Degreasing substances consumption – total territory

The figure above shows national degreasing substances consumption (Prod+Imp-Exp).

From 2012 onwards, there is a strong increase in consumption. This increase is due, specifically, in p-xylene import data from EUROSTAT. Upon a contact with INE, they confirmed the data and indicated that in the period 2012-2013, p-xylene was imported as raw material, and incorporated into another product, which was then exported. Furthermore, the increase in 2014, specifically due to m-xylene production data from INE, was also confirmed by this entity, who referred it was due to the restructuring of a large company.

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.

4.5.17.6 Recalculations

Activity data in the period 1990 to 1994 were updated upon publication of a GDP revised time series.

Imports data for the years 2016 and 2017 were updated based on EUROSTAT.

4.5.17.7 Further Improvements

No further improvements are expected.

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, by the aid of solvents, of contamination or dirt from cloths, textile, furs, leather, down leathers, textiles or other objects made of fibers.

4.5.18.2 Methodology

Apparent consumption of dry cleaning products was estimated according to the following equation:

Equation 4-73: Glues and adhesives 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 4-74: 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 were chosen to estimate emissions for dry cleaning.

Table 4-80: 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/EEA air pollutant emission inventory guidebook 2016"
Closed Circuit	Kg NMVOC/ kg PER	0.4	

Table 4-81: % 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 and other materials in dry cleaning activity, because such activity is not included under IAIT and IAPI industrial surveys. Therefore, it was assumed that all PER (Perchloroethylene)[15] consumed in Portugal is used in dry-cleaning[16] activity and that all PER used is imported (no national production).

From 1995 onwards, annual apparent consumption was estimated from EUROSTAT data on imports and exports of perchloroethylene. In the period 1990-1994, data was estimated based on 1995 apparent consumption and on GDP trend.

[15] 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.

[16] There is no reference to PER consumption in other industrial activities according to IAIT and IAPI industrial surveys from INE.

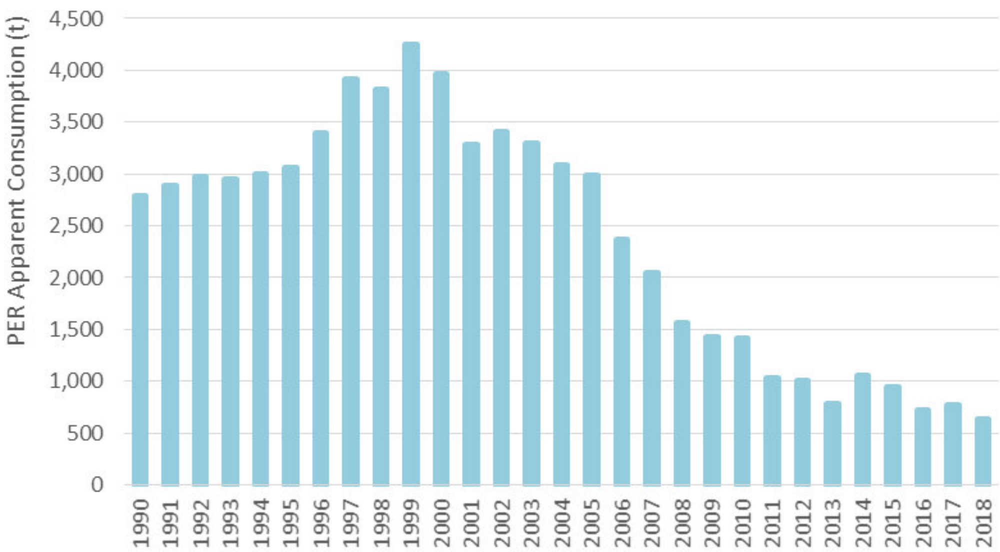


Figure 4-61: Annual consumption of PER (Perchloroethylene) – total territory

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

Activity data in the period 1990 to 1994 were updated upon publication of a GDP revised time series.

4.5.18.7 Further Improvements

No further improvements are planned for this sector.

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 in accordance with the EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2016). A tier 2 approach was used as activity data and emissions factors were stratified for polyester processing.

NMVOC emissions were estimated from the quantity of polyester processed according to the following equation:

Equation 4-75: NMVOC emissions from polyester processing

$$Emi_{NMVOC(y)} = EF_{NMVOC} \times Proc_{POLYESTER} \times 10^{-3}$$

Where:

$Emi_{NMVOC(y)}$: NMVOC total emissions from polyester processing (t)

EF_{NMVOC}: NMVOC emission factor for polyester processing (g/kg monomer used)

$Prod_{FOAM(y)}$: Quantity of monomer used (t)

4.5.19.3 Emission Factors

The technology specific emission factor was obtained from EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2016). The emissions factor was assumed constant for all covered period.

Table 4-82: NMVOC foam processing emission factor

SNAP	Unit	NMVOC	Source
Polyester processing	g/kg monomer used	50	Tablr 3-2 of chapter “2.D.3.g Chemical Products” of “EMEP/EEA air pollutant emission inventory guidebook 2016”

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.

Figure 4-62: Polyester processed

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

Activity data in the periods from 1990 to 1999 and from 2003 to 2007 have been updated upon publication of a GDP revised time series.

4.5.19.7 Further Improvements

No further improvements are planned for this sector.

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 in accordance with the EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2016).

Emissions were estimated according to the following equation:

Equation 4-76: 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 2016 and are listed in the table below.

Table 4-83: Emission factors

Pollutant	Material	Unit	EF	Source
NMVOC	S-PVC	Kg/t product	0.096	EMEP/EEA emission inventory guidebook 2016, Volume 2.B Chemical Industry (Table 3.41)
NMVOC	E-PVC	Kg/t product	0.813	EMEP/EEA emission inventory guidebook 2016, Volume 2.B Chemical Industry (Table 3.42)
TSP	S-PVC/E-PVC	Kg/t product	0.263	EMEP/EEA emission inventory guidebook 2016, Volume 2.B Chemical Industry (Table 3.41 and Table 3.42)
PM10	S-PVC/E-PVC	Kg/t product	0.100	EMEP/EEA emission inventory guidebook 2016, Volume 2.B Chemical Industry (Table 3.41 and Table 3.42)
PM2.5	S-PVC/E-PVC	Kg/t product	0.005	EMEP/EEA emission inventory guidebook 2016, Volume 2.B Chemical Industry (Table 3.41 and Table 3.42)

4.5.20.4 Activity Data

Data on polyvinylchloride is available from the IAPI industrial surveys from INE.

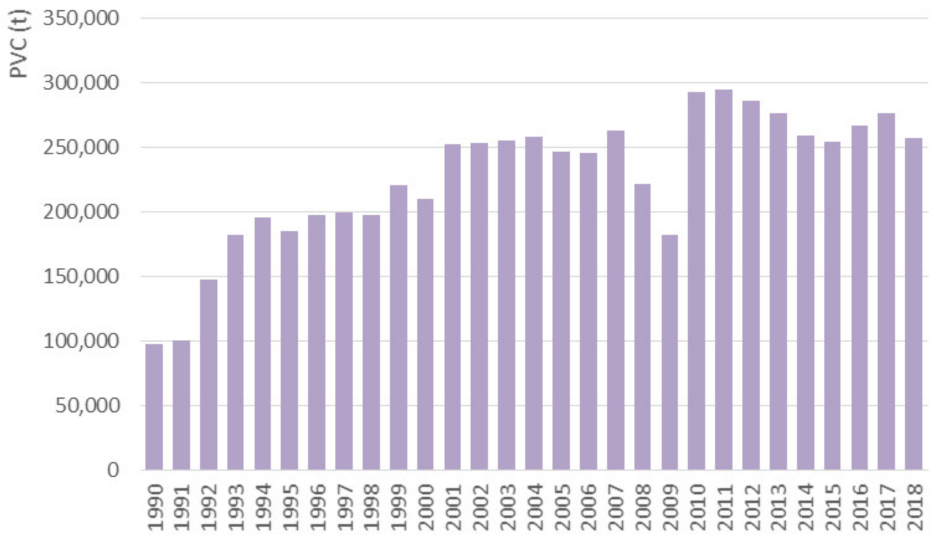


Figure 4-63: PVC production

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 EMEP/EEA air pollutant emission inventory guidebook 2016.

NMVOC emissions were estimated from the quantity of foam processed according to a Tier 2 approach:

Equation 4-77: NMVOC emissions from Polyurethane foam processing

$$Emi_{NMVOC(y)} = EF_{NMVOC} \times Proc_{FOAM} \times 10^{-3}$$

Where:

$Emi_{NMVOC(y)}$: NMVOC total emissions from foam processing (t)

EF_{NMVOC}: NMVOC emission factor for foam processing (g/kg foam processed)

$Prod_{FOAM(y)}$: Quantity of foam processed (t)

4.5.21.3 Emission Factors

The technology specific emission factor was obtained from EMEP/EEA air pollutant emission inventory guidebook 2016.

Table 4-84: 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 EMEP/EEA air pollutant emission inventory guidebook 2016

4.5.21.4 Activity Data

In the period 1992-onwards, data on polyurethane foam processing 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).

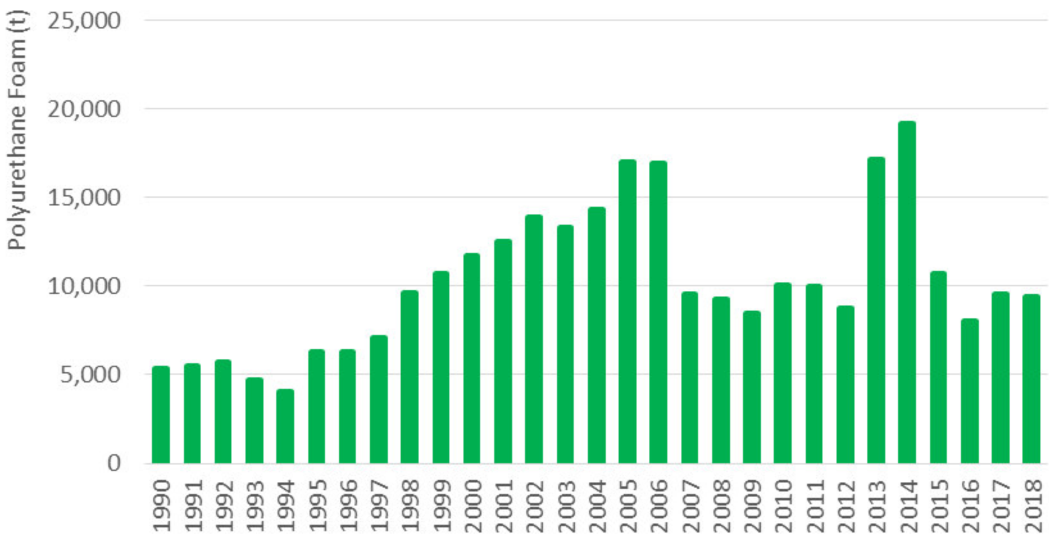


Figure 4-64: Polyurethane Foam Processing (Index 1990=100)

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

1990 and 1991 activity data has been updated upon publication of a GDP revised time series.

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 EMEP/EEA air pollutant emission inventory guidebook 2016.

Emissions were estimated from the quantity of foam processed according to Tier 2 approach:

Equation 4-78: NMVOC emissions from Polyurethane foam processing

$$Emi_{NMVOC(y)} = EF_{NMVOC} \times Proc_{FOAM} \times 10^{-3}$$

Where:

$Emi_{NMVOC(y)}$: NMVOC total emissions from foam processing (t)

EF_{NMVOC}: NMVOC emission factor for foam processing (g/kg foam processed)

$Prod_{FOAM(y)}$: Quantity of foam processed (t)

4.5.22.3 Emission Factors

The technology specific emission factor was obtained from EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2016). The emission factor was assumed constant for all covered period.

Table 4-85: 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 EMEP/EEA air pollutant emission inventory guidebook 2016

4.5.22.4 Activity Data

Data on polystyrene foam processing 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).

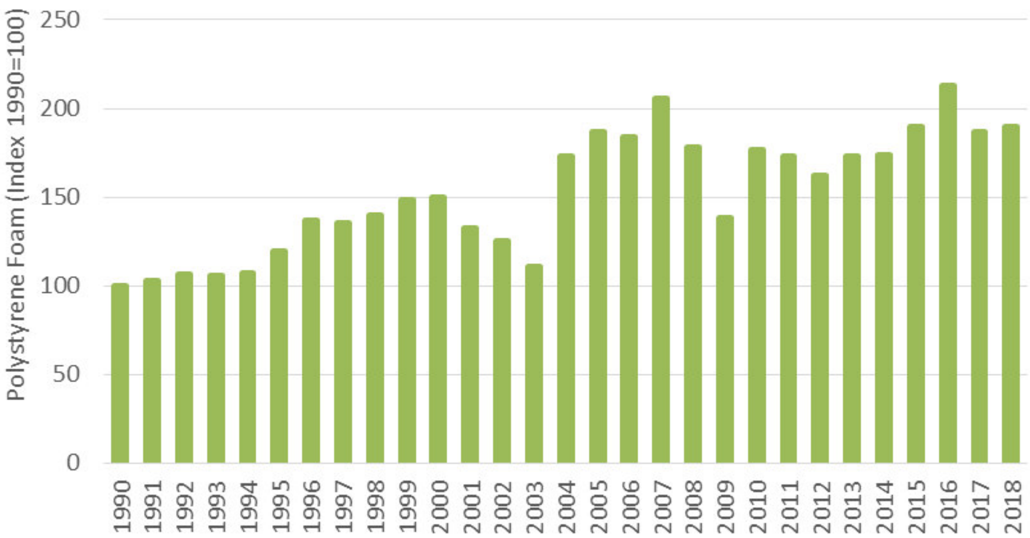


Figure 4-65: Polystyrene Foam Processing (Index 1990=100)

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

From 1990 to 1994, activity data has been updated upon publication of a GDP revised time series.

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 in accordance with EMEP/EEA air pollutant emission inventory guidebook 2016. Rubber processed for tyre production is not included in this sector.

NMVOC emissions were estimated from the quantity of rubber processed according to:

Equation 4-79: NMVOC emissions from rubber processing

$$Emi_{NMVOC(y)} = EF_{NMVOC} \times Proc_{RUBBER} \times 10^{-3}$$

Where:

$Emi_{NMVOC(y)}$: NMVOC total emissions from rubber processing (t)

EF_{NMVOC}: NMVOC emission factor for rubber processing (g/kg rubber processed)

$Prod_{FOAM(y)}$: Quantity of rubber processed (t)

4.5.23.3 Emission Factors

The emission factor used for rubber processing was obtained from EMEP/EEA air pollutant emission inventory guidebook 2016.

Table 4-86: 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 EMEP/EEA air pollutant emission inventory guidebook 2016

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.

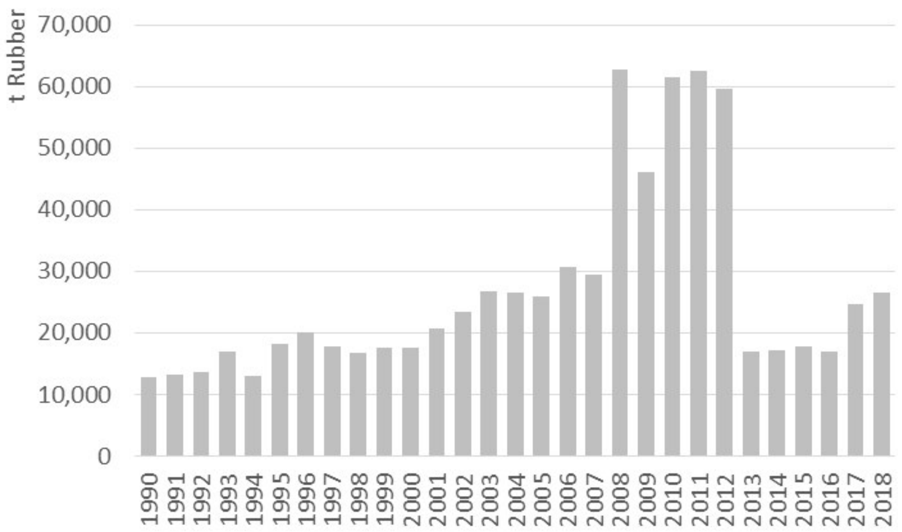


Figure 4-66: Rubber processed – total territory

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

Emissions from pharmaceutical products manufacturing were estimated in accordance with the EMEP/EEA air pollutant emission inventory guidebook 2016.

NMVOC emissions were estimated according to a Tier 1 approach, based on the quantity of pharmaceutical products produced:

Equation 4-80: NMVOC emissions from Pharmaceutical Products Manufacturing

$$Emi_{NMVOC} = EF_{NMVOC} \times Pharm_{prod} \times 10^{-6}$$

Where:

Emi_{NMVOC}: NMVOC emissions from chemical products (t)

EF_{NMVOC}: NMVOC tier 1 reference emission factor for chemical products (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 EMEP/EEA air pollutant emission inventory guidebook 2016.

Table 4-87: NMVOC pharmaceutical products manufacturing emission factor

SNAP	Unit	NMVOC	Source
Chemical Products Use	g/kg product	10	Table 3-1 of chapter "2.D.3.g Chemical Products" of EMEP/EEA air pollutant emission inventory guidebook 2016

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.

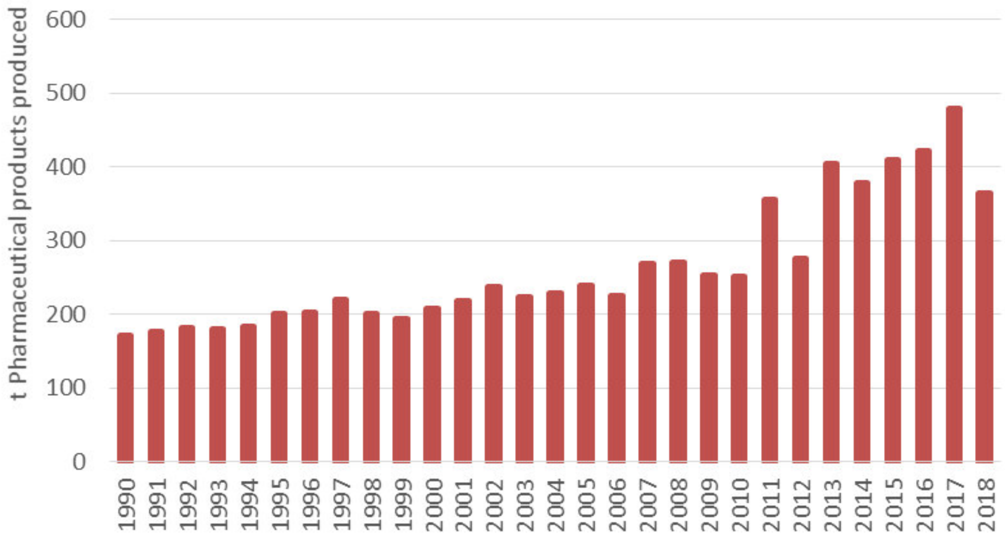


Figure 4-67: Pharmaceutical products produced – total territory

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

From 2016 onwards, activity data has been updated upon publication of a GDP revised time series.

4.5.24.7 Further Improvements

Efforts will be made 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 product manufactured.

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 in accordance with EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2016).

Emissions were estimated from the quantity of Paints, Inks and Glues processed according to:

Equation 4-81: Emissions from Paints, Inks and Glues Manufacturing

$$Emi_{(p,y)} = EF_{(y)} \times ProductManuf_{(p,y)} \times 10^{-3}$$

Where:

Emi $_{(p,y)}$: 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 EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2016). Control strategies were obtained from GAINS model developed by IIASA (http://gains.iiasa.ac.at) and applied in the following manner:

Equation 4-82: 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 4-88: 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 EMEP/EEA air pollutant emission inventory guidebook 2016
Paints and Inks Manufacturing	g/kg product	TSP	10	USEPA AP-42

Table 4-89: NMVOC Abatement technology (Source: EMEP/EEA, 2016)

Abatement Technology	Unit	Efficiency
Use of good practices	%	27

Table 4-90: 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 4-91: 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.

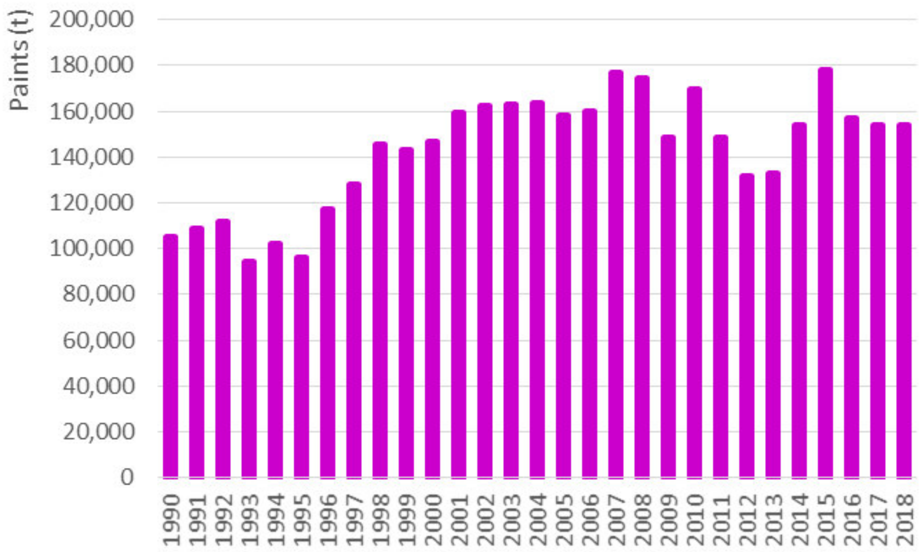


Figure 4-68: Paints Manufacturing – total territory

From 1994 onwards, production of inks was available from. In the period 1990-1993, data has been estimated based on GDP trend and on 1994 inks production data.

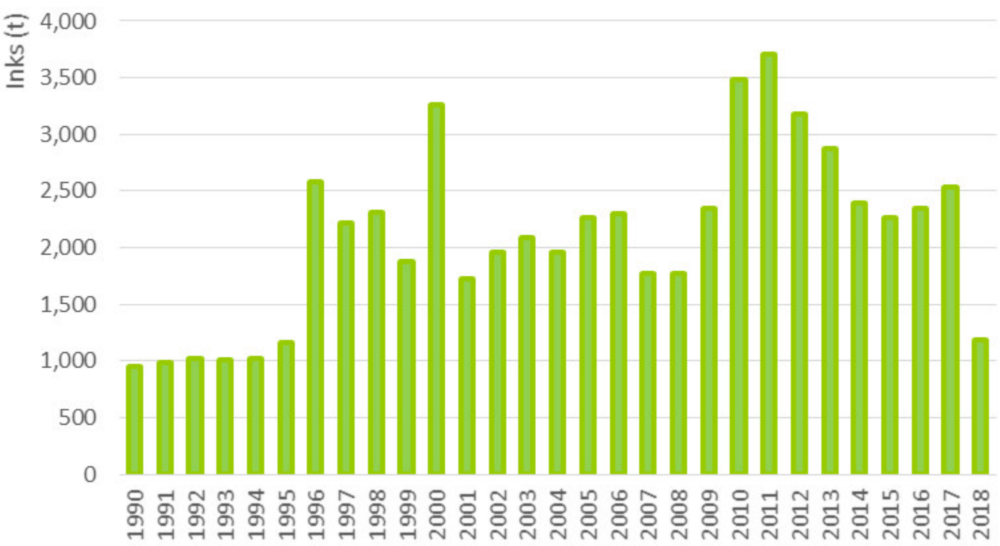


Figure 4-69: Inks manufacturing – total territory

In the 1990-1991 period, production of glues was available from IAIT (INE industrial survey). From 1992 onwards, that data was available from IAPI.

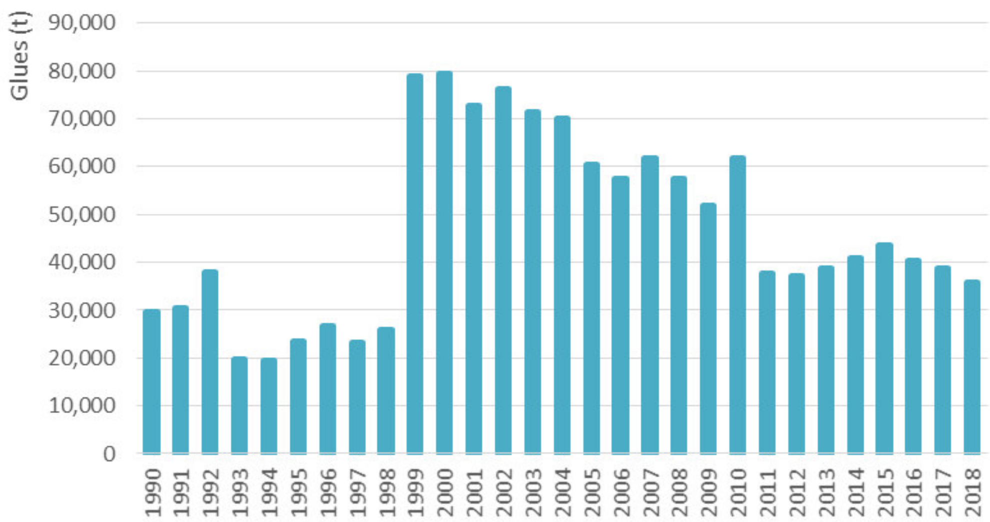


Figure 4-70: Glues Manufacturing – total territory

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

1990 and 1991 activity data has been updated upon publication of a GDP revised time series.

4.5.25.7 Further Improvements

No further improvements are planned for this sector.

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 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 4-83: 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 4-92: Emission Factors for Asphalt Blowing

Pollutant	Unit	EF
NMVOC	g/t asphalt	27200
TSP	g/t asphalt	400
PM10	g/t asphalt	400
PM2.5	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 (t) 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.

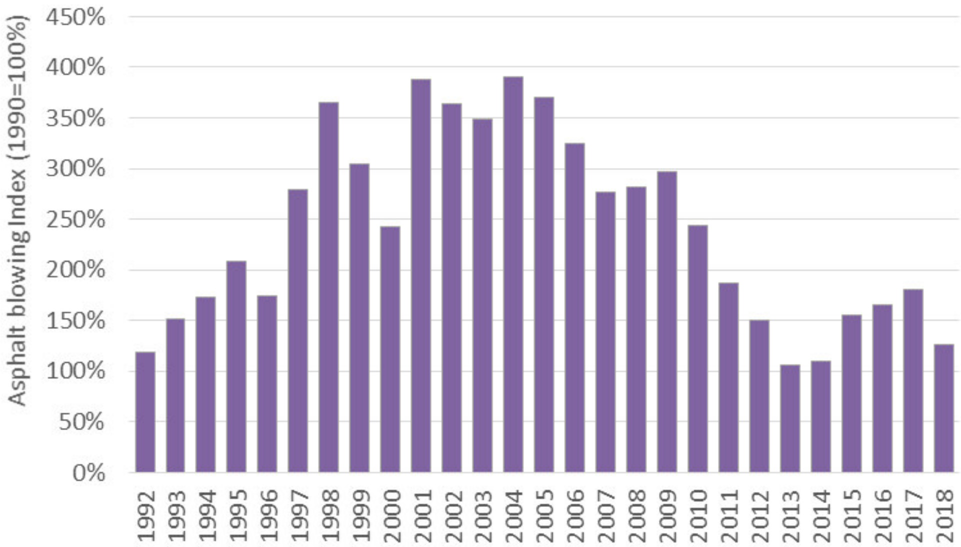


Figure 4-71: Asphalt produced in the Asphalt Blowing Units (Index related to 1990 value)

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

Following generic QA/QC procedures to atmosferic pollutants, a high level of Benzo(a)pyrene emissions was identified for this category. After thorough analysis to the 2019 EMEP Guidebook, we found that there were updated emission factors for this category. In fact, according to Table 3-8 of chapter 2D3g of the latest guidebook, Benzo(a)pyrene should now be reported as Not Estimated and there is a new total PAH emission factor. Also, PM10 and PM2.5 should be reported as Not Estimated, given that there is only emission factor for TSP.

4.5.26.6 Recalculations

Asphalt blowing activity data was updated for 2017, based on information provided from one of the facilities.

QA/QC procedures above mentioned resulted in recalculations concerning Benzo(a)pyrene, total PAH, PM10 and PM2.5 for the whole time series. Indeed, Benzo(a)pyrene, PM10 and PM2.5 are now reported as Not Estimated and PAH is now estimated for the first time with a specific emission factor.

In the previous submission, total PAH emissions corresponded to Benzo(a)pyrene emissions, given that the other PAH were reported as Not Estimated, following 2019 EMEP guidance. In that submission, Benzo(a)pyrene emission factor was 4000 g/t asphalt. In the present submission, Benzo(a)pyrene appears in Table 3-8 as Not Estimated and total PAH emission factor is 2.55 g/t asphalt.

As shown in the table below, in asphalt blowing process there was a decrease in PAH emissions of about 99.94% throughout the time series. In terms of impact on Portugal mainland, methodological changes to this sector were responsible for a decrease of total NMVOC emissions of about 1787% in 1990 and 5355% in 2017.

Table 4-93: Recalculated data for total PAH emissions from asphalt blowing: Portugal Mainland - for Compliance Assessment

Recalculated data *NFR 2.D.3.g (asphalt blowing)*	Previous submission	Latest submission	Difference	Difference	Impact on total emissions
Year	**ton**			**%**	
1990	432.75	0.28	-432.47	*-99.94*	*-1,787.09*
2005	1,536.97	0.98	-1,535.99	*-99.94*	*-8,067.24*
2015	611.81	0.39	-611.42	*-99.94*	*-4,474.90*
2016	646.64	0.41	-646.22	*-99.94*	*-4,734.71*
2017	774.49	0.49	-774.00	*-99.94*	*-5,355.46*

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:

Equation 4-84: 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 2016 and is listed in the table below.

Table 4-94: Emission factors

Parameter	Unit	EF	Source
NMVOC	Kg/t product	10	Table 3-1 of chapter "2.D.3.g Chemical Products" of EMEP/EEA air pollutant emission inventory guidebook 2016

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.

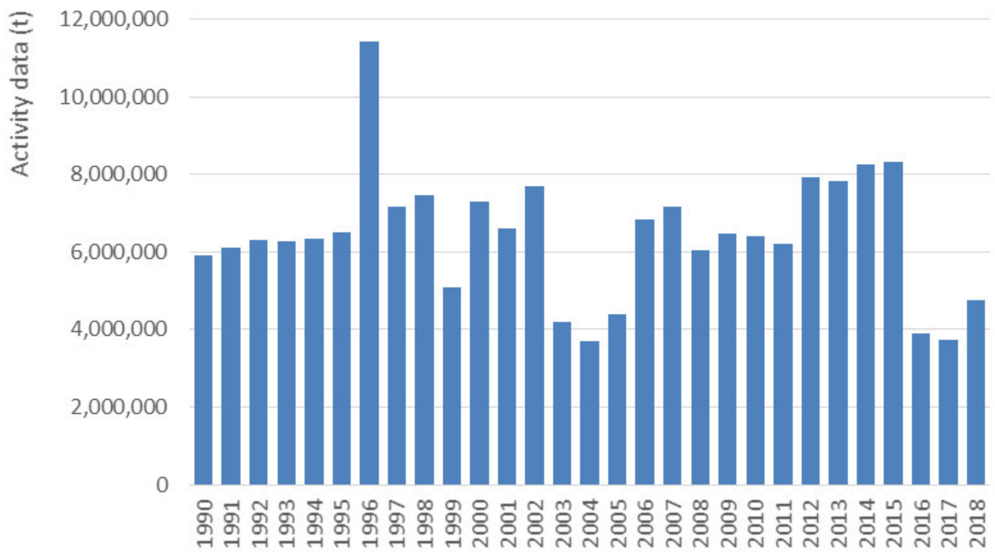


Figure 4-72: Adhesive, magnetic tapes, films and photographs production

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

From 1990 to 1994, activity data has been updated upon publication of a GDP revised time series.

4.5.27.7 Further Improvements

Efforts will be made in order to apply a tier 2 approach methodology for estimating NMVOC emissions from this category.

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 EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2016).

Equation 4-85: 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 EMEP/EEA air pollutant emission inventory guidebook 2016.

Table 4-95: Emission Factors

SNAP	Unit	Pollutant	EF	Source
Manufacture of Shoes	kg/pair of shoes	NMVOC	0.045	Table 3-13 of chapter 2.D.3.g Chemical Products of EMEP/EEA air pollutant emission inventory guidebook 2016

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.

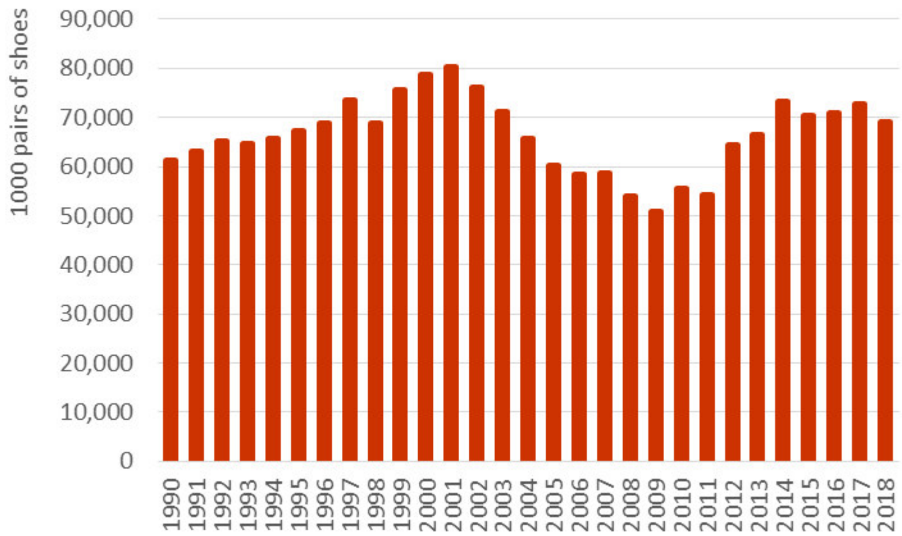


Figure 4-73: Shoes Manufactured – total territory

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

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

4.5.28.6 Recalculations

From 1990 to 1994, activity data has been updated upon publication of a GDP revised time series.

4.5.28.7 Further Improvements

No further improvements are expected.

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 in accordance with EMEP/EEA air pollutant emission inventory guidebook 2016.

Equation 4-86: NH_3 emissions from Leather Tanning

$$Emi_{NH3} = EF_{NH3} \times Leather_{Prod} \times 10^{-6}$$

Where:

Emi_{NH3}: NH_3 emissions from Leather Tanning (t)

EF_{NH3}: NH_3 emission factor for Leather Tanning (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 4-96: 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 EMEP/EEA air pollutant emission inventory guidebook 2016.

Table 4-97: Emission Factor

SNAP	Unit	Pollutant	EF	Source
Leather Tanning	g/kg raw hid	NH_3	0.68	Table 3-14 of chapter “2.D.3.g Chemical Products” of EMEP/EEA air pollutant emission inventory guidebook 2016

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.

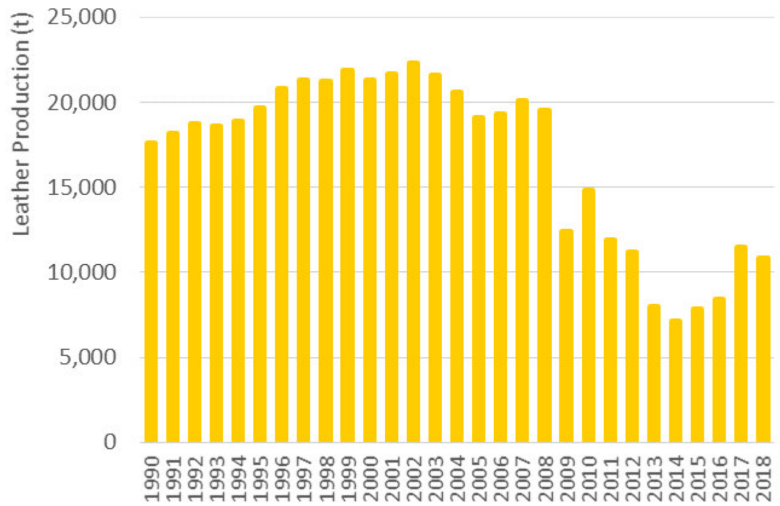


Figure 4-74: Leather production – total territory

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

No recalculations were made.

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 in accordance with EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2016). NMVOC emissions result from the solvents used to treat the tyre rubber and were estimated according to:

Equation 4-87: 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 4-98: 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 EMEP/EEA air pollutant emission inventory guidebook 2016

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 tire collection and final disposal system) and is indicated in the table below:

Table 4-99: 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.

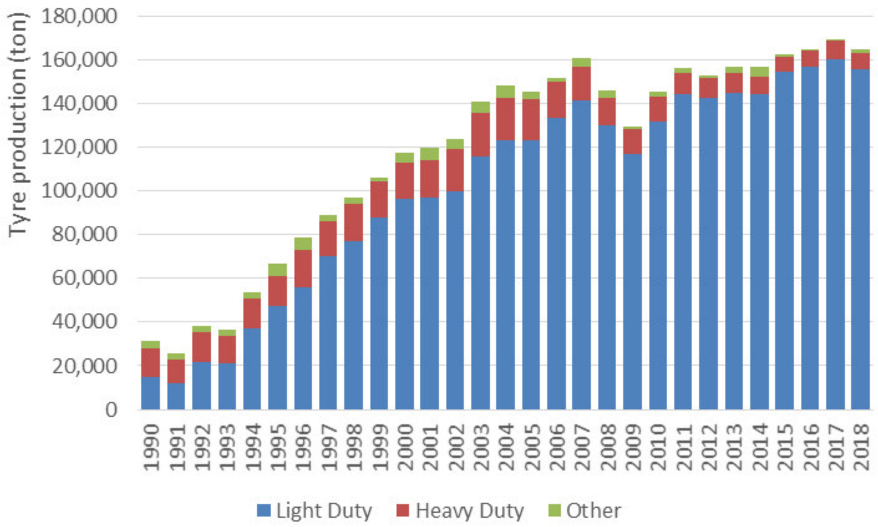


Figure 4-75: Tyre Production – Total territory

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

Following QA/QC procedures to activity data, we found rubber profiles in kg were being added to the other categories, which were reported in number of items. This error has been corrected.

4.5.30.6 Recalculations

Following a 2018 NECD Review recommendation, in order to develop an average tyre weight taking into account the weighting of each type of tyre produced, NMVOC estimates from tyre production were revised for the whole time series.

Major differences between submissions for the whole time series are related to activity data, as shown in the figure below. Concerning activity data from INE, in 2019 estimates, besides new tyres and retreaded tyres, we were also considering tyre's inner tubes, rubber straps and profiles for this category. Furthermore, rubber profiles in kg were being added to the other categories, which were reported in number of items. Further analysis to the category lead us to believe we might be double-counting activity data, given that tyre's inner tubes, rubber straps and profiles could already be included in new tyres and retreaded tyres´activity data. Therefore, for this submission we considered only new tyres and retreaded tyres, as already explained in activity data section.

Concerning tyre weight, in 2019 estimates we were considering an average value that did not take into account the weighting of the total of each type of tyre produced. For this submission we now consider an average tyre weight taking into account the types of vehicles, as already described in activity data section.

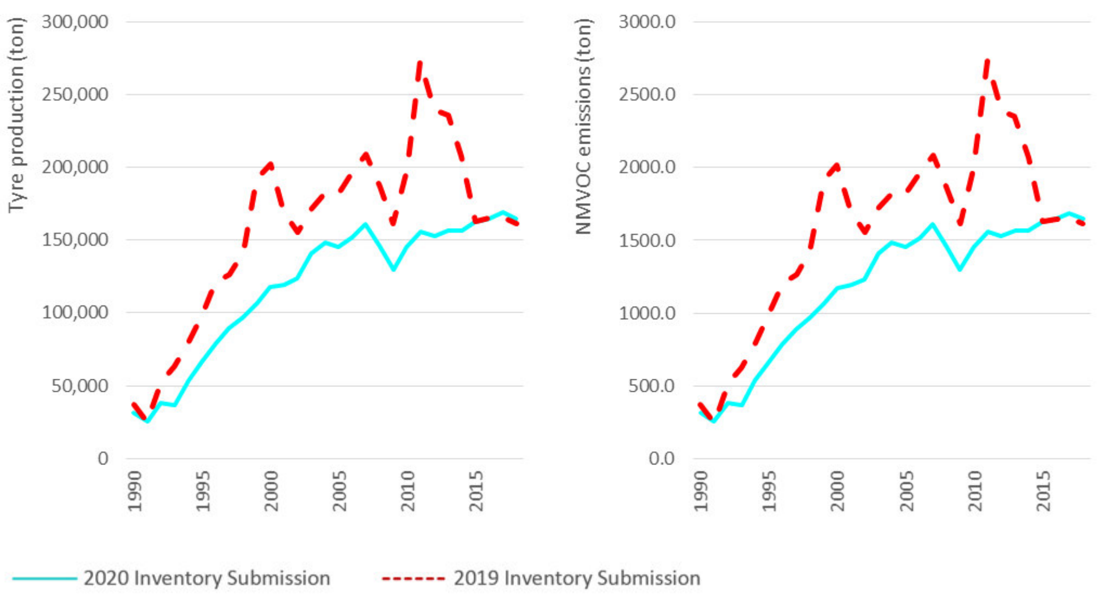


Figure 4-76: Recalculations in tyre production

4.5.30.7 Further Improvements

No further improvements are planned.

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). The following technologies are available:

- Lithography: the image and non-image areas are on the same plane. The image area is ink wettable and water repellent, and the non-image area is chemically repellent to ink, by action of a dampener. In offset lithography the image is applied to a rubber-covered blanket cylinder and then transferred onto the substrate. This technique dominates the production of books and pamphlets and has been used increasing in newspapers;
- Rotogravure: uses cylindrical image carrier, where the printing area is below the non-printing area. The low relive is filled with ink and the surplus is cleaned off the non-printing area before the surface to be printed contacts the cylinder. Used mostly in packaging, advertising, greeting cards, art books, catalogues, and directories;
- Flexography: the image carrier, made of rubber or elastic photopolymers on which the printing areas are above the non-printing areas. Used mostly in packaging, advertising newspapers, books, magazines, financial and legal document and directories;
- Letterpress: similar to flexography, it uses a relief printing plate, but these plates differ from flexographic plates in that they have a rigid backing and are not "flexible." Traditionally, letterpress printing dominated periodical and newspaper publishing; however, the majority of newspapers have converted to non-heatset web offset;
- Screen: the ink is passed onto the surface to be printed by forcing it through a porous image carrier (stencil), in which the printing area is open and the non-printing area is sealed off. It is used for signs, displays, electronics, wallpaper, greeting cards, ceramics, decals, banners, and textiles;
- Plateless: Images printed on paper by laser printers, photo copiers, fax machines, and ink jets

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).

4.5.31.2 Methodology

Emissions from printing industry was estimated in accordance with Tier 1 methodology from EMEP/EEA air pollutant emission inventory guidebook 2016.

Equation 4-88: NMVOC emissions from printing industry

$$Emi_{NMVOC} = EF \; X \; Ink_{CONS} \; x \; 10^{-3}$$

Where:

Emi_{NMVOC}: NMVOC emissions resulting from printing activities (t)

$Ink_{CONS(y)}$: Use of printing ink (t)

EF: NMVOC emission factor (solvent content) for ink use (g/kg ink)

4.5.31.3 Emission Factors

The emission factor used for printing activities was obtained from EMEP/EEA air pollutant emission inventory guidebook 2016. The same emission factor was used for the entire time series.

Table 4-100: NMVOC emission factor for printing industry

SNAP	Unit	NMVOC	Source
Printing	g/kg ink	500	Table 3-1 of chapter "2.D.3.h Printing" of EMEP/EEA air pollutant emission inventory guidebook 2016

4.5.31.4 Activity Data

Consumption of inks in printing industry according to printing product is available from the INE's statistical database for the period 1995-2010. In the period 1990-1994, values were estimated based on 1995 values and on GDP trend. In the period 2002-2003, values were estimated based on 2001 values and on GDP trend. From 2011 onwards, values were forecasted based on 2010 values and on GDP trend.

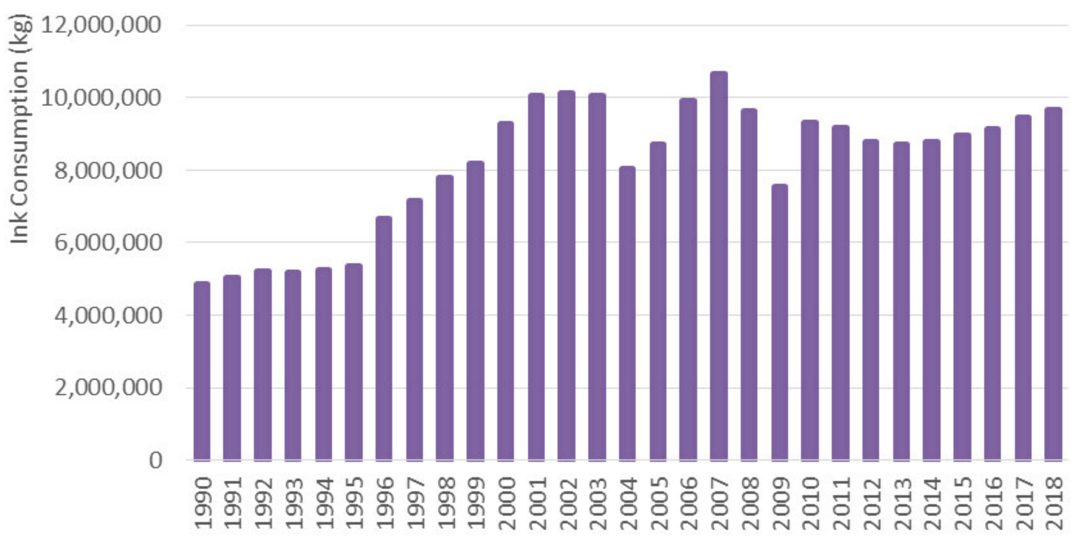


Figure 4-77: Inks consumption in Printing Industry

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

In the periods from 1990 to 1994, from 2002 to 2003 and from 2011 onwards, activity data has been updated upon publication of a GDP revised time series.

4.5.31.7 Further Improvements

No further improvements are planned for this sector.

4.5.32 Glass Wool Induction (NFR 2.D.3.i – SNAP 060401)

A thorough research on glass wool industry (namely, upon the contact of the facilities which provided data to the national statistics) showed that such activity does not take place in Portugal. Indeed, data obtained from national statistics in the previous submission, was regarding final glass wool products, whereas glass wool primary material was imported.

4.5.33 Mineral Wool Induction (NFR 2.D.3.i – SNAP 060402)

4.5.33.1 Category description

In the mineral wool induction, the emissions to air can be divided into three parts: raw materials handling, emissions from melting activities, and emissions from downstream processes or line operations (i.e. fiberizing and forming, product curing, product cooling, and product finishing).

4.5.33.2 Methodology

Emissions from mineral wool induction were estimated in accordance with EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2016).

NMVOC emissions were estimated from the mass of mineral wool produced according to:

Equation 4-89: NMVOC emissions from mineral wool production

$$Emi_{NMVOC} = EF_{NMVOC} \text{ x Mineral Wool}_{prod} \text{ x } 10^{-6}$$

Where:

Emi_{NMVOC}: NMVOC emissions from mineral wool induction (t)

EF_{NMVOC}: NMVOC emission factor for mineral wool induction (g/t mineral wool)

Mineral $Wool_{prod}$: Mineral Wool produced (t)

4.5.33.3 Emission Factors

NMVOC emission factor was taken from EMEP Guidebook 2016 and is listed in the table below.

Table 4-101: 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 "EMEP/EEA air pollutant emission inventory guidebook 2016"

4.5.33.4 Activity Data

In the period 1992-2007 and from 2015 onwards, data on mineral wool production was obtained from INE. Due to lack of data in the period 1990-2001, data has been estimated based on GDP and on 1992 production data. For the same reason, in the period 2008-2014, data has been estimated based on GDP and on 2015 production value.

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%).

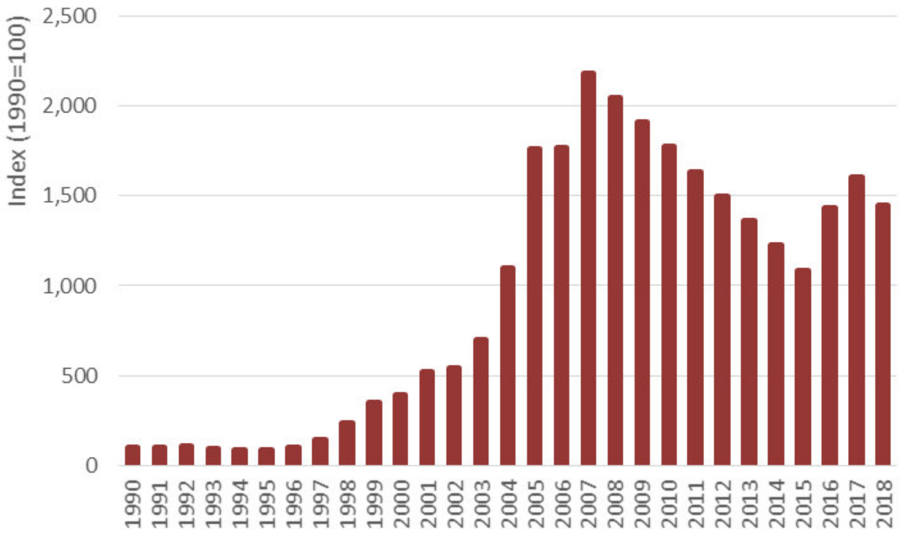


Figure 4-78: Mineral Wool produced (Index)

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).

4.5.33.5 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.

4.5.33.6 Recalculations

1990 and 1991 activity data were updated upon publication of a GDP revised time series.

4.5.33.7 Further Improvements

Efforts will be made to improve national statistics data in the period 2008-2014.

4.5.34 Fat, Edible and Non-Edible Oil Extraction (NFR 2.D.3.i – SNAP 060404)

4.5.34.1 Category description

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.

4.5.34.2 Methodology

Emissions from fat, edible and non-edible oil extraction were estimated in accordance with EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2016).

Emissions were estimated from the mass of seeds/grains consumed, according to the following equation:

Equation 4-90: 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” from fat, edible and non-edible oil extraction (t)

EF_{Polx}: Emission factor of pollutant “x” from fat, edible and non-edible oil extraction (kg/t of seed)

$Seeds_{cons}$: Seeds/grains consumption (t)

4.5.34.3 Emission Factors

Emission factors applied were taken from EMEP Guidebook 2016 and are listed below.

Table 4-102: 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/EEA air pollutant emission inventory guidebook 2016”
TSP	kg/t seed	1.10	
PM_{10}	kg/t seed	0.90	
$PM_{2.5}$	kg/t seed	0.60	

4.5.34.4 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%).

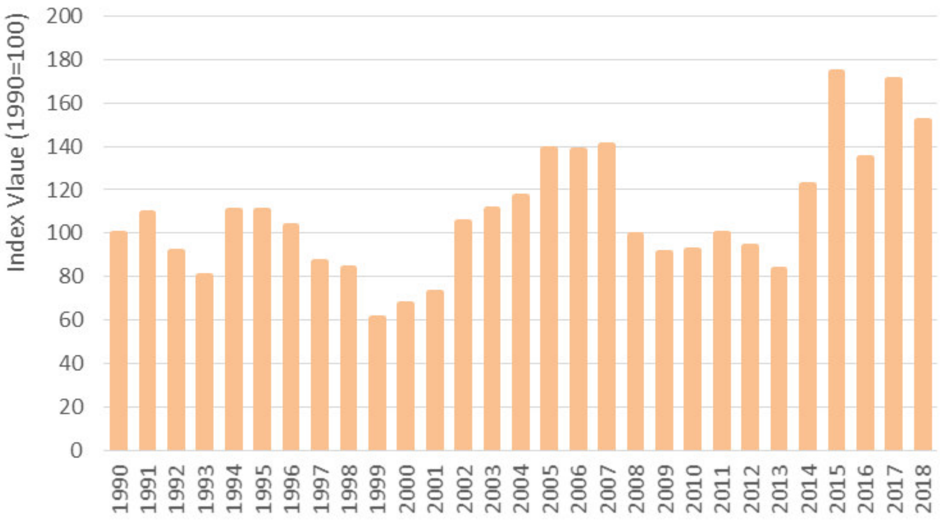


Figure 4-79: Seeds/grains consumption

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).

4.5.34.5 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.

4.5.34.6 Recalculations

No recalculations were made.

4.5.34.7 Further Improvements

No further improvements are expected.

4.5.35 Application of glues and adhesives (NFR 2.D.3.i – SNAP 060405)

4.5.35.1 Category description

This chapter addresses emissions estimates from the application of glues and adhesives.

4.5.35.2 Methodology

Apparent consumption of glues and adhesives was estimated according to the following equation:

Equation 4-91: Glues and adhesives apparent consumption

$$\text{App Cons} = \text{Production} + \text{Imports} - \text{Exports}$$

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 4-92: 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 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" (%)

4.5.35.3 Emission Factors

The following parameters were chosen to estimate emissions for the application of glues and adhesives.

Table 4-103: 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 2016"

Table 4-104: Abatement efficiencies

Abatement Technology	Efficiency	Source
Traditional solvent based adhesives (65% solvent, 35% solid) with activated carbon adsorption or condensation	76%	Table 3-21 of chapter "2.D.3.i, 2.G Other solvent and product use" of "EMEP/EEA air pollutant emission inventory guidebook 2016"
Emulsions (2% solvent, 50% solid) without secondary abatement	98%	

Table 4-105: Share of 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%	

4.5.35.4 Activity Data

Activity data regarding glues and adhesives consumption was obtained from EUROSTAT.

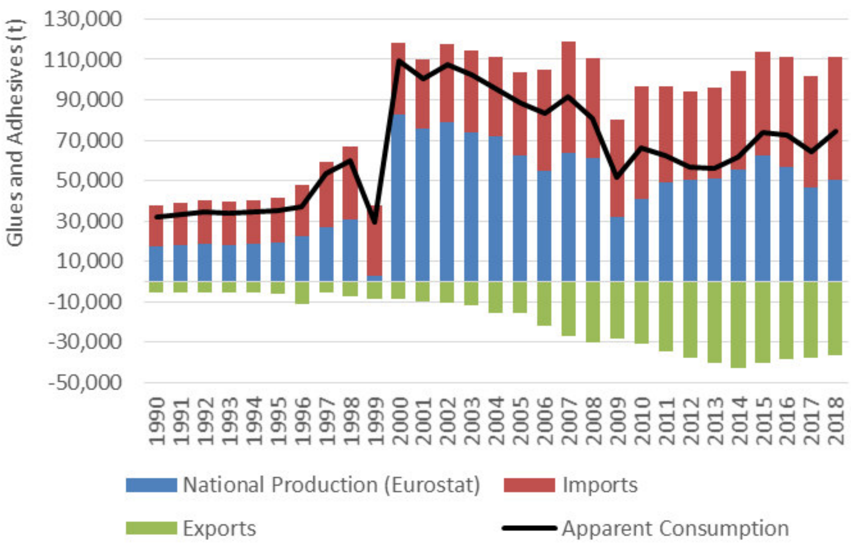


Figure 4-80: Glues and adhesives apparent consumption

4.5.35.5 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.

4.5.35.6 Recalculations

1990 to 1994 activity data were updated upon publication of a GDP revised time series.

4.5.35.7 Further Improvements

In the future, we intend to discuss the share of each abatement technology with sectoral associations. We also intend to discuss the national production trend in the periods 1998-2000 and 2008-2010 with INE (National Statistics).

4.5.36 Preservation of Wood (NFR 2.D.3.i – SNAP 060406)

4.5.36.1 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).

4.5.36.2 Methodology

Apparent consumption of treated wood was estimated according to the following equation:

Equation 4-93: 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 4-94: 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 "EMEP/EEA air pollutant emission inventory 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 4-95: 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 4-96: 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 4-97: 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)

4.5.36.3 Emission Factors

The following parameters were chosen to estimate emissions for preservation of wood.

Table 4-106: 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 4-107: Amount of wood preservative (kg) used per m³ of wood preserved

Wood Preservative Type	Kg/m³	Source
Waterborne Preservative	24	Page 14 of chapter "2.D.3.i, 2.G Other solvent and product use" of EMEP/EEA Guidebook 2016"
Creosote Preservative	75	
Solvent-Borne Preservative	24	

Table 4-108: 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 "EMEP/EEA air pollutant emission inventory guidebook 2016"
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 "EMEP/EEA air pollutant emission inventory guidebook 2016"
Creosote Preservative	NMVOC	g/kg creosote	105	Table 3-5 of chapter "2.D.3.i, 2.G Other solvent and product use" of "EMEP/EEA air pollutant emission inventory guidebook 2016"
	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 "EMEP/EEA air pollutant emission inventory guidebook 2016"

Table 4-109: 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 "EMEP/EEA air pollutant emission inventory guidebook 2016"

Table 4-110: 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 "EMEP/EEA air pollutant emission inventory guidebook 2016"
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 4-111: 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 "EMEP/EEA air pollutant emission inventory guidebook 2016"
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%**	

4.5.36.4 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 14 of chapter "2.D.3.i, 2.G - Other solvent and product use" of EMEP/EEA Guidebook 2016".

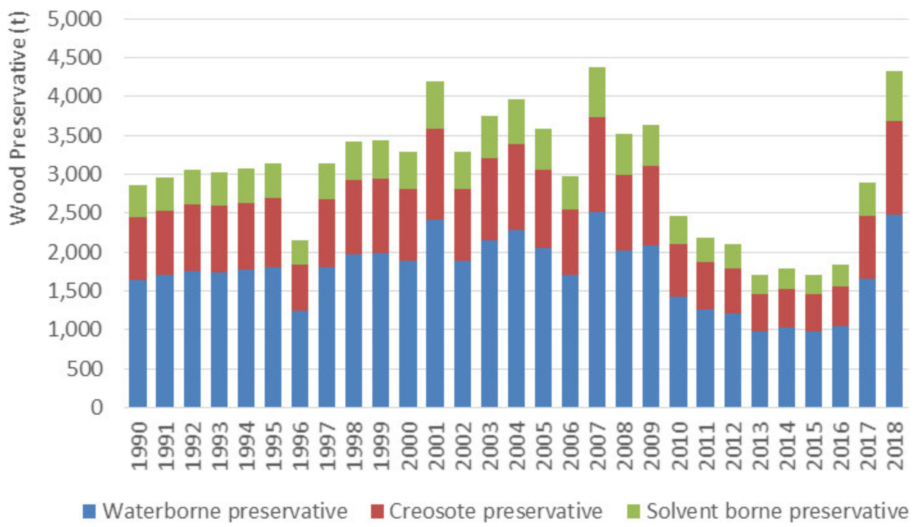


Figure 4-81: Wood Preservative applied by type – total territory

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).

4.5.36.5 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.

4.5.36.6 Recalculations

1990 to 1994 activity data were updated upon publication of a GDP revised time series.

4.5.36.7 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.

4.5.37 Underseal Treatment and Conservation of Vehicles (NFR 2.D.3.i – SNAP 060407)

4.5.37.1 Category description

This chapter addresses emissions estimates from Underseal Treatment and Conservation of Vehicles.

4.5.37.2 Methodology

NMVOC emissions from Underseal Treatment and Conservation of Vehicles were estimated according to the following equation:

Equation 4-98: 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)

4.5.37.3 Emission Factors

NMVOC emission factor was taken from EMEP Guidebook 2016 and is listed in the table below.

Table 4-112: 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 "EMEP/EEA air pollutant emission inventory guidebook 2016"

4.5.37.4 Activity Data

National population data was obtained from INE.

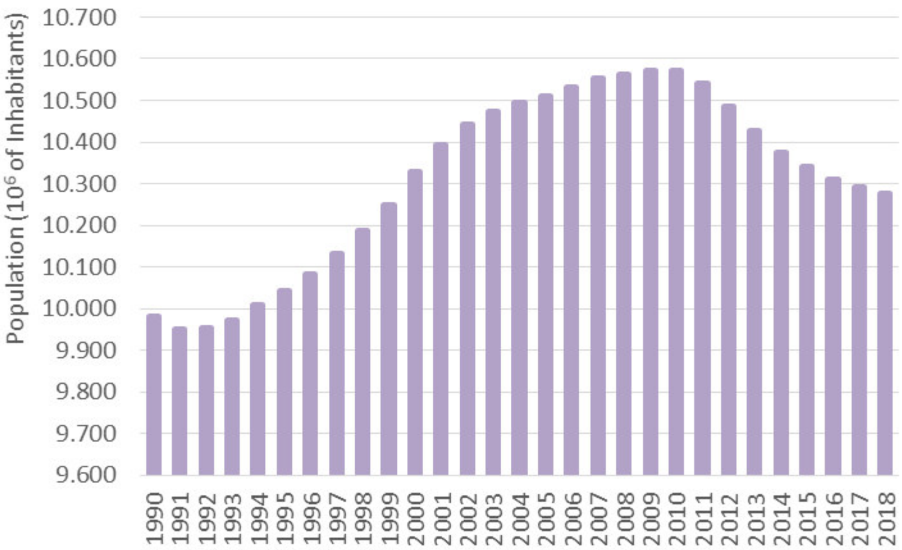


Figure 4-82: Population (10^6 of Inhabitants)

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).

4.5.37.5 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.

4.5.37.6 Recalculations

No recalculations were made.

4.5.37.7 Further Improvements

No further improvements are expected.

4.5.38 Vehicles Dewaxing (NFR 2.D.3.i – SNAP 060409)

4.5.38.1 Category description

This chapter addresses emissions estimates from Vehicles Dewaxing.

4.5.38.2 Methodology

NMVOC emissions from vehicle dewaxing were estimated according to the following equation:

Equation 4-99: 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)

4.5.38.3 Emission Factors

NMVOC emission factor was taken from EMEP Guidebook 2016 and is listed in the table below.

Table 4-113: 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 "EMEP/EEA air pollutant emission inventory guidebook 2016"

4.5.38.4 Activity Data

National vehicles sales data was obtained from Portuguese Automobile Association (ACAP).

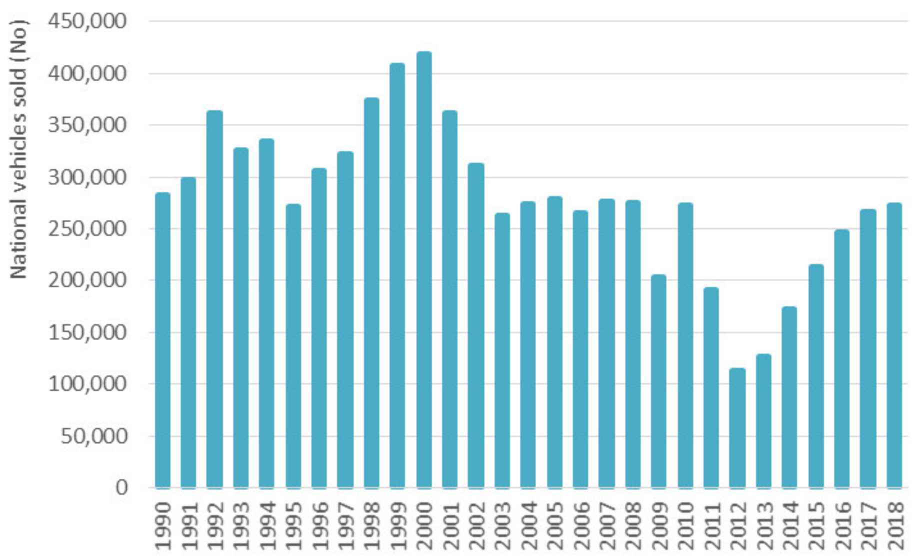


Figure 4-83: Annual vehicles sales – Total Territory

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).

4.5.38.5 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.

4.5.38.6 Recalculations

National vehicles sales data was updated for the whole time series based on ACAP.

4.5.38.7 Further Improvements

No further improvements are expected.

4.5.39 Use of Fireworks (NFR 2.G – SNAP 060601)

4.5.39.1 Category description

This chapter addresses emissions estimates from the Use of Fireworks.

4.5.39.2 Methodology

Fireworks apparent consumption was estimated according to the following equation:

Equation 4-100: 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 4-101: 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 4-102: 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)

4.5.39.3 Emission Factors

Emission factors were taken from EMEP Guidebook 2016 and are listed in the table below.

Table 4-114: Default emission factors

Pollutant	Unit	EF	Source
SO_2	g/t product	3020	Table 3-13 of chapter "2.D.3.i, 2.G Other solvent and product use" of "EMEP/EEA air pollutant emission inventory guidebook 2016"
NO_x	g/t product	260	
NMVOC	kg/t product	342	Table 3-12 of chapter "2.D.3.i, 2.G Other solvent and product use" of "EMEP/EEA air pollutant emission inventory guidebook 2016"
CO	g/t product	7150	Table 3-13 of chapter "2.D.3.i, 2.G Other solvent and product use" of "EMEP/EEA air pollutant emission inventory guidebook 2016"
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	

4.5.39.4 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.

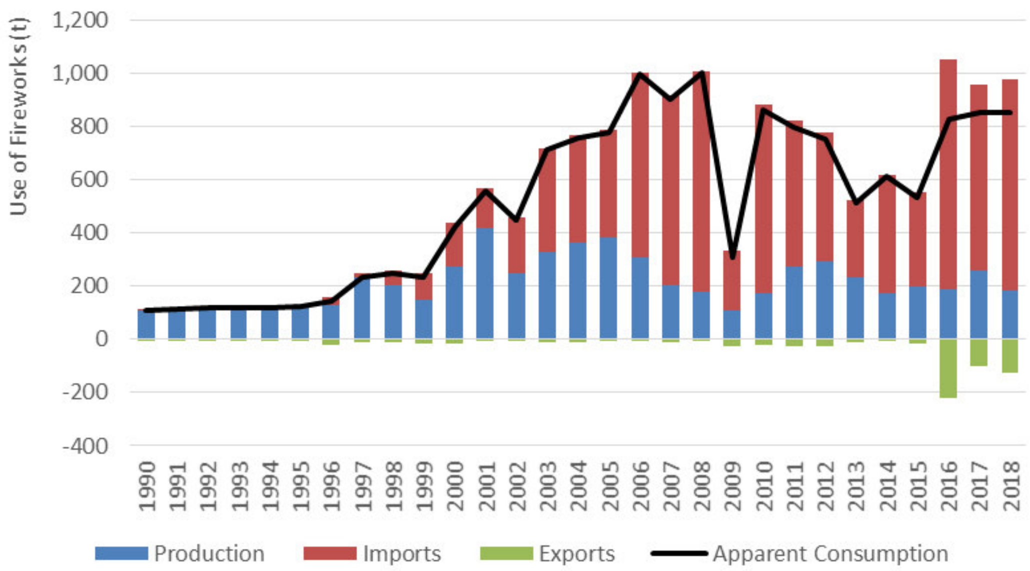


Figure 4-84: Use of Fireworks (Apparent Consumption)

From the figure above it's possible to verify that a substantial part of the use of fireworks is based on imports.

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).

4.5.39.5 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.

4.5.39.6 Recalculations

1990 to 1995 activity data were updated upon publication of a GDP revised time series.

2017 activity data was updated based on EUROSTAT data.

4.5.39.7 Further Improvements

No further improvements are expected.

4.5.40 Use of Tobacco (NFR 2.G – SNAP 060602)

4.5.40.1 Category description

This chapter addresses emissions estimates from the Use of Tobacco.

4.5.40.2 Methodology

Tobacco apparent consumption was estimated according to the following equation:

Equation 4-103: 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 4-104: Emissions from tobacco consumption

$$Emi = \frac{Apparent\ Consumption_{Tobacco} \times EF}{1000}$$

Where:

Emi: Pollutant emissions (t)

$\text{Apparent Consumption}_{\text{Tobacco}}$: 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 4-105: Emissions from tobacco consumption

$$Emi = \frac{Apparent\ Consumption_{Tobacco} \times EF}{1 \times 10^6}$$

Where:

Emi: Pollutant emissions (t)

$\text{Apparent Consumption}_{\text{Tobacco}}$: Apparent consumption of tobacco (t)

EF: Emission factor (g/t tobacco)

PCDD/F (Dioxines and Furanes) were estimated according to the following equation:

Equation 4-106: 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)

$\text{Apparent Consumption}_{\text{Tobacco}}$: Apparent consumption of tobacco (t)

EF: Emission factor (µg I-teq/t tobacco)

Black Carbon was estimated according to the following equation:

Equation 4-107: Black carbon emissions from tobacco consumption

$$Emi_{Black\ Carbon} = Emi_{PM2.5} \times \%_{Black\ Carbon}$$

Where:

$\text{Emi}_{\text{Black Carbon}}$: Black Carbon emissions (t)

$Emi_{PM2.5}$: $PM_{2.5}$ emissions (t)

$\%_{Black\ Carbon}$: % of Black Carbon in $PM_{2.5}$ emissions (% $PM_{2.5}$)

4.5.40.3 Emission Factors

Emission factors were taken from EMEP Guidebook 2016 and are listed in the table below.

Table 4-115: Default emission factors

Pollutant	Unit	EF	Source
NO_x	kg/t tobacco	1.8	Table 3-14 of chapter "2.D.3.i, 2.G Other solvent and product use" of "EMEP/EEA air pollutant emission inventory guidebook 2016"
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	

4.5.40.4 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.

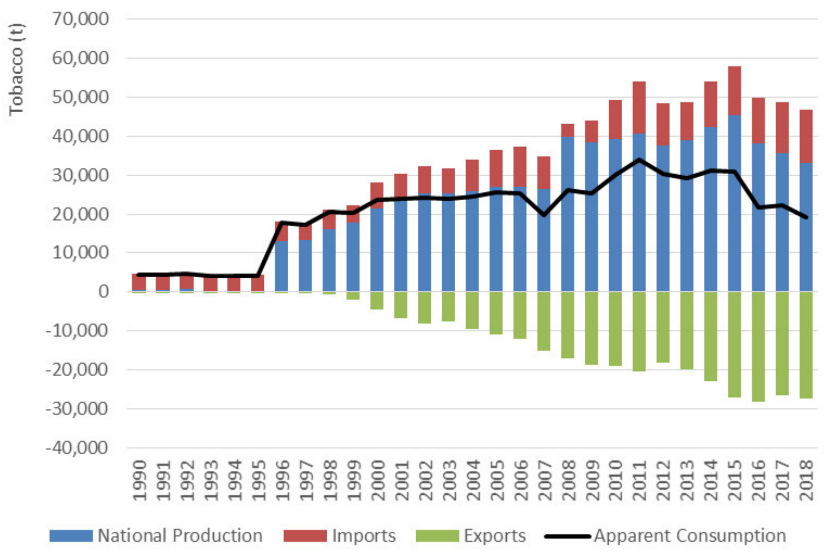


Figure 4-85: Tobacco apparent consumption – Total territory

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).

4.5.40.5 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.

4.5.40.6 Recalculations

1990 to 1994 activity data were updated upon publication of a GDP revised time series.

2008 to 2009 and 2017 imports and exports activity data were updated based on EUROSTAT.

4.5.40.7 Further Improvements

No further improvements are expected.

4.5.41 Use of Shoes (NFR 2.G - SNAP 060603)

4.5.41.1 Category description

This chapter addresses emissions estimates from the use of shoes.

4.5.41.2 Methodology

Shoes apparent consumption was estimated according to the following equation:

Equation 4-108: 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 4-109: 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 (%)

4.5.41.3 Emission Factors

The following parameters were chosen to estimate emissions for the use of shoes.

Table 4-116: Default emission factor

SNAP	Unit	NMVOC	Source
Use of shoes	g/pair of shoes	60	Table 3-15 of chapter "2.D.3.i, 2.G Other solvent and product use" of "EMEP/EEA air pollutant emission inventory guidebook 2016"

Table 4-117: 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 2016"
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).

4.5.41.4 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.

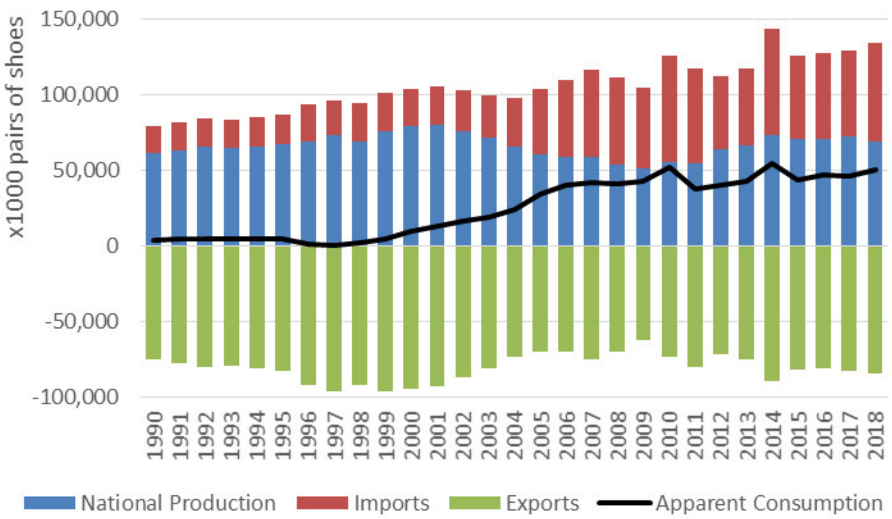


Figure 4-86: Apparent consumption of shoes (x1000 pairs of shoes) – Total territory

Shoes exports in Portugal are more relevant than imports, and thus the apparent consumption values are lower than the national production values.

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).

4.5.41.5 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.

4.5.41.6 Recalculations

1990 to 2000 activity data were updated upon publication of a GDP revised time series.

2017 imports and exports data were updated based on EUROSTAT.

4.5.41.7 Further Improvements

Efforts will be made in order to obtain a better characterization of abatement technologies share over time.

4.5.42 Lubricants consumption (NFR 2.G – SNAP 060604)

4.5.42.1 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.

4.5.42.2 Methodology

Lubricants accounted for in this category can be estimated according to the following:

Equation 4-110: 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 calculated using a Tier 2 approach.

Equation 4-111: 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.

4.5.42.3 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.

4.5.42.4 Activity Data

Total lubricants consumption was obtained from the energy balance (DGEG). Lubricants consumption in two-stroke engines were estimated by COPERT V.

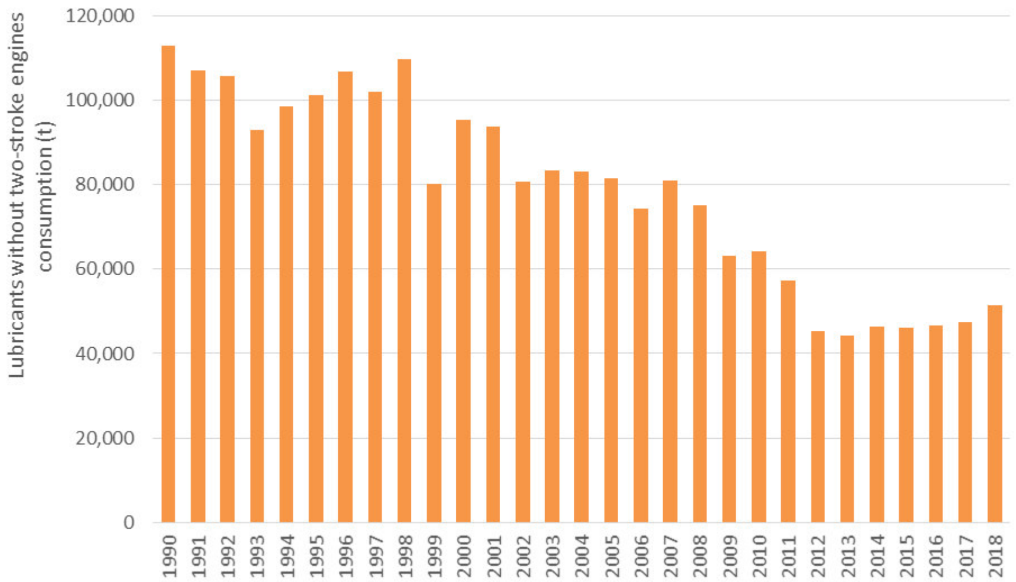


Figure 4-87: Lubricants consumption in engines other than two-stroke

4.5.42.5 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.

4.5.42.6 Recalculations

Update on lubricants energy consumption data by DGEG in 2013.

4.5.42.7 Further Improvements

No further improvements are expected.

4.5.43 Other Industry Production - Wood Chipboard Production (NFR 2.H.1 – SNAP 040601)

4.5.43.1 Category description

This chapter addresses emissions estimates from Wood Chipboard Production. Chipboard manufacturing involves solvent emission but it is included in this source sector.

4.5.43.2 Methodology

Emissions were estimated by the use of emission factors multiplied by the quantity of material produced:

Equation 4-112: 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)

4.5.43.3 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.

4.5.43.4 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.

4.5.43.5 Uncertainty Assessment

Table 4-118: Wood Chipboard Production

Parameter	U (%)
AD Combined Uncertainty	**10%**
EF Combined Uncertainty	**51%**

4.5.43.6 Category specific QA/QC and verification

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

4.5.43.7 Recalculations

No recalculations were made.

4.5.43.8 Further Improvements

In the future, we intend to improve consistency and completeness of activity data.

4.5.44 Other Industry Production - Paper pulp production (NFR 2.H.1 – SNAP 040602; 040603; 040604)

4.5.44.1 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.

4.5.44.2 Methodology

Emissions for each pollutant are estimated according to the following equation:

Equation 4-113: Emissions from Pulp and Paper Industry

$$Emission_{(p)} = EF_{(p)} \times Pulp_{PROD} \times 10^{-3}$$

Where:

Emi_p: Annual emission of pollutant p (t)

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

$Pulp_{PROD}$: Annual Paper pulp production (t)

4.5.44.3 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 4-119: 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

4.5.44.4 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[17] 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.

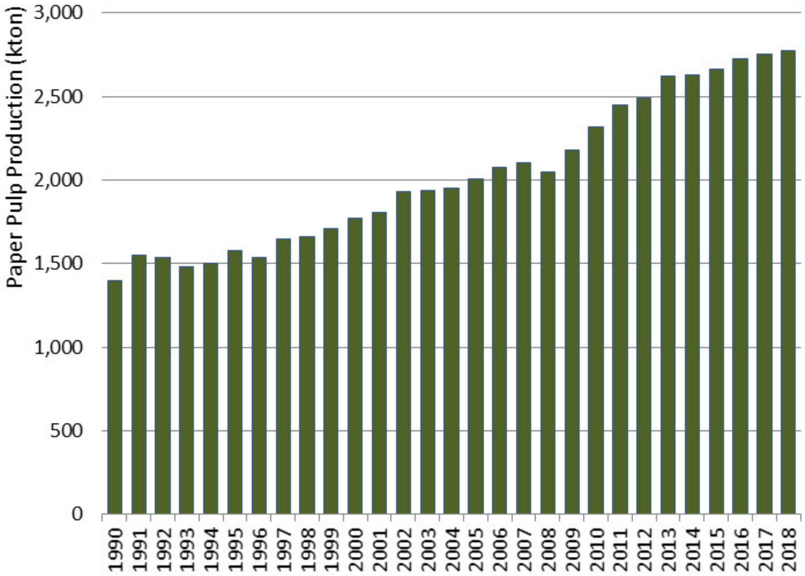


Figure 4-88: Total production of paper pulp

4.5.44.5 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.

4.5.44.6 Recalculations

No recalculations were made.

4.5.44.7 Further Improvements

No further improvements are planned.

[17] Specific information for sulphide pulping can not be delivered because presently there is only one plant operating which raised confidential constraints.

4.5.45 Other Industry Production - Food Manufacturing (NFR 2.H.2 – SNAP 040605; 040625; 040626; 040627)

4.5.45.1 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;
- 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.

4.5.45.2 Methodology

Emissions were estimated according to a Tier 2 methodology, using "EMEP/EEA air pollutant emission inventory guidebook 2016"'s emission factors.

For the activities regarding 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 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016". For PM_{10} there are no specific abatement techniques.

NMVOC emissions were estimated using the following equation:

Equation 4-114: Emissions from Food Industry

$$EmiNMVOC = \frac{AD \times EF \times (1 - \eta_{abatement})}{1000}$$

Where:

Emi_{NMVOC}: Annual NMVOC emissions (t)

AD: Activity Data (t of product)

$\eta_{abatement}$: Abatement Technology efficiency (=0.9)

TSP and PM_{10} emissions were estimated using the following equation:

Equation 4-115: TSP and PM10 emissions from Food Industry

$$Emissions = \frac{AD \times EF}{1 \times 10^6}$$

Where:

Emissions - Emissions (t)

AD - Activity Data (t product)

EF – Emission factor (g/t product)

4.5.45.3 Emission Factors

Emission factors were obtained from chapter "2.H.2 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016" and are listed in the table below.

Table 4-120: 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 "EMEP/EEA air pollutant emission inventory guidebook 2016"
Fish meal processing	NMVOC	Kg/t fish	1	Table 3-3 of chapter "2.H.2 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016"
Grain Drying	NMVOC	Kg/t grain dried	1.3	Table 3-4 of chapter "2.H.2 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016"
Handling of agricultural products (grains, soya)	TSP and PM_{10}	g/t	24	Table 3-10 of chapter "2.H.2 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016"
White Bread	NMVOC	Kg/t bread	4.5	Table 3-14 of chapter "2.H.2 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016"
Wholemeal Bread	NMVOC	Kg/t bread	3	Table 3-16 of chapter "2.H.2 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016"
Cakes, biscuits and breakfast cereals	NMVOC	Kg/t product	1	Table 3-18 of chapter "2.H.2 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016"
Meat, fish and poultry	NMVOC	Kg/t product	0.3	Table 3-19 of chapter "2.H.2 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016"
Sugar	NMVOC	Kg/t sugar	10	Table 3-20 of chapter "2.H.2 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016"
Margarine and solid cooking fats	NMVOC	Kg/t product	10	Table 3-21 of chapter "2.H.2 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016"
Animal feed	NMVOC	Kg/t feed	1	Table 3-22 of chapter "2.H.2 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016"
Coffee roasting	NMVOC	Kg/t beans	0.55	Table 3-23 of chapter "2.H.2 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016"

4.5.45.4 Activity Data

From 1992 onwards, information about activity data for this sector was obtained from the INE. In the period 1990-1991, data has been estimated based on 1992 activity data values and on GDP.

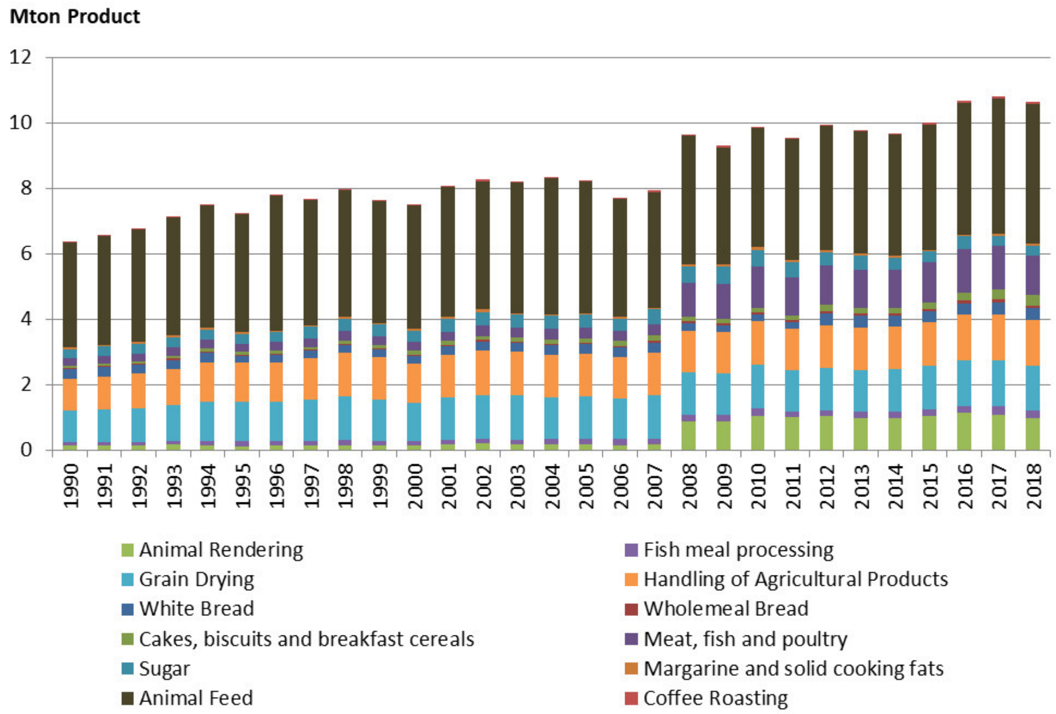


Figure 4-89: Food manufacturing by food product – Total territory

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).

4.5.45.5 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.

4.5.45.6 Recalculations

Concerning "Handling of agricultural products (grains, soya)", a compilation error regarding NMVOC emissions was corrected in NFR tables, given that no emissions from this pollutant result from this activity. Also regarding this sub-category, PM emissions are now estimated and reported under this 2.H.2.

4.5.45.7 Further Improvements

No further improvements are planned.

4.5.46 Other Industry Production - Drink Manufacturing (NFR 2.H.2 – SNAP 040606; 040607; 040608)

4.5.46.1 Category description

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.

4.5.46.2 Methodology

Emissions were estimated according to a Tier 2 methodology, using “EMEP/EEA air pollutant emission inventory guidebook 2016” emission factors.

Barley Malting

Emissions from barley malting were estimated according to the following equations:

Equation 4-116: 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 (1×10^{-3} t/l)

Equation 4-117: 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 4-118: 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 4-119: 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: 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 4-121: 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 4-122: 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 4-123: 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 4-124: Emissions from fermentation, casking and maturation

$$EmiNMVOC = \frac{m_{Alcohol} \times EF \times (1 - \eta_{abatement})}{1000}$$

Where:

Emi_{NMVOC}: 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 4-125: Emissions from red wine, white wine and beer

$$EmiNMVOC = \frac{V_{drink\ x} \times EF \times (1 - \eta_{abatement})}{1000}$$

Where:

Emi_{NMVOC}: 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 4-126: 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 4-127: Emissions from spirits

$$EmiNMVOC = \frac{v_{Alcohol\ in\ spirits} \times EF \times (1 - \eta_{abatement})}{1000}$$

Where:

Emi_{NMVOC}: 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)

4.5.46.3 Emission Factors

Emission factors were obtained from chapter "2.H.2 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016" and are listed in the table below.

Table 4-121: Emission Factors for drink industry

Product	Unit	EF	Source
Barley Malting	g/t barley	0.55	Table 3-5 of chapter "2.H.2 Food and beverages industry"
Hop Processing	g/t beer	7.8	Table 3-6 of chapter "2.H.2 Food and beverages industry"
Fermentation	Kg/t alcohol	2	Table 3-7 of chapter "2.H.2 Food and beverages industry"
Casking	Kg/t alcohol	0.5	Table 3-8 of chapter "2.H.2 Food and beverages industry"
Maturation	Kg/t alcohol	20	Table 3-9 of chapter "2.H.2 Food and beverages industry"
Red Wine	Kg/hl wine	0.080	Table 3-25 of chapter "2.H.2 Food and beverages industry"
White Wine	Kg/hl wine	0.035	Table 3-26 of chapter "2.H.2 Food and beverages industry"
Beer	Kg/hl beer	0.035	Table 3-27 of chapter "2.H.2 Food and beverages industry"
Spirits	Kg/hl alcohol	15	Table 3-28 of chapter "2.H.2 Food and beverages industry"

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 "EMEP/EEA air pollutant emission inventory guidebook 2016").

4.5.46.4 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

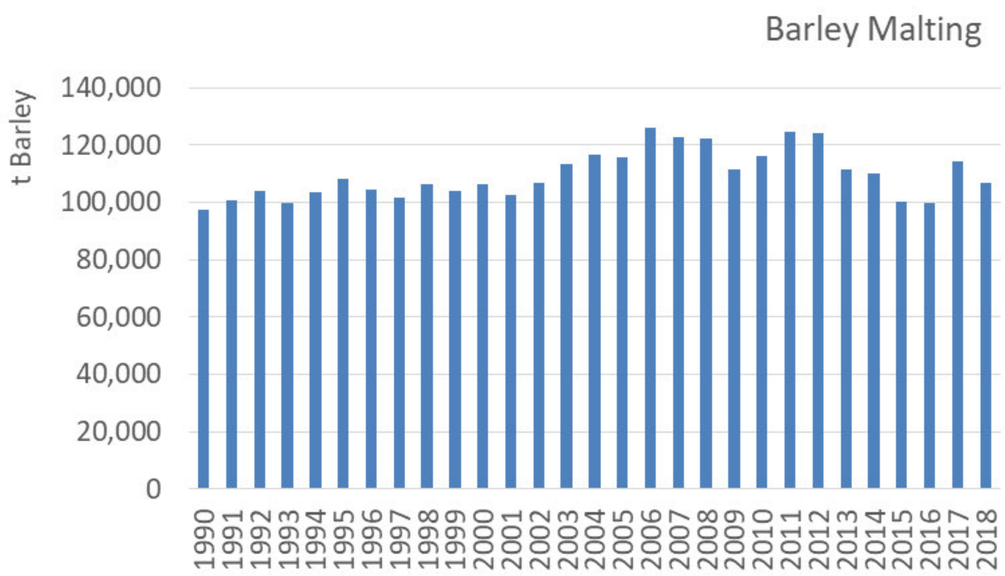


***Figure 4-90:** Barley Malting*

Hop Processing

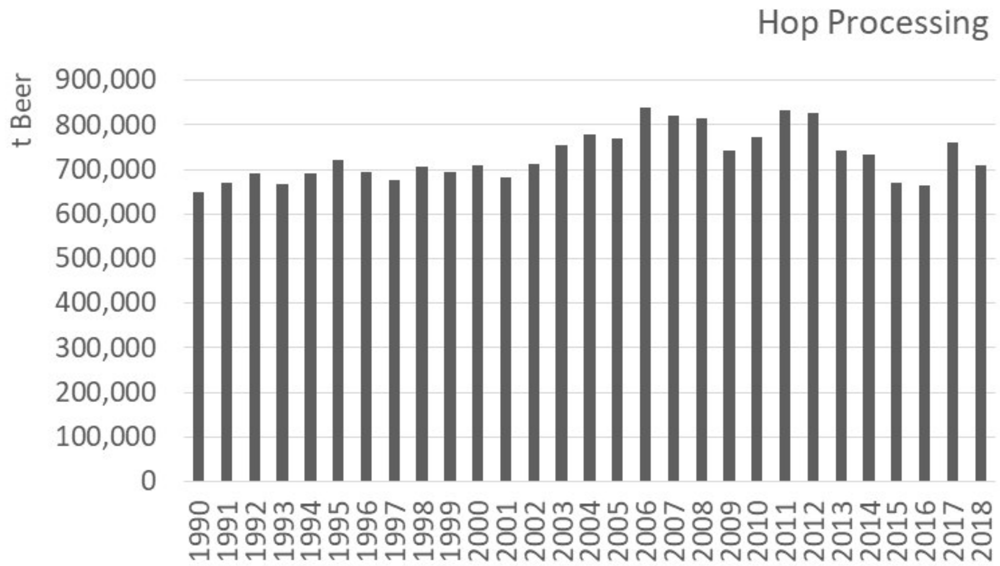


Figure 4-91: Hop Processing

Fermentation, Casking and Maturation

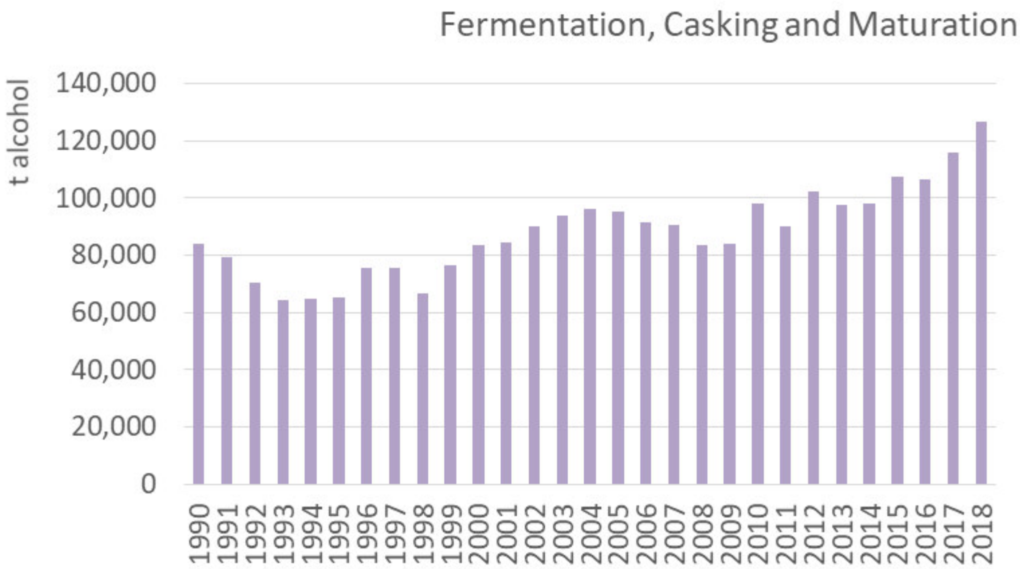


Figure 4-92: Fermentation, Casking and Maturation

Red Wine, White Wine, Beer

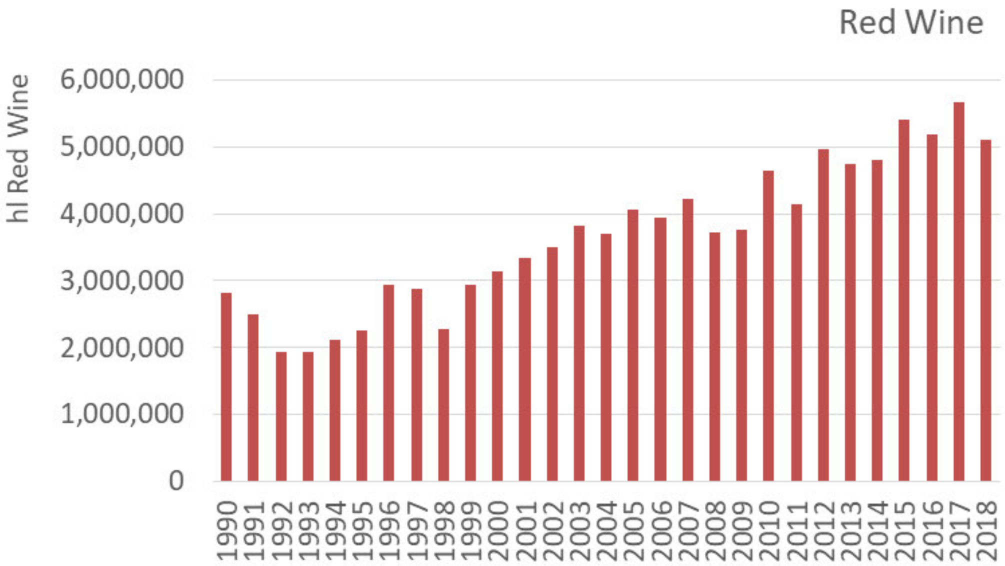


Figure 4-93: Red Wine

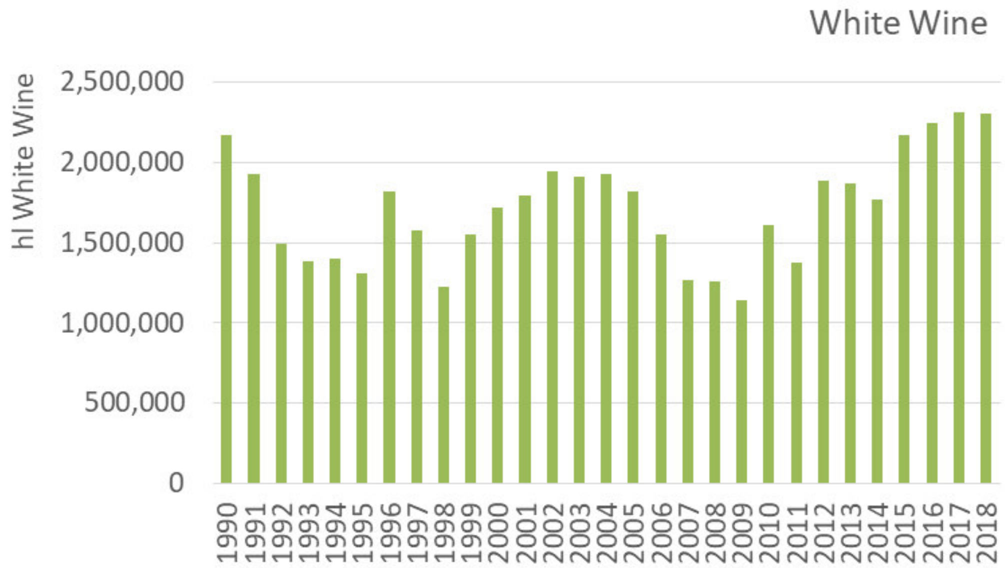


Figure 4-94: White Wine

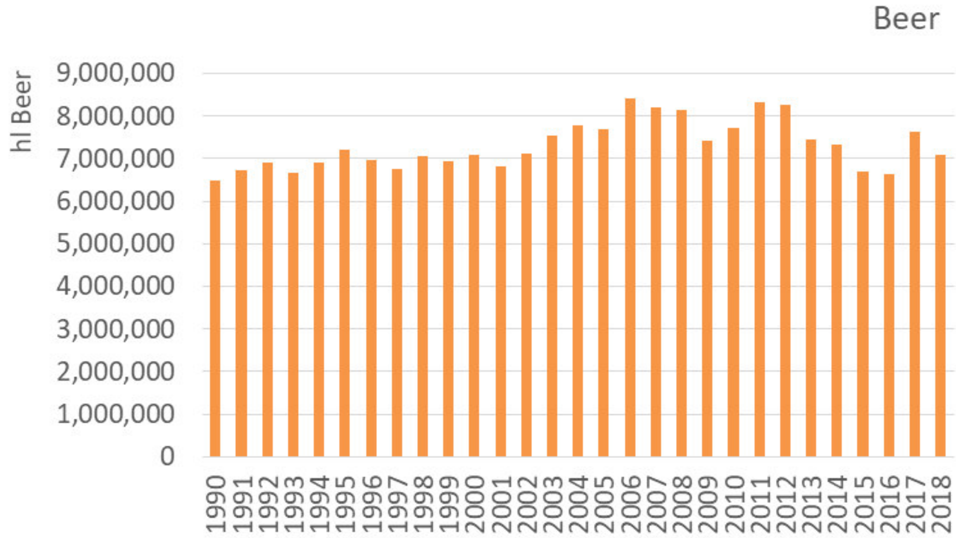


Figure 4-95: Beer

Spirits

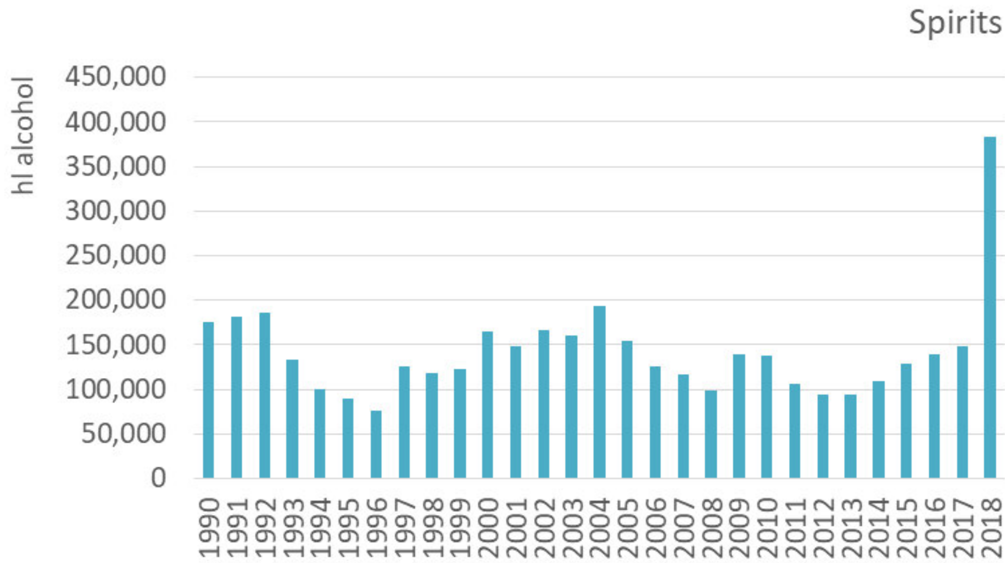


Figure 4-96: Spirits

4.5.46.5 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.

4.5.46.6 Recalculations

No recalculations were made.

4.5.46.7 Further Improvements

No further improvements are planned.

4.5.47 Wood Processing (2.I – SNAP 040620)

4.5.47.1 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.

4.5.47.2 Methodology

TSP emissions were estimated according to a Tier 1 methodology through the following equation:

Equation 4-128: 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)

4.5.47.3 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 4-122: 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

4.5.47.4 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.

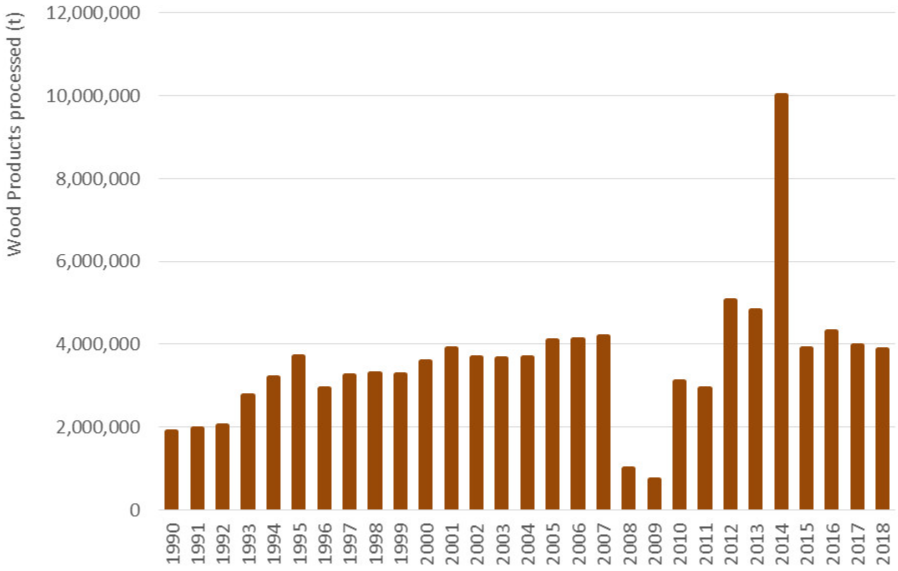


Figure 4-97: Wood Processing (t wood products processed)

4.5.47.5 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.

4.5.47.6 Recalculations

No recalculations were made.

4.5.47.7 Further Improvements

No further improvements are expected.

4.5.48 Consumption of persistent organic pollutants and heavy metals (NFR 2.K – SNAP 060502; 060504; 060507)

4.5.48.1 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.

4.5.48.2 Methodology

Hg emissions were estimated using a Tier 1 methodology through the following equation:

Equation 4-129: Hg emissions

$$Emi_{Hg} = EF \times Population \times 10^{-6}$$

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 4-130: PCB emissions in 1990

$$Emi_{PCB\ 1990} = EF \times Population_{1990} \times 10^{-3}$$

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 4-131: 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)

4.5.48.3 Emission Factors

The emission factors applied are listed in the table below.

Table 4-123: 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

4.5.48.4 Activity Data

For Hg emissions estimates, national population data was obtained from INE.

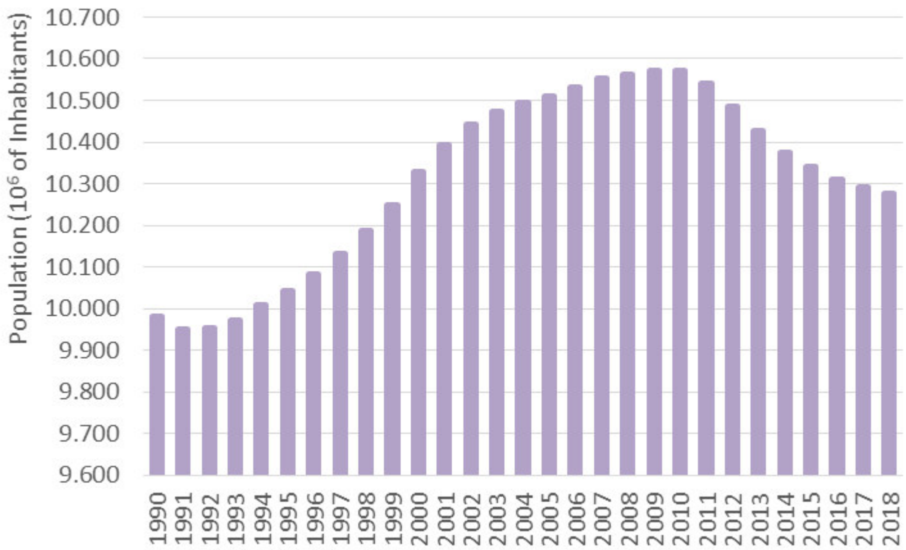


Figure 4-98: Population

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.

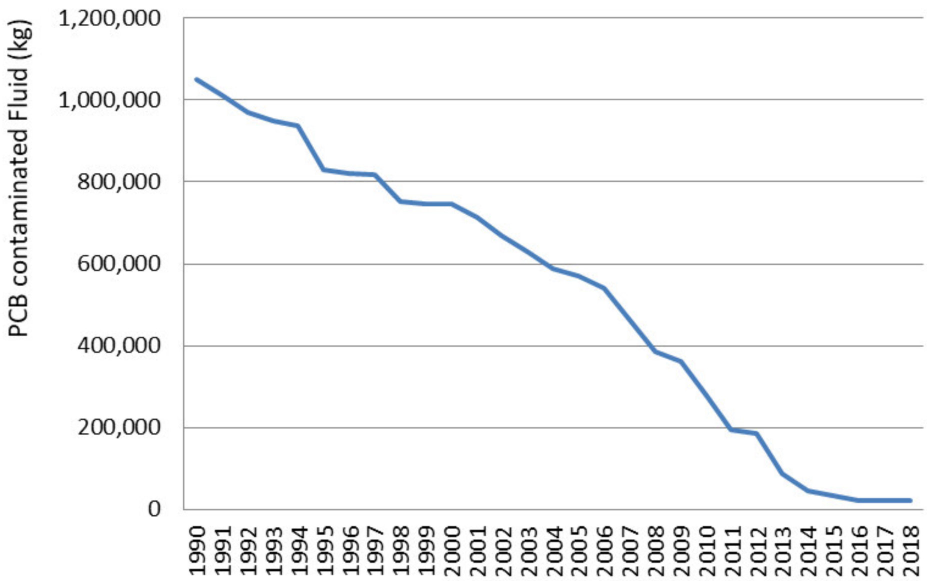


Figure 4-99: PCB contaminated fluid leaks

4.5.48.5 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.

4.5.48.6 Recalculations

No recalculations were made.

4.5.48.7 Further Improvements

No further improvements are planned.

5 Agriculture (NFR Sector 3)

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5 Agriculture (NFR Sector 3)

Ana Pina

5.1 Overview of the sector

Agriculture activities generate the largest part of NH_3 national emissions. In 2018, NH_3 emissions from the agriculture sector were 46.0 kt, corresponding to 82.0% of the national[1] NH_3 emissions. From 1990 to 2018, NH_3 agriculture emissions decreased 19.3%. From 2005 to 2018 the ratio of decrease is lower staying at minus 2.2%. The complete time series trend is shown in figure below.

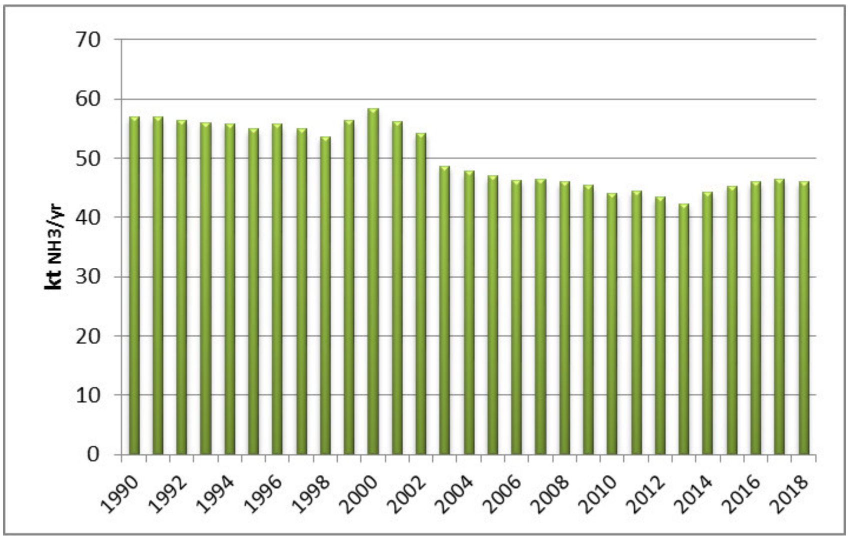


Figure 5-1: Total NH_3 emissions (kt) from agriculture -Trends

Overall, NH_3 emissions from agriculture presented reductions between 1990 and 2018 in almost all source categories. The next figure shows the ammonia emissions in the years 1990 and 2018 by category of emission source.

[1] See section 1.4 – Geographical and sectoral coverage of this Informative Inventory Report. 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 serie.

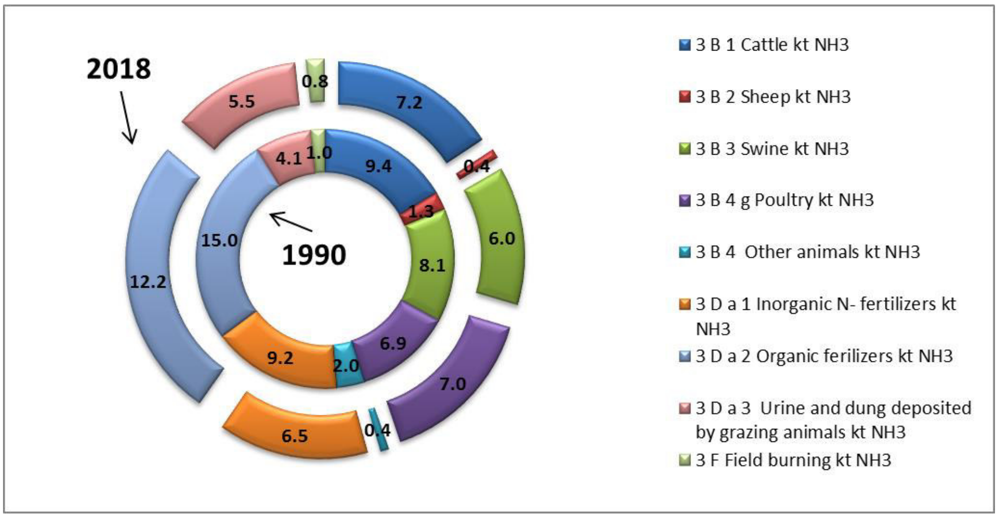


Figure 5-2: NH_3 emissions (kt) by source category in 1990 and in 2018

The most significant reductions are linked to a decrease in the number of animals (cattle, sheep, 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 relative importance of each Source (NFR codes) of NH_3 emissions from agriculture, in 1990 and 2018, is presented in figure below.

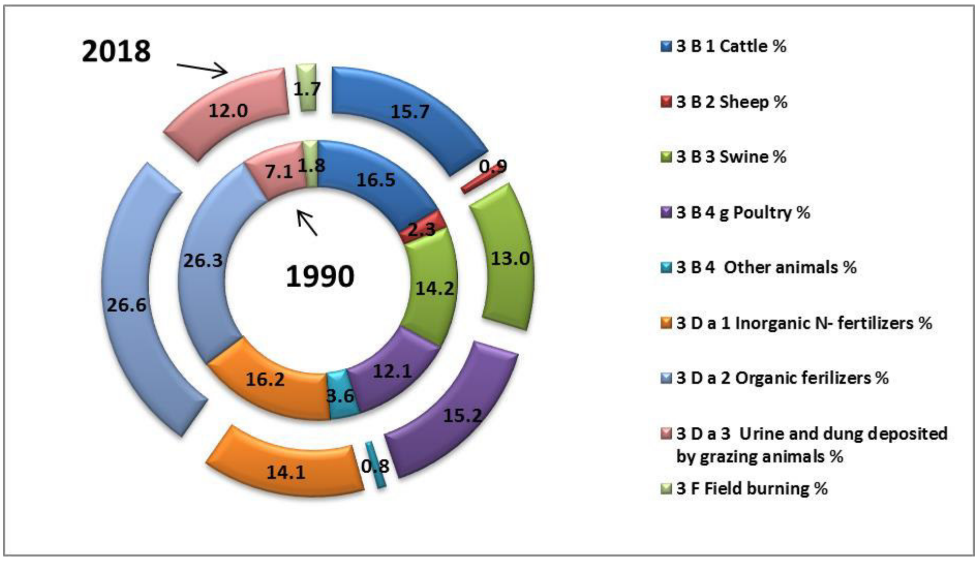


Figure 5-3: Comparative share (%) of NH_3 emissions (kt) by source category in 1990 and in 2018

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, NMVOC, $PM_{2.5}$, PM_{10}, TSP;
- From Crop Production and Agricultural Soils (3D): NO, NMVOC, $PM_{2.5}$, PM_{10}, TSP;
- From Field Burning of Agricultural Residues (3F): NO, NMVOC, SOx, $PM_{2.5}$, 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 2018.

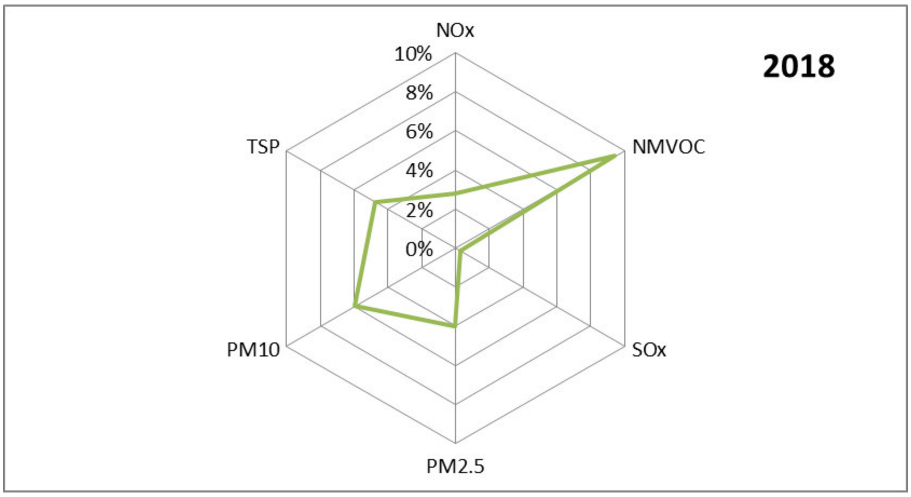


Figure 5-4: Contribution (%) of agricultural emissions of air pollutants other than NH_3, in total national emissions 2018

Table 5-1: Total Main Pollutants and PM2.5 emissions from Agriculture sector

Source /Gas	1990	2005	2016	2017	2018	Δ 2018-2017	Δ 2018-2005	Δ 2018-1990
			Kt				%	
NOx								
Portugal	5.23	4.15	4.33	4.35	4.30	-1.14	3.58	-17.72
Mainland	4.96	3.85	4.01	4.02	3.99	-0.94	3.41	-19.72
NMVOC								
Portugal	18.66	14.84	14.18	14.52	14.62	0.72	-1.48	-21.62
Mainland	16.99	12.77	12.14	12.42	12.48	0.53	-2.29	-26.54
SOx								
Portugal	0.19	0.13	0.14	0.14	0.14	-1.08	6.04	-23.92
Mainland	0.18	0.13	0.14	0.14	0.14	-1.08	4.45	-25.44
NH3								
Portugal	56.97	46.98	46.01	46.45	45.95	-1.09	-2.20	-19.34
Mainland	52.11	40.78	39.97	40.27	39.80	-1.17	-2.40	-23.62
PM2.5								
Portugal	2.74	1.85	2.04	2.08	2.05	-1.43	10.34	-25.35
Mainland	2.68	1.79	1.96	1.99	1.96	-1.46	9.25	-26.83

Recalculations

The major changes between last year submission and this year submission result from the following actions:

- update of 2016 and 2017 data for apparent consumption of inorganic N fertilizers (total amount and by type of fertilizer) revised by the National Statistics Authority (INE);
- elimination of step 6 of the algorithm to estimate ammonia emissions from fertilizers (tier 2 approach) updated by the EMEP/EEA Guidebook 2019;
- update of the emission factors of PAPHs used to estimate emissions from field burning agricultural residues, following the update version (October 2018) of the EMEP/EEA Guidebook 2016;
- update of Nex rates of non-dairy cattle in coherence with the updating of the enteric fermentation emission factors done in the framework of the UNFCCC inventory emission estimates;
- minor corrections as a result of internal QA/QC procedures.

5.2 Manure Management (NFR 3.B)

5.2.1 Methodology

For all 3B sub source categories, were estimated emissions for pollutants recommended in *EMEP/EEA air pollutant emission inventory guidebook 2016* (EMEP/EEA, Guidebook 2016): NH_3, NOx, NMVOC, $PM_{2.5}$, PM_{10} and TSP.

Methodologies, activity data, parameters and emission factors used for the calculation of each pollutant emissions are summarized in the table below.

Table 5-2: Methods, Activity data, Parameters and Emission factors used, by pollutant, for manure management source

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 NOx emissions estimates, Portugal used the Tier 2 mass flow approach described in the EMEP/EEA Guidebook 2016, chapter 3B – Manure management[2]. 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 NOx 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 NOx 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 NOx emissions in chapter 3D.

Emission estimates are done separately for each animal category (NFR 3B1a,b; 3B2; 3B4d,e,f,h and 3Bgi,ii,iii,iv).

For NMVOC emission estimates were used the calculation algorithms (cattle and all other animals) recommended by the EMEP/EEA Guidebook 2016 (pg.27 and 28), which covers different sources 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[3] 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

[2] 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

[3] In portuguese Recenseamento Geral Agrícola (RGA 1989 and RGA 1999), Recenseamento Agrícola (RA 2009).

by exercises in 1968, 1979, 1989, 1999 and 2009. Last census (RA, 2009), 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 http://ec.europa.eu/eurostat/web/agriculture/national-methodology-reports.

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[4] to 3 years. The complete National Methodological Report of 2013[5] FSS is also available to the public at Eurostat website (same link).

Annually livestock numbers[6] for cattle, swine, sheep and goats are estimated through the National Animal Registration database (SNIRA).

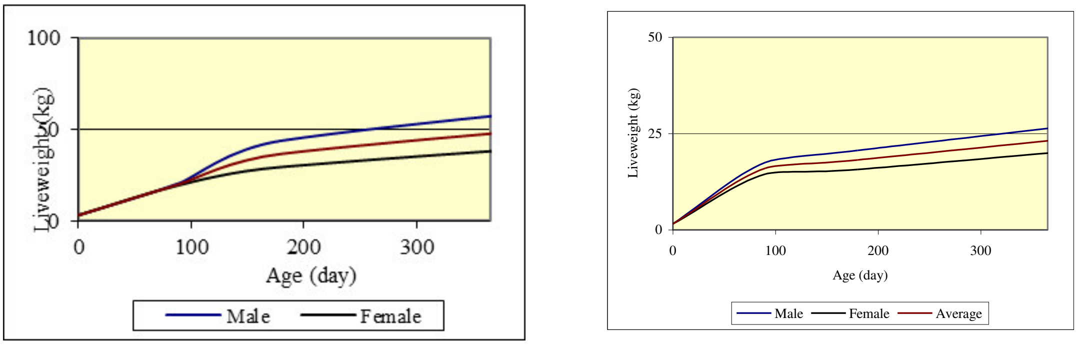
Using these data sources, INE built consistent time series of annual livestock numbers from 1987 to 2018 for cattle, swine, sheep and goats, disaggregated per region[7], age and sex.

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.:

$$Lambs/Kids\ (hd) = Annual\ Slaughter\ (hd/yr) * Age\_Slaughter\ (days) / 365$$

The age at which slaughter occurs (Age_Slaughter) was determined from the inverse function of the growth models[8] 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.



(a) (b)

Figure 5-5: Evolution pattern growth for sheep (a) and goats (b)

[4] Regulation (EC) nº 1166/2008, on Farm Structure Surveys and the Survey on Agricultural Production methods, repealing Regulation (EEC) nº 571/88.
[5] The methodological report of 2016 Farm Structure Survey is not available yet.
[6] Regulation (EC) nº 1165/2008, concerning livestock and meat statistics and repealing Council Directives 93/23/EEC, 93/24/EEC and 93/25/EEC,
[7] 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.
[8] Set up from the information on existing breeds in Portugal, complemented by information of Jarrige (1988) related with growth patterns.

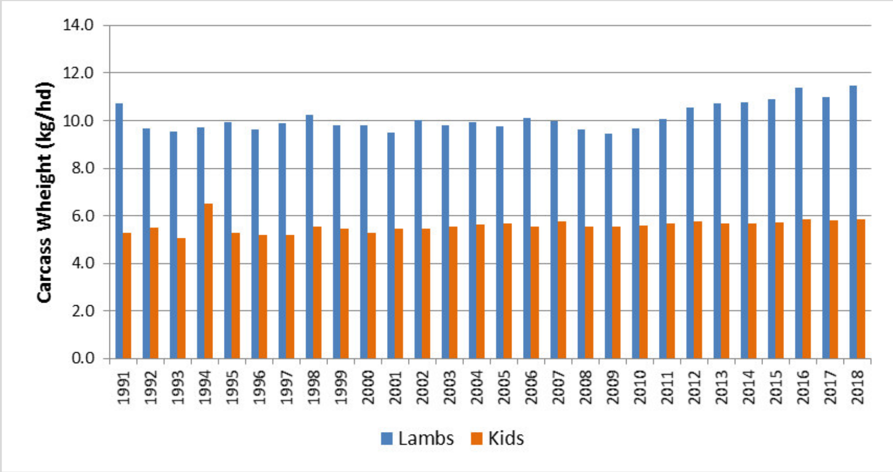


Figure 5-6: Lambs and Kids: average carcass weight at slaughtering

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 ANNEX D: Agriculture.

In a consistent way the same activity data were used for UNFCCC and for UNECE/CLRTAP emission inventory.

Table 5-3: Livestock population (thousands)

Animal class	Sub-class	1990	1995	2000	2005	2010	2015	2016	2017	2018
Dairy cattle	Dairy cows	394	383	353	290	255	235	238	240	239
Non-dairy cattle	Beef calves (<1 yr)	46	60	67	104	114	112	114	114	115
	Calves M.Rep. (<1 yr)	186	162	144	136	123	152	162	166	167
	Calves F Rep. (<1 yr)	177	158	174	183	171	209	221	226	226
	Males 1-2 yrs	112	103	82	81	66	58	67	74	79
	Beef Fem. 1-2 yrs	18	22	17	17	20	15	14	14	16
	Females rep. 1-2 yrs	111	109	127	135	137	148	159	165	165
	Steers (>2 yrs)	38	33	26	25	38	37	38	45	53
	Heifers Beef (>2 yrs)	4	10	6	9	12	15	14	15	16
	Heifers rep. (>2 yrs)	45	52	67	94	110	96	92	90	94
	Non-dairy cows	242	273	345	397	438	461	474	483	490
Swine	Piglets (<20 kg)	727	726	663	574	597	713	729	739	738
	Fatt. Pigs (20-50 kg)	662	660	585	467	448	485	490	488	471
	Fatt. Pigs (50-80 kg)	525	525	483	368	360	380	387	385	378
	Fatt. Pigs (80-110 kg)	218	198	174	214	244	285	294	301	311
	Fatt. Pigs (> 110 kg)	44	44	38	41	36	30	33	33	34
	Boars (>50 kg)	26	26	20	12	7	6	5	6	5
	Sows, pregnant	210	211	195	191	179	162	164	163	162
	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	1 639	1,659	1,666
	Other Ovine	663	817	733	234	191	155	189	239	298
	Lambs	307	278	319	322	277	275	285	274	263
Goats	Does	614	517	460	380	356	324	311	298	285
	Other Caprine	149	151	129	57	40	37	34	33	35
	kids	47	41	33	26	29	23	22	21	20
Equidae	Horses	33	48	58	52	38	30	30	29	29
	Asses & Mules	118	103	69	40	22	11	10	13	13
Poultry	Hens, reproductive	3 421	3 271	2 644	3 056	3 453	2,920	2 890	2,791	2,741
	Hens eggs	7 539	7 745	9 060	7 349	7 867	6,710	6 607	6,618	6,624
	Broilers	18 524	18 813	24 374	18 686	19 207	19 395	21 745	23,311	24,095
	Turkeys	1 149	945	1 208	798	1 445	785	800	811	816
	Other poultry	1 667	1 648	1 707	1 353	1 522	1 284	1 530	1,695	1,777
Other	Rabbits[1]	475	401	336	289	255	148	128	114	107

[1]Female reproductive

5.2.3 Parameters

5.2.3.1 Nitrogen excretion rates

The quantity of nitrogen excreted (Nex) per head results from expert information provided by the Ministry of Agriculture[9]. The detailed pattern was chosen also to allow the use of different excretion rates for animals according to age and sex, in accordance with the enhanced livestock characterization that was used in other source sectors (CH_4 emissions from Enteric Fermentation and from Manure Management).

Most of the Nex rates used in the inventory were established on the basis of the nitrogen excretion rates proposed by the Revised[10] Agriculture Good Practice Code.

This revision process was conducted in close coordination with the Ministry of Agriculture expert team including the INIAV experts. The following procedures were also considered on the analysis done:

[9] Drª Fátima Calouro, expert of the National Institute for Agriculture and Veterinary Research (INIAV), in the area of soil fertility, mineral nutrition of plants and crop fertilization and who performs research in the environmental impact of organic fertilization.

[10] 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).

- Compliance of the nitrogen excretion rates from CBPA with the detailed livestock information used in the inventory;
- Resort to expert guess when animal types are not covered in CBPA, by comparing with similar animal types reported in this document.

The following sections presents the detailed methodology used for establishing the country specific nitrogen ratios for dairy-cattle (which vary with milk production) and for the estimates of the nitrogen excreted by non-dairy cattle. For all other animal the nitrogen excretion rates were determined following the methodology explained above.

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 5-4: 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	106.3
2005	7,233	115.5
2010	7,649	117.0
2015	8,287	118.0
2016	8,046	117.4
2017	8,039	117.4
2018	8,099	117.5

The 2018 Nex value of 117.5 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[11] 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 in coherence with the updating done to the emission factors from enteric fermentation, using IPCC 2006 equations 10.31, 10.32 and 10.33[12]. The values used of gross energy (GE), weight gain (WG), net energy for growth (NEg) , milk production and fat content of milk, are the same that were calculated in the framework of the UNFCCC inventory emissions (chapter 5.2.3 of the Portuguese National Inventory Report (NIR) 1990-2018). The percent crude protein in the representative diets were estimated by the expert[13] of INIAV on Chemical and Nutritive evaluation of Animal Feed, considering the proportion and the data of the different feed constituents of each diet. In the table below are presented the weighted average values of Nex by subcategory of non-dairy cattle, for the time series.

[11] Volume 4, chapter 10, page 10.59 of IPCC 2006. Default Nex of the EMEP/EEA Guidebook 2016 are taken from IPCC 2006
[12] Volume 4, chapter 10, pages 10.58 and 10.59
[13] Engª Teresa Dentinho.

Table 5-5: 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	2016	2017	2018
Beef calves (<1 yr)	25.0	25.0	24.8	24.3	23.7	23.4	23.4	23.4	23.4
Calves M.Rep. (<1 yr)	25.0	25.0	27.1	32.5	37.8	41.0	41.0	41.0	41.0
Calves F Rep. (<1 yr)	25.0	25.0	27.1	32.5	37.8	44.8	44.8	44.8	44.8
Males 1-2 yrs	40.0	40.0	42.6	49.1	55.5	59.4	59.4	59.4	59.4
Beef Fem. 1-2 yrs	40.0	40.0	41.7	45.9	50.0	52.5	52.5	52.5	52.5
Females rep. 1-2 yrs	40.0	40.0	41.8	46.5	51.1	53.9	53.9	53.9	53.9
Steers (>2 yrs)	41.0	41.0	47.7	64.4	81.1	91.1	91.1	91.1	91.1
Heifers Beef (>2 yrs)	55.0	55.0	55.7	57.6	59.4	60.5	60.5	60.5	60.5
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	80.0	80.0	78.7	75.3	71.9	69.9	69.9	69.9	69.9

The average Nex, weighted by the 2018 non-dairy cattle population is 56.2 kg. hd^{-1}. $year^{-1}$, which is higher but close of the default value for Western Europe[14] (considering the average weight of 442.5 kg of the non-dairy cattle population in 2018.

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[15] 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.

[14] Table 10.19 of IPCC 2006, volume 4, chapter 10, page 10.59. Default Nex of the EMEP/EEA Guidebook 2016 are taken from IPCC 2006
[15] Volume 4, chapter 10, page 10.57

Table 5-6: 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[16]		
			Typical animal mass (average) (kg)	Kg N (1000 kg animal mass)$^{-1}$ .day^{-1}	Kg N hd^{-1}·yr^{-1}
Swine	Piglets (<20 kg)	0.00	65	0.51	12.10
	Fatt. Pigs (20-50 kg)	9.00			
	Fatt. Pigs (50-80 kg)	13.00			
	Fatt. Pigs (80-110 kg)				
	Fatt. Pigs (> 110 kg)				
	Boars (>50 kg)	18.0	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 piglets (< 20kg), lambs and goat kids, are 0 kg N.hd^{-1}.yr^{-1} because the Nex is included in the Nex of their respective mothers.

The Nex values for rabbits correspond to a breeding female with 40 young animals with a final weight of 2.7/3.0 kg per rabbit per year.

There is an acceptable agreement between country-specific values and IPCC 2006 defaults for all species other than sheep and goats. These two categories nitrogen excretion rate appears to be low, when in comparison with default values, but it has similarities to those used by other parties.

The total quantity of nitrogen in manure produced (including deposition on pasture) per animal type, and its annual variation in the period 1990 to 2018, is presented in the ANNEX D: Agriculture (NFR 3).

The proportion of total ammoniacal-N (TAN) used to calculate NH_3 emissions (N-flow method) of was obtained from Table 3.9[17] of EMEP/EEA Guidebook 2016 for each animal type excretion.

[16] Default Nex of the EMEP/EEA Guidebook 2016 are taken from table 10.19, Chapter 10 of IPCC 2006
[17] Page 29 of Chapter 3B Manure Management of the EMEP/EEA Guidebook 2016

5.2.3.2 Manure Management Systems

Expert guess[18], 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 last General Agriculture Census (RA09) included in the inquiry to the farmers, for the first time, a question related with the type of manure management system in use on the farm. Based on that information collected from the RA09 and on the information resident in the National Animal Registration database (SNIRA) about the number of livestock produced in extensive mode (pasture), the trend 1990-2010 was updated in September 2017[19] for cattle (dairy cows, non - dairy cows, other cattle), sheep (ewes, other ovine), goats (does, other caprine) and equidae (horses, mules and asses).

Although the exact year at which the situation changes is unknown, a linear evolution between year 1990 and the target year of 2010 was assumed.

Since no new data is available[20], for 2018 we assume the 2010 distribution.

The values for the fraction of manure handled in each MMS in 1990 and in 2018 are presented in Table 5-7.

[18] Information received from Eng. Carlos Pereira, from the Ministry of Agriculture in 3, March 2005, and in 7, October 2009, following update.
[19] 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. 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.
[20] Next General Agriculture Census will be in 2019/2020

Table 5-7: Share (%) of each Manure Management System per animal type in 1990 and 2018

Animal Type	1990					2018*				
	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	-	-	70.0	30.0	100.0		2.0	12.0	86.0	100.0
Ewes	-	-	20.0	80.0	100.0	-	-	9.0	91.0	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

*equal to 2010

Based on the same information are presented in table 5-8 the proportion of N excreted on building, yard and grazing and in table 5-9 the proportion of housed livestock managed on liquid/slurry and solid manure systems, for 1990 and 2018.

Table 5-8: Proportion of N excreted on building, yard and grazing (%)

Animal type	1990			2018		
	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	8.82	0.18	91.00
Other ovine	20.00	0.00	80.00	8.82	0.18	91.00
Does	20.00	0.00	80.00	10.78	0.22	89.00
Other caprine	20.00	0.00	80.00	10.78	0.22	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 5-9: Proportion of housed livestock managed on liquid/slurry and solid manure systems (%)

Animal type	1990		2018	
	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[21] of EMEP/EEA Guidebook 2016, and are shown in table below.

[21] Page 23 of Chapter 3B Manure Management

Table 5-10: Annual average, in the time series, of the amount of straw used in 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 Cows	1 465.90	5.86
Other cattle	224.23	0.90
Sheep & goats	31.59	0.13
Sows	565.03	2.26
Other Swine	192.17	0.77
Equidae	291.43	1.17

Specific parameters related to NMVOC emissions estimates are presented in table 5-11: Cattle and in table 5-12: 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 5-11: Cattle specific parameters

	1990	1995	2000	2005	2010	2015	2016	2017	2018
Dairy cattle									
GE (MJ.hd^{-1}.yr^{-1})	82918	83465	96905	105142	109817	112950	111556	111656	111730
$Frac_{Silage}$	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})	55221	56213	56388	55025	54810	53151	52914	53054	53334
$Frac_{Silage}$	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 5-12: All animal categories other than cattle, specific parameters

	1990	1995	2000	2005	2010	2015	2016	2017	2018
Sows									
VS (kg dm.hd^{-1}.yr^{-1})	230.62	232.95	233.82	211.33	212.77	219.17	219.23	219.73	219.69
Housed days.yr^{-1}	358	352	347	341	336	336	347	341	340
Other swine									
VS (kg dm.hd^{-1}.yr^{-1})	83.47	82.81	82.32	83.70	83.25	80.93	81.07	80.98	81.16
Housed days.yr^{-1}	358	355	352	349	347	347	352	349	349
Sheep									
VS (kg dm.hd^{-1}.yr^{-1})	183.61	186.89	184.28	175.19	174.73	172.41	172.93	175.09	177.24
Housed days.yr^{-1}	73	63	53	43	33	33	53	43	41
Goats									
VS (kg dm.hd^{-1}.yr^{-1})	170.48	168.62	169.66	174.68	174.74	175.90	176.20	176.00	175.51
Housed days.yr^{-1}	73	65	57	48	40	40	57	48	47
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	130	85	76
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	130	85	76
Hens									
VS (kg dm.hd^{-1}.yr^{-1})	14.99	14.99	15.02	14.99	14.99	14.99	14.99	14.99	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	358	354	353
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

Also relevant to the calculation of NMVOC emissions from manure store and manure application, are the estimated NH_3 emissions (tier2) from livestock housing, manure store and manure application, which are presented, for all animal categories, in ANNEX D: AGRICULTURE (NFR 3).

5.2.4 Emission Factors

The emission factors used to estimate **ammonia emissions** from manure management were obtained from table 3.9[22] of EMEP/EEA Guidebook 2016.

Ammonia emissions following manure application and from grazing animals are calculated in this source category but reported in the agricultural soils source category (3D).

[22] Page 29, chapter 3B-Manure management

Table 5-13: 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 spreading	EF grazing
Dairy cattle	Slurry	0.20	0.30	0.20	0.55	0.10
	Solid	0.19		0.27	0.79	
Other cattle	Slurry	0.20	0.53	0.20	0.55	0.06
	Solid	0.19		0.27	0.79	
Sows	Slurry	0.22	-	0.14	0.29	0.25
	Solid	0.25		0.45	0.81	
Other swine	Slurry	0.28	0.53	0.14	0.4	0.20#
	Solid	0.27		0.45	0.81	
Sheep & Goats	Solid	0.22	0.75	0.28	0.9	0.09
Horses & Asses	Solid	0.22	-	0.35	0.9	0.35
Hens	Solid	0.41	-	0.14	0.69	-
Broilers	Solid	0.28	-	0.17	0.66	-
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	0.28	-	0.17	0.66	-

*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[23] of EMEP/EEA Guidebook 2016.

Table 5-14: Emission factors used for calculation of the NO-N emissions from manure management. EF as proportion of TAN (volatilization rates)

EF storage	
Slurry	Solid
0.0001	0.0100

In a consistent way the storage N_2O-N emission factors derivate (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 was calculated following the IPCC methodology and inserted in the N flow calculations (step 10, equation 30)[24].

Emission factors used to estimate **NMVOC emissions** from this source category were from EMEP/EEA Guidebook 2016, table 3.11[25] for cattle and table 3.12[26] for all other animal categories than cattle.

There are no available NMVOC emission factors for manure applied to soil and for manure storage. Emissions from these two sources are estimated as fraction of those from livestock housing, as recommended by the methodology of the EMEP/EEA Guidebook 2016[27]. The fraction is assumed to be the same ratio as for NH_3 emission (equations 48 and 49 for cattle categories; equations 54 and 55 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).

Table 5-15: Default NMVOC tier 2 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

[23] Page 30, chapter 3B-Manure management
[24] Page 25 o, chapter 3B-Manure management of the EMEP/EEA Guidebook 2016
[25] Page 30, chapter 3B-Manure management
[26] Page 31, chapter 3B-Manure management
[27] Pages 26 to 28, chapter 3B-Manure management

Table 5-16: Default NMVOC tier 2 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[28] of EMEP/EEA Guidebook 2016. of chapter 3B-Manure management.

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 1990-2017 (2018 not available) and the results are presented in the Figure 5-7 for cattle, swine and sheep.

[28] Page 19 , chapter 3B-Manure management

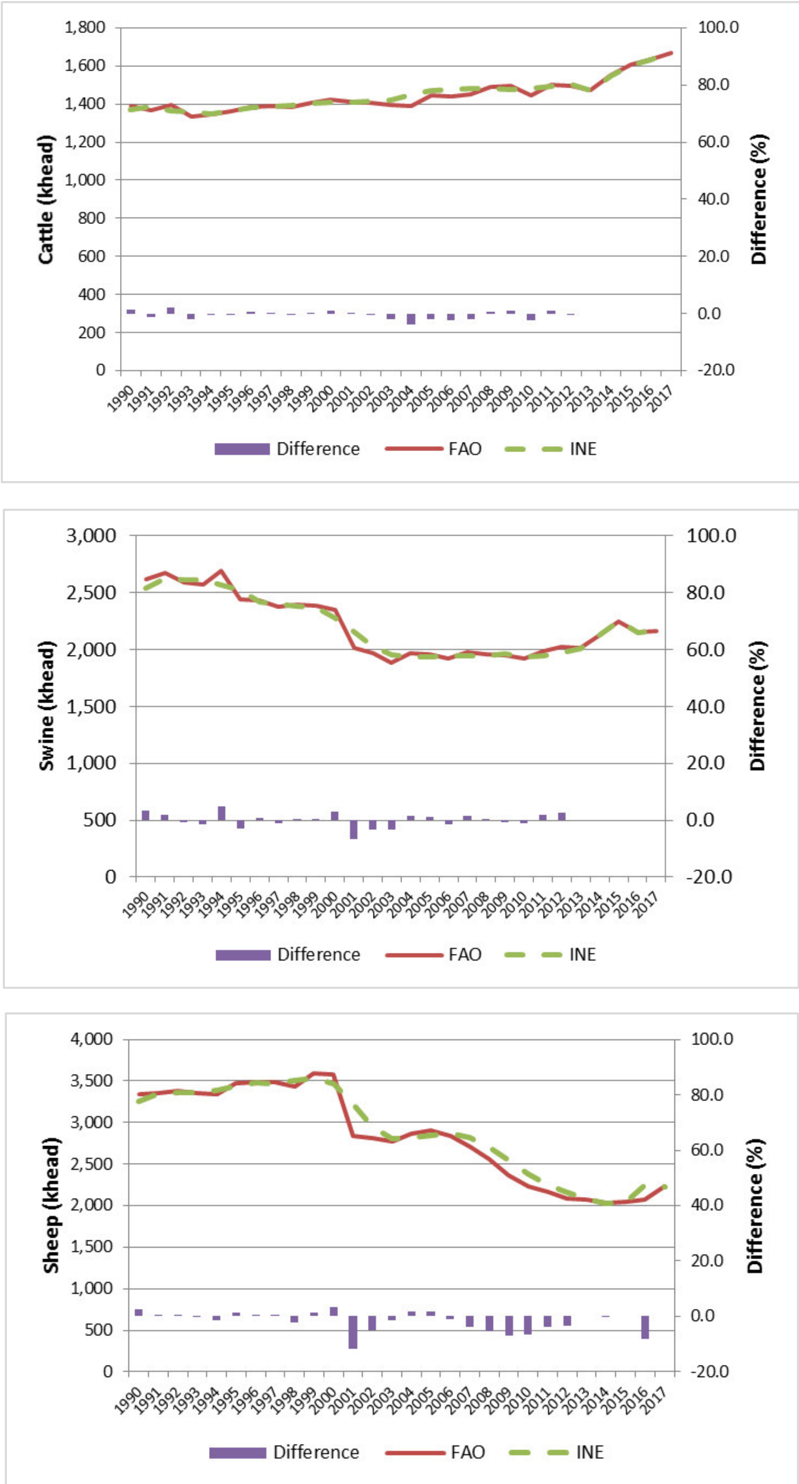


Figure 5-7: Livestock numbers: comparison between National Statistics and FAO database

FAO and INE livestock numbers have a good adhesion for all species. From 2012 onwards, values total agree in both dataset.

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 submissions, 2019 and 2020, are mainly due to the update of the Nex of non-dairy cattle in coherence with the updating of the emission factors from enteric fermentation done in the framework of the UNFCCC emissions inventory as referred in chapter 5.2.3 (Parameters) of this report. There is no significant impact in the source category 3B because the non-dairy cattle is mainly managed in extensive mode, i.e, animals are maintain in pasture most of the time in the year, and therefore the proportion of housed and stored manure is very low.

For NH_3 emissions estimates the differences between last year submission and this year submission are represented in the next figure.

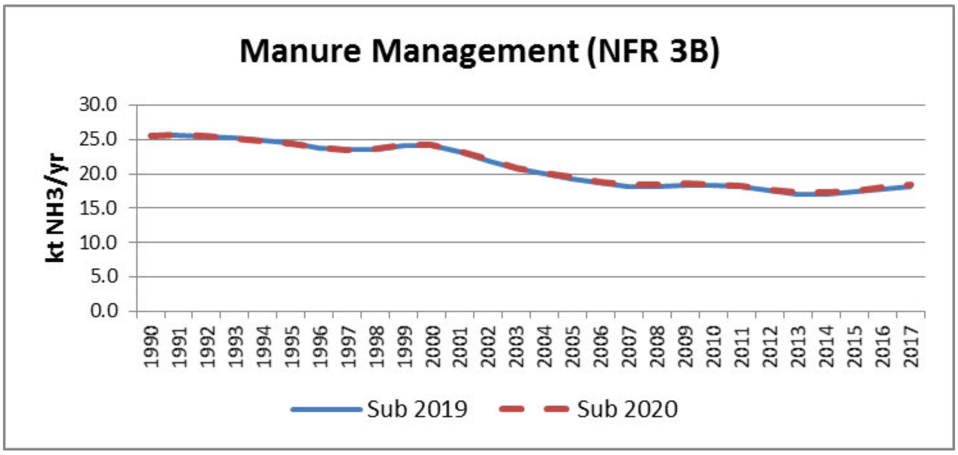


Figure 5-8: Manure management emission estimates. Differences between 2019 and 2020 submissions

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[29] 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 3.D)

For the source category 3D, the Portuguese inventory includes emission estimates of the pollutants from the sub sources categories, as described below.

Table 5-17: Pollutant emission estimates, by source 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 source category chapter.

[29] Decree-Law nº 81/2013

5.3.1 Synthetic N_fertilizers

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[30] of IPCC 2006.

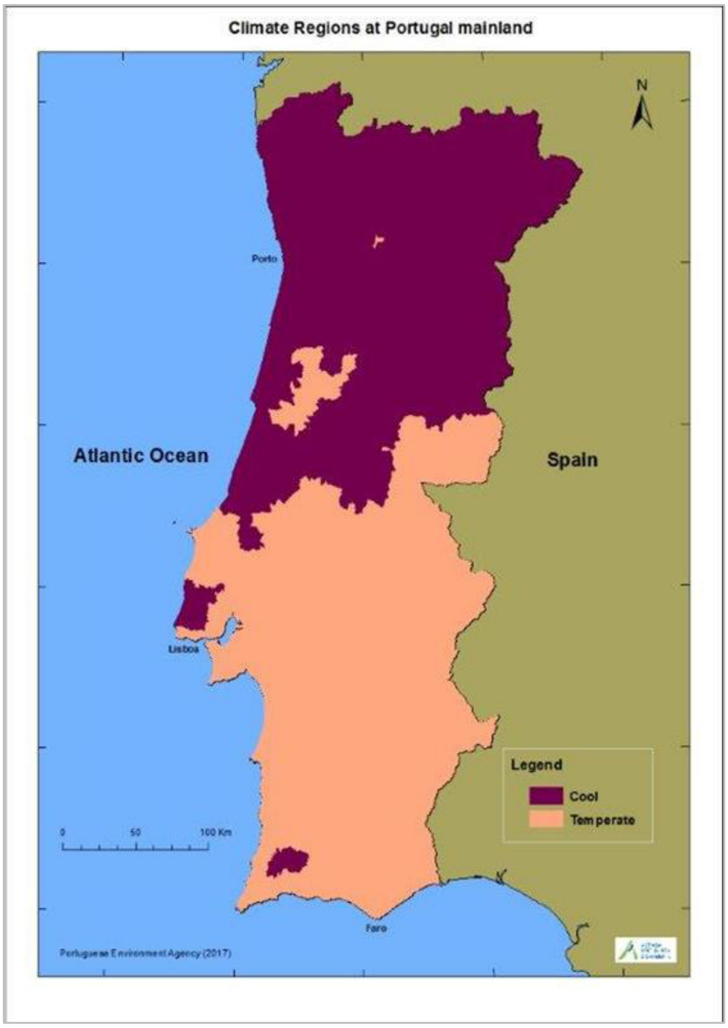


Figure 5-9: Climate regions presentation

[30] Volume 4, chapter 10, page 10.38

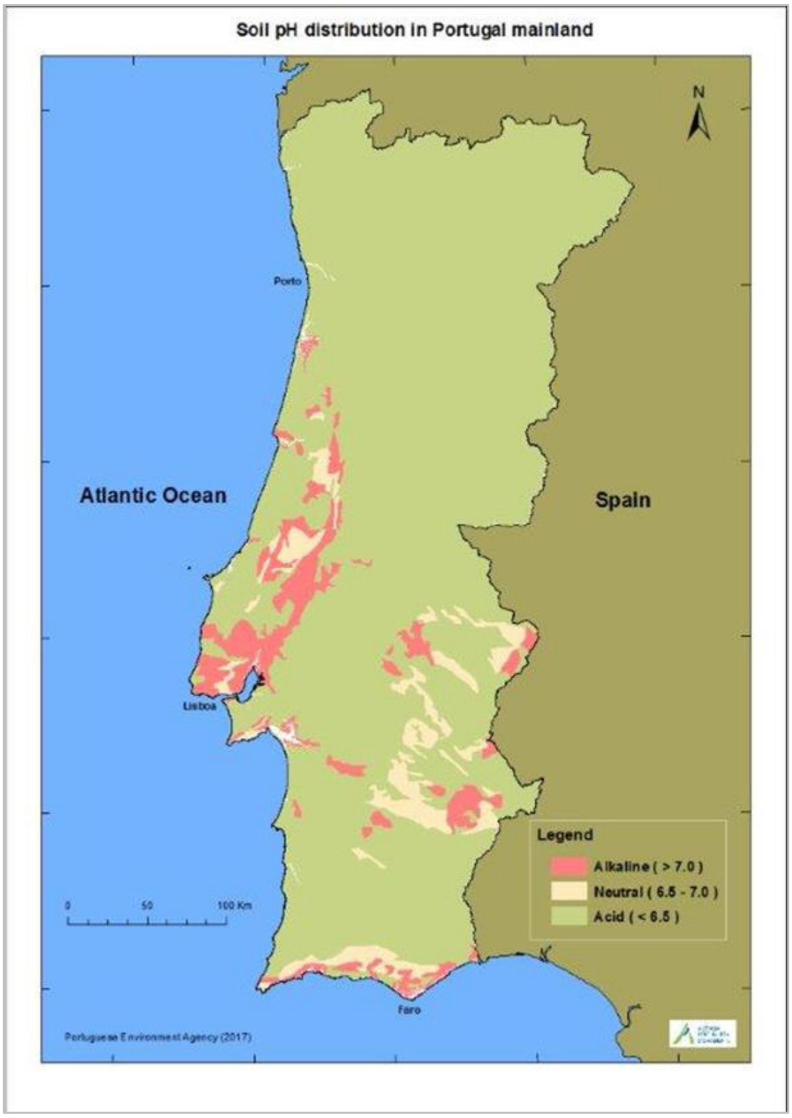


Figure 5-10: Alkaline, Neutral and Acid soils representation at Portugal mainland

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[31] 7.0 (normal) is presented in the next table.

Table 5-18: 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), of tier 2 methodology of the EMEP/EEA Guidebook 2019, chapter 3D – Crop production and agricultural soils. In table 5-19 are presented the calculation results for the year 2018.

[31] Below or equal 7.0. Includes Neutral and Acid soils

Table 5-19: Nitrogen amount (kt.yr^{-1}) by type of fertilizer and emission region in 2018

Type of fertilizer	Emission regions			
	NC	NT	HC	HT
Ammonium nitrate (AN)	0.06	0.05	0.01	0.05
Ammonium phosphate (MAP & DAP)	0.66	0.55	0.06	0.48
Ammonium sulfate (AS)	0.50	0.41	0.04	0.36
Calcium ammonia nitrate (CAN)	7.47	6.19	0.65	5.48
Urea	9.59	7.95	0.84	7.03
Other NP & NPK	8.35	6.92	0.73	6.12
Other N	11.28	9.36	0.99	8.28
Total	**37.90**	**31.42**	**3.32**	**27.80**

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 Tier 1. However, it was only considered the amount of N-fertilizer proportional to the surface of the national soils predominantly neutral (pH 6.5 - 7.0) or alkaline (pH >7.0), based on the guidebook references that *in agricultural soils, where pH is likely to be maintained above 5, nitrification is considered to be the dominant pathway of NO emission* (page 7 of EMEP/EEA Guidebook 2019, chapter 3D – Crop production and agricultural soils).

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[32] and ADP[33], 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[34] 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.

[32] 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).

[33] ADP, Adubos de Portugal, S.A., is the main producer of fertilizers in Portugal, and responsible for about 75% of fertilizer sales (INE,2004)

[34] 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 (NFR 3). Table 5-20 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 5-20: Nitrogen amount ($kt.yr^{-1}$) by type of fertilizer

Type of fertilizer	1990	1995	2000	2005	2010	2015	2016	2017	2018
Ammonium nitrate (AN)	-	-	-	-	2.01	0.67	0.85	0.77	0.16
Ammonium phosphate (MAP & DAP)	13.28	16.75	11.83	-	4.01	0.58	1.94	2.10	1.75
Ammonium sulfate (AS)	17.72	25.40	14.47	10.30	0.54	1.80	1.91	1.71	1.32
Calcium ammonia nitrate (CAN)	46.13	40.67	45.72	29.68	3.06	17.89	21.76	16.52	19.78
Urea	13.35	7.06	20.52	11.85	34.99	30.52	30.20	28.39	25.41
Other NP & NPK	49.54	40.76	57.74	39.94	13.85	27.97	24.89	25.43	22.12
Other N	18.49	15.18	19.72	10.90	24.90	38.48	26.88	30.77	29.91
Total	**158.50**	**145.82**	**170.01**	**102.66**	**18.90**	**117.91**	**108.44**	**105.68**	**100.45**

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 EMEP/EEA Guidebook 2019, of chapter 3D – Crop production and agricultural soils, and are presented in the table below

Table 5-21: 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)	0.000	0.000	0.000	0.000
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 EMEP/EEA Guidebook 2016, chapter 3D - Crop production and agricultural soils). The dominant pathway of NO emission is nitrification in agricultural soils where pH is likely to be maintained above 5.0, considered correspond to the percentage of agricultural land in High Cool and High Temperate emission regions (table above). Nitric oxide emission estimates were done considering the proportional amount of the annual consumption of N-fertilizers.

5.3.2 Animal manure applied to soil

5.3.2.1 Methodology and activity data

NH_3, NO 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 **NH3 emission factors** used for manure applied to soil were the ones referred in Table 5-13 of this Report – EF spreading - for each animal type.

The **emission factor** used to estimate **NO** emissions from manure applied to soil was the default value of 0.04 kg NO_2. kg N applied (table 3-1 of EMEP/EEA Guidebook 2016, of the chapter 3D – crop production and agricultural soils). The emission estimates were made with the same assumption that the dominant pathway of NO emission is nitrification in agricultural soils where pH is likely to be maintained above 5.0.

There are no available **NMVOC emission factors** for manure applied to soil and for manure storage. Emissions from these two sources are estimated as fraction of those from livestock housing, as recommended by the methodology of the EMEP/EEA Guidebook 2016, pages 26 -28, chapter 3B – Manure management. The fraction is assumed to be the same ratio as for NH_3 emission (Chapter 3B - equations 48 and 49 for cattle categories; equations 54 and 55 for all livestock categories other than cattle).

5.3.3 Other organic fertilizers applied to soil

5.3.3.1 Sewage sludge applied to soils

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 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 emission factor is from table 3.1 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).

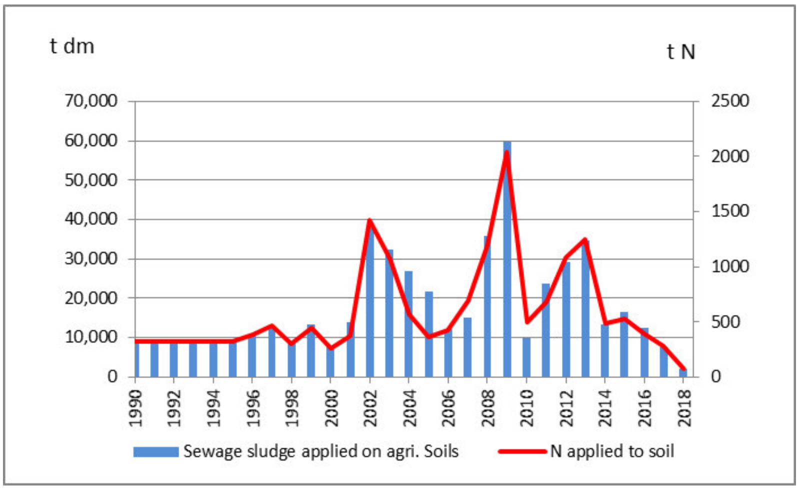


Figure 5-11: Application of sewage sludge (t dm.yr^{-1}) and quantities of N (t N) applied in agriculture soils

5.3.3.2 Compost from municipal solid waste applied to soil

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 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 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, NH3 and NO, are estimated since then.

In 2018 a total amount of 46 885 t of MSW compost was applied to agricultural soils which corresponds to the N amount application of 929 t.

5.3.4 Urine and dung deposited by grazing animals

5.3.4.1 Methodology and activity data

NH_3, NO 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 5-13 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 5-15 and table 5-16 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). The emission estimates were made with the same assumption that the dominant pathway of NO emission is nitrification in agricultural soils where pH is likely to be maintained above 5.0.

5.3.5 Cultivated crops and farm level agricultural operations

5.3.5.1 Methodology and activity data

In this sources categories 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 2016) for all the above pollutants mentioned.

In this sources categories 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 2016) 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 5-22: Crop area (ha)

Year	Crop area
1990	1 048 641
1995	865 276
2000	742 494
2005	593 994
2010	475 618
2015	369 644
2016	354 939
2017	331 823
2018	325 947

5.3.5.2 Emission factors

Emission factors used are from table 3-1 of EMEP/EEA Guidebook 2019, chapter 3D – Crop production and agricultural soils, and are shown in next table.

Table 5-23: NMVOC, $PM_{2.5}$, PM_{10} and TSP emission factors ($kg.ha^{-1}$)

NMVOC	$PM_{2.5}$	PM_{10}	TSP
0.85	0.06	1.56	1.56

5.3.6 Uncertainties

To be provided in the future.

5.3.7 QA/QC and verification

For synthetic N fertilizers data a comparison was made 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[35] (https://www.ifastat.org/databases/plant-nutrition) for the period 2002 – 2016. For previous years (1990-2001) FAO database archive has no data registers. In both databases (FAO and IFA) 2017 is the last year available. Comparison results are shown in Figure below.

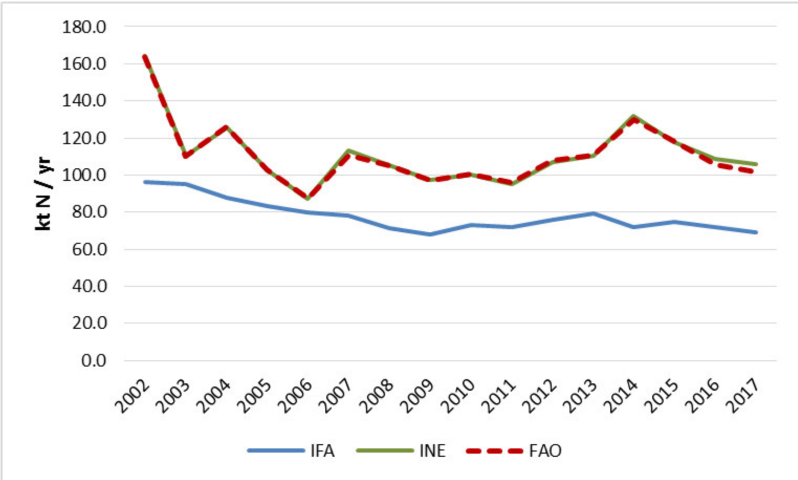


Figure 5-12: Data bases comparison of inorganic N fertilizers (t $N.yr^{-1}$)

FAO and INE series agree quite well. Differences for the two last years are due to the recent update done by INE to the previous values that should then be transmitted by Eurostat to FAO, what apparently has not been done yet.

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 were produced. 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

[35] International Fertilizers Association

5.3.8 Recalculations

Differences between submissions, 2019 and 2020, are mainly due to:

- the elimination of step 6 of the algorithm to estimate ammonia emissions from fertilizers (tier 2 approach) updated by the EMEP/EEA Guidebook 2019 (NFR 3Da1);
- the update of Nex estimates for non-dairy cattle, in coherence with the updating of the emission factors from enteric fermentation done in the framework of the UNFCCC emissions inventory as referred in chapter 5.2.3 (Parameters) of this report. The update of Nex affects the N amount of manure applied to soils and the N amount deposited on soils by grazing animals (NFR 3Da2a and NFR 3Da3);
- the update of 2016 and 2017 values for apparent consumption of synthetic N fertilizers (total amount and by type of fertilizer) revised by the National Statistics Authority, INE (NFR 3Da1).

Other minor corrections done in result of QA/QC verifications had no significant impact.

For NH_3 emissions the graphical representation of the differences between submissions is shown in the figure below.

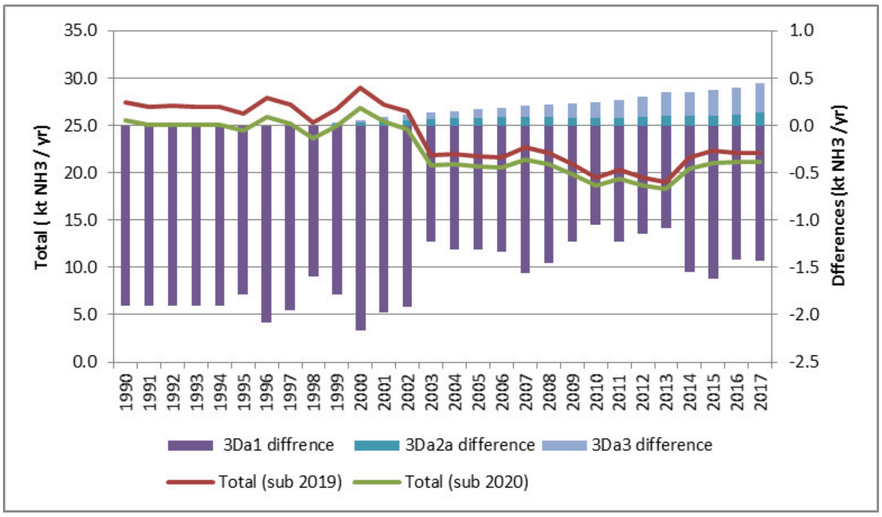


Figure 5-13: Crop production and agricultural soils NH_3 emissions. Differences between submissions (2019 and 2020)

5.3.9 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[36] 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 3.F)

In-site burning of agricultural residues is still practiced nowadays in Portugal, being however forbidden by law-decree from May to September, when normally forest fires occur. The Portuguese inventory includes emission estimates of the pollutants described in the table below.

[36] Decree-Law nº 81/2013

Table 5-24: 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[37] from the IPCC 2006 which is summarized in the following equation:

Equation 5-5: 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 occur 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[38] limits. In these situations the practice of burning crop residues is forbidden[39] 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[40] all rice cultivation areas subjected to "Techniques of Integrated Production and Protection[41]" 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.

[37] Volume 4, chapter 2, pg 2.42

[38] 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

[39] National Laws: DL 140/99 artº 11º (revised by DL 49/2005); RCM 177/2008 artº 21º; RCM 182/2008 artº 8º.

[40] From 2009 onwards the limitation of residues burnt was removed (Circular / DSPFSV/ 08 from Directorate General of Agriculture and Rural Development -DGADR)

[41] "Modos de proteção e produção integrada" in the original in Portuguese.

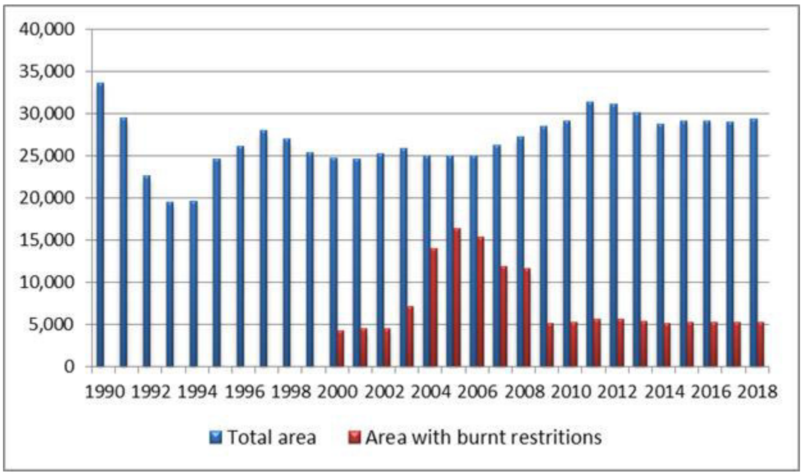


Figure 5-14: Rice cultivation areas (ha) in Portugal

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 the last General 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[42] .

The amounts of pruning material produced for each of the permanent crops are country specific[43] values presented in Table 5-25.

Activity data and parameters used to estimate emissions from cereal and permanent crops residues burnt on field are summarized in table below for 2018. Combustion factors used for cereals are the default values from Table 2.6 of IPCC 2006[44]. For pruning material from permanent crops the combustion factor considered was made equal to 1, following the recommendation of the EMEP/EEA Guidebook 2016.

In a consistent way the same activity data were used for UNFCCC and for UNECE/CLRTAP emission inventory.

Table 5-25: Activity data and parameters used to estimate emissions from field burning of crop residues, 2018

Crop	Area burnt* (kha)	Biomass available for combustion (t dm.ha^{-1})	Combustion factor
Wheat	0.27	3.89	0.9
Barley	0.21	2.70	0.9
Maize	1.17	8.28	0.8
Rice	16.54	7.09	0.8
Other cereals	0.69	2.16	0.9
Orchards	24.49	1.86	1.0
Vineyards	92.07	1.19	1.0
Olive grove	234.96	0.27	1.0
*Area where the on field burning practice of crop residues occurs			

In the next figure is shown the annual biomass burnt for the period 1990-2018.

[42] Volume 4. chapter 11, page 11.17
[43] Dias, J.J. Mestre (2002), "Utilização da biomassa: avaliação dos resíduos e utilização de pellets em caldeiras domésticas".
[44] Volume 4, chapter 2, page 2.49

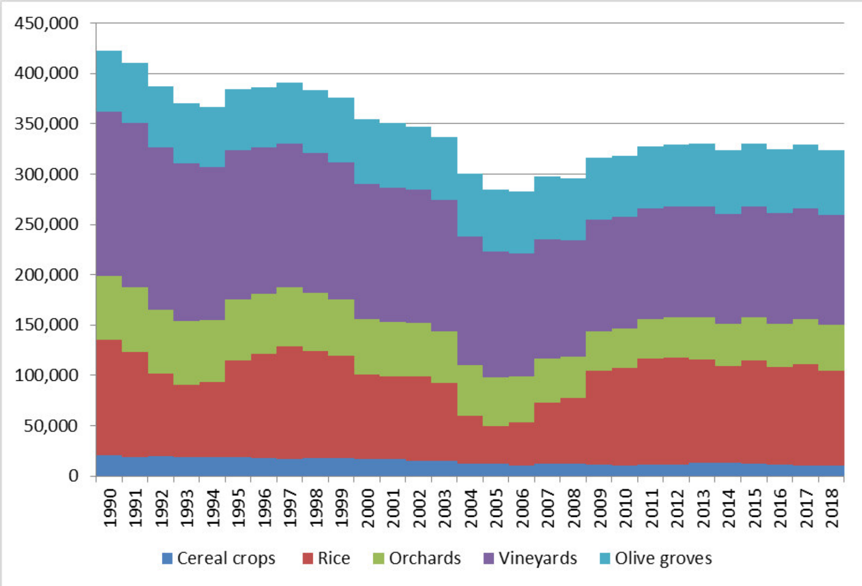


Figure 5-15: Annual biomass burnt (t dm /yr) for the time series

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 5-26.

For PM $_{2.5}$, PM_{10}, TSP and BC emission estimates were used the emission factors presented in table 5-27.

Table 5-26: 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 2016; chapter 3F; #Table 3-1 of EMEP/EEA guidebook 2016; chapter 3F; » Table 2.5-5 AP_ 42 USEPA ;“Table 2.5 of IPCC guidelines 2006

Table 5-27: 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 2016; chapter 3F; #Table 3-1 of EMEP/EEA guidebook 2016; chapter 3F

For all other pollutant emission estimates the emission factors used are those presented in the following two tables.

Table 5-28: 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 2016; chapter 3F; #Table 3-1 of EMEP/EEA guidebook 2016					

Table 5-29: 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 2016; chapter 3F; #Table 3-1 of EMEP/EEA guidebook 2016									

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

No recalculations done as shown in the figure below.

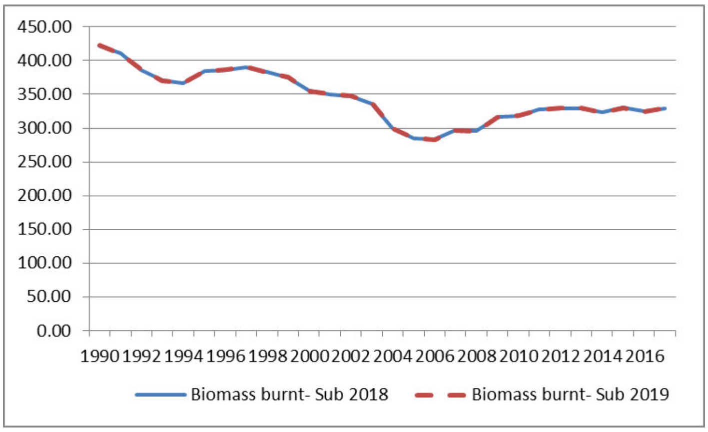


Figure 5-16: Amount of biomass burnt (kt dm). Differences between submissions, 2019 and 2020

5.4.7 Further improvements

No specific improvements are planned.

5.5 Use of pesticides (NFR 3.D.f)

5.5.1 Methodology

With the October 2018 update version of EMEP/EEA Guidebook 2016 the emissions from pesticides including HCB as impurity shall be reported. The estimates of HCB emissions were done with the available tier 1 default approach of the Guidebook, based in the following equation:

Equation 5-6: 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})

5.5.2 Activity data

From the National Authority responsible for the management and authorization of plant protection products[45] , information has been received that the active substances in use in Portugal are clopiralide and clorotalonil. 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 5-30: Quantities sold (kg a.s^{-1}) - Clopiralide and Clorotalonil

Year	Clopiralide	Clorotalonil
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	15 221.00
2018	74.80	19 019.00

5.5.3 Impurity factors

The impurity factors used are the default ones from table 3 of chapter 3 D.f of the EMEP/EEA Guidebook 2016 that are shown in the next table.

Table 5-31: Impurity factors (mg. kg^{1}) - Clopiralide and Clorotalonil

Clopiralide	Clorotalonil
2.5	40

5.5.4 Uncertainties

To be provided in the future

[45] Engª Miriam Cavaco- Divisão de Gestão e Autorização de Produtos Fitofarmacêuticos da DGAV

5.5.5 QA/QC verifications

QA/QC procedures included a series of checks: calculation formulas verification, data and parameters verification and the information provided in this report.

5.5.6 Recalculations

No recalculations done.

5.5.7 Further improvements

No planned improvements

6 Waste (NFR 5)

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6 Waste (NFR 5)

Teresa Costa Pereira

6.1 Overview

Waste management and treatment 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 clinical 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 1A(a) Public electricity and heat production).

Incineration of municipal solid wastes (MSW) in Portugal is done in three modern units (two in Portugal Mainland) where energy is recovered, and thus these emissions are accounted for in the energy sector. The incineration of clinical 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.

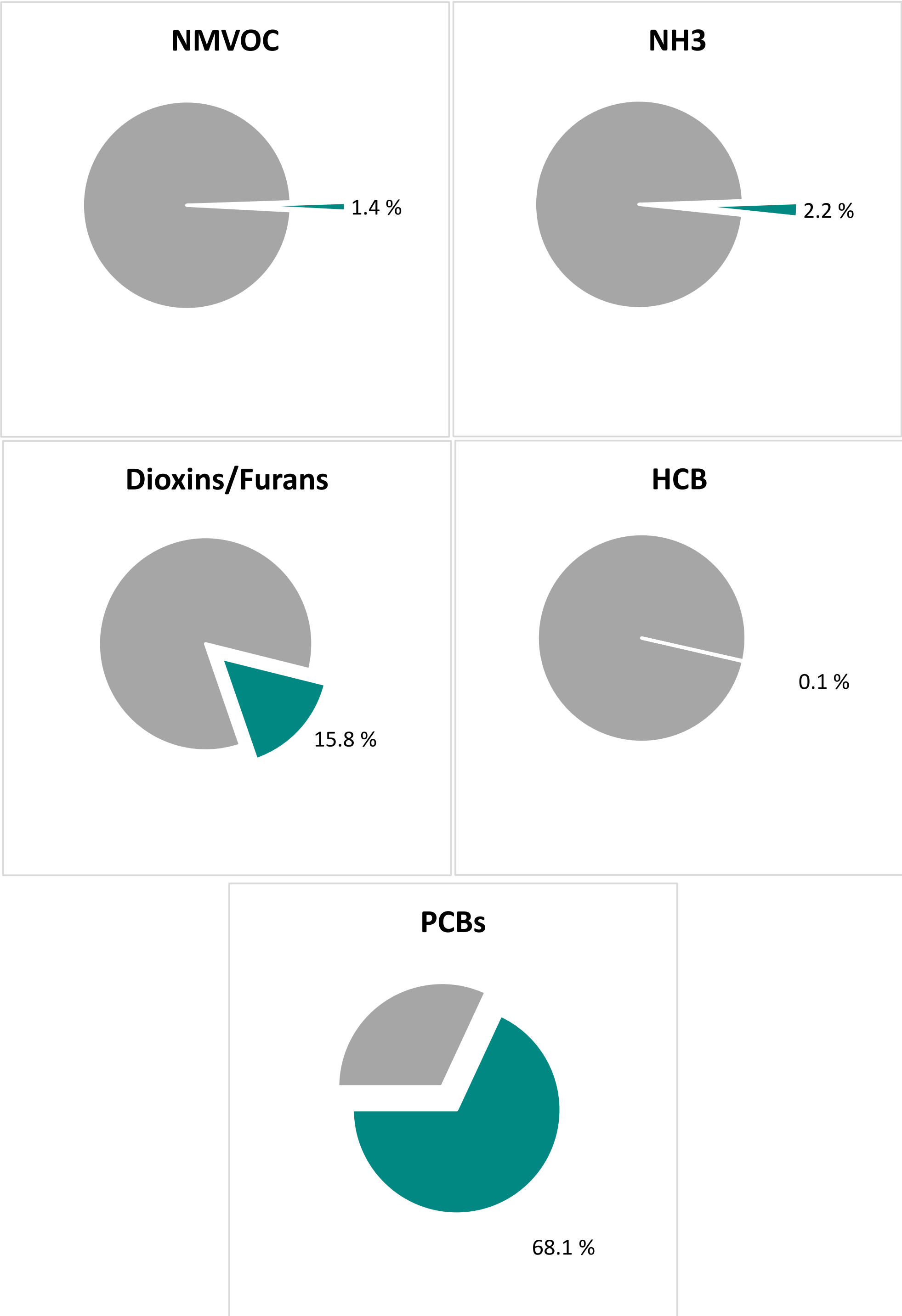


Figure 6-1: Share of the waste sector as a percentage of total emissions in 2018

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

At present the National legislation (Decree-Law no. 178/2006 amended and republished in the Decree-Law no. 73/2011) defines the legal obligations related to the Waste Registry for: waste producers, management waste operators (municipal and non-municipal), waste carriers, integrated schemes for management of specific waste streams, and waste brokers and dealers.

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 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 (MRRU, for municipal waste) the information regarding production, 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.

On the basis of data collected from the MRRU (Municipal Waste Registration Form), APA, I.P. produces annual information referring to 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 waste management systems from Portugal Mainland and the Autonomous Region of Madeira. Information for 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 ”systems” (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 (7.2.1.2.1.3 - 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:

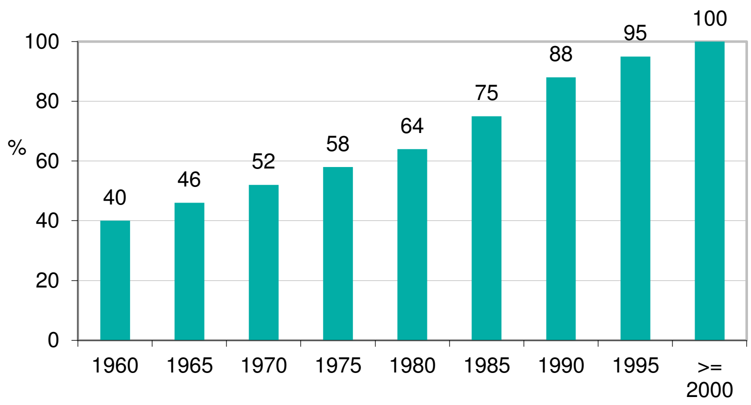
[Population (inhabitants) * Annual amount of municipal waste generated per capita (t/inhabitant/year)]

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]

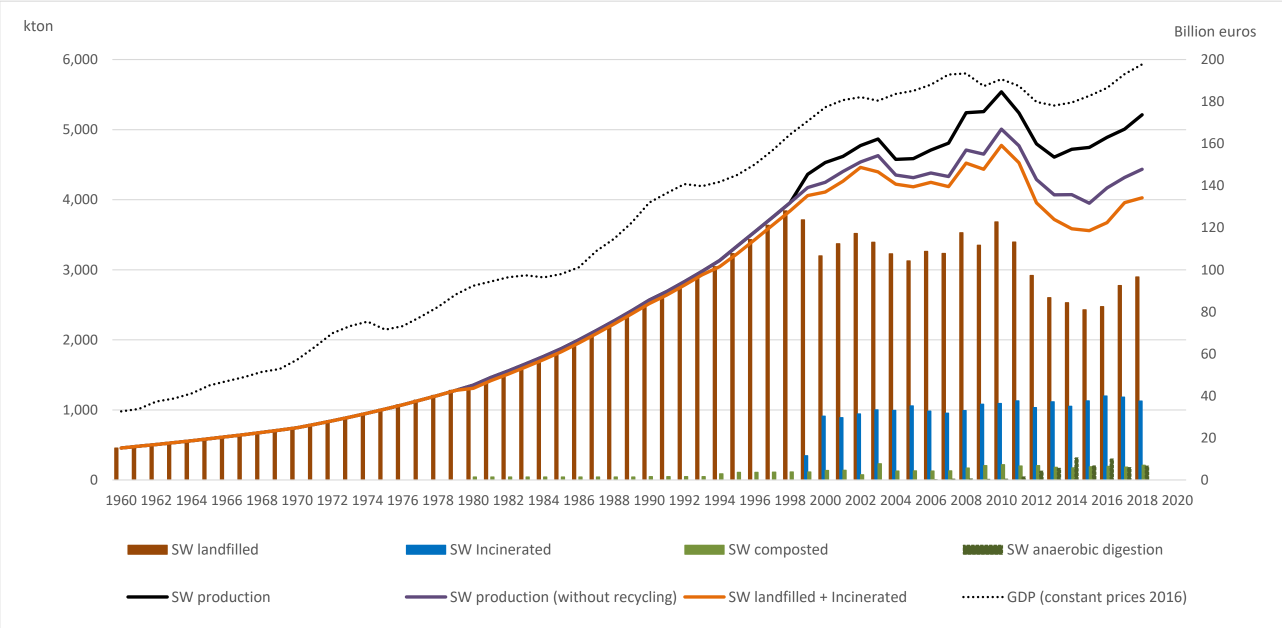
– Quantity of incinerated waste – Quantity of composted/digested waste



Source: APA

Figure 6-2: Population served by waste collection systems

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 the policies on preventing, reducing and recycling of waste, but also due to the economic crisis effect on consumption. Since 2014, however, an inversion of this tendency is registered.

In 2018 they were produced around 5.2 million tonnes (t) of municipal waste in Portugal, approximately 4.0% more than in 2017, maintaining the growing trend registered since 2014.

This increase is believed to be related with an improvement of the economic situation of Portugal, which recorded approximately 2.4% growth in GDP in 2018 as compared to 2017, seeming to indicate that the objective of decoupling waste production from economic growth continues not to be fulfilled, and that the measures to prevent waste generation are not having the expected results.

Among the factors that explain these most recent tendencies, is the remarkable growth of tourist inbound in Portugal in the recent years, contributing both to the Portuguese economic development and to the growth of municipal waste generation.

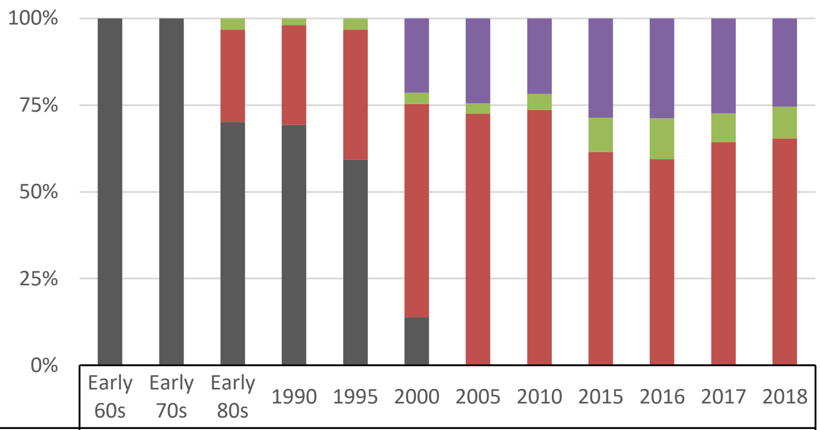
The Portuguese MSW production per capita in 2018 corresponded to 507 kg/year above the EU28 average per capita MSW production (http://ec.europa.eu/eurostat/statistics-explained/index.php/Municipal_waste_statistics).

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 the 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 practice. 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.

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) 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, representing in 2018 approx. 9% of waste final treatment. These measures have contributed also to an increase in multi-material recycling and the organic recovery and recycling of waste, with a consequent decrease of biodegradable waste in landfills.



	Early 60s	Early 70s	Early 80s	1990	1995	2000	2005	2010	2015	2016	2017	2018
Incinerated	0	0	0	0	0	21	24	22	29	29	27	25
Composted/ AD	0	0	3	2	3	3	3	5	10	12	8	9
Managed landfills	0	0	27	29	37	61	72	74	62	59	64	65
Open dump sites	100	100	70	69	59	14	0	0	0	0	0	0

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 (non-organic recycling excluded)

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
		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
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
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
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
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
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
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
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
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
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**

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 2010-18: 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: $k = \ln 2 / t_{1/2}$. 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.

Historical time series are based on 1999 data, which refer to the first set of data available on industrial waste disposal that was collected via an annual registry of industrial declarations received from the regional environment directorates (CCDR).

Data for the period 1960-1999 have been estimated 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. 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.

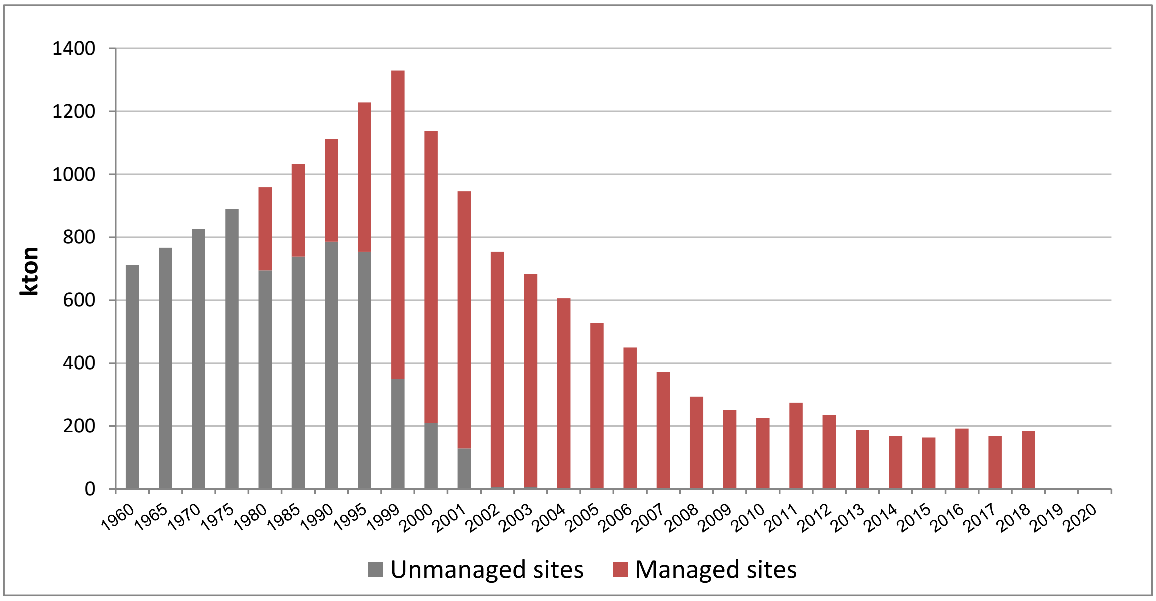
Data from 2008 onwards refer to data collected via SIRER (Integrated System for Electronic Registry on Waste), first in SIRAPA (2008-2011) and, since 2012, in the SILIAMB electronic platform. After data collection and the respective validation at APA, I.P., data is handled by INE (National Statistical 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).

In 2012, the Statistical Office made a methodological change in the sectoral waste statistics, consisting in the harmonization of the sample used for these statistics with other statistical operations related to the Common Corporate Sector/ Business Sector, in which a set of statistical units, such as municipalities and other entities from public administrations, are excluded since 2012.

This revision is considered to have increase the quality of the waste statistics, as it was found to exist an overlap of content and double accounting between the sectoral and the municipal statistics, due to a double registry, in the MRRU and MIRR, of waste operations by many operators.

In order to make the time series more consistent, the data from 2008 has been revised to exclude the information from entities not considered from 2012 onwards. This double accounting phenomenon is more difficult to quantify for previous years.

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.

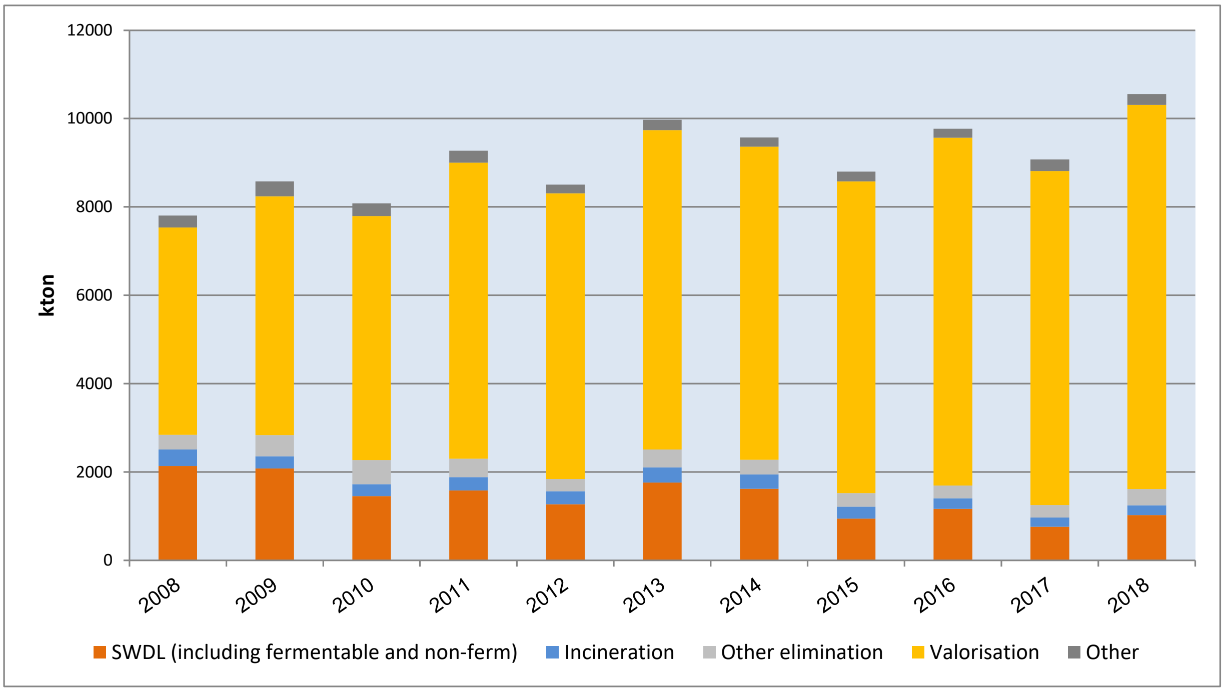


Source: APA

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, such as incineration, shipping abroad and recycling.

Next figure presents the evolution of all industrial wastes treatment types since 2008. From 2008 to 2018 as the total amount of industrial waste increased from 7.81 Mt in 2008 to 10.55 Mt in 2018, the amount disposed in SWDS decreased from 2.14 Mt in 2008 to 1.03 Mt in 2018 as the recovery of waste increased from 4.69 Mt in 2008 to 8.70 Mt in 2018.



Notes:
Other elimination - includes biological and physio-chemical treatment not specified.
Valorisation – includes regeneration, recovery 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. For the submission 2018, a disaggregation of the previously reported category "paper and textiles" has been made in order to consider separately the different default DOC values for "paper" and "textiles".

Since 2008, data refer to the National Waste Registry that collects data via the SIRER's MIRR registration map 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	-	-
Paper and cardboard (07.2)	0.40	wet waste	1,325	1,178	797	385	314	206	349	287	300	-	-
Wood 07.5)	0.43	wet waste	6,965	5,326	3,394	1,190	593	869	1,003	3,273	4,037	-	-
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	-	-
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	-	-
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	-	-
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	-	-
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	-	-
Screening waste (10.3)	0.11	wet waste	0	0	336	3,579	99	382	368	278	709	-	-
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	-	-
Total fermentable waste disposed on land	-		**225,583**	**273,921**	**235,735**	**187,689**	**166,314**	**164,059**	**190,858**	**168,734**	**183,448**	**-**	**-**
DOC (weighted average)	-		**0.171**	**0.171**	**0.160**	**0.156**	**0.157**	**0.157**	**0.152**	**0.160**	**0.165**	**-**	**-**

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.

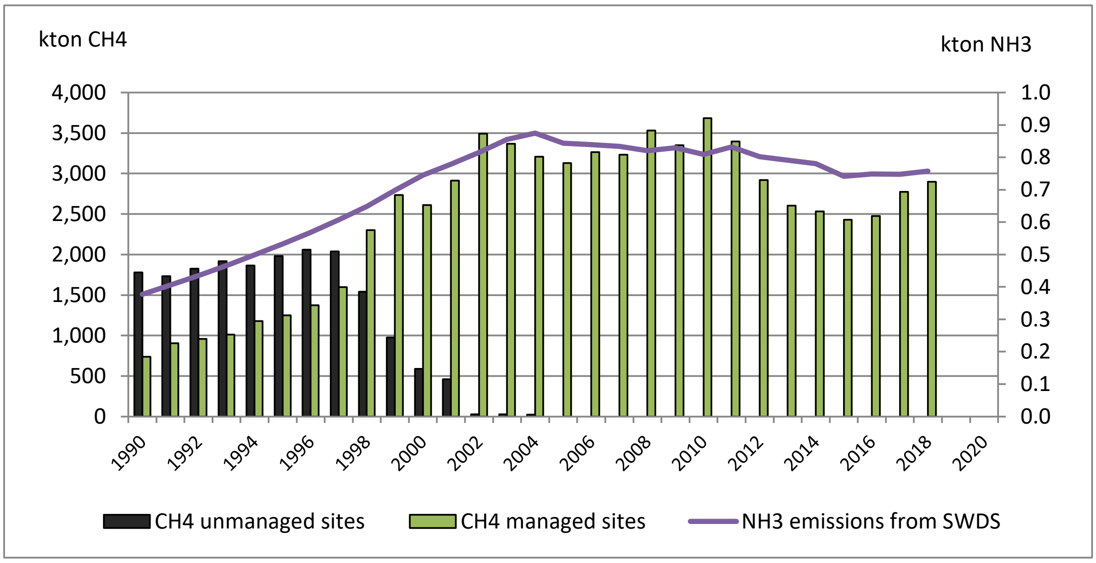


Figure 6-7: Emissions of CH4 and NH3

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
	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	2,589,761
	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

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
	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
	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
	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
	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
	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
	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
	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
	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
	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	0.000028
	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
	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	0.001398
	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	0.000259
	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
	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
	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
	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	0.000150
	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	0.001891
	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	0.001347
	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
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**
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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

Notes:
DGEG data
Data refer to landfill gas flared without energy recovery. APA data.

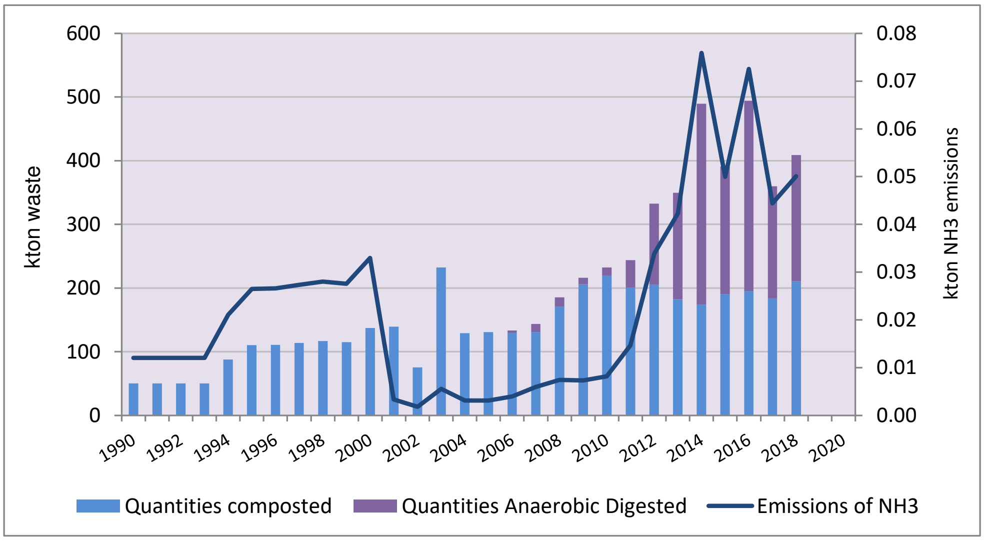
6.2.4 NH3 emissions from Biological Treatment of Waste - Composting (NFR 5.B.1) and Anaerobic Digestion (NFR 5.B.2)

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 1A(a) Public electricity and heat production).

Incineration of municipal waste (MSW) in Portugal takes place in three modern units (two in Portugal Mainland) where energy is recovered, and thus these emissions are accounted for in the energy sector. The incineration of clinical 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

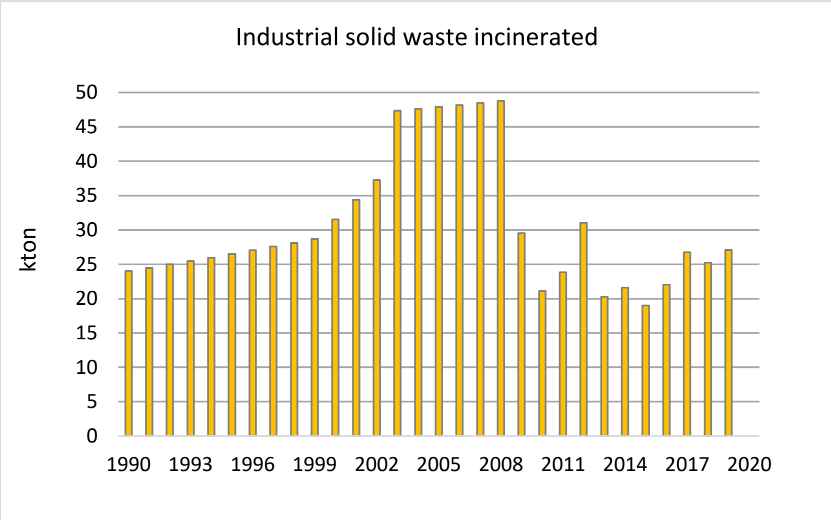
6.2.5.2.1 Industrial waste incineration (NFR 5.C.1.b.i)

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).

As previously mentioned, in 2014, the Statistical Office made a methodological change in the sectoral waste statistics, consisting in the harmonization of the sample used for these statistics with other statistical operations related to the Common Corporate Sector/ Business Sector, in which a set of statistical units, such as municipalities and other entities from public administrations, are excluded since 2012.



Source: APA (include estimates).

Figure 6-9: Quantities of combusted industrial waste

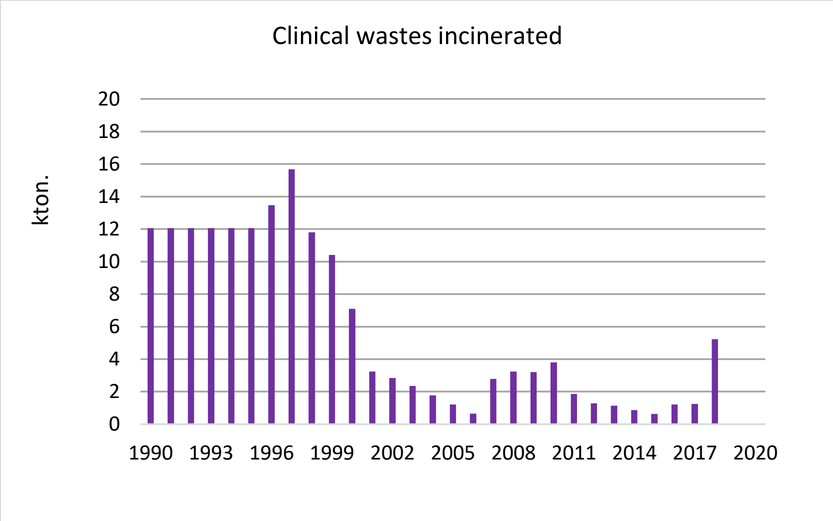
The fluctuations on the amounts of industrial waste incineration, as shown in the previous figure, results, at least partially, from the variation of fluxes to other treatments (landfilling, shipping abroad and recycling) as a consequence of the annual waste market demand.

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 Clinical waste (NFR 5.C.1.b.iii)

Data on clinical 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 clinical 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 clinical waste incinerator is operating since 2004. This infrastructure is nowadays closed.



Sources: APA; DGS.

Figure 6-10: Quantities of clinical 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 hospital wastes, as well as drug residues, animal by-products and other residues 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).

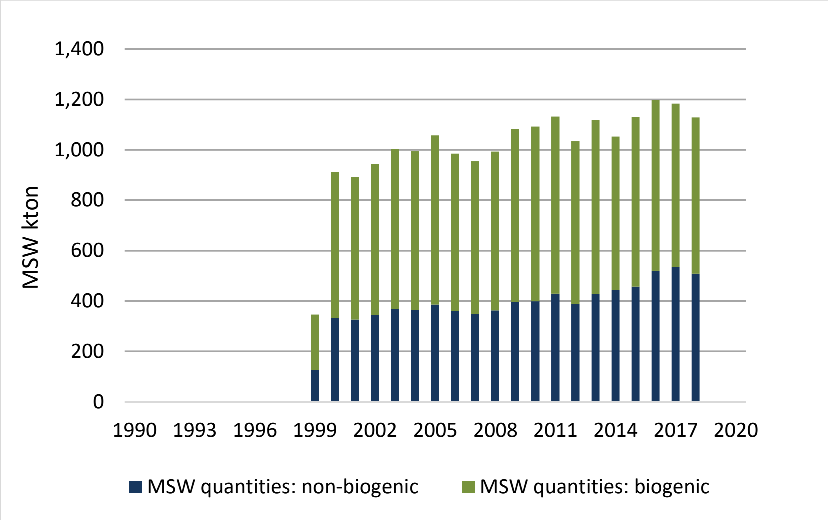


Figure 6-11: Quantities of Municipal Solid Waste incinerated

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 clinical 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 clinical 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)

The inventory covers the cremation of human corpses. 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	-

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/National Institute for Water 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.) 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 Açores.

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	2006	2007	2008	2009	2010	2015	2016	2017	2018
		% population													
Population without sewerage		**38.5**	**31.6**	**21.2**	**22.3**	**27.5**	**24.0**	**23.0**	**22.0**	**21.0**	**21.2**	**16.1**	**16.0**	**16.0**	**15.9**
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	0.0	0.0
1.2-	% Pop: individual treatment (private septic tanks)	1.5	8.2	14.8	16.9	27.5	24.0	23.0	22.0	21.0	21.2	16.1	16.0	16.0	15.9
Population with sewerage		**43.3**	**47.4**	**36.8**	**31.9**	**7.5**	**6.0**	**7.0**	**8.0**	**8.0**	**7.1**	**1.5**	**1.5**	**1.5**	**1.5**
2.1-	% de Pop: with discharge into the ocean, without treatment	6.5	6.5	6.5	5.6	1.0	1.0	1.3	1.5	1.2	1.1	0.4	0.4	0.4	0.4
2.2-	% de Pop: with discharge into inland waters, without treatment	36.8	40.8	30.3	25.9	4.0	3.0	2.5	1.9	1.2	1.1	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	0.0	0.0
2.4-	% de Pop: unknown disposal	0.0	0.0	0.0	0.4	2.4	2.0	3.3	4.6	5.6	4.9	0.9	0.9	0.9	0.9
3-	**% Pop: with treatment**	**18.2**	**21.1**	**42.0**	**45.8**	**65.0**	**70.0**	**70.0**	**70.0**	**71.0**	**71.7**	**82.4**	**82.4**	**82.5**	**82.6**
3.1-	**% Pop: colective septic tanks**	2.2	2.3	5.0	5.0	5.0	7.0	5.1	3.3	3.0	2.7	0.7	0.7	0.7	0.7
3.2-	**% Pop: with preliminary treatment**	0.0	0.0	0.0	0.5	3.0	7.0	7.5	8.0	7.6	6.9	1.8	1.8	1.8	1.1
3.3-	**% Pop: with primary treatment**	5.2	5.2	9.0	8.5	6.0	3.0	4.4	5.9	1.9	2.9	10.1	10.1	10.1	9.5
3.4-	**% Pop: with secondary and tertiary treatment**	**10.8**	**13.6**	**28.0**	**31.8**	**51.0**	**53.0**	**52.9**	**52.9**	**58.5**	**59.3**	**69.7**	**69.8**	**69.8**	**71.3**
3.4.1-	Biodisks with anaerobic sludge digestion	1.1	1.4	2.0	1.7	0.2	0.2	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	0.8	0.6	0.3	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	18.9	18.2	17.5	16.7	18.3	30.8	30.9	30.9	30.9
3.4.4-	Activated sludge without anaerobic sludge digestion	1.4	2.0	4.6	5.8	11.7	11.9	11.6	11.3	14.0	14.4	18.4	18.5	18.5	18.5
3.4.5-	Laguning, with anaerobic pond	1.7	1.9	3.6	3.0	0.2	0.2	0.2	0.2	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	5.5	5.3	5.1	4.4	4.2	4.2	4.2	4.2	4.3
3.4.7-	Percolation beds with anaerobic sludge digestion	3.6	4.6	8.8	8.0	3.7	3.7	3.4	3.1	2.9	2.8	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	4.0	3.2	2.4	1.8	1.9	2.5	2.5	2.6	2.6
3.4.9-	Imhoff Tank	0.6	0.3	0.1	0.3	1.3	1.3	1.2	1.0	0.8	0.8	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	0.7	0.7	0.6	0.6	0.6	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	1.6	1.5	1.4	1.4	1.3	0.6	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	2.3	2.2	2.0	2.5	2.1	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	0.2	0.2	0.2	0.2	1.4	9.4	9.5	9.5	10.9
3.4.14-	With unspecified treatment	0.0	0.0	0.0	0.1	0.8	1.7	4.7	7.7	12.8	10.8	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 2016 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).

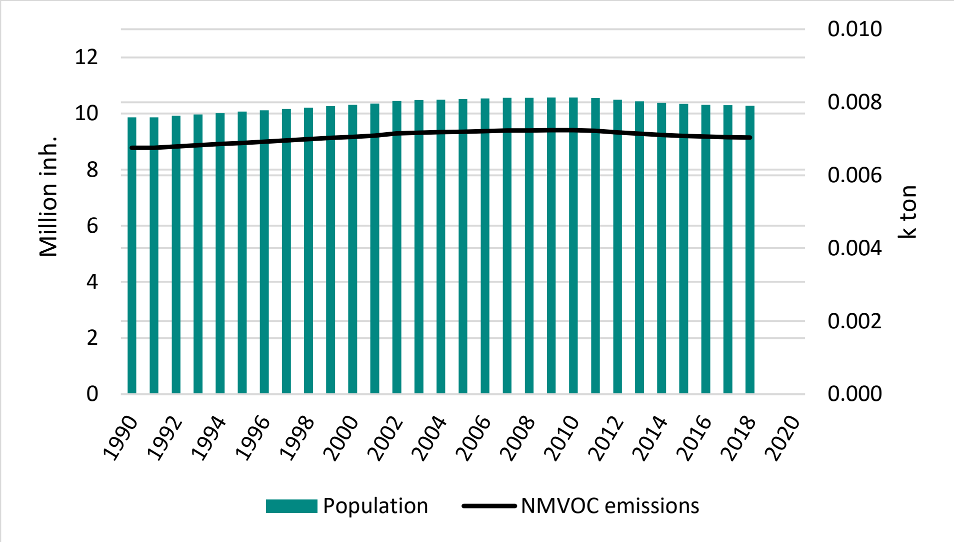


Figure 6-12: NMVOC emissions

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.

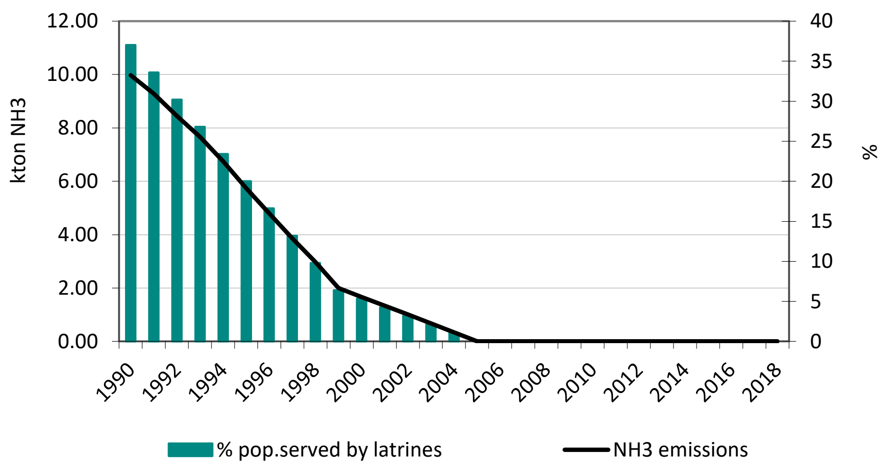


Figure 6-13: NH3 emissions and % population served by latrines

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	43.95
	2013	44.24
	2014	43.84
	2015	44.35
	2016	45.26
	2017	*45.26*
	2018	*45.26*
	2019	-
	2020	-
Fraction of nitrogen in protein	16%	2006 IPCC default
Fraction of non-consumed	20%	Expert judgement

Source: INE (2017), Portuguese Food Balance Sheet (BAP) - 2012 – 2016

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, which data is available annually from 1990 till 2017;
- 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			1990-2018	Cattle, sheep, goats and horses
Slaughter House, sw ine			1990-2018	
Slaughter House, Poultry			1990-2018	Broilers, Turkeys, ducks, quails, ostrich, guinea-fow l, geese, pheasants, partridge and pigeons
Meat Packing	311120	15130-1513013-151301190200	-	
Milk processing	3112		1994-2018	
Cheese	3112	15510	-	
Other dairy products	3112		1994-2018	Cream, yugurt, pow der milk, ice-creams
Fruit and vegetables conservation	3114		1994-2018	
Tomato juice			1994-2018	
Fruit Juices	3131+3132		1994-2018	
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			1993-2018	
Ethanol	313110	159101070; 1592011	-	
Spirits Distillation	3131+3132	1591010-159101070+1592012	-	
Wine Cellars	3131+3132	15930; 15950	2001-2018	
Beer	3133	1596010	-	
Mineral w ater and similars			1993-2018	

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;1710052 31/32/33/39/91/92/93 /99;1710055	171003039+17 1005231/32/33/ 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 w ere 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			1998-2018	
Soaps		2451131	-	
detergents		2451120/32	-	
Petroleum refining			-	Energy Balance (DGGE): 1990-2018

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.

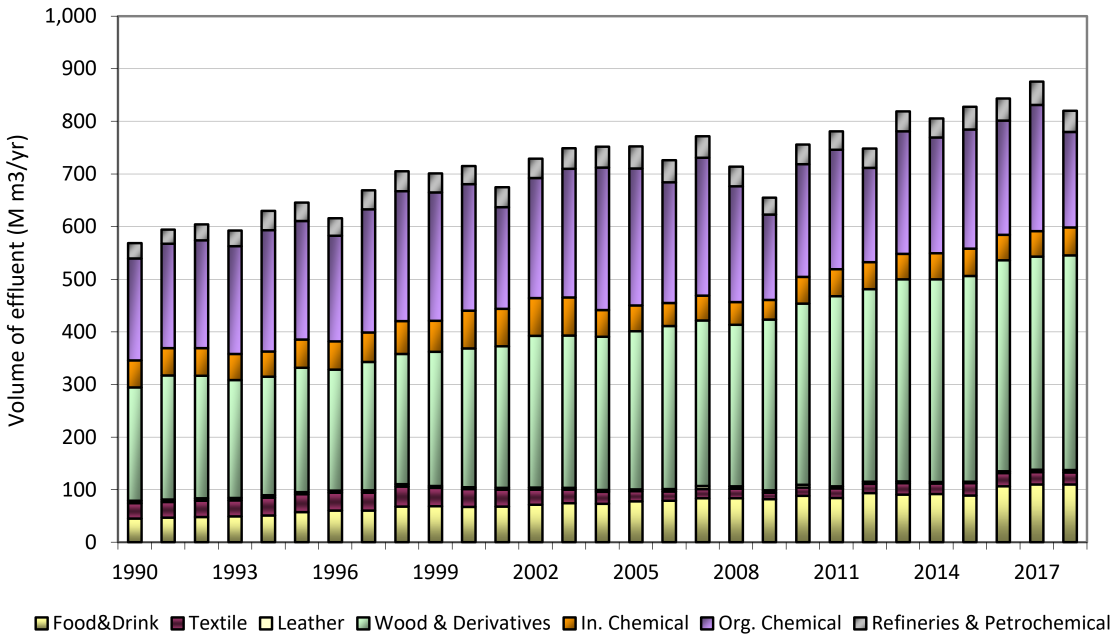


Figure 6-14: Industrial Wastewater discharges, expressed in 1000 m3, from major groups of industrial activity

The next figure presents the estimated total volumes of industrial wastewater produced and the elated NMVOC emissions during the period analysed.

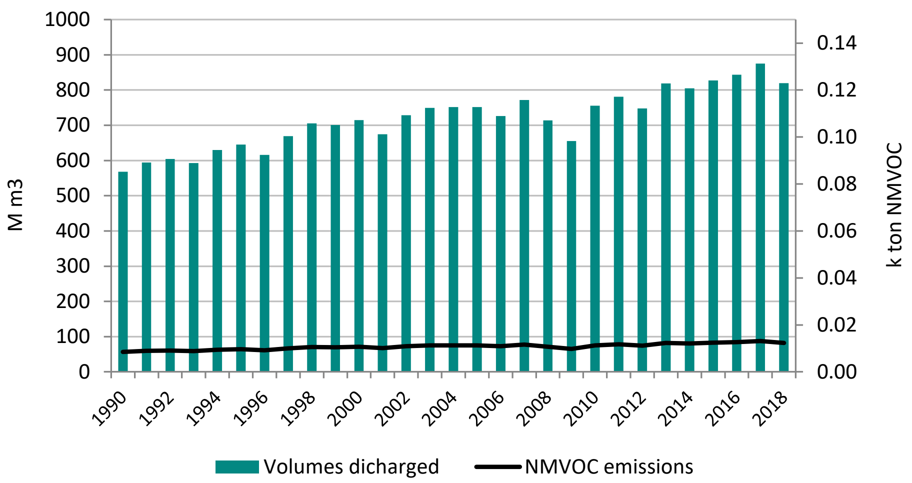


Figure 6-15: Total industrial wastewater discharge and NMVOC emissions

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.

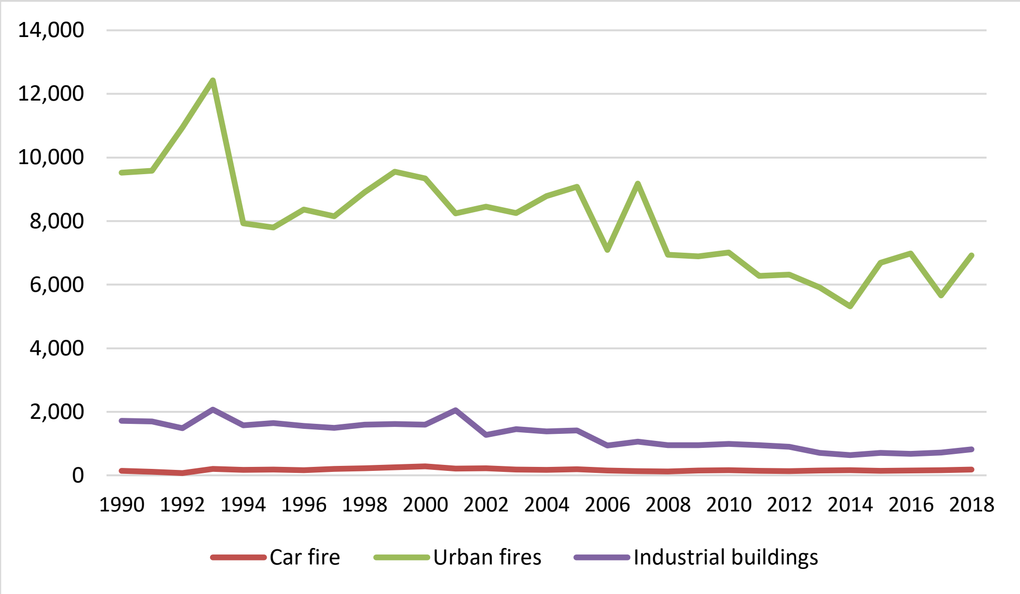


Figure 6-16: Number of fire occurrences

Table 6-18: Emission factors

	Unit	Car Fires		House Fires		Industrial Fires	
		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

No major recalculations have been made since last submission. Revisions refer to category Wastewater treatment and discharge (NFR 5D) due to the update of AD on industrial production.

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

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7 Memo Items

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

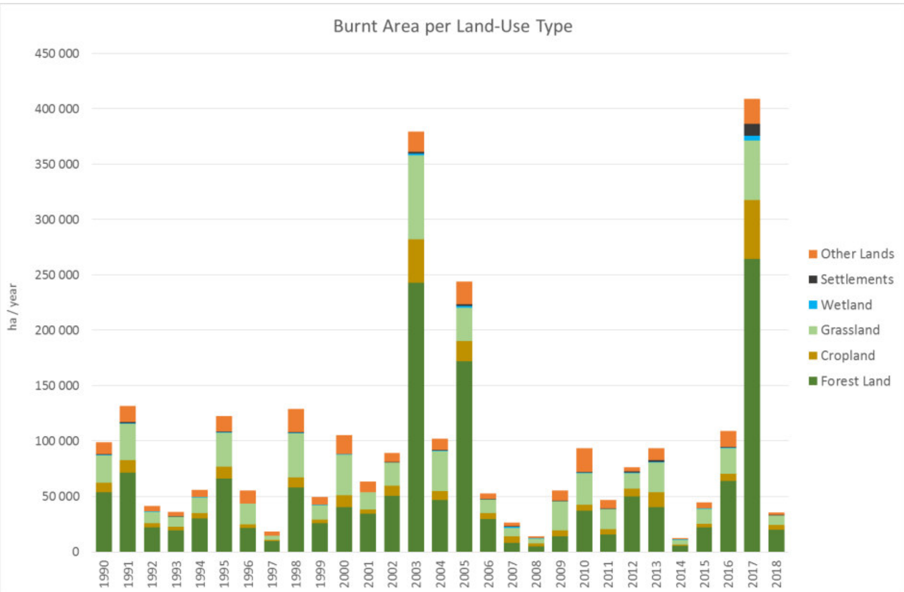


Figure 7-1: Wildfires: annual area burnt (1000 hectares)

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 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:

$$\text{Emissions NMVOC (expressed as CH4)} = L_{Direct} * \text{emission ratio} * 16/12$$

$$\text{Emissions CO} = L_{Direct} * \text{emission ratio} * 28/12$$

$$\text{Emissions TSP} = L_{Direct} * \text{emission ratio}$$

$$\text{Emissions NOx} = L_{Direct} * \text{ratio N/C (0.01)} * \text{emission ratio} * 46/14$$

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 1995 GgC/1.000ha	Above Ground Biomass 2005 GgC/1.000ha	Above Ground Biomass 2010 GgC/1.000ha	Litter All years GgC/1.000ha	Notes
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 a

(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 ⍰-pinene and ⍰-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 kd dm/m2		Vegetation Period	ε 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	
Mixed broadleaves/ coniferous	-	380	Average other species	Mixed Evergreen and Deciduous	-	Average other species	-	Average other species	1.5	

Tree Specie		D kd dm/m2		Vegetation Period	ε µgC/g dm/h @standart L,T Isoprene		Monoterpenes		OVOC
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:

$$C_L = \frac{0.0027 * 1.066 * Q}{\sqrt{1 + (0.027 * Q)}}$$

Where:

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 ɣ

Specie	Compound	Equation	Reference
P. Pinaster	Monoterpernes	ɣ = exp[0.138 * (T-30)]	Pio et al (1999)
Eucalyptus	Monoterpenes	ɣ = exp[0.07 * (T-30)]	Nunes (1996)
Cork Oak	Isoprene	ɣ = {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	ɣ = {CL*CT + exp[0.09* (T-Ts)]}	-

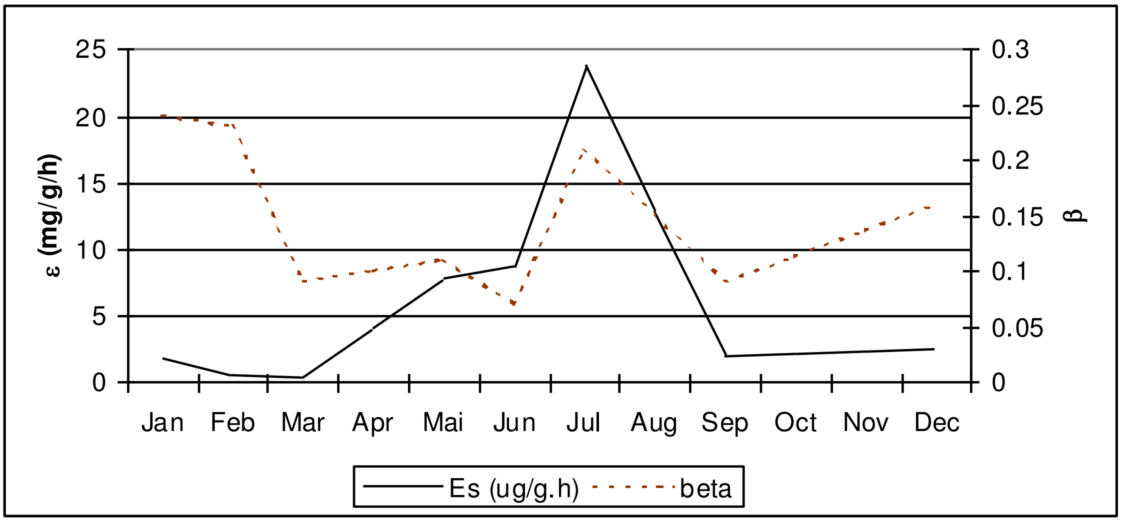


Figure 7-2: Time variable Ɛ for Cork Oak (adapted from Silva et al, 1999)

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:

$$\gamma_{(n,s)} = \sum_{m,h} \{ \gamma [PAR_{(n,m,h)}, T_{(n,m,h)}, s] \}$$

Where:

$\gamma [PAR_{(n,m,h)}, T_{(n,m,h)}, s]$: 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)

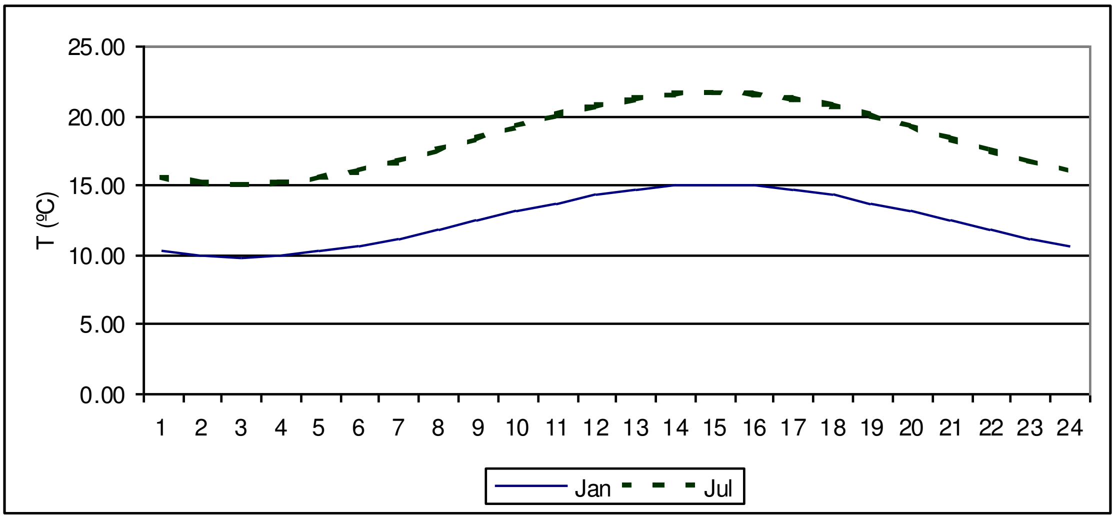
specie	1990	1995	2000	2005	Last year
Pinus pinaster	1,069,000	976,069	974,015	741,741	741,741
P. Pinea	35,000	77,650	83,559	102,143	77,650
Other conifer	69,000	27,358	29,440	46,499	70,992
Quercus suber	693,000	712,813	728,693	851,958	851,958
Q. Rotundifolia	462,000	461,577	465,295	420,244	420,244
Other 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.

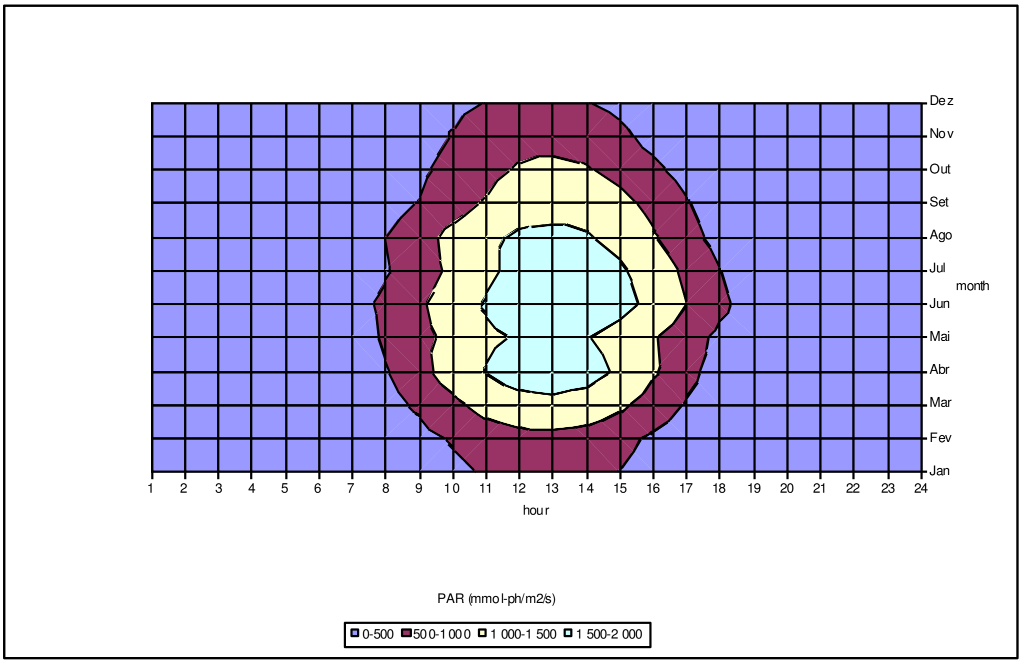


Figure 7-4: Pattern of evolution of PAR (mmol/m2/s) according to month and hour of day (Nunes, 1996)

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

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8 Recalculations and Improvements

8.1 Overview of the review process

The next table presents the status of implementation of recommendations issued from the 2018 and 2019 NECD review process: Final Review Report 2019 Third phase of review of national air pollution emission inventory data pursuant to the Directive on the Reduction of National Emissions of Certain Atmospheric Pollutants (Directive (EU) 2016/2284 or 'NECD'), 22 November 2019, Table 1: Recommendations from the NECD Review 2018, for NOX, NMVOC, SO2, NH3, PM2.5 that have not been implemented in the inventory submission 2019, Table 2: Additional recommendations made during the NECD Review 2019 for NOX, NMVOC, SO2, NH3, PM2.5 and Table 3: Additional recommendations made during the NECD Review 2019 for POPs and heavy metals.

Table 8-1: Reporting on implementation of NECD recommendations

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
PT-0A-2019-0001	No	0A National Total - National Total for the Entire Territory - Based on Fuel Sold/Fuel Used, PAHs, 1990-2017	For some source categories such as 1A2e, 1A2gviii or 5C1bi and pollutants PAHs, the TERT noted that Portugal does not report PAHs separately, but only includes the total PAH value in the NFR tables. In response to a question raised during the review, Portugal explained that this will be further improved for the next submission. The TERT agreed with the explanation provided by Portugal. The TERT recommends that Portugal reports PAHs as a total and individually for all relevant source categories as required by the Reporting Guidelines**.**	No	Addressing.	
PT-1A2f-2017-0003	Yes	1A2f: Non-metallic Minerals; SO2; 2000-2015	For NFR category 1A2f Stationary Combustion in Manufacturing Industries and Construction: Non-metallic Minerals and SOX emissions, the TERT noted that the emission factor for tiles and other ceramics was higher than the emission factors in the 2016 EMEP/EEA Guidebook. The TERT recommends that Portugal revises the emission factor based on new information of the sulphur content and recalculates emissions to the next submission. Assessment of implementation: The TERT reiterates the recommendation to obtain the actual Sulphur content of fuels from refineries and to report an improved estimate for all affected categories as part of the next submission	No	Response during Review: Portugal explained that the emission factor used is calculated from the sulphur content in the fuel oil. This information was provided by refineries in 1990-1994. Portugal explained that they intend to review the emission factors used in the estimation of emissions of the ceramics sector for the next submission. Status at Submission: Addressing. Contacts were made with the refineries to obtain more current information on the sulfur content of liquid fuels. However, we have not received an answer so far. Alternatively, SO2 emission estimates are now estimated on the basis of national legal limits for sulfur content in liquid fuels for the ceramics industry.	NFR Tables 3.3.3 Emission Factors
PT-1A3ai(ii)-2017-0001	No	1A3ai(ii) International Aviation Cruise	For category 1A3ai(ii) International Aviation Cruise (Civil) and PM2.5 for all years, the TERT noted that	No	Status at Submission: Due to time and resources constraints, it was not possible to include PM 2.5 Cruise emissions in this submission. It was	3.4.1 Civil Aviation (NFR 1.A.3.a)/ 3.4.1.7

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
		(Civil); PM2.5; 1990-2015	Portugal answered to the previous recommendation (PT-1A3ai(ii)-2017-0001) in its IIR. Portugal writes that it was not possible to include PM2.5 in this submission. This recommendation implies several changes to the database and will be implemented as soon as possible. In response to a question raised during the review, Portugal explained that it will not be possible to make all changes in time for the 2019 submission, so the implementation of this improvement is planned for a later submission. The TERT understands and recommends that Portugal include these emissions as soon as possible and report on the progress of implementing this recommendation in the IIR. Assessment of implementation: The TERT recommends that Portugal reports PM2.5 emissions from sectors 1A3ai(ii) and 1A3aii(ii)		included in the IIR indication that we intend to include these emissions in a future submission	Further Improvements
PT-1A4bii-2017-001	No	1A4bii Residential: Household and Gardening (Mobile); SO2, NOX, NH3, NMVOC, PM2.5; 1990-2015	2017 Review: For category 1A4bii Residential: Household and Gardening (Mobile), the TERT noted that activity data and emissions are reported as 'included elsewhere' ('IE'), assuming from the information available from the IIR that these data are included in category 1A4bi Residential: Stationary. The TERT acknowledged the answer provided by Portugal, understanding that separate fuel consumption data might be hard to obtain. However, the TERT recommends that Portugal puts further effort into making the needed input data available (for example via modelling studies).	No	Response during Review: Portugal explained that it will be necessary to investigate if there is a source of information that allows to apply a proxy to the values reported in the Energy Balance. Portugal cannot provide a date for the implementation of this improvement, since it is not considered a priority in the 2019 methodological development plan. Status at Submission: Not Implemented. We intend to include this task in the methodological development plan for 2020.	3.5 Small Combustion 3.5.7 Further Improvements

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			2018 Review: The TERT recommends that Portugal looks for a proxy to be able to separate activity data (for example via modelling) and to report on the progress made in the next IIR. Assessment of implementation: The TERT recommends that Portugal reports separate emissions from categories 1A4bi and 1A4bii in its next submission			
PT-1A4cii-2017-0001	Yes	1A4cii: Off-road Vehicles and Other Machinery; SO2, NOX, NH3, NMVOC, PM2.5; 2003, 2004	For category 1A4cii Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery and the years 2003 and 2004, the TERT noted that activity data for liquid fuels show remarkable declines. The TERT agreed with the answer provided by Portugal. However, the TERT recommends that Portugal checks the options to revise the activity data in order to resolve any inconsistencies. Furthermore, for the time being, the TERT recommends that Portugal includes sufficient information on such country-specific circumstances in the IIR. Assessment of implementation: The TERT recommends that Portugal finalize the allocation of emissions in all sub-sectors of 1A4 in its next submission.	No	Response during Review: Portugal explained that in 2003, marked diesel for heating was introduced, separating the consumptions of diesel used for mobile and stationary combustion purposes Status at Submission: Addressing. In the 2019 submission, a QAQC analysis was included to sector 1A4, trying to identify inconsistencies between consumption allocation between subsectors, Commercial, Residential and Agriculture.	3.5 Small Combustion 3.5.5 Category-specific QA/QC 3.5.7 Further Improvements
PT-1A5b-2017-0001	No	1A5b Other, Mobile (Including Military, Land Based and Recreational Boats); SO2, NOX, NH3, NMVOC,	For category 1A5b Other, Mobile (including Military, Land Based and Recreational Boats) and all pollutants for all years, the TERT noted that Portugal does not explain in the IIR as recommended previously (PT-1A5b-2017-0001) the reasons of strong fluctuations in the reported activity data. The TERT noted that no improvement are planned for this sector. In response	No	This issue was discussed with DGEG that confirmed the activity data and indicated that the fluctuations in Jet Fuel consumption is related to the budget availability and the frequency of training and missions of the military aviation activities. This information was included in the IIR.	3.6.1 Military Aviation (NFR 1.A.5.b)/ 3.6.1.3 Activity data

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
		PM2.5; 1990-2015	to a question raised during the review, Portugal explained that the Energy Balance data compiled by the national energy authority (DGEG) are based on fuel sales from market operators by economic activity (CAE rev 3). Accordingly, it is not possible to ensure that the fuel fluctuations under the CAE “Serviços” is related to stock holding due to the confidentiality of military data; Portugal explain that no improvements are planned for now. The TERT recommends that Portugal explain transparently the possible source of fluctuations in its next IIR submission. Assessment of implementation: The TERT recommends that Portugal report on the under lying causes of these fluctuations in its next submission			
PT-1B2b-2017-0001	No	1B2b Fugitive emissions from Natural Gas; SO2, NMVOC; 1990-2015	For category 1B2b Fugitive Emissions from Natural Gas, pollutants NMVOC and SO2, the TERT noted a lack of transparency regarding the NMVOC methodology, and a potential under-estimate of emissions of SO2, following the partial implementation of recommendation PT-1B2b-2017-0001 from the 2017 NECD review. The TERT also noted a calculation error in the derivation of NMVOC emission estimates. The TERT notes that the under-estimations of NMVOC and SO2 emissions are below the threshold of significance for a technical correction. The TERT recommends that Portugal include the methodology detail for NMVOC in the 2019 submission to improve transparency, corrects the calculation error for NMVOC emissions, and progresses research to estimate fugitive SO2 emissions for the 2019 submission.	No	Response during Review: Portugal provided the explanatory data, and confirmed the error in NMVOC calculations leading to an under-estimate of emissions below the threshold of significance for a technical correction, and provided the TERT with a time series of corrected NMVOC emissions. Portugal stated that they will investigate information concerning the sulphur content in natural gas to enable estimation of SO2 emissions for the next submission. Status at Submission: Addressing. In 2019 the error in NMVOC calculations was corrected. However, no progress has been made in the collection of information that allows the determination of the sulfur content in Natural Gas.	3.9 Fugitive Emissions from Natural Gas NFR Tables

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			Assessment of implementation: The TERT reiterates the recommendation that Portugal estimates fugitive SO2 emissions in the 2020 submission			
PT-1A2a-2019-0001	No	1A2a Stationary Combustion in Manufacturing Industries and Construction: Iron and Steel, $PM_{2.5}$, 2000, 2001, 2007	For $PM_{2.5}$ emissions from 1A2a Stationary Combustion in Manufacturing Industries and Construction: Iron and Steel and years 2000, 2001 and 2007, the TERT noted that no emissions were reported while emissions are expected. In response to a question raised during the review, Portugal acknowledged the missing estimates and stated its intent to include these in the 2020 submission. The TERT noted that the issue is below the threshold of significance for a technical correction. The TERT recommends that Portugal includes the missing $PM_{2.5}$ emissions in the 2020 submission**.**		Implemented. Iron and Steel sector underwent major methodological changes.	Section 3.3.
PT-1A1a-2019-0001	Yes	1A1a Public Electricity and Heat Production, Cd, Hg, Pb, 2005, 2017, 2017	For Cd, Hg and Pb emissions from category 1A1a Public Electricity and Heat Production, the TERT noted that the ratio of these pollutants to PM_{10} are larger than for most other Member States and there could be an over-estimation of the emissions. Furthermore, the TERT noted that there is a lack of transparency in the IIR regarding the source of the emission factors used. In response to a question raised during the review, Portugal explained that emission factors from the AP-42 database are used. Furthermore, Portugal answered that they consider these emission factor to be outdated and intend to update them with the 2016 EMEP/EEA Guidebook factors. As an indication to where this would lead, a provisional estimate was sent with the answer. The TERT notes that the provisional estimation based on total fuel consumption in this sector show that emission levels are lower and in the range of most other Member States. However,		Addressing. The default emission factors of the AP42 for EMEP / EEA Guidebook 2019 were updated. As explained during the review, the transition to the estimation of emissions through monitoring is very time consuming, and it was not possible to make this methodological improvement in time. to include it in the 2020 submission.	3.2.1.3 Emission factors

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			Portugal stated that implementing a complete Tier 2 or country-specific methodology is very time consuming and impossible during the review and that their intention is to apply this installation approach in the estimates of heavy metals in the 2020 submission. The TERT recommends that Portugal completes the transition to the installation approach and reports the emissions under this method and the necessary documentation in the 2020 submission.			
PT-1A2a-2019-0002	No	1A2a Stationary Combustion in Manufacturing Industries and Construction: Iron and Steel, Cd, PCDD/F, Hg, Pb, 1990, 2005, 2016, 2017	For 1A2a Stationary Combustion in Manufacturing Industries and Construction: Iron and Steel, emissions of Cd (1990, 2005, 2016, 2017); PCDD/F (1990, 2005); Hg (1990, 2005, 2016, 2017); Pb (2005, 2016, 2017), the TERT noted that the notation key 'NE' is used whilst a Tier 1 methodology is available in the 2016 EMEP/EEA Guidebook. In response to a question raised during the review, Portugal acknowledged the missing estimates and stated its intent to include these in the 2020 submission. The TERT noted that the issue is below the threshold of significance for a technical correction. The TERT recommends that Portugal includes the missing emissions for all years in the time series in the 2020 submission.		Implemented. Iron and Steel sector underwent major methodological changes.	Section 3.3 NFR Tables.
PT-1A2b-2019-0001	No	1A2b Stationary Combustion in Manufacturing Industries and Construction: Non-ferrous Metals, HCB, 1990	For HCB emissions coming from 1A2b Stationary Combustion in Manufacturing Industries and Construction: Non-ferrous Metals, year 1990, the TERT noted that the notation key 'NA' is used whilst a Tier 1 method is available in the 2016 EMEP/EEA Guidebook. In response to a question raised during the review, Portugal answered that this is an error as the energy consumption cannot be split, all		Implemented	NFR Tables

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			emissions are included in 1A2gviii and stated this will be corrected in the next submission. The TERT recommends that efforts are made to split the energy consumption for these sources and that in the meantime the correct notation key ('IE') is used for 1A2b in the NFR tables			
PT-1A2f-2019-0001	No	1A2f Stationary Combustion in Manufacturing Industries and Construction: Non-metallic Minerals, Cd, 2017	For emissions of Cd from 1A2f Stationary Combustion in Manufacturing Industries and Construction: Non-metallic Minerals, year 2017, the TERT noted that the ratio of Cd to PM_{10} is high compared to the average from all other Member States. In response to a question raised during the review, Portugal explained that in the case of cement plants the production approach is used, with the emission factor inferred from specific monitoring at each of the six facilities in the country. Portugal has reviewed the specific emission factors of each facility and concluded that some factors are outdated and that there is a need for an update. The TERT recommends that Portugal updates the emission factors from the specific cement plants and includes a revised emission estimate in the 2020 submission.		Implemented. Cd emission factor was revised to a Tier 2 value according to Table 3-24 of the 2019 EMEP Guidebook.	Section 4.2.1.3
PT-2D3g-2017-0001	Yes	2D3g Chemical Products; NMVOC; 1990-2015	For category 2D3g Chemical Products and pollutants NMVOC for the whole time series, the TERT noted that Portugal implemented the recommendation PT-2D3g-2017-0001 regarding the estimation of NMVOC emissions, but asked for further clarification on methods used, AD and EF. For Pharmaceutical Products Manufacturing. The TERT recommends that Portugal include the new estimate in its next submission, and add related information in the IIR.	No	Status at Submission: For Pharmaceutical Products Manufacturing: Implemented For asphalt blowing processes. Addressing. Portugal will further investigate if this process occurs in any other facilities besides refineries.	Pharmaceutical Products Manufacturing: Section 4.5.24 Asphalt Blowing: Section 4.5.26 Adhesive, Magnetic Tapes, Films and

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			For asphalt blowing processes. The TERT recommends that Portugal investigate if asphalt blowing process occurs only in refineries, and implement NMVOC estimates, if relevant, or provide feedback resulting from the investigation in its next submission For Adhesive, Magnetic Tapes, Films and Photographs Manufacturing, the TERT recommends that Portugal keeps on assessing if a Tier 2 methodology can be applied, and to inform on that progress in its next submission. For Leather tanning, Portugal confirmed that there was an error in the IIR. The TERT recommends that Portugal fixes this error, for transparency reasons, in its next submission. For manufacture of tyres, The TERT agreed with the explanation provided by Portugal and recommends that Portugal implement it in its next submission, or provide information on the progress of this implementation in its next IIR. Assessment of implementation: The TERT recommends that Portugal implements emission estimates for all those sources in its next submission		For Adhesive, Magnetic Tapes, Films and Photographs Manufacturing: Implemented For manufacture of tyres: Implemented.	Photographs Manufacturing: Section 4.5.27 Tyre Production: Section 4.5.30
PT-2D3i-2017-0002	Yes	2D3i Other Solvent Use; NMVOC; 1990-2015	For 2D3i Other Solvent Use, the TERT noted that for the other pollutants than NMVOC, and according to the 2016 EMEP/EEA Guidebook, the notation keys should be 'NE' instead of 'NO'. The TERT recommends that Portugal reports appropriate NKs in its next submission. Further, the TERT recommends Portugal to further investigate the trends and abatement technologies and include information in the IIR in the next submission. Assessment of implementation: The TERT recommends that Portugal further investigate the	-	Status at Submission: Addressing. Notation keys were corrected in NFR Tables. We intend to discuss the share of each abatement technology with sectoral associations	NFR Tables

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			trends and abatement technologies and include information in the IIR in the next submission			
PT-2L-2018-0001	No	2L Other Production, Consumption, Storage, Transportation or Handling of Bulk Products, PM2.5, 2005.2010, 2015	For category 2L Other Production, Consumption, Storage, Transportation or Handling of Bulk Products and pollutant $PM_{2.5}$, the TERT noted that Portugal did not report the $PM_{2.5}$ emissions from handling of agricultural products. This was first raised during the 2018 NECD review. In response to a question raised by the 2019 TERT regarding emissions in 2L, Portugal explained that these emissions were not estimated by mistake and Portugal plans to report those under NFR 2H2. Portugal provided a revised estimate for year 1990-2017 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 2020 NFR submission and clearly addresses the allocation issue in its IIR.	RE	Implemented. PM emissions from handling of agricultural products are now estimated and reported under category 2.H.2 – Food Manufacturing. Following further analysis to chapter 2.L of the 2019 EMEP Guidebook, we concluded that there is no other production, consumption, storage, transportation or handling of bulk products. Therefore, this category will be reported as NO.	Chapter 4.5.45 NFR Tables
PT-2D3a-2019-0001	Yes	2D3a Domestic solvent use including fungicides, NMVOC, 1990-2017	For NFR category 2D3a Domestic solvent use including fungicides, pollutant NMVOC, all years, the TERT noted that Portugal uses all of the emission factors from table 3.5 of chapter 2D3a of the 2016 EMEP/EEA Guidebook, while these should mainly be used for gap filling. In response to a question raised during the review, Portugal explained that no detailed statistics are available to calculate emissions by applying the emission factors from tables 3.2 or 3.4 of chapter 2D3a. Portugal provided a revised estimate for years 1990-2017 using data from ESIG and default mapping and correction factors from the 2016 EMEP/EEA Guidebook. The TERT agreed with the revised estimate provided by Portugal, but the TERT notes that there is a steep	RE	Implemented. Domestic solvent use sector underwent major methodological changes.	Chapter 4.5.1

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			decrease in emissions per capita between 2008 and 2013. The TERT recommends that Portugal include the revised estimate in its 2020 NFR and IIR submission and check the trend in NMVOC emissions in this sector.			
PT-2A2-2019-0001	No	2A2 Lime Production, $PM_{2.5}$, 1990-2017	For category 2A2 Lime Production and pollutant $PM_{2.5}$, complete time series, the TERT noted that Portugal uses emission factors from the 2009 EMEP/EEA Guidebook. In response to a question raised during the review, Portugal acknowledged the dated emission factors for TSP, PM_{10} and $PM_{2.5}$ and explained that these emission factors will be exchanged for the ones in the 2016 EMEP/EEA Guidebook in the next submission. The TERT noted that the issue is below the threshold of significance for a technical correction. The TERT recommends that Portugal calculates the $PM_{2.5}$ emissions in 2A2 using emission factors from the 2016 EMEP/EEA Guidebook and to update the IIR accordingly.		Implemented. TSP, PM_{10} and $PM_{2.5}$ these emission factors were updated according to Table 3.2 of Chapter 2.A.2 of 2019 EMEP Guidebook.	Section 4.2.2.3
PT-2D3e-2019-0001	Yes	2D3e Degreasing, NMVOC, 1990-2017	For category 2D3e Degreasing and pollutant NMVOC, complete times series, the TERT noted that a Tier 1 method is applied to calculate emissions from this key category. In response to a question raised during the review Portugal explained that they do not apply a Tier 2 approach given the fact that there is no available stratified data regarding the different degreasing technologies and abatement techniques that may occur in the country. Portugal indicated that they will further investigate if there is such data and report on the progress in the next submission. The		Not Implemented. We intend to gather information regarding the different degreasing technologies and abatement techniques, however, so far we were not able to find available data.	

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			TERT noted that the issue is below the threshold of significance for a technical correction. The TERT recommends that Portugal investigates the occurrence of different degreasing technologies and abatement techniques and calculates the NMVOC emissions in 2D3h using a higher Tier methodology.			
PT-2D3h-2019-0001	Yes	2D3h Printing, NMVOC, 1990-2017	For category 2D3h Printing and pollutant NMVOC, complete times series, the TERT noted that a Tier 1 method is applied to calculate emissions from this key category. In response to a question raised during the review Portugal explained that they do not apply a Tier 2 approach given the fact that there is no available stratified data regarding the different printing processes that may occur in the country. Portugal indicated that they will further investigate if there is such data and report on the progress in the next submission. The TERT noted that the issue is below the threshold of significance for a technical correction. The TERT recommends that Portugal investigates the occurrence of different printing processes and calculates the NMVOC emissions in 2D3h using a higher Tier methodology.		Not Implemented. We intend to gather information regarding the different printing processes, however, so far we were not able to find available data.	
PT-3F-2019-0002	Yes	3F Field Burning of Agricultural Residues, PAHs, 1990, 2005, 2016, 2017	For 3F Field Burning of Agricultural Residues the TERT noted that there may be an over-estimate of PAH emissions for years 1990-2017. This over-estimate may have an impact on total emissions that is above the threshold of significance. The TERT noted that this over-estimate might be because of an update to 3F PAH emission factor (Table 3-1) in the 2016 EMEP/EEA Guidebook, which was significant higher in previous versions of	RE	Implemented	Chapter 5.4.3 of the IIR and NFR tables

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			the Guidebook. In response to a question raised during the review, Portugal explained that the update of the 2016 EMEP/EEA Guidebook was not noticed and provided a revised estimate for PAH emissions from 3F category and years 1990-2017 based on the updated PAH EFs. Portugal stated that it will include the RE 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 2020 submission.			
PT-3Df-2019-0002	No	3Df Use of Pesticides, HCB, 1990-2017	The TERT notes with reference to the IIR, p. 5-3, that Portugal does not report emissions from 3Df Use of Pesticides (NA), explaining that in Portugal the use of fungicides with HCB as active substance has not been allowed since 1986, according to information from the National Authority responsible for the management and authorization of plant protection products. However, the TERT notes that there may be an under-estimate of emissions. The October 2018 update version of the EMEP/EEA Guidebook notes that emissions from pesticides including HCB as impurity shall be currently reported. A Tier 1 default approach is available in the Guidebook. In response to a question raised during the review, Portugal explained that due to time and resource constraints it was not possible to implement the approach of the October 2018 updated version of the EMEP/EEA Guidebook, chapter 3.D.f, in the 2019 submission. The information from the National Authority referred in the 2019 IIR concerns the list of pesticides given in the previous version of the Guidebook. Thus, the notation key should be changed from 'NA' to 'NE'. Portugal		Implemented	Chapter 5.5 of the IIR and NFR tables

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			explained that it will start an investigation and intends to provide estimates for 2020 submission if the use of any of the pesticides listed in table 3 of the updated Guidebook version will be confirmed by the National Authority. The TERT recommends that Portugal carries out the investigation as announced in its answer to the review and that it includes estimates for HCB as soon as results are available			
PT-5-2019-0001	No	5C1biv Sewage sludge incineration, SO_2, NO_X, NMVOC, $PM_{2.5}$, BaP, PAHs, PCBs, HCB, Cd, Hg, Pb, PCDD/F, 2000-2017	For category 5C1biv Sewage sludge incineration and pollutants SO_2, NO_X, NMVOC, $PM_{2.5}$, BaP, PAHs, PCBs, HCB, Cd, Hg, Pb, PCDD/F for years 2000-2017, the TERT noted that emissions have been reported as 'included elsewhere (IE)' without providing information where these emission have been included. In response to a question raised during the review, Portugal explained that emissions from sewage sludge incineration are included in 5C1bi Industrial waste incineration. The TERT agreed with the explanation provided by Portugal and recommends Portugal to include this information in the IIR chapter on waste for the next submission.		Implemented	IIR section on Sewage sludge incineration (NFR 5.C.1.b.iv)
PT-5C1bii-2019-0001	No	5C1bii Hazardous Waste Incineration, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, BaP, PAHs, PCBs, HCB, Cd, Hg, Pb, PCDD/F, 2000-2017	For category 5C1bii Hazardous Waste Incineration the TERT noted that emissions have been reported as 'included elsewhere' (IE) without providing information where these emissions have been included. In response to a question raised during the review, Portugal explained that emissions from hazardous waste incineration are included in 5C1bi Industrial Waste Incineration. The TERT agreed with the explanation provided by Portugal and recommends Portugal to include this		Implemented	IIR section on Hazardous Waste Incineration (NFR 5.C.1.b.ii)

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation/ assessment of implementation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			information in the IIR chapter on waste in the next submission.			
PT-5C2-2019-0001	No	5C2 Open Burning of Waste, SO_2, NO_X, NMVOC, $PM_{2.5}$, BaP, PAHs, PCBs, HCB, Cd, Hg, Pb, PCDD/F, 2000-2017	For category 5C2 Open Burning of Waste and pollutants SO_2, NO_X, NMVOC, $PM_{2.5}$, BaP, PAHs, PCBs, HCB, Cd, Hg, Pb, PCDD/F for years 2000-2017, the TERT noted that emissions have been reported as 'not occurring (NO)' without providing further information. In response to a question raised during the review, Portugal explained that open burning of waste is prohibited, and any emissions resulting from burning of wood and other plant material are considered in the agricultural sector. The TERT agreed with the explanation provided by Portugal and recommends Portugal to include this information in the IIR chapter on waste in its next submission.		Implemented	IIR section Waste Incineration (NFR 5.C)/introduction
PT-5E-2019-0001	No	5E Other Waste, SO_2, NO_X, NMVOC, PCBs, HCB, 2000-2017	For category 5E Other Waste and pollutants SO_2, NO_X, NMVOC, PCBs, HCB for years 2000-2017, the TERT noted that Portugal used the notation key 'not occurring (NO)'. The 2016 EMEP/EEA Guidebook does not provide default emission factors for this category, but considers this emission as potentially existing from house and car fires. In response to a question raised during the review, Portugal explained that it will change the notation key to 'not estimated (NE)' in the next submission. The TERT agreed with the explanation provided by Portugal and recommends to either report emissions or use the notation key 'NE'.		Implemented	NFR Annex 1 Tables

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 2018 NECD review process, 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)

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

Update of Pb, Cd and Hg emission factors.

Solid Fuel Transformation – Metallurgical Coke Production (CRF 1.A.1.c)

Methodological changes to the sector: update of activity data; revision of emission factors.

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

The main recalculations in category 1.A.2 are mainly due to the revision of the methodology for estimating emissions made to the subcategory Iron and Steel, and the estimate for the first time of the category Mobile combustion in industry and construction.

In subcategory Cement production, Cd emission factor was revised to a Tier 2 value according to Table 3-24 of the 2019 EMEP Guidebook, for the whole time series; 2016 and 2017 fuel consumption data were updated.

Road Transportation (NFR 1.A.3)

The major changes between submissions result from the following actions:

- Estimation of the CO2 emissions from the fossil part of biofuels, from 2006 to 2018, in accordance with the “note on fossil carbon content in biofuels” developed by the Working Group I – “Annual inventories” under the Climate Change Committee.
- Allocation of petrol consumption, between 1990 and 2011, from 1A4a (Comercial/Institutional) in the Road Transportation sector as described in 3.6 Other Sectors (1A4).
- Allocation of diesel consumption, between 1990 and 1997, from 1A4c (Agriculture) in the Road Transportation sector as described in 3.6 Other Sectors (1A4).
- Correction of a compilation error detected in dioxins emissions.
- Update of activity data::
    - revision of the 2014 and 2017 Energy Balances data provided by DGEG;
    - revision of the stock data from 2014 to 2017;
    - revision of the assumed mileage percentage driven by each driving mode.

Small Combustion (NFR 1.A.4)

The main recalculations in category 1A4 are related to the allocation of diesel fuel consumption to the Road Transport sector. Explanations regarding the rationale for this allocation can be found in the previous section on the category's QA / QC.

International navigation (marine bunkers) – Memo Item

Recalculations for this source category comprise a revision of the 2013, 2014 and 2017 Energy Balances data provided by DGEG.

8.2.2 Recalculations Industrial Processes sector (NFR 2)

The major changes between submissions (2018 and 2019) result from the following actions:

- 2.A.1 (Cement production): Cd emission factor was revised to a Tier 2 value according to Table 3-24 of the 2019 EMEP Guidebook, for the whole time series; 2016 and 2017 fuel consumption data were updated;
- 2.A.2 (Lime production): TSP, PM_{10} and $PM_{2.5}$ emission factors were updated according to Table 3.2 of Chapter 2.A.2 of 2019 EMEP Guidebook; NOx, SOx, NMVOC and CO emissions from lime production were removed, given that, according to section 3.2.2 of chapter 2.A.2 of the 2019 EMEP Guidebook, it is expected that they are due to the combustion of fuels;
- 2.A.5.b (Construction and Demolition): 2017 data on the number of new houses/apartments constructed and non-residential construction was revised by INE; In the period 1990-2002, data on the number of new houses/apartments constructed and non-residential construction was updated for the period 1990-2002 based on the average from 2003-2007 values and on GDP trend, also from INE;
- 2.A.5.c (Storage, handling and transport of mineral products): A new data series on imports was obtained from EUROSTAT;
- 2.B.10.a (Polystyrene): 2008 to 2010 activity data were updated based on national statistics;
- 2.C.1 (Iron and Steel Production): Methodological revision of the sector for the whole time series;
- 2.C.3 (Aluminium Production): Update on assumptions to reflect Portuguese legislation regarding the use of HCE in aluminium production industry;
- 2.C.7.d (Storage, Handling and Transport of Metal Products): Activity data were revised for the whole time series upon revision of iron, aluminium, copper and lead’s activity data;
- 2.D.3.a (Domestic solvent use including fungicides): Methodological revision of the sector for the whole time series;
- 2.D.3.b (Road Paving with Asphalt): 2017-2018 and 2010-2014 asphalt production data were updated based on the Energy Balance;
- 2.D.3.c (Asphalt Roofing): 2017 data on Imports was updated according to EUROSTAT database;
- 2.D.3.e (Degreasing): Imports data for the years 2016 and 2017 were updated based on EUROSTAT;
- 2.D.3.g (Chemical Products - Tyre Production): development of an average tyre weight taking into account the weighting of each type of tyre produced;
- 2.D.3.g (Chemical Products – Asphalt Blowing): Update of emission factors according to EMEP 2019 Guidebook;
- 2.D.3.i (Vehicle Dewaxing): National vehicles sales data was updated for the whole time series based on ACAP;
- 2.G (Other solvent and product use): Use of fireworks - 2017 activity data was updated based on EUROSTAT data; Use of Tobacco - 2008 to 2009 and 2017 imports and exports activity data were updated based on EUROSTAT; Use of Shoes - 2017 imports and exports data were updated based on EUROSTAT; Lubricants use: Lubricant consumption values were updated for 2013, based on the Energy Balance by DGEG;
- 2.H.2 (Food Manufacturing): Correction of compilation error regarding NMVOC emissions; Handling of agricultural products is now estimated and reported in this category;
- 2.L (Other Production, Consumption, Storage, Transportation or Handling of Bulk Products): This category is not occurring in Portugal;

– Several minor sub-categories: Update on Gross Domestic Product (GDP) for the whole time series; Update on and Gross Value Added (GVA) in 2016 and 2017.

8.2.3 Recalculations Agriculture sector (NFR 3)

The major changes between last year submission and this year submission result from the following actions:

- update of 2016 and 2017 data for apparent consumption of inorganic N fertilizers (total amount and by type of fertilizer) revised by the National Statistics Authority (INE);
- elimination of step 6 of the algorithm to estimate ammonia emissions from fertilizers (tier 2 approach) updated by the EMEP/EEA Guidebook 2019;
- update of the emission factors of PAPHs used to estimate emissions from field burning agricultural residues, following the update version (October 2018) of the EMEP/EEA Guidebook 2016;
- update of Nex rates of non-dairy cattle in coherence with the updating of the enteric fermentation emission factors done in the framework of the UNFCCC inventory emission estimates;
- minor corrections as a result of internal QA/QC procedures.

8.2.4 Recalculations Waste sector (NFR 5)

Revisions since last submission include:

– Solid waste disposal (CRF 5A): revision of sludge DOC value (industrial organic waste).
– Wastewater treatment and discharge (CRF 5D): revision of AD on industrial production.

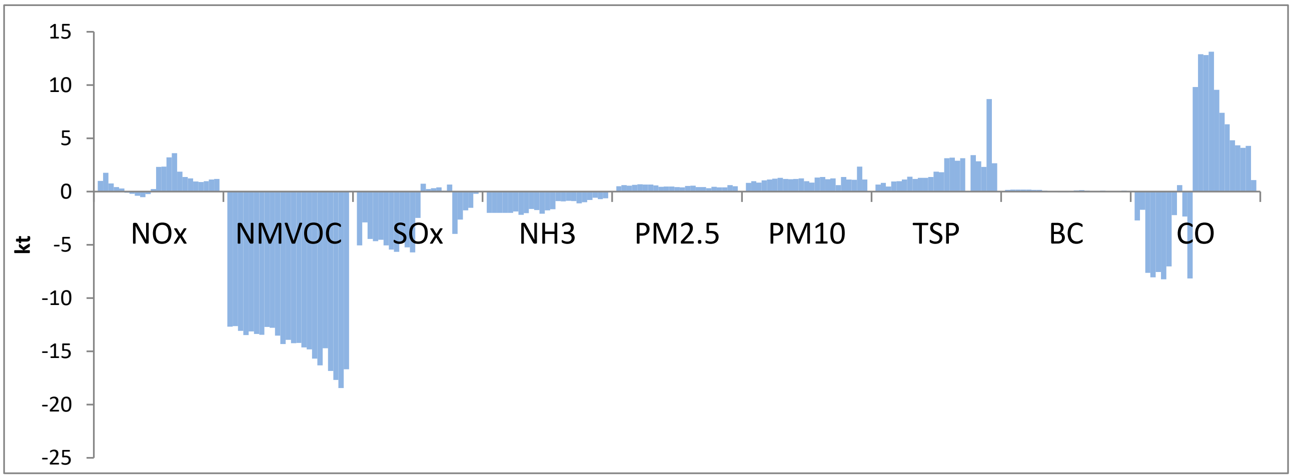

Figure 8-1: Recalculations for main pollutants and particulate matter for 1990-2017 (absolute difference between 2020 and 2019 submissions)

The impact of the recalculation in each sector for the 2017 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).

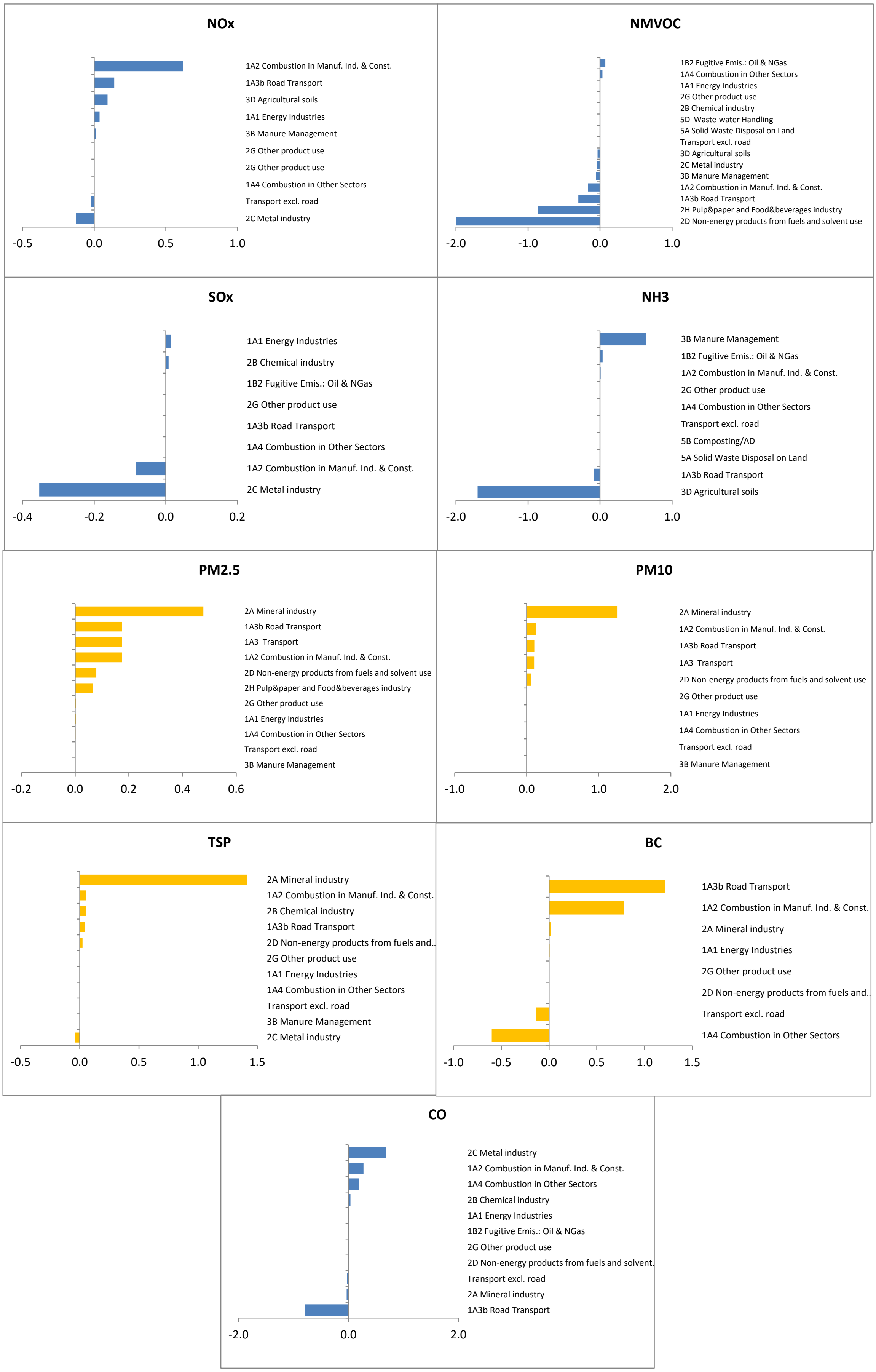

Figure 8-2: Sectoral contribution in recalculations: Main pollutants and particulate matter (% contribution to the total emissions of each pollutant in 2017)

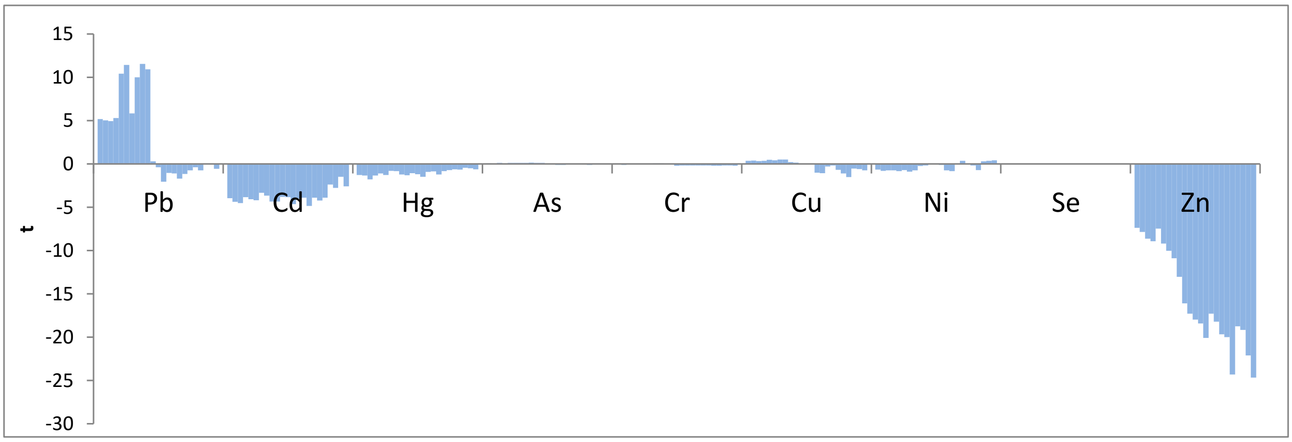

Figure 8-3: Recalculations for heavy metals for 1990-2016 (absolute difference between 2020 and 2019 submissions)

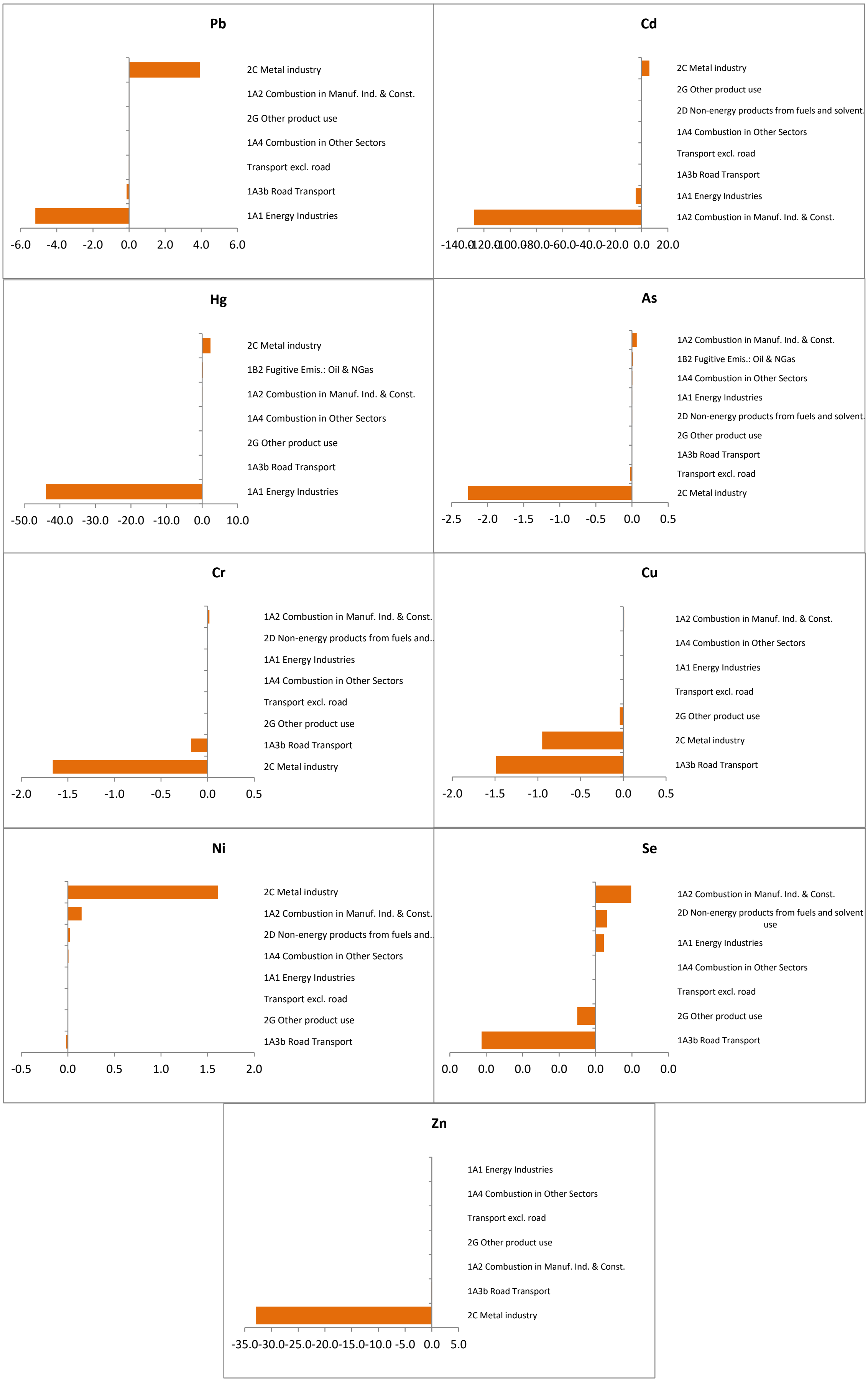

Figure 8-4: Sectoral contribution in recalculations: Heavy Metals (% contribution to the total emissions of each pollutant in 2017)

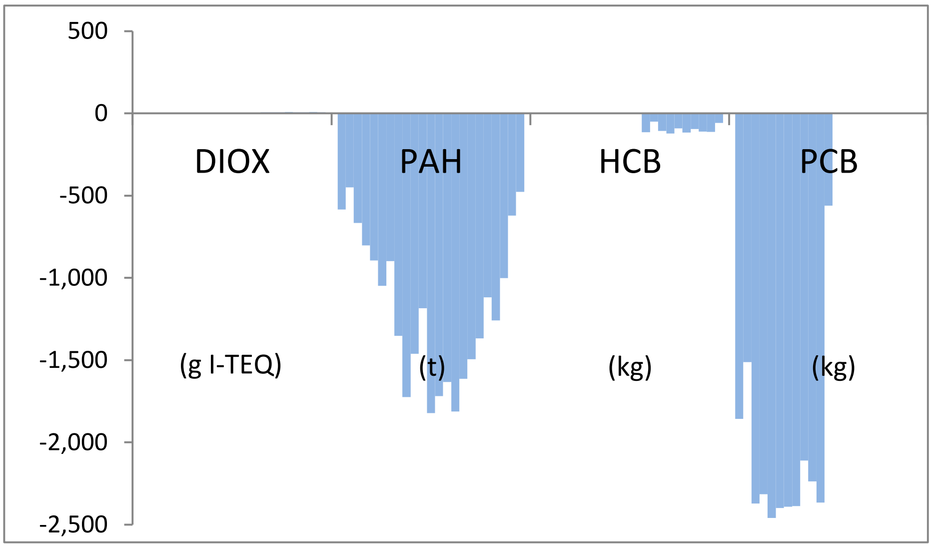

Figure 8-5: Recalculations for Dioxines, PAHs, HCB and PCB for 1990-2017 (absolute difference between 2020 and 2019 submissions)

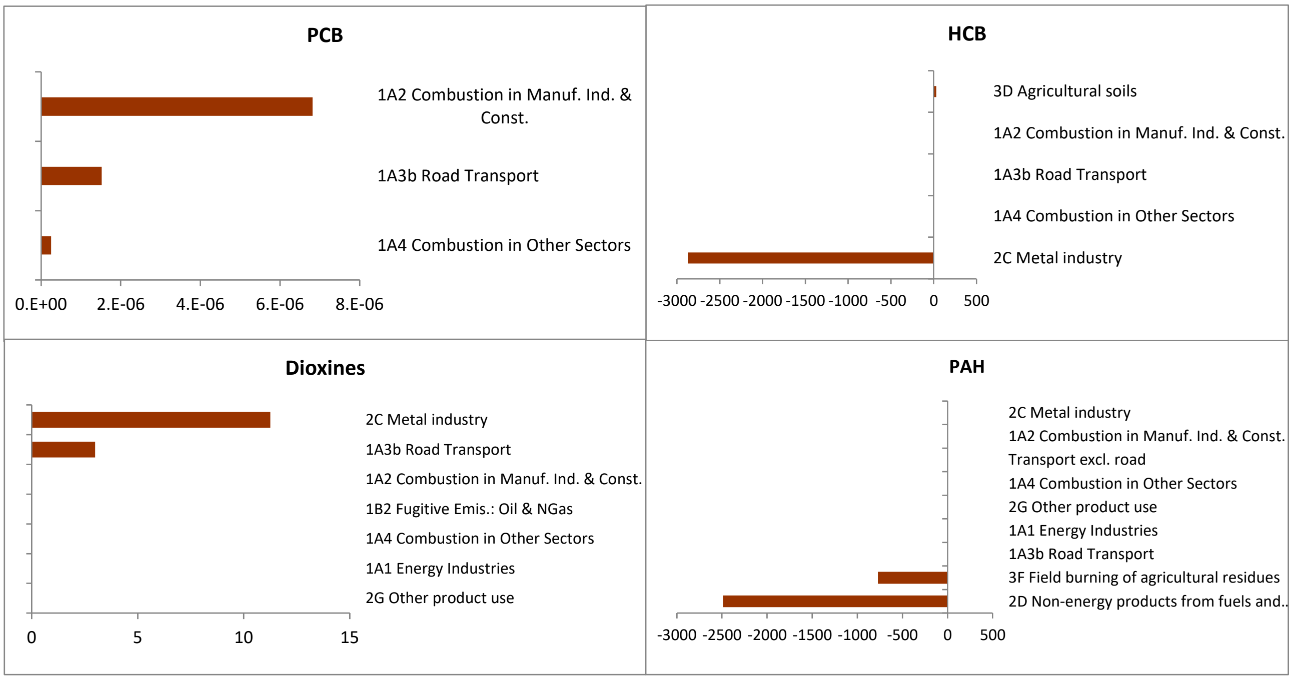

Figure 8-6: Sectoral contribution in recalculations: PCB, Dioxines and PAHs (% contribution to the total emissions of each pollutant in 2017)

9 Projections

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9 Projections

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9.1 Introduction

The estimation of emissions of acidifying and eutrophic gases (NO_x, VOC, NH_3), ozone precursors (NO_x and VOC), particles (PM_{10}, $PM_{2.5}$, TSP), heavy metals and persistent organic pollutants, for 2020, 2030, 2040 and 2050 is based in 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)[1].

The estimated projections do not include emissions from the Azores and Madeira Islands. The historical emissions data presented are based on the submission version of the IIR carried out in 2018 (with emissions data up to the year 2016 (APA, 2018)).

The estimation of emissions of atmospheric pollutants is based on the assumptions made within the scope of the roadmap for carbon neutrality, by 2050. It is based on the projection of activity variables that are associated with their origin. These, in turn, result from scenarios of demand for energy and materials services. For the purpose of this projection report, the macroeconomic scenario associated with the Pelotão (PL) scenario "with neutrality" – corresponding to a WAM scenario in Climate Policy - was selected as the scenario With Measures (WM) in the context of the new NEC Directive, since it was assumed that the respective measures will be adopted under Climate framework. So the scenario WAM 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.

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[2]. A summary of the most relevant assumptions are:

<u>Electricity production sector</u>: The phase-out of production of thermal power plants, namely the 2 existing coal power plants in Pego and Sines; Ribatejo natural gas combined cycle plant; Lares and Pego natural gas combined cycle power plants.

[1] VOC throughout this chapter means NMVOC

[2] 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

The scenarios were modeled using the climate scenario RCP4.5[3], therefore considering a gradual reduction in water availability until 2050.

Buildings: There is a reduction in urban housing and a slight increase in rural housing; increase in apartment buildings due to urban pressure, due to increased tourism in large cities; reduction in the average area of houses justified by the higher price of houses, real estate pressure and greater modularity of houses.

It is also considered an improvement in the thermal comfort inside the houses both in the heating and cooling seasons.

Mobility and Transport: There is a greater demand for passenger's mobility and goods, due to greater equity in access to mobility services and growth in economic activity; moderate evolution of "mobility-as-a-service" systems with predominance of classic public transport and smooth modes; technological developments, including autonomous mobility very much allocated to a structure centered on individual use.

Agriculture: There is a greater demand for food products of plant and biological products; moderate productivity growth of agricultural production factors; maintenance of the composition of the system of direct payments to producers, more oriented to the environment, climate change and territory.

Land Use: There is a tendency to decrease the average annual burnt area, as a result of the improvement in land management and planning and a greater investment in the management of stands; the burnt areas will mostly be reforested with production species (cork oak, 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: It is characterized by the development and application of new technologies, which, however, do not alter either the production structures or the ways of life of the populations. This assumes a gradual increase in the separate collection of recyclables, including bio-waste, reaching the target of 65% in 2030; relative reduction in the deposition of biodegradable urban waste in landfills; and regression in the production of urban waste *per capita* reaching 421 kg / person.year in 2050.

9.2 Sectoral methodologies

The energy system evolution was determined based on the TIMES_PT optimization model, which includes, in an integrated way, the entire Portuguese energy system, from energy production, transport and distribution to consumption in sectors of end use, such as industry, transport, residential, services and agriculture in its multiple uses (heating, cooling, lighting, electrical equipment, mobility of passengers and goods, among others).

The projected emission estimates of atmospheric pollutants until the year 2050 was based on a methodological approach consistent with national submissions (APA, 2018) and was carried out for three decarbonisation scenarios of the Portuguese economy, elaborated under the scope of Roadmap for Carbon Neutrality 2050 (RNC2050). Figure 1.1 summarizes the methodology adopted.

[3] The scenario RCP4.5 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 / m2. 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.

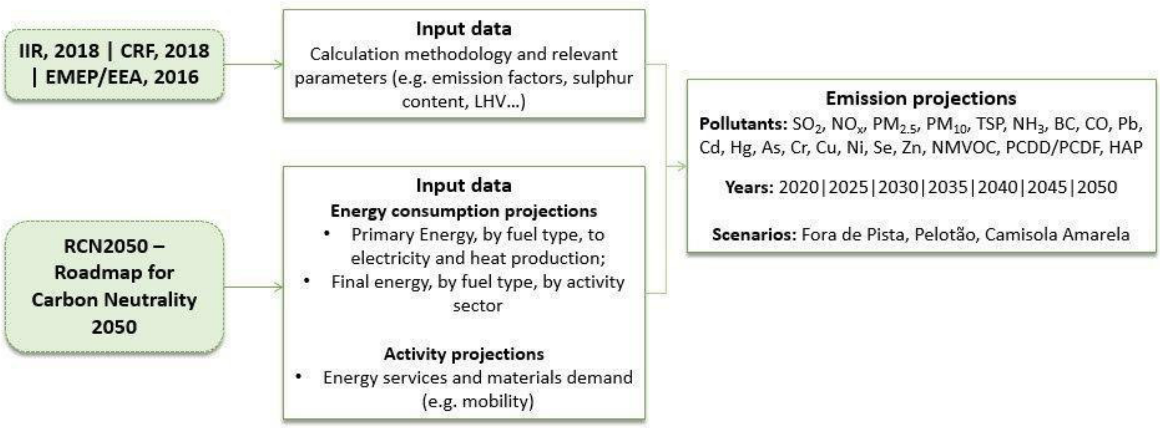

Figure 9-1: Methodological approach adopted for the projection of air pollutant emissions under the scope of the RNC2050

The methodology used to estimate projected emissions was supported by the IIR - Informative Inventory Report (APA, 2018), namely with regard to specific emission factors by fuel type and process emission factors.

An adaptation was made for emission factors to be used taking into account the level of technological detail of the TIMES_PT model.

In order to guarantee an adequate adherence to the calculation methodology used at national level, the estimates for the industrial sector were made based on the determination of implicit emission factors, taking into account the information provided in the most recent IIR available at the date of the calculation (APA, 2018). The implicit emission factors are expressed as the amount of pollutant emitted by the energy consumed, or the amount of pollutant emitted by the amount of product produced, associated with each technology / fuel used.

In the case of the transport sector, what was considered were emission factors related to the existing Euro Standards and others that reflect technological and fuel developments, according to the results of fleet composition and demand satisfaction recommended in the future scenarios under analysis.

In the commercial / services and residential sectors, current emission factors were used and changes in relation to technologies to control emissions and improve efficiency were also considered to be implemented by 2050.

For the waste sector, the methodology adopted for emissions projection considers data for each activity, i.e., the physical quantities of urban waste and domestic waste water generated each year, considering the resident population, and the respective emission factor.

9.3 Emission Projections

9.3.1 Energy supply: 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.

Energy consumption, projected for the centralized electricity production, is shown in Table 2.1 (excluding renewable sources that do not emit pollutants), by fuel type. This scenario responds to a greater demand for electricity.

Table 9-1: Energy consumption in the energy supply sector (NFR 1A1a) (PJ)

Combustion	Historical				Projection		
	2005	2010	2015	2020	2030	2040	2050
Coal	137	67	123	116	0	0	0
Petroleum Products	57	0	11	9	6	2	0
Natural Gas	72	85	32	22	7	0	0
Biogas	0	1	2	3	2	0	0
Biomass	1	6	8	8	16	4	0
Waste	9	8	4	4	7	4	4
Geothermal	0	1	1	2	2	1	0
Total	**275**	**168**	**181**	**164**	**40**	**12**	**4**

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 source of primary energy in the country (> 40%), mainly needed for transport.

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 2.1, 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.

NOx and SOx emissions (Table 2.2) are sharply reduced, 98% and 100%, respectively, due to the reduction in the consumption of coal and petroleum products. There is a slight increase in some pollutants' percentual emissions, such as VOC, CO, PM (although with relatively small absolute values), up to 2030, due to the transitory increase of biomass consumption.

Table 9-2: Emissions of the main atmospheric pollutants in the energy supply sector (NFR 1A1)

Pollutant	Historical			Projection				
	2005	2010	2015	2020	2030	2040	2050	Tendency
NOx (as NO2) (kt)	59,54	16,77	14,46	13,02	6,04	2,36	1,30	
VOC (kt)	1,00	1,65	1,70	1,66	2,33	0,58	0,02	
SOx (as SO2) (kt)	118,61	11,49	3,28	2,28	1,35	0,39	0,05	
PM2.5 (kt)	1,05	0,34	0,21	0,21	0,27	0,07	0,01	
CO (kt)	3,35	5,35	6,52	6,26	8,13	2,17	0,15	
Pb (t)	4,35	1,61	3,11	2,62	0,19	0,07	0,04	
Zn (t)	8,61	5,43	6,60	6,00	4,34	1,16	0,10	
PCDD/ PCDF (g I-TEQ)	1,65	1,09	1,82	1,60	0,90	0,29	0,11	

Table 9-3: Percentage variation of main atmospheric pollutants emissions in energy supply sector in 2030 and 2050, compared to 2005

Pollutant	Projection	
	Δ2030-2005 (%)	Δ2050-2005 (%)
NO_x (as NO2)	-90%	-98%
VOC	133%	-98%
SO_x (as SO2)	-99%	-100%
$PM_{2.5}$	-75%	-99%
CO	143%	-96%

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 (45% in 2015). In the last decades this sector showed the greatest growth, being the road sub-sector 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;
- heavy duty vehicles: in addition to the growing electrification, new fuels (H_2) or new technologies (dynamic charging systems) will be introduced. 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 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 according with the results obtained through 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 kilometers travelled by each type of vehicle. 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 emissions associated with tire wear, braking and abrasion (NFR codes: 1A3bvi - Road transport: Automobile tire and brake wear and 1A3bvii - Road transport: Automobile road abrasion), the respective mileage was taken into account.

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 takes 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 the tables below.

Table 9-4: Emissions of the main atmospheric pollutants in the transport sector (NFR 1A3) (kt)

			Historical			Projection				
Pollutant	NFR	NFR - Description	2005	2010	2015	2020	2030	2040	2050	Tendência
NOx (as NO2) (kt)	1A3b	Road transport	96	82	61	59	19	3	0	
	1A3a,c,d,e	Aviation, Navigation, Railway	7	7	8	8	8	7	6	
		Subtotal	**103**	**90**	**69**	**67**	**27**	**9**	**6**	
VOC (kt)	1A3b	Road transport	36	23	16	15	8	1	0	
	1A3a,c,d,e	Aviation, Navigation, Railway	1	1	1	0	0	0	0	
		Subtotal	**37**	**24**	**16**	**15**	**8**	**1**	**0**	
SOx (as SO2) (kt)	1A3b	Road transport	0,57	0,11	0,09	0,08	0,05	0,01	0,00	
	1A3a,c,d,e	Aviation, Navigation, Railway	1,83	1,11	1,35	1,31	1,63	1,45	1,19	
		Subtotal	**2**	**1**	**1**	**1**	**2**	**1**	**1**	
PM2,5 (kt)	1A3b	Road transport	7	6	4	4	2	2	1	
	1A3a,c,d,e	Aviation, Navigation, Railway	1	1	1	1	1	1	1	
		Subtotal	**8**	**7**	**5**	**5**	**3**	**2**	**2**	
CO (kt)	1A3b	Road transport	194	120	77	67	25	2	0	
	1A3a,c,d,e	Aviation, Navigation, Railway	4	4	4	3	2	1	1	
		Subtotal	**198**	**123**	**80**	**70**	**27**	**4**	**1**	
BC (kt)	1A3b	Road transport	3	3	2	1	0	0	0	
	1A3a,c,d,e	Aviation, Navigation, Railway	0	1	1	1	0	0	0	
		Subtotal	**4**	**3**	**3**	**1**	**1**	**0**	**0**	

Table 9-5: Percentage variation of main atmospheric pollutants emissions in transport sector in 2030 and 2050, compared to 2005

Pollutant	Projection	
	Δ2030-2005 (%)	Δ2050-2005 (%)
NOx (as NO2)	-73%	-95%
VOC	-78%	-99%
SOx (as SO2)	-30%	-50%
$PM_{2,5}$	-61%	-76%
CO	-86%	-99%
BC	-86%	-96%

For most air pollutants there is a significant reduction in emissions in the road sector as of 2030, which is more notable for NOx and CO. The electrification of the sector has a decisive influence on the reduction of these emissions.

In the road transport, the efficiency gains through electric mobility compared to fossil fuels are also important. The adoption of shared mobility models, cost-effective in 2050, contributes to the reduction of energy intensity, having a positive effect on the reduction of GHG and air pollutants. This sector reaches, in 2050, a 100% emissions' reduction compared to 2005 for most pollutants. This is not the case for particulate matter, due to the contribution of abrasion and the wear action of tires and brakes, which will continue to exist.

The shipping sector is the highest contributor to SOx emissions. 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 term distance) and electricity (in short distance, in particular in river passenger transport).

9.3.3 Commerce / Services, Residential, Agriculture / Forest / Fisheries - 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 spaces, lighting, refrigeration and cooking, among others. In a long-term perspective for emissions reduction, the following aspects stand out:

- same trend in electrification for 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, justified by greater decentralization in the territory, with more rural homes;
- thermal solar energy for water heating and heat pumps for air conditioning are the cost-effective options with the greatest potential for decarbonizing buildings.

The projected values show the possibility of a decrease in energy consumption per m^2 in residential buildings in 2050 compared to 2015, also justified by the adoption of high performance electrical equipment such as LEDs for lighting and class A +++ equipment.

The estimation of emissions from stationary combustion sources associated with the tertiary, residential and agriculture / forest / fisheries sectors was based on the methodology and information sources of the various parameters (i.e. emission factors) contained in IIR 2016 (APA, 2018) and in the EMEP / EEA Guide Air pollutant emission inventory guidebook 2016 (EEA, 2016).

In order to maintain a similarity with the IIR reporting model, the combustion emissions from non-road mobile machinery in the agriculture / forest / fisheries were included.

When calculating emissions from 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 VOCs.

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 2.7 and Table 2.8).

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 NOx, 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 for the case of $PM_{2.5}$ and VOCs, 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 9-6: Emissions of the main atmospheric pollutants (NFR 1A4ai), Residential (NFR 1A4bi) and related to combustion in Agriculture/Forestry/Fishing (NFR 1A4cii)

Polutant	NFR	Setor	Historical			Projection				
			2005	2010	2015	2020	2030	2040	2050	Tendência
NOx (as NO2) (kt)	1A4ai	Com/Inst	17,6	4,4	2,3	1,7	1,7	0,2	0,0	
	1A4bi	Residential	4,5	4,3	3,8	3,8	3,4	2,0	0,2	
	1A4cii	Agr/For/Fish.	17,1	13,8	14,5	12,4	12,6	12,3	12,2	
		Total	**39,2**	**22,5**	**20,6**	**17,9**	**17,8**	**14,5**	**12,4**	
VOC (kt)	1A4ai	Com/Inst	0,9	0,2	0,3	0,2	0,2	0,0	0,0	
	1A4bi	Residential	15,1	12,3	13,2	11,6	7,0	5,5	0,4	
	1A4cii	Agr/For/Fish.	2,5	2,1	2,2	2,0	2,0	2,0	2,0	
		Total	**18,5**	**14,5**	**15,7**	**13,8**	**9,2**	**7,5**	**2,4**	
SOx (as SO2) (kt)	1A4ai	Com/Inst	2,99	1,46	0,72	0,1	0,1	0,0	0,0	
	1A4bi	Residential	1,76	1,45	1,55	0,2	0,2	0,0	0,0	
	1A4cii	Agr/For/Fish.	0,03	0,02	0,02	0,6	0,7	0,6	0,6	
		Total	**4,8**	**2,9**	**2,3**	**0,9**	**1,0**	**0,6**	**0,6**	
NH3 (kt)	1A4ai	Com/Inst	NA	NA	0,0	0,0	0,0	0,0	0,0	
	1A4bi	Residential	2,6	2,1	2,3	2,3	2,6	0,0	0,0	
	1A4cii	Agr/For/Fish.	0,0	0,0	0,0	0,0	0,0	0,0	0,0	
		Total	**2,6**	**2,1**	**2,3**	**2,3**	**2,6**	**0,0**	**0,0**	
PM2.5 (kt)	1A4ai	Com/Inst	0,7	0,2	0,2	0,3	0,3	0,1	0,0	
	1A4bi	Residential	18,1	14,8	15,9	14,0	9,7	7,7	0,6	
	1A4cii	Agr/For/Fish.	0,5	0,4	0,4	0,3	0,3	0,3	0,3	
		Total	**19,3**	**15,3**	**16,5**	**14,6**	**10,3**	**8,0**	**0,9**	
PM10 (kt)	1A4ai	Com/Inst	0,7	0,2	0,2	0,3	0,5	0,1	0,0	
	1A4bi	Residential	18,6	15,1	16,3	14,3	13,8	10,9	0,9	
	1A4cii	Agr/For/Fish.	0,5	0,4	0,4	0,3	0,3	0,3	0,3	
		Total	**19,8**	**15,7**	**16,9**	**14,9**	**14,5**	**11,3**	**1,1**	
CO (kt)	1A4ai	Com/Inst	2,6	0,9	1,2	2,9	3,8	1,0	0,0	
	1A4bi	Residential	147,4	120,0	129,4	113,7	109,6	86,4	6,8	
	1A4cii	Agr/For/Fish.	6,2	5,0	5,3	0,9	0,9	0,9	0,9	
		Total	**156,1**	**126,0**	**135,9**	**117,5**	**114,2**	**88,4**	**7,7**	
Zn (t)	1A4ai	Com/Inst	1,0	0,2	0,8	0,3	0,5	0,1	0,0	
	1A4bi	Residential	18,7	15,2	16,5	14,4	13,9	11,0	0,9	
	1A4cii	Agr/For/Fish.	0,3	0,2	0,3	0,4	0,4	0,4	0,4	
		Total	**20,0**	**15,7**	**17,5**	**15,1**	**14,7**	**11,5**	**1,2**	
PCDD/ PCDF (g I-TEQ)	1A4ai	Com/Inst	0,1	0,0	0,1	0,3	0,4	0,1	0,0	
	1A4bi	Residential	15,8	12,9	13,9	12,2	11,7	9,3	0,7	
	1A4cii	Agr/For/Fish.	NE	NE	NE	0,0	0,0	0,0	0,0	
		Total	**15,9**	**12,9**	**14,0**	**12,4**	**12,1**	**9,4**	**0,8**	

Table 9-7: Percentage variation of main atmospheric pollutants emissions in Commerce/Services, Residential sector and combustion in Agriculture / Forest / Fisheries, in 2030 and 2050, compared to 2005

Pollutant	Projection Δ2030-2005 (%)	Projection Δ2050-2005 (%)
NOx (as NO2)	-55%	-69%
VOC	-50%	-87%
SOx (as SO2)	-80%	-87%
NH3	1%	-100%
$PM_{2,5}$	-47%	-96%
PM10	-27%	-94%
CO	-27%	-95%

9.3.4 Fugitive Emissions (NFR 1B)

9.3.4.1 Methodology and activity variables

This sector includes fugitive emissions mainly from VOCs resulting from activities such as crude oil transportation, refueling, 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 emissions history with the projection of the future scenario. Therefore, these emission factors were based on quantities of processed crude in the case of the estimation of NFRs related to operations in refineries and in the consumption of gasoline and diesel in the road transport in the case of the estimation of NFRs related to fugitive emissions in gas stations.

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[4]. These estimates take into account the application of the fugitive emission control measure 'Stage II and IB at gas station' with an estimated 73% removal potential for VOCs, covering 100% of gas stations in Portugal in 2030.

9.3.4.2 Emissions

The table below summarizes the results obtained, regarding fugitive emissions from VOCs derived from petroleum products. VOCs emissions follow the downward trend of activity variables (from the quantity of processed crude and gasoline / diesel for supply in the road sector) on which its projection was based.

Table 9-8: Fugitive emissions from VOCs accounted in NFR 1B (kt)

NFR	NFR - Description	Historical			Projection				
		2005	2010	2015	2020	2030	2040	2050	Tendência
1B2ai	Exploration, production, transport	2,6	2,3	2,8	2,8	2,4	1,0	0,3	
1B2aiv	Refining / storage	2,9	2,9	2,0	2,0	1,7	0,7	0,2	
1B2av	Distribution of oil products	5,4	4,5	4,5	4,6	2,6	0,9	0,3	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0,1	0,1	0,1	0,1	0,1	0,0	0,0	
1B	Total fugitive emissions from oil products	11,0	9,7	9,4	9,5	6,7	2,6	0,9	

The overall reduction of VOCs in this sector is about 10 % in 2030 compared to 2005 (table below).

Table 9-9: Percentage variation of fugitive emissions from COVNM, in 2030 and 2050, compared to 2005

Pollutant	Projection	
	Δ2030-2005 (%)	Δ2050-2005 (%)
VOC	-10%	-88%

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. Different methodologies were used to calculate emissions in this sector, depending on their origin:

i. *energy approach* for the estimation of combustion emissions in the IIR, fuel consumption data in each sector were used as activity variables;
ii. *production approach* for the combustion emissions estimated in the IIR the quantities produced were used;

[4] 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.

iii. process emissions were estimated in the same way, using the quantities produced or the demand in each industrial sub-sector.

The estimation of air pollutant emissions in the industry and construction sector resulted from the application of implicit emission factors (by fuel type, or according to the expected evolution of demand for certain products), in order to guarantee the consistency between the historical and projected emissions.

NFR 1A2 also includes emissions resulting from cogeneration in the industrial sector.

The activity variables used are represented in the tables below. 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.

Table 9-10: Final energy consumption in the industry and construction sector (without cogeneration) (NFR 1A2) (PJ)

Type of fuel	Historical			Projection			
	2005	2010	2015	2020	2030	2040	2050
Coal	0,7	2,1	0,6	0,3	0,4	0,4	0,4
Fuel oil	50,8	26,5	19,1	15,1	0,0	0,0	0,0
Gasoline/ Diesel	15,8	12,2	10,8	8,1	0,2	0,1	0,1
GPL	6,2	3,8	3,8	4,7	0,1	0,1	0,1
Natural Gas	39,7	41,4	41,8	50,4	67,7	39,7	28,8
Biomass	22,9	24,2	11,8	3,6	14,2	23,4	16,1
Other	1,4	2,3	3,9	6,0	10,6	0,0	0,0
Total	**137,4**	**112,4**	**91,9**	**88,1**	**93,2**	**63,6**	**45,5**

Table 9-11: Final energy consumption in cogeneration from industrial sector l (NFR 1A2) (PJ)

Type of fuel	Historical			Projection			
	2005	2010	2015	2020	2030	2040	2050
Fuel oil	8,9	14,1	0,0	1,7	0,0	0,0	0,0
Diesel	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Natural Gas	17,8	17,4	24,2	26,8	2,0	9,2	0,0
Black liquor	30,6	11,4	40,8	40,8	42,1	52,1	49,7
Biogas	0,1	0,0	0,0	0,0	0,0	0,0	1,0
Biomass	7,5	6,0	0,0	0,8	0,0	4,3	3,8
Total	**65,0**	**49,0**	**65,0**	**70,1**	**44,1**	**65,6**	**54,5**

The scenarios designed for the industrial sector, will imply profound changes in the national industrial sector. By 2030 the consumption of petroleum products, mainly associated with 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 robotization 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, 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 values of 2015.

9.3.5.2 Emissions

The tables below summarize the results obtained, in terms of combustion and process emissions for the main pollutants.

In general, between 2005 and 2050, there is a decrease in NOx and SOx emissions, due to the reduction in the consumption of fuel oil, gasoline / diesel and natural gas in the industrial sector, but an increase of VOC and PM due to the contribution of process emissions and biomass consumption.

The subsectors responsible for the largest emissions of pollutants are those of cement, paper and glass, with the reductions in the main pollutants being achieved due to changes in fuels, efficiency improvements and decreasing / constant demands (between 2015 and 2050) in the first two subsectors. The glass sub-sector, with a growing demand until 2050, registers an increase in emissions, mainly from process.

Table 9-12: Emissions of the main atmospheric pollutants in the industrial sector (NFR 1A2 e NFR 2A,B,C,H,I,J,K,L) (kt)

Pollutant (kt)	NFR	Tipo	Historical			Projection				
			2005	2010	2015	2020	2030	2040	2050	Tendência
NOx (as NO2)	1A2	Combustion	41	36	32	25	22	20	19	
	2A,B,C,H,I,J,K,L	Process	5	5	6	6	7	7	7	
		Total	**46**	**41**	**38**	**32**	**29**	**26**	**26**	
VOC	1A2	Combustion	11	13	12	12	13	15	16	
	2A,B,C,H,I,J,K,L	Process	10	10	11	12	13	13	14	
		Total	**22**	**23**	**24**	**24**	**26**	**28**	**29**	
SOx as SO2)	1A2	Combustion	32	24	17	13	11	13	13	
	2A,B,C,H,I,J,K,L	Process	13	6	5	6	6	6	7	
		Total	**45**	**31**	**22**	**19**	**18**	**20**	**20**	
PM2,5	1A2	Combustion	11	8	6	6	6	7	7	
	2A,B,C,H,I,J,K,L	Process	14	13	13	14	15	16	17	
		Total	**25**	**21**	**20**	**20**	**21**	**23**	**24**	
PM10	1A2	Combustion	12	9	7	6	6	7	7	
	2A,B,C,H,I,J,K,L	Process	23	21	18	19	21	22	23	
		Total	**35**	**30**	**25**	**25**	**27**	**29**	**30**	
CO	1A2	Combustion	32	28	18	14	13	13	12	
	2A,B,C,H,I,J,K,L	Process	10	10	10	10	11	11	12	
		Total	**42**	**38**	**28**	**23**	**23**	**24**	**24**	

Table 9-13: Percentage variation of main atmospheric pollutants emissions in 2030 and 2050, compared to 2005, of the main air pollutants in the industrial sector

Pollutant	Projection	
	Δ2030-2005 (%)	Δ2050-2005 (%)
NOx (as NO2)	-38%	-43%
VOC	19%	35%
SOx (as SO2)	-60%	-55%
$PM_{2,5}$	-14%	-4%
PM_{10}	-21%	-13%
CO	-45%	-43%

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 growth drivers (quantitative of production and population evolution) to which the emission subsectors are associated. In this way the estimated emissions take into account the existing control measures.

This is one of the sectors that contributes the most to VOCs emissions from anthropogenic origin. Regarding the estimation of emissions of this pollutant, an additional set of control strategies was also considered[5]. A set of measures was selected to be applied to NFR 2D3a (domestic solvent use) and NFR 2D3i (in the fraction of industrial adhesives / adhesives)[6].

9.3.6.2 Emissions

The tables below summarizes the results obtained, in terms of VOCs emissions from the use of solvents (pollutant with greater relevance in the sector). In general, the total emissions of VOCs show a reduction of about 25% between 2005 and 2030.

Table 9-14: VOC emissions in the solvent use subsector (NFR 2D, 2G) (kt)

		Historical			Projection				
NFR Code	NFR Description	2005	2010	2015	2020	2030	2040	2050	Tendência
2D3a	Domestic solvent use including fungicid	24,6	24,8	24,3	24,0	18,7	16,1	15,2	
2D3b	Road paving with asphalt	2,1	1,0	0,6	0,6	0,4	0,2	0,1	
2D3c	Asphalt roofing	0,0	0,0	0,0	0,0	0,0	0,0	0,0	
2D3d	Coating applications	22,1	17,4	18,4	16,9	18,0	18,8	19,7	
2D3e	Degreasing	1,0	0,3	3,5	2,4	2,8	3,3	3,8	
2D3f	Dry cleaning	1,1	0,5	0,4	0,3	0,3	0,3	0,2	
2D3g	Chemical products	25,1	20,6	18,1	17,2	17,1	17,2	17,8	
2D3h	Printing	4,0	4,3	4,1	4,3	4,7	4,7	4,8	
2D3i	Other solvent use *	11,2	8,9	9,6	9,5	6,7	4,1	4,7	
2G	Other product use **	0,9	1,3	1,1	1,1	1,0	0,9	0,8	
2D, 2G	**Utilização de Solventes e de Outros Produtos | TOTAL**	**92,3**	**79,0**	**80,0**	**76,3**	**69,5**	**65,5**	**67,2**	

*Application of glues and adhesives, Fat, edible and non-edible oil extraction, Glass Wool Enduction, Mineral Wool Enduction, Preservation of Wood, Underseal treatment and conservation of vehicles, Vehicles Dewaxing

** Production of adhesives and magnetic tapes, glues, printing inks and others, dyeing of leather goods, pharmaceutical products, polystyrene foam, polyurethane foam, rubber, tires; fiber manufacturing: acrylic, acrylic, polyamide, polymer, polypropylene, PVC; footwear manufacturing.

[5] Measures listed for Portugal, in the GAINS Model - Greenhouse gas Air pollution INteractions and Synergies. Maximum Technically Possible Reduction Scenario (MTFR) calculated for the case 'CEP_post2014_CLE. Source: http://gains.iiasa.ac.at/models/gains_models3.html.

[6] The measures considered assume a maximum mitigation potential for 2030 in the emission of NMVOCs, and are as follows: i) NFR 2D3a Domestic use of solvents (other than paint). Inclusion of product reformulation measures (stage 1, stage 2, stage 3, with VOC removal efficiencies of 10%, 28% and 60%, respectively); 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 VOC removal efficiencies of 98% (M1), 100% (M2) and 76% (M3), with a coverage of 76% of installations (M1), 13% (M2), 11% (M3).

Table 9-15: Percentage variation of VOC emissions in 2030 and 2050, compared to 2005 in the subsector of solvent use

Pollutant	Projection	
	Δ2030-2005 (%)	Δ2050-2005 (%)
VOC	-25%	-27%

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 estimation of air pollutants, the emission factors contained in the IIR (APA, 2018) and in the EMEP / EEA Guide (EEA, 2016) were used.

The main trends of evolution in the last decade of plant production are projected to be maintained, and with a later stabilization (table below), characterized by:

(i) reduction in the area occupied by rainfed and irrigated cereals, accompanied by productivity gains;
(ii) increase in the areas occupied by vegetables and permanent irrigated crops, accompanied by productivity gains in nuts;
(iii) slightly negative evolution of the areas occupied by temporary forage crops and pastures;

Table 9-16: Main sectorial variables of plant production in the agricultural sector

Main variables of plant production (agricultural area expressed in 10^3 ha)	Historical				Projection			
	2005	2010	2015	2020	2030	2050	Δ2030-2005 (%)	Δ2050-2005 (%)
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**
PP enhanced	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, accompanied 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 herd is assumed (table below) 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 beef cattle herds is characterized by the maintenance of herds belonging to extensive and mixed meat 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 for the respective 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 herds.

Table 9-17: Main sectorial variables of animal production in the agricultural sector

Main variables of animal production (animal herd expressed in 10^3 103 CN)	Historical				Projection			
	2005	2010	2015	2020	2030	2050	Δ2030-2005 (%)	Δ2050-2005 (%)
Dairy Cows	290	255	235	238	199	199	-31%	-31%
Non Dairy Cows	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%**

The projections show an increasing rate of diffusion of precision animal husbandry in general and of mitigation and carbon sequestration measures associated with both animal feed and effluent management and permanent pastures.

A set of decarbonisation measures (Table 2.18) 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.

Table 9-18: Decarbonizing (MD) and circularity measures

Type of Measures	Projection 2020	2030	2050
Food efficiency[1)] (%)	-	+ 2,5	+ 8
Effluent management[2)] (%)	-	+ 3	+ 10
Precision agriculture[3)] (10^3ha)	100	150	150
Technological level 1[4)] **(10^3ha)**	90	80	20
Technological level 2[5)] **(10^3ha)**	5	50	50
Technological level 3[6)] **(10^3ha)**	5	20	80
Conservation or Regenerative Agriculture[7)] (10^3ha)	20	20	60
Enhanced Permanent Pastures[8)] (10^3ha)	50	180	200
Biologic Agriculture [9)] (10^3ha)	50	100	300
1) Variations in feed efficiency according to different animal species and over time			
2) Changes in the composition of effluent management systems with variations according to different animal species and over time			
3) Precision agriculture area benefited by Variable Rate Technology (VRT) until 2050			
4) Installation of sensors and weather stations			
5) Installation of sensors, installation of weather stations and production of cartography			
6) Installation of sensors, installation of weather stations, production of cartography and management software (variable speed)			
7) Area benefited, until 2050, for different agricultural practices that contribute to the increase of the organic matter content in the soils (including pastures)			
8) Permanent pastures sown with an identical effect to the biodiverse pastures considered in the NIR			
9) Area benefited, until 2050, from organic farming, occupied by temporary and permanent crops			

The summary of the forecasts regarding the evolution of the main sectorial variables related to plant and animal production is shown in the table below.

Table 9-19: Summary of the main sectorial variables of the agricultural sector

Main sectoral variables	Historical			Projection		
	2005	2010	2015	2020	2050	Δ2050-2005 (%)
Areas occupied by temporary and permanent crops (10^3ha)	1 578	1 397	1 387	1 319	1 227	-22%
Areas occupied by enhanced permanent pastures (10^3ha)	ND	ND	ND	50	200	ND
Number of cattle (10^3CN)	1 209	1 232	1 260	1 298	1 212	0%
Number of other animals (10^3CN)	3 108	3 107	3 090	1 957	2 092	-33%
Areas related to precision agriculture and conservation (10^3ha)	ND	ND	ND	120	210	ND

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 stands. Regarding forest fires, the emissions of air pollutants were determined from the projected burnt areas.

9.3.7.2 Emissions

The tables below represent emissions for the pollutants with the greatest weight in this sector.

Agricultural activities are currently responsible for a large part of NH_3 emissions at the national level (about 78% in 2015).

The sources of emission pollutants in this sector can be classified in manure management, agricultural soils (including the use of fertilizers) and burning of agricultural waste.

For NH_3, there is a 14% reduction in emissions between 2005 and 2030, compared to 2005.

NH_3 emissions show a reduction until 2050, both in the manure management component (NFR 3B, due to the reduction in the number of livestock in cattle farming), and in the application component of nitrogenous inorganic synthetic fertilizers (including urea). In contrast, there is an increase in emissions of this pollutant in the portion related to the future trend of greater application of compost of urban solid waste as organic fertilizer.

Table 9-20: Emissions of the main atmospheric pollutants in the agricultural sector (NFR 3B, 3D, 3F)

			Historical			Projection				
Pollutant	NFR	Sector	2005	2010	2015	2020	2030	2040	2050	Tendência
NOx (as NO2) (kt)	3B	Animal husbandry and manure management	1,5	1,4	1,1	0,4	0,3	0,3	0,3	
	3D	Plant production and agricultural soils	3,4	3,3	3,6	1,7	1,6	1,6	1,6	
	3F	Field burning and other agriculture	0,7	0,8	0,8	1,0	0,9	0,9	0,9	
	Total	Subtotal	5,6	5,5	5,5	3,0	2,9	2,8	2,8	
VOC(kt)	3B	Animal husbandry and manure management	0,0	0,0	0,0	7,5	7,5	7,4	7,2	
	3D	Plant production and agricultural soils	0,5	0,4	0,3	4,4	4,3	4,2	4,2	
	3F	Field burning and other agriculture	1,9	2,2	2,2	1,6	1,6	1,5	1,5	
	Total	Subtotal	2,5	2,6	2,6	13,4	13,4	13,1	12,9	
NH3 (kt)	3B	Animal husbandry and manure management	19,3	18,3	17,3	16,4	16,5	16,5	16,6	
	3D	Plant production and agricultural soils	21,9	19,7	21,4	19,7	18,8	18,6	18,6	
	3F	Field burning and other agriculture	0,6	0,7	0,7	0,8	0,8	0,8	0,8	
	Total	Subtotal	42	39	39	37	36	36	36	
PM2.5 (kt)	3B	Animal husbandry and manure management	0,0	0,0	0,0	0,4	0,4	0,4	0,4	
	3D	Plant production and agricultural soils	0,0	0,0	0,0	0,0	0,0	0,0	0,0	
	3F	Field burning and other agriculture	1,3	1,5	1,6	1,0	0,9	0,9	0,9	
	Total	Subtotal	1,4	1,6	1,6	1,4	1,4	1,4	1,4	
PM10 (kt)	3B	Animal husbandry and manure management	0,0	0,0	0,0	1,9	1,9	1,9	1,9	
	3D	Plant production and agricultural soils	0,9	0,7	0,6	0,5	0,5	0,4	0,4	
	3F	Field burning and other agriculture	1,4	1,6	1,7	2,0	1,9	1,9	1,9	
	Total	Subtotal	2,3	2,3	2,2	4,4	4,3	4,2	4,2	
CO (kt)	3B	Animal husbandry and manure management								
CO (kt)	3D	Plant production and agricultural soils								
CO (kt)	3F	Field burning and other agriculture	24	25	26	31	31	31	31	
CO (kt)	Total	Subtotal	24	25	26	31	31	31	31	
HAP (t)	3B	Animal husbandry and manure management								
HAP (t)	3D	Plant production and agricultural soils								
HAP (t)	3F	Field burning and other agriculture	22	20	22	121	119	116	113	
	Total	Subtotal	22	20	22	121	119	116	113	

Table 9-21: Percentage variation of the emissions from the main air pollutants in the agriculture sector in 2030 and 2050 compared to 2005

Pollutant	Projection	
	Δ2030-2005 (%)	Δ2050-2005 (%)
NOx (as NO2)	-49%	-50%
VOC	447%	425%
NH3	-14%	-14%
PM2,5	1%	-1%
PM10	88%	82%
CO	31%	29%
HAP	451%	426%

Table 9-22: Emissions of the main atmospheric pollutants in the forest sector (NFR 11B)

Pollutant	NFR	Historical			Projection				
		2005	2010	2015	2020	2030	2040	2050	Tendência
NOx (as NO2) (kt)	11B | Forest Fires	8,3	2,6	1,4	3,3	1,9	1,9	1,8	
VOC (kt)		44,0	14,0	7,3	17,2	10,1	9,9	9,7	
SOx (as SO2) (kt)		3,4	1,1	0,6	1,3	0,8	0,8	0,7	
NH3 (kt)		3,8	1,2	0,6	1,5	0,9	0,8	0,8	
TSP (kt)		17,8	5,7	3,0	7,0	4,1	4,0	3,9	
CO (kt)		293,5	93,1	48,8	114,6	67,5	65,9	64,4	

9.3.8 Waste (NFR 5A, 5B, 5C, 5D, 5E)

9.3.8.1 Methodology and activity variables

The waste sector encompasses emissions associated with waste and wastewater treatment systems, whether urban or industrial.

This sector has an important contribution of GHG emissions associated with the anaerobic decomposition processes of organic matter present in waste and residual water. Decarbonisation in this sector therefore bets on reducing the weight of methane emissions related to 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 factor 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 tourist activity has been gaining at the national level (accounted for about 42 million overnight stays in the year 2017) this was considered in addition to the statistics of the resident population.

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, for the socioeconomic scenario, in line with the values used by the rest of the modeling sectors, in particular that of energy / industry.

When setting the scenario, a set of policies and measures was taken into account, embedded in the different socio-economic scenarios, which would influence the evolution of emissions 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[7].

In terms of the evolution of the composition of urban waste until 2050, a behavior compatible with the fulfillment of the goal of preparation for reuse and recycling (2035 = 65%) was assumed, and with the consequent increase in the quantities of separate recollection. Measures to encourage the circular economy and, in particular, the production of bio-waste were also considered.

In the future evolution of the deposition of this type of waste, in the scenario of carbon neutrality, factors such as the optimization of solutions to reduce production and increase reuse were considered, within the framework of the impact of measures and policies to encourage the circular economy, and the reduction of food waste and widespread restriction on landfill.

[7] https://descarbonizar2050.pt/documentos/

9.3.8.2 Emissions

The tables below summarize the results obtained, in terms of emissions from this sector. It should be noted that activities related to the energy use of waste are excluded, being directly accounted in the energy sector.

The waste sector includes mainly activities not related to combustion processes, such as deposition in soil and wastewater treatment, resulting in a greater global representativeness in terms of the emissions of VOC and NH_3.

In terms of the emissions of VOC and NH_3, it is possible to observe a very sharp reduction over time, which is due to the expected phasing-out of landfill of urban waste.

On the contrary, the set of emissions from the industrial waste incineration segment (without energy recovery) shows an increase related to the scenarios of economic growth and industrial activity.

Table 9-23: Emissions of the main atmospheric pollutants in the waste sector (NFR 5A, B, C, D, E)

Pollutant	NFR	Historical			Projection				
		2005	2010	2015	2020	2030	2040	2050	Tendência
VOC (kt)	5A | Biological treatment of waste - Solid waste disposal on	2,07	2,15	2,04	1,79	1,28	0,82	0,54	
	5C1bi | Industrial waste incineration	0,44	0,14	0,14	0,17	0,20	0,22	0,25	
	5D1 | Domestic wastewater handling	0,01	0,01	0,01	0,01	0,01	0,01	0,01	
	5D2 | Industrial wastewater handling	0,11	0,11	0,12	0,01	0,01	0,02	0,02	
	Subtotal	**2,6**	**2,4**	**2,3**	**2,0**	**1,5**	**1,1**	**0,8**	
NH3 (kt)	5A | Solid waste disposal on land	1,65	1,53	1,30	1,14	0,82	0,52	0,34	
	5B1 | Composting	0,00	0,01	0,00	0,00	0,01	0,02	0,02	
	5B2 |Anaerobic digestion at biogas facilities	NO	0,00	0,05	0,11	0,23	0,28	0,24	
	Subtotal	**1,7**	**1,5**	**1,4**	**1,3**	**1,1**	**0,8**	**0,6**	
PCDD/ PCDF	5C1bi | Industrial waste incineration	20,6	6,6	6,8	7,4	7,7	7,9	8,2	
	5C1biii | Clinical waste incineration	48,7	137,0	25,1	43,9	42,8	41,4	39,3	
	5E | Other waste: biogas burning and fire occurences	6,0	4,6	4,3	4,1	3,7	3,4	3,2	
	Subtotal	**75**	**148**	**36**	**55**	**54**	**53**	**51**	
HCB (kg)	5C1bi | Industrial waste incineration	0,12	0,04	0,04	0,05	0,05	0,06	0,07	
PCB (kg)	5C1bi |Industrial waste incineration	159	51	52	61	71	81	91	

Table 9-24: Percentage change in VOC emissions, in 2030 and 2050, compared to 2005 in the waste sector

Pollutant	Projection	
	Δ2030-2005 (%)	Δ2050-2005 (%)
VOC	-43%	-69%
NH_3	-36%	-63%
PCDD/ PCDF	-28%	-33%
HCB	-55%	-43%
PCB	-55%	-43%

9.4 Impacts of the decarbonizing trajectory on atmospheric emissions

With regard to the main pollutants, the largest percentage emission reductions are obtained (in 2030 compared to 2005) for NOx and SOx, due to the reduction in fossil fuel consumption and the transition to the use of renewable energy sources (Figure 2.26). The smallest reductions are obtained for NH_3 with 17%.

The sectors of activity with the greatest percentage emission reductions are electricity production, buildings and transport. Underlying these results are the trajectories of renewable electricity production, ensured by endogenous resources, as well as the electrification that is transversal to many sectors of final consumption, especially in transport. In buildings, the significant role is due to solar energy.

In particular, the transport sector (mainly in the road transport component) reduces 73% of NOx emissions. The reductions achieved in 2030 depend strongly on the penetration of electric vehicles, which will unfold in 2020-2030.

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).

Table 9-25: Atmospheric emissions, projections and percentage reductions compared to 2005 by sector

Pollutant	Sector	Historical			Projection				Δ2030-2005(%)
		2005	2010	2015	2020	2030	2040	2050	
NOx (as NO2)	Energy	60	18	15	14	7	3	1	-89%
	Industry	46	41	38	32	29	26	26	-38%
	Buildings	45	30	26	18	18	15	12	-60%
	Transport	103	90	69	67	27	9	6	-73%
	Agriculture	6	6	6	3	3	3	3	-49%
	Waste	0	0	0	0	0	0	0	-70%
	TOTAL	**260**	**184**	**154**	**134**	**84**	**56**	**48**	**-68%**
VOC	Energy	12	11	11	11	9	3	1	-24%
	Industry	114	102	104	100	95	93	96	-16%
	Buildings	19	15	16	14	9	8	2	-51%
	Transport	37	24	16	15	8	1	0	-78%
	Agriculture	2	3	3	13	13	13	13	447%
	Waste	3	2	2	2	2	1	1	-43%
	TOTAL	**187**	**157**	**152**	**156**	**136**	**119**	**114**	**-27%**
SOx (as SO2)	Energy	124	16	8	7	6	2	1	-95%
	Industry	45	31	22	19	18	20	20	-60%
	Buildings	6	4	3	1	1	1	1	-83%
	Transport	2	1	1	1	2	1	1	-30%
	Agriculture	0	0	0	0	0	0	0	31%
	Waste	0	0	0	0	0	0	0	-65%
	TOTAL	**176**	**51**	**35**	**29**	**26**	**24**	**23**	**-85%**
NH_3	Energy	0	1	1	1	1	1	0	156%
	Industry	9	7	6	5	6	7	7	-33%
	Buildings	3	2	2	2	3	0	0	1%
	Transport	2	1	1	1	1	0	0	-69%
	Agriculture	42	39	39	37	36	36	36	-14%
	Waste	2	2	1	1	1	1	1	-36%
	TOTAL	**57**	**51**	**50**	**48**	**47**	**44**	**43**	**-17%**
$PM_{2,5}$	Energy	2	1	1	1	1	0	0	-66%
	Industry	31	25	22	22	23	24	25	-25%
	Buildings	19	16	17	15	10	8	1	-47%
	Transport	8	7	5	5	3	2	2	-61%
	Agriculture	1	2	2	1	1	1	1	1%
	Waste	1	0	0	0	0	0	0	-38%
	TOTAL	**61**	**50**	**47**	**44**	**38**	**36**	**29**	**-37%**

Emission Reduction intensity + -

9.5 Assessment of compliance of the national emission reduction commitments

The table below shows the state of compliance for the national emission reduction commitments, as established in the new NEC Directive, in 2020 and 2030 compared with 2005. It shows that the reductions in emissions of atmospheric pollutants, obtained under the scope of the trajectory outlined by the RNC2050, are not sufficient to achieve the reduction commitment of $PM_{2.5}$ and of VOCs in 2030.

In 2030, $PM_{2,5}$ are mainly emitted by the industrial sector, also having a significant contribution from the building sector with the use of biomass for heating. It should be noted that, in the building sector, an additional reduction in $PM_{2,5}$ emissions was considered, resulting from the adoption of the Ecodesign Directive, even though this will not be sufficient to achieve the necessary emissions reduction.

For VOCs, the reduction commitment is not attained, in 2030, with a gap closure of 3%. The projected scenario, although more efficient and using less polluting technologies / fuels, presents a higher demand for materials, goods and services. This pollutant is emitted essentially by the industrial sector. It should be noted that, in this sector, additional emissions reduction were considered as a result of the adoption of control strategies, namely measures with mitigation potential in the area of industrial solvent use.

However, it was not possible to achieve a significant reduction in emissions from production processes, contrary to combustion, particularly in the subsectors responsible for the largest emissions, such as cement, paper and glass. In the long term, the industry acquires the greatest weight in national emissions, due to the current technological limitations, which do not allow for significant reductions, especially in what relates to processes emissions.

The reduction of NH_3 emissions, points towards the achievement of the reduction commitment in 2030. However, the projected emissions leave no margin for deviations.

In 2020, the reduction commitments for the pollutants under NEC Directive are expected to be achieved. Regarding the 2030, to comply with the emission reduction commitments will require the implementation of additional measures to reduce emissions for $PM_{2.5}$ and VOC, mainly oriented to the industrial sector, and also for the agriculture sector to ensure no deviation in 2030.

Table 9-26: Assessment of compliance of the national emission reduction commitments in 2020 and 2030, with regards to 2005

Projections		NO_x			VOC			SO_2			NH_3			$PM_{2,5}$		
		2005	[2020; 2029]	≥2030	2005	[2020; 2029]	≥2030	2005	[2020; 2029]	≥2030	2005	[2020; 2029]	≥2030	2005	[2020; 2029]	≥2030
Historical (2005) and emission reduction	Emissions (kt)	245	157	91	190	156	118	172	64	29	56	52	48	65	56	31
	Δ 2005 (%)		-36%	-63%		-18%	-38%		-63%	-83%		-7%	-15%		-15%	-53%
Projection	Emissions (kt)		132	82		144	124		29	26		48	47		44	38
	Δ 2005 (%)		-46%	-67%		-25%	-35%		-83%	-85%		-15%	-16%		-33%	-41%
Attainment			✓	✓		✓	✗		✓	✓		✓	✓		✓	✗
Emission Gap	Emissions (kt)		-25	-9		-12	6		-34	-3		-4	-1		-12	8
	(%)		-10%	-4%		-7%	3%		-20%	-2%		-8%	-1%		-18%	12%

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	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 Residuais
ZA	Agricultural Zone	Zona Agrária

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Annex A: Completeness and Key categories

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				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	NE				NE	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 and			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											
2A3	Glass production								NE											NE	NE		
2A5b	Construction and demolition		NE																				
2A6	Other mineral products (please specify in the IIR)	NE		NE		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE		
2B1	Ammonia production					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				NE	
2C2	Ferroalloys production	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE		
2D3a	Domestic solvent use including fungicides					NE	NE	NE	NE														
2D3b	Road paving with asphalt	NE		NE					NE										NE	NE	NE		
2D3c	Asphalt roofing										NE	NE							NE	NE	NE		
2D3d	Coating applications					NE	NE	NE	NE														
2D3e	Degreasing					NE	NE	NE	NE														
2D3f	Dry cleaning					NE	NE	NE	NE														
2D3g	Chemical products								NE	NE	NE		NE			NE			NE	NE		NE	NE
2D3h	Printing					NE	NE	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		
2I	Wood processing	NE	NE	NE	NE	NE	NE		NE	NE				NE		NE							
2J	Production of POPs	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	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 party	Explanation
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(i) International maritime navigation	International inland waterways is considered almost negligible in Portugal and our National Energy Balance don't have the separation for inland waterways.
1A2f - 3.4 Manufacturing Industries and Construction	Emissions related with combustion in cement kilns
1A2f - 3.4 Manufacturing Industries and Construction	Emissions related with combustion in glass kilns
2B10a - Chemical industry: Other	All default Tier 1 emission factors for the chemical industry also include storage and handling in production
3Dc - Farm-level agricultural operations including storage, handling and transport of agricultural products	No EF available
5C1bi - Industrial waste incineration	No specific EF available.
5C1bi - Industrial waste incineration	No specific EF available.

Table A-3: Key category analysis of 2018 inventory

NOx Level Assessment

NFR	Sectors	%total 2018	Cumulative total	Key category
1A3bi	Road transport: Passenger cars	18.52	18.5	x
1A1a	Public electricity and heat production	12.87	31.4	x
1A3biii	Road transport: Heavy duty vehicles and buses	11.45	42.8	x
1A3bii	Road transport: Light duty vehicles	10.77	53.6	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	10.16	63.8	x
1A3dii	National navigation (shipping)	4.30	68.1	x
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	3.57	71.7	x
2H1	Pulp and paper industry	3.34	75.0	x
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	3.01	78.0	x
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	2.68	80.7	x
1A3ai(i)	International aviation LTO (civil)	2.66	83.3	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	2.16	85.5	
1A4bi	Residential: Stationary	2.12	87.6	
1A1b	Petroleum refining	1.98	89.6	
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	1.22	90.8	
1A4ci	Agriculture/Forestry/Fishing: Stationary	1.02	91.9	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.99	92.8	
1A3aii(i)	Domestic aviation LTO (civil)	0.98	93.8	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.93	94.7	
1A4ai	Commercial/institutional: Stationary	0.81	95.6	
3Da1	Inorganic N-fertilizers (includes also urea application)	0.80	96.4	
3Da3	Urine and dung deposited by grazing animals	0.79	97.1	
3F	Field burning of agricultural residues	0.58	97.7	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.37	98.1	
1A3c	Railways	0.32	98.4	
3Da2a	Animal manure applied to soils	0.26	98.7	
2C1	Iron and steel production	0.19	98.9	
2B10a	Chemical industry: Other (please specify in the IIR)	0.17	99.0	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.16	99.2	
1A3biv	Road transport: Mopeds & motorcycles	0.16	99.3	
3B4gii	Manure mangement - Broilers	0.11	99.5	
1B2aiv	Fugitive emissions oil: Refining / storage	0.10	99.6	
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.08	99.6	
2B2	Nitric acid production	0.08	99.7	
3B1b	Manure management - Non-dairy cattle	0.06	99.8	
3B4gi	Manure mangement - Laying hens	0.05	99.8	
3B1a	Manure management - Dairy cattle	0.04	99.9	
3Da2c	Other organic fertilisers applied to soils (including compost)	0.02	99.9	
2G	Other product use (please specify in the IIR)	0.02	99.9	
5C1bi	Industrial waste incineration	0.01	99.9	
3B2	Manure management - Sheep	0.01	99.9	
3B4giii	Manure mangement - Turkeys	0.01	100.0	
5C1bv	Cremation	0.01	100.0	
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	

NOx Trend Assessment (1990-2018)

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
1A1a	Public electricity and heat production	83.47	20.01	0.12	35.02	35.0	x
1A3biii	Road transport: Heavy duty vehicles and buses	43.08	17.81	0.03	9.73	44.8	x
1A3bii	Road transport: Light duty vehicles	13.03	16.75	0.03	9.72	54.5	x
1A2f	Stationary combustion in manufacturing industries and	15.10	15.80	0.03	7.24	61.7	x
1A3bi	Road transport: Passenger cars	37.84	28.79	0.02	6.10	67.8	x
2H1	Pulp and paper industry	2.50	5.20	0.01	4.08	71.9	x
1A2d	Stationary combustion in manufacturing industries and	3.10	5.56	0.01	4.07	76.0	x
1A3ai(i)	International aviation LTO (civil)	1.24	4.14	0.01	3.76	79.7	x
1A4ciii	Agriculture/Forestry/Fishing: National fishing	9.94	3.37	0.01	3.07	82.8	x
1A3dii	National navigation (shipping)	6.67	6.68	0.01	2.86	85.7	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	3.46	4.68	0.01	2.84	88.5	
1A1b	Petroleum refining	2.80	3.07	0.01	1.50	90.0	
1A3c	Railways	2.94	0.50	0.01	1.46	91.5	
1A3aii(i)	Domestic aviation LTO (civil)	0.72	1.53	0.00	1.21	92.7	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.93	1.59	0.00	1.14	93.8	
1A2gviii	Stationary combustion in manufacturing industries and	5.39	4.16	0.00	0.94	94.7	
1A4bi	Residential: Stationary	4.16	3.30	0.00	0.82	95.6	
3Da3	Urine and dung deposited by grazing animals	0.83	1.23	0.00	0.80	96.4	
1A4ai	Commercial/institutional: Stationary	0.90	1.25	0.00	0.78	97.1	
1A2a	Stationary combustion in manufacturing industries and	0.91	0.13	0.00	0.48	97.6	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.27	0.58	0.00	0.46	98.1	
1A2e	Stationary combustion in manufacturing industries and	1.90	1.45	0.00	0.31	98.4	
2C1	Iron and steel production	0.06	0.29	0.00	0.29	98.7	
1A2gvii	Mobile Combustion in manufacturing industries and cor	2.71	1.90	0.00	0.25	98.9	
2B10a	Chemical industry: Other (please specify in the IIR)	0.13	0.26	0.00	0.20	99.1	
3F	Field burning of agricultural residues	1.18	0.90	0.00	0.20	99.3	
1A2c	Stationary combustion in manufacturing industries and	2.24	1.53	0.00	0.17	99.5	
3B4gii	Manure mangement - Broilers	0.14	0.17	0.00	0.10	99.6	
1A3biv	Road transport: Mopeds & motorcycles	0.30	0.24	0.00	0.06	99.7	
2B2	Nitric acid production	0.25	0.12	0.00	0.04	99.7	
3Da1	Inorganic N-fertilizers (includes also urea application)	1.96	1.24	0.00	0.04	99.7	
3Da2a	Animal manure applied to soils	0.59	0.40	0.00	0.04	99.8	
2G	Other product use (please specify in the IIR)	0.01	0.03	0.00	0.03	99.8	
3B4gi	Manure mangement - Laying hens	0.10	0.08	0.00	0.03	99.8	
3B1b	Manure management - Non-dairy cattle	0.11	0.09	0.00	0.03	99.9	
3B4h	Manure management - Other animals (please specify ir	0.05	0.01	0.00	0.02	99.9	
3B2	Manure management - Sheep	0.06	0.02	0.00	0.02	99.9	
5C1bv	Cremation	0.00	0.02	0.00	0.02	99.9	
3B4f	Manure management - Mules and asses	0.02	0.00	0.00	0.01	99.9	
5C1bi	Industrial waste incineration	0.02	0.02	0.00	0.01	100.0	
1A4aii	Commercial/institutional: Mobile	0.01	0.00	0.00	0.01	100.0	
1A4bii	Residential: Household and gardening (mobile)	0.01	0.00	0.00	0.01	100.0	
3Da2b	Sewage sludge applied to soils	0.01	0.00	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	
3B4giv	Manure management - Other poultry	0.01	0.01	0.00	0.00	100.0	
3B1a	Manure management - Dairy cattle	0.11	0.06	0.00	0.00	100.0	
1A5b	Other, Mobile (including military, land based and recrea	0.40	0.25	0.00	0.00	100.0	
3B4giii	Manure mangement - Turkeys	0.02	0.02	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 2018	Cumulative total	Key category
2D3d	Coating applications	12.63	12.6	x
2D3g	Chemical products	10.69	23.3	x
1A4bi	Residential: Stationary	9.08	32.4	x
2D3i	Other solvent use (please specify in the IIR)	7.05	39.5	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	6.23	45.7	x
2D3e	Degreasing	5.32	51.0	x
2H1	Pulp and paper industry	5.15	56.1	x
2D3a	Domestic solvent use including fungicides	4.85	61.0	x
1A3bv	Road transport: Gasoline evaporation	3.93	64.9	x
1A3bi	Road transport: Passenger cars	3.43	68.3	x
2D3h	Printing	3.12	71.5	x
1B2av	Distribution of oil products	2.80	74.3	x
3Da2a	Animal manure applied to soils	2.18	76.5	x
2G	Other product use (please specify in the IIR)	1.75	78.2	x
1A3biv	Road transport: Mopeds & motorcycles	1.64	79.8	x
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	1.62	81.5	x
1B2ai	Fugitive emissions oil: Exploration, production, transport	1.62	83.1	
3F	Field burning of agricultural residues	1.61	84.7	
3B1a	Manure management - Dairy cattle	1.53	86.2	
2H2	Food and beverages industry	1.45	87.7	
3B4gii	Manure mangement - Broilers	1.28	89.0	
5A	Biological treatment of waste - Solid waste disposal on land	1.23	90.2	
1A1a	Public electricity and heat production	1.12	91.3	
2B10a	Chemical industry: Other (please specify in the IIR)	1.09	92.4	
1B2aiv	Fugitive emissions oil: Refining / storage	0.95	93.3	
3B1b	Manure management - Non-dairy cattle	0.73	94.1	
1A3bii	Road transport: Light duty vehicles	0.67	94.7	
3B4gi	Manure mangement - Laying hens	0.62	95.4	
3B3	Manure management - Swine	0.56	95.9	
1A3biii	Road transport: Heavy duty vehicles and buses	0.40	96.3	
2D3b	Road paving with asphalt	0.40	96.7	
3Da3	Urine and dung deposited by grazing animals	0.38	97.1	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.33	97.4	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.31	97.7	
1A3ai(i)	International aviation LTO (civil)	0.26	98.0	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.18	98.2	
3De	Cultivated crops	0.18	98.4	
2D3f	Dry cleaning	0.17	98.5	
1A3dii	National navigation (shipping)	0.15	98.7	
3B4giii	Manure mangement - Turkeys	0.13	98.8	
3B4giv	Manure management - Other poultry	0.12	98.9	
5C1bi	Industrial waste incineration	0.12	99.1	
1A4ai	Commercial/institutional: Stationary	0.12	99.2	
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.11	99.3	
1A3aii(i)	Domestic aviation LTO (civil)	0.09	99.4	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.08	99.5	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.08	99.5	
3B2	Manure management - Sheep	0.07	99.6	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.07	99.7	
2C1	Iron and steel production	0.07	99.7	
1A1b	Petroleum refining	0.06	99.8	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.04	99.9	
1A3c	Railways	0.03	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	
1A4bii	Residential: Household and gardening (mobile)	0.02	99.9	
3B4d	Manure management - Goats	0.01	100.0	
3B4h	Manure management - Other animals (please specify in IIR)	0.01	100.0	
5D2	Industrial wastewater handling	0.01	100.0	
2D3c	Asphalt roofing	0.01	100.0	

NMVOC Trend Assessment (1990-2018)

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
1A3bi	Road transport: Passenger cars	41.31	5.32	0.09	19.22	19.2	x
1A3biv	Road transport: Mopeds & motorcycles	28.41	2.55	0.06	14.23	33.4	x
2D3g	Chemical products	12.19	16.60	0.04	8.07	41.5	x
2D3e	Degreasing	0.71	8.25	0.03	7.13	48.6	x
1A2f	Stationary combustion in manufacturing industries and	3.10	9.67	0.03	7.03	55.7	x
2D3i	Other solvent use (please specify in the IIR)	6.22	10.94	0.03	6.38	62.1	x
2H1	Pulp and paper industry	4.12	7.98	0.02	4.90	67.0	x
1A4bi	Residential: Stationary	29.36	14.08	0.02	4.24	71.2	x
1A3bv	Road transport: Gasoline evaporation	16.65	6.10	0.02	4.13	75.3	x
2D3h	Printing	2.44	4.84	0.01	3.00	78.3	x
2D3d	Coating applications	35.82	19.60	0.01	2.96	81.3	x
1A3biii	Road transport: Heavy duty vehicles and buses	3.79	0.62	0.01	1.64	82.9	
1A2d	Stationary combustion in manufacturing industries and	1.30	2.51	0.01	1.54	84.5	
1A1a	Public electricity and heat production	0.37	1.74	0.01	1.38	85.8	
2H2	Food and beverages industry	1.47	2.26	0.01	1.20	87.0	
1B2av	Distribution of oil products	4.86	4.35	0.01	1.15	88.2	
1B2ai	Fugitive emissions oil: Exploration, production, transpoi	2.09	2.51	0.00	1.07	89.3	
5A	Biological treatment of waste - Solid waste disposal on	1.16	1.91	0.00	1.07	90.3	
3B4gii	Manure mangement - Broilers	1.59	1.99	0.00	0.89	91.2	
3Da2a	Animal manure applied to soils	3.92	3.39	0.00	0.81	92.0	
1A3bii	Road transport: Light duty vehicles	2.91	1.03	0.00	0.75	92.8	
2D3f	Dry cleaning	1.68	0.26	0.00	0.74	93.5	
2B10a	Chemical industry: Other (please specify in the IIR)	1.41	1.70	0.00	0.73	94.3	
2G	Other product use (please specify in the IIR)	3.29	2.72	0.00	0.56	94.8	
1A4bii	Residential: Household and gardening (mobile)	0.99	0.03	0.00	0.55	95.4	
3F	Field burning of agricultural residues	3.02	2.50	0.00	0.53	95.9	
1B2aiv	Fugitive emissions oil: Refining / storage	1.43	1.48	0.00	0.52	96.4	
2D3a	Domestic solvent use including fungicides	11.16	7.52	0.00	0.37	96.8	
3Da3	Urine and dung deposited by grazing animals	0.42	0.59	0.00	0.30	97.1	
3De	Cultivated crops	0.90	0.28	0.00	0.27	97.4	
3B1a	Manure management - Dairy cattle	3.32	2.37	0.00	0.24	97.6	
3B4gi	Manure mangement - Laying hens	1.12	0.96	0.00	0.22	97.8	
1A2e	Stationary combustion in manufacturing industries and	0.80	0.28	0.00	0.21	98.0	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.41	0.49	0.00	0.21	98.2	
3B1b	Manure management - Non-dairy cattle	2.06	1.14	0.00	0.16	98.4	
1A2c	Stationary combustion in manufacturing industries and	0.33	0.07	0.00	0.13	98.5	
3B2	Manure management - Sheep	0.37	0.11	0.00	0.11	98.6	
1A3c	Railways	0.26	0.04	0.00	0.11	98.7	
1A3ai(i)	International aviation LTO (civil)	0.82	0.41	0.00	0.11	98.9	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.35	0.12	0.00	0.10	99.0	
1A4ai	Commercial/institutional: Stationary	0.12	0.18	0.00	0.10	99.0	
2D3b	Road paving with asphalt	0.81	0.61	0.00	0.09	99.1	
1A2gviii	Stationary combustion in manufacturing industries and	0.96	0.52	0.00	0.09	99.2	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.05	0.12	0.00	0.08	99.3	
1A3dii	National navigation (shipping)	0.23	0.23	0.00	0.08	99.4	
3B4giv	Manure management - Other poultry	0.18	0.19	0.00	0.07	99.4	
5C1bi	Industrial waste incineration	0.18	0.19	0.00	0.07	99.5	
3B3	Manure management - Swine	1.25	0.86	0.00	0.06	99.6	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.07	0.11	0.00	0.06	99.6	
2C1	Iron and steel production	0.07	0.10	0.00	0.06	99.7	
1A1b	Petroleum refining	0.06	0.10	0.00	0.06	99.8	
1A3aii(i)	Domestic aviation LTO (civil)	0.32	0.14	0.00	0.06	99.8	
3B4f	Manure management - Mules and asses	0.07	0.00	0.00	0.04	99.9	
3B4d	Manure management - Goats	0.08	0.02	0.00	0.03	99.9	
3B4h	Manure management - Other animals (please specify ir	0.06	0.01	0.00	0.02	99.9	
1A4aii	Commercial/institutional: Mobile	0.03	0.00	0.00	0.02	99.9	
3B4giii	Manure mangement - Turkeys	0.28	0.20	0.00	0.02	99.9	
1A2a	Stationary combustion in manufacturing industries and	0.04	0.04	0.00	0.02	100.0	
3B4e	Manure management - Horses	0.04	0.01	0.00	0.01	100.0	
1A2gvii	Mobile Combustion in manufacturing industries and cor	0.25	0.18	0.00	0.01	100.0	
5D2	Industrial wastewater handling	0.01	0.01	0.00	0.01	100.0	
2D3c	Asphalt roofing	0.01	0.01	0.00	0.00	100.0	
5D1	Domestic wastewater handling	0.01	0.01	0.00	0.00	100.0	

SOx **Level Assessment**

NFR	Sectors	%total 2018	Cumulative total	Key category
1A1a	Public electricity and heat production	30.31	30.3	x
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	21.59	51.9	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	13.39	65.3	x
2H1	Pulp and paper industry	10.16	75.4	x
1B2aiv	Fugitive emissions oil: Refining / storage	10.00	85.4	x
1A3dii	National navigation (shipping)	4.16	89.6	
2B10a	Chemical industry: Other (please specify in the IIR)	1.91	91.5	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	1.77	93.3	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	1.69	95.0	
1A1b	Petroleum refining	0.95	95.9	
1A4bi	Residential: Stationary	0.80	96.7	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.76	97.5	
1A4ai	Commercial/institutional: Stationary	0.72	98.2	
3F	Field burning of agricultural residues	0.31	98.5	
2C1	Iron and steel production	0.30	98.8	
2C5	Lead production	0.28	99.1	
1A3ai(i)	International aviation LTO (civil)	0.25	99.4	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.18	99.5	
1A3bi	Road transport: Passenger cars	0.13	99.7	
1A3aii(i)	Domestic aviation LTO (civil)	0.09	99.8	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.09	99.9	
1A3bii	Road transport: Light duty vehicles	0.05	99.9	
1A3biii	Road transport: Heavy duty vehicles and buses	0.03	99.9	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.03	100.0	
2G	Other product use (please specify in the IIR)	0.01	100.0	
5C1bv	Cremation	0.01	100.0	

SOx **Trend Assessment (1990-2018)**

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
1A1a	Public electricity and heat production	180.93	13.74	0.04	26.35	26.4	x
1A2d	Stationary combustion in manufacturing industries and	16.64	9.79	0.02	16.19	42.5	x
1A2f	Stationary combustion in manufacturing industries and	8.02	6.07	0.02	10.76	53.3	x
1B2aiv	Fugitive emissions oil: Refining / storage	0.34	4.53	0.01	9.80	63.1	x
2H1	Pulp and paper industry	4.55	4.61	0.01	8.64	71.7	x
1A2gviii	Stationary combustion in manufacturing industries and	26.05	0.77	0.01	6.44	78.2	x
1A1b	Petroleum refining	18.80	0.43	0.01	4.92	83.1	x
1A2c	Stationary combustion in manufacturing industries and	14.19	0.35	0.01	3.67	86.8	
1A3dii	National navigation (shipping)	3.54	1.89	0.00	3.02	89.8	
1A2e	Stationary combustion in manufacturing industries and	12.99	0.80	0.00	2.29	92.1	
1A3biii	Road transport: Heavy duty vehicles and buses	6.43	0.02	0.00	1.97	94.0	
1A3bii	Road transport: Light duty vehicles	3.49	0.02	0.00	1.03	95.1	
1A3bi	Road transport: Passenger cars	3.29	0.06	0.00	0.89	96.0	
1A4ai	Commercial/institutional: Stationary	4.81	0.33	0.00	0.79	96.8	
2B10a	Chemical industry: Other (please specify in the IIR)	7.96	0.87	0.00	0.58	97.3	
1A4bi	Residential: Stationary	0.77	0.36	0.00	0.55	97.9	
1A4ci	Agriculture/Forestry/Fishing: Stationary	1.52	0.08	0.00	0.30	98.2	
2C1	Iron and steel production	0.02	0.14	0.00	0.29	98.5	
2C5	Lead production	0.06	0.13	0.00	0.26	98.7	
3F	Field burning of agricultural residues	0.19	0.14	0.00	0.25	99.0	
1A3ai(i)	International aviation LTO (civil)	0.03	0.11	0.00	0.24	99.2	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.76	0.00	0.00	0.23	99.4	
1A2gvii	Mobile Combustion in manufacturing industries and cor	0.44	0.00	0.00	0.13	99.6	
1A3c	Railways	0.34	0.00	0.00	0.10	99.7	
1A3aii(i)	Domestic aviation LTO (civil)	0.02	0.04	0.00	0.09	99.8	
1A2a	Stationary combustion in manufacturing industries and	0.23	0.00	0.00	0.07	99.8	
1A3biv	Road transport: Mopeds & motorcycles	0.20	0.00	0.00	0.06	99.9	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.15	0.04	0.00	0.04	99.9	
1A5b	Other, Mobile (including military, land based and recrea	0.03	0.02	0.00	0.03	100.0	
2G	Other product use (please specify in the IIR)	0.00	0.00	0.00	0.01	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	
5C1biii	Clinical waste incineration	0.01	0.00	0.00	0.00	100.0	
5C1bi	Industrial waste incineration	0.00	0.00	0.00	0.00	100.0	

NH3 Level Assessment

NFR	Sectors	%total 2018	Cumulative total	Key category
3Da2a	Animal manure applied to soils	21.60	21.6	x
3Da1	Inorganic N-fertilizers (includes also urea application)	11.58	33.2	x
3B3	Manure management - Swine	10.65	43.8	x
3Da3	Urine and dung deposited by grazing animals	9.81	53.6	x
3B1a	Manure management - Dairy cattle	8.74	62.4	x
3B4gii	Manure mangement - Broilers	6.34	68.7	x
2B10a	Chemical industry: Other (please specify in the IIR)	5.63	74.4	x
3B4gi	Manure mangement - Laying hens	4.65	79.0	x
3B1b	Manure management - Non-dairy cattle	4.13	83.1	x
1A4bi	Residential: Stationary	3.33	86.5	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	3.11	89.6	
5A	Biological treatment of waste - Solid waste disposal on land	2.16	91.7	
1A3bi	Road transport: Passenger cars	1.49	93.2	
3F	Field burning of agricultural residues	1.38	94.6	
3B4giii	Manure mangement - Turkeys	0.87	95.5	
1B2d	Other fugitive emissions from energy production	0.76	96.2	
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	0.76	97.0	
3B2	Manure management - Sheep	0.72	97.7	
3B4giv	Manure management - Other poultry	0.57	98.3	
3B4h	Manure management - Other animals (please specify in IIR)	0.42	98.7	
1B2aiv	Fugitive emissions oil: Refining / storage	0.22	98.9	
2G	Other product use (please specify in the IIR)	0.14	99.1	
3Da2c	Other organic fertilisers applied to soils (including compost)	0.13	99.2	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.13	99.3	
3B4d	Manure management - Goats	0.11	99.4	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.09	99.5	
1A4ai	Commercial/institutional: Stationary	0.08	99.6	
5B2	Biological treatment of waste - Anaerobic digestion at biogas facilities	0.08	99.7	
3B4e	Manure management - Horses	0.07	99.8	
1A3bii	Road transport: Light duty vehicles	0.05	99.8	
1A3biii	Road transport: Heavy duty vehicles and buses	0.04	99.9	
3B4f	Manure management - Mules and asses	0.03	99.9	
1A1a	Public electricity and heat production	0.03	99.9	
3Da2b	Sewage sludge applied to soils	0.02	99.9	
2D3g	Chemical products	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	

NH3 Trend Assessment (1990-2018)

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
3Da3	Urine and dung deposited by grazing animals	4.06	5.51	0.03	19.43	19.4	x
3B4gii	Manure mangement - Broilers	2.85	3.56	0.02	11.27	30.7	x
3Da2a	Animal manure applied to soils	14.95	12.13	0.01	8.11	38.8	x
1A4bi	Residential: Stationary	3.81	1.87	0.01	7.47	46.3	x
1A2d	Stationary combustion in manufacturing industries and	1.13	1.75	0.01	7.06	53.3	x
2B10a	Chemical industry: Other (please specify in the IIR)	5.42	3.16	0.01	6.70	60.0	x
1A3bi	Road transport: Passenger cars	0.04	0.84	0.01	6.27	66.3	x
3B2	Manure management - Sheep	1.29	0.40	0.01	4.28	70.6	x
3B4h	Manure management - Other animals (please specify ir	1.04	0.24	0.01	4.19	74.8	x
5A	Biological treatment of waste - Solid waste disposal on	1.06	1.21	0.01	3.29	78.1	x
1B2d	Other fugitive emissions from energy production	0.01	0.43	0.01	3.29	81.4	x
3B4f	Manure management - Mules and asses	0.56	0.02	0.01	3.08	84.4	
3B4gi	Manure mangement - Laying hens	3.01	2.61	0.00	2.92	87.3	
1A2f	Stationary combustion in manufacturing industries and	1.03	0.43	0.00	2.65	90.0	
3Da1	Inorganic N-fertilizers (includes also urea application)	9.20	6.50	0.00	2.52	92.5	
3B1b	Manure management - Non-dairy cattle	2.77	2.32	0.00	2.09	94.6	
3B4d	Manure management - Goats	0.26	0.06	0.00	1.03	95.6	
3B4e	Manure management - Horses	0.16	0.04	0.00	0.57	96.2	
3B4giv	Manure management - Other poultry	0.33	0.32	0.00	0.57	96.8	
2G	Other product use (please specify in the IIR)	0.02	0.08	0.00	0.52	97.3	
1A2e	Stationary combustion in manufacturing industries and	0.15	0.05	0.00	0.45	97.7	
1A4ai	Commercial/institutional: Stationary	NO	0.05	0.00	0.36	98.1	
5B2	Biological treatment of waste - Anaerobic digestion at b	NO	0.05	0.00	0.35	98.5	
3B1a	Manure management - Dairy cattle	6.66	4.91	0.00	0.25	98.7	
3F	Field burning of agricultural residues	1.01	0.78	0.00	0.20	98.9	
1A3bii	Road transport: Light duty vehicles	0.01	0.03	0.00	0.18	99.1	
1A2c	Stationary combustion in manufacturing industries and	0.04	0.01	0.00	0.18	99.3	
3B4giii	Manure mangement - Turkeys	0.69	0.49	0.00	0.17	99.4	
3B3	Manure management - Swine	8.09	5.98	0.00	0.16	99.6	
3Da2b	Sewage sludge applied to soils	0.04	0.01	0.00	0.15	99.7	
1A3biii	Road transport: Heavy duty vehicles and buses	0.01	0.02	0.00	0.12	99.9	
1A2gviii	Stationary combustion in manufacturing industries and	0.11	0.07	0.00	0.08	99.9	
5B1	Biological treatment of waste - Composting	0.01	0.01	0.00	0.03	100.0	
2D3g	Chemical products	0.01	0.01	0.00	0.01	100.0	
2B2	Nitric acid production	0.01	0.01	0.00	0.01	100.0	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.00	0.00	0.00	0.00	100.0	
1A3biv	Road transport: Mopeds & motorcycles	0.00	0.00	0.00	0.00	100.0	
1A3c	Railways	0.00	0.00	0.00	0.00	100.0	
1A2gvii	Mobile Combustion in manufacturing industries and cor	0.00	0.00	0.00	0.00	100.0	

PM2.5 **Level Assessment**

NFR	Sectors	%total 2018	Cumulative total	Key category
1A4bi	Residential: Stationary	35.76	35.8	x
2H1	Pulp and paper industry	13.32	49.1	x
2B10a	Chemical industry: Other (please specify in the IIR)	9.44	58.5	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	9.30	67.8	x
3F	Field burning of agricultural residues	3.45	71.3	x
2D3b	Road paving with asphalt	3.13	74.4	x
2A3	Glass production	3.07	77.5	x
1A3ai(i)	International aviation LTO (civil)	2.73	80.2	x
1A3bi	Road transport: Passenger cars	2.43	82.6	
1A3bii	Road transport: Light duty vehicles	2.33	85.0	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	1.54	86.5	
1A3bvi	Road transport: Automobile tyre and brake wear	1.43	87.9	
1A3aii(i)	Domestic aviation LTO (civil)	1.02	89.0	
2G	Other product use (please specify in the IIR)	1.01	90.0	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	1.00	91.0	
5E	Other waste (please specify in IIR)	0.88	91.8	
1A1a	Public electricity and heat production	0.78	92.6	
1A3dii	National navigation (shipping)	0.73	93.4	
2A2	Lime production	0.69	94.1	
1A3bvii	Road transport: Automobile road abrasion	0.67	94.7	
1A3biii	Road transport: Heavy duty vehicles and buses	0.67	95.4	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.56	96.0	
2A5a	Quarrying and mining of minerals other than coal	0.52	96.5	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.51	97.0	
1B2aiv	Fugitive emissions oil: Refining / storage	0.37	97.4	
2D3i	Other solvent use (please specify in the IIR)	0.36	97.7	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.30	98.0	
2A5b	Construction and demolition	0.23	98.2	
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.21	98.5	
1A4ai	Commercial/institutional: Stationary	0.21	98.7	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.13	98.8	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.12	98.9	
3B1a	Manure management - Dairy cattle	0.12	99.0	
3B4giii	Manure mangement - Turkeys	0.11	99.1	
2D3g	Chemical products	0.10	99.2	
2C1	Iron and steel production	0.09	99.3	
3B4gii	Manure mangement - Broilers	0.09	99.4	
1A3biv	Road transport: Mopeds & motorcycles	0.09	99.5	
1A1b	Petroleum refining	0.07	99.6	
3B4giv	Manure management - Other poultry	0.07	99.7	
2H2	Food and beverages industry	0.06	99.7	
2A5c	Storage, handling and transport of mineral products	0.06	99.8	
3B4gi	Manure mangement - Laying hens	0.05	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	

PM2.5 **Trend Assessment (1990-2018)**

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
1A4bi	Residential: Stationary	37.53	18.29	0.12	33.17	33.2	x
2H1	Pulp and paper industry	3.27	6.81	0.06	16.88	50.0	x
1A2f	Stationary combustion in manufacturing industries and	2.83	4.76	0.04	10.29	60.3	x
2A3	Glass production	0.53	1.57	0.02	4.50	64.8	x
1A3ai(i)	International aviation LTO (civil)	0.39	1.40	0.02	4.23	69.1	x
1A3biii	Road transport: Heavy duty vehicles and buses	1.90	0.34	0.01	3.90	73.0	x
1A1a	Public electricity and heat production	1.68	0.40	0.01	3.07	76.0	x
1A3bi	Road transport: Passenger cars	0.63	1.24	0.01	3.01	79.0	x
2B10a	Chemical industry: Other (please specify in the IIR)	7.30	4.83	0.01	1.66	80.7	x
2G	Other product use (please specify in the IIR)	0.12	0.52	0.01	1.65	82.3	
2D3b	Road paving with asphalt	1.62	1.60	0.01	1.64	84.0	
1A3bii	Road transport: Light duty vehicles	2.21	1.19	0.01	1.53	85.5	
1A3bvi	Road transport: Automobile tyre and brake wear	0.47	0.73	0.01	1.50	87.0	
1A3biv	Road transport: Mopeds & motorcycles	0.60	0.04	0.01	1.47	88.5	
1A3aii(i)	Domestic aviation LTO (civil)	0.23	0.52	0.00	1.34	89.8	
1A2e	Stationary combustion in manufacturing industries and	0.84	0.28	0.00	1.21	91.0	
1A2gviii	Stationary combustion in manufacturing industries and	1.08	0.51	0.00	1.02	92.1	
1A2c	Stationary combustion in manufacturing industries and	0.42	0.07	0.00	0.89	93.0	
2A2	Lime production	0.18	0.35	0.00	0.84	93.8	
2A5b	Construction and demolition	0.46	0.12	0.00	0.82	94.6	
1A3bvii	Road transport: Automobile road abrasion	0.19	0.34	0.00	0.79	95.4	
1A2d	Stationary combustion in manufacturing industries and	0.83	0.79	0.00	0.72	96.1	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.19	0.26	0.00	0.46	96.6	
3F	Field burning of agricultural residues	2.30	1.76	0.00	0.40	97.0	
1A3dii	National navigation (shipping)	0.38	0.38	0.00	0.40	97.4	
2D3i	Other solvent use (please specify in the IIR)	0.12	0.18	0.00	0.37	97.8	
1A4ai	Commercial/institutional: Stationary	0.02	0.11	0.00	0.34	98.1	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.10	0.15	0.00	0.32	98.4	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.18	0.06	0.00	0.26	98.7	
1A1b	Petroleum refining	0.13	0.04	0.00	0.21	98.9	
2A5a	Quarrying and mining of minerals other than coal	0.30	0.27	0.00	0.19	99.1	
1A3c	Railways	0.08	0.01	0.00	0.16	99.2	
3Dc	Farm-level agricultural operations including storage, har	0.06	0.02	0.00	0.10	99.3	
3B1a	Manure management - Dairy cattle	0.11	0.06	0.00	0.08	99.4	
2D3g	Chemical products	0.04	0.05	0.00	0.08	99.5	
3B4gii	Manure mangement - Broilers	0.04	0.04	0.00	0.07	99.5	
2H2	Food and beverages industry	0.02	0.03	0.00	0.06	99.6	
1A2a	Stationary combustion in manufacturing industries and	0.02	0.00	0.00	0.06	99.7	
3B4giv	Manure management - Other poultry	0.03	0.04	0.00	0.04	99.7	
1A4bii	Residential: Household and gardening (mobile)	0.02	0.00	0.00	0.04	99.8	
2C1	Iron and steel production	0.05	0.05	0.00	0.03	99.8	
5C1biii	Clinical waste incineration	0.01	0.00	0.00	0.03	99.8	
5E	Other waste (please specify in IIR)	0.63	0.45	0.00	0.03	99.8	
2A5c	Storage, handling and transport of mineral products	0.04	0.03	0.00	0.02	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	
3B4gi	Manure mangement - Laying hens	0.03	0.03	0.00	0.02	100.0	
1A2gvii	Mobile Combustion in manufacturing industries and cor	0.16	0.11	0.00	0.01	100.0	
2D3c	Asphalt roofing	0.01	0.01	0.00	0.01	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 2018	Cumulative total	Key category
1A4bi	Residential: Stationary	26.41	26.4	x
2D3b	Road paving with asphalt	14.24	40.6	x
2H1	Pulp and paper industry	11.63	52.3	x
2B10a	Chemical industry: Other (please specify in the IIR)	6.87	59.2	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	6.70	65.9	x
2A5a	Quarrying and mining of minerals other than coal	3.75	69.6	x
3F	Field burning of agricultural residues	2.62	72.2	x
2A2	Lime production	2.47	74.7	x
2A3	Glass production	2.31	77.0	x
1A3ai(i)	International aviation LTO (civil)	1.97	79.0	x
1A3bvi	Road transport: Automobile tyre and brake wear	1.91	80.9	x
1A3bi	Road transport: Passenger cars	1.75	82.6	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	1.73	84.4	
1A3bii	Road transport: Light duty vehicles	1.68	86.0	
2A5b	Construction and demolition	1.62	87.7	
1A3bvii	Road transport: Automobile road abrasion	0.89	88.6	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.79	89.3	
1A3aii(i)	Domestic aviation LTO (civil)	0.74	90.1	
2G	Other product use (please specify in the IIR)	0.73	90.8	
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	0.72	91.5	
1A1a	Public electricity and heat production	0.64	92.2	
5E	Other waste (please specify in IIR)	0.63	92.8	
3B4gii	Manure mangement - Broilers	0.62	93.4	
1B2aiv	Fugitive emissions oil: Refining / storage	0.61	94.0	
3B4giii	Manure mangement - Turkeys	0.60	94.6	
1A3dii	National navigation (shipping)	0.58	95.2	
3B4gi	Manure mangement - Laying hens	0.53	95.8	
1A3biii	Road transport: Heavy duty vehicles and buses	0.48	96.2	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.48	96.7	
2A5c	Storage, handling and transport of mineral products	0.46	97.2	
2D3i	Other solvent use (please specify in the IIR)	0.39	97.6	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.37	97.9	
3B4giv	Manure management - Other poultry	0.35	98.3	
3B3	Manure management - Swine	0.30	98.6	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.27	98.9	
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.15	99.0	
1A4ai	Commercial/institutional: Stationary	0.15	99.2	
3B1a	Manure management - Dairy cattle	0.13	99.3	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.12	99.4	
2D3g	Chemical products	0.11	99.5	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.09	99.6	
2C1	Iron and steel production	0.08	99.7	
1A3biv	Road transport: Mopeds & motorcycles	0.06	99.7	
1A1b	Petroleum refining	0.06	99.8	
2D3c	Asphalt roofing	0.05	99.8	
3B1b	Manure management - Non-dairy cattle	0.05	99.9	
2H2	Food and beverages industry	0.05	99.9	
1A3c	Railways	0.02	100.0	
3B2	Manure management - Sheep	0.02	100.0	
2C7d	Storage, handling and transport of metal products (please specify in the IIR)	0.01	100.0	

PM10 Trend Assessment (1990-2018)

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
1A4bi	Residential: Stationary	38.49	18.75	0.10	25.93	25.9	x
2H1	Pulp and paper industry	3.97	8.26	0.06	14.52	40.4	x
1A2f	Stationary combustion in manufacturing industries and	2.84	4.76	0.03	7.26	47.7	x
2D3b	Road paving with asphalt	10.23	10.11	0.03	7.05	54.8	x
2A5b	Construction and demolition	4.61	1.15	0.02	6.08	60.8	x
1A1a	Public electricity and heat production	3.11	0.46	0.02	4.97	65.8	x
2A3	Glass production	0.55	1.64	0.01	3.35	69.2	x
1A3ai(i)	International aviation LTO (civil)	0.39	1.40	0.01	3.01	72.2	x
2A2	Lime production	0.90	1.76	0.01	2.97	75.1	x
1A3biii	Road transport: Heavy duty vehicles and buses	1.90	0.34	0.01	2.87	78.0	x
1A3bi	Road transport: Passenger cars	0.63	1.24	0.01	2.13	80.1	x
1A3bvi	Road transport: Automobile tyre and brake wear	0.88	1.36	0.01	1.92	82.1	
3Dc	Farm-level agricultural operations including storage, har	1.64	0.51	0.01	1.89	83.9	
2B10a	Chemical industry: Other (please specify in the IIR)	7.37	4.88	0.01	1.46	85.4	
1A2gviii	Stationary combustion in manufacturing industries and	1.40	0.56	0.00	1.26	86.7	
2A5a	Quarrying and mining of minerals other than coal	3.00	2.66	0.00	1.24	87.9	
1A2e	Stationary combustion in manufacturing industries and	1.06	0.34	0.00	1.20	89.1	
1A3bii	Road transport: Light duty vehicles	2.21	1.19	0.00	1.19	90.3	
2G	Other product use (please specify in the IIR)	0.12	0.52	0.00	1.18	91.5	
1A3biv	Road transport: Mopeds & motorcycles	0.60	0.04	0.00	1.08	92.6	
1A3bvii	Road transport: Automobile road abrasion	0.35	0.63	0.00	1.02	93.6	
1A3aii(i)	Domestic aviation LTO (civil)	0.23	0.52	0.00	0.95	94.5	
1A2c	Stationary combustion in manufacturing industries and	0.57	0.08	0.00	0.91	95.4	
1A2d	Stationary combustion in manufacturing industries and	1.39	1.23	0.00	0.56	96.0	
3B4gii	Manure mangement - Broilers	0.37	0.44	0.00	0.47	96.5	
2D3i	Other solvent use (please specify in the IIR)	0.18	0.28	0.00	0.39	96.8	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.19	0.26	0.00	0.32	97.2	
1A1b	Petroleum refining	0.21	0.04	0.00	0.31	97.5	
1A3dii	National navigation (shipping)	0.41	0.41	0.00	0.30	97.8	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.12	0.19	0.00	0.28	98.1	
1A4ai	Commercial/institutional: Stationary	0.02	0.11	0.00	0.25	98.3	
3B4giv	Manure management - Other poultry	0.23	0.25	0.00	0.21	98.5	
3F	Field burning of agricultural residues	2.42	1.86	0.00	0.21	98.7	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.19	0.06	0.00	0.20	98.9	
2A5c	Storage, handling and transport of mineral products	0.36	0.33	0.00	0.16	99.1	
3B4gi	Manure mangement - Laying hens	0.44	0.37	0.00	0.14	99.2	
1A3c	Railways	0.08	0.01	0.00	0.12	99.4	
2D3g	Chemical products	0.05	0.08	0.00	0.10	99.5	
3B1a	Manure management - Dairy cattle	0.17	0.09	0.00	0.10	99.6	
3B2	Manure management - Sheep	0.04	0.01	0.00	0.05	99.6	
5E	Other waste (please specify in IIR)	0.63	0.45	0.00	0.05	99.6	
2H2	Food and beverages industry	0.02	0.03	0.00	0.04	99.7	
3B4giii	Manure mangement - Turkeys	0.60	0.42	0.00	0.04	99.7	
1A2a	Stationary combustion in manufacturing industries and	0.02	0.00	0.00	0.04	99.8	
5C1biii	Clinical waste incineration	0.02	0.00	0.00	0.03	99.8	
1A4bii	Residential: Household and gardening (mobile)	0.02	0.00	0.00	0.03	99.8	
3B1b	Manure management - Non-dairy cattle	0.06	0.03	0.00	0.03	99.9	
2D3c	Asphalt roofing	0.04	0.04	0.00	0.03	99.9	
3B4f	Manure management - Mules and asses	0.01	0.00	0.00	0.02	99.9	
1A2gvii	Mobile Combustion in manufacturing industries and cor	0.16	0.11	0.00	0.01	99.9	
3B4d	Manure management - Goats	0.01	0.00	0.00	0.01	99.9	
3B4h	Manure management - Other animals (please specify ir	0.01	0.00	0.00	0.01	100.0	
3B3	Manure management - Swine	0.29	0.22	0.00	0.01	100.0	
2C1	Iron and steel production	0.07	0.05	0.00	0.01	100.0	
2C7d	Storage, handling and transport of metal products (plea	0.00	0.00	0.00	0.01	100.0	
3B4e	Manure management - Horses	0.00	0.00	0.00	0.01	100.0	

TSP **Level Assessment**

NFR	Sectors	%total 2018	Cumulative total	Key category
2D3b	Road paving with asphalt	36.00	36.0	x
1A4bi	Residential: Stationary	12.51	48.5	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	10.68	59.2	x
2B10a	Chemical industry: Other (please specify in the IIR)	7.36	66.5	x
2H1	Pulp and paper industry	5.93	72.5	x
2A5a	Quarrying and mining of minerals other than coal	3.45	75.9	x
2A2	Lime production	2.87	78.8	x
2I	Wood processing	2.47	81.3	x
2A5b	Construction and demolition	2.43	83.7	
3F	Field burning of agricultural residues	1.20	84.9	
1A3bvi	Road transport: Automobile tyre and brake wear	1.15	86.0	
3B4gi	Manure mangement - Laying hens	1.13	87.2	
2A3	Glass production	1.10	88.3	
2D3g	Chemical products	1.06	89.3	
3B3	Manure management - Swine	0.90	90.2	
1A3ai(i)	International aviation LTO (civil)	0.89	91.1	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	0.87	92.0	
1A3bvii	Road transport: Automobile road abrasion	0.80	92.8	
1A3bi	Road transport: Passenger cars	0.79	93.6	
1A3bii	Road transport: Light duty vehicles	0.76	94.3	
3B4gii	Manure mangement - Broilers	0.56	94.9	
2A5c	Storage, handling and transport of mineral products	0.42	95.3	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.39	95.7	
1A1a	Public electricity and heat production	0.36	96.1	
1B2aiv	Fugitive emissions oil: Refining / storage	0.35	96.4	
1A3aii(i)	Domestic aviation LTO (civil)	0.33	96.7	
2G	Other product use (please specify in the IIR)	0.33	97.1	
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	0.32	97.4	
5E	Other waste (please specify in IIR)	0.29	97.7	
3B4giii	Manure mangement - Turkeys	0.27	98.0	
1A3dii	National navigation (shipping)	0.26	98.2	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.24	98.5	
1A3biii	Road transport: Heavy duty vehicles and buses	0.22	98.7	
2D3i	Other solvent use (please specify in the IIR)	0.21	98.9	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.16	99.1	
3B4giv	Manure management - Other poultry	0.16	99.2	
3B1a	Manure management - Dairy cattle	0.13	99.3	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.12	99.5	
2D3c	Asphalt roofing	0.09	99.5	
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.07	99.6	
1A4ai	Commercial/institutional: Stationary	0.07	99.7	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.06	99.7	
3B1b	Manure management - Non-dairy cattle	0.05	99.8	
2C1	Iron and steel production	0.04	99.8	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.04	99.9	
1A3biv	Road transport: Mopeds & motorcycles	0.03	99.9	
1A1b	Petroleum refining	0.03	99.9	
2H2	Food and beverages industry	0.02	100.0	
3B2	Manure management - Sheep	0.02	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 (1990-2018)**

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
1A4bi	Residential: Stationary	40.41	19.68	0.08	21.75	21.8	x
2A5b	Construction and demolition	15.37	3.82	0.05	13.59	35.3	x
1A2f	Stationary combustion in manufacturing industries and	9.21	16.81	0.05	12.91	48.3	x
2D3b	Road paving with asphalt	57.30	56.65	0.04	10.81	59.1	x
2H1	Pulp and paper industry	4.48	9.33	0.03	7.95	67.0	x
1A1a	Public electricity and heat production	4.68	0.57	0.02	5.00	72.0	x
2A2	Lime production	2.32	4.52	0.01	3.66	75.7	x
2I	Wood processing	1.91	3.88	0.01	3.26	78.9	x
1A3biii	Road transport: Heavy duty vehicles and buses	1.90	0.34	0.01	1.87	80.8	x
2A3	Glass production	0.58	1.73	0.01	1.77	82.6	
1A3ai(i)	International aviation LTO (civil)	0.39	1.40	0.01	1.54	84.1	
2B10a	Chemical industry: Other (please specify in the IIR)	12.35	11.59	0.01	1.43	85.5	
3Dc	Farm-level agricultural operations including storage, har	1.64	0.51	0.00	1.30	86.8	
1A3bvi	Road transport: Automobile tyre and brake wear	1.15	1.80	0.00	1.18	88.0	
1A2gviii	Stationary combustion in manufacturing industries and	1.60	0.61	0.00	1.10	89.1	
1A3bii	Road transport: Light duty vehicles	2.21	1.19	0.00	1.03	90.1	
1A3bi	Road transport: Passenger cars	0.63	1.24	0.00	1.03	91.2	
2D3g	Chemical products	1.13	1.67	0.00	1.02	92.2	
1A3bvii	Road transport: Automobile road abrasion	0.70	1.27	0.00	0.97	93.2	
1A2e	Stationary combustion in manufacturing industries and	1.20	0.38	0.00	0.94	94.1	
1A2c	Stationary combustion in manufacturing industries and	0.69	0.10	0.00	0.72	94.8	
1A3biv	Road transport: Mopeds & motorcycles	0.60	0.04	0.00	0.68	95.5	
2G	Other product use (please specify in the IIR)	0.12	0.52	0.00	0.61	96.1	
1A3aii(i)	Domestic aviation LTO (civil)	0.23	0.52	0.00	0.47	96.6	
3B4gii	Manure mangement - Broilers	0.74	0.89	0.00	0.37	96.9	
3F	Field burning of agricultural residues	2.46	1.88	0.00	0.33	97.3	
1A1b	Petroleum refining	0.27	0.04	0.00	0.28	97.5	
3B3	Manure management - Swine	1.87	1.42	0.00	0.27	97.8	
2A5a	Quarrying and mining of minerals other than coal	6.12	5.43	0.00	0.25	98.1	
2D3i	Other solvent use (please specify in the IIR)	0.22	0.34	0.00	0.21	98.3	
3B1a	Manure management - Dairy cattle	0.38	0.20	0.00	0.18	98.5	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.19	0.06	0.00	0.14	98.6	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.19	0.26	0.00	0.14	98.7	
5E	Other waste (please specify in IIR)	0.63	0.45	0.00	0.14	98.9	
3B4giii	Manure mangement - Turkeys	0.60	0.42	0.00	0.13	99.0	
1A4ai	Commercial/institutional: Stationary	0.02	0.11	0.00	0.13	99.1	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.12	0.19	0.00	0.13	99.3	
1A3dii	National navigation (shipping)	0.41	0.41	0.00	0.09	99.3	
1A3c	Railways	0.09	0.01	0.00	0.09	99.4	
3B2	Manure management - Sheep	0.09	0.03	0.00	0.07	99.5	
3B4giv	Manure management - Other poultry	0.23	0.25	0.00	0.07	99.6	
3B1b	Manure management - Non-dairy cattle	0.14	0.08	0.00	0.06	99.6	
2A5c	Storage, handling and transport of mineral products	0.73	0.65	0.00	0.05	99.7	
2C1	Iron and steel production	0.11	0.07	0.00	0.04	99.7	
1A2gvii	Mobile Combustion in manufacturing industries and cor	0.16	0.11	0.00	0.04	99.8	
5C1biii	Clinical waste incineration	0.03	0.00	0.00	0.03	99.8	
3B4f	Manure management - Mules and asses	0.02	0.00	0.00	0.03	99.8	
2D3c	Asphalt roofing	0.14	0.14	0.00	0.03	99.8	
1A2a	Stationary combustion in manufacturing industries and	0.02	0.00	0.00	0.03	99.9	
3B4d	Manure management - Goats	0.02	0.01	0.00	0.02	99.9	
1A2d	Stationary combustion in manufacturing industries and	1.60	1.36	0.00	0.02	99.9	
1A4bii	Residential: Household and gardening (mobile)	0.02	0.00	0.00	0.02	99.9	
2H2	Food and beverages industry	0.02	0.03	0.00	0.02	99.9	
3B4h	Manure management - Other animals (please specify ir	0.02	0.00	0.00	0.02	100.0	
3B4gi	Manure mangement - Laying hens	2.08	1.78	0.00	0.01	100.0	
3B4e	Manure management - Horses	0.01	0.00	0.00	0.01	100.0	
2C7d	Storage, handling and transport of metal products (plea:	0.00	0.01	0.00	0.01	100.0	

BC **Level Assessment**

NFR	Sectors	%total 2018	Cumulative total	Key category
1A4bi	Residential: Stationary	28.06	28.1	x
1A3bi	Road transport: Passenger cars	14.82	42.9	x
1A3bii	Road transport: Light duty vehicles	13.07	56.0	x
1A3ai(i)	International aviation LTO (civil)	10.47	66.4	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	8.14	74.6	x
1A3aii(i)	Domestic aviation LTO (civil)	3.91	78.5	x
1A3biii	Road transport: Heavy duty vehicles and buses	3.50	82.0	x
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	3.18	85.2	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	2.97	88.1	
3F	Field burning of agricultural residues	2.56	90.7	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	2.35	93.0	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	1.62	94.7	
1A4ci	Agriculture/Forestry/Fishing: Stationary	1.48	96.1	
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	1.04	97.2	
1A3dii	National navigation (shipping)	0.88	98.1	
2B10a	Chemical industry: Other (please specify in the IIR)	0.43	98.5	
1A4ai	Commercial/institutional: Stationary	0.35	98.8	
1A1a	Public electricity and heat production	0.34	99.2	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.29	99.5	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.27	99.7	
1A3biv	Road transport: Mopeds & motorcycles	0.11	99.9	
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	
1B2aiv	Fugitive emissions oil: Refining / storage	0.00	100.0	
5C1biii	Clinical waste incineration	0.00	100.0	
2C3	Aluminium production	0.00	100.0	
5C1bi	Industrial waste incineration	0.00	100.0	
2D3c	Asphalt roofing	0.00	100.0	
2B6	Titanium dioxide production	0.00	100.0	
1A4aii	Commercial/institutional: Mobile	0.00	100.0	

BC **Trend Assessment (1990-2018)**

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
1A4bi	Residential: Stationary	3.76	1.80	0.10	23.75	23.7	x
1A3bi	Road transport: Passenger cars	0.33	0.95	0.08	18.36	42.1	x
1A3ai(i)	International aviation LTO (civil)	0.19	0.67	0.06	13.76	55.9	x
1A3biii	Road transport: Heavy duty vehicles and buses	0.95	0.22	0.05	11.95	67.8	x
1A2f	Stationary combustion in manufacturing industries and	0.24	0.52	0.04	8.92	76.7	x
1A3aii(i)	Domestic aviation LTO (civil)	0.11	0.25	0.02	4.37	81.1	x
1A2gviii	Stationary combustion in manufacturing industries and	0.49	0.20	0.02	3.88	85.0	
1A2e	Stationary combustion in manufacturing industries and	0.32	0.10	0.01	3.34	88.3	
1A2c	Stationary combustion in manufacturing industries and	0.16	0.02	0.01	2.48	90.8	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.11	0.15	0.01	1.81	92.6	
1A3biv	Road transport: Mopeds & motorcycles	0.09	0.01	0.01	1.48	94.1	
1A3bii	Road transport: Light duty vehicles	1.22	0.84	0.01	1.15	95.2	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.07	0.09	0.00	1.09	96.3	
1A4ai	Commercial/institutional: Stationary	0.00	0.02	0.00	0.57	96.9	
1A4bii	Residential: Household and gardening (mobile)	0.03	0.00	0.00	0.55	97.5	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.05	0.02	0.00	0.54	98.0	
1A1a	Public electricity and heat production	0.06	0.02	0.00	0.48	98.5	
2B10a	Chemical industry: Other (please specify in the IIR)	0.02	0.03	0.00	0.41	98.9	
1A3dii	National navigation (shipping)	0.06	0.06	0.00	0.40	99.3	
1A2d	Stationary combustion in manufacturing industries and	0.28	0.19	0.00	0.25	99.5	
3F	Field burning of agricultural residues	0.21	0.16	0.00	0.24	99.8	
1A2gvii	Mobile Combustion in manufacturing industries and cor	0.10	0.07	0.00	0.08	99.9	
1A1b	Petroleum refining	0.01	0.00	0.00	0.06	99.9	
2G	Other product use (please specify in the IIR)	0.00	0.00	0.00	0.05	100.0	
2A2	Lime production	0.00	0.00	0.00	0.03	100.0	
5C1biii	Clinical waste incineration	0.00	0.00	0.00	0.01	100.0	
1A4aii	Commercial/institutional: Mobile	0.00	0.00	0.00	0.00	100.0	
2C3	Aluminium production	0.00	0.00	0.00	0.00	100.0	
5C1bi	Industrial waste incineration	0.00	0.00	0.00	0.00	100.0	
2C7a	Copper production	0.00	0.00	0.00	0.00	100.0	

CO Level Assessment

NFR	Sectors	%total 2018	Cumulative total	Key category
1A4bi	Residential: Stationary	35.75	35.7	x
1A3bi	Road transport: Passenger cars	18.80	54.5	x
1B2aiv	Fugitive emissions oil: Refining / storage	10.86	65.4	x
3F	Field burning of agricultural residues	10.37	75.8	x
1A3biv	Road transport: Mopeds & motorcycles	3.70	79.5	x
2B10a	Chemical industry: Other (please specify in the IIR)	3.09	82.6	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	2.52	85.1	
1A3bii	Road transport: Light duty vehicles	2.29	87.4	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	2.13	89.5	
1A1a	Public electricity and heat production	1.97	91.5	
1A3biii	Road transport: Heavy duty vehicles and buses	1.61	93.1	
2C1	Iron and steel production	1.35	94.4	
1A3ai(i)	International aviation LTO (civil)	1.30	95.7	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.66	96.4	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.58	97.0	
1A3aii(i)	Domestic aviation LTO (civil)	0.48	97.5	
2G	Other product use (please specify in the IIR)	0.37	97.8	
1A1b	Petroleum refining	0.35	98.2	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.34	98.5	
1A4ai	Commercial/institutional: Stationary	0.34	98.9	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.26	99.1	
1A3dii	National navigation (shipping)	0.22	99.3	
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.20	99.5	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.15	99.7	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.11	99.8	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.09	99.9	
1A3c	Railways	0.04	99.9	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.03	100.0	
1A4bii	Residential: Household and gardening (mobile)	0.03	100.0	
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.02	100.0	

CO Trend Assessment (1990-2018)

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
1A3bi	Road transport: Passenger cars	385.37	53.48	0.10	40.54	40.5	x
1B2aiv	Fugitive emissions oil: Refining / storage	0.14	30.91	0.04	14.95	55.5	x
1A4bi	Residential: Stationary	213.27	101.72	0.03	12.50	68.0	x
3F	Field burning of agricultural residues	38.63	29.50	0.02	7.63	75.6	x
1A3biv	Road transport: Mopeds & motorcycles	59.03	10.54	0.01	5.07	80.7	x
2B10a	Chemical industry: Other (please specify in the IIR)	5.44	8.79	0.01	3.32	84.0	
1A3bii	Road transport: Light duty vehicles	33.29	6.51	0.01	2.59	86.6	
1A1a	Public electricity and heat production	2.11	5.59	0.01	2.35	88.9	
1A2d	Stationary combustion in manufacturing industries and	5.67	6.06	0.01	1.96	90.9	
2C1	Iron and steel production	1.87	3.83	0.00	1.53	92.4	
1A3ai(i)	International aviation LTO (civil)	3.30	3.71	0.00	1.23	93.7	
1A2a	Stationary combustion in manufacturing industries and	6.28	0.05	0.00	1.06	94.7	
1A2f	Stationary combustion in manufacturing industries and	14.07	7.17	0.00	1.05	95.8	
2G	Other product use (please specify in the IIR)	0.24	1.06	0.00	0.47	96.2	
1A1b	Petroleum refining	0.25	1.00	0.00	0.44	96.7	
1A4bii	Residential: Household and gardening (mobile)	2.70	0.07	0.00	0.43	97.1	
1A4ai	Commercial/institutional: Stationary	0.21	0.96	0.00	0.43	97.5	
1A3aii(i)	Domestic aviation LTO (civil)	1.52	1.37	0.00	0.40	97.9	
1A2gviii	Stationary combustion in manufacturing industries and	2.54	1.66	0.00	0.37	98.3	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	3.36	1.89	0.00	0.34	98.6	
1A3biii	Road transport: Heavy duty vehicles and buses	11.38	4.58	0.00	0.25	98.9	
1A4aii	Commercial/institutional: Mobile	1.31	0.00	0.00	0.23	99.1	
1A3dii	National navigation (shipping)	0.62	0.63	0.00	0.20	99.3	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.23	0.43	0.00	0.17	99.5	
1A2gvii	Mobile Combustion in manufacturing industries and cor	0.80	0.56	0.00	0.13	99.6	
1A2c	Stationary combustion in manufacturing industries and	1.43	0.74	0.00	0.11	99.7	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.12	0.26	0.00	0.11	99.8	
1A2e	Stationary combustion in manufacturing industries and	2.19	0.96	0.00	0.09	99.9	
1A3c	Railways	0.60	0.10	0.00	0.05	100.0	
1A5b	Other, Mobile (including military, land based and recrea	0.13	0.08	0.00	0.02	100.0	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.94	0.32	0.00	0.01	100.0	
5C1bv	Cremation	0.00	0.00	0.00	0.00	100.0	
5C1biii	Clinical waste incineration	0.02	0.01	0.00	0.00	100.0	
5C1bi	Industrial waste incineration	0.00	0.00	0.00	0.00	100.0	

Pb **Level Assessment**

NFR	Sectors	% total 2018	Cumulative total	Key category
2A3	Glass production	54.52	54.5	x
1A3bi	Road transport: Passenger cars	14.92	69.4	x
2C1	Iron and steel production	13.62	83.1	x
1A3bvi	Road transport: Automobile tyre and brake wear	4.15	87.2	
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	3.43	90.6	
1A1a	Public electricity and heat production	2.45	93.1	
1A4bi	Residential: Stationary	2.01	95.1	
2G	Other product use (please specify in the IIR)	1.55	96.6	
1A3biv	Road transport: Mopeds & motorcycles	0.86	97.5	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	0.60	98.1	
1B2aiv	Fugitive emissions oil: Refining / storage	0.59	98.7	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.20	98.9	
1A4ai	Commercial/institutional: Stationary	0.19	99.1	
1A3ai(i)	International aviation LTO (civil)	0.15	99.2	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.12	99.4	
1A1b	Petroleum refining	0.09	99.4	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.08	99.5	
5C1bi	Industrial waste incineration	0.08	99.6	
3F	Field burning of agricultural residues	0.07	99.7	
2C5	Lead production	0.07	99.7	
1A3bii	Road transport: Light duty vehicles	0.06	99.8	
1A3aii(i)	Domestic aviation LTO (civil)	0.06	99.9	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.04	99.9	
1A3dii	National navigation (shipping)	0.03	99.9	
5C1biii	Clinical waste incineration	0.02	99.9	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.02	100.0	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.01	100.0	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.01	100.0	

Pb **Trend Assessment (1990-2018)**

NFR	Sectors	1990	Last year	Trend assess.	% cont. to trend	Cumulative total	Key category
1A3bi	Road transport: Passenger cars	485.68	6.42	0.05	43.15	43.1	x
2A3	Glass production	7.35	23.45	0.04	33.00	76.1	x
2C1	Iron and steel production	3.61	5.86	0.01	8.05	84.2	x
1A3biv	Road transport: Mopeds & motorcycles	41.01	0.37	0.00	3.89	88.1	
1A3bii	Road transport: Light duty vehicles	26.71	0.03	0.00	2.84	90.9	
1A3bvi	Road transport: Automobile tyre and brake wear	1.25	1.79	0.00	2.44	93.4	
1A2f	Stationary combustion in manufacturing industries and	2.19	1.48	0.00	1.89	95.3	
1A1a	Public electricity and heat production	1.02	1.05	0.00	1.41	96.7	
1A4bi	Residential: Stationary	1.45	0.86	0.00	1.09	97.7	
2G	Other product use (please specify in the IIR)	0.09	0.67	0.00	0.95	98.7	
1B2aiv	Fugitive emissions oil: Refining / storage	NO	0.25	0.00	0.36	99.1	
1A2d	Stationary combustion in manufacturing industries and	0.36	0.26	0.00	0.33	99.4	
1A4ai	Commercial/institutional: Stationary	0.00	0.08	0.00	0.12	99.5	
1A3ai(i)	International aviation LTO (civil)	0.02	0.06	0.00	0.09	99.6	
1A1b	Petroleum refining	0.09	0.04	0.00	0.05	99.6	
5C1bi	Industrial waste incineration	0.03	0.03	0.00	0.04	99.7	
3F	Field burning of agricultural residues	0.04	0.03	0.00	0.04	99.7	
2C5	Lead production	0.01	0.03	0.00	0.04	99.8	
1A3aii(i)	Domestic aviation LTO (civil)	0.01	0.02	0.00	0.03	99.8	
5C1biii	Clinical waste incineration	0.44	0.01	0.00	0.03	99.8	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.31	0.00	0.00	0.03	99.9	
1A2e	Stationary combustion in manufacturing industries and	0.45	0.05	0.00	0.03	99.9	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.00	0.02	0.00	0.02	99.9	
1A3dii	National navigation (shipping)	0.01	0.01	0.00	0.02	99.9	
1A2c	Stationary combustion in manufacturing industries and	0.32	0.03	0.00	0.01	100.0	
1A2gviii	Stationary combustion in manufacturing industries and	1.27	0.09	0.00	0.01	100.0	
1A5b	Other, Mobile (including military, land based and recrea	0.01	0.01	0.00	0.01	100.0	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.02	0.01	0.00	0.01	100.0	
1A4bii	Residential: Household and gardening (mobile)	0.06	0.00	0.00	0.01	100.0	
2C7a	Copper production	0.06	0.00	0.00	0.00	100.0	

Cd **Level Assessment**

NFR	Sectors	% total 2018	Cumulative total	Key category
2C1	Iron and steel production	22.13	22.1	x
1A4bi	Residential: Stationary	20.43	42.6	x
2A3	Glass production	14.44	57.0	x
3F	Field burning of agricultural residues	10.33	67.3	x
2G	Other product use (please specify in the IIR)	7.47	74.8	x
1A1a	Public electricity and heat production	6.25	81.0	x
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	5.01	86.1	
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	2.57	88.6	
1B2aiv	Fugitive emissions oil: Refining / storage	2.44	91.1	
1A3ai(i)	International aviation LTO (civil)	1.80	92.9	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	1.55	94.4	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.94	95.3	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.89	96.2	
1A4ai	Commercial/institutional: Stationary	0.82	97.0	
1A1b	Petroleum refining	0.77	97.8	
1A3aii(i)	Domestic aviation LTO (civil)	0.67	98.5	
1A3bvi	Road transport: Automobile tyre and brake wear	0.41	98.9	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.24	99.1	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.21	99.3	
5E	Other waste (please specify in IIR)	0.13	99.5	
5C1bi	Industrial waste incineration	0.12	99.6	
1A3biv	Road transport: Mopeds & motorcycles	0.11	99.7	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.08	99.8	
1A3dii	National navigation (shipping)	0.07	99.9	
2C5	Lead production	0.06	99.9	
5C1biii	Clinical waste incineration	0.03	99.9	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.02	100.0	
1A3bi	Road transport: Passenger cars	0.01	100.0	
5C1bv	Cremation	0.01	100.0	
1A3c	Railways	0.00	100.0	
2C7a	Copper production	0.00	100.0	
1A3bii	Road transport: Light duty vehicles	0.00	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.00	100.0	
2D3g	Chemical products	0.00	100.0	
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.00	100.0	
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.00	100.0	

Cd **Trend Assessment (1990-2018)**

NFR	Sectors	1990	Last year	Trend assess.	% cont. to trend	Cumulative total	Key category
2C1	Iron and steel production	0.11	0.45	0.15	22.85	22.8	x
1A2gviii	Stationary combustion in manufacturing industries and	0.29	0.02	0.09	14.27	37.1	x
2A3	Glass production	0.09	0.29	0.09	13.69	50.8	x
1A4bi	Residential: Stationary	0.70	0.42	0.07	10.51	61.3	x
2G	Other product use (please specify in the IIR)	0.05	0.15	0.04	6.78	68.1	x
1A2e	Stationary combustion in manufacturing industries and	0.16	0.03	0.04	6.33	74.4	x
1A2c	Stationary combustion in manufacturing industries and	0.14	0.02	0.04	5.91	80.3	x
1A2d	Stationary combustion in manufacturing industries and	0.19	0.10	0.02	3.69	84.0	
1A2f	Stationary combustion in manufacturing industries and	0.12	0.05	0.02	3.23	87.3	
1B2aiv	Fugitive emissions oil: Refining / storage	NO	0.05	0.02	3.13	90.4	
1A3ai(i)	International aviation LTO (civil)	0.01	0.04	0.01	1.75	92.1	
5C1biii	Clinical waste incineration	0.03	0.00	0.01	1.70	93.8	
3F	Field burning of agricultural residues	0.28	0.21	0.01	1.51	95.4	
1A1a	Public electricity and heat production	0.18	0.13	0.01	1.36	96.7	
1A4ai	Commercial/institutional: Stationary	0.00	0.02	0.01	1.01	97.7	
1A3aii(i)	Domestic aviation LTO (civil)	0.01	0.01	0.00	0.53	98.3	
1A1b	Petroleum refining	0.03	0.02	0.00	0.41	98.7	
1A3biv	Road transport: Mopeds & motorcycles	0.01	0.00	0.00	0.28	98.9	
2C7a	Copper production	0.01	0.00	0.00	0.27	99.2	
1A3bvi	Road transport: Automobile tyre and brake wear	0.01	0.01	0.00	0.23	99.4	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.00	0.00	0.00	0.17	99.6	
1A5b	Other, Mobile (including military, land based and recrea	0.01	0.00	0.00	0.11	99.7	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.00	0.00	0.00	0.07	99.8	
2C5	Lead production	0.00	0.00	0.00	0.05	99.8	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.00	0.00	0.00	0.04	99.9	
5C1bi	Industrial waste incineration	0.00	0.00	0.00	0.03	99.9	
5E	Other waste (please specify in IIR)	0.00	0.00	0.00	0.03	99.9	
1A3c	Railways	0.00	0.00	0.00	0.02	100.0	
1A3dii	National navigation (shipping)	0.00	0.00	0.00	0.02	100.0	
5C1bv	Cremation	0.00	0.00	0.00	0.01	100.0	
1A3bi	Road transport: Passenger cars	0.00	0.00	0.00	0.01	100.0	

Hg **Level Assessment**

NFR	Sectors	%total 2018	Cumulative total	Key category
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	30.76	30.8	x
1A1a	Public electricity and heat production	14.28	45.0	x
2C1	Iron and steel production	7.91	53.0	x
2K	Consumption of POPs and heavy metals (e.g. electrical and scientific equipment)	7.21	60.2	x
2A3	Glass production	6.88	67.0	x
1B2d	Other fugitive emissions from energy production	6.30	73.4	x
2D3a	Domestic solvent use including fungicides	4.04	77.4	x
1B2aiv	Fugitive emissions oil: Refining / storage	3.87	81.3	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	3.84	85.1	
3F	Field burning of agricultural residues	2.41	87.5	
5C1bv	Cremation	2.16	89.7	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	2.15	91.8	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	1.65	93.5	
1A4bi	Residential: Stationary	1.47	94.9	
1A3bi	Road transport: Passenger cars	1.41	96.4	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.60	97.0	
5C1biii	Clinical waste incineration	0.59	97.5	
1A3bii	Road transport: Light duty vehicles	0.48	98.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.40	98.4	
1A4ai	Commercial/institutional: Stationary	0.33	98.8	
1A3biii	Road transport: Heavy duty vehicles and buses	0.31	99.1	
1A1b	Petroleum refining	0.27	99.3	
5E	Other waste (please specify in IIR)	0.18	99.5	
1A3dii	National navigation (shipping)	0.13	99.7	
5C1bi	Industrial waste incineration	0.10	99.8	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.09	99.8	
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.07	99.9	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.05	100.0	
1A3biv	Road transport: Mopeds & motorcycles	0.03	100.0	
2G	Other product use (please specify in the IIR)	0.00	100.0	
5A	Biological treatment of waste - Solid waste disposal on land	0.00	100.0	

Hg **Trend Assessment (1990-2018)**

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
5C1biii	Clinical waste incineration	0.65	0.01	0.19	27.42	27.4	x
1A2d	Stationary combustion in manufacturing industries and	0.33	0.44	0.10	14.75	42.2	x
1A2gviii	Stationary combustion in manufacturing industries and	0.24	0.02	0.06	8.80	51.0	x
1A1a	Public electricity and heat production	0.15	0.20	0.05	6.93	57.9	x
1B2d	Other fugitive emissions from energy production	0.00	0.09	0.04	5.91	63.8	x
2C1	Iron and steel production	0.04	0.11	0.04	5.87	69.7	x
1A2f	Stationary combustion in manufacturing industries and	0.21	0.05	0.04	5.32	75.0	x
2A3	Glass production	0.03	0.10	0.04	5.20	80.2	x
1A2e	Stationary combustion in manufacturing industries and	0.15	0.03	0.03	4.23	84.4	
1A2c	Stationary combustion in manufacturing industries and	0.10	0.01	0.03	3.86	88.3	
1B2aiv	Fugitive emissions oil: Refining / storage	NO	0.06	0.03	3.67	92.0	
2K	Consumption of POPs and heavy metals (e.g. electrica	0.10	0.10	0.02	2.53	94.5	
5C1bv	Cremation	0.00	0.03	0.01	2.04	96.5	
2D3a	Domestic solvent use including fungicides	0.06	0.06	0.01	1.42	97.9	
1A3bi	Road transport: Passenger cars	0.01	0.02	0.01	0.85	98.8	
3F	Field burning of agricultural residues	0.05	0.03	0.00	0.31	99.1	
1A3bii	Road transport: Light duty vehicles	0.00	0.01	0.00	0.30	99.4	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.00	0.01	0.00	0.18	99.6	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.00	0.00	0.00	0.08	99.7	
1A3biii	Road transport: Heavy duty vehicles and buses	0.01	0.00	0.00	0.05	99.7	
1A3dii	National navigation (shipping)	0.00	0.00	0.00	0.05	99.8	
1A2a	Stationary combustion in manufacturing industries and	0.00	0.00	0.00	0.04	99.8	
1A4ai	Commercial/institutional: Stationary	0.01	0.00	0.00	0.04	99.9	
5C1bi	Industrial waste incineration	0.00	0.00	0.00	0.04	99.9	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.00	0.00	0.00	0.03	99.9	
1A1b	Petroleum refining	0.01	0.00	0.00	0.03	100.0	
1A4bi	Residential: Stationary	0.03	0.02	0.00	0.03	100.0	
5E	Other waste (please specify in IIR)	0.00	0.00	0.00	0.01	100.0	
1A3biv	Road transport: Mopeds & motorcycles	0.00	0.00	0.00	0.01	100.0	
2G	Other product use (please specify in the IIR)	0.00	0.00	0.00	0.00	100.0	

As **Level Assessment**

NFR	Sectors	%total 2018	Cumulative total	Key category
1A1a	Public electricity and heat production	53.85	53.8	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	14.40	68.3	x
2A3	Glass production	13.98	82.2	x
1A4ai	Commercial/institutional: Stationary	2.78	85.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	2.64	87.6	
1A3dii	National navigation (shipping)	2.54	90.2	
2C1	Iron and steel production	2.02	92.2	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	1.59	93.8	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	1.16	95.0	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.80	95.8	
1B2aiv	Fugitive emissions oil: Refining / storage	0.66	96.4	
1A1b	Petroleum refining	0.63	97.0	
3F	Field burning of agricultural residues	0.60	97.6	
1A4bi	Residential: Stationary	0.55	98.2	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	0.48	98.7	
2C5	Lead production	0.45	99.1	
1B2d	Other fugitive emissions from energy production	0.30	99.4	
5E	Other waste (please specify in IIR)	0.25	99.7	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.10	99.8	
2G	Other product use (please specify in the IIR)	0.07	99.9	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.04	99.9	
1A3bi	Road transport: Passenger cars	0.03	99.9	
5C1bi	Industrial waste incineration	0.02	100.0	
5C1bv	Cremation	0.02	100.0	
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.01	100.0	
1A3bii	Road transport: Light duty vehicles	0.01	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.01	100.0	

As **Trend Assessment (1990-2018)**

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
2A3	Glass production	0.07	0.23	0.06	29.04	29.0	x
1A2gviii	Stationary combustion in manufacturing industries and	0.25	0.02	0.04	16.78	45.8	x
1A2c	Stationary combustion in manufacturing industries and	0.12	0.01	0.02	7.65	53.5	x
1A2e	Stationary combustion in manufacturing industries and	0.14	0.03	0.01	6.82	60.3	x
2C1	Iron and steel production	0.15	0.03	0.01	6.40	66.7	x
1A1a	Public electricity and heat production	1.65	0.90	0.01	6.16	72.8	x
1A4ai	Commercial/institutional: Stationary	0.16	0.05	0.01	5.52	78.4	x
1A2f	Stationary combustion in manufacturing industries and	0.41	0.24	0.01	4.20	82.6	x
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.04	0.04	0.01	3.42	86.0	
1A3dii	National navigation (shipping)	0.04	0.04	0.01	3.01	89.0	
1A2d	Stationary combustion in manufacturing industries and	0.05	0.01	0.01	2.95	91.9	
1A1b	Petroleum refining	0.06	0.01	0.01	2.82	94.8	
1B2aiv	Fugitive emissions oil: Refining / storage	NO	0.01	0.00	1.63	96.4	
2C5	Lead production	0.00	0.01	0.00	0.83	97.2	
1B2d	Other fugitive emissions from energy production	0.00	0.01	0.00	0.75	98.0	
3F	Field burning of agricultural residues	0.01	0.01	0.00	0.52	98.5	
1A4bi	Residential: Stationary	0.01	0.01	0.00	0.35	98.9	
2C7a	Copper production	0.00	0.00	0.00	0.35	99.2	
5E	Other waste (please specify in IIR)	0.01	0.00	0.00	0.16	99.4	
2G	Other product use (please specify in the IIR)	0.00	0.00	0.00	0.16	99.5	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.01	0.00	0.00	0.14	99.7	
5C1biii	Clinical waste incineration	0.00	0.00	0.00	0.11	99.8	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.00	0.00	0.00	0.08	99.9	
1A3bi	Road transport: Passenger cars	0.00	0.00	0.00	0.05	99.9	
5C1bv	Cremation	0.00	0.00	0.00	0.04	99.9	
5C1bi	Industrial waste incineration	0.00	0.00	0.00	0.03	100.0	
1A3bii	Road transport: Light duty vehicles	0.00	0.00	0.00	0.01	100.0	
1A2a	Stationary combustion in manufacturing industries and	0.00	0.00	0.00	0.01	100.0	
2D3g	Chemical products	0.00	0.00	0.00	0.01	100.0	

Cr **Level Assessment**

NFR	Sectors	%total 2018	Cumulative total	Key category
2A3	Glass production	43.03	43.0	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	23.24	66.3	x
1A1a	Public electricity and heat production	8.78	75.0	x
1A4bi	Residential: Stationary	6.73	81.8	x
1A3bvi	Road transport: Automobile tyre and brake wear	6.02	87.8	
1B2aiv	Fugitive emissions oil: Refining / storage	2.37	90.2	
2C1	Iron and steel production	2.06	92.2	
2G	Other product use (please specify in the IIR)	1.94	94.2	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.95	95.1	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	0.86	96.0	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.66	96.6	
1A1b	Petroleum refining	0.57	97.2	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.47	97.7	
1A4ai	Commercial/institutional: Stationary	0.47	98.1	
1A3dii	National navigation (shipping)	0.41	98.6	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.38	98.9	
3F	Field burning of agricultural residues	0.26	99.2	
1A3bi	Road transport: Passenger cars	0.23	99.4	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.12	99.5	
1A3bii	Road transport: Light duty vehicles	0.10	99.6	
1A3biv	Road transport: Mopeds & motorcycles	0.09	99.7	
1A3ai(i)	International aviation LTO (civil)	0.07	99.8	
1A3biii	Road transport: Heavy duty vehicles and buses	0.07	99.9	
5E	Other waste (please specify in IIR)	0.04	99.9	
5C1bi	Industrial waste incineration	0.03	99.9	
1A3aii(i)	Domestic aviation LTO (civil)	0.02	100.0	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.02	100.0	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.01	100.0	
2D3g	Chemical products	0.01	100.0	

Cr **Trend Assessment (1990-2018)**

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
2A3	Glass production	1.48	4.71	0.26	39.29	39.3	x
1A1a	Public electricity and heat production	3.86	0.96	0.17	25.02	64.3	x
1A2gviii	Stationary combustion in manufacturing industries and	0.73	0.04	0.04	6.33	70.6	x
2C1	Iron and steel production	0.82	0.23	0.03	5.08	75.7	x
1A4bi	Residential: Stationary	1.24	0.74	0.02	3.19	78.9	x
1A3bvi	Road transport: Automobile tyre and brake wear	0.46	0.66	0.02	3.11	82.0	x
1B2aiv	Fugitive emissions oil: Refining / storage	NO	0.26	0.02	2.92	84.9	
1A2e	Stationary combustion in manufacturing industries and	0.39	0.07	0.02	2.77	87.7	
1A2f	Stationary combustion in manufacturing industries and	2.79	2.55	0.02	2.72	90.4	
1A2d	Stationary combustion in manufacturing industries and	0.40	0.09	0.02	2.68	93.1	
1A2c	Stationary combustion in manufacturing industries and	0.35	0.05	0.02	2.66	95.8	
1A1b	Petroleum refining	0.23	0.06	0.01	1.46	97.2	
2G	Other product use (please specify in the IIR)	0.13	0.21	0.01	1.20	98.4	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.07	0.10	0.00	0.52	98.9	
1A3biv	Road transport: Mopeds & motorcycles	0.03	0.01	0.00	0.21	99.1	
1A3bi	Road transport: Passenger cars	0.01	0.02	0.00	0.20	99.3	
1A4ai	Commercial/institutional: Stationary	0.08	0.05	0.00	0.17	99.5	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.01	0.01	0.00	0.09	99.6	
1A3dii	National navigation (shipping)	0.05	0.05	0.00	0.09	99.7	
1A3bii	Road transport: Light duty vehicles	0.01	0.01	0.00	0.07	99.8	
1A3ai(i)	International aviation LTO (civil)	0.00	0.01	0.00	0.06	99.8	
5C1biii	Clinical waste incineration	0.00	0.00	0.00	0.04	99.9	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.01	0.00	0.00	0.03	99.9	
3F	Field burning of agricultural residues	0.04	0.03	0.00	0.02	99.9	
1A3c	Railways	0.00	0.00	0.00	0.02	99.9	
1A3aii(i)	Domestic aviation LTO (civil)	0.00	0.00	0.00	0.02	100.0	
5C1bi	Industrial waste incineration	0.00	0.00	0.00	0.01	100.0	
5E	Other waste (please specify in IIR)	0.01	0.00	0.00	0.01	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.01	0.01	0.00	0.00	100.0	

Cu **Level Assessment**

NFR	Sectors	% total 2018	Cumulative total	Key category
1A3bvi	Road transport: Automobile tyre and brake wear	47.69	47.7	x
2G	Other product use (please specify in the IIR)	28.21	75.9	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	5.60	81.5	x
1A1a	Public electricity and heat production	4.21	85.7	
2A3	Glass production	3.88	89.6	
1A4ai	Commercial/institutional: Stationary	2.22	91.8	
1A4ci	Agriculture/Forestry/Fishing: Stationary	2.03	93.8	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	1.51	95.4	
1A3biv	Road transport: Mopeds & motorcycles	1.25	96.6	
1A4bi	Residential: Stationary	0.63	97.2	
1A3ai(i)	International aviation LTO (civil)	0.52	97.8	
1B2aiv	Fugitive emissions oil: Refining / storage	0.36	98.1	
1A3dii	National navigation (shipping)	0.32	98.4	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.25	98.7	
1A3aii(i)	Domestic aviation LTO (civil)	0.19	98.9	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.18	99.1	
1A1b	Petroleum refining	0.17	99.2	
2C1	Iron and steel production	0.15	99.4	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.13	99.5	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.12	99.6	
3F	Field burning of agricultural residues	0.08	99.7	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.07	99.8	
1A3bi	Road transport: Passenger cars	0.06	99.8	
1A3c	Railways	0.05	99.9	
5E	Other waste (please specify in IIR)	0.03	99.9	
1A3bii	Road transport: Light duty vehicles	0.02	99.9	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.02	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.02	100.0	
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.01	100.0	

Cu **Trend Assessment (1990-2018)**

NFR	Sectors	1990	Last year	Trend assess.	% cont. to trend	Cumulative total	Key category
1A3bvi	Road transport: Automobile tyre and brake wear	10.18	14.43	0.11	22.00	22.0	x
2G	Other product use (please specify in the IIR)	5.20	8.54	0.10	20.17	42.2	x
1A4ai	Commercial/institutional: Stationary	2.40	0.67	0.08	15.67	57.8	x
1A1a	Public electricity and heat production	2.15	1.28	0.04	8.91	66.8	x
1A3biv	Road transport: Mopeds & motorcycles	1.35	0.38	0.04	8.81	75.6	x
2A3	Glass production	0.37	1.17	0.03	5.77	81.3	x
1A2f	Stationary combustion in manufacturing industries and	2.16	1.70	0.03	5.76	87.1	
1A2gviii	Stationary combustion in manufacturing industries and	0.38	0.07	0.01	2.71	89.8	
1A2e	Stationary combustion in manufacturing industries and	0.21	0.05	0.01	1.45	91.3	
1A2c	Stationary combustion in manufacturing industries and	0.19	0.04	0.01	1.37	92.6	
1A4bi	Residential: Stationary	0.32	0.19	0.01	1.33	94.0	
1A1b	Petroleum refining	0.19	0.05	0.01	1.24	95.2	
1B2aiv	Fugitive emissions oil: Refining / storage	NO	0.11	0.00	0.84	96.0	
1A3ai(i)	International aviation LTO (civil)	0.05	0.16	0.00	0.81	96.8	
1A3c	Railways	0.10	0.02	0.00	0.70	97.5	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.11	0.04	0.00	0.68	98.2	
2C7a	Copper production	0.06	0.00	0.00	0.55	98.8	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.57	0.61	0.00	0.28	99.1	
1A3aii(i)	Domestic aviation LTO (civil)	0.03	0.06	0.00	0.22	99.3	
1A5b	Other, Mobile (including military, land based and recrea	0.03	0.02	0.00	0.14	99.4	
1A3dii	National navigation (shipping)	0.10	0.10	0.00	0.10	99.5	
3F	Field burning of agricultural residues	0.03	0.02	0.00	0.09	99.6	
1A2d	Stationary combustion in manufacturing industries and	0.39	0.46	0.00	0.09	99.7	
1A3bi	Road transport: Passenger cars	0.01	0.02	0.00	0.08	99.8	
2C1	Iron and steel production	0.03	0.05	0.00	0.07	99.8	
5C1biii	Clinical waste incineration	0.01	0.00	0.00	0.05	99.9	
5E	Other waste (please specify in IIR)	0.01	0.01	0.00	0.04	99.9	
1A3bii	Road transport: Light duty vehicles	0.00	0.01	0.00	0.03	100.0	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.00	0.01	0.00	0.02	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.01	0.00	0.00	0.02	100.0	

Ni **Level Assessment**

NFR	Sectors	%total 2018	Cumulative total	Key category
1A1a	Public electricity and heat production	27.47	27.5	x
2A3	Glass production	15.62	43.1	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	14.22	57.3	x
1A3dii	National navigation (shipping)	8.31	65.6	x
2C1	Iron and steel production	6.61	72.2	x
1A4ci	Agriculture/Forestry/Fishing: Stationary	6.14	78.4	x
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	5.42	83.8	x
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	4.09	87.9	
1A4ai	Commercial/institutional: Stationary	2.79	90.7	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	2.11	92.8	
1B2aiv	Fugitive emissions oil: Refining / storage	2.01	94.8	
2G	Other product use (please specify in the IIR)	1.71	96.5	
1A1b	Petroleum refining	1.23	97.7	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.87	98.6	
1A3bvi	Road transport: Automobile tyre and brake wear	0.44	99.0	
1A4bi	Residential: Stationary	0.27	99.3	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.18	99.5	
1A3ai(i)	International aviation LTO (civil)	0.17	99.7	
3F	Field burning of agricultural residues	0.07	99.7	
1A3biv	Road transport: Mopeds & motorcycles	0.07	99.8	
1A3aii(i)	Domestic aviation LTO (civil)	0.06	99.9	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.06	99.9	
2D3g	Chemical products	0.03	99.9	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.02	100.0	
5C1bi	Industrial waste incineration	0.01	100.0	
1A3bi	Road transport: Passenger cars	0.01	100.0	
5C1biii	Clinical waste incineration	0.01	100.0	

Ni **Trend Assessment (1990-2018)**

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
1A1a	Public electricity and heat production	55.85	6.56	0.05	23.92	23.9	x
2A3	Glass production	1.17	3.73	0.03	15.70	39.6	x
1A1b	Petroleum refining	13.30	0.29	0.02	11.42	51.0	x
1A2gviii	Stationary combustion in manufacturing industries and	11.26	0.21	0.02	9.85	60.9	x
1A2f	Stationary combustion in manufacturing industries and	6.00	3.40	0.02	9.55	70.4	x
1A3dii	National navigation (shipping)	1.98	1.98	0.01	7.04	77.5	x
2C1	Iron and steel production	0.36	1.58	0.01	6.76	84.2	x
1A4ci	Agriculture/Forestry/Fishing: Stationary	1.09	1.47	0.01	5.57	89.8	
1A2c	Stationary combustion in manufacturing industries and	5.53	0.50	0.01	3.02	92.8	
1B2aiv	Fugitive emissions oil: Refining / storage	NO	0.48	0.00	2.17	95.0	
2G	Other product use (please specify in the IIR)	0.22	0.41	0.00	1.62	96.6	
1A2e	Stationary combustion in manufacturing industries and	5.99	0.98	0.00	1.34	98.0	
1A4ai	Commercial/institutional: Stationary	2.40	0.67	0.00	0.70	98.7	
1A3bvi	Road transport: Automobile tyre and brake wear	0.07	0.11	0.00	0.41	99.1	
1A2d	Stationary combustion in manufacturing industries and	6.35	1.30	0.00	0.25	99.3	
1A4bi	Residential: Stationary	0.11	0.06	0.00	0.19	99.5	
1A3ai(i)	International aviation LTO (civil)	0.01	0.04	0.00	0.17	99.7	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.13	0.04	0.00	0.07	99.7	
1A3aii(i)	Domestic aviation LTO (civil)	0.01	0.02	0.00	0.06	99.8	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.01	0.01	0.00	0.06	99.9	
3F	Field burning of agricultural residues	0.02	0.02	0.00	0.05	99.9	
2D3g	Chemical products	0.01	0.01	0.00	0.02	99.9	
1A3biv	Road transport: Mopeds & motorcycles	0.06	0.02	0.00	0.02	100.0	
1A5b	Other, Mobile (including military, land based and recrea	0.01	0.01	0.00	0.02	100.0	
5C1bi	Industrial waste incineration	0.00	0.00	0.00	0.01	100.0	
1A3bi	Road transport: Passenger cars	0.00	0.00	0.00	0.01	100.0	

Se **Level Assessment**

NFR	Sectors	%total 2018	Cumulative total	Key category
2A3	Glass production	97.78	97.8	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	1.12	98.9	
1A1a	Public electricity and heat production	0.39	99.3	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	0.27	99.6	
2G	Other product use (please specify in the IIR)	0.13	99.7	
1A4bi	Residential: Stationary	0.05	99.7	
1A3dii	National navigation (shipping)	0.04	99.8	
1A3bvi	Road transport: Automobile tyre and brake wear	0.04	99.8	
1B2aiv	Fugitive emissions oil: Refining / storage	0.03	99.8	
1A1b	Petroleum refining	0.03	99.9	
3F	Field burning of agricultural residues	0.03	99.9	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.02	99.9	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.02	99.9	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.02	100.0	
1A3ai(i)	International aviation LTO (civil)	0.01	100.0	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.01	100.0	
1A3biv	Road transport: Mopeds & motorcycles	0.01	100.0	

Se **Trend Assessment (1990-2018)**

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
2A3	Glass production	11.11	35.41	0.21	50.13	50.1	x
1A2f	Stationary combustion in manufacturing industries and	0.60	0.41	0.11	27.26	77.4	x
1A1a	Public electricity and heat production	0.20	0.14	0.04	9.00	86.4	x
1A2gviii	Stationary combustion in manufacturing industries and	0.04	0.01	0.01	2.23	88.6	
1A2d	Stationary combustion in manufacturing industries and	0.07	0.10	0.01	1.90	90.5	
1A1b	Petroleum refining	0.03	0.01	0.01	1.77	92.3	
1A2c	Stationary combustion in manufacturing industries and	0.03	0.01	0.01	1.58	93.9	
1A4bi	Residential: Stationary	0.03	0.02	0.01	1.27	95.1	
1A2e	Stationary combustion in manufacturing industries and	0.02	0.01	0.01	1.26	96.4	
2G	Other product use (please specify in the IIR)	0.03	0.05	0.00	0.82	97.2	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.01	0.00	0.00	0.66	97.9	
1A3dii	National navigation (shipping)	0.02	0.02	0.00	0.59	98.5	
3F	Field burning of agricultural residues	0.01	0.01	0.00	0.51	99.0	
1A3biv	Road transport: Mopeds & motorcycles	0.01	0.00	0.00	0.42	99.4	
1A3bvi	Road transport: Automobile tyre and brake wear	0.01	0.01	0.00	0.26	99.6	
1B2aiv	Fugitive emissions oil: Refining / storage	NO	0.01	0.00	0.22	99.9	
1A5b	Other, Mobile (including military, land based and recrea	0.00	0.00	0.00	0.04	99.9	
1A3c	Railways	0.00	0.00	0.00	0.03	99.9	
1A4ai	Commercial/institutional: Stationary	0.00	0.00	0.00	0.02	99.9	
1A3ai(i)	International aviation LTO (civil)	0.00	0.00	0.00	0.01	100.0	
1A3aii(i)	Domestic aviation LTO (civil)	0.00	0.00	0.00	0.01	100.0	
5C1bv	Cremation	0.00	0.00	0.00	0.01	100.0	
1A2a	Stationary combustion in manufacturing industries and	0.00	0.00	0.00	0.01	100.0	
1A3bi	Road transport: Passenger cars	0.00	0.00	0.00	0.01	100.0	

Zn **Level Assessment**

NFR	Sectors	% total 2018	Cumulative total	Key category
2A3	Glass production	27.91	27.9	x
1A4bi	Residential: Stationary	21.24	49.2	x
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	11.13	60.3	x
2C1	Iron and steel production	10.52	70.8	x
1A1a	Public electricity and heat production	8.02	78.8	x
1A3bvi	Road transport: Automobile tyre and brake wear	7.54	86.4	x
2G	Other product use (please specify in the IIR)	6.39	92.8	
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	1.59	94.3	
1A4ai	Commercial/institutional: Stationary	0.87	95.2	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.81	96.0	
1A1b	Petroleum refining	0.73	96.8	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.60	97.4	
1A3ai(i)	International aviation LTO (civil)	0.56	97.9	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.54	98.5	
1A3biv	Road transport: Mopeds & motorcycles	0.29	98.7	
3F	Field burning of agricultural residues	0.28	99.0	
1A3aii(i)	Domestic aviation LTO (civil)	0.21	99.2	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.17	99.4	
1A3dii	National navigation (shipping)	0.13	99.5	
1B2aiv	Fugitive emissions oil: Refining / storage	0.12	99.7	
1A3bi	Road transport: Passenger cars	0.09	99.7	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.07	99.8	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.07	99.9	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.04	99.9	
1A3bii	Road transport: Light duty vehicles	0.03	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.02	100.0	
1A3c	Railways	0.01	100.0	

Zn **Trend Assessment (1990-2018)**

NFR	Sectors	1990	Last year	Trend assess.	% cont. to trend	Cumulative total	Key category
1A4bi	Residential: Stationary	27.55	16.39	0.25	32.83	32.8	x
2A3	Glass production	6.75	21.54	0.21	27.04	59.9	x
2C1	Iron and steel production	2.87	8.11	0.07	9.42	69.3	x
1A2f	Stationary combustion in manufacturing industries and	3.60	1.23	0.05	6.11	75.4	x
1A2d	Stationary combustion in manufacturing industries and	4.75	8.59	0.05	5.89	81.3	x
1A3bvi	Road transport: Automobile tyre and brake wear	3.73	5.82	0.02	2.77	84.1	
2G	Other product use (please specify in the IIR)	3.00	4.93	0.02	2.72	86.8	
1A2gviii	Stationary combustion in manufacturing industries and	1.45	0.63	0.02	2.19	89.0	
1A2e	Stationary combustion in manufacturing industries and	1.08	0.42	0.01	1.74	90.7	
1A1a	Public electricity and heat production	5.93	6.19	0.01	1.74	92.4	
1A2c	Stationary combustion in manufacturing industries and	1.10	0.47	0.01	1.69	94.1	
1A3biv	Road transport: Mopeds & motorcycles	0.79	0.22	0.01	1.43	95.6	
1A1b	Petroleum refining	1.03	0.56	0.01	1.33	96.9	
1A4ai	Commercial/institutional: Stationary	0.08	0.67	0.01	1.15	98.0	
1A3ai(i)	International aviation LTO (civil)	0.12	0.43	0.00	0.57	98.6	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.15	0.05	0.00	0.26	98.9	
3F	Field burning of agricultural residues	0.28	0.22	0.00	0.23	99.1	
1B2aiv	Fugitive emissions oil: Refining / storage	NO	0.09	0.00	0.19	99.3	
1A3aii(i)	Domestic aviation LTO (civil)	0.07	0.16	0.00	0.15	99.4	
1A3c	Railways	0.06	0.01	0.00	0.11	99.6	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.06	0.13	0.00	0.11	99.7	
1A5b	Other, Mobile (including military, land based and recrea	0.09	0.06	0.00	0.11	99.8	
1A2a	Stationary combustion in manufacturing industries and	0.03	0.00	0.00	0.07	99.8	
1A3bi	Road transport: Passenger cars	0.04	0.07	0.00	0.04	99.9	
1A3dii	National navigation (shipping)	0.10	0.10	0.00	0.04	99.9	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.02	0.03	0.00	0.03	100.0	
1A3bii	Road transport: Light duty vehicles	0.01	0.02	0.00	0.02	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.02	0.02	0.00	0.02	100.0	
5C1bv	Cremation	0.00	0.00	0.00	0.01	100.0	

Diox **Level Assessment**

NFR	Sectors	%total 2018	Cumulative total	Key category
1A4bi	Residential: Stationary	35.50	35.5	x
5C1bi	Industrial waste incineration	15.94	51.4	x
2D3i	Other solvent use (please specify in the IIR)	12.46	63.9	x
2C1	Iron and steel production	12.20	76.1	x
5E	Other waste (please specify in IIR)	8.16	84.3	x
1A1a	Public electricity and heat production	4.87	89.1	
5C1biii	Clinical waste incineration	3.77	92.9	
1A3bi	Road transport: Passenger cars	2.77	95.7	
1A3bii	Road transport: Light duty vehicles	1.22	96.9	
2C3	Aluminium production	0.72	97.6	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	0.61	98.2	
1A3biii	Road transport: Heavy duty vehicles and buses	0.29	98.5	
3F	Field burning of agricultural residues	0.29	98.8	
1A4ai	Commercial/institutional: Stationary	0.28	99.1	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.20	99.3	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.14	99.4	
1B2aiv	Fugitive emissions oil: Refining / storage	0.13	99.6	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.13	99.7	
2C5	Lead production	0.12	99.8	
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	0.11	99.9	
1A3biv	Road transport: Mopeds & motorcycles	0.03	99.9	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.02	100.0	
1A1b	Petroleum refining	0.02	100.0	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.01	100.0	

Diox **Trend Assessment (1990-2018)**

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
5C1biii	Clinical waste incineration	482.30	2.09	0.08	49.93	49.9	x
1A4bi	Residential: Stationary	40.05	19.68	0.03	16.86	66.8	x
5C1bi	Industrial waste incineration	8.40	8.84	0.01	8.61	75.4	x
2D3i	Other solvent use (please specify in the IIR)	4.58	6.91	0.01	6.94	82.3	x
2C1	Iron and steel production	4.21	6.76	0.01	6.83	89.2	
5E	Other waste (please specify in IIR)	6.38	4.52	0.01	4.18	93.3	
1A1a	Public electricity and heat production	1.05	2.70	0.00	2.79	96.1	
1A3bi	Road transport: Passenger cars	0.73	1.54	0.00	1.58	97.7	
1A3bii	Road transport: Light duty vehicles	0.43	0.67	0.00	0.68	98.4	
2C3	Aluminium production	0.40	0.40	0.00	0.39	98.8	
1A2d	Stationary combustion in manufacturing industries and	0.28	0.34	0.00	0.33	99.1	
1A4ai	Commercial/institutional: Stationary	0.08	0.16	0.00	0.16	99.3	
1A3biii	Road transport: Heavy duty vehicles and buses	0.21	0.16	0.00	0.15	99.4	
3F	Field burning of agricultural residues	0.21	0.16	0.00	0.15	99.6	
1A2gviii	Stationary combustion in manufacturing industries and	0.20	0.11	0.00	0.10	99.7	
1B2aiv	Fugitive emissions oil: Refining / storage	0.06	0.07	0.00	0.07	99.8	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.05	0.07	0.00	0.07	99.8	
2C5	Lead production	0.03	0.07	0.00	0.07	99.9	
1A2e	Stationary combustion in manufacturing industries and	0.22	0.08	0.00	0.06	100.0	
1A3biv	Road transport: Mopeds & motorcycles	0.04	0.01	0.00	0.01	100.0	
2C7a	Copper production	0.12	0.00	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	0.01	100.0	
1A2f	Stationary combustion in manufacturing industries and	0.64	0.06	0.00	0.01	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 2018	Cumulative total	Key category
1A4bi	Residential: Stationary	56.46	56.5	x
2D3i	Other solvent use (please specify in the IIR)	20.41	76.9	x
2C1	Iron and steel production	6.95	83.8	x
3F	Field burning of agricultural residues	4.24	88.1	
2D3g	Chemical products	2.07	90.1	
1A2gviii	Stationary combustion in manufacturing industries and constructio	1.70	91.8	
1A3bi	Road transport: Passenger cars	1.54	93.4	
1A3dii	National navigation (shipping)	1.09	94.5	
1A2e	Stationary combustion in manufacturing industries and constructio	0.98	95.4	
1A2f	Stationary combustion in manufacturing industries and constructio	0.81	96.2	
1A2d	Stationary combustion in manufacturing industries and constructio	0.69	96.9	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.66	97.6	
1A3bii	Road transport: Light duty vehicles	0.66	98.2	
1A4ai	Commercial/institutional: Stationary	0.65	98.9	
1A2c	Stationary combustion in manufacturing industries and constructio	0.42	99.3	
1A3biii	Road transport: Heavy duty vehicles and buses	0.34	99.7	
1A1a	Public electricity and heat production	0.11	99.8	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.07	99.8	
1A2a	Stationary combustion in manufacturing industries and constructio	0.07	99.9	
2G	Other product use (please specify in the IIR)	0.03	99.9	
1A2gvii	Mobile Combustion in manufacturing industries and construction: (	0.03	100.0	
1B2aiv	Fugitive emissions oil: Refining / storage	0.02	100.0	
1A3biv	Road transport: Mopeds & motorcycles	0.01	100.0	

Total PAH Trend Assessment (1990-2018)

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
1A4bi	Residential: Stationary	18.35	8.79	0.12	41.53	41.5	x
2D3i	Other solvent use (please specify in the IIR)	2.11	3.18	0.08	26.17	67.7	x
2C1	Iron and steel production	0.20	1.08	0.04	13.62	81.3	x
1A2f	Stationary combustion in manufacturing industries and	0.59	0.13	0.01	3.56	84.9	
1A3bi	Road transport: Passenger cars	0.07	0.24	0.01	2.82	87.7	
2D3g	Chemical products	0.28	0.32	0.01	2.09	89.8	
3F	Field burning of agricultural residues	0.85	0.66	0.00	1.67	91.5	
1A2gviii	Stationary combustion in manufacturing industries and	0.58	0.26	0.00	1.48	92.9	
1A2c	Stationary combustion in manufacturing industries and	0.24	0.07	0.00	1.29	94.2	
1A3bii	Road transport: Light duty vehicles	0.05	0.10	0.00	1.03	95.3	
1A2e	Stationary combustion in manufacturing industries and	0.35	0.15	0.00	0.99	96.3	
1A3dii	National navigation (shipping)	0.17	0.17	0.00	0.88	97.1	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.07	0.10	0.00	0.86	98.0	
1A2d	Stationary combustion in manufacturing industries and	0.09	0.11	0.00	0.71	98.7	
1A4ai	Commercial/institutional: Stationary	0.21	0.10	0.00	0.44	99.1	
1A3biii	Road transport: Heavy duty vehicles and buses	0.05	0.05	0.00	0.35	99.5	
1A1a	Public electricity and heat production	0.01	0.02	0.00	0.18	99.7	
1A2a	Stationary combustion in manufacturing industries and	0.03	0.01	0.00	0.11	99.8	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.01	0.01	0.00	0.08	99.9	
2G	Other product use (please specify in the IIR)	0.00	0.00	0.00	0.06	99.9	
1B2aiv	Fugitive emissions oil: Refining / storage	NO	0.00	0.00	0.04	100.0	
1A3c	Railways	0.00	0.00	0.00	0.03	100.0	
1A2gvii	Mobile Combustion in manufacturing industries and cor	0.01	0.00	0.00	0.00	100.0	
1A3biv	Road transport: Mopeds & motorcycles	0.00	0.00	0.00	0.00	100.0	

HCB **Level Assessment**

NFR	Sectors	% total 2018	Cumulative total	Key category
1A1a	Public electricity and heat production	34.65	34.6	x
3Df	Use of pesticides	32.00	66.6	x
5C1biii	Clinical waste incineration	21.98	88.6	x
1A4bi	Residential: Stationary	6.73	95.4	
5C1bi	Industrial waste incineration	2.12	97.5	
1A2d	Stationary combustion in manufacturing industries and constructio	1.12	98.6	
1A2gviii	Stationary combustion in manufacturing industries and constructio	0.41	99.0	
1A2e	Stationary combustion in manufacturing industries and constructio	0.29	99.3	
1A4ai	Commercial/institutional: Stationary	0.27	99.6	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.14	99.7	
5C1bv	Cremation	0.13	99.8	
1A3bi	Road transport: Passenger cars	0.06	99.9	
1A2c	Stationary combustion in manufacturing industries and constructio	0.03	99.9	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.03	100.0	
1A3bii	Road transport: Light duty vehicles	0.02	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 (1990-2018)**

NFR	Sectors	1990	Last year	Trend assess.	% cont. to trend	Cumulative total	Key category
1A1a	Public electricity and heat production	0.57	0.82	0.01	52.37	52.4	x
5C1biii	Clinical waste incineration	1.21	0.52	0.01	30.98	83.4	x
1A4bi	Residential: Stationary	0.27	0.16	0.00	9.75	93.1	
5C1bi	Industrial waste incineration	0.05	0.05	0.00	3.17	96.3	
1A2d	Stationary combustion in manufacturing industries and	0.03	0.03	0.00	1.67	98.0	
1A2gviii	Stationary combustion in manufacturing industries and	0.02	0.01	0.00	0.60	98.6	
1A4ai	Commercial/institutional: Stationary	NO	0.01	0.00	0.41	99.0	
1A2e	Stationary combustion in manufacturing industries and	0.02	0.01	0.00	0.40	99.4	
5C1bv	Cremation	0.00	0.00	0.00	0.20	99.6	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.01	0.00	0.00	0.20	99.8	
1A3bi	Road transport: Passenger cars	0.00	0.00	0.00	0.10	99.9	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.00	0.00	0.00	0.05	99.9	
1A3bii	Road transport: Light duty vehicles	0.00	0.00	0.00	0.04	100.0	
1A2c	Stationary combustion in manufacturing industries and	0.01	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	
1A3biv	Road transport: Mopeds & motorcycles	0.00	0.00	0.00	0.00	100.0	

PCBs **Level Assessment**

NFR	Sectors	% total 2018	Cumulative total	Key category
5C1bi	Industrial waste incineration	71.253	71.3	x
2K	Consumption of POPs and heavy metals (e.g. electrical and scien	22.307	93.6	x
2C1	Iron and steel production	6.129	99.7	
5C1biii	Clinical waste incineration	0.132	99.8	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.082	99.9	
1A2gviii	Stationary combustion in manufacturing industries and constructio	0.050	100.0	
1A1a	Public electricity and heat production	0.028	100.0	
5C1bv	Cremation	0.009	100.0	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.006	100.0	
1A4bi	Residential: Stationary	0.002	100.0	
1A2f	Stationary combustion in manufacturing industries and constructio	0.001	100.0	

PCBs **Trend Assessment (1990-2018)**

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	20.51	0.06	50.00	50.0	x
5C1bi	Industrial waste incineration	62.29	65.52	0.06	45.71	95.7	x
2C1	Iron and steel production	2.74	5.64	0.01	4.10	99.8	
5C1biii	Clinical waste incineration	0.28	0.12	0.00	0.07	99.9	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.06	0.08	0.00	0.05	99.9	
1A2gviii	Stationary combustion in manufacturing industries and	0.10	0.05	0.00	0.03	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

Table B-1: Energy Balance Sheet for 2018

BALANÇO ENERGÉTICO tep		Hulha e Antracite	Coque de Carvão	Total de Carvão	Petróleo Bruto	Refugos e Produtos Intermédios	GPL	Gasolinas	Petróleos	Jets	Gasóleo	Fuelóleo	Nafta	Coque de Petróleo	Total de Petróleo Energético	Lubrificantes	Asfaltos	Parafinas	Solventes	Outros	Total de Petróleo Não Energético	Total de Petróleo	Gás Natural
2018 provisório		1	2	3 = 1 + 2	4	5	6	7	8	9	10	11	12	13	14 = 4 a 13	15	16	17	18	19	20 = 15 a 19	21= 14 + 20	22
IMPORTAÇÕES	01	2 772 977	6 606	**2 779 583**	13 004 816	980 878	600 668	157 908	321	136 004	871 646	423 223	135 583	279 731	**16 590 778**	45 258	127 816	4 047	4 490		**181 611**	**16 772 389**	**5 097 682**
PRODUÇÃO DOMÉSTICA	02																						
VARIAÇÃO DE "STOCKS"	03	- 29 336	48	**- 29 288**	114 332	- 25 042	16 502	1 802	- 164	37 114	96 697	218 516	- 26 263	16 000	**449 494**	5 377	3 176	418	155	574	**9 700**	**459 194**	**53 305**
SAÍDAS	04	112 745	160	**112 905**		100 454	69 278	1 727 470		1 385 937	1 293 213	1 916 468	721 247		**7 214 067**	103 379	70 856	5 009	12 908	145 631	**337 783**	**7 551 850**	
Exportações	*04.01*	*112 745*	*160*	*112 905*		*100 454*	*69 278*	*1 727 470*		*22 109*	*1 154 281*	*1 248 910*	*721 247*		*5 043 749*	*102 660*	*70 856*	*5 009*	*12 908*	*145 631*	*337 064*	*5 380 813*	
Transportes Marítimos Internacionais	*04.02*										*138 932*	*667 558*			*806 490*	*719*					*719*	*807 209*	
Aviação Internacional	*04.03*									*1 363 828*					*1 363 828*							*1 363 828*	
CONSUMO DE ENERGIA PRIMÁRIA	05	2 689 568	6 398	**2 695 966**	12 890 484	905 466	514 888	-1 571 364	485	-1 287 047	- 518 264	-1 711 761	- 559 401	263 731	**8 927 217**	- 63 498	53 784	- 1 380	- 8 573	- 146 205	**- 165 872**	**8 761 345**	**5 044 377**
PARA NOVAS FORMAS DE ENERGIA	06	2 684 480		**2 684 480**	12 875 012	284 078	- 161 012	-2 635 479	- 222	-1 470 542	-5 599 324	-2 017 999	- 907 086		**367 426**	- 115 957	- 127 189	- 8 624	- 17 025	- 159 997	**- 428 792**	**- 61 365**	**3 162 845**
Briquetes	*06.01*																						
Coque	*06.02*																						
Produtos de Petróleo	*06.03*				*12 875 012*	*492 927*	*- 224 955*	*-2 635 479*	*- 222*	*-1 470 542*	*-5 616 875*	*-2 253 181*	*-1 079 686*		*86 999*	*- 115 957*	*- 127 189*	*- 8 624*	*- 17 025*	*- 159 997*	*- 428 791*	*- 341 792*	
Hidrogénio	*06.04*																						*222 124*
Petroquímica	*06.05*					*- 226 328*	*63 943*						*172 600*		*10 215*							*10 215*	
Eletricidade	*06.06*	*2 684 480*		*2 684 480*							*17 490*	*156 639*			*174 129*							*174 129*	*1 656 523*
Cogeração	*06.07*					*17 479*					*61*	*78 543*			*96 083*							*96 083*	*1 284 198*
Produção de Eletricidade	*06.07.01*										*34*	*39 352*			*39 386*							*39 386*	
Refinação de Petróleo	*06.07.02*					*17 479*									*17 479*							*17 479*	*417 402*
Gás de Cidade	*06.07.03*																						
Agricultura	*06.07.04*																						*5 434*
Alimentação, bebidas e tabaco	*06.07.05*											*9 934*			*9 934*							*9 934*	*72 168*
Têxteis	*06.07.06*										*20*				*20*							*20*	*111 551*
Papel e Artigos de Papel	*06.07.07*										*7*	*11 495*			*11 502*							*11 502*	*405 335*
Químicas e Plásticos	*06.07.08*											*17 762*			*17 762*							*17 762*	*123 102*
Cerâmicas	*06.07.09*																						*34 408*
Vidro e Artigos de Vidro	*06.07.10*																						
Cimento e Cal	*06.07.11*																						*2 920*
Metalúrgicas	*06.07.12*																						
Siderurgia	*06.07.13*																						
Vestuário, Calçado e Curtumes	*06.07.14*																						*7 972*
Madeira e Artigos de Madeira	*06.07.15*																						
Borracha	*06.07.16*																						*10 875*
Metálo-eletro-mecânicas	*06.07.17*																						*3 046*
Outras Indústrias Transformadoras	*06.07.18*																						*2 142*
Indústrias Extrativas	*06.07.19*																						*14 069*
Serviços	*06.07.20*																						*73 774*

BALANÇO ENERGÉTICO tep 2018 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				15 473	621 388	1 164		3		43	120 320	1 103		**759 494**	1 717	476		221	26	**2 440**	**761 934**	**101 355**
Consumo Próprio da Refinação	*07.01*					*584 172*	*1 164*				*17*	*118 415*			*703 768*	*215*					*215*	*703 983*	*95 017*
Perdas da Refinação	*07.02*				*15 473*	*37 216*			*3*			*1 905*	*1 103*		*55 700*		*476*		*221*		*697*	*56 397*	
Coquerie e outras não especificadas	*07.03*																						
Centrais Elétricas	*07.04*															*1 502*					*1 502*	*1 502*	
Bombagem Hidroeléctrica	*07.05*																						
Extração de Carvão, Petróleo e GN	*07.06*																						
Perdas de Transporte e Distribuição	*07.07*										*26*				*26*					*26*	*26*	*52*	*6 338*
CONSUMO COMO MATÉRIA PRIMA	08						*108 775*						*346 582*		*455 357*							*455 357*	
DISPONÍVEL PARA CONSUMO FINAL	09	5 088	6 398	**11 486**			565 961	1 064 115	704	183 495	5 081 017	185 918		263 731	**7 344 940**	50 742	180 497	7 244	8 231	13 766	**260 480**	**7 605 419**	**1 780 177**
ACERTOS		1 850	- 539	1 311			- 3 743	- 16 259	230	- 14 200	23 974	21 208		818	12 027	- 1 244	- 2 253	- 416	2 444	- 312	- 1 781	10 245	25 303
CONSUMO FINAL	10	3 238	6 937	**10 175**			569 704	1 080 374	474	197 695	5 057 043	164 710		262 913	**7 332 913**	51 986	182 750	7 660	5 787	14 078	**262 261**	**7 595 174**	**1 754 874**
AGRICULTURA E PESCAS	10.01						4 915	1 035	296		356 402	3 655			**366 303**	303					**303**	**366 606**	3 679
Agricultura	*10.01.01*						*4 915*	*161*	*296*		*275 972*	*569*			*281 913*	*126*					*126*	*282 039*	*3 672*
Pescas	*10.01.02*							*874*			*80 430*	*3 086*			*84 390*	*177*					*177*	*84 567*	*7*
INDÚSTRIAS EXTRATIVAS	10.02	25		**25**			973				29 029	1 124			**31 126**	948					**948**	**32 074**	**1 027**
INDÚSTRIAS TRANSFORMADORAS	10.03	3 213	6 937	**10 150**			52 828	1 264	28		77 800	68 179		262 913	**463 012**	14 080	4 274	7 659	5 667	14 078	**45 758**	**508 770**	**1 186 451**
Alimentação, bebidas e tabaco	*10.03.01*						*16 855*				*19 445*	*24 393*			*60 693*	*174*					*174*	*60 867*	*149 743*
Têxteis	*10.03.02*						*2 171*				*311*	*3 297*			*5 779*	*758*					*758*	*6 537*	*126 758*
Papel e Artigos de Papel	*10.03.03*						*1 328*		*4*		*3 543*	*28 749*			*33 624*	*251*			*3 755*	*3 783*	*7 789*	*41 413*	*140 601*
Químicas e Plásticos	*10.03.04*						*2 671*		*2*		*1 534*	*9 738*			*13 945*	*4 689*	*4 274*	*5 334*	*1 804*	*10 295*	*26 396*	*40 341*	*155 224*
Cerâmicas	*10.03.05*						*2 650*		*2*		*1 347*			*12 350*	*16 349*	*84*					*84*	*16 433*	*200 684*
Vidro e Artigos de Vidro	*10.03.06*		*149*	*149*			*186*				*208*				*394*	*211*					*211*	*605*	*197 147*
Cimento e Cal	*10.03.07*						*427*		*18*		*12 598*			*250 563*	*263 606*	*325*					*325*	*263 931*	*47 309*
Metalúrgicas	*10.03.08*	*2*	*4 045*	*4 047*			*2 404*				*398*				*2 802*	*464*			*1*		*465*	*3 267*	*21 817*
Siderurgia	*10.03.09*	*3 074*	*1 528*	*4 602*			*66*				*1 445*				*1 511*	*351*			*13*		*364*	*1 875*	*48 108*
Vestuário, Calçado e Curtumes	*10.03.10*						*2 365*				*2 068*	*346*			*4 779*	*23*			*2*		*25*	*4 804*	*13 972*
Madeira e Artigos de Madeira	*10.03.11*						*1 134*				*5 125*	*659*			*6 918*	*327*		*1 852*			*2 179*	*9 097*	*13 271*
Borracha	*10.03.12*	*2*		*2*			*204*								*204*	*2 127*		*439*	*1*		*2 567*	*2 771*	*5 013*
Metálo-eletro-mecânicas	*10.03.13*	*21*	*110*	*131*			*17 941*	*1 264*	*2*		*7 439*	*123*			*26 769*	*3 737*		*28*	*91*		*3 856*	*30 625*	*56 114*
Outras Indústrias Transformadoras	*10.03.14*	*114*	*1 105*	*1 219*			*2 426*				*22 339*	*874*			*25 639*	*559*		*6*			*565*	*26 204*	*10 690*
CONSTRUÇÃO E OBRAS PÚBLICAS	10.04						8 624	139	1		69 213	15 291			**93 268**	1 276	178 476		91		**179 843**	**273 111**	**13 626**
TRANSPORTES	10.05						39 860	1 077 936	22	178 092	4 429 988	62 173			**5 788 071**	32 837					**32 837**	**5 820 908**	**16 073**
Aviação Nacional	*10.05.01*							*845*		*178 092*					*178 937*							*178 937*	
Transportes Marítimos Nacionais	*10.05.02*										*40 500*	*62 173*			*102 673*	*99*					*99*	*102 772*	
Caminho de Ferro	*10.05.03*										*9 739*				*9 739*							*9 739*	
Rodoviários	*10.05.04*						*39 860*	*1 077 091*	*22*		*4 379 749*				*5 496 722*	*32 738*					*32 738*	*5 529 460*	*16 073*
SETOR DOMÉSTICO	10.06						364 249		125		56 067				**420 441**							**420 441**	**274 226**
SERVIÇOS	10.07						98 255		2	19 603	38 544	14 288			**170 692**	2 542		1	29		**2 572**	**173 264**	**259 792**

BALANÇO ENERGÉTICO tep		Gases Incond. de Petroquímica	Hidrogénio	**Gases e Outros Derivados**	Hidro-eletricidade	Eólica	Foto-voltaica	Geo-térmica	Termo-eletricidade	**Total de Eletricidade**	**Calor**	Resíduos não Renováveis	Solar Térmico	Lenhas e Resíduos Vegetais	Resíduos Sólidos Urbanos	Licores Sulfitivos	Outros Renováveis	Biogás	Biocombustíveis	Bombas de Calor	**Renováveis Sem Eletricidade**	**TOTAL GERAL**
2018 provisório		23	24	25 = 23 + 24	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42 = 34 a 41	43=3+21+22+25+31+32+33+42
IMPORTAÇÕES	01									**487 411**		18 943		51 680			38 258		11 675		**101 613**	25 257 621
PRODUÇÃO DOMÉSTICA	02				1 172 030	1 085 026	86 507	19 813		**2 363 377**		167 200	92 077	1 568 320	106 480	1 050 073	9 209	82 734	327 069	649 813	**3 885 775**	**6 416 352**
VARIAÇÃO DE "STOCKS"	03																		- 9 147		**- 9 147**	**474 064**
SAÍDAS	04									**715 910**				275 226					68 263		**343 489**	**8 724 154**
Exportações	*04.01*									*715 910*				*275 226*					*68 263*		*343 489*	*6 553 117*
Transportes Marítimos Internacionais	*04.02*																					*807 209*
Aviação Internacional	*04.03*																					*1 363 828*
CONSUMO DE ENERGIA PRIMÁRIA	05				*1 172 030*	*1 085 026*	*86 507*	*19 813*		**2 134 878**		186 143	92 077	1 344 774	106 480	1 050 073	47 467	82 734	279 628	649 813	**3 653 046**	**22 475 755**
PARA NOVAS FORMAS DE ENERGIA	06				*1 172 030*	*1 085 026*	*86 507*	*19 813*	-2 765 327	**-2 765 327**	**-1 378 424**	99 313		415 248	106 480	1 050 073		74 693	277 926		**1 924 420**	**3 665 942**
Briquetes	*06.01*																					
Coque	*06.02*																					
Produtos de Petróleo	*06.03*		*187 390*	*187 390*															*277 926*		*277 926*	*123 524*
Hidrogénio	*06.04*		*- 187 390*	*- 187 390*																		*34 734*
Petroquímica	*06.05*	*- 44 789*		*- 44 789*																		*- 34 574*
Eletricidade	*06.06*				*1 172 030*	*1 085 026*	*86 507*	*19 813*	*-2 156 647*	*-2 156 647*		*87 473*		*297 439*	*106 480*			*70 181*			474 100	*2 920 058*
Cogeração	*06.07*	*44 789*		*44 789*					*- 608 680*	*- 608 680*	*-1 378 424*	*11 840*		*117 809*		*1 050 073*		*4 512*			*1 172 394*	*622 200*
Produção de Eletricidade	*06.07.01*								*- 16 540*	*- 16 540*	*- 1 055*											*21 791*
Refinação de Petróleo	*06.07.02*								*- 132 871*	*- 132 871*	*- 212 530*											*89 480*
Gás de Cidade	*06.07.03*																					
Agricultura	*06.07.04*								*- 2 154*	*- 2 154*	*- 1 752*							*270*			*270*	*1 798*
Alimentação, bebidas e tabaco	*06.07.05*								*- 21 719*	*- 21 719*	*- 40 655*											*19 728*
Têxteis	*06.07.06*								*- 44 362*	*- 44 362*	*- 36 601*											*30 608*
Papel e Artigos de Papel	*06.07.07*								*- 295 639*	*- 295 639*	*- 928 086*			*108 059*		*1 050 073*					*1 158 132*	*351 244*
Químicas e Plásticos	*06.07.08*	*44 789*		*44 789*					*- 39 112*	*- 39 112*	*- 91 290*	*10 295*										*65 546*
Cerâmicas	*06.07.09*								*- 11 491*	*- 11 491*	*- 16 367*											*6 550*
Vidro e Artigos de Vidro	*06.07.10*																					
Cimento e Cal	*06.07.11*								*- 1 230*	*- 1 230*	*- 923*											*767*
Metalúrgicas	*06.07.12*																					
Siderurgia	*06.07.13*																					
Vestuário, Calçado e Curtumes	*06.07.14*								*- 3 027*	*- 3 027*	*- 2 451*											*2 494*
Madeira e Artigos de Madeira	*06.07.15*								*- 565*	*- 565*	*- 3 606*			*9 750*							*9 750*	*5 579*
Borracha	*06.07.16*								*- 3 705*	*- 3 705*	*- 6 047*	*1 545*										*2 668*
Metálo-eletro-mecânicas	*06.07.17*								*- 1 288*	*- 1 288*	*- 1 132*											*626*
Outras Indústrias Transformadoras	*06.07.18*								*- 1 746*	*- 1 746*	*- 943*							*2 247*			*2 247*	*1 700*
Indústrias Extrativas	*06.07.19*								*- 4 247*	*- 4 247*	*- 7 641*											*2 181*
Serviços	*06.07.20*								*- 28 984*	*- 28 984*	*- 27 345*							*1 995*			*1 995*	*19 440*

BALANÇO ENERGÉTICO tep 2018 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									**774 547**	**212 530**											**1 850 366**
Consumo Próprio da Refinação	*07.01*									*61 838*	*212 530*											*1 073 368*
Perdas da Refinação	*07.02*																					*56 397*
Coquerie e outras não especificadas	*07.03*																					
Centrais Elétricas	*07.04*									*141 502*												*143 004*
Bombagem Hidroeléctrica	*07.05*									*136 083*												*136 083*
Extração de Carvão, Petróleo e GN	*07.06*									*- 11*												*- 11*
Perdas de Transporte e Distribuição	*07.07*									*435 135*												*441 525*
CONSUMO COMO MATÉRIA PRIMA	08																					*455 357*
DISPONÍVEL PARA CONSUMO FINAL	09									**4 125 658**	**1 165 894**	86 830	92 077	929 526			47 467	8 041	1 702	649 813	**1 728 626**	**16 504 090**
ACERTOS										- 27									- 2 515		- 2 515	34 317
CONSUMO FINAL	10									**4 125 685**	**1 165 894**	86 830	92 077	929 526			47 467	8 041	4 217	649 813	**1 731 141**	**16 469 773**
AGRICULTURA E PESCAS	10.01									**95 399**	**1 752**			***1 422***					37		**1 459**	**468 895**
Agricultura	*10.01.01*									*91 461*	*1 752*			*1 422*					*37*		*1 459*	*380 383*
Pescas	*10.01.02*									*3 938*												*88 512*
INDÚSTRIAS EXTRATIVAS	10.02									**38 046**	**7 641**											**78 813**
INDÚSTRIAS TRANSFORMADORAS	10.03									**1 349 258**	**1 129 340**	**86 830**		**133 209**			45 725	8 041	203		**187 178**	**4 457 977**
Alimentação, bebidas e tabaco	*10.03.01*									*175 058*	*40 655*			*33 198*				*1 547*			*34 745*	*461 068*
Têxteis	*10.03.02*									*82 306*	*36 601*			*6 594*							*6 594*	*258 796*
Papel e Artigos de Papel	*10.03.03*									*262 440*	*928 086*			*28 396*			*193*	*6 494*			*35 083*	*1 407 623*
Químicas e Plásticos	*10.03.04*									*204 903*	*91 290*	*125*		*3 864*					*203*		*4 067*	*495 950*
Cerâmicas	*10.03.05*									*39 378*	*16 367*			*24 068*							*24 068*	*296 930*
Vidro e Artigos de Vidro	*10.03.06*									*48 170*												*246 071*
Cimento e Cal	*10.03.07*									*60 911*	*923*	*86 705*		*7 455*			*45 532*				*52 987*	*512 766*
Metalúrgicas	*10.03.08*									*23 975*												*53 106*
Siderurgia	*10.03.09*									*130 239*												*184 824*
Vestuário, Calçado e Curtumes	*10.03.10*									*28 192*	*2 451*			*2 168*							*2 168*	*51 587*
Madeira e Artigos de Madeira	*10.03.11*									*75 412*	*3 606*			*27 076*							*27 076*	*128 462*
Borracha	*10.03.12*									*20 257*	*6 047*			*179*							*179*	*34 269*
Metálo-eletro-mecânicas	*10.03.13*									*149 318*	*1 132*			*141*							*141*	*237 461*
Outras Indústrias Transformadoras	*10.03.14*									*48 699*	*2 182*			*70*							*70*	*89 064*
CONSTRUÇÃO E OBRAS PÚBLICAS	10.04									38 039				91							**91**	**324 867**
TRANSPORTES	10.05									41 685									3 977		**3 977**	**5 882 643**
Aviação Nacional	*10.05.01*																					*178 937*
Transportes Marítimos Nacionais	*10.05.02*																					*102 772*
Caminho de Ferro	*10.05.03*									*41 226*												*50 965*
Rodoviários	*10.05.04*									*459*									*3 977*		*3 977*	*5 549 969*
SETOR DOMÉSTICO	10.06									**1 148 211**			47 373	*764 583*						265 274	**1 077 230**	**2 920 108**
SERVIÇOS	10.07									**1 415 047**	**27 161**		44 704	30 221			1 742			384 539	**461 206**	**2 336 470**

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
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
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

Fuel Sales		NAPFUE	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	
Aviation Gasoline	L	209	2,192	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	
Jet Fuel	L	207	865,857	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	

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	Representative 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 (kg/GJ) for 2018 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	kg/GJ	kg/GJ	kg/GJ	kg/GJ	kg/GJ	kg/GJ	kg/GJ	kg/GJ	kg/GJ
Passenger Cars	Petrol	Small & Mini	PRE ECE - ECE 15/04	0.778	1.127	0.00044	0.0007	0.005	0.009	0.014	0.0002	5.798
Passenger Cars	Petrol	Small & Mini	Euro 1	0.201	0.454	0.00045	0.0303	0.006	0.010	0.014	0.0002	2.006
Passenger Cars	Petrol	Small & Mini	Euro 2	0.098	0.312	0.00045	0.0399	0.006	0.010	0.015	0.0002	1.133
Passenger Cars	Petrol	Small & Mini	Euro 3	0.043	0.178	0.00045	0.0109	0.005	0.009	0.014	0.0001	1.074
Passenger Cars	Petrol	Small & Mini	Euro 4	0.025	0.120	0.00045	0.0107	0.005	0.009	0.014	0.0001	0.390
Passenger Cars	Petrol	Small & Mini	Euro 5	0.016	0.089	0.00045	0.0052	0.006	0.010	0.014	0.0001	0.382
Passenger Cars	Petrol	Small & Mini	Euro 6 up to 2016	0.017	0.076	0.00045	0.0051	0.006	0.010	0.014	0.0001	0.358
Passenger Cars	Petrol	Medium	PRE ECE - ECE 15/04	0.820	0.970	0.00045	0.0006	0.004	0.008	0.011	0.0001	4.898
Passenger Cars	Petrol	Medium	Euro 1	0.170	0.272	0.00045	0.0258	0.005	0.008	0.012	0.0002	1.581
Passenger Cars	Petrol	Medium	Euro 2	0.086	0.162	0.00045	0.0357	0.005	0.009	0.013	0.0002	0.913
Passenger Cars	Petrol	Medium	Euro 3	0.036	0.094	0.00045	0.0092	0.004	0.008	0.012	0.0001	0.833
Passenger Cars	Petrol	Medium	Euro 4	0.021	0.065	0.00045	0.0090	0.004	0.008	0.012	0.0001	0.305
Passenger Cars	Petrol	Medium	Euro 5	0.014	0.058	0.00045	0.0043	0.005	0.008	0.012	0.0001	0.296
Passenger Cars	Petrol	Medium	Euro 6 up to 2016	0.014	0.053	0.00045	0.0042	0.005	0.008	0.012	0.0001	0.275
Passenger Cars	Petrol	Large-SUV-Executive	PRE ECE - ECE 15/04	0.765	0.893	0.00044	0.0005	0.004	0.006	0.009	0.0001	4.238
Passenger Cars	Petrol	Large-SUV-Executive	Euro 1	0.126	0.179	0.00045	0.0200	0.004	0.006	0.009	0.0002	1.050
Passenger Cars	Petrol	Large-SUV-Executive	Euro 2	0.059	0.101	0.00045	0.0260	0.004	0.006	0.009	0.0002	0.542
Passenger Cars	Petrol	Large-SUV-Executive	Euro 3	0.028	0.068	0.00045	0.0078	0.004	0.007	0.010	0.0000	0.589
Passenger Cars	Petrol	Large-SUV-Executive	Euro 4	0.014	0.041	0.00045	0.0066	0.003	0.006	0.009	0.0000	0.194
Passenger Cars	Petrol	Large-SUV-Executive	Euro 5	0.009	0.034	0.00045	0.0032	0.003	0.006	0.009	0.0001	0.187
Passenger Cars	Petrol	Large-SUV-Executive	Euro 6 up to 2016	0.010	0.036	0.00045	0.0030	0.003	0.006	0.009	0.0001	0.172
Passenger Cars	Diesel	Small & Mini	Conventional	0.205	0.058	0.00044	0.0003	0.098	0.102	0.106	0.0518	0.236
Passenger Cars	Diesel	Small & Mini	Euro 1	0.294	0.023	0.00044	0.0004	0.049	0.053	0.058	0.0305	0.201
Passenger Cars	Diesel	Small & Mini	Euro 2	0.314	0.015	0.00044	0.0004	0.031	0.035	0.040	0.0211	0.142
Passenger Cars	Diesel	Small & Mini	Euro 3	0.352	0.009	0.00044	0.0004	0.025	0.029	0.035	0.0170	0.042
Passenger Cars	Diesel	Small & Mini	Euro 4	0.300	0.007	0.00044	0.0004	0.021	0.025	0.031	0.0137	0.044
Passenger Cars	Diesel	Small & Mini	Euro 5	0.294	0.001	0.00044	0.0008	0.006	0.011	0.016	0.0002	0.019
Passenger Cars	Diesel	Small & Mini	Euro 6 up to 2016	0.241	0.001	0.00044	0.0029	0.006	0.010	0.016	0.0002	0.028
Passenger Cars	Diesel	Medium	Conventional	0.205	0.058	0.00044	0.0003	0.098	0.102	0.106	0.0518	0.236
Passenger Cars	Diesel	Medium	Euro 1	0.294	0.023	0.00044	0.0004	0.049	0.053	0.058	0.0305	0.201
Passenger Cars	Diesel	Medium	Euro 2	0.314	0.015	0.00044	0.0004	0.031	0.035	0.040	0.0211	0.142
Passenger Cars	Diesel	Medium	Euro 3	0.352	0.009	0.00044	0.0004	0.025	0.029	0.035	0.0170	0.042
Passenger Cars	Diesel	Medium	Euro 4	0.289	0.007	0.00044	0.0004	0.020	0.025	0.030	0.0132	0.043
Passenger Cars	Diesel	Medium	Euro 5	0.289	0.001	0.00044	0.0008	0.006	0.011	0.016	0.0002	0.019
Passenger Cars	Diesel	Medium	Euro 6 up to 2016	0.238	0.001	0.00044	0.0028	0.006	0.010	0.015	0.0002	0.028
Passenger Cars	Diesel	Large-SUV-Executive	Conventional	0.320	0.058	0.00044	0.0003	0.098	0.102	0.106	0.0518	0.236
Passenger Cars	Diesel	Large-SUV-Executive	Euro 1	0.220	0.026	0.00044	0.0003	0.036	0.039	0.043	0.0228	0.150
Passenger Cars	Diesel	Large-SUV-Executive	Euro 2	0.242	0.035	0.00044	0.0003	0.024	0.027	0.031	0.0163	0.110
Passenger Cars	Diesel	Large-SUV-Executive	Euro 3	0.256	0.014	0.00044	0.0003	0.018	0.021	0.025	0.0124	0.031
Passenger Cars	Diesel	Large-SUV-Executive	Euro 4	0.211	0.005	0.00044	0.0003	0.015	0.018	0.022	0.0096	0.031
Passenger Cars	Diesel	Large-SUV-Executive	Euro 5	0.210	0.000	0.00044	0.0006	0.005	0.008	0.011	0.0002	0.014
Passenger Cars	Diesel	Large-SUV-Executive	Euro 6 up to 2016	0.173	0.000	0.00044	0.0021	0.004	0.007	0.011	0.0001	0.020
Passenger Cars	Petrol Hybrid	All Segments	Euro 4	0.014	0.081	0.00045	0.0148	0.006	0.012	0.018	0.0000	0.274
Passenger Cars	Petrol Hybrid	All Segments	Euro 5	0.014	0.064	0.00045	0.0143	0.006	0.012	0.018	0.0000	0.249
Passenger Cars	Petrol Hybrid	All Segments	Euro 6 up to 2016	0.014	0.061	0.00045	0.0143	0.006	0.012	0.018	0.0000	0.256

				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	kg/GJ	kg/GJ	kg/GJ	kg/GJ	kg/GJ	kg/GJ	kg/GJ	kg/GJ	kg/GJ
Passenger Cars	LPG Bifuel	All Segments	Conventional	0.854	0.417	0.00000	0.0007	0.005	0.009	0.014	0.0002	3.738
Passenger Cars	LPG Bifuel	All Segments	Euro 1	0.163	0.322	0.00000	0.0279	0.005	0.009	0.013	0.0002	1.720
Passenger Cars	LPG Bifuel	All Segments	Euro 2	0.073	0.150	0.00000	0.0371	0.005	0.009	0.013	0.0002	1.195
Passenger Cars	LPG Bifuel	All Segments	Euro 3	0.038	0.051	0.00000	0.0098	0.005	0.008	0.013	0.0001	0.887
Passenger Cars	LPG Bifuel	All Segments	Euro 4	0.022	0.025	0.00000	0.0098	0.005	0.008	0.013	0.0001	0.329
Passenger Cars	LPG Bifuel	All Segments	Euro 5	0.018	0.025	0.00000	0.0048	0.005	0.008	0.013	0.0001	0.329
Passenger Cars	LPG Bifuel	All Segments	Euro 6	0.018	0.025	0.00000	0.0044	0.005	0.008	0.013	0.0001	0.329
Light Commercial Vehicles	Diesel	N1-I	Conventional	0.320	0.058	0.00044	0.0003	0.100	0.104	0.110	0.0518	0.236
Light Commercial Vehicles	Diesel	N1-I	Euro 1	0.220	0.026	0.00044	0.0003	0.038	0.042	0.047	0.0228	0.150
Light Commercial Vehicles	Diesel	N1-I	Euro 2	0.242	0.035	0.00044	0.0003	0.026	0.030	0.035	0.0163	0.110
Light Commercial Vehicles	Diesel	N1-I	Euro 3	0.256	0.014	0.00044	0.0003	0.020	0.024	0.029	0.0124	0.031
Light Commercial Vehicles	Diesel	N1-I	Euro 4	0.211	0.005	0.00044	0.0003	0.016	0.021	0.025	0.0096	0.031
Light Commercial Vehicles	Diesel	N1-I	Euro 5	0.210	0.000	0.00044	0.0006	0.006	0.010	0.015	0.0002	0.014
Light Commercial Vehicles	Diesel	N1-I	Euro 6 up to 2016	0.173	0.000	0.00044	0.0021	0.006	0.010	0.015	0.0001	0.020
Light Commercial Vehicles	Diesel	N1-II & N1-III	Conventional	0.490	0.036	0.00044	0.0002	0.090	0.093	0.097	0.0471	0.340
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 1	0.349	0.041	0.00044	0.0003	0.041	0.044	0.049	0.0253	0.179
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 2	0.349	0.043	0.00044	0.0003	0.041	0.044	0.049	0.0289	0.179
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 3	0.293	0.027	0.00044	0.0003	0.029	0.033	0.037	0.0206	0.146
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 4	0.237	0.010	0.00044	0.0003	0.017	0.021	0.025	0.0110	0.116
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 5	0.491	0.000	0.00044	0.0005	0.005	0.009	0.014	0.0001	0.000
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 6 up to 2017	0.397	0.000	0.00044	0.0020	0.005	0.009	0.014	0.0001	0.000
Heavy Duty Trucks	Diesel	<=7,5 t	Conventional	0.854	0.179	0.00044	0.0005	0.061	0.069	0.078	0.0267	0.338
Heavy Duty Trucks	Diesel	<=7,5 t	Euro I	0.708	0.034	0.00044	0.0006	0.034	0.042	0.053	0.0160	0.143
Heavy Duty Trucks	Diesel	<=7,5 t	Euro II	0.782	0.023	0.00044	0.0007	0.024	0.033	0.044	0.0093	0.119
Heavy Duty Trucks	Diesel	<=7,5 t	Euro III	0.563	0.020	0.00044	0.0006	0.021	0.029	0.040	0.0084	0.128
Heavy Duty Trucks	Diesel	<=7,5 t	Euro IV	0.398	0.004	0.00044	0.0006	0.012	0.021	0.031	0.0024	0.069
Heavy Duty Trucks	Diesel	<=7,5 t	Euro V	0.314	0.003	0.00044	0.0024	0.013	0.022	0.033	0.0029	0.116
Heavy Duty Trucks	Diesel	<=7,5 t	Euro VI	0.028	0.002	0.00044	0.0020	0.010	0.018	0.029	0.0001	0.012
Heavy Duty Trucks	Diesel	7,5 - 20 t	Conventional	1.048	0.104	0.00044	0.0003	0.045	0.049	0.054	0.0200	0.293
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro I	0.744	0.044	0.00044	0.0004	0.035	0.040	0.046	0.0191	0.167
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro II	0.835	0.029	0.00044	0.0004	0.022	0.028	0.034	0.0108	0.146
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro III	0.638	0.025	0.00044	0.0004	0.021	0.026	0.032	0.0104	0.169
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro IV	0.458	0.004	0.00044	0.0004	0.010	0.015	0.022	0.0026	0.084
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro V	0.416	0.004	0.00044	0.0015	0.011	0.016	0.023	0.0033	0.139
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro VI	0.035	0.003	0.00044	0.0012	0.007	0.012	0.019	0.0001	0.016
Heavy Duty Trucks	Diesel	20 - 28 t	Conventional	0.914	0.046	0.00044	0.0002	0.039	0.043	0.047	0.0177	0.190
Heavy Duty Trucks	Diesel	20 - 28 t	Euro I	0.751	0.045	0.00044	0.0003	0.036	0.040	0.044	0.0203	0.179
Heavy Duty Trucks	Diesel	20 - 28 t	Euro II	0.832	0.031	0.00044	0.0003	0.022	0.026	0.031	0.0116	0.160
Heavy Duty Trucks	Diesel	20 - 28 t	Euro III	0.638	0.028	0.00044	0.0003	0.020	0.023	0.028	0.0107	0.176
Heavy Duty Trucks	Diesel	20 - 28 t	Euro IV	0.456	0.005	0.00044	0.0003	0.008	0.012	0.017	0.0027	0.084
Heavy Duty Trucks	Diesel	20 - 28 t	Euro V	0.394	0.004	0.00044	0.0011	0.009	0.013	0.018	0.0033	0.134
Heavy Duty Trucks	Diesel	20 - 28 t	Euro VI	0.032	0.003	0.00044	0.0009	0.005	0.009	0.014	0.0001	0.017
Heavy Duty Trucks	Diesel	28 - 40 t	Conventional	0.931	0.043	0.00044	0.0002	0.039	0.042	0.046	0.0179	0.191
Heavy Duty Trucks	Diesel	28 - 40 t	Euro I	0.757	0.044	0.00044	0.0002	0.036	0.039	0.044	0.0208	0.184
Heavy Duty Trucks	Diesel	28 - 40 t	Euro II	0.835	0.029	0.00044	0.0002	0.022	0.026	0.030	0.0120	0.166
Heavy Duty Trucks	Diesel	28 - 40 t	Euro III	0.656	0.026	0.00044	0.0002	0.019	0.022	0.027	0.0106	0.181
Heavy Duty Trucks	Diesel	28 - 40 t	Euro IV	0.472	0.005	0.00044	0.0002	0.008	0.011	0.015	0.0027	0.082
Heavy Duty Trucks	Diesel	28 - 40 t	Euro V	0.364	0.004	0.00044	0.0009	0.008	0.012	0.016	0.0033	0.138
Heavy Duty Trucks	Diesel	28 - 40 t	Euro VI	0.026	0.003	0.00044	0.0008	0.004	0.008	0.012	0.0001	0.014

				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	kg/GJ	kg/GJ	kg/GJ	kg/GJ	kg/GJ	kg/GJ	kg/GJ	kg/GJ	kg/GJ
Heavy Duty Trucks	Diesel	40 - 60 t	Conventional	0.940	0.040	0.00044	0.0002	0.040	0.043	0.048	0.0182	0.191
Heavy Duty Trucks	Diesel	40 - 60 t	Euro I	0.751	0.041	0.00044	0.0002	0.038	0.041	0.046	0.0216	0.192
Heavy Duty Trucks	Diesel	40 - 60 t	Euro II	0.801	0.026	0.00044	0.0002	0.023	0.027	0.032	0.0122	0.168
Heavy Duty Trucks	Diesel	40 - 60 t	Euro III	0.646	0.024	0.00044	0.0002	0.019	0.023	0.028	0.0103	0.184
Heavy Duty Trucks	Diesel	40 - 60 t	Euro IV	0.463	0.004	0.00044	0.0002	0.008	0.012	0.017	0.0026	0.078
Buses	Diesel	Urban Buses Midi <=15 t	Conventional	0.764	0.274	0.00044	0.0002	0.081	0.084	0.087	0.0388	0.452
Buses	Diesel	Urban Buses Midi <=15 t	Euro I	0.747	0.053	0.00044	0.0002	0.035	0.039	0.043	0.0203	0.202
Buses	Diesel	Urban Buses Midi <=15 t	Euro II	0.872	0.040	0.00044	0.0002	0.020	0.024	0.028	0.0100	0.197
Buses	Diesel	Urban Buses Midi <=15 t	Euro III	0.815	0.035	0.00044	0.0002	0.019	0.023	0.027	0.0106	0.200
Buses	Diesel	Urban Buses Midi <=15 t	Euro IV	0.519	0.005	0.00044	0.0002	0.009	0.013	0.018	0.0030	0.120
Buses	Diesel	Urban Buses Midi <=15 t	Euro V	0.698	0.005	0.00044	0.0009	0.010	0.014	0.019	0.0037	0.217
Buses	Diesel	Urban Buses Midi <=15 t	Euro VI	0.055	0.003	0.00044	0.0008	0.005	0.010	0.014	0.0001	0.026
Buses	Diesel	Urban Buses Standard 15 - 18 t	Conventional	0.971	0.136	0.00044	0.0001	0.058	0.060	0.063	0.0277	0.378
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro I	0.739	0.056	0.00044	0.0002	0.036	0.039	0.042	0.0212	0.200
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro II	0.857	0.042	0.00044	0.0002	0.019	0.022	0.025	0.0102	0.200
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro III	0.789	0.036	0.00044	0.0002	0.018	0.021	0.024	0.0106	0.205
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro IV	0.503	0.006	0.00044	0.0002	0.008	0.011	0.014	0.0031	0.114
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro V	0.664	0.005	0.00044	0.0007	0.008	0.012	0.015	0.0037	0.213
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro VI	0.043	0.003	0.00044	0.0006	0.004	0.007	0.011	0.0001	0.024
Buses	Diesel	Urban Buses Articulated >18 t	Conventional	1.001	0.120	0.00044	0.0001	0.058	0.060	0.062	0.0278	0.389
Buses	Diesel	Urban Buses Articulated >18 t	Euro I	0.746	0.050	0.00044	0.0001	0.035	0.038	0.040	0.0209	0.215
Buses	Diesel	Urban Buses Articulated >18 t	Euro II	0.828	0.035	0.00044	0.0001	0.019	0.022	0.025	0.0107	0.219
Buses	Diesel	Urban Buses Articulated >18 t	Euro III	0.779	0.032	0.00044	0.0001	0.017	0.020	0.023	0.0103	0.218
Buses	Diesel	Urban Buses Articulated >18 t	Euro IV	0.519	0.005	0.00044	0.0001	0.007	0.010	0.013	0.0031	0.109
Buses	Diesel	Urban Buses Articulated >18 t	Euro V	0.558	0.004	0.00044	0.0006	0.008	0.011	0.014	0.0035	0.215
Buses	Diesel	Urban Buses Articulated >18 t	Euro VI	0.027	0.003	0.00044	0.0004	0.003	0.006	0.009	0.0001	0.022
Buses	Diesel	Coaches	Conventional	0.945	0.041	0.00044	0.0003	0.037	0.041	0.046	0.0162	0.170
Buses	Diesel	Coaches	Euro I	0.781	0.044	0.00044	0.0003	0.032	0.036	0.042	0.0178	0.160
Buses	Diesel	Coaches	Euro II	0.860	0.030	0.00044	0.0003	0.020	0.024	0.030	0.0101	0.141
Buses	Diesel	Coaches	Euro III	0.654	0.028	0.00044	0.0003	0.019	0.023	0.028	0.0100	0.161
Buses	Diesel	Coaches	Euro IV	0.467	0.004	0.00044	0.0003	0.008	0.012	0.018	0.0027	0.084
Buses	Diesel	Coaches	Euro V	0.298	0.004	0.00044	0.0011	0.009	0.013	0.018	0.0032	0.127
Buses	Diesel	Coaches	Euro VI	0.020	0.003	0.00044	0.0009	0.005	0.009	0.014	0.0001	0.017
Buses	CNG	Urban CNG Buses	Euro III	0.457	0.001	0.00000	0.0000	0.003	0.006	0.008	0.0000	0.046
Buses	CNG	Urban CNG Buses	EEV	0.208	0.011	0.00000	0.0000	0.003	0.005	0.007	0.0000	0.054
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Conventional	0.048	7.628	0.00042	0.0009	0.156	0.161	0.166	0.0300	12.536
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Euro 1	0.191	4.086	0.00042	0.0011	0.055	0.062	0.068	0.0048	4.888
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Euro 2	0.181	3.178	0.00042	0.0011	0.035	0.042	0.048	0.0055	2.988
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Euro 3	0.183	2.186	0.00043	0.0011	0.027	0.033	0.039	0.0039	1.935
L-Category	Petrol	Mopeds 4-stroke <50 cm^3	Conventional	0.048	7.628	0.00042	0.0009	0.156	0.161	0.166	0.0150	12.536
L-Category	Petrol	Mopeds 4-stroke <50 cm^3	Euro 1	0.234	1.302	0.00042	0.0011	0.050	0.056	0.062	0.0085	7.120
L-Category	Petrol	Mopeds 4-stroke <50 cm^3	Euro 2	0.181	1.247	0.00042	0.0011	0.015	0.021	0.027	0.0015	4.482
L-Category	Petrol	Mopeds 4-stroke <50 cm^3	Euro 3	0.183	0.831	0.00043	0.0011	0.012	0.018	0.024	0.0009	2.903
L-Category	Petrol	Motorcycles 2-stroke >50 cm^3	Conventional	0.020	7.021	0.00043	0.0013	0.130	0.133	0.137	0.0127	13.191
L-Category	Petrol	Motorcycles 2-stroke >50 cm^3	Euro 1	0.033	2.858	0.00043	0.0014	0.059	0.062	0.066	0.0111	9.491
L-Category	Petrol	Motorcycles 2-stroke >50 cm^3	Euro 2	0.038	1.665	0.00043	0.0014	0.032	0.035	0.039	0.0056	7.535
L-Category	Petrol	Motorcycles 2-stroke >50 cm^3	Euro 3	0.018	1.062	0.00044	0.0014	0.012	0.016	0.019	0.0017	4.183
L-Category	Petrol	Motorcycles 4-stroke <250 cm^3	Conventional	0.255	1.154	0.00045	0.0013	0.017	0.020	0.024	0.0020	13.254
L-Category	Petrol	Motorcycles 4-stroke <250 cm^3	Euro 1	0.329	1.113	0.00045	0.0016	0.021	0.025	0.029	0.0041	12.991

				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	kg/GJ	kg/GJ	kg/GJ	kg/GJ	kg/GJ	kg/GJ	kg/GJ	kg/GJ	kg/GJ
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 2	0.362	0.676	0.00045	0.0020	0.010	0.015	0.020	0.0012	5.818
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 3	0.317	0.452	0.00045	0.0020	0.010	0.015	0.020	0.0012	3.225
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Conventional	0.239	1.409	0.00045	0.0010	0.012	0.015	0.017	0.0015	12.387
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 1	0.220	0.902	0.00045	0.0010	0.013	0.016	0.018	0.0026	7.189
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 2	0.110	0.603	0.00045	0.0011	0.006	0.009	0.012	0.0007	3.578
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 3	0.056	0.395	0.00045	0.0011	0.006	0.009	0.012	0.0007	1.983
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Conventional	0.132	1.422	0.00045	0.0009	0.011	0.013	0.015	0.0013	10.860
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 1	0.146	0.794	0.00045	0.0009	0.012	0.014	0.016	0.0023	6.375
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 2	0.163	0.452	0.00045	0.0009	0.005	0.007	0.009	0.0006	2.915
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 3	0.083	0.294	0.00045	0.0009	0.005	0.007	0.009	0.0006	1.615

Table C-4: Road transportation energy based implied emission factors (g/GJ) for 2018 for Heavy Metals.

				Priority Heavy Metals			Additional Heavy Metals					
				Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
Category	Fuel	Segment	Euro Standard	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ
Passenger Cars	Petrol	Small & Mini	PRE ECE - ECE 15/04	0.156	0.273	0.195	0.007	3.78	98.00	2.12	0.299	47.81
Passenger Cars	Petrol	Small & Mini	Euro 1	0.158	0.289	0.197	0.007	3.99	103.75	2.24	0.316	50.58
Passenger Cars	Petrol	Small & Mini	Euro 2	0.158	0.291	0.197	0.007	4.02	104.45	2.25	0.318	50.91
Passenger Cars	Petrol	Small & Mini	Euro 3	0.158	0.290	0.198	0.007	4.01	104.15	2.25	0.317	50.77
Passenger Cars	Petrol	Small & Mini	Euro 4	0.159	0.289	0.198	0.007	3.99	103.63	2.24	0.316	50.53
Passenger Cars	Petrol	Small & Mini	Euro 5	0.159	0.285	0.198	0.007	4.00	103.54	2.21	0.312	50.38
Passenger Cars	Petrol	Small & Mini	Euro 6 up to 2016	0.159	0.271	0.198	0.007	3.94	101.22	2.12	0.298	49.02
Passenger Cars	Petrol	Medium	PRE ECE - ECE 15/04	0.155	0.230	0.195	0.007	3.19	82.14	1.78	0.251	40.19
Passenger Cars	Petrol	Medium	Euro 1	0.158	0.245	0.198	0.007	3.40	87.74	1.90	0.268	42.89
Passenger Cars	Petrol	Medium	Euro 2	0.158	0.257	0.198	0.007	3.56	92.18	1.99	0.281	45.02
Passenger Cars	Petrol	Medium	Euro 3	0.158	0.245	0.198	0.007	3.40	87.69	1.90	0.268	42.86
Passenger Cars	Petrol	Medium	Euro 4	0.158	0.242	0.199	0.007	3.35	86.49	1.87	0.264	42.29
Passenger Cars	Petrol	Medium	Euro 5	0.158	0.237	0.199	0.007	3.33	85.69	1.84	0.259	41.82
Passenger Cars	Petrol	Medium	Euro 6 up to 2016	0.158	0.225	0.199	0.007	3.28	83.64	1.76	0.247	40.64
Passenger Cars	Petrol	Large-SUV-Executive	PRE ECE - ECE 15/04	0.154	0.183	0.195	0.007	2.56	65.27	1.43	0.200	32.07
Passenger Cars	Petrol	Large-SUV-Executive	Euro 1	0.156	0.191	0.199	0.007	2.67	68.20	1.49	0.209	33.49
Passenger Cars	Petrol	Large-SUV-Executive	Euro 2	0.156	0.190	0.199	0.007	2.65	67.65	1.48	0.207	33.23
Passenger Cars	Petrol	Large-SUV-Executive	Euro 3	0.157	0.210	0.199	0.007	2.92	74.78	1.63	0.229	36.66
Passenger Cars	Petrol	Large-SUV-Executive	Euro 4	0.156	0.178	0.199	0.007	2.50	63.42	1.39	0.195	31.20
Passenger Cars	Petrol	Large-SUV-Executive	Euro 5	0.156	0.175	0.199	0.007	2.48	62.83	1.36	0.191	30.86
Passenger Cars	Petrol	Large-SUV-Executive	Euro 6 up to 2016	0.156	0.166	0.199	0.007	2.44	61.32	1.30	0.182	29.98
Passenger Cars	Diesel	Small & Mini	Conventional	0.007	0.251	0.125	0.002	3.52	89.96	1.92	0.275	43.71
Passenger Cars	Diesel	Small & Mini	Euro 1	0.008	0.307	0.125	0.002	4.28	110.31	2.35	0.337	53.51
Passenger Cars	Diesel	Small & Mini	Euro 2	0.008	0.298	0.125	0.002	4.15	106.87	2.28	0.326	51.86
Passenger Cars	Diesel	Small & Mini	Euro 3	0.008	0.316	0.125	0.002	4.39	113.33	2.42	0.346	54.97
Passenger Cars	Diesel	Small & Mini	Euro 4	0.009	0.327	0.125	0.002	4.54	117.33	2.50	0.358	56.90
Passenger Cars	Diesel	Small & Mini	Euro 5	0.008	0.314	0.125	0.002	4.43	114.14	2.41	0.345	55.23
Passenger Cars	Diesel	Small & Mini	Euro 6 up to 2016	0.008	0.293	0.125	0.002	4.33	110.27	2.26	0.324	53.04
Passenger Cars	Diesel	Medium	Conventional	0.007	0.251	0.125	0.002	3.52	89.96	1.92	0.275	43.71
Passenger Cars	Diesel	Medium	Euro 1	0.008	0.307	0.125	0.002	4.28	110.31	2.35	0.337	53.51
Passenger Cars	Diesel	Medium	Euro 2	0.008	0.298	0.125	0.002	4.15	106.87	2.28	0.326	51.86
Passenger Cars	Diesel	Medium	Euro 3	0.008	0.316	0.125	0.002	4.39	113.33	2.42	0.346	54.97
Passenger Cars	Diesel	Medium	Euro 4	0.008	0.316	0.125	0.002	4.39	113.33	2.42	0.346	54.97
Passenger Cars	Diesel	Medium	Euro 5	0.008	0.308	0.125	0.002	4.35	112.01	2.36	0.338	54.21
Passenger Cars	Diesel	Medium	Euro 6 up to 2016	0.008	0.289	0.125	0.002	4.27	108.71	2.23	0.319	52.30
Passenger Cars	Diesel	Large-SUV-Executive	Conventional	0.007	0.251	0.125	0.002	3.52	89.96	1.92	0.275	43.71
Passenger Cars	Diesel	Large-SUV-Executive	Euro 1	0.006	0.230	0.125	0.002	3.25	82.55	1.76	0.253	40.14
Passenger Cars	Diesel	Large-SUV-Executive	Euro 2	0.006	0.230	0.125	0.002	3.25	82.55	1.76	0.253	40.14
Passenger Cars	Diesel	Large-SUV-Executive	Euro 3	0.006	0.230	0.125	0.002	3.25	82.55	1.76	0.253	40.14
Passenger Cars	Diesel	Large-SUV-Executive	Euro 4	0.006	0.230	0.125	0.002	3.25	82.55	1.76	0.253	40.14
Passenger Cars	Diesel	Large-SUV-Executive	Euro 5	0.006	0.225	0.125	0.002	3.23	81.59	1.72	0.247	39.58
Passenger Cars	Diesel	Large-SUV-Executive	Euro 6 up to 2016	0.006	0.211	0.125	0.002	3.17	79.19	1.62	0.233	38.19
Passenger Cars	Petrol Hybrid	All Segments	Euro 4	0.162	0.394	0.198	0.007	5.41	142.03	3.05	0.431	68.99
Passenger Cars	Petrol Hybrid	All Segments	Euro 5	0.161	0.376	0.198	0.007	5.24	137.03	2.91	0.412	66.45
Passenger Cars	Petrol Hybrid	All Segments	Euro 6 up to 2016	0.162	0.360	0.198	0.007	5.20	134.79	2.80	0.396	65.05
Passenger Cars	LPG Bifuel	All Segments	Conventional	0.007	0.270	0.000	0.000	3.65	98.36	2.08	0.295	47.29

				Priority Heavy Metals			Additional Heavy Metals					
				Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
Category	Fuel	Segment	Euro Standard	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ
Passenger Cars	LPG Bifuel	All Segments	Euro 1	0.007	0.256	0.000	0.000	3.46	93.17	1.97	0.280	44.79
Passenger Cars	LPG Bifuel	All Segments	Euro 2	0.007	0.256	0.000	0.000	3.46	93.17	1.97	0.280	44.79
Passenger Cars	LPG Bifuel	All Segments	Euro 3	0.007	0.256	0.000	0.000	3.46	93.17	1.97	0.280	44.79
Passenger Cars	LPG Bifuel	All Segments	Euro 4	0.007	0.256	0.000	0.000	3.46	93.17	1.97	0.280	44.79
Passenger Cars	LPG Bifuel	All Segments	Euro 5	0.007	0.251	0.000	0.000	3.44	92.28	1.93	0.275	44.28
Passenger Cars	LPG Bifuel	All Segments	Euro 6	0.007	0.237	0.000	0.000	3.38	90.06	1.84	0.262	42.99
Light Commercial Vehicles	Diesel	N1-I	Conventional	0.010	0.268	0.125	0.002	4.87	119.38	2.14	0.306	56.11
Light Commercial Vehicles	Diesel	N1-I	Euro 1	0.009	0.246	0.125	0.002	4.48	109.54	1.96	0.281	51.52
Light Commercial Vehicles	Diesel	N1-I	Euro 2	0.009	0.246	0.125	0.002	4.48	109.54	1.96	0.281	51.52
Light Commercial Vehicles	Diesel	N1-I	Euro 3	0.009	0.246	0.125	0.002	4.48	109.54	1.96	0.281	51.52
Light Commercial Vehicles	Diesel	N1-I	Euro 4	0.009	0.246	0.125	0.002	4.48	109.54	1.96	0.281	51.52
Light Commercial Vehicles	Diesel	N1-I	Euro 5	0.009	0.241	0.125	0.002	4.46	108.58	1.92	0.276	50.96
Light Commercial Vehicles	Diesel	N1-I	Euro 6 up to 2016	0.009	0.227	0.125	0.002	4.40	106.18	1.82	0.262	49.57
Light Commercial Vehicles	Diesel	N1-II & N1-III	Conventional	0.007	0.195	0.125	0.002	3.58	86.53	1.55	0.223	40.77
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 1	0.008	0.216	0.125	0.002	3.96	96.05	1.72	0.247	45.21
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 2	0.008	0.216	0.125	0.002	3.96	96.05	1.72	0.247	45.21
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 3	0.008	0.216	0.125	0.002	3.96	96.05	1.72	0.247	45.21
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 4	0.008	0.216	0.125	0.002	3.96	96.05	1.72	0.247	45.21
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 5	0.009	0.228	0.125	0.002	4.24	103.02	1.82	0.262	48.37
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 6 up to 2017	0.009	0.212	0.125	0.002	4.17	100.29	1.71	0.246	46.79
Heavy Duty Trucks	Diesel	<=7,5 t	Conventional	0.013	0.192	0.125	0.002	5.75	132.56	1.70	0.218	47.09
Heavy Duty Trucks	Diesel	<=7,5 t	Euro I	0.015	0.220	0.125	0.002	6.55	151.50	1.94	0.249	53.76
Heavy Duty Trucks	Diesel	<=7,5 t	Euro II	0.016	0.229	0.125	0.002	6.83	158.32	2.03	0.260	56.17
Heavy Duty Trucks	Diesel	<=7,5 t	Euro III	0.015	0.217	0.125	0.002	6.46	149.47	1.92	0.246	53.05
Heavy Duty Trucks	Diesel	<=7,5 t	Euro IV	0.015	0.220	0.125	0.002	6.57	152.16	1.95	0.250	54.00
Heavy Duty Trucks	Diesel	<=7,5 t	Euro V	0.016	0.227	0.125	0.002	6.77	156.81	2.01	0.258	55.64
Heavy Duty Trucks	Diesel	<=7,5 t	Euro VI	0.016	0.225	0.125	0.002	6.71	155.45	1.99	0.256	55.15
Heavy Duty Trucks	Diesel	7,5 - 20 t	Conventional	0.008	0.111	0.125	0.002	3.38	76.03	0.98	0.126	27.19
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro I	0.009	0.131	0.125	0.002	3.97	89.96	1.15	0.149	32.31
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro II	0.009	0.137	0.125	0.002	4.14	94.14	1.21	0.158	34.58
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro III	0.009	0.129	0.125	0.002	3.88	87.68	1.14	0.154	34.50
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro IV	0.009	0.135	0.125	0.002	4.02	90.94	1.18	0.161	36.50
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro V	0.010	0.139	0.125	0.002	4.13	93.51	1.22	0.167	38.01
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro VI	0.009	0.137	0.125	0.002	4.08	92.36	1.20	0.165	37.59
Heavy Duty Trucks	Diesel	20 - 28 t	Conventional	0.006	0.084	0.125	0.002	2.57	56.44	0.74	0.103	23.41
Heavy Duty Trucks	Diesel	20 - 28 t	Euro I	0.007	0.097	0.125	0.002	2.92	64.87	0.85	0.118	26.85
Heavy Duty Trucks	Diesel	20 - 28 t	Euro II	0.007	0.100	0.125	0.002	3.00	66.77	0.87	0.121	27.63
Heavy Duty Trucks	Diesel	20 - 28 t	Euro III	0.007	0.096	0.125	0.002	2.90	64.28	0.84	0.117	26.61
Heavy Duty Trucks	Diesel	20 - 28 t	Euro IV	0.007	0.100	0.125	0.002	3.00	66.75	0.87	0.121	27.62
Heavy Duty Trucks	Diesel	20 - 28 t	Euro V	0.007	0.102	0.125	0.002	3.07	68.46	0.89	0.124	28.31
Heavy Duty Trucks	Diesel	20 - 28 t	Euro VI	0.007	0.101	0.125	0.002	3.03	67.45	0.88	0.122	27.90
Heavy Duty Trucks	Diesel	28 - 40 t	Conventional	0.005	0.075	0.125	0.002	2.29	49.84	0.65	0.091	20.92
Heavy Duty Trucks	Diesel	28 - 40 t	Euro I	0.006	0.085	0.125	0.002	2.57	56.61	0.74	0.103	23.48
Heavy Duty Trucks	Diesel	28 - 40 t	Euro II	0.006	0.087	0.125	0.002	2.64	58.09	0.76	0.106	24.12
Heavy Duty Trucks	Diesel	28 - 40 t	Euro III	0.006	0.084	0.125	0.002	2.57	56.48	0.74	0.103	23.42
Heavy Duty Trucks	Diesel	28 - 40 t	Euro IV	0.006	0.088	0.125	0.002	2.66	58.66	0.77	0.107	24.31
Heavy Duty Trucks	Diesel	28 - 40 t	Euro V	0.006	0.089	0.125	0.002	2.71	59.78	0.78	0.109	24.77
Heavy Duty Trucks	Diesel	28 - 40 t	Euro VI	0.006	0.089	0.125	0.002	2.69	59.44	0.78	0.108	24.63
Heavy Duty Trucks	Diesel	40 - 60 t	Conventional	0.005	0.072	0.125	0.002	2.10	45.03	0.62	0.102	26.22
Heavy Duty Trucks	Diesel	40 - 60 t	Euro I	0.005	0.081	0.125	0.002	2.36	51.04	0.70	0.116	29.68

				Priority Heavy Metals			Additional Heavy Metals					
				Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
Category	Fuel	Segment	Euro Standard	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ
Heavy Duty Trucks	Diesel	40 - 60 t	Euro II	0.005	0.081	0.125	0.002	2.36	50.97	0.70	0.115	29.64
Heavy Duty Trucks	Diesel	40 - 60 t	Euro III	0.005	0.081	0.125	0.002	2.35	50.81	0.70	0.115	29.55
Heavy Duty Trucks	Diesel	40 - 60 t	Euro IV	0.006	0.084	0.125	0.002	2.42	52.42	0.72	0.119	30.47
Buses	Diesel	Urban Buses Midi <=15 t	Conventional	0.007	0.249	0.125	0.002	3.91	98.70	1.94	0.258	37.81
Buses	Diesel	Urban Buses Midi <=15 t	Euro I	0.010	0.323	0.125	0.002	5.00	127.79	2.51	0.333	48.85
Buses	Diesel	Urban Buses Midi <=15 t	Euro II	0.010	0.342	0.125	0.002	5.29	135.43	2.66	0.353	51.75
Buses	Diesel	Urban Buses Midi <=15 t	Euro III	0.010	0.321	0.125	0.002	4.98	127.36	2.51	0.332	48.68
Buses	Diesel	Urban Buses Midi <=15 t	Euro IV	0.011	0.379	0.125	0.002	5.83	150.03	2.95	0.391	57.28
Buses	Diesel	Urban Buses Midi <=15 t	Euro V	0.011	0.321	0.125	0.002	5.63	140.95	2.55	0.334	51.80
Buses	Diesel	Urban Buses Midi <=15 t	Euro VI	0.011	0.167	0.125	0.002	4.89	112.80	1.47	0.181	36.16
Buses	Diesel	Urban Buses Standard 15 - 18 t	Conventional	0.006	0.201	0.125	0.002	3.18	79.33	1.56	0.208	30.47
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro I	0.007	0.244	0.125	0.002	3.82	96.50	1.90	0.252	36.98
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro II	0.008	0.256	0.125	0.002	4.01	101.40	2.00	0.265	38.84
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro III	0.007	0.244	0.125	0.002	3.82	96.40	1.90	0.252	36.94
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro IV	0.008	0.279	0.125	0.002	4.35	110.51	2.17	0.289	42.29
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro V	0.008	0.239	0.125	0.002	4.24	104.90	1.90	0.249	38.64
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro VI	0.008	0.125	0.125	0.002	3.69	84.10	1.10	0.135	27.06
Buses	Diesel	Urban Buses Articulated >18 t	Conventional	0.005	0.169	0.125	0.002	2.69	66.37	1.31	0.179	27.37
Buses	Diesel	Urban Buses Articulated >18 t	Euro I	0.006	0.200	0.125	0.002	3.16	78.74	1.56	0.212	32.41
Buses	Diesel	Urban Buses Articulated >18 t	Euro II	0.006	0.206	0.125	0.002	3.24	80.91	1.60	0.218	33.29
Buses	Diesel	Urban Buses Articulated >18 t	Euro III	0.006	0.200	0.125	0.002	3.16	78.76	1.56	0.212	32.41
Buses	Diesel	Urban Buses Articulated >18 t	Euro IV	0.007	0.224	0.125	0.002	3.52	88.27	1.75	0.237	36.29
Buses	Diesel	Urban Buses Articulated >18 t	Euro V	0.007	0.191	0.125	0.002	3.39	82.76	1.51	0.204	33.01
Buses	Diesel	Urban Buses Articulated >18 t	Euro VI	0.007	0.100	0.125	0.002	2.95	66.04	0.87	0.113	23.71
Buses	Diesel	Coaches	Conventional	0.006	0.117	0.125	0.002	2.82	64.56	0.98	0.135	26.94
Buses	Diesel	Coaches	Euro I	0.006	0.123	0.125	0.002	2.95	67.46	1.02	0.145	29.51
Buses	Diesel	Coaches	Euro II	0.006	0.123	0.125	0.002	2.94	67.20	1.02	0.145	29.72
Buses	Diesel	Coaches	Euro III	0.006	0.122	0.125	0.002	2.92	66.80	1.02	0.144	29.62
Buses	Diesel	Coaches	Euro IV	0.006	0.123	0.125	0.002	2.93	67.15	1.02	0.145	29.94
Buses	Diesel	Coaches	Euro V	0.006	0.114	0.125	0.002	2.78	63.28	0.95	0.136	28.10
Buses	Diesel	Coaches	Euro VI	0.006	0.109	0.125	0.002	2.74	61.85	0.91	0.130	27.58
Buses	CNG	Urban CNG Buses	Euro III	0.006	0.202	0.000	0.000	3.01	80.17	1.58	0.208	30.41
Buses	CNG	Urban CNG Buses	EEV	0.006	0.158	0.000	0.000	2.68	69.53	1.26	0.164	25.37
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Conventional	0.155	4.027	0.186	0.006	21.64	782.26	28.53	4.040	427.16
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Euro 1	0.158	5.018	0.185	0.006	26.93	974.78	35.54	5.034	532.12
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Euro 2	0.158	5.039	0.186	0.006	27.05	978.99	35.69	5.055	534.42
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Euro 3	0.159	5.077	0.188	0.006	27.25	986.30	35.96	5.093	538.41
L-Category	Petrol	Mopeds 4-stroke <50 cm^3	Conventional	0.155	4.027	0.186	0.006	21.64	782.26	28.53	4.040	427.16
L-Category	Petrol	Mopeds 4-stroke <50 cm^3	Euro 1	0.158	5.018	0.185	0.006	26.93	974.78	35.54	5.034	532.12
L-Category	Petrol	Mopeds 4-stroke <50 cm^3	Euro 2	0.158	5.039	0.186	0.006	27.05	978.99	35.69	5.055	534.42
L-Category	Petrol	Mopeds 4-stroke <50 cm^3	Euro 3	0.159	5.077	0.188	0.006	27.25	986.30	35.96	5.093	538.41
L-Category	Petrol	Motorcycles 2-stroke >50 cm^3	Conventional	0.150	2.983	0.188	0.006	14.88	554.29	21.04	2.990	311.38
L-Category	Petrol	Motorcycles 2-stroke >50 cm^3	Euro 1	0.151	3.253	0.189	0.007	16.22	604.50	22.95	3.260	339.52
L-Category	Petrol	Motorcycles 2-stroke >50 cm^3	Euro 2	0.152	3.264	0.190	0.007	16.28	606.70	23.03	3.272	340.76
L-Category	Petrol	Motorcycles 2-stroke >50 cm^3	Euro 3	0.153	3.283	0.191	0.007	16.37	610.12	23.16	3.291	342.68
L-Category	Petrol	Motorcycles 4-stroke <250 cm^3	Conventional	0.156	0.167	0.196	0.007	3.16	76.48	1.36	0.187	34.33
L-Category	Petrol	Motorcycles 4-stroke <250 cm^3	Euro 1	0.158	0.203	0.196	0.007	3.83	93.34	1.65	0.228	41.75
L-Category	Petrol	Motorcycles 4-stroke <250 cm^3	Euro 2	0.160	0.243	0.196	0.007	4.57	112.15	1.97	0.273	50.02
L-Category	Petrol	Motorcycles 4-stroke <250 cm^3	Euro 3	0.160	0.244	0.197	0.007	4.59	112.64	1.98	0.274	50.24
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm^3	Conventional	0.154	0.123	0.195	0.007	2.34	55.71	1.00	0.138	25.20

				Priority Heavy Metals			Additional Heavy Metals					
				Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
Category	Fuel	Segment	Euro Standard	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 1	0.155	0.130	0.197	0.007	2.47	58.97	1.06	0.145	26.63
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 2	0.156	0.141	0.197	0.007	2.68	64.31	1.15	0.158	28.98
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 3	0.156	0.142	0.198	0.007	2.69	64.58	1.16	0.159	29.10
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Conventional	0.153	0.108	0.196	0.007	2.07	48.86	0.89	0.121	22.18
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 1	0.155	0.115	0.197	0.007	2.20	52.30	0.95	0.129	23.70
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 2	0.155	0.116	0.197	0.007	2.21	52.43	0.95	0.130	23.76
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 3	0.155	0.116	0.198	0.007	2.22	52.62	0.95	0.130	23.84

Table C-5: Road transportation distance based implied emission factor (mg/km) for 2018 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	Small & Mini	PRE ECE - ECE 15/04	2,192.43	3,177.75	1.25	2.00	15.08	25.63	38.40	0.47	16,344.76
Passenger Cars	Petrol	Small & Mini	Euro 1	536.46	1,209.07	1.19	80.66	15.08	25.63	38.40	0.62	5,340.43
Passenger Cars	Petrol	Small & Mini	Euro 2	258.76	824.87	1.19	105.50	15.08	25.63	38.40	0.62	2,997.01
Passenger Cars	Petrol	Small & Mini	Euro 3	113.06	472.08	1.20	28.87	13.73	24.28	37.05	0.17	2,849.88
Passenger Cars	Petrol	Small & Mini	Euro 4	65.72	320.27	1.20	28.63	13.73	24.28	37.05	0.17	1,040.22
Passenger Cars	Petrol	Small & Mini	Euro 5	43.21	234.69	1.19	13.78	14.60	25.15	37.92	0.30	1,010.33
Passenger Cars	Petrol	Small & Mini	Euro 6 up to 2016	46.00	200.45	1.19	13.39	14.52	25.08	37.85	0.29	944.24
Passenger Cars	Petrol	Medium	PRE ECE - ECE 15/04	2,757.76	3,261.72	1.50	2.00	15.08	25.63	38.40	0.47	16,478.37
Passenger Cars	Petrol	Medium	Euro 1	536.75	857.91	1.42	81.10	15.08	25.63	38.40	0.62	4,979.94
Passenger Cars	Petrol	Medium	Euro 2	258.97	485.61	1.36	107.00	15.08	25.63	38.40	0.62	2,737.46
Passenger Cars	Petrol	Medium	Euro 3	113.15	294.92	1.43	28.93	13.73	24.28	37.05	0.17	2,626.38
Passenger Cars	Petrol	Medium	Euro 4	65.77	207.51	1.45	28.64	13.73	24.28	37.05	0.17	975.33
Passenger Cars	Petrol	Medium	Euro 5	43.26	185.01	1.45	13.84	14.60	25.15	37.92	0.30	945.44
Passenger Cars	Petrol	Medium	Euro 6 up to 2016	46.05	169.28	1.45	13.39	14.52	25.08	37.85	0.29	879.35
Passenger Cars	Petrol	Large-SUV-Executive	PRE ECE - ECE 15/04	3,241.09	3,781.69	1.88	2.00	15.08	25.63	38.40	0.43	17,949.54
Passenger Cars	Petrol	Large-SUV-Executive	Euro 1	511.42	725.02	1.83	80.92	15.08	25.63	38.40	0.62	4,253.98
Passenger Cars	Petrol	Large-SUV-Executive	Euro 2	240.73	412.21	1.85	106.39	15.08	25.63	38.40	0.62	2,214.77
Passenger Cars	Petrol	Large-SUV-Executive	Euro 3	105.04	251.78	1.67	28.89	13.73	24.28	37.05	0.17	2,176.28
Passenger Cars	Petrol	Large-SUV-Executive	Euro 4	61.21	176.98	1.98	28.64	13.73	24.28	37.05	0.17	844.66
Passenger Cars	Petrol	Large-SUV-Executive	Euro 5	38.70	147.72	1.98	13.75	14.60	25.15	37.92	0.30	814.77
Passenger Cars	Petrol	Large-SUV-Executive	Euro 6 up to 2016	41.49	157.10	1.98	13.27	14.52	25.08	37.85	0.29	748.67
Passenger Cars	Diesel	Small & Mini	Conventional	636.98	179.10	1.37	1.00	305.15	315.70	328.47	160.91	734.21
Passenger Cars	Diesel	Small & Mini	Euro 1	744.22	58.51	1.12	1.00	123.04	133.59	146.36	77.32	508.93
Passenger Cars	Diesel	Small & Mini	Euro 2	820.44	40.16	1.15	1.00	81.59	92.14	104.91	55.20	372.16
Passenger Cars	Diesel	Small & Mini	Euro 3	868.04	22.01	1.09	1.00	61.97	72.52	85.29	41.98	103.39
Passenger Cars	Diesel	Small & Mini	Euro 4	713.59	16.38	1.05	1.00	49.98	60.53	73.30	32.53	105.11
Passenger Cars	Diesel	Small & Mini	Euro 5	711.53	1.29	1.07	1.90	15.47	26.02	38.79	0.58	46.53
Passenger Cars	Diesel	Small & Mini	Euro 6 up to 2016	586.08	1.29	1.07	7.00	14.65	25.20	37.97	0.41	69.16
Passenger Cars	Diesel	Medium	Conventional	636.98	179.10	1.37	1.00	305.15	315.70	328.47	160.91	734.21
Passenger Cars	Diesel	Medium	Euro 1	744.22	58.51	1.12	1.00	123.04	133.59	146.36	77.32	508.93
Passenger Cars	Diesel	Medium	Euro 2	820.44	40.16	1.15	1.00	81.59	92.14	104.91	55.20	372.16
Passenger Cars	Diesel	Medium	Euro 3	868.04	22.01	1.09	1.00	61.97	72.52	85.29	41.98	103.39
Passenger Cars	Diesel	Medium	Euro 4	713.59	16.38	1.09	1.00	49.98	60.53	73.30	32.53	105.11
Passenger Cars	Diesel	Medium	Euro 5	711.53	1.29	1.09	1.90	15.47	26.02	38.79	0.58	46.53
Passenger Cars	Diesel	Medium	Euro 6 up to 2016	586.08	1.29	1.09	7.00	14.65	25.20	37.97	0.41	69.16
Passenger Cars	Diesel	Large-SUV-Executive	Conventional	992.97	179.10	1.37	1.00	305.15	315.70	328.47	160.91	734.21
Passenger Cars	Diesel	Large-SUV-Executive	Euro 1	744.22	87.66	1.50	1.00	123.04	133.59	146.36	77.32	508.93
Passenger Cars	Diesel	Large-SUV-Executive	Euro 2	820.44	117.66	1.50	1.00	81.59	92.14	104.91	55.20	372.16
Passenger Cars	Diesel	Large-SUV-Executive	Euro 3	868.04	47.98	1.50	1.00	61.97	72.52	85.29	41.98	103.39
Passenger Cars	Diesel	Large-SUV-Executive	Euro 4	713.59	16.38	1.50	1.00	49.98	60.53	73.30	32.53	105.11
Passenger Cars	Diesel	Large-SUV-Executive	Euro 5	711.53	1.29	1.50	1.90	15.47	26.02	38.79	0.58	46.53
Passenger Cars	Diesel	Large-SUV-Executive	Euro 6 up to 2016	586.08	1.29	1.50	7.00	14.65	25.20	37.97	0.41	69.16
Passenger Cars	Petrol Hybrid	All Segments	Euro 4	28.12	157.37	0.88	28.82	12.59	23.14	35.91	0.00	532.96
Passenger Cars	Petrol Hybrid	All Segments	Euro 5	28.15	127.98	0.90	28.64	12.59	23.14	35.91	0.00	496.52
Passenger Cars	Petrol Hybrid	All Segments	Euro 6 up to 2016	28.14	120.16	0.90	28.39	12.59	23.14	35.91	0.00	506.98

				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	LPG Bifuel	All Segments	Conventional	2,397.09	1,170.82	0.00	2.00	15.08	25.63	38.40	0.50	10,487.22
Passenger Cars	LPG Bifuel	All Segments	Euro 1	482.18	953.22	0.00	82.68	15.08	25.63	38.40	0.62	5,095.52
Passenger Cars	LPG Bifuel	All Segments	Euro 2	217.46	445.61	0.00	109.89	15.08	25.63	38.40	0.62	3,540.46
Passenger Cars	LPG Bifuel	All Segments	Euro 3	113.15	151.61	0.00	29.17	13.73	24.28	37.05	0.17	2,626.38
Passenger Cars	LPG Bifuel	All Segments	Euro 4	65.77	75.23	0.00	28.91	13.73	24.28	37.05	0.17	975.33
Passenger Cars	LPG Bifuel	All Segments	Euro 5	53.95	75.23	0.00	14.17	13.73	24.28	37.05	0.17	975.33
Passenger Cars	LPG Bifuel	All Segments	Euro 6	53.95	75.23	0.00	13.15	13.73	24.28	37.05	0.17	975.33
Light Commercial Vehicles	Diesel	N1-I	Conventional	992.97	179.10	1.37	1.00	310.03	324.60	340.43	160.91	734.21
Light Commercial Vehicles	Diesel	N1-I	Euro 1	744.22	87.66	1.50	1.00	127.93	142.50	158.32	77.32	508.93
Light Commercial Vehicles	Diesel	N1-I	Euro 2	820.44	117.66	1.50	1.00	86.47	101.05	116.87	55.20	372.16
Light Commercial Vehicles	Diesel	N1-I	Euro 3	868.04	47.98	1.50	1.00	66.86	81.43	97.25	41.98	103.39
Light Commercial Vehicles	Diesel	N1-I	Euro 4	713.59	16.38	1.50	1.00	54.86	69.44	85.26	32.53	105.11
Light Commercial Vehicles	Diesel	N1-I	Euro 5	711.53	1.29	1.50	1.90	20.36	34.93	50.75	0.58	46.53
Light Commercial Vehicles	Diesel	N1-I	Euro 6 up to 2016	586.08	1.29	1.50	7.00	19.53	34.10	49.93	0.41	69.16
Light Commercial Vehicles	Diesel	N1-II & N1-III	Conventional	2,101.82	152.64	1.89	1.00	384.85	399.43	415.25	202.06	1,458.40
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 1	1,347.79	158.67	1.71	1.00	157.16	171.73	187.55	97.78	689.94
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 2	1,347.79	164.69	1.71	1.00	157.16	171.73	187.55	111.75	689.94
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 3	1,132.14	103.35	1.71	1.00	111.06	125.64	141.46	79.55	565.75
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 4	916.50	38.35	1.71	1.00	66.36	80.94	96.76	42.53	448.46
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 5	1,751.71	0.25	1.58	1.90	18.97	33.54	49.37	0.30	0.36
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 6 up to 2017	1,415.22	0.25	1.58	7.00	18.97	33.54	49.37	0.30	0.36
Heavy Duty Trucks	Diesel	<=7,5 t	Conventional	4,544.46	949.89	2.35	2.90	326.17	365.44	414.19	141.80	1,800.04
Heavy Duty Trucks	Diesel	<=7,5 t	Euro I	3,296.82	158.29	2.06	2.90	157.30	196.57	245.32	74.57	663.83
Heavy Duty Trucks	Diesel	<=7,5 t	Euro II	3,485.18	103.57	1.97	2.90	106.24	145.50	194.26	41.38	530.18
Heavy Duty Trucks	Diesel	<=7,5 t	Euro III	2,657.44	96.23	2.08	2.90	99.06	138.32	187.08	39.54	603.78
Heavy Duty Trucks	Diesel	<=7,5 t	Euro IV	1,844.75	18.80	2.05	2.90	57.69	96.95	145.70	11.34	319.38
Heavy Duty Trucks	Diesel	<=7,5 t	Euro V	1,413.07	14.61	1.99	11.00	59.72	98.99	147.74	12.86	522.88
Heavy Duty Trucks	Diesel	<=7,5 t	Euro VI	128.99	9.71	2.00	9.00	44.24	83.50	132.25	0.25	55.59
Heavy Duty Trucks	Diesel	7,5 - 20 t	Conventional	9,733.67	968.87	4.10	2.90	414.39	453.67	502.45	185.89	2,717.46
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro I	5,834.88	348.84	3.47	2.90	273.25	312.62	361.61	149.78	1,308.95
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro II	6,262.56	220.92	3.31	2.90	168.06	207.77	257.52	80.89	1,093.23
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro III	5,141.44	201.97	3.56	2.90	165.40	206.17	258.28	83.51	1,363.58
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro IV	3,555.56	32.40	3.43	2.90	74.16	115.27	168.11	20.48	653.98
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro V	3,141.94	29.51	3.34	11.00	80.20	121.52	174.84	24.63	1,048.91
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro VI	265.57	20.48	3.38	9.00	50.89	92.23	145.60	0.52	119.45
Heavy Duty Trucks	Diesel	20 - 28 t	Conventional	11,450.36	571.46	5.54	2.90	492.61	534.16	588.01	222.34	2,381.61
Heavy Duty Trucks	Diesel	20 - 28 t	Euro I	8,189.51	494.11	4.82	2.90	389.11	430.66	484.50	221.78	1,954.38
Heavy Duty Trucks	Diesel	20 - 28 t	Euro II	8,814.17	323.89	4.68	2.90	237.06	278.62	332.46	122.95	1,697.60
Heavy Duty Trucks	Diesel	20 - 28 t	Euro III	7,021.91	303.23	4.86	2.90	216.24	257.79	311.63	117.83	1,940.11
Heavy Duty Trucks	Diesel	20 - 28 t	Euro IV	4,827.27	48.32	4.68	2.90	85.53	127.08	180.91	28.21	886.41
Heavy Duty Trucks	Diesel	20 - 28 t	Euro V	4,064.33	42.25	4.56	11.00	92.95	134.50	188.34	33.78	1,386.96
Heavy Duty Trucks	Diesel	20 - 28 t	Euro VI	339.31	29.30	4.63	9.00	52.51	94.06	147.89	0.69	175.42
Heavy Duty Trucks	Diesel	28 - 40 t	Conventional	13,212.56	608.74	6.28	2.90	556.77	598.49	652.71	254.23	2,712.96
Heavy Duty Trucks	Diesel	28 - 40 t	Euro I	9,453.36	550.73	5.52	2.90	448.07	489.62	543.45	260.10	2,294.99
Heavy Duty Trucks	Diesel	28 - 40 t	Euro II	10,162.12	353.04	5.38	2.90	272.97	314.56	368.46	146.24	2,023.80
Heavy Duty Trucks	Diesel	28 - 40 t	Euro III	8,208.01	323.90	5.54	2.90	238.12	279.67	333.51	133.15	2,262.31
Heavy Duty Trucks	Diesel	28 - 40 t	Euro IV	5,684.37	54.44	5.33	2.90	91.19	132.74	186.58	32.46	989.50
Heavy Duty Trucks	Diesel	28 - 40 t	Euro V	4,305.96	47.38	5.23	11.00	99.54	141.09	194.93	38.72	1,635.45
Heavy Duty Trucks	Diesel	28 - 40 t	Euro VI	312.21	32.66	5.26	9.00	52.91	94.46	148.30	0.75	164.45

				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
Heavy Duty Trucks	Diesel	40 - 60 t	Conventional	14,831.67	623.87	6.98	2.90	636.85	685.26	754.35	286.46	3,009.45
Heavy Duty Trucks	Diesel	40 - 60 t	Euro I	10,451.83	575.09	6.15	2.90	525.27	573.69	642.78	299.87	2,675.33
Heavy Duty Trucks	Diesel	40 - 60 t	Euro II	11,160.36	368.24	6.16	2.90	326.02	374.44	443.53	170.36	2,343.47
Heavy Duty Trucks	Diesel	40 - 60 t	Euro III	9,023.02	333.14	6.18	2.90	269.23	317.65	386.74	143.71	2,577.21
Heavy Duty Trucks	Diesel	40 - 60 t	Euro IV	6,273.95	60.32	5.99	2.90	110.81	159.23	228.32	35.16	1,051.18
Buses	Diesel	Urban Buses Midi <=15 t	Conventional	13,592.58	4,878.43	7.85	2.90	1,434.05	1,489.42	1,541.01	689.54	8,045.62
Buses	Diesel	Urban Buses Midi <=15 t	Euro I	10,262.99	724.32	6.06	2.90	484.24	539.61	591.19	279.03	2,769.37
Buses	Diesel	Urban Buses Midi <=15 t	Euro II	11,303.13	519.10	5.72	2.90	254.13	309.50	361.09	129.46	2,558.99
Buses	Diesel	Urban Buses Midi <=15 t	Euro III	11,236.19	482.20	6.08	2.90	264.10	319.46	371.05	146.39	2,750.80
Buses	Diesel	Urban Buses Midi <=15 t	Euro IV	6,068.95	61.36	5.16	2.90	102.54	157.91	209.49	35.68	1,402.08
Buses	Diesel	Urban Buses Midi <=15 t	Euro V	8,104.23	56.09	5.12	11.00	112.65	168.02	219.61	43.26	2,523.59
Buses	Diesel	Urban Buses Midi <=15 t	Euro VI	653.85	41.35	5.24	9.00	61.23	116.59	168.18	0.94	306.62
Buses	Diesel	Urban Buses Standard 15 - 18 t	Conventional	21,497.93	3,021.04	9.78	2.90	1,283.47	1,338.84	1,390.43	614.25	8,362.89
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro I	13,446.35	1,027.22	8.03	2.90	649.80	705.17	756.76	386.64	3,644.68
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro II	14,849.59	723.13	7.64	2.90	327.39	382.76	434.34	177.07	3,460.17
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro III	14,369.38	662.60	8.04	2.90	332.07	387.44	439.02	193.97	3,732.59
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro IV	7,999.20	90.30	7.01	2.90	119.87	175.24	226.82	48.68	1,814.57
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro V	10,367.92	75.11	6.89	11.00	130.98	186.35	237.94	57.01	3,328.40
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro VI	682.72	54.66	7.04	9.00	63.08	118.45	170.04	1.22	376.54
Buses	Diesel	Urban Buses Articulated >18 t	Conventional	26,517.47	3,184.90	11.70	2.90	1,534.50	1,592.68	1,650.51	736.49	10,308.88
Buses	Diesel	Urban Buses Articulated >18 t	Euro I	16,648.28	1,118.61	9.86	2.90	779.41	837.59	895.42	466.62	4,810.12
Buses	Diesel	Urban Buses Articulated >18 t	Euro II	17,990.73	769.01	9.59	2.90	420.48	478.66	536.49	233.32	4,748.88
Buses	Diesel	Urban Buses Articulated >18 t	Euro III	17,393.16	706.51	9.86	2.90	389.04	447.22	505.05	229.26	4,857.79
Buses	Diesel	Urban Buses Articulated >18 t	Euro IV	10,330.26	107.71	8.79	2.90	144.35	202.53	260.36	62.12	2,169.94
Buses	Diesel	Urban Buses Articulated >18 t	Euro V	11,038.08	86.54	8.74	11.00	154.46	212.64	270.48	69.70	4,264.21
Buses	Diesel	Urban Buses Articulated >18 t	Euro VI	552.81	61.63	8.98	9.00	70.82	129.00	186.83	1.39	438.46
Buses	Diesel	Coaches	Conventional	9,309.14	407.97	4.36	2.90	362.68	399.86	450.27	160.08	1,670.96
Buses	Diesel	Coaches	Euro I	7,370.15	413.31	4.17	2.90	302.61	340.55	392.65	167.91	1,508.32
Buses	Diesel	Coaches	Euro II	8,148.82	282.84	4.19	2.90	192.60	230.71	283.20	96.13	1,335.41
Buses	Diesel	Coaches	Euro III	6,232.69	270.43	4.21	2.90	180.56	218.71	271.30	95.03	1,538.71
Buses	Diesel	Coaches	Euro IV	4,429.89	42.61	4.19	2.90	79.02	117.27	170.06	25.50	796.20
Buses	Diesel	Coaches	Euro V	2,983.97	40.33	4.42	11.00	87.83	126.03	178.70	32.20	1,267.63
Buses	Diesel	Coaches	Euro VI	200.34	28.89	4.47	9.00	49.32	87.65	140.61	0.62	170.57
Buses	CNG	Urban CNG Buses	Euro III	10,000.00	20.00	0.00	0.00	64.97	120.33	171.92	0.00	1,000.00
Buses	CNG	Urban CNG Buses	EEV	4,878.54	253.27	0.00	0.00	68.42	123.79	175.38	0.00	1,270.51
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Conventional	56.00	8,945.11	0.50	1.00	182.72	188.89	194.57	35.20	14,700.00
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Euro 1	180.00	3,845.42	0.40	1.00	51.72	57.89	63.57	4.50	4,600.00
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Euro 2	170.00	2,978.02	0.40	1.00	32.72	38.89	44.57	5.20	2,800.00
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Euro 3	170.00	2,032.72	0.40	1.00	24.72	30.89	36.57	3.60	1,800.00
L-Category	Petrol	Mopeds 4-stroke <50 cm^3	Conventional	56.00	8,945.11	0.50	1.00	182.72	188.89	194.57	17.60	14,700.00
L-Category	Petrol	Mopeds 4-stroke <50 cm^3	Euro 1	220.00	1,225.42	0.40	1.00	46.72	52.89	58.57	8.00	6,700.00
L-Category	Petrol	Mopeds 4-stroke <50 cm^3	Euro 2	170.00	1,168.02	0.40	1.00	13.72	19.89	25.57	1.40	4,200.00
L-Category	Petrol	Mopeds 4-stroke <50 cm^3	Euro 3	170.00	772.72	0.40	1.00	10.72	16.89	22.57	0.80	2,700.00
L-Category	Petrol	Motorcycles 2-stroke >50 cm^3	Conventional	31.66	11,072.75	0.68	2.00	205.49	210.23	215.51	20.00	20,802.83
L-Category	Petrol	Motorcycles 2-stroke >50 cm^3	Euro 1	47.10	4,133.00	0.62	2.00	85.49	90.23	95.51	16.00	13,724.42
L-Category	Petrol	Motorcycles 2-stroke >50 cm^3	Euro 2	54.61	2,398.75	0.62	2.00	45.49	50.23	55.51	8.00	10,857.32
L-Category	Petrol	Motorcycles 2-stroke >50 cm^3	Euro 3	25.78	1,522.27	0.62	2.00	17.49	22.23	27.51	2.40	5,992.79
L-Category	Petrol	Motorcycles 4-stroke <250 cm^3	Conventional	380.23	1,721.53	0.67	2.00	25.49	30.23	35.51	3.00	19,764.38
L-Category	Petrol	Motorcycles 4-stroke <250 cm^3	Euro 1	401.94	1,359.42	0.55	2.00	25.49	30.23	35.51	5.00	15,869.67

				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	Motorcycles 4-stroke <250 cm³	Euro 2	367.72	687.39	0.46	2.00	10.49	15.23	20.51	1.25	5,913.93
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 3	321.03	457.24	0.46	2.00	10.49	15.23	20.51	1.25	3,263.48
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Conventional	489.69	2,884.89	0.91	2.00	25.49	30.23	35.51	3.00	25,370.21
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 1	424.91	1,744.99	0.87	2.00	25.49	30.23	35.51	5.00	13,910.85
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 2	195.57	1,069.44	0.80	2.00	10.49	15.23	20.51	1.25	6,345.98
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 3	99.06	698.64	0.80	2.00	10.49	15.23	20.51	1.25	3,502.88
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Conventional	307.90	3,321.44	1.04	2.00	25.49	30.23	35.51	3.00	25,370.21
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 1	319.10	1,731.80	0.98	2.00	25.49	30.23	35.51	5.00	13,910.85
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 2	354.33	984.44	0.98	2.00	10.49	15.23	20.51	1.25	6,345.98
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 3	180.91	637.92	0.98	2.00	10.49	15.23	20.51	1.25	3,502.88

Table C-6: Road transportation distance based implied emission factor (mg/km) for 2018 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	Small & Mini	PRE ECE - ECE 15/04	0.439	0.0008	0.0005	1.89E-05	0.011	0.276	0.0060	0.0008	0.135
Passenger Cars	Petrol	Small & Mini	Euro 1	0.419	0.0008	0.0005	1.80E-05	0.011	0.276	0.0060	0.0008	0.135
Passenger Cars	Petrol	Small & Mini	Euro 2	0.417	0.0008	0.0005	1.80E-05	0.011	0.276	0.0060	0.0008	0.135
Passenger Cars	Petrol	Small & Mini	Euro 3	0.420	0.0008	0.0005	1.81E-05	0.011	0.276	0.0060	0.0008	0.135
Passenger Cars	Petrol	Small & Mini	Euro 4	0.423	0.0008	0.0005	1.82E-05	0.011	0.276	0.0060	0.0008	0.135
Passenger Cars	Petrol	Small & Mini	Euro 5	0.420	0.0008	0.0005	1.81E-05	0.011	0.274	0.0059	0.0008	0.133
Passenger Cars	Petrol	Small & Mini	Euro 6 up to 2016	0.419	0.0007	0.0005	1.80E-05	0.010	0.267	0.0056	0.0008	0.129
Passenger Cars	Petrol	Medium	PRE ECE - ECE 15/04	0.521	0.0008	0.0007	2.27E-05	0.011	0.276	0.0060	0.0008	0.135
Passenger Cars	Petrol	Medium	Euro 1	0.496	0.0008	0.0006	2.15E-05	0.011	0.276	0.0060	0.0008	0.135
Passenger Cars	Petrol	Medium	Euro 2	0.474	0.0008	0.0006	2.05E-05	0.011	0.276	0.0060	0.0008	0.135
Passenger Cars	Petrol	Medium	Euro 3	0.497	0.0008	0.0006	2.16E-05	0.011	0.276	0.0060	0.0008	0.135
Passenger Cars	Petrol	Medium	Euro 4	0.504	0.0008	0.0006	2.19E-05	0.011	0.276	0.0060	0.0008	0.135
Passenger Cars	Petrol	Medium	Euro 5	0.504	0.0008	0.0006	2.19E-05	0.011	0.274	0.0059	0.0008	0.134
Passenger Cars	Petrol	Medium	Euro 6 up to 2016	0.504	0.0007	0.0006	2.19E-05	0.010	0.267	0.0056	0.0008	0.130
Passenger Cars	Petrol	Large-SUV-Executive	PRE ECE - ECE 15/04	0.650	0.0008	0.0008	2.85E-05	0.011	0.276	0.0060	0.0008	0.136
Passenger Cars	Petrol	Large-SUV-Executive	Euro 1	0.634	0.0008	0.0008	2.77E-05	0.011	0.276	0.0060	0.0008	0.136
Passenger Cars	Petrol	Large-SUV-Executive	Euro 2	0.639	0.0008	0.0008	2.80E-05	0.011	0.276	0.0060	0.0008	0.136
Passenger Cars	Petrol	Large-SUV-Executive	Euro 3	0.580	0.0008	0.0007	2.53E-05	0.011	0.276	0.0060	0.0008	0.135
Passenger Cars	Petrol	Large-SUV-Executive	Euro 4	0.681	0.0008	0.0009	2.99E-05	0.011	0.276	0.0061	0.0008	0.136
Passenger Cars	Petrol	Large-SUV-Executive	Euro 5	0.681	0.0008	0.0009	2.99E-05	0.011	0.274	0.0059	0.0008	0.134
Passenger Cars	Petrol	Large-SUV-Executive	Euro 6 up to 2016	0.681	0.0007	0.0009	2.99E-05	0.011	0.267	0.0057	0.0008	0.131
Passenger Cars	Diesel	Small & Mini	Conventional	0.020	0.0008	0.0004	7.32E-06	0.011	0.280	0.0060	0.0009	0.136
Passenger Cars	Diesel	Small & Mini	Euro 1	0.020	0.0008	0.0003	5.97E-06	0.011	0.279	0.0060	0.0009	0.136
Passenger Cars	Diesel	Small & Mini	Euro 2	0.020	0.0008	0.0003	6.16E-06	0.011	0.279	0.0060	0.0009	0.136
Passenger Cars	Diesel	Small & Mini	Euro 3	0.020	0.0008	0.0003	5.81E-06	0.011	0.279	0.0060	0.0009	0.136
Passenger Cars	Diesel	Small & Mini	Euro 4	0.020	0.0008	0.0003	5.61E-06	0.011	0.279	0.0060	0.0009	0.136
Passenger Cars	Diesel	Small & Mini	Euro 5	0.020	0.0008	0.0003	5.70E-06	0.011	0.276	0.0058	0.0008	0.134
Passenger Cars	Diesel	Small & Mini	Euro 6 up to 2016	0.020	0.0007	0.0003	5.72E-06	0.011	0.268	0.0055	0.0008	0.129
Passenger Cars	Diesel	Medium	Conventional	0.020	0.0008	0.0004	7.32E-06	0.011	0.280	0.0060	0.0009	0.136
Passenger Cars	Diesel	Medium	Euro 1	0.020	0.0008	0.0003	5.97E-06	0.011	0.279	0.0060	0.0009	0.136
Passenger Cars	Diesel	Medium	Euro 2	0.020	0.0008	0.0003	6.16E-06	0.011	0.279	0.0060	0.0009	0.136
Passenger Cars	Diesel	Medium	Euro 3	0.020	0.0008	0.0003	5.81E-06	0.011	0.279	0.0060	0.0009	0.136
Passenger Cars	Diesel	Medium	Euro 4	0.020	0.0008	0.0003	5.81E-06	0.011	0.279	0.0060	0.0009	0.136
Passenger Cars	Diesel	Medium	Euro 5	0.020	0.0008	0.0003	5.81E-06	0.011	0.276	0.0058	0.0008	0.134
Passenger Cars	Diesel	Medium	Euro 6 up to 2016	0.020	0.0007	0.0003	5.81E-06	0.011	0.268	0.0055	0.0008	0.129
Passenger Cars	Diesel	Large-SUV-Executive	Conventional	0.020	0.0008	0.0004	7.32E-06	0.011	0.280	0.0060	0.0009	0.136
Passenger Cars	Diesel	Large-SUV-Executive	Euro 1	0.020	0.0008	0.0004	7.98E-06	0.011	0.280	0.0060	0.0009	0.136
Passenger Cars	Diesel	Large-SUV-Executive	Euro 2	0.020	0.0008	0.0004	7.98E-06	0.011	0.280	0.0060	0.0009	0.136
Passenger Cars	Diesel	Large-SUV-Executive	Euro 3	0.020	0.0008	0.0004	7.98E-06	0.011	0.280	0.0060	0.0009	0.136
Passenger Cars	Diesel	Large-SUV-Executive	Euro 4	0.020	0.0008	0.0004	7.98E-06	0.011	0.280	0.0060	0.0009	0.136
Passenger Cars	Diesel	Large-SUV-Executive	Euro 5	0.020	0.0008	0.0004	7.98E-06	0.011	0.276	0.0058	0.0008	0.134
Passenger Cars	Diesel	Large-SUV-Executive	Euro 6 up to 2016	0.020	0.0007	0.0004	7.98E-06	0.011	0.268	0.0055	0.0008	0.129
Passenger Cars	Petrol Hybrid	All Segments	Euro 4	0.314	0.0008	0.0004	1.33E-05	0.011	0.276	0.0059	0.0008	0.134
Passenger Cars	Petrol Hybrid	All Segments	Euro 5	0.322	0.0008	0.0004	1.37E-05	0.010	0.274	0.0058	0.0008	0.133
Passenger Cars	Petrol Hybrid	All Segments	Euro 6 up to 2016	0.320	0.0007	0.0004	1.36E-05	0.010	0.267	0.0055	0.0008	0.129
Passenger Cars	LPG Bifuel	All Segments	Conventional	0.020	0.0008	0.0000	6.74E-14	0.010	0.276	0.0058	0.0008	0.133

				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	LPG Bifuel	All Segments	Euro 1	0.020	0.0008	0.0000	6.74E-14	0.010	0.276	0.0058	0.0008	0.133
Passenger Cars	LPG Bifuel	All Segments	Euro 2	0.020	0.0008	0.0000	6.74E-14	0.010	0.276	0.0058	0.0008	0.133
Passenger Cars	LPG Bifuel	All Segments	Euro 3	0.020	0.0008	0.0000	6.74E-14	0.010	0.276	0.0058	0.0008	0.133
Passenger Cars	LPG Bifuel	All Segments	Euro 4	0.020	0.0008	0.0000	6.74E-14	0.010	0.276	0.0058	0.0008	0.133
Passenger Cars	LPG Bifuel	All Segments	Euro 5	0.020	0.0007	0.0000	6.74E-14	0.010	0.273	0.0057	0.0008	0.131
Passenger Cars	LPG Bifuel	All Segments	Euro 6	0.020	0.0007	0.0000	6.74E-14	0.010	0.267	0.0054	0.0008	0.127
Light Commercial Vehicles	Diesel	N1-I	Conventional	0.032	0.0008	0.0004	7.32E-06	0.015	0.371	0.0066	0.0010	0.174
Light Commercial Vehicles	Diesel	N1-I	Euro 1	0.032	0.0008	0.0004	7.98E-06	0.015	0.371	0.0066	0.0010	0.174
Light Commercial Vehicles	Diesel	N1-I	Euro 2	0.032	0.0008	0.0004	7.98E-06	0.015	0.371	0.0066	0.0010	0.174
Light Commercial Vehicles	Diesel	N1-I	Euro 3	0.032	0.0008	0.0004	7.98E-06	0.015	0.371	0.0066	0.0010	0.174
Light Commercial Vehicles	Diesel	N1-I	Euro 4	0.032	0.0008	0.0004	7.98E-06	0.015	0.371	0.0066	0.0010	0.174
Light Commercial Vehicles	Diesel	N1-I	Euro 5	0.032	0.0008	0.0004	7.98E-06	0.015	0.368	0.0065	0.0009	0.173
Light Commercial Vehicles	Diesel	N1-I	Euro 6 up to 2016	0.032	0.0008	0.0004	7.98E-06	0.015	0.360	0.0062	0.0009	0.168
Light Commercial Vehicles	Diesel	N1-II & N1-III	Conventional	0.032	0.0008	0.0005	1.01E-05	0.015	0.371	0.0066	0.0010	0.175
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 1	0.032	0.0008	0.0005	9.11E-06	0.015	0.371	0.0066	0.0010	0.175
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 2	0.032	0.0008	0.0005	9.11E-06	0.015	0.371	0.0066	0.0010	0.175
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 3	0.032	0.0008	0.0005	9.11E-06	0.015	0.371	0.0066	0.0010	0.175
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 4	0.032	0.0008	0.0005	9.11E-06	0.015	0.371	0.0066	0.0010	0.175
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 5	0.032	0.0008	0.0004	8.41E-06	0.015	0.368	0.0065	0.0009	0.173
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 6 up to 2017	0.032	0.0008	0.0004	8.41E-06	0.015	0.358	0.0061	0.0009	0.167
Heavy Duty Trucks	Diesel	<=7,5 t	Conventional	0.071	0.0010	0.0007	1.25E-05	0.031	0.705	0.0090	0.0012	0.251
Heavy Duty Trucks	Diesel	<=7,5 t	Euro I	0.071	0.0010	0.0006	1.10E-05	0.030	0.705	0.0090	0.0012	0.250
Heavy Duty Trucks	Diesel	<=7,5 t	Euro II	0.071	0.0010	0.0006	1.05E-05	0.030	0.705	0.0090	0.0012	0.250
Heavy Duty Trucks	Diesel	<=7,5 t	Euro III	0.071	0.0010	0.0006	1.11E-05	0.030	0.705	0.0090	0.0012	0.250
Heavy Duty Trucks	Diesel	<=7,5 t	Euro IV	0.071	0.0010	0.0006	1.09E-05	0.030	0.705	0.0090	0.0012	0.250
Heavy Duty Trucks	Diesel	<=7,5 t	Euro V	0.071	0.0010	0.0006	1.06E-05	0.030	0.705	0.0090	0.0012	0.250
Heavy Duty Trucks	Diesel	<=7,5 t	Euro VI	0.071	0.0010	0.0006	1.07E-05	0.030	0.705	0.0090	0.0012	0.250
Heavy Duty Trucks	Diesel	7,5 - 20 t	Conventional	0.071	0.0010	0.0012	2.19E-05	0.031	0.706	0.0091	0.0012	0.252
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro I	0.071	0.0010	0.0010	1.85E-05	0.031	0.706	0.0091	0.0012	0.253
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro II	0.071	0.0010	0.0009	1.77E-05	0.031	0.706	0.0091	0.0012	0.259
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro III	0.072	0.0010	0.0010	1.90E-05	0.031	0.706	0.0092	0.0012	0.278
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro IV	0.072	0.0010	0.0010	1.83E-05	0.031	0.706	0.0092	0.0013	0.283
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro V	0.072	0.0010	0.0009	1.78E-05	0.031	0.706	0.0092	0.0013	0.287
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro VI	0.072	0.0010	0.0010	1.80E-05	0.031	0.706	0.0092	0.0013	0.288
Heavy Duty Trucks	Diesel	20 - 28 t	Conventional	0.072	0.0011	0.0016	2.96E-05	0.032	0.707	0.0092	0.0013	0.293
Heavy Duty Trucks	Diesel	20 - 28 t	Euro I	0.072	0.0011	0.0014	2.57E-05	0.032	0.707	0.0092	0.0013	0.293
Heavy Duty Trucks	Diesel	20 - 28 t	Euro II	0.072	0.0011	0.0013	2.50E-05	0.032	0.707	0.0092	0.0013	0.293
Heavy Duty Trucks	Diesel	20 - 28 t	Euro III	0.072	0.0011	0.0014	2.60E-05	0.032	0.707	0.0092	0.0013	0.293
Heavy Duty Trucks	Diesel	20 - 28 t	Euro IV	0.072	0.0011	0.0013	2.50E-05	0.032	0.707	0.0092	0.0013	0.292
Heavy Duty Trucks	Diesel	20 - 28 t	Euro V	0.072	0.0011	0.0013	2.44E-05	0.032	0.707	0.0092	0.0013	0.292
Heavy Duty Trucks	Diesel	20 - 28 t	Euro VI	0.072	0.0011	0.0013	2.47E-05	0.032	0.707	0.0092	0.0013	0.292
Heavy Duty Trucks	Diesel	28 - 40 t	Conventional	0.072	0.0011	0.0018	3.35E-05	0.033	0.708	0.0093	0.0013	0.297
Heavy Duty Trucks	Diesel	28 - 40 t	Euro I	0.072	0.0011	0.0016	2.95E-05	0.032	0.707	0.0092	0.0013	0.293
Heavy Duty Trucks	Diesel	28 - 40 t	Euro II	0.072	0.0011	0.0015	2.87E-05	0.032	0.707	0.0092	0.0013	0.294
Heavy Duty Trucks	Diesel	28 - 40 t	Euro III	0.072	0.0011	0.0016	2.95E-05	0.032	0.707	0.0092	0.0013	0.293
Heavy Duty Trucks	Diesel	28 - 40 t	Euro IV	0.072	0.0011	0.0015	2.84E-05	0.032	0.707	0.0092	0.0013	0.293
Heavy Duty Trucks	Diesel	28 - 40 t	Euro V	0.072	0.0011	0.0015	2.79E-05	0.032	0.707	0.0092	0.0013	0.293
Heavy Duty Trucks	Diesel	28 - 40 t	Euro VI	0.072	0.0011	0.0015	2.81E-05	0.032	0.707	0.0092	0.0013	0.293
Heavy Duty Trucks	Diesel	40 - 60 t	Conventional	0.075	0.0011	0.0020	3.72E-05	0.033	0.710	0.0097	0.0016	0.414
Heavy Duty Trucks	Diesel	40 - 60 t	Euro I	0.075	0.0011	0.0017	3.28E-05	0.033	0.710	0.0097	0.0016	0.413

				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
Heavy Duty Trucks	Diesel	40 - 60 t	Euro II	0.075	0.0011	0.0017	3.29E-05	0.033	0.710	0.0097	0.0016	0.413
Heavy Duty Trucks	Diesel	40 - 60 t	Euro III	0.075	0.0011	0.0017	3.30E-05	0.033	0.710	0.0097	0.0016	0.413
Heavy Duty Trucks	Diesel	40 - 60 t	Euro IV	0.075	0.0011	0.0017	3.20E-05	0.033	0.710	0.0097	0.0016	0.413
Buses	Diesel	Urban Buses Midi <=15 t	Conventional	0.132	0.0044	0.0022	4.19E-05	0.069	1.756	0.0346	0.0046	0.673
Buses	Diesel	Urban Buses Midi <=15 t	Euro I	0.132	0.0044	0.0017	3.24E-05	0.069	1.756	0.0345	0.0046	0.671
Buses	Diesel	Urban Buses Midi <=15 t	Euro II	0.132	0.0044	0.0016	3.05E-05	0.069	1.755	0.0345	0.0046	0.671
Buses	Diesel	Urban Buses Midi <=15 t	Euro III	0.132	0.0044	0.0017	3.25E-05	0.069	1.756	0.0345	0.0046	0.671
Buses	Diesel	Urban Buses Midi <=15 t	Euro IV	0.132	0.0044	0.0015	2.75E-05	0.068	1.755	0.0345	0.0046	0.670
Buses	Diesel	Urban Buses Midi <=15 t	Euro V	0.132	0.0037	0.0014	2.73E-05	0.065	1.636	0.0296	0.0039	0.601
Buses	Diesel	Urban Buses Midi <=15 t	Euro VI	0.132	0.0020	0.0015	2.80E-05	0.058	1.339	0.0175	0.0021	0.429
Buses	Diesel	Urban Buses Standard 15 - 18 t	Conventional	0.132	0.0044	0.0028	5.22E-05	0.070	1.757	0.0346	0.0046	0.675
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro I	0.132	0.0044	0.0023	4.29E-05	0.070	1.756	0.0346	0.0046	0.673
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro II	0.132	0.0044	0.0022	4.08E-05	0.069	1.756	0.0346	0.0046	0.673
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro III	0.132	0.0044	0.0023	4.29E-05	0.070	1.756	0.0346	0.0046	0.673
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro IV	0.132	0.0044	0.0020	3.74E-05	0.069	1.756	0.0345	0.0046	0.672
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro V	0.132	0.0037	0.0019	3.68E-05	0.066	1.637	0.0297	0.0039	0.603
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro VI	0.132	0.0020	0.0020	3.76E-05	0.059	1.339	0.0175	0.0022	0.431
Buses	Diesel	Urban Buses Articulated >18 t	Conventional	0.133	0.0045	0.0033	6.25E-05	0.071	1.758	0.0348	0.0047	0.725
Buses	Diesel	Urban Buses Articulated >18 t	Euro I	0.133	0.0045	0.0028	5.26E-05	0.071	1.758	0.0348	0.0047	0.723
Buses	Diesel	Urban Buses Articulated >18 t	Euro II	0.133	0.0045	0.0027	5.12E-05	0.070	1.758	0.0348	0.0047	0.723
Buses	Diesel	Urban Buses Articulated >18 t	Euro III	0.133	0.0045	0.0028	5.26E-05	0.071	1.758	0.0348	0.0047	0.723
Buses	Diesel	Urban Buses Articulated >18 t	Euro IV	0.133	0.0045	0.0025	4.69E-05	0.070	1.758	0.0348	0.0047	0.722
Buses	Diesel	Urban Buses Articulated >18 t	Euro V	0.133	0.0038	0.0025	4.67E-05	0.067	1.638	0.0299	0.0040	0.654
Buses	Diesel	Urban Buses Articulated >18 t	Euro VI	0.133	0.0020	0.0025	4.79E-05	0.060	1.341	0.0177	0.0023	0.482
Buses	Diesel	Coaches	Conventional	0.060	0.0012	0.0012	2.32E-05	0.028	0.636	0.0096	0.0013	0.265
Buses	Diesel	Coaches	Euro I	0.060	0.0012	0.0012	2.23E-05	0.028	0.637	0.0097	0.0014	0.278
Buses	Diesel	Coaches	Euro II	0.060	0.0012	0.0012	2.23E-05	0.028	0.637	0.0097	0.0014	0.282
Buses	Diesel	Coaches	Euro III	0.060	0.0012	0.0012	2.25E-05	0.028	0.637	0.0097	0.0014	0.282
Buses	Diesel	Coaches	Euro IV	0.060	0.0012	0.0012	2.24E-05	0.028	0.637	0.0097	0.0014	0.284
Buses	Diesel	Coaches	Euro V	0.060	0.0011	0.0013	2.36E-05	0.028	0.633	0.0095	0.0014	0.281
Buses	Diesel	Coaches	Euro VI	0.060	0.0011	0.0013	2.39E-05	0.028	0.625	0.0092	0.0013	0.279
Buses	CNG	Urban CNG Buses	Euro III	0.132	0.0044	0.0000	2.83E-13	0.066	1.754	0.0345	0.0045	0.665
Buses	CNG	Urban CNG Buses	EEV	0.132	0.0037	0.0000	2.83E-13	0.063	1.635	0.0296	0.0039	0.596
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Conventional	0.181	0.0047	0.0002	7.52E-06	0.025	0.917	0.0335	0.0047	0.501
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Euro 1	0.148	0.0047	0.0002	6.02E-06	0.025	0.917	0.0334	0.0047	0.501
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Euro 2	0.148	0.0047	0.0002	6.02E-06	0.025	0.917	0.0334	0.0047	0.501
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Euro 3	0.148	0.0047	0.0002	6.02E-06	0.025	0.917	0.0334	0.0047	0.501
L-Category	Petrol	Mopeds 4-stroke <50 cm^3	Conventional	0.181	0.0047	0.0002	7.52E-06	0.025	0.917	0.0335	0.0047	0.501
L-Category	Petrol	Mopeds 4-stroke <50 cm^3	Euro 1	0.148	0.0047	0.0002	6.02E-06	0.025	0.917	0.0334	0.0047	0.501
L-Category	Petrol	Mopeds 4-stroke <50 cm^3	Euro 2	0.148	0.0047	0.0002	6.02E-06	0.025	0.917	0.0334	0.0047	0.501
L-Category	Petrol	Mopeds 4-stroke <50 cm^3	Euro 3	0.148	0.0047	0.0002	6.02E-06	0.025	0.917	0.0334	0.0047	0.501
L-Category	Petrol	Motorcycles 2-stroke >50 cm^3	Conventional	0.236	0.0047	0.0003	1.02E-05	0.023	0.874	0.0332	0.0047	0.491
L-Category	Petrol	Motorcycles 2-stroke >50 cm^3	Euro 1	0.219	0.0047	0.0003	9.44E-06	0.023	0.874	0.0332	0.0047	0.491
L-Category	Petrol	Motorcycles 2-stroke >50 cm^3	Euro 2	0.219	0.0047	0.0003	9.44E-06	0.023	0.874	0.0332	0.0047	0.491
L-Category	Petrol	Motorcycles 2-stroke >50 cm^3	Euro 3	0.219	0.0047	0.0003	9.44E-06	0.023	0.874	0.0332	0.0047	0.491
L-Category	Petrol	Motorcycles 4-stroke <250 cm^3	Conventional	0.233	0.0002	0.0003	1.01E-05	0.005	0.114	0.0020	0.0003	0.051
L-Category	Petrol	Motorcycles 4-stroke <250 cm^3	Euro 1	0.193	0.0002	0.0002	8.27E-06	0.005	0.114	0.0020	0.0003	0.051
L-Category	Petrol	Motorcycles 4-stroke <250 cm^3	Euro 2	0.162	0.0002	0.0002	6.88E-06	0.005	0.114	0.0020	0.0003	0.051
L-Category	Petrol	Motorcycles 4-stroke <250 cm^3	Euro 3	0.162	0.0002	0.0002	6.88E-06	0.005	0.114	0.0020	0.0003	0.051
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm^3	Conventional	0.315	0.0003	0.0004	1.38E-05	0.005	0.114	0.0021	0.0003	0.052

				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	Motorcycles 4-stroke 250 - 750 cm³	Euro 1	0.300	0.0003	0.0004	1.31E-05	0.005	0.114	0.0021	0.0003	0.052
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 2	0.276	0.0003	0.0003	1.20E-05	0.005	0.114	0.0020	0.0003	0.051
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 3	0.276	0.0003	0.0003	1.20E-05	0.005	0.114	0.0020	0.0003	0.051
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Conventional	0.359	0.0003	0.0005	1.58E-05	0.005	0.114	0.0021	0.0003	0.052
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 1	0.337	0.0003	0.0004	1.48E-05	0.005	0.114	0.0021	0.0003	0.052
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 2	0.337	0.0003	0.0004	1.48E-05	0.005	0.114	0.0021	0.0003	0.052
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 3	0.337	0.0003	0.0004	1.48E-05	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
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
Petrol**	61,131.89	67,292.71	75,053.58	79,027.39	81,634.69	84,278.16	86,723.90	87,421.13	90,985.20	91,939.77
CNG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LPG	0.98	2.56	4.51	5.03	5.40	13.28	82.77	796.75	910.55	1,097.65
Lubricants 2-stroke	72.95	68.14	63.21	57.53	51.99	47.70	43.72	39.81	37.29	33.99
Lubricants 4-stroke	276.55	290.49	310.71	321.16	335.35	345.79	362.10	373.40	399.30	413.80

Fuel	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Diesel*	160,136.37	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
Petrol**	92,726.71	88,213.20	92,090.66	89,279.19	85,913.49	80,628.17	74,582.73	69,599.57	65,280.21	64,030.24
CNG	29.78	197.04	304.13	397.29	391.52	440.00	437.06	483.91	505.81	502.58
LPG	1,027.14	996.03	975.81	942.26	867.96	963.02	1,028.40	1,068.05	1,189.80	1,394.20
Lubricants 2-stroke	30.94	25.90	25.34	22.35	20.61	19.46	18.84	18.51	17.65	18.64
Lubricants 4-stroke	445.22	444.60	458.33	455.37	457.01	453.75	460.10	456.10	451.60	461.84

Fuel	2010	2011	2012	2013	2014	2015	2016	2017	2018
Diesel*	194,527.94	182,938.79	167,871.09	164,487.36	168,842.84	173,023.45	177,089.50	181,287.35	183,537.88
Petrol**	60,754.32	54,704.18	49,812.33	48,042.65	48,023.89	47,491.25	46,263.68	45,381.65	45,095.65
CNG	526.74	528.29	503.17	520.13	552.16	592.14	583.14	616.92	672.94
LPG	1,331.70	1,385.83	1,465.38	1,537.39	1,541.87	1,647.00	1,720.61	1,700.22	1,668.90
Lubricants 2-stroke	19.85	18.85	17.60	17.85	18.15	18.83	20.79	19.84	20.41
Lubricants 4-stroke	465.78	435.49	403.17	397.52	407.42	417.63	425.23	431.85	434.90

* includes incorporation of Biodiesel

** includes incorporation of Bioethanol

Table C-8: Vehicle fleet.

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2015	2016	2017	2018
Passenger Cars	Petrol	Mini	Euro 4	0	0	0	0	32,145	29,767	30,005	30,253	30,580
Passenger Cars	Petrol	Mini	Euro 5	0	0	0	0	0	32,638	34,340	31,780	28,108
Passenger Cars	Petrol	Mini	Euro 6 up to 2016	0	0	0	0	0	0	13,220	13,154	13,154
Passenger Cars	Petrol	Mini	Euro 6 2017-2019	0	0	0	0	0	0	0	14,363	29,440
Passenger Cars	Petrol	Small	PRE ECE	27,628	13,353	8,497	8,270	9,346	9,524	9,416	9,492	8,664
Passenger Cars	Petrol	Small	ECE 15/00-01	161,368	55,483	17,015	10,632	10,698	10,441	10,304	10,256	9,704
Passenger Cars	Petrol	Small	ECE 15/02	74,468	42,543	10,589	2,959	2,538	2,243	2,227	2,151	2,103
Passenger Cars	Petrol	Small	ECE 15/03	299,000	231,059	124,594	39,149	19,958	13,076	12,190	11,465	10,614
Passenger Cars	Petrol	Small	ECE 15/04	751,878	1,167,994	986,378	617,896	338,728	198,177	179,484	163,289	147,573
Passenger Cars	Petrol	Small	Euro 1	0	544,032	695,574	555,115	427,631	303,928	279,193	255,383	231,988
Passenger Cars	Petrol	Small	Euro 2	0	0	574,509	510,073	478,939	417,071	399,792	380,361	360,753
Passenger Cars	Petrol	Small	Euro 3	0	0	0	364,643	336,001	327,523	323,522	318,848	314,075
Passenger Cars	Petrol	Small	Euro 4	0	0	0	0	174,241	159,967	160,362	160,533	160,814
Passenger Cars	Petrol	Small	Euro 5	0	0	0	0	0	117,828	112,901	108,611	103,986
Passenger Cars	Petrol	Small	Euro 6 up to 2016	0	0	0	0	0	0	44,700	44,477	44,477
Passenger Cars	Petrol	Small	Euro 6 2017-2019	0	0	0	0	0	0	0	51,078	107,563
Passenger Cars	Petrol	Medium	PRE ECE	2,535	1,302	807	794	969	997	1,004	989	794
Passenger Cars	Petrol	Medium	ECE 15/00-01	6,493	2,096	701	530	607	617	603	618	490
Passenger Cars	Petrol	Medium	ECE 15/02	3,483	1,994	504	147	117	108	106	107	100
Passenger Cars	Petrol	Medium	ECE 15/03	13,205	9,552	4,738	1,351	963	737	711	687	632
Passenger Cars	Petrol	Medium	ECE 15/04	23,289	40,707	35,187	22,653	14,384	9,376	8,679	8,046	7,559
Passenger Cars	Petrol	Medium	Euro 1	0	42,397	66,756	72,893	57,398	40,698	37,705	34,700	31,900
Passenger Cars	Petrol	Medium	Euro 2	0	0	185,430	167,393	160,952	141,023	135,540	129,507	123,324
Passenger Cars	Petrol	Medium	Euro 3	0	0	0	180,661	167,216	163,184	161,159	158,904	156,514
Passenger Cars	Petrol	Medium	Euro 4	0	0	0	0	89,578	82,307	82,597	82,771	83,165
Passenger Cars	Petrol	Medium	Euro 5	0	0	0	0	0	24,084	23,217	25,798	29,589
Passenger Cars	Petrol	Medium	Euro 6 up to 2016	0	0	0	0	0	0	7,255	7,219	7,219
Passenger Cars	Petrol	Medium	Euro 6 2017-2019	0	0	0	0	0	0	0	9,397	25,611
Passenger Cars	Petrol	Large-SUV-Executive	PRE ECE	4,039	2,001	1,258	1,360	1,695	1,724	1,810	1,791	1,326
Passenger Cars	Petrol	Large-SUV-Executive	ECE 15/00-01	20,158	6,857	2,114	1,531	1,740	1,749	1,678	1,680	1,379
Passenger Cars	Petrol	Large-SUV-Executive	ECE 15/02	11,854	6,791	1,713	531	529	476	439	462	415
Passenger Cars	Petrol	Large-SUV-Executive	ECE 15/03	27,622	20,014	9,938	3,064	2,659	2,259	2,188	2,143	1,923
Passenger Cars	Petrol	Large-SUV-Executive	ECE 15/04	27,647	40,482	33,919	18,011	14,136	11,038	10,482	10,122	9,537
Passenger Cars	Petrol	Large-SUV-Executive	Euro 1	0	17,144	21,751	17,101	14,858	11,861	11,317	10,729	10,189
Passenger Cars	Petrol	Large-SUV-Executive	Euro 2	0	0	26,680	28,162	29,249	26,723	26,065	25,482	24,832
Passenger Cars	Petrol	Large-SUV-Executive	Euro 3	0	0	0	16,474	16,639	16,853	16,770	16,622	16,471
Passenger Cars	Petrol	Large-SUV-Executive	Euro 4	0	0	0	0	7,206	6,153	7,309	7,612	7,755
Passenger Cars	Petrol	Large-SUV-Executive	Euro 5	0	0	0	0	0	5,422	4,898	4,726	3,975
Passenger Cars	Petrol	Large-SUV-Executive	Euro 6 up to 2016	0	0	0	0	0	0	2,374	2,362	2,362
Passenger Cars	Petrol	Large-SUV-Executive	Euro 6 2017-2019	0	0	0	0	0	0	0	1,497	3,853
Passenger Cars	Diesel	Mini	Euro 4	0	0	0	0	6,055	6,282	6,671	7,120	7,610
Passenger Cars	Diesel	Mini	Euro 5	0	0	0	0	0	4,519	4,617	4,820	4,926
Passenger Cars	Diesel	Mini	Euro 6 up to 2016	0	0	0	0	0	0	2,559	2,559	2,559
Passenger Cars	Diesel	Mini	Euro 6 2017-2019	0	0	0	0	0	0	0	1,637	2,852
Passenger Cars	Diesel	Small	Conventional	31,145	52,304	50,885	43,369	29,400	19,428	17,724	16,156	14,546
Passenger Cars	Diesel	Small	Euro 1	0	33,346	43,841	42,456	34,746	28,085	26,502	25,096	23,650
Passenger Cars	Diesel	Small	Euro 2	0	0	37,486	37,250	35,885	33,745	33,100	32,352	31,757
Passenger Cars	Diesel	Small	Euro 3	0	0	0	71,323	71,133	72,403	72,422	71,984	71,489

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2015	2016	2017	2018
Passenger Cars	Diesel	Small	Euro 4	0	0	0	0	50,792	51,113	51,945	52,824	53,555
Passenger Cars	Diesel	Small	Euro 5	0	0	0	0	0	54,539	55,033	56,063	56,599
Passenger Cars	Diesel	Small	Euro 6 up to 2016	0	0	0	0	0	0	31,759	31,759	31,759
Passenger Cars	Diesel	Small	Euro 6 2017-2019	0	0	0	0	0	0	0	31,671	61,965
Passenger Cars	Diesel	Medium	Conventional	9,902	26,450	26,190	24,159	18,657	12,999	11,915	10,895	9,790
Passenger Cars	Diesel	Medium	Euro 1	0	49,845	72,530	74,093	68,423	58,530	55,815	53,159	50,191
Passenger Cars	Diesel	Medium	Euro 2	0	0	144,097	143,182	144,836	137,124	134,781	132,045	129,212
Passenger Cars	Diesel	Medium	Euro 3	0	0	0	285,107	283,682	280,755	278,700	276,386	274,275
Passenger Cars	Diesel	Medium	Euro 4	0	0	0	0	388,526	389,210	391,935	393,122	394,477
Passenger Cars	Diesel	Medium	Euro 5	0	0	0	0	0	301,689	306,160	317,617	324,603
Passenger Cars	Diesel	Medium	Euro 6 up to 2016	0	0	0	0	0	0	58,318	58,318	58,318
Passenger Cars	Diesel	Medium	Euro 6 2017-2019	0	0	0	0	0	0	0	61,106	115,511
Passenger Cars	Diesel	Large-SUV-Executive	Conventional	57,173	70,532	65,192	57,821	50,984	43,722	42,321	40,900	39,296
Passenger Cars	Diesel	Large-SUV-Executive	Euro 1	0	37,787	65,106	67,426	64,727	57,454	55,576	53,827	51,985
Passenger Cars	Diesel	Large-SUV-Executive	Euro 2	0	0	211,246	209,863	209,622	195,252	191,224	187,247	183,261
Passenger Cars	Diesel	Large-SUV-Executive	Euro 3	0	0	0	238,066	236,996	235,335	234,113	232,779	231,447
Passenger Cars	Diesel	Large-SUV-Executive	Euro 4	0	0	0	0	239,424	238,400	246,375	249,367	250,788
Passenger Cars	Diesel	Large-SUV-Executive	Euro 5	0	0	0	0	0	142,143	145,151	150,787	153,415
Passenger Cars	Diesel	Large-SUV-Executive	Euro 6 up to 2016	0	0	0	0	0	0	41,069	41,069	41,069
Passenger Cars	Diesel	Large-SUV-Executive	Euro 6 2017-2019	0	0	0	0	0	0	0	40,850	75,402
Passenger Cars	Petrol Hybrid	Small	Euro 4	0	0	0	971	1,213	1,208	1,202	1,203	1,186
Passenger Cars	Petrol Hybrid	Small	Euro 5	0	0	0	0	0	1,134	1,138	1,149	1,157
Passenger Cars	Petrol Hybrid	Small	Euro 6 up to 2016	0	0	0	0	0	0	814	814	814
Passenger Cars	Petrol Hybrid	Small	Euro 6 2017-2019	0	0	0	0	0	0	0	1,072	2,861
Passenger Cars	Petrol Hybrid	Medium	Euro 4	0	0	0	240	5,947	6,026	6,034	6,062	6,055
Passenger Cars	Petrol Hybrid	Medium	Euro 5	0	0	0	0	0	3,026	3,037	3,140	3,232
Passenger Cars	Petrol Hybrid	Medium	Euro 6 up to 2016	0	0	0	0	0	0	1,445	1,445	1,445
Passenger Cars	Petrol Hybrid	Medium	Euro 6 2017-2019	0	0	0	0	0	0	0	3,352	9,438
Passenger Cars	Petrol Hybrid	Large-SUV-Executive	Euro 4	0	0	0	16	441	465	482	514	527
Passenger Cars	Petrol Hybrid	Large-SUV-Executive	Euro 5	0	0	0	0	0	5,980	6,002	6,451	6,878
Passenger Cars	Petrol Hybrid	Large-SUV-Executive	Euro 6 up to 2016	0	0	0	0	0	0	1,993	1,993	1,993
Passenger Cars	Petrol Hybrid	Large-SUV-Executive	Euro 6 2017-2019	0	0	0	0	0	0	0	2,710	6,251
Passenger Cars	LPG Bifuel	Mini	Euro 4	0	0	0	0	44	45	45	45	46
Passenger Cars	LPG Bifuel	Mini	Euro 5	0	0	0	0	0	64	64	64	71
Passenger Cars	LPG Bifuel	Mini	Euro 6	0	0	0	0	0	0	16	45	44
Passenger Cars	LPG Bifuel	Small	Conventional	15	112	3,096	3,039	3,850	5,134	5,162	5,314	5,596
Passenger Cars	LPG Bifuel	Small	Euro 1	0	96	3,476	3,412	4,323	5,765	5,795	5,966	6,282
Passenger Cars	LPG Bifuel	Small	Euro 2	0	0	3,007	2,952	3,740	4,986	5,013	5,161	5,434
Passenger Cars	LPG Bifuel	Small	Euro 3	0	0	0	1,192	1,510	2,014	2,025	2,084	2,195
Passenger Cars	LPG Bifuel	Small	Euro 4	0	0	0	0	417	419	419	422	429
Passenger Cars	LPG Bifuel	Small	Euro 5	0	0	0	0	0	973	969	966	1,118
Passenger Cars	LPG Bifuel	Small	Euro 6	0	0	0	0	0	0	253	686	675
Passenger Cars	LPG Bifuel	Medium	Conventional	2	21	595	584	739	986	991	1,021	1,075
Passenger Cars	LPG Bifuel	Medium	Euro 1	0	58	2,360	2,317	2,935	3,913	3,934	4,050	4,265
Passenger Cars	LPG Bifuel	Medium	Euro 2	0	0	4,137	4,061	5,145	6,860	6,897	7,100	7,476
Passenger Cars	LPG Bifuel	Medium	Euro 3	0	0	0	2,762	3,499	4,665	4,690	4,829	5,084
Passenger Cars	LPG Bifuel	Medium	Euro 4	0	0	0	0	851	850	851	856	870
Passenger Cars	LPG Bifuel	Medium	Euro 5	0	0	0	0	0	1,674	1,670	1,665	1,939
Passenger Cars	LPG Bifuel	Medium	Euro 6	0	0	0	0	0	0	461	1,252	1,232
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Conventional	8	31	870	854	1,082	1,442	1,450	1,493	1,572
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Euro 1	0	32	1,230	1,208	1,530	2,040	2,051	2,112	2,224
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Euro 2	0	0	2,156	2,116	2,681	3,575	3,594	3,700	3,896

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2015	2016	2017	2018
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Euro 3	0	0	0	799	1,012	1,349	1,357	1,397	1,471
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Euro 4	0	0	0	0	280	271	271	272	275
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Euro 5	0	0	0	0	0	1,039	1,034	1,029	1,202
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Euro 6	0	0	0	0	0	0	290	786	774
Light Commercial Vehicles	Petrol	N1-I	Conventional	35,580	35,948	30,761	21,038	13,153	9,754	9,160	8,753	8,290
Light Commercial Vehicles	Petrol	N1-I	Euro 1	0	461	919	832	533	322	291	270	229
Light Commercial Vehicles	Petrol	N1-I	Euro 2	0	0	230	214	190	178	159	146	136
Light Commercial Vehicles	Petrol	N1-I	Euro 3	0	0	0	402	480	431	425	397	391
Light Commercial Vehicles	Petrol	N1-I	Euro 4	0	0	0	0	11	13	15	14	15
Light Commercial Vehicles	Petrol	N1-I	Euro 5	0	0	0	0	0	4	4	5	8
Light Commercial Vehicles	Petrol	N1-I	Euro 6 up to 2016	0	0	0	0	0	0	2	2	2
Light Commercial Vehicles	Petrol	N1-I	Euro 6 2017-2019	0	0	0	0	0	0	0	4	4
Light Commercial Vehicles	Petrol	N1-II	Conventional	2,085	2,467	2,192	1,784	1,424	1,261	1,245	1,208	1,174
Light Commercial Vehicles	Petrol	N1-II	Euro 1	0	31	67	54	49	36	31	30	32
Light Commercial Vehicles	Petrol	N1-II	Euro 2	0	0	48	49	126	103	98	87	86
Light Commercial Vehicles	Petrol	N1-II	Euro 3	0	0	0	202	223	221	226	204	217
Light Commercial Vehicles	Petrol	N1-II	Euro 4	0	0	0	0	21	27	27	29	31
Light Commercial Vehicles	Petrol	N1-II	Euro 5	0	0	0	0	0	0	0	0	1
Light Commercial Vehicles	Petrol	N1-III	Conventional	134	264	243	216	185	161	165	155	145
Light Commercial Vehicles	Petrol	N1-III	Euro 1	0	7	16	17	21	19	19	19	17
Light Commercial Vehicles	Petrol	N1-III	Euro 2	0	0	10	12	18	16	13	15	18
Light Commercial Vehicles	Petrol	N1-III	Euro 3	0	0	0	12	29	34	35	39	44
Light Commercial Vehicles	Petrol	N1-III	Euro 4	0	0	0	0	1	8	7	11	9
Light Commercial Vehicles	Petrol	N1-III	Euro 5	0	0	0	0	0	2	2	3	2
Light Commercial Vehicles	Petrol	N1-III	Euro 6 up to 2017	0	0	0	0	0	0	1	1	1
Light Commercial Vehicles	Diesel	N1-I	Conventional	46,471	161,742	160,307	141,339	97,499	65,074	59,401	54,162	49,462
Light Commercial Vehicles	Diesel	N1-I	Euro 1	0	28,452	107,939	104,661	89,788	73,461	69,552	65,669	61,751
Light Commercial Vehicles	Diesel	N1-I	Euro 2	0	0	143,654	142,123	132,054	118,382	114,753	111,177	107,440
Light Commercial Vehicles	Diesel	N1-I	Euro 3	0	0	0	162,955	167,534	157,942	155,403	152,812	150,433
Light Commercial Vehicles	Diesel	N1-I	Euro 4	0	0	0	0	103,686	105,451	104,571	103,613	103,027
Light Commercial Vehicles	Diesel	N1-I	Euro 5	0	0	0	0	0	30,213	30,203	30,745	31,043
Light Commercial Vehicles	Diesel	N1-I	Euro 6 up to 2016	0	0	0	0	0	0	4,381	4,359	4,359
Light Commercial Vehicles	Diesel	N1-I	Euro 6 2017-2019	0	0	0	0	0	0	0	3,115	6,404
Light Commercial Vehicles	Diesel	N1-II	Conventional	121,314	178,916	168,491	141,922	115,117	96,589	93,483	91,260	89,316
Light Commercial Vehicles	Diesel	N1-II	Euro 1	0	6,517	21,882	21,438	19,560	17,727	17,357	17,172	16,946
Light Commercial Vehicles	Diesel	N1-II	Euro 2	0	0	27,109	27,039	28,380	26,224	25,829	25,220	25,028
Light Commercial Vehicles	Diesel	N1-II	Euro 3	0	0	0	41,175	41,360	38,799	38,206	37,679	37,209
Light Commercial Vehicles	Diesel	N1-II	Euro 4	0	0	0	0	43,648	43,267	42,855	42,504	42,350
Light Commercial Vehicles	Diesel	N1-II	Euro 5	0	0	0	0	0	44,417	44,763	45,526	46,939
Light Commercial Vehicles	Diesel	N1-II	Euro 6 up to 2017	0	0	0	0	0	0	14,553	34,054	34,054
Light Commercial Vehicles	Diesel	N1-II	Euro 6 2018-2020	0	0	0	0	0	0	0	0	21,519
Light Commercial Vehicles	Diesel	N1-III	Conventional	84,877	165,350	158,939	136,653	100,615	74,970	71,214	68,395	65,885
Light Commercial Vehicles	Diesel	N1-III	Euro 1	0	11,668	47,148	45,346	38,436	31,950	30,984	30,208	29,528
Light Commercial Vehicles	Diesel	N1-III	Euro 2	0	0	90,170	88,725	82,097	72,722	71,345	70,270	69,354
Light Commercial Vehicles	Diesel	N1-III	Euro 3	0	0	0	99,686	98,486	90,642	89,403	88,433	87,646
Light Commercial Vehicles	Diesel	N1-III	Euro 4	0	0	0	0	80,313	79,670	79,083	78,351	78,358
Light Commercial Vehicles	Diesel	N1-III	Euro 5	0	0	0	0	0	30,213	30,318	30,916	31,844
Light Commercial Vehicles	Diesel	N1-III	Euro 6 up to 2017	0	0	0	0	0	0	8,011	27,544	27,544
Light Commercial Vehicles	Diesel	N1-III	Euro 6 2018-2020	0	0	0	0	0	0	0	0	21,519
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Conventional	14,202	18,317	16,911	12,734	7,564	4,359	4,007	3,767	3,533
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Euro I	0	1,595	2,288	2,092	1,554	1,062	1,003	938	876
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Euro II	0	0	3,130	3,538	3,108	2,421	2,346	2,256	2,233

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2015	2016	2017	2018
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Euro III	0	0	0	777	997	905	895	861	853
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Euro IV	0	0	0	0	440	427	425	405	409
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Euro V	0	0	0	0	92	259	284	292	293
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Euro VI	0	0	0	0	0	333	584	843	1,107
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Conventional	6,249	8,773	8,176	6,313	3,801	2,216	2,023	1,904	1,794
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Euro I	0	882	1,304	1,280	1,088	784	751	704	687
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Euro II	0	0	4,031	4,978	4,554	3,662	3,559	3,452	3,354
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Euro III	0	0	0	2,855	3,498	3,391	3,416	3,433	3,412
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Euro IV	0	0	0	0	1,591	1,494	1,552	1,562	1,623
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Euro V	0	0	0	0	392	907	920	946	973
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Euro VI	0	0	0	0	0	398	530	682	852
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Conventional	1,872	2,428	2,244	1,780	1,104	646	591	549	533
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Euro I	0	263	393	392	367	288	282	278	269
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Euro II	0	0	892	1,135	1,078	939	908	870	852
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Euro III	0	0	0	557	698	746	754	766	756
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Euro IV	0	0	0	0	438	446	439	444	458
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Euro V	0	0	0	0	118	299	304	314	321
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Euro VI	0	0	0	0	0	126	186	264	349
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Conventional	11,119	14,122	12,963	10,560	6,920	4,035	3,781	3,556	3,359
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Euro I	0	1,475	2,177	2,289	2,030	1,558	1,492	1,451	1,388
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Euro II	0	0	4,466	5,462	5,602	4,654	4,544	4,462	4,369
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Euro III	0	0	0	2,041	2,702	3,109	3,196	3,282	3,338
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Euro IV	0	0	0	0	1,222	1,358	1,465	1,655	1,840
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Euro V	0	0	0	0	251	897	907	943	1,048
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Euro VI	0	0	0	0	0	474	785	1,129	1,476
Heavy Duty Trucks	Diesel	Rigid 20 - 26 t	Conventional	2,443	2,940	2,642	2,057	1,118	572	535	480	441
Heavy Duty Trucks	Diesel	Rigid 20 - 26 t	Euro I	0	173	257	243	178	107	99	102	96
Heavy Duty Trucks	Diesel	Rigid 20 - 26 t	Euro II	0	0	550	608	463	282	277	253	248
Heavy Duty Trucks	Diesel	Rigid 20 - 26 t	Euro III	0	0	0	63	94	103	109	118	117
Heavy Duty Trucks	Diesel	Rigid 20 - 26 t	Euro IV	0	0	0	0	12	31	38	47	62
Heavy Duty Trucks	Diesel	Rigid 20 - 26 t	Euro V	0	0	0	0	13	16	19	26	35
Heavy Duty Trucks	Diesel	Rigid 20 - 26 t	Euro VI	0	0	0	0	0	0	2	5	8
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Conventional	6,428	8,141	7,523	5,767	3,119	1,622	1,455	1,332	1,223
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Euro I	0	816	1,263	1,292	1,057	716	662	646	607
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Euro II	0	0	2,894	3,641	3,571	2,838	2,715	2,651	2,609
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Euro III	0	0	0	1,338	1,825	1,984	2,076	2,111	2,208
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Euro IV	0	0	0	0	803	845	924	985	1,051
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Euro V	0	0	0	0	155	446	481	564	641
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Euro VI	0	0	0	0	0	183	281	496	715
Heavy Duty Trucks	Diesel	Rigid 28 - 32 t	Conventional	60	88	84	66	29	14	9	10	9
Heavy Duty Trucks	Diesel	Rigid 28 - 32 t	Euro I	0	10	14	14	8	4	4	2	1
Heavy Duty Trucks	Diesel	Rigid 28 - 32 t	Euro II	0	0	49	44	26	14	13	14	12
Heavy Duty Trucks	Diesel	Rigid 28 - 32 t	Euro III	0	0	0	4	4	2	4	3	3
Heavy Duty Trucks	Diesel	Rigid 28 - 32 t	Euro IV	0	0	0	0	1	1	1	1	3
Heavy Duty Trucks	Diesel	Rigid 28 - 32 t	Euro VI	0	0	0	0	0	1	1	2	3
Heavy Duty Trucks	Diesel	Rigid >32 t	Conventional	673	1,298	1,245	1,055	565	222	197	179	161
Heavy Duty Trucks	Diesel	Rigid >32 t	Euro I	0	316	492	507	336	183	164	156	138
Heavy Duty Trucks	Diesel	Rigid >32 t	Euro II	0	0	1,735	2,097	1,540	842	818	802	791
Heavy Duty Trucks	Diesel	Rigid >32 t	Euro III	0	0	0	948	1,257	866	869	880	906
Heavy Duty Trucks	Diesel	Rigid >32 t	Euro IV	0	0	0	0	982	582	580	624	667
Heavy Duty Trucks	Diesel	Rigid >32 t	Euro V	0	0	0	0	90	137	155	166	180
Heavy Duty Trucks	Diesel	Rigid >32 t	Euro VI	0	0	0	0	0	76	152	290	426

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2015	2016	2017	2018
Heavy Duty Trucks	Diesel	Articulated 14 - 20 t	Conventional	126	145	126	93	49	19	22	33	29
Heavy Duty Trucks	Diesel	Articulated 14 - 20 t	Euro I	0	24	81	98	126	60	57	98	90
Heavy Duty Trucks	Diesel	Articulated 14 - 20 t	Euro II	0	0	814	1,070	1,748	1,002	882	1,819	1,625
Heavy Duty Trucks	Diesel	Articulated 14 - 20 t	Euro III	0	0	0	805	4,325	4,977	4,917	6,323	6,521
Heavy Duty Trucks	Diesel	Articulated 14 - 20 t	Euro IV	0	0	0	0	7,652	7,516	7,590	7,520	7,267
Heavy Duty Trucks	Diesel	Articulated 14 - 20 t	Euro V	0	0	0	0	1,849	6,777	6,825	7,222	7,590
Heavy Duty Trucks	Diesel	Articulated 14 - 20 t	Euro VI	0	0	0	0	0	2,866	2,849	5,611	8,709
Heavy Duty Trucks	Diesel	Articulated 20 - 28 t	Conventional	20	27	24	16	9	4	4	3	3
Heavy Duty Trucks	Diesel	Articulated 20 - 28 t	Euro I	0	0	3	3	1	0	0	0	0
Heavy Duty Trucks	Diesel	Articulated 20 - 28 t	Euro II	0	0	7	9	6	4	4	4	3
Heavy Duty Trucks	Diesel	Articulated 28 - 34 t	Conventional	95	78	58	35	14	5	6	4	3
Heavy Duty Trucks	Diesel	Articulated 28 - 34 t	Euro I	0	1	3	1	2	0	0	0	0
Heavy Duty Trucks	Diesel	Articulated 28 - 34 t	Euro II	0	0	6	5	5	3	5	2	3
Heavy Duty Trucks	Diesel	Articulated 34 - 40 t	Conventional	219	227	178	98	36	13	11	10	6
Heavy Duty Trucks	Diesel	Articulated 34 - 40 t	Euro I	0	8	14	9	3	0	0	0	0
Heavy Duty Trucks	Diesel	Articulated 34 - 40 t	Euro II	0	0	26	18	9	3	2	2	2
Heavy Duty Trucks	Diesel	Articulated 34 - 40 t	Euro III	0	0	0	1	0	0	0	0	0
Heavy Duty Trucks	Diesel	Articulated 40 - 50 t	Conventional	8,546	13,351	11,834	7,066	2,355	759	639	515	417
Heavy Duty Trucks	Diesel	Articulated 40 - 50 t	Euro I	0	3,576	5,671	5,221	2,636	1,061	914	768	678
Heavy Duty Trucks	Diesel	Articulated 40 - 50 t	Euro II	0	0	12,354	15,387	10,798	5,236	4,544	2,945	2,529
Heavy Duty Trucks	Diesel	Articulated 40 - 50 t	Euro III	0	0	0	7,054	7,268	5,074	4,655	2,669	1,771
Heavy Duty Trucks	Diesel	Articulated 40 - 50 t	Euro IV	0	0	0	0	105	61	54	48	41
Heavy Duty Trucks	Diesel	Articulated 50 - 60 t	Conventional	2	2	1	1	1	1	0	0	0
Heavy Duty Trucks	Diesel	Articulated 50 - 60 t	Euro II	0	0	1	0	0	0	0	0	0
Buses	Diesel	Urban Buses Midi <=15 t	Conventional	1,803	2,230	2,113	1,762	787	366	318	283	245
Buses	Diesel	Urban Buses Midi <=15 t	Euro I	0	330	480	406	347	185	152	132	117
Buses	Diesel	Urban Buses Midi <=15 t	Euro II	0	0	1,033	1,272	1,262	1,047	973	899	843
Buses	Diesel	Urban Buses Midi <=15 t	Euro III	0	0	0	1,189	1,581	1,605	1,580	1,554	1,516
Buses	Diesel	Urban Buses Midi <=15 t	Euro IV	0	0	0	0	1,037	1,093	1,119	1,147	1,178
Buses	Diesel	Urban Buses Midi <=15 t	Euro V	0	0	0	0	207	558	569	566	594
Buses	Diesel	Urban Buses Midi <=15 t	Euro VI	0	0	0	0	0	183	340	514	697
Buses	Diesel	Urban Buses Standard 15 - 18 t	Conventional	3,024	3,270	3,041	2,413	1,254	558	463	382	313
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro I	0	130	238	226	232	170	148	128	102
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro II	0	0	760	747	525	334	312	292	258
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro III	0	0	0	230	209	187	196	205	220
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro IV	0	0	0	0	45	46	48	49	54
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro V	0	0	0	0	1	51	51	51	51
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro VI	0	0	0	0	0	6	12	12	12
Buses	Diesel	Urban Buses Articulated >18 t	Conventional	631	1,103	1,084	1,090	834	427	376	338	286
Buses	Diesel	Urban Buses Articulated >18 t	Euro I	0	346	581	601	843	657	593	528	452
Buses	Diesel	Urban Buses Articulated >18 t	Euro II	0	0	1,198	1,496	1,863	2,096	2,061	1,976	1,917
Buses	Diesel	Urban Buses Articulated >18 t	Euro III	0	0	0	812	1,108	1,585	1,748	1,881	2,003
Buses	Diesel	Urban Buses Articulated >18 t	Euro IV	0	0	0	0	616	701	788	904	1,059
Buses	Diesel	Urban Buses Articulated >18 t	Euro V	0	0	0	0	187	475	498	534	597
Buses	Diesel	Urban Buses Articulated >18 t	Euro VI	0	0	0	0	0	201	369	538	726
Buses	Diesel	Coaches Standard <=18 t	Conventional	621	672	624	495	258	115	95	79	64
Buses	Diesel	Coaches Standard <=18 t	Euro I	0	27	49	47	48	35	30	26	21
Buses	Diesel	Coaches Standard <=18 t	Euro II	0	0	156	153	108	68	64	60	53
Buses	Diesel	Coaches Standard <=18 t	Euro III	0	0	0	47	43	38	40	42	45
Buses	Diesel	Coaches Standard <=18 t	Euro IV	0	0	0	0	9	10	10	10	11
Buses	Diesel	Coaches Standard <=18 t	Euro V	0	0	0	0	0	10	10	11	11
Buses	Diesel	Coaches Standard <=18 t	Euro VI	0	0	0	0	0	1	2	2	3

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2015	2016	2017	2018
Buses	Diesel	Coaches Articulated >18 t	Conventional	130	226	223	224	171	88	77	69	59
Buses	Diesel	Coaches Articulated >18 t	Euro I	0	71	119	123	173	135	122	108	93
Buses	Diesel	Coaches Articulated >18 t	Euro II	0	0	246	307	383	431	423	406	394
Buses	Diesel	Coaches Articulated >18 t	Euro III	0	0	0	167	227	326	359	386	411
Buses	Diesel	Coaches Articulated >18 t	Euro IV	0	0	0	0	127	144	162	186	217
Buses	Diesel	Coaches Articulated >18 t	Euro V	0	0	0	0	38	98	102	110	123
Buses	Diesel	Coaches Articulated >18 t	Euro VI	0	0	0	0	0	41	76	111	149
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	35	34	44
Buses	CNG	Urban CNG Buses	EEV	0	0	0	0	90	89	88	89	90
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Conventional	417,346	341,022	264,699	140,866	100,710	92,770	87,014	85,274	84,727
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Euro 1	0	0	0	9,163	7,145	5,651	5,320	4,989	4,659
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Euro 2	0	0	0	15,238	15,911	11,368	10,672	10,373	9,964
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Euro 3	0	0	0	0	17,922	26,070	31,834	30,116	29,096
L-Category	Petrol	Mopeds 2-stroke <50 cm^3	Euro 4	0	0	0	0	0	0	0	0	1,355
L-Category	Petrol	Mopeds 4-stroke <50 cm^3	Conventional	417,346	341,022	264,699	140,866	100,710	92,770	87,014	85,274	84,727
L-Category	Petrol	Mopeds 4-stroke <50 cm^3	Euro 1	0	0	0	9,163	7,145	5,651	5,320	4,989	4,659
L-Category	Petrol	Mopeds 4-stroke <50 cm^3	Euro 2	0	0	0	15,238	15,911	11,368	10,672	10,373	9,964
L-Category	Petrol	Mopeds 4-stroke <50 cm^3	Euro 3	0	0	0	0	17,922	26,070	31,834	30,116	29,096
L-Category	Petrol	Mopeds 4-stroke <50 cm^3	Euro 4	0	0	0	0	0	0	0	0	1,355
L-Category	Petrol	Motorcycles 2-stroke >50 cm^3	Conventional	14,753	20,578	31,798	14,218	29,622	28,748	31,042	31,870	31,774
L-Category	Petrol	Motorcycles 2-stroke >50 cm^3	Euro 1	0	0	0	10,200	14,985	14,535	13,995	17,799	17,746
L-Category	Petrol	Motorcycles 2-stroke >50 cm^3	Euro 2	0	0	0	6,158	12,526	12,961	12,796	14,879	14,834
L-Category	Petrol	Motorcycles 2-stroke >50 cm^3	Euro 3	0	0	0	0	20,774	56,563	69,285	73,062	72,547
L-Category	Petrol	Motorcycles 2-stroke >50 cm^3	Euro 4	0	0	0	0	0	0	0	11,381	23,550
L-Category	Petrol	Motorcycles 4-stroke <250 cm^3	Conventional	7,869	10,975	17,591	9,473	8,375	5,565	5,542	5,690	5,673
L-Category	Petrol	Motorcycles 4-stroke <250 cm^3	Euro 1	0	0	0	6,796	4,237	2,814	2,499	3,178	3,168
L-Category	Petrol	Motorcycles 4-stroke <250 cm^3	Euro 2	0	0	0	4,103	3,541	2,509	2,285	2,657	2,649
L-Category	Petrol	Motorcycles 4-stroke <250 cm^3	Euro 3	0	0	0	0	5,873	10,950	12,371	13,045	12,953
L-Category	Petrol	Motorcycles 4-stroke <250 cm^3	Euro 4	0	0	0	0	0	0	0	2,032	4,205
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm^3	Conventional	26,481	36,936	54,811	27,567	22,198	14,564	14,727	15,120	15,074
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm^3	Euro 1	0	0	0	19,777	11,229	7,364	6,640	8,444	8,419
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm^3	Euro 2	0	0	0	11,940	9,387	6,566	6,071	7,059	7,037
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm^3	Euro 3	0	0	0	0	15,567	28,656	32,870	34,661	34,417
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm^3	Euro 4	0	0	0	0	0	0	0	5,399	11,172
L-Category	Petrol	Motorcycles 4-stroke >750 cm^3	Conventional	17,027	23,749	40,396	21,773	21,039	16,289	17,607	18,077	18,022
L-Category	Petrol	Motorcycles 4-stroke >750 cm^3	Euro 1	0	0	0	15,620	10,643	8,236	7,938	10,096	10,065
L-Category	Petrol	Motorcycles 4-stroke >750 cm^3	Euro 2	0	0	0	9,430	8,897	7,344	7,258	8,439	8,414
L-Category	Petrol	Motorcycles 4-stroke >750 cm^3	Euro 3	0	0	0	0	14,755	32,049	39,298	41,440	41,148
L-Category	Petrol	Motorcycles 4-stroke >750 cm^3	Euro 4	0	0	0	0	0	0	0	6,455	13,357

Table C-9: Km per year per vehicle type.

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2015	2016	2017	2018
Passenger Cars	Petrol	Mini	Euro 4	0	0	0	0	7,087	7,429	7,355	7,127	6,853
Passenger Cars	Petrol	Mini	Euro 5	0	0	0	0	0	4,934	5,138	6,329	7,065
Passenger Cars	Petrol	Mini	Euro 6 up to 2016	0	0	0	0	0	0	6,083	5,930	6,997
Passenger Cars	Petrol	Mini	Euro 6 2017-2019	0	0	0	0	0	0	0	5,930	5,785
Passenger Cars	Petrol	Small	PRE ECE	7,883	4,788	2,442	1,498	1,104	905	880	851	796
Passenger Cars	Petrol	Small	ECE 15/00-01	6,669	4,576	2,904	1,768	1,341	1,119	1,032	985	935
Passenger Cars	Petrol	Small	ECE 15/02	8,146	5,933	4,218	2,903	2,021	1,545	1,461	1,370	1,309
Passenger Cars	Petrol	Small	ECE 15/03	12,672	9,754	7,272	5,652	4,027	3,039	2,894	2,727	2,582
Passenger Cars	Petrol	Small	ECE 15/04	14,886	13,208	10,389	8,225	6,211	4,933	4,696	4,444	4,207
Passenger Cars	Petrol	Small	Euro 1	0	14,858	13,049	10,691	8,330	6,745	6,436	6,126	5,810
Passenger Cars	Petrol	Small	Euro 2	0	0	12,872	11,720	9,337	7,642	7,329	7,004	6,687
Passenger Cars	Petrol	Small	Euro 3	0	0	0	11,822	10,032	8,402	8,105	7,730	7,431
Passenger Cars	Petrol	Small	Euro 4	0	0	0	0	7,264	8,096	8,018	7,729	7,489
Passenger Cars	Petrol	Small	Euro 5	0	0	0	0	0	5,806	6,230	7,221	7,992
Passenger Cars	Petrol	Small	Euro 6 up to 2016	0	0	0	0	0	0	7,231	7,050	8,318
Passenger Cars	Petrol	Small	Euro 6 2017-2019	0	0	0	0	0	0	0	7,050	6,878
Passenger Cars	Petrol	Medium	PRE ECE	9,536	5,962	2,859	1,557	1,155	939	881	945	826
Passenger Cars	Petrol	Medium	ECE 15/00-01	7,508	5,366	3,277	1,798	1,415	1,079	1,008	1,004	912
Passenger Cars	Petrol	Medium	ECE 15/02	12,091	9,057	6,827	3,707	2,445	1,973	1,869	1,992	1,827
Passenger Cars	Petrol	Medium	ECE 15/03	15,097	11,795	8,752	6,769	4,694	3,556	3,420	3,282	3,111
Passenger Cars	Petrol	Medium	ECE 15/04	13,916	15,846	13,404	10,727	7,960	6,192	5,866	5,549	5,225
Passenger Cars	Petrol	Medium	Euro 1	0	11,305	14,442	12,049	9,303	7,448	7,101	6,745	6,438
Passenger Cars	Petrol	Medium	Euro 2	0	0	11,613	13,758	10,790	8,837	8,459	8,084	7,738
Passenger Cars	Petrol	Medium	Euro 3	0	0	0	11,247	10,922	9,056	8,714	8,386	8,023
Passenger Cars	Petrol	Medium	Euro 4	0	0	0	0	7,367	8,284	8,057	7,893	7,544
Passenger Cars	Petrol	Medium	Euro 5	0	0	0	0	0	5,304	5,978	6,565	7,537
Passenger Cars	Petrol	Medium	Euro 6 up to 2016	0	0	0	0	0	0	7,116	6,938	8,186
Passenger Cars	Petrol	Medium	Euro 6 2017-2019	0	0	0	0	0	0	0	6,938	6,768
Passenger Cars	Petrol	Large-SUV-Executive	PRE ECE	11,542	6,713	3,298	1,842	1,469	1,289	1,199	948	990
Passenger Cars	Petrol	Large-SUV-Executive	ECE 15/00-01	10,702	7,692	4,565	2,468	1,728	1,371	1,315	1,252	1,221
Passenger Cars	Petrol	Large-SUV-Executive	ECE 15/02	13,730	9,932	6,878	4,820	3,323	2,515	2,438	2,389	2,264
Passenger Cars	Petrol	Large-SUV-Executive	ECE 15/03	16,449	12,479	9,099	6,859	4,858	3,642	3,457	3,205	3,180
Passenger Cars	Petrol	Large-SUV-Executive	ECE 15/04	19,371	17,668	13,986	10,747	7,727	5,778	5,446	5,176	4,847
Passenger Cars	Petrol	Large-SUV-Executive	Euro 1	0	17,892	17,170	13,596	9,684	7,363	6,880	6,483	6,131
Passenger Cars	Petrol	Large-SUV-Executive	Euro 2	0	0	16,411	15,217	10,903	8,403	8,023	7,614	7,231
Passenger Cars	Petrol	Large-SUV-Executive	Euro 3	0	0	0	14,462	11,596	8,814	8,472	8,012	7,594
Passenger Cars	Petrol	Large-SUV-Executive	Euro 4	0	0	0	0	8,088	8,364	8,058	7,596	7,463
Passenger Cars	Petrol	Large-SUV-Executive	Euro 5	0	0	0	0	0	5,447	5,814	6,936	7,806
Passenger Cars	Petrol	Large-SUV-Executive	Euro 6 up to 2016	0	0	0	0	0	0	5,407	5,271	6,220
Passenger Cars	Petrol	Large-SUV-Executive	Euro 6 2017-2019	0	0	0	0	0	0	0	5,271	5,143
Passenger Cars	Diesel	Mini	Euro 4	0	0	0	0	8,551	9,770	9,527	9,263	8,909
Passenger Cars	Diesel	Mini	Euro 5	0	0	0	0	0	6,954	7,638	8,896	9,308
Passenger Cars	Diesel	Mini	Euro 6 up to 2016	0	0	0	0	0	0	5,953	5,929	7,815
Passenger Cars	Diesel	Mini	Euro 6 2017-2019	0	0	0	0	0	0	0	5,929	5,827
Passenger Cars	Diesel	Small	Conventional	24,074	14,285	12,240	9,570	8,690	6,871	6,742	6,588	6,307
Passenger Cars	Diesel	Small	Euro 1	0	19,559	18,101	13,252	12,095	9,643	9,571	9,341	9,075
Passenger Cars	Diesel	Small	Euro 2	0	0	20,592	16,612	13,873	11,090	10,893	10,623	10,206
Passenger Cars	Diesel	Small	Euro 3	0	0	0	15,059	14,478	11,170	10,988	10,734	10,335

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2015	2016	2017	2018
Passenger Cars	Diesel	Small	Euro 4	0	0	0	0	13,753	11,919	11,447	11,554	10,772
Passenger Cars	Diesel	Small	Euro 5	0	0	0	0	0	14,063	14,216	13,809	13,280
Passenger Cars	Diesel	Small	Euro 6 up to 2016	0	0	0	0	0	0	14,984	14,926	13,850
Passenger Cars	Diesel	Small	Euro 6 2017-2019	0	0	0	0	0	0	0	14,926	14,668
Passenger Cars	Diesel	Medium	Conventional	23,375	17,482	15,372	12,114	10,964	8,369	8,252	7,892	7,441
Passenger Cars	Diesel	Medium	Euro 1	0	18,064	18,296	13,944	12,617	9,732	9,688	9,353	8,985
Passenger Cars	Diesel	Medium	Euro 2	0	0	18,927	16,776	14,666	11,633	11,591	11,287	10,903
Passenger Cars	Diesel	Medium	Euro 3	0	0	0	15,739	16,092	12,440	12,319	12,026	11,629
Passenger Cars	Diesel	Medium	Euro 4	0	0	0	0	13,815	13,205	12,717	12,633	11,852
Passenger Cars	Diesel	Medium	Euro 5	0	0	0	0	0	13,207	13,928	14,229	14,480
Passenger Cars	Diesel	Medium	Euro 6 up to 2016	0	0	0	0	0	0	13,116	13,065	13,236
Passenger Cars	Diesel	Medium	Euro 6 2017-2019	0	0	0	0	0	0	0	13,065	12,839
Passenger Cars	Diesel	Large-SUV-Executive	Conventional	22,312	17,603	16,072	12,731	11,700	9,213	9,137	8,900	8,531
Passenger Cars	Diesel	Large-SUV-Executive	Euro 1	0	13,813	22,220	16,169	14,133	10,780	10,618	10,343	9,858
Passenger Cars	Diesel	Large-SUV-Executive	Euro 2	0	0	15,218	18,548	14,696	11,262	11,160	10,776	10,338
Passenger Cars	Diesel	Large-SUV-Executive	Euro 3	0	0	0	14,372	18,101	13,195	13,013	12,681	12,203
Passenger Cars	Diesel	Large-SUV-Executive	Euro 4	0	0	0	0	13,039	15,409	14,777	14,451	13,273
Passenger Cars	Diesel	Large-SUV-Executive	Euro 5	0	0	0	0	0	12,354	13,869	14,912	15,929
Passenger Cars	Diesel	Large-SUV-Executive	Euro 6 up to 2016	0	0	0	0	0	0	8,741	8,707	11,476
Passenger Cars	Diesel	Large-SUV-Executive	Euro 6 2017-2019	0	0	0	0	0	0	0	8,707	8,557
Passenger Cars	Petrol Hybrid	Small	Euro 4	0	0	0	15,526	13,237	11,015	10,655	10,435	9,863
Passenger Cars	Petrol Hybrid	Small	Euro 5	0	0	0	0	0	14,387	14,430	14,583	14,661
Passenger Cars	Petrol Hybrid	Small	Euro 6 up to 2016	0	0	0	0	0	0	14,078	13,726	13,994
Passenger Cars	Petrol Hybrid	Small	Euro 6 2017-2019	0	0	0	0	0	0	0	13,726	13,390
Passenger Cars	Petrol Hybrid	Medium	Euro 4	0	0	0	15,067	12,459	11,656	10,999	10,845	10,286
Passenger Cars	Petrol Hybrid	Medium	Euro 5	0	0	0	0	0	13,761	14,050	14,096	14,107
Passenger Cars	Petrol Hybrid	Medium	Euro 6 up to 2016	0	0	0	0	0	0	14,078	13,726	13,994
Passenger Cars	Petrol Hybrid	Medium	Euro 6 2017-2019	0	0	0	0	0	0	0	13,726	13,390
Passenger Cars	Petrol Hybrid	Large-SUV-Executive	Euro 4	0	0	0	16,179	12,121	11,550	10,941	11,011	10,291
Passenger Cars	Petrol Hybrid	Large-SUV-Executive	Euro 5	0	0	0	0	0	14,876	14,905	15,198	15,481
Passenger Cars	Petrol Hybrid	Large-SUV-Executive	Euro 6 up to 2016	0	0	0	0	0	0	14,078	13,726	13,994
Passenger Cars	Petrol Hybrid	Large-SUV-Executive	Euro 6 2017-2019	0	0	0	0	0	0	0	13,726	13,390
Passenger Cars	LPG Bifuel	Mini	Euro 4	0	0	0	0	13,431	14,246	14,350	13,141	12,403
Passenger Cars	LPG Bifuel	Mini	Euro 5	0	0	0	0	0	12,701	12,776	13,460	12,440
Passenger Cars	LPG Bifuel	Mini	Euro 6	0	0	0	0	0	0	11,987	11,721	14,165
Passenger Cars	LPG Bifuel	Small	Conventional	14,973	12,499	16,878	12,335	8,857	6,198	6,037	4,892	3,906
Passenger Cars	LPG Bifuel	Small	Euro 1	0	15,829	22,448	16,724	14,323	12,677	13,395	11,740	11,125
Passenger Cars	LPG Bifuel	Small	Euro 2	0	0	14,599	11,174	14,622	12,124	12,230	11,590	10,302
Passenger Cars	LPG Bifuel	Small	Euro 3	0	0	0	14,616	16,640	13,889	13,817	13,158	12,218
Passenger Cars	LPG Bifuel	Small	Euro 4	0	0	0	0	13,316	14,087	14,289	13,013	12,404
Passenger Cars	LPG Bifuel	Small	Euro 5	0	0	0	0	0	12,495	12,723	13,236	12,245
Passenger Cars	LPG Bifuel	Small	Euro 6	0	0	0	0	0	0	11,987	11,721	14,165
Passenger Cars	LPG Bifuel	Medium	Conventional	14,897	12,714	17,235	12,990	9,326	6,174	6,047	5,140	4,223
Passenger Cars	LPG Bifuel	Medium	Euro 1	0	15,353	21,743	16,089	14,039	12,587	13,310	11,587	10,997
Passenger Cars	LPG Bifuel	Medium	Euro 2	0	0	15,571	11,402	14,861	12,272	12,379	11,670	10,371
Passenger Cars	LPG Bifuel	Medium	Euro 3	0	0	0	14,691	16,783	13,900	13,846	13,159	12,214
Passenger Cars	LPG Bifuel	Medium	Euro 4	0	0	0	0	13,267	14,152	14,315	13,034	12,400
Passenger Cars	LPG Bifuel	Medium	Euro 5	0	0	0	0	0	12,510	12,709	13,237	12,225
Passenger Cars	LPG Bifuel	Medium	Euro 6	0	0	0	0	0	0	11,987	11,721	14,165
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Conventional	13,523	11,085	14,702	10,898	7,790	6,070	5,812	4,496	3,770
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Euro 1	0	15,786	22,272	16,546	14,182	12,623	13,348	11,704	11,076
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Euro 2	0	0	15,582	11,583	14,913	12,283	12,429	11,718	10,421

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2015	2016	2017	2018
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Euro 3	0	0	0	14,572	16,649	13,885	13,805	13,140	12,186
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Euro 4	0	0	0	0	12,629	13,646	14,102	12,721	12,225
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Euro 5	0	0	0	0	0	12,433	12,710	13,179	12,206
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Euro 6	0	0	0	0	0	0	11,987	11,721	14,165
Light Commercial Vehicles	Petrol	N1-I	Conventional	15,363	11,196	7,959	5,825	4,049	3,020	2,855	2,704	2,562
Light Commercial Vehicles	Petrol	N1-I	Euro 1	0	23,056	16,831	12,763	9,541	7,048	6,615	6,357	6,234
Light Commercial Vehicles	Petrol	N1-I	Euro 2	0	0	19,753	14,217	10,487	8,092	7,647	7,267	7,184
Light Commercial Vehicles	Petrol	N1-I	Euro 3	0	0	0	13,572	10,896	8,974	8,578	8,263	8,145
Light Commercial Vehicles	Petrol	N1-I	Euro 4	0	0	0	0	18,552	11,072	10,762	9,992	9,343
Light Commercial Vehicles	Petrol	N1-I	Euro 5	0	0	0	0	0	9,413	8,865	8,726	8,873
Light Commercial Vehicles	Petrol	N1-I	Euro 6 up to 2016	0	0	0	0	0	0	15,381	14,996	13,034
Light Commercial Vehicles	Petrol	N1-I	Euro 6 2017-2019	0	0	0	0	0	0	0	14,996	14,630
Light Commercial Vehicles	Petrol	N1-II	Conventional	15,287	13,781	10,350	8,122	5,219	3,478	3,334	3,074	2,929
Light Commercial Vehicles	Petrol	N1-II	Euro 1	0	19,954	15,838	11,079	6,406	4,864	4,705	5,212	4,660
Light Commercial Vehicles	Petrol	N1-II	Euro 2	0	0	22,721	14,459	11,651	9,188	8,758	8,338	8,046
Light Commercial Vehicles	Petrol	N1-II	Euro 3	0	0	0	14,193	10,961	9,477	9,000	8,836	8,269
Light Commercial Vehicles	Petrol	N1-II	Euro 4	0	0	0	0	6,756	6,613	7,083	6,703	6,769
Light Commercial Vehicles	Petrol	N1-II	Euro 5	0	0	0	0	0	0	0	0	12,139
Light Commercial Vehicles	Petrol	N1-II	Euro 6 up to 2017	0	0	0	0	0	0	16,029	15,628	14,519
Light Commercial Vehicles	Petrol	N1-III	Conventional	10,376	17,627	10,918	8,832	5,778	4,469	3,962	3,692	3,633
Light Commercial Vehicles	Petrol	N1-III	Euro 1	0	25,363	16,935	9,327	6,744	5,691	5,119	6,572	4,537
Light Commercial Vehicles	Petrol	N1-III	Euro 2	0	0	22,190	12,575	9,402	14,220	8,071	7,483	6,292
Light Commercial Vehicles	Petrol	N1-III	Euro 3	0	0	0	32,542	9,044	6,728	5,412	6,070	5,627
Light Commercial Vehicles	Petrol	N1-III	Euro 4	0	0	0	0	4,125	4,995	7,718	6,096	5,988
Light Commercial Vehicles	Petrol	N1-III	Euro 5	0	0	0	0	0	14,340	12,782	12,130	11,296
Light Commercial Vehicles	Petrol	N1-III	Euro 6 up to 2017	0	0	0	0	0	0	14,566	14,201	11,435
Light Commercial Vehicles	Diesel	N1-I	Conventional	25,415	19,517	14,336	10,716	10,014	8,131	8,087	7,898	7,644
Light Commercial Vehicles	Diesel	N1-I	Euro 1	0	25,963	19,797	14,291	12,483	9,348	9,184	8,857	8,474
Light Commercial Vehicles	Diesel	N1-I	Euro 2	0	0	23,368	16,494	14,683	11,134	10,954	10,616	10,165
Light Commercial Vehicles	Diesel	N1-I	Euro 3	0	0	0	18,021	17,051	13,123	12,915	12,535	12,012
Light Commercial Vehicles	Diesel	N1-I	Euro 4	0	0	0	0	19,355	15,700	15,523	14,945	14,401
Light Commercial Vehicles	Diesel	N1-I	Euro 5	0	0	0	0	0	19,067	18,476	18,127	17,914
Light Commercial Vehicles	Diesel	N1-I	Euro 6 up to 2016	0	0	0	0	0	0	19,082	19,007	16,642
Light Commercial Vehicles	Diesel	N1-I	Euro 6 2017-2019	0	0	0	0	0	0	0	19,007	18,679
Light Commercial Vehicles	Diesel	N1-II	Conventional	25,765	16,984	14,056	10,775	9,716	7,536	7,432	7,220	6,931
Light Commercial Vehicles	Diesel	N1-II	Euro 1	0	21,403	18,939	14,401	12,690	9,745	9,471	9,175	8,816
Light Commercial Vehicles	Diesel	N1-II	Euro 2	0	0	20,355	16,053	14,400	10,937	10,811	10,442	10,102
Light Commercial Vehicles	Diesel	N1-II	Euro 3	0	0	0	18,043	17,725	13,476	13,326	12,819	12,244
Light Commercial Vehicles	Diesel	N1-II	Euro 4	0	0	0	0	18,883	16,453	16,295	15,896	15,283
Light Commercial Vehicles	Diesel	N1-II	Euro 5	0	0	0	0	0	16,963	17,222	17,245	17,331
Light Commercial Vehicles	Diesel	N1-II	Euro 6 up to 2017	0	0	0	0	0	0	16,306	16,242	15,638
Light Commercial Vehicles	Diesel	N1-II	Euro 6 2018-2020	0	0	0	0	0	0	0	0	15,962
Light Commercial Vehicles	Diesel	N1-III	Conventional	28,353	18,802	13,313	9,930	8,782	6,720	6,624	6,461	6,185
Light Commercial Vehicles	Diesel	N1-III	Euro 1	0	35,126	23,386	16,051	13,774	10,233	10,023	9,676	9,241
Light Commercial Vehicles	Diesel	N1-III	Euro 2	0	0	26,794	16,999	14,634	10,852	10,637	10,295	9,816
Light Commercial Vehicles	Diesel	N1-III	Euro 3	0	0	0	20,027	17,933	13,323	13,046	12,560	12,000
Light Commercial Vehicles	Diesel	N1-III	Euro 4	0	0	0	0	21,136	16,253	16,075	15,501	14,838
Light Commercial Vehicles	Diesel	N1-III	Euro 5	0	0	0	0	0	19,752	19,558	19,227	18,905
Light Commercial Vehicles	Diesel	N1-III	Euro 6 up to 2017	0	0	0	0	0	0	19,494	19,418	18,819
Light Commercial Vehicles	Diesel	N1-III	Euro 6 2018-2020	0	0	0	0	0	0	0	0	19,083
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Conventional	29,249	20,017	16,242	11,856	10,639	8,091	7,990	7,690	7,466
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Euro I	0	21,701	23,913	17,586	14,749	11,676	11,057	10,350	10,090

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2015	2016	2017	2018
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Euro II	0	0	23,750	20,840	19,214	13,711	13,388	13,123	12,173
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Euro III	0	0	0	19,948	24,137	18,444	17,480	16,744	15,741
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Euro IV	0	0	0	0	21,035	19,143	18,641	18,506	18,074
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Euro V	0	0	0	0	21,862	20,828	21,037	19,625	19,644
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Euro VI	0	0	0	0	0	18,221	18,328	18,758	19,127
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Conventional	29,881	23,419	20,373	15,125	13,237	10,044	9,833	9,434	9,135
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Euro I	0	20,980	28,405	22,224	19,998	13,389	13,308	12,387	11,666
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Euro II	0	0	24,245	25,374	23,140	16,469	15,845	15,051	14,278
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Euro III	0	0	0	20,479	24,888	20,298	20,095	19,821	18,949
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Euro IV	0	0	0	0	20,493	21,206	21,457	21,770	21,027
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Euro V	0	0	0	0	17,716	20,266	21,925	22,726	22,486
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Euro VI	0	0	0	0	0	18,207	18,424	18,859	18,985
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Conventional	48,825	35,331	28,952	20,694	17,554	12,912	12,913	12,225	11,526
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Euro I	0	34,962	42,376	31,400	24,407	16,718	15,823	15,342	14,562
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Euro II	0	0	45,911	42,354	32,444	21,227	20,362	19,547	18,254
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Euro III	0	0	0	36,299	39,309	31,060	30,660	29,607	29,136
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Euro IV	0	0	0	0	33,967	35,502	36,406	36,091	35,702
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Euro V	0	0	0	0	29,137	30,776	32,550	34,136	34,775
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Euro VI	0	0	0	0	0	22,924	25,034	27,124	28,467
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Conventional	47,683	34,745	28,503	20,326	17,115	12,542	12,496	11,817	11,184
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Euro I	0	34,909	42,408	31,407	24,408	16,681	15,860	15,364	14,584
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Euro II	0	0	45,868	41,969	32,065	21,086	20,207	19,441	18,202
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Euro III	0	0	0	37,698	39,247	30,818	30,286	29,282	28,707
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Euro IV	0	0	0	0	32,557	35,307	36,045	35,922	35,389
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Euro V	0	0	0	0	29,137	28,693	30,570	33,521	33,542
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Euro VI	0	0	0	0	0	22,644	25,063	26,915	28,224
Heavy Duty Trucks	Diesel	Rigid 20 - 26 t	Conventional	52,359	36,965	30,139	21,463	19,558	13,978	13,749	13,338	12,268
Heavy Duty Trucks	Diesel	Rigid 20 - 26 t	Euro I	0	37,605	46,375	35,151	27,308	19,150	18,827	18,566	17,360
Heavy Duty Trucks	Diesel	Rigid 20 - 26 t	Euro II	0	0	46,184	42,361	33,644	22,218	21,508	20,781	19,316
Heavy Duty Trucks	Diesel	Rigid 20 - 26 t	Euro III	0	0	0	40,976	43,777	33,170	31,880	30,850	28,994
Heavy Duty Trucks	Diesel	Rigid 20 - 26 t	Euro IV	0	0	0	0	32,799	38,734	40,558	39,865	38,269
Heavy Duty Trucks	Diesel	Rigid 20 - 26 t	Euro V	0	0	0	0	32,935	45,133	48,726	52,327	48,969
Heavy Duty Trucks	Diesel	Rigid 20 - 26 t	Euro VI	0	0	0	0	0	0	25,408	25,309	26,062
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Conventional	53,439	39,140	32,018	22,683	20,730	14,422	14,144	13,572	12,660
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Euro I	0	37,410	46,287	35,170	27,346	19,130	18,857	18,599	17,372
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Euro II	0	0	45,137	42,712	34,191	22,450	21,686	20,974	19,434
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Euro III	0	0	0	38,907	43,340	33,365	31,842	30,887	28,969
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Euro IV	0	0	0	0	33,963	39,216	40,670	39,851	38,264
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Euro V	0	0	0	0	32,935	39,529	46,034	50,807	49,265
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Euro VI	0	0	0	0	0	24,223	25,939	27,957	28,428
Heavy Duty Trucks	Diesel	Rigid 28 - 32 t	Conventional	56,413	42,137	34,390	23,589	20,344	14,839	14,568	13,825	13,327
Heavy Duty Trucks	Diesel	Rigid 28 - 32 t	Euro I	0	36,624	45,073	34,046	26,882	18,788	18,080	18,050	17,558
Heavy Duty Trucks	Diesel	Rigid 28 - 32 t	Euro II	0	0	43,767	42,222	33,013	21,929	21,356	20,704	19,143
Heavy Duty Trucks	Diesel	Rigid 28 - 32 t	Euro III	0	0	0	44,233	44,158	31,513	32,277	32,791	28,173
Heavy Duty Trucks	Diesel	Rigid 28 - 32 t	Euro IV	0	0	0	0	32,336	36,285	38,034	37,970	36,274
Heavy Duty Trucks	Diesel	Rigid 28 - 32 t	Euro VI	0	0	0	0	0	27,368	27,700	29,085	28,268
Heavy Duty Trucks	Diesel	Rigid >32 t	Conventional	56,041	42,637	35,660	24,820	21,715	15,211	15,005	14,143	13,561
Heavy Duty Trucks	Diesel	Rigid >32 t	Euro I	0	37,622	46,517	35,263	27,280	19,124	18,760	18,522	17,378
Heavy Duty Trucks	Diesel	Rigid >32 t	Euro II	0	0	45,124	42,893	34,472	22,603	21,825	21,058	19,511
Heavy Duty Trucks	Diesel	Rigid >32 t	Euro III	0	0	0	37,616	43,093	33,887	32,301	31,217	29,561
Heavy Duty Trucks	Diesel	Rigid >32 t	Euro IV	0	0	0	0	34,715	39,113	40,572	39,584	37,570
Heavy Duty Trucks	Diesel	Rigid >32 t	Euro V	0	0	0	0	32,935	41,805	47,240	51,974	49,126

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2015	2016	2017	2018
Heavy Duty Trucks	Diesel	Rigid >32 t	Euro VI	0	0	0	0	0	24,356	25,849	27,171	27,584
Heavy Duty Trucks	Diesel	Articulated 14 - 20 t	Conventional	117,286	70,908	42,679	23,933	20,692	15,091	14,321	13,179	12,280
Heavy Duty Trucks	Diesel	Articulated 14 - 20 t	Euro I	0	86,181	84,921	40,352	28,856	19,269	18,972	18,494	17,384
Heavy Duty Trucks	Diesel	Articulated 14 - 20 t	Euro II	0	0	101,604	69,459	38,180	25,559	24,690	23,252	21,440
Heavy Duty Trucks	Diesel	Articulated 14 - 20 t	Euro III	0	0	0	81,284	86,352	60,755	60,778	56,723	54,377
Heavy Duty Trucks	Diesel	Articulated 14 - 20 t	Euro IV	0	0	0	0	78,894	74,490	71,566	68,075	65,175
Heavy Duty Trucks	Diesel	Articulated 14 - 20 t	Euro V	0	0	0	0	76,426	82,561	84,609	82,578	79,021
Heavy Duty Trucks	Diesel	Articulated 14 - 20 t	Euro VI	0	0	0	0	0	72,625	78,695	78,592	76,641
Heavy Duty Trucks	Diesel	Articulated 20 - 28 t	Conventional	118,970	73,935	44,303	25,629	20,242	13,505	9,962	12,781	11,536
Heavy Duty Trucks	Diesel	Articulated 20 - 28 t	Euro I	0	0	90,093	41,915	29,739	0	0	0	0
Heavy Duty Trucks	Diesel	Articulated 20 - 28 t	Euro II	0	0	106,330	61,781	33,999	22,591	21,333	20,372	18,702
Heavy Duty Trucks	Diesel	Articulated 28 - 34 t	Conventional	102,534	49,295	29,271	16,773	15,794	9,046	10,080	7,459	6,248
Heavy Duty Trucks	Diesel	Articulated 28 - 34 t	Euro I	0	84,622	82,530	41,915	26,629	0	0	0	0
Heavy Duty Trucks	Diesel	Articulated 28 - 34 t	Euro II	0	0	100,269	68,342	36,715	24,619	23,318	22,892	21,388
Heavy Duty Trucks	Diesel	Articulated 34 - 40 t	Conventional	108,640	59,292	36,471	21,248	17,307	12,880	13,138	12,881	11,953
Heavy Duty Trucks	Diesel	Articulated 34 - 40 t	Euro I	0	86,657	80,650	38,884	28,390	0	0	0	0
Heavy Duty Trucks	Diesel	Articulated 34 - 40 t	Euro II	0	0	100,905	66,317	36,408	23,118	22,284	21,595	20,215
Heavy Duty Trucks	Diesel	Articulated 34 - 40 t	Euro III	0	0	0	79,462	0	0	0	0	0
Heavy Duty Trucks	Diesel	Articulated 40 - 50 t	Conventional	131,330	77,586	46,809	26,523	21,611	14,463	14,371	13,584	13,372
Heavy Duty Trucks	Diesel	Articulated 40 - 50 t	Euro I	0	86,506	79,543	39,053	28,057	19,024	18,754	17,964	16,635
Heavy Duty Trucks	Diesel	Articulated 40 - 50 t	Euro II	0	0	100,767	72,836	37,531	25,168	24,195	22,950	21,198
Heavy Duty Trucks	Diesel	Articulated 40 - 50 t	Euro III	0	0	0	84,586	81,320	54,883	54,210	51,003	47,811
Heavy Duty Trucks	Diesel	Articulated 40 - 50 t	Euro IV	0	0	0	0	83,862	72,190	69,562	66,664	63,837
Heavy Duty Trucks	Diesel	Articulated 50 - 60 t	Conventional	146,883	65,312	36,780	22,400	17,142	12,540	0	0	0
Heavy Duty Trucks	Diesel	Articulated 50 - 60 t	Euro II	0	0	97,034	0	0	0	0	0	0
Buses	Diesel	Urban Buses Midi <=15 t	Conventional	31,258	22,950	19,863	14,960	13,041	9,450	8,876	8,545	8,320
Buses	Diesel	Urban Buses Midi <=15 t	Euro I	0	21,443	32,155	24,139	20,659	14,572	13,380	13,060	11,908
Buses	Diesel	Urban Buses Midi <=15 t	Euro II	0	0	28,232	26,732	22,670	17,269	17,317	15,958	15,006
Buses	Diesel	Urban Buses Midi <=15 t	Euro III	0	0	0	34,698	30,330	24,954	24,027	23,064	21,854
Buses	Diesel	Urban Buses Midi <=15 t	Euro IV	0	0	0	0	23,141	24,126	24,462	24,354	22,509
Buses	Diesel	Urban Buses Midi <=15 t	Euro V	0	0	0	0	15,499	21,877	22,492	23,327	23,314
Buses	Diesel	Urban Buses Midi <=15 t	Euro VI	0	0	0	0	0	15,209	15,075	15,757	16,167
Buses	Diesel	Urban Buses Standard 15 - 18 t	Conventional	64,660	38,235	28,526	21,002	18,465	13,584	13,160	12,927	12,413
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro I	0	66,439	57,762	38,030	26,597	15,740	15,421	18,042	15,619
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro II	0	0	91,984	60,199	36,504	25,360	23,432	20,691	19,168
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro III	0	0	0	161,370	53,412	32,328	31,494	30,448	28,987
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro IV	0	0	0	0	43,679	50,239	50,455	50,348	45,601
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro V	0	0	0	0	17,506	46,176	47,486	48,953	49,283
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro VI	0	0	0	0	0	41,470	17,631	20,497	28,409
Buses	Diesel	Urban Buses Articulated >18 t	Conventional	81,727	58,703	44,451	29,709	21,821	14,564	13,689	12,395	11,568
Buses	Diesel	Urban Buses Articulated >18 t	Euro I	0	60,556	64,396	44,727	32,285	17,444	16,118	15,452	15,056
Buses	Diesel	Urban Buses Articulated >18 t	Euro II	0	0	59,347	54,291	44,136	27,308	25,679	23,213	21,230
Buses	Diesel	Urban Buses Articulated >18 t	Euro III	0	0	0	45,881	54,633	38,447	37,310	35,419	32,393
Buses	Diesel	Urban Buses Articulated >18 t	Euro IV	0	0	0	0	54,263	55,414	54,710	51,824	48,231
Buses	Diesel	Urban Buses Articulated >18 t	Euro V	0	0	0	0	41,291	62,015	62,769	57,771	58,485
Buses	Diesel	Urban Buses Articulated >18 t	Euro VI	0	0	0	0	0	46,719	50,206	51,652	50,908
Buses	Diesel	Coaches Standard <=18 t	Conventional	64,660	38,235	28,526	21,002	18,465	13,584	13,160	12,927	12,413
Buses	Diesel	Coaches Standard <=18 t	Euro I	0	66,439	57,762	38,030	26,597	15,740	15,421	18,042	15,619
Buses	Diesel	Coaches Standard <=18 t	Euro II	0	0	91,984	60,199	36,504	25,360	23,432	20,691	19,168
Buses	Diesel	Coaches Standard <=18 t	Euro III	0	0	0	161,370	53,412	32,328	31,494	30,448	28,987
Buses	Diesel	Coaches Standard <=18 t	Euro IV	0	0	0	0	43,679	50,239	50,455	50,348	45,601
Buses	Diesel	Coaches Standard <=18 t	Euro V	0	0	0	0	17,506	46,176	47,486	48,953	49,283

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2015	2016	2017	2018
Buses	Diesel	Coaches Standard <=18 t	Euro VI	0	0	0	0	0	41,470	17,631	20,497	28,409
Buses	Diesel	Coaches Articulated >18 t	Conventional	81,727	58,703	44,451	29,709	21,821	14,564	13,689	12,395	11,568
Buses	Diesel	Coaches Articulated >18 t	Euro I	0	60,556	64,396	44,727	32,285	17,444	16,118	15,452	15,056
Buses	Diesel	Coaches Articulated >18 t	Euro II	0	0	59,347	54,291	44,136	27,308	25,679	23,213	21,230
Buses	Diesel	Coaches Articulated >18 t	Euro III	0	0	0	45,881	54,633	38,447	37,310	35,419	32,393
Buses	Diesel	Coaches Articulated >18 t	Euro IV	0	0	0	0	54,263	55,414	54,710	51,824	48,231
Buses	Diesel	Coaches Articulated >18 t	Euro V	0	0	0	0	41,291	62,015	62,769	57,771	58,485
Buses	Diesel	Coaches Articulated >18 t	Euro VI	0	0	0	0	0	46,719	50,206	51,652	50,908
Buses	CNG	Urban CNG Buses	Euro I	0	0	0	0	0	53,124	56,339	56,070	55,136
Buses	CNG	Urban CNG Buses	Euro II	0	0	1,204,723	336,960	155,692	160,615	0	0	0
Buses	CNG	Urban CNG Buses	Euro III	0	0	0	541,651	191,051	190,446	209,585	220,987	201,110
Buses	CNG	Urban CNG Buses	EEV	0	0	0	0	148,136	182,616	203,958	215,977	226,298
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Conventional	3,941	3,080	2,436	1,881	1,327	983	924	865	810
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 1	0	0	0	4,152	2,587	1,686	1,544	1,409	1,287
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 2	0	0	0	3,973	3,181	2,073	1,898	1,732	1,582
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 3	0	0	0	0	3,686	2,850	2,985	2,772	2,611
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 4	0	0	0	0	0	0	0	0	1,948
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Conventional	3,941	3,080	2,436	1,881	1,327	983	924	865	810
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 1	0	0	0	4,152	2,587	1,686	1,544	1,409	1,287
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 2	0	0	0	3,973	3,181	2,073	1,898	1,732	1,582
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 3	0	0	0	0	3,686	2,850	2,985	2,772	2,611
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 4	0	0	0	0	0	0	0	0	1,948
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Conventional	3,941	3,080	2,436	1,881	1,327	983	924	865	810
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 1	0	0	0	4,152	2,587	1,686	1,544	1,409	1,287
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 2	0	0	0	3,973	3,181	2,073	1,898	1,732	1,582
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 3	0	0	0	0	3,686	2,850	2,985	2,772	2,611
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 4	0	0	0	0	0	0	0	0	1,948
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Conventional	8,623	6,738	5,330	4,116	2,903	2,151	2,022	1,893	1,772
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 1	0	0	0	9,408	5,873	3,824	3,503	3,199	2,921
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 2	0	0	0	8,306	7,152	4,657	4,266	3,891	3,551
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 3	0	0	0	0	7,466	6,802	6,621	6,617	6,137
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 4	0	0	0	0	0	0	0	4,370	6,024
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Conventional	8,623	6,738	5,330	4,116	2,903	2,151	2,022	1,893	1,772
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 1	0	0	0	9,408	5,873	3,824	3,503	3,199	2,921
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 2	0	0	0	8,306	7,152	4,657	4,266	3,891	3,551
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 3	0	0	0	0	7,466	6,802	6,621	6,617	6,137
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 4	0	0	0	0	0	0	0	4,370	6,024
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Conventional	8,623	6,738	5,330	4,116	2,903	2,151	2,022	1,893	1,772
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 1	0	0	0	9,408	5,873	3,824	3,503	3,199	2,921
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 2	0	0	0	8,306	7,152	4,657	4,266	3,891	3,551
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 3	0	0	0	0	7,466	6,802	6,621	6,617	6,137
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 4	0	0	0	0	0	0	0	4,370	6,024

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	-	-	-
	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	-	-	-
	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	-	-	-
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	-	-	-
	Heat Pump	TJ	19	24	26	29	37	37	44	51	68	95	73	77	82	-	-	-
	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	-	-	-
	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	-	-	-
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	-	-	-
Wood and Wood Waste	Medium Boilers	TJ	-	-	-	-	-	665	400	458	598	433	452	525	520	-	-	-
	Ovens	TJ	-	-	-	-	-	1,870	1,065	1,005	1,158	860	775	821	745	-	-	-
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	-	-	-

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	-	-	-
	Condensing boilers	TJ	4,476	4,205	4,180	3,484	3,179	2,081	1,430	1,173	997	836	746	546	336	-	-	-
	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	-	-	-
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	-	-	-
	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	-	-	-
	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	-	-	-
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	-	-	-
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	-	-	-
	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	-	-	-
	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	-	-	-
	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	-	-	-
	Automatic Boilers	TJ	70	134	193	247	296	275	307	346	376	407	439	471	503	-	-	-
	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	-	-	-
	Reciprocating engines	TJ	611	611	576	522	513	506	513	530	532	541	560	569	578	-	-	-
	-	TJ	692	518	590	717	845	1,132	1,155	1,288	1,312	1,917	1,542	1,490	1,541	-	-	-
LPG	Medium Boilers	TJ	79	110	57	102	155	173	47	34	36	54	38	32	24	-	-	-
Natural Gas & Gas Work Gas	Medium Boilers	TJ	175	215	142	214	147	199	216	292	315	247	205	242	154	-	-	-
	Gas Turbines	TJ	173	169	179	179	304	316	322	313	146	181	209	213	239	-	-	-
Wood Waste	Medium boilers	TJ	-	-	-	-	-	100	159	129	202	130	60	60	60	-	-	-
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	-	-	-
Other Kerosene	-	TJ	56	32	39	45	39	30	33	30	25	26	21	23	12	-	-	-

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	Tractors, Others	TJ	6,107	6,105	5,761	5,219	5,133	5,059	5,131	5,295	5,323	5,406	5,604	5,690	5,777	-	-	-
	Fishing Vessels	TJ	2,875	2,399	2,347	2,883	2,958	2,571	2,541	2,596	2,118	1,893	1,915	1,789	1,826	-	-	-
Thick Fuel Oil	Fishing Vessels	TJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thin Fuel Oil	Fishing Vessels	TJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gasoline	Residential: 2-Stroke	TJ	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Agriculture: 4-Stroke	TJ	70	63	42	62	45	31	20	36	20	33	42	42	43	-	-	-
Other Kerosene	Commercial: mobile	TJ	0	0	1	5	1	2	2	4	0	2	0	0	0	-	-	-
	Residential: mobile	TJ	31	25	29	22	27	27	18	20	11	8	7	7	5	-	-	-

Table C-15: 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-16: 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
Aviation Gasoline	L	209	1,893	1,751	1,560	1,212	1,435	1,914	1,540	1,876	1,925	1,964
Jet Fuel	L	207	554,471	564,264	596,977	565,406	572,457	599,465	595,172	613,723	654,021	720,960

Fuel Sales		NAPFUE	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Aviation Gasoline	L	209	2,353	2,304	2,334	1,985	1,847	2,192	2,179	2,086	2,280	2,280
Jet Fuel	L	207	752,932	741,541	715,095	770,040	835,208	865,857	907,189	949,650	969,349	907,530

Fuel Sales		NAPFUE	2010	2011	2012	2013	2014	2015	2016	2017	2018
Aviation Gasoline	L	209	2,869	2,258	1,268	1,168	1,333	1,257	1,256	1,211	804
Jet Fuel	L	207	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

Annex D: Agriculture

***Table D-1:** Livestock numbers (thousand)*

Type		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Dairy cattle	Dairy cows	394	388	381	383	382	383	380	379	375	369	353	331	311	297	294
Non-dairy cattle	Beef calfs (<1 yr)	46	52	53	53	58	60	64	64	65	66	67	72	75	82	91
	Calfs M.Rep. (<1 yr)	186	185	182	176	167	162	155	151	149	149	144	140	137	141	140
	Calfs F Rep. (<1 yr)	177	178	178	174	164	158	152	152	155	165	174	180	186	186	187
	Males 1-2 yrs	112	114	114	108	103	103	105	101	95	86	82	81	80	80	79
	Beef Fem. 1-2 yrs	18	19	20	22	22	22	24	24	24	20	17	14	14	15	16
	Females rep. 1-2 yrs	111	115	112	109	106	109	112	109	108	116	127	135	136	133	135
	Steers (>2 yrs)	38	38	36	37	35	33	33	31	31	29	26	24	23	23	23
	Heifers Beef (>2 yrs)	4	5	7	9	10	10	9	9	9	7	6	6	8	8	8
	Heifers rep. (>2 yrs)	45	46	45	48	50	52	51	50	52	60	67	77	80	86	90
	non-dairy cows	242	245	238	241	252	273	296	316	332	338	345	352	362	371	382
Swine	Piglets (<20 kg)	727	756	756	750	735	726	703	701	695	691	663	626	591	571	570
	Fatt. Pigs (20-50 kg)	662	675	660	671	668	660	633	631	633	623	585	535	493	471	467
	Fatt. Pigs (50-80 kg)	525	545	544	539	532	525	505	496	492	498	483	446	402	374	373
	Fatt. Pigs (80-110 kg)	218	227	226	225	210	198	179	177	174	176	174	184	197	208	213
	Fatt. Pigs (> 110 kg)	44	46	46	47	45	44	40	39	38	38	38	43	42	43	40
	Boars (>50 kg)	26	28	27	28	28	26	24	23	23	22	20	19	17	16	14
	Sows, pregnant	210	219	218	220	216	211	204	204	202	201	195	197	196	198	194
	Sows, non-pregnant	124	131	135	136	134	132	127	128	127	127	124	111	91	73	67
Sheep	Ewes	2 292	2 293	2 257	2 268	2 303	2 339	2 376	2 368	2 367	2 388	2 410	2 388	2 328	2 282	2 273
	Other Ovine	663	725	789	794	811	817	813	802	834	840	733	506	299	204	216
	Lambs	307	326	320	300	279	278	292	297	301	307	319	320	330	324	329
Goats	Does	614	588	556	538	528	517	509	498	485	472	460	440	417	392	382
	Other Caprine	149	156	166	160	153	151	147	151	154	151	129	91	62	48	52
	kids	47	49	47	44	45	41	41	36	37	36	33	30	29	28	28
Horses	Horses	33	38	40	42	44	48	52	54	56	57	58	59	59	58	56
Asses	Asses and Mules.	118	116	114	114	109	103	96	90	82	75	69	63	57	51	45
Poultry	Hens, reproductive	3 421	3 300	3 116	2 941	2 947	3 271	3 477	3 390	2 982	2 636	2 644	2 780	3 019	3 206	3 253
	Hens eggs	7 539	7 695	7 932	8 159	8 143	7 745	7 392	7 322	7 859	8 627	9 060	9 089	8 739	8 440	7 942
	Broilers	18 524	18 812	19 243	19 674	19 530	18 813	18 355	18 733	20 538	22 936	24 374	24 259	22 590	20 921	19 620
	Turkeys	1 149	1 122	1 082	1 041	996	945	936	972	1 061	1 158	1 208	1 201	1 139	1 077	963
	Other poultry	1 667	1 656	1 639	1 622	1 625	1 648	1 648	1 606	1 591	1 648	1 707	1 695	1 613	1 531	1 445
Other	Rabbits*	475	464	447	430	415	401	384	363	346	338	336	332	325	318	306
*Females reproductives																

Table D-1: Livestock numbers (thousand)

Type		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Dairy cattle	Dairy cows	290	284	275	269	263	255	247	241	236	233	235	238	240	239
Non-dairy cattle	Beef calfs (<1 yr)	104	108	108	108	109	114	120	125	119	113	112	114	114	115
	Calfs M.Rep. (<1 yr)	136	131	129	127	123	123	128	136	136	142	152	162	166	167
	Calfs F Rep. (<1 yr)	183	180	178	174	169	171	179	190	191	198	209	221	226	226
	Males 1-2 yrs	81	77	75	73	72	66	60	55	54	53	58	67	74	79
	Beef Fem. 1-2 yrs	17	17	16	17	18	20	19	20	19	17	15	14	14	16
	Females rep. 1-2 yrs	135	139	139	141	142	137	132	131	135	139	148	159	165	165
	Steers (>2 yrs)	25	28	31	33	34	38	41	44	42	39	37	38	45	53
	Heifers Beef (>2 yrs)	9	9	9	9	10	12	13	14	14	15	15	14	15	16
	Heifers rep. (>2 yrs)	94	96	96	97	102	110	111	110	105	103	96	92	90	94
	non-dairy cows	397	411	425	432	436	438	440	442	443	450	461	474	483	490
Swine	Piglets (<20 kg)	574	583	590	592	602	597	614	634	658	681	713	729	739	738
	Fatt. Pigs (20-50 kg)	467	466	468	464	460	448	446	455	464	472	485	490	488	471
	Fatt. Pigs (50-80 kg)	368	362	356	357	362	360	362	366	366	369	380	387	385	378
	Fatt. Pigs (80-110 kg)	214	221	222	227	237	244	251	255	263	273	285	294	301	311
	Fatt. Pigs (> 110 kg)	41	43	44	44	40	36	30	27	25	28	30	33	33	34
	Boars (>50 kg)	12	12	11	10	8	7	6	5	5	5	6	5	6	5
	Sows, pregnant	191	189	185	183	181	179	172	166	159	159	162	164	163	162
	Sows, non-pregnant	68	70	71	70	69	66	66	66	68	69	71	72	73	72
Sheep	Ewes	2 293	2 275	2 225	2 137	2 030	1 915	1 811	1 735	1 683	1 638	1 620	1 639	1,659	1,666
	Other Ovine	234	267	250	225	206	191	179	160	167	162	155	189	239	298
	Lambs	322	328	340	337	307	277	264	267	263	267	275	285	274	263
Goats	Does	380	380	373	365	358	356	353	349	342	333	324	311	298	285
	Other Caprine	57	65	59	52	44	40	38	35	36	35	37	34	33	35
	kids	26	25	28	30	31	29	29	28	27	25	23	22	21	20
Horses	Horses	52	49	47	46	42	38	36	34	33	32	30	30	29	29
Asses	Asses and Mules.	40	36	33	29	26	22	21	20	18	13	11	10	13	13
Poultry	Hens, reproductive	3 056	2 800	2 717	2 877	3 218	3 453	3 542	3 396	3 179	3 047	2 920	2 890	2,791	2,741
	Hens eggs	7 349	6 830	6 490	6 758	7 341	7 867	7 883	7 475	7 138	6 857	6 710	6 607	6,618	6,624
	Broilers	18 686	17 885	16 848	16 780	17 915	19 207	19 452	18 650	17 847	18 096	19 395	21 745	23,311	24 095
	Turkeys	798	799	1 017	1 318	1 485	1 445	1 331	1 144	956	836	785	800	811	816
	Other poultry	1 353	1 314	1 332	1 414	1 504	1 522	1 460	1 319	1 178	1 164	1 284	1 530	1,695	1,777
Other	Rabbits*	289	270	254	251	255	255	243	218	193	170	148	128	114	107

*Females reproductives

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
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
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
Sheep	25 391	25 809	25 910	26 037	26 474	26 837	27 154	27 006	27 213	27 444	26 943	25 237	23 319	22 270	22 274
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
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
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
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
Poultry	17 889	18 060	18 316	18 568	18 430	17 839	17 407	17 523	18 745	20 483	21 574	21 577	20 503	19 454	18 288
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
Total	160 219	162 013	160 634	159 783	160 441	162 188	162 942	163 899	166 291	171 799	173 372	170 090	166 239	161 744	161 346

Type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Dairy cattle	33 467	32 919	31 822	31 289	30 783	29 845	28 894	28 329	27 683	27 532	27 760	27,982	28,173	28,069
Non-dairy cattle	61 310	62 868	64 220	65 270	66 149	67 256	68 282	69 532	70 408	71 033	72 758	75 474	77 877	79 759
Sheep	22 565	22 621	22 054	21 087	19 975	18 824	17 793	16 970	16 529	16 090	15 878	16 250	16 789	17 241
Goats	3 041	3 094	3 004	2 898	2 793	2 758	2 717	2 670	2 631	2 570	2 513	2 403	2 308	2 224
Horses	2 273	2 141	2 083	2 009	1 833	1 672	1 569	1 511	1 437	1 393	1 335	1,311	1,273	1 293
Asses & Mules	880	785	726	645	565	491	455	433	389	293	242	230	277	295
Swine	19 190	19 248	19 183	19 131	19 114	18 836	18 696	18 703	18 820	19 133	19 739	20 104	20 184	20 018
Poultry	17 053	16 174	15 721	16 417	17 785	18 818	18 784	17 721	16 691	16 361	16 765	17,863	18 631	19 015
Rabbits*	2 599	2 429	2 290	2 256	2 294	2 295	2 184	1 962	1 741	1 531	1 334	1,149	1 026	965
Total	162 379	162 279	161 103	161 003	161 291	160 795	159 374	157 831	156 335	155 937	158 323	162 766	166 539	168 878

*Per female cage

Table D-3: NH_3 emissions from housing, manure storage and manure application (kg.hd^{-1}.yr^{-1})

	1990	2000	2005	2010	2015	2016	2017	2018
Dairy cattle								
housing (slurry and solid)	6.40	7.46	7.83	7.66	7.72	7.69	7.69	7.69
storage (slurry and solid)	10.48	12.42	13.08	12.79	12.89	12.83	12.83	12.85
application (slurry and solid)	10.07	12.81	13.95	14.09	14.21	14.14	14.14	14.16
Non-dairy cattle								
housing (slurry and solid)	1.24	0.93	0.83	0.67	0.67	0.67	0.68	0.69
storage (slurry and solid)	1.59	1.24	1.13	0.93	0.93	0.93	0.94	0.95
application (slurry and solid)	1.03	0.92	0.88	0.76	0.76	0.76	0.77	0.78
Sows								
housing (slurry and solid)	5.18	5.09	4.51	4.47	4.60	4.61	4.62	4.62
storage (slurry and solid)	2.80	2.72	2.40	2.36	2.44	2.44	2.44	2.44
application (slurry and solid)	4.67	4.63	4.13	4.11	4.23	4.24	4.25	4.24
Other swine								
housing (slurry and solid)	1.76	1.71	1.70	1.67	1.61	1.61	1.60	1.60
storage (slurry and solid)	0.70	0.68	0.67	0.65	0.63	0.63	0.63	0.63
application (slurry and solid)	1.60	1.57	1.56	1.53	1.47	1.47	1.47	1.47
Sheep								
housing (slurry and solid)	0.19	0.14	0.12	0.09	0.09	0.09	0.09	0.09
storage (slurry and solid)	0.19	0.14	0.12	0.09	0.09	0.09	0.09	0.09
application (slurry and solid)	0.19	0.14	0.12	0.09	0.09	0.09	0.09	0.09
Goats								
housing (slurry and solid)	0.17	0.14	0.12	0.10	0.10	0.10	0.10	0.10
storage (slurry and solid)	0.15	0.12	0.11	0.09	0.09	0.09	0.09	0.09
application (slurry and solid)	0.15	0.12	0.11	0.09	0.09	0.09	0.09	0.09
Horses								
housing (slurry and solid)	2.58	1.82	1.28	0.63	0.67	0.67	0.66	0.65
storage (slurry and solid)	2.16	1.90	1.43	0.75	0.80	0.80	0.78	0.78
application (slurry and solid)	1.80	1.60	1.21	0.63	0.68	0.68	0.66	0.66
Mules & asses								
housing (slurry and solid)	2.58	1.82	1.28	0.63	0.67	0.67	0.66	0.65
storage (slurry and solid)	2.16	1.90	1.43	0.75	0.80	0.80	0.78	0.78
application (slurry and solid)	1.80	1.60	1.21	0.63	0.68	0.68	0.66	0.66
Hens								
housing (slurry and solid)	0.23	0.24	0.23	0.23	0.23	0.23	0.23	0.23
storage (slurry and solid)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
application (slurry and solid)	0.12	0.13	0.12	0.12	0.12	0.12	0.12	0.12
Broilers								
housing (slurry and solid)	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10
storage (slurry and solid)	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04
application (slurry and solid)	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Turkeys								
housing (slurry and solid)	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
application (slurry and solid)	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Other poultry								
housing (slurry and solid)	0.15	0.15	0.14	0.14	0.14	0.14	0.14	0.14
storage (slurry and solid)	0.05	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
Rabbits								
housing (slurry and solid)	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53
storage (slurry and solid)	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

Table D-4: 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
Ammonium nitrate (AN)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ammonium phosphate (MAP&DAP)	13.28	13.28	13.28	13.28	13.28	16.75	15.74	12.40	12.60	14.34	11.83	10.52	12.04	9.10	8.55
Ammonium sulphate (AS)	17.72	17.72	17.72	17.72	17.72	25.40	26.70	20.43	19.84	12.45	14.47	10.92	11.58	10.31	10.27
Calcium ammonia nitrate (CAN)	46.13	46.13	46.13	46.13	46.13	40.67	52.91	52.45	53.21	42.77	45.72	38.78	42.50	35.89	43.31
Urea	13.35	13.35	13.35	13.35	13.35	7.06	14. 07	15.26	7.75	14.51	20.52	17.53	10.07	9.23	8.20
Other NK & NPK	49.54	49.54	49.54	49.54	49.54	40.76	42.54	43.45	36.29	46.45	57.74	59.10	69.99	30.64	37.00
Other N	18.49	18.49	18.49	18.49	18.49	15.18	16 26	20.30	19.60	18.43	19.72	20.67	17.73	14.96	18.51
Total	158.50	158.50	158.50	158.50	158.50	145.82	168.23	164.29	149.30	148.94	170.01	157.51	163.90	110.13	125.84

Type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Ammonium nitrate (AN)	-	-	-	-	-	4.01	4.18	3.70	7.70	4.63	0.67	0.85	0.77	0.16
Ammonium phosphate (MAP&DAP)	-	-	-	-	1.01	0.54	0.21	1.37	2.04	1.17	0.58	1.94	2.10	1.75
Ammonium sulphate (AS)	10.30	4.22	5.86	2.54	1.95	3.06	0.00	0.00	0.00	1.20	1.80	1.91	1.71	1.32
Calcium ammonia nitrate (CAN)	29.68	19.21	34.63	26.75	27.18	34.99	23.49	17.62	25.38	18.55	17.89	21.76	16.52	19.78
Urea	11.85	20.45	21.98	26.01	24.06	13.85	22.19	20.88	15.57	25.40	30.52	30.20	28.39	25.41
Other NK & NPK	39.94	33.76	41.10	28.97	16.09	24.90	23.13	17.19	24.57	31.87	27.97	24.89	25.43	22.12
Other N	10.90	9.76	9.43	20.86	22.71	18.90	21.89	46.10	35.39	48.81	38.48	26.89	30.77	29.91
Total	102.66	87.39	113.01	105.13	97.29	100.25	95.09	106.86	110.64	131.64	117.91	108.44	105.68	100.45

Table D-5: 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
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	67.68	78.68
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	90.12	92.39
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	99.65	99.58
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	95.63	97.57
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	96.60	97.11
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	92.31	88.00
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	97.44	97.00
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	95.36	96.24
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	97.17	96.47
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	99.60	99.73
3 B 4 g iv	Manure management – Other poultry	98.93	98.90	98.86	98.83	98.79	98.75	98.68	98.59	98.63	98.66	98.63	98.60	98.57	98.46	98.93
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	98.60	98.65
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	96.60	96.86
3 D a 2 a	Animal manure applied to soil	87.56	86.34	85.65	85.54	84.19	84.69	84.34	84.27	83.94	83.75	83.06	82.63	80.91	79.30	87.56
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	96.60	96.86
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	96.60	96.86
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	91.35	92.91
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	96.60	96.86
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	96.60	96.86
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	96.86
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	98.74

Table D-5: Share (%) of the National emissions corresponding to the mainland territory

NFR code	Description	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
3 B 1 a	Manure management – Dairy cattle	65.96	65.19	65.06	64.91	63.53	62.55	62.40	61.18	61.47	61.97	62.55	62.34	61.92	60.96
3 B 1 b	Manure management – Non - Dairy cattle	89.63	89.39	89.27	89.03	88.46	88.16	88.22	87.58	87.76	88.25	88.17	88.56	88.56	88.25
3 B 2	Manure management – Sheep	99.62	99.65	99.67	99.73	99.66	99.64	99.63	99.62	99.66	99.66	99.66	99.66	99.73	99.73
3 B 3	Manure management – Swine	96.42	96.45	96.92	96.73	97.07	96.92	97.38	97.68	98.31	98.45	98.44	98.51	98.43	95.50
3 B 4 d	Manure management – Goats	96.63	96.37	97.27	97.46	97.41	96.42	96.61	96.78	96.98	96.34	96.25	96.25	95.88	100.00
3 B 4 e	Manure management –Horses	93.75	93.62	93.48	92.68	94.44	94.29	94.44	93.94	93.55	93.75	93.10	93.34	93.34	100.00
3 B 4 f	Manure management – Mules & asses	97.14	96.88	96.55	96.00	95.00	95.00	95.00	94.44	93.33	100.00	100.00	98.10	98.10	100.00
3 B 4 g i	Manure management – Laying hens	95.93	95.95	95.98	96.43	96.78	96.82	96.87	96.93	96.99	96.95	96.91	96.87	96.87	96.87
3 B 4 g ii	Manure management – Broilers	96.80	96.08	95.24	96.35	97.20	97.12	97.03	96.94	96.84	97.09	97.29	97.45	97.45	97.45
3 B 4 g iii	Manure management – Turkeys	99.33	99.72	99.88	99.76	99.65	99.66	99.67	99.68	99.69	99.71	99.72	99.73	99.73	99.73
3 B 4 g iv	Manure management – Other poultry	98.36	98.42	98.47	98.52	98.57	98.53	98.49	98.43	98.36	98.75	99.01	99.20	99.20	99.20
3 B 4 h	Manure management – Other animals	98.28	98.18	98.07	97.75	97.47	97.47	97.49	97.50	97.52	97.57	97.64	97.74	97.74	97.74
3 D a 1	Inorganic N_Fertilizers	96.58	96.48	96.38	96.48	96.57	96.57	96.57	96.57	96.60	96.60	96.60	96.60	96.47	96.47
3 D a 2 a	Animal manure applied to soil	78.61	78.86	78.90	77.80	77.29	77.16	76.97	75.99	75.35	75.31	74.38	74.62	75.24	74.61
3 D a 2 b	Sewage sludge applied to soil	96.58	96.48	96.38	96.48	96.57	96.57	96.57	96.57	96.60	96.60	96.60	96.60	96.47	96.47
3 D a 2 c	Other organic fertilizers applied to soil	96.58	96.48	96.38	96.48	96.57	96.57	96.57	96.57	96.60	96.60	96.60	96.60	96.47	96.47
3 D a 3	Urine & dung deposited by grazing animals	91.31	91.08	91.17	90.93	90.80	90.43	90.53	90.18	90.15	91.20	91.17	90.97	90.85	92.06
3 D c	Farm level agricultural operations	96.58	96.48	96.38	96.48	96.57	96.57	96.57	96.57	96.60	96.60	96.60	96.60	96.47	96.47
3 D e	Cultivated crops	96.58	96.48	96.38	96.48	96.57	96.57	96.57	96.57	96.60	96.60	96.60	96.60	96.47	96.47
3D f	Use of pesticides	96.58	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
3 F	Field burning of agricultural residues	98.23	98.18	98.04	98.13	98.05	97.97	97.92	97.94	97.45	97.45	97.36	97.35	96.47	96.77

Annex E: Waste (NFR 5)

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.	Urban 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.	Urban 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

Notes:
Sources: INE; APA; 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	711.9	0	661.6	0	**1990**	1,112.7	29	1053.7	31
1961	722.6	0	671.8	0	**1991**	1,135.0	34	1075.0	36
1962	733.4	0	682.3	0	**1992**	1,157.7	34	1097.0	36
1963	744.4	0	692.9	0	**1993**	1,180.8	34	1119.4	36
1964	755.6	0	703.6	0	**1994**	1,204.4	39	1141.5	40
1965	766.9	0	714.6	0	**1995**	1,228.5	39	1165.4	40
1966	778.4	0	725.6	0	**1996**	1,253.1	40	1190.1	41
1967	790.1	0	736.9	0	**1997**	1,278.2	44	1215.1	46
1968	801.9	0	748.4	0	**1998**	1,303.7	60	1240.4	62
1969	814.0	0	760.0	0	**1999**	1,329.8	74	1265.5	74
1970	826.2	0	771.8	0	**2000**	1,137.8	82	1068.8	83
1971	838.6	0	784.5	0	**2001**	945.9	86	882.4	86
1972	851.1	0	797.4	0	**2002**	753.9	99	715.1	100
1973	863.9	0	810.5	0	**2003**	684.2	99	655.0	100
1974	876.9	0	823.7	0	**2004**	606.1	99	579.6	100
1975	890.0	0	837.1	0	**2005**	528.0	100	506.1	100
1976	903.4	0	850.7	0	**2006**	449.9	100	433.1	100
1977	916.9	0	864.5	0	**2007**	371.8	100	358.0	100
1978	930.7	0	878.5	0	**2008**	293.7	100	283.1	100
1979	944.6	0	892.7	0	**2009**	250.5	100	239.3	100
1980	958.8	28	905.3	29	**2010**	225.6	100	217.0	100
1981	973.2	28	920.1	30	**2011**	273.9	100	262.6	100
1982	987.8	28	934.1	30	**2012**	235.7	100	225.0	100
1983	1,002.6	28	948.3	30	**2013**	187.7	100	179.7	100
1984	1,017.6	28	962.7	30	**2014**	168.4	100	161.4	100
1985	1,032.9	29	977.4	30	**2015**	164.1	100	157.8	100
1986	1,048.4	29	992.2	30	**2016**	192.2	100	184.5	100
1987	1,064.1	29	1007.3	30	**2017**	168.7	100	162.5	100
1988	1,080.1	29	1022.6	30	**2018**	183.4	100	177.5	100
1989	1,096.3	29	1038.1	31	**2019**	-	-	-	-

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	*24*	*95*	-	-
1991	*12.1*	100	*24*	*95*	-	-
1992	*12.1*	100	*25*	*95*	-	-
1993	*12.1*	100	*25*	*95*	-	-
1994	*12.1*	100	*26*	*95*	-	-
1995	12.1	100	*27*	*95*	-	-
1996	13.5	100	*27*	*95*	-	-
1997	15.7	100	*28*	*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

Note: Estimates in italics
Sources: APA; DGS

Annex F: Information on inclusion/exclusion of the condensable component from PM_{10} and $PM_{2.5}$ emission factors

Annex Table 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 2016
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	unclear	unclear	EMEP/EEA Guidebook 2016
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 2016
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	unclear	unclear	EMEP/EEA Guidebook 2016
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	unclear	unclear	EMEP/EEA Guidebook 2016
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 2016
1A3dii	National navigation (shipping)	not mentioned	not mentioned	EMEP/EEA Guidebook 2016
1A4ai	Commercial/institutional: Stationary	✓		EMEP/EEA Guidebook 2016
1A4bi	Residential: Stationary	✓		EMEP/EEA Guidebook 2016
1A4ci	Agriculture/Forestry/Fishing: Stationary	✓		EMEP/EEA Guidebook 2016
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	✓		EMEP/EEA Guidebook 2016
1A4ciii	Agriculture/Forestry/Fishing: National fishing	not mentioned	not mentioned	EMEP/EEA Guidebook 2016
1B2aiv	Fugitive emissions oil: Refining / storage	not mentioned	not mentioned	EMEP/EEA Guidebook 2016

NFR Code	Source/Sector name	PM emissions: the condensable component is included	PM emissions: the condensable component is excluded	EF reference and comments
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 2016
2A3	Glass production	not mentioned	not mentioned	EMEP/EEA Guidebook 2016
2A5a	Quarrying and mining of minerals other than coal	not mentioned	not mentioned	EMEP/EEA Guidebook 2016
2A5b	Construction and demolition	not mentioned	not mentioned	EMEP/EEA Guidebook 2016
2A5c	Storage, handling and transport of mineral products	not mentioned	not mentioned	EMEP/EEA Guidebook 2016
2B6	Titanium dioxide production	not mentioned	not mentioned	EMEP/EEA Guidebook 2016
2B10a	Chemical industry: Other (please specify in the IIR)	not mentioned	not mentioned	USEPA AP-42 and EMEP/EEA Guidebook 2016 and Plant specific monitoring data
2C1	Iron and steel production	unknown	unknown	USEPA AP-42
2C1	Iron and steel production - Sinter		✓	EMEP/EEA Guidebook 2016
2C3	Aluminium production		✓	EMEP/EEA Guidebook 2016
2C5	Lead production		✓	EMEP/EEA Guidebook 2016
2C7a	Copper production		✓	EMEP/EEA Guidebook 2016
2C7d	Storage, handling and transport of metal products (please specify in the IIR)	not mentioned	not mentioned	EMEP/EEA Guidebook 2016
2D3b	Road paving with asphalt	unknown	unknown	USEPA (2000)
2D3c	Asphalt roofing	not mentioned	not mentioned	EMEP/EEA Guidebook 2016
2D3g	Chemical products	unknown	unknown	USEPA AP-42
2D3i	Other solvent use (please specify in the IIR)	not mentioned	not mentioned	EMEP/EEA Guidebook 2016
2G	Other product use (please specify in the IIR)	not mentioned	not mentioned	EMEP/EEA Guidebook 2016
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 2016
3B1b	Manure management - Non-dairy cattle	not mentioned	not mentioned	EMEP/EEA Guidebook 2016
3B2	Manure management - Sheep	not mentioned	not mentioned	EMEP/EEA Guidebook 2016
3B3	Manure management - Swine	not mentioned	not mentioned	EMEP/EEA Guidebook 2016
3B4d	Manure management - Goats	not mentioned	not mentioned	EMEP/EEA Guidebook 2016
3B4e	Manure management - Horses	not mentioned	not mentioned	EMEP/EEA Guidebook 2016
3B4f	Manure management - Mules and asses	not mentioned	not mentioned	EMEP/EEA Guidebook 2016
3B4gi	Manure mangement - Laying hens	not mentioned	not mentioned	EMEP/EEA Guidebook 2016
3B4gii	Manure mangement - Broilers	not mentioned	not mentioned	EMEP/EEA Guidebook 2016
3B4giii	Manure mangement - Turkeys	not mentioned	not mentioned	EMEP/EEA Guidebook 2016
3B4giv	Manure management - Other poultry	not mentioned	not mentioned	EMEP/EEA Guidebook 2016

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 2016
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	not mentioned	not mentioned	EMEP/EEA Guidebook 2016
3F	Field burning of agricultural residues	not mentioned	not mentioned	EMEP/EEA Guidebook 2016
5A	Biological treatment of waste - Solid waste disposal on land	not mentioned	not mentioned	EMEP/EEA Guidebook 2016
5C1bi	Industrial waste incineration	not mentioned	not mentioned	EMEP/EEA Guidebook 2016
5C1biii	Clinical waste incineration	not mentioned	not mentioned	EMEP/EEA Guidebook 2016
5C1bv	Cremation	not mentioned	not mentioned	EMEP/EEA Guidebook 2016
5E	Other waste (please specify in IIR)	not mentioned	not mentioned	Aasestad (2007)