AGÊNCIA PORTUGUESA DO AMBIENTE

PORTUGUESE INFORMATIVE INVENTORY REPORT 1990 – 2016

SUBMITTED UNDER

THE NEC DIRECTIVE (EU) 2016/2284 AND

THE UNECE CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR POLLUTION

Amadora

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Technical Reference

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

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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 2018 Portuguese submission includes inventory emission data provided in the latest version of the templates "NFR14", which accompanies this report.

This IIR refers to the 2018 Portuguese inventory submission on air pollutant emissions for the period 1990-2016. 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 for the first time BC), heavy metals and persistent organic pollutants (POPs).

The report was prepared by the Portuguese Environmental Agency (*Agência Portuguesa do Ambiente*), Ministry for the Environment, which is the national entity responsible for the overall coordination of the Portuguese inventory of air pollutants emissions.

Ministry for the Environment

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EXECUTIVE SUMMARY

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 2018 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.

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 1990-2016.

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.

Time coverage

Emissions are estimated for each civil year from 1990 to 2016.

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 centres 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.

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;

this report includes information both for the whole national territory and for Portugal Mainland.

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.

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.

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.

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	2014	2015	2016	% change 1990-2016
NOx	kt	259.8	289.6	289.5	279.0	201.8	165.5	167.9	161.0	-38.0
NMVOC	kt	222.9	219.9	224.0	193.3	162.9	156.5	157.4	153.7	-31.1
SOx	kt	323.8	330.6	265.3	193.5	67.7	46.0	47.1	46.8	-85.6
NH3	kt	81.8	75.1	77.6	62.9	57.1	55.9	56.6	56.3	-31.1
PM2.5	kt	59.8	61.9	67.1	62.4	51.3	47.6	47.7	47.5	-20.7
PM10	kt	87.0	98.0	100.5	102.0	78.6	62.6	64.1	65.0	-25.2
TSP	kt	180.1	238.9	251.6	289.0	199.9	135.7	141.8	148.0	-17.8
BC	kt	6.3	7.2	8.9	8.0	6.6	5.6	5.2	5.1	-19.6
CO	kt	728.4	788.2	666.8	513.4	400.3	326.2	333.9	322.0	-55.8
Pb	t	577.5	795.9	53.5	44.4	40.6	40.9	40.8	40.0	-93.1
Cd	t	6.4	6.7	6.5	7.3	4.9	4.9	4.6	3.6	-43.8
Hg	t	3.4	3.7	3.4	3.0	2.1	1.9	2.1	1.9	-44.8
As	t	2.9	3.1	3.1	3.1	1.7	1.7	1.8	1.6	-43.7
Cr	t	12.3	13.8	14.4	15.1	12.1	11.2	11.4	10.8	-12.7
Cu	t	23.4	29.4	38.5	38.6	36.5	31.4	31.6	31.3	34.0
Ni	t	108.5	111.9	100.0	95.5	44.7	23.2	23.2	22.4	-79.4
Se	t	12.2	17.0	23.4	26.7	30.2	32.1	31.7	31.7	159.3
Zn	t	72.5	79.0	94.6	97.2	93.3	95.0	95.7	97.4	34.4
DIOX	g I-TEQ	531.1	530.2	334.9	103.6	170.9	83.5	59.0	83.3	-84.3
PAHs	t	589.8	1053.3	1190.0	1721.2	1166.3	594.7	787.4	828.7	40.5
HCB	kg	58.7	73.8	100.3	107.8	111.7	83.9	87.9	48.6	-17.2
PCB	kg	2305.7	2666.2	2686.9	1213.7	1112.2	1105.1	1093.0	1095.5	-52.5

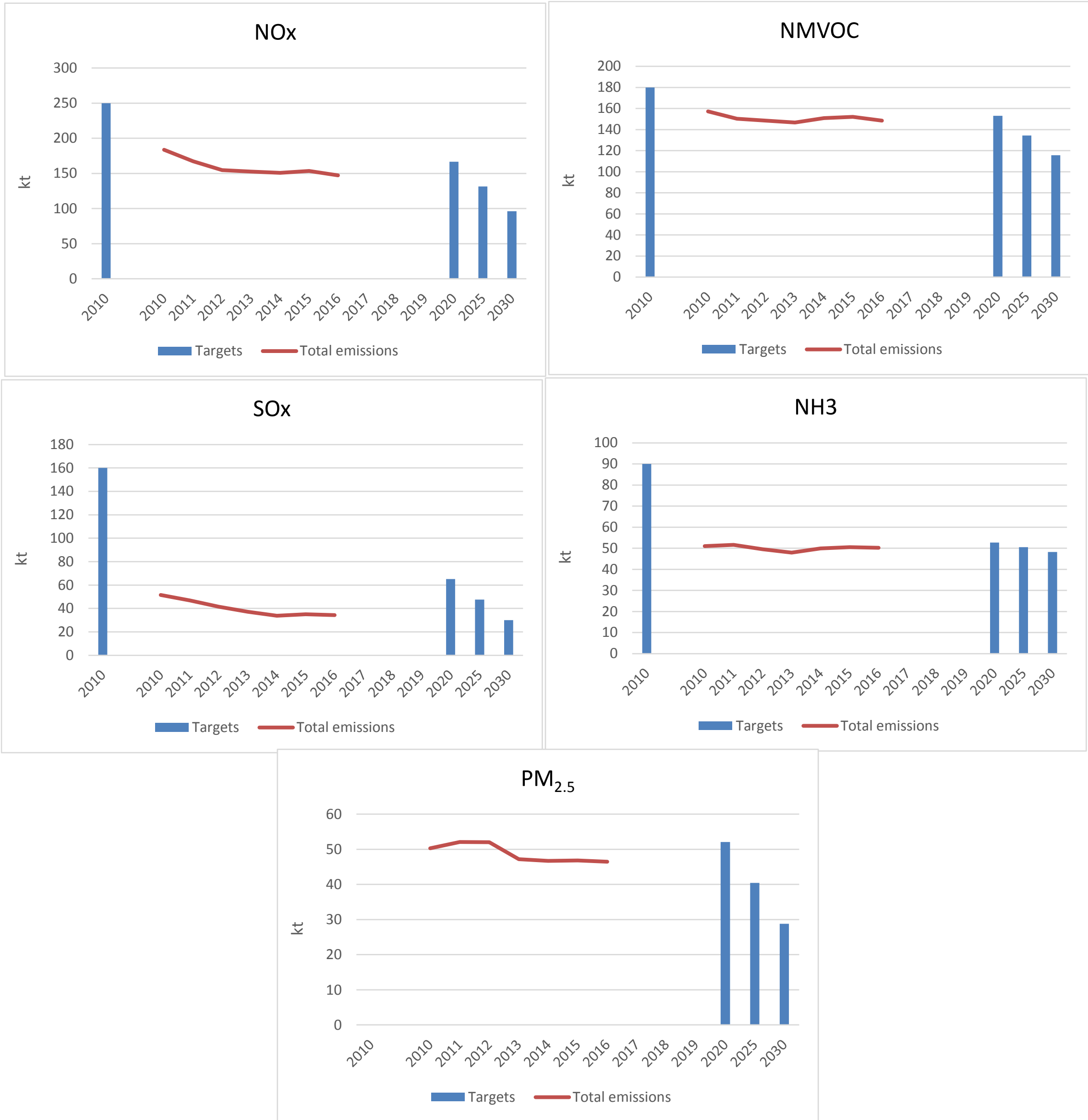
Table ES. 2 – Total emissions (Mainland)

Pollutant	Unit	1990	1995	2000	2005	2010	2014	2015	2016	% change 1990-2016
NOx	kt	249.6	277.3	274.3	260.4	183.8	150.7	153.7	147.4	-40.9
NMVOC	kt	217.2	213.4	216.2	186.7	157.3	151.0	152.1	148.5	-31.6
SOx	kt	315.9	321.0	252.7	176.2	51.5	33.7	35.1	34.4	-89.1
NH3	kt	76.6	69.7	71.3	56.7	51.0	49.9	50.5	50.2	-34.5
PM2.5	kt	59.2	61.1	66.2	61.3	50.3	46.7	46.8	46.5	-21.4
PM10	kt	85.7	96.5	99.1	100.5	77.1	61.4	63.0	63.8	-25.5
TSP	kt	177.4	236.0	249.5	286.6	197.7	134.1	140.3	146.4	-17.5
BC	kt	6.2	7.1	8.8	7.8	6.5	5.4	5.0	4.9	-21.1
CO	kt	720.4	773.8	652.5	501.5	390.6	319.4	327.1	315.3	-56.2
Pb	t	570.5	775.0	52.7	43.4	39.7	40.2	40.0	39.3	-93.1
Cd	t	6.3	6.6	6.4	7.1	4.7	4.7	4.5	3.4	-45.6
Hg	t	3.4	3.6	3.3	2.9	1.9	1.8	1.9	1.8	-47.3
As	t	2.8	3.1	3.0	2.9	1.6	1.5	1.7	1.5	-46.9
Cr	t	12.1	13.5	14.0	14.5	11.6	10.8	11.0	10.4	-14.6
Cu	t	23.0	28.9	37.6	37.4	35.0	30.3	30.5	30.2	31.0
Ni	t	104.8	107.6	94.1	87.2	36.7	17.0	17.1	15.9	-84.9
Se	t	12.2	17.0	23.4	26.6	30.1	32.1	31.7	31.7	159.4
Zn	t	72.2	78.5	93.8	96.2	92.1	94.0	94.7	96.4	33.5
DIOX	g I-TEQ	530.2	529.2	333.7	102.1	170.2	81.6	57.2	81.3	-84.7
PAHs	t	588.1	1051.7	1188.2	1719.3	1164.3	592.0	784.7	826.0	40.5
HCB	kg	58.7	73.8	100.3	107.8	111.6	83.8	87.9	48.6	-17.2
PCB	kg	2257.1	2617.3	2636.8	1162.6	1060.7	1054.5	1042.5	1045.2	-53.7

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. 3 – National emissions for compliance (Mainland Portugal)



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 are 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

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 (1990-2015), 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;
- In-depth NEC 2017 emission inventory review

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 2016.

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.

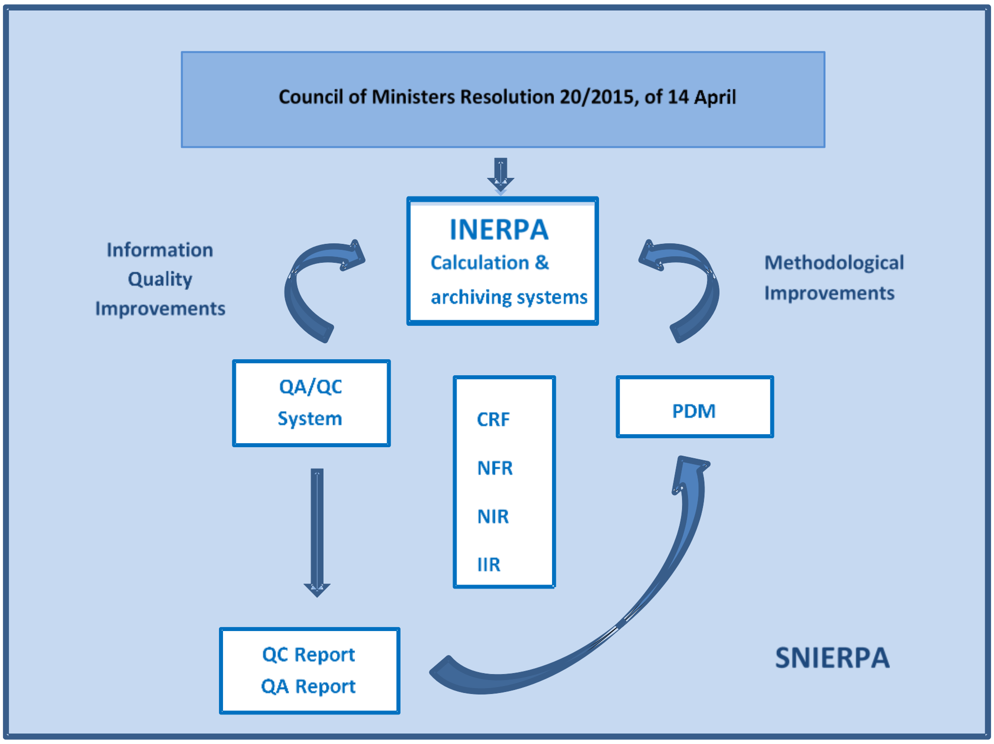
The principal objective of the SNIERPA is to prepare in a timely manner the National Inventory of Emissions by Sources and Removals by Sinks of Air Pollutants (INERPA), in accordance with the directives defined at international and EC levels, in order to make easier and more cost-effective the tasks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

The APA, is the Responsible Body responsible 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.

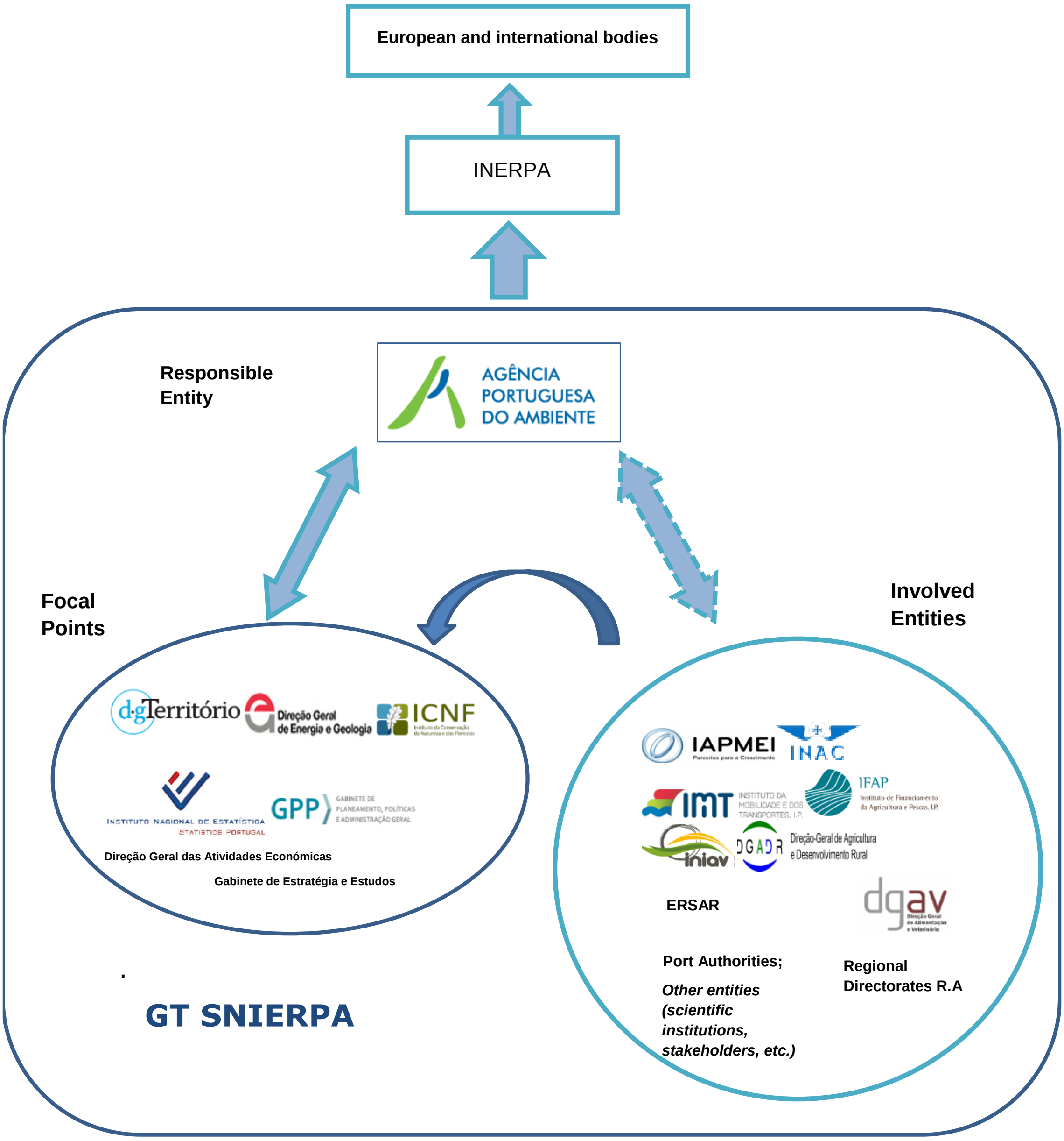
The involved entities are public or private bodies which generate or hold information which is relevant to the INERPA, and which actions are subordinate to the Focal Points or directly to the Responsible Body.

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.

Next figure presents the main entities that make part of the national system.

Figure 1.1 – 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:

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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.

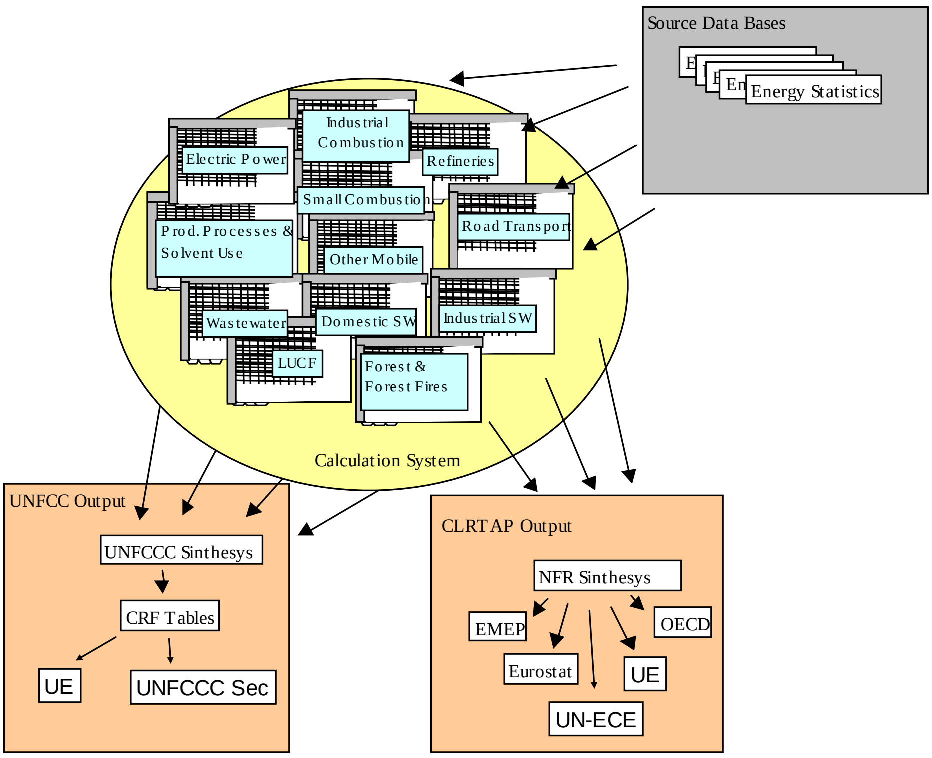
All calculation and reporting rely in a set of different Excel spreadsheet workbooks which had been developed in order that all information and calculations occur automatically. The structure of the information system is outlined in the figure below.

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 1.2 – 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 2016.

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 2016 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 2015 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 almost 80% of total NH_3 emissions in 2016.

For NMVCOs, key categories refer in majority to the IPPU sector (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.2 Food and beverages 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 Use of Chemical products (2.D.3.g) represents the bulk of PAHs emissions, and the waste sources are related to most of dioxins/furans and PCBs emissions with category 2.K (Consumption of POPs and heavy metals).

Table 1.3 – Key category analysis of 2015 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
1A1a	Public electricity and heat production	ENERGY	7.1% (L1, T1)		6.5% (L1, T1)		0.4% (T1)	0.4% (T1)	0.2% (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		3.8% (L1, T1)		28.9% (L1, T1)	3.5% (T1)					
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco									2.2% (T1)	
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals		10.2% (L1, T1)	6% (L1, T1)	14.7% (L1, T1)		9.4% (L1, T1)	6.9% (L1, T1)	10.6% (L1, T1)	10.2% (L1, T1)	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)		3.5% (L1)		2.5% (T1)					4.7% (L1, T1)	
1A3ai(i)	International aviation LTO (civil)		2.2% (T1)				2.4% (L1, T1)	1.7% (T1)		10.8% (L1, T1)	
1A3bi	Road transport: Passenger cars		16% (L1)	3.9% (L1, T1)		1.9% (T1)	2.3% (T1)			16.6% (L1, T1)	16.5% (L1, T1)
1A3bii	Road transport: Light duty vehicles		8.7% (L1, T1)							14.3% (L1)	
1A3biii	Road transport: Heavy duty vehicles and buses		15.3% (L1)				0.9% (T1)	0.7% (T1)		5.7% (L1, T1)	
1A3biv	Road transport: Mopeds & motorcycles			1.8% (T1)							3% (L1, T1)
1A3bv	Road transport: Gasoline evaporation			3.1% (L1, T1)							
1A3bvi	Road transport: Automobile tyre and brake wear							2.3% (L1, T1)			
1A3dii	National navigation (shipping)										
1A4bi	Residential: Stationary			8.9% (L1)	4.5% (L1)	4.5% (L1)	34.3% (L1, T1)	25.6% (L1, T1)	11.7% (L1, T1)	15.8% (L1, T1)	41.1% (L1, T1)
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery		9.9% (L1, T1)							5.2% (L1)	
1A4ciii	Agriculture/Forestry/Fishing: National fishing		2.7% (L1, T1)								
1B2ai	Fugitive emissions oil: Exploration, production, transport			1.9% (L1)							
1B2aiv	Fugitive emissions oil: Refining / storage				14.5% (L1, T1)						14% (L1, T1)
1B2av	Distribution of oil products			3% (L1)							
2A3	Glass production	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)					3% (L1, T1)	2.3% (L1, T1)			
2A5a	Quarrying and mining of minerals other than coal							3.5% (L1)	3.1% (L1)		
2A5b	Construction and demolition						0.2% (T1)	1.7% (T1)	2.4% (T1)		
2B10a	Chemical industry: Other (please specify in the IIR)					6.6% (L1)	10.8% (L1, T1)	7.9% (L1)	7.8% (L1)		
2C1	Iron and steel production										
2C3	Aluminium production										
2D3a	Domestic solvent use including fungicides			16.3% (L1, T1)							
2D3b	Road paving with asphalt						3.7% (L1)	17% (L1, T1)	41.5% (L1, T1)		
2D3d	Coating applications			11.5% (L1, T1)							
2D3g	Chemical products			12.2% (L1, T1)							
2D3h	Printing			2.8% (L1, T1)							
2D3i	Other solvent use (please specify in the IIR)			6.4% (L1, T1)							
2G	Other product use (please specify in the IIR)										
2H1	Pulp and paper industry		3.5% (L1, T1)	5.3% (L1, T1)	13.2% (L1, T1)		14.4% (L1, T1)	12.7% (L1, T1)	6.3% (L1, T1)		
2I	Wood processing								3% (T1)		
2K	Consumption of POPs and heavy metals (e.g. electrical and scientific equipment)										
3B1a	Manure management - Dairy cattle	AGRICULTURE				6.1% (L1, T1)					
3B2	Manure management - Sheep					0.7% (T1)					
3B3	Manure management - Swine					11.8% (L1, T1)					
3B4gi	Manure mangement - Laying hens					5.1% (L1, T1)					
3B4gii	Manure mangement - Broilers					6.2% (L1, T1)					
3B4h	Manure management - Other animals (please specify in IIR)					0.5% (T1)					
3Da1	Inorganic N-fertilizers (includes also urea application)					15.7% (L1, T1)					
3Da2a	Animal manure applied to soils					17.4% (L1)					
3Da3	Urine and dung deposited by grazing animals					9% (L1, T1)					
3F	Field burning of agricultural residues						3.3% (L1)	2.6% (L1)			8% (L1)
5A	Biological treatment of waste - Solid waste disposal on land	WASTE				2.6% (T1)					
5C1bi	Industrial waste incineration										
5C1biii	Clinical waste incineration										
	TOTAL	(%)	80.7	81.3	82.2	82.2	81.3	80.7	81.0	83.5	82.7

NFR sectors			Priority Heavy Metals (from 1990)			Additional Heavy Metals (from 1990, voluntary reporting)					
			Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
1A1a	Public electricity and heat production	ENERGY	6.9% (L1)	2.4% (T1)	39.7% (L1)	54.5% (L1)	6% (L1, T1)	3.6% (T1)	8.7% (L1, T1)	0.4% (T1)	
1A1b	Petroleum refining								2.1% (T1)		
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals					1% (T1)					
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print				25% (L1, T1)				12.2% (L1)		8.8% (L1, T1)
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco					1.8% (T1)			6.5% (L1)		
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals			49.4% (L1, T1)	3.1% (T1)	16% (L1, T1)	25.6% (L1)	5.6% (L1, T1)	22% (L1, T1)	1.3% (T1)	1.3% (T1)
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)			0.6% (T1)	1.6% (T1)	1.5% (T1)	0.5% (T1)		2% (T1)		
1A3ai(i)	International aviation LTO (civil)										
1A3bi	Road transport: Passenger cars		15.7% (L1, T1)					17.1% (L1, T1)			
1A3bii	Road transport: Light duty vehicles							5.3% (L1, T1)			
1A3biii	Road transport: Heavy duty vehicles and buses										
1A3biv	Road transport: Mopeds & motorcycles							2% (T1)			
1A3bv	Road transport: Gasoline evaporation										
1A3bvi	Road transport: Automobile tyre and brake wear						7% (L1, T1)	52.4% (L1, T1)			6.5% (L1)
1A3dii	National navigation (shipping)								6.3% (L1)		
1A4bi	Residential: Stationary			12.3% (L1)			7.2% (L1, T1)				17.1% (L1, T1)
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery										
1A4ciii	Agriculture/Forestry/Fishing: National fishing										
1B2ai	Fugitive emissions oil: Exploration, production, transport										
1B2aiv	Fugitive emissions oil: Refining / storage				4.4% (L1)						
1B2av	Distribution of oil products										
2A3	Glass production	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)	52.1% (L1, T1)	7.5% (L1, T1)	4.8% (L1, T1)	13.6% (L1, T1)	39.7% (L1, T1)		20.5% (L1, T1)	97.5% (L1, T1)	19.5% (L1, T1)
2A5a	Quarrying and mining of minerals other than coal										
2A5b	Construction and demolition										
2B10a	Chemical industry: Other (please specify in the IIR)										
2C1	Iron and steel production		9.3% (L1, T1)	8.2% (L1, T1)	3.7% (L1, T1)	4.5% (T1)		1.1% (T1)	6.3% (L1, T1)		31.7% (L1, T1)
2C3	Aluminium production										
2D3a	Domestic solvent use including fungicides										
2D3b	Road paving with asphalt										
2D3d	Coating applications										
2D3g	Chemical products										
2D3h	Printing										
2D3i	Other solvent use (please specify in the IIR)										
2G	Other product use (please specify in the IIR)			3.4% (T1)							
2H1	Pulp and paper industry										
2I	Wood processing										
2K	Consumption of POPs and heavy metals (e.g. electrical and scientific equipment)				5.5% (L1, T1)						
3B1a	Manure management - Dairy cattle	AGRICULTURE									
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										
3F	Field burning of agricultural residues			5.2% (L1)							
5A	Biological treatment of waste - Solid waste disposal on land	WASTE									
5C1bi	Industrial waste incineration										
5C1biii	Clinical waste incineration				0.1% (T1)						
	TOTAL	(%)	83.9	82.5	83.2	84.1	85.5	80.5	82.6	97.5	83.6

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		
1A1a	Public electricity and heat production	ENERGY							1.7% (T1)	
1A1b	Petroleum refining									
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals									
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print									
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco									
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals									
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)									
1A3ai(i)	International aviation LTO (civil)									
1A3bi	Road transport: Passenger cars									
1A3bii	Road transport: Light duty vehicles									
1A3biii	Road transport: Heavy duty vehicles and buses									
1A3biv	Road transport: Mopeds & motorcycles									
1A3bv	Road transport: Gasoline evaporation									
1A3bvi	Road transport: Automobile tyre and brake wear									
1A3dii	National navigation (shipping)									
1A4bi	Residential: Stationary		17.1% (L1, T1)							
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery									
1A4ciii	Agriculture/Forestry/Fishing: National fishing									
1B2ai	Fugitive emissions oil: Exploration, production, transport									
1B2aiv	Fugitive emissions oil: Refining / storage									
1B2av	Distribution of oil products									
2A3	Glass production	INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)								
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									0.5% (T1)
2C3	Aluminium production								97.8% (L1, T1)	
2D3a	Domestic solvent use including fungicides									
2D3b	Road paving with asphalt									
2D3d	Coating applications									
2D3g	Chemical products							86.4% (L1, T1)		
2D3h	Printing									
2D3i	Other solvent use (please specify in the IIR)									
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)									94% (L1, T1)
3B1a	Manure management - Dairy cattle	AGRICULTURE								
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									
3F	Field burning of agricultural residues							11.7% (T1)		
5A	Biological treatment of waste - Solid waste disposal on land	WASTE								
5C1bi	Industrial waste incineration		9.2% (L1, T1)							
5C1biii	Clinical waste incineration		59.9% (L1, T1)						0.3% (T1)	
	TOTAL	(%)	86.2					86.4	97.8	94.0

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 1.1).

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 CO2 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 gaseous 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 1 included in ANNEX A: COMPLETENESS AND KEY CATEGORIES, indicates the source categories/pollutants emissions reported as “NE” (Not Estimated). These situations result, in some cases, from a lack of methodological guidance (e.g. non-availability of EF). In other cases, they 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.

2 EMISSION TRENDS

SO_x emissions are generated in majority in the energy sector (~88% of total emissions in 2015) in 2016) which is a major consumer of fossil fuels. Within this sector, the combustion in manufacturing industries, with approximately 37% of national total emissions in 2016, and fugitive emissions from refining (~11% of national total emissions in 2016) represent the major sources.

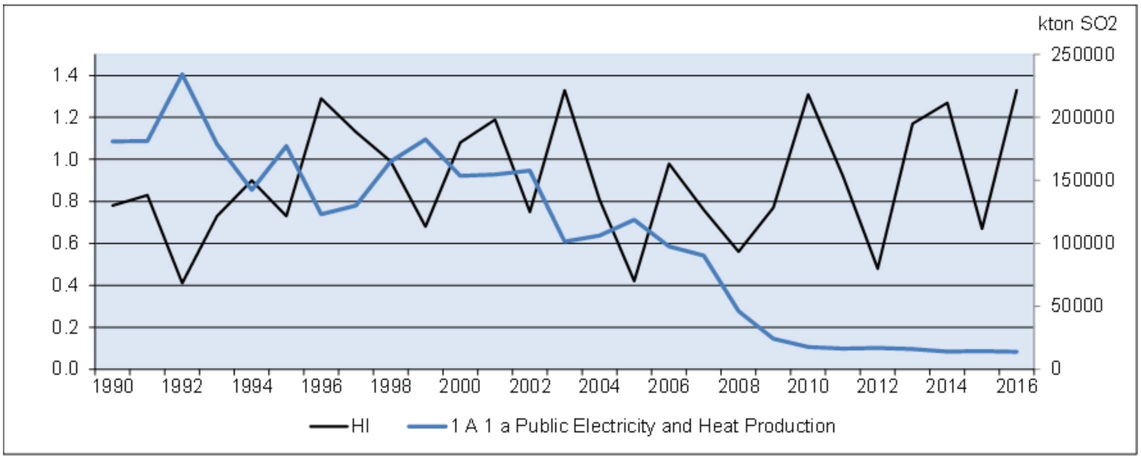
The variation of SOx emissions in the period 1990-2016 registered an overall trend variation of -85.6% for the same period, that resulted from the significant decrease of most of sub-categories: energy industries –93.0%, manufacturing industries –79.0%, transport -86.9% and combustion of other sectors -75.5%.

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).

SO_x emissions presented until the early 2000s 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 2016 as compared to 2007).

The 2016 year was characterized by an increase of the hydropower production due to a favorable year in terms of water availability (HPI = 1.33), contributing to a reduction of the use of coal in the electro producer.

Figure 2.1 – Hydraulic index and SO_2 emissions from Public Electricity and Heat Production



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

Energy is also the major responsible sector for emissions of NO_x, and CO, representing, respectively, approx. 93% and 88.5% of 2016 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. 46% for NO_x, 25.3% for CO and 11% for NMVOC of 2016 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 1990-2016 for NMVOC, CO and NOx emissions are, respectively, -81%, -81% and -32%.

Other sectors (commercial/institutional, residential and agriculture/ forestry) within energy, also amount for a significant share of CO: approx. 42% of 2016 totals.

NH_3 is primarily generated in biological systems, such as agriculture soil (44% of 2016 national totals), manure management systems (36% of 2016 national totals), chemical industry and decomposition of municipal wastes. Road transport represents a smaller amount of emissions with 1.8% of 2016 national total, but has grown significantly since 1990 (~900%). The overall evolution of ammonia in the period analysed is downwards with a -3511% variation between 1990 and 2016.

A significant share of particulate matter is generated in other sectors (residential) which represents approximately 35% of 2016 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 (-18%), and a negative trend for BC, (-20%), PM2.5 (-21%) and PM10 (-25%).

Figure 2.2 – Main pollutants and particulate matter total emissions

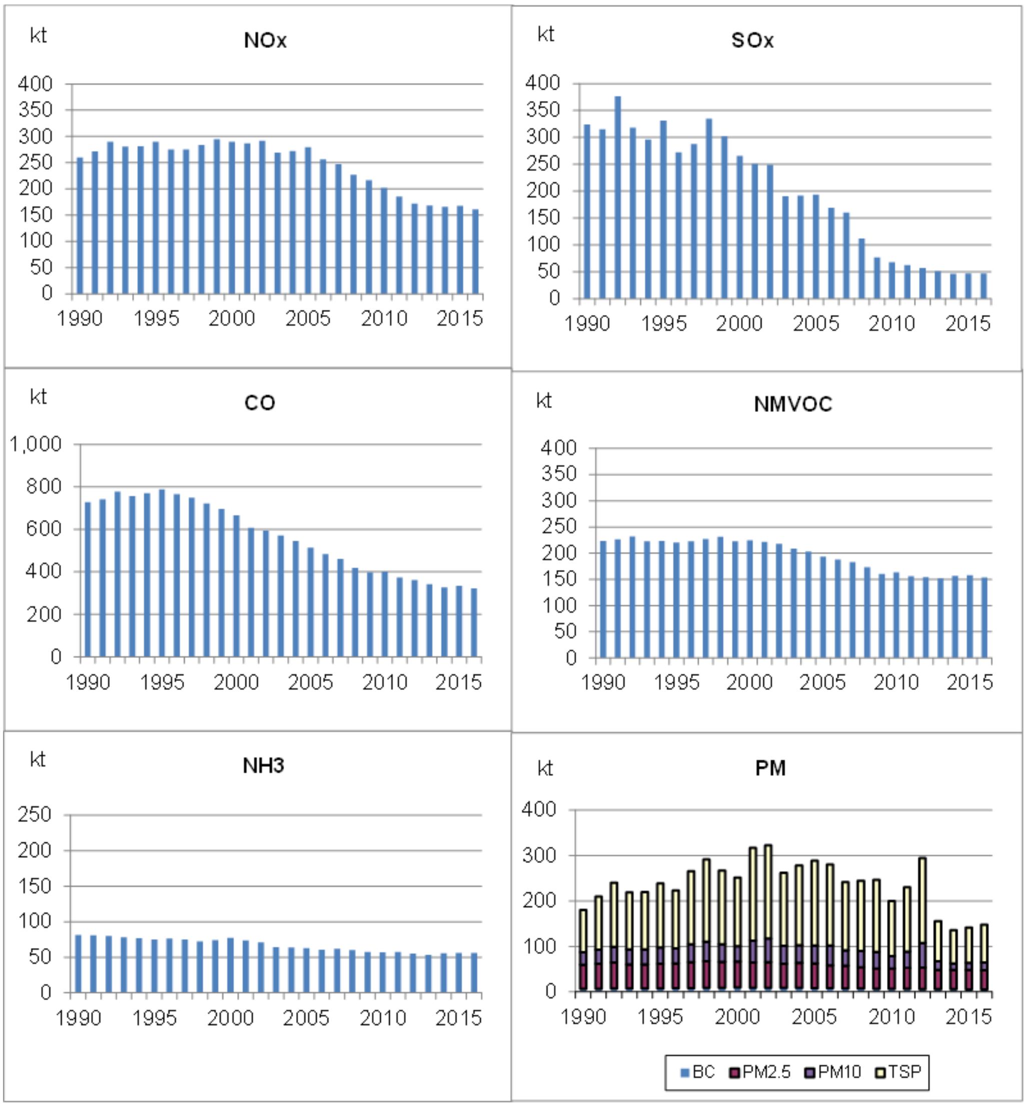


Figure 2.3 – Percentage variation of main pollutant emissions: 1990-2016 period

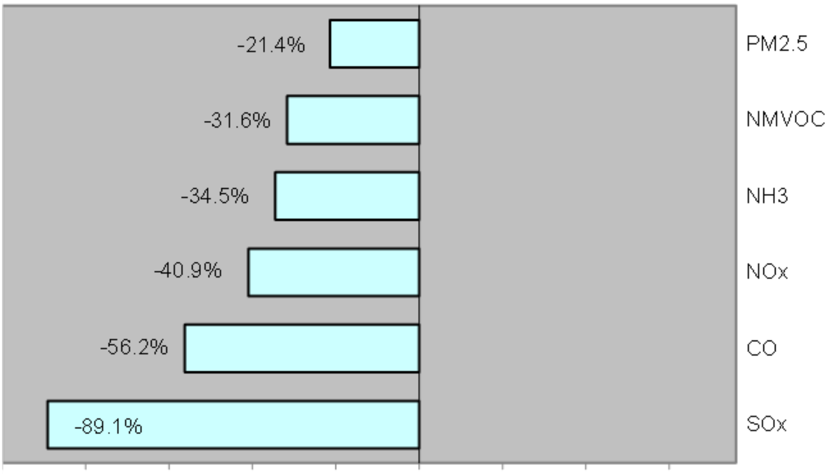
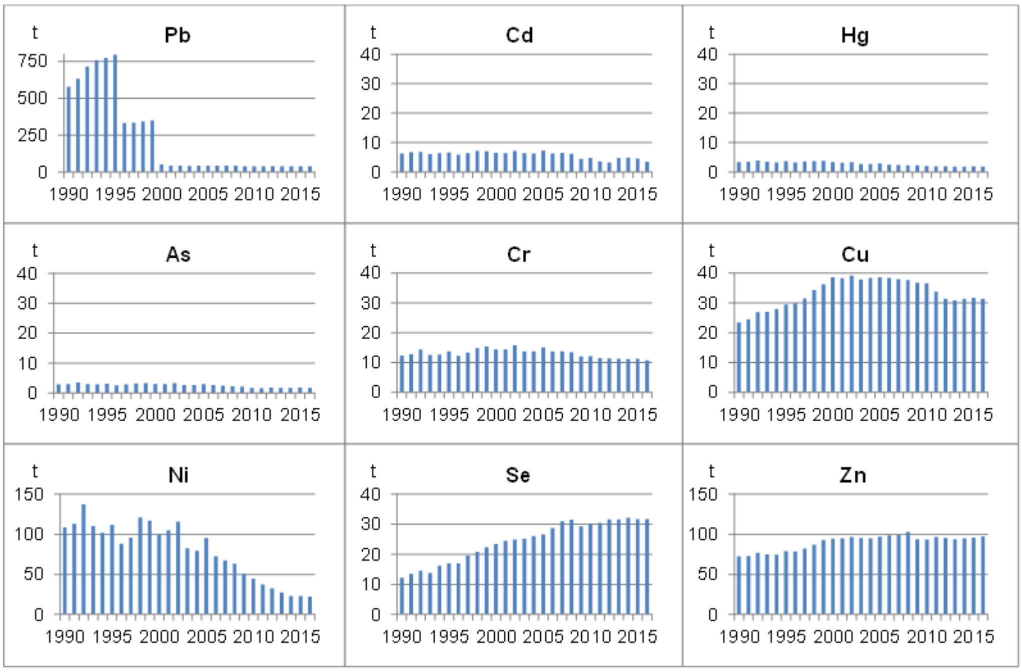


Table 2.1 – Main pollutants and particulate matter total emissions

	NOx kt	NMVOC kt	SOx kt	NH3 kt	PM2.5 kt	PM10 kt	TSP kt	BC kt	CO kt
1990	259.8	222.9	323.8	81.8	59.8	87.0	180.1	6.3	728.4
1991	271.5	225.9	314.8	81.2	62.1	93.2	209.9	6.6	741.3
1992	289.8	232.3	376.5	80.1	64.6	99.5	240.1	6.9	778.6
1993	280.6	222.5	317.9	78.4	60.8	93.6	219.1	6.8	757.8
1994	281.1	222.9	295.4	77.2	60.7	93.9	219.9	7.0	770.7
1995	289.6	219.9	330.6	75.1	61.9	98.0	238.9	7.2	788.2
1996	275.2	222.3	272.1	76.4	62.7	95.7	223.0	7.4	765.3
1997	275.3	227.0	287.1	75.2	65.7	104.6	265.7	7.9	749.0
1998	283.4	231.2	334.6	72.6	67.6	110.4	291.8	8.4	721.9
1999	294.3	222.5	301.5	74.5	66.5	105.1	266.5	8.5	696.9
2000	289.5	224.0	265.3	77.6	67.1	100.5	251.6	8.9	666.8
2001	286.7	220.9	250.3	73.8	65.1	112.8	316.9	8.7	608.3
2002	291.6	217.6	248.4	71.4	65.4	117.4	322.2	8.5	593.9
2003	268.9	208.0	190.0	64.6	62.1	101.4	261.6	8.2	572.1
2004	272.2	202.5	191.5	64.1	63.7	102.8	277.8	8.2	544.8
2005	279.0	193.3	193.5	62.9	62.4	102.0	289.0	8.0	513.4
2006	256.1	187.4	169.0	61.0	58.4	101.8	280.1	7.5	483.4
2007	247.1	182.9	160.1	62.5	57.4	91.4	241.4	7.3	460.5
2008	227.0	172.9	111.6	60.3	54.4	90.4	244.4	6.8	418.2
2009	216.6	160.4	76.6	57.7	51.3	88.3	246.1	6.6	397.8
2010	201.8	162.9	67.7	57.1	51.3	78.6	199.9	6.6	400.3
2011	185.0	155.7	62.2	57.6	53.1	89.0	230.1	6.5	372.6
2012	172.0	153.7	56.7	55.5	53.2	107.5	294.0	5.9	360.9
2013	168.5	151.8	51.2	53.9	48.1	67.4	155.7	5.7	342.2
2014	165.5	156.5	46.0	55.9	47.6	62.6	135.7	5.6	326.2
2015	167.9	157.4	47.1	56.6	47.7	64.1	141.8	5.2	333.9
2016	161.0	153.7	46.8	56.3	47.5	65.0	148.0	5.1	322.0

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 2016 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 and mercury 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 1990-2016. The growth of copper emissions is associated with road transportation, which represents around 79% of national total copper emissions in 2016. Selenium emissions are mostly related to the evolution of glass production sector (2.A.3), and zinc emissions (31%) 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: 1990-2016 period

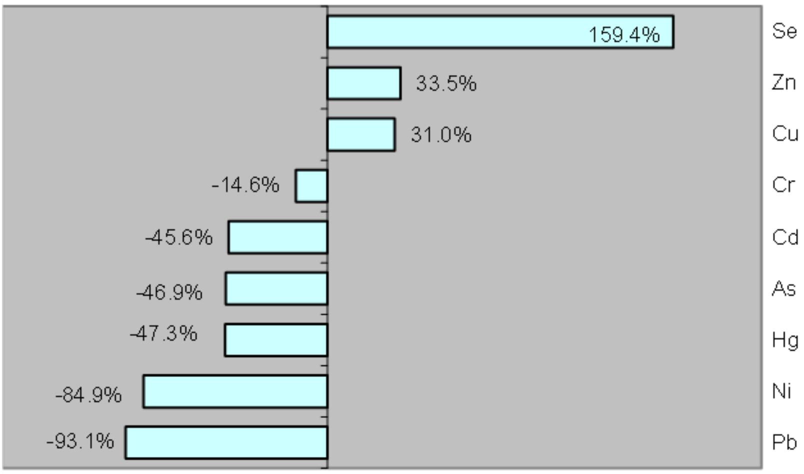


Table 2.2 – Heavy metals total emissions

	Pb t	Cd t	Hg t	As t	Cr t	Cu t	Ni t	Se t	Zn t
1990	577.5	6.4	3.4	2.9	12.3	23.4	108.5	12.2	72.5
1991	632.5	6.8	3.6	3.1	12.8	24.5	112.9	13.5	73.2
1992	713.7	6.9	4.0	3.6	14.5	26.9	137.3	14.6	77.0
1993	757.1	6.2	3.5	3.1	12.6	26.9	110.0	13.9	75.0
1994	775.8	6.5	3.4	2.8	12.7	27.9	101.6	16.3	74.7
1995	795.9	6.7	3.7	3.1	13.8	29.4	111.9	17.0	79.0
1996	332.1	6.0	3.3	2.6	12.3	29.9	88.1	17.1	78.8
1997	335.3	6.5	3.6	2.9	13.4	31.4	95.8	19.6	82.3
1998	345.0	7.2	3.8	3.3	14.9	34.3	120.9	20.9	87.1
1999	349.7	7.1	3.8	3.4	15.4	36.1	117.0	22.4	93.0
2000	53.5	6.5	3.4	3.1	14.4	38.5	100.0	23.4	94.6
2001	44.6	6.5	3.2	3.1	14.5	38.2	104.9	24.5	95.2
2002	44.4	7.2	3.5	3.4	15.8	39.2	116.0	24.9	96.8
2003	43.2	6.5	2.8	2.7	13.7	37.8	82.5	25.2	95.6
2004	44.2	6.4	2.8	2.7	13.8	38.3	79.7	26.1	95.0
2005	44.4	7.3	3.0	3.1	15.1	38.6	95.5	26.7	97.2
2006	44.8	6.3	2.6	2.6	13.8	38.3	72.8	28.8	98.5
2007	45.0	6.5	2.5	2.4	13.7	37.9	67.5	31.0	99.2
2008	44.5	6.2	2.3	2.2	13.5	37.5	63.5	31.5	102.8
2009	41.5	4.5	2.3	2.1	12.0	36.7	50.7	29.2	94.0
2010	40.6	4.9	2.1	1.7	12.1	36.5	44.7	30.2	93.3
2011	40.8	3.7	2.0	1.6	11.5	33.7	37.8	30.5	96.6
2012	41.1	3.3	2.0	1.8	11.4	31.4	32.8	31.6	95.5
2013	40.6	4.9	1.9	1.7	11.3	30.8	27.4	31.7	93.9
2014	40.9	4.9	1.9	1.7	11.2	31.4	23.2	32.1	95.0
2015	40.8	4.6	2.1	1.8	11.4	31.6	23.2	31.7	95.7
2016	40.0	3.6	1.9	1.6	10.8	31.3	22.4	31.7	97.4

Main sources of dioxines emissions refer to the incineration of waste (68% of 2016 national total emissions) and the combustion in the residential sector (17% of 2016 national total emissions). These emissions registered a decrease of -85%) in the period 1990-2016. Polycyclic aromatic hydrocarbons (PAH) emissions are related in majority to the use of chemical products in category 2D, and category 3.F Field burning of agricultural wastes and the combustion in the residential sector. HCBs emissions occur in majority in metal industry/ aluminium production, energy industries (1.A.1) and waste incineration sources (5.C) and. Polychlorobiphenyls (PCB) estimated emissions are related to the consumption of POPs and heavy metals (2K) and the incineration of industrial waste (5C).

Figure 2.6 – Persistent organic pollutant total emissions

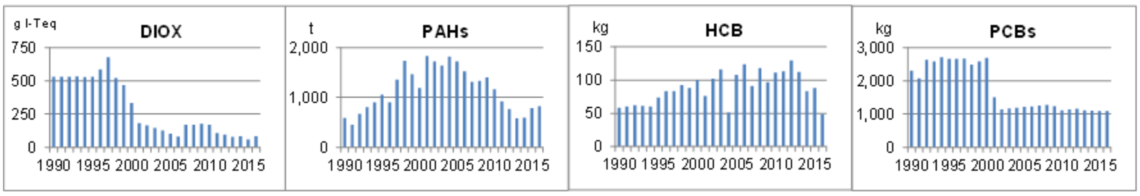


Figure 2.7 – Percentage variation of POP emissions: 1990-2016 period

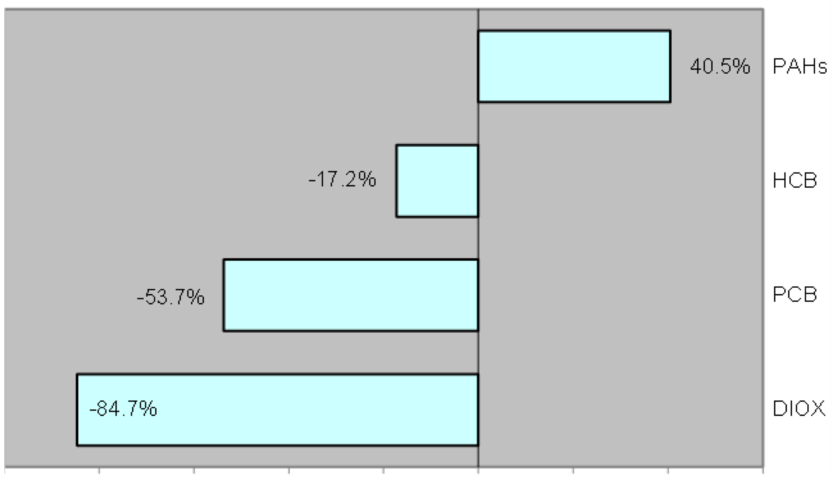


Table 2.3 – Persistent organic pollutant total emissions

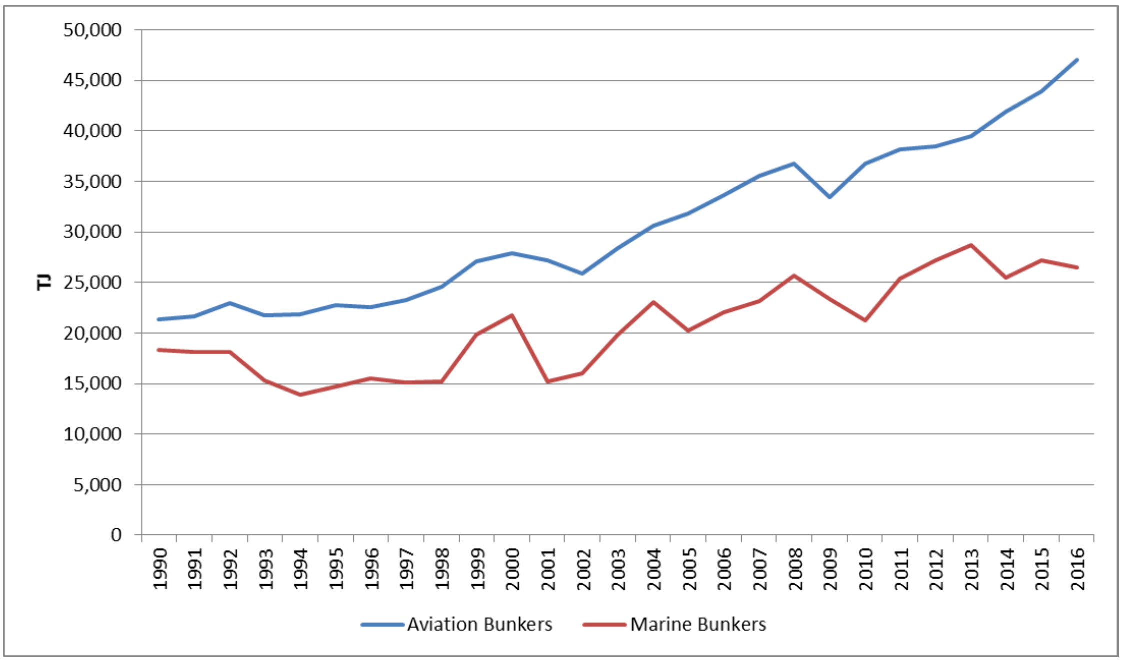
	DIOX g I-TEQ	PAHs t	HCB kg	PCB kg
1990	531.1	589.8	58.7	2,305.7
1991	530.3	455.5	60.5	2,072.5
1992	531.5	670.2	62.4	2,632.4
1993	532.3	807.7	61.2	2,585.6
1994	529.3	899.5	60.1	2,701.2
1995	530.2	1,053.3	73.8	2,666.2
1996	585.7	903.5	83.7	2,666.3
1997	675.7	1,357.9	83.2	2,671.4
1998	521.4	1,731.1	92.3	2,492.9
1999	467.1	1,468.1	88.2	2,584.4
2000	334.9	1,190.0	100.3	2,686.9
2001	180.7	1,829.5	76.2	1,507.6
2002	164.2	1,724.7	102.3	1,142.2
2003	147.9	1,638.9	116.4	1,171.9
2004	127.4	1,819.1	51.6	1,193.3
2005	103.6	1,721.2	107.8	1,213.7
2006	80.7	1,519.7	124.0	1,234.3
2007	171.2	1,313.1	91.3	1,254.9
2008	171.2	1,333.0	118.3	1,275.1
2009	176.9	1,400.7	96.8	1,242.9
2010	170.9	1,166.3	111.7	1,112.2
2011	107.4	924.4	113.2	1,134.2
2012	95.1	769.3	129.9	1,159.9
2013	77.0	581.3	112.1	1,110.1
2014	83.5	594.7	83.9	1,105.1
2015	59.0	787.4	87.9	1,093.0
2016	83.3	828.7	48.6	1,095.5

3 ENERGY (NFR 1)

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

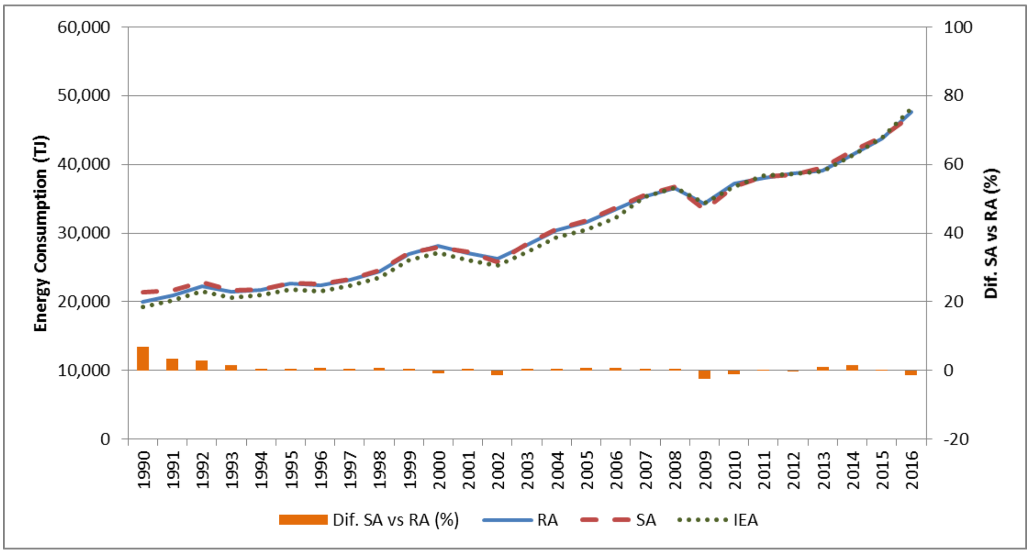


3.1.1 International aviation bunkers

The majority of jet fuel is used for international aviation. In 2016 the quantity of jet fuel for international aviation was about 88% 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



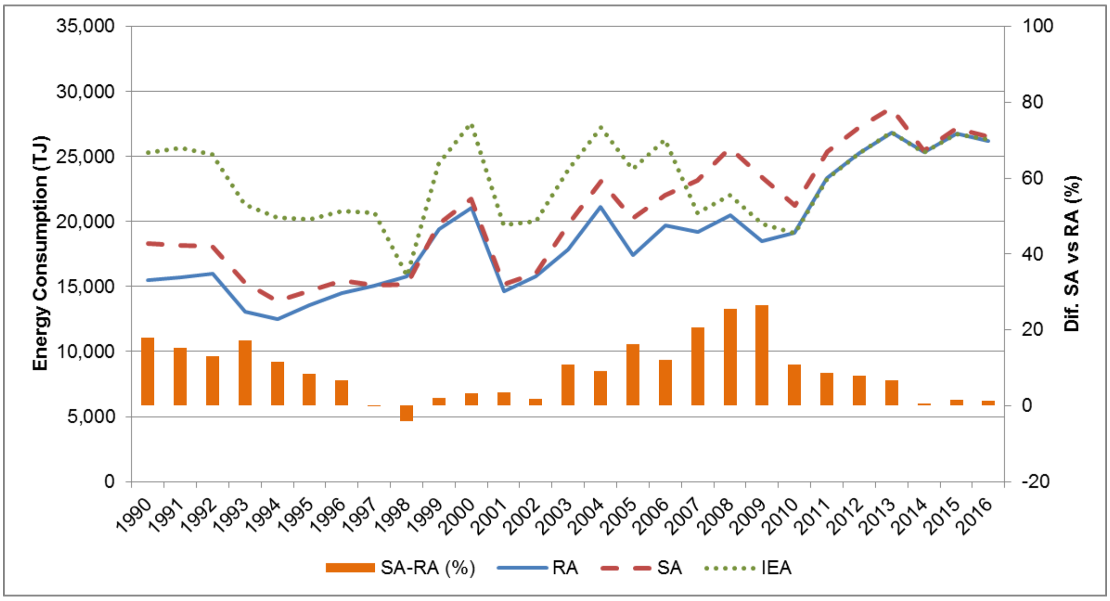
3.1.2 International marine bunkers

In 2016 the energy consumption for international navigation was about 89% 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 Category Sources

3.2.1 Energy Industries (NFR 1.A.1)

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

3.2.1.1.1 Overview

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

[1] TER – Termoeléctrica do Carregado

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.

3.2.1.1.1.1 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.

[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	Alhamdra	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.	-	-	-

Power Plant	Location	Start	Situation	Fuel***	Power	Technology	Treatment of Gas Effluents****	Stack Height (m)	Comments
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
**** WFGD – Wet Flue Gas Desulphurization; 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 begin its operation in 2011.

3.2.1.1.1.2 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:

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

This 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.

3.2.1.1.1.3 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

3.2.1.1.1.4 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.

3.2.1.1.2 Methodology

3.2.1.1.2.1 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 percentage);

$CF_{(f)}$ - 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 percentage).

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:

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

and,

$HM_{p\,(u,f,y)}$ - 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 percentage).

3.2.1.1.2.2 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:

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

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

$CO_2\ Emission_{(u,y)}$ – 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.

3.2.1.1.3 Emission Factors

3.2.1.1.3.1 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 function of 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 from Table 3.3 to Table 3.6. For most units (*Sines*, *Pêgo*, Carregado, Barreiro, Setúbal, *Turbogas and TER*) emission factors reflect actual monitoring data under *Autocontrolo* program.

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	310	1.5	16	5
Hard Coal	62 - 537	1.5	10	5
Fuel-oil	180 - 300	3.0	15	0
Orimulsion	300	3.0	15	0
Natural Gas	22 - 120	5.0	13 - 19	0
LPG	90	2.5	17	0
Biomass	70	150	500	0
Diesel (GT)	350	4.0	15	0
Diesel (Engine)	1 300	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)[1]	30	100	100	33.5
Diesel (Engine)	30	82.2	77.3	33.5

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

Table 3.5 – Emission Factors for energy production sector. Heavy Metals (g/t)

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

a) g/km^3

Table 3.6 – Emission Factors for energy production sector. Dioxins/Furans and PAHs

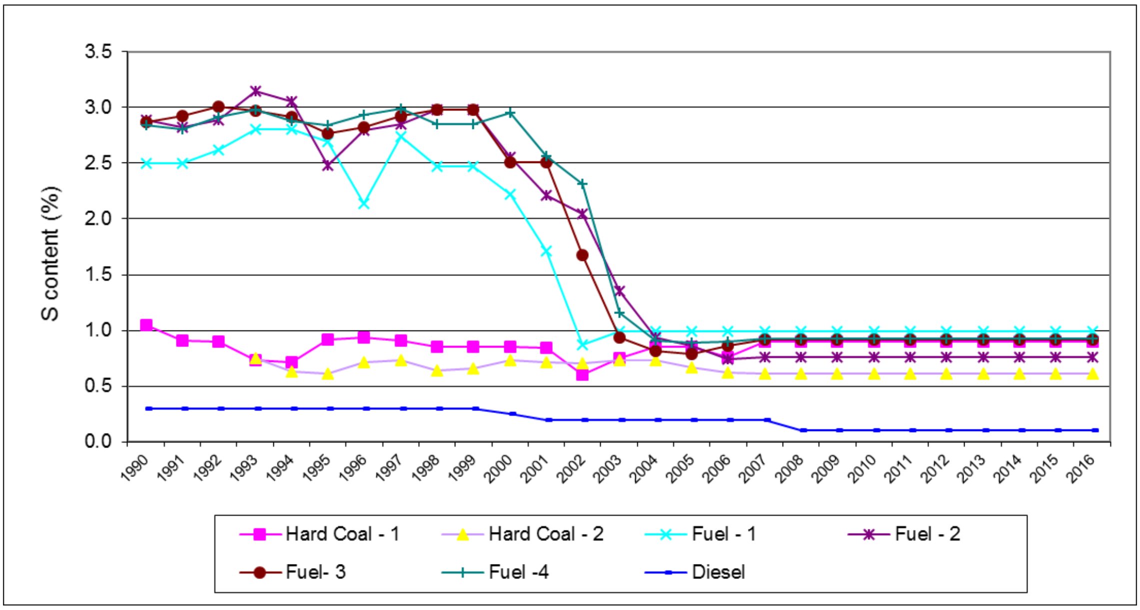
Fuel	DioxFur	PAH	PCBs	HCB
	microg TEQ/TJ	µg/GJ	µg/GJ	µg/GJ
Lignite	10	67.8	0.003	6.7
Hard Coal	10	69.4	0.003	6.7
Fuel-oil	3	15.9	-	-
Orimulsion	3	15.9	-	-
Natural Gas	1	3.1	-	-
LPG	-	3.1	-	-
Biomass	50	1.2	3.5	5
Diesel (GT)	1	6.9	-	-
Diesel (Engine)	1	6.9	-	-

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

[1] Mainly used in Gas Turbine plants

Average sulphur content for each fuel type has evolved along the 1990-2015 time series as shown in Figure 3.4 for the most important fuel types and power plants.

Figure 3.4 – Trends of sulphur content by fuel type[1]



3.2.1.1.3.2 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[2].

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

[2] Power producers as main activity only.

Table 3.7 – Emission Factors for thermo-electricity production in Azores and Madeira. Ozone Precursors and other pollutants.

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

Table 3.8 – Emission Factors for thermo-electricity production in Azores and Madeira. Particulate Matter

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

Table 3.9 – Emission Factors for thermo-electricity production in Azores and Madeira. Heavy Metals

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

Table 3.10 – Emission Factors for non public co-generation self producers. Ozone Precursors gases and other pollutants

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

Table 3.11 – Emission Factors for non public co-generation self producers. Particulate Matter

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

(a) According to sulphur content

Table 3.12 – Emission Factors for non public co-generation self producers. Heavy Metals

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

a) g/km^3

Table 3.13 – Emissions factors of Dioxins/Furans and PAH for for non public co-generation self producers

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

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

3.2.1.1.4 Activity Data

Activity data has different origins according to specific energy plants.

3.2.1.1.4.1 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*)[1];
- Plant activity reports from EDP;

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

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

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

or

Energy (GJ) = Consumption (Nm3/year) * LHV (MJ/Nm3)

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

Table 3.14 – Low Heating Value per fuel type

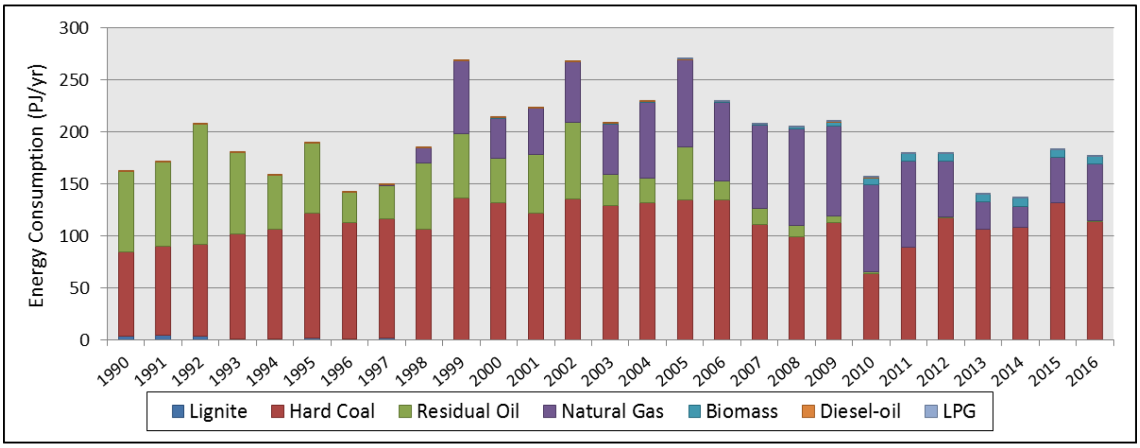
Fuel	LHV/NCV	
Lignite	16.42 (15.57 - 17.02)	MJ/kg
Hard Coal	25.62 (24.45 - 27.23)	MJ/kg
Fuel-oil	40.24 (39.42 - 41.61)	MJ/kg
Orimulsion	28.00	MJ/kg
Diesel oil	43.30	MJ/kg
Natural Gas	38.16 (36.02 - 39.16)	MJ/kNm^3
LPG	47.44 (47.28 - 48.55)	MJ/kg
Biomass	7.8	MJ/kg

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

Total consumption per fuel type in comparable energy units (PJ) may be verified in Figure 3.5.

[1] 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.

Figure 3.5 – Trends of fuel consumption per fuel type



Not visible in the graph is the increase in biomass consumption (wood waste) from 2000 to 2016 (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 per cent). 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

3.2.1.1.4.2 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.

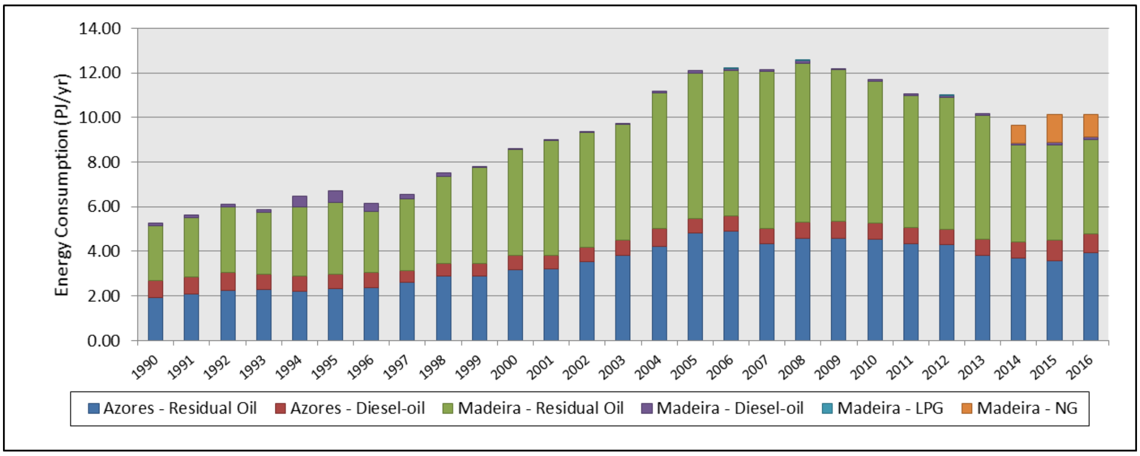
3.2.1.1.4.3 Energy Plants in Azores and Madeira Autonomous Regions

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:

Figure 3.6 – Trends of fuel consumption in Azores and Madeira Archipelagos



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

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

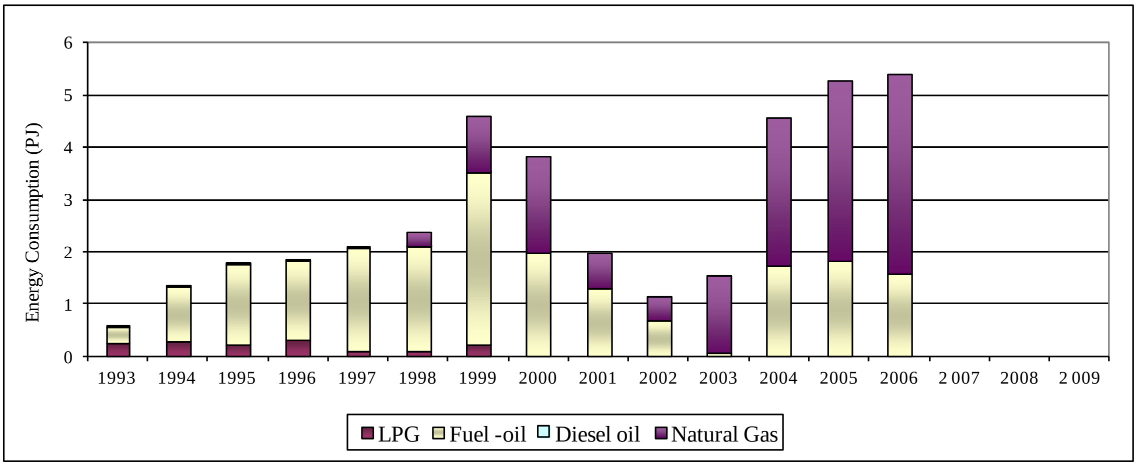
Table 3.15 – LHV per fuel type

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

3.2.1.1.4.4 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 Figure 3.7.

Figure 3.7 – Trends in consumption of fuels in non-public co-generation plants



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

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

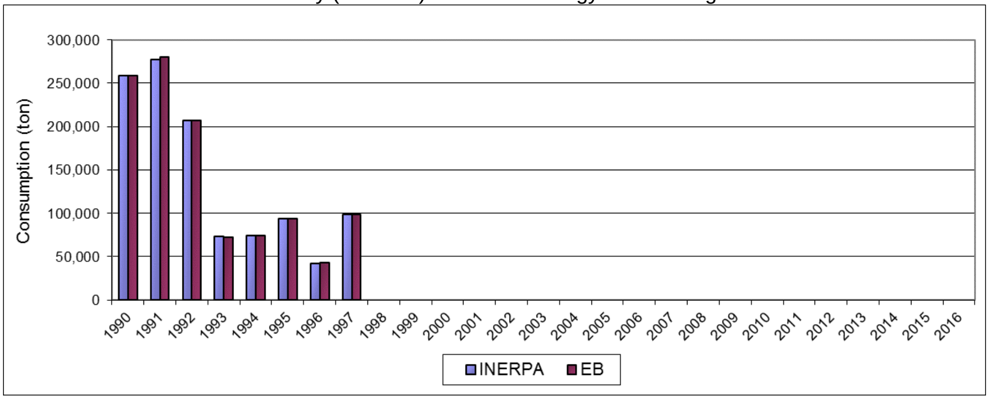
Table 3.16 – LHV per fuel type used for non-public co-generation plants estimates

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

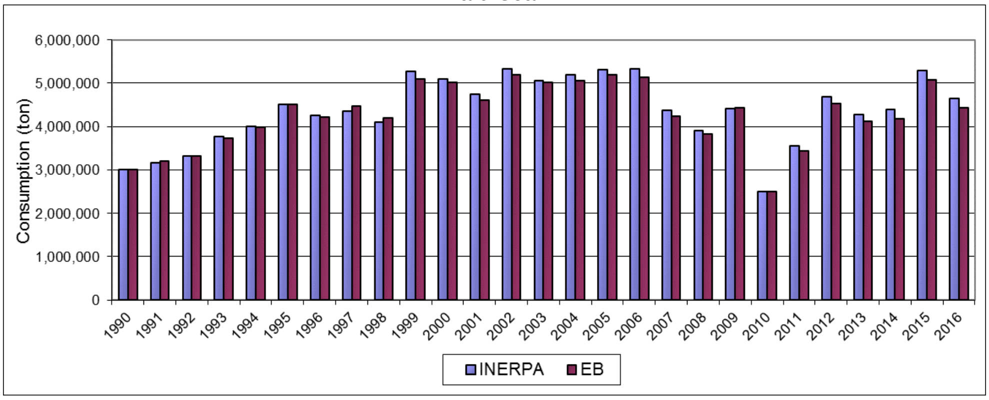
3.2.1.1.4.5 Comparison of LPS data vs. National Statistics

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.

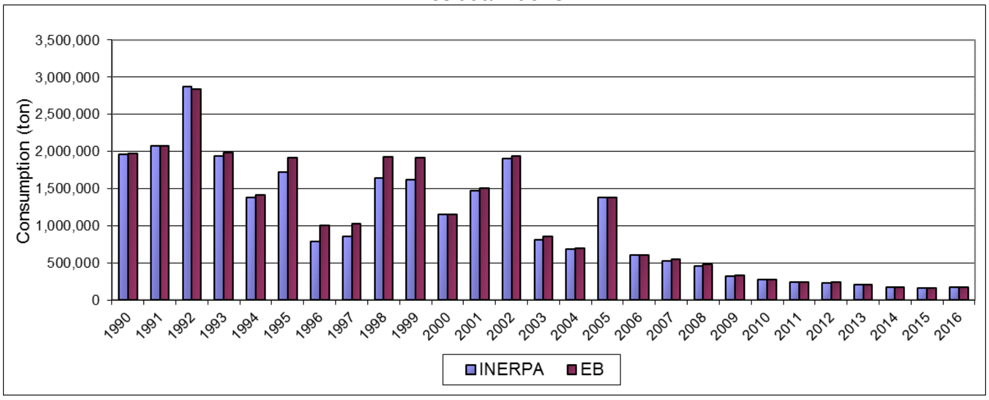
Figure 3.8 – Comparison of total fuel consumption in large power plants, between values used in the inventory (INERPA) and in the Energy Balance.Lignite



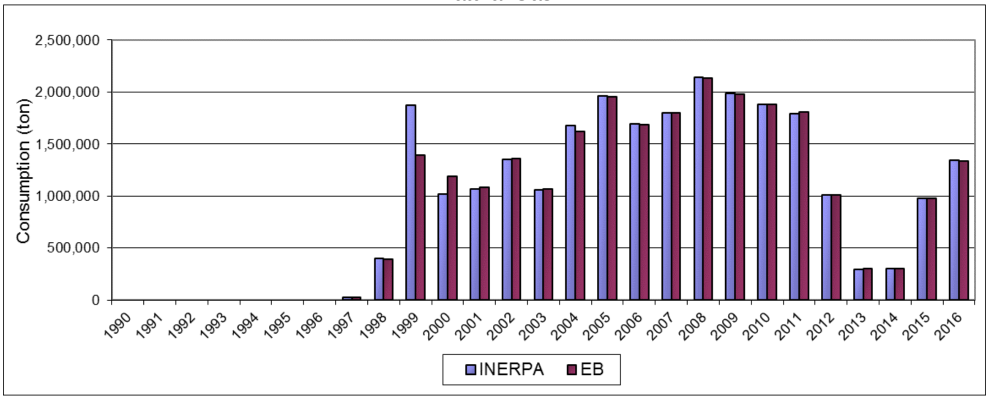
Hard Coal



Residual Fuel Oil



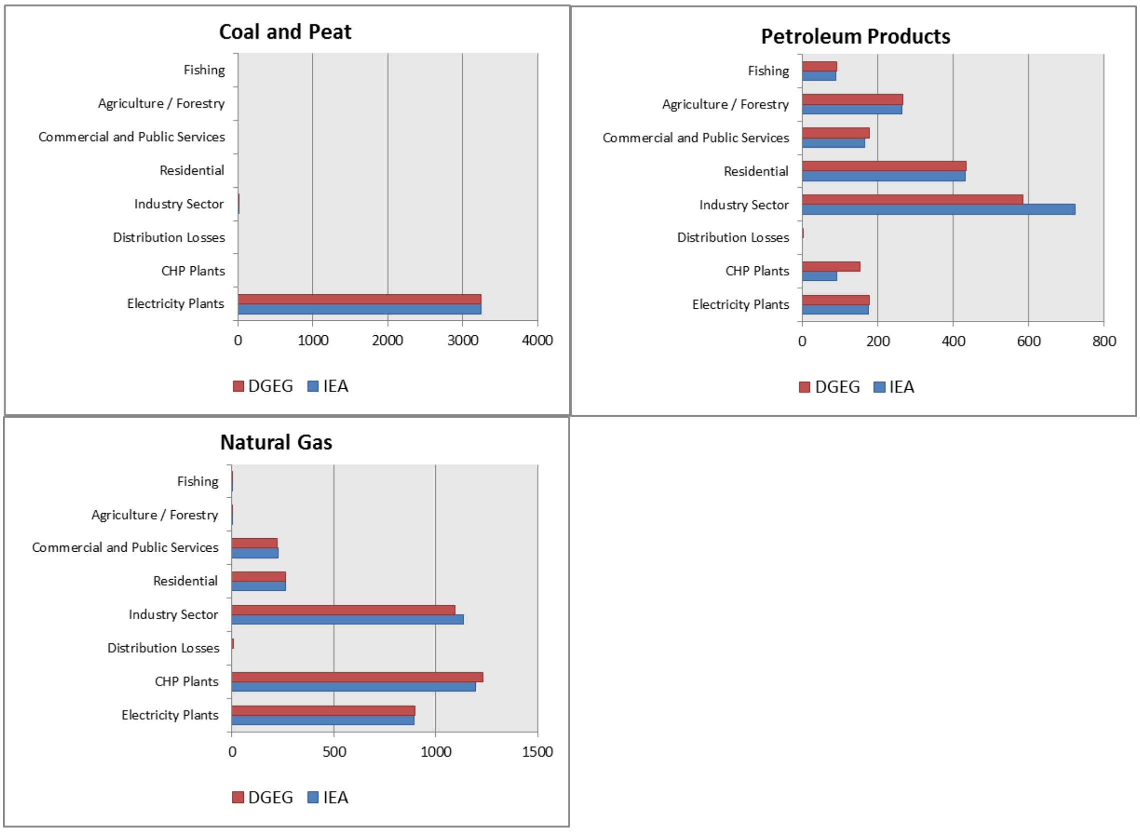
Natural Gas



3.2.1.1.4.6 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 2015, is shown in the figure below.

Figure 3.9 – 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.

3.2.1.1.5 Recalculations

Update of continuous NOx monitoring, with a focus on the years 2011-2016.

3.2.1.1.6 Further Improvements

Even though efforts were made to increase the percentage o 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[1] has set to streamline data collection for the inventories and for the EU-ETS[2]. 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.

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

3.2.1.2.1 Overview

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).

3.2.1.2.2 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:

[1] European Commission.

[2] European CO2 trading scheme.

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

Where

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

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

$EF_{(e,f,y,p)}$ - Emission factor pollutant p, for fuel f under burning conditions in combustion equipment e in year y (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:

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

Where

$SOx_{(e,f,y)}$ - Sulphur oxide emission estimated from consumption of fuel f in combustion equipment e in year y (t/yr);

$Fuel_{Cons(e,f,y)}$ - Consumption of fuel f in combustion equipment e in year y (t/yr);

$S_{(e,f,y)}$ - Sulphur content of fuel (mass percentage);

$AshRet_{(e,f)}$ - Sulphur retention in ash (mass percentage). It was assumed no ash retention for all fuels and combustion equipments in the refinery process.

3.2.1.2.3 Emission Factors

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

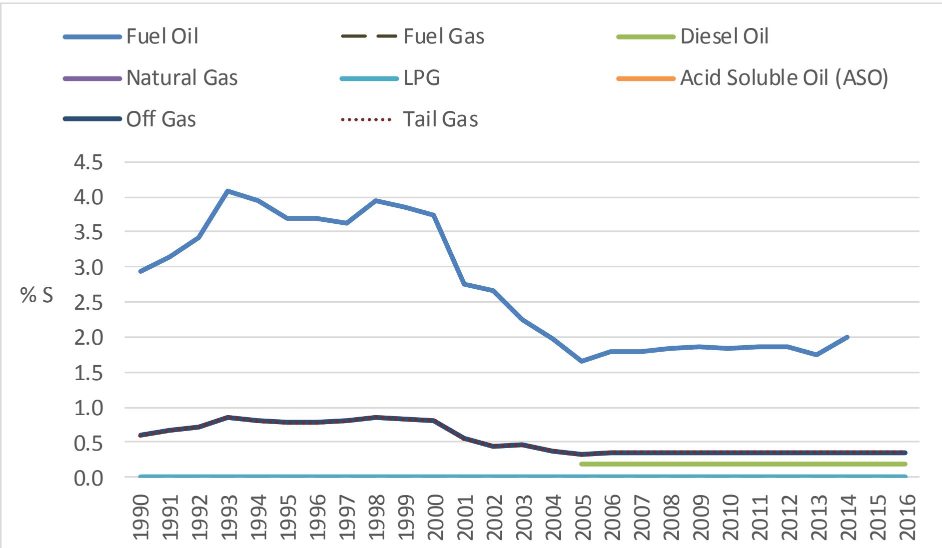
Table 3.17 – Emission Factors for combustion sources in Refining of Petroleum Products.

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)

Composition of fuels, in what concern sulphur, 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 3.10 - Trends of sulphur content



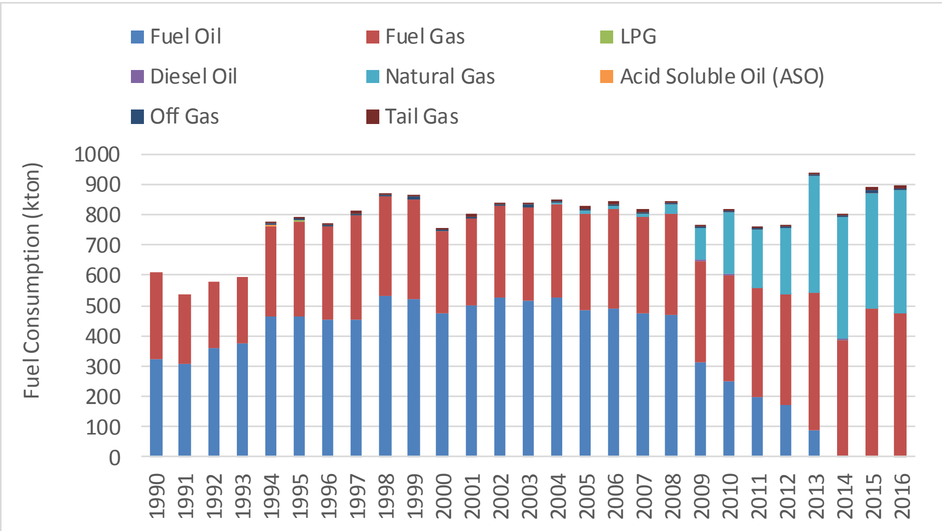
3.2.1.2.4 Activity Data

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.

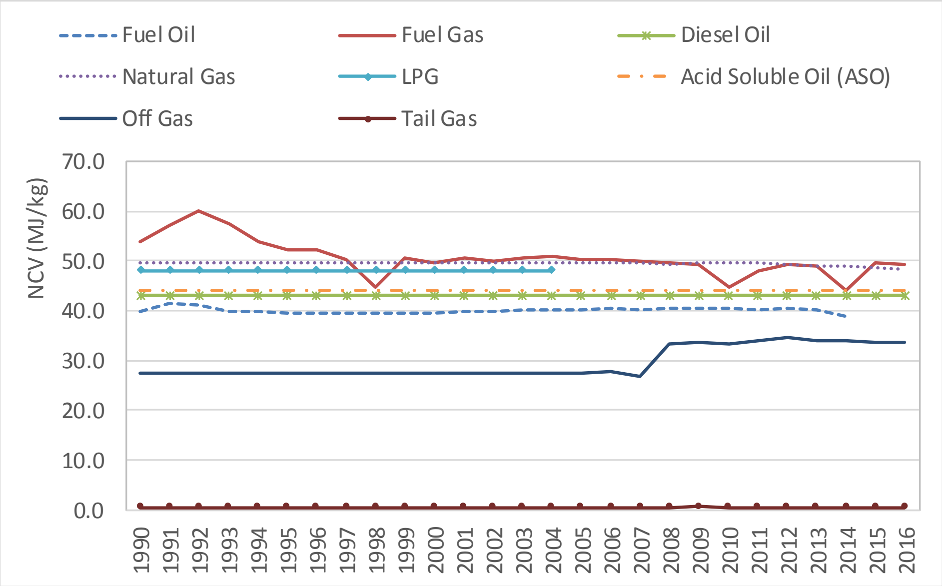
Figure 3.11 – Fuel consumption



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 3.12 – Net Calorific Value (NCV) or Low Heating Value (LHV) expressed in MJ/ kg by type of equipment



3.2.1.2.5 Recalculations

CO emission factor related to residual oil combustion has been updated according to table 4-4 of chapter 1.A.1 Energy industries of EMEP/EEA air pollutant emission inventory guidebook 2016 (EF=6 g/GJ instead of 15 g/GJ).

Benzo(α)pyrene, benzo(β)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene emission factors related to gas oil consumption in reciprocating engines have been updated according to table 4-8 of chapter 1.A.1 Energy industries of EMEP/EEA air pollutant emission inventory guidebook 2016.

CO emission factor related to refinery gas combustion has been updated according to table 4-2 of chapter 1.A.1 Energy industries of EMEP/EEA air pollutant emission inventory guidebook 2016 (EF=12.1 g/GJ instead of 39.3 g/GJ).

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

3.2.1.3.1 Overview

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

- External fuel consumption realized in the coquerie unit, that existed within the only integrated iron and steel plant in Portugal, and that was closed in 2001. Coke gas was the only fuel combustion used as energy source in the coquerie unit;
- 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 substitution of this energy source by Natural Gas, and was fully deactivated in 2001.

3.2.1.3.2 Methodology

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

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

where

$SOx_{(y)}$ - Sulphur oxide emission estimated from consumption of coke gas in year y (t/yr);

$Fuel_{Cons(y)}$ - Consumption of coke gas in the coquerie in year y (M m3/yr) or fuel f in city gas production (t/yr);

S - Sulphur content of coke gas used in the coquerie (g S/Nm3) or sulphur fraction of fuel f in city gas production (0..1).

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

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

and,

$HM_{p\ (f,y)}$ - 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 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 percentage).

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

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

where

$Emission_{(y,p)}$ - Emission of pollutant p in year y (t except CO2 in t);

$Energy_{Cons\ (y)}$ - Consumption of energy in coke gas (Low Heating Value) in year y (GJ);

$EF_{(f,p)}$ - Emission factor pollutant p from coke gas combustion (g/GJ except CO2 in kg/GJ).

3.2.1.3.3 Emission Factors

Emissions factors for combustion of coke gas in the coquerie unit and in the city gas factory were set from IPCC96, EMEP/CORINAIR and AP-42. They are reported in table below.

Table 3.18 – Emission Factors used for the coquerie and city gas production

Source	Coquerie	City Gas Production			Unit
Fuel	Coke Gas	FO	Naphta	NG a)	
CH_4	2.5	(ii) 2.9	(ii) 2.9	(i) 1.4	g/GJ
N_2O (i)	1.40	0.60	0.60	1.40	g/GJ
SO_x	7.05 gS/Nm^3	2.6-2.9	0.1	0.0007	% S
NO_x	120	160	160	100	g/GJ
NMVOC	2.5	3.0	3.0	5.0	g/GJ
CO	17	15	15	13	g/GJ
PST	3	85	6.5	0.8	g/GJ
PM_{10}	95.9	86.0	50.0	100	% PST
$PM_{2.5}$	93.5	56.0	12.0	100	% PST
PM_1	77.4	36.0	8.0	100	% PST
Cd	NE	6.84E-01	2.55E-01	1.76E-05	g/t
Hg	NE	5.07E-01	0.00E+00	4.18E-03	g/t
Ar	NE	5.56E-01	0.00E+00	3.20E-06	g/t
Cr	NE	1.70E+00	5.00E-02	2.24E-05	g/t
Cu	NE	7.41E-01	1.10E+00	1.36E-05	g/t
Ni	NE	2.69E+01	2.85E-01	3.36E-05	g/t
Se	NE	6.84E-02	3.00E-02	3.84E-07	g/t

(i) IPCC (1997); (ii) EEA (2002); (iii) from plant information; a) Heavy Metais - g/km^3

3.2.1.3.4 Activity Data

3.2.1.3.4.1 Coke Production

Consumption of coke gas in the coquerie unit was available directly from the industry plant for 1991-1994. For the remaining years, the use of coke in coquerie was estimated from total consumption of coke gas in the all plant, which information was collected from the energy balances of DGEG. Therefore, except for 1991 to 1994, annual consumption of coke in the integrated iron and steel plant was estimated from:

$$Coquerie_{CONS\ (y)} = Coquerie_{CONS\ (91-94)} / \ Total_{CONS\ (91-94)} * Total_{CONS\ (y)}$$

where

$Coquerie_{CONS\ (y)}$ - consumption of coke gas in the coquerie in year y;

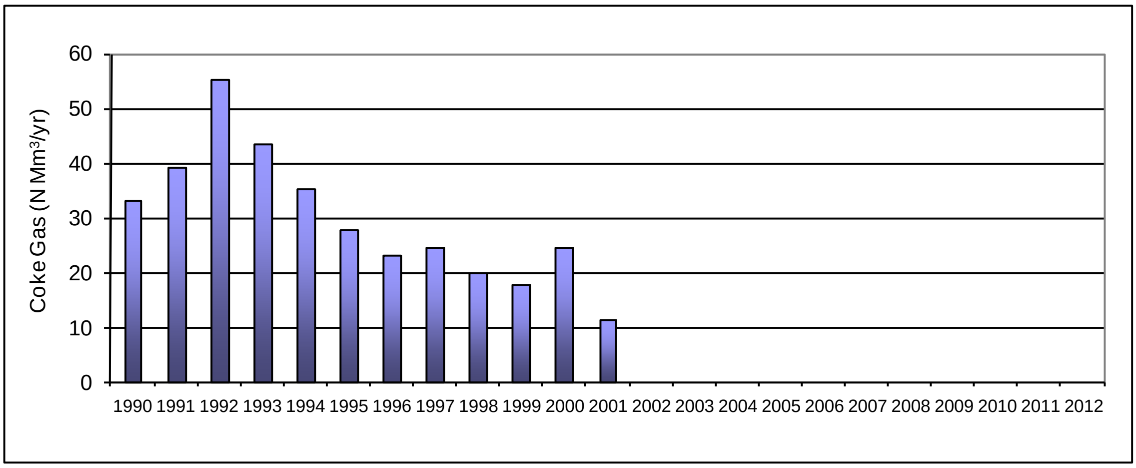
$Coquerie_{CONS\ (91-94)}$ - consumption of coke gas in the coquerie from 1990 till 1994;

$TotalPlant_{CONS\ (91-94)}$ - total consumption of coke gas in the iron and steel sector, from 91 to 94, as reported in DGEG's energy balance;

$TotalPlant_{CONS\ (y)}$ - total consumption of coke gas in year y.

The coquerie has interrupted operations in 2001 and was later dismantled. The complete time series may be seen in Figure 3.13. Conversion in energy units was calculated using a LHV of 18.78 MJ/Nm3, the value that is reported under LCP directive.

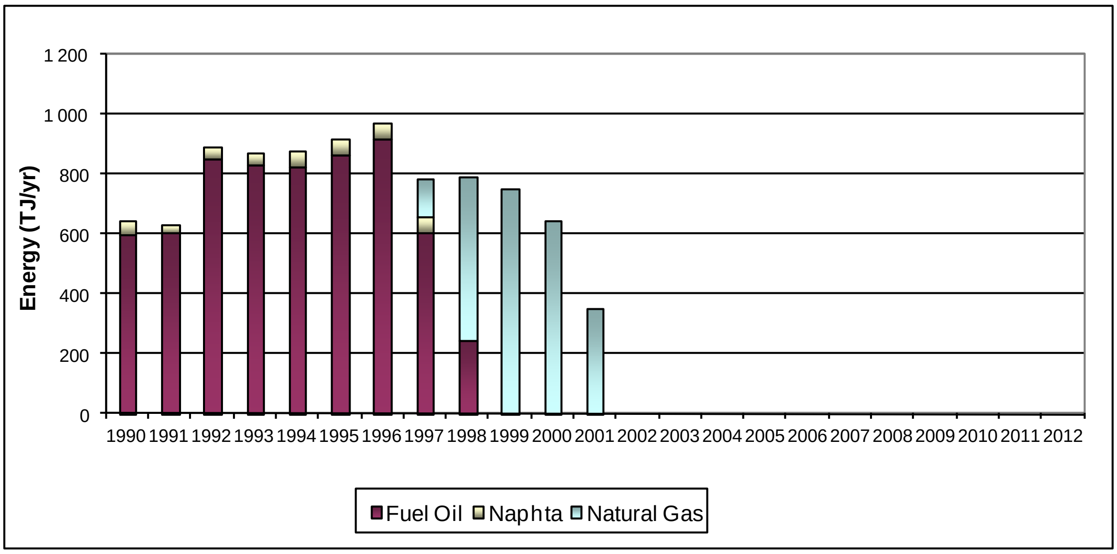
Figure 3.13 – Coke gas consumption in the coquerie



3.2.1.3.4.2 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 till 2001[1]. The available time series is presented in Figure 3.14.

Figure 3.14 – Consumption of fuels in co-generation in city gas production



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

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

Table 3.19 – NCV/LHV per fuel type for city gas production

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

3.2.1.3.5 Recalculations

No major recalculations were made to this sector.

3.2.2 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[1].

The consumption of liquid fuels considered in the estimation of emissions of the Manufacturing Industry is based on information from the Energy Balance, which groups 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

3.2.2.1 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[2]. Estimates for SO_x were calculated assuming that there were no abatement technologies. The following equation applies:

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

[1] 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).

[2] For some activities SOx emissions may also be estimated using the production approach, as presented below.

where:

Em_{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 percentage).

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:

$$Emi_{(p)} = \Sigma_f \Sigma_s \Sigma_t [EF_{(p,f,s,t)} * Energy_{(f,s,t)}] * 10^{-6}$$

where:

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

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

$Activity_{(f,s,t)}$ - Energy Consumption of fuel type f, sector activity s and technology/ combustion equipment t (GJ).

When 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:

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

and,

$HM_{p\ (f,y)}$ - 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 percentage).

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[1]:

- Total pure gas oil consumed was obtained by subtracting the total biodiesel produced (that is going to be incorporated in gas oil) to the gas oil reported in the energy balance;
- With the pure gas oil and the pure biodiesel values an incorporation rate was derived;
- For each industrial sector this incorporation rate was applied to obtain value for total gas oil and total biodiesel consumed;
- Not all the gas oil reported has biodiesel. Because of this, before applying the incorporation rate the total gas oil for heating was subtracted;
- In the end we have, for 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 2006-2016.

Table 3.20 – Incorporation rate of biodiesel (% toe/toe)

	1990-2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Incorporation rate	0	1.31	2.50	2.43	4.16	6.03	6.25	6.22	6.05	5.90	6.72	5.31

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;

[1] 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.

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.

3.2.2.1.1 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).

3.2.2.1.2 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). Carbon dioxide originated from decarbonising limestone and dolomite is quantified in production processes and reported in CRF sector 2A.

3.2.2.1.3 Lime Production

Emissions of SO_x, NO_x 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.

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

3.2.2.1.4 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

3.2.2.1.5 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 “Industrial Processes: Glass Production (NFR 2.A.3)”.

3.2.2.1.6 Iron and Steel Production

Air emissions from sintering (SO_x, NO_x, NMVOC and CO) and production of lime (SO_x, NO_x, CO and CO_2) 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, activity data and emission factors for this source are discussed in chapter 4.3.3.1 – Industrial Processes: Iron and Steel Production.

3.2.2.2 Activity data

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

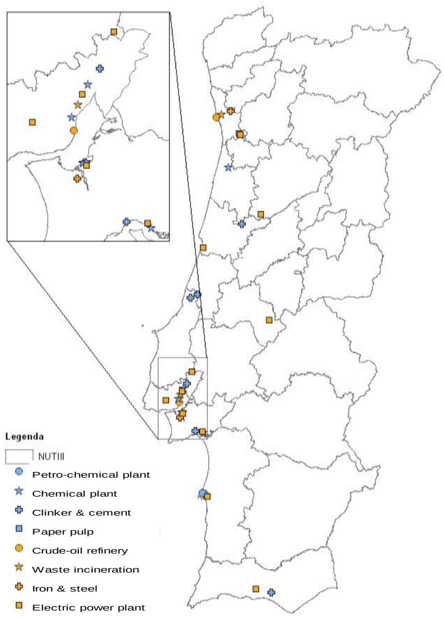
3.2.2.2.1 Combustion Data

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 3.15 – Distribution of Large Point Sources in continental Portugal[1]



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

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 3.16 and in the following formula set:

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

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

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

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);

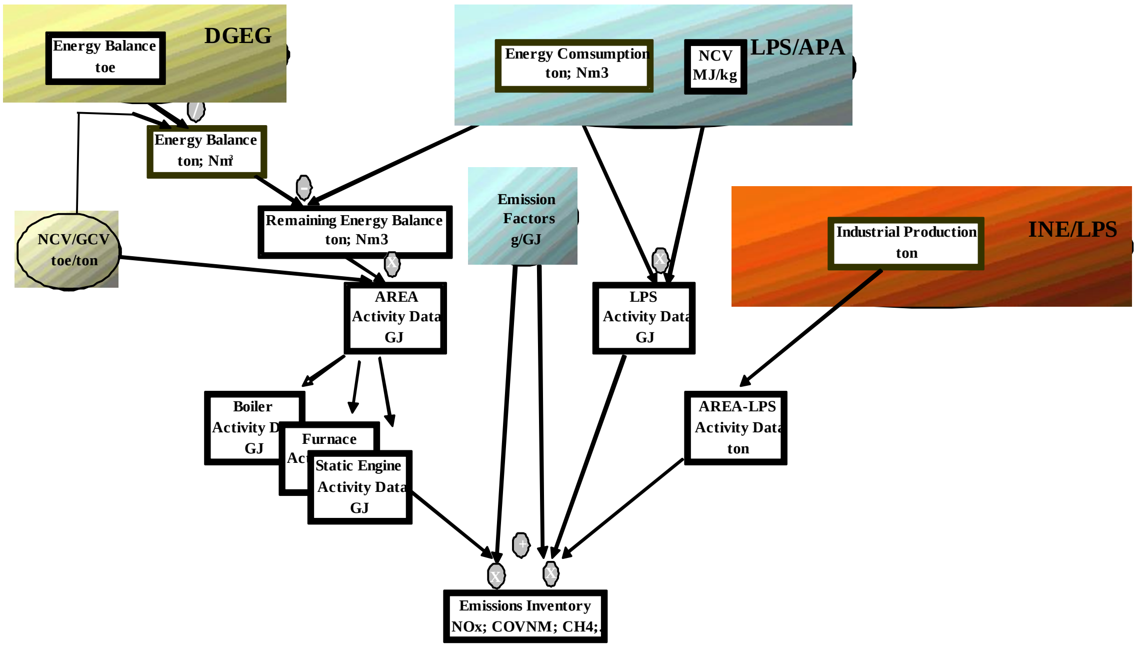
$LHV_{LPS(u,f,e)}$ – Low Heating Value/ Net Calorific Value, reported by LPS unit u, for fuel f in combustion equipment e (MJ/kg or MJ/Nm3);

$LHV_{EB(f,s)}$ – 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);

$LHV_{AREA(f,s,e)}$ - 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)[1].

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

Figure 3.16 – 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.

3.2.2.2.1.1 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 for 2016 is presented in annex to the IIR.

Table 3.21 – 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 3.22 – 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 3.23 – Definition of Sectors in accordance with Economic Activity Classes

Sub sector	EAC (1977)
Agriculture	111, 112, 113, 121, 122
Fisheries	130
Extractive Industry	220, 230, 290
Food processing, beverages and tobacco	311, 312, 313
Textile	321
Paper and paper pulp	341
Chemical and Plastic Industry	351, 352, 356
Ceramic	361, 3691
Glass	362
Cement	369 except 3691
Metallurgy	271, 272 except Iron&Steel
Iron and Steel Industry	Iron & Steel
Clothing, shoes and leather	322, 323, 324
Wood & wood products	331, 332
Rubber	355
Manufacturing of machines and metallic Equipments	381, 382, 383, 384
Other	390, 314, 342, 385
Construction & Building	500

3.2.2.2.1.2 Tables of consumption per activity

For confidential reasons, LPS data on fuel consumption for the iron and steel industry, the petrochemical and carbon black units are presented lumped together with data in energy balances, with no separation from the other non-LPS sources within the respective sector. Data on paper pulp plants are presented for the eight LCP units summed together with non-LPS sources (like paper production). In the cement industry since only two companies represent the six factories that exist in Portugal, for confidential reasons no activity data can be presented in this report.

1.1.1.1.1.1.1 Iron and Steel Industry

Table 3.24 – Low Heating Values/ Net Calorific Values (LHV/NCV) in the Iron and Steel Industry

Steam Coal	Coke	LPG	Kerosene	Gas Oil	Residual Fuel Oil	Natural Gas
MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/Nm3
30.95	29.40	46.0	43.8	42.6	40.0	38.7

Coke Oven Gas	Blast Furnace Gas	Tar	Gasoline	Biodiesel	Other
MJ/Nm3	MJ/Nm3	MJ/kg	MJ/kg	MJ/kg	MJ/kg
17.6	3.8	40.1	44.0	37.0	34.7

Table 3.25 – Fuel consumption in the Iron and Steel Industry in boilers and furnaces (GJ) (1/2)

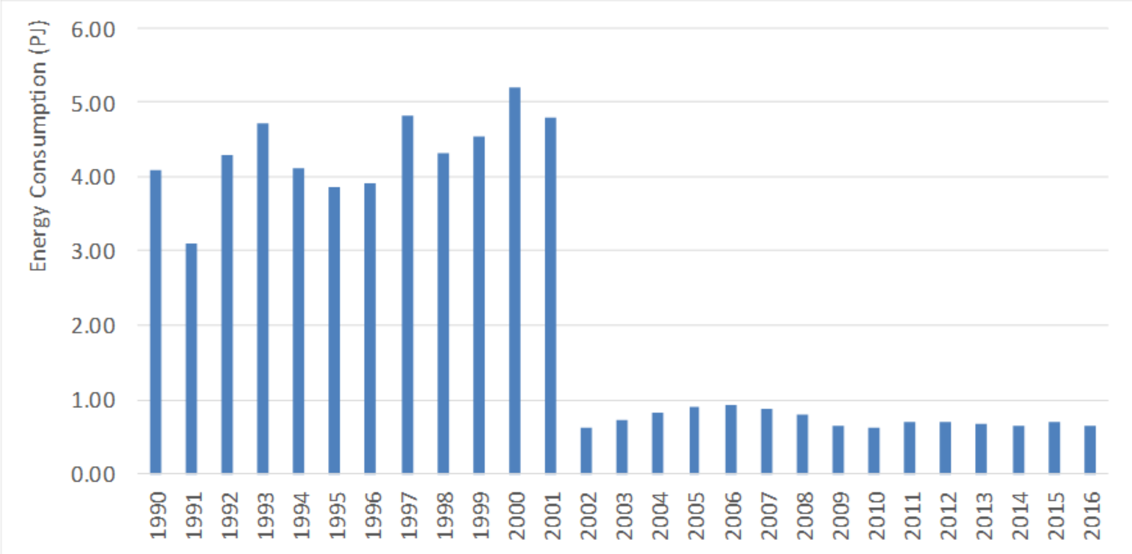
Year	Steam Coal	Coke	LPG	Gasoline	Kerosene	Gas Oil	Residual Oil	Natural Gas
1990	0	0	257,384	0	0	3,890	1,556,327	0
1995	0	0	239,855	0	0	4,663	1,328,397	0
2000	0	0	289,016	0	0	8,290	1,426,004	0
2005	0	0	40	0	0	0	716,823	179,427
2010	0	0	9	0	0	586	0	624,383
2014	0	0	0	0	0	3,987	0	673,236
2015	0	0	0	0	0	603	0	652,823
2016	0	0	0	0	0	303	0	705,162

Table 3.26 – Fuel consumption in the Iron and Steel Industry in boilers and furnaces (GJ) (2/2)

Year	Coke oven gas	Blast furnace gas	Tar	Waste oil
1990	418,816	1,460,387	341,000	40,348
1995	654,721	1,343,038	272,878	7,318
2000	1,393,519	1,746,675	333,420	10,255
2005	0	0	0	0
2010	0	0	0	0
2014	0	0	0	0
2015	0	0	0	0
2016	0	0	0	0

The expressive decrease in fuel consumption that can be observed from 2001 to 2002 is explained by the significant changes in the only integrated iron and steel plant that existed in Portugal, particularly the closure and dismantling of the production of coke, sinter and of the blast furnace. Presently iron and steel is produced from scrap and metallic foils. This changed has also caused substantial changes in the contribution of fuels, with the disappearance of coke oven gas and blast furnace gas, and the increase in the use of natural gas, that not only was used to replace the other by product gases, but also partially the use of LPG and residual fuel oil.

Figure 3.17 – Total Energy Consumption in the Iron and Steel Industry



There is also Coke gas consumption associated with the Iron and Steel Sector, that consumption is realized in a coquerie unit that existed within the only integrated iron and steel plant in Portugal. That activity data is presented in sub-chapter 1.2.1.3 - Other Energy Industries.

1.1.1.1.1.1.2 Metallurgy Industry

Table 3.27 – Low Heating Values/ Net Calorific Value (LHV/NCV) in Metallurgy Industry

Steam Coal	Coal Coke	LPG	Kerosene	Gas Oil	Residual Oil
MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg
31.0	29.4	46.0	43.8	42.6	40.0

Natural Gas	Wood	Gasoline	Biodiesel
MJ/Nm3	MJ/kg	MJ/kg	MJ/kg
38.7	12.6	44.0	37.0

Table 3.28 – Fuel Consumption in Metallurgy Industry – Boilers and Furnaces (GJ)

Year	Steam Coal	Coke	LPG	Kerosene	Gas Oil	Residual Oil	Natural Gas	Wood	Biodiesel
1990	132,971	381,617	535,849	1,715	35,795	1,163,364	0	142,678	0
1995	0	0	797,476	2,916	31,846	387,450	0	135,314	0
2000	0	0	241,885	593	47,627	81,208	1,334,087	143,515	0
2005	0	0	302,818	16	99,637	64,698	880,881	232,894	0
2010	0	0	157,373	126	31,761	31,233	661,870	239,874	1,950
2014	7,243	196,614	105,272	0	42,319	0	1,013,529	0	167
2015	0	184,807	104,378	0	52,717	0	1,258,286	0	84
2016	9,420	7,243	108,772	0	9,178	0	813,370	0	84

Table 3.29 – Fuel Consumption in Metallurgy Industry – Static Engines (GJ)

Year	Gasoline	Gas Oil	Biodiesel
1990	1,674	35,795	0
1995	8,587	31,846	0
2000	462	47,627	0
2005	350	99,637	0
2010	0	31,761	1,950
2014	0	42,319	838
2015	0	52,717	1,464
2016	0	9,178	514

Emissions from this sector cover both the industry producing iron products and non iron products. The original information source does not allow the separation of these activities. Here too is noticeable the partial shift from the use of residual fuel oil and LPG to natural gas, after 1997. Also observable is the abandonment of the use of coal and coke, already in 1994.

Since 2007 the fuel consumption has been decreasing, explained with the abandonment of residual fuel oil and LPG and their substitution by natural gas in more recent years. The drop in total energy consumption in 2011 it's due to the significant reduction on wood fuel consumption.

Figure 3.18 – Total Energy Consumption in the Metallurgy Industry

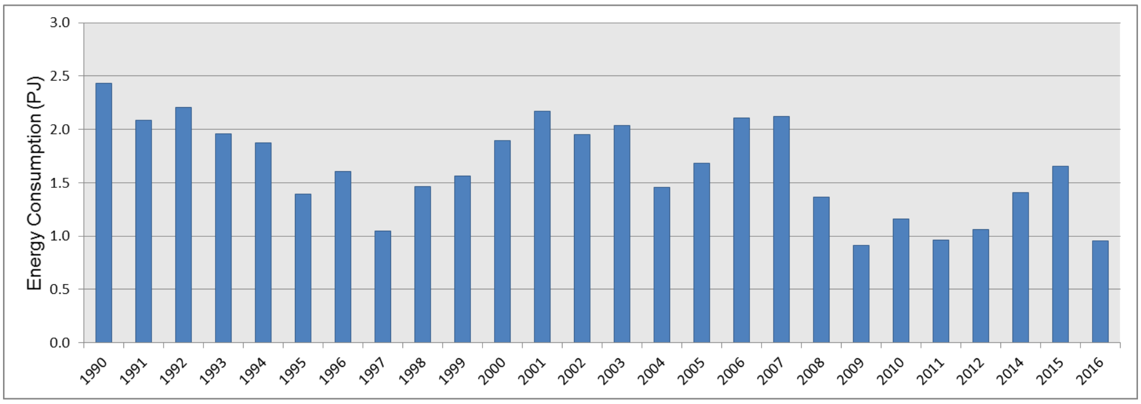
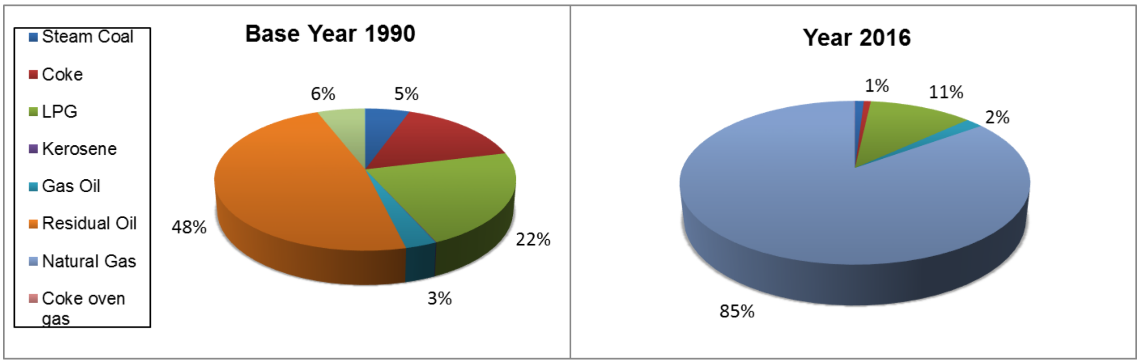


Figure 3.19 – Fuel Consumption per fuel type in Metallurgy Industries in 1990 and 2016



1.1.1.1.1.1.3 *Chemical and Plastics Industry*

Table 3.30 – Low Heating Values/ Net Calorific Values (LHV/NCV) in Chemical and Plastics Industry

Steam Coal	Coal Coke	LPG	Kerosene	Gas Oil	Residual Fuel Oil*
MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg
31.0	29.4	46	43.8	42.6	39.61 – 40.0

Natural Gas	Wood	Fuel Gas[1]	Gasoline	Flare Gas[2]	Biodiesel
MJ/Nm3	MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg
38.4 – 37.9	12.6	46.8 – 53.7	44.0	46.8 – 53.7	37.0

* Including Pyrolisys fuel oil and non traded similar sub-products

[1] Several streams of intermediate gaseous products and tail gases that are used as energy source

[2] Several streams of intermediate gaseous products and tail gases that are used as energy source

Table 3.31 – Fuel consumption in Chemical and Plastics Industry – Boilers and Furnaces (GJ)

Year	Steam Coal	Coke	LPG	Kerosene	Gas Oil	Residual Oil	Natural Gas	Wood	Residual Gas	Biodiesel
1990	216,237	196,840	283,414	1,180	78,977	7,065,040	0	1,051,213	10,648,080	0
1995	0	492,226	1,603,061	54	170,090	6,942,874	0	996,904	9,552,594	0
2000	0	2,141,169	333,022	12,395	119,791	6,643,160	2,306,626	1,360,854	11,432,539	0
2005	482,572	135,743	1,173,641	2,360	100,475	3,883,228	3,904,192	1,471,332	11,183,390	0
2010	423,327	91,315	346,468	377	36,910	1,417,707	7,557,173	1,536,318	10,407,661	1,991
2014	25,916	0	91,104	167	41,386	210,718	6,134,750	17,113	10,990,438	6,375
2015	0	0	101,487	84	45,850	159,179	6,197,329	44,979	11,733,143	8,770
2016	0	0	358,262	84	37,613	446,347	5,608,219	44,979	11,630,414	5,766

Table 3.32 – Fuel consumption in Chemical and Plastics Industry – Static Engines (GJ)

Year	Gasoline	Gas Oil	Residual Oil	Biodiesel
1990	7,803	78,712	2,814,826	0
1995	166,006	169,825	3,710,999	0
2000	48,157	119,525	4,181,690	0
2005	12,349	102,028	3,960,893	0
2010	0	38,066	1,629,457	1,991
2014	0	41,364	935,933	6,375
2015	0	46,135	961,141	8,770
2016	0	37,186	1,001,625	5,766

Table 3.33 – Fuel consumption in Chemical and Plastics Industry – Flares (GJ)

Year	Residual Gas
1990	2,020,225
1995	2,027,080
2000	1,992,060
2005	2,052,772
2010	2,299,712
2014	559,438
2015	462,716
2016	547,751

Two industrial plants in this sector were treated as Large Point Sources, representing a substantial component of total energy consumption, but for confidentiality constrains plant specific information cannot be published individually. In the beginning of the period under analysis, fuel consumption[1] was based on residual fuel oil, traded or by-product of the unit, and residual gases, also obtained as a by-product from the production processes. More recently, natural gas has gained a relevant importance as the third energy source. An increasing trend in total energy consumption - is verifiable in Figure 3.21. 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.

[1] Not considering feedstocks. Emissions from feedstock use are only included when by products (pyrolysis fuel or and fuel gas) are generated and reported explicitly in the industrial plant as fuels.

Figure 3.20 – Total Energy Consumption in the Chemical and Plastic Industry

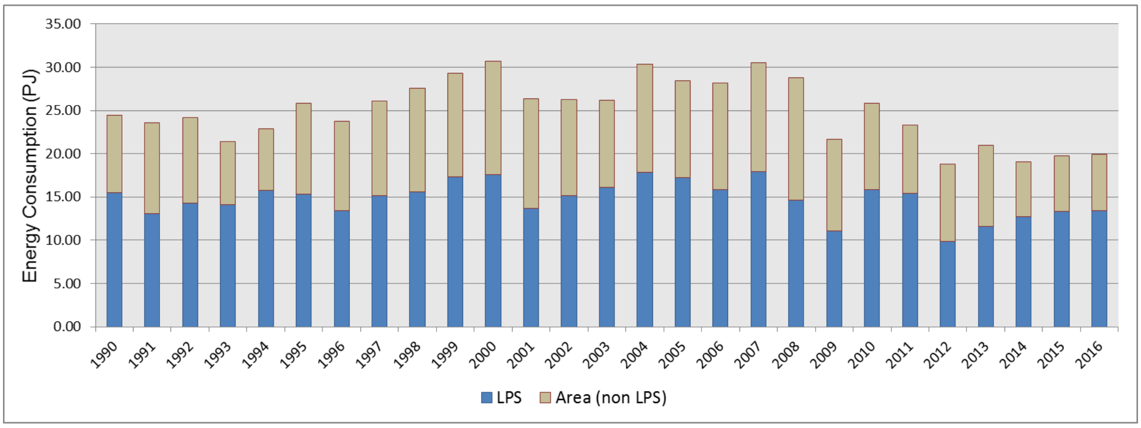
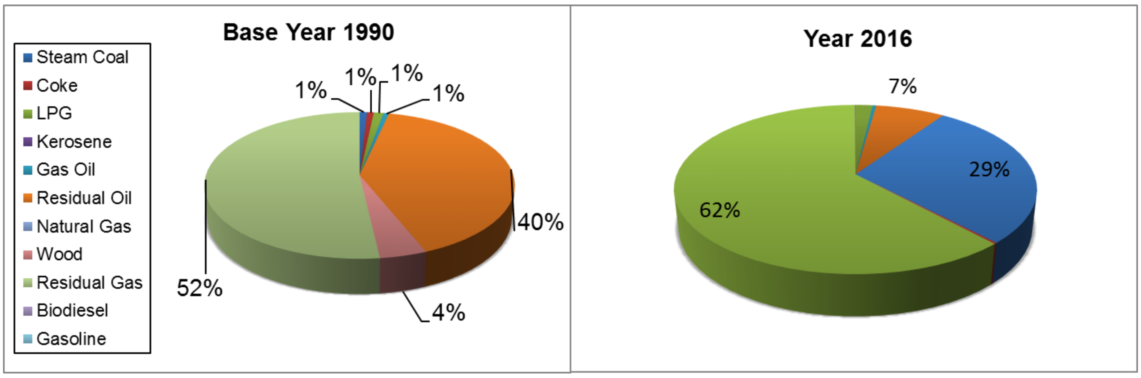


Figure 3.21 – Fuel consumption per fuel type in Chemical and Plastics Industry in 1990 and 2016



1.1.1.1.1.1.4 Paper and Paper Pulp Industry

Table 3.34 – Low Heating Values / Net Calorific Values (LHV/NCV) in the Paper and Paper Pulp Industry

Steam Coal	LPG	Kerosene	Gas Oil	Residual Fuel Oil	Natural Gas
MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/Nm3
31.0	46 - 52.7	43.8	42.6 - 43.3	37.9 - 41.8	37.9 - 39.1

Gasoline	Biodiesel	Biogas	Wood	Black Liquor	Bisulphite Liquor
MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg
44.0	37.0	34.7	6.3 - 20.5	7.4 - 16.7	7.2 - 15.8

Gasified Biomass	Methanol	NCG	Tall-oil
MJ/kg	MJ/kg	MJ/Nm3	MJ/kg
14.7 - 14.7	17 - 19.5	0.0069 - 0.0074	34 - 35.7

Table 3.35 – Fuel consumption in the Paper and Paper Pulp Industry – Boilers and Furnaces (GJ)

Year	LPG	Kerosene	Gas Oil	Residual Oil	Natural Gas	Wood	Liquors	Biodiesel
1990	103,423	7	90,172	9,478,929	0	5,148,908	25,397,844	0
1995	283,226	23	72,544	11,038,222	0	7,360,136	27,222,347	0
2000	249,182	26	54,762	11,559,810	2,375,616	6,489,241	33,489,524	0
2005	92,399	55	81,294	4,988,837	3,578,750	7,431,556	31,534,746	0
2010	93,532	126	75,718	3,759,716	13,141,915	6,265,175	36,429,196	4,783
2014	74,818	419	77,212	6,253,080	8,043,565	40,003,577	0	4,747
2015	84,070	293	93,703	5,296,042	10,985,194	40,063,594	0	6,617
2016	79,549	251	84,982	5,420,168	12,712,830	41,549,025	0	4,740

(i) Wood waste includes methanol, NCG, tall-oil, biogas and gasified biomass.

Emissions report in this sub sector include all the eight paper pulp plants that existed in Portugal from 1990 to 2016 (six Kraft plants and two bisulphite smaller plants), but also smaller units dedicated to paper production. The increasing trend in total fuel consumption is evident and was almost continuous in the period. The lower temporary value in 2003 reflects a re-qualification period for one unit. Considering the share of energy sources, there is a dominance of liquor, followed by residual fuel oil, wood waste and natural gas - this last only recently - as auxiliary primary energy sources.

Table 3.36 – Fuel consumption in the Paper and Paper Pulp Industry – Static Engines (GJ)

Year	Gasoline	Gas Oil	Biogas	Biodiesel
1990	2,678	90,172	0	0
1995	6,137	72,544	0	0
2000	796	54,762	9,705	0
2005	911	81,294	28,895	0
2010	335	73,596	34,055	4,783
2014	0	74,322	225,243	4,747
2015	0	93,609	207,770	6,617
2016	0	84,158	227,546	4,740

Figure 3.22 – Total Energy Consumption in the Paper and Paper Pulp Industry

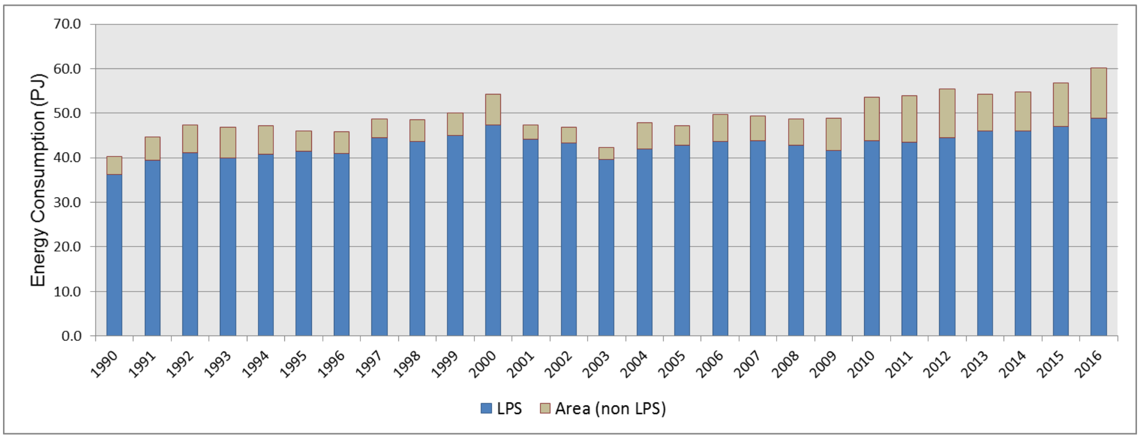
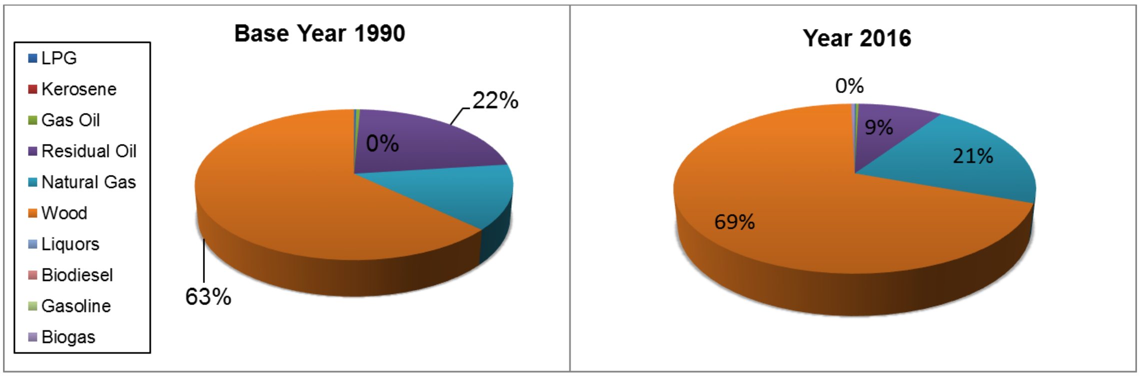


Figure 3.23 – Fuel consumption per fuel type in the Paper and Paper Pulp Industry in 1990 and 2016



1.1.1.1.1.1.5 Food Processing, Beverages and Tobacco Industries

Table 3.37 – Low Heating Values/ Net Calorific Values (LHV/NCV) in the Food Processing, Beverages and Tobacco Industries

Steam Coal	LPG	Kerosene	Gas Oil	Residual Fuel Oil	Natural Gas
MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/Nm3
31.0	46.0	43.8	42.6	40.0	38.7

Wood	Gasoline	Biodiesel	Biogas
MJ/kg	MJ/kg	MJ/kg	MJ/kg
12.6	44.0	37.0	34.7

Table 3.38 – Fuel consumption in Food Processing, Beverages and Tobacco Industries – Boilers and Furnaces (GJ)

Year	Steam Coal	LPG	Kerosene	Gas Oil	Residual Oil	Natural Gas	Wood	Biodiesel
1990	12,416	906,272	13,318	545,639	8,902,333	0	3,981,464	0
1995	0	1,462,813	5,078	735,940	9,399,512	0	3,775,858	0
2000	0	1,699,805	1,729	669,262	9,384,736	1,800,027	3,435,549	0
2005	0	1,231,248	5	753,087	5,798,837	4,518,346	3,714,314	0
2010	0	927,704	209	487,347	5,782,876	6,842,069	3,883,222	29,569
2014	0	849,788	42	514,619	1,754,574	9,284,773	978,787	0
2015	0	743,025	251	620,455	1,573,037	9,623,025	1,153,640	0
2016	0	700,069	209	503,683	1,516,391	9,791,711	1,153,640	0

Table 3.39 – Fuel consumption in Food Processing, Beverages and Tobacco Industries – Static Engines (GJ)

Year	Gasoline	Gas Oil	Biogas	Biodiesel
1990	17,588	545,639	0	0
1995	109,277	735,940	0	0
2000	117,945	669,262	0	0
2005	68,883	753,087	0	0
2010	22,023	487,347	61	29,569
2014	0	514,619	34,301	31,500
2015	0	620,455	38,631	44,316
2016	0	503,683	42,561	27,929

In 1990 the dominant fuel source of this sector was residual fuel oil, followed by biomass and also with a representative use of propane and gasoil. After 1997, natural gas has been replacing the use of former fuels.

Figure 3.24 – Total Energy Consumption in the Food Processing, Beverages and Tobacco Industries

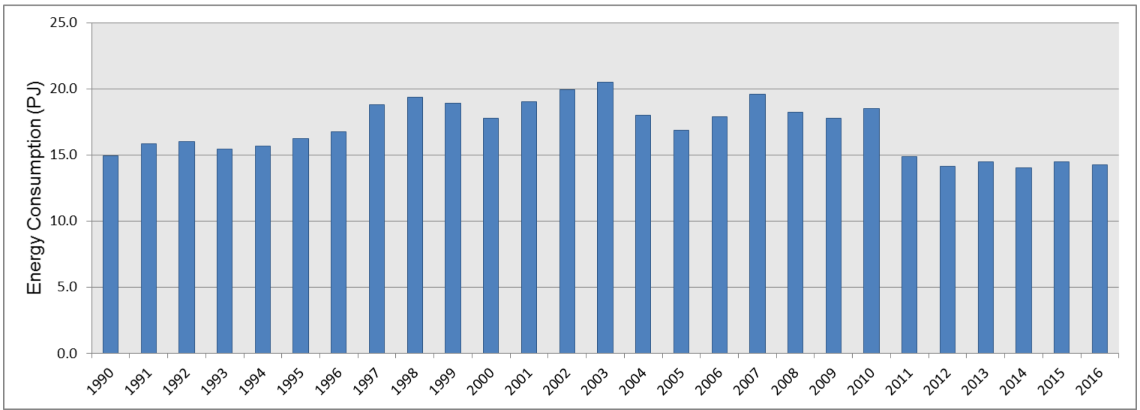
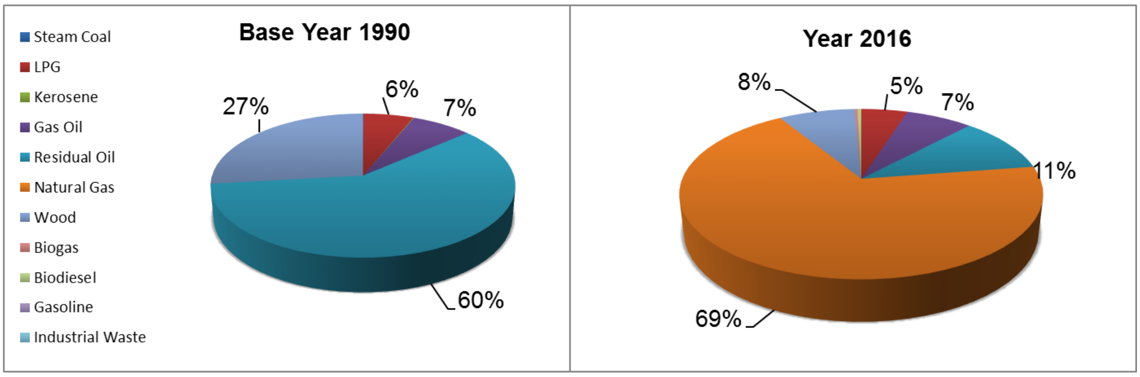


Figure 3.25 – Fuel consumption per fuel type in the Food Processing, Beverages and Tobacco Industries in 1990 and 2016



1.1.1.1.1.1.6 Textile Industry

Table 3.40 – Low Heating Values/ Net Calorific Values (LHV/NCV) in the Textile Industry

LPG	Kerosene	Gas Oil	Residual Oil	Natural Gas	Wood
MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/Nm3	MJ/kg
46.0	43.8	42.6	40.0	38.7	12.6

Gasoline	Biodiesel
MJ/kg	MJ/kg
44.0	37.0

Table 3.41 – Fuel consumption per fuel type in Textile Industry – Boilers and Furnaces (GJ)

Year	LPG	Kerosene	Gas Oil	Residual Oil	Natural Gas	Wood	Biodiesel
1990	211,214	125	27,579	10,404,993	0	1,136,569	0
1995	375,912	4	37,333	8,878,803	0	1,077,866	0
2000	508,000	0	75,347	11,337,089	4,196,215	2,059,507	0
2005	362,613	4	108,672	7,295,236	7,979,600	2,225,989	0
2010	134,730	42	19,604	3,921,248	7,845,017	2,328,954	597
2014	104,878	0	7,971	174,293	9,570,522	72,845	402
2015	115,178	0	34,541	88,926	9,786,478	87,824	2,428
2016	92,569	0	6,407	118,317	9,673,434	88,201	292

Table 3.42 – Fuel consumption in Textile Industry – Static Engines (GJ)

Year	Gasoline	Gas Oil	Biodiesel
1990	4,315	27,579	0
1995	18,913	37,333	0
2000	66,391	75,347	0
2005	43,123	108,672	0
2010	0	19,604	597
2014	0	7,971	402
2015	0	34,541	2,428
2016	0	6,407	292

Figure 3.26 – Total Energy Consumption in the Textile Industry

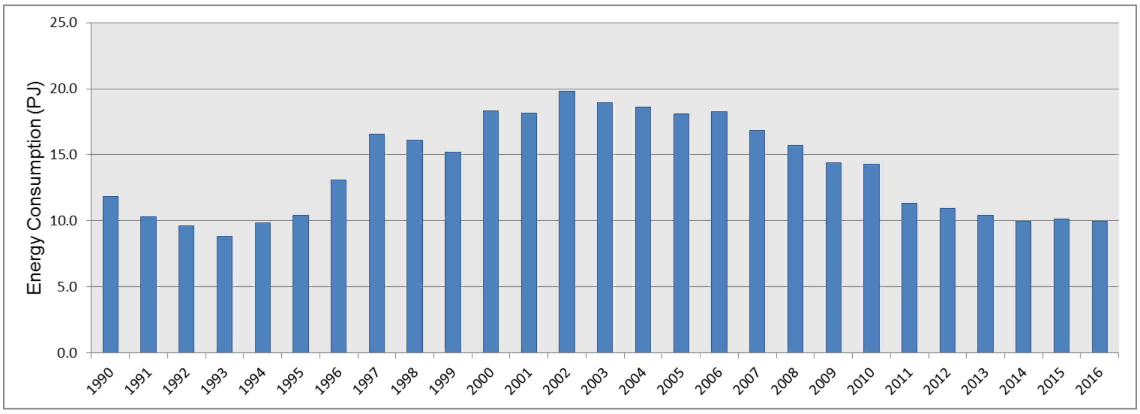
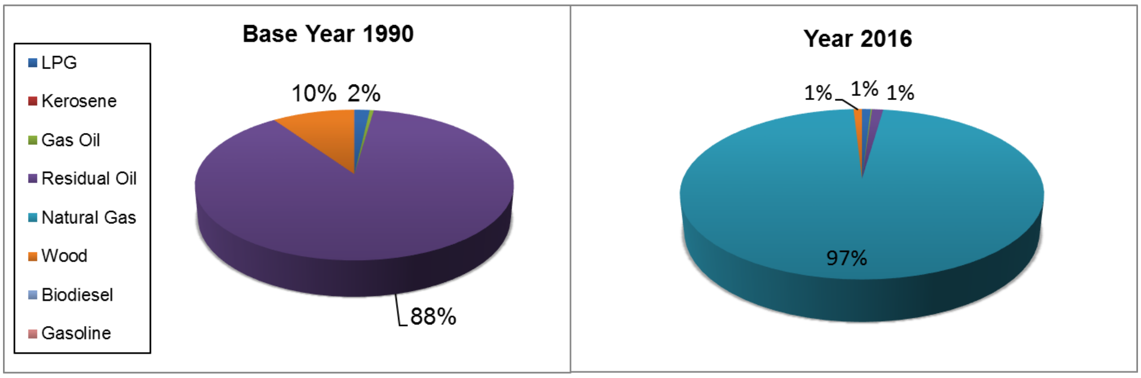


Figure 3.27 – Fuel consumption per fuel type in Textile Industry in 1990 and 2016



1.1.1.1.1.1.7 Ceramic Industry

Table 3.43 – Low Heating Values/ Net Calorific Values (LHV/NCV) in the Ceramic Industry

Steam Coal	Pet Coke	LPG	Kerosene	Gas Oil	Residual Oil
MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg
31.0	32.0	46.0	43.8	42.6	40.0

Natural Gas	Wood	Gasoline	Biodiesel
MJ/Nm3	MJ/kg	MJ/kg	MJ/kg
38.7	12.6	44.0	37.0

Table 3.44 – Fuel consumption in the Ceramic Industry – Boilers and Furnaces (GJ)

Year	Coal	Pet Coke	LPG	Kerosene	Gas oil	Residual Oil	Natural Gas	Wood	Industrial Waste	Biodiesel
1990	6,556	0	6,150,865	28	128,086	3,301,796	0	12,476,234	0	0
1995	0	0	8,792,146	0	130,307	3,727,408	0	11,831,883	0	0
2000	0	0	1,410,200	347	181,234	3,754,710	13,870,518	13,510,325	0	0
2005	0	539,058	540,176	166	126,016	810,594	14,790,173	14,022,734	480,348	0
2010	0	462,743	244,800	251	57,487	375,633	11,517,845	13,913,347	0	3,640
2014	0	437,361	126,147	167	42,117	0	9,225,991	688,326	0	2,639
2015	0	447,330	149,174	84	75,218	0	9,458,232	748,410	0	5,419
2016	0	545,592	144,904	84	32,351	0	9,446,551	853,222	0	1,813

Table 3.45 – Fuel consumption in the Ceramic Industry – Static Engines (GJ)

Year	Gasoline	Gas Oil	Biodiesel
1990	38,533	128,086	0
1995	48,847	130,307	0
2000	17,199	181,234	0
2005	435	126,016	0
2010	377	57,487	3,640
2014	0	42,117	2,639
2015	0	75,218	5,419
2016	0	32,351	1,813

The figure below shows two periods: the first goes from 1990 to 2001 and characterizes a steady increase in fuel consumption, after that total energy consumption has declined until 2011 (except for 2007 and 2008). The pattern of fuel consumption has also changed, with the abandonment of residual fuel oil and LPG and their substitution by natural gas in more recent years. This sector, together with the glass industry, is in fact one in which the substitution was more visible. The decrease in use of biomass is only apparent in per cent, because values of consumption of these fuels did in fact increased slightly. Since 2004 the gasoline consumption has been dropping significantly. In the last four years (2011-2015) a significant decrease in wood consumption was reported in the energy balance.

Figure 3.28 – Total Energy Consumption in the Ceramic Industry

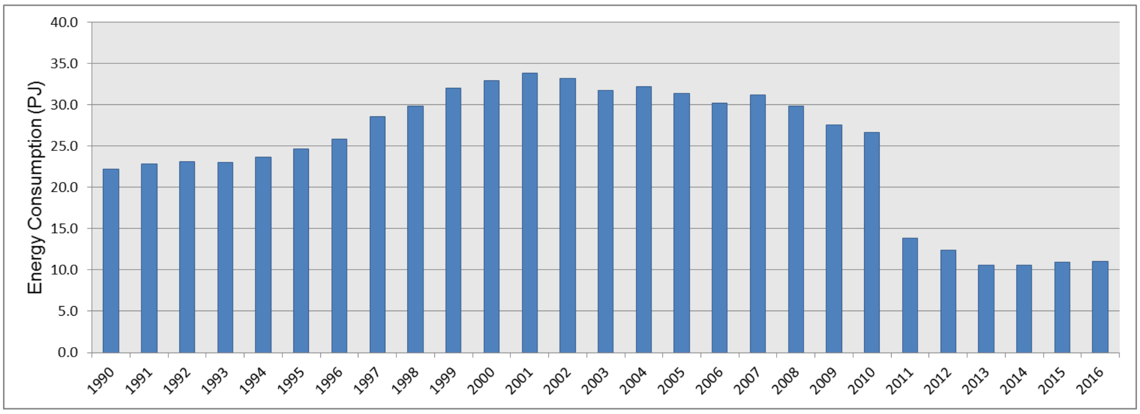
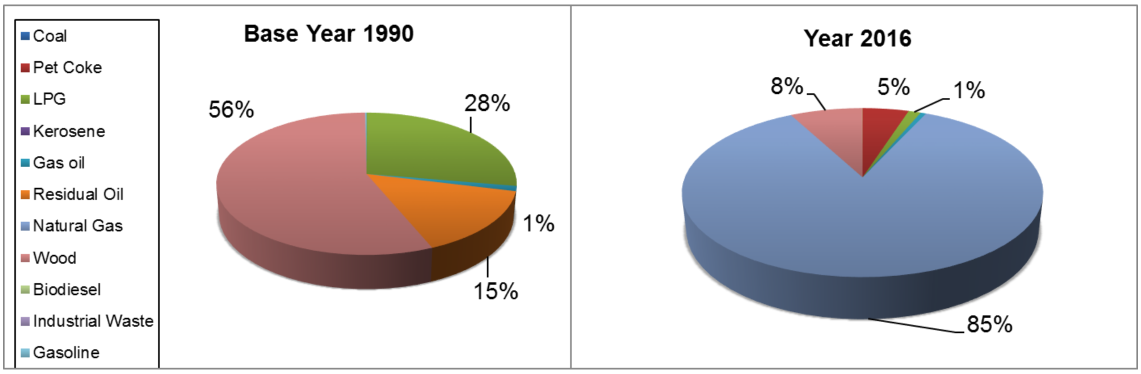


Figure 3.29 – Fuel consumption per fuel type in Ceramic Industry in 1990 and 2016



1.1.1.1.1.1.8 Glass Industry

Table 3.46 – Low Heating Values/ Net Calorific Values (LHV/NCV) in the Glass Industry

Coal	Pet Coke	LPG	Kerosene	Gas Oil	Residual Oil	Natural Gas
MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/Nm3
30.95	32.0	46.0	43.8	42.6	40.0	38.7

Wood	Gasoline	Biodiesel
MJ/kg	MJ/kg	MJ/kg
12.6	44.0	37.0

Table 3.47 – Fuel consumption in the Glass Industry – Boilers and Furnaces (GJ)

Year	Coal	LPG	Kerosene	Gas Oil	Residual Oil	Natural Gas	Wood	Biodiesel
1990	324	1,162,470	0	25,226	4,460,995	0	1,381	0
1995	272	1,383,684	0	21,384	6,578,946	0	1,297	0
2000	356	346,329	7	23,699	3,739,016	5,243,975	1,381	0
2005	0	20,930	0	19,841	1,998,340	6,675,198	0	0
2010	5,766	13,287	0	27,212	146,454	7,702,477	0	1,723
2014	7,501	0	5,671	0	24,189	0	8,126,059	0
2015	5,775	0	5,905	0	21,808	1,968	8,610,343	0
2016	6,503	0	21,685	0	23,438	564	8,079,057	0

Table 3.48 – Fuel consumption in the Glass Industry – Static Engines (GJ)

Year	Gasoline	Gas Oil	Biodiesel
1990	4,001	25,143	0
1995	3,648	21,274	0
2000	1,030	23,474	0
2005	174	18,734	0
2010	0	26,587	1,723
2014	0	23,569	1,496
2015	0	21,506	1,560
2016	0	22,991	1,301

In this sector 9 plants are treated as LPS, convering flat, container and crystal glass production. The fuel consumption contribution of these 9 plants has increased from 1990 to 2012, covering in this year more than 97 per cent of the total fuel consumption in this sector.

The consumption of energy in this sector has suffered stagnation in the most recent years after 1999, showing a slight increase in 2007 and a decrease thereafter. The introduction of natural gas has almost fully replaced the consumption of LPG and most of the consumption of residual fuel oil that was in dominance in 1990. The decrese in residual oil consumption in 2012 results from fact that the only cogeneration plant from this sector did not work that year.

Figure 3.30 – Total Energy Consumption in the Glass Industry

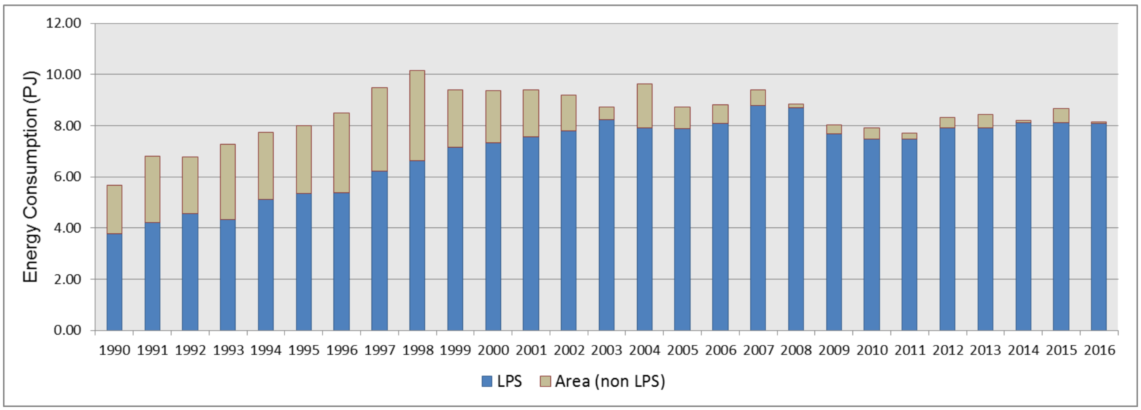
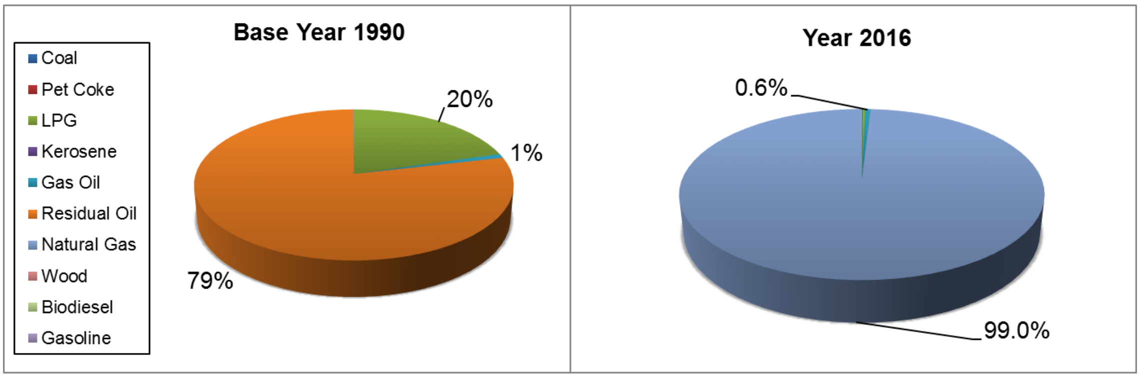


Figure 3.31 – Fuel consumption per fuel type in Glass Industry in 1990 and 2016



1.1.1.1.1.1.9 Cement Industry

In the 2009 inventory new data concerning fuel consumption in Clinker Production was obtained through the LCP operator. In this new data batch, previously unreported fuels were accounted. These fuels were:

- Industrial waste – Fluff (fiber residue) and RDF (unrecycled cardboard and plastics)
- Hazardous industrial waste – composition unknown;
- Animal and wood waste – animal carcass and general wood waste;

Other changes were made to this sector in the 2012 inventory. These changes concern the inclusion of Lime Production activities as LPS in the inventory. This improvement resulted from the ongoing integration of EU-ETS data in the inventory.

Table 3.49 – Low Heating Values/ Net Calorific Values (LHV/NCV) in the Cement Industry

Steam Coal	Petcoke	LPG	Gasoline	Kerosene	Gas Oil	Residual Oil
MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg
18.7 - 31	30.9 - 34.6	46.0	44.0	43.8	42.6	39.8 - 40.4

Natural Gas (MJ/Nm3)	Biodiesel	Tires	Industrial Waste	Hazardous Industrial Waste	Animal + Wood Waste
MJ/Nm3	MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg
38.7	37.0	23.8 - 31.4	10.7 - 32.3	12.3 - 23.5	9.8 - 21.0

Six units (belonging to two companies) produce clinker and cement in Portugal, representing the majority of fuel combustion in this economic sector. Petroleum coke has been, in recent years, gradually replacing the use of imported coal in the kilns. Relevant is also to note the use of old tires and other industrial waste as energy source.

Currently there are 7 dedicated lime production plants in operation in Portugal which use natural gas as main fuel since 2000 (prior to that was residual oil). In this sector there is also comsumption of petcoke and biomass, and small amounts of LPG and gas oil.

Even though fuel consumption in this sector includes at least 9 companies we consider this data to be confidential, because there are only two companies (associated with clinker production) for most fuels, and both represent more than 90 per cent of consumption for all other fuels. Because of this no table will be included in this report with energy consumption data desegregated by fuel type.

Figure 3.32 – Total Energy Consumption in the Cement Industry

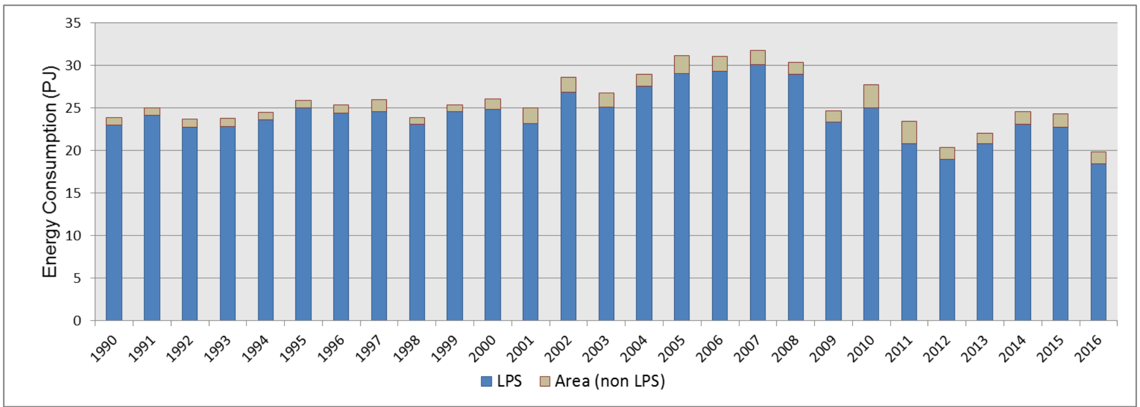
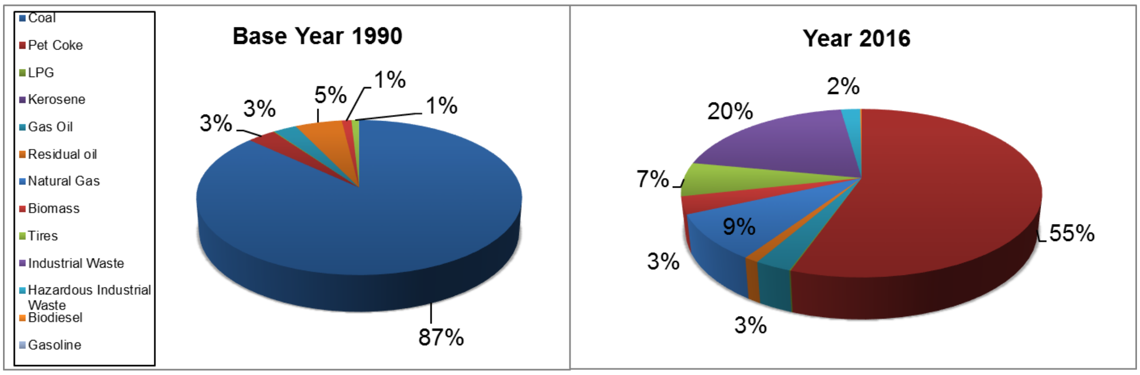


Figure 3.33 – Fuel consumption per fuel type in the Cement Industry in 1990 and 2016



1.1.1.1.1.1.10 Clothing, Shoes and Leather Industries

Table 3.50 – Low Heating Values/ Net Calorific Values (LHV/NCV) in Clothing, Shoes and Leather Industries

LPG	Kerosene	Gas Oil	Residual Oil	Natural Gas	Wood
MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/Nm3	MJ/kg
46.0	43.8	42.6	40.0	38.7	12.6

Gasoline	Biodiesel
MJ/kg	MJ/kg
44.0	37.0

Table 3.51 – Fuel consumption in the Clothing, Shoes and Leather Industries – Boilers and Furnaces (GJ)

Year	LPG	Kerosene	Gas Oil	Residual Oil	Natural Gas	Wood	Biodiesel
1990	56,737	28	27,665	766,086	0	279,958	0
1995	239,172	0	22,330	704,818	0	265,481	0
2000	226,044	0	15,078	350,076	148,572	282,636	0
2005	231,177	8	11,608	241,561	471,671	0	0
2010	155,078	0	7,382	373,331	767,189	0	384
2014	115,345	0	39,757	47,352	843,682	41,297	2,466
2015	125,519	42	66,956	85,828	885,006	78,243	4,783
2016	105,213	0	39,993	24,074	920,845	78,243	2,210

Table 3.52 – Fuel consumption in the Clothing, Shoes and Leather Industries – Static Engines (GJ)

Year	Gasoline	Gas Oil	Biodiesel
1990	1,962	27,665	0
1995	8,668	22,330	0
2000	3,836	15,078	0
2005	465	11,608	0
2010	0	7,382	384
2014	0	39,757	2,466
2015	0	66,956	4,783
2016	0	39,993	2,210

Figure 3.34 – Total Energy Consumption in the Clothing, Shoes and Leather Industries

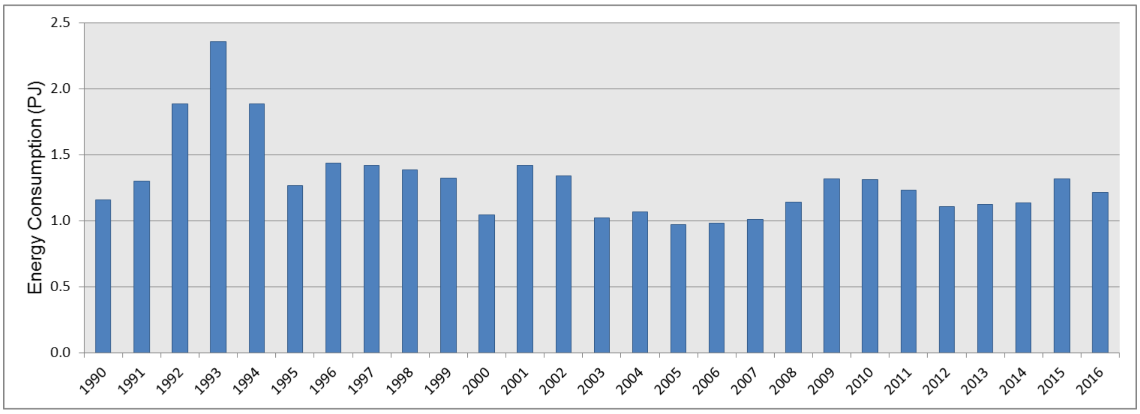
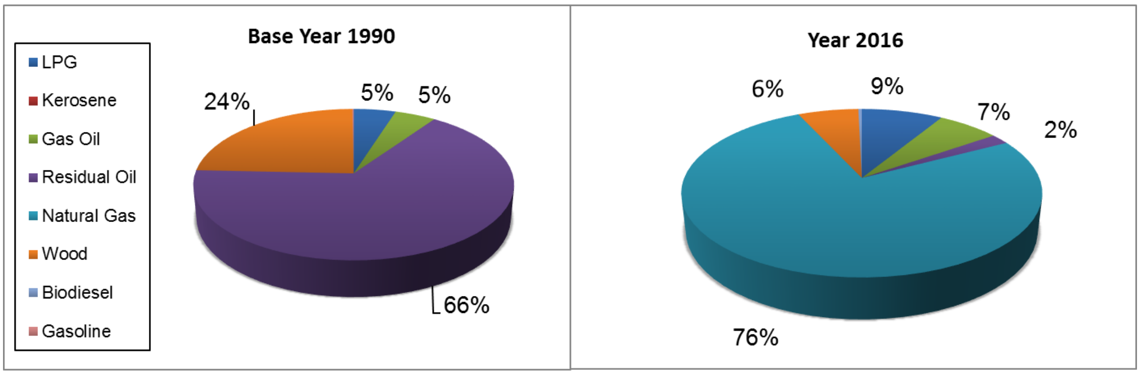


Figure 3.35 - Fuel consumption per fuel type in the Clothing, Shoes and Leather Industries in 1990 and 2016



1.1.1.1.1.1.11 Wood Industry

Table 3.53 – Low Heating Values/ Net Calorific Values (LHV/NCV) in the Wood Industry

LPG	Kerosene	Gas Oil	Residual Oil	Natural Gas	Wood
MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/Nm3	MJ/kg
46.0	43.8	42.6	40.0	38.7	12.6

Gasoline	Biodiesel
MJ/kg	MJ/kg
44.0	37.0

Table 3.54 – Fuel consumption in the Wood Industry – Boilers and Furnaces (GJ)

Year	LPG	Kerosene	Gas Oil	Residual Oil	Natural Gas	Wood	Biodiesel
1990	85,312	69	250,404	1,346,386	0	1,309,205	0
1995	115,297	0	192,250	3,036,372	0	1,241,590	0
2000	467,887	85	206,253	2,939,646	237,201	907,236	0
2005	260,611	1,127	215,627	1,998,707	524,175	1,632,259	0
2010	59,326	0	122,508	1,667,574	335,823	1,706,234	7,553
2014	50,241	0	117,214	430,772	379,240	1,908,954	7,049
2015	70,212	0	138,575	551,350	327,994	2,022,887	9,929
2016	70,673	0	104,650	185,891	328,203	1,980,628	5,838

Table 3.55 – Fuel consumption in the Wood Industry – Static Engines (GJ)

Year	Gasoline	Gas Oil	Biodiesel
1990	793	250,404	0
1995	11,017	192,250	0
2000	4,050	206,253	0
2005	1,373	215,627	0
2010	0	122,508	7,553
2014	0	117,214	7,049
2015	0	138,575	9,929
2016	0	104,650	5,838

Although total consumption of energy from combustion has decreased from 1990 to 2015, there is not a constant trend along periods, but instead oscillations along the period.

Figure 3.36 – Total Energy Consumption in the Wood Industry

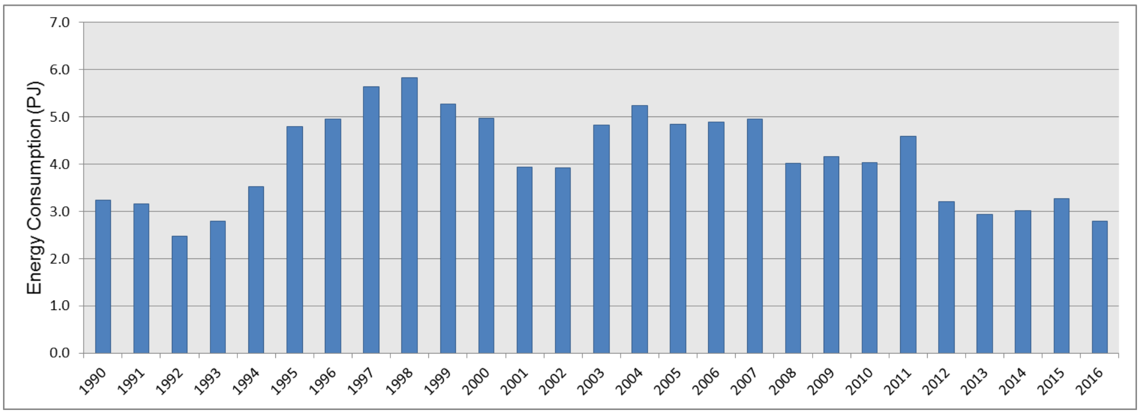
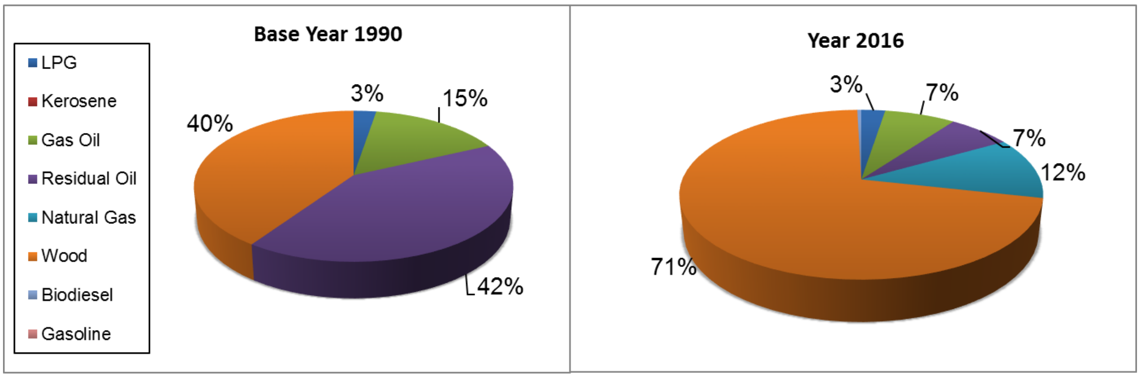


Figure 3.37 – Fuel consumption per fuel type in the Wood Industry in 1990 and 2016



1.1.1.1.1.1.1.12 Rubber Industry

Table 3.56 – Low Heating Values/ Net Calorific Values (LHV/NCV) in the Rubber Industry

LPG	Kerosene	Gas Oil	Residual Oil	Natural Gas	Wood
MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/Nm3	MJ/kg
46.0	43.8	42.6	40.0	38.7	12.6

Gasoline	Biodiesel
MJ/kg	MJ/kg
44.0	37.0

Table 3.57 – Fuel consumption in the Rubber Industry – Boilers and Furnaces (GJ)

Year	LPG	Kerosene	Gas Oil	Residual Oil	Natural Gas	Wood	Industrial Waste
1990	27,688	240	5,481	571,475	0	46,820	0
1995	33,286	135	13,470	270,653	0	44,393	0
2000	28,111	48	29,578	379,923	34,818	47,280	0
2005	20,546	0	1,314	27,107	419,232	0	0
2010	4,145	42	0	20,682	733,695	0	59,620
2014	4,940	0	0	0	802,986	21,255	114,299
2015	6,113	0	2,089	0	808,639	19,540	98,389
2016	6,531	0	0	0	833,759	19,540	72,347

Table 3.58 – Fuel consumption in the Rubber Industry – Static Engines (GJ)

Year	Gasoline	Gas Oil
1990	0	5,481
1995	4,728	13,470
2000	57,450	29,578
2005	48	1,314
2010	0	0
2014	0	0
2015	0	2,088
2016	0	0

The sharp increase in natural gas consumption from 2007 to 2008 results from a reclassification of a co-generation plant in the energy balance (previously accounted in another sector).

Figure 3.38 – Total Energy Consumption in the Rubber Industry

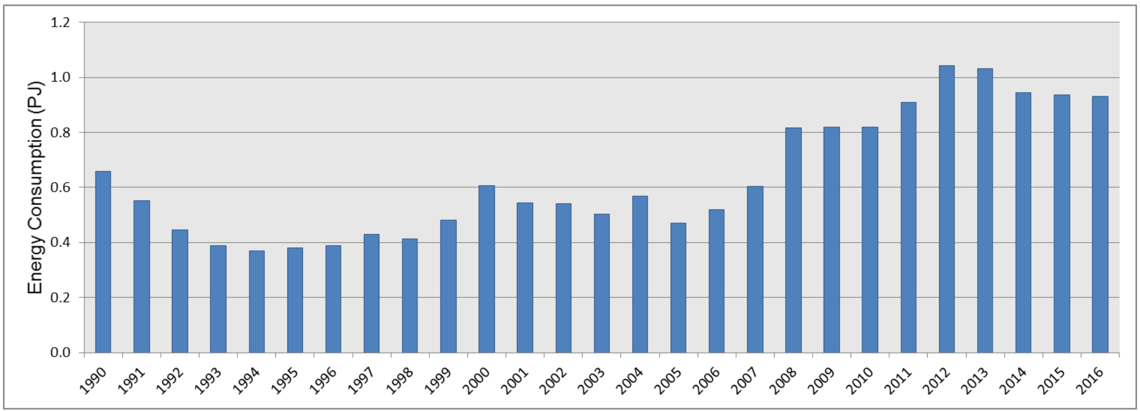
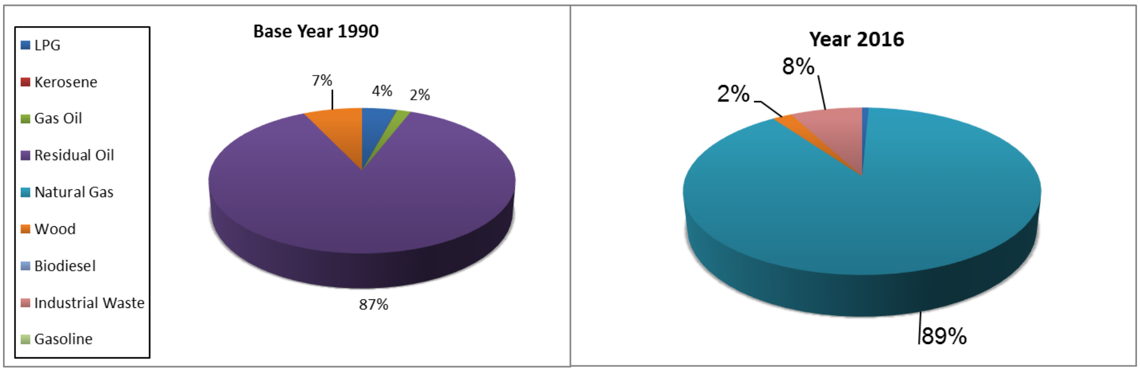


Figure 3.39 – Fuel consumption per fuel type in the Rubber Industry in 1990 and 2016



1.1.1.1.1.1.13 Manufacturing of Machines and Metallic Equipments Industry

Table 3.59 – Low Heating Values/ Net Calorific Values (LHV/NCV) in the Manufacturing of Machines and Metallic Equipments Industry

LPG	Kerosene	Gas Oil	Residual Oil	Natural Gas	Wood
MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/Nm3	MJ/kg
46.0	43.8	42.6	40.0	38.7	12.6

Gasoline	Biodiesel
MJ/kg	MJ/kg
44.0	37.0

Table 3.60 – Fuel consumption in the Manufacturing of Machines and Metallic Equipments Industry – Boilers and Furnaces (GJ)

Year	LPG	Coal	Coke	Kerosene	Gas Oil	Residual Oil	Natural Gas	Wood	Biodiesel
1990	1,464,554	0	0	5,901	166,018	885,983	0	28,368	0
1995	1,606,517	0	0	77	210,899	508,561	0	26,904	0
2000	1,785,009	0	0	324	117,664	770,616	1,196,654	16,201	0
2005	1,293,735	0	0	296	142,488	215,524	2,120,737	16,992	0
2010	927,704	0	0	921	106,258	111,618	2,040,186	16,987	6,031
2014	681,354	0	0	167	108,473	28,260	2,284,360	3,849	6,684
2015	715,225	1,089	4,438	544	157,325	15,491	2,382,080	22,929	11,192
2016	809,428	837	4,145	419	120,293	15,407	2,703,040	22,929	6,628

Table 3.61 – Fuel consumption in the Manufacturing of Machines and Metallic Equipments Industry – Static Engines (GJ)

Year	Gasoline	Gas Oil	Biodiesel
1990	43,723	166,018	0
1995	101,341	210,899	0
2000	45,687	117,664	0
2005	10,951	142,488	0
2010	90,353	106,258	6,031
2014	754	108,473	6,684
2015	1,130	157,325	11,192
2016	502	120,293	6,628

Figure 3.40 – Total Energy Consumption in the Manufacturing of Machines and Metallic Equipments Industry

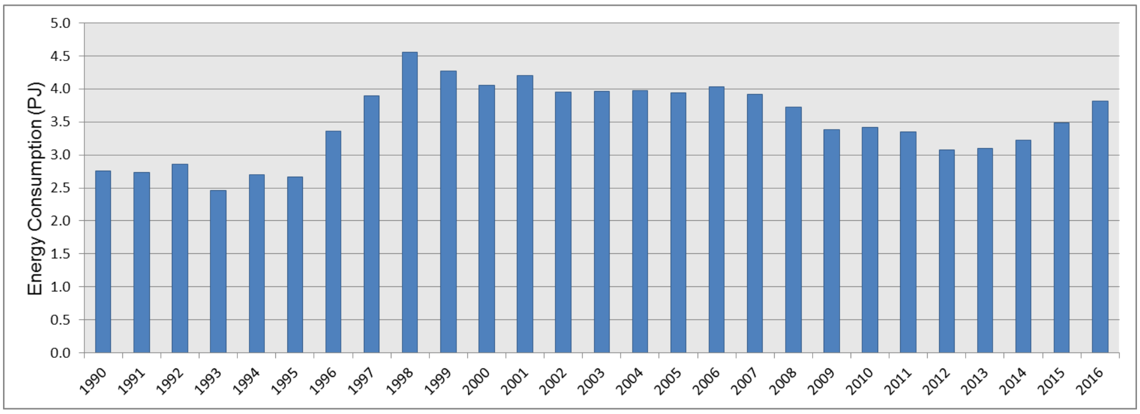
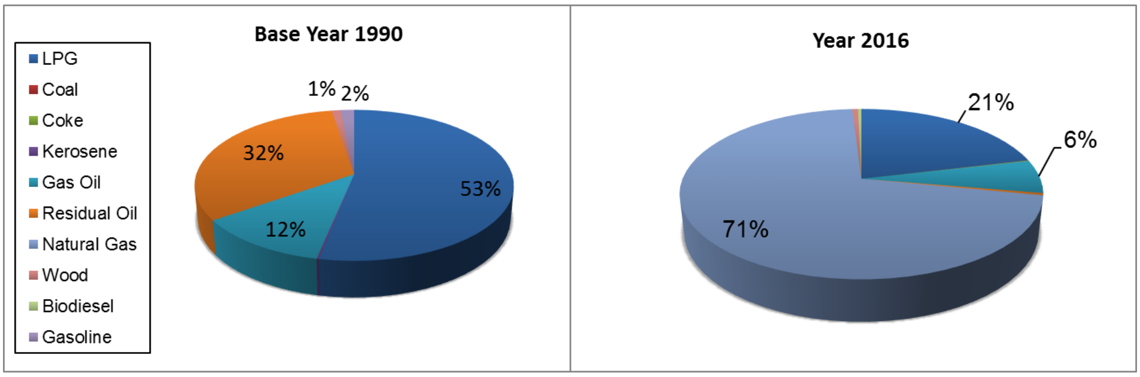


Figure 3.41 – Fuel consumption per fuel type in the Manufacturing of Machines and Metallic Equipments Industry in 1990 and 2016



1.1.1.1.1.1.14 Other Transformation Industry

Table 3.62 – Low Heating Values/ Net Calorific Values (LHV/NCV) in Other Transformation Industry

Lignite	LPG	Kerosene	Gas Oil	Residual Oil	City Gas
MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg
17.2	46.0	43.8	42.6	40.0	15.7

Natural Gas	Wood	Gasoline	Biodiesel	Biogas
MJ/Nm3	MJ/kg	MJ/kg	MJ/kg	MJ/kg
38.7	12.6	44.0	37.0	34.7

Table 3.63 – Fuel consumption in Other Transformation Industry – Boilers and Furnaces (GJ)

Year	Lignite	Coal	Coke	LPG	Kerosene	Gas Oil	Residual Oil	City Gas	Natural Gas	Wood	Biodiesel
1990	446	0	0	152,483	4,090	169,380	1,450,485	78	0	6,234	0
1995	0	0	0	431,055	37	180,662	168,426	55,690	0	5,900	0
2000	0	0	0	79,493	0	17,846	0	44,451	108,896	6,276	0
2005	0	0	0	33,769	0	8,023	0	0	198,239	34,984	0
2010	0	0	0	114,382	84	515,036	175,215	0	477,128	34,979	32,757
2014	0	0	0	86,750	0	390,402	44,254	0	397,830	18,996	24,379
2015	0	5,987	1,717	104,418	84	512,234	56,563	0	318,322	7,197	36,816
2016	0	5,820	203,271	102,157	84	415,738	40,988	0	349,054	2,929	23,200

Table 3.64 – Fuel consumption in Other Transformation Industry – Static Engines (GJ)

Year	Gasoline	Gas Oil	Biogás	Biodiesel
1990	307	169,380	0	0
1995	51,541	180,662	0	0
2000	2,621	17,846	0	0
2005	2,706	8,023	0	0
2010	0	515,036	26,347	32,757
2014	0	390,402	73,238	24,379
2015	0	512,234	82,758	36,816
2016	0	415,738	81,284	23,200

An increase in fuel consumption is noticeable from 2008 to 2009. This is mainly due to gas oil and natural gas fuel consumption.

Figure 3.42 – Total Energy Consumption in Other Transformation Industry

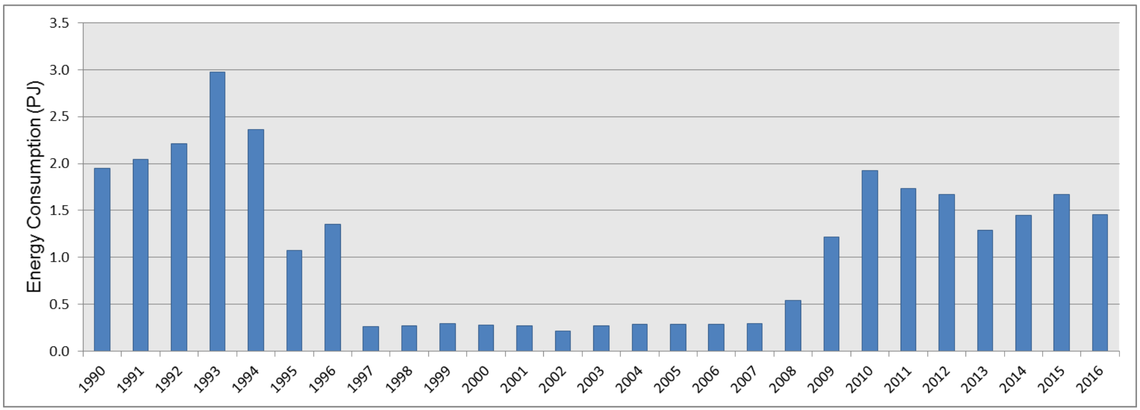
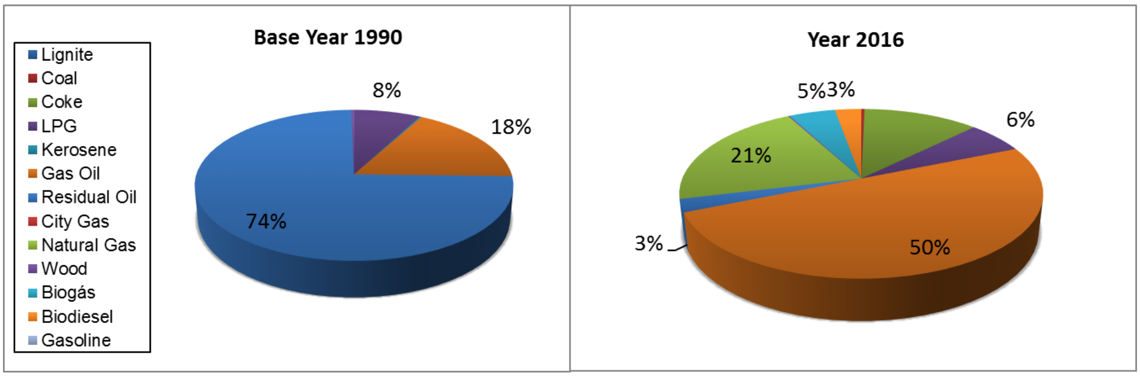


Figure 3.43 – Fuel consumption per fuel type in other transformation industry in 1990 and 2016



1.1.1.1.1.1.15 Extractive Industry

Table 3.65 – Low Heating Values/ Net Calorific Values (LHV/NCV) in the Extractive Industry

Lignite	LPG	Gasoline	Kerosene	Gas Oil	Residual Oil
MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg
17.2	46.0	44.0	43.8	42.6	40.0

Natural Gas	Biodiesel
MJ/Nm3	MJ/kg
38.7	37.0

Table 3.66 – Fuel consumption in the Extractive Industry – Boilers and Furnaces

Year	Coal	LPG	Gasoline	Kerosene	Gas Oil	Residual oil	Natural Gas	Biodiesel
1990	2,402	77,429	0	1,929	496,778	119,777	0	0
1995	0	106,523	0	625	497,405	53,492	0	0
2000	0	176,933	28,632	0	1,054,333	103,471	14,990	0
2005	0	72,128	2,881	0	971,618	435,410	287,341	0
2010	0	89,764	0	0	849,610	40,153	332,892	55,253
2014	0	48,540	0	0	581,123	18,206	173,417	35,705
2015	0	56,286	0	0	663,589	22,074	169,858	46,933
2016	0	0	0	0	582,466	52,010	103,665	32,040

Table 3.67 – Fuel consumption in the Extractive Industry – Static Engines

Year	Gasoline	Gas Oil	Biodiesel
1990	16,254	466,146	0
1995	2,037	495,098	0
2000	20,681	756,662	0
2005	22,469	880,964	0
2010	20,181	849,610	55,253
2014	0	581,123	35,705
2015	0	663,589	46,933
2016	0	582,466	32,040

Figure 3.44 – Total Energy Consumption in the Extractive Industry

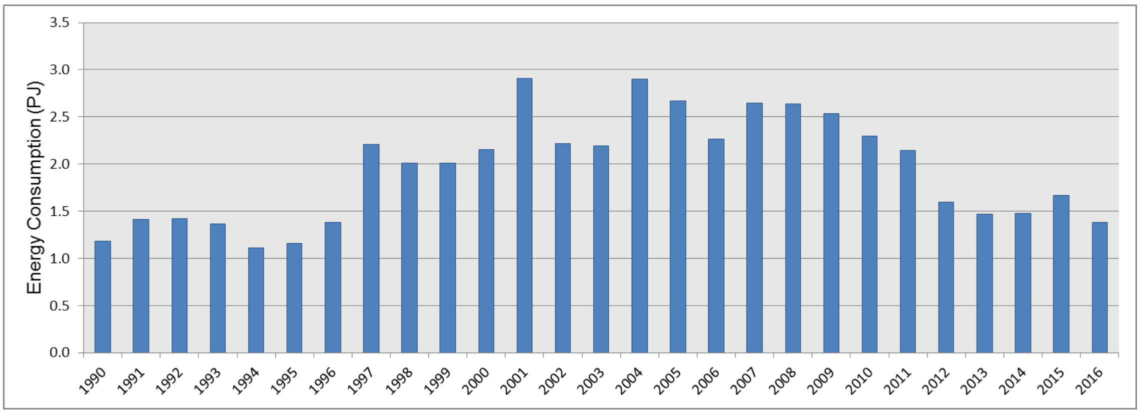
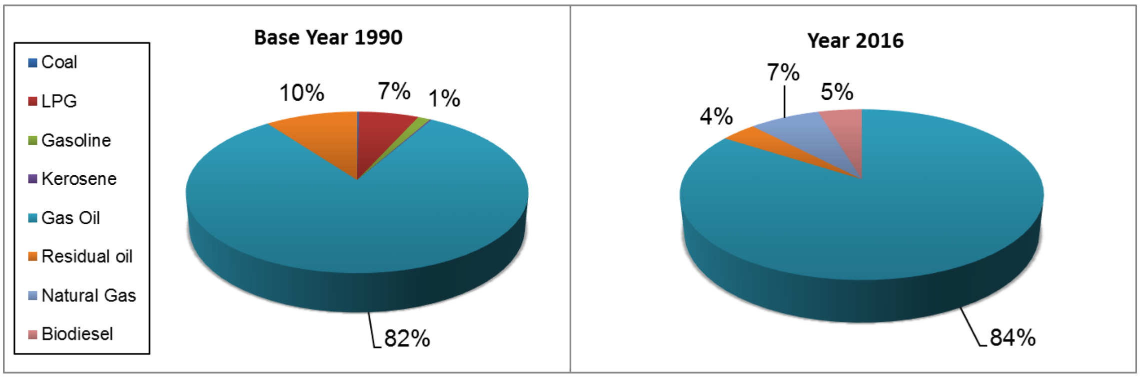


Figure 3.45 – Fuel consumption per fuel type in the Extractive Industry in 1990 and 2016



1.1.1.1.1.1.16 Construction and Building Industry

Table 3.68 – Low Heating Values/ Net Calorific Values (LHV/NCV) in the Construction and Building Industry

LPG	Gasoline	Kerosene	Gas Oil	Residual Oil	Natural Gas	Biodiesel
MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/Nm3	MJ/kg
46.0	44.0	43.8	42.6	40.0	38.7	37.0

Table 3.69 – Fuel consumption in the Construction and Building Industry (GJ)

Year	LPG	Gasoline	Kerosene	Gas Oil	Residual oil	Natural Gas	Biodiesel
1990	226,695	27,676	6,859	5,864,312	668,507	0	0
1995	887,678	447,712	640	7,580,456	1,756,467	0	0
2000	545,639	72,532	130	7,548,443	1,467,006	8,455	0
2005	412,087	67,399	184	9,135,498	1,717,788	891,143	0
2010	484,791	91,783	126	5,583,764	1,072,740	1,202,436	353,676
2014	317,888	0	42	2,684,174	401,792	1,076,367	164,460
2015	334,131	0	126	3,253,716	593,125	1,105,649	229,547
2016	358,352	0	0	2,637,507	657,000	1,577,569	143,350

Figure 3.46 – Total Energy Consumption in the Construction and Building Industry

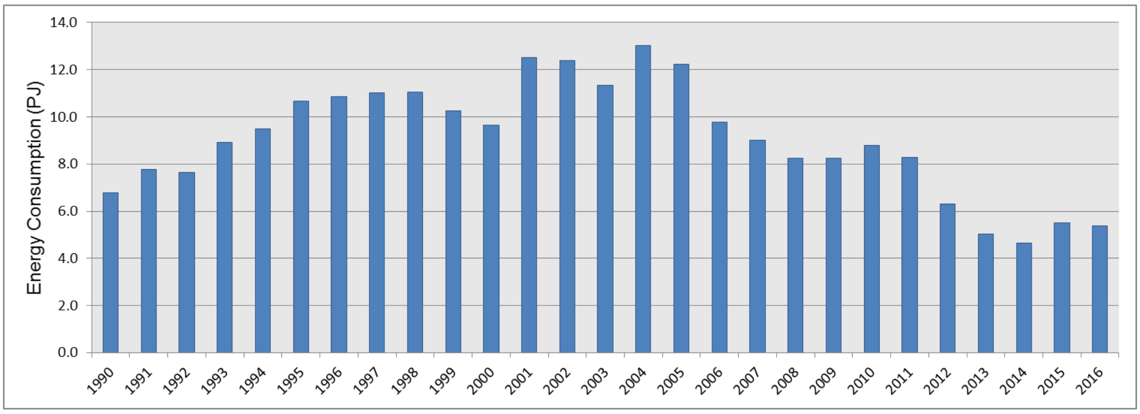
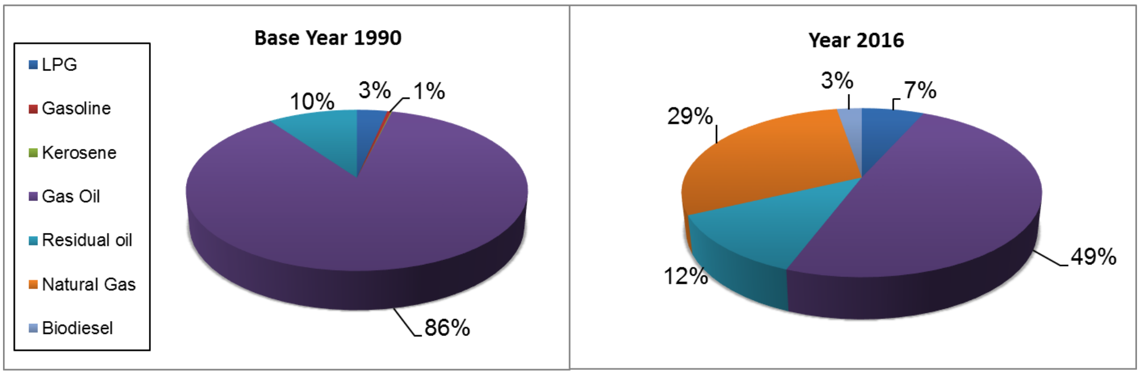


Figure 3.47 – Fuel consumption per fuel type in the Construction and Building Industry in 1990 and 2016



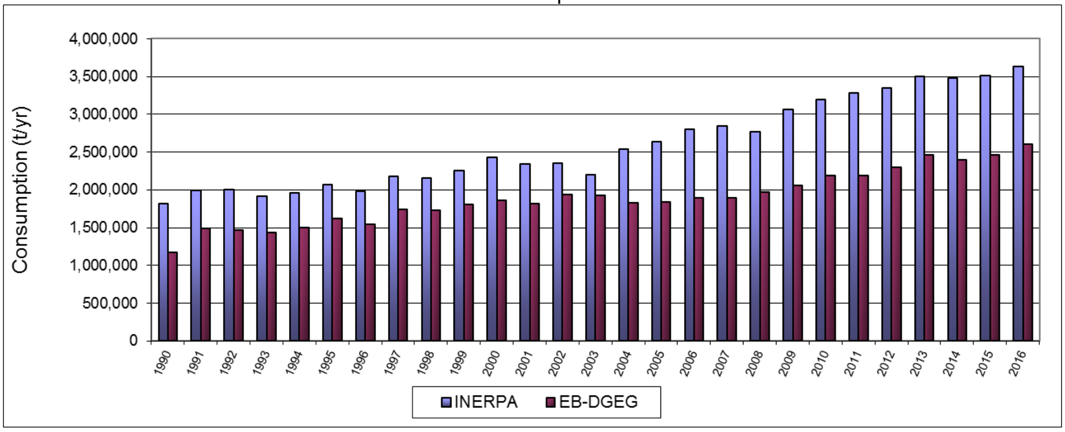
3.2.2.2.1.3 Comparison of LPS data vs. Energy Balance

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.

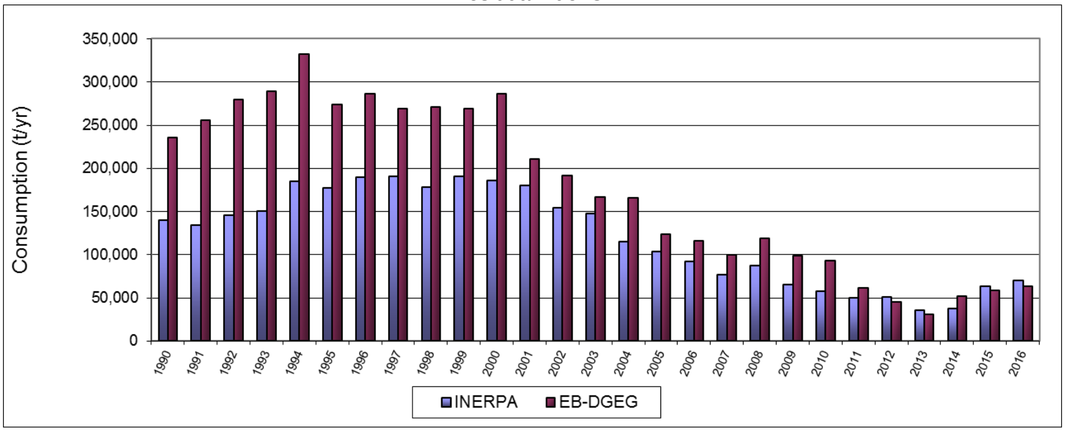
Before hand, it must be realized that to conclude for consistency between both distinct datasets, the comparison should result in higher or equal consumption in the EB than in the inventory, because apart from specific fuels (black liquor in the paper and pulp industry, coke oven gas and blast furnace 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).

Figure 3.48 – Comparison of total LPS consumption in Paper Pulp units with the reported consumption in the EB for the sector "Paper pulp and paper production"

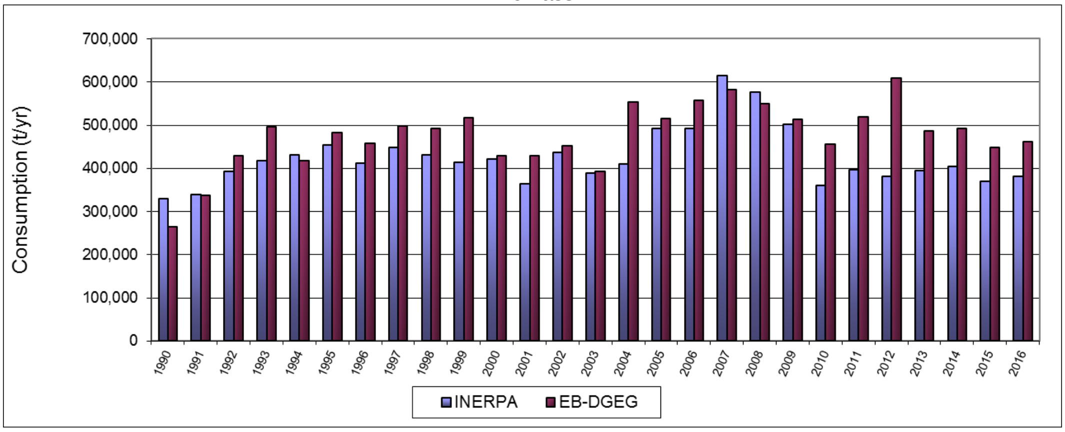
Black Liquor



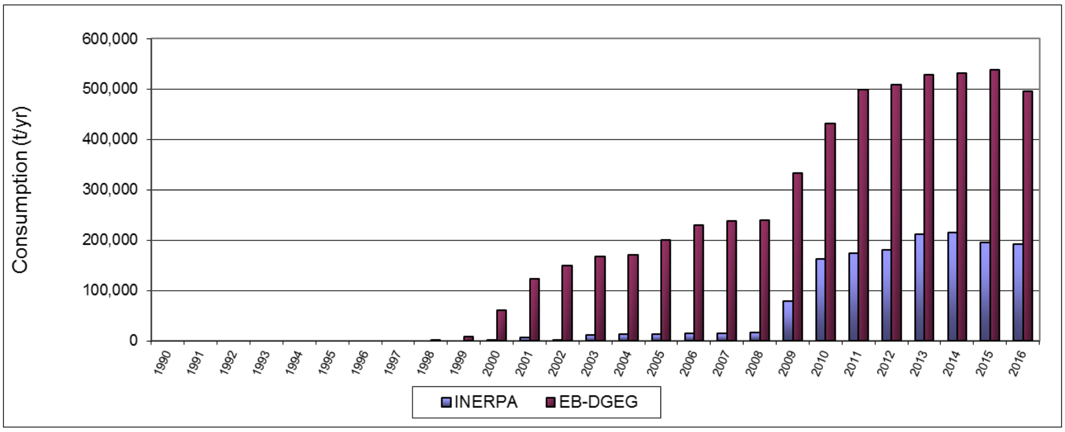
Residual Fuel Oil



Biomass

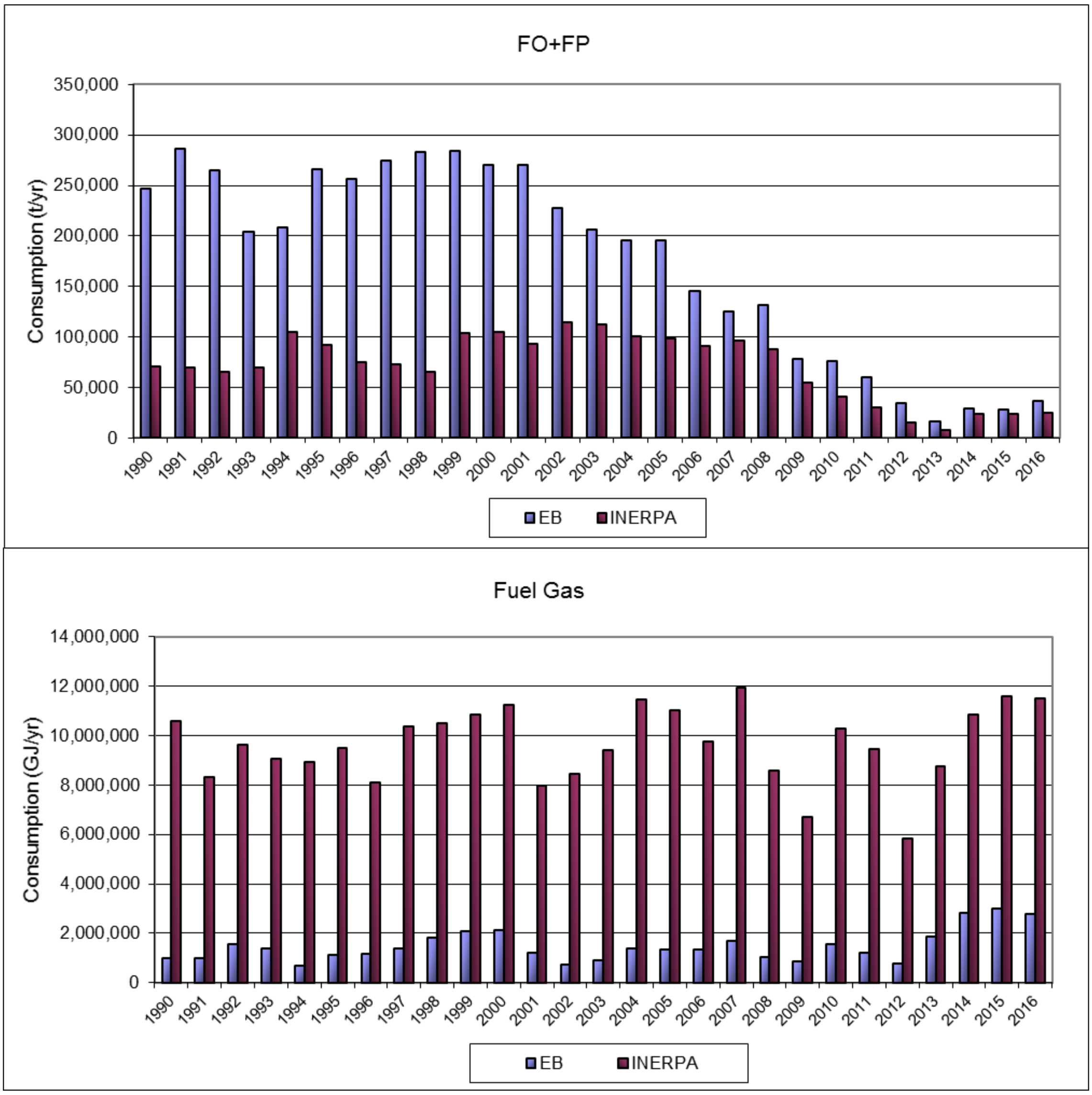


Natural Gas



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 3.49 – Comparison of total LPS consumption in Petrochemical units with the reported consumption in the EB for the sector "Chemical and Plastics"[1]



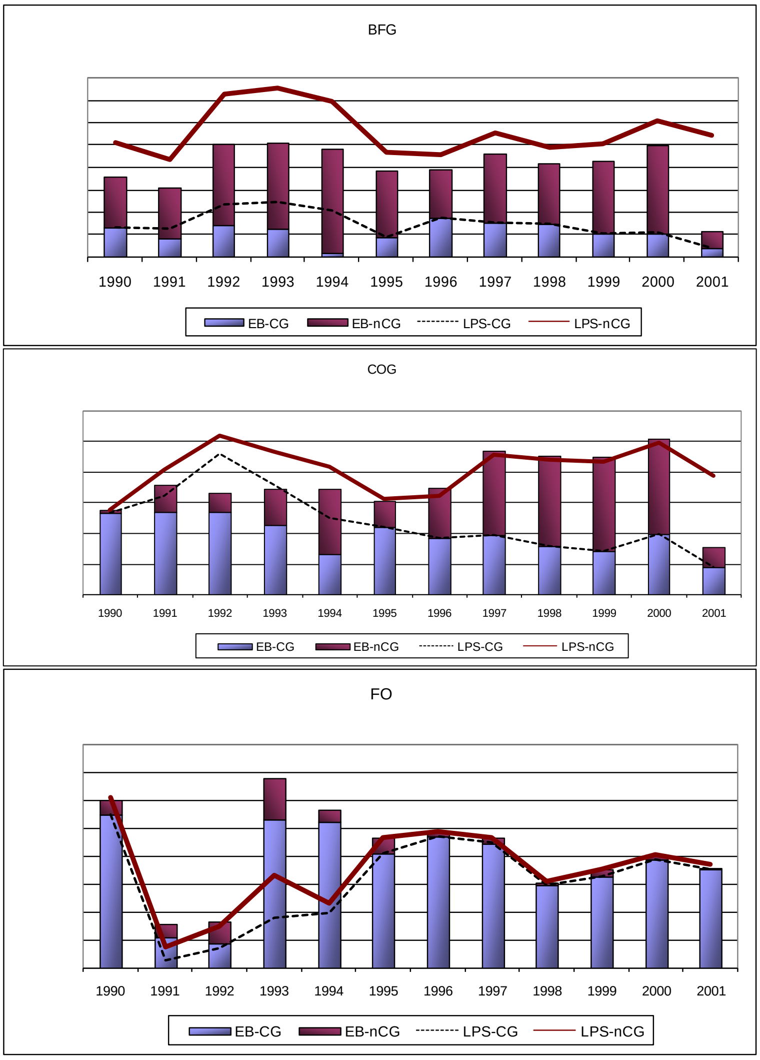
For the Petrochemical industry the comparison shows that the share of LPS in the consumption of residual fuel oil[2] is about 50 per cent until 2005. The two values show a tendency to converge in the later years. Also importante to note that in 2012 LPS values surpasse energy balance data by 8 %. Consumption 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.

[1] Units in the vertical axis are not indicated due to considenciality issues.

[2] 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.

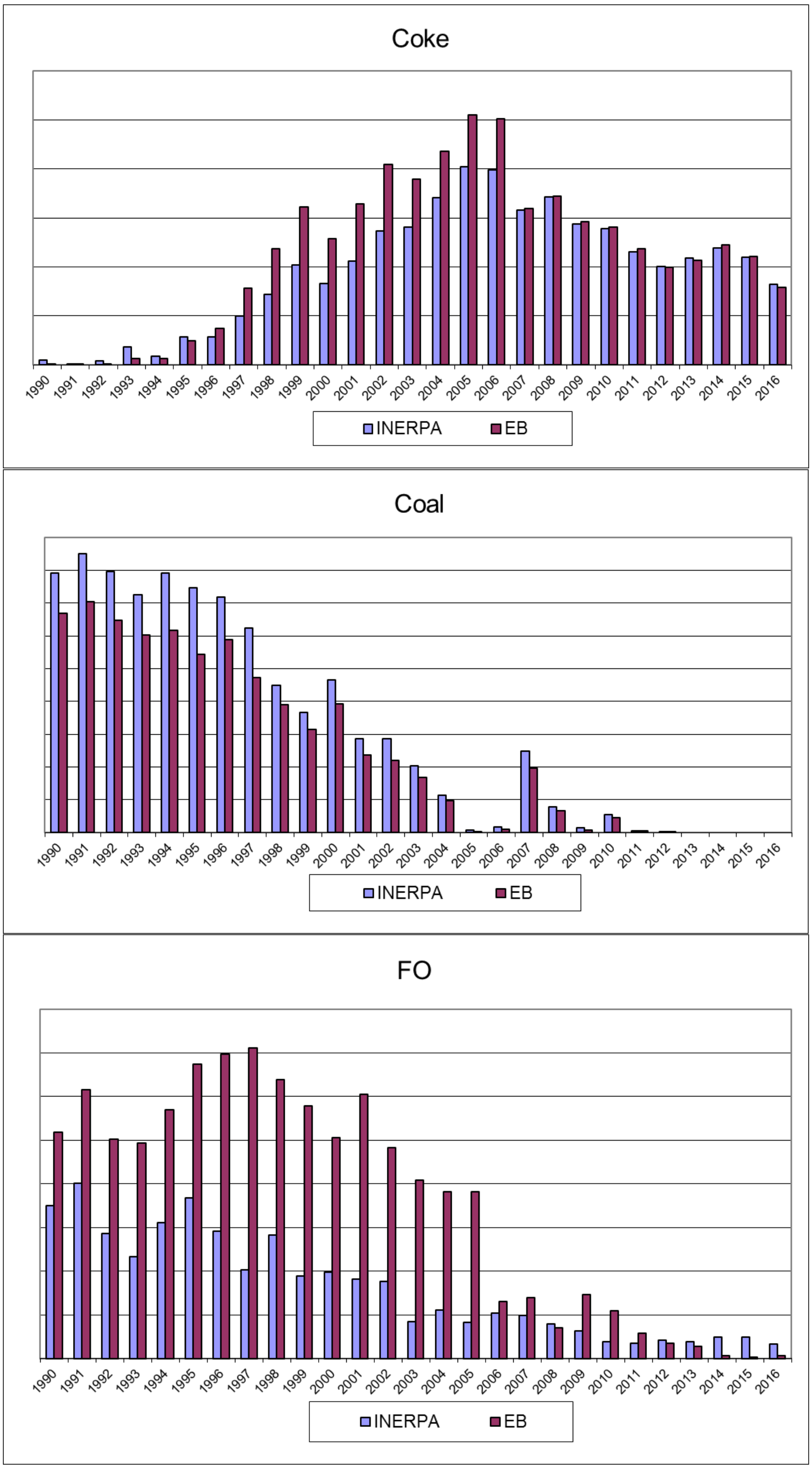
The match for the iron and steel industry show a good consistency, except for intermediate years, and for the slightly higher consumption of Blast Furnace Gas. This last difference may result from the use of different LHV values.

Figure 3.50 – Comparison of total LPS consumption in the only Integrated Iron and Steel Plant with the reported consumption in the EB for the sector "Iron and Steel"[1] (1990-2001)



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

Figure 3.51 – 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.

3.2.2.2.2 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 3.71. Production data for Kraft paper pulp was obtained fro the following data sources:

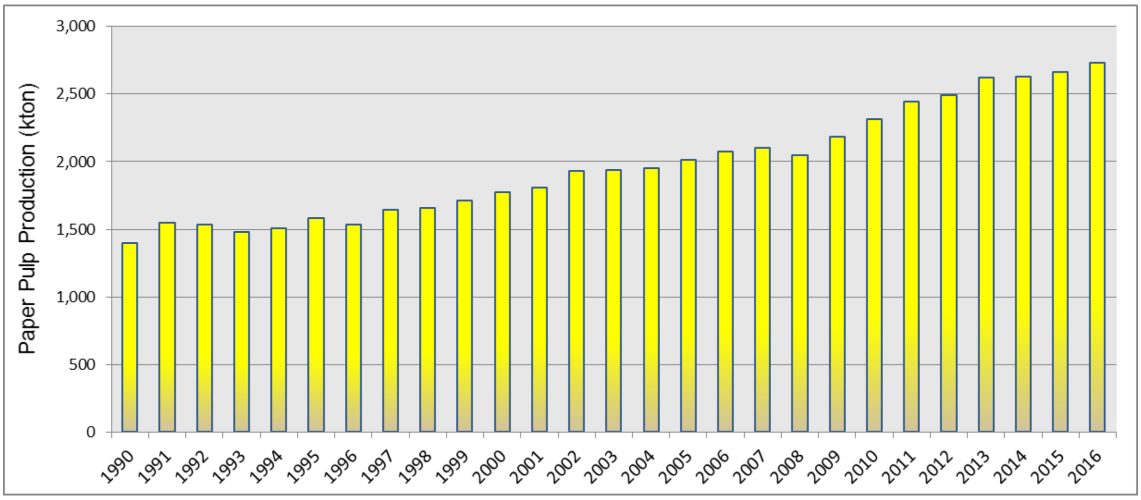
- LCP Directive – 1990 to 2000;
- CELPA – 2003 to 2009 (Kraft paper pulp);
- INE industrial production data – 2003 to 2009 (Acid sulphite paper pulp);
- EU-ETS – 2010 onwards.

Even though different sources were used the ultimate data source was the same: the industrial plants.

Table 3.70 – Total Paper Pulp Production (Kraft and sulphide paper pulp)

Product	Unit	1990	1995	2000	2005	2010	2014	2015	2016
Pulp Production	kt	1,398	1,581	1,774	2,010	2,316	2,631	2,664	2,729

Figure 3.52 – Total paper pulp production: Kraft and sulphide paper pulp



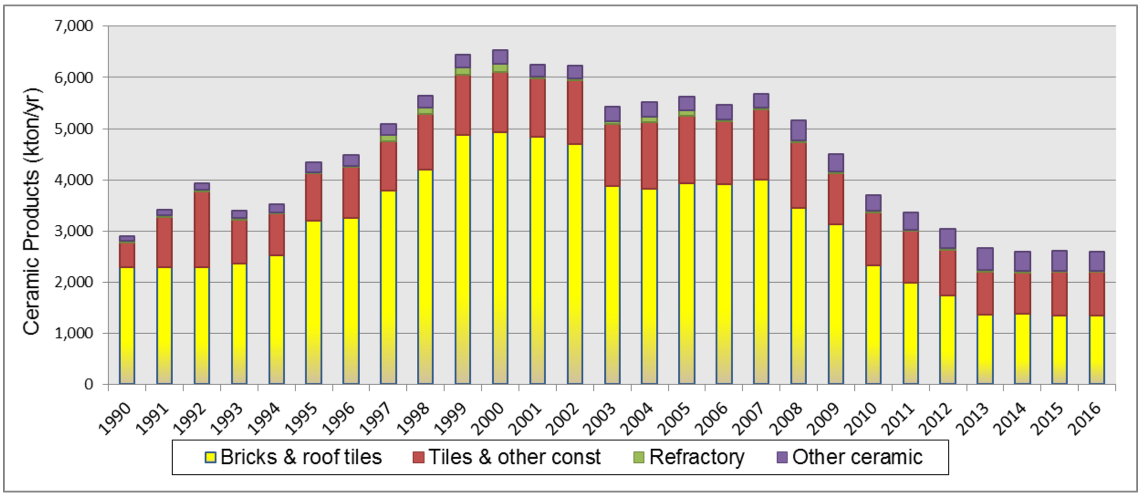
Clinker production values cannot be shown in this reported because of confidentiality issues.

Data on annual manufacturing of ceramic products is available from 1990 to 2015 from INE statistical database. The time series for total production is shown in Table 3.72 and Figure 3.54, according to type of ceramic.

Table 3.71 – Ceramic Production according to type of ceramic (kt)

Product	Unit	1990	1995	2000	2005	2010	2014	2015	2016
Bricks & roof tiles	kt	2,290	3,200	4,932	3,923	2,321	1,374	1,338	1,342
Tiles & other const	kt	478	921	1,170	1,327	1,043	816	859	853
Refractory	kt	31	27	167	100	25	24	24	24
Other ceramic	kt	104	185	260	278	310	384	384	376

Figure 3.53 – Ceramic Production according to 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 3.54 – Glass production by glass type (excluding flat glass production)

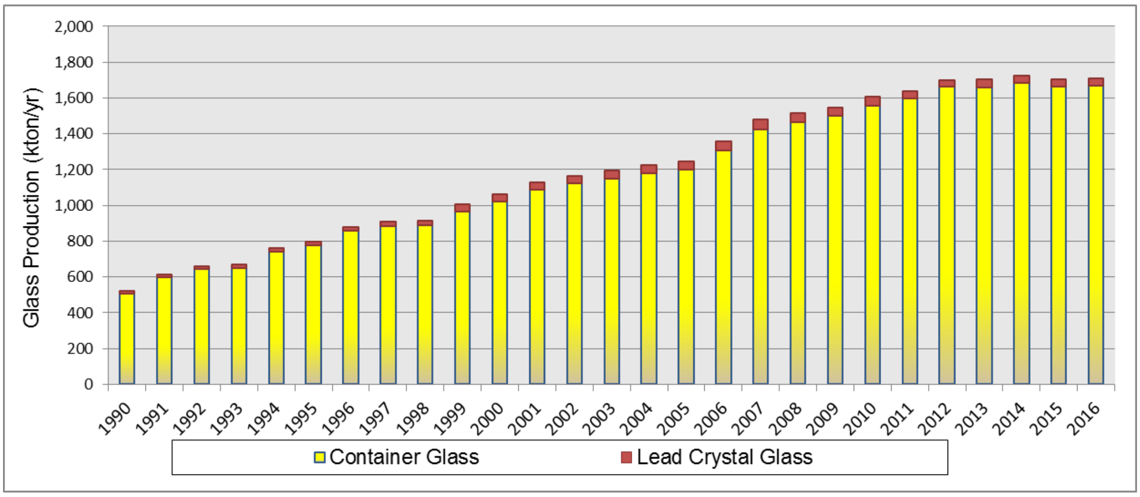


Table 3.72 – Glass production by glass type (kt/yr) excluding flat glass production

Product	Unit	1990	1995	2000	2005	2010	2014	2015	2016
Container Glass	kt	508	776	1,019	1,201	1,558	1,682	1,666	1670
Lead Crystal Glass	kt	16	22	44	45	52	44	39	42

Sinter and lime production in iron and steel integrated plan are reported in chapter 4.2.C.1 – Industrial Processes: Iron and Steel Production.

3.2.2.3 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 3.73 – 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 3.74 – Default sulphur content of fuels for combustion equipments in the Manufacturing Industry

Fuel		NAPFUE	Unit	1990	1995	2000	2001	2005	2015
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 3.75 – 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 3.76 – Default emissions factors of Heavy Metals for combustion equipments in Manufacturing Industry

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

a) g/km^3

Table 3.77 – Default emissions factors of Dioxins/Furans and PAH for combustion equipments in Manufacturing Industry

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

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

Table 3.78 – 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 3.79 – 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
2014	0.0016	0.02	0.005	0.15	0.10	1.00	0.0007	0.65	0
2015	0.0016	0.02	0.005	0.15	0.10	1.00	0.0007	0.65	0
2016	0.0016	0.02	0.005	0.15	0.10	1.00	0.0007	0.65	0

Table 3.80 – 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 3.81 – 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 3.82 – Emission factors of Dioxins/Furans and PAH in the extractive industry

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

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

Table 3.83 – Emission factors for Ozone Precursor gases in the building and construction industry

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

Table 3.84 – 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 3.85 – 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 3.86 – Emission factors for Heavy Metals in the building and construction industry

Fuel		NAPFUE	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
			g/ton	g/ton	g/ton	g/ton	g/ton	g/ton	g/ton	g/ton	g/ton
Residual Oil	L	203	0.00320	0.00024	0.00480	0.00120	0.00800	0.00880	0.00032	0.00440	1.16000
Gas Oil	L	204	0.00341	0.00026	0.00511	0.00128	0.00852	0.00937	0.00034	0.00469	1.23540
Kerosene	L	206	0.00350	0.00026	0.00525	0.00131	0.00875	0.00963	0.00035	0.00481	1.26875
Motor Gasoline	L	208	0.00352	0.00026	0.00528	0.00132	0.00880	0.00968	0.00035	0.00484	1.27600
LPG	L	303	0.00368	0.00028	0.00552	0.00138	0.00920	0.01012	0.00037	0.00506	1.33400
Natural Gas	G	301	0.00051	0.00004	0.02488	0.00461	0.00060	0.00012	0.00060	0.00267	0.03363
Biodiesel	B	223	0.00296	0.00022	0.00444	0.00111	0.00740	0.00814	0.00030	0.00407	1.07300

a) g/km^3

Other specific emission factors were used for some industrial units, some of them obtained from direct measurements in Large Point Sources (LPS) or result from bibliographic references specific of the industrial sector. Some of the emission factors are used in the process approach and are applied to production data instead of fuel consumption data. These emission factors are listed in the tables below, arranged by sector and indicating if they only apply to Large Point Sources (LPS).

Table 3.87 – Emission factors (Energy Approach) for use in LPS units in the Iron and Steel Industry: Indirect Precursors from combustion

Equipment	Fuel		NAPFUE	NO_x	%S		NMVOC	CO
				g/GJ	%	Units	g/GJ	g/GJ
Coquerie	Coke oven gas	S	304	120	7.05	g S/Nm3	2.5	17
Sintering	Coke oven gas	S	304	PA	7.05	g S/Nm3	PA	PA
Blast Furnace Cowpers	Coke oven gas	S	304	120	7.05	g S/Nm3	2.5	17
	Blast furnace gas	S	305	70	0.045	g S/Nm3	2.5	17
Rolling mills	Residual oil	L	203	190	3.5	% S	3	15
	Coke oven gas	S	304	120	7.05	g S/Nm3	2.5	17
Thermo Electric Power plant	Coke oven gas	S	304	120	7.05	g S/Nm3	2.5	17
	Blast furnace gas	S	305	70	0.045	g S/Nm3	2.5	17
	Residual oil (3.5%)	L	203	190	3.5	% S	3	15
	Residual oil (1%)	L	203	190	1	% S	3	15
	Tar	L	299	300	0.6	% S	3	15
Heat power plant	LPG	L	303	160	0.005	% S	4	17
	Tar	L	299	300	0.6	% S	3	15
	Waste Oils	O	115	190	0	% S	3	15
Lime kiln	Residual Oil	L	203	PA	3.5	% S	3	PA

Note: PA = Process Approach

Table 3.88 – Emission factors (Production Approach) for use in LPS units in the Iron and Steel Industry: Ozone Precursors from combustion

Equipment	Fuel		NAPFUE	NO_x (kg/t)	SO_x (kg/t)	NMVOC (kg/t)	CO (kg/t)
Sintering	Coke oven gas	S	304	0.5	1.0	0.10	30
Lime kiln	Residual Oil	L	203	0.1	0.42	-	2

Table 3.89 – Emission factors (Energy Approach) for use in LPS units in the Iron and Steel Industry: Particulate Matter from combustion

Equipment	Fuel		NAPFUE	TSP	PM_{10}	$PM_{2.5}$	$PM_{1.0}$
				g/GJ	(% TSP)	(% TSP)	(% TSP)
Cokery	Coke oven gas	S	304	3	96	94	77
Sintering	Coke oven gas	S	304	PA	15	7	4
Blast Furnace Cowpers	Coke oven gas	S	304	3	100	100	100
	Blast furnace gas	S	305	3	100	100	100
Thermo Electric Power plant	Coke oven gas	S	304	3	100	100	100
	Blast furnace gas	S	305	3	100	100	100
	Residual oil (3.5%)	L	203	108	86	56	36
	Residual oil (1%)	L	203	37.5	86	56	36
	Tar	L	299	108	86	56	36
Heat power plant	LPG	L	303	3	100	100	100
	Tar	L	299	108	86	56	1
	Waste Oils	O	115	108	86	56	36
Lime kiln	Residual Oil	L	203	PA	100	100	100

Note: PA = Process Approach

In the 2012 inventory, for the paper and pulp industrial sector, efforts were made to improve the emission estimation by reviewing and update emission factors when possible. To this end new EF data sources were used (EEA, 2009) as well as an in depth revision of the plant specific emission factors. The EF used for this industrial sector (LPS estimation only) can be found in the next tables.

Table 3.90 – Emission factors used in LPS units in the Paper Pulp Industry: Ozone precursors from combustion – Energy Approach – International EF sources

Equipment	Fuel	NAPFUE		NOx	NMVOC	CO
				EF (g/GJ)	EF (g/GJ)	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 3.91 – Emission factors used in LPS units in the Paper Pulp Industry: Ozone precursors from combustion – Production Approach – International EF sources

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

(i) Only for Bisulfite.

Table 3.92 – Emission factors used in LPS units in the Paper Pulp Industry: Ozone precursors from combustion – Production Approach and Energy Approach – Plant specific EF

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

Table 3.93 – 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 3.94 – 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 3.95 – 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 3.96 – 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 3.97 – 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 3.98 – 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 3.99 – 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 3.100 – 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 source, sector emissions were estimated using either activity data as energy consumption (energy approach) or either cement produced (production approach), although both represent similar emissions in cement kiln. Emission factors will not be presented in this report because of confidentiality issues (please see Activity Date chapter for more explanations).Most emission factors result from plant specific emission factors developed from monitoring at each installation.

Table 3.101 – 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 3.102 – 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 and lime production in iron and steel integrated plan are reported in chapter 4.2.C.1 – Industrial Processes: Iron and Steel Production.

3.2.2.4 Recalculations

No major recalculations were made.

3.2.2.5 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 Steel production and 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).*

3.2.3 Transport (NFR 1.A.3)

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

3.2.3.1.1 Overview

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.

3.2.3.1.2 Methodology

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

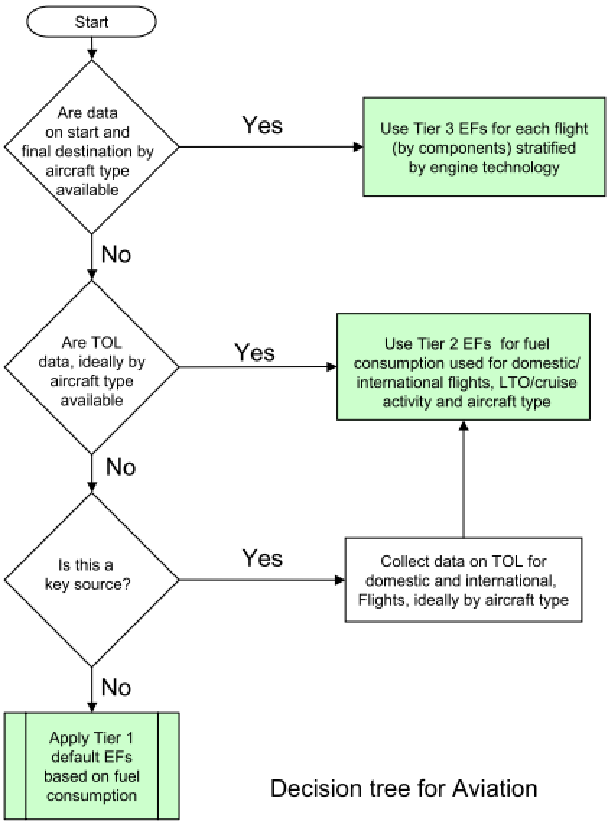


Figure 3.55 – Decision tree for emissions from aviation (EMEP/EEA, 2016)

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.

3.2.3.1.2.1 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 s 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;

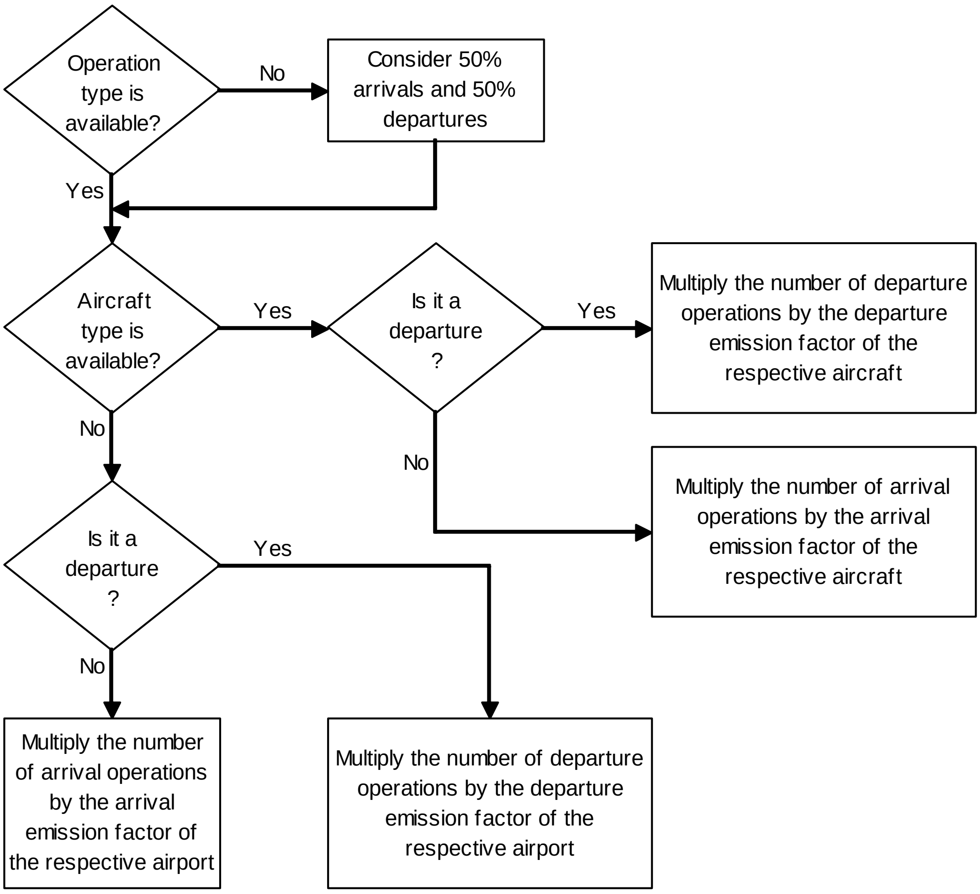
y – year.

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 3.56 – Decision tree for LTO_{Cycle} emission calculation



3.2.3.1.2.2 Cruise

Domestic cruise emissions are estimated based on aircraft movement data. The approach relies on a origin and destination matrix. The distances between airports are calculated from an airport coordinates database (Partow, 2003) applied to a great circle distance algorithm (GCD) assuming the Earth as a perfect sphere. Emission factors are given for each aircraft type and for a specific flight distance. International cruise emissions are estimated from fuel consumption. The international fuel consumption is estimated by subtracting the LTO_{Cycle} and the domestic cruise fuel from the total fuel sales.

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

where

$Emission_{cruise(p,d,a,s,y)}$ – Domestic cruise emissions of pollutant p resulting from flight with origin/destiny d in airport a performed by aircraft s during year y (t/yr);

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

$EF_{cruise(p,d,a,s,t,y)}$ – Emission factor for pollutant p specific for flight with origin/destination d taking time t performed by aircraft type s in year y (kg/LTO).

In national airports the same national flight is registered in origin airport as a departure and in destiny airport as an arrival therefore the number of national movements must be divided by two to avoid double counting.

3.2.3.1.3 Emission Factors

3.2.3.1.3.1 LTO

1.1.1.1.1.1.17 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 3.103 - 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

1.1.1.1.1.1.18 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 3.104 – Airport based LTO emission factors (kg/movement).

Airport	Operation	Parameter	1990	1995	2000	2005	2010	2014	2015	2016
Lisboa (LIS)	Take-off	Fuel Consumption	670.2	608.9	567.4	452.6	451.6	462.5	468.4	443.3
		VOC	16.4	14.9	15.2	9.3	2.8	2.3	2.3	2.4
		CO	37.1	33.7	35.4	21.5	13.8	12.3	12.8	13.3
		NOx	26.3	23.9	23.6	16.2	15.9	16.0	17.1	16.3
		PM_{10}	6.2	5.6	5.2	4.2	4.2	4.3	4.4	4.1
	Landing	Fuel Consumption	291.0	264.4	240.2	204.2	206.6	178.6	223.7	204.5
		VOC	7.0	6.4	6.0	4.4	1.5	1.3	1.2	1.3
		CO	17.8	16.2	16.3	11.1	7.0	6.2	6.5	6.6
		NOx	4.9	4.4	4.3	3.3	3.4	2.9	3.8	3.5
		PM_{10}	3.1	2.8	2.6	2.2	2.2	1.9	2.4	2.2
Porto (OPO)	Take-off	Fuel Consumption	530.0	481.5	401.1	374.4	427.6	423.7	358.1	368.7
		VOC	8.2	7.5	6.5	4.1	3.3	2.9	2.6	2.3
		CO	26.3	23.9	23.0	13.7	12.8	12.7	10.7	11.3
		NOx	19.1	17.3	15.0	11.9	14.7	14.3	11.9	12.1
		PM_{10}	4.9	4.5	3.7	3.5	4.0	3.9	3.3	3.4
	Landing	Fuel Consumption	236.2	214.6	181.3	172.9	191.7	160.6	171.1	168.6
		VOC	3.7	3.3	2.9	2.2	1.6	1.7	1.4	1.2
		CO	12.7	11.5	11.1	7.2	6.3	6.7	5.8	5.7
		NOx	3.8	3.5	3.0	2.6	3.2	2.7	2.8	2.6
		PM_{10}	2.5	2.3	1.9	1.9	2.1	1.7	1.8	1.8
Faro (FAO)	Take-off	Fuel Consumption	514.8	467.7	443.6	348.7	339.1	319.6	263.5	293.1
		VOC	5.3	4.8	4.9	3.0	2.4	2.0	2.1	2.0
		CO	19.2	17.4	17.2	12.2	11.0	9.3	8.5	9.0
		NOx	17.4	15.8	16.0	11.0	10.0	9.6	7.7	8.7
		PM_{10}	4.8	4.3	4.1	3.2	3.1	3.0	2.4	2.7
	Landing	Fuel Consumption	231.8	210.6	198.9	158.2	161.1	117.5	139.3	139.9
		VOC	2.7	2.5	2.5	1.7	1.4	1.4	1.4	1.2
		CO	10.0	9.1	9.0	6.5	5.9	5.0	5.0	5.0
		NOx	3.5	3.2	3.1	2.3	2.4	1.6	2.0	2.1
		PM_{10}	2.5	2.3	2.1	1.7	1.7	1.3	1.5	1.5
Santa Maria (SMA)	Take-off	Fuel Consumption	424.1	385.3	328.4	393.3	446.6	272.4	335.2	280.2
		VOC	9.2	8.3	9.8	7.6	5.2	2.3	2.0	1.8
		CO	23.1	21.0	22.2	19.1	17.6	9.8	10.2	10.2
		NOx	16.3	14.8	12.0	16.0	20.0	8.2	12.4	10.4
		PM_{10}	3.9	3.6	3.0	3.7	4.2	2.5	3.1	2.6
	Landing	Fuel Consumption	216.1	196.3	169.9	196.1	223.3	151.9	178.3	141.1
		VOC	4.6	4.1	4.9	3.4	2.6	1.8	1.3	1.0
		CO	13.2	12.0	12.4	10.7	9.8	8.2	6.6	5.9
		NOx	3.6	3.2	2.6	3.6	4.3	2.5	3.3	2.4
		PM_{10}	2.3	2.1	1.8	2.1	2.4	1.6	1.9	1.5
Ponta Delgada (PDL)	Take-off	Fuel Consumption	616.3	559.9	895.0	403.0	475.3	476.2	525.1	437.5
		VOC	7.7	7.0	10.1	3.8	2.7	2.3	2.3	2.1
		CO	19.5	17.7	24.2	12.4	12.6	11.0	13.7	13.3
		NOx	20.4	18.6	31.5	13.0	15.9	15.7	20.3	15.2
		PM_{10}	5.7	5.2	8.3	3.8	4.4	4.4	4.9	4.1
	Landing	Fuel Consumption	285.0	258.9	414.5	175.7	202.8	176.5	243.4	210.1
		VOC	4.4	4.0	7.6	1.8	1.3	1.0	1.1	1.3
		CO	11.2	10.2	16.4	6.2	6.3	5.1	6.5	7.5
		NOx	4.1	3.7	6.3	2.6	3.1	2.7	4.3	3.4
		PM_{10}	3.1	2.8	4.5	1.9	2.2	1.9	2.6	2.3

Airport	Operation	Parameter	1990	1995	2000	2005	2010	2014	2015	2016
Horta (HOR)	Take-off	Fuel Consumption	457.9	416.0	783.6	287.9	405.3	391.5	263.2	365.5
		VOC	3.8	3.5	1.8	4.8	3.6	3.0	1.0	1.4
		CO	13.0	11.8	15.6	10.6	10.7	10.4	6.6	20.1
		NOx	14.4	13.1	25.7	8.5	13.1	13.0	8.9	11.9
		PM_{10}	4.3	3.9	7.3	2.7	3.8	3.7	2.5	3.4
	Landing	Fuel Consumption	219.8	199.6	337.9	146.4	194.9	115.2	163.8	190.3
		VOC	1.8	1.7	0.7	2.1	1.9	1.9	0.7	0.7
		CO	6.8	6.2	6.7	5.6	5.7	5.2	4.6	9.2
		NOx	3.2	2.9	5.3	2.0	2.9	1.7	2.5	2.8
		PM_{10}	2.4	2.2	3.7	1.6	2.1	1.2	1.8	2.1
Flores (FLW)	Take-off	Fuel Consumption	422.4	383.8	299.1	359.5	343.4	384.7	380.6	612.1
		VOC	5.3	4.8	4.3	5.3	3.9	3.2	1.0	1.3
		CO	14.2	12.9	9.3	11.8	9.5	9.6	7.4	22.8
		NOx	13.0	11.8	8.9	10.8	10.6	12.3	12.2	20.5
		PM_{10}	4.0	3.6	2.8	3.4	3.2	3.6	3.6	5.8
	Landing	Fuel Consumption	227.7	206.8	164.9	170.2	176.2	185.2	210.6	269.9
		VOC	2.2	2.0	1.9	2.6	1.9	1.6	0.7	0.5
		CO	7.5	6.8	5.1	6.6	5.0	5.0	4.3	9.3
		NOx	3.4	3.1	2.4	2.4	2.4	2.6	3.0	4.4
		PM_{10}	2.5	2.3	1.8	1.9	1.9	2.0	2.3	2.9
Funchal (FNC)	Take-off	Fuel Consumption	623.5	566.5	465.6	466.6	469.7	519.8	448.7	459.1
		VOC	5.9	5.4	4.5	2.7	1.7	1.7	1.4	1.5
		CO	20.2	18.3	15.1	13.0	12.1	12.1	10.6	11.6
		NOx	19.3	17.6	14.0	15.2	14.6	16.5	14.0	14.0
		PM_{10}	5.8	5.2	4.3	4.3	4.4	4.8	4.2	4.3
	Landing	Fuel Consumption	280.8	255.1	210.8	206.3	209.3	187.4	205.1	206.4
		VOC	2.9	2.7	2.2	1.5	0.9	0.9	0.8	0.7
		CO	10.3	9.4	7.9	6.5	5.7	5.1	5.2	5.4
		NOx	4.0	3.7	2.9	3.2	3.2	2.8	3.1	3.2
		PM_{10}	3.0	2.7	2.3	2.2	2.3	2.0	2.2	2.2
Porto Santo (PXO)	Take-off	Fuel Consumption	561.0	509.6	534.2	438.3	447.3	483.7	443.3	454.0
		VOC	7.9	7.2	4.8	6.7	2.8	1.7	1.5	1.6
		CO	25.0	22.7	15.8	19.3	14.1	10.7	12.2	12.8
		NOx	18.6	16.9	18.4	16.0	13.9	15.6	13.7	14.6
		PM_{10}	5.2	4.7	4.9	4.1	4.2	4.5	4.1	4.2
	Landing	Fuel Consumption	277.8	252.4	238.5	196.3	207.6	215.8	218.0	212.5
		VOC	3.2	2.9	2.3	2.8	1.2	0.9	0.7	0.8
		CO	12.0	10.9	8.1	8.8	6.6	5.1	6.1	5.8
		NOx	4.1	3.7	4.0	3.2	3.1	3.3	3.3	3.3
		PM_{10}	3.0	2.7	2.6	2.1	2.2	2.3	2.4	2.3
Terceira (TER)	Take-off	Fuel Consumption	958.6	870.9	743.3	847.6	623.2	654.0	702.0	597.7
		VOC	7.4	6.7	5.7	8.9	5.5	2.0	2.6	2.3
		CO	28.2	25.6	21.8	29.0	18.7	13.5	17.2	15.8
		NOx	39.1	35.6	30.3	36.8	23.4	22.9	29.1	24.0
		PM_{10}	9.0	8.1	7.0	7.9	5.8	6.1	6.6	5.6
	Landing	Fuel Consumption	391.8	355.9	303.8	338.7	262.6	285.6	287.7	257.7
		VOC	3.0	2.7	2.3	3.3	2.3	1.3	1.1	0.9
		CO	11.8	10.7	9.1	11.9	8.5	7.4	7.0	6.5
		NOx	6.9	6.3	5.4	6.4	4.6	5.1	5.3	4.7
		PM_{10}	4.3	3.9	3.3	3.7	2.9	3.1	3.1	2.8

3.2.3.1.3.2 Cruise Emissions

1.1.1.1.1.1.19 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 3.105 – 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

1.1.1.1.1.1.20 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.

3.2.3.1.3.3 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 I ANNEX ANNEX C: ENERGY (NFR 1) shows the correspondence between aircrafts and representative aircrafts for LTO and cruise emissions factors.

3.2.3.1.3.4 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 3.106 – Fuel dependent emission factors.

Pollutant	Aviation Gasoline	Jet Fuel
LHV (MJ/kg)	44.0	43.0
SO_2 (%)	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

3.2.3.1.4 Activity Data

3.2.3.1.4.1 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 2016 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 3.107 – LTO_{Cycle} per airport

Region	Airport Code	1990	1995	2000	2005	2010	2014	2015	2016
Mainland	LIS	30,862	34,932	56,073	68,168	73,783	79,898	84,385	92,741
	OPO	11,574	13,348	23,280	25,910	28,502	32,016	35,248	39,549
	FAO	11,252	13,067	18,243	20,397	22,359	22,484	22,330	26,719
	TOTAL	53,688	61,347	97,596	114,475	124,643	134,398	141,963	159,009
Region	Airport Code	1990	1995	2000	2005	2010	2014	2015	2016
Islands	FNC	6,475	9,460	12,040	15,952	12,697	11,988	12,442	14,079
	TER	3,801	4,049	4,501	4,875	4,988	4,670	4,755	5,496
	PDL	2,954	3,382	4,134	7,196	8,182	7,665	8,499	9,993
	PXO	2,403	4,243	3,788	3,688	2,325	2,051	2,103	2,394
	HOR	1,237	1,542	1,756	2,964	2,919	2,272	2,331	2,818
	SMA	634	893	1,557	1,649	1,275	974	1,073	1,292
	FLW	281	357	552	1,101	1,136	954	1,002	1,242
	TOTAL	17,785	23,924	28,327	37,425	33,521	30,572	32,204	37,312

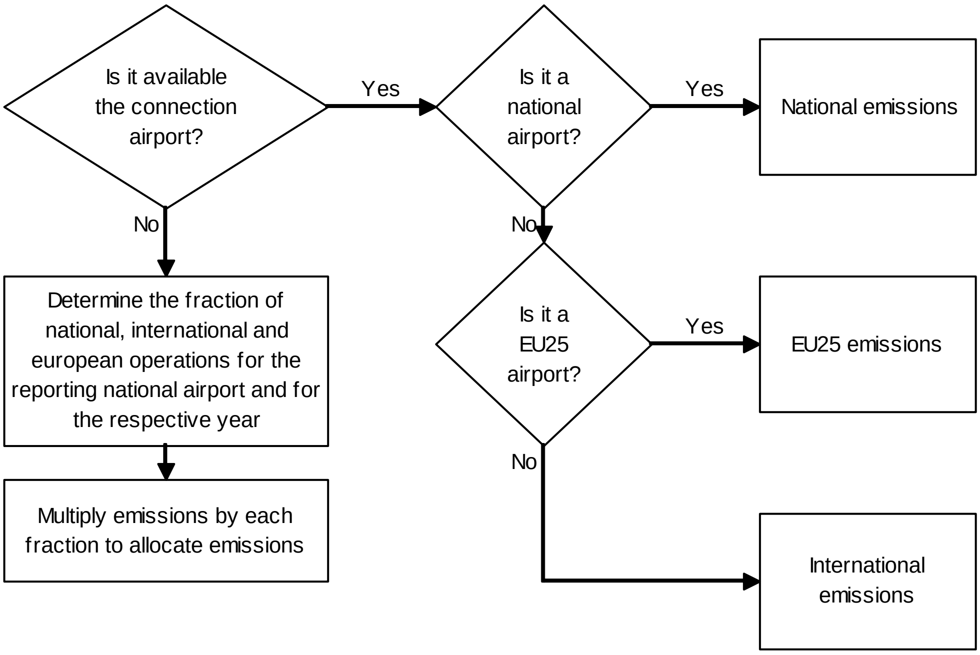
Source: ANAC

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.

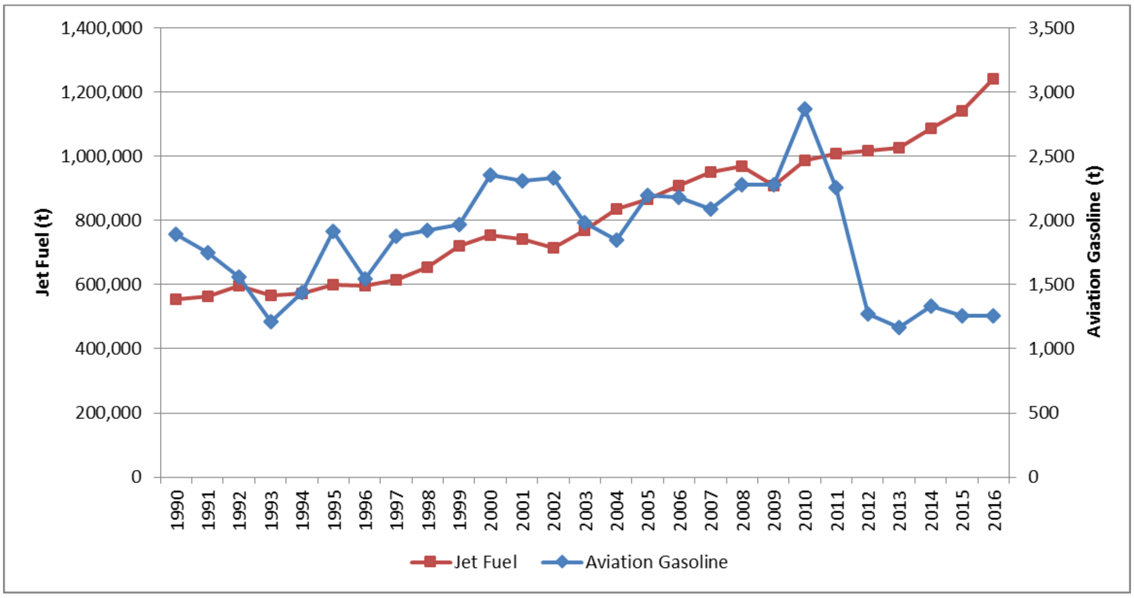
Figure 3.57 – Decision tree for distinction between domestic and international emissions.



3.2.3.1.4.2 Fuel Consumption

Fuel consumption is available from fuel sales statistics from DGEG for main territory and islands and is presented in the figure bellow and ANNEX ANNEX C: ENERGY (NFR 1). 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.

Figure 3.58 – Total Fuel consumption of Aviation Gasoline and Jet Fuel



Source: DGEG

3.2.3.1.5 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.

3.2.3.1.6 Recalculations

No recalculations were made.

3.2.3.1.7 Further Improvements

No further improvements are planned for this sector.

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

3.2.3.2.1 Overview

Road transportation is one of the most important emission sources of pollutants associated with trans-boundary, regional and, particularly, local air problems, comprehending sulphur oxides (SO_x), nitrogen oxides (NO_x), carbon monoxide (CO), non-volatile organic compounds (NMVOC) that are indirectly responsible for the formation of ozone (O_3) in the lower troposphere. Substantial emissions of ammonia, particulate matter and heavy metals result also from this mode of transportation.

Table 3.108 – Main pollutants and particulate matter emissions from road transport in mainland territory (t)

Pollutant	1990	1995	2000	2005	2010	2014	2015	2016
NOx	89,302	98,667	114,740	99,626	85,542	64,345	63,271	61,189
NMVOC	81,829	80,995	61,281	37,805	24,189	17,055	16,461	15,573
SOx	12,334	12,181	5,801	593	113	96	97	98
NH_3	102	636	1,472	1,788	1,439	1,102	1,077	1,029
$PM_{2.5}$	5,339	6,643	8,262	6,941	5,713	4,128	3,984	3,793
PM_{10}	5,862	7,396	9,387	8,092	6,851	5,088	4,958	4,769
CO	402,842	415,077	319,319	203,029	125,561	84,147	80,898	75,652

The NH_3 emission growth is due to the increased use of three-way catalytic converters in the vehicle fleet and is expected to decrease as second generation of catalysts are progressively introduced

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

Table 3.109 – Heavy metals emissions from road transport in mainland territory (kg)

Pollutant	1990	1995	2000	2005	2010	2014	2015	2016
Pb	549,659	755,901	16,097	14,406	11,618	9,291	9,103	8,906
Cd	42	50	65	66	67	57	58	58
Hg	20	28	38	38	36	31	31	31
As	1	1	1	1	1	1	1	1
Cr	579	792	1,149	1,169	1,160	980	993	994
Cu	15,034	19,991	28,384	28,844	28,688	24,301	24,610	24,651
Ni	320	389	517	526	529	452	458	460
Se	45	54	72	74	74	64	65	65
Zn	6,997	9,122	12,809	13,081	13,092	11,151	11,312	11,348

Table 3.110 – Persistent organic pollutant emissions from road transport in mainland territory (kg)

Pollutant	1990	1995	2000	2005	2010	2014	2015	2016
Dioxins/Furans	0.0005	0.0007	0.0013	0.0014	0.0015	0.0011	0.0011	0.0010
PAH's	103	161	289	342	383	337	342	344
HCB	0.0006	0.0011	0.0025	0.0030	0.0034	0.0026	0.0025	0.0024
PCB's	0.0002	0.0003	0.0005	0.0006	0.0006	0.0005	0.0005	0.0004

3.2.3.2.2 Methodology

Emissions from road transportation, estimated using the COPERT V (version 5.1.1 - December 2017) 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 (1A3bi, 1A3bii, 1A3biii, 1A3iv) – heavy metals;
- Gasoline Evaporation Emissions (1A3bv) – NMVOC;
- Automobile Tyre and Brake Wear Emissions (1A3bvi) - $PM_{2.5}$, PM_{10}, TSP and heavy metals.

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 (Fuel and lubricants specifications, Reid Vapour Pressure)
- Fuel and Lubricant Consumption
- Vehicle Fleet
- Distance travelled (Mean Activity - Km)
- Circulation Data (Average Speed, Mileage % per driving mode)

Furthermore emissions of $PM_{2.5}$, PM_{10} and TSP for Automobile Road Abrasion (1A3bvii) are also calculated using default emission factors from EMEP/EEA Guidebook 2016 and National Vehicle-kilometers data.

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 fuel consumption is provided by the national energy authority. To ensure that the statistical fuel consumption match the calculated fuel 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 this two Autonomous Regions.

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

3.2.3.2.3 Emission Factors

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

For the emission of TSP, $PM_{2.5}$ and PM_{10} from Road Surface Wear (1A3bvii) the default emission factors from EMEP/EEA Guidebook 2016 were used.

Table 3.111 – Emission factors for Road Surface Wear (g/km.vehicle)

Pollutant	Vehicle type	Value
TSP	Two-Wheelers	0.006
	Passenger cars	0.015
	Light duty trucks	0.015
	Heavy Duty Vehicles	0.076
PM10	Two-Wheelers	0.003
	Light duty trucks	0.0075
	Passenger cars	0.0075
	Heavy Duty Vehicles	0.038
PM2.5	Two-Wheelers	0.0016
	Passenger cars	0.0041
	Light duty trucks	0.0041
	Heavy Duty Vehicles	0.0205

Source: EMEP/EEA Guidebook 2016.

3.2.3.2.3.1 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 ANNEX C: ENERGY (NFR 1).

3.2.3.2.4 Activity Data and Input Variables

3.2.3.2.4.1 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 3.112 – Monthly average ambient temperatures (ºC)

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/)

3.2.3.2.4.2 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 hours.

3.2.3.2.4.3 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 3.113 – Fuel specifications.

Fuel	Energy Content (Mj/kg)	Density (kg/m^3)	H:C Ratio	O:C Ratio
Petrol	43.77	750.00	1.89	0.02
Diesel	42.70	840.00	1.86	0.01
LPG	46.56	835.00	2.53	0.00
CNG	48.00	775.00	3.90	0.00
Biodiesel	37.30	750.00	1.94	0.11
Bioethanol	28.80	710.00	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 3.114 – Sulphur content in petrol and diesel (ppm wt)

Fuel	1990-1999	2000-2001	2002-2004	2005-2008	2008-2015
Petrol	1000	500	150	50	10

Fuel	1990-1994	1995	1996-2000	2001-2004	2005-2008	2009-2016
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 3.115 – 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 3.116 – Reid Vapour Pressure (kPa)

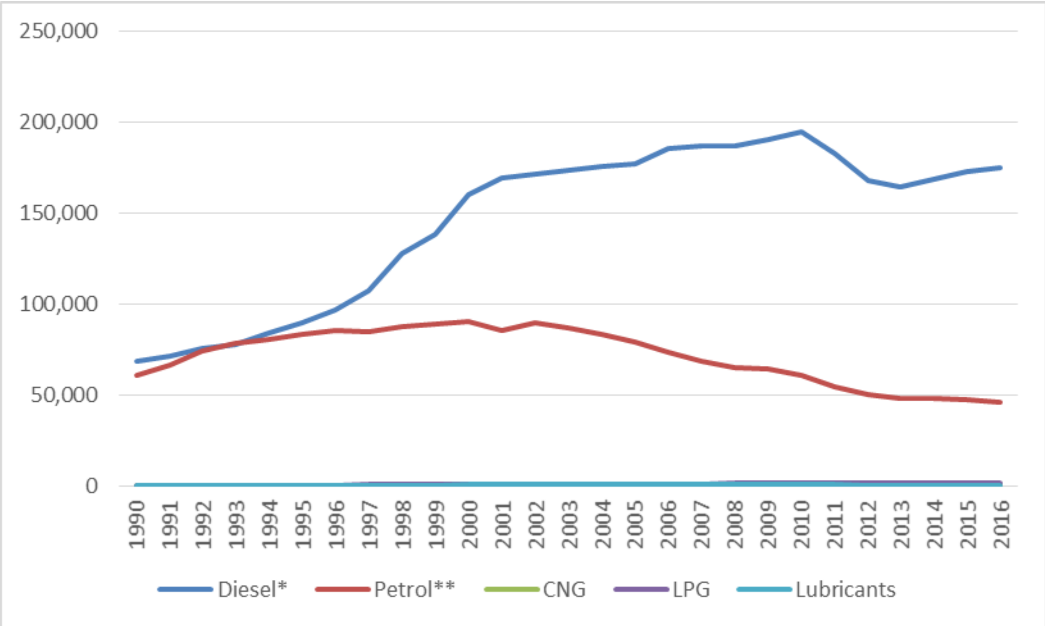
Month	1990 to 1995	1996 to 1999	2000 to 2015
January	98	95	90
February	98	95	90
March	98	95	90
April	83	80	90
May	83	80	60
June	70	70	60
July	70	70	60
August	70	70	60
September	70	70	60
October	83	95	90
November	98	95	90
December	98	95	90

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).

3.2.3.2.4.4 Fuel and Lubricant Consumption

Fuel consumption from road transport 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 ANNEX ANNEX C: ENERGY (NFR 1).

Figure 3.59 – Fuel and lubricant consumption from road transport sector



* includes incorporation of Biodiesel
** includes incorporation of Bioethanol

Lubricant consumption that contributes to exhaust emission in Road Transport includes lubricant consumed as energy in some two-stroke engines and lubricant that enters accidentally in the engines combustion chambers.

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 Transport Sector are presented in the next tables.

Table 3.117 – Incorporation rate of Biodiesel in Diesel (%).

2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1.31	2.50	2.43	4.16	6.03	6.25	6.22	6.05	5.90	6.72	5.31

Source: (DGEG)

Table 3.118 – Incorporation rate of Bioethanol in Petrol (%)

2013	2014	2015	2016
0.16	0.17	2.00	2.01

Source: (DGEG)

3.2.3.2.4.5 Vehicle Fleet

The active fleet of Passenger Cars, Light Commercial Vehicles, Heavy Duty Trucks and Buses, for the period between 2003 and 2016, 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 was applied a function that consider vehicle abatement.

The number of mopeds and motorcycles was obtained from insurance data from *Autoridade de Supervisão de Seguros e Fundos de Pensões* (ASF) since this 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 V 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 3.119 – COPERT V segments.

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

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

Table 3.120 – 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

Vehicle Category	Fuel	Euro Standard	First Registry year	
			from	to
		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 2016	2017	2017
		Euro 6 2017-2019	2018	2020
		Euro 6 2020+	2021	…
Heavy Duty Trucks	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	…
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	…

Vehicle Category	Fuel	Euro Standard	First Registry year	
			from	**to**
	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	…

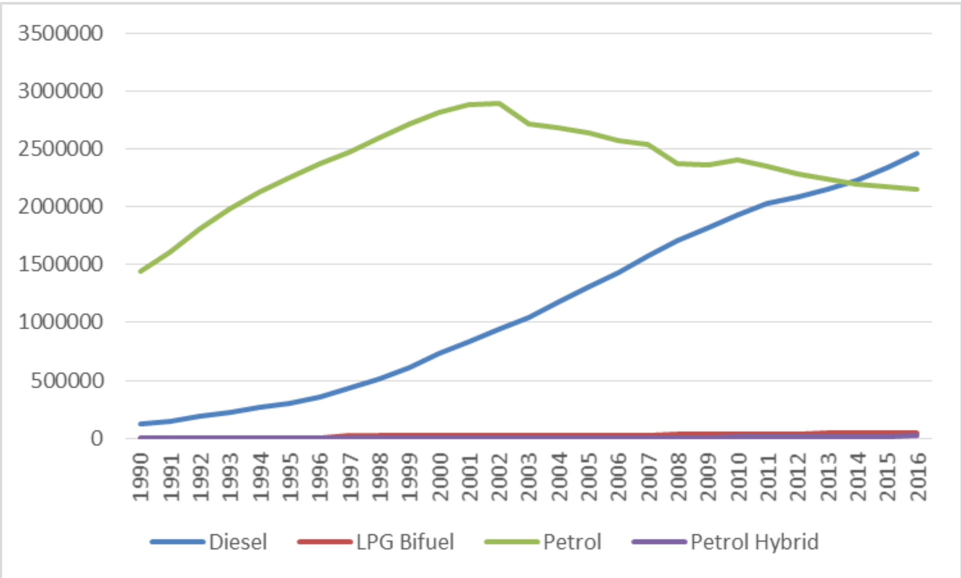
The following table shows the vehicle fleet by vehicle category.

Table 3.121 – Vehicle fleet synthesis.

Vehicle Category	1990	1995	2000	2005	2010	2015	2014	2016
Passenger Cars	1,565,827	2,552,724	3,562,867	3,971,037	4,385,411	4,486,031	4,575,287	4,689,420
Light Commercial Vehicles	248,452	549,955	921,634	1,149,816	1,238,576	1,196,318	1,203,480	1,210,085
Heavy Duty Trucks	59,287	88,442	111,568	115,549	107,503	91,874	93,432	94,998
Buses	8,170	10,176	12,400	13,808	14,666	14,143	14,209	14,317
L-Category	900,822	774,282	673,994	487,590	497,023	506,882	524,416	549,952
Total	**2,782,558**	**3,975,579**	**5,282,463**	**5,737,800**	**6,243,179**	**6,295,248**	**6,410,824**	**6,558,772**

Detailed information, regarding vehicle fleet, with information of Vehicle Category, Fuel, Segment and Euro Standard is presented in ANNEX ANNEX C: ENERGY (NFR 1).

Figure 3.60 – 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.

3.2.3.2.4.6 Distances Travelled

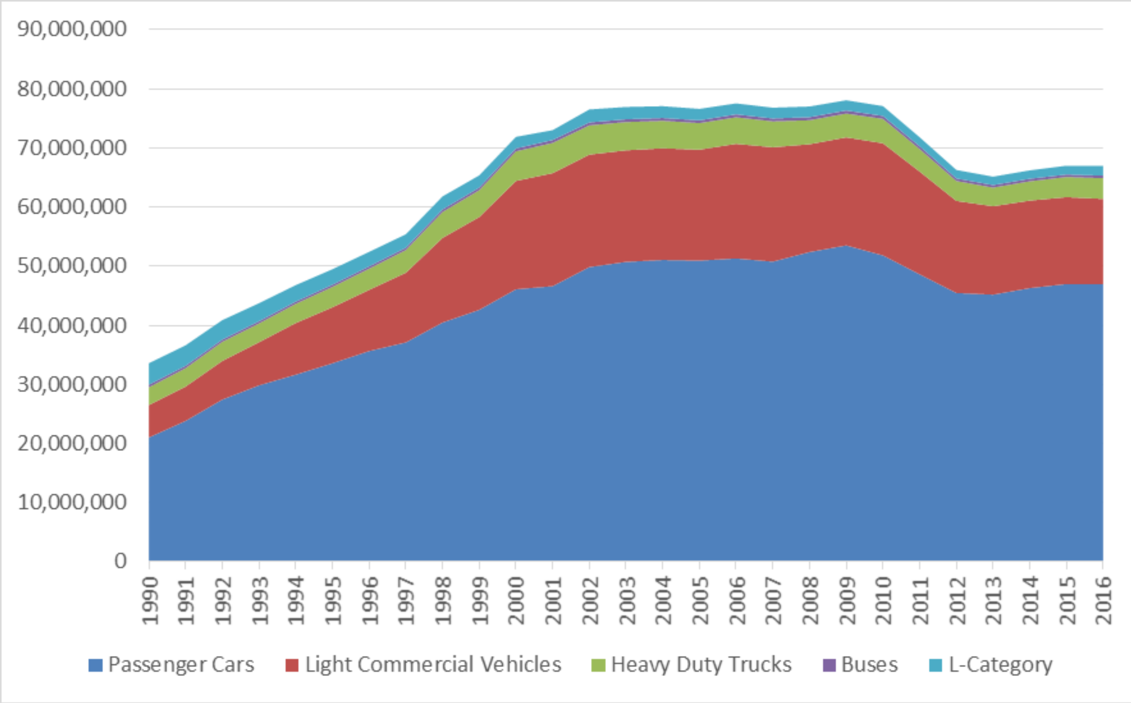
Distance travelled for each year for Passenger Cars, Light Commercial Vehicles, Heavy Duty Trucks and Buses was established using a model based on data from vehicle inspection centers.

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

Detailed information on distance travelled, for the period between 1990 and 2016, regarding different Vehicle Categories, Fuel types, Segments and Euro Standard is presented in ANNEX ANNEX C: ENERGY (NFR 1).

Total road traffic activity has increased 99% between 1990 and 2016.

Figure 3.61 – Kilometers travelled by vehicle type (kvkm).



3.2.3.2.4.7 Circulation data

Three driving modes where 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.

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 3.122 – 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

3.2.3.2.5 Recalculations

The major changes between submissions (2017 and 2018) result from implementation of the Copert V (Version 5.1.0 – December 2017) and the following actions:

- Major revision on the vehicle stock and mean activity due to the new vehicle categories adopt in Copert V and EMEP/EEA Guidebook 2016, update of vehicles technologies, correction of the vehicles abatement rate, update of the data from the vehicle inspection centers);
- Revision of the biodiesel and bioethanol incorporation rates and data, from 2013 to 2015, with information of the split in biofuels by the National Energy Authority (DGEG);
- Inclusion of heavy metals exhaust emission from lubricants;
- Revision of the S and PB content data regarding National Legislation values;
- Update of the monthly maximum and minimum average temperature by the Portuguese Sea and Atmosphere Institute (IPMA)
- Insertion of relative humidity per month by the Portuguese Sea and Atmosphere Institute (IPMA);
- Update of the trip length average to 10 Km as described in the EMEP/EEA Guidebook 2016.

3.2.3.2.6 Further Improvements

No further improvements are planned for this sector.

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

3.2.3.3.1 Overview

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.

3.2.3.3.2 Methodology

Emissions to atmosphere of ultimate CO_2 from fossil origin were estimated from CO_2 total emissions by:

$$Fossil_{CO2(y)} = \Sigma_f [EF_{CO2\ (f)} * Fac_{OX\ (f)} * C_{Fossil(f)} * Cons_{Fuel(f,y)} * LHV_{(f)}] * 10^{-5}$$

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} - Percentage of carbon from fossil origin in fuel f (%);

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

$Cons_{Fuel(f,y)}$ - Consumption of fuel f in year y (t/yr);

$LHV_{(f)}$ - Low Heating Value (MJ/kg).

For all other pollutants the following formula was used:

$$Emission_{(p,y)} = \Sigma_f[EF_{(f,p)} * Cons_{Fuel(f,y)}] * 10^{-3}$$

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).

3.2.3.3.3 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 3.123 – 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 3.124 – Emission factors in Railways

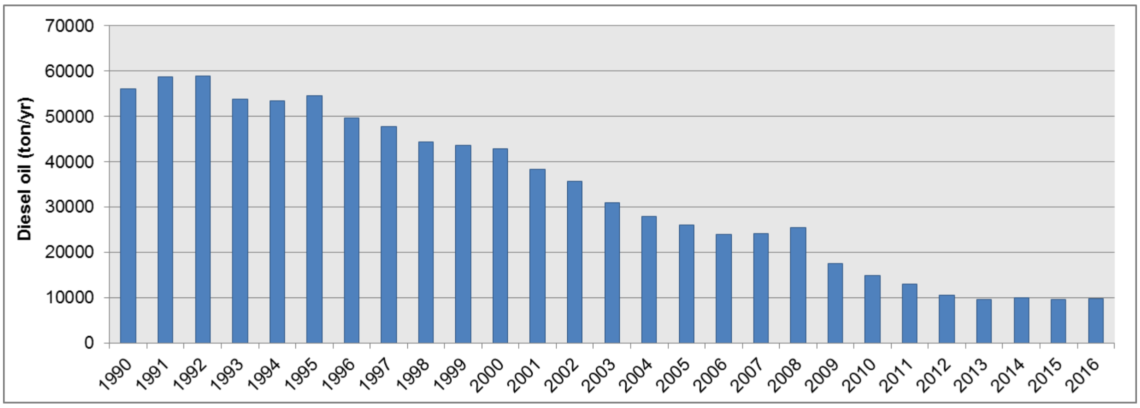
Fuel	Coal			Coke			Diesel-oil			Biodiesel		
Pollutant	**Value**	**Unit**	**Reference**	**Value**	**Unit**	**Reference**	**Value**	**Unit**	**Reference**	**Value**	**Unit**	**Reference**
NO_x (v)	55.63	kg/t	Guidebook	55.63	kg/t	Guidebook	55.63	kg/t	Guidebook	55.63	kg/t	Guidebook
NMVOC (iv)	5.08	kg/t	Guidebook	5.08	kg/t	Guidebook	5.08	kg/t	Guidebook	5.08	kg/t	Guidebook
CO (v)	19.60	kg/t	Guidebook	19.60	kg/t	Guidebook	19.60	kg/t	Guidebook	19.60	kg/t	Guidebook
TSP	1.52	kg/t	Guidebook	1.52	kg/t	Guidebook	1.52	kg/t	Guidebook	1.52	kg/t	Guidebook
PM_{10}	1.44	kg/t	Guidebook	1.44	kg/t	Guidebook	1.44	kg/t	Guidebook	1.44	kg/t	Guidebook
$PM_{2.5}$	1.37	kg/t	Guidebook	1.37	kg/t	Guidebook	1.37	kg/t	Guidebook	1.37	kg/t	Guidebook
BC	0	% PM2.5	Guidebook	0	% PM2.5	Guidebook	0.65	% PM2.5	Guidebook	0.00	% PM2.5	Guidebook
Pb	1.22	g/t	Guidebook	1.22	g/t	Guidebook	0.59	g/t	Guidebook	0.59	g/t	Guidebook
Cd	0.01	g/t	Guidebook	0.01	g/t	Guidebook	0.01	g/t	Guidebook	0.01	g/t	Guidebook
As	0.05	g/t	Guidebook	0.05	g/t	Guidebook	0.05	g/t	Guidebook	0.05	g/t	Guidebook
Cr	0.05	g/t	Guidebook	0.05	g/t	Guidebook	0.05	g/t	Guidebook	0.05	g/t	Guidebook
Cu	1.70	g/t	Guidebook	1.70	g/t	Guidebook	1.70	g/t	Guidebook	1.70	g/t	Guidebook
Ni	0.07	g/t	Guidebook	0.07	g/t	Guidebook	0.07	g/t	Guidebook	0.07	g/t	Guidebook
Se	0.01	g/t	Guidebook	0.01	g/t	Guidebook	0.01	g/t	Guidebook	0.01	g/t	Guidebook
Zn	1.00	g/t	Guidebook	1.00	g/t	Guidebook	1.00	g/t	Guidebook	1.00	g/t	Guidebook
PAH	3.32	g/t	Guidebook	3.32	g/t	Guidebook	3.32	g/t	Guidebook	3.32	g/t	Guidebook

(iv) Average of EMEP/CORINAIR (Eurpean values) and IPCC (US values);
(v) Average of EMEP/CORINAIR, IPCC and MEET;

3.2.3.3.4 Activity Data

Consumption of fuel in the railway transport sector is available by fuel type from 1990 to 2016 from the energy balance produced by General-Directorate of Geology and Energy (DGEG) and are presented in ANNEX ANNEX C: ENERGY (NFR 1). 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[22]. The quantities that were consumed have been decreasing steadily since 1992 due to electrification of the power lines, as can be seen in Figure 3.64.

Figure 3.62 - Consumption of diesel oil in the railway transport sector



3.2.3.3.5 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.

3.2.3.3.6 Recalculations

No recalculations were made.

3.2.3.3.7 Further Improvements

No further improvements are planned for this sector.

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

3.2.3.4.1 Overview

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.

3.2.3.4.2 Methodology

Statistics on fuel used in shipping activities are available at national level as an aggregated figure provided in the energy balance from the energy authority (DGEG).

[22] Gas oil represents no less than 98.4 per cent of total annual use of combustible energy.

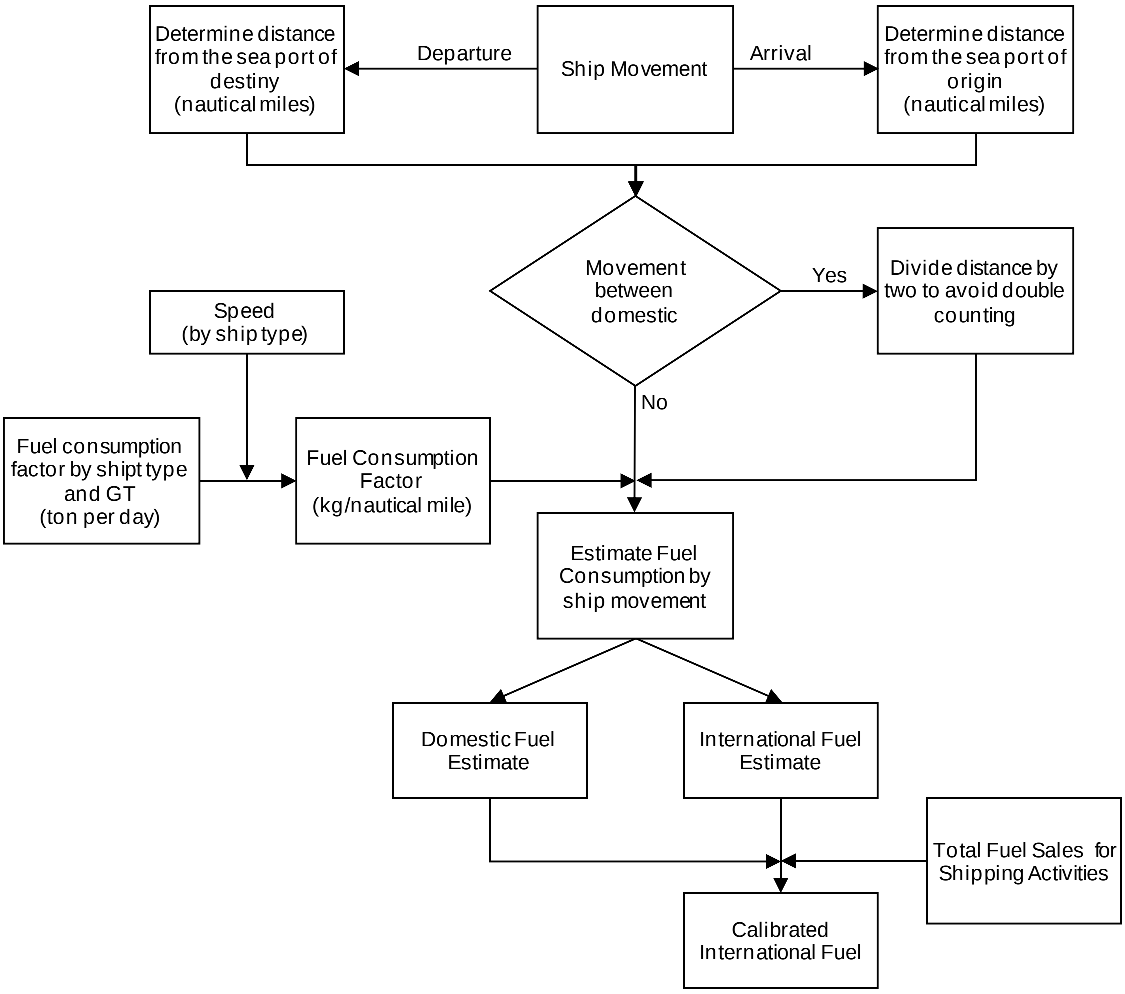
National seaports provide detailed ship movements andships technical information (such as gross tonnage, ship type and speed).

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).

The methodology takes into account the 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 3.63 – Generic methodology flowchart.

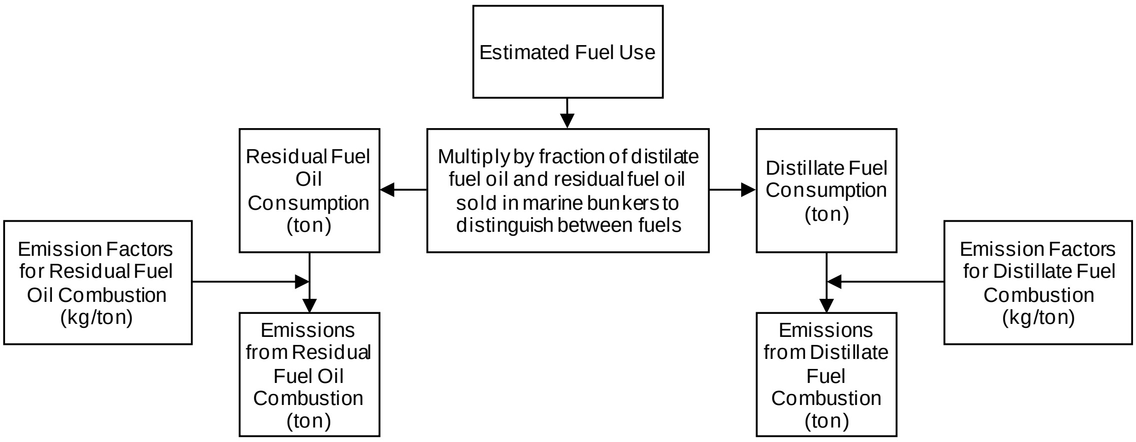


For each dock (which includes one arrival and one departures) is possible to calculate national and international distance and fuel consumptions.

The consumption factor (in tonne/day) is calculated with the gross tonnage of each ship. Then the ships speed is used to convert the consumption factor to kg/nautical miles. This consumption factor and the distance travelled by each ship serve to determine the fuel consumption.

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

Emissions factors vary according with the type of fuel used. To distinguish between residual and distillate fuel an additional calculation step is required:



International Inland Waterways (1A3d1(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 (1A3di(i)).

3.2.3.4.3 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 3.125 – 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 3.126 – 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 3.127 – Consumption factors

Ship Type	Consumption at fuel 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)

3.2.3.4.4 Activity Data

3.2.3.4.4.1 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 2016. 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.

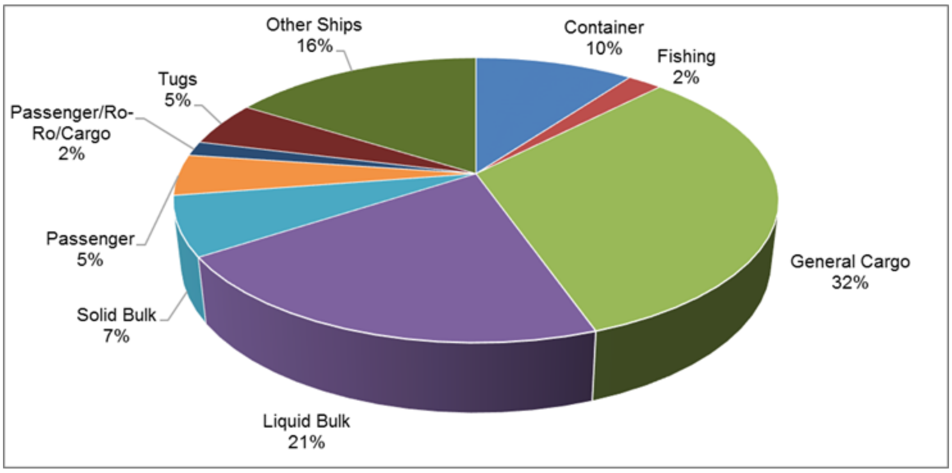
Table 3.128 – Ship docks

Sea Port	Location	Unit	1990	1995	2000	2005	2010	2014	2015	2016
Aveiro	Mainland	docks	876	1,098	1,009	1,028	961	988	1,025	1,038
Caniçal	Madeira	docks	76	76	76	178	390	274	241	248
Faro	Mainland	docks	163	163	163	32	12	79	85	34
Figueira da Foz	Mainland	docks	315	297	307	321	476	528	496	528
Funchal	Madeira	docks	1,063	1,063	1,063	948	758	640	664	646
Leixões	Mainland	docks	2,742	2,896	3,050	2,814	2,612	2,627	2,735	2,924
Lisboa	Mainland	docks	5,586	4,993	3,869	3,474	3,129	2,709	2,605	2,300
Ponta Delgada	Azores	docks	1,080	1,080	1,080	1,078	1,035	810	831	839
Portimão	Mainland	docks	34	34	37	42	136	50	70	58
Porto Santo	Madeira	docks	402	402	402	400	392	349	348	349
Setúbal	Mainland	docks	1,453	1,453	1,699	1,592	1,632	1,576	1,627	1,659
Sines	Mainland	docks	1,038	979	808	1,124	1,632	1,994	2,173	2,410
Viana do Castelo	Mainland	docks	254	293	348	214	179	227	198	208

3.2.3.4.4.2 Ship Fleet

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

Figure 3.64 – Ship fleet.



3.2.3.4.4.3 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 3.129 – Total fuel sales (ton)

Fuel Sales		NAPFUE	1990	1995	2000	2005	2010	2014	2015	2016
Gas-oil	L	204	126,903	141,272	125,554	110,197	94,064	92,625	158,232	129,745
Residual Fuel-oil	L	203	407,823	290,920	475,743	457,115	506,320	624,401	603,295	610,316

Source: DGEG

Table 3.130 – Estimated fuel consumption (ton)

Fuel	Region	1990	1995	2000	2005	2010	2014	2015	2016
Residual Fuel-oil	Domestic	61,244	53,023	46,988	48,804	53,458	61,448	65,968	61,115
Residual Fuel-oil	International	431,554	448,716	430,253	411,428	515,738	746,122	805,707	832,495
Residual Fuel-oil	Total	492,797	501,739	477,242	460,233	569,196	807,570	871,676	893,610
Gas-oil	Domestic	23,132	20,027	17,748	18,434	20,192	23,209	24,917	23,084
Gas-oil	International	163,002	169,485	162,511	155,401	194,799	281,818	304,324	314,442
Gas-oil	Total	186,135	189,512	180,259	173,835	214,991	305,027	329,241	337,526

Table 3.131 – Estimated fuel consumption after top-down calibration (ton)

Fuel	Region	1990	1995	2000	2005	2010	2014	2015	2016
Residual Fuel-oil	Domestic	61,244	53,023	46,988	48,804	53,458	61,448	65,968	61,115
Residual Fuel-oil	International	346,579	237,897	428,754	408,311	452,862	562,954	537,327	549,201
Residual Fuel-oil	Total	407,823	290,920	475,743	457,115	506,320	624,401	603,295	610,316
Gas-oil	Domestic	23,132	20,027	17,748	18,434	20,192	23,209	24,917	23,084
Gas-oil	International	103,770	121,244	107,806	91,763	73,872	69,416	133,315	106,662
Gas-oil	Total	126,903	141,272	125,554	110,197	94,064	92,625	158,232	129,745

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 3.132 – Spatial allocation of fuel consumption in mainland territory (ton)

Fuel	Region	1990	1995	2000	2005	2010	2014	2015	2016
Residual Fuel-oil	Domestic	37,315	32,306	28,629	29,736	32,571	37,439	40,194	30,989
Residual Fuel-oil	International	317,684	218,063	393,008	374,269	415,105	516,018	492,528	487,171
Residual Fuel-oil	Total	354,999	250,369	421,637	404,004	447,676	553,457	532,721	518,160
Gas-oil	Domestic	14,094	12,202	10,814	11,231	12,302	14,141	15,182	11,705
Gas-oil	International	95,119	111,136	98,818	84,113	67,713	63,628	122,200	68,541
Gas-oil	Total	109,213	123,338	109,631	95,344	80,016	77,769	137,382	80,246

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.

1.1.1.1.1.1.21 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 3.133 – 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 3.134 – 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.

3.2.3.4.5 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.

3.2.3.4.6 Recalculations

Recalculations for this source category comprise:

- update and correction of the 2015 data for the Sines Port (from 901 to 2173 ship docks);
- review of the NOx, CO, NMNVOC, TSP, PM 2.5, Pb, Cd, Hg, As, Cr, Cu, Ni, Se and Zn emission factors in line with the EEA/EMEP Air Pollutant Inventory Guidebook 2016.

3.2.3.4.7 Further Improvements

No further improvements are planned for this sector.

3.2.4 Small Combustion (NFR 1.A.4)

This source category refers to combustion in stationary and mobile sources (off-road equipments) that occur in commercial/institutional, residential, and agriculture/forestry/fishing activity sectors. The following stationary combustion equipments were included in this sector: boilers, co-generation equipment, machines and static engines. 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).

There is not much information allowing the estimation of emissions from off-road vehicles and machines, mainly because they are not individualized in the energy balances from DGEG. The only exceptions are the agriculture/forestry sector, where it is more or less evident that all gas-oil is used as energy source to vehicles and mobile machines, and the fishing vessels.

3.2.4.1 Commercial/Institutional (NFR 1.A.4.a)

3.2.4.1.1 Overview

The sources covered in this chapter refer to those emissions resulting from combustion in commercial, services and institutional sector. In this sector small other mobile sources are not considered because no separation between fuel consumption is possible in the energy balance.

3.2.4.1.2 Methodology

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

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

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).

In the case of emissions of Heavy Metals the following equation was used:

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

and,

$HM_{p\ (f,s)}$ - Heavy Metal p emission estimated from consumption of fuel f in sub-sector s (t/yr);

$Fuel_{Cons(f,s)}$ - Consumption of fuel f in sub-sector s (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);

$AshRet_{(f,s,p)}$ - Retention of Heavy Metal p in ash from fuel f under burning conditions in sub-sector s (mass percentage).

Emissions were estimated from fuel/energy consumption using either mass balance (SO_x) or emission factors, according to the pollutant, and using a IPCC Tier 2 methodology.

Emissions of other pollutants that were also calculated from energy activity rate use the following basic formula (Energy Approach):

$$Emi_{(p,s)} = \Sigma_f \Sigma_t [EF_{(f,s,t,y,p)} * Activity_{(f,s,t,p)}] * 10^{-3}$$

where:

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

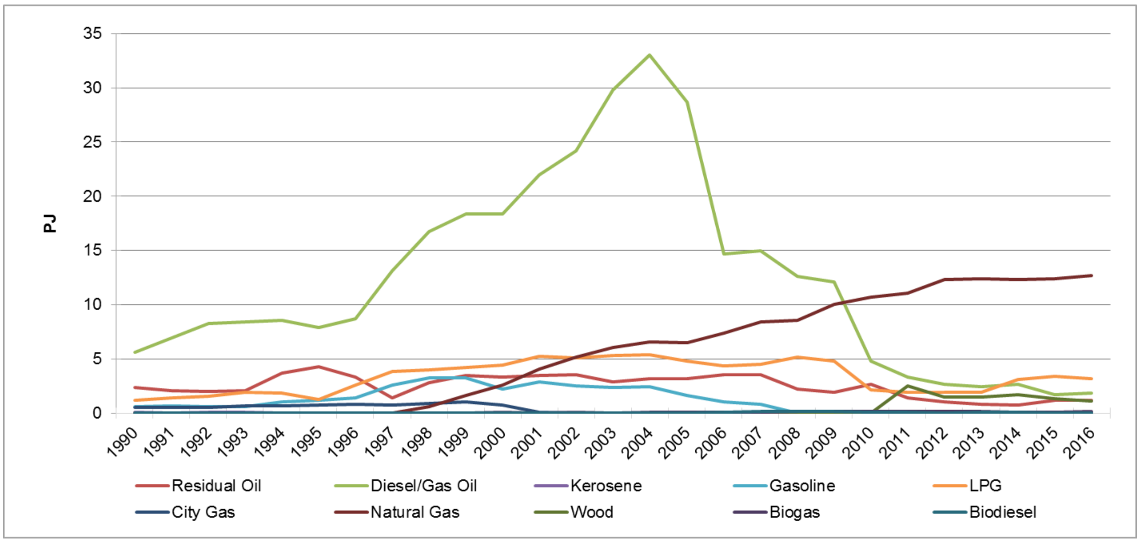
$EF_{(f,s,t,p)}$ - Emission Factor for fuel f used in sub-sector s and equipment t in year y (g/GJ except CO_2 in kg/GJ);

$Activity_{(f,s,t)}$ - Energy Consumption of fuel f in sub-sector s and in equipment/technology t (GJ).

3.2.4.1.3 Activity Data

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

Figure 3.65 – Fuels consumed in the commercial, services and institutional sector



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.

Figure 3.66 – Total Energy Consumption in fuels in the commercial/services/institutional sector

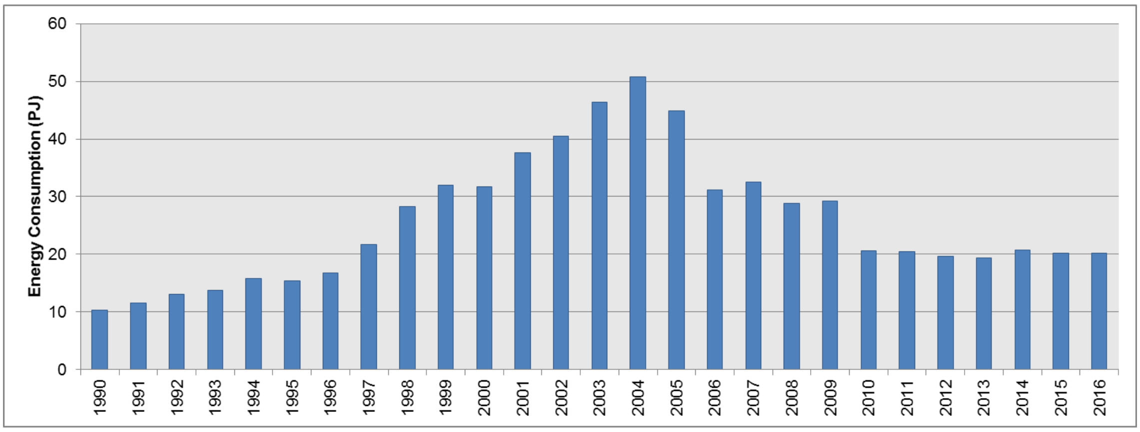
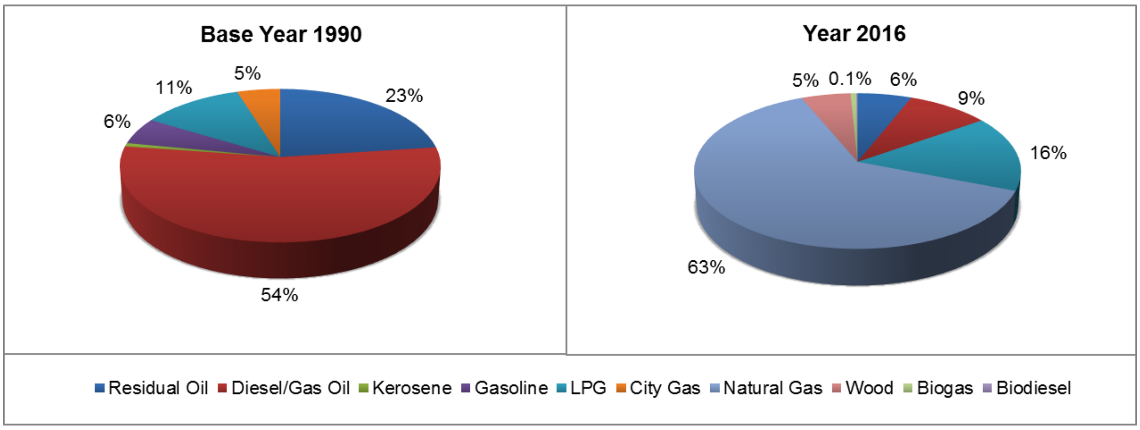


Figure 3.67 – Consumption of energy in fuels in the commercial/services/institutional sector in 1990 and 2016



3.2.4.1.4 Emission Factors

The emission factors that were used were collected from international bibliography sources, namely:

- EMEP/EEA air pollutant emission inventory guidebook 2016 (EEA,2016);
- 2006 IPCC Guidelines (IPPC,2006).

Table 3.135 – Low Heating Value (LHV) - Commercial, services and institutional sector

Fuel		NAPFUE	LHV MJ/kg
Residual Oil	L	203	40.0
Gas Oil	L	204	42.6
Diesel Oil	L	205	42.6
Kerosene	L	206	43.8
Motor Gasoline	L	208	44.0
LPG	L	303	46.0
City Gas	L	308	15.7
Natural Gas	G	301	46.1
Biogas	B	309	34.7
Biodiesel	B	223	37.0

Table 3.136 – Emissions factors - Commercial, services and institutional sector (1/2)

Fuel	Residual Oil			Gas Oil / Diesel Oil			Kerosene			Motor Gasoline			LPG		
Pollutant	Value	Unit	Reference	Value	Unit	Reference	Value	Unit	Reference	Value	Unit	Reference	Value	Unit	Reference
NO_x	513	g/GJ	Guidebook	513	g/GJ	Guidebook	513	g/GJ	Guidebook	513	g/GJ	Guidebook	40	g/GJ	Guidebook
NMVOC	25	g/GJ	Guidebook	25	g/GJ	Guidebook	25	g/GJ	Guidebook	25	g/GJ	Guidebook	2	g/GJ	Guidebook
CO	66	g/GJ	Guidebook	66	g/GJ	Guidebook	66	g/GJ	Guidebook	66	g/GJ	Guidebook	30	g/GJ	Guidebook
TSP	20	g/GJ	Guidebook	20	g/GJ	Guidebook	20	g/GJ	Guidebook	20	g/GJ	Guidebook	0.45	g/GJ	Guidebook
PM_{10}	100	% TSP	Guidebook	100	% TSP	Guidebook	100	% TSP	Guidebook	100	% TSP	Guidebook	100	% TSP	Guidebook
$PM_{2.5}$	100	% TSP	Guidebook	100	% TSP	Guidebook	100	% TSP	Guidebook	100	% TSP	Guidebook	100	% TSP	Guidebook
BC	56	% PM2.5	Guidebook	56	% PM2.5	Guidebook	56	% PM2.5	Guidebook	56	% PM2.5	Guidebook	5.4	% PM2.5	Guidebook
Pb	0.0032	g/ton	Guidebook	0.0034	g/ton	Guidebook	0.0035	g/ton	Guidebook	0.0035	g/ton	Guidebook	0.000069	g/ton	Guidebook
Cd	0.0002	g/ton	Guidebook	0.0003	g/ton	Guidebook	0.0003	g/ton	Guidebook	0.0003	g/ton	Guidebook	0.000012	g/ton	Guidebook
Hg	0.0048	g/ton	Guidebook	0.0051	g/ton	Guidebook	0.0053	g/ton	Guidebook	0.0053	g/ton	Guidebook	0.004600	g/ton	Guidebook
As	0.0012	g/ton	Guidebook	0.0013	g/ton	Guidebook	0.0013	g/ton	Guidebook	0.0013	g/ton	Guidebook	0.005520	g/ton	Guidebook
Cr	0.0080	g/ton	Guidebook	0.0085	g/ton	Guidebook	0.0088	g/ton	Guidebook	0.0088	g/ton	Guidebook	0.000035	g/ton	Guidebook
Cu	0.0088	g/ton	Guidebook	0.0094	g/ton	Guidebook	0.0096	g/ton	Guidebook	0.0097	g/ton	Guidebook	0.000003	g/ton	Guidebook
Ni	0.0003	g/ton	Guidebook	0.0003	g/ton	Guidebook	0.0004	g/ton	Guidebook	0.0004	g/ton	Guidebook	0.000023	g/ton	Guidebook
Se	0.0044	g/ton	Guidebook	0.0047	g/ton	Guidebook	0.0048	g/ton	Guidebook	0.0048	g/ton	Guidebook	0.000506	g/ton	Guidebook
Zn	1.16	g/ton	Guidebook	1.24	g/ton	Guidebook	1.27	g/ton	Guidebook	1.28	g/ton	Guidebook	0.000069	g/ton	Guidebook
DioxFur	1.40	µg TEQ/TJ	Guidebook	1.40	µg TEQ/TJ	Guidebook	1.40	µg TEQ/TJ	Guidebook	1.40	µg TEQ/TJ	Guidebook	0.50	µg TEQ/TJ	Guidebook
PAH	0.80	mg/t	Guidebook	0.86	mg/t	Guidebook	0.88	mg/t	Guidebook	0.88	mg/t	Guidebook	0.14	mg/t	Guidebook

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

Table 3.137 – Emissions factors - Commercial, services and institutional sector (2/2)

Fuel	City Gas			Natural Gas			Biogas			Biodiesel		
Pollutant	**Value**	**Unit**	**Reference**	**Value**	**Unit**	**Reference**	**Value**	**Unit**	**Reference**	**Value**	**Unit**	**Reference**
NO_x	40	g/GJ	Guidebook	40	g/GJ	Guidebook	40	g/GJ	Guidebook	513	g/GJ	Guidebook
NMVOC	2	g/GJ	Guidebook	2	g/GJ	Guidebook	2	g/GJ	Guidebook	25	g/GJ	Guidebook
CO	30	g/GJ	Guidebook	30	g/GJ	Guidebook	30	g/GJ	Guidebook	66	g/GJ	Guidebook
TSP	0.45	g/GJ	Guidebook	0.45	g/GJ	Guidebook	0.45	g/GJ	Guidebook	20	g/GJ	Guidebook
PM_{10}	100	% TSP	Guidebook	100	% TSP	Guidebook	100	% TSP	Guidebook	100	% TSP	Guidebook
$PM_{2.5}$	100	% TSP	Guidebook	100	% TSP	Guidebook	100	% TSP	Guidebook	100	% TSP	Guidebook
BC	5.4	% PM2.5	Guidebook	5.4	% PM2.5	Guidebook	5.4	% PM2.5	Guidebook	56	% PM2.5	Guidebook
Pb	0.000024	g/ton	Guidebook	0.000069	g/ton	Guidebook	0.000052	g/ton	Guidebook	0.00296	g/ton	Guidebook
Cd	0.000004	g/ton	Guidebook	0.000012	g/ton	Guidebook	0.000009	g/ton	Guidebook	0.00022	g/ton	Guidebook
Hg	0.001569	g/ton	Guidebook	0.004607	g/ton	Guidebook	0.003470	g/ton	Guidebook	0.00444	g/ton	Guidebook
As	0.001883	g/ton	Guidebook	0.005529	g/ton	Guidebook	0.004164	g/ton	Guidebook	0.00111	g/ton	Guidebook
Cr	0.000012	g/ton	Guidebook	0.000035	g/ton	Guidebook	0.000026	g/ton	Guidebook	0.00740	g/ton	Guidebook
Cu	0.000001	g/ton	Guidebook	0.000004	g/ton	Guidebook	0.000003	g/ton	Guidebook	0.00814	g/ton	Guidebook
Ni	0.000008	g/ton	Guidebook	0.000023	g/ton	Guidebook	0.000018	g/ton	Guidebook	0.00030	g/ton	Guidebook
Se	0.000173	g/ton	Guidebook	0.000507	g/ton	Guidebook	0.000382	g/ton	Guidebook	0.00407	g/ton	Guidebook
Zn	0.000024	g/ton	Guidebook	0.000069	g/ton	Guidebook	0.000052	g/ton	Guidebook	1.07	g/ton	Guidebook
DioxFur	0.50	µg TEQ/TJ	Guidebook	0.50	µg TEQ/TJ	Guidebook	0.50	µg TEQ/TJ	Guidebook	1.40	µg TEQ/TJ	Guidebook
PAH	0.05	mg/t	Guidebook	0.14	mg/t	Guidebook	0.11	mg/t	Guidebook	0.74	mg/t	Guidebook

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

Table 3.138 – Emissions factors for sulphur content of fuels (%S) - Commercial, services and institutional sector

Year	Residual Fuel Oil	Diesel/ Gas Oil	Kerosene	Motor Gasoline	LPG	City Gas	Natural Gas	Biogas	Biodiesel
1990	2.84	0.30	0.15	0.100	0.0016	0.0	0.0007	0.0	0.0
1995	2.60	0.25	0.15	0.100	0.0016	0.0	0.0007	0.0	0.0
2000	2.60	0.15	0.15	0.100	0.0016	0.0	0.0007	0.0	0.0
2005	1.00	0.10	0.15	0.015	0.0016	0.0	0.0007	0.0	0.0
2010	1.00	0.05	0.15	0.015	0.0016	0.0	0.0007	0.0	0.0
2014	1.00	0.05	0.15	0.015	0.0016	0.0	0.0007	0.0	0.0
2015	1.00	0.05	0.15	0.015	0.0016	0.0	0.0007	0.0	0.0
2016	1.00	0.05	0.15	0.015	0.0016	0.0	0.0007	0.0	0.0

(a) Weighted average of gas oil and diesel oil for heating

3.2.4.1.5 Category-specific QA/QC and Verification

To further improve the QA/QC analysis a comparison between fuel consumption values reported by DGEG and IEA (International Energy Agency) was made. Only minor differences in natural gas consumption between data sources were identified for Commercial and Public Services sector (less than 10 per cent). For petroleum product the differences between data sources are greater than natural gas (around 30 per cent). DGEG reported that there were compilation errors in the information sent to IEA, which may explain the differences found.

3.2.4.1.6 Recalculations

No recalculations were made.

3.2.4.1.7 Further Improvements

No further improvements are planned for this sector.

3.2.4.2 Residential (NFR 1.A.4.b)

3.2.4.2.1 Overview

The sources covered in this chapter refer to those emissions resulting from combustion in the residential sector. In this sector small other mobile sources are not considered because no separation between fuel consumption is possible with DGEG's energy balance data.

3.2.4.2.2 Methodology

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

$$Emis_{SOx(s)} = 2 * \Sigma_f \Sigma_t [S_{(f,s,t,y)} / 100 * Fuel_{Cons(f,s,t)}]$$

where:

$Emis_{SOx(s)}$ - 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).

In the case of emissions of Heavy Metals the following equation was used:

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

and,

$HM_{p\ (f,s)}$ - Heavy Metal p emission estimated from consumption of fuel f in sub-sector s (t/yr);

$Fuel_{Cons(f,s)}$ - Consumption of fuel f in sub-sector s (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);

$AshRet_{(f,s,p)}$ - Retention of Heavy Metal p in ash from fuel f under burning conditions in sub-sector s (mass percentage).

Emissions were estimated from fuel/energy consumption using either mass balance (SO_x) or emission factors, according to the pollutant, and using a IPCC Tier 2 methodology.

Emissions of other pollutants that were also calculated from energy activity rate use the following basic formula (Energy Approach):

$$Emi_{(p,s)} = \Sigma_f \Sigma_t [EF_{(f,s,t,y,p)} * Activity_{(f,s,t,p)}] * 10^{-3}$$

where:

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

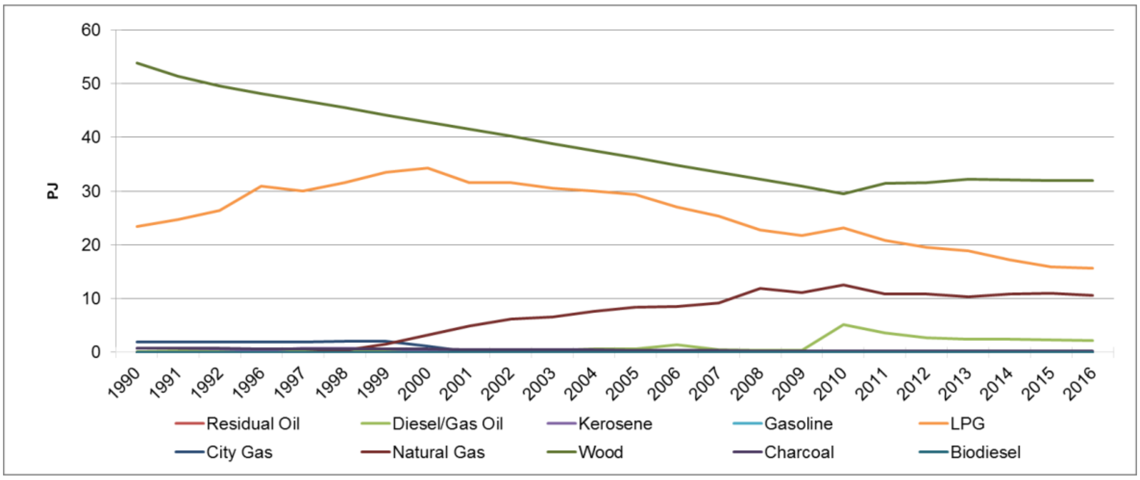
$EF_{(f,s,t,p)}$ - Emission Factor for fuel f used in sub-sector s and equipment t in year y (g/GJ except CO_2 in kg/GJ);

$Activity_{(f,s,t)}$ - Energy Consumption of fuel f in sub-sector s and in equipment/technology t (GJ).

3.2.4.2.3 Activity Data

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

Figure 3.68 – Fuels consumption in the residential sector



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.

Figure 3.69 – Total Energy Consumption in fuels in the residential sector

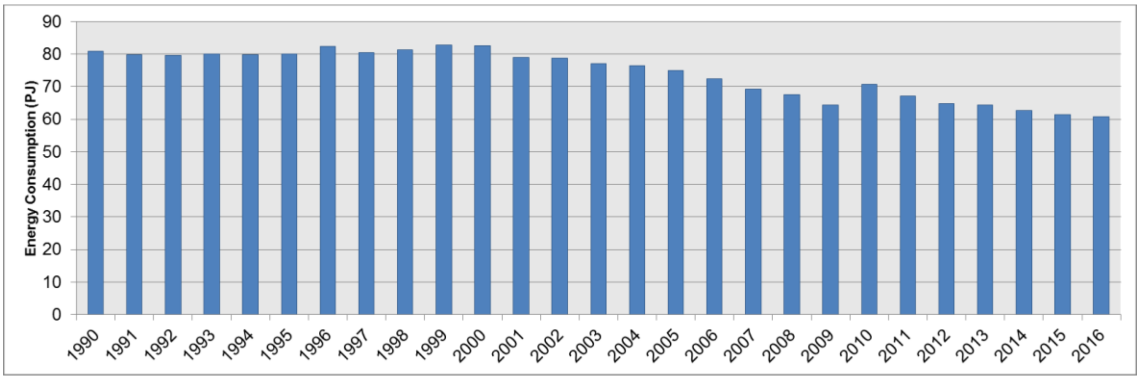
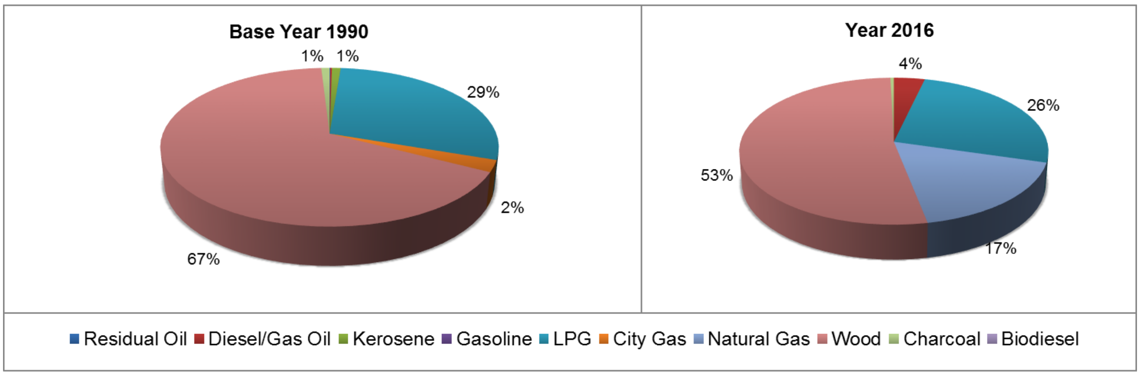


Figure 3.70 – Consumption of energy in fuels in the residential sector in 1990 and 2016



3.2.4.2.4 Emission Factors

The emission factors that were used were collected from international bibliography sources, namely:

- EMEP/EEA air pollutant emission inventory guidebook 2016 (EEA,2016);
- 2006 IPCC Guidelines (IPPC,2006).

Table 3.139 – Low Heating Value (LHV) – Residential sector

Fuel		NAPFUE	LHV
			MJ/kg
Residual Oil	L	203	40.00
Diesel/Gas Oil	L	204	42.60
Kerosene	L	206	43.75
Motor Gasoline	L	208	44.00
LPG	L	303	46.00
City Gas	L	308	15.69
Natural Gas	G	301	46.07
Wood	B	111	12.55
Charcoal	B	112	25.10
Biodiesel	B	223	37.00

Table 3.140 – Emissions factors – Residential sector (1/2)

Fuel	Residual Oil			Gas Oil / Diesel Oil			Kerosene			Motor Gasoline			LPG		
Pollutant	**Value**	**Unit**	**Reference**	**Value**	**Unit**	**Reference**	**Value**	**Unit**	**Reference**	**Value**	**Unit**	**Reference**	**Value**	**Unit**	**Reference**
NO_x	51	g/GJ	Guidebook	69	g/GJ	Guidebook	51	g/GJ	Guidebook	51	g/GJ	Guidebook	48	g/GJ	Guidebook
NMVOC	1	g/GJ	Guidebook	0.2	g/GJ	Guidebook	0.7	g/GJ	Guidebook	0.7	g/GJ	Guidebook	1.9	g/GJ	Guidebook
CO	57	g/GJ	Guidebook	4	g/GJ	Guidebook	57	g/GJ	Guidebook	57	g/GJ	Guidebook	25	g/GJ	Guidebook
TSP	1.9	g/GJ	Guidebook	1.9	g/GJ	Guidebook	1.9	g/GJ	Guidebook	1.9	g/GJ	Guidebook	0.90	g/GJ	Guidebook
PM_{10}	100	% TSP	Guidebook	100	% TSP	Guidebook	100	% TSP	Guidebook	100	% TSP	Guidebook	100	% TSP	Guidebook
$PM_{2.5}$	100	% TSP	Guidebook	100	% TSP	Guidebook	100	% TSP	Guidebook	100	% TSP	Guidebook	100	% TSP	Guidebook
BC	8.5	% PM2.5	Guidebook	3.9	% PM2.5	Guidebook	8.5	% PM2.5	Guidebook	8.5	% PM2.5	Guidebook	5.4	% PM2.5	Guidebook
Pb	0.00048	g/ton	Guidebook	0.00051	g/ton	Guidebook	0.00053	g/ton	Guidebook	0.00053	g/ton	Guidebook	0.000069	g/ton	Guidebook
Cd	0.00004	g/ton	Guidebook	0.00004	g/ton	Guidebook	0.00004	g/ton	Guidebook	0.00004	g/ton	Guidebook	0.000012	g/ton	Guidebook
Hg	0.00480	g/ton	Guidebook	0.00511	g/ton	Guidebook	0.00525	g/ton	Guidebook	0.00528	g/ton	Guidebook	0.004600	g/ton	Guidebook
As	0.00008	g/ton	Guidebook	0.00009	g/ton	Guidebook	0.00009	g/ton	Guidebook	0.00009	g/ton	Guidebook	0.005520	g/ton	Guidebook
Cr	0.00800	g/ton	Guidebook	0.00852	g/ton	Guidebook	0.00875	g/ton	Guidebook	0.00880	g/ton	Guidebook	0.000035	g/ton	Guidebook
Cu	0.00520	g/ton	Guidebook	0.00554	g/ton	Guidebook	0.00569	g/ton	Guidebook	0.00572	g/ton	Guidebook	0.000003	g/ton	Guidebook
Ni	0.00020	g/ton	Guidebook	0.00021	g/ton	Guidebook	0.00022	g/ton	Guidebook	0.00022	g/ton	Guidebook	0.000023	g/ton	Guidebook
Se	0.00008	g/ton	Guidebook	0.00009	g/ton	Guidebook	0.00009	g/ton	Guidebook	0.00009	g/ton	Guidebook	0.000506	g/ton	Guidebook
Zn	0.017	g/ton	Guidebook	0.018	g/ton	Guidebook	0.018	g/ton	Guidebook	0.018	g/ton	Guidebook	0.000069	g/ton	Guidebook
DioxFur	5.90	µg TEQ/TJ	Guidebook	1.80	µg TEQ/TJ	Guidebook	5.90	µg TEQ/TJ	Guidebook	5.90	µg TEQ/TJ	Guidebook	1.50	µg TEQ/TJ	Guidebook
PAH	14.0	mg/t	Guidebook	14.91	mg/t	Guidebook	15.31	mg/t	Guidebook	15.40	mg/t	Guidebook	0.14	mg/t	Guidebook

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

Table 3.141 – Emissions factors – Residential sector (2/2)

Fuel	City Gas			Natural Gas			Wood			Charcoal			Biodiesel		
Pollutant	**Value**	**Unit**	**Reference**	**Value**	**Unit**	**Reference**	**Value**	**Unit**	**Reference**	**Value**	**Unit**	**Reference**	**Value**	**Unit**	**Reference**
NO_x	48	g/GJ	Guidebook	48	g/GJ	Guidebook	73	g/GJ	Guidebook	73	g/GJ	Guidebook	69	g/GJ	Guidebook
NMVOC	1.9	g/GJ	Guidebook	1.9	g/GJ	Guidebook	410	g/GJ	Guidebook	410	g/GJ	Guidebook	0.2	g/GJ	Guidebook
CO	25	g/GJ	Guidebook	25	g/GJ	Guidebook	4000	g/GJ	Guidebook	4000	g/GJ	Guidebook	4	g/GJ	Guidebook
TSP	0.90	g/GJ	Guidebook	0.90	g/GJ	Guidebook	531	g/GJ	Guidebook	531	g/GJ	Guidebook	2	g/GJ	Guidebook
PM_{10}	100	% TSP	Guidebook	100	% TSP	Guidebook	95	% TSP	Guidebook	158	% TSP	Guidebook	100	% TSP	Guidebook
$PM_{2.5}$	100	% TSP	Guidebook	100	% TSP	Guidebook	93	% TSP	Guidebook	154	% TSP	Guidebook	100	% TSP	Guidebook
BC	5.4	% PM2.5	Guidebook	5.4	% PM2.5	Guidebook	4.8	% PM2.5	Guidebook	7	% PM2.5	Guidebook	3.9	% PM2.5	Guidebook
Pb	0.000024	g/ton	Guidebook	0.000069	g/ton	Guidebook	0.339	g/ton	Guidebook	0.678	g/ton	Guidebook	0.00044	g/ton	Guidebook
Cd	0.000004	g/ton	Guidebook	0.000012	g/ton	Guidebook	0.163	g/ton	Guidebook	0.326	g/ton	Guidebook	0.00004	g/ton	Guidebook
Hg	0.001569	g/ton	Guidebook	0.004607	g/ton	Guidebook	0.007	g/ton	Guidebook	0.014	g/ton	Guidebook	0.00444	g/ton	Guidebook
As	0.001883	g/ton	Guidebook	0.005529	g/ton	Guidebook	0.002	g/ton	Guidebook	0.005	g/ton	Guidebook	0.00007	g/ton	Guidebook
Cr	0.000012	g/ton	Guidebook	0.000035	g/ton	Guidebook	0.289	g/ton	Guidebook	0.577	g/ton	Guidebook	0.00740	g/ton	Guidebook
Cu	0.000001	g/ton	Guidebook	0.000004	g/ton	Guidebook	0.075	g/ton	Guidebook	0.151	g/ton	Guidebook	0.00481	g/ton	Guidebook
Ni	0.000008	g/ton	Guidebook	0.000023	g/ton	Guidebook	0.025	g/ton	Guidebook	0.050	g/ton	Guidebook	0.00019	g/ton	Guidebook
Se	0.000173	g/ton	Guidebook	0.000507	g/ton	Guidebook	0.006	g/ton	Guidebook	0.013	g/ton	Guidebook	0.00007	g/ton	Guidebook
Zn	0.000024	g/ton	Guidebook	0.000069	g/ton	Guidebook	6.4	g/ton	Guidebook	12.9	g/ton	Guidebook	0.02	g/ton	Guidebook
DioxFur	1.50	µg TEQ/TJ	Guidebook	1.50	µg TEQ/TJ	Guidebook	430	µg TEQ/TJ	Guidebook	430	µg TEQ/TJ	Guidebook	1.80	µg TEQ/TJ	Guidebook
PAH	0.05	mg/t	Guidebook	0.14	mg/t	Guidebook	4331	mg/t	Guidebook	8661	mg/t	Guidebook	12.95	mg/t	Guidebook

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

Table 3.142 – Emissions factors for sulphur content of fuel (%S) – Residential sector

Year	Residual Fuel Oil	Diesel/ Gas Oil	Kerosene	Motor Gasoline	LPG	City Gas	Natural Gas	Wood / Charcoal	Biodiesel
1990	2.84	0.30	0.15	0.100	0.0016	0.0	0.0007	0.03	0.0
1995	2.60	0.20	0.15	0.100	0.0016	0.0	0.0007	0.03	0.0
2000	2.60	0.05	0.15	0.100	0.0016	0.0	0.0007	0.03	0.0
2005	1.00	0.01	0.15	0.015	0.0016	0.0	0.0007	0.03	0.0
2010	1.00	0.01	0.15	0.015	0.0016	0.0	0.0007	0.03	0.0
2014	1.00	0.01	0.15	0.015	0.0016	0.0	0.0007	0.03	0.0
2015	1.00	0.01	0.15	0.015	0.0016	0.0	0.0007	0.03	0.0
2016	1.00	0.01	0.15	0.015	0.0016	0.0	0.0007	0.03	0.0

3.2.4.2.5 Category-specific QA/QC and Verification

To further improve the QA/QC analysis a comparison between fuel consumption values reported by DGEG and IEA (International Energy Agency) was made. There is a general agreement between data source for this source category.

3.2.4.2.6 Recalculations

No recalculations were made.

3.2.4.2.7 Further Improvements

No further improvements are planned for this sector.

3.2.4.3 Agriculture / Forestry / Fishing: Stationary (NFR 1.A.4.c.i)

3.2.4.3.1 Overview

Emission considered in this source category cover stationary combustion in the agriculture, forestry and fishing sectors. Mobile sources for these sectors were included in 1.A.4.c.ii and 1.A.4.c.iii.

3.2.4.3.2 Methodology

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

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

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).

In the case of emissions of Heavy Metals the following equation was used:

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

and,

$HM_{p\ (f,s)}$ - Heavy Metal p emission estimated from consumption of fuel f in sub-sector s (t/yr);

$Fuel_{Cons(f,s)}$ - Consumption of fuel f in sub-sector s (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);

$AshRet_{(f,s,p)}$ - Retention of Heavy Metal p in ash from fuel f under burning conditions in sub-sector s (mass percentage).

Emissions were estimated from fuel/energy consumption using either mass balance (SO_x) or emission factors, according to the pollutant, and using the IPCC Tier 2 methodology.

Emissions of other pollutants that were also calculated from energy activity rate use the following basic formula (Energy Approach):

$$Emi_{(p,s)} = \Sigma_f \Sigma_t [EF_{(f,s,t,y,p)} * Activity_{(f,s,t,p)}] * 10^{-3}$$

where:

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

$EF_{(f,s,t,p)}$ - Emission Factor for fuel f used in sub-sector s and equipment t in year y (g/GJ except CO_2 in kg/GJ);

$Activity_{(f,s,t)}$ - Energy Consumption of fuel f in sub-sector s and in equipment/technology t (GJ).

3.2.4.3.3 Activity Data

Data on fuel consumption was obtained from the annual energy balances compiled by DGEG. To account the true stationary fuel consumption in the fishing sector, bunker fuel sales (also given by DGEG) were subtracted to the energy balance fishing sector consumption. Further explanation on bunker fuel sales are given in sector 1.A.4.c.iii. Fuel consumption values used in this source category emission estimation are presented in the following figures and in ANNEX ANNEX C: ENERGY (NFR 1).

Figure 3.71 – Fuels consumed in agriculture and forestry sector (excluding mobile sources)

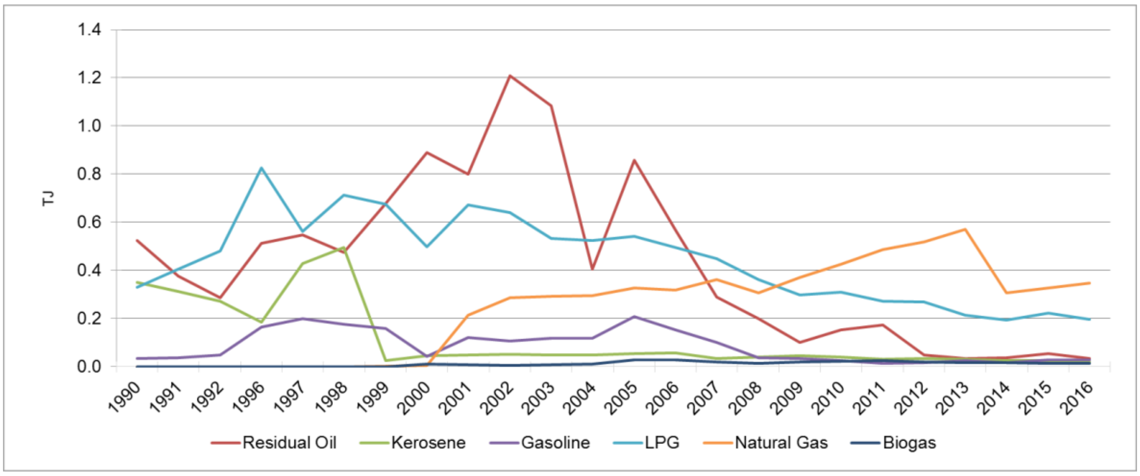


Figure 3.72 – Total Energy Consumption in fuels in the agriculture and forestry sector (excluding mobile sources)

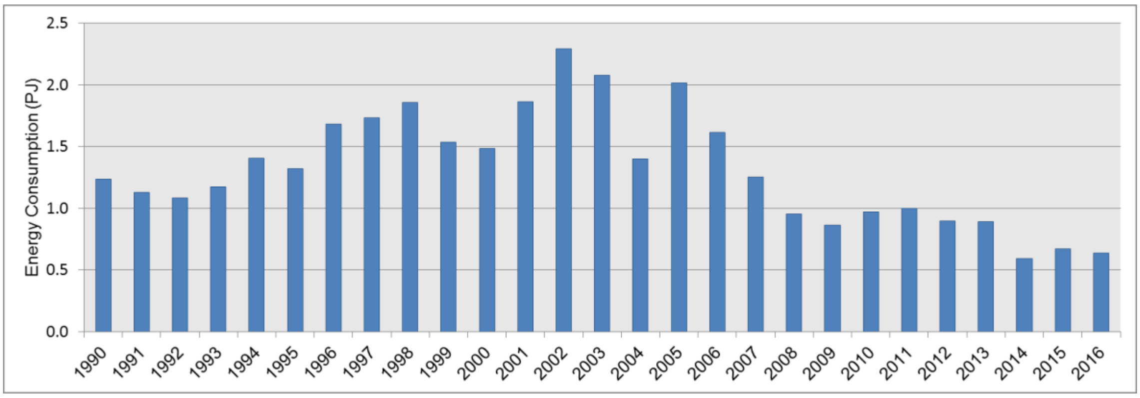


Figure 3.73 – Consumption of energy in fuels in the agriculture and forestry sector (excluding mobile sources) in 1990 and 2015

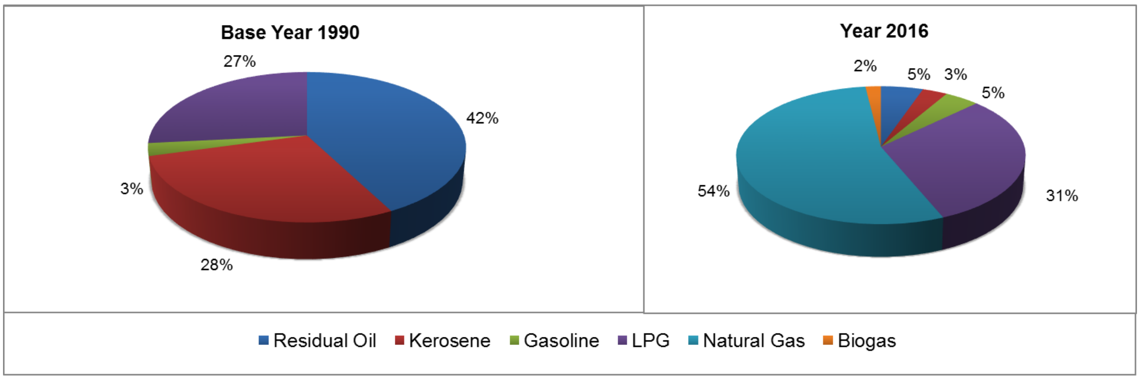


Figure 3.74 – Fuel consumed in fisheries (excluding consumption in fishing vessels)

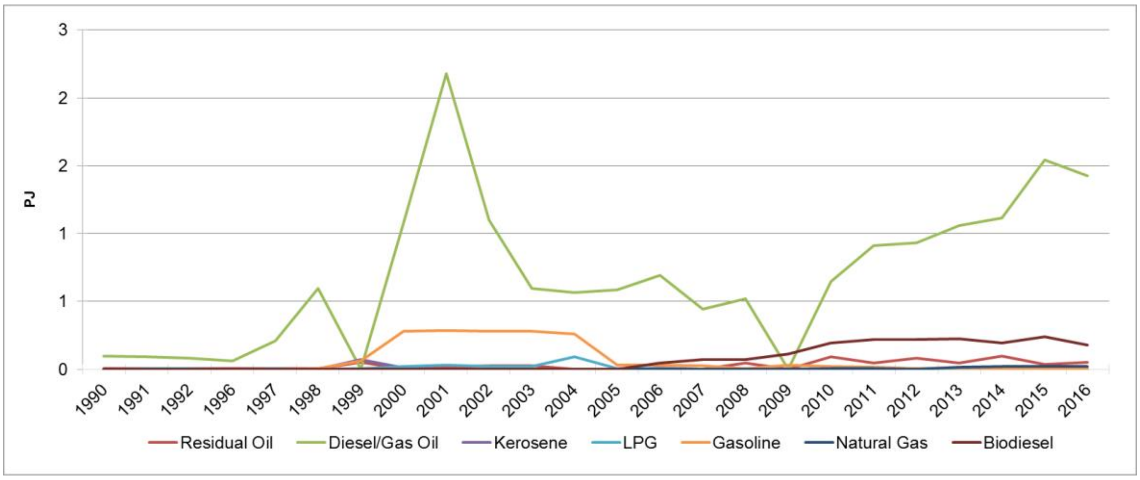


Figure 3.75 – Total Energy Consumption in fuels in fisheries (excluding consumption in fishing vessels)

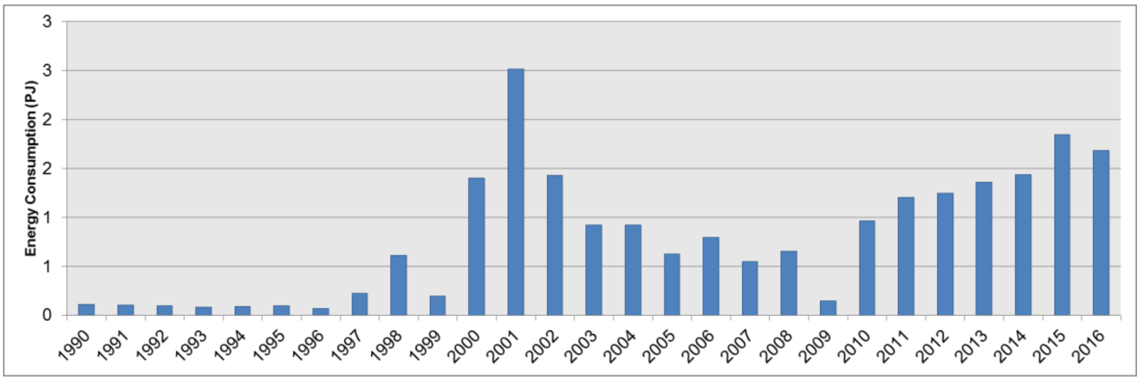
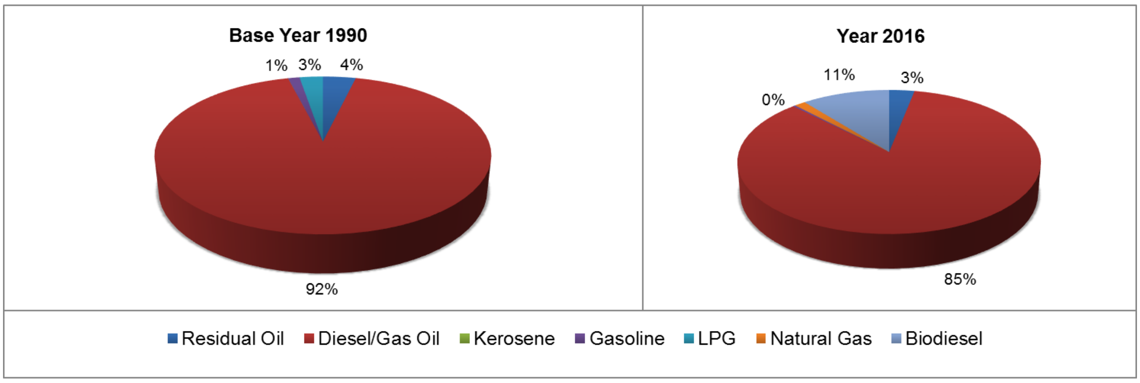


Figure 3.76 – Consumption of energy in fuels in fisheries (excluding consumption in fishing vessels) in 1990 and 2016



3.2.4.3.4 Emission Factors

The emission factors that were used were collected from international bibliography sources, namely:

- EMEP/EEA air pollutant emission inventory guidebook 2016 (EEA, 2016);
- 2006 IPCC Revised Guidelines (IPPC, 2006).

Table 3.143 – Low Heating Value (LHV) – Agriculture, forestry and fishing sectors (except mobile sources)

Fuel		NAPFUE	LHV
			MJ/kg
Residual Oil	L	203	40.00
Gas Oil	L	204	42.60
Kerosene	L	206	43.75
Motor Gasoline	L	208	44.00
LPG	L	303	46.00
Natural Gas	G	301	46.07
Biogas	B	309	34.70
Biodiesel	B	223	37.00

Table 3.144 – Emissions factors - Agriculture, forestry and fishing sectors (except mobile sources) (1/2)

Fuel	Residual Oil			Gas Oil			Kerosene			Motor Gasoline		
Pollutant	Value	Unit	Reference	Value	Unit	Reference	Value	Unit	Reference	Value	Unit	Reference
NO_x	513	g/GJ	Guidebook	513	g/GJ	Guidebook	513	g/GJ	Guidebook	513	g/GJ	Guidebook
NMVOC	25	g/GJ	Guidebook	25	g/GJ	Guidebook	25	g/GJ	Guidebook	25	g/GJ	Guidebook
CO	66	g/GJ	Guidebook	66	g/GJ	Guidebook	66	g/GJ	Guidebook	66	g/GJ	Guidebook
TSP	20	g/GJ	Guidebook	20	g/GJ	Guidebook	20	g/GJ	Guidebook	20	g/GJ	Guidebook
PM_{10}	100	% TSP	Guidebook	100	% TSP	Guidebook	100	% TSP	Guidebook	100	% TSP	Guidebook
$PM_{2.5}$	100	% TSP	Guidebook	100	% TSP	Guidebook	100	% TSP	Guidebook	100	% TSP	Guidebook
BC	56	% PM2.5	Guidebook	56	% PM2.5	Guidebook	56	% PM2.5	Guidebook	56.0	% PM2.5	Guidebook
Pb	0.0032	g/ton	Guidebook	0.0034	g/ton	Guidebook	0.0035	g/ton	Guidebook	0.0035	g/ton	Guidebook
Cd	0.0002	g/ton	Guidebook	0.0003	g/ton	Guidebook	0.0003	g/ton	Guidebook	0.0003	g/ton	Guidebook
Hg	0.0048	g/ton	Guidebook	0.0051	g/ton	Guidebook	0.0053	g/ton	Guidebook	0.0053	g/ton	Guidebook
As	0.0012	g/ton	Guidebook	0.0013	g/ton	Guidebook	0.0013	g/ton	Guidebook	0.0013	g/ton	Guidebook
Cr	0.0080	g/ton	Guidebook	0.0085	g/ton	Guidebook	0.0088	g/ton	Guidebook	0.0088	g/ton	Guidebook
Cu	0.0088	g/ton	Guidebook	0.0094	g/ton	Guidebook	0.0096	g/ton	Guidebook	0.0097	g/ton	Guidebook
Ni	0.0003	g/ton	Guidebook	0.0003	g/ton	Guidebook	0.0004	g/ton	Guidebook	0.0004	g/ton	Guidebook
Se	0.0044	g/ton	Guidebook	0.0047	g/ton	Guidebook	0.0048	g/ton	Guidebook	0.0048	g/ton	Guidebook
Zn	1.16	g/ton	Guidebook	1.24	g/ton	Guidebook	1.27	g/ton	Guidebook	1.28	g/ton	Guidebook
DioxFur	1.40	µg TEQ/TJ	Guidebook	1.40	µg TEQ/TJ	Guidebook	1.40	µg TEQ/TJ	Guidebook	1.40	µg TEQ/TJ	Guidebook
PAH	0.80	mg/t	Guidebook	0.86	mg/t	Guidebook	0.88	mg/t	Guidebook	0.88	mg/t	Guidebook

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

Table 3.145 – Emissions factors - Agriculture, forestry and fishing sectors (except mobile sources) (2/2)

Fuel	LPG			Natural Gas			Biogas			Biodiesel		
Pollutant	Value	Unit	Reference	Value	Unit	Reference	Value	Unit	Reference	Value	Unit	Reference
NO_x	40	g/GJ	Guidebook	40	g/GJ	Guidebook	40	g/GJ	Guidebook	513	g/GJ	Guidebook
NMVOC	2	g/GJ	Guidebook	2	g/GJ	Guidebook	2	g/GJ	Guidebook	25	g/GJ	Guidebook
CO	30	g/GJ	Guidebook	30	g/GJ	Guidebook	30	g/GJ	Guidebook	66	g/GJ	Guidebook
TSP	0.45	g/GJ	Guidebook	0.45	g/GJ	Guidebook	0.45	g/GJ	Guidebook	20	g/GJ	Guidebook
PM_{10}	100	% TSP	Guidebook	100	% TSP	Guidebook	100	% TSP	Guidebook	100	% TSP	Guidebook
$PM_{2.5}$	100	% TSP	Guidebook	100	% TSP	Guidebook	100	% TSP	Guidebook	100	% TSP	Guidebook
BC	5.4	% PM2.5	Guidebook	5.4	% PM2.5	Guidebook	5.4	% PM2.5	Guidebook	56	% PM2.5	Guidebook
Pb	0.00007	g/ton	Guidebook	0.00007	g/ton	Guidebook	0.00005	g/ton	Guidebook	0.0030	g/ton	Guidebook
Cd	0.00001	g/ton	Guidebook	0.00001	g/ton	Guidebook	0.00001	g/ton	Guidebook	0.0002	g/ton	Guidebook
Hg	0.00460	g/ton	Guidebook	0.00461	g/ton	Guidebook	0.00347	g/ton	Guidebook	0.0044	g/ton	Guidebook
As	0.00552	g/ton	Guidebook	0.00553	g/ton	Guidebook	0.00416	g/ton	Guidebook	0.0011	g/ton	Guidebook
Cr	0.00003	g/ton	Guidebook	0.00004	g/ton	Guidebook	0.00003	g/ton	Guidebook	0.0074	g/ton	Guidebook
Cu	0.00000	g/ton	Guidebook	0.00000	g/ton	Guidebook	0.00000	g/ton	Guidebook	0.0081	g/ton	Guidebook
Ni	0.00002	g/ton	Guidebook	0.00002	g/ton	Guidebook	0.00002	g/ton	Guidebook	0.0003	g/ton	Guidebook
Se	0.00051	g/ton	Guidebook	0.00051	g/ton	Guidebook	0.00038	g/ton	Guidebook	0.0041	g/ton	Guidebook
Zn	0.00007	g/ton	Guidebook	0.00007	g/ton	Guidebook	0.00005	g/ton	Guidebook	1.07	g/ton	Guidebook
DioxFur	0.50	µg TEQ/TJ	Guidebook	0.50	µg TEQ/TJ	Guidebook	0.50	µg TEQ/TJ	Guidebook	1.40	µg TEQ/TJ	Guidebook
PAH	0.14	mg/t	Guidebook	0.14	mg/t	Guidebook	0.11	mg/t	Guidebook	0.74	mg/t	Guidebook

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

Table 3.146 – Emissions factors for sulphur content of fuels (%S) - Agriculture, forestry and fishing sectors (except mobile sources)

Year	Residual Fuel Oil	Gas Oil	Kerosene	Motor Gasoline	LPG	Natural Gas	Biogas	Biodiesel
1990	2.84	0.30	0.15	0.100	0.0016	0.0007	0.0	0.0
1995	2.60	0.25	0.15	0.100	0.0016	0.0007	0.0	0.0
2000	2.60	0.15	0.15	0.100	0.0016	0.0007	0.0	0.0
2005	1.00	0.10	0.15	0.015	0.0016	0.0007	0.0	0.0
2010	1.00	0.05	0.15	0.015	0.0016	0.0007	0.0	0.0
2014	1.00	0.05	0.15	0.015	0.0016	0.0007	0.0	0.0
2015	1.00	0.05	0.15	0.015	0.0016	0.0007	0.0	0.0
2016	1.00	0.05	0.15	0.015	0.0016	0.0007	0.0	0.0

3.2.4.3.5 Category-specific QA/QA and Verification

Following the same procedure as in other 1.A.4 source categories where energy balance was used as the main data source, a comparison between fuel consumption values reported by DGEG and IEA (International Energy Agency) was made. Only minor differences between data sources were identified for this source category.

3.2.4.3.6 Recalculations

No recalculations were made.

3.2.4.3.7 Further Improvements

No further improvements are planned for this sector.

3.2.4.4 Agriculture / Forestry / Fishing: Off-road Vehicles and Other Machinery (NFR 1.A.4.c.ii)

3.2.4.4.1 Overview

Due to typical operation in vast land areas, agriculture and forestry activities are heavily dependent on machines and off-road vehicles: agricultural and forest tractors from 5 kW up to 250 kW, harvesters, sprayers, mowers, tillers, chain saws, haulers, shredders and log loaders among others.

Only gas-oil is assumed to be an energy source for mobile equipments in this activity. Although emissions from mobile sources in agriculture and forestry are reported under category source 1.A.4.c.i, methodology used to estimate emissions from this activity is better presented here together with the other individualized mobile sources. Consumption of biodiesel with gas oil was assumed in the energy balance data, in accordance with the explained in 1.A.2. Methodology chapter.

3.2.4.4.2 Methodology

Emissions for all pollutants are estimated with the following formula:

$$Emission_{(p,y)} = EF_{(p)} * Cons_{Fuel(y)} * 10^{-3}$$

where

Emission $_{(p,y)}$ - Emission of pollutant p in year y (t/yr);

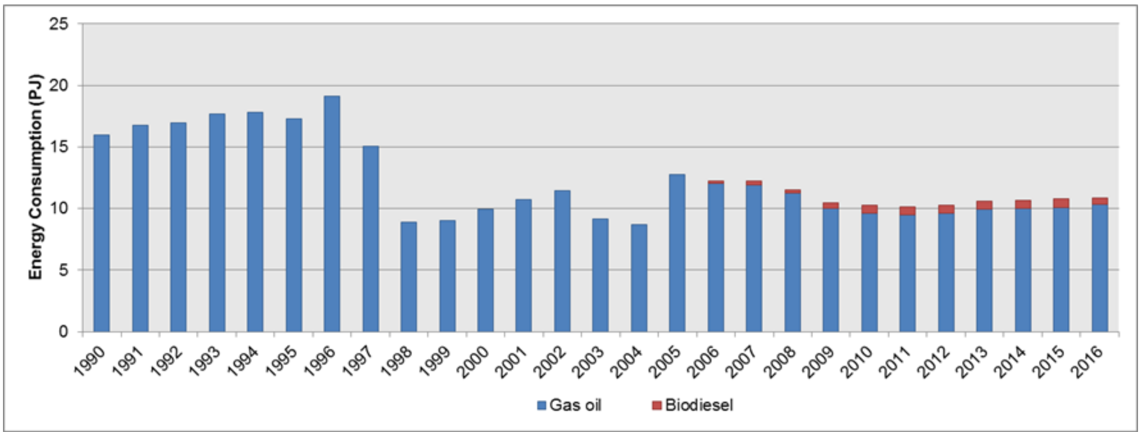
$EF_{(p)}$ - Emission factor for pollutant p (kg/t);

$Cons_{Fuel(y)}$ - consumption of gas oil in agriculture machines and off-road vehicles during in year y (t/yr).

3.2.4.4.3 Activity Data

Consumption of fuels in the agriculture and forestry sector is available from 1990 to the latest inventory year from General-Directorate of Geology and Energy (DGEG) in the energy balance. Although there is no clear specification, in the original database, in which combustion equipment each fuel is used it was assumed that all gas-oil is used in machines and other off-road vehicles. The same suppositions were made for biodiesel since both are used together. Energy consumption are presented in figure below and in ANNEX ANNEX C: ENERGY (NFR 1).

Figure 3.77 – Fuel consumption in machines and other off-road vehicles



3.2.4.4.4 Emission Factors

The set of emission factors utilized to estimate air emissions from use of gas oil in agriculture machines and other off-road vehicles were determined as the average value of the values proposed in tables I-47 and I-49 of the Revised 2006 IPCC Guidelines (IPCC, 2006), except the emission factor for Particulate Matter and Black Carbon, set from the EMEP/EEA air pollutant emission inventory guidebook 2016 (EEA, 2016). In general for biodiesel EF were considered the same as for gas oil, with the exceptions shown in the following tables.

Table 3.147 – Low Heating Value (LHV) – Agriculture machines and other off-road vehicles

Fuel		NAPFUE	LHV
			MJ/kg
Diesel/Gas Oil	L	204	42.60
Biodiesel	B	223	37.00

Table 3.148 – Emissions factors - Agriculture machines and other off-road vehicles

Fuel	Gas Oil			Biodiesel		
Pollutant	Value	Unit	Reference	Value	Unit	Reference
NO_x	56.9	g/kg	Guidebook	56.9	g/kg	Guidebook
NMVOC	8.4	g/kg	Guidebook	8.4	g/kg	Guidebook
CO	20.7	g/kg	Guidebook	20.7	g/kg	Guidebook
TSP	1.7	g/kg	Guidebook	1.7	g/kg	Guidebook
PM_{10}	1.7	g/kg	Guidebook	1.7	g/kg	Guidebook
$PM_{2.5}$	1.7	g/kg	Guidebook	1.7	g/kg	Guidebook
BC	57	% PM2.5	Guidebook	57	% PM2.5	Guidebook
Pb	0.20	g/ton	Guidebook	0.20	g/ton	Guidebook
Cd	0.01	g/ton	Guidebook	0.01	g/ton	Guidebook
Hg	0.00	g/ton	Guidebook	0.00	g/ton	Guidebook
As	0.05	g/ton	Guidebook	0.05	g/ton	Guidebook
Cr	0.05	g/ton	Guidebook	0.05	g/ton	Guidebook
Cu	1.70	g/ton	Guidebook	1.70	g/ton	Guidebook
Ni	0.07	g/ton	Guidebook	0.07	g/ton	Guidebook
Se	0.01	g/ton	Guidebook	0.01	g/ton	Guidebook
Zn	1.00	g/ton	Guidebook	1.00	g/ton	Guidebook
DioxFur	0.0	µg TEQ/TJ	Guidebook	0.0	µg TEQ/TJ	Guidebook
PAH	3.32	g/ton	Guidebook	3.32	g/ton	Guidebook

3.2.4.4.5 Uncertainty Assessment

To be developed in the future.

3.2.4.4.6 Category-specific QA/QA and Verification

General revision of time series consistency for fuel consumption and emission factors was the only QA/QC procedure adopted for this sector.

3.2.4.4.7 Recalculations

No recalculations were made.

3.2.4.4.8 Further Improvements

No further improvements are planned for this sector.

3.2.4.5 Agriculture / Forestry / Fishing: National Fishing (NFR 1.A.4.c.iii)

3.2.4.5.1 Overview

This chapter deals with emissions from fishing ships and boats. Emissions associated with fuel consumption in fishing industry, aquaculture or sea ports that are realized inland and not in water vessels are included in 1.A.4.c.i.. Fishing bunker represent emission from local costal fishing, deep-see fishing and cod-fish fishing vessels.

In the inventory process it was assumed that marine diesel engines are the main power source for ships either for transport or shipping activities. Small local fishing and sport ships do in fact use petrol-engines but they represent a small proportion of total consumption and for most situations their fuel consumption cannot be individualised from road traffic consumption. Again consumption of biodiesel was determined as a part of the gas oil since 2006.

3.2.4.5.2 Methodology

Emissions for all pollutants are estimated for each ship type using the following formula:

$$Emission_{(n,p,y)} = \Sigma_f [EF_{(n,f,p)} * Cons_{Fuel(n,f,y)}] * 10^{-3}$$

where

$Emission_{(n,p,y)}$ - Total emission of pollutant p in year y from ships of class n (t/yr);

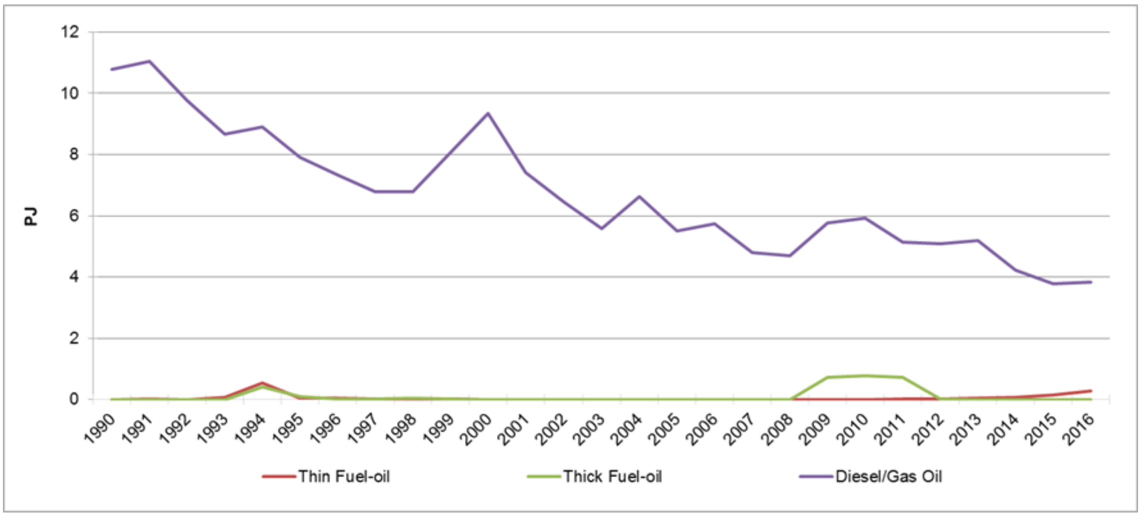
$EF_{(n,f,p)}$ - Quantity of pollutant p emitted, variable with fuel type f and ship class n (kg/t);

$Cons_{Fuel(n,f,y)}$ - consumption by ships of type n of fuel f during year y (t/yr).

3.2.4.5.3 Activity Data

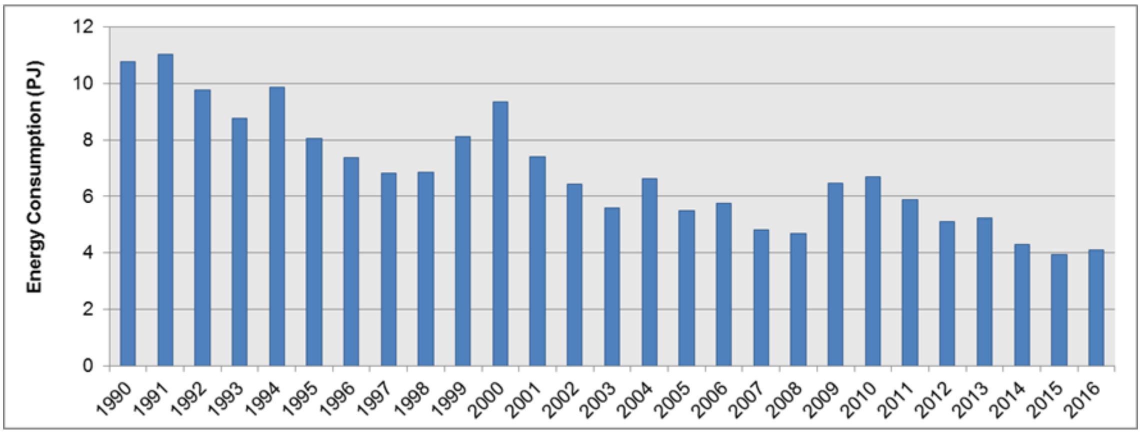
Data on fuel consumption in the fishing sector was obtained from DGEG's energy balance. Since there is no distinction between fishing vessels and static equipment in this data source new data was obtained concerning bunker fuel sales (source: DGEG). With this new data a separation between fuel consumption in mobile and non-mobile equipment was possible. Fuel consumption reported by DGEG as bunker sales is presented in the following figures and in ANNEX ANNEX C: ENERGY (NFR 1).

Figure 3.78 – Fuel consumed in fishing bunkers (GJ) [23]



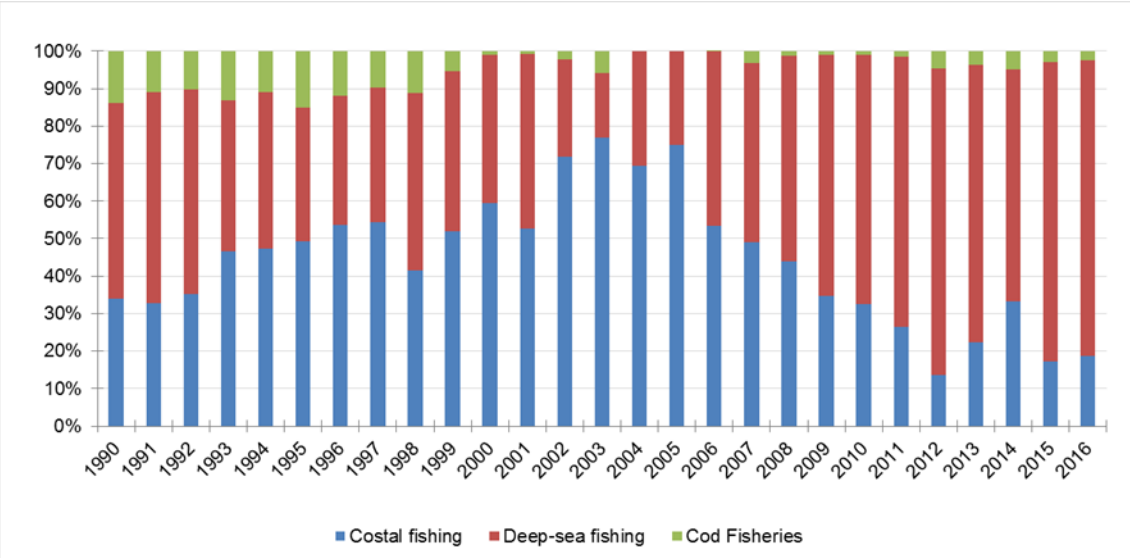
[23] The same situation that was described for transport navigation is true here. It was possible to distinguish between thin-fuel-oil, thick-fuel-oil and NATO's naphtha, gas-oil and diesel oil, but available emission factors again do not distinguish these fuel types

Figure 3.79 – Total energy consumption in fishing bunkers



Additional information in DGEG annual reports, allows for the division of each fuel type in several different fishing activities: (1) Local coastal fishing; (2) Deep-sea fishing and (3) Cod-fish fishing vessels[24]. Percentage for each type of fisheries is presented in next figure.

Figure 3.80 – Consumption of fuel by fishing vessel type in percentage of total consumption in bunkers for fisheries



3.2.4.5.4 Emission Factors

Except for sulphur oxide, emissions were estimated using default emission factors (kg/t) from IPCC 1996 Revised Guidelines (table I-47 in IPCC,1997) for most pollutants. The following criteria were used to choose the most suitable emission factors:

[24] All fishing activities were allocated to national total although it is true that some may not be realized in territorial waters or EMEP area. That is clearly the case of cod-fish fishing and it is also partly true for deep-sea fishing.

- "Ocean-going ships" for national and international transport navigation, deep-sea fishing and cod fishing;
- "Boat" in the case of coastal fishing vessels.

Sulphur oxide emissions are dependent on sulphur content of fuel. Particulate matter emission factors are from EMEP/EEA air pollutant emission inventory guidebook 2016 (EEA,2016). Emission factors are presented in the following tables.

Table 3.149 – Low Heating Value (LHV) - Water Borne Navigation and Fishing Vessels

Fuel		LHV
		MJ/kg
Coastal Fisheries	Gas Oil	42.60
Other Fisheries		
Coastal Fisheries	Biodiesel	37.00
Other Fisheries		
Coastal Fisheries	Fuel-oil	40.00
Other Fisheries		

Table 3.150 – Emissions factors - Water Borne Navigation and Fishing Vessels

		Coastal Fisheries	Other Fisheries	Coastal Fisheries	Other Fisheries	Coastal Fisheries	Other Fisheries
Fuel		Gas Oil		Biodiesel		Fuel-oil	
Pollutant	Unit	Value	Value	Value	Value	Value	Value
SO_x	%	0.3	0.3	0.0	0.0	2.8	2.8
NO_x	g/kg	67.5	87.0	67.5	87	67.5	87
NMVOC	g/kg	4.9	4.9	4.9	5	4.9	4.9
CO	g/kg	21.3	1.9	21.3	1.9	21.3	1.9
TSP	kg/t	1.5	1.5	1.5	1.5	6.2	6.2
PM_{10}	kg/t	1.5	1.5	1.5	1.5	6.2	6.2
$PM_{2.5}$	kg/t	1.4	1.4	1.4	1.4	5.6	5.6
BC	% PM2.5	31	31	31	31	12	12
Pb	g/ton	0.20	0.20	0.20	0.20	1.30	1
Cd	g/ton	0.01	0.01	0.01	0.01	0.03	0.03
Hg	g/ton	0.05	0.05	0.05	0.05	0.02	0.02
As	g/ton	0.05	0.05	0.05	0.05	0.50	0.50
Cr	g/ton	0.04	0.04	0.04	0.04	0.20	0.20
Cu	g/ton	0.05	0.05	0.05	0.05	0.50	0.50
Ni	g/ton	0.07	0.07	0.07	0.07	30	30
Se	g/ton	0.20	0.20	0.20	0.20	0.40	0.40
Zn	g/ton	0.50	0.50	0.50	0.50	0.90	0.90

3.2.4.5.5 Category-specific QA/QA and Verification

For this sector the comparison between DGED and IEA fuel consumption values was also made (please see the chapter Comparison of Energy Balance vs. IEA Energy Statistics). There are major differences between the two data sources for this source category. No precise justification for this difference was found, apart from the reported compilation errors made by DGEG in the information sent to IEA.

3.2.4.5.6 Recalculations

Correction of a compilation error in residual fueloil consumption between 2004 and 2013.

3.2.4.5.7 Further Improvements

No further improvements are planned for this sector.

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

Emissions from military reported under category 1 A 5 include only military aviation.

The energy balance does not provide a specific fuel consumption classification for military operations. Fuel consumption reported under category "Serviços" includes fuel used in military operations however it is not possible to explicity derive the fraction of fuel used only in military operations. Therefore emissions from military operations, except military aviation, are reported under category NFR 1 A 4 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.

3.2.5.1 Other Mobile (NFR 1.A.5.b)

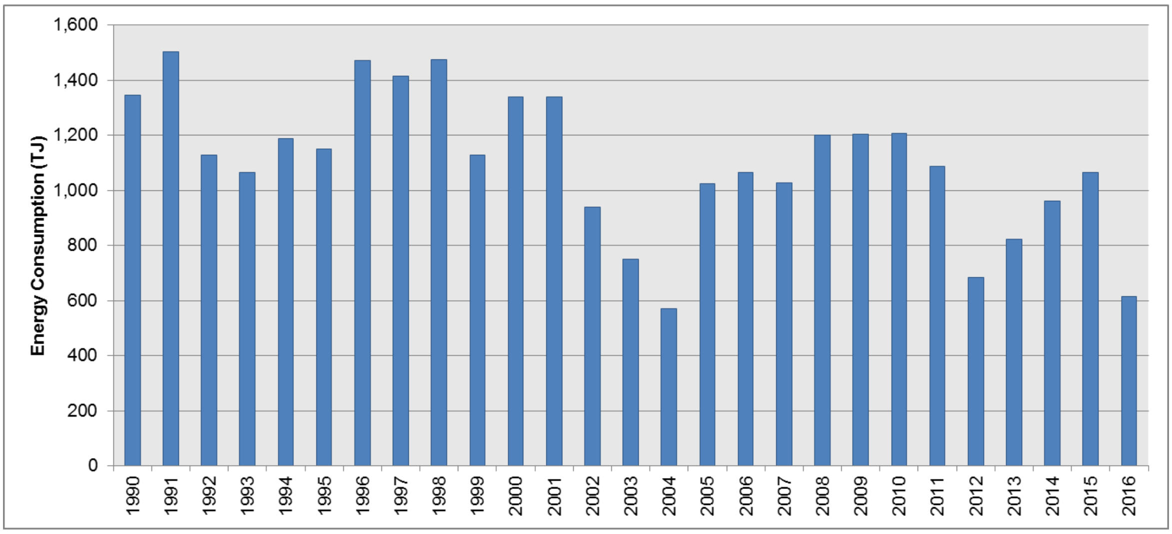
Emissions from military reported under category 1 A 5 b include only military aviation.

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 1 A 4 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.

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 3.81 – Energy Consumption in Military aviation



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

Table 3.151 – 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

3.2.5.1.1 Recalculations

No recalculations were made for this subsector.

3.2.5.1.2 Further Improvements

No further improvements are planned for this sector.

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

3.2.6.1 Coal Mining and Handling

3.2.6.1.1 Overview

Coal contains some proportion of methane 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.

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 lignite, 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.

3.2.6.1.2 Methodology

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

where

Emi - Emissions of pollutant x in year y (t);

EF – Emission factor (kg/t of coal);

$Coal_U$ – Coal extracted from underground mines (t of coal).

3.2.6.1.3 Emission Factors

It were used the following emission factors:

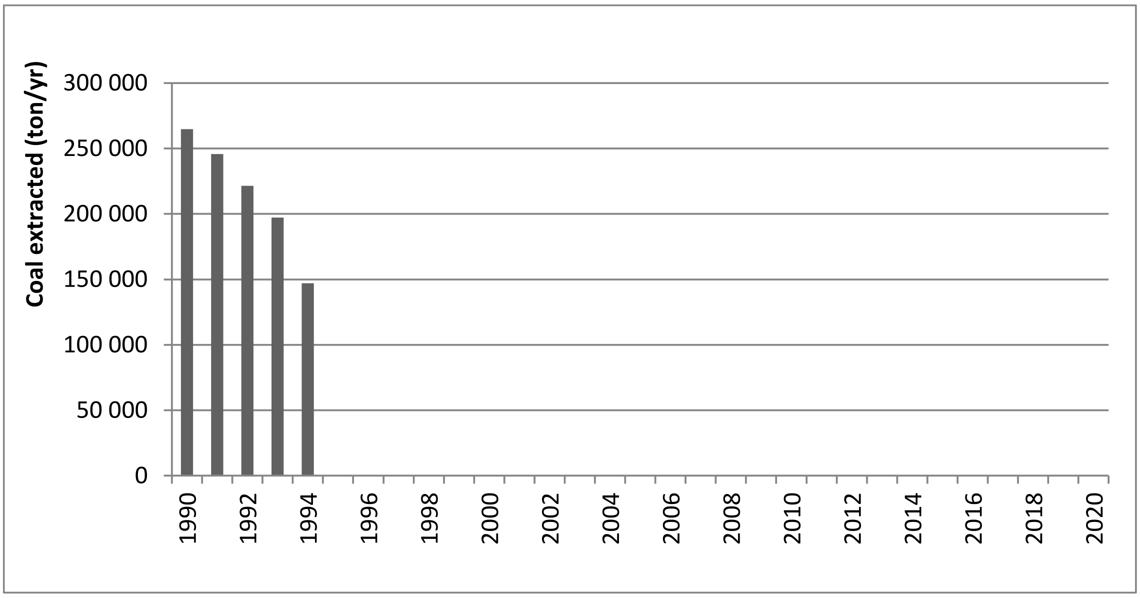
Table 3.152– Emission Factors for coal extraction and processing

Parameter	Emission Factor	Unit	Source
NMVOC	3	Kg/t of coal	Table 3-3 of EMEP/EEA emission inventory guidebook 2016 (Tier 2)
TSP	0.089	Kg/t of coal	Table 3-1 EMEP/EEA emission inventory guidebook 2016 (Tier 1)
PM10	0.042	Kg/t of coal	Table 3-1 EMEP/EEA emission inventory guidebook 2016 (Tier 1)
PM2.5	0.005	Kg/t of coal	Table 3-1 EMEP/EEA emission inventory guidebook 2016 (Tier 1)

3.2.6.1.4 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 3.82 – Quantities of coal extracted from mines in Portugal



3.2.6.1.5 Recalculations

NVMOC emission factor has been revised. The two mines were of the underground type. The tier 2 emission factor is 3 kg/t coal, while the previous tier 1 emission factor was 0.8 Kg/t coal. NMVOC emissions are now 2.75 higher than were in the previous submission.

3.2.6.1.6 Further Improvement

No further improvements are expected.

3.2.7 Fugitive Emissions from Oil Production and Refining (NFR 1.B.2.a)

3.2.7.1 Overview

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.

3.2.7.1.1 Transport of Crude/Marine Terminals (NFR 1.B.2.a.i)

3.2.7.1.1.1 Overview

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.

3.2.7.1.1.2 Methodology

NMVOC emissions were estimated from:

$$Emis_{NMVOC} = \frac{(Crude_{cons} \times EF_{NMVOC})}{1000}$$

where:

$Emis_{NMVOC}$ – NMVOC emissions (kt);

$Crude_{cons}$ - Crude consumption in refineries (t);

EF_{NMVOC} – NMVOC emission factor (kg/t crude).

3.2.7.1.1.3 Emission Factors

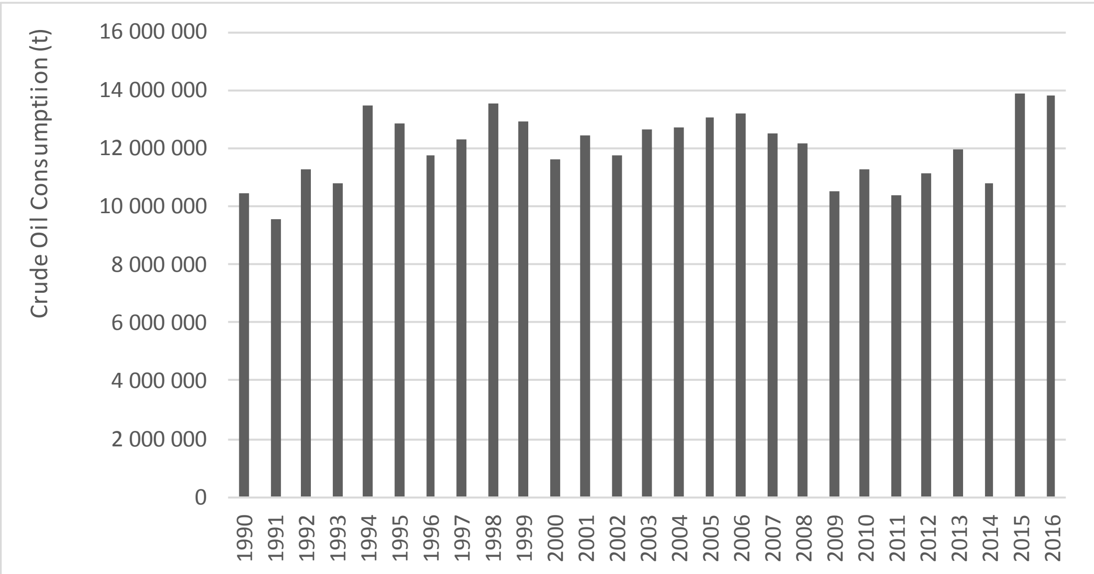
Table 3.153 – Emission Factors

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"

3.2.7.1.1.4 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 3.83 – Total amounts of crude in Marine Terminals (t)



3.2.7.1.1.5 Recalculations

This subsector methodology, activity data and emission factors have been revised.

3.2.7.2 Refining and Storage (NFR 1.B.2.a.iv)

3.2.7.2.1 Overview

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 vapor space, and pressure (low and high).

NMVOC and methane emissions may also result from “normal” leaks[25] 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

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

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 percent 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.

3.2.7.2.2 Fluid Catalytic Cracking (FCC)

3.2.7.2.2.1 Methodology

NO_x, CO, NMVOC, SO_x, NH_3, TSP, PM_{10} and $PM_{2.5}$ emissions where estimated as follows:

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

where

$Emis_p$ - emission of pollutant "p" (t);

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

EF_p – emission factor pollutant "p" (kg/m^3).

Black Carbon (BC) emissions where estimated as follows:

$$Emis_{BC} = Emis_{PM2.5} \times EF_{BC}$$

where

$Emis_{BC}$ - Black Carbon emissions (t);

$Emis_{PM2.5}$ - $PM_{2.5}$ emissions (t);

EF_{BC} – Black Carbon emission factor (% $PM_{2.5}$).

Pb, Cd, Hg, As, Cr, Cu, Ni, Se and Zn emissions where estimated as follows:

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

where

$Emis_p$ - 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).

3.2.7.2.2.2 Emission Factors

Emission factors from Table 3-2 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016 were used.

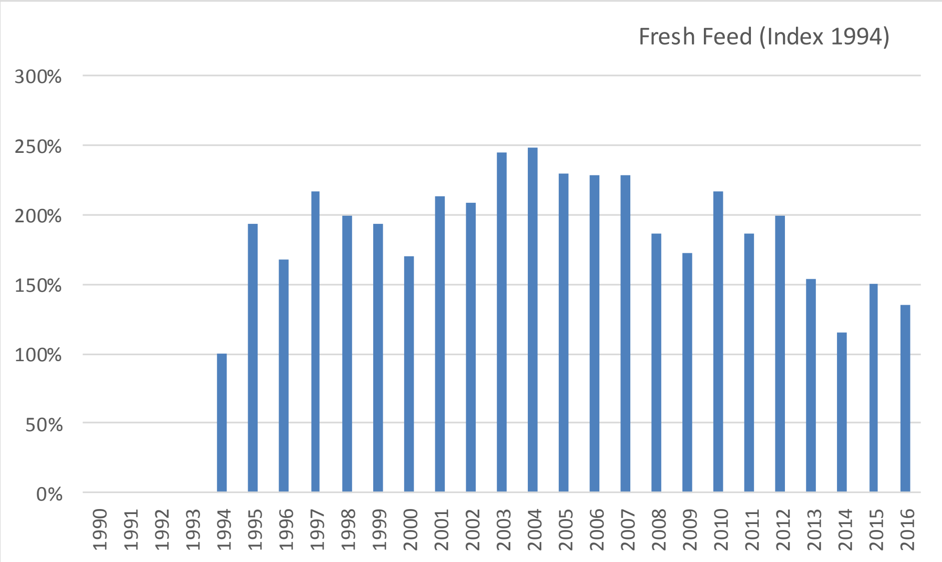
Table 3.154 – Emission Factors for FCC Units in refineries

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

3.2.7.2.2.3 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 3.84 – Fresh feed in the Fluid Catalytic Cracking Unit (Index related to 1994 value)



3.2.7.2.2.4 Recalculations

We have implemented the methodology proposed in chapter 16.2.2.1 of Concawe report no. 4/17 (Air pollutant emission estimation methods for E-PRTR reporting by refineries – 2017 edition).

3.2.7.2.2.5 Further Improvements

No further improvements are planned for this sector.

3.2.7.2.3 Platforming/Continuous Catalyst Regenerators (CCR)

3.2.7.2.3.1 Methodology

CO and SO_x emissions where estimated as follows:

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

where

$Emis_p$ - emission 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 where estimated as follows:

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

where

$Emis_p$ - 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).

3.2.7.2.3.2 Emission Factors

Emission factors from Table 3-3 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016 were used.

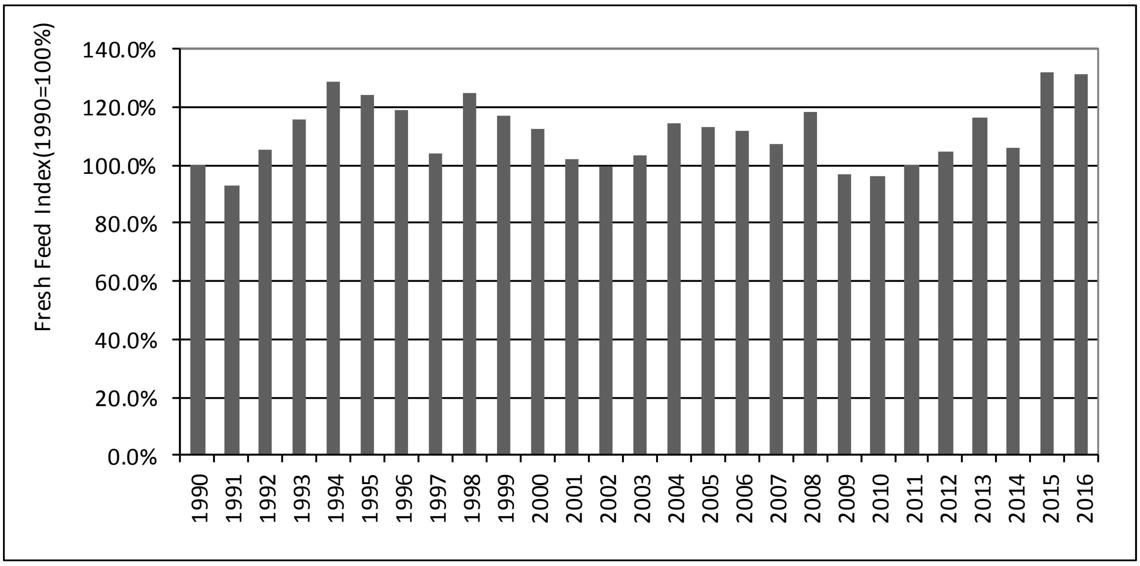
Table 3.155 – Emission Factors for Continuous Catalyst Regeneration (Platforming) in Refineries

Pollutant	Unit	EF	Source
CO	g/m^3 fresh feed	42	Table 3-3 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016
SO_x	g/m^3 fresh feed	4	Table 3-3 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016
PCDD/F	µg I-teq/m^3 fresh feed	0.019	Table 3-3 of chapter 1.B.2.a.iv of EMEP/EEA guidebook 2016

3.2.7.2.3.3 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 3.85 – Fresh feed in the Platforming Units (Index related to 1990 value)



3.2.7.2.3.4 Recalculations

We have implemented the methodology proposed in chapter 16.2.2.1 of Concawe report no. 4/17 (Air pollutant emission estimation methods for E-PRTR reporting by refineries – 2017 edition).

3.2.7.2.3.5 Further Improvements

No further improvements are planned for this sector.

3.2.7.2.4 Asphalt Blowing in Refineries

Emissions related to Asphalt blowing in refineries are estimated and reported in NFR 2D.3.g.

3.2.7.2.5 Oil-Water Separators

3.2.7.2.5.1 Methodology

From 2005 onwards, NMVOC emissions are estimated as:

$$Emis_{NMVOC} = V_{Wastewater} \times EF_{NMVOC} \times 10^{-3}$$

Where,

$Emis_{NMVOC}$ – 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 are estimated as:

$$Emis_{NMVOC,y} = Emis_{NMVOC,2005} \times \frac{Crude_{cons,y}}{Crude_{cons,2005}}$$

Where,

$Emis_{NMVOC,y}$ – NMVOC emissions in year “y” (t);

$Emis_{NMVOC,2005}$ – NMVOC emissions in year 2005 (t);

$Crude_{cons,y}$ – Crude consumption in year “y” (t);

$Crude_{cons,2005}$ – Crude consumption in year 2005 (t).

3.2.7.2.5.2 Emission Factors

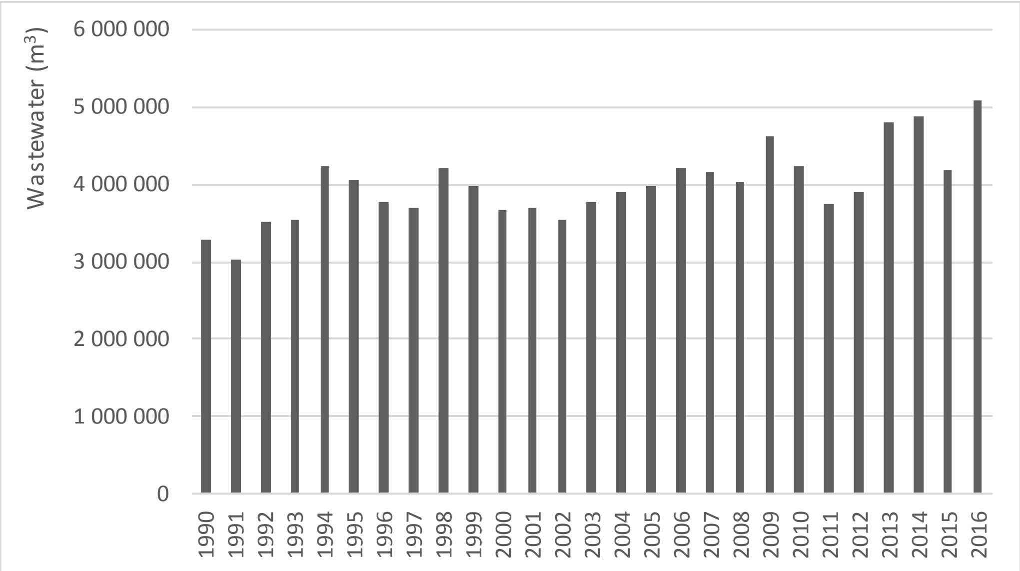
Table 3.156 – Emission Factor for Oil-Water Separators

Pollutant	Unit	EF	Source
NMVOC	kg/m^3 wastewater	4x10^{-3}	Table 8 of Concawe report no. 4/17 (Concawe 2017)

3.2.7.2.5.3 Activity Data

Emissions from oil-water separators consider wastewater treated as activity data. Data on wastewater treated is obtained from Annual Environmental Reports and publication and from security and environment databooks from 2005 onwards. In the period 1990-2014, wastewater treated is estimated based on crude input trend in refineries.

Figure 3.86 – Wastewater treated (m^3)



3.2.7.2.5.4 Recalculations

We have implemented the methodology proposed in chapter 13.6.3.2 of Concawe report no. 4/17 (Air pollutant emission estimation methods for E-PRTR reporting by refineries – 2017 edition).

3.2.7.2.5.5 Further Improvements

No further improvements are expected.

3.2.7.2.6 Sulphur Recovery Units

3.2.7.2.6.1 Methodology

Emissions of SO_x were estimated annually according to the following procedure:

$$Emis_{SO2} = Emis_{Claus\ Units} + Emis_{Absorption\ Towers} + Emis_{Incinerators}$$

Where,

$Emis_{SOx}$ – SO_x emissions in the Refineries (t SO_x);

$Emis_{Claus\ Units}$ – SOx emissions in Claus Units due to the inefficiency of the process (t SO_x);

$Emis_{Absoption\ Towers}$ – SOx emissions in the Absorption Towers before the Incinerator (t SO_x);

$Emis_{Incinerators}$ – 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 procedure:

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

Where,

$Emis_{Claus\ Unit}$ – 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 Absoption Tower were estimated according to the following procedure:

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

Where,

$Emis_{Absorption\ Tower}$ – 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 procedure:

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

Where,

$Emis_{Incinerator}$ – 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 (%).

3.2.7.2.6.2 Emission Factors

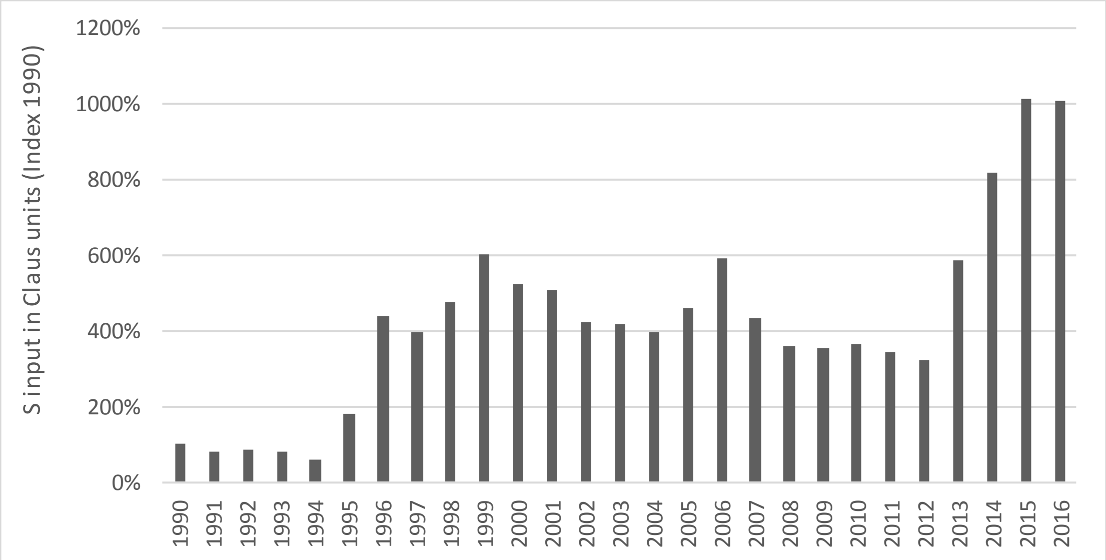
Sulphur Claus Recovery units efficiency lies between 94.8-98.0%. According to the performance evaluation of one of the Refineries, the absorption towers efficiency is 99.98% and the recovery efficiency in the incinerator is 99.92%.

3.2.7.2.6.3 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”.

Sulphur recovery has been increasing from 1996 onwards, 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 3.87 – Sulphur input in Claus Units (Index related to 1990 value)



3.2.7.2.6.4 Recalculations

We have implemented the methodology proposed in chapter 16.2.2.1 of Concawe report no. 4/17 (Air pollutant emission estimation methods for E-PRTR reporting by refineries – 2017 edition).

3.2.7.2.6.5 Further Improvements

No further improvements are planned for this sector.

3.2.7.2.7 Storage/Tanks

3.2.7.2.7.1 Methodology

For one of the refineries there are estimates, relying on the 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 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:

$$Emis_{NMVOC} = EF_{(y)} * Throughput * 10^{-6}$$

Where:

$Emis_{NMVOC}$ – 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:

$$Emis_{NMVOC,y} = Emis_{NMVOC,y\ TANKS} \times \frac{Throughput_y}{Throughput_{y\ TANKS}}$$

Where,

$Emis_{NMVOC,y}$ – NMVOC emissions in year “y” (t);

$Emis_{NMVOC,y\ TANKS}$ – 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).

3.2.7.2.7.2 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[26].

Emissions were determined relying on methodologies that vary according to each tank type. The possible type of tanks, a very short description of their characteristics and the number of tanks by type in 2005 at Porto and Sines refineries are presented in the table below.

Table 3.157 – 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 3.158 – 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

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

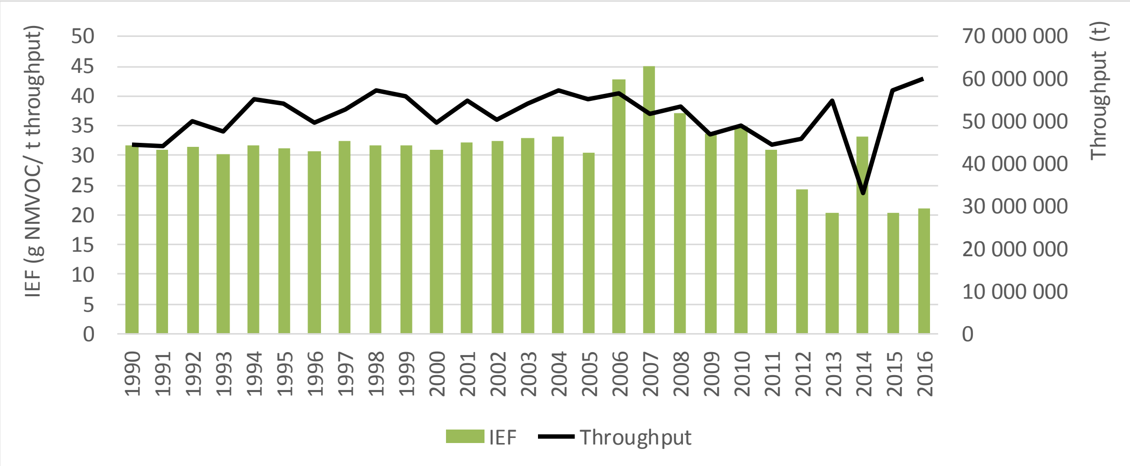
Table 3.159 – NMVOC IEF trend from storage and tank in refineries

Pollutant	Unit	1990	1995	2000	2005	2010	2015	2016
NMVOC	kg/t throughput	31.8	31.2	31.0	30.6	34.8	20.3	21.1

3.2.7.2.7.3 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 3.88 – Total throughput in Lisbon, Porto and Sines refineries (t)



3.2.7.2.7.4 Recalculations

Activity data has been revised based on data provided by the refineries as input to TANKS software.

3.2.7.2.7.5 Further Improvements

No further improvements are expected.

3.2.7.3 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.

3.2.7.3.1 Terminal Dispatch Stations

3.2.7.3.1.1 Methodology

For gasoline, crude oil, jet naphtha, jet kerosene, distillate oil and residual oil, emissions are estimated according to:

$$Emis_{NMVOC} = V_{liquid} \times EF_{NMVOC}$$

Where:

$Emis_{NMVOC}$ – 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:

$$Emis_{NMVOC} = V_{liquid} \times \left(\frac{0.0004535924}{3785.412}\right) \times 12.46 \times \frac{S \times P \times M}{T}$$

Where:

$Emis_{NMVOC}$ – 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 (psia);

M – Molecular weight of vapours (lb/lb-mole);

T – Temperature of bulk liquid loaded (°R).

3.2.7.3.1.2 Emission Factors

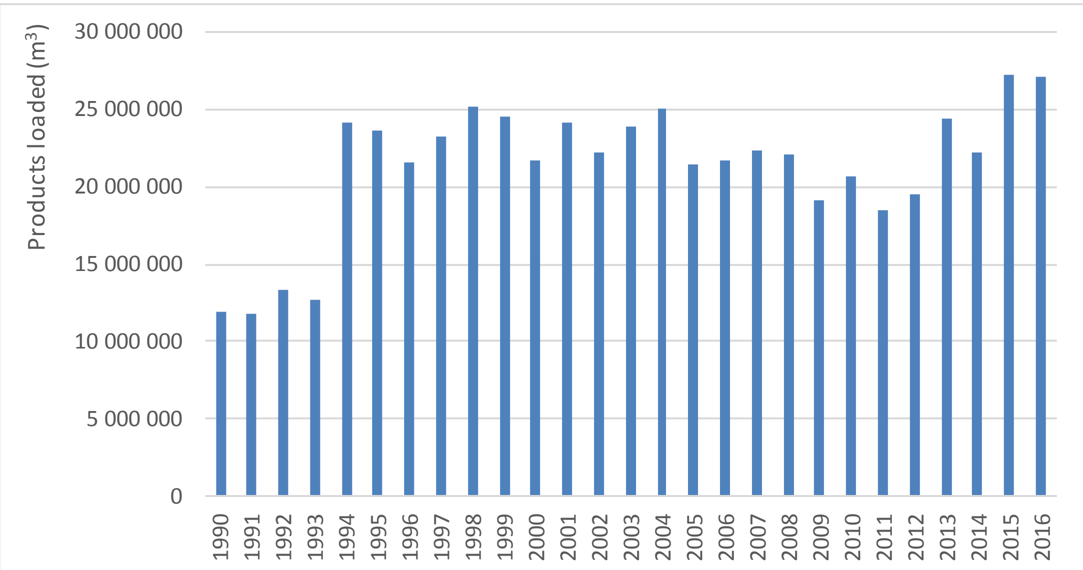
Table 3.160 – NMVOC emission factors

Liquid loaded	Type of loading	Unit	EF	Source
Fuel oil	Submerged loading – dedicated normal service	t/L	$1X10^{-11}$	Table 5.2-5 of chapter 5.2 Transportation and marketing of Petroleum Products of USEPA AP-42
Gasoline	Submerged loading – dedicated normal service	t/L	$5.9x10^{-7}$	Table 5.2-5 of chapter 5.2 Transportation and marketing of Petroleum Products of USEPA AP-42
Jet Kerosene	Submerged loading – dedicated normal service	t/L	$1.9x10^{-9}$	Table 5.2-5 of chapter 5.2 Transportation and marketing of Petroleum Products of USEPA AP-42
Gasoil	Submerged loading – dedicated normal service	t/L	$1.7x10^{-9}$	Table 5.2-5 of chapter 5.2 Transportation and marketing of Petroleum Products of USEPA AP-42

3.2.7.3.1.3 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 3.89 – Products loaded at terminal dispatch stations of refineries and depots



3.2.7.3.1.4 *Recalculations*

No recalculations were made.

3.2.7.3.1.5 *Further Improvements*

No further improvements are expected.

3.2.7.3.2 Transport of oil products

3.2.7.3.2.1 *Methodology*

The most relevant emissions of transport of oil products are related to gasoline transport.

Emissions are estimated according to:

$$Emis_{NMVOC} = V_{liquid} \times EF_{NMVOC}$$

Where:

$Emis_{NMVOC}$ – NMVOC emissions (t);

V_{liquid} – Volume of the liquid transported (L);

EF_{NMVOC} – NMVOC emission factor (t NMVOC/L liquid).

3.2.7.3.2.2 *Emission Factors*

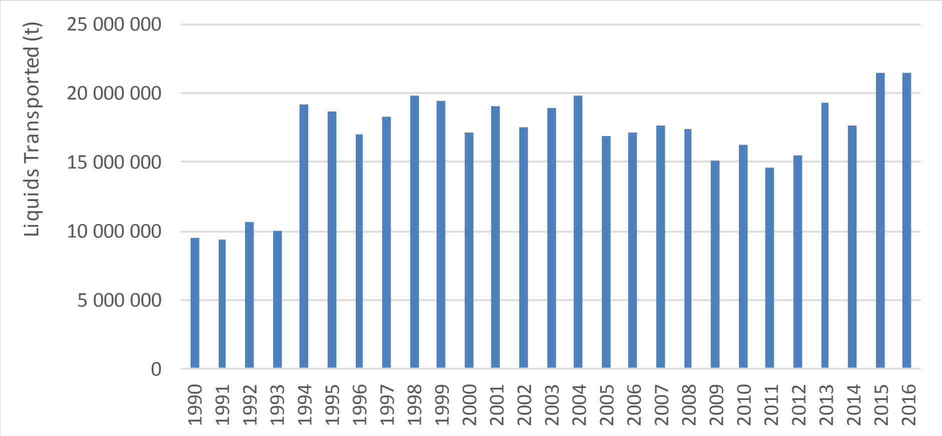
There are only emission factors related to gasoline transport.

Table 3.161 – NMVOC emission factors

Liquid Transported	**Type of Transport**	**Unit**	**EF**	**Source**
Gasoline	Transit Losses-Loaded with Product-Extreme	t/L	4.5×10^{-9}	Table 5.2-5 of chapter 5.2 Transportation and marketing of Petroleum Products of USEPA AP-42

3.2.7.3.2.3 Activity Data

Figure 3.90 – Liquids transports from Refineries and Depots (t product)



3.2.7.3.2.4 Recalculations

No recalculations were made.

3.2.7.3.2.5 Further Improvements

No further improvements are expected.

3.2.7.3.3 Storage of oil products in Depots

3.2.7.3.3.1 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:

$$Emis_{NMVOC} = EF_{(y)} * Throughput * 10^{-6}$$

Where:

$Emis_{NMVOC}$ – 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:

$$Emis_{NMVOC,y} = Emis_{NMVOC,2005} \times \frac{Throughput_y}{Throughput_{2005}}$$

Where,

$Emis_{NMVOC,y}$ – NMVOC emissions in year "y" (t);

$Emis_{NMVOC,2005}$ – NMVOC emissions in year 2005;

$Throughput_y$ – Throughput in year "y" (t);

$Throughput_{2005}$ – Throughput in year 2005 (t).

3.2.7.3.3.2 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[27].

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

Emissions were determined relying on methodologies that vary according to each tank type. The possible type of tanks and a very short description of their characteristics are presented in the table below.

Table 3.162 – Type of tanks classes distinguished in TANKS4.0 model

Tank Type	Description
External Floating Roof Tank	cylindrical steel shell equipped with a roof that floats on the surface of the stored liquid
Horizontal Tank	above-ground or underground storage with the axis parallel to the foundation
Internal Floating Roof Tank	permanent fixed roof and a floating deck
Vertical Fixed Roof Tank	cylindrical shells with permanently affixed roofs; the tank axis is perpendicular to the foundation. The fixed roof may be dome-shaped or cone shaped
Domed External Floating Roof.	external floating roof tank that has been retrofit with a domed fixed roof

(a) Inventory covers only tanks for storage of liquids with Vapour Pressure above 27kPa

TANKS4.0 methodology differentiates the following emissions, according to the cause of release:

Table 3.163 – Types of losses from tanks for storage of organic compounds and petroleum products

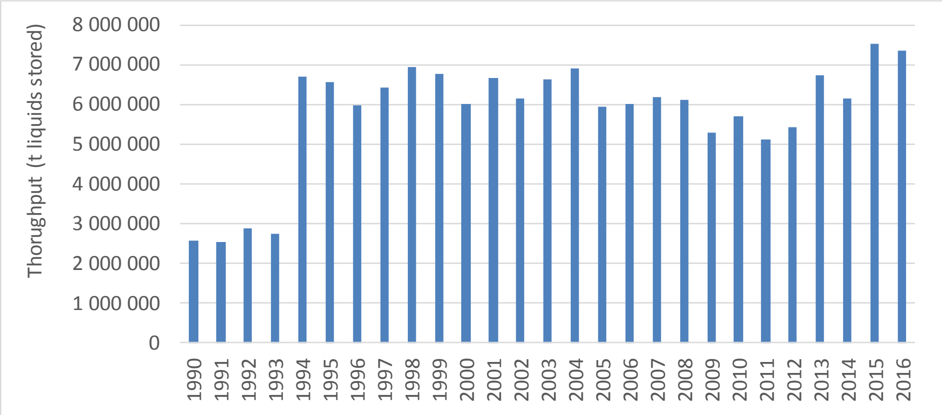
Tank	Loss	Description
Fixed Roof	Breathing	Expulsion of vapour from a tank through vapour expansion and contraction, which are the results of changes in temperature and barometric pressure
	Working	Combined loss from filling and emptying. Evaporation during filling operations is a result of an increase 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 3.164 – NMVOC IEF trend from storage and tank in depots

Pollutant	Unit	1990	1995	2000	2005	2010	2015	2016
NMVOC	kg/t throughput	37.5	22.1	22.1	22.1	22.1	22.1	22.1

3.2.7.3.3.3 Activity Data

Figure 3.91 – Throughput in depots (t liquids stored)



3.2.7.3.3.4 Recalculations

No recalculations were made.

3.2.7.3.3.5 Further Improvements

No further improvements are expected.

3.2.7.3.4 Service Stations

3.2.7.3.4.1 Methodology

From “Portaria 646/97” 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, estimates are based on:

$$E_{FUT} = V_{StageIB} \times TVP \times EF_{StageIB} + V_{other} \times TVP \times EF_{other}$$

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 Filling Underground Tanks 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 Filling Underground Tanks 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)

EFStageIB – Emission Factor for Filling Underground Tanks at Service Stations with Stage IB (kg/m^3/Kpa TVP)

3.2.7.3.4.2 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 3.165 – 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).

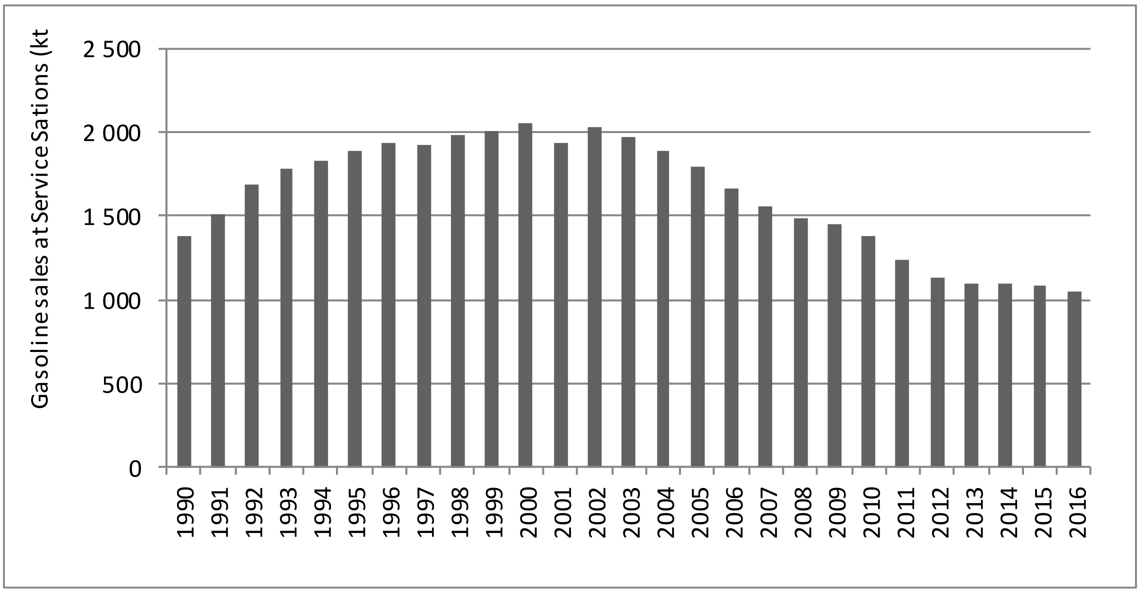
Table 3.166 – Vehicle Refuelling Operations (Stage II) NMVOC Emission Factors

Vehicle Refuelling Operations	Emission Factor (kg/m^3/kPa TVP)
Drips and Minor Spillage	2.20E^{-03}
Refuelling with no emission controls in operations (without Stage II measures)	3.67E^{-02}

3.2.7.3.4.3 Activity data

Data on gasoline sales was obtained from DGEG Energy Balance for the entire period.

Figure 3.92 – Fuel Sales at Service Stations (t)



3.2.7.3.4.4 Recalculations

A correction was made in a compilation error.

3.2.7.3.4.5 Further Improvements

Efforts should be addressed in order to verify stage II implementation in service stations in Portugal.

3.2.8 Fugitive Emissions from Natural Gas (NFR 1.B.2.b.)

3.2.8.1.1 Overview

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:

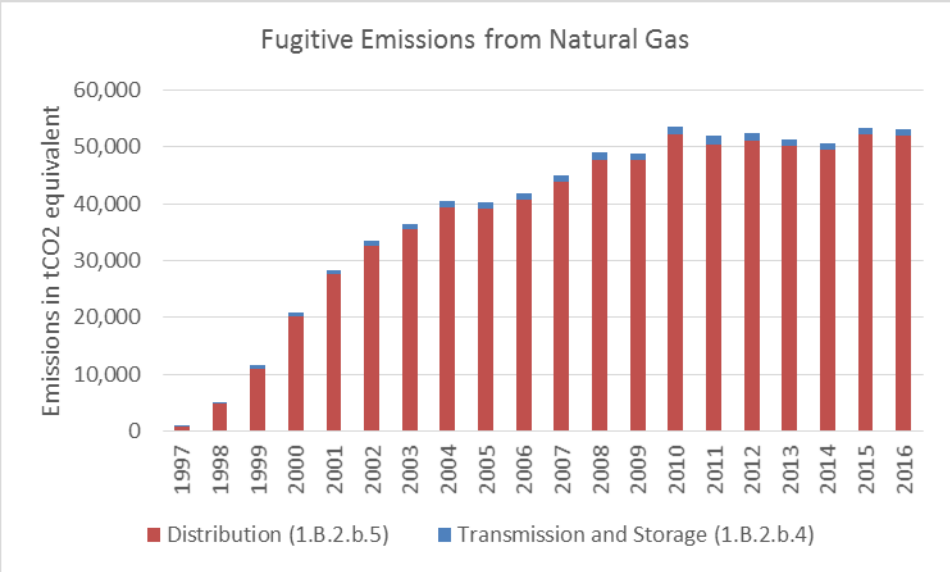
- Transmission lines. Operating at high pressure, are used to transport natural gas in bulk over large distances till distribution centres;

- 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 3.93 – Fugitive Emissions from Natural Gas..



3.2.8.1.2 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:

<u>NG Distribution Medium Pressure:</u> Manufacturing industries

<u>NG Distribution Low Pressure:</u> 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

3.2.8.1.3 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 3.167 – 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 3.168 – Characteristics of natural gas.

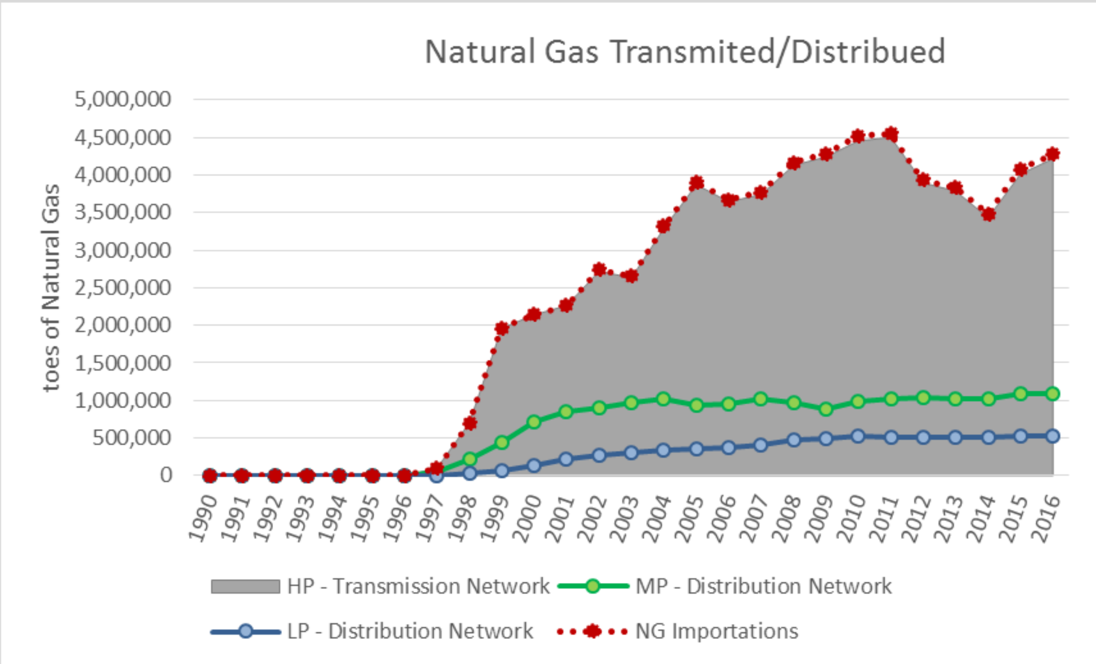
	Unit	value
Methane	mole %	90.05
Ethane (COVNM)	mole %	6.45
Propane (COVNM)	mole %	1.74
i-butane (COVNM)	mole %	0.23
n-butane (COVNM)	mole %	0.27
i-pentane (COVNM)	mole %	0.02
n-pentane (COVNM)	mole %	0.01
n-hexane (COVNM)	mole %	0.01
Nitrogen	mole %	0.58
CO2	mole %	0.63

3.2.8.1.4 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 3.94 – Natural Gas transported by High, Medium and Low Pressure Networks



3.2.8.1.5 Recalculations

This sector has undergone a profound revision, having substantially altered the calculation methodology. The emissions of this category have been considerably reduced.

3.2.8.1.6 Further Improvements

We intend, if possible, to obtain information on leaks in the transportation and distribution of Natural Gas related to the period prior to 2009.

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

3.2.9.1 Overview

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.

3.2.9.2 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 are estimated from:

$$Emis_{(p,y)} = EF_{(p)} * Flare_{GAS(y)} * m_{(p,y)}/m_{(gas,y)} * 10^{-3}$$

Where,

$Emis_{(p,y)}$ – 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 are estimated from:

$$Emis_{(p,y)} = EF_{(p)} \times Flare_{Gas(y)} \times NCV_{Gas} \times 10^{-3}$$

Where,

$Emis_{(p,y)}$ – 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).

Heavy Metals, PAHs, TSP, PM_{10} and $PM_{2.5}$ emissions are estimated from:

$$Emis_{(p,y)} = EF_{(p)} \times Flare_{Gas(y)} \times NCV_{Gas} \times 10^{-6}$$

Where,

$Emis_{(p,y)}$ – 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).

SO_x emissions are estimated from:

$$Emis_{SOx} = EF_{SOx} * S_{(m/m)} * Flare_{GAS(y)} * 10^{-3}$$

Where,

$Emis_{SOx}$ – 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).

3.2.9.3 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 3.169 – Emission Factors for flaring in refineries

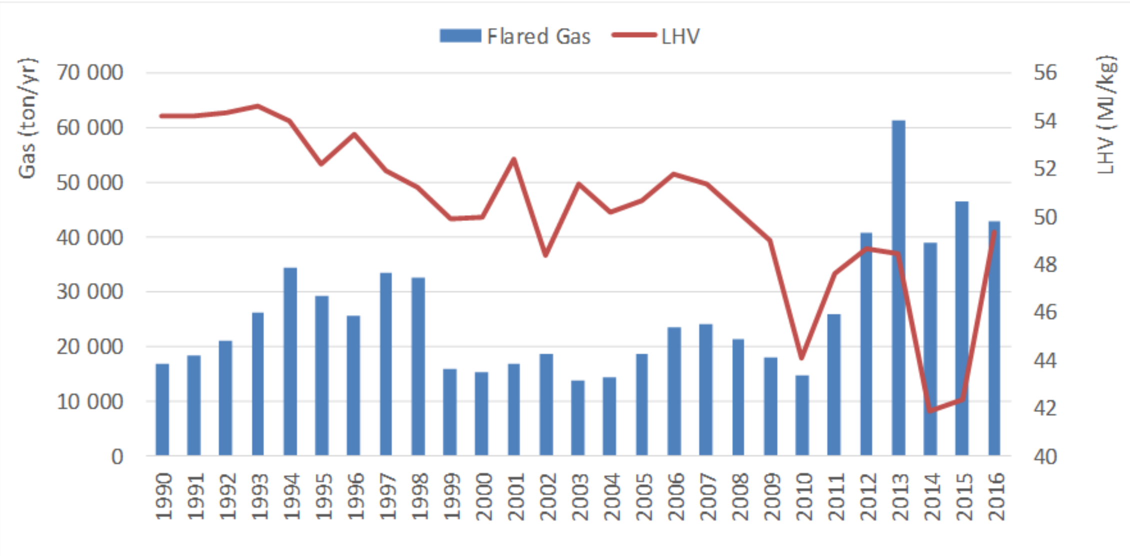
Pollutant	EF Unit	EF	Source
NMVOC	kg/t gas	5	Chapter 13.2.1.1. (Flare Stream Details Known) of "Concawe - Air pollutant emission estimation methods for E-PRTR reporting by refineries – report no. 4/17 (2017 Edition)"
CO	kg/GJ gas	0.133	Chapter 8.2.2.1. (Flare Stream Details Known) of "Concawe - Air pollutant emission estimation methods for E-PRTR reporting by refineries – report no. 4/17 (2017 Edition)"
NO_x	kg/GJ gas	$29.2x10^{-2}$	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	$2x10^{3}$	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	$3.52x10^{-4}$	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	$2.19x10^{-3}$	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	$6.69x10^{-3}$	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	$3.29x10^{-3}$	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	$3.72x10^{-4}$	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	$7.37x10^{-3}$	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	$1.61x10^{-3}$	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	$1.70x10^{-2}$	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	$6.688x10^{-7}$	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	$1.137x10^{-6}$	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)"

Pollutant	EF Unit	EF	Source
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[28]	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)"
$PM_{2.5}$[29]	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)"

3.2.9.4 Activity data

Total flare gas consumed in the three units and Low Heating Value were made available from PETROGAL for the period 1990-2004. From 2005 onwards, data is obtained from EU-ETS.

Figure 3.95 – Total consumption of flare gas in Portuguese refineries and Low Heating Value



3.2.9.5 Recalculations

CO and NO_x emission factors have been updated according to "Concawe – Air pollutant emission estimation methods for E-PRTR reporting by refineries – report no. 4/17 (2017 Edition)".

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

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

We start estimating As, Cd, Cr, Cu, Hg, Ni, Pb, Zn, PAH and PM_{10} emissions according to "Concawe – Air pollutant emission estimation methods for E-PRTR reporting by refineries – report no. 4/17 (2017 Edition)".

3.2.9.6 Further Improvements

No further improvements are expected for this sector.

4 INDUSTRIAL PROCESSES (NFR 2)

4.1 Category Sources

4.1.1 Mineral Industry (NFR 2.A)

4.1.1.1 Cement Production (NFR 2.A.1)

4.1.1.1.1 Overview

There are six cement production plants operating in Portugal, mostly dedicated to Portland cement production[30] 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[31].

Although emissions may result from both fuel and raw material, they are reported in Energy (CRF 1.A.2.f) for simplicity sake.

4.1.1.1.2 Methodology

For cement production emissions estimated, for all pollutants except black carbon, the methodology used is:

$$E = AD * EF * 10^{-3}$$

Where,

E – Total emission of each pollutant (t);

AD – Clinker Production (t of Clinker);

EF – Emission Factor (kg/t of clinker).

For black carbon, the methodology used is:

$$E = \% \, Fuely * EPM2.5 * EFy$$

Where,

E – Total emission of black carbon (t) related to each type of fuel (liquid, solid, gaseous, biomass);

[30] 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.

[31] One calciner is a false pre-calciner.

$E_{PM2.5}$ – Emissions of $PM_{2.5}$ (t);

EF – Emission Factor related to each type of fuel (liquid, solid, gaseous, biomass) - kg/t of clinker.

4.1.1.1.3 Emission Factors

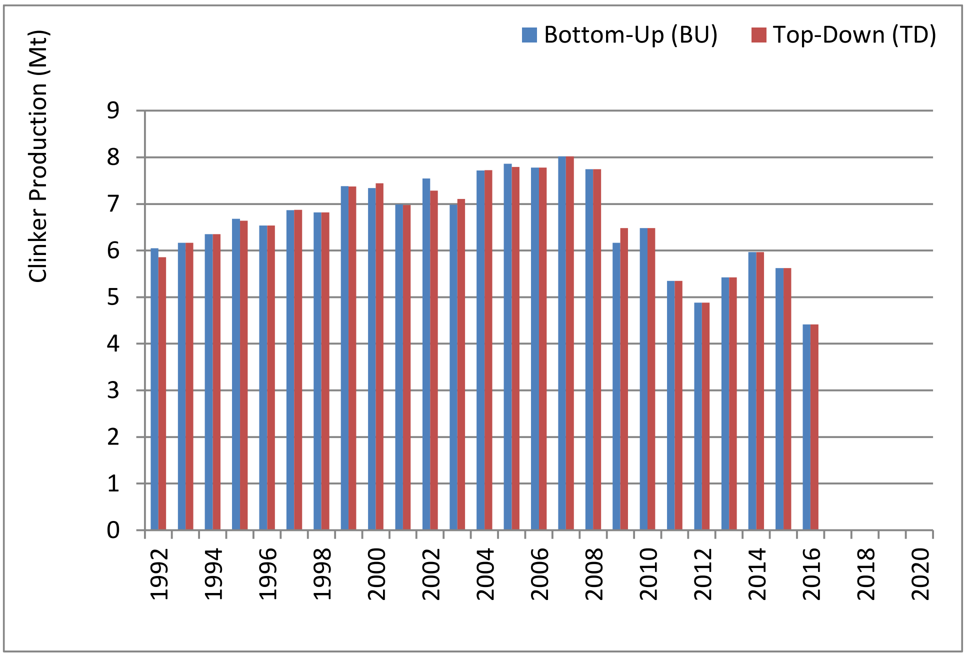
Table 4.1 – Emission Factors for Cement Production

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		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]	Chapter 1.A.1 Energy Industries of EMEP/EEA air pollutant emission inventory guidebook 2016 (Table 3-2 to 3-7)
CO	kg/t clinker	[0.06 – 1.80]]	Plant Specific (Monitoring Data)
Pb	kg/t clinker	[3.00×10^{-5} – 1.51×10^{-3}]	Plant Specific (Monitoring Data)
Cd	kg/t clinker	[1.10×10^{-6} – 2.77×10^{-3}]	Plant Specific (Monitoring Data)
Hg	kg/t clinker	[1.87×10^{-6} – 2.52×10^{-5}]	Plant Specific (Monitoring Data)
As	kg/t clinker	[2.24×10^{-7} – 5.57×10^{-4}]	Plant Specific (Monitoring Data)
Cr	kg/t clinker	[1.49×10^{-5} – 1.58×10^{-3}]	Plant Specific (Monitoring Data)
Cu	kg/t clinker	[2.82×10^{-5} – 2.60×10^{-3}]	Plant Specific (Monitoring Data)
Ni	kg/t clinker	[6.38×10^{-7} – 1.88×10^{-3}]	Plant Specific (Monitoring Data)
Se	kg/t clinker	[7.50×10^{-5} – 1.00×10^{-4}]	Plant Specific (Monitoring Data)
Zn	kg/t clinker	[2.69×10^{-5} – 8.77×10^{-4}]	Plant Specific (Monitoring Data)
PCDD/PCDF	kg/t clinker	[1.64×10^{-12} – 2.38×10^{-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	-

4.1.1.1.4 Activity Data

In emissions estimates it is used clinker production data provided from the facilities (Bottom-Up) for the entire period. We also obtained clinker production data from National Statistics (Top-Down) and made the comparison of Figure 4.1. The 2009 clinker production value from national statistics is an outlier and this situation has been communicated to national statistics authorities.

Figure 4.1 – Clinker Production



The decrease from 2011 to 2012 is 0.47 Mt and 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 of 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.

4.1.1.1.5 Recalculations

Revision of Black Carbon emission factors from Chapter 1.A.1 Energy Industries of EMEP/EEA air pollutant emission inventory guidebook 2016.

4.1.1.1.6 Further Improvements

We will revise plant specific emission factors based on updated monitoring data, and will introduce these values in future submissions.

4.1.1.2 Lime Production (NFR 2.A.2)

4.1.1.2.1 Overview

Lime is produced through calcination, a process of thermal conversion (at temperatures at about 900-1200ºC) in a kiln, of carbonate bearing materials (mostly limestone and dolomite, but aragonite, chalk, marble or sea shells could be also used) releasing carbon dioxide and leaving calcium oxide (CaO) or magnesium oxide (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 percent) 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 percent 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 (7 until 2008 and 6 until 2013).

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 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. That is also the case of iron and steel production.

4.1.1.2.2 Methodology

For lime production emissions estimates, the used methodology is:

$$E = AD * EF * 10^{-3}$$

Where,

E – Total emission of each pollutant (t);

AD – Lime Production (t of lime);

EF – Emission Factor (kg/t of lime).

4.1.1.2.3 Emission Factors

Table 4.2 – Emission Factors for lime production

Pollutant	Unit	Emission Factor	Source
SOx	kg/t lime	0.006	Table 11.17-5 of USEPA AP-42
NOx	kg/t lime	0.12	Table 11.17-5 of USEPA AP-42
NMVOC	-	NE	-
NH3	-	NA	-
PM2.5	kg/t lime	0.05	EMEP/EEA emission inventory guidebook 2009 (Table 3.1)
PM10	kg/t lime	0.24	EMEP/EEA emission inventory guidebook 2009 (Table 3.1)
TSP	kg/t lime	0.59	EMEP/EEA emission inventory guidebook 2009 (Table 3.1)
BC	% of $PM_{2.5}$	0.46	EMEP/EEA emission inventory guidebook 2013 (Table 3.1)

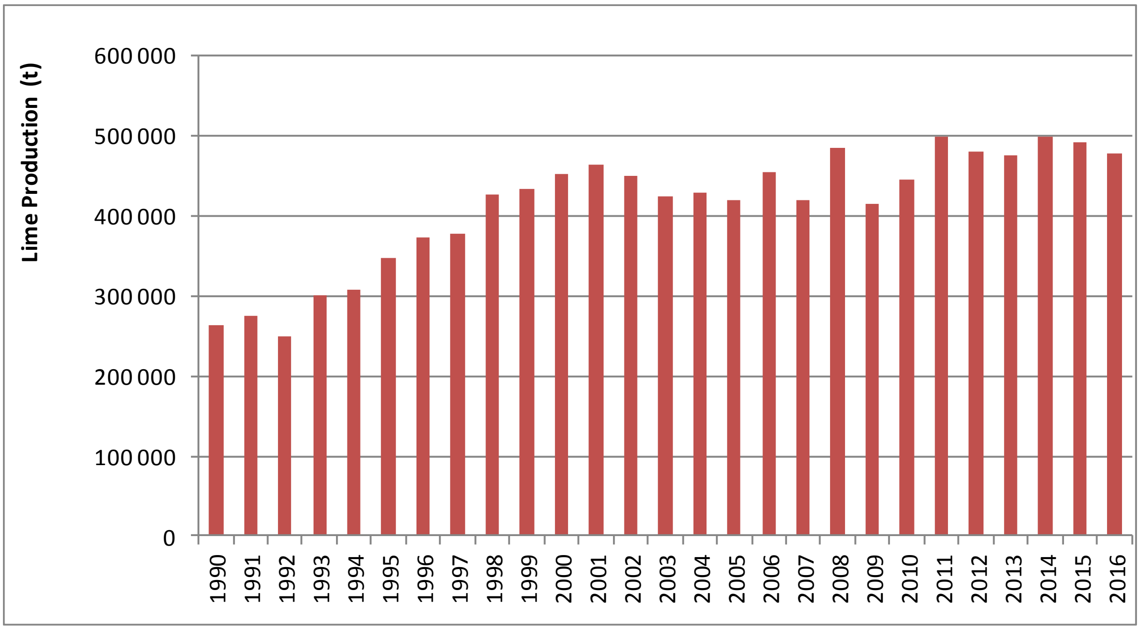
Pollutant	Unit	Emission Factor	Source
CO	kg/t lime	0.23	Table 11.17-5 of USEPA AP-42
Pb	-	NE	-
Cd	-	NE	-
Hg	-	NE	-
As	-	NA	-
Cr	-	NA	-
Cu	-	NA	-
Ni	-	NA	-
Se	-	NA	-
Zn	-	NA	-
PCDD/PCDF	-	NA	-
Benzo(a)pyrene	-	NA	-
Benzo(b)fluoranthene	-	NA	-
Benzo(k)fluoranthene	-	NA	-
Indeno(1,2,3-cd)pyrene	-	NA	-
HCB	-	NA	-
PCBs	-	NA	-

4.1.1.2.4 Activity Data

Lime production was obtained directly from the lime production plants from 2010 onwards. From 1990 to 2009, activity data was estimated based on National Statistics trend.

Lime production 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. After year 2002 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 4.2 – Lime Production (kt)



The Lime production values in 2016 are 1.8 times higher than in 1990.

4.1.1.2.5 Recalculations

No recalculations were made.

4.1.1.2.6 Further Improvements

We will estimate plant specific emission factors based on monitoring data, and will introduce these values in future submissions.

4.1.1.3 Glass Production (NFR 2.A.3)

4.1.1.3.1 Overview

Glass is normally made from sand, limestone, soda ash, and possibly recycled broken glass. 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[32].

4.1.1.3.2 Methodology

Carbon dioxide emissions from glass production were estimated from:

$$Emission_{CO2(t,y)} = EF_{CO2(t)} * Carbonate_{(t,y)}$$

where

$Emission_{CO2(t,y)}$ - annual emission of carbon dioxide from consumption of specific carbonate (t/yr);

$Carbonate_{(t,y)}$ - Carbonate of type t consumed in a given year y (t/yr);

$EF_{CO2(t)}$ - emission factor from consumption of carbonate t (t CO_2/t carbonate)

4.1.1.3.3 Emission Factors

The following emission factors were considered in the estimates:

[32] They were not used to derive the country specific emission factors for instance.

Table 4.3 – 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)
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

(b) Source: USEPA (1986)

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.

4.1.1.3.4 Activity Data

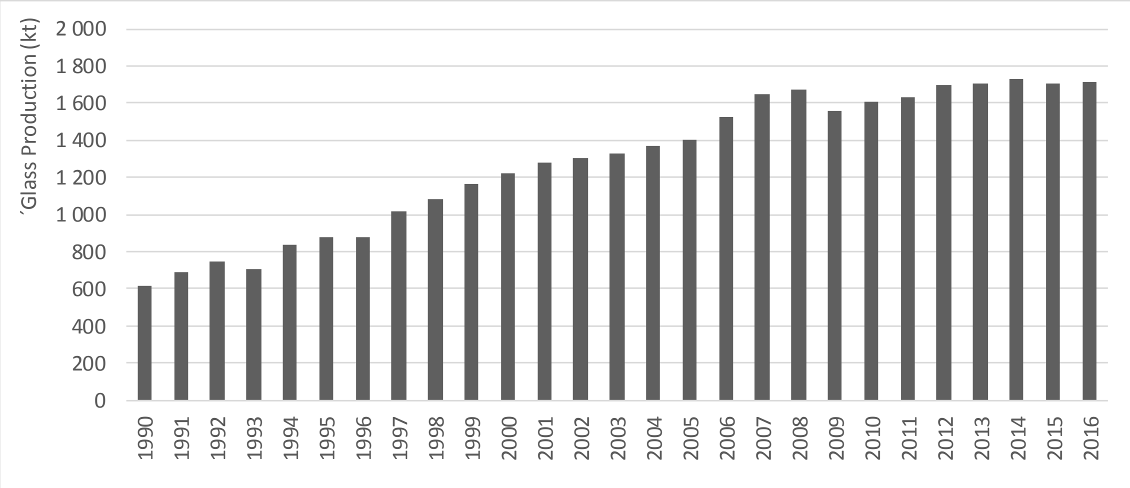
We don’t use data from INE because not all products are reported in weight, but instead are measured in area-units (m^2) or number of produced pieces.

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).

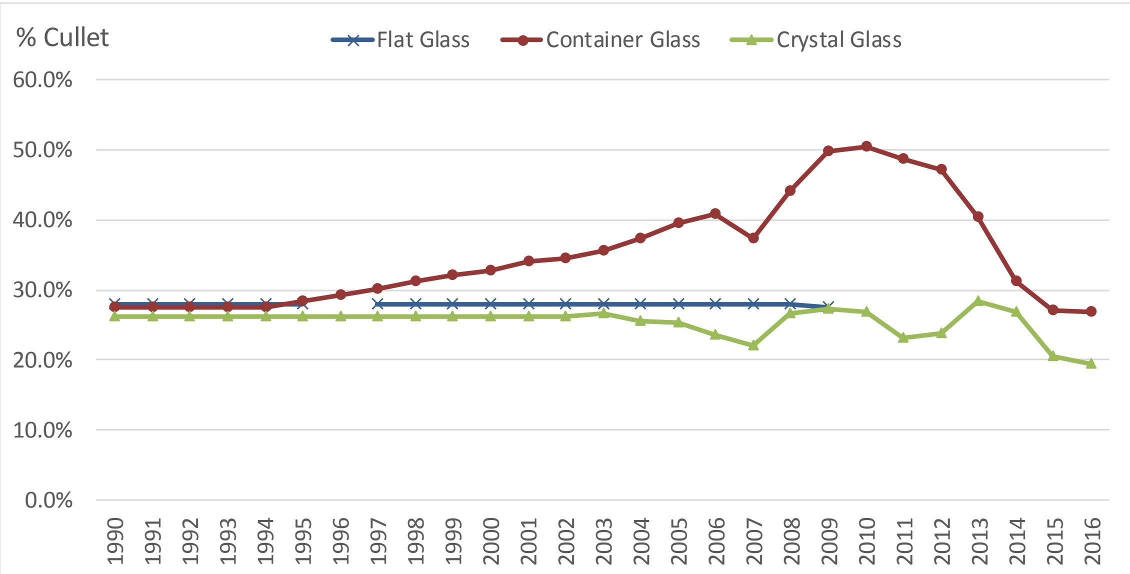
Figure 4.3 - Glass production



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 next figure.

Figure 4.4 - % of Cullet incorporation by type of glass



4.1.1.3.5 Recalculations

It was made a correction in glass production activity data that is also reflected in combustion related emissions.

4.1.1.3.6 Further Improvements

No further improvements expected.

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

4.1.1.4.1 Overview

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).

4.1.1.4.2 Methodology

We use a Tier 1 methodology to estimate particulate matter emissions, as proposed in chapter "2.A.5.a Quarrying and mining of minerals other than coal" from EMEP/EEA guidebook 2016:

$$Emission = AR \times EF \times 1 \times 10^{-6}$$

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).

4.1.1.4.3 Emission Factors

The following emission factors were considered in the estimates:

Table 4.4 – Emission Factors considered

Parameter	Unit	EF	Source
TSP	g/t	102	EMEP/EEA guidebook 2016, Volume "2.A.5.a Quarrying and mining of minerals other than coal", table 3.1
PM_{10}	g/t	50	EMEP/EEA guidebook 2016, 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 2016, Volume "2.A.5.a Quarrying and mining of minerals other than coal", table 3.1

4.1.1.4.4 Activity Data

Data on quarrying and mining of minerals other than coal was obtained from geology and energy national authority (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.

Figure 4.5 – Gross Domestic Product and Extractive Industry Gross Value Added

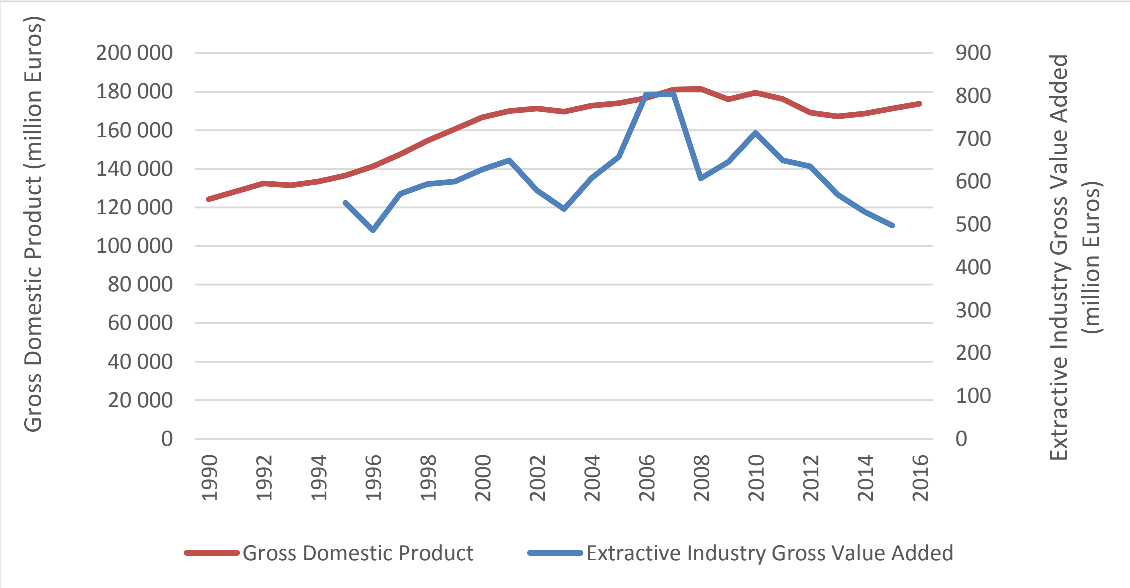
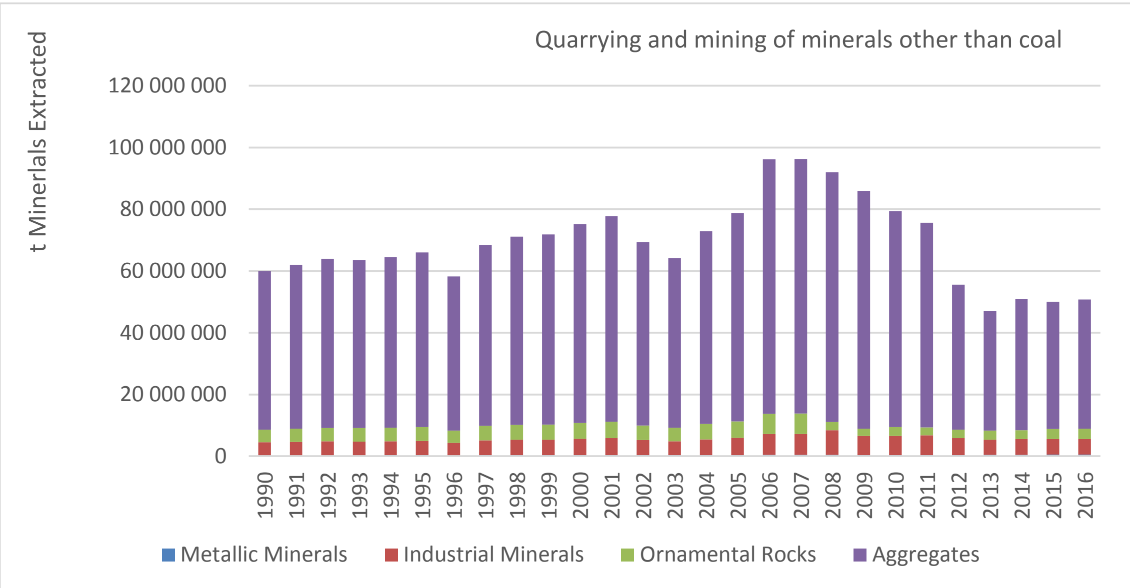


Figure 4.6 – Quarrying and mining of minerals other than coal



4.1.1.4.5 Recalculations

Previously there were no particulate matter emissions estimates for this source category.

4.1.1.4.6 Further Improvements

We will contact geology and energy national authority (DGEG) in order to obtain consistent data on quarrying and mining of minerals other than coal in the 1990-2006 period.

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

4.1.1.5.1 Overview

The construction of infrastructure 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 $PM_{2.5}$).

4.1.1.5.2 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:

$$Emission = AD \times \frac{EF}{1000} \times A_{affected} \times d \times (1 - CE) \times \frac{24}{PE} \times \frac{S}{9\%}$$

where

Emission – Particulate matter (TSP, PM_{10} or $PM_{2.5}$) emissions;

AD – Activity data;

EF – Emission factor (kg/[m^2.year]);

$A_{affected}$ – Area affected by construction activity (m^2);

d – Duration of construction (year);

CE – Efficiency of emission control measures (dimensionless);

PE – Thornthwaite precipitation-evaporation index (dimensionless);

S – Soil silt content (%);

4.1.1.5.3 Emission Factors

The following emission factors were considered in the estimates:

Table 4.5 – Emission Factors considered

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

Source Category	Parameter	Unit	EF	Source
	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 4.6 – 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 4.7 – 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 4.8 – 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

Source Category	Control Efficiency	Source
Road construction	0.5	EMEP/EEA guidebook 2016, Volume "2.A.5.b Construction and demolition", pages 8-9

The Thornthwaite precipation-evaporation index (PE=53.56) was estimated based on the monthly precipitation and mean temperature of Lisbon for the period 1981-2010, according to:

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

The soil silt content (S) was considered equal to 20%, as assumed for Germany (EMEP/EEA guidebook 2016, Volume "2.A.5.b Construction and demolition", page 10).

4.1.1.5.4 Activity Data

The data on the number of new houses/apartments constructed and non-residential construction for each year was obtained from national statistics on construction (INE) from 2003 onwards. In the period 1990-2002 the data was estimated based on 2003 values and on gross domestic product trend.

Figure 4.7 – Houses/apartments construction (Number/year)

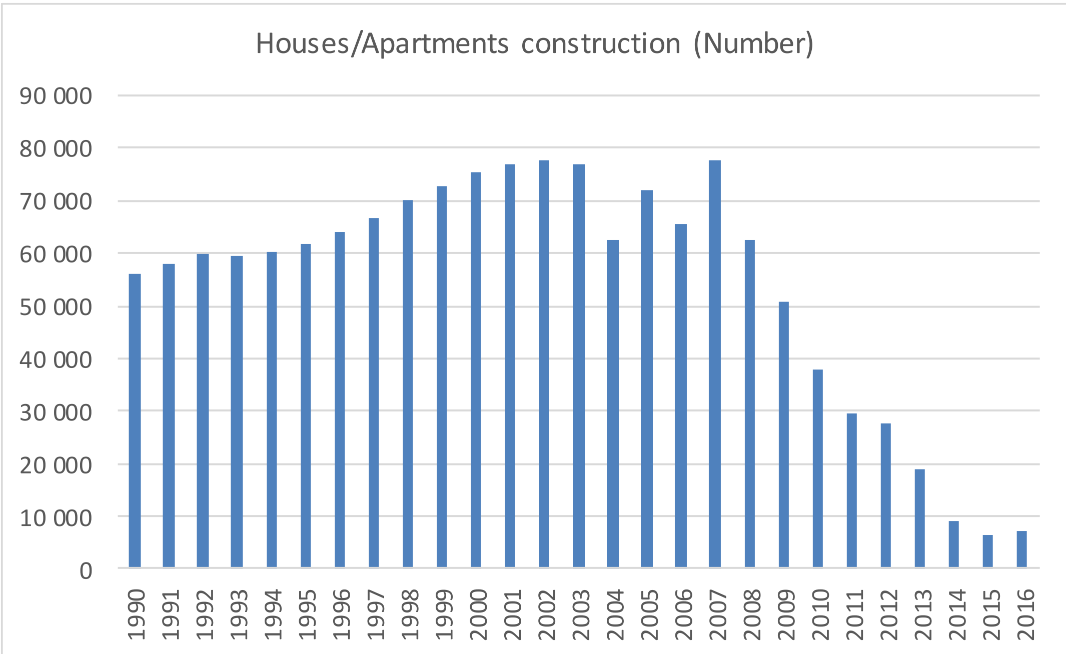
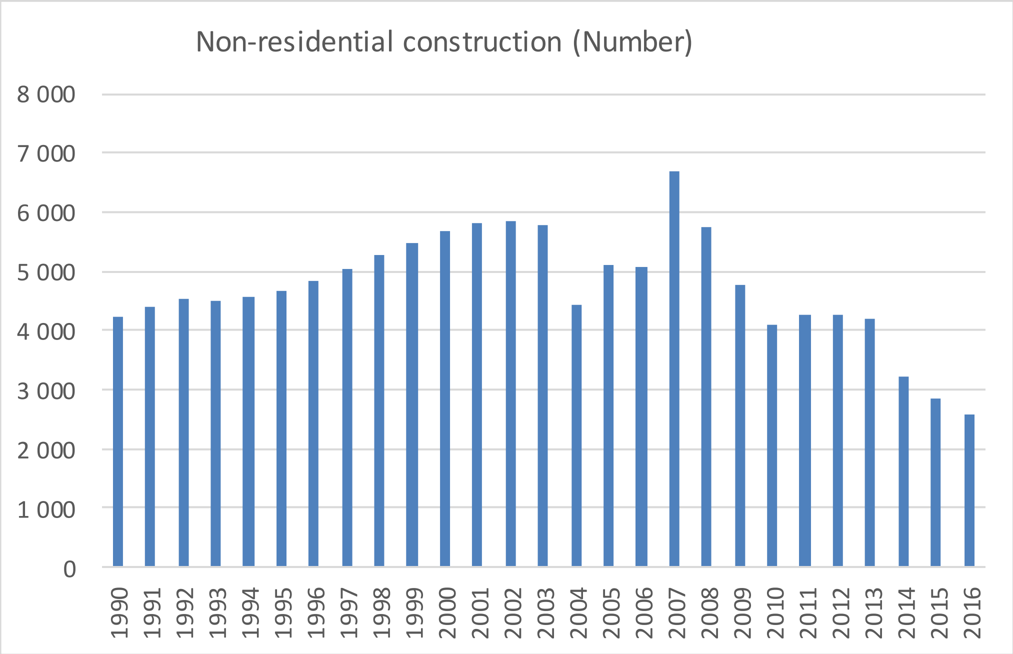
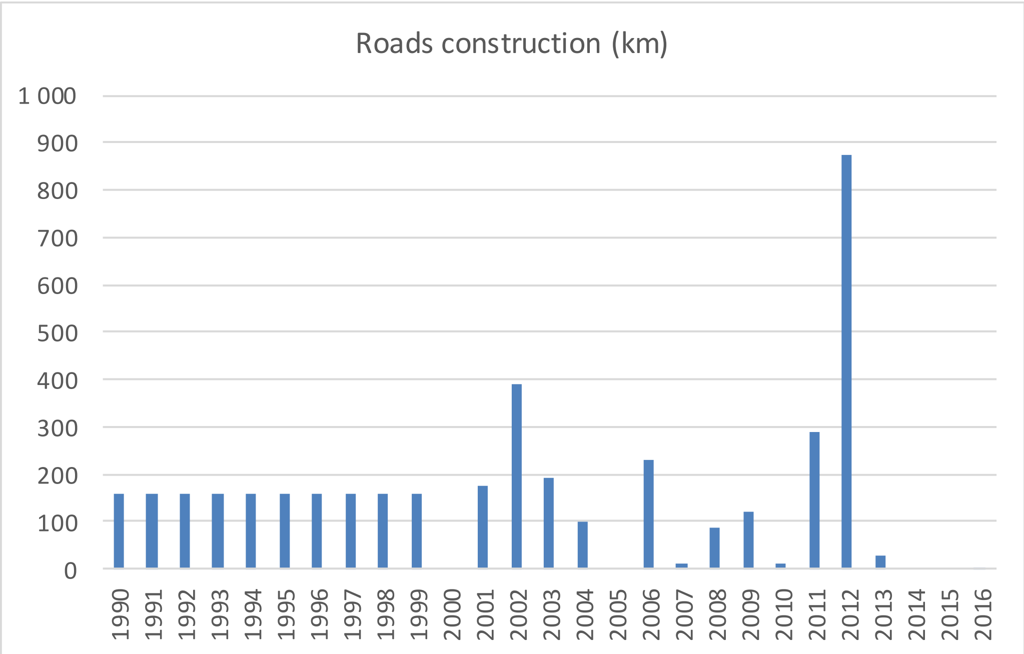


Figure 4.8 – Non-residential construction (Number/year)



The extension of new roads constructed each year was estimated based on the evolution of the extension of the national roads from 2000 onwards. In the period 1990-1999 the data was estimated based on the average value of the period 2000-2015.

Figure 4.9 – Roads construction (km/year)



4.1.1.5.5 Recalculations

Previously there were no particulate matter emissions estimates for this source category.

4.1.1.5.6 Further Improvements

We will contact national authorities in order to obtain better estimates on houses/apartments and non-residential construction in the period 1990-2002 and on road construction in the period 1990-1999.

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

4.1.1.6.1 Overview

This chapter discusses the quarrying and mining of minerals other than coal and results in emissions of particulates (TSP, PM_{10} and $PM_{2.5}$).

4.1.1.6.2 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:

$$Emission = AR \times EF \times 1 \times 10^{-6}$$

where

Emission – Particulate matter (TSP, PM_{10} or $PM_{2.5}$) emissions (t);

AR – Activity rate for storage, handling and transport of mineral products (t);

EF – Emission factor (g/t).

4.1.1.6.3 Emission Factors

The following emission factors were considered in the estimates:

Table 4.9 – 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

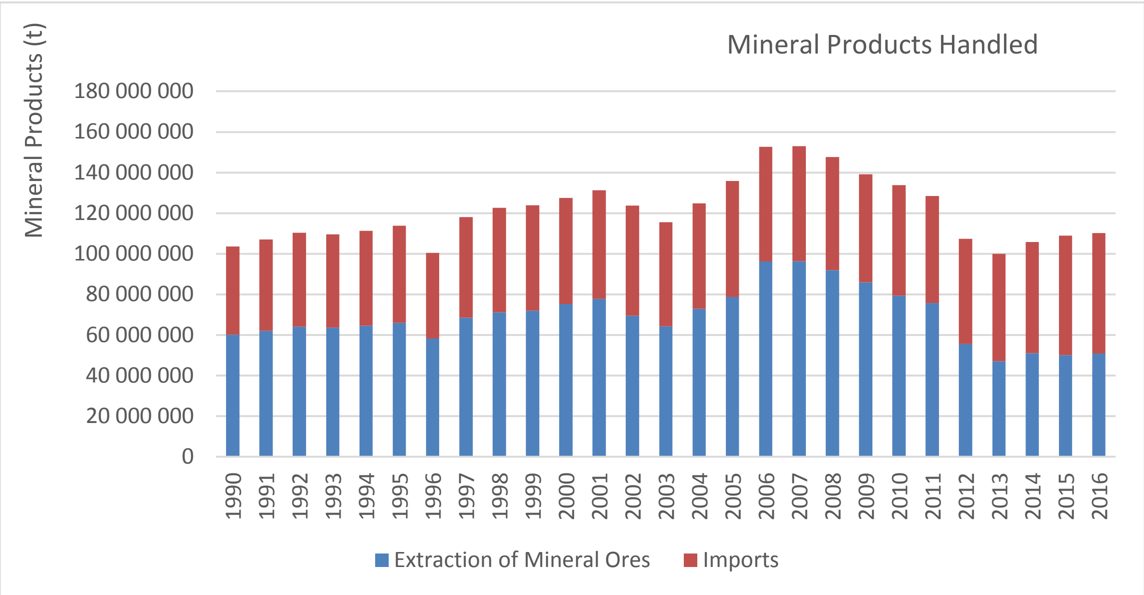
4.1.1.6.4 Activity Data

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).

As explained in category 2.A.5.a, data on quarrying and mining of minerals other than coal was obtained from geology and energy national authority (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.

Data on imports was obtained from Eurostat from 1990 onwards (G25 and G26 of CN8 international trade codes).

Figure 4.10 – Mineral products stored, handled and transported



4.1.1.6.5 Recalculations

Previously there were no particulate matter emissions estimates for this source category.

4.1.1.6.6 Further Improvements

We only estimate emissions related to handling because we don't have data that allows us to estimate storage related emissions (storage areas). We pretend to estimate storage areas in order to apply the 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".

4.1.2 Chemical Industry (NFR 2.B)

4.1.2.1 Ammonia Production (NFR 2.B.1 – SNAP 040403)

4.1.2.1.1 Overview

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:

$$N_2 + 3H_2 \leftrightarrow 2NH_3$$

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:

$$2CH_n + O_2 \rightarrow 2CO + nH_2$$

Emissions result from the process, either from escape of ammonia (NH_3) or either from release of products from feedstock (CO and NMVOC).

4.1.2.1.2 Methodology

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

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

where

$Emission_{(p,y)}$ - annual emission of pollutant p in year y (t/yr);

$ActivityRate_{(y)}$ - quantity of ammonia produced in year y (t/yr);

$EF_{(p)}$ - emission factor for pollutant p (kg/ t)

4.1.2.1.3 Emission Factors

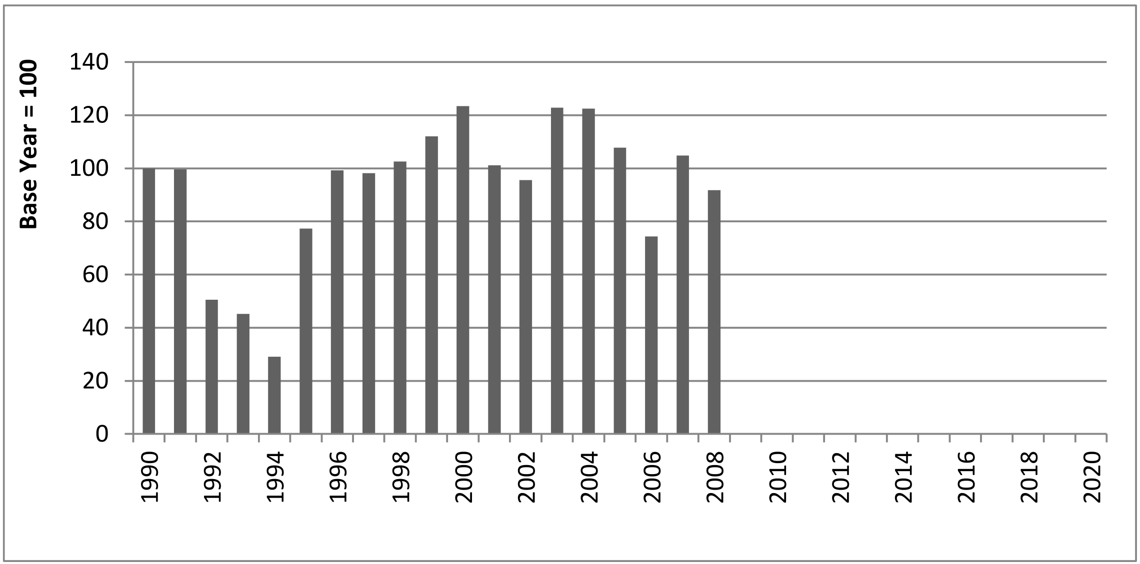
Due to confidentiality constraints it is not possible to publish the chosen emission factors.

4.1.2.1.4 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 4.11 – Trend in Ammonia production



The overall trend in the amount of ammonia produced in the period may be depicted in the Figure 4.11, 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.

Ammonia production data was obtained from the facilities for the period 1990-2008. From 2009 onwards there is no ammonia production. This data is consistent with national statistics ammonia production data.

4.1.2.1.5 Recalculations

In Portugal, hydrogen is obtained from partial oxidation of heavy hydrocarbons. Emission factors have been corrected in order to be fully consistent with partial oxidation process.

4.1.2.1.6 Further Improvements

No further improvements are planned.

4.1.2.2 Nitric Acid (NFR 2.B.2 – SNAP 040402)

4.1.2.2.1 Overview

There are only three industrial plants producing nitric acid in Portugal, located in Estarreja, Alverca and Lavradio. In all, weak nitric acid (60 percent) 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.

4.1.2.2.2 Methodology

For all pollutants emissions are estimated using the following equation:

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

where

Emission $_{(p,y)}$ - annual emission of pollutant p in year y (t/yr);

ActivityRate $_{(y)}$ – production of Nitric Acid in year y (t/yr);

EF $_{(p)}$ - emission factor for pollutant p (kg/ t)

4.1.2.2.3 Emission Factors

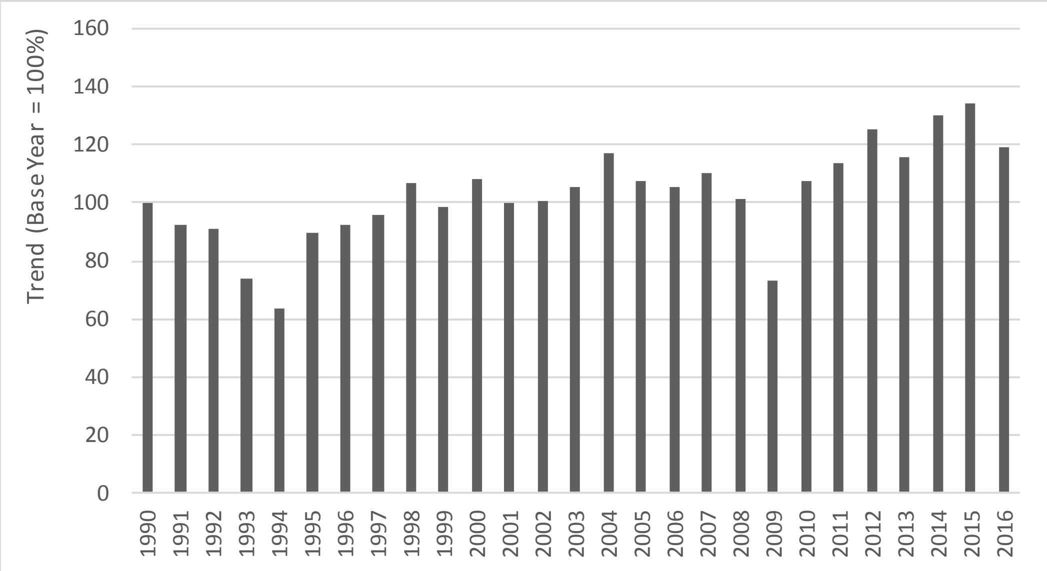
Due to confidentiality constraints it is not possible to publish the chosen emission factors. They were estimated based on monitoring data from the facilities.

4.1.2.2.4 Activity Data

The activity data that was used to estimate emissions from this sub-source sector is subjected to confidentiality constraints due to the limited number of existing production units and may not be presented here in actual figures, but only in relation to production in 1990 (trends).

Activity Data is obtained directly from the facilities. One of the plants was closed during year 2010 and replaced by a new facility.

Figure 4.12 – Trend in Nitric Acid production



4.1.2.2.5 Recalculations

No recalculations were made.

4.1.2.2.6 Further Improvements

No further improvements are planned for this sector.

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

There is no Adipic Acid production in Portugal, only imports and exports.

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

There is no Calcium Carbide production in Portugal, only imports and exports.

4.1.2.5 Titanium Dioxide (NFR 2.B.6 – SNAP 040410)

4.1.2.5.1 Methodology

Emissions from Titanium Dioxide production were estimated in accordance with EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2016).

$$AD_y = AD \times \%_y$$

Where:

AD_y – Titanium Dioxide production using a specific technology/practice (chloride or sulphate process) – t;

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 BC:

$$Emis_{x,y} = AD_y \times \frac{EF_{x,y}}{1000}$$

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:

$$Emis_{BC} = Emis_{PM2.5} \times EF_{BC}$$

Where:

$Emis_{BC}$ – Black Carbon emissions (t);

$Emis_{PM2.5}$ – $PM_{2.5}$ emissions (t);

EF_{BC} – Black Carbon emission factor (% $PM_{2.5}$).

4.1.2.5.2 Emission Factors

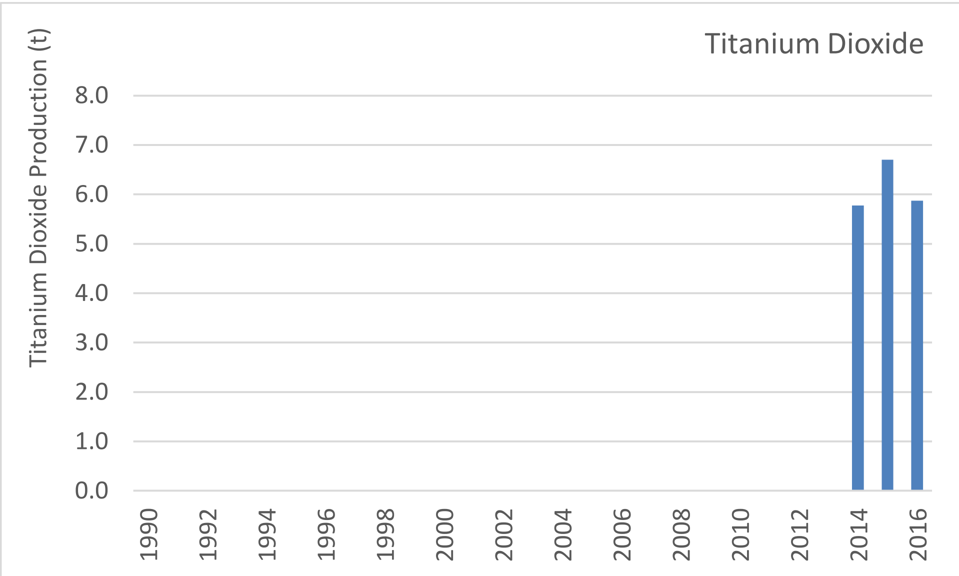
Table 4.10 – Default emission factor

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	0.2	Expert Judgement
	$PM_{2.5}$	Kg/t	0.2	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
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	0.3	Expert Judgement
	$PM_{2.5}$	Kg/t	0.3	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

4.1.2.5.3 Activity Data

Data on Titanium Dioxide production was obtained from Eurostat from 1992 onwards (production started in 2014). 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 4.13 – Titanium Dioxide Production (t)



4.1.2.5.4 Recalculations

This sector has been included for the first time.

4.1.2.5.5 Further Improvements

Efforts will be made to obtain the share of each Titanium Dioxide technology in Portugal, by collecting plant specific data.

4.1.2.6 Sulphuric Acid (NFR 2.B.10.a – SNAP 040401)

4.1.2.6.1 Overview

In 1990 in Portugal there were two industrial units producing Sulphuric acid from mineral processing and more 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 result 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.

4.1.2.6.2 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[33]:

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

where

[33] 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.

$EmiSOx_{(y)}$ - Emission of Sulphur oxides[34] (t/yr);

$FeedStock_{(y)}$ - Annual consumption of feedstock (t/yr)

$S_{Feed(y)}$ - Sulphur content of feedstock (%);

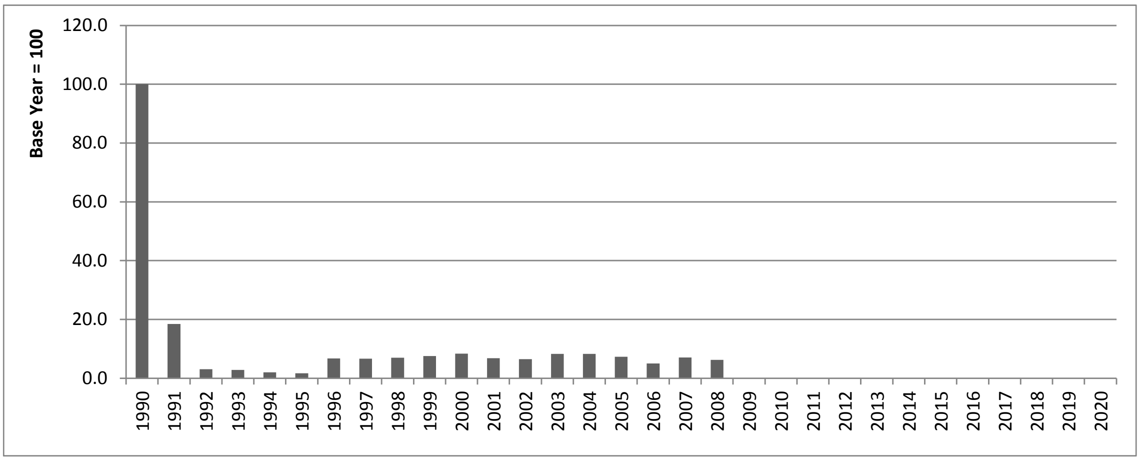
$Prod_{H2SO4\ (y)}$ - production of Sulphuric acid from Sulphur recovery in year y (t/yr).

4.1.2.6.3 Emission Factors

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

4.1.2.6.4 Activity Data

Figure 4.14 – 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[35];
- 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;

[34] 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.

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

- Finally a linear relation was also set between VRF consumption and the quantity of H_2SO_4 that was recovered.

4.1.2.6.5 Recalculations

No recalculations were made.

4.1.2.6.6 Further Improvements

Specific issues to improve comprehend the revision of the different reporting placement for SOx emissions from flaring in Sulphur recovery.

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

4.1.2.7.1 Methodology

Emissions from Ammonium Sulphate production were estimated in accordance with EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2016).

For TSP, PM_{10} and $PM_{2.5}$:

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

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:

$$Emis_{BC} = Emis_{PM2.5} \times EF_{BC}$$

Where:

$Emis_{BC}$ – Black Carbon emissions (t);

$Emis_{PM2.5}$ – $PM_{2.5}$ emissions (t);

EF_{BC} – Black Carbon emission factor (% $PM_{2.5}$).

4.1.2.7.2 Emission Factors

Table 4.11 – Emission factors

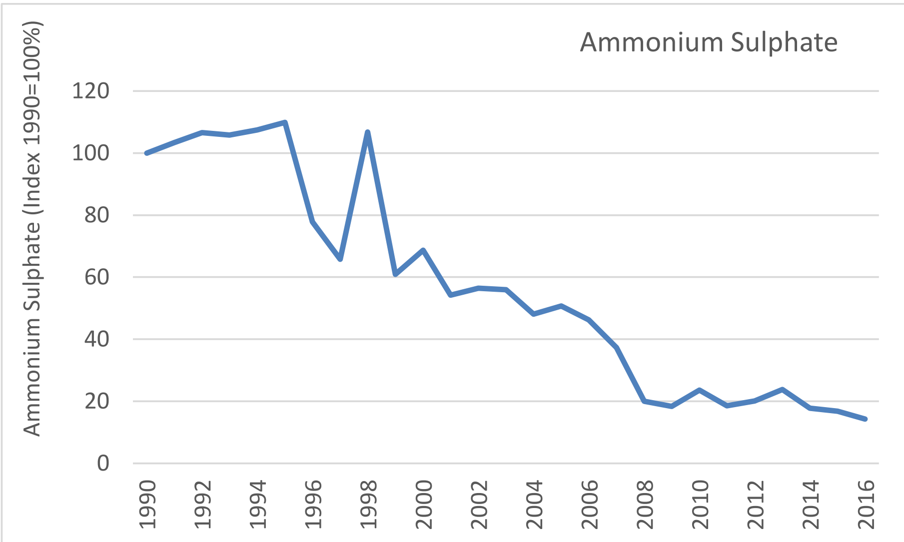
Pollutant	Unit	EF	Source
TSP	Kg/t	0.02	Table 8.4-1 of chapter “8.4 Ammonium Sulphate” of USEPA AP-42 emission factors
PM_{10}	Kg/t	0.02	Expert Judgement
$PM_{2.5}$	Kg/t	0.02	Expert Judgement
BC	% $PM_{2.5}$	1.8	Table 3.1 of chapter "2.B Chemical Industry" of EMEP/EEA air pollutant emission inventory guidebook 2016

4.1.2.7.3 Activity Data

Ammonium Sulphate production was obtained from National Statistics from 1995 onwards. In the period 1990-1994, data has been estimated based on 1995 production value and on gross domestic product trend.

Due to the fact that there is only one plant in Portugal, there are confidentiality constraints and the activity data is presented as an index value (1990=100%).

Figure 4.15 – Ammonium Sulphate production (Index 1990=100%)



4.1.2.7.4 Recalculations

The activity data in the period 1990-1994 has been revised.

4.1.2.7.5 Further Improvements

Efforts will be made in order to obtain plant specific production data in the period 1990-1994.

4.1.2.8 Ammonium Nitrate (NFR 2.B.10.a – SNAP 040405)

4.1.2.8.1 Methodology

Emissions from Ammonium Nitrate production were estimated according to:

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

Where:

Emi_x – Emissions of pollutant “x” (t);

AD – Ammonium Nitrate production data (t Ammonium Nitrate);

EF_x – Emission factor of pollutant “x” (kg/t Ammonium Nitrate).

4.1.2.8.2 Emission Factors

Table 4.12 – 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

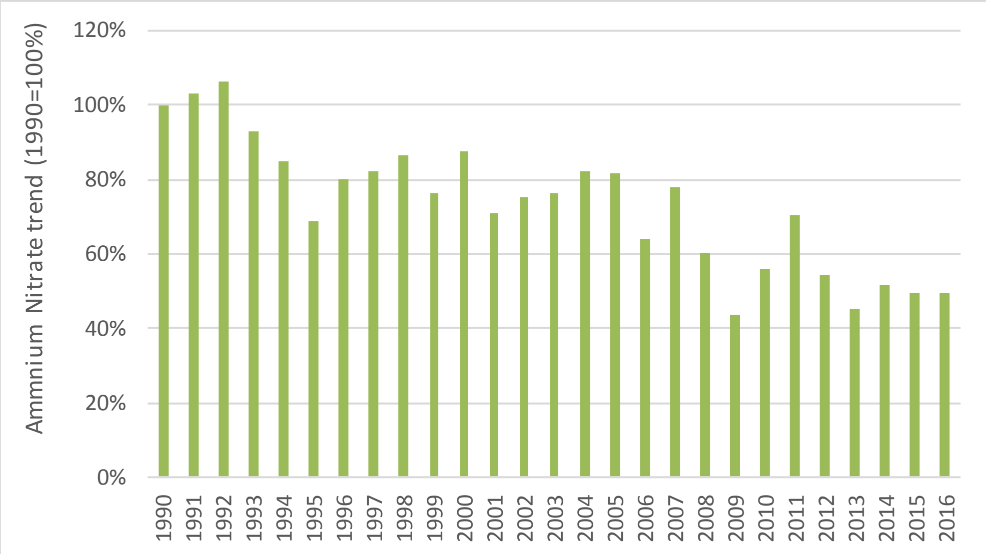
Table 4.13 – Neutralizer and Evaporator

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

4.1.2.8.3 Activity Data

Due to confidentiality constrains, ammonium nitrate production is presented as an index value related to 1990 production.

Figure 4.16 – Ammonium Nitrate production (1990=100%)



4.1.2.8.4 Recalculations

No recalculations were made.

4.1.2.8.5 Further Improvements

No further improvements are expected.

4.1.2.9 Ammonium Phosphates (NFR 2.B.10.a – SNAP 040406)

4.1.2.9.1 Methodology

Emissions from Ammonium Phosphates production were estimated in accordance with EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2016).

For TSP, PM_{10} and $PM_{2.5}$:

$$Emis_x = AD \times \frac{EF_x}{1 \times 10^6}$$

Where:

Emi_x – Emissions of pollutant "x" (t);

AD – Ammonium Phosphates production (t Ammonium Phosphates);

EF_x – Emission factor of pollutant "x" (g/t Ammonium Phosphates).

For BC:

$$Emis_{BC} = Emis_{PM2.5} \times EF_{BC}$$

Where:

$Emis_{BC}$ – Black Carbon emissions (t);

$Emis_{PM2.5}$ – $PM_{2.5}$ emissions (t);

EF_{BC} – Black Carbon emission factor (% $PM_{2.5}$).

4.1.2.9.2 Emission Factors

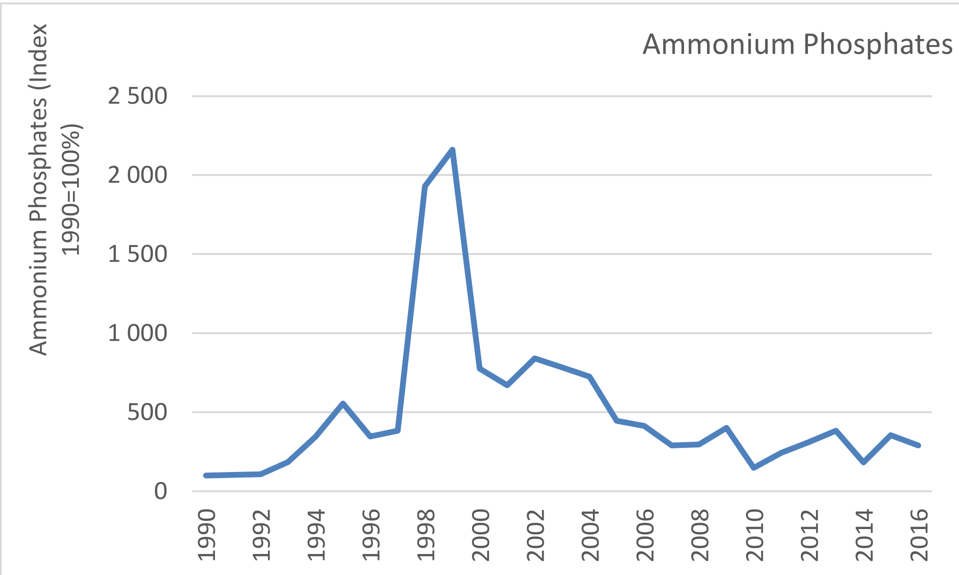
Pollutant	Unit	EF	Source
TSP	g/t Ammonium Phosphates	300	Table 3.28 of chapter "2.B Chemical Industry" of EMEP/EEA air pollutant emission inventory guidebook 2016
PM_{10}	g/t Ammonium Phosphates	240	
$PM_{2.5}$	g/t Ammonium Phosphates	180	
BC	% $PM_{2.5}$	1.8	Table 3.1 of chapter "2.B Chemical Industry" of EMEP/EEA air pollutant emission inventory guidebook 2016

4.1.2.9.3 Activity Data

From 1992 onwards, Ammonium Phosphates production was obtained from National Statistics. In the period 1990-1991, data was estimated based on 1992 Ammonium Phosphates production and on gross domestic product trend.

Due to confidentiality constraints, data is presented as an index value related to year 1990 production.

Figure 4.17 – Ammonium Phosphates (Index 1990=100%)



4.1.2.9.4 Recalculations

This sector has been considered for the first time.

4.1.2.9.5 Further Improvements

No further improvements are planned for this sector.

4.1.2.10 NPK Fertilisers (NFR 2.B.10.a – SNAP 040407)

4.1.2.10.1 Methodology

Emissions from NPK Fertilisers production were estimated in accordance with EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2016).

For NH_3, TSP, PM_{10} and $PM_{2.5}$:

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

Where:

Emi_x – Emissions of pollutant "x" (t);

AD – NPK Fertilisers production (t NPK Fertilisers);

EF_x – Emission factor of pollutant "x" (kg/t NPK Fertilisers).

For BC:

$$Emis_{BC} = Emis_{PM2.5} \times EF_{BC}$$

Where:

$Emis_{BC}$ – Black Carbon emissions (t);

$Emis_{PM2.5}$ – $PM_{2.5}$ emissions (t);

EF_{BC} – Black Carbon emission factor (% $PM_{2.5}$).

4.1.2.10.2 Emission Factors

Table 4.14 – Emission factors

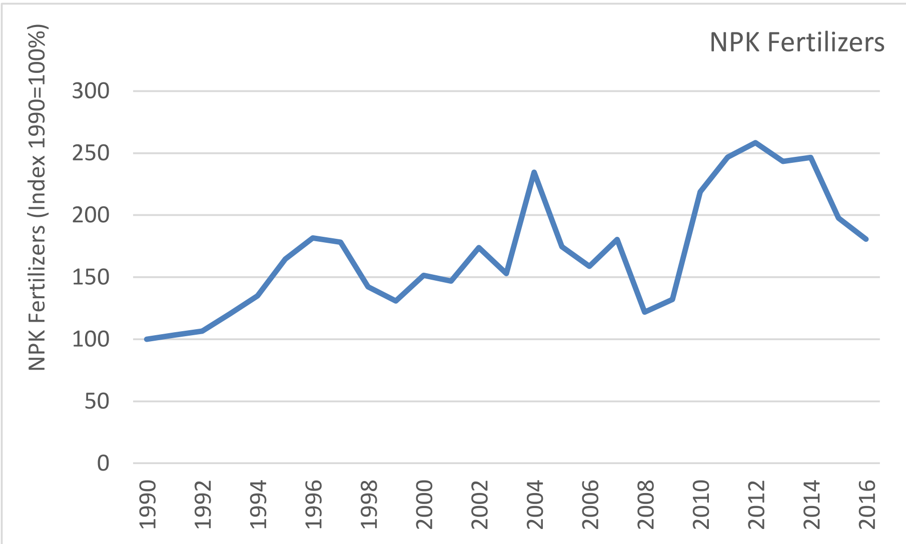
Pollutant	Unit	EF	Source
NH_3	Kg/t NPK Fertilisers	1.84	Plant specific monitoring data
TSP	Kg/t NPK Fertilisers	4.22	Plant specific monitoring data
PM_{10}	Kg/t NPK Fertilisers	3.43	Expert Judgement
$PM_{2.5}$	Kg/t NPK Fertilisers	3.41	Expert Judgement
BC	% $PM_{2.5}$	1.8	Table 3.1 of chapter "2.B Chemical Industry" of EMEP/EEA air pollutant emission inventory guidebook 2016

4.1.2.10.3 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 4.18 – NPK Fertilisers production (Index 1990=100%)



4.1.2.10.4 Recalculations

Activity data in the period 1990-1991 has been revised.

Black carbon emissions have been estimated for the first time.

4.1.2.10.5 Further Improvements

Efforts will be made in order to update plant specific emission factors based on monitoring data.

4.1.2.11 Urea (NFR 2.B.10.a – SNAP 040408)

4.1.2.11.1 Methodology

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

For NH_3, TSP, PM_{10} and $PM_{2.5}$:

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

Where:

Emi_x – Emissions of pollutant "x" (t);

AD – Urea production (t Urea);

EF_x – Emission factor of pollutant "x" (kg/t Urea).

For BC:

Where:

$Emis_{BC}$ – Black Carbon emissions (t);

$Emis_{PM2.5}$ – $PM_{2.5}$ emissions (t);

EF_{BC} – Black Carbon emission factor (% $PM_{2.5}$).

4.1.2.11.2 Emission Factors

Table 4.15 – 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	

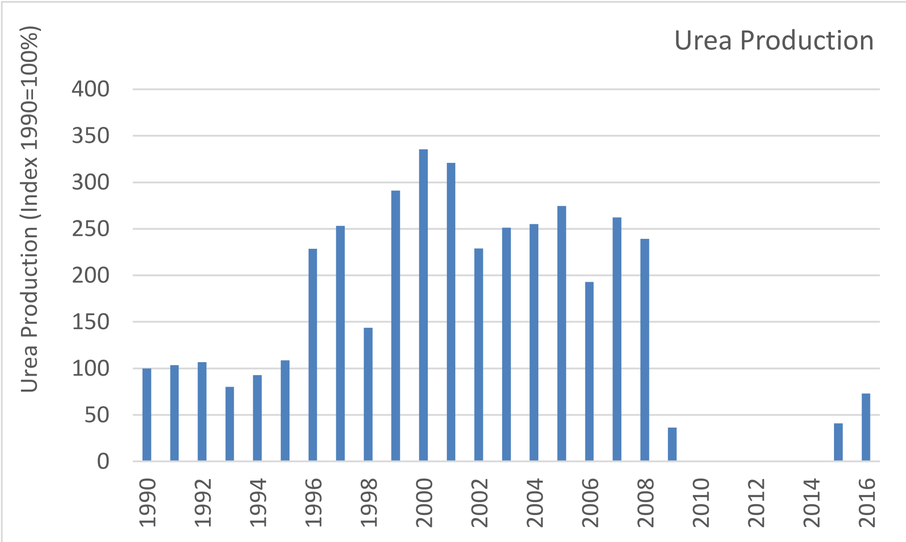
4.1.2.11.3 Activity Data

In the periods 1992-2008 and from 2010 onwards, urea production was obtained from National Statistics. In year 2009, data was obtained from Eurostats due to lack of information in National

Statistics. In the period 1990-1991, data was estimated based on 1992 production and on gross domestic product trend for this period.

For the same reason that was explained for ammonia manufacturing, the existence of only one industrial plant producing urea in Portugal, prohibits the publication of any activity data.

Figure 4.19 – Trend in Urea production



There is no urea production in Portugal in the period 2010-2014.

4.1.2.11.4 Recalculations

Urea production was revised based on National Statistics and Eurostat streamline.

We have introduced the NH_3 and Black Carbon emissions estimates.

TSP, PM10 and PM2.5 emission factors have been revised based on EMEP/EEA air pollutant emission inventory guidebook 2016.

4.1.2.11.5 Further Improvements

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

4.1.2.12 Carbon Black (NFR 2.B.10.a – SNAP 040409)

4.1.2.12.1 Methodology

In the case of carbon black, where CO2 emissions result from liberation of carbon in tail gas to atmosphere, emissions were estimated using a simple mass balance:

$$44 / 12 * C_{TailGas} = C_{Feedstock} + C_{AuxFuels} - C_{CarbonBlack}$$

Where,

$C_{TailGas}$ – carbon emitted in tail gas (t C/yr);

$C_{Feedstock}$ – Carbon entered in feedstock (t C/yr);

$C_{AuxFuels}$ – additional carbon entered into system in fuels (t C/yr);

$C_{CarbonBlack}$ – carbon stored in carbon black and not emitted to atmosphere (t C/yr);

4.1.2.12.2 Emission Factors

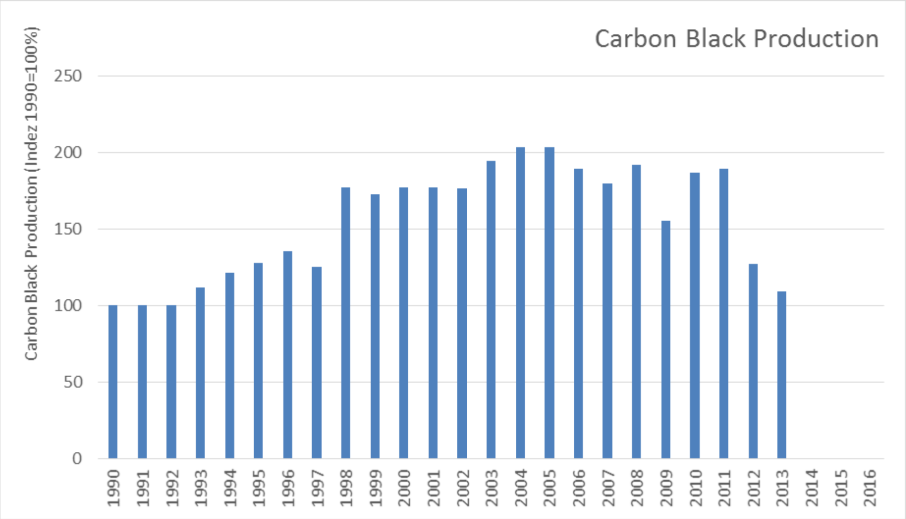
In the same way, the carbon black industrial unit was subjected, also for period 2009 - 2012, to a detailed inventory exercise. Consequently emission factors were established for carbon black unit and emission estimates were extended for the rest of the time series using carbon black production as indicator of activity rate. Carbon Gas emissions include also emissions suffering partial combustion.

Table 4.16 – Emission Factors in calculation of Carbon Black process emissions

Pollutant	Process Emissions (kg/t carbon black)	EF Source
CO2	2,379	Carbon Balance Approach
CH4	0.060	IPCC 2006 Guidelines
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

4.1.2.12.3 Activity Data

Due to confidentiality constraints, data is presented as an index value related to year 1990 production.



4.1.2.12.4 Recalculations

Review of the time series of activity data and emission factors for the Carbon Black sector.

4.1.2.12.5 Further Improvements

No further improvements are expected.

4.1.2.13 Graphite (NFR 2.B.10.a – SNAP 040411)

There is no relevant activity on graphite production in Portugal. In National Statistics there is only data in year 2000.

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

4.1.2.14 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.

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

Considered in “NPK Fertilisers” (SNAP 040407).

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

4.1.2.16.1 Methodology

Emissions were estimated according to:

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

Where:

Emi_x – Emissions of pollutant “x” (t);

AD – Ethylene production data (t Ethylene);

EF_x – Emission factor of pollutant “x” (kg/t Ethylene).

4.1.2.16.2 Emission Factors

Table 4.17 – Emission factors

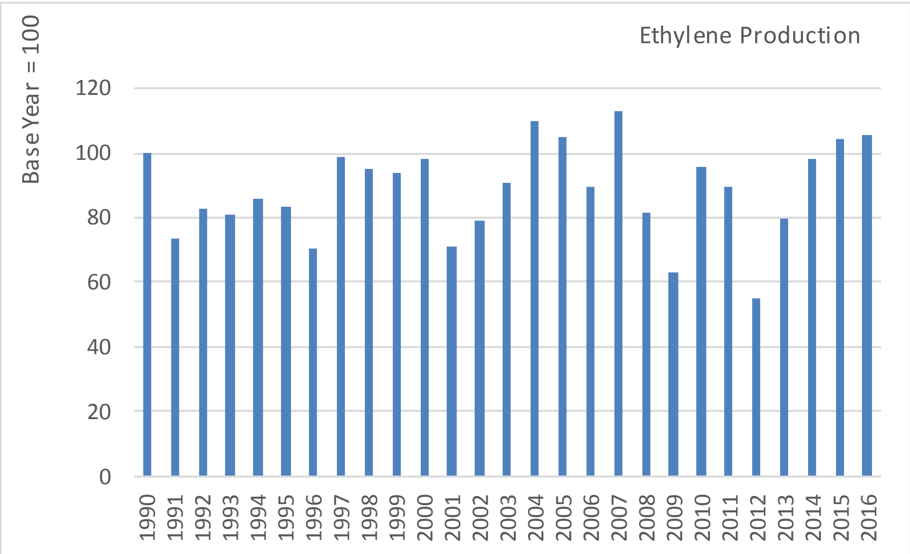
Pollutant	Unit	EF	Source
NMVOC	Kg/t Ethylene	0.6	Table 3.36 of chapter "2.B. Chemical Industry" of "EMEP/EEA emission inventory guidebook 2016".

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

Figure 4.20 – Ethylene production trend (1990=100%)



4.1.2.16.4 Recalculations

No recalculations were made.

4.1.2.16.5 Further Improvements

In future submissions it will be introduced emission factors updates based on monitoring data.

4.1.2.17 1,2-Dichloroethane + Vinylchloride (balanced) (NFR 2.B.10.a – SNAP 040505)

4.1.2.17.1 Overview

We consider that vinyl chloride monomer (VCM) is produced from ethylene by a balanced process, as follows:

$$2C_2H_4 + Cl_2 + \frac{1}{2}O_2 \rightarrow 2CH_2CHCl + H_2O \qquad (Ethylene\ Dichloride - VCM\ Reaction)$$

$$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O \qquad (Feedstock\ Oxidation\ Reaction)$$

4.1.2.17.2 Methodology

Emissions were estimated according to:

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

Where:

Emi_x – Emissions of pollutant "x" (t);

AD – VCM production data (t VCM);

EF_x – Emission factor of pollutant "x" (kg/t VCM).

4.1.2.17.3 Emission Factors

Table 4.18 – Emission factors

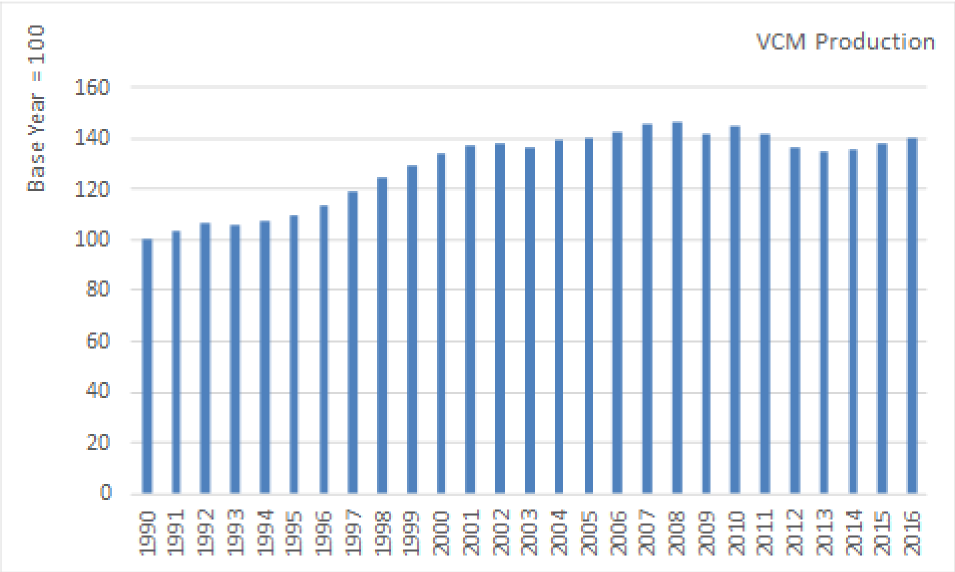
Pollutant	Unit	EF	Source
NMVOC	Kg/t VCM	2.5	Table 3.38 of chapter "2.B. Chemical Industry" of "EMEP/EEA emission inventory guidebook 2016".

4.1.2.17.4 Activity Data

Activity data for year 1990 is from national production statistics. From 1991 onwards, data is estimated based on gross domestic product trend.

Due to confidentiality constrains, VCM production is presented as a trend related to 1990 production.

Figure 4.21 – Trend in VCM production



4.1.2.17.5 Recalculations

No recalculations were made.

4.1.2.17.6 Further Improvements

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

4.1.2.18 Polyethylene Low Density (NFR 2.B.10.a – SNAP 040506)

4.1.2.18.1 Methodology

Emissions were estimated according to:

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

Where:

Emi_x – Emissions of pollutant “x” (t);

AD – Polyethylene Low-Density (PELD) production data (t PELD);

EF_x – Emission factor of pollutant “x” (kg/t PELD).

4.1.2.18.2 Emission Factors

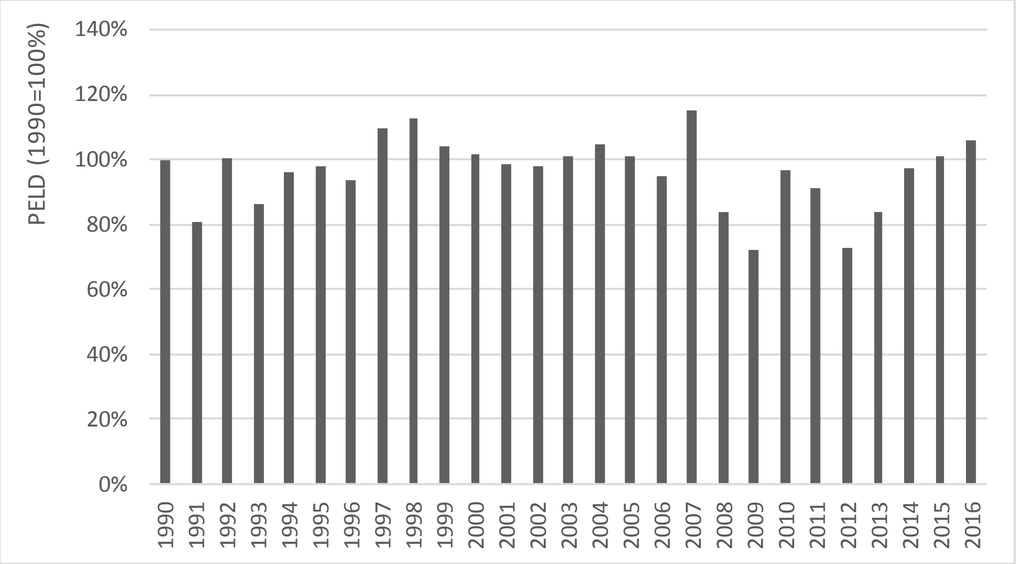
Table 4.19 – Emission factors

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"

4.1.2.18.3 Activity Data

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

Figure 4.22 – Polyethylene Low-Density (PELD) trend (1990=100%)



4.1.2.18.4 Recalculations

No recalculations were made.

4.1.2.18.5 Further Improvements

No further improvements are expected.

4.1.2.19 Polyethylene High Density (NFR 2.B.10.a – SNAP 040507)

4.1.2.19.1 Methodology

Emissions were estimated according to:

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

Where:

Emi_x – Emissions of pollutant “x” (t);

AD – Polyethylene High-Density (PEHD) production data (t PEHD);

EF_x – Emission factor of pollutant “x” (kg/t PEHD).

4.1.2.19.2 Emission Factors

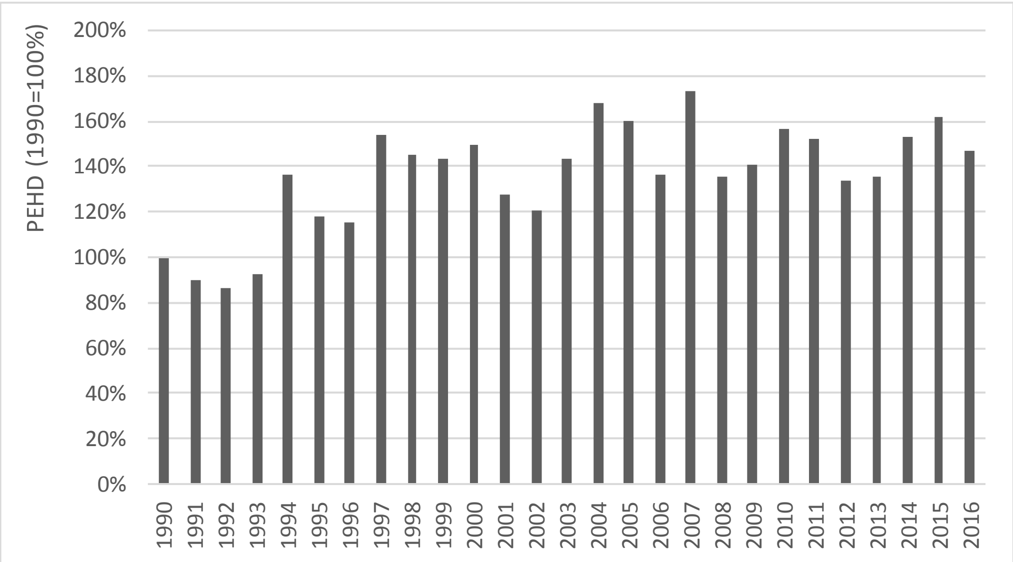
Table 4.20 – Emission factors

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"

4.1.2.19.3 Activity Data

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

Figure 4.23 – Polyethylene High-Density (PEHD) trend (1990=100%)



4.1.2.19.4 Recalculations

No recalculations were made.

4.1.2.19.5 Further Improvements

No further improvements are expected.

4.1.2.20 Polypropylene (NFR 2.B.10.a – SNAP 040509)

4.1.2.20.1 Methodology

Emissions were estimated according to:

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

Where:

Emi_x – Emissions of pollutant “x” (t);

AD – Polypropylene production data (t polypropylene);

EF_x – Emission factor of pollutant “x” (kg/t polypropylene).

4.1.2.20.2 Emission Factors

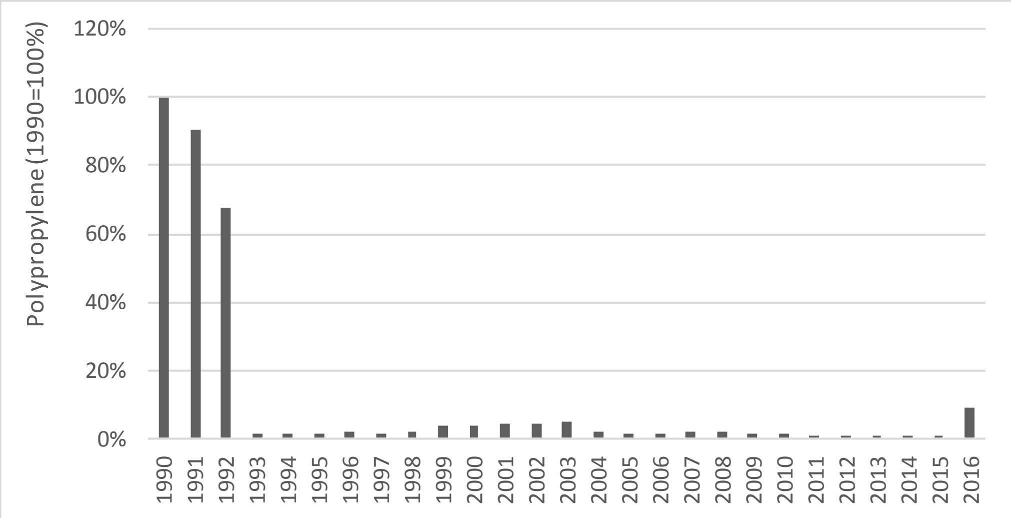
Table 4.21 – Emission factors

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"

4.1.2.20.3 Activity Data

Activity data was obtained from National Statistics. Due to confidentiality constrains, polypropylene production is presented as a trend related to 1990 production.

Figure 4.24 – Polypropylene trend (1990=100%)



4.1.2.20.4 Recalculations

We have implemented EMEP/EEA emission inventory Guidebook 2016 emission factors.

4.1.2.20.5 Further Improvements

No further improvements are expected.

4.1.2.21 Polystyrene (NFR 2.B.10.a – SNAP 040511)

4.1.2.21.1 Methodology

Emissions were estimated according to:

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

Where:

Emi_x – Emissions of pollutant “x” (t);

AD – Polystyrene production data (t polystyrene);

EF_x – Emission factor of pollutant “x” (kg/t polystyrene).

4.1.2.21.2 Emission Factors

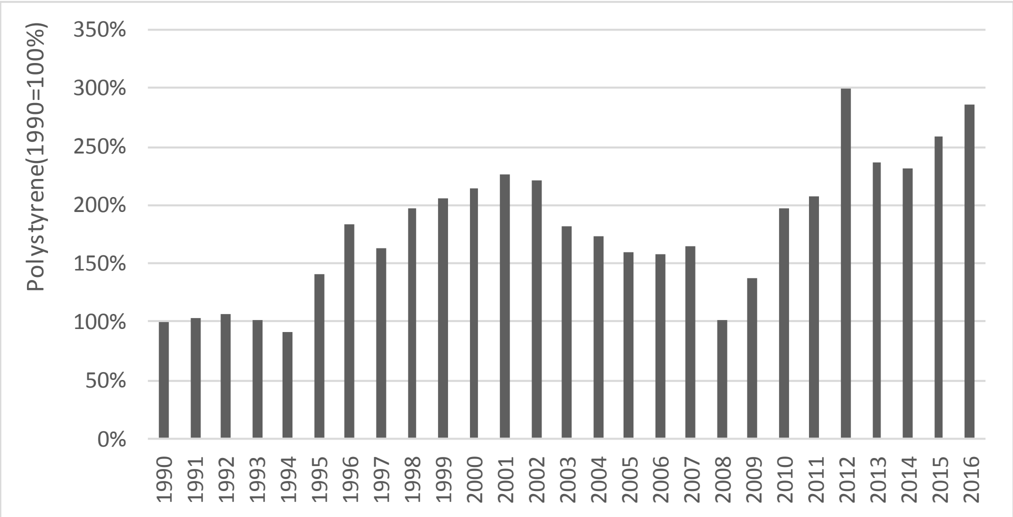
Table 4.22 – Emission factors

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"

4.1.2.21.3 Activity Data

Activity data was obtained from National Statistics from 1992 onwards. In the period 1990-1991, data was estimated based on 1992 production and on gross domestic product trend. Due to confidentiality constrains, polystyrene production is presented as a trend related to 1990 production.

Figure 4.25 – Polystyrene trend (1990=100%)



4.1.2.21.4 Recalculations

We have implemented EMEP/EEA emission inventory Guidebook 2016 emission factors.

4.1.2.21.5 Further Improvements

No further improvements are expected.

4.1.2.22 Formaldehyde (NFR 2.B.10.a – SNAP 040517)

4.1.2.22.1 Methodology

Emissions were estimated according to:

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

Where:

Emi_x – Emissions of pollutant “x” (t);

AD – Formaldehyde production data (t formaldehyde);

EF_x – Emission factor of pollutant “x” (kg/ t formaldehyde).

4.1.2.22.2 Emission Factors

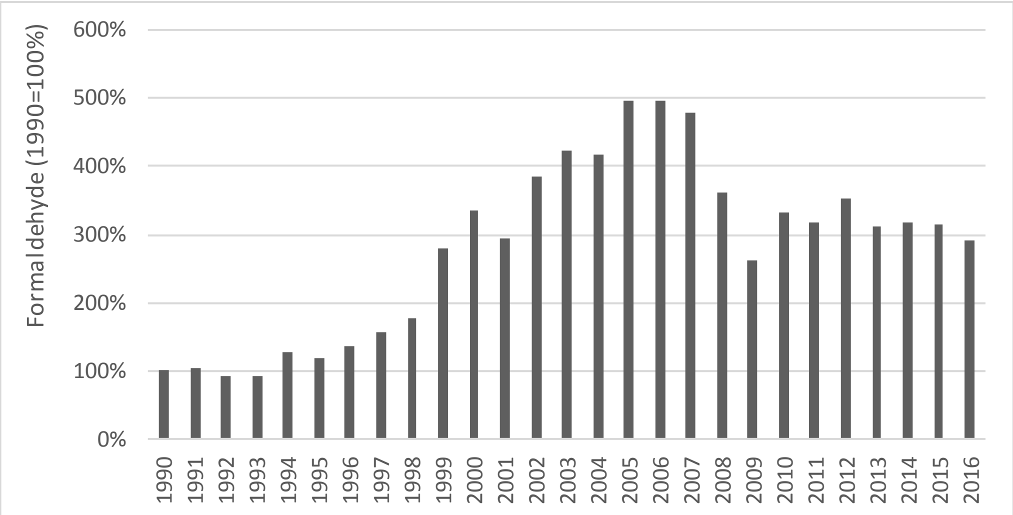
Table 4.23 – Emission factors

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"

4.1.2.22.3 Activity Data

Activity data was obtained from National Statistics. Due to confidentiality constrains, polystyrene production is presented as a trend related to 1990 production.

Figure 4.26 – Formaldehyde trend (1990=100%)



4.1.2.22.4 Recalculations

We have implemented EMEP/EEA emission inventory Guidebook 2016 emission factors.

4.1.2.22.5 Further Improvements

No further improvements are expected.

4.1.2.23 Phthalic Anhydride (NFR 2.B.10.a – SNAP 040519)

4.1.2.23.1 Methodology

Emissions were estimated according to:

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

Where:

Emi_x – Emissions of pollutant "x" (t);

AD – Phthalic Anhydride production data (t Phthalic Anhydride);

EF_x – Emission factor of pollutant "x" (kg/t Phthalic Anhydride).

4.1.2.23.2 Emission Factors

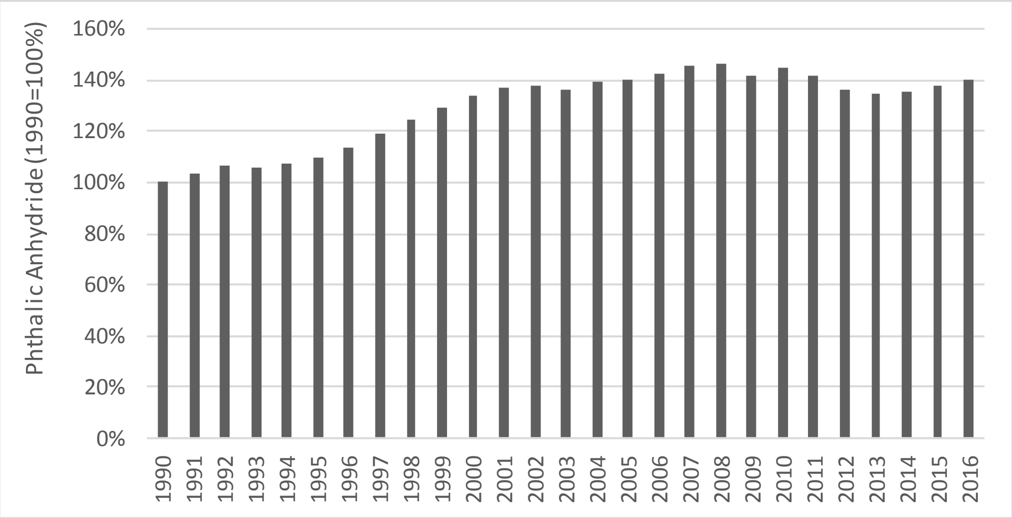
Table 4.24 – Emission factors

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

4.1.2.23.3 Activity Data

Activity data was obtained from National Statistics from 2015 onwards. In the period 1990-2014, data was estimated based on 2015 production and on gross domestic product trend. Due to confidentiality constrains, polystyrene production is presented as a trend related to 1990 production.

Figure 4.27 – Phthalic Anhydride production trend (1990=100%)



4.1.2.23.4 Recalculations

No recalculations were made.

4.1.2.23.5 Further Improvements

No further improvements are expected.

4.1.2.24 Explosives Manufacturing (NFR 2.B.10.a – SNAP 040622)

4.1.2.24.1 Methodology

Emissions were estimated according to:

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

Where:

Emi_x – Emissions of pollutant “x” (t);

AD – Explosives production data (t explosive);

EF_x – Emission factor of pollutant “x” (kg/t explosive).

4.1.2.24.2 Emission Factors

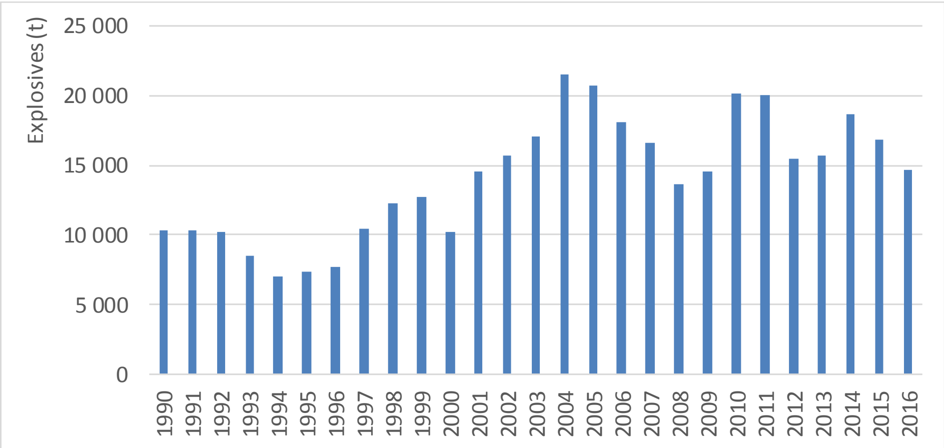
Table 4.25 – Emission factors

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	

4.1.2.24.3 Activity Data

Activity data was obtained from National Statistics.

Figure 4.28 – Explosives production (t)



4.1.2.24.4 Recalculations

No recalculations were made.

4.1.2.24.5 Further Improvements

No further improvements are expected.

4.1.3 Metal Production (NFR 2.C)

4.1.3.1 Iron and Steel Production (NFR 2.C.1)

4.1.3.1.1 Overview

Iron results from reduction of the iron element present in mineral ores by contact with coke - reducing agent - at high temperatures in the blast furnace. The resulting material, pig iron – and also scrap in some steel plants - is transformed into steel into subsequent furnaces which may be a Basic Oxygen Furnace (BOF) or Electric Arc Furnace (EAF). Coke, sinter and lime are intermediate materials necessary for iron and steel production.

Sintering modifies the structure of ore material making it more suitable for iron formation, by converting fine-sized raw materials, including iron ore, coke breeze, limestone, mill scale, and flue dust, into an agglomerated product. Sintering emissions occur from the windbox, discharge and sinter crusher, coolers and screens. Emissions from sintering, which result from a combustion process with contact, are reported under 1.A.2, although the emission factors are reported in this chapter.

Coke is produced by destructive distillation of imported fossil coal in coke ovens, where coal is subjected to heat in an oxygen-free atmosphere until all volatile components in the coal evaporate, forming a fuel used in industry, the Coke Gas. Process heat comes from the combustion of gases between the coke chambers. Excluding emissions associated with coke production resulting from use of fuels in under-fired heating furnaces (which are accounted in Energy source sector 1A1), air emissions from the cokerie 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)

Coke and sinter are added to the Blast Furnace where iron oxides, coke and fluxes react with blast air to form molten reduced iron, carbon monoxide (CO), and slag. Emissions occur during casting and in the blast furnace top. However the gas resulting from process in the blast furnace, which has a high CO content, is normally not emitted to atmosphere but used as fuel in integrated units (Blast Furnace Gas). Emissions from its combustion are also quantified and discussed under chapter 1.A.2.a – Combustion in Manufacturing Industries and Construction. The emissions that are quantified here, in source 2.C, are only those resulting from casting operations and seal leaks at top of furnace.

In Basic Oxygen Furnace original material are re-melted with the addition of substantial source of oxygen which is lanced (injected) and oxidizes part of the carbon associated with iron: This carbon is emitted mostly as CO (contributing nevertheless to ultimate CO_2 emissions). Other emissions from BOF are iron oxides, oxides of other metals and Sulphur and particulate matter. In EAF the original material, which is basically scrap, is subjected to an electric discharge that also reduces carbon content. Emissions in furnaces may also result from carbon additives such as limestone and coke.

Steel is finally finished in rolling mills. Emissions from this finishing process are mostly particulate matter besides combustion pollutants which is already included in emissions from the 1.A.2.a sector.

Lime is necessary for the blast furnace charging and EAF mixtures.

Emissions of ultimate fossil CO_2 are the result of the oxidation of carbon in coke, anodes and electrodes. Part of the carbon may be sequestered in final product and not emitted to atmosphere as carbon dioxide. Only emissions of carbon that has origin in fossil fuels should be considered as emissions of final or ultimate CO2 and not those from the use of biomass origin carbon - charcoal. 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 blast furnace 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 blast furnace during casting and oxygen blow in BOF. Particulate materials are mostly composed of iron, Sulphur and other metal oxides.

During the period 1990-2001 two main industrial plants in Portugal were associated with steel production which later turn into three units as result of the split of one of the units in two separate plants. Later, during 2001, the cokerie, blast furnace and sintering were closed and only steel furnaces and trimming remain as emission sources.

From 2002 onwards, there is only secondary steel production in Portugal.

We do a cross-check between data received from the two plants and the energy balance data. Part of the differences (coke and coal consumption) is considered under source “1.A.2.a”. The differences related to other fuels are reported under source “1.A.2.g.viii”, since this could be a misallocation from the energy balance.

4.1.3.1.2 Methodology

Emissions are simply calculated from multiplication of activity levels by a suitable emission factor:

$$\text{Emission}_{(p,y)} = \Sigma_a[\text{EF}_{(p,a)} * \text{Activity}_{\text{Indicator }(p,a,y)}] * 10^{-3}$$

and,

$\text{Emission}_{(p,y)}$ - Emission of pollutant p in a specific year y from all sector activities and equipments (t/yr);

$\text{Activity}_{\text{Indicator }(p,act,y)}$ - Most suitable indicator for emissions of a particular pollutant p resulting from a specific source activity or equipment a (t/yr);

$\text{EF}_{(p,act)}$ - Emission factor specific of pollutant and activity/ equipment a (kg/t).

Emissions from sintering and lime production from limestone at iron and steel unit were also estimated using similar equation and using production of lime as activity data. Emissions for all pollutants from these two emission sources are reported however in source category Lime Production (2A2).

Methodology to estimate emissions from combustion of coke gas and blast furnace gas were already discussed in source sector 1A.2.a - manufacturing industries and construction (iron and steel) - and 1A.1.c.1 - Manufacture of Solid Fuels.

4.1.3.1.3 Emission Factors

Due to the fact that from 1990 to 2001 there was primary steel production in Portugal, in this period there are emissions related to coke oven (door leakage and extinction), sinter production, blast furnace charging, tapping and teeming, basic oxygen furnace, electric arc furnace and rolling.

Table 4.26 – Coke oven (door leakage and extinction) emission factors

Pollutant	Unit	EF	Source
SOx	kg/t coke	1.59	Chapter "12.2 Coke Production" of USEPA AP-42
NOx	kg/t coke	0.83	
NMVOC	kg/t coke	0.09	
CO	kg/t coke	15.4	
TSP	kg/t coke	4.5	
PM_{10}	kg/t coke	1.8	
$PM_{2.5}$	kg/t coke	1.4	
Pb	g/t coke	$3x10^{-2}$	
Cd	g/t coke	$2.9x10^{-4}$	
Hg	g/t coke	$1.7x10^{-4}$	
As	g/t coke	$1.9x10^{-2}$	
Cr	g/t coke	$9.3x10^{-3}$	
Cu	g/t coke	$1.2x10^{-2}$	
Ni	g/t coke	$2.1x10^{-2}$	
Se	g/t coke	$6.3x10^{-3}$	
Zn	g/t coke	$5.9x10^{-2}$	
Benzo(α)pyrene	g/t coke	$9.7x10^{-3}$	
Benzo(β)fluoranthene	g/t coke	$5.3x10^{-3}$	
Benzo(k)fluoranthene	g/t coke	$2.9x10^{-3}$	
Indeno(1,2,3-cd)pyrene	g/t coke	$3.1x10^{-3}$	

Table 4.27 – Sinter production emission factors

Pollutant	Unit	EF	Source
SOx	kg/t sinter	0.6	Table 3.4 of JRC Reference Report - BAT Reference Document for Iron and Steel Production (2013)
NOx	kg/t sinter	0.67	
NMVOC	kg/t sinter	0.138	Table 3.2 of chapter "2.C.1 Iron and steel production" of EMEP/EEA air pollutant emission inventory guidebook 2016
CO	kg/t sinter	22.89	Table 3.4 of JRC Reference Report - BAT Reference Document for Iron and Steel Production (2013)
TSP	kg/t sinter	0.2	Table 3.2 of chapter "2.C.1 Iron and steel production" of EMEP/EEA air pollutant emission inventory guidebook 2016
PM_{10}	kg/t sinter	0.1	
$PM_{2.5}$	kg/t sinter	0.08	
BC	% $PM_{2.5}$	0.17%	
Pb	g/t sinter	3.5	
Cd	g/t sinter	0.004	
Hg	g/t sinter	0.049	
As	g/t sinter	0.018	
Cr	g/t sinter	0.016	
Cu	g/t sinter	0.033	
Ni	g/t sinter	0.09	
Se	g/t sinter	0.02	
Zn	g/t sinter	0.06	
PCDD/F	µg/t sinter	8	
Total 4 PAHs	g/t sinter	0.3	
HCB	mg/t sinter	30	
PCBs	mg/t sinter	0.09	

Table 4.28 – Blast Furnace charging emission factors

Pollutant	Unit	EF	Source
SOx	kg/t pig iron	0.1	Table 6.5 of JRC Reference Report - BAT Reference Document for Iron and Steel Production (2013)
NOx	kg/t pig iron	$2.08x10^{-3}$	
CO	kg/t pig iron	$2.86x10^{-2}$	Table 6.5 of JRC Reference Report - BAT Reference Document for Iron and Steel Production (2013)
TSP	kg/t pig iron	0.05	Table 3.8 of chapter "2.C.1 Iron and steel production" of EMEP/EEA air pollutant emission inventory guidebook 2016
PM_{10}	kg/t pig iron	0.04	
$PM_{2.5}$	kg/t pig iron	0.025	
BC	% $PM_{2.5}$	2.4%	
Pb	g/t pig iron	$6x10^{-4}$	
Cd	g/t pig iron	$1.44x10^{-4}$	Table 6.5 of JRC Reference Report - BAT Reference Document for Iron and Steel Production (2013)
Hg	g/t pig iron	$1x10^{-4}$	Table 3.8 of chapter "2.C.1 Iron and steel production" of EMEP/EEA air pollutant emission inventory guidebook 2016
As	g/t pig iron	$2.53x10^{-4}$	Table 6.5 of JRC Reference Report - BAT Reference Document for Iron and Steel Production (2013)
Cr	g/t pig iron	2.3	Table 3.8 of chapter "2.C.1 Iron and steel production" of EMEP/EEA air pollutant emission inventory guidebook 2016
Cu	g/t pig iron	0.015	
Ni	g/t pig iron	$6.3x10^{-3}$	Table 6.5 of JRC Reference Report - BAT Reference Document for Iron and Steel Production (2013)
Zn	g/t pig iron	0.073	Table 3.8 of chapter "2.C.1 Iron and steel production" of EMEP/EEA air pollutant emission inventory guidebook 2016
PCDD/F	µg I-TEQ/t pig iron	0.002	
Total 4 PAHs	g/t pig iron	2.5	
PCBs	g/t pig iron	2	

Table 4.29 – Basic Oxygen Furnace emission factors

Pollutant	Unit	EF	Source
NOx	kg/t steel	0.01	Table 3.14 of chapter "2.C.1 Iron and steel production" of EMEP/EEA air pollutant emission inventory guidebook 2016
CO	kg/t steel	3.5	
TSP	kg/t steel	0.035	
PM_{10}	kg/t steel	0.032	
$PM_{2.5}$	kg/t steel	0.028	
BC	% $PM_{2.5}$	0.36%	
Pb	g/t steel	4	
Cd	g/t steel	0.067	
Hg	g/t steel	0.0014	
As	g/t steel	0.4	
Cr	g/t steel	2.3	
Cu	g/t steel	0.02	
Ni	g/t steel	0.13	
Se	g/t steel	0.003	
Zn	g/t steel	4	
PCDD/F	µg I-TEQ/t pig iron	0.69	
Total 4 PAHs	g/t steel	0.01	
PCBs	mg/t steel	2.5	

Table 4.30 – Electric Arc Furnace emission factors (with Fabric Filter)

Pollutant	Unit	EF	Source
SOx	kg/t steel	0.082	Plant specific monitoring data
NOx	kg/t steel	0.23	Plant specific monitoring data
NMVOC	kg/t steel	0.118	Plant specific monitoring data
CO	kg/t steel	0.516	Plant specific monitoring data
TSP	kg/t steel	0.082	Plant specific monitoring data
PM_{10}	kg/t steel	0.024	Table 3.19 of chapter "2.C.1 Iron and steel production" of EMEP/EEA air pollutant emission inventory guidebook 2016
$PM_{2.5}$	kg/t steel	0.021	
BC	% $PM_{2.5}$	0.36%	
Pb	g/t steel	1.5	
Cd	g/t steel	0.12	
Hg	g/t steel	0.076	
As	g/t steel	0.008	
Cr	g/t steel	0.105	
Cu	g/t steel	0.02	
Ni	g/t steel	0.41	
Zn	g/t steel	2.3	
PCB	mg/t steel	2.5	
PCDD/F	µg I-TEQ/t steel	18.86	Plant Specific Monitoring Data
Total 4 PAHs	g/t steel	0.21	

Table 4.31 – Rolling Mills emission factors

Pollutant	Unit	EF	Source
NOx	kg/t steel	0.07	Monitoring Data
NMVOC	kg/t steel	0.007	
TSP	kg/t steel	0.023	
PM_{10}	kg/t steel	0.023	Expert Judgement
$PM_{2.5}$	kg/t steel	0.023	
BC	% $PM_{2.5}$	100%	
Zn	g/t steel	0.006	Monitoring Data

From 2002 onwards there is only secondary steel production. Therefore,in this period there are only emission factors related to electric arc furnace and rolling mills.

4.1.3.1.4 Activity Data

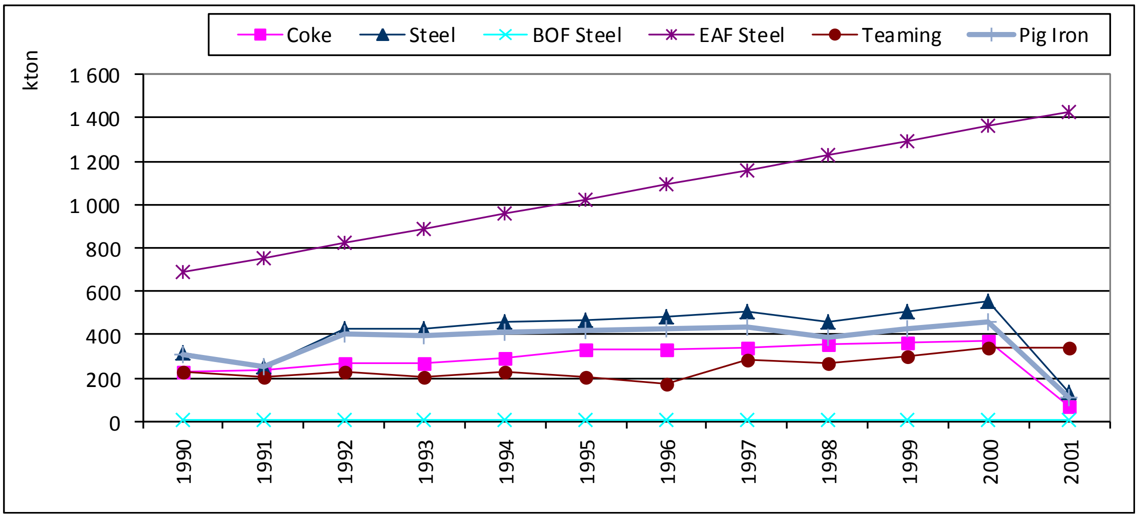
There are differences in the activity data used in estimates for the period 1990-2001 and from 2002 onwards.

Activity data for emissions estimates from iron and steel production for the period 1990-2001 comprehend coke, sinter, pig iron and steel production and also scrap consumption. The following sources of information were used to establish activity data time series:

- Coke production is available from DGEG (Cokerie Balance) annually from 1990 to 2001. From 2002 onwards there is no coke production in the iron and steel industry in Portugal;
- production time series for sinter, pig iron and steel production in blast furnace are available from industrial plant from 1990 to 1994 (APA direct survey). Thereafter and until 2001, annual values were estimated using coke production as surrogate data. From 2002 onwards there is no sinter, pig iron and steel production in blast furnace;
- Steel resulting from BOF in Seixal Iron and Steel Plant was estimated from production data in 1990 and forecasted until 2001; from 2002 onwards there is no steel production resulting from BOF.
- the same procedure was used to establish the full time series of scrap use and lime consumption, although in this case information data from the industrial plant was available from 1990 to 1994;
- steel production and scrap use in the EAF oven in Maia steel plant was available for 1990 and forecasted in the period 1991-2001 based on energy consumption;

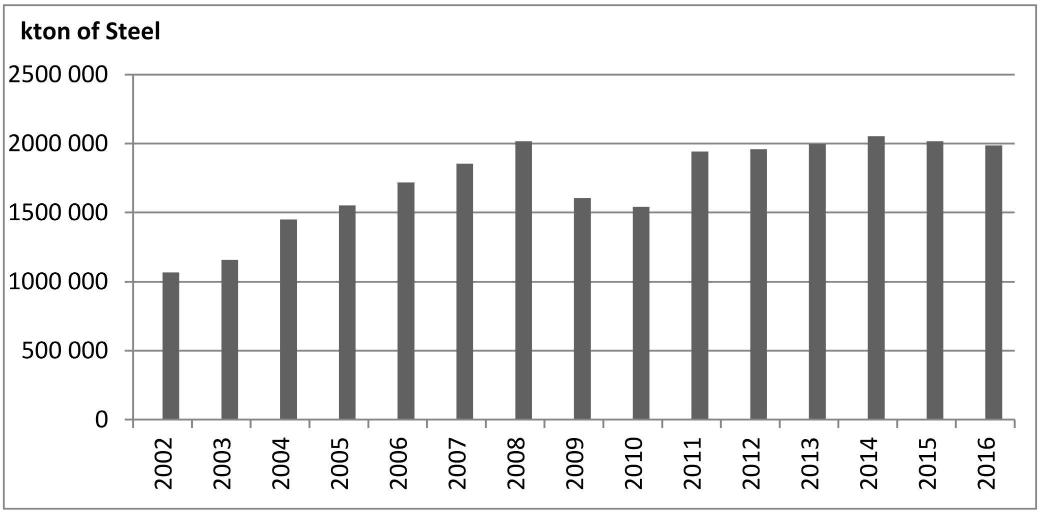
Production of total steel and intermediate products in the period 1990-2001 could be checked in the next figure.

Figure 4.29 – Production of iron and steel, production/consumption of intermediate products of the iron and steel industry: coke, sinter and pig iron, and consumption of scrap (1990-2001)



Production of secondary steel from 2002 onwards could be checked in the next figure.

Figure 4.30 – Production of secondary steel from 2002 onwards



4.1.3.1.5 Recalculations

BC emissions estimates have been introduced for the period 1990-2001.

An error in PCDD/F emissions estimates has been corrected.

There is no NH_3 emission factor related to Coke oven (door leakage and extinction).

Sinter production PCDD/F, PAH, HCB and PCBs emission factors have been corrected based on EMEP/EEA air pollution emission inventory guidebook 2016.

The PCDD/F, PAH and PCBs emission factors related to Basic Oxygen Furnace have also been corrected based on Table 3.14 of chapter "2.C.1 Iron and steel production" of EMEP/EEA air pollutant emission inventory guidebook 2016.

Emission factors related to electric arc furnace have been revised based on plant specific monitoring data and on Table 3.19 of chapter "2.C.1 Iron and steel production" of EMEP/EEA air pollutant emission inventory guidebook 2016.

Emission factors related to rolling mills have been revised based on plant specific monitoring data and on expert judgement.

4.1.3.1.6 Further Improvements

No further improvements are expected.

4.1.3.2 Ferroalloys Production (NFR 2.C.2 – SNAP 040302)

According to National Statistics, there is no Ferroalloys production in Portugal.

4.1.3.3 Aluminium Production (NFR 2.C.3 – SNAPs 040301 & 030310)

4.1.3.3.1 Methodology

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

For TSP, PM_{10} and $PM_{2.5}$:

$$Emis_x = AD \times \frac{EF_x}{1000} \times (100\% - \eta_{abatement})$$

Where:

Emi_x – Emissions of pollutant "x" (t);

AD – Aluminium production (t Aluminium);

EF_x – Emission factor of pollutant "x" (kg/t Aluminium);

$\eta_{abatement}$ – Abatement technology efficiency (%).

For BC:

$$Emis_{BC} = Emis_{PM2.5} \times EF_{BC}$$

Where:

$Emis_{BC}$ – Black Carbon emissions (t);

$Emis_{PM2.5}$ – $PM_{2.5}$ emissions (t);

EF_{BC} – Black Carbon emission factor (% $PM_{2.5}$).

For PCDD/F (Dioxins and Furans):

$$Emis_{PCDD/F} = AD \times \frac{EF_{PCDD/F}}{1 \times 10^6}$$

Where:

$Emi_{PCDD/F}$ – Emissions of dioxins and furans (g I-TEQ);

AD – Aluminium production (t Aluminium);

EF_x – Emission factor of dioxins and furans (µg I-TEQ/t Aluminium).

For HCB:

$$Emis_{HCB} = AD \times \frac{EF_{HCB}}{1000}$$

Where:

Emi_{HCB} – Emissions of HCB (kg);

AD – Aluminium production (t Aluminium);

EF_{HCB} – Emission factor of HCB (g/t Aluminium).

4.1.3.3.2 Emission Factors

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 2016
PM_{10}	kg/t Aluminium	1.4	
$PM_{2.5}$	kg/t Aluminium	0.55	
BC	% $PM_{2.5}$	2.3%	
PCDD/F	µg I-TEQ/t Aluminium	35	
HCB	g/t Aluminium	5	

Table 4.33 – Abatement Technologies Efficiencies

Abatement Technology	Pollutant	Unit	EF	Source
Coated Fabric Filter	TSP	%	98.1%	Table 3.5 of chapter "2.C.3 Aluminium Production" of EMEP/EEA air pollutant emission inventory guidebook 2016
	PM_{10}	%	99.9%	
	$PM_{2.5}$	%	99.6%	

Data on abatement technologies was selected based on expert judgement. This data will be improved in future submissions based on plant specific data.

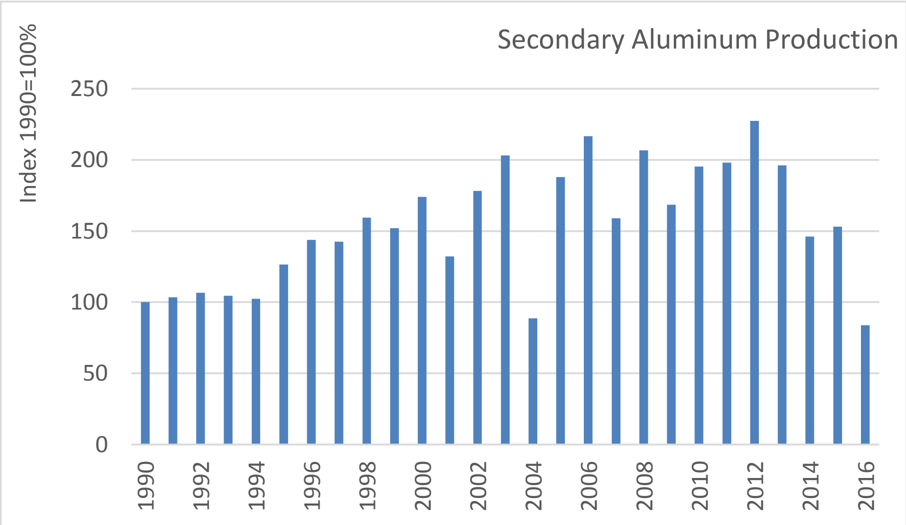
4.1.3.3.3 Activity Data

There is only secondary Aluminium production in Portugal.

From 1992 onwards, data on secondary Aluminium production was obtained from National Statistics. In the period 1990-1991, data was estimated based on 1992 production and on gross domestic product trend.

Due to confidentiality constraints data is presented as an index value related to 1990 production.

Figure 4.31 – Secondary Aluminium production (Index 1990=100%)



4.1.3.3.4 Recalculations

This sector has been estimated for the first time.

4.1.3.3.5 Further Improvements

Efforts will be made in order to obtain plant specific data on abatement technologies.

4.1.3.4 Magnesium Production (NFR 2.C.4)

According to National Statistics, there is no Magnesium production in Portugal.

4.1.3.5 Lead Production (NFR 2.C.5 – SNAP 040309b)

4.1.3.5.1 Methodology

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

For TSP, PM_{10} and $PM_{2.5}$:

$$Emis_x = AD \times \frac{EF_x}{1 \times 10^6} \times (100\% - \eta_{abatement})$$

Where:

Emi_x – Emissions of pollutant "x" (t);

AD – Lead production (t Lead);

EF_x – Emission factor of pollutant "x" (g/t Lead);

$\eta_{abatement}$ – Abatement technology efficiency (%).

For SO_x, Pb, Cd, As and Zn:

$$Emis_x = AD \times \frac{EF_x}{1 \times 10^6}$$

Where:

Emi_x – Emissions of pollutant "x" (t);

AD – Lead production (t Lead);

EF_x – Emission factor of pollutant "x" (kg/t Lead).

For PCDD/F (Dioxins and Furans):

$$Emis_{PCDD/F} = AD \times \frac{EF_{PCDD/F}}{1 \times 10^6}$$

Where:

$Emi_{PCDD/F}$ – Emissions of dioxins and furans (g I-TEQ);

AD – Lead production (t Lead);

EF_x – Emission factor of dioxins and furans (µg I-TEQ/t Lead).

For PCB:

$$Emis_{HCB} = AD \times \frac{EF_{HCB}}{1000}$$

Where:

Emi_{HCB} – Emissions of PCB (kg);

AD – Lead production (t Lead);

EF_{PCB} – Emission factor of PCB (µg/t Lead).

4.1.3.5.2 Emission Factors

Table 4.34 – 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 4.35 – Abatement Technologies Efficiencies

Abatement Technology	Pollutant	Unit	EF	Source
Coated Fabric Filter	TSP	%	98.1%	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%	

4.1.3.5.3 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 gross domestic product trend.

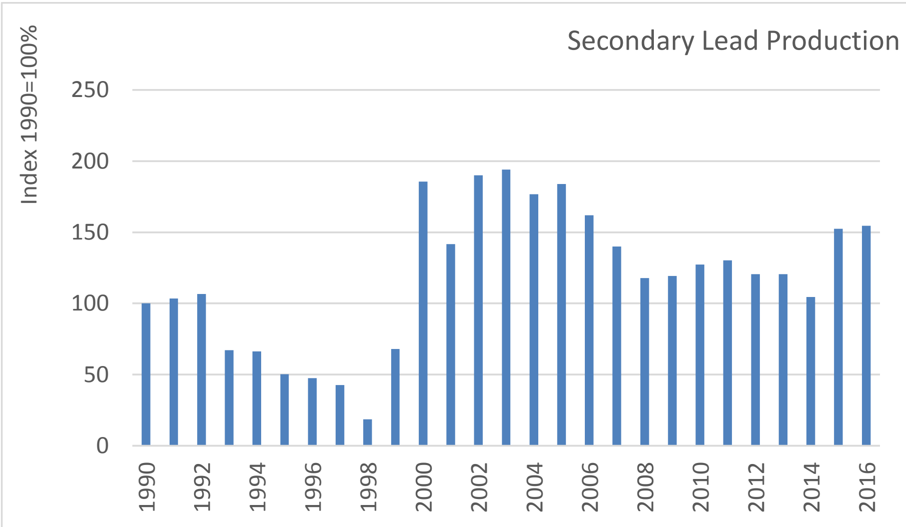
In the period 1992-2005, data on secondary Lead production was obtained from National Statistics.

Due to lack of information in National Statistics and Eurostat, in the period 2006-2007 data has been estimated based on the interpolation of 2005 and 2008 production data.

From 2008 onwards, data on secondary Lead production was obtained from Eurostat.

Due to confidentiality constraints data is presented as an index value related to 1990 production.

Figure 4.32 – Secondary Lead production data (Index 1990=100%)



4.1.3.5.4 Recalculations

This sector has been considered for the first time.

4.1.3.5.5 Further Improvements

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

4.1.3.6 Zinc Production (NFR 2.C.6 – SNAP 040309c)

According to National Statistics, there is no Zinc production in Portugal.

4.1.3.7 Copper Production (NFR 2.C.7.a – SNAP 040309a)

4.1.3.7.1 Methodology

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

For TSP, PM_{10} and $PM_{2.5}$:

$$Emis_x = AD \times \frac{EF_x}{1 \times 10^6} \times (100\% - \eta_{abatement})$$

Where:

Emi_x – Emissions of pollutant "x" (t);

AD – Copper production (t Copper);

EF_x – Emission factor of pollutant "x" (g/t Copper);

$\eta_{abatement}$ – Abatement technology efficiency (%).

For SO_x, Pb, Cd, As and Zn:

$$Emis_x = AD \times \frac{EF_x}{1 \times 10^6}$$

Where:

Emi_x – Emissions of pollutant "x" (t);

AD – Copper production (t Copper);

EF_x – Emission factor of pollutant "x" (kg/t Copper).

For PCDD/F (Dioxins and Furans):

$$Emis_{PCDD/F} = AD \times \frac{EF_{PCDD/F}}{1 \times 10^6}$$

Where:

$Emi_{PCDD/F}$ – Emissions of dioxins and furans (g I-TEQ);

AD – Copper production (t Copper);

EF_x – Emission factor of dioxins and furans (µg I-TEQ/t Copper).

For PCB:

$$Emis_{HCB} = AD \times \frac{EF_{HCB}}{1000}$$

Where:

Emi_{HCB} – Emissions of PCB (kg);

AD – Copper production (t Copper);

EF_{PCB} – Emission factor of PCB (µg/t Copper).

4.1.3.7.2 Emission Factors

Table 4.36 – 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 4.37 – 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%	

4.1.3.7.3 Activity Data

There is only secondary Copper production in Portugal.

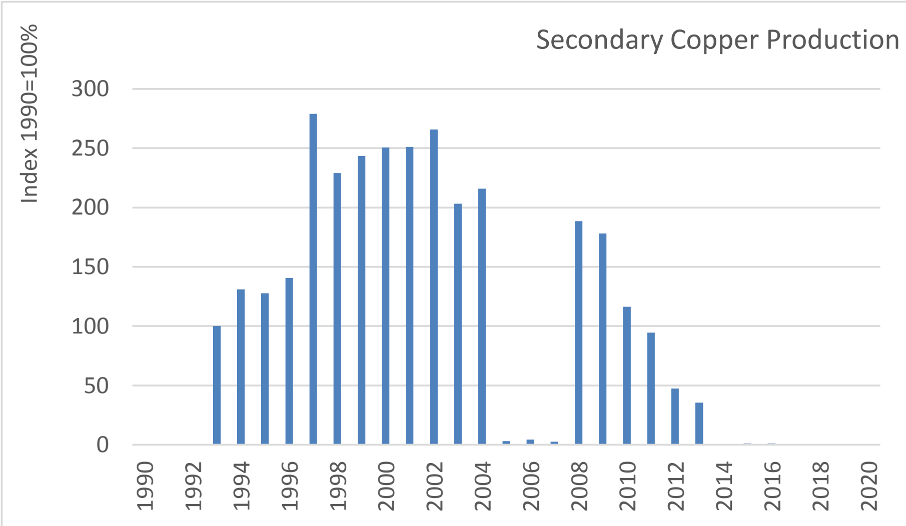
In the period 1990-1991, data was estimated based on 1992 production and on gross domestic product trend.

In the period 1992-2007, data on secondary Copper production was obtained from National Statistics.

From 2008 onwards, data was obtained from Eurostat.

Due to confidentiality constraints data is presented as an index value related to 1990 production.

Figure 4.33 – Secondary Copper production (Index 1990=100%)



4.1.3.7.4 Recalculations

This sector has been estimated for the first time.

4.1.3.7.5 Further Improvements

Secondary copper production data will be analyzed in order to better understand the reasons behind the sharp decrease in the 2005-2007 period and from 2014 onwards.

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

4.1.3.8 Nickel Production (NFR 2.C.7.b – SNAP 040305)

According to National Statistics, there is no Nickel production in Portugal.

4.1.3.9 Other Metal Production (NFR 2.C.7.c – SNAP 040309z)

There is no other metal production in Portugal.

4.1.3.10 Storage, Handling and Transport of Metal Products (NFR 2.C.7.d – SNAP 041000)

4.1.3.10.1 Methodology

Emissions from Handling of Metal Products were estimated in accordance with EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2016).

For TSP, PM_{10} and $PM_{2.5}$:

$$Emis_x = AD \times \frac{EF_x}{1 \times 10^6}$$

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. This will be a further improvement.

4.1.3.10.2 Emission Factors

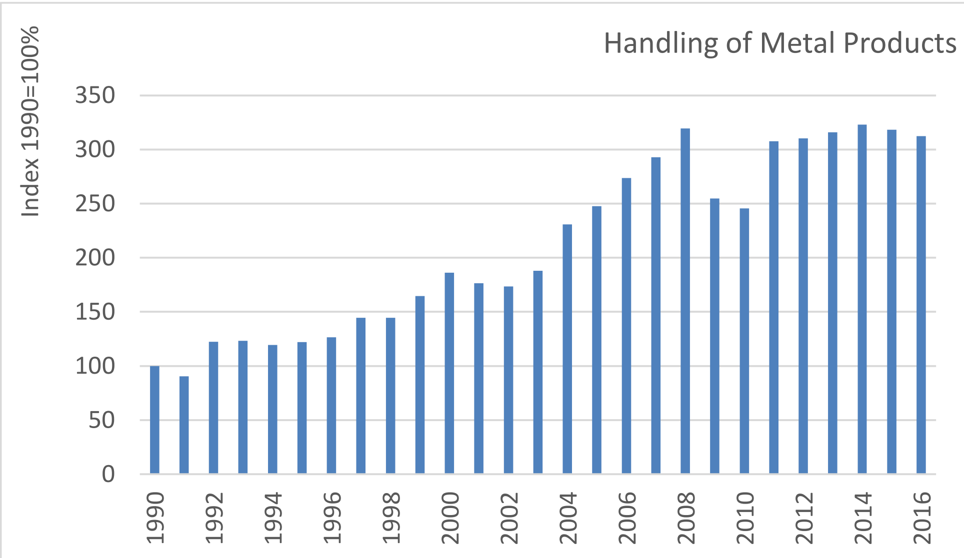
Table 4.38 – Emission factors

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	

1.1.1.1.2 Activity Data

Due to confidentiality constraints data is presented as an index value related to 1990 production.

Figure 4.34 – Metal products handled (Index 1990=100%)



4.1.3.10.3 Recalculations

This sector has been estimated for the first time.

4.1.3.10.4 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.

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

4.1.4.1 Domestic solvent use including fungicides (NFR 2.D.3.a)

4.1.4.1.1 Methodology

NMVOC's are used in a large number of products sold for use by the public. 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.

Emission from this sector were calculated using a Tier 2 approach. Due to lack of information on product types, it were used per-capita emission factors.

$$NMVOC_i = Population_i \times EF_{NMVOC}/1000$$

where:

$NMVOC_i$ - Emissions of NMVOC associated to the use of domestic products containing solvents [t]

$Population_i$ – inhabitants in year i;

EF_{NMVOC} - Emission factor associated with the use of domestic products containing solvents [kg/person/year]

4.1.4.1.2 Emission Factors

Emission factors for NMVOC were obtained from EMEP/CORINAIR Guidebook, 2016. Due to lack of information on product types, it were used per-capita emission factors (Table 3.5 of volume "2.D.3.a Domestic solvent use including fungicides").

We start using Tier 2 Hg emission factor (Table 3.6 of volume "2.D.3.a Domestic solvent use including fungicides").

Table 4.39 – Tier 2 NMVOC emission factors.

Description	Unit	Value	Source
Household products (aerosol)	g/person	200	Table 3.5 of volume "2.D.3.a Domestic solvent use including fungicides"of EMEP/EEA guidebook 2016
Household (cleaning) products – aerosol	g/person	201	Table 3.5 of volume "2.D.3.a Domestic solvent use including fungicides"of EMEP/EEA guidebook 2016
Household (cleaning) products – non aerosol	g/person	252	Table 3.5 of volume "2.D.3.a Domestic solvent use including fungicides"of EMEP/EEA guidebook 2016
Car care product - aerosol	g/person	161	Table 3.5 of volume "2.D.3.a Domestic solvent use including fungicides"of EMEP/EEA guidebook 2016
Car care product – non aerosol	g/person	303	Table 3.5 of volume "2.D.3.a Domestic solvent use including fungicides"of EMEP/EEA guidebook 2016
Cosmetics and toiletries - aerosol	g/person	355	Table 3.5 of volume "2.D.3.a Domestic solvent use including fungicides"of EMEP/EEA guidebook 2016
Cosmetics and toiletries – non aerosol	g/person	494	Table 3.5 of volume "2.D.3.a Domestic solvent use including fungicides"of EMEP/EEA guidebook 2016
DIY/buidlings – adhesives	g/person	76	Table 3.5 of volume "2.D.3.a Domestic solvent use including fungicides"of EMEP/EEA guidebook 2016
DIY/buidlings – paint thinner	g/person	205	Table 3.5 of volume "2.D.3.a Domestic solvent use including fungicides"of EMEP/EEA guidebook 2016
DIY/buidlings – paint and varnish removers, solvents	g/person	68	Table 3.5 of volume "2.D.3.a Domestic solvent use including fungicides"of EMEP/EEA guidebook 2016
DIY/buidlings – sealants, filling agents	g/person	23	Table 3.5 of volume "2.D.3.a Domestic solvent use including fungicides"of EMEP/EEA guidebook 2016
Pharmaceutical products	g/person	48	Table 3.5 of volume "2.D.3.a Domestic solvent use including fungicides"of EMEP/EEA guidebook 2016
Pesticides	g/person	76	Table 3.5 of volume "2.D.3.a Domestic solvent use including fungicides"of EMEP/EEA guidebook 2016

Table 4.40 – Tier 2 Hg emission factor.

Description	Unit	Value	Source
Fluorescent tubes	mg/person	5.6	Table 3.6 of volume "2.D.3.a Domestic solvent use including fungicides"of EMEP/EEA guidebook 2016

4.1.4.1.3 Activity Data

Table 4.41 - Activity data (inhabitants)

Description	1990	1995	2000	2005	2010	2016
Inhabitants (National Total) *	9 983 200	10 026 200	10 289 900	10 503 300	10 573 101	10 325 452
Inhabitants (For Compliance Assessment)	9 513 027	9 5554 002	9 805 283	10 008 632	10 058 932	9 824 277

*Source: National Statistics Institute (INE)

4.1.4.1.4 Recalculations

We start using Tier 2 per-capita NMVOC emission factors (Table 3.5 of volume “2.D.3.a Domestic solvent use including fungicides”of EMEP/EEA guidebook 2016) and Tier 2 Hg emission factor (Table 3.6 of volume “2.D.3.a Domestic solvent use including fungicides”of EMEP/EEA guidebook 2016).

4.1.4.2 Road Paving with Asphalt (NFR 2.D.3.b)

4.1.4.2.1 Overview

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.

Roads 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 (150º-160º)[36]. 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 (40-60º).

Asphalt emulsions are mixtures of asphalt cement with water and emulsifiers[37]. 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/naphta (Rapid Cure).

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

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

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 percent 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 percent 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)[38]. 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[39].

Emissions during production of emulsions, cutback binders and cold mix asphalt concretes are not estimated and assumed negligible[40].

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.

4.1.4.2.2 Methodology

Ultimate carbon dioxide emissions are calculated assuming that solvents are 100 per cent composed of VOC (USEPA, 2001) and that emitted VOC have on average 60 per cent of carbon[41]:

$$Emi_{CO2} = 44 / 12 * 0.60 * Emi_{NMVOC}$$

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

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

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

[40] 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.

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

4.1.4.2.2.1 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 formula was used to estimate emissions from this source, and were adapted from (USEPA, 1997; USEPA, 2001):

$$Emi_{NMVOC\ (y)} = Cure_{FC} * Binder_{(y)} * d_{Bin}^{-1} * SLV_{Fac} * d_{SLV}$$

where

$Emi_{NMVOC\ (y)}$ - Emissions of NMVOC from asphalt application during year y (t/yr);

Binder (y) – Total quantity of asphalt binder used in road paving during year y (t/yr);

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, expressing the percentage of total distillate that evaporates as emission (l/l).

4.1.4.2.2.2 Hot Mix Asphalt Production

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

$$Emi_{(p,y)} = Hotmix_{Batch\ (y)} * EF_{(p)} + Hotmix_{Drum\ (y)} * EF_{(p)}$$

Where,

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

$Hotmix_{Batch\ (y)}$ and $Hotmix_{Drum\ (y)}$ – Production of Hot mix asphalt, respectively in discontinuous (batch) and continuous (drum) plants (t/yr);

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

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.

4.1.4.2.3 Emission Factors

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

Table 4.42 – 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 next table.

Table 4.43 –- 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

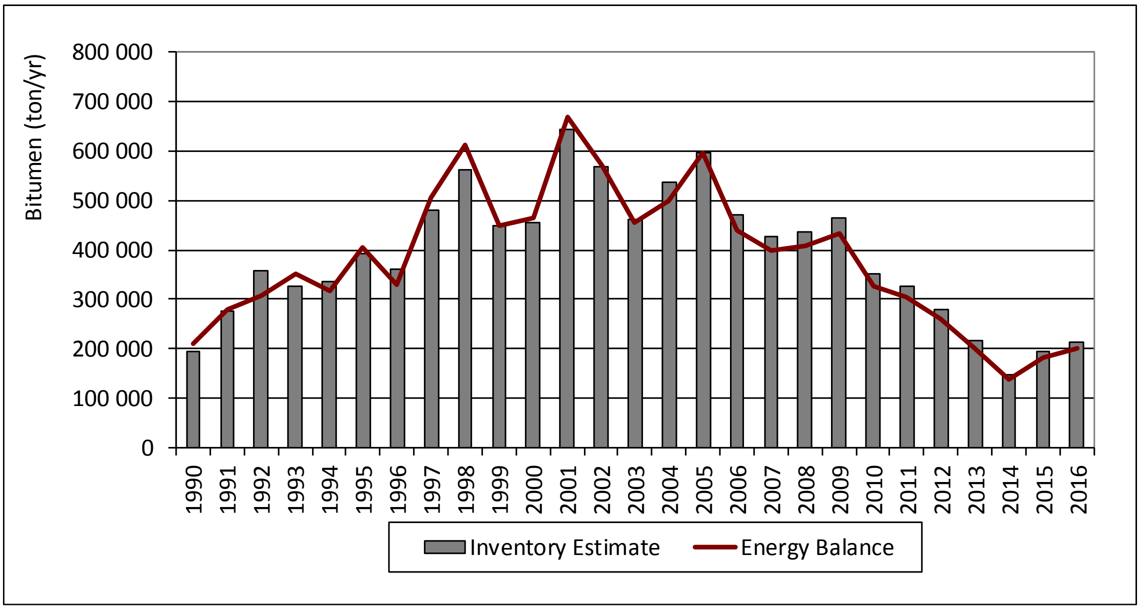
Source: USEPA (2000)

4.1.4.2.4 Activity Data

The total quantity of bitumen sold to construction and building economic sector is available from the Energy Balance and was collected by the General Directorate of Energy and Geology (DGEG) based on surveys[42], 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.

[42] 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 4.35 – 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 percentage of that bitumen that is emulsions. It was also assumed that this percentage was zero in 1990 and has increased to 19 per cent 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 per cent 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.

Figure 4.36 – Quantities of asphalt binders (cutback and emulsified asphalts) consumed in Portugal

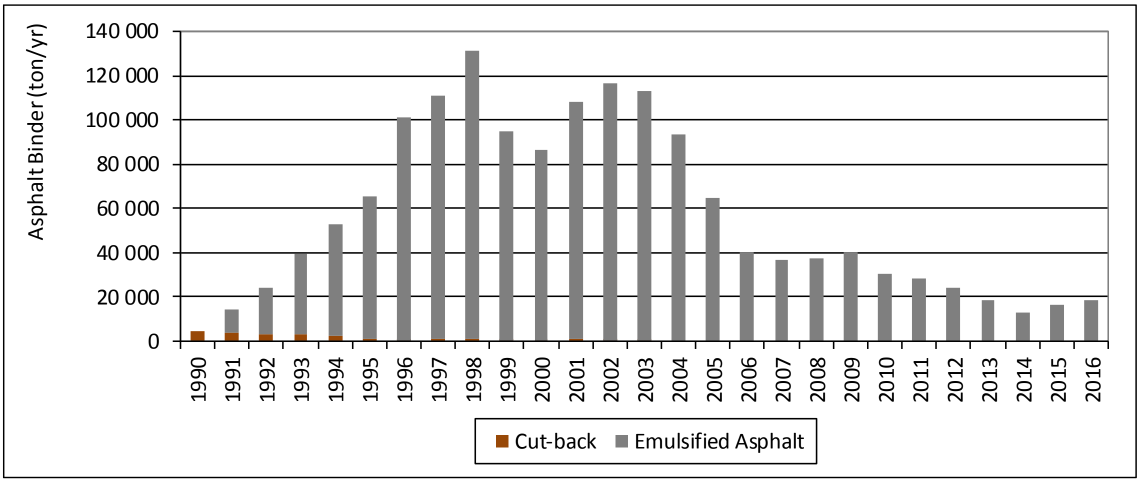
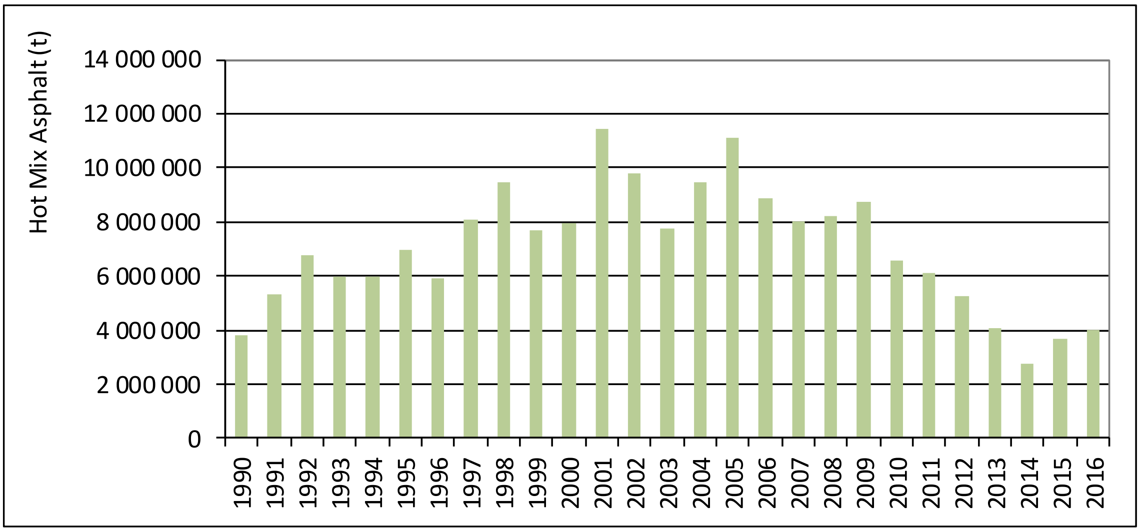


Figure 4.37 – Total Production of Hotmix Asphalt



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 per cent continuous equipment and 54 per cent 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.

4.1.4.2.5 Recalculations

No recalculations were made.

4.1.4.2.6 Further Improvements

No further improvements are planned.

4.1.4.3 Asphalt Roofing (NFR 2.D.3.c)

4.1.4.3.1 Methodology

$$Emis = (Prod + Imp - Exp) \times \frac{EF}{1 \times 10^6}$$

where:

Emis – 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 – Emission factor of pollutant "x" (g/t of asphalt roofing products).

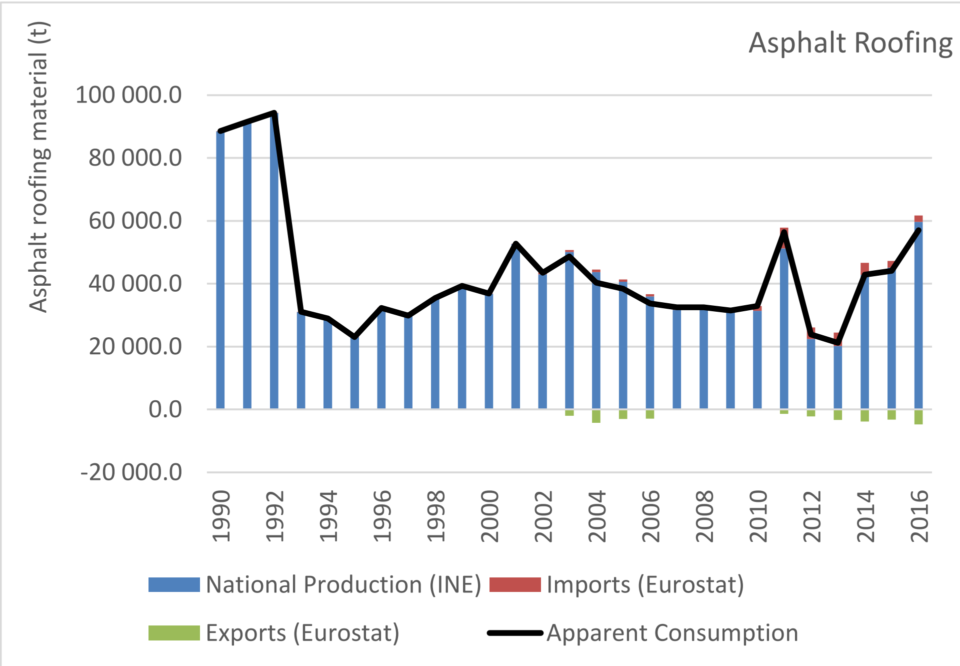
4.1.4.3.2 Emission Factors

Table 4.44 – 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	

4.1.4.3.3 Activity Data

Figure 4.38 – Asphalt roofing materials production, imports, exports and apparent consumption



Asphalt roofing materials national production was obtained from national statistics in the periods 1992-2007 and from 2011 onwards. In the period 1990-1991, data has been estimated based on 1992 production and on gross domestic trend. In the period 2008-2010, due to statistical inconsistencies, data has been estimated based on 2007 production and on gross domestic 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).

Imports and exports data was obtained from Eurostat database from 1995 onwards. In the period 1990-1994, imports and exports data has been estimated based on 1995 data and on gross domestic product trend.

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.

4.1.4.3.4 Recalculations

This sector was not previously accounted.

4.1.4.3.5 Further Improvements

Efforts will be made to better understand the reasons behind the sharp decrease (National statistics) in asphalt roofing materials from 1992 to 1993.

4.1.4.4 Coating applications/Paint Applications (NFR 2.D.3.d)

4.1.4.4.1 Manufacture of automobiles (NFR 2.D.3.d - SNAP 060101)

4.1.4.4.1.1 Methodology

Emissions were estimated according to:

$$Emis_{NMVOC} = AD \times \frac{EF_{NMVOC}}{1000} \times (100\% - Eff_{Abat\ Techn})$$

Where:

Emi_{NMVOC} – NMVOC emissions (t);

AD – Number of cars manufactured (Number of cars);

EF_{NMVOC} – NMVOC emission factor (kg NMVOC/car);

$Eff_{Abat\ Techn}$ – Efficiency of Abatement Technology Mix (%).

4.1.4.4.1.2 Emission Factors

Table 4.45 – 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 4.46 – 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 4.47 – % Efficiency of the abatement technology mix

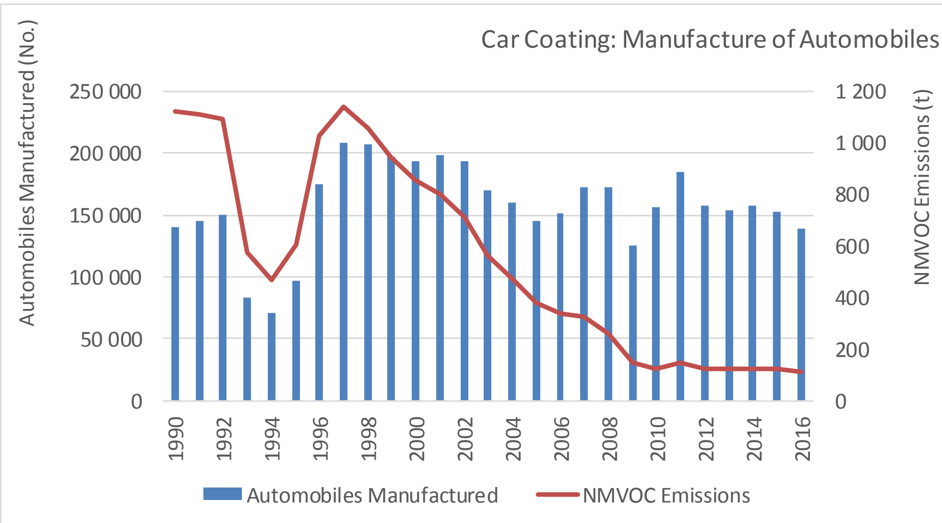
Technology	Unit	1990	1995	2000	2005	2010	2015	2016
Manufacture of automobiles-Vehicles-Process modification and substitution	% Efficiency of Abatement technology mix	0.0	22.5	45.0	67.5	90.0	90.0	90.0

Table 4.48 – Final emission factor

Parameter	Unit	1990	1995	2000	2005	2010	2015	2016
Final EF Car coating	kg/car	8.0	6.2	4.4	2.6	0.8	0.8	0.8

4.1.4.4.1.3 Activity Data

Figure 4.39 – Number of cars manufactured (No.)



4.1.4.4.1.4 Recalculations

This sector has been revised in order to apply the EMEP/EEA air pollutant emission inventory guidebook 2016 guidelines emission factors and respective abatement technologies.

4.1.4.4.1.5 Further Improvements

No further improvements are expected.

4.1.4.4.2 Car Repairing (NFR 2.D.3.d - SNAP 060102)

4.1.4.4.2.1 Methodology

Emissions were estimated according to:

$$Emis_{NMVOC} = AD \times \frac{EF_{NMVOC}}{1000} \times (100\% - Eff_{Abat\ Techn})$$

Where:

Emi_{NMVOC} – NMVOC emissions (t);

AD – Paint consumption (t paint);

EF_{NMVOC} – NMVOC emission factor (kg NMVOC/t paint);

$Eff_{Abat\ Techn}$ – Efficiency of Abatement Technology Mix (%).

4.1.4.4.2.2 Emission Factors

Table 4.49 – 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 4.50 – 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 4.51 – % Efficiency of the abatement technology mix

SNAP	Unit	1990	1995	2000	2005	2010	2015	2016
Coating Applications: Car Repairing	% Efficiency of abatement technology mix	0.0	17.0	34.0	49.5	65.0	67.5	68.0

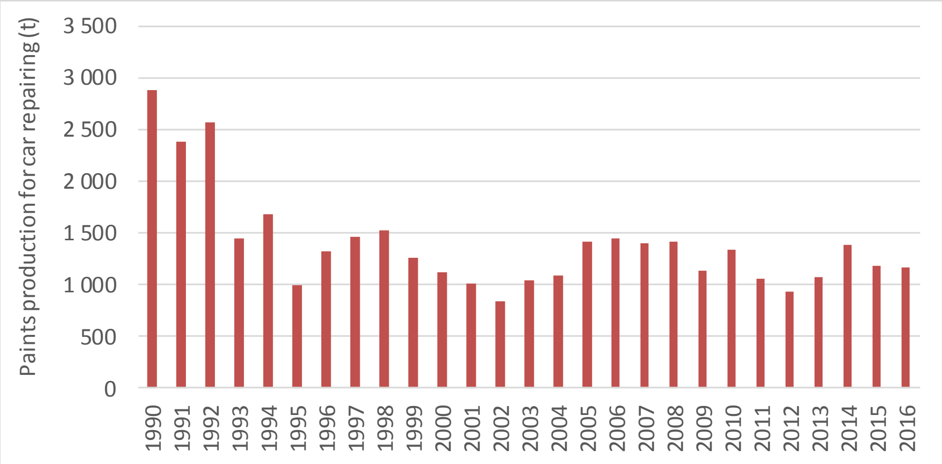
Table 4.52 – Final emission factor

Parameter	Unit	1990	1995	2000	2005	2010	2015	2016
Final EF Car coating	kg/t paint	720	598	475	364	252	234	230

4.1.4.4.2.3 Activity Data

Data on paint production for car repairing was obtained from national statistics (IAPI) in the period 1990-2006. From 2007 onwards, data has been estimated based on synthetic polymers paints production trend.

Figure 4.40 – Paints production for car repairing (t)



4.1.4.4.2.4 Recalculations

This sector has been revised in order to apply the EMEP/EEA air pollutant emission inventory guidebook 2016 guidelines emission factors and respective abatement technologies.

4.1.4.4.2.5 Further Improvements

No further improvements are expected.

4.1.4.4.3 Construction and buildings (NFR 2.D.3.d - SNAP 060103)

4.1.4.4.3.1 Methodology

Emissions were estimated according to:

$$Emis_{NMVOC} = AD \times \frac{EF_{NMVOC}}{1000} \times (100\% - Eff_{Abat\ Techn})$$

Where:

Emi_{NMVOC} – NMVOC emissions (t);

AD – Paint consumption (t paint);

EF_{NMVOC} – NMVOC emission factor (kg NMVOC/t paint);

$Eff_{Abat\ Techn}$ – Efficiency of Abatement Technology Mix (%).

4.1.4.4.3.2 Emission Factors

Table 4.53 – 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 4.54 – Abatement technology

Abatement Technology	Efficiency
Substitution with dispersion/emulsion (2-3 wt-% solvent)	39
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

Source: (Table 3-17 of chapter "2.D.3.d Coating applications" of "EMEP/EEA air pollutant emission inventory guidebook 2016")

Table 4.55 – Share of each abatement technology over time

Technology	Unit	1990	1995	2000	2005	2010	2015	2016
Substitution with dispersion/emulsion (2-3 wt-% solvent)	%	0	0	100	50	0	0	0
Substitution with water-based paints (efficiency 80%)	%	0	100	0	0	0	0	0
Substitution with high solids paints (efficiency 40-60%)	%	100	0	0	0	0	0	0
Substitution with dispersion/emulsion and water-based paints	%	0	0	0	0	0	0	0
Substitution with dispersion/emulsion and high solids paints	%	0	0	0	0	0	0	0
Substitution with dispersion/emulsion, water-based and high solids paints	%	0	0	0	50	100	100	100

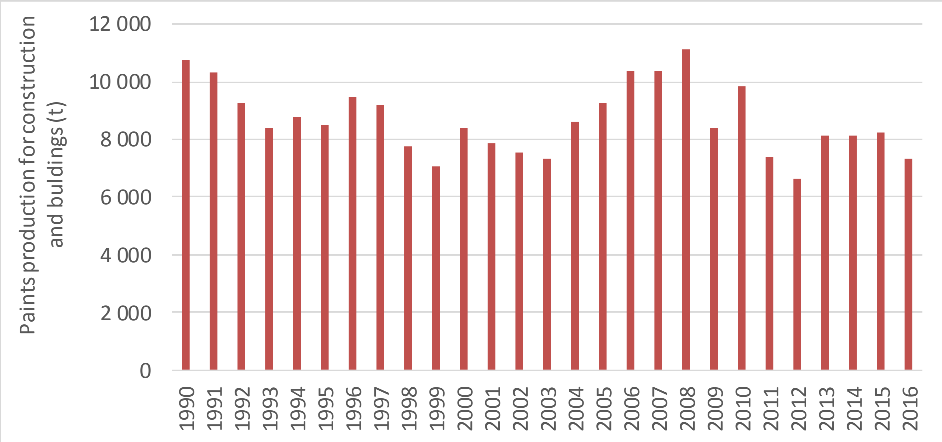
Table 4.56 – Final emission factor

Parameter	Unit	1990	1995	2000	2005	2010	2015	2016
Final EF	kg/t paint	221	170	140	105	69	69	69

4.1.4.4.3.3 Activity Data

Data on paint production for construction and buildings was obtained from national statistics (IAPI) in the period 1990-2003. From 2004 onwards, data has been estimated based on synthetic polymers paints production trend.

Figure 4.41 – Paints production for construction and buildings (t)



4.1.4.4.3.4 Recalculations

This sector has been revised in order to apply the EMEP/EEA air pollutant emission inventory guidebook 2016 guidelines emission factors and respective abatement technologies.

4.1.4.4.3.5 Further Improvements

No further improvements are expected.

4.1.4.4.4 Domestic Use (NFR 2.D.3.d - SNAP 060104)

4.1.4.4.4.1 Methodology

Emissions were estimated according to:

$$Emis_{NMVOC} = AD \times \frac{EF_{NMVOC}}{1000} \times (100\% - Eff_{Abat\ Techn})$$

Where:

Emi_{NMVOC} – NMVOC emissions (t);

AD – Paint consumption (t paint);

EF_{NMVOC} – NMVOC emission factor (kg NMVOC/t paint);

$Eff_{Abat\ Techn}$ – Efficiency of Abatement Technology Mix (%).

4.1.4.4.4.2 Emission Factors

Table 4.57 – 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 4.58 – Abatement technology

Abatement Technology	Efficiency
Substitution with dispersion/emulsion (2-3 wt-% solvent)	39
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

Source: (Table 3-17 of chapter "2.D.3.d Coating applications" of "EMEP/EEA air pollutant emission inventory guidebook 2016")

Table 4.59 – Share of each abatement technology over time

Technology	Unit	1990	1995	2000	2005	2010	2015	2016
Substitution with dispersion/emulsion (2-3 wt-% solvent)	%	0	0	100	50	0	0	0
Substitution with water-based paints (efficiency 80%)	%	0	100	0	0	0	0	0
Substitution with high solids paints (efficiency 40-60%)	%	100	0	0	0	0	0	0
Substitution with dispersion/emulsion and water-based paints	%	0	0	0	0	0	0	0
Substitution with dispersion/emulsion and high solids paints	%	0	0	0	0	0	0	0
Substitution with dispersion/emulsion, water-based and high solids paints	%	0	0	0	50	100	100	100

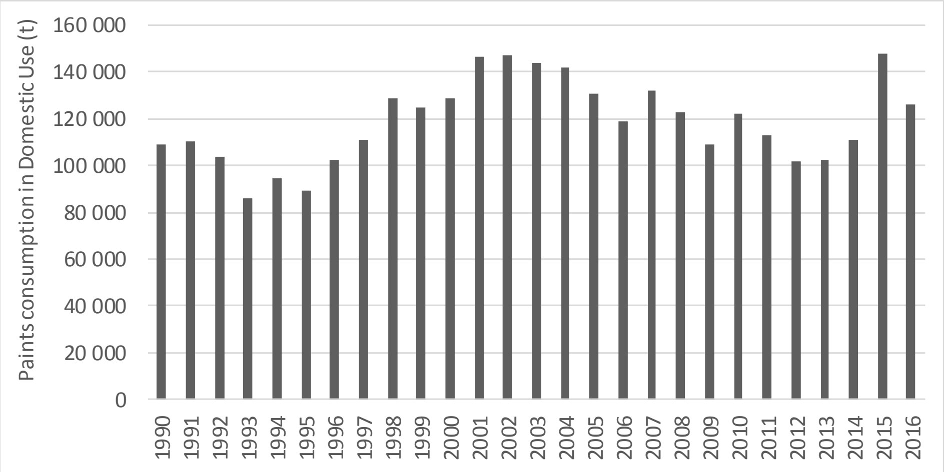
Table 4.60 – Final emission factor

Parameter	Unit	1990	1995	2000	2005	2010	2015	2016
Final EF	g/kg paint applied	221	170	140	105	69	69	69

4.1.4.4.4.3 Activity Data

Data not considered in the other subcategories of "Coating Applications" is considered in Domestic Use.

Figure 4.42 – Paints consumption in domestic use (t)



4.1.4.4.4.4 Recalculations

This sector has been revised in order to apply the EMEP/EEA air pollutant emission inventory guidebook 2016 guidelines emission factors and respective abatement technologies.

4.1.4.4.4.5 Further Improvements

No further improvements are expected.

4.1.4.4.5 Coil Coating (NFR 2.D.3.d - SNAP 060105)

4.1.4.4.5.1 Methodology

Emissions were estimated according to:

$$Emis_{NMVOC} = AD \times \frac{EF_{NMVOC}}{1000} \times (100\% - Eff_{Abat\ Techn})$$

Where:

Emi_{NMVOC} – NMVOC emissions (t);

AD – Coil coatings application (t coil coating);

EF_{NMVOC} – NMVOC emission factor (kg NMVOC/t coil coating);

$Eff_{Abat\ Techn}$ – Efficiency of Abatement Technology Mix (%).

4.1.4.4.5.2 Emission Factors

Table 4.61 – 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 4.62 – 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 4.63 – Share of each abatement technology over time

Technology	Unit	1990	1995	2000	2005	2010	2015	2016
No abatement technology	%	30.0	15.0	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	8.5	7.8
Coil coating line with powder coating systems (solvent free)	%	20.0	35.0	50.0	69.0	88.0	91.5	92.2

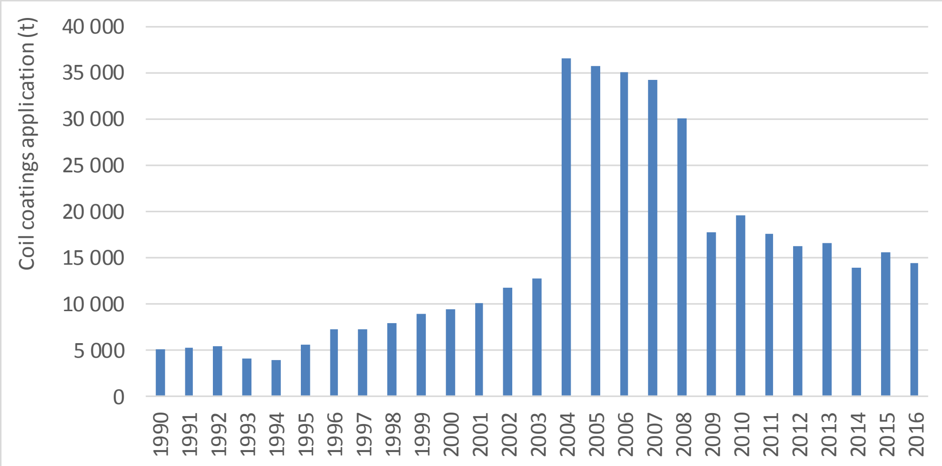
Table 4.64 – Final emission factor

Parameter	Unit	1990	1995	2000	2005	2010	2015	2016
Final EF	Kg/t coil coating	221	170	140	105	69	69	69

4.1.4.4.5.3 Activity Data

Data on coil coatings application was obtained from national statistics (IAPI) in the period 1992-2003. In the period 1990-1991, data has been estimated based on gross domestic product trend. From 2004 onwards, data has been estimated based on total paints production trend.

Figure 4.43 – Coil coatings application (t)



4.1.4.4.5.4 Recalculations

This sector has been revised in order to apply the EMEP/EEA air pollutant emission inventory guidebook 2016 guidelines emission factors and respective abatement technologies.

4.1.4.4.5.5 Further Improvements

No further improvements are expected.

4.1.4.4.6 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.

4.1.4.4.7 Wood (NFR 2.D.3.d - SNAP 060107)

4.1.4.4.7.1 Methodology

Emissions were estimated according to:

$$Emis_{NMVOC} = AD \times \frac{EF_{NMVOC}}{1000} \times (100\% - Eff_{Abat\ Techn})$$

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 (%).

4.1.4.4.7.2 Emission Factors

Table 4.65 – 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 4.66 – 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 4.67 – Share of each abatement technology over time

Technology	Unit	1990	1995	2000	2005	2010	2015	2016
Uncontrolled	%	13.99	13.99	13.99	13.74	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
High solids system (20% solvent content)	%	38.13	38.13	38.13	38.38	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
Add-on: Thermal oxidation	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00

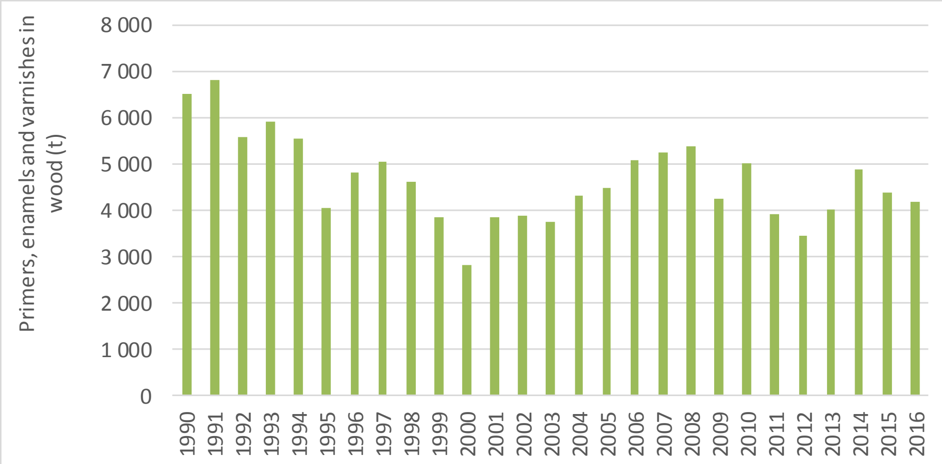
Table 4.68 – Final emission factor

Parameter	Unit	1990	1995	2000	2005	2010	2015	2016
Final EF	g/kg material applied	211.2	211.2	211.2	209.7	153.4	153.4	153.4

4.1.4.4.7.3 Activity Data

Data on primers, enamels and varnishes use in wood were obtained from national statistics (IAPI) in the period 1990-2003. From 2004 onwards, data has been estimated based on synthetic polymers paints production trend.

Figure 4.44 – Primers, enamels and varnishes use in wood (t)



4.1.4.4.7.4 Recalculations

This sector has been revised in order to apply the EMEP/EEA air pollutant emission inventory guidebook 2016 guidelines emission factors and respective abatement technologies.

4.1.4.4.7.5 Further Improvements

No further improvements are expected.

4.1.4.4.8 Truck/Van coating (NFR 2.D.3.d - SNAP 060108)

4.1.4.4.8.1 Methodology

Emissions were estimated according to:

$$Emis_{NMVOC} = AD \times \frac{EF_{NMVOC}}{1000}$$

Where:

Emi_{NMVOC} – NMVOC emissions (t);

AD – Number of cars manufactured (Number of vehicles);

EF_{NMVOC} – NMVOC emission factor (kg NMVOC/vehicle).

4.1.4.4.8.2 Emission Factors

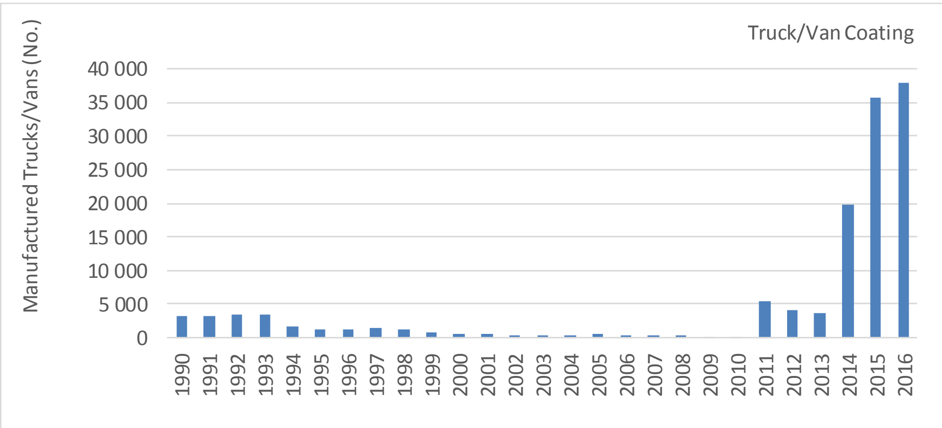
Table 4.69 – Default emission factor

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"

4.1.4.4.8.3 Activity Data

The number of trucks/vans assembled each year was obtained from national statistics (IAPI) from 1992 onwards. In the period 1990-1991, data has been estimated based on gross domestic product trend.

Figure 4.45 – Number of vehicles manufactured (No.)



4.1.4.4.8.4 Recalculations

This sector has been revised in order to apply the EMEP/EEA air pollutant emission inventory guidebook 2016 guidelines emission factors and respective abatement technologies.

4.1.4.4.8.5 Further Improvements

No further improvements are expected.

4.1.4.4.9 Truck cabin coating (NFR 2.D.3.d - SNAP 060108)

4.1.4.4.9.1 Methodology

Emissions were estimated according to:

$$Emis_{NMVOC} = AD \times \frac{EF_{NMVOC}}{1000}$$

Where:

Emi_{NMVOC} – NMVOC emissions (t);

AD – Number of cars manufactured (Number of vehicles);

EF_{NMVOC} – NMVOC emission factor (kg NMVOC/vehicle).

4.1.4.4.9.2 Emission Factors

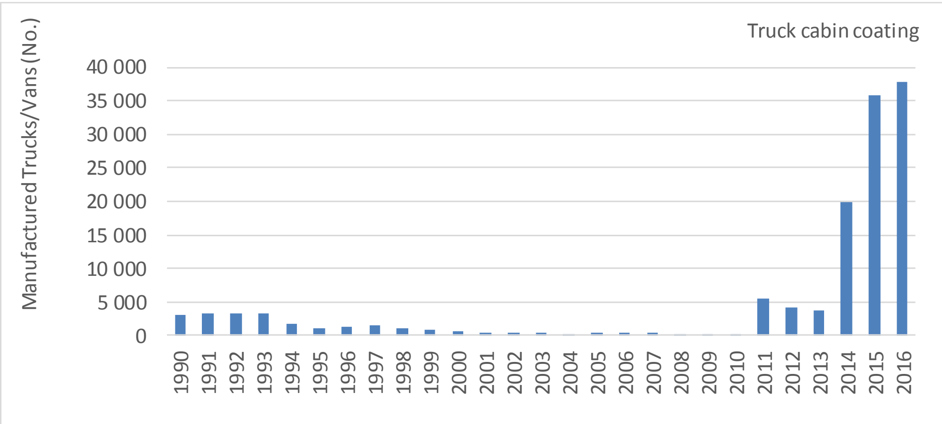
Table 4.70 – Default emission factor

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”

4.1.4.4.9.3 Activity Data

The number of truck cabins assembled each year was obtained from national statistics (IAPI) from 1992 onwards. In the period 1990-1991, data has been estimated based on gross domestic product trend.

Figure 4.46 – Number of truck cabins manufactured (No.)



4.1.4.4.9.4 Recalculations

This sector has been revised in order to apply the EMEP/EEA air pollutant emission inventory guidebook 2016 guidelines emission factors and respective abatement technologies.

4.1.4.4.9.5 Further Improvements

No further improvements are expected.

4.1.4.4.10 Bus coating (NFR 2.D.3.d - SNAP 060108)

4.1.4.4.10.1 Methodology

Emissions were estimated according to:

$$Emis_{NMVOC} = AD \times \frac{EF_{NMVOC}}{1000}$$

Where:

Emi_{NMVOC} – NMVOC emissions (t);

AD – Number of vehicles manufactured (Number of vehicles);

EF_{NMVOC} – NMVOC emission factor (kg NMVOC/vehicle).

4.1.4.4.10.2 Emission Factors

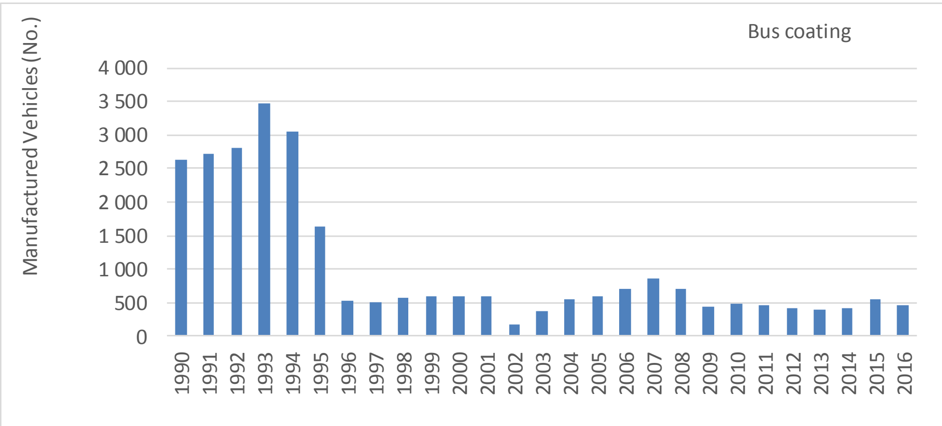
Table 4.71 – Default emission factor

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"

4.1.4.4.10.3 Activity Data

The number of vehicles assembled each year was obtained from national statistics (IAPI) from 1992 onwards. In the period 1990-1991, data has been estimated based on gross domestic product trend.

Figure 4.47 – Number of vehicles manufactured (No.)



4.1.4.4.10.4 Recalculations

This sector has been revised in order to apply the EMEP/EEA air pollutant emission inventory guidebook 2016 guidelines emission factors and respective abatement technologies.

4.1.4.4.10.5 Further Improvements

No further improvements are expected.

4.1.4.4.11 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).

4.1.4.4.12 Leather finishing (NFR 2.D.3.d - SNAP 060108)

4.1.4.4.12.1 Methodology

Emissions were estimated according to:

$$Emis_{NMVOC} = AD \times \frac{EF_{NMVOC}}{1000} \times (100\% - Eff_{Abat\ Techn})$$

Where:

Emi_{NMVOC} – NMVOC emissions (t);

AD – Leather production (t leather);

EF_{NMVOC} – NMVOC emission factor (kg NMVOC/t leather);

$Eff_{Abat\ Techn}$ – Efficiency of Abatement Technology Mix (%).

4.1.4.4.12.2 Emission Factors

Table 4.72 – Default emission factor

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

Source: (EMEP/EEA, 2016)

Table 4.73 – 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 4.74 – Control strategy

Technology	Unit	1990	1995	2000	2005	2010	2015	2016
Use of water based products (30 wt-% solvent content)	%	0	0	0	10	30	50	50
Add on: Thermal oxidation	%	0	0	0	0	0	0	0
Add on: Biofiltration	%	0	0	0	0	5	5	5
Uncontroled	%	100	100	100	90	65	45	45

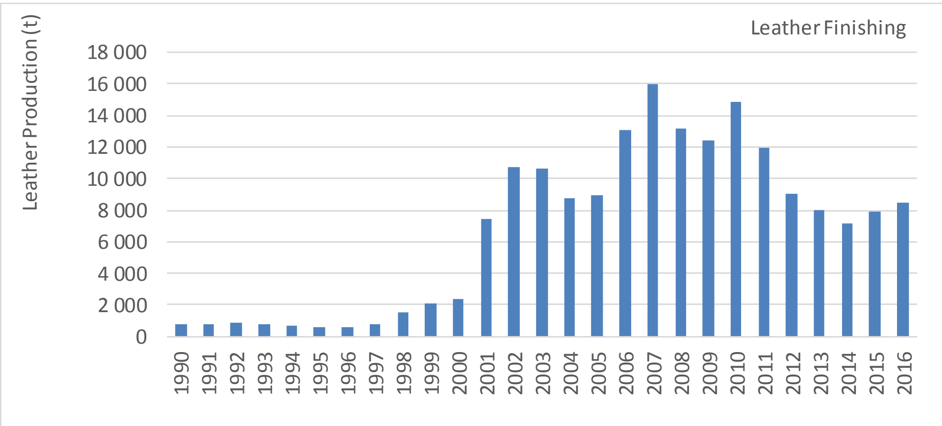
Table 4.75 – Final emission factor

Parameter	Unit	1990	1995	2000	2005	2010	2015	2016
Final EF leather finishing	kg/t leather	200.0	200.0	200.0	187.0	152.9	126.9	126.9

4.1.4.4.12.3 Activity Data

The leather production data was obtained from national statistics (IAPI) from 1992 onwards. In the period 1990-1991, data has been estimated based on gross domestic product trend.

Figure 4.48 – Leather production (t)



4.1.4.4.12.4 Recalculations

This sector has been revised in order to apply the EMEP/EEA air pollutant emission inventory guidebook 2016 guidelines emission factors and respective abatement technologies.

4.1.4.4.12.5 Further Improvements

No further improvements are expected.

4.1.4.4.13 Other Industrial Applications (NFR 2.D.3.d - SNAP 060108)

4.1.4.4.13.1 Methodology

Emissions were estimated according to:

$$Emis_{NMVOC} = AD \times \frac{EF_{NMVOC}}{1000} \times (100\% - Eff_{Abat\ Techn})$$

Where:

Emi_{NMVOC} – NMVOC emissions (t);

AD – Paint applied (t paint);

EF_{NMVOC} – NMVOC emission factor (kg NMVOC/t paint);

$Eff_{Abat\ Techn}$ – Efficiency of Abatement Technology Mix (%).

4.1.4.4.13.2 Emission Factors

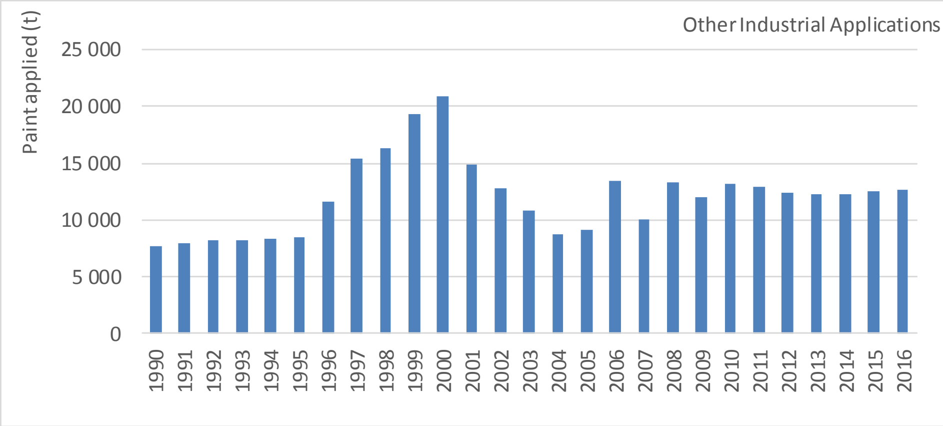
Table 4.76 – Default emission factor (Tier 1)

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”

4.1.4.4.13.3 Activity Data

The leather production data was obtained from national statistics (IAPI) in the period 1995-2010. In the period 1990-1994 and from 2011 onwards, data has been estimated based on gross domestic product trend.

Figure 4.49 – Paint applied in Other Industrial Applications (t)



4.1.4.4.13.4 Recalculations

This sector has been revised in order to apply the EMEP/EEA air pollutant emission inventory guidebook 2016 guidelines emission factors and respective abatement technologies.

4.1.4.4.13.5 Further Improvements

No further improvements are expected.

4.1.4.5 Degreasing (NFR 2.D.3.e)

4.1.4.5.1 Overview

Degreasing refers to operation processes, usually realized 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 precedes normally the application of other treatment processes and occurs mainly in metal industry, plastics products manufacturing, rubber[43], textiles, glass, paper and fiber-glass, 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).

4.1.4.5.2 Methodology

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

where:

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

$Emis_{NMVOC}$ – NMVOC emissions (t);

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

Imp – Imports of metal degreasing substances (t);

Exp – Exports of metal degreasing substances (t);

EF – emission factor (kg NMVOC/t of metal degreasing substance).

4.1.4.5.3 Emission Factors

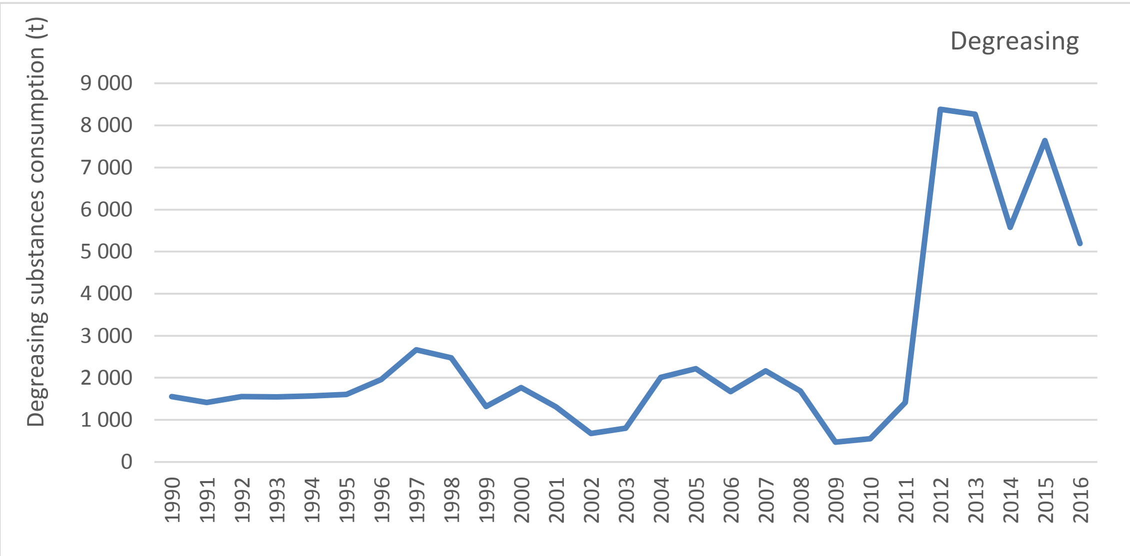
Table 4.77 – Emission Factor

Unit	Emission Factor	Source
kg NMVOC/ t cleaning product	460	2016 EMEP/EEA Guidebook (2.D.3.e Degreasing), Table 3-1

4.1.4.5.4 Activity Data

National production of metal degreasing substances was obtained from National Statistics (IAPI) from 1995 onwards. Data on imports and exports was obtained from Eurostat from 1995 onwards. Both national production and imports/exports data for the period 1990-1994 was estimated based on 1995 value and on gross domestic product trend for this period.

Figure 4.50 – Degreasing substances consumption (t) – total territory



From 2012 onwards there is a strong increase in m-xylene and p-xylene apparent consumption. The reasons for this strong increase will be discussed with national statistics authorities.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).

4.1.4.5.5 Recalculations

This sector has been completely revised (both emission factor, methodology and activity data).

4.1.4.5.6 Further Improvements

From 2012 onwards there is a strong increase in m-xylene and p-xylene apparent consumption. The reasons for this strong increase will be discussed with national statistics authorities.

4.1.4.6 Dry cleaning (NFR 2.D.3.f)

4.1.4.6.1 Overview

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.

4.1.4.6.2 Methodology

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

where:

App Cons = Apparent consumption of Perchloroethylene (t);

Production = National production of Perchloroethylene (t);

Imports = Imports of Perchloroethylene (t);

Exports = Exports of Perchloroethylene (t).

$$Emis_{NMVOC} = PER_{Cons} \times (EF_{OC} \times \%_{OC} + EF_{CC} \times \%_{CC})$$

where:

$Emis_{NMVOC}$ – NMVOC emissions;

PER_{Cons} – Percloroethylene apparent consumption (t);

EF_{OC} – Open circuit equipemt emission factor;

$\%_{OC}$ – Percentage of Open circuit equipments;

EF_{CC} – Closed circuit equipemt emission factor;

$\%_{CC}$ – Percentage of Closed circuit equipments;

4.1.4.6.3 Emission Factors

Table 4.78 – Emission Factors

Type of Equipment	Unit	Emission Factor	Source
Open Circuit	Kg NMVOC/ kg PER	0.8	2016 EMEP/EEA Guidebook (2.D.3.f Dry cleaning), page 6
Closed Circuit	Kg NMVOC/ kg PER	0.4	2016 EMEP/EEA Guidebook (2.D.3.f Dry cleaning), page 6

Table 4.79 - % of Open Circuit and Closed Circuit equipments

Type of Equipment	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999 onwards
Open Circuit	50	44	39	33	28	22	17	11	6	0
Closed Circuit	50	56	61	67	72	78	83	89	94	100

Source: INE

4.1.4.6.4 Activity Data

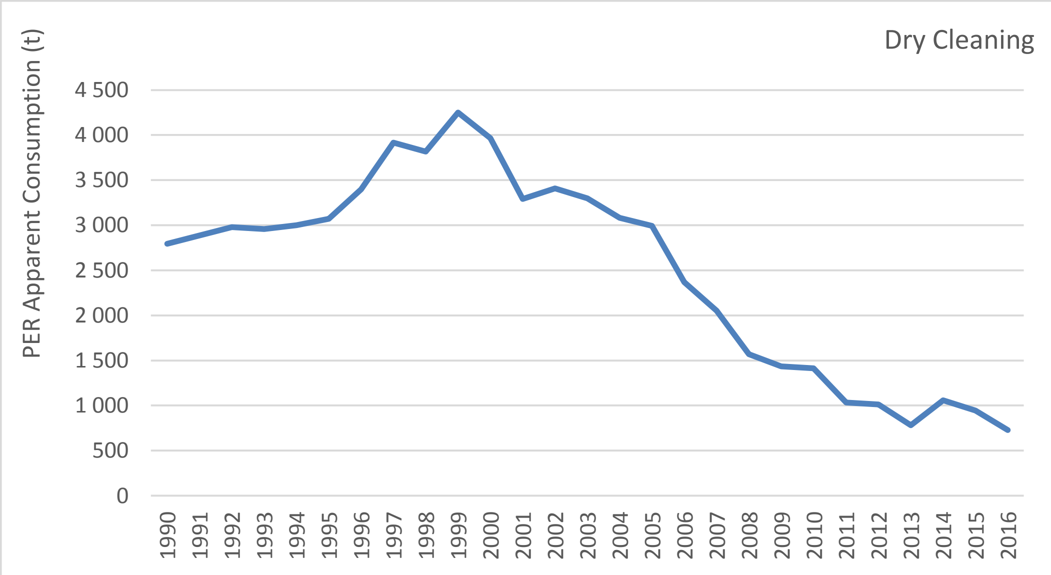
There is no available statistical information concerning consumption of solvents and other materials in dry cleaning activity, because this activity is not included under IAIT and IAPI industrial surveys. Therefore, it was assumed that all PER (Perchloroethylene)[44] consumed in Portugal is used in dry-cleaning[45] 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 gross domestic product trend.

[44] 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.

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

Figure 4.51 – Annual consumption of PER (Perchloroethylene) (t) – total territory



Emissions of Mainland Portugal represent 95.1% of the total territory. This share has been estimated based on the population.

4.1.4.6.5 Recalculations

The methodology and emission factors have been revised based on EMEP/EEA Guidebook 2016. The activity data have also been revised based on Eurostat data.

4.1.4.6.6 Further Improvements

No further improvements are planned for this sector.

4.1.4.7 Polyester processing (NFR 2.D.3.g - SNAP 060301)

4.1.4.7.1 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.

Emissions were estimated from the quantity of polyester processed according to:

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

Where:

$Emi_{NMVOC(y)}$ – NMVOC total emissions from polyester processing (t/yr);

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

$Prod_{FOAM(y)}$ – Quantity of monomer used y (t/yr).

4.1.4.7.2 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 4.80 – NMVOC foam processing emission factor

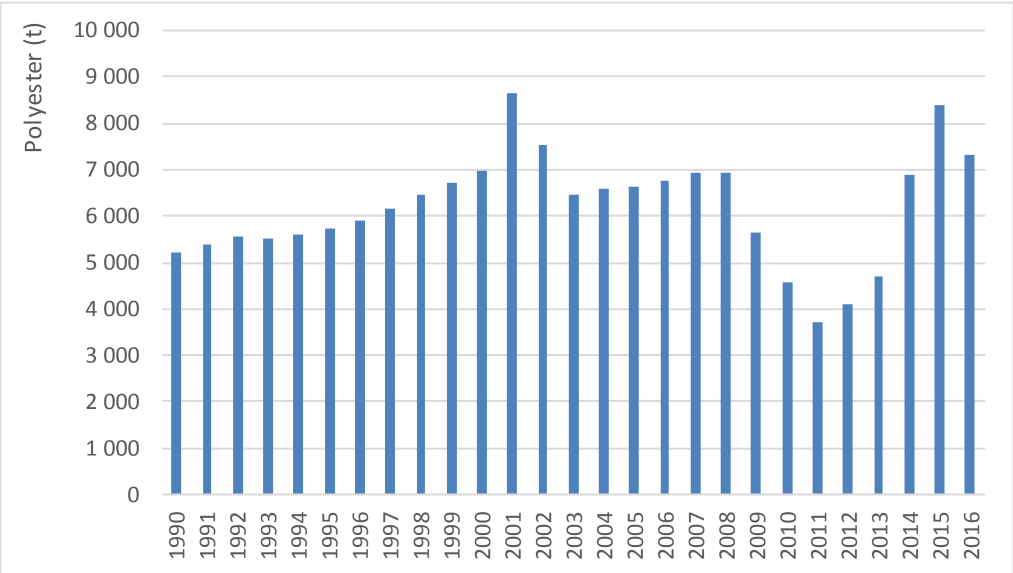
SNAP	Unit	NMVOC
Polyester processing	g/kg monomer used	50

Source: (EMEP/EEA, 2016)

4.1.4.7.3 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.

Table 4.81 –Polyester processed



4.1.4.7.4 Recalculations

Activity data have been revised based on Eurostat data.

4.1.4.7.5 Further Improvements

No further improvements are planned for this sector.

4.1.4.8 Polyvinylchloride processing (NFR 2.D.3.g - SNAP 060302)

4.1.4.8.1 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:

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

Where:

Emi_x – Emissions of pollutant “x” (t);

AD – PVC production data (t PVC);

EF_x – Emission factor of pollutant “x” (kg/t PVC).

4.1.4.8.2 Emission Factors

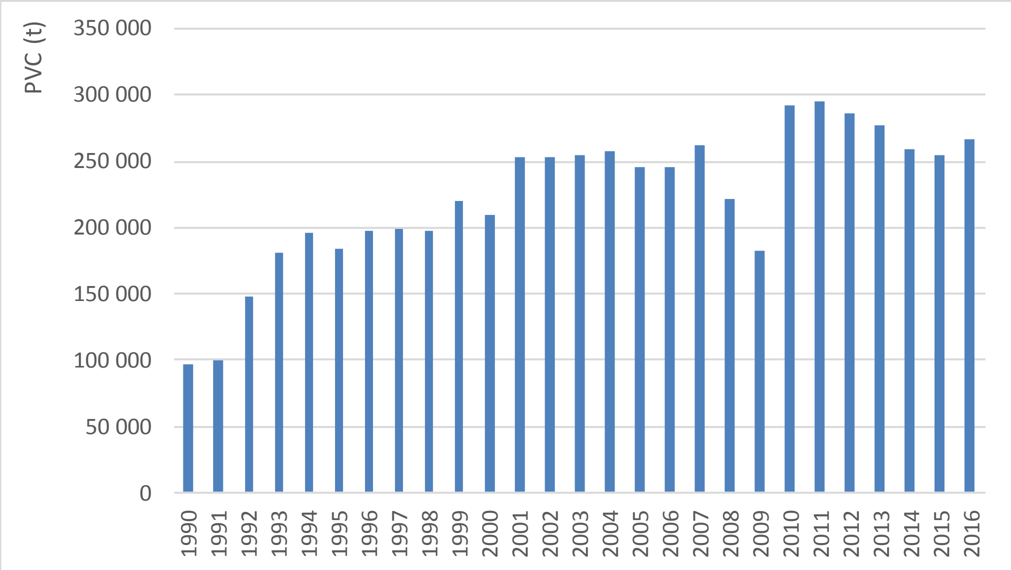
Table 4.82 – Emission factors

Parameter	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)

4.1.4.8.3 Activity Data

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

Figure 4.52 – PVC production (t)



4.1.4.8.4 Recalculation

Activity data has been revised based on national statistics.

4.1.4.8.5 Further Improvements

No further improvements are planned for this sector.

4.1.4.9 Polyurethane foam processing (NFR 2.D.3.g - SNAP 060303)

4.1.4.9.1 Methodology

Emissions from polyurethane foam processing were estimated in accordance with the EMEP/EEA air pollutant emission inventory guidebook 2016. A tier 2 approach was used.

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

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

Where:

$Emi_{NMVOC(y)}$ – NMVOC total emissions from foam processing (t/yr);

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

$Prod_{FOAM(y)}$ – Quantity of foam processed in year y (t/yr).

4.1.4.9.2 Emission Factors

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

Table 4.83 – NMVOC foam processing emission factor

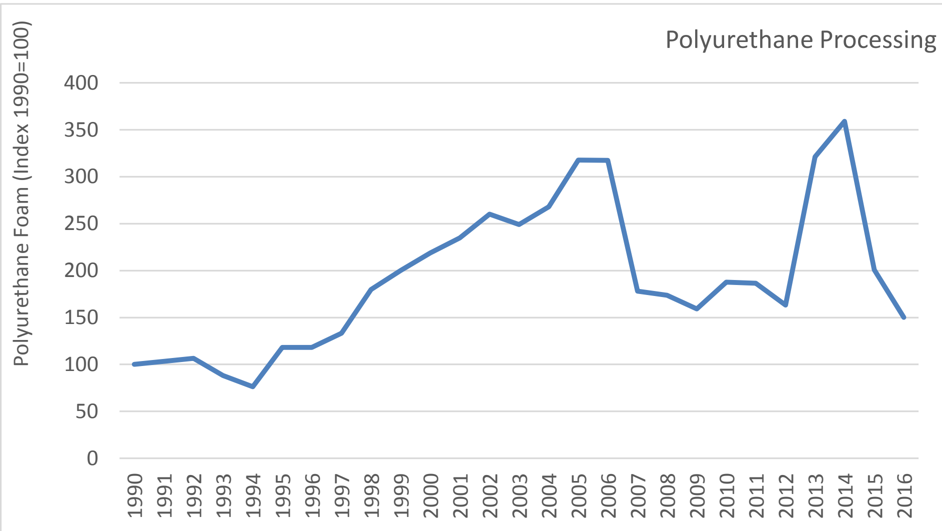
SNAP	Unit	NMVOC	Source
Polyurethane foam processing	g/kg foam processed	120	Table 3-3 of chapter 2.D.3.g Chemical Products of EMEP/EEA air pollutant emission inventory guidebook 2016

4.1.4.9.3 Activity Data

Data on polyurethane foam processing is available from the IAPI industrial surveys from INE in the period 1992-2015. The 1990-1991 production values were estimated based on gross value added trend for the chemical and fibres sector and on the 1992 national survey value. The 2016 production value was obtained from Eurostat.

Due to confidentiality constraints, the activity data is presented in index (1990 year = 100).

Figure 4.53 – Polyurethane Foam Processing (Index 1990=100)



4.1.4.9.4 Recalculations

Emissions have been revised in the 1990-1991 period based on gross value added trend for the chemical and fibres sector.

4.1.4.9.5 Further Improvements

No further improvements are planned for this sector.

4.1.4.10 Polystyrene foam processing (NFR 2.D.3.g - SNAP 060304)

4.1.4.10.1 Methodology

Emissions from polystyrene foam processing were estimated in accordance with the EMEP/EEA air pollutant emission inventory guidebook 2016. A tier 2 approach was used.

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

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

Where:

$Emi_{NMVOC(y)}$ – NMVOC total emissions from foam processing (t/yr);

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

$Prod_{FOAM(y)}$ – Quantity of foam processed in year y (t/yr).

4.1.4.10.2 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 4.84 – NMVOC foam processing emission factor

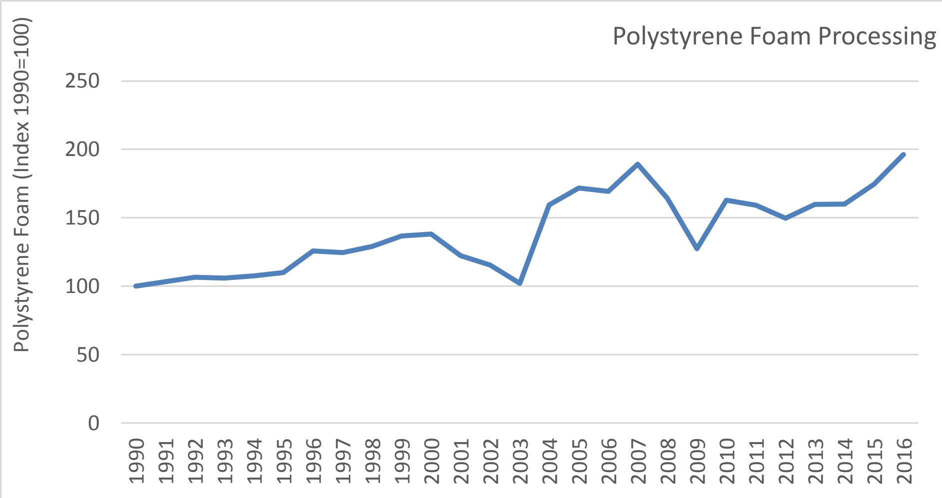
SNAP	Unit	NMVOC	Source
Polystyrene foam processing	g/kg foam processed	60	Table 3-4 of chapter 2.D.3.g Chemical Products of EMEP/EEA air pollutant emission inventory guidebook 2016

4.1.4.10.3 Activity Data

Data on polystyrene foam processing is available from the IAPI industrial surveys from INE in the period 1995-2015. 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. The 2016 production value was obtained from Eurostat.

Due to confidentiality constraints, the activity data is presented in index (1990 year = 100).

Figure 4.54 – Polystyrene Foam Processing (Index 1990=100)



4.1.4.10.4 Recalculations

Emissions have been revised in the 1990-1994 period based on gross value added trend for the chemical and fibres sector.

4.1.4.10.5 Further Improvements

No further improvements are planned for this sector.

4.1.4.11 Rubber processing (NFR 2.D.3.g - SNAP 060305)

4.1.4.11.1 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:

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

Where:

$Emi_{NMVOC(y)}$ – NMVOC total emissions from rubber processing (t/yr);

EF_{NMVOC} – NMVOC default emission factor for rubber processing (g/kg rubber produced);;

$Prod_{RUBBER(p,y)}$ – Production of rubber in year y (t/yr).

4.1.4.11.2 Emission Factors

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

Table 4.85 – NMVOC rubber processing emission factor

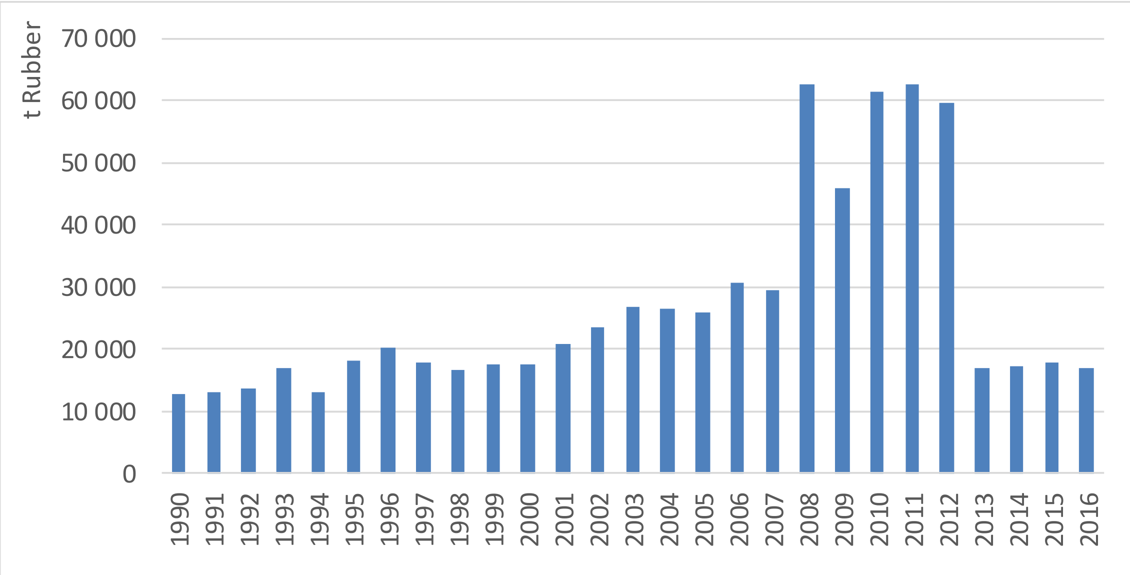
SNAP	Unit	NMVOC
Rubber processing	g/kg rubber produced	8

Source: EMEP/EEA, 2016, 2.D.3.g Chemical products, table 3-5, pp18

4.1.4.11.3 Activity Data

Production data of rubber artefacts was available from IAPI industrial surveys from INE from 1992 onwards. 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 gross value added trend for rubber industry in 1990-1991 period and on 1992 rubber production data.

Figure 4.55 – Rubber processed (t) – 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).

4.1.4.11.4 Recalculations

Rubber production data has been revised for the 1990-1991 period, based on gross value added trend for rubber industry in 1990-1991 period and on 1992 rubber production data.

4.1.4.11.5 Further Improvements

Activity data in the period 2008-2012 will be analyzed with national statistics authorities in order to understand the reasons behind the relevant increase of rubber production in this period.

4.1.4.12 Pharmaceutical Products Manufacturing (NFR 2.D.3.g – SNAP 060306)

4.1.4.12.1 Methodology

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

NMVOC emissions were estimated from the quantity of solvents used in pharmaceutical products manufacturing, according to:

$$Emi_{NMVOC} = EF_{NMVOC} \times Solv_{used} \times 10^{-6}$$

Where:

Emi_{NMVOC} – NMVOC emissions from pharmaceutical products manufacturing (t);

EF_{NMVOC} – NMVOC tier 2 reference emission factor for pharmaceutical products manufacturing (g/kg solvents used);

$Solv_{used}$ – Solvents used in pharmaceutical products manufacturing (kg).

4.1.4.12.2 Emission Factors

The emission factor used for pharmaceutical products manufacturing was obtained from EMEP/EEA air pollutant emission inventory guidebook 2016.

Table 4.86 – NMVOC pharmaceutical products manufacturing emission factor

SNAP	Unit	NMVOC
Pharmaceutical Products Manufacturing	g/kg solvents used	300

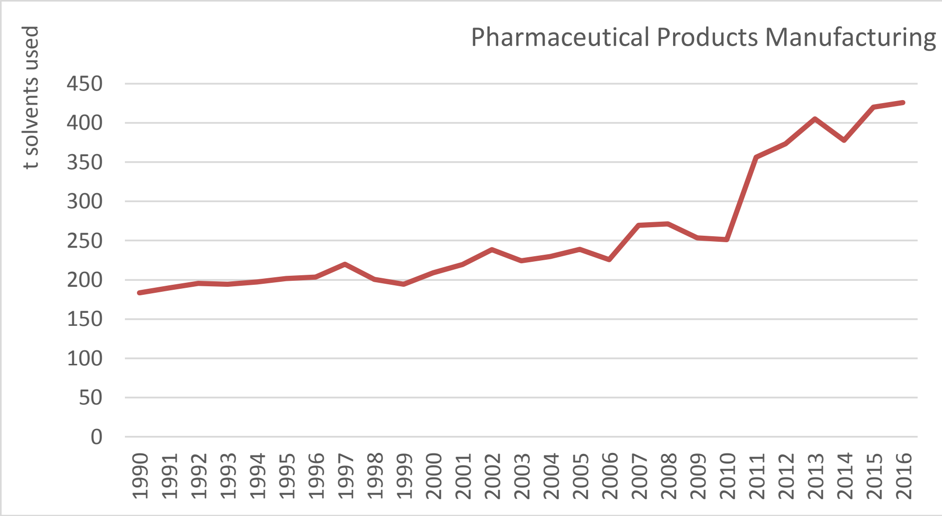
Source: EMEP/EEA, 2016, 2.D.3.g Chemical products, table 3-7, pp19

4.1.4.12.3 Activity Data

Pharmaceutical products manufacturing data was obtained from Eurostat for the period 2008-2011. For the 1990-2007 period, data was estimated based on gross value added trend for pharmaceutical industry and on 2008 production data. For the 2012-2015 period, data was estimated based on gross value added trend for pharmaceutical industry and on 2011 production data. For 2016, data was estimated based on gross domestic product trend.

For simplicity sake it was considered that the amount of solvent used is the same as the amount of pharmaceutical products manufactured.

Figure 4.56 – Solvents used in pharmaceutical products manufacturing (t) – 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).

4.1.4.12.4 Recalculations

This sector was not previously accounted.

4.1.4.12.5 Further Improvements

Efforts will be made to collect national statistics data for the periods 1990-2007, 2012 onwards and also information on solvents amounts used in pharmaceutical product manufactured.

4.1.4.13 Paints, Inks and Glues Manufacturing (NFR 2.D.3.g - SNAPs 060307, 060308 and 060309)

4.1.4.13.1 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:

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

Where:

$Emi_{(p,y)}$ – Emissions from manufacturing of product p in year y (t/yr);

$EF_{(y)}$ – Emission factor for production of paints, inks and glue during year y (g/kg product);

$ProductManuf_{(p,y)}$ – Quantity of product p manufactured in year y (t/yr);

p – product (paint, ink, glue)

y - year

4.1.4.13.2 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:

$$EF_{NMVOC(y)} = \sum_{t} \left(\frac{CS_{(t,y)}}{100} \times \left(1 - \frac{AT_{(t)}}{100}\right) \times EF_{NMVOC(default)} \right)$$

Where:

$EF_{NMVOC(y)}$ – NMVOC emission factor in year y (t/yr);

$CS_{(t,y)}$ – Control strategy, share of Abatement technology t during year y (%);

$AT_{(t)}$ – Efficiency of Abatement technology t (%);

t – Abatement technology;

$EF_{NMVOC(default)}$ – Default NMVOC emission factor.

Table 4.87 – Emission Factors

SNAP	Unit	Pollutant	EF	Source
Paints, Inks and Glues Manufacturing	g/kg product	NMVOC	11	EMEP/EEA, 2016
Paints and Inks Manufacturing	g/kg product	TSP	10	USEPA AP-42

Table 4.88 – NMVOC Abatement technology (Source: EMEP/EEA, 2016)

Abatement Technology	Unit	Efficiency
Use of good practices	%	27

Table 4.89 – 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

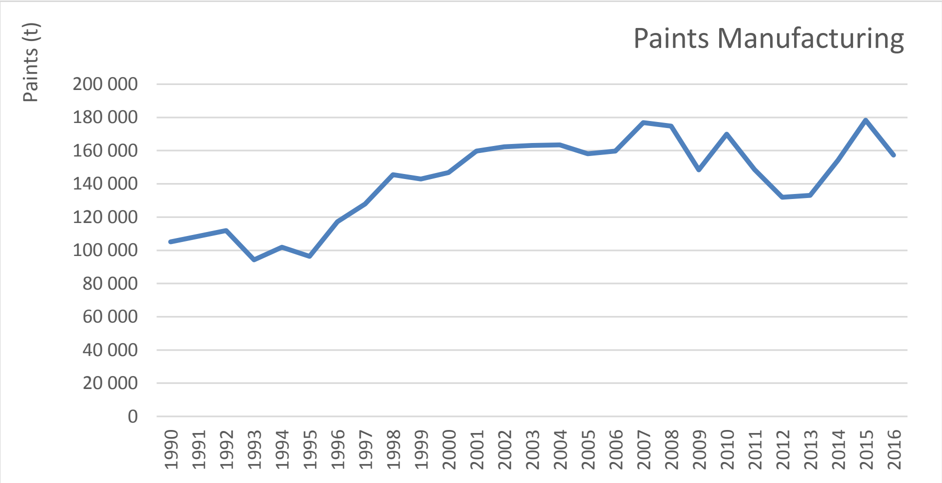
Table 4.90 – NMVOC final emission factor

Parameter	Unit	1990	1995	2000	2005	2010 onwards
Final EF	g/kg product	11.0	11.0	11.0	9.5	8.0

4.1.4.13.3 Activity Data

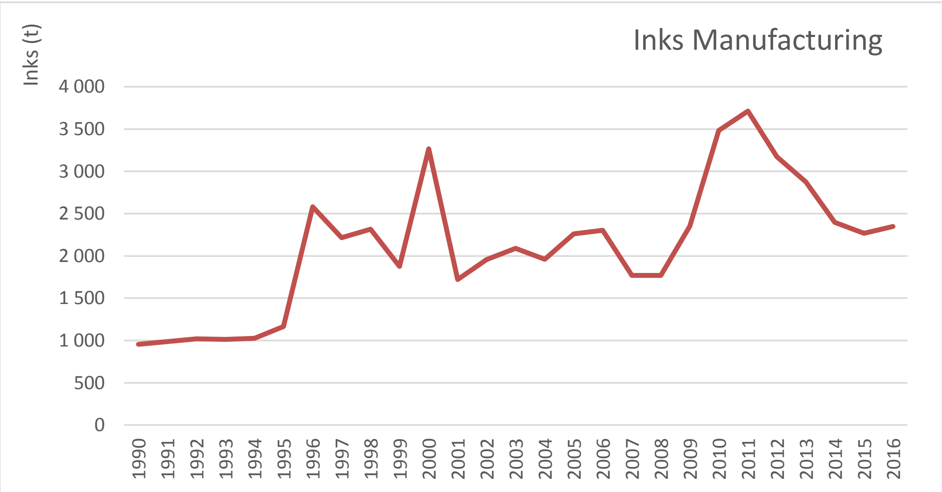
Production of paints was available from IAPI INE industrial survey from 1992 onwards. In the period 1990-1991, data has been estimated based on gross domestic product trend and on 1992 paints production data.

Figure 4.57 – Paints Manufacturing (t of paints) – total territory



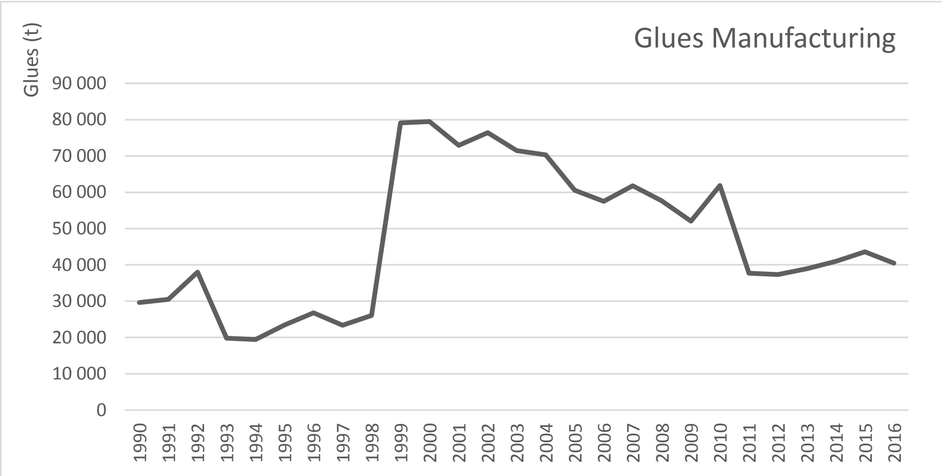
Production of inks was available from IAPI INE industrial survey from 1994 onwards. In the period 1990-1993, data has been estimated based on gross domestic product trend and on 1994 inks production data.

Figure 4.58 – Inks manufacturing (t of inks) – total territory



Production of glues was available from IAIT INE industrial survey in the 1990-1991 period and from IAPI INE industrial survey from 1992 onwards.

Figure 4.59 – Glues Manufacturing (t of glues) – 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).

4.1.4.13.4 Recalculations

The 1990-1991 paints production data has been revised based on gross domestic product trend and on 1992 paints production value, due to inconsistencies between IAIT INE survey statistical data (1990-1991 period) and IAPI INE survey statistical data (from 1992 onwards).

The 1990-1993 inks production data has been revised based on gross domestic trend and on 1994 inks production value, due to inconsistencies in national statistical data.

4.1.4.13.5 Further Improvements

No further improvements are planned for this sector.

4.1.4.14 Asphalt Blowing in Refineries (NFR 2.D.3.g – SNAP 060310)

4.1.4.14.1 Methodology

Emissions related to asphalt blowing were estimated in accordance with the EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2016).

Emissions were estimated from the amount of asphalt produced in the asphalt blowing units of each refinery, according to:

$$Emi_{pol(y)} = EF_{pol(y)} \times Asphalt_{prod} \times 10^{-6}$$

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).

4.1.4.14.2 Emission Factors

Emission factors from Table 3-8 of chapter 2.D.3.g of EMEP/EEA guidebook 2016 were used.

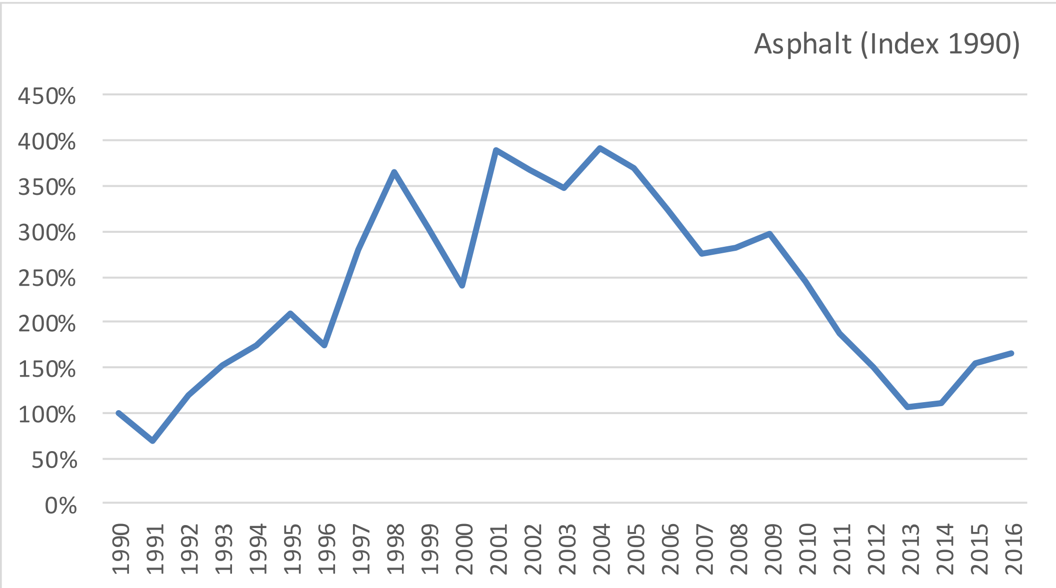
Table 4.91 – Emission Factors for Asphalt Blowing Units in refineries

Pollutant	Unit	EF	Source
NMVOC	g/t asphalt	27200	Table 3-8 of chapter 2.D.3.g of EMEP/EEA guidebook 2016
TSP	g/t asphalt	400	Table 3-8 of chapter 2.D.3.g of EMEP/EEA guidebook 2016
PM10	g/t asphalt	400	Expert Judgement
PM2.5	g/t asphalt	400	Expert Judgement
Cd	g/t asphalt	0.0001	Table 3-8 of chapter 2.D.3.g of EMEP/EEA guidebook 2016
As	g/t asphalt	0.0005	Table 3-8 of chapter 2.D.3.g of EMEP/EEA guidebook 2016
Cr	g/t asphalt	0.006	Table 3-8 of chapter 2.D.3.g of EMEP/EEA guidebook 2016
Ni	g/t asphalt	0.05	Table 3-8 of chapter 2.D.3.g of EMEP/EEA guidebook 2016
Se	g/t asphalt	0.0005	Table 3-8 of chapter 2.D.3.g of EMEP/EEA guidebook 2016
Benzo(α)pyrene	g/t asphalt	4000	Table 3-8 of chapter 2.D.3.g of EMEP/EEA guidebook 2016

4.1.4.14.3 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 4.60 – 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).

4.1.4.14.4 Recalculations

This source code was not previously considered.

4.1.4.14.5 Further Improvements

No further improvements are expected.

4.1.4.15 Adhesive, Magnetic Tapes, Films and Photographs Manufacturing (SNAP 060311)

4.1.4.15.1 Methodology

Emissions were estimated according to:

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

Where:

Emi_x – Emissions of pollutant "x" (t);

AD – Production data (t);

EF_x – Emission factor of pollutant "x" (kg/t).

4.1.4.15.2 Emission Factors

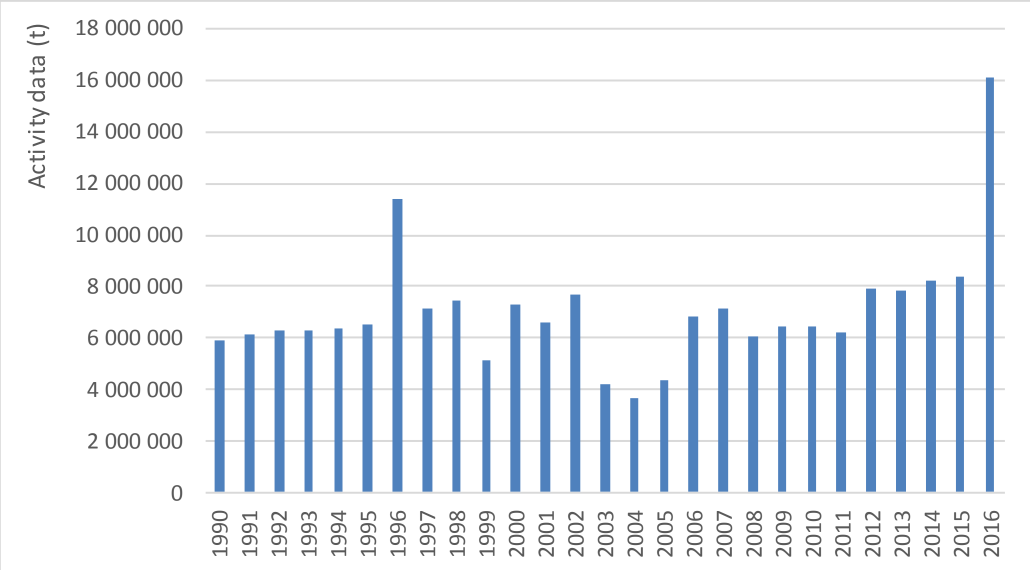
Table 4.92 – Emission factors

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

4.1.4.15.3 Activity Data

Activity data on adhesive, magnetic tapes, films and photographs was obtained from Eurostat from 1995 onwards. In the period 1990-1994, data has been estimated based on 1995 production data and on gross domestic product trend.

Figure 4.61 – Adhesive, magnetic tapes, films and photographs production (t)



4.1.4.15.4 Recalculation

This sector has been estimated for the first time.

4.1.4.15.5 Further Improvements

No further improvements are planned for this sector.

4.1.4.16 Manufacture of Shoes

4.1.4.16.1 Methodology

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

Emissions were estimated from the quantity of shoes manufactured according to:

$$Emi_{NMVOC} = EF_{NMVOC} \times Shoes_{Manufactured} \times 10^{-3}$$

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).

4.1.4.16.2 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.

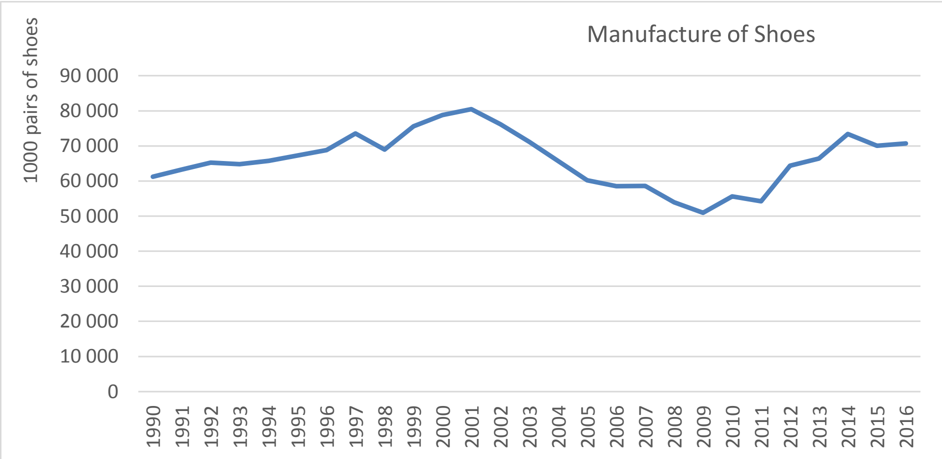
Table 4.93 – Emission Factors

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

4.1.4.16.3 Activity Data

Production data on manufacture of shoes was available from Eurostat from 1995 onwards. In the period 1990-1994, data has been estimated based on gross domestic product trend and on 1995 manufacture of shoes production value.

Figure 4.62 – Shoes Manufactured – 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).

4.1.4.16.4 Recalculations

This sector was previously not accounted.

4.1.4.16.5 Further Improvements

No further improvements are expected.

4.1.4.17 Leather Tanning (SNAP 060313)

4.1.4.17.1 Methodology

Emissions from leather tanning were estimated in accordance with EMEP/EEA air pollutant emission inventory guidebook 2016.

Emissions were estimated from the amount of leather produced according to:

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

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).

4.1.4.17.2 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 4.94 – Mass vs area leather conversion factor

Parameter	Unit	EF	Source
Mass vs area leather conversion factor	Kg/m^2	10	Expert judgment

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.

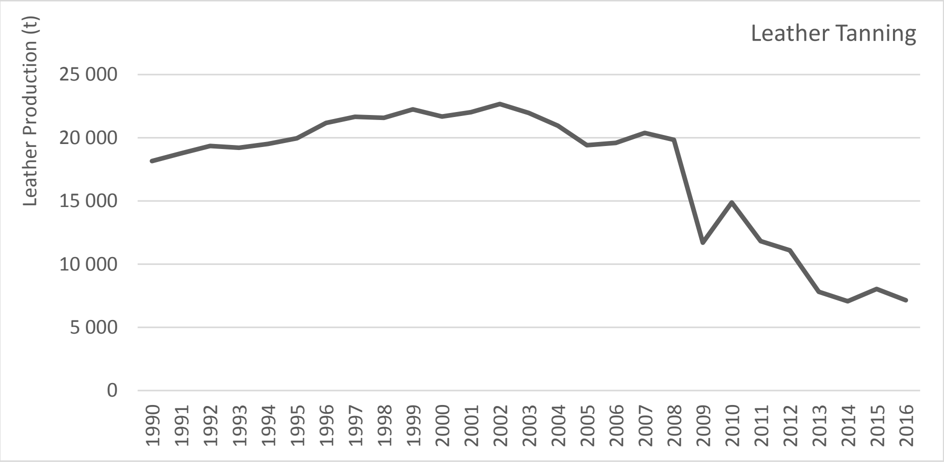
Table 4.95 – Emission Factor

SNAP	Unit	Pollutant	EF	Source
Leather Tanning	g/kg raw hid	NH_3	0.68	Table 3-13 of chapter 2.D.3.g Chemical Products of EMEP/EEA air pollutant emission inventory guidebook 2016

4.1.4.17.3 Activity Data

Leather production data was available from Eurostat from 2008 onwards. In the period 1990-2007, data has been estimated based on textile and leather industry gross value added trend and on 2008 leather production value.

Figure 4.63 – Leather production – 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).

4.1.4.17.4 Recalculations

This sector was previously not accounted.

4.1.4.17.5 Further Improvements

Efforts will be made to compile national statistics data on leather production for the 1990-2007 period.

4.1.4.18 Manufacture of Tyres (SNAP 060314)

4.1.4.18.1 Methodology

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

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

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

Where:

Emi_{NMVOC} – NMVOC emissions from manufacturing of tyres (t/yr);

EF_{NMVOC} – NMVOC emission factor for manufacturing of tyres (g/kg tyres);

$Tyres_{prod}$ – Tyres produced (kg/yr).

4.1.4.18.2 Emission Factors

By expert judgment it was considered that the average weight of a tyre is 8.81 kg.

Emission factors were taken from EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2016).

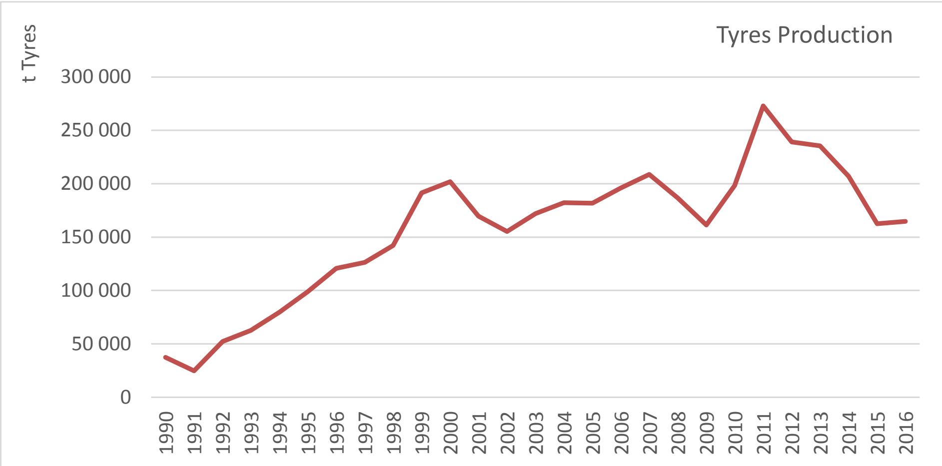
Table 4.96 – Default emission factor (Source: EMEP/EEA, 2016)

SNAP	Unit	NMVOC
Tyre production	g/kg tyre	10

4.1.4.18.3 Activity Data

Production data for tyres (in number of tyres) was available from the IAIT and IAPI industrial surveys from INE. Given that the emission factor unit is in g/kg tyres, we have developed an average tyre weight (8.81 kg) based on expert judgment.

Figure 4.64 – Tyres Production (t) – 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).

4.1.4.18.4 Recalculations

National statistics provide only tyres production data in number of tyres. Since the emission factor unit is in g/kg tyres, we have developed an average tyre weight based on expert judgment.

4.1.4.18.5 Further Improvements

No further improvements are planned for this sector.

4.1.4.19 Printing Industry (NFR 2.D.3.h – SNAP 060403)

4.1.4.19.1 Overview

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 artifacts 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 repellant 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).

4.1.4.19.2 Methodology

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

$$Emi_{NMVOC(y)} = EF_{(i)} * INK_{CONS(y)} \times 10^{-3}$$

Where

$Emi_{NMVOC(y)}$ – NMVOC emissions resulting from printing activities during year y (t/yr);

$Ink_{CONS(y)}$ – Use of printing ink during year y (t/yr);

$EF_{(i)}$ – NMVOC emission factor (solvent content) for ink use (g/kg ink).

4.1.4.19.3 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.

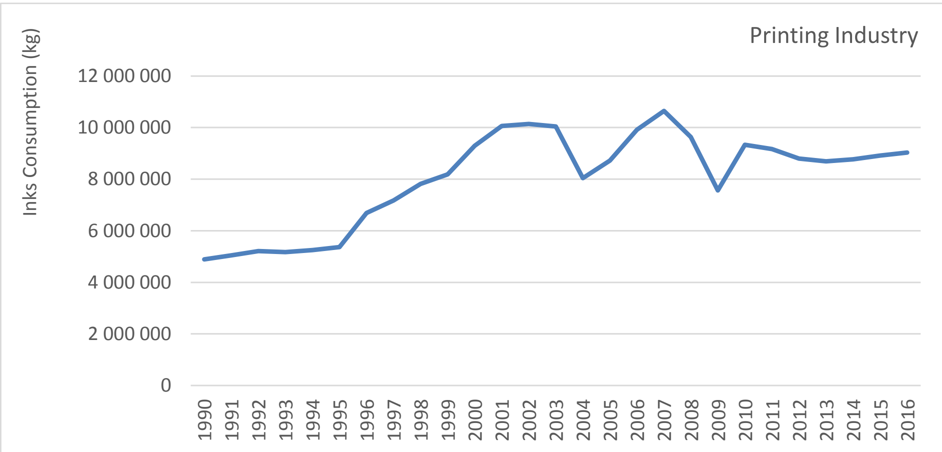
Table 4.97 – NMVOC emission factor for printing activities

SNAP	Unit	NMVOC
Printing	g/kg ink	500

Source: EMEP/EEA, 2016

4.1.4.19.4 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 4.65 – Inks consumption in Printing Industry (kg)



4.1.4.19.5 Recalculations

Inks consumption for the periods 1990-1994 and 2002-2003 have been corrected based on GDP trend.

4.1.4.19.6 Further Improvements

No further improvements are planned for this sector.

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

4.1.4.20.1 Overview

In the glass 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).

4.1.4.20.2 Methodology

Emissions from glass 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 glass wool produced according to:

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

Where:

Emi_{NMVOC} – NMVOC emissions from glass wool induction (t/yr);

EF_{NMVOC} – NMVOC emission factor for glass wool induction (g/t glass wool);

$Glass\ Wool_{prod}$ – Glass Wool produced (t/yr).

4.1.4.20.3 Emission Factors

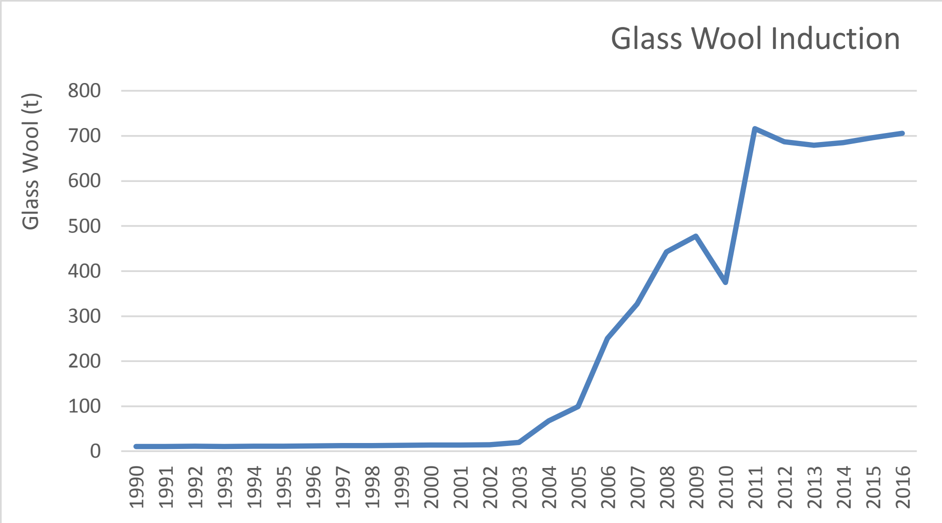
Table 4.98 – Default emission factor

SNAP	Unit	NMVOC	Source
Glass Wool Induction	g/t glass wool	850	Table 3-2 of chapter "2.D.3.i, 2.G Other solvent and product use" of "EMEP/EEA air pollutant emission inventory guidebook 2016"

4.1.4.20.4 Activity Data

Data on glass wool production was obtained from National Statistics in the period 2002-2011. Due to lack of data in the period 1990-2001, data has been estimated based on gross domestic trend and on 2002 production value. From 2012 onwards, due to national statistics data inconsistencies, production values have been estimated based on gross domestic trend and on 2011 glass wool production values.

Figure 4.66 – Glass Wool produced (t)



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).

4.1.4.20.5 Recalculations

This sector has been included for the first time.

4.1.4.20.6 Further Improvements

Efforts will be made to improve national statistics data in the periods 1990-2001 and from 2012 onwards.

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

4.1.4.21.1 Overview

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).

4.1.4.21.2 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:

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

Where:

Emi_{NMVOC} – NMVOC emissions from mineral wool induction (t/yr);

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

Mineral $Wool_{prod}$ – Mineral Wool produced (t/yr).

4.1.4.21.3 Emission Factors

Table 4.99 – Default emission factor

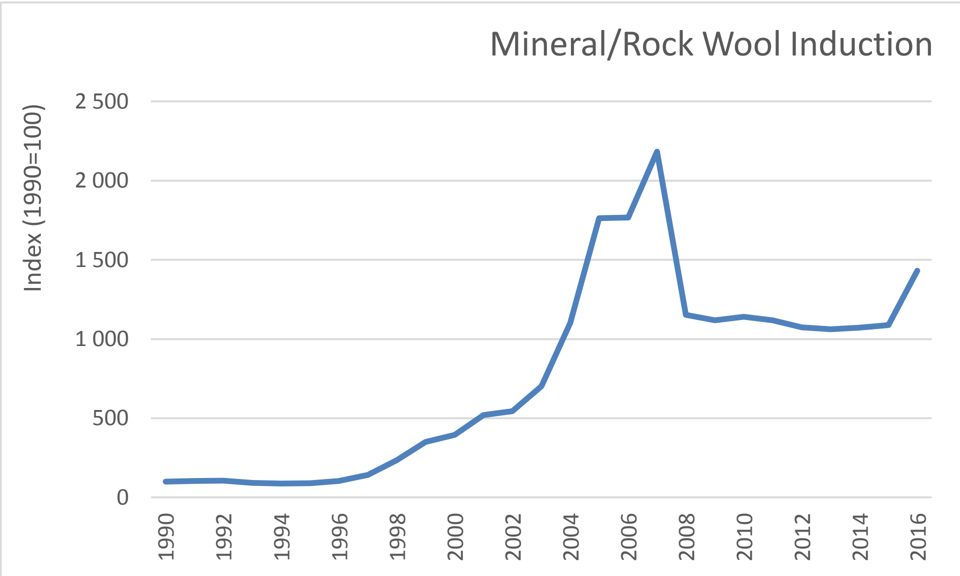
SNAP	Unit	NMVOC	Source
Mineral Wool Induction	g/t mineral wool	300	Table 3-3 of chapter “2.D.3.i, 2.G Other solvent and product use” of “EMEP/EEA air pollutant emission inventory guidebook 2016”

4.1.4.21.4 Activity Data

Data on mineral wool production was obtained from National Statistics in the period 1992-2007 and from 2015 onwards. Due to lack of data in the period 1990-2001, data has been estimated based on gross domestic trend and on 1992 production value. For the same reason, in the period 2008-2014, data has been estimated based on gross domestic trend 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 that 1990 production value is equal to 100%).

Figure 4.67 – 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).

4.1.4.21.5 Recalculations

This sector has been included for the first time.

4.1.4.21.6 Further Improvements

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

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

4.1.4.22.1 Overview

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.

4.1.4.22.2 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).

NMVOC emissions were estimated from the mass of seeds/grains consumed, according to:

$$Emi_{Polx} = EF_{Polx} \times Seeds_{cons} \times 10^{-3}$$

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).

4.1.4.22.3 Emission Factors

Table 4.100 – Default emission factors

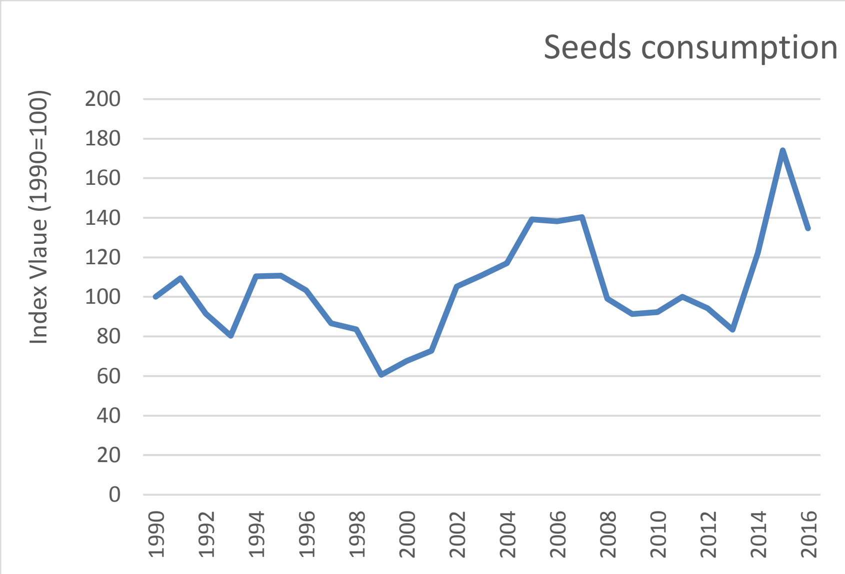
Pollutant	Unit	EF	Source
NMVOC	kg/t seed	1.57	Table 3-4 of chapter “2.D.3.i, 2.G Other solvent and product use” of “EMEP/EEA air pollutant emission inventory guidebook 2016”
TSP	kg/t seed	1.10	
PM_{10}	kg/t seed	0.90	
$PM_{2.5}$	kg/t seed	0.60	

4.1.4.22.4 Activity Data

It was not possible to obtain seeds/grains consumption from National Statistics for the entire timeseries. 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 National Statistics.

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 4.68 – 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).

4.1.4.22.5 Recalculations

This sector has been revised (both activity data and emission factors) in order to apply 2016 EMEP/EEA air pollutant emission inventory guidebook methodology.

4.1.4.22.6 Further Improvements

No further improvements are expected.

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

4.1.4.23.1 Methodology

App Cons = Production + Imports - Exports

where:

App Cons = Apparent consumption of glues and adhesives (t);

Production = National production of glues and adhesives (t);

Imports = Imports of glues and adhesives (t);

Exports = Exports of glues and adhesives (t).

$$NMVOC = \sum_{Abat\ Techn\ i} \frac{[App\ Cons \times EF \times Share_{Abat\ Techn\ i} \times (100\% - Effic_{Abat\ Techn\ i})]}{1000}$$

where:

NMVOC = 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” (%).

4.1.4.23.2 Emission Factors

Table 4.101 – 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 4.102 – Abatement Efficiencies

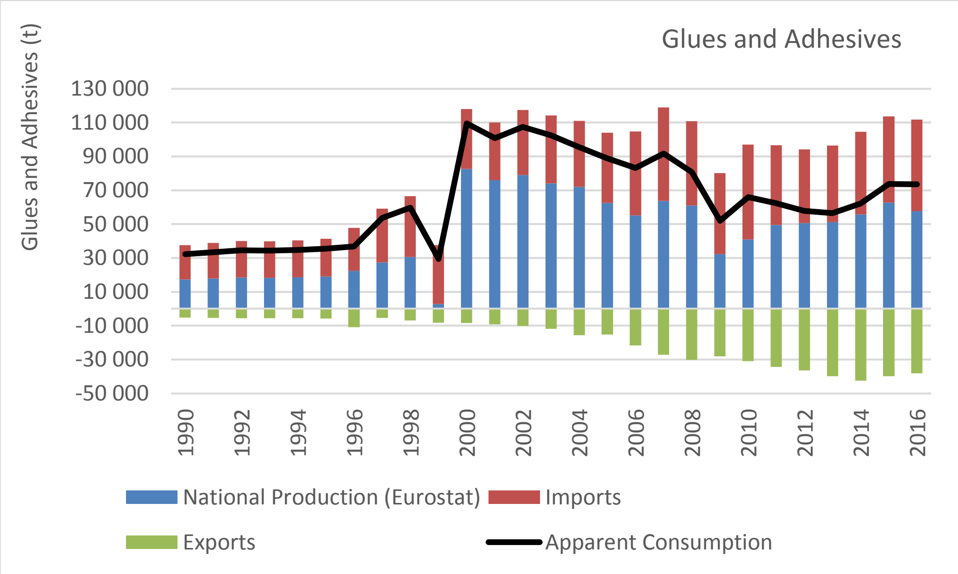
Abatement Technology	Efficiency	Source
Traditional solvent based adhesives (65% solvente, 35% solid) with activated carbon adsorption or condensation	76%	Table 3-21 of chapter “2.D.3.i, 2.G Other solvent and product use” of “EMEP/EEA air pollutant emission inventory guidebook 2016”
Emulsions (2% solvente,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

Table 4.103 – 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%	

4.1.4.23.3 Activity Data

Figure 4.69 – Glues and adhesives apparent consumption (t)



Source: Eurostat

4.1.4.23.4 Recalculations

Both activity data and emission factors have been revised.

4.1.4.23.5 Further Improvements

We pretend to discuss the share of each abatement technology with sectoral associations.

The national production trend in the periods 1998-2000 and 2008-2010 will be discussed with national statistics authorities.

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

4.1.4.24.1 Overview

Preservation of wood, against weathering, fungi and insect attack, is applied to wood furniture, artifacts 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).

4.1.4.24.2 Methodology

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).

$$Wood\ Pres_x = App\ Cons \times \%Wood\ Pres_x \times {}^{m\ wood\ pres_x}/_{m^3 wood}$$

where:

Wood $Pres_x$ = Mass of wood preservative of type “x” (waterborne preservative, creosote preservative or solvent borne preservative) - kg;

App Cons = Apparent consumption of treated wood (m^3);

%Wood Presx = Share of wood preservative of type “x” (%). According to the document “Wood Preservation with chemicals – Best Available Technics”, the share is 71% waterborne preservative, 18% solvent borne preservative and 11% creosote preservative;

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 “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 estimates:

$$NMVOC_{wood\ Pres\ x} = \frac{m\ Wood\ Pres_x \times EF\ Wood\ Pres_x \times (100\% - Eff_{Abat\ Techn})}{1 \times 10^6}$$

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 Presx = NMVOC Emission factor related to wood preservative “x” (g NMVOC/kg wood preservative);

$Eff_{Abat\ Techn}$ = Efficiency of abatement technology (%).

PCDD/F emissions estimates:

$$PCDD/F_{wood\ Pres\ x} = \frac{m\ Wood\ Pres_x \times EF\ Wood\ Pres_x}{1000}$$

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 Presx = 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 estimates:

$$Emissions_{Creosote} = \frac{m_{Creosote} \times EF_{Creosote}}{1 \times 10^6}$$

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).

4.1.4.24.3 Emission Factors

Table 4.104 – 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 4.105 – Amount of wood preservative (kg) used per m^3 of wood preserved

Wood Preservative Type	Kg/m^3	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 4.106 – 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 4.107 – 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 4.108 – 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 4.109 – 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%**	

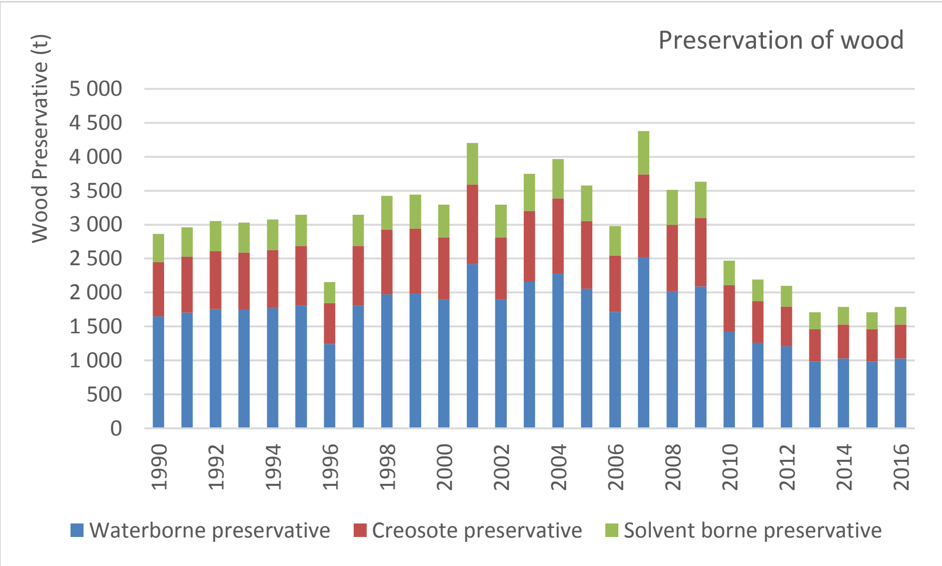
4.1.4.24.4 Activity Data

Production, imports and exports of treated wood were obtained from Eurostat from 1995 onwards. Data in the period 1990-1994 has been estimated based on 1995 values and on gross domestic trend.

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 4.70 – Wood Preservative applied by type (t) – 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).

4.1.4.24.5 Recalculations

This sector has been completely revised, both on activity data, methodology and emission factors.

4.1.4.24.6 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.

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

4.1.4.25.1 Methodology

$$Emissions_{NMVOC} = \frac{Population \times EF_{NMVOC}}{1000}$$

where:

$Emissions_{NMVOC}$ = NMVOC emissions (t);

Population = National population (Number of persons);

EF_{NMVOC} = NMVOC emission factor (kg/person).

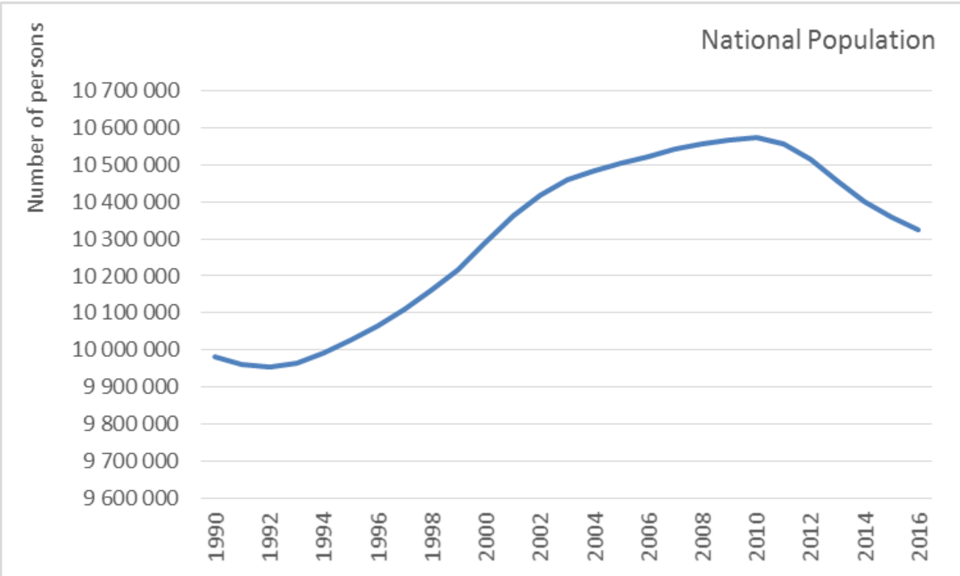
4.1.4.25.2 Emission Factors

Table 4.110 – 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"

4.1.4.25.3 Activity Data

Figure 4.71 – National population (number of persons) – 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).

4.1.4.25.4 Recalculations

This sector emissions were not previously accounted.

4.1.4.25.5 Further Improvements

No further improvements are expected.

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

4.1.4.26.1 Methodology

$$Emissions_{NMVOC} = \frac{Vehicles_{sales} \times EF_{NMVOC}}{1000}$$

where:

$Emissions_{NMVOC}$ = NMVOC emissions (t);

$Vehicles_{sales}$ = Vehicles sales (Number of vehicles);

EF_{NMVOC} = NMVOC emission factor (kg/car).

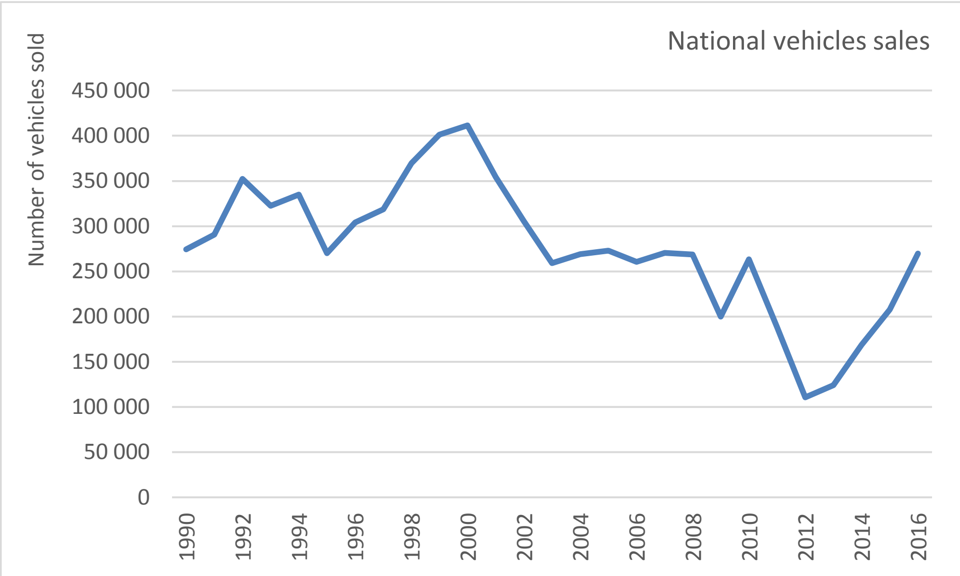
4.1.4.26.2 Emission Factors

Table 4.111 – 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"

4.1.4.26.3 Activity Data

Figure 4.72 – Annual vehicles sales (Number of vehicles) – Total Territory



Source: ACAP

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).

4.1.4.26.4 Recalculations

This sector emissions were not previously accounted.

4.1.4.26.5 Further Improvements

No further improvements are expected.

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

4.1.4.27.1 Methodology

$$App\ Cons = Production + Imports - Exports$$

where:

App Cons = Apparent consumption (Use) of fireworks (t);

Production = National production of fireworks (t);

Imports = Imports of fireworks (t);

Exports = Exports of fireworks (t).

Methodology for all pollutants except NMVOC:

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

where:

Emissions = Emissions of pollutant (t);

$Use_{Fireworks}$ = Product used in Fireworks (t);

EF = Emission factor (g/t product).

Methodology for NMVOC:

$$Emissions_{NMVOC} = \frac{Use_{Fireworks} \times EF_{NMVOC}}{1000}$$

where:

$Emissions_{NMVOC}$ = NMVOC emissions (t);

$Use_{Fireworks}$ = Product used in Fireworks (t);

EF = Emission factor (kg/t product).

4.1.4.27.2 Emission Factors

Table 4.112 – Default emission factors

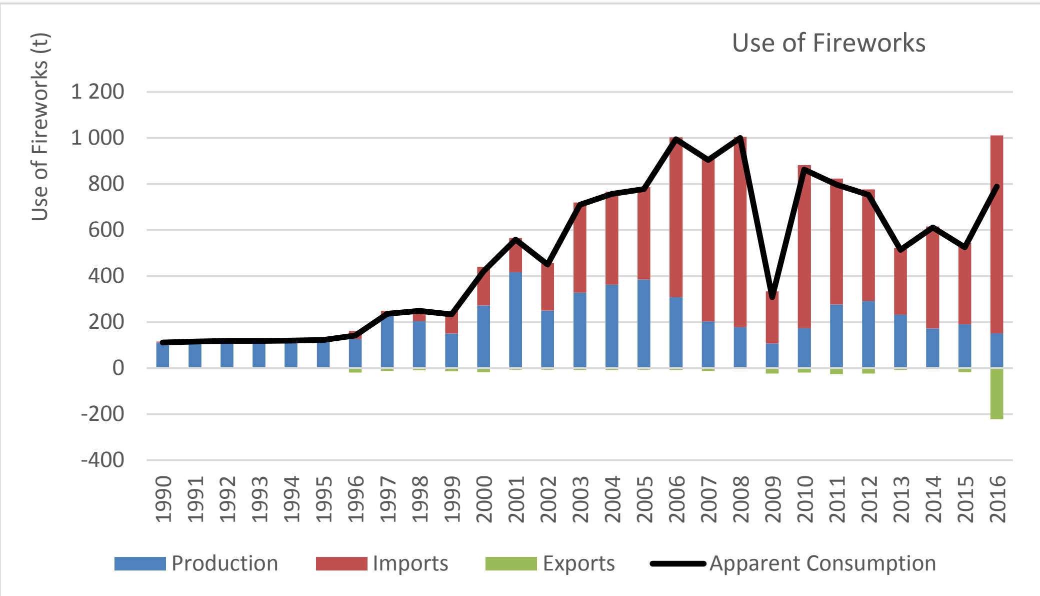
Pollutant	Unit	EF	Source
SO_2	g/t product	3020	Table 3-13 of chapter "2.D.3.i, 2.G Other solvent and product use" of "EMEP/EEA air pollutant emission inventory guidebook 2016"
NO_x	g/t product	260	
NMVOC	kg/t product	342	Table 3-12 of chapter "2.D.3.i, 2.G Other solvent and product use" of "EMEP/EEA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

4.1.4.27.3 Activity Data

From 1996 onwards, fireworks production data was obtained from Eurostat. In the period 1990-1995, data was estimated based on gross domestic product trend and on 1996 production value.

From 1995 onwards, fireworks exports and imports data was obtained from Eurostat. In the period 1990-1994, data was estimated based on gross domestic product trend and on 1995 exports/imports data values.

Figure 4.73 – 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).

4.1.4.27.4 Recalculations

This sector has been completely revised both on activity data and on emission factors.

4.1.4.27.5 Further Improvements

No further improvements are expected.

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

4.1.4.28.1 Methodology

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

where:

App Cons = Apparent consumption of tobacco (t);

Production = National production of tobacco (t);

Imports = Imports of tobacco (t);

Exports = Exports of tobacco (t).

Methodology for NO_x, NMVOC, CO, NH_3, TSP, PM_{10} and $PM_{2.5}$:

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

where:

Emissions = Pollutant emissions (t);

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

EF = Emission factor (kg/t tobacco).

Methodology for Cd, Cu, Ni, Zn, Benzo(α)pyrene, Benzo(β)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene:

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

where:

Emissions = Pollutant emissions (t);

Apparent $Consumption_{Tobacco}$ = Apparent consumption of tobacco (t);

EF = Emission factor (g/t tobacco).

Methodology for PCDD/F (Dioxines and Furanes):

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

where:

Emissions = Pollutant emissions (g I-teq);

Apparent $Consumption_{Tobacco}$ = Apparent consumption of tobacco (t);

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

Methodology for Black Carbon:

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

where:

$Emissions_{Black\ Carbon}$ = Black Carbon emissions (t);

$Emissions_{PM2.5}$ = $PM_{2.5}$ emissions (t);

$\%_{Black\ Carbon}$ = Percentage of Black Carbon in $PM_{2.5}$ emissions (% $PM_{2.5}$).

4.1.4.28.2 Emission Factors

Table 4.113 – 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	

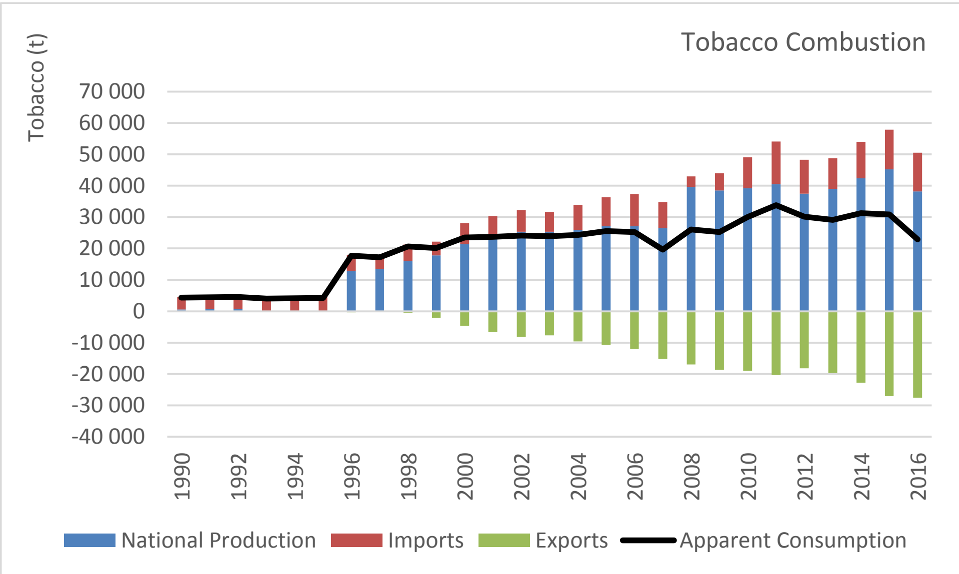
Pollutant	Unit	EF	Source
BC	% PM2.5	0.45	
Cd	g/t tobacco	5.4	
Cu	g/t tobacco	5.4	
Ni	g/t tobacco	2.7	
Zn	g/t tobacco	2.7	
PCDD/F	µg I-teq/t tobacco	0.1	
Benzo(α)pyrene	g/t tobacco	0.111	
Benzo(β)fluoranthene	g/t tobacco	0.045	
Benzo(k)fluoranthene	g/t tobacco	0.045	
Indeno(1,2,3-cd)pyrene	g/t tobacco	0.045	

4.1.4.28.3 Activity Data

Tobacco production has been obtained from national statistics from 1992 onwards. In the period 1990-1991 it was estimated based on 1992 tobacco production and on gross domestic product 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 gross domestic product trend. In 2016 imports/exports data was estimated based on 2015 value and on gross domestic product trend.

Figure 4.74 – Tobacco apparent consumption (t) – 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).

4.1.4.28.4 Recalculations

This sector has been completely revised, both on activity data and emission factors.

4.1.4.28.5 Further Improvements

No further improvements are expected.

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

4.1.4.29.1 Methodology

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).

$$Emissions_{NMVOC} = \frac{Apparent\ Consumption_{Shoes} \times EF}{1 \times 10^6} \times (100\% - Eff_{Abat.\ Techn.})$$

where:

$Emissions_{NMVOC}$ = 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 (%).

4.1.4.29.2 Emission Factors

Table 4.114 – 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 4.115 – Efficiency of Abatement Technologies

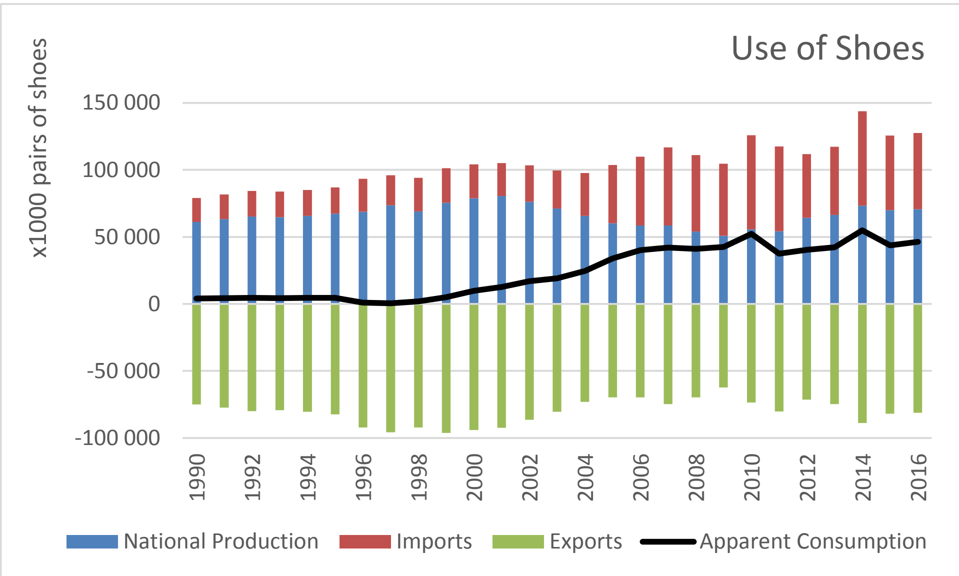
Abatement Technology	Efficiency	Source
90% solvent based/10% water based adhesives, Incineration	71%	Table 3-15 of chapter "2.D.3.i, 2.G Other solvent and product use" of "EMEP/EEA air pollutant emission inventory guidebook 2016"
90% solvent based/10% water based adhesives, Biofiltration	71%	
60% solvent 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).

4.1.4.29.3 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 gross domestic product trend.

Figure 4.75 – 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).

4.1.4.29.4 Recalculations

This sector was not previously accounted.

4.1.4.29.5 Further Improvements

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

4.1.4.30 Wood Chipboard Production (NFR 2.H.1)

4.1.4.30.1 Methodology

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

$$Emission_{NMVOC\ (y)} = EF_{\ NMVOC} * ActivityRate_{\ (y)} * 10^{-3}$$

where

$Emission_{NMVOC}$ - annual emission of NMVOC in year y (t/yr);

ActivityRate - Indicator of activity in the production process (t/yr);

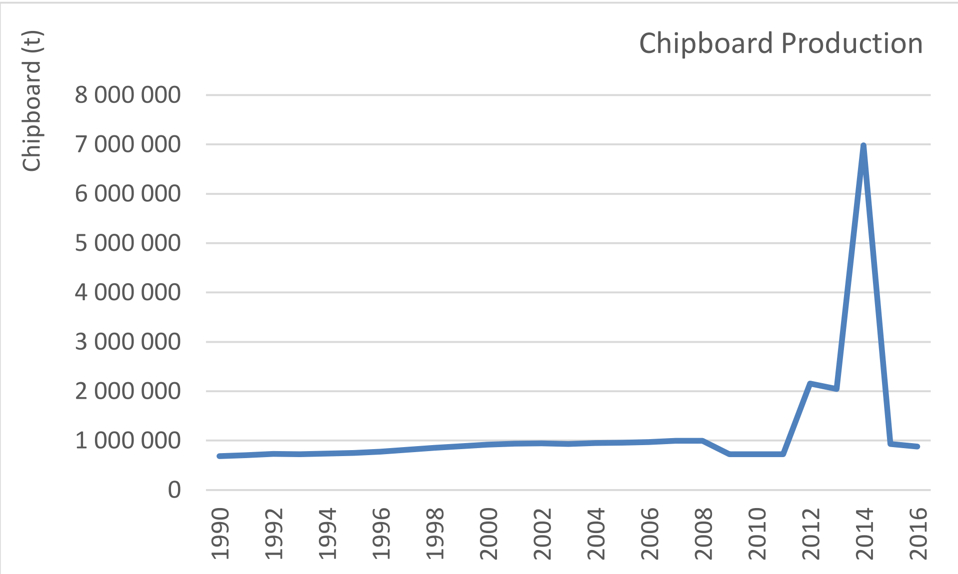
EF_{NMVOC} - emission factor (kg/ t)

4.1.4.30.2 Emission Factors

Emission factor is 0.9 kg/t, from Corinair90 Default Emission Factor Handbook.

4.1.4.30.3 Activity Data

Figure 4.76 – Chipboard production (t)



Due to inconsistencies between the units in which the data is provided to National Statistics 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 gross domestic product trend.

There is a strong increase in chipboard production in the period 2011-2014 that needs to be clarified with National Statistics.

4.1.4.30.4 Recalculations

Following the 2017 comprehensive review of NECD air pollutant inventory, the emissions from this sector have been relocated from 2.I to 2.H.1, according to the 2016 EMEP/EEA Guidebook.

Activity data has been revised due to inconsistencies.

4.1.4.30.5 Further Improvements

There is a strong increase in chipboard production in the period 2011-2014 that needs to be clarified with National Statistics.

4.1.4.31 Paper pulp production (NFR 2.H.1)

4.1.4.31.1 Overview

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 (1A2 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.

4.1.4.31.2 Methodology

Air emissions (t/yr) for each pollutant are estimated from production of air dried paper pulp ($Pulp_{PROD}$ - t AD/yr) after applying emission factors (EF - kg/t AD) specific of each pollutant:

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

4.1.4.31.3 Emission Factors

The following emissions factors (kg/ t AD pulp) 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 realized in:

- 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 4.116 – Emission Factors for paper pulp production (non-combustion)

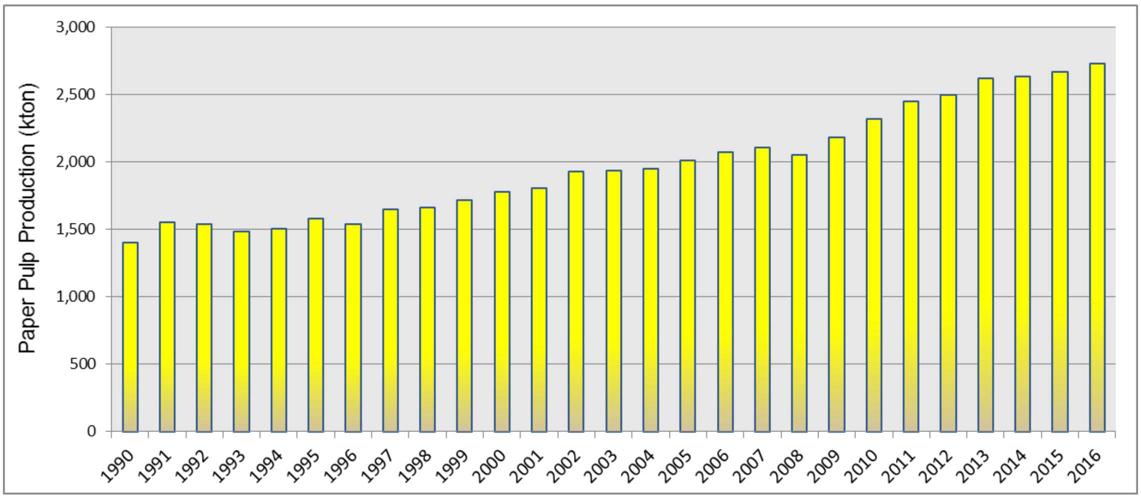
Process	SO_x	NO_x	NMVOC	TSP	PM_{10} (%)	$PM_{2.5}$ (%)	PM_1 (%)
Kraft	0.31	1.95	2.74	3.5	88.5	73	40
Sulphide	35.5	NA	NA	NA	NA	NA	NA

4.1.4.31.4 Activity Data

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[46] but may not be published individualised due to confidentiality constraints. However, sulphide production is about 5 to 8 per cent 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 4.77 – Total production of paper pulp - Kraft and semi-sulphide



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

4.1.4.31.5 Recalculations

No recalculations were made.

4.1.4.32 Food Manufacturing (NFR 2.H.2)

4.1.4.32.1 Overview

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.

4.1.4.32.2 Methodology

Emissions where estimated by a Tier 2 methodology using EMEP/EEA air pollutant emission inventory guidebook 2016 emission factors.

NMVOC emissions:

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

where

Emissions - NMVOC emissions (t);

AD - Activity Data (t product);

EF – Emission factor (kg/t product);

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

TSP and PM_{10} emissions:

$$Emissions = \frac{AD \times EF \times (1 - \eta_{abatement})}{1 \times 10^6}$$

where

Emissions - Emissions (t);

AD - Activity Data (t product);

EF – Emission factor (g/t product);

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

4.1.4.32.3 Emission Factors

Emission factors are from chapter “2.H.2 Food and beverages industry” of “EMEP/EEA air pollutant emission inventory guidebook 2016”.

Table 4.117 – Emission Factors

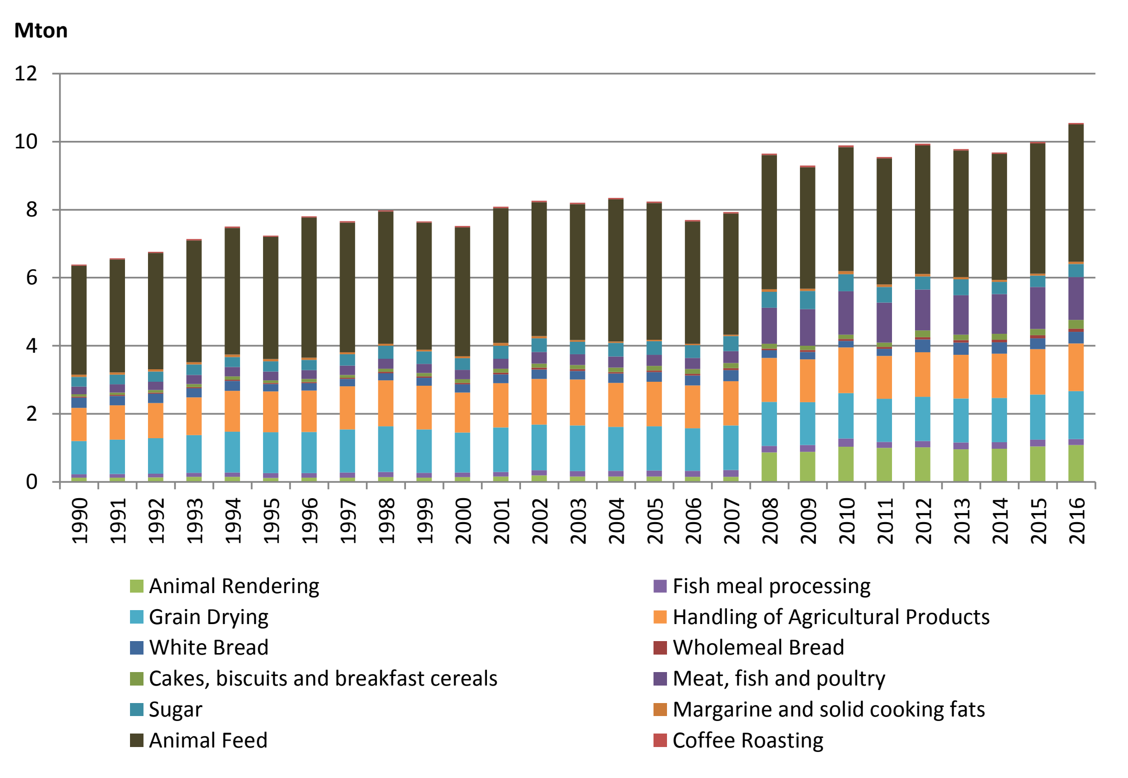
Food Product	Pollutant	Unit	EF	Source
Animal rendering	NMVOC	Kg/t meat	0.33	Table 3-2 of chapter “2.H.2 Food and beverages industry” of “EMEP/EEA air pollutant emission inventory guidebook 2016”
Fish meal processing	NMVOC	Kg/t fish	1	Table 3-3 of chapter “2.H.2 Food and beverages industry” of “EMEP/EEA 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”

For the activities in the food 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”).

4.1.4.32.4 Activity Data

Information about activity data for this sector is from National Statistics Institute (INE) from 1992 onwards, In the period 1990-1991, data has been estimated based on 1992 activity data values and on gross domestic trend.

Figure 4.78 – 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).

4.1.4.32.5 Recalculations

It was introduced the value of 90% for abatement technologies efficiency.

Emissions of animal rendering, fish meal processing, grain drying and handling of agricultural products have been estimated for the first time.

4.1.4.32.6 Further Improvements

No further improvements are planned.

4.1.4.33 Drink Manufacturing (NFR 2.H.2)

4.1.4.33.1 Overview

Under this sector we consider:

- Barley malting;
- Hop processing;
- Fermentation;
- Casking;
- Maturation;
- Red wine;
- White wine;
- Beer;
- Spirits.

4.1.4.33.2 Methodology

4.1.4.33.2.1 Barley Malting

$$m_{Beer} = V_{Beer} \times \frac{100\ l\ Beer}{1\ hl\ Beer} \times d_{Beer}$$

where

V_{Beer} – Volume of Beer (hl);

m_{Beer} – Mass of Beer (t);

d_{Beer} – Density of Beer (=$1x10^{-3}$ t/l).

$$m_{Barley} = m_{Beer} \times \frac{0.15\ t\ Barley}{1\ t\ Beer}$$

where

m_{Barley} – Mass of Barley (t);

m_{Beer} – Mass of Beer (t);

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

where

Emissions - NMVOC emissions (t);

m_{Barley} – Mass of Barley (t);

EF – Emission factor (kg/t barley);

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

4.1.4.33.2.2 Hop Processing

$$m_{Beer} = V_{Beer} \times \frac{100\ l\ Beer}{1\ hl\ Beer} \times d_{Beer}$$

where

V_{Beer} – Volume of Beer (hl);

m_{Beer} – Mass of Beer (t);

d_{Beer} – Density of Beer (=1x10^{-3} t/l).

$$Emissions = \frac{m_{Beer} \times EF \times (1 - \eta_{abatement})}{1 \times 10^6}$$

where

Emissions - NMVOC emissions (t);

m_{Barley} – Mass of Beer (t);

EF – Emission factor (g/t beer);

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

4.1.4.33.2.3 Fermentation, Casking and Maturation

$$V_{alcohol\ in\ drink\ x} = \frac{V_{drink\ x}}{10} \times \%(v/v)_{alcohol\ in\ drink\ x}$$

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%.

$$m_{alcohol\ in\ drink\ x} = V_{alcohol\ in\ drink\ x} \times d_{alcohol}$$

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);

dalcohol – density of alcohol/ethanol (=789 kg/m^3).

$$m_{alcohol} = m_{alcohol\ in\ red\ wine} + m_{alcohol\ in\ white\ wine} + m_{alcohol\ in\ beer} + m_{alcohol\ in\ spirits}$$

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.

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

where

Emissions - NMVOC emissions (t);

$m_{Alcohol}$ – mass of Alcohol (t);

EF – Emission factor (kg/t alcohol);

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

4.1.4.33.2.4 Red Wine, White Wine, Beer

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

where

Emissions - 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).

4.1.4.33.2.5 Spirits

$$V_{alcohol\ in\ spirits} = V_{spirits} \times \%(v/v)_{alcohol\ in\ spirits}$$

where

$V_{alcohol\ in\ spirits}$ – Volume of alcohol in spirits (hl of alcohol);

$V_{spirits}$ – Volume of spirits (hl of spirits);

$\%(v/v)_{alcohol\ in\ spirits}$ – Percentage of alcohol by volume in spirits (=40%).

$$Emissions = \frac{V_{alcohol\ in\ spirits} \times EF \times (1 - \eta_{abatement})}{1000}$$

where

Emissions - 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).

4.1.4.33.3 Emission Factors

Emission factors are from chapter “2.H.2 Food and beverages industry” of “EMEP/EEA air pollutant emission inventory guidebook 2016”.

Table 4.118 – NMVOC emission factors

Product	Unit	EF	Source
Barley Malting	g/t barley	0.55	Table 3-5 of chapter "2.H.2 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016"
Hop Processing	g/t beer	7.8	Table 3-6 of chapter "2.H.2 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016"
Fermentation	Kg/t alcohol	2	Table 3-7 of chapter "2.H.2 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016"
Casking	Kg/t alcohol	0.5	Table 3-8 of chapter "2.H.2 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016"
Maturation	Kg/t alcohol	20	Table 3-9 of chapter "2.H.2 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016"
Red Wine	Kg/hl wine	0.080	Table 3-25 of chapter "2.H.2 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016"
White Wine	Kg/hl wine	0.035	Table 3-26 of chapter "2.H.2 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016"
Beer	Kg/hl beer	0.035	Table 3-27 of chapter "2.H.2 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016"
Spirits	Kg/hl alcohol	15	Table 3-28 of chapter "2.H.2 Food and beverages industry" of "EMEP/EEA air pollutant emission inventory guidebook 2016"

It were made the following additional assumptions 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/m^3 (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 drinks 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").

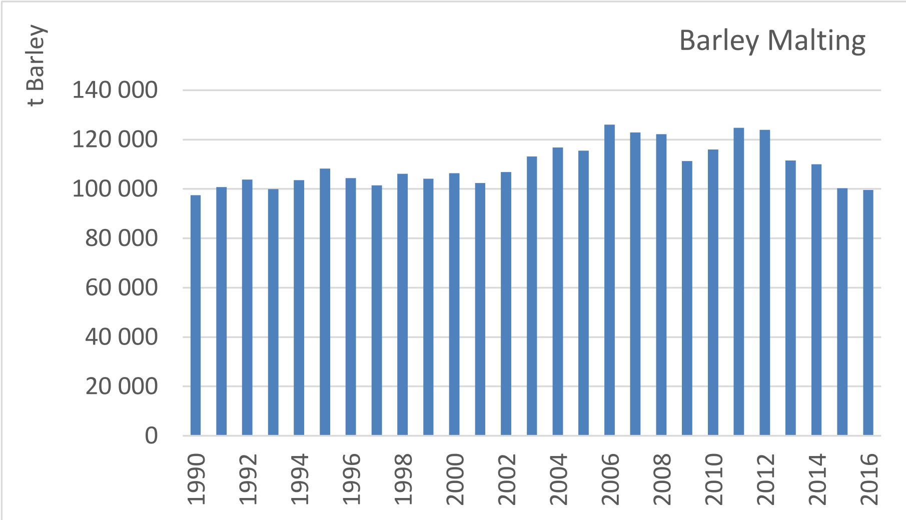
4.1.4.33.4 Activity Data

Data on drinks production was obtained from National Statistics from 1992 onwards. In the period 1990-1991, data was estimated based on 1992 production and on gross domestic trend.

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).

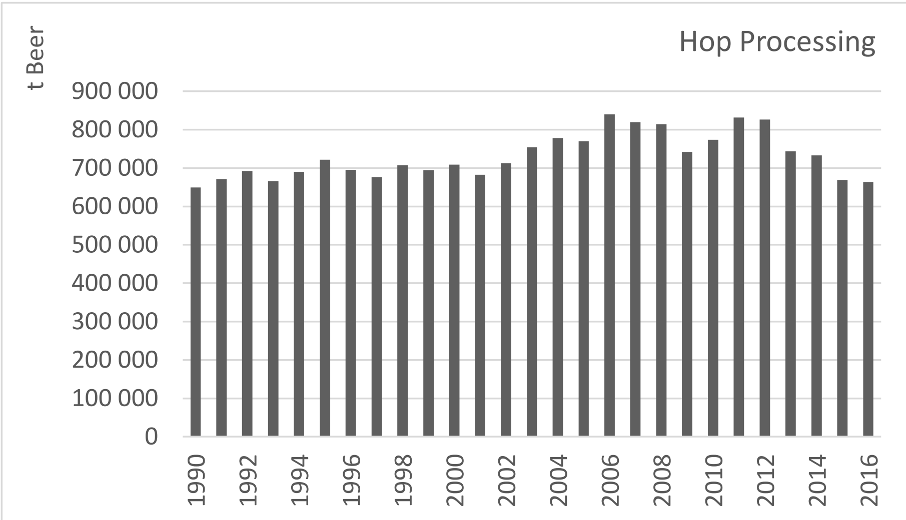
4.1.4.33.4.1 Barley Malting

Figure 4.79 – Barley Malting (t Barley) – Total territory



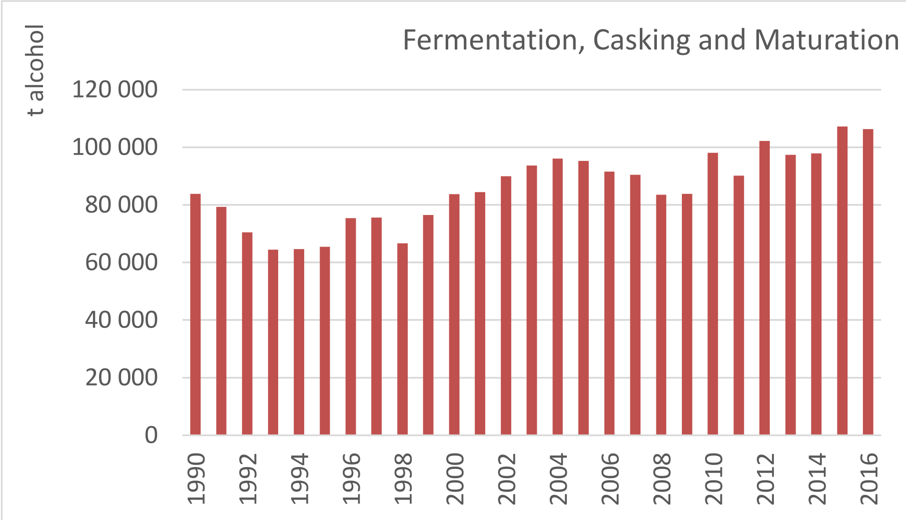
4.1.4.33.4.2 Hop Processing

Figure 4.80 – Hop Processing (t Beer)



4.1.4.33.4.3 Fermentation, Casking and Maturation

Figure 4.81 – Fermentation, Casking and Maturation (t alcohol)



4.1.4.33.4.4 Red Wine, White Wine, Beer

Figure 4.82 – Red wine production (hl of red wine)

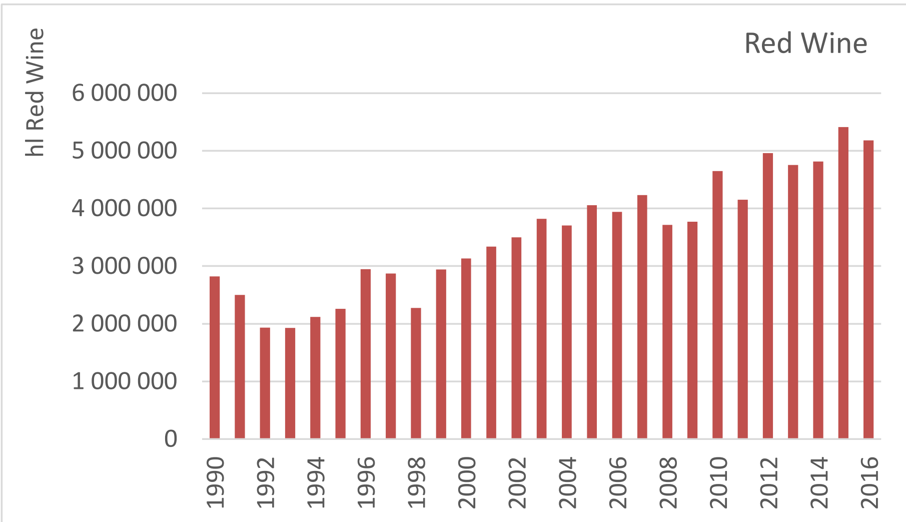


Figure 4.83 – White wine production (hl of white wine)

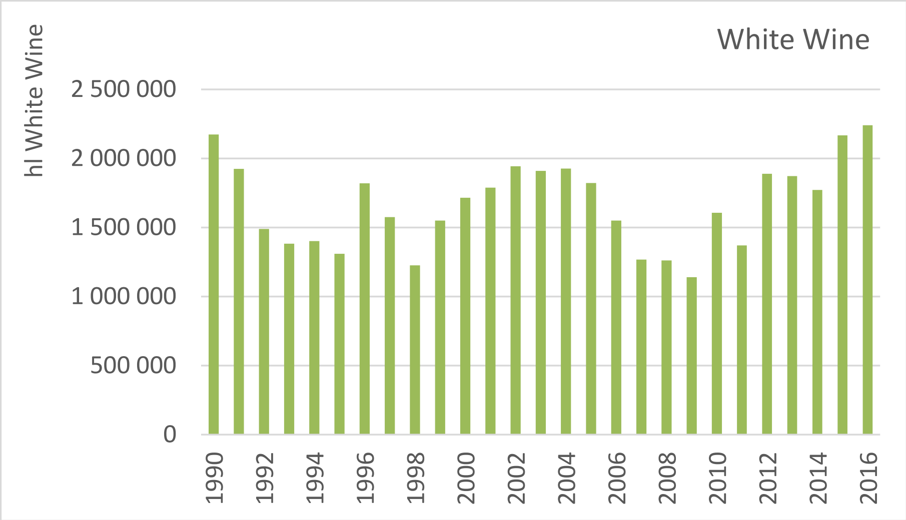
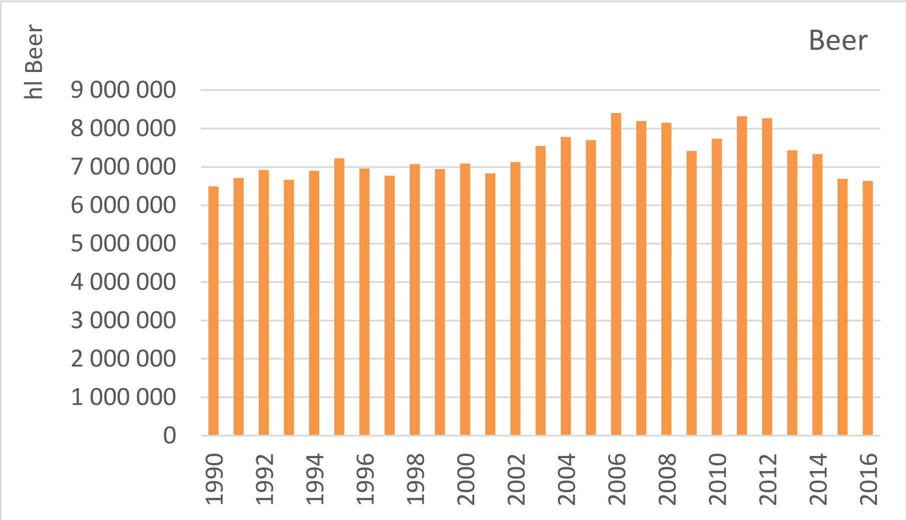
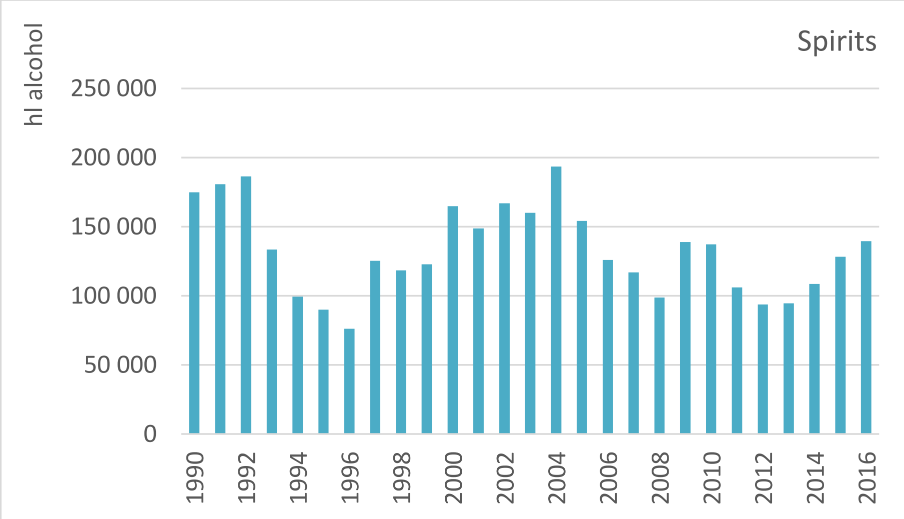


Figure 4.84 – Beer production (hl of beer)



4.1.4.33.4.5 Spirits

Figure 4.85 – Spirits production (hl of spirits)



4.1.4.33.5 Recalculations

It were introduced estimates for emissions related to Barley Malting, Hop Processing, Fermentation, Casking and Maturation.

4.1.4.33.6 Further Improvements

No further improvements are planned.

4.1.4.34 Wood Processing (2.I)

4.1.4.34.1 Methodology

Methodology for TSP:

$$Emissions_{TSP} = \frac{Wood\ Products_{Production} \times EF_{TSP}}{1000}$$

where:

$Emissions_{TSP}$ = TSP emissions (t);

$Wood\ Products_{Production}$ = National production of Wood Products (t);

EF_{TSP} = TSP emission factor (kg/t wood product).

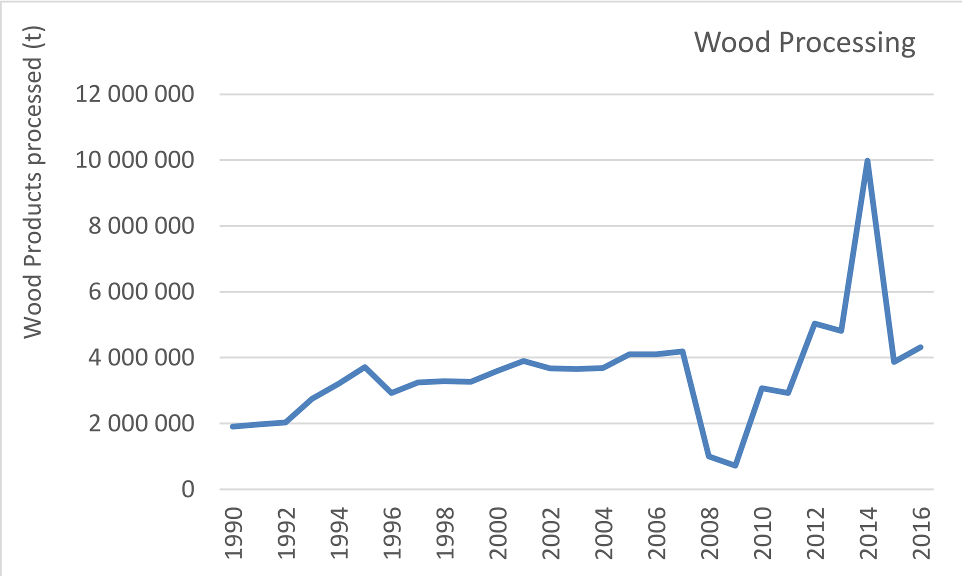
4.1.4.34.2 Emission Factors

Parameter	Unit	EF	Source
TSP	kg/t wood	1	Table 3.1 of chapter "2.I Wood processing" of EMEP/EEA guidebook 2016

4.1.4.34.3 Activity Data

Data on wood products processed has been obtained from National Statistics from 1992 onwards. In the period 1990-1991, data has been estimated based on 1992 production data and on gross domestic trend.

Figure 4.86 – Wood Processing (t wood products processed)



4.1.4.34.4 Recalculations

This sector has been considered for the first time.

4.1.4.34.5 Further Improvements

No further improvements are expected.

4.1.4.35 Consumption of persistent organic pollutants and heavy metals (NFR 2.K)

4.1.4.35.1 Overview

The major source of PCBs arises from leaks of dielectric fluid from large electrical transformers and capacitors that are in poor condition. Fragmenticising 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.

4.1.4.35.2 Methodology

Emissions where estimated by the use of per capita emission factors multiplied by the national population.

$$\text{Emission} = \text{EF} * \text{Population} * 10^{-6}$$

where

Emission - annual emission (t/yr);

Population – National population (inhabitants);

EF - emission factor (g/capita)

4.1.4.35.3 Emission Factors

We use Tier 1 per capita emission factors from Table 3.1 of chapter "2.K Consumption of persistent organic pollutants and heavy metals" of EMEP/EEA guidebook 2016.

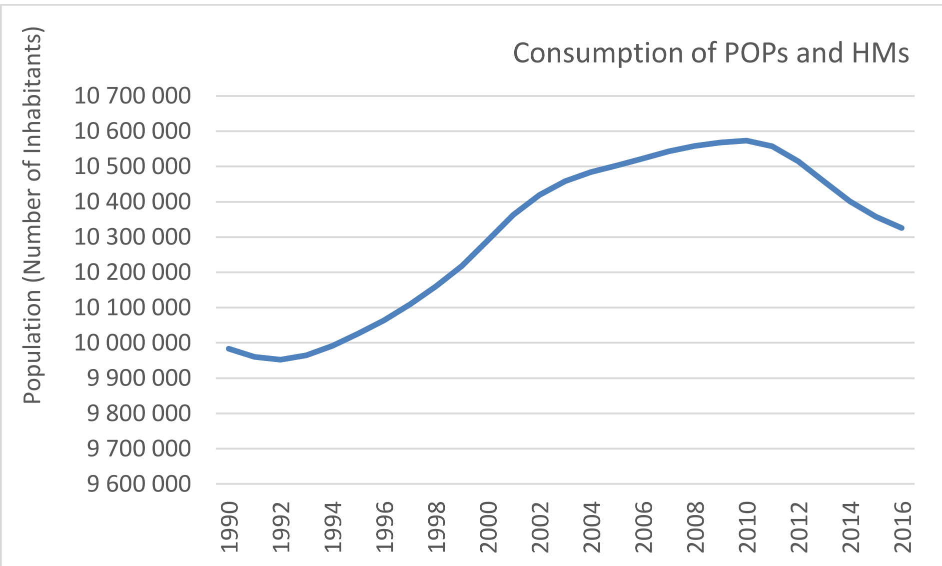
Table 4.119 – Emission Factors

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/capita	0.1	Table 3.1 of chapter "2.K Consumption of persistent organic pollutants and heavy metals" of EMEP/EEA guidebook 2016

4.1.4.35.4 Activity Data

Information about national population is obtained from National Statistics (INE).

Figure 4.87 – Population (Number of Inhabitants)



4.1.4.35.5 Recalculations

Emissions from this source category were not previously estimated.

4.1.4.35.6 Further Improvements

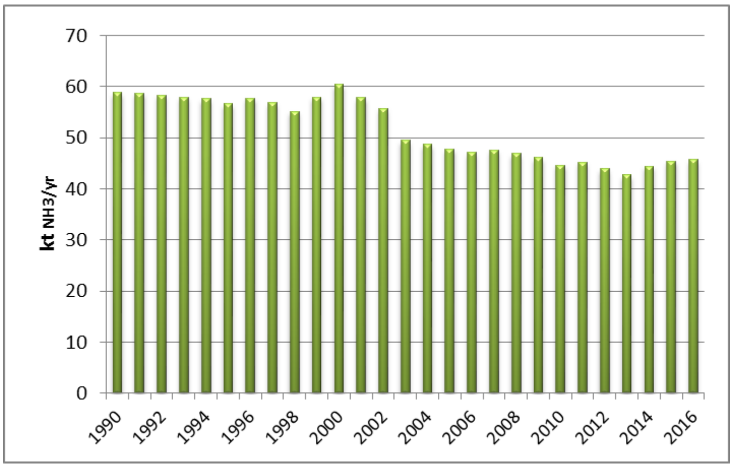
No further improvements are planned.

5 AGRICULTURE (NFR 3)

5.1 Overview

Agriculture activities generate the largest part of NH_3 national emissions. In 2016, NH_3 emissions from the agriculture sector were 45.7 kt, corresponding to 81.2% of the national[47] NH_3 emissions. From 1990 to 2016, NH_3 agriculture emissions decreased 22.3 %. From 2005 to 2016 the ratio of decrease is lower staying at 4.4 %.The complete time series trend is shown in figure below.

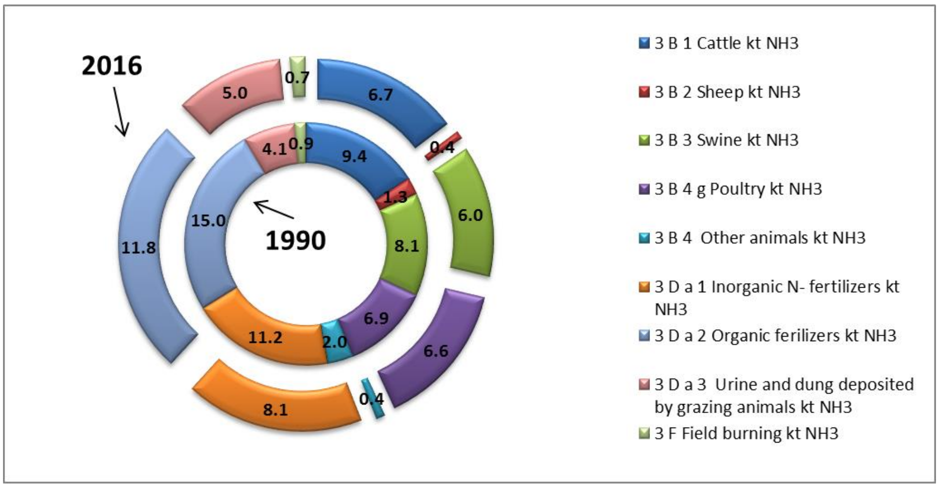
Figure 5.1– Total NH3 emissions from agriculture – trends



Overall, NH_3 emissions from agriculture presented reductions between 1990 and 2016 in almost all source categories. Next figure shows the ammonia emissions in the years 1990 and 2016 by category of emission source.

[47] 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 26 of Annex D: Agriculture for the time serie.

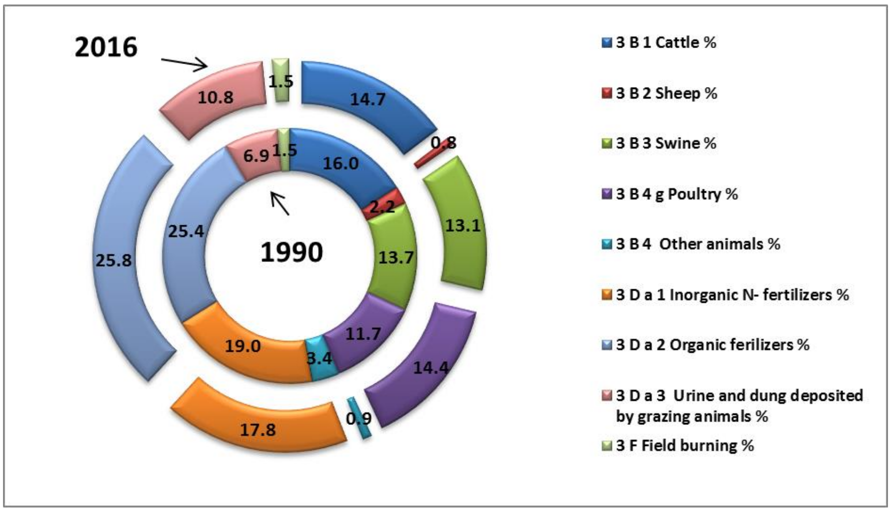
Figure 5.2– NH3 emissions (kt) by source category in the years 1990 (internal ring) and 2016 (external ring)



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, 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 2016, is presented in Figure below.

Figure 5.3 - Comparative share of NH_3 emissions by source, in1990 and in 2016 (%)



Besides NH_3 emissions the Portuguese Inventory includes also other pollutant emissions estimates related with agricultural activity that are summarized as follow:

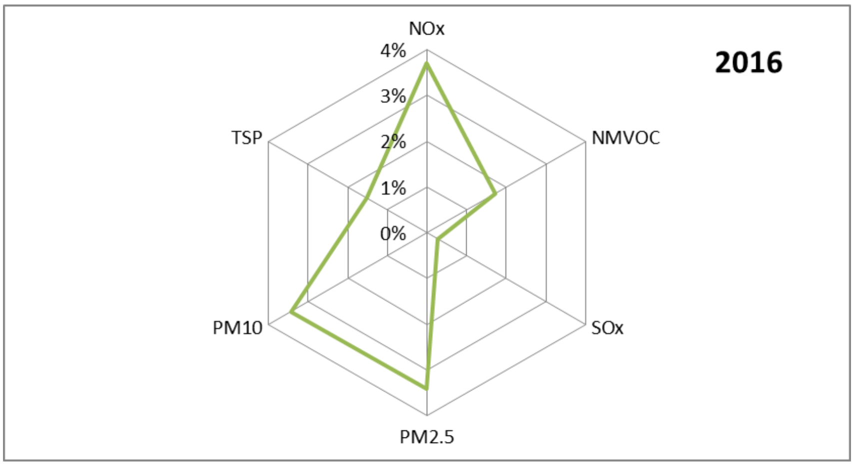
- From Manure management (3B): NO, NMVOC, $PM_{2.5}$, PM_{10}, TSP
- From Crop production and agricultural soils (3D): NO, NMVOC, $PM_{2.5}$, $PM_{10, TSP}$

- From field burning of agricultural residues (3F): NO, NMVOC, SO_x, $PM_{2.5}$, PM_{10}, TSP,BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCDD/F and PAHs

In Portugal the use of fungicides with HCB as active substance is not allowed since 1986 according to information of the National Authority responsible for the management and authorization of plant protection products. Thus the Portuguese inventory does not include HCB emissions related to the use of pesticides.

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 2016.

Figure 5.4 – Contribution (%) of agricultural emissions of air pollutants other than NH_3, in total national emissions in 2016



5.2 Recalculations

The major changes between last year submission and this year submission result from the following actions:

- revision of 2015 values of N inorganic fertilizers, updated by INE;
- revision of 2014 and 2015 animal numbers for poultry, rabbits, horses, mules & asses, according to the results of the last Farm Structure Survey (2016) published[48] by INE;
- revision of 2014 milk production (kg/hd/yr) of dairy cows, updated by INE. Milk production is a relevant parameter for N excretion estimates of dairy cows;
- revision of the share (trend 1990-2010) of the manure of cattle, sheep, goats and equidae, in each type of management system, based on the information collected from the last Agriculture General Census (RA09) and the information resident in the National Animal Registration database (SNIRA), for the same livestock categories;
- minor corrections as a result of internal QA/QC procedures.

[48] Data were recently published (28.11.2017)

5.3 Source Categories

5.3.1 Manure Management (NFR 3B)

5.3.1.1 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; NO; 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 Table below.

Table 5.1 – Methods, activity data, parameters and emission factors used by pollutant for manure management

Pollutant	Method	Activity data	Parameters	Emission Factor
NH_3	Tier 2	NS	CS, D	D
NO	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 2 or Tier 1 from the guidebook

For NH_3 and NO emissions estimates, Portugal used the Tier 2 mass flow approach described in the EMEP/EEA Guidebook 2016, chapter 3B – Manure management[49]. From the N-flow calculation process were obtained NH_3 emission estimates from manure management systems which occur from livestock housing, yards, storage, on field application and grazing. In the same process are also calculated NO emissions from manure storage and the net amount of Nitrogen returned to soil from manure (after N losses from emissions during building, yard, storage, manure application and from leaching of solid manure storage) which is used in the calculations of NO emissions in chapter 3D – Crop production and agricultural soils. The same calculations were done for the net return of N during grazing which is also used to estimate NO 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 originate mainly from feed.

[49] 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.

5.3.1.2 Activity data

General census on agriculture[50] and animal husbandry activities are made every 10 years by the National Statistical Institute (INE). The first census was made in 1952/54, followed 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[51] about 40 000 farms (production units) were surveyed, every two years. From 2010 the interval between surveys has been extended to 3 years. The complete National Methodological Report of 2013[52] farm structure survey is also available at Eurostat website (same link).

Annually livestock numbers[53] 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 2016 for cattle, swine, sheep and goats disaggregated per region[54], 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 evolution pattern of growth[55] for both species, Figure 5.5 , using the weight at slaughter that

[50] In Portuguese, Recenseamento Geral Agrícola (RGA 1989 and RGA 1999), Recenseamento Agrícola (RA 2009). The framework for the production of this statistics is established in the Regulation (EC) nº 1166/2008 of the European Parliament and of the Council of 19 November.

[51] Inquérito à estrutura das explorações agrícolas, in Portuguese.The framework for the production of this statistics is the same that for General Agriculture Census, i. e., the Regulation (EC) nº 1166/2008 of the European Parliament and of the Council of 19 November.

[52] The methodological report of 2016 Farm Structure Survey is not available yet. Data were recently published (28.11.2017)

[53] The framework for the production of this annual statistics, livestock numbers and meat production, is established in the Regulation (EC) nº 1165/2008 of the European Parliament and of the Council of 19 November:

[54] 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.

[55] Set up from the information on the s existent breeds in Portugal, complemented by information in Jarrige (1988) concerning growth pattern.

was calculated from the information published by INE, which values are presented in Figure 5.6. Resultant average ages vary from 107 to 134 days for sheep and 69 to 104 days for kids.

Figure 5.5 – Evolution pattern of growth for Sheep (a) and Goats (b)

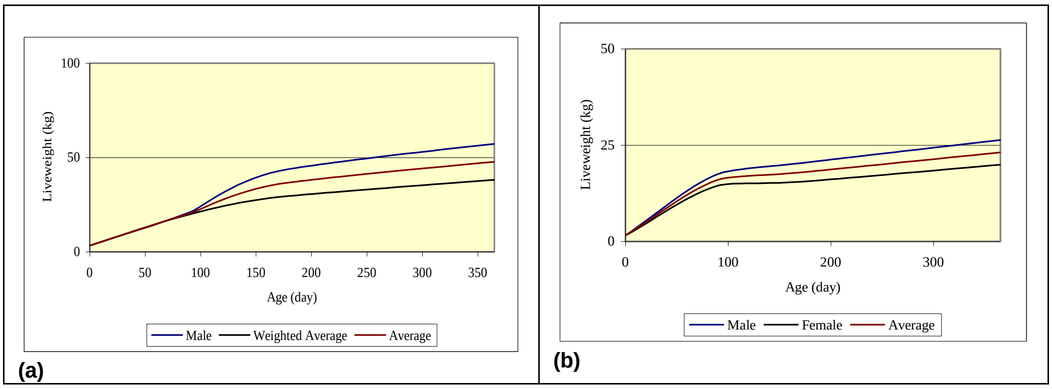
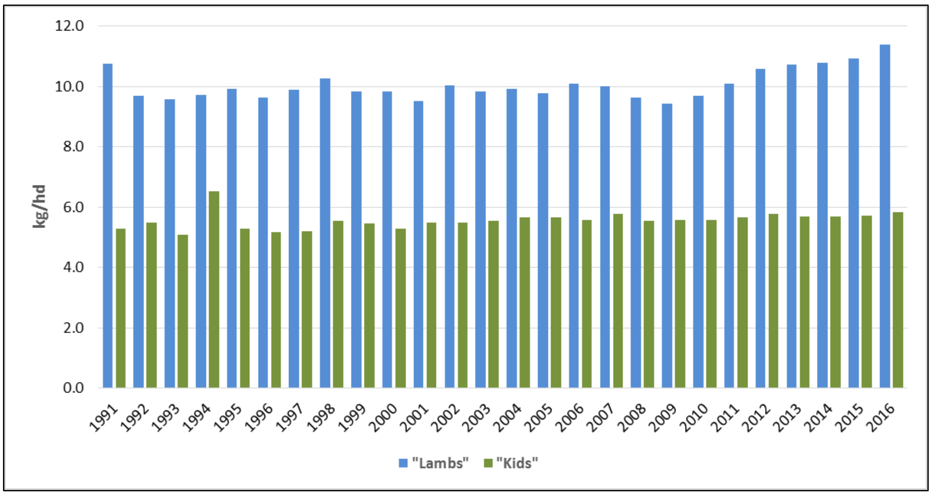


Figure 5.6 - Lambs and kids average carcass weight at slaughtering



The number of animals remaining from the total ovine and caprine numbers 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 is established from the results of the Agricultural Census and the Farm Structure Survey. The disaggregation of hens for eggs production and hens for chicks' production was obtained from the Annual Survey of eggs production and the Annual Survey of Industrial Poultry, published by the 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 next Table is presented the annual livestock numbers (1990, 1995, 2000, 2005, 2010 and 2014 to 2016) that are activity data for emission estimates from: manure management (3B), urine and dung deposited by grazing animals (3Da2) and animal manure applied to soil (3Da3).The complete time-series data can be seen in **ANNEX D: AGRICULTURE (NFR 3)**.

Also in the same table is shown the correspondence of animals type with the respective sub source category - 3B1a,b;3B2;3B4d,e,f,h and 3Bgi,ii,iii,iv.

In a consistent way the same activity data were used for UNFCCC and for UNECE/CLRTAP emission inventory.

Table 5.2– Animal numbers (thousands)

Animal class		1990	1995	2000	2005	2010	2014	2015	2016
Dairy-Cattle (3B1a)	Dairy cows	394	383	353	290	255	233	235	238
Non-dairy cattle (3B1b)	Beef calves (<1 yr)	46	60	67	104	114	113	112	114
	Calves M.Rep. (<1 yr)	186	162	144	136	123	142	152	162
	Calves F Rep. (<1 yr)	177	158	174	183	171	198	209	221
	Males 1-2 yrs	112	103	82	81	66	53	58	67
	Beef Fem. 1-2 yrs	18	22	17	17	20	17	15	14
	Females rep. 1-2 yrs	111	109	127	135	137	139	148	159
	Steers (>2 yrs)	38	33	26	25	38	39	37	38
	Heifers Beef (>2 yrs)	4	10	6	9	12	15	15	14
	Heifers rep. (>2 yrs)	45	52	67	94	110	103	96	92
	non-dairy cows	242	273	345	397	438	450	461	474
Swine (3B3)	Piglets (<20 kg)	727	726	663	574	597	681	713	729
	Fatt. Pigs (20-50 kg)	662	660	585	467	448	472	485	490
	Fatt. Pigs (50-80 kg)	525	525	483	368	360	369	380	387
	Fatt. Pigs (80-110 kg)	218	198	174	214	244	273	285	294
	Fatt. Pigs (> 110 kg)	44	44	38	41	36	28	30	33
	Boars (>50 kg)	26	26	20	12	7	5	6	5
	Sows, pregnant	210	211	195	191	179	159	162	164
	Sows, non-pregnant	124	132	124	68	66	69	71	72
Sheep (3B2)	Ewes	2 292	2 339	2 410	2 293	1 915	1 638	1 620	1 610
	Other Ovine	663	817	733	234	191	162	155	154
	Lambs	307	278	319	322	277	267	275	285
Goats (3B4d)	Does	614	517	460	380	356	333	324	311
	Other Caprine	149	151	129	57	40	36	37	34
	kids	47	41	33	26	29	25	23	22
Equidae (3B4e; 3B4f)	Horses	33	48	58	52	38	32	30	30
	Asses & Mules	118	103	69	40	22	13	11	10
Poultry (3B4gi,ii,iii,iv)	Hens, reproductive	3 421	3 271	2 644	3 056	3 453	3 047	2 920	2 890
	Hens eggs	7 539	7 745	9 060	7 349	7 867	6 857	6 710	6 607
	Broilers	18 524	18 813	24 374	18 686	19 207	18 096	19 395	21 745
	Turkeys	1 149	945	1 208	798	1 445	836	785	800
	Other poultry	1 667	1 648	1 707	1 353	1 522	1 164	1 284	1 530
Other (3B4h)	Rabbits[1]	475	401	336	289	255	170	148	128

1-reproductive females

5.3.1.3 Parameters

Nitrogen Excretion

The quantity of nitrogen excreted per head (Nexc rates) used in the inventory were established on the basis of the nitrogen excretion rates proposed by the Revised Agriculture Good Practice Code (CBPA - Código de Boas Práticas Agrícolas), and are the same that are published in Annex XII of Portaria[56] nº 259/2012, 28th August.

This process was conducted in close coordination with the Ministry of Agriculture expert team including the INIAV experts[57]. The following procedures were also considered on the analysis done:

- Compliance of the nitrogen excretion rates from CBPA with 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.

For dairy cows CBPA defines the nitrogen excretion rate as a function of milk production. The base nitrogen value for dairy-cattle is 115 kg N/hd/yr for 7000 kg milk produced/hd/year. For different milk production values the extrapolation procedures defined in CBPA are the following:

- The Nex decreases 10 per cent for every 1000 kg less of milk production;
- The Nex increases 2 per cent for every 1000 kg extra of milk production.

Whereas the production of milk from different years the corresponding excretion rates are given in Table 5.3.

Finally, Table 5.4 shows the excreta coefficients for all categories and subcategories animals which are used in inventory as well as the default values set in EMEP Guidebook 2016.

In a consistent way the same Nex rates are used for UNFCC and for UNECE/CLRTAP emission inventory.

[56] Nacional law related with the implementation of Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources

[57]Coordinated by Drª Fátima Calouro, expert from INIAV - National Institute for Agriculture and Veterinary Research

Table 5.3 – Dairy cattle - Milk production values and corresponding Nex

Year	Milk per Cow (kg/hd/yr)	Nex (kg/hd/yr)
1990	4 464	85.8
1991	4 440	85.6
1992	4 412	85.2
1993	4 111	81.8
1994	4 322	84.2
1995	4 556	86.9
1996	4 747	89.1
1997	4 813	89.8
1998	4 973	91.7
1999	5 718	100.3
2000	6 262	106.5
2001	6 502	109.3
2002	7 032	115.1
2003	6 768	112.3
2004	6 775	112.4
2005	7 233	115.5
2006	7 337	115.8
2007	7 311	115.7
2008	7 634	116.5
2009	7 826	116.9
2010	7 886	117.0
2011	7 929	117.1
2012	8 178	117.7
2013	8 011	117.3
2014	8 302	118.0
2015	8 287	118.0
2016	8 045	117.4

Table 5.4 – N excretion rate per head and by animal class/subclass (Nex)

		Nex (kg N/hd/yr)	
Animal Class	**Animal sub class**	**Country Specific**	**Default Guidebook**
Dairy-cattle	Dairy Cows	117.4	105
Non-dairy cattle	Beef calves (<1 yr)	25.00	41
	Calves, Males for Rep. (<1 yr)		
	Calves, Females for Rep. (<1 yr)		
	Males 1-2 yrs	40.00	
	Beef Fem. 1-2 yrs		
	Females for R. 1-2 yrs		
	Steers (>2 yrs)	41.00	
	Heifers for Beef (>2 yrs)	55.00	
	Heifers for Rep. (>2 yrs)		
	Non-dairy cows	80.0	
Swine	Piglets (<20 kg)	0.00	12.1
	Fat. Pigs (20-50 kg)	9.00	
	Fat Pigs (50-80 kg)	13.00	
	Fat Pigs (80-110 kg)		
	Fat Pigs (> 110 kg)		
	Boars (>50 kg)	18.0	34.5
	Sows, pregnant	20.0	
	Sows, non-pregnant	42.0	
Sheep	Ewes	9.17	15.5
	Other Ovine	6.60	
	Lambs	0.00	
Goats	Does	7.00	
	Other Caprine	6.60	
	kids	0.00	
Equidae	Horses	44.0	47.5
	Asses & Mules	22.0	
Poultry	Hens Reproductive	0.34	0.77
	Hens eggs	0.80	
	Broilers	0.45	0.36
	Turkeys	1.40	1.64
	Other Poultry	0.45	0.55 -1.26
Other	Rabbits[1]	9.00	-

1 Reproductive females

Values for piglet (<20kg), lambs and goat kids, are 0 kg N/hd/yr because the Nex is included with their respective mothers.

The Nex values for rabbits correspond to a breeding female with 40 young animals with a final weight of 2.7 to 3 kg per rabbit per year.

There is an acceptable agreement between country-specific values and EMEP Guidebook 2016 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 per animal type, and its variation from 1990 to 2016, is presented in ANNEX D: AGRICULTURE (NFR 3).

The proportion of total ammoniacal-N (TAN) used for the N-mass flow methodology applied to calculate emissions of NH_3 is, for each animal type excretion, was obtained from Table 3.9 of EMEP/EEA Guidebook 2016.

Manure Management Systems

Expert guess[58], based on survey data and field knowledge of technical personnel of the Ministry of Agriculture was used to establish the percent of each Management System (MMS) in 1990. The same expertise was used to establish a prevailing trend in the period 1990-2010[59], 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 an extensive way (pasture), the trend 1990-2010 was revised[60] for cattle (dairy cows, non - dairy cows, other cattle), sheep (ewes, other ovine), goats (does, other caprine) and equidae (horses, mules and asses).

As a result of the revision done the proportion of livestock produced in an extensive way increased in all animal species, excepted for non-dairy cows where a slight decrease was verified. Also in case of dairy cows manure management the proportion of slurry manure storage increased versus solid storage.

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, Table 5.5.

Since no new data is available[61], for 2016 we assume the 2010 distribution.

The different shares of Management Systems for Manure that we use are presented in Table 5.6.

[58] Information received from Dr. Carlos Pereira, from the Ministry of Agriculture in 3, March 2005.

[59] Information received from Dr. Carlos Pereira, from the Ministry of Agriculture in 7, October 2009.

[60] 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.

[61] Next General Agriculture Census will be in 2019

Table 5.5 – Annual variation of the share of each Manure Management System per animal type.

Animal Type	Lagoon System	Tanks/Earthen pond	Solid Storage	Pasture/range /paddock
Dairy Cows	0.600	-0.500	-0.550	0.450
non-dairy cows	-	0.050	0.300	-0.350
Other cattle	-	0.100	-2.900	2.800
Ewes	-	-	-0.550	0.550
Other ovine	-	-	-0.550	0.550
Does	-	-	-0.450	0.450
Other caprine	-	-	-0.450	0.450
Sows	0.250	-0.450	-0.100	0.300
Other Swine	0.250	-0.350	-0.050	0.150
Hens	-	-	-	-
Broilers	-	-	-0.195	0.195
Turkeys	-	-	-0.005	0.005
Other poultry	-	0.500	-0.500	-
Rabbits	-	-	-	-
Equidae	-		-2.450	2.450

Note: values represent the annual increment in the per cent of MMS use. Positive values represent increment in the per cent of the MMS. Negative values represent decrease in use

Table 5.6 – Share of each Manure Management System per animal type in 1990 and 2016 (equal to 2010) (%)

Animal Type	1990					2016*				
	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 5.7 the proportion of N excreted on building, yard and grazing and in

Table 5.8 the proportion of housed livestock managed on liquid and solid manure systems, for 1990 and 2016.

Table 5.7 – Proportion of N excreted on building, yard and grazing (%)

Animal type	1990			2016		
	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	19.60	0.40	80.00	8.82	0.18	90.00
Other ovine	19.60	0.40	80.00	8.82	0.18	90.00
Does	19.60	0.40	80.00	10.78	0.22	89.00
Other caprine	19.60	0.40	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	0.00
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 5.8 – Proportion of housed livestock managed on liquid and solid manure systems (%)

Animal Type	1990		2016	
	Liquid Manure	Solid Manure	Liquid Manure	Solid manure
Dairy Cows	50.00	50.00	35.79	64.21
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

Other parameters

The amounts of straw used and the N inputs from animal bedding were based on the default values of table 3.7 of EMEP/EEA Guidebook 2016, chapter 3B – Manure management, and are shown in table below.

Table 5.9 – Annual average, in the time series, of the amount of straw use in bedding - solid manure management systems and N content of straw

Animal type	Straw (kg/hd/yr)	N added in straw (kg/hd/yr)
Dairy cows	1 471.41	5.89
Non dairy cows	39.03	0.16
Other cattle	326.47	1.31
Sheep & goats	31.66	0.13
Sows	566.00	2.26
Other swine	192.33	0.77
Horses & asses	304.73	1.22

Specific parameters related to NMVOC emissions estimates are presented inTable 5.10 – Cattle and in Table 5.11– Other animal categories than cattle.

The values of gross feed intake (Mj / yr) 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 submission UNFCCC. Detailed information for all-time series is presented in ANNEX D: AGRICULTURE (NFR 3).

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 the all other animal categories than cattle the $Frac_{silage}$ was considered as zero.

Table 5.10 – Gross feed intake – cattle

Animal type	Gross feed intake (Mj/hd/yr)							
	1990	1995	2000	2005	2010	2014	2015	2016
Dairy cattle	82 917	83 465	96 904	105 142	109 818	115 441	112 978	111 410
Other cattle	50 646	57 905	58 341	59 186	56 365	57 387	57 255	57 134

Table 5.11 – Volatile solid excreted – all other animal categories than cattle

Animal type	Volatile solid excreted (kg/hd/yr)							
	1990	1995	2000	2005	2010	2014	2015	2016
Sows	230.62	232.95	233.82	211.33	212.77	218.55	219.17	219.23
Other swine	83.47	82.81	82.32	83.70	83.25	81.11	80.93	81.07
Sheep	183.64	186.93	184.31	175.23	174.77	173.18	172.45	171.86
Goats	170.48	168.62	169.66	174.68	174.74	175.59	178.36	176.20
Horses	627.80	627.80	627.80	627.80	627.80	627.80	627.80	627.80
Mules & asses	343.10	343.10	343.10	343.10	343.10	343.10	343.10	343.10
Hens	14.99	14.99	15.02	14.99	14.99	14.99	14.99	14.99
Broilers	6.54	6.54	6.54	6.54	6.54	6.54	6.54	6.54
Turkeys	29.28	29.28	29.28	29.28	29.28	29.28	29.28	29.28
Other poultry	14.76	14.76	14.76	14.76	14.76	14.76	14.76	14.76
Rabbits	52.79	52.79	52.79	52.79	52.79	52.79	52.79	52.79

5.3.1.4 Emission Factors

The emission factors used to estimate **ammonia emissions** from manure management were obtained from table 3.9 of EMEP/EEA Guidebook 2016, chapter 3B - Manure management.

Ammonia emissions following manure application and from grazing animals are calculated in this source category but reported in the agricultural soils source category (3D).

Table 5.12 – Emission factors used for calculation of the NH3-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 - chapter 11

Emission factors used to estimate **nitric oxide emissions** from manure management were obtained from table 3.10 of EMEP/EEA Guidebook 2016, chapter 3B - Manure management.

Table 5.13 – Emission factors used for calculation of the NO-N emissions from manure management. EF as proportion of TAN

EF Storage	
Slurry	Solid
0.0001	0.0100

In a consistent way the storage N_2O-N emission factors were 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).

Emission factors used to estimate **NMVOC emissions** from this source category were from EMEP/EEA Guidebook 2016, table 3.11 for cattle and table 3.12 for all other animal categories than cattle, of chapter 3B - Manure management

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 of chapter 3B – Manure management. 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 5.14 – Default NMVOC tier 2 emission factors for cattle (kg NMVOC / MJ feed intake)

Animal Type	EF sillage feed	EF house	EF grazing
Dairy cattle	0.0002002	0.0000353	0.0000069
Other cattle	0.0002002	0.0000353	0.0000069

Table 5.15 – Default NMVOC tier 2 emission factors for all other animal categories than cattle (kg NMVOC/kg VS excreted)

Animal Type	EF sillage 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 of EMEP/EEA Guidebook 2016, of chapter 3B-Manure management.

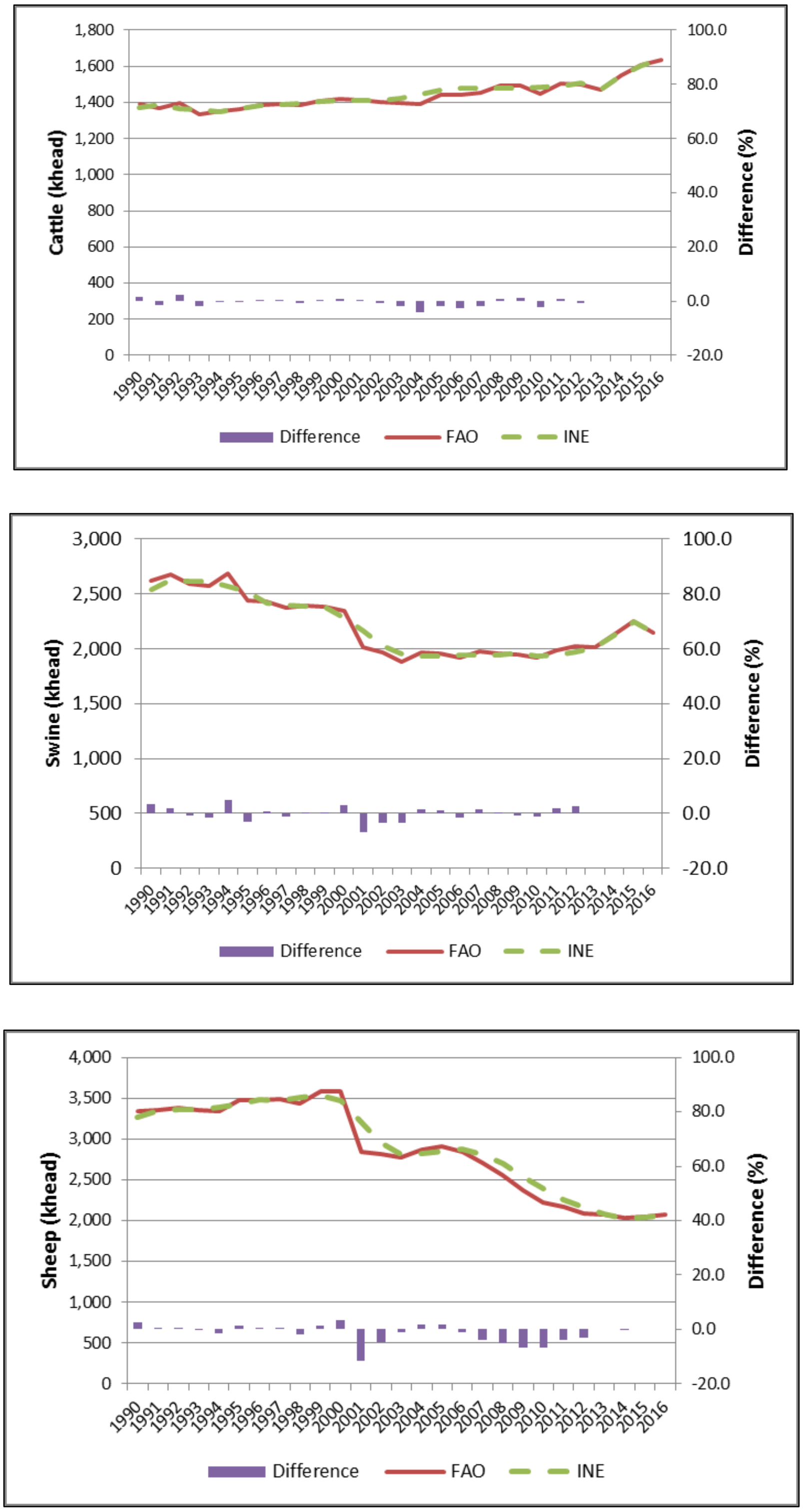
5.3.1.5 Uncertainties

To be provided in the future

5.3.1.6 Quality Assessment of Livestock numbers

Livestock numbers used in the inventory, as collected from National Statistics, were compared to FAO livestock numbers for years 1990-2016, and results are presented in the below figures for cattle, swine and sheep.

Figure 5.7 – Comparison of Livestock numbers between national statistics and FAO database. Values represent the relative per cent difference to National Statistics



FAO and INE livestock numbers have a good adhesion for all species. From 2012 values total agree in both dataset.

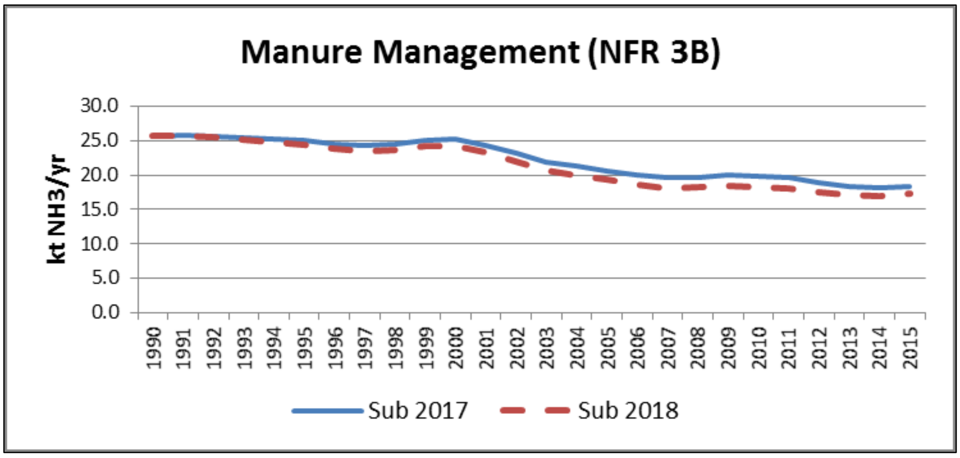
5.3.1.7 Recalculations

Recalculations made for 3B category are mainly due to:

- revision of 2014 and 2015 animal numbers for poultry, rabbits, horses, mules & asses, according to the results of the last Farm Structure Survey (2016) published[62] by INE;
- revision of 2014 milk production (kg/hd/yr) of dairy cows, updated by INE. Milk production is a relevant parameter for N excretion estimates of dairy cows;
- revision of the share (trend 1990-2010) of the manure of cattle, sheep, goats and equidae, in each type of management system, based on the information collected from the last Agriculture General Census (RA09) and the information resident in the National Animal Registration database (SNIRA), for the same livestock categories. The proportion of grazing animals increased in all of them which means, in the N_flow approach, less N_excreted in housing and stored in the management systems and more N_excreted deposited in pasture (NFR 3 Da3). Consequently, in 3B source category the emissions lowered and in 3 Da3 source category the emissions went up (Figure 5.13);
- minor corrections as a result of internal QA/QC procedures.

For NH_3 emissions estimates the differences between last year submission and this year submission are represented in the figure below.

Figure 5.8 – Manure management NH_3 emissions estimates, differences between submission 2017 and submission 2018



5.3.1.8 Further improvements

It is planned to continue the improvement of the characterization of the manure management systems framed by the new national law[63] related with livestock farming. Further efforts will be done to obtain more detailed information exploring new sources of information.

5.3.2 Crop production and agricultural soils (NFR 3D)

For the source category 3D, the Portuguese inventory includes emission estimates of the pollutants from the sub sources categories, as described below:

[62] Data were recently published (28.11.2017)

[63] Decree-Law nº 81/2013

Table 5.16 – Pollutant emissions estimates by sub source category 3D

NFR code	Source	Pollutant emissions
3Da1	Inorganic N- fertilizers	NH_3; NO
3Da2a	Animal manure applied to soil	NH_3; NO; NMVOC
3Da2b	Other organic fertilizer applied to soil	NH_3; NO
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.

1.1.1.2 *Inorganic N-fertilizers (NFR 3Da1)*

1.1.1.2.1 Methodology

The **ammonia emissions** estimates from inorganic N - fertilizers are based on the tier 2 methodology of the EMEP/EEA Guidebook 2016, 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 of chapter 10 of IPCC 2006.

In Figures below are represented the distribution of climate zones and soil pH in Portugal mainland[64].

[64] Azores and Madeira archipelagos are in temperate climatic zone with normal pH soil.

Figure 5.9 – Climate regions representation at Portugal mainland according to IPCC 2006 classification

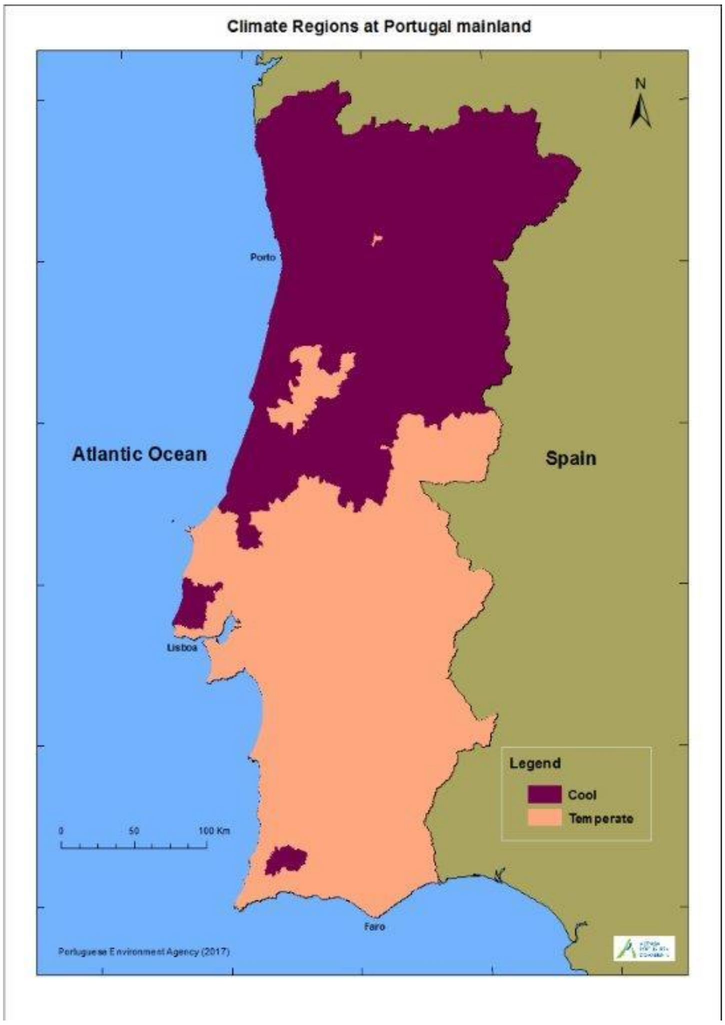
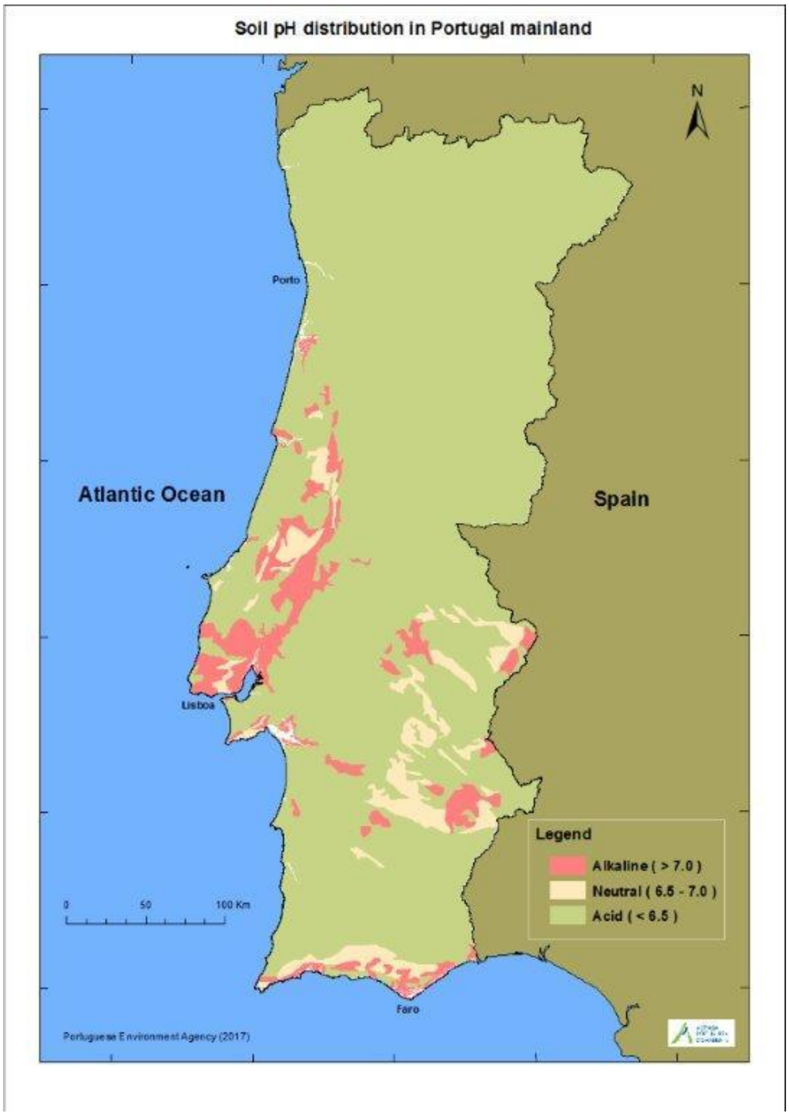


Figure 5.10 – Alkaline, Neutral and Acid soils representation at Portugal mainland



Source: "Acidez e Alcalinidade dos solos em Portugal" – Atlas do Ambiente (1984)

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[65] 7.0 (normal) is presented in the next table.

[65] Below or equal 7.0. Includes Neutral and Acid soils

Table 5.17 – Proportion (%) of the agricultural land in each emission region

Emission regions		Agricultural land %
Description	Code	
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), page 16, of EMEP/EEA Guidebook 2016, chapter 3D – Crop production and agricultural soils. In Table 5.18 are presented the calculation results for the year 2016.

Table 5.18 – Nitrogen amount (kt/yr) by type of fertilizer and emission region in 2016

	Emission regions			
Type of N fertilizer	**NC**	**NT**	**HC**	**HT**
Ammonium nitrate (AN)	1.49	1.24	0.13	1.10
Ammonium phosphate (MAP&DAP)	0.64	0.53	0.06	0.47
Ammonium sulfate (AS)	0.00	0.00	0.00	0.00
Calcium ammonia nitrate (CAN)	7.35	6.09	0.64	5.39
Urea	9.56	7.93	0.84	7.01
Other NP & NPK	9.29	7.70	0.81	6.81
Other N	14.54	12.05	1.27	10.66
Total	**42.87**	**35.54**	**3.76**	**31.44**

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 8 of EMEP/EEA Guidebook 2016, chapter 3D – Crop production and agricultural soils).

1.1.1.2.2 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 synthetic 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, having found the same lack of available data, produced a methodology (INE,2004), in collaboration with the Laboratório Químico Agrícola Rebelo da Silva and ADP, that estimates the Apparent Consumption of Fertilizers in the Agriculture activity (ACFA) by a simple mass balance, from national production and international market information data. The fertilizer consumption data reported by INE are obtained by the following methodology:

$$Consumption_{(f)} = Production_{(f)} + Import_{(f)} - Export_{(f)}$$

where,

$Consumption_{(f)}$ – Annual consumption in Portugal of nitrogen fertilizer f (ton N/yr);

$Production_{(f)}$ – Annual production in industrial plants in Portugal of nitrogen fertilizer f (ton N/yr);

$Import_{(f)}$ – Annual imports in Portugal of nitrogen fertilizer f (ton N/yr);

$Export_{(f)}$ - Annual exports in Portugal of nitrogen fertilizer f (ton N/yr).

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 N fertilizers in the period 1995-2002, (158 500 t N/yr) 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). The Table 5.19 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 5.19 – Nitrogen amount (kt/yr) by type of fertilizer

Type of fertilizers	1990	1995	2000	2005	2010	2014	2015	2016
Ammonium nitrate (AN)	-	-	-	-	4.01	4.63	4.69	3.96
Ammonium phosphate (MAP&DAP)	13.28	16.75	11.83	-	0.54	1.11	0.59	1.70
Ammonium sulphate (AS)	17.72	25.40	14.47	10.30	3.06	0.00	0.00	7.04
Calcium ammonia nitrate (CAN)	46.13	40.67	45.72	29.68	34.99	18.55	17.88	19.47
Urea	13.35	7.06	20.52	11.85	13.85	24.01	27.60	25.34
Other NK & NPK	49.54	40.76	57.74	39.94	24.90	30.27	27.32	24.51
Other N	18.49	15.18	19.72	10.90	18.90	44.26	35.87	38.52
TOTAL	**158.50**	**145.82**	**170.01**	**102.66**	**100.25**	**122.84**	**113.96**	**113.62**

1.1.1.2.3 Emission factors

The emission factors used to **estimate ammonia emissions** from synthetic N-fertilizers were obtained from table 3-2 of EMEP/EEA Guidebook 2016, of chapter 3D – Crop production and agricultural soils, and are presented in the table below.

Table 5.20 – NH_3 emission factors (kg NH_3-N/kg N applied)

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 / kg N applied (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, which in Portugal occur in 12.3% of mainland territory[66]. Nitric oxide emission estimates were done considering the proportional amount of the annual consumption of N-fertilizers.

1.1.1.3 *Animal manure applied to soil (NFR 3Da2a)*

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.

The **NH3 emission factors** used for manure applied to soil were the ones referred in Table 5.12 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 / 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)

[66] Source:Acidez e Alcalinidade dos solos de Portugal" – Atlas do Ambiente (1984)

1.1.1.4 *Other organic fertilizers applied to soil (NFR 3Da2b; NFR 3Da2c)*

a) Sewage sludge applied to soil (SS)

NH_3 emissions from sewage sludge applied to soils (Emi_{NH3}) was estimated by:

$$Emi_{NH3} = SS * NSSF * EFss$$

where

SS - quantity of sewage sludge spread on agricultural lands (ton/yr)

NSSF - nitrogen fraction of sewage sludge (percentage of dry solids)

EFss - NH_3 emission factor for sewage sludge (kg NH_3 / Kg N applied)

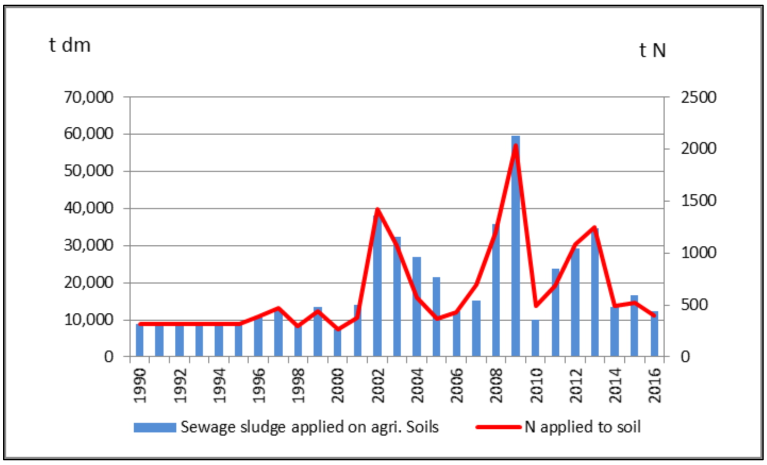
The **emission factor** used to estimate **ammonia** emissions was obtained from EMEP/EEA Guidebook 2016, chapter 3D – crop production and agricultural soils, Annex 1, section A1.1.2, page 30[67], and is equal to 0.13 kg NH_3 / Kg of N applied to soil from sewage sludge.

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/ kg of N applied to soil from sewage sludge. The NO emission factor was obtained from EMEP/EEA Guidebook 2016, chapter 3D – crop production and agricultural soils, Annex 2, section A 2.3, page 32.

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).

[67] Development of Tier methodology for ammonia emissions from sewage sludge

Figure 5.11 – Quantities of sewage sludge (t dm) and amounts of N (t N) applied on agricultural soils



b) Compost from municipal solid waste applied to soil (MSW)

NH3 emissions from MSW compost applied to soils ($EmiNH_3$) was estimated by:

$$Emi_{NH3} = MSW * NMSWF * EF_{MSW}$$

where

MSW - quantity of compost from MSW spread on agricultural lands (t/yr)

NMSWF - nitrogen fraction of compost (%)

EF_{MSW} - NH_3 emission factor for MSW compost (kg NH_3 / Kg N applied)

The **emission factor** used to estimate **ammonia** emissions was obtained from EMEP/EEA Guidebook 2016, table 3-1 of chapter 3D – Crop production and agricultural soils and is equal to 0.08 kg NH_3 / Kg of N applied 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/ kg of N applied to soil from compost. The NO emission factor was obtained from EMEP/EEA Guidebook 2016, chapter 3D – crop production and agricultural soils, table 3-1.

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 2016 a total amount of 49 408 t of MSW compost was applied to agricultural soils which corresponds to the N amount application of 988 t.

1.1.1.5 *Urine and dung deposited by grazing animals (NFR 3Da3)*

NH3, 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 manure management 3B as it was already highlighted there.

The **NH3 emission factors** used for urine and dung deposited by grazing animals were the ones referred in Table 5.12 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 5.14 and Table 5.15 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 / kg N applied (table 3-1 of EMEP/EEA Guidebook 2016, 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.

1.1.1.6 *Cultivated crops and farm level agricultural operations (NFR 3De and 3Dc)*

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.

$$Emi_{pollutant} = AR_{area} * EF_{pollutant}$$

where

$Emi_{pollutant}$ – amount of pollutant emmited (kg)

AR_{area} – area covered by crop (ha)

$EF_{pollutant}$ – emission factor of pollutant (kg/ha)

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 5.21.

Table 5.21 – Crop area (ha)

Year	Crops
1990	1 048 641
1991	998 805
1992	980 620
1993	924 189
1994	888 768
1995	865 276
1996	866 570
1997	807 363
1998	784 539
1999	746 935
2000	742 494
2001	716 686
2002	674 645
2003	664 955
2004	623 696
2005	593 994
2006	537 812
2007	523 555
2008	510 623
2009	511 398
2010	475 618
2011	533 431
2012	617 110
2013	622 154
2014	405 128
2015	369 644
2016	354 939

Emissions factors used are from table 3-1 of EMEP/EEA Guidebook 2016, chapter 3D – Crop production and agricultural soils, and are shown in next table

Table 5.22 – NMVOC, $PM_{2.5}$, PM_{10} and TSP emission factors (kg/ha)

NMVOC	$PM_{2.5}$	PM_{10}	TSP
0.85	0.06	1.56	1.56

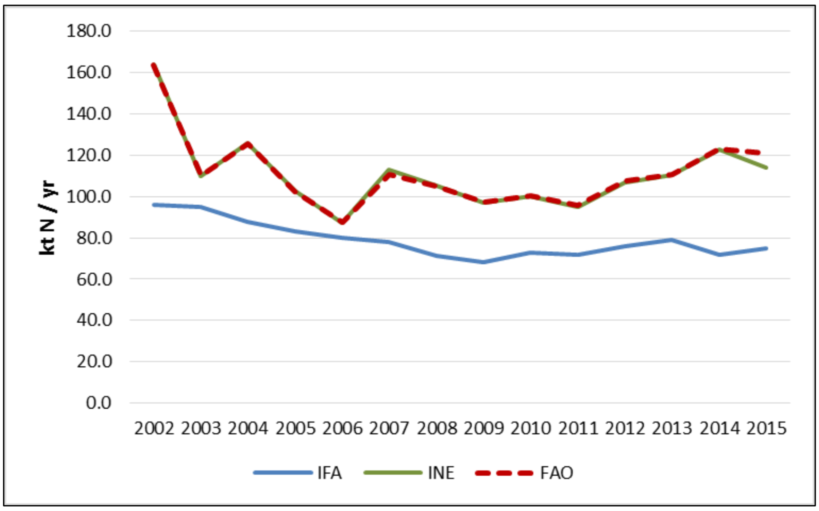
1.1.1.7 *Uncertainties*

To be provided in the future.

1.1.1.8 *Quality assessment of inorganic fertilizer 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 (http://ifadata.fertilizer.org/ucSearch.aspx) for the period 2002 – 2015. For previous years (1990-2001) FAO database archive has no data registers. In both databases (FAO and IFA) 2015 is the last year available. Comparison results are shown in the next Figure.

Figure 5.12 – Consumption of N- fertilizers in Portugal. Comparison data of INE (inventory) with FAO and IFA data (kt N / yr)



FAO and INE series agree quite well. The difference for 2015 is due to the recent update done by INE to the previous value that should then be transmitted by Eurostat to FAO, what apparently has not been made.

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

1.1.1.9 *Recalculations*

The major recalculations in this source category were due to:

- revision of 2015 values for apparent consumption of N inorganic fertilizers updated by INE;
- revision of 2014 and 2015 animal numbers for poultry, rabbits, horses, mules & asses, according to the results of the last Farm Structure Survey (2016) published[68] by INE;
- revision of the share (trend 1990-2010) of the manure of cattle, sheep, goats and equidae, in each type of management system, as explained in chapter 3B. The proportion

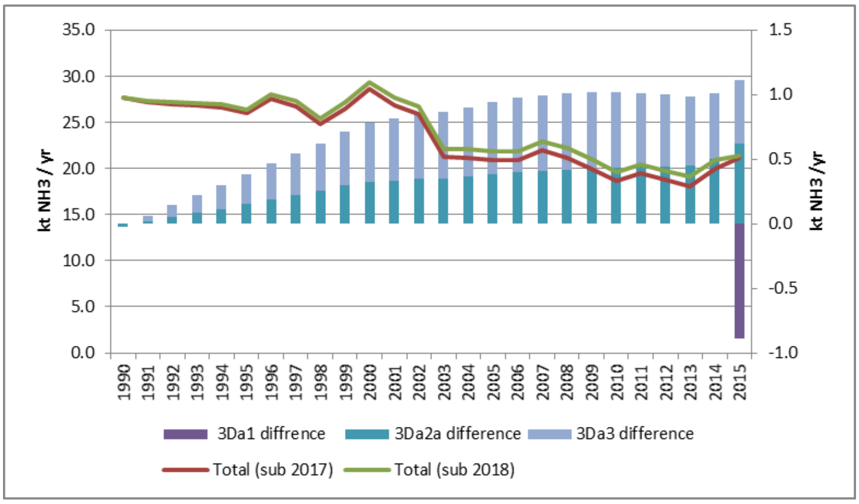
[68] Data were recently published (28.11.2017)

of grazing animals increased in all of them which means more N_excreted deposited in pasture and consequently more emissions in 3 Da3 source category. There is also an increment in the 3Da2 source category that is related with the increase of the proportion of slurry manure applied to soil versus solid manure from dairy cows storage systems;

– minor corrections as a result of internal QA/QC procedures.

For the NH_3 emissions estimates the differences between 2017 submission and this year submission are represented in the figure below.

Figure 5.13 – Crop production and agricultural soils NH3 emissions. Differences between submission 2017 and submission 2018



1.1.1.10 *Further improvement*

As referred in the source 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[69] related with livestock farming. It is likely that the possible outcome will also have impact on the emissions from manure applied to soil.

5.3.3 Field burning of agricultural residues (NFR 3F)

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.

Table 5.23 – Pollutant emission estimates from field burning of agricultural residues

	Pollutants
Main Pollutants	NH_3, NMVOC, NO_x, SO_x
Particulate Matter	$PM_{2.5}$, PM_{10}, TSP, BC
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

[69] Decree-Law nº 81/2013

1.1.1.11 *Methodology*

Emissions of in-site burning of agricultural residues were estimated with the IPCC (2006) methodology to calculate emissions from biomass burning (volume 4, chapter 2, and page 2.42) which is summarized in the following equation:

$$Emission_{(p,crop,)} = A_{(crop)} * M_{B(crop)} * C_f * EF_{(p,crop)} * 10^{-3}$$

where

$Emission_{(p,crop,y)}$ - Emission estimate of pollutant p from field burning of residues from a specific crop (ton/year)[70];

$A_{(crop)}$ – correspond to the crop area where the practice of field burning residues occurs (ha/yr);

$M_{B\ (crop)}$ - biomass of a specific crop that is available for combustion (t dm/ha/yr);

C_f – combustion factor, dimensionless;

$EF_{(p,crop)}$ - emission factor from field burning of agriculture residues of a specific crop (g/kg dm burnt).

1.1.1.12 *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[71] limits. In these situations the practice of burning crop residues is forbidden[72] 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[73] all rice cultivation areas subjected to “Techniques of Integrated Production and Protection[74]” had the same burnt residues restrictions. Straw were left on ground and incorporated into soil by plowing before next crop season.

[70] For PCCD/PCDF is gI-TEQ

[71] Natura 2000 network includes Special Zones for Conservation (ZPC) established under Habitats Directive (92/43/ CEE) and Special Proctetion Zones (ZPE) established under Birds Directive (last revision 2009/147/CE). http://www.icnf.pt/portal/naturaclas/rn2000

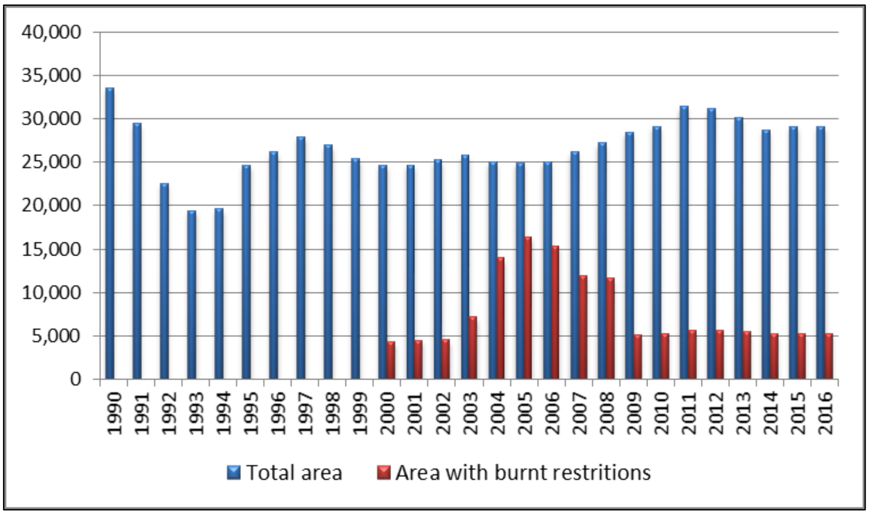
[72] National Laws: DL 140/99 artº 11º (revised by DL 49/2005); RCM 177/2008 artº 21º; RCM 182/2008 artº 8º.

[73] From 2009 onwards the limitation of residues burnt was removed (Circular / DSPFSV/ 08 from Directorate General of Agriculture and Rural Development -DGADR)

[74] “Modos de protecção e produção integrada” in the original in Portuguese.

The next figure shows the evolution of rice cultivation areas where the practice of residues burnt is not allowed.

Figure 5.14 – Rice cultivation areas (ha) in Portugal



Source: Ministry of Agriculture

For other cereals the practice of straw burning occurs in 1% of the cultivated area according to the INE information based on the last General Agricultural Census (2009) which included a set of questions about some agricultural practices.

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 area and 65% of the olive grove area, according to the information collected in the General Agricultural Census.

The amount of biomass available for combustion of cereal crops was estimated using the IPCC 2006 methodology, i.e, the regression equations in table 11.2 (volume 4, chapter 11, pg. 11.17).

The amounts of pruning material produced for each of the permanent crops are country specific[75] values presented in the Table 5.24.

Activity data and parameters used to estimate emissions from cereal and permanent crops residues burnt on fields are summarized in Table 5.24 for 2016.Combustion factors used for cereal crops are from IPCC 2006, table 2.6 of volume 4, chapter 2, page 2.49. It was considered a combustion factor equal to 1 for the pruning material from permanent crops.

In a consistent way the same activity data were used for UNFCCC and for UNECE/CLRTAP emission inventory.

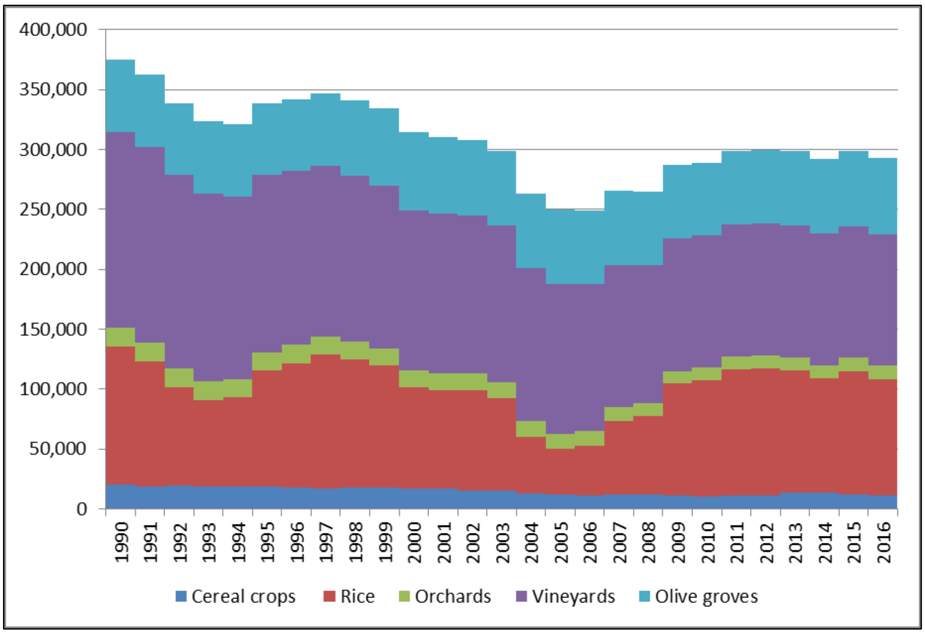
[75] Source: Dias, J.J.Mestre (2002), " Utilização da biomassa: avaliação dos resíduos e utilização de pellets em caldeiras domésticas".

Table 5.24 – Activity data and parameters used to estimate emissions from on field burning of agricultural residues, for 2016

Crop	Area with residues burnt (kha)	Biomass available for combustion (t dm/ha)	Combustion factor
Wheat	0.38	3.69	0.90
Barley	0.21	2.56	0.90
Maize	1.24	7.80	0.80
Rice	16.43	7.37	0.80
Other cereals	0.81	2.21	0.90
Orchards	9.47	2.27	1.00
Vineyard	92.21	1.19	1.00
Olive grove	231.46	0.27	1.00

In figure below is presented the annual biomass burnt (t dm/yr) for the period 1990-2016.

Figure 5.15 – Annual Biomass burnt (t dm /yr) – 1990 to 2016



1.1.1.13 *Emission factors*

The emission factors used to estimate NO_x, NMVOC, SO_x, NH_3 and CO emissions from on field burning agricultural residues are presented in Table 5.25.

For $PM_{2.5}$, PM_{10}, TSP and BC emission estimates were used the emission factors presented in Table 5.26.

Table 5.25 – Emission factors for field burning of agricultural residues by pollutant and crop (kg/kg dm) – Main pollutants 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”
Vineyard	0.0030”	0.0006»	0.0005#	0.0024#	0.1070”
Olive grove	0.0030”	0.014»	0.0005#	0.0024#	0.1070”

Sources: Wheat, barley, maize and rice 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 5.26 – Emission factors for field burning of agricultural residues by pollutant and crop (kg/kg dm) - 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#
Vineyard	0.0054#	0.0057#	0.0058#	0.0005#
Olive grove	0.0054#	0.0057#	0.0058#	0.0005#

Sources: Wheat, barley, maize and rice 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 5.27 – Emission factors for field burning of agricultural residues by pollutant and crop – POP's

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#	67.70	189.10	80.70	57.90
Barley	0.5000#	98.80	307.40	77.00	38.20
Maize	0.5000#	1 136.9	554.70	339.30	383.40
Rice	0.5000#	0.92	19.00	31.5	14.50
Other cereals	0.5000#	67.70#	189.10#	80.70#	57.90#
Orchards	0.5000#	67.70#	189.10#	80.70#	57.90#
Vineyard	0.5000#	67.70#	189.10#	80.70#	57.90#
Olive grove	0.5000#	67.70#	189.10#	80.70#	57.90#

Sources: Wheat, barley, maize and rice 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 5.28 – Emission factors for field burning of agricultural residues by pollutant and crop (mg/kg dm) – 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#
Vineyard	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 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

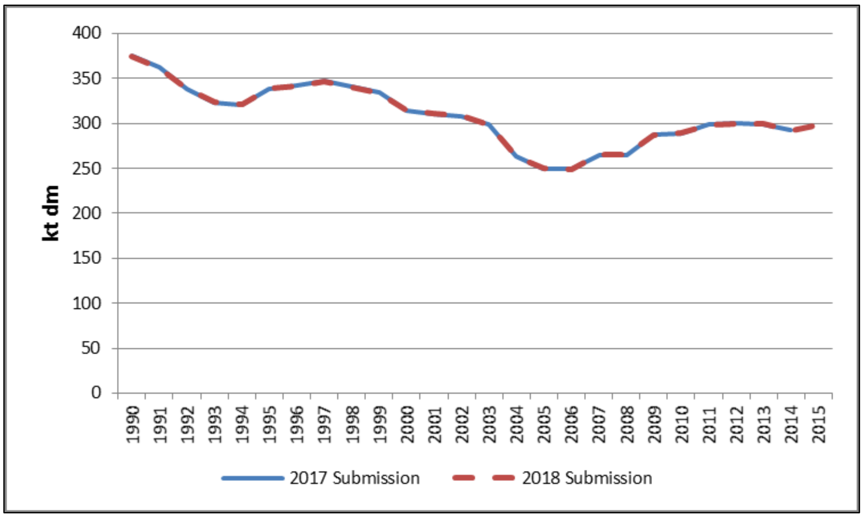
1.1.1.14 *Uncertainties*

To be provided in the future.

1.1.1.15 *Recalculations*

No recalculations to point out as shown in figure below

Figure 5.16 - Differences between previous submission (2017) and this year submission (2018) for the total amount of biomass burnt.



1.1.1.16 *Further improvements*

No specific improvements are planned.

6 WASTE (NFR 5)

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.

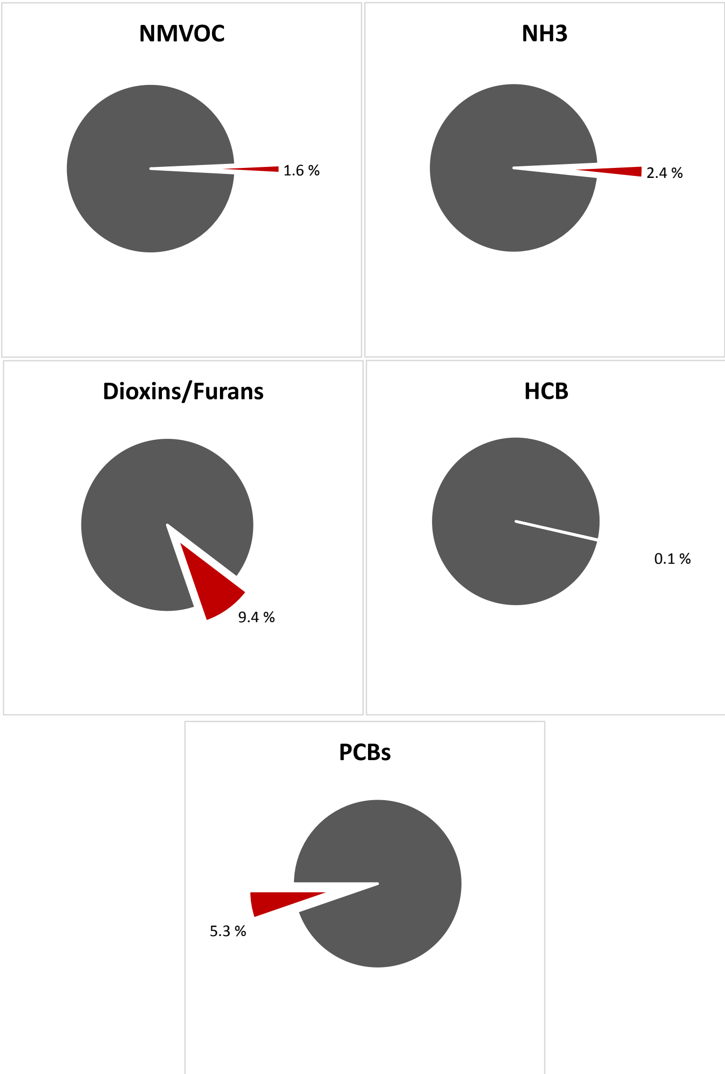
This sector includes also the incineration of industrial waste that occurs in industrial units without energy recovery.

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.

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 2016



6.2 Source categories

6.2.1 Solid Waste Disposal on Land (NFR 5 A)

6.2.1.1 NMVOC emissions from Solid Waste Disposal Sites (SWDS)

6.2.1.1.1 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).

6.2.1.1.2 Activity data and parameters

SWDS include solid municipal waste (household, garden, commercial-services wastes) and industrial wastes.

6.2.1.1.2.1 Municipal waste

6.2.1.1.2.1.1 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 as ”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 (please see 6.2.1.1.2.1.3-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:

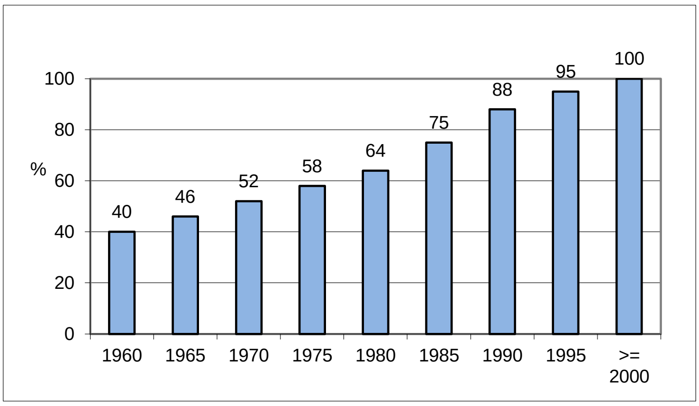
[Population (inhabitants) * Annual amount of municipal waste generated per capita (t/inhabitant/year)]

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 * Percentage of Population served by waste collection] – Quantity of incinerated waste – Quantity of composted/digested waste

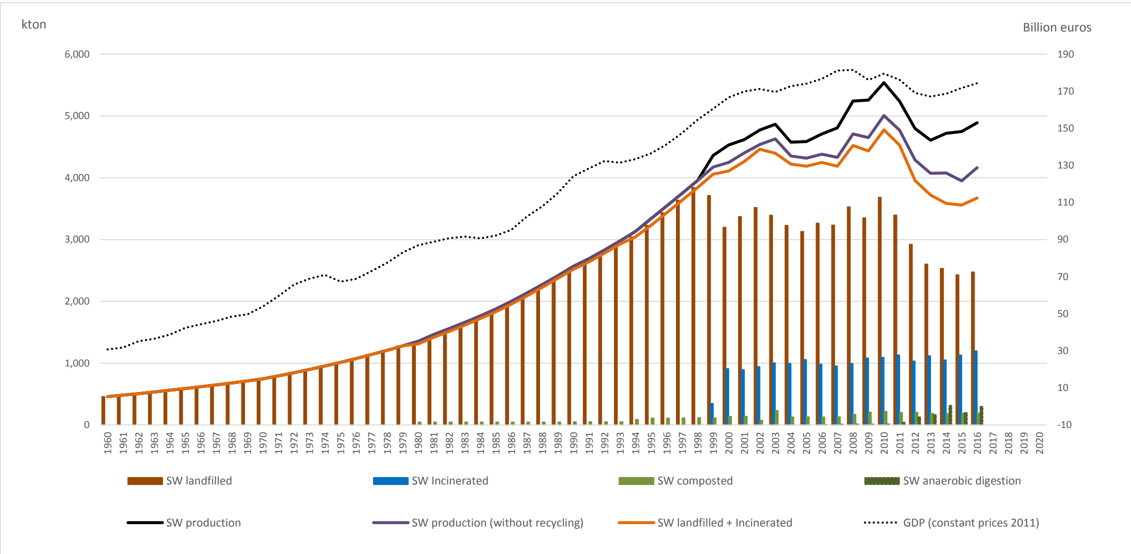
Figure 6.2 – Population served by waste collection systems



Source: APA

Next figure presents the trends of SW generation amounts and the quantities of waste per type of final disposal.

Figure 6.3 – Municipal waste



Source: APA, include estimates.

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 the peak around the year 2010, total municipal solid waste (MSW) production presents mostly 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 occurred.

In 2016 they were produced around 4.9 million tonnes (t) of urban waste in Portugal, approximately 3.0% more than in 2015, accentuating the inversion of the trend registered in 2014.

This increase is believed to be related with an improvement of the economic situation of Portugal, which recorded approximately 1.5% growth in 2016 as compared to 2015, seeming to indicate that the objective of decoupling waste production from economic growth is not being fulfilled, and that the measures to prevent the production of waste 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 production.

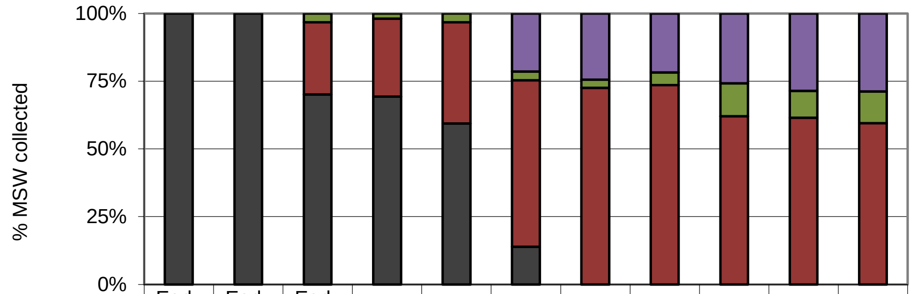
In 2016, 2015 and 2014, the tourist inbound markets presented a +13.3% growth (with 41.9 million overnight stays), +7.5% and +14.1%. as compared respectively to 2015, 2014 and 2013. According to the item “Travel and Tourism” from the Balance of Payments (source: Banco de Portugal), in 2016 the net balance of this item reached a 12.7% increase in comparison to 2015, totaling EUR 8.8 billion. In 2015, the net balance amounted at EUR 7.8 thousand million reflecting a 9.5% rise compared to 2014 (+15.4% in 2014/2013).

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 disposal 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 tendentiallydecreasing 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 organic recovery and 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 2016 approx. 12% of waste final disposal. These measures have contributed also to an increase in multi-material recycling and the organic recovery of waste, with a consequent decrease of biodegradable waste in landfills.

Figure 6.4 – Waste treatment by final destination. (recycling excluded)



	Early 60s	Early 70s	Early 80s	1990	1995	2000	2005	2010	2014	2015	2016
Incinerated	0	0	0	0	0	21	24	22	26	29	29
Composted/ AD	0	0	3	2	3	3	3	5	12	10	12
Managed landfills	0	0	27	29	37	61	72	74	62	62	59
Open dump sites	100	100	70	69	59	14	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.

6.2.1.1.2.1.2 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
		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
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
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
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
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
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
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
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
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
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

Notes:

Data on waste composition: Early 60s, 70s and 80s data refer to Fernandes, A Pastor (1982), "RSU do Continente - um Guia para Orientação e Inform. Das Autarquias", LNETI. Early 90s: estimates from interpolation. Mid 90s: data refer to 1994; DGA. 2000 and 2010-16: APA

DOC content: 2006 IPCC defaults.

6.2.1.1.2.1.3 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.

6.2.1.1.2.2 Industrial waste

6.2.1.1.2.2.1 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 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).

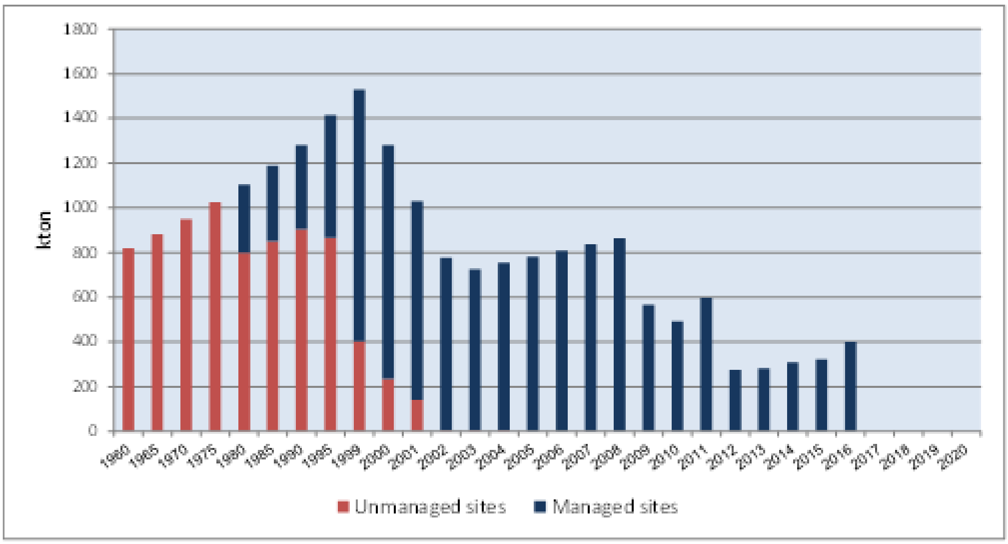
In 2012, the Statistical Office made a methodological change in the sectoral waste statistics, consisting in the harmonization of the sample used for these statistics with other statistical operations related to the Common Corporate Sector/ Business Sector, in which a set of statistical units, such as 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.

Figure 6.5 – Quantities of fermentable industrial waste disposed to SWDS



Source: APA

The fluctuations of industrial waste amounts disposed in landfills, as shown in the figure above, results in part from the use of different data sets along the time. There are however other factors, that explain these differences, such as the landfill diversion. The treatment of industrial waste includes landfilling, incineration, shipping abroad and recycling. The differences result, at least partially, from the variation of fluxes to other treatments as a consequence of the annual waste market demand.

6.2.1.1.2.2.2 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 SILIAMB electronic plataform. 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.

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 (percentage of weight) for composite packaging as: 75% cardboard, 20% polyethylene and 5% aluminium (http://www.protegeoqueebom.pt/2010/02/18/embalagens-de-cartao-para-liquidos/); and mixed packaging as 20% for each fraction: paper, glass, plastic, metal and wood.

For the new category “Screening waste”, the DOC value was estimated on the basis of the composition of rejected waste disposed into landfills, considering two thirds of the fractions as inerts materials and one third as biogenic.

Table 6.3 - Industrial organic waste composition and DOC

waste groups	DOC (0...1)	1960-99	1999	2000	2001	2002	2003
		ton					
paper	0.40		775,315			58,364	275,005
textiles	0.24		63,364			326,329	38,530
garden waste, park waste or other non-food organic g	0.20		77,269			205,965	172,135
food waste	0.15		19,209			58,455	158,256
wood or straw	0.43		155,142			64,044	14,566
sludge from natural origin	0.14		220,250			29,736	22,607
TOTAL	-	estimates	1,330,834	[illegible]	[illegible]	777,537	725,846
DOC (weighted average)	-	0.291	0.291	0.273	0.258	0.238	0.259

waste groups (EWC-Stat/Version 4)	DOC (0...1)	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
		ton												
03.2 + 03.3 Sluge from industrial origin	0.14					28,874	40,149	32,944	33,738	23,203	25,905	29,733	28,919	30,437
05 Health care and biological wastes	0.15					9,791	9,790	9,759	10,898	9,916	3,886	505	2,395	1,635
07.2 Paper and cardboard wastes	0.40					3,214	3,548	1,372	54,438	323	275	144	214	183
07.5 Wood wastes	0.43					22,776	12,755	5,197	7,548	4,713	1,053	628	856	756
07.6 Textile wastes	0.24					29,400	25,346	26,054	24,762	14,923	13,930	16,002	15,282	15,962
09.1 Animal waste of food preparation and products	0.15					20,277	14,173	13,062	14,063	11,616	14,020	19,803	17,257	16,909
09.2 Vegetal waste	0.15					24,531	14,715	9,664	15,216	2,465	2,611	4,312	3,430	3,848
10.1 Household and similar wastes	0.16					456,787	181,907	150,310	211,005	37,290	24,742	34,291	35,224	35,469
10.21 + 10.22 Mixed and undifferentiated materials	0.22					129,227	127,215	90,968	99,042	45,971	42,461	54,843	49,849	53,316
10.3 Screening waste	0.11					31,832	46,421	40,606	27,329	23,630	53,628	77,733	70,104	72,431
11 Common sludges	0.14					89,469	93,815	95,137	88,537	87,977	73,884	88,295	87,330	84,099
TOTAL	-	754,833	752,320	840,006	837,893	885,380	566,972	491,447	598,709	275,080	281,207	309,581	301,441	311,765
DOC (weighted average)	-	0.244	0.230	0.215	0.201	0.188	0.185	0.181	0.200	0.169	0.159	0.161	0.160	0.161

Notes:
a) DOC values: IPCC 2006.
b) Data on italics: estimates.

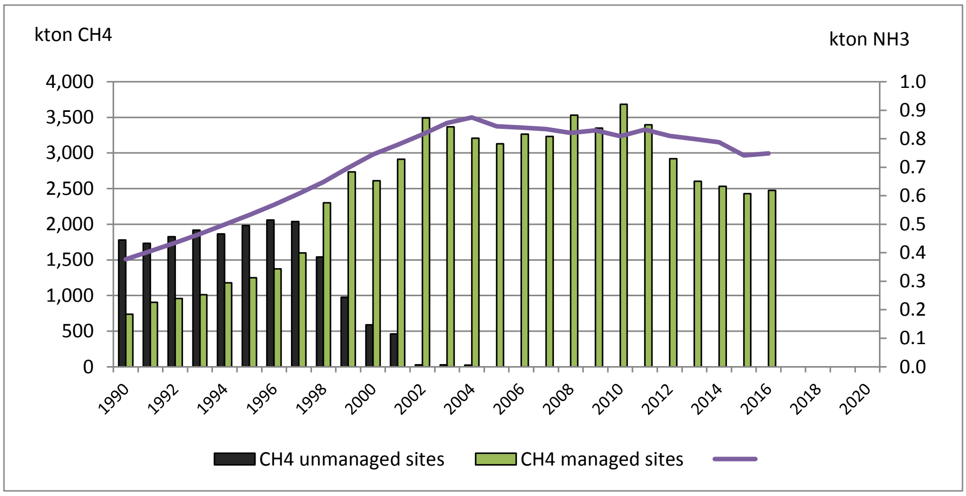
Total amounts of organic industrial waste and associated DOC values refer to estimates based on interpolation for the years: 2000, 2001 (interpolation of 1999 and 2002 data); and 2004-2007 (interpolation of 2003 and 2008 data). The amounts of waste for the previous decades (1960-1998) were calculated 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.

6.2.1.2 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 6.6 – Emissions of CH4 and NH3



6.2.2 NH3 emissions from Biological Treatment of Waste - Composting (NFR 5 B 1) and Anaerobic Digestion (NFR 5 B 2)

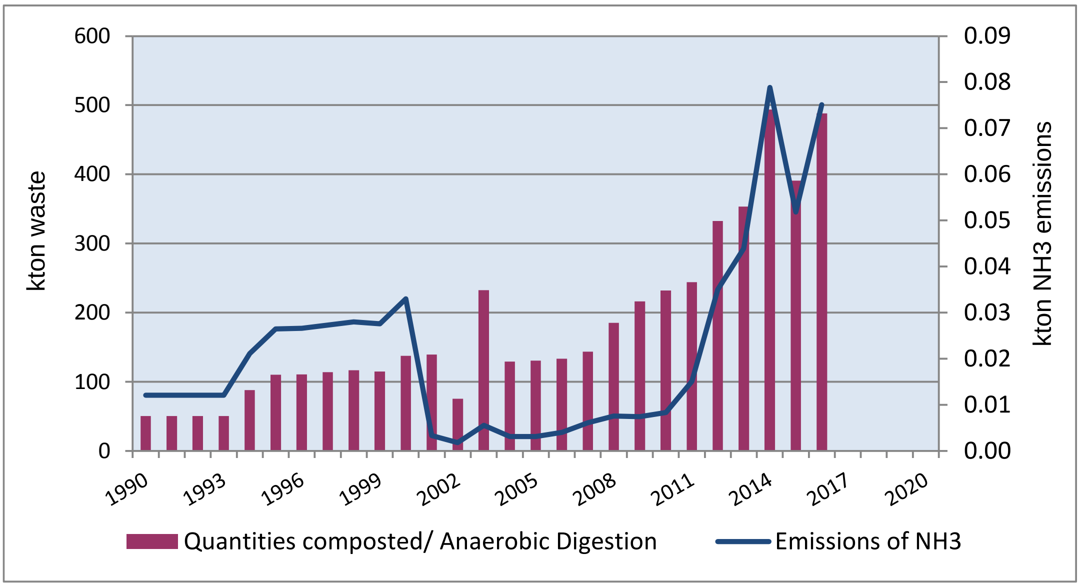
6.2.2.1 Methodology

Emission estimates follow Tier 2 approach for composting indicated in the 2016 Guidebook.

6.2.2.2 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.

Figure 6.7 – Quantities of municipal waste composted/ Digested and related NH3 emissions



Source:APA

6.2.2.3 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 6.4 – Ammonia emission factors for compost production

	EF g NH3/ton SW	Source
Uncontrolled	240	2016 EEA Guidebook (Tier 2 default)
Biofilter	24	2016 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 6.5 – Ammonia emissions factors for anaerobic digestion at biogas facilities

	Value	Source
EF (kg NH3-N per kg N in feedstock)	0.0286	2016 EEA Guidebook (Tier 1)
N content of fresh matter (kg kg–1) in Municipal organic waste	0.0068	2016 EEA Guidebook (Tier 1)

6.2.3 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 solid wastes. 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 solid wastes (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.

6.2.3.1 Non-CO2 emissions

6.2.3.1.1 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.

$$\text{Non-}CO_2\text{ emissions (Gg/yr)} = \Sigma_i \, (IW_i * EF_i) * 10^{-6}$$

where:

IW_i = Amount of incinerated waste of type i (Gg/yr);

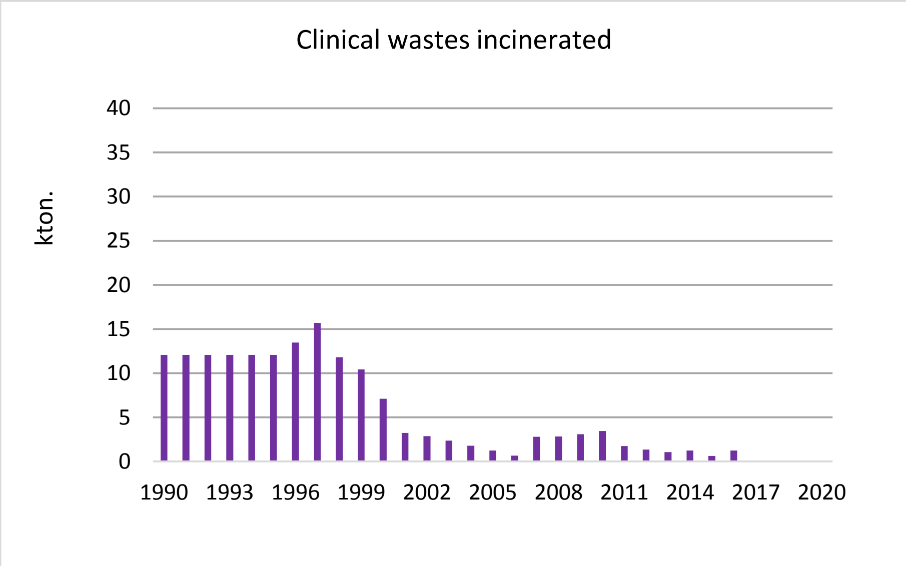
EF_i = Aggregate pollutant emission factor for waste type i (kg pollutant/Gg)

6.2.3.1.2 Activity data

6.2.3.1.2.1 Clinical waste (NFR 5C1biii)

Data on clinical waste incinerated refers to data declared in registry maps of public and private hospital units, research centers 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. Other clinical wastes receive alternative treatment or are sent abroad.

Figure 6.8 – Quantities of clinical waste incinerated



Sources: APA; DGS.

The remaining clinical waste incinerator suffered two main requalification processes, the most significant occurred in 2004.

The plant type is a "controlled air incinerator", which includes 2 combustion chambers. At a first stage, the waste is burnt in oxygen deficit conditions at temperatures from 850ºC to 950ºC. The resulting gases get into a second combustion chamber or thermal reactor where the gases suffer a new combustion reaching higher temperatures (1100ºC – 1200ºC) during 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 sodium bicarbonate and activated carbon in the gas flux. At the end, the gas is conducted into a ceramic filter where the particulate matter is trapped.

6.2.3.1.2.2 Industrial waste (NFR 5 C 1 b i)

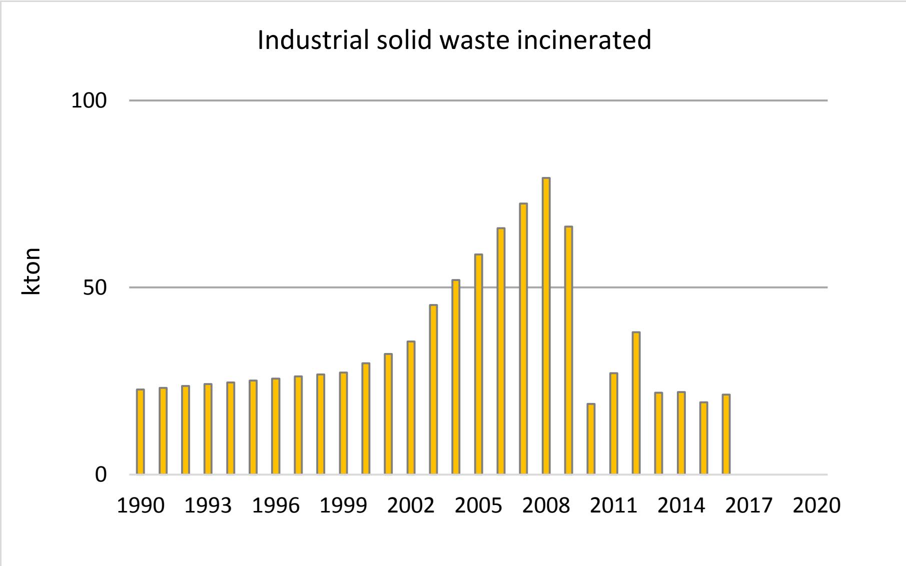
Data refer to incineration of industrial solid waste in industrial units collected in APA. Data for the years 1999, 2002 and 2003 refer to industrial units declarations. Data for the period 1990-98 are based on the same assumptions used for Industrial Solid Waste Disposed on Land: a per year growth rate 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.

Figure 6.9 – Quantities of combusted industrial waste



Source: APA (include estimates).

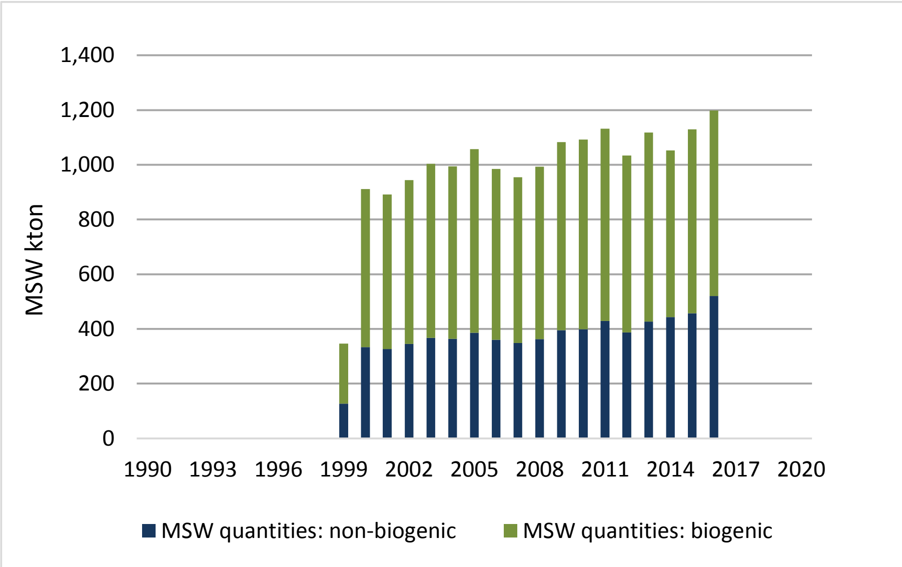
The fluctuations on the amounts of industrial waste incineration, as shown in the previous figure, results, at least partially, from the variation of fluxes to other treatments (landfilling, shipping abroad and recycling) as a consequence of the annual waste market demand.

6.2.3.1.2.3 Municipal waste (accounted in NFR 1A1a)

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 6.10 – 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.

6.2.3.1.3 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 6.6 – Emissions factors of CLRTAP gases from incineration of clinical wastes: until 2004

Pollutants	Unit	EF	Source
SOx	kg/ton W	1.09	2016 EEA Guidebook (Tier 2, Uncontroled)
NOx	kg/ton W	1.78	2016 EEA Guidebook (Tier 2, Uncontroled)
COVNM	kg/ton W	0.7	2016 EEA Guidebook (Tier 2, Uncontroled)
CO	kg/ton W	1.48	2016 EEA Guidebook (Tier 2, Uncontroled)
NH3	kg/ton W	0.004	Country measured data
Pb	kg/ton W	0.036	2016 EEA Guidebook (Tier 2, Uncontroled)
PST	kg/ton W	2.33	2016 EEA Guidebook (Tier 2, Uncontroled)
PM10	% PST	65	2016 EEA Guidebook (Tier 2, Uncontroled)
PM2.5	% PST	43.3	2016 EEA Guidebook (Tier 2, Uncontroled)
BC	% PST	2.3	2016 EEA Guidebook (Tier 2, Uncontroled)
Cd	kg/ton W	0.00274	2016 EEA Guidebook (Tier 2, Uncontroled)
Hg	kg/ton W	0.0537	2016 EEA Guidebook (Tier 2, Uncontroled)
As	kg/ton W	0.000121	2016 EEA Guidebook (Tier 2, Uncontroled)
Cr	kg/ton W	0.000388	2016 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	2016 EEA Guidebook (Tier 2, Uncontroled)
DioxFur	g I-TEQ/ton W	0.04	2016 EEA Guidebook (Tier 2, Uncontroled)
PAH	g/ton W	0.00004	2016 EEA Guidebook (Tier 2, Uncontroled)
PCB	g/ton W	0.0233	2016 EEA Guidebook (Tier 2, Uncontroled)
HCB	g/ton W	0.1	2016 EEA Guidebook (Tier 2, Uncontroled)

Table 6.7 – Emissions factors of CLRTAP gases from incineration of clinical wastes: after 2005

Pollutants	Unit	EF	Efficiency	Source
SOx	kg/ton W	0.0872	92.0%	2016 EEA Guidebook (Tier 2, Controled by various types of abatement)
NOx	kg/ton W	1.78	-	2016 EEA Guidebook (Tier 2, Uncontroled)
COVNM	kg/ton W	0.7	-	2016 EEA Guidebook (Tier 2, Uncontroled)
CO	kg/ton W	1.48	-	2016 EEA Guidebook (Tier 2, Uncontroled)
NH3	kg/ton W	0.004	-	Country measured data
Pb	kg/ton W	0.002	94.5%	2016 EEA Guidebook (Tier 2, Controled by various types of abatement)
PST	kg/ton W	0.233	90.0%	2016 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%	2016 EEA Guidebook (Tier 2, Controled by various types of abatement)
Hg	kg/ton W	0.001611	97.0%	2016 EEA Guidebook (Tier 2, Controled by various types of abatement)
As	kg/ton W	0.00000121	99.0%	2016 EEA Guidebook (Tier 2, Controled by various types of abatement)
Cr	kg/ton W	0.00001552	96.0%	2016 EEA Guidebook (Tier 2, Controled by various types of abatement)
Cu	kg/ton W	0.000246	59.0%	2016 EEA Guidebook (Tier 2, Controled by various types of abatement)
Ni	kg/ton W	0.000295	-	2016 EEA Guidebook (Tier 2, Uncontroled)
DioxFur	g I-TEQ/ton W	0.04	-	2016 EEA Guidebook (Tier 2, Uncontroled)
PAH	g/ton W	0.00004	-	2016 EEA Guidebook (Tier 2, Uncontroled)
PCB	g/ton W	0.0233	-	2016 EEA Guidebook (Tier 2, Uncontroled)
HCB	g/ton W	0.1	-	2016 EEA Guidebook (Tier 2, Uncontroled)

Table 6.9 – Emissions factors of CLRTAP gases for incineration of Industrial Waste

Pollutants	Unit	EF	Source
SOx	kg/ton MSW	0.05	2016 EEA Guidebook (Tier 1 default EF)
NOx	kg/ton MSW	0.9	2016 EEA Guidebook (Tier 1 default EF)
NMVOC	kg/ton MSW	7.4	2016 EEA Guidebook (Tier 1 default EF)
CO	kg/ton MSW	0.1	2016 EEA Guidebook (Tier 1 default EF)
PST	kg/ton MSW	0.01	2016 EEA Guidebook (Tier 1 default EF)
PM10	kg/ton MSW	0.01	2016 EEA Guidebook (Tier 1 default EF)
PM2.5	kg/ton MSW	0.004	2016 EEA Guidebook (Tier 1 default EF)
BC	% of PM2.5	3.50	2016 EEA Guidebook (Tier 1 default EF)
Pb	g/ton MSW	1.30	2016 EEA Guidebook (Tier 1 default EF)
As	g/ton MSW	0.016	2016 EEA Guidebook (Tier 1 default EF)
Cd	g/ton MSW	0.100	2016 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	2016 EEA Guidebook (Tier 1 default EF)
Ni	g/ton MSW	0.140	2016 EEA Guidebook (Tier 1 default EF)
PCDD/ Fs	g TEQ/ton MSW	0.0004	2016 EEA Guidebook (Tier 1 default EF)
Total PAHs b)	g/ton MSW	0.02	2016 EEA Guidebook (Tier 1 default EF)
HCB	g/ton MSW	0.002	2016 EEA Guidebook (Tier 1 default EF)
PCB	g/ton MSW	2.595	EIIP: chapter 16 Open burning municipal w aste; 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

b) Total tetra- through octa- chlorinated dibenzo- p- dioxin/ chlorinated dibenzofurans

Table 6.8 – Emissions 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	[0.0191 - 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	[0.00235 - 0.01736]	Plant Specific (Monitoring Data)
PM10	kg/ton MSW	[0.00235 - 0.01736]	
PM2.5	kg/ton MSW	[0.00235 - 0.01736]	
BC	% of PM2.5	3.5	2016 EEA Guidebook (Olmez et al. (1988))
Cd	kg/ton MSW	[0.0000007 - 0.0000117]	Plant Specific (Monitoring Data)
Hg	kg/ton MSW	[0.0000081 - 0.0000328]	Plant Specific (Monitoring Data)
As	g/ton MSW	[0.00056 - 0.0154]	Plant Specific (Monitoring Data)
Cr	g/ton MSW	[0.01034 - 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	2016 Guidebook (Tier 1); Nielsen et al. (2010)
Zn	g/ton MSW	0.0245	2016 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	2016 Guidebook (Tier 1); Nielsen et al. (2010)
HCB	g/ton MSW	0.0000452	2016 Guidebook (Tier 1); Nielsen et al. (2010)
PCB	g/ton MSW	0.0000000034	2016 Guidebook (Tier 1); Nielsen et al. (2010)

6.2.4 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.

6.2.4.1 Activity data

The importance of cremation has been steadily growing and represents at present 14.1 per cent of funeral types.

Figure 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	17,665
1997	912	2007	5,323	2017	-
1998	1,124	2008	6,889	2018	-
1999	1,541	2009	7,750	2019	-

Source: Servilusa/ Associação Portuguesa dos Profissionais do Sector Funerário

Figure 6.12 – Emissions factors of CLRTAP gases for cremation

Pollutants	Unit	EF	Source
SOx	kg/body	0.113	2016 EEA Guidebook, Tier 1 default
NOx	kg/body	0.825	2016 EEA Guidebook, Tier 1 default
COVNM	kg/body	0.013	2016 EEA Guidebook, Tier 1 default
CO	kg/body	0.14	2016 EEA Guidebook, Tier 1 default
Pb	mg/body	30.03	2016 EEA Guidebook, Tier 1 default
PST	g/body	38.56	2016 EEA Guidebook, Tier 1 default
Cd	mg/body	5.03	2016 EEA Guidebook, Tier 1 default
Hg	g/body	1.49	2016 EEA Guidebook, Tier 1 default
As	mg/body	13.61	2016 EEA Guidebook, Tier 1 default
Cr	mg/body	13.56	2016 EEA Guidebook, Tier 1 default
Cu	mg/body	12.43	2016 EEA Guidebook, Tier 1 default
Ni	mg/body	17.33	2016 EEA Guidebook, Tier 1 default
Se	mg/body	19.78	2016 EEA Guidebook, Tier 1 default
Zn	mg/body	160.12	2016 EEA Guidebook, Tier 1 default
PCDD/ PCDF (DioxFur)	µg/body	0.027	2016 EEA Guidebook, Tier 1 default
benzo(a)pyrene	µg/body	13.2	2016 EEA Guidebook, Tier 1 default
benzo(b)fluoranthene	µg/body	7.21	2016 EEA Guidebook, Tier 1 default
benzo(k)fluoranthene	µg/body	6.44	2016 EEA Guidebook, Tier 1 default
indeno(1,2,3-cd)pyrene	µg/body	6.99	2016 EEA Guidebook, Tier 1 default
PCB	mg/body	0.41	2016 EEA Guidebook, Tier 1 default
HCB	mg/body	0.15	2016 EEA Guidebook, Tier 1 default

6.2.5 Wastewater Handling (NFR 5 D)

6.2.5.1 Domestic Wastewater

Wastewater treatment systems types determine the level of air pollution emissions. Data trends on wastewater handling systems and types of treatment were compiled by APA (previously INAG/National Institute for Water which was integrated in the APA).

Table 6.9 – Percentage of population by wastewater handling system

Wastewater handling systems		1990	1994	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009-2016
		% population												
Population without sewerage														
1.1-	**% Pop: without sewerage (latrines)**	37.0	23.4	6.4	5.3	4.3	3.2	2.1	1.1	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	19.0	21.2	23.3	25.4	27.5	24.0	23.0	22.0	21.0
Population with sewerage														
2.1-	**% de Pop: with discharge into the ocean, without treatment**	6.5	6.5	6.5	5.6	4.7	3.8	2.8	1.9	1.0	1.0	1.3	1.5	1.2
2.2-	**% de Pop: with discharge into inland waters, without treatment**	36.8	40.8	30.3	25.9	21.5	17.1	12.8	8.4	4.0	3.0	2.5	1.9	1.2
2.3-	**% de Pop: with discharge into soil, without treatment**	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
2.4-	**% de Pop: unknown disposal**	0.0	0.0	0.0	0.4	0.8	1.2	1.6	2.0	2.4	2.0	3.3	4.6	5.6
3-	**% Pop: with treatment**	18.2	21.1	42.0	45.8	49.7	53.5	57.3	61.2	65.0	70.0	70.0	70.0	71.0
3.1-	**% Pop: colective septic tanks**	2.2	2.3	5.0	5.0	5.0	5.0	5.0	5.0	5.0	7.0	5.1	3.3	3.0
3.2-	**% Pop: with preliminary treatment**	0.0	0.0	0.0	0.5	1.0	1.5	2.0	2.5	3.0	7.0	7.5	8.0	7.6
3.3-	**% Pop: with primary treatment**	5.2	5.2	9.0	8.5	8.0	7.5	7.0	6.5	6.0	3.0	4.4	5.9	1.9
3.4-	**% Pop: with secondary and tertiary treatment**	10.8	13.6	28.0	31.8	35.7	39.5	43.3	47.2	51.0	53.0	52.9	52.9	58.5
3.4.1-	Biodisks with anaerobic sludge digestion	1.1	1.4	2.0	1.7	1.4	1.1	0.8	0.5	0.2	0.2	0.2	0.1	0.1
3.4.2-	Biodisks without anaerobic sludge digestion	0.0	0.0	0.0	0.1	0.3	0.4	0.5	0.7	0.8	0.8	0.6	0.3	0.2
3.4.3-	Activated sludge with anaerobic sludge digestion	1.4	2.0	4.6	6.9	9.2	11.5	13.9	16.2	18.5	18.9	18.2	17.5	16.7
3.4.4-	Activated sludge without anaerobic sludge digestion	1.4	2.0	4.6	5.8	7.0	8.1	9.3	10.5	11.7	11.9	11.6	11.3	14.0
3.4.5-	Laguning, with anaerobic pond	1.7	1.9	3.6	3.0	2.4	1.9	1.3	0.8	0.2	0.2	0.2	0.2	0.3
3.4.6-	Laguning, without anaerobic pond	0.6	0.6	1.2	1.9	2.6	3.2	3.9	4.6	5.3	5.5	5.3	5.1	4.4
3.4.7-	Percolation beds with anaerobic sludge digestion	3.6	4.6	8.8	8.0	7.1	6.3	5.4	4.6	3.7	3.7	3.4	3.1	2.9
3.4.8-	Percolation beds without anaerobic sludge digestion	0.0	0.0	0.0	0.7	1.3	2.0	2.6	3.3	3.9	4.0	3.2	2.4	1.8
3.4.9-	Imhoff Tank	0.6	0.3	0.1	0.3	0.5	0.7	0.9	1.1	1.3	1.3	1.2	1.0	0.8
3.4.10-	Oxidation ponds with anaerobic sludge digestion	0.0	0.0	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.7	0.6	0.6
3.4.11-	Oxidation ponds without anaerobic sludge digestion	0.3	0.4	1.6	1.6	1.6	1.6	1.5	1.5	1.5	1.6	1.5	1.4	1.4
3.4.12-	Other treatment with anaerobic sludge digestion	0.0	0.0	0.0	0.4	0.8	1.2	1.5	1.9	2.3	2.3	2.2	2.0	2.5
3.4.13-	Other treatment without anaerobic sludge digestion	0.0	0.3	1.6	1.4	1.1	0.9	0.7	0.4	0.2	0.2	0.2	0.2	0.2
3.4.14-	With unspecified treatment	0.0	0.0	0.0	0.1	0.3	0.4	0.5	0.7	0.8	1.7	4.7	7.7	12.8

Source: ex-INAG.

Until 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. More recent data (from 2005 onwards) 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.

Since the restructuration of the National Water Authority the referred “Inventário Nacional de Sistemas de Abastecimento de Água e Águas Residuais (INSAAR)”, the national data base for wastewater treatment systems, has been deactivated. As a consequence, data considered since 2010 refer to INSAAR latest available year (2009).

6.2.5.1.1 NMVOC emissions from wastewater (Human Sewage)

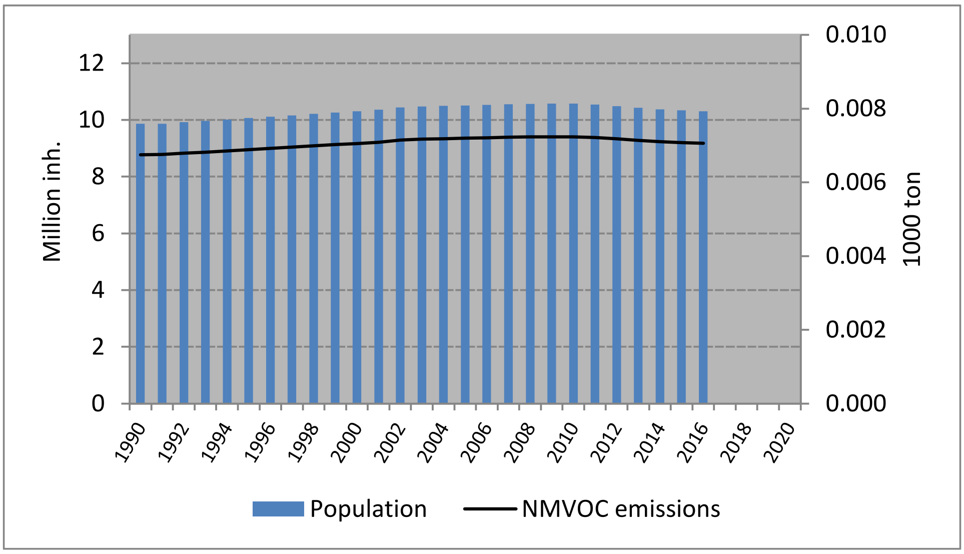
6.2.5.1.1.1 Methodology, activity data and parameters

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).

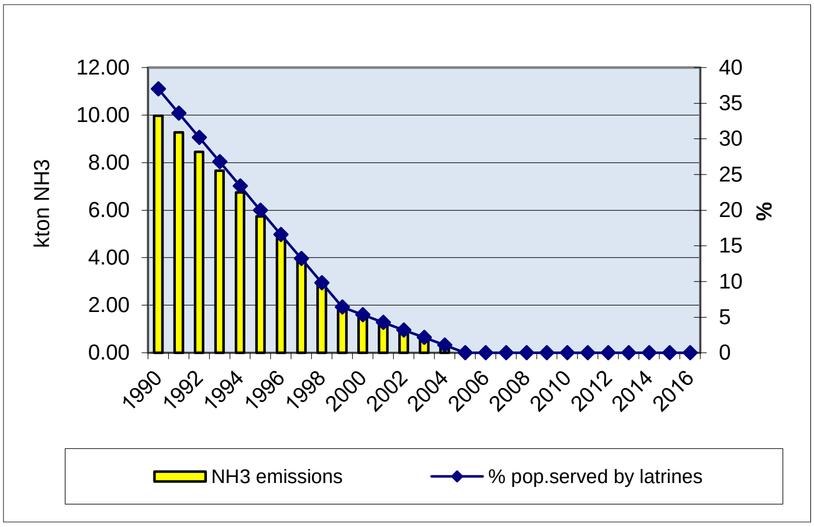
Figure 6.13 – NMVOC emissions



6.2.5.1.2 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 6.14 – NH_3 emissions and % population served by latrines



6.2.5.1.2.1 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);

$F_{NON\text{-}CON}$ - 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.

6.2.5.1.2.2 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 available refer to the 2013 enquiry that considers the 2008-2012 period. Data for 2013 refer to the latest available year (2012). Other parameters used in the estimations are based on the 2006 IPCC defaults.

Table 6.10 – Data and parameters used calculation of NH3 emissions from wastewater

Parameter	Year	INE data (kg/person/year)
Annual per capita protein intake	1990	39.2
	1991	40.2
	1992	40.5
	1993	41.2
	1994	41.4
	1995	40.9
	1996	41.1
	1997	41.4
	1998	42.7
	1999	43.8
	2000	43.5
	2001	43.6
	2002	43.9
	2003	43.7
	2004	43.7
	2005	43.2
	2006	44.0
	2007	45.2
	2008	46.0
	2009	46.0
	2010	45.7
	2011	44.8
	2012	43.9
	2013	44.2
	2014	43.8
	2015	44.3
	2016	45.3
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.

6.2.5.1.2.3 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.

6.2.5.2 Industrial Wastewater

6.2.5.2.1 NMVOC emissions

6.2.5.2.1.1 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 2016. 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 2016;

- Production of paper pulp was available directly from the individual industrial plants, for the all period.

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 information[76]. 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

[76] 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.

in IAIT. It was assumed that an adaptation period to the new industrial survey lead to a temporary underestimation of industrial production statistics.

Table 6.11 – Sources of Information used to define the time-series of industrial production (1/2)

Industry	IAIT CAE rev1	IAPI PRODCOM	Infoline	Note
Slaughter House			1990-2016	Cattle, sheep, goats and horses
Slaughter House, sw ine			1990-2016	
Slaughter House, Poultry			1990-2016	Broilers, Turkeys, ducks, quails, ostrich, guinea-fow l, geese, pheasants, partridge and pigeons
Meat Packing	311120	15130-1513013-151301190200	-	
Milk processing	3112		1994-2016	
Cheese	3112	15510	-	
Other dairy products	3112		1994-2016	Cream, yugurt, pow der milk, ice-creams
Fruit and vegetables conservation	3114		1994-2016	
Tomato juice			1994-2016	
Fruit Juices	3131+3132		1994-2016	
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			1993-2016	
Ethanol	313110	159101070; 1592011	-	
Spirits Distillation	3131+3132	1591010-159101070+1592012	-	
Wine Cellars	3131+3132	15930; 15950	2001-2016	
Beer	3133	1596010	-	
Mineral w ater and similars			1993-2016	

Table 6.12 – 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		2010	-	AD is cork consumption in all industrial activities
Cork granulation		2052213; 2052214	-	
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			1998-2016	
Soaps		2451131	-	
detergents		2451120/32	-	
Petroleum refining			-	Energy Balance (DGGE): 1990-2016

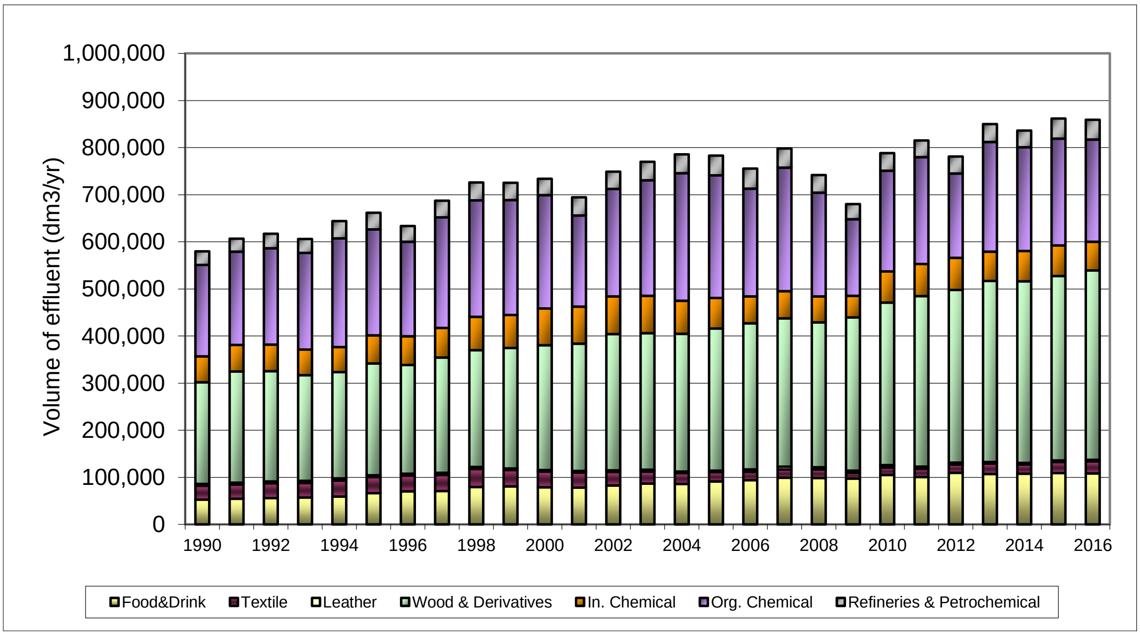
The following table shows the discharge coefficients that were used to estimate the volumes of wastewater produced by industrial sector, having as a basis the coefficients available in Cartaxo et al (1985).

Table 6.13 – Coefficients used to estimate volumes of industrial wastewater production

Portuguese classification	IPCC industrial branches	Unit prod (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	-	m3	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

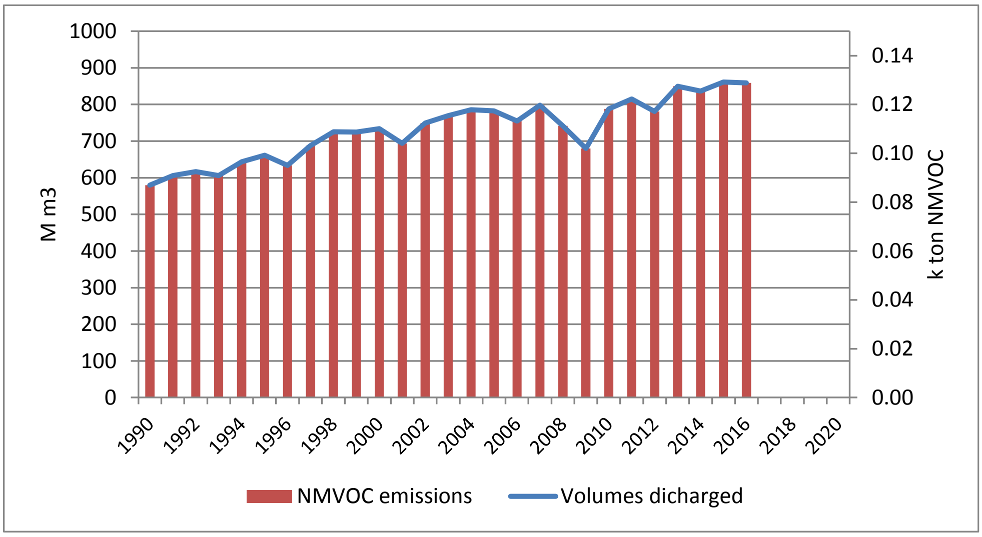
Total wastewater load aggregated per industrial group is presented in the Figure below, from where it is evident the predominant importance of wastewater loads from the industry of wood and wood derivatives and from the organic industry.

Figure 6.15 – Industrial Wastewater discharges, expressed in 1000 m^3, from major groups of industrial activity



Next Figure presents the estimated total volumes of industrial wastewater produced and the related NMVOC emissions during the period analysed.

Figure 6.16 – Total industrial wastewater discharge and NMVOC emissions



6.2.6 Emissions from other waste: landfill gas and other biogas burning (NFR5 E)

The capture and burning of landfill gas and biogas (e.g. from sewage sludge) is used for energy purposes or flaring (without energy recovery). Emissions from the combustion of landfill gas and biogas captured should be included in the energy sector when there is energy recovery, or in the waste sector when is flared.

For practical reasons all information related to the estimates of emissions from biogas combustion (with and without energy recovery) is presented here. However, the emissions related to energy recovery situations are accounted in sector 1A1a, and the emissions resulting from flaring are considered in category 5E.

6.2.6.1 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).

6.2.6.2 Activity data and parameters

Table 6.14 – 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**
	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	2,619,233
	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

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

Emissions with energy recovery (CRF 1A1a)		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
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
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
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
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
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
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
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
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
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
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
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	0.001414
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
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
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
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
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
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	0.001912
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	0.001362
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
Emissions without energy recovery (CRF 6D)		**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2015**
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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

Notes:

a) DGEG data
b) Data refer to landfill gas flared without energy recovery. APA data..

6.2.7 Emissions from other waste: car and house fires. (NFR 5E)

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).

6.2.7.1 Methodology, activity data and emission factors

Emissions were calculated on the basis of an emission factor porposed in the 2016 EEAGuidebook, for occurences referring to car fires, and residential and industrial buildings.

6.3 Recalculations

The recalculations made since last submission result mainly from:

- Municipal waste incineration (NFR 1A1a): EF updates based in monitored data from plant incineration units.
- Solid waste disposal (NFR 5A)
  - Urban waste: revision of waste composition, in order to take into account the outcomes from the last (2016) UNFCCC review report (Sept. 2017);
  - Landfill biogas recovered: revision of landfill biogas amounts for the 2011-2015 period;
  - Industrial waste: following the recommendations from the last (2016) UNFCCC review report (Sept. 2017the DOC values for several categories have been revised in order to fully apply the default DOC values from the 2006 IPCC Guidelines
- Biological treatment of waste – anaerobic digestion at biogas facilities (NFR 5B2): revision of estimates based on information from 2016 Guidebook.
- Wastewater treatment and discharge (NFR 5D1)
  - revision of population data: 2014-2015;
  - changes from 2013-2015 result from an update of INE data for protein consumption for this period.

6.4 Further improvements

Since the restructuration of the National Water Authority (ex-INAG), the referred “Inventário Nacional de Sistemas de Abastecimento de Água e Águas Residuais (INSAAR)”, the national data base for wastewater treatment systems, has been deactivated. Alternative data sources have to be developed or a new methodological approach should be followed in order to update the time series for the whole period in a consistent way.

Considering the limitations in the time trend in load and the share of each treatment system concerning industrial wastewater handling, efforts will continue in order to improve the assessment of the situation concerning industrial wastewater. These should include the development of a data base aggregating information collected under different schemes: IPPC, PRTR and information from the discharge permits.

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

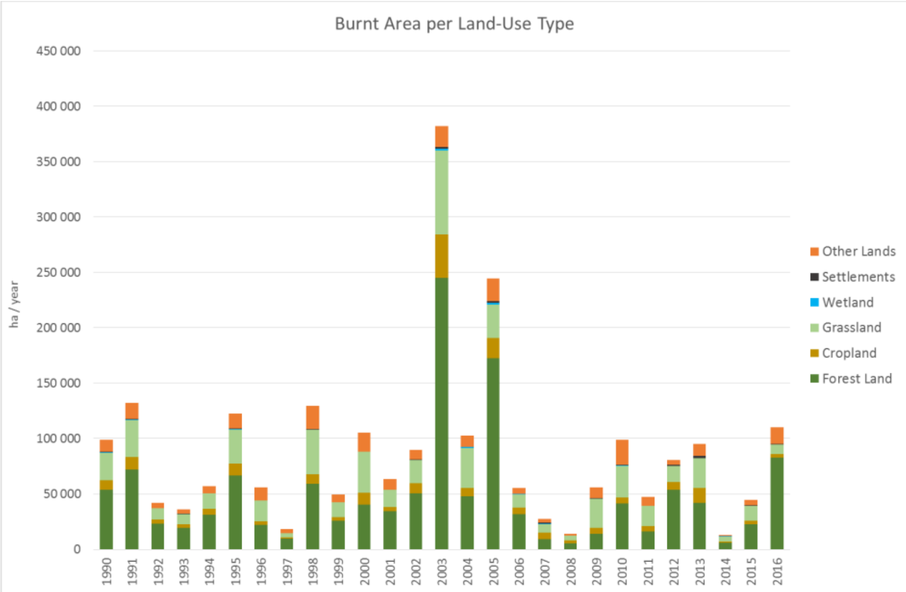
The main source of burnt areas are the fire reports issued every year by the National Forest Authority, currently the Institute for Nature Conservation and Forestry. The reports are derived from satellite imagery and the results cover all burnt areas, divided by forest, shrubland and agriculture.

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)



Source: ICNF.

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 1996 Revised Guidelines (IPCC,1997) 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.

Emissions ratios:

IPCC 1996 - CO: 0.06; NOx: 0.121

AP-42 - NMVOC: 0.0068, TSP: 0.0085

Emissions estimation:

Emissions NMVOC (expressed as CH4) = L_{Direct} * emission ratio * 16/12

Emissions CO = L_{Direct} * emission ratio * 28/12

Emissions TSP = L_{Direct} * emission ratio

Emissions NOx = L_{Direct} * ratio N/C (0.01) * emission ratio * 46/14

7.1.2.1 Carbon losses due to wildfires

The annual carbon loss in living biomass resulting from wildfires was estimated based on direct carbon loss, and was calculated as follows:

$$L_{Direct} = \sum A_{burnt,j} \times B_{ABG,j} \times (B_{leafs,j} \times BCF_{leafs,j} + B_{branches,j} \times BCF_{branches,j})$$

where:

L_{Direct} = annual carbon loss, Gg C

j = corresponds to 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} = Percentage of leaf's biomass in above ground biomass, %

BCF_{leafs} = Combustion factor of leafs, %

$B_{branches}$ = Percentage 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 (B_{ABG}) in Above Ground Living Biomass and Litter per Land Use Type

Average Carbon Stocks per Landuse Type	Above Ground Biomass			Litter	Notes
	1995 GgC/1.000ha	2005 GgC/1.000ha	2010 GgC/1.000ha	All years GgC/1.000ha	
Pinus pinaster	28.29	26.74	26.74	2.96	(1); (8)
Quercus suber	20.67	20.04	20.04	2.04	(1); (8)
Eucalyptus spp.	16.72	17.97	17.97	1.85	(1); (8)
Quercus rotundifolia	9.47	8.37	8.37	2.04	(1); (8)
Quercus spp.	15.45	15.87	15.87	1.85	(1); (8)
Other broadleaves	20.40	30.79	30.79	1.85	(1); (8)
Pinus pinea	25.40	18.79	18.79	2.41	(1); (8)
Other coniferous	8.70	14.51	14.51	2.96	(1); (8)
Rainfed annual crops	0.31	0.31	0.31	0.33	(4)
Irrigated annual crops (except rice)	0.31	0.31	0.31	0.33	(4)
Rice padies	0.31	0.31	0.31	0.33	(4)
Vineyards	3.34	3.34	3.34	0.33	(5); (6)
Olive groves	7.85	7.85	7.85	0.33	(5); (6)
Other permanent crops	8.46	8.46	8.46	0.33	(5); (6)
All grasslands	0.53	0.53	0.53	0.41	(2)
Wetlands	0.00	0.00	0.00	0.00	(9)
Settlements	0.00	0.00	0.00	0.00	(9)
Shrubland	8.78	8.78	8.78	4.96	(3)
Other	1.05	1.05	1.05	2.07	(7)

(1) Living biomass calculated from NFI4 (1995), NFI5 (2005) and NFI6 (2010). NFI6 data will be available in 2013; NIR 2013

(2) Calculated from EMEP/EEA emission inventory guidebook 2009, Chapter 11b Forest fires, Table 2-1 "Grassland vegetated

(3) Calculated from Rosa 2009 "Estimativa das emissões de gases com efeito de estufa"

(4) Calculated from EMEP/EEA emission inventory guidebook 2009, Chapter 11b Forest fires, Table 2-1 "Grassland vegetated

(5) Litter calculated from EMEP/EEA emission inventory guidebook 2009, Chapter 11b Forest fires, Table 2-1 "Non-forest class

(6) Living biomass from NIR Spain 2012, Tabla 7.3.3, page 7.59

(7) Calculated from EMEP/EEA emission inventory guidebook 2009, Chapter 11b Forest fires, Table 2-1 "Sparsely vegetated ar

(8) Litter values from expert judgement based on Rosa 2009 "Estimativa das emissões de gases com efeito de estufa", Quad

(9) No values were found in literature; assumed = 0

7.2 NMVOC Biogenic Emissions (NFR 11.C)

7.2.1 Overview

Emissions of Volatile Organic Compounds occur from plant foliage, either in forest or in agricultural lands, and are commonly called biogenic emissions. Usually in emission inventories a distinction is made for emissions of Isoprene, monoterpenes (α-pinene, β-pinene, limonene, etc.) and OVOC (Other Volatile Organic Compounds, mostly oxygenated compounds such as alcohols, aldehydes, etc). This separation pretends to distinguish compounds with different importance in ozone formation, which is apparently higher for isoprene than for terpenes (Simpson et 1, 1995)

Biogenic emissions are highly dependent on the vegetation specie and also on climatic conditions. Temperature affects almost all species. Light affects mostly isoprene emissions, but terpene emissions are also affected for a few species.

In Portugal, besides emissions from foliage, the emission inventory considers also monoterpene emissions resulting from resin-tapping. In fact, when coniferous live tissues are damaged, the exposed resin channels result in increased terpene emission. This process is artificially increased by resin-tapping, that is practiced to obtain resin-derivatives. In Portugal resin tapping is common in maritime pine (*Pinus pinaster*) during the spring-autumn period and is done by extraction of part of the bark in the tree trunk. The majority of emissions comprehend α-pinene and β-pinene.

7.2.2 Methodology

7.2.2.1 Vegetation foliage

Emission of NMVOC from vegetation foliage are estimated separately for isoprenes, monoterpenes and Other Volatile Organic Compounds (OVOC), and using emission factors that are regional specific, at nut 3 level, using the general equation:

$$Emi\_NMVOC_{(s,t)} = \Sigma_n [(EF\_Iso_{(s,n)} + EF\_Mono_{(s,n)} + EF\_OVOC_{(s,n)}) * Veget_{AREA(s,n)}] * 10^{-6}$$

where,

$Emi\_NMVOC_{(s,t)}$ - Emissions of NMVOC resulting from crop or tree specie s, 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):

$$Resin\_NMVOC_{(s)} = \Sigma_n [(EF\_tapping_{(n)} * N_{tappedtrees(n)}] * 10^{-3}$$

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 (millions) subjected to resin-tapping in territorial unit n;

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 ε where 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 [77]:

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.

[77] During this period emissions from foliage are obviously zero.

Table 7.3 – Meteorological independent parameters used to determine foliage emission factors

Tree Specie		**D**		**Vegetation Period**	□ **µgC/g dm/h @standart L,T**					
		kd dm/m2			**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	
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	Guenther et al, 1994
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	
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 γ 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 from:

$$C_T = \frac{0.0027 * 1.066 * Q}{\sqrt{1 + (0.027 * Q)}}$$

where Q is the flux of PAR (mmol/m^2/s)

C_T, the temperature dependence is described by:

$$C_T = \frac{\exp\left[\frac{95\,000 * (T - Ts)}{R * T * Ts}\right]}{1 + \exp\left[\frac{230\,000 * (T - 314)}{R * T * Ts}\right]}$$

Where

T is leaf temperature (K) and T_s is standard temperature (303 K).

R is the ideal gas constant (=8.314 J/K/mol)

For monoterpenes Guenther et al (1993) proposed the general formulation:

$$\gamma = \exp\left[\beta * (T - T_s)\right]$$

Where

β is a constant, assumed 0.09 K^{-1} (Guenther et al, 1993),

T is leaf temperature (K) and

T_s is 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).

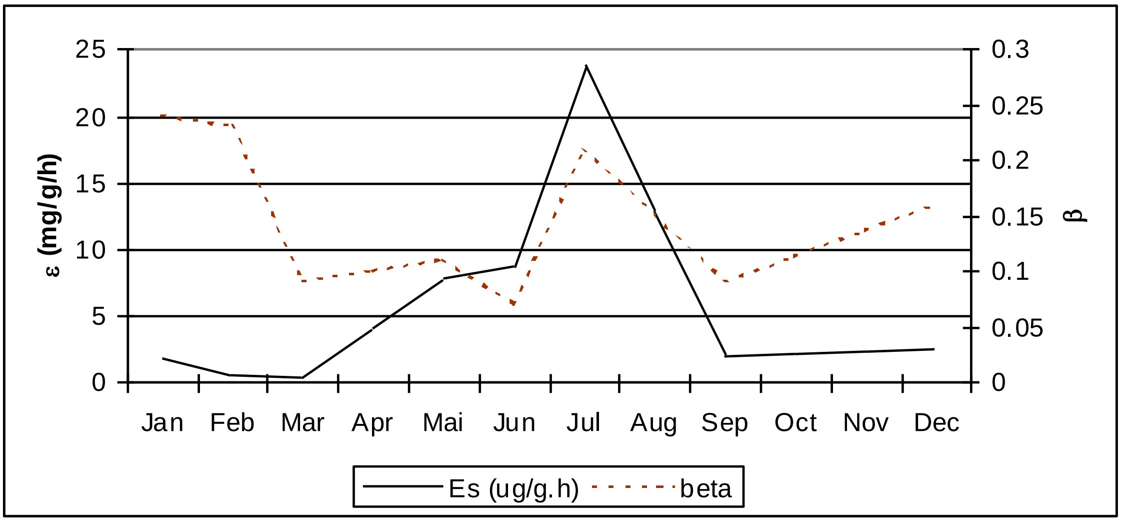
For some species however, this general formulation was not used but it is replaced by country specific equations. This is particularly the case for cork and Holm oaks, where monoterpene emissions are also function of light[78]. These equations are summarized in table 9.2.

[78] 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)

Table 7.4 – Specie and country specific equations for γ

Specie	Compound	Equation	Reference
P. Pinaster	Monoterpernes	γ = exp[0.138 * (T-30)]	Pio et al (1999)
Eucalyptus	Monoterpenes	γ = exp[0.07 * (T-30)]	Nunes (1996)
Cork Oak	Isoprene	γ = {CL*CT + exp[β* (T-Ts)]}	Silva et al (1999); CL*CT is Guenther's model. B parameter changes during the year, and the considered variation is in Figure 9.2
Holm Oak	Isoprene	γ = {CL*CT + exp[0.09* (T-Ts)]}	

Figure 7.2 - Time variable ε for Cork Oak (adapted from Silva et al (1999))



The γ 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:

$$\gamma_{(n,s)} = \Sigma_{m,h} \{\gamma[PAR_{(n,m,h)}, T_{(n,m,h)}, s]\}$$

where,

$\gamma[PAR_{(n,m,h)}, T_{(n,m,h)}, s]$ - γ 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^{2}h. The considered values in the Portuguese inventory, from (Veldt,1991; Veldt,1998), are presented in table 9.3.

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:

$$EF\_tapping_{(n)} = \Sigma_{m,h} \{EF\_Tapping_{(m,h)}\}$$

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[79] 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);

[79] Linear interpolation

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)

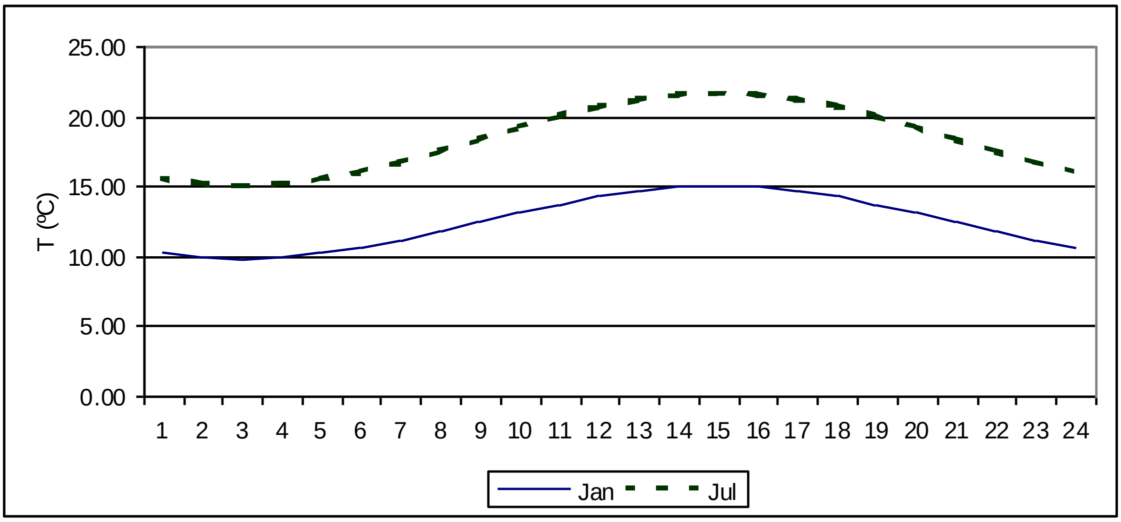
specie	1990	1995	2000	2005	Last year
Pinus pinaster	1,069,000	976,069	974,015	741,741	741,741
P. Pinea	35,000	77,650	83,559	102,143	77,650
Other conifer	69,000	27,358	29,440	46,499	70,992
Quercus suber	693,000	712,813	728,693	851,958	851,958
Q. Rotundifolia	462,000	461,577	465,295	420,244	420,244
Other 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.

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)

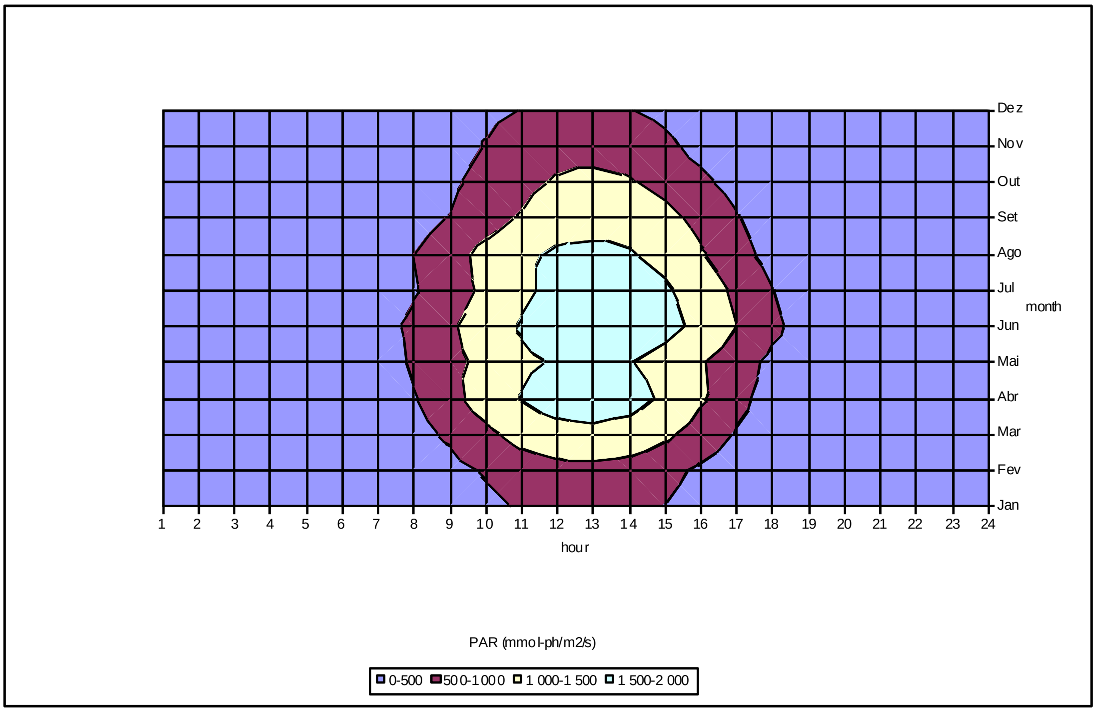


Source: INMG

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 Figure 9.4.

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

8.1 Overview of the Review Processes

Next table presents the status of implementation of recommendations issued from the 2017 NECD review process: Final Review Report 2017 Comprehensive Technical Review of National Emission Inventories pursuant to the Directive on the Reduction of National Emissions of Certain Atmospheric Pollutants (Directive (EU) 2016/2284), 30 November 2017, Table 3: Recommendations from TERT, considering revised estimates (RE) and technical corrections (TC) from.

Table 8.1 – Reporting on implementation of NECD recommendations.

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
PT-1A1-2017-0001	Yes	1A1 Energy Production, SO_2, NO_X, 2000-2015	For 1A1a Energy Production the TERT noted that continuous measurement results were used to calculate part of the NO_X emissions. When continuous measurements are used to estimate annual emissions, there is a risk that operators have misinterpreted the IED and have used validated average values (after having subtracted the value of the confidence interval), which would result in an under estimated emission of up to 20-30% depending on the pollutant and the confidence limits. In response to a question raised during the review, Portugal explained that NO_X emissions are calculated with validated average value with the confidence intervals subtracted and that this adjustment, by subtracting the confidence intervals, came into force in 2003 with the approval of Decree-Law 178/2003. Portugal provided revised estimates of NO_X emissions from NFR 1A1a for the years 2003-2015. The TERT agreed with the revised estimate provided by Portugal. The TERT recommends that Portugal includes the revised estimates in its next submission.	RE	After the issue raised in the review, a revision was made of the continuous monitoring data in the power generation plants. We conclude that the values we received in the monthly monitoring reports did not make note of the effect of the correction of confidence intervals. Continuous NOx monitoring was also updated throughout the time series.	
PT-1A2-2017-0002	No	1A2 Stationary Combustion in Manufacturing Industries and Construction, and 1A4 Commercial, Residential and Agriculture/Forestry/Fishing Stationary, NH_3, 2000-2015	For NFRs 1A2, 1A4ai, 1A4bi and 1A4ci, the TERT noted that NH_3 emissions from biomass combustion were not estimated. In response to a question raised during the review, Portugal provided revised estimates for the years 1990-2015 and explained that they intend to review the NH_3 estimates for these categories in the next submission. The TERT agreed with the revised estimates provided by Portugal. The TERT recommends	RE	Estimates made to NH3 for biomass combustion were included in the March 2018 submission	

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			that Portugal reviews the NH_3 estimates from biomass combustion and includes them in its next submission.			
PT-1A2a-2017-0001	No	1A2a Stationary Combustion in Manufacturing Industries and Construction: Iron and Steel, SO_2, NO_X, NMVOC, $PM_{2.5}$, 2000-2015	For NFR category 1A2a Stationary Combustion in Manufacturing Industries and Construction: Iron and Steel the TERT noted that the notation key 'NO' was used for activity data for 2015, while emissions are reported in this sector. In response to the question on the issue Portugal explained that all emissions from two individual plants are included under NFR 2C1. Portugal explained that there are some differences between the energy balance data and the data provided by the plants, namely the coke consumption in combustion. In order to streamline data with the energy balance, these differences are reported under NFR 1A2a and are the reason for the emissions of NO_X, NMVOC and SO_X reported under NFR 1A2a. The TERT notes that this issue does not relate to an under- or over-estimate and recommends that Portugal includes coke consumption data under NFR 1A2a.	no	Implemented	
PT-1A2f-2017-0001	Yes	1A2f Stationary Combustion in Manufacturing Industries and Construction: Non-metallic Minerals, SO_2, NO_X, NMVOC, $PM_{2.5}$, 2015	For category 1A2f the TERT noted that there was an inconsistency between the activity data in the NFR tables and in the IIR. In response to the question on this issue Portugal provided the activity data used to calculate the emissions from NFR 1A2f. The TERT notes that this issue does not relate to an under- or over-estimate and recommends that Portugal includes the activity data in the IIR of the next submission.	no	More detailed information was provided during the review exercise of 2017 and was not included in IIR 2018 for confidentiality purposes.	
PT-1A2f-2017-0003	Yes	1A2f Stationary Combustion in Manufacturing Industries and Construction: Non-metallic Minerals, SO_2, 2000-2015	For NFR category 1A2f and SO_X 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. In response to the question on the issue Portugal explained that the emission factor used is calculated from the sulphur content	no	No progress has been made in improving the proposed methodology. The Inventory will	

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			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. The TERT recommends that Portugal revises the emission factor based on new information of the sulphur content and recalculates emissions to the next submission.		continue to make every possible effort to implement new approaches to increase the quality of data.	
PT-1A2gvii - 2017-0001	No	1A2gvii Mobile Combustion in Manufacturing Industries and Construction: SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990-2015	For category 1A2gvii, the TERT noted that activity data and emissions are reported as 'included elsewhere' ('IE'). In response to a question raised during the review, Portugal explained that due to the approach of compiling these data for the national energy balance, no distinction between mobile and stationary sources is possible with category 1A2gvii being included in 1A2gviii. The TERT acknowledged the explanation provided by Portugal. However, given the lack of information provided in the NFR tables and in the IIR, the TERT recommends that Portugal includes sufficient information on categories reported as 'IE' in the next submission.	no	Implemented	3.2.2 Manufacturing Industries and Construction (NFR 1.A.2)
PT-1A3ai(i)-2017-0002	No	1A3ai(i) International aviation LTO (civil), NH_3, 1990-2015	For category 1A3ai(i) International Aviation LTO (Civil) together with 1A3aii(i) Domestic Aviation LTO (Civil) and NH_3, the TERT noted that emissions are reported as 'not applicable' ('NA'), stating that aviation gasoline is used (see IIR chapter 3.2.3.1.1). However, in the 2016 EMEP/EEA Guidebook the notation key 'NE' ('not estimated') is proposed for this fuel. In response to a question raised during the review, Portugal agreed with the adoption of the notation key 'NE' for NH_3 emissions for these two categories. The TERT recommends that Portugal change the notation key to 'NE' in their next submission.	no	Implemented	Notation Key corrected

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
PT-1A3ai(ii)-2017-0001	No	1A3ai(ii) International Aviation Cruise (Civil) - Memo Item, $PM_{2.5}$, 1990-2015	For category 1A3ai(ii) International Aviation Cruise (Civil) together with 1A3aii(ii) Domestic Aviation Cruise (Civil) for $PM_{2.5}$ emissions, the TERT noted that the emissions are reported as 'NE' with the respective emissions being reported for the 1A3a LTO cycles. In response to the question on the issue Portugal explained that although cruise emissions are a memo item only, these emissions will be included in future submissions. The TERT welcomed the answer provided, and recommends that Portugal includes the emissions in the next submission to improve the inventory's completeness and comparability.	no	Not Implemented It was not possible to include $PM_{2.5}$ in this submission. This recommendation implies with several changes to the database and will be implemented as soon as possible	
PT-1A3b-2017-0003	No	1A3b Road transport, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990-2015	For 1A3b Road Transport, all pollutants and years, the TERT noted that there was no evidence that the consumption of lubricants was accounted for in the energy balance for road transport. In response to a question raised during the review, Portugal explained that the inventory does include lubricants in NFR 1A3b for 2-stroke vehicles, but the contribution of lubricant consumption in vehicles with 4-stroke engines have not been included. The TERT acknowledges that lubricant consumption represents a very small contribution to energy consumption by the sector and therefore makes a very small contribution to emissions. The TERT notes that this issue does not relate to an under- or over-estimate but recommends that, for completion, the contribution of lubricants to the energy consumption assigned to NFR 1A3b is taken into account in the future submissions, and that the correct assignment is applied to 2-stroke engines in 1A3b and to 4-stroke engines in the IPPU NFR categories 2D3/2G (avoiding a double-count for the IPPU sector).	no	Implemented In this submission we included exhaust emission from lubricants in Road Transport as lubricant consumed as energy in some two-stroke engines and lubricant that enters accidentally in the engines combustion chambers.	3.2.3.2 Road Transportation

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
PT-1A3bv-2017-0001	No	1A3bv Road transport: Gasoline evaporation, NMVOC, 1990-2015	For category 1A3bv Road Transport: Gasoline Evaporation and emissions of NMVOCs the TERT noted that the emissions are reported as 'IE'. In response to a question raised during the review, Portugal explained that NFR 1A3bv emissions are included with exhaust emissions under NFRs 1A3bi-iv. Portugal was able to provide separate emissions for NFR 1A3bv which the TERT consider realistic in relation to the exhaust emissions from NFRs 1A3bi and 1A3biv. The TERT notes that this issue does not relate to an under- or over-estimate and recommends that for transparency, evaporative emissions from NFR 1A3bv are reported separately to the exhaust emissions under NFRs 1A3bi-iv in the next submission. The TERT understands that Portugal is working on adoption of COPERT 5 to enable this. The TERT has not used Portugal's figures for NFR 1A3bv as revised estimates for this review as the TERT is unable to subtract the relevant amounts from each of the 1A3bi-iv categories, but has been able to use them to check that the overall figures are realistic.	no	Implemented Gasoline Evaporation emissions are now reported separately	3.2.3.2 Road Transportation
PT-1A3bvi-2017-0001	Yes	1A3bvi Road Transport: Automobile Tyre and Brake Wear, $PM_{2.5}$, 1990-2015	For 1A3bvi Road Transport: Automobile Tyre and Brake Wear and 1A3bvii Road Transport: Road Abrasion, and $PM_{2.5}$ emissions, the TERT noted that emissions are reported as 'IE' in the NFR tables. In response to a question raised during the review, Portugal explained that emissions for these sources are included with the exhaust emissions in the 1A3bi-1A3biv Road Transport categories, but was able to provide the TERT with the separate emissions for these sources during the review. Upon examination of these results, the TERT considered that emissions for tyre and brake wear were realistic and concluded that this issue does not relate to an under- or over-estimate of $PM_{2.5}$ emissions above the threshold of significance. The TERT recommends that emissions for NFRs 1A3bvi and 1A3bvii are	no	Implemented Automobile Tyre and Brake Wear and Road Abrasion emissions are now reported separately	3.2.3.2 Road Transportation

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			reported separately in the NFR tables in the next submission. This will be possible using the COPERT 5 version which Portugal is working towards adopting for their next inventory. The TERT has not used Portugal's figures for NFR 1A3bvi and 1A3bvii as revised estimates for this review as the TERT is unable to subtract the relevant amounts from each of the 1A3bi-iv categories, but has been able to use them to check the overall figures are realistic.			
PT-1A3c-2017-0001	No	1A3c Railways, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1997-2015	For category 1A3c Railways, all years after 1996 and solid fuels, the TERT noted that activity data are reported as 'not estimated' ('NE'), with no information in the IIR. In response to a question raised during the review, Portugal confirmed, that small amounts of coal were indeed used until 2012 for historic tourist trains, but were not allocated to the railways sector in the national energy balance. The TERT welcomed the answer provided by Portugal. Given the small amounts of coal used until 2012 (~20 tons per year) not considered in the railways sector of the national energy balance, the TERT recommends checking where in the energy balance these amounts are included (e.g. the commercial sector). The TERT further recommends applying the notation key 'IE' ('included elsewhere') for all years after 1996 and to include sufficient explanatory information in the IIR chapter for 1A3c.	no	Implemented	
PT-1A3c-2017-0002	No	1A3c Railways, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2008	For category 1A3c Railways and the year 2008, the TERT noted that activity data for liquid fuels show a remarkable increase that does not seem to fit the overall trend. In response to a question raised during the review, Portugal explained that in 2008 there was a significant change in the energy balance inquiries process, namely the codes of economic activity, which obliged the operators to make corrections in the classification of	no	No progress has been made in improving the proposed methodology. The Inventory will continue to make every possible effort	

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			the information. The TERT welcomed the answer provided by Portugal. However, as the TERT understands from the answer that there has been a methodological change to the statistics, the TERT recommends putting additional effort into consolidating the statistics in order to resolve inconsistencies resulting from such methodological changes as soon as resources allow.		to implement new approaches to increase the quality of data.	
PT-1A3di(ii)-2017-0001	No	1A3di(ii) International Inland Waterways, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990-2015	For category 1A3di(ii) International Inland Waterways, the TERT noted that activity data and emissions are reported as 'included elsewhere' ('IE') with no further information available in both the NFR tables and the IIR. In response to a question raised during the review, Portugal explained that international inland waterways can be considered almost negligible with the national energy balance not allowing for such separation. The TERT understands that international inland navigation is restricted to the Douro River coming from Spain, which is navigable only upstream to the border to Spain. Therefore, the TERT assumes there should be nearly no international inland waterways possible in Portugal, agreeing with the answer provided by Portugal. However, the TERT recommends including additional explanatory information on inland waterways in the next IIR.	no	Implemented	3.2.3.4 Water Borne Navigation
PT-1A3dii-2017-0001	No	1A3dii National Navigation (Shipping), SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2011	For category 1A3dii National Navigation (Shipping) and the year 2011, the TERT noted a remarkable decline in the activity data for liquid fuels. In response to a question raised during the review, Portugal explained that this decrease resulted from a slight drop in the number of docks in some of the major ports in mainland Portugal, referring to IIR Table 3.133 together with the reduction of the overall distance travelled in 2011. The TERT agreed with the answer provided by Portugal, and recommends	no	Implemented	3.2.3.4 Water Borne Navigation

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			that they include sufficient information on such country-specific circumstances in the IIR.			
PT-1A4aii-2017-0001	No	1A4aii Commercial/institutional: Mobile, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990-2015	For category 1A4aii Commercial/Institutional: Mobile, the TERT noted that the emissions are reported as 'not estimated' ('NE'). In response to a question raised during the review, Portugal confirmed that this is incorrect and that, as it is not possible to distinguish between stationary and mobile combustion, emissions reported for category 1A4aii are included in category 1A4ai. Portugal further proposed that the notation key 'NE' is replaced with 'IE' in the next annual submission. The TERT acknowledged the answer provided by Portugal, further welcoming the plan to revise the notation key. Here, the TERT recommends that Portugal includes sufficient explanatory information in future IIRs. In addition, in order to improve the inventory's transparency and comparability, the TERT recommends that Portugal puts additional effort in making a separate reporting of this sub-category available, based on other statistical or modelled data.	no	Implemented	
PT-1A4bi-2017-0001	Yes	1A4bi Residential: Stationary, SO_2, NO_X, NMVOC, $PM_{2.5}$, 2000-2015	For NMVOC and $PM_{2.5}$ emissions from NFR 1A4bi Residential: Stationary, the TERT noted that it was not entirely clear if Portugal used a Tier 1 or Tier 2 method. In response to the question on the issue Portugal explained that they used weighted average Tier 2 emission factors for wood combustion. The TERT notes that Tier 1 emission factors are used for the other fuels, although this is a key source and a higher tier method should be used. Portugal explained that they intend to update the emission factors to Tier 3 as soon as possible. The TERT noted that the issue is below the threshold of significance for a technical correction. The TERT recommends that Portugal	no	No progress has been made in improving the proposed methodology. The Inventory will continue to make every possible effort to implement new approaches to increase the quality of data.	

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			carries out the plans for a Tier 3 method, or updates the method to a Tier 2 method for the next submission.			
PT-1A4bii-2017-0001	No	1A4bii Residential: Household and gardening (mobile), SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990-2015	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. In response to a question raised during the review, Portugal confirmed that fuel consumed by such equipment is accounted for by the energy balance in the residential sector, in public services and even in road transport, when the fuel is bought directly at filling stations. Portugal further stated that emissions from this category are included in 1A4bi Residential: Stationary, 1A4ai Commercial/institutional: Stationary, and 1A3b Road Transport. 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	No progress has been made in improving the proposed methodology. The Inventory will continue to make every possible effort to implement new approaches to increase the quality of data.	
PT-1A4cii-2017-0001	Yes	1A4cii Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 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. In response to a question raised during the review, Portugal explained that in 2003, marked diesel for heating was introduced, separating the consumptions of diesel used for mobile and stationary combustion purposes. 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	no	No progress has been made in improving the proposed methodology. The Inventory will continue to make every possible effort to implement new approaches to increase the quality of data.	

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			Portugal includes sufficient information on such country-specific circumstances in the IIR.			
PT-1A5b-2017-0001	No	1A5b Other, Mobile (including military, land based and recreational boats), SO_2, NO_x, NH_3, NMVOC, $PM_{2.5}$, 1990-2015	For category 1A5b Other, Mobile (including Military, Land Based and Recreational Boats), the TERT noted strong fluctuations in the activity data reported. With no further information available in the IIR, the TERT assumed that these fluctuations could result from stock holding. In response to a question raised during the review, Portugal confirmed that it would check this issue with the national energy authority (DGEG) responsible for the energy balance. The TERT acknowledged the answer provided by Portugal, and recommends that Portugal clarifies this issue in their next submission.	no	Energy Balance data compiled by the national energy authority (DGEG) is based on fuel sales from market operators by economic activity (CAE rev 3). Accordingly, it´s not possible to ensure that the fuel fluctuations under the CAE "Serviços" is related to stock holding	
PT-1B1a-2017-0001	No	1B1a Fugitive Emission from Solid Fuels: Coal Mining and Handling, $PM_{2.5}$, 1990-2015	For category 1B1a Fugitive Emission from Solid Fuels: Coal mining and Handling and pollutant $PM_{2.5}$ the TERT noted that emissions from storage and handling of imported coal have not been estimated. In response to the question on the issue Portugal confirmed that $PM_{2.5}$ emissions had not been reported since the closure of the coal mines in 1995. The TERT noted that the issue is below the threshold of significance for a technical correction and recommends that Portugal includes an estimation of $PM_{2.5}$ emissions from storing and handling of (imported) coal after the closure of the mines and recalculates the years before the closure of the mines using the methodology	no		

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			provided in the 2016 EMEP/EEA Guidebook in their next submission.			
PT-1B2aiv-2017-0001	No	1B2aiv Fugitive Emissions Oil: Refining/Storage, NO_X, 1990-2015	For category 1B2aiv Fugitive Emissions Oil: Refining/Storage and pollutant NMVOC, the TERT noted a lack of transparency in the IIR, as the reasons for NMVOC emissions trends were insufficiently explained. The TERT calculated implied emission factors by unit of crude oil processed in refineries. In response to the question on the issue Portugal provided the time series of the total throughput in refineries, the main driver of the NMVOC emissions, and of the amount of coke burnt. The TERT accepted the explanation by Portugal and notes that this issue does not relate to an under- or over-estimate and recommends that Portugal explains in the IIR the emission trends including the main reasons for the trends.	no	Implemented. Please check revised text of Refining and Storage (NFR 1.B.2.a.iv) chapter	3.2.7.3 Refining and Storage (NFR 1.B.2.a.iv)
PT-1B2aiv-2017-0002	No	1B2aiv Fugitive Emissions Oil: Refining/Storage, NH_3, 1990-2015	For category NFR 1B2aiv Fugitive Emissions Oil: Refining/Storage and pollutant NH_3 the TERT noted that the notation key 'NE' had been reported. In response to the question on the issue, Portugal provided a revised estimate for NH_3 emissions using the Tier 2 approach. The TERT disagreed with the revised estimate as no appropriate activity (fresh feed related to the catalytic cracking regenerators without CO boiler) data had been applied. Portugal stated that refineries had been asked to provide the activity data and, when these data were not available, the ratio between atmospheric distillation design capacity and catalytic cracking units was applied. The TERT noted that the issue would be below the threshold of significance for a technical correction and recommends that Portugal collects information on the activity data related to the Tier 2 approach to calculate NH_3 emissions from recovery of catalysts and that, if activity data	no	Implemented. Please check revised text in IIR chapter "Fluid Catalytic Cracking (FCC)"	3.2.7.3.2 Fluid Catalytic Cracking (FCC)

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			were not available, Portugal applies the Tier 1 approach (based on crude oil input) to their next submission.			
PT-1B2b-2017-0001	No	1B2b Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other), SO_2, NMVOC, 1990-2015	For category 1B2b Fugitive Emissions from Natural Gas and pollutants NMVOC and SO_X the TERT noted that the notation key 'NE' had been reported. In response to the question on the issue, Portugal provided the time series of NMVOC emissions estimated with a methodology similar to the one applied for GHG emissions. Portugal explained that natural gas leaks had been estimated using the adjustment factors published by the national regulatory body of natural gas and the NMVOC emissions from these leaks were calculated applying the composition of natural gas imported. The TERT noted that the issue is below the threshold of significance for a technical correction. The TERT recommends that Portugal recalculates the emissions for their next submission and provides a detailed description in the IIR on the methodology applied, including the time series of activity data, loss rates and natural gas composition. The TERT recommends that Portugal applies data on the SO_X content (traces) for the natural gas composition, in order to estimate the SO_X emissions from this category.	no	Implemented	3.2.8 Fugitive Emissions from Natural Gas
PT-1B2c-2017-0001	No	1B2c Venting and flaring (oil, gas, combined oil and gas), SO_2, NO_X, NMVOC, $PM_{2.5}$, 1990-2015	For category 1B2c Venting and Flaring the TERT noted a lack of transparency in the IIR related to background information, which did not explain the time series of the emissions estimated. In response to a question raised during the review, Portugal stated that the composition of (and emissions from) the residual gas burned varied according to the industrial process that generates it and explained that the decrease in emissions between 2014 and 2015 was due to the carbon black facility stopping operations. Portugal provided the background information, including activity data and emission factors applied	no	Implemented. Please check revised text of Flaring in Oil Industry chapter (NFR 1.B.2.c).	3.2.8 Flaring in Oil Industry (NFR 1.B.2.c)

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			at plant level and recognized the need for enhance the methodological explanation in the IIR as well as the reporting of activity data in the NFR tables. The TERT noted that Portugal had allocated emissions from flaring at facilities of the petrochemical and chemical industry, including carbon black production, under NFR 1B2c. The TERT notes that the issue does not relate to an under- or over-estimate below the threshold of significance for a technical correction. The TERT recommends that emissions be included under NFR 1B2c if occurring at refineries and under NFR 2 if occurring in other (downstream) facilities where the petroleum products are used. The TERT recommends that Portugal enhances the transparency of the IIR regarding this NFR category for the next submission.			
PT-2A5a-2017-0001	No	2A5a Quarrying and mining of minerals other than coal, $PM_{2.5}$, 1990-2015	For the category NFR 2A5a Quarrying and Mining of Minerals Other Than Coal and pollutant $PM_{2.5}$ the TERT noted that the notation key 'NE' had been reported. In response to the question on the issue Portugal explained that the emissions would be included for the next submission but did not provide a revised estimate. The TERT noted that the issue is below the threshold of significance for a technical correction and recommends that Portugal includes $PM_{2.5}$ emissions from this category in the NFR tables and documents the methodology used in their IIR.	no	Implemented. Please check revised text in IIR.	4.1.1.4 Quarrying and mining of minerals other than coal (NFR 2.A.5.a)
PT-2A5b-2017-0001	No	2A5b Construction and demolition, $PM_{2.5}$, 1990-2015	For the category NFR 2A5b Construction and Demolition and pollutant $PM_{2.5}$ the TERT noted that the notation key 'NE' had been reported. In response to a question raised during the review, Portugal provided a revised estimate for the period 1990-2015. The TERT agreed with the revised estimate provided by Portugal. The TERT notes that the impact of the revised estimate is below the threshold of significance and recommends	RE	Implemented. Please check revised text in IIR.	4.1.1.5 Construction and Demolition (NFR 2.A.5.b)

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			that Portugal includes the revised estimate in its next submission as well as the documentation of the methodology used in the IIR. Additionally, the TERT recommends that Portugal investigates the accuracy of the activity data as the currently reported emissions show large inter-annual variations.			
PT-2A5c-2017-0001	No	2A5c Storage, handling and transport of mineral products, $PM_{2.5}$, 1990-2015	For category 2A5c Storage, Handling and Transport of Mineral Products and pollutant $PM_{2.5}$ the TERT noted that the notation key 'NE' had been reported. In response to the question on the issue Portugal confirmed that a fraction of $PM_{2.5}$ emissions from storage, handling and transport had been reported under NFRs 2A2 Lime Production and 2A3 Glass Production applying the Tier 1 approach of the 2016 EMEP/EEA Guidebook and acknowledged that these estimates did not cover all mineral products. The TERT agrees with Portugal's comment and notes that the issue is below the threshold of significance for a technical correction. However, the TERT recommends that Portugal recalculates $PM_{2.5}$ emissions from storage, handling and transport according to the Tier 2 method provided in the 2016 EMEP/EEA Guidebook and includes the emissions in the next submission.	no	Implemented. Please check revised text in IIR.	4.1.1.6 Storage, handling and transport of mineral products (NFR 2.A.5.c)
PT-2D3a-2017-0001	Yes	2D3a Domestic solvent use including fungicides, NMVOC, 2005, 2010, 2015	For NFR 2D3a Domestic Solvent Use Including Fungicides the TERT noted that the 2013 EMEP/EEA Guidebook Tier 1 methodology has been applied to the key category and that the NMVOC emissions reported by Portugal do not correspond to the activity data provided in the NFR tables. In response to the question on the issue Portugal explained that they will implement the 2016 EMEP/EEA Guidebook Tier 2 methodology based on the amounts of inhabitants. Portugal also provided an example of the description of the methodology that will be included in the IIR and an Excel table with revised estimates.	no	Implemented. Please check revised text in IIR.	4.1.4.1 Domestic solvent use including fungicide (NFR 2.D.3.a)

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			However, the file provided by Portugal accidentally dealt with revised estimates for another sector of the review (NFR 2D3e). Portugal stated that the revised estimates will be included in the next submission. The TERT noted that the issue is above the threshold of significance for a technical correction. The TERT is not able to calculate a technical correction but agrees with the methodology presented by Portugal and recommends that Portugal includes the revised estimate in the next submission.			
PT-2D3e-2017-0001	No	2D3e Degreasing, NMVOC, 1990-2015	For category 2D3e Degreasing and pollutant NMVOC the TERT noted that the same amount of used solvent has been used for the years after 1992 and that the emission factor of 1 has been used for the whole time series. In response to a question raised during the review, Portugal provided revised estimates for the years 1990-2015 and stated that these will be included in the next submission. The TERT agreed with the revised estimates provided by Portugal. The TERT noted that the issue is above the threshold of significance for a technical correction. The TERT recommends that Portugal includes the revised estimates in its next submission, but double-checks the activity data, as the amounts of used solvents have a very large difference (about 6-fold) between the amounts of used solvent that are before 2012 and after that year.	RE	Implemented. Please check revised text in IIR.	4.1.4.5 Degreasing (NFR 2.D.3.e)
PT-2D3f-2017-0001	No	2D3f Dry Cleaning, NMVOC, 1990-2015	For category 2D3f Dry Cleaning and pollutant NMVOC the TERT noted that Portugal has calculated NMVOC emissions from dry cleaning using statistical trade information (import/export) on PER as activity data and that the emissions from the consumption were calculated by applying the EF of 1. In response to the question on the issue and the reference to the methodology provided in the 2016 EMEP/EEA Guidebook Portugal provided revised estimates for the years 1990-2015.	RE	Implemented. Please check revised text in IIR.	4.1.4.6 Dry Cleaning (NFR 2.D.3.f)

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			The TERT agreed with the revised estimates provided by Portugal. The TERT noted that the overestimation is below the threshold of significance for a technical correction and recommends that Portugal includes the revised estimates in the next submission.			
PT-2D3g-2017-0001	Yes	2D3g Chemical Products, NMVOC, 1990-2015	For category 2D3g Chemical Products the TERT noted that Portugal has not included in the inventory emissions from activities like: pharmaceutical products manufacturing, asphalt blowing, textile finishing, leather tanning and adhesive, magnetic tapes, films and photographs manufacturing. The TERT notes that the 2016 EMEP/EEA Guidebook provides methodologies to calculate emissions from those activities. In response to the question on the issue Portugal explained that they do not have information on emissions on these activities in Portugal but that they will check if these activities are taking place and include emissions from those activities that exist in the next inventory. The TERT agreed with the response provided by Portugal. The TERT can't assess if the issue is below or above the threshold of significance for a technical correction. The TERT recommends that Portugal investigates if these activities take place in Portugal and reports emissions from existing sources and documents them and the applied methods in the IIR of the next submission.	no	Implemented. Please check revised text in IIR.	4.1.4.12, 4.1.4.14, 4.1.4.15, 4.1.4.16, 4.1.4.17
PT-2D3i-2017-0001	Yes	2D3i Other Solvent Use, NMVOC, 1990-2015	For category 2D3i Other Solvent Use the TERT noted that the 2016 EMEP/EEA Guidebook provides methodologies for the following activities which might be missing from the inventory: glass and mineral wool enduction, vehicles dewaxing, underseal treatment and conservation of vehicles and fat, edible and non-edible oil extraction. In response to the question on the issue Portugal stated that these activities take place in Portugal and	no	Implemented. Please check revised text in IIR.	4.1.4.20, 4.1.4.21, 4.1.4.22, 4.1.4.25, 4.1.4.26

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			that NMVOC emissions from the activities will be included 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 includes the emissions for activities currently missing from the inventory in the next submission.			
PT-2D3i-2017-0002	Yes	2D3i Other Solvent Use, NMVOC, 1990-2015	For category 2D3i Other Solvent Use the TERT noted that Portugal has reported the same amount of NMVOC emission from the use of adhesives almost for the whole time series. In response to the question on the issue Portugal stated that they will find better alternatives and data sources (sectoral associations) in order to obtain more reliable emissions estimates. The TERT recommends that Portugal investigates the possibilities to improve the methodology used for estimation of emissions from NFR 2D3i and asks Portugal to give an overview on the development in solving that issue in the IIR of the next submission.	no	Implemented. Please check revised text in IIR.	4.1.4.23 Application of glues and adhesives (NFR 2.D.3.i – SNAP 060405)
PT-2G-2017-0001	No	2G Other Product Use, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990-2015	For category 2G Other Product Use the TERT noted that Portugal has not presented in the IIR a methodology description and has used in the NFR table the notation key 'NO'. In response to the question on the issue Portugal explained that they do not report any activity under NFR 2G and stated that this issue will be addressed in the next submission. The TERT noted that the issue is below the threshold of significance for technical correction. The TERT recommends that Portugal studies possible sources that might fall under this category and estimates and reports possible emissions from these in the next submission.	no	Implemented. Please check revised text in IIR.	4.1.4.27, 4.1.4.28, 4.1.4.29
PT-2H2-2017-0001	Yes	2H2 Food and beverages industry, NMVOC, 1990-2015	For category 2H2 Food and Beverages Industry the TERT noted that Portugal applies the methodology from the 2009 EMEP/EEA Guidebook, but points out that all emission factors in the 2016	no	Implemented.	4.1.4.32 Food Manufacturi

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			EMEP/EEA Guidebook are unchanged for NFR 2H2, except the EF for spirits. In response to a question on the issue Portugal stated that they will correct the references in the IIR to the next submission and explained that the EF for spirits will not change the methodology used in the inventory, because Portugal uses an EF of 15 kg/hl of alcohol and assumes that the spirits have 40% of alcohol in their composition which leads to an emission factor of 6 kg/hl of spirits. The TERT agreed with the explanation provided by Portugal and recommends that Portugal updates the references to the latest version of the Guidebook in the IIR to the next submission.		Please check revised text in IIR.	ng (NFR 2.H.2) 4.1.4.33 Drink Manufacturing (NFR 2.H.2)
PT-2I-2017-0001	No	2I Wood Processing, NMVOC, 1990-2015	The TERT noted that Portugal has reported NMVOC emissions under NFR 2I Wood Processing, although the 2016 EMEP/EEA Guidebook states that NFR 2I should address particle emissions from wood processing. In response to a question on the issue Portugal explained that NMVOC emissions are calculated from chipboard production using the EF from the Corinair 90 publication. The TERT agreed with the explanation provided by Portugal and recommends that Portugal reallocates emissions from chipboard production from category 2I to 2H1 Pulp and Paper Industry according to the 2016 EMEP/EEA Guidebook, in the next submission.	no	Implemented. Please check revised text in IIR.	4.1.4.34 Wood Processing (NFR 2.I)
PT-3B1a-2017-0001	No	3B1a Manure Management - Dairy Cattle, NMVOC, 2005, 2010, 2015	The TERT noted with reference to NMVOC emissions from NFRs 3B1a Manure Management - Dairy Cattle and 3B1b Manure Management – non-dairy Cattle that although NMVOC emissions from other subcategories of NFR 3B are reported, those from NFRs 3B1a and 3B1b are reported as 'NE', while on page 309 of the IIR there is documentation of the method used to calculate NMVOC emissions from these two sources (pages 5-4 and 5-14). Portugal replied to a question on this issue,	RE	Implemented	NMVOC emission estimates included in NFR 3B1a and NFR 3B1b are

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			explaining that due to a compilation error the estimates of NMVOC emissions from NFRs 3B1a and 3B1b were not included in the NFR tables. Portugal provided a file in which the estimated NMVOC emissions from NFRs 3B1a and 3B1b were calculated as described in the IIR. The TERT recommends that Portugal includes these in the next inventory.			reporting tables tables
PT-3B1b-2017-0001	No	3B1b Manure Management - Non-dairy Cattle, NO_X, NH_3, $PM_{2.5}$, 1990-2015	The TERT notes with reference to emissions of NH_3, NO_X and PM from category 3B1b Manure Management - Non-dairy Cattle that these have all declined for the period 2000-2015, yet the numbers of almost all classes of non-dairy cattle have increased, some considerably. This deviation is not explained by differences in N excretion as those remain constant. Based on the data presented in Table 5.6 of the IIR the TERT asked Portugal if the decline in emissions is a result of the increase in the proportion of time spent on pasture by Other cattle (3B1b). The Party replied that the TERT was correct. The decline in emissions of NH_3, NO_X and PM from 3B1b is related with the increase of the proportion of time spent in pasture (extensive production). This means that more N is deposited in pasture than the N in housing and storage leading to lower emissions from manure management of non-dairy cattle. The TERT recommends that Portugal includes this explanation in the next IIR in order to increase transparency.	no	Implemented	Chapter Agriculture, Overview
PT-3Da3-2017-0001	No	3Da3 Urine and dung deposited by grazing animals, NO_X, NH_3, 2005, 2010, 2015	The TERT noted with reference to NH_3 and NO_X emissions from NFR 3Da3 Urine and Dung Deposited by Grazing Animals that the trend toward decreasing emissions over the time series does not appear to be consistent with the increase in the number of non-dairy cattle over the period, especially as the time spent grazing by those livestock has increased. To the question on why the emissions do not appear to change in line with the livestock	no	Implemented	Chapter Agriculture, Overview

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			numbers, Portugal replied that emissions from urine and dung deposited by grazing animals are reported not by livestock category but rather as the sum of the emissions of all livestock categories in pasture. In Portugal, besides non-dairy cattle, there is also a significant proportion of sheep and goats that spend time in pasture (Table 5.6 of the IIR) While the population of non-dairy cattle increased over the time, the same is not true for sheep and goats whose numbers decreased significantly in the same period. The NH_3 EF for grazing of non-dairy cattle (0.06) is lower than the EF for grazing sheep and goats (0.09). The combination of these conditions explains why NH_3 and NO_X emissions from NFR 3Da3 do not appear to change. To support this Portugal provided the figures in an Excel file. The TERT recommends that Portugal includes the explanation in future IIR submissions in order to increase the transparency of the inventory.			
PT-3De-2017-0001	No	3De Cultivated Crops, $PM_{2.5}$, 2005, 2010, 2015	The TERT notes with reference to $PM_{2.5}$ emissions from category 3De Cultivated Crops that these are reported as 'NA', while $PM_{2.5}$ emissions are reported under 3Dc Farm-level agricultural operations. Table 5-16 of the IIR indicates that $PM_{2.5}$ emissions are calculated for NFR 3De. The TERT assumes the $PM_{2.5}$ emissions presented under NFR 3Dc include those arising from NFR 3De, in which case $PM_{2.5}$ emissions from NFR 3De should be reported as 'IE'. To the question on the issue Portugal confirmed that the notation key of NFR 3De for $PM_{2.5}$ should be corrected from 'NA' to 'IE'. The TERT recommends that Portugal uses the appropriate notation key of 'IE' for the next submission.	no	Implemented	Notation key corrected in NFR 3De reporting table
PT-5B-2017-0001	No	5B Biological Treatment of Waste, NH_3, 2005, 2010, 2015	The TERT noted that the description in the IIR for the method used to calculate NH_3 emissions from NFR 5B Biological Treatment of Waste is not transparent. To the question on the	no	Implemented. Anaerobic digestion at biogas facilities	2018 IIR. Chapter 6.2.2

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			issue Portugal replied that the EFs used for NFRs 5B1 Biological treatment of waste - Composting and 5B2 Biological treatment of waste – Anaerobic Digestion are the same. The TERT notes that the method used results in an under-estimation of emissions below the threshold of significance with no technical correction necessary. The TERT recommends that Portugal recalculates NH_3 emissions from NFR 5B for the next submission.		(5B2): revision of estimates based on information from 2016 Guidebook.	NH 3 emissions from Biological Treatment of Waste - Composting (NFR 5 B 1) and Anaerobic Digestion (NFR 5 B 2)
PT-5E-2017-0001	No	5E Other Waste, NO_X, NMVOC, 2017	The TERT noted that NMVOC and NO_X emissions from NFR 5E Other Waste for 1990-2004 and 2012-2014 are reported as 'NO' and that in the reported years the emissions would be below of the threshold of significance. In response to a question raised during the review, Portugal explained that emissions from biogas combustion without energy recovery (flaring) are reported under NFR 5E and that activity data for these years are not available. Portugal also proposed to change the notation key to 'NE'. The TERT recommends that Portugal estimates activity data with an extrapolation method between the years for which activity data are available and reports emissions for the whole time.	no	Implemented. Data have been estimated for the 2012-2014 years based on interpolation of AD for available years.	2018 IIR. Chapter 6.2.6 Emissions from other waste: landfill gas and other biogas burning (NFR5 E)
PT-NatTot-2017-0001	No	National Total, NO_X, SO_X, NMVOC, NH_3, $PM_{2.5}$, 1990-2015	The TERT have noticed that Portugal reported a total in row 141 "National total for the entire territory" that does not equal the sum of the individual emission sources reported in rows 14-140. The TERT understand that Portugal have reported a figure here that is the total for Portugal's geographical coverage defined by the CLRTAP, but for the NECD submissions Portugal are required	TC	Implemented. Reported values in row 141 refer now to the sum of categories reported in rows 14-140 and are also	NFR Tables 1A.

Observation	KC	NFR, Pollutant(s), Year(s)	Recommendation	RE or TC	MS response / Status of implementation	Chapter/section in the IIR
			to report using a different geographical coverage. So the TERT conclude that the totals reported in row 144 National total for compliance assessment should be reported in Row 141. Portugal explained that they were not in favour of this approach, but the TERT note that this is a requirement of the reporting under the NECD.		equal to figures in row 144.	

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 2017 NECD review process, and other inventory review processes under the UNFCCC and the EC. Other recalculations refer to changes resulting from the internal aplication of QA\QC procedures.

The recalculations performed are summarized as follows:

Energy Combustion

Energy Industries (NFR 1.A.1)

Update of continuous monitoring of NOx in electricity generation plants with main focus in the years 2011-2016

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

CO emission factor related to residual oil combustion has been updated according to table 4-4 of chapter 1.A.1 Energy industries of EMEP/EEA air pollutant emission inventory guidebook 2016 (EF=6 g/GJ instead of 15 g/GJ).

Benzo(α)pyrene, benzo(β)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene emission factors related to gas oil consumption in reciprocating engines have been updated according to table 4-8 of chapter 1.A.1 Energy industries of EMEP/EEA air pollutant emission inventory guidebook 2016.

CO emission factor related to refinery gas combustion has been updated according to table 4-2 of chapter 1.A.1 Energy industries of EMEP/EEA air pollutant emission inventory guidebook 2016 (EF=12.1 g/GJ instead of 39.3 g/GJ)."

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

NVMOC emission factor has been revised. The two mines were of the underground type. The tier 2 emission factor is 3 kg/t coal, while the previous tier 1 emission factor was 0.8 Kg/t coal. NMVOC emissions are now 2.75 higher than were in the previous submission.

Transport of Crude/Marine Terminals (NFR1.B.2.a.i)

This subsector methodology, activity data and emission factors have been revised.

Storage/Tanks (NFR 1.B.2.a.iv)

Activity data has been revised based on data provided by the refineries as input to TANKS software.

Fluid Catalytic Cracking (FCC), Platforming/Continuous Catalyst Regenerators (CCR), Oil-Water Separators, Sulphur Recovery Units (1.B.2.a.iv)

We have implemented the methodology proposed in Concawe report no. 4/17 (Air pollutant emission estimation methods for E-PRTR reporting by refineries – 2017 edition).

Service Stations (NFR 1.B.2.a.v)

A correction was made in a compilation error.

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

CO and NOx emission factors have been updated according to “Concawe – Air pollutant emission estimation methods for E-PRTR reporting by refineries – report no. 4/17 (2017 Edition)”.

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

No major recalculations were made.

Transports (NFR 1.A.3)

For Road Transportation (NFR 1.A.3.b) the major changes between submissions (2017 and 2018) result from implementation of the Copert V (Version 5.1.0 – December 2017) and the following actions:

- Major revision on the vehicle stock and mean activity due to the new vehicle categories adopt in Copert V and EMEP/EEA Guidebook 2016, update of vehicles technologies, correction of the vehicles abatement rate, update of the data from the vehicle inspection centers);
- Revision of the biodiesel and bioethanol incorporation rates and data, from 2013 to 2015, with information of the split in biofuels by the National Energy Authority (DGEG);
- Inclusion of heavy metals exhaust emission from lubricants;
- Revision of the S and PB content data regarding National Legislation values;
- Update of the monthly maximum and minimum average temperature by the Portuguese Sea and Atmosphere Institute (IPMA)
- Insertion of relative humidity per month by the Portuguese Sea and Atmosphere Institute (IPMA);
- Update of the trip length average to 10 Km as described in the EMEP/EEA Guidebook 2016.

Recalculations for Water Borne Navigation (NFR 1.A.3.d) comprise:

- update and correction of the 2015 data for the Sines Port (from 901 to 2173 ship docks);
- review of the NOx, CO, NMNVOC, TSP, PM 2.5, Pb, Cd, Hg, As, Cr, Cu, Ni, Se and Zn emission factors in line with the EEA/EMEP Air Pollutant Inventory Guidebook 2016.

Industrial Processes

Detailed explanations of recalculations are in the respective chapters’ description of the following NFR codes

NFR 2,A,3 ; 2.A.5 a,b and c; 2.B.6; 2.B.10.a; 2.C.1; 2.C.3; 2.C.5; 2.C.7.a; 2.C.7.d;2.D.3.a; 2.D.3.c; 2.D.3.e; 2.D.3.f; 2.D.3.g; 2.D.3.h; 2.D.3.i; 2.G: 2.H.1; 2.H.2; 2.I; 2.K

Agriculture

The major changes between last year submission and this year submission result from the following actions:

- revision of 2015 values of N inorganic fertilizers, updated by INE (NFR 3Da1);
- revision of 2014 and 2015 animal numbers for poultry, rabbits, horses, mules & asses, according to the results of the last Farm Structure Survey (2016) published[80] by INE (NFR 3B2 and 3B4, 3Da2a, 3Da3);
- revision of 2014 milk production (kg/hd/yr) of dairy cows, updated by INE. Milk production is a relevant parameter for N excretion estimates of dairy cows (NFR 3B1a, 3Da2a, 3Da3);
- revision of the share (trend 1990-2010) of the manure of cattle, sheep, goats and equidae, in each type of management system, based on the information collected from the last Agriculture General Census (RA09) and the information resident in the National Animal Registration database (SNIRA), for the same livestock categories (NFR 3B1a, 3B1b, 3B3, 3B4,3Da2a, 3Da3);
- minor corrections as a result of internal QA/QC procedures.

Waste

MSW incineration with energy recovery (NFR 1A1a).

– EF updates based in monitored data from plant incineration units.

Solid waste disposal (NFR 5A)

– Urban waste: revision of waste composition, in order to take into account the outcomes from the last (2016) UNFCCC review report (Sept. 2017), which recommended (W4-W5) to revise DOC values for the “non-food fermentable materials” and “wood” waste categories, which were reported as zero for the 1960s, 1970s and 1980s and included in “food waste” with a lower DOC value. New accounting includes the estimate of those fractions and the consideration of DOC content values of 20 and 43, for “non-food fermentable materials” and “wood”, respectively.

– Landfill biogas recovered: revision of landfill biogas amounts for the 2011-2015 period; previous data considered errounously biogas recovered in biological treatment of waste (anaerobic digestion).

– Industrial waste: following the recommendations from the last (2016) UNFCCC review report (Sept. 2017the DOC values for several categories have been revised in order to fully apply the default DOC values from the 2006 IPCC Guidelines for also historical depositions. Furthermore some waste categories have been disaggregated (e.g. previously reported category “paper and textiles”) in order to consider diverse DOC defaults.

[80] Data were recently published (28.11.2017)

Biological treatment of solid waste (NFR 5B)

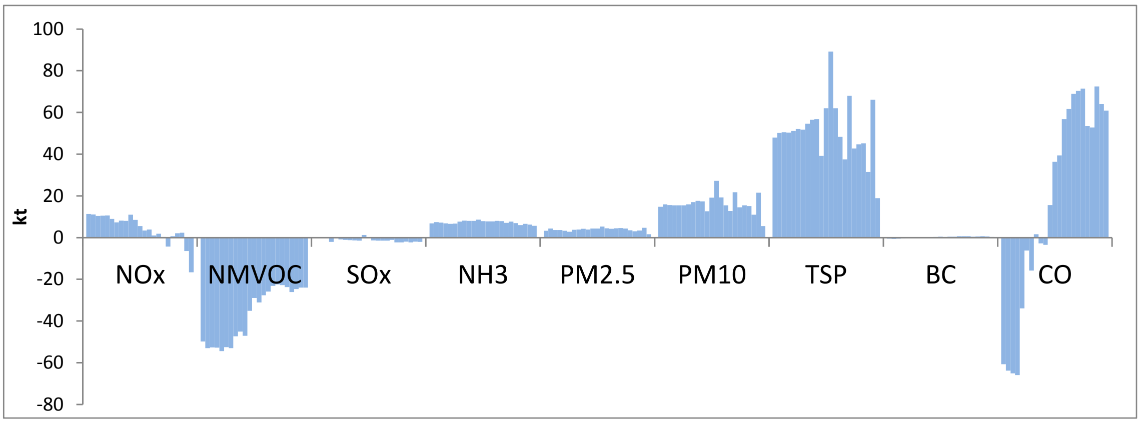
– Anaerobic digestion at biogas facilities (5B2): revision of estimates based on information from 2016 Guidebook.

Wastewater treatment and discharge (CRF 5D1):

- revision of population data: 2014-2015
- changes from 2013-2015 result from an update of INE data for protein consumption for this period.

The recalculations of emission levels are presented in the following figures which show the absolute differences between the latest submission (2018) and the previous submission (2017) for Portugal Mainland.

Figure 8.1 – Recalculations for main pollutants and particulate matter for 1990-2015 (absolute difference between 2018 and 2017 submissions)



The impact of the recalculation in each sector for the 2015 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 2015)

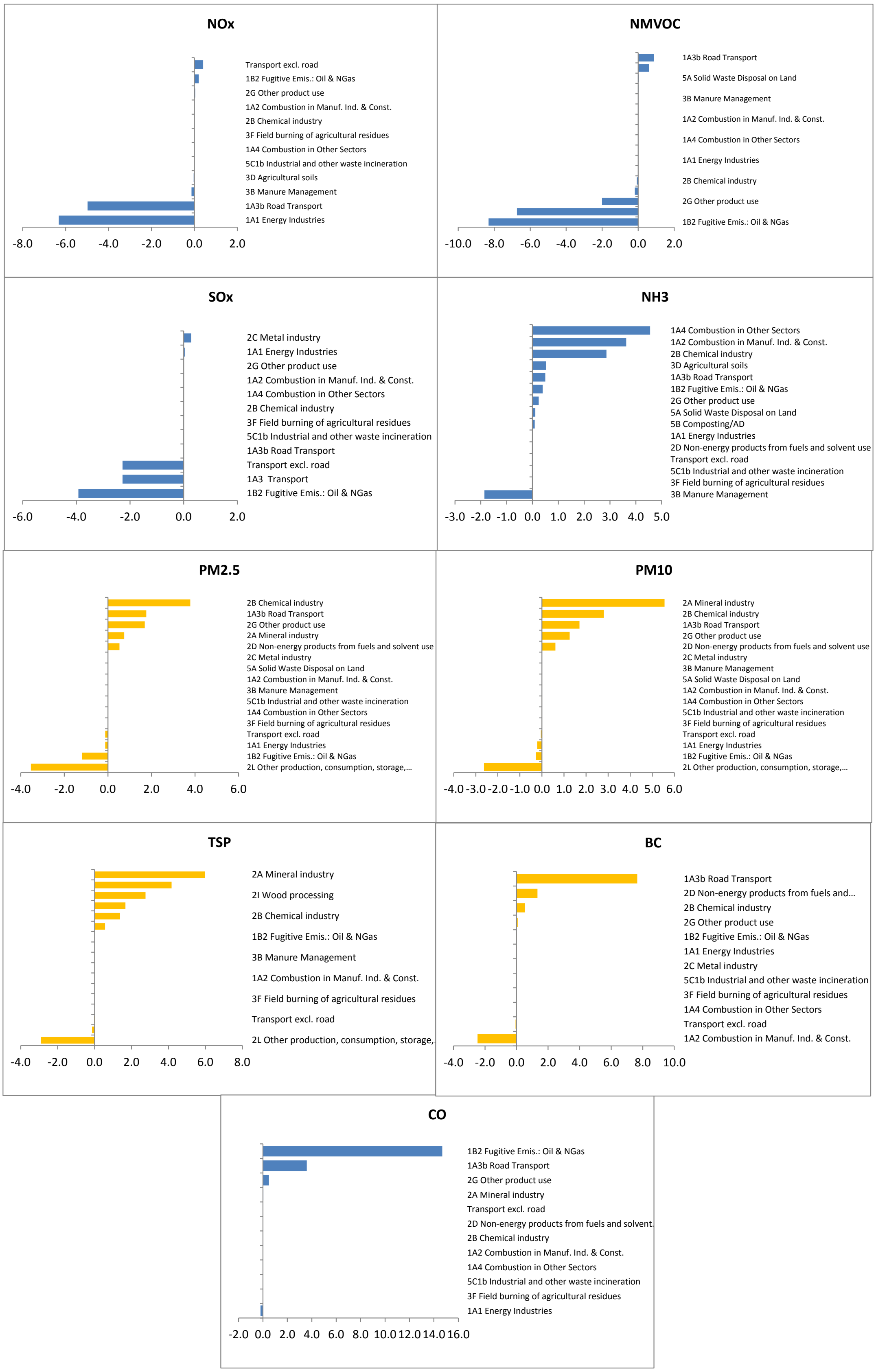


Figure 8.3 – Recalculations for heavy metals for 1990-2015 (absolute difference between 2018 and 2017 submissions)

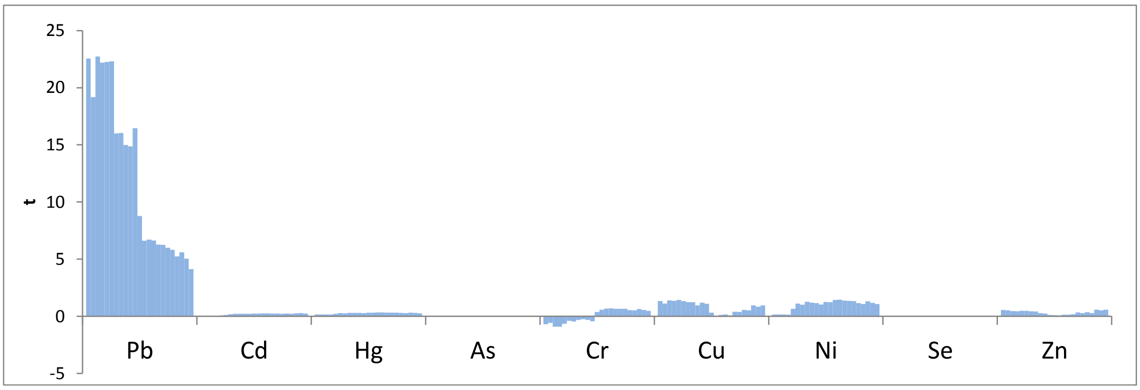


Figure 8.4 – Sectoral contribution in recalculations: Heavy Metals (% contribution to the total emissions of each pollutant in 2015)

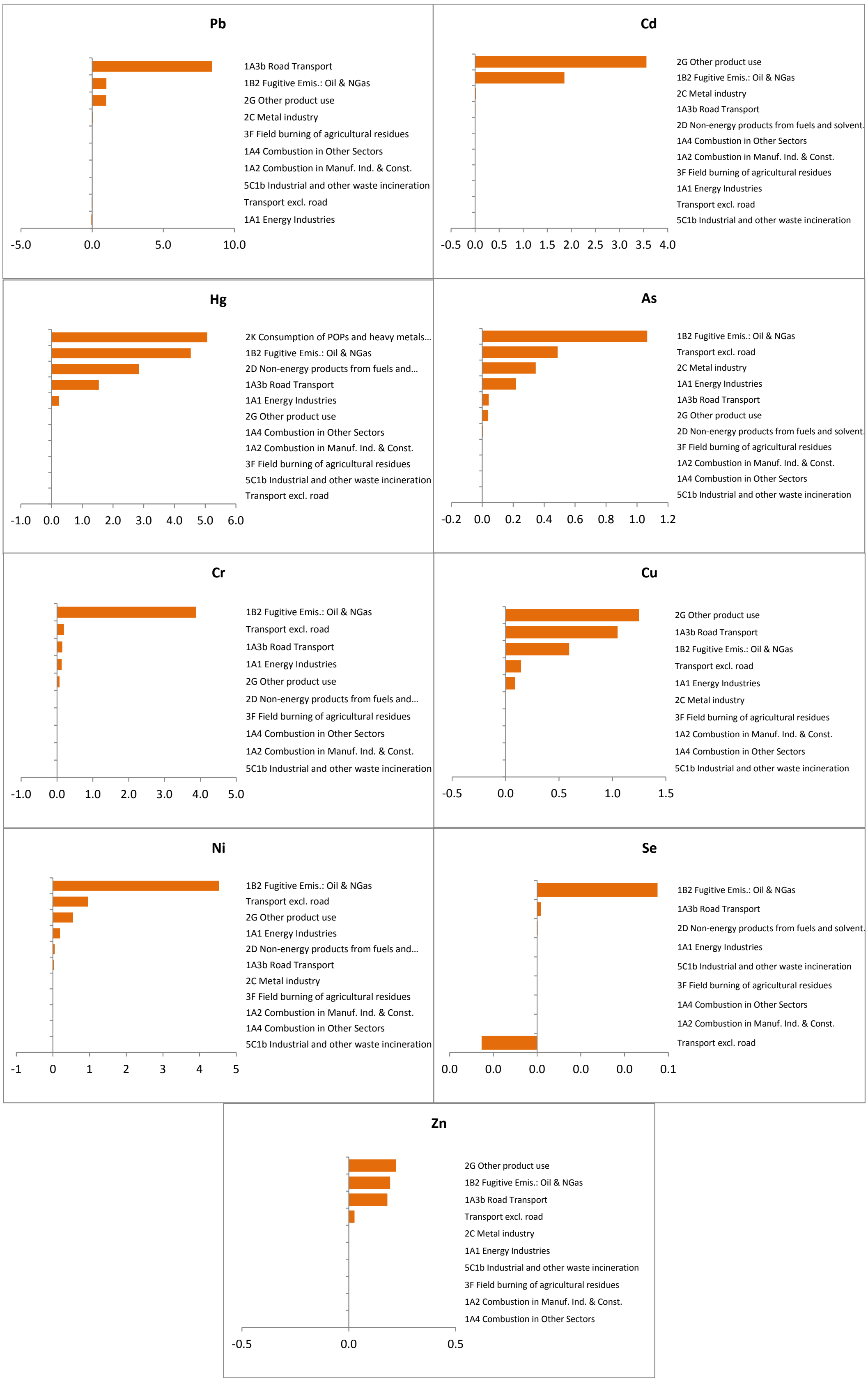


Figure 8.5 – Recalculations for Dioxines, PAHs, HCB and PCB for 1990-2015 (absolute difference between 2018 and 2017 submissions)

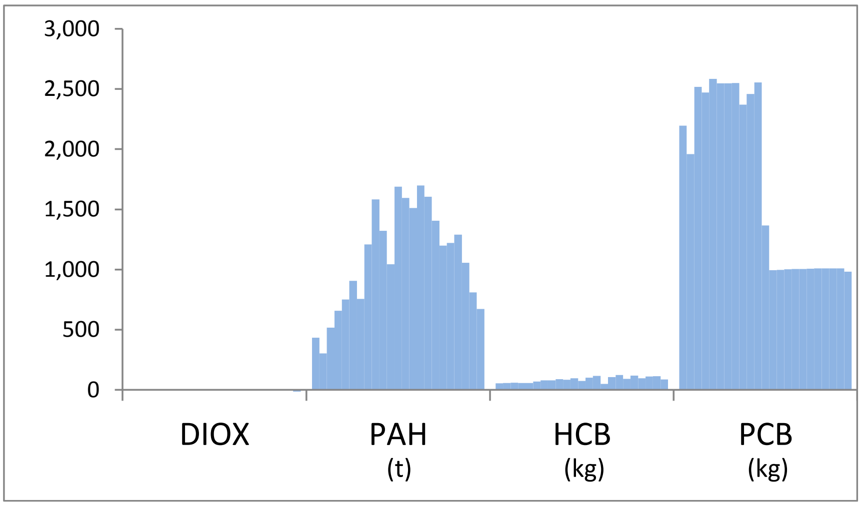
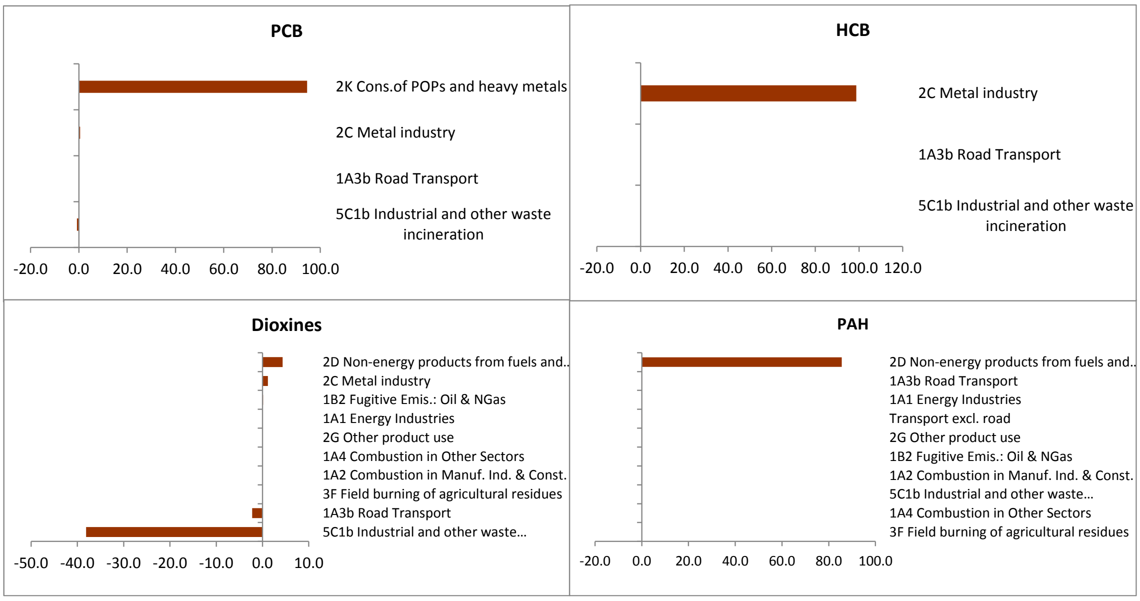


Figure 8.6 – Sectoral contribution in recalculations: PCB, Dioxines and PAHs (% contribution to the total emissions of each pollutant in 2015)



9 List of Acronyms

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
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
FCR	Fixation in Crop Residues	-
FCT-UNL	Faculty of Science and Technology of New University of Lisbon	Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa
FGR	Annual amount of nitrogen in animal excreta (faeces and urine) deposited directly in soil during grazing in pasture and adjusted to account for the amount that volatilises as NH3	-
FOD	First Order Decay	Decaimento de Primeira Ordem
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
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
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)
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

Annex Table 1 – Completeness table

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	NE	NE	NE		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	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
1A3c	Railways												NE							NE			
1A3dii	National navigation (shipping)																			NE			
1A4aii	Commercial/institutional: Mobile	NE	NE	NE		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1A4bi	Residential: Stationary																						NE
1A4ci	Agriculture/Forestry/Fishing: Stationary																					NE	NE
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery												NE							NE			
1A4ciii	Agriculture/Forestry/Fishing: National fishing																			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					
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 ar			NE															NE				
1B2c	Venting and flaring (oil, gas, combined oil and gas)				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	NE	NE	NE
2A1	Cement production																			NE	NE		
2A2	Lime production										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					
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														
2H1	Pulp and paper industry				NE				NE											NE	NE		
2H2	Food and beverages industry					NE	NE	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
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	
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products				NE																		
5A	Biological treatment of waste - Solid waste disposal on land									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	NE
5D2	Industrial wastewater handling				NE	NE	NE	NE	NE		NE	NE											

Annex Table 2 – Key category analysis of 2016 inventory

NOx **Level Assessment**

NFR	Sectors	%total 2016	Cumulative total	Key category
1A3bi	Road transport: Passenger cars	15.99	16.0	x
1A3biii	Road transport: Heavy duty vehicles and buses	15.28	31.3	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	10.16	41.4	x
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	9.95	51.4	x
1A3bii	Road transport: Light duty vehicles	8.71	60.1	x
1A1a	Public electricity and heat production	7.12	67.2	x
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	3.76	71.0	x
2H1	Pulp and paper industry	3.47	74.4	x
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	3.47	77.9	x
1A4ciii	Agriculture/Forestry/Fishing: National fishing	2.75	80.7	x
1A4bi	Residential: Stationary	2.56	83.2	
1A3dii	National navigation (shipping)	2.29	85.5	
1A1b	Petroleum refining	2.20	87.7	
1A3ai(i)	International aviation LTO (civil)	2.17	89.9	
1A4ai	Commercial/institutional: Stationary	1.58	91.5	
3Da1	Inorganic N-fertilizers (includes also urea application)	1.20	92.7	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	1.08	93.7	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.96	94.7	
3Da3	Urine and dung deposited by grazing animals	0.87	95.6	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.62	96.2	
3F	Field burning of agricultural residues	0.53	96.7	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.44	97.2	
1A3aii(i)	Domestic aviation LTO (civil)	0.40	97.6	
1A3c	Railways	0.40	98.0	
2C1	Iron and steel production	0.31	98.3	
3Da2a	Animal manure applied to soils	0.25	98.5	
3B4gii	Manure mangement - Broilers	0.22	98.8	
3B4h	Manure management - Other animals (please specify in IIR)	0.19	98.9	
1B2aiv	Fugitive emissions oil: Refining / storage	0.15	99.1	
2B10a	Chemical industry: Other (please specify in the IIR)	0.14	99.2	
1A3biv	Road transport: Mopeds & motorcycles	0.12	99.4	
3B4gi	Manure mangement - Laying hens	0.12	99.5	
3B1b	Manure management - Non-dairy cattle	0.09	99.6	
3Da2c	Other organic fertilisers applied to soils (including compost)	0.09	99.7	
2B2	Nitric acid production	0.07	99.7	
3B1a	Manure management - Dairy cattle	0.06	99.8	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.05	99.8	
3Da2b	Sewage sludge applied to soils	0.03	99.9	
2G	Other product use (please specify in the IIR)	0.03	99.9	
3B2	Manure management - Sheep	0.02	99.9	
3B4giii	Manure mangement - Turkeys	0.02	99.9	
5C1bi	Industrial waste incineration	0.01	100.0	
3B4giv	Manure management - Other poultry	0.01	100.0	
3B3	Manure management - Swine	0.01	100.0	
5C1bv	Cremation	0.01	100.0	
3B4d	Manure management - Goats	0.00	100.0	
5E	Other waste (please specify in IIR)	0.00	100.0	
3B4f	Manure management - Mules and asses	0.00	100.0	
3B4e	Manure management - Horses	0.00	100.0	
5C1biii	Clinical waste incineration	0.00	100.0	
2B6	Titanium dioxide production	0.00	100.0	

NOx **Trend Assessment (1990-2016)**

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
1A1a	Public electricity and heat production	65.25	10.50	0.11	40.70	40.7	x
1A3bii	Road transport: Light duty vehicles	7.47	12.85	0.03	12.24	52.9	x
1A2f	Stationary combustion in manufacturing industries and	15.10	14.97	0.02	8.79	61.7	x
1A2d	Stationary combustion in manufacturing industries and	3.10	5.54	0.01	5.39	67.1	x
2H1	Pulp and paper industry	2.50	5.12	0.01	5.29	72.4	x
1A3ai(i)	International aviation LTO (civil)	1.15	3.20	0.01	3.66	76.1	x
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	21.31	14.66	0.01	3.01	79.1	x
1A4ciii	Agriculture/Forestry/Fishing: National fishing	10.17	4.05	0.01	2.84	81.9	x
1A3biii	Road transport: Heavy duty vehicles and buses	40.85	22.53	0.01	2.32	84.2	
1A1b	Petroleum refining	2.80	3.25	0.01	2.31	86.5	
1A3c	Railways	3.12	0.58	0.01	1.83	88.4	
1A3dii	National navigation (shipping)	4.07	3.38	0.00	1.42	89.8	
1A2gviii	Stationary combustion in manufacturing industries and	7.06	5.12	0.00	1.37	91.2	
3Da3	Urine and dung deposited by grazing animals	1.01	1.29	0.00	1.01	92.2	
1A4bi	Residential: Stationary	5.25	3.77	0.00	0.97	93.1	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.53	0.92	0.00	0.88	94.0	
1A3bi	Road transport: Passenger cars	38.92	23.58	0.00	0.86	94.9	
1A2e	Stationary combustion in manufacturing industries and	1.90	1.59	0.00	0.67	95.5	
1A3aii(i)	Domestic aviation LTO (civil)	0.31	0.59	0.00	0.60	96.1	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.44	0.65	0.00	0.57	96.7	
1A4ai	Commercial/institutional: Stationary	4.52	2.33	0.00	0.50	97.2	
3B4h	Manure management - Other animals (please specify ir	1.04	0.28	0.00	0.49	97.7	
3Da1	Inorganic N-fertilizers (includes also urea application)	2.48	1.77	0.00	0.45	98.1	
2C1	Iron and steel production	0.35	0.46	0.00	0.37	98.5	
1A2c	Stationary combustion in manufacturing industries and	2.04	1.42	0.00	0.31	98.8	
3F	Field burning of agricultural residues	1.02	0.79	0.00	0.27	99.1	
3B4gii	Manure mangement - Broilers	0.29	0.32	0.00	0.23	99.3	
2B10a	Chemical industry: Other (please specify in the IIR)	0.13	0.20	0.00	0.18	99.5	
3B4gi	Manure mangement - Laying hens	0.20	0.18	0.00	0.08	99.6	
2B2	Nitric acid production	0.25	0.10	0.00	0.07	99.6	
3B2	Manure management - Sheep	0.12	0.04	0.00	0.05	99.7	
2G	Other product use (please specify in the IIR)	0.01	0.04	0.00	0.05	99.7	
3Da2b	Sewage sludge applied to soils	0.04	0.05	0.00	0.04	99.8	
3Da2a	Animal manure applied to soils	0.67	0.37	0.00	0.03	99.8	
3B1a	Manure management - Dairy cattle	0.18	0.08	0.00	0.03	99.9	
1A5b	Other, Mobile (including military, land based and recrea	0.16	0.07	0.00	0.03	99.9	
5C1bv	Cremation	0.00	0.01	0.00	0.02	99.9	
5C1biii	Clinical waste incineration	0.02	0.00	0.00	0.02	99.9	
3B1b	Manure management - Non-dairy cattle	0.22	0.14	0.00	0.01	99.9	
1A3biv	Road transport: Mopeds & motorcycles	0.30	0.18	0.00	0.01	99.9	
3B4d	Manure management - Goats	0.02	0.01	0.00	0.01	100.0	
5C1bi	Industrial waste incineration	0.02	0.02	0.00	0.01	100.0	
3B4giii	Manure mangement - Turkeys	0.05	0.04	0.00	0.01	100.0	
5E	Other waste (please specify in IIR)	NO	0.01	0.00	0.01	100.0	
3B4giv	Manure management - Other poultry	0.02	0.02	0.00	0.01	100.0	
3B4f	Manure management - Mules and asses	0.01	0.00	0.00	0.00	100.0	
3B4e	Manure management - Horses	0.01	0.00	0.00	0.00	100.0	
3B3	Manure management - Swine	0.03	0.02	0.00	0.00	100.0	
2B6	Titanium dioxide production	NO	0.00	0.00	0.00	100.0	

NMVOC Level Assessment

NFR	Sectors	%total 2016	Cumulative total	Key category
2D3a	Domestic solvent use including fungicides	16.29	16.3	x
2D3g	Chemical products	12.15	28.4	x
2D3d	Coating applications	11.50	39.9	x
1A4bi	Residential: Stationary	8.94	48.9	x
2D3i	Other solvent use (please specify in the IIR)	6.45	55.3	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	5.97	61.3	x
2H1	Pulp and paper industry	5.33	66.6	x
1A3bi	Road transport: Passenger cars	3.94	70.6	x
1A3bv	Road transport: Gasoline evaporation	3.08	73.6	x
1B2av	Distribution of oil products	2.98	76.6	x
2D3h	Printing	2.78	79.4	x
1B2ai	Fugitive emissions oil: Exploration, production, transport	1.86	81.3	x
1A3biv	Road transport: Mopeds & motorcycles	1.82	83.1	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	1.65	84.7	
2D3e	Degreasing	1.61	86.3	
3F	Field burning of agricultural residues	1.49	87.8	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	1.46	89.3	
5A	Biological treatment of waste - Solid waste disposal on land	1.34	90.6	
1B2aiv	Fugitive emissions oil: Refining / storage	1.34	92.0	
2B10a	Chemical industry: Other (please specify in the IIR)	1.25	93.2	
2H2	Food and beverages industry	1.17	94.4	
1A1a	Public electricity and heat production	1.04	95.4	
2G	Other product use (please specify in the IIR)	0.77	96.2	
1A3bii	Road transport: Light duty vehicles	0.61	96.8	
1A3biii	Road transport: Heavy duty vehicles and buses	0.51	97.3	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.42	97.8	
2D3b	Road paving with asphalt	0.42	98.2	
1A3ai(i)	International aviation LTO (civil)	0.21	98.4	
3De	Cultivated crops	0.20	98.6	
1A4ai	Commercial/institutional: Stationary	0.19	98.8	
2D3f	Dry cleaning	0.19	99.0	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.17	99.1	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.16	99.3	
5C1bi	Industrial waste incineration	0.11	99.4	
2C1	Iron and steel production	0.11	99.5	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.09	99.6	
5D2	Industrial wastewater handling	0.08	99.7	
1A3dii	National navigation (shipping)	0.08	99.7	
1A1b	Petroleum refining	0.07	99.8	
1A3aii(i)	Domestic aviation LTO (civil)	0.05	99.9	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.04	99.9	
1A3c	Railways	0.04	99.9	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.03	100.0	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.01	100.0	
2D3c	Asphalt roofing	0.00	100.0	
5D1	Domestic wastewater handling	0.00	100.0	
3Da2a	Animal manure applied to soils	0.00	100.0	
3B4gii	Manure mangement - Broilers	0.00	100.0	
5E	Other waste (please specify in IIR)	0.00	100.0	
3B1a	Manure management - Dairy cattle	0.00	100.0	
3B4gi	Manure mangement - Laying hens	0.00	100.0	
5C1biii	Clinical waste incineration	0.00	100.0	
3B3	Manure management - Swine	0.00	100.0	
3B1b	Manure management - Non-dairy cattle	0.00	100.0	
3Da3	Urine and dung deposited by grazing animals	0.00	100.0	
5C1bv	Cremation	0.00	100.0	
1B2b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)	0.00	100.0	
3B4giii	Manure mangement - Turkeys	0.00	100.0	
3B4giv	Manure management - Other poultry	0.00	100.0	
3B2	Manure management - Sheep	0.00	100.0	
3B4h	Manure management - Other animals (please specify in IIR)	0.00	100.0	
3B4d	Manure management - Goats	0.00	100.0	
3B4e	Manure management - Horses	0.00	100.0	
3B4f	Manure management - Mules and asses	0.00	100.0	

NMVOC Trend Assessment (1990-2016)

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
1A3bi	Road transport: Passenger cars	34.50	5.84	0.08	17.24	17.2	x
1A3biv	Road transport: Mopeds & motorcycles	26.91	2.71	0.07	15.24	32.5	x
2D3g	Chemical products	12.33	18.04	0.04	9.33	41.8	x
2D3a	Domestic solvent use including fungicides	23.38	24.18	0.04	7.96	49.8	x
1A2f	Stationary combustion in manufacturing industries and	3.35	8.87	0.03	6.39	56.2	x
2D3d	Coating applications	34.07	17.08	0.03	6.04	62.2	x
1A3bv	Road transport: Gasoline evaporation	15.32	4.57	0.03	5.74	67.9	x
2D3i	Other solvent use (please specify in the IIR)	5.67	9.57	0.03	5.53	73.5	x
2H1	Pulp and paper industry	4.07	7.91	0.02	4.98	78.5	x
2D3h	Printing	2.23	4.12	0.01	2.52	81.0	x
1A4bi	Residential: Stationary	22.40	13.27	0.01	1.99	83.0	
2D3e	Degreasing	0.71	2.39	0.01	1.85	84.8	
1A2d	Stationary combustion in manufacturing industries and	1.30	2.46	0.01	1.52	86.3	
1A3biii	Road transport: Heavy duty vehicles and buses	3.26	0.76	0.01	1.43	87.8	
1B2ai	Fugitive emissions oil: Exploration, production, transpor	2.09	2.77	0.01	1.30	89.1	
1A1a	Public electricity and heat production	0.36	1.54	0.01	1.26	90.3	
1B2av	Distribution of oil products	4.63	4.43	0.01	1.22	91.6	
5A	Biological treatment of waste - Solid waste disposal on	1.10	1.99	0.01	1.20	92.8	
2G	Other product use (please specify in the IIR)	0.13	1.15	0.00	1.03	93.8	
1B2aiv	Fugitive emissions oil: Refining / storage	1.43	1.99	0.00	0.98	94.8	
2B10a	Chemical industry: Other (please specify in the IIR)	1.41	1.85	0.00	0.87	95.6	
2D3f	Dry cleaning	1.59	0.28	0.00	0.79	96.4	
2H2	Food and beverages industry	1.37	1.74	0.00	0.78	97.2	
3F	Field burning of agricultural residues	2.67	2.22	0.00	0.38	97.6	
1A3bii	Road transport: Light duty vehicles	0.76	0.91	0.00	0.38	98.0	
3De	Cultivated crops	0.87	0.29	0.00	0.29	98.2	
1A2e	Stationary combustion in manufacturing industries and	0.80	0.25	0.00	0.29	98.5	
1A3ai(i)	International aviation LTO (civil)	0.78	0.31	0.00	0.22	98.8	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.62	0.24	0.00	0.18	98.9	
1A2c	Stationary combustion in manufacturing industries and	0.32	0.06	0.00	0.16	99.1	
1A3c	Railways	0.28	0.05	0.00	0.14	99.2	
1A4ai	Commercial/institutional: Stationary	0.22	0.28	0.00	0.13	99.4	
2D3b	Road paving with asphalt	0.77	0.62	0.00	0.10	99.5	
2C1	Iron and steel production	0.10	0.16	0.00	0.09	99.5	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.06	0.13	0.00	0.09	99.6	
1A2gviii	Stationary combustion in manufacturing industries and	1.04	0.63	0.00	0.08	99.7	
5D2	Industrial wastewater handling	0.08	0.12	0.00	0.06	99.8	
1A1b	Petroleum refining	0.06	0.11	0.00	0.06	99.8	
5C1bi	Industrial waste incineration	0.17	0.16	0.00	0.04	99.9	
1A3aii(i)	Domestic aviation LTO (civil)	0.16	0.07	0.00	0.04	99.9	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.03	0.04	0.00	0.03	99.9	
1A3dii	National navigation (shipping)	0.14	0.12	0.00	0.02	100.0	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	3.16	2.17	0.00	0.01	100.0	
1A5b	Other, Mobile (including military, land based and recrea	0.03	0.01	0.00	0.01	100.0	
5C1biii	Clinical waste incineration	0.01	0.00	0.00	0.00	100.0	
5D1	Domestic wastewater handling	0.01	0.01	0.00	0.00	100.0	
5E	Other waste (please specify in IIR)	NO	0.00	0.00	0.00	100.0	
3B4gii	Manure mangement - Broilers	0.00	0.00	0.00	0.00	100.0	
2D3c	Asphalt roofing	0.01	0.01	0.00	0.00	100.0	
3Da3	Urine and dung deposited by grazing animals	0.00	0.00	0.00	0.00	100.0	
3B1a	Manure management - Dairy cattle	0.00	0.00	0.00	0.00	100.0	
3B1b	Manure management - Non-dairy cattle	0.00	0.00	0.00	0.00	100.0	
5C1bv	Cremation	0.00	0.00	0.00	0.00	100.0	
3B4gi	Manure mangement - Laying hens	0.00	0.00	0.00	0.00	100.0	
3B2	Manure management - Sheep	0.00	0.00	0.00	0.00	100.0	
3Da2a	Animal manure applied to soils	0.00	0.00	0.00	0.00	100.0	
3B4giv	Manure management - Other poultry	0.00	0.00	0.00	0.00	100.0	
3B4f	Manure management - Mules and asses	0.00	0.00	0.00	0.00	100.0	
3B4h	Manure management - Other animals (please specify ir	0.00	0.00	0.00	0.00	100.0	
3B4d	Manure management - Goats	0.00	0.00	0.00	0.00	100.0	
3B4e	Manure management - Horses	0.00	0.00	0.00	0.00	100.0	
3B3	Manure management - Swine	0.00	0.00	0.00	0.00	100.0	
3B4giii	Manure mangement - Turkeys	0.00	0.00	0.00	0.00	100.0	

SOx **Level Assessment**

NFR	Sectors	%total 2016	Cumulative total	Key category
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	28.88	28.9	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	14.68	43.6	x
1B2aiv	Fugitive emissions oil: Refining / storage	14.48	58.0	x
2H1	Pulp and paper industry	13.18	71.2	x
1A1a	Public electricity and heat production	6.47	77.7	x
1A4bi	Residential: Stationary	4.51	82.2	x
1A3dii	National navigation (shipping)	3.63	85.8	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	2.55	88.4	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	2.44	90.8	
2B10a	Chemical industry: Other (please specify in the IIR)	2.08	92.9	
1A4ai	Commercial/institutional: Stationary	2.06	94.9	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	1.19	96.1	
2C1	Iron and steel production	0.82	97.0	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.79	97.7	
1A1b	Petroleum refining	0.51	98.3	
3F	Field burning of agricultural residues	0.35	98.6	
2C5	Lead production	0.29	98.9	
1A3ai(i)	International aviation LTO (civil)	0.26	99.2	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.23	99.4	
1A3bi	Road transport: Passenger cars	0.15	99.5	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.13	99.7	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.07	99.7	
1A3biii	Road transport: Heavy duty vehicles and buses	0.07	99.8	
1A3c	Railways	0.06	99.9	
1A3bii	Road transport: Light duty vehicles	0.06	99.9	
1A3aii(i)	Domestic aviation LTO (civil)	0.05	100.0	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.01	100.0	
2G	Other product use (please specify in the IIR)	0.01	100.0	
5C1bv	Cremation	0.01	100.0	
5C1bi	Industrial waste incineration	0.00	100.0	
1A3biv	Road transport: Mopeds & motorcycles	0.00	100.0	
5C1biii	Clinical waste incineration	0.00	100.0	
5E	Other waste (please specify in IIR)	0.00	100.0	
2C7a	Copper production	0.00	100.0	
2B6	Titanium dioxide production	0.00	100.0	

SOx **Trend Assessment (1990-2016)**

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
1A1a	Public electricity and heat production	174.63	2.22	0.05	34.53	34.5	x
1A2d	Stationary combustion in manufacturing industries and	16.64	9.92	0.03	16.70	51.2	x
1B2aiv	Fugitive emissions oil: Refining / storage	0.34	4.97	0.02	10.16	61.4	x
1A2f	Stationary combustion in manufacturing industries and	6.70	5.04	0.01	8.88	70.3	x
2H1	Pulp and paper industry	4.55	4.53	0.01	8.30	78.6	x
1A2gviii	Stationary combustion in manufacturing industries and	26.35	0.87	0.01	4.10	82.7	x
1A1b	Petroleum refining	18.80	0.18	0.01	3.85	86.5	
1A4bi	Residential: Stationary	2.75	1.55	0.00	2.57	89.1	
1A2c	Stationary combustion in manufacturing industries and	13.81	0.41	0.00	2.25	91.3	
1A3dii	National navigation (shipping)	2.16	1.25	0.00	2.09	93.4	
1A3biii	Road transport: Heavy duty vehicles and buses	5.95	0.02	0.00	1.29	94.7	
1A2e	Stationary combustion in manufacturing industries and	12.99	0.84	0.00	1.18	95.9	
1A3bi	Road transport: Passenger cars	3.38	0.05	0.00	0.65	96.5	
1A3bii	Road transport: Light duty vehicles	2.53	0.02	0.00	0.53	97.1	
1A4ai	Commercial/institutional: Stationary	4.20	0.71	0.00	0.52	97.6	
2C1	Iron and steel production	0.32	0.28	0.00	0.51	98.1	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	2.25	0.02	0.00	0.45	98.5	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.76	0.27	0.00	0.39	98.9	
2B10a	Chemical industry: Other (please specify in the IIR)	7.96	0.71	0.00	0.31	99.2	
3F	Field burning of agricultural residues	0.16	0.12	0.00	0.21	99.5	
2C5	Lead production	0.06	0.10	0.00	0.19	99.6	
1A3ai(i)	International aviation LTO (civil)	0.03	0.09	0.00	0.18	99.8	
1A3biv	Road transport: Mopeds & motorcycles	0.19	0.00	0.00	0.04	99.9	
1A3c	Railways	0.34	0.02	0.00	0.03	99.9	
1A3aii(i)	Domestic aviation LTO (civil)	0.01	0.02	0.00	0.03	99.9	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.54	0.04	0.00	0.03	100.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.79	0.08	0.00	0.01	100.0	
1A5b	Other, Mobile (including military, land based and recrea	0.01	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	
5C1bv	Cremation	0.00	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	
2C7a	Copper production	0.00	0.00	0.00	0.00	100.0	
5E	Other waste (please specify in IIR)	NO	0.00	0.00	0.00	100.0	
2B6	Titanium dioxide production	NO	0.00	0.00	0.00	100.0	

NH3 Level Assessment

NFR	Sectors	%total 2016	Cumulative total	Key category
3Da2a	Animal manure applied to soils	17.36	17.4	x
3Da1	Inorganic N-fertilizers (includes also urea application)	15.68	33.0	x
3B3	Manure management - Swine	11.79	44.8	x
3Da3	Urine and dung deposited by grazing animals	8.98	53.8	x
2B10a	Chemical industry: Other (please specify in the IIR)	6.56	60.4	x
3B4gii	Manure mangement - Broilers	6.24	66.6	x
3B1a	Manure management - Dairy cattle	6.08	72.7	x
3B4gi	Manure mangement - Laying hens	5.07	77.7	x
1A4bi	Residential: Stationary	4.50	82.2	x
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	3.45	85.7	
3B1b	Manure management - Non-dairy cattle	3.25	88.9	
5A	Biological treatment of waste - Solid waste disposal on land	2.55	91.5	
1A3bi	Road transport: Passenger cars	1.86	93.4	
3F	Field burning of agricultural residues	1.36	94.7	
3B4giii	Manure mangement - Turkeys	0.96	95.7	
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	0.83	96.5	
3B2	Manure management - Sheep	0.75	97.3	
3B4h	Manure management - Other animals (please specify in IIR)	0.55	97.8	
3B4giv	Manure management - Other poultry	0.55	98.4	
1B2aiv	Fugitive emissions oil: Refining / storage	0.36	98.7	
2G	Other product use (please specify in the IIR)	0.18	98.9	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.16	99.1	
3Da2c	Other organic fertilisers applied to soils (including compost)	0.15	99.2	
5B2	Biological treatment of waste - Anaerobic digestion at biogas facilities	0.14	99.3	
3B4d	Manure management - Goats	0.13	99.5	
3Da2b	Sewage sludge applied to soils	0.09	99.6	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.09	99.7	
3B4e	Manure management - Horses	0.08	99.7	
1A4ai	Commercial/institutional: Stationary	0.08	99.8	
1A3biii	Road transport: Heavy duty vehicles and buses	0.04	99.9	
1A3bii	Road transport: Light duty vehicles	0.04	99.9	
3B4f	Manure management - Mules and asses	0.03	99.9	
1A1a	Public electricity and heat production	0.03	100.0	
2B2	Nitric acid production	0.01	100.0	
2D3g	Chemical products	0.01	100.0	
5B1	Biological treatment of waste - Composting	0.01	100.0	
1A3biv	Road transport: Mopeds & motorcycles	0.01	100.0	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.00	100.0	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.00	100.0	
1A3c	Railways	0.00	100.0	
5C1biii	Clinical waste incineration	0.00	100.0	

NH3 Trend Assessment (1990-2016)

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
3Da3	Urine and dung deposited by grazing animals	3.78	4.51	0.03	18.15	18.1	x
3B4gii	Manure mangement - Broilers	2.75	3.13	0.02	11.88	30.0	x
1A2d	Stationary combustion in manufacturing industries and	1.13	1.73	0.01	8.85	38.9	x
1A3bi	Road transport: Passenger cars	0.07	0.93	0.01	7.90	46.8	x
3Da1	Inorganic N-fertilizers (includes also urea application)	10.82	7.87	0.01	6.92	53.7	x
3B3	Manure management - Swine	7.89	5.91	0.01	6.64	60.3	x
3B4gi	Manure mangement - Laying hens	2.90	2.54	0.01	5.74	66.1	x
5A	Biological treatment of waste - Solid waste disposal on	1.01	1.28	0.01	5.53	71.6	x
3B2	Manure management - Sheep	1.30	0.37	0.01	4.27	75.9	x
3B4h	Manure management - Other animals (please specify ir	1.03	0.27	0.01	3.57	79.5	x
3B1a	Manure management - Dairy cattle	5.24	3.05	0.01	3.42	82.9	x
3B4f	Manure management - Mules and asses	0.54	0.02	0.00	3.04	85.9	
1A2f	Stationary combustion in manufacturing industries and	1.03	0.42	0.00	2.32	88.2	
2B10a	Chemical industry: Other (please specify in the IIR)	5.42	3.29	0.00	2.31	90.5	
1A4bi	Residential: Stationary	3.82	2.26	0.00	2.18	92.7	
3Da2a	Animal manure applied to soils	13.07	8.71	0.00	1.28	94.0	
3B4d	Manure management - Goats	0.26	0.07	0.00	0.93	94.9	
3F	Field burning of agricultural residues	0.89	0.68	0.00	0.91	95.8	
2G	Other product use (please specify in the IIR)	0.02	0.09	0.00	0.70	96.5	
5B2	Biological treatment of waste - Anaerobic digestion at b	NO	0.07	0.00	0.63	97.2	
3B4giv	Manure management - Other poultry	0.33	0.27	0.00	0.51	97.7	
1A2e	Stationary combustion in manufacturing industries and	0.15	0.04	0.00	0.48	98.2	
3B4e	Manure management - Horses	0.14	0.04	0.00	0.43	98.6	
3B1b	Manure management - Non-dairy cattle	2.55	1.63	0.00	0.38	99.0	
3B4giii	Manure mangement - Turkeys	0.69	0.48	0.00	0.25	99.2	
1A2c	Stationary combustion in manufacturing industries and	0.04	0.00	0.00	0.21	99.4	
3Da2b	Sewage sludge applied to soils	0.04	0.05	0.00	0.19	99.6	
1A3bii	Road transport: Light duty vehicles	0.01	0.02	0.00	0.14	99.8	
1A2gviii	Stationary combustion in manufacturing industries and	0.11	0.08	0.00	0.09	99.8	
1A3biii	Road transport: Heavy duty vehicles and buses	0.02	0.02	0.00	0.08	99.9	
5B1	Biological treatment of waste - Composting	0.01	0.00	0.00	0.03	100.0	
2D3g	Chemical products	0.01	0.00	0.00	0.03	100.0	
2B2	Nitric acid production	0.01	0.01	0.00	0.01	100.0	
1A3c	Railways	0.00	0.00	0.00	0.00	100.0	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.00	0.00	0.00	0.00	100.0	
5C1biii	Clinical waste incineration	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	

PM2.5 Level Assessment

NFR	Sectors	%total 2016	Cumulative total	Key category
1A4bi	Residential: Stationary	34.31	34.3	x
2H1	Pulp and paper industry	14.42	48.7	x
2B10a	Chemical industry: Other (please specify in the IIR)	10.75	59.5	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	9.45	68.9	x
2D3b	Road paving with asphalt	3.69	72.6	x
3F	Field burning of agricultural residues	3.34	76.0	x
2A3	Glass production	2.97	78.9	x
1A3ai(i)	International aviation LTO (civil)	2.36	81.3	x
1A3bi	Road transport: Passenger cars	2.29	83.6	
1A3bii	Road transport: Light duty vehicles	2.19	85.8	
1A3bvi	Road transport: Automobile tyre and brake wear	1.70	87.5	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	1.63	89.1	
2G	Other product use (please specify in the IIR)	1.25	90.3	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	1.24	91.6	
5E	Other waste (please specify in IIR)	0.97	92.5	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.96	93.5	
1A3biii	Road transport: Heavy duty vehicles and buses	0.91	94.4	
1A3bvii	Road transport: Automobile road abrasion	0.69	95.1	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.59	95.7	
1B2aiv	Fugitive emissions oil: Refining / storage	0.58	96.3	
2A5a	Quarrying and mining of minerals other than coal	0.48	96.8	
1A3aii(i)	Domestic aviation LTO (civil)	0.45	97.2	
1A3dii	National navigation (shipping)	0.41	97.6	
1A1a	Public electricity and heat production	0.38	98.0	
1A4ai	Commercial/institutional: Stationary	0.35	98.4	
2D3i	Other solvent use (please specify in the IIR)	0.32	98.7	
2A5b	Construction and demolition	0.23	98.9	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.18	99.1	
2D3g	Chemical products	0.16	99.2	
2A5c	Storage, handling and transport of mineral products	0.13	99.4	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.13	99.5	
1A3biv	Road transport: Mopeds & motorcycles	0.11	99.6	
2C1	Iron and steel production	0.09	99.7	
1A1b	Petroleum refining	0.09	99.8	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.08	99.9	
2A2	Lime production	0.05	99.9	
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	0.04	100.0	
1A3c	Railways	0.03	100.0	
2D3c	Asphalt roofing	0.01	100.0	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.01	100.0	
5C1bv	Cremation	0.00	100.0	
2C7d	Storage, handling and transport of metal products (please specify in the IIR)	0.00	100.0	
2C3	Aluminium production	0.00	100.0	
5C1biii	Clinical waste incineration	0.00	100.0	
5A	Biological treatment of waste - Solid waste disposal on land	0.00	100.0	
3B4giii	Manure mangement - Turkeys	0.00	100.0	
3B4gii	Manure mangement - Broilers	0.00	100.0	
3B1a	Manure management - Dairy cattle	0.00	100.0	
3B4giv	Manure mangement - Other poultry	0.00	100.0	
3B4gi	Manure mangement - Laying hens	0.00	100.0	
3B1b	Manure management - Non-dairy cattle	0.00	100.0	
3B3	Manure management - Swine	0.00	100.0	
2C5	Lead production	0.00	100.0	
2C7a	Copper production	0.00	100.0	
3B2	Manure management - Sheep	0.00	100.0	
2B6	Titanium dioxide production	0.00	100.0	
3B4d	Manure management - Goats	0.00	100.0	
3B4e	Manure management - Horses	0.00	100.0	
3B4h	Manure management - Other animals (please specify in IIR)	0.00	100.0	
3B4f	Manure management - Mules and asses	0.00	100.0	
5C1bi	Industrial waste incineration	0.00	100.0	

PM2.5 Trend Assessment (1990-2016)

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
1A4bi	Residential: Stationary	26.96	15.95	0.09	24.47	24.5	x
2H1	Pulp and paper industry	3.27	6.70	0.07	19.33	43.8	x
1A2f	Stationary combustion in manufacturing industries and	2.83	4.39	0.04	10.14	53.9	x
1A1a	Public electricity and heat production	1.56	0.18	0.02	4.89	58.8	x
2A3	Glass production	0.53	1.38	0.02	4.51	63.3	x
1A3biii	Road transport: Heavy duty vehicles and buses	1.71	0.42	0.02	4.30	67.6	x
1A3ai(i)	International aviation LTO (civil)	0.36	1.10	0.01	3.82	71.5	x
2B10a	Chemical industry: Other (please specify in the IIR)	7.31	5.00	0.01	3.48	74.9	x
2A5b	Construction and demolition	0.90	0.11	0.01	2.82	77.7	x
1A3bi	Road transport: Passenger cars	0.61	1.06	0.01	2.74	80.5	x
2G	Other product use (please specify in the IIR)	0.11	0.58	0.01	2.32	82.8	
1A3bvi	Road transport: Automobile tyre and brake wear	0.41	0.79	0.01	2.16	85.0	
2D3b	Road paving with asphalt	1.62	1.71	0.01	2.07	87.0	
1A3biv	Road transport: Mopeds & motorcycles	0.57	0.05	0.01	1.86	88.9	
1A2gviii	Stationary combustion in manufacturing industries and	1.24	0.58	0.01	1.85	90.7	
1A2e	Stationary combustion in manufacturing industries and	0.84	0.27	0.01	1.80	92.5	
1A3bii	Road transport: Light duty vehicles	1.73	1.02	0.01	1.62	94.2	
1A2c	Stationary combustion in manufacturing industries and	0.41	0.06	0.00	1.23	95.4	
1A3bvii	Road transport: Automobile road abrasion	0.18	0.32	0.00	0.84	96.2	
1A3aii(i)	Domestic aviation LTO (civil)	0.10	0.21	0.00	0.63	96.9	
1A2d	Stationary combustion in manufacturing industries and	0.83	0.76	0.00	0.49	97.3	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.65	0.45	0.00	0.30	97.6	
2D3i	Other solvent use (please specify in the IIR)	0.11	0.15	0.00	0.29	97.9	
1A1b	Petroleum refining	0.13	0.04	0.00	0.29	98.2	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.18	0.08	0.00	0.27	98.5	
5E	Other waste (please specify in IIR)	0.63	0.45	0.00	0.23	98.7	
1A3c	Railways	0.08	0.01	0.00	0.22	98.9	
2D3g	Chemical products	0.04	0.07	0.00	0.18	99.1	
3F	Field burning of agricultural residues	2.02	1.55	0.00	0.14	99.3	
2C1	Iron and steel production	0.02	0.04	0.00	0.13	99.4	
1A4ai	Commercial/institutional: Stationary	0.17	0.16	0.00	0.13	99.5	
3Dc	Farm-level agricultural operations including storage, har	0.06	0.02	0.00	0.13	99.6	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.02	0.04	0.00	0.09	99.7	
2A5c	Storage, handling and transport of mineral products	0.06	0.06	0.00	0.07	99.8	
2A2	Lime production	0.01	0.02	0.00	0.06	99.9	
1A3dii	National navigation (shipping)	0.23	0.19	0.00	0.05	99.9	
5C1biii	Clinical waste incineration	0.01	0.00	0.00	0.04	100.0	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.01	0.00	0.00	0.02	100.0	
2A5a	Quarrying and mining of minerals other than coal	0.29	0.22	0.00	0.01	100.0	
2D3c	Asphalt roofing	0.01	0.00	0.00	0.00	100.0	
5C1bv	Cremation	0.00	0.00	0.00	0.00	100.0	
2C7a	Copper production	0.00	0.00	0.00	0.00	100.0	
2C7d	Storage, handling and transport of metal products (plea	0.00	0.00	0.00	0.00	100.0	
5C1bi	Industrial waste incineration	0.00	0.00	0.00	0.00	100.0	
3B1a	Manure management - Dairy cattle	0.00	0.00	0.00	0.00	100.0	
2C3	Aluminium production	0.00	0.00	0.00	0.00	100.0	
3B4gii	Manure mangement - Broilers	0.00	0.00	0.00	0.00	100.0	
3B1b	Manure management - Non-dairy cattle	0.00	0.00	0.00	0.00	100.0	
3B4giii	Manure mangement - Turkeys	0.00	0.00	0.00	0.00	100.0	
3B2	Manure management - Sheep	0.00	0.00	0.00	0.00	100.0	
3B4f	Manure management - Mules and asses	0.00	0.00	0.00	0.00	100.0	
3B4giv	Manure mangement - Other poultry	0.00	0.00	0.00	0.00	100.0	
2C5	Lead production	0.00	0.00	0.00	0.00	100.0	
3B4gi	Manure mangement - Laying hens	0.00	0.00	0.00	0.00	100.0	
5A	Biological treatment of waste - Solid waste disposal on	0.00	0.00	0.00	0.00	100.0	
3B4d	Manure management - Goats	0.00	0.00	0.00	0.00	100.0	
2B6	Titanium dioxide production	NO	0.00	0.00	0.00	100.0	
3B4e	Manure management - Horses	0.00	0.00	0.00	0.00	100.0	
3B4h	Manure management - Other animals (please specify ir	0.00	0.00	0.00	0.00	100.0	
3B3	Manure management - Swine	0.00	0.00	0.00	0.00	100.0	

PM10 Level Assessment

NFR	Sectors	%total 2016	Cumulative total	Key category
1A4bi	Residential: Stationary	25.63	25.6	x
2D3b	Road paving with asphalt	16.98	42.6	x
2H1	Pulp and paper industry	12.74	55.3	x
2B10a	Chemical industry: Other (please specify in the IIR)	7.91	63.3	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	6.89	70.1	x
2A5a	Quarrying and mining of minerals other than coal	3.49	73.6	x
3F	Field burning of agricultural residues	2.57	76.2	x
1A3bvi	Road transport: Automobile tyre and brake wear	2.29	78.5	x
2A3	Glass production	2.26	80.7	x
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	1.86	82.6	
1A3ai(i)	International aviation LTO (civil)	1.72	84.3	
2A5b	Construction and demolition	1.67	86.0	
1A3bi	Road transport: Passenger cars	1.67	87.7	
1A3bii	Road transport: Light duty vehicles	1.59	89.3	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	1.00	90.3	
1B2aiv	Fugitive emissions oil: Refining / storage	0.97	91.2	
2A5c	Storage, handling and transport of mineral products	0.95	92.2	
1A3bvii	Road transport: Automobile road abrasion	0.93	93.1	
2G	Other product use (please specify in the IIR)	0.91	94.0	
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	0.84	94.9	
5E	Other waste (please specify in IIR)	0.70	95.6	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.70	96.3	
1A3biii	Road transport: Heavy duty vehicles and buses	0.67	96.9	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.51	97.4	
1A1a	Public electricity and heat production	0.35	97.8	
2D3i	Other solvent use (please specify in the IIR)	0.35	98.1	
1A3aii(i)	Domestic aviation LTO (civil)	0.33	98.5	
1A3dii	National navigation (shipping)	0.33	98.8	
1A4ai	Commercial/institutional: Stationary	0.26	99.1	
2A2	Lime production	0.18	99.2	
2D3g	Chemical products	0.15	99.4	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.14	99.5	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.11	99.7	
1A3biv	Road transport: Mopeds & motorcycles	0.08	99.7	
2C1	Iron and steel production	0.07	99.8	
1A1b	Petroleum refining	0.07	99.9	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.06	99.9	
2D3c	Asphalt roofing	0.03	100.0	
1A3c	Railways	0.02	100.0	
2C7d	Storage, handling and transport of metal products (please specify in the IIR)	0.01	100.0	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.00	100.0	
5A	Biological treatment of waste - Solid waste disposal on land	0.00	100.0	
5C1bv	Cremation	0.00	100.0	
2C3	Aluminium production	0.00	100.0	
3B4giii	Manure mangement - Turkeys	0.00	100.0	
3B4gii	Manure mangement - Broilers	0.00	100.0	
3B4gi	Manure mangement - Laying hens	0.00	100.0	
3B3	Manure management - Swine	0.00	100.0	
3B4giv	Manure management - Other poultry	0.00	100.0	
5C1biii	Clinical waste incineration	0.00	100.0	
3B1a	Manure management - Dairy cattle	0.00	100.0	
3B1b	Manure management - Non-dairy cattle	0.00	100.0	
2C5	Lead production	0.00	100.0	
3B2	Manure management - Sheep	0.00	100.0	
2C7a	Copper production	0.00	100.0	
3B4h	Manure management - Other animals (please specify in IIR)	0.00	100.0	
3B4d	Manure management - Goats	0.00	100.0	
2B6	Titanium dioxide production	0.00	100.0	
3B4e	Manure management - Horses	0.00	100.0	
3B4f	Manure management - Mules and asses	0.00	100.0	
5C1bi	Industrial waste incineration	0.00	100.0	

PM10 Trend Assessment (1990-2016)

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
2A5b	Construction and demolition	9.02	1.07	0.07	17.72	17.7	x
2H1	Pulp and paper industry	3.97	8.13	0.06	16.21	33.9	x
1A4bi	Residential: Stationary	27.63	16.35	0.05	13.26	47.2	x
2D3b	Road paving with asphalt	10.23	10.83	0.04	10.08	57.3	x
1A2f	Stationary combustion in manufacturing industries and	2.84	4.39	0.03	7.15	64.4	x
1A1a	Public electricity and heat production	2.98	0.22	0.02	6.26	70.7	x
2A3	Glass production	0.55	1.44	0.01	3.23	73.9	x
1A3bvi	Road transport: Automobile tyre and brake wear	0.77	1.46	0.01	2.76	76.7	x
1A3biii	Road transport: Heavy duty vehicles and buses	1.71	0.42	0.01	2.66	79.3	x
1A3ai(i)	International aviation LTO (civil)	0.36	1.10	0.01	2.60	81.9	x
3Dc	Farm-level agricultural operations including storage, har	1.58	0.53	0.01	2.02	84.0	
1A3bi	Road transport: Passenger cars	0.61	1.06	0.01	1.91	85.9	
1A2gviii	Stationary combustion in manufacturing industries and	1.55	0.64	0.01	1.62	87.5	
2G	Other product use (please specify in the IIR)	0.11	0.58	0.01	1.57	89.1	
1A2e	Stationary combustion in manufacturing industries and	1.06	0.32	0.01	1.47	90.5	
2B10a	Chemical industry: Other (please specify in the IIR)	7.37	5.05	0.01	1.38	91.9	
1A3biv	Road transport: Mopeds & motorcycles	0.57	0.05	0.00	1.17	93.1	
1A3bvii	Road transport: Automobile road abrasion	0.33	0.59	0.00	1.08	94.2	
1A2c	Stationary combustion in manufacturing industries and	0.55	0.07	0.00	1.07	95.2	
1A3bii	Road transport: Light duty vehicles	1.73	1.02	0.00	0.86	96.1	
2A5c	Storage, handling and transport of mineral products	0.59	0.61	0.00	0.52	96.6	
1A2d	Stationary combustion in manufacturing industries and	1.39	1.19	0.00	0.48	97.1	
1A3aii(i)	Domestic aviation LTO (civil)	0.10	0.21	0.00	0.43	97.5	
1A1b	Petroleum refining	0.21	0.04	0.00	0.35	97.9	
2A5a	Quarrying and mining of minerals other than coal	2.85	2.23	0.00	0.32	98.2	
2D3i	Other solvent use (please specify in the IIR)	0.17	0.22	0.00	0.31	98.5	
2A2	Lime production	0.06	0.11	0.00	0.21	98.7	
2D3g	Chemical products	0.05	0.10	0.00	0.18	98.9	
3F	Field burning of agricultural residues	2.13	1.64	0.00	0.17	99.1	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.19	0.09	0.00	0.16	99.2	
1A3c	Railways	0.08	0.02	0.00	0.14	99.4	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.65	0.45	0.00	0.12	99.5	
1A4ai	Commercial/institutional: Stationary	0.17	0.17	0.00	0.12	99.6	
2C1	Iron and steel production	0.02	0.05	0.00	0.10	99.7	
5E	Other waste (please specify in IIR)	0.63	0.45	0.00	0.07	99.8	
1A3dii	National navigation (shipping)	0.25	0.21	0.00	0.07	99.9	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.02	0.04	0.00	0.06	99.9	
5C1biii	Clinical waste incineration	0.02	0.00	0.00	0.04	100.0	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.01	0.00	0.00	0.02	100.0	
2D3c	Asphalt roofing	0.03	0.02	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	
5C1bv	Cremation	0.00	0.00	0.00	0.00	100.0	
2C7a	Copper production	0.00	0.00	0.00	0.00	100.0	
3B4gii	Manure mangement - Broilers	0.00	0.00	0.00	0.00	100.0	
5C1bi	Industrial waste incineration	0.00	0.00	0.00	0.00	100.0	
2C3	Aluminium production	0.00	0.00	0.00	0.00	100.0	
3B4gi	Manure mangement - Laying hens	0.00	0.00	0.00	0.00	100.0	
3B1a	Manure management - Dairy cattle	0.00	0.00	0.00	0.00	100.0	
3B4giv	Manure management - Other poultry	0.00	0.00	0.00	0.00	100.0	
3B4giii	Manure mangement - Turkeys	0.00	0.00	0.00	0.00	100.0	
3B2	Manure management - Sheep	0.00	0.00	0.00	0.00	100.0	
5A	Biological treatment of waste - Solid waste disposal on	0.00	0.00	0.00	0.00	100.0	
3B1b	Manure management - Non-dairy cattle	0.00	0.00	0.00	0.00	100.0	
3B4f	Manure management - Mules and asses	0.00	0.00	0.00	0.00	100.0	
2C5	Lead production	0.00	0.00	0.00	0.00	100.0	
3B4d	Manure management - Goats	0.00	0.00	0.00	0.00	100.0	
3B3	Manure management - Swine	0.00	0.00	0.00	0.00	100.0	
3B4h	Manure management - Other animals (please specify ir	0.00	0.00	0.00	0.00	100.0	
3B4e	Manure management - Horses	0.00	0.00	0.00	0.00	100.0	
2B6	Titanium dioxide production	NO	0.00	0.00	0.00	100.0	

TSP **Level Assessment**

NFR	Sectors	%total 2016	Cumulative total	Key category
2D3b	Road paving with asphalt	41.48	41.5	x
1A4bi	Residential: Stationary	11.72	53.2	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	10.60	63.8	x
2B10a	Chemical industry: Other (please specify in the IIR)	7.78	71.6	x
2H1	Pulp and paper industry	6.27	77.9	x
2A5a	Quarrying and mining of minerals other than coal	3.11	81.0	x
2I	Wood processing	2.95	83.9	
2A5b	Construction and demolition	2.41	86.3	
1A3bvi	Road transport: Automobile tyre and brake wear	1.32	87.6	
2D3g	Chemical products	1.19	88.8	
3F	Field burning of agricultural residues	1.13	90.0	
2A3	Glass production	1.04	91.0	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	0.90	91.9	
2A5c	Storage, handling and transport of mineral products	0.83	92.7	
1A3bvii	Road transport: Automobile road abrasion	0.81	93.5	
1A3ai(i)	International aviation LTO (civil)	0.75	94.3	
1A3bi	Road transport: Passenger cars	0.73	95.0	
1A3bii	Road transport: Light duty vehicles	0.69	95.7	
1B2aiv	Fugitive emissions oil: Refining / storage	0.54	96.3	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.48	96.7	
2G	Other product use (please specify in the IIR)	0.40	97.1	
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	0.37	97.5	
5E	Other waste (please specify in IIR)	0.31	97.8	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.31	98.1	
1A3biii	Road transport: Heavy duty vehicles and buses	0.29	98.4	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.24	98.6	
1A1a	Public electricity and heat production	0.20	98.8	
2A2	Lime production	0.19	99.0	
2D3i	Other solvent use (please specify in the IIR)	0.19	99.2	
1A3aii(i)	Domestic aviation LTO (civil)	0.14	99.4	
1A3dii	National navigation (shipping)	0.14	99.5	
1A4ai	Commercial/institutional: Stationary	0.12	99.6	
2C1	Iron and steel production	0.09	99.7	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.06	99.8	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.06	99.8	
2D3c	Asphalt roofing	0.06	99.9	
1A3biv	Road transport: Mopeds & motorcycles	0.03	99.9	
1A1b	Petroleum refining	0.03	100.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	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	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.00	100.0	
3B4gi	Manure mangement - Laying hens	0.00	100.0	
3B3	Manure management - Swine	0.00	100.0	
5A	Biological treatment of waste - Solid waste disposal on land	0.00	100.0	
3B4gii	Manure mangement - Broilers	0.00	100.0	
5C1bv	Cremation	0.00	100.0	
2C3	Aluminium production	0.00	100.0	
3B4giii	Manure mangement - Turkeys	0.00	100.0	
5C1biii	Clinical waste incineration	0.00	100.0	
5C1bi	Industrial waste incineration	0.00	100.0	
3B4giv	Manure management - Other poultry	0.00	100.0	
3B1a	Manure management - Dairy cattle	0.00	100.0	
3B1b	Manure management - Non-dairy cattle	0.00	100.0	
3B2	Manure management - Sheep	0.00	100.0	
2C5	Lead production	0.00	100.0	
2C7a	Copper production	0.00	100.0	
3B4d	Manure management - Goats	0.00	100.0	
3B4h	Manure management - Other animals (please specify in IIR)	0.00	100.0	
2B6	Titanium dioxide production	0.00	100.0	
3B4e	Manure management - Horses	0.00	100.0	
3B4f	Manure management - Mules and asses	0.00	100.0	

TSP **Trend Assessment (1990-2016)**

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
2A5b	Construction and demolition	30.13	3.53	0.12	28.87	28.9	x
2D3b	Road paving with asphalt	57.30	60.71	0.08	18.20	47.1	x
1A2f	Stationary combustion in manufacturing industries and	9.21	15.52	0.04	10.73	57.8	x
1A4bi	Residential: Stationary	28.99	17.15	0.04	9.16	67.0	x
2H1	Pulp and paper industry	4.48	9.18	0.03	7.43	74.4	x
1A1a	Public electricity and heat production	4.53	0.29	0.02	4.66	79.0	x
2I	Wood processing	1.91	4.32	0.02	3.72	82.8	x
2B10a	Chemical industry: Other (please specify in the IIR)	12.37	11.39	0.01	1.61	84.4	
1A3bvi	Road transport: Automobile tyre and brake wear	1.02	1.93	0.01	1.48	85.9	
2A3	Glass production	0.58	1.52	0.01	1.40	87.3	
1A3biii	Road transport: Heavy duty vehicles and buses	1.71	0.42	0.01	1.33	88.6	
2D3g	Chemical products	1.13	1.74	0.00	1.09	89.7	
1A3ai(i)	International aviation LTO (civil)	0.36	1.10	0.00	1.09	90.8	
3Dc	Farm-level agricultural operations including storage, har	1.58	0.53	0.00	1.05	91.8	
1A2gviii	Stationary combustion in manufacturing industries and	1.75	0.70	0.00	1.01	92.8	
1A3bvii	Road transport: Automobile road abrasion	0.67	1.18	0.00	0.86	93.7	
1A2e	Stationary combustion in manufacturing industries and	1.20	0.36	0.00	0.85	94.5	
1A3bi	Road transport: Passenger cars	0.61	1.06	0.00	0.76	95.3	
2G	Other product use (please specify in the IIR)	0.11	0.58	0.00	0.66	96.0	
1A2c	Stationary combustion in manufacturing industries and	0.67	0.09	0.00	0.63	96.6	
1A3biv	Road transport: Mopeds & motorcycles	0.57	0.05	0.00	0.57	97.2	
1A3bii	Road transport: Light duty vehicles	1.73	1.02	0.00	0.56	97.7	
2A5a	Quarrying and mining of minerals other than coal	5.82	4.55	0.00	0.35	98.1	
2A5c	Storage, handling and transport of mineral products	1.18	1.21	0.00	0.32	98.4	
1A1b	Petroleum refining	0.27	0.04	0.00	0.24	98.6	
2A2	Lime production	0.16	0.28	0.00	0.21	98.9	
1A3aii(i)	Domestic aviation LTO (civil)	0.10	0.21	0.00	0.18	99.0	
3F	Field burning of agricultural residues	2.15	1.66	0.00	0.16	99.2	
2D3i	Other solvent use (please specify in the IIR)	0.20	0.27	0.00	0.14	99.3	
2C1	Iron and steel production	0.05	0.14	0.00	0.13	99.5	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.65	0.45	0.00	0.12	99.6	
5E	Other waste (please specify in IIR)	0.63	0.45	0.00	0.10	99.7	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.19	0.09	0.00	0.09	99.8	
1A3c	Railways	0.09	0.02	0.00	0.07	99.8	
1A4ai	Commercial/institutional: Stationary	0.17	0.17	0.00	0.04	99.9	
2D3c	Asphalt roofing	0.13	0.09	0.00	0.03	99.9	
5C1biii	Clinical waste incineration	0.03	0.00	0.00	0.03	99.9	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.02	0.04	0.00	0.02	100.0	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	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	
1A2d	Stationary combustion in manufacturing industries and	1.60	1.32	0.00	0.00	100.0	
1A3dii	National navigation (shipping)	0.25	0.21	0.00	0.00	100.0	
5C1bv	Cremation	0.00	0.00	0.00	0.00	100.0	
2C7a	Copper production	0.00	0.00	0.00	0.00	100.0	
3B4gii	Manure mangement - Broilers	0.00	0.00	0.00	0.00	100.0	
3B1a	Manure management - Dairy cattle	0.00	0.00	0.00	0.00	100.0	
3B3	Manure management - Swine	0.00	0.00	0.00	0.00	100.0	
5A	Biological treatment of waste - Solid waste disposal on	0.00	0.00	0.00	0.00	100.0	
3B4gi	Manure mangement - Laying hens	0.00	0.00	0.00	0.00	100.0	
3B4giii	Manure mangement - Turkeys	0.00	0.00	0.00	0.00	100.0	
3B2	Manure management - Sheep	0.00	0.00	0.00	0.00	100.0	
3B1b	Manure management - Non-dairy cattle	0.00	0.00	0.00	0.00	100.0	
5C1bi	Industrial waste incineration	0.00	0.00	0.00	0.00	100.0	
3B4giv	Manure management - Other poultry	0.00	0.00	0.00	0.00	100.0	
3B4f	Manure management - Mules and asses	0.00	0.00	0.00	0.00	100.0	
3B4d	Manure management - Goats	0.00	0.00	0.00	0.00	100.0	
3B4h	Manure management - Other animals (please specify ir	0.00	0.00	0.00	0.00	100.0	
2C3	Aluminium production	0.00	0.00	0.00	0.00	100.0	
2C5	Lead production	0.00	0.00	0.00	0.00	100.0	
3B4e	Manure management - Horses	0.00	0.00	0.00	0.00	100.0	
2B6	Titanium dioxide production	NO	0.00	0.00	0.00	100.0	

BC Level Assessment

NFR	Sectors	%total 2016	Cumulative total	Key category
1A3bi	Road transport: Passenger cars	16.62	16.6	x
1A4bi	Residential: Stationary	15.84	32.5	x
1A3bii	Road transport: Light duty vehicles	14.35	46.8	x
1A3ai(i)	International aviation LTO (civil)	10.81	57.6	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	10.21	67.8	x
1A3biii	Road transport: Heavy duty vehicles and buses	5.74	73.6	x
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	5.24	78.8	x
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	4.75	83.5	x
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	3.76	87.3	
3F	Field burning of agricultural residues	2.97	90.3	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	2.16	92.4	
1A3aii(i)	Domestic aviation LTO (civil)	2.08	94.5	
2D3g	Chemical products	1.46	96.0	
1A4ai	Commercial/institutional: Stationary	1.14	97.1	
1A3dii	National navigation (shipping)	0.58	97.7	
2B10a	Chemical industry: Other (please specify in the IIR)	0.53	98.2	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.45	98.7	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.40	99.1	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.30	99.4	
1A3c	Railways	0.19	99.6	
1A3biv	Road transport: Mopeds & motorcycles	0.16	99.7	
1A1a	Public electricity and heat production	0.10	99.8	
1A1b	Petroleum refining	0.09	99.9	
2G	Other product use (please specify in the IIR)	0.05	100.0	
1B2aiv	Fugitive emissions oil: Refining / storage	0.01	100.0	
2A2	Lime production	0.00	100.0	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.00	100.0	
2C3	Aluminium production	0.00	100.0	
5C1biii	Clinical waste incineration	0.00	100.0	
2D3c	Asphalt roofing	0.00	100.0	
2B6	Titanium dioxide production	0.00	100.0	
5E	Other waste (please specify in IIR)	0.00	100.0	
2C7a	Copper production	0.00	100.0	
5C1bi	Industrial waste incineration	0.00	100.0	

BC Trend Assessment (1990-2016)

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
1A3bi	Road transport: Passenger cars	0.32	0.81	0.09	20.18	20.2	x
1A3biii	Road transport: Heavy duty vehicles and buses	0.85	0.28	0.06	14.23	34.4	x
1A3ai(i)	International aviation LTO (civil)	0.17	0.53	0.06	14.09	48.5	x
1A2f	Stationary combustion in manufacturing industries and	0.24	0.50	0.05	11.09	59.6	x
1A4bi	Residential: Stationary	1.30	0.77	0.04	9.29	68.9	x
1A2gviii	Stationary combustion in manufacturing industries and	0.53	0.23	0.03	6.64	75.5	x
1A2e	Stationary combustion in manufacturing industries and	0.32	0.11	0.02	5.36	80.9	x
1A2c	Stationary combustion in manufacturing industries and	0.16	0.01	0.02	3.92	84.8	
1A3aii(i)	Domestic aviation LTO (civil)	0.05	0.10	0.01	2.32	87.1	
1A3biv	Road transport: Mopeds & motorcycles	0.08	0.01	0.01	2.12	89.2	
1A3bii	Road transport: Light duty vehicles	0.95	0.70	0.01	1.93	91.2	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.37	0.26	0.01	1.35	92.5	
2D3g	Chemical products	0.04	0.07	0.01	1.34	93.9	
1A2d	Stationary combustion in manufacturing industries and	0.28	0.18	0.01	1.22	95.1	
1A3c	Railways	0.05	0.01	0.00	1.08	96.2	
1A1a	Public electricity and heat production	0.04	0.00	0.00	1.06	97.2	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.05	0.02	0.00	0.77	98.0	
1A4ai	Commercial/institutional: Stationary	0.10	0.06	0.00	0.76	98.8	
2B10a	Chemical industry: Other (please specify in the IIR)	0.02	0.03	0.00	0.48	99.2	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.01	0.02	0.00	0.38	99.6	
3F	Field burning of agricultural residues	0.19	0.14	0.00	0.13	99.7	
1A1b	Petroleum refining	0.01	0.00	0.00	0.10	99.8	
2G	Other product use (please specify in the IIR)	0.00	0.00	0.00	0.08	99.9	
1A3dii	National navigation (shipping)	0.03	0.03	0.00	0.05	100.0	
5C1biii	Clinical waste incineration	0.00	0.00	0.00	0.02	100.0	
2A2	Lime production	0.00	0.00	0.00	0.00	100.0	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.00	0.00	0.00	0.00	100.0	
5C1bi	Industrial waste incineration	0.00	0.00	0.00	0.00	100.0	
2C3	Aluminium production	0.00	0.00	0.00	0.00	100.0	
2C7a	Copper production	0.00	0.00	0.00	0.00	100.0	
2D3c	Asphalt roofing	0.00	0.00	0.00	0.00	100.0	
2B6	Titanium dioxide production	NO	0.00	0.00	0.00	100.0	
5E	Other waste (please specify in IIR)	NO	0.00	0.00	0.00	100.0	

CO Level Assessment

NFR	Sectors	%total 2016	Cumulative total	Key category
1A4bi	Residential: Stationary	41.10	41.1	x
1A3bi	Road transport: Passenger cars	16.48	57.6	x
1B2aiv	Fugitive emissions oil: Refining / storage	14.00	71.6	x
3F	Field burning of agricultural residues	8.03	79.6	x
1A3biv	Road transport: Mopeds & motorcycles	3.03	82.7	x
2B10a	Chemical industry: Other (please specify in the IIR)	2.65	85.3	
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	2.19	87.5	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	1.92	89.4	
1A3biii	Road transport: Heavy duty vehicles and buses	1.83	91.2	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	1.69	92.9	
1A1a	Public electricity and heat production	1.62	94.6	
1A3bii	Road transport: Light duty vehicles	1.46	96.0	
1A3ai(i)	International aviation LTO (civil)	0.83	96.8	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.61	97.4	
2G	Other product use (please specify in the IIR)	0.38	97.8	
1A4ai	Commercial/institutional: Stationary	0.37	98.2	
2C1	Iron and steel production	0.35	98.5	
1A1b	Petroleum refining	0.33	98.9	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.28	99.2	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.21	99.4	
1A3aii(i)	Domestic aviation LTO (civil)	0.20	99.6	
1A3dii	National navigation (shipping)	0.10	99.7	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.10	99.8	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.08	99.8	
1A3c	Railways	0.07	99.9	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.04	100.0	
2A2	Lime production	0.03	100.0	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.01	100.0	
5C1bv	Cremation	0.00	100.0	
5E	Other waste (please specify in IIR)	0.00	100.0	
5C1biii	Clinical waste incineration	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	

CO Trend Assessment (1990-2016)

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
1A3bi	Road transport: Passenger cars	324.92	51.97	0.13	40.49	40.5	x
1B2aiv	Fugitive emissions oil: Refining / storage	0.14	44.16	0.06	19.78	60.3	x
1A4bi	Residential: Stationary	218.76	129.61	0.05	15.18	75.5	x
1A3biv	Road transport: Mopeds & motorcycles	56.06	9.56	0.02	6.72	82.2	x
3F	Field burning of agricultural residues	33.11	25.33	0.02	4.86	87.0	
2B10a	Chemical industry: Other (please specify in the IIR)	5.46	8.36	0.01	2.68	89.7	
1A1a	Public electricity and heat production	2.03	5.11	0.01	1.89	91.6	
1A2d	Stationary combustion in manufacturing industries and	5.67	6.06	0.00	1.60	93.2	
2C1	Iron and steel production	8.12	1.12	0.00	1.09	94.3	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	7.75	5.33	0.00	0.87	95.2	
1A3bii	Road transport: Light duty vehicles	6.33	4.60	0.00	0.82	96.0	
1A3ai(i)	International aviation LTO (civil)	2.16	2.61	0.00	0.74	96.7	
1A3biii	Road transport: Heavy duty vehicles and buses	10.27	5.77	0.00	0.57	97.3	
2G	Other product use (please specify in the IIR)	0.23	1.19	0.00	0.49	97.8	
1A1b	Petroleum refining	0.25	1.05	0.00	0.42	98.2	
1A4ai	Commercial/institutional: Stationary	0.62	1.16	0.00	0.40	98.6	
1A2f	Stationary combustion in manufacturing industries and	13.82	6.91	0.00	0.39	99.0	
1A2gviii	Stationary combustion in manufacturing industries and	2.76	1.92	0.00	0.32	99.3	
1A3aii(i)	Domestic aviation LTO (civil)	0.68	0.62	0.00	0.14	99.5	
1A3c	Railways	1.10	0.21	0.00	0.12	99.6	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	1.08	0.26	0.00	0.10	99.7	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.24	0.30	0.00	0.09	99.8	
1A3dii	National navigation (shipping)	0.38	0.32	0.00	0.07	99.8	
1A2c	Stationary combustion in manufacturing industries and	1.29	0.67	0.00	0.05	99.9	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.08	0.13	0.00	0.04	99.9	
2A2	Lime production	0.06	0.11	0.00	0.04	100.0	
1A2e	Stationary combustion in manufacturing industries and	2.19	0.89	0.00	0.03	100.0	
5C1biii	Clinical waste incineration	0.02	0.00	0.00	0.00	100.0	
5C1bv	Cremation	0.00	0.00	0.00	0.00	100.0	
5E	Other waste (please specify in IIR)	NO	0.00	0.00	0.00	100.0	
1A5b	Other, Mobile (including military, land based and recrea	0.05	0.02	0.00	0.00	100.0	
5C1bi	Industrial waste incineration	0.00	0.00	0.00	0.00	100.0	
2B6	Titanium dioxide production	NO	0.00	0.00	0.00	100.0	
2D3c	Asphalt roofing	0.00	0.00	0.00	0.00	100.0	

Pb **Level Assessment**

NFR	Sectors	% total 2016	Cumulative total	Key category
2A3	Glass production	52.07	52.1	x
1A3bi	Road transport: Passenger cars	15.73	67.8	x
2C1	Iron and steel production	9.26	77.1	x
1A1a	Public electricity and heat production	6.88	83.9	x
1A3bvi	Road transport: Automobile tyre and brake wear	4.97	88.9	
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	3.76	92.7	
1A4bi	Residential: Stationary	2.22	94.9	
2G	Other product use (please specify in the IIR)	1.50	96.4	
1B2aiv	Fugitive emissions oil: Refining / storage	0.92	97.3	
1A3biv	Road transport: Mopeds & motorcycles	0.81	98.1	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	0.70	98.8	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.18	99.0	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.15	99.1	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.13	99.3	
1A3ai(i)	International aviation LTO (civil)	0.13	99.4	
1A1b	Petroleum refining	0.11	99.5	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.10	99.6	
1A4ai	Commercial/institutional: Stationary	0.08	99.7	
5C1bi	Industrial waste incineration	0.07	99.7	
3F	Field burning of agricultural residues	0.07	99.8	
2C5	Lead production	0.06	99.9	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.03	99.9	
1A3aii(i)	Domestic aviation LTO (civil)	0.02	99.9	
1A3dii	National navigation (shipping)	0.02	100.0	
1A3c	Railways	0.02	100.0	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.01	100.0	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.01	100.0	
5C1biii	Clinical waste incineration	0.01	100.0	
5E	Other waste (please specify in IIR)	0.00	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.00	100.0	
1A3bii	Road transport: Light duty vehicles	0.00	100.0	
2C7a	Copper production	0.00	100.0	
5C1bv	Cremation	0.00	100.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.00	100.0	

Pb **Trend Assessment (1990-2016)**

NFR	Sectors	1990	Last year	Trend assess.	% cont. to trend	Cumulative total	Key category
1A3bi	Road transport: Passenger cars	502.75	6.18	0.05	46.33	46.3	x
2A3	Glass production	7.35	20.46	0.03	32.50	78.8	x
2C1	Iron and steel production	9.28	3.64	0.01	4.89	83.7	x
1A1a	Public electricity and heat production	3.50	2.70	0.00	4.01	87.7	
1A3biv	Road transport: Mopeds & motorcycles	38.95	0.32	0.00	3.85	91.6	
1A3bvi	Road transport: Automobile tyre and brake wear	1.07	1.95	0.00	3.06	94.6	
1A2f	Stationary combustion in manufacturing industries and	2.19	1.48	0.00	2.16	96.8	
1A4bi	Residential: Stationary	1.47	0.87	0.00	1.25	98.0	
2G	Other product use (please specify in the IIR)	0.08	0.59	0.00	0.95	99.0	
1A2d	Stationary combustion in manufacturing industries and	0.36	0.28	0.00	0.41	99.4	
1A3ai(i)	International aviation LTO (civil)	0.02	0.05	0.00	0.08	99.5	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.07	0.05	0.00	0.08	99.6	
1A1b	Petroleum refining	0.09	0.04	0.00	0.06	99.6	
1A4ai	Commercial/institutional: Stationary	0.00	0.03	0.00	0.05	99.7	
5C1biii	Clinical waste incineration	0.44	0.00	0.00	0.05	99.7	
1A2e	Stationary combustion in manufacturing industries and	0.45	0.06	0.00	0.04	99.8	
5C1bi	Industrial waste incineration	0.03	0.03	0.00	0.04	99.8	
3F	Field burning of agricultural residues	0.04	0.03	0.00	0.04	99.8	
2C5	Lead production	0.01	0.02	0.00	0.03	99.9	
1A2gviii	Stationary combustion in manufacturing industries and	1.27	0.07	0.00	0.03	99.9	
1A2c	Stationary combustion in manufacturing industries and	0.31	0.04	0.00	0.03	99.9	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.03	0.01	0.00	0.02	99.9	
1A3aii(i)	Domestic aviation LTO (civil)	0.00	0.01	0.00	0.02	100.0	
1A3dii	National navigation (shipping)	0.01	0.01	0.00	0.01	100.0	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.01	0.00	0.00	0.01	100.0	
1A3c	Railways	0.03	0.01	0.00	0.01	100.0	
2C7a	Copper production	0.06	0.00	0.00	0.01	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.05	0.00	0.00	0.00	100.0	
1A5b	Other, Mobile (including military, land based and recrea	0.01	0.00	0.00	0.00	100.0	
5E	Other waste (please specify in IIR)	0.00	0.00	0.00	0.00	100.0	
1A3bii	Road transport: Light duty vehicles	0.00	0.00	0.00	0.00	100.0	
5C1bv	Cremation	0.00	0.00	0.00	0.00	100.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.00	0.00	0.00	0.00	100.0	

Cd Level Assessment

NFR	Sectors	%total 2016	Cumulative total	Key category
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	49.40	49.4	x
1A4bi	Residential: Stationary	12.26	61.7	x
2C1	Iron and steel production	8.17	69.8	x
2A3	Glass production	7.51	77.3	x
3F	Field burning of agricultural residues	5.16	82.5	x
2G	Other product use (please specify in the IIR)	3.44	85.9	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	3.41	89.3	
1A1a	Public electricity and heat production	2.37	91.7	
1B2aiv	Fugitive emissions oil: Refining / storage	2.08	93.8	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.97	94.8	
1A3bi	Road transport: Passenger cars	0.89	95.7	
1A3ai(i)	International aviation LTO (civil)	0.84	96.5	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.61	97.1	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.58	97.7	
1A1b	Petroleum refining	0.49	98.2	
1A4ai	Commercial/institutional: Stationary	0.42	98.6	
1A3bii	Road transport: Light duty vehicles	0.28	98.9	
1A3bvi	Road transport: Automobile tyre and brake wear	0.27	99.1	
1A3aii(i)	Domestic aviation LTO (civil)	0.16	99.3	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.15	99.5	
1A3biii	Road transport: Heavy duty vehicles and buses	0.11	99.6	
1A3biv	Road transport: Mopeds & motorcycles	0.10	99.7	
5E	Other waste (please specify in IIR)	0.08	99.7	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.08	99.8	
5C1bi	Industrial waste incineration	0.06	99.9	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.04	99.9	
2C5	Lead production	0.03	100.0	
1A3dii	National navigation (shipping)	0.02	100.0	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.02	100.0	
5C1biii	Clinical waste incineration	0.00	100.0	
1A3c	Railways	0.00	100.0	
5C1bv	Cremation	0.00	100.0	
2C7a	Copper production	0.00	100.0	
2D3g	Chemical products	0.00	100.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.00	100.0	

Cd Trend Assessment (1990-2016)

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
1A1a	Public electricity and heat production	1.35	0.08	0.10	36.62	36.6	x
2C1	Iron and steel production	0.03	0.28	0.04	14.77	51.4	x
2A3	Glass production	0.09	0.26	0.03	11.60	63.0	x
1A2gviii	Stationary combustion in manufacturing industries and	0.29	0.02	0.02	7.81	70.8	x
2G	Other product use (please specify in the IIR)	0.02	0.12	0.02	5.92	76.7	x
1A2f	Stationary combustion in manufacturing industries and	2.92	1.69	0.02	5.66	82.4	x
1A2e	Stationary combustion in manufacturing industries and	0.16	0.03	0.01	2.98	85.4	
1A2c	Stationary combustion in manufacturing industries and	0.13	0.02	0.01	2.97	88.3	
3F	Field burning of agricultural residues	0.24	0.18	0.01	2.68	91.0	
1A4bi	Residential: Stationary	0.71	0.42	0.01	1.89	92.9	
1A3ai(i)	International aviation LTO (civil)	0.01	0.03	0.00	1.32	94.2	
1A3bi	Road transport: Passenger cars	0.01	0.03	0.00	1.28	95.5	
5C1biii	Clinical waste incineration	0.03	0.00	0.00	1.00	96.5	
1A4ai	Commercial/institutional: Stationary	0.00	0.01	0.00	0.81	97.3	
1A2d	Stationary combustion in manufacturing industries and	0.19	0.12	0.00	0.65	97.9	
1A3bii	Road transport: Light duty vehicles	0.00	0.01	0.00	0.42	98.4	
1A3bvi	Road transport: Automobile tyre and brake wear	0.00	0.01	0.00	0.36	98.7	
1A3biv	Road transport: Mopeds & motorcycles	0.02	0.00	0.00	0.26	99.0	
1A3aii(i)	Domestic aviation LTO (civil)	0.00	0.01	0.00	0.23	99.2	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.00	0.01	0.00	0.18	99.4	
2C7a	Copper production	0.01	0.00	0.00	0.16	99.6	
1A1b	Petroleum refining	0.03	0.02	0.00	0.14	99.7	
1A3biii	Road transport: Heavy duty vehicles and buses	0.00	0.00	0.00	0.10	99.8	
5C1bi	Industrial waste incineration	0.00	0.00	0.00	0.05	99.8	
2C5	Lead production	0.00	0.00	0.00	0.04	99.9	
5E	Other waste (please specify in IIR)	0.00	0.00	0.00	0.03	99.9	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.00	0.00	0.00	0.03	99.9	
1A5b	Other, Mobile (including military, land based and recrea	0.00	0.00	0.00	0.02	100.0	
1A3dii	National navigation (shipping)	0.00	0.00	0.00	0.01	100.0	
1A3c	Railways	0.00	0.00	0.00	0.01	100.0	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.00	0.00	0.00	0.01	100.0	
5C1bv	Cremation	0.00	0.00	0.00	0.00	100.0	
2D3g	Chemical products	0.00	0.00	0.00	0.00	100.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.00	0.00	0.00	0.00	100.0	

Hg **Level Assessment**

NFR	Sectors	%total 2016	Cumulative total	Key category
1A1a	Public electricity and heat production	39.69	39.7	x
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	25.03	64.7	x
2K	Consumption of POPs and heavy metals (e.g. electrical and scientific equipment)	5.52	70.2	x
2A3	Glass production	4.81	75.0	x
1B2aiv	Fugitive emissions oil: Refining / storage	4.44	79.5	x
2C1	Iron and steel production	3.70	83.2	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	3.10	86.3	
2D3a	Domestic solvent use including fungicides	3.09	89.4	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	1.68	91.1	
3F	Field burning of agricultural residues	1.63	92.7	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	1.60	94.3	
5C1bv	Cremation	1.45	95.7	
1A4bi	Residential: Stationary	1.18	96.9	
1A3bi	Road transport: Passenger cars	0.99	97.9	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.45	98.4	
1A3biii	Road transport: Heavy duty vehicles and buses	0.36	98.7	
1A3bii	Road transport: Light duty vehicles	0.31	99.0	
1A1b	Petroleum refining	0.23	99.3	
5E	Other waste (please specify in IIR)	0.15	99.4	
1A4ai	Commercial/institutional: Stationary	0.15	99.5	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.13	99.7	
5C1biii	Clinical waste incineration	0.11	99.8	
5C1bi	Industrial waste incineration	0.07	99.9	
1A3dii	National navigation (shipping)	0.05	99.9	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.05	100.0	
1A3biv	Road transport: Mopeds & motorcycles	0.02	100.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.02	100.0	
2G	Other product use (please specify in the IIR)	0.00	100.0	
1A3bvi	Road transport: Automobile tyre and brake wear	0.00	100.0	

Hg **Trend Assessment (1990-2016)**

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
5C1biii	Clinical waste incineration	0.65	0.00	0.10	29.90	29.9	x
1A2d	Stationary combustion in manufacturing industries and	0.33	0.45	0.08	23.70	53.6	x
1A2gviii	Stationary combustion in manufacturing industries and	0.24	0.03	0.03	8.67	62.3	x
2A3	Glass production	0.03	0.09	0.02	6.11	68.4	x
2C1	Iron and steel production	0.02	0.07	0.02	4.79	73.2	x
1A2f	Stationary combustion in manufacturing industries and	0.21	0.06	0.02	4.77	77.9	x
2K	Consumption of POPs and heavy metals (e.g. electrica	0.09	0.10	0.01	4.24	82.2	x
1A2e	Stationary combustion in manufacturing industries and	0.15	0.03	0.01	4.10	86.3	
1A2c	Stationary combustion in manufacturing industries and	0.10	0.01	0.01	4.05	90.3	
2D3a	Domestic solvent use including fungicides	0.05	0.06	0.01	2.38	92.7	
5C1bv	Cremation	0.00	0.03	0.01	2.27	95.0	
1A1a	Public electricity and heat production	1.38	0.71	0.01	1.68	96.6	
1A3bi	Road transport: Passenger cars	0.01	0.02	0.00	1.02	97.7	
3F	Field burning of agricultural residues	0.04	0.03	0.00	0.75	98.4	
1A3bii	Road transport: Light duty vehicles	0.00	0.01	0.00	0.38	98.8	
1A3biii	Road transport: Heavy duty vehicles and buses	0.01	0.01	0.00	0.31	99.1	
1A4bi	Residential: Stationary	0.03	0.02	0.00	0.30	99.4	
1A4ai	Commercial/institutional: Stationary	0.00	0.00	0.00	0.17	99.6	
1A1b	Petroleum refining	0.01	0.00	0.00	0.11	99.7	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.01	0.00	0.00	0.09	99.8	
5E	Other waste (please specify in IIR)	0.00	0.00	0.00	0.06	99.8	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.00	0.00	0.00	0.05	99.9	
5C1bi	Industrial waste incineration	0.00	0.00	0.00	0.05	99.9	
1A3dii	National navigation (shipping)	0.00	0.00	0.00	0.03	100.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.00	0.00	0.00	0.02	100.0	
2G	Other product use (please specify in the IIR)	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	
1A3bvi	Road transport: Automobile tyre and brake wear	0.00	0.00	0.00	0.00	100.0	

As Level Assessment

NFR	Sectors	%total 2016	Cumulative total	Key category
1A1a	Public electricity and heat production	54.51	54.5	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	16.00	70.5	x
2A3	Glass production	13.62	84.1	x
2C1	Iron and steel production	4.50	88.6	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	1.83	90.5	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	1.51	92.0	
1A3dii	National navigation (shipping)	1.43	93.4	
1B2aiv	Fugitive emissions oil: Refining / storage	1.05	94.5	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	1.00	95.5	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.86	96.3	
1A1b	Petroleum refining	0.76	97.1	
3F	Field burning of agricultural residues	0.66	97.7	
1A4bi	Residential: Stationary	0.62	98.3	
2C5	Lead production	0.39	98.7	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	0.30	99.0	
5E	Other waste (please specify in IIR)	0.28	99.3	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.27	99.6	
1A4ai	Commercial/institutional: Stationary	0.15	99.7	
2G	Other product use (please specify in the IIR)	0.07	99.8	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.06	99.9	
1A3c	Railways	0.03	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	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.01	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.01	100.0	
1A3bii	Road transport: Light duty vehicles	0.01	100.0	
2D3g	Chemical products	0.01	100.0	
2C7a	Copper production	0.00	100.0	
1A3biv	Road transport: Mopeds & motorcycles	0.00	100.0	
5C1biii	Clinical waste incineration	0.00	100.0	
1A3bvi	Road transport: Automobile tyre and brake wear	0.00	100.0	

As Trend Assessment (1990-2016)

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
2A3	Glass production	0.07	0.20	0.06	30.23	30.2	x
1A2gviii	Stationary combustion in manufacturing industries and	0.26	0.02	0.04	20.56	50.8	x
2C1	Iron and steel production	0.03	0.07	0.02	9.79	60.6	x
1A2c	Stationary combustion in manufacturing industries and	0.12	0.01	0.02	9.23	69.8	x
1A2e	Stationary combustion in manufacturing industries and	0.14	0.03	0.02	8.46	78.3	x
1A2f	Stationary combustion in manufacturing industries and	0.41	0.24	0.01	4.38	82.7	x
1A2d	Stationary combustion in manufacturing industries and	0.05	0.00	0.01	4.36	87.0	
1A1a	Public electricity and heat production	1.59	0.82	0.01	4.05	91.1	
1A1b	Petroleum refining	0.06	0.01	0.01	3.40	94.5	
1A3dii	National navigation (shipping)	0.03	0.02	0.00	1.42	95.9	
2C5	Lead production	0.00	0.01	0.00	0.71	96.6	
3F	Field burning of agricultural residues	0.01	0.01	0.00	0.63	97.2	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.02	0.01	0.00	0.54	97.8	
2C7a	Copper production	0.00	0.00	0.00	0.44	98.2	
1A4bi	Residential: Stationary	0.01	0.01	0.00	0.40	98.6	
1A4ai	Commercial/institutional: Stationary	0.00	0.00	0.00	0.36	99.0	
5E	Other waste (please specify in IIR)	0.01	0.00	0.00	0.19	99.2	
1A3c	Railways	0.00	0.00	0.00	0.18	99.3	
2G	Other product use (please specify in the IIR)	0.00	0.00	0.00	0.17	99.5	
5C1biii	Clinical waste incineration	0.00	0.00	0.00	0.14	99.6	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.01	0.00	0.00	0.12	99.8	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.00	0.00	0.00	0.07	99.8	
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	99.9	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.00	0.00	0.00	0.02	100.0	
1A3bii	Road transport: Light duty vehicles	0.00	0.00	0.00	0.01	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.00	0.00	0.00	0.01	100.0	
2D3g	Chemical products	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	
1A3bvi	Road transport: Automobile tyre and brake wear	0.00	0.00	0.00	0.00	100.0	

Cr Level Assessment

NFR	Sectors	%total 2016	Cumulative total	Key category
2A3	Glass production	39.71	39.7	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	25.63	65.3	x
1A4bi	Residential: Stationary	7.17	72.5	x
1A3bvi	Road transport: Automobile tyre and brake wear	6.97	79.5	x
1A1a	Public electricity and heat production	6.03	85.5	x
2C1	Iron and steel production	3.61	89.1	
1B2aiv	Fugitive emissions oil: Refining / storage	3.59	92.7	
1A3bi	Road transport: Passenger cars	1.43	94.1	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	1.29	95.4	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.75	96.2	
1A1b	Petroleum refining	0.65	96.8	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.55	97.4	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.47	97.9	
1A3bii	Road transport: Light duty vehicles	0.47	98.3	
1A4ai	Commercial/institutional: Stationary	0.25	98.6	
1A3biii	Road transport: Heavy duty vehicles and buses	0.25	98.8	
3F	Field burning of agricultural residues	0.24	99.1	
1A3dii	National navigation (shipping)	0.22	99.3	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.15	99.4	
1A3biv	Road transport: Mopeds & motorcycles	0.14	99.6	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.12	99.7	
2G	Other product use (please specify in the IIR)	0.11	99.8	
1A3ai(i)	International aviation LTO (civil)	0.05	99.9	
5E	Other waste (please specify in IIR)	0.04	99.9	
5C1bi	Industrial waste incineration	0.03	99.9	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.02	100.0	
1A3aii(i)	Domestic aviation LTO (civil)	0.01	100.0	
2D3g	Chemical products	0.01	100.0	
1A3c	Railways	0.01	100.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.00	100.0	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.00	100.0	
5C1bv	Cremation	0.00	100.0	
5C1biii	Clinical waste incineration	0.00	100.0	

Cr Trend Assessment (1990-2016)

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
2A3	Glass production	1.48	4.11	0.24	34.48	34.5	x
1A1a	Public electricity and heat production	3.67	0.62	0.21	30.41	64.9	x
1A2gviii	Stationary combustion in manufacturing industries and	0.74	0.05	0.05	7.01	71.9	x
1A3bvi	Road transport: Automobile tyre and brake wear	0.40	0.72	0.03	4.64	76.5	x
1A4bi	Residential: Stationary	1.25	0.74	0.03	3.98	80.5	x
2C1	Iron and steel production	0.11	0.37	0.02	3.41	83.9	
1A2f	Stationary combustion in manufacturing industries and	2.79	2.65	0.02	3.24	87.2	
1A2e	Stationary combustion in manufacturing industries and	0.39	0.08	0.02	3.06	90.2	
1A2c	Stationary combustion in manufacturing industries and	0.34	0.06	0.02	2.85	93.1	
1A2d	Stationary combustion in manufacturing industries and	0.40	0.13	0.02	2.55	95.6	
1A1b	Petroleum refining	0.23	0.07	0.01	1.59	97.2	
1A3bi	Road transport: Passenger cars	0.07	0.15	0.01	1.10	98.3	
1A3biv	Road transport: Mopeds & motorcycles	0.06	0.01	0.00	0.48	98.8	
1A3bii	Road transport: Light duty vehicles	0.02	0.05	0.00	0.39	99.2	
1A4ai	Commercial/institutional: Stationary	0.00	0.03	0.00	0.30	99.5	
2G	Other product use (please specify in the IIR)	0.00	0.01	0.00	0.12	99.6	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.01	0.02	0.00	0.07	99.7	
1A3biii	Road transport: Heavy duty vehicles and buses	0.02	0.03	0.00	0.07	99.7	
1A3ai(i)	International aviation LTO (civil)	0.00	0.01	0.00	0.05	99.8	
5C1biii	Clinical waste incineration	0.00	0.00	0.00	0.05	99.8	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.02	0.01	0.00	0.04	99.9	
3F	Field burning of agricultural residues	0.03	0.02	0.00	0.03	99.9	
1A3c	Railways	0.00	0.00	0.00	0.02	99.9	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.01	0.00	0.00	0.02	100.0	
5E	Other waste (please specify in IIR)	0.01	0.00	0.00	0.01	100.0	
1A3aii(i)	Domestic aviation LTO (civil)	0.00	0.00	0.00	0.01	100.0	
1A3dii	National navigation (shipping)	0.03	0.02	0.00	0.01	100.0	
2D3g	Chemical products	0.00	0.00	0.00	0.01	100.0	
1A5b	Other, Mobile (including military, land based and recrea	0.00	0.00	0.00	0.00	100.0	
5C1bv	Cremation	0.00	0.00	0.00	0.00	100.0	
5C1bi	Industrial waste incineration	0.00	0.00	0.00	0.00	100.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.00	0.00	0.00	0.00	100.0	

Cu **Level Assessment**

NFR	Sectors	%total 2016	Cumulative total	Key category
1A3bvi	Road transport: Automobile tyre and brake wear	52.38	52.4	x
1A3bi	Road transport: Passenger cars	17.12	69.5	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	5.65	75.2	x
1A3bii	Road transport: Light duty vehicles	5.33	80.5	x
1A1a	Public electricity and heat production	3.64	84.1	
2A3	Glass production	3.39	87.5	
1A3biii	Road transport: Heavy duty vehicles and buses	2.12	89.6	
1A3biv	Road transport: Mopeds & motorcycles	1.97	91.6	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	1.56	93.2	
2G	Other product use (please specify in the IIR)	1.49	94.7	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	1.45	96.1	
2C1	Iron and steel production	1.05	97.2	
1A4bi	Residential: Stationary	0.64	97.8	
1B2aiv	Fugitive emissions oil: Refining / storage	0.52	98.3	
1A3ai(i)	International aviation LTO (civil)	0.41	98.7	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.26	99.0	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.19	99.2	
1A1b	Petroleum refining	0.18	99.4	
1A3dii	National navigation (shipping)	0.16	99.5	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.14	99.7	
1A3aii(i)	Domestic aviation LTO (civil)	0.08	99.7	
3F	Field burning of agricultural residues	0.07	99.8	
1A3c	Railways	0.06	99.9	
5E	Other waste (please specify in IIR)	0.03	99.9	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.03	99.9	
1A4ai	Commercial/institutional: Stationary	0.02	100.0	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.02	100.0	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.01	100.0	
2C7a	Copper production	0.00	100.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.00	100.0	
5C1biii	Clinical waste incineration	0.00	100.0	
5C1bv	Cremation	0.00	100.0	

Cu **Trend Assessment (1990-2016)**

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
1A3bvi	Road transport: Automobile tyre and brake wear	8.68	15.80	0.19	26.59	26.6	x
1A3biv	Road transport: Mopeds & motorcycles	2.57	0.59	0.12	16.60	43.2	x
1A3bi	Road transport: Passenger cars	2.36	5.16	0.09	12.45	55.6	x
1A1a	Public electricity and heat production	2.06	1.10	0.07	9.61	65.2	x
1A2f	Stationary combustion in manufacturing industries and	2.16	1.70	0.05	6.75	72.0	x
1A3bii	Road transport: Light duty vehicles	0.64	1.61	0.03	4.63	76.6	x
2C1	Iron and steel production	0.82	0.32	0.03	4.51	81.1	x
2A3	Glass production	0.37	1.02	0.02	3.25	84.4	
1A2gviii	Stationary combustion in manufacturing industries and	0.38	0.08	0.02	2.53	86.9	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.64	0.44	0.02	2.37	89.3	
2G	Other product use (please specify in the IIR)	0.07	0.45	0.02	2.15	91.4	
1A4bi	Residential: Stationary	0.33	0.19	0.01	1.41	92.9	
1A2e	Stationary combustion in manufacturing industries and	0.21	0.06	0.01	1.34	94.2	
1A2c	Stationary combustion in manufacturing industries and	0.19	0.04	0.01	1.21	95.4	
1A1b	Petroleum refining	0.19	0.05	0.01	1.14	96.6	
1A3biii	Road transport: Heavy duty vehicles and buses	0.62	0.64	0.01	1.05	97.6	
1A3c	Railways	0.10	0.02	0.00	0.64	98.3	
2C7a	Copper production	0.06	0.00	0.00	0.50	98.8	
1A3ai(i)	International aviation LTO (civil)	0.04	0.12	0.00	0.42	99.2	
1A2d	Stationary combustion in manufacturing industries and	0.39	0.47	0.00	0.27	99.4	
1A3dii	National navigation (shipping)	0.06	0.05	0.00	0.17	99.6	
3F	Field burning of agricultural residues	0.03	0.02	0.00	0.09	99.7	
1A5b	Other, Mobile (including military, land based and recrea	0.01	0.01	0.00	0.07	99.8	
1A3aii(i)	Domestic aviation LTO (civil)	0.01	0.02	0.00	0.06	99.8	
5C1biii	Clinical waste incineration	0.01	0.00	0.00	0.06	99.9	
5E	Other waste (please specify in IIR)	0.01	0.01	0.00	0.05	99.9	
1A4ai	Commercial/institutional: Stationary	0.00	0.01	0.00	0.03	100.0	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.01	0.00	0.00	0.03	100.0	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.01	0.01	0.00	0.01	100.0	
5C1bv	Cremation	0.00	0.00	0.00	0.00	100.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.00	0.00	0.00	0.00	100.0	

Ni Level Assessment

NFR	Sectors	%total 2016	Cumulative total	Key category
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	22.03	22.0	x
2A3	Glass production	20.52	42.6	x
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	12.21	54.8	x
1A1a	Public electricity and heat production	8.74	63.5	x
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	6.50	70.0	x
2C1	Iron and steel production	6.33	76.3	x
1A3dii	National navigation (shipping)	6.32	82.6	x
1B2aiv	Fugitive emissions oil: Refining / storage	4.33	87.0	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	3.80	90.8	
1A1b	Petroleum refining	2.15	92.9	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	2.01	94.9	
1A3bi	Road transport: Passenger cars	1.35	96.3	
1A3bvi	Road transport: Automobile tyre and brake wear	0.72	97.0	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.68	97.7	
2G	Other product use (please specify in the IIR)	0.51	98.2	
1A3bii	Road transport: Light duty vehicles	0.42	98.6	
1A4bi	Residential: Stationary	0.41	99.0	
1A3ai(i)	International aviation LTO (civil)	0.20	99.2	
1A3biii	Road transport: Heavy duty vehicles and buses	0.17	99.4	
1A3biv	Road transport: Mopeds & motorcycles	0.15	99.5	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.11	99.7	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.11	99.8	
3F	Field burning of agricultural residues	0.09	99.9	
2D3g	Chemical products	0.06	99.9	
1A3aii(i)	Domestic aviation LTO (civil)	0.04	99.9	
5C1bi	Industrial waste incineration	0.02	100.0	
1A4ai	Commercial/institutional: Stationary	0.01	100.0	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.01	100.0	
1A3c	Railways	0.00	100.0	
5C1biii	Clinical waste incineration	0.00	100.0	
5C1bv	Cremation	0.00	100.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.00	100.0	
2C7a	Copper production	0.00	100.0	
5E	Other waste (please specify in IIR)	0.00	100.0	

Ni Trend Assessment (1990-2016)

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
1A1a	Public electricity and heat production	52.92	1.39	0.06	34.49	34.5	x
2A3	Glass production	1.17	3.26	0.03	16.03	50.5	x
1A2f	Stationary combustion in manufacturing industries and	6.00	3.50	0.02	13.47	64.0	x
1A1b	Petroleum refining	13.30	0.34	0.02	8.71	72.7	x
1A2gviii	Stationary combustion in manufacturing industries and	11.26	0.32	0.01	7.22	79.9	x
2C1	Iron and steel production	0.14	1.00	0.01	5.12	85.0	x
1A2d	Stationary combustion in manufacturing industries and	6.35	1.94	0.01	5.08	90.1	
1A3dii	National navigation (shipping)	1.21	1.00	0.01	4.27	94.4	
1A2c	Stationary combustion in manufacturing industries and	5.52	0.60	0.00	1.21	95.6	
1A3bi	Road transport: Passenger cars	0.10	0.21	0.00	1.03	96.6	
1A2e	Stationary combustion in manufacturing industries and	5.99	1.03	0.00	0.64	97.3	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.01	0.11	0.00	0.55	97.8	
1A3bvi	Road transport: Automobile tyre and brake wear	0.06	0.11	0.00	0.55	98.4	
2G	Other product use (please specify in the IIR)	0.01	0.08	0.00	0.41	98.8	
1A3bii	Road transport: Light duty vehicles	0.03	0.07	0.00	0.32	99.1	
1A4bi	Residential: Stationary	0.11	0.06	0.00	0.25	99.4	
1A3ai(i)	International aviation LTO (civil)	0.01	0.03	0.00	0.16	99.5	
1A3biii	Road transport: Heavy duty vehicles and buses	0.03	0.03	0.00	0.12	99.6	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.01	0.02	0.00	0.08	99.7	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.03	0.02	0.00	0.07	99.8	
3F	Field burning of agricultural residues	0.02	0.01	0.00	0.06	99.8	
1A3biv	Road transport: Mopeds & motorcycles	0.11	0.02	0.00	0.04	99.9	
2D3g	Chemical products	0.01	0.01	0.00	0.04	99.9	
1A3aii(i)	Domestic aviation LTO (civil)	0.00	0.01	0.00	0.03	100.0	
5C1bi	Industrial waste incineration	0.00	0.00	0.00	0.01	100.0	
1A4ai	Commercial/institutional: Stationary	0.00	0.00	0.00	0.01	100.0	
1A5b	Other, Mobile (including military, land based and recrea	0.00	0.00	0.00	0.01	100.0	
5C1bv	Cremation	0.00	0.00	0.00	0.00	100.0	
5C1biii	Clinical waste incineration	0.00	0.00	0.00	0.00	100.0	
1A3c	Railways	0.00	0.00	0.00	0.00	100.0	
2C7a	Copper production	0.00	0.00	0.00	0.00	100.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.00	0.00	0.00	0.00	100.0	
5E	Other waste (please specify in IIR)	NO	0.00	0.00	0.00	100.0	

Se **Level Assessment**

NFR	Sectors	%total 2016	Cumulative total	Key category
2A3	Glass production	97.46	97.5	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	1.31	98.8	
1A1a	Public electricity and heat production	0.40	99.2	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	0.31	99.5	
1A3bi	Road transport: Passenger cars	0.10	99.6	
1A4bi	Residential: Stationary	0.05	99.6	
1B2aiv	Fugitive emissions oil: Refining / storage	0.05	99.7	
1A3bvi	Road transport: Automobile tyre and brake wear	0.05	99.7	
1A1b	Petroleum refining	0.03	99.8	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.03	99.8	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.03	99.8	
1A3bii	Road transport: Light duty vehicles	0.03	99.9	
3F	Field burning of agricultural residues	0.03	99.9	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.03	99.9	
1A3dii	National navigation (shipping)	0.02	99.9	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.02	99.9	
1A3biii	Road transport: Heavy duty vehicles and buses	0.01	100.0	
1A3biv	Road transport: Mopeds & motorcycles	0.01	100.0	
1A3ai(i)	International aviation LTO (civil)	0.01	100.0	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.01	100.0	
1A4ai	Commercial/institutional: Stationary	0.00	100.0	
1A3aii(i)	Domestic aviation LTO (civil)	0.00	100.0	
5C1bv	Cremation	0.00	100.0	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.00	100.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.00	100.0	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.00	100.0	
1A3c	Railways	0.00	100.0	
2D3g	Chemical products	0.00	100.0	
5E	Other waste (please specify in IIR)	0.00	100.0	

Se **Trend Assessment (1990-2016)**

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
2A3	Glass production	11.11	30.89	0.17	49.82	49.8	x
1A2f	Stationary combustion in manufacturing industries and	0.60	0.42	0.09	27.40	77.2	x
1A1a	Public electricity and heat production	0.19	0.13	0.03	8.91	86.1	x
1A2gviii	Stationary combustion in manufacturing industries and	0.04	0.01	0.01	2.38	88.5	
1A1b	Petroleum refining	0.03	0.01	0.01	1.82	90.3	
1A2d	Stationary combustion in manufacturing industries and	0.07	0.10	0.01	1.70	92.0	
1A2c	Stationary combustion in manufacturing industries and	0.03	0.01	0.01	1.57	93.6	
1A2e	Stationary combustion in manufacturing industries and	0.02	0.01	0.00	1.32	94.9	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.03	0.01	0.00	1.32	96.2	
1A4bi	Residential: Stationary	0.03	0.02	0.00	1.31	97.6	
1A3biv	Road transport: Mopeds & motorcycles	0.01	0.00	0.00	0.84	98.4	
3F	Field burning of agricultural residues	0.01	0.01	0.00	0.46	98.9	
1A3dii	National navigation (shipping)	0.01	0.01	0.00	0.39	99.2	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.00	0.00	0.00	0.17	99.4	
1A3bi	Road transport: Passenger cars	0.01	0.03	0.00	0.14	99.6	
1A3biii	Road transport: Heavy duty vehicles and buses	0.00	0.00	0.00	0.14	99.7	
1A3bvi	Road transport: Automobile tyre and brake wear	0.01	0.02	0.00	0.14	99.8	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.00	0.00	0.00	0.05	99.9	
1A4ai	Commercial/institutional: Stationary	0.00	0.00	0.00	0.03	99.9	
1A3c	Railways	0.00	0.00	0.00	0.03	99.9	
1A5b	Other, Mobile (including military, land based and recrea	0.00	0.00	0.00	0.02	100.0	
1A3ai(i)	International 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	
1A3bii	Road transport: Light duty vehicles	0.00	0.01	0.00	0.01	100.0	
1A3aii(i)	Domestic aviation LTO (civil)	0.00	0.00	0.00	0.00	100.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.00	0.00	0.00	0.00	100.0	
2D3g	Chemical products	0.00	0.00	0.00	0.00	100.0	
5E	Other waste (please specify in IIR)	NO	0.00	0.00	0.00	100.0	

Zn **Level Assessment**

NFR	Sectors	%total 2016	Cumulative total	Key category
2C1	Iron and steel production	31.69	31.7	x
2A3	Glass production	19.48	51.2	x
1A4bi	Residential: Stationary	17.12	68.3	x
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	8.82	77.1	x
1A3bvi	Road transport: Automobile tyre and brake wear	6.47	83.6	x
1A1a	Public electricity and heat production	5.76	89.3	
1A3bi	Road transport: Passenger cars	3.16	92.5	
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	1.28	93.8	
1A3bii	Road transport: Light duty vehicles	0.98	94.8	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.75	95.5	
1A4ai	Commercial/institutional: Stationary	0.68	96.2	
1A1b	Petroleum refining	0.63	96.8	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.50	97.3	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.41	97.7	
1A3biii	Road transport: Heavy duty vehicles and buses	0.40	98.1	
1A3biv	Road transport: Mopeds & motorcycles	0.36	98.5	
1A3ai(i)	International aviation LTO (civil)	0.35	98.8	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.27	99.1	
2G	Other product use (please specify in the IIR)	0.26	99.4	
3F	Field burning of agricultural residues	0.20	99.6	
1B2aiv	Fugitive emissions oil: Refining / storage	0.14	99.7	
1A3aii(i)	Domestic aviation LTO (civil)	0.07	99.8	
1A3dii	National navigation (shipping)	0.05	99.8	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.05	99.9	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.05	99.9	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.03	100.0	
1A5b	Other, Mobile (including military, land based and recreational boats)	0.02	100.0	
1A3c	Railways	0.01	100.0	
5C1bv	Cremation	0.00	100.0	
2C5	Lead production	0.00	100.0	
5E	Other waste (please specify in IIR)	0.00	100.0	

Zn **Trend Assessment (1990-2016)**

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
1A4bi	Residential: Stationary	27.92	16.51	0.29	31.67	31.7	x
2C1	Iron and steel production	10.47	30.57	0.23	25.30	57.0	x
2A3	Glass production	6.75	18.79	0.14	14.91	71.9	x
1A2f	Stationary combustion in manufacturing industries and	3.60	1.24	0.05	5.44	77.3	x
1A2d	Stationary combustion in manufacturing industries and	4.75	8.51	0.03	3.30	80.6	x
1A1a	Public electricity and heat production	5.71	5.56	0.03	3.15	83.8	
1A3bvi	Road transport: Automobile tyre and brake wear	3.29	6.24	0.03	2.83	86.6	
1A3biv	Road transport: Mopeds & motorcycles	1.49	0.34	0.02	2.50	89.1	
1A2gviii	Stationary combustion in manufacturing industries and	1.55	0.72	0.02	2.05	91.1	
1A3bi	Road transport: Passenger cars	1.40	3.04	0.02	1.78	92.9	
1A2e	Stationary combustion in manufacturing industries and	1.08	0.39	0.01	1.60	94.5	
1A2c	Stationary combustion in manufacturing industries and	1.04	0.49	0.01	1.38	95.9	
1A1b	Petroleum refining	1.03	0.61	0.01	1.17	97.1	
1A3bii	Road transport: Light duty vehicles	0.38	0.95	0.01	0.68	97.8	
1A4ai	Commercial/institutional: Stationary	0.25	0.66	0.00	0.49	98.2	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	0.37	0.26	0.00	0.37	98.6	
2G	Other product use (please specify in the IIR)	0.04	0.25	0.00	0.31	98.9	
1A3ai(i)	International aviation LTO (civil)	0.11	0.34	0.00	0.29	99.2	
3F	Field burning of agricultural residues	0.25	0.20	0.00	0.21	99.4	
1A3biii	Road transport: Heavy duty vehicles and buses	0.38	0.39	0.00	0.17	99.6	
1A3c	Railways	0.06	0.01	0.00	0.10	99.7	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.06	0.03	0.00	0.09	99.8	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.07	0.05	0.00	0.06	99.8	
1A5b	Other, Mobile (including military, land based and recrea	0.04	0.02	0.00	0.05	99.9	
1A3dii	National navigation (shipping)	0.06	0.05	0.00	0.05	99.9	
1A3aii(i)	Domestic aviation LTO (civil)	0.03	0.07	0.00	0.04	100.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.03	0.05	0.00	0.02	100.0	
5C1bv	Cremation	0.00	0.00	0.00	0.00	100.0	
2C5	Lead production	0.00	0.00	0.00	0.00	100.0	
5E	Other waste (please specify in IIR)	NO	0.00	0.00	0.00	100.0	

Diox **Level Assessment**

NFR	Sectors	%total 2016	Cumulative total	Key category
5C1biii	Clinical waste incineration	59.91	59.9	x
1A4bi	Residential: Stationary	17.10	77.0	x
5C1bi	Industrial waste incineration	9.21	86.2	x
5E	Other waste (please specify in IIR)	5.56	91.8	
2D3i	Other solvent use (please specify in the IIR)	3.21	95.0	
1A1a	Public electricity and heat production	1.99	97.0	
1A3bi	Road transport: Passenger cars	0.78	97.8	
2C3	Aluminium production	0.41	98.2	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	0.41	98.6	
1A3bii	Road transport: Light duty vehicles	0.35	98.9	
3F	Field burning of agricultural residues	0.18	99.1	
2C1	Iron and steel production	0.17	99.3	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.16	99.4	
1A4ai	Commercial/institutional: Stationary	0.15	99.6	
1B2aiv	Fugitive emissions oil: Refining / storage	0.10	99.7	
1A3biii	Road transport: Heavy duty vehicles and buses	0.08	99.8	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.08	99.8	
2C5	Lead production	0.06	99.9	
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	0.06	100.0	
1A1b	Petroleum refining	0.01	100.0	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.01	100.0	
1A3biv	Road transport: Mopeds & motorcycles	0.01	100.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.00	100.0	
2G	Other product use (please specify in the IIR)	0.00	100.0	
2C7a	Copper production	0.00	100.0	
5C1bv	Cremation	0.00	100.0	

Diox **Trend Assessment (1990-2016)**

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
5C1biii	Clinical waste incineration	482.30	48.72	0.05	49.49	49.5	x
1A4bi	Residential: Stationary	23.49	13.91	0.02	20.19	69.7	x
5C1bi	Industrial waste incineration	7.96	7.49	0.01	12.29	82.0	x
5E	Other waste (please specify in IIR)	6.38	4.52	0.01	6.94	88.9	
2D3i	Other solvent use (please specify in the IIR)	4.18	2.61	0.00	3.86	92.8	
1A1a	Public electricity and heat production	1.04	1.62	0.00	2.86	95.6	
1A3bi	Road transport: Passenger cars	0.23	0.63	0.00	1.17	96.8	
1A2d	Stationary combustion in manufacturing industries and	0.28	0.33	0.00	0.56	97.4	
2C3	Aluminium production	0.40	0.33	0.00	0.53	97.9	
1A3bii	Road transport: Light duty vehicles	0.13	0.28	0.00	0.51	98.4	
2C1	Iron and steel production	2.13	0.14	0.00	0.37	98.8	
1A4ai	Commercial/institutional: Stationary	0.01	0.12	0.00	0.24	99.0	
3F	Field burning of agricultural residues	0.18	0.14	0.00	0.22	99.2	
1A2gviii	Stationary combustion in manufacturing industries and	0.20	0.13	0.00	0.19	99.4	
1B2aiv	Fugitive emissions oil: Refining / storage	0.06	0.08	0.00	0.14	99.6	
1A3biii	Road transport: Heavy duty vehicles and buses	0.08	0.07	0.00	0.11	99.7	
1A2f	Stationary combustion in manufacturing industries and	0.64	0.05	0.00	0.09	99.8	
2C5	Lead production	0.03	0.05	0.00	0.09	99.9	
1A2e	Stationary combustion in manufacturing industries and	0.22	0.07	0.00	0.06	99.9	
2C7a	Copper production	0.12	0.00	0.00	0.03	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	
1A3biv	Road transport: Mopeds & motorcycles	0.01	0.01	0.00	0.01	100.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.00	0.00	0.00	0.00	100.0	
2G	Other product use (please specify in the IIR)	0.00	0.00	0.00	0.00	100.0	
5C1bv	Cremation	0.00	0.00	0.00	0.00	100.0	

Total PAH Level Assessment

NFR	Sectors	% total 2016	Cumulative total	Key category
2D3g	Chemical products	86.43	86.4	x
3F	Field burning of agricultural residues	11.73	98.2	
1A4bi	Residential: Stationary	1.35	99.5	
2D3i	Other solvent use (please specify in the IIR)	0.16	99.7	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.10	99.8	
2C1	Iron and steel production	0.07	99.8	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.03	99.9	
1A3bi	Road transport: Passenger cars	0.03	99.9	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.02	99.9	
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	0.01	99.9	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	0.01	99.9	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.01	100.0	
1A3bii	Road transport: Light duty vehicles	0.01	100.0	
1A3dii	National navigation (shipping)	0.01	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.01	100.0	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.01	100.0	
1A4ai	Commercial/institutional: Stationary	0.00	100.0	
1A3c	Railways	0.00	100.0	
1A1a	Public electricity and heat production	0.00	100.0	
2G	Other product use (please specify in the IIR)	0.00	100.0	
1B2aiv	Fugitive emissions oil: Refining / storage	0.00	100.0	
1A3biv	Road transport: Mopeds & motorcycles	0.00	100.0	
5C1bi	Industrial waste incineration	0.00	100.0	
1A1b	Petroleum refining	0.00	100.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.00	100.0	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.00	100.0	
5C1bv	Cremation	0.00	100.0	
5E	Other waste (please specify in IIR)	0.00	100.0	
5C1biii	Clinical waste incineration	0.00	100.0	

Total PAH Trend Assessment (1990-2016)

NFR	Sectors	1990	Last year	Trend assess.	% cont. to trend	Cumulative total	Key category
2D3g	Chemical products	432.75	713.88	0.18	49.89	49.9	x
3F	Field burning of agricultural residues	125.30	96.88	0.13	37.21	87.1	x
1A4bi	Residential: Stationary	18.81	11.12	0.03	7.20	94.3	
2C1	Iron and steel production	5.34	0.59	0.01	3.25	97.5	
2D3i	Other solvent use (please specify in the IIR)	2.11	1.32	0.00	0.77	98.3	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and othe	1.24	0.86	0.00	0.42	98.7	
1A2f	Stationary combustion in manufacturing industries and	0.59	0.12	0.00	0.33	99.1	
1A2gviii	Stationary combustion in manufacturing industries and	0.58	0.27	0.00	0.25	99.3	
1A2e	Stationary combustion in manufacturing industries and	0.35	0.15	0.00	0.16	99.5	
1A2c	Stationary combustion in manufacturing industries and	0.24	0.05	0.00	0.14	99.6	
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.25	0.10	0.00	0.12	99.7	
1A3c	Railways	0.19	0.03	0.00	0.11	99.9	
1A3bi	Road transport: Passenger cars	0.06	0.22	0.00	0.06	99.9	
1A3dii	National navigation (shipping)	0.10	0.09	0.00	0.03	99.9	
1A3bii	Road transport: Light duty vehicles	0.04	0.10	0.00	0.02	100.0	
1A4ai	Commercial/institutional: Stationary	0.00	0.04	0.00	0.02	100.0	
1A2d	Stationary combustion in manufacturing industries and	0.09	0.11	0.00	0.01	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.05	0.05	0.00	0.01	100.0	
1A1a	Public electricity and heat production	0.01	0.02	0.00	0.00	100.0	
2G	Other product use (please specify in the IIR)	0.00	0.01	0.00	0.00	100.0	
1A3biv	Road transport: Mopeds & motorcycles	0.00	0.00	0.00	0.00	100.0	
5C1bi	Industrial waste incineration	0.00	0.00	0.00	0.00	100.0	
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.00	0.00	0.00	0.00	100.0	
1B2c	Venting and flaring (oil, gas, combined oil and gas)	0.00	0.00	0.00	0.00	100.0	
1A1b	Petroleum refining	0.00	0.00	0.00	0.00	100.0	
5C1biii	Clinical waste incineration	0.00	0.00	0.00	0.00	100.0	
5C1bv	Cremation	0.00	0.00	0.00	0.00	100.0	
5E	Other waste (please specify in IIR)	NO	0.00	0.00	0.00	100.0	

HCB **Level Assessment**

NFR	Sectors	%total 2016	Cumulative total	Key category
2C3	Aluminium production	97.81	97.8	x
1A1a	Public electricity and heat production	1.74	99.5	
5C1biii	Clinical waste incineration	0.25	99.8	
5C1bi	Industrial waste incineration	0.09	99.9	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	0.06	99.9	
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.02	100.0	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.01	100.0	
1A4ai	Commercial/institutional: Stationary	0.01	100.0	
5C1bv	Cremation	0.01	100.0	
1A3bi	Road transport: Passenger cars	0.00	100.0	
1A3bii	Road transport: Light duty vehicles	0.00	100.0	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.00	100.0	
1A4bi	Residential: Stationary	0.00	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.00	100.0	
1A3biv	Road transport: Mopeds & motorcycles	0.00	100.0	
1A1b	Petroleum refining	0.00	100.0	

HCB **Trend Assessment (1990-2016)**

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
5C1biii	Clinical waste incineration	1.21	0.12	0.01	44.42	44.4	x
2C3	Aluminium production	56.66	47.49	0.01	30.19	74.6	x
1A1a	Public electricity and heat production	0.57	0.84	0.01	19.07	93.7	x
1A4bi	Residential: Stationary	0.11	0.00	0.00	4.66	98.3	
1A2e	Stationary combustion in manufacturing industries and	0.02	0.01	0.00	0.54	98.9	
1A2d	Stationary combustion in manufacturing industries and	0.03	0.03	0.00	0.34	99.2	
5C1bi	Industrial waste incineration	0.05	0.04	0.00	0.26	99.5	
1A2c	Stationary combustion in manufacturing industries and	0.01	0.00	0.00	0.22	99.7	
5C1bv	Cremation	0.00	0.00	0.00	0.13	99.8	
1A2gviii	Stationary combustion in manufacturing industries and	0.02	0.01	0.00	0.07	99.9	
1A3bi	Road transport: Passenger cars	0.00	0.00	0.00	0.06	100.0	
1A3bii	Road transport: Light duty vehicles	0.00	0.00	0.00	0.03	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 2016	Cumulative total	Key category
2K	Consumption of POPs and heavy metals (e.g. electrical and scien	93.98	94.0	x
5C1bi	Industrial waste incineration	5.54	99.5	
2C1	Iron and steel production	0.47	100.0	
1A2gviii	Stationary combustion in manufacturing industries and constructio	0.00	100.0	
5C1biii	Clinical waste incineration	0.00	100.0	
1A1a	Public electricity and heat production	0.00	100.0	
5C1bv	Cremation	0.00	100.0	
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	0.00	100.0	
1A3bi	Road transport: Passenger cars	0.00	100.0	
1A3bii	Road transport: Light duty vehicles	0.00	100.0	
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.00	100.0	
2C5	Lead production	0.00	100.0	
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	0.00	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	0.00	100.0	
1A3biv	Road transport: Mopeds & motorcycles	0.00	100.0	
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.00	100.0	
2C7a	Copper production	0.00	100.0	
1A1b	Petroleum refining	0.00	100.0	

PCBs Trend Assessment (1990-2016)

NFR	Sectors	1990	Last year	Trend assess.	%cont. to trend	Cumulative total	Key category
2C1	Iron and steel production	1244.64	4.96	0.25	49.99	50.0	x
2K	Consumption of POPs and heavy metals (e.g. electrica	949.68	982.24	0.24	47.46	97.4	x
5C1bi	Industrial waste incineration	62.29	57.86	0.01	2.54	100.0	
5C1biii	Clinical waste incineration	0.28	0.03	0.00	0.01	100.0	
1A2c	Stationary combustion in manufacturing industries and	0.07	0.00	0.00	0.00	100.0	
1A1a	Public electricity and heat production	0.00	0.02	0.00	0.00	100.0	
1A2gviii	Stationary combustion in manufacturing industries and	0.10	0.04	0.00	0.00	100.0	
5C1bv	Cremation	0.00	0.01	0.00	0.00	100.0	
1A2e	Stationary combustion in manufacturing industries and	0.00	0.00	0.00	0.00	100.0	
1A2f	Stationary combustion in manufacturing industries and	0.00	0.00	0.00	0.00	100.0	
1A2d	Stationary combustion in manufacturing industries and	0.00	0.00	0.00	0.00	100.0	
1A3bi	Road transport: Passenger cars	0.00	0.00	0.00	0.00	100.0	
1A3bii	Road transport: Light duty vehicles	0.00	0.00	0.00	0.00	100.0	
2C5	Lead production	0.00	0.00	0.00	0.00	100.0	
1A3biii	Road transport: Heavy duty vehicles and buses	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	
2C7a	Copper production	0.00	0.00	0.00	0.00	100.0	

ANNEX B: ENERGY BALANCE SHEET FOR 2016

Annex Table 3 – Energy Balance Sheet for 2016

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**
2016 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	1.	3 031 289	9 517	**3 040 806**	14 256 786	807 305	750 676	169 904	762	16 026	978 234	229 261	87 257	280 236	**17 576 446**	39 272	115 946	4 954	4 731	8 770	**173 673**	**17 750 119**	**4 278 613**
PRODUÇÃO DOMÉSTICA	2.																						
VARIAÇÃO DE "STOCKS"	3.	64 023	518	**64 541**	85 961	101 967	- 1 099	1 051			71 225	- 70 700		- 29 761	**158 644**	- 19 061	- 2 495	- 1 001	868	- 17 920	**- 39 609**	**119 035**	**- 62 005**
SAÍDAS	4.	128 498	25	**128 523**		167 256	72 861	1 539 202		1 138 559	2 202 872	2 168 672	575 136		**7 864 558**	109 027	75 359	5 157	23 480	162 503	**375 525**	**8 240 083**	
Exportações	*4.1*	*128 498*	*25*	*128 523*		*167 256*	*72 861*	*1 539 202*		*574*	*2 111 695*	*1 634 264*	*575 136*		*6 100 988*	*108 261*	*75 359*	*5 157*	*23 480*	*162 503*	*374 759*	*6 475 748*	
Transportes Marítimos Internacionais	*4.2*										*91 177*	*534 407*			*625 584*	*766*					*766*	*626 350*	
Aviação Internacional	*4.3*									*1 137 986*					*1 137 986*							*1 137 986*	
CONSUMO DE ENERGIA PRIMÁRIA	5.	2 838 768	8 974	**2 847 742**	14 170 825	538 082	678 914	-1 370 349	762	-1 122 533	-1 295 863	-1 868 711	- 487 880	309 997	**9 553 243**	- 50 694	43 082	798	- 19 617	- 135 813	**- 162 243**	**9 391 000**	**4 340 618**
PARA NOVAS FORMAS DE ENERGIA	6.	2 832 498		**2 832 498**	14 033 508	- 164 706	- 190 124	-2 745 854	- 294	-1 260 487	-6 185 031	-2 066 054	- 880 086		**540 871**	- 97 298	- 166 245	- 11 175	- 30 178	- 207 299	**- 512 195**	**28 677**	**2 631 816**
Briquetes	*6.1*																						
Coque	*6.2*																						
Produtos de Petróleo	*6.3*				*14 033 508*	*4 702*	*- 190 124*	*-2 745 854*	*- 294*	*-1 260 487*	*-6 203 952*	*-2 350 757*	*-1 133 847*		*152 895*	*- 97 298*	*- 166 245*	*- 11 175*	*- 30 178*	*- 207 299*	*- 512 195*	*- 359 299*	
Hidrogénio	*6.4*																						*220 546*
Petroquímica	*6.5*					*- 187 041*							*253 761*		*66 720*							*66 720*	
Eletricidade	*6.6*	*2 832 498*		*2 832 498*							*18 847*	*165 500*			*184 347*							*184 347*	*1 231 140*
Cogeração	*6.7*					*17 633*					*73*	*119 203*			*136 909*							*136 909*	*1 180 130*
Produção de Eletricidade	*6.7.1*										*28*	*40 677*			*40 704*							*40 704*	
Refinação de Petróleo	*6.7.2*					*17 633*									*17 633*							*17 633*	*428 473*
Gás de Cidade	*6.7.3*																						
Agricultura	*6.7.4*																						*4 703*
Alimentação, bebidas e tabaco	*6.7.5*											*10 692*			*10 692*							*10 692*	*87 427*
Têxteis	*6.7.6*										*22*				*22*							*22*	*113 474*
Papel e Artigos de Papel	*6.7.7*										*19*	*39 342*			*39 361*							*39 361*	*350 996*
Químicas e Plásticos	*6.7.8*											*24 281*			*24 281*							*24 281*	*47 179*
Cerâmicas	*6.7.9*																						*28 939*
Vidro e Artigos de Vidro	*6.7.10*																						
Cimento e Cal	*6.7.11*																						*3 364*
Metalúrgicas	*6.7.12*																						
Siderurgia	*6.7.13*																						
Vestuário, Calçado e Curtumes	*6.7.14*																						*7 669*
Madeira e Artigos de Madeira	*6.7.15*										*5*	*4 211*			*4 216*							*4 216*	
Borracha	*6.7.16*																						*15 647*
Metálo-eletro-mecânicas	*6.7.17*																						*2 313*
Outras Indústrias Transformadoras	*6.7.18*																						*2 373*
Indústrias Extrativas	*6.7.19*																						*14 316*
Serviços	*6.7.20*																						*73 257*

BALANÇO ENERGÉTICO tep 2016 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	7.				137 316	651 804	2 418	3	131		1	116 553	354	258	**908 838**	1 106	- 51	63	118	1 505	**2 742**	**911 580**	**108 674**
Consumo Próprio da Refinação	*7.1*					*633 544*	*2 135*				*1*	*115 980*			*751 660*	*25*					*25*	*751 684*	*100 472*
Perdas da Refinação	*7.2*				*137 316*	*18 259*	*267*		*131*				*354*		*156 328*	*177*	*- 51*	*63*	*118*		*307*	*156 635*	
Coquerie e outras não especificadas	*7.3*																						
Centrais Elétricas	*7.4*															*904*					*904*	*904*	
Bombagem Hidroeléctrica	*7.5*																						
Extração de Carvão, Petróleo e GN	*7.6*															*1*					*1*	*1*	*5*
Perdas de Transporte e Distribuição	*7.7*						*16*	*3*				*573*		*258*	*851*					*1 505*	*1 505*	*2 356*	*8 197*
CONSUMO COMO MATÉRIA PRIMA	8.						*298 069*						*385 717*		*683 786*							*683 786*	
DISPONÍVEL PARA CONSUMO FINAL	9.	6 270	8 974	**15 244**		50 985	568 550	1 375 502	925	137 954	4 889 168	80 790	6 135	309 738	**7 419 747**	45 498	209 378	11 910	10 443	69 981	**347 210**	**7 766 957**	**1 600 128**
ACERTOS		1 563	918	2 481		50 985	1 867	270 808	223	- 11 487	35 296	- 81 939	6 135	54 236	326 124	- 1 540	15 462	2 432	4 200	51 910	72 465	398 589	- 1 752
CONSUMO FINAL	10.	4 707	8 056	**12 763**			566 684	1 104 694	701	149 441	4 853 872	162 729		255 503	**7 093 623**	47 037	193 916	9 478	6 243	18 070	**274 745**	**7 368 368**	**1 601 880**
AGRICULTURA E PESCAS	10.1						4 704	790	478		344 208	5 377			**355 558**	303					**303**	**355 861**	4 121
Agricultura	*10.1.1*						*4 704*	*666*	*478*		*260 084*	*809*			*266 742*	*87*					*87*	*266 829*	*3 573*
Pescas	*10.1.2*							*123*			*84 124*	*4 568*			*88 815*	*216*					*216*	*89 031*	*548*
INDÚSTRIAS EXTRATIVAS	10.2	22		**22**							28 905	1 237			**30 142**	948					**948**	**31 091**	**2 476**
INDÚSTRIAS TRANSFORMADORAS	10.3	4 685	8 056	**12 741**			62 629	12	28		84 658	62 772		255 503	**465 601**	12 258	2 648	9 439	6 205	18 070	**48 621**	**514 222**	**1 079 471**
Alimentação, bebidas e tabaco	*10.3.1*						*16 721*		*5*		*25 395*	*25 527*			*67 648*	*201*					*201*	*67 849*	*146 444*
Têxteis	*10.3.2*						*2 211*				*298*	*2 826*			*5 335*	*839*					*839*	*6 174*	*117 572*
Papel e Artigos de Papel	*10.3.3*						*1 900*		*6*		*4 266*	*21 292*			*27 464*	*336*				*5 155*	*5 490*	*32 954*	*106 891*
Químicas e Plásticos	*10.3.4*						*8 557*		*2*		*1 873*	*10 661*			*21 093*	*3 210*	*2 648*	*6 126*	*6 031*	*12 916*	*30 931*	*52 024*	*133 950*
Cerâmicas	*10.3.5*						*3 461*		*2*		*1 632*			*13 026*	*18 121*	*78*					*78*	*18 199*	*196 688*
Vidro e Artigos de Vidro	*10.3.6*						*490*				*1 171*				*1 662*	*194*					*194*	*1 856*	*176 728*
Cimento e Cal	*10.3.7*						*506*		*2*		*13 767*	*314*		*242 476*	*257 066*	*249*					*249*	*257 314*	*38 782*
Metalúrgicas	*10.3.8*	*225*	*173*	*398*			*2 598*				*463*				*3 061*	*386*			*1*		*387*	*3 448*	*19 427*
Siderurgia	*10.3.9*	*4 301*	*2 929*	*7 230*			*55*				*1 470*				*1 525*	*647*			*1*		*648*	*2 173*	*48 346*
Vestuário, Calçado e Curtumes	*10.3.10*						*2 513*				*2 016*	*575*			*5 104*	*13*			*1*		*15*	*5 119*	*14 325*
Madeira e Artigos de Madeira	*10.3.11*						*1 688*				*5 273*	*229*			*7 190*	*222*		*2 876*			*3 098*	*10 287*	*7 839*
Borracha	*10.3.12*						*156*								*157*	*2 186*		*378*			*2 565*	*2 721*	*4 267*
Metálo-eletro-mecânicas	*10.3.13*	*20*	*99*	*119*			*19 333*	*12*	*10*		*6 063*	*368*			*25 786*	*3 169*		*38*	*56*		*3 262*	*29 049*	*62 248*
Outras Indústrias Transformadoras	*10.3.14*	*139*	*4 855*	*4 994*			*2 440*		*2*		*20 968*	*979*			*24 390*	*529*		*21*	*115*		*665*	*25 054*	*5 964*
CONSTRUÇÃO E OBRAS PÚBLICAS	10.4						8 803				67 504	15 768			**92 075**	1 043	191 267		31		**192 341**	**284 416**	**15 125**
TRANSPORTES	10.5						40 523	1 103 892		134 787	4 230 556	48 689			**5 558 446**	30 103					**30 103**	**5 588 550**	**19 216**
Aviação Nacional	*10.5.1*						*10*	*1 320*		*134 787*					*136 117*							*136 117*	
Transportes Marítimos Nacionais	*10.5.2*						*10*	*17*			*40 839*	*48 689*			*89 554*	*109*					*109*	*89 663*	
Caminho de Ferro	*10.5.3*						*112*				*9 385*				*9 497*							*9 497*	
Rodoviários	*10.5.4*						*40 391*	*1 102 555*			*4 180 332*				*5 323 279*	*29 994*					*29 994*	*5 353 273*	*19 216*
SETOR DOMÉSTICO	10.6						374 614		150		53 051				**427 815**							**427 815**	**252 470**
SERVIÇOS	10.7						75 410		45	14 654	44 989	28 887			**163 985**	2 383		39	7		**2 429**	**166 413**	**229 001**

BALANÇO ENERGÉTICO tep 2016 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	**Renováveis Sem Eletricidade** 41 = 34 a 40	**TOTAL GERAL** 42=3+21+22+25+31+32+33+41
IMPORTAÇÕES	1.									**396 985**		33 609		88 235			18 036		23 320	**129 591**	25 629 722
PRODUÇÃO DOMÉSTICA	2.				1 454 206	1 072 779	70 722	14 756		**2 612 462**		174 403	83 963	1 526 314	103 650	1 041 598	28 578	80 341	297 783	**3 162 227**	**5 949 092**
VARIAÇÃO DE "STOCKS"	3.																		- 6 232	**- 6 232**	**115 340**
SAÍDAS	4.									**834 277**				290 866					51 810	**342 676**	**9 545 560**
Exportações	*4.1*									*834 277*				*290 866*					*51 810*	*342 676*	*7 781 224*
Transportes Marítimos Internacionais	*4.2*																				*626 350*
Aviação Internacional	*4.3*																				*1 137 986*
CONSUMO DE ENERGIA PRIMÁRIA	5.				*1 454 206*	*1 072 779*	*70 722*	*14 756*		**2 175 169**		208 012	83 963	1 323 683	103 650	1 041 598	46 614	80 341	275 525	**2 955 374**	**21 917 915**
PARA NOVAS FORMAS DE ENERGIA	6.				*1 454 206*	*1 072 779*	*70 722*	*14 756*	-2 571 537	**-2 571 537**	**-1 410 366**	118 093		427 829	103 650	1 041 598		71 545	274 735	**1 919 357**	**3 548 538**
Briquetes	*6.1*																				
Coque	*6.2*																				
Produtos de Petróleo	*6.3*		*201 918*	*201 918*															*274 735*	*274 735*	*117 353*
Hidrogénio	*6.4*		*- 201 918*	*- 201 918*																	*18 628*
Petroquímica	*6.5*	*- 66 720*		*- 66 720*																	
Eletricidade	*6.6*				*1 454 206*	*1 072 779*	*70 722*	*14 756*	*-1 969 504*	*-1 969 504*		*103 650*		*285 003*	*103 650*			*67 231*		*455 884*	*2 838 015*
Cogeração	*6.7*	*66 721*		*66 721*					*- 602 033*	*- 602 033*	*-1 410 366*	*14 443*		*142 826*		*1 041 598*		*4 314*		*1 188 738*	*574 542*
Produção de Eletricidade	*6.7.1*								*- 16 535*	*- 16 535*	*- 836*										*23 334*
Refinação de Petróleo	*6.7.2*								*- 142 824*	*- 142 824*	*- 216 984*										*86 298*
Gás de Cidade	*6.7.3*																				
Agricultura	*6.7.4*								*- 1 984*	*- 1 984*	*- 1 795*							*295*		*295*	*1 220*
Alimentação, bebidas e tabaco	*6.7.5*								*- 25 226*	*- 25 226*	*- 44 282*										*28 611*
Têxteis	*6.7.6*								*- 45 444*	*- 45 444*	*- 37 615*										*30 437*
Papel e Artigos de Papel	*6.7.7*								*- 292 296*	*- 292 296*	*- 967 829*			*119 026*		*1 041 598*				*1 160 624*	*290 856*
Químicas e Plásticos	*6.7.8*	*66 721*		*66 721*					*- 20 943*	*- 20 943*	*- 69 262*	*12 715*									*60 691*
Cerâmicas	*6.7.9*								*- 9 804*	*- 9 804*	*- 15 205*										*3 930*
Vidro e Artigos de Vidro	*6.7.10*																				
Cimento e Cal	*6.7.11*								*- 1 396*	*- 1 396*	*- 1 044*										*924*
Metalúrgicas	*6.7.12*																				
Siderurgia	*6.7.13*																				
Vestuário, Calçado e Curtumes	*6.7.14*								*- 2 593*	*- 2 593*	*- 2 364*										*2 712*
Madeira e Artigos de Madeira	*6.7.15*								*- 2 676*	*- 2 676*	*- 8 020*			*23 800*						*23 800*	*17 320*
Borracha	*6.7.16*								*- 3 897*	*- 3 897*	*- 10 465*	*1 728*									*3 013*
Metálo-eletro-mecânicas	*6.7.17*								*- 1 043*	*- 1 043*	*- 696*										*574*
Outras Indústrias Transformadoras	*6.7.18*								*- 1 925*	*- 1 925*	*- 1 068*							*2 647*		*2 647*	*2 027*
Indústrias Extrativas	*6.7.19*								*- 4 301*	*- 4 301*	*- 7 553*										*2 462*
Serviços	*6.7.20*								*- 29 148*	*- 29 148*	*- 25 349*							*1 372*		*1 372*	*20 132*

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	**Renováveis Sem Eletricidade**	**TOTAL GERAL**
2016 provisório		23	24	25 = 23 + 24	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41 = 34 a 40	42=3+21+22+25+31+32+33+41
CONSUMO DO SECTOR ENERGÉTICO	7.									**760 237**	**216 984**										**1 997 475**
Consumo Próprio da Refinação	*7.1*									*66 307*	*216 984*										*1 135 447*
Perdas da Refinação	*7.2*																				*156 635*
Coquerie e outras não especificadas	*7.3*									*17*											*17*
Centrais Elétricas	*7.4*									*143 055*											*143 959*
Bombagem Hidroeléctrica	*7.5*									*130 720*											*130 720*
Extração de Carvão, Petróleo e GN	*7.6*									*255*											*261*
Perdas de Transporte e Distribuição	*7.7*									*419 883*											*430 435*
CONSUMO COMO MATÉRIA PRIMA	8.																				*683 786*
DISPONÍVEL PARA CONSUMO FINAL	9.									**3 986 469**	**1 193 382**	89 919	83 963	895 854			46 614	8 796	790	**1 036 017**	**15 688 116**
ACERTOS										3									- 1 969	- 1 969	397 352
CONSUMO FINAL	10.									**3 986 466**	**1 193 382**	89 919	83 963	895 854			46 614	8 796	2 759	**1 037 986**	**15 290 764**
AGRICULTURA E PESCAS	10.1									**71 399**	**1 795**			***1 422***						**1 422**	**434 597**
Agricultura	*10.1.1*									*67 050*	*1 795*			*1 422*						*1 422*	*340 669*
Pescas	*10.1.2*									*4 349*											*93 928*
INDÚSTRIAS EXTRATIVAS	10.2									**26 128**	**7 553**										**67 269**
INDÚSTRIAS TRANSFORMADORAS	10.3									**1 240 736**	**1 158 686**	**89 919**		**103 366**			45 251	8 796	**189**	**157 602**	**4 253 377**
Alimentação, bebidas e tabaco	*10.3.1*									*172 434*	*44 282*			*27 572*				*1 386*		*28 958*	*459 967*
Têxteis	*10.3.2*									*78 316*	*37 615*			*2 108*						*2 108*	*241 785*
Papel e Artigos de Papel	*10.3.3*									*242 927*	*967 829*			*19 449*			*461*	*7 410*		*27 320*	*1 377 921*
Químicas e Plásticos	*10.3.4*									*184 245*	*69 262*	*102*		*1 075*					*189*	*1 264*	*440 847*
Cerâmicas	*10.3.5*									*35 744*	*15 205*			*20 392*						*20 392*	*286 228*
Vidro e Artigos de Vidro	*10.3.6*									*40 543*											*219 126*
Cimento e Cal	*10.3.7*									*56 973*	*1 044*	*89 817*		*6 276*			*44 790*			*51 066*	*494 997*
Metalúrgicas	*10.3.8*									*22 499*				*2*						*2*	*45 774*
Siderurgia	*10.3.9*									*115 746*											*173 495*
Vestuário, Calçado e Curtumes	*10.3.10*									*28 322*	*2 364*			*1 870*						*1 870*	*52 000*
Madeira e Artigos de Madeira	*10.3.11*									*71 801*	*8 020*			*23 537*						*23 537*	*121 484*
Borracha	*10.3.12*									*17 357*	*10 465*			*467*						*467*	*35 278*
Metálo-eletro-mecânicas	*10.3.13*									*128 171*	*696*			*548*						*548*	*220 831*
Outras Indústrias Transformadoras	*10.3.14*									*45 657*	*1 904*			*70*						*70*	*83 643*
CONSTRUÇÃO E OBRAS PÚBLICAS	10.4									45 249				91						**91**	**344 880**
TRANSPORTES	10.5									32 552									2 570	**2 570**	**5 642 888**
Aviação Nacional	*10.5.1*																				*136 117*
Transportes Marítimos Nacionais	*10.5.2*																				*89 663*
Caminho de Ferro	*10.5.3*									*32 525*											*42 022*
Rodoviários	*10.5.4*									*27*									*2 570*	*2 570*	*5 375 086*
SETOR DOMÉSTICO	10.6									1 125 737			40 639	*764 583*						**805 222**	**2 611 244**
SERVIÇOS	10.7									**1 444 666**	**25 349**		43 324	26 392			1 363			**71 079**	**1 936 509**

ANNEX C: ENERGY (NFR 1)

Transport (NFR 1.A.3)

Annex Table 4- 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
Aviation Gasol	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
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

Fuel Sales		NAPFUE	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Aviation Gasol	L	209	1,847	2,192	2,179	2,086	2,280	2,280	2,869	2,258	1,268	1,168	1,333	1,257	1,256
Jet Fuel	L	207	835,208	865,857	907,189	949,650	969,349	907,530	985,343	1,006,836	1,015,897	1,027,228	1,086,001	1,139,566	1,239,312

Annex Table 5- 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
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
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
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
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

Annex Table 6 - Road transportation energy based implied emission factors (kg/GJ) for 2016 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	0.731	1.093	0.0004	0.0008	0.005	0.008	0.010	0.0002	5.761
Passenger Cars	Petrol	Small & Mini	Euro 1	0.172	0.367	0.0004	0.0399	0.005	0.008	0.010	0.0002	1.848
Passenger Cars	Petrol	Small & Mini	Euro 2	0.100	0.234	0.0004	0.0495	0.005	0.008	0.010	0.0002	1.067
Passenger Cars	Petrol	Small & Mini	Euro 3	0.043	0.125	0.0004	0.0087	0.004	0.007	0.010	0.0001	0.909
Passenger Cars	Petrol	Small & Mini	Euro 4	0.029	0.102	0.0004	0.0091	0.004	0.008	0.010	0.0001	0.314
Passenger Cars	Petrol	Small & Mini	Euro 5	0.018	0.077	0.0004	0.0041	0.004	0.008	0.010	0.0001	0.308
Passenger Cars	Petrol	Small & Mini	Euro 6 up to 2016	0.020	0.082	0.0004	0.0039	0.004	0.008	0.010	0.0001	0.295
Passenger Cars	Petrol	Medium	PRE ECE - ECE 15/04	0.769	0.936	0.0004	0.0006	0.004	0.006	0.008	0.0002	4.812
Passenger Cars	Petrol	Medium	Euro 1	0.143	0.260	0.0004	0.0334	0.004	0.007	0.009	0.0002	1.428
Passenger Cars	Petrol	Medium	Euro 2	0.085	0.146	0.0004	0.0422	0.004	0.007	0.009	0.0002	0.815
Passenger Cars	Petrol	Medium	Euro 3	0.036	0.079	0.0004	0.0073	0.004	0.006	0.008	0.0001	0.690
Passenger Cars	Petrol	Medium	Euro 4	0.022	0.054	0.0004	0.0070	0.003	0.006	0.008	0.0001	0.223
Passenger Cars	Petrol	Medium	Euro 5	0.015	0.054	0.0004	0.0034	0.004	0.006	0.008	0.0001	0.230
Passenger Cars	Petrol	Medium	Euro 6 up to 2016	0.016	0.064	0.0004	0.0032	0.004	0.006	0.008	0.0001	0.219
Passenger Cars	Petrol	Large-SUV-Executive	PRE ECE - ECE 15/04	0.707	1.035	0.0004	0.0005	0.003	0.005	0.006	0.0001	5.228
Passenger Cars	Petrol	Large-SUV-Executive	Euro 1	0.105	0.168	0.0004	0.0259	0.003	0.005	0.007	0.0002	0.930
Passenger Cars	Petrol	Large-SUV-Executive	Euro 2	0.057	0.088	0.0004	0.0308	0.003	0.005	0.006	0.0002	0.474
Passenger Cars	Petrol	Large-SUV-Executive	Euro 3	0.028	0.054	0.0004	0.0060	0.003	0.005	0.007	0.0000	0.456
Passenger Cars	Petrol	Large-SUV-Executive	Euro 4	0.015	0.032	0.0004	0.0050	0.002	0.004	0.006	0.0000	0.132
Passenger Cars	Petrol	Large-SUV-Executive	Euro 5	0.010	0.033	0.0004	0.0024	0.003	0.004	0.006	0.0001	0.137
Passenger Cars	Petrol	Large-SUV-Executive	Euro 6 up to 2016	0.010	0.036	0.0004	0.0023	0.003	0.005	0.006	0.0001	0.129
Passenger Cars	Diesel	Small & Mini	Conventional	0.205	0.066	0.0004	0.0004	0.094	0.097	0.100	0.0501	0.278
Passenger Cars	Diesel	Small & Mini	Euro 1	0.291	0.024	0.0004	0.0004	0.038	0.042	0.044	0.0240	0.204
Passenger Cars	Diesel	Small & Mini	Euro 2	0.296	0.016	0.0004	0.0004	0.028	0.031	0.033	0.0192	0.153
Passenger Cars	Diesel	Small & Mini	Euro 3	0.335	0.009	0.0004	0.0004	0.021	0.024	0.027	0.0141	0.047
Passenger Cars	Diesel	Small & Mini	Euro 4	0.275	0.007	0.0004	0.0005	0.020	0.024	0.027	0.0140	0.049
Passenger Cars	Diesel	Small & Mini	Euro 5	0.275	0.001	0.0004	0.0008	0.005	0.009	0.011	0.0002	0.022
Passenger Cars	Diesel	Small & Mini	Euro 6 up to 2016	0.226	0.001	0.0004	0.0031	0.005	0.008	0.011	0.0002	0.027

				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	Diesel	Medium	Conventional	0.205	0.066	0.0004	0.0004	0.094	0.097	0.100	0.0501	0.278
Passenger Cars	Diesel	Medium	Euro 1	0.291	0.024	0.0004	0.0004	0.038	0.042	0.044	0.0240	0.204
Passenger Cars	Diesel	Medium	Euro 2	0.296	0.016	0.0004	0.0004	0.028	0.031	0.033	0.0192	0.153
Passenger Cars	Diesel	Medium	Euro 3	0.335	0.009	0.0004	0.0004	0.021	0.024	0.027	0.0141	0.047
Passenger Cars	Diesel	Medium	Euro 4	0.253	0.007	0.0004	0.0004	0.019	0.022	0.025	0.0129	0.045
Passenger Cars	Diesel	Medium	Euro 5	0.271	0.001	0.0004	0.0008	0.005	0.009	0.011	0.0002	0.022
Passenger Cars	Diesel	Medium	Euro 6 up to 2016	0.223	0.001	0.0004	0.0030	0.005	0.008	0.011	0.0002	0.027
Passenger Cars	Diesel	Large-SUV-Executive	Conventional	0.325	0.066	0.0004	0.0004	0.094	0.097	0.100	0.0501	0.278
Passenger Cars	Diesel	Large-SUV-Executive	Euro 1	0.215	0.027	0.0004	0.0003	0.028	0.031	0.033	0.0177	0.151
Passenger Cars	Diesel	Large-SUV-Executive	Euro 2	0.229	0.038	0.0004	0.0003	0.022	0.024	0.026	0.0148	0.118
Passenger Cars	Diesel	Large-SUV-Executive	Euro 3	0.247	0.014	0.0004	0.0003	0.015	0.018	0.020	0.0104	0.035
Passenger Cars	Diesel	Large-SUV-Executive	Euro 4	0.187	0.005	0.0004	0.0003	0.014	0.017	0.018	0.0095	0.033
Passenger Cars	Diesel	Large-SUV-Executive	Euro 5	0.200	0.000	0.0004	0.0006	0.004	0.006	0.008	0.0002	0.016
Passenger Cars	Diesel	Large-SUV-Executive	Euro 6 up to 2016	0.165	0.000	0.0004	0.0022	0.004	0.006	0.008	0.0001	0.020
Passenger Cars	Petrol Hybrid	All Segments	Euro 4	0.017	0.070	0.0004	0.0122	0.005	0.010	0.013	0.0000	0.285
Passenger Cars	Petrol Hybrid	All Segments	Euro 5	0.016	0.059	0.0004	0.0118	0.005	0.010	0.013	0.0000	0.263
Passenger Cars	Petrol Hybrid	All Segments	Euro 6 up to 2016	0.016	0.057	0.0004	0.0117	0.005	0.010	0.013	0.0000	0.266
Passenger Cars	LPG Bifuel	All Segments	Conventional	0.860	0.445	0.0000	0.0008	0.004	0.007	0.010	0.0002	2.099
Passenger Cars	LPG Bifuel	All Segments	Euro 1	0.174	0.330	0.0000	0.0379	0.004	0.008	0.010	0.0002	1.364
Passenger Cars	LPG Bifuel	All Segments	Euro 2	0.079	0.157	0.0000	0.0470	0.004	0.008	0.010	0.0002	0.954
Passenger Cars	LPG Bifuel	All Segments	Euro 3	0.040	0.052	0.0000	0.0083	0.004	0.007	0.009	0.0001	0.777
Passenger Cars	LPG Bifuel	All Segments	Euro 4	0.026	0.026	0.0000	0.0082	0.004	0.007	0.009	0.0001	0.258
Passenger Cars	LPG Bifuel	All Segments	Euro 5	0.021	0.026	0.0000	0.0040	0.004	0.007	0.009	0.0001	0.258
Passenger Cars	LPG Bifuel	All Segments	Euro 6	0.021	0.026	0.0000	0.0037	0.004	0.007	0.009	0.0001	0.258
Light Commercial Vehicles	Diesel	N1-I	Conventional	0.336	0.063	0.0004	0.0004	0.096	0.101	0.104	0.0499	0.276
Light Commercial Vehicles	Diesel	N1-I	Euro 1	0.214	0.025	0.0004	0.0003	0.031	0.035	0.038	0.0184	0.140
Light Commercial Vehicles	Diesel	N1-I	Euro 2	0.226	0.036	0.0004	0.0003	0.023	0.027	0.030	0.0148	0.105
Light Commercial Vehicles	Diesel	N1-I	Euro 3	0.251	0.014	0.0004	0.0003	0.017	0.021	0.024	0.0108	0.031
Light Commercial Vehicles	Diesel	N1-I	Euro 4	0.183	0.005	0.0004	0.0003	0.016	0.020	0.022	0.0096	0.029
Light Commercial Vehicles	Diesel	N1-I	Euro 5	0.198	0.000	0.0004	0.0006	0.006	0.009	0.012	0.0002	0.015

				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
Light Commercial Vehicles	Diesel	N1-I	Euro 6 up to 2016	0.163	0.000	0.0004	0.0023	0.005	0.009	0.012	0.0001	0.020
Light Commercial Vehicles	Diesel	N1-II & N1-III	Conventional	0.425	0.039	0.0004	0.0003	0.101	0.104	0.107	0.0533	0.362
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 1	0.363	0.045	0.0004	0.0003	0.035	0.039	0.042	0.0216	0.157
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 2	0.363	0.047	0.0004	0.0003	0.035	0.039	0.042	0.0247	0.157
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 3	0.305	0.030	0.0004	0.0003	0.025	0.029	0.031	0.0176	0.129
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 4	0.247	0.011	0.0004	0.0003	0.015	0.019	0.022	0.0094	0.102
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 5	0.414	0.000	0.0004	0.0006	0.005	0.009	0.011	0.0001	0.000
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 6 up to 2017	0.335	0.000	0.0004	0.0022	0.005	0.009	0.011	0.0001	0.000
Heavy Duty Trucks	Diesel	<=7,5 t	Conventional	0.844	0.182	0.0004	0.0006	0.059	0.065	0.067	0.0267	0.338
Heavy Duty Trucks	Diesel	<=7,5 t	Euro I	0.729	0.039	0.0004	0.0007	0.032	0.039	0.042	0.0167	0.137
Heavy Duty Trucks	Diesel	<=7,5 t	Euro II	0.811	0.026	0.0004	0.0008	0.021	0.028	0.031	0.0092	0.125
Heavy Duty Trucks	Diesel	<=7,5 t	Euro III	0.578	0.023	0.0004	0.0007	0.019	0.026	0.029	0.0090	0.130
Heavy Duty Trucks	Diesel	<=7,5 t	Euro IV	0.411	0.004	0.0004	0.0007	0.010	0.017	0.020	0.0025	0.072
Heavy Duty Trucks	Diesel	<=7,5 t	Euro V	0.294	0.003	0.0004	0.0028	0.011	0.018	0.021	0.0030	0.122
Heavy Duty Trucks	Diesel	<=7,5 t	Euro VI	0.026	0.002	0.0004	0.0022	0.007	0.014	0.017	0.0001	0.014
Heavy Duty Trucks	Diesel	7,5 - 20 t	Conventional	1.062	0.104	0.0004	0.0003	0.043	0.046	0.047	0.0197	0.288
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro I	0.749	0.046	0.0004	0.0004	0.032	0.036	0.038	0.0187	0.162
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro II	0.841	0.030	0.0004	0.0004	0.019	0.023	0.024	0.0096	0.141
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro III	0.635	0.026	0.0004	0.0004	0.018	0.022	0.024	0.0100	0.154
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro IV	0.457	0.004	0.0004	0.0004	0.007	0.011	0.013	0.0026	0.083
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro V	0.394	0.004	0.0004	0.0017	0.008	0.013	0.014	0.0032	0.136
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro VI	0.033	0.003	0.0004	0.0013	0.004	0.009	0.010	0.0001	0.015
Heavy Duty Trucks	Diesel	20 - 28 t	Conventional	0.930	0.045	0.0004	0.0003	0.037	0.040	0.042	0.0173	0.184
Heavy Duty Trucks	Diesel	20 - 28 t	Euro I	0.755	0.045	0.0004	0.0003	0.033	0.036	0.038	0.0197	0.174
Heavy Duty Trucks	Diesel	20 - 28 t	Euro II	0.835	0.030	0.0004	0.0003	0.019	0.022	0.024	0.0104	0.145
Heavy Duty Trucks	Diesel	20 - 28 t	Euro III	0.630	0.026	0.0004	0.0003	0.018	0.021	0.023	0.0105	0.167
Heavy Duty Trucks	Diesel	20 - 28 t	Euro IV	0.450	0.004	0.0004	0.0003	0.007	0.010	0.011	0.0026	0.082
Heavy Duty Trucks	Diesel	20 - 28 t	Euro V	0.371	0.004	0.0004	0.0011	0.008	0.011	0.012	0.0032	0.132
Heavy Duty Trucks	Diesel	20 - 28 t	Euro VI	0.029	0.003	0.0004	0.0009	0.004	0.007	0.008	0.0001	0.016
Heavy Duty Trucks	Diesel	28 - 40 t	Conventional	0.949	0.041	0.0004	0.0002	0.037	0.039	0.040	0.0172	0.181

				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	28 - 40 t	Euro I	0.766	0.043	0.0004	0.0003	0.033	0.036	0.037	0.0196	0.175
Heavy Duty Trucks	Diesel	28 - 40 t	Euro II	0.840	0.028	0.0004	0.0003	0.019	0.022	0.023	0.0106	0.149
Heavy Duty Trucks	Diesel	28 - 40 t	Euro III	0.655	0.024	0.0004	0.0003	0.017	0.020	0.021	0.0101	0.167
Heavy Duty Trucks	Diesel	28 - 40 t	Euro IV	0.469	0.004	0.0004	0.0003	0.006	0.009	0.010	0.0026	0.080
Heavy Duty Trucks	Diesel	28 - 40 t	Euro V	0.332	0.004	0.0004	0.0010	0.007	0.010	0.011	0.0032	0.137
Heavy Duty Trucks	Diesel	28 - 40 t	Euro VI	0.023	0.003	0.0004	0.0008	0.003	0.006	0.008	0.0001	0.013
Heavy Duty Trucks	Diesel	40 - 60 t	Conventional	0.958	0.038	0.0004	0.0006	0.037	0.040	0.042	0.0169	0.177
Heavy Duty Trucks	Diesel	40 - 60 t	Euro I	0.761	0.040	0.0004	0.0002	0.034	0.037	0.039	0.0196	0.177
Heavy Duty Trucks	Diesel	40 - 60 t	Euro II	0.826	0.026	0.0004	0.0002	0.021	0.024	0.026	0.0110	0.154
Heavy Duty Trucks	Diesel	40 - 60 t	Euro III	0.647	0.022	0.0004	0.0002	0.017	0.020	0.022	0.0098	0.166
Heavy Duty Trucks	Diesel	40 - 60 t	Euro IV	0.455	0.004	0.0004	0.0002	0.006	0.009	0.011	0.0024	0.073
Heavy Duty Trucks	Diesel	40 - 60 t	Euro V	0.260	0.003	0.0004	0.0007	0.007	0.010	0.012	0.0029	0.126
Heavy Duty Trucks	Diesel	40 - 60 t	Euro VI	0.018	0.002	0.0004	0.0006	0.004	0.006	0.008	0.0001	0.011
Buses	Diesel	Urban Buses Midi <=15 t	Conventional	0.764	0.274	0.0004	0.0002	0.079	0.082	0.082	0.0388	0.452
Buses	Diesel	Urban Buses Midi <=15 t	Euro I	0.747	0.053	0.0004	0.0002	0.034	0.037	0.038	0.0203	0.202
Buses	Diesel	Urban Buses Midi <=15 t	Euro II	0.872	0.040	0.0004	0.0002	0.018	0.021	0.022	0.0100	0.197
Buses	Diesel	Urban Buses Midi <=15 t	Euro III	0.815	0.035	0.0004	0.0002	0.018	0.020	0.021	0.0106	0.200
Buses	Diesel	Urban Buses Midi <=15 t	Euro IV	0.519	0.005	0.0004	0.0003	0.007	0.010	0.011	0.0030	0.120
Buses	Diesel	Urban Buses Midi <=15 t	Euro V	0.699	0.005	0.0004	0.0003	0.008	0.011	0.012	0.0037	0.218
Buses	Diesel	Urban Buses Midi <=15 t	Euro VI	0.055	0.003	0.0004	0.0003	0.003	0.007	0.008	0.0001	0.026
Buses	Diesel	Urban Buses Standard 15 - 18 t	Conventional	0.971	0.136	0.0004	0.0001	0.057	0.059	0.059	0.0277	0.378
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro I	0.739	0.056	0.0004	0.0002	0.035	0.037	0.037	0.0212	0.200
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro II	0.857	0.042	0.0004	0.0002	0.018	0.020	0.021	0.0102	0.200
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro III	0.789	0.036	0.0004	0.0002	0.017	0.019	0.020	0.0106	0.205
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro IV	0.503	0.006	0.0004	0.0002	0.006	0.009	0.009	0.0031	0.114
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro V	0.665	0.005	0.0004	0.0002	0.007	0.010	0.010	0.0037	0.213
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro VI	0.043	0.003	0.0004	0.0002	0.003	0.005	0.006	0.0001	0.024
Buses	Diesel	Urban Buses Articulated >18 t	Conventional	1.001	0.120	0.0004	0.0001	0.057	0.059	0.059	0.0278	0.389
Buses	Diesel	Urban Buses Articulated >18 t	Euro I	0.746	0.050	0.0004	0.0001	0.034	0.036	0.037	0.0209	0.215
Buses	Diesel	Urban Buses Articulated >18 t	Euro II	0.828	0.035	0.0004	0.0001	0.018	0.020	0.021	0.0107	0.219

				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
Buses	Diesel	Urban Buses Articulated >18 t	Euro III	0.779	0.032	0.0004	0.0001	0.017	0.018	0.019	0.0103	0.218
Buses	Diesel	Urban Buses Articulated >18 t	Euro IV	0.519	0.005	0.0004	0.0002	0.006	0.008	0.009	0.0031	0.109
Buses	Diesel	Urban Buses Articulated >18 t	Euro V	0.558	0.004	0.0004	0.0002	0.007	0.009	0.010	0.0035	0.215
Buses	Diesel	Urban Buses Articulated >18 t	Euro VI	0.027	0.003	0.0004	0.0001	0.002	0.004	0.005	0.0001	0.022
Buses	Diesel	Coaches	Conventional	0.920	0.047	0.0004	0.0003	0.036	0.039	0.040	0.0169	0.179
Buses	Diesel	Coaches	Euro I	0.770	0.049	0.0004	0.0003	0.032	0.035	0.036	0.0189	0.166
Buses	Diesel	Coaches	Euro II	0.854	0.033	0.0004	0.0003	0.019	0.021	0.023	0.0101	0.136
Buses	Diesel	Coaches	Euro III	0.654	0.032	0.0004	0.0003	0.018	0.021	0.022	0.0106	0.162
Buses	Diesel	Coaches	Euro IV	0.464	0.005	0.0004	0.0003	0.007	0.009	0.011	0.0027	0.086
Buses	Diesel	Coaches	Euro V	0.369	0.004	0.0004	0.0003	0.007	0.010	0.012	0.0034	0.138
Buses	Diesel	Coaches	Euro VI	0.028	0.003	0.0004	0.0003	0.003	0.006	0.007	0.0001	0.018
Buses	CNG	Urban CNG Buses	Euro III	0.457	0.001	0.0000	0.0000	0.002	0.004	0.004	0.0000	0.046
Buses	CNG	Urban CNG Buses	EEV	0.208	0.011	0.0000	0.0000	0.002	0.004	0.004	0.0000	0.054
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Conventional	0.048	7.535	0.0004	0.0009	0.155	0.160	0.162	0.0302	12.619
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 1	0.192	3.980	0.0004	0.0011	0.054	0.059	0.062	0.0048	4.918
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 2	0.182	3.087	0.0004	0.0011	0.033	0.038	0.041	0.0056	3.003
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 3	0.183	2.135	0.0004	0.0011	0.025	0.030	0.033	0.0039	1.940
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Conventional	0.048	7.535	0.0004	0.0009	0.155	0.160	0.162	0.0151	12.619
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 1	0.235	1.178	0.0004	0.0011	0.048	0.053	0.056	0.0086	7.163
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 2	0.182	1.145	0.0004	0.0011	0.013	0.018	0.021	0.0015	4.505
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 3	0.183	0.776	0.0004	0.0011	0.010	0.015	0.018	0.0009	2.911
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Conventional	0.021	6.999	0.0004	0.0014	0.145	0.147	0.149	0.0142	12.807
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 1	0.034	2.658	0.0004	0.0015	0.065	0.068	0.070	0.0123	9.207
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 2	0.039	1.538	0.0004	0.0015	0.034	0.037	0.039	0.0062	7.305
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 3	0.019	0.988	0.0004	0.0016	0.013	0.016	0.017	0.0019	4.049
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Conventional	0.255	1.064	0.0004	0.0015	0.018	0.021	0.023	0.0022	12.994
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 1	0.327	1.109	0.0004	0.0018	0.022	0.025	0.028	0.0045	11.663
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 2	0.326	0.638	0.0004	0.0021	0.010	0.014	0.017	0.0013	5.217
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 3	0.288	0.437	0.0004	0.0021	0.010	0.014	0.017	0.0013	2.888
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Conventional	0.189	1.448	0.0004	0.0011	0.013	0.016	0.017	0.0017	12.531

				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 - 750 cm³	Euro 1	0.192	0.940	0.0004	0.0012	0.014	0.017	0.018	0.0030	6.712
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 2	0.077	0.556	0.0004	0.0013	0.006	0.009	0.010	0.0008	2.202
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 3	0.039	0.377	0.0004	0.0013	0.006	0.009	0.010	0.0008	1.219
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Conventional	0.084	1.353	0.0004	0.0010	0.012	0.014	0.015	0.0014	10.855
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 1	0.104	0.745	0.0004	0.0010	0.012	0.014	0.015	0.0025	5.624
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 2	0.094	0.384	0.0004	0.0010	0.005	0.007	0.008	0.0006	1.722
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 3	0.049	0.258	0.0004	0.0010	0.005	0.007	0.008	0.0006	0.953

Annex Table 7 - Road transportation energy based implied emission factors (g/GJ) for 2016 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	0.16	0.30	0.20	0.01	4.62	118.06	2.38	0.33	54.71
Passenger Cars	Petrol	Small & Mini	Euro 1	0.16	0.32	0.20	0.01	4.86	124.59	2.51	0.35	57.71
Passenger Cars	Petrol	Small & Mini	Euro 2	0.16	0.32	0.20	0.01	4.91	125.83	2.53	0.35	58.28
Passenger Cars	Petrol	Small & Mini	Euro 3	0.16	0.32	0.20	0.01	4.80	122.88	2.47	0.34	56.93
Passenger Cars	Petrol	Small & Mini	Euro 4	0.16	0.33	0.20	0.01	5.06	129.66	2.61	0.36	60.03
Passenger Cars	Petrol	Small & Mini	Euro 5	0.16	0.30	0.20	0.01	4.76	121.18	2.39	0.33	55.89
Passenger Cars	Petrol	Small & Mini	Euro 6 up to 2016	0.16	0.29	0.20	0.01	4.71	118.70	2.29	0.32	54.43
Passenger Cars	Petrol	Medium	PRE ECE - ECE 15/04	0.15	0.25	0.20	0.01	3.87	98.39	1.99	0.28	45.71
Passenger Cars	Petrol	Medium	Euro 1	0.16	0.27	0.20	0.01	4.09	104.04	2.10	0.29	48.31
Passenger Cars	Petrol	Medium	Euro 2	0.16	0.27	0.20	0.01	4.16	106.08	2.14	0.30	49.24
Passenger Cars	Petrol	Medium	Euro 3	0.16	0.26	0.20	0.01	4.04	102.73	2.08	0.29	47.71
Passenger Cars	Petrol	Medium	Euro 4	0.16	0.26	0.20	0.01	3.94	100.16	2.03	0.28	46.53
Passenger Cars	Petrol	Medium	Euro 5	0.16	0.25	0.20	0.01	3.90	98.42	1.95	0.27	45.53
Passenger Cars	Petrol	Medium	Euro 6 up to 2016	0.16	0.23	0.20	0.01	3.84	96.22	1.87	0.26	44.26
Passenger Cars	Petrol	Large-SUV-Executive	PRE ECE - ECE 15/04	0.15	0.20	0.20	0.01	3.02	76.10	1.55	0.22	35.51
Passenger Cars	Petrol	Large-SUV-Executive	Euro 1	0.16	0.21	0.20	0.01	3.21	80.84	1.64	0.23	37.70
Passenger Cars	Petrol	Large-SUV-Executive	Euro 2	0.16	0.20	0.20	0.01	3.09	77.83	1.59	0.22	36.32
Passenger Cars	Petrol	Large-SUV-Executive	Euro 3	0.16	0.22	0.20	0.01	3.38	85.47	1.74	0.24	39.82
Passenger Cars	Petrol	Large-SUV-Executive	Euro 4	0.16	0.19	0.20	0.01	2.88	72.25	1.48	0.20	33.77
Passenger Cars	Petrol	Large-SUV-Executive	Euro 5	0.15	0.18	0.20	0.01	2.85	71.00	1.42	0.20	33.04
Passenger Cars	Petrol	Large-SUV-Executive	Euro 6 up to 2016	0.15	0.17	0.20	0.01	2.81	69.43	1.36	0.19	32.13
Passenger Cars	Diesel	Small & Mini	Conventional	0.01	0.29	0.12	0.00	4.51	114.18	2.28	0.32	52.74
Passenger Cars	Diesel	Small & Mini	Euro 1	0.01	0.34	0.12	0.00	5.22	133.04	2.65	0.37	61.39
Passenger Cars	Diesel	Small & Mini	Euro 2	0.01	0.33	0.12	0.00	4.99	126.91	2.53	0.36	58.58
Passenger Cars	Diesel	Small & Mini	Euro 3	0.01	0.34	0.12	0.00	5.22	132.98	2.65	0.37	61.36
Passenger Cars	Diesel	Small & Mini	Euro 4	0.01	0.37	0.12	0.00	5.65	144.41	2.88	0.41	66.60
Passenger Cars	Diesel	Small & Mini	Euro 5	0.01	0.33	0.12	0.00	5.21	131.86	2.57	0.36	60.51
Passenger Cars	Diesel	Small & Mini	Euro 6 up to 2016	0.01	0.31	0.12	0.00	5.12	128.08	2.42	0.34	58.34
Passenger Cars	Diesel	Medium	Conventional	0.01	0.29	0.12	0.00	4.51	114.18	2.28	0.32	52.74
Passenger Cars	Diesel	Medium	Euro 1	0.01	0.34	0.12	0.00	5.22	133.04	2.65	0.37	61.39

				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	Diesel	Medium	Euro 2	0.01	0.33	0.12	0.00	4.99	126.91	2.53	0.36	58.58
Passenger Cars	Diesel	Medium	Euro 3	0.01	0.34	0.12	0.00	5.22	132.98	2.65	0.37	61.36
Passenger Cars	Diesel	Medium	Euro 4	0.01	0.34	0.12	0.00	5.22	132.98	2.65	0.37	61.36
Passenger Cars	Diesel	Medium	Euro 5	0.01	0.33	0.12	0.00	5.15	130.19	2.54	0.36	59.74
Passenger Cars	Diesel	Medium	Euro 6 up to 2016	0.01	0.30	0.12	0.00	5.06	126.69	2.39	0.34	57.72
Passenger Cars	Diesel	Large-SUV-Executive	Conventional	0.01	0.29	0.12	0.00	4.51	114.18	2.28	0.32	52.74
Passenger Cars	Diesel	Large-SUV-Executive	Euro 1	0.01	0.25	0.12	0.00	3.91	98.27	1.96	0.28	45.44
Passenger Cars	Diesel	Large-SUV-Executive	Euro 2	0.01	0.25	0.12	0.00	3.91	98.27	1.96	0.28	45.44
Passenger Cars	Diesel	Large-SUV-Executive	Euro 3	0.01	0.25	0.12	0.00	3.91	98.27	1.96	0.28	45.44
Passenger Cars	Diesel	Large-SUV-Executive	Euro 4	0.01	0.25	0.12	0.00	3.91	98.27	1.96	0.28	45.44
Passenger Cars	Diesel	Large-SUV-Executive	Euro 5	0.01	0.24	0.12	0.00	3.86	96.20	1.88	0.27	44.24
Passenger Cars	Diesel	Large-SUV-Executive	Euro 6 up to 2016	0.01	0.23	0.12	0.00	3.79	93.62	1.77	0.25	42.74
Passenger Cars	Petrol Hybrid	All Segments	Euro 4	0.16	0.44	0.20	0.01	6.74	173.97	3.48	0.49	80.30
Passenger Cars	Petrol Hybrid	All Segments	Euro 5	0.16	0.42	0.20	0.01	6.52	167.11	3.28	0.46	76.81
Passenger Cars	Petrol Hybrid	All Segments	Euro 6 up to 2016	0.16	0.40	0.20	0.01	6.44	163.88	3.14	0.44	74.88
Passenger Cars	LPG Bifuel	All Segments	Conventional	0.01	0.29	0.00	0.00	4.35	114.61	2.26	0.32	52.43
Passenger Cars	LPG Bifuel	All Segments	Euro 1	0.01	0.29	0.00	0.00	4.38	115.64	2.28	0.32	52.90
Passenger Cars	LPG Bifuel	All Segments	Euro 2	0.01	0.29	0.00	0.00	4.38	115.64	2.28	0.32	52.90
Passenger Cars	LPG Bifuel	All Segments	Euro 3	0.01	0.29	0.00	0.00	4.38	115.64	2.28	0.32	52.90
Passenger Cars	LPG Bifuel	All Segments	Euro 4	0.01	0.29	0.00	0.00	4.38	115.64	2.28	0.32	52.90
Passenger Cars	LPG Bifuel	All Segments	Euro 5	0.01	0.28	0.00	0.00	4.34	113.64	2.20	0.31	51.75
Passenger Cars	LPG Bifuel	All Segments	Euro 6	0.01	0.27	0.00	0.00	4.27	111.15	2.10	0.29	50.31
Light Commercial Vehicles	Diesel	N1-I	Conventional	0.01	0.33	0.12	0.00	6.36	156.04	2.69	0.38	71.06
Light Commercial Vehicles	Diesel	N1-I	Euro 1	0.01	0.28	0.12	0.00	5.34	130.32	2.25	0.32	59.41
Light Commercial Vehicles	Diesel	N1-I	Euro 2	0.01	0.28	0.12	0.00	5.34	130.32	2.25	0.32	59.41
Light Commercial Vehicles	Diesel	N1-I	Euro 3	0.01	0.28	0.12	0.00	5.34	130.32	2.25	0.32	59.41
Light Commercial Vehicles	Diesel	N1-I	Euro 4	0.01	0.28	0.12	0.00	5.34	130.32	2.25	0.32	59.41
Light Commercial Vehicles	Diesel	N1-I	Euro 5	0.01	0.27	0.12	0.00	5.29	128.17	2.16	0.31	58.16
Light Commercial Vehicles	Diesel	N1-I	Euro 6 up to 2016	0.01	0.25	0.12	0.00	5.23	125.48	2.05	0.29	56.61
Light Commercial Vehicles	Diesel	N1-II & N1-III	Conventional	0.01	0.24	0.12	0.00	4.56	110.40	1.90	0.27	50.38
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 1	0.01	0.26	0.12	0.00	5.07	123.38	2.13	0.30	56.26

Category	Fuel	Segment	Euro Standard	Priority Heavy Metals			Additional Heavy Metals					
				Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
				g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 2	0.01	0.26	0.12	0.00	5.07	123.38	2.13	0.30	56.26
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 3	0.01	0.26	0.12	0.00	5.07	123.38	2.13	0.30	56.26
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 4	0.01	0.26	0.12	0.00	5.07	123.38	2.13	0.30	56.26
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 5	0.01	0.25	0.12	0.00	5.02	121.33	2.04	0.29	55.08
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 6 up to 2017	0.01	0.23	0.12	0.00	4.94	118.28	1.92	0.27	53.31
Heavy Duty Trucks	Diesel	<=7,5 t	Conventional	0.02	0.22	0.12	0.00	8.02	183.26	2.09	0.25	58.70
Heavy Duty Trucks	Diesel	<=7,5 t	Euro I	0.02	0.27	0.12	0.00	9.67	222.06	2.53	0.31	71.05
Heavy Duty Trucks	Diesel	<=7,5 t	Euro II	0.02	0.28	0.12	0.00	10.06	231.15	2.63	0.32	73.95
Heavy Duty Trucks	Diesel	<=7,5 t	Euro III	0.02	0.27	0.12	0.00	9.55	219.28	2.50	0.30	70.17
Heavy Duty Trucks	Diesel	<=7,5 t	Euro IV	0.02	0.27	0.12	0.00	9.65	221.51	2.52	0.31	70.88
Heavy Duty Trucks	Diesel	<=7,5 t	Euro V	0.02	0.28	0.12	0.00	9.95	228.51	2.60	0.32	73.10
Heavy Duty Trucks	Diesel	<=7,5 t	Euro VI	0.02	0.28	0.12	0.00	9.83	225.66	2.57	0.31	72.20
Heavy Duty Trucks	Diesel	7,5 - 20 t	Conventional	0.01	0.13	0.13	0.00	4.68	105.24	1.20	0.15	33.97
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro I	0.01	0.15	0.13	0.00	5.53	124.98	1.43	0.17	40.27
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro II	0.01	0.16	0.13	0.00	5.81	131.62	1.50	0.18	42.39
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro III	0.01	0.16	0.13	0.00	5.61	126.90	1.45	0.18	40.88
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro IV	0.01	0.16	0.13	0.00	5.79	131.19	1.50	0.18	42.24
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro V	0.01	0.17	0.13	0.00	6.01	136.36	1.56	0.19	43.90
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro VI	0.01	0.17	0.13	0.00	5.93	134.36	1.54	0.19	43.26
Heavy Duty Trucks	Diesel	20 - 28 t	Conventional	0.01	0.10	0.13	0.00	3.50	77.31	0.90	0.12	28.73
Heavy Duty Trucks	Diesel	20 - 28 t	Euro I	0.01	0.11	0.13	0.00	3.97	88.34	1.03	0.14	32.77
Heavy Duty Trucks	Diesel	20 - 28 t	Euro II	0.01	0.11	0.13	0.00	4.07	90.57	1.05	0.14	33.59
Heavy Duty Trucks	Diesel	20 - 28 t	Euro III	0.01	0.11	0.13	0.00	3.92	87.18	1.01	0.13	32.34
Heavy Duty Trucks	Diesel	20 - 28 t	Euro IV	0.01	0.11	0.13	0.00	4.03	89.63	1.04	0.14	33.24
Heavy Duty Trucks	Diesel	20 - 28 t	Euro V	0.01	0.12	0.13	0.00	4.14	92.37	1.07	0.14	34.25
Heavy Duty Trucks	Diesel	20 - 28 t	Euro VI	0.01	0.12	0.13	0.00	4.08	90.97	1.06	0.14	33.73
Heavy Duty Trucks	Diesel	28 - 40 t	Conventional	0.01	0.09	0.13	0.00	3.10	68.02	0.79	0.11	25.70
Heavy Duty Trucks	Diesel	28 - 40 t	Euro I	0.01	0.10	0.13	0.00	3.49	77.00	0.90	0.12	28.61
Heavy Duty Trucks	Diesel	28 - 40 t	Euro II	0.01	0.10	0.13	0.00	3.56	78.71	0.92	0.12	29.30
Heavy Duty Trucks	Diesel	28 - 40 t	Euro III	0.01	0.10	0.13	0.00	3.47	76.51	0.89	0.12	28.43
Heavy Duty Trucks	Diesel	28 - 40 t	Euro IV	0.01	0.10	0.13	0.00	3.56	78.75	0.92	0.12	29.25

				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	28 - 40 t	Euro V	0.01	0.10	0.13	0.00	3.66	80.93	0.94	0.12	30.05
Heavy Duty Trucks	Diesel	28 - 40 t	Euro VI	0.01	0.10	0.13	0.00	3.63	80.40	0.94	0.12	29.86
Heavy Duty Trucks	Diesel	40 - 60 t	Conventional	0.01	0.08	0.13	0.00	2.80	60.46	0.74	0.12	31.04
Heavy Duty Trucks	Diesel	40 - 60 t	Euro I	0.01	0.09	0.13	0.00	3.12	67.96	0.83	0.13	34.85
Heavy Duty Trucks	Diesel	40 - 60 t	Euro II	0.01	0.09	0.13	0.00	3.13	68.04	0.83	0.13	34.89
Heavy Duty Trucks	Diesel	40 - 60 t	Euro III	0.01	0.08	0.13	0.00	2.86	61.92	0.75	0.12	31.78
Heavy Duty Trucks	Diesel	40 - 60 t	Euro IV	0.01	0.08	0.13	0.00	2.70	58.26	0.71	0.11	29.92
Heavy Duty Trucks	Diesel	40 - 60 t	Euro V	0.01	0.08	0.13	0.00	2.75	59.28	0.72	0.11	30.44
Heavy Duty Trucks	Diesel	40 - 60 t	Euro VI	0.01	0.08	0.13	0.00	2.73	58.75	0.72	0.11	30.17
Buses	Diesel	Urban Buses Midi <=15 t	Conventional	0.01	0.25	0.12	0.00	3.91	98.70	1.94	0.26	37.81
Buses	Diesel	Urban Buses Midi <=15 t	Euro I	0.01	0.32	0.12	0.00	5.00	127.79	2.51	0.33	48.85
Buses	Diesel	Urban Buses Midi <=15 t	Euro II	0.01	0.34	0.12	0.00	5.29	135.43	2.66	0.35	51.75
Buses	Diesel	Urban Buses Midi <=15 t	Euro III	0.01	0.32	0.12	0.00	4.98	127.36	2.51	0.33	48.68
Buses	Diesel	Urban Buses Midi <=15 t	Euro IV	0.01	0.38	0.12	0.00	5.83	150.03	2.95	0.39	57.28
Buses	Diesel	Urban Buses Midi <=15 t	Euro V	0.01	0.26	0.12	0.00	5.38	130.77	2.13	0.27	45.89
Buses	Diesel	Urban Buses Midi <=15 t	Euro VI	0.01	0.11	0.13	0.00	4.64	102.83	1.06	0.12	30.38
Buses	Diesel	Urban Buses Standard 15 - 18 t	Conventional	0.01	0.20	0.12	0.00	3.18	79.33	1.56	0.21	30.47
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro I	0.01	0.24	0.12	0.00	3.82	96.50	1.90	0.25	36.98
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro II	0.01	0.26	0.12	0.00	4.01	101.40	2.00	0.26	38.84
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro III	0.01	0.24	0.12	0.00	3.82	96.40	1.90	0.25	36.94
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro IV	0.01	0.28	0.12	0.00	4.35	110.51	2.17	0.29	42.29
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro V	0.01	0.19	0.12	0.00	4.05	97.31	1.59	0.20	34.24
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro VI	0.01	0.08	0.13	0.00	3.51	76.66	0.79	0.09	22.74
Buses	Diesel	Urban Buses Articulated >18 t	Conventional	0.01	0.17	0.12	0.00	2.69	66.37	1.31	0.18	27.37
Buses	Diesel	Urban Buses Articulated >18 t	Euro I	0.01	0.20	0.12	0.00	3.16	78.74	1.56	0.21	32.41
Buses	Diesel	Urban Buses Articulated >18 t	Euro II	0.01	0.21	0.12	0.00	3.24	80.91	1.60	0.22	33.29
Buses	Diesel	Urban Buses Articulated >18 t	Euro III	0.01	0.20	0.12	0.00	3.16	78.76	1.56	0.21	32.41
Buses	Diesel	Urban Buses Articulated >18 t	Euro IV	0.01	0.22	0.12	0.00	3.52	88.27	1.75	0.24	36.29
Buses	Diesel	Urban Buses Articulated >18 t	Euro V	0.01	0.16	0.12	0.00	3.24	76.77	1.26	0.17	29.54
Buses	Diesel	Urban Buses Articulated >18 t	Euro VI	0.01	0.07	0.13	0.00	2.80	60.20	0.63	0.08	20.33
Buses	Diesel	Coaches	Conventional	0.01	0.12	0.13	0.00	3.70	83.34	1.05	0.14	29.87

				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
Buses	Diesel	Coaches	Euro I	0.01	0.13	0.13	0.00	3.86	87.03	1.11	0.15	32.61
Buses	Diesel	Coaches	Euro II	0.01	0.12	0.13	0.00	3.85	86.83	1.11	0.15	32.81
Buses	Diesel	Coaches	Euro III	0.01	0.12	0.13	0.00	3.79	85.52	1.09	0.14	32.46
Buses	Diesel	Coaches	Euro IV	0.01	0.13	0.13	0.00	3.85	86.89	1.11	0.15	33.11
Buses	Diesel	Coaches	Euro V	0.01	0.12	0.13	0.00	3.71	83.25	1.04	0.14	31.55
Buses	Diesel	Coaches	Euro VI	0.01	0.11	0.13	0.00	3.59	80.04	0.98	0.13	30.38
Buses	CNG	Urban CNG Buses	Euro III	0.01	0.20	0.00	0.00	3.01	80.17	1.58	0.21	30.41
Buses	CNG	Urban CNG Buses	EEV	0.01	0.13	0.00	0.00	2.55	64.49	1.05	0.13	22.44
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Conventional	0.15	4.05	0.19	0.01	21.78	787.47	28.72	4.07	430.01
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 1	0.16	5.05	0.19	0.01	27.10	980.75	35.76	5.06	535.38
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 2	0.16	5.06	0.19	0.01	27.18	983.87	35.87	5.08	537.09
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 3	0.16	5.09	0.19	0.01	27.32	988.89	36.05	5.11	539.83
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Conventional	0.15	4.05	0.19	0.01	21.78	787.47	28.72	4.07	430.01
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 1	0.16	5.05	0.19	0.01	27.10	980.75	35.76	5.06	535.38
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 2	0.16	5.06	0.19	0.01	27.18	983.87	35.87	5.08	537.09
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 3	0.16	5.09	0.19	0.01	27.32	988.89	36.05	5.11	539.83
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Conventional	0.15	3.33	0.19	0.01	17.06	628.74	23.55	3.34	349.73
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 1	0.15	3.63	0.19	0.01	18.58	685.15	25.65	3.64	381.05
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 2	0.15	3.64	0.19	0.01	18.63	687.20	25.73	3.65	382.19
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 3	0.15	3.66	0.19	0.01	18.71	690.10	25.84	3.67	383.81
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Conventional	0.16	0.19	0.20	0.01	3.98	95.67	1.58	0.21	40.51
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 1	0.16	0.23	0.20	0.01	4.81	116.26	1.91	0.26	49.08
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 2	0.16	0.27	0.20	0.01	5.63	136.72	2.23	0.30	57.59
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 3	0.16	0.27	0.20	0.01	5.65	137.16	2.24	0.30	57.78
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Conventional	0.15	0.14	0.20	0.01	3.00	71.30	1.19	0.16	30.37
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 1	0.15	0.15	0.20	0.01	3.22	76.71	1.28	0.17	32.63
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 2	0.16	0.17	0.20	0.01	3.52	84.24	1.40	0.19	35.76
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 3	0.16	0.17	0.20	0.01	3.53	84.51	1.40	0.19	35.87
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Conventional	0.15	0.12	0.20	0.01	2.62	61.77	1.04	0.14	26.41
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 1	0.15	0.13	0.20	0.01	2.72	64.29	1.08	0.14	27.46
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 2	0.15	0.13	0.20	0.01	2.79	65.92	1.10	0.15	28.14

				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 >750 cm³	Euro 3	0.15	0.13	0.20	0.01	2.79	66.10	1.11	0.15	28.21

Annex Table 8 - Road transportation distance based implied emission factor (mg/km) for 2016 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	1,891.67	2,826.44	1.14	2.00	11.78	19.85	25.41	0.47	14,903.08
Passenger Cars	Petrol	Small & Mini	Euro 1	420.71	900.24	1.09	97.71	11.78	19.85	25.41	0.60	4,529.42
Passenger Cars	Petrol	Small & Mini	Euro 2	243.46	567.95	1.08	120.20	11.78	19.85	25.41	0.60	2,590.72
Passenger Cars	Petrol	Small & Mini	Euro 3	106.41	311.62	1.11	21.54	10.41	18.48	24.04	0.16	2,259.37
Passenger Cars	Petrol	Small & Mini	Euro 4	67.92	240.90	1.05	21.41	10.41	18.48	24.04	0.16	740.40
Passenger Cars	Petrol	Small & Mini	Euro 5	44.94	190.69	1.10	10.17	10.92	18.99	24.54	0.23	761.54
Passenger Cars	Petrol	Small & Mini	Euro 6 up to 2016	48.37	202.15	1.10	9.77	10.96	19.04	24.59	0.24	728.98
Passenger Cars	Petrol	Medium	PRE ECE - ECE 15/04	2,387.99	2,904.80	1.37	2.00	11.78	19.85	25.41	0.47	14,938.32
Passenger Cars	Petrol	Medium	Euro 1	421.00	763.58	1.31	98.10	11.78	19.85	25.41	0.60	4,192.16
Passenger Cars	Petrol	Medium	Euro 2	243.67	420.94	1.28	121.36	11.78	19.85	25.41	0.60	2,347.89
Passenger Cars	Petrol	Medium	Euro 3	106.50	236.30	1.33	21.58	10.41	18.48	24.04	0.16	2,050.27
Passenger Cars	Petrol	Medium	Euro 4	67.97	163.86	1.36	21.32	10.41	18.48	24.04	0.16	679.69
Passenger Cars	Petrol	Medium	Euro 5	44.99	163.60	1.36	10.31	10.92	18.99	24.54	0.23	700.83
Passenger Cars	Petrol	Medium	Euro 6 up to 2016	48.42	194.17	1.36	9.76	10.96	19.04	24.59	0.24	668.27
Passenger Cars	Petrol	Large-SUV-Executive	PRE ECE - ECE 15/04	2,839.53	4,157.47	1.75	2.00	11.78	19.85	25.41	0.33	20,991.29
Passenger Cars	Petrol	Large-SUV-Executive	Euro 1	395.91	635.51	1.69	97.91	11.78	19.85	25.41	0.60	3,516.15
Passenger Cars	Petrol	Large-SUV-Executive	Euro 2	225.60	347.12	1.75	120.96	11.78	19.85	25.41	0.60	1,861.16
Passenger Cars	Petrol	Large-SUV-Executive	Euro 3	98.47	193.75	1.60	21.56	10.41	18.48	24.04	0.16	1,631.14
Passenger Cars	Petrol	Large-SUV-Executive	Euro 4	63.45	135.13	1.89	21.33	10.41	18.48	24.04	0.16	558.01
Passenger Cars	Petrol	Large-SUV-Executive	Euro 5	40.48	137.96	1.89	10.09	10.92	18.99	24.54	0.23	579.15
Passenger Cars	Petrol	Large-SUV-Executive	Euro 6 up to 2016	43.91	153.23	1.89	9.76	10.96	19.04	24.59	0.24	546.59
Passenger Cars	Diesel	Small & Mini	Conventional	553.94	178.06	1.20	1.00	255.37	263.45	269.00	135.30	750.49
Passenger Cars	Diesel	Small & Mini	Euro 1	674.73	54.83	1.03	1.00	88.95	97.03	102.58	55.71	473.38
Passenger Cars	Diesel	Small & Mini	Euro 2	719.00	39.95	1.08	1.00	67.58	75.66	81.21	46.57	371.61
Passenger Cars	Diesel	Small & Mini	Euro 3	776.95	22.03	1.03	1.00	47.97	56.04	61.59	32.80	108.98
Passenger Cars	Diesel	Small & Mini	Euro 4	586.94	15.62	0.94	1.00	43.78	51.85	57.40	29.93	104.34
Passenger Cars	Diesel	Small & Mini	Euro 5	628.95	1.28	1.01	1.90	12.23	20.31	25.86	0.57	51.44
Passenger Cars	Diesel	Small & Mini	Euro 6 up to 2016	518.06	1.28	1.01	7.00	11.42	19.49	25.04	0.41	61.94

				Main Pollutants				Particulate Matter				Other
				NOx (as NO_2)	NMVOC	SOx (as SO_2)	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
Category	**Fuel**	**Segment**	**Euro Standard**	**mg/km**	**mg/km**	**mg/km**	**mg/km**	**mg/km**	**mg/km**	**mg/km**	**mg/km**	**mg/km**
Passenger Cars	Diesel	Medium	Conventional	553.94	178.06	1.20	1.00	255.37	263.45	269.00	135.30	750.49
Passenger Cars	Diesel	Medium	Euro 1	674.73	54.83	1.03	1.00	88.95	97.03	102.58	55.71	473.38
Passenger Cars	Diesel	Medium	Euro 2	719.00	39.95	1.08	1.00	67.58	75.66	81.21	46.57	371.61
Passenger Cars	Diesel	Medium	Euro 3	776.95	22.03	1.03	1.00	47.97	56.04	61.59	32.80	108.98
Passenger Cars	Diesel	Medium	Euro 4	586.94	15.62	1.03	1.00	43.78	51.85	57.40	29.93	104.34
Passenger Cars	Diesel	Medium	Euro 5	628.95	1.28	1.03	1.90	12.23	20.31	25.86	0.57	51.44
Passenger Cars	Diesel	Medium	Euro 6 up to 2016	518.06	1.28	1.03	7.00	11.42	19.49	25.04	0.41	61.94
Passenger Cars	Diesel	Large-SUV-Executive	Conventional	877.23	178.06	1.20	1.00	255.37	263.45	269.00	135.30	750.49
Passenger Cars	Diesel	Large-SUV-Executive	Euro 1	674.73	84.40	1.39	1.00	88.95	97.03	102.58	55.71	473.38
Passenger Cars	Diesel	Large-SUV-Executive	Euro 2	719.00	119.54	1.39	1.00	67.58	75.66	81.21	46.57	371.61
Passenger Cars	Diesel	Large-SUV-Executive	Euro 3	776.95	45.46	1.39	1.00	47.97	56.04	61.59	32.80	108.98
Passenger Cars	Diesel	Large-SUV-Executive	Euro 4	586.94	15.62	1.39	1.00	43.78	51.85	57.40	29.93	104.34
Passenger Cars	Diesel	Large-SUV-Executive	Euro 5	628.95	1.28	1.39	1.90	12.23	20.31	25.86	0.57	51.44
Passenger Cars	Diesel	Large-SUV-Executive	Euro 6 up to 2016	518.06	1.28	1.39	7.00	11.42	19.49	25.04	0.41	61.94
Passenger Cars	Petrol Hybrid	All Segments	Euro 4	29.15	123.71	0.78	21.45	9.37	17.45	23.00	0.00	500.33
Passenger Cars	Petrol Hybrid	All Segments	Euro 5	29.18	106.57	0.80	21.18	9.37	17.45	23.00	0.00	472.75
Passenger Cars	Petrol Hybrid	All Segments	Euro 6 up to 2016	29.18	101.81	0.80	21.02	9.37	17.45	23.00	0.00	475.63
Passenger Cars	LPG Bifuel	All Segments	Conventional	2,289.48	1,183.45	0.00	2.00	11.78	19.85	25.40	0.48	5,587.72
Passenger Cars	LPG Bifuel	All Segments	Euro 1	459.33	870.30	0.00	99.92	11.78	19.85	25.40	0.60	3,597.96
Passenger Cars	LPG Bifuel	All Segments	Euro 2	208.82	413.25	0.00	123.96	11.78	19.85	25.40	0.60	2,516.73
Passenger Cars	LPG Bifuel	All Segments	Euro 3	106.50	137.07	0.00	21.81	10.41	18.48	24.04	0.16	2,050.22
Passenger Cars	LPG Bifuel	All Segments	Euro 4	67.97	68.87	0.00	21.53	10.41	18.48	24.04	0.16	679.68
Passenger Cars	LPG Bifuel	All Segments	Euro 5	55.56	68.87	0.00	10.60	10.41	18.48	24.04	0.16	679.68
Passenger Cars	LPG Bifuel	All Segments	Euro 6	55.56	68.87	0.00	9.89	10.41	18.48	24.04	0.16	679.68
Light Commercial Vehicles	Diesel	N1-I	Conventional	848.31	160.13	1.12	1.00	242.73	254.60	263.11	125.78	697.20
Light Commercial Vehicles	Diesel	N1-I	Euro 1	647.45	76.92	1.34	1.00	93.27	105.14	113.65	55.46	423.85
Light Commercial Vehicles	Diesel	N1-I	Euro 2	682.77	108.51	1.34	1.00	70.04	81.90	90.41	44.80	317.65
Light Commercial Vehicles	Diesel	N1-I	Euro 3	757.47	40.90	1.34	1.00	52.24	64.11	72.62	32.47	94.58
Light Commercial Vehicles	Diesel	N1-I	Euro 4	554.19	13.88	1.34	1.00	47.26	59.13	67.64	28.90	88.28
Light Commercial Vehicles	Diesel	N1-I	Euro 5	599.20	1.21	1.34	1.90	16.72	28.59	37.10	0.54	46.01

				Main Pollutants				Particulate Matter				Other
				NOx (as NO_2)	NMVOC	SOx (as SO_2)	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
Category	**Fuel**	**Segment**	**Euro Standard**	**mg/km**	**mg/km**	**mg/km**	**mg/km**	**mg/km**	**mg/km**	**mg/km**	**mg/km**	**mg/km**
Light Commercial Vehicles	Diesel	N1-I	Euro 6 up to 2016	493.56	1.21	1.34	7.00	15.93	27.80	36.31	0.38	59.25
Light Commercial Vehicles	Diesel	N1-II & N1-III	Conventional	1,516.91	138.85	1.58	1.00	359.47	371.34	379.85	189.99	1,290.19
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 1	1,159.36	142.30	1.41	1.00	112.41	124.27	132.78	68.86	501.01
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 2	1,159.36	149.72	1.41	1.00	112.41	124.27	132.78	78.69	501.01
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 3	973.86	94.30	1.41	1.00	79.95	91.81	100.32	56.02	410.83
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 4	788.36	34.99	1.41	1.00	48.47	60.34	68.85	29.95	325.66
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 5	1,320.85	0.23	1.41	1.90	15.42	27.29	35.80	0.28	0.34
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 6 up to 2017	1,067.13	0.23	1.41	7.00	15.42	27.29	35.80	0.28	0.34
Heavy Duty Trucks	Diesel	<=7,5 t	Conventional	4,201.02	907.76	2.20	3.00	293.41	321.71	333.54	133.20	1,682.53
Heavy Duty Trucks	Diesel	<=7,5 t	Euro I	2,996.90	160.68	1.82	3.00	132.68	160.98	172.81	68.68	562.82
Heavy Duty Trucks	Diesel	<=7,5 t	Euro II	3,202.77	103.67	1.75	3.00	83.03	111.33	123.16	36.41	494.25
Heavy Duty Trucks	Diesel	<=7,5 t	Euro III	2,406.32	94.71	1.84	3.00	80.58	108.88	120.71	37.50	542.33
Heavy Duty Trucks	Diesel	<=7,5 t	Euro IV	1,692.54	17.36	1.82	3.00	40.63	68.93	80.76	10.21	295.18
Heavy Duty Trucks	Diesel	<=7,5 t	Euro V	1,172.12	13.63	1.77	11.00	43.09	71.40	83.22	12.06	488.34
Heavy Duty Trucks	Diesel	<=7,5 t	Euro VI	106.84	9.25	1.79	9.00	28.52	56.83	68.65	0.23	57.77
Heavy Duty Trucks	Diesel	7,5 - 20 t	Conventional	9,139.10	897.05	3.81	3.00	366.76	394.84	406.63	169.96	2,483.59
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro I	5,426.82	330.94	3.21	3.00	234.87	262.96	274.75	135.21	1,176.71
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro II	5,787.76	206.42	3.05	3.00	128.61	156.69	168.48	66.15	968.48
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro III	4,534.02	183.12	3.16	3.00	128.47	156.55	168.34	71.14	1,098.18
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro IV	3,154.09	28.49	3.06	3.00	50.36	78.44	90.22	17.64	570.40
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro V	2,619.84	25.92	2.94	11.00	55.40	83.48	95.26	21.42	903.68
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro VI	221.53	18.41	2.99	9.00	29.70	57.78	69.57	0.43	103.56
Heavy Duty Trucks	Diesel	20 - 28 t	Conventional	10,871.21	522.75	5.18	3.00	437.70	468.15	485.41	202.59	2,151.44
Heavy Duty Trucks	Diesel	20 - 28 t	Euro I	7,726.60	460.11	4.53	3.00	342.31	372.75	390.00	201.36	1,777.15
Heavy Duty Trucks	Diesel	20 - 28 t	Euro II	8,336.25	295.61	4.42	3.00	191.53	221.97	239.24	103.35	1,447.84
Heavy Duty Trucks	Diesel	20 - 28 t	Euro III	6,526.32	268.78	4.59	3.00	188.40	218.84	236.10	109.12	1,729.23
Heavy Duty Trucks	Diesel	20 - 28 t	Euro IV	4,538.82	44.04	4.47	3.00	68.10	98.54	115.79	26.68	825.38
Heavy Duty Trucks	Diesel	20 - 28 t	Euro V	3,625.85	37.63	4.33	11.00	74.54	104.99	122.24	31.52	1,289.65
Heavy Duty Trucks	Diesel	20 - 28 t	Euro VI	286.12	25.85	4.40	9.00	36.72	67.16	84.42	0.63	163.83
Heavy Duty Trucks	Diesel	28 - 40 t	Conventional	12,611.90	551.70	5.89	3.00	489.56	520.30	538.22	228.17	2,402.34

				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	28 - 40 t	Euro I	8,991.66	509.17	5.20	3.00	386.52	416.96	434.21	230.10	2,058.79
Heavy Duty Trucks	Diesel	28 - 40 t	Euro II	9,640.80	320.73	5.09	3.00	219.82	250.31	267.66	121.68	1,705.52
Heavy Duty Trucks	Diesel	28 - 40 t	Euro III	7,735.51	285.76	5.23	3.00	203.12	233.56	250.81	119.42	1,968.86
Heavy Duty Trucks	Diesel	28 - 40 t	Euro IV	5,378.01	48.54	5.09	3.00	72.46	102.90	120.15	29.95	919.19
Heavy Duty Trucks	Diesel	28 - 40 t	Euro V	3,706.42	41.91	4.95	11.00	80.60	111.04	128.30	36.06	1,529.36
Heavy Duty Trucks	Diesel	28 - 40 t	Euro VI	261.69	28.65	4.98	9.00	37.07	67.51	84.77	0.68	151.22
Heavy Duty Trucks	Diesel	40 - 60 t	Conventional	14,382.44	567.93	6.65	8.84	558.43	596.29	630.02	254.31	2,654.57
Heavy Duty Trucks	Diesel	40 - 60 t	Euro I	10,155.23	536.44	5.91	3.00	452.93	490.78	524.51	262.02	2,360.66
Heavy Duty Trucks	Diesel	40 - 60 t	Euro II	11,008.29	343.42	5.91	3.00	276.31	314.16	347.90	147.22	2,052.85
Heavy Duty Trucks	Diesel	40 - 60 t	Euro III	9,477.77	319.09	6.49	3.00	254.06	291.91	325.65	142.97	2,429.00
Heavy Duty Trucks	Diesel	40 - 60 t	Euro IV	7,083.91	64.30	6.90	3.00	100.67	138.53	172.26	38.14	1,139.30
Heavy Duty Trucks	Diesel	40 - 60 t	Euro V	3,986.55	52.91	6.78	11.00	109.52	147.37	181.11	44.77	1,921.66
Heavy Duty Trucks	Diesel	40 - 60 t	Euro VI	278.31	35.28	6.84	9.00	55.44	93.29	127.02	0.84	169.78
Buses	Diesel	Urban Buses Midi <=15 t	Conventional	13,592.58	4,878.43	7.87	3.00	1,413.53	1,451.42	1,465.01	689.54	8,045.62
Buses	Diesel	Urban Buses Midi <=15 t	Euro I	10,262.99	724.32	6.07	3.00	463.72	501.61	515.19	279.03	2,769.37
Buses	Diesel	Urban Buses Midi <=15 t	Euro II	11,303.13	519.10	5.73	3.00	233.61	271.50	285.09	129.46	2,558.99
Buses	Diesel	Urban Buses Midi <=15 t	Euro III	11,236.19	482.20	6.10	3.00	243.58	281.46	295.05	146.39	2,750.80
Buses	Diesel	Urban Buses Midi <=15 t	Euro IV	6,068.95	61.36	5.17	3.00	82.02	119.91	133.49	35.68	1,402.08
Buses	Diesel	Urban Buses Midi <=15 t	Euro V	8,104.23	56.09	5.13	3.00	92.13	130.02	143.61	43.26	2,523.59
Buses	Diesel	Urban Buses Midi <=15 t	Euro VI	653.85	41.35	5.26	3.00	40.71	78.59	92.18	0.94	306.62
Buses	Diesel	Urban Buses Standard 15 - 18 t	Conventional	21,497.93	3,021.04	9.80	3.00	1,262.95	1,300.84	1,314.43	614.25	8,362.89
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro I	13,446.35	1,027.22	8.05	3.00	629.28	667.17	680.76	386.64	3,644.68
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro II	14,849.59	723.13	7.66	3.00	306.87	344.76	358.34	177.07	3,460.17
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro III	14,369.38	662.60	8.06	3.00	311.55	349.44	363.02	193.97	3,732.59
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro IV	7,999.20	90.30	7.03	3.00	99.35	137.24	150.82	48.68	1,814.57
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro V	10,367.92	75.11	6.90	3.00	110.46	148.35	161.94	57.01	3,328.40
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro VI	682.72	54.66	7.05	3.00	42.56	80.45	94.04	1.22	376.54
Buses	Diesel	Urban Buses Articulated >18 t	Conventional	26,517.47	3,184.90	11.73	3.00	1,513.98	1,554.68	1,574.51	736.49	10,308.88
Buses	Diesel	Urban Buses Articulated >18 t	Euro I	16,648.28	1,118.61	9.88	3.00	758.89	799.59	819.42	466.62	4,810.12
Buses	Diesel	Urban Buses Articulated >18 t	Euro II	17,990.73	769.01	9.62	3.00	399.96	440.66	460.49	233.32	4,748.88

				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**
Buses	Diesel	Urban Buses Articulated >18 t	Euro III	17,393.16	706.51	9.88	3.00	368.52	409.22	429.05	229.26	4,857.79
Buses	Diesel	Urban Buses Articulated >18 t	Euro IV	10,330.26	107.71	8.81	3.00	123.83	164.53	184.36	62.12	2,169.94
Buses	Diesel	Urban Buses Articulated >18 t	Euro V	11,038.08	86.54	8.76	3.00	133.94	174.64	194.48	69.70	4,264.21
Buses	Diesel	Urban Buses Articulated >18 t	Euro VI	552.81	61.63	9.00	3.00	50.30	91.00	110.83	1.39	438.46
Buses	Diesel	Coaches	Conventional	9,842.70	506.96	4.74	3.00	389.66	417.52	431.53	180.62	1,912.32
Buses	Diesel	Coaches	Euro I	7,895.98	499.70	4.54	3.00	329.22	357.93	373.84	194.24	1,699.40
Buses	Diesel	Coaches	Euro II	8,779.57	343.89	4.55	3.00	190.51	219.39	235.67	103.82	1,399.41
Buses	Diesel	Coaches	Euro III	6,828.73	329.92	4.62	3.00	188.85	217.81	234.29	110.50	1,688.73
Buses	Diesel	Coaches	Euro IV	4,766.37	48.33	4.55	3.00	68.17	97.22	113.86	27.75	888.28
Buses	Diesel	Coaches	Euro V	3,928.84	46.39	4.71	3.00	79.12	108.13	124.69	36.03	1,468.50
Buses	Diesel	Coaches	Euro VI	304.08	33.48	4.86	3.00	36.08	65.20	82.02	0.71	201.67
Buses	CNG	Urban CNG Buses	Euro III	10,000.00	20.00	0.00	0.00	44.45	82.33	95.92	0.00	1,000.00
Buses	CNG	Urban CNG Buses	EEV	4,878.54	253.27	0.00	0.00	47.90	85.79	99.38	0.00	1,270.51
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Conventional	56.00	8,777.93	0.49	1.00	181.10	185.90	188.58	35.20	14,700.38
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 1	180.00	3,722.18	0.39	1.00	50.10	54.89	57.57	4.50	4,600.12
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 2	170.00	2,877.77	0.39	1.00	31.10	35.89	38.57	5.20	2,800.07
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 3	170.00	1,980.26	0.39	1.00	23.10	27.89	30.57	3.60	1,800.05
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Conventional	56.00	8,777.93	0.49	1.00	181.10	185.90	188.58	17.60	14,700.38
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 1	220.01	1,102.11	0.39	1.00	45.10	49.89	52.57	8.00	6,700.17
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 2	170.00	1,067.72	0.39	1.00	12.10	16.89	19.57	1.40	4,200.11
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 3	170.00	720.23	0.39	1.00	9.10	13.89	16.57	0.80	2,700.07
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Conventional	29.09	9,890.67	0.60	2.00	204.27	208.10	210.50	20.00	18,098.49
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 1	44.02	3,447.28	0.55	2.00	84.27	88.10	90.50	16.00	11,939.86
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 2	51.02	1,988.60	0.55	2.00	44.27	48.10	50.50	8.00	9,445.47
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 3	24.67	1,272.42	0.55	2.00	16.27	20.10	22.50	2.40	5,213.62
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Conventional	342.01	1,427.66	0.59	2.00	24.27	28.10	30.50	3.00	17,441.87
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 1	361.38	1,225.24	0.49	2.00	24.27	28.10	30.50	5.00	12,879.74
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 2	305.76	599.04	0.41	2.00	9.27	13.10	15.50	1.25	4,898.26
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 3	269.25	408.96	0.41	2.00	9.27	13.10	15.50	1.25	2,703.32
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Conventional	339.69	2,608.24	0.80	2.00	24.27	28.10	30.50	3.00	22,577.43

				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 - 750 cm³	Euro 1	322.04	1,574.09	0.74	2.00	24.27	28.10	30.50	5.00	11,239.06
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 2	117.50	847.50	0.67	2.00	9.27	13.10	15.50	1.25	3,356.62
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 3	59.57	573.17	0.67	2.00	9.27	13.10	15.50	1.25	1,852.44
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Conventional	175.14	2,813.80	0.92	2.00	24.27	28.10	30.50	3.00	22,577.43
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 1	207.51	1,489.02	0.88	2.00	24.27	28.10	30.50	5.00	11,239.06
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 2	183.89	747.93	0.86	2.00	9.27	13.10	15.50	1.25	3,356.62
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 3	94.56	501.02	0.86	2.00	9.27	13.10	15.50	1.25	1,852.44

Annex Table 9 - Road transportation distance based implied emission factor (mg/km) for 2016 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	0.403	0.0008	0.0005	1.76E-05	0.012	0.305	0.0062	0.0009	0.142
Passenger Cars	Petrol	Small & Mini	Euro 1	0.387	0.0008	0.0005	1.68E-05	0.012	0.305	0.0061	0.0009	0.141
Passenger Cars	Petrol	Small & Mini	Euro 2	0.384	0.0008	0.0005	1.67E-05	0.012	0.305	0.0061	0.0009	0.141
Passenger Cars	Petrol	Small & Mini	Euro 3	0.394	0.0008	0.0005	1.71E-05	0.012	0.305	0.0061	0.0009	0.141
Passenger Cars	Petrol	Small & Mini	Euro 4	0.374	0.0008	0.0005	1.62E-05	0.012	0.305	0.0061	0.0009	0.141
Passenger Cars	Petrol	Small & Mini	Euro 5	0.393	0.0008	0.0005	1.71E-05	0.012	0.300	0.0059	0.0008	0.138
Passenger Cars	Petrol	Small & Mini	Euro 6 up to 2016	0.392	0.0007	0.0005	1.70E-05	0.012	0.293	0.0057	0.0008	0.135
Passenger Cars	Petrol	Medium	PRE ECE - ECE 15/04	0.480	0.0008	0.0006	2.11E-05	0.012	0.305	0.0062	0.0009	0.142
Passenger Cars	Petrol	Medium	Euro 1	0.461	0.0008	0.0006	2.02E-05	0.012	0.305	0.0062	0.0009	0.142
Passenger Cars	Petrol	Medium	Euro 2	0.453	0.0008	0.0006	1.99E-05	0.012	0.305	0.0062	0.0009	0.142
Passenger Cars	Petrol	Medium	Euro 3	0.467	0.0008	0.0006	2.05E-05	0.012	0.305	0.0062	0.0009	0.142
Passenger Cars	Petrol	Medium	Euro 4	0.479	0.0008	0.0006	2.10E-05	0.012	0.305	0.0062	0.0009	0.142
Passenger Cars	Petrol	Medium	Euro 5	0.479	0.0008	0.0006	2.10E-05	0.012	0.300	0.0060	0.0008	0.139
Passenger Cars	Petrol	Medium	Euro 6 up to 2016	0.479	0.0007	0.0006	2.10E-05	0.012	0.294	0.0057	0.0008	0.135
Passenger Cars	Petrol	Large-SUV-Executive	PRE ECE - ECE 15/04	0.610	0.0008	0.0008	2.71E-05	0.012	0.306	0.0062	0.0009	0.143
Passenger Cars	Petrol	Large-SUV-Executive	Euro 1	0.588	0.0008	0.0008	2.61E-05	0.012	0.306	0.0062	0.0009	0.142
Passenger Cars	Petrol	Large-SUV-Executive	Euro 2	0.610	0.0008	0.0008	2.71E-05	0.012	0.306	0.0062	0.0009	0.143
Passenger Cars	Petrol	Large-SUV-Executive	Euro 3	0.557	0.0008	0.0007	2.47E-05	0.012	0.306	0.0062	0.0009	0.142
Passenger Cars	Petrol	Large-SUV-Executive	Euro 4	0.656	0.0008	0.0008	2.92E-05	0.012	0.306	0.0062	0.0009	0.143
Passenger Cars	Petrol	Large-SUV-Executive	Euro 5	0.656	0.0008	0.0008	2.92E-05	0.012	0.300	0.0060	0.0008	0.140
Passenger Cars	Petrol	Large-SUV-Executive	Euro 6 up to 2016	0.656	0.0007	0.0008	2.92E-05	0.012	0.294	0.0058	0.0008	0.136
Passenger Cars	Diesel	Small & Mini	Conventional	0.024	0.0008	0.0003	6.36E-06	0.012	0.309	0.0062	0.0009	0.143
Passenger Cars	Diesel	Small & Mini	Euro 1	0.024	0.0008	0.0003	5.46E-06	0.012	0.309	0.0062	0.0009	0.142
Passenger Cars	Diesel	Small & Mini	Euro 2	0.024	0.0008	0.0003	5.72E-06	0.012	0.309	0.0062	0.0009	0.142
Passenger Cars	Diesel	Small & Mini	Euro 3	0.024	0.0008	0.0003	5.46E-06	0.012	0.309	0.0062	0.0009	0.142
Passenger Cars	Diesel	Small & Mini	Euro 4	0.024	0.0008	0.0003	5.03E-06	0.012	0.309	0.0062	0.0009	0.142
Passenger Cars	Diesel	Small & Mini	Euro 5	0.024	0.0008	0.0003	5.39E-06	0.012	0.302	0.0059	0.0008	0.139
Passenger Cars	Diesel	Small & Mini	Euro 6 up to 2016	0.024	0.0007	0.0003	5.40E-06	0.012	0.294	0.0056	0.0008	0.134
Passenger Cars	Diesel	Medium	Conventional	0.024	0.0008	0.0003	6.36E-06	0.012	0.309	0.0062	0.0009	0.143
Passenger Cars	Diesel	Medium	Euro 1	0.024	0.0008	0.0003	5.46E-06	0.012	0.309	0.0062	0.0009	0.142

Category	Fuel	Segment	Euro Standard	Priority Heavy Metals			Additional Heavy Metals					
				Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
				mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km
Passenger Cars	Diesel	Medium	Euro 2	0.024	0.0008	0.0003	5.72E-06	0.012	0.309	0.0062	0.0009	0.142
Passenger Cars	Diesel	Medium	Euro 3	0.024	0.0008	0.0003	5.46E-06	0.012	0.309	0.0062	0.0009	0.142
Passenger Cars	Diesel	Medium	Euro 4	0.024	0.0008	0.0003	5.46E-06	0.012	0.309	0.0062	0.0009	0.142
Passenger Cars	Diesel	Medium	Euro 5	0.024	0.0008	0.0003	5.46E-06	0.012	0.302	0.0059	0.0008	0.139
Passenger Cars	Diesel	Medium	Euro 6 up to 2016	0.024	0.0007	0.0003	5.46E-06	0.012	0.294	0.0056	0.0008	0.134
Passenger Cars	Diesel	Large-SUV-Executive	Conventional	0.024	0.0008	0.0003	6.36E-06	0.012	0.309	0.0062	0.0009	0.143
Passenger Cars	Diesel	Large-SUV-Executive	Euro 1	0.024	0.0008	0.0004	7.40E-06	0.012	0.309	0.0062	0.0009	0.143
Passenger Cars	Diesel	Large-SUV-Executive	Euro 2	0.024	0.0008	0.0004	7.40E-06	0.012	0.309	0.0062	0.0009	0.143
Passenger Cars	Diesel	Large-SUV-Executive	Euro 3	0.024	0.0008	0.0004	7.40E-06	0.012	0.309	0.0062	0.0009	0.143
Passenger Cars	Diesel	Large-SUV-Executive	Euro 4	0.024	0.0008	0.0004	7.40E-06	0.012	0.309	0.0062	0.0009	0.143
Passenger Cars	Diesel	Large-SUV-Executive	Euro 5	0.024	0.0008	0.0004	7.40E-06	0.012	0.302	0.0059	0.0008	0.139
Passenger Cars	Diesel	Large-SUV-Executive	Euro 6 up to 2016	0.024	0.0007	0.0004	7.40E-06	0.012	0.294	0.0056	0.0008	0.134
Passenger Cars	Petrol Hybrid	All Segments	Euro 4	0.285	0.0008	0.0004	1.21E-05	0.012	0.305	0.0061	0.0009	0.141
Passenger Cars	Petrol Hybrid	All Segments	Euro 5	0.291	0.0007	0.0004	1.24E-05	0.012	0.300	0.0059	0.0008	0.138
Passenger Cars	Petrol Hybrid	All Segments	Euro 6 up to 2016	0.291	0.0007	0.0004	1.23E-05	0.012	0.293	0.0056	0.0008	0.134
Passenger Cars	LPG Bifuel	All Segments	Conventional	0.024	0.0008	0.0000	7.43E-14	0.012	0.305	0.0060	0.0008	0.140
Passenger Cars	LPG Bifuel	All Segments	Euro 1	0.024	0.0008	0.0000	7.43E-14	0.012	0.305	0.0060	0.0008	0.140
Passenger Cars	LPG Bifuel	All Segments	Euro 2	0.024	0.0008	0.0000	7.43E-14	0.012	0.305	0.0060	0.0008	0.140
Passenger Cars	LPG Bifuel	All Segments	Euro 3	0.024	0.0008	0.0000	7.43E-14	0.012	0.305	0.0060	0.0008	0.140
Passenger Cars	LPG Bifuel	All Segments	Euro 4	0.024	0.0008	0.0000	7.43E-14	0.012	0.305	0.0060	0.0008	0.140
Passenger Cars	LPG Bifuel	All Segments	Euro 5	0.024	0.0007	0.0000	7.43E-14	0.011	0.300	0.0058	0.0008	0.137
Passenger Cars	LPG Bifuel	All Segments	Euro 6	0.024	0.0007	0.0000	7.43E-14	0.011	0.293	0.0055	0.0008	0.133
Light Commercial Vehicles	Diesel	N1-I	Conventional	0.034	0.0008	0.0003	5.94E-06	0.016	0.394	0.0068	0.0010	0.179
Light Commercial Vehicles	Diesel	N1-I	Euro 1	0.034	0.0008	0.0004	7.11E-06	0.016	0.394	0.0068	0.0010	0.179
Light Commercial Vehicles	Diesel	N1-I	Euro 2	0.034	0.0008	0.0004	7.11E-06	0.016	0.394	0.0068	0.0010	0.179
Light Commercial Vehicles	Diesel	N1-I	Euro 3	0.034	0.0008	0.0004	7.11E-06	0.016	0.394	0.0068	0.0010	0.179
Light Commercial Vehicles	Diesel	N1-I	Euro 4	0.034	0.0008	0.0004	7.11E-06	0.016	0.394	0.0068	0.0010	0.179
Light Commercial Vehicles	Diesel	N1-I	Euro 5	0.034	0.0008	0.0004	7.11E-06	0.016	0.387	0.0065	0.0009	0.176
Light Commercial Vehicles	Diesel	N1-I	Euro 6 up to 2016	0.034	0.0008	0.0004	7.11E-06	0.016	0.379	0.0062	0.0009	0.171
Light Commercial Vehicles	Diesel	N1-II & N1-III	Conventional	0.034	0.0008	0.0004	8.40E-06	0.016	0.394	0.0068	0.0010	0.180
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 1	0.034	0.0008	0.0004	7.52E-06	0.016	0.394	0.0068	0.0010	0.180

Category	Fuel	Segment	Euro Standard	Priority Heavy Metals			Additional Heavy Metals					
				Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
				mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km	mg/km
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 2	0.034	0.0008	0.0004	7.52E-06	0.016	0.394	0.0068	0.0010	0.180
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 3	0.034	0.0008	0.0004	7.52E-06	0.016	0.394	0.0068	0.0010	0.180
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 4	0.034	0.0008	0.0004	7.52E-06	0.016	0.394	0.0068	0.0010	0.180
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 5	0.034	0.0008	0.0004	7.52E-06	0.016	0.387	0.0065	0.0009	0.176
Light Commercial Vehicles	Diesel	N1-II & N1-III	Euro 6 up to 2017	0.034	0.0007	0.0004	7.52E-06	0.016	0.377	0.0061	0.0009	0.170
Heavy Duty Trucks	Diesel	<=7,5 t	Conventional	0.096	0.0011	0.0006	1.17E-05	0.040	0.913	0.0104	0.0013	0.292
Heavy Duty Trucks	Diesel	<=7,5 t	Euro I	0.096	0.0011	0.0005	9.68E-06	0.040	0.912	0.0104	0.0013	0.292
Heavy Duty Trucks	Diesel	<=7,5 t	Euro II	0.096	0.0011	0.0005	9.30E-06	0.040	0.912	0.0104	0.0013	0.292
Heavy Duty Trucks	Diesel	<=7,5 t	Euro III	0.096	0.0011	0.0005	9.81E-06	0.040	0.912	0.0104	0.0013	0.292
Heavy Duty Trucks	Diesel	<=7,5 t	Euro IV	0.096	0.0011	0.0005	9.71E-06	0.040	0.912	0.0104	0.0013	0.292
Heavy Duty Trucks	Diesel	<=7,5 t	Euro V	0.096	0.0011	0.0005	9.41E-06	0.040	0.912	0.0104	0.0013	0.292
Heavy Duty Trucks	Diesel	<=7,5 t	Euro VI	0.096	0.0011	0.0005	9.53E-06	0.040	0.912	0.0104	0.0013	0.292
Heavy Duty Trucks	Diesel	7,5 - 20 t	Conventional	0.095	0.0011	0.0011	2.03E-05	0.040	0.906	0.0104	0.0013	0.292
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro I	0.095	0.0011	0.0009	1.71E-05	0.040	0.906	0.0104	0.0013	0.292
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro II	0.095	0.0011	0.0009	1.62E-05	0.040	0.906	0.0104	0.0013	0.292
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro III	0.095	0.0011	0.0009	1.68E-05	0.040	0.906	0.0104	0.0013	0.292
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro IV	0.095	0.0011	0.0009	1.63E-05	0.040	0.906	0.0104	0.0013	0.292
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro V	0.095	0.0011	0.0008	1.57E-05	0.040	0.906	0.0104	0.0013	0.292
Heavy Duty Trucks	Diesel	7,5 - 20 t	Euro VI	0.095	0.0011	0.0008	1.59E-05	0.040	0.906	0.0104	0.0013	0.292
Heavy Duty Trucks	Diesel	20 - 28 t	Conventional	0.096	0.0011	0.0015	2.76E-05	0.041	0.904	0.0105	0.0014	0.336
Heavy Duty Trucks	Diesel	20 - 28 t	Euro I	0.096	0.0011	0.0013	2.41E-05	0.041	0.904	0.0105	0.0014	0.335
Heavy Duty Trucks	Diesel	20 - 28 t	Euro II	0.096	0.0011	0.0012	2.35E-05	0.041	0.904	0.0105	0.0014	0.335
Heavy Duty Trucks	Diesel	20 - 28 t	Euro III	0.096	0.0011	0.0013	2.45E-05	0.041	0.904	0.0105	0.0014	0.335
Heavy Duty Trucks	Diesel	20 - 28 t	Euro IV	0.096	0.0011	0.0013	2.38E-05	0.041	0.904	0.0105	0.0014	0.335
Heavy Duty Trucks	Diesel	20 - 28 t	Euro V	0.096	0.0011	0.0012	2.31E-05	0.041	0.904	0.0105	0.0014	0.335
Heavy Duty Trucks	Diesel	20 - 28 t	Euro VI	0.096	0.0011	0.0012	2.34E-05	0.041	0.904	0.0105	0.0014	0.335
Heavy Duty Trucks	Diesel	28 - 40 t	Conventional	0.096	0.0012	0.0017	3.14E-05	0.041	0.904	0.0106	0.0014	0.342
Heavy Duty Trucks	Diesel	28 - 40 t	Euro I	0.096	0.0011	0.0015	2.77E-05	0.041	0.904	0.0105	0.0014	0.336
Heavy Duty Trucks	Diesel	28 - 40 t	Euro II	0.096	0.0011	0.0014	2.71E-05	0.041	0.904	0.0105	0.0014	0.337
Heavy Duty Trucks	Diesel	28 - 40 t	Euro III	0.096	0.0011	0.0015	2.79E-05	0.041	0.904	0.0105	0.0014	0.336
Heavy Duty Trucks	Diesel	28 - 40 t	Euro IV	0.096	0.0011	0.0014	2.71E-05	0.041	0.904	0.0105	0.0014	0.336

				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	28 - 40 t	Euro V	0.096	0.0011	0.0014	2.63E-05	0.041	0.904	0.0105	0.0014	0.336
Heavy Duty Trucks	Diesel	28 - 40 t	Euro VI	0.096	0.0011	0.0014	2.65E-05	0.041	0.904	0.0105	0.0014	0.336
Heavy Duty Trucks	Diesel	40 - 60 t	Conventional	0.099	0.0012	0.0019	3.54E-05	0.042	0.907	0.0111	0.0017	0.466
Heavy Duty Trucks	Diesel	40 - 60 t	Euro I	0.099	0.0012	0.0017	3.15E-05	0.042	0.907	0.0110	0.0017	0.465
Heavy Duty Trucks	Diesel	40 - 60 t	Euro II	0.099	0.0012	0.0017	3.15E-05	0.042	0.907	0.0110	0.0017	0.465
Heavy Duty Trucks	Diesel	40 - 60 t	Euro III	0.099	0.0012	0.0018	3.46E-05	0.042	0.907	0.0111	0.0017	0.466
Heavy Duty Trucks	Diesel	40 - 60 t	Euro IV	0.099	0.0012	0.0019	3.68E-05	0.042	0.907	0.0111	0.0017	0.466
Heavy Duty Trucks	Diesel	40 - 60 t	Euro V	0.099	0.0012	0.0019	3.61E-05	0.042	0.907	0.0111	0.0017	0.466
Heavy Duty Trucks	Diesel	40 - 60 t	Euro VI	0.099	0.0012	0.0019	3.64E-05	0.042	0.907	0.0111	0.0017	0.466
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	3.23E-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	0.0030	0.0014	2.73E-05	0.062	1.517	0.0248	0.0032	0.532
Buses	Diesel	Urban Buses Midi <=15 t	Euro VI	0.132	0.0013	0.0015	2.80E-05	0.055	1.220	0.0126	0.0015	0.360
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	0.0030	0.0019	3.68E-05	0.063	1.518	0.0248	0.0032	0.534
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro VI	0.132	0.0013	0.0020	3.76E-05	0.056	1.220	0.0126	0.0015	0.362
Buses	Diesel	Urban Buses Articulated >18 t	Conventional	0.133	0.0045	0.0033	6.24E-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	0.0031	0.0025	4.67E-05	0.064	1.519	0.0250	0.0033	0.585
Buses	Diesel	Urban Buses Articulated >18 t	Euro VI	0.133	0.0013	0.0025	4.79E-05	0.057	1.222	0.0128	0.0016	0.413
Buses	Diesel	Coaches	Conventional	0.090	0.0013	0.0013	2.52E-05	0.040	0.892	0.0113	0.0015	0.320

				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
Buses	Diesel	Coaches	Euro I	0.091	0.0013	0.0013	2.42E-05	0.040	0.892	0.0113	0.0015	0.334
Buses	Diesel	Coaches	Euro II	0.091	0.0013	0.0013	2.42E-05	0.040	0.892	0.0114	0.0015	0.337
Buses	Diesel	Coaches	Euro III	0.091	0.0013	0.0013	2.46E-05	0.040	0.892	0.0114	0.0015	0.339
Buses	Diesel	Coaches	Euro IV	0.091	0.0013	0.0013	2.42E-05	0.040	0.892	0.0114	0.0015	0.340
Buses	Diesel	Coaches	Euro V	0.091	0.0012	0.0013	2.51E-05	0.039	0.886	0.0111	0.0015	0.336
Buses	Diesel	Coaches	Euro VI	0.091	0.0012	0.0014	2.59E-05	0.039	0.878	0.0108	0.0014	0.333
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	0.0030	0.0000	2.83E-13	0.060	1.516	0.0247	0.0032	0.527
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Conventional	0.179	0.0047	0.0002	7.58E-06	0.025	0.917	0.0335	0.0047	0.501
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 1	0.146	0.0047	0.0002	6.06E-06	0.025	0.917	0.0334	0.0047	0.501
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 2	0.146	0.0047	0.0002	6.06E-06	0.025	0.917	0.0334	0.0047	0.501
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 3	0.146	0.0047	0.0002	6.06E-06	0.025	0.917	0.0334	0.0047	0.501
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Conventional	0.179	0.0047	0.0002	7.58E-06	0.025	0.917	0.0335	0.0047	0.501
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 1	0.146	0.0047	0.0002	6.06E-06	0.025	0.917	0.0334	0.0047	0.501
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 2	0.146	0.0047	0.0002	6.06E-06	0.025	0.917	0.0334	0.0047	0.501
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 3	0.146	0.0047	0.0002	6.06E-06	0.025	0.917	0.0334	0.0047	0.501
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Conventional	0.212	0.0047	0.0003	9.25E-06	0.024	0.889	0.0333	0.0047	0.494
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 1	0.196	0.0047	0.0002	8.54E-06	0.024	0.889	0.0333	0.0047	0.494
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 2	0.196	0.0047	0.0002	8.54E-06	0.024	0.889	0.0333	0.0047	0.494
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 3	0.196	0.0047	0.0002	8.54E-06	0.024	0.889	0.0333	0.0047	0.494
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Conventional	0.210	0.0003	0.0003	9.18E-06	0.005	0.128	0.0021	0.0003	0.054
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 1	0.175	0.0003	0.0002	7.55E-06	0.005	0.128	0.0021	0.0003	0.054
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 2	0.150	0.0003	0.0002	6.42E-06	0.005	0.128	0.0021	0.0003	0.054
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 3	0.150	0.0003	0.0002	6.42E-06	0.005	0.128	0.0021	0.0003	0.054
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Conventional	0.278	0.0003	0.0004	1.23E-05	0.005	0.128	0.0021	0.0003	0.055
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 1	0.259	0.0003	0.0003	1.15E-05	0.005	0.128	0.0021	0.0003	0.055
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 2	0.237	0.0003	0.0003	1.04E-05	0.005	0.128	0.0021	0.0003	0.055
L-Category	Petrol	Motorcycles 4-stroke 250 - 750 cm³	Euro 3	0.237	0.0003	0.0003	1.04E-05	0.005	0.128	0.0021	0.0003	0.055
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Conventional	0.319	0.0003	0.0004	1.42E-05	0.005	0.128	0.0022	0.0003	0.055
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 1	0.308	0.0003	0.0004	1.37E-05	0.005	0.128	0.0022	0.0003	0.055
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 2	0.301	0.0003	0.0004	1.34E-05	0.005	0.128	0.0022	0.0003	0.055

				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 >750 cm³	Euro 3	0.301	0.0003	0.0004	1.34E-05	0.005	0.128	0.0022	0.0003	0.055

Annex Table 10 - Fuel and lubricant consumption from road transport sector (TJ).

Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Diesel*	68,316.94	70,954.81	75,364.56	77,647.09	83,746.42	89,896.40	96,665.92	107,070.33	127,740.58	138,050.34	160,136.37	169,398.15	171,651.80	173,177.29
Petrol**	60,552.28	66,657.90	74,442.87	78,434.97	80,525.54	83,039.56	85,211.37	84,700.25	87,623.56	88,657.43	90,284.86	85,043.95	89,276.49	86,562.22
CNG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	29.78	197.04	304.13	397.29
LPG	0.98	2.56	4.51	5.03	5.40	13.28	82.77	796.75	910.55	1,097.65	1,027.14	996.03	975.81	942.26
Lubricants	333.11	343.87	362.07	368.21	375.92	384.36	395.07	404.83	438.73	454.01	489.87	487.98	504.46	501.68

Fuel	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Diesel*	175,597.29	176,673.02	185,226.47	186,797.14	186,665.76	190,450.08	194,527.94	182,938.79	167,871.09	164,487.36	168,763.96	172,914.67	175,129.74
Petrol**	83,144.26	78,819.19	73,438.95	68,735.74	65,249.27	63,999.98	60,714.17	54,699.05	49,809.40	48,039.49	48,020.23	47,485.63	46,158.07
CNG	391.52	440.00	437.06	483.91	505.81	502.58	526.74	528.29	503.17	520.13	508.32	548.05	804.54
LPG	867.96	963.02	1,028.40	1,068.05	1,189.80	1,394.20	1,331.70	1,385.83	1,465.38	1,537.39	1,541.87	1,647.00	1,691.09
Lubricants	501.31	499.20	505.72	500.15	501.99	510.79	506.47	471.57	435.48	428.96	436.40	442.41	444.14

* includes incorporation of Biodiesel
** includes incorporation of Bioethanol

Annex Table 11 - Vehicle fleet.

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2014	2015	2016
Passenger Cars	Petrol	Mini	PREC ECE to Euro 4	179,177	301,666	356,954	280,180	236,598	196,974	189,460	180,902
Passenger Cars	Petrol	Mini	Euro 5	0	0	0	0	0	22,231	32,638	34,205

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2014	2015	2016
Passenger Cars	Petrol	Mini	Euro 6 up to 2016	0	0	0	0	0	0	0	13,220
Passenger Cars	Petrol	Small	PRE ECE	542	303	181	168	673	340	695	683
Passenger Cars	Petrol	Small	ECE 15/00-01	2,870	1,117	287	174	552	526	557	546
Passenger Cars	Petrol	Small	ECE 15/02	5,400	3,100	790	201	160	132	148	142
Passenger Cars	Petrol	Small	ECE 15/03	130,894	105,767	59,995	20,983	9,704	6,403	5,903	5,461
Passenger Cars	Petrol	Small	ECE 15/04	597,886	948,815	803,933	511,263	285,087	183,877	167,578	151,919
Passenger Cars	Petrol	Small	Euro 1	0	479,351	624,327	508,806	397,286	302,659	281,901	260,401
Passenger Cars	Petrol	Small	Euro 2	0	0	479,863	408,698	387,305	347,693	337,076	324,942
Passenger Cars	Petrol	Small	Euro 3	0	0	0	331,858	304,977	299,463	296,907	293,306
Passenger Cars	Petrol	Small	Euro 4	0	0	0	0	174,236	159,176	159,964	160,273
Passenger Cars	Petrol	Small	Euro 5	0	0	0	0	0	87,989	117,826	112,650
Passenger Cars	Petrol	Small	Euro 6 up to 2016	0	0	0	0	0	0	0	44,700
Passenger Cars	Petrol	Medium	PRE ECE	112	60	37	55	108	114	120	129
Passenger Cars	Petrol	Medium	ECE 15/00-01	681	283	65	31	48	51	55	48
Passenger Cars	Petrol	Medium	ECE 15/02	523	300	76	22	14	18	16	19
Passenger Cars	Petrol	Medium	ECE 15/03	4,599	3,576	1,944	732	413	330	331	314
Passenger Cars	Petrol	Medium	ECE 15/04	23,567	40,978	35,374	23,547	13,883	9,543	8,989	8,314
Passenger Cars	Petrol	Medium	Euro 1	0	42,397	66,756	74,158	57,193	44,912	41,886	37,548
Passenger Cars	Petrol	Medium	Euro 2	0	0	185,430	167,423	160,798	146,487	142,171	135,448
Passenger Cars	Petrol	Medium	Euro 3	0	0	0	180,543	166,735	164,520	163,157	161,158
Passenger Cars	Petrol	Medium	Euro 4	0	0	0	0	89,572	81,794	82,302	82,546
Passenger Cars	Petrol	Medium	Euro 5	0	0	0	0	0	21,491	24,083	23,082
Passenger Cars	Petrol	Medium	Euro 6 up to 2016	0	0	0	0	0	0	0	7,255
Passenger Cars	Petrol	Large-SUV-Executive	PRE ECE	29,130	14,017	8,926	8,932	11,034	11,270	11,053	11,186
Passenger Cars	Petrol	Large-SUV-Executive	ECE 15/00-01	155,817	53,594	16,389	10,576	12,300	11,693	11,893	11,835
Passenger Cars	Petrol	Large-SUV-Executive	ECE 15/02	88,643	50,671	12,647	3,467	2,913	2,593	2,535	2,511
Passenger Cars	Petrol	Large-SUV-Executive	ECE 15/03	179,140	130,307	65,063	17,367	10,501	7,848	7,547	7,205
Passenger Cars	Petrol	Large-SUV-Executive	ECE 15/04	42,485	54,677	43,372	28,082	18,496	14,405	13,931	13,220
Passenger Cars	Petrol	Large-SUV-Executive	Euro 1	0	17,144	21,751	17,720	16,096	13,185	12,712	12,121
Passenger Cars	Petrol	Large-SUV-Executive	Euro 2	0	0	26,680	25,973	29,751	27,543	27,131	26,449
Passenger Cars	Petrol	Large-SUV-Executive	Euro 3	0	0	0	16,282	16,647	16,994	16,947	16,851
Passenger Cars	Petrol	Large-SUV-Executive	Euro 4	0	0	0	0	7,217	6,859	6,164	7,266
Passenger Cars	Petrol	Large-SUV-Executive	Euro 5	0	0	0	0	0	4,154	5,422	4,848
Passenger Cars	Petrol	Large-SUV-Executive	Euro 6 up to 2016	0	0	0	0	0	0	0	2,374
Passenger Cars	Diesel	Mini	Conventional to Euro 4	23	29	964	10,877	17,455	19,281	19,952	20,643
Passenger Cars	Diesel	Mini	Euro 5	0	0	0	0	0	3,941	5,889	5,889
Passenger Cars	Diesel	Mini	Euro 6 up to 2016	0	0	0	0	0	0	0	2,559

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2014	2015	2016
Passenger Cars	Diesel	Small	Conventional	33,551	55,410	54,301	46,700	28,179	20,207	18,592	16,963
Passenger Cars	Diesel	Small	Euro 1	0	31,270	40,171	39,120	34,557	29,231	27,941	26,368
Passenger Cars	Diesel	Small	Euro 2	0	0	34,220	34,005	34,516	32,605	32,120	31,478
Passenger Cars	Diesel	Small	Euro 3	0	0	0	61,397	61,031	60,622	60,295	59,952
Passenger Cars	Diesel	Small	Euro 4	0	0	0	0	50,791	50,538	51,115	51,730
Passenger Cars	Diesel	Small	Euro 5	0	0	0	0	0	58,546	88,418	88,418
Passenger Cars	Diesel	Small	Euro 6 up to 2016	0	0	0	0	0	0	0	31,759
Passenger Cars	Diesel	Medium	Conventional	11,761	30,641	30,345	27,959	18,510	13,864	12,883	11,813
Passenger Cars	Diesel	Medium	Euro 1	0	53,595	76,329	78,186	68,185	60,285	58,309	55,626
Passenger Cars	Diesel	Medium	Euro 2	0	0	139,639	138,746	144,689	138,726	136,971	134,685
Passenger Cars	Diesel	Medium	Euro 3	0	0	0	285,283	283,682	281,951	280,747	278,769
Passenger Cars	Diesel	Medium	Euro 4	0	0	0	0	388,513	386,580	389,221	391,588
Passenger Cars	Diesel	Medium	Euro 5	0	0	0	0	0	189,789	244,259	244,259
Passenger Cars	Diesel	Medium	Euro 6 up to 2016	0	0	0	0	0	0	0	58,318
Passenger Cars	Diesel	Large-SUV-Executive	Conventional	79,001	95,950	88,500	77,934	52,345	45,864	44,580	43,207
Passenger Cars	Diesel	Large-SUV-Executive	Euro 1	0	37,356	62,027	65,179	65,153	59,107	57,811	55,945
Passenger Cars	Diesel	Large-SUV-Executive	Euro 2	0	0	204,604	203,237	209,850	198,380	195,477	191,478
Passenger Cars	Diesel	Large-SUV-Executive	Euro 3	0	0	0	238,667	237,011	235,967	235,330	234,180
Passenger Cars	Diesel	Large-SUV-Executive	Euro 4	0	0	0	0	239,410	238,219	238,381	245,473
Passenger Cars	Diesel	Large-SUV-Executive	Euro 5	0	0	0	0	0	109,458	143,689	143,689
Passenger Cars	Diesel	Large-SUV-Executive	Euro 6 up to 2016	0	0	0	0	0	0	0	41,069
Passenger Cars	Petrol Hybrid	Small	Euro 4	0	0	0	971	1,213	1,214	1,208	1,202
Passenger Cars	Petrol Hybrid	Small	Euro 5	0	0	0	0	0	678	1,226	1,226
Passenger Cars	Petrol Hybrid	Small	Euro 6 up to 2016	0	0	0	0	0	0	0	814
Passenger Cars	Petrol Hybrid	Medium	Euro 4	0	0	0	223	5,947	5,978	6,007	6,023
Passenger Cars	Petrol Hybrid	Medium	Euro 5	0	0	0	0	0	1,993	2,930	2,930
Passenger Cars	Petrol Hybrid	Medium	Euro 6 up to 2016	0	0	0	0	0	0	0	1,445
Passenger Cars	Petrol Hybrid	Large-SUV-Executive	Euro 4	0	0	0	16	440	444	462	477
Passenger Cars	Petrol Hybrid	Large-SUV-Executive	Euro 5	0	0	0	0	0	2,340	4,313	4,313
Passenger Cars	Petrol Hybrid	Large-SUV-Executive	Euro 6 up to 2016	0	0	0	0	0	0	0	1,993
Passenger Cars	LPG Bifuel	Mini	Conventional to Euro 4	1	6	292	326	424	559	566	552
Passenger Cars	LPG Bifuel	Mini	Euro 5	0	0	0	0	0	226	232	227
Passenger Cars	LPG Bifuel	Mini	Euro 6	0	0	0	0	0	0	0	16
Passenger Cars	LPG Bifuel	Small	Conventional	14	108	2,998	2,943	3,728	4,912	4,968	4,853
Passenger Cars	LPG Bifuel	Small	Euro 1	0	94	3,420	3,357	4,253	5,604	5,667	5,536
Passenger Cars	LPG Bifuel	Small	Euro 2	0	0	2,869	2,816	3,568	4,701	4,754	4,644
Passenger Cars	LPG Bifuel	Small	Euro 3	0	0	0	1,153	1,460	1,924	1,946	1,901

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2014	2015	2016
Passenger Cars	LPG Bifuel	Small	Euro 4	0	0	0	0	1,238	1,176	1,191	1,189
Passenger Cars	LPG Bifuel	Small	Euro 5	0	0	0	0	0	1,395	1,540	1,527
Passenger Cars	LPG Bifuel	Small	Euro 6	0	0	0	0	0	0	0	253
Passenger Cars	LPG Bifuel	Medium	Conventional	2	21	595	584	739	974	985	963
Passenger Cars	LPG Bifuel	Medium	Euro 1	0	58	2,360	2,317	2,935	3,867	3,911	3,820
Passenger Cars	LPG Bifuel	Medium	Euro 2	0	0	4,137	4,061	5,145	6,779	6,856	6,697
Passenger Cars	LPG Bifuel	Medium	Euro 3	0	0	0	2,762	3,499	4,610	4,662	4,554
Passenger Cars	LPG Bifuel	Medium	Euro 4	0	0	0	0	260	293	295	291
Passenger Cars	LPG Bifuel	Medium	Euro 5	0	0	0	0	0	1,034	1,313	1,306
Passenger Cars	LPG Bifuel	Medium	Euro 6	0	0	0	0	0	0	0	461
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Conventional	8	31	870	854	1,082	1,425	1,441	1,408
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Euro 1	0	32	1,230	1,208	1,530	2,016	2,039	1,992
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Euro 2	0	0	2,156	2,116	2,681	3,532	3,573	3,490
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Euro 3	0	0	0	799	1,012	1,333	1,349	1,317
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Euro 4	0	0	0	0	83	85	85	85
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Euro 5	0	0	0	0	0	511	690	690
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Euro 6	0	0	0	0	0	0	0	290
Light Commercial Vehicles	Diesel	N1-I	Conventional	46,343	162,132	160,807	141,787	97,139	70,185	64,819	59,161
Light Commercial Vehicles	Diesel	N1-I	Euro 1	0	28,483	107,363	104,155	89,781	76,597	73,445	69,573
Light Commercial Vehicles	Diesel	N1-I	Euro 2	0	0	143,420	141,977	132,054	121,000	118,377	114,787
Light Commercial Vehicles	Diesel	N1-I	Euro 3	0	0	0	162,981	167,534	159,794	157,934	155,440
Light Commercial Vehicles	Diesel	N1-I	Euro 4	0	0	0	0	103,686	105,862	105,434	104,592
Light Commercial Vehicles	Diesel	N1-I	Euro 5	0	0	0	0	0	24,540	28,919	28,942
Light Commercial Vehicles	Diesel	N1-I	Euro 6 up to 2016	0	0	0	0	0	0	0	3,292
Light Commercial Vehicles	Diesel	N1-II	Conventional	118,689	176,638	166,719	140,615	115,117	99,007	96,457	93,521
Light Commercial Vehicles	Diesel	N1-II	Euro 1	0	6,393	21,379	20,973	19,560	18,006	17,731	17,361
Light Commercial Vehicles	Diesel	N1-II	Euro 2	0	0	26,824	26,795	28,380	26,503	26,228	25,833
Light Commercial Vehicles	Diesel	N1-II	Euro 3	0	0	0	41,054	41,360	39,225	38,800	38,219
Light Commercial Vehicles	Diesel	N1-II	Euro 4	0	0	0	0	43,648	43,403	43,270	42,868
Light Commercial Vehicles	Diesel	N1-II	Euro 5	0	0	0	0	0	32,307	48,271	48,685
Light Commercial Vehicles	Diesel	N1-II	Euro 6 up to 2017	0	0	0	0	0	0	0	18,927
Light Commercial Vehicles	Diesel	N1-III	Conventional	83,420	164,681	158,632	136,462	100,975	78,786	75,133	71,491
Light Commercial Vehicles	Diesel	N1-III	Euro 1	0	11,628	46,634	44,906	38,443	32,842	31,960	30,999
Light Commercial Vehicles	Diesel	N1-III	Euro 2	0	0	89,856	88,512	82,098	73,812	72,720	71,362
Light Commercial Vehicles	Diesel	N1-III	Euro 3	0	0	0	99,599	98,486	91,687	90,637	89,438
Light Commercial Vehicles	Diesel	N1-III	Euro 4	0	0	0	0	80,315	80,082	79,666	79,099
Light Commercial Vehicles	Diesel	N1-III	Euro 5	0	0	0	0	0	22,680	33,679	33,824

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2014	2015	2016
Light Commercial Vehicles	Diesel	N1-III	Euro 6 up to 2017	0	0	0	0	0	0	0	12,671
Heavy Duty Trucks	Petrol	>3,5 t	Conventional	15	15	12	3	0	4	5	0
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Conventional	13,969	18,137	16,786	12,634	7,539	4,728	4,344	4,002
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Euro I	0	1,581	2,267	2,082	1,553	1,123	1,060	1,003
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Euro II	0	0	2,966	3,370	3,090	2,485	2,407	2,337
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Euro III	0	0	0	749	997	911	904	895
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Euro IV	0	0	0	0	440	431	427	425
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Euro V	0	0	0	0	92	252	257	284
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Euro VI	0	0	0	0	0	106	296	486
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Conventional	6,557	9,182	8,562	6,642	3,801	2,398	2,218	2,025
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Euro I	0	887	1,284	1,264	1,088	812	784	753
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Euro II	0	0	3,751	4,702	4,554	3,785	3,662	3,561
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Euro III	0	0	0	2,796	3,498	3,373	3,389	3,417
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Euro IV	0	0	0	0	1,591	1,505	1,494	1,553
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Euro V	0	0	0	0	392	896	907	920
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Euro VI	0	0	0	0	0	234	371	508
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Conventional	2,065	2,615	2,411	1,912	1,104	705	646	591
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Euro I	0	250	373	382	367	302	288	282
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Euro II	0	0	784	1,026	1,078	952	939	908
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Euro III	0	0	0	552	698	723	746	754
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Euro IV	0	0	0	0	438	417	446	439
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Euro V	0	0	0	0	118	295	299	304
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Euro VI	0	0	0	0	0	57	122	187
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Conventional	13,036	16,163	14,784	12,054	6,920	4,318	4,033	3,782
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Euro I	0	1,474	2,093	2,272	2,030	1,626	1,558	1,492
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Euro II	0	0	3,299	4,279	5,602	4,760	4,657	4,545
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Euro III	0	0	0	1,797	2,702	2,979	3,109	3,199
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Euro IV	0	0	0	0	1,222	1,245	1,358	1,465
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Euro V	0	0	0	0	251	880	897	907
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Euro VI	0	0	0	0	0	255	466	677
Heavy Duty Trucks	Diesel	Rigid 20 - 26 t	Conventional	3,366	3,843	3,415	2,647	1,118	624	572	535
Heavy Duty Trucks	Diesel	Rigid 20 - 26 t	Euro I	0	117	155	161	178	121	107	99
Heavy Duty Trucks	Diesel	Rigid 20 - 26 t	Euro II	0	0	97	154	463	296	281	277
Heavy Duty Trucks	Diesel	Rigid 20 - 26 t	Euro III	0	0	0	33	94	96	103	109
Heavy Duty Trucks	Diesel	Rigid 20 - 26 t	Euro IV	0	0	0	0	12	22	31	38
Heavy Duty Trucks	Diesel	Rigid 20 - 26 t	Euro V	0	0	0	0	13	13	16	19
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Conventional	7,123	9,081	8,396	6,465	3,119	1,767	1,621	1,456

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2014	2015	2016
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Euro I	0	898	1,335	1,400	1,057	756	716	662
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Euro II	0	0	2,282	3,036	3,571	2,873	2,840	2,718
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Euro III	0	0	0	1,193	1,825	1,925	1,984	2,076
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Euro IV	0	0	0	0	803	806	845	924
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Euro V	0	0	0	0	155	436	446	481
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Euro VI	0	0	0	0	0	80	178	276
Heavy Duty Trucks	Diesel	Rigid 28 - 32 t	Conventional	107	139	132	99	29	14	14	9
Heavy Duty Trucks	Diesel	Rigid 28 - 32 t	Euro I	0	14	16	18	8	6	4	4
Heavy Duty Trucks	Diesel	Rigid 28 - 32 t	Euro II	0	0	12	15	26	15	14	13
Heavy Duty Trucks	Diesel	Rigid 28 - 32 t	Euro III	0	0	0	0	4	2	2	4
Heavy Duty Trucks	Diesel	Rigid 28 - 32 t	Euro IV	0	0	0	0	1	0	1	1
Heavy Duty Trucks	Diesel	Rigid 28 - 32 t	Euro VI	0	0	0	0	0	0	1	2
Heavy Duty Trucks	Diesel	Rigid >32 t	Conventional	1,104	1,954	1,865	1,512	590	264	230	205
Heavy Duty Trucks	Diesel	Rigid >32 t	Euro I	0	379	540	580	337	200	183	164
Heavy Duty Trucks	Diesel	Rigid >32 t	Euro II	0	0	1,305	1,715	1,558	889	853	828
Heavy Duty Trucks	Diesel	Rigid >32 t	Euro III	0	0	0	892	1,257	861	866	869
Heavy Duty Trucks	Diesel	Rigid >32 t	Euro IV	0	0	0	0	982	580	582	582
Heavy Duty Trucks	Diesel	Rigid >32 t	Euro V	0	0	0	0	90	140	137	155
Heavy Duty Trucks	Diesel	Rigid >32 t	Euro VI	0	0	0	0	0	32	70	108
Heavy Duty Trucks	Diesel	Articulated 14 - 20 t	Conventional	40	48	41	26	8	5	5	4
Heavy Duty Trucks	Diesel	Articulated 14 - 20 t	Euro I	0	7	10	13	10	4	5	4
Heavy Duty Trucks	Diesel	Articulated 14 - 20 t	Euro II	0	0	5	8	13	5	8	6
Heavy Duty Trucks	Diesel	Articulated 14 - 20 t	Euro III	0	0	0	1	0	0	0	0
Heavy Duty Trucks	Diesel	Articulated 20 - 28 t	Conventional	37	39	32	23	9	6	4	4
Heavy Duty Trucks	Diesel	Articulated 20 - 28 t	Euro I	0	0	0	0	1	0	0	0
Heavy Duty Trucks	Diesel	Articulated 20 - 28 t	Euro II	0	0	3	5	6	5	4	4
Heavy Duty Trucks	Diesel	Articulated 28 - 34 t	Conventional	106	86	63	37	14	7	5	6
Heavy Duty Trucks	Diesel	Articulated 28 - 34 t	Euro I	0	1	2	1	2	1	0	0
Heavy Duty Trucks	Diesel	Articulated 28 - 34 t	Euro II	0	0	1	2	5	4	3	5
Heavy Duty Trucks	Diesel	Articulated 34 - 40 t	Conventional	341	307	225	121	36	20	13	11
Heavy Duty Trucks	Diesel	Articulated 34 - 40 t	Euro I	0	4	4	4	3	1	0	0
Heavy Duty Trucks	Diesel	Articulated 34 - 40 t	Euro II	0	0	3	2	9	4	3	2
Heavy Duty Trucks	Diesel	Articulated 40 - 50 t	Conventional	11,338	16,884	14,761	8,765	2,355	883	759	640
Heavy Duty Trucks	Diesel	Articulated 40 - 50 t	Euro I	0	4,247	6,489	6,060	2,636	1,237	1,059	914
Heavy Duty Trucks	Diesel	Articulated 40 - 50 t	Euro II	0	0	10,390	13,722	10,798	5,868	5,239	4,547
Heavy Duty Trucks	Diesel	Articulated 40 - 50 t	Euro III	0	0	0	7,362	7,268	5,958	5,079	4,656
Heavy Duty Trucks	Diesel	Articulated 40 - 50 t	Euro IV	0	0	0	0	105	249	61	54

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2014	2015	2016
Heavy Duty Trucks	Diesel	Articulated 50 - 60 t	Conventional	83	82	70	50	42	22	15	18
Heavy Duty Trucks	Diesel	Articulated 50 - 60 t	Euro I	0	8	15	30	116	59	54	53
Heavy Duty Trucks	Diesel	Articulated 50 - 60 t	Euro II	0	0	532	709	1,735	1,108	991	876
Heavy Duty Trucks	Diesel	Articulated 50 - 60 t	Euro III	0	0	0	172	4,325	4,499	4,973	4,918
Heavy Duty Trucks	Diesel	Articulated 50 - 60 t	Euro IV	0	0	0	0	7,645	7,055	7,516	7,590
Heavy Duty Trucks	Diesel	Articulated 50 - 60 t	Euro V	0	0	0	0	1,907	6,919	6,779	6,826
Heavy Duty Trucks	Diesel	Articulated 50 - 60 t	Euro VI	0	0	0	0	0	2,580	6,071	9,545
Buses	Diesel	Urban Buses Midi <=15 t	Conventional	2,080	2,479	2,343	1,950	780	418	364	318
Buses	Diesel	Urban Buses Midi <=15 t	Euro I	0	257	376	351	341	201	183	150
Buses	Diesel	Urban Buses Midi <=15 t	Euro II	0	0	883	1,138	1,262	1,096	1,047	974
Buses	Diesel	Urban Buses Midi <=15 t	Euro III	0	0	0	1,101	1,581	1,636	1,606	1,582
Buses	Diesel	Urban Buses Midi <=15 t	Euro IV	0	0	0	0	1,037	1,065	1,093	1,119
Buses	Diesel	Urban Buses Midi <=15 t	Euro V	0	0	0	0	207	543	558	569
Buses	Diesel	Urban Buses Midi <=15 t	Euro VI	0	0	0	0	0	81	183	309
Buses	Diesel	Urban Buses Standard 15 - 18 t	Conventional	4,221	4,419	4,145	3,338	1,254	642	557	464
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro I	0	56	75	116	232	190	170	148
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro II	0	0	87	125	525	348	334	312
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro III	0	0	0	24	209	177	187	196
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro IV	0	0	0	0	45	42	46	48
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro V	0	0	0	0	1	49	50	51
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro VI	0	0	0	0	0	3	6	9
Buses	Diesel	Urban Buses Articulated >18 t	Conventional	831	1,346	1,319	1,277	840	489	427	376
Buses	Diesel	Urban Buses Articulated >18 t	Euro I	0	350	588	610	848	708	659	595
Buses	Diesel	Urban Buses Articulated >18 t	Euro II	0	0	1,084	1,383	1,863	2,117	2,097	2,062
Buses	Diesel	Urban Buses Articulated >18 t	Euro III	0	0	0	780	1,108	1,434	1,585	1,751
Buses	Diesel	Urban Buses Articulated >18 t	Euro IV	0	0	0	0	616	654	701	790
Buses	Diesel	Urban Buses Articulated >18 t	Euro V	0	0	0	0	187	487	475	498
Buses	Diesel	Urban Buses Articulated >18 t	Euro VI	0	0	0	0	0	98	201	311
Buses	Diesel	Coaches Standard <=18 t	Conventional	867	908	851	686	258	132	115	95
Buses	Diesel	Coaches Standard <=18 t	Euro I	0	12	15	24	48	39	35	30
Buses	Diesel	Coaches Standard <=18 t	Euro II	0	0	18	26	108	71	68	64
Buses	Diesel	Coaches Standard <=18 t	Euro III	0	0	0	5	43	36	38	40
Buses	Diesel	Coaches Standard <=18 t	Euro IV	0	0	0	0	9	9	10	10
Buses	Diesel	Coaches Standard <=18 t	Euro V	0	0	0	0	0	10	10	10
Buses	Diesel	Coaches Standard <=18 t	Euro VI	0	0	0	0	0	1	1	2
Buses	Diesel	Coaches Articulated >18 t	Conventional	171	277	271	262	172	100	88	77
Buses	Diesel	Coaches Articulated >18 t	Euro I	0	72	121	125	174	145	135	122

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2014	2015	2016
Buses	Diesel	Coaches Articulated >18 t	Euro II	0	0	223	284	383	435	431	423
Buses	Diesel	Coaches Articulated >18 t	Euro III	0	0	0	160	227	294	325	360
Buses	Diesel	Coaches Articulated >18 t	Euro IV	0	0	0	0	127	134	144	162
Buses	Diesel	Coaches Articulated >18 t	Euro V	0	0	0	0	38	100	98	102
Buses	Diesel	Coaches Articulated >18 t	Euro VI	0	0	0	0	0	20	41	64
Buses	CNG	Urban CNG Buses	Euro I	0	0	0	0	0	0	1	1
Buses	CNG	Urban CNG Buses	Euro II	0	0	1	23	23	19	16	0
Buses	CNG	Urban CNG Buses	Euro III	0	0	0	20	30	31	35	35
Buses	CNG	Urban CNG Buses	EEV	0	0	0	0	90	89	89	88
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Conventional	417,346	341,022	264,699	140,866	100,710	93,130	92,770	87,014
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 1	0	0	0	9,163	7,145	5,982	5,651	5,320
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 2	0	0	0	15,238	15,911	12,256	11,368	10,672
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 3	0	0	0	0	17,922	24,566	26,070	31,834
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Conventional	417,346	341,022	264,699	140,866	100,710	93,130	92,770	87,014
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 1	0	0	0	9,163	7,145	5,982	5,651	5,320
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 2	0	0	0	15,238	15,911	12,256	11,368	10,672
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 3	0	0	0	0	17,922	24,566	26,070	31,834
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Conventional	14,753	20,578	31,798	14,218	29,622	25,879	26,657	28,713
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 1	0	0	0	7,196	10,320	10,401	9,828	9,255
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 2	0	0	0	9,162	17,191	17,749	16,914	16,268
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 3	0	0	0	0	20,774	46,797	55,013	66,006
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Conventional	7,869	10,975	17,591	9,473	8,375	5,395	5,558	5,986
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 1	0	0	0	4,795	2,918	2,169	2,049	1,930
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 2	0	0	0	6,105	4,860	3,700	3,526	3,392
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 3	0	0	0	0	5,873	9,757	11,470	13,761
L-Category	Petrol	Motorcycles 4-stroke 250-750 cm³	Conventional	26,481	36,936	54,811	27,567	22,198	14,100	14,524	15,644
L-Category	Petrol	Motorcycles 4-stroke 250-750 cm³	Euro 1	0	0	0	13,952	7,733	5,667	5,355	5,043
L-Category	Petrol	Motorcycles 4-stroke 250-750 cm³	Euro 2	0	0	0	17,764	12,882	9,670	9,216	8,864
L-Category	Petrol	Motorcycles 4-stroke 250-750 cm³	Euro 3	0	0	0	0	15,567	25,498	29,974	35,964
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Conventional	17,027	23,749	40,396	21,773	21,039	14,946	15,396	16,583
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 1	0	0	0	11,020	7,330	6,007	5,676	5,345
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 2	0	0	0	14,031	12,210	10,251	9,769	9,396
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 3	0	0	0	0	14,755	27,028	31,773	38,122

Annex Table 12 - Km per year per vehicle type.

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2014	2015	2016
Passenger Cars	Petrol	Mini	PRE ECE to Euro 4	11,706	11,655	10,128	9,621	8,289	7,261	7,333	7,162
Passenger Cars	Petrol	Mini	Euro 5	0	0	0	0	0	5,533	5,845	6,298
Passenger Cars	Petrol	Mini	Euro 6 up to 2016	0	0	0	0	0	0	0	5,202
Passenger Cars	Petrol	Small	PRE ECE	7,746	5,253	2,689	1,672	1,116	928	895	843
Passenger Cars	Petrol	Small	ECE 15/00-01	7,716	5,856	3,704	2,325	1,391	1,140	1,174	1,167
Passenger Cars	Petrol	Small	ECE 15/02	8,944	6,783	5,032	3,702	2,563	2,130	2,190	2,020
Passenger Cars	Petrol	Small	ECE 15/03	13,117	10,337	7,768	6,202	4,788	3,920	3,857	3,729
Passenger Cars	Petrol	Small	ECE 15/04	15,138	13,441	10,620	8,673	6,796	5,464	5,478	5,238
Passenger Cars	Petrol	Small	Euro 1	0	15,230	13,149	11,103	8,931	7,300	7,283	7,011
Passenger Cars	Petrol	Small	Euro 2	0	0	13,272	12,146	10,007	8,273	8,247	7,970
Passenger Cars	Petrol	Small	Euro 3	0	0	0	12,148	10,697	9,023	9,039	8,781
Passenger Cars	Petrol	Small	Euro 4	0	0	0	0	7,648	9,451	8,709	8,686
Passenger Cars	Petrol	Small	Euro 5	0	0	0	0	0	5,918	6,361	6,954
Passenger Cars	Petrol	Small	Euro 6 up to 2016	0	0	0	0	0	0	0	5,316
Passenger Cars	Petrol	Medium	PRE ECE	7,332	5,074	2,405	1,292	896	868	908	866
Passenger Cars	Petrol	Medium	ECE 15/00-01	9,341	7,029	4,430	1,837	1,440	1,146	1,170	1,150
Passenger Cars	Petrol	Medium	ECE 15/02	10,596	8,089	5,902	4,216	2,676	2,036	3,086	2,726
Passenger Cars	Petrol	Medium	ECE 15/03	15,295	12,538	9,489	7,726	5,536	4,410	4,273	4,192
Passenger Cars	Petrol	Medium	ECE 15/04	13,492	15,718	13,399	11,096	8,565	6,791	6,729	6,428
Passenger Cars	Petrol	Medium	Euro 1	0	11,216	14,268	12,566	9,927	8,098	8,091	7,703
Passenger Cars	Petrol	Medium	Euro 2	0	0	11,408	13,964	11,506	9,505	9,518	9,167
Passenger Cars	Petrol	Medium	Euro 3	0	0	0	11,552	11,649	9,758	9,744	9,442
Passenger Cars	Petrol	Medium	Euro 4	0	0	0	0	7,768	8,743	8,911	8,733
Passenger Cars	Petrol	Medium	Euro 5	0	0	0	0	0	5,709	6,243	7,068
Passenger Cars	Petrol	Medium	Euro 6 up to 2016	0	0	0	0	0	0	0	4,792
Passenger Cars	Petrol	Large-SUV-Executive	PRE ECE	8,789	5,216	2,569	1,591	1,242	1,001	1,042	1,013
Passenger Cars	Petrol	Large-SUV-Executive	ECE 15/00-01	7,415	5,328	3,288	1,968	1,493	1,192	1,242	1,157
Passenger Cars	Petrol	Large-SUV-Executive	ECE 15/02	10,120	7,533	5,290	3,824	2,417	1,865	1,855	1,763
Passenger Cars	Petrol	Large-SUV-Executive	ECE 15/03	12,969	10,132	7,461	5,865	4,239	3,303	3,213	3,092
Passenger Cars	Petrol	Large-SUV-Executive	ECE 15/04	16,986	15,626	12,463	10,009	7,618	5,896	5,819	5,706
Passenger Cars	Petrol	Large-SUV-Executive	Euro 1	0	17,003	16,069	14,042	10,076	7,815	7,740	7,298

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2014	2015	2016
Passenger Cars	Petrol	Large-SUV-Executive	Euro 2	0	0	14,963	14,522	11,575	9,152	8,996	8,648
Passenger Cars	Petrol	Large-SUV-Executive	Euro 3	0	0	0	14,261	12,286	9,729	9,455	9,156
Passenger Cars	Petrol	Large-SUV-Executive	Euro 4	0	0	0	0	8,624	8,747	8,988	8,727
Passenger Cars	Petrol	Large-SUV-Executive	Euro 5	0	0	0	0	0	5,263	5,663	6,140
Passenger Cars	Petrol	Large-SUV-Executive	Euro 6 up to 2016	0	0	0	0	0	0	0	4,841
Passenger Cars	Diesel	Mini	Conventional to Euro 4	0	0	8,649	10,196	10,382	9,112	9,044	8,604
Passenger Cars	Diesel	Mini	Euro 5	0	0	0	0	0	6,176	6,603	7,209
Passenger Cars	Diesel	Mini	Euro 6 up to 2016	0	0	0	0	0	0	0	5,277
Passenger Cars	Diesel	Small	Conventional	20,243	13,006	13,698	10,927	9,043	6,963	6,815	6,493
Passenger Cars	Diesel	Small	Euro 1	0	16,952	18,589	14,309	12,531	9,792	9,520	9,174
Passenger Cars	Diesel	Small	Euro 2	0	0	21,567	17,961	14,523	11,314	11,085	10,568
Passenger Cars	Diesel	Small	Euro 3	0	0	0	18,097	15,606	11,829	11,480	10,966
Passenger Cars	Diesel	Small	Euro 4	0	0	0	0	14,246	11,990	11,776	10,963
Passenger Cars	Diesel	Small	Euro 5	0	0	0	0	0	12,727	12,513	12,060
Passenger Cars	Diesel	Small	Euro 6 up to 2016	0	0	0	0	0	0	0	12,610
Passenger Cars	Diesel	Medium	Conventional	19,205	15,466	16,712	13,373	11,374	8,595	8,286	7,921
Passenger Cars	Diesel	Medium	Euro 1	0	15,990	19,269	15,385	13,081	9,994	9,622	9,293
Passenger Cars	Diesel	Medium	Euro 2	0	0	19,849	17,608	15,197	11,885	11,497	11,109
Passenger Cars	Diesel	Medium	Euro 3	0	0	0	17,387	16,669	12,655	12,291	11,802
Passenger Cars	Diesel	Medium	Euro 4	0	0	0	0	14,311	13,313	13,047	12,181
Passenger Cars	Diesel	Medium	Euro 5	0	0	0	0	0	12,925	13,086	13,440
Passenger Cars	Diesel	Medium	Euro 6 up to 2016	0	0	0	0	0	0	0	12,621
Passenger Cars	Diesel	Large-SUV-Executive	Conventional	18,102	15,447	17,306	13,984	12,024	9,365	9,050	8,698
Passenger Cars	Diesel	Large-SUV-Executive	Euro 1	0	11,795	22,324	17,179	14,615	11,102	10,640	10,155
Passenger Cars	Diesel	Large-SUV-Executive	Euro 2	0	0	15,274	19,230	15,220	11,533	11,123	10,689
Passenger Cars	Diesel	Large-SUV-Executive	Euro 3	0	0	0	15,691	18,750	13,482	13,036	12,467
Passenger Cars	Diesel	Large-SUV-Executive	Euro 4	0	0	0	0	13,506	15,516	15,224	14,145
Passenger Cars	Diesel	Large-SUV-Executive	Euro 5	0	0	0	0	0	11,828	12,447	13,477
Passenger Cars	Diesel	Large-SUV-Executive	Euro 6 up to 2016	0	0	0	0	0	0	0	8,879
Passenger Cars	Petrol Hybrid	Mini	Euro 6 up to 2016	0	0	0	0	0	0	0	14,556
Passenger Cars	Petrol Hybrid	Small	Euro 4	0	0	0	15,740	13,758	11,797	11,852	11,542
Passenger Cars	Petrol Hybrid	Small	Euro 5	0	0	0	0	0	14,184	14,730	14,898
Passenger Cars	Petrol Hybrid	Small	Euro 6 up to 2016	0	0	0	0	0	0	0	14,556
Passenger Cars	Petrol Hybrid	Medium	Euro 4	0	0	0	16,418	12,842	12,316	12,572	11,915
Passenger Cars	Petrol Hybrid	Medium	Euro 5	0	0	0	0	0	13,149	14,112	14,547
Passenger Cars	Petrol Hybrid	Medium	Euro 6 up to 2016	0	0	0	0	0	0	0	14,556
Passenger Cars	Petrol Hybrid	Large-SUV-Executive	Euro 4	0	0	0	16,665	12,579	12,106	12,426	11,848

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2014	2015	2016
Passenger Cars	Petrol Hybrid	Large-SUV-Executive	Euro 5	0	0	0	0	0	14,513	14,877	15,059
Passenger Cars	Petrol Hybrid	Large-SUV-Executive	Euro 6 up to 2016	0	0	0	0	0	0	0	14,556
Passenger Cars	LPG Bifuel	Mini	Conventional to Euro 4	16,272	13,666	16,978	13,614	14,288	11,856	12,215	12,369
Passenger Cars	LPG Bifuel	Mini	Euro 5	0	0	0	0	0	13,479	14,572	14,981
Passenger Cars	LPG Bifuel	Mini	Euro 6	0	0	0	0	0	0	0	14,020
Passenger Cars	LPG Bifuel	Small	Conventional	15,017	12,506	17,160	13,032	9,555	6,970	6,835	6,715
Passenger Cars	LPG Bifuel	Small	Euro 1	0	15,836	22,822	17,664	15,443	12,861	14,005	14,934
Passenger Cars	LPG Bifuel	Small	Euro 2	0	0	14,851	11,781	15,771	13,235	13,395	13,628
Passenger Cars	LPG Bifuel	Small	Euro 3	0	0	0	15,455	17,978	14,604	15,354	15,409
Passenger Cars	LPG Bifuel	Small	Euro 4	0	0	0	0	13,281	14,023	14,638	15,532
Passenger Cars	LPG Bifuel	Small	Euro 5	0	0	0	0	0	13,362	14,522	14,535
Passenger Cars	LPG Bifuel	Small	Euro 6	0	0	0	0	0	0	0	14,020
Passenger Cars	LPG Bifuel	Medium	Conventional	15,023	12,721	17,520	13,719	10,061	6,909	6,824	6,743
Passenger Cars	LPG Bifuel	Medium	Euro 1	0	15,362	22,103	16,991	15,146	12,712	13,912	14,841
Passenger Cars	LPG Bifuel	Medium	Euro 2	0	0	15,829	12,041	16,032	13,432	13,563	13,803
Passenger Cars	LPG Bifuel	Medium	Euro 3	0	0	0	15,515	18,106	14,629	15,363	15,438
Passenger Cars	LPG Bifuel	Medium	Euro 4	0	0	0	0	17,462	16,871	18,417	17,121
Passenger Cars	LPG Bifuel	Medium	Euro 5	0	0	0	0	0	13,088	13,977	14,667
Passenger Cars	LPG Bifuel	Medium	Euro 6	0	0	0	0	0	0	0	14,020
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Conventional	13,638	11,091	14,946	11,510	8,404	6,763	6,710	6,480
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Euro 1	0	15,796	22,640	17,474	15,299	12,818	13,951	14,883
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Euro 2	0	0	15,840	12,233	16,089	13,431	13,576	13,858
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Euro 3	0	0	0	15,389	17,961	14,597	15,346	15,392
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Euro 4	0	0	0	0	15,505	16,201	17,424	16,655
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Euro 5	0	0	0	0	0	12,918	13,841	14,517
Passenger Cars	LPG Bifuel	Large-SUV-Executive	Euro 6	0	0	0	0	0	0	0	14,020
Light Commercial Vehicles	Diesel	N1-I	Conventional	21,045	17,490	15,799	12,006	10,392	8,280	8,049	7,765
Light Commercial Vehicles	Diesel	N1-I	Euro 1	0	23,256	21,703	15,872	12,930	9,572	9,236	8,799
Light Commercial Vehicles	Diesel	N1-I	Euro 2	0	0	25,599	18,318	15,209	11,441	11,000	10,495
Light Commercial Vehicles	Diesel	N1-I	Euro 3	0	0	0	20,044	17,663	13,490	12,965	12,373
Light Commercial Vehicles	Diesel	N1-I	Euro 4	0	0	0	0	20,049	15,986	15,511	14,872
Light Commercial Vehicles	Diesel	N1-I	Euro 5	0	0	0	0	0	18,499	18,958	17,785
Light Commercial Vehicles	Diesel	N1-I	Euro 6 up to 2016	0	0	0	0	0	0	0	19,333
Light Commercial Vehicles	Diesel	N1-II	Conventional	21,318	15,289	15,554	12,076	10,065	7,732	7,450	7,120
Light Commercial Vehicles	Diesel	N1-II	Euro 1	0	18,958	20,607	15,981	13,145	9,847	9,627	9,073
Light Commercial Vehicles	Diesel	N1-II	Euro 2	0	0	22,267	17,886	14,917	11,218	10,805	10,357
Light Commercial Vehicles	Diesel	N1-II	Euro 3	0	0	0	20,030	18,360	13,842	13,312	12,766

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2014	2015	2016
Light Commercial Vehicles	Diesel	N1-II	Euro 4	0	0	0	0	19,560	16,692	16,253	15,610
Light Commercial Vehicles	Diesel	N1-II	Euro 5	0	0	0	0	0	16,659	16,786	16,521
Light Commercial Vehicles	Diesel	N1-II	Euro 6 up to 2017	0	0	0	0	0	0	0	16,522
Light Commercial Vehicles	Diesel	N1-III	Conventional	23,694	16,980	14,767	11,165	9,084	6,924	6,633	6,338
Light Commercial Vehicles	Diesel	N1-III	Euro 1	0	31,228	25,588	17,831	14,268	10,516	10,110	9,603
Light Commercial Vehicles	Diesel	N1-III	Euro 2	0	0	29,333	18,895	15,159	11,212	10,721	10,191
Light Commercial Vehicles	Diesel	N1-III	Euro 3	0	0	0	22,265	18,576	13,705	13,162	12,498
Light Commercial Vehicles	Diesel	N1-III	Euro 4	0	0	0	0	21,894	16,512	16,056	15,400
Light Commercial Vehicles	Diesel	N1-III	Euro 5	0	0	0	0	0	20,095	20,394	19,642
Light Commercial Vehicles	Diesel	N1-III	Euro 6 up to 2017	0	0	0	0	0	0	0	22,073
Heavy Duty Trucks	Petrol	>3,5 t	Conventional	54,925	41,338	29,997	14,712	0	3,147	3,008	0
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Conventional	24,778	18,420	18,352	13,629	11,026	8,293	7,999	7,650
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Euro I	0	19,754	26,174	19,913	15,274	11,547	11,542	10,593
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Euro II	0	0	25,106	22,737	19,841	14,266	13,504	12,807
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Euro III	0	0	0	21,457	25,003	18,908	18,293	16,747
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Euro IV	0	0	0	0	21,790	19,869	18,913	17,859
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Euro V	0	0	0	0	22,646	19,946	20,686	20,155
Heavy Duty Trucks	Diesel	Rigid <=7,5 t	Euro VI	0	0	0	0	0	20,180	19,973	20,004
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Conventional	25,586	21,578	23,015	17,488	13,712	10,158	9,924	9,424
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Euro I	0	18,977	30,995	25,886	20,715	14,662	13,228	12,759
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Euro II	0	0	24,177	26,810	23,970	17,037	16,270	15,177
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Euro III	0	0	0	21,986	25,781	20,575	20,044	19,248
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Euro IV	0	0	0	0	21,400	21,454	20,950	20,559
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Euro V	0	0	0	0	18,232	18,783	20,021	21,005
Heavy Duty Trucks	Diesel	Rigid 7,5 - 12 t	Euro VI	0	0	0	0	0	19,427	19,228	19,754
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Conventional	42,062	32,845	32,988	23,994	18,184	13,475	12,751	12,372
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Euro I	0	31,613	46,477	35,788	25,282	17,617	16,517	15,160
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Euro II	0	0	40,750	42,175	33,607	23,035	20,973	19,509
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Euro III	0	0	0	31,557	40,719	31,574	30,686	29,365
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Euro IV	0	0	0	0	34,743	35,170	35,074	34,879
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Euro V	0	0	0	0	27,636	28,289	30,405	31,185
Heavy Duty Trucks	Diesel	Rigid 12 - 14 t	Euro VI	0	0	0	0	0	21,068	20,851	21,683
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Conventional	41,107	32,209	32,360	23,501	17,729	13,110	12,387	11,973
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Euro I	0	31,573	46,547	35,820	25,283	17,644	16,480	15,195
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Euro II	0	0	40,834	42,228	33,215	22,845	20,833	19,361
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Euro III	0	0	0	31,971	40,655	31,400	30,446	29,009
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Euro IV	0	0	0	0	33,188	35,311	34,882	34,533

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2014	2015	2016
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Euro V	0	0	0	0	27,636	25,985	28,347	29,288
Heavy Duty Trucks	Diesel	Rigid 14 - 20 t	Euro VI	0	0	0	0	0	21,068	20,851	21,967
Heavy Duty Trucks	Diesel	Rigid 20 - 26 t	Conventional	44,595	33,355	33,132	24,481	20,259	14,313	13,813	13,169
Heavy Duty Trucks	Diesel	Rigid 20 - 26 t	Euro I	0	34,204	51,580	40,052	28,288	20,410	18,919	18,037
Heavy Duty Trucks	Diesel	Rigid 20 - 26 t	Euro II	0	0	46,033	44,908	34,851	23,617	21,952	20,609
Heavy Duty Trucks	Diesel	Rigid 20 - 26 t	Euro III	0	0	0	33,829	45,347	33,921	32,771	30,543
Heavy Duty Trucks	Diesel	Rigid 20 - 26 t	Euro IV	0	0	0	0	33,976	37,527	38,267	38,857
Heavy Duty Trucks	Diesel	Rigid 20 - 26 t	Euro V	0	0	0	0	31,341	40,112	44,589	46,682
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Conventional	45,516	36,173	36,351	26,581	21,473	14,908	14,258	13,544
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Euro I	0	34,455	52,408	40,604	28,327	20,387	18,900	18,066
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Euro II	0	0	42,309	43,992	35,418	23,856	22,174	20,779
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Euro III	0	0	0	33,965	44,894	34,164	32,963	30,507
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Euro IV	0	0	0	0	34,391	38,878	38,743	38,965
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Euro V	0	0	0	0	31,341	34,496	39,052	44,103
Heavy Duty Trucks	Diesel	Rigid 26 - 28 t	Euro VI	0	0	0	0	0	20,157	19,950	20,667
Heavy Duty Trucks	Diesel	Rigid 28 - 32 t	Conventional	48,283	38,272	38,024	27,421	21,073	14,886	14,670	13,957
Heavy Duty Trucks	Diesel	Rigid 28 - 32 t	Euro I	0	33,715	49,937	38,437	27,847	19,993	18,561	17,322
Heavy Duty Trucks	Diesel	Rigid 28 - 32 t	Euro II	0	0	41,666	44,427	34,197	23,588	21,658	20,462
Heavy Duty Trucks	Diesel	Rigid 28 - 32 t	Euro III	0	0	0	0	45,742	32,165	31,133	30,924
Heavy Duty Trucks	Diesel	Rigid 28 - 32 t	Euro IV	0	0	0	0	30,771	0	35,848	36,438
Heavy Duty Trucks	Diesel	Rigid 28 - 32 t	Euro VI	0	0	0	0	0	0	19,950	19,580
Heavy Duty Trucks	Diesel	Rigid >32 t	Conventional	47,508	38,777	39,631	28,773	22,282	15,900	14,927	14,261
Heavy Duty Trucks	Diesel	Rigid >32 t	Euro I	0	34,574	52,413	40,578	28,261	20,416	18,893	17,974
Heavy Duty Trucks	Diesel	Rigid >32 t	Euro II	0	0	40,508	43,520	35,697	23,995	22,314	20,905
Heavy Duty Trucks	Diesel	Rigid >32 t	Euro III	0	0	0	33,718	44,638	34,611	33,479	30,946
Heavy Duty Trucks	Diesel	Rigid >32 t	Euro IV	0	0	0	0	35,561	38,790	38,642	38,873
Heavy Duty Trucks	Diesel	Rigid >32 t	Euro V	0	0	0	0	31,341	37,036	41,301	45,259
Heavy Duty Trucks	Diesel	Rigid >32 t	Euro VI	0	0	0	0	0	20,157	19,950	20,691
Heavy Duty Trucks	Diesel	Articulated 14 - 20 t	Conventional	107,784	69,226	50,637	29,539	23,283	15,541	15,080	14,678
Heavy Duty Trucks	Diesel	Articulated 14 - 20 t	Euro I	0	84,883	90,852	46,774	27,779	20,066	18,297	17,358
Heavy Duty Trucks	Diesel	Articulated 14 - 20 t	Euro II	0	0	110,752	81,505	40,549	25,845	24,779	22,324
Heavy Duty Trucks	Diesel	Articulated 14 - 20 t	Euro III	0	0	0	96,289	0	0	0	0
Heavy Duty Trucks	Diesel	Articulated 20 - 28 t	Conventional	90,368	56,752	42,468	25,675	20,968	14,106	13,343	10,400
Heavy Duty Trucks	Diesel	Articulated 20 - 28 t	Euro I	0	0	0	0	30,806	0	0	0
Heavy Duty Trucks	Diesel	Articulated 20 - 28 t	Euro II	0	0	117,154	73,238	35,218	23,144	22,332	20,438
Heavy Duty Trucks	Diesel	Articulated 28 - 34 t	Conventional	84,122	44,085	32,529	18,971	16,360	10,468	8,937	9,657
Heavy Duty Trucks	Diesel	Articulated 28 - 34 t	Euro I	0	88,267	100,570	53,405	27,585	19,451	0	0

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2014	2015	2016
Heavy Duty Trucks	Diesel	Articulated 28 - 34 t	Euro II	0	0	97,438	89,966	38,032	25,779	24,330	22,336
Heavy Duty Trucks	Diesel	Articulated 34 - 40 t	Conventional	90,820	49,059	36,721	22,571	17,928	12,444	12,725	12,587
Heavy Duty Trucks	Diesel	Articulated 34 - 40 t	Euro I	0	84,317	82,698	42,079	29,408	19,451	0	0
Heavy Duty Trucks	Diesel	Articulated 34 - 40 t	Euro II	0	0	114,197	74,001	37,714	25,618	22,853	21,349
Heavy Duty Trucks	Diesel	Articulated 40 - 50 t	Conventional	112,626	72,138	53,748	30,822	22,386	14,958	14,288	13,779
Heavy Duty Trucks	Diesel	Articulated 40 - 50 t	Euro I	0	86,551	95,494	48,225	29,064	20,286	18,768	17,968
Heavy Duty Trucks	Diesel	Articulated 40 - 50 t	Euro II	0	0	109,816	83,610	38,877	26,442	24,873	23,177
Heavy Duty Trucks	Diesel	Articulated 40 - 50 t	Euro III	0	0	0	91,254	84,237	57,202	54,210	51,931
Heavy Duty Trucks	Diesel	Articulated 40 - 50 t	Euro IV	0	0	0	0	86,870	76,439	71,320	66,644
Heavy Duty Trucks	Diesel	Articulated 50 - 60 t	Conventional	103,336	65,016	47,363	26,472	20,995	15,271	14,685	13,518
Heavy Duty Trucks	Diesel	Articulated 50 - 60 t	Euro I	0	86,297	96,815	49,258	30,073	20,324	19,090	18,238
Heavy Duty Trucks	Diesel	Articulated 50 - 60 t	Euro II	0	0	110,483	82,095	39,542	26,948	25,251	23,661
Heavy Duty Trucks	Diesel	Articulated 50 - 60 t	Euro III	0	0	0	89,361	89,449	62,070	60,035	58,229
Heavy Duty Trucks	Diesel	Articulated 50 - 60 t	Euro IV	0	0	0	0	81,728	77,781	73,592	68,564
Heavy Duty Trucks	Diesel	Articulated 50 - 60 t	Euro V	0	0	0	0	79,168	78,533	81,558	81,063
Heavy Duty Trucks	Diesel	Articulated 50 - 60 t	Euro VI	0	0	0	0	0	72,839	72,089	72,240
Buses	Diesel	Urban Buses Midi <=15 t	Conventional	31,451	23,768	24,870	19,535	13,288	10,181	9,332	8,356
Buses	Diesel	Urban Buses Midi <=15 t	Euro I	0	18,036	32,211	27,473	21,403	15,270	14,361	12,768
Buses	Diesel	Urban Buses Midi <=15 t	Euro II	0	0	20,143	25,265	23,483	18,273	17,061	16,613
Buses	Diesel	Urban Buses Midi <=15 t	Euro III	0	0	0	23,240	31,418	25,226	24,647	23,022
Buses	Diesel	Urban Buses Midi <=15 t	Euro IV	0	0	0	0	23,112	23,326	23,835	23,436
Buses	Diesel	Urban Buses Midi <=15 t	Euro V	0	0	0	0	15,026	19,653	21,613	21,549
Buses	Diesel	Urban Buses Midi <=15 t	Euro VI	0	0	0	0	0	10,904	15,026	16,749
Buses	Diesel	Urban Buses Standard 15 - 18 t	Conventional	58,462	37,597	34,289	25,253	18,888	13,992	13,422	12,509
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro I	0	70,105	70,870	51,990	27,550	16,844	15,550	14,774
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro II	0	0	82,151	61,310	37,814	27,770	25,055	22,449
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro III	0	0	0	56,233	55,328	30,374	31,939	30,173
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro IV	0	0	0	0	46,263	47,722	49,634	48,339
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro V	0	0	0	0	17,753	43,654	46,216	45,495
Buses	Diesel	Urban Buses Standard 15 - 18 t	Euro VI	0	0	0	0	0	36,648	36,271	35,206
Buses	Diesel	Urban Buses Articulated >18 t	Conventional	68,306	52,799	48,938	34,197	22,522	15,527	14,398	13,115
Buses	Diesel	Urban Buses Articulated >18 t	Euro I	0	56,396	73,051	52,558	33,372	18,448	17,235	15,445
Buses	Diesel	Urban Buses Articulated >18 t	Euro II	0	0	61,213	59,569	45,719	29,602	26,974	24,604
Buses	Diesel	Urban Buses Articulated >18 t	Euro III	0	0	0	44,922	56,593	42,172	37,996	35,740
Buses	Diesel	Urban Buses Articulated >18 t	Euro IV	0	0	0	0	54,273	54,763	54,747	52,517
Buses	Diesel	Urban Buses Articulated >18 t	Euro V	0	0	0	0	35,411	55,519	61,267	60,136
Buses	Diesel	Urban Buses Articulated >18 t	Euro VI	0	0	0	0	0	51,218	46,156	48,416

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2014	2015	2016
Buses	Diesel	Coaches Standard <=18 t	Conventional	58,462	37,597	34,289	25,253	18,888	13,992	13,422	12,509
Buses	Diesel	Coaches Standard <=18 t	Euro I	0	70,105	70,870	51,990	27,550	16,844	15,550	14,774
Buses	Diesel	Coaches Standard <=18 t	Euro II	0	0	82,151	61,310	37,814	27,770	25,055	22,449
Buses	Diesel	Coaches Standard <=18 t	Euro III	0	0	0	56,233	55,328	30,374	31,939	30,173
Buses	Diesel	Coaches Standard <=18 t	Euro IV	0	0	0	0	46,263	47,722	49,634	48,339
Buses	Diesel	Coaches Standard <=18 t	Euro V	0	0	0	0	17,753	43,654	46,216	45,495
Buses	Diesel	Coaches Standard <=18 t	Euro VI	0	0	0	0	0	36,648	36,271	35,206
Buses	Diesel	Coaches Articulated >18 t	Conventional	68,306	52,799	48,938	34,197	22,522	15,527	14,398	13,115
Buses	Diesel	Coaches Articulated >18 t	Euro I	0	56,396	73,051	52,558	33,372	18,448	17,235	15,445
Buses	Diesel	Coaches Articulated >18 t	Euro II	0	0	61,213	59,569	45,719	29,602	26,974	24,604
Buses	Diesel	Coaches Articulated >18 t	Euro III	0	0	0	44,922	56,593	42,172	37,996	35,740
Buses	Diesel	Coaches Articulated >18 t	Euro IV	0	0	0	0	54,273	54,763	54,747	52,517
Buses	Diesel	Coaches Articulated >18 t	Euro V	0	0	0	0	35,411	55,519	61,267	60,136
Buses	Diesel	Coaches Articulated >18 t	Euro VI	0	0	0	0	0	51,218	46,156	48,416
Buses	CNG	Urban CNG Buses	Euro I	0	0	0	0	0	0	49,182	0
Buses	CNG	Urban CNG Buses	Euro II	0	0	1,204,723	346,610	150,762	138,285	148,696	0
Buses	CNG	Urban CNG Buses	Euro III	0	0	0	556,173	185,002	167,963	176,122	289,904
Buses	CNG	Urban CNG Buses	EEV	0	0	0	0	151,338	157,748	169,065	282,120
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Conventional	3,785	3,040	2,425	1,929	1,414	1,081	1,058	1,001
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 1	0	0	0	4,259	2,759	1,903	1,814	1,673
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 2	0	0	0	4,075	3,391	2,340	2,231	2,056
L-Category	Petrol	Mopeds 2-stroke <50 cm³	Euro 3	0	0	0	0	3,930	3,137	3,066	3,234
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Conventional	3,785	3,040	2,425	1,929	1,414	1,081	1,058	1,001
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 1	0	0	0	4,259	2,759	1,903	1,814	1,673
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 2	0	0	0	4,075	3,391	2,340	2,231	2,056
L-Category	Petrol	Mopeds 4-stroke <50 cm³	Euro 3	0	0	0	0	3,930	3,137	3,066	3,234
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Conventional	3,785	3,040	2,425	1,929	1,414	1,081	1,058	1,001
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 1	0	0	0	4,259	2,759	1,903	1,814	1,673
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 2	0	0	0	4,075	3,391	2,340	2,231	2,056
L-Category	Petrol	Motorcycles 2-stroke >50 cm³	Euro 3	0	0	0	0	3,930	3,137	3,066	3,234
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Conventional	8,281	6,652	5,306	7,913	5,126	3,540	3,377	3,115
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 1	0	0	0	9,356	6,063	4,181	3,986	3,676
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 2	0	0	0	9,122	7,373	5,100	4,856	4,482
L-Category	Petrol	Motorcycles 4-stroke <250 cm³	Euro 3	0	0	0	0	7,959	7,302	7,318	7,173
L-Category	Petrol	Motorcycles 4-stroke 250-750 cm³	Conventional	8,281	6,652	5,306	7,913	5,126	3,540	3,377	3,115
L-Category	Petrol	Motorcycles 4-stroke 250-750 cm³	Euro 1	0	0	0	9,356	6,063	4,181	3,986	3,676
L-Category	Petrol	Motorcycles 4-stroke 250-750 cm³	Euro 2	0	0	0	9,122	7,373	5,100	4,856	4,482

Category	Fuel	Segment	Euro Standard	1990	1995	2000	2005	2010	2014	2015	2016
L-Category	Petrol	Motorcycles 4-stroke 250-750 cm³	Euro 3	0	0	0	0	7,959	7,302	7,318	7,173
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Conventional	8,281	6,652	5,306	7,913	5,126	3,540	3,377	3,115
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 1	0	0	0	9,356	6,063	4,181	3,986	3,676
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 2	0	0	0	9,122	7,373	5,100	4,856	4,482
L-Category	Petrol	Motorcycles 4-stroke >750 cm³	Euro 3	0	0	0	0	7,959	7,302	7,318	7,173

Annex Table 13 - Activity data for NFR 1.A.3.c: Fuel consumption from railways (GJ)

Fuel		NAPFUE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Coal	S	102	845	456	583	482	502	185	255	0	0	0	0	0	77	77
Coke	S	108	252	168	168	84	84	28	56	0	0	0	0	0	0	0
Diesel-oil	L	204	2,389,791	2,501,912	2,507,433	2,292,868	2,275,613	2,326,174	2,119,240	2,035,611	1,889,302	1,858,765	1,828,984	1,630,079	1,522,420	1,522,420
Biodiesel	B	223	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fuel		NAPFUE		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Coal	S	102		0	0	0	0	0	0	0	0	0	0	0	0	0
Coke	S	108		0	0	0	0	0	0	0	0	0	0	0	0	0
Diesel-oil	L	204		1,192,991	1,110,181	1,020,949	1,029,964	1,088,146	746,675	634,969	553,578	451,450	407,922	428,930	407,371	407,371
Biodiesel	B	223		0	0	13,593	26,433	27,117	32,394	40,730	36,878	29,941	26,285	26,881	29,348	29,348

Small combustion (NFR 1.A.4)

Annex Table 14 - Activity data for NFR 1.A.4.a: Fuel consumption in the commercial, services and institutional sector (GJ)

Fuel		NAPFUE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Residual Oil	L	203	2,377,775	2,082,473	1,987,019	2,067,733	3,669,386	4,274,308	3,304,671	1,388,428	2,838,261	3,440,598	3,314,158	3,449,183	3,534,234	3,534,234
Diesel/Gas Oil	L	204	5,639,815	6,917,498	8,280,078	8,445,426	8,591,550	7,888,815	8,726,269	13,105,635	16,719,028	18,351,231	18,391,384	21,956,952	24,194,942	24,194,942
Kerosene	L	206	74,919	33,396	64,201	73,783	24,510	13,467	12,685	25,068	27,142	17,200	6,137	7,572	9,494	9,494
Gasoline	L	208	579,621	638,690	617,687	605,093	1,036,563	1,174,935	1,419,347	2,593,860	3,262,569	3,219,051	2,217,473	2,854,812	2,486,947	2,486,947
LPG	L	303	1,198,048	1,373,765	1,580,371	1,897,820	1,870,938	1,268,113	2,562,028	3,836,555	4,010,705	4,233,884	4,414,101	5,206,806	5,113,787	5,113,787
City Gas	L	308	504,399	556,773	528,075	643,808	647,871	732,803	785,507	777,866	908,944	1,044,085	732,238	69,195	0	0
Natural Gas	G	301	0	0	0	0	0	0	0	15,786	563,881	1,593,080	2,579,983	4,042,999	5,152,623	5,152,623
Wood	B	111	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biogas	B	309	0	0	0	0	0	0	0	0	0	37,572	76,912	41,033	45,650	45,650
Biodiesel	B	223	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fuel		NAPFUE		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Residual Oil	L	203		3,152,344	3,182,777	3,540,956	3,560,519	2,220,557	1,905,882	2,672,347	1,385,221	1,030,689	850,701	768,683	1,218,547	1,218,547
Diesel/Gas Oil	L	204		33,061,615	28,690,066	14,638,625	14,949,750	12,587,334	12,101,443	4,807,532	3,312,792	2,680,918	2,454,655	2,659,761	1,721,037	1,721,037
Kerosene	L	206		7,216	6,334	8,228	4,563	1,298	5,191	879	2,219	2,177	4,103	84	2,386	2,386
Gasoline	L	208		2,426,561	1,637,165	1,025,939	797,979	28,471	27,801	37,473	2,177	0	0	0	0	0
LPG	L	303		5,413,453	4,806,060	4,349,043	4,487,167	5,143,317	4,804,021	2,146,848	1,927,378	1,919,549	1,958,653	3,135,595	3,383,577	3,383,577
City Gas	L	308		0	0	0	0	0	0	0	0	0	0	0	0	0
Natural Gas	G	301		6,592,309	6,494,120	7,344,546	8,433,471	8,545,510	10,053,470	10,731,187	11,091,210	12,311,704	12,384,387	12,315,682	12,423,534	12,423,534
Wood	B	111		0	0	0	0	0	0	0	2,532,762	1,463,891	1,462,176	1,679,456	1,302,845	1,302,845
Biogas	B	309		76,039	102,253	97,016	81,522	130,750	135,839	157,677	166,930	146,480	170,539	104,655	91,330	91,330
Biodiesel	B	223		0	0	97,336	176,796	128,950	190,896	51,132	52,967	39,371	50,897	72,295	26,548	26,548

Annex Table 15 - Activity data for NFR 1.A.4.b: Fuel consumption in the residential sector (GJ)

Fuel		NAPFUE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Residual Oil	L	203	63,570	62,136	55,570	51,491	66,733	42,592	43,339	40,296	10,922	3,883	2,596	0	0	0
Diesel/Gas Oil	L	204	158,313	210,952	285,685	205,156	190,401	201,062	132,690	91,954	106,045	144,312	90,483	82,460	120,375	120,375
Kerosene	L	206	793,847	753,503	626,435	530,823	514,054	356,029	416,128	728,737	761,963	705,693	365,545	194,522	147,927	147,927
Gasoline	L	208	6,189	7,791	5,904	5,653	6,256	9,584	13,758	14,908	14,701	6,081	773	93	24,864	24,864
LPG	L	303	23,458,865	24,712,407	26,379,429	27,970,640	28,407,682	28,700,786	30,988,266	30,036,100	31,626,170	33,487,398	34,345,777	31,576,352	31,565,739	31,565,739
City Gas	L	308	1,923,876	1,950,110	1,984,435	2,073,096	1,984,456	1,929,958	1,977,160	1,991,632	2,106,088	2,039,388	1,212,913	156,763	0	0
Natural Gas	G	301	0	0	0	0	0	0	0	35,408	400,760	1,506,342	3,192,297	4,927,459	6,165,244	6,165,244
Wood	B	111	53,770,921	51,344,184	49,611,501	48,513,399	48,000,716	48,033,473	48,172,943	46,841,627	45,510,311	44,178,995	42,847,679	41,516,363	40,185,047	40,185,047
Charcoal	B	112	749,950	738,791	727,632	716,473	705,314	694,155	682,996	671,837	660,678	626,132	591,586	557,041	522,495	522,495
Biodiesel	B	223	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fuel		NAPFUE		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Residual Oil	L	203		0	0	0	0	0	0	0	0	0	0	0	0	0
Diesel/Gas Oil	L	204		667,243	600,226	1,439,049	574,557	332,928	395,815	5,191,318	3,670,468	2,726,117	2,516,863	2,407,177	2,269,471	2,221,766
Kerosene	L	206		88,654	50,117	30,792	25,203	28,678	22,398	27,213	26,711	18,463	19,803	11,178	7,871	6,280
Gasoline	L	208		37,371	57	79	0	0	0	0	0	0	0	0	0	0
LPG	L	303		30,029,737	29,312,438	27,074,925	25,417,104	22,777,808	21,795,551	23,214,739	20,873,374	19,522,514	18,948,048	17,170,849	15,889,364	15,684,212
City Gas	L	308		0	0	0	0	0	0	0	0	0	0	0	0	0
Natural Gas	G	301		7,618,313	8,394,267	8,512,134	9,250,483	11,924,258	11,103,017	12,571,537	10,851,181	10,839,207	10,415,042	10,852,311	11,049,300	10,570,414
Wood	B	111		37,522,415	36,191,099	34,859,783	33,528,467	32,197,151	30,865,835	29,534,519	31,507,615	31,522,887	32,256,276	32,080,962	31,922,552	31,990,921
Charcoal	B	112		453,404	418,858	384,312	349,767	315,221	280,675	246,130	246,130	246,130	246,130	246,130	246,130	246,130
Biodiesel	B	223		0	0	1,546	2,794	1	41	26,859	710	2,921	75	68	2,585	0

Annex Table 16 - Activity data for NFR 1.A.4.c.i: Fuel consumption in agriculture and forestry sector (GJ) (excluding mobile sources)

Fuel		NAPFUE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Residual Oil	L	203	524,617	376,193	286,335	343,681	488,068	426,845	511,483	547,071	474,723	677,941	889,643	799,840	1,207,470	1,207,470
Kerosene	L	206	350,338	311,043	272,158	207,862	200,980	191,157	183,421	427,000	494,010	24,166	44,397	47,082	50,284	50,284
Gasoline	L	208	33,650	35,681	47,407	44,936	134,763	129,648	162,646	197,586	174,417	159,737	42,723	119,538	106,820	106,820
LPG	L	303	329,856	405,427	478,962	575,900	580,807	572,444	826,953	560,179	713,861	674,638	496,882	673,259	639,651	639,651
Natural Gas	G	301	0	0	0	0	0	0	0	0	36	174	4,897	213,356	284,851	284,851
Biogas	B	309	0	0	0	0	0	0	0	0	0	0	9,294	7,773	5,939	5,939

Fuel		NAPFUE		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Residual Oil	L	203		405,069	858,912	567,179	290,101	199,621	99,477	153,402	172,535	46,849	33,703	36,048	53,674	33,871
Kerosene	L	206		48,915	54,581	56,434	32,446	38,935	45,173	39,019	30,395	33,493	29,516	24,785	25,538	20,012
Gasoline	L	208		117,435	208,555	153,501	100,611	36,091	32,407	24,033	13,147	16,203	24,619	14,780	27,717	27,885
LPG	L	303		523,451	541,228	493,957	449,407	362,700	296,549	308,858	271,637	267,660	214,446	194,350	222,317	196,945
Natural Gas	G	301		295,599	325,872	319,153	360,944	305,260	370,699	423,872	486,213	516,693	570,870	305,385	327,408	346,500
Biogas	B	309		11,122	29,039	26,931	20,251	13,766	19,833	23,013	24,686	18,787	16,527	15,774	12,929	12,343

Annex Table 17 - Activity data for NFR 1.A.4.c.i: Fuels consumed in fisheries (excluding consumption in fishing vessels) (GJ)

Fuel		NAPFUE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Residual Oil	L	203	4,004	5,415	7,458	9,303	7,681	12,145	5,132	8,888	6,383	49,680	6,483	18,055	28,129	28,129
Diesel/Gas Oil	L	204	99,086	95,355	84,795	74,186	77,645	84,915	64,556	209,384	597,882	0	1,081,354	2,179,005	1,097,824	1,097,824
Kerosene	L	206	7	0	7	7	0	0	0	0	2,652	74,960	10,079	94	47	47
Gasoline	L	208	1,406	0	214	85	278	707	985	728	4,040	61,587	279,165	286,314	280,882	280,882
LPG	L	303	2,847	5,792	4,077	1,499	2,148	0	110	3,902	2,531	8,434	20,809	32,648	21,140	21,140
Natural Gas	G	301	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biodiesel	B	223	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fuel		NAPFUE		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Residual Oil	L	203		0	0	13,012	0	48,147	0	91,830	47,735	84,842	44,785	95,603	35,958	51,899
Diesel/Gas Oil	L	204		568,387	587,681	693,512	445,146	519,123	0	649,478	913,983	932,934	1,061,286	1,117,458	1,542,559	1,426,304
Kerosene	L	206		320	15	0	0	0	0	0	0	0	0	0	0	0
Gasoline	L	208		260,910	29,919	31,819	26,126	5,569	30,062	21,060	18,255	4,145	11,305	5,317	4,899	5,150
LPG	L	303		91,294	5,903	5,967	2,303	5,778	3,014	1,675	461	209	0	0	293	0
Natural Gas	G	301		0	0	1,363	2,261	2,010	3,098	4,396	4,145	2,219	16,789	23,739	22,441	22,944
Biodiesel	B	223		0	0	47,489	73,387	70,531	112,475	195,569	218,127	221,762	227,313	194,189	239,391	180,825

Annex Table 18 - Activity data for NFR 1.A.4.c.ii: Fuels consumption in machines and other off-road vehicles (GJ)

Fuel		NAPFUE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Diesel/Gas O	L	204	15,954,739	16,738,690	16,949,965	17,675,330	17,825,456	17,289,762	19,142,892	15,029,333	8,912,769	9,042,482	9,950,538	10,757,924	11,433,231	11,433,231
Biodiesel	B	223	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fuel		NAPFUE		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Diesel/Gas O	L	204		8,703,013	12,775,956	12,053,442	11,905,304	11,241,230	10,005,353	9,649,630	9,487,624	9,624,560	9,950,122	10,017,693	10,049,319	10,049,319
Biodiesel	B	223		0	0	159,969	307,367	280,546	433,071	618,948	631,782	637,571	640,626	627,942	723,891	723,891

Annex Table 19 - Activity data for NFR 1.A.4.c.iii: Fuels consumed in fishing bunkers (GJ)

Fuel		NAPFUE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Thin Fuel-oil	L	203	0	6,000	0	81,600	552,240	53,520	32,000	19,520	21,760	12,880	4,000	0	0	0
Thick Fuel-oil	L	204	0	0	0	0	413,200	96,000	24,000	22,400	42,240	21,120	0	0	0	0
Diesel/Gas Oil	L	206	10,783,849	11,035,700	9,752,418	8,671,656	8,912,346	7,898,551	7,321,406	6,789,503	6,794,700	8,072,743	9,350,785	7,398,427	6,446,147	6,446,147
NATO's Nafta	L	208	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fuel		NAPFUE		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Thin Fuel-oil	L	203		0	0	0	0	0	0	0	22,014	18,018	52,026	66,026	149,898	278,702
Thick Fuel-oil	L	204		0	0	0	0	0	714,669	765,555	717,098	9,158	0	0	0	0
Diesel/Gas Oil	L	206		6,630,905	5,496,620	5,749,321	4,798,240	4,694,265	5,765,758	5,916,129	5,142,046	5,082,892	5,192,645	4,236,519	3,785,012	3,829,853
NATO's Nafta	L	208		0	0	0	0	0	0	0	0	0	0	0	0	0

Other Mobile (NFR 1.A.5)

Annex Table 20 - Activity data for NFR 1.A.5.b: Energy Consumption in Military aviation (TJ)

Fuel		NAPFUE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Jet Fuel	L	207	1,344	1,504	1,127	1,065	1,188	1,149	1,471	1,413	1,474	1,127	1,338	1,338	939	749

Fuel		NAPFUE	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Jet Fuel	L	207	570	1,025	1,064	1,026	1,200	1,205	1,208	1,086	683	822	961	1,065	614

ANNEX D: AGRICULTURE (NFR 3)

Annex Table 21- Livestock numbers (thousands) – time series

Animal	Sub-class	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Dairy-Cattle	Dairy cows	394	388	381	383	382	383	380	379	375	369	353	331	311	297
Non-dairy cattle	Beef calves (<1 yr)	46	52	53	53	58	60	64	64	65	66	67	72	75	82
	Calves M.Rep. (<1 yr)	186	185	182	176	167	162	155	151	149	149	144	140	137	141
	Calves F Rep. (<1 yr)	177	178	178	174	164	158	152	152	155	165	174	180	186	186
	Males 1-2 yrs	112	114	114	108	103	103	105	101	95	86	82	81	80	80
	Beef Fem. 1-2 yrs	18	19	20	22	22	22	24	24	24	20	17	14	14	15
	Females rep. 1-2 yrs	111	115	112	109	106	109	112	109	108	116	127	135	136	133
	Steers (>2 yrs)	38	38	36	37	35	33	33	31	31	29	26	24	23	23
	Heifers Beef (>2 yrs)	4	5	7	9	10	10	9	9	9	7	6	6	8	8
	Heifers rep. (>2 yrs)	45	46	45	48	50	52	51	50	52	60	67	77	80	86
	non-dairy cows	242	245	238	241	252	273	296	316	332	338	345	352	362	371
Swine	Piglets (<20 kg)	727	756	756	750	735	726	703	701	695	691	663	626	591	571
	Fatt. Pigs (20-50 kg)	662	675	660	671	668	660	633	631	633	623	585	535	493	471
	Fatt. Pigs (50-80 kg)	525	545	544	539	532	525	505	496	492	498	483	446	402	374
	Fatt. Pigs (80-110 kg)	218	227	226	225	210	198	179	177	174	176	174	184	197	208
	Fatt. Pigs (> 110 kg)	44	46	46	47	45	44	40	39	38	38	38	43	42	43
	Boars (>50 kg)	26	28	27	28	28	26	24	23	23	22	20	19	17	16
	Sows, pregnant	210	219	218	220	216	211	204	204	202	201	195	197	196	198
	Sows, non-pregnant	124	131	135	136	134	132	127	128	127	127	124	111	91	73
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
	Other Ovine	663	725	789	794	811	817	813	802	834	840	733	506	299	204
	Lambs	307	326	320	300	279	278	292	297	301	307	319	320	330	324
Goats	Does	614	588	556	538	528	517	509	498	485	472	460	440	417	392
	Other Caprine	149	156	166	160	153	151	147	151	154	151	129	91	62	48
	kids	47	49	47	44	45	41	41	36	37	36	33	30	29	28
Equidae	Horses	33	38	40	42	44	48	52	54	56	57	58	59	59	58
	Asses and Mules.	118	116	114	114	109	103	96	90	82	75	69	63	57	51
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
	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
	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
	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
	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
Other	Rabbits[1]	475	464	447	430	415	401	384	363	346	338	336	332	325	318

1 Reproductive females

Livestock numbers (thousands) – time series (continuation)

Animal	Sub-class	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Dairy-Cattle	Dairy cows	294	290	284	275	269	263	255	247	241	236	233	235	238
Non-dairy cattle	Beef calves (<1 yr)	91	104	108	108	108	109	114	120	125	119	113	112	114
	Calves M.Rep. (<1 yr)	140	136	131	129	127	123	123	128	136	136	142	152	162
	Cavefs F Rep. (<1 yr)	187	183	180	178	174	169	171	179	190	191	198	209	221
	Males 1-2 yrs	79	81	77	75	73	72	66	60	55	54	53	58	67
	Beef Fem. 1-2 yrs	16	17	17	16	17	18	20	19	20	19	17	15	14
	Females rep. 1-2 yrs	135	135	139	139	141	142	137	132	131	135	139	148	159
	Steers (>2 yrs)	23	25	28	31	33	34	38	41	44	42	39	37	38
	Heifers Beef (>2 yrs)	8	9	9	9	9	10	12	13	14	14	15	15	14
	Heifers rep. (>2 yrs)	90	94	96	96	97	102	110	111	110	105	103	96	92
	non-dairy cows	382	397	411	425	432	436	438	440	442	443	450	461	474
Swine	Piglets (<20 kg)	570	574	583	590	592	602	597	614	634	658	681	713	729
	Fatt. Pigs (20-50 kg)	467	467	466	468	464	460	448	446	455	464	472	485	490
	Fatt. Pigs (50-80 kg)	373	368	362	356	357	362	360	362	366	366	369	380	387
	Fatt. Pigs (80-110 kg)	213	214	221	222	227	237	244	251	255	263	273	285	294
	Fatt. Pigs (> 110 kg)	40	41	43	44	44	40	36	30	27	25	28	30	33
	Boars (>50 kg)	14	12	12	11	10	8	7	6	5	5	5	6	5
	Sows, pregnant	194	191	189	185	183	181	179	172	166	159	159	162	164
	Sows, non-pregnant	67	68	70	71	70	69	66	66	66	68	69	71	72
Sheep	Ewes	2 273	2 293	2 275	2 225	2 137	2 030	1 915	1 811	1 735	1 683	1 638	1,620	1 610
	Other Ovine	216	234	267	250	225	206	191	179	160	167	162	155	154
	Lambs	329	322	328	340	337	307	277	264	267	263	267	275	285
Goats	Does	382	380	380	373	365	358	356	353	349	342	333	324	311
	Other Caprine	52	57	65	59	52	44	40	38	35	36	35	37	34
	kids	28	26	25	28	30	31	29	29	28	27	25	23	22
Equidae	Horses	56	52	49	47	46	42	38	36	34	33	32	30	30
	Asses and Mules.	45	40	36	33	29	26	22	21	20	18	13	11	10
Poultry	Hens, reproductive	3 253	3 056	2 800	2 717	2 877	3 218	3 453	3 542	3 396	3 179	3 047	2,920	2 890
	Hens eggs	7 942	7 349	6 830	6 490	6 758	7 341	7 867	7 883	7 475	7 138	6 857	6,710	6 607
	Broilers	19 620	18 686	17 885	16 848	16 780	17 915	19 207	19 452	18 650	17 847	18 096	19 395	21 745
	Turkeys	963	798	799	1 017	1 318	1 485	1 445	1 331	1 144	956	836	785	800
	Other poultry	1 445	1 353	1 314	1 332	1 414	1 504	1 522	1 460	1 319	1 178	1 164	1 284	1 530
Other	Rabbits[1]	306	289	270	254	251	255	255	243	218	193	170	148	128

1 Reproductive females

Annex Table 22- Total Nitrogen in manure produced by livestock (t N / yr)

Animal Type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Dairy	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
Non-Dairy	43 438	44 308	43 599	43 602	43 888	45 511	47 217	48 392	49 477	50 316	51 394	52 693	53 869	55 201
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
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
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
Mules and Asses	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
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
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
Rabbits[1]	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
Total	160 219	162 013	160 634	159 783	160 441	162 188	162 942	163 899	166 291	171 340	172 468	168 744	164 467	159 541

Animal Type	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Dairy	33 086	33 467	32 919	31 822	31 289	30 783	29 845	28 894	28 329	27 683	27 532	27 760	27 981
Non-Dairy	56 592	58 318	59 523	60 536	61 211	61 741	62 388	62 835	63 410	63 203	63 778	65 181	67 291
Sheep	22 274	22 565	22 621	22 054	21 087	19 975	18 824	17 793	16 970	16 529	16 090	15 878	15 777
Goats	3 016	3 041	3 094	3 004	2 898	2 793	2 758	2 717	2 670	2 631	2 570	2 513	2 402
Horses	2 449	2 273	2 141	2 083	2 009	1 833	1 672	1 569	1 511	1 437	1 393	1 335	1 311
Mules and Asses	983	880	785	726	645	565	491	455	433	389	293	242	230
Swine	19 285	19 190	19 248	19 183	19 131	19 114	18 836	18 696	18 703	18 820	19 133	19 739	20 104
Poultry	18 288	17 053	16 174	15 721	16 417	17 785	18 818	18 784	17 721	16 691	16 361	16 765	17 863
Rabbits[1]	2 754	2 599	2 429	2 290	2 256	2 294	2 295	2 184	1 962	1 741	1 531	1 334	1 149
Total	158 726	159 387	158 934	157 419	156 944	156 882	155 927	153 927	151 709	149 130	148 682	150 746	154 111

1 Reproductive females

Annex Table 23- Gross feed intake (Mj/hd/yr), cattle

Animal type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Dairy cattle	82 918	82 763	82 450	80 091	81 665	83 465	84 941	85 473	86 801	92 826	96 905	98 852	103 401	101 235
Other cattle	55 221	55 194	55 014	55 201	55 624	56 213	56 880	57 312	57 501	57 162	57 008	56 843	56 834	56 856

Animal type	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Dairy cattle	101 480	105 142	105 478	105 708	107 871	109 437	109 817	110,276	112 278	111 341	113 447	112 978	111 551
Other cattle	56 873	57 097	57 411	57 726	57 937	58 099	58 019	57,747	57 387	57 432	57 387	57 255	57 134

Annex Table 24- Volatile solid excreted (kg dm/hd/yr) – all other animal categories than cattle

Animal type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Sows	230.62	231.20	232.76	232.66	232.77	232.95	233.09	233.18	233.37	233.55	233.82	228.58	221.25	212.66
Other swine	83.47	83.43	83.35	83.46	83.21	82.81	82.14	81.82	81.75	82.01	82.32	83.13	83.64	84.00
Sheep	183.64	183.94	185.14	185.89	186.86	186.93	186.36	186.07	186.36	186.24	184.31	180.66	176.39	174.49
Goats	170.48	169.24	168.13	168.29	168.34	168.62	168.70	168.90	168.20	168.04	169.66	172.52	174.64	175.44
Horses	627.80	627.80	627.80	627.80	627.80	627.80	627.80	627.80	627.80	627.80	627.80	627.80	627.80	627.80
Mules & asses	343.10	343.10	343.10	343.10	343.10	343.10	343.10	343.10	343.10	343.10	343.10	343.10	343.10	343.10
Hens	14.99	14.99	15.00	15.00	15.00	14.99	14.99	14.99	15.00	15.02	15.02	15.01	15.01	15.00
Broilers	6.54	6.54	6.54	6.54	6.54	6.54	6.54	6.54	6.54	6.54	6.54	6.54	6.54	6.54
Turkeys	29.28	29.28	29.28	29.28	29.28	29.28	29.28	29.28	29.28	29.28	29.28	29.28	29.28	29.28
Other poultry	14.76	14.76	14.76	14.76	14.76	14.76	14.76	14.76	14.76	14.76	14.76	14.76	14.76	14.76
Rabbits	52.79	52.79	52.79	52.79	52.79	52.79	52.79	52.79	52.79	52.79	52.79	52.79	52.79	52.79

Animal type	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Sows	210.59	211.33	212.76	214.11	214.22	213.93	212.77	214.16	215.61	218.01	218.55	219.17	81.07
Other swine	84.00	83.70	83.54	83.15	83.22	83.12	83.25	82.57	81.87	81.28	81.11	80.93	219.23
Sheep	174.55	175.23	175.65	174.68	173.94	174.29	174.77	174.64	173.60	173.74	173.18	172.45	171.86
Goats	174.67	174.68	173.88	173.61	173.66	173.95	174.74	175.06	175.35	175.41	175.59	178.36	176.20
Horses	627.80	627.80	627.80	627.80	627.80	627.80	627.80	627.80	627.80	627.80	627.80	627.80	627.80
Mules & asses	343.10	343.10	343.10	343.10	343.10	343.10	343.10	343.10	343.10	343.10	343.10	343.10	343.10
Hens	15.00	14.99	15.00	14.99	14.99	14.99	14.99	14.99	14.99	14.99	14.99	14.99	14.99
Broilers	6.54	6.54	6.54	6.54	6.54	6.54	6.54	6.54	6.54	6.54	6.54	6.54	6.54
Turkeys	29.28	29.28	29.28	29.28	29.28	29.28	29.28	29.28	29.28	29.28	29.28	29.28	29.28
Other poultry	14.76	14.76	14.76	14.76	14.76	14.76	14.76	14.76	14.76	14.76	14.76	14.76	14.76
Rabbits	52.79	52.79	52.79	52.79	52.79	52.79	52.79	52.79	52.79	52.79	52.79	52.79	52.79

Annex Table 25 - Annual Nitrogen consumption (kt N/yr) by type of N inorganic fertilizer - time series activity data

Type of N fertilizer	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
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
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
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
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
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
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
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**

Sources	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ammonium nitrate (AN)	-	-	-	-	-	-	4.01	4.18	3.70	7.70	4.63	4.69	3.96
Ammonium phosphate (MAP&DAP)	8.55	-	-	-	-	1.01	0.54	0.21	1.37	2.04	1.11	0.59	1.70
Ammonium sulphate (AS)	10.27	10.30	4.22	5.86	2.54	1.95	3.06	0.00	0.00	0.00	0.00	0.00	7.04
Calcium ammonia nitrate (CAN)	43.31	29.68	19.21	34.63	26.75	27.18	34.99	23.49	17.62	25.38	18.55	17.88	19.47
Urea	8.20	11.85	20.45	21.98	26.01	24.06	13.85	22.19	20.88	15.57	24.01	27.60	25.34
Other NK & NPK	37.00	39.94	33.76	41.10	28.97	16.09	24.90	23.13	17.19	24.57	30.27	27.32	24.61
Other N	18.51	10.90	9.76	9.43	20.86	22.71	18.90	21.89	46.10	35.39	44.26	35.87	38.52
Total	**125.84**	**102.66**	**87.39**	**113.01**	**105.13**	**97.29**	**100.25**	**95.09**	**106.86**	**110.64**	**122.84**	**113.96**	**113.62**

Annex Table 26 – Share (%) of the national emissions corresponding to the mainland territory

NFR Code	Description	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2002	2003
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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

Share (%) of the national emissions corresponding to the mainland territory - continuation

NFR Code	Description	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
3 B 1 a	**Manure management – Dairy cattle**	67.68	65.96	65.19	65.06	64.91	63.53	62.55	62.40	61.18	61.47	61.97	62.55	62.34
3 B 1 b	**Manure management – Non - Dairy cattle**	90.12	89.63	89.39	89.27	89.03	88.46	88.16	88.22	87.58	87.76	88.25	88.17	88.56
3 B 2	**Manure management – Sheep**	99.65	99.62	99.65	99.67	99.73	99.66	99.64	99.63	99.62	99.66	99.66	99.66	99.66
3 B 3	**Manure management – Swine**	95.63	96.42	96.45	96.92	96.73	97.07	96.92	97.38	97.68	98.31	98.45	98.44	98.51
3 B 4 d	**Manure management – Goats**	96.60	96.63	96.37	97.27	97.46	97.41	96.42	96.61	96.78	96.98	96.34	96.25	96.25
3 B 4 e	**Manure management –Horses**	92.31	93.75	93.62	93.48	92.68	94.44	94.29	94.44	93.94	93.55	93.75	93.10	93.34
3 B 4 f	**Manure management – Mules & asses**	97.44	97.14	96.88	96.55	96.00	95.00	95.00	95.00	94.44	93.33	100.00	100.00	98.10
3 B 4 g i	**Manure management – Laying hens**	95.36	95.93	95.95	95.98	96.43	96.78	96.82	96.87	96.93	96.99	96.95	96.91	96.87
3 B 4 g ii	**Manure management – Broilers**	97.17	96.80	96.08	95.24	96.35	97.20	97.12	97.03	96.94	96.84	97.09	97.29	97.45
3 B 4 g iii	**Manure management – Turkeys**	99.60	99.33	99.72	99.88	99.76	99.65	99.66	99.67	99.68	99.69	99.71	99.72	99.73
3 B 4 g iv	**Manure management – Other poultry**	98.46	98.36	98.42	98.47	98.52	98.57	98.53	98.49	98.43	98.36	98.75	99.01	99.20
3 B 4 h	**Manure management – Other animals**	98.60	98.28	98.18	98.07	97.75	97.47	97.47	97.49	97.50	97.52	97.57	97.64	97.74
3 D a 1	**Inorganic N_Fertilizers**	96.60	96.58	96.48	96.38	96.48	96.57	96.57	96.57	96.57	96.60	96.60	96.60	96.60
3 D a 2 a	**Animal manure applied to soil**	79.30	78.61	78.86	78.90	77.80	77.29	77.16	76.97	75.99	75.35	75.31	74.38	74.62
3 D a 2 b	**Sewage sludge applied to soil**	96.60	96.58	96.48	96.38	96.48	96.57	96.57	96.57	96.57	96.60	96.60	96.60	96.60
3 D a 2 c	**Other organic fertilizers applied to soil**	96.60	96.58	96.48	96.38	96.48	96.57	96.57	96.57	96.57	96.60	96.60	96.60	96.60
3 D a 3	**Urine & dung deposited by grazing animals**	91.35	91.31	91.08	91.17	90.93	90.80	90.43	90.53	90.18	90.15	91.20	91.17	90.97
3 D c	**Farm level agricultural operations**	96.60	96.58	96.48	96.38	96.48	96.57	96.57	96.57	96.57	96.60	96.60	96.60	96.60
3 D e	**Cultivated crops**	96.60	96.58	96.48	96.38	96.48	96.57	96.57	96.57	96.57	96.60	96.60	96.60	96.60
3 F	**Field burning of agricultural residues**	98.35	98.23	98.18	98.04	98.13	98.05	97.97	97.92	97.94	97.45	97.45	97.36	97.35

ANNEX E: WASTE (NFR 5)

Annex Table 27 – 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		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		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	2,789.6	332.7	332.7	1,034.3	919.3
2013	10,572,721	10,057,999	435.8	433.7	100	4,607.4	4,362.4	0.0	0.0	2,601.9	2,491.3	353.4	343.9	1,117.8	1,019.5
2014	10,542,398	10,030,968	447.7	446.0	100	4,720.0	4,473.8	0.0	0.0	2,532.1	2,425.6	493.9	483.1	1,051.9	948.8
2015	10,487,289	9,976,649	452.7	451.6	100	4,747.4	4,505.8	0.0	0.0	2,429.0	2,335.9	390.7	377.4	1,129.5	1,020.7
2016	10,427,301	9,918,548	469.1	467.8	100	4,891.0	4,640.0	0.0	0.0	2,474.3	2,375.6	488.3	477.4	1,198.8	1,070.1

Notes:
Sources: INE; APA; Quercus Study

Annex Table 28 – 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	819.4	0	761.5	0	**1990**	1,280.8	29	1212.9	31
1961	831.7	0	773.3	0	**1991**	1,306.4	34	1237.3	36
1962	844.2	0	785.3	0	**1992**	1,332.5	34	1262.7	36
1963	856.8	0	797.5	0	**1993**	1,359.2	34	1288.5	36
1964	869.7	0	809.9	0	**1994**	1,386.4	39	1314.0	40
1965	882.7	0	822.5	0	**1995**	1,414.1	39	1341.4	40
1966	896.0	0	835.2	0	**1996**	1,442.4	40	1369.8	41
1967	909.4	0	848.2	0	**1997**	1,471.2	44	1398.6	46
1968	923.0	0	861.4	0	**1998**	1,500.6	60	1427.8	62
1969	936.9	0	874.8	0	**1999**	1,530.7	74	1456.7	74
1970	950.9	0	888.4	0	**2000**	1,279.6	82	1202.0	83
1971	965.2	0	903.0	0	**2001**	1,028.6	86	959.6	86
1972	979.7	0	917.8	0	**2002**	777.5	99	737.5	100
1973	994.4	0	932.9	0	**2003**	726.9	99	695.9	100
1974	1,009.3	0	948.1	0	**2004**	754.6	99	721.6	100
1975	1,024.4	0	963.6	0	**2005**	782.3	100	749.9	100
1976	1,039.8	0	979.2	0	**2006**	810.0	100	779.8	100
1977	1,055.4	0	995.1	0	**2007**	837.7	100	806.7	100
1978	1,071.2	0	1011.2	0	**2008**	865.4	100	834.3	100
1979	1,087.3	0	1027.6	0	**2009**	567.0	100	541.5	100
1980	1,103.6	28	1042.1	29	**2010**	491.4	100	472.7	100
1981	1,120.2	28	1059.1	30	**2011**	596.7	100	572.1	100
1982	1,137.0	28	1075.2	30	**2012**	275.1	100	262.7	100
1983	1,154.0	28	1091.5	30	**2013**	281.2	100	269.2	100
1984	1,171.3	28	1108.1	30	**2014**	309.6	100	296.6	100
1985	1,188.9	29	1125.0	30	**2015**	321.8	100	309.5	100
1986	1,206.7	29	1142.1	30	**2016**	399.0	100	383.1	100
1987	1,224.8	29	1159.4	30	**2017**	-	-	-	-
1988	1,243.2	29	1177.0	30	**2018**	-	-	-	-
1989	1,261.9	29	1194.9	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 29 – 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*	100	*23*	*95*	-	-
1991	*12*	100	*23*	*95*	-	-
1992	*12*	100	*24*	*95*	-	-
1993	*12*	100	*24*	*95*	-	-
1994	*12*	100	*25*	*95*	-	-
1995	12	100	*25*	*95*	-	-
1996	13	100	*26*	*95*	-	-
1997	16	100	*26*	*95*	-	-
1998	12	100	*27*	*95*	-	-
1999	10	100	27	*95*	346	100
2000	7	100	*30*	*94*	911	100
2001	3	100	*32*	*93*	892	100
2002	3	100	36	*95*	915	97
2003	2	100	45	*96*	893	89
2004	*2*	100	52	*96*	877	88
2005	*1*	100	59	*96*	937	89
2006	1	100	66	*96*	861	88
2007	3	100	72	*96*	832	87
2008	3	100	79	*96*	869	88
2009	3	100	66	*95*	959	89
2010	3	100	19	*96*	964	88
2011	2	100	27	*96*	1012	89
2012	1	100	38	*96*	919	89
2013	1	100	22	*96*	1020	91
2014	1	100	22	*96*	949	90
2015	1	100	19	*96*	1021	90
2016	*1*	*100*	*21*	*96*	1070	89

Note: Estimates in italics
Sources: APA; DGS