MINISTÉRIO DAS CIDADES, ORDENAMENTO DO TERRITÓRIO E AMBIENTE

Instituto do Ambiente

PORTUGUESE NATIONAL INVENTORY REPORT

ON GREENHOUSE GASES, 1990 - 2001

Submitted under the United Nations Framework Convention on Climate Change

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14th August 2003

Preface

The Institute for the Environment (Instituto do Ambiente)/ Ministry for Urban Affairs, Land-Use Planning and the Environment (Ministério das Cidades, Ordenamento do Território e Ambiente), in accordance to its attributions of national entity responsible for the overall coordination of the Portuguese inventory of air pollutants emissions, has prepared the National Inventory of Greenhouse Gas (GHGs) Emissions and Sinks to comply with international commitments under the United Nations Framework Convention on Climate Change (UNFCCC) and the European Commission.

The Conference of Parties to the UNFCCC and the Council Decision 296/1999/EC, define that each Party should provide each year an update of its inventory of emissions and removals of GHG not controlled by the Montreal Protocol, taking into account the UNFCCC Reporting Guidelines on Annual Inventories. These include a report on annual emissions estimates (CRF tables), accompanied by a National Inventory Report (NIR), describing the input data, methodologies, background information and explanation on the whole process of inventory preparation.

This report is the first Portuguese NIR. It was not possible to present it together with the 2003 Portuguese Submission on GHG (CRF report) sent to the UNFCCC in early April 2003. The intention of submitting the report now, is to enable the review of the Portuguese inventories (Central Review) by the UNFCCC in September of this year. In addition, the report is aimed to inform Portuguese Governmental departments, national institutions and other data suppliers of the state of the art of the Portuguese GHGs inventories, in order to make them fully aware of the importance of their contribution to the inventory process and as a way to identify areas where improvements are needed and may be possibly implemented. The report is also intended to serve as basis for the discussion among national agencies, in the framework of the establishment of a national inventory system.

Despite the effort that has been put to assemble all the information here presented, it is recognised that many improvements would be needed, and progress should be expected in future reports.

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EXECUTIVE SUMMARY

ES.1 Background information on greenhouse gas inventories and climate change

By ratifying the United Nations Framework Convention on Climate Change (UNFCCC) on 31st May of 1994, Portugal is committed to provide each year an update of its inventory of emissions and removals of greenhouse gas not controlled by the Montreal Protocol, taking into account the adopted Reporting Guidelines on Annual Inventories.

The UNFCCC Guidelines require that Parties prepare a National Inventory Report (NIR) as one part of their annual submissions. The NIR should include references of information related to methodologies, emission factors, activity data, and give explanations concerning any recalculations of historical inventories, in order to ensure transparency and enable the inventory review.

This report is the first Portuguese NIR. It presents a description of the methods, assumptions and basic data used. The Revised (1996) IPCC Guidelines for National Greenhouse Gas Inventories and the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2000) have been applied as far as possible. However many issues need to be improved in the near future, and work is ongoing.

The Portuguese inventory has been continuously amended mainly from the use of more detailed methodologies, better access to underlying data allowing the comprehensiveness of the inventory, and better database storage and calculation structure. Important issues such as QA/QC procedures and the development of a QA/QC plan have not yet been tackled in this report. Also, the uncertainties quantification has not yet been implemented.

The report presents estimates for the 6 gaseous air pollutants included in Annex A to the Kyoto Protocol: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6), as well as estimates for indirect GHGs, including carbon monoxide (CO), nitrogen oxides (NOx), and non-methane volatile organic compounds (NMVOC). Data are also reported for sulphur oxides (SOx). The period covered is 1990-2001.

The inventory covers the whole Portuguese territory, i.e., mainland Portugal and the two autonomous regions of Madeira and Azores Islands.

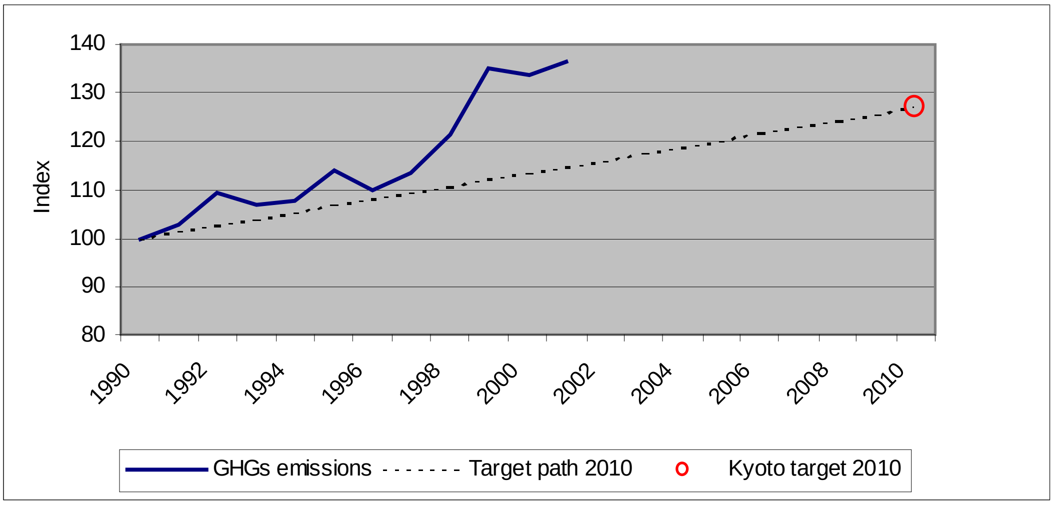
Changes in methodology, source coverage or scope of the data were reflected in the estimation of the emissions for the different years considered (1990-2001), i.e., the inventory is internally consistent.

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 and hospitals solid wastes, and domestic and industrial waste water treatment), agriculture, forestry and animal husbandry emissions, as well as emissions and sinks from land use changes.

ES.2 Summary of national emissions and removal related trends

Portuguese total GHG emissions without land-use change and forestry (LUCF) were estimated about 83.8 Mton CO2eq. in 2001, representing an increase of 36.4% compared to 1990 levels. Under the burden-sharing agreement, Portugal is bind to limit its emissions to +27% compared to the 1990 level. Comparing the 1990-2001 growth with the linear target path from 1990 to 2010, Portuguese GHG emissions were, in 2001, 21.6 % above this target path.

Figure ES.1 – GHG emissions 1990-2001 compared with target 2008-2012 (LUCF excl.)



The single year increase in emissions from 2000 to 2001 was 1.9%, which is smaller than the average annual growth from 1990 to 2001 (3.3%). The decrease or reduced growth in emission trends registered in the last years, which is partly due to the slow down of Portuguese economy, can be also explained by some introduced measures having positive impact in emission trends, such as: new combined cycle thermoelectric unit of natural gas (1999), the progressive installation of co-generation units, the amelioration of energetic and technologic efficiency of industrial processes, and the improvement of fuels quality.

Table ES.1 presents the main trends in direct GHGs emissions for the 1990-2001 period.

Table ES.1 – GHG emissions and removals in Portugal by gas: 1990-2001

GHGs EMISSIONS	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	CO_2 equivalent (Gg)											
Net CO_2 emissions/removals	43 807	45 201	49 232	47 515	47 486	50 541	47 850	49 925	54 441	61 840	61 342	62 741
CO_2 emissions (without LUCF)	43 809	45 616	50 056	48 727	49 115	52 546	49 941	52 104	56 699	64 199	63 493	64 892
CH_4	10 124	10 127	9 983	9 700	9 962	9 997	10 031	10 133	10 206	10 654	10 689	10 788
N_2O	7 508	7 507	7 283	7 191	7 176	7 424	7 519	7 427	7 660	8 003	8 031	8 073
HFCs	-	-	-	-	-	0	0	2	6	19	37	62
PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
SF_6	-	-	-	-	-	5	5	5	5	6	6	7
Total (with net CO_2 emis./removals)	**61 438**	**62 835**	**66 498**	**64 405**	**64 625**	**67 967**	**65 405**	**67 492**	**72 319**	**80 521**	**80 104**	**81 671**
Total (without CO_2 from LUCF)	**61 441**	**63 251**	**67 322**	**65 617**	**66 253**	**69 972**	**67 496**	**69 670**	**74 577**	**82 880**	**82 256**	**83 823**

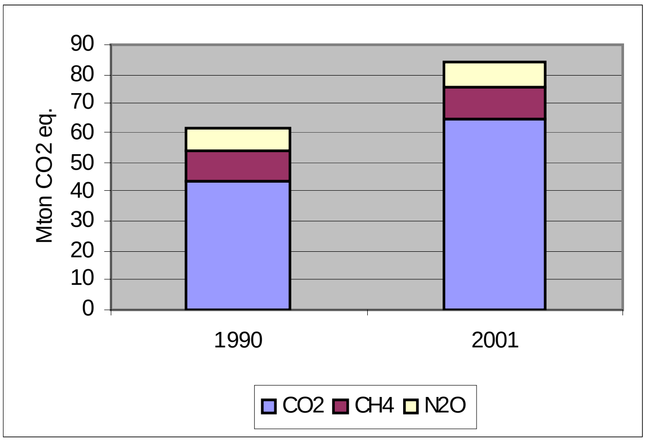
Figure ES.2 illustrates the trend of the absolute contribution of direct GHGs to the total emissions for 1990 and 2001, showing CO2 as the primary GHG, accounting for about 77% of Portuguese emissions on a carbon equivalent basis in 2001. The second most important gas is CH4, followed by N2O, representing, respectively, about 13 % and 10 % of total emissions.

Portugal has chosen 1995 as the base year for fluorinated gases. In 2001 these gases represented about 0.08% of total GHG emissions.

Over the 1990-2001 period, all GHG emission (LUCF excl.) levels grew:

- carbon dioxide emissions 48.1%;
- methane emissions 6.6%; and
- nitrous oxide emissions 7.5%.

Figure ES.2 – GHG emissions in Portugal by gas: 1990-2001 (F-gases and LUCF excl.)



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

According to the UNFCCC Reporting Guidelines, emissions estimates are grouped into six sectors: Energy, Industrial Processes, Solvent use, Agriculture, Land-Use Change and Forestry, and Waste.

Emissions have risen in almost all these sectors. The exception was agriculture, where the emissions have declined.

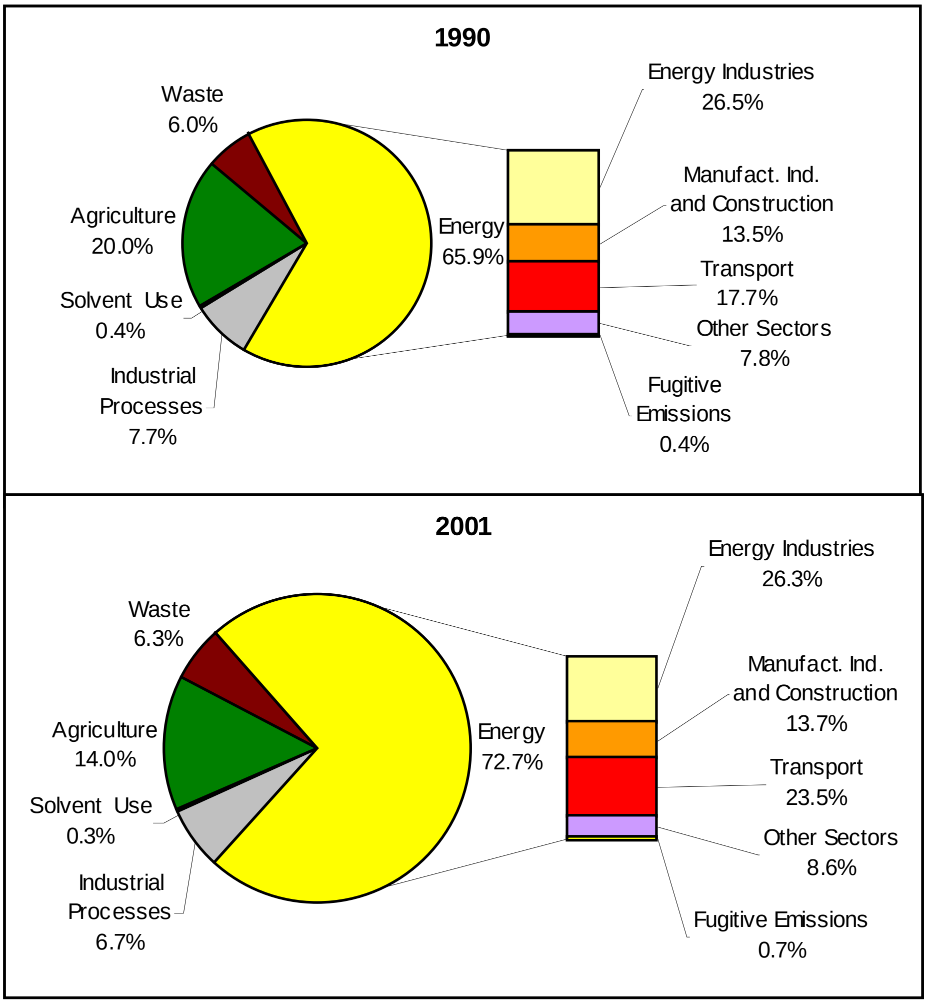
Using this aggregated division, Energy is by far the most important sector, accounting for almost 73% of total emissions in 2001 (excluding LUCF), and presenting an increase of 51% over the 1990-2001 period. Transport (23.5% of total emissions without LUCFs) is within the energy sector, the second most important source, appearing after energy industries (26.3% of total emissions without LUCFs). This reflects the country heavy dependence on fossil fuels for electricity generation (which continues to grow due to the continued increase of electricity demand) and transport sources. Transportation sources, which are largely dominated by road traffic, are one of the sectors that are rising faster. In the period 1990-2001 these emissions increased approximately 81%, due to the steady growth of vehicle fleets and road travel, reflecting the increase in family income and the strong investment in road infrastructure of the country in the 90s decade.

Agriculture is the second most significant source of GHGs emissions (14% of total emissions without LUCFs) and is the only category showing a negative trend for the period analysed (-4.4%). Industrial processes and Waste represent, respectively, 6.7% and 6.3% of Portuguese emissions in 2001, recording an increase of approximately 19% (industrial processes) and 42% (waste).

Solvent use represents less than 1% of total emissions, and is mainly related to NMVOC emissions. The overall trend for this source has stabilised, which is in part due to unavailability of updated activity data. It is expected that this situation will be solved in the next submission of the inventories.

Land use change and forestry, as a carbon sink, accounted for the intake of an estimated 2.2 Mt CO2 eq. in 2001.

Figure ES.3 –GHG emissions (LUCF excluded) in Portugal by sector: 1990-2001



E.S.4 Information on indirect GHG and SOx emissions

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

Table ES.2 – Indirect GHG and SOx emissions

Gas emissions	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	(Gg)											
CO	1 077.5	1 148.2	1 240.6	1 224.8	1 204.9	1 191.5	1 171.2	1 133.3	1 132.6	1 100.7	1 085.2	1 057.5
NOx	286.8	302.6	324.6	319.5	323.7	336.6	332.0	339.1	362.8	385.4	406.1	398.7
NMVOC	379.4	407.8	435.1	442.4	442.7	463.5	439.2	499.6	532.1	484.2	476.7	484.6
SOx	287.8	283.2	342.9	307.7	278.7	318.4	260.7	265.3	299.3	315.3	288.1	310.1

All emissions except CO, have increased from 1990 levels: NOx 39%, NMVOC 28%, and SO2 8%. CO emissions declined slightly (2%) in the same period. Energy is the major responsible sector for emissions of NOx, SOx, CO and NMVOC. Industrial processes and Solvent use contribute also significantly for NMVOC emissions.

Within energy, transportation is responsible for the greatest share of NOx, NMVOC and CO emissions, respectively 54%, 27% and 65% of 2001 totals. Emissions reductions due to the introduction of new petrol-engine passenger cars with catalysts converters and stricter regulations on diesel vehicles emissions, were overweight by the fast growing trends of the transport sector (mainly road). NOx emissions from transport presented a 55% increase over the 1990-2001 period; NMVOC 33%; and CO decreased slightly (2.5%).

SOx emissions are mainly due to the energy industry sector, which is a major consumer of fossil fuels. Oil and coal represent the biggest share of the fuel mix used in thermal electrical production in the country, and they are in majority imported. Since natural gas was introduced in 1998, it has been registering a growing importance, accounting, in 2000, for 22% of thermal production. All energy production from country resources is from renewable sources: hydro and wind electricity. Hydro is the most important renewable source but its contribution to the overall energy production is irregular, due to pronounced fluctuations in hydroelectric power generation.

CHAPTER1: INTRODUCTION

This report constitutes the first Portuguese NIR, prepared in order to comply with international commitments under the United Nations Framework Convention on Climate Change (UNFCCC) and the European Commission (EC). It presents a description of methods, assumptions and background data used in the preparation of the 2003 national inventory submission of GHG. Inventory data in CRF format were sent previously (March/April 2003) to the EC and UNFCCC, as it was not possible to prepare both reports at the same time.

Air emission inventories in Portugal were only initiated in the late ninety-eighties/ early nineties when the first estimates of NOx, SOx 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. However a major breakthrough occurred during the CORINAIR90 inventory realized during 1992 and 1993 by General-Directorate of Environment (DGA, renamed now IA). This inventory exercise, aiming also EMEP and OECD/IPCC, extended the range of the pollutants (SOx, NOx, NMVOC, CH4, CO, CO2, N2O and NH3) 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 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 compromises under conventions UNFCCC and CLRTAP, together with the publication of the IPCC Draft Guidelines for National Greenhouse Gas Inventories (IPPC, 1994) 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 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 communication was also reviewed by international experts. Both exercises had an important role in problem detection and contribute to overall improvement.

Since then 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.

Following the UNFCCC Reporting Guidelines on Annual Inventories (SBSTA 1999 and SBSTA 2002), the Revised (1996) IPCC Guidelines for National Greenhouse Gas Inventories and the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2000) have been applied as far as possible.

Since its first compilation, the Portuguese inventory of GHG 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 (1990-2001), i.e., the inventory is internally consistent.

The report is structured generally in accordance with the UNFCCC Reporting Guidelines on Annual Inventories (SBSTA 2002). There are however some important issues that have not yet been treated in this report. Subjects such as QA/QC procedures and the development of a QA/QC plan have not yet been tackled in the report, because they have not been formally developed. Also, uncertainty quantification has not yet been implemented. Many issues need therefore to be improved and work is ongoing. Several improvements are expected for next year inventory submission.

1.1 Background Information

Scope of GHG inventories

The report presents total national emission estimates for the 6 gaseous air pollutants included in Annex A to the Kyoto Protocol: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFC), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6), as well as estimates for indirect GHGs, including carbon monoxide (CO), nitrogen oxides (NOx), and non-methane volatile organic compounds (NMVOC). Data are also reported for sulphur oxides (SOx).

Emissions are estimated for each civil year for the years 1990 to 2001. Emission estimates for 2001 are however preliminary and subject to change in next report when better information on activity data will be available.

As a general rule the inventory covers emissions realized in the whole Portuguese territory, i.e., mainland Portugal and the two autonomous regions of Madeira and Azores Islands. The only exception to this rule, which results in an inconsistency, refers to data for the two Portuguese islands in what concerns Land Use Change and Forestry (IPCC 5) which have not been compiled; therefore this category refers only to mainland Portugal.

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 and hospitals solid wastes, and domestic and industrial waste water treatment), agriculture, forestry and animal husbandry emissions, as well as emissions and sinks from land use changes.

The inventory comprehends only those emissions and sinks resulting from anthropogenic activity. This criteria may be however subject of controversy in the following situations:

- forest fires: the 2003 submission exclude forest fires from total[1] as it was very difficult to establish whether they were man-induced or natural fires;

[1] despite the fact they have been estimated and presented as additional information in CRF table 9

- NMVOC from all types of vegetation including forests, were estimated but not included in the inventory submission because it was considered that these emissions would also occur from natural vegetation (although in different quantities because different species would exist), and also because CRF tables do not have any suitable place for these emissions to be reported;

- CO2 from geothermal electric production. Emissions from this source were considered anthropogenic in the present inventory, although they had existed, at least partially, before being used in electricity production.

Estimates are grouped into six sector-specific categories, corresponding to the six main IPCC source categories: Energy (IPCC 1), Industrial Processes (IPCC 2), Solvent and Other Product Use (IPCC 3), Agriculture (IPCC 4), Land Use Change and Forestry (IPCC 5), and Waste (IPCC 6).

Global warming potentials

A Global Warming Potential (GWP) is defined as the cumulative radiative forcing over a specified time horizon resulting from the emission of a unit mass of gas relative to some reference gas (IPCC 1996). The reference gas used is CO2. The mass emission of each gas multiplied by its GWP gives the equivalent emission of the gas as carbon dioxide (CO2 equivalents – CO2 Eq.).

The parties to the UNFCCC have agreed to use GWPs based on a 100-year time horizon.

Table 1.1 – Global Warming Potentials (100-year time horizon)

GHG	GWP
CO2	1
CH4	21
N2O	310
HFC	
HFC-23	11 700
HFC-32	650
HFC-41	150
HFC-43-10mee	1 300
HFC-125	2 800
HFC-134	1 000
HFC-134[a]	1 300
HFC-152[a]	140
HFC-143	300
HFC-143[a]	3 800
HFC-227ea	2 900
HFC-236fa	6 300
HFC-245ca	560
PFC	
CF4	6 500
C2F6	9 200
SF6	23 900

1.2 Institutional arrangements and data sources for inventory preparation

The Institute for the Environment[2] (Instituto do Ambiente - IA)/ Ministry for Urban Affairs, Land-Use Planning and the Environment (Ministério das Cidades, Ordenamento do Território e

[2] Previously named General Directorate of Environment (Direcção Geral do Ambiente)

Ambiente), is the national entity responsible for the overall coordination of the Portuguese inventory of air pollutants emissions. According to these attributions, the Institute makes an annual compilation of the National Inventory of Greenhouse Gas (GHGs) Emissions and Sinks. This year, for the first time, it has prepared this national inventory report.

All emissions calculations have been performed by the IA. However many other institutions and agencies contributed to the inventory process, providing activity data, technical support and comments. Table 1.2 gives an overview of the institutions and data sources involved in the compilation of the Portuguese emission inventories.

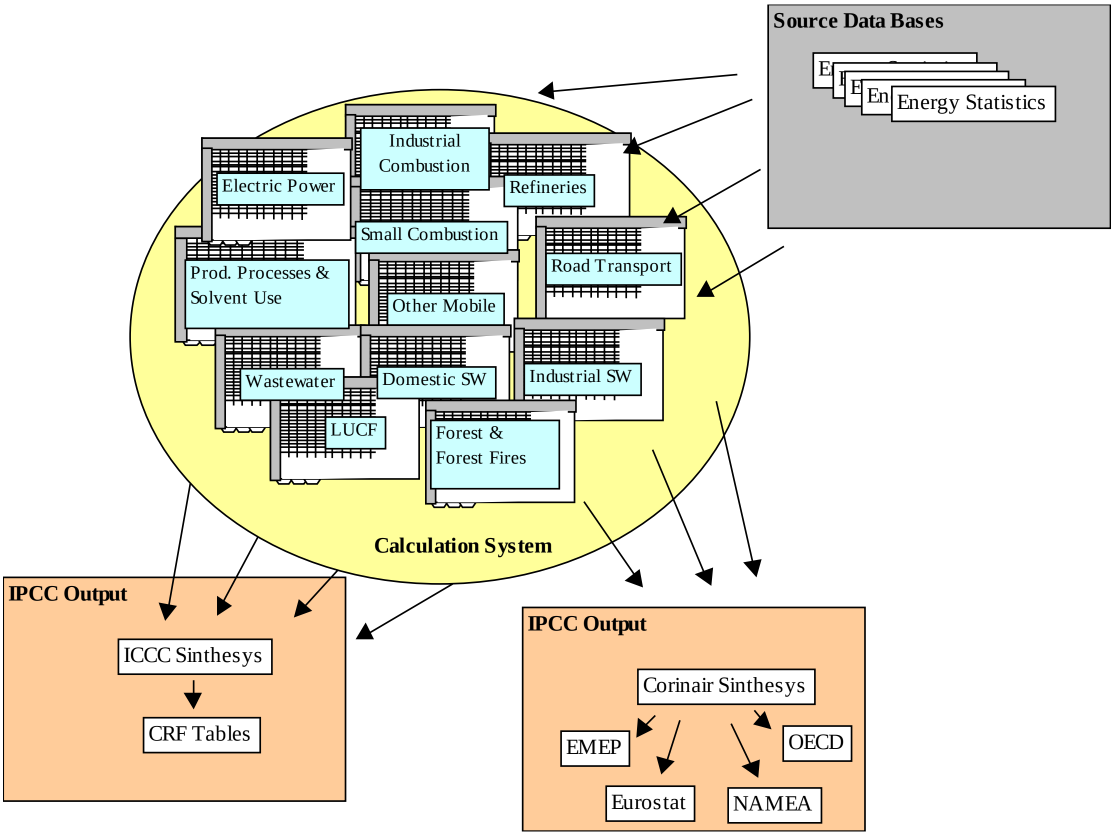
Table 1.2 – Inventory Institutional Arrangements and Data Sources

IPCC category	IPCC sub-category	Sources of data
CRF 1 A - Energy. Fuel Combustion	CRF 1A1 - Energy Industry	• Large Point Source Surveys (LPS) • Large Combustion Plants (LCP) • General Directorate of Energy (DGE): energy balances • Autonomous Gov. of Azores • National Statistical Institute (INE)
	CRF 1A2 - Manufacturing Industries and Construction	• LPS • LCP • Regional Air Inventories • DGE: energy balances
	CRF 1A3 – Transport	• DGE: energy balances • ACAP • ANECRA • Road Institute (IEP) • INE • General Directorate of Terrestrial Transportation (DGTT) • ANA· NAVE ou DGV (Aviation)
	CRF 1A4 – Other Sectors	• DGE: energy balances
CRF 1 B – Fugitive Emissions from Fuels		• DGE: energy balances and statistical yearbooks
CRF 2 – Industrial Processes	CRF 2A – Mineral Products	• LPS • LCP • DGE: energy balances
	CRF 2B – Chemical Industry	• DGE: energy balances • LCP • INE • Regional Air Inventories
	CRF 2C – Metal Production	• DGE: energy balances • LCP • INE • Regional Air Inventories
	CRF 2D – Other Production	• LCP • DGE: energy balances
	CRF 2F – Consumption of Halocarbons and SF6	• INE • APIRAC • Data from Industry Importers· EDP
CRF 3 – Solvent and Other Product Use		• DGE: energy balances • INE
CRF 4 – Agriculture		• Ministry of Agriculture • General-Directorate of Forests (DGF) • INE: agriculture survey
CRF 5 – Land Use Change and Forestry		• DGF • UNL-FCT
CRF 6 – Waste	CRF 6A – Solid Waste Disposal on Land	• National Institute for Waste (INR) • INE • Quercus Survey
	CRF 6B – Wastewater Handling	• National Institute for Water (INAG) • INE
	CRF 6C – Waste Incineration	• INR • General Direction for Health/Ministry of Health • Data from Incineration Units

1.3 Data archiving and documentation system

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 below.

Figure 1.1 – Informatic System Structure of the estimation and reporting system



The information received from the several data suppliers is stored in its original format (paper or magnetic). A copy of this information is done into the working workbooks, where data is treated and calculations performed, maintaining hence the integrity of the original data sources.

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

Backup is done periodically by the system manager in accordance with the outlined procedures for the whole IA. 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, 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.

Annually reported data, e.g. CRF tables, are stored both in paper and magnetic format. IA plans to rebuild this informatics system, having found some limitations for its expansion, namely in what concerns the storage of big amounts of data. This problem will be aggravated in the future with the implementation of inventory improvements: spacialization of emission data, connection to plant-specific monitoring programs and uncertainty analysis. The restructuring of all the inventory system is under study.

1.4 General overview of methodologies

The inventory has been compiled to the extent as possible in accordance with the recommendations from the UNFCCC Reporting Guidelines on Annual Inventories (SBSTA 1999 and SBSTA 2002). The Revised (1996) IPCC Guidelines for National Greenhouse Gas Inventories and the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2000) have been applied as far as appropriate and feasible.

Table 1.3 gives an overview of the methodologies and emission factors used in the inventory. Default methods and emission factors used and the choice between Tier 1 and Tier 2 approaches, were case by case dictated by the availability of proper background information and from national circumstances.

1.5 Brief description of key source categories

Key source analysis was conducted using the Tier 1 and the qualitative approach applied to the 2003 Portuguese inventory estimates (1990-2001). Guidance from IPCC 2000 was followed, but the source category level adopted for the analysis does not match exactly the original list of source categories proposed by IPCC 2000 (table 7.1). The analysis was carried according to the sectoral breakdown defined in the CRF (Common Report Format), i.e., the base format for inventory reporting under the UNFCCC.

The level assessment was undertaken for all years; the trend assessment was performed for the 1990-2001 period; and a qualitative criteria was applied to identify some additional sources that are recognised to be significantly uncertain and insufficiently covered.

The analysis resulted in the identification of 57 key sources that are listed in table 1.4. These sources cover 97 % of total Portuguese GHG emissions for 2001.

1.6 Information on QA/QC and uncertainty assessment

No formal quality assurance and quality control (QA/QC) procedures have been established so far for the National Inventory that are in accordance with the IPCC Good Practice Guidance (IPCC 2000). In particular, a system of review procedures by personnel not directly involved in the inventory preparation that could be regarded as quality assurance has not been set up.

However the inventory compilation process includes already a number of technical activities that can be considered as fundamental elements of quality control. Activities such as: accuracy checks on data acquired and estimated, the use of well documented emission estimations methodologies and emission factors, and adequate information archiving and reporting with proper backup scheme, can be regarded as quality control procedures. These procedures assure calculation and reporting error detection and retrace of former estimates enabling a degree of confidence on final results. During the recent development of the Portuguese National Plan on Greenhouse Gas Emissions (PNAC) and the Plan for Emission Ceiling (PTEN) extensive interaction has occurred with the team responsible for those plans, with institutional organisms (Ministry of Agriculture, DGF, INR, DGE) and also economic sectors representatives (Electric sector, cement, paper pulp, chemical industry, glass industry and ceramics), where these have been given an opportunity to be briefly informed of basic methodologies, activity data and emission factors, and some of their comments were used to improve the quality of the inventory.

Also uncertainty quantification has not yet been implemented in Portugal. The only information available is qualitative and based on expert judgement. Table 1.5 shows the qualitative information available.

1.7 Overview of the completeness

Table 1.5 gives an overview of the level of completeness of the 2003 submitted inventories to the UNFCCC and EC.

Table 1.3 – Summary of methods and emission factors (CRF summary 3 table)

GHG	CO_2		CH_4		N_2O		HFCs		PFCs		SF_6	
	Met. [1]	EF [2]	Met. [1]	EF [2]	Met. [1]	EF [2]	Met. [1]	EF [2]	Met. [1]	EF [2]	Met. (1)	EF (2)
1. Energy												
A. Fuel Combustion												
1. Energy Industries	C+T2	C	C+T2	C	C+T2	C						
2. Manufacturing Industries and Construction	C+T2	C	C+T2	C	C+T2	C						
3. Transport	C	C	C	C	C	C						
4. Other Sectors	C+T2	C	C+T2	C	C+T2	C						
5. Other	C+T2	C	C+T2	C	C+T2	C						
B. Fugitive Emissions from Fuels												
1. Solid Fuels	MB		C+T2	C								
2. Oil and Natural Gas	MB		C+T2	C								
2. Industrial Processes												
A. Mineral Products	D+C	D+C	D+C	D+C	D+C	D+C						
B. Chemical Industry	MB+D+C	D+C	D+C	D+C	D+C	D+C						
C. Metal Production	D+C	D+C	D+C	D+C	D+C	D+C						
D. Other Production	D+C	D+C										
E. Production of Halocarbons and SF_6												
F. Consumption of Halocarbons and SF_6							D	D			D	CS
G. Other												
3. Solvent and Other Product Use	D	D										
4. Agriculture												
A. Enteric Fermentation			T1	D								
B. Manure Management			T2	D (CS)	T2	D (CS)						
C. Rice Cultivation			D	D (CS)								
D. Agricultural Soils					D	D						
E. Prescribed Burning of Savannas												
F. Field Burning of Agricultural Residues			D	D+C	D	D+C						
G. Other												
5. Land-Use Change and Forestry												
A. Changes in Forest and Other Woody Biomass Stocks	D	D										
B. Forest and Grassland Conversion	D	D										
C. Abandonment of Managed Lands												
D. CO_2 Emissions and Removals from Soil												
E. Other												
6. Waste												
A. Solid Waste Disposal on Land	MB		D	D (CS)								
B. Wastewater Handling			D	D (CS)								
C. Waste Incineration	MB		D	D+C	D	D+C						
D. Other												
7. Other *(please specify)*												

(1) Methods applied: D (IPCC default), RA (Reference Approach), T1 (IPCC Tier 1), T1a, T1b, T1c (IPCC Tier 1a, Tier 1b and Tier 1c, respectively), T2 (IPCC Tier 2), T3 (IPCC Tier 3), C (CORINAIR), CS (Country Specific), M (Model).
(2) Emission Factors: D (IPCC default), C (CORINAIR), CS (Country Specific), PS (Plant Specific), M (Model), MB-Mass Balance.

Table 1.4 – Portuguese key source categories (1990-2001) based on Tier 1 approach

IPCC Source Categories	Activity	GHG	Criteria	Comment	2001 Emission (kton CO2 eq)
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CO2	Level Trend	All years	11 317
1 A 3 b Road Transportation	Diesel Oil	CO2	Level Trend	All years	10 532
1 A 3 b Road Transportation	Gasoline	CO2	Level Trend	All years	6 819
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CO2	Level Trend	All years	5 548
1 A 2 f Other	Liquid Fuels	CO2	Level Trend	All years	4 179
2 A 1 Cement Production	Production Quantities	CO2	Level Trend	All years	3 754
1 A 1 b Petroleum refining	Liquid Fuels	CO2	Level Trend	All years	2 722
4 B 8 Swine	Population size	CH4	Level Trend	All years	2 677
6 A 3 Other	Industrial Waste Disposal	CH4	Level Trend	All years	2 435
1 A 4 a Commercial / Institutional	Liquid Fuels	CO2	Level Trend	All years	2 323
1 A 4 b Residential	Liquid Fuels	CO2	Level	All years	2 278
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	CO2	Level Trend	1998, 1999, 2000, 2001	2 267
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CO2	Level Trend	All years	1 656
4 D 2 Animal Production	Input to soils	N2O	Level Trend	All years	1 612
4 D 3 Indirect Emissions	Input to soils	N2O	Level Trend	All years	1 541
1 A 2 c Chemicals	Liquid Fuels	CO2	Level Trend	All years	1 538
4 D 1 Direct Soil Emissions	Input to soils	N2O	Level Trend	All years	1 480
1 A 3 a ii Domestic	Jet Kerosene	CO2	Level Trend	All years	1 328
4 B 12 Solid Storage and Dry Lot	Animal Excretion	N2O	Level Trend	All years	1 139
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CO2	Level Trend	All years	1 090
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CO2	Level	All years	1 088
4 A 1 b Non-Dairy Cattle	Population size	CH4	Level Trend	All years	1 067
1 A 2 f Other	Gaseous Fuels	CO2	Level Trend	1998, 1999, 2000, 2001	1 007
1 A 2 f Other	Solid Fuels	CO2	Level Trend	All years	989
6 A 2 Unmanaged Waste Disposal	Municipal Waste Disposal on Land	CH4	Level Trend	All years	911
4 A 1 a Dairy Cattle	Population size	CH4	Level Trend	All years	746
1 A 2 a Iron and Steel	Solid Fuels	CO2	Level	All years	713
2 B 2 Nitric Acid Production	Production Quantities	N2O	Level Trend	All years	606
4 A 3 Sheep	Population size	CH4	Level Trend	All years	601
6 B 2 Domestic and Commercial wastewater	Wastewater	CH4	Level Trend	All years	578
2 B 1 Ammonia Production	Production Quantities	CO2	Level Trend	All years	396
6 C WASTE INCINERATION	Waste Incinerated	CO2	Level Trend	2000, 2001	376
1 A 3 b Road Transportation	Gasoline	N2O	Level Trend	2001	368
6 B 2 Domestic and Commercial wastewater	Wastewater	N2O	Level	All years	360
2 A 6 Road Paving with Asphalt	Production Quantities	CO2	Level Trend	All years	346
1 A 4 b Residential	Biomass	CH4	Level Trend	All years	297
1 A 4 b Residential	Gaseous Fuels	CO2	Level Trend	2000, 2001	232
6 B 1 Industrial Wastewater	Wastewater	CH4	Level	1996, 1997, 1998, 1999,	208
6 B 1 Industrial Wastewater	Wastewater	N2O	Level	1996, 1997, 1998, 1999,	205
4 B 1 a Dairy Cattle	Population size	CH4	Level Trend	All years	192
4 C 1 Irrigated	Culture Surface	CH4	Level Trend	1997, 1998, 1999, 2000,	181
2 A 7 Other	Production Quantities	CO2	Level Trend	1990, 2001	180
1 A 3 b Road Transportation	Diesel Oil	N2O	Level Trend	2000	179
6 A 1 Managed Waste disposal	Municipal Waste Disposal on Land	CH4	Trend		165
1 B 2 b ii Transmission/ Distribution	Gaseous Fuels	CH4	Level Trend	1999	153
1 A 3 d ii National navigation	Gas/Diesel Oil	CO2	Level Trend	1994, 1995, 1996, 1997,	153
1 A 2 a Iron and Steel	Liquid Fuels	CO2	Trend		152
1 B 2 d Other (Geothermal)	Energy Production	CO2	Trend		145
1 A 3 c Railways	Liquid Fuels	CO2	Level Trend	1990, 1991	128
1 A 2 c Chemicals	Solid Fuels	CO2	Level	2000	119
1 A 2 c Chemicals	Gaseous Fuels	CO2	Trend		98
1 A 2 e Food Processing, Beverages and Tobacco	Gaseous Fuels	CO2	Trend		70
1 A 3 b Road Transportation	Natural Gas	CO2	Trend		69
2 F 1 Refrigeration and Air Conditioning Equipment	Consumption	HFCs	Qual		57
1 A 2 b Non-ferrous Metals	Liquid Fuels	CO2	Trend		31
2 F 7 Electrical Equipment	Consumption	SF6	Qual		7
2 F 2 Foam Blowing	Consumption	HFCs	Qual		6
Sub-Total		All			**81 415**
% of Total		All			**97**
TOTAL EMISSIONS		All			**83 823**

Table 1.5 – Summary of completeness (CRF overview table 7)

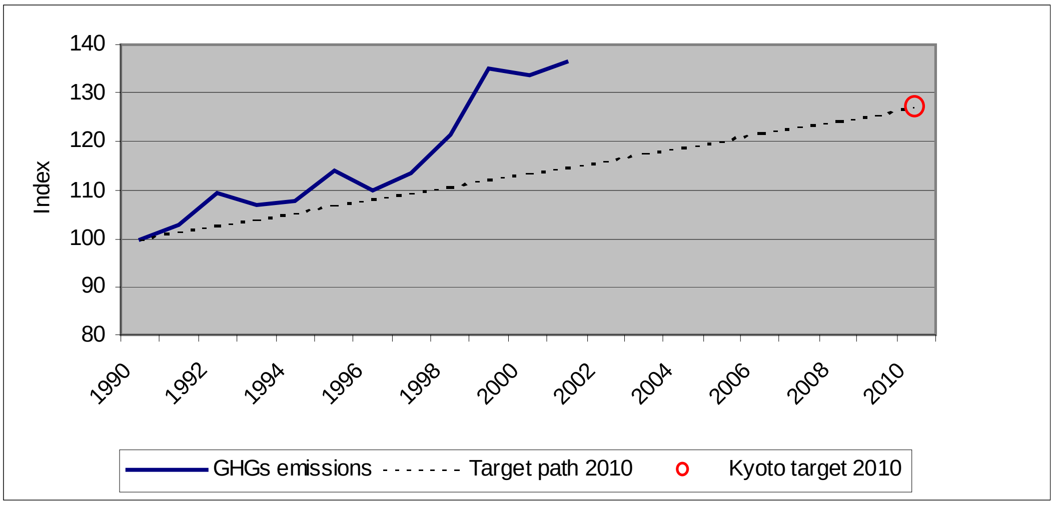
GHG		CO2		CH4		N2O		HFCs		PFCs		SF6		NOx		CO		NMVOC		SO2	
		Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality
1	**Energy**																				
A.	Fuel Combustion Activities																				
	Reference Approach	All	H																		
	Sectoral Approach																				
	1. Energy Industries	All	H	All	M	All	L							All	H	All	M	All	M	All	H
	2. Manufacturing Industries and Construction	All	H	All	M	All	L							All	M	All	M	All	M	All	H
	3. Transport	All	H	All	M	All	M							All	H	All	H	All	H	All	H
	4. Other Sectors	All	H	All	M	All	L							All	M	All	M	All	M	All	H
	5. Other	NO		NO		NO								NO		NO		NO		NO	
B.	Fugitive Emissions from Fuels																				
	1. Solid Fuels	All	H	Part	M	NE															
	2. Oil and Natural Gas	Part	M	Part	M	NE								NE		NE		NE		NE	
2	**Industrial Processes**																				
A.	Mineral Products	Part	M																	Part	M
B.	Chemical Industry	All	H	All	M	All	M							All	M	Part	M	All	M	All	M
C.	Metal Production	All	H	NE		NE				Part	L			All	M	All	M	All	M	All	M
D.	Other Production	All	H											All	H	All	M	All	M	All	H
E.	Production of Halocarbons and SF6							NO		NO		NO									
F.	Consumption of Halocarbons and SF6																				
	Potential							NE		NE		NE									
	Actual							Part	L	NO		Part	H								
G.	Other	NO		NO		NO		NO		NO		NO		NO		NO		NO		NO	
3	**Solvent and Other Product Use**	All	M			NE								NE		NE		All	M	NE	
4	**Agriculture**																				
	Enteric Fermentation			All	M																
	Manure Management			All	M	All	M											NE			
	Rice Cultivation			All	M													NE			
	Agricultural Soils			NE		All	M											NE			
	Prescribed Burning of Savannas			NO		NO								NO		NO		NO		NO	
	Field Burning of Agricultural Residues			Part	L	Part	L							Part	L	Part	L	Part	L		
	Other			NO		NO								NO		NO		NO		NO	
5	**Land-Use Change and Forestry**																				
	A. Changes in Forest and Other Woody Biomass Stocks	Part	M																		
	B. Forest and Grassland Conversion	IE												NO		NO		NO			
	C. Abandonment of Managed Lands	NE																			
	D. CO_2 Emissions and Removals from Soil	NE																			
	E. Other	NO		NO		NO								NO		NO		NO		NO	
6	**Waste**																				
	A. Solid Waste Disposal on Land	All	M	All	M											NE		All	L		
	B. Wastewater Handling			All	M	All	L							NE		NE		All	L		
	C. Waste Incineration	All	H	All	M	All	L							All	M	All	M	All	M	All	M
	D. Other	NO		NO		NO								NO		NO		NO		NO	
7	**Other *(please specify)***	NO		NO		NO								NO		NO		NO		NO	
	Memo Items:																				
	International Bunkers																				
	Aviation	All	H	All	M	All	M							All	M	All	M	All	M	All	H
	Marine	All	H	All	M	All	M							All	M	All	M	All	M	All	H
	Multilateral Operations	NO		NO		NO								NO		NO		NO		NO	
	CO2 Emissions from Biomass	All	H																		

CHAPTER 2: TRENDS IN PORTUGUESE GHG EMISSIONS

2.1 Trends of Total Emissions

Portuguese total GHG emissions without land-use change and forestry (LUCF) were estimated about 83.8 Mton CO2eq. in 2001, representing an increase of 36.4% compared to 1990 levels. Under the burden-sharing agreement, Portugal is bind to limit its emissions to +27% compared to the 1990 level. Comparing the 1990-2001 growth with the linear target path from 1990 to 2010, Portuguese GHG emissions were, in 2001, 21.6 % above this target path.

Figure 2.1 – GHG emissions 1990-2001 compared with target 2008-2012 (LUCF excl.)



The single year increase in emissions from 2000 to 2001 was 1.9%, which is smaller than the average annual growth from 1990 to 2001 (3.3%). The decrease or reduced growth in emission trends registered in the last years, which is partly due to the slow down of Portuguese economy, can be also explained by some introduced measures having positive impact in emission trends, such as: new combined cycle thermoelectric unit of natural gas (1999), the progressive installation of co-generation units, the amelioration of energetic and technologic efficiency of industrial processes, and the improvement of fuels quality.

2.2 Trends by Gas

Table 2.1 presents the main trends in direct GHGs emissions for the 1990-2001 period. It shows CO2 as the primary GHG, accounting for about 77% of Portuguese emissions on a carbon equivalent basis in 2001. The second most important gas is CH4, followed by N2O, representing, respectively, about 13 % and 10 % of total emissions.

Portugal has chosen 1995 as the base year for fluorinated gases. In 2001 these gases represented about 0.08% of total GHG emissions.

Over the 1990-2001 period, all GHG emission levels grew:

- carbon dioxide emissions 48.1%;
- methane emissions 6.6%;
- nitrous oxide emissions 7.5%.

Table 2.1 – GHG emissions and removals in Portugal by gas: 1990-2001

GHGs EMISSIONS	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	CO_2 equivalent (Gg)											
Net CO_2 emissions/removals	43 807	45 201	49 232	47 515	47 486	50 541	47 850	49 925	54 441	61 840	61 342	62 741
CO_2 emissions (without LUCF)	43 809	45 616	50 056	48 727	49 115	52 546	49 941	52 104	56 699	64 199	63 493	64 892
CH_4	10 124	10 127	9 983	9 700	9 962	9 997	10 031	10 133	10 206	10 654	10 689	10 788
N_2O	7 508	7 507	7 283	7 191	7 176	7 424	7 519	7 427	7 660	8 003	8 031	8 073
HFCs	-	-	-	-	-	0	0	2	6	19	37	62
PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
SF_6	-	-	-	-	-	5	5	5	5	6	6	7
Total (with net CO_2 emis./removals)	**61 438**	**62 835**	**66 498**	**64 405**	**64 625**	**67 967**	**65 405**	**67 492**	**72 319**	**80 521**	**80 104**	**81 671**
Total (without CO_2 from LUCF)	**61 441**	**63 251**	**67 322**	**65 617**	**66 253**	**69 972**	**67 496**	**69 670**	**74 577**	**82 880**	**82 256**	**83 823**

NE - not Estimated; NO - not occurring

2.3 Trends by Sector

According to the UNFCCC Reporting Guidelines, emissions estimates are grouped into six IPCC categories: Energy, Industrial Processes, Solvent use, Agriculture, Land-Use Change and Forestry, and Waste. Emissions have risen in almost all these sectors. The exception was agriculture, where the emissions have declined.

Table 2.2 –GHG emissions and removals in Portugal by sector: 1990-2001

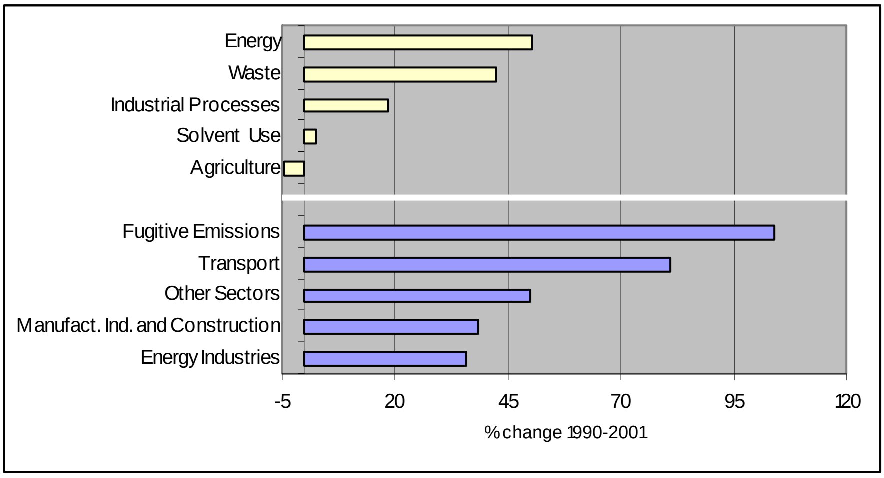
GHGs SOURCE AND SINK CATEGORIES	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	CO_2 equivalent (Gg)											
1. Energy	40 462	42 287	46 918	45 482	45 930	48 775	46 504	48 342	52 961	60 429	59 524	60 934
2. Industrial Processes	4 705	4 674	4 514	4 550	4 393	5 213	4 929	5 287	5 374	5 527	5 568	5 585
3. Solvent and Other Product Use	271	286	279	279	279	279	279	279	279	279	279	279
4. Agriculture	12 299	12 193	11 688	11 262	11 516	11 485	11 476	11 375	11 490	11 867	11 755	11 755
5. Land-Use Change and Forestry	-3	-415	-824	-1 212	-1 628	-2 005	-2 091	-2 179	-2 258	-2 359	-2 152	-2 152
6. Waste	3 703	3 811	3 924	4 045	4 134	4 219	4 308	4 388	4 473	4 777	5 129	5 269
7. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Energy is by far the most important sector, accounting for almost 73% of total emissions in 2001 (excluding LUCF), and presenting an increase of 51% over the 1990-2001 period. Transport (23.5% of total emissions without LUCF) is within the energy sector, the second most important source, appearing after energy industries (26.3% of total emissions without LUCF). This reflects the country heavy dependence on fossil fuels for electricity generation (which continues to grow due to the continued increase of electricity demand) and transport sources. Transportation sources, which are largely dominated by road traffic, are one of the sectors that are rising faster. In the period 1990-2001 these emissions increased approximately 81%, due to the steady growth of vehicle fleets and road travel, reflecting the increase in family income and the strong investment in the road infrastructure of the country in the 1990s decade. Indirectly the increase in road traffic activity augments also the emissions from fossil fuel storage, handling and distribution.

Agriculture is the second most significant source of GHGs emissions (14% of total emissions without LUCF) and is the only category showing a negative trend or emissions decrease in the period analysed (-4.4% reduction from 1990 to 2001). Industrial processes and Waste represent, respectively, 6.7% and 6.3% of Portuguese emissions in 2001, recording an increase of approximately 19% (industrial processes) and 42% (waste).

Solvent use represents less than 1% of total emissions, and is mainly related to NMVOC emissions[3]. The overall trend for this source has stabilised, which is in part due to unavailability of updated activity data. It is expected that this situation will be solved in the next submission of the inventories.

Figure 2.2 – GHGs emissions percentage change (1990-2001) by IPCC category



2.4 Indirect GHG and SOx emissions

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

Table 2.3 presents estimated emissions for these gases.

Gas emissions	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	(Gg)											
CO	1 077.5	1 148.2	1 240.6	1 224.8	1 204.9	1 191.5	1 171.2	1 133.3	1 132.6	1 100.7	1 085.2	1 057.5
NOx	286.8	302.6	324.6	319.5	323.7	336.6	332.0	339.1	362.8	385.4	406.1	398.7
NMVOC	379.4	407.8	435.1	442.4	442.7	463.5	439.2	499.6	532.1	484.2	476.7	484.6
SOx	287.8	283.2	342.9	307.7	278.7	318.4	260.7	265.3	299.3	315.3	288.1	310.1

All emissions except CO, have increased from 1990 levels: NOx 39%, NMVOC 28%, and SO2 8%. CO emissions declined slightly (2%) in the same period. Energy is the major responsible sector for emissions of NOx, SOx, CO and NMVOC. Industrial processes and Solvent use contribute also significantly for NMVOC emissions.

Within energy, transportation is responsible for the greatest share of NOx, NMVOC and CO emissions, respectively 54%, 27% and 65% of 2001 totals. Emissions reductions due to the introduction of new petrol-engine passenger cars with catalyst converters and stricter regulations on diesel vehicles emissions, were overweight by the fast growing trends of the transport sector (mainly road). NOx emissions from transport presented a 55% increase over the 1990-2001 period; NMVOC 33%; and CO decreased slightly (2.5%).

SOx emissions are mainly due to the energy industry sector, which is a major consumer of fossil fuels. Oil and coal represent the biggest share of the fuel mix used in thermal electrical

[3] These are converted into ultimate carbon dioxide after being emitted to atmosphere.

production in the country, and they are in majority imported. Since natural gas was introduced in 1998, it has been registering a growing importance, accounting, in 2000, for 22% of thermal production. All energy production from country resources is from renewable sources: hydro and wind electricity. Hydro is the most important renewable source but its contribution to the overall energy production is irregular, due to pronounced fluctuations in hydroelectric power generation.

CHAPTER 3: ENERGY (CRF SECTOR 1)

3.1 Overview

Energy-related activities are the major sources of Portuguese GHG emissions, accounting for almost 73% of total emissions (CO_2 eq.) in 2001 (LUCF excluded). The most important gas emitted by this sector is CO_2, which represents by itself approximately 71% of national emissions.

Energy emissions are primarily related to fossil fuel combustion. Due to the heavy dependence on fossil fuels for electricity generation and transportation, energy industries and transport appear as the primary sources of Portuguese GHG emissions, representing, respectively, 26.3% and 23.5% of total emissions. Manufacturing industries and construction is the third larger source within this sector with 13.7% of total emissions. Other sectors which include residential, commercial/institutional, agriculture/forestry and fisheries (excluding bunkers) represents 8.6% of national emissions.

CO_2 emissions, the principal gas produced, depend on the carbon content of the fuel used. For this reason estimates of CO_2 emissions are more accurate and methodology simpler to apply. During the combustion process some carbon is released in smaller amounts of other gases, including CH_4, CO and NMVOC. It is presumed that all these other carbon containing non-CO_2 gases oxidise to CO_2 in the atmosphere and are include in carbon dioxide estimates (ultimate CO_2)[4].

Emissions from fossil fuel combustion include also N_2O, NO_x, and SO_x. Unlike CO_2, emissions estimates of these gases require more detailed information, such as operating conditions, combustion and emission control technologies and fuel characteristics.

Fossil fuel combustion from international bunkers, i.e., international aviation and marine transportation, also generates emissions like any other fuel combustion activity. In accordance with international guidelines, these emissions are not included in national totals, but are reported separately as a memo item. Portuguese emissions from these sources are however not correctly reported because they are based on fuel consumption by company flag, instead of a real share between traffic inside and outside the country. This inventory problem has to be solved in the future.

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

Apart from fuel combustion emissions, this sector includes also emissions from production, transmission, storage and distribution of fossil fuels. The generated gases from these sources are CO_2, COVNM, SO_x, CH_4, NO_x and CO.

---

[4] Three CO_2 may be referred in the inventory with different definitions: (1) End of pipe CO_2 - Carbon dioxide effectively emitted from the source: exhaust, chimney, etc; (2) Ultimate CO_2 - carbon dioxide increase contribution to atmosphere. Includes end of pipe CO_2 but also the conversion of other gases and particles that are emitted to atmosphere containing carbon and that are supposedly latter converted in Co2; (3) Fossil ultimate CO_2 - CO_2 emissions resulting from carbon with fossil origin: fossil fuels, mineral rocks and all other non biomass carbon.

3.2 Category sources

3.2.A. Energy Industries

3.2.A.1 Public Electricity and Heat Production (CRF 1A1a)

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 *Carregado* unit still in construction phase).

Apart from dedicated electric power plants, auto-producers generate electric energy for own consume or to be sold to the public system. However not all combustion from these sources are included here because, according to the Revised 1996 IPCC Guidelines, emissions from auto-producers are to be reported under the industrial or commercial branch in which their main economic activity occurs. The present source sector includes only emissions resulting from main power producers[5].

Several components where individualized in the Inventory of Air Emissions from the energy sector and they were dealt differently in the inventory.

<u>Large Point Source Energy Plants</u>

The number of Large Point Source Energy Plants (LPS-EP) in continental Portugal have increased from 6 units in 1990 to 11 units in 2001. Power plants and installed power are listed in table 3.1 together with their main relevant characteristics.

[5] Main Power Producers generate and sell electricity or heat as their main activity (primary activity) either public or private in nature. 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 – Portuguese Energy Large Point Sources

Power Plant	Location	Start	Fuel***	Power MW_e	Treatment of gas effluents	Stack Height (m)	Comment
Tapada do Outeiro	Gondomar	1959	LIG& FO	150/100/50**	ESP	60 (3)	Lignite use stopped in 1997
Turbogas	Gondomar	1998	NG	990			Combined Cycle
Soporgen	Lavos	2001	NG	67	-		Co-generation. Combined Cycle
Mortágua	Mortágua	1999	Wood wastes & NG	10	ESP		
Pêgo	Abrantes	1993	HC	615.2	ESP & Low NOx Burner	225 (1)	
Carregado	Alenquer	1968	FO & NG	750 (250*)	ESP	100 (3)	Natural Gas introduced in 1997
Alto do Mira	Amadora	1975	GO	135	-	10-11	Gas turbine
Barreiro	Lavradio	1978	FO	64.5	-	104 (1)	Co-generation
Setúbal	Setúbal	1979	FO	1 000	ESP	200 (2)	
Sines	Sines	1985	HC	1 256	ESP & Low NOx burners (after 2000)	225 (2)	
Tunes	Silves	1973	GO	199.2	-	9-17	Gas Turbine

* 250 MW in 2 groups using fuel oil and natural gas.
** This central is being de-activated. 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

There has also been a change in the production structure along the 1990-2001 period, with a reduction in the importance of the use of petroleum products (fuel-oil) and an increase of the use of imported coal - in first place - and then natural gas. The only other energy source used in these units was Orimulsion, 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 (*Turbogás*) consuming natural gas was build in northern Portugal near the old unit of *Tapada do Outeiro* and started producing in 1998;
- *Mortágua* unit in central Portugal initiated production in 1999 using natural gas and wood wastes;
- Finally another new unit (*Soporgen*) also in central Portugal has just started producing electricity from natural gas in close connection with an industrial paper pulp plant to where it delivers heat.

Table 3.2 - Number of plants using each type of fuel

Fuel	Number of units		
	1990	1995	2001
Lignite coal/Fuel-oil	1	1	0
Hard coal	1	2	2
Fuel oil	3	3	3
Natural gas	0	0	2
Natural gas/ Fuel-oil	0	0	1
Natural gas/ Wood Wastes	0	0	1

Two of the units labouring in 2001 are co-generation plants selling heat (water vapour) to nearby industrial plants. 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, is used to support the increase of demand during touristy seasonal peak demands.

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 diesel oil.

Non public co-generation Energy Producers

Apart from *Barreiro* power plant, which is public, production of electricity in the co-generation process started in private owned units after 1993. Although some of these units may actually work in close association with other industrial activities they are independent companies which main activity is electric and heat production. Consequently they must be included in this source sector. *Soporgen* power plant is an example of a co-generation unit working in close association with a paper pulp industry which is included in this sub-category.

Geothermic Energy

A small amount of electricity is produced from two geothermic sources in Azores archipelago: *Pico Vermelho* and *Ribeira Grande* Plants.

Carbon dioxide resulting from gas venting is included in the inventory and discussed here for simplicity although resultant emissions are reported under IPCC source category 1-B2.

Methodology

Thermo-electricity Power Plants

A bottom-up sectoral Tier 2 approach was used to estimate emissions of CO2 and other air emissions from this activity.

For all pollutants but sulphur oxides (SOx), emission estimates were calculated for each year, power plant and fuel type from the following equation:

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

where:

$Emission_{(u,f,y,p)}$ - Emission of pollutant p estimated from consumption of fuel f in power plant u in year y (ton except CO2 in ton);

$Energy_{Cons(u,f,y)}$ - Consumption of energy (Low Heating 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 except CO2 in kg/GJ).

For emissions of sulphur oxides the following equation was used instead:

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

Where

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

$Fuel_{Cons(u,f,y)}$ - 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 tons. Equals 1 except to natural gas where it refers to density (ton/original unit);

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

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

For carbon dioxide emissions, the mass balance approach could be used in principle to estimate emissions from the carbon content of fuels. But because that information is not available from most power plants, the IPCC recommendation of using emission factors based on energy consumption was used: “Emission factors for CO2 from fossil fuel combustion are expressed on a per unit energy basis because the carbon content of fuels is generally less variable when expressed on a per unit energy basis than when expressed on a per unit mass basis” (GPG).

Emissions of ultimate CO2 from fossil origin was estimated from CO2 total emissions by:

$$Fossil_{CO2} = U_{CO2} * Fossil_{C} * 10^{-2}$$

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

U_{CO2} - Total ultimate carbon dioxide emissions (ton);

$Fossil_{C}$ - Percentage of carbon from fossil origin in fuel (%).

However it is a fact that some carbon in the fuel is not released directly as carbon dioxide but instead in the form of carbon monoxide, methane, volatile organic compounds and even in soot, ash and particulate matter as consequence of the incomplete combustion of fuel. Emissions of these compounds in airborne fraction are transformed sooner or latter into CO2 in the atmosphere or after deposition on soil. Emissions of CO2 at stack exaust (End-of-pipe emissions) may be estimated from final CO2 emissions from:

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

where

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

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

CO - carbon monoxide emissions (ton);

CH_4 - Methane emissions (ton);

TPM - Total Particulate Matter emissions (ton);

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

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

Geothermic Energy

In Azores since 1994 the Regional Authority of Economy (Secretaria Regional da Economia. Direcção Regional do Comércio, Indústria e Energia) performs own estimates of carbon dioxide to atmosphere from geothermic units and these were considered in the National Inventory. For the years prior to 1994, when the only available activity data for geothermic electricity production is from General-Directorate of Energy (DGE), emission factors estimated for the post-1994 time series were used.

Emission Factors

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 chose those that best match national circumstances:

- IPCC 1996 Revised Guidelines;
- IPCC Good Practice Guidebook;
- EMEP/ CORINAIR Emission Factor Handbook;
- AP-42.

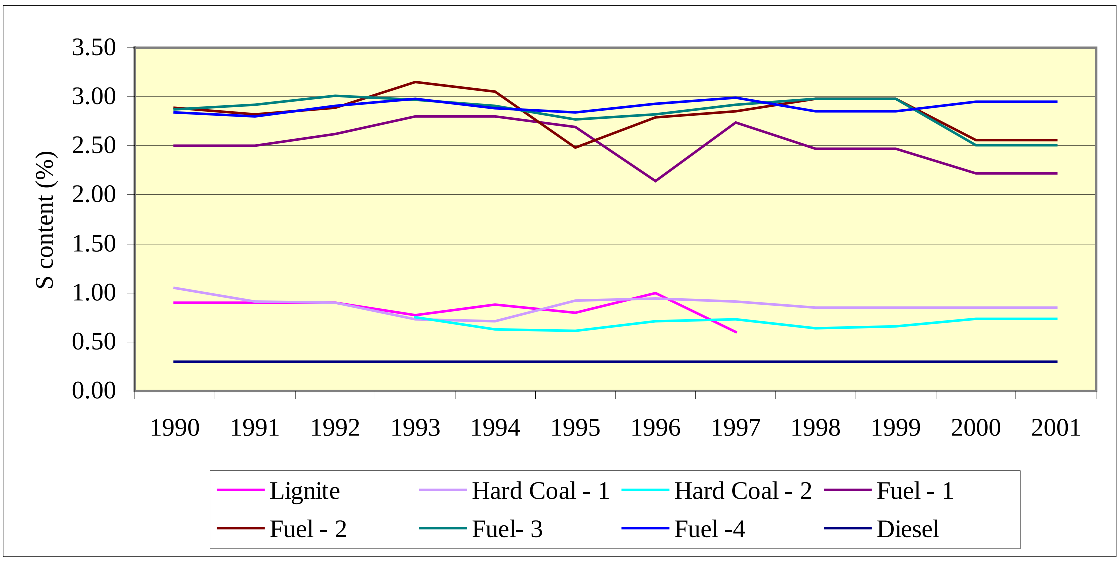
Table 3.3 – Emission Factors for energy production sector

Fuel	U_{CO2} kg/GJ	$Fossil_C$ %	CH_4 G/GJ	N_2O G/GJ	NOx g/GJ	NMVOC G/GJ	CO g/GJ	$AshRet_{(S)}$ %
Lignite	101.2	100	1	1.4	310	1.5	16	5
Hard Coal	92.0	100	0.7	1.4	260 - 500	1.5	10	5
Fuel-oil	77.4	100	0.7	0.6	210 - 300	3	15	0
Orimulsion	80.7	100	0.7	0.6	300	3	15	0
Natural Gas	56.1	100	0.1 - 1.4	1.4	85 - 100	5	19 - 13	0
Biomass	109.6	0	15	4.3		150	15	0
Diesel (Gas Turbine)	74.07	100	0.4	2.5	350	4	15	0

Nitrogen Oxides (NOx) emissions 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 in table 3.3. For three units (Sines, Pêgo and Portgen) emission factors reflect actual monitoring data under Autocontrolo program.

Avearage sulphur content for each fuel type has evolved along the 1990-2001 time series as shown in next figure for the most important fuel types and power plants .

Figure 3.1 – Trends of sulphur content by fuel type[6]



<u>Other Thermo-electricity Power Plants</u>

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

- IPCC 1996 Revised Guidelines;
- IPCC Good Practice Guidebook;
- EMEP/ CORINAIR Emission Factor Handbook;
- AP-42.

Emission factors are present in table 3.4 for the public power plants belonging to the public system, and in table 3.5 for the non public co-generation self producers[7].

Table 3.4 - Azores and Madeira

Region	Fuel	U_{CO2} kg/GJ	$Fossil_C$ %	CH_4 G/GJ	N_2O g/GJ	NOx g/GJ	NMVOC g/GJ	CO g/GJ	$AshRet_{(S)}$ %
Azores	Fuel-oil	77.4	100	2.9	0.6	180	3	15	0
Azores	Diesel oil	74.1	100	0.14	0.6	1 300	2	15	0
Madeira	Fuel-oil	77.4	100	2.9	0.6	180	3	15	0

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

[7] Power producers as main activity only.

Table 3.5 - non public co-generation self producers

Fuel	U_{CO2} kg/GJ	$Fossil_C$ %	CH_4 G/GJ	N_2O g/GJ	NOx g/GJ	NMVOC G/GJ	CO g/GJ	S %	AshRet %
LPG	63.1	100	0.06	1.4	80	2.5	20	0.01	0
Fuel –oil	77.4	100	2.9	0.6	180	3	15	2.84	0
Diesel oil	74.1	100	0.14	0.6	130	2	15	0.3	0
Natural Gas	56.1	100	1.4	1.4	100	5	13	0.0058	0

Geothermic Energy

Measurements of carbon dioxide emissions are available from one plant after 1994. These results were used to establish an emission factor that was latter used to estimate emissions for Pico Vermelho before 1994: 500 ton CO2/GWh. Although this figure was not used in emission estimates for the other power plant the emission factor varied from 1994 to 1999 from 737 to 782 ton CO2/GWh. These emission factors were set from available information from Azores Autonomous Region.

Activity Data

Activity data has different origins according to specific energy plants:

Large Point Source Energy Plants

Data on consumption of fuels by fuel type were available until 1998 from the Large Combustion Plants (LCP) directive - which relies in direct information reported from the individual plant producer to the Environment Ministry - for all power plants except the two gas turbines. From 1999 onwards consumption of fuels was also collected directly from energy plants but under the Self-control program (Programa Autocontrolo)[8] or, when the unit is not obliged to this agreement, from plant activity reports. Activity data for both gas turbine units is from DGE until 1997 and from industry reports thereafter.

As a general rule power plant units report information about consumption in tons or cubic meters of gas together with the Low Heating Value [9] for that specific year from where consumption of fuels in energy units are calculated from:

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

or

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

When LHV 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.

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

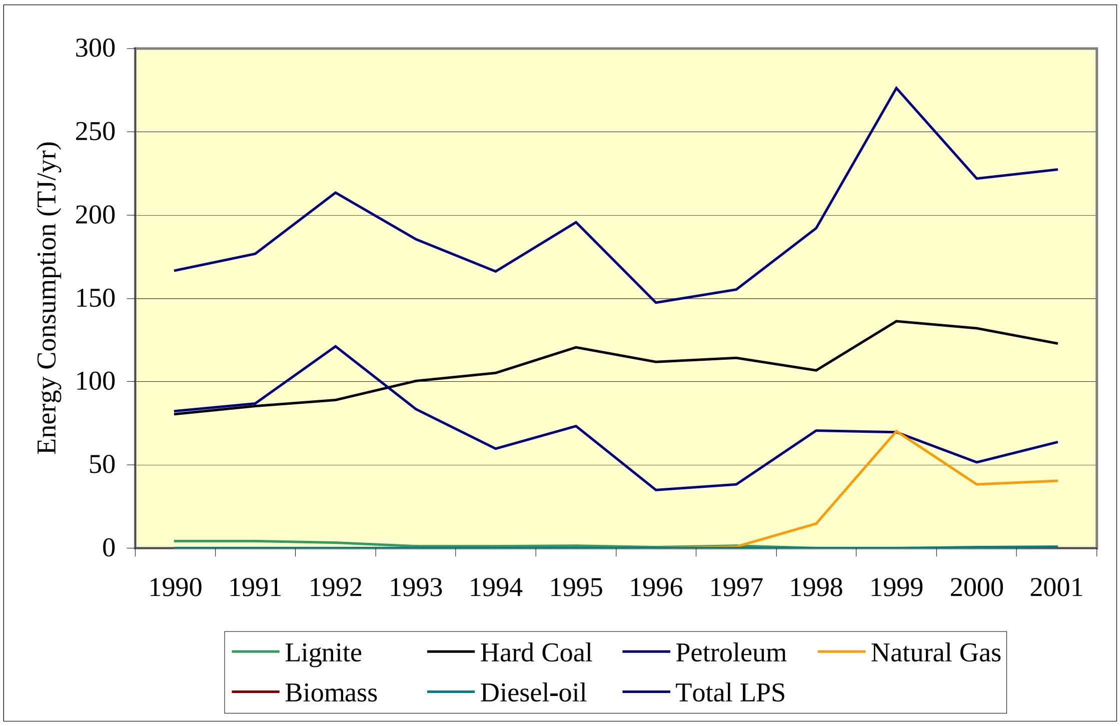
[9] Low Heating Value (LHV) or Net Calorific Values (NCV) measure the quantity of heat liberated by the complete combustion of a unit volume or mass of a fuel, assuming that the water resulting from combustion remains as a vapour and the heat of the vapour is not recovered (GPG). In contrast, Gross Calorific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

Table 3.6 – LHV per fuel type

Fuel	LHV	
Lignite	16.42 (15.57 - 17.02)	MJ/kg
Hard Coal	26.32 (24.96 - 27.23)	MJ/kg
Fuel-oil	39.92 (39.42 - 40.52)	MJ/kg
Orimulsion	28.00	MJ/kg
Diesel oil	43.30	MJ/kg
Natural Gas	37.31 (36.02 - 38.01)	MJ/N m3
Biomass	7.8	MJ/kg

Total consumption per fuel type in comparable energy units (GJ) may be verified in next figure:

Figure 3.2 – Trends of fuel consumption per fuel type [10]

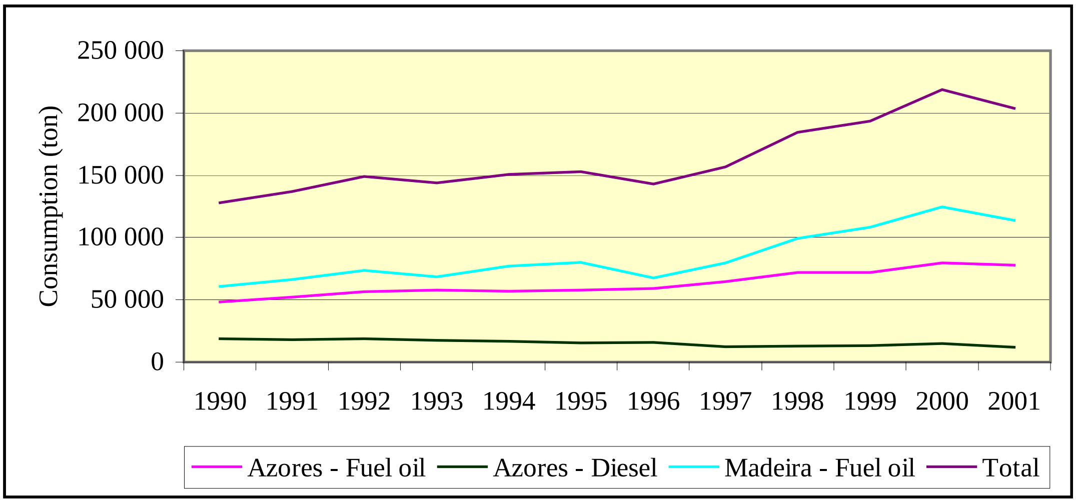


Energy Plants in Azores and Madeira Autonomous Regions

The quantity of residual fuel-oil and diesel oil used in Madeira and Azores in electricity production is available from 1990 to 2000 from General-Directorate of Energy (DGE, 2003) and may be observed in the next figure. Figures for 2001 are still provisional and result from a forecast based in 1990-2000 data using a linear interpolation.

[10] Time series not visible in the graph: Consumption of diesel oil in gas turbines increased from 29 TJ in 1990 to 784 TJ in 2001. Biomass (wood wastes) consumption was only 86 PJ in 1999, 147 PJ in 2000 and 316 PJ in 2001. Orimulsion and fuel-oil are represented together as Petroleum products.

Figure 3.3 – Trends of fuel consumption in Azores and Madeira Islands



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

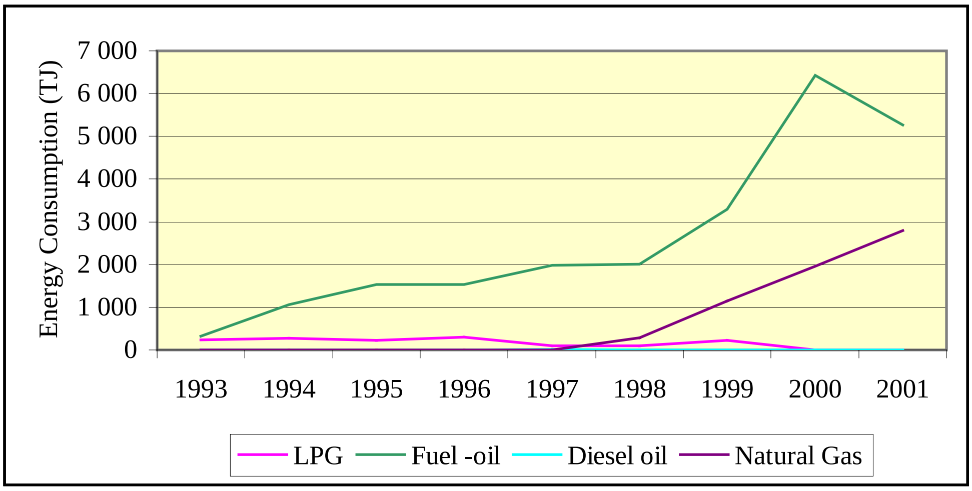
Table 3.7 - LHV per fuel type

Region	Fuel type	LHV (Mj/kg)
Azores	Residual fuel oil	40.17
	Diesel oil	43.30
Madeira	Residual fuel oil	40.17

Non-public co-generation Energy Producers

Consumption of fuels in co-generation units except Barreiro and Soporgen power plants is available in toe units from the revised energy balances from DGE and it is presented in next figure.

Figure 3.4 – Trends in consumption of fuels in non-public co-generation plants



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

Table 3.8 - LHV per fuel type used for non-public co-generation plants estimates

Fuel	LHV (MJkg)
LPG	49.76
Fuel -oil	40.17
Diesel oil	43.30
Natural Gas	44.70

3.2.A.2 Petroleum Refining (CRF 1A1b)

Overview

In 1990 there were three oil refining plants in Portugal: Oporto, Lisbon and Sines. After 1993, the Lisbon unit was closed for most of its activity and only two units remain now in operation.

Oporto refinery transforms crude oil and other intermediate materials received from Sines refinery by atmospheric and vacuum distillation, cracking, platforming. This refinery unit has also a lubricant factory. Sines refinery, in southern Portugal, has also extensive transformation of crude products after atmospheric and vacuum distillation, which are subjected to FCC, platforming, alquilation and production of asphalts. The now 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 emissions, including combustion emissions realized in the FCC unit and in flaring systems, are included elsewhere.

SOx emissions may also result from sulphur that is removed from final products and that is conveyed to final flux gases. Sulphur from the refining process is recovered in both Sines and Oporto refineries but emissions from this source are discussed under Emissions from Flaring and Venting in part 3.2.B.

Methodology

A bottom-up sectoral Tier 2 approach was used to estimate emissions of CO2 and other air emissions 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 other than sulphur oxides (SOx) emission, the following equation was applied:

$$\text{Emission}_{(e,f,y,p)} = \text{Energy}_{Cons(e,f,y)} * \text{EF}_{(e,f,y,p)} * 10^{-6}$$

where

$\text{Emission}_{(e,f,y,p)}$ - Emission of pollutant p estimated from consumption of fuel f in combustion equipment e in year y (ton except CO2 in ton);

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

$\text{EF}_{(e,f,y,p)}$ - Emission factor pollutant p, for fuel f under burning conditions in combustion equipment e in year y (g/GJ except CO2 in kg/GJ).

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 (ton/yr);

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

Emission Factors

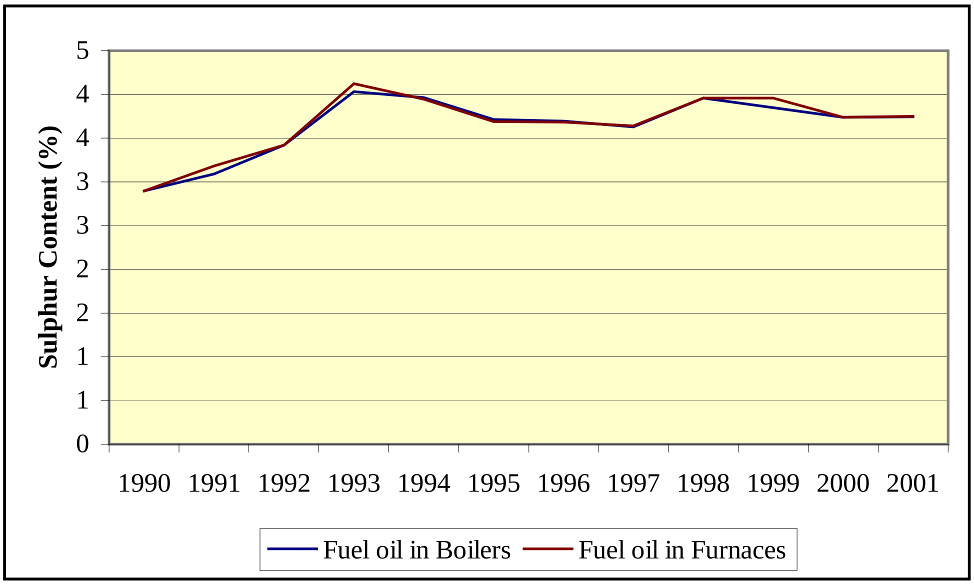
The same emission factors were used for all three refineries and were set from international bibliography such as IPCC96, EMEP/CORINAIR and AP-42, and they are presented in table below.

Table 3.9 – Emission Factors

Fuel	Equipment	U_{CO2} kg/GJ	FossilC %	CH_4 g/GJ	N_2O g/GJ	NO_x g/GJ	NMVOC g/GJ	CO g/GJ	AshRet %
Fuel-oil	Boilers	77.4	100	2.9	0.6	180-190	3	15	0
	Furnaces	77.4	100	2.9	0.6	210	3	15	0
Fuel gas	Boilers	60.0	100	2.5	1.4	140	2.5	17	0
	Furnaces	60.0	100	2.5	1.4	150	2.5	17	0
LPG	Boilers	63.1	100	4	1.4	160	4	17	0
	Furnaces	63.1	100	4	1.4	160	4	17	0
Diesel oil	Boilers	74.1	100	0.15	0.6	100	1.5	12	0
	Furnaces	74.1	100	0.15	0.6	100	1.5	12	0

Composition of fuels, in what concern sulphur, are reported for each year and for each pollutant directly from refineries under the LCP directive. Weighted average values from 1990 to 2000 are reported in next figure for fuel-oil and show a slight increase over years. Fuel gas was reported to have no sulphur.

Figure 3.5 - Trends of sulphur content by fuel type



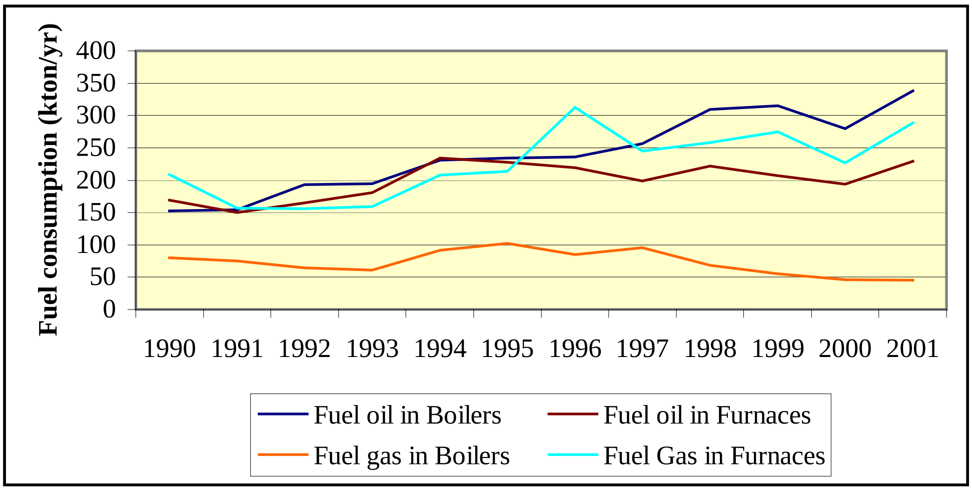
Activity Data

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

The three refinery units consume self produced fuel-oil, fuel-gas, Liquefied Petroleum Gases (LPG) and diesel oil. Sines and Oporto units will start to use of natural gas in order to reduce SOx emissions to atmosphere.

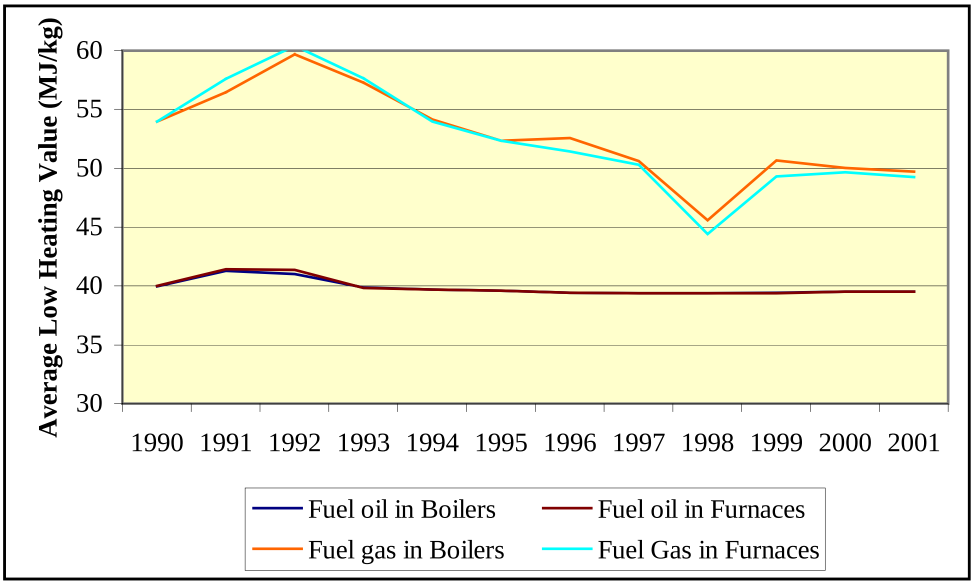
Values of fuel consumption from 1990 to 2000 in boilers and furnaces were received directly from individual units under the Large Combustion Plants (LCP) directive and may be observed in figure 3.6 for fuel oil and fuel gas. Values for 2001 are projections done by the Environmental Institute (IA) and are provisional data. Use of other fuels such as diesel oil and LPG although included in inventory estimates are not at all significant and do not need to be reported here.

Figure 3.6 – Fuel consumption in kton per year by type of equipment



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 and are weighted averages for all three plants.

Figure 3.7 – Fuel consumption in MJ/ kg by type of equipment



3.2.A.3 Other Energy Industries (CRF 1A1c)

Overview

Only external fuel consumption realized in the coquerie unit that exists within the only integrated iron and steel plant in Portugal was included in this source sector, together with electric power plants and refineries. This coquerie unit was closed in 2001.

Coke gas is the only fuel combustion used as energy source in the coquerie unit.

Methodology

For all pollutants other than sulphur oxides (SOx) emission, the following equation was applied:

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

where

$Emission_{(y,p)}$ - Emission of pollutant p in year y (ton except CO2 in ton);
$Energy_{Cons\ (y)}$ - 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).

Sulphur oxides emission from combustion are estimated from coke gas consumption quantities and from 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 (ton/yr);
>
> $Fuel_{Cons(y)}$ - Consumption of coke gas in the coquerie in year y (M m3/yr);
>
> S - Sulphur content of coke gas (g S/Nm3).

Emission Factors

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

Table 3.10 – Emission Factors used for the coquerie emissions

Parameter	Value
U_{CO2}	96.3 kg/GJ
$Fossil_C$	100 %
CH4	2.5 g/GJ
N_2O	1.4 g/GJ
NO_x	120 g/GJ
NMVOC	2.5 g/GJ
CO	17 g/GJ

Sulphur content in coke gas results from the industry plant information; the value of 7.05 gS/Nm3 was assumed.

Activity Data

Consumption of coke gas in the coquerie unit was available directly from the industry plant for 1990-1994. For the following years, the use of coke in coquerie was estimated from total consumption of coke gas in the associated Power Plant, which information was collected directly from the industry under the LCP directive for all time series. Therefore, time series after 1995 where estimated from:

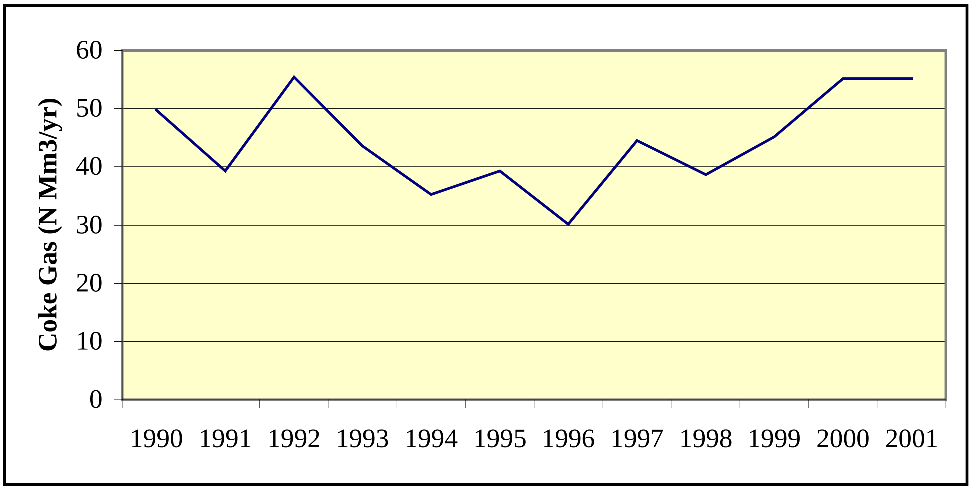
$$Coquerie_{CONS\ (y)} = Coquerie_{CONS\ (90-94)} / PowerPlant_{CONS\ (90-94)} * PowerPlant_{CONS\ (y)}$$

where

> $Coquerie_{CONS\ (y)}$ - consumption of coke gas in the coquerie in year y, after 1995;
>
> $Coquerie_{CONS\ (90-94)}$ - consumption of coke gas in the coquerie from 1990 till 1994;
>
> $PowerPlant_{CONS\ (90-94)}$ - total consumption of coke gas in the power plant from 90 to 94, as reported to the LCP directive;
>
> $PowerPlant_{CONS\ (y)}$ - total consumption of coke gas in the power plant in year y, as reported to the LCP directive.

Time series that was used in emission estimates is presented in figure 3.8. Conversion in energy units was calculated using a LHV of 18.78 MJ/Nm3, the value that is reported under LCP directive.

Figure 3.8 – Coke gas consumption in the coquerie: 1990-2001



3.2.A.4 Manufacturing Industries and Construction (CRF 1A2)

The sources covered in this category refer to the industries of Iron and Steel, Non-Ferrous Metals, Chemicals, Pulp and Paper, Food Processing, Beverages and Tobacco, Textile, Ceramic, Glass, Cement, Clothing, Wood, Rubber, Metal Equipment and Machines, Extractive industry, Construction, and Other Transformation Industry.

Methodology

Emissions of GHG from combustion of manufacturing industries and construction were estimated using Tier 2 methodology described in IPCC 96. The following basic formula was used for each sector:

$$\text{Emissions} = \Sigma\ [EF_{(f,s,t)} * Activity_{(f,s,t)}] * 10^{-3}$$

where:

- Emissions - Total emissions (ton/yr except CO2 in ton);
- $EF_{(f,s,t)}$ - Emission Factor (g/GJ except CO2 in kg/GJ);
- $Activity_{(f,s,t)}$ - Energy Input (GJ);
- f - Fuel type;
- s - Sector-activity;
- t - Technology type.

The total emission for this sub/sector is the sum of different industrial activities, using diverse fuels and combustion technologies.

In special situations, when there is a close contact between combustion gases and product, which is the case of sintering and lime kilns in the iron and steel industry and lime kilns in paper pulp industry, or when combustion occurs also with a recovery purpose, which is the case for the recovery boiler in paper pulp industry, emissions were estimated from produced quantities as activity data (which is expressed in tonnes), and the associated emission factor is expressed in g/ton.

The emissions of SOx are directly related to the fuel content of the fuel. Estimates for SOx were calculated assuming that there is no retention of sulphur in ash and no abatement technologies. The following equation applies:

$$SOx = 2 * \Sigma [S_{(f,s,t)} /100 * Fuel_{Consumption(f,s,t)}]$$

where:

Emissions - Total emissions of SOx (ton/yr);

$S_{(f,s,t)}$- Sulphur content of fuel (%);

$Fuel_{Consumption\ (f,s,t)}$ - For each particular fuel (ton/yr);

f - Fuel type;

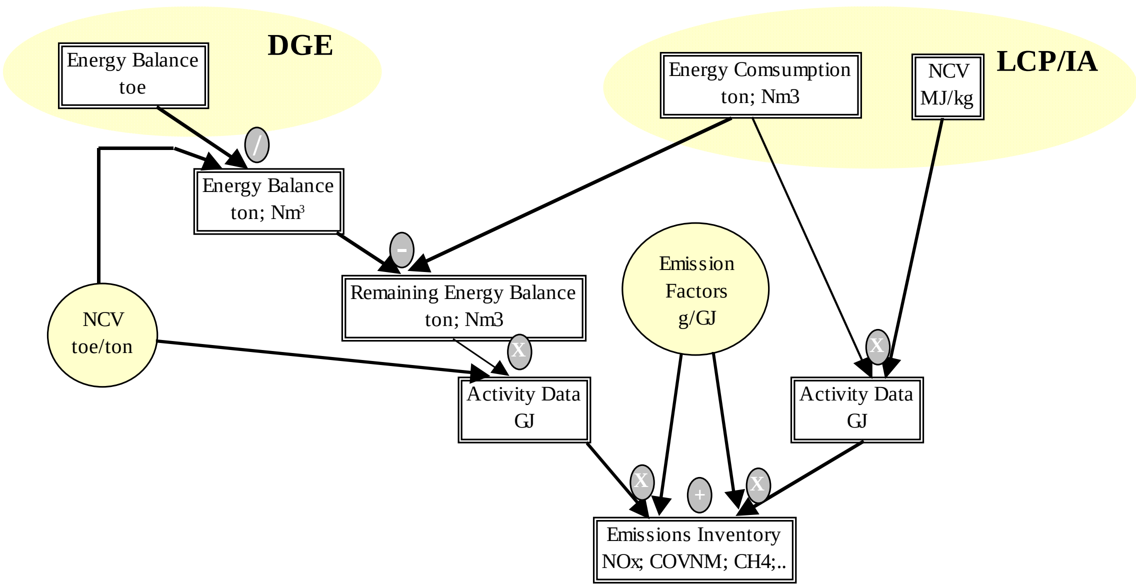
s - Sector-activity;

t - Technology type.

Activity data

Data on fuel consumption for the larger emission sources were obtained directly from Large Combustion Plants (LCP) submitted to the IA under the provisions of the LCP Directive. The information provided under this Directive for this sub-category, refers to the national iron and steel industry, 1 petrochemical unit and 6 paper pulp plants. Additional information was available for the only carbon black industrial plant from direct inquiry. The remaining energy consumption data is estimated subtracting LCP consumption data from annual energy balance compiled by DGE for each industrial sector. This procedure is synthetized in next figure.

Figure 3.9 – General procedure for emissions estimate



Data on combustion equipments was also taken from LCP sources, as well as fuels characteristics. For the sources not covered by LCP Directive or the remaining energy consumed that are accounted in the energy balances, the division of fuel consumption among technologies/equipments was made by expert judgement.

Emissions refer to the full emissions of the industry sector, including emissions from process dedicated fuel combustion together with all emissions originated in co-generation units. Data on fuel consumption is however split between quantities used in co-generation and quantities used without co-generation and emissions could be disaggregated accordingly.

For confidential reasons, LPS data on fuel consumption for the iron and steel industry, the petrochemical and carbon black units are presented together with data in energy balances, which include other sources within each of these sectors. Data on paper pulp plants are presented for the 6 existing units summed together.

Table 3.11 – Fuels consumption in manufacturing industries and construction

Iron and Steel

BOILERS AND FURNACES

	Code	Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	30 530	8 039	8 406	34 037	28 232	23 342	24 390	23 337	15 441	17 647	20 354	22 718
L	204	Gas oil	ton	531	345	379	434	375	362	400	131	157	159	180	110
L	206	Kerosene	ton	31	37	31	41	66	67	64	75	72	67	13	63
L	208	Motor gasoline	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	10 000	10 494	11 386	9 128	6 680	8 002	5 825	8 809	7 364	8 256	9 778	9 778
L	299	Intermediate products	ton	10 000	10 494	11 386	9 128	6 680	8 002	5 825	8 809	7 364	8 256	9 778	9 778
L	303	LPG	ton	9 867	9 663	11 118	12 781	12 679	12 845	11 888	8 755	6 029	7 008	8 817	8 965
L	308	Refinery gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
L	399	Propylen	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	102	Steam coal	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	105	Brown coal/lignite	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	107	Coke oven from hard coal	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	304	Coke oven gas	k m3	32 304	41 894	48 052	49 769	47 895	41 887	45 555	79 009	79 431	85 382	92 630	92 630
S	305	Blast furnace gas	k m3	580 000	433 610	724 695	752 091	690 573	557 878	415 705	602 134	513 011	605 933	752 238	752 238
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	5 874	19 227	20 643	26 748	22 176
B	111	Biomass wood	ton	0	0	0	0	0	0	0	0	0	0	0	0
B	215	Black liquor	ton	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0
O	115	Waste industrial (used oils)	ton	1 000	30	0	0	0	181	139	205	178	208	254	254
O	313	Hydrogen	ton	0	0	0	0	0	0	0	0	0	0	0	0

STATIC ENGINES

	Code	Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	204	Gas oil	ton	531	345	379	434	375	362	400	131	157	159	180	110
L	206	Kerosene	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	208	Motor gasoline	ton	37	25	39	23	40	33	50	5	3	4	3	3
L	303	LPG	ton	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0

Non-Ferrous Metals

BOILERS AND FURNACES

	Code	Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	28 945	23 853	26 368	17 947	13 800	9 640	11 947	1 965	1 868	1 659	2 020	0
L	204	Gas oil	ton	334	452	457	468	517	423	744	663	650	1 020	1 013	987
L	206	Kerosene	ton	9	0	0	0	0	0	0	0	12	36	0	13
L	208	Motor gasoline	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	303	LPG	ton	11 122	11 007	12 614	10 470	11 127	12 441	13 420	11 607	10 406	7 941	5 113	8 241
L	308	Refinery gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
L	399	Propylen	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	102	Steam coal	ton	4 537	4 133	1 054	1 736	211	0	0	0	0	0	0	0
S	105	Brown coal/lignite	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	107	Coke oven from hard coal	ton	13 604	8 569	8 567	0	0	0	0	0	0	0	0	0
S	304	Coke oven gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
S	305	Blast furnace gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	31	890	5 086	12 594	6 384
B	111	Biomass wood	ton	11 367	11 167	10 997	10 777	10 780	10 780	11 433	11 433	11 458	11 500	11 433	11 467
B	215	Black liquor	ton	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0
O	313	Hydrogen	ton	0	0	0	0	0	0	0	0	0	0	0	0

STATIC ENGINES

Code		Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	204	Gas oil	ton	334	452	457	468	517	423	744	663	650	1 020	1 013	987
L	206	Kerosene	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	208	Motor gasoline	ton	0	6	15	80	144	159	183	188	157	71	7	145
L	303	LPG	ton	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0

Chemical and Plastics Industry

BOILERS

Code		Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	245 961	289 084	255 874	191 785	207 444	258 492	251 732	265 561	275 348	278 323	291 782	279 380
L	204	Gas oil	ton	1 792	2 835	2 475	2 291	3 428	3 853	4 837	3 852	4 901	4 891	2 674	4 773
L	206	Kerosene	ton	27	12	8	3	2	1	2	223	445	1 041	283	576
L	208	Motor gasoline	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	303	LPG	ton	5 480	2 702	2 670	4 541	23 849	34 014	21 859	18 450	10 028	8 873	7 219	17 132
L	308	Refinery gas	k m3	24 523	18 851	30 003	26 222	13 520	20 484	21 303	25 286	36 994	39 529	40 509	37 358
L	310	Gas from waste tips	k Nm3	C	C	C	C	C	C	C	C	C	C	C	C
L	399	Propylen	ton	21 137	21 004	33 164	30 174	16 110	33 125	26 689	34 283	79 332	87 361	76 243	79 780
S	102	Steam coal	ton	8 914	6 783	0	0	0	0	0	0	0	0	0	0
S	105	Brown coal/lignite	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	107	Coke oven from hard coal	ton	7 017	9 865	16 661	15 251	16 429	17 547	16 749	14 433	18 583	18 583	76 329	41 725
S	304	Coke oven gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
S	305	Blast furnace gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	0	18 603	54 420	67 689	46 170
B	111	Biomass wood	ton	83 747	82 280	81 040	79 420	79 420	79 420	84 290	84 290	84 468	107 023	108 415	100 194
B	215	Black liquor	ton	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0
O	313	Hydrogen	ton	0	0	0	0	0	0	0	0	0	0	0	0

STATIC ENGINES

Code		Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	3 897	6 666	10 324	14 273	4 942	9 191	7 804	8 122	8 688	11 881	11 800	11 089
L	204	Gas oil	ton	1 849	2 977	2 669	2 441	3 501	3 995	4 957	3 976	5 035	5 074	2 855	4 943
L	206	Kerosene	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	208	Motor gasoline	ton	174	540	1 490	1 506	2 406	3 706	2 940	4 260	4 203	3 608	1 075	4 044
L	303	LPG	ton	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0

Note: An error has been identified concerning feedstock data for residual oil and naphta. Consequently data presented in these tables differ from 2003 CRF submitted tables.

Paper Pulp and Paper

Large Combustion Plants

Data for combustion in paper pulp production is individualized for the 6 industrial units that are covered under LCP directive.

FUEL CONSUMPTION

Equipment		Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Boilers	L	Oil residual + Gas LPG	kton	96.0	91.2	92.3	100.5	147.9	203.8	213.6	213.4	207.1	218.7	217.0	263.5
Lime kiln	L	Oil residual	kton	43.8	37.5	49.0	49.1	53.2	53.2	53.2	53.2	53.2	53.2	53.2	57.3
Flare	L	Gas LPG	kton	C	C	C	C	C	C	C	C	C	C	C	C
Biomass boiler	G	Gas natural	k m3	C	C	C	C	C	C	C	C	C	C	C	C
Boilers	B	Black liquor + bark + biomass + bisulfite and sulfite liquor	kton	2 126.4	2 270.3	2 347.5	2 304.9	2 295.4	2 434.0	2 321.9	2 533.2	2 489.2	2 564.1	2 628.2	2 656.9
Lime kiln	B	Tall Oil + biomass gasef. + NCG	kton	22.9	26.3	26.3	26.2	26.4	26.4	26.4	26.4	26.4	26.4	26.4	27.1

C - confidential; NCG - non-condensable gases

PAPER PULP PRODUCTION

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Paper pulp production	kton of pulp	1 472	1 555	1 546	1 488	1 536	1 627	1 578	1 703	1 698	1 752	1 764	1 792

Other production units

BOILERS AND FURNACES

	Code	Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	94 644	125 565	137 109	138 364	130 020	19 992	34 636	41 035	32 176	24 680	42 132	23 324
L	204	Gas oil	ton	2 081	1 820	1 758	1 638	1 530	1 674	1 656	1 854	1 408	1 376	1 264	1 295
L	206	Kerosene	ton	0	1	1	0	0	1	0	0	0	0	1	0
L	208	Motor gasoline	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	303	LPG	ton	2 186	4 028	4 997	4 217	5 750	5 984	6 378	6 894	7 315	5 608	5 265	7 220
L	308	Refinery gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
L	399	Propylen	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	102	Steam coal	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	105	Brown coal/lignite	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	107	Coke oven from hard coal	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	304	Coke oven gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
S	305	Blast furnace gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	0	230	9 919	67 879	27 808
B	111	Biomass wood	ton	0	24 498	62 805	105 689	78 610	120 819	127 386	136 044	152 279	197 419	101 525	186 673
B	215	Black liquor	ton	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0
O	313	Hydrogen	ton	0	0	0	0	0	0	0	0	0	0	0	0

STATIC ENGINES

	Code	Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	204	Gas oil	ton	2 081	1 820	1 758	1 638	1 530	1 674	1 656	1 854	1 408	1 376	1 264	1 295
L	206	Kerosene	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	208	Motor gasoline	ton	60	141	197	108	246	137	120	212	199	172	18	146
L	303	LPG	ton	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	280	102

Food processing, Beverages and Tobacco

BOILERS AND FURNACES

	Code	Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	221 492	240 269	237 822	224 279	222 569	233 862	233 962	276 772	282 653	263 625	233 494	264 853
L	204	Gas oil	ton	12 592	13 632	15 769	15 887	16 812	16 983	18 431	17 258	16 619	18 770	15 445	18 476
L	206	Kerosene	ton	304	154	173	175	142	116	49	105	127	159	40	49
L	208	Motor gasoline	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	303	LPG	ton	19 156	22 049	24 258	25 726	28 823	30 919	34 385	41 554	41 095	40 155	35 929	44 587
L	308	Refinery gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
L	399	Propylen	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	102	Steam coal	ton	424	227	15	0	0	0	0	0	0	0	0	0
S	105	Brown coal/lignite	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	107	Coke oven from hard coal	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	304	Coke oven gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
S	305	Blast furnace gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	114	11 541	35 156	52 823	33 035
B	111	Biomass wood	ton	317 190	311 640	306 947	300 807	300 810	300 810	319 200	319 200	319 875	270 186	273 699	287 889
B	215	Black liquor	ton	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0
O	313	Hydrogen	ton	0	0	0	0	0	0	0	0	0	0	0	0

STATIC ENGINES

	Code	Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	204	Gas oil	ton	12 592	13 632	15 769	15 887	16 812	16 983	18 431	17 258	16 619	18 770	15 445	18 476
L	206	Kerosene	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	208	Motor gasoline	ton	393	607	1 524	1 136	2 321	2 439	2 636	4 289	3 898	3 828	2 633	4 400
L	303	LPG	ton	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0

Textile

BOILERS AND FURNACES

	Code	Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	258 878	220 824	202 600	183 439	208 016	220 906	283 790	366 226	352 478	291 191	282 069	331 224
L	204	Gas oil	ton	636	650	717	730	860	862	934	1 174	1 211	1 190	1 739	1 525
L	206	Kerosene	ton	3	3	2	1	1	0	0	4	4	0	0	1
L	208	Motor gasoline	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	303	LPG	ton	4 464	5 500	6 628	6 534	6 915	7 946	9 440	11 730	13 925	15 105	10 738	14 698
L	308	Refinery gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
L	399	Propylen	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	102	Steam coal	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	105	Brown coal/lignite	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	107	Coke oven from hard coal	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	304	Coke oven gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
S	305	Blast furnace gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	0	462	18 390	123 140	50 580
B	111	Biomass wood	ton	90 547	88 963	87 623	85 870	85 870	85 870	91 133	91 133	91 326	161 968	164 074	148 573
B	215	Black liquor	ton	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0
O	313	Hydrogen	ton	0	0	0	0	0	0	0	0	0	0	0	0

STATIC ENGINES

	Code	Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	204	Gas oil	ton	636	650	717	730	860	862	934	1 174	1 211	1 190	1 739	1 525
L	206	Kerosene	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	208	Motor gasoline	ton	96	105	269	206	416	422	430	487	507	412	1 482	954
L	303	LPG	ton	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0

Ceramics

BOILERS AND FURNACES

	Code	Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	82 149	88 093	83 170	79 391	81 824	92 739	97 608	150 207	146 403	111 422	93 418	127 681
L	204	Gas oil	ton	2 956	3 619	3 632	3 033	3 083	3 007	3 137	4 342	4 608	4 103	4 182	4 355
L	206	Kerosene	ton	1	5	99	32	2	0	0	0	0	0	8	3
L	208	Motor gasoline	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	303	LPG	ton	130 011	142 121	154 888	161 895	173 893	185 839	191 983	172 227	95 131	53 006	29 807	81 091
L	308	Refinery gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
L	399	Propylen	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	102	Steam coal	ton	224	77	0	0	0	0	0	0	0	0	0	0
S	105	Brown coal/lignite	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	107	Coke oven from hard coal	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	304	Coke oven gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
S	305	Blast furnace gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	41 098	188 169	331 730	407 037	306 666
B	111	Biomass wood	ton	993 940	976 550	961 843	942 610	942 607	942 607	1 000 333	1 000 333	1 002 449	1 062 510	1 076 323	1 048 414
B	215	Black liquor	ton	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0
O	313	Hydrogen	ton	0	0	0	0	0	0	0	0	0	0	0	0

STATIC ENGINES

	Code	Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	204	Gas oil	ton	2 956	3 619	3 632	3 033	3 083	3 007	3 137	4 342	4 608	4 103	4 182	4 355
L	206	Kerosene	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	208	Motor gasoline	ton	860	926	1 149	1 132	1 185	1 090	780	671	683	462	384	468
L	303	LPG	ton	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0

Glass

BOILERS AND FURNACES

	Code	Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	109 573	135 444	136 872	149 790	158 017	161 631	168 860	188 310	200 901	139 139	85 792	158 167
L	204	Gas oil	ton	581	545	576	391	336	492	823	677	624	717	544	667
L	206	Kerosene	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	208	Motor gasoline	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	303	LPG	ton	24 532	26 394	24 147	23 952	26 748	29 197	32 742	36 649	23 461	11 990	7 269	18 029
L	308	Refinery gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
L	399	Propylen	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	102	Steam coal	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	105	Brown coal/lignite	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	107	Coke oven from hard coal	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	304	Coke oven gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
S	305	Blast furnace gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	831	23 473	83 174	154 951	88 195
B	111	Biomass wood	ton	110	107	107	103	103	103	110	110	110	110	110	110
B	215	Black liquor	ton	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0
O	313	Hydrogen	ton	0	0	0	0	0	0	0	0	0	0	0	0

STATIC ENGINES

	Code	Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	204	Gas oil	ton	581	545	576	391	336	492	823	677	624	717	544	667
L	206	Kerosene	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	208	Motor gasoline	ton	89	89	117	125	110	81	85	80	96	60	23	53
L	303	LPG	ton	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0

Cement

BOILERS AND FURNACES

	Code	Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	25 774	30 608	24 965	24 567	28 353	33 556	34 691	35 430	31 785	28 792	25 194	31 521
L	204	Gas oil	ton	7 216	8 185	8 391	8 512	8 149	8 518	8 960	9 621	5 507	6 668	7 414	7 338
L	206	Kerosene	ton	1	0	1	1	0	0	0	0	0	0	0	0
L	208	Motor gasoline	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	303	LPG	ton	629	853	1 436	1 364	1 314	1 384	1 530	5 640	4 539	2 722	3 725	4 523
L	308	Refinery gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
L	399	Propylen	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	102	Steam coal	ton	688 924	727 565	672 451	631 568	649 368	574 927	621 518	499 018	412 479	331 360	414 624	346 027
S	105	Brown coal/lignite	ton	15 956	16 145	11 497	4 799	2 262	0	0	0	0	0	0	0
S	107	Coke oven from hard coal	ton	5 456	2 603	5 471	28 004	28 320	27 190	27 904	378	127	127	0	5 477
S	304	Coke oven gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
S	305	Blast furnace gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	0	2	9	2 193	801
B	111	Biomass wood	ton	20 460	20 103	19 800	19 403	19 403	19 403	20 600	20 600	20 644	20 617	20 633	20 645
B	215	Black liquor	ton	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0
O	313	Hydrogen	ton	0	0	0	0	0	0	0	0	0	0	0	0

STATIC ENGINES

Code		Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	204	Gas oil	ton	7 216	8 185	8 391	8 512	8 149	8 518	8 960	9 621	5 507	6 668	7 414	7 338
L	206	Kerosene	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	208	Motor gasoline	ton	170	140	190	151	179	245	298	259	188	136	67	173
L	303	LPG	ton	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0

Clothing

BOILERS AND FURNACES

Code		Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	19 060	21 342	34 637	45 435	33 251	17 536	19 694	19 308	17 787	16 093	8 710	13 001
L	204	Gas oil	ton	638	632	595	564	585	515	555	460	467	445	348	374
L	206	Kerosene	ton	1	1	1	0	0	0	0	0	0	0	0	0
L	208	Motor gasoline	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	303	LPG	ton	1 199	2 354	3 428	4 359	4 695	5 055	6 461	6 640	6 979	6 616	4 778	7 611
L	308	Refinery gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
L	399	Propylen	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	102	Steam coal	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	105	Brown coal/lignite	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	107	Coke oven from hard coal	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	304	Coke oven gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
S	305	Blast furnace gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	0	226	989	4 360	1 949
B	111	Biomass wood	ton	22 303	21 913	21 583	21 153	21 150	21 150	22 433	22 433	22 481	22 500	22 517	22 508
B	215	Black liquor	ton	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0
O	313	Hydrogen	ton	0	0	0	0	0	0	0	0	0	0	0	0

STATIC ENGINES

Code		Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	204	Gas oil	ton	638	632	595	564	585	515	555	460	467	445	348	374
L	206	Kerosene	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	208	Motor gasoline	ton	44	61	174	159	210	193	184	178	168	138	86	173
L	303	LPG	ton	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0

Wood

BOILERS AND FURNACES

Code		Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	33 498	31 763	17 151	26 757	44 444	75 546	76 827	72 138	70 655	70 776	73 139	88 676
L	204	Gas oil	ton	5 779	5 687	4 805	4 143	4 272	4 437	4 723	11 075	13 346	11 498	4 760	9 943
L	206	Kerosene	ton	2	1	0	0	0	0	0	44	66	2	2	26
L	208	Motor gasoline	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	303	LPG	ton	1 803	2 118	2 043	2 340	2 450	2 437	2 782	6 982	7 261	8 000	9 890	9 263
L	308	Refinery gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
L	399	Propylen	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	102	Steam coal	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	105	Brown coal/lignite	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	107	Coke oven from hard coal	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	304	Coke oven gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
S	305	Blast furnace gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	0	0	1 023	6 961	2 848
B	111	Biomass wood	ton	104 300	102 477	100 933	98 913	98 913	98 913	104 967	104 967	105 189	71 349	72 276	82 816
B	215	Black liquor	ton	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0
O	313	Hydrogen	ton	0	0	0	0	0	0	0	0	0	0	0	0

STATIC ENGINES

Code		Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	204	Gas oil	ton	5 779	5 687	4 805	4 143	4 272	4 437	4 723	11 075	13 346	11 498	4 760	9 943
L	206	Kerosene	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	208	Motor gasoline	ton	18	41	79	81	206	246	267	2 967	3 778	2 894	90	2 535
L	303	LPG	ton	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0

Rubber

BOILERS AND FURNACES

Code		Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	14 218	11 507	8 565	7 139	6 534	6 734	6 673	7 001	7 656	8 782	9 453	6 519
L	204	Gas oil	ton	126	157	314	315	337	311	323	268	274	388	683	507
L	206	Kerosene	ton	5	6	5	4	3	3	4	1	1	0	1	0
L	208	Motor gasoline	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	303	LPG	ton	585	636	599	590	650	704	829	1 504	592	550	594	804
L	308	Refinery gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
L	399	Propylen	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	102	Steam coal	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	105	Brown coal/lignite	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	107	Coke oven from hard coal	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	304	Coke oven gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
S	305	Blast furnace gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	0	11	46	1 022	388
B	111	Biomass wood	ton	3 730	3 663	3 610	3 537	3 537	3 537	3 767	3 767	3 775	3 770	3 767	3 776
B	215	Black liquor	ton	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0
O	313	Hydrogen	ton	0	0	0	0	0	0	0	0	0	0	0	0

STATIC ENGINES

Code		Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	204	Gas oil	ton	126	157	314	315	337	311	323	268	274	388	683	507
L	206	Kerosene	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	208	Motor gasoline	ton	0	0	37	53	78	106	115	163	156	457	1 282	706
L	303	LPG	ton	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0

Machines and other Metal Equipment

BOILERS AND FURNACES

Code		Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	22 043	20 284	21 477	13 337	16 123	12 653	25 431	18 122	24 289	16 207	19 173	18 830
L	204	Gas oil	ton	3 831	3 772	4 066	3 690	3 574	4 867	5 878	5 017	5 779	5 514	2 715	5 054
L	206	Kerosene	ton	135	62	28	10	2	2	5	5	5	9	7	0
L	208	Motor gasoline	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	303	LPG	ton	30 956	31 988	32 450	31 985	34 263	33 957	34 445	50 132	51 946	47 987	37 730	48 503
L	308	Refinery gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
L	399	Propylen	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	102	Steam coal	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	105	Brown coal/lignite	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	107	Coke oven from hard coal	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	304	Coke oven gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
S	305	Blast furnace gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	4 795	12 731	21 084	35 116	23 486
B	111	Biomass wood	ton	2 260	2 220	2 187	2 143	2 143	2 143	2 267	2 267	2 271	1 274	1 291	1 606
B	215	Black liquor	ton	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0
O	313	Hydrogen	ton	0	0	0	0	0	0	0	0	0	0	0	0

STATIC ENGINES

Code		Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	204	Gas oil	ton	3 831	3 772	4 066	3 690	3 574	4 867	5 878	5 017	5 779	5 514	2 715	5 054
L	206	Kerosene	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	208	Motor gasoline	ton	976	1 126	1 882	1 563	2 124	2 262	3 691	3 638	3 509	3 103	1 020	3 284
L	303	LPG	ton	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0

Other Transformation Industry

BOILERS AND FURNACES

Code		Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	36 088	34 508	31 385	23 366	20 195	4 190	4 459	8	0	0	0	0
L	204	Gas oil	ton	3 909	5 062	5 508	8 393	6 746	4 169	6 057	462	733	633	412	222
L	206	Kerosene	ton	93	91	76	50	23	1	24	0	0	0	0	0
L	208	Motor gasoline	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	299	Intermediate products	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	303	LPG	ton	3 223	4 303	4 961	7 209	8 374	9 111	10 378	2 425	2 044	2 723	1 680	3 475
L	308	Refinery gas	k m3	5	175	405	4 123	3 565	3 549	3 946	4 648	4 380	3 859	2 833	5 166
L	399	Propylen	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	102	Steam coal	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	105	Brown coal/lignite	ton	26	12	2	27	41	0	0	0	0	0	0	0
S	107	Coke oven from hard coal	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	304	Coke oven gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
S	305	Blast furnace gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	0	12	534	3 196	1 330
B	111	Biomass wood	ton	497	487	480	470	470	470	500	500	501	500	500	501
B	215	Black liquor	ton	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0
O	313	Hydrogen	ton	0	0	0	0	0	0	0	0	0	0	0	0

STATIC ENGINES

Code		Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	204	Gas oil	ton	3 909	5 062	5 508	8 393	6 746	4 169	6 057	462	733	633	412	222
L	206	Kerosene	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	208	Motor gasoline	ton	7	108	4 938	20 012	11 246	1 150	1 967	637	732	535	59	562
L	303	LPG	ton	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	k Nm3	0	0	0	0	0	0	0	0	0	0	0	0
B	309	Biogas	ton	0	0	0	0	0	0	0	0	0	0	0	0

Extractive Industry

Equipment	Code		Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Boilers	L	203	Oil residual	ton	2 752	4 440	3 888	2 014	1 241	1 229	1 315	3 088	2 583	2 009	2 378	1 838
Boilers	L	204	Oil gas	ton	10 482	11 370	12 301	12 242	10 399	11 133	13 407	21 085	18 796	18 955	17 015	19 918
Boilers	L	206	Kerosene	ton	44	0	29	14	14	14	5	13	12	5	0	0
Boilers	L	208	Gasoline motor	ton	0	0	0	0	0	0	0	0	0	0	0	0
Boilers	L	303	Gas GPL	ton	1 589	1 609	1 582	1 773	2 131	2 190	2 625	3 857	4 205	4 046	3 638	4 433
Boilers	G	301	Gas natural	ton	0	0	0	0	0	0	0	0	0	299	412	650
Static engines	L	203	Oil residual	ton	0	0	0	0	0	0	0	0	0	0	0	0
Static engines	L	204	Oil gas	ton	10 482	11 370	12 301	12 242	10 399	11 133	13 407	21 085	18 796	18 955	17 015	19 918
Static engines	L	206	Kerosene	ton	0	0	0	0	0	0	0	0	0	0	0	0
Static engines	L	208	Gasoline motor	ton	363	353	233	193	143	45	70	128	444	676	462	726
Static engines	L	303	Gas GPL	ton	0	0	0	0	0	0	0	0	0	0	0	0
Static engines	G	301	Gas natural	ton	0	0	0	0	0	0	0	0	0	0	0	0

Construction

Code		Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	16 713	22 026	21 809	44 214	35 177	43 912	33 705	47 107	44 259	26 549	28 400	41 162
L	204	Gas oil	ton	137 660	155 909	149 261	152 173	165 203	177 945	183 098	190 628	190 513	187 406	177 193	199 302
L	205	Diesel oil	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	206	Kerosene	ton	157	8	48	63	27	15	4	41	253	5	3	3
L	208	Motor gasoline	ton	629	1 212	3 754	4 859	8 122	10 175	15 249	8 496	7 941	6 736	1 648	9 211
L	303	LPG	ton	4 928	4 359	5 593	9 776	14 729	19 297	22 563	13 669	12 142	12 231	11 862	11 862
G	301	Natural gas	ton	0	0	0	0	0	0	0	0	17	74	209	293

Emission Factors

The emissions factors used depend, 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 (3rd rev);
- 1996 IPCC Guidebook;
- US EPA AP-42 and EIIP.

Table 3.12 – Emissions factors from international sources

Code		Fuel	Unit	NCV	Unit	SOx	NOx g/GJ	COVNM g/GJ	CH4 g/GJ	CO g/GJ	CO2 kg/GJ	N2O g/GJ
L	203	Residual oil	GJ/ton	40.17	ton/ton	0.0014286	160	3.0	2.90	15	77.37	0.6
L	204	Gas oil	GJ/ton	43.31	ton/ton	0.0060000	60	1.0	0.10	12	74.07	0.6
L	206	Kerosene	GJ/ton	43.72	ton/ton	0.0030000	60	1.0	0.10	12	71.87	0.6
L	208	Motor gasoline	GJ/ton	44.77	ton/ton	0.0020000	60	1.0	0.10	12	69.30	0.6
L	299	Intermediate products	GJ/ton	42.74	ton/ton	0.0000000	160	3.0	2.90	15	77.37	0.6
L	299	Intermediate products	GJ/ton	40.17	ton/ton	0.0120000	160	3.0	2.90	15	80.67	0.6
L	303	LPG	GJ/ton	47.28	ton/ton	0.0000320	90	2.5	1.40	17	63.07	1.4
L	308	Refinery gas	GJ/k m3	15.69	ton/ kNm3	0.0000000	140	25.0	1.40	17	60.00	1.4
L	399	Propylen	GJ/ton	47.28	ton/ton	0.0000320	90	2.5	1.40	17	63.07	1.4
S	102	Steam coal	GJ/ton	29.29	ton/ton	0.0130000	170	190.0	2.40	150	96.07	0.7
S	105	Brown coal/lignite	GJ/ton	17.15	ton/ton	0.0130000	200	190.0	2.40	160	101.20	0.7
S	107	Coke oven from hard coal	GJ/ton	28.03	ton/ton	0.0200000	300	12.0	2.40	160	101.95	0.7
S	304	Coke oven gas	GJ/k m3	17.57	ton/ kNm3	0.0001410	90	2.5	1.40	17	46.50	1.4
S	305	Blast furnace gas	GJ/k m3	3.77	ton/ kNm3	0.0000009	55	0.0	1.40	17	102.50	1.4
G	301	Natural gas	GJ/k Nm3	37.66	ton/ kNm3	0.0000014	67	5.0	1.40	13	56.10	1.4
B	111	Biomass wood	GJ/ton	12.55	ton/ton	0.0000000	70	150.0	15.00	500	109.63	4.3
B	215	Black liquor	GJ/ton	16.74	ton/ton	0.0000000	70	150.0	15.00	500	73.33	4.3
B	309	Biogas	GJ/ton	34.70	ton/ton	0.0000320	90	2.5	1.40	17	52.00	1.4
O	313	Hydrogen	GJ/ton	47.28	ton/ton	0.0000320	90	2.5	1.40	17	63.07	1.4

Table 3.13 – Emissions factors for static engines from international sources

Code		Fuel	NOx g/GJ	COVNM g/GJ	CH4 g/GJ
L	204	Gas oil	1100	100	9.89
L	206	Kerosene	60	100	9.89
L	208	Motor gasoline	1300	100	9.89

The emission factors presented in previous tables 3.2 and 3.3 were applied in the majority of the sectors considered. Exception to this, are specific emission factors used for some sectors that are presented separately in the following tables.

Table 3.14 –Emission factors for the extractive industry

Extractive industry: Emission Factors

Equipment			Fuel	PCI MJ/Kg	SOx %	NOx g/GJ	COVNM g/GJ	CH4 g/GJ	CO g/GJ	CO2 g/GJ	N2O g/GJ
Boilers	L	203	Oil residual	40.17	3	160	3	1.4	20	72.6	0.6
Boilers	L	204	Oil gas	43.30	0.3	60	1	0.6	20	73	0.6
Boilers	L	206	Kerosene	43.72	0.15	60	1	0.6	20	73	0.6
Boilers	L	208	Gasoline motor	44.77	0.1	0	0	0	0	71	0.6
Boilers	L	303	Gas GPL	47.28	0.0016	65	2.5	1.5	50	64.5	1.4
Boilers	G	301	Gas natural	37.86	0.0059	67	5	1.4	13	56	1.4
Static engines	L	203	Oil residual	40.17	3	0	0	0	0	72.6	0.6
Static engines	L	204	Oil gas	43.30	0.3	1100	100	60	20	73	0.6
Static engines	L	206	Kerosene	43.72	0.15	0	0	0	0	73	0.6
Static engines	L	208	Gasoline motor	44.77	0.1	1300	100	60	20	71	0.6
Static engines	L	303	Gas GPL	47.28	0.0016	0	0	0	0	64.5	0.6
Static engines	G	301	Gas natural	37.86	0.0059	0	0	0	0	56	1.4

Table 3.15 –Emission factors for the construction industry

Construction and public works: Emissions Factors

Code		Fuel	PCI MJ/Kg	SOx %	NOx g/GJ	COVNM g/GJ	CH4 g/GJ	CO g/GJ	CO2 kg/GJ	N2O g/GJ
L	203	Residual oil	40.17	3	160	3	1.6	20	77.4	0.6
L	204	Gas oil	43.31	0.3	1100	50.5	5.0	20	74.1	0.6
L	205	Diesel oil	43.31	0.3	60	1	0.6	20	74.1	0.6
L	206	Kerosene	43.72	0.15	60	50.5	5.0	20	71.9	0.6
L	208	Motor gasoline	44.77	0.1	1300	100	9.9	20	69.3	0.6
L	303	LPG	47.28	0.0016	1200	2.5	1.5	50	63.1	1.4
G	301	Natural gas	42.60	0.0059	1200	100	9.9	20	56.1	1.4

Other specific emission factors were used for some industrial units, some of them obtained from direct measurements in LCPs.

Table 3.16 – Specific emission factors for LCP

Iron and Steel

Iron and Steel: Emission Factors (1/2)

Equipment	Code		Fuel	PCI		SOx		NOx		COVNM	
				Unit		Estimation method	EF	Estimation method	EF	Estimation method	EF
Rolling mills	L	203	Residual oil	MJ/kg	40.35	1	3.500	1	190	1	3.0
Power plant	L	203	Oil residual 3.5%	MJ/kg	40.35	1	3.500	1	190	1	3.0
Power plant	L	203	Oil residual 1%	MJ/kg	40.35	1	1.000	1	190	1	3.0
Power plant	L	299	Intermediate products	MJ/kg	34.10	1	0.600	1	300	1	3.0
Heat power plant	L	303	LPG	MJ/kg	46.04	1	0.005	1	160	1	4.0
Heat power plant	L	299	Intermediate products	MJ/kg	34.10	1	0.600	1	300	1	3.0
Lime kiln a)	L	-	-	-	-	4	0.421	4	0.1	1	0.0
Sintering	S	304	Coke oven gas	MJ/Nm3	18.78	3	1.000	3	0.5	3	0.1
Blast furnacec cowpers	S	304	Coke oven gas	MJ/Nm3	18.78	2	7.050	1	120	1	2.5
Blast furnacec cowpers	S	305	Blast furnace gas	MJ/Nm3	2.87	2	0.045	1	70	1	2.5
Rolling mills	S	304	Coke oven gas	MJ/Nm3	18.78	2	7.050	1	120	1	2.5
Power plant	S	304	Coke oven gas	MJ/Nm3	18.78	2	7.050	1	120	1	2.5
Power plant	S	305	Blast furnace gas	MJ/Nm3	2.87	2	0.045	1	70	1	2.5
Heat power plant	O	115	Waste industrial (used oils)	MJ/kg	40.35	1	0.000	1	190	1	3.0

Iron and Steel: Emission Factors (2/2)

Equipment	Code		Fuel	CH4		CO		CO2		N2O	
				Unit	EF	Estimation method	EF	Unit	EF	Unit	EF
Rolling mills	L	203	Residual oil	g/GJ	3.0	1	15	kg/GJ	76.04	g/GJ	0.6
Power plant	L	203	Oil residual 3.5%	g/GJ	3.0	1	15	kg/GJ	76.04	g/GJ	0.6
Power plant	L	203	Oil residual 1%	g/GJ	3.0	1	15	kg/GJ	76.04	g/GJ	0.6
Power plant	L	299	Intermediate products	g/GJ	3.0	1	15	kg/GJ	74.04	g/GJ	0.6
Heat power plant	L	303	LPG	g/GJ	4.0	1	17	kg/GJ	64.55	g/GJ	1.4
Heat power plant	L	299	Intermediate products	g/GJ	3.0	1	15	kg/GJ	74.04	g/GJ	0.6
Lime kiln a)	L	-	-		0.0	4	2	kg/GJ	790.00	g/GJ	0.0
Sintering	S	304	Coke oven gas	g/GJ	2.5	3	30	kg/GJ	96.31	g/GJ	1.4
Blast furnacec cowpers	S	304	Coke oven gas	g/GJ	2.5	1	17	kg/GJ	96.30	g/GJ	1.4
Blast furnacec cowpers	S	305	Blast furnace gas	g/GJ	2.5	1	17	kg/GJ	241.34	g/GJ	1.4
Rolling mills	S	304	Coke oven gas	g/GJ	2.5	1	17	kg/GJ	96.30	g/GJ	1.4
Power plant	S	304	Coke oven gas	g/GJ	2.5	1	17	kg/GJ	96.30	g/GJ	1.4
Power plant	S	305	Blast furnace gas	g/GJ	2.5	1	17	kg/GJ	241.34	g/GJ	1.4
Heat power plant	O	115	Waste industrial (used oils)	g/GJ	3.0	1	15	kg/GJ	76.04	g/GJ	0.6

a) Emissions estimated based on lime production.
SOx: Estimation method: 1 - from % S; 2- from gS/Nm3; 3- from prod sinter unit kg/ton sinter; 4- from lime production: kg/ton lime
NOx: Estimation method : 1 - from g/GJ; 3- from prod sinter: kg/ton sinter; 4- from lime production: kg/ton lime
COVNM: Estimation method : 1 - from g/GJ; 3- from prod sinter: kg/ton sinter
CO: Estimation method : 1 - from g/GJ; 3- from prod sinter: kg/ton sinter

Chemical Industry

Chemical LPS 1: Net Calorific Value

Equipment	Code	Fuel	Unit	Range
Boilers	203	Residual oil	MJ/kg	39.33 - 41.24
Boilers	308	Refinery gas	MJ/kg	47.70 - 52.67
Furnaces	303	LPG	MJ/kg	52.67
Furnaces	308	Refinery gas	MJ/kg	52.67
Static engines	203	Residual oil	MJ/kg	41.24
Static engines	204	Gas oil	MJ/kg	43.30
Flares	308	Refinery gas	MJ/kg	47.84 - 53.08

Chemical LPS 1: Sulphur content

Equipment	Code	Fuel	Unit	Range
Boilers	203	Residual oil	%	0.35 - 3.5
Boilers	308	Refinery gas	%	0.0005
Furnaces	303	LPG	%	0.0005
Furnaces	308	Refinery gas	%	0.0005
Static engines	203	Residual oil	%	1.6 - 3.5
Static engines	204	Gas oil	%	0.3
Flares	308	Refinery gas	%	0

Chemical LPS 1: Emission Factors

Equipment	Code	Fuel	NOx g/GJ	COVNM g/GJ	CH4 g/GJ	CO g/GJ	CO2 (t/t)	N2O g/GJ
Boilers	203	Residual oil	140 - 170	3	3	15	87.5 - 91.6	0.6
Boilers	308	Refinery gas	147	2.5	2.5	13	87.9 - 96.8	1.4
Furnaces	303	LPG	88	2.5	2.5	13	96.8	1.4
Furnaces	308	Refinery gas	88	2.5	2.5	13	96.8	1.4
Static engines	203	Residual oil	900	60	60	15	1753.8	0.6
Static engines	204	Gas oil	900	60	60	12	1841.1	0.6
Flares	308	Refinery gas	NE	NE	NE	NE	3.14	NE

NE - Not estimated
CO2 Global or ultimate CO2.

Chemical LPS 2: Emission Factors

Equipment	Code		Fuel	NCV unit		SOx kg/ ton gas	NOx g/GJ	COVNM g/GJ	CH4 g/GJ	CO g/GJ	CO2 g/GJ	N2O g/GJ
Boiler	L	310	Gas from waste tips	MJ/Nm3	2.02	0.1953	90	2.5	1.4	17	a)	1.4
Boiler	L	303	LPG	MJ/kg	47.28	0.0320	90	2.5	1.4	17	66.34	1.4

a) CO2 emissions estimated based on mass balance from feedstock and fuel consumption, and carbon black produced.

Paper pulp

Paper Pulp: Net Calorific Value

Equipment	Code		Fuel	Unit	NCV
Boilers	L	203	Oil residual	kcal/kg	9062-9988
Boilers	L	303	Gas LPG	kcal/kg	11400
Lime kiln	L	203	Oil residual	kcal/kg	9413-9700
Flare	L	303	Gas LPG	kcal/kg	12587
Biomass boiler	G	301	Gas natural	kcal/m3	9058
Recuperation boilers	B	215	Black liquor	kcal/kg	1766-3970
Biomass boiler	B	111	Biomass wood	kcal/kg	2500-7538
Biomass boiler	B	111	Bark	kcal/kg	3680-4898
Boilers	B	215	Bisulfite liquor	kcal/kg	3700
Boilers	B	215	Sulfite liquor	kcal/kg	3769
Lime kiln	B	-	Tall oil	kcal/kg	8130-8520
Lime kiln	B	-	Gasified biomass	kcal/kg	3500
Lime kiln	B	-	NCG	kcal/kg	23312

NCG - Non Condensable Gases
Source: LPS and Corinair 90

Paper Pulp: Emission Factors (1/3)

Equipment	Code		Fuel	SOx				NOx			
				Estimation method	% S	Estimation method	kg/ ton pulp	Estimation method	g/GJ	Estimation method	kg/ ton pulp
Boilers	L	203	Oil residual	1	1.0-3.5			1	180-210		
Boilers	L	303	Gas LPG	1	0.0			1	80		
Lime kiln	L	203	Oil residual			2	0.2			2	0.5
Flare	L	303	Gas LPG	1	0.0			1	80		
Biomass boiler	G	301	Gas natural	1	0.0			1	67		
Recuperation boilers	B	215	Black liquor			2	3.5			2	1.16
Biomass boiler	B	111	Biomass wood	1	0.0			1	200		
Biomass boiler	B	111	Bark	1	0.0			1	200		
Boilers	B	215	Bisulfite liquor			2	12.5			2	1.25
Boilers	B	215	Sulfite liquor			2	12.5			2	1.25
Lime kiln	B	-	Tall oil			2	0.0			2	0.5
Lime kiln	B	-	Gasified biomass			2	0.2			2	0.5
Lime kiln	B	-	NCG			2	3.0			2	0.5

Paper Pulp: Emission Factors (2/3)

Equipment	Code		Fuel	COVNM				CH4			
				Estimation method	g/GJ	Estimation method	kg/ ton pulp	Estimation method	g/GJ	Estimation method	kg/ ton pulp
Boilers	L	203	Oil residual	1	3			1	3		
Boilers	L	303	Gas LPG	1	2.5			1	0.72		
Lime kiln	L	203	Oil residual			2	0.065			2	0.065
Flare	L	303	Gas LPG	1	2.5			1	0.72		
Biomass boiler	G	301	Gas natural	1	5			1	1.4		
Recuperation boilers	B	215	Black liquor			2	0.49			2	0.49
Biomass boiler	B	111	Biomass wood	1	80			1	30		
Biomass boiler	B	111	Bark	1	80			1	30		
Boilers	B	215	Bisulfite liquor			2	0.625			2	0.625
Boilers	B	215	Sulfite liquor			2	0.625			2	0.625
Lime kiln	B	-	Tall oil			2	0.065			2	0.065
Lime kiln	B	-	Gasified biomass			2	0.065			2	0.065
Lime kiln	B	-	NCG			2	0.065			2	0.065

PULP: Emission Factors (3/3)

Equipment	Code		Fuel	CO		CO2		N2O	
				Estimation method	g/GJ	Estimation method	kg/GJ	Estimation method	g/GJ
Boilers	L	203	Oil residual	1	15	1	76	1	0.6
Boilers	L	303	Gas LPG	1	15	1	65	1	1.4
Lime kiln	L	203	Oil residual	1	15	1	76	1	0.6
Flare	L	303	Gas LPG	1	15	1	65	1	1.4
Biomass boiler	G	301	Gas natural	1	13	1	56.1	1	1.4
Recuperation boilers	B	215	Black liquor	1	15	1	106	1	0.6
Biomass boiler	B	111	Biomass wood	1	500	1	101	1	4.3
Biomass boiler	B	111	Bark	1	500	1	101	1	4.3
Boilers	B	215	Bisulfite liquor	1	15	1	106	1	0.6
Boilers	B	215	Sulfite liquor	1	15	1	106	1	0.6
Lime kiln	B	-	Tall oil	1	15	1	77-82	1	0.6
Lime kiln	B	-	Gasified biomass	1	500	1	101-107	1	4.3
Lime kiln	B	-	NCG	1	15	1	65	1	1.4

NCG - Non Condensable Gases
SOx: Estimation method: 1 - from % S; 2 - from paper pulp production: kg/ton pulp
Other pollutants: 1 - g/GJ; 2 - from paper pulp production: kg/ton pulp
Source: LPS and Corinair 90

3.2.A.5 Transport (CRF 1A3)

3.2.A.5.1 Road Transportation

<u>Overview</u>

Road transportation is an important emitter of greenhouse gases such as carbon dioxide, methane and nitrous oxide. But road traffic is particularly a significant emission source of pollutants associated with trans-boundary air pollutants and regional and local air problems such as sulphur oxides (SO_x), nitrous oxides (NO_x), carbon monoxide (CO), non volatile organic compounds (NMVOC) and consequently is indirectly responsible for the formation of ozone (O_3) in lower troposphere. This source is also responsible for substantial emissions of ammonia, particulate matter and heavy metals.

Exhaust emissions result from the combustion in the engine and include all the gases considered in the inventory, although CO_2, NO_x, SO_x, CO and NMVOC are particularly important pollutants emitted from this source sector. Exhaust emissions are estimated for each of the following classes from SNAP97[11]:

- Light Passenger Vehicles or Gasoline Passenger Cars;
- Light Duty Vehicles;
- Heavy Duty Vehicles, buses an coaches;
- 2 wheeler motorcycles (>50 cc);
- Mopeds and Motorcycles (<50 cc).

For each vehicle class, exhaust emissions were further disaggregated by driving mode: Urban, Rural and Highway driving modes. Finally emissions were disaggregated by fuel type:

- petrol/gasoline;
- diesel oil for road transport (gas-oil);

[11] 3rd version of the EMEP/CORINAIR Atmospheric Emission Inventory Guidebook considers a further subdivision of passenger cars in conventional gasoline passenger cars, catalyst gasoline passenger cars, diesel passenger cars, LPG passenger cars and two-stroke passenger cars, and a similar situation for other vehicle classes. This subdivision is still not consider in this inventory.

- Liquefied Petroleum Gases.

Evaporative emissions from petrol-engine vehicles are also included in this source sector. They consist of losses of volatile organic compounds present in the fuel and are associated with:

- Diurnal emissions, resulting from the thermal expansion of the air/fuel vapour volume inside the gasoline tank as consequence of diurnal air temperature cycles;
- Running losses, again the result of vapour outflow from the gasoline tank but during vehicle operation, and as result of the combined effect of high air temperature and the heat from engine and exhaust system;
- Hot soak emissions, occurring when the engine is turned off, and the fuel that remains in the system is no longer flowing and becames hotter from hear generated in the engine and exhaust system.

Methodology

Exauts emission estimate follow a country specific methodology that is however based extensively in the EMEP/CORINAIR methodology and emission factors. Data flow is summarized in next figure from where main following steps may be identified:

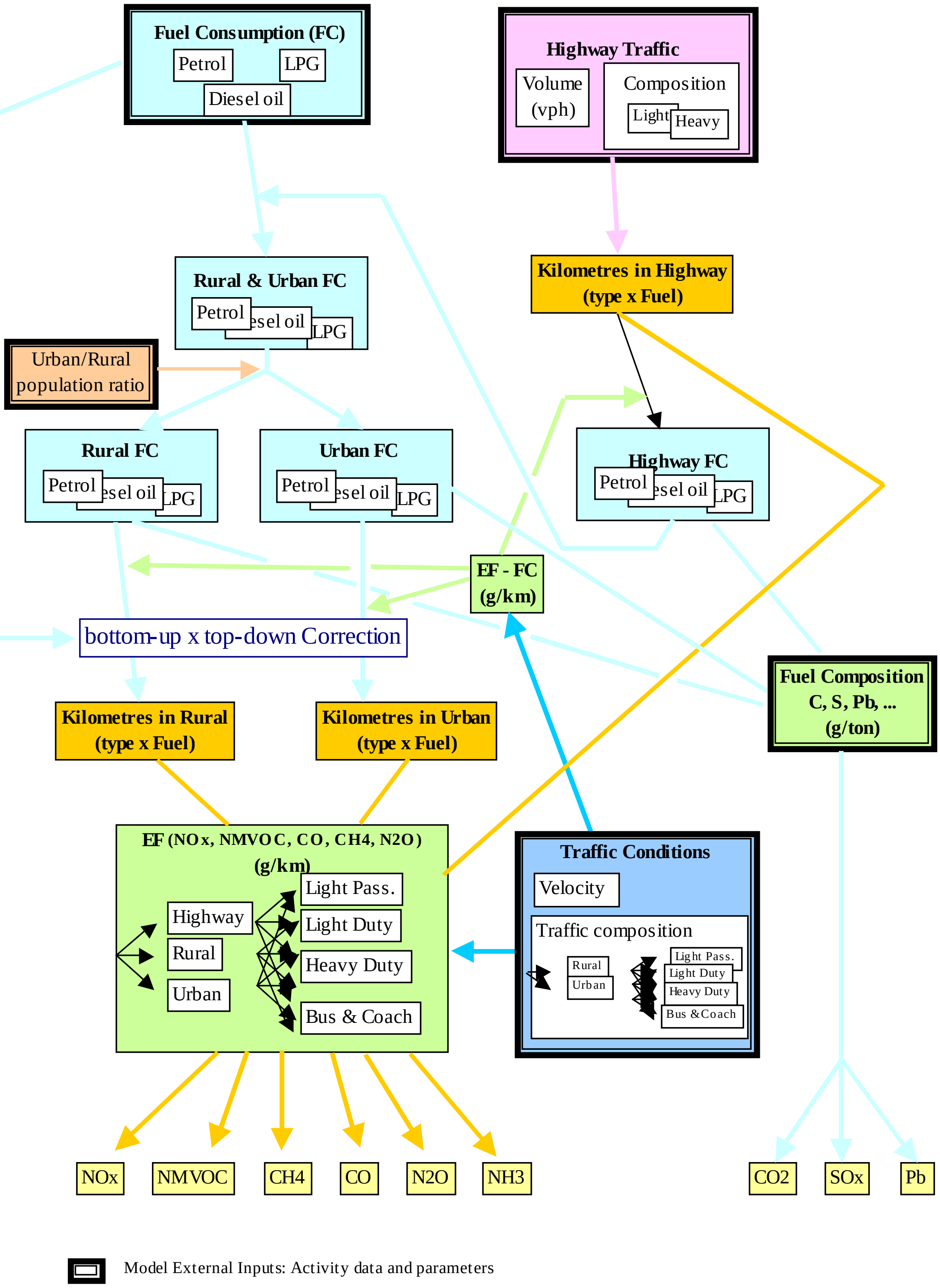
- estimate kilometres driven per vehicle type, driving conditions and vehicle technology;
- estimate fuel consumption per vehicle type, driving conditions and vehicle technology (bottom-up approach);
- correct fuel consumption using bottom-up approach in conjunction with top-down approach;
- determine emission factors, corrected for hot and cold-start emissions;
-estimate emissions from kilometres driven or fuel consumption.

Emissions estimate incorporate a substantial level of territorial desegregation in the sense that:

- distance driven and fuel consumption in highways is estimated at *concelho*[12] level;
- fuel consumption is split between urban, rural and highway modes at nut III level;
- exhaust emission factors are corrected for cold-start emissions with meteorological information at nut III level. Emission factors for evaporative emissions are also determined at nut III disaggregation.

[12] Portuguese area is composed of 32 nut 3 regions each composed of several *Concelhos*, territorial units associated with a municipal authority (*Câmara Municipal*). *Concelhos* are composed of smaller units *Freguesias* and are also included in greater areas named *Distritos*, which are not however coincident with nut regions. No administrative authority is associated with nut3 regions while some ministerial services have regional services at nut2 level.

Figure 3.10 – General scheme of methodology applied for road transport emission estimates



[13] Portuguese area is composed of 32 nut 3 regions each composed of several *Concelhos*, territorial units associated with a municipal authority (*Câmara Municipal*). *Concelhos* are composed of smaller units *Freguesias* and are also included in greater areas named *Distritos*, which are not however coincident with nut regions. No administrative authority is associated with nut3 regions while some ministerial services have regional services at nut2 level.

Distance driven estimate[14]

Highway traffic

Information about traffic volume is available annually for highways either free or subjected to a toll payment[15]. The length of the highway system and its evolution in the 1990 - 2001 period was also available from National Road Institute (IEP) and the main highway commissioner, BRISA. Kilometres driven on highways are therefore estimated from:

$$Highway_{km(c,f,y)} = T_{class\ (c,y,Hway)} * C_{fuel\ (c,f,y)} * \sum_l [L_{Length(l,r,y)} * L_{Traficc\ (l,r,y)}]$$

where

- $Highway_{km(c,f,y)}$ - total kilometres driven in highway net-road by vehicles of class c using fuel f in year y (km/yr);
- c - vehicle class or type: light passenger, light duty vehicle, heavy duty vehicle, etc;
- r - highway code;
- l - a link connect two nodes of the highway. Traffic volume are constant along each link;
- y - civil year;
- $L_{Length(l,r,y)}$ - full length of inter-nodal link l from highway road r (km);
- $L_{Traficc\ (l,r,c,y)}$ - Traffic volume (vehicles per year) of vehicle class c registered in link l in year y (vehicles per year);
- $T_{class\ (c,y,Hway)}$ - ratio of cars of class c in representative fleet circulating in highways in year y;
- $C_{fuel\ (c,f,y)}$ - ratio of cars of class c using fuel f in year y.

Urban and Rural Traffic

Urban and Rural kilometers where calculated from fuel consumption in urban and rural driving mode, using:

$$Urban_{km\ (c,f,y)} = Urban_{FC\ (c,f,y)}/EF_{(FC,c,f,urban)} * 10^6$$
$$Rural_{km\ (c,f,y)} = Rural_{FC\ (c,f,y)}/EF_{(FC,c,f,rural)} * 10^6$$

where

- $Urban_{km(c,f,y)}$ - total kilometres driven in urban areas by vehicles of class c using fuel f in year y (km/yr);
- $Rural_{km(c,f,y)}$ - total kilometres driven in non highway rural roads by vehicles of class c using fuel f in year y (km/yr);
- $Rural_{FC(c,f,y),}$ $Urban_{FC(c,f,y)}$ - fuel consumption in rural and urban areas made by vehicles of class c using fuel f in year y (km/yr);

[14] Vehicle classes counted in highways do not correspond to vehicle class as considered in the inventory. There is no distinction between light passenger vehicles and light duty vehicles and light vehicles are split in two classes as function of vehicle height at front axel. Original classes where corrected as necessary from information obtained from monitoring data in rural roads.

[15] Highways were defined as road with two lanes in each direction, where there is a separation of opposite direction lanes, where vehicles may only enter or leave at specific nodes and where speed limit is 120 km/hr. Most of highways in Portugal are commissioned and circulation is subjected to toll payment.

$EF_{(FC,c,f,rural)}$, $EF_{(FC,c,f,urban)}$ - Fuel consumption factors of vehicle type c using fuel f in rural and urban driving modes respectively (g/km)

Estimate of fuel consumption

Fuel Consumption under Highway mode

Fuel consumption in highway mode is estimated for each fuel from estimates of distance driven in this driving mode. Therefore:

$$Highway_{FC(f,y)} = \sum_c [Highway_{km(c,f,y)} * EF_{(FC,c,f,Hway)}] * 10^{-6}$$

and,

$Highway_{FC(c,f,y)}$ - Fuel consumption of fuel type f in highway driving mode by vehicles of all classes in year y (km/yr);

$Highway_{km(c,f,y)}$ - total kilometres driven in highway net-road by vehicles of class c using fuel f in year y (km/yr);

$EF_{(FC,c,f,Hway)}$ - Fuel consumption factor for vehicle type c using fuel f in highway driving mode (g/km).

Individual fuel consumptions by each car type are estimated from:

$$Highway_{FC(c,f,y)} = Highway_{km(c,f,y)} * EF_{(FC,c,f,Hway)} * 10^{-6}$$

Fuel Consumption in Urban and Rural driving modes

Total fuel consumption in urban and rural driving modes was estimated simply by subtracting fuel consumption estimated in highway mode from total fuel sales:

$$[Urban_{FC(f,y)}+Rural_{FC(f,y)}] = Total_{FC\ (f,y)} - Highway_{FC(f,y)}$$

where

$[Urban_{FC(f,y)}+Rural_{FC(f,y)}]$ - total fuel consumption of fuel type f in urban and rural driving modes in year y;

$Highway_{FC(f,y)}$ - Fuel consumption of fuel type f in highway driving mode by vehicles of all classes in year y (km/yr);

$Total_{FC(f,y)}$ - Total National fuel consumption of fuel type f in year y (km/yr).

This difference was determined at each nut III territorial unit[16]. Individual fuel use in rural and urban driving modes was finally calculated from:

$$Urban_{FC(f,y)} = Urban_{POP\ (y)} * [Urban_{FC(f,y)}+Rural_{FC(f,y)}]$$
$$Rural_{FC(f,y)} = [1-Urban_{POP\ (y)}] * [Urban_{FC(f,y)}+Rural_{FC(f,y)}]$$

[16] Although some correction have to be made because some territorial units although crossed by highways do not sell fuel to vehicles circulating in the highway.

where $Urban_{POP\ (y)}$ is ratio of urban population to total population in year y. This division of fuel was also made at nut III territorial unit.

Finally total fuel use per driven mode and fuel type was divided among several class types in the following manner:

$$Rural_{FC(c,f,y)} = Rural_{FC(f,y)} * T_{class\ (c,f,y,rural)}$$
$$Urban_{FC(c,f,y)} = Urban_{FC(f,y)} * T_{class\ (c,f,y,urban)}$$

and,

$Rural_{FC(c,f,y),}$ $Urban_{FC(c,f,y)}$ - fuel consumption in rural and urban areas made by vehicles of class c using fuel f in year y (km/yr);

$T_{class\ (c,f,y,rural),}$ $T_{class\ (c,f,y,urban)}$ - ratio of cars of class c using fuel f in representative fleet circulating in rural and urban driving modes in year y;

Adjustment of bottom-up and top-down approaches

This step is necessary because presently in the process of splitting total fuel among car types and fuel types not all class percentages add to unity. Therefore a correction must be made to make total fuel consumption equal original statistical data. Therefore, all fuel use estimates where corrected by the following factor for car type c, fuel f, driving mode m and year y.

$$Correc_{Factor(c,f,m,y)} = [Urban_{FC(f,y)} + Rural_{FC(f,y)} + Highway_{FC(f,y)}] / Total_{FC(f,y)}$$

Which is latter applied as it is expressed in the following example for urban driving mode:

$$Urban_{FC(c,f,y)} = Urban_{FC(c,f,y)} * Correc_{Factor(c,f,urban,y)}$$

Is this correction that guarantees that at least carbon dioxide emission estimates are in accordance with good practices (equation 2.4) because although they where estimated from estimate of vehicle driven kilometres and from fuel consumption per kilometre, they where corrected for total national fuel sales.

Emission Factor Determination

Emission Functions

Emissions factors for NO_x, CO, NMVOC, CH_4, N_2O and NH_3 were determined from the available set of algorithms reported in EMEP/CORINAIR, which results from a compilation for the CORINAIR85 and CORINAIR90 programs and updated with results from the MEET (Methodologies to Estimate Emissions from Transport) project and the COST19 action (Estimation of Emissions from Transport). This set of equations is translated in Copert software and allow estimation of emission factors as function of driving conditions and vehicle properties:

- Vehicle class: Light Passenger Vehicles (LPV); Light Duty Vehicles (LDV); Heavy Duty Vehicles (HDV); Mopeds & Motorcycles (<50 cc) and Motorcycles (>50 cc);
- Technology standard;
- Vehicle dimensions: motor size (cubic centimetres) for light vehicles and two wheelers and vehicle weight for Heavy Vehicles;
- Average vehicle speed, for each driving mode.

Technology standards depend on vehicle class and are those identified in table 1.2 of EMEP/CORINAIR. In the present inventory, and due to constrains in basic data - concerning vehicle age - information, the only differentiation is between passenger cars classified as conventional vehicles[17] and vehicles provided with a 3W Closed Loop Catalyst Converter (Euro I)[18].

Fuel consumption factors are similar in development and use to emission factors and are also presented here. Fuel consumption factors are used in first step in the methodology to help to share total fuel consumption per vehicle class.

Hot and Cold emission factors

Final emission factors in EMEP/CORINAIR methodology are estimated in two steps:

- hot emission factor. Representing emission factors (g/km) when vehicles have warmed up to normal operating conditions;
- cold-start extra emissions. Exhaust emissions from vehicles during a certain time, until engine temperature[19] increases to normal operation temperature, have generally increased emissions over *normal* hot emissions.

Total emission factor (ef^T) is estimated from:

$$ef^{T}_{(c,t,d,f,p)} = \sum_m \{ef^{hot}_{(c,t,d,f,p)} * [1+ \beta_m * (cf^{cold/hot}_{(c,t,d,f,p)} - 1)]\}/12$$

where

$ef^{T}_{(c,t,d,f,p)}$ - average annual total (hot and cold-start) emissions from vehicle type c with technology t and using fuel type f (g/km);

m - month;

$ef^{hot}_{(c,t,d,f,p)}$ - hot emission factor from vehicle type c with technology t and using fuel type f (g/km)

β_m - average monthly value for the fraction of mileage driven with cold engines or catalyst operated below the light-off temperature. This parameter is calculated from average monthly temperature T_a (ºC) and average trip length (km/trip) (Table 8.6 of 3[ed] EMEP/CORINAIR).

$cf^{cold/hot}_{(c,t,d,f,p)}$ - cold to hot ratio of emissions (g/g).

Cold-start corrections were performed for cars using all three fuels: petrol, diesel and LPG, and for all driving modes[20]. Correction factors $cf^{cold/hot}$, where set from table 8.7, table 8.8, table 8.11 and table 8.14 in EMEP/CORINAIR Handbook.

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[17] Pre-ECE vehicles were assumed using a conservative approach. Available information was not clear concerning the introduction in Portugal of the ECE standards and the importance in vehicle fleet of cars imported from abroad. This problem is even bigger for heavy duty vehicles were age classes concern vehicle but legal constrains apply to engine.

[18] Actually there is no legal obligation for the existence of a catalyst converter, but in fact is the methodology that allows the respect of 91/441/EEC directive.

[19] Cold engines are defined as those with water temperature below 70ºC (EMEP/CORINAIR)

[20] Although it may be true that cold-start extra emissions seldom occur in highway mode.

Emission estimate

Two different sets of pollutants are distinguishable:

- pollutants for which a mass balance may be performed such as CO_2 and SO_x;
- pollutants for which emissions are best estimated from kilometres driven: NO_x, CO, NMVOC, N_2O and NH_3.

Emissions of ultimate carbon dioxide were estimated from:

$$U_{CO2\ (y)} = \sum_c \sum_t \sum_d \sum_f [Fuel_{Cons(c,t,d,f,y)} * EF_{CO2(f)}] * 10^{-3}$$

which is equivalent to equation 14 of CORINAIR/EMEP Handbook. Where

$U_{CO2(y)}$ - Ultimate or final emission of carbon dioxide in year y (kton/yr);

$Fuel_{Cons\ (c,t,d,f,y)}$ - Fuel consumption in year y allocated to vehicle type c, with technology t, using fuel type f and under driving conditions d (ton/yr);

$EF_{CO2(f)}$ - Emission factor for fuel type f (ton/ton).

End of pipe emissions of CO2 may be estimated from the several carbon compounds that are also emitted as proposed in equation 15 of the EMEP/CORINAIR Emission Inventory Guidebook.

Emissions of SO_x are also estimated by mass balance:

$$SO_{x\ (y)} = 2 * \sum_c \sum_t \sum_d \sum_f [Fuel_{Cons(c,t,d,f,y)} * S_{(f,y)} * 10^{-2}]$$

where

$SO_{x\ (y)}$ - Sulphur oxide emission estimated in exhaust gas from road vehicles in year y (ton/yr);

$Fuel_{Cons(c,t,d,f,y)}$ - Fuel consumption in year y allocated to vehicle type c, with technology t, using fuel type f and under driving conditions d (ton/yr);

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

Emissions estimate for those pollutants that are estimated from distance driven are estimated from:

$$Emission_{(p,y)} = \sum_c \sum_t \sum_d \sum_f [Driven_{km\ (c,t,d,f,y)} * EF_{(c,t,d,f,p)}] * 10^{-6}$$

where

$Emission_{(p,y)}$ - emission of pollutant p in year y (tonyr);

$Driven_{km\ (c,t,d,f,y)}$ - Total distance driven in year y by vehicles of type c, with technology t, using fuel type f and under driving conditions d (km/yr);

$EF_{(c,t,d,f,p)}$] - Emission factor for pollutant p for vehicles of type c, with technology t, using fuel type f and under driving conditions d (g/km).

Evaporative emissions

Calculation of evaporative emissions was adapted from the methodology presented in document B760-1 of EMEP/CORINAIR Handbook (3rd edition). Total evaporative emissions are estimated from:

$$Evap_{NMVOC\ (y)} = [Urban_{km(c,f,y)} + Rural_{km(c,f,y)} + Highway_{km(c,f,y)}] * EF_{evap} * 10^{-6}$$

where

$Evap_{NMVOC\ (y)}$ - NMVOC evaporative emissions in year y (ton/yr);

[$Urban_{km(c,f,y)}$, $Rural_{km(c,f,y)}$, $Highway_{km(c,f,y)}$ - total kilometres driven in each mode (km/yr);

EF_{evap} - Emission factor (g/km).

NMVOC emissions from evaporation where not converted in ultimate CO_2 emissions because carbon results mostly from carbon in fuel and it is already accounted in fuel consumption emissions.

Emission Factors

Carbon Dioxide

Final or ultimate CO2 emission factors where established considering equation 14 of the CORINAIR/EMEP Emission Inventory Guidebook:

$$EF_{CO2(f)} = 44.011 / (12.011+1.008 * R_{H/C})$$

Where

$EF_{CO2(f)}$ - Emission factor for fuel type f;

$R_{H/C}$ - the ratio of hydrogen to carbon atoms in the fuel. Values for this ratio and the resulting CO2 emission factor are presented in table 3.17.

Table 3.17 - $R_{H/C}$ ratio and CO2 emission factor

Fuel	$R_{H/C}$	EF_{CO2} (t CO2/t)
Diesel-oil	2.00	3.14
Petrol	1.80	3.18
LPG	2.58	3.01

Sulphur Dioxide

Following legal constrains the sulphur content of diesel oil and petrol was reduced in the 1990-2001 period. The following sulphur contents was set as data presented in next table.

Table 3.18 – Legal levels for sulphur content

	1989	1995	1996	2000	2005
Lead gasoline	0.1		0.1	-	
Unleaded Gasoline	0.1		0.05	0.015	0.005
Gas oil	0.3	0.2	0.05	0.035	0.005

Emission Factors Function of driven distance

Emission factors reported here already include cold start correction factor.

Constant Emission Factors

At present state of the inventory it is not possible to quantify the time evolution of emission factors for all diesel vehicles and for light petrol duty vehicles and two wheelers. The following emission factors, expressed in g per kilometre, were therefore used for all inventory years:

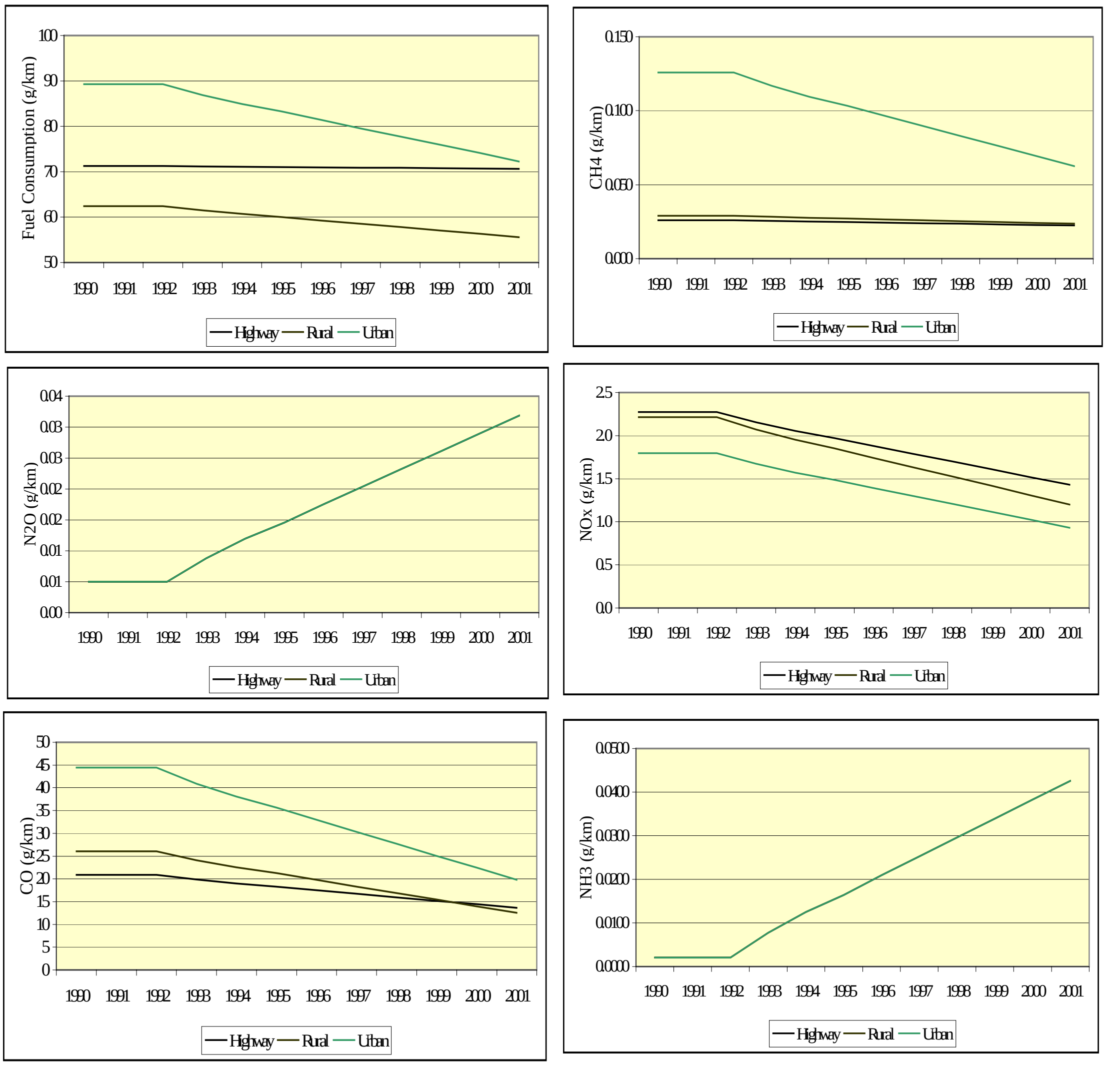
Table 3.19 – Emission factors for diesel vehicles, light petrol duty vehicles and two wheelers (in g/km)

Vehicle	Mode	Fuel	FC	CH4	N2O	NOx	CO	NMVOC	NH3	PM
	Highway		41.1	0.01	0.01	0.5	0.43	0.068	0.0010	0.19
LPV	Rural		33.9	0.01	0.01	0.4	0.53	0.097	0.0010	0.15
	Urban		56.3	0.01	0.01	0.6	0.86	0.221	0.0010	0.28
	Highway		52.4	0.01	0.02	1.3	0.67	0.149	0.0010	0.18
LDV	Rural	Diesel	55.9	0.01	0.02	1.2	0.89	0.292	0.0010	0.60
	Urban		87.3	0.01	0.02	1.6	2.23	0.470	0.0010	0.29
	Highway		174.0	0.05	0.03	9.8	4.20	1.405	0.0030	0.66
HV	Rural		200.8	0.05	0.03	11.1	7.30	1.629	0.0030	0.82
	Urban		230.3	0.13	0.03	12.5	18.80	4.145	0.0030	0.95
	Highway		63.7	0.03	0.01	3.2	16.17	1.206	0.0020	0.00
LDV	Rural		67.4	0.04	0.01	2.7	20.21	2.053	0.0020	0.00
	Urban		119.7	0.15	0.01	3.0	40.41	4.283	0.0020	0.00
2WD <50cc	R/U	Petrol	16.5	0.10	0.00	0.1	10.00	5.900	0.0010	0.00
	Highway		31.2	0.18	0.00	0.2	21.00	8.825	0.0020	0.00
2WD >50cc	Rural		31.2	0.18	0.00	0.2	21.00	8.825	0.0020	0.00
	Urban		31.2	0.18	0.00	0.2	21.00	8.825	0.0020	0.00
	Highway		65.7	0.08	0.02	0.2	12.99	0.450	0.0000	0.00
LPV	Rural		54.8	0.04	0.02	0.2	3.17	0.686	0.0000	0.00
	Urban	LPG	71.8	0.03	0.02	0.3	4.67	1.476	0.0000	0.00
	Highway		65.7	0.08	0.02	0.2	12.99	0.450	0.0000	0.00
LDV	Rural		54.8	0.04	0.02	0.2	3.17	0.686	0.0000	0.00
	Urban		71.8	0.03	0.02	0.3	4.67	1.476	0.0000	0.00
Evaporative	-	-	-	-	-	-	-	1.5	-	-

Variable Emission Factors

Emission factors for petrol light passenger cars were subjected to variations as the result of the use of new technologies, particularly the catalyst converter. Time evolution for relevant pollutants is presented in the next figures.

Figures 3.11 to 3.16 – Trends for fuel consumption and emission factors: 1990-2001



Evaporative Emissions

Emission factors EF_{vap} were set in accordance with the methodology proposed in EMEP/CORINAIR Handbook, but with small modifications so all emission factors are expressed in g/km. Parameters for the algorithms were calculated with the set of equations in table 5.32 of Copert III (Samaras et al,2000). At present no distinction is made on vehicle class and year[21], although it may be included in the methodology. It is estimated in g/km for light vehicles (LPV and LDV) as:

$$EF_{vap(c,y)} = e^{r} + 365 * (e^{d} + S^{c} + S^{fi})/V_{km(c,y)}$$

where

$EF_{vap(c,y)}$ - Emission factor for vehicle class c in year y (g/km);
e^{r} - Emission factor for hot and warm running losses (g/km);

[21] Emission factor was estimated for 1990 and LPV and applied to all other years and vehicle classes in the time series

e^d - Annual average daily emission factor for diurnal losses (g/day/vehicle). This parameter was estimated at each nut III at a monthly basis, from RVP (Reid Vapour Pressure) and t_{min} and t_{rise}; (monthly mean minimum and rise air temperature);

S^c - Annual average daily hot and warm soak emission factor of gasoline powered vehicles equipped with carburettor (g/day/vehicle);

S^{fi} - Annual average daily hot and warm soak emission factor of gasoline powered vehicles equipped with fuel injection (g/day/vehicle);

$V_{km(c,y)}$ - Annual average distance driven per vehicle of class c in year y (km/yr). It was estimated dividing total kilometres driven by the vehicle class, as obtained in the above methodology, by the number of vehicles for that class.

The following equations were used to estimate the intermediate parameters:

$$S^c = (1-q) * (p * x * e^{shot} + (1-p) * x * e^{swarm})$$

$$S^{fi} = q * e^{fi} * x$$

$$e^r = p * e^{rhot} + (1-p) * e^{rwarm}$$

and

q - fraction of gasoline powered vehicles equipped with fuel injection;

x - mean number of trips of a vehicle per day, average over the year. Estimated for each vehicle class from

$$x = Km_{veich(LDV,Gas,y)} \ / \ (365 * Ltrip)$$

p - fraction of trips finished with hot engine, which is dependent on the average monthly ambient temperature;

e^{shot} - mean emission factor for hot soak emissions (g/day/vehicle), function of fuel volatility RVP, and estimated from equation in table 5.32 of Copert III (Samaras et al,2000);

e^{swarm} - mean emission factor for cold and warm soak emissions (g/day/vehicle). This parameter is also dependent on fuel volatility RVP and average monthly ambient temperature;

e^{fi} - mean emission factor for hot and warm soak emissions of gasoline for powered vehicles equipped with fuel injection (g/day/vehicle);

e^{rhot} - average emission factor for hot running losses of gasoline powered vehicles estimated from fuel volatility RVP and average monthly ambient temperature (g/day/vehicle);

$Km_{veich(c,Gas,y)}$ - Annual average driven distance for Light Passenger Vehicles with petrol-engines (km/vehicle/yr);

Finally the emission factor for motorcycles is estimated from the emission factor for LPV but assuming that it is only 20% in the case of Motorcycles <50 cm^3 and 40% for other type of two wheelers, as proposed in EMEP/CORINAIR.

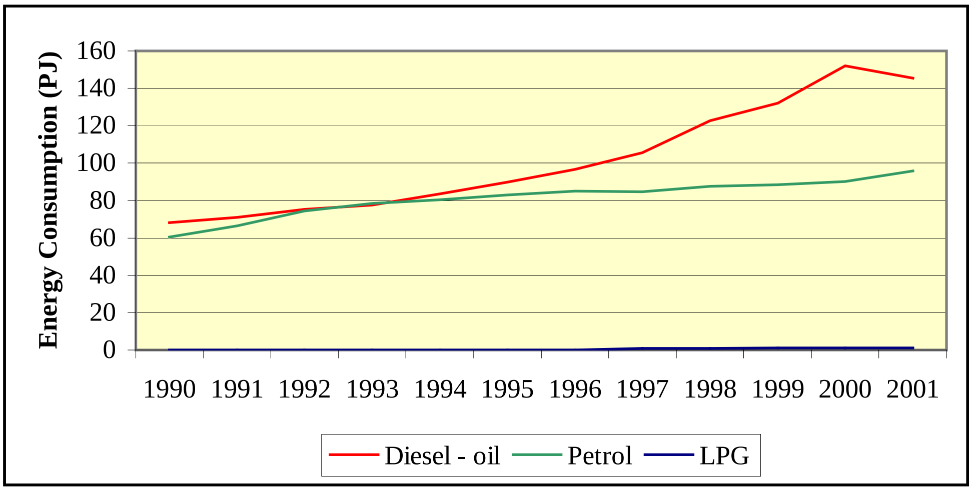
<u>Activity Data</u>

<u>*Fuel Consumption*</u>

Consumption of fuel in the road transport sector is available for the years from 1990 to 2000 from the newly revised energy balances of the national directorate-general of energy (DGE).

Consumption in 2001 is still a preliminary figure and it was forecasted from the available time series. Total consumption of petrol, diesel-oil and LPG is shown in figure 3.17.

Figure 3.17 - Consumption of fuel in the road transport sector



Original data in DGE energy balances were in energy units - tonnes oil equivalent and they were converted to mass units by the following Low Heat Values (LHV), also from DGE.

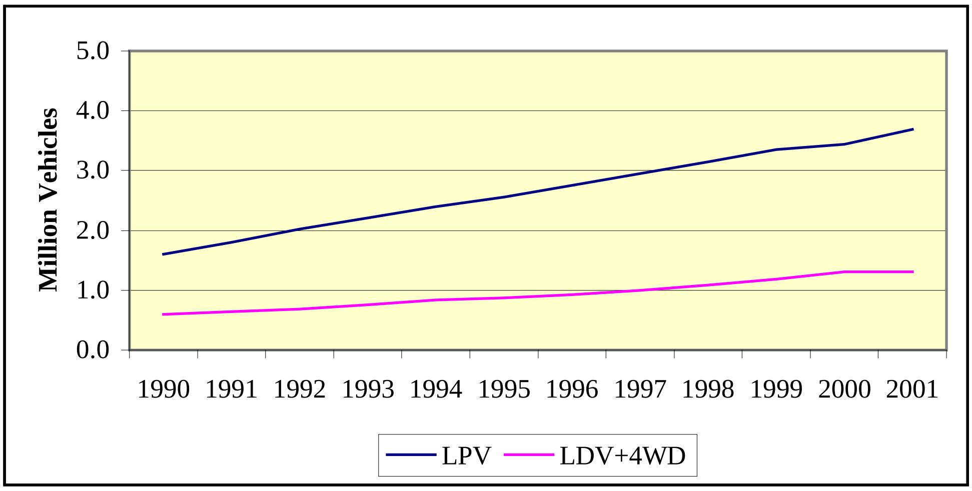
Table 3.20 – Low Heat Values (LHV) in Road Transportation

Fuel	toe/ton	MJ/kg
Diesel oil	1.035	43.31
Petrol	1.070	44.77
LPG	1.130	47.28

Vehicle Fleet

The Number of light vehicles in the 1990-2001 period were set from statistical information from a national association of vehicle commerce (Figure 3.18).

Figure 3.18 - Number of light vehicles: 1990-2001



However, the methodology used in the inventory requires the knowledge of the share of each vehicle class at an instant time of the moving fleet, and not the static fleet in existence. Fuel consumption must be split among the cars in movement incorporating the effect that some vehicle classes drive more kilometres per year than other classes. Moving fleet share of each vehicle class was determined for rural roads from information collected at traffic volume monitoring survey points under the responsibility of Portuguese Road Institute (IEP).

IEP periodically survey traffic volume in about 711 specific points distributed over national and regional roads in the portuguese territory. Information collected at this surveys distinguish light passenger vehicles (cars), light duty vehicles, heavy duty vehicles and heavy passenger vehicles (coaches). Since 1993, IEP has started the installation of automatic traffic monitoring points collecting information in a comprehensive mode during all year. The percentage of each vehicle class in the moving fleet in rural areas is presented in next table. It was obtained adding car countings in all survey points until 1995 and only from automatic survey points thereafter.

Table 3.21 - Percentage of each vehicle class in the moving fleet in rural areas

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Light Passenger	81.8	82.1	83.6	83.2	83.6	83.3	84	82	86	85	81
Light Duty	6.3	7.3	6.1	6.5	7.7	7.8	10	12	9	9	11
Heavy Duty	10.1	9.5	9.3	9.2	7.8	8.2	5	6	5	5	7
Bus & Coaches	1.7	1.1	0.9	1.2	0.9	0.7	1	1	0	0	0
2 wheelers	*	*	*	*	*	*	0.01	0.15	0.19	0.11	0.07

* Data not available

Because there similar kind of information is not available for urban areas, the same percentage of vehicle class in rural road as had to be assumed also.

Although there is extensive documentation about the Portuguese fleet concerning vehicle class, motor dimension and weight, this information it is still not reported with sufficient desegregation to be fully useful in the inventory methodology. Fleet distribution by age in 2000 is presented in figure 3.19 from ACAP (2001). The percentage of light passenger vehicles per motor size class available from (DGV,1999)[22] is shown in table 3.21.

[22] Report to Eurostat.

Figure 3.19 - Fleet distribution by age in 2000

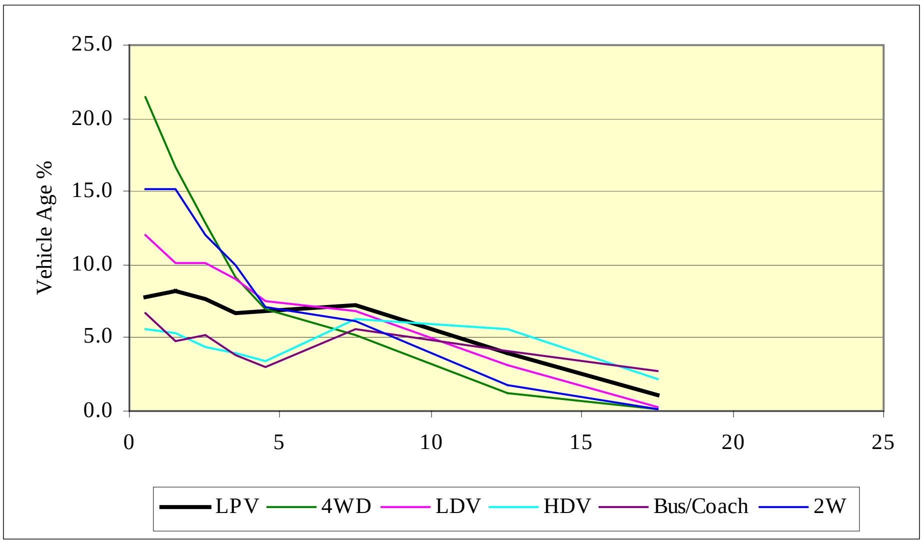
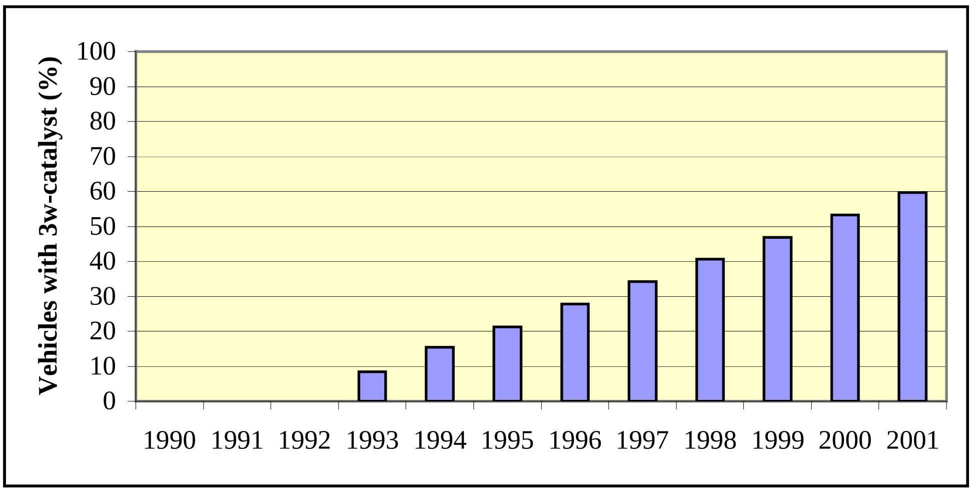


Table 3.22 - Percentage of light passenger vehicles per motor size class

Fuel	Motor size	1990	1995
Petrol	<1400	88.5	87.0
Petrol	1400-1999	10.9	12.4
Petrol	>=2000	0.6	0.6
Diesel-oil	<2000	67.3	81.0
Diesel-oil	>=2000	32.7	19.0

The percentage of light passenger vehicles fuelled by petrol and having a three way closed loop catalyst converter from 1990 to 2001 was estimated by a numeric balance of the number of cars licensed in each year, from the average fleet in that same year and assuming that excess cars are removed from the fleet. Percentage of light passenger cars over the period is reported in next figure.

Figure 3.20 - Percentage of light passenger cars



The share of vehicles using a specific fuel type was set in the following mode:

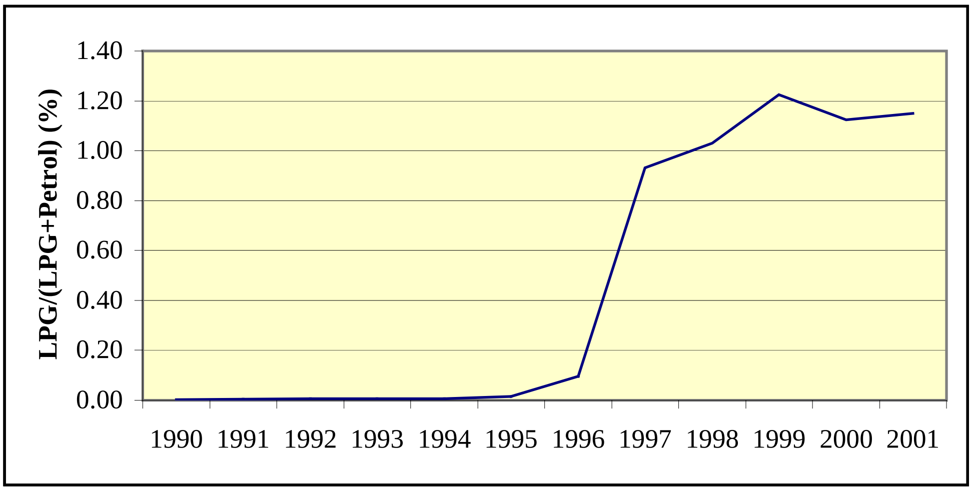
- the percentage of light passenger and light duty vehicles that use petrol or diesel oil resulted from a comprehensive survey on the database of the National Vehicle Authority (DGV) for 1992;

Table 3.23 - Percentage of light passenger and light duty vehicles that use petrol or diesel oil

Vehicle Type	Fuel type Use (%)	
	Petrol	Diesel-oil
Light Passenger	93.2	6.8
Light Duty	3.4	96.6

- all heavy vehicles, either duty vehicles or passenger vehicles, are assumed to use diesel-oil;
- the percentage of light vehicles using LPG fuel was estimated assuming that they have replaced petrol fuelled vehicles in the same percentage[23] as total fuel sales in road traffic energy sector. The percentage of LPG sales to petrol and LPG may be seen in next figure. After an initial growth in LPG use, percentage of LPG use appears to have stabilised as a small percentage of petrol.

Figure 3.21 - Percentage of LPG sales to petrol and LPG



Driving modes

Three driving modes where individualized in accordance with source categories SNAP97 and CORINAIR/EMEP methodology: Urban, Rural and Highway. The following average velocity was assumed for each driving mode which was assumed the same for all vehicle class:

[23] After conversion to comparable energy units.

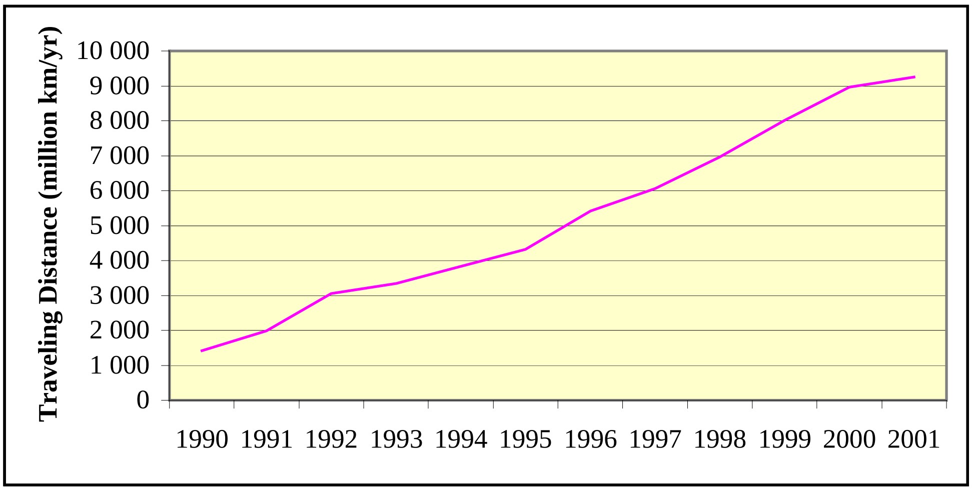
Table 3.24 - Average velocity by driving mode

Mode	Average Velocity (km/hr)
Urban	30
Rural	70
Highway	100

Highway Traffic

Total distance driven in highways was estimated by Environment Institute using the methodology already explained. Traffic data was obtained from the National Road Institute (IEP) and BRISA, the main highway commissioner in Portugal. Evolution in time of road lenght (information concerning the data when each link was set open to road traffic circulation) is from the IEP's GIS system. Total national figures have increased steadily in this period as could be seen in next figure.

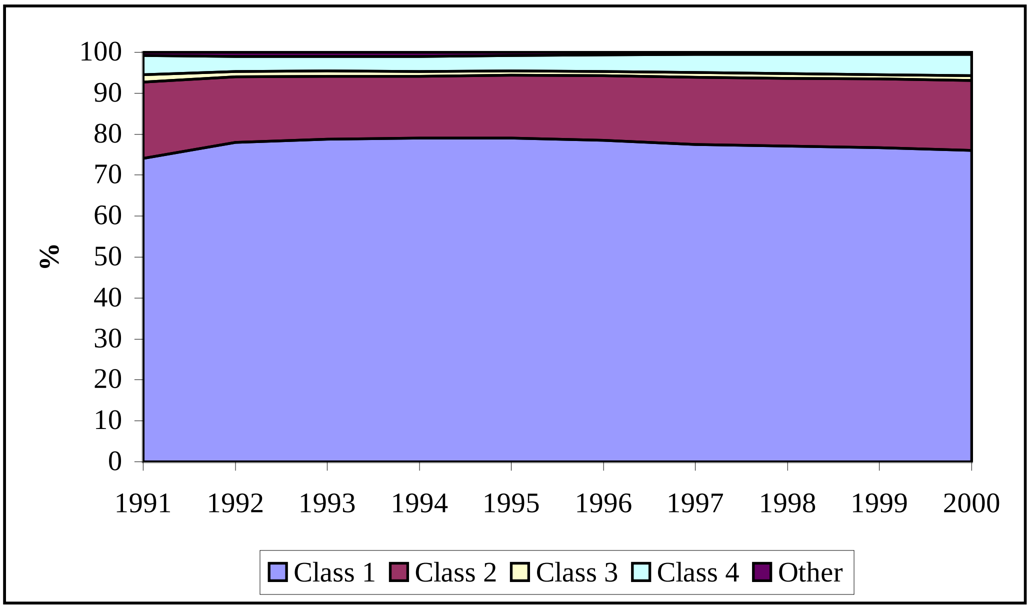
Figure 3.22 – Trends for total distance driven in highways: 1990-2001



The increase in highway circulation, which has grown 6.5 times from 1990 to 2001, reflects not only the growth of the portuguese highway road-net but also an increase in intensity of road use: highway use has grown from 18 740 km driven per available km per day in 1990 to about 25 860 km/km/day in 2001 - about 38% increase in its intensity of use.

Traffic volume in highways is classified in four classes. The share of each class in total traffic volume has not changed significantly, as may be seen in figure 3.23.

Figure 3.23 – Traffic volume in highways by class (%)



The percentage of each car type was corrected from original classes and set constant to the values presented in table 3.24. The percentage of cars that use petrol or diesel oil was assumed equal to other driving modes which was already discussed elsewhere.

Table 3.25 – Percentage of car types in moving fleet

Vehicle Class	Percentage in moving fleet
Light Passenger Vehicles	84.2
Light Duty Vehicles	3.9
Heavy Vehicles	11.54
Motorcycles >50 cc	0.34
Motorcycles <50 cc	Not allowed in highways

Urban Population

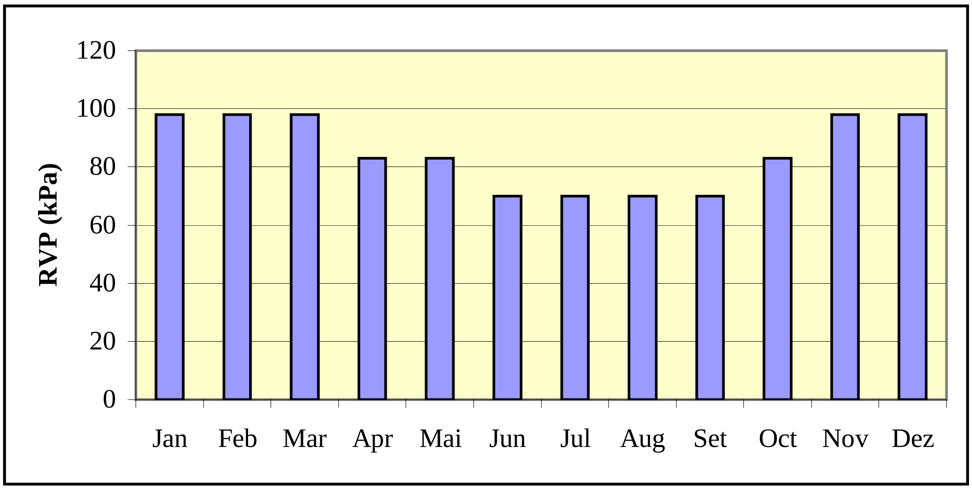
The proportion of population living in urban areas was determined at nut III level for 1991 and used as surrogate data for the percentage of road circulation in urban mode. Urban population was estimated as total population in places with over 20 000 inhabitants and was calculated using data from the 1991 population census (INE). In 1991 26 % of total population in Portugal was living in urban areas.

Cold Start and Evaporative Emissions Parameters

L_{trip}, the average trip length was set at 12 km, which results in a annual β factor of 0.267. Only about 5% of vehicles are equipped with fuel injection. It was considered, according to EMEP/CORINAIR recommendations to set w (fraction of trips finished with cold or warm engine) equal to β.

Monthly values of fuel volatility (RVP - Reid Vapour Pressure) were established from Portuguese legislation (figure 3.24).

Figure 3.24 – Legal values for RVP



Meteorological data necessary for calculus (annual average minimum temperature and maximum temperature) was received for year 1990 from IM (National Meteorological Institute) from 49 monitoring meteorological stations spread all over the country. Adequate values of annual average minimum temperature and maximum temperature were established for each nut III territorial unit from individual stations that were assumed to reflect better the meteorological conditions prevailing on that territorial unit.

Parameters for cold start evaporation and evaporative emissions were estimated for each nut III area for 1990 and a global national correction factor was obtained after weighting each individual nut III area with emissions realized at that specific territorial unit. A representative national average temperature T_a (ºC) was therefore estimated and defined as the temperature that results in the same correction factor at national level. Ta was estimated as 15.57ºC for 1990, and this value was used to make cold start emission corrections for the other years.

3.2.A.5.2 Railways

Overview

Although there has been a growing electrification of railway lines, locomotives, shunting locomotives and railcars are still responsible for substantial rail transport and consequent emission of GHG in exhaust.

Methodology

Emissions for all pollutants other than SOx are estimated with the following formula:

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

where

$\text{Emission}_{(p,y)}$ - Emission of pollutant p in year y (ton/yr);
$EF_{(f,p)}$ - Quantity of pollutant p emitted from fuel f (kg/ton);
$Cons_{Fuel(n,f,y)}$ - consumption of fuel f during in year y (ton/yr).

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

$$SO_{x\ (y)} = 2 * \Sigma_f[Fuel_{Cons(f,y)} * S_{(f,y)} * 10^{-2}]$$

where

$SO_{x\ (y)}$ - Sulphur oxide emission in year y (ton/yr);
$FuelCons_{(f,y)}$ - Consumption of fuel f in railway sector in year y (ton/yr);
$S_{(f,y)}$ - Sulphur content of fuel f (mass percentage).

Emission Factors

Emission factors, expressed in kg/ton of fuel, were obtained from available emission factors in EMEP/CORINAIR Handbook, IPCC96 and MEET project, and are presented in next table . LHV are also presented, expressed in MJ/kg.

Table 3.26 - Emission factors (in kg/ton of fuel)

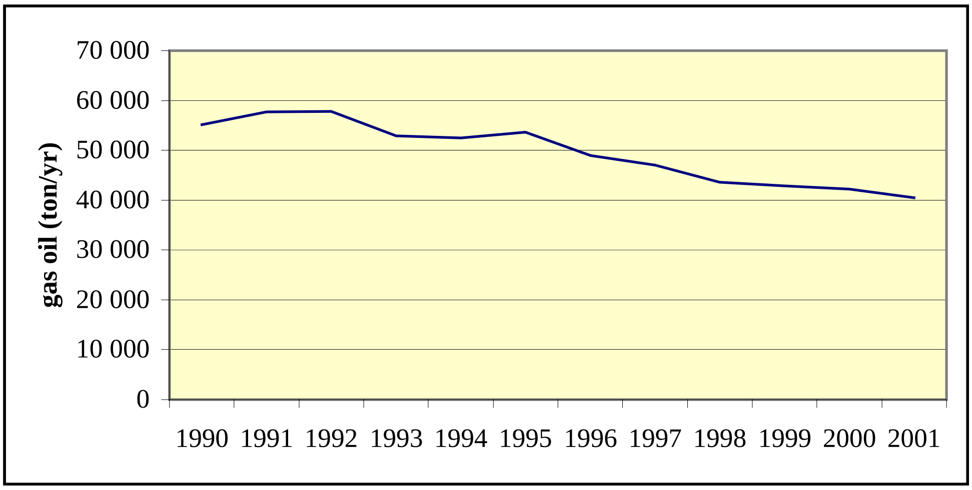
	Coal	**Coke**	**Diesel-oil**	**Fuel-oil**
LHV	29.3	28.0	43.3	40.2
NO_x	55.6	55.6	55.6	55.6
COVNM	5.1	5.1	5.1	5.1
CH_4	0.22	0.22	0.22	0.22
CO	20	20	20	20
U_{CO2}	3 168	3 168	3 168	3 168
N_2O	0.66	0.66	0.66	0.66
NH_3	0.01	0.01	0.007	0.01

Activity Data

Consumption of fuel in the railway transport sector is available by fuel type from 1990 to 2000 from General-Directorate of Energy (DGE) in the energy balance. Besides some very small use of coal and coke until 1996 the majority of combustible energy originates from gas oil[24]. The quantities that were consumed have been decreasing steadily since 1992, as can be seen in figure 3.25.

[24] Gas oil represents no less than 99.9% of total annual use of combustible energy.

Figure 3.25 - Consumption of fuel in the railway transport sector: 1990-2001



3.2.A.5.3 Water-borne Navigation and Fishing Vessels

Overview

This chapter discusses all combustion emissions resulting from fuel used as energy source to propel water-borne vessels, including ships used for transportation and fishing activities. Emissions from navigation for transport purposes is included in source sector 1.A3d - Fuel Combustion Activities in Navigation. Emissions from fishing ships and boats are discussed here because of similarities to navigation, although associated emissions are included in 1A3.c Fuel Combustion Activities in Agriculture, fisheries and forestry.

Also emissions from additional consumption in fishing industry, aquaculture or sea ports that are realized inland are not included here but under Fuel Combustion Activities, Other Sectors and are discussed in chapter 3.2.A.6. They are not discussed here but under 1.A4.

It was assumed that marine diesel engines are the main power source for ships either for transport or shipping. Small local fishing and sport ships use petrol-engines but they represent a small proportion of total consumption and for most of situations their fuel consumption can not be individualised from road traffic consumption.

Methodology

The methodology that is used is coherent with good practices and equals Tier2 approach.

Four classes of ship are differentiated, from the available activity data information: (1) National (flag) Transport navigation; (2) International Transport Navigation; (3) Coastal Fishing; (4) Deep-ocean fishing (including Cod fishing). Two fuel types are also considered: gas-oil and fuel-oil.

Emissions for all pollutants other than CO_2 and SO_x are estimated for each ship type using the following formula:

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

where

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

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

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

Emissions of carbon dioxide are estimated from:

$$U_{CO2\ (n,y)} = \Sigma_f[Cons_{Fuel(n,f,y)} * LHV_{(f)} * EF_{CO2(f)}]*10^{-3}$$

where

$U_{CO2\ (n,y)}$ - Emission of carbon dioxide in year y from ships of class n(ton/yr);

$Cons_{Fuel(n,f,y)}$ - Consumption of fuel f in year y from ship type n (ton/yr);

$LHV_{(f)}$ - Low Heating Vaue (MJkg);

$EF_{CO2\ (f)}$ - Emission factor pollutant p from fuel f combustion (kg/GJ).

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

$$SO_{x\ (n,y)} = 2 * \Sigma_f[Fuel_{Cons(n,f,y)} * S_{(f,y)} * 10^{-2}]$$

where

$SO_{x\ (n,y)}$ - Sulphur oxide emission estimated from consumption from navigation or fishing in year y from ships of class n (ton/yr);

$FuelCons_{(n,f,y)}$ - Consumption of fuel f in ship n in year y (ton/yr);

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

Emission Factors

Except for carbon dioxide and sulphur oxide, emissions was estimated using the default emission factors (kg/ton) from IPCC96 (table I-47). The following criteria was used to chose the most suitable emission factors:

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

For carbon dioxide emission factors are in kg/GJ in a similar mode to other combustion activities. Sulphur oxide emissions depend on sulphur content of fuel.

Emission factors are presented in next table.

Table 3.27 – Emission factors

EF	Units	Coastal Fisheries Gas-oil	Other Fisheries Gas-oil	Navigation Gas-oil	Coastal Fisheries Fuel-oil	Other Fisheries Fuel-oil	Navigation Fuel-oil
LHV	MJ/kg	43.31	43.31	43.31	40.17	40.17	40.17
SO_x	%	0.3	0.3	0.3	3	3	3
NO_x	g/kg	67.5	87	87	67.5	87	87
NMVOC	g/kg	4.9	4.9	4.9	4.9	4.9	4.9
CH_4	g/kg	0.23	0.23	0.23	0.23	0.23	0.23
CO	g/kg	21.3	1.9	1.9	21.3	1.9	1.9
U_{CO2}	kg/GJ	74.07	74.07	74.07	77.37	77.37	77.37
N_2O	g/kg	0.08	0.08	0.08	0.08	0.08	0.08

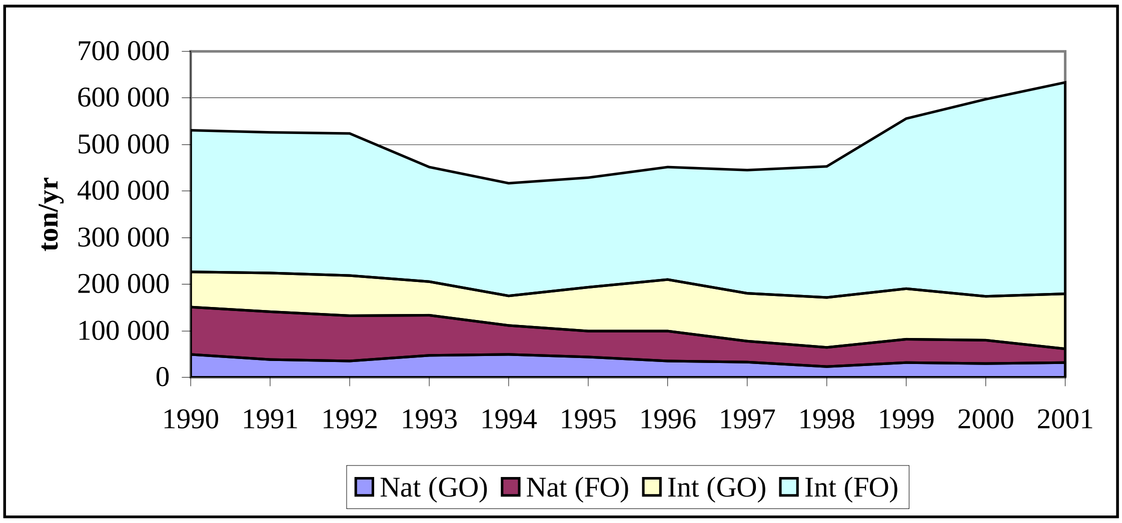
Activity Data

Fuel sales to navigation bunkers and fishing activities was used as basic activity data for both source sectors. This information was collected from the energy balances, produced under the responsibility of the General-Directorate of Energy (DGE).

Transport Navigation

Fuel consumption expressed in energy units (toe) is available from DGE, with separate entries for national navigation and international navigation[25]. Desegregated consumption of fuel-oil and diesel-oil is available annually from 1990 to 2000, which time series are represented in figure 3.26. Values for 2001 are preliminary forecasts.

Figure 3.26 - Fuel consumption by fuel and by national and international navigation: 1990-2001



More information was however available from DGE until 1998, namely it was possible to distinguish between thin-fuel-oil, thick-fuel-oil and NATO's naphtha and diesel-oil was further classified in gas-oil and diesel oil. This information was used to construct more desegregated

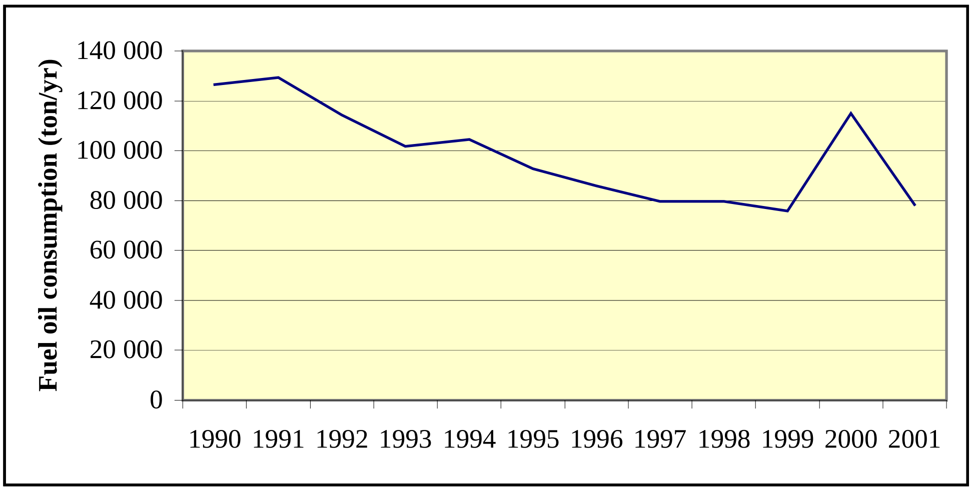
[25] Separation is by ship's flag.

time series for each one of those fuels from 1990 to 2001. For the time being, however, this additional detail has no consequences because emission factors do not distinguish between these particular fuel types.

Fishing Vessels

Total fuel consumption in fishing activities is also available from the energy balance in energy units (toe). Because information from DGE does not separate energy consumption in ships and in inland static equipments, it was assumed that the totality of diesel oil, gas oil and fuel oil were used as energy sources for ships. All other fuel types (LPG, petrol and kerosene) where used in inland combustion activities. Combustion of gas oil in fishing bunkers is present in figure 3.27[26] where values for 2001 are preliminary forecasts from IA.

Figure 3.27 – Consumption of fuel oil in fishing bunkers



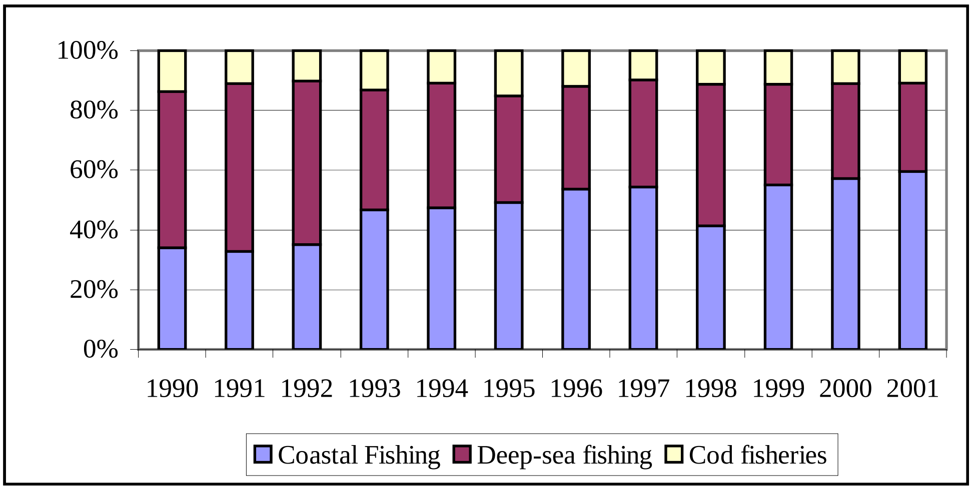
Additional information in DGE annual reports, available only until 1998, allow the division[27] of each fuel type in several different fishing activities: (1) Local coastal fishing; (2) Deep-sea fishing and (3) Cod-fish fishing vessels[28]. Percentage for each type of fisheries is presented in next figure.

[26] Use of diesel oil and fuel oil is insignificant, allways less than 2.5% of gas oil consumption.

[27] 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

[28] 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.

Figure 3.28 – Consumption of fuel by fishing type (%)



3.2.A.5.4 Aviation

Overview

Emissions from aircraft mobile combustion 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.

Although greenhouse gas emissions are independent of the place where they are realized inventories done with the aim to access local and regional air problems (such as the LRTAP convention) require the distinction between two different emissions components:

- Landing/Take-off emissions. 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 914 m (3000 feet), including ascend and descend between cruise altitude and 3000 feet.

Two fuels are usually distinguished in aircraft activity: jet fuel (JP) and aviation gasoline (AG). Jet fuel is used mostly in large commercial aircraft. Aviation gasoline is used only in small aircraft.

Separate emissions of domestic flights and international flights should be reported separately for UNFCCC, and domestic flights are define as all traffic between two airports in one country. Presently the Portuguese inventory does not follows that definition and domestic emissions are considered those realized by flight companies with Portuguese flag.

Emissions from other airborne activities, such as planes used in agriculture for pesticide spreading, helicopters and private airplanes and jets, are also included in this inventory because the fuel they consume is used to estimate emissions, although it is not possible to individualize their emission from those emissions from large commercial planes.

[29] Separation of emissions between national and international transportation it is still not clearly defined in IPCC. COFIRMAR

Methodology

The methodology that is used in the inventory is coherent with good practices and equals Tier2a approach as it is defined in equations 2.8 though 2.11 of GPG. Emissions are calculated separately for: (1) LTO and cruise; (2) Jet Fuel and Aviation Gasoline; (3) National and International company flag.

Emissions during Landing/Take-off are estimated from:

$$Emission_{LTO\ (p,y)} = EF_{LTO(p)} * LTO_{Number(y)} * 10^{-3}$$

where

$Emission_{LTO\ (p,y)}$ - Emission of pollutant p in year y during LTO movements (ton/yr);

$EF_{LTO(p)}$ - Quantity of pollutant p emitted for each LTO movement (kg/LTO);

$LTO_{Number(y)}$ - number of LTO movements realized in year y.

Total LTO emissions where separated by aircraft type and fuel using fuel consumption as surrogate data:

$$Emission_{LTO\ (n,f,p,y)} = Emission_{LTO\ (p,y)} * FC_{(n,f,y)}/FC_{TOTAL(y)}$$

where

$Emission_{LTO\ (n,fp,y)}$ - Emission of pollutant p in year y during LTO movements for airplanes using fuel f and under flag n (ton/yr);

$Emission_{LTO\ (p,y)}$ - Total emission of pollutant p in year y during LTO movements for all fuel use and flag (ton/yr);

$FC_{(n,f,y)}$ - Fuel consumption in year y realized by planes of flag n and using fuel f (ton/yr);

$FC_{TOTAL\ (y)}$ - Total fuel consumption (JP+AG) in year y (ton/yr);

Emissions during cruise are estimated from the following formula:

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

where

$Emission_{CRUISE\ (n,p,y)}$ - Emission of pollutant p in year y from cruise movement of aircraft with flag n (National/International) (ton/yr);

$EF_{CRUISE\ (n,f,p)}$ - Quantity of pollutant p emitted during cruise mode, variable with fuel type f (kg/ton);

$Cruise_{Fuel(n,f,y)}$ - consumption by airplanes of flag n of fuel f during cruise mode in year y (ton/yr).

The used methodology diverges slighthly from GPG because domestic flights are not actually differentiated from international flights and because the LTO/cruise distinction was also made to aviation gasoline.

Emission Factors

Emissions factors (kg/ton) for LTO were set from the pattern of LTO per aircraft type realized in the airports of Lisbon, Oporto and Faro in 1990, and using the emission factors for each plane type from EMEP/CORINAIR and some information from ICAO exhaust emission databank.

Table 3.28 - Emissions factors (kg/ton) for LTO per aircraft type

ID (ANA)	LTO	FC	NOx	MVOC	CH4	CO	N2O
737	38 457	2 760	7.6	2.2	0.3	11.5	0.1
BAT	15 194	4 760	17.1	28.1	3.1	46.0	0.2
727	9 696	4 218	10.9	4.7	0.5	16.8	0.1
AB3	8 782	4 310	20.3	4.4	0.5	19.8	0.2
HG7	3 708	4 760	17.1	28.1	3.1	46.0	0.2
M80	6 497	4 760	17.1	28.1	3.1	46.0	0.2
L15	5 155	4 760	17.1	28.1	3.1	46.0	0.2
100	5 094	2 340	5.7	1.2	0.2	13.0	0.1
D08	3 219	4 760	17.1	28.1	3.1	46.0	0.2
757	2 866	4 110	21.6	0.8	0.1	10.6	0.1
DC10	2 436	7 460	41.0	19.2	2.1	59.3	0.2
747	1 075	10 428	52.9	27.2	3.0	80.0	0.3
B11	1 052	2 150	4.9	61.6	6.8	67.8	0.1
767	998	5 405	26.7	3.2	0.4	20.3	0.2
F28	672	2 115	5.3	49.3	5.5	54.8	0.1
TUPOLEV	633	6 920	14.0	75.9	8.3	116.8	0.2
CRV	537	2 655	3.2	4.1	0.5	16.3	0.1
DC8	361	5 890	14.8	52.2	5.8	65.2	0.2
707	270	5 880	10.8	87.8	9.8	92.4	0.2
OUTROS	581	4 760	17.1	28.1	3.1	46.0	0.2
Total	116 545	**3 916**	**13.7**	**13.2**	**1.5**	**27.5**	**0.1**

Cruise emission factors were estimated using the default emission factors (kg/ton) from IPCC96. It is still not possible to differentiate emissions by aircraft type.

Table 3.29 – Emission factors for cruise (kg/ton)

Pollutant	AG	JP
LHV (MJ/kg)	44.77	44.56
SO_x (%)	0.04	0.04
NO_x	3.52	12.50
COVNM	24.00	0.78
CH_4	2.64	0.09
CO	1 034	5
U_{CO2}	3 172	3 149
N_2O	0.04	0.04

Activity Data

The most important activity data is fuel consumption which is available from the energy balances from 1990 to 2000 and are produced by the national General-Directorate of Energy (DGE). The energy balances differentiate total fuel consumption in air flight activity for the following categories. Domestic and international fuel use is based on company’s flag.

Table 3.30 – Fuel consumption in aviation

Flag	Fuel
National	Jet Fuel (JP)
	Aviation Gasoline (AG)
International	Jet Fuel (JP)
	Aviation Gasoline (AG)

Fuel consumption for these four classes is presented in figures 3.29 and 3.30 below.

Figure 3.29 – Aviation gasoline consumption in national and international aviation

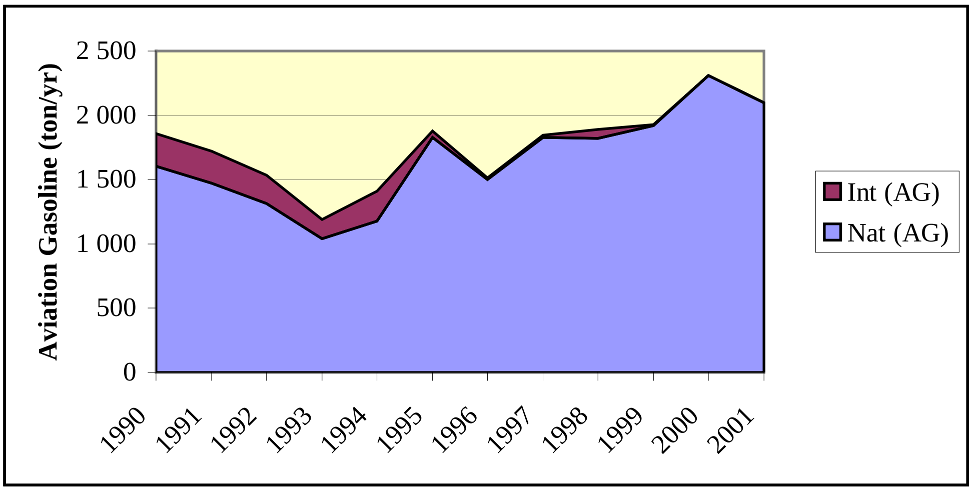
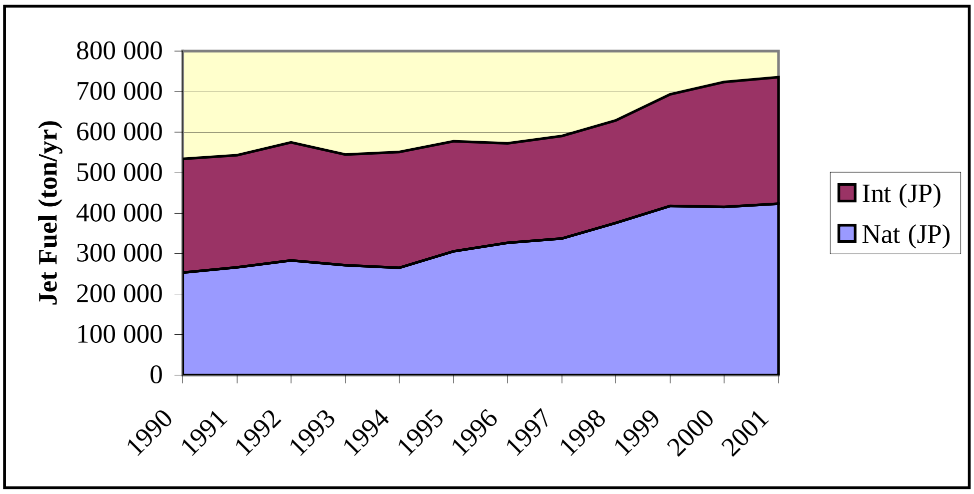


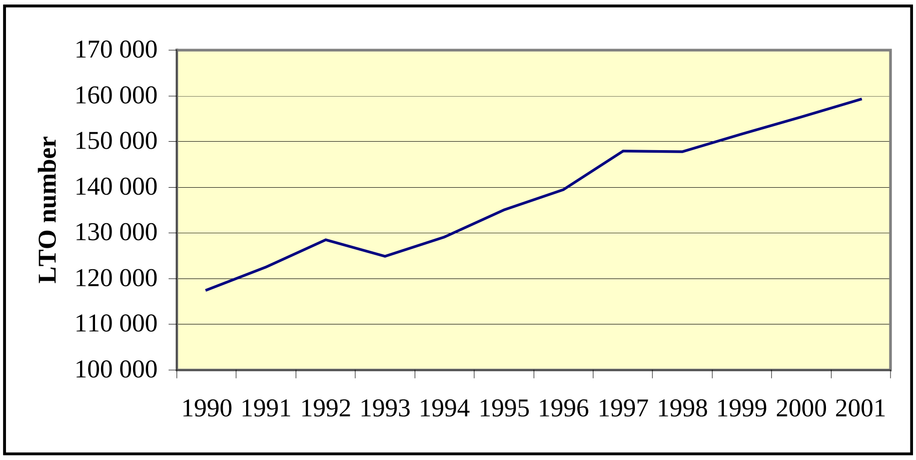
Figure 3.30 – Jet Fuel consumption in national and international aviation



The other necessary piece of activity data information is the number of Land/Take-Off movements[30]. LTO movements are available for the international airports[31] in Portugal from ANA. LTO for last two years was forecasted and will probably be revised.

[30] A LTO movement is defined as both a single landing together with a single take-off.

Figure 3.31 –Number of LTO



Finally total fuel sales ($FC_{TOTAL\ (y)}$) were deduced from fuel consumption during LTO ($FC_{LTO\ (y)}$), and consumption during cruising ($FC_{CRUISE\ (y)}$) is estimated as the remaining:

$$FC_{CRUISE\ (y)} = FC_{TOTAL\ (y)} - FC_{LTO\ (y)}$$

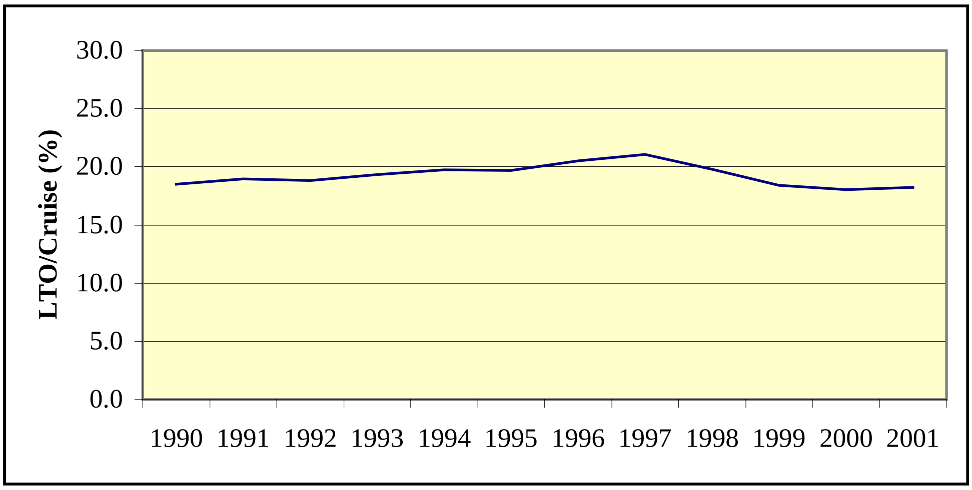
$$FC_{LTO\ (y)} = LTO_{Number(y)} * EF_{LTO(FC)} *10\text{-}3$$

where

$LTO_{Number(y)}$ - number of LTO movements realized in year y.
$EF_{LTO(FC)}$ - Fuel consumption factor (kg/LTO).

The percentage of fuel consumption in LTO mode is comparatively high in the inventory but remains approximately constant in time (figure 3.32).

Figure 3.32 – Percentage of fuel consumption in LTO



[31] Lisbon, Oporto, Faro, Funchal and Azores (Santa Maria, Ponta Delgada, Horta and Flores airports)

Fuel consumption in cruise mode[32] had to be further separated for fuel type and flag ($FC_{CRUISE\ (n,f,y)}$). The following calculation applies:

$$FC_{CRUISE\ (n,f,y)} = FC_{CRUISE\ (y)} * FC_{(n,f,y)} / \sum_n \sum_f FC_{(n,f,y)}$$

Where $FC_{(n,f,y)}$ represent fuel sales by aircraft flag f and fuel f.

3.2.A.5.5 Other Mobile Sources

Overview

There is no much information allowing estimation of emissions from off-road vehicles and machines mainly because they are not individualized in the energy balances from DGE. The only exception is the agriculture/forestry sector where it is more or less evident that all gas-oil is used as energy source to vehicles and machines.

Emissions from off-road vehicles and machines from other sectors: industry, residential, institutional and fisheries, are however quantified and included in emission totals but under activity-specific emission estimates. The fact that they are different equipments with different emission factors is also considered in the inventory because when emission factors were established for all those activities some assumptions were made concerning where the fuel was used. For instance, it was assumed that all petrol/gasoline and half of the diesel-oil was used in engines, and these may be either static or mobile.

Agriculture

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 a energy source for mobile equipements in this activity. Although emissions from mobile sources in agriculture and forestry are reported under 1A4, methodology used to estimate emissions from this activity is better presented here together with the other individualized mobile sources.

Methodology

Emissions for all pollutants other than SOx 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 (ton/yr);

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

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

[32] And also for fuel consumption under LTO mode

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

$$SO_{x\ (y)} = 2 * Fuel_{Cons(y)} * S_{(y)} * 10^{-2}$$

where

$SO_{x\ (y)}$ - Sulphur oxide emission in year y (ton/yr);

$FuelCons_{(y)}$ - Consumption of gas oil in off-road vehicles and machines in agriculture/forestry sector in year y (ton/yr);

$S_{(y)}$ - Sulphur content of gas oil (mass percentage).

Emission Factors

The set of emission factors utilized to estimate air emissions from use 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 1996 IPCC Guidelines.

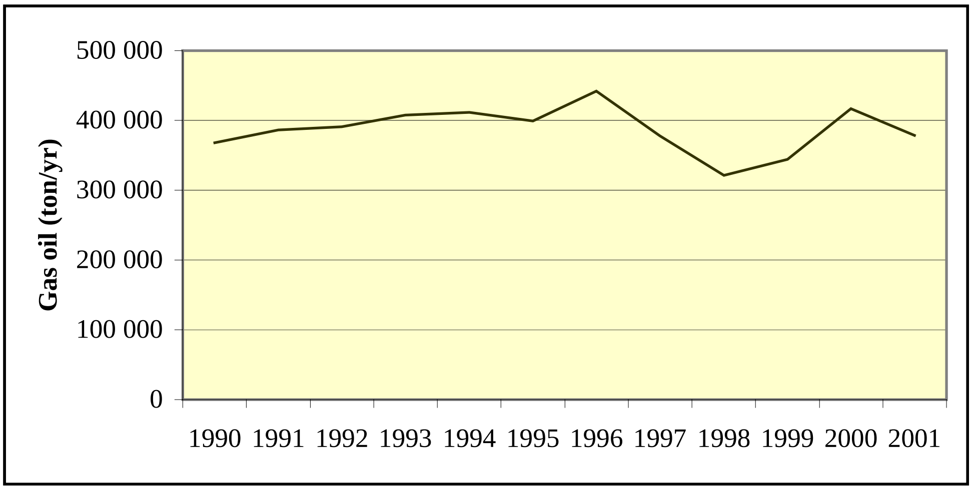
Table 3.31 –Emission factors for gas oil in agriculture machines and other off-road vehicles

Parameter	EF	Unit
LHV	43.3	MJ/kg
SOx	0.3	%
NOx	56.9	g/kg
NMVOC	8.4	g/kg
CH4	0.3	g/kg
CO	20.7	g/kg
U CO2	3 136.0	g/kg
N2O	1.3	g/kg
NH3	0.007	g/kg

Activity Data

Consumption of fuels in the agriculture and forestry sector is available from 1990 to 2000 from General-Directorate of Energy (DGE) in the energy balance. Although where each fuel is used it is not explicitly specified in the published information it was assumed that all gas-oil is used in machines and other off-road vehicles. Quantities consumed are presented in figure 3.33.

Figure 3.33 - Consumption of gas-oil in machines and other off-road vehicles



3.2.A.6 Other Sectors (CRF 1A4)

The sources covered in this category refer to residential, commercial/institutional, agriculture/forestry and fisheries (excluding bunkers) sources.

Methodology

Emissions were estimated from fuel/energy consumption using mass balance (SOx and CO2) or emission factors according to the pollutant. The emissions of SOx are directly related to the fuel content of the fuel. Emissions were estimated using Tier 2 methodology described in IPCC 96. The following basic formula was used:

$$Emissions = \sum [EF_{(f,s,t)} * Activity_{(f,s,t)}] * 10^{-3}$$

where:

Emissions - Total emissions (ton/yr except CO2 in ton);
$EF_{(f,s,t)}$ - Emission Factor (g/GJ except CO2 in kg/GJ);
$Activity_{(f,s,t)}$ - Energy Input (GJ);
f - Fuel type;
s - Sector-activity;
t - Technology type.

Emissions of SOx are directly related to the fuel content of the fuel. The following equation applies:

$$SOx = 2 * \sum [S_{(f,s,t)} /100 * Fuel_{Consumptio}n_{(f,s,t)}]$$

where:

Emissions - Total emissions of SOx (ton/yr);

S $_{(f,s,t)}$- Sulphur content of fuel (%);

Fuel$_{Consumption\ (f,s,t)}$ - For each particular fuel (ton/yr);

f - Fuel type;

s - Sector-activity;

t - Technology type.

The total emission for this sub/sector is the sum of different activities, using diverse fuels and combustion technologies.

Activity data

Data on fuel consumption were obtained from the annual energy balances compiled by DGE, presented in the following tables.

Table 3.32 - Fuels consumed in residential sector

	NAPFUE	Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	1 582	1 546	1 383	1 281	1 660	1 060	1 078	1 003	272	97	65	65
L	204	Gas oil	ton	3 653	4 868	6 593	4 734	4 394	4 640	3 062	2 122	2 447	3 330	2 088	2 014
L	205	Diesel oil	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	206	Kerosene	ton	18 145	17 223	14 319	12 133	11 750	8 138	9 511	16 657	17 416	16 130	8 355	11 586
L	208	Motor gasoline	ton	138	174	132	126	140	214	307	333	328	136	17	17
L	303	LPG	ton	483 026	508 837	543 161	575 925	584 924	590 959	638 059	618 453	651 193	689 517	707 191	724 977
L	308	Refinery gas	k m3	122 615	124 287	126 475	132 125	126 476	123 003	126 011	126 933	134 228	129 977	77 303	77 303
S	102	Steam coal	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	105	Brown coal/lignite	ton	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	ton	0	0	0	0	0	0	0	876	9 918	37 276	78 974	97 174
B	111	Biomass wood	ton	4 283 750	4 090 420	3 952 383	3 864 901	3 824 057	3 826 667	3 837 778	3 850 000	3 816 667	3 766 667	3 750 000	3 708 333
B	112	Biomass charcoal	ton	29 873	29 429	28 984	28 540	28 095	27 651	27 206	26 762	26 317	25 873	25 428	24 984

Table 3.33 - Fuels consumed in commercial/institutional sector

	NAPFUE	Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	58 889	51 571	49 216	51 199	91 138	106 164	82 018	33 176	63 677	75 195	81 240	102 249
L	204	Gas oil	ton	130 054	159 551	191 049	194 870	198 238	182 017	201 353	302 401	385 767	423 476	424 423	435 557
L	205	Diesel oil	ton	98	86	33	27	32	36	25	41	23	0	0	0
L	206	Kerosene	ton	1 703	760	1 465	1 686	557	307	288	333	487	329	98	98
L	207	Jet Fuel	ton	30 146	33 739	25 266	23 881	26 642	25 758	32 995	31 698	33 047	25 272	30 014	29 540
L	208	Motor gasoline	ton	12 938	14 257	13 788	13 507	23 138	26 226	31 682	57 899	72 826	71 854	49 497	72 745
L	303	LPG	ton	24 668	28 286	32 540	39 077	38 523	26 111	52 753	78 996	81 070	87 105	90 888	96 694
L	308	Refinery gas	k m3	0	0	0	0	0	0	0	0	0	0	0	0
S	102	Steam coal	ton	0	0	0	0	0	0	0	0	0	0	0	0
S	105	Brown coal/lignite	ton	0	0	0	0	0	0	0	0	0	0	0	0
G	301	Natural gas	ton	32 147	35 485	33 656	41 032	41 291	46 704	50 063	49 576	57 930	66 543	46 668	61 673
B	111	Biomass wood	ton	0	0	0	0	0	0	0	0	0	0	0	0

Table 3.34 - Fuels consumed in agriculture/forestry (excluding mobile sources)

Equipment		NAPFUE	Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Boilers cogeneration	L	203	Residual oil	ton	0	0	0	0	130	6 490	6 297	7 091	6 976	6 904	14 098	11 965
Boilers non cogener.	L	203	Residual oil	ton	13 053	9 360	7 124	8 551	12 014	4 161	6 459	6 554	4 868	9 996	8 104	6 103
Boilers	L	206	Kerosene	ton	8 008	7 110	6 221	4 751	4 594	4 369	4 192	9 760	11 292	552	1 015	3 640
Boilers	L	208	Motor gasoline	ton	751	796	1 058	1 003	3 008	2 894	3 631	4 410	3 893	3 566	954	3 889
Boilers	L	303	LPG	ton	6 972	8 569	10 124	12 173	12 276	12 100	17 479	11 840	15 089	14 260	10 503	13 298
Boilers non cogener.	G	301	Natural gas	ton	0	0	0	0	0	0	0	0	1	4	121	162
-	B	309	Biogas	m3	1 659 919	1 659 919	1 659 919	1 659 919	1 659 919	1 659 919	1 659 919	1 659 919	1 659 919	1 659 919	1 659 919	1 659 919

Gas biogas: data refer to 1994

Table 3.35 - Fuels consumed in fisheries (excluding consumption in fishing vessels)

	NAPFUE	Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
L	203	Residual oil	ton	100	134	186	227	133	293	124	219	155	269	34	127
L	204	Gas oil	ton	147	129	142	94	23	392	37	3 485	12 449	11 861	17 938	12 238
L	205	Diesel oil	ton	0	0	0	0	0	0	0	0	0	0	0	0
L	206	Kerosene	ton	0	0	0	0	0	0	0	0	61	1 713	230	1 087
L	208	Motor gasoline	ton	31	0	5	2	6	16	22	16	90	1 375	6 231	8 707
L	303	LPG	ton	60	122	86	32	45	0	2	82	53	178	440	443

Emission Factors

The emission factors were taken from international sources:

- EMEP/CORINAIR (3rd revision);
- 1996 IPCC Guidelines;
- US EPAP-42 and EIIP.

Table 3.36– Emissions factors: domestic sector

	NAPFUE	Fuel	PCI		SOx	NOx	COVNM	CH4	CO	CO2	N2O
			unit		%	g/GJ	g/GJ	g/GJ	g/GJ	kg/GJ	g/GJ
L	203	Residual oil	MJ/Kg	40.17	3	160	3	5.1	20	77.4	0.14
L	204	Gas oil	MJ/Kg	43.31	0.3	577.5	51	5.0	40	74.1	1.55
L	205	Diesel oil	MJ/Kg	43.31	0.3	55	2	5.5	40	74.1	0.6
L	206	Kerosene	MJ/Kg	43.72	0.15	55	51	5.0	40	71.9	1.55
L	208	Motor gasoline	MJ/Kg	44.77	0.1	1 300	100	9.9	40	69.3	0.6
L	303	LPG	MJ/Kg	47.28	0.0016	65	2.5	1.5	250	63.1	1.4
L	308	Refinery gas	MJ/Nm3	15.69	0	65	2.5	1.5	250	60.0	1.4
S	102	Steam coal	MJ/Kg	29.29	1	150	200	200	4 800	94.6	0.7
S	105	Brown coal/lignite	MJ/Kg	17.16	1	150	200	200	4 800	96.1	0.7
G	301	Natural gas	MJ/Kg	42.6	0.0059	40	2.5	2.5	14	56.1	
B	111	Biomass wood	MJ/Kg	12.55	0	67	400	300	5 000	109.6	4.3
B	112	Biomass charcoal	MJ/Kg	25.10	0	67	400	300	5 000	109.6	4.3

Table 3.37– Emissions factors: commercial/institutional, agriculture/forestry and fisheries (excluding fuel use in ship vessels)

	NAPFUE	Fuel	PCI		SOx	NOx	COVNM	CH4	CO	CO2	N2O
			unit		%	g/GJ	g/GJ	g/GJ	g/GJ	kg/GJ	g/GJ
L	203	Residual oil	MJ/Kg	40.17	3	160	3	1.6	20	77.4	0.6
L	204	Gas oil	MJ/Kg	43.31	0.3	580	50.5	5.0	20	74.1	0.6
L	205	Diesel oil	MJ/Kg	43.31	0.3	60	1	0.6	20	74.1	0.6
L	206	Kerosene	MJ/Kg	43.72	0.15	60	50.5	5.0	20	71.9	0.6
L	207	Jet Fuel	MJ/Kg	44.56	0.1	1300	100	9.9	20	71.5	0.6
L	208	Motor gasoline	MJ/Kg	44.77	0.1	1300	100	9.9	20	69.3	0.6
L	303	LPG	MJ/Kg	47.28	0.0016	65	2.5	1.5	50	63.1	1.4
L	308	Refinery gas	MJ/Nm3	15.69	0	65	2.5	1.5	50	60.0	1.4
S	102	Steam coal	MJ/Kg	29.29	1	150	200	86	200	94.6	0.7
S	105	Brown coal/lignite	MJ/Kg	17.16	1	150	200	86	200	96.1	0.7
G	301	Natural gas	MJ/Kg	42.6	0.0059	48	10	1.2	20	56.1	1.4
B	111	Biomass wood	MJ/Kg	12.55	0	67	400	15	500	109.6	4.3
B	309	Biogas	MJ/m3	34.7	0	65	2.5	0.72	17	52.0	1.4

3.2.B. Fugitive Emissions from Fossil Fuels

3.2.B.1 Fugitive Emissions from Solid Fuels (CRF 1B1a)

Coal Mining and Handling

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. Emissions at open cast mines are usually lower and result from coal mobilization and blasting operations. 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 there was extraction of coal at only two coal mines in Portugal, but they where 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 Portugal. Coal from these mines it is classified as a 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). One mine - *Pejão* - is an underground mine and the other is an open cast 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, as it is recognized in GPG. Because no methodology is available to calculate present day flux from abandoned mines - which would require knowledge of all abandoned mines, not only *Pejão* and *S. Pedro da Cova* - no estimates are included in the inventory.

Methodology

Emission estimates include both emissions occurring during extraction of coal as well as those resulting from its processing.

A simple tier 1 approach was used to estimate emissions, which is sufficient due to scarcity of technical information about these mines and because this emission source is no key source and has small relevance. The following equation is similar to the methodology proposed in IPCC96:

$$Emi_{CH4} = [(EF_U^{ex} + EF_U^{post}) * Coal_U + (EF_S^{ex} + EF_S^{post}) * Coal_S] * 0.67 * 10^{-3}$$

where

Emi_{CH4} - Methane emissions in year y (ton);

$Coal_U$, $Coal_S$ - quantity of coal extracted from underground mines and open cast/surface mines, respectively (ton/yr);

EF_U^{ex} - emission factor for extraction emissions in underground mining (m^3/ton);

EF_U^{post} - emission factor for post-extraction emissions in underground mining (m^3/ton);

EF_S^{ex} - emission factor for extraction emissions in surface mining (m^3/ton);

EF_S^{post} - emission factor for post-extraction emissions in surface mining (m^3/ton);

0.67 is the conversion factor, the density of methane at 20ºC and at atmospheric pressure (kg/m^3).

<u>Emission Factors</u>

Although it is known that high rank coals contain usually more methane than lower rank coals such as lignite, average emission factors from IPCC96 defaults were used for both mines, which are presented in next table. The same emission factor range was maintained in GPG.

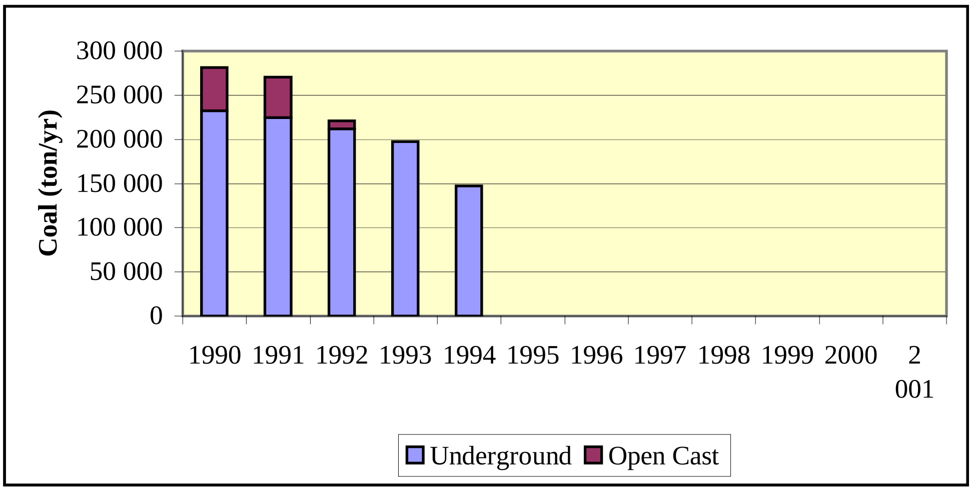
Table 3.38 – Emission Factors

Mine	Type of Emission	Emission Factor	Value (m^3/ton)
Underground	Extraction	EF_U^{ex}	11.73
	Post-mining	EF_U^{post}	1.64
Open cast	Extraction	EF_S^{ex}	0.77
	Post-mining	EF_S^{post}	0.07

<u>Activity data</u>

The quantity of extracted coal was always more expressive in the underground mine but nevertheless has decreased as a whole towards the final closure of both mines in 1994, as may be seen in next figure. Statistical information is from annual energy reports from General-Directorate of Energy (DGE).

Figure 3.34 – Quantities of coal extracted from mines



3.2.B.2 Fugitive Emissions from Oil Production and Refining

<u>Overview/ sectors</u>

There is no oil extraction and production in Portugal. Fugitive emissions comprehend only those resulting from refining, storage and transport of crude oil, other raw materials, intermediate products and final products, particularly gasoline, until 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 : (1) flaring and venting in oil refining; (2) emissions due to storage of raw materials, intermediate products and final products in the refinery;
- emissions from refinery dispatch station;
- emissions from the country transport and distribution system, including transport depots and service stations.

Transport of Crude/ Marine Terminals

Overview

Emissions from this source are mainly volatile organic compounds, including methane, that escape to atmosphere during transport of crude oil to refineries for processing. The three oil refineries that existed in Portugal during the 1990-2001 period where all located at a small distance from the coast. Crude oil is received near refineries by sea tankers and transported directly to each refinery by small connecting pipelines. Most of emissions from crude oil transportation occur at tank downloading.

Methodology

Emissions of methane and non-methane volatile organic compounds where estimated from:

$$Emission = Crude_{InFlow} * EF * 10^{-6}$$

where

Emission - of methane or NMVOC (ton/yr);

$Crude_{InFlow}$ - is total crude oil received at each refinery plant for processing (ton/yr);

EF - emission factor for methane or NMVOC (g/ton crude oil).

Emissions of VOC will ultimately be oxidized in atmosphere and contribute to ultimate carbon dioxide, which estimates are also included in the inventory. Emissions of ultimate carbon dioxide result from conversion of carbon in NMVOC and CH4:

$$Emi_{CO2U} = 44/12 * (Emi_{NMVOC} * 0.85 + Emi_{CH4} * 12/16)$$

Emission Factors

Emission factors for NMVOC and CH4 are those reported in next table and where set from COCAWE, US-EPA (AP-42) and IPCC96.

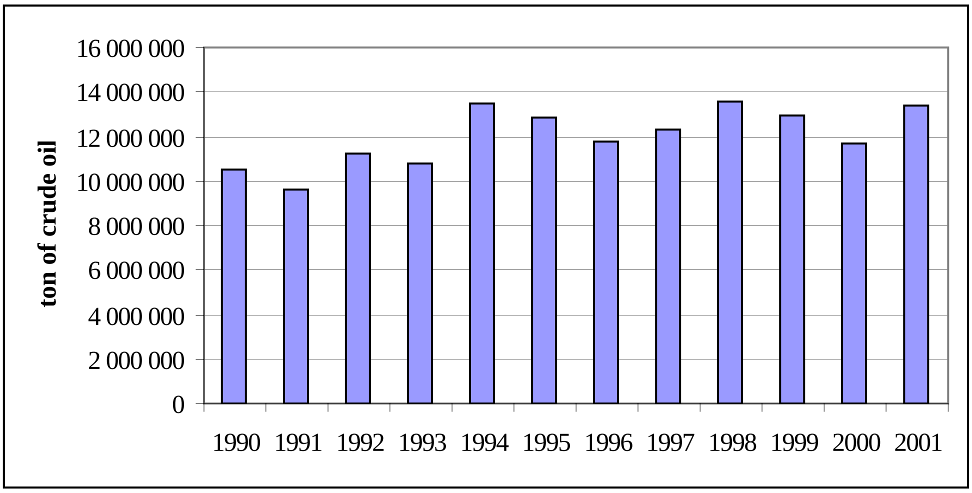
Table 3.39 – Emission Factors

Component	Emission Factor (g/ton crude oil)
NMVOC	300
CH_4	60 (2500 kg CH_4/PJ)
Ultimate CO_2	1 100

<u>Activity data</u>

Quantity of crude oil entered to the Portuguese refining system is available from energy balances from General-Directorate of Energy (DGE), and have increased unsteadily since 1990, as may be seen in next figure.

Figure 3.35 – Total imports of crude oil: 1990-2001



Refining and Storage

<u>Overview</u>

In 1990 there were three oil refining plants in Portugal, located in Oporto, Lisbon and Sines. After 1993, the Lisbon unit was closed for most 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 may be classified as:

- Separation process of crude separate individual constituents in 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: (1) Cracking - Chemical transformation of separated fractions breaking molecules of heavy molecular height into smaller ones, including visbreaking; (2) Polymerisation of small molecules combined in bigger molecules with different characteristics. Alkylation has similar objectives and (3) chemical transformations that change molecular structure such as Isomerization, reforming and asphalt blowing;
- Treatment processes. Operations which include hydrodesulfurization, hydrotreating, chemical sweetening, acid gas removal, deasphaltating 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 being considered part of the refining process.

Methodology

Process Operations

As a general rule air emissions from refining operations where estimated from:

$$Emission_{(p,r)} = ActivityRate * EF_{(p,r)} * 10^{-6}$$

where

Emission (p,r) - annual emissions of pollutant p occurring from refining operation r (ton/yr);

ActivityRate - is a suitable activity indicator, specific of each pollutant and refining operation (ton/yr);

EF (p,r)- emission factor for a particular pollutant p and a specific refining operation (g/ton).

Total crude use was used as activity data to estimate process emissions other than for Fluid Catalytic Converter, where total feed consumption was used.

Storage and Tanks

Detailed information is still not available to estimate emissions for each specific storage tank existing at each refinery unit. Therefore, total emissions of NMVOV (ton/yr) are estimated using an emission factor (EF in g/ton) and relying in total crude oil processed (ton/yr) as indicator of activity.

$$Emission_{NMVOC} = EF * Crude * 10^{-6}$$

Sulphur Recovery

Sulphur oxide emissions in tail gas that are not recovered in Claus units were set by the following mode:

- Estimate total sulphur in refinery feed, multiplying each inflow material by its sulphur content;
- quantity of sulphur recovered in Claus units and efficiency, for year know to be working in good conditions, allows estimation of sulphur emitted as tail gas and not recovered;
- emissions of sulphur oxides are finally estimated from the difference between total sulphur in tail gas less the quantity that is actually recovered in the Claus unit for each plant.

Ultimate Carbon Dioxide Emissions

All carbon in emitted compounds, such as CO, NMVOC and methane, has fossil origin and must be included in ultimate emissions inventory. Individual pollutants (ton/yr) are converted into ultimate CO_2 (kton/yr) from:

$$U_{CO2} = 44/12 * (0.85 * NMVOC + 12/16 * CH_4 + 12/28 * CO) * 10^{-3}$$

Emission Factors

Operation Processes

The following emission factors (kg/ton) where used to FCC and other emission processes. FCC emission factors are from IPCC96 while NMVOC emission factor for other processes is still from Corinair90 Emission Factor Handbook. Original emission factors were expressed in kg/m^3 refinery feed, and where converted to kg/ton of feed assuming a density of 0.85 kg/L.

Table 3.40 – Emission Factors

Pollutant	FCC	Process
SOx	0.68	0
NOx	0.04	
CO	0.07	
NMVOV		0.9
CH4		0.1

Storage/ Tanks

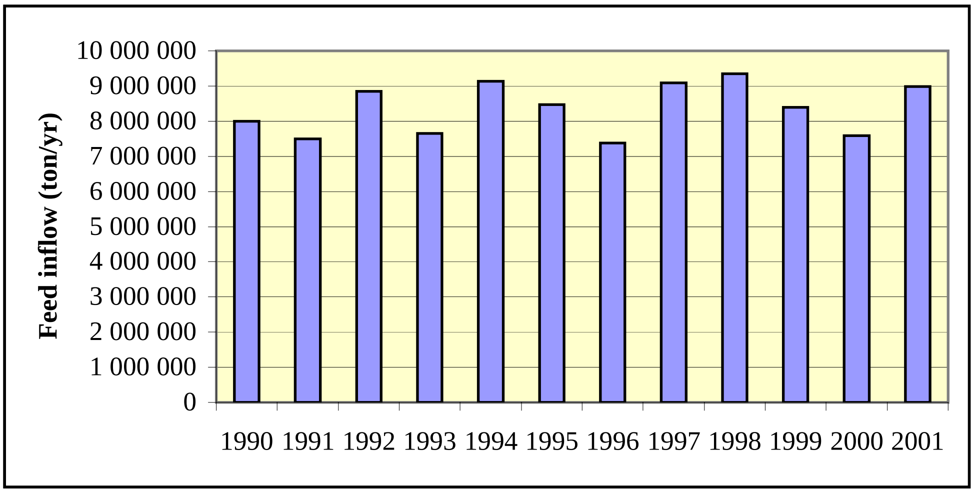
An emission factor of 2790 g/ton of crude was set from US-EPA (in EMEP/CORINAIR) and assuming that half of tanks are with fixed roof and half with floating roof.

Activity data

Activity data to estimate storage emissions and process emissions is total crude oil processed and was already presented in "Transport of Crude" (Figure 3.35).

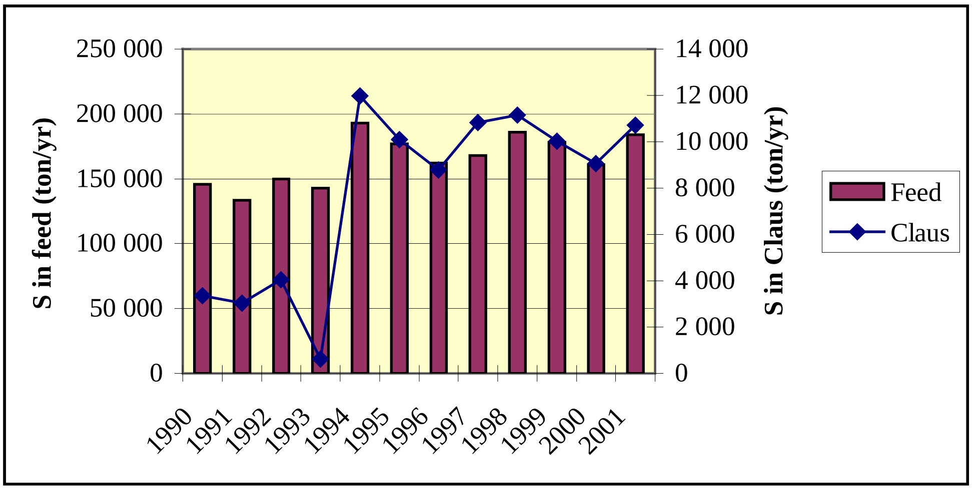
For FCC, activity data refers to total material (feed) entered in Lisbon and Sines refinery units only. This information is available from Energy Balances (DGE) until 1998, and was forecasted to latter years from previous ratio between feed and crude inflow into refineries. Final time series is again presented in next figure.

Figure 3.36 – Total material (feed) entered in Lisbon and Sines refineries: 1990-2001



Total sulphur in refinery feed could be estimated from information collected for each refinery units from 1991 to 1994, and projections were made for the remaining years. Time series of total sulphur inflow and recovered in Claus units is presented in next figure.

Figure 3.37 – Total sulphur inflow and recovered in Claus



Distribution of Oil Products

<u>Overview</u>

This sub-source sector include 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 equipments - trucks, rail cars - when dispatching products of the refining unit. Most emissions occur when light products it high level of volatile compounds are dispatched;

(2) Transport and Depots, occurring in storage tanks not in the refineries and widespread in 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.

<u>Methodology</u>

Emissions of NMVOC, in tonnes per year, are estimated from the application of emission factors (EF in g/ton) to total quantities mobilized (ActivityRate in ton/yr):

$$Emission_{NMVOC} = EF * ActivityRate * 10^{-6}$$

The specific activity data/ Indicator to which the emission factor is multiplied differs with emission source:

Emission	Activity Rate Indicator
Terminal Dispatch Station	Total Gasoline/Petrol Output from Refinery to internal market and exportation
Transport and Depots	Total Gasoline/Petrol Output from Refinery to internal market and exportation
Service Stations	Total Gasoline/Petrol Output from Refinery to internal market

Ultimate carbon dioxide emissions, also in ton/yr, are calculated assuming that emitted VOC have on average 85% of carbon:

$$Emi_{CO2} = 0.85 * Emi_{NMVOC}$$

Emission Factors

Emission Factors for NMVOC, corresponding to those proposed in the simpler methodology of EMEP/CORINAIR, which result from CONCAWE studies, are reported in next table.

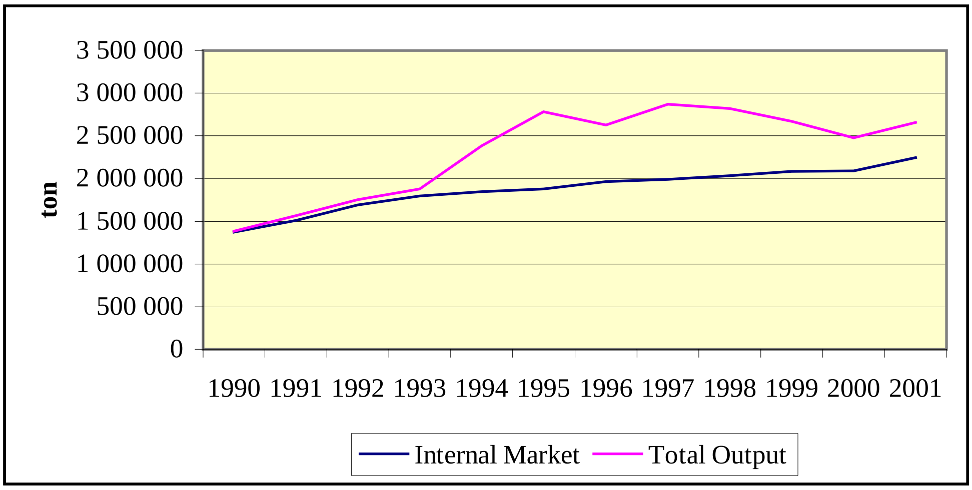
Table 3.41 – Emission Factors

Sub-source category	Emission Factor (g /ton)
Refinery Dispatch Station	310
Transport and Depots	740
Service Stations	2 880

Activity data

Activity data, in accordance to what was already defined in the methodology, for the years 1990 to 2000 is from the energy balances of the General-Directorate of Energy (DGE). Values for 2001 are preliminary forecasts. Total gasoline output for internal market and exportation is presented in the figure below.

Figure 3.38 – Gasoline consumption in the internal markect and gasoline expotation



Venting and Flaring in Oil Industry

Overview

In the three refineries in Portugal, flares were used to control and burn non-condensable gases recovered from leakages and blow down operations, that would otherwise be emitted as volatile organic compounds. Although smokeless and complete combustion is always an objective, sometimes the gas influx exceeds flare combustion capacity and partly unburned organic compounds are emitted: NMVOC, CH_4 and CO.

Methodology

Air emissions in flaring, resulting from combustion, where estimated applying emission factors to total refinery feed processing, according to methodology in AP-42 (US-EPA, 1995). The following formulation applies:

$$Emission_{(p)} = Feed_{InFlow} * EF_{(pol)} * 10^{-6}$$

where

Emission (p) - of pollutant p (ton/yr);

FeedInFlow - is total feed, including, crude oil, received at all refinery plants for processing (ton/yr);

EF (p) - emission factor for pollutant p (g/ton feed).

All carbon emitted in compounds, such as CO, NMVOC and methane, has fossil origin and must be included in ultimate emissions inventory. Individual pollutants (end of pipe carbon dioxide, NMVOC, methane and carbon monoxide) are converted into ultimate CO2 from:

$$U_{CO2} = EndofPipe_{CO2} + 44/12 * (0.85 * NMVOC + 12/16 * CH_4 + 12/28 * CO) * 10^{-3}$$

Emission Factors

Emission factors where set from US-EPA (1995). Original emission factors were expressed in kg/m3 refinery feed, and where converted to kg/ton of feed assuming a density of 0.85 kg/L.

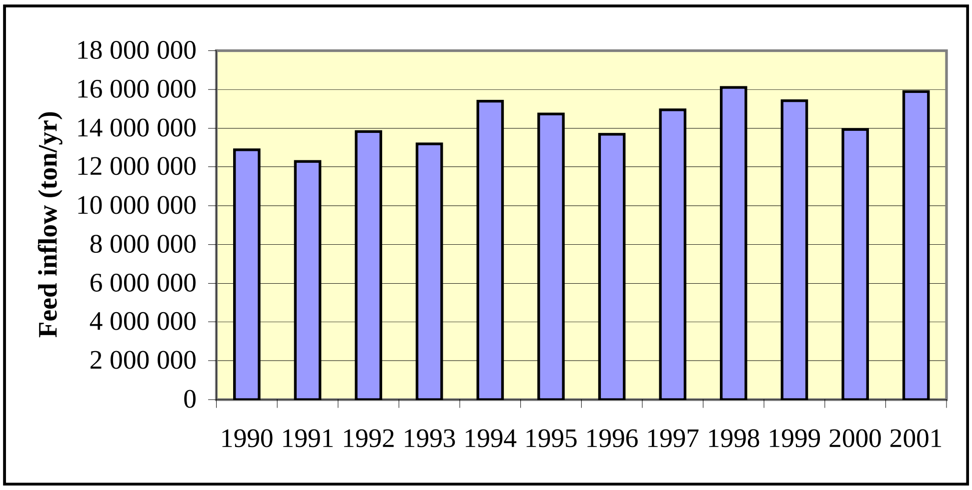
Table 3.42 – Emission Factors

Pollutant	EF (g/103 L)
SO_x	77.0
NO_x	54.0
COV	2.0
COVNM	1.6
CH_4	0.4
CO	12.0

Activity data

Activity data refers to total material (feed) entered in refinery units for processing and not only crude oil. This information is available from Energy Balances (DGE) until 1998, and was forecast to latter years from previous ratio between feed and crude inflow into refineries. Final time series is replicated in next figure .

Figure 3.39 – Total material (feed) entered in refinery units



3.2.B.3 Fugitive Emissions from Natural Gas

Overview

The use of natural gas in Portugal was initiated only in 1997 (DGE) when 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. There is however no production of natural gas in Portugal. All the gas is imported and received in pipelines from Spain or in shipping transport from Algeria as Liquefied Natural Gas (LNG). There are also no major processing operations in Portugal.

Natural gas pipelines may be classified in two different sub-goups:

- 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 both for industrial consumers, services and domestic users.

Methane emissions from natural gas result mostly from leaks of unmodified natural gas. Although they happen as result of maintenance operations or abnormal accident situations (pressure surges due to failure of equipment that controls pressure), they occur constantly also as 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.

Methodology

Presently emissions of methane from natural gas transport and distribution are estimated from production data using a tier1 approach based on total energy consumed in the country. Emissions are associated to each specific consumer of natural gas:

$$Emission_{CH4\ (S)}\ (ton/yr) = NG_{Cons(S)} * EF * 10^{-6}$$

where

$NG_{Cons(S)}$ - Total quantity of natural gas consumed in a year in economic activity S (GJ);
EF - Emission factor (g/GJ).

Emission Factors

The value of 100 g CH4/GJ was used in emission estimates for all natural gas consumption in Portugal in all economic sectors. This value was set temporarily from available information from US-EPA and from information displayed in IPCC96 (GASA,1999). Actual emission factor does not result from a specific source but reflects the order of dimension of available emission factors, being aware that national inventory only considers transport and distribution. Because no default IPCC emission factors are available and because GPG proposes emission factors based on line length (km) and not gas consumed, and that information was not available for the time being the same emission factor was used.

Table 3.43 –Net Calorific Value and Emission Factor

Fuel	NCV	EF CH4
	MJ/Kg	g/GJ
Natural gas	42.6	100

Activity data

Emissions were estimated for total natural gas consumed, but specific emissions were attributed for each end-user activity consuming this fuel. Natural gas consumed for each activity is presented in next figure.

Table 3.44 – Natural gas consumed by each sector

Sectors	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Domestic	ton	0	0	0	0	0	0	0	876	9 918	37 276	78 974	97 174
Services/Commercial	ton	32 147	35 485	33 656	41 032	41 291	46 704	50 063	49 576	57 930	66 543	46 668	61 673
Agriculture	ton	0	0	0	0	0	0	0	0	1	4	121	162
Fisheries	ton												
Construction and public works	ton	0	0	0	0	0	0	0	0	17	74	209	293
TOTAL	ton	32 147	35 485	33 656	41 032	41 291	46 704	50 063	50 452	67 866	103 898	125 972	159 302

3.3 Recalculations

In the end of 2002 General-Directorate of Energy (DGE) and the Environment Institute (IA) have agreed upon the need of common energy statistical information (Energy balances for Eurostat and GHG inventories for UNFCCC) and also that an harmonized procedure should be used by both institutions. A more detailed energy balance was also found to be necessary. A comprehensive study was made by DGE (2003) and consequently energy balances were revised for all years from 1990 to 2000[33].

Energy Sector and Industry

Combustion in the energy sector together with combustion in industry have been subjected to substantial changes due to modifications in the energy balance. In energy balances done for previous years the energy combustion done in all sectors - including energy sector - was lumped together in a class named *Primary Energy Consumption for Thermo-electricity*, which was in disagreement with IPCC reporting guidelines: combustion in the same industry sector

[33] As a general rule comments do not apply to year 2000. Changes for emission year 2000 are mostly explained by the fact that in submission 2002, statistical information for 2000 was still preliminary.

was split in two categories. Worst than that, each individual economic sector could not be individualized and had to be guessed in the lumped electric-production category. This also lead to further problems because it was difficult to subtract fuel consumption, as received from LCP units, in order to avoid double counting. This was a source of uncertainty and error in the inventory.

For all those reasons DGE has decided to report consumption in thermo-electricity production with more detail in energy balances. A separate entrance was made to dedicated electric power plants and co-generation was considered apart and disaggregated by the economic sector where it is realized. Co-generation in auto-producers is also separated from other sources.

Energy balances were also improved and they consider now the fact that during feedstock processing some sub-products are used as energy sources, such as petrochemical gas. Although this change makes energy balances more comparable to activity data in the inventory, no changes arose in the inventory because this energy use was already accounted in the inventory from information received directly from large industries.

Construction Industry

Fuel consumption in construction public building was also split between co-generation and other combustion. Some changes have been made for all fuel types, some of them substantial but not affecting base year (1990).

Mobile Sources and Bunkers

Apart from year 2000 (that was reported in submission 2002 as preliminary data) only minor corrections were made for specific years and fuels in the time series of fuel consumption in aviation. The changes have not affected base year (1990).

Energy consumption in navigation sector was also corrected, particularly some previous mistakes in energy balances for 1998. Smaller corrections for the other years of time series were made but they do not affect total energy consumption in this sector more than 2.5 % for all years.

Finally in what concerns railways, diesel-oil consumption in 1998 and 1999 was revised downward about 8%. Again energy consumption in base year (1990) has not changed.

Domestic Sector

The main modification results from the review of activity data for consumption of *Wood and vegetable residues* in the domestic sector. Up to now, in energy balances, consumption of this fuel type in the domestic sector has been estimated from information of firewood sales. It was realized however that in Portugal not all wood consumption goes through market but there is a certain quantity that is directly collected in forests, woodlands and even cultivated fields and that is latter consumed at households. Because energy balances were made basically from statistical information on sales this quantity was not included. However although this was a source of discrepancy between energy balances from DGE and energy activity data from IA, in fact this modification had small impact in emission inventories because the inventory was already aware of this problem and this situation was already subjected to correction in the activity data used in previous submissions of the GHG emission inventory - and that correction was made according to recommendations from DGE experts.

Nevertheless previous corrections by IA and new values from DGE do not match. Values considered now in energy balances are lower than values assumed in last year's GHG emission submission (IA) up to 1998. After 1998 - where there was a exact match - values in DGE energy balances are higher up to 5.1% than activity data in 2002 submission. The corrected time series for wood consumption in the domestic sector made by IA until submission 2002, was totally abandoned in the inventory and DGE estimates were entered directly as activity data.

The new energy balance brought also small changes for activity data for LPG, and new estimates are now somehow higher up to 24% from previous values. Small use of fuel-oil, gas-oil and gasoline where added to this sector and consumption of kerosene was revised. However all consumption of this fuel types added together is less than 0.5% of all energy consumption and the changes made in the energy balance have no effect in GHG emission estimates.

Services

In a similar way that was done to transformation industry the new energy balance now separates combustion in co-generation processes and non co-generation processes. This split has lesser consequences for this sector because co-generation represents only a smaller proportion of natural gas use in this sector (13%) and occurring only after 1999.

The revision of energy balances lead also to substantial changes in the quantities of fuel allocated to this source sector:

- substantial decrease of LPG until 1996 (up to 58 %) and increase thereafter (up to 22%);
- very substantial increase in gas-oil (which has doubled in 1991, 1993 and 1998) and also increase in gasoline for most years. Increase in gas-oil consumption had the major impact in energy balance for this sector;
- substantial decrease in kerosene consumption over all time series, although this fuel has lesser importance;
- lesser and irregular changes in fuel-oil consumption. Although evolution scheme is different from previous energy balances the values for 1990 and 2000 are more or less maintained.

Refinery gas was wrongly included in natural gas for this sector in submission 2003. This situation which was only detected after CRF submission reflects only an allocation error and will be corrected in next submission.

Fishing

Apart for the correction of some incorrect values for years 1998 and 1999 changes in total energy consumption have not changed more than 1 %.

Agriculture, Forestry

Non mobile sources

The revision of energy balances has resulted in substantial increase in energy consumption in this sector, including base year (1990), mainly for kerosene.

Machines and Other Mobile Sources in Agriculture

During the nineties there was in Portugal an unconventional use of agriculture gas oil in private road vehicles that has distorted energy balances in the sense that consumption in agriculture mobile sources were over-estimated. Being aware of that situation and supported by technical advice from DGE, the Environment Institute had corrected the original time series by removal of a fixed percentage of diesel-oil sales to agriculture.

The new energy balances now available also correct that situation but with more detailed information based on information provided by the ministry of Agriculture, as well as on data on recent direct sales of coloured gas-oil to agricultural activities (DGE,2003). Use of gas-oil in agriculture is now estimated to be higher than previous values corrected by IA.

This change in fuel allocation does not change overall carbon dioxide emissions but affects emissions of other pollutants that are dependent on particular combustion equipments and emission factors.

Emission factors

Emission estimates were also recalculated. It was felt necessary to review carbon dioxide emission factors because some inconsistencies were detected and also because sometimes CO_2 emission factors were entered as ultimate carbon dioxide and others as end-of-pipe. In the revision process several sources of information were collected (IPCC, EMEP/CORINAIR and AP42 from US-EPA). The following modifications were more notorious:

- fuel-oil emission factor was revised upward from 19.8 kg C/GJ to 21.1 kg C/GJ;
- carbon dioxide emission factor for LPG, petrol/gasoline, aviation gasoline, jet-fuel, and kerosene were all changed to slightly lower values, and gas -oil and diesel-oil for higher values but these changes were less than 3 %;
- emission factor for high energy coal (sub-bituminous coal) in industry was revised upward, from 25.3 kg C to 26.2 kg C.

Some errors were corrected for other pollutants:

- Emission factor for N2O from wood combustion in domestic sector was corrected from 29 g/GJ to 4.3 g/GJ;
- emission factors for CH4 and NMVOC were interchanged by mistake in calculation of emissions from water-borne navigation;

Some NCV were also revised: NCV for Jet-fuel was increased about 4%, from 43.1 MJ/kg up to 44.6 MJ/kg.

3.4 Further Improvements

A better integration between the Air Inventory and other surveys such as LCP directive, *Auto-controlo* program and own surveys made annually by DGE it was considered necessary and contacts are being made to implement it.

Plans are ahead to revise the methodology for road traffic with a deeper insight in vehicle classes. The following actions are planned:

- update of data concerning fleet composition and establishing of reliable time series for most important parameters;
- estimate of emissions for the more detailed vehicle category split similar to table 1.1 of the EMEP/CORINAIR Handbook with a further division of Heavy Vehicles in Heavy Duty Vehicles and Buses and Coaches;
- improvement in vehicle age classes and its incorporation in emission factors determination: ECE standards and Euro Copert classes and following legal emission levels;
- improvement of the knowledge of motor volume classes for light vehicles and weight for heavy duty vehicles;
- review of average velocities per driving mode;
- consideration of annual distance driven per vehicle from Inspection centres;
- incorporation of traffic monitoring data recorded in rural roads to estimate traffic emissions under rural driving mode and to improve specialisation of emissions;

- methodology to estimate emissions from a small consumption of natural gas and diesel oil mixture with vegetable oil that has been used after 2000;
- update of meteorological data for each emission year;
- removal of the adjustment step;
- incorporation of factors in emission factors calculation such as vehicle aging and maintenance;
- incorporation of regional and local emission estimates.

These modifications will affect mostly emissions of such pollutants as NO_x, NMVOC, CO and PM, will have less implications in CH_4 and N_2O and will have no implications in total national carbon dioxide emissions.

Presently water-borne navigation emissions are not disaggregated in adequate categories to answer UNFCCC and LRTAP conventions, and efforts are going to be made to separate emissions realized in the EMEP area from international sea traffic for domestic and international flag ships and to separate emissions from international transportation[34].

A similar situation applies to aviation emissions. The present inventory does not fulfil fully IPCC requirements concerning the separation of domestic from international flight. Domestic flights should concern only emissions resulting from flights internal to the country, (i.e. departure and arrival are in the same country) and not, as it is done in the Portuguese inventory, emissions from flight companies with Portuguese flag. There is a strong believe that domestic flights represent a lesser fraction of emissions resulting from national flag companies. A clear distinction between national flag emissions and domestic flights will be done from flight registry. A effort will be made to differentiate between emissions of large commercial flights and local emissions resulting from small airplanes, private jets and helicopters. It must also be made clearer if emissions from military aircraft are or are not included in energy balance -and emissions - under aviation. Emission factors from LTO movements could be improved using actual database records of airport movements, using specific durations for idle, taxi, take-off, for the individual airports considered and being aware of airplane age. This will improve methodology toward an Tier2b approach and will make LTO emission factors to evolve over time, although emission estimates for base year (1990) will be not much affected.

Emission estimates from refinery sector will be revised in detail, with application of more recent methodologies and emission factors and collecting more detailed and specific information from each refinery. A specific inquiry was initiated concerning inventory and characterization of storage tanks in Portuguese refineries and it is planned to estimate emissions according to a more detailed methodology like TANKS from USEPA.

Inventory of methane emissions and other gases from natural gas transport and distribution may be enhanced substantially in the future towards a tier 2 or a tier3 approach.

[34] Separation of emissions between national and international transportation it is still not clearly defined in IPCC. COFIRMAR

CHAPTER 4: INDUSTRIAL PROCESSES (CRF SECTOR 2)

4.1 Overview

Industrial activities not related to energy result also in GHG emissions. In transformation processes, where raw materials are chemically or physically transformed, many different GHG can be released, such as CO_2, CH_4 and N_2O. Some industrial sources also produce NO_x, NMVOC, CO and SO_x.

Fluorinated compounds (HFC, PFC and SF_6) are consumed in industrial processes or used in different applications as substitutes to ozone depleting substances (ODS). They have also been considered in the inventory under this sector although some occur associated with domestic and services activity.

4.2 Category Sources

4.2.1 Mineral Industry (CRF 2A)

4.2.1.1 Cement Production

Overview

There are six cement production plants in Portugal, almost all installed in the southern halve of the country and mostly dedicated to Portland cement production[35]. There are also two additional cement plants, but that do not produce clinker but only cement. Five of the clinker producing units are based on the dry process while the remaining one uses both the wet and the semi-wet process - although the wet process is prevalent. All dry process units have short kilns with pre-heaters, except in one case where there is also a pre-calciner.

Portland cement is broadly a mixture of clinker and gypsum with some minor additives. Cement production is basically a pyro-processing operation on calcium carbonate, aluminium-siliceous and iron-oxide materials to form a mixture of calcium silicates, aluminates and aluminoferrites that forms a binder with water.

Carbon dioxide emissions from cement production result from the conversion of $CaCO_3$, the main constituent of limestone, to lime (CaO), while leaving CO_2 as by product to atmosphere. Sulphur oxides emissions result from sulphur existence both in fuel and in some constituent materials such as clay. However contrary to what occurs with CO_2, usually most of the SO_x that is formed during calcination will be absorbed and long term immobilized in clinker and then in cement.

Methodology

In cement production combustion occurs in ovens and there is a close contact between product and combustion materials in reaction. Consequently, resulting emissions from this industrial process can be established neither from fuel characteristics alone neither only from characteristics of raw materials, and emissions reflect the interactive effect of both. Different situations apply to different pollutants however. For instance, while carbon dioxide result from oxidation of carbon content in fuel and rock carbonates and emissions of this pollutant may be known from total carbon in both fuel and raw materials, for sulphur oxides and also heavy metals, part of sulphur that exists in fuel or mineral raw material may be chemically bound to final cement compounds and not emitted to atmosphere. Therefore an important guideline rules

[35] There is also some production of white Portland cement, which has lower iron and manganese contents than grey cement and is used primarily for decorative purposes (EPA, 1995)

methodologies used to estimate emissions in cement manufacture[36]: except for carbon dioxide, emissions must be calculated from emission factors, whenever possible preferably as a function of cement/clinker production and function of technology conditions. Emissions from this source were established in the following mode:

Carbon Dioxide emissions

Separate emissions are estimated from carbon originally present in fuel and carbon present in raw materials, although they are in fact emitted at same place and are inseparable in concept.

CO_2 from carbon in fuel was estimated from fuel consumption for each fuel type and emissions of this kind were already included under source sector A2 - Energy Combustion in Industry, and are discussed in chapter 4.2.1.1.

Emissions of carbon dioxide resulting from carbon in raw materials are determined according to equation 3.1 of GPG, which is basically a mass balance:

$$Emi_{CO2\ (y)} = EF_{Clinker} * Prod_{CLINKER\ (y)} * CKD * 10^{-6}$$

where

$Emi_{CO2\ (y)}$ - emissions of CO2 from cement production, originated from carbon in mineral constituent materials (kton/yr);

$EF_{Clinker}$ - emission factor (kg/ton clinker);

$Prod_{CLINKER\ (y)}$ - Total production of clinker (ton/yr);

CKD - Cement Kiln Dust correction factor, accounting to the fact that some part of calcinated raw materials and clinker collected at stack air emission control equipment can not be returned to process and are not included in clinker. But because this material include calcinated constituents it must be included in mass balance accounts and correct activity data in clinker units.

Pollutants emission estimated from cement or clinker production

For SO_x and NH_3 emissions are calculated from clinker production only (Tier 2):

$$Emi_{(p,y)} = EF_{(p)} * Prod_{CLINKER\ (y)} * 10^{-3}$$

where

$Emi_{(p,y)}$ = emission of pollutant p in year y (tonyr);

$EF_{(p)}$ - Emission factor (kg/ton clinker produced);

$Prod_{CLINKER\ (y)}$ - Annual production of clinker (ton/yr);

Pollutants emission estimated from fuel consumption

Emissions of NO_x, NMVOC, CO and N_2O are estimated from energy consumption, as described in chapter 4.2.1.1 about source sector 1A2 - Energy in Industry.

[36] Assuming that there are no available direct monitoring at stack.

Emission Factors

Carbon Dioxide

According to GPG (equation 3.3), the emission factor for CO_2 is:

$$EF_{Clinker} = 0.785 * Ratio_{CaO}$$

where $Ratio_{CaO}$ is the Calcium oxide (lime) content of clinker (kg CaO/ kg clinker). The default IPCC CaO fraction in clinker was considered in the inventory (64.5%). Final emission factor is therefore 0.507 ton CO_2/ ton clinker.

Other Parameters

Emission factors for the following parameters were set from US-EPA AP42 and EMEP/CORINAIR Handbook.

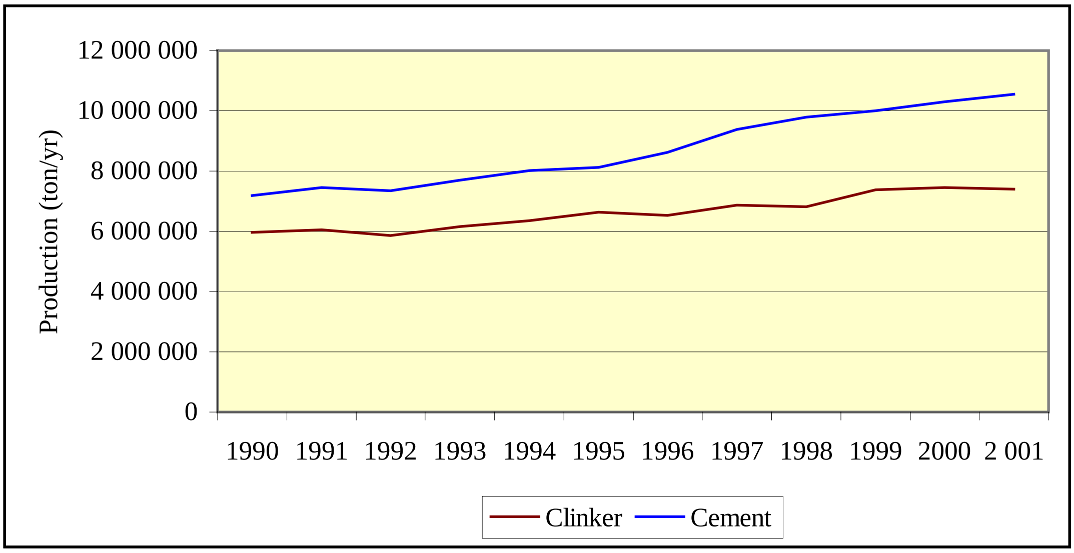
Table 4.1 - Emission Factors for Cement Production

Parameter	EF	Unit
SO_x	0.5	Kg/ton clinker
NH_3	5.1	g/ton clinker

Activity Data

Time series of cement and clinker production are available from information collected by the National Statistical Institute INE from 1990 to 2000. Information for year 2001 is still provisional and it was forecasted at IA. Evolution of cement production and clinker may be observed in next figure. There is an apparent reduction in clinker content of final cement product, from 83% in 1990 to 72% in year 2000, which does not corresponds to changes in cement composition.

Figure 4.1 - Production of clinker and cement



Because no information is available about parameter CKD, this parameter is still not considered in this inventory and clinker production is not corrected.

Recalculations

Small changes took place since submission of last year due to the revision of cement and clinker production data from INE database.

Further Improvements

A review of methodology will be done for next submission in order to remove emission duplication between this activity and emissions reported as combustion in cement industry sector.

Information collected recently will allow a plant-specific determination of CaO/clinker content. Also, monitoring data collected at industry plants and a deeper insight into technology and abatement equipment specific to each industry plant will be used to ameliorate emission estimates particularly for NOx.

4.2.1.2 Lime Production and other Limestone and Dolomite Use

Overview

Carbon dioxide is emitted in several industrial activities that use limestone (CaCO3), dolomite rock ($CaCO_3.MgCO_3$) and carbonates, but only when original materials are not incorporated as inert components but suffer a chemical removal of carbon, as for example when calcium carbonate is added to nitric acid to form calcium nitrate.

Lime products may presented in several forms:

- Calcium oxide, lime, quicklime: CaO. It is produced by heating CaCO3 to high temperatures (900-1200ºC). It is used in building, agriculture and chemical processes (manufacture of Na2CO3, NAOH, steel, refractory material, SO2 absorption, CaC2, glass, pulp and paper, sugar and ore concentration and refining. It is also used in waste and water treatment;
- Calcium Hydroxide, slaked 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). It is also called dead lime or burned lime;
- Hydraulic lime.

In some situations emissions of lime use were estimated inside industrial sectors, such as paper pulp production or iron and steel production. These emissions are estimated after sector specific activity data and emission factors, and hence for those situations methodologies, activity data and emission factors are discussed under each industrial sector.

Methodology

CO_2 emissions are estimated from the quantification of carbon in original raw materials, and making a mass balance for the quantities of CO_2 that are liberated in the conversion process. Therefore emissions are estimated from consumption of carbonate materials:

$$Emi_{CO2\ (y)} = 44/12 * Mat_{Carb\ (m,y)} * C_{content\ (m)} * 10^{-3}$$

where

$Emi_{CO2\ (y)}$ - emission of carbon dioxide in year y (kton/yr);
Mat_{Carb} (m,y) - consumption of carbonate containing material m in year y (ton/yr);
$C_{content\ (m)}$ - carbon content of material m consumed in year y (ton C/ton).

Emission Factors

Carbon content of materials consumed in Portugal was set from molecular stechiometry[37]:

Table 4.2 - Carbon content in carbonate materials

Material	Ccontent
Limestone	0.31
Sodium Carbonate	0.42
Calcium Carbonate	0.31

Activity Data

Consumption of mineral carbonaceous materials, other than those already quantified in the paper pulp industry and iron industry, were set from statistical information from INE for 1990 and 1991 and thereafter the average value for those two years was considered.

Table 4.3 - Consumption of carbonate materials in industry

Material	Consumption (ton/yr)		
	1990	1991	1992 - 2001
Limestone	24 658	26 501	25 580
Sodium Carbonate	13 563	12 134	12 849
Calcium Carbonate	127 945	104 941	116 443

Recalculations

No changes have been made in estimates of emissions from this sector since last inventory submission.

Further Improvements

An improvement in the time series of activity data must be performed extending them beyond 1991. Because some industrial activities might not report carbonate consumption use of these materials and completion of activity data will be checked from national producers and import/export correction. Finally care must be made to avoid double counting of emissions that may be already included in other industrial sectors.

[37] It was assumed that limestone was totally pure, which causes over-estimated emissions.

4.2.1.3. Road Paving with Asphalt

Overview

Roads pavement with asphalt consists of the application in the road surface of a mixture of compacted aggregated and an asphalt or bitumen binder.

In the case that liquefied asphalts are applied, NMVOC emissions result from evaporation of part of the solvent additive that was used to make bitumen more fluid. Emissions depend on the quantity of distillate that is used as liquefier and on its VOC content. Cutback asphalts result in major emissions while emulsified asphalts, in which case water is used as fluidiser, result in less NMVOC.

Hot mix asphalts do not result in so important NMVOC emission during asphalt application because solvents are a minor component, and emissions result mostly from combustion gases escaping from the drier.

Methodology

Due to scarce information concerning application of asphalts in Portugal, apart from that reported in energy balances, and following US-EPA and CORINAIR/EMEP recommendations for default emissions estimates when not detailed information is available, it was assumed that all asphalt is cutback asphalt that is liquefied by mixture with petroleum distillate, or kerosene.

Non methane emissions of volatile organic compounds from liquefied asphalt are dependent on the quantity of distillate that is added to bitumen and on the rapidity of the curing process. The following formulation was used to estimate emissions from this source, and was derived from US-EPA AP-42:

$$Emi_{NMVOC\ (y)} = Cure_{FC} * d_{dil} * (1-Dil_{FAC})^{-1} * Dil_{FAC} * Bin_{(y)} * d_{Bin}^{-1}$$

where

$Emi_{NMVOC\ (y)}$ - Emissions of NMVOC from asphalt application during year y (ton/yr);

$Bin_{(y)}$ - Total quantity of bitumen or asphalt binder used in road paving during year y (ton/yr);

Dil_{Fac} - Fraction of distillate in final asphalt mixture during pavement application (kgkg);

d_{Dill} - density of distillate used as liquefier (kg/l);

d_{Bin} - density of bitumen (kg/l);

$Cure_{FC}$ - Factor dependent on cure, expressing the percentage of total distillate that evaporates as emission (l/l).

Ultimate carbon dioxide emissions are calculated assuming that emitted VOC have on average 85% of carbon:

$$Emi_{CO2} = 0.85 * Emi_{NMVOC}$$

Emission Factors

The following parameters were chosen to determine emission factors, according to values recomended in AP-42 and EMEP/CORINAIR:

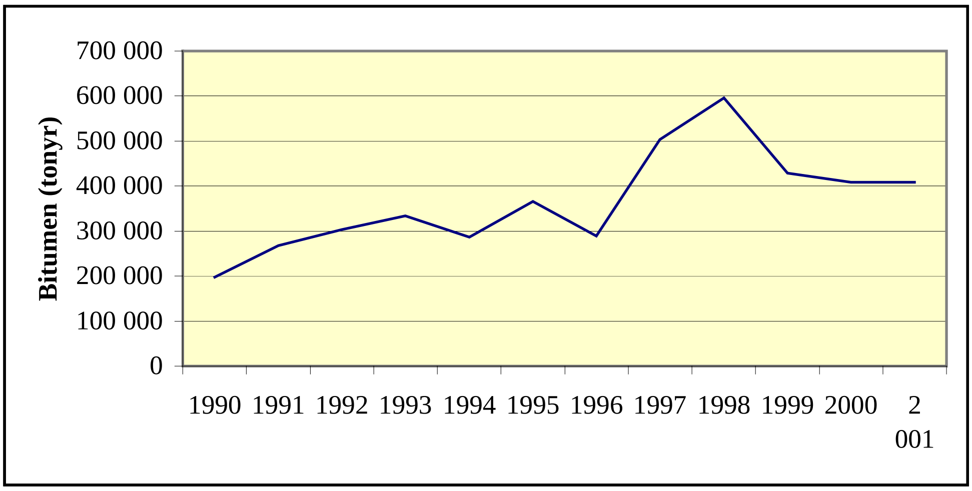
Table 4.4 - Emission Factors for road Paving with asphalt

Parameter	Setting
Dil_{Fac}	45 %
d_{Dill}	0.7 kg/l
d_{Bin}	1.1 kg/l
Cure type	Rapid Cure (RC)
$Cure_{FC}$	0.95 kg/kg

Activity Data

Quantity of asphalt used as binder in road paving was made equal to the quantity of asphalt of bitumen consumed by public and private construction according to the statistical information (Energy Balances) published by the General-directorate of energy (DGE). Figure 4.2 represents the available time series from 1990 to 2000 and provisional data forecasted to 2001 by IA[38].

Figure 4.2 - Total consumption of asphalt in the construction sector



Recalculations

No changes have been made since last submission.

Further Improvements

Emissions of volatile organic compounds from this source activity are probably over-estimated and particularly more as one moves toward 2001, because emulsified asphalts and hot mix asphalt use has became more widespread and may even be now the predominant method. Hot mix asphalt technology result in much smaller emissions than the traditional use of liquefied asphalt as binder.

Because this source is one of the major emission sources of NMVOC special effort will be made in next year to improve knowledge of this sector.

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

4.2.1.4 Glass Production

Overview

Glass is normally made from sand, limestone, soda ash, and also recycled broken glass. Combustion emissions from glass production are already considered in source sector A2. But glass involves also carbon dioxide emissions from decarbonising of limestone and carbonate materials that are considered here.

Methodology

Carbon dioxide emissions from glass production were estimated from:

$$Emission_{CO2(t,y)} = EF_{CO2(t)} * ActivityRate_{(t,y)} * 10^{-3}$$

where

$Emission_{CO2(t,y)}$ - annual emission of carbon dioxide from specific glass type t in year y (ton/yr);

$ActivityRate_{(t,y)}$ - Glass of type t produced in a given year y (ton/yr);

$EF_{CO2(t)}$ - emission factor from production of glass of type t (kg/ton)

Emission Factors

The following emission factors were considered:

Table 4.5 - Carbon Dioxide Emission Factors for Glass Production

Material	EF	Unit EF
Flat Glass	210	kg/ton
Container Glass	200	kg/ton
Other Glass	210	kg/ton

Activity Data

Glass production was considered constant in the period 1990 to 2001 and equal to production value in 1990, which was available from National Statistical Institute.

Table 4.6 - Glass production by glass type

Material	Production (ton/yr)
Flat Glass	107 472
Container Glass	746 700
Other Glass	39 330

Further Improvements

Emissions estimates from glass manufacturing - both combustion emissions and decarbonising - are being improved and new emission estimates will be available in next submission. Time series of activity data is also being improved after 1990 and will be reported in next inventory report.

4.2.2 Chemical Industry (CRF 2B)

4.2.2.1 Inorganic Chemistry and Fertilizers

Overview

Emission from the following production processes are included in this sub-source category:

Sulphuric Acid Production

In the beginning of the nineties there where two industrial units in Portugal producing sulphuric acid from mineral processing and two additional industrial plants that produce H_2SO_4 under a process aiming primarily to recover sulphur and abatement of air emission. Since then all sulphuric acid plants were closed and only sulphur recovery process remained. Presently, most emissions of SOx from sulphuric acid production result from an ammonia industrial plant that uses a high sulphur content raw material - Vaccum Residual Fuel-oil as feedstock.

Production of sulphuric acid (Contact Process) comprehends in first step the formation of SO_2 from oxidation of elemental sulphur with air, then the conversion to SO_3 in a catalytic converter and finally its absorption in a strong acid solution.

In the case of sulphur recovery units a flux of hydrogen sulphide is converted into H_2SO_4 also by air oxidation but without previous conversion to sulphur. The process then proceeds in a similar fashion to sulphuric acid production.

Nitric Acid Production

Only three units produce nitric acid in Portugal. Weak nitric acid is produced from ammonia involving oxidation of ammonia to NO_2 and subsequent absorption with water to form acid in a dual-stage process.

Ammonia

One fertilizer industrial plants still produces ammonia using Vacuum Residual Fuel Oil as feedstock to form reacting hydrogen. Ammonia is formed after reaction of hydrogen with nitrogen from air. Another existing unit in Portugal has stopped activity during the year 1990.

Other emissions associated with Chemical Industry and Fertilizer industry

Other industrial inorganic chemical activities contribute to air emissions comprehend ammonium sulphate, ammonium nitrate, urea, super phosphates and NPK fertilizers.

Methodology

Emissions estimates are based extensively on the use of emission factors multiplied by the quantity of material produced:

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

where

$Emission_{(p,y)}$ - annual emission of pollutant p in year y (ton/yr);

$ActivityRate_{(y)}$ - Indicator of activity in the production process. Quantity of product produced in year y as a general rule for this emission source sector (ton/yr);

$EF_{(p)}$ - emission factor for pollutant p (kg/ ton)

In the case of sulphur recovery with sulphuric acid production, emissions are estimated from knowledge of sulphur content in original feedstock and from recovery efficiency assuming that all sulphur in feedstock is recovered or goes to atmosphere:

$$Emi_{SOx(y)} = 2 * Feedstock_{(y)} * S_{Feed(y)} * 10^{-2} - Prod_{H2SO4\ (y)}$$

where

$EmiSOx_{(y)}$ - Emission of sulphur oxides[39] (ton/yr);
$FeedStock_{(y)}$ - Annual consumption of feedstock (ton/yr)
$S_{Feed(y)}$ - Sulphur content of feedstock (%);
$Prod_{H2SO4\ (y)}$ - production of sulphuric acid from recovery in year y (ton/yr).

Finally, conversion of feedstock to hydrogen results in the liberation of carbon - although not included in fuels - and ultimate CO2. Carbon dioxide emissions were estimated from:

$$Emi_{CO2(y)} = 44/12 * Feedstock_{(y)} * C_{Feed(y)} * 10^{-5}$$

where

$Emi_{CO2(y)}$ - Emission of carbon dioxide (kton/yr);
$FeedStock_{(y)}$ - Annual consumption of feedstock (ton/yr)
$C_{Feed(y)}$ - Carbon content of feedstock (%);

Emission Factors

The following emissions factors were applied to production data for each substance. They were set from emission factors in CORINAIR/EMEP and AP-42.

Table 4.7 - Emission Factors for inorganic chemical industry processes

- Pollutant	Sulphuric Acid kg/ton H2SO4	Nitric Acid kg/ton HO3	Ammonia kg/ton NH3	Urea kg/ton Urea	Ammonium Sulphate kg/ton (NH4)2 SO4	Ammonium Nitrate kg/ton NH4 O3
U_{CO2}			3.20			
CH_4						
N_2O		8.00				
SO_x	16.4-30.7*					
NO_x		7.50				
NMVOC			0.60		1.04	
CO			1.00			
NH_3			2.10	9.66	1.06	46.30

* From individual units production efficiency

Sulphur content of feedstock is subjected to confidential constraints and can not be made explicit. Carbon content was assumed as 86%.

[39] In fact, this emissions include also H2S and other sulphur compounds, but it is assumed that they are converted to SOx in atmosphere.

Activity Data

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. Information about activity data is based on the following sources:

- National Statistical Information concerning production in Transformation Industry for years 1991 and 1992;
- Quantities of sulphuric acid, nitric acid production for year 1990 is available from specific questionnaires to industrial units made under Corinair90 project;
- some information is available for particular years for some of the industrial plants, the result of questionnaires made under regional inventory surveys.

Recalculations

Some minor mistakes concerning activity data for ammonia production were corrected.

Further Improvements

Statistical information recently obtained from INE and concerning production in inorganic chemical industry will allow the review of activity data for years beyond 1992. It is expected therefore that emission estimates for years in that period - but not in base year - could suffer some changes.

Regional inventory surveys, EPER and monitoring under *Autocontrolo* programa presently under way may also allow better insight of technologies of this sector and may possibly improve methodologies and emission factors.

Some new sources may also be considered in connection of the increase of pollutants covered in the inventory: Hydrocloric-acid, chlor-alkaly, etc.

4.2.2.2 Adipic Acid and Silicon Carbide

According to the information from the National Statistical Institute (INE) there was not production of Adipic Acid or carbide in Portugal between 1992 and 2000, although Adipic Acid it was used as raw material. No emissions occur therefore from the production process.

4.2.2.3 Organic Chemical Industry

Overview

Chemical organic industry in Portugal is not very extensive. In the inventory emissions some units were estimated individually using detailed characterization and information about their industrial activities.

The major organic chemical plant in Portugal is Borealis unit, a petrochemical unit situated in the southern part of the country, near Sines. The basic process in this unit is Ethylene production by Thermal Steam Cracking of petroleum feedstock. From ethylene this unit produces Low Density Poly Ethylene (LDPE) and High Density Poly Ethylene (HDPE). As by product of ethylene production other organic compounds are produced, such as propylene, butadiene and C4 fraction, aromatics and a residual fuel oil used in the unit as energy source.

Most emissions of this unit consist of NMVOC that escape as fugitive sources in valves, flanges, pumps and compressors and also from start-ups and blowdows. Regeneration of catalityc equipments also result in combustion emissions. SOx is produced as consequence of hydrogen sulphide in process flue gas, which is burnt in a combustor before being emitted in the stack.

Other LPS individualized is the only Carbon Black plant in Portugal. It is situated in the southern part of the country, near Sines. Carbogal unit produces Carbon Black by the Oil Furnace Process, a partial combustion process. A feedstock with a high content of aromatic material is injected into 3 reactors with a limited supply of air and is converted (incomplete combustion, thermal cracking and dehydrogenation to carbon black. Emissions result from Gas Vent, combined dryer vent and fugitive emission in the vacuum system vent.

Finally the last individualized unit is an industrial plant producing Phthalic Anhydride from aromatic compounds.

Apart from those individualized industrial plants other chemical industrial activities were included in this sub-source sector:

- Vinyl Chloride Monomer (VCM);
- Low Density Poly-ethylene (LDPE);
- Poly Vinyl Chloride (PVC);
- Poly propylene (PP);
- Poly styrene (PS);
- Formaldehyde;
- Explosives.

Methodology

Also for this sub-sector emissions estimates are extensively based on the use of emission factors multiplied by quantity of material produced:

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

where

$Emission_{(p,y)}$ - annual emission of pollutant p in year y (ton/yr);

$ActivityRate_{(y)}$ - Indicator of activity in the production process. Quantity of product produced per year as a general rule for this emission source sector (ton/yr);

$EF_{(p)}$ - emission factor (kg/ ton)

Emission Factors

A specific and detailed inventory survey was made for Borealis unit in 1993-1994. Emissions estimated for this period where used to determine plant-specific process emission factors that were used to estimate emissions for all time series from 1990 to 2001 and using ethylene production as activity rate indicator[40]. Emissions from flares and flue gas combustor where included in the emission factors.

In the same way the carbon black industrial unit was subjected, also for period 1993-94, to a detailed survey. From that exercise emission factors were established for the unit and emission estimates extended for the rest of the time series using carbon black production as indicator of activity rate. Emission factors for the Phthalic Anhydride Plant are from US-EPA (1983) and are presented in table 4.8:

[40] This is an integrated industrial plant and it is difficult to attribute emissions to specific products.

Table 4.8 - Emission Factors for the production of Phthalic Anhydride

Pollutant	kg/ton
SOx	4.7
COVNM	1.2
CO	151
PST	120.4

Concerning explosives: Emission estimate methodologies are available from USEPA (1995) but only for the production of: TNT and Nitrocellulose. But because it is expected that the production of other explosives result in similar emissions the following assumptions were made:

- The most probable emission factors for Nitrocellulose production were set as:

Table 4.9 - Emission Factors for Nitrocellulose production (explosives)

FE (Kg/ton)	SOx	NOx
Total	34.7	14
Nitration reactors	0.7	7
Nitric acid concentrator	-	7
Sulphuric acid concentrator	34	-

- it was assumed that the production of nitroglycerin is similar, in what concerns emissions, to nitrocellulose production, and the same emission factors were used;
- Black powder is made from carbon, sulphur and saltpetre (KNO3) mixed together. There are no reference to emissions from it production. It was assumed that the production process is basically physical and that no relevant atmospheric emissions occur;
- Emission factors for the production of TNT are also from AP-42 chapter 6.3 (USEPA, 1995):

Table 4.10 - Emission Factors for TNT production (explosives)

kg/ton	SOx	NOx
TNT - Batch process (Total)	36.5	78.5
Nitration reactors	-	-
Fume recovery	-	12.5
Acid recovery	-	27.5
Nitric acid concentrators	-	18.5
Sulphuric acid concentrators (with ESP)	7	20
Red water (Sellite exhaust)	29.5	-

Emission factors for all other chemical producing units follow international bibliography sources, particularly AP42 (US-EPA).

Table 4.11 - Emission factors for chemical organic industrial processes

Compound	EF (kgton) NMVOC
VCM	2.5
LDPE	10.0
PVC	3.0
PP	8.0
PS	1.0
Formaldehyde	5.0

Activity Data

Activity data used to estimate emission can not be reported because of confidentiality issues resulting from the limited number of units producing the materials that are responsible for air emissions.

Presently there is a limited knowledge of the quantities produced in this source sector. For only one industrial plant - Borealis Petrochemical Plant in Sines - produced quantities are available from 1990 to 1997 and where forecasted thereafter. Production of carbon black and explosives is available from 1990 to 2000 from INE Statistical Database.

But for the other smaller units, including Phthalic Anhydride, information is only available for base year (1990) and was kept constant for following years. Statistical information for all emissions sources other than Sines Plant were obtained from the National Statistical Institute (INE).

Recalculations

No changes have been made on this emission source sector.

Further Improvements

The quality of emission estimates from this sub-source sector must be improved, namely:

- update of activity data from 1991 to 2001;
- obtaining a deeper knowledge for the limited number of industrial units and performing emission estimates with more detailed methodologies, similar to those performed for Borealis and Carbogal industrial units;
- revision of emission methodologies and possible inclusion of more production processes.

4.2.3 Metal Production (CRF 2C)

4.2.3.1 Iron and Steel Production

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 scrap are transformed into steel into subsequent furnaces which may be a Basic Oxygen Furnace (BOF) or Electric Arc Furnace (EAF). Coke, sinter and lime are produced as necessary associated steps to obtain basic materials.

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.

Coke is produced by destructive distillation of 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.

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.

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 however 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 in pig iron.

Steel is finally finished in rolling mills. Emissions from this finishing process are mostly particulate matter besides combustion pollutants already considered in A2 sector.

Emission of ultimate fossil CO_2 is the result of the oxidation of carbon in coke, anodes and electrodes, that acts as a reducing agent of mineral ore. 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 if resulting from the use of biomass origin carbon - charcoal. Emissions of carbon may occur as CO and NMVOC but it is assumed that they are latter 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 from steel production as result of its presence (or it precursors) in original ore or in the material used to produce coke. That is the case of SOx and heavy metals. But because combustion occur with contact, emissions are modified - increase or decrease - by contact of combustion gases with products.

Finally NOx is formed due to reaction of atmospheric air at high temperatures, which may result from fuel combustion or from high temperature generated at production processes.

During 1990-2001 period two main industrial plants in Portugal were associated with steel production which latter turn into three units as result of the split of one of the units in two separate plants. As result of closure of one production unit production of steel has stopped in 2001. Coke in Portugal was produced from imported coal.

Methodology

Emissions are simply calculated from multiplication for a suitable emission factor:

$$\text{Emission}_{(p,y)} = \sum_{act}[EF_{(p,act)} * \text{Activity}_{\text{Indicator}\,(p,act,y)}] * 10^{-3}$$

and,

Emission $_{(p,y)}$ - Emission of pollutant pol in a specific year y from all sector activities and equipments (ton/yr);

$Activity_{Indicator\ (p,act,y)}$ - Most suitable indicator for emissions of a particular pollutant p resulting from a specific source activity or equipment (ton/yr);

$EF_{(p,act)}$ - Emission factor specific of pollutant and activity/ equipment (kg/ton).

Emissions from lime production from limestone were also estimated using similar equation and using production of lime as activity data.

To avoid double counting, carbon dioxide emissions from oxidation of the carbon that was used as a reducing agent were not estimated from steel or coke production data but simply from use of coke derivative fuels (coke gas and blast furnace gas) in all combustion equipments. Methodology to estimate emissions from this source were already discussed in chapter A3 – Manufacturing Industries and Construction and emissions are included in source sector A2a - Energy use in industry - and A1 - Manufacture of Solid Fuels. Carbon dioxide emissions from anodes in EAF is still not contemplated in the inventory.

Emissions from sintering are included under A2 although they result from a combustion process with combustion and are estimated from sinter production. Emission factors for sintering are also reported below.

Excluding emissions in coke production resulting from use of fuels in heating furnaces, air emissions 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, offtake caps, collecting main, and cracks that may develop in oven brickwork (USEPA, 2000).

Gas resulting from process in the blast furnace is normally not emitted to atmosphere but due to its high carbon monoxide content used as fuel in integrated units (Blast Furnace Gas). Emissions from it combustion are also quantified and discussed under chapter A2. Quantified emissions here are only those resulting from casting operations and seal leaks at top of furnace.

Emission Factors

Emissions factors for production process where set mostly from CORINAIR/EMEP also with contributions from IPCC96 and US-EPA AP42. Emission factors in kg/ton are present in next table.

Table 4.12 - Emission Factors for Iron and Steel Production

Pollutant	Coke Oven * (kg/ton coke)	Sintering (kg/ton sinter)	Blast Furnace ** (kg/ton steel)	BOF (kg ton/steel)	EAF (kg/ton steel)
SOx	0.01	1	2	0.01	
NOx	0.02	0.5	0.076		
COVNM	2.1	0.1	0.12		
CH4					9
CO2				22.5	119
CO	0.635	30	1.412	69	
N2O					
NH3	0.09				25

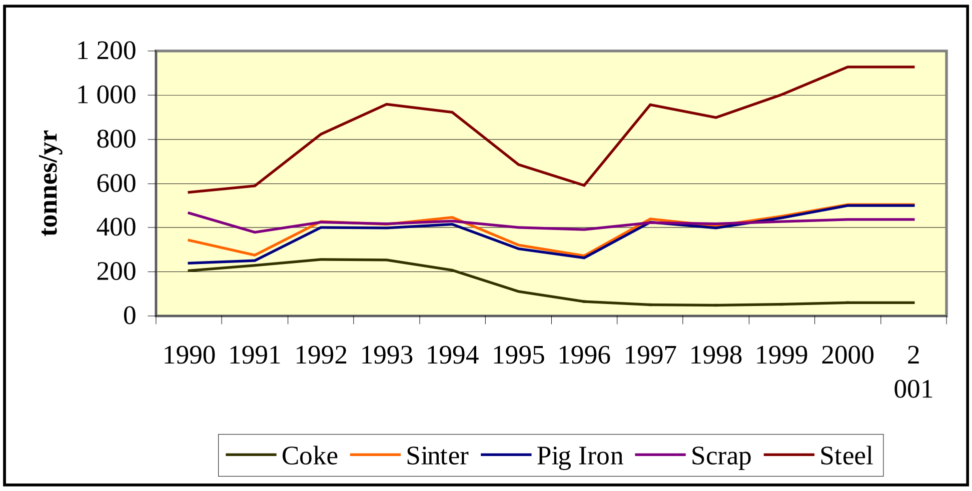
* door leakage and Extinction; ** Charging, Tapping & Teeming

Activity Data

Activity data for this source sector has low quality for all years since 1994. Before this year activity data information was collected directly from industrial plants and it is mostly probably of good quality. Since them information had to be collected from statistical information from National Statistical Institute (INE), or even obtained using projections and considering past time series and annual energy consumption in associated power plants - information collected under LCP directive. Quality of activity data for this latter period decreased substantially because available statistical information is not detailed enough for intermediate products and transparency problems exists concerning the fact that the same quantity of steel may appear in different products as result of sequential transformation.

Production total steel and intermediate products as presently considered may be seen in next figure. Details about specific products and origin by furnace technology (BOF and EAF) can not be reported due to confidentiality constrains.

Figure 4.3 - 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



Recalculations

No significant changes have been made in estimates in this sub-source sector since last submission.

Further Improvements

Lack of information concerning activity data and possible double counting in steel production activities substantially lowers quality of activity data since 1994, increases uncertainty and creates inconsistencies in overall time-series. Although this sector is undergoing deep changes with closure of main source activities (coquerie, blast furnace and sintering) an effort will have to be made to clarify the situation and increase the quality of emission estimates for base year.

Possible double counting of emissions of CO, NMVOC and SOx will be reviewed.

4.2.3.2 Ferroalloys Production

Overview

Iron is smelted with other elements, such as silicon, manganese, chromium, molybdenium, vanadium or tungsten, forming alloys that have specific material characteristics requirements.

Usually alloy formation occurs in Electric Arc Furnaces (EAF) and, like the situation described in steel factoring, carbon monoxide and carbon dioxide emissions occur from oxidation of carbon still present in coke - used as raw material - and from consumption of the graphite electrodes.

Methodology

Emissions are estimated by multiplication of emission factors, because no data is available to estimate oxidation of coke and electrodes:

$$Emission_{CO2(y)} = EF_{CO2} * ActivityRate_{(y)}$$

where

$Emission_{CO2(y)}$ - annual emission of carbon dioxide in year y (ton/yr);

$ActivityRate_{(y)}$ - Indicator of activity in the production process, the quantity of ferro-alloy produced in a given year y (ton/yr);

EF_{CO2} - emission factor (ton/ton)

Emission Factors

The emission factor, 2.5 ton/ton, was set from emission factors proposed by IPCC96 and CITEPA (Draft contribution for Corinair90 Default Emission Factor Handbook).

Activity Data

Quantity of ferro-alloy produced is only available for 1990 from National Statistical Institute (INE) and a constant production was temporarily assumed for the whole period: 1 049 ton/yr.

Recalculations

No changes have been made in emission estimates from this source category.

Further Improvements

Although this is a less important emission source, improvement of emissions estimates will have to be made in future, concerning:

- update of time series from 1990;
- specification of ferro-alloys by alloy, and application of specific emission sources.

4.2.3.3 Aluminium Production

Overview

Aluminium production may result in carbon dioxide emissions when it is reduced using carbon electrodes in smelting pots, and because the carbon electrode is consumed in the reaction. Ultimate CO2 emissions are the result of electrodes from fossil fuel origin.

Methodology

Similarly to ferro-alloys, emissions of carbon dioxide are estimated by multiplication of emission factors, because no data is available to estimate oxidation of coke and electrodes:

$$Emission_{CO2\ (y)} = EF_{CO2} * ActivityRate_{\ (y)}$$

where

$Emission_{CO2\ (y)}$ - annual emission of carbon dioxide (ton/yr);

$ActivityRate_{(y)}$ - Indicator of activity in the production process, the quantity of ferro-alloy produced in a given year y (ton/yr);

EF_{CO2} - emission factor (ton/ton)

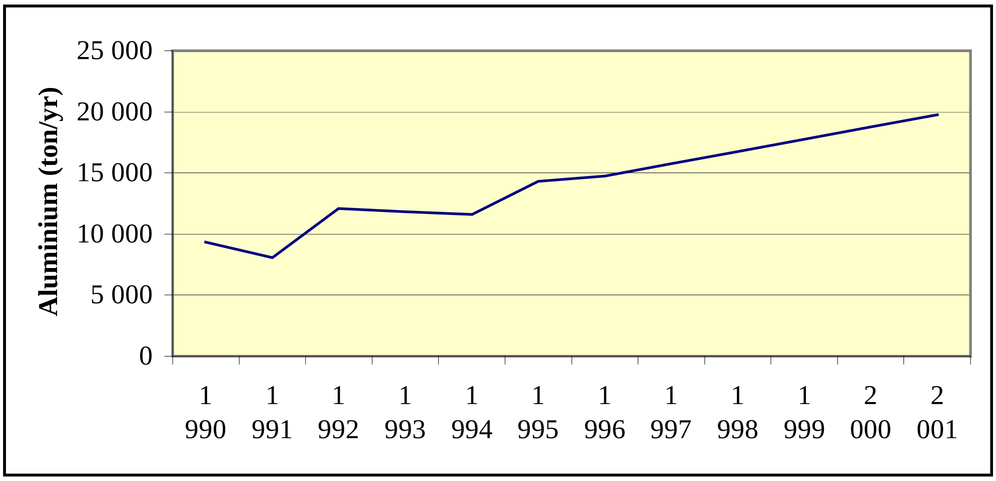
Emission Factors

The Soderberg process was assumed and the default emission factor from IPCC96 for this technology (1.8 ton CO2/ton) was considered.

Activity Data

Total production of aluminium and its alloys in bulk is available from National Statistical Institute until 1995 and forecasted thereafter by IA, which time series is present in next figure.

Figure 4.4 - Total production of aluminium and its alloys in bulk



Recalculations

No changes have been made in this source sector.

Further Improvements

Recent information concerning this source indicates that there is no aluminium production from alumina in Portugal, and probably this CO_2 source should not be considered in the inventory altogether.

4.2.4 Other Production (CRF 2D)

4.2.4.1 Wood Chipboard Production

Overview

Chipboard manufacturing involves solvent emission but it included in this source sector.

Methodology

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

$$Emission_{NMVOC\ (y)} = EF_{NMVOC} * ActivityRate_{(y)} * 10^{-3}$$

where

$Emission_{NMVOC}$ - annual emission of NMVOC in year y (ton/yr);
ActivityRate - Indicator of activity in the production process (ton/yr);
EF_{NMVOC} - emission factor (kg/ ton)

It was assumed that NMVOC result mostly from solvents and these have fossil origin contributing to ultimate carbon dioxide emissions. Ultimate carbon dioxide emissions are calculated assuming that emitted VOC have on average 85% of carbon:

$$Emi_{CO2} = 0.85 * Emi_{NMVOC}$$

Emission Factors

Emission factor is 0.9 kg/ton from Corinair90 Default Emission Factor Handbook.

Activity Data

Information about activity data for this sector is still scarce and limited to 1990, from National Statistics Institute (INE). In 1990 571 kilo-tons of chipboard were produced in Portugal.

Recalculations

No changes have been made since last submission.

Further Improvements

Emissions from chipboard should be moved to “Solvent Use” and NMVOC emissions from these activity should be estimated according to methodologies for these source sector avoiding double counting of emissions that result in fact from solvent use.

Time series of chipboard production will be updated from new information from INE.

4.2.4.2 Food and Beverages

Overview

Food and Beverage industrial processes are responsible for some NMVOC emissions resulting mostly from alcohol generation by microbial fermentation and consequent evaporation, and from evaporation of organic compounds during processing.

The National Inventory Report includes emissions estimates for NMVOC from:

- Bread backing;
- Wine preparation;

- Beer production;
- Spirituous beverages distillation;
- Meat and fish processing;
- Sugar processing;
- Margarine and other fat production[41];
- Coffee roasting;
- Animal feed production.

Methodology

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

$$Emission_{NMVOC\ (y)} = EF_{NMVOC} * ActivityRate_{\ (y)} * 10^{-3}$$

where

$Emission_{NMVOC\ (y)}$ - annual emission of NMVOC in year y (ton/yr);

$ActivityRate_{\ (y)}$ - Indicator of activity in the production process. Quantity of product produced per year as a general rule for this emission source sector (ton/yr);

EF_{NMVOC} - emission factor (kg/ ton)

Although NMVOC are emitted, they have biological origin and do not contribute to ultimate carbon dioxide emissions.

Emission Factors

The following emission factors were set from CORINAIR/EMEP, IPCC96 and US-EPA AP42:

Table 4.13 - NMVOC emission factors for food and beverage industrial processes

Material	EF	Unit EF
Patisserie	1.00	
Meat	0.3	
Fish	0.3	
Sugar	10	
Margarine	10	kg/ton
Animal Feed	1	
Coffee Roasting	0.55	
Wheat Bread	4.5	
Other Bread	3	
White wine	0.035	
Red Wine	0.080	kg/hl
Beer	0.035	
Spirits	6.000	

[41] Emissions of NMVOC from edible oil extractions are included in “Use of Solvents”.

Activity Data

Activity data was collected for most activities only for years 1990 and 1991 from INE. Information about break backing, animal feed, coffee roasting and sugar include also information about years 1996 and 1997. Information lacking for the other years were forectasted and interpolated from available time series or kept constant during all period. Annual activity levels from 1990 to 2001 are presented in table 4.14 below.

Table 4.14 Production in the Food and Beverage Industry

-	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2 001
White wine	410.4	410.4	410.4	410.4	410.4	410.4	391.7	391.7	391.7	391.7	391.7	391.7
Red Wine	592.3	592.3	592.3	592.3	592.3	592.3	477.8	477.8	477.8	477.8	477.8	477.8
Beer	687.4	688.8	690.2	691.6	693	694.3	695.7	676.7	687.1	687.1	687.1	687.1
Spirits	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
Wheat Bread	301.9	277.8	269.3	260.7	252.1	243.5	235	171.6	186.5	172.1	157.7	143.2
Other Bread	28.2	28.4	27.1	25.8	24.5	23.2	21.9	16	17.4	15.9	14.3	12.8
Cakes	38.3	38.1	38.2	38.2	38.2	38.2	38.2	38.2	38.2	38.2	38.2	38.2
Meat	0	0	0	0	0	0	0	0	0	0	0	0
Fish	237.6	237.6	237.6	237.6	237.6	237.6	237.6	237.6	237.6	237.6	237.6	237.6
Sugar	305.4	281.7	285.5	289.3	293.1	296.9	300.7	348.4	323.3	328.5	333.6	338.8
Margarine	71.4	63.3	67.3	67.3	67.3	67.3	67.3	67.3	67.3	67.3	67.3	67.3
Animal Feed	3 761.4	3 761.4	3 761.4	3 761.4	3 761.4	3 761.4	3 713.6	3 809.1	3 761.4	3 761.4	3 761.4	3 761.4
Coffee Roasting	27.9	27.9	27.9	27.9	27.9	27.9	28.3	27.4	27.9	27.9	27.9	27.9

* Beverages expressed in million litters; food products (including coffee) as kton.

Recalculations

No changes have been made since last submission.

Further Improvements

No improvements are expected for this source, which is responsible for minor emission quantities, besides update of activity data time series until 2001 using statistical information from National Statistical Institute (INE).

4.2.4.3 Paper pulp production

Overview

In 1990 there were in Portugal six paper pulp plants working on kraft process and two units using the acid sulphide process. Latter in the period the smaller of the acid sulphide plants was decommissioned.

Kraft pulping is essentially a digestion process of wood by a solution of sodium sulphide (Na_2S) and sodium hydroxide (NaOH) (white liquor) 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 bleaching. Recovery of sulphur from the 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 in a causticizing tank generating white liquor and lime mud. Quicklime is recovered by combustion in a lime kiln.

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.

Methodology

Air emissions (ton/yr) for each pollutant are estimated from production of air dried paper pulp ($Pulp_{PROD}$ - ton AD/yr) after appliyng emission factors (EF - kg/ton AD) specific of each pollutant:

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

Emission Factors

The following emissions factors (kg/ ton 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.

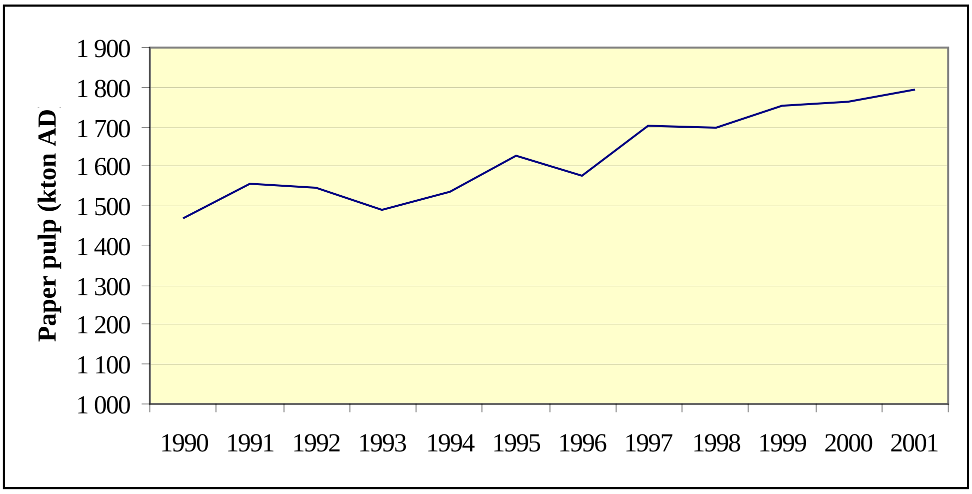
Table 4.15 - Emission Factors for paper pulp production

Process	SO_x	NO_x	COVNM
Kraft	0.31	1.95	2.74
Sulphide	35.5		

Activity Data

Production of paper pulp expressed as air dried weight was collected directly from paper pulp plants under direct inquiry, under LCP directive and from information published by CELPA, the Portuguese Paper Industry Association. Value for 2001 was extrapolated from historical data. Acid Sulphide production is only a minor component of total production[42] but may not be published due to possible confidentiality constraints. Paper pulp production has been steadily raising during last decade.

Figure 4.5 - Total production of paper pulp (kraft and semi-sulphide)



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

Recalculations

No changes have been made on emission estimates for this emission source since last submission.

Further Improvements

Emission factors for SO_x, NO_x and NMVOC will be revised to avoid some possible double counting with emissions that although estimated from production data are in fact combustion emissions and are already included in A2. A program to improve knowledge of specific technology conditions in each factory plant and of emission abatement methodologies is under way.

4.2.5 Consumption of Halocarbons and Sulphur Hexafluoride (CRF 2F)

4.2.5.1 Overview

Several simple halogenated organic compounds have high warming potentials and long atmospheric residence times. These include predominantly synthetic substances that have been used mostly as inert gases in such diverse applications as refrigeration gas, aerosols propellants, foam fillers, gas insulation and fire suppressants. Clorofluorcarbons (CFC), Hydroclorofluorcarbons (HCFC), Perfluorinated hydrocarbons (PFC) and sulphur hexafluoride (SF6)[43] are the most important among those compounds. CFC and HCFC are already under control and being phased out under the Montreal Protocol, as consequence of their role as Ozone Depleting Substances (ODS). Therefore, under the United Nations Convention on Climate Change it was decided to consider in the GHG inventory those substances not included in the Montreal Protocol: HFC, PFC and SF6.

Some emission sources are still not included in the inventory:

- Aerosols. According to information from industry importers (Carreira, 2002) fluorine gases have not been used as aerosol propellants produced in Portugal. Instead Portugal has been using R12 (CFC), hydrocarbons (butane and propane) and even N2O. The presence of fluorine gases incorporated in imported aerosols in unknown because F gases are not reported explicitly at customs services and consequent emission cannot be estimated;
- Solvents. According from information from national importers in Portugal there is no reference for the use of HFC as solvents, but only of HCFC (Carreira, 2002). The use of HFC as solvent represents probably a minor source in global terms;
- Fire Protection. Fire protection systems using fluorine gases are mostly fixed equipments (acting by flooding) and are used mainly to protect electronic equipment. In Portugal there is no information concerning this type of fire suppressant and emissions from this sub-source must remain unaccounted.

Some emissions sources are not completely included in the inventory, mainly as result of lack of adequate basic activity data, although there is a strong believe that they are minor sources not decisively affecting total emissions:

- First-fill emissions of Mobile Air-conditioning (MAC) systems. There is no available information concerning the installation of MAC in new cars or aftermarket MAC system;

[43] Other substances with greenhouse gas potential but less common are NF3 and some halons. They are not included neither in Montreal Protocol neither in FCCC.

- Operation and disposal emissions of MAC systems in heavy-weight vehicles: heavy duty, busses and coaches;

- HFC gases used as aerosols propellants in imported products, including Metered Dose Inhalers (MDI);

- HFC emissions from closed-cell foams imported and used in Portugal;

- some non-electrical use of SF_6 such as gas tracer in air dispersion and air emission studies.

One source, HFC-23 emissions from HCFC-22 manufacture, did not exist in Portugal during the reporting period and is reported as Not Occurring (NO)

4.2.5.2 General Methodology

For those sources for which sufficient data was available, actual emissions where estimated with a Tier 2 (advanced or actual method) approach which is considered Good Practice in accordance with GPG. This approach allows the quantification of emissions in the year in which they actually occur accounting for the time lag between consumption and emissions. On the contrary the Tier 1, or potential approach, allocates emissions in the year that the chemical is sold into a particular end-user.

As a general rule bottom-up methodology was used, and in fact methodology should be classified as Tier 2a. This approach departs from the knowledge of the number of equipments using HFC compounds and estimates emissions to atmosphere from charge (amount of chemical used in the equipment), service life, emission rate during the various periods of the equipment life and possible recovery of emissions.

Whenever possible emission estimates include:

- assembly emissions when equipment is first filled[44];

- operation emissions, occurring during equipment lifetime or usage and resulting mainly from leaks;

- disposal emissions, the remaining charge that it is released to the atmosphere at end of equipment life and for those emissions that are neither recycled or destroyed.

4.2.5.3 Recalculation

Extensive changes have been made since last year submission: the collection of new data enabled the quantification of some sources never covered before, and the improvement of background data for some other

4.2.5.4 Further Improvement

It is expected that emission estimates will improve as a consequence of the inclusion of non quantified sources and the improvement in methodologies and parameters for the already quantified sources. Main aspects that will be subjected to future improvements comprehend the aspects following presented:

- Emission of F gases from manufacturing, operation and disposal of certain sources where not estimated because no reliable activity data was available: Fire extinguishers; Aerosols including Metered Dose Inhalers; solvent use and semiconductors. Although it

[44] Assembly emissions could include also emissions during refilling but no data was available to make this distinction

is probable that these sources are minor and less relevant in Portugal, further work should be developed to obtain activity data for these sources.

- There are still no estimates of HFC emissions from industrial refrigeration units due to the lack of information on basic activity data. This situation will be improved in the near future.
- Inclusion of emissions of mobile AC in heavy duty vehicles, buses and coaches. And a better knowledge of the time series of light vehicles with AC should also be followed.
- It is known that SF6 was used in Portugal as a tracer in scientific studies, even in the development of air emission methodologies (VOC from forest). But the quantities used in this activity remain unknown.
- Whenever possible a study of a better characterization of refrigeration equipment in households should be followed.
- The consideration of refilling of refrigeration equipments should be better addressed in the inventory.
- A better knowledge of the fleet of refrigerated vehicles will be followed together with the development of a time series.
- Differentiation as much as possible between foam types: closed cell/open cell and polymer constitution;
- Emissions from certain source sectors rely in less accurate activity data, which was estimated from surrogate data and assumptions. Efforts will be made to reduce uncertainty on activity data and parameters.

4.2.5.5 Domestic Refrigeration

Methodology

CFC, HCFC and HFC emissions from operation and disposal of Domestic Refrigeration Equipments were estimated using the bottom-up approach (Tier 2 or actual method) as proposed in chapter 3.7.4 of the GPG.

The emissions were estimated according to the following set of equations after GPG:

Assembly/First fill

$$Ass_{Emi\ (t)} = Equip_{Assembly\ (t)} * Initial_{Charge\ (t)} * (k/100)$$

Operation/Lifetime

$$Oper_{Emi\ (t)} = Equip_{Stock\ (t)} * Initial_{Charge\ (t)} * (x/100)$$

Disposal

$$Disp_{Emi\ (t)} = Equip_{Disposal\ (t)} * Initial_{Charge\ (t\text{-}lifetime)} * (y/100) * (1\text{-}z/100)$$

HFC emissions for each particular compound were estimated from total refrigeration gas emissions based on the percentage of HFC use in total refrigeration gas use in each year, according to the following equations:

Assembly

$$Ass_{Emi\ (t,j)} = Ass_{Emi\ (t)}\ .\ HFC_{\%\ (j,t)}$$

Operation/ Lifetime

$$Oper_{Emi(t,j)} = Oper_{Emi(t)} \sum_{y=t}^{t\text{-Lifetime}} [Equip_{\%(t,y)}.HFC_{\%(j,y)}]$$

Disposal

$$Disp_{Emi(t,j)} = Disp_{Emi(t)} [Equip_{\%(t,t\text{-lifetime})}.HFC_{\%(j,t\text{-lifetime})}]$$

where

$Ass_{Emi(t)}$, $Oper_{Emi(t)}$, $Disp_{Emi(t)}$ - total HFC emissions in year t from during assembly (Ass), Operation (Oper) and Disposal (Disp);

$Ass_{Emi(t,j)}$, $Oper_{Emi(t,j)}$, $Disp_{Emi(t,j)}$ - HFC emissions of compound j in year t from during assembly (Ass), Operation (Oper) and Disposal (Disp);

$Equip_{Assembly\ (t)}$ - Equipments assembled in year t;

$Equip_{Stock\ (t)}$ - Existing stock of equipment in year t;

$Equip_{Disposal\ (t)}$ - Number of equipments disposed at year t;

$Initial_{Charge\ (t)}$ - Initial charge of refrigeration gas filled in year t;

$Equip_{\%(t,y)}$ - Percentage of equipments assembled in year y in the existing stock in year t;

$HFC_{\%(j,t)}$ - Percentage of use of HFC compound j in year t;

K - percentage of initial charge that it is released during assembly;

X - annual emissions rate as a percentage of total initial charge;

Y - percentage of initial charge remaining in equipment at the time of disposal;

Z - the recovery efficiency at the time of disposal.

Emission Factors

The following emission factors were considered for this activity corresponding to the average values from the proposed range in IPCC GPG table 3.22.

Table 4.16 - Emission Factors for Domestic Refrigeration

Emission Factor (percentage of initial charge)	
Charging	**Lifetime emission**
0.6	0.3

No recovery of gas was considered at end of product life (z=0). The emitted quantity to the atmosphere is therefore the residual product remaining in equipment (variable y) which was set at 90%, according to *1996 IPCC Revised Guidelines*.

Activity Data Sources

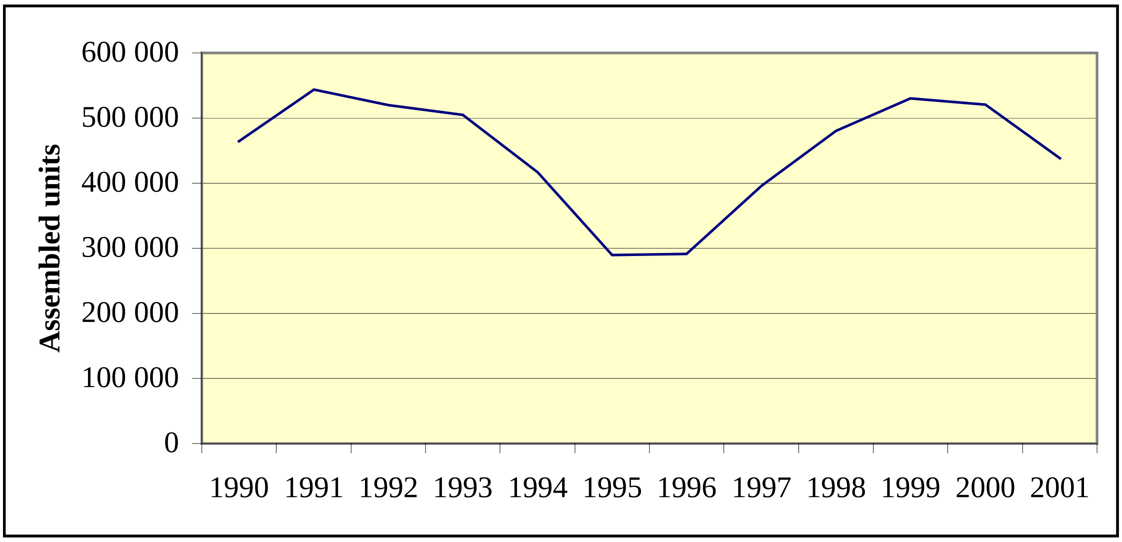
The stock of domestic refrigeration equipments was estimated from the number of households and from the percentage of households with refrigeration equipments, available for years 1990 and 1995 according to an unpublished report from INE. For year 2000 onward the percentage of equipments per household was assumed constant. The number of households was also assumed constant at about 3.1 million units during, which is consistent with the stabilization of the Portuguese population in the period, and refers to 1995 (INE-Family Survey).

Table 4.17 - Percentage of households with refrigeration equipments

Equipment	1990	1995	2000 and beyond
Combined (Refrigerator and Freezer)	91.9	96.1	100
Freezers	34.4	50.6	50

The number of assembled domestic refrigeration units in Portugal is available for each year from the National Statistic Institute (INE), and the available time trend is presented in next figure[45].

Figure 4.6 - Number of assembled refrigeration units



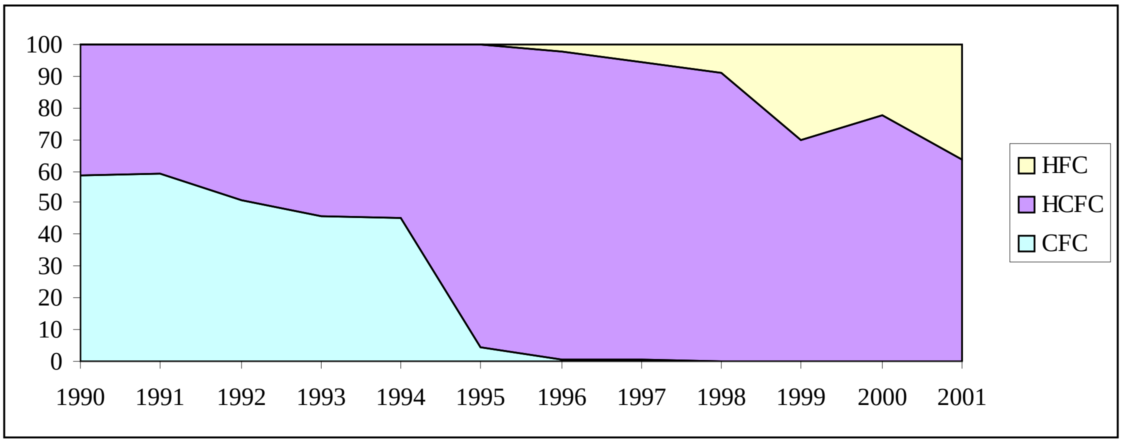
Number of disposed units (scrap rate) is not available in Portugal. It was assumed that 10% of the stock is removed every year.

Other Relevant Data and Parameters

The share of each gas used in the assemblage of refrigeration equipments was estimated for each year from importation data from an important national importer and supplier of assemblage units. Although this data does not refer for the totality of national market it was considered well representative of the situation. HFC has been imported since 1996 and increasingly substituting HCFC import. The share of import of each gas can be seen in the following figure. According to the same data source HFC refers to HCF 134a, HFC 125 and HFC 143a.

[45] The distinction between assembled domestic units and commercial/institutional units it is not always clear in the statistical results. It was decided to include here all refrigeration units with a opaque door and in commercial/institutional assemblage all units with a showing panel.

Figure 4.7 - Percentage of imported fluorine gases in Portugal



The percentage of each gas in the existing stock in each year is estimated from the arithmetic average for the lifetime period of each equipment type. For the disposal it was considered that HFC composition is that of emission year less the lifetime of the equipment[46]. Prior to 1990 no HFC was used in the assemblage of refrigeration units and it was assumed that there is an equal share of R12 and R 502. Lifetime of domestic equipments was set at 12 years according to the lower value in table 3.22 of GPG.

The quantity of refrigeration gas charged into the equipment was assumed at an average value of 100 g/equipment unit (GASA, 2000 after information from APIRAC) which is well within the range set in GPG table 3.22.

4.2.5.6 Commercial Refrigeration

Methodology

In a similar mode to other Stationary Refrigeration Equipments, CFC, HCFC and HFC emissions from operation and disposal of non domestic Refrigeration Equipments were estimated using the bottom-up approach (Tier 2 or actual method) as proposed in chapter 3.7.4 of the GPG.

Lifetime and disposal emissions[47] were estimated according to the following set of equations after GPG:

Assembly/First fill

$$Ass_{Emi\ (t)} = Equip_{Assembly\ (t)} * Initial_{Charge\ (t)} * (k/100)$$

Operation/Lifetime

$$Oper_{Emi\ (t)} = Equip_{Stock\ (t)} * Initial_{Charge\ (t)} * (x/100)$$

[46] In consequence no emissions of HFC from disposal are estimated for the reported period.

[47] Assembly emissions are included in domestic refrigeration because the discrimination of equipment usage it is not feasible for all years

Disposal

$$Disp_{Emi\ (t)} = Equip_{Disposal\ (t)} * Initial_{Charge\ (t\text{-}lifetime)} * (y/100) * (1\text{-}z/100)$$

HFC emissions for each particular compound were estimated from total refrigeration gas emissions based on the percentage of HFC use in total refrigeration gas use in each particular year, according to the following equations:

Assembly

$$Ass_{Emi\ (t,j)} = Ass_{Emi\ (t)} \cdot HFC_{\%\ (j,t)}$$

Operation/ Lifetime

$$Oper_{Emi(t,j)} = Oper_{Emi(t)} \sum_{y=t}^{t\text{-}Lifetime} [Equip_{\%(t,y)} . HFC_{\%\ (j,y)}]$$

Disposal

$$Disp_{Emi\ (t,j)} = Disp_{Emi(t)} [Equip_{\%(t,t\text{-}lifetime)} . HFC_{\%\ (j,t\text{-}lifetime)}]$$

where

$Ass_{Emi(t)}$, $Oper_{Emi(t)}$, $Disp_{Emi(t)}$ - total HFC emissions in year t from during assembly (Ass), Operation (Oper) and Disposal (Disp);

$Ass_{Emi(t,j)}$, $Oper_{Emi(t,j)}$, $Disp_{Emi(t,j)}$ - HFC emissions of compound j in year t from during assembly (Ass), Operation (Oper) and Disposal (Disp);

$Equip_{Assembly\ (t)}$ - Equipments assembled in year t;

$Equip_{Stock\ (t)}$ - Existing stock of equipment in year t;

$Equip_{Disposal\ (t)}$ - Number of equipments disposed at year t;

$Initial_{Charge\ (t)}$ - Initial charge of refrigeration gas filled in year t;

$Equip_{\%(t,y)}$ - Percentage of equipments assembled in year y in the existing stock in year t;

$HFC_{\%(j,t)}$ - Percentage of use of HFC compound j in year t;

X - annual emissions rate as a percentage of total initial charge;

Y - percentage of initial charge remaining in equipment at the time of disposal;

Z - the recovery efficiency at the time of disposal.

Emission Factors

In a similar way to domestic equipments, emission factors were set as the average values from the proposed range in IPCC GPG table 3.22.

Table 4.18 - Emission Factor for commercial, industry and services refrigeration equipments

Emission Factor (percentage of initial charge)	
Charging	**Lifetime emission**
1.8	5.5

Similarly no recovery of gas was considered at end of product life (z=0) and the emitted quantity to the atmosphere is therefore the residual product remaining in equipment (variable y) which was set at 90% from *1996 IPCC Revised Guidelines*.

Activity Data Sources

There are no available national statistics concerning the number and dimension of non-domestic refrigeration equipments used in commerce, industry, tourism, services and institutional. Activity data had to be estimated with the technical support of APIRAC.

Number of refrigeration equipments were estimated from the following activities, for which unit numbers were available from National Statistics Institute (INE):

Table 4.19 - Number of commercial installations in Portugal

Activity	number	Period
Hotels	1 753	1995
Restaurant & café	36 453	1995
Food & Beverage stores	49 844	1995
Hypermarkets	88	1997
Total	88 138	-

The following assumptions are responsibility of the Environment Institute:

- number of equipments per activity unit was estimated with the technical support of APIRAC:

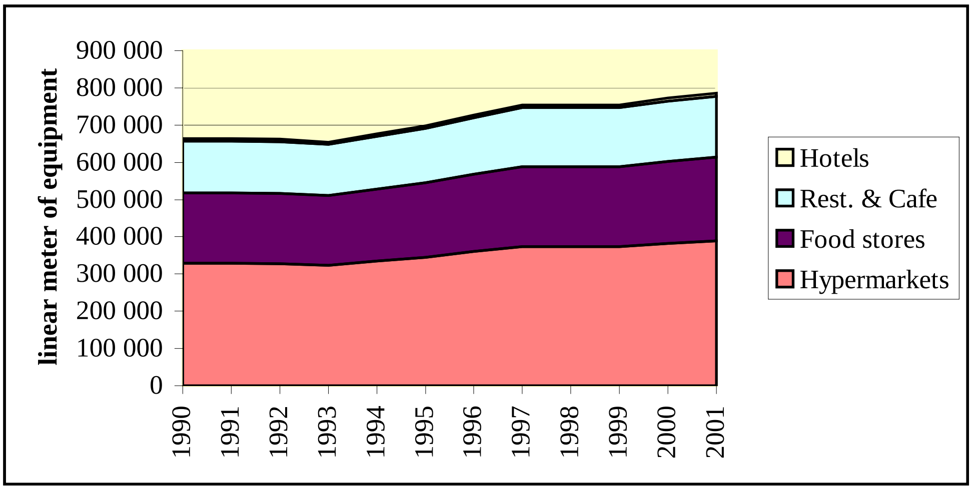
Table 4.20 - Estimation of refrigeration equipments in commercial installations in Portugal

Activity	Equipments (m/unit)[1]
Hotels	4
Restaurant & Cafe	4
Food & Beverage stores	4
Hypermarkets	240

[1] linear meter per activity unit

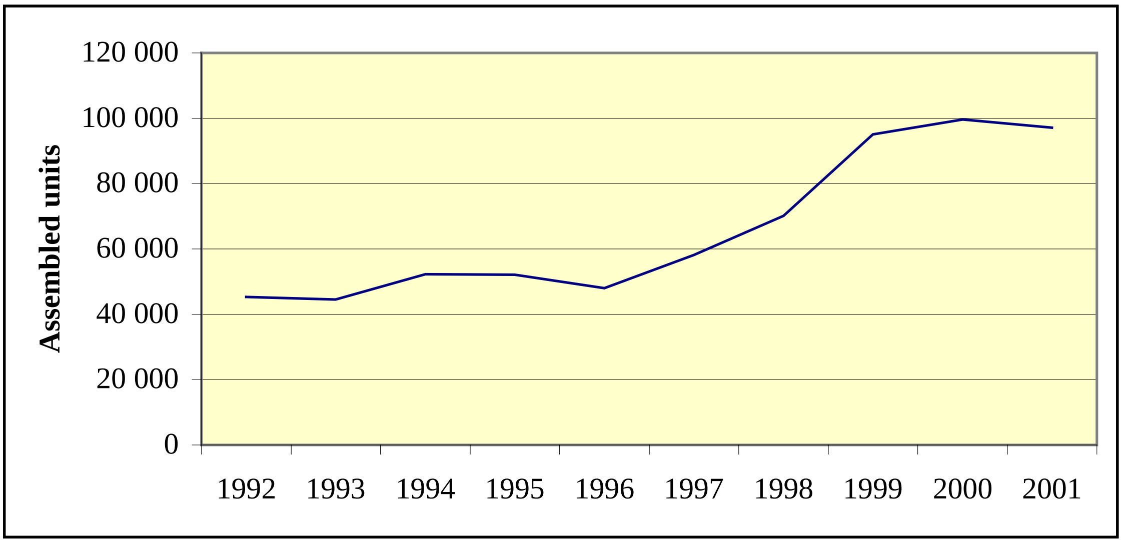
- activity data time trend was assumed to follow Gross National Product (GNP) in the period 1990-2001.

Figure 4.8 - Refrigeration Equipments in Portugal in the 1990-2001 period



Assemblage of commercial and industrial refrigeration units is only available after 1992 with the new Industrial Survey (IAPI) and refers to refrigeration with a showing panel. Numbers are comparatively smaller than domestic units and are presented in next figure.

Figure 4.9 - Assemblage of commercial and industrial refrigeration units in Portugal



In a similar mode to domestic refrigeration equipments, the number of disposed units is not available and it was assumed that 10% of the stock is removed yearly.

Other Relevant Data and Parameters

The percentage of HFC gases in assembled equipments, existing stock and disposed units follows the same procedure and background data used for domestic equipments. Lifetime was set however at 10 years, the average value proposed in GPG table 3.22 for commercial units.

IPCC GPG admits a too much wide range for the charge in commercial stand-alone refrigeration equipments. The considered value, 450 g per linear meter of equipment unit, results from information from a equipment supplier. Stand alone equipments were assume to predominate in Portugal.

4.2.5.7 Transport Refrigeration

Methodology

In a similar mode done for other Stationary Refrigeration Equipments, CFC, HCFC and HFC emissions from operation and disposal of transport refrigeration equipments were estimated using the bottom-up approach (Tier 2 or actual method) as proposed in chapter 3.7.4 of the GPG. Lifetime and disposal emissions[48] were estimated according to the following set of equations after GPG:

Operation/Lifetime

$$Oper_{Emi\ (t)} = Equip_{Stock\ (t)} * Initial_{Charge\ (t)} * (x/100)$$

Disposal

$$Disp_{Emi\ (t)} = Equip_{Disposal\ (t)} * Initial_{Charge\ (t\text{-}lifetime)} * (y/100) * (1\text{-}z/100)$$

HFC emissions for each particular compound were estimated from total refrigeration gas emissions from the percentage of HFC use in total refrigeration gas use in each particular year, according to the following equations:

Operation/ Lifetime

$$Oper_{Emi(t,j)} = Oper_{Emi(t)} \sum_{y=t}^{t\text{-}Lifetime} [Equip_{\%(t,y)}.HFC_{\%\ (j,y)}]$$

Disposal

$$Disp_{Emi\ (t,j)} = Disp_{Emi(t)} [Equip_{\%(t,t\text{-}lifetime)}.HFC_{\%\ (j,t\text{-}lifetime)}]$$

Where

$Oper_{Emi(t)}$, $Disp_{Emi(t)}$ - total HFC emissions in year t from during Operation (Oper) and Disposal (Disp);

$Oper_{Emi(t,j)}$, $Disp_{Emi(t,j)}$ - HFC emissions of compound j in year t from during Operation (Oper) and Disposal (Disp);

$Equip_{Stock\ (t)}$ - Existing stock of equipment in year t;

$Equip_{Disposal\ (t)}$ - Number of equipments disposed at year t;

$Initial_{Charge\ (t)}$ - Initial charge of refrigeration gas filled in year t;

$Equip_{\%(t,y)}$ - Percentage of equipments assembled in year y in the existing stock in year t;

$HFC_{\%(j,t)}$ - Percentage of use of HFC compound j in year t;

X - annual emissions rate as a percentage of total initial charge;

Y - percentage of initial charge remaining in equipment at the time of disposal;

Z - the recovery efficiency at the time of disposal.

[48] Assembly emissions are not estimated and they are included in assemblage of other refrigeration equipments

Emission Factors

Lifetime emissions are supposed to occur with a yearly rate of 32.5 % of initial charge per year in accordance with the average rate proposed in table 3.22 of the GPG. The emitted quantity to the atmosphere is the residual product remaining in equipment (variable y) which was set at 90% from *1996 IPCC Revised Guidelines* and no recovery is assumed at disposal.

Activity Data Sources

A constant fleet of 15937 vehicles provided with refrigeration equipments for transport was provided by the Portuguese Authority on Vehicles (DGV).

Other Relevant Data and Parameters

It was assumed that each refrigeration transport vehicle has 5.5 kg of refrigeration gas, the average value recommended by the IPCC GPG in table 3.22. Lifetime was set at 8 years also the average value from table 3.22 of IPCC GPG.

4.2.5.8 Stationary Air conditioning

Methodology

In a similar to other Stationary Refrigeration Equipments, fluorine gas emissions from operation and disposal of Stationary Air conditioning equipments were estimated using the bottom-up approach (Tier 2 or actual method) as proposed in chapter 3.7.4 of the GPG.

Emissions were estimated according to the following set of equations after GPG:

Assembly/First fill

$$Ass_{Emi\ (t)} = Equip_{Assembly\ (t)} * Initial_{Charge\ (t)} * (k/100)$$

Operation/Lifetime

$$Oper_{Emi\ (t)} = Equip_{Stock\ (t)} * Initial_{Charge\ (t)} * (x/100)$$

Disposal

$$Disp_{Emi\ (t)} = Equip_{Disposal\ (t)} * Initial_{Charge\ (t\text{-}lifetime)} * (y/100) * (1\text{-}z/100)$$

Assembly

$$Ass_{Emi\ (t,j)} = Ass_{Emi\ (t)} \,.\, HFC_{\%\ (j,t)}$$

Operation/ Lifetime

$$Oper_{Emi(t,j)} = Oper_{Emi(t)} \sum_{y=t}^{t\text{-}Lifetime} [Equip_{\%(t,y)}.HFC_{\%\ (j,y)}]$$

Disposal

$$Disp_{Emi\ (t,j)} = \quad Disp_{Emi(t)} \quad [Equip_{\%(t,t\text{-}lifetime)} . HFC_{\%\ (j,t\text{-}lifetime)}]$$

where

$Ass_{Emi(t)}$, $Oper_{Emi(t)}$, $Disp_{Emi(t)}$ - total HFC emissions in year t from during assembly (Ass), Operation (Oper) and Disposal (Disp);

$Ass_{Emi(t,j)}$, $Oper_{Emi(t,j)}$, $Disp_{Emi(t,j)}$ - HFC emissions of compound j in year t from during assembly (Ass), Operation (Oper) and Disposal (Disp);

$Equip_{Assembly\ (t)}$ - Equipments assembled in year t;

$Equip_{Stock\ (t)}$ - Existing stock of equipment in year t;

$Equip_{Disposal\ (t)}$ - Number of equipments disposed at year t;

$Initial_{Charge\ (t)}$ - Initial charge of refrigeration gas filled in year t;

$Equip_{\%(t,y)}$ - Percentage of equipments assembled in year y in the existing stock in year t;

$HFC_{\%(j,t)}$ - Percentage of use of HFC compound j in year t;

K - percentage of initial charge that it is released during assembly;

X - annual emissions rate as a percentage of total initial charge;

Y - percentage of initial charge remaining in equipment at the time of disposal;

Z - the recovery efficiency at the time of disposal.

Emission Factors

Lifetime emission factor was set as 3 per cent of initial charge per year, which is the average values from the proposed range in IPCC GPG table 3.22.

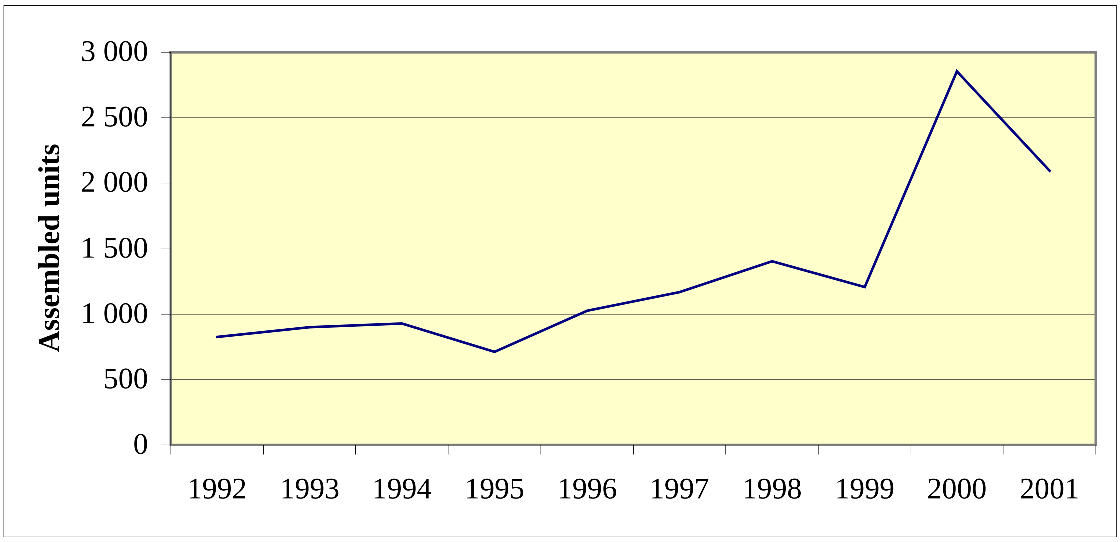
No recovery of gas was considered at end of product life (z=0). The emitted quantity to the atmosphere is therefore the residual product remaining in equipment (variable y) which was set at 90% from IPCC 1996 Revised Guidelines.

Activity Data Sources

From available data on industry statistics it is not possible to have a clear view of the time trend of assembled units, as consequence of the change that occurred in the industrial survey in 1992, when IAIT was replaced by IAPI with different products categories. IAIT categories are not detailed enough to differentiate the production of refrigeration components - not resulting in emissions - from it final assemblage. The closure of an important factory in the same period complicates the exact knowledge of the time series. This situation is nonetheless irrelevant for the inventory because HFC emissions in assemblage of AC equipments did not occur at that period.

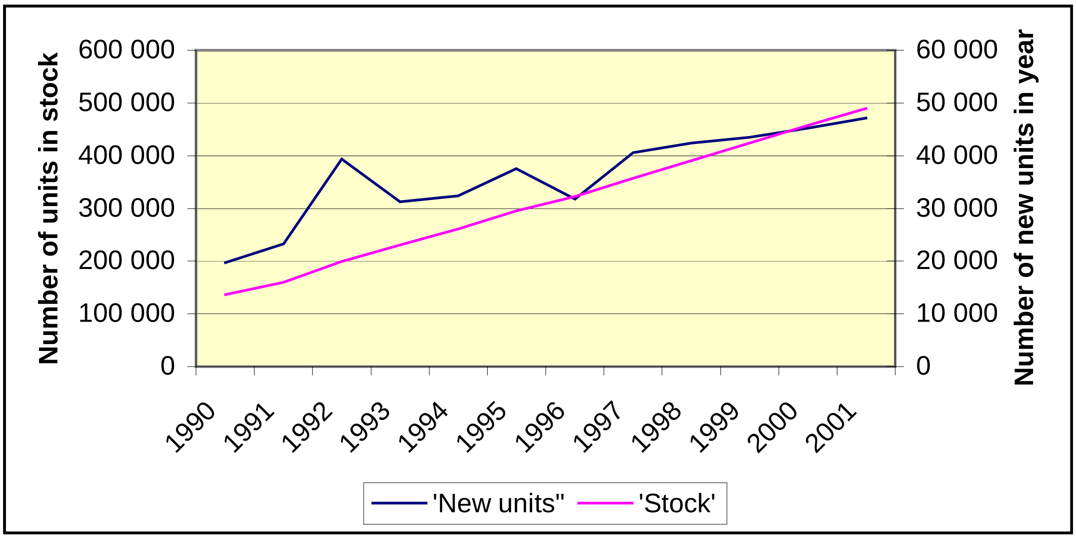
According to the available data, the following time series (Figure 4.10) was assumed in the inventory. Activity data for 2001 was forecasted from 1992-2000 time series. According to IAIT, , 50 821 and 63 108 were assembled units, respectively, in 1990 and 1991, which are not shown in graph.

Figure 4.10 - Number of stationary air-conditioning assembled in Portugal in the period 1990-2001



Existing stock and yearly disposed units is available from unpublished information received from IST-UTL. Time series from 1990 to 2001 are presented in next figure.

Figure 4.11 - Annual new installed units and stock of stationary air-conditioning equipments in Portugal from 1990 to 2001



Other Relevant Data and Parameters

The quantity of initial gas charged per equipment, set at 300 g/unit, follows information collected from the industry association APIRAC by Seixas et al (2000).

4.2.5.9 Mobile Air Conditioning

Methodology

CFC, HCFC and HFC emissions from operation and disposal of Mobile Air Conditioning (MAC) systems were estimated using the bottom-up approach (Tier 2 or actual method) as proposed in chapter 3.7.5.1 of the GPG. Due to lack of information it was not possible to estimate emissions by vehicle class and age. Emissions refer only to light vehicles[49]. Nevertheless the chosen methodology and emission factors choice is in accordance with the decision tree in GPG figure 3.16.

Emissions were estimated according to the following set of equations from GPG:

Operation/Lifetime

$$Oper_{Emi\ (t)} = Equip_{Stock\ (t)} * Initial_{Charge\ (t)} * (x/100)$$

Disposal

$$Disp_{Emi\ (t)} = Equip_{Disposal\ (t)} * Initial_{Charge\ (t\text{-}lifetime)} * (y/100) * (1\text{-}z/100)$$

HFC emissions for each particular compound were estimated from total refrigeration gas emissions from the percentage of HFC use in total refrigeration gas use in each particular year, according to the following equations:

Operation/ Lifetime

$$Oper_{Emi(t,j)} = Oper_{Emi(t)} \sum_{y=t}^{t\text{-}Lifetime} [Equip_{\%(t,y)}.HFC_{\%\ (j,y)}]$$

Disposal

$$Disp_{Emi\ (t,j)} = Disp_{Emi(t)} [Equip_{\%(t,t\text{-}lifetime)}.HFC_{\%\ (j,t\text{-}lifetime)}]$$

Where

$Oper_{Emi(t)}$, $Disp_{Emi(t)}$ - total HFC emissions in year t from during Operation (Oper) and Disposal (Disp);

$Oper_{Emi(t,j)}$, $Disp_{Emi(t,j)}$ - HFC emissions of compound j in year t from during Operation (Oper) and Disposal (Disp);

$Equip_{Stock\ (t)}$ - Existing stock of equipment in year t;

$Equip_{Disposal\ (t)}$ - Number of equipments disposed at year t;

$Initial_{Charge\ (t)}$ - Initial charge of refrigeration gas filled in year t;

$Equip_{\%(t,y)}$ - Percentage of equipments assembled in year y in the existing stock in year t;

$HFC_{\%(j,t)}$ - Percentage of use of HFC compound j in year t;

X - annual emissions rate as a percentage of total initial charge;

Y - percentage of initial charge remaining in equipment at the time of disposal;

Z - the recovery efficiency at the time of disposal.

[49] Although in calculation worksheets space is already available for class desegregation it is still not possible to know the number of vehicles with MAC per class

Emission Factors

Operation emissions are estimated with an annual rate of 15%, the average of the updated default range (10-20%) in IPCC GPG (table 3.23). Lifetime was set at 12 years also the default value both in IPCC 96 and IPCC GPG.

The emitted quantity to the atmosphere equals the residual product remaining in equipment (variable y) and was set at 40 % the new default value in IPCC GPG.

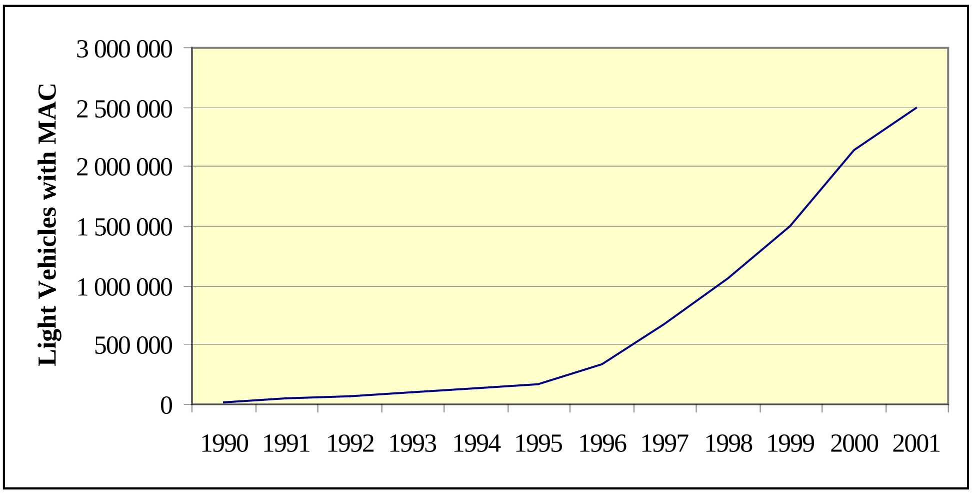
Activity Data Sources

There is scarce information concerning the fleet of road vehicles with air conditioning equipment. The number of light vehicles with MAC were estimated from the total number of light vehicles (ACAP) and the following percentage of new cars with MAC according to information collected in Seixas et al (2000).

Table 4.21 - Assumptions used to estimate number of light vehicles equipped with Mobile Air Conditioning

Year	Light Vehicles with MAC (%)	Source/ assumptions
1990	1	Top class vehicles only
1995	5	Top class vehicles
2000	50	Figure for most important passenger car

Figure 4.12 - Estimated number of Light Vehicles equipped with MAC systems



Emissions do not cover air AC equipments on heavy vehicles, buses and coaches.

Other Relevant Data and Parameters

The assumed quantity of initial charge is 1.2 kg/MAC unit. IPCC GPG proposes an initial charge of 0.8 kg/MAC for passenger cars and 1.2 kg/unit for light trucks while however *1996 IPCC Revised Guidelines* refers 1.2 kg/MAC as adequate for cars[50] and 0.8 kg/MAC is only proposed for new Japanese cars. Because information between these two sources is contradictory it was

[50] According to UNEP Technical Options Report (UNEP, 1989)

decided to maintain the previous figures and change it only after complete clarification of the issue.

It was assumed that HFC 134a is the only HFC substituting CFCs and HCFC, which agrees with IPCC GPG.

4.2.5.10 Foam Blowing

Overview

Fluorine gases are now used as blowing agents in the manufacture of foams that are used as insulating, cushioning and packaging materials.

The foams blowing agent is eventually ventilated to the atmosphere, but at a rate dependent on the type of foam and its structure. Open cell foams emit virtually all blowing agent at time of manufacture. Closed-cell foams emit the HFC blowing agent during their lifetime and three phases may be individualised:

- Foam Manufacturing emissions, occurring in the first year where the foam is produced;
- Annual losses. Occurring where the foam was used, result from the slow liberation of the blowing agent trapped inside the foam.
- disposal. Emissions when foam is removed and destroyed. The remaining gas in cells is emitted to atmosphere.

Activity data on the use of HFC in foam manufacturing in Portugal is available allowing estimate of manufacturing emissions. Annual losses are however harder to estimate because it is not known neither the quantity of closed-cells imported that were manufactured with F gases, nor the quantities of foams that were exported with HFC.

Methodology

It was assumed that all HFC were used in closed-cell foam and that other gases are used in open-cell foams. It was not possible however to distinguish the type of foam where the filling gas is used. Methodology is classified as Tier 2, using national data but with default emission factors. Therefore emissions comprehend:

First year losses from Foam Manufacture and Installation

$$FGas_{Emi\ (t,j)} = FillGas_{Consumption\ (t)} * HFC_{\%(j,t)} * (k/100)$$

Annual losses.

$$FGas_{Emi\ (t)} = FGas_{inFoam\ (t)} * (x/100)$$

$$FGas_{inFoam\ (t,j)} = \sum_{y=t}^{t-Lifetime} [FillGas_{Consumption\ (y)} * HFC_{\%\ (j,y)}]$$

Where:

$FGas_{Emi(t,j)}$ - gas emission in year t of fluorine gas j;

$FGas_{Consumption\ (t)}$ - Total F gas consumption in year t used in closed cell manufacturing;

$HFC_{\%(j,t)}$ - Percentage of Fluorine gas J used in year t in closed-cell manufacturing;

$FGas_{inFoam\ (t,j)}$ - quantity of F gas j in closed-cell existing in the country in year t[51];

K - first year loss emission factor;

X - annual loss emission factor.

This formulation is similar to equation 3.38 of the GPG.

Emissions due to decommissioning of foams was not included in estimates due to the lack of necessary information about foam stock and about expected lifetime and supposing that this period is probably bigger[52] than the time between the first use of HFC and 2001.

Emission Factors

Due to unavailability of country-specific information default emission factors from GPG (table 3.17) where used, which are reproduced in the following table:

Table 4.22 - Emission Factors to estimate F gas emissions from foam losses

Emission Factor		EF (% Original Charge)
K	First Year Losses	10
x	Annual Losses	4.5

Activity Data Sources

Statistical data concerning use of HFC in foam manufacture is very scarce. According to information in an unpublished article (Carreira, 2002) the foam industry has shifted mainly to cycle-pentane as blowing agent and only a few still produce foams with HCFC or more recently HFC. The share of each blowing agent from 1998 to 2001 is presented in next table (Carreira, 2002).

Table 4.23 - Percentage of blowing agents in Foam Blowing in Portugal

Ton	1999	2000	2001
HCFC 141b	220	150	120
HCFC 142/22	70	70	60
HFC 134a	20	30	35
HFC 134a/152	-	30	35
Total	310	280	250

It was assumed that no HFC gas was used in foams before 1998.

For closed-cell foams activity data should be corrected from imports and exports. HFC in foams imported result in annual losses emissions while HFC included in foams exported should be deduced from national emissions. Available statistical data at present moment it is not detailed enough to differentiate HFC foams from other blowing agent foams neither in imports nor in exports and the option was to consider in the inventory only emissions from foams manufactured in Portugal.

[51] For the time being the stock is restricted to foam filled in Portugal;

[52] Good Practice Guidebook sets the default product lifetime as 20 years (table 3.17)

Further Improvement

A mistake was detected in the spreadsheets where calculations are done after CRF tables completion. This will be corrected in next submission.

4.2.5.11 Electric Equipment

Overview

In Portugal, Sulphur hexafluoride (SF_6) is used in the electrical sector both as insulation gas in substations and current interruption media mostly in switch-gear and in circuit breakers. While most gas is recovered at equipment disposal, emissions occur annually as consequence of leaks and equipment failure.

Methodology

Actual emissions of SF_6 from electrical equipment were estimated with a tier 2b method and using a country-specific emission factor. Emissions are determined using the following equation:

$$Emi_{SF6\ (t)} = Stock_{SF6\ (t)} * (k/100)$$

where:

- $Emi_{SF6\ (t)}$ - Equipment use emissions, including leakage emissions, servicing and maintenance;
- $Stock_{SF6\ (t)}$ - total SF_6 gas in existence in year t in all electrical equipments;
- X - percentage of SF_6 in stock in year t that is emitted to atmosphere.

Disposal or retiring units are not included in the inventory as emission sources because, according to industry, the collection of gas at end of lifetime is done in a systematic and efficient mode. Manufacturing and installation emissions were assumed to be included in emissions from equipment usage.

Emission Factors

The emission factor was determined for country-specific conditions after information from the Portuguese company responsible for electricity transmission at high voltage (REN). The emission factor was calculated comparing total SF_6 contained in REN equipments with the quantity of SF_6 that is used annually for losses reposition in years 1995 and 1998-2000, in a manner similar to that recommended in GPG for the development of emission factors. It was assumed that reposition quantities equals losses due to equipment failure. The emission factor used for all years is the average value in the period, and it was set as 0.9%. This value is slightly smaller than the default emission factor recommended in the *1996 IPCC Revised Guidelines*. The GPG proposes higher values, 5% for equipments installed before 1996 and 2% thereafter It was assumed that this country-specific emission factor applies also to non-REN users and also to specific uses: insulating gas in electric equipment.

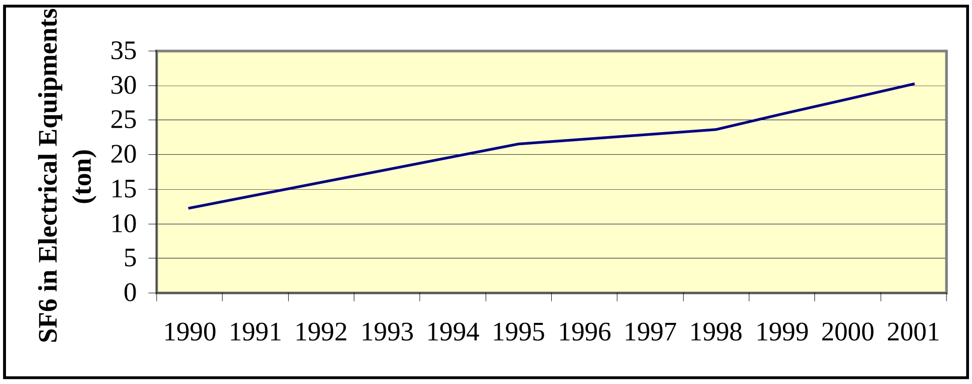
Activity Data Sources

Activity data was available directly from REN, the major national electricity distributor, but only for a restricted number of years (1990, 1995,1998 and projections for 2020). Information for circuit switch breakers and substations for the available years is presented in next table. Interpolation was done to estimate SF_6 stock in equipments for intermediate years, and total SF_6 can be seen in next figure.

Table 4.24 - Quantity of Sulphur hexafluoride stock in Electric Equipments in Portugal

SF_6 (tons)	1900	1995	1998	2010
Switch Breakers	12.3	16.5	18.0	38.0
Sub-stations	0.0	5.1	5.7	11.9
Total	12.3	21.6	23.7	49.9

Figure 4.13 - Total SF6 in stock in electric equipments in Portugal in the period 1990-2001



Further Improvements

The use of a tier 3 methodology is to be pursued for this sector. At present it is possible to follow the amount of new SF6 used to replace leaked gas but only for that part of total stock that is managed by REN. But it is viable to extend that survey to the rest of total country use of SF_6 in electrical equipments.

CHAPTER 5: SOLVENT AND OTHER PRODUCT USE (CRF 3)

5.1 Overview

Solvents and related compounds are a significant source of emissions of non-methane volatile organic compounds (NMVOC) in Portugal. N_2O may also be emitted, from its use in specific applications, but estimates are still not available for this gas in Portugal.

The main sources of NMVOC from this sector in Portugal are Paint Application, Chemical Products Manufacture and Processing and other solvent use, while Degreasing and Dry Cleaning also contribute to emissions at a smaller scale.

5.2 Category Sectors

5.2.1 Paint Application (CRF 3A)

Methodology

Specific emission factors were used for national production paint and varnishes, incorporating that way country-specific information concerning the quantity of solvents that compose paint materials. For imported materials typical solvent content was used instead and differentiation concerns only water based from solvent base paints. NMVOC emissions associated to paint application were therefore estimated from:

$$NMVOC = Cons_{Nat} * FE_{Nat} + Imp_{(W)} * FE_{imp\ (W)} + Imp_{(S)} * FE_{imp\ (S)}$$

where:

NMVOC = Global emissions of NMVOC (ton);

$Cons_{Nat}$ = Consumption of paint and varnishes produced in Portugal (ton);

FE_{Nat} = Emission factor for paint and varnishes produced in Portugal (kg NMVOC/ton Ink);

$Imp_{(W)}$ = Importation of water based paints and varnish (ton);

$FE_{imp(W)}$ = Emission factor associated to the use of imported water based paints and varnishes;

$Imp_{(S)}$ = Importation of solvent based paints and varnish (ton);

$FE_{imp(S)}$ = Emission factor associated to the use of imported solvent based paints and varnishes.

Total VOC emission from paint and varnishes application was disaggregated by different uses. Table 5.1 shows the percentage of VOC emission by activities in the years 1990 and 1991.

Table 5.1- Distribution of VOC emission by activities

	1990	1991
Industry total	**44.1**	**43.8**
Automobile manufacture (including motor-cycles and bicycles)	5.0	4.1
Ceramics, porcelain, faience manufacture	3.3	2.5
Manufacture of metal articles	10.0	10.0
Manufacture of electrical industrial equipment	0.6	0.8
Ship building and repair	0.8	0.8
Vehicle refinishing	4.8	4.0
Wooden furniture	19.3	21.2
Other industry	0.3	0.4
Construction, building and domestic total	**55.9**	**56.2**

The disaggregation of emissions for specific sectors was determined according to the following procedures:

- NMVOC emissions were estimated in a first approach from paint consumption and emission factors representing typical composition of the paints used in each specific sector:

$$NMVOC_{first\ (s,y)} = Paint_{Cons(s,y)} * DFE_{NMVOC\ (s)}$$

where

$NMVOC_{first\ (s,y)}$ - Fist approximation emission of NMVOC from sector s (ton/yr);

$Paint_{Cons(s,y)}$ - Consumption of paint and varnishes in sector s (ton/year);

$DFE_{NMVOC\ (s)}$ - Emission factor specific of sector s used for desegregation purposes only (kg/ton).

- to estimate VOC emission in industry CORINAIR90 Default Emission Factors were applied to the amount of paint and varnish consumed in industry. The emission factor is 500 kg/ton for paint and varnish applied in industry and 280 kg/ton in the case of vehicle refinishing (including coating, paint, cleaning solvents);

- It was assumed that the paint and varnish not consumed in industry was used for construction, building and domestic, and that all water based paint and varnish consumed was used in construction, building and domestic use. An weighted emission factor of 350 kg/ton was adopted which is the average value between : CORINAIR90 default VOC emission factor for paint and varnish applied in construction and building (300 kg/ton) and the default emission factor for domestic use (400 kg/ton);

- finally emissions per sector were corrected to equal total emissions estimated from mass balance of production, import and export, because this estimation method is more reliable:

$$NMVOC_{(s,y)} = NNVOC_{Balance\ (y)} * NMVOC_{first\ (s,y)} / \Sigma_s [NMVOC_{first\ (s,y)}]$$

where

NMVOC (s,y) - Final emission attributed to sector s (ton/yr);

$NNVOC_{Balance\ (y)}$ - Total emission of NMVOC estimated from global balance (ton/yr);

Emission Factor

To estimate the emission factor for the use of national produced paint and varnish the ratio of the amount of solvents consumed during manufacture processes with the amount of paint and varnish produced was computed. The emission factor used for calculating the VOC emission from the manufacture of paint and varnish was subtracted from this value in order to obtain the national emission factor presented in Table 5.2.

Table 5.2- National emission factor (kg/ton).

	1990	1991	Average
Production and use of paint and varnish	243	238	240.5
Only for use of paint and varnish	228	223	225.5

Emission factors from *CORINAIR90 Default Emission Factors Handbook* were used for use of imported paints. For water based paint and varnish the emission factor is 30 kg/ton ($EF_{Imp(W)}$) while for solvent based paint and varnish is was set as 500 kg/ton - $EF_{Imp(S)}$.

Ultimate CO_2 emissions are calculated assuming that 85 percent of the mass emissions of NMVOC is carbon and it is converted to carbon dioxide in the atmosphere:

$$U_{CO2} = 44/12 * NMVOC * 0.85$$

where:

U_{CO2} = Ultimate CO_2 (ton)
NMVOC = Global emissions of NMVOC (ton)

Activity Data

Statistical information concerning use of paints is not available for all activities in Portugal. Total consumed paint and varnish in Portugal may be estimated by mass balance:

$$Cons = NP + Imp - Exp$$

where:

Cons = Consumed paint and Varnish (ton)
NP = National Produced Paint and Varnish (ton)
Imp = Imported Paint and Varnish (ton)
Exp = Exported Paint and Varnish (ton)

Consumption of paint and varnishes that were produced in Portugal was estimated from.

$$Cons_{Nat} = Prod_{Nat} - Exp$$

where:

$Cons_{Nat}$ = Consumed paints produced in Portugal (ton);

$Prod_{Nat}$ = National production of paints and varnishes (ton);
Exp = Exported paints and varnishes (ton).

Statistical information associated to production, importation and exportation was available from the National Statistics Institute (INE) for years 1990 and 1991. No information was available concerning following years and therefore the average 1990-1991 value was considered.

Table 5.3 **-** Paint and varnish production, importation and exportation values (ton)

Year	National Produced Paint and Varnish			Imported Paint and Varnish				Exported Paint and Varnish			
	Water Based Paint and Varnish	Solvent Based Paint and Varnish	Other non water based paint and varnish	Water Based Paint and Varnish	Solvent Based Paint and Varnish	Other non water based paint and varnish	Artistic Based Paint and Varnish	Water Based Paint and Varnish	Solvent Based Paint and Varnish	Other non water based paint and varnish	Artistic Based Paint and Varnish
1990	78 380	21 277	15 953	1 742	5 817	2 612	102	1 170	3 491	1 287	2
1991	81 539	20 582	15 157	2 689	7 399	2 803	95	1 482	3 771	1 272	5

Therefore, the following consumption of Paint and Varnish it is considered in the inventory.

Table 5.4 **-** Consumed Paint and Varnish (ton)

Year	Consumed Paint and Varnish				
	Water Based Paint and Varnish	Solvent Based Paint and Varnish	Other non water based paint and varnish	Artistic Based Paint and Varnish	Total
1990	78 952	23 603	17 278	100	**11 9933**
1991	82 746	24 210	16 688	90	**12 3734**
92-2001	80 849	23 907	16 983	95	**12 1834**

Table 5.5 presents the quantity of solvents and similar substances used in the manufacture of paint and varnish (obtained also from INE Statistical Database). These values were used to calculate the national emission factors as explained before.

Table 5.5 - Solvents consumption in paint and varnish manufacture (ton).

Substance	1990	1991
Plasticiers	543	529
Dryers	242	238
Others solvents	27 247	27 083
Total	**28 032**	**27 850**

In Table 5.6 paint and varnish industrial consumption is shown per industrial sector according to information from INE. Because this database did not include consumption of paint in vehicle refinishing and wooden furniture industry, they were set from national production paints and varnishes for that specific uses[53] which is shown in Table 5.7.

[53] Corrected to incorporate imports and exports.

Table 5.6 - Paint and varnish industrial consumption

	Paint and varnish consumption (ton)		
	1989	**1990**	**1991**
Automobile manufacture (including motor-cycles and bicycles)	1 520	1 889	1 548
Ceramics, porcelain, faience manufacture	972	1 245	929
Manufacture of metal articles (except automobiles)	2 867	3 732	3 775
Manufacture of electrical industrial equipment	264	216	297
Ship building and reparation	374	308	291
Manufacture of wooden boxes and packings	0	1	1
Osier articles industry	7	11	4
Manufacture of window and door blinds	9	5	9
Tyres reconstruction	13	6	13
Glass industry	16	32	33
Manufacture of publicitary material	22	47	75
Manufacture of electrical equipment for houses	2	n.a.	n.a.
Manufacture of filaments and cables	89	n.a.	n.a.
Manufacture of wax and shoe polishing	13	n.a.	n.a.
Manufacture of railway material	90	n.a.	n.a.
Total	**6 258**	**7 492**	**6 975**

n.a.- not available information

Table 5.7 - National produced paint and varnish for vehicle refinishing and furniture manufacture

	Vehicle Refinishing Use (ton)		*Furniture Manufacture Use (ton)*	
	1990	**1991**	**1990**	**1991**
Celulosic based paint and varnish	1 270	992	4 832	4 969
Resinous based paint and varnish	518	503	1 676	1 855
Oil paint and varnish	1 095	881	0	0
Total	**2 883**	**2 376**	**6 508**	**6 824**

5.2.2 Degreasing and dry cleaning (CRF 3B)

Methodology

Assuming that all solvents consumed, during other industries manufacture processes, evaporate, NMVOC emission will be equal to the amount of solvents used.

The CO_2 emissions are derived by assuming that 85 percent of the mass emissions of NMVOC is carbon:

$$U_{CO2} = 44/12 * NMVOC * 0.85$$

where:

U_{CO2} = Ultimate CO_2 (ton);
NMVOC = Global emissions of NMVOC (ton).

Activity Data

The statistical information concerning total solvent use in these sectors, from the National Statistics Institute (INE), was used to estimate VOC emissions.

Table 5.8 **-** Solvent use in degreasing and dry cleaning (ton)

Sub-Sector / Year	1990	1991	1992-2001
Metal Degreasing	1 552	1 415	1 484
Dry Cleaning	2 341	2 341	2 341

5.2.3 Chemical products, manufacture and processing (CRF 3C)

Methodology

Emissions where estimated by the use of emission factors that are multiplied by the quantity of material produced:

$$Emission_{NMVOC} = EF * ActivityRate * 10^{-3}$$

where

$Emission_{NMVOC}$ - annual emission of NMVOC (ton/yr);
ActivityRate - Indicator of activity in the production process. Quantity of product produced per year as a general rule for this emission source sector (ton/yr);
EF - emission factor (kg/ ton)

It was assumed that NMVOC result mostly from solvents and these have fossil origin contributing to ultimate carbon dioxide emissions. Ultimate carbon dioxide emissions are calculated assuming that emitted VOC have on average 85% of carbon:

$$Emi_{CO2} = 0.85 * Emi_{NMVOC}$$

a. Polymer processing

Processing of polymers to produce plastic materials involve organic compounds emission to atmosphere resulting from leakage of some monomers still present in the polymer mass, some polymer decomposing, evaporation of additives - such as phthalic anhydride - but mostly from solvents used in the production process.

Synthetic fibbers production emit non-methane volatile organic compounds that result from solvent use, for example to dissolve the polymer prior to extrusion.

Activity Data

Information about activity data for this sector is still scarce and limited to 1990, from National Statistics Institute (INE). However, because some polymers and fibbers are produced in a restricted number of industrial units confidentiality constrains avoid their publication in NIR.

<u>Emission Factors</u>

Emission factors applied to polymer processing and fibber production were all set from AP42 (US-EPA), and from CORINAIR/EMEP as it is presented below:

Table 5.9 – Emission factors

Material	NMVOC
Rayon	0
Poliamides	3.93
Polyester	0.6
Polyethylene	5
Polypropylene	5
PVC	150
Acrylics	40
Polyester	40.0
PVC	40.0
Poly-urethane	6.0
Poly-Styrene	6.0

b. Rubber processing

<u>Methodology</u>

Assuming that all solvents consumed during rubber processing evaporate, NMVOC emission will be equal to the amount of solvents used.

<u>Activity Data</u>

The data shown in Table 5.10 and 5.11, from INE, were used to estimate NMVOC emission from rubber processing. In Table 5.10 the amount of rubber processed is presented. Table 5.11 shows solvents consumption (benzene and others) in tyres and rubber articles manufacture and tyre reconstruction.

Table 5.10 - Processed rubber (ton).

	1989	1990	1991
Manufacture of tyres	29 466	n.a.	n.a.
Manufacture of rubber articles	13 455	12 375	12 644
Reconstruction of tyres	10 615	n.a.	n.a.
Total	**53 536**	**12 375**	**12 644**

n.a.-not available

Table 5.11 - Solvents consumption from rubber processing (ton).

	1989	1990	1991
Manufacture of tyres	615	430	n.a.
Manufacture of rubber articles	752	285	244
Reconstruction of tyres	11 579	11 180	12 851
Total	**12 946**	**11 895**	**-**

n.a.-not available

c. Paints Manufacturing

Activity Data

Production of paints and varnish in Portugal was already presented in chapter 5.2 – Paint Application.

Emission Factors

The CORINAIR emission factor was used - 15 kg for each tone of paint or varnish manufactured, that includes emissions during cleaning of installations. This emission factor was applied to the value of paint and varnish produced in Portugal

d. Inks Manufacturing

Activity Data

Production of inks in Portugal is available in Portugal for years 1990 and 1991 from INE. Average values were considered for subsequent years. Production of inks is reported in chapter 5.5.

Emission Factors

The CORINAIR emission factor was adopted - 30 kg for each tone of ink manufactured, including the cleaning of industrial installations.

e. Glues Manufacturing

Activity Data

Production of glues and adhesives in Portugal is available in Portugal for years 1990 and 1991 from INE. Average values were considered for subsequent years. Production of glues and adhesives is reported in chapter 5.5.

Emission Factors

The CORINAIR emission factor was adopted - 20 kg for each tone of glues and adhesives manufactured, which is applied to all kind of glues and adhesives, with or without solvents in their composition, and includes the cleaning of industrial installations.

5.2.4 Other use of solvents and related activities (CRF 3D)

Overview

In this chapter are included emission calculations for different activities, such as: 1) printing Ink; 2) edible and non edible oils; 3) glue and adhesives; 4) preservation of wood; 5) solvents use; 6) perfume use; 7) waxes and polishing products; 8) soaps and detergents.

a. Printing Ink

Methodology

$$NMVOC = Cons_{Nat} * FE_{Nat} + Imp * FE_{imp}$$

where:

NMVOC = Global emissions of NMVOC (ton)
$Cons_{Nat}$ = Consumption of Printing Ink produced in Portugal (ton)
FE_{Nat} = Emission factor for inks produced in Portugal (kg NMVOC/ton Ink)
Imp = Importation of Printing Ink (ton)
FE_{imp} = Emission factor associated to the use of imported Printing Ink.

$$Cons_{Nat} = Prod_{Nat} - Exp$$

where:

$Cons_{Nat}$ = Consumed printing ink produced in Portugal (ton)
$Prod_{Nat}$ = National Produced printing ink (ton)
Exp = Exported Ink (ton

Emission Factors

To estimate the emission factor for the use of national produced printing inks, the ratio of the amount of solvents consumed (table 5.12) during manufacture processes with the amount of ink manufactured was computed.

Table 5.12 - Solvents consumption in paint and varnish manufacture (ton).

	1989	1990	1991
Plastifiers	19	20	19
Dryers	13	11	11
Others solvents	1 029	1 155	1 159
Total	**1 061**	**1 186**	**1 189**

The emission factor used to calculate VOC emission from ink manufacture was subtracted from this value, in order to obtain the national emission factors (Table 5.13).

Table 5.13- National emission factors (kg/ton)

	1989	1990	1991	Average
For production and use of ink	315	383	352	350
Only for use of ink	285	353	322	320

The CORINAIR VOC emission factor of 500 kg/ton of ink applied was used to estimate VOC emission from imported ink consumption.

Activity Data

Table 5.14 - Activity Data (ton)

Year	1990	1991	1992 -2001
National Production	3 098	3 375	3 280
Importation	1 611	1 850	1 731
Exportation	213	184	199

b. Edible and non edible oils

Methodology

$$NMVOC = Produced\ Solvents$$

where:

NMVOC - Emissions of NMVOC (ton)

Consumed Solvents - quantity of produced solvents in edible oil industry (ton)

Emission Factors

The national emission factor was calculated[54] by the ratio of the amount of solvents consumed during manufacture processes with the amount of edible and non edible oil manufactured (table 5.15). The average emission factor is smaller than the one proposed in CORINAIR (18 kg/ton).

Table 5.15 - National emission factor (kg/ton).

1989	1990	1991	Average
18	13	14	15

Activity Data

Table 5.16 **-** Solvent consumption (ton)

Year	1990	1991	1992 - 2001
Olive Oil Production (ton)	9 883	8 368	9 126
Other edible oils (ton)	218 052	223 375	220 714
Solvents Consumption (ton)	2 978	3 105	3 042

Source: National Statistics Institute (INE)

c. Glues and adhesives

Methodology

$$NMVOC = Cons_{Nat} \times FE_{Nat} + Imp \times FE_{imp}$$

where:

NMVOC = Global emissions of NMVOC (ton)

$Cons_{Nat}$ = Consumption of Glues and Adhesives produced in Portugal (ton)

FE_{Nat} = Emission factor for Glues and Adhesives produced in Portugal (kg NMVOC/ton Ink)

Imp = Importation of Glues and Adhesives (ton)

FE_{imp} = Emission factor associated to the use of imported Glues and Adhesives.

[54] only for comparison purposes because it is not used in emission estimate.

$$Cons_{Nat} = Prod_{Nat} - Exp$$

where:

$Cons_{Nat}$ = Consumed Glues and Adhesives produced in Portugal (ton)
$Prod_{Nat}$ = National Produced Glues and Adhesives (ton)
Exp = Exported Glues and Adhesives (ton)

Emission Factors

To estimate the emission factor applied for the use of national glues and adhesives, the ratio of the amount of solvents consumed (table 5.17 from INE) during manufacture processes with the amount of glues and adhesives manufactured was computed, and an average emission factor obtained (Table 5.18). The emission factor for VOC emission from the manufacture of glue and adhesives was subtracted from this value to obtain the emission factors for use of national produced glue and adhesives.

Table 5.17- Solvents consumption in glue and adhesives manufacture (ton).

	1989	1990	1991
Methyl ketone	361	328	328
Dibutyl phthalate	97	134	143
Ethyl Acetate	373	351	355
Hexane	1 567	1 357	1 277
Benzene	295	354	335
Toluene	1 839	1 690	1 799
Other solvents	1 876	2 010	2 003
Total	**6 408**	**6 224**	**6 240**

Table 5.18 - National emission factors (kg/ton).

	1989	1990	1991	Average
For production and use of glue and adhesives	190	172	175	179
Only for use of glue and adhesives	170	152	155	159

For non-natural imported glues and adhesives the CORINAIR90 Default Emission Factor was used: 600 kg/ton. It is considered that natural based glue does not contribute to NMVOC emission.

Activity Data

Table 5.19 - Activity Data for non natural glues and adhesives (ton)

Year	1990	1991	1992 - 2001
National Production (ton)	36 297	35 769	35 473
Importation (ton)	2 192	2 328	2 260
Exportation (ton)	707	532	620

Source: National Statistics Institute (INE) *d. Wood Preservation*

Methodology

$$NMVOC\ (Consumption) = Consumption \ * FE_{Consumption}$$

where:

NMVOC (Consumption) - Emissions of NMVOC associated to consumption of wood preservation products (ton)

Consumption - Consumption of wood preservation products (ton)

$FE_{Consumption}$ - Emission factor associated to the consumption of wood preservation products (=100 kg/ton)

Emission Factors

CORINAIR90 Emission Factor Handbook proposes three emission factors for VOC emission from wood preservation, depending on the type of product used. The emission factor is 100 kg/ton of product applied for creosote; 900 kg/ton for solvent based products and 0 for water based products. The available data do not discriminate the share of the several types of preservation products, therefore, it was assumed that the main product used in Portugal is creosote.

Activity Data

Table 5.20 **-** Wood preservation products consumption (ton)

Year	1990	1991	1992 - 2001
Wood Preservation products Consumption (ton)	2083	2900	2491

Source: National Statistics Institute (INE)

e. Perfumes and Cosmetics Use

Methodology

Perfumes, personal hygiene and cosmetic products. Lipsticks, brilliantine, beauty creams and milks, depilatories, deodorants, hair sprays, sun lotions, tanner products, shampoos, tooth-cleaning, hair coloration and nail varnishes, among others, were considered in perfume, personal hygiene or cosmetic product. Emissions are estimated from:

$$NMVOC \ = Use \ * FE_{Prod+use}$$

where:

NMVOC - Emissions of NMVOC associated to the production and use of perfumes (ton)

Use - Use of perfumes (ton);

$FE_{Prod+use}$ - Emission factor associated to the production and use of perfumes (ton)

Emission Factors

Since there are no available VOC emission factor for this activity an emission factor for VOC emission during the production and the use of these products was calculated. It was estimated by the ratio of the amount of solvents consumed during the manufacture process with the amount of perfumes, personal hygiene and cosmetic products manufactured..

$$FE_{Prod+use} = Solvents / National\ Production$$

where:

$FE_{Prod+use}$ = Emissions of NMVOC associated to consumption of perfume and cosmetics use (ton)

Solvents = Solvent content of perfumes (ton)

National Production = National production values of perfumes (ton)

Table 5.21 - Calculated emission factor (kg/ton).

1989	1990	1991	Average
162	170	184	172

Activity Data

Table 5.22 **-** Activity data associated to Perfumes Use (ton)

Year	1990	1991	1992-2001
National Production (ton)	21 587	19 540	20 957
Imports (ton)	10 830	15 210	13 020
Exports (ton)	3 829	4 201	4 015
Solvents (ton)	3 665	3 590	3 595

Source: National Statistics Institute (INE)

f. Waxes and polishing products

Methodology

The Methodology is equal to the used for Perfume Use.

Emission Factors

The national emission factor, obtained in the same mode, was (kg/ton):

Table 5.23 – Emission factors

1989	1990	1991	Average
525	299	293	372

Activity Data

Table 5.24- Activity data associated to Waxes and polishing products use (ton)

Year	1990	1991	1992 - 2001
National Production (ton)	3 963	3 781	3 312
Imports (ton)	12 390	12 429	12 410
Exports (ton)	983	403	693
Solvents (ton)	1 185	1 106	1 147

Source: National Statistics Institute (INE)

g. Soaps and Detergents

Methodology

The Methodology is equal to the used one used for Perfume Use.

Emission Factors

The national emission factor (kg/ton), obtained in the same mode kg/ton is:

Table 5.25 – Emission factors

1990	1991	Average
2	2	2

Activity Data

Table 5.26 **-** Activity data associated to Waxes and polishing products use (ton)

Year	1990	1991	1992 - 2001
National Production (ton)	209 575	185 681	197 628
Imports (ton)	57 488	59 831	58 660
Exports (ton)	34 710	23 972	29 341
Solvents (ton)	461	426	437

Source: National Statistics Institute (INE)

h. Uses of solvents from biomass

There are two organic substances used as solvents: ethanol and rosin derivatives that may be emitted to atmosphere when used. Emissions may be estimated from consumption of these substances. However, in some activities, such as beverage and food industry, use of alcohol does not contribute to air emissions because it is ingested, and it is not included in emissions.

Methodology

Emissions are therefore estimated from:

$$NMVOC = TotalConsumption - Cons_{NONEMI}$$

Where

NMVOC – Emission (ton/yr);

TotalConsumption – Total consumption of biological solvent in all activities (ton/yr);

$Cons_{NONEMI}$ – Consumption of biological solvents in activities where solvents are not emitted to atmosphere (ton/yr).

For rosin derivatives total consumption is obtained from industrial production corrected from imports and exports:

$$TotalConsumption = IndustrialProduction + Imports - Exports$$

Because these two compounds have a biological origin they are not used to estimate emissions from ultimate carbon dioxide.

Activity Data

Industrial production of ethanol is presented in Table 4.23, which may be considered, neglecting foreign trades, equal to the consumption of alcohol. Industrial consumption of alcohol in 1989 is shown in Table 5.27 by use. Statistical data is from INE in both cases.

Table 5.27 - Industrial production of ethanol (ton).

1989	1990	1991
7 754	9 941	8 027

Table 5.28 - Industrial consumption of alcohol in 1989 (ton).

Use	ton
Food and beverage industry	2 185
Manufacture of perfumes, personal hygiene and cosmetic products	1 913
Manufacture of waxes and polishing products	235
Total	**4 333**

Rosin derivatives include turpentine oil, α-pinene, etc. The annual production of rosin derivatives is presented in Table 4.25 and foreign trades values in Table 4.26. Statistical information is from the National Statistical Institute (INE).

Table 5.29- Rosin derivatives production (ton).

1989	1990	1991
13 362	12 145	11 299

Table 5.30 - Foreign trades of rosin derivatives (ton).

Imports (ton)		***Exports (ton)***	
1990	**1991**	**1990**	**1991**
722	700	11 558	13 692

i. Other uses of synthetic solvents from fossil fuels

Methodology

NMVOC = Produced Solvents

where:

NMVOC = Emissions of NMVOC (ton)
Consumed Solvents = quantity of produced solvents(ton)

The calculation of Global CO_2 emissions is made using equation (8).

Activity Data

Table 5.31 **-** Synthetic solvents consumption in other industries (ton)

Year	1990	1991	1992 - 2001
Solvents (ton)	3 885	4 014	3 950

Source: General Directorate of Energy (DGE)

5.3 Recalculations

No changes have been made since last submission.

5.4 Further Improvements

Production values used on emission values calculation were obtained with severe limitations. Reliable data is available only for years 1990 and 1991. The production values for the year 1992 and beyond were calculated by arithmetic average of 1990 and 1991 values.

Recently the National Statistical Institute (INE) has made available to IA more detailed statistical information concerning use of raw materials and quantities of products in the extractive and transformation industry. This information will be used to update the inventory and ameliorate information in time-series. It is expected that new time series will be available since 1992. However, similar information was already available for 1990 and 1991 and emission estimates for base year are not expected to vary appreciably.

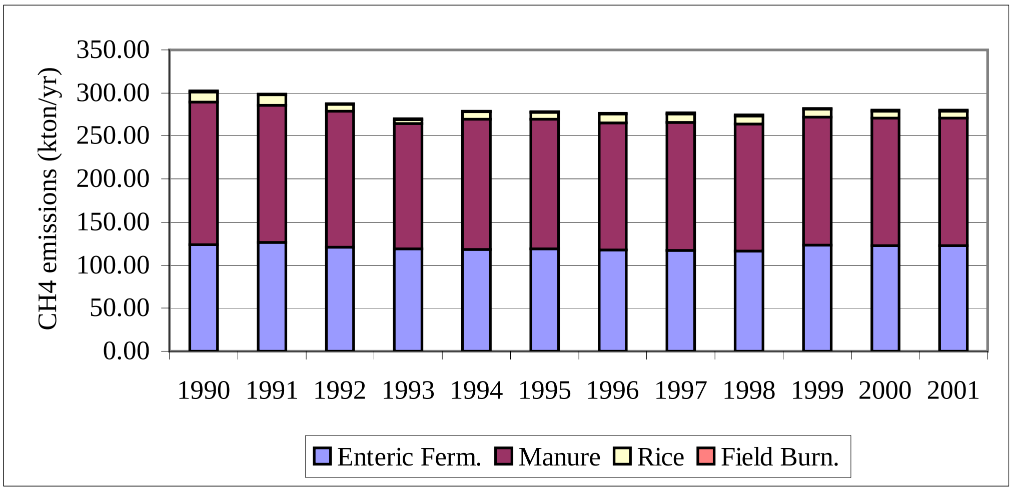
CHAPTER 6: AGRICULTURE (CRF 4)

6.1 Overview

Agriculture activities generate emissions of GHG from a variety of different sources. This section includes the quantification of: CH4 emissions from enteric fermentation and rice cultivation, CH4 and N2O emissions form manure management; direct and indirect N2O emissions from agriculture soils; field burning of agriculture residues; and NH3 emissions from agriculture. There are no ecosystems in Portugal that could be considered natural savannas and no greenhouse gas emissions exist therefore for this sub-category.

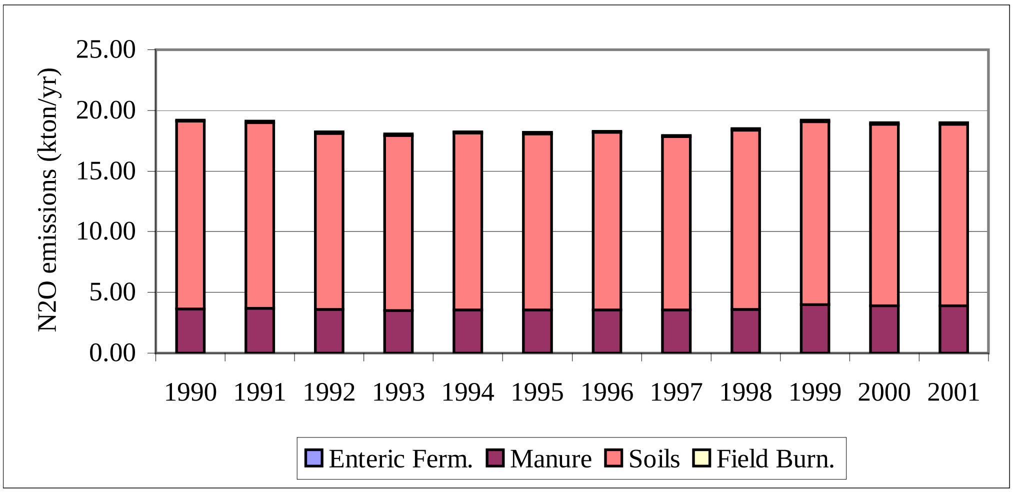
Emissions of CH4 from agriculture have decreased slightly (6 %) from 1990 until 2001 (Figure 6.1) and result mostly from Manure Management (54 % on average) and Enteric Fermentation (43 % on average). The remaining 3.2% of emissions are emitted by rice cultivation and emissions from field burning of residues are only 0.3% of total emissions (average value in the period 1990 to 2001).

Figure 6.1 - Methane emissions from agriculture



N2O emissions are more or less constant in the 1990-2001 period (Figure 6.2). The great majority of emissions are associated with direct and indirect emissions from agricultural soils (79.6%), manure management is responsible for 19.8% of emissions, while the small remaining fraction results from field burning of agricultural residues.

Figure 6.2 - Nitrous Oxide emissions from agriculture



Total GWP emissions from the agriculture sector has decreased 6% in the 1990-2001 period.

6.2 Source categories

6.2.1 CH4 Emissions from Enteric Fermentation in Domestic Livestock (CRF 4A)

Overview

CH4 emissions from enteric fermentation in animals result from methane being produced as a by-product in the digestive process of carbohydrates by micro-organisms in the digestive system. This process occurs specially in ruminant animals, due to the presence of specific micro-organisms in their digestive tracts, but also in smaller quantities in monogastric animals (swine, equines, birds and rabbits). The estimates in this inventory include only emissions in domestic animals. Emissions from wild animals and semi-domesticated game are not quantified neither are emissions from humans or pet animals.

CH4 emissions from enteric fermentation is a key source, both by level and trend assessment. Dairy cattle and non-dairy cattle are significant sources: dairy cattle represents 32.5% to 29% of total CH4 emissions from Enteric Fermentation while non-dairy cattle represents about 37% to 41% of total CH4 from enteric fermentation. Together cattle is responsible for about 70% of total CH4 emissions from enteric fermentation.

Sheep are also an important source which emissions have oscillated between 21% and 24% of total CH4 from Enteric Fermentation. Emissions from goats were 2.5-3.5% of total enteric fermentation and swine represented 2.9-3.2% of emissions. Emissions of methane from all other species decreased from 1.6% to 1.1% along 1990 to 2001 and are therefore slightly representative.

Methodology

Emissions were estimated for each specie by multiplying the number of animals by the respective emission factor according to equation 4.12 of the Good Practice Handbook (Tier 1 method).

$$E_{CH4} = EF \bullet N$$

where, for each specie:

E_{CH4} - methane emissions from enteric fermentation, kg CH4/year
EF - emission factor for the specific population, kg/head/year
N - the number of animals, head.

Because CH4 from enteric fermentation is a key source, for a strict application of Good Practices a tier 2 approach with and enhanced livestock characterization should be used at least for the most significant sources: dairy cattle and non-dairy cattle, which together sum about 70% of total CH4 emissions from enteric fermentation (dairy cattle importance changes from 32.5% to 29% where non-dairy cattle represent about 37% to 41% of total CH4 from enteric fermentation). However, presently the inventory can not go beyond tier 1 as consequence of lack of appropriate country -specific data about energy requirements, feed intake and methane conversion rate. Any calculation done with data available at this moment would result in emission factors different from IPCC defaults that would not be actually country-specific in nature.

Emission Factors

Emission factors may be seen in next table. For most species they are the default emission factors proposed by IPCC96 for West Europe (tables 4-3 and 4-4). For rabbits the emission factor was set approximately from horses, the available animal in IPCC with a most similar digestive system, but scaled to differences in size according to the equation proposed by GP to assess the importance of emissions for the specie:

$$EF_{Rabbit} = [(\text{rabbit weight})^{0.75} / (\text{horse weight})^{0.75}] \bullet EF_{Horse}$$

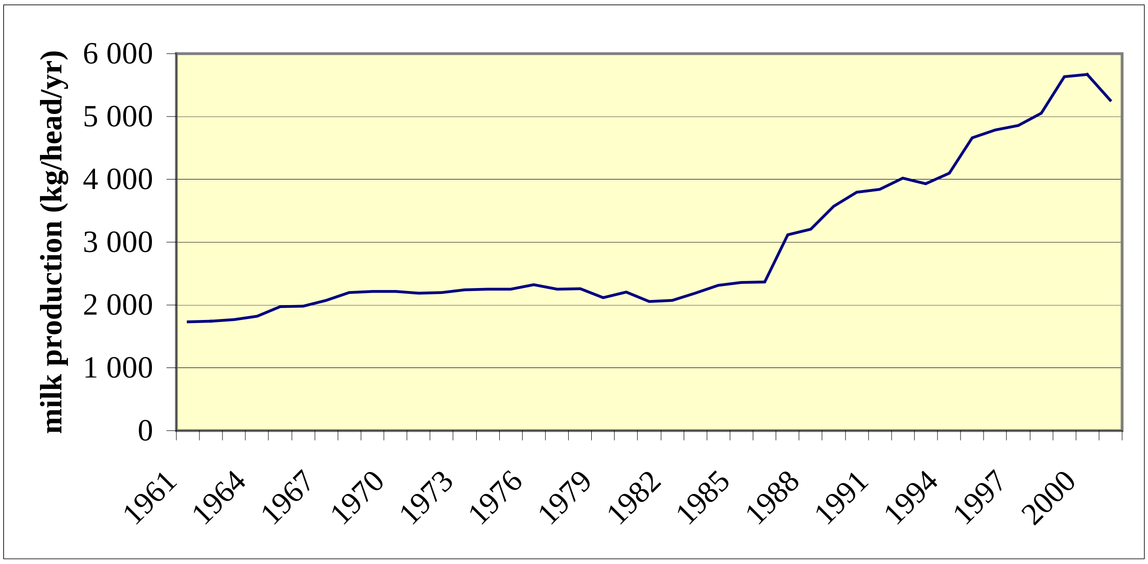
Table 6.1 - Emission Factors (kg CH4/head/year)

Class	EF (kg CH4/head/year
Dairy Cows	100
Other Cattle	48
Ewes (Breeders)	8
Other sheep	8
Female goats (Breeders)	5
Other Goats	5
Female Pigs (breeders)	1.5
Other swine	1.5
Horses	18
Mules and Asses	10
Rabbits (Female breeders)	0.5

In accordance with the unavailability of emissions factors in IPCC96 for broilers, laying hens, turkeys, ducks, geese, guinea fowl and other poultry, emissions from these classes were not estimated and were assumed negligible.

The average milk production per cow in Portugal is presented in figure 6.1. It can be seen that milk production has increased sharply, particularly since the entrance in the EEC/UE in 1986. In the period 1990 to 2001 the average milk production per head was about 4633 Kg milk/head/year which is slightly bigger than the value assumed in IPCC 1996 to derive default emission factors for Western Europe (4 200 kg/head/yr in IPCC 96 table 4-4). No attempt was made to incorporate the effect of increased milk production in the increase of the emission factor.

Figure 6.3 - Milk production per cow (kg milk/head/year): 1961 to 2001 (FAO Statistical Database)



Activity Data Sources

Livestock numbers, presented in table 6.2, were collected by the National Statistics Institute (INE). However not all species are inventoried annually and interpolations were done in the intermediate years. Number of rabbits, turkeys, ducks, geese and guinea-fowl are only available for 1999 and are assumed constant during the all period. All numbers represent stock numbers at a particular time in the year, mostly December and consequently for some species such as goats and sheep real numbers are higher than annual averages.

Table 6.2 - Livestock Numbers (Thousands)

Classe	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Dairy Cows**	403	404	381	375	356	364	362	362	355	357	355	355*
Other Cattle	972	1 012	964	948	961	960	949	923	912	1 064	1 059	1 059*
Ewes (Breeders)	2 227	2 240	2 219	2 191	2 264	2 301	2 265	2 288	2 266	2 439	2 436	2 436*
Other sheep	1 133	1 140	1 129	1 114	1 152	1 127	1 115	1 126	1 254	1 145	1 143	1 143*
Female goats (Breeders)	616	634	617	601	588	581	569	572	561	457	453	453*
Other Goats	241	248	241	235	230	218	212	213	235	172	169	169*
Sows (Breeders)	346	333	331	363	330	333	330	334	325	326	323	323*
Other swine	2 318	2 231	2 216	1 901	2 086	2 069	2 014	2 031	2 016	2 024	2 015	2 015*
Horses	36	36*	35*	35*	35*	35	36*	38*	40*	41	40*	40*
Mules and Asses	114	106*	98*	90*	82*	74	69*	65*	60*	55	45*	45*
Rabbits (Female breeders)	338*	338*	338*	338*	338*	338*	338*	338*	338*	338	338*	338*
Broilers and Male Breeders	22 271	22 677*	23 084*	23 490*	23 896*	24 303*	24 709*	25 115*	25 522*	25 928	26 335*	26 335*
Hens (Laying and Breeders)	4 565*	4 565*	4 565*	4 565*	4 565	4 908	4 758	5 238	6 332	11 980	10 480*	10 480*
Turkeys	1 263*	1 263*	1 263*	1 263*	1 263*	1 263*	1 263*	1 263*	1 263*	1 263	1 263*	1 263*
Ducks, Geese, Guinea-fowl	771*	771*	771*	771*	771*	771*	771*	771*	771*	771	771*	771*

* estimated/interpolated/extrapolated from time series
** adult animals only.

National statistics from INE agree quite well with FAO data on cattle particularly toward the end of the period. The situation is similar with goats and pigs. However FAO reports sheep numbers are about 70% higher than National statistics for every year. This probably results from the inclusion of temporary animals in stock (lambs) that did not exist in December. Correction for this number was not made because it is not clear if the default emission factor from IPCC includes or does not include this situation. Emissions from lambs are probably less important due to the smaller size and ingestion of milk during part of the grow period. The correction of sheep population with FAO data would not make sheep a significant source of CH4 for this source category.

The number of horses, mules, asses and turkeys is very different when comparing statistics from FAO and INE, but they have a small importance in the emissions inventory.

Recalculations

No modifications were performed in submission 2003.Some changes in livestock population occurred between submission 2001 and 2002 for all species concerning the last years (1999 and 2000) of the time series. These changes were due to new available data concerning a special statistical characterisation of the agricultural sector performed at national level. New species were included: turkeys, laying hens, ducks, geese and rabbits. The emission factors remained the same for all species.

Further Improvements

Because CH4 from Enteric Fermentation is a key source (both in level and trend assessment) emissions estimates must improve to a tier 2 methodology at least for dairy cattle and non-dairy cattle the most significant sources[55]. It is expected that on-going contacts with the Agriculture Ministry will allow improvements in the knowledge of basic data concerning feed intake, digestibility and methane conversion and that a tier 2 could be applied in next inventory reports. Information for latter years allow also a better desegregation per age and sex classes at least for cattle, sheep and swine. An improvement must be made about sheep livestock numbers and is also needed to clarify if the default IPCC emission factor is to be applied with or without correction for temporary lambs.

Although tier 1 was used to estimate emissions for all species there is now some available information allowing a better characterisation of sub-category populations for cattle, swine, sheep and goats. The new information allows sub-categorisation of cattle by race, age and sex groups, sheep and goats by race and swine by animal weight and sex.

These information will be used to enhance livestock characterisation and determine tier 2 emission factors in the near future, using for instance the feed intake energetic model proposed in the Good Practice. It is expected that this update could be available in the report for next year for cattle, sheep and swine.

It is expected to clarify differences between FAO statistical data and national statistics at least for sheep and goats. Clarification about what type of statistical data should be used with the IPCC default emission factor must also be improved.

Activity data for 2001 is still provisional and will be updated with official values in the next submission.

An estimate of wild and semi-wild game animals it is expected in the near future although this is not a priority action.

If tier 2 cannot be applied at least the increase of milk production per cow must be included in the emission factor trend.

[55] Established according to the rule of thumb in note 2 of page 4.24 of GPG.

6.2.2 CH4 Emissions from Manure Management (CRF 4B)

Overview

Methane is emitted from manure when the organic material it contains decomposes in a anaerobic environment by the action of methanogenic bacteria. The emission depends mostly in the anaerobic conditions in storage of manure that promotes activity of methanogenic microorganisms. Methane formation is therefore particularly important in highly anaerobic Manure Management Systems (MMS) such as anaerobic lagoons, anaerobic digesters, accumulation in tanks in liquid or slurry state or long time residence on stall floor.

In some systems, such as anaerobic lagoons and digesters, the emitted gas may be collected and burned for energy or simply flared in which case methane emissions to the atmosphere may be significantly reduced.

Manure Management is a key source in what concerns methane.

Methodology

Following IPCC96 and the Good Practice Handbook, emission estimates are calculated from equation 4.15 applied for each animal type. According to this scheme the production of manure and storage conditions are included in the emission factors which reflect more or less the detail in the method to its determination.

$$ECH4 = EF \bullet N$$

where, for each specie:

E_{CH4} = methane emissions from manure management, kg CH4/year

EF = emission factor for the specific population, kg/head/year

N = the number of animals, head.

The emission factors for each specie were set with tier 2 methodology for all species.

Emission Factors

Emissions Factors were established according to the methodology proposed in GPG (equation 4.17) and including country specific information for all animal species. The equation that allowed calculation of the EF for each animal species is:

$$EF_i = VS_i * 365 * B_{oi} * 0.67 * \sum_{jk} MCF_{jk} * MMS_{jk}$$

EF_i - annual emission factor for a defined livestock animal specie i (kg/year);

VS_i - Amount of excretion for an average animal i in the livestock population (kg VS[56]/day);

B_{oi} - Maximum methane production capacity from manure (m^3/kg VS) for animal specie i. 0.67 kg/m^3 is methane density;

[56] VS is Volatile Solids

MCF_{jk} - methane conversion factor for each Manure Management System j and for each climate region k;

MMS_{jk} - fraction of total manure from animal specie i handled with Manure Management System j and for each climate region k.

The amount of manure produced per capita and dry matter content of manure are from (Seixas et al ,2000) and were established from unpublished information received from the Ministry of Agriculture and some assumptions concerning indoor and outdoor dejections. Bo parameter was set from IPCC96. Next table presents total annual production of fresh manure per individual, dry matter content and maximum methane production capacity from manure (B_o). It also compares daily manure produced, expressed as dry matter, together with the default values proposed in IPCC96 for Western Europe or developed countries.

Table 6.3 – Average Annual Manure Production and other parameter

	Manure Production per capita			IPCC96	dm content	Bo	
	kg wt/head/y	kg dm/head/y	kg dm/head/day	kg dm/head/day	%	m3/kg dm	kg CH4/kg dm
Dairy Cows	19 167	2 391	6.55	5.52	12.5	0.24	0.16
Other Cattle	9 583	1 195	3.27	2.88	12.5	0.17	0.11
Ewes	3 638	910	2.49	0.4	25	0.19	0.13
Other sheep	3 638	910	2.49	0.4	25	0.19	0.13
Female goats	3 638	910	2.49	0.28	25	0.17	0.11
Other goats	3 638	910	2.49	0.28	25	0.17	0.11
Sows	4 579	397	1.09	0.5	8.7	0.45	0.3
Other swine	2 289	199	0.54	0.5	8.7	0.45	0.3
Horses	9 583	1 195	3.27	1.72	12.5	0.33	0.22
Mules & asses	9 583	1 195	3.27	0.94	12.5	0.33	0.22
Rabbits	266	33	0.09	-	12.5	0.32	0.21
Broilers & male breeders	47	12	0.03	0.1	25.2	0.32	0.21
Hens	99	25	0.07	0.1	25.2	0.32	0.21
Turkeys	207	52	0.14	0.1	25.2	0.32	0.21
Ducks, geese, Guinea-fowl, etc	99	25	0.07	0.1	25.2	0.32	0.21

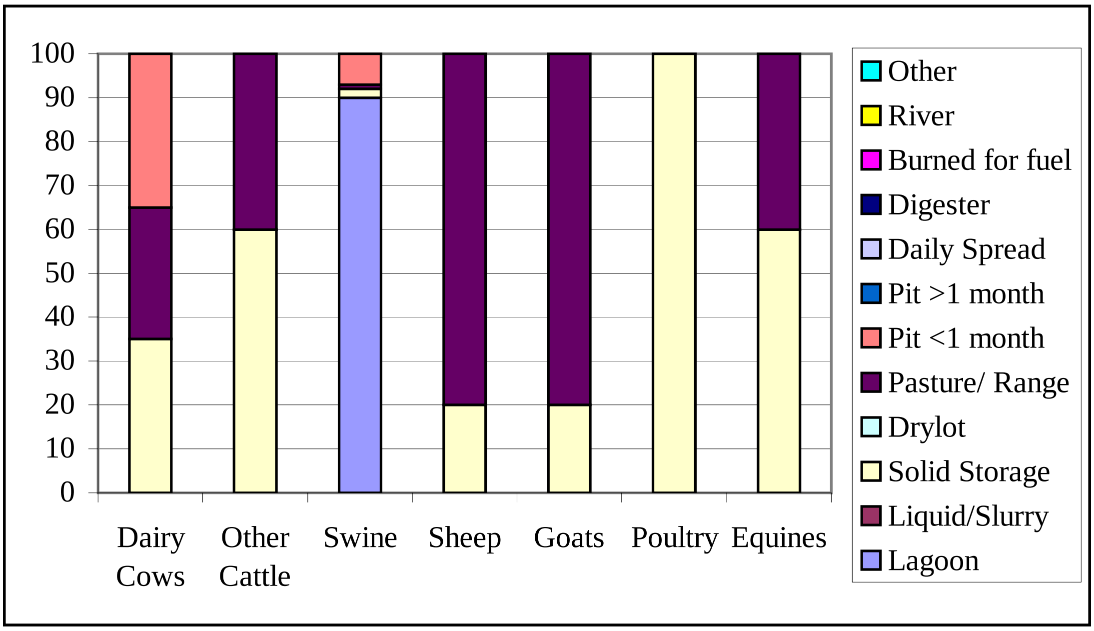
Comparing national manure production factors with those provided by IPCC96 it appears that the biggest difference concerns the much higher VS quantities assumed in Portugal for sheep and goats. One possible explanation is the inclusion of bedding in national data.

The biggest difference between Portuguese country-specific emission factors (PT) and IPCC defaults arises however mostly from a different share of Management Systems for Manure. Percentages used in Portugal differ substantially from those in IPCC default and were set from the Agriculture Ministry (Seixas et al, 2000).

Table 6.4 – MCF for each manure management system and animal specie

MMS	MCF	Dairy Cows		Other Cattle		Swine		Sheep	Goats	Poultry	Equines
		PT	IPCC	PT	IPCC	PT	IPCC	PT			
Lagoon	90					90					
Liquid/Slurry	35		40		50						
Solid Storage	1.5	35	18	60		2	21	20	20	100	60
Drylot	1.5				2		2				
Pasture/ Range	1.5	30	19	40	38	1		80	80		40
Pit <1 month	18	35				8	3				
Pit >1 month	35						73				
Daily Spread	0.5		20								
Digester	10										
Burned for fuel	10		2		2						
River	1.5										
Other	1		1		8		1				
Total	-	100	100	100	100	100	100	100	100	100	100
MCF	-	7.3	14.9	1.5	18.4	81.7	26.4	1.5	1.5	1.5	1.5

Figure 6.4 – Percentage of manure treatment system for each animal species

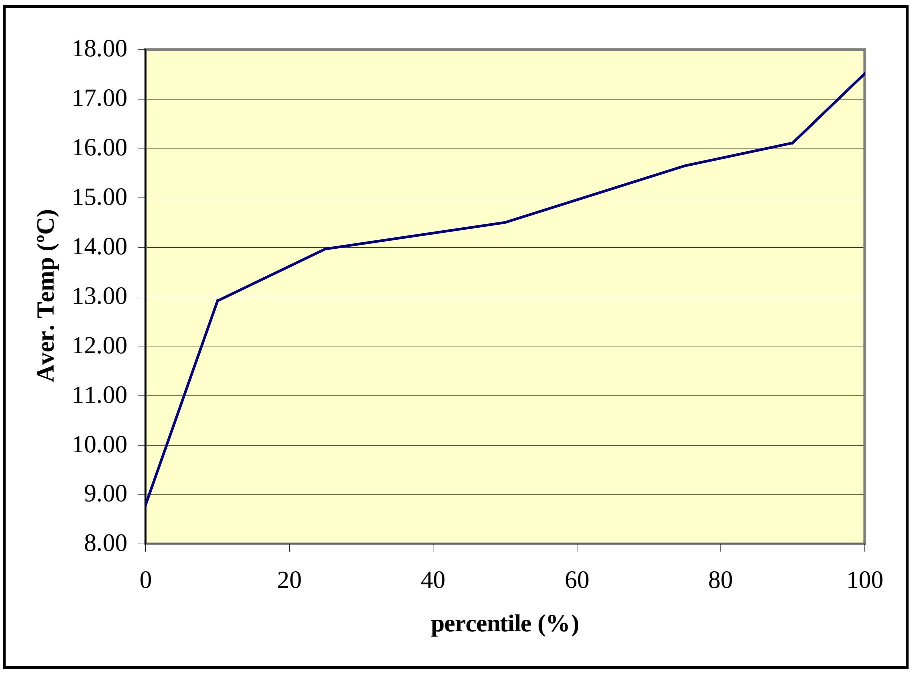


Major differences between country-specific data and IPCC defaults consist of:

- Swine manure in Portugal is usually treated with anaerobic lagoons, which have the highest MCF among MMS;
- the management of wastes from dairy cows kept in stall is split among solid storage and short retention time pits;
- dairy cows in pasture are commoner in Portugal than the default assumption;
- Solid storage is still the prevalent method of treatment for wastes from other cattle;
- Daily spread and usage as fuel are almost unknown in Portugal;
- there is a small percentage of traditional swine kept outdoors and feed pasture in range;
- there is no seasonal variations in management system.

For the sake of MCF determination it was assumed that Portugal is a temperate climatic region, although this classification does not follows strictly the rule in IPCC 1996. In page 4.25 of the guidelines it is said that “Cool climate have an average temperature bellow 15ºC; temperate climate have an average temperature from 15ºC to 25ºC inclusive ; warm climates have an average temperature above 25ºC.” Actually from long-term time series the average temperature in Portugal is about 14.55ºC[57] precisely at the edge between climate regions cool and temperate. Except for two nut 3 regions most regions have an annual average temperature very near 15ºC. It was felt however that classifying most of Portuguese areas as cool regions, as would outcome from figure 6.3, would not be in agreement with most climatic classification systems and it would be misleading at end to use default parameters for cool regions or to compare IEF (Implied Emission Factors) also with cool areas. Because a new limit could not be defined it was decided to include all areas under temperate region for the time being. It must be recognised that this needs to be eventually discussed and potentially revised in next submissions.

Figure 6.5 – Percentage distribution of average temperatures in Portugal



Final emissions factors are therefore those presented in next table, where is also done a comparison with the IPCC96 defaults for temperate regions of western Europe and developed countries:

[57] Average Annual temperature in national territory (including Madeira and Azores Islands) estimated from climatic values in the period 1950-81. Average values were established for each nut 3 territorial unit from monitoring stations and then weighted over all territory from land area. Data from Meteorology Institute. Calculus by Environmental Institute.

Table 6.5 – Final emission factors

Animal	EF (kg CH4/hd/yr)	
	National Inventory	IPCC Default
Dairy Cows	25.7	44
Other Cattle	1.9	20
Ewes	1.6	0.28
Other sheep	1.6	0.28
Female goats	1.4	0.18
Other goats	1.4	0.18
Sows	95.8	10
Other swine	47.9	10
Horses	3.8	2.1
Mules & asses	3.8	1.14
Rabbits	0.1	-
Broilers & male breeders	0.03	0.117
Hens	0.07	0.117
Turkeys	0.15	0.117
Ducks, geese, Guinea-fowl, etc	0.07	0.117

Because Vs and MMS were only available for all species as best estimates for all the period 1990-2001 considered and there is no further hint for an evolution in time, the emission factors were kept constant from 1990 to 2001.

Activity Data Sources

In a consistent manner livestock numbers are the same that were used in previous sub-category: CH4 from enteric fermentation. Although here more species are considered in the emissions estimates. Livestock data are therefore already presented in table 6.2.

Differences between number of horses, mules, asses and turkeys reported in National Statistics (INE) and FAO have also a minor importance for this source. As already noticed FAO reports sheep numbers are about 70% higher than those reported in National Statistics.

Recalculations

Livestock numbers were changed between submissions 2001 and 2002 and new species included in a consistent way to what have been done for Enteric Fermentation emissions. IPCC Default Emission Factors suffered changes in result of the inclusion of the new MCF values proposed by GP (Table 4.10) which partly changed table 4-8 of IPCC96. No further changes were made for submission 2003.

Further Improvements

The percentage of each manure management system should be updated for the more recent years, with the probable consideration of time evolution in the emission factors.

The quantity of manure per animal is a factor with great implications in the estimation of emission factors. The values that are presently used will be revised and documented, in particular for sheep. The revision would take place in accordance with revision of Gross Energy Intake review for CH4 from enteric fermentation.

In strict terms climatic regions should not be considered temperate but a mix of temperate and cool. The share of different climate regions should be revised or better addressed in next submissions.

6.2.3 CH4 Emissions from Rice Cultivation (CRF 4C)

Overview

Methane production is enhanced in rice cultivation areas (rice paddies) due to the prevalence of anaerobic conditions which result from flooding and high levels of organic material in soil surface. Methane formed in soil underwater escapes to atmosphere as greenhouse gas emission, as visible bobbles or trough transport inside plant stems.

Methodology

Methane emissions from rice production were estimated with equation 4.41 of GPG, but simplified because there are no appreciable differences in Portugal in what concerns water management regimes or any other conditions that are known to affect emissions from this source sector. Original formula was therefore simplified to:

$$E\_Rice_{CH4(y)} = EF * Rice_{Area\ (y)} * 10^{-2}$$

where

$E\_Rice_{CH4(y)}$ - Emission from rice production estimated for year y (ton/yr);

EF - Final emission factor, seasonally integrated and adjusted for management practices ($g/m^2/yr$);

$Rice_{Area\ (y)}$ - Area under rice cultivation in year y (ha).

Emission Factors

According to GPG formulation final emission factor results from the multiplication of several factors:

$$EF = Ef_c * SF_w * SF_o * SF_s$$

where

EF - Final emission factor, seasonally integrated and adjusted for management practices ($g/m^2/yr$);

Ef_c - Seasonally integrated emission factor for continuously flooded fields without organic amendments ($g/m^2/yr$);

SF_w - Scaling factor for water management regime and ecosystem hydrologic conditions;

SF_o - Scaling factor reflecting organic amendments (rice straw, manure, compost, wastes), because easily decomposable carbon increase methane formation;

SF_s - Scaling factor for soil type.

The default Ef_c proposed in GPG (20 $g/m^2/yr$) was not used, but 36 $g/m^2/yr$ was used instead which is the value proposed by IPCC96 in table 4-13 for Italy. In accordance with opinion expressed by the Portuguese Agriculture Ministry it was considered that this value, determined for a European country with environmental conditions more similar to Portugal was better suited than GPG default.

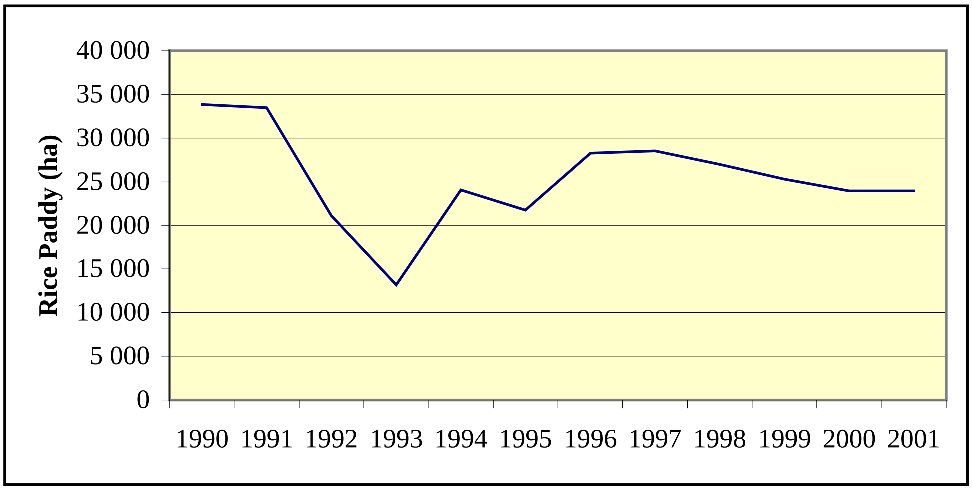
Concerning water management regime, rice culture in Portugal is almost homogeneous and characterized by cultivation under irrigated continuous flooded areas[58], where water regime is controlled by human activity (water diversion, irrigation and dikes). Rice fields are in standing water throughout all rice growing season and are only dry for harvest. All areas under rice cultivation are situated close to river banks almost at sea level. Accordingly SF_w was set as 1.0.

No statistical information exists concerning the use of organic amendments in rice fiels but it was assumed that they are not representative in Portuguese oriziculture, and SF_o is unity. In a similar way no information is available to establish influence of soil type and SF_s was also set to one.

Activity Data Sources

Rice cultivated area is available from annual statistics from National Statistical Institute and it is reproduced in figure 6.6. It is noticeable the existence of huge variations in annual rice paddy areas, expressing annual variations in hydrological conditions. There is only one rice crop per year.

Figure 6.6 – Rice cultivated area



Characteristics of rice cultivated areas, such as water management regime, organic amendments and soil type are included already in emission factor settling.

Recalculations

No changes have occurred since last submission.

Further Improvements

No improvements are expected in near future. The establishing of a national integrated emission factor would be welcomed but there are no current plans or studies to achieve that goal.

[58] During crop period.

6.2.4 N2O Emissions from Manure Management (CRF 4B)

Overview

Nitrogen included in manure either in faeces or urine may be emitted as N2O while manure is being managed or stored, as consequence of nitrification-denitrification processes from ammonia nitrogen. Although there is no extensive information concerning the factors that affect this process it is believed that N2O emissions increase with aeration and hence opposite to methane emissions solid storage or deposition during grazing and dry lot result in greater emissions than manure management in more anaerobic systems like liquid systems and anaerobic lagoons.

Methodology

Emissions of N2O from manure for each Manure Management Systems S was estimated with the following formula:

$$EN2O_{(s)} = 44/28 * \sum_t [N_{(t)} * Nex_{(t)} * (1 - EFNH_{3(t,s)}) * MS_{(t,s)}] * EF_{3(s)}$$

where,

$EN2O_{(s)}$ - N2O emissions from manure in Manure Management System S;

S - Manure Management System;

T - Animal/species category of livestock;

$N_{(t)}$ - Number (head) of individuals from livestock category T in the country;

$Nex_{(t)}$ - Annual country average N excretion per head of animal species/category T;

$MS_{(t,s)}$ - Fraction of Manure/Nitrogen from livestock category T that is managed in Manure Management System s;

$EFNH_{3(t,s)}$ - Fraction of nitrogen received in Manure Management System S from livestock category T that is lost to atmosphere as ammonia;

$EF_{3(s)}$ - N2O emission factor for Manure Management System S (kg N2O-Nkg N).

This formulation is different from the one proposed in GPG (equation 4.18) where the emission factor is multiplied by total nitrogen added to each MMS before subtraction of ammonia emissions.

The following Manure Management Systems were added to estimate total N2O emissions from manure management:

- Anaerobic Lagoons;
- Liquid Systems;
- Solid Storage;
- Used as Fuel;
- Other MMS.

This same methodology was used to assess Direct N2O soil emissions from manure deposited in soil during grazing (Pasture Range and Paddock) and also Direct N2O soil emissions from manure that is applied to soil as fertilizers. This will be further discussed under next sub-chapter (6.25) “Direct Nitrous Oxide Emissions from agricultural soils”.

Parameters $N_{(t)}$, $Nex_{(t)}$ and $MS_{(t,s)}$ will be discussed as activity data and $EF_{3(s)}$ and $EFNH_{3(t,s)}$ will be discussed as emission factors.

Emission Factors

N_2O emission factors are presented in next table for all MMS (although daily spread, used for fuel and other systems are not considered in the Portuguese inventory). They were all set according to the default IPCC96 emission factors (table 4-22 which were maintained in GPG table 4.12) because there are no available studies to support country-specific emission factors.

Table 6.6 – N2O emission factors for MMS

MMS	EF3 (kg N2O-N/kg N)
Anaerobic Lagoon	0.001
Liquid Systems	0.001
Daily Spread	0
Solid Storage and Drylot	0.02
Pasture Range and Paddock	0.02
Used Fuel	0
Other System	0.005

Losses of ammonia from nitrogen volatilisation from manure in animal housing or in storage where estimated using the following emission factors. They were set from information in the 3rd edition of the EMEP/CORINAIR Guidebook. Emissions due to application of manure in soil and from pasture range are estimated with emission factors from the same information source.

Table 6.7 – Losses of ammonia in Housing and storage

Class	Losses in Housing & storage (kg NH3-N/kg N)
Cattle	0.17
Sheep, goats	0.10
Swine	0.22
Equines	0.12
Poultry	0.22
Rabbits	0.22

Activity Data Sources

Number of head of livestock is the same used to estimate emissions of CH4 from Enteric Fermentation and CH4 from Manure Management. Livestock numbers are therefore those reported in table 6.2.

The quantity of nitrogen excreted per head was estimated from the dry weight of manure emitted per head, already presented in the chapter concerning CH4 from Manure Management (6.2.2), and also from the nitrogen percentage in manure, which was set also from information from the Agriculture Ministry (Seixas et al,2000). It was assumed that these percentages include nitrogen both in urine and in faeces. Basic data is presented in next table together with the default nitrogen excretion rates from IPCC for Western Europe (table 4-20 of IPCC96).

Table 6.8 – N excretion per head by animal species/category (Nex)

Animal	N content	Nex	Nex
	kg N/t dm	kg N/head/yr	IPCC Default
Dairy Cows	45.21	108.1	100
Other Cattle	45.21	54	70
Ewes	45.01	40.9	20
Other sheep	45.01	40.9	20
Female goats	45.01	40.9	(1) 20
Other goats	45.01	40.9	(1) 20
Sows	74.99	29.8	20
Other swine	74.99	14.9	20
Horses	45.21	54	(2) 25
Mules & asses	45.21	54	(2) 25
Rabbits	45.21	1.5	(2) 25
Broilers & male breeders	63.26	0.7	(3) 0.6
Hens	63.26	1.6	(3) 0.6
Turkeys	63.26	3.3	(3) 0.6
Ducks, geese, Guinea-fowl, etc	63.26	1.6	(3) 0.6

(1) IPCC96 does not set N excretion rate for goats. Comparison is with value for sheep; (2) IPCC96 default value for other animals; (3) IPCC96 reports only for poultry in general

The following comments apply:

- country-specific N excretion rates for dairy cows are similar to IPCC defaults;
- divergence of nitrogen excretion rates between Portugal and IPCC96 is biggest for sheep and goats. These probably results from the high value that it is considered in the Portuguese inventory for total manure excretion per head (which was already discussed under CH4 from Manure Management).

The percentage of manure that goes to each Manure Management System is coherent with the share considered in CH4 emissions from Manure Management but here a different aggregation is requested by UNFCCC[59].

[59] It must be realized however that in the 1996 Revised IPCC Guidelines there is no agreement between default Manure Management System percentage under CH4 and N2O emissions from Manure Management

Table 6.9 – Percentage of manure from each animal species by manure management system

Animal	Anaerobic Lagoons		Liquid Systems		Daily Spread		Solid Storage and Drylot		Pasture Range and Paddock		Used Fuel		Other System	
	CS	IPCC	CS	IPCC	CS	IPCC	CS	IPCC	CS	IPCC	CS	IPCC	CS	IPCC
Dairy Cows			35	46		24	35	21	30	8				1
Other Cattle				55			60	2	40	33				9
Ewes							20	2	80	87				11
Other sheep							20	2	80	87				11
Female goats							20	2	80	87				11
Other goats							20	2	80	87				11
Sows	90		8	77			2	23	1					
Other swine	90		8	77			2	23						
Horses							60		40	96				4
Mules & asses							60		40	96				4
Rabbits							100							
Broilers & male breeders				13			100	1		2				84
Hens							100							
Turkeys							100							
Ducks, geese, Guinea-fowl, etc							100							

According to national data there are more cattle in pasture range than considered in IPCC, particularly for dairy cattle. Other cattle not in pasture is managed in dry storage manure systems and the percentage of dairy cows in solid storage is also bigger than that assumed by IPCC. Therefore N2O emissions from manure are bigger than if default MMS from IPCC were used.

For pigs the fact that IPCC assumes most manure managed in Liquid systems while national information considers Anaerobic Lagoons is not much relevant because EF3 is the same for both MMS. However IPCC assumes a higher level of solid storage systems than really exist, according to the Agriculture Ministry.

For sheep, goats and equines, there is a different percentage of animals in closed systems and in Pasture, but that does not affect total N2O estimates - because EF3 is similar for both MMS - although emissions are allocated to different emission categories.

At national level it was preferred to classify MMS for poultry as solid storage rather than the ambiguous IPCC classification of other systems. Manure in poultry and small mammals installations use mostly dry manure removal systems.

Recalculations

No changes in emission factors and other parameters were made since submission 2002. Livestock numbers were also kept equal for the period 1990 to 2000. Because no statistical information is available concerning livestock numbers for 2001, emissions for this year were set with livestock numbers equal to 2000.

Further Improvements

The subtraction of ammonia before estimate of emissions must be revised. It must be checked with the IPCC team responsible for GPG and IPCC96 if the $EF_{3(s)}$ are effectively to be applied before NH3 subtraction. The NH3 emission factors will be also revised accordingly because in EMEP/UNECE 3rd revision Guidebook they where set from information from Netherlands.

Nitrogen excretion per head should be revised particularly for sheep, goats and non-dairy cattle. These factors must be cross-checked against a mass balance of nitrogen ingested and expelled (retention rates estimation method). Because some statistical data exists concerning age/sex classes adjustment factors will be used for young animals in accordance with GPG.

The percentage of each Manure Management Systems was defined by the Ministry of Agriculture in 1999 not being aware of the new MMS types considered in table 4.12 of the GPP. This situation will be revised although it will not affect emission estimates.

6.2.5 Direct N2O Emissions from Agricultural Soil (CRF 4D1)

Overview

In agricultural soils emission of N2O is enhanced by an increase in available mineral nitrogen which promotes soil biogenic activities of nitrification and denitrification. Increase of available nitrogen in soil may be caused by anthropogenic activities such as adding nitrogen to soil as a fertilizer or crop residues or as consequence of cultivation of organic soils where degradation of organic matter is enhanced liberating fixed nitrogen. N2O emissions considered in this inventory include therefore only N2O soil emissions increase due to human management of (in managed) soils over the emissions that would occur in the same area under unmanaged conditions (background emissions).

Although some references indicate that soils may also be soil sinks of N2O there are no sound available estimate techniques and these were not estimated.

Direct emissions of N2O resulting from the increase of nitrogen added to cultivated soils due to agricultural activities include the following sub-categories:

- application of synthetic fertilisers;
- application of animal manure;
- animal manure deposited directly by animals on pasture, range and paddock;
- nitrogen fixation by N-fixing crops (leguminous plants);
- nitrogen input from incorporation of crop residues into soils.

Most effort was put to made estimates of this source fully consistent:

- along time series. All activity data for each sub-source was obtained from the same data source for all inventory years;
- methodology is the same applied to all inventory years;
- activity data for this source is also used in the emission estimates of other sources: N2O, CH4 and NH3 from Manure Management is the same.

The inventory of N2O from Direct Soil Emissions from Agricultural Soils is almost complete. The lack of estimates for N2O emissions from histosols and due to the application of sewage sludge correspond most probably to minor sources. The estimates do not include N2O emissions from organic soils (histosoils) mineralisation. Calculations for these emissions could not be done due to lack of activity data (histosoils under cultivation) but they represent most probably a minor emission quantity in Portugal.

Emissions due to application of sewage sludge as a soil amendment is also not included in the inventory. There are no reliable statistics for this activity which is considered nevertheless negligible.

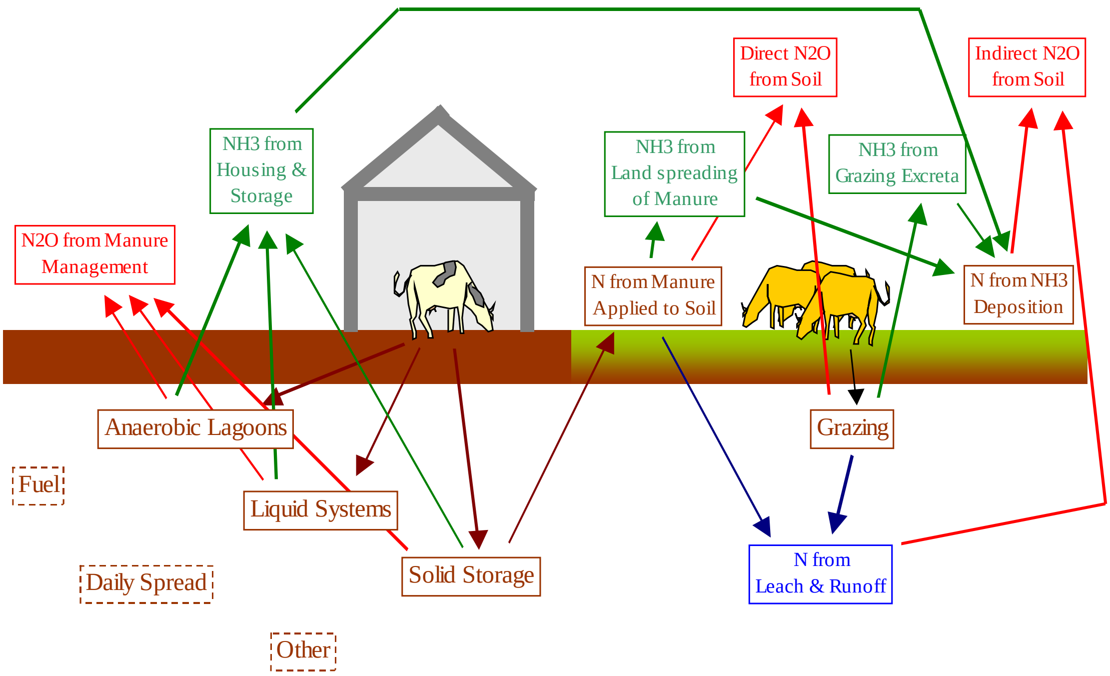
It is worth mentioning that N fixed by crops includes both annual crops and a permanent crop, carob production.

The situation concerning N2O emissions from manure is somehow complex because nitrogen originally in manure may give origin to N2O emissions that are considered in different IPCC categories:

- emissions during the period that manure is stored in house or any Manure Managed System was already considered under source category N2O emissions from Manure Management. They were estimated after subtraction of ammonia volatilisation during housing and storage;
- emissions from nitrogen in manure added to soil as fertilizer is included in source category direct N2O from agricultural soils. In Portugal it was assumed that only nitrogen from manure managed as solid storage, from all animal species, is used as soil fertilizer;

The following figure synthesizes the livestock system in what concerns nitrogen fluxes and direct and indirect N2O emissions.

Figure 6.7 – Nitrogen fluxes from livestock system



Methodology

N2O emissions from agricultural soils other than animal production

The approach used to estimate N2O emissions from agricultural soils other than animal production (emissions of N2O in Pasture Range and Paddock) may be better classified as Tier1a because the same emission factor was used to all nitrogen sources to soil[60].

Final N2O emissions are estimated with a formulation derived from equation 4.20 of GPG:

[60] But in fact in the spreadsheets calculation system it is possible to define different emission factors for all nitrogen sources

$$EN2O_{Direct} = 44/28 * (F_{SN} + F_{AM} + F_{BN} + F_{CR}) * EF_1$$

where:

$EN2O_{Direct}$ - Annual emission of N2O

F_{SN} - Annual amount of synthetic fertilizer nitrogen applied to soils adjusted to account for the amount that volatilises as NH_3

F_{AM} - Annual amount of animal manure nitrogen intentionally applied to soils adjusted to account for the amount that volatilises as NH_3

F_{BN} - Amount of nitrogen fixed by N-fixing crops cultivated annually

F_{CR} - Amount of nitrogen in crop residues returned to soil annually

EF_1 - N2O emission factor from N input to soil (kg N2O-N/kg N input)

F_{SN}, the annual amount of synthetic fertilizer nitrogen applied to after adjusting to account for the amount that volatilises, is estimated from:

$$F_{SN} = N_{Fert} * (1-Frac_{GASF})$$

where,

N_{Fert} - total amount of nitrogen in synthetic fertilizers consumed annually

$Frac_{GASF}$ - fraction of nitrogen in synthetic fertilizers applied ton soil that volatilises as NH_3 or NO_x

The amount of nitrogen in animal manure that is used as fertilizer (F_{AM}) was estimated from total nitrogen excreted from livestock that is applied to agricultural soils and after subtraction of nitrogen that volatilises in housing, manure storage and after deposition in soil as fertilizer. The following equation applies:

$$F_{AM} = \Sigma_t\{N_{(t)}*Nex_{(t)}*\Sigma_s[MS_{(t,s)}*MS_{SD(t,s)}*(1-EFNH3_{(t,s)})]\}*(1-EFNH3_{SD})$$

where

F_{AM} - total amount of nitrogen in manure from Manure Management System that is applied to soil as fertilizer;

$N_{(t)}$ - Number (head) of individuals from livestock category T in the country;

$Nex_{(t)}$ - Annual country average N excretion per head of animal species/category T;

$MS_{(t,s)}$ - Fraction of Manure/Nitrogen from livestock category T that is managed in Manure Management System s;

$MS_{SD(t,s)}$ - Fraction of Manure/Nitrogen from livestock category T treated in Manure Management System S that is used as fertilizer in agriculture soils;

$EFNH3_{(t)}$ - Fraction of nitrogen in Manure Management System S from livestock category T that is lost to atmosphere as ammonia during housing and manure storage;

$EFNH3_{SD}$ - Fraction of nitrogen in manure that is lost to atmosphere as ammonia after application to soil as fertilizer.

This equation is equivalent to equation 4.23 of GPG if one considers that $Frac_{GASM}$ equals the sum of $EFNH_{3(t,s)}$ and $EFNH3_{SD}$ and being aware that $Frac_{PRP}$ is already subtracted because only manure managed under solid storage is accounted for. Emissions of N2O from manure handled in Anaerobic Lagoons and Liquid Storage are already included in Liquid and Solid Waste emission source categories and are not double counted here.

Estimates of nitrogen fixed by crops follows exactly the Tier1b approach of the GPG (Equation 4.26) which means that crop-specific residue to product ratio and dry matter content are used:

$$F_{BN} = \sum_i \{Crop_{BF(i)} * (1 + Res_{BF}/Crop_{BF(i)}) * Frac_{DM(i)} * Frac_{NCRBF(i)}\}$$

where

I - Crop type

$Crop_{BF(i)}$ - Crop production of nitrogen fixing crops (ton/yr)

$Res_{BF}/Crop_{BF(i)}$ - Residue to crop product mass ratio for nitrogen fixing crop i (ton/ton)

$Frac_{DM(i)}$ - Fraction of dry matter in the aboveground biomass of crop type i

$Frac_{NCRBF(i)}$ - nitrogen fraction in crop dry biomass (ton/ton)

Finally F_{CR}, nitrogen input to soil in crop residues returned to soil, is estimated for all crops, whether they are nitrogen fixing crops or not, with the GPG tier 1b approach, which can be represented to the following equation, a similar simplification of equation 4.29 of the GPG:

$$F_{CR} = \sum_i \{[Crop_{(i)} * Res/Crop_{(i)} * Frac_{DM(i)} * Frac_{NCR(i)}] * [1 - Frac_{BURN(i)} - Frac_{FUEL(i)} - Frac_{CNST(i)} - Frac_{FOD(i)}]$$

where

I - Crop type

$Crop_{(i)}$ - Crop production (ton/yr)

$Res/Crop_{(i)}$ - Residue to crop product mass ratio for crop i (ton/ton)

$Frac_{DM(i)}$ - Fraction of dry matter in the aboveground biomass of crop type i (assumed to be equal to the fraction in the all plant)

$Frac_{NCRBF(i)}$ - nitrogen fraction in crop dry biomass (ton/ton)

$Frac_{BURN(i)}$ - fraction of crop residue burned in the field before and after harvest

$Frac_{FUEL(i)}$ - fraction of crop residue burned as fuel outside field

$Frac_{CNST(i)}$ - fraction of crop residue used for construction

$Frac_{FOD(i)}$ - fraction of crop residue used as animal fodder.

Emissions of N2O in Pasture Range and Paddock

Emissions of N2O due to the input of nitrogen to soils from pasture, range and paddock were estimated with the same methodology used to estimate emissions of N2O from Manure Management, which differs from the one proposed in GPG (chapter 4.4) because ammonia volatilisation is subtracted before nitrous oxide emission factor is applied. Emissions where therefore estimated with the following formula:

$$EN2O = 44/28 * F_{GR} * EF_3$$

where,

EN2O - N2O emissions from manure in Pasture, range and paddock;

EF_3 - N2O emission factor (kg N2O-Nkg N);

F_{GR} - 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 NH_3. This variable is determined from equation:

$$F_{GR} = \sum_t [N_{(t)} * Nex_{(t)} * (1 - EFNH_{3(t)}) * MS_{(t)}]$$

where:

- T - Animal/species category of livestock;
- $N_{(t)}$ - Number (head) of individuals from livestock category T in the country;
- $Nex_{(t)}$ - Annual country average N excretion per head of animal species/category T;
- $MS_{(t)}$ - Fraction of Manure/Nitrogen from livestock category T that is managed in Pasture Range and Paddock;
- $EFNH_{3(t)}$ - Fraction of nitrogen excreted from livestock category T during grazing that is lost to atmosphere as ammonia.

Emission Factors

EF_1, the emission factor relating N input to soil with N2O emissions, was set equal to the IPCC default value of 0.0125 kg N2O-N/kg N input[61](table 4.17 of GPG and table 4.18 of IPCC96).

Ammonia volatilisation from nitrogen in manure after disposal on agricultural soil as fertilizer where estimated using the volatilisation fractions in land spreading in the 3rd edition of the EMEP/UNECE Guidebook (table 3A in chapter B1050). These emission factors depend only on animal class and not of Manure Management System.

Table 6.10 – Emission factors used for NH3 volatilisation estimation from land spreading

Class	Losses after land spreading (kg NH3-N/kg N)
Cattle	0.17
Sheep, goats	0.07
Swine	0.16
Equines	0.07
Poultry	0.16
Rabbits	0.16

Emission factors for ammonia volatilisation from excreta and urine deposited into grasslands during grazing are from EMEP/CORINAIR chapter B1010 version 4.0 (Sutton, 2003) assuming an average loss rate of 7.5% of applied nitrogen from livestock.

The use of emission factors of ammonia volatilisation from EMEP/UNECE results therefore in values for $Frac_{GASM}$ that are different and higher than the default value for $Frac_{GASM}$ (0.2 kg N-NH3 + N-NOx/ kg of N excreted, in table 4-19 of IPCC96).

The emission factor of N2O for Pasture, Range and Paddock (EF_3) was set at 0.02 kg N2O-N/kg N which is the default IPCC96 emission factor (table 4-22) that is also maintained in GPG (table 4.12). Ammonia volatilisation factor (EFNH3) during grazing is the same percentage as the one used in manure applied to soil as fertilizer.

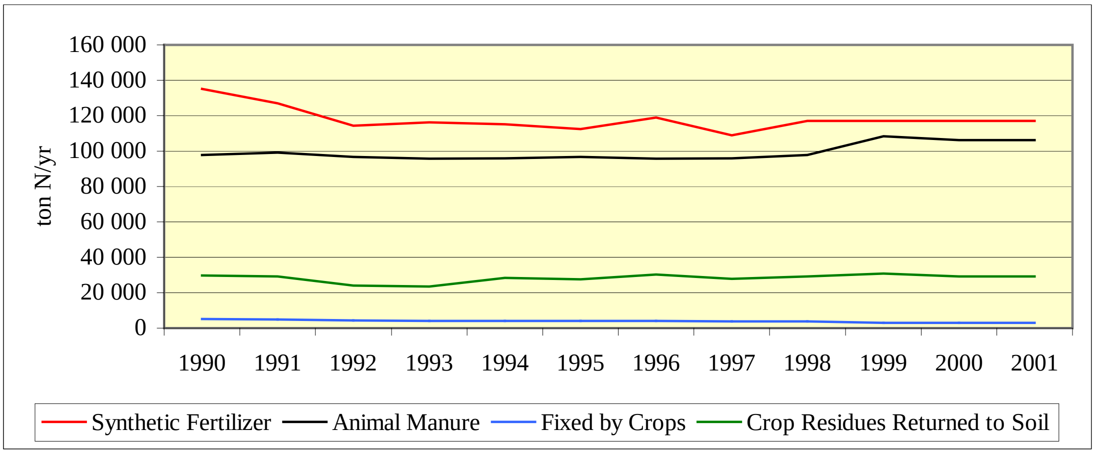
Activity Data

The time series from 1990 to 2000 on the quantity of nitrogen used as synthetic fertilizers is from FAO statistical database (http://www.apps.fao.org) which itself results from information gathered in Portugal. The value for 2001 is provisional and was set equal to 2000 in agreement with the observed trend in time series. This time series shows an abrupt decrease until 1992

[61] The same as saying that 1.25% of nitrogen input to soil is emitted as N2O

and thereafter a stabilization. Nitrogen in fertilizers is the first source of nitrogen to soils in Portugal just above nitrogen in animal manure applied to soil, as may be seen in the following figure.

Figure 6.8 – Input of Nitrogen to soil from the different sources



Losses of nitrogen from volatilisation of NH3 and NOx were estimated considering a constant $Frac_{GASF}$ of 0.1kg (NH3+NOx)-N/kg N input which is the default value from table 4-19 of IPCC96. In what concerns acidification emissions it was assumed that these emissions are fully ammonia.

The quantity of nitrogen in manure that is applied to soil as fertilizer resulting in N2O emissions is estimated from the same data that was used to estimate nitrogen excreted in N2O from Manure Management and assuming that only manure treated under Solid Storage is used as soil fertilizer, i.e. $MS_{SD(t,s)}$ equals 1 only for Solid Storage and is zero for all other Manure Management Systems. Quantities applied each year are also presented in figure 6.5 above, where is shown that manure is the second main source of nitrogen applied to soil. $EFNH_{3(t,s)}$ and $EFNH3_{SD}$ are the same emission factors reported in chapter NH3 Emissions from Agriculture.

The quantities of nitrogen added to soil as result of crop fixation (F_{BN}) and in crop residues returned to soil (F_{CR}) where estimated from crop production. The National Institute of Statistics (INE - Instituto Nacional de Estatística) records crop production each year at Regional Area level (RA - Região Agrária) for the most important species. INE has also records of the area under cultivation of each species allowing the estimate of productivity. For the year 1989 data gathered by the Statistical Institute was collected at a lower level of territorial desegregation: Agricultural Zone (ZA - Zona Agrária) and for 1999 the data was collected at an even thinner desegregation: Concelho. For some crops however the only available information is from FAO Statistical Database (http://www.apps.fao.org).

The data series for crops considered in the inventory at National level is presented in tables 6.11 and 6.12, respectively for leguminous crops and non leguminous crops. It must be stressed that not only pulses and beans were included in nitrogen fixing crops but all leguminous crops. In a similar way when estimating crop residues not only annual crops were considered but also permanent crops, such as orchards and pastures, were included.

Table 6.11 - Leguminous Crop Production (metric tons)[62]

English	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Peanut	19	21	29	21	21	18	13	30	25	25	25
Broad Beans	18 801	18 798	18 749	18 628	18 628	14 000	16 000	14 487	15 000	15 000	15 000
Broad Beans, green	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000
Beans	31 007	28 083	22 565	16 613	15 480	14 758	15 075	14 414	13 648	6 689	6 371
Chick-Peas	3 563	3 485	2 194	2 069	2 040	1 701	1 956	1 789	1 684	960	1 007
Lupins	57	30	42	34	34	34	34	34	34	34	34
Peas Green	6 300	6 000	5 300	5 000	6 300	6 300	7 000	8 329	6 921	6 921	7 000
Carobs	20 000	20 000	20 000	20 000	20 000	20 000	20 000	20 000	20 000	20 000	20 000
Beans Green	25 000	25 000	25 000	25 000	25 000	46 600	40 700	33 625	26 059	20 847	20 000
Total	134 747	131 417	123 879	117 365	117 503	133 411	130 778	122 708	113 371	100 476	99 437

Source: All data From National Statistical Institute except: (1) - FAO Statistical Database (http://www.fao.org)

[62] Data for 2001 is still provisional and was therefore in the inventory equal values to year 2000 were assumed.

Table 6.12 - Other Crop (non leguminous) Production (metric tons)

English	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Wheat	296 623	618 697	361 963	421 926	462 624	360 094	406 071	329 481	151 148	352 373	352 519
Triticale	60 549	63 500	60 000	78 000	85 388	48 268	55 768	39 004	17 289	33 067	40 308
Maize	665 560	656 187	628 415	638 143	725 976	766 493	854 352	913 017	1 023 949	935 115	890 753
Barley	78 532	124 104	63 000	98 500	96 213	53 058	69 950	28 792	26 203	29 293	33 119
Rye	96 502	80 358	69 500	66 727	63 792	36 263	53 924	40 689	32 488	55 614	46 661
Oats	72 104	76 100	45 103	76 400	79 217	57 636	60 480	44 295	28 714	99 724	112 622
Rice Paddy	156 072	170 477	109 704	69 000	131 741	124 554	172 230	164 189	161 774	151 650	143 369
Sunflower	60 741	34 190	51 000	45 064	40 000	26 120	38 297	26 980	37 679	17 538	30 000
Hops	171	164	102	39	97	127	164	102	56	50	50
Tomatoes	825 862	697 957	450 000	509 073	879 000	838 850	914 300	792 736	1 088 549	1 010 406	900 000
Tobacco	4 911	5 457	4 335	2 536	4 699	4 945	6 206	5 845	6 880	5 780	6 121
Tea	184	129	69	21	40	82	63	25	24	27	27
Chicory	2 095	2 600	2 905	2 778	3 423	2 365	2 143	2 666	2 060	2 300	2 300
Potatoes	1 343 005	1 420 870	1 568 953	1 241 192	1 326 654	1 435 663	1 325 854	1 049 314	1 224 932	1 367 327	1 250 000
Sugar Beet	12 692	11 931	19 259	31 962	50 085	56 991	32 400	149 514	187 649	506 611	475 000
Yams	1 360	1 163	1 792	1 153	997	1 395	1 137	2 074	2 100	2 100	2 100
Sugar Cane	3 646	3 989	4 000	4 000	4 000	4 000	4 000	4 000	4 000	4 000	4 000
Sweet Potatoes	26 000	27 000	27 000	30 000	25 000	24 000	22 000	22 000	22 000	22 000	22 000
Maize for Forage	3 500 000	3 465 000	3 670 000	4 515 000	4 500 000	4 520 000	4 880 000	4 900 000	5 000 000	5 000 000	5 000 000
Sorghum for Forage	350 000	335 000	405 000	345 000	320 000	360 000	360 000	360 000	360 000	360 000	360 000
RootsFodder	375 000	385 000	390 000	390 000	400 000	370 000	415 000	420 000	420 000	420 000	420 000
Forage	6 500 000	6 400 000	5 200 000	5 900 000	7 000 000	6 400 000	7 200 000	7 200 000	7 200 000	7 200 000	7 200 000
Pumpkins	4 500	4 300	3 800	4 000	3 800	12 000	13 300	12 500	12 000	12 000	12 000
Lettuce	32 000	32 000	32 000	40 000	48 000	59 800	61 300	67 200	93 722	93 722	95 000
Garlic	20 000	20 000	20 000	20 000	20 000	20 000	20 000	20 000	20 000	20 000	20 000
Eggplants	7 200	6 800	6 000	5 500	6 000	6 000	5 500	5 500	5 500	5 500	5 500
Onions	57 200	57 200	57 200	90 000	100 000	115 800	107 900	104 920	100 618	120 742	120 000
Carrots	83 000	83 000	83 000	83 000	83 000	127 100	174 300	115 785	144 615	173 538	150 000
Cauliflower	20 000	20 000	20 000	20 000	20 000	29 900	30 200	28 224	31 046	34 151	35 000
Cabbages	180 000	170 000	150 000	140 000	150 000	160 000	140 000	140 000	140 000	140 000	140 000
Spinach	18 000	17 000	15 000	14 000	15 000	15 000	14 000	14 000	14 000	14 000	14 000
Watermelons	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000
Melons	20 000	20 000	20 000	20 000	20 000	20 000	20 000	20 000	20 000	20 000	20 000
Cucumbers	9 000	8 500	7 500	7 000	7 500	7 500	7 000	7 000	7 000	7 000	7 000
Chillies	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000
Quinces	4 900	3 300	4 000	3 380	4 000	2 065	1 877	1 805	1 775	1 800	1 800
Loquat	1 619	1 543	1 619	1 419	1 829	1 569	1 600	1 486	1 079	1 656	1 682
PomeGranat	1 800	1 800	1 810	1 700	1 700	1 600	1 608	1 058	760	1 532	1 528
Pineapples	1 500	1 500	2 280	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000
Bananas	45 568	39 900	38 000	37 000	38 000	30 000	30 000	35 000	30 000	35 000	40 000
Peach	85 116	95 131	108 148	92 240	91 648	89 735	75 884	94 919	66 034	71 326	65 640
Apples	282 521	263 350	281 033	264 088	211 981	234 965	256 780	286 212	165 404	295 368	245 954
Kiwi	2 515	5 025	10 048	10 136	9 239	8 854	10 546	10 438	5 055	10 895	8 939
Pears	94 730	94 573	100 618	95 558	116 715	73 728	101 480	173 947	120 033	131 592	109 931
Sour Cherries	576	750	720	670	640	580	597	154	53	600	600
Fig	14 800	15 500	13 750	11 500	7 176	6 313	6 479	3 853	3 767	4 236	3 477
Persimmon	4 700	4 700	4 500	4 180	4 500	2 220	1 634	892	457	2 117	2 156
Apricots	4 650	4 480	4 700	4 260	5 124	5 052	4 693	4 968	3 859	6 040	5 782
Cherry	11 310	13 570	13 068	10 868	9 868	7 831	9 438	9 362	3 155	16 704	7 421
Plum	17 964	15 219	16 733	15 933	17 733	18 065	17 722	17 928	14 879	18 447	17 517
Avocados	21 300	20 300	19 400	16 300	13 000	13 000	13 000	13 000	13 000	13 000	13 000
Strawberries	2 500	2 500	2 500	2 500	2 500	2 500	2 500	2 500	2 500	2 500	2 500
Raspberries	100	100	100	100	100	100	100	100	100	100	100
Berries nes	100	100	200	100	100	100	100	100	100	100	100
Tangerine	23 425	26 468	26 977	26 777	34 822	34 983	34 502	35 234	37 707	46 253	60 798
Lemon	10 200	10 250	10 863	10 363	10 988	11 063	8 782	9 656	9 023	10 461	11 587
Orange	176 597	171 127	177 198	173 080	189 198	209 133	179 102	212 838	271 670	212 892	253 816
Pomelo	4 700	5 500	5 600	5 550	6 576	6 833	6 898	6 859	6 848	3 740	3 740
Grapefruit	900	700	800	780	975	1 017	997	878	766	326	403
Wallnut	5 850	5 800	4 200	3 523	2 927	2 864	3 369	3 502	3 121	4 598	3 793
Chestnuts	20 405	15 713	15 102	12 825	18 682	19 194	20 423	20 643	22 022	30 913	33 359
Hazelnuts	1 900	2 000	1 800	1 271	1 234	842	852	901	649	702	660
Almonds	18 190	20 963	19 530	18 815	9 819	7 172	8 322	12 158	24 796	34 631	26 064
Olives (Oil)	177 476	420 643	140 625	237 511	222 210	311 257	275 143	309 091	225 615	322 371	252 169
Olives (fruit)	20 210	22 990	16 500	10 974	10 000	8 495	8 974	10 274	8 578	11 629	7 831
Wine grapes	1 500 289	1 329 516	1 026 941	634 941	816 249	1 053 333	1 238 955	755 172	460 156	984 985	845 720
Grapes	54 711	55 484	53 059	50 059	53 218	57 059	55 925	61 408	39 844	55 815	54 280
Total	17 499 631	17 693 168	15 673 022	16 674 415	18 590 997	18 291 526	19 852 121	19 132 188	19 134 800	20 553 958	19 997 796

Source: All data From National Statistical Institute except: (1) - FAO Statistical Database (http://www.fao.org)

N fixed by crops was estimated from residue to crop product mass ($Res_{BF}/Crop_{BF}$), fraction of dry matter in product ($Frac_{DM}$) and the fraction of dry biomass in the whole plant that is nitrogen

($Frac_{NCRBF}$). These parameters were established for each leguminous plants after the default IPPC values (table 4.17 of IPCC 1996 Revised Guidelines which was latter replaced by table 4.16 of Good Practice Handbook) when available and from other sources (Jarrige, 1988; INRA, AFRC). The considered values are presented in table 6.13.

Table 6.13 – Parameters considered for estimation of N fixed by nitrogen fixing plants

Crop	Portuguese	$Res_{BF}/Crop_{BF}$	$Frac_{DM}$ (%)	$Frac_{NCRBF}$ (%)
Peanut	Amendoim	1.0	86.0	1.06
Broad Beans	Fava	1.5	86.5	2.02
Broad Beans, green	Fava, verde	1.5	35.0	2.02
Beans	Feijão	2.1	85.5	2.62
Chick-Peas	Grão de Bico	1.5	85.0	2.62
Lupins	Tremoço	1.5	85.0	2.96
Peas Green	Ervilhas, verdes	1.5	87.0	1.42
Carobs	Alfarroba	1.0	85.0	2.62
Beans Green	Feijão Verde	1.5	20.0	2.62

Nitrogen added to soil in crop residue was also estimated from Res/Crop, $Frac_{DM}$ and $Frac_{NCR}$. Values for nitrogen fixing plants are the same that were used in the estimate of nitrogen fixed by crops. The values for other crops were also determined from IPCC defaults (IPCC96 and GP) and other sources (Jarrige, 1988; INRA, AFRC). The considered values are presented in next table.

Table 6.14 - Parameters considered for estimation of N added to soil in crop residue

Crop	ResBF/CropBF	FracDM (%)	FracNCRO (%)
Wheat	1.3	85.0	0.28
Triticale	1.5	87.5	0.38
Maize	1.0	78.0	0.81
Barley	1.2	85.0	0.43
Rye	1.6	90.0	0.48
Oats	1.3	92.0	0.70
Rice	1.4	85.0	0.67
Sunflower	1.0	93.3	1.94
Hops	0.1	0.0	0.00
Tomatoes	2.0	27.0	1.50
Tobacco	2.0	15.0	0.67
Tea	2.0	15.0	0.67
Chicory	2.0	15.0	0.67
Potatoes	0.4	22.0	1.10
Sugar Beet	0.2	15.0	1.50
Yams	1.0	15.0	1.50
Sugar Cane	1.0	83.0	0.40
Maize for Forage	0.1	17.8	1.58
Sorghum for Forage	0.1	27.6	1.08
RootsFodder	0.3	10.0	2.28
Forage	0.1	20.0	1.08
Pumpkins	1.0	15.0	1.50
Lettuce	0.1	10.0	1.36
Garlic	0.1	10.0	1.36
Eggplants	1.0	15.0	1.50
Onions	0.1	10.0	1.36
Carrots	0.1	12.5	1.36
Cauliflower	0.1	13.5	2.70
Cabbages	0.1	13.5	2.70
Spinach	0.1	10.0	1.36
Watermelon	1.0	15.0	1.50
Melons	1.0	15.0	1.50
Cucumbers	1.0	15.0	1.50
Chillies	1.0	15.0	1.50
Quinces	1.0	15.0	1.50
Loquat	1.0	15.0	1.50
PomeGranate	1.0	15.0	1.50
Pineapples	1.0	15.0	1.50
Bananas	1.0	15.0	1.50
Peach	1.0	15.0	1.50
Apples	1.0	15.0	1.50
Kiwi	1.0	15.0	1.50
Pears	1.0	15.0	1.50
Sour Cherries	1.0	15.0	1.50
Fig	1.0	15.0	1.50
Parsimmon	1.0	15.0	1.50
Apricots	1.0	15.0	1.50
Cherry	1.0	15.0	1.50
Plum	1.0	15.0	1.50
Avocados	1.0	15.0	1.50
Strawberries	1.0	15.0	1.50
Raspberries	1.0	15.0	1.50
Berries nes	1.0	15.0	1.50
Tangerine	1.0	15.0	1.50
Lemon	1.0	15.0	1.50
Orange	1.0	15.0	1.50
Pomelo	1.0	15.0	1.50
Grapefruit	1.0	15.0	1.50
Wallnut	1.0	85.0	1.50
Chestnuts	1.0	85.0	1.50
Hazelnuts	1.0	85.0	1.50
Almonds	1.0	85.0	1.50
Olives (Oil)	1.0	15.0	1.50
Olives (eatable)	1.0	15.0	1.50
Wine grapes	1.0	15.0	1.50
Grapes	1.0	15.0	1.50

In estimating FCR the following assumption was also made: - $Frac_{FUEL}$, $Frac_{CNST}$ and $Frac_{FOD}$ were set to zero for all crops. Use of crop residues as combustible has negligible expression in

Portugal and also there is no tradition of its use as a building material. Although some residues are used as animal feeding, particularly, as result of grazing in after harvesting cereal areas, it is not possible to estimate their quantity. Using a conservative approach it was decided not to remove this part of nitrogen added to soil which may result in some doubling counting of nitrogen added to soil in this sub-category and in nitrogen added to soil from animal production (Pasture Range and Paddock).

In a consistent way FracBURN is the same value used in estimate of GHG emissions from field burning of agriculture residues.

Recalculations

No changes have been done in the 2003 inventory submission

Further Improvements

Some improvements in these emission source will result indirectly from improvements in activity data used primarily in other source estimates, such as a better knowledge of nitrogen excretion rates and the percentage of manure that is managed under each management system.

Time series of nitrogen in synthetic fertilizers applied to soil should be cross-checked with other sources of information, namely production, import and export and also a different estimate of nitrogen input with agricultural area and nitrogen input rates per hectare. It is expected that this improvement will be done together with the Agriculture Ministry under QA/QC.

The part of crop residues that is submitted to grazing should be assessed and corrected in $Frac_{BURN}$ parameter.

Nitrogen added as sewage sludge should be estimated according to manure management and included in agriculture sector.

6.2.6 Indirect N2O Emissions from Agricultural Soils

Overview

Emissions of N2O from agriculture are considered indirect emissions from agriculture when they result from nitrogen that was not emitted when was applied the first time into soil but has first suffered a path though the atmospheric system - after volatilization as ammonia or nitrogen oxides and intermediate transformation in nitric acid and ammonium salts in particulate or aerosol form- or in the soil-water system - after leaching and/or runoff as ammonia, nitrite, nitrate or light organic compounds.

Actually N2O indirect emissions result from the same microbial process associated to nitrification and denitrification that causes direct emissions. The only difference results from the fact that direct emissions occur solely in agricultural soils whether indirect emissions will occur in whenever conditions are adequate: in agricultural soils, non agicultural soils and even aquatic, Bentic and wetland systems.

Also, all NOx and NH3 emissions from other emissions sources may settle in soil and water and result in similar N2O emissions.

Indirect emissions of N2O from ammonia and NOx volatilization where estimated (only?) from ammonia volatilized whether actual emissions occur in the Portuguese territory or not. In the case of N2O indirect emissions from leaching and runoff the geographical characteristics of the territory - where there are no water basins discharging to other countries - cause that all indirect emissions will occur still on the national territory or nearby ocean waters[63].

Methodology

Different methodologies where used to estimate emissions from:

$N2O_{(G)}$, Indirect N2O emissions from atmospheric deposition of nitrogen that has volatilized as NOx and ammonia from nitrogen used in agriculture as an external input[64], either synthetic or in animal manure. The following equation, that is similar to GPG Tier1a equation, was utilized for N2O emissions from volatilization:

$$N2O_{(G)} = 44/28 * (SF\_NVol+MMS\_NVol+AM\_NVol+GR\_NVol) * EF4$$

where

SF_NVol - Total volatilization as ammonia or nitrogen oxides of nitrogen from synthetic fertilizers applied to soil (ton NH3-N+NOx-N/yr);

MMS_NVol - Volatilization of nitrogen from manure in Manure Management Systems (emissions in housing and outside storage) (ton NH3-N+NOx-N/yr);

AM_NVol - Volatilization of nitrogen from manure applied to soil as fertilizer (ton NH3-N+NOx-N/yr);

GR_NVol - Volatilization of nitrogen from animal excreta deposited in soil during grazing in pasture range and paddock (ton NH3-N+NOx-N/yr);

EF4 - Emission factor for N2O emissions from atmospheric deposition of nitrogen on soil and water surfaces (kg N2O-N/kg NH3-N+kg NOx-N).

Methodologies for the estimation of ammonia from synthetic fertilizers, manure and animal excreta are explained in chapter NH3 Emissions from agriculture (6.2.8). It was assumed that volatilization emissions are mostly ammonia.

Indirect N2O emissions from nitrogen that was removed from agricultural soils after being applied as fertilizer - either as synthetic fertilizer or as manure - and from there removed as consequence of infiltration/percolation and runoff was estimated from next equation, which differs from the methodology proposed in GPG (equation 4.35 or 4.37) because ammonia volatilization is subtracted before $Frac_{LEACH}$ is applied to estimate lixiviation and estimates are therefore smaller:

$$N2O_{(L)} = 44/28 * (F_{SN} + F_{AM} + F_{GR}) * Frac_{LEACH} * EF_5$$

where,

F_{SN} - Annual amount of synthetic fertilizer nitrogen applied to soils adjusted to account for the amount that volatilises as NH_3;

F_{AM} - Annual amount of animal manure nitrogen intentionally applied applied to soils adjusted to account for the amount that volatilises as NH_3;

[63] In fact part of indirect N2O emissions from leaching and runoff from agriculture activities in Spain will occur most probably in Portugal. These emissions are not included in the portuguese inventory however.

[64] No indirect emissions are estimated from nitrogen leached or removed in runoff from nitrogen fixation or crop residues

F_{GR} - 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 NH_3.

$Frac_{LEACH}$ – Fraction of N input that is lost through leaching and runoff

EF_5 – Emission factor for leaching/runoff (Kg N2O / kg NH3-N + NOx-N)

Emission Factors

Default IPCC emission factors where used for EF4 and EF5 (table 4-23 of the 1996IPCC and table 4.18 of the GPG):

Table 6.15 – Emission factors

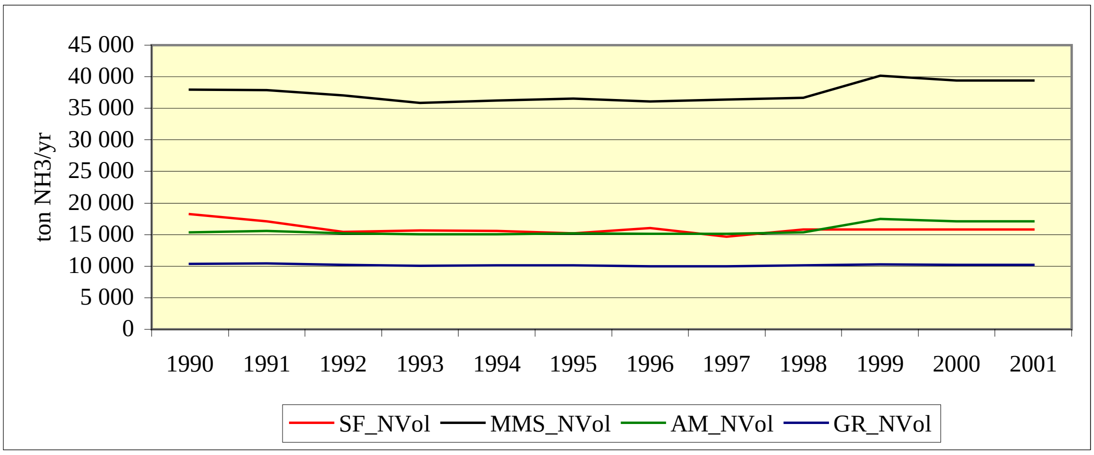
Emission Factor	Kg N2O / kg NH3-N + NOx-N
EF_4 (Deposited nitrogen from volatilization)	0.01
EF_5 (Leaching and Runoff)	0.025

GPG recommends strongly the use of the default IPCC emission factor for deposited nitrogen after volatilization (EF4). Also according to GPG the default value for EF5 will be probably revised in the near future.

Activity Data

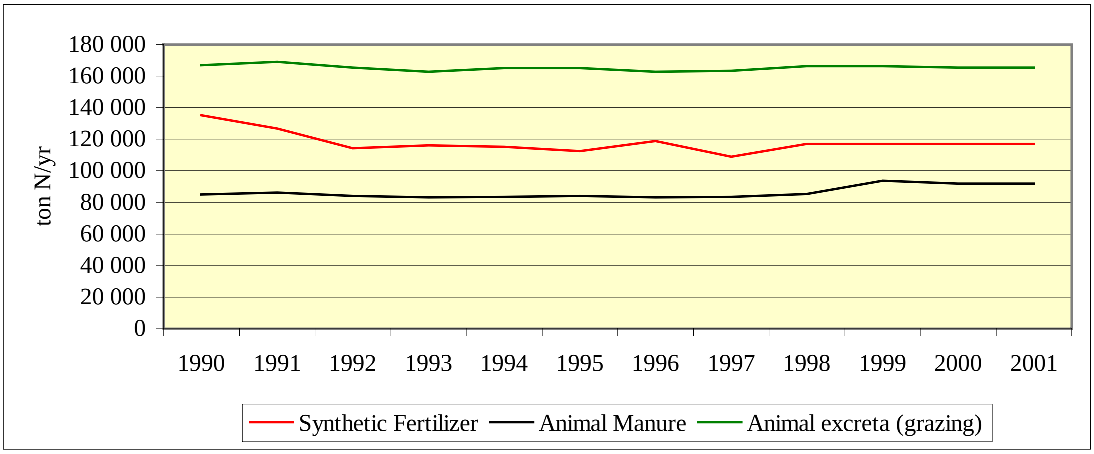
Emissions of N2O from atmospheric deposition of nitrogen compounds that were volatilized consider 4 components: SF_NVol; MMS_NVol; AM_NVol and GR_NVol, that are presented in next figure. Nitrogen from NH3 volatilization from Manure Management Systems is the major contributor to indirect emissions with about 47% of total deposition. Total ammonia emissions and deposition has grown about one percent from base year to 2001.

Figure 6.9 – Nitrogen from NH3 volatilization by emission source/component



The amount of nitrogen in synthetic fertilizers and manure applied to soil is presented in figure 6.10, for each component that is considered in lixiviation/runoff estimate: F_{SN}, F_{AM} and F_{GR}. Nitrogen deposited in soil directly from grazing is the major source of nitrogen to soil while nitrogen in animal manure is the smaller source. From 1990 to 2001 nitrogen deposited into soil has decreased by a small amount (3%).

Figure 6.10 – Nitrogen applied to soils from each component



Recalculations

No changes have been made since previous submission.

Further Improvements

Indirect N2O emissions from ammonia and NOx emissions from other sources will in the future be estimated using the same methodology that it is used for NH3 from agriculture. This emissions will be allocated to the original ammonia emitting source because although they occur mainly in soils and may contribute with nitrogen to plant growth they are not a result of agriculture activity and they do not necessarily occur in agricultural soils, but also in forest soils, unmanaged soils and even in inland and ocean waters.

For consistency with IPCC methodology, emissions will be estimated before ammonia volatilization is deduced.

6.2.7 Field Burning of Agriculture Residues (CRF 4F)

Overview

In-site burning of agricultural residues is still practiced nowadays in Portugal being only forbidden by law-decree during *Forest Fire Season* from May to September. This burning, results in emissions of trace gases as in other combustion processes, including methane, nitrous oxide, carbon monoxide, nitrous oxides and volatile organic compounds. Carbon dioxide is of course also emitted in this process but because it has biomass origin and it is in principle re-absorbed during next growing season, it is not considered in GHG emission inventory.

Methodology

Emissions of in-site burning of agriculture residues were estimated from the following equation:

$$\text{Emission}_{(pol,crop,y)} = EF_{(pol,crop)} * \text{Crop}_{BURN\ (crop,y)} * 10^{-3}$$

where

Emission $_{(pol,crop,y)}$ - Emission estimate of pollutant pol from field burning of residues from a specific crop in year y (ton/year);

$Crop_{BURN\ (crop,y)}$ - Biomass of residue of a specific crop in year y that it is burned in site expressed in biomass dry matter (t dm/yr);

$EF_{(pol,crop)}$ - Emission factor from field burning of agriculture residues of a specific crop (kg/ton dm).

Other methodology formulations could be used that would result in equal results. However activity data definition in dry matter terms was chosen in order that emission factors would be expressed in the same units that are presented in Implied Emission Factors (IEF) of table 4.F of CRF format. Consequently part of methodology that is in fact used to determine emissions is included in emission factor determination and part also in activity data determination and it is subsequently described in the appropriate chapters. But for all relevant aspects, the methodology that it is used, follow the same methodology proposed in IPCC96 except for the fact that residue biomass is not estimated from crop production but from residue production quantities by cultivated area.

Emission Factors

Emission factors for each specific pollutant are estimated from different equations whether they are carbon containing pollutants (CO_2, CH_4 and CO) or nitrogen containing pollutants (NO_x and N_2O). This methodology - after IPCC96 - assumes that some fixed part of carbon and nitrogen that are submitted to burning are emitted as specific compounds.

For carbon containing pollutants the equation is:

$$EF_{(pol,crop)} = C_{Fraction\ (Crop)} * Frac_{RESOXI\ (crop)} * ER_{(crop,pol)} * MW_{C(Pol)}$$

For nitrogen containing compounds the equation is:

$$EF_{(pol,crop)} = C_{Fraction\ (Crop)} * Frac_{RESOXI\ (crop)} * NC_{Ratio\ (crop)} * ER_{(crop,pol)} * MW_{C(Pol)}$$

where

$EF_{(pol,crop)}$ - Emission factor from field burning of agriculture residues of a specific crop (kg/ton dm);

$C_{Fraction\ (Crop)}$ - Ratio of carbon content in dry biomass matter (kg C/kg dm);

$Frac_{RESOXI\ (crop)}$ - Fraction or ratio of carbon that it is oxidized during the active burning period (kg C/kg C);

$NC_{Ratio\ (crop)}$ - Ratio of nitrogen to carbon in crop residue (kg N/kg C);

$ER_{(crop,pol)}$ - Emission ratio, the fraction of total carbon/nitrogen content that it is emitted as pollutant pol (kg C/kg C or kg N/kg N);

$MW_{C(Pol)}$ - Stechiometric correction fraction to convert emissions in carbon/nitrogen units to total molecular weight emissions (kg/kg C or kg/kg N respectively for carbon compounds or nitrogen compounds).

The values set for the parameters used to establish emission factors for each crop are presented in next table.

Table 6.16 – Parameters used for emission factors determination for each crop

Crop	Cfraction	FracRESOXI	NCRatio
Rice	0.6	0.9	0.04
Orchards	0.6	0.9	0.05
Wine/Grapes	0.6	0.9	0.04
Olive oil	0.6	0.9	0.04

Pollutant specific emission ratios that were used follow IPCC default emission ratios as proposed in table 4-17 of IPCC96. They were still not updated in GPG (Annex 4.A.2).

Table 6.17 – Pollutant specific emission ratios

Pollutant	Emission Ratio (ER)	Units	MW_C Ratio
CH_4	0.5	% Carbon Released from fuel	16/12
N_2O	0.7	% Nitrogen Released from fuel	44/28
CO	6	% Carbon Released from fuel	28/12
NO_x	12.1	% Nitrogen Released from fuel	46/14

Final emission factors by pollutant and crop are summarized in table 6.18.

Table 6.18 – Final emission factors by pollutant and crop

Crop	CH4	N2O	NOx	CO
Rice	2.1	0.3	5.0	44.2
Orchards	0.4	0.1	1.3	9.1
Wine/grapes	1.8	0.2	4.3	37.8
Olive oil	0.7	0.1	1.6	14.2

Activity data

According to expert information collected from the Ministry of Agriculture (GASA,2000) only vegetal residues from wine, olive oil cultivation and orchards[65] are subjected to significant burning.

Basic activity data available from the National Statistical Institute is cultivated area for each relevant crop. Expert opinion from the Agriculture Ministry was used to established the quantity of residues that is generated annually by each crop and what percentage is actually burnt in site. Activity data in suitable units is estimated from:

$$Crop_{BURN\ (crop,y)} = CropAREA(crop,y) * Resid_{PROD\ (crop)} * Dm_{Content(crop)} * Frac_{RESBURN\ (crop)} * 10^{-7}$$

where

[65] Comprehending fresh fruit and dry fruits (nuts).

$Crop_{BURN\ (crop,y)}$ - Biomass of residue of a specific crop in year y that it is burned in site expressed in biomass dry matter (t dm/yr);

$Crop_{AREA\ (crop,y)}$ - Cultivated area for each specific crop in year y (ha/yr);

$Resid_{PROD\ (crop)}$ - Quantity of residue generated from each unit cultivation area of crop y expressed in live weight (kg/ha);

$Dm_{Content(crop)}$ - Dry matter content of crop residues (% dm/live weight);

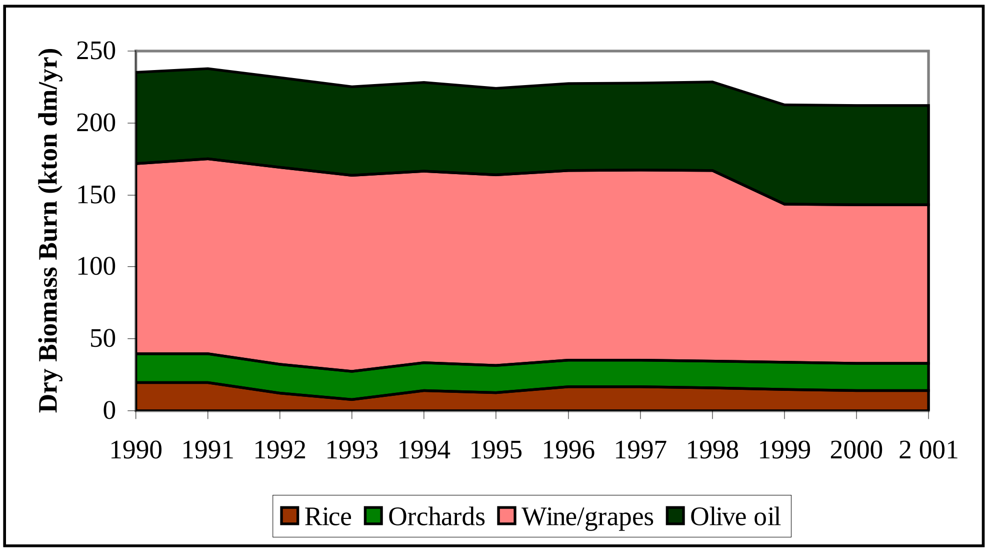
$Frac_{RESBURN\ (crop)}$ - Fraction of total residues from a specific crop that are burnt in site (%).

Parameters $Resid_{PROD}$, $Dm_{Content}$ and $Frac_{RESBURN}$ are the same considered in (GASA, 2000) and are presentd in table 6.17. Final activity data expressed in dry matter content may be seen in figure 6.8.

Table 6.19 – Parameters used for the estimation of burnt crop residues quantities

Crop	$Resid_{PROD}$ kg live weight/ha	$Frac_{RESBURN}$ %	$DM_{Content}$ %
Rice	3900	50	30
Orchards	800	30	50
Wine/Grapes	2500	40	50
Olive oil	375	100	50

Figure 6.11 – Estimated quantities of burnt crop residues



Recalculations

No changes have been made in estimates of greenhouse gas emissions from this source sector since last submission, neither in activity data or methodology and emission factors.

Further improvements

Associated with agriculture activities, the burning of hedge rows and some infestants is still practice in Portugal. There is still no data concerning this activity and a better insight on this subject will have to be developed in next inventories.

6.2.8 NH3 Emissions from Agriculture

Methodology

Ammonia emission from manure may occur in 3 different places in the life cycle of manure, according to EMEP/CORINAIR:

- Emission in housing;
- Emission in outside storage;
- Emission in land spreading.

The following figure shows the procedures used to estimate ammonia emissions from manure.

Emission Factors

The emission factors that where used to estimate ammonia emissions from manure from domestic livestock where already presented in source categories N2O emissions from Manure Management and Direct nitrous Oxide Emissions from Agricultural Soils and are present again in table 6.20. These emission factors result from EMEP/UNECE 3rd edition in annex A of chapter B1050 and version 4.0 of chapter B1010 and are not dependent on the Manure Management System that is used. Final emission factors per animal class are presented in next table (kg N-NH3/kg N excreted):

Table 6.20 - Emission factors used for NH3 volatilisation estimation from animal housing, land spreading and grazing in pasture

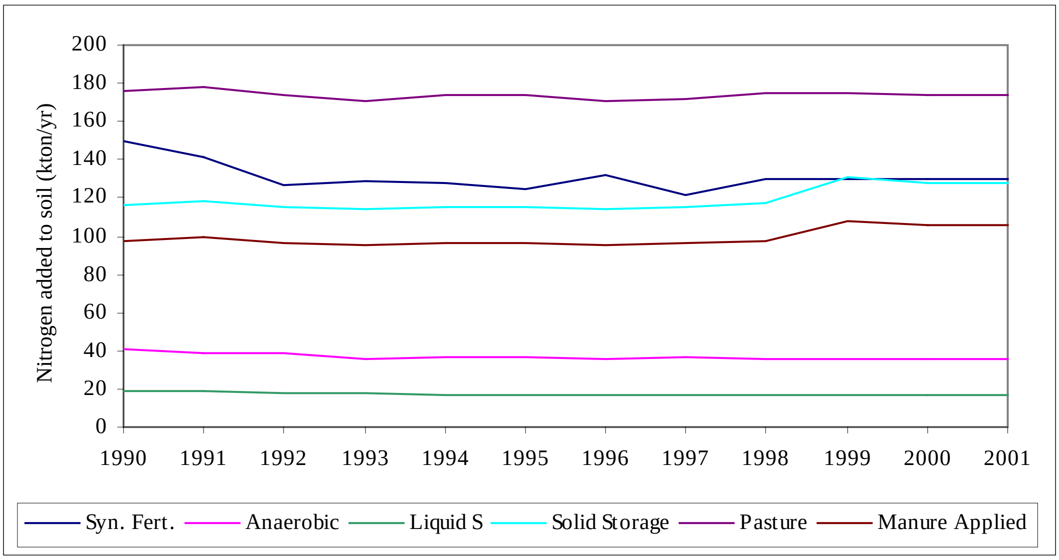
Classe	Housing & Outside Storage	Land spreading of Manure	Grazing in Pasture	Total
Dairy Cows	0.17	0.17	0.08	0.42
Other Cattle	0.17	0.17	0.08	0.42
Sheep	0.10	0.07	0.04	0.21
Goats	0.10	0.07	0.04	0.21
Swine	0.22	0.16	-	0.38
Equines	0.12	0.07	0.08	0.27
Poultry	0.22	0.16	-	0.38
Hens	0.23	0.15	-	0.39
Rabbits	0.22	0.16	-	0.38

The use of emission factors from EMEP/UNECE results therefore in values for FracGASM that are different and higher than the default value for FracGASM (0.2 kg N-NH3 + N-NOx/ kg of N excreted, in table 4-19 of IPCC96).

Emission of ammonia volatilisation from synthetic fertilizers where calculated with the following emission factor: 01 kg (NH3-N+NOx-N)/kg N.

Activity Data

Figure 6.12 – Nitrogen applied to soils from each emission source/component



Recalculations

No changes have been made on this source sector.

CHAPTER 7: LAND-USE CHANGE AND FORESTRY (LUCF) (CRF SECTOR 5)

7.1 Overview

Emissions of GHGs related to Land-use and Land-Use Changes refer predominantly to CO2. Other significant direct gases include CH4 and N2O; indirect GHGs include CO, NOx and NMVOC. NMVOCs are emitted in significant quantities from biomass burning.

Forestry activity is included in a broad category - Changes in Forest and Other Woody Biomass Stocks (IPCC 5A) – that should account for all significant human interactions with forests that affect CO2 fluxes to and from the atmosphere, but which do not result in a land-use change. Changes in forest and other woody biomass stocks includes tree-planting activities, which can result in land-use changes. For practical reasons, these activities are however included in this category.

Forest and Grassland Conversion (IPCC 5B) includes conversion of existing forests and natural grasslands to a wide variety of other uses, such as agriculture, highways and urban development. Abandonment of Managed Lands (IPCC 5C), e.g., croplands and pastures, can lead to the natural re-accumulation of carbon, or to the opposite situation, where the accumulation of biomass does not occur or even degrade.

The Portuguese inventory covers CO2 emissions and removals from changes in forest. Other wooded land (shrubs) had not been quantified, due to the high uncertainty of background information.

Tree plantations are accounted in forest areas covered by the National Forest Inventory. Estimates for carbon sequestration from land-use changes resulting from these new forest stocks, corresponding to IPCC categories 5B (Forest and Grassland Conversion) and 5C (Abandonment of Managed Lands), are accounted in category 5A.

The main source/sink of CO2 in soils are related with changes in the amount of organic carbon stored in soils, which depends on the quantity and quality of organic matter inputs and the rate of decomposition that are a function of climate, soil and land-use and management practices (forest and agriculture). In Portugal, there are some regional studies about the organic carbon content of the soils, but there are few elements about its relation to land use changes. Also is not possible to evaluate the net change in carbon stocks as a result of soil management practices and its evolution in time. In this way, IPCC category 5D (CO2 Emissions and Removals from Soils) cannot be quantified.

7.2 Source categories

7.2.1 Changes in forest and other woody biomass stocks (CRF 5 A)

Methodology

The methodology used follows the IPCC Basic Calculation method (IPCC 96) and relies on the carbon flux approach. It assesses net CO2 flux due to changes in forest carbon stocks taking account of emissions caused by tree fellings and uptakes from the atmosphere due to tree growth.

1. INCREMENT
= area of forest (ha) * annual growth rate (m3/ha/y) *
expansion factor * biomass conversion factor (t dm/m3) *
C-fraction of dry matter

2. BIOMASS LOSS
= total harvest (m3) * expansion factor *
biomass conversion factor (t dm/m3) * C-fraction of dry matter

3. NET ANNUAL CO2 CHANGE (emission or removal)
1.-2. = Net annual C Change * 44/12

Activity data and parameters

Increment

Estimates of biomass increment are largely based on data from periodic forest surveys: National Forestry Inventories (Inventários Florestais Nacional) conducted by the General Direction for Forestry/Ministry of Agriculture and Forestry (Direcção Geral das Florestas (DGF)/Ministério da Agricultura e Floresta).

Forest definition used by DGF is based on the UN-ECE/FAO definition: Forest is defined as vegetation formations constituted by woody trees having crown cover with more than 10%, minimum area of 0.5 ha and 20 m width, and trees having a potential to reach a minimum height of 5 meters. Areas under afforestation and reforestation which will reach in the future a minimum crown density of 10% and a minimum height of 5 meters are also included under this definition.

All forest and woody biomass stocks in Portugal are consider to be affected by human intervention, and consequently considered as non-natural/managed.

Forest area data used to calculate growth increments come from NFIs. Relevant inventory surveys for the period analysed (1990-2001) are the NFI 2nd revision (1982) and the NFI 3rd revision (1995[66]). Data for 1990 are estimates from General Direction for Forestry. Figures for 2000 were estimated having as a basis 1995 NFI data but summing up with new areas from forestry plans, which already do not include unsuccessful plantations. Forest areas for the intermediate years were calculated by interpolation from figures presented in the following table. Forest area presented in the table below, exclude burnt areas from forest fires.

[66] The 3rd Revision was based on the 1995 national aerial photo coverage and on field work developed in 1997/98.The inventory covered 35 attributes of the Portuguese forests for continental Portugal. The results were published in 2001: DGF(2001), Inventário Florestal Nacional – Portugal Continental, 3ª revisão 1995-98.

Table 7.1 – Forest area trends (1000 ha)

	1982 (NFI 2nd rev.)	1990 (DGF estimates)	1995 (NFI 3rd rev.)	2000 (estimates)
Pinus pinaster	1 217	1 069	976	959
Pinus pinea	-	-	-	-
other softwood	104	104	105	119
Eucalyptus	366	554	672	640
Quercus suber	662	693	713	793
Quercus ilex	464	462	462	495
other Quercus	109	123	131	131
Castanea sativa	30	37	41	41
other hardwood	89	98	102	117
Total	3 041	3 140	3 202	3 295

Sources:
1982 and 1995: data refer to National Forestry Inventory data, respectively, 2nd and 3rd revision.
1990: estimated data from DGF (Direcção Geral das Florestas).
2000: estimates based on 1995 data plus plantations data from forestry plans.

New trees (plantations) are included in forest areas surveyed. However, as carbon sequestration associated to plantations have different growth rates, these areas have been considered separately in the estimates. In the calculation it was taken into consideration the difference of time for species to reach a dbh of 7.5 cm: Pinus 8 years; Quercus 12 years, Eucalyptus 4 years and other softwood and hardwood 10 years.

Carbon uptake increment had been calculated separately for mature forests and new tree plantations, using different national average growth rates representing national circumstances. Other wooded land (shrubs) had not been quantified, due to the high uncertainty of background information.

Growth rates refer to m^3 of roundwood over bark per ha and per year. This requires the subsequent multiplication with expansion factors to consider the whole tree volume increment and biomass density factors. National values for these parameters are also presented in a table below. The IPCC default value for the carbon fraction of dry matter (0.5) was used.

Table 7.2 – Area of plantations (1000 ha)

	1980-90	1990-95	1995-99
Pinus pinaster	58	22	4
Pinus pinea	2	0	0
other softwood	27	22	29
Eucalyptus	15	32	0
Quercus suber	14	3	66
Quercus ilex	0	2	28
other Quercus	0	0	0
Castanea sativa	1	0	0
other hardwood	11	21	29
Total	128	102	156

Sources:
DGF, IFADAP (PAF, Reg 797, PDF, Reg 2080, Modelo 47, Projecto Florestal Português do Banco Mundial, Fundo Fomento Florestal)

Table 7.3 – Parameters used in the calculations

	Growth Rates (m3/ha/a)	Expansion Factors	Conversion Factors (t dm/m3)
total forest			
Pinus pinaster	5.6	1.247	0.260
Pinus pinea	5.6	1.247	0.260
other softwood	5.0	1.247	0.260
Eucalyptus	9.5	1.237	0.522
Quercus suber	0.5	1.237	0.522
Quercus ilex	0.5	1.237	0.522
other Quercus	0.5	1.237	0.522
Castanea sativa	5.0	1.237	0.522
other hardwood	2.9	1.237	0.522
plantations			
Pinus pinaster	6.2	1.00	0.200
Pinus pinea		1.00	0.200
other softwood	5.0	1.00	0.200
Eucalyptus	10.9	1.00	0.500
Quercus suber	0.6	1.00	0.500
Quercus ilex	0.6	1.00	0.500
other Quercus	0.6	1.00	0.500
Castanea sativa		1.00	0.500
other hardwood	2.9	1.00	0.500

Source: DGF

Biomass Loss

Tree harvesting data is considered to be one of the least known part of Portuguese forest system. Data available refer only to a few species - pinus pinaster and eucalyptus -, and is based on statistical data of wood consumption. It has been assumed that forest biomass used in heat production (domestic firewood or industrial) is a forest sub-product resulting from forest management practices, and consequently is not consider as a depletion of carbon sequestration capacity.

Values for tree feelings refer to roundwood over bark and do not include residues from exploration, i.e. branches, etc. To account for the whole tree volume, it was used the same expansion factors that were used to estimate growth. The conversion to dry matter was done using the same parameters used for increment growth estimates.

Table 7.4 – Volumes of harvested wood (1000 m^3)

	1990	1995	2000 a)
Pinus pinaster	7 562	6 674	6 000
Eucalyptus	5 726	5 440	5 500
Total	13 288	12 114	11 500

a) Estimates based on 1995-2000 average.
Source: DGF

7.3 Recalculations

Changes related to this section result from changes in background data. Growth rates have been revised for some species to take in account more recent information from national studies. Also, activity data such as forest area, data on tree plantations, and harvest data have been revised according to updates from DGF. Further to this, traditional fuel-wood consumption, which was previously accounted in the previous submissions, was not counted as forest depletion. Firewood has now been considered as a forest sub-product resulting from forest clearing and not as real forest depletion.

Estimates for IPCC 5B and 5C categories, which were formerly presented, are not counted anymore as they were considered to result in double counting: changes in forest are already consider in the evolution of forest areas accounted in IPCC category 5A.

7.4 Further improvements

Concerning category IPCC 5A some efforts should be focused on data collection on harvest. This data is considered as one main weakness of forest accounting system. Further to this, a special effort should be done to account for carbon sequestration in bush land.

Furthermore, national estimates do not refer to total National but only to Portugal Mainland. Information on Azores and Madeira Islands is not available (NFI refer to Portugal Mainland only). A special effort should be made in the future to improve this shortfall.

CO2 Emissions and Removals from Soils were never quantified. In Portugal, the information allowing the evaluation of the net change in carbon stocks of the soils is scarce and dispersed. There are few regional studies about the organic carbon content of the soils and its relation to land use. However there is no information concerning the evolution in the time of the net carbon storage of the soils due to management practices, land use changes, etc. Major research should be undertaken to develop the necessary background data that would enable the quantification of this category using the IPCC guidelines.

CHAPTER 8: WASTE (CRF SECTOR 6)

8.1 Overview

Waste management and treatment of industrial and municipal wastes are sources of GHGs emissions. The inventory covers emissions resulting from solid waste disposal on land, treatment of liquid wastes and waste incineration.

The most important gas produced is CH4, resulting from the anaerobic decomposition of organic waste disposed on land and from handling of wastewater treatment under anaerobic conditions.

Decomposition of organic waste does not occur instantaneously after disposition on land, but rather over a long period of time, and CH4 is emitted at a diminishing rate.

Different factors affect the generation of CH4: Waste disposal practices (degree of control of disposal sites – in general, controlled placement of waste favours anaerobic activity and consequently landfill gas formation, but the gas can be recovered and be either flared or used for energy purposes); Waste composition (quantities of degradable materials is one major element influencing biogas production); and Physical factors (e.g. moisture content and temperature).

Solid waste disposal sites (SWDS), which include both managed landfills and open dump sites, can also produce directly significant amounts of CO2. The decomposition of organic materials originates landfill gas or biogas consisting of approximately 50 percent CH4 and 50 percent CO2 by volume. Only CO2 from non biomass materials is included in the GHG inventory. Additionally, a much smaller percentage of landfill gas is composed of NMVOC (less than 1 percent, according to EPA, April 2001). This was not considered in the estimates for the time being.

The biodegradation of soluble organic matter in wastewater can occur under aerobic or anaerobic conditions. CH4 emissions result from handling of wastewater and the biomass (sludge) produced under anaerobic conditions. The amount of CH4 produced depends on the extent of biodegradation occurring under anaerobic versus aerobic conditions. CH4 produced during deliberate anaerobic wastewater treatment processes can be collected and flared or combusted for energy. Untreated wastewater may originate CH4 if hold under anaerobic circumstances.

CH4 production depends mainly on: Wastewater characteristics (the degradable organic content determines the CH4 producing potential of wastewater; under anaerobic conditions and all the same conditions, such as temperature, wastewater with higher BOD (Biochemical Oxygen Demand) or COD (Chemical Oxygen Demand) concentrations will produce more CH4 than wastewater with lower BOD or COD concentrations); Handling Systems – anaerobic versus aerobic conditions (the management conditions of collection and wastewater treatment systems determine the potential of CH4 generation; systems providing anaerobic conditions will generally produce higher CH4 emissions than systems having aerobic conditions); Temperature (CH4 generation increases with temperature; CH4 production occurs with temperatures higher than 15º; this factor is specially important in uncontrolled systems and warm climates); Systems characteristics (other factors affecting CH4 production are retention time, degree of wastewater treatment, and other site specific conditions).

In addition to CH4, wastewater treatment is also potentially a source of NMVOC and N2O, but for the time being there are no available methodologies for their complete calculation. Nevertheless, N2O emissions from human sewage were estimated using a basic approach, and rough NMVOC estimates are also presented based on indicative default emission factors from CORINAIR90 Default Emission Handbook.

Incineration of municipal solid wastes (MSW) and hazardous wastes originates emissions of CO2, CH4, N2O, CO, NOx and NMVOCs. Out of the direct GHGs, CH4 emissions are considered to be the less significant due to combustion conditions in incinerators. According to the IPCC Guidelines, only CO2 emissions resulting from the incineration of carbon in waste of fossil origin (e.g. plastics, certain textiles, rubber, liquid solvents, and waste oil) should be included in emissions estimates. The carbon fraction that is derived from biomass materials (e.g. paper, food waste, and wooden material) should not be included. Thus, CO2 emissions from waste combustion depends, on the quantities of waste incinerated, the carbon content of the waste, and the fraction of the carbon that is of fossil origin. In respect to other pollutants, emissions are estimated as the product of the mass of total waste combusted, an emission factor for the pollutant emitted per unit mass of waste incinerated, and emissions control removal efficiency.

8.2 Source categories

8.2.1 Solid Waste Disposal on Land (CRF 6 A)

CH4 emissions from Solid Waste Disposal Sites (SWDS)

Methodology

To better take into account the fact that CH4 emissions from SWDS occur over a long period of time and not immediately after disposal of waste on land, the methodological approach considered was the First Order Decay Method (Tier 2).

This method can be represented by equations (1) and (2):

$$Q = L_O R (e^{-kc} - e^{-kt}) \qquad (1)$$

where:

Q - methane generated in current year (Mg CH4/yr);

L_0 - methane generation potential (Mg CH4/Mg waste);

R - quantity of waste landfilled - average annual waste acceptance rate during the SWDS's active life (Mg/yr);

k - methane generation rate constant (1/yr);

c - time since SWDS closure (yr) (c = 0 for active SWDS);

t - time since SWDS opened (yr).

$$CH4\ emitted_{(Gg/yr)} = [CH4_{generated} – Rec] * (1 – OX) \qquad (2)$$

where:

Rec - CH4 recovered (Gg/yr);

OX - oxidation factor (fraction).

CH4 recovery (Rec) is the amount of CH4 generated at SWDS that is recovered and combusted (e.g. flared or used for energy). If CH4 is extracted and burned, then this amount of CH4 will not be emitted as CH4, but will be oxidized to CO2. On the other hand, CH4 recovered and subsequently vented is not subtracted from emissions.

Oxidation factor (OX) reflects the portion of CH4 from SWDS that is oxidised in the soil or other material covering the waste. The amount of CH4 that oxidises turns primarily to CO2. If the OX is zero, no oxidation takes place, and if OX is 1 then 100% of CH4 is oxidised. Well-managed disposal sites tend to have higher oxidation results than unmanaged dump sites with no cover or where large amounts of CH4 can escape through cracks in the cover.

The methane generation potential (L_o) depends upon the composition of waste, on waste disposal practices and on the physical characteristics of the SWDS. It is estimated by the formula:

$$Lo = MCF * DOC * DOC_F * F * 16/12$$

where:

MCF - CH4 correction factor (fraction);

DOC - degradable organic carbon (fraction) (Mg C/Mg waste);

DOCF - fraction DOC dissimilated;

F - fraction by volume of CH4 in landfill gas;

16/12 is the conversion from C to CH4.

Methane correction factor (MCF) accounts for the effect of management practices on CH4 generation. Unmanaged disposal sites present lower methane-generating potential, because a larger fraction of waste decomposes aerobically in the top layers of unmanaged SWDS.

Degradable organic carbon (DOC) is the organic carbon that is accessible to biochemical decomposition. It is a function of the composition of waste and can be calculated from a weighted average of carbon content of various components of waste.

$$DOC = (0.4 * A) + (0.17 * B) + (0.15 * C) + (0.3 * D)$$

where:

A = fraction of waste that is paper and textiles;

B = fraction of waste that is garden waste, park waste or other non-food organic putrescibles;

C = fraction of waste that is food waste;

D = fraction of waste that is wood or straw.

Fraction of degradable organic carbon dissimilated (DOC_F) is an estimate of the fraction of carbon that is ultimately degraded and converted into landfill gas, and reflects the fact that some organic carbon does not degrade, or degrades very slowly, when deposited in SWDS. Theoretically it is assumed that it varies mainly with the temperature (T) in the anaerobic zone of a landfill: 0.014T + 0.28 (Tabasaran, 1981).

Fraction of CH4 in landfill gas (F) reflects the fact that biogas are mainly consisted of CH4 and CO2 (usually considered half of each gas).

Activity data and parameters

<u>Quantities of waste landfilled</u>

SWDS include solid municipal or urban waste (household, garden, commercial-services wastes) and industrial wastes.

<u>Urban waste</u>

In 2001, the management of municipal solid waste (MSW) in Portuguese mainland was under the responsibility of 31 management systems: 12 multi-municipal, 18 inter-municipal and 1 municipal system. In the Autonomous Region of Azores, the municipalities 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.

Since 1999, data on MSW is available for the majority of these systems, including production amounts, final disposal and, to a less extent, waste composition.

For previous years, information on urban waste was not collected on a regular basis, and come mainly 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, and 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 their characteristics (opening and closure year of operation, waste composition, existence of flaring equipment, etc). Data included in this study (Quercus 1995), refer to 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 data for several decades in the past concerning waste quantities, composition and disposal practices. According to IPCC 2000, it is good practice to estimate historical data if such data are not available, when this is a key source category (Annex A). In what concerns the extent of the time series, it was adopted the criteria from USA, based on the emissions model from EPA (1993). The model considers that landfilled waste produces CH4 for 30 years after disposal.

Before 1994, data were 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.

Municipal solid waste production were estimated for each municipality as follows:

[Population (inhabitants) * Annual per capita generation rate (ton/inhabitants/year)]

Population data refer to resident population from National Statistical Office (INE) Census for the years: 1960, 1970, 1981, 1991 e 2001. Data for intermediate years were estimated, by interpolation, for each municipality.

To take into account the fact that part of the population (rural areas) is not served by an organised waste collection and waste disposal system, these data were multiplied by the percentage of population served by waste collection in each municipality. After 2000, it was considered 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 per capita generation rate * Percentage of Population served by waste collection] – Quantity of incinerated waste – Quantity of composted waste

Table 8.1 - Urban waste disposed to SWDS

Year	ton	Year	ton	Year	ton	Year	ton	Year	ton
1960	455 772	**1970**	743 229	1980	1 304 508	**1990**	2 447 370	**2000**	3 062 756
1961	480 215	**1971**	791 255	1981	1 411 746	**1991**	2 635298	**2001**	3 131 732
1962	505 538	**1972**	841 766	1982	1 507 539	**1992**	2 762 961		
1963	531 768	**1973**	894 871	1983	1 607 917	**1993**	2 893 546		
1964	558 933	**1974**	950 681	1984	1 713 074	**1994**	2 964 402		
1965	587 061	**1975**	1 009 314	1985	1 823 211	**1995**	3 118 546		
1966	616 183	**1976**	1 070 889	1986	1 948 812	**1996**	3 314 487		
1967	646 329	**1977**	1 135 534	1987	2 080 467	**1997**	3 508 627		
1968	677 531	**1978**	1 203 377	1988	2 218 430	**1998**	3 707 215		
1969	709 819	**1979**	1 274 555	1989	2 362 968	**1999**	3 557 756		

Having as a basis the survey of Quercus, the amounts of waste disposed in SWDS, were split between open dump sites and managed landfills.

Table 8.2 - Percentage of waste disposed to open dump sites and managed landfills (% of waste disposed to SWDS)

Year	Open dump sites %	Managed landfills
Early 60s	100	-
Early 70s	100	-
Early 80s	70	13
1990	69	28
1995	60	38
2001	19	81

CH4 generation potential (Lo)

The parameters used in the calculation are mainly IPCC default values.

Table 8.3 – Parameters used in Lo calculation

Parameter	Explanation	Value considered
MCF	IPCC defaults	Managed landfills = 1.0 Open dump sites = 0.6
DOC	National estimate	18.8
DOCF	IPCC default (considering T = 35º)	0.77
F	IPCC default	0.5

The estimation of Degradable Organic carbon (DOC) was based on information on the waste composition from annual municipal registries, and the Quercus survey, presented in the following table.

Table 8.4 - Composition of waste disposed to SWDS (fermentable fractions)

Fermentable fractions	Percentage of weight
Paper and textiles (fraction A)	25.8
Non-food fermentable materials (fraction B)	18.7
Food waste (fraction C)	34.8
Wood or straw (fraction D)	0.3

Other parameters

Two different values were considered for the CH4 generation rate constant (k), to take into consideration diverse regional circumstances. A higher k value (0.04) was applied for municipalities above Tagus River reflecting higher moisture conditions; a lower k figure (0.02) was used for the others.

In the absence of metering landfill gas recovered data, estimates of recovered CH4 were done based on: the information from INR for each waste management system - existence of burners, and the starting year of landfill operation -; and on an average efficiency for the gas capture (75%) and for the burners (97%).

Table 8.5 – Quantities of CH4 recovered and combusted

Year	Unmanaged disposal sites	Landfill sites
	ton CH4	
1990	0	1 769
1991	0	2 129
1992	0	2 513
1993	0	3 071
1994	0	3 602
1995	0	4 206
1996	0	4 879
1997	0	5 621
1998	0	6 429
1999	0	7 097
2000	812	7 494
2001	1 213	8 209

Concerning uncontrolled dumping sites, it was considered that there is gas burning when a dumping site has been closed and is associated with a managed landfill having recovery of CH4. It was assumed that gas burning starts typically 2-3 years after the beginning of the landfill operation.

In what concerns the oxidation factor (OX), the default value recommended by the IPCC Guidelines was used, i.e., zero, given that no national data exists and there is no internationally accepted factor.

Industrial waste

Information on industrial waste refers to the fermentable part of industrial waste. Since 1999, data refer to annual registries referring to industrial units declarations sent to the regional environment directorates (DRAOTs).

Historical waste disposal data have been estimated based on expert judgement. For the period 1960-1990 it was considered a growth rate of 1.5% per year; for the following years (1990-1998) 2% per year.

Until now there are no dedicated industrial disposal sites. Hence, all industrial waste generated was consider to be disposed in SWDS together with urban waste. However, as there is no available information concerning the disposal of industrial waste between uncontrolled and controlled SWDS, it was assumed that all estimated waste produced until 1999 have been disposed into unmanaged SWDS; since 1999 into managed SWDS. This assumption reflects the significant national effort that has been done in recent years to deactivate and closure most of uncontrolled dumping sites. Out of 328 uncontrolled dumping sites, 272 had been closed by the end of 2000. In 2000 a small % of the waste produced was disposed in uncontrolled dumping sites: 14%.

Table 8.6 – Quantities of fermentable industrial waste disposed to SWDS

Year	Open dump sites	Managed landfills	Year	Open dump sites	Managed landfills	Year	Open dump sites	Managed landfills
	Ton			ton			ton	
1960	823 557	0	**1974**	1 014 422	0	**1988**	1 249 520	0
1961	835 911	0	**1975**	1 029 638	0	**1989**	1 268 262	0
1962	848 450	0	**1976**	1 045 083	0	**1990**	1 287 286	0
1963	861 176	0	**1977**	1 060 759	0	**1991**	1 313 032	0
1964	874 094	0	**1978**	1 076 670	0	**1992**	1 339 293	0
1965	887 205	0	**1979**	1 092 820	0	**1993**	1 366 079	0
1966	900 513	0	**1980**	1 109 213	0	**1994**	1 393 400	0
1967	914 021	0	**1981**	1 125 851	0	**1995**	1 421 268	0
1968	927 731	0	**1982**	1 142 738	0	**1996**	1 449 694	0
1969	941 647	0	**1983**	1 159 880	0	**1997**	1 478 687	0
1970	955 772	0	**1984**	1 177 278	0	**1998**	1 508 261	0
1971	970 109	0	**1985**	1 194 937	0	**1999**	0	1 538 426
1972	984 660	0	**1986**	1 212 861	0	**2000**	0	1 569 195
1973	999 430	0	**1987**	1 231 054	0	**2001**	0	1 600 579

8.2.2 Wastewater Handling (CRF 6 B)

Domestic Wastewater

CH4 emissions from Wastewater Handling (WWH)

Methodology

CH4 emissions from domestic wastewater handling were estimated using a methodology adapted from IPCC 1996 and IPCC 2000, which follows three basic steps:

1 – Determination of the total amount of organic material originated in each wastewater handling system

The main factor determining the CH4 generation potential of waste is the amount of degradable organic component (DC) of the wastewater stream, which is expressed in terms of either BOD (recommended for domestic wastewater and sludge), or COD (more appropriate for industrial waste streams). Total organic waste (TOW) is a function of human population and the amount of waste generated per person.

$$TOWdom = P * Ddom$$

where:

TOWdom - total domestic/commercial organic waste in kg BOD/yr;

P - population in 1000 persons;

Ddom - domestic/commercial degradable organic component in kg BOD/1000 persons/yr.

Calculations have been made separately for TOWdom for wastewater and sludge.

2 – Estimation of emission factors

The emission factor for each wastewater and sludge type depends on the maximum CH4 producing potential of each waste type (Bo) and a weighted average of CH4 conversion factors (MCF) for the different wastewater treatment systems existing in a country.

$$EF_i = B_{oi} \times \Sigma_x (WS_{ix} \times MCF_x)$$

where:

- EF_i - emission factor (kg CH4 /kg DC) for waste type i (e.g., domestic wastewater or sludge, etc);
- B_{oi} - maximum methane producing capacity (kg CH4/kg DC) for waste type I;
- WS_{ix} - fraction of waste type i treated using wastewater handling system x;
- MCF_x - methane conversion factors of each wastewater system x.

Maximum CH4 producing capacity (B_o) is the maximum amount of CH4 that can be generated from a given quantity of wastewater or sludge.

Metane Conversion Factor (MCF) is an estimate of the fraction of DC that will ultimately degrade anaerobically. The MCF varies between 0 for a completely aerobic system to 1.0 for a completely anaerobic system.

3 – Calculation of emissions

Emissions are a function of total organic waste generated and an emission factor characterising the extent of CH4 generation for each wastewater handling system. CH4 that is recovered and flared or used for energy should be subtracted from total emissions, as it is not emitted into the atmosphere.

$$M = \Sigma_i (TOW_i * EF_i - MR_i)$$

where:

- M - Total CH4 emissions from wastewater and sludge handling in kg CH4
- TOW_i - total organic waste for waste type i in kg DC/yr. (Step 1)
- EF_i - emission factor for waste type i in kg CH4/kg DC (Step 2)
- MR_i - total amount of methane recovered or flared from wastewater type i in kg CH4.

This method can be applied at different levels of disaggregation according to data availability.

All calculations have been done at municipal territorial units. National totals result from the summation of estimates performed for each municipality.

Activity data and parameters

Total organic content of domestic sewage (TOW_{dom}) was determined multiplying the total population for each year by a per capita wastewater BOD5 production rate. National population data refer to National Statistical Office (INE) Census for the years 1981, 1991 and 2001;

intermediate years have been estimated by interpolation. The BOD5 factor considered was 56 g BOD5/cap/day.

Table 8.7 - National population and wastewater BOD produced

Year	Population Inhabitants	BOD5 Ton/year
1990	9 863 734	201 615
1991	9 867 147	201 684
1992	9 916 044	202 684
1993	9 964 941	203 683
1994	10 013 838	204 683
1995	10 062 735	205 682
1996	10 111 632	206 682
1997	10 160 529	207 681
1998	10 209 426	208 681
1999	10 258 323	209 680
2000	10 307 220	210 680
2001	10 356 117	211 679

Data for population included in wastewater treatment systems at regional level was established from Environmental State Reports, which include data from the National Plan for Environmental Policy (PNPA 1995) and data from INAG (National Water Institute).

Table 8.8 - Percentage of population by wastewater handling system

Region	Treatment Systems			Individual treatment (a)			Discharge into waterways or ocean		
	1990	1995	2000	1990	1995	2000	1990	1995	2000
Norte	11.0	32.0	42.0	64.0	56.0	41.0	25.0	12.0	17.0
Centro	18.0	30.0	51.0	61.0	48.0	29.0	21.0	22.0	20.0
Lisboa e Vale do Tejo	26.0	47.0	64.0	21.0	14.0	11.0	53.0	39.0	25.0
Alentejo	32.0	58.0	74.0	31.0	17.0	15.0	37.0	25.0	11.0
Algarve	37.0	60.0	83.0	24.0	32.0	16.0	39.0	8.0	1.0
Açores	24.8	45.4	62.8	40.2	33.4	22.4	35.0	21.2	14.8
Madeira	24.8	45.4	62.8	40.2	33.4	22.4	35.0	21.2	14.8
Average	20.1	39.3	55.2	45.1	36.7	25.4	34.7	24.0	19.3

a) Population served by individual private treatment facilities (e.g. septic tanks)

The estimated total organic waste (TOW in terms of BO5 produced) has been divided into four fractions, according to the wastewater handling types considered: wastewater treatment plants, septic tanks, discharge into water, and the amount of sludge produced. The quantities of sludge are assumed to be, for all years, 20% of TOW originated in wastewater treatment plants.

Table 8.9 - Fractions of BOD produced according to handling systems (ton BOD_5)

Year	Treatment systems		Individual treatment (a)	Discharge into waterways or ocean
	wastewater	sludge		
1990	32 465	8 116	91 011	70 023
1991	38 662	9 666	87 623	65 734
1992	45 071	11 268	84 620	61 726
1993	51 540	12 885	81 584	57 674
1994	58 072	14 518	78 513	53 580
1995	64 664	16 166	75 409	49 443
1996	70 248	17 562	71 136	47 736
1997	75 883	18 971	66 818	46 009
1998	81 569	20 392	62 456	44 263
1999	87 306	21 827	58 048	42 499
2000	93 095	23 274	53 596	40 716
2001	93 718	23 429	53 863	40 669

a) Population served by individual private treatment facilities (e.g. septic tanks)

Parameters: Bo and MCF: The default IPCC 2000 value for Bo 0.6 kg CH4/kg BOD was used for wastewater and sludge.

Average MCF factors for wastewater treatment systems were estimated, based on information on the type of treatment for each region, and resulted from the MCF values established by expert judgement for each treatment type, weighted by the percentage of wastewater treatment type used in each region.

Table 8.10 - Wastewater treatment by type (%) and Methane Conversion Factors

Region	Anaerobic digestion	Imhoff tank	Percolation beds	Other treatment		MCF estimated
	%					
Norte	2.08	12.50	31.25	54.17		**0.21**
Centro	0.00	6.52	44.56	48.92		**0.16**
Lisboa e Vale do Tejo	0.00	4.35	28.26	67.39		**0.17**
Alentejo	0.00	0.00	32.10	67.90		**0.15**
Algarve	0.00	1.72	17.24	81.04		**0.17**
Açores	..	..	..	..		**..**
Madeira	..	..	..	..		**..**
Average	0.42	5.02	30.68	63.88		**0.17**
MCF	**1.00**	**0.50**	**0.10**	**0.18**		

MCF value used for individual private treatment facilities, such as septic tanks was 0.5; MCF figure considered for sludge was 0.15. The fraction of wastewater discharged into rivers and coastal waters, was considered to degrade aerobically (MCF = 0).

MCF evolution over time was estimated considering an annual average rate of: -2% for wastewater treatment plants, and +5% for sludge.

Recovery of CH4 data was estimated as a percentage of the calculated emissions for each wastewater treatment systems and sludge. The percentage considered for the base year (1990) for wastewater treatment systems was 0.5%, and for sludge 2%. CH4 recovery trends were calculated considering an annual increase rate of 4% for CH4 recovery.

Table 8.11 - Estimated quantities of CH4 flared

Year	Wastewater treatment systems		Sludge treatment systems	
	ton/year	% total without recovery	ton/year	% total without recovery
1990	17	0.50	15	2.00
1991	21	0.52	19	2.08
1992	25	0.54	24	2.16
1993	29	0.56	30	2.25
1994	33	0.58	37	2.34
1995	38	0.61	45	2.43
1996	42	0.63	54	2.53
1997	46	0.66	63	2.63
1998	50	0.68	74	2.74
1999	55	0.71	87	2.85
2000	59	0.74	101	2.96
2001	61	0.77	111	3.08

N2O emissions from wastewater (Human Sewage)

Human sewage can be disposed on land or discharged into aquatic environments (e.g. rivers and estuaries), either directly without treatment or after treatment in septic systems or wastewater treatment facilities. N2O can be generated during all these stages through nitrification/denitrification of nitrogen present in sewage, typically in the form of urea and proteins. In general, temperature, pH, BOD, and nitrogen concentration influence N2O production from human sewage. The amount of protein consumed by humans determines the quantity of nitrogen contained in sewage.

Methodology

Emissions of N2O from domestic wastewater were estimated following the proposal of IPCC96.

$$N2O_{(S)} = Protein * Frac_{NPR} * NR_{PEOPLE} * EF \times 44/28$$

where:

- $N2O_{(s)}$ - N_2O emissions from human sewage (kg N_2O-N/yr);
- Protein - annual per capita protein intake (kg/person/yr);
- NR_{PEOPLE} - number of people in country;
- EF - emissions factor (kg N_2O-N/kg sewage-N produced);
- $Frac_{NPR}$ - fraction of nitrogen in protein (kg N/kg protein);
- 44/28 is the molecular weight ratio of N_2O to N_2.

Activity data and parameters

Data and parameters considered for the estimations are based on IPCC96 defaults.

Table 8.12 - Data and parameters used in N2O emissions from wastewater estimates

Parameter	**Explanation**	**Values considered**	
		Year	**Value (kg)**
Annual per capita protein intake	FAO data	1990	37.3
		1991	37.8
		1992	38.0
		1993	39.1
		1994	39.8
		1995	39.5
		1996	40.5
		1997	39.9
		1998	42.0
		1999	43.5
		2000	43.5
		2001	44.6
Fraction of nitrogen in protein	IPCC96 default	16%	(constant)
Emission factor	IPCC96 default	0.01 kg N2O-N/kg N	(constant)

National population data refer to National Statistical Office (INE) Census for the years 1981, 1991 and 2001; intermediate years have been estimated by interpolation.

NMCOV emissions from wastewater (Human Sewage)

Methodology, activity data and parameters

Total population for each year was multiplied by an emission factor value of 16.425 g COVNM/inhabitant/year, which results from the following emission factor from CORINAIR90 Default Emission Factor:

EF = 0.36 kg/106 l wastewater * 125 l/inhabitant/year * 365

The daily human sewage production average (125 l/inh.day) taken from "*Regulamento Geral dos Sistemas Públicos e Prediais de Distribuição de Água e Drenagem de Águas Residuais*".

Industrial Wastewater

Methodology

Emissions from industrial wastewater represent rough estimates based on national estimates for industry wastewater organic content, and default emission factors from Corinair Guidebook (CH4 and N2O) and national data for domestic wastewater (COVNM). Quantities of industrial wastewater organic charge (in millions of inh. eq.) were multiplied by an emission factor for each pollutant considered.

Activity data and parameters

Estimates are based in The State of the Environment Report (1993) data, which proposes the figure of 26 million inh.eq. for 1990, and 33 million inh.eq. for 1993 for the total organic load from industry. Sectors covered are presented in the following table.

Table 8.13 - Industrial wastewater: total organic charge (million inh.eq.)

Sectors	1990	1993
Paper and pulp	5	7
Textile	3	4
Olive Oil	3	3
Other Agro-Food	3	4
Pig breeding units	3	3
Alcohol and derived	1	2
Resins	1	1
Yeast	1	1
Refineries	1	1
Other Chemical	3	4
Other	1	2
Total	**26**	**33**

Emission estimates were determined using the emission factors presented in the table below, considering the 1993 figure for industry wastewater organic content as the best available estimate for recent years.

Table 8.14 - Emissions factors

Polutant	Unit	EF	Source
CH4	Kg/ inh.eq.	0.30	CORINAIR (3rd edition), chp B9101
N2O	Kg/ inh.eq.	0.02	CORINAIR (3rd edition), chp B9101
COVNM	Kg/ inh.eq.	0.02	National estimate for domestic sewage

8.2.3 Waste Incineration (CRF 6 C)

CO2 emissions

Methodology

IPCC Guidelines proposes the following method for ultimate CO2 emissions estimation from waste incineration, for each waste type (e.g. municipal solid waste (MSW), hazardous waste, clinical waste, and sewage sludge):

$$CO2\ emissions\ (Gg/yr) = \Sigma_i\ (IWi * CCW_i * FCF_i * EF_i * 44 / 12)$$

where:

- i - waste type;
- IW_i - Amount of incinerated waste of type i (Gg/yr);
- CCW_i - Fraction of carbon content in waste of type I;
- FCF_i - Fraction of fossil carbon in waste of type I;
- EF_i - Burn out efficiency of combustion of incinerators for waste of type i (fraction);
- 44 / 12 is the Conversion from C to CO2 (44g CO2/ 12g C).

It was assumed that all incineration occurs without energy recovery.

Activity data and parameters

Until 1999, incineration of solid wastes refer to uncontrolled combustion of industrial solid waste on land, and to incineration of hospital hazardous wastes. Data on the quantities of industrial waste combusted have been estimated for the years previous to 1999, based on the same assumption used for MSW (a per year growth rate of 2%). In what refers to clinical waste, the figure for 1995 was used as an estimated for the former years.

Table 8.15 - Municipal solid wastes and clinical wastes combusted

Year	MSW quantities incinerated Ton	Industrial solid waste incinerated ton	Clinical waste quantities incinerated ton
1990	-	24 242	12 058
1991	-	24 727	12 058
1992	-	25 221	12 058
1993	-	25 726	12 058
1994	-	26 240	12 058
1995	-	26 765	12 058
1996	-	27 300	13 469
1997	-	27 846	15 679
1998	-	28 403	11 800
1999	346 421	28 971	10 416
2000	911 144	29 551	7 100
2001	949 626	30 142	7 100

In 1999, two new 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 exclusively dedicated to the combustion of MSW which is composed of domestic/commercial waste. Most of the organic materials in MSW are of biogenic origin (e.g. food waste, paper), and so they are not accounted for in net emissions calculations, according to the IPCC Guidelines. However, the components of fossil origin – plastics, synthetic fibbers, and synthetic rubber – is to be accounted in the estimates.

These non biogenic components fractions were considered different for MSW, industrial solid waste and clinical waste. Data are presented in the following table.

Table 8.16- Parameters considered

	Unit	MSW	Industrial Solid Waste	Clinical waste
C content of waste	%	30 a)	12 a)	60 b)
Fraction of fossil carbon in waste	% total C	37 a)	54 a)	40 b)
Efficiency of combustion	%	95 b)		

a) National figure; b) IPCC default.

In all cases it was assumed incineration occurring without any control emission systems.

Non-CO2 emissions

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.

$$\text{Non-}CO_2 \text{ emissions (Gg/yr)} = \Sigma_i \text{ (} IW_i * EF_i \text{) } * 10^{-6}$$

where:

IW_i = Amount of incinerated waste of type i (Gg/yr);

EF_i = Aggregate N2O emission factor for waste type i (kg N2O/Gg)

Activity data and parameters

Emission factors applied are from US/AP42 and EMEP/CORINAIR.

Table 8.17 - Emissions factors considered for estimates related to MSW combustion

Pollutants	Unit	EF	Source
Sox	kg/ton MSW	0.4	Corinair 99. Chp B921. New Plants
Nox	kg/ton MSW	1.8	Corinair 99. Chp B921. New Plants
COVNM	kg/ton MSW	0.02	Corinair 99. Chp B921. Old Plants
CH4	g/GJ	6.5	CORINAIR 94
CO	kg/ton MSW	0.5	Corinair 99. Chp B921. New Plants
N2O	kg/ton MSW	0.1	Corinair 99. Chp B921. New Plants

Table 8.18 - Emissions factors considered for estimates related to Industrial Solid Waste combustion

Pollutants	Unit	EF	Source
Sox	kg/ton MSW	0.327	AP-42. Chp 2.1 (Refuse Combustion) a)
Nox	kg/ton MSW	1.83	AP-42. Chp 2.1 (Refuse Combustion) b)
COVNM	kg/ton MSW	0.02	Corinair 99. Chp B921 c)
CH4	g/GJ	6.5	CORINAIR 94
CO	kg/ton MSW	0.232	AP-42. Chp 2.1 (Refuse Combustion) b)
N2O	kg/ton MSW	0.1	Corinair 99. Chp B921. New Plants

a) Mass Burn Waterwall Combustor (MW/WW) with Eletrostatic Prec. And Semi-wet scrubber (same as Spray Dryier) SD/ESP;

b) Mass Burn Waterwall Combustor (MW/WW). EF does not depend on emissions control precesses.

c) Mass Burn Excess Air Combustor. Uncontrolled.

Table 8.19 - Emissions factors considered for estimates related to clinical wastes combustion

Pollutants	Unit	EF	Source
Sox	kg/ton	1.09	AP-42 Uncontrolled
Nox	kg/ton	1.78	AP-42 Uncontrolled
COVNM	kg/ton MH	7.4	Corinair 99. Chp B922
CH4	g/GJ	6.5	CORINAIR 94
CO	kg/ton	1.48	AP-42 Uncontrolled
N2O	kg/ton	0.1	Corinair 99. Chp B921. New Plants

8.3 Recalculations

A number of significant methodological and data revisions have been done in the 2003 inventory submission.

Solid Waste Disposal on Land

The methodology used to estimate CH_4 emissions from industrial waste was changed from default Tier 1 to FOD method Tier 2. Changes have also been made to historical data. Previously, data concerning industrial disposed to SWDS refer to an estimate from the Waste National Institute for non-dangerous industrial solid waste. The figure used was about 3 million tones for all the years analysed. This was considered a very rough estimate and was changed in present inventory. Historical waste disposal data have been estimated based on expert judgement.

Major changes have also been made concerning activity data for municipal (urban) waste. New time series have been revised for the amounts of waste disposed on land, based on per capita generation growth rates established by expert judgment. Data for population served by waste collection rates have also been reviewed. Information on the final disposal of solid waste has been updated for recent years.

Smaller changes were made for the population time series based on data provided by the National Statistical Office (INE).

These revisions affected mainly CH_4 emissions estimates.

Wastewater Handling

Most significant modifications refer to CH_4 emissions estimates due to revisions of historical data: new census population data mentioned previously, and the update of population served by wastewater treatment systems. As proposed by IPCC2000, the value for the maximum methane production capacity (Bo) was also changed from 0.25 to 0.6 kg CH_4/kg BOD.

In what refers to Human Sewage, N_2O emissions were revised based on new estimates for protein intake (from FAO database).

Waste Incineration

A new sub-category was considered: the uncontrolled combustion of industrial solid waste on land. Data on the quantities of industrial waste combusted have been estimated for the years previous to 1999.

In what refers to clinical waste, activity data have been revised.

8.4 Further improvements

Despite the improvements made in the waste sector in the present inventory, there are several aspects that should be submitted to a thorough analysis in the future. Among these is the need to better quantify the amount of CH4 that is recovered and burned in flares. Data used presently refer to estimates of CH4 based on the existence of operating flares in the waste management units, and not on metering of gas recovered and flared as proposed in good practice guidance (IPCC2000). Data on waste composition should also be updated each year according to information from waste management systems.

CH4 emissions estimates for industrial wastewater should be further develop and subject to a specific study to better characterise industrial organic wastewater. Background data used in the calculations are out of date (most recent available data refer to 1993).

N2O emissions from human sewage have been estimated according to the IPCC default methodology (IPCC96), assuming that all sewage nitrogen is discharged into aquatic environments, and not counting with N2O emissions related with land disposal and sewage treatment. In Portugal, part of nitrogen present in sewage is applied to soils through sewage sludge applications. This is not accounted for the moment but could be estimated in the future, if data on sewage sludge application on land is collected.

GLOSSARY AND ABREVIATIONS

MCOTA	Ministério das Cidades, Ordenamento do Território e Ambiente	Ministry for Urban Affairs, Land Use Planning and the Environment
MAOT	Ministério do Ambiente e Ordenamento do Território	Ministry of Environment and Physical Planing
IR	Instituto dos Resíduos	Institute of Solid Wastes
PCI	Poder Calorífico Inferior	Low Heat Value
GIC	Grandes Instalações de Combustão	Large Combustion Plants
ACAP	Associação do Comércio e ...	
DGTT	Direcção Geral dos Transportes Terrestres	General Directorate of Terrestrial Transportation
ANA	Aeroportos e Navegação Aérea	
NAVE	Navegação Aérea	National Entity responsible for air traffic
ANECRA	Assoc. Nacional das Empresas do Comércio e da Reparação Automóvel	
APIRAC	Assoc. Portuguesa dos Industriais da Refrigeração e Ar Condicionado	National Association of Industry of Refrigeration and Air Conditioning
IEP	Instituto de Estradas de Portugal	Portuguese Road Institute
IA	Instituto do Ambiente	Environment Institute
IAIT	Inquérito Annual à Indústria Transformadora	Annual Survey to Manufacturing Industry
IAPI	Inquérito Annual à Produção Industrial	Annual Survey to Industrial Production
IST-UNL	Instituto Superior Técnico – Universidade Técnica de Lisboa	
DGA	Direcção Geral do Ambiente	General Directorate of Environment
LUCF	Alteração do Uso do Solo e Florestas	Land Use Change and Forestry
DGF	Direcção-Geral das Florestas	General Directorate of Forests
FCT-UNL	Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa	Faculty of Science and Technology of New University of Lisbon
INE	Instituto Nacional de Estatística	National Statistics Institute
DGE	Direcção Geral da Energia	General Directorate of Energy
DGV	Direcção Geral de Viação	National Entity responsible for road traffic
NMVOC	Compostos Orgânicos não Metânicos	Non methane Organic Compounds
CO2	Dióxido de Carbono ou anidrido carbónico	Carbon Dioxide
Nox	Óxidos de Azoto (NO+NO2)	Nitrogen Oxides (NO + NO2)
NUTS (0..III)	Numenclatura de Unidades Territoriais para fins estatísticos	Nomenclature of Territorial Units for Statistics
LPS	Grandes Fontes Poluidoras	Large Point Sources (Corinair definition)
REN	Rede Eléctrica Nacional	
PNAC	Programa Nacional para as Alterações Climáticas	Climate Change Program
CRF		Common Reporting Format
CORINAIR		
Concelho	-	Portuguese territorial unit under the responsibility of a municipal authority
Distrito	-	Portuguese territorial unit comprehending several concelhos but not coincident with a region which is NUT II.

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[67] Established according to the rule of thumb in note 2 of page 4.24 of GPG.

Annex A: Key Source Category Analysis

A.1 Introduction

This chapter provides an analysis of key sources categories following recommendations of the IPCC´s Good Practice Guidance (IPCC 2000). A key source category "*is one that is prioritised within the national inventory system because its estimate has a significant influence on a country's total inventory of direct greenhouse gases in terms of the absolute level of emissions, the trend in emissions, or both.*" The aim of defining key sources is the improvement of the inventory´s accuracy. As key sources categories are the most important sources in terms of their contribution to the absolute level of national emissions, the identification of these categories enables the prioritisation of national efforts and a more efficient use of available resources in order to reach an improvement of national estimates. Information on key sources is also important for the development of policies and measures for emissions reduction.

IPCC´s Good Practice Guidance (IPCC 2000) purposes several methods for performing key source analysis, which are:

- Tier 1 approach (level and trend assessments);
- Tier 2 approach (level and trend assessments with uncertainty analysis);
- Qualitative approach.

A. 2 Methodology for key source identification: Portuguese inventory

The determination of key source categories was conducted using the Tier 1 and the qualitative approach having as a basis the 2003 Portuguese inventory estimates (1990-2001). The Tier 2 method could not be used, as uncertainty estimates are not yet available. This method is however more sophisticated, as it incorporates source category uncertainty estimates, and should be applied in the future, when uncertainty analysis is developed.

Tier 1 - Level assessment

The contribution of each source category to the total national inventory was calculated for all years for which inventory estimates were available (1990-2001), according to the following equation:

Source Category Level Assessment = Source Category estimate / Total estimate

$$L_{x,t} = E_{x,t} / E_t$$

Where,

$L_{x,t}$ = level assessment for source category x in year t
$E_{x,t}$ = total emissions estimate for year t
E_t = emissions estimate for source category x in year t

Only emission source categories were considered. Key source categories are those that, when summed in descending order of magnitude for a given year, add up to 95 percent of the total national inventory for that year1.

[1] This threshold is intended to be applied to sources and to exclude sinks. The pre-determined threshold of 95% for both level assessment and trend assessment was determined to be the level at which 90% of the uncertainty in a "typical" inventory would be covered by key source categories, and was based on an analysis (Flugsrud at al., 1999 and Norwegian Pollution Control Authority, 1999) of selected inventories where sinks were excluded.

Tier 1 - Trend assessment

The trend assessment enables the identification of source categories that have a different trend to the trend of the overall inventory. The calculation of the contribution of each category´s trend to the trend in the total inventory was done upon the following equation:

Source Category Trend Assessment = (Source Category Level assessment) •| (Source Category Trend – Total trend) |

$$T_{x,t} = L_{x,t} \bullet \left| \left[\left((E_{x,t} - E_{x,0}) / E_{x,t} \right) - \left((E_t - E_0) / E_t \right) \right] \right|$$

Where,

Tx,t = trend assessment for source category *x* in year *t*

Lx,t = level assessment for source category *x* in year *t*

Ex,t and Ex,0 = emissions estimates for source category *x* in years *t* and 0, respectively

Et and E0 = total inventory estimates in years t and 0, respectively

0 = base year (1990)

Qualitative approach

Several qualitative criteria are purposed by the IPCC´s Good Practice Guidance (IPCC 2000). In addition to the Tier 1 quantitative assessment, some qualitative criteria were used to identify additional key source categories.

A.3 Analysis and presentation of results

Key source analysis can be very influenced by the definitions of source categories (extent of the split). If a large category is broken into many subcategories, then these subcategories may not have a significant contribution to the total inventory to be considered as a key source. On the opposite, several non-key sources categories may become key source categories if aggregated into a unique source category. The source category level used in this analysis was based on the sectoral breakdown defined in the CRF (Common Report Format), which is the base format for inventory reporting under the UNFCCC.

Table A-1 presents the key source categories identified in the analysis, and the criteria used (level, trend, qualitative approach) in the identification. Tables A-2.1 to A-2.13 contain data for each inventory year´s level assessment and trend assessment for 1990-2001.

The most important sources for all year´s level assessment are CO2 emissions from combustion of fossil fuels in Public Electricity and Heat Production (1A1a) (solid fuels – coal and liquid fuels – Oil) and Road Transportation (1A3b) (Diesel and Gasoline). CO2 emissions from combustion in Manufacturing Industries and Construction (1A2f) (liquid fuels – Oil) are also one of the most significant contributors to the level assessment for each year, which is partly due to the level of aggregation of this category, which includes: textile, ceramic, glass, cement, cloths, wood, rubber, metal equipment and other transformation industry. Some of these sub-categories would probably have been considered as non key sources if considered separately. However they have been assessed as so, because some of background data are out of date and/or there is some uncertainty related to them. Special efforts are presently being done in order to ameliorate the emissions of this category.

Other main large contributors to the level assessment for each year are: CO2 emissions from Cement production (2A1); CO2 emissions from Petroleum refining (1A1b); CH4 emissions from Swine Manure Management; CH4 emissions from Manure Management (4B8) (Swine) and N2O from Agriculture Soils (4D1, 4D2 and 4D3). Among other main emissions are: CH4 emissions from Industrial Waste Disposal on Land (6A3) and Municipal Waste Disposal (mainly from unmanaged waste disposal which represented the main disposal practice until mid 90s).

CO2 emissions from diesel road transports appear as the biggest contributor to the trend 1990-2001; the contribution from gasoline road transports is also important. This situation is related to the marked increase verified in road transportation during the last decade. Less important but still significant since 1997, is the increase of N2O emissions from road transportation from gasoline engines, which is a consequence of the increased use of catalytic converters.

Among other sectors that contribute the most to the overall trend is: Public Electricity and Heat Production (1A1a) (liquid and gaseous fuels). Since the introduction of natural gas in 1998, CO2 emissions from the combustion of gaseous fuels from several sources, start to contribute significantly to the level assessment and to the trend assessment: Public Electricity and Heat Production (1A1a) (gaseous fuels), Manufacturing Industries and Construction (1A2f) (gaseous fuels), which was acompained, in the last case, by the decline of combustion of solid fuels (1A2f).

The start of operation in 2000 of two new installation units dedicated to the incineration of municipal waste made CO2 emissions from Waste Incineration (6C) become a key source.

Other source categories were determined to be key source using the qualitative criteria. This is the case of estimates for HFCs and SF6 emissions, which are associated with high uncertainty due to poor coverage. These emission estimates should be improved in the future.

One important source category was not included in the analysis: international bunkers. As allocation of domestic and international emissions are based on fuel consumption by company flag, and not on real traffic inside and outside the country, there is an underlying error and consequently a significant uncertainty of these estimates, and therefore this source should be considered as a potential key source category. Therefore special efforts should be made in the near future to better evaluate these estimates.

Table A-1 – Portuguese key source categories (1990-2001) based on Tier 1 approach

(1/2)

IPCC SOURCE CATEGORIES	ACTIVITY	GHG	Key source Category Flag	Criteria for Identification	Comments	2001 emissions estimate (kton CO2 eq.)
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CO2	√	Level Trend	All years	11317
1 A 3 b Road Transportation	Diesel Oil	CO2	√	Level Trend	All years	10532
1 A 3 b Road Transportation	Gasoline	CO2	√	Level Trend	All years	6819
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CO2	√	Level Trend	All years	5548
1 A 2 f Other	Liquid Fuels	CO2	√	Level Trend	All years	4179
2 A 1 Cement Production	Production Quantities	CO2	√	Level Trend	All years	3754
1 A 1 b Petroleum refining	Liquid Fuels	CO2	√	Level Trend	All years	2722
4 B 8 Swine	Population size	CH4	√	Level Trend	All years	2677
6 A 3 Other	Industrial Waste Disposal on Land	CH4	√	Level Trend	All years	2435
1 A 4 a Commercial / Institutional	Liquid Fuels	CO2	√	Level Trend	All years	2323
1 A 4 b Residential	Liquid Fuels	CO2	√	Level	All years	2278
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	CO2	√	Level Trend	1998, 1999, 2000, 2001	2267
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CO2	√	Level Trend	All years	1656
4 D 2 Animal Production	Input to soils	N2O	√	Level Trend	All years	1612
4 D 3 Indirect Emissions	Input to soils	N2O	√	Level Trend	All years	1541
1 A 2 c Chemicals	Liquid Fuels	CO2	√	Level Trend	All years	1538
4 D 1 Direct Soil Emissions	Input to soils	N2O	√	Level Trend	All years	1480
1 A 3 a ii Domestic	Jet Kerosene	CO2	√	Level Trend	All years	1328
4 B 12 Solid Storage and Dry Lot	Animal Excretion	N2O	√	Level Trend	All years	1139
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CO2	√	Level Trend	All years	1090
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CO2	√	Level	All years	1088
4 A 1 b Non-Dairy Cattle	Population size	CH4	√	Level Trend	All years	1067
1 A 2 f Other	Gaseous Fuels	CO2	√	Level Trend	1998, 1999, 2000, 2001	1007
1 A 2 f Other	Solid Fuels	CO2	√	Level Trend	All years	989
6 A 2 Unmanaged Waste Disposal	Municipal Waste Disposal on Land	CH4	√	Level Trend	All years	911
4 A 1 a Dairy Cattle	Population size	CH4	√	Level Trend	All years	746
1 A 2 a Iron and Steel	Solid Fuels	CO2	√	Level	All years	713
2 B 2 Nitric Acid Production	Production Quantities	N2O	√	Level Trend	All years	606
4 A 3 Sheep	Population size	CH4	√	Level Trend	All years	601
6 B 2 Domestic and Commercial wastewater	Wastewater	CH4	√	Level Trend	All years	578

(2/2)

IPCC SOURCE CATEGORIES	ACTIVITY	GHG	Key source Category Flag	Criteria for Identification	Comments	2001 emissions estimate (kton CO2 eq.)
2 B 1 Ammonia Production	Production Quantities	CO2	√	Level Trend	All years	396
6 C WASTE INCINERATION	Waste Incinerated	CO2	√	Level Trend	2000, 2001	376
1 A 3 b Road Transportation	Gasoline	N2O	√	Level Trend	1997, 1998, 1999, 2000, 2001	368
6 B 2 Domestic and Commercial wastewater	Wastewater	N2O	√	Level	All years	360
2 A 6 Road Paving with Asphalt	Production Quantities	CO2	√	Level Trend	All years	346
1 A 4 b Residential	Biomass	CH4	√	Level Trend	All years	297
1 A 4 b Residential	Gaseous Fuels	CO2	√	Level Trend	2000, 2001	232
6 B 1 Industrial Wastewater	Wastewater	CH4	√	Level	1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001	208
6 B 1 Industrial Wastewater	Wastewater	N2O	√	Level	1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001	205
4 B 1 a Dairy Cattle	Population size	CH4	√	Level Trend	All years	192
4 C 1 Irrigated	Culture Surface	CH4	√	Level Trend	1990, 1991, 1994, 1996, 1997, 1998, 1999, 2000, 2001	181
2 A 7 Other	Production Quantities	CO2	√	Level Trend	1990, 2001	180
1 A 3 b Road Transportation	Diesel Oil	N2O	√	Level Trend	2000	179
6 A 1 Managed Waste disposal	Municipal Waste Disposal on Land	CH4	√	Trend		165
1 B 2 b ii Transmission/ Distribution	Gaseous Fuels	CH4	√	Level Trend	1999	153
1 A 3 d ii National navigation	Gas/Diesel Oil	CO2	√	Level Trend	1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1999, 2000	153
1 A 2 a Iron and Steel	Liquid Fuels	CO2	√	Trend		152
1 B 2 d Other (Geothermal)	Energy Production	CO2	√	Trend		145
1 A 3 c Railways	Liquid Fuels	CO2	√	Level Trend	1990, 1991	128
1 A 2 c Chemicals	Solid Fuels	CO2	√	Level	2000	119
1 A 2 c Chemicals	Gaseous Fuels	CO2	√	Trend		98
1 A 2 e Food Processing, Beverages and Tobacco	Gaseous Fuels	CO2	√	Trend		70
1 A 3 b Road Transportation	Natural Gas	CO2	√	Trend		69
2 F 1 Refrigeration and Air Conditioning Equipment	Consumption	HFCs	√	Qual		57
1 A 2 b Non-ferrous Metals	Liquid Fuels	CO2	√	Trend		31
2 F 7 Electrical Equipment	Consumption	SF6	√	Qual		7
2 F 2 Foam Blowing	Consumption	HFCs	√	Qual		6
Sub-Total		All gases				**81415**
% of Total		All gases				97.1
TOTAL EMISSIONS		All gases				**83823**

Tables A-2.1 to A.2-12 – Tier 1 Level assessment: 1990 to 2001

Tier 1 Level Assessment (1990)

IPCC SOURCE CATEGORIES	ACTIVITY	GHG	Base year Estimate (kton CO2 eq.) 1990	Current year Estimate (kton CO2 eq.) 1990	Level Assess.	Cumulative Total
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CO2	7816	7816	0.13	0.13
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CO2	6364	6364	0.10	0.23
1 A 3 b Road Transportation	Diesel Oil	CO2	4947	4947	0.08	0.31
1 A 3 b Road Transportation	Gasoline	CO2	4303	4303	0.07	0.38
1 A 2 f Other	Liquid Fuels	CO2	3227	3227	0.05	0.43
4 B 8 Swine	Population size	CH4	3028	3028	0.05	0.48
2 A 1 Cement Production	Production Quantities	CO2	3024	3024	0.05	0.53
1 A 2 f Other	Solid Fuels	CO2	1982	1982	0.03	0.56
1 A 1 b Petroleum refining	Liquid Fuels	CO2	1929	1929	0.03	0.60
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CO2	1675	1675	0.03	0.62
6 A 3 Other	Industrial Waste Disposal on Land	CH4	1655	1655	0.03	0.65
1 A 4 b Residential	Liquid Fuels	CO2	1630	1630	0.03	0.68
4 D 2 Animal Production	Input to soils	N2O	1627	1627	0.03	0.70
4 D 3 Indirect Emissions	Input to soils	N2O	1591	1591	0.03	0.73
4 D 1 Direct Soil Emissions	Input to soils	N2O	1573	1573	0.03	0.75
4 B 12 Solid Storage and Dry Lot	Animal Excretion	N2O	1045	1045	0.02	0.77
4 A 1 b Non-Dairy Cattle	Population size	CH4	980	980	0.02	0.79
4 A 1 a Dairy Cattle	Population size	CH4	846	846	0.01	0.80
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CO2	828	828	0.01	0.81
1 A 4 a Commercial / Institutional	Liquid Fuels	CO2	816	816	0.01	0.83
1 A 3 a ii Domestic	Jet Kerosene	CO2	794	794	0.01	0.84
6 A 2 Unmanaged Waste Disposal	Municipal Waste Disposal on Land	CH4	749	749	0.01	0.85
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CO2	744	744	0.01	0.87
6 B 2 Domestic and Commercial wastewater	Wastewater	CH4	659	659	0.01	0.88
2 B 2 Nitric Acid Production	Production Quantities	N2O	603	603	0.01	0.89
2 B 1 Ammonia Production	Production Quantities	CO2	569	569	0.01	0.90
4 A 3 Sheep	Population size	CH4	564	564	0.01	0.90
1 A 2 a Iron and Steel	Solid Fuels	CO2	476	476	0.01	0.91
1 A 2 c Chemicals	Liquid Fuels	CO2	456	456	0.01	0.92
1 A 3 d ii National navigation	Gas/Diesel Oil	CO2	433	433	0.01	0.93
1 A 4 b Residential	Biomass	CH4	343	343	0.01	0.93
6 B 2 Domestic and Commercial wastewater	Wastewater	N2O	287	287	0.00	0.94
4 C 1 Irrigated	Culture Surface	CH4	256	256	0.00	0.94
4 B 1 a Dairy Cattle	Population size	CH4	218	218	0.00	0.94
2 A 7 Other	Production Quantities	CO2	180	180	0.00	0.95
1 A 3 c Railways	Liquid Fuels	CO2	175	175	0.00	0.95
2 A 6 Road Paving with Asphalt	Production Quantities	CO2	168	168	0.00	0.95
6 B 1 Industrial Wastewater	Wastewater	CH4	164	164	0.00	0.96
1 A 2 a Iron and Steel	Liquid Fuels	CO2	163	163	0.00	0.96
6 B 1 Industrial Wastewater	Wastewater	N2O	161	161	0.00	0.96
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	N2O	151	151	0.00	0.96
1 A 2 b Non-ferrous Metals	Liquid Fuels	CO2	125	125	0.00	0.97
1 B 2 a iv Refining/ Storage	Liquid Fuels	CO2	124	124	0.00	0.97
4 B 3 Sheep	Population size	CH4	113	113	0.00	0.97
3 A PAINT APPLICATION	Paint application	CO2	91	91	0.00	0.97
4 A 4 Goats	Population size	CH4	90	90	0.00	0.97
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	CO2	90	90	0.00	0.97
3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING	Chemical manufacture and processing	CO2	86	86	0.00	0.98
1 A 3 b Road Transportation	Diesel Oil	N2O	84	84	0.00	0.98
4 A 8 Swine	Population size	CH4	84	84	0.00	0.98
3 D OTHER	Other Use of Chemicals	CO2	82	82	0.00	0.98
1 A 4 a Commercial / Institutional	Gaseous Fuels	CO2	77	77	0.00	0.98
1 A 4 b Residential	Biomass	N2O	73	73	0.00	0.98
1 B 1 a I Underground Mines	Solid Fuels	CH4	65	65	0.00	0.98
1 A 2 c Chemicals	Other Fuels	CO2	63	63	0.00	0.98
4 B 10 Anaerobic	Animal Excretion	N2O	59	59	0.00	0.98
2 A 3 Limestone and Dolomite Use	Production Quantities	CO2	54	54	0.00	0.99
1 A 2 b Non-ferrous Metals	Solid Fuels	CO2	52	52	0.00	0.99
2 B 5 Carbon black	Production Quantities	CO2	51	51	0.00	0.99
1 A 2 c Chemicals	Solid Fuels	CO2	45	45	0.00	0.99
1 A 3 d ii National navigation	Residual Oil	CO2	44	44	0.00	0.99
4 B 1 b Non-Dairy Cattle	Population size	CH4	38	38	0.00	0.99
1 A 1 a Public Electricity and Heat Production	Solid Fuels	N2O	36	36	0.00	0.99
4 F 5 Other	Residues Burning	N2O	34	34	0.00	0.99
1 A 3 b Road Transportation	Gasoline	N2O	33	33	0.00	0.99
4 B 9 Poultry	Population size	CH4	29	29	0.00	0.99
4 B 4 Goats	Population size	CH4	26	26	0.00	0.99
1 A 3 b Road Transportation	Gasoline	CH4	25	25	0.00	0.99
4 B 11 Liquid Systems	Animal Excretion	N2O	24	24	0.00	0.99
4 A 7 Mules and Asses	Population size	CH4	24	24	0.00	0.99
1 B 2 a iv Refining/ Storage	Liquid Fuels	CH4	22	22	0.00	0.99
1 A 2 f Other	Biomass	N2O	21	21	0.00	0.99
1 A 2 d Pulp, Paper and Print	Biomass	CH4	19	19	0.00	0.99
6 A 1 Managed Waste disposal	Municipal Waste Disposal on Land	CH4	18	18	0.00	0.99
1 B 2 a v Distribution of Oil Products	Liquid Fuels	CO2	17	17	0.00	0.99
2 C 3 Aluminium production	Production Quantities	CO2	17	17	0.00	0.99
4 F 5 Other	Residues Burning	CH4	16	16	0.00	1.00
2 C 1 Iron and Steel Production	Production Quantities	CO2	15	15	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	N2O	15	15	0.00	1.00
4 A 6 Horses	Population size	CH4	14	14	0.00	1.00
1 B 2 a iii Transport	Liquid Fuels	CH4	13	13	0.00	1.00
3 B DEGREASING AND DRY CLEANING	Degreasing and Dry Cleaning	CO2	12	12	0.00	1.00
1 B 2 a iii Transport	Liquid Fuels	CO2	12	12	0.00	1.00
1 A 2 d Pulp, Paper and Print	Biomass	N2O	11	11	0.00	1.00
1 A 3 c Railways	Liquid Fuels	N2O	11	11	0.00	1.00
1 A 4 b Residential	Liquid Fuels	N2O	11	11	0.00	1.00
1 A 2 f Other	Liquid Fuels	N2O	11	11	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	CO2	10	10	0.00	1.00
1 A 3 b Road Transportation	Diesel Oil	CH4	9	9	0.00	1.00

1 A 1 b Petroleum refining	Liquid Fuels	N2O	9	9	0.00	1.00
4 B 7 Mules and Asses	Population size	CH4	9	9	0.00	1.00
1 B 1 a I Underground Mines	Solid Fuels	CO2	9	9	0.00	1.00
1 A 5 Other	Solid Fuels	CO2	8	8	0.00	1.00
2 B 5 Etileno (Borealis)	Production Quantities	CO2	7	7	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Biomass	N2O	5	5	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	CO2	5	5	0.00	1.00
2 B 5 Etileno (Borealis)	Production Quantities	CH4	5	5	0.00	1.00
1 A 2 f Other	Biomass	CH4	5	5	0.00	1.00
1 A 3 a ii Domestic	Jet Kerosene	N2O	5	5	0.00	1.00
1 A 2 f Other	Solid Fuels	N2O	4	4	0.00	1.00
1 A 2 c Chemicals	Liquid Fuels	N2O	4	4	0.00	1.00
2 B 5 Explosivos e Anid. Ftálico	Production Quantities	CO2	4	4	0.00	1.00
4 A 10 Other	Population size	CH4	4	4	0.00	1.00
1 A 3 d ii National navigation	Gas/Diesel Oil	N2O	3	3	0.00	1.00
2 B 5 Carbon black	Production Quantities	CH4	3	3	0.00	1.00
1 A 2 f Other	Liquid Fuels	CH4	3	3	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CH4	3	3	0.00	1.00
1 A 2 a Iron and Steel	Other Fuels	CO2	3	3	0.00	1.00
4 F 1 Cereals	Residues Burning	N2O	3	3	0.00	1.00
4 B 6 Horses	Population size	CH4	3	3	0.00	1.00
1 B 2 b ii Transmission/ Distribution	Gaseous Fuels	CH4	3	3	0.00	1.00
2 C 2 Ferroalloys Production	Production Quantities	CO2	3	3	0.00	1.00
1 A 4 a Commercial / Institutional	Liquid Fuels	N2O	2	2	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	N2O	2	2	0.00	1.00
2 B 5 Produção de Monómeros e Polimeros Orgânicos	Production Quantities	CO2	2	2	0.00	1.00
1 A 3 a ii Domestic	Jet Kerosene	CH4	2	2	0.00	1.00
1 B 2 d Other (Geothermal)	Energy Production	CO2	2	2	0.00	1.00
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CH4	2	2	0.00	1.00
1 A 2 d Pulp, Paper and Print	Liquid Fuels	N2O	2	2	0.00	1.00
1 A 1 b Petroleum refining	Liquid Fuels	CH4	2	2	0.00	1.00
4 F 1 Cereals	Residues Burning	CH4	1	1	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 2 c Chemicals	Biomass	N2O	1	1	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Biomass	CH4	1	1	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CH4	1	1	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Solid Fuels	CO2	1	1	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	N2O	1	1	0.00	1.00
1 A 4 a Commercial / Institutional	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 2 f Other	Solid Fuels	CH4	1	1	0.00	1.00
1 A 2 a Iron and Steel	Solid Fuels	N2O	1	1	0.00	1.00
1 A 4 b Residential	Liquid Fuels	CH4	1	1	0.00	1.00
1 B 1 a ii Surface Mines	Solid Fuels	CH4	1	1	0.00	1.00
1 A 2 c Chemicals	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 3 d ii National navigation	Gas/Diesel Oil	CH4	1	1	0.00	1.00
1 A 4 a Commercial / Institutional	Gaseous Fuels	N2O	1	1	0.00	1.00
1 A 2 a Iron and Steel	Liquid Fuels	N2O	1	1	0.00	1.00
1 A 2 b Non-ferrous Metals	Liquid Fuels	N2O	0.44993	0.44993	0.00	1.00
2 D 2 Food and Drink	Production Quantities	CO2	0.43657	0.43657	0.00	1.00
1 A 2 c Chemicals	Other Fuels	N2O	0.43372	0.43372	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	N2O	0.40511	0.40511	0.00	1.00
1 A 3 d ii National navigation	Residual Oil	N2O	0.34933	0.34933	0.00	1.00
1 A 2 c Chemicals	Biomass	CH4	0.33113	0.33113	0.00	1.00
1 B 2 c I Oil	Liquid Fuels	CO2	0.27336	0.27336	0.00	1.00
1 A 3 c Railways	Liquid Fuels	CH4	0.24900	0.24900	0.00	1.00
1 A 2 b Non-ferrous Metals	Biomass	N2O	0.19019	0.19019	0.00	1.00
1 A 5 Other	Solid Fuels	CH4	0.15135	0.15135	0.00	1.00
1 A 3 c Railways	Solid Fuels	CO2	0.13335	0.13335	0.00	1.00
1 A 2 a Iron and Steel	Liquid Fuels	CH4	0.12724	0.12724	0.00	1.00
1 A 2 a Iron and Steel	Solid Fuels	CH4	0.11925	0.11925	0.00	1.00
1 B 1 a ii Surface Mines	Solid Fuels	CO2	0.11285	0.11285	0.00	1.00
1 A 2 b Non-ferrous Metals	Solid Fuels	N2O	0.11159	0.11159	0.00	1.00
1 A 2 c Chemicals	Solid Fuels	N2O	0.09934	0.09934	0.00	1.00
1 B 2 c I Oil	Liquid Fuels	CH4	0.09206	0.09206	0.00	1.00
1 A 2 b Non-ferrous Metals	Liquid Fuels	CH4	0.08930	0.08930	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	CH4	0.08337	0.08337	0.00	1.00
1 A 3 d ii National navigation	Residual Oil	CH4	0.06804	0.06804	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	CO2	0.06049	0.06049	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	CH4	0.04901	0.04901	0.00	1.00
1 A 2 b Non-ferrous Metals	Biomass	CH4	0.04494	0.04494	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	CH4	0.03875	0.03875	0.00	1.00
1 A 4 a Commercial / Institutional	Gaseous Fuels	CH4	0.03451	0.03451	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	N2O	0.03034	0.03034	0.00	1.00
1 A 2 c Chemicals	Other Fuels	CH4	0.02938	0.02938	0.00	1.00
1 A 2 b Non-ferrous Metals	Solid Fuels	CH4	0.02592	0.02592	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Biomass	N2O	0.02500	0.02500	0.00	1.00
1 A 2 c Chemicals	Solid Fuels	CH4	0.02307	0.02307	0.00	1.00
1 A 5 Other	Solid Fuels	N2O	0.01818	0.01818	0.00	1.00
1 A 3 c Railways	Solid Fuels	N2O	0.00861	0.00861	0.00	1.00
1 A 2 a Iron and Steel	Other Fuels	N2O	0.00750	0.00750	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Solid Fuels	N2O	0.00269	0.00269	0.00	1.00
1 A 2 a Iron and Steel	Other Fuels	CH4	0.00254	0.00254	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	N2O	0.00158	0.00158	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Biomass	CH4	0.00087	0.00087	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Solid Fuels	CH4	0.00063	0.00063	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	CH4	0.00025	0.00025	0.00	1.00
1 A 3 c Railways	Solid Fuels	CH4	0.00019	0.00019	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Biomass	CH4	0.00000	0.00000	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Other Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Solid Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Biomass	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Other Fuels	CH4	0.00000	0.00000	0.00	1.00

Tier 1 Level Assessment (1991)

IPCC SOURCE CATEGORIES	ACTIVITY	GHG	Base year Estimate (kton CO2 eq.) 1990	Current year Estimate (kton CO2 eq.) 1991	Level Assess.	Cumulative Total
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CO2	7816	8289	0.13	0.13
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CO2	6364	6722	0.11	0.24
1 A 3 b Road Transportation	Diesel Oil	CO2	4947	5138	0.08	0.32
1 A 3 b Road Transportation	Gasoline	CO2	4303	4733	0.07	0.39
1 A 2 f Other	Liquid Fuels	CO2	3227	3369	0.05	0.45
2 A 1 Cement Production	Production Quantities	CO2	3024	3069	0.05	0.50
4 B 8 Swine	Population size	CH4	3028	2915	0.05	0.54
1 A 2 f Other	Solid Fuels	CO2	1982	2083	0.03	0.57
1 A 1 b Petroleum refining	Liquid Fuels	CO2	1929	1770	0.03	0.60
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CO2	1675	1733	0.03	0.63
1 A 4 b Residential	Liquid Fuels	CO2	1630	1709	0.03	0.66
6 A 3 Other	Industrial Waste Disposal on Land	CH4	1655	1700	0.03	0.68
4 D 2 Animal Production	Input to soils	N2O	1627	1647	0.03	0.71
4 D 3 Indirect Emissions	Input to soils	N2O	1591	1570	0.02	0.73
4 D 1 Direct Soil Emissions	Input to soils	N2O	1573	1524	0.02	0.76
4 B 12 Solid Storage and Dry Lot	Animal Excretion	N2O	1045	1060	0.02	0.78
4 A 1 b Non-Dairy Cattle	Population size	CH4	980	1020	0.02	0.79
1 A 4 a Commercial / Institutional	Liquid Fuels	CO2	816	911	0.01	0.81
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CO2	828	902	0.01	0.82
4 A 1 a Dairy Cattle	Population size	CH4	846	848	0.01	0.83
1 A 3 a ii Domestic	Jet Kerosene	CO2	794	835	0.01	0.85
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CO2	744	812	0.01	0.86
6 A 2 Unmanaged Waste Disposal	Municipal Waste Disposal on Land	CH4	749	778	0.01	0.87
6 B 2 Domestic and Commercial wastewater	Wastewater	CH4	659	653	0.01	0.88
2 B 2 Nitric Acid Production	Production Quantities	N2O	603	603	0.01	0.89
4 A 3 Sheep	Population size	CH4	564	568	0.01	0.90
1 A 2 c Chemicals	Liquid Fuels	CO2	456	563	0.01	0.91
2 B 1 Ammonia Production	Production Quantities	CO2	569	447	0.01	0.92
1 A 2 a Iron and Steel	Solid Fuels	CO2	476	389	0.01	0.92
1 A 3 d ii National navigation	Gas/Diesel Oil	CO2	433	388	0.01	0.93
1 A 4 b Residential	Biomass	CH4	343	328	0.01	0.93
6 B 2 Domestic and Commercial wastewater	Wastewater	N2O	287	291	0.00	0.94
4 C 1 Irrigated	Culture Surface	CH4	256	253	0.00	0.94
2 A 6 Road Paving with Asphalt	Production Quantities	CO2	168	227	0.00	0.95
4 B 1 a Dairy Cattle	Population size	CH4	218	218	0.00	0.95
1 A 3 c Railways	Liquid Fuels	CO2	175	183	0.00	0.95
2 A 7 Other	Production Quantities	CO2	180	180	0.00	0.96
6 B 1 Industrial Wastewater	Wastewater	CH4	164	179	0.00	0.96
6 B 1 Industrial Wastewater	Wastewater	N2O	161	176	0.00	0.96
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	N2O	151	158	0.00	0.96
1 B 2 a iv Refining/ Storage	Liquid Fuels	CO2	124	113	0.00	0.97
4 B 3 Sheep	Population size	CH4	113	113	0.00	0.97
1 A 2 b Non-ferrous Metals	Liquid Fuels	CO2	125	110	0.00	0.97
3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING	Chemical manufacture and processing	CO2	86	94	0.00	0.97
1 A 2 a Iron and Steel	Liquid Fuels	CO2	163	93	0.00	0.97
3 A PAINT APPLICATION	Paint application	CO2	91	93	0.00	0.97
4 A 4 Goats	Population size	CH4	90	93	0.00	0.97
3 D OTHER	Other Use of Chemicals	CO2	82	87	0.00	0.98
1 A 3 b Road Transportation	Diesel Oil	N2O	84	87	0.00	0.98
1 A 4 a Commercial / Institutional	Gaseous Fuels	CO2	77	85	0.00	0.98
4 A 8 Swine	Population size	CH4	84	81	0.00	0.98
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	CO2	90	71	0.00	0.98
1 A 4 b Residential	Biomass	N2O	73	69	0.00	0.98
1 B 1 a I Underground Mines	Solid Fuels	CH4	65	63	0.00	0.98
1 A 2 c Chemicals	Other Fuels	CO2	63	63	0.00	0.98
1 A 3 d ii National navigation	Residual Oil	CO2	44	57	0.00	0.99
4 B 10 Anaerobic	Animal Excretion	N2O	59	56	0.00	0.99
2 B 5 Carbon black	Production Quantities	CO2	51	51	0.00	0.99
1 A 2 c Chemicals	Solid Fuels	CO2	45	47	0.00	0.99
2 A 3 Limestone and Dolomite Use	Production Quantities	CO2	54	46	0.00	0.99
4 B 1 b Non-Dairy Cattle	Population size	CH4	38	40	0.00	0.99
1 A 1 a Public Electricity and Heat Production	Solid Fuels	N2O	36	38	0.00	0.99
1 A 3 b Road Transportation	Gasoline	N2O	33	38	0.00	0.99
1 A 2 b Non-ferrous Metals	Solid Fuels	CO2	52	36	0.00	0.99
4 F 5 Other	Residues Burning	N2O	34	34	0.00	0.99
4 B 9 Poultry	Population size	CH4	29	30	0.00	0.99
1 A 3 b Road Transportation	Gasoline	CH4	25	28	0.00	0.99
4 B 4 Goats	Population size	CH4	26	26	0.00	0.99
4 B 11 Liquid Systems	Animal Excretion	N2O	24	24	0.00	0.99
6 A 1 Managed Waste disposal	Municipal Waste Disposal on Land	CH4	18	24	0.00	0.99
4 A 7 Mules and Asses	Population size	CH4	24	22	0.00	0.99
1 A 2 f Other	Biomass	N2O	21	20	0.00	0.99
1 A 2 d Pulp, Paper and Print	Biomass	CH4	19	20	0.00	0.99
1 B 2 a iv Refining/ Storage	Liquid Fuels	CH4	22	20	0.00	0.99
1 B 2 a v Distribution of Oil Products	Liquid Fuels	CO2	17	19	0.00	0.99
4 F 5 Other	Residues Burning	CH4	16	16	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	N2O	15	16	0.00	1.00
2 C 1 Iron and Steel Production	Production Quantities	CO2	15	16	0.00	1.00
2 C 3 Aluminium production	Production Quantities	CO2	17	15	0.00	1.00
4 A 6 Horses	Population size	CH4	14	14	0.00	1.00
1 A 2 d Pulp, Paper and Print	Biomass	N2O	11	13	0.00	1.00
1 B 2 a iii Transport	Liquid Fuels	CH4	13	12	0.00	1.00
1 A 3 c Railways	Liquid Fuels	N2O	11	12	0.00	1.00
1 A 4 b Residential	Liquid Fuels	N2O	11	12	0.00	1.00
3 B DEGREASING AND DRY CLEANING	Degreasing and Dry Cleaning	CO2	12	12	0.00	1.00
1 A 2 f Other	Liquid Fuels	N2O	11	11	0.00	1.00
1 B 2 a iii Transport	Liquid Fuels	CO2	12	11	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	CO2	10	10	0.00	1.00
1 A 3 b Road Transportation	Diesel Oil	CH4	9	10	0.00	1.00
4 B 7 Mules and Asses	Population size	CH4	9	8	0.00	1.00
1 B 1 a I Underground Mines	Solid Fuels	CO2	9	8	0.00	1.00

1 A 1 b Petroleum refining	Liquid Fuels	N2O	9	8	0.00	1.00
1 A 5 Other	Solid Fuels	CO2	8	6	0.00	1.00
2 B 5 Etileno (Borealis)	Production Quantities	CO2	7	6	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Biomass	N2O	5	5	0.00	1.00
1 A 3 a ii Domestic	Jet Kerosene	N2O	5	5	0.00	1.00
1 A 2 f Other	Biomass	CH4	5	5	0.00	1.00
1 A 2 f Other	Solid Fuels	N2O	4	5	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	CO2	5	5	0.00	1.00
1 A 2 c Chemicals	Liquid Fuels	N2O	4	4	0.00	1.00
2 B 5 Etileno (Borealis)	Production Quantities	CH4	5	4	0.00	1.00
2 B 5 Explosivos e Anid. Ftálico	Production Quantities	CO2	4	4	0.00	1.00
4 A 10 Other	Population size	CH4	4	4	0.00	1.00
1 A 2 f Other	Liquid Fuels	CH4	3	3	0.00	1.00
2 B 5 Carbon black	Production Quantities	CH4	3	3	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CH4	3	3	0.00	1.00
1 B 2 b ii Transmission/ Distribution	Gaseous Fuels	CH4	3	3	0.00	1.00
1 A 3 d ii National navigation	Gas/Diesel Oil	N2O	3	3	0.00	1.00
4 F 1 Cereals	Residues Burning	N2O	3	3	0.00	1.00
4 B 6 Horses	Population size	CH4	3	3	0.00	1.00
2 C 2 Ferroalloys Production	Production Quantities	CO2	3	3	0.00	1.00
1 A 4 a Commercial / Institutional	Liquid Fuels	N2O	2	3	0.00	1.00
1 B 2 d Other (Geothermal)	Energy Production	CO2	2	3	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	N2O	2	2	0.00	1.00
1 A 3 a ii Domestic	Jet Kerosene	CH4	2	2	0.00	1.00
2 B 5 Produção de Monómeros e Polimeros Orgânicos	Production Quantities	CO2	2	2	0.00	1.00
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CH4	2	2	0.00	1.00
1 A 2 d Pulp, Paper and Print	Liquid Fuels	N2O	2	2	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CH4	1	1	0.00	1.00
4 F 1 Cereals	Residues Burning	CH4	1	1	0.00	1.00
1 A 1 b Petroleum refining	Liquid Fuels	CH4	2	1	0.00	1.00
1 A 2 c Chemicals	Biomass	N2O	1	1	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CH4	1	1	0.00	1.00
1 A 4 a Commercial / Institutional	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Biomass	CH4	1	1	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	N2O	1	1	0.00	1.00
1 A 2 f Other	Solid Fuels	CH4	1	1	0.00	1.00
1 A 4 b Residential	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 2 a Iron and Steel	Solid Fuels	N2O	1	1	0.00	1.00
1 A 2 c Chemicals	Liquid Fuels	CH4	1	1	0.00	1.00
1 B 1 a ii Surface Mines	Solid Fuels	CH4	1	1	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 4 a Commercial / Institutional	Gaseous Fuels	N2O	1	1	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Solid Fuels	CO2	1	1	0.00	1.00
1 A 3 d ii National navigation	Gas/Diesel Oil	CH4	1	1	0.00	1.00
1 A 3 d ii National navigation	Residual Oil	N2O	0	0	0.00	1.00
2 D 2 Food and Drink	Production Quantities	CO2	0	0	0.00	1.00
1 A 2 c Chemicals	Other Fuels	N2O	0.43372	0.43099	0.00	1.00
1 A 2 b Non-ferrous Metals	Liquid Fuels	N2O	0.44993	0.41139	0.00	1.00
1 A 2 a Iron and Steel	Liquid Fuels	N2O	0.50132	0.32901	0.00	1.00
1 A 2 c Chemicals	Biomass	CH4	0.33113	0.32533	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	N2O	0.40511	0.32037	0.00	1.00
1 A 3 c Railways	Liquid Fuels	CH4	0.24900	0.26068	0.00	1.00
1 B 2 c I Oil	Liquid Fuels	CO2	0.27336	0.26017	0.00	1.00
1 A 2 b Non-ferrous Metals	Biomass	N2O	0.19019	0.18684	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	CO2	0.06049	0.15875	0.00	1.00
1 A 5 Other	Solid Fuels	CH4	0.15135	0.10916	0.00	1.00
1 A 2 a Iron and Steel	Solid Fuels	CH4	0.11925	0.10665	0.00	1.00
1 B 1 a ii Surface Mines	Solid Fuels	CO2	0.11285	0.10478	0.00	1.00
1 A 2 c Chemicals	Solid Fuels	N2O	0.09934	0.10312	0.00	1.00
1 A 2 a Iron and Steel	Other Fuels	CO2	3.06811	0.09204	0.00	1.00
1 A 3 d ii National navigation	Residual Oil	CH4	0.06804	0.08783	0.00	1.00
1 B 2 c I Oil	Liquid Fuels	CH4	0.09206	0.08761	0.00	1.00
1 A 2 b Non-ferrous Metals	Solid Fuels	N2O	0.11159	0.07839	0.00	1.00
1 A 2 b Non-ferrous Metals	Liquid Fuels	CH4	0.08930	0.07781	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	CH4	0.08337	0.07638	0.00	1.00
1 A 3 c Railways	Solid Fuels	CO2	0.13335	0.07561	0.00	1.00
1 A 2 a Iron and Steel	Liquid Fuels	CH4	0.12724	0.06904	0.00	1.00
1 A 2 b Non-ferrous Metals	Biomass	CH4	0.04494	0.04415	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	CH4	0.03875	0.03926	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	CH4	0.04901	0.03875	0.00	1.00
1 A 4 a Commercial / Institutional	Gaseous Fuels	CH4	0.03451	0.03809	0.00	1.00
1 A 2 c Chemicals	Other Fuels	CH4	0.02938	0.02920	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	N2O	0.03034	0.02809	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Biomass	N2O	0.02500	0.02500	0.00	1.00
1 A 2 c Chemicals	Solid Fuels	CH4	0.02307	0.02395	0.00	1.00
1 A 2 b Non-ferrous Metals	Solid Fuels	CH4	0.02592	0.01821	0.00	1.00
1 A 5 Other	Solid Fuels	N2O	0.01818	0.01312	0.00	1.00
1 A 3 c Railways	Solid Fuels	N2O	0.00861	0.00488	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	N2O	0.00158	0.00420	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Solid Fuels	N2O	0.00269	0.00144	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Biomass	CH4	0.00087	0.00087	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	CH4	0.00025	0.00070	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Solid Fuels	CH4	0.00063	0.00033	0.00	1.00
1 A 2 a Iron and Steel	Other Fuels	N2O	0.00750	0.00023	0.00	1.00
1 A 3 c Railways	Solid Fuels	CH4	0.00019	0.00011	0.00	1.00
1 A 2 a Iron and Steel	Other Fuels	CH4	0.00254	0.00008	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Biomass	CH4	0.00000	0.00000	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Other Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Solid Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Biomass	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Other Fuels	CH4	0.00000	0.00000	0.00	1.00

Tier 1 Level Assessment (1992)

IPCC SOURCE CATEGORIES	ACTIVITY	GHG	Base year Estimate (kton CO2 eq.) 1990	Current year Estimate (kton CO2 eq.) 1992	Level Assess.	Cumulative Total
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CO2	6364	9388	0.14	0.14
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CO2	7816	8514	0.13	0.27
1 A 3 b Road Transportation	Diesel Oil	CO2	4947	5457	0.08	0.35
1 A 3 b Road Transportation	Gasoline	CO2	4303	5286	0.08	0.43
1 A 2 f Other	Liquid Fuels	CO2	3227	3321	0.05	0.47
2 A 1 Cement Production	Production Quantities	CO2	3024	2969	0.04	0.52
4 B 8 Swine	Population size	CH4	3028	2895	0.04	0.56
1 A 1 b Petroleum refining	Liquid Fuels	CO2	1929	1933	0.03	0.59
1 A 2 f Other	Solid Fuels	CO2	1982	1928	0.03	0.62
1 A 4 b Residential	Liquid Fuels	CO2	1630	1810	0.03	0.65
6 A 3 Other	Industrial Waste Disposal on Land	CH4	1655	1746	0.03	0.67
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CO2	1675	1696	0.03	0.70
4 D 2 Animal Production	Input to soils	N2O	1627	1613	0.02	0.72
4 D 3 Indirect Emissions	Input to soils	N2O	1591	1494	0.02	0.74
4 D 1 Direct Soil Emissions	Input to soils	N2O	1573	1395	0.02	0.76
4 B 12 Solid Storage and Dry Lot	Animal Excretion	N2O	1045	1034	0.02	0.78
1 A 4 a Commercial / Institutional	Liquid Fuels	CO2	816	991	0.01	0.79
4 A 1 b Non-Dairy Cattle	Population size	CH4	980	972	0.01	0.81
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CO2	828	918	0.01	0.82
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CO2	744	889	0.01	0.84
1 A 3 a ii Domestic	Jet Kerosene	CO2	794	889	0.01	0.85
1 A 2 c Chemicals	Liquid Fuels	CO2	456	866	0.01	0.86
6 A 2 Unmanaged Waste Disposal	Municipal Waste Disposal on Land	CH4	749	808	0.01	0.87
4 A 1 a Dairy Cattle	Population size	CH4	846	800	0.01	0.89
6 B 2 Domestic and Commercial wastewater	Wastewater	CH4	659	651	0.01	0.90
1 A 2 a Iron and Steel	Solid Fuels	CO2	476	609	0.01	0.90
2 B 2 Nitric Acid Production	Production Quantities	N2O	603	608	0.01	0.91
4 A 3 Sheep	Population size	CH4	564	562	0.01	0.92
1 A 3 d ii National navigation	Gas/Diesel Oil	CO2	433	342	0.01	0.93
2 B 1 Ammonia Production	Production Quantities	CO2	569	335	0.00	0.93
1 A 4 b Residential	Biomass	CH4	343	317	0.00	0.94
6 B 2 Domestic and Commercial wastewater	Wastewater	N2O	287	294	0.00	0.94
2 A 6 Road Paving with Asphalt	Production Quantities	CO2	168	257	0.00	0.94
4 B 1 a Dairy Cattle	Population size	CH4	218	206	0.00	0.95
6 B 1 Industrial Wastewater	Wastewater	CH4	164	193	0.00	0.95
6 B 1 Industrial Wastewater	Wastewater	N2O	161	190	0.00	0.95
1 A 3 c Railways	Liquid Fuels	CO2	175	183	0.00	0.96
2 A 7 Other	Production Quantities	CO2	180	180	0.00	0.96
4 C 1 Irrigated	Culture Surface	CH4	256	160	0.00	0.96
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	N2O	151	160	0.00	0.96
1 B 2 a iv Refining/ Storage	Liquid Fuels	CO2	124	133	0.00	0.97
1 A 2 b Non-ferrous Metals	Liquid Fuels	CO2	125	123	0.00	0.97
4 B 3 Sheep	Population size	CH4	113	112	0.00	0.97
1 A 2 a Iron and Steel	Liquid Fuels	CO2	163	110	0.00	0.97
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	CO2	90	100	0.00	0.97
1 A 2 c Chemicals	Other Fuels	CO2	63	99	0.00	0.97
1 A 3 b Road Transportation	Diesel Oil	N2O	84	93	0.00	0.97
3 A PAINT APPLICATION	Paint application	CO2	91	92	0.00	0.98
4 A 4 Goats	Population size	CH4	90	90	0.00	0.98
3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING	Chemical manufacture and processing	CO2	86	90	0.00	0.98
3 D OTHER	Other Use of Chemicals	CO2	82	85	0.00	0.98
1 A 4 a Commercial / Institutional	Gaseous Fuels	CO2	77	80	0.00	0.98
4 A 8 Swine	Population size	CH4	84	80	0.00	0.98
1 A 3 d ii National navigation	Residual Oil	CO2	44	75	0.00	0.98
1 A 4 b Residential	Biomass	N2O	73	67	0.00	0.98
1 B 1 a I Underground Mines	Solid Fuels	CH4	65	59	0.00	0.99
4 B 10 Anaerobic	Animal Excretion	N2O	59	56	0.00	0.99
2 B 5 Carbon black	Production Quantities	CO2	51	51	0.00	0.99
2 A 3 Limestone and Dolomite Use	Production Quantities	CO2	54	50	0.00	0.99
1 A 2 c Chemicals	Solid Fuels	CO2	45	48	0.00	0.99
1 A 3 b Road Transportation	Gasoline	N2O	33	42	0.00	0.99
1 A 1 a Public Electricity and Heat Production	Solid Fuels	N2O	36	39	0.00	0.99
4 B 1 b Non-Dairy Cattle	Population size	CH4	38	38	0.00	0.99
4 F 5 Other	Residues Burning	N2O	34	35	0.00	0.99
6 A 1 Managed Waste disposal	Municipal Waste Disposal on Land	CH4	18	31	0.00	0.99
1 A 3 b Road Transportation	Gasoline	CH4	25	31	0.00	0.99
4 B 9 Poultry	Population size	CH4	29	30	0.00	0.99
1 A 2 b Non-ferrous Metals	Solid Fuels	CO2	52	27	0.00	0.99
4 B 4 Goats	Population size	CH4	26	26	0.00	0.99
1 B 2 a iv Refining/ Storage	Liquid Fuels	CH4	22	24	0.00	0.99
4 B 11 Liquid Systems	Animal Excretion	N2O	24	23	0.00	0.99
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	N2O	15	23	0.00	0.99
2 C 3 Aluminium production	Production Quantities	CO2	17	22	0.00	0.99
1 B 2 a v Distribution of Oil Products	Liquid Fuels	CO2	17	21	0.00	0.99
1 A 2 d Pulp, Paper and Print	Biomass	CH4	19	21	0.00	0.99
4 A 7 Mules and Asses	Population size	CH4	24	21	0.00	1.00
2 C 1 Iron and Steel Production	Production Quantities	CO2	15	20	0.00	1.00
1 A 2 f Other	Biomass	N2O	21	20	0.00	1.00
4 F 5 Other	Residues Burning	CH4	16	17	0.00	1.00
1 A 2 d Pulp, Paper and Print	Biomass	N2O	11	15	0.00	1.00
1 B 2 a iii Transport	Liquid Fuels	CH4	13	14	0.00	1.00
4 A 6 Horses	Population size	CH4	14	13	0.00	1.00
1 A 4 b Residential	Liquid Fuels	N2O	11	12	0.00	1.00
1 B 2 a iii Transport	Liquid Fuels	CO2	12	12	0.00	1.00
3 B DEGREASING AND DRY CLEANING	Degreasing and Dry Cleaning	CO2	12	12	0.00	1.00
1 A 3 c Railways	Liquid Fuels	N2O	11	12	0.00	1.00
1 A 2 f Other	Liquid Fuels	N2O	11	11	0.00	1.00
1 A 3 b Road Transportation	Diesel Oil	CH4	9	10	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	CO2	10	10	0.00	1.00
1 A 1 b Petroleum refining	Liquid Fuels	N2O	9	8	0.00	1.00
4 B 7 Mules and Asses	Population size	CH4	9	8	0.00	1.00

1 B 1 a I Underground Mines	Solid Fuels	CO2	9	8	0.00	1.00
2 B 5 Etileno (Borealis)	Production Quantities	CO2	7	7	0.00	1.00
1 A 5 Other	Solid Fuels	CO2	8	6	0.00	1.00
1 A 3 a ii Domestic	Jet Kerosene	N2O	5	5	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Biomass	N2O	5	5	0.00	1.00
1 A 2 c Chemicals	Liquid Fuels	N2O	4	5	0.00	1.00
1 A 2 f Other	Biomass	CH4	5	5	0.00	1.00
1 A 2 f Other	Solid Fuels	N2O	4	4	0.00	1.00
2 B 5 Etileno (Borealis)	Production Quantities	CH4	5	4	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	CO2	5	4	0.00	1.00
2 B 5 Explosivos e Anid. Ftálico	Production Quantities	CO2	4	4	0.00	1.00
4 A 10 Other	Population size	CH4	4	4	0.00	1.00
1 A 2 f Other	Liquid Fuels	CH4	3	3	0.00	1.00
2 B 5 Carbon black	Production Quantities	CH4	3	3	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CH4	3	3	0.00	1.00
1 B 2 b ii Transmission/ Distribution	Gaseous Fuels	CH4	3	3	0.00	1.00
1 A 4 a Commercial / Institutional	Liquid Fuels	N2O	2	3	0.00	1.00
4 B 6 Horses	Population size	CH4	3	3	0.00	1.00
1 A 3 d ii National navigation	Gas/Diesel Oil	N2O	3	3	0.00	1.00
2 C 2 Ferroalloys Production	Production Quantities	CO2	3	3	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	N2O	2	3	0.00	1.00
1 B 2 d Other (Geothermal)	Energy Production	CO2	2	3	0.00	1.00
1 A 3 a ii Domestic	Jet Kerosene	CH4	2	2	0.00	1.00
1 A 2 d Pulp, Paper and Print	Liquid Fuels	N2O	2	2	0.00	1.00
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CH4	2	2	0.00	1.00
2 B 5 Produção de Monómeros e Polimeros Orgânicos	Production Quantities	CO2	2	2	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CH4	1	2	0.00	1.00
4 F 1 Cereals	Residues Burning	N2O	3	2	0.00	1.00
1 A 1 b Petroleum refining	Liquid Fuels	CH4	2	2	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CH4	1	1	0.00	1.00
1 A 2 c Chemicals	Biomass	N2O	1	1	0.00	1.00
1 A 4 a Commercial / Institutional	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 2 c Chemicals	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 2 a Iron and Steel	Solid Fuels	N2O	1	1	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Biomass	CH4	1	1	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	N2O	1	1	0.00	1.00
1 A 2 f Other	Solid Fuels	CH4	1	1	0.00	1.00
1 A 4 b Residential	Liquid Fuels	CH4	1	1	0.00	1.00
4 F 1 Cereals	Residues Burning	CH4	1	1	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 2 c Chemicals	Other Fuels	N2O	0	1	0.00	1.00
1 A 4 a Commercial / Institutional	Gaseous Fuels	N2O	1	1	0.00	1.00
1 A 3 d ii National navigation	Residual Oil	N2O	0	1	0.00	1.00
1 A 3 d ii National navigation	Gas/Diesel Oil	CH4	1	1	0.00	1.00
1 A 2 b Non-ferrous Metals	Liquid Fuels	N2O	0	0	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	N2O	0	0	0.00	1.00
2 D 2 Food and Drink	Production Quantities	CO2	0.43657	0.43657	0.00	1.00
1 A 2 a Iron and Steel	Liquid Fuels	N2O	0.50132	0.36776	0.00	1.00
1 A 2 c Chemicals	Biomass	CH4	0.33113	0.32043	0.00	1.00
1 B 2 c I Oil	Liquid Fuels	CO2	0.27336	0.29323	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	CO2	0.06049	0.27951	0.00	1.00
1 A 3 c Railways	Liquid Fuels	CH4	0.24900	0.26126	0.00	1.00
1 A 2 b Non-ferrous Metals	Biomass	N2O	0.19019	0.18400	0.00	1.00
1 B 1 a ii Surface Mines	Solid Fuels	CH4	0.86175	0.16369	0.00	1.00
1 A 2 a Iron and Steel	Solid Fuels	CH4	0.11925	0.15658	0.00	1.00
1 A 3 d ii National navigation	Residual Oil	CH4	0.06804	0.11546	0.00	1.00
1 A 5 Other	Solid Fuels	CH4	0.15135	0.10339	0.00	1.00
1 A 2 c Chemicals	Solid Fuels	N2O	0.09934	0.10135	0.00	1.00
1 B 2 c I Oil	Liquid Fuels	CH4	0.09206	0.09875	0.00	1.00
1 A 3 c Railways	Solid Fuels	CO2	0.13335	0.09133	0.00	1.00
1 A 2 b Non-ferrous Metals	Liquid Fuels	CH4	0.08930	0.08633	0.00	1.00
1 A 2 a Iron and Steel	Liquid Fuels	CH4	0.12724	0.07564	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	CH4	0.08337	0.06817	0.00	1.00
1 A 2 b Non-ferrous Metals	Solid Fuels	N2O	0.11159	0.05882	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	CH4	0.04901	0.05463	0.00	1.00
1 A 2 c Chemicals	Other Fuels	CH4	0.02938	0.04610	0.00	1.00
1 A 2 b Non-ferrous Metals	Biomass	CH4	0.04494	0.04348	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Solid Fuels	CO2	1.19204	0.04147	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	CH4	0.03875	0.03979	0.00	1.00
1 A 4 a Commercial / Institutional	Gaseous Fuels	CH4	0.03451	0.03613	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Biomass	N2O	0.02500	0.02500	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	N2O	0.03034	0.02499	0.00	1.00
1 A 2 c Chemicals	Solid Fuels	CH4	0.02307	0.02354	0.00	1.00
1 B 1 a ii Surface Mines	Solid Fuels	CO2	0.11285	0.02144	0.00	1.00
1 A 2 b Non-ferrous Metals	Solid Fuels	CH4	0.02592	0.01366	0.00	1.00
1 A 5 Other	Solid Fuels	N2O	0.01818	0.01242	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	N2O	0.00158	0.00730	0.00	1.00
1 A 3 c Railways	Solid Fuels	N2O	0.00861	0.00590	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	CH4	0.00025	0.00125	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Biomass	CH4	0.00087	0.00087	0.00	1.00
1 A 3 c Railways	Solid Fuels	CH4	0.00019	0.00013	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Solid Fuels	N2O	0.00269	0.00009	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Solid Fuels	CH4	0.00063	0.00002	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Biomass	CH4	0.00000	0.00000	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Other Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Solid Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Biomass	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Other Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Liquid Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Biomass	CH4	0.00000	0.00000	0.00	1.00

Tier 1 Level Assessment (1993)

IPCC SOURCE CATEGORIES	ACTIVITY	GHG	Base year Estimate (kton CO2 eq.) 1990	Current year Estimate (kton CO2 eq.) 1993	Level Assess.	Cumulative Total
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CO2	7816	9375	0.14	0.14
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CO2	6364	6508	0.10	0.24
1 A 3 b Road Transportation	Diesel Oil	CO2	4947	5622	0.09	0.33
1 A 3 b Road Transportation	Gasoline	CO2	4303	5569	0.08	0.41
1 A 2 f Other	Liquid Fuels	CO2	3227	3468	0.05	0.47
2 A 1 Cement Production	Production Quantities	CO2	3024	3125	0.05	0.51
4 B 8 Swine	Population size	CH4	3028	2643	0.04	0.55
1 A 1 b Petroleum refining	Liquid Fuels	CO2	1929	1925	0.03	0.58
1 A 4 b Residential	Liquid Fuels	CO2	1630	1899	0.03	0.61
1 A 2 f Other	Solid Fuels	CO2	1982	1865	0.03	0.64
6 A 3 Other	Industrial Waste Disposal on Land	CH4	1655	1792	0.03	0.67
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CO2	1675	1717	0.03	0.69
4 D 2 Animal Production	Input to soils	N2O	1627	1586	0.02	0.72
4 D 3 Indirect Emissions	Input to soils	N2O	1591	1486	0.02	0.74
4 D 1 Direct Soil Emissions	Input to soils	N2O	1573	1390	0.02	0.76
1 A 4 a Commercial / Institutional	Liquid Fuels	CO2	816	1024	0.02	0.78
4 B 12 Solid Storage and Dry Lot	Animal Excretion	N2O	1045	1022	0.02	0.79
4 A 1 b Non-Dairy Cattle	Population size	CH4	980	956	0.01	0.81
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CO2	744	915	0.01	0.82
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CO2	828	880	0.01	0.83
1 A 3 a ii Domestic	Jet Kerosene	CO2	794	854	0.01	0.85
6 A 2 Unmanaged Waste Disposal	Municipal Waste Disposal on Land	CH4	749	839	0.01	0.86
1 A 2 c Chemicals	Liquid Fuels	CO2	456	792	0.01	0.87
4 A 1 a Dairy Cattle	Population size	CH4	846	788	0.01	0.88
6 B 2 Domestic and Commercial wastewater	Wastewater	CH4	659	648	0.01	0.89
1 A 2 a Iron and Steel	Solid Fuels	CO2	476	631	0.01	0.90
4 A 3 Sheep	Population size	CH4	564	555	0.01	0.91
2 B 2 Nitric Acid Production	Production Quantities	N2O	603	507	0.01	0.92
1 A 4 b Residential	Biomass	CH4	343	310	0.00	0.92
1 A 3 d ii National navigation	Gas/Diesel Oil	CO2	433	305	0.00	0.93
6 B 2 Domestic and Commercial wastewater	Wastewater	N2O	287	303	0.00	0.93
2 A 6 Road Paving with Asphalt	Production Quantities	CO2	168	283	0.00	0.94
2 B 1 Ammonia Production	Production Quantities	CO2	569	281	0.00	0.94
6 B 1 Industrial Wastewater	Wastewater	CH4	164	208	0.00	0.95
6 B 1 Industrial Wastewater	Wastewater	N2O	161	205	0.00	0.95
4 B 1 a Dairy Cattle	Population size	CH4	218	203	0.00	0.95
1 A 2 a Iron and Steel	Liquid Fuels	CO2	163	188	0.00	0.96
2 A 7 Other	Production Quantities	CO2	180	180	0.00	0.96
1 A 3 c Railways	Liquid Fuels	CO2	175	168	0.00	0.96
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	N2O	151	166	0.00	0.96
1 B 2 a iv Refining/ Storage	Liquid Fuels	CO2	124	128	0.00	0.96
1 A 3 d ii National navigation	Residual Oil	CO2	44	116	0.00	0.97
4 B 3 Sheep	Population size	CH4	113	111	0.00	0.97
4 C 1 Irrigated	Culture Surface	CH4	256	100	0.00	0.97
1 A 4 a Commercial / Institutional	Gaseous Fuels	CO2	77	98	0.00	0.97
1 A 3 b Road Transportation	Diesel Oil	N2O	84	96	0.00	0.97
3 A PAINT APPLICATION	Paint application	CO2	91	92	0.00	0.97
1 A 2 b Non-ferrous Metals	Liquid Fuels	CO2	125	90	0.00	0.98
1 A 2 c Chemicals	Other Fuels	CO2	63	90	0.00	0.98
3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING	Chemical manufacture and processing	CO2	86	90	0.00	0.98
4 A 4 Goats	Population size	CH4	90	88	0.00	0.98
3 D OTHER	Other Use of Chemicals	CO2	82	85	0.00	0.98
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	CO2	90	79	0.00	0.98
1 A 3 b Road Transportation	Gasoline	N2O	33	78	0.00	0.98
4 A 8 Swine	Population size	CH4	84	71	0.00	0.98
1 A 4 b Residential	Biomass	N2O	73	66	0.00	0.99
2 B 5 Carbon black	Production Quantities	CO2	51	56	0.00	0.99
1 B 1 a I Underground Mines	Solid Fuels	CH4	65	55	0.00	0.99
4 B 10 Anaerobic	Animal Excretion	N2O	59	51	0.00	0.99
2 A 3 Limestone and Dolomite Use	Production Quantities	CO2	54	50	0.00	0.99
1 A 2 c Chemicals	Solid Fuels	CO2	45	44	0.00	0.99
1 A 1 a Public Electricity and Heat Production	Solid Fuels	N2O	36	44	0.00	0.99
6 A 1 Managed Waste disposal	Municipal Waste Disposal on Land	CH4	18	38	0.00	0.99
4 B 1 b Non-Dairy Cattle	Population size	CH4	38	37	0.00	0.99
4 F 5 Other	Residues Burning	N2O	34	34	0.00	0.99
1 A 3 b Road Transportation	Gasoline	CH4	25	31	0.00	0.99
4 B 9 Poultry	Population size	CH4	29	30	0.00	0.99
4 B 4 Goats	Population size	CH4	26	25	0.00	0.99
1 B 2 a iv Refining/ Storage	Liquid Fuels	CH4	22	23	0.00	0.99
2 C 1 Iron and Steel Production	Production Quantities	CO2	15	22	0.00	0.99
1 B 2 a v Distribution of Oil Products	Liquid Fuels	CO2	17	22	0.00	0.99
4 B 11 Liquid Systems	Animal Excretion	N2O	24	22	0.00	0.99
2 C 3 Aluminium production	Production Quantities	CO2	17	21	0.00	0.99
1 A 2 d Pulp, Paper and Print	Biomass	CH4	19	21	0.00	0.99
1 A 2 f Other	Biomass	N2O	21	20	0.00	1.00
4 A 7 Mules and Asses	Population size	CH4	24	19	0.00	1.00
1 A 2 d Pulp, Paper and Print	Biomass	N2O	11	17	0.00	1.00
4 F 5 Other	Residues Burning	CH4	16	16	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	N2O	15	16	0.00	1.00
1 B 2 a iii Transport	Liquid Fuels	CH4	13	14	0.00	1.00
4 A 6 Horses	Population size	CH4	14	13	0.00	1.00
1 A 4 b Residential	Liquid Fuels	N2O	11	13	0.00	1.00
3 B DEGREASING AND DRY CLEANING	Degreasing and Dry Cleaning	CO2	12	12	0.00	1.00
1 B 2 a iii Transport	Liquid Fuels	CO2	12	12	0.00	1.00
1 A 2 f Other	Liquid Fuels	N2O	11	12	0.00	1.00
1 A 3 c Railways	Liquid Fuels	N2O	11	11	0.00	1.00
1 A 3 b Road Transportation	Diesel Oil	CH4	9	10	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	CO2	10	10	0.00	1.00
1 A 1 b Petroleum refining	Liquid Fuels	N2O	9	8	0.00	1.00
1 B 1 a I Underground Mines	Solid Fuels	CO2	9	7	0.00	1.00
4 B 7 Mules and Asses	Population size	CH4	9	7	0.00	1.00

2 B 5 Etileno (Borealis)	Production Quantities	CO2	7	6	0.00	1.00
1 A 3 a ii Domestic	Jet Kerosene	N2O	5	5	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Biomass	N2O	5	5	0.00	1.00
1 A 2 b Non-ferrous Metals	Solid Fuels	CO2	52	5	0.00	1.00
1 A 2 f Other	Biomass	CH4	5	5	0.00	1.00
1 A 2 c Chemicals	Liquid Fuels	N2O	4	5	0.00	1.00
1 A 2 f Other	Solid Fuels	N2O	4	4	0.00	1.00
2 B 5 Etileno (Borealis)	Production Quantities	CH4	5	4	0.00	1.00
2 B 5 Carbon black	Production Quantities	CH4	3	4	0.00	1.00
1 A 2 f Other	Liquid Fuels	CH4	3	4	0.00	1.00
1 B 2 b ii Transmission/ Distribution	Gaseous Fuels	CH4	3	4	0.00	1.00
2 B 5 Explosivos e Anid. Ftálico	Production Quantities	CO2	4	4	0.00	1.00
4 A 10 Other	Population size	CH4	4	4	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	CO2	5	3	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CH4	3	3	0.00	1.00
1 A 4 a Commercial / Institutional	Liquid Fuels	N2O	2	3	0.00	1.00
1 A 5 Other	Solid Fuels	CO2	8	3	0.00	1.00
4 B 6 Horses	Population size	CH4	3	3	0.00	1.00
2 C 2 Ferroalloys Production	Production Quantities	CO2	3	3	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	N2O	2	2	0.00	1.00
1 A 3 d ii National navigation	Gas/Diesel Oil	N2O	3	2	0.00	1.00
1 A 3 a ii Domestic	Jet Kerosene	CH4	2	2	0.00	1.00
1 A 2 d Pulp, Paper and Print	Liquid Fuels	N2O	2	2	0.00	1.00
2 B 5 Produção de Monómeros e Polimeros Orgânicos	Production Quantities	CO2	2	2	0.00	1.00
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CH4	2	2	0.00	1.00
1 B 2 d Other (Geothermal)	Energy Production	CO2	2	2	0.00	1.00
1 A 1 b Petroleum refining	Liquid Fuels	CH4	2	2	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CH4	1	1	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 2 c Chemicals	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 4 a Commercial / Institutional	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 2 a Iron and Steel	Solid Fuels	N2O	1	1	0.00	1.00
1 A 2 c Chemicals	Biomass	N2O	1	1	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Biomass	CH4	1	1	0.00	1.00
4 F 1 Cereals	Residues Burning	N2O	3	1	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	N2O	1	1	0.00	1.00
1 A 4 b Residential	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 2 f Other	Solid Fuels	CH4	1	1	0.00	1.00
1 A 3 d ii National navigation	Residual Oil	N2O	0	1	0.00	1.00
1 A 4 a Commercial / Institutional	Gaseous Fuels	N2O	1	1	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 2 c Chemicals	Other Fuels	N2O	0	1	0.00	1.00
4 F 1 Cereals	Residues Burning	CH4	1	1	0.00	1.00
1 A 2 a Iron and Steel	Liquid Fuels	N2O	1	1	0.00	1.00
1 A 3 d ii National navigation	Gas/Diesel Oil	CH4	1	0	0.00	1.00
2 D 2 Food and Drink	Production Quantities	CO2	0	0	0.00	1.00
1 A 2 b Non-ferrous Metals	Liquid Fuels	N2O	0.44993	0.35714	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	N2O	0.40511	0.35542	0.00	1.00
1 A 2 c Chemicals	Biomass	CH4	0.33113	0.31402	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	CO2	0.06049	0.31188	0.00	1.00
1 B 2 c I Oil	Liquid Fuels	CO2	0.27336	0.27962	0.00	1.00
1 A 3 c Railways	Liquid Fuels	CH4	0.24900	0.23890	0.00	1.00
1 A 2 b Non-ferrous Metals	Biomass	N2O	0.19019	0.18032	0.00	1.00
1 A 3 d ii National navigation	Residual Oil	CH4	0.06804	0.17867	0.00	1.00
1 A 2 a Iron and Steel	Solid Fuels	CH4	0.11925	0.16240	0.00	1.00
1 A 2 a Iron and Steel	Liquid Fuels	CH4	0.12724	0.13754	0.00	1.00
1 B 2 c I Oil	Liquid Fuels	CH4	0.09206	0.09416	0.00	1.00
1 A 2 c Chemicals	Solid Fuels	N2O	0.09934	0.09278	0.00	1.00
1 A 3 c Railways	Solid Fuels	CO2	0.13335	0.06925	0.00	1.00
1 A 2 b Non-ferrous Metals	Liquid Fuels	CH4	0.08930	0.06346	0.00	1.00
1 A 5 Other	Solid Fuels	CH4	0.15135	0.05602	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	CH4	0.08337	0.05386	0.00	1.00
1 A 4 a Commercial / Institutional	Gaseous Fuels	CH4	0.03451	0.04405	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	CH4	0.04901	0.04299	0.00	1.00
1 A 2 b Non-ferrous Metals	Biomass	CH4	0.04494	0.04261	0.00	1.00
1 A 2 c Chemicals	Other Fuels	CH4	0.02938	0.04194	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	CH4	0.03875	0.04033	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Biomass	N2O	0.02500	0.02500	0.00	1.00
1 A 2 c Chemicals	Solid Fuels	CH4	0.02307	0.02155	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	N2O	0.03034	0.01996	0.00	1.00
1 A 2 b Non-ferrous Metals	Solid Fuels	N2O	0.11159	0.01103	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	N2O	0.00158	0.00810	0.00	1.00
1 A 5 Other	Solid Fuels	N2O	0.01818	0.00673	0.00	1.00
1 A 3 c Railways	Solid Fuels	N2O	0.00861	0.00447	0.00	1.00
1 A 2 b Non-ferrous Metals	Solid Fuels	CH4	0.02592	0.00256	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	CH4	0.00025	0.00139	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Biomass	CH4	0.00087	0.00087	0.00	1.00
1 A 3 c Railways	Solid Fuels	CH4	0.00019	0.00010	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Biomass	CH4	0.00000	0.00000	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Other Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Solid Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Biomass	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Other Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Liquid Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Biomass	CH4	0.00000	0.00000	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Other Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 2 a Iron and Steel	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 2 a Iron and Steel	Biomass	CH4	0.00000	0.00000	0.00	1.00
1 A 2 a Iron and Steel	Other Fuels	CH4	0.00254	0.00000	0.00	1.00
1 A 2 b Non-ferrous Metals	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00

Tier 1 Level Assessment (1994)

IPCC SOURCE CATEGORIES	ACTIVITY	GHG	Base year Estimate (kton CO2 eq.) 1990	Current year Estimate (kton CO2 eq.) 1994	Level Assess.	Cumulative Total
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CO2	7816	9813	0.15	0.15
1 A 3 b Road Transportation	Diesel Oil	CO2	4947	6064	0.09	0.24
1 A 3 b Road Transportation	Gasoline	CO2	4303	5718	0.09	0.33
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CO2	6364	4722	0.07	0.40
1 A 2 f Other	Liquid Fuels	CO2	3227	3647	0.06	0.45
2 A 1 Cement Production	Production Quantities	CO2	3024	3221	0.05	0.50
4 B 8 Swine	Population size	CH4	3028	2763	0.04	0.54
1 A 1 b Petroleum refining	Liquid Fuels	CO2	1929	2410	0.04	0.58
1 A 4 b Residential	Liquid Fuels	CO2	1630	1920	0.03	0.61
1 A 2 f Other	Solid Fuels	CO2	1982	1912	0.03	0.64
6 A 3 Other	Industrial Waste Disposal on Land	CH4	1655	1839	0.03	0.66
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CO2	1675	1788	0.03	0.69
4 D 2 Animal Production	Input to soils	N2O	1627	1610	0.02	0.72
4 D 3 Indirect Emissions	Input to soils	N2O	1591	1494	0.02	0.74
4 D 1 Direct Soil Emissions	Input to soils	N2O	1573	1418	0.02	0.76
1 A 4 a Commercial / Institutional	Liquid Fuels	CO2	816	1192	0.02	0.78
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CO2	744	1052	0.02	0.79
4 B 12 Solid Storage and Dry Lot	Animal Excretion	N2O	1045	1027	0.02	0.81
1 A 2 c Chemicals	Liquid Fuels	CO2	456	1012	0.02	0.82
4 A 1 b Non-Dairy Cattle	Population size	CH4	980	969	0.01	0.84
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CO2	828	893	0.01	0.85
6 A 2 Unmanaged Waste Disposal	Municipal Waste Disposal on Land	CH4	749	868	0.01	0.87
1 A 3 a ii Domestic	Jet Kerosene	CO2	794	832	0.01	0.88
4 A 1 a Dairy Cattle	Population size	CH4	846	748	0.01	0.89
6 B 2 Domestic and Commercial wastewater	Wastewater	CH4	659	645	0.01	0.90
1 A 2 a Iron and Steel	Solid Fuels	CO2	476	586	0.01	0.91
4 A 3 Sheep	Population size	CH4	564	574	0.01	0.92
2 B 2 Nitric Acid Production	Production Quantities	N2O	603	381	0.01	0.92
6 B 2 Domestic and Commercial wastewater	Wastewater	N2O	287	311	0.00	0.93
1 A 4 b Residential	Biomass	CH4	343	307	0.00	0.93
1 A 3 d ii National navigation	Gas/Diesel Oil	CO2	433	269	0.00	0.94
2 A 6 Road Paving with Asphalt	Production Quantities	CO2	168	243	0.00	0.94
6 B 1 Industrial Wastewater	Wastewater	CH4	164	208	0.00	0.94
6 B 1 Industrial Wastewater	Wastewater	N2O	161	205	0.00	0.95
4 B 1 a Dairy Cattle	Population size	CH4	218	192	0.00	0.95
2 B 1 Ammonia Production	Production Quantities	CO2	569	190	0.00	0.95
4 C 1 Irrigated	Culture Surface	CH4	256	182	0.00	0.95
2 A 7 Other	Production Quantities	CO2	180	180	0.00	0.96
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	N2O	151	168	0.00	0.96
1 A 3 c Railways	Liquid Fuels	CO2	175	166	0.00	0.96
1 A 2 a Iron and Steel	Liquid Fuels	CO2	163	165	0.00	0.96
1 B 2 a iv Refining/ Storage	Liquid Fuels	CO2	124	159	0.00	0.97
4 B 3 Sheep	Population size	CH4	113	115	0.00	0.97
1 A 3 b Road Transportation	Gasoline	N2O	33	110	0.00	0.97
1 A 3 b Road Transportation	Diesel Oil	N2O	84	103	0.00	0.97
1 A 4 a Commercial / Institutional	Gaseous Fuels	CO2	77	99	0.00	0.97
3 A PAINT APPLICATION	Paint application	CO2	91	92	0.00	0.97
3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING	Chemical manufacture and processing	CO2	86	90	0.00	0.98
4 A 4 Goats	Population size	CH4	90	86	0.00	0.98
3 D OTHER	Other Use of Chemicals	CO2	82	85	0.00	0.98
1 A 3 d ii National navigation	Residual Oil	CO2	44	85	0.00	0.98
1 A 2 b Non-ferrous Metals	Liquid Fuels	CO2	125	80	0.00	0.98
4 A 8 Swine	Population size	CH4	84	76	0.00	0.98
1 A 4 b Residential	Biomass	N2O	73	65	0.00	0.98
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	CO2	90	64	0.00	0.98
2 B 5 Carbon black	Production Quantities	CO2	51	61	0.00	0.99
4 B 10 Anaerobic	Animal Excretion	N2O	59	53	0.00	0.99
2 A 3 Limestone and Dolomite Use	Production Quantities	CO2	54	50	0.00	0.99
1 A 2 c Chemicals	Other Fuels	CO2	63	48	0.00	0.99
6 A 1 Managed Waste disposal	Municipal Waste Disposal on Land	CH4	18	47	0.00	0.99
1 A 2 c Chemicals	Solid Fuels	CO2	45	47	0.00	0.99
1 A 1 a Public Electricity and Heat Production	Solid Fuels	N2O	36	46	0.00	0.99
1 B 1 a I Underground Mines	Solid Fuels	CH4	65	41	0.00	0.99
4 B 1 b Non-Dairy Cattle	Population size	CH4	38	38	0.00	0.99
4 F 5 Other	Residues Burning	N2O	34	34	0.00	0.99
1 A 3 b Road Transportation	Gasoline	CH4	25	31	0.00	0.99
4 B 9 Poultry	Population size	CH4	29	31	0.00	0.99
1 B 2 a iv Refining/ Storage	Liquid Fuels	CH4	22	28	0.00	0.99
1 B 2 d Other (Geothermal)	Energy Production	CO2	2	28	0.00	0.99
4 B 4 Goats	Population size	CH4	26	25	0.00	0.99
1 B 2 a v Distribution of Oil Products	Liquid Fuels	CO2	17	24	0.00	0.99
4 B 11 Liquid Systems	Animal Excretion	N2O	24	22	0.00	0.99
2 C 1 Iron and Steel Production	Production Quantities	CO2	15	21	0.00	0.99
2 C 3 Aluminium production	Production Quantities	CO2	17	21	0.00	0.99
1 A 2 d Pulp, Paper and Print	Biomass	CH4	19	20	0.00	1.00
1 A 2 f Other	Biomass	N2O	21	20	0.00	1.00
4 A 7 Mules and Asses	Population size	CH4	24	17	0.00	1.00
1 B 2 a iii Transport	Liquid Fuels	CH4	13	17	0.00	1.00
4 F 5 Other	Residues Burning	CH4	16	16	0.00	1.00
1 B 2 a iii Transport	Liquid Fuels	CO2	12	15	0.00	1.00
1 A 2 d Pulp, Paper and Print	Biomass	N2O	11	14	0.00	1.00
4 A 6 Horses	Population size	CH4	14	13	0.00	1.00
1 A 4 b Residential	Liquid Fuels	N2O	11	13	0.00	1.00
1 A 2 f Other	Liquid Fuels	N2O	11	13	0.00	1.00
3 B DEGREASING AND DRY CLEANING	Degreasing and Dry Cleaning	CO2	12	12	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	N2O	15	11	0.00	1.00
1 A 3 b Road Transportation	Diesel Oil	CH4	9	11	0.00	1.00
1 A 3 c Railways	Liquid Fuels	N2O	11	11	0.00	1.00
1 A 1 b Petroleum refining	Liquid Fuels	N2O	9	11	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	CO2	10	10	0.00	1.00
2 B 5 Etileno (Borealis)	Production Quantities	CO2	7	7	0.00	1.00

4 B 7 Mules and Asses	Population size	CH4	9	7	0.00	1.00
1 B 1 a I Underground Mines	Solid Fuels	CO2	9	5	0.00	1.00
1 A 3 a ii Domestic	Jet Kerosene	N2O	5	5	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Biomass	N2O	5	5	0.00	1.00
1 A 2 c Chemicals	Liquid Fuels	N2O	4	5	0.00	1.00
1 A 2 f Other	Biomass	CH4	5	5	0.00	1.00
1 A 2 f Other	Solid Fuels	N2O	4	4	0.00	1.00
2 B 5 Carbon black	Production Quantities	CH4	3	4	0.00	1.00
2 B 5 Etileno (Borealis)	Production Quantities	CH4	5	4	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	CO2	5	4	0.00	1.00
1 A 2 f Other	Liquid Fuels	CH4	3	4	0.00	1.00
1 B 2 b ii Transmission/ Distribution	Gaseous Fuels	CH4	3	4	0.00	1.00
2 B 5 Explosivos e Anid. Ftálico	Production Quantities	CO2	4	4	0.00	1.00
4 A 10 Other	Population size	CH4	4	4	0.00	1.00
1 A 4 a Commercial / Institutional	Liquid Fuels	N2O	2	3	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CH4	3	3	0.00	1.00
4 B 6 Horses	Population size	CH4	3	3	0.00	1.00
2 C 2 Ferroalloys Production	Production Quantities	CO2	3	3	0.00	1.00
1 A 2 d Pulp, Paper and Print	Liquid Fuels	N2O	2	3	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	N2O	2	3	0.00	1.00
1 A 3 a ii Domestic	Jet Kerosene	CH4	2	2	0.00	1.00
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CH4	2	2	0.00	1.00
4 F 1 Cereals	Residues Burning	N2O	3	2	0.00	1.00
2 B 5 Produção de Monómeros e Polimeros Orgânicos	Production Quantities	CO2	2	2	0.00	1.00
1 A 3 d ii National navigation	Gas/Diesel Oil	N2O	3	2	0.00	1.00
1 A 1 b Petroleum refining	Liquid Fuels	CH4	2	2	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CH4	1	2	0.00	1.00
1 A 4 a Commercial / Institutional	Liquid Fuels	CH4	1	2	0.00	1.00
1 A 2 c Chemicals	Biomass	N2O	1	1	0.00	1.00
1 A 2 a Iron and Steel	Solid Fuels	N2O	1	1	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Biomass	CH4	1	1	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	N2O	1	1	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 2 c Chemicals	Liquid Fuels	CH4	1	1	0.00	1.00
4 F 1 Cereals	Residues Burning	CH4	1	1	0.00	1.00
1 A 4 b Residential	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 2 f Other	Solid Fuels	CH4	1	1	0.00	1.00
1 A 4 a Commercial / Institutional	Gaseous Fuels	N2O	1	1	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 3 d ii National navigation	Residual Oil	N2O	0	1	0.00	1.00
1 A 2 b Non-ferrous Metals	Solid Fuels	CO2	52	1	0.00	1.00
1 A 2 a Iron and Steel	Liquid Fuels	N2O	1	1	0.00	1.00
2 D 2 Food and Drink	Production Quantities	CO2	0	0	0.00	1.00
1 A 5 Other	Solid Fuels	CO2	8	0	0.00	1.00
1 A 3 d ii National navigation	Gas/Diesel Oil	CH4	1	0	0.00	1.00
1 A 2 b Non-ferrous Metals	Liquid Fuels	N2O	0	0	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	CO2	0.06049	0.33468	0.00	1.00
1 A 2 c Chemicals	Other Fuels	N2O	0.43372	0.33058	0.00	1.00
1 B 2 c I Oil	Liquid Fuels	CO2	0.27336	0.32609	0.00	1.00
1 A 2 c Chemicals	Biomass	CH4	0.33113	0.31402	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	N2O	0.40511	0.28776	0.00	1.00
1 A 3 c Railways	Liquid Fuels	CH4	0.24900	0.23710	0.00	1.00
1 A 2 b Non-ferrous Metals	Biomass	N2O	0.19019	0.18037	0.00	1.00
1 A 2 a Iron and Steel	Solid Fuels	CH4	0.11925	0.15128	0.00	1.00
1 A 3 d ii National navigation	Residual Oil	CH4	0.06804	0.13080	0.00	1.00
1 A 2 a Iron and Steel	Liquid Fuels	CH4	0.12724	0.11535	0.00	1.00
1 B 2 c I Oil	Liquid Fuels	CH4	0.09206	0.10981	0.00	1.00
1 A 2 c Chemicals	Solid Fuels	N2O	0.09934	0.09994	0.00	1.00
1 A 3 c Railways	Solid Fuels	CO2	0.13335	0.07178	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	CH4	0.08337	0.06097	0.00	1.00
1 A 2 b Non-ferrous Metals	Liquid Fuels	CH4	0.08930	0.05526	0.00	1.00
1 A 4 a Commercial / Institutional	Gaseous Fuels	CH4	0.03451	0.04433	0.00	1.00
1 A 2 b Non-ferrous Metals	Biomass	CH4	0.04494	0.04262	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	CH4	0.03875	0.04088	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	CH4	0.04901	0.03481	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Biomass	N2O	0.02500	0.02500	0.00	1.00
1 A 2 c Chemicals	Solid Fuels	CH4	0.02307	0.02321	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	N2O	0.03034	0.02279	0.00	1.00
1 A 2 c Chemicals	Other Fuels	CH4	0.02938	0.02239	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	N2O	0.00158	0.00876	0.00	1.00
1 A 5 Other	Solid Fuels	CH4	0.15135	0.00784	0.00	1.00
1 A 3 c Railways	Solid Fuels	N2O	0.00861	0.00464	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	CH4	0.00025	0.00153	0.00	1.00
1 A 2 b Non-ferrous Metals	Solid Fuels	N2O	0.11159	0.00134	0.00	1.00
1 A 5 Other	Solid Fuels	N2O	0.01818	0.00094	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Biomass	CH4	0.00087	0.00087	0.00	1.00
1 A 2 b Non-ferrous Metals	Solid Fuels	CH4	0.02592	0.00031	0.00	1.00
1 A 3 c Railways	Solid Fuels	CH4	0.00019	0.00010	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Biomass	CH4	0.00000	0.00000	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Other Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Solid Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Biomass	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Other Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Liquid Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Biomass	CH4	0.00000	0.00000	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Other Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 2 a Iron and Steel	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 2 a Iron and Steel	Biomass	CH4	0.00000	0.00000	0.00	1.00
1 A 2 a Iron and Steel	Other Fuels	CH4	0.00254	0.00000	0.00	1.00
1 A 2 b Non-ferrous Metals	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00

Tier 1 Level Assessment (1995)

IPCC SOURCE CATEGORIES	ACTIVITY	GHG	Base year Estimate (kton CO2 eq.) 1990	Current year Estimate (kton CO2 eq.) 1995	Level Assess.	Cumulative Total
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CO2	7816	11256	0.16	0.16
1 A 3 b Road Transportation	Diesel Oil	CO2	4947	6509	0.09	0.25
1 A 3 b Road Transportation	Gasoline	CO2	4303	5896	0.08	0.34
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CO2	6364	5811	0.08	0.42
1 A 2 f Other	Liquid Fuels	CO2	3227	3842	0.05	0.48
2 A 1 Cement Production	Production Quantities	CO2	3024	3367	0.05	0.52
4 B 8 Swine	Population size	CH4	3028	2752	0.04	0.56
1 A 1 b Petroleum refining	Liquid Fuels	CO2	1929	2407	0.03	0.60
1 A 4 b Residential	Liquid Fuels	CO2	1630	1922	0.03	0.63
6 A 3 Other	Industrial Waste Disposal on Land	CH4	1655	1886	0.03	0.65
1 A 2 f Other	Solid Fuels	CO2	1982	1695	0.02	0.68
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CO2	1675	1674	0.02	0.70
4 D 2 Animal Production	Input to soils	N2O	1627	1609	0.02	0.72
4 D 3 Indirect Emissions	Input to soils	N2O	1591	1484	0.02	0.74
4 D 1 Direct Soil Emissions	Input to soils	N2O	1573	1403	0.02	0.76
1 A 4 a Commercial / Institutional	Liquid Fuels	CO2	816	1156	0.02	0.78
4 B 12 Solid Storage and Dry Lot	Animal Excretion	N2O	1045	1034	0.01	0.80
1 A 2 c Chemicals	Liquid Fuels	CO2	456	999	0.01	0.81
4 A 1 b Non-Dairy Cattle	Population size	CH4	980	968	0.01	0.82
1 A 3 a ii Domestic	Jet Kerosene	CO2	794	959	0.01	0.84
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CO2	828	936	0.01	0.85
6 A 2 Unmanaged Waste Disposal	Municipal Waste Disposal on Land	CH4	749	899	0.01	0.86
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CO2	744	882	0.01	0.88
4 A 1 a Dairy Cattle	Population size	CH4	846	764	0.01	0.89
6 B 2 Domestic and Commercial wastewater	Wastewater	CH4	659	642	0.01	0.90
2 B 2 Nitric Acid Production	Production Quantities	N2O	603	606	0.01	0.91
4 A 3 Sheep	Population size	CH4	564	576	0.01	0.91
2 B 1 Ammonia Production	Production Quantities	CO2	569	563	0.01	0.92
1 A 2 a Iron and Steel	Solid Fuels	CO2	476	477	0.01	0.93
2 A 6 Road Paving with Asphalt	Production Quantities	CO2	168	311	0.00	0.93
6 B 2 Domestic and Commercial wastewater	Wastewater	N2O	287	310	0.00	0.94
1 A 4 b Residential	Biomass	CH4	343	307	0.00	0.94
1 A 3 d ii National navigation	Gas/Diesel Oil	CO2	433	243	0.00	0.95
6 B 1 Industrial Wastewater	Wastewater	CH4	164	208	0.00	0.95
6 B 1 Industrial Wastewater	Wastewater	N2O	161	205	0.00	0.95
4 B 1 a Dairy Cattle	Population size	CH4	218	197	0.00	0.95
2 A 7 Other	Production Quantities	CO2	180	180	0.00	0.96
1 A 3 c Railways	Liquid Fuels	CO2	175	170	0.00	0.96
4 C 1 Irrigated	Culture Surface	CH4	256	164	0.00	0.96
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	N2O	151	162	0.00	0.96
1 B 2 a iv Refining/ Storage	Liquid Fuels	CO2	124	152	0.00	0.97
1 A 2 a Iron and Steel	Liquid Fuels	CO2	163	149	0.00	0.97
1 A 3 b Road Transportation	Gasoline	N2O	33	139	0.00	0.97
4 B 3 Sheep	Population size	CH4	113	115	0.00	0.97
1 A 4 a Commercial / Institutional	Gaseous Fuels	CO2	77	112	0.00	0.97
1 A 3 b Road Transportation	Diesel Oil	N2O	84	111	0.00	0.97
3 A PAINT APPLICATION	Paint application	CO2	91	92	0.00	0.98
3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING	Chemical manufacture and processing	CO2	86	90	0.00	0.98
3 D OTHER	Other Use of Chemicals	CO2	82	85	0.00	0.98
4 A 4 Goats	Population size	CH4	90	84	0.00	0.98
4 A 8 Swine	Population size	CH4	84	76	0.00	0.98
1 A 2 c Chemicals	Other Fuels	CO2	63	73	0.00	0.98
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	CO2	90	71	0.00	0.98
1 A 3 d ii National navigation	Residual Oil	CO2	44	71	0.00	0.98
1 A 2 b Non-ferrous Metals	Liquid Fuels	CO2	125	70	0.00	0.98
1 A 4 b Residential	Biomass	N2O	73	65	0.00	0.99
2 B 5 Carbon black	Production Quantities	CO2	51	65	0.00	0.99
6 A 1 Managed Waste disposal	Municipal Waste Disposal on Land	CH4	18	58	0.00	0.99
4 B 10 Anaerobic	Animal Excretion	N2O	59	53	0.00	0.99
1 A 1 a Public Electricity and Heat Production	Solid Fuels	N2O	36	52	0.00	0.99
1 A 2 c Chemicals	Solid Fuels	CO2	45	50	0.00	0.99
2 A 3 Limestone and Dolomite Use	Production Quantities	CO2	54	50	0.00	0.99
4 B 1 b Non-Dairy Cattle	Population size	CH4	38	38	0.00	0.99
4 F 5 Other	Residues Burning	N2O	34	33	0.00	0.99
4 B 9 Poultry	Population size	CH4	29	31	0.00	0.99
1 A 3 b Road Transportation	Gasoline	CH4	25	31	0.00	0.99
1 B 2 d Other (Geothermal)	Energy Production	CO2	2	31	0.00	0.99
1 B 2 a iv Refining/ Storage	Liquid Fuels	CH4	22	27	0.00	0.99
1 B 2 a v Distribution of Oil Products	Liquid Fuels	CO2	17	26	0.00	0.99
2 C 3 Aluminium production	Production Quantities	CO2	17	26	0.00	0.99
4 B 4 Goats	Population size	CH4	26	24	0.00	0.99
4 B 11 Liquid Systems	Animal Excretion	N2O	24	22	0.00	0.99
1 A 2 d Pulp, Paper and Print	Biomass	CH4	19	21	0.00	1.00
1 A 2 f Other	Biomass	N2O	21	20	0.00	1.00
2 C 1 Iron and Steel Production	Production Quantities	CO2	15	17	0.00	1.00
1 B 2 a iii Transport	Liquid Fuels	CH4	13	16	0.00	1.00
4 F 5 Other	Residues Burning	CH4	16	16	0.00	1.00
4 A 7 Mules and Asses	Population size	CH4	24	16	0.00	1.00
1 A 2 d Pulp, Paper and Print	Biomass	N2O	11	15	0.00	1.00
1 B 2 a iii Transport	Liquid Fuels	CO2	12	14	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	N2O	15	14	0.00	1.00
1 A 2 f Other	Liquid Fuels	N2O	11	13	0.00	1.00
1 A 4 b Residential	Liquid Fuels	N2O	11	13	0.00	1.00
4 A 6 Horses	Population size	CH4	14	13	0.00	1.00
1 A 3 b Road Transportation	Diesel Oil	CH4	9	12	0.00	1.00
3 B DEGREASING AND DRY CLEANING	Degreasing and Dry Cleaning	CO2	12	12	0.00	1.00
1 A 3 c Railways	Liquid Fuels	N2O	11	11	0.00	1.00
1 A 1 b Petroleum refining	Liquid Fuels	N2O	9	11	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	CO2	10	10	0.00	1.00
2 B 5 Etileno (Borealis)	Production Quantities	CO2	7	6	0.00	1.00
4 B 7 Mules and Asses	Population size	CH4	9	6	0.00	1.00

1 A 3 a ii Domestic	Jet Kerosene	N2O	5	6	0.00	1.00
1 A 2 c Chemicals	Liquid Fuels	N2O	4	6	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	CO2	5	6	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Biomass	N2O	5	5	0.00	1.00
2 F 7 Electrical Equipment	Consumption	SF6	0	5	0.00	1.00
1 A 2 f Other	Biomass	CH4	5	5	0.00	1.00
2 B 5 Carbon black	Production Quantities	CH4	3	4	0.00	1.00
1 B 2 b ii Transmission/ Distribution	Gaseous Fuels	CH4	3	4	0.00	1.00
2 B 5 Etileno (Borealis)	Production Quantities	CH4	5	4	0.00	1.00
1 A 2 f Other	Liquid Fuels	CH4	3	4	0.00	1.00
1 A 2 f Other	Solid Fuels	N2O	4	4	0.00	1.00
2 B 5 Explosivos e Anid. Ftálico	Production Quantities	CO2	4	4	0.00	1.00
4 A 10 Other	Population size	CH4	4	4	0.00	1.00
1 A 4 a Commercial / Institutional	Liquid Fuels	N2O	2	3	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CH4	3	3	0.00	1.00
4 B 6 Horses	Population size	CH4	3	3	0.00	1.00
2 C 2 Ferroalloys Production	Production Quantities	CO2	3	3	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	N2O	2	3	0.00	1.00
1 A 3 a ii Domestic	Jet Kerosene	CH4	2	3	0.00	1.00
1 A 2 d Pulp, Paper and Print	Liquid Fuels	N2O	2	2	0.00	1.00
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CH4	2	2	0.00	1.00
2 B 5 Produção de Monómeros e Polimeros Orgânicos	Production Quantities	CO2	2	2	0.00	1.00
1 A 1 b Petroleum refining	Liquid Fuels	CH4	2	2	0.00	1.00
4 F 1 Cereals	Residues Burning	N2O	3	2	0.00	1.00
1 A 3 d ii National navigation	Gas/Diesel Oil	N2O	3	2	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CH4	1	2	0.00	1.00
1 A 4 a Commercial / Institutional	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 2 c Chemicals	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 2 c Chemicals	Biomass	N2O	1	1	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	N2O	1	1	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Biomass	CH4	1	1	0.00	1.00
1 A 2 a Iron and Steel	Solid Fuels	N2O	1	1	0.00	1.00
1 A 4 b Residential	Liquid Fuels	CH4	1	1	0.00	1.00
4 F 1 Cereals	Residues Burning	CH4	1	1	0.00	1.00
1 A 2 f Other	Solid Fuels	CH4	1	1	0.00	1.00
1 A 4 a Commercial / Institutional	Gaseous Fuels	N2O	1	1	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	CO2	0	1	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 3 d ii National navigation	Residual Oil	N2O	0	1	0.00	1.00
1 A 2 a Iron and Steel	Other Fuels	CO2	3	1	0.00	1.00
1 A 2 c Chemicals	Other Fuels	N2O	0	0	0.00	1.00
1 A 2 a Iron and Steel	Liquid Fuels	N2O	1	0	0.00	1.00
2 D 2 Food and Drink	Production Quantities	CO2	0	0	0.00	1.00
1 A 3 d ii National navigation	Gas/Diesel Oil	CH4	1	0	0.00	1.00
1 A 2 b Non-ferrous Metals	Liquid Fuels	N2O	0	0	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	N2O	0.40511	0.32055	0.00	1.00
1 A 2 c Chemicals	Biomass	CH4	0.33113	0.31402	0.00	1.00
1 B 2 c I Oil	Liquid Fuels	CO2	0.27336	0.31255	0.00	1.00
1 A 3 c Railways	Liquid Fuels	CH4	0.24900	0.24237	0.00	1.00
1 A 2 b Non-ferrous Metals	Biomass	N2O	0.19019	0.18037	0.00	1.00
1 A 2 a Iron and Steel	Solid Fuels	CH4	0.11925	0.12536	0.00	1.00
1 A 3 d ii National navigation	Residual Oil	CH4	0.06804	0.10964	0.00	1.00
1 A 2 c Chemicals	Solid Fuels	N2O	0.09934	0.10674	0.00	1.00
1 A 2 a Iron and Steel	Liquid Fuels	CH4	0.12724	0.10571	0.00	1.00
1 B 2 c I Oil	Liquid Fuels	CH4	0.09206	0.10525	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	CH4	0.08337	0.09465	0.00	1.00
1 A 4 a Commercial / Institutional	Gaseous Fuels	CH4	0.03451	0.05014	0.00	1.00
1 A 2 b Non-ferrous Metals	Liquid Fuels	CH4	0.08930	0.04619	0.00	1.00
1 A 2 b Non-ferrous Metals	Biomass	CH4	0.04494	0.04262	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	CH4	0.03875	0.04144	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	CH4	0.04901	0.03878	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	N2O	0.03034	0.03535	0.00	1.00
1 A 2 c Chemicals	Other Fuels	CH4	0.02938	0.03387	0.00	1.00
1 A 3 c Railways	Solid Fuels	CO2	0.13335	0.02607	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Biomass	N2O	0.02500	0.02500	0.00	1.00
1 A 2 c Chemicals	Solid Fuels	CH4	0.02307	0.02479	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	N2O	0.00158	0.02165	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	CH4	0.00025	0.00382	0.00	1.00
1 A 3 c Railways	Solid Fuels	N2O	0.00861	0.00168	0.00	1.00
1 A 2 a Iron and Steel	Other Fuels	N2O	0.00750	0.00136	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Biomass	CH4	0.00087	0.00087	0.00	1.00
1 A 2 a Iron and Steel	Other Fuels	CH4	0.00254	0.00046	0.00	1.00
1 A 3 c Railways	Solid Fuels	CH4	0.00019	0.00004	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Biomass	CH4	0.00000	0.00000	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Other Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Solid Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Biomass	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Other Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Liquid Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Biomass	CH4	0.00000	0.00000	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Other Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 2 a Iron and Steel	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 2 a Iron and Steel	Biomass	CH4	0.00000	0.00000	0.00	1.00
1 A 2 b Non-ferrous Metals	Solid Fuels	CH4	0.02592	0.00000	0.00	1.00
1 A 2 b Non-ferrous Metals	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 2 b Non-ferrous Metals	Other Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 2 c Chemicals	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 2 d Pulp, Paper and Print	Solid Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 2 d Pulp, Paper and Print	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00

Tier 1 Level Assessment (1996)

IPCC SOURCE CATEGORIES	ACTIVITY	GHG	Base year Estimate (kton CO2 eq.) 1990	Current year Estimate (kton CO2 eq.) 1996	Level Assess.	Cumulative Total
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CO2	7816	10368	0.15	0.15
1 A 3 b Road Transportation	Diesel Oil	CO2	4947	6999	0.10	0.26
1 A 3 b Road Transportation	Gasoline	CO2	4303	6050	0.09	0.35
1 A 2 f Other	Liquid Fuels	CO2	3227	4234	0.06	0.41
2 A 1 Cement Production	Production Quantities	CO2	3024	3313	0.05	0.46
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CO2	6364	2840	0.04	0.50
4 B 8 Swine	Population size	CH4	3028	2690	0.04	0.54
1 A 1 b Petroleum refining	Liquid Fuels	CO2	1929	2621	0.04	0.58
1 A 4 b Residential	Liquid Fuels	CO2	1630	2065	0.03	0.61
6 A 3 Other	Industrial Waste Disposal on Land	CH4	1655	1934	0.03	0.64
1 A 2 f Other	Solid Fuels	CO2	1982	1828	0.03	0.67
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CO2	1675	1808	0.03	0.69
4 D 2 Animal Production	Input to soils	N2O	1627	1585	0.02	0.72
4 D 3 Indirect Emissions	Input to soils	N2O	1591	1498	0.02	0.74
4 D 1 Direct Soil Emissions	Input to soils	N2O	1573	1456	0.02	0.76
1 A 4 a Commercial / Institutional	Liquid Fuels	CO2	816	1262	0.02	0.78
1 A 3 a ii Domestic	Jet Kerosene	CO2	794	1029	0.02	0.79
4 B 12 Solid Storage and Dry Lot	Animal Excretion	N2O	1045	1024	0.02	0.81
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CO2	744	958	0.01	0.82
4 A 1 b Non-Dairy Cattle	Population size	CH4	980	957	0.01	0.84
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CO2	828	956	0.01	0.85
6 A 2 Unmanaged Waste Disposal	Municipal Waste Disposal on Land	CH4	749	930	0.01	0.87
4 A 1 a Dairy Cattle	Population size	CH4	846	760	0.01	0.88
1 A 2 c Chemicals	Liquid Fuels	CO2	456	722	0.01	0.89
6 B 2 Domestic and Commercial wastewater	Wastewater	CH4	659	629	0.01	0.90
2 B 2 Nitric Acid Production	Production Quantities	N2O	603	606	0.01	0.91
4 A 3 Sheep	Population size	CH4	564	568	0.01	0.91
2 B 1 Ammonia Production	Production Quantities	CO2	569	396	0.01	0.92
1 A 2 a Iron and Steel	Solid Fuels	CO2	476	383	0.01	0.93
6 B 2 Domestic and Commercial wastewater	Wastewater	N2O	287	319	0.00	0.93
1 A 4 b Residential	Biomass	CH4	343	308	0.00	0.93
2 A 6 Road Paving with Asphalt	Production Quantities	CO2	168	245	0.00	0.94
1 A 3 d ii National navigation	Gas/Diesel Oil	CO2	433	228	0.00	0.94
4 C 1 Irrigated	Culture Surface	CH4	256	214	0.00	0.95
6 B 1 Industrial Wastewater	Wastewater	CH4	164	208	0.00	0.95
6 B 1 Industrial Wastewater	Wastewater	N2O	161	205	0.00	0.95
4 B 1 a Dairy Cattle	Population size	CH4	218	196	0.00	0.95
2 A 7 Other	Production Quantities	CO2	180	180	0.00	0.96
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	N2O	151	179	0.00	0.96
1 A 3 b Road Transportation	Gasoline	N2O	33	173	0.00	0.96
1 A 3 c Railways	Liquid Fuels	CO2	175	155	0.00	0.96
1 A 2 a Iron and Steel	Liquid Fuels	CO2	163	143	0.00	0.97
1 B 2 a iv Refining/ Storage	Liquid Fuels	CO2	124	139	0.00	0.97
1 A 4 a Commercial / Institutional	Gaseous Fuels	CO2	77	120	0.00	0.97
1 A 3 b Road Transportation	Diesel Oil	N2O	84	119	0.00	0.97
4 B 3 Sheep	Population size	CH4	113	113	0.00	0.97
3 A PAINT APPLICATION	Paint application	CO2	91	92	0.00	0.97
3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING	Chemical manufacture and processing	CO2	86	90	0.00	0.98
1 A 3 d ii National navigation	Residual Oil	CO2	44	85	0.00	0.98
3 D OTHER	Other Use of Chemicals	CO2	82	85	0.00	0.98
1 A 2 b Non-ferrous Metals	Liquid Fuels	CO2	125	82	0.00	0.98
4 A 4 Goats	Population size	CH4	90	82	0.00	0.98
1 A 2 c Chemicals	Other Fuels	CO2	63	76	0.00	0.98
4 A 8 Swine	Population size	CH4	84	74	0.00	0.98
6 A 1 Managed Waste disposal	Municipal Waste Disposal on Land	CH4	18	71	0.00	0.98
2 B 5 Carbon black	Production Quantities	CO2	51	68	0.00	0.99
1 A 4 b Residential	Biomass	N2O	73	65	0.00	0.99
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	CO2	90	55	0.00	0.99
4 B 10 Anaerobic	Animal Excretion	N2O	59	52	0.00	0.99
2 A 3 Limestone and Dolomite Use	Production Quantities	CO2	54	50	0.00	0.99
1 A 1 a Public Electricity and Heat Production	Solid Fuels	N2O	36	48	0.00	0.99
1 A 2 c Chemicals	Solid Fuels	CO2	45	48	0.00	0.99
4 B 1 b Non-Dairy Cattle	Population size	CH4	38	37	0.00	0.99
1 B 2 d Other (Geothermal)	Energy Production	CO2	2	37	0.00	0.99
4 F 5 Other	Residues Burning	N2O	34	33	0.00	0.99
4 B 9 Poultry	Population size	CH4	29	31	0.00	0.99
1 A 3 b Road Transportation	Gasoline	CH4	25	31	0.00	0.99
2 C 3 Aluminium production	Production Quantities	CO2	17	27	0.00	0.99
1 B 2 a v Distribution of Oil Products	Liquid Fuels	CO2	17	26	0.00	0.99
1 B 2 a iv Refining/ Storage	Liquid Fuels	CH4	22	25	0.00	0.99
4 B 4 Goats	Population size	CH4	26	23	0.00	0.99
4 B 11 Liquid Systems	Animal Excretion	N2O	24	22	0.00	0.99
1 A 2 f Other	Biomass	N2O	21	21	0.00	0.99
1 A 2 d Pulp, Paper and Print	Biomass	CH4	19	21	0.00	1.00
4 F 5 Other	Residues Burning	CH4	16	16	0.00	1.00
2 C 1 Iron and Steel Production	Production Quantities	CO2	15	15	0.00	1.00
1 B 2 a iii Transport	Liquid Fuels	CH4	13	15	0.00	1.00
4 A 7 Mules and Asses	Population size	CH4	24	15	0.00	1.00
1 A 2 f Other	Liquid Fuels	N2O	11	15	0.00	1.00
1 A 2 d Pulp, Paper and Print	Biomass	N2O	11	14	0.00	1.00
1 A 4 b Residential	Liquid Fuels	N2O	11	14	0.00	1.00
4 A 6 Horses	Population size	CH4	14	14	0.00	1.00
1 A 3 b Road Transportation	Diesel Oil	CH4	9	13	0.00	1.00
1 B 2 a iii Transport	Liquid Fuels	CO2	12	13	0.00	1.00
1 A 1 b Petroleum refining	Liquid Fuels	N2O	9	12	0.00	1.00
3 B DEGREASING AND DRY CLEANING	Degreasing and Dry Cleaning	CO2	12	12	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	CO2	10	11	0.00	1.00
1 A 3 c Railways	Liquid Fuels	N2O	11	10	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	N2O	15	7	0.00	1.00
1 A 3 a ii Domestic	Jet Kerosene	N2O	5	6	0.00	1.00
2 B 5 Etileno (Borealis)	Production Quantities	CO2	7	6	0.00	1.00

4 B 7 Mules and Asses	Population size	CH4	9	6	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Biomass	N2O	5	5	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	CO2	0	5	0.00	1.00
1 A 2 f Other	Biomass	CH4	5	5	0.00	1.00
2 F 7 Electrical Equipment	Consumption	SF6	0	5	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	CO2	5	5	0.00	1.00
1 A 2 c Chemicals	Liquid Fuels	N2O	4	5	0.00	1.00
2 B 5 Carbon black	Production Quantities	CH4	3	5	0.00	1.00
1 B 2 b ii Transmission/ Distribution	Gaseous Fuels	CH4	3	4	0.00	1.00
1 A 2 f Other	Liquid Fuels	CH4	3	4	0.00	1.00
1 A 2 f Other	Solid Fuels	N2O	4	4	0.00	1.00
1 A 4 a Commercial / Institutional	Liquid Fuels	N2O	2	4	0.00	1.00
2 B 5 Explosivos e Anid. Ftálico	Production Quantities	CO2	4	4	0.00	1.00
4 A 10 Other	Population size	CH4	4	4	0.00	1.00
2 B 5 Etileno (Borealis)	Production Quantities	CH4	5	3	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CH4	3	3	0.00	1.00
1 A 3 a ii Domestic	Jet Kerosene	CH4	2	3	0.00	1.00
4 B 6 Horses	Population size	CH4	3	3	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	N2O	2	3	0.00	1.00
2 C 2 Ferroalloys Production	Production Quantities	CO2	3	3	0.00	1.00
4 F 1 Cereals	Residues Burning	N2O	3	3	0.00	1.00
1 A 2 d Pulp, Paper and Print	Liquid Fuels	N2O	2	2	0.00	1.00
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CH4	2	2	0.00	1.00
1 A 1 b Petroleum refining	Liquid Fuels	CH4	2	2	0.00	1.00
2 B 5 Produção de Monómeros e Polimeros Orgânicos	Production Quantities	CO2	2	2	0.00	1.00
1 A 3 d ii National navigation	Gas/Diesel Oil	N2O	3	2	0.00	1.00
1 A 4 a Commercial / Institutional	Liquid Fuels	CH4	1	2	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CH4	1	2	0.00	1.00
1 A 2 c Chemicals	Biomass	N2O	1	1	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	N2O	1	1	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Biomass	CH4	1	1	0.00	1.00
4 F 1 Cereals	Residues Burning	CH4	1	1	0.00	1.00
1 A 4 b Residential	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 2 c Chemicals	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 2 f Other	Solid Fuels	CH4	1	1	0.00	1.00
1 A 4 a Commercial / Institutional	Gaseous Fuels	N2O	1	1	0.00	1.00
1 A 2 a Iron and Steel	Solid Fuels	N2O	1	1	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 3 d ii National navigation	Residual Oil	N2O	0	1	0.00	1.00
1 A 2 c Chemicals	Other Fuels	N2O	0	1	0.00	1.00
1 A 2 a Iron and Steel	Liquid Fuels	N2O	1	0	0.00	1.00
2 D 2 Food and Drink	Production Quantities	CO2	0	0	0.00	1.00
1 A 2 a Iron and Steel	Other Fuels	CO2	3	0	0.00	1.00
1 A 2 b Non-ferrous Metals	Liquid Fuels	N2O	0	0	0.00	1.00
1 A 3 d ii National navigation	Gas/Diesel Oil	CH4	1	0	0.00	1.00
1 A 2 c Chemicals	Biomass	CH4	0.33113	0.33328	0.00	1.00
2 F 1 Refrigeration and Air Conditioning Equipment	Consumption	HFCs	0.00000	0.31489	0.00	1.00
1 B 2 c I Oil	Liquid Fuels	CO2	0.27336	0.29032	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	N2O	0.40511	0.24561	0.00	1.00
1 A 3 c Railways	Liquid Fuels	CH4	0.24900	0.22081	0.00	1.00
1 A 2 b Non-ferrous Metals	Biomass	N2O	0.19019	0.19131	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	N2O	0.00158	0.13557	0.00	1.00
1 A 3 d ii National navigation	Residual Oil	CH4	0.06804	0.13129	0.00	1.00
1 A 2 a Iron and Steel	Solid Fuels	CH4	0.11925	0.10756	0.00	1.00
1 A 2 c Chemicals	Solid Fuels	N2O	0.09934	0.10189	0.00	1.00
1 A 2 a Iron and Steel	Liquid Fuels	CH4	0.12724	0.10031	0.00	1.00
1 B 2 c I Oil	Liquid Fuels	CH4	0.09206	0.09777	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	CH4	0.08337	0.07740	0.00	1.00
1 A 2 b Non-ferrous Metals	Liquid Fuels	CH4	0.08930	0.05634	0.00	1.00
1 A 4 a Commercial / Institutional	Gaseous Fuels	CH4	0.03451	0.05374	0.00	1.00
1 A 2 b Non-ferrous Metals	Biomass	CH4	0.04494	0.04521	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	CH4	0.03875	0.04352	0.00	1.00
1 A 3 c Railways	Solid Fuels	CO2	0.13335	0.03802	0.00	1.00
1 A 2 c Chemicals	Other Fuels	CH4	0.02938	0.03534	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	CH4	0.04901	0.02971	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	N2O	0.03034	0.02942	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Biomass	N2O	0.02500	0.02500	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	CH4	0.00025	0.02421	0.00	1.00
1 A 2 c Chemicals	Solid Fuels	CH4	0.02307	0.02366	0.00	1.00
1 A 3 c Railways	Solid Fuels	N2O	0.00861	0.00246	0.00	1.00
1 A 2 a Iron and Steel	Other Fuels	N2O	0.00750	0.00104	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Biomass	CH4	0.00087	0.00087	0.00	1.00
1 A 2 a Iron and Steel	Other Fuels	CH4	0.00254	0.00035	0.00	1.00
1 A 3 c Railways	Solid Fuels	CH4	0.00019	0.00005	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Biomass	CH4	0.00000	0.00000	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Other Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Solid Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Biomass	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Other Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Liquid Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Biomass	CH4	0.00000	0.00000	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Other Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 2 a Iron and Steel	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 2 a Iron and Steel	Biomass	CH4	0.00000	0.00000	0.00	1.00
1 A 2 b Non-ferrous Metals	Solid Fuels	CH4	0.02592	0.00000	0.00	1.00
1 A 2 b Non-ferrous Metals	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 2 b Non-ferrous Metals	Other Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 2 c Chemicals	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 2 d Pulp, Paper and Print	Solid Fuels	CH4	0.00000	0.00000	0.00	1.00

Tier 1 Level Assessment (1997)

IPCC SOURCE CATEGORIES	ACTIVITY	GHG	Base year Estimate (kton CO2 eq.) 1990	Current year Estimate (kton CO2 eq.) 1997	Level Assess.	Cumulative Total
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CO2	7816	10684	0.15	0.15
1 A 3 b Road Transportation	Diesel Oil	CO2	4947	7655	0.11	0.26
1 A 3 b Road Transportation	Gasoline	CO2	4303	6014	0.09	0.35
1 A 2 f Other	Liquid Fuels	CO2	3227	4771	0.07	0.42
2 A 1 Cement Production	Production Quantities	CO2	3024	3483	0.05	0.47
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CO2	6364	3114	0.04	0.51
4 B 8 Swine	Population size	CH4	3028	2715	0.04	0.55
1 A 1 b Petroleum refining	Liquid Fuels	CO2	1929	2419	0.03	0.59
1 A 4 b Residential	Liquid Fuels	CO2	1630	2027	0.03	0.62
6 A 3 Other	Industrial Waste Disposal on Land	CH4	1655	1982	0.03	0.64
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CO2	1675	1601	0.02	0.67
4 D 2 Animal Production	Input to soils	N2O	1627	1591	0.02	0.69
1 A 4 a Commercial / Institutional	Liquid Fuels	CO2	816	1590	0.02	0.71
4 D 3 Indirect Emissions	Input to soils	N2O	1591	1460	0.02	0.73
1 A 2 f Other	Solid Fuels	CO2	1982	1405	0.02	0.75
4 D 1 Direct Soil Emissions	Input to soils	N2O	1573	1374	0.02	0.77
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CO2	828	1108	0.02	0.79
1 A 3 a ii Domestic	Jet Kerosene	CO2	794	1058	0.02	0.80
4 B 12 Solid Storage and Dry Lot	Animal Excretion	N2O	1045	1028	0.01	0.82
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CO2	744	983	0.01	0.83
6 A 2 Unmanaged Waste Disposal	Municipal Waste Disposal on Land	CH4	749	961	0.01	0.85
4 A 1 b Non-Dairy Cattle	Population size	CH4	980	930	0.01	0.86
1 A 2 c Chemicals	Liquid Fuels	CO2	456	770	0.01	0.87
4 A 1 a Dairy Cattle	Population size	CH4	846	760	0.01	0.88
6 B 2 Domestic and Commercial wastewater	Wastewater	CH4	659	615	0.01	0.89
2 B 2 Nitric Acid Production	Production Quantities	N2O	603	606	0.01	0.90
1 A 2 a Iron and Steel	Solid Fuels	CO2	476	581	0.01	0.91
4 A 3 Sheep	Population size	CH4	564	574	0.01	0.92
2 A 6 Road Paving with Asphalt	Production Quantities	CO2	168	427	0.01	0.92
2 B 1 Ammonia Production	Production Quantities	CO2	569	396	0.01	0.93
6 B 2 Domestic and Commercial wastewater	Wastewater	N2O	287	316	0.00	0.93
1 A 4 b Residential	Biomass	CH4	343	309	0.00	0.94
4 C 1 Irrigated	Culture Surface	CH4	256	216	0.00	0.94
6 B 1 Industrial Wastewater	Wastewater	CH4	164	208	0.00	0.94
6 B 1 Industrial Wastewater	Wastewater	N2O	161	205	0.00	0.95
1 A 3 b Road Transportation	Gasoline	N2O	33	201	0.00	0.95
4 B 1 a Dairy Cattle	Population size	CH4	218	196	0.00	0.95
1 A 3 d ii National navigation	Gas/Diesel Oil	CO2	433	181	0.00	0.95
2 A 7 Other	Production Quantities	CO2	180	180	0.00	0.96
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	N2O	151	154	0.00	0.96
1 A 3 c Railways	Liquid Fuels	CO2	175	149	0.00	0.96
1 B 2 a iv Refining/ Storage	Liquid Fuels	CO2	124	146	0.00	0.96
1 A 2 a Iron and Steel	Liquid Fuels	CO2	163	145	0.00	0.97
1 A 3 b Road Transportation	Diesel Oil	N2O	84	130	0.00	0.97
1 A 4 a Commercial / Institutional	Gaseous Fuels	CO2	77	118	0.00	0.97
4 B 3 Sheep	Population size	CH4	113	115	0.00	0.97
1 A 2 f Other	Gaseous Fuels	CO2	0	99	0.00	0.97
3 A PAINT APPLICATION	Paint application	CO2	91	92	0.00	0.97
3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING	Chemical manufacture and processing	CO2	86	90	0.00	0.98
1 A 2 c Chemicals	Other Fuels	CO2	63	90	0.00	0.98
6 A 1 Managed Waste disposal	Municipal Waste Disposal on Land	CH4	18	87	0.00	0.98
3 D OTHER	Other Use of Chemicals	CO2	82	85	0.00	0.98
4 A 4 Goats	Population size	CH4	90	82	0.00	0.98
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	CO2	90	80	0.00	0.98
4 A 8 Swine	Population size	CH4	84	74	0.00	0.98
1 A 4 b Residential	Biomass	N2O	73	65	0.00	0.98
1 A 3 d ii National navigation	Residual Oil	CO2	44	64	0.00	0.98
2 B 5 Carbon black	Production Quantities	CO2	51	63	0.00	0.98
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	CO2	0	56	0.00	0.99
4 B 10 Anaerobic	Animal Excretion	N2O	59	52	0.00	0.99
2 A 3 Limestone and Dolomite Use	Production Quantities	CO2	54	50	0.00	0.99
1 A 1 a Public Electricity and Heat Production	Solid Fuels	N2O	36	50	0.00	0.99
1 A 3 b Road Transportation	Natural Gas	CO2	0	49	0.00	0.99
1 A 2 b Non-ferrous Metals	Liquid Fuels	CO2	125	46	0.00	0.99
1 A 2 c Chemicals	Solid Fuels	CO2	45	41	0.00	0.99
1 B 2 d Other (Geothermal)	Energy Production	CO2	2	40	0.00	0.99
4 B 1 b Non-Dairy Cattle	Population size	CH4	38	36	0.00	0.99
4 F 5 Other	Residues Burning	N2O	34	33	0.00	0.99
4 B 9 Poultry	Population size	CH4	29	32	0.00	0.99
1 A 3 b Road Transportation	Gasoline	CH4	25	29	0.00	0.99
2 C 3 Aluminium production	Production Quantities	CO2	17	28	0.00	0.99
1 B 2 a v Distribution of Oil Products	Liquid Fuels	CO2	17	27	0.00	0.99
1 B 2 a iv Refining/ Storage	Liquid Fuels	CH4	22	26	0.00	0.99
4 B 4 Goats	Population size	CH4	26	24	0.00	0.99
1 A 2 d Pulp, Paper and Print	Biomass	CH4	19	22	0.00	0.99
4 B 11 Liquid Systems	Animal Excretion	N2O	24	22	0.00	0.99
2 C 1 Iron and Steel Production	Production Quantities	CO2	15	21	0.00	0.99
1 A 2 f Other	Biomass	N2O	21	21	0.00	1.00
4 F 5 Other	Residues Burning	CH4	16	16	0.00	1.00
1 A 2 f Other	Liquid Fuels	N2O	11	16	0.00	1.00
1 A 2 d Pulp, Paper and Print	Biomass	N2O	11	16	0.00	1.00
1 B 2 a iii Transport	Liquid Fuels	CH4	13	16	0.00	1.00
4 A 6 Horses	Population size	CH4	14	14	0.00	1.00
1 A 3 b Road Transportation	Diesel Oil	CH4	9	14	0.00	1.00
1 A 4 b Residential	Liquid Fuels	N2O	11	14	0.00	1.00
1 B 2 a iii Transport	Liquid Fuels	CO2	12	14	0.00	1.00
4 A 7 Mules and Asses	Population size	CH4	24	14	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	CO2	10	13	0.00	1.00
1 A 2 a Iron and Steel	Gaseous Fuels	CO2	0	12	0.00	1.00
3 B DEGREASING AND DRY CLEANING	Degreasing and Dry Cleaning	CO2	12	12	0.00	1.00
1 A 1 b Petroleum refining	Liquid Fuels	N2O	9	11	0.00	1.00

1 B 2 b ii Transmission/ Distribution	Gaseous Fuels	CH4	3	11	0.00	1.00
1 A 3 c Railways	Liquid Fuels	N2O	11	10	0.00	1.00
2 B 5 Etileno (Borealis)	Production Quantities	CO2	7	8	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	N2O	15	8	0.00	1.00
1 A 3 a ii Domestic	Jet Kerosene	N2O	5	7	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	CO2	5	6	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Biomass	N2O	5	5	0.00	1.00
4 B 7 Mules and Asses	Population size	CH4	9	5	0.00	1.00
1 A 2 f Other	Liquid Fuels	CH4	3	5	0.00	1.00
1 A 4 a Commercial / Institutional	Liquid Fuels	N2O	2	5	0.00	1.00
2 F 7 Electrical Equipment	Consumption	SF6	0	5	0.00	1.00
1 A 2 f Other	Biomass	CH4	5	5	0.00	1.00
1 A 2 c Chemicals	Liquid Fuels	N2O	4	5	0.00	1.00
2 B 5 Etileno (Borealis)	Production Quantities	CH4	5	4	0.00	1.00
2 B 5 Carbon black	Production Quantities	CH4	3	4	0.00	1.00
2 B 5 Explosivos e Anid. Ftálico	Production Quantities	CO2	4	4	0.00	1.00
4 A 10 Other	Population size	CH4	4	4	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	N2O	2	3	0.00	1.00
1 A 2 f Other	Solid Fuels	N2O	4	3	0.00	1.00
1 A 3 a ii Domestic	Jet Kerosene	CH4	2	3	0.00	1.00
4 B 6 Horses	Population size	CH4	3	3	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CH4	3	3	0.00	1.00
2 C 2 Ferroalloys Production	Production Quantities	CO2	3	3	0.00	1.00
4 F 1 Cereals	Residues Burning	N2O	3	3	0.00	1.00
1 A 2 d Pulp, Paper and Print	Liquid Fuels	N2O	2	2	0.00	1.00
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CH4	2	2	0.00	1.00
1 A 4 a Commercial / Institutional	Liquid Fuels	CH4	1	2	0.00	1.00
2 B 5 Produção de Monómeros e Polimeros Orgânicos	Production Quantities	CO2	2	2	0.00	1.00
1 A 4 b Residential	Gaseous Fuels	CO2	0	2	0.00	1.00
1 A 1 b Petroleum refining	Liquid Fuels	CH4	2	2	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CH4	1	2	0.00	1.00
2 F 1 Refrigeration and Air Conditioning Equipment	Consumption	HFCs	0	2	0.00	1.00
1 A 3 d ii National navigation	Gas/Diesel Oil	N2O	3	1	0.00	1.00
1 A 2 c Chemicals	Biomass	N2O	1	1	0.00	1.00
1 A 2 a Iron and Steel	Solid Fuels	N2O	1	1	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	N2O	1	1	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	N2O	0	1	0.00	1.00
4 F 1 Cereals	Residues Burning	CH4	1	1	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Biomass	CH4	1	1	0.00	1.00
1 A 2 c Chemicals	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 4 b Residential	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 4 a Commercial / Institutional	Gaseous Fuels	N2O	1	1	0.00	1.00
1 A 2 f Other	Gaseous Fuels	N2O	0	1	0.00	1.00
1 A 2 f Other	Solid Fuels	CH4	1	1	0.00	1.00
1 A 2 a Iron and Steel	Other Fuels	CO2	3.06811	0.62975	0.00	1.00
1 A 2 c Chemicals	Other Fuels	N2O	0.43372	0.61716	0.00	1.00
1 A 3 d ii National navigation	Residual Oil	N2O	0.34933	0.51061	0.00	1.00
2 D 2 Food and Drink	Production Quantities	CO2	0.43657	0.43657	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	N2O	0.00000	0.43292	0.00	1.00
1 A 2 a Iron and Steel	Liquid Fuels	N2O	0.50132	0.41069	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	N2O	0.40511	0.36274	0.00	1.00
1 A 2 c Chemicals	Biomass	CH4	0.33113	0.33328	0.00	1.00
1 B 2 c I Oil	Liquid Fuels	CO2	0.27336	0.31674	0.00	1.00
1 A 3 d ii National navigation	Gas/Diesel Oil	CH4	0.66203	0.27526	0.00	1.00
1 A 2 b Non-ferrous Metals	Liquid Fuels	N2O	0.44993	0.26509	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Gaseous Fuels	CO2	0.00000	0.24016	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	CH4	0.00025	0.23742	0.00	1.00
1 A 3 c Railways	Liquid Fuels	CH4	0.24900	0.21210	0.00	1.00
1 A 2 b Non-ferrous Metals	Biomass	N2O	0.19019	0.19131	0.00	1.00
1 A 2 a Iron and Steel	Solid Fuels	CH4	0.11925	0.16864	0.00	1.00
1 B 2 c I Oil	Liquid Fuels	CH4	0.09206	0.10667	0.00	1.00
1 A 2 a Iron and Steel	Liquid Fuels	CH4	0.12724	0.10049	0.00	1.00
1 A 3 d ii National navigation	Residual Oil	CH4	0.06804	0.09944	0.00	1.00
1 A 2 a Iron and Steel	Gaseous Fuels	N2O	0.00000	0.09600	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	CH4	0.08337	0.09417	0.00	1.00
1 A 2 c Chemicals	Solid Fuels	N2O	0.09934	0.08780	0.00	1.00
1 A 2 b Non-ferrous Metals	Gaseous Fuels	CO2	0.00000	0.06553	0.00	1.00
1 A 4 a Commercial / Institutional	Gaseous Fuels	CH4	0.03451	0.05322	0.00	1.00
1 A 2 f Other	Gaseous Fuels	CH4	0.00000	0.05173	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	CH4	0.03875	0.04646	0.00	1.00
1 A 2 b Non-ferrous Metals	Biomass	CH4	0.04494	0.04521	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	CH4	0.04901	0.04388	0.00	1.00
1 A 2 c Chemicals	Other Fuels	CH4	0.02938	0.04181	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	N2O	0.03034	0.03624	0.00	1.00
1 A 2 b Non-ferrous Metals	Liquid Fuels	CH4	0.08930	0.02871	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Biomass	N2O	0.02500	0.02500	0.00	1.00
1 A 2 c Chemicals	Solid Fuels	CH4	0.02307	0.02039	0.00	1.00
1 A 2 a Iron and Steel	Gaseous Fuels	CH4	0.00000	0.00650	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	CH4	0.00000	0.00209	0.00	1.00
1 A 4 b Residential	Gaseous Fuels	CH4	0.00000	0.00196	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Gaseous Fuels	N2O	0.00000	0.00186	0.00	1.00
1 A 2 a Iron and Steel	Other Fuels	N2O	0.00750	0.00154	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Biomass	CH4	0.00087	0.00087	0.00	1.00
1 A 2 a Iron and Steel	Other Fuels	CH4	0.00254	0.00052	0.00	1.00
1 A 2 b Non-ferrous Metals	Gaseous Fuels	N2O	0.00000	0.00051	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Gaseous Fuels	CH4	0.00000	0.00013	0.00	1.00
1 A 2 b Non-ferrous Metals	Gaseous Fuels	CH4	0.00000	0.00003	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Biomass	CH4	0.00000	0.00000	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Other Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Solid Fuels	CH4	0.00000	0.00000	0.00	1.00
1 A 1 b Petroleum refining	Gaseous Fuels	CH4	0.00000	0.00000	0.00	1.00

Tier 1 Level Assessment (1998)

IPCC SOURCE CATEGORIES	ACTIVITY	GHG	Base year Estimate (kton CO2 eq.) 1990	Current year Estimate (kton CO2 eq.) 1998	Level Assess.	Cumulative Total
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CO2	7816	9819	0.13	0.13
1 A 3 b Road Transportation	Diesel Oil	CO2	4947	8887	0.12	0.25
1 A 3 b Road Transportation	Gasoline	CO2	4303	6222	0.08	0.33
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CO2	6364	5636	0.08	0.41
1 A 2 f Other	Liquid Fuels	CO2	3227	4462	0.06	0.47
2 A 1 Cement Production	Production Quantities	CO2	3024	3458	0.05	0.52
4 B 8 Swine	Population size	CH4	3028	2682	0.04	0.55
1 A 1 b Petroleum refining	Liquid Fuels	CO2	1929	2494	0.03	0.59
1 A 4 b Residential	Liquid Fuels	CO2	1630	2133	0.03	0.61
6 A 3 Other	Industrial Waste Disposal on Land	CH4	1655	2031	0.03	0.64
1 A 4 a Commercial / Institutional	Liquid Fuels	CO2	816	2010	0.03	0.67
4 D 2 Animal Production	Input to soils	N2O	1627	1622	0.02	0.69
4 D 3 Indirect Emissions	Input to soils	N2O	1591	1513	0.02	0.71
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CO2	1675	1456	0.02	0.73
4 D 1 Direct Soil Emissions	Input to soils	N2O	1573	1437	0.02	0.75
1 A 3 a ii Domestic	Jet Kerosene	CO2	794	1181	0.02	0.76
1 A 2 f Other	Solid Fuels	CO2	1982	1161	0.02	0.78
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CO2	828	1120	0.02	0.80
4 B 12 Solid Storage and Dry Lot	Animal Excretion	N2O	1045	1048	0.01	0.81
1 A 2 c Chemicals	Liquid Fuels	CO2	456	1010	0.01	0.82
6 A 2 Unmanaged Waste Disposal	Municipal Waste Disposal on Land	CH4	749	977	0.01	0.84
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CO2	744	934	0.01	0.85
4 A 1 b Non-Dairy Cattle	Population size	CH4	980	919	0.01	0.86
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	CO2	0	835	0.01	0.87
4 A 1 a Dairy Cattle	Population size	CH4	846	746	0.01	0.88
2 B 2 Nitric Acid Production	Production Quantities	N2O	603	606	0.01	0.89
6 B 2 Domestic and Commercial wastewater	Wastewater	CH4	659	602	0.01	0.90
4 A 3 Sheep	Population size	CH4	564	591	0.01	0.91
1 A 2 a Iron and Steel	Solid Fuels	CO2	476	518	0.01	0.91
2 A 6 Road Paving with Asphalt	Production Quantities	CO2	168	506	0.01	0.92
1 A 2 f Other	Gaseous Fuels	CO2	0	476	0.01	0.93
2 B 1 Ammonia Production	Production Quantities	CO2	569	396	0.01	0.93
6 B 2 Domestic and Commercial wastewater	Wastewater	N2O	287	335	0.00	0.94
1 A 4 b Residential	Biomass	CH4	343	306	0.00	0.94
1 A 3 b Road Transportation	Gasoline	N2O	33	240	0.00	0.94
6 B 1 Industrial Wastewater	Wastewater	CH4	164	208	0.00	0.95
6 B 1 Industrial Wastewater	Wastewater	N2O	161	205	0.00	0.95
4 C 1 Irrigated	Culture Surface	CH4	256	204	0.00	0.95
4 B 1 a Dairy Cattle	Population size	CH4	218	192	0.00	0.95
2 A 7 Other	Production Quantities	CO2	180	180	0.00	0.96
1 B 2 a iv Refining/ Storage	Liquid Fuels	CO2	124	161	0.00	0.96
1 A 3 b Road Transportation	Diesel Oil	N2O	84	151	0.00	0.96
1 A 3 d ii National navigation	Gas/Diesel Oil	CO2	433	143	0.00	0.96
1 A 4 a Commercial / Institutional	Gaseous Fuels	CO2	77	138	0.00	0.96
1 A 3 c Railways	Liquid Fuels	CO2	175	138	0.00	0.97
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	N2O	151	131	0.00	0.97
4 B 3 Sheep	Population size	CH4	113	118	0.00	0.97
1 A 2 c Chemicals	Other Fuels	CO2	63	118	0.00	0.97
1 A 2 a Iron and Steel	Liquid Fuels	CO2	163	108	0.00	0.97
6 A 1 Managed Waste disposal	Municipal Waste Disposal on Land	CH4	18	105	0.00	0.97
3 A PAINT APPLICATION	Paint application	CO2	91	92	0.00	0.98
3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING	Chemical manufacture and processing	CO2	86	90	0.00	0.98
2 B 5 Carbon black	Production Quantities	CO2	51	90	0.00	0.98
3 D OTHER	Other Use of Chemicals	CO2	82	85	0.00	0.98
4 A 4 Goats	Population size	CH4	90	84	0.00	0.98
4 A 8 Swine	Population size	CH4	84	74	0.00	0.98
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	CO2	90	70	0.00	0.98
1 A 4 b Residential	Biomass	N2O	73	65	0.00	0.98
1 A 3 d ii National navigation	Residual Oil	CO2	44	60	0.00	0.98
1 B 2 b ii Transmission/ Distribution	Gaseous Fuels	CH4	3	60	0.00	0.98
1 A 3 b Road Transportation	Natural Gas	CO2	0	56	0.00	0.99
1 A 2 c Chemicals	Solid Fuels	CO2	45	53	0.00	0.99
4 B 10 Anaerobic	Animal Excretion	N2O	59	52	0.00	0.99
2 A 3 Limestone and Dolomite Use	Production Quantities	CO2	54	50	0.00	0.99
1 A 1 a Public Electricity and Heat Production	Solid Fuels	N2O	36	46	0.00	0.99
1 B 2 d Other (Geothermal)	Energy Production	CO2	2	44	0.00	0.99
1 A 2 b Non-ferrous Metals	Liquid Fuels	CO2	125	42	0.00	0.99
1 A 2 a Iron and Steel	Gaseous Fuels	CO2	0	41	0.00	0.99
1 A 2 c Chemicals	Gaseous Fuels	CO2	0	39	0.00	0.99
4 B 1 b Non-Dairy Cattle	Population size	CH4	38	36	0.00	0.99
4 B 9 Poultry	Population size	CH4	29	34	0.00	0.99
4 F 5 Other	Residues Burning	N2O	34	33	0.00	0.99
2 C 3 Aluminium production	Production Quantities	CO2	17	30	0.00	0.99
1 A 3 b Road Transportation	Gasoline	CH4	25	29	0.00	0.99
1 B 2 a iv Refining/ Storage	Liquid Fuels	CH4	22	28	0.00	0.99
1 B 2 a v Distribution of Oil Products	Liquid Fuels	CO2	17	27	0.00	0.99
1 A 2 e Food Processing, Beverages and Tobacco	Gaseous Fuels	CO2	0	24	0.00	0.99
4 B 4 Goats	Population size	CH4	26	24	0.00	0.99
1 A 4 b Residential	Gaseous Fuels	CO2	0	24	0.00	0.99
1 A 2 d Pulp, Paper and Print	Biomass	CH4	19	22	0.00	0.99
4 B 11 Liquid Systems	Animal Excretion	N2O	24	21	0.00	0.99
1 A 2 f Other	Biomass	N2O	21	21	0.00	1.00
2 C 1 Iron and Steel Production	Production Quantities	CO2	15	20	0.00	1.00
1 B 2 a iii Transport	Liquid Fuels	CH4	13	17	0.00	1.00
1 A 3 b Road Transportation	Diesel Oil	CH4	9	17	0.00	1.00
4 F 5 Other	Residues Burning	CH4	16	16	0.00	1.00
1 A 2 d Pulp, Paper and Print	Biomass	N2O	11	16	0.00	1.00
4 A 6 Horses	Population size	CH4	14	15	0.00	1.00
1 B 2 a iii Transport	Liquid Fuels	CO2	12	15	0.00	1.00
1 A 4 b Residential	Liquid Fuels	N2O	11	15	0.00	1.00
1 A 2 f Other	Liquid Fuels	N2O	11	14	0.00	1.00

1 A 1 a Public Electricity and Heat Production	Liquid Fuels	N2O	15	14	0.00	1.00
4 A 7 Mules and Asses	Population size	CH4	24	13	0.00	1.00
3 B DEGREASING AND DRY CLEANING	Degreasing and Dry Cleaning	CO2	12	12	0.00	1.00
1 A 1 b Petroleum refining	Liquid Fuels	N2O	9	10	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	CO2	10	10	0.00	1.00
1 A 3 c Railways	Liquid Fuels	N2O	11	9	0.00	1.00
1 A 3 a ii Domestic	Jet Kerosene	N2O	5	7	0.00	1.00
2 B 5 Etileno (Borealis)	Production Quantities	CO2	7	7	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	N2O	0	6	0.00	1.00
1 A 4 a Commercial / Institutional	Liquid Fuels	N2O	2	6	0.00	1.00
1 A 2 c Chemicals	Liquid Fuels	N2O	4	6	0.00	1.00
2 B 5 Carbon black	Production Quantities	CH4	3	6	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	CO2	5	6	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Biomass	N2O	5	5	0.00	1.00
2 F 7 Electrical Equipment	Consumption	SF6	0	5	0.00	1.00
1 A 2 f Other	Biomass	CH4	5	5	0.00	1.00
1 A 2 f Other	Liquid Fuels	CH4	3	5	0.00	1.00
4 B 7 Mules and Asses	Population size	CH4	9	5	0.00	1.00
2 F 1 Refrigeration and Air Conditioning Equipment	Consumption	HFCs	0	5	0.00	1.00
2 B 5 Etileno (Borealis)	Production Quantities	CH4	5	4	0.00	1.00
1 A 2 f Other	Gaseous Fuels	N2O	0	4	0.00	1.00
2 B 5 Explosivos e Anid. Ftálico	Production Quantities	CO2	4	4	0.00	1.00
4 A 10 Other	Population size	CH4	4	4	0.00	1.00
1 A 3 a ii Domestic	Jet Kerosene	CH4	2	3	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	N2O	2	3	0.00	1.00
4 B 6 Horses	Population size	CH4	3	3	0.00	1.00
1 A 4 a Commercial / Institutional	Liquid Fuels	CH4	1	3	0.00	1.00
2 C 2 Ferroalloys Production	Production Quantities	CO2	3	3	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CH4	3	3	0.00	1.00
1 A 2 f Other	Solid Fuels	N2O	4	3	0.00	1.00
4 F 1 Cereals	Residues Burning	N2O	3	2	0.00	1.00
1 A 2 d Pulp, Paper and Print	Liquid Fuels	N2O	2	2	0.00	1.00
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CH4	2	2	0.00	1.00
2 B 5 Produção de Monómeros e Polimeros Orgânicos	Production Quantities	CO2	2	2	0.00	1.00
1 A 1 b Petroleum refining	Liquid Fuels	CH4	2	2	0.00	1.00
1 A 2 b Non-ferrous Metals	Gaseous Fuels	CO2	0	2	0.00	1.00
2 F 2 Foam Blowing	Consumption	HFCs	0	2	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CH4	1	2	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	N2O	0	2	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 2 c Chemicals	Biomass	N2O	1	1	0.00	1.00
1 A 2 c Chemicals	Liquid Fuels	CH4	1	1	0.00	1.00
1 A 2 a Iron and Steel	Solid Fuels	N2O	1	1	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Biomass	CH4	1	1	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	N2O	1	1	0.00	1.00
4 F 1 Cereals	Residues Burning	CH4	1	1	0.00	1.00
1 A 4 b Residential	Liquid Fuels	CH4	0.88887	1.13229	0.00	1.00
1 A 3 d ii National navigation	Gas/Diesel Oil	N2O	3.39926	1.11787	0.00	1.00
1 A 4 a Commercial / Institutional	Gaseous Fuels	N2O	0.59435	1.07103	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CH4	0.68650	0.93577	0.00	1.00
1 A 2 c Chemicals	Other Fuels	N2O	0.43372	0.81149	0.00	1.00
1 A 2 f Other	Solid Fuels	CH4	1.03881	0.60906	0.00	1.00
1 A 2 a Iron and Steel	Other Fuels	CO2	3.06811	0.54718	0.00	1.00
1 A 2 d Pulp, Paper and Print	Gaseous Fuels	CO2	0.00000	0.48517	0.00	1.00
1 A 3 d ii National navigation	Residual Oil	N2O	0.34933	0.47982	0.00	1.00
2 D 2 Food and Drink	Production Quantities	CO2	0.43657	0.43657	0.00	1.00
1 B 2 c I Oil	Liquid Fuels	CO2	0.27336	0.34116	0.00	1.00
1 A 2 c Chemicals	Biomass	CH4	0.33113	0.33399	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	N2O	0.40511	0.31518	0.00	1.00
1 A 2 a Iron and Steel	Gaseous Fuels	N2O	0.00000	0.31425	0.00	1.00
1 A 2 c Chemicals	Gaseous Fuels	N2O	0.00000	0.30406	0.00	1.00
1 A 2 a Iron and Steel	Liquid Fuels	N2O	0.50132	0.28722	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	CH4	0.00025	0.27659	0.00	1.00
1 A 2 f Other	Gaseous Fuels	CH4	0.00000	0.24936	0.00	1.00
1 A 2 b Non-ferrous Metals	Liquid Fuels	N2O	0.44993	0.23936	0.00	1.00
1 A 3 d ii National navigation	Gas/Diesel Oil	CH4	0.66203	0.21771	0.00	1.00
1 A 3 c Railways	Liquid Fuels	CH4	0.24900	0.19685	0.00	1.00
1 A 2 b Non-ferrous Metals	Biomass	N2O	0.19019	0.19171	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Gaseous Fuels	N2O	0.00000	0.18863	0.00	1.00
1 A 2 a Iron and Steel	Solid Fuels	CH4	0.11925	0.15563	0.00	1.00
1 B 2 c I Oil	Liquid Fuels	CH4	0.09206	0.11489	0.00	1.00
1 A 2 c Chemicals	Solid Fuels	N2O	0.09934	0.11305	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	CH4	0.08337	0.09400	0.00	1.00
1 A 3 d ii National navigation	Residual Oil	CH4	0.06804	0.09345	0.00	1.00
1 A 2 a Iron and Steel	Liquid Fuels	CH4	0.12724	0.07302	0.00	1.00
1 A 4 a Commercial / Institutional	Gaseous Fuels	CH4	0.03451	0.06219	0.00	1.00
1 A 2 c Chemicals	Other Fuels	CH4	0.02938	0.05497	0.00	1.00
1 A 2 b Non-ferrous Metals	Biomass	CH4	0.04494	0.04530	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	CH4	0.03875	0.04291	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	CH4	0.04901	0.03813	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	N2O	0.03034	0.03517	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	CH4	0.00000	0.03126	0.00	1.00
1 A 2 b Non-ferrous Metals	Liquid Fuels	CH4	0.08930	0.02640	0.00	1.00
1 A 2 c Chemicals	Solid Fuels	CH4	0.02307	0.02626	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Biomass	N2O	0.02500	0.02500	0.00	1.00
1 A 4 b Residential	Gaseous Fuels	CH4	0.00000	0.02218	0.00	1.00
1 A 2 a Iron and Steel	Gaseous Fuels	CH4	0.00000	0.02129	0.00	1.00
1 A 2 c Chemicals	Gaseous Fuels	CH4	0.00000	0.02060	0.00	1.00
1 A 2 b Non-ferrous Metals	Gaseous Fuels	N2O	0.00000	0.01455	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Gaseous Fuels	CH4	0.00000	0.01278	0.00	1.00
1 A 2 d Pulp, Paper and Print	Gaseous Fuels	N2O	0.00000	0.00375	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Gaseous Fuels	CO2	0.00000	0.00212	0.00	1.00
1 A 2 a Iron and Steel	Other Fuels	N2O	0.00750	0.00134	0.00	1.00

Tier 1 Level Assessment (1999)

IPCC SOURCE CATEGORIES	ACTIVITY	GHG	Base year Estimate (kton CO2 eq.) 1990	Current year Estimate (kton CO2 eq.) 1999	Level Assess.	Cumulative Total
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CO2	7816	12530	0.15	0.15
1 A 3 b Road Transportation	Diesel Oil	CO2	4947	9570	0.12	0.27
1 A 3 b Road Transportation	Gasoline	CO2	4303	6295	0.08	0.34
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CO2	6364	5723	0.07	0.41
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	CO2	0	3944	0.05	0.46
2 A 1 Cement Production	Production Quantities	CO2	3024	3740	0.05	0.50
1 A 2 f Other	Liquid Fuels	CO2	3227	3679	0.04	0.55
4 B 8 Swine	Population size	CH4	3028	2692	0.03	0.58
1 A 1 b Petroleum refining	Liquid Fuels	CO2	1929	2571	0.03	0.61
1 A 4 b Residential	Liquid Fuels	CO2	1630	2240	0.03	0.64
6 A 3 Other	Industrial Waste Disposal on Land	CH4	1655	2167	0.03	0.67
1 A 4 a Commercial / Institutional	Liquid Fuels	CO2	816	2156	0.03	0.69
4 D 2 Animal Production	Input to soils	N2O	1627	1620	0.02	0.71
4 D 3 Indirect Emissions	Input to soils	N2O	1591	1553	0.02	0.73
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CO2	1675	1506	0.02	0.75
4 D 1 Direct Soil Emissions	Input to soils	N2O	1573	1504	0.02	0.77
1 A 3 a ii Domestic	Jet Kerosene	CO2	794	1311	0.02	0.78
1 A 2 c Chemicals	Liquid Fuels	CO2	456	1178	0.01	0.80
4 B 12 Solid Storage and Dry Lot	Animal Excretion	N2O	1045	1163	0.01	0.81
4 A 1 b Non-Dairy Cattle	Population size	CH4	980	1073	0.01	0.82
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CO2	828	1072	0.01	0.84
6 A 2 Unmanaged Waste Disposal	Municipal Waste Disposal on Land	CH4	749	980	0.01	0.85
1 A 2 f Other	Gaseous Fuels	CO2	0	966	0.01	0.86
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CO2	744	938	0.01	0.87
1 A 2 f Other	Solid Fuels	CO2	1982	933	0.01	0.88
4 A 1 a Dairy Cattle	Population size	CH4	846	750	0.01	0.89
2 B 2 Nitric Acid Production	Production Quantities	N2O	603	606	0.01	0.90
4 A 3 Sheep	Population size	CH4	564	602	0.01	0.91
1 A 2 a Iron and Steel	Solid Fuels	CO2	476	596	0.01	0.91
6 B 2 Domestic and Commercial wastewater	Wastewater	CH4	659	588	0.01	0.92
2 B 1 Ammonia Production	Production Quantities	CO2	569	396	0.00	0.92
2 A 6 Road Paving with Asphalt	Production Quantities	CO2	168	364	0.00	0.93
6 B 2 Domestic and Commercial wastewater	Wastewater	N2O	287	348	0.00	0.93
1 A 4 b Residential	Biomass	CH4	343	302	0.00	0.94
1 A 3 b Road Transportation	Gasoline	N2O	33	275	0.00	0.94
6 B 1 Industrial Wastewater	Wastewater	CH4	164	208	0.00	0.94
1 B 2 b ii Transmission/ Distribution	Gaseous Fuels	CH4	3	205	0.00	0.95
6 B 1 Industrial Wastewater	Wastewater	N2O	161	205	0.00	0.95
4 B 1 a Dairy Cattle	Population size	CH4	218	193	0.00	0.95
4 C 1 Irrigated	Culture Surface	CH4	256	191	0.00	0.95
1 A 3 d ii National navigation	Gas/Diesel Oil	CO2	433	190	0.00	0.95
2 A 7 Other	Production Quantities	CO2	180	180	0.00	0.96
1 A 3 b Road Transportation	Diesel Oil	N2O	84	163	0.00	0.96
1 A 4 a Commercial / Institutional	Gaseous Fuels	CO2	77	159	0.00	0.96
1 B 2 a iv Refining/ Storage	Liquid Fuels	CO2	124	153	0.00	0.96
6 C WASTE INCINERATION	Waste Incinerated	CO2	10	144	0.00	0.96
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	N2O	151	140	0.00	0.97
1 A 3 c Railways	Liquid Fuels	CO2	175	136	0.00	0.97
1 A 2 c Chemicals	Other Fuels	CO2	63	134	0.00	0.97
6 A 1 Managed Waste disposal	Municipal Waste Disposal on Land	CH4	18	126	0.00	0.97
1 A 2 a Iron and Steel	Liquid Fuels	CO2	163	123	0.00	0.97
4 B 3 Sheep	Population size	CH4	113	120	0.00	0.97
1 A 2 c Chemicals	Gaseous Fuels	CO2	0	115	0.00	0.98
3 A PAINT APPLICATION	Paint application	CO2	91	92	0.00	0.98
3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING	Chemical manufacture and processing	CO2	86	90	0.00	0.98
1 A 4 b Residential	Gaseous Fuels	CO2	0	89	0.00	0.98
2 B 5 Carbon black	Production Quantities	CO2	51	87	0.00	0.98
3 D OTHER	Other Use of Chemicals	CO2	82	85	0.00	0.98
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	CO2	90	82	0.00	0.98
1 B 2 d Other (Geothermal)	Energy Production	CO2	2	77	0.00	0.98
1 A 2 e Food Processing, Beverages and Tobacco	Gaseous Fuels	CO2	0	74	0.00	0.98
4 A 8 Swine	Population size	CH4	84	74	0.00	0.98
1 A 3 b Road Transportation	Natural Gas	CO2	0	68	0.00	0.98
1 A 3 d ii National navigation	Residual Oil	CO2	44	68	0.00	0.99
4 A 4 Goats	Population size	CH4	90	66	0.00	0.99
1 A 4 b Residential	Biomass	N2O	73	64	0.00	0.99
1 A 1 a Public Electricity and Heat Production	Solid Fuels	N2O	36	58	0.00	0.99
1 A 2 c Chemicals	Solid Fuels	CO2	45	53	0.00	0.99
4 B 10 Anaerobic	Animal Excretion	N2O	59	52	0.00	0.99
2 A 3 Limestone and Dolomite Use	Production Quantities	CO2	54	50	0.00	0.99
1 A 2 a Iron and Steel	Gaseous Fuels	CO2	0	44	0.00	0.99
4 B 9 Poultry	Population size	CH4	29	44	0.00	0.99
4 B 1 b Non-Dairy Cattle	Population size	CH4	38	42	0.00	0.99
1 A 2 b Non-ferrous Metals	Liquid Fuels	CO2	125	36	0.00	0.99
2 C 3 Aluminium production	Production Quantities	CO2	17	32	0.00	0.99
4 F 5 Other	Residues Burning	N2O	34	31	0.00	0.99
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	N2O	0	31	0.00	0.99
1 A 3 b Road Transportation	Gasoline	CH4	25	29	0.00	0.99
1 B 2 a v Distribution of Oil Products	Liquid Fuels	CO2	17	27	0.00	0.99
1 B 2 a iv Refining/ Storage	Liquid Fuels	CH4	22	27	0.00	0.99
1 A 2 d Pulp, Paper and Print	Biomass	CH4	19	23	0.00	0.99
1 A 2 f Other	Biomass	N2O	21	22	0.00	0.99
2 C 1 Iron and Steel Production	Production Quantities	CO2	15	22	0.00	0.99
4 B 11 Liquid Systems	Animal Excretion	N2O	24	21	0.00	1.00
1 A 2 d Pulp, Paper and Print	Gaseous Fuels	CO2	0	21	0.00	1.00
4 B 4 Goats	Population size	CH4	26	19	0.00	1.00
1 A 3 b Road Transportation	Diesel Oil	CH4	9	18	0.00	1.00
2 F 1 Refrigeration and Air Conditioning Equipment	Consumption	HFCs	0	17	0.00	1.00
1 A 2 d Pulp, Paper and Print	Biomass	N2O	11	17	0.00	1.00
1 B 2 a iii Transport	Liquid Fuels	CH4	13	16	0.00	1.00
4 A 6 Horses	Population size	CH4	14	16	0.00	1.00

1 A 4 b Residential	Liquid Fuels	N2O	11	15	0.00	1.00
4 F 5 Other	Residues Burning	CH4	16	15	0.00	1.00
1 B 2 a iii Transport	Liquid Fuels	CO2	12	14	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	N2O	15	14	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	N2O	1	12	0.00	1.00
3 B DEGREASING AND DRY CLEANING	Degreasing and Dry Cleaning	CO2	12	12	0.00	1.00
4 A 7 Mules and Asses	Population size	CH4	24	12	0.00	1.00
1 A 2 f Other	Liquid Fuels	N2O	11	11	0.00	1.00
1 A 1 b Petroleum refining	Liquid Fuels	N2O	9	11	0.00	1.00
1 A 2 b Non-ferrous Metals	Gaseous Fuels	CO2	0	11	0.00	1.00
1 A 3 c Railways	Liquid Fuels	N2O	11	9	0.00	1.00
1 A 3 a ii Domestic	Jet Kerosene	N2O	5	8	0.00	1.00
1 A 2 f Other	Gaseous Fuels	N2O	0	7	0.00	1.00
1 A 2 c Chemicals	Liquid Fuels	N2O	4	7	0.00	1.00
2 B 5 Etileno (Borealis)	Production Quantities	CO2	7	7	0.00	1.00
1 A 4 a Commercial / Institutional	Liquid Fuels	N2O	2	7	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	CO2	5	6	0.00	1.00
2 B 5 Carbon black	Production Quantities	CH4	3	6	0.00	1.00
2 F 7 Electrical Equipment	Consumption	SF6	0	6	0.00	1.00
1 A 2 f Other	Biomass	CH4	5	5	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Biomass	N2O	5	5	0.00	1.00
4 B 7 Mules and Asses	Population size	CH4	9	4	0.00	1.00
1 A 2 f Other	Liquid Fuels	CH4	3	4	0.00	1.00
2 B 5 Etileno (Borealis)	Production Quantities	CH4	5	4	0.00	1.00
2 B 5 Explosivos e Anid. Ftálico	Production Quantities	CO2	4	4	0.00	1.00
4 A 10 Other	Population size	CH4	4	4	0.00	1.00
1 A 3 a ii Domestic	Jet Kerosene	CH4	2	3	0.00	1.00
4 B 6 Horses	Population size	CH4	3	3	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	N2O	2	3	0.00	1.00
1 A 4 a Commercial / Institutional	Liquid Fuels	CH4	1	3	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CH4	3	3	0.00	1.00
2 C 2 Ferroalloys Production	Production Quantities	CO2	3	3	0.00	1.00
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CH4	2	2	0.00	1.00
1 A 2 d Pulp, Paper and Print	Liquid Fuels	N2O	2	2	0.00	1.00
4 F 1 Cereals	Residues Burning	N2O	3	2	0.00	1.00
2 B 5 Produção de Monómeros e Polimeros Orgânicos	Production Quantities	CO2	2	2	0.00	1.00
1 A 1 b Petroleum refining	Liquid Fuels	CH4	2	2	0.00	1.00
1 A 2 f Other	Solid Fuels	N2O	4	2	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CH4	1	2	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	N2O	0	2	0.00	1.00
1 A 2 c Chemicals	Biomass	N2O	1	2	0.00	1.00
2 F 2 Foam Blowing	Consumption	HFCs	0	2	0.00	1.00
1 A 2 c Chemicals	Liquid Fuels	CH4	1	2	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CH4	1	2	0.00	1.00
1 A 3 d ii National navigation	Gas/Diesel Oil	N2O	3	1	0.00	1.00
1 A 2 a Iron and Steel	Solid Fuels	N2O	1	1	0.00	1.00
1 A 4 a Commercial / Institutional	Gaseous Fuels	N2O	0.59435	1.23027	0.00	1.00
1 A 4 b Residential	Liquid Fuels	CH4	0.88887	1.18282	0.00	1.00
4 F 1 Cereals	Residues Burning	CH4	1.49590	1.11923	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Biomass	CH4	1.25416	1.06831	0.00	1.00
1 A 2 c Chemicals	Other Fuels	N2O	0.43372	0.92348	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CH4	0.68650	0.90682	0.00	1.00
1 A 2 c Chemicals	Gaseous Fuels	N2O	0.00000	0.88947	0.00	1.00
1 A 2 a Iron and Steel	Other Fuels	CO2	3.06811	0.63881	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Gaseous Fuels	N2O	0.00000	0.57461	0.00	1.00
1 A 3 d ii National navigation	Residual Oil	N2O	0.34933	0.53622	0.00	1.00
1 A 2 f Other	Gaseous Fuels	CH4	0.00000	0.50663	0.00	1.00
1 A 2 f Other	Solid Fuels	CH4	1.03881	0.48932	0.00	1.00
2 D 2 Food and Drink	Production Quantities	CO2	0.43657	0.43657	0.00	1.00
1 A 2 c Chemicals	Biomass	CH4	0.33113	0.42317	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	CH4	0.03875	0.41182	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	N2O	0.40511	0.36796	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	CH4	0.00025	0.33988	0.00	1.00
1 A 2 a Iron and Steel	Gaseous Fuels	N2O	0.00000	0.33739	0.00	1.00
1 A 2 a Iron and Steel	Liquid Fuels	N2O	0.50132	0.32919	0.00	1.00
1 B 2 c I Oil	Liquid Fuels	CO2	0.27336	0.32710	0.00	1.00
1 A 3 d ii National navigation	Gas/Diesel Oil	CH4	0.66203	0.28924	0.00	1.00
1 A 3 c Railways	Liquid Fuels	CH4	0.24900	0.19367	0.00	1.00
1 A 2 b Non-ferrous Metals	Liquid Fuels	N2O	0.44993	0.19266	0.00	1.00
1 A 2 b Non-ferrous Metals	Biomass	N2O	0.19019	0.19242	0.00	1.00
1 A 2 a Iron and Steel	Solid Fuels	CH4	0.11925	0.17550	0.00	1.00
1 A 2 d Pulp, Paper and Print	Gaseous Fuels	N2O	0.00000	0.16212	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	CH4	0.00000	0.14763	0.00	1.00
1 A 2 c Chemicals	Solid Fuels	N2O	0.09934	0.11305	0.00	1.00
1 B 2 c I Oil	Liquid Fuels	CH4	0.09206	0.11015	0.00	1.00
1 A 3 d ii National navigation	Residual Oil	CH4	0.06804	0.10443	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	CH4	0.08337	0.09972	0.00	1.00
1 A 2 a Iron and Steel	Liquid Fuels	CH4	0.12724	0.08339	0.00	1.00
1 A 4 b Residential	Gaseous Fuels	CH4	0.00000	0.08337	0.00	1.00
1 A 2 b Non-ferrous Metals	Gaseous Fuels	N2O	0.00000	0.08313	0.00	1.00
1 A 4 a Commercial / Institutional	Gaseous Fuels	CH4	0.03451	0.07144	0.00	1.00
1 A 2 c Chemicals	Other Fuels	CH4	0.02938	0.06256	0.00	1.00
1 A 2 c Chemicals	Gaseous Fuels	CH4	0.00000	0.06025	0.00	1.00
1 A 2 b Non-ferrous Metals	Biomass	CH4	0.04494	0.04547	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	CH4	0.04901	0.04451	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Gaseous Fuels	CH4	0.00000	0.03893	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	N2O	0.03034	0.03620	0.00	1.00
1 A 2 c Chemicals	Solid Fuels	CH4	0.02307	0.02626	0.00	1.00
1 A 2 b Non-ferrous Metals	Liquid Fuels	CH4	0.08930	0.02503	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Biomass	N2O	0.02500	0.02500	0.00	1.00
1 A 2 a Iron and Steel	Gaseous Fuels	CH4	0.00000	0.02286	0.00	1.00
1 A 2 d Pulp, Paper and Print	Gaseous Fuels	CH4	0.00000	0.01098	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Gaseous Fuels	CO2	0.00000	0.01032	0.00	1.00

Tier 1 Level Assessment (2000)

IPCC SOURCE CATEGORIES	ACTIVITY	GHG	Base year Estimate (kton CO2 eq.) 1990	Current year Estimate (kton CO2 eq.) 2000	Level Assess.	Cumulative Total
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CO2	7816	12138	0.15	0.15
1 A 3 b Road Transportation	Diesel Oil	CO2	4947	11007	0.13	0.28
1 A 3 b Road Transportation	Gasoline	CO2	4303	6416	0.08	0.36
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CO2	6364	4628	0.06	0.42
2 A 1 Cement Production	Production Quantities	CO2	3024	3773	0.05	0.46
1 A 2 f Other	Liquid Fuels	CO2	3227	3165	0.04	0.50
4 B 8 Swine	Population size	CH4	3028	2677	0.03	0.53
6 A 3 Other	Industrial Waste Disposal on Land	CH4	1655	2301	0.03	0.56
1 A 1 b Petroleum refining	Liquid Fuels	CO2	1929	2262	0.03	0.59
1 A 4 b Residential	Liquid Fuels	CO2	1630	2215	0.03	0.61
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	CO2	0	2153	0.03	0.64
1 A 4 a Commercial / Institutional	Liquid Fuels	CO2	816	2134	0.03	0.67
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CO2	1675	1889	0.02	0.69
4 D 2 Animal Production	Input to soils	N2O	1627	1612	0.02	0.71
1 A 2 f Other	Gaseous Fuels	CO2	0	1560	0.02	0.73
4 D 3 Indirect Emissions	Input to soils	N2O	1591	1541	0.02	0.75
4 D 1 Direct Soil Emissions	Input to soils	N2O	1573	1480	0.02	0.77
1 A 3 a ii Domestic	Jet Kerosene	CO2	794	1304	0.02	0.78
1 A 2 f Other	Solid Fuels	CO2	1982	1167	0.01	0.80
4 B 12 Solid Storage and Dry Lot	Animal Excretion	N2O	1045	1139	0.01	0.81
1 A 2 c Chemicals	Liquid Fuels	CO2	456	1111	0.01	0.82
4 A 1 b Non-Dairy Cattle	Population size	CH4	980	1067	0.01	0.84
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CO2	744	987	0.01	0.85
6 A 2 Unmanaged Waste Disposal	Municipal Waste Disposal on Land	CH4	749	953	0.01	0.86
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CO2	828	940	0.01	0.87
4 A 1 a Dairy Cattle	Population size	CH4	846	746	0.01	0.88
1 A 2 a Iron and Steel	Solid Fuels	CO2	476	713	0.01	0.89
2 B 2 Nitric Acid Production	Production Quantities	N2O	603	606	0.01	0.90
4 A 3 Sheep	Population size	CH4	564	601	0.01	0.90
6 B 2 Domestic and Commercial wastewater	Wastewater	CH4	659	574	0.01	0.91
2 B 1 Ammonia Production	Production Quantities	CO2	569	396	0.00	0.91
6 C WASTE INCINERATION	Waste Incinerated	CO2	10	361	0.00	0.92
6 B 2 Domestic and Commercial wastewater	Wastewater	N2O	287	350	0.00	0.92
2 A 6 Road Paving with Asphalt	Production Quantities	CO2	168	346	0.00	0.93
1 A 3 b Road Transportation	Gasoline	N2O	33	314	0.00	0.93
1 A 4 b Residential	Biomass	CH4	343	301	0.00	0.94
1 A 2 c Chemicals	Solid Fuels	CO2	45	218	0.00	0.94
6 B 1 Industrial Wastewater	Wastewater	CH4	164	208	0.00	0.94
6 B 1 Industrial Wastewater	Wastewater	N2O	161	205	0.00	0.94
4 B 1 a Dairy Cattle	Population size	CH4	218	192	0.00	0.95
1 A 4 b Residential	Gaseous Fuels	CO2	0	189	0.00	0.95
1 A 3 b Road Transportation	Diesel Oil	N2O	84	187	0.00	0.95
1 A 3 d ii National navigation	Gas/Diesel Oil	CO2	433	184	0.00	0.95
4 C 1 Irrigated	Culture Surface	CH4	256	181	0.00	0.95
2 A 7 Other	Production Quantities	CO2	180	180	0.00	0.96
1 B 2 b ii Transmission/ Distribution	Gaseous Fuels	CH4	3	172	0.00	0.96
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	N2O	151	170	0.00	0.96
6 A 1 Managed Waste disposal	Municipal Waste Disposal on Land	CH4	18	147	0.00	0.96
1 A 2 a Iron and Steel	Liquid Fuels	CO2	163	145	0.00	0.96
1 A 2 d Pulp, Paper and Print	Gaseous Fuels	CO2	0	143	0.00	0.97
1 A 2 c Chemicals	Gaseous Fuels	CO2	0	143	0.00	0.97
1 B 2 a iv Refining/ Storage	Liquid Fuels	CO2	124	138	0.00	0.97
1 A 2 c Chemicals	Other Fuels	CO2	63	137	0.00	0.97
1 A 3 c Railways	Liquid Fuels	CO2	175	134	0.00	0.97
4 B 3 Sheep	Population size	CH4	113	120	0.00	0.97
1 A 2 e Food Processing, Beverages and Tobacco	Gaseous Fuels	CO2	0	112	0.00	0.98
1 A 4 a Commercial / Institutional	Gaseous Fuels	CO2	77	112	0.00	0.98
1 B 2 d Other (Geothermal)	Energy Production	CO2	2	111	0.00	0.98
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	CO2	90	100	0.00	0.98
3 A PAINT APPLICATION	Paint application	CO2	91	92	0.00	0.98
3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING	Chemical manufacture and processing	CO2	86	90	0.00	0.98
2 B 5 Carbon black	Production Quantities	CO2	51	90	0.00	0.98
3 D OTHER	Other Use of Chemicals	CO2	82	85	0.00	0.98
4 A 8 Swine	Population size	CH4	84	74	0.00	0.98
1 A 3 d ii National navigation	Residual Oil	CO2	44	69	0.00	0.99
4 A 4 Goats	Population size	CH4	90	65	0.00	0.99
1 A 3 b Road Transportation	Natural Gas	CO2	0	64	0.00	0.99
1 A 4 b Residential	Biomass	N2O	73	64	0.00	0.99
1 A 2 a Iron and Steel	Gaseous Fuels	CO2	0	57	0.00	0.99
1 A 1 a Public Electricity and Heat Production	Solid Fuels	N2O	36	56	0.00	0.99
4 B 10 Anaerobic	Animal Excretion	N2O	59	52	0.00	0.99
2 A 3 Limestone and Dolomite Use	Production Quantities	CO2	54	50	0.00	0.99
4 B 1 b Non-Dairy Cattle	Population size	CH4	38	42	0.00	0.99
4 B 9 Poultry	Population size	CH4	29	42	0.00	0.99
2 C 3 Aluminium production	Production Quantities	CO2	17	34	0.00	0.99
2 F 1 Refrigeration and Air Conditioning Equipment	Consumption	HFCs	0	33	0.00	0.99
4 F 5 Other	Residues Burning	N2O	34	31	0.00	0.99
6 C WASTE INCINERATION	Waste Incinerated	N2O	1	29	0.00	0.99
1 A 2 b Non-ferrous Metals	Liquid Fuels	CO2	125	28	0.00	0.99
1 A 3 b Road Transportation	Gasoline	CH4	25	28	0.00	0.99
1 B 2 a v Distribution of Oil Products	Liquid Fuels	CO2	17	27	0.00	0.99
1 A 2 b Non-ferrous Metals	Gaseous Fuels	CO2	0	27	0.00	0.99
1 B 2 a iv Refining/ Storage	Liquid Fuels	CH4	22	25	0.00	0.99
2 C 1 Iron and Steel Production	Production Quantities	CO2	15	24	0.00	0.99
1 A 2 f Other	Biomass	N2O	21	23	0.00	1.00
1 A 2 d Pulp, Paper and Print	Biomass	CH4	19	22	0.00	1.00
4 B 11 Liquid Systems	Animal Excretion	N2O	24	21	0.00	1.00
1 A 3 b Road Transportation	Diesel Oil	CH4	9	20	0.00	1.00
4 B 4 Goats	Population size	CH4	26	19	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	N2O	0	17	0.00	1.00
1 A 4 b Residential	Liquid Fuels	N2O	11	15	0.00	1.00

4 A 6 Horses	Population size	CH4	14	15	0.00	1.00
4 F 5 Other	Residues Burning	CH4	16	15	0.00	1.00
1 A 2 d Pulp, Paper and Print	Biomass	N2O	11	15	0.00	1.00
1 B 2 a iii Transport	Liquid Fuels	CH4	13	15	0.00	1.00
1 B 2 a iii Transport	Liquid Fuels	CO2	12	13	0.00	1.00
1 A 2 f Other	Gaseous Fuels	N2O	0	12	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	N2O	15	12	0.00	1.00
3 B DEGREASING AND DRY CLEANING	Degreasing and Dry Cleaning	CO2	12	12	0.00	1.00
4 A 7 Mules and Asses	Population size	CH4	24	9	0.00	1.00
1 A 2 f Other	Liquid Fuels	N2O	11	9	0.00	1.00
1 A 1 b Petroleum refining	Liquid Fuels	N2O	9	9	0.00	1.00
1 A 3 c Railways	Liquid Fuels	N2O	11	9	0.00	1.00
1 A 3 a ii Domestic	Jet Kerosene	N2O	5	8	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	CO2	5	7	0.00	1.00
2 B 5 Etileno (Borealis)	Production Quantities	CO2	7	7	0.00	1.00
1 A 2 c Chemicals	Liquid Fuels	N2O	4	7	0.00	1.00
1 A 4 a Commercial / Institutional	Liquid Fuels	N2O	2	7	0.00	1.00
2 F 7 Electrical Equipment	Consumption	SF6	0	6	0.00	1.00
2 B 5 Carbon black	Production Quantities	CH4	3	6	0.00	1.00
1 A 2 f Other	Biomass	CH4	5	5	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Biomass	N2O	5	5	0.00	1.00
2 F 2 Foam Blowing	Consumption	HFCs	0	4	0.00	1.00
2 B 5 Etileno (Borealis)	Production Quantities	CH4	5	4	0.00	1.00
1 A 2 f Other	Liquid Fuels	CH4	3	4	0.00	1.00
2 B 5 Explosivos e Anid. Ftálico	Production Quantities	CO2	4	4	0.00	1.00
4 B 7 Mules and Asses	Population size	CH4	9	4	0.00	1.00
4 A 10 Other	Population size	CH4	4	4	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CH4	3	3	0.00	1.00
1 A 3 a ii Domestic	Jet Kerosene	CH4	2	3	0.00	1.00
4 B 6 Horses	Population size	CH4	3	3	0.00	1.00
1 A 4 a Commercial / Institutional	Liquid Fuels	CH4	1	3	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	N2O	2	3	0.00	1.00
2 C 2 Ferroalloys Production	Production Quantities	CO2	3	3	0.00	1.00
1 A 2 f Other	Solid Fuels	N2O	4	3	0.00	1.00
1 A 2 d Pulp, Paper and Print	Liquid Fuels	N2O	2	2	0.00	1.00
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CH4	2	2	0.00	1.00
4 F 1 Cereals	Residues Burning	N2O	3	2	0.00	1.00
2 B 5 Produção de Monómeros e Polimeros Orgânicos	Production Quantities	CO2	2	2	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CH4	1	2	0.00	1.00
1 A 1 b Petroleum refining	Liquid Fuels	CH4	2	2	0.00	1.00
1 A 2 c Chemicals	Biomass	N2O	1	2	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	N2O	0	2	0.00	1.00
1 A 2 a Iron and Steel	Solid Fuels	N2O	1	2	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CH4	1	2	0.00	1.00
1 A 2 c Chemicals	Liquid Fuels	CH4	1	2	0.00	1.00
1 A 3 d ii National navigation	Gas/Diesel Oil	N2O	3	1	0.00	1.00
1 A 4 b Residential	Liquid Fuels	CH4	0.88887	1.14016	0.00	1.00
1 A 2 d Pulp, Paper and Print	Gaseous Fuels	N2O	0.00000	1.10944	0.00	1.00
1 A 2 c Chemicals	Gaseous Fuels	N2O	0.00000	1.10634	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Biomass	CH4	1.25416	1.08220	0.00	1.00
4 F 1 Cereals	Residues Burning	CH4	1.49590	1.05939	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	CH4	0.03875	1.01170	0.00	1.00
1 A 2 c Chemicals	Other Fuels	N2O	0.43372	0.94239	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Gaseous Fuels	N2O	0.00000	0.86336	0.00	1.00
1 A 4 a Commercial / Institutional	Gaseous Fuels	N2O	0.59435	0.86282	0.00	1.00
1 A 2 f Other	Gaseous Fuels	CH4	0.00000	0.81894	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CH4	0.68650	0.78590	0.00	1.00
1 A 2 a Iron and Steel	Other Fuels	CO2	3.06811	0.77979	0.00	1.00
1 A 2 f Other	Solid Fuels	CH4	1.03881	0.61205	0.00	1.00
1 A 3 d ii National navigation	Residual Oil	N2O	0.34933	0.54903	0.00	1.00
1 A 2 c Chemicals	Solid Fuels	N2O	0.09934	0.46433	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	N2O	0.40511	0.44916	0.00	1.00
1 A 2 a Iron and Steel	Gaseous Fuels	N2O	0.00000	0.43719	0.00	1.00
2 D 2 Food and Drink	Production Quantities	CO2	0.43657	0.43657	0.00	1.00
1 A 2 c Chemicals	Biomass	CH4	0.33113	0.42867	0.00	1.00
1 A 2 a Iron and Steel	Liquid Fuels	N2O	0.50132	0.39562	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	CH4	0.00025	0.32386	0.00	1.00
1 B 2 c I Oil	Liquid Fuels	CO2	0.27336	0.29565	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Gaseous Fuels	CO2	0.00000	0.28950	0.00	1.00
1 A 3 d ii National navigation	Gas/Diesel Oil	CH4	0.66203	0.28023	0.00	1.00
1 A 2 b Non-ferrous Metals	Gaseous Fuels	N2O	0.00000	0.20584	0.00	1.00
1 A 2 a Iron and Steel	Solid Fuels	CH4	0.11925	0.20469	0.00	1.00
1 A 2 b Non-ferrous Metals	Biomass	N2O	0.19019	0.19131	0.00	1.00
1 A 3 c Railways	Liquid Fuels	CH4	0.24900	0.19057	0.00	1.00
1 A 4 b Residential	Gaseous Fuels	CH4	0.00000	0.17662	0.00	1.00
1 A 2 b Non-ferrous Metals	Liquid Fuels	N2O	0.44993	0.13638	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	CH4	0.08337	0.12024	0.00	1.00
1 A 2 c Chemicals	Solid Fuels	CH4	0.02307	0.10784	0.00	1.00
1 A 3 d ii National navigation	Residual Oil	CH4	0.06804	0.10693	0.00	1.00
1 B 2 c I Oil	Liquid Fuels	CH4	0.09206	0.09956	0.00	1.00
1 A 2 a Iron and Steel	Liquid Fuels	CH4	0.12724	0.09839	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	CH4	0.00000	0.08058	0.00	1.00
1 A 2 d Pulp, Paper and Print	Gaseous Fuels	CH4	0.00000	0.07516	0.00	1.00
1 A 2 c Chemicals	Gaseous Fuels	CH4	0.00000	0.07495	0.00	1.00
1 A 2 c Chemicals	Other Fuels	CH4	0.02938	0.06384	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Gaseous Fuels	CH4	0.00000	0.05849	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	CH4	0.04901	0.05433	0.00	1.00
1 A 4 a Commercial / Institutional	Gaseous Fuels	CH4	0.03451	0.05010	0.00	1.00
1 A 2 b Non-ferrous Metals	Biomass	CH4	0.04494	0.04521	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	N2O	0.03034	0.04332	0.00	1.00
1 A 2 a Iron and Steel	Gaseous Fuels	CH4	0.00000	0.02962	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Biomass	N2O	0.02500	0.02500	0.00	1.00
1 A 2 b Non-ferrous Metals	Liquid Fuels	CH4	0.08930	0.02131	0.00	1.00

Tier 1 Level Assessment (2001)

IPCC SOURCE CATEGORIES	ACTIVITY	GHG	Base year Estimate (kton CO2 eq.) 1990	Current year Estimate (kton CO2 eq.) 2001	Level Assess.	Cumulative Total
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CO2	7,816	11,317	0.14	0.14
1 A 3 b Road Transportation	Diesel Oil	CO2	4,947	10,532	0.13	0.26
1 A 3 b Road Transportation	Gasoline	CO2	4,303	6,819	0.08	0.34
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CO2	6,364	5,548	0.07	0.41
1 A 2 f Other	Liquid Fuels	CO2	3,227	4,179	0.05	0.46
2 A 1 Cement Production	Production Quantities	CO2	3,024	3,754	0.04	0.50
1 A 1 b Petroleum refining	Liquid Fuels	CO2	1,929	2,722	0.03	0.54
4 B 8 Swine	Population size	CH4	3,028	2,677	0.03	0.57
6 A 3 Other	Industrial Waste Disposal on Land	CH4	1,655	2,435	0.03	0.60
1 A 4 a Commercial / Institutional	Liquid Fuels	CO2	816	2,323	0.03	0.62
1 A 4 b Residential	Liquid Fuels	CO2	1,630	2,278	0.03	0.65
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	CO2	0	2,267	0.03	0.68
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CO2	1,675	1,656	0.02	0.70
4 D 2 Animal Production	Input to soils	N2O	1,627	1,612	0.02	0.72
4 D 3 Indirect Emissions	Input to soils	N2O	1,591	1,541	0.02	0.74
1 A 2 c Chemicals	Liquid Fuels	CO2	456	1,538	0.02	0.75
4 D 1 Direct Soil Emissions	Input to soils	N2O	1,573	1,480	0.02	0.77
1 A 3 a ii Domestic	Jet Kerosene	CO2	794	1,328	0.02	0.79
4 B 12 Solid Storage and Dry Lot	Animal Excretion	N2O	1,045	1,139	0.01	0.80
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CO2	744	1,090	0.01	0.81
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CO2	828	1,088	0.01	0.83
4 A 1 b Non-Dairy Cattle	Population size	CH4	980	1,067	0.01	0.84
1 A 2 f Other	Gaseous Fuels	CO2	0	1,007	0.01	0.85
1 A 2 f Other	Solid Fuels	CO2	1,982	989	0.01	0.86
6 A 2 Unmanaged Waste Disposal	Municipal Waste Disposal on Land	CH4	749	911	0.01	0.87
4 A 1 a Dairy Cattle	Population size	CH4	846	746	0.01	0.88
1 A 2 a Iron and Steel	Solid Fuels	CO2	476	713	0.01	0.89
2 B 2 Nitric Acid Production	Production Quantities	N2O	603	606	0.01	0.90
4 A 3 Sheep	Population size	CH4	564	601	0.01	0.91
6 B 2 Domestic and Commercial wastewater	Wastewater	CH4	659	578	0.01	0.91
2 B 1 Ammonia Production	Production Quantities	CO2	569	396	0.00	0.92
6 C WASTE INCINERATION	Waste Incinerated	CO2	10	376	0.00	0.92
1 A 3 b Road Transportation	Gasoline	N2O	33	368	0.00	0.93
6 B 2 Domestic and Commercial wastewater	Wastewater	N2O	287	360	0.00	0.93
2 A 6 Road Paving with Asphalt	Production Quantities	CO2	168	346	0.00	0.94
1 A 4 b Residential	Biomass	CH4	343	297	0.00	0.94
1 A 4 b Residential	Gaseous Fuels	CO2	0	232	0.00	0.94
6 B 1 Industrial Wastewater	Wastewater	CH4	164	208	0.00	0.94
6 B 1 Industrial Wastewater	Wastewater	N2O	161	205	0.00	0.95
4 B 1 a Dairy Cattle	Population size	CH4	218	192	0.00	0.95
4 C 1 Irrigated	Culture Surface	CH4	256	181	0.00	0.95
2 A 7 Other	Production Quantities	CO2	180	180	0.00	0.95
1 A 3 b Road Transportation	Diesel Oil	N2O	84	179	0.00	0.96
6 A 1 Managed Waste disposal	Municipal Waste Disposal on Land	CH4	18	165	0.00	0.96
1 B 2 a iv Refining/ Storage	Liquid Fuels	CO2	124	158	0.00	0.96
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	N2O	151	154	0.00	0.96
1 B 2 b ii Transmission/ Distribution	Gaseous Fuels	CH4	3	153	0.00	0.96
1 A 3 d ii National navigation	Gas/Diesel Oil	CO2	433	153	0.00	0.96
1 A 2 a Iron and Steel	Liquid Fuels	CO2	163	152	0.00	0.97
1 A 4 a Commercial / Institutional	Gaseous Fuels	CO2	77	147	0.00	0.97
1 B 2 d Other (Geothermal)	Energy Production	CO2	2	145	0.00	0.97
1 A 2 c Chemicals	Other Fuels	CO2	63	130	0.00	0.97
1 A 3 c Railways	Liquid Fuels	CO2	175	128	0.00	0.97
4 B 3 Sheep	Population size	CH4	113	120	0.00	0.97
1 A 2 c Chemicals	Solid Fuels	CO2	45	119	0.00	0.98
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	CO2	90	100	0.00	0.98
1 A 2 c Chemicals	Gaseous Fuels	CO2	0	98	0.00	0.98
2 B 5 Carbon black	Production Quantities	CO2	51	97	0.00	0.98
3 A PAINT APPLICATION	Paint application	CO2	91	92	0.00	0.98
3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING	Chemical manufacture and processing	CO2	86	90	0.00	0.98
3 D OTHER	Other Use of Chemicals	CO2	82	85	0.00	0.98
4 A 8 Swine	Population size	CH4	84	74	0.00	0.98
1 A 2 e Food Processing, Beverages and Tobacco	Gaseous Fuels	CO2	0	70	0.00	0.98
1 A 3 b Road Transportation	Natural Gas	CO2	0	69	0.00	0.98
4 A 4 Goats	Population size	CH4	90	65	0.00	0.99
1 A 4 b Residential	Biomass	N2O	73	63	0.00	0.99
1 A 2 d Pulp, Paper and Print	Gaseous Fuels	CO2	0	59	0.00	0.99
2 F 1 Refrigeration and Air Conditioning Equipment	Consumption	HFCs	0	57	0.00	0.99
1 A 1 a Public Electricity and Heat Production	Solid Fuels	N2O	36	53	0.00	0.99
4 B 10 Anaerobic	Animal Excretion	N2O	59	52	0.00	0.99
2 A 3 Limestone and Dolomite Use	Production Quantities	CO2	54	50	0.00	0.99
1 A 2 a Iron and Steel	Gaseous Fuels	CO2	0	47	0.00	0.99
4 B 1 b Non-Dairy Cattle	Population size	CH4	38	42	0.00	0.99
4 B 9 Poultry	Population size	CH4	29	42	0.00	0.99
1 A 3 d ii National navigation	Residual Oil	CO2	44	41	0.00	0.99
2 C 3 Aluminium production	Production Quantities	CO2	17	36	0.00	0.99
1 A 2 b Non-ferrous Metals	Liquid Fuels	CO2	125	31	0.00	0.99
4 F 5 Other	Residues Burning	N2O	34	31	0.00	0.99
6 C WASTE INCINERATION	Waste Incinerated	N2O	1	31	0.00	0.99
1 B 2 a v Distribution of Oil Products	Liquid Fuels	CO2	17	29	0.00	0.99
1 A 3 b Road Transportation	Gasoline	CH4	25	28	0.00	0.99
1 B 2 a iv Refining/ Storage	Liquid Fuels	CH4	22	28	0.00	0.99
2 C 1 Iron and Steel Production	Production Quantities	CO2	15	24	0.00	0.99
1 A 2 d Pulp, Paper and Print	Biomass	CH4	19	23	0.00	0.99
1 A 2 f Other	Biomass	N2O	21	22	0.00	1.00
4 B 11 Liquid Systems	Animal Excretion	N2O	24	21	0.00	1.00
1 A 3 b Road Transportation	Diesel Oil	CH4	9	20	0.00	1.00
4 B 4 Goats	Population size	CH4	26	19	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	N2O	0	18	0.00	1.00
1 B 2 a iii Transport	Liquid Fuels	CH4	13	17	0.00	1.00
1 A 2 d Pulp, Paper and Print	Biomass	N2O	11	17	0.00	1.00

1 A 4 b Residential	Liquid Fuels	N2O	11	16	0.00	1.00
4 A 6 Horses	Population size	CH4	14	15	0.00	1.00
4 F 5 Other	Residues Burning	CH4	16	15	0.00	1.00
1 B 2 a iii Transport	Liquid Fuels	CO2	12	15	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	N2O	15	15	0.00	1.00
1 A 2 b Non-ferrous Metals	Gaseous Fuels	CO2	0	13	0.00	1.00
1 A 2 f Other	Liquid Fuels	N2O	11	13	0.00	1.00
3 B DEGREASING AND DRY CLEANING	Degreasing and Dry Cleaning	CO2	12	12	0.00	1.00
1 A 1 b Petroleum refining	Liquid Fuels	N2O	9	11	0.00	1.00
4 A 7 Mules and Asses	Population size	CH4	24	9	0.00	1.00
1 A 3 c Railways	Liquid Fuels	N2O	11	8	0.00	1.00
1 A 2 c Chemicals	Liquid Fuels	N2O	4	8	0.00	1.00
1 A 3 a ii Domestic	Jet Kerosene	N2O	5	8	0.00	1.00
1 A 2 f Other	Gaseous Fuels	N2O	0	8	0.00	1.00
2 B 5 Etileno (Borealis)	Production Quantities	CO2	7	7	0.00	1.00
1 A 4 a Commercial / Institutional	Liquid Fuels	N2O	2	7	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	CO2	5	7	0.00	1.00
2 F 7 Electrical Equipment	Consumption	SF6	0	7	0.00	1.00
2 B 5 Carbon black	Production Quantities	CH4	3	6	0.00	1.00
2 F 2 Foam Blowing	Consumption	HFCs	0	6	0.00	1.00
1 A 2 f Other	Biomass	CH4	5	5	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Biomass	N2O	5	5	0.00	1.00
1 A 2 f Other	Liquid Fuels	CH4	3	5	0.00	1.00
2 B 5 Etileno (Borealis)	Production Quantities	CH4	5	4	0.00	1.00
2 B 5 Explosivos e Anid. Ftálico	Production Quantities	CO2	4	4	0.00	1.00
4 B 7 Mules and Asses	Population size	CH4	9	4	0.00	1.00
4 A 10 Other	Population size	CH4	4	4	0.00	1.00
1 A 3 a ii Domestic	Jet Kerosene	CH4	2	3	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	N2O	2	3	0.00	1.00
1 A 4 a Commercial / Institutional	Liquid Fuels	CH4	1	3	0.00	1.00
4 B 6 Horses	Population size	CH4	3	3	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CH4	3	3	0.00	1.00
1 A 2 d Pulp, Paper and Print	Liquid Fuels	N2O	2	3	0.00	1.00
2 C 2 Ferroalloys Production	Production Quantities	CO2	3	3	0.00	1.00
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CH4	2	3	0.00	1.00
1 A 2 f Other	Solid Fuels	N2O	4	2	0.00	1.00
1 A 1 b Petroleum refining	Liquid Fuels	CH4	2	2	0.00	1.00
4 F 1 Cereals	Residues Burning	N2O	3	2	0.00	1.00
2 B 5 Produção de Monómeros e Polimeros Orgânicos	Production Quantities	CO2	2	2	0.00	1.00
1 A 2 c Chemicals	Liquid Fuels	CH4	1	2	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	N2O	0	2	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CH4	1	2	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CH4	1	2	0.00	1.00
1 A 2 a Iron and Steel	Solid Fuels	N2O	1	2	0.00	1.00
1 A 2 c Chemicals	Biomass	N2O	1	2	0.00	1.00
1 A 3 d ii National navigation	Gas/Diesel Oil	N2O	3	1	0.00	1.00
1 A 4 b Residential	Liquid Fuels	CH4	0.88887	1.18127	0.00	1.00
1 A 4 a Commercial / Institutional	Gaseous Fuels	N2O	0.59435	1.14024	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Biomass	CH4	1.25416	1.13831	0.00	1.00
4 F 1 Cereals	Residues Burning	CH4	1.49590	1.05939	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	CH4	0.03875	1.05341	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CH4	0.68650	0.91862	0.00	1.00
1 A 2 c Chemicals	Other Fuels	N2O	0.43372	0.89700	0.00	1.00
1 A 2 a Iron and Steel	Other Fuels	CO2	3.06811	0.77979	0.00	1.00
1 A 2 c Chemicals	Gaseous Fuels	N2O	0.00000	0.75463	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Gaseous Fuels	N2O	0.00000	0.53994	0.00	1.00
1 A 2 f Other	Gaseous Fuels	CH4	0.00000	0.52989	0.00	1.00
1 A 2 f Other	Solid Fuels	CH4	1.03881	0.51853	0.00	1.00
1 A 2 d Pulp, Paper and Print	Gaseous Fuels	N2O	0.00000	0.45450	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	N2O	0.40511	0.44916	0.00	1.00
2 D 2 Food and Drink	Production Quantities	CO2	0.43657	0.43657	0.00	1.00
1 A 2 a Iron and Steel	Liquid Fuels	N2O	0.50132	0.41559	0.00	1.00
1 A 2 c Chemicals	Biomass	CH4	0.33113	0.39617	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Gaseous Fuels	CO2	0.00000	0.38803	0.00	1.00
1 A 2 a Iron and Steel	Gaseous Fuels	N2O	0.00000	0.36245	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	CH4	0.00025	0.35120	0.00	1.00
1 B 2 c I Oil	Liquid Fuels	CO2	0.27336	0.33648	0.00	1.00
1 A 3 d ii National navigation	Residual Oil	N2O	0.34933	0.32182	0.00	1.00
1 A 2 c Chemicals	Solid Fuels	N2O	0.09934	0.25382	0.00	1.00
1 A 3 d ii National navigation	Gas/Diesel Oil	CH4	0.66203	0.23213	0.00	1.00
1 A 4 b Residential	Gaseous Fuels	CH4	0.00000	0.21733	0.00	1.00
1 A 2 a Iron and Steel	Solid Fuels	CH4	0.11925	0.20469	0.00	1.00
1 A 2 b Non-ferrous Metals	Biomass	N2O	0.19019	0.19186	0.00	1.00
1 A 2 b Non-ferrous Metals	Liquid Fuels	N2O	0.44993	0.18631	0.00	1.00
1 A 3 c Railways	Liquid Fuels	CH4	0.24900	0.18267	0.00	1.00
1 B 2 c I Oil	Liquid Fuels	CH4	0.09206	0.11331	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	CH4	0.08337	0.10899	0.00	1.00
1 A 2 b Non-ferrous Metals	Gaseous Fuels	N2O	0.00000	0.10435	0.00	1.00
1 A 2 a Iron and Steel	Liquid Fuels	CH4	0.12724	0.10374	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	CH4	0.00000	0.08485	0.00	1.00
1 A 4 a Commercial / Institutional	Gaseous Fuels	CH4	0.03451	0.06621	0.00	1.00
1 A 3 d ii National navigation	Residual Oil	CH4	0.06804	0.06268	0.00	1.00
1 A 2 c Chemicals	Other Fuels	CH4	0.02938	0.06076	0.00	1.00
1 A 2 c Chemicals	Solid Fuels	CH4	0.02307	0.05895	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	CH4	0.04901	0.05433	0.00	1.00
1 A 2 c Chemicals	Gaseous Fuels	CH4	0.00000	0.05112	0.00	1.00
1 A 2 b Non-ferrous Metals	Biomass	CH4	0.04494	0.04534	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	N2O	0.03034	0.03941	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Gaseous Fuels	CH4	0.00000	0.03658	0.00	1.00
1 A 2 d Pulp, Paper and Print	Gaseous Fuels	CH4	0.00000	0.03079	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Biomass	N2O	0.02500	0.02500	0.00	1.00
1 A 2 a Iron and Steel	Gaseous Fuels	CH4	0.00000	0.02455	0.00	1.00
1 A 2 b Non-ferrous Metals	Liquid Fuels	CH4	0.08930	0.02177	0.00	1.00

Tables A-2.13 – Tier 1 Trend assessment: 1990-2001

Tier 1 Trend Assessment (1990-2001)

IPCC SOURCE CATEGORIES	ACTIVITY	GHG	Base year Estimate (kton CO2 eq.) 1990	Current year Estimate (kton CO2 eq.) 2001	Trend Assess.	Contribution to Trend	Cumulative Total
1 A 3 b Road Transportation	Diesel Oil	CO2	4947	10532	0.03	0.14	0.14
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CO2	6364	5548	0.03	0.11	0.25
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	CO2	0	2267	0.02	0.08	0.34
1 A 2 f Other	Solid Fuels	CO2	1982	989	0.01	0.06	0.40
4 B 8 Swine	Population size	CH4	3028	2677	0.01	0.05	0.45
1 A 4 a Commercial / Institutional	Liquid Fuels	CO2	816	2323	0.01	0.04	0.50
1 A 2 f Other	Gaseous Fuels	CO2	0	1007	0.01	0.04	0.53
1 A 3 b Road Transportation	Gasoline	CO2	4303	6819	0.01	0.03	0.57
1 A 2 c Chemicals	Liquid Fuels	CO2	456	1538	0.01	0.03	0.60
4 D 1 Direct Soil Emissions	Input to soils	N2O	1573	1480	0.01	0.02	0.63
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CO2	7816	11317	0.01	0.02	0.65
4 D 3 Indirect Emissions	Input to soils	N2O	1591	1541	0.01	0.02	0.67
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CO2	1675	1656	0.01	0.02	0.70
4 D 2 Animal Production	Input to soils	N2O	1627	1612	0.01	0.02	0.72
1 A 3 d ii National navigation	Gas/Diesel Oil	CO2	433	153	0.00	0.02	0.74
4 A 1 a Dairy Cattle	Population size	CH4	846	746	0.00	0.02	0.75
2 B 1 Ammonia Production	Production Quantities	CO2	569	396	0.00	0.01	0.76
2 A 1 Cement Production	Production Quantities	CO2	3024	3754	0.00	0.01	0.78
6 C WASTE INCINERATION	Waste Incinerated	CO2	10	376	0.00	0.01	0.79
1 A 3 b Road Transportation	Gasoline	N2O	33	368	0.00	0.01	0.80
6 B 2 Domestic and Commercial wastewater	Wastewater	CH4	659	578	0.00	0.01	0.82
4 B 12 Solid Storage and Dry Lot	Animal Excretion	N2O	1045	1139	0.00	0.01	0.83
4 A 1 b Non-Dairy Cattle	Population size	CH4	980	1067	0.00	0.01	0.84
1 A 3 a ii Domestic	Jet Kerosene	CO2	794	1328	0.00	0.01	0.84
1 A 4 b Residential	Gaseous Fuels	CO2	0	232	0.00	0.01	0.85
1 A 2 f Other	Liquid Fuels	CO2	3227	4179	0.00	0.01	0.86
2 B 2 Nitric Acid Production	Production Quantities	N2O	603	606	0.00	0.01	0.87
6 A 3 Other	Industrial Waste Disposal on Land	CH4	1655	2435	0.00	0.01	0.88
1 A 4 b Residential	Biomass	CH4	343	297	0.00	0.01	0.88
4 A 3 Sheep	Population size	CH4	564	601	0.00	0.01	0.89
4 C 1 Irrigated	Culture Surface	CH4	256	181	0.00	0.01	0.89
1 B 2 b ii Transmission/ Distribution	Gaseous Fuels	CH4	3	153	0.00	0.01	0.90
1 B 2 d Other (Geothermal)	Energy Production	CO2	2	145	0.00	0.01	0.90
6 A 1 Managed Waste disposal	Municipal Waste Disposal on Land	CH4	18	165	0.00	0.01	0.91
1 A 2 b Non-ferrous Metals	Liquid Fuels	CO2	125	31	0.00	0.01	0.92
2 A 6 Road Paving with Asphalt	Production Quantities	CO2	168	346	0.00	0.00	0.92
6 A 2 Unmanaged Waste Disposal	Municipal Waste Disposal on Land	CH4	749	911	0.00	0.00	0.92
1 A 3 c Railways	Liquid Fuels	CO2	175	128	0.00	0.00	0.93
4 B 1 a Dairy Cattle	Population size	CH4	218	192	0.00	0.00	0.93
1 A 2 c Chemicals	Gaseous Fuels	CO2	0	98	0.00	0.00	0.93
1 A 1 b Petroleum refining	Liquid Fuels	CO2	1929	2722	0.00	0.00	0.94
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CO2	744	1090	0.00	0.00	0.94
1 A 2 a Iron and Steel	Liquid Fuels	CO2	163	152	0.00	0.00	0.94
1 A 2 e Food Processing, Beverages and Tobacco	Gaseous Fuels	CO2	0	70	0.00	0.00	0.95
1 A 3 b Road Transportation	Natural Gas	CO2	0	69	0.00	0.00	0.95
2 A 7 Other	Production Quantities	CO2	180	180	0.00	0.00	0.95
1 A 3 b Road Transportation	Diesel Oil	N2O	84	179	0.00	0.00	0.95
1 A 2 a Iron and Steel	Solid Fuels	CO2	476	713	0.00	0.00	0.96
1 A 2 d Pulp, Paper and Print	Gaseous Fuels	CO2	0	59	0.00	0.00	0.96
1 A 2 c Chemicals	Solid Fuels	CO2	45	119	0.00	0.00	0.96
4 A 4 Goats	Population size	CH4	90	65	0.00	0.00	0.96
2 F 1 Refrigeration and Air Conditioning Equipment	Consumption	HFCs	0	57	0.00	0.00	0.96
1 A 4 b Residential	Liquid Fuels	CO2	1630	2278	0.00	0.00	0.97
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	N2O	151	154	0.00	0.00	0.97
1 A 2 a Iron and Steel	Gaseous Fuels	CO2	0	47	0.00	0.00	0.97
1 A 2 c Chemicals	Other Fuels	CO2	63	130	0.00	0.00	0.97
1 A 4 a Commercial / Institutional	Gaseous Fuels	CO2	77	147	0.00	0.00	0.97
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CO2	828	1088	0.00	0.00	0.97
4 A 8 Swine	Population size	CH4	84	74	0.00	0.00	0.98
1 A 4 b Residential	Biomass	N2O	73	63	0.00	0.00	0.98
4 B 3 Sheep	Population size	CH4	113	120	0.00	0.00	0.98
3 A PAINT APPLICATION	Paint application	CO2	91	92	0.00	0.00	0.98
6 B 2 Domestic and Commercial wastewater	Wastewater	N2O	287	360	0.00	0.00	0.98
6 C WASTE INCINERATION	Waste Incinerated	N2O	1	31	0.00	0.00	0.98
4 B 10 Anaerobic	Animal Excretion	N2O	59	52	0.00	0.00	0.98
2 B 5 Carbon black	Production Quantities	CO2	51	97	0.00	0.00	0.98
3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING	Chemical manufacture and processing	CO2	86	90	0.00	0.00	0.98
3 D OTHER	Other Use of Chemicals	CO2	82	85	0.00	0.00	0.99
4 A 7 Mules and Asses	Population size	CH4	24	9	0.00	0.00	0.99
2 A 3 Limestone and Dolomite Use	Production Quantities	CO2	54	50	0.00	0.00	0.99
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	CO2	90	100	0.00	0.00	0.99
1 A 3 d ii National navigation	Residual Oil	CO2	44	41	0.00	0.00	0.99
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	N2O	0	18	0.00	0.00	0.99
4 B 4 Goats	Population size	CH4	26	19	0.00	0.00	0.99
6 B 1 Industrial Wastewater	Wastewater	CH4	164	208	0.00	0.00	0.99
6 B 1 Industrial Wastewater	Wastewater	N2O	161	205	0.00	0.00	0.99
4 F 5 Other	Residues Burning	N2O	34	31	0.00	0.00	0.99
1 A 2 b Non-ferrous Metals	Gaseous Fuels	CO2	0	13	0.00	0.00	0.99
2 C 3 Aluminium production	Production Quantities	CO2	17	36	0.00	0.00	0.99
4 B 11 Liquid Systems	Animal Excretion	N2O	24	21	0.00	0.00	0.99
1 B 2 a iv Refining/ Storage	Liquid Fuels	CO2	124	158	0.00	0.00	0.99
4 B 1 b Non-Dairy Cattle	Population size	CH4	38	42	0.00	0.00	0.99
4 B 7 Mules and Asses	Population size	CH4	9	4	0.00	0.00	0.99
1 A 2 f Other	Gaseous Fuels	N2O	0	8	0.00	0.00	0.99
4 F 5 Other	Residues Burning	CH4	16	15	0.00	0.00	1.00
1 A 3 c Railways	Liquid Fuels	N2O	11	8	0.00	0.00	1.00
1 A 3 b Road Transportation	Diesel Oil	CH4	9	20	0.00	0.00	1.00
2 F 7 Electrical Equipment	Consumption	SF6	0	7	0.00	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	N2O	15	15	0.00	0.00	1.00

1 A 2 f Other	Biomass	N2O	21	22	0.00	0.00	1.00
1 B 2 a v Distribution of Oil Products	Liquid Fuels	CO2	17	29	0.00	0.00	1.00
2 F 2 Foam Blowing	Consumption	HFCs	0	6	0.00	0.00	1.00
1 A 3 b Road Transportation	Gasoline	CH4	25	28	0.00	0.00	1.00
3 B DEGREASING AND DRY CLEANING	Degreasing and Dry Cleaning	CO2	12	12	0.00	0.00	1.00
1 A 4 a Commercial / Institutional	Liquid Fuels	N2O	2	7	0.00	0.00	1.00
1 A 2 f Other	Solid Fuels	N2O	4	2	0.00	0.00	1.00
4 A 6 Horses	Population size	CH4	14	15	0.00	0.00	1.00
1 A 3 d ii National navigation	Gas/Diesel Oil	N2O	3	1	0.00	0.00	1.00
1 A 2 a Iron and Steel	Other Fuels	CO2	3	1	0.00	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Solid Fuels	N2O	36	53	0.00	0.00	1.00
2 C 1 Iron and Steel Production	Production Quantities	CO2	15	24	0.00	0.00	1.00
2 B 5 Etileno (Borealis)	Production Quantities	CH4	5	4	0.00	0.00	1.00
1 A 2 d Pulp, Paper and Print	Biomass	CH4	19	23	0.00	0.00	1.00
2 B 5 Etileno (Borealis)	Production Quantities	CO2	7	7	0.00	0.00	1.00
1 A 2 c Chemicals	Liquid Fuels	N2O	4	8	0.00	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Biomass	N2O	5	5	0.00	0.00	1.00
4 F 1 Cereals	Residues Burning	N2O	3	2	0.00	0.00	1.00
1 B 2 a iv Refining/ Storage	Liquid Fuels	CH4	22	28	0.00	0.00	1.00
2 B 5 Carbon black	Production Quantities	CH4	3	6	0.00	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	N2O	0	2	0.00	0.00	1.00
1 A 4 a Commercial / Institutional	Liquid Fuels	CH4	1	3	0.00	0.00	1.00
1 A 2 f Other	Liquid Fuels	N2O	11	13	0.00	0.00	1.00
4 B 9 Poultry	Population size	CH4	29	42	0.00	0.00	1.00
1 A 3 a ii Domestic	Jet Kerosene	N2O	5	8	0.00	0.00	1.00
1 A 2 f Other	Biomass	CH4	5	5	0.00	0.00	1.00
2 B 5 Explosivos e Anid. Ftálico	Production Quantities	CO2	4	4	0.00	0.00	1.00
4 A 10 Other	Population size	CH4	4	4	0.00	0.00	1.00
1 A 1 b Petroleum refining	Liquid Fuels	N2O	9	11	0.00	0.00	1.00
1 B 2 a iii Transport	Liquid Fuels	CH4	13	17	0.00	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Liquid Fuels	CH4	3	3	0.00	0.00	1.00
1 A 2 d Pulp, Paper and Print	Biomass	N2O	11	17	0.00	0.00	1.00
6 C WASTE INCINERATION	Waste Incinerated	CH4	0	1	0.00	0.00	1.00
1 B 2 a iii Transport	Liquid Fuels	CO2	12	15	0.00	0.00	1.00
4 F 1 Cereals	Residues Burning	CH4	1	1	0.00	0.00	1.00
2 C 2 Ferroalloys Production	Production Quantities	CO2	3	3	0.00	0.00	1.00
1 A 2 c Chemicals	Liquid Fuels	CH4	1	2	0.00	0.00	1.00
1 A 2 f Other	Solid Fuels	CH4	1	1	0.00	0.00	1.00
2 B 5 Produção de Monómeros e Polimeros Orgânicos	Production Quantities	CO2	2	2	0.00	0.00	1.00
1 A 2 c Chemicals	Gaseous Fuels	N2O	0	1	0.00	0.00	1.00
4 B 6 Horses	Population size	CH4	3	3	0.00	0.00	1.00
1 A 3 d ii National navigation	Gas/Diesel Oil	CH4	1	0	0.00	0.00	1.00
1 A 3 a ii Domestic	Jet Kerosene	CH4	2	3	0.00	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Biomass	CH4	1	1	0.00	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Gaseous Fuels	N2O	0	1	0.00	0.00	1.00
1 A 2 f Other	Gaseous Fuels	CH4	0	1	0.00	0.00	1.00
1 A 2 d Pulp, Paper and Print	Gaseous Fuels	N2O	0	0	0.00	0.00	1.00
1 A 2 b Non-ferrous Metals	Liquid Fuels	N2O	0	0	0.00	0.00	1.00
1 A 4 b Residential	Liquid Fuels	N2O	11	16	0.00	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Gaseous Fuels	CO2	0	0	0.00	0.00	1.00
1 A 2 a Iron and Steel	Gaseous Fuels	N2O	0	0	0.00	0.00	1.00
1 A 3 b Road Transportation	Natural Gas	CH4	0	0	0.00	0.00	1.00
1 A 2 a Iron and Steel	Solid Fuels	N2O	1	2	0.00	0.00	1.00
1 A 4 a Commercial / Institutional	Gaseous Fuels	N2O	1	1	0.00	0.00	1.00
1 A 2 c Chemicals	Other Fuels	N2O	0	1	0.00	0.00	1.00
1 A 3 a ii Domestic	Aviation Gasoline	CO2	5	7	0.00	0.00	1.00
1 A 2 f Other	Liquid Fuels	CH4	3	5	0.00	0.00	1.00
1 A 2 a Iron and Steel	Liquid Fuels	N2O	1	0	0.00	0.00	1.00
1 A 2 d Pulp, Paper and Print	Liquid Fuels	N2O	2	3	0.00	0.00	1.00
1 A 2 c Chemicals	Biomass	N2O	1	2	0.00	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Liquid Fuels	CH4	1	2	0.00	0.00	1.00
1 A 4 b Residential	Gaseous Fuels	CH4	0	0	0.00	0.00	1.00
2 D 2 Food and Drink	Production Quantities	CO2	0	0	0.00	0.00	1.00
1 A 3 c Railways	Liquid Fuels	CH4	0	0	0.00	0.00	1.00
1 A 3 d ii National navigation	Residual Oil	N2O	0	0	0.00	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	N2O	2	3	0.00	0.00	1.00
1 A 2 c Chemicals	Solid Fuels	N2O	0	0	0.00	0.00	1.00
1 A 2 b Non-ferrous Metals	Gaseous Fuels	N2O	0	0	0.00	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	N2O	0	0	0.00	0.00	1.00
1 A 2 b Non-ferrous Metals	Liquid Fuels	CH4	0	0	0.00	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Gaseous Fuels	CH4	0	0	0.00	0.00	1.00
1 A 1 a Public Electricity and Heat Production	Solid Fuels	CH4	1	2	0.00	0.00	1.00
1 A 2 a Iron and Steel	Liquid Fuels	CH4	0	0	0.00	0.00	1.00
1 A 2 b Non-ferrous Metals	Biomass	N2O	0	0	0.00	0.00	1.00
1 A 2 c Chemicals	Biomass	CH4	0	0	0.00	0.00	1.00
1 A 2 c Chemicals	Gaseous Fuels	CH4	0	0	0.00	0.00	1.00
1 A 2 d Pulp, Paper and Print	Liquid Fuels	CH4	2	3	0.00	0.00	1.00
1 A 1 b Petroleum refining	Liquid Fuels	CH4	2	2	0.00	0.00	1.00
1 A 2 a Iron and Steel	Solid Fuels	CH4	0	0	0.00	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Gaseous Fuels	CH4	0	0	0.00	0.00	1.00
1 B 2 c I Oil	Liquid Fuels	CO2	0	0	0.00	0.00	1.00
1 A 4 b Residential	Liquid Fuels	CH4	1	1	0.00	0.00	1.00
1 A 2 d Pulp, Paper and Print	Gaseous Fuels	CH4	0	0	0.00	0.00	1.00
1 A 3 d ii National navigation	Residual Oil	CH4	0	0	0.00	0.00	1.00
1 A 2 c Chemicals	Solid Fuels	CH4	0	0	0.00	0.00	1.00
1 A 2 a Iron and Steel	Gaseous Fuels	CH4	0	0	0.00	0.00	1.00
1 A 2 c Chemicals	Other Fuels	CH4	0	0	0.00	0.00	1.00
1 A 4 a Commercial / Institutional	Gaseous Fuels	CH4	0	0	0.00	0.00	1.00
1 A 2 e Food Processing, Beverages and Tobacco	Liquid Fuels	CH4	1	1	0.00	0.00	1.00
1 A 2 b Non-ferrous Metals	Biomass	CH4	0	0	0.00	0.00	1.00
1 A 1 c Manufacture of Solid fuels and Other Energy Industries	Solid Fuels	CH4	0	0	0.00	0.00	1.00
1 B 2 c I Oil	Liquid Fuels	CH4	0	0	0.00	0.00	1.00
1 A 4 c Agriculture / Forestry / Fishing	Biomass	N2O	0	0	0.00	0.00	1.00
1 A 2 a Iron and Steel	Other Fuels	N2O	0	0	0.00	0.00	1.00
1 A 2 b Non-ferrous Metals	Gaseous Fuels	CH4	0	0	0.00	0.00	1.00