MINISTRY OF ENVIRONMENT AND ENERGY

GREECE'S INFORMATIVE INVENTORY REPORT (IIR) 2020

Submission under the UNECE Convention on Long-range Transboundary Air Pollution and Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants

ATHENS
FEBRUARY 2020

EXECUTIVE SUMMARY

ES.1 Reporting obligations under UNECE/LRTAP and Directive (EU) 2016/2284 (NEC Directive)

Greece's Informative Inventory Report (IIR) and the complete set of NFR tables (the latter are submitted in digital format only) represent Greece's official submission under the United Nations Economic Commission for Europe (UNECE) Convention on Long-rage Transboundary Air Pollution (LRTAP) and under Directive (EU) 2016/2284 (NEC Directive).

The Ministry of Environment and Energy (MEEN) is designated as single national entity with overall responsibility for CLRTAP/UNECE and NEC inventory. The preparation of the inventory is based on the existed National Greenhouse Gas Inventory System, after a streamlining effort of incorporating the processes of preparing emissions inventories into one. This report and NFR tables were prepared by the National Technical University of Athens (NTUA) / School of Chemical Engineering, which has the technical and scientific responsibility for the compilation of the annual inventory for all NFR sectors for the 2017 – 2020 submissions of CLRTAP/UNECE and NEC inventories.

As a Party to the UNECE/LRTAP Convention and under the NEC Directive, Greece is required to annually report data on emissions of air pollutants covered in the Convention and its Protocols:

- main pollutants: nitrogen oxides (NOx), non-methane volatile organic compounds (NMVOC), sulphur oxides (SOx), ammonia (NH3) and carbon monoxide (CO);
- particulate matter (PM): primary PM (fine particulate matter (PM2.5) and coarse particulate matter (PM10);
- priority heavy metals (HMs): lead (Pb), cadmium (Cd) and mercury (Hg);
- persistent organic pollutants (POPs): polychlorinated dibenzodioxins/dibenzofurans (PCDD/Fs), polycyclic aromatic hydrocarbons (PAHs), hexachlorobenzene (HCB) and polychlorinated bi-phenyls (PCBs).

From the 2017 submission onwards, Greece reports all pollutants included in the NFR14 reporting format from 1990 to the latest inventory year. Emissions of the years before 1990 were last updated and published in previous submissions (e.g. 2014 submission).

The Convention on Long-Range Transboundary Air Pollution (LRTAP) was ratified by Greece in 1983. The Convention has been extended by eight Protocols, of which Greece has ratified the 1994 Sulphur Protocol and the 1988 NOx Protocol:

- ✓ **1988 Sofia Protocol concerning the Control of Emissions of Nitrogen Oxides or their Transboundary Fluxes**: This Protocol requires as a first step, to freeze emissions of nitrogen oxides or their transboundary fluxes. The general reference year is 1987. The second step to the NOx Protocol requires the application of an effects-based approach to further reduce emissions of nitrogen compounds. Greece was successful in fulfilling the stabilisation target set out in the Protocol. As reported in previous submissions, the base year (1987) emissions are 340.89kt. It is concluded from this report and associated NFR tables that Greece since the year 2011 has been in compliance with the relevant provisions of the Protocol. Moreover, NOx emissions have a decreasing trend since 2008.

- ✓ **The 1994 Oslo Protocol on Further Reduction of Sulphur Emissions:** The Protocol sets emission ceilings until 2010 and beyond. In addition, Parties are required to take the most effective measures for the reduction of sulphur emissions, including, inter alia, measures to increase energy efficiency, the use of renewable energy, measures to reduce the sulphur content of fuels, and to apply best available control technologies. The Protocol also encourages the application of economic instruments for the adoption of cost-effective approaches to the reduction of sulphur emissions. Greece was successful in fulfilling the emission ceilings set out in the Protocol.

The IIR 2020 at hand complements the reported emission data by providing background information. It follows the template of the "Informative Inventory Report – IIR" as elaborated by the LRTAP Convention's "Task Force on Emission Inventories and Projections – TFEIP". The structure of this report follows closely the structure of Greece's National Inventory Report (NIR) submitted annually under the United Nations Framework Convention on Climate Change (UNFCCC) which includes a complete and comprehensive description of methodologies used for compilation of Greece's greenhouse gas inventory.

In addition, the report includes both detailed descriptions of methods, data sources and uncertainties and information on quality assurance and quality control (QA/QC) activities as well as analyses of emission trends.

The emission data presented in this report were compiled according to the revised 2016 Reporting Guidelines (ECE/EB.AIR.125) that were approved by the Executive Body for the UNECE/LRTAP Convention at its 36th session. The Guidelines also define the new format of reporting emission data (Nomenclature for Reporting – NFR (latest version of the templates 'NFR19 dated 18.11.2019)) as well as standards for providing supporting documentation which should ensure the transparency of the inventory.

The Greek inventory is complete with regard to reported gases, reported years and reported emissions from all sources, and also complete in terms of geographic coverage.

ES.2 Overview of emission trends

NOx emissions decreased from 403.52 kt in 1990 to 254.53 kt in 2018. The emissions in 2018 have been decreased by 36.9% and 46.6% compared to 1990 and 2005, respectively. This decrease is attributed to the increasing share of natural gas and RES technologies in energy mix; energy efficiency improvements of the conventional power production plants; and the renewal of vehicle fleet. Other reasons are the reduction of consumption of electricity and other fuels, due to the economic recession of the recent years.

NMVOC emissions decreased from 317.58 kt in 1990 to 150.09 kt in 2018. The emissions in 2018 have been decreased by 52.7% and 55.5% compared to 1990 and 2005, respectively. This decrease is attributed to the implementation of the Directives 1999/13/EC, 2004/42/EC and 2010/75/EU on the limitation of emissions of volatile organic compounds due to the use of organic solvents; the Directives 94/63/EC and 2009/126/EC on the control of volatile organic compound emissions resulting from the storage and distribution of petrol; and the reduction of emissions in the road transport sector, due to the renewal of vehicle fleet.

SOx emissions decreased from 483.79 kt in 1990 to 64.42 kt in 2018. The emissions in 2018 have been decreased by 86.7% and 88.3% compared to 1990 and 2005, respectively. The operation of desulphurisation plants at large power plants since 1998 and the increasing share of RES technologies and NG for electricity production resulted in the reduction of SO2 emissions from electricity generation. Reductions with respect to the sulphur content of liquid fossil fuels and the introduction of natural gas in the Greek energy system resulted in a reduction of SO2 emissions from manufacturing industry, transport and residential sectors.

NH3 emissions decreased from 90.43 kt in 1990 to 62.96 kt in 2018. The emissions in 2018 have been decreased by 30.4% and 18.3% compared to 1990 and 2005, respectively. The decreasing trend of NH3 emissions is mainly attributed to the decrease in animal population and the use of synthetic nitrogen fertilizers, which is due to the increase of organic farming and the impact of initiatives to promote good practice in fertilizer use.

Total PM2.5 emissions decreased from 55.87 kt in 1990 to 32.97 kt in 2018. The emissions in 2018 have been decreased by 41.0% and 47.6% compared to 1990 and 2005, respectively. This decrease is attributed to the increasing share of natural gas and RES technologies in energy mix; energy efficiency improvements of the conventional power production plants; and the renewal of vehicle fleet. Other reasons are the reduction of consumption of electricity and other fuels, due to the economic recession of the recent years.

ES.3 Key categories

To determine key categories, a trend and a level assessment have been carried out, which resulted in 8 identified key categories for NOx; 14 for NMVOC; 8 for SOx; 9 for NH3; and 10 for PM2.5. In the following table the identified key categories are listed.

Table 1. Key categories per pollutant in Greece for air emissions 2018

Pollutant	Key categories
NOx	1A1a; 1A2f; 1A2gviii; 1A3bi; 1A3bii; 1A3biii; 1A4cii; and 1A3dii
NMVOC	1A1b; 1A3bi; 1A3bii; 1A3biii; 1A3biv; 1A3bv; 1A4bi; 1A4cii; 1B1a; 1B2av; 2D3a; 2D3d; 2D3g; and 5A
SOx	1A1a; 1A1b; 1A2a; 1A2b; 1A2f; 1A2gviii; 1A3biii; and 1A4bi
NH3	1A3bi; 3B1b; 3B2; 3B3; 3B4gi; 3B4gii; 3Da1; 3Da2a; and 3Da3
PM2.5	1A1a; 1A2e; 1A2gviii; 1A3biii; 1A3dii; 1A4bi; 1A4cii; 2A5b; 2G; and 3F

ES.4 Recalculations in the inventory since the last submission

The recalculations compared to the previous submission (2019 submission) were driven by the results of the internal QA/QC checks and the recommendations of the 2019 NECD Comprehensive Review pursuant to the Directive on National Emissions Ceilings for certain Atmospheric Pollutants (Directive (EU) 2016/2284 or 'NECD'). Moreover, recalculations were also driven by internal QA/QC checks, ESD and UNFCCC reviews of the GHG inventory, in particular for the cases of air pollution emission source categories that are associated to the same activity data with GHG emission source categories.

The reasons for observed recalculations compared to previous submissions of NFR tables, can be classified as follows:

- Changes or refinements in methods.
- Inclusion of new sources.
- Allocation to another category.

- Correction of errors.
- Updated activity data.

ES.5 Improvement Process

An inventory improvement procedure is in place, which utilizes:

a) the recommendations from NECD review reports;

b) the findings of annual internal audits taken place by MEEN personnel; and

c) the output of key category analysis, uncertainty analysis and QA/QC procedures;

as a basis to prioritize, plan and materialize future improvements and recalculations. Details on the resulted recalculations and improvements planned per source/sink category have been presented in the respective chapters (Chapters 3 – 6). Information regarding the implementation of 2018 NECD Review recommendations is presented in Table 7-1, Table 7-2, Table 7-3 and Table 7-4.

ES.6 Differences with other reporting obligations

NEC Directive (EU) 2016/2284 sets out national emission reduction commitments for the pollutants SO2, NOx, VOC, NH3 and PM2.5. Greece uses the national emission totals calculated on the basis of fuel sold for compliance assessment under the NEC Directive.

The annual greenhouse gas reporting under the UNFCCC and the Kyoto Protocoll also requires the reporting of indirect GHGs (NOx, CO, NMVOC) and SO2 emissions based on fuel sold. The national UNFCCC total includes only domestic aviation emissions (LTO and cruise). In contrast to UNFCCC requirements, in national totals under the NEC Directive and the LRTAP Convention only emissions during LTO procedure are taken into account, whereas emissions during cruise are calculated but considered as memo items.

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1.1 National inventory background

The Ministry of Environment and Energy (MEEN) is the main governmental body entrusted with the development and implementation of environmental policy in Greece. MEEN is responsible, among others, for the formulation of policies concerning environmental protection, energy, climate change and forestry, for the coordination of implementation efforts and to ensure compliance with the current legislative framework. For this purpose, MEEN cooperates both with other competent ministries and with regional, prefectural and local authorities. Other ministries are responsible for integrating environmental policy and climate change targets within their respective fields

The Ministry of Environment and Energy (MEEN) administrates Greece's reporting obligations to the:

- Convention on Long-range Transboundary Air Pollution (LRTAP) of the United Nations Eco-nomic Commission for Europe (UNECE),
- United Nations Framework Convention on Climate Change (UNFCCC),
- European Commission (EC), and the
- European Environment Agency (EEA).

MEEN is designated as single national entity with overall responsibility for inventory preparation.

1.2 Institutional, legal and procedural arrangements

MEEN is responsible for the provision of information concerning the state of the environment in Greece in compliance with relevant requirements defined in international conventions, protocols and agreements.

The preparation of the Greek CLRTAP/UNECE and NEC emissions inventories is based on the existed National Greenhouse Gas Inventory System, after a streamlining effort of incorporating the processes of preparing emissions inventories into one. An overview of the organizational structure of the National Emmission Inventory System is presented in Figure 1-1.

The entities participating for the preparation of the CLRTAP/UNECE and NEC submission are:

- The **MEEN** designated as the national entity responsible for the national inventory, which keeps the overall responsibility, but also plays an active role in the inventory planning, preparation and management.

- The **National Technical University of Athens (NTUA) / School of Chemical Engineering**, which has the technical and scientific responsibility for the compilation of the annual inventory for all NFR sectors for the 2017 - 2020 submissions of CLRTAP/UNECE and NEC inventories.

- **Governmental ministries and agencies** through their appointed focal persons, ensure the data provision.

International or national associations, along with individual public or private industrial companies contribute to data providing and development of methodological issues as appropriate.

The legal framework defining the roles-responsibilities and the co-operation between the MEEN, NTUA and the designated contact points of the competent Ministries was formalized and updated by Joint Ministerial Decision 22993/2017 entitled "Structure and operation of the National Greenhouse Gases Inventory System". The above mentioned decision includes a description of each entity's responsibilities, concerning the inventory preparation, data providing or other relative information. This formal framework ensures the efficient collaboration between the entities involved, assuring the timely collection and quality of the activity data required and solving data access restriction problems raised due to confidentiality issues.

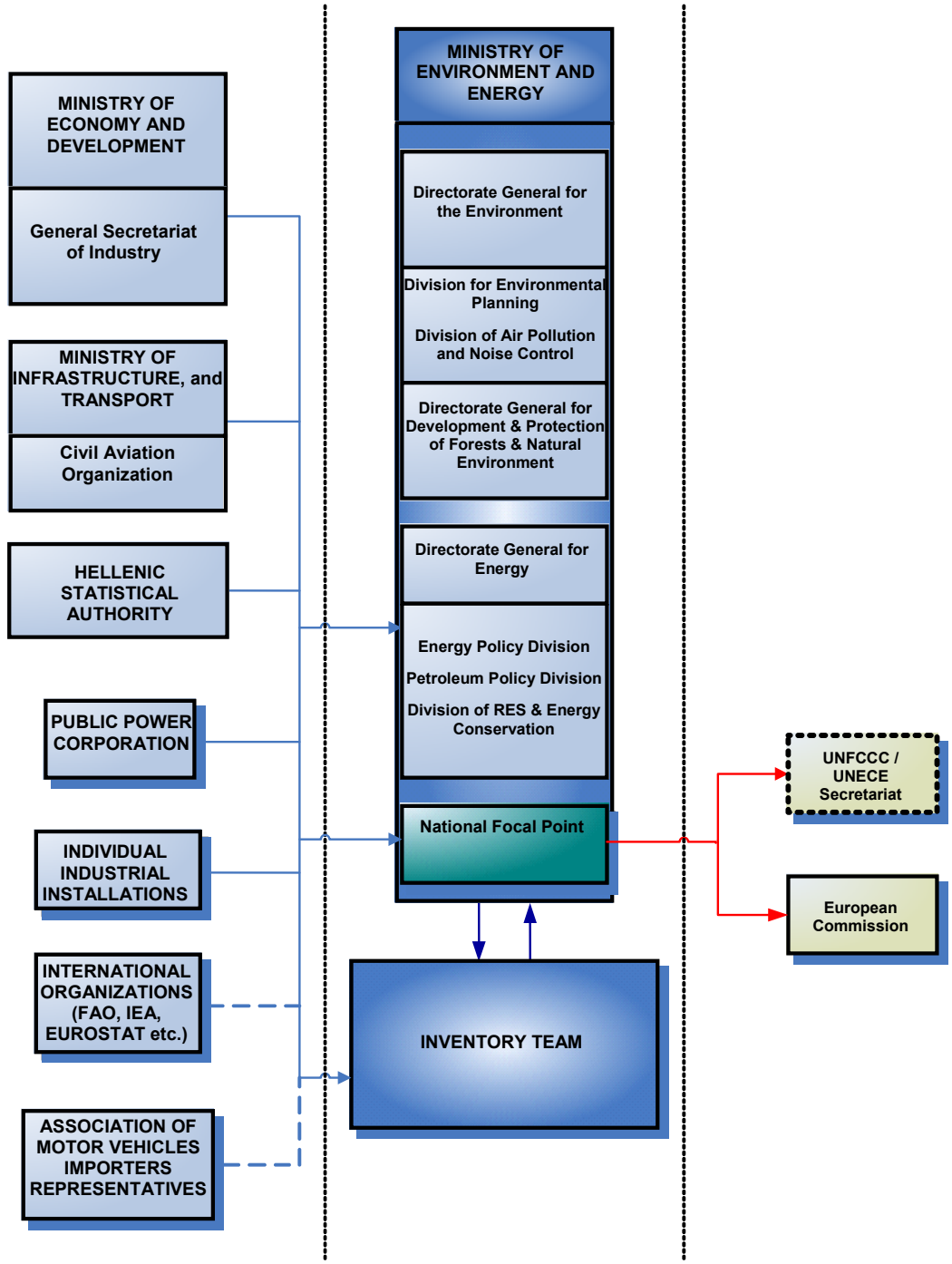

Figure 1-1 Organizational Structure of the National Inventory System

1.2.1 Roles and Responsibilities

1.2.1.1 Ministry of Environment and Energy

The Ministry of Environment and Energy, MEEN, has the overall responsibility, as the national entity, for the national GHG, CLRTAP/UNECE and NEC inventory. Among its responsibilities are the following:

- The co-ordination of all ministries and governmental agencies involved, as well as any relevant public or private organization. In this context, it oversees the operation of the National System and decides on the necessary arrangements to ensure compliance with relevant decisions.
- The official consideration and approval of the inventory prior to its submission.
- The response to any issues raised by the inventory review process, in co-operation with the technical consultant (NTUA), who have the technical and scientific responsibility for the inventory planning, preparation and management of the inventory, as mentioned above.
- The timely submission of the GHG, CLRTAP and NEC inventory to the European Commission and the UNFCCC / UNECE Secretariats.
- The keeping of the Centralised Inventory File, which is delivered to the inventory team which has the technical responsibility for the inventory planning, preparation and management (currently NTUA) at the beginning of each inventory cycle. The Centralised Inventory File is kept at the premises of the MEEN.
- The supervision of Quality Assurance/Quality Control Plan (QA/QC)

As it appears from the above description, the role of the MEEN is not narrowed to the co-ordination of the entities involved in the inventory process and to facilitate the activity data transfer from the data providers to the Inventory Team (NTUA). MEEN has an active role in monitoring and overseeing the inventory process through continuous communication and frequent scheduled and / or ad-hoc meetings with the Inventory Team (NTUA) and the competent ministries or other agencies involved.

1.2.1.2 National Technical University of Athens (NTUA) School of Chemical Engineering

The Ministry of Environment and Energy has assigned, on a contract basis, the National Technical University of Athens (NTUA) / School of Chemical Engineering as the national institution that has the technical and scientific responsibility for the planning, preparation and management of the

2017-2020 national inventories for all NFR sectors. In this framework, NTUA has the following responsibilities / tasks to fulfil for the inventory preparation:

1. Data collection (activity data and emission factors) for all source categories.
2. Reliability check of input data through
   - ✓ the comparison of the same or similar data from alternative data sources and
   - ✓ time-series assessment in order to identify changes that cannot be explained.
3. Selection of the appropriate methodologies according to the EMEP/EEA air pollutant emission inventory guidebook - 2019, preparation of air pollutant emissions estimates by applying the methodologies and models having been selected.
4. Data processing and archiving.
5. Assessment of the consistency of the methodologies applied, inventory improvement – recalculations.
6. Reliability check of results.
7. Key categories analysis.
8. Uncertainty assessment.
9. Preparation of the NFR tables.
10. Preparation of Informative Inventory Report (IIR).
11. Preparation and keeping of annual Centralised Inventory File.
12. Development of QA/QC procedures.
13. Implementing the QA/QC procedures under the supervision of MEEN.

The NTUA co-operates with a number of government agencies and other entities for the preparation of the inventory (see next section). It should be mentioned that this co-operation is not restricted to data collection but it also concerns methodological issues as appropriate.

The names and contact details of the NTUA inventory team follows:

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It should be mentioned that, whenever necessary, the above mentioned NTUA's Inventory Team is ad hoc supported by experts either from the NTUA or other institutions.

1.2.1.3 Government Ministries/ Government agencies

The following government agencies and ministries, develop and maintain, within their terms of operation, data sets and emission methodology information necessary for the estimation of air pollutant emissions / removals.

The co-operation with the following government agencies and other entities for the preparation of the inventory is indispensable, as those agencies and entities develop and maintain statistical data necessary for the estimation of GHG and air pollutant emissions / removals:

- The Ministry of Environment and Energy provides
    - annual data for energy consumption and production (more specifically: Energy policy division – Solid fuels and electricity; Petroleum policy division – Liquid and gaseous fuels; Division of RES and energy conservation – Renewable energy sources).
    - data for solid waste management (Department of Solid Waste Management) data for wastewater treatment (Cental Water Agency)
    - activity data and emissions for the installations included in the Emissions Trading system (Directorate of Climate Change and Air Quality)
    - data for f-gases use (Directorate of Climate Change and Air Quality)
    - data for emissions / removals from LULUCF activities (General Directorate for the Development and Protection of Forests and Agricultural Environment).
- The Hellenic Statistical Authority represents the main source of information for the estimation of emissions / removals from most of the IPCC source / sink categories.
- The Ministry of Economy and Development provides industry data
- The Ministry of Rural Development and Food provides information and data (through the Hellenic Statistical Authority which processes primary data collected by the Ministry) for the main indices and parameters of rural economy (e.g. animal population, cultivated areas, crops production, etc.).
- The Ministry of Infrastructure and Transport provides information and data for the vehicle fleet and its technical characteristics. The Civil Aviation Organization, supervised by the same Ministry provides information on Landing and Take-off cycles for both domestic and international aviation.

Data are also obtained from International Organizations as the United Nations Food and Agricultural Organization (FAO), the EUROSTAT, the International Iron and Steel Institute, the International Energy Association. These data are supplementary to the data collected from the aforementioned data providers.

Furthermore, other government organisations, associations, and individual public and private industrial companies contribute to data providing and development of methodological issues as appropriate. For example, data is provided from the National Oganization for Medicines, while data from the Association of Motor Vehicles Importers Representatives or the Hellenic Association of

Fertilizer professionals and traders are supplementary to the official data and are used in cases where official data are temporarily not available. Individual industrial companies / installations, either public or private, as Power Public Corporation, cement plants, etc, constitute an additional data source for the inventory preparation. However, these data are used as supplementary to the official data (e.g. for QC).

1.3 Inventory planning and preparation

1.3.1 CLRTAP/UNECE and NEC inventory, data collection, processing and storage

The preparation of the Greek air pollutant emissions inventory is based on the application of the EMEP/EEA air pollutant emission inventory guidebook – 2019.

The compilation of the inventory is completed in three main stages (Figure 1-2)*:*

Stage 1: The first stage consists of data collection and check for all source/sink categories. The main data sources used are the Hellenic Statistical Authority, the national energy balance, the government ministries/agencies involved and large private enterprises, along with the verified reports from installations under the EU ETS.

Quality control of activity data include the comparison of the same or similar data from alternative data sources (e.g. Hellenic Statistical Authority and ETS reports) as well as time-series assessment in order to identify changes that cannot be explained. In cases where problems and/or inconsistencies are identified, the agency's representative, responsible for data providing, is called to explain the inconsistency and/or help solving the problem.

Stage 2: Once the reliability of input data is checked and certified, emissions/removals per source/sink category are estimated. Emissions estimates are then transformed to the format required by the NFR tables. This stage also includes the evaluation of the emission factors used and the assessment of the consistency of the methodologies applied in relation to the provisions of the EMEP/EEA air pollutant emission inventory guidebook – 2019.

Quality control checks, when at this stage, are related to time-series assessment as well as to the identification and correction of any errors / gaps while estimating emissions / removals and filling in the NFR tables.

Stage 3: The last stage involves the compilation of the IIR and its internal (i.e. within technical consultants) check. The official approval procedure follows for one month period of interactions between the Inventory Team (NTUA) and MEEN. During this period, the Inventory Team has to revise the report according to the observations and recommendations of MEEN. On the basis of this interaction process, the final version of the report is compiled. MEEN, who supervises the National System, approves the inventory and then the MEEN submits the IIR to the European Commission and to the UNECE Secretariat.

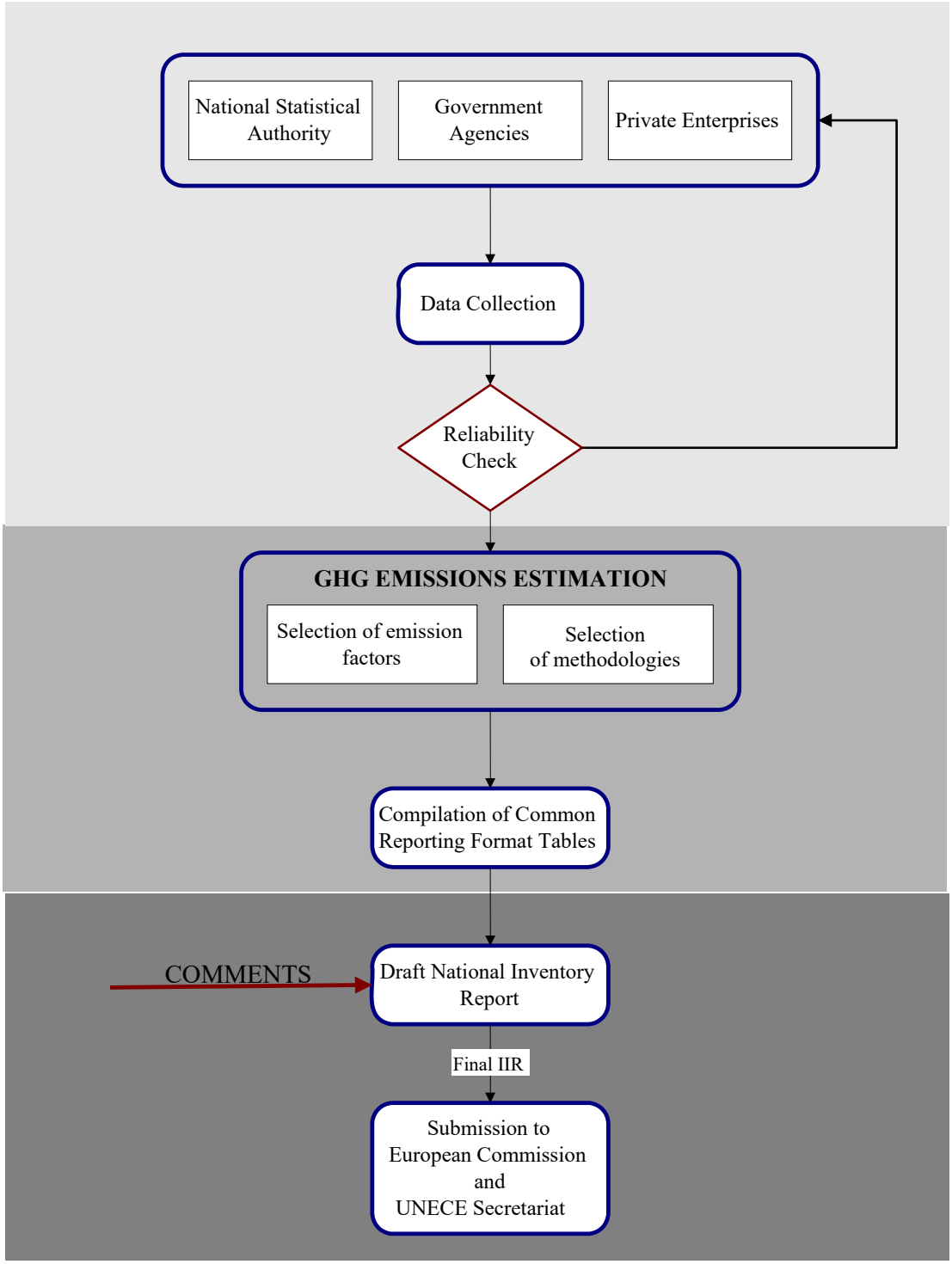

Figure 1-2 Air pollutant emissions inventory preparation process in Greece

The information that is related to the annual air-pollutant emissions inventory (activity data, emission factors, analytic results, compilation in the required analysis level of the NFR tables) is stored in MS Excel spreadsheets. Moreover, the final results (IIR and NFR tables) are available in the MEEN web site (http://www.ypeka.gr).

In addition, and within the context of the Quality Assurance/Quality Control system developed, a master file has been organized aiming at the systematic and safe archiving of inventory information.

1.4 Brief general description of methodologies and data sources used

1.4.1 Emission factors

The estimation of air pollutant emissions per source category is based on the methods described in the EMEP/EEA air pollutant emission inventory guidebook – 2019. The emission factors used derive from the above-mentioned methodological source and special attention was paid in selecting the emission factors that better describe practices in Greece. An overview of the methods applied for the calculation of emissions is presented at the beginning of each NFR sector's section.

The key categories analysis (see Paragraph 1.5) constitutes the basic tool for methodological choice and for the prioritisation of the necessary improvements. In addition, the results of the various review processes (at national, european and international level) represent key input information for the identification of possible improvements. It should be mentioned however, that data availability as well as availability of resources (both human and financial) also have to be considered.

- Data availability could become a significant restrictive parameter when selecting an estimation methodology. The accuracy and the consistency of the emissions estimated depend on the availability of the data needed for the correct application of the selected methodology.
- Availability of resources needs also to be considered as the searching for and the collection of the necessary data in order to apply a detailed methodology for a source category should not affect the completeness and the on-time preparation of an inventory submission.

1.4.2 Activity data

Data collection, processing and check constitute the activity with the longest duration in the annual inventory cycle. The duration of this activity is related to the amount of the necessary data and the number of the entities involved. The on-time and successful completion of this activity has a major effect on the timeliness preparation and submission of the inventory as well as on its accuracy, completeness and consistency.

Table 1-1 gives an overview of the main data sets used for the estimation of emissions. Data from international organizations and databases are supplementary to the data collected from the above data providers.

It should be noted that information and data collected (through questionnaires developed according to the guidelines described in the Commission Decision 2004/156/EC) in the framework of the formulation of the National Allocation Plan (NAP) for the period 2005 – 2007, according to the EU Directive 2003/87/EC (and its transposition to the national Law, JMD 2004) along with the data from the verified reports from installations under the EU ETS for years 2005-2019 constituted a significant source of information and an additional quality control check.

If available, exactly the same data, which have been used for the estimation of GHG emissions for UNFCCC reporting, were used for the estimation of emissions of air pollutants that are presented in this report and NFR tables. Other sources of activity data (e.g. the Hellenic Statistical Authority or EUROSTAT) were used, in the cases of categories that the GHG inventory submission to UNFCCC did not include any relevant data.

Table 1-1 Data sources and data sets per IPCC sector, source category

SECTOR		STATISTICAL DATA	DATA SOURCES
1.A1	Electricity generation	Fuel consumption	• Public Power Corporation • Ministry of Environment and Energy • ETS verified reports
1.A2	Manufacturing industry and construction	Fuel consumption	• Ministry of Environment and Energy • ETS verified reports
1.A3	Transport	Number of vehicles	• Ministry of Infrastructure and Transport • Hellenic Statistical Authority • Association of Greek Auto Importers
		Aircraft landing and take off cycles	• Civil Aviation Organization
1.A4	Residential / Tertiary sector / Agriculture	Fuel consumption	• Ministry of Environment and Energy
1.B	Fugitive emissions from fuels	Amount of fuels Transmission/distribution pipelines length	• Ministry of Environment and Energy
2	IPPU	Industrial production and Amount of solvents/other products use	• Hellenic Statistical Authority • Industrial units • ETS verified reports • Market surveys • National Association of Refrigerating and Cooling Technicians • Hellenic Aerosol Association • Public Power Corporation • National Organization of Medicines • Private companies
3	Agriculture	Cultivated areas Agricultural production Livestock population	• Hellenic Statistical Authority • Ministry of Rural Development and Food
		Fertilizer use	• UN Food and Agricultural Organisation • Hellenic Fertilizer' Association
5	Waste	Quantities - composition of solid waste generated Recycling Population Industrial production	• Ministry of Environment and Energy • Association of Communities and Municipalities in the Attica Region (ACMAR) • Hellenic Statistical Authority • UN Food and Agricultural Organisation

1.5 Brief description of key categories

1.5.1 General description

The identification of key categories is described in the "EMEP/EEA air pollutant emission inventory guidebook 2019". It stipulates that a key category is one that is prioritised with-in the national inventory system because its is significantly important for one or a number of air pollutants in a country's national inventory of air pollutants in terms of the absolute level, the trend, or the uncertainty in emissions.

Furthermore, it is good practice:

- ✓ to identify the national key categories in a systematic and objective manner. This can be achieved by a quantitative analysis of the relationship between the magnitude of emission in any year (level) and the change in emission year to year (trend) of each category's emissions compared to the total national emissions;

- ✓ to focus the available resources for improvement in data and methods on categories indentified as key. The identification of key categories in national inventories enables the limited resources available for preparing inventories to be prioritised; more detailed, higher tier meth-ods can the be slected for key categories. Invetory compilers should use the category specific methods presented in sectoral decision tress Iin the sectoral volumes;

- ✓ that the analysis should be performed at the level of NFR categories or subcategoreis at which the guidebook methods and decision trees are provided in the sectoral volumes. Where possible, some categories should be disaggregated by main fuel types;

- ✓ that each air pollutant emitted from each category should be considered separately;

- ✓ that for each key category, the inventory compiler should determine if certain subcategoreis are particulary significant usually, for this purpose, the subcategories should be ranked according to their contribution to the aggregate key categories. Those subcategoreis that contribute together more than 60% to the key category should be treated as particularly significant. It may be appropriate to focus efforts towards methodological improvements of these most significant subcategories.

All notations, descriptions of identification and results for key categories included in this chapter are based on the latest Inventory Guidebook (EEA 2019).

In this report, the identification of key categories covers all NFR categories and the following reported pollutants:

- ➢ Main pollutants: SO2, NOx, NMVOC, NH3

- Particulate matter: PM2.5

1.5.2 Used methodology for identification of key categories: Approach 1

The methodology follows the IPCC approach to produce pollutant-specific key categories and covers for both level and trend assessment. In Approach 1, key categories are identified using a predetermined cumulative emissions threshold. **Key categories are those which, when summed together in descending order of magnitude, cumulatively add up to 80% of the total level**.

The suggested aggregation level of analysis for Approach 1 provided in Table 2-1 of Chapter 2 of the EMEP/EEA emission inventory guidebook 2019 was used. No special considerations like disaggregation to main fuel types have been made. For reasons of transparency, the same level of aggregation for all pollutants was used.

The presented key category analysis was performed by NTUA with data for air emissions of the submission 2020 to the CLRTAP/UNECE and the European Commission. For all examined pollutants a level assessment for year 2018 (last year), as well as a trend assessment for 1990 to 2018 was prepared.

1.5.3 Results of the Level and Trend Assessment (Approach 1)

The results of the key category analysis for the pollutants SO2, NOx, NMVOC, NH3 and PM2.5 are presented in the following tables. More details are given in Annex I.

Table 1-2 Summary of KCA for NOx

NFR Code	Longname	Pollutant	Identification criteria
1A1a	Public electricity and heat production	NOx	L,T
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	NOx	L,T
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	NOx	T
1A3bi	Road transport: Passenger cars	NOx	L,T
1A3bii	Road transport: Light duty vehicles	NOx	L,T
1A3biii	Road transport: Heavy duty vehicles and buses	NOx	L
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	NOx	T
1A3dii	National navigation (shipping)	NOx	L,T

Table 1-3 Summary of KCA for NMVOC

NFR Code	Longname	Pollutant	Identification criteria
1A1b	**Petroleum refining**	NMVOC	L
1A3bi	Road transport: Passenger cars	NMVOC	L, T
1A3bii	Road transport: Light duty vehicles	NMVOC	L, T
1A3biii	Road transport: Heavy duty vehicles and buses	NMVOC	L
1A3biv	Road transport: Mopeds & motorcycles	NMVOC	L
1A3bv	Road transport: Gasoline evaporation	NMVOC	L, T
1A4bi	Residential: Stationary	NMVOC	L, T
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	NMVOC	T
1B1a	Fugitive emission from solid fuels: Coal mining and handling	NMVOC	L, T
1B2av	Distribution of oil products	NMVOC	L
2D3a	Domestic solvent use including fungicides	NMVOC	L, T
2D3d	Coating applications	NMVOC	L, T
2D3g	Chemical products	NMVOC	L, T
5A	Biological treatment of waste - Solid waste disposal on land	NMVOC	L, T

Table 1-4 Summary of KCA for SOx

NFR Code	Longname	Pollutant	Identification criteria
1A1a	Public electricity and heat production	SOx	L, T
1A1b	Petroleum refining	SOx	L, T
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	SOx	T
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	SOx	T
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	SOx	T
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	SOx	T
1A3biii	Road transport: Heavy duty vehicles and buses	SOx	T
1A4bi	Residential: Stationary	SOx	T

Table 1-5 Summary of KCA for NH3

NFR Code	Longname	Pollutant	Identification criteria
1A3bi	Road transport: Passenger cars	NH3	T
3B1b	Manure management - Non-dairy cattle	NH3	L, T

3B2	Manure management - Sheep	NH3	L
3B3	Manure management - Swine	NH3	L
3B4gi	Manure mangement - Laying hens	NH3	T
3B4gii	Manure mangement - Broilers	NH3	L,T
3Da1	Inorganic N-fertilizers (includes also urea application)	NH3	L,T
3Da2a	Animal manure applied to soils	NH3	L, T
3Da3	Urine and dung deposited by grazing animals	NH3	L,T

Table 1-6 Summary of KCA for PM2.5

NFR Code	Longname	Pollutant	Identification criteria
1A1a	Public electricity and heat production	PM2.5	L,T
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	PM2.5	L,T
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	PM2.5	T
1A3biii	Road transport: Heavy duty vehicles and buses	PM2.5	L,T
1A3dii	National navigation (shipping)	PM2.5	L,T
1A4bi	Residential: Stationary	PM2.5	L,T
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	PM2.5	T
2A5b	Construction and demolition	PM2.5	L
2G	Other product use (please specify in the IIR)	PM2.5	T
3F	Field burning of agricultural residues	PM2.5	L,T

1.6 Information on the QA/QC plan including verification and treatment of confidentiality issues where relevant

1.6.1 QA/QC procedures and verification activities

The development and the implementation of an inventory Quality Assurance / Quality Control (QA/QC) plan represents a key tool for meeting the objectives of National Systems under Article 5 Paragraph 1 of the Protocol as described in Decision 20/CP.7. The same Quality Assurance / Quality Control (QA/QC) plan is applied for the CLRTAP/UNECE and NEC inventories.

Quality management is essential in order to comply with the requirements of (a) producing transparent, consistent, comparable, complete and accurate emissions estimates, (b) establishing a reliable central archiving system concerning all necessary information for emissions inventories development and (c) compiling national reports according to the provisions of the adopted decisions.

In this framework, a QA/QC system is being implemented since April 2004. For the implementation of the QA/QC system the NTUA is responsible in close co-operation with the MEEN. The system is based on the ISO 9001:2000 standard and its quality objectives, as stated in the quality management handbook, are the following:

1. Compliance with the 2006 IPCC guidelines and the UNFCCC reporting guidelines while estimating and reporting emissions/removals.
2. Compliance with the EMEP/EEA air pollutant emission inventory guidebook – 2019 and the UNECE reporting guidelines while estimating and reporting emissions.
3. Continuous improvement of GHG and CLRTAP/UNECE / NEC emissions/removals estimates.
4. Timely submission of necessary information in compliance with relevant requirements defined in international conventions, protocols and agreements.

The accomplishment of the above-mentioned objectives can only be ensured by the implementation, from all the members of the Inventory Team (see Figure 1-3 for the flow chart of activities concerning emissions inventory), of the QA/QC procedures included in the plan for:

- data collection and processing,
- applying methods consistent with EMEP/EEA air pollutant emission inventory guidebook – 2019
- making quantitative estimates of inventory uncertainty,
- archiving information and record keeping and
- compiling national inventory reports.

The QA/QC system developed covers the following processes (see Table 1-7 for the list of procedures within each process):

- **QA/QC system management**, comprising all activities that are necessary for the management and control of the inventory agency in order to ensure the accomplishment of the above-mentioned quality objectives.
- **Quality control,** that is directly related to the estimation of emissions. The process includes activities related to (a) data inquiry, collection and documentation, (b) methodological choice in accordance with the 2006 IPCC Guidelines / EMEP/EEA air pollutant emission inventory guidebook – 2019, (c) quality control checks for data from secondary sources and (d) record keeping.
- **Archiving inventory information**, comprising activities related to centralised archiving of inventory information and the compilation of the national inventory report.
- **Quality assurance**, comprising activities related to the different levels of review processes including the review of input data from experts, if necessary, and comments from the public
- **Estimation of uncertainties**, defining procedures for estimating and documenting uncertainty estimates per source / sink category and for the whole inventory.
- **Inventory improvement**, that is related to the preparation and the justification of any recalculations made.

All the procedures described in the QA/QC manual are followed by both the MEEN and NTUA. As described in the chapters of the NIR/UNFCCC entitled "Source-specific QA/QC and verification", source-specific Tier 2 QC procedures are applied in the majority of source categories for quality control and verification purposes.

Furthermore, annual internal audits take place by MEEN/NTUA between January and March of each year and audits by independent local experts are planned and implemented.

Each year the EU prerfoms QA/QC checks (called initial checks) to its member states as a part of EU QA/QC system (UNFCCC inventory). These tests are preformed annually between 15/1 to 28/2. These checks have been designed to verify the transparency, accuracy, consistency, comparability and completeness of the information submitted and include: (a) an assessment whether all emission source categories and gases required under Regulation (EU) No 525/2013 are reported; (b) an assessment whether emissions data time series are consistent; (c) an assessment whether implied emission factors across Member States are comparable taking the IPCC default emission factors for different national circumstances into account; (d) an assessment of the use of 'Not Estimated' notation keys where IPCC tier 1 methodologies exist and where the use of the notation key is not justified in accordance with paragraph 37 of the UNFCCC reporting guidelines on annual greenhouse gas inventories as included in Annex I to Decision 24/CP.19; I an analysis of recalculations performed for the inventory submission, in particular if the recalculations are based on methodological changes; (f) a comparison of the verified emissions reported under the Union's

Emissions Trading System with the greenhouse gas emissions reported pursuant to Article 7 of Regulation (EU) No 525/2013 with a view of identifying areas where the emission data and trends as submitted by the Member State under review deviate considerably from those of other Member States; (g) a comparison of the results of Eurostat's reference approach with the Member States' reference approach; (h) a comparison of the results of Eurostat's sectoral approach with the Member States' sectoral approach; (i) an assessment whether recommendations from earlier Union or UNFCCC reviews, not implemented by the Member State could lead to a technical correction; (j) an assessment whether there are potential overestimations or underestimations relating to a key category in a Member State's inventory.

Moreover, EU carries out comprehensive reviews (similar to centralized UNFCCC reviews) of the national inventory data submitted by Member States. Two comprehensive reviews of the Greek inventory (all sectors except LULUCF) have been performed by EU, i.e. in 2012 and 2016.

Finally, in 2013, a Bilateral QA exercise between the Spanish and the Greek Inventory teams was performed. The Spanish inventory team reviewed the Agriculture, Waste and IPPU (F-gases) sectors of the Greek inventory. On the other hand, the Greek inventory team reviewed the industrial combustion, industrial processes and waste sectors of the Spanish inventory.

Table 1-7 ***Quality assurance / quality control procedures for the Greek emissions inventory***

Process	Procedure code	Procedures
Quality management	QM 01	System review
	QM 02	System improvement
	QM 03	Training
	QM 04	Record keeping
	QM 05	Internal reviews
	QM 06	Non compliance – Corrective and preventive actions
	QM 07	Supplies
	QM 08	Quality management system
	QM 09	Documents control
	QM 10	Internal communication
Quality control	QC 01	Data collection
	QC 02	Estimation of emissions / removals
	QC 03	Data quality control check
	QC 04	Input data record keeping
Archiving of inventory information	AI 01	Centralised archiving of inventory information
	AI 02	Compilation of reports
Quality assurance	QA 01	Expert review of input data and parameters
	QA 02	Expert review of emissions / removals inventory
	QA 03	Review from public
Estimation of uncertainties	EU 01	Uncertainty analysis
Inventory improvement	II 01	Recalculations management

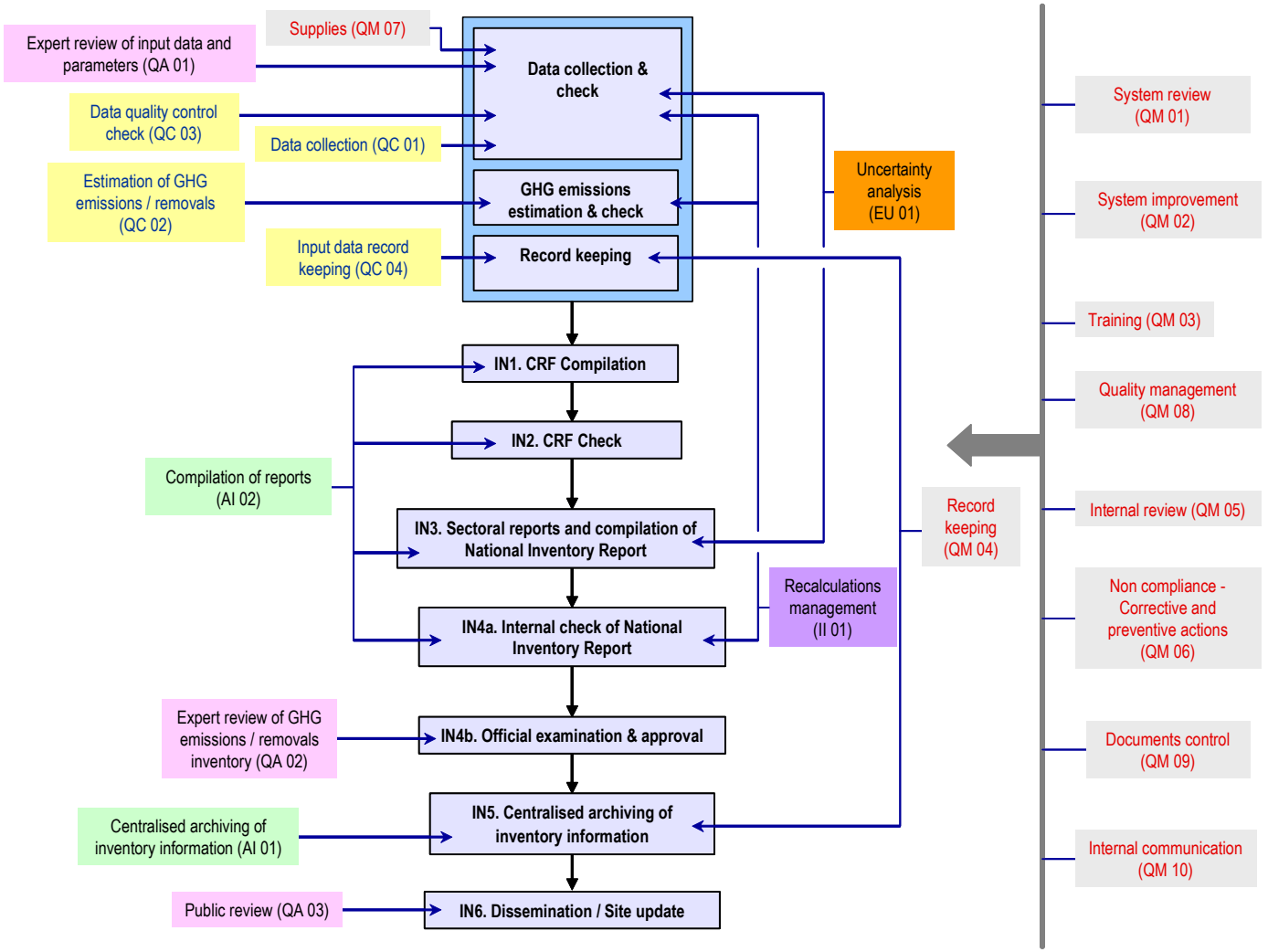

Figure 1-3 QA/QC processes and procedures and inventory related activities

1.6.2 Treatment of confidentiality issues

Confidentiality issues concern mainly the IPPU sector in cases were the activity data relate directly to the production activity of one plant. This is the case in a number of categories of the industrial processes sector.

The provision of data that are concerned as confidential is quite difficult, since these data are not published in the national statistics.

In the past, there were also procedures of confidential data exchange between the inventory team and the Hellenic Statistics Authority (El.Stat). More specifically, the cooperation established under this system contributed to the confidentiality waiver that was decided by the relevant committee of the Service in 2008. The received data have been entered in Greece's QA/QC input file and are constantly used as primary data or in QA/QC checks. Moreover, whenever a confidentiality issue arrises, the inventory system is working in close cooperation with the Prodcom Section of the El. Stat. throughout all the stages of the inventory preparation and during the reviews if necessary. It should be also mentioned that in any case, the El. Stat. provides the inventory team with all the information regarding the plant's id, information that has also been considered as confidential in the past. This enables the resolve of any sub-category completeness issues.

In the recent years, the most efficient way for collecting such information is by communicating directly to the respective plants, building a very good cooperation between the plants and the inventory team and ensuring that the published data are the most updated.

Finally, in a number of cases activity data are reported as confidential in the inventory files. This happens in cases when the inventory team has not received an official approval by the corresponding industry in order to publish direct activity data. It should be noted, however, that in any case the activity data are kept in the Input File of the inventory and are made available at any request during the review processes. For example, this has been the case for ferroalloys productions, when the only plant operating in Greece has not granted permission to publish the reported production data.

1.7 General uncertainty evaluation

In the 2020 submission, a quantitative uncertainty analysis for the main pollutants (SO2, NOx, NMVOC, NH3 and PM2.5) has been carried out. Information on methodology and data sources used is provided in the following sections.

1.7.1 Method used

The method used for the assessment of uncertainty is described in the "EMEP/EEA air pollutant emission inventory guidebook 2019".

In the Greek uncertainty analysis the Tier 1 method was applied for the following pollutants: SO2, NOx, NMVOC, NH3 and PM2.5. By using the error propagation method, the uncertainties for a specific source category can be estimated and by combining these uncertainties an overall uncertainty can be calculated.

The Tier 2 method (Monte Carlo Simulation) was not included in this assessment as the less comprehensive Tier 1 method already gives a clear reference point of the general uncertainty per pollutant.

1.7.2 Data source

In order to estimate the overall uncertainty, the uncertainty of activity data and emission factor, respectively, has to be quantified. The uncertainties of activity data on sectoral level are based on the GHG uncertainty analysis (for more information see NIR submission of Greece to UNFCCC).

Uncertainties of emission factors of the relevant pollutants are based on the qualitative ratings according to the EMEP/EEA air pol-lutant emission inventory guidebook 2019. Therefore the arithmetic mean value of the proposed upper and lower emission factor uncertainty was calculated and used for the calculation of the overall combined uncertainty.

The quality of estimates for all relevant pollutants has been rated using qualitative indicators as suggested in Chapter 5 of the EMEP/EEA air pollutant emission inventory guidebook 2019.

1.7.3 Results of uncertainty estimation

The quantitative uncertainty assessment was performed with the Tier 1 methods according to (EEA 2019) for the air pollutants SO2, NOx, NMVOC, NH3 and PM2.5 in the year 2018 and the respective level and trend uncertainties.

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

Table 1-8 Result of overall uncertainty estimation for the main pollutants SOx, NOx, NMVOC, NH3 and PM2.5.

Pollutant	Emissions 2018, kt	Level Uncertainty 2018, %	Trend Uncertainty 2018, %
NOx	254.53	34.68	11.58
NMVOC	150.09	42.30	9.52
SOx	64.58	14.10	0.65
NH3	62.96	70.43	24.79
PM2.5	32.97	103.95	21.08

A more detailed presentation of the uncertainties on sectoral level per pollutant is given in Annex II.

1.8 General assessment of the completeness

In the present inventory report, which supersedes all previous ones, estimates of air pollutant emissions in Greece for the years 1990-2018 are presented. Emissions estimates included in the NFR tables submitted and discussed in the present report, cover the whole territory of Greece. Emissions were not estimated (NE), only for categories and pollutants that there is no methodology included in the EMEP/EEA air pollutant emission inventory guidebook – 2019.

2. Trends

2.1 Overview

This chapter describes the trends and the drivers of air pollutant emissions, which Greece is obliged to report based on the Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants.

From the 2017 submission onwards, Greece reports all mandatory pollutants in the NFR14 reporting format from 1990 to the latest inventory year. Emissions of the years before 1990 were last updated and published in previous submissions (e.g. 2014 submission).

The Convention on Long-Range Transboundary Air Pollution (LRTAP) was ratified by Greece in 1983. The Convention has been extended by eight Protocols, of which Greece has ratified the 1994 Sulphur Protocol and the 1988 NOx Protocol:

- ✓ **1988 Sofia Protocol concerning the Control of Emissions of Nitrogen Oxides or their Transboundary Fluxes**: This Protocol requires as a first step, to freeze emissions of nitrogen oxides or their transboundary fluxes. The general reference year is 1987. The second step to the NOx Protocol requires the application of an effects-based approach to further reduce emissions of nitrogen compounds. Greece was successful in fulfilling the stabilisation target set out in the Protocol. As reported in previous submissions, the base year (1987) emissions are 340.89kt. It is concluded from this report and associated NFR tables that Greece since the year 2010 has been in compliance with the relevant provisions of the Protocol. Moreover, NOx emissions have a decreasing trend since 2008.

- ✓ **The 1994 Oslo Protocol on Further Reduction of Sulphur Emissions:** The Protocol sets emission ceilings until 2010 and beyond. In addition, Parties are required to take the most effective measures for the reduction of sulphur emissions, including, inter alia, measures to increase energy efficiency, the use of renewable energy, measures to reduce the sulphur content of fuels, and to apply best available control technologies. The Protocol also encourages the application of economic instruments for the adoption of cost-effective approaches to the reduction of sulphur emissions. Greece was successful in fulfilling the emission ceilings set out in the Protocol.

2.2 Description and interpretation of emission trends by gas

2.2.1 NOx

The trend of NOx emissions from 1990 to 2018 by source category is presented in Figure 2-1. Total NOx emissions decreased from 403.52 kt in 1990 to 254.53 kt in 2018. The emissions in 2018 have been decreased by 36.9% and 46.6% compared to 1990 and 2005, respectively. This decrease is attributed to the increasing share of natural gas and RES technologies in energy mix; energy

efficiency improvements of the conventional power production plants; and the renewal of vehicle fleet. Other reasons are the reduction of consumption of electricity and other fuels, due to the economic recession of the recent years.

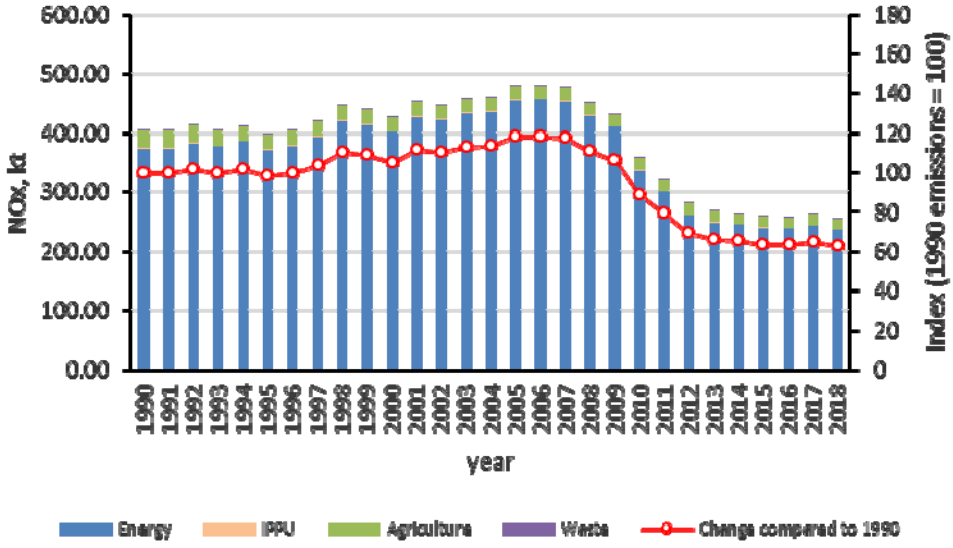

Figure 2-1 NOx emissions by sector (in kt) for the years 1990 – 2018

2.2.2 NMVOC

The trend of NMVOC emissions from 1990 to 2018 by source category is presented in Figure 2-2. Total NMVOC emissions decreased from 317.58 kt in 1990 to 150.09 kt in 2018. The emissions in 2018 have been decreased by 52.7% and 55.5% compared to 1990 and 2005, respectively. This decrease is attributed to the implementation of the Directives 1999/13/EC, 2004/42/EC and 2010/75/EU on the limitation of emissions of volatile organic compounds due to the use of organic solvents; the Directives 94/63/EC and 2009/126/EC on the control of volatile organic compound emissions resulting from the storage and distribution of petrol; and the reduction of emissions in the road transport sector, due to the renewal of vehicle fleet.

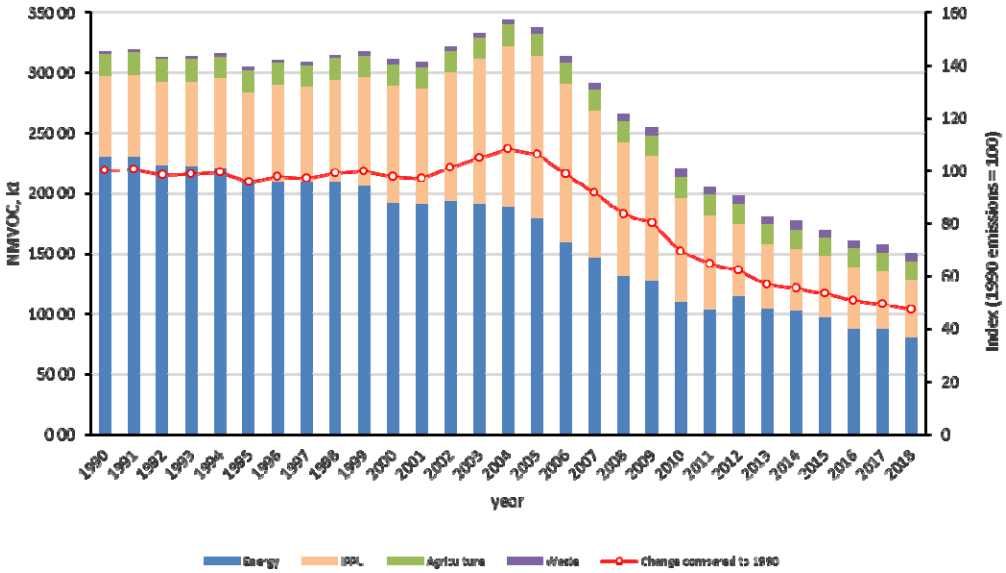

Figure 2-2 NMVOC emissions by sector (in kt) for the years 1990 – 2018

2.2.3 SOx

The trend of SOx emissions from 1990 to 2018 by source category is presented in Figure 2-3. Total SOx emissions decreased from 483.79 kt in 1990 to 64.42 kt in 2018. The emissions in 2018 have been decreased by 86.7% and 88.3% compared to 1990 and 2005, respectively. The operation of desulphurisation plants at large power plants since 1998 and the increasing share of RES technologies and NG for electricity production resulted in the reduction of SO2 emissions from electricity generation. Reductions with respect to the sulphur content of liquid fossil fuels and the introduction of natural gas in the Greek energy system resulted in a reduction of SO2 emissions from manufacturing industry, transport and residential sectors.

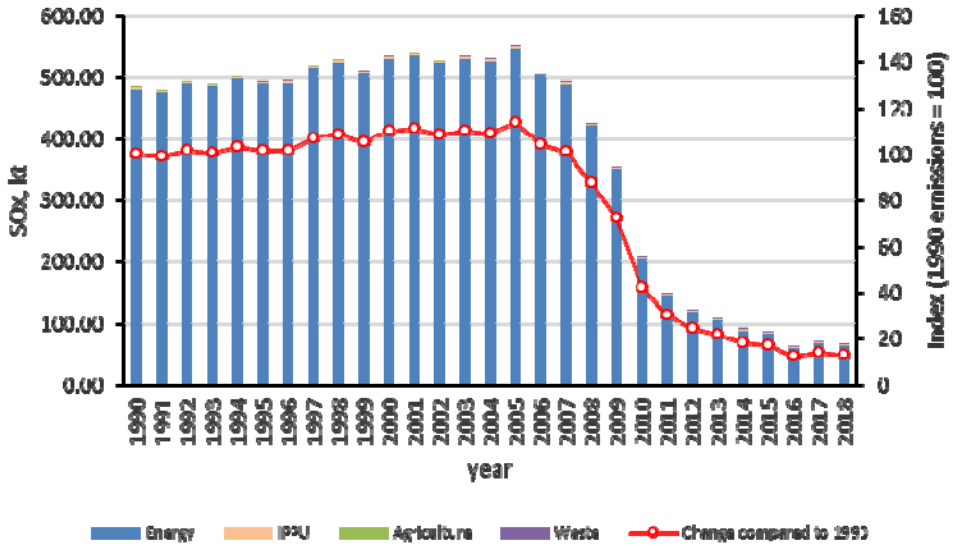

Figure 2-3 SOx emissions by sector (in kt) for the years 1990 – 2018

2.2.4 NH3

The trend of NH3 emissions from 1990 to 2018 by source category is presented in Figure 2-4. Total NH3 emissions decreased from 90.43 kt in 1990 to 62.96 kt in 2018. The emissions in 2018 have been decreased by 30.4% and 18.3% compared to 1990 and 2005, respectively. The decreasing trend of NH3 emissions is mainly attributed to the decrease in animal population and the use of synthetic nitrogen fertilizers, which is due to the increase of organic farming and the impact of initiatives to promote good practice in fertilizer use.

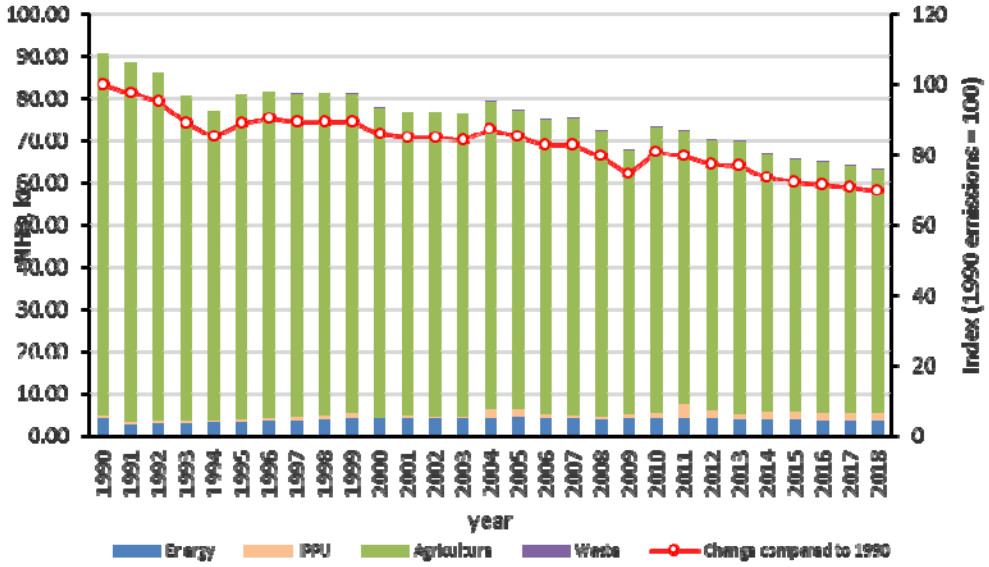

Figure 2-4 NH3 emissions by sector (in kt) for the years 1990 – 2018

2.2.5 PM2.5

The trend of PM2.5 emissions from 1990 to 2018 by source category is presented in Figure 2-5. Total PM2.5 emissions decreased from 55.87 kt in 1990 to 32.97 kt in 2018. The emissions in 2018 have been decreased by 41.0% and 47.6% compared to 1990 and 2005, respectively. This decrease is attributed to the increasing share of natural gas and RES technologies in energy mix; energy efficiency improvements of the conventional power production plants; and the renewal of vehicle fleet. Other reasons are the reduction of consumption of electricity and other fuels, due to the economic recession of the recent years.

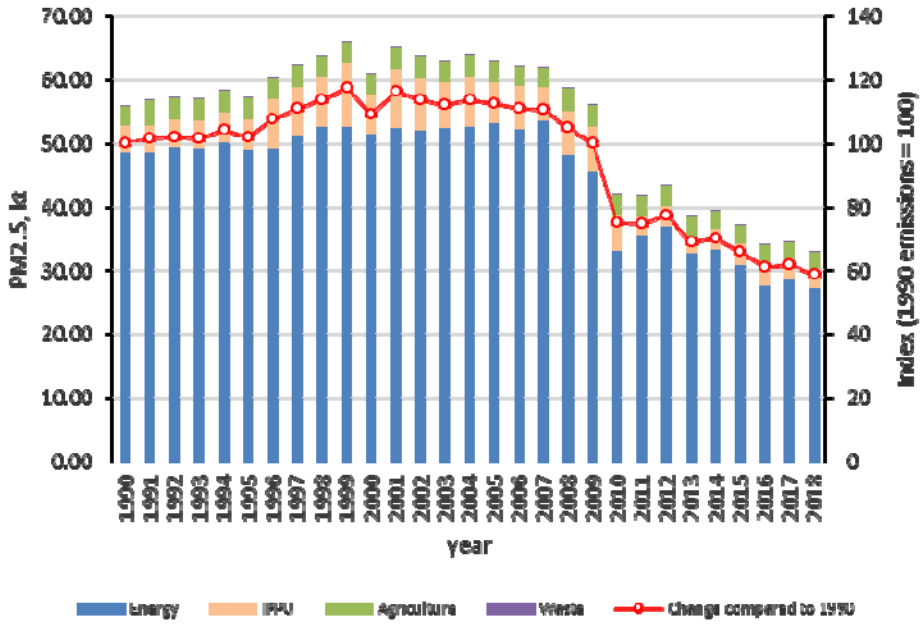

Figure 2-5 PM2.5 emissions by sector (in kt) for the years 1990 – 2018

2.2.6 Pb

The trend of Pb emissions from 1990 to 2018 by source category is presented in Figure 2-6. Total Pb emissions decreased from 504.13 t in 1990 to 10.60 t in 2018. The emissions in 2018 have been decreased by 97.9% and 83.9.3% compared to 1990 and 2005, respectively. This decrease is mainly attributed to the ban in use of leaded gasoline.

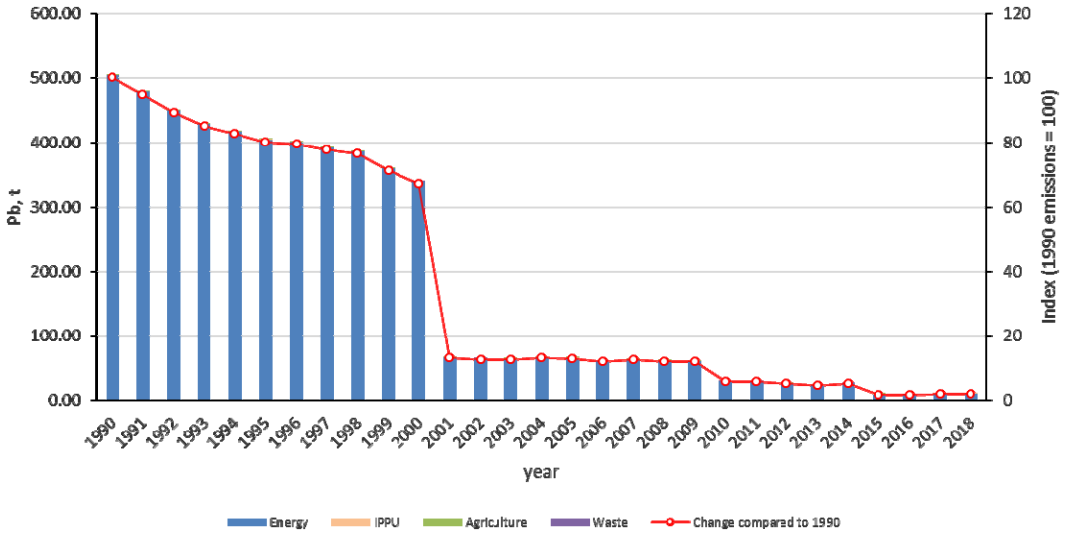

Figure 2-6 Pb emissions by sector (in kt) for the years 1990 – 2018

3. Energy (NFR sector 1)

Sector 1 Energy considers emissions originating from fuel combustion activities (NFR 1.A):

- 1.A.1 Energy Industries,
- 1.A.2 Manufacturing Industries and Construction,
- 1.A.3 Transport,
- 1.A.4 Other Sectors (commercial and residential),
- 1.A.5 Other,

as well as fugitive emissions from fuels (NFR 1.B):

- 1.B.1 Solid fuels,
- 1.B.2 Oil and natural gas.

3.1 NFR 1.A Stationary Fuel Combustion Activities

3.1.1 General description

This chapter gives an overview of category 1.A Stationary Fuel Combustion Activities. It includes information on completeness and planned improvements as well as on emissions, emission trends and methodologies applied (including emission facors).

Information is also provided in the Greek National Inventory Report 2020 and CRF tables which constitute the submission under the UNFCCC (https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/national-inventory-submissions-2019).

3.1.1.1 Completeness

Table 3-1 provides information on the status of emission estimates of all sub categories. A "√" indicates that emissions from this sub-category have been estimated. Emissions were not estimated (NE), only for categories and gases that there is no methodology included in the EMEP/EEA air pollutant emission inventory guidebook – 2019.

Emissions of 1A4aii are included under category 1A3b. Emissions of 1A4bii are included under category 1A4cii. Emissions of 1A4ciii are included under category 1A4cii. Finally, emissions of 1A5a are included under category 1A4ai.

3.1.1.2 Key Categories

Key category analysis is presented in Chapter 1.5. This chapter includes information on the Energy (stationary) sector. Key sources within this category are presented in Table 3-2.

3.1.1.3 Uncertainty Assessment

The method used for the assessment of uncertainty is according to the EMEP/EEA air pollutant emission in-ventory guidebook 2019 (EEA 2019). Further information on the uncertainty assessment of activity data can be found in Greece`s National Inventory Report. Where no specific information on uncertainties of emission factors was available, an average of the default values, based on the definitions of the qualitative ratings given in the EMEP/EEA Emission Inventory Guidebook 2019 is used. Please refer to chapter 1.7 for further information about uncertainty.

Table 3-1 Completeness of "1.A Stationary Fuel Combustion Activities".

NFR code	NOx (as NO2)	NMVOC	SOx (as SO2)	NH3	PM2.5	PM10	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/ PCDF (dioxins/ furans)	benzo(a) pyrene	benzo(b) fluoranthene	benzo(k) fluoranthene	Indeno (1,2,3-cd)	Total 1-4	HCB	PCBs
1A1a	√	√	√	NE	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
1A1b	√	√	√	NE	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	NE	NE
1A1c	√	√	√	NE	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	NE	NE
1A2a	√	√	√	NE	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	NE	NE
1A2b	√	√	√	NE	√	√	√	√	√	√	√	√	√	IE	√	IE	√	√	√	√	√	√	√	√	NE	NE
1A2c	√	√	√	NE	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	NE	NE
1A2d	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
1A2e	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
1A2f	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
1A2gvii	√	√	√	√	√	√	√	√	√	NE	√	NE	NA	√	√	√	√	√	NA	√	√	NA	NA	NA	NA	NA
1A2gviii	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
1A4ai	√	√	√	NO	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
1A4aii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1A4bi	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
1A4bii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1A4ci	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
1A4cii	√	√	√	√	√	√	√	√	√	√	√	√	NA	√	√	√	√	√	NA	√	√	NA	NA	NA	NA	NA
1A4ciii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1A5a	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

Table 3-2 Key sources of sector Energy (stationary).

NFR Code	Longname	Pollutant	Identification criteria
1A1a	Public electricity and heat production	NOx	L,T
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	NOx	L,T
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	NOx	T
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	NOx	T
1A1b	Petroleum refining	NMVOC	L
1A4bi	Residential: Stationary	NMVOC	L, T
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	NMVOC	T
1B1a	Fugitive emission from solid fuels: Coal mining and handling	NMVOC	L, T
1B2av	Distribution of oil products	NMVOC	L
1A1a	Public electricity and heat production	SOx	L, T
1A1b	Petroleum refining	SOx	L, T
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	SOx	T
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	SOx	T
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	SOx	T
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	SOx	T
1A4bi	Residential: Stationary	SOx	T
1A1a	Public electricity and heat production	PM2.5	L,T
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	PM2.5	L,T
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	PM2.5	T
1A4bi	Residential: Stationary	PM2.5	L,T
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	PM2.5	T

L = Level Assessment 2018

T = Trend Assessment 2018/1990

3.1.2 Methodological issues

Methodology and emission factors

Table 3-3 summarizes the methodology that is applied per pollutant and category. Some clarifications about this table:

- ✓ T1 refers to Tier 1 methodology with default EFs from EMEP/EEA air pollutant emission inventory guidebook 2019.
- ✓ T2 refers to Tier 2 technology specific activity data and EFs. The source of technology specific Tier 2 EFs is the EMEP/EEA air pollutant emission in-ventory guidebook 2019.
- ✓ T3/T2 refers to the combined use of Tier 3 facility data obtained from E-PRTR and/or through direct communication with the plants; and the application of Tier 2 technology specific activity data and EFs for the facilities that there are no plant specific data available through E-PRTR or other source.
- ✓ For the estimation of SO2 emissions from liquid fuels, a Tier 2/ CS EFs is applied, which is based on measurements of the sulphur content of oil products.
- ✓ For 1A1a, detailed technology specific AD are available for the whole time-series 1988-2018. Tier 3 facility emission data are also available from E-PRTR. Emissions estimation is based on plant specific emission data, if available through E-PRTR. For the pollutants and plants that Tier 3 data are not available, Tier 2 methodology was applied based on detailed technology specific AD, which were provided by PPC (Public Power Company of Greece).

Activity data

Exactly the same data, which have been used for the estimation of GHG emissions for UNFCCC reporting, were used for the estimation of emissions of air pollutants that are presented in this report and NFR tables. The energy data used for the calculation of emissions derived from the national energy balance and the reports of installations under the EU ETS. A description of the activity data is included in the National Inventory Report of Greece under the UNFCCC.

Table 3-3 Methodology that is applied per pollutant and category of sector Energy (stationary).

NFR code	NOx (as NO2)	NMVOC	SOx (as SO2)	NH3	PM2.5	PM10	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/ PCDF (dioxins/ furans)	benzo(a) pyrene	benzo(b) fluoranthene	benzo(k) fluoranthene	Indeno (1,2,3-cd) pyrene	Total 1-4	HCB	PCBs
1A1a	T3	T3/T2	T3	NE	T2	T3/T2	T2	T2	T3/T2	T3/T2	T3/T2	T3/T2	T3/T2	T3/T2	T3/T2	T3/T2	T2	T3/T2	T3/T2	T2	T2	T2	T2	T2	T2	T2
1A1b	T3/T2	T3/T2	T3/T2	NE	T3/T2	T3/T2	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	NE	NE
1A1c	T1	T1	T1	NE	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	NE	NE
1A2a	T1	T1	T2/CS EFs	NE	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	NE	NE
1A2b	T1	T1	T2/CS EFs	NE	T1	T1	T1	T1	T1	T1	T1	T1	T1	IE	T1	IE	T1	T1	T1	T1	T1	T1	T1	T1	NE	NE
1A2c	T1	T1	T2/CS EFs	NE	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	NE	NE
1A2d	T1	T1	T2/CS EFs	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
1A2e	T1	T1	T2/CS EFs	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
1A2f	T3/T2	T1	T2/CS EFs	T1	T3/T2	T3/T2	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
1A2gvii	T1	T1	T2/CS EFs	T1	T1	T1	T1	T1	T1	NE	T1	NE	NA	T1	T1	T1	T1	T1	T1	NA	T1	T1	NA	NA	NA	NA
1A2gviii	T1	T1	T2/CS EFs	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
1A4ai	T1	T1	T2/CS EFs	NO	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
1A4aii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1A4bi	T1/T2	T1/T2	T2/CS EFs	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2
1A4bii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1A4ci	T1	T1	T2/CS EFs	NE	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
1A4cii	T1	T1	T2/CS EFs	NE	T1	T1	T1	T1	T1	T1	T1	T1	NA	T1	T1	T1	T1	T1	NA	T1	T1	NA	NA	NA	NA	NA
1A4ciii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1A5a	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

3.1.3 NFR 1.A.1 Energy Industries

NFR Category 1.A.1 comprises emissions from fuel combustion for public electricity and heat production (NFR 1.A.1.a), in petroleum refining (NFR 1.A.1.b), and in manufacture of solid fuels and other energy industries (NFR 1.A.1.c).

For 2005–2018 activity data from the emission trading system (ETS) has been considered. ETS data fully covers category 1.A.1.b and 1.A.1.c and covers more than 99% category 1.A.1.a.

3.1.3.1 NFR 1.A.1.a Public Electricity and Heat Production

The calculation of the emissions from this sector was performed as described in section 3.1.2 and Table 3-3, which is a combination of Tier 2 and Tier 3 method. The allocation of energy consumption by technology was made on the basis of detailed technology specific AD, which were provided by PPC (Public Power Company of Greece) that cover the whole time-series 1988-2019. The plants that do not belong to PPC are natural gas fired plants of combined cycle technology. Therefore, based on this information, the Tier 2 method from 2019 GB can be easily applied (Tier 2 with default technology specific EF from 2019 GB). However, to increase the accuracy of the inventory, the Tier 2 method is combined with Tier 3 method.

Tier 3 facility emission data are available through E-PRTR. Reported emissions are based on plant specific emission data, if available through E-PRTR. For the years, the plants and the pollutants that E-PRTR data are available, it is considered that the emissions associated to these plants are as reported in the E-PRTR. For the plants and the respective pollutants that E-PRTR data were not available, Tier 2 method was applied.

For the years that E-PRTR emission data are not available, country specific EFs were estimated based on E-PRTR data of nearby years. In particular, for the last reported year, because E-PRTR data are not available by the time that the inventory was being compiled, IEF per fuel from nearby years were used. It is considered that the IEF based on previous years' E-PRTR data are more accurate compared to the default Tier 2 technology specific EF from 2019 GB. For the 2020 submission, plant specific data for NOx and SO2 for year 2018 were available and were used for the emissions estimation.

For the pollutants and plants that Tier 3 data were not available through E-PRTR for any year, Tier 2 methodology was applied based on the detailed technology specific AD (Tier 2 with default technology specific EF from 2019 GB).

Based on the above described analysis, Emission Factors per fuel (i.e. lignite, HFO, diesel and NG) are calculated. These IEF are applied to the total fuel quantity combusted in Greek power plants in order to ensure the completeness of the emissions of 1A1a.

Summarizing the allocation of energy consumption per technology, we can say that:

- Electricity production from lignite is produced exclusively by steam turbines.
- Natural gas is used mainly in combined cycle units and secondarily in gas turbines.
- Heavy fuel oil is used in gas turbines and in internal combustion engines (only in the islands' electricity systems).
- Diesel is used in gas turbines and in internal combustion engines in the islands' electricity systems.

Table 3-4 shows activity data of category 1.A.1.a.

Table 3-4 Fuel consumption (TJ) from NFR 1.A.1.a Public Electricity and Heat Production 1990–2018

Year	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass
1990	70,521	288,532	IE,NO	IE,NO
1991	76,296	275,344	IE,NO	IE,NO
1992	75,172	295,447	IE,NO	IE,NO
1993	76,860	293,710	IE,NO	IE,NO
1994	75,286	309,364	IE,NO	IE,NO
1995	81,418	295,241	IE,NO	IE,NO
1996	80,348	287,297	IE,NO	IE,NO
1997	77,849	315,696	1,913	IE,NO
1998	75,677	331,753	14,267	IE,NO
1999	78,260	325,642	35,735	19
2000	83,849	346,024	52,324	IE,NO
2001	78,003	353,854	51,586	1,300
2002	76,733	347,508	55,058	1,948
2003	84,273	351,573	61,215	1,149
2004	75,297	364,177	66,404	1,330
2005	82,692	363,954	64,764	1,156
2006	84,528	333,858	77,249	1,130
2007	86,798	348,960	103,081	1,465
2008	91,534	337,798	104,200	1,412
2009	70,046	335,399	75,756	2,288
2010	53,279	317,772	84,186	2,004
2011	50,073	322,769	108,432	3,048
2012	50,455	330,414	92,798	3,197
2013	45,035	292,551	82,455	2,992
2014	46,506	275,553	53,634	2,961
2015	47,564	237,197	55,131	3,181

2016	47,324	182,414	93,499	3,666
2017	52,509	204,777	109,465	3,710
2018	47,191	195,472	112,748	4,110

3.1.3.2 NFR 1.A.1.b Petroleum Refining

The inventory for the sector of petroleum refining includes emissions from the production of heat, steam and/or electricity in furnaces, gas turbines and internal combustion engines within the refineries as well as emissions from thermal cracking of heavy hydrocarbons. Additionally, emissions from fluid catalytic cracking/CO boiler and flaring are also included.

The calculation of the emissions from this sector was performed as described in section 3.1.2 and Table 3-3. The emissions of pollutants NOx, SOx, NMVOC and PM10 are based on Tier 3 facility emission data available from E-PRTR. For the years of the time-series that facility data (through E-PRTR) were not available, country specific emission factors (CS EFs) were applied. These CS EFs were determined by using the available E-PRTR data of the other years. The emissions of the other pollutants (except the four above-mentioned pollutants) were estimated by applying a Tier 1 method with default EFs from EMEP/EEA air pollutant emission in-ventory guidebook 2019. The activity data of the years 2005-2018 were obtained form the EU ETS reports, while the activity data for the years 1990-2004 from the national energy balance. Table 3-5 shows activity data of category 1.A.1.b.

Table 3-5 Fuel consumption (TJ) from NFR 1.A.1.b Petroleum Refining 1990–2018

Year	Liquid Fuels
1990	34,197
1991	34,215
1992	32,937
1993	33,178
1994	35,418
1995	35,994
1996	39,483
1997	40,307
1998	41,164
1999	37,372
2000	44,769
2001	45,781
2002	47,185
2003	45,394
2004	47,343
2005	53,136
2006	62,950

2007	63,902
2008	60,162
2009	55,493
2010	54,485
2011	50,429
2012	53,330
2013	72,803
2014	77,330
2015	76,712
2016	80,138
2017	71,471
2018	70,868

3.1.3.3 NFR 1.A.1.c Manufacture of Solid fuels and Other Energy Industries

The inventory for the other energy industries includes GHG emissions from the combustion of natural gas during oil and gas extraction. The annual variation of emissions is related to the changes of the primary production of crude oil and natural gas.

The calculation of the emissions from this sector was performed as described in section 3.1.2 and Table 3-3. The emissions of pollutants were estimated by applying a Tier 1 method with default EFs from EMEP/EEA air pollutant emission in-ventory guidebook 2019. The activity data of the years 2005-2017 were obtained form the EU ETS reports, while the activity data for the years 1990-2004 from the national energy balance. Table 3-6 shows activity data of category 1.A.1.b.

Table 3-6 Fuel consumption (TJ) from NFR 1.A.1.c Manufacture of Solid fuels and Other Energy Industries 1990–2018

Year	Gaseous Fuels
1990	1,737
1991	1,847
1992	1,603
1993	1,524
1994	1,756
1995	1,679
1996	1,769
1997	1,879
1998	1,424
1999	105
2000	1,771
2001	1,683
2002	1,776

2003	1,537
2004	1,855
2005	1,564
2006	1,640
2007	1,589
2008	1,566
2009	1,506
2010	862
2011	812
2012	800
2013	732
2014	584
2015	505
2016	595
2017	619
2018	745

3.1.4 NFR 1.A.2 Manufacturing Industry and Combustion

NFR Category 1.A.2 Manufacturing Industries and Construction comprises emissions from fuel combustion in the sub categories:

- Iron and steel (NFR 1.A.2.a),
- Non-ferrous metals (NFR 1.A.2.b),
- Chemicals (NFR 1.A.2.c),
- Pulp, paper and print (NFR 1.A.2.d),
- Food processing, beverages and tobacco (NFR 1.A.2.e),
- Non-metallic Minerals (NFR 1.A.2.f)
- Mobile Combustion in Manufacturing Industries and Construction (NFR 1.A.2.g.vii)
- Other Stationary Combustion in Manufacturing Industries and Construction (NFR 1.A.2.g.viii).

Exactly the same data, which have been used for the estimation of GHG emissions for UNFCCC reporting, were used for the estimation of emissions of air pollutants that are presented in this report and NFR tables. The energy data used for the calculation of emissions derived from the national energy balance and the reports of installations under the EU ETS. A description of the activity data is included in the National Inventory Report of Greece under the UNFCCC

The calculation of the emissions from this sector was performed as described in section 3.1.2 and Table 3-3. The emissions of all pollutants were estimated by applying a Tier 1 method with default EFs from EMEP/EEA air pollutant emission in-ventory guidebook 2019, with the following exceptions:

- SO2 from liquid fuels: for the estimation of SO2 emissions from liquid fuels, a Tier 2/ CS EFs is applied, which is based on measurements of the sulphur content of oil products (Table 3-7).

- PM2.5 emissions from cement plants were estimated by a Tier 3/2 method. A country specific PM2.5 EF was developed based on PM10 plant specific data, derived from E-PRTR data and applying the Tier 1 share of PM10:PM2.5 ratio from the 2019 EMEP/EEA Guidebook. The emissions were reported under category 2A1.

- Emissions of PMs from cement production are reported under category 2A1. The category1A2f includes PM2.5 and PM10 emissions that are associated with other production except cement. Given that the majority of solid fuels are used in the cement sector, the PM2.5 emissions reported under 1A2f resulted from the combustion of gaseous and liquid fuels, which have identical Tier 1 emission factors for PM2.5 and PM10.

- A Tier 3/2 method was applied to estimate NOx emissions from 1A2f category. A combined use of Tier 3 facility data obtained from E-PRTR; and the development of country specific EFs based on E-PRTR data, which are applied for the years that plant specific data are not available through E-PRTR was followed.

For the estimation of emissions for category 1A2gvii (off-road transport), detail fuel specific information on petroleum fuels were used after consultation with national energy balance compiler. More specific, the fuel consumption and associated emissions of the categories: “transport equipment”, “mining and quarrying” and “construction” were reported under category 1A2gvii. The emissions associated to stationary combustion (except non-metallic industries) were reported under 1A2gviii. Emissions associated to non-metallic industries were reported under 1A2f.

Table 3-7 SO2 emission factors of liquid fuels (2018)

Fue type	EF (kg SO2 / TJ)
HFO	1741.73
LowS FO	348.35

Diesel	46.16
LPG	40

3.1.5 NFR 1.A.3.e.1 Pipeline compressors

Category 1.A.3.e considers emissions from natural gas powered turbines used for natural gas pipelines transport. It is to be noted that all pollutants for years prior to 2001 and post 2011, were allocated to 1A4a or 1A2f as no activity data were provided separately in the energy balance.

Activity data is taken from the energy balance. The calculation of the emissions from this sector was performed as described in section 3.1.2 and Table 3 3. The emissions of all pollutants were estimated by applying a Tier 1 method with default EFs from EMEP/EEA air pollutant emission inventory guidebook 2019.

3.1.6 NFR 1.A.4 Other Sectors

Category 1.A.4 Other sectors enfolds emissions from stationary fuel combustion in the small combustion sector. It also includes emissions from mobile sources from agriculture and forestry.

Emissions from the residential – tertiary sector result from energy consumption for heat in order to cover the needs for the space heating, water heating etc. Thermal needs in these sectors are covered mainly by liquid fossil fuels, while the contribution of biomass (fuel wood), especially in the residential sector, is also significant (mainly in rural areas). The penetration of natural gas to the fuel mixture has an increasing trend.

In 2020 submission, the activity data of biomass consumption for the whole time-series were obtained from the national energy balance. In the previous submissions, the biomass data were obtained from the fuelwood statistics of the Ministry of Rural Development and Food. The change of the source of activity data was decided because the activity data from the national energy balance are more complete, since they cover all biomass sources and not only fuelwood from forests as the statistics from the Ministry of Rural Development and Food.

Emissions from agriculture result from combustion activities that are related to heating needs (e.g. space heating in greenhouses) and to agricultural machinery. Fuel consumption is not allocated to forestry or fisheries since the available information does not allow for such a disaggregation.

Energy needs are covered by diesel and heavy fuel oil in boilers and by lignite and biomass in other stationary equipment. Agricultural machinery uses diesel oil and gasoline. The distribution of

diesel consumption between thermal needs and machinery is kept constant during the whole period 1990 – 2018.

Emissions of 1A4aii are included under category 1A3b. Emissions of 1A4bii are included under category 1A4cii. Emissions of 1A4ciii are included under category 1A4cii. Finally, emissions of 1A5a are included under category 1A4ai.

The calculation of the emissions from this sector was performed as described in section 3.1.2 and Table 3-3. The emissions of all pollutants, with the exception of SO2 from liquid fuels, and the air pollutants from biomass combustion in the residential sector were estimated by applying a Tier 1 method with default EFs from EMEP/EEA air pollutant emission inventory guidebook 2019. For the estimation of SO2 emissions from liquid fuels, a Tier 2/ CS EFs is applied, which is based on measurements of the sulphur content of oil products. For the estimation of all air pollutants associated to the combustion of biomass in the residential sector, a Tier 2 method was applied from the EMEP/EEA air pollutant emission inventory guidebook 2019. The allocation of biomass consumption over the various appliance types was based on data from a biennial survey from the Hellenic Statistical Authority. The biomass consumption in the residential sector was split to the following appliance types: pellet stoves and boilers, open fireplaces, high efficient fireplaces, conventional stoves, high efficient stoves, and conventional boilers.

The activity data of categories 1.A.4.a.i, 1.A.4.b.i, 1.A.4.c.i and 1.A.4.c.ii are presented in Table 3-8, Table 3-9, Table 3-10 and Table 3-11, respectively.

Table 3-8 Fuel consumption (TJ) from NFR 1.A.4.a.i Commercial/Institutional: Stationary 1990–2018

Year	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass
1990	6,729	323	IE,NO	IE,NO
1991	9,012	321	IE,NO	IE,NO
1992	8,459	263	IE,NO	IE,NO
1993	8,082	241	IE,NO	IE,NO
1994	8,321	250	IE,NO	IE,NO
1995	9,011	227	IE,NO	IE,NO
1996	11,012	227	IE,NO	IE,NO
1997	10,658	IE,NO	238	IE,NO
1998	10,748	IE,NO	365	IE,NO
1999	10,370	IE,NO	311	IE,NO
2000	10,494	IE,NO	360	IE,NO
2001	13,565	IE,NO	510	IE,NO
2002	13,573	IE,NO	761	IE,NO
2003	14,669	IE,NO	1,158	IE,NO
2004	15,584	IE,NO	1,822	IE,NO

2005	18,767	82	3,074	213
2006	19,228	IE,NO	3,698	241
2007	17,374	IE,NO	4,395	64
2008	16,572	IE,NO	5,393	21
2009	12,460	IE,NO	6,063	46
2010	11,436	IE,NO	5,818	57
2011	9,737	IE,NO	6,899	91
2012	14,556	IE,NO	5,777	565
2013	7,728	IE,NO	5,219	916
2014	3,887	NO,IE	5,254	782
2015	4,686	NO,IE	6,978	1,352
2016	5,061	NO,IE	6,208	984
2017	5,237	NO,IE	6,325	784
2018	5,109	NO,IE	6,049	1,077

Table 3-9 Fuel consumption (TJ) from NFR 1.A.4.b.i Residential: stationary 1990–2018

Year	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass
1990	62,568	942	IE,NO	29,393
1991	62,899	1,303	IE,NO	29,393
1992	61,704	1,279	IE,NO	29,393
1993	61,238	1,265	IE,NO	29,393
1994	61,590	1,241	IE,NO	29,393
1995	64,739	1,158	IE,NO	29,393
1996	87,908	1,255	IE,NO	29,393
1997	91,853	1,386	IE,NO	29,393
1998	96,479	1,073	191	29,426
1999	94,842	666	163	29,393
2000	102,646	742	203	29,393
2001	110,582	698	219	29,393
2002	114,943	253	358	29,393
2003	136,443	153	783	29,393
2004	129,909	252	1,451	29,393
2005	132,412	122	3,022	29,393
2006	125,994	60	5,750	29,393
2007	111,830	73	7,394	31,696
2008	107,777	244	8,688	25,687
2009	92,966	152	10,715	22,611
2010	83,147	141	10,661	23,586
2011	97,051	187	14,571	31,179
2012	85,708	16	12,992	38,053
2013	41,639	37	9,732	32,439

2014	44,314	121	9,696	31,400
2015	57,380	237	14,892	32,831
2016	53,347	183	13,778	28,513
2017	52,501	185	15,100	29,108
2018	43,684	151	13,872	27,551

Table 3-10 Fuel consumption (TJ) from NFR 1.A.4.c.1 Agriculture/Forestry/Fishing: Stationary 1990–2018

Year	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass
1990	2,357	109	NO	NO
1991	2,119	137	NO	NO
1992	1,913	175	NO	NO
1993	1,645	218	NO	NO
1994	1,653	163	NO	NO
1995	1,377	218	NO	NO
1996	1,592	227	NO	NO
1997	1,591	165	NO	NO
1998	1,591	168	NO	NO
1999	1,591	260	NO	15
2000	1,591	286	NO	78
2001	1,724	265	NO	13
2002	1,828	NO	NO	13
2003	1,971	NO	NO	253
2004	1,866	NO	NO	345
2005	2,671	102	NO	483
2006	3,077	284	NO	443
2007	2,833	NO	NO	505
2008	2,856	NO	NO	420
2009	2,096	NO	NO	623
2010	1,099	NO	NO	624
2011	1,174	NO	NO	1,156
2012	5,236	NO	NO	1,471
2013	1,851	42	NO	1,076
2014	1,407	116	NO	1,034
2015	1,564	15	NO	1,156
2016	1,573	20	NO	1,142
2017	1,740	35	NO	1,141
2018	1,890	25	NO	1,203

Table 3-11 ***Fuel consumption (TJ) from NFR 1.A.4.c.2 Agriculture/ For-estry/Fishing: Off-road Vehicles and Other Machinery***

Year	Liquid Fuels
1990	36,944
1991	39,048
1992	36,226
1993	35,396
1994	35,645
1995	33,240
1996	33,696
1997	33,655
1998	33,655
1999	33,655
2000	33,655
2001	34,027
2002	37,387
2003	40,021
2004	34,006
2005	34,078
2006	35,572
2007	31,809
2008	30,942
2009	24,607
2010	21,873
2011	22,578
2012	6,831
2013	4,890
2014	4,972
2015	5,378
2016	4,440
2017	4,642
2018	4,599

3.1.7 Planned improvements

Based on the findings of EU internal audits and UNECE reviews, actions will be planned and executed that may lead to recalculations / improvements of the inventory of stationary combustion activities. Improvements that are associated to key categories will be prioritized. All recommendations from 2019 NEC review were implemented in this submission.

3.1.8 Recalculations

1A1a Public electricity and heat production / years 1990-2017 / PAHs, PCBs, HCB, Cd, Pb, PCDD/F: Emissions were recalculated based on the ratio of the Tier 2 EF of the pollutants PCDD/F, HCB, PAH, PCB, Cd and Pb compared to the EF of PM2.5, which is based on plant specific data. By this way, the effect of abatement technologies and the closure of old lignite-fired power plants during the rescent years of the time series (after 2009) is reflected on the emissions of these pollutants. This recalculation was made following the observation and recommendation of the 2019 TERT.

1A4bi Residentional: Stationary / years 1990-2017 / all pollutants: years 1990-2017 were recalculated by using a Tier 2 from the 2019 EEA GB. The biomass consumption was allocated to specific appliance types by the use of data from the Hellenic Statistical Authority. Moreover, a different source of activity data of biomass was used compared to previous submissions. In 2020 submission, the activity data of biomass consumption for the whole time-series were obtained from the national energy balance. In the previous submissions, the biomass data were obtained from the fuelwood statistics of the Ministry of Rural Development and Food. The change of the source of activity data was decided because the activity data from the national energy balance are more complete, since they cover all biomass sources and not only fuelwood from forests as the statistics from the Ministry of Rural Development and Food.

3.2 NFR 1.A Mobile Fuel Combustion Activities

3.2.1 NFR 1.A.3 Transport

NFR Category 1.A.3 comprises emissions from fuel combustion for transport activities as presented in the following Table 3-12. The methodology applied for calculations is presented in Table 3-14.

Aviation during LTO, road transportation, railways and national navigation are included in the transport sector. Emissions from international marine and aviation during cruise conditions are not included in national totals, but are calculated and reported separately as Memo items.

Total fuel consumed ranged from 194,357 TJ in 1990 to 234995 TJ in 2018. In Table 3-15 fuel consumption from transport in Greece is presented.

In general, activity data from the energy balance were considered in order to calculate emissions.

Key category analysis is presented in Chapter 1.5. This chapter includes information on the Energy (stationary) sector. Key sources within this category are presented in Table 3-13.

Activity data

Exactly the same data that were used for the estimation of GHG emissions for UNFCCC reporting have been used for the estimation of air pollutants presented in this report and NFR tables. The energy data used for the calculation of emissions derived from the national energy balance and the reports of installations under the EU ETS. A description of the activity data is included in the National Inventory Report of Greece under the UNFCCC.

Table 3-12 Transport activities taken into account for emission calculations.

H_Aviation	1A3ai(i)	International aviation LTO (civil)
H_Aviation	1A3aii(i)	Domestic aviation LTO (civil)
F_RoadTransport	1A3bi	Road transport: Passenger cars
F_RoadTransport	1A3bii	Road transport: Light duty vehicles
F_RoadTransport	1A3biii	Road transport: Heavy duty vehicles and buses
F_RoadTransport	1A3biv	Road transport: Mopeds & motorcycles

F_RoadTransport	1A3bv	Road transport: Gasoline evaporation
F_RoadTransport	1A3bvi	Road transport: Automobile tyre and brake wear
F_RoadTransport	1A3bvii	Road transport: Automobile road abrasion
I_Offroad	1A3c	Railways
G_Shipping	1A3di(ii)	International inland waterways
G_Shipping	1A3dii	National navigation (shipping)
I_Offroad	1A5b	Other, Mobile (including military, land based and recreational boats)

Memo Items

O_AviCruise	1A3ai(ii)	International aviation cruise (civil)
O_AviCruise	1A3aii(ii)	Domestic aviation cruise (civil)
P_IntShipping	1A3di(i)	International maritime navigation

Table 3-13 Key sources of sector Energy (transport activities).

NFR Category	Category Name	Pollutant	KS-assessment
1A3bi	Road transport: Passenger cars	NOx	L,T
1A3bii	Road transport: Light duty vehicles	NOx	L,T
1A3biii	Road transport: Heavy duty vehicles and buses	NOx	L
1A3dii	National navigation (shipping)	NOx	L,T
1A3bi	Road transport: Passenger cars	NMVOC	L, T
1A3bii	Road transport: Light duty vehicles	NMVOC	L, T
1A3biii	Road transport: Heavy duty vehicles and buses	NMVOC	L
1A3biv	Road transport: Mopeds & motorcycles	NMVOC	L
1A3bv	Road transport: Gasoline evaporation	NMVOC	L, T
1A3biii	Road transport: Heavy duty vehicles and buses	SOx	T
1A3bi	Road transport: Passenger cars	NH3	T
1A3biii	Road transport: Heavy duty vehicles and buses	NH3	T
1A3biii	Road transport: Heavy duty vehicles and buses	PM2.5	L,T
1A3bvi	Road transport: Automobile road abrasion	PM2.5	L
1A3dii	National navigation (shipping)	PM2.5	L,T

L = Level Assessment 2018

T = Trend Assessment 2018/1990

Table 3-14 Methodology that is applied per pollutant and category of sector Energy (mobile).

NFR code	NOx (as NO2)	NMVOC	SOx (as SO2)	NH3	PM2.5	PM10	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/ PCDF (dioxins/ furans)	benzo(a) pyrene	benzo(b) fluoranthene	benzo(k) fluoranthene	Indeno (1,2,3-cd)	Total 1-4	HCB	PCBs
1A3a	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
1A3b	T3	T3	T3	T3	T3	T3	T3	T3	T3	T3	T3	T3	T3	T3	T3	T3	T3	T3	T3	T3	T3	T3	T3	T3	T3	T3
1A3c	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
1A3d	T2	T1	T1	T1	T2	T2	T2	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
1A3e	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
1A5b	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1

Table 3-15 Fuel consumption (TJ) from NFR 1.A.3 Transport 1990–2018

Year	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass
1990	194357	NO	NO	NO
1991	205360	NO	NO	NO
1992	211245	NO	NO	NO
1993	213795	NO	NO	NO
1994	218093	NO	NO	NO
1995	222458	NO	NO	NO
1996	228500	NO	NO	NO
1997	237978	NO	NO	NO
1998	261491	NO	NO	NO
1999	265988	NO	NO	NO
2000	254070	NO	NO	NO
2001	265449	NO	NO	NO
2002	269820	NO	404	NO
2003	284525	NO	446	NO
2004	290326	NO	444	NO
2005	288420	NO	490	NO
2006	297117	NO	516	1958
2007	305904	NO	600	3588
2008	296958	NO	535	2897
2009	334309	NO	660	3266
2010	298060	NO	658	5355
2011	267715	NO	626	4444
2012	221690	NO	617	5355
2013	221740	NO	562	5203
2014	222329	NO	640	5659
2015	229651	NO	633	6808
2016	253939	NO	649	7225
2017	233631	NO	595	8036
2018	234995	NO	706,71	7698,78

3.2.2 NFR 1.A.3.a Aviation

Category 1.A.3.a considers emissions from aviation including international flights (NFR 1.A.3.ai) and domestic flights (NFR 1.A.3.aii). In national totals only emissions during LTO procedure are taken into account, whereas emissions during cruise are calculated but considered as memo items. The calculation of emissions from this sector was performed as described in section 3.2.1 and Table 3-14. Since 2005, emissions from aviation were taken from EUROCONTROL, based on the combination of energy consumption data and air traffic data (Tier 3 Method). For the period 1990-2004, adjustments have been carried out in order to ensure consistency with the EUROCONTROL methodology calculations. To this aim, the splicing technique applied is the surrogate method which was the most convenient for the case, according to the **EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019.** The data on energy consumption derive from the national energy balance and EUROCONTROL, while data on LTOs are provided by the Civil Aviation Organisation and EUROCONTROL.

In Table 3-16 fuel consumption from aviation (LTOs) in Greece is presented.

Table 3-16 Fuel consumption (TJ) from NFR 1.A.3.a Aviation 1990–2018

Year	Liquid Fuels	Liquid Fuels
	Domestic LTO	International LTO
1990	2479	4646
1991	2179	4438
1992	2397	5383
1993	2636	5616
1994	2645	6051
1995	2804	5906
1996	3008	5788
1997	3418	6301
1998	3477	6605
1999	4157	7371
2000	4617	7681
2001	4142	7393
2002	3559	7099
2003	4062	7511
2004	4932	7805
2005	1883	3475
2006	1938	3700
2007	2073	3962
2008	1959	3855
2009	2210	3672
2010	1937	3595
2011	1760	3699
2012	1618	3341
2013	1469	3493

2014	1575	4001
2015	1853	4142
2016	1920	4477
2017	1892	4881
2018	2049	5650

3.2.3 NFR 1.A.3.b Road Transport

Category 1.A.3.b considers emissions from road transport including emissions from all vehicle types, namely passenger cars, light duty vehicles, heavy duty vehicles and buses and mopeds and motorcycles. In this category non exhaust emissions as emissions from gasoline evaporation and tyre and break wear are also included.

The calculation of emissions from this sector was performed as described in section 3.2.1 and Table 3-14. For the estimation of emissions from road transportation the newer version of COPERT, COPERT 5 (Computer programme to calculate emissions from road transport - Users Manual, D. Gkatzoflias, L. Ntziachristos and Z. Samaras (LAT/AUTH)., 2007, ETC-ACC European Topic Centre on Air and Climate Change), was applied.

COPERT 5 is an MS Windows software program aiming at the calculation of air pollutant emissions from road transport. The technical development of COPERT is financed by the European Environment Agency (EEA), in the framework of the activities of the European Topic Centre on Air and Climate Change. Since 2007, the European Commission's Joint Research Centre has been coordinating and financing the further scientific development of the model. In principle, COPERT has been developed for use from the National Experts to estimate emissions from road transport to be included in official annual national inventories. In this version of COPERT hybrid vehicle fuel consumption and emission factors were introduced as well as N_2O/NH_3 emission factors for PCs and LDVs and heavy duty vehicle emissions calculation methodology.

The methodology applied is also part of the EMEP/CORINAIR Emission Inventory Guidebook. The Guidebook, developed by the UNECE Task Force on Emissions Inventories and Projections, is intended to support reporting under the UNECE Convention on Long-Range Transboundary Air Pollution and the EU directive on national emission ceilings. The COPERT 5 methodology is fully consistent with the Road Transport chapter of the Guidebook. The use of a software tool to calculate road transport emissions allows for a transparent and standardized, hence consistent and comparable data collecting and emissions reporting procedure, in accordance with the requirements of international conventions and protocols and EU legislation.

Basic data requirements for the application of the model include: (a) energy consumption by fuel type, (b) fuel characteristics, (c) the number of vehicles per vehicle category, engine size or weight and emission control technology, (d) other parameters such as: the mileage per vehicle class and per road class, the average speed per vehicle type and per road (urban, rural and highway) and (e) climatic conditions. Energy consumption and data on vehicles market (new and used vehicles,

withdrawn vehicles, type of vehicles etc.) are provided by the Hellenic Statistical Authority. The energy consumption as well as the associated emissions are calculated based on those data and a number of equations described in Ntziachristos and Samaras (2000). It is to be noted, that contrary to other methods based exclusively on fuel consumption, in these calculations emissions depend very much on the category of the vehicle, e.g. size and technology of the engine. Of course fuel characteristics have a decisive role on heavy metals and sulfur oxides emissions. However, it has to be noted that, especially during the economic crisis, changes in fuel consumption and kilometres driven has lead to discrepancies in the corresponding timeseries. Trends in kilometres driven is often related to fiscal, economic and social conditions. Greece has been in deep economic recession since 2008-2009, which aggravated after 2012. Emissions depend also on the fleet composition that changes through the years. In Greece, there has been an old car replacement programme from 2011-2016 which has lead to a "cleaner" fleet and, thus, for the same driving parameters and mileage, lower pollutant amounts were emitted. Especially concerning NO_X emissions from PCs, it should be noted that the following parameters interact: 1) The number of kilometres driven, 2) The car withdrawal programme, 3) The evolution of the recession deepening after 2011 and improving in 2015 to worsen again in 2016 and onwards. Finally, it has to be taken into account that newer, Euro V and Euro VI PCs have increased NOx enissions. As a combined result of these last parameters, there is an 18% decrease of PCs NO emissions in 2013 compared to 2012 and a slight increase of PCs NOx emissions in 2017 compared to 2015 and 2016 respective emissions. Hence, it can be concluded that emissions do not depend only on fuel consumption, as engines' technology plays an important role,they depend on various parameters resulting in non-linear relations among them. Emission calculations from road abrasion for the whole time series for PM2.5, PM10 and TSP were carried out by applying the EMEP Guidebook 2019 methodology.It is to be noted that, despite fuel consumption increases, all pollutants present a decreasing trend during the years as a result of newer and cleaner technology vehicles.

The calculation results have been published in peer reviewed scientific journals (Athena Progiou, Ioannis Ziomas (2011): Twenty-Year Road Traffic Emissions Trend in Greece, Water Air Soil Pollut DOI 10.1007/s11270-011-0859-9) and have been approved by measurements (Athena G. Progiou, Ioannis C. Ziomas (2011): Road traffic emissions impact on air quality of the Greater Athens Area based on a 20 year emissions inventory. Science of the Total Environment DOI information: 10.1016/ j.scitotenv.2011.09.050 and Ministry of Environment official reports). As from the above these emissions are not linearly related to FC. Finally, the fuel allocation from total to each vehicle category is not provided and assumptions have been made justifying thus some slight inaccuracies. However the whole fuel consumed is taken into account in the calculations. Biofuel is also taken into account and emissions from biofuel combustion are included in the total emissions for each vehicle category calculated by COPERT.

In Table 3-17 fuel consumption from road transport in Greece is presented.

Table 3-17 Fuel consumption (TJ) from NFR 1.A.3.b Road Transport 1990–2018

Year	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass
1990	161185	NO	NO	NO

1991	172677	NO	NO	NO
1992	176893	NO	NO	NO
1993	181013	NO	NO	NO
1994	183515	NO	NO	NO
1995	189417	NO	NO	NO
1996	198512	NO	NO	NO
1997	203096	NO	NO	NO
1998	213313	NO	NO	NO
1999	217089	NO	NO	NO
2000	219719	NO	NO	NO
2001	224516	NO	NO	NO
2002	232469	NO	404	NO
2003	246526	NO	446	NO
2004	248107	NO	444	NO
2005	254739	NO	490	NO
2006	260555	NO	516	1958
2007	271040	NO	600-	3588
2008	265138	NO	535	2897
2009	290341	NO	660	3266
2010	261712	NO	658	5355
2011	240136	NO	626	4444
2012	194129	NO	617	5355
2013	198080	NO	562	5203
2014	196178	NO	640	5659
2015	199646	NO	633	6680
2016	202833	NO	646	7139
2017	199322	NO	595	7955
2018	199981	NO	707	7623

3.2.4 NFR 1.A.3.c Railways

Air pollutant emissions from railways are calculated according to the default methodology proposed in EMEP EEA Air Pollutant Emission Inventory Guidebook (2019) Tier 1, which is based on the relative consumption of energy per fuel and the typical emission factors. Fuel consumption data used are provided by the national energy balance and are based on real fuel used. The national energy balance is the official energy balance provided by the Hellenic Statistical Authority and is also submitted to EUROSTAT. The fuel consumption fluctuations during the period 2010-2013 are related to the economic crisis and its subsequent post effects.

The calculation of emissions from this sector was performed as described in section 3.2.1 and Table 3-14.

In Table 3-18 fuel consumption from railways in Greece is presented.

Table 3-18 Fuel consumption (TJ) from NFR 1.A.3.c Railways 1990–2018

Year	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass
1990	2717	NO	NO	NO
1991	2113	NO	NO	NO
1992	2027	NO	NO	NO
1993	2070	NO	NO	NO
1994	2242	NO	NO	NO
1995	1854	NO	NO	NO
1996	1940	NO	NO	NO
1997	1811	NO	NO	NO
1998	2027	NO	NO	NO
1999	1765	NO	NO	NO
2000	1765	NO	NO	NO
2001	1765	NO	NO	NO
2002	1765	NO	NO	NO
2003	1765	NO	NO	NO
2004	1765	NO	NO	NO
2005	1750	NO	NO	NO
2006	1793	NO	NO	NO
2007	1622	NO	NO	NO
2008	1579	NO	NO	NO
2009	1322	NO	NO	NO
2010	855	NO	NO	NO
2011	641	NO	NO	NO
2012	1069	NO	NO	NO
2013	770	NO	NO	NO
2014	1838	NO	NO	NO
2015	1710	NO	NO	128
2016	1710	NO	NO	86
2017	1668	NO	NO	82
2018	1585	NO	NO	76

3.2.5 NFR 1.A.3.d Navigation

Nox, PM10, PM2.5 and TSP emissions from national navigation are calculated according to the default methodology proposed in EMEP EEA Air Pollutant Emission Inventory Guidebook (2019), which is based on the ship category and the type of engines (Tier 2 Method). The rest of emissions of this category are calculated according to Tier 1 Methology, which is included in EMEP EEA Air Pollutant Emission Inventory Guidbook (2019)
The calculation of emissions from this sector was performed as described in section 3.2.1 and Table 3-14.

In Greece, the AD (fuel consumption by fuel type) for navigation, separated between National and International navigation, NFR 1.A.3.dii and 1.A.3.di respectively, are obtained from the national energy balance, which is submitted to the EUROSTAT and other international statistics agencies. Hence, these data are verified and accepted as reliable. Additionally, data on the number of ships by engine type are obtained from EUROSTAT.
The consumption fluctuations are affected by the existing national economic conditions and international circumstances the complication of which overpasses the scope of the present NIR.

Except from National Navigation (NFR 1.A.3.dii), emissions from International Inland Waterways (NFR 1.A.3.di(ii)), a sub-category of International Navigation (NFR 1.A.3.di), are also included in the national totals. Nevertheless, this category of activity does not exist in Greece. International Maritime Navigation (NFR 1.A.3.di(i)) emissions are calculated as memo items and they are not included in the national totals.

In Table 3-19 fuel consumption from navigation in Greece is presented.

Table 3-19 Fuel consumption (TJ) from NFR 1.A.3.d Navigation 1990–2018

Year	Liquid Fuels	Liquid Fuels
	Domestic Navigation	International Navigation*
1990	23330	105347
1991	23952	96681
1992	24545	111031
1993	22460	129395
1994	23640	137062
1995	22477	147259
1996	19251	129612
1997	23352	129928
1998	36070	144526
1999	35606	128740
2000	20288	148693
2001	27633	144463
2002	24929	129872
2003	24660	132831

2004	27717	134212
2005	26573	118750
2006	29131	128197
2007	27207	133710
2008	24427	127898
2009	36765	108610
2010	29961	113376
2011	21479	115239
2012	21533	94163
2013	17929	88761
2014	18736	78040
2015	22299	74470
2016	23166	71489
2017	23718	88954
2018	25731	91117

**International maritime navigation is not taken into account in the national totals.*

3.2.6 NFR 1.A.5.b Other, Mobile (including military, land based and recreational boats)

In this category emissions from military aviation were included. As for military aviation there are no activity data included in the energy balance, for the period 2005-2018 the fuel consumption for civil aviation as given by EUROCONTROL was subtracted from the total aviation fuel consumption and the result was considered to be consumed for military flights. For the period 1990-2004 there are no data available to perform any calculations.

Tier 1 Method was applied and emission factors from EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019 were taken into account.

The calculation of emissions from this sector was performed as described in section 3.2.1 and Table 3-14.

3.2.7 Planned improvements

Based on the findings of EU internal audits and UNECE reviews, actions will be planned and executed that may lead to recalculations / improvements of the inventory of stationary combustion activities. Imrpovements that are associated to key categories will be prioritized.

3.2.8 Recalculations

Tyre and brake wear emissions recalculations for the period 1990-2017 were carried out due to a mistake found in data processing.

Automobile road abrasion emissions were recalculated for the years 2016 and 2017 due to a mistake found in data processing.

NOX emissions from National Navigation were recalculated for the period 1990-2017 so as to ensure consistency to Tier 2 methodology.

There has been a NMVOCs exhaust and evaporative emissions recalculation for the whole timeseries 2005-2017 for petrol vehicles, namely passenger cars, light duty vehicles and mopeds/motorcycles. The reason was that a range of petrol specifications as the NMVOCs composition and H-C ratio for petrol were wrongly imported and hence NMVOCs exhaust and evaporative emissions were affected for the whole period 2005-2017. For all other pollutants no substantial change was identified.

3.3 NFR 1.B Fugitive Emissions

Fugitive Emissions arise from the production and extraction of lignite (surface extraction), oil and natural gas; their storage, processing and distribution. These emissions are fugitive emissions and are reported in NFR Category 1.B. Emissions from fuel combustion during these processes are reported in NFR Category 1.A.

3.3.1 Completeness

Table 3-20 provides information on the status of emission estimates of all sub categories. A "√" indicates that emissions from this sub category have been estimated. Emissions were not estimated (NE), only for categories and gases that there is no methodology included in the EMEP/EEA air pollutant emission inventory guidebook – 2019.

Emissions of subcategory 1.B.2.c (flaring in oil refineries) was reported under 1.A.1.b subcategory.

3.3.2 Key Categories

Key category analysis is presented in Chapter 1.5. Key sources within this category are presented in Table 3-21.

3.3.3 Uncertainty Assessment

The method used for the assessment of uncertainty is according to the EMEP/EEA air pollutant emission in-ventory guidebook 2019 (EEA 2019). Further information on the uncertainty assessment of activity data can be found in Greece`s National Inventory Report. Where no specific information on uncertainties of emission factors was available, an average of the default values, based on the definitions of the qualitative ratings given in the EMEP/EEA Emission Inventory Guidebook 2019 is used. Please refer to chapter 1.7 for further information about uncertainty.

Table 3-20 Overview of sub categories of Category 1.B Fugitive Emissions and status of estimation.

NFR code	NOx (as NO2)	NMVOC	SOx (as SO2)	NH3	PM2.5	PM10	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/ PCDF (dioxins/ furans)	benzo(a) pyrene	benzo(b) fluoranthene	benzo(k) fluoranthene	Indeno (1,2,3-cd) pyrene	Total 1-4	HCB	PCBs
1B1a	NA	T2	NA	NA	T2	T2	T2	NE	NA	NE	NE	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
1B1b	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1B1c	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1B2ai	NA	T1	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA
1B2aiv	IE	IE	IE	T1	IE	IE	IE	NA	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	NA	NA	NA	NA	NA	NA	NA
1B2av	NA	T2	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA
1B2b	NA	T1	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA
1B2c	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1B2d	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 3-21 Key sources of sector 1.B Fugitive Emissions.

NFR Code	Longname	Pollutant	Identification criteria
1B1a	Fugitive emission from solid fuels: Coal mining and handling	NMVOC	L, T
1B2av	Distribution of oil products	NMVOC	L

L = Level Assessment 2018

T = Trend Assessment 2018/1990

3.3.4 NFR 1.B.1.a Coal mining and handling

Coal mining in Greece concerns exclusively the extraction of lignite. All lignite mines in Greece are surface mines and methane is emitted directly into the atmosphere, as the rock strata overlying the coal are removed during the process.

NMVOC, TSP, PM10 and PM2.5 emissions from lignite mining are calculated on the basis of lignite production and the use of Tier 2 EFs from the EMEP/EEA air pollutant emission inventory guidebook 2019. Both mining and handling emissions are reported.

The national energy balance is the basic source for the activity data (production of lignite, see Table) used for the calculation of emissions.

Table 3-22 Lignite production in Mt

Year	Lignite production (Mt)
1990	51.90
1991	52.70
1992	55.05
1993	54.82
1994	56.67
1995	57.66
1996	59.78
1997	58.84
1998	60.88
1999	62.05
2000	63.89
2001	66.34
2002	70.47
2003	68.30
2004	70.04

2005	69.40
2006	64.52
2007	66.46
2008	65.72
2009	64.89
2010	56.52
2011	58.67
2012	62.96
2013	53.92
2014	50.85
2015	46.25
2016	32.64
2017	37.73
2018	36.49

3.3.5 NFR 1.B.2.a Oil, NFR 1.B.2.b Natural Gas and 1.B.2.c Venting and flaring

Activities related to exploration, primary production (extraction), processing, storage and transmission/ distribution of crude oil, petroleum products and natural gas are included in this sector. The Greek market of oil and petroleum products comprises four refineries, approximately 50 companies active in the marketing of petroleum products and a large number of retailers and gas stations. The refining capacity of the four refineries exceed 20 Mt of crude oil.

The domestic production of crude oil and natural gas (Table 3-23) present a continuous decreasing trend and as a result emissions are decreasing. Emissions were calculated on the basis of domestic production of crude oil and natural gas and crude oil input in refineries; and the use of Tier 1 EFs from the EMEP/EEA air pollutant emission inventory guidebook 2019. NOx, SOx, NMVOC and PM2.5 emissions associated to fugitive emissions of oil refining / storage were reported as "IE", because they were reported under category 1A1b through the use of E-PRTR data.[1] Emissions of subcategory 1.B.2.c (flaring in oil refineries) was reported under 1.A.1.b subcategory.

For the category 1B2av Distribution of oil products, in order to reflect the effect of the implementation of the Directive 2009/126/EC "on Stage II petrol vapour recovery during refuelling of motor vehicles at service stations", a country-specific T2 method was applied. Based on information from the 2016 evaluation report of the directive, which is entitled "Evaluation of Directive 1994/63/EC on VOC emissions from petrol storage & distribution and Directive 2009/126/EC on petrol vapour recovery"[2], and country specific information related to the implementation of the directive, it was concluded that the implementation of Stage II petrol vapour

[1] The reported emissions of 1A1b category were based on E-PRTR data. These data include all relevant emission sources, including fugitives.
[2] ISBN 978-92-79-55105-5 doi:10.2779/08944

recovery measures resulted to a reduction of emissions by 20% in 2015 and will result to a reduction by 43% in 2020 compared to the default Tier 1 EF from 2019 EEA Guidebook.

Table 3-23 Activity data of NFR 1.B.2 category

Year	Primary production		Imports
	Crude oil (kt)	Natural gas (10^6 m^3)	Crude oil input (kt)
1990	773	123	14539
1991	789	116	12362
1992	653	109	13967
1993	537	81	11777
1994	500	38	12914
1995	435	36	15329
1996	483	38	17529
1997	436	37	17957
1998	293	33	18569
1999	15	2	15944
2000	256	36	19371
2001	171	35	18906
2002	165	37	19116
2003	120	27	19782
2004	118	25	20297
2005	100	16	18699
2006	94	23	19836
2007	74	21	20330
2008	59	14	19286
2009	80	11	17780
2010	115	7	20129
2011	98	6	16514
2012	94	6	20978
2013	70	6	19434
2014	64	5	20826
2015	62	4	22085
2016	176	9	23186
2017	142	8	24030
2018	206	12	24327

3.3.6 Planned improvements

Based on the findings of EU internal audits and UNECE reviews, actions will be planned and executed that may lead to recalculations / improvements of the inventory. Imrpovements that are associated to key categories will be prioritized.

3.3.7 Recalculations

An error in calcalations was corrected for category !B2aiv / PCDD/F emissions / years 1990-2017.

4. INDUSTRIAL PROCESSES AND PRODUCT USE (NFR SECTOR 2)

4.1 Sector overview

This chapter includes information on the estimation of emissions of air pollutants, as well as references for activity data and emission factors reported under NFR Category 2 Industrial Processes and Product Use for the period from 1990 to 2018.

Emissions from this sector comprise emissions from the following categories:

- Mineral Products (2.A)
- Chemical Industry (2.B)
- Metal Production (2.C)
- Solvent use (2.D.3)
- Other product use (2.G)
- Other production (2.H)
- Wood processing (2.I)
- Production of POPs (2.J)
- Consumption of POPs and heavy metals (2.K)
- Other production, consumption, storage, transportation or handling of bulk products (2.L)

Only process related emissions are considered in this sector; emissions due to fuel combustion in manufacturing industries are allocated to NFR Category 1.A.2 Fuel Combustion – Manufacturing Industries and Construction (see Chapter 3.1.4).

4.1.1 Completeness

Table 4-1 provides information on the status of emission estimates of all sub categories. A "√" indicates that emissions from this sub category have been estimated. Emissions were not estimated (NE), only for categories and gases that there is no methodology included in the EMEP/EEA air pollutant emission inventory guidebook – 2019.

IE in subcategories 2.A.1 – 2.A.3 was used for emissions that are reported under energy sector.

4.1.2 Key Categories

Key category analysis is presented in Chapter 1.5. Key sources within this category are presented in Table 4-2.

4.1.3 Uncertainty Assessment

The method used for the assessment of uncertainty is according to the EMEP/EEA air pollutant emission in-ventory guidebook 2019 (EEA 2019). Further information on the uncertainty assessment of activity data can be found in Greece`s National Inventory Report. Where no specific information on uncertainties of emission factors was available, an average of the default values, based on the definitions of the qualitative ratings given in the EMEP/EEA Emission Inventory Guidebook 2019 is used. Please refer to chapter 1.7 for further information about uncertainty.

Table 4-1 Completeness of sub categories in sector 2 Industrial Processes and Product Use.

NFR code	NOx (as NO2)	NMVOC	SOx (as SO2)	NH3	PM2.5	PM10	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/ PCDF (dioxins/ furans)	benzo(a) pyrene	benzo(b) fluoranthene	benzo(k) fluoranthene	Indeno (1,2,3-cd)	Total 1-4	HCB	PCBs
2A1	IE	IE	IE	IE	√	√	√	√	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	NA
2A2	IE	IE	IE	IE	√	√	√	√	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	NA
2A3	IE	IE	IE	IE	√	√	√	√	IE	√	√	√	√	√	√	√	√	√	IE	IE	IE	IE	IE	IE	IE	IE
2A5a	NA	NA	NA	NA	√	√	√	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2A5b	NA	NA	NA	NA	√	√	√	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2A5c	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2A6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2B1	√	√	NA	√	NA	NA	NA	NA	√	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2B2	√	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2B3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B5	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B7	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B10a	NA	NO	√	√	√	√	√	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2B10b	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C1	√	√	√	NE	√	√	√	√	√	√	√	√	√	√	√	√	NE	√	√	NE	NE	NE	NE	√	NE	√
2C2	√	NE	√	NE	√	√	√	√	NE	NE	NE	NE	NE	√	NE	√	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2C3	√	NE	√	NE	√	√	√	√	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	√	√	√	√	√	NE	NE
2C4	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C5	NE	NE	√	NE	√	√	√	NE	NE	√	√	NE	√	NE	NE	NE	NE	√	√	NE	NE	NE	NE	NE	NE	√

NFR code	NOx (as NO2)	NMVOC	SOx (as SO2)	NH3	PM2.5	PM10	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/ PCDF (dioxins/ furans)	benzo(a) pyrene	benzo(b) fluoranthene	benzo(k) fluoranthene	Indeno (1,2,3-cd)	Total 1-4	HCB	PCBs
2C6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C7a	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C7b	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C7c	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C7d	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D3a	NA	√	NA	NA	NE	NE	NE	NA	NA	NA	NA	√	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2D3b	NE	√	NE	NA	√	√	√	√	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE	NE	NE	NE	NA
2D3c	NE	√	NA	NA	√	√	√	√	√	NE	NE	NE	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE	NE	NE	NE	NA
2D3d	NA	√	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2D3e	NA	√	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2D3f	NA	√	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2D3g	NE	√	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	√	NE	NE	NE	NE	NE	NE
2D3h	NA	√	NA	NA	NE	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2D3i	NA	√	NA	NA	√	√	√	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	√	√	√	√	√	NA	NA
2G	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	NE	√	√	√	√	√	√	√	NE	NE
2H1	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2H2	NA	√	NA	NA	NE	NE	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2H3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2I	NE	NE	NE	NE	NE	NE	√	NE	NE	NA	NA	NA	NE	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2J	NE	NE	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NE	NE
2K	NA	NA	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA	NA	NA	NA	NE	NE
2L	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 4-2 Key sources of sector 2 Industrial Processes and Product Use.

NFR Code	Longname	Pollutant	Identification criteria
2D3a	Domestic solvent use including fungicides	NMVOC	L, T
2D3d	Coating applications	NMVOC	L, T
2D3g	Chemical products	NMVOC	L, T
2A5b	Construction and demolition	PM2.5	L
2G	Other product use (please specify in the IIR)	PM2.5	T

L = Level Assessment 2018

T = Trend Assessment 2018/1990

4.1.4 Methodological issues

Methodology and emission factors

Table 4-3 summarizes the methodology that is applied per pollutant and category. Some clarifications about this table:

- ✓ T1 refers to Tier 1 methodology with default EFs from EMEP/EEA air pollutant emission in-ventory guidebook 2019.
- ✓ T2 refers to Tier 2 technology specific activity data and EFs. The source of technology specific Tier 2 EFs is the EMEP/EEA air pollutant emission in-ventory guidebook 2019.
- ✓ T3/T2 refers to the combined use of Tier 3 facility data obtained from E-PRTR and/or through direct communication with the plants; and the application of Tier 2 technology specific activity data and EFs for the facilities that there are no plant specific data available through E-PRTR or other source.
- ✓ NOx emissions of subcategory 2.B.2 are based on facility level measurements. (Tier 3)
- ✓ Subcategory 2B10a: NMVOC. PM2.5, PM10 and TSP are associated to the production of ethylene (1990-1998), 1,2-dichloethane (1990-2000), PVC (1990-2006) and polyestyrene (1990-2006). SO2 is associated with the production of sulfuric acid. Facility data of sulfuric acid production are available and having been used from E-PRTR. NH3 and TSP emissions are associated to the production of ammonium nitrate and are estimated by a Tier 2 method. TSP, PM10 and PM2.5 were also estimated by Tier 2 method, which are associated to NPK fertiliser production.
- ✓ Subcategory 2C2: CS EFs were based on EPRTR data.

- ✓ Subcategory 2D3e (T3/T1): NMVOC is associated the use of xylenes (XYL), methylene chloride (MC), tetrachloroethylene (PER) and trichloethylene (TRI). Estimated emissions from XYL is done using Tier 1 method. Estimated emissions from MC, PER, and TRI is done using national studies for the usage of those solvents on degreasing applications.

- ✓ Subcategory 2D3f: NMVOC is associated the use of methylene chloride (MC), tetrachloroethylene (PER) and trichloethylene (TRI). Estimated emissions from MC, PER, and TRI is done using national studies for the usage of those solvents on dry cleaning applications.

Activity data

If available, exactly the same data, which have been used for the estimation of GHG emissions for UNFCCC reporting, were used for the estimation of the emissions of air pollutants that are presented in this report and NFR tables. Other sources of activity data (mainly the Hellenic Statistical Authority) were used, in the cases of categories that the GHG inventory submission to UNFCCC did not include any relevant data. A description of the activity data is included in the National Inventory Report of Greece under the UNFCCC and in the following chapters

Table 4-3 Methodology that is applied per pollutant and category of sub categories in sector 2 Industrial Processes and Product Use.

NFR code	NOx (as NO2)	NMVOC	SOx (as SO2)	NH3	PM2.5	PM10	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/ PCDF (dioxins/ furans)	benzo(a) pyrene	benzo(b) fluoranthene	benzo(k) fluoranthene	Indeno (1,2,3-cd)	Total 1-4	HCB	PCBs
2A1	IE	IE	IE	IE	T1	T1	T1	T1	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	NA
2A2	IE	IE	IE	IE	T2	T2	T2	T2	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	NA
2A3	IE	IE	IE	IE	T1	T1	T1	T1	IE	T1	T1	T1	T1	T1	T1	T1	T1	T1	IE	IE	IE	IE	IE	IE	IE	IE
2A5a	NA	NA	NA	NA	T1	T1	T1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2A5b	NA	NA	NA	NA	T1	T1	T1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2A5c	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2A6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2B1	T2	T2	NA	T2	NA	NA	NA	NA	T2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2B2	T3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2B3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B5	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B7	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B10a	NA	T2	T3/T2	NA	T2	T2	T2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2B10b	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C1	T2	T2	T2	NE	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	NE	T2	T2	NE	NE	NE	NE	T2	NE	T2
2C2	T2/CSEFs	NE	T2/CSEFs	NE	T1	T2/CSEFs	T1	T1	NE	NE	NE	NE	NE	T2/CSEFs	NE	T2/CSEFs	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2C3	T1	NE	T1	NE	T1	T1	T1	T1	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	T1	T1	T1	T1	T1	NE	NE
2C4	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C5	NE	NE	T2	NE	T2	T2	T2	NE	NE	T2	T2	NE	T2	NE	NE	NE	NE	T2	T2	NE	NE	NE	NE	NE	NE	T2
2C6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C7a	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

NFR code	NOx (as NO2)	NMVOC	SOx (as SO2)	NH3	PM2.5	PM10	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/ PCDF (dioxins/ furans)	benzo(a) pyrene	benzo(b) fluoranthene	benzo(k) fluoranthene	Indeno (1,2,3-cd)	Total 1-4	HCB	PCBs
2C7b	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C7c	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C7d	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D3a	NA	T2	NA	NA	NE	NE	NE	NA	NA	NA	NA	T1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2D3b	NE	T1	NE	NA	T1	T1	T1	T1	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE	NE	NE	NE	NA
2D3c	NE	T1	NA	NA	T1	T1	T1	T1	T1	NE	NE	NE	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE	NE	NE	NE	NA
2D3d	NA	T2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2D3e	NA	T3/T1	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2D3f	NA	T3	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2D3g	NE	T2	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2D3h	NA	T2	NA	NA	NE	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2D3i	NA	T2	NA	NA	T2	T2	T2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	T2	T2	T2	T2	T2	NA	NA
2G	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	NE	T2	T2	T2	T2	T2	T2	T2	NE	NE
2H1	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2H2	NA	T2	NA	NA	NE	NE	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2H3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2I	NE	NE	NE	NE	NE	NE	T1	NE	NE	NA	NA	NA	NE	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2J	NE	NE	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NE	NE
2K	NA	NA	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA	NA	NA	NA	NE	NE
2L	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

4.2 NFR 2.A.1-2.A.5 Mineral Products

In this category, fugitive PM emissions from bulk material handling are reported. These include emissions from quarrying and mining of minerals other than coal, construction and demolition. Most fugitive PM emissions are reported in NFR category 2.A.5, except emissions from cement that are reported in NFR category 2.A.1, from lime production that are reported in NFR category 2.A.2, and from glass production that are reported in NFR category 2.A.3. Emissions from cement and lime production include point source emissions from kilns.

4.2.1 NFR 2.A.1

PM emissions from cement plants were estimated by a Tier 3/2 method. A combined use of Tier 3 facility data obtained from E-PRTR; and the development of country specific EFs based on E-PRTR data, which are applied for the years that plant specific data are not available through E-PRTR was followed. A country specific PM2.5 EF was developed based on PM10 plant specific data, derived from E-PRTR data and applying the Tier 1 share of PM10:PM2.5 ratio from the 2019 EMEP/EEA Guidebook. The other air pollutants were reported as IE, since they are mainly associated to fuel combustion and therefore, they were reported in the Energy sector. Activity data (i.e. clinker production) were obtained from CRF Tables from UNFCCC inventory submission (original source of data is the Hellenic Statistical Authority). Activity data were also reported in NFR tables.

4.2.2 NFR 2.A.2

The air pollutants TSP, PM10, PM2.5 and BC associated to lime production were calculated by applying Tier 2 methodology with Tier 2 EFs from EMEP/EEA air pollutant emission inventory guidebook 2019. The other air pollutants were reported as IE, since they are mainly associated to fuel combustion and therefore, they were reported in the Energy sector. Activity data (i.e. lime production) were obtained from CRF Tables from UNFCCC inventory submission (original source of data is the Hellenic Statistical Authority). Activity data were also reported in NFR tables.

4.2.3 NFR 2.A.3

The air pollutants TSP, PM10, PM2.5, BC and heavy metals associated to glass production were calculated by applying Tier 1 methodology with default EFs from EMEP/EEA air pollutant emission inventory guidebook 2019. The other air pollutants were reported as IE, since they are mainly associated to fuel combustion and therefore, they were reported in the Energy sector. Activity data (i.e. glass production) were obtained from CRF Tables from UNFCCC inventory

submission (original source of data is the Hellenic Statistical Authority). Activity data were also reported in NFR tables.

4.2.4 NFR 2.A.5a

The air pollutants TSP, PM10 and PM2.5 associated to quarrying and mining of minerals other than coal were calculated by applying Tier 1 methodology with default EFs from EMEP/EEA air pollutant emission inventory guidebook 2019. Activity data (i.e. mineral production) were obtained from the annual production statistics of the Greek Mining Enterprises Association. Activity data were also reported in NFR tables. The production quantities of the following minerals were considered: limestone aggregates, Bauxite, Lecholithos, Marbles, Bentonite, Nickel iron, Pearlite, Pozolani, Plaster, fists, attapulgite, dipyros magnesia, kaolin, quisque, mixed sulfur, olivine, and Chuditi. No other mineral production occurs in Greece.

4.2.5 NFR 2.A.5b

The air pollutants TSP, PM10 and PM2.5 associated to construction and demolition were calculated by applying Tier 1 methodology with default EFs and other parameters from EMEP/EEA air pollutant emission inventory guidebook 2019. Activity data (i.e. construction of houses, appartments and non-residential construction) were obtained from the Hellenic Statistics Authority. AD related to road construction were obtained from the EU Road Federation. For the years for which no AD is provided by the EU Road Federation, the consumption of bitumen (obtainrd from national energy balance) is used as a driver. Activity data were also reported in NFR tables.

4.3 NFR 2.B Chemical Products

4.3.1 NFR 2.B.1 Ammonia

Up to 1999 there were two ammonia plants in Greece. The first one (Plant A) has been operating since 1990, with an interruption between the years 1994-1997. It should be mentioned that imported Natural Gas was introduced to the Greek energy system by the Public Gas Company (DEPA) in 1996 and that till 1996 the NG consumption in Greece corresponds to small amounts of domestic NG explored by the company Kavala Oil. As a result, the plant has been using natural gas, provided by the Public Gas Company SA (DEPA) since 1998 while in the years 1990-1993 natural gas has been provided to the plant by the Kavala Oil Corporation.

The other plant (Plant B) has been operating since 1990 and up to 1999 with intervals. According to information already provided in NIR 2010, it used lignite as feedstock until 1991, and liquid fuels until its closure in 1999. It should also be mentioned that both plants were closed during year 1994.

The air pollutants NOx, NMVOC, NH3 and CO associated to the production of ammonia were calculated by applying Tier 2 methodology with Tier 2 EFs for steam reforming (conventional as well as advanced processes) from EMEP/EEA air pollutant emission inventory guidebook 2019. Activity data (i.e. annual ammonia production) were obtained from CRF Tables from UNFCCC inventory submission (original source of data is the Hellenic Statistical Authority). Activity data were also reported in NFR tables.

4.3.2 NFR 2.B.2 Nitric Acid Production

Since 2006 there is only one unit producing nitric acid in Greece therefore, data are received directly by the unit. The methodology used for the production of nitric acid is Dual Pressure. Ammonia is catalytically burned in presence of air at 4 bars. The abatement system used by the Greek installations for reduction of NO_x emissions is the absorption tower.

The reported NOx emissions are based on measurements (Tier 3) reported by the respective plants.

4.3.3 NFR 2.B.10 Other Chemical Industry

The following air pollutants were reported under this subcategory:

- ✓ NMVOC. PM2.5, PM10 and TSP are associated to the production of ethylene (1990-1998), 1,2-dichloethane (1990-2000), PVC (1990-2006) and polyestyrene (1990-2006). Emissions were estimated by a Tier 2 method / EFs from EMEP/EEA air pollutant emission inventory guidebook 2019. Activity data (i.e. annual chemical production) were obtained from CRF Tables from UNFCCC inventory submission (original source of data is the Hellenic Statistical Authority).

- ✓ SO2 is associated with the production of sulfuric acid. Facility data of sulfuric acid production are available and having been used from E-PRTR. Country specific EFs (CS EFs) have been applied for the years that E-PRTR data are not available. These CS EFs were determined by using the available E-PRTR data of the other years. Activity data (i.e. annual sulfuric acid production) were obtained from CRF Tables from UNFCCC inventory submission (original source of data is the Hellenic Statistical Authority).

- ✓ NH3 and TSP emissions are associated to the production of ammonium nitrate and estimated by a Tier 2 method / EFs from EMEP/EEA air pollutant emission inventory

guidebook 2019. Activity data (i.e. annual production of fertilizers) were obtained from the Hellenic Statistical Authority.

- ✓ TSP, PM10 and PM2.5 were also estimated by Tier 2 method / EFs associated to NPK fertiliser production from EMEP/EEA air pollutant emission inventory guidebook 2019. Activity data (i.e. annual production of fertilizers) were obtained from the Hellenic Statistical Authority.

4.4 NFR 2.C Metal Production

In this category, emissions from iron and steel production as well as process emissions from ferroalloys and non-ferrous metal production are considered.

4.4.1 NFR 2.C.1 Iron and Steel Production

Steel production in Greece is based on the use of electric arc furnaces (EAF). There are no integrated iron and steel plants for primary production as no units for primary production of iron exist, but there are several iron and steel foundries.

The air pollutants associated to the production of steel were calculated by applying Tier 2 methodology with Tier 2 EFs for electric furnace steel plant (equipped with dry ESP abatement technology) from EMEP/EEA air pollutant emission inventory guidebook 2019. Activity data (i.e. annual steel production) were obtained from CRF Tables from UNFCCC inventory submission (original source of data is the Hellenic Statistical Authority). Activity data were also reported in NFR tables.

4.4.2 NFR 2.C.2 Ferroalloys production

Ferroalloy production involves a metallurgical reduction process. As there is only one unit operating in Greece data is plant specific and are characterized by fluctuations.

The air pollutants NOx, SOx, PM10, Cr and Ni associated to the production of Ferronickel were calculated by applying Tier 2 methodology with country specific EFs. These CS EFs were based on available E-PRTR data. The air pollutants TSP, PM2.5 and BC were estimated based on the Tier 1 EFs from EMEP/EEA air pollutant emission inventory guidebook 2019. Activity data (i.e. annual production), which were used for emission calculations were the same as the ones used in the UNFCCC inventory submission. Activity data were reported as “C” (i.e. confidential) in NFR tables, because there is only one plant operating in Greece.

4.4.3 NFR 2.C.3 Aluminium production

There is only one plant associated to primary aluminium production in Greece. As there is only one unit operating in Greece data are characterized by fluctuations.

Aluminium production data are considered confidential. However, publicly available data from the US Geological Survey and the UN Commodity Statistics Database. These data are reported in the CRF Tables from the UNFCCC inventory submission, which were also used for the estimation of emissions from this category.

The air pollutants associated to the production of Aluminium were calculated by applying Tier 1 methodology with default EFs from EMEP/EEA air pollutant emission inventory guidebook 2019.

4.4.4 NFR 2.C.5 Lead production and NFR 2.C.6 Zinc production

Only secondary lead production occurs in Greece. The mine output concentrates of the sole extraction site in Greece that contain lead and zinc are sent abroad for further processing.

The air pollutants associated to the secondary lead production were calculated by applying Tier 2 methodology with technology specific Tier 2 EFs from EMEP/EEA air pollutant emission inventory guidebook 2019. Activity data (i.e. annual production), were obtained from CRF Tables from UNFCCC inventory submission (original source of data is the Hellenic Statistical Authority). Activity data were also reported in NFR tables.

4.5 NFR 2.D.3-2.G Solvents and other Product use

4.5.1 NFR 2.D.3.a Domestic solvent use including fungicides

This category refers to the emissions (mainly NMVOCs) from the domestic use of solvent containing products (including pharmaceuticals). This category does not include products for paint applications (these products are included in category 2.D.3.d "Coating applications"). Emissions of NMVOC associated to population of Greece were calculated by applying Tier 2 methodology with country specific EFs. According to a national study, emission factors of NMVOC associated to population of Greece are provided for the period 1996-2006 disaggregated in several sub-categories, i.e. for Washing and cleaning products, for personal healthcare products, for cosmetics, for homeware and DIY products and for car care products. Utilizing these emissions factors, emissions are estimated for the same period, i.e. 1996-2006, while for the rest years, an

extrapolation of emissions factors was performed based on the total consumption of relevant products for each sub-category, based on statistical data provided by the Hellenic Statistical Authority (www.statistics.gr), i.e. on total annual purchases per capita.

Activity data (population data) derive from EUROSTAT database (http://ec.europa.eu/eurostat/data/database).

4.5.2 NFR 2.D.3.b Road paving with asphalt

This category refer to the emissions from the road paving with asphalt. Emissions of NMVOC, TSP, PM10, PM2.5 and BC associated to anual sales weight of asphalt mixture in Greece (with the assumption that 100% of sales used on road paving) were calculated by applying Tier 1 methodology with EFs from EMEP/EEA air pollutant emission inventory guidebook 2019. Activity data derive from the Prodcom database of the Hellenic Statistical Authority (www.statistics.gr).

4.5.3 NFR 2.D.3.c Asphalt roofing

This category refers to the emissions from the asphalt roofing materials produced. Emissions of CO, NMVOC, TSP, PM10, PM2.5 and BC associated to anual product weight of roofing materials in Greece were calculated by applying Tier 1 methodology with EFs from EMEP/EEA air pollutant emission inventory guidebook 2019. Activity data calculated as the production of asphalt roofing materials (derive from the Prodcom database of the Hellenic Statistical Authority (www.statistics.gr)) in cylinders (m^2) multiplied by an average weight of 4,5 kg/m^2 (based on bibliographic search the weight of asphalt roofing materials range from 2.5 to 6 kg/m^2).

4.5.4 NFR 2.D.3.d Coating applications

This category refers to the emissions from the coating application for decorative, industrial or other applications of paint (including lacquers and varnishes and excluding glues and adhesives use). Emissions of NMVOC associated to annual paint sales for different types of paint (assuming that 100% of sales used for coating applications) in Greece were calculated by applying Tier 2 methodology and country specific emission factors:

NMVOC emissions = Σ (ADi * Pi * EFj) where

- ADi: Activity data for every type (i) of paint used derive from the Prodcom database of the Hellenic Statistical Authority (www.statistics.gr), see Table 4-5.
- Pi: percentage of (i) type of paint used which consumed in one of the above three (j) coating applications (decorative, industrial and other) derive from national studies.

- Efj: emissions factors for each one (j) of the coating applications. For the period 1990-2006, emissions factors for each one (j) of the three coating applications derive from EMEP/EEA air pollutant emission inventory guidebook 2019. From 2007, it is considered that the DIRECTIVE 2004/42/CE of the European parliament and of the council of 21 April 2004, on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products and amending Directive 1999/13/EC, is applicable. In accordance with this directive, data presented in Table 4-6 are utilized as emission factors for the relevant years, from 2007 to 2010 and after 2010.

Table 4-4 Percentage of paint use on coating applications

	Percentage of paint used on		
Type of paint	***Decorative app.***	***Industrial app.***	***Other app.***
Paints and varnishes, based on acrylic or vinyl polymers dispersed/dissolved in non-aqueous medium, weight of the solvent > 50 % of the solution weight including enamels and lacquers	0.05	0.85	0.10
Paints and varnishes, based on acrylic or vinyl polymers dispersed or dissolved in an aqueous medium (including enamels and lacquers)	0.40	0.40	0.20
Paints and varnishes, based on polyesters dispersed/dissolved in a non-aqueous medium, weight of the solvent > 50 % of the weight of the solution including enamels and lacquers	0.05	0.85	0.10
Paints and varnishes, based on polyesters dispersed/dissolved in a non-aqueous medium including enamels and lacquers excluding weight of the solvent > 50 % of the weight of the solution	0.05	0.85	0.10
Other paints and varnishes based on acrylic or vinyl polymers	0.05	0.85	0.10
Paints and varnishes: solutions n.e.c.	0.20	0.40	0.40
Other paints and varnishes based on synthetic polymers n.e.c.	0.20	0.40	0.40
Other paints, varnishes dispersed or dissolved in an aqueous medium	0.40	0.40	0.20
Painters fillings	0.05	0.80	0.15

Table 4-5 Activity data

Year	Decorative use (kg)	industrial use (kg)	Other use (kg)
1990	18104029	37372929	12048710
1991	18473499	38135642	12294602
1992	18850509	38913920	12545512
1993	19235214	39708082	12801543
1994	21321273	45542956	14445139
1995	22264214	43689769	14425078
1996	22247208	44922029	14478554
1997	23680798	47938259	15261844
1998	25387987	49652675	16113298
1999	26636211	51842784	16857946
2000	27798596	54082968	17486300
2001	26419195	59199991	17673655
2002	28029187	63144616	18877615
2003	35350790	77643992	23032826
2004	33735369	77500200	22536776
2005	34449760	78416099	23277823
2006	37433574	80172512	24800827
2007	38803037	85643806	25957062
2008	33183660	73739740	22010502
2009	31502491	65946317	20346419
2010	34115470	72905993	22459348
2011	32522012	73829609	21541166
2012	25938434	61635302	17507272
2013	28268950	64868394	18867267
2014	28982118	65850572	20087003
2015	31083395	66992757	22292131
2016	34543039	73922618	24531142
2017	37106393	76186366	25647247
2018	38481421	82375559	27030080

Table 4-6 ***Maximum VOC content limit values for paints and varnishes in accordance with DIRECTIVE 2004/42/CE of the European parliament and of the council of 21 April 2004***

	Product Subcategory	Type	Phase I (g/l) (from 1.1.2007)	Phase II (g/l) (from 1.1.2010)
a	Interior matt walls and ceilings (Gloss <25@60°)	WB	75	30
		SB	400	30
b	Interior glossy walls and ceilings (Gloss >25@60°)	WB	150	100
		SB	400	100
c	Exterior walls of mineral substrate	WB	75	40
		SB	450	430
d	Interior/exterior trim and cladding paints for wood and metal	WB	150	130
		SB	400	300
e	Interior/exterior trim varnishes and woodstains, including opaque woodstains	WB	150	130
		SB	500	400
f	Interior and exterior minimal build woodstains	WB	150	130
		SB	700	700
g	Primers	WB	50	30
		SB	450	350
h	Binding primers	WB	50	30
		SB	750	750
i	One-pack performance coatings	WB	140	140
		SB	600	500
j	Two-pack reactive performance coatings for specific end use such as floors	WB	140	140
		SB	550	500
k	Multi-coloured coatings	WB	150	100
		SB	400	100
l	Decorative effect coatings	WB	300	200
		SB	500	200

Water-borne coatings (WB)'

Solvent-borne coatings (SB)'

4.5.5 NFR 2.D.3.e Degreasing

This category refers to the emissions from the cleaning process of industrial products (mainly metals) from water insoluble substances (grease, fats, oil etc). According to EMEP/EEA air pollutant emission inventory guidebook 2019, the most common organic solvents used are: methylene chloride (MC), tetrachloroethylene (PER), trichloroethylene (TRI), xylenes (XYL). Emissions of NMVOC associated to annual use (Product + Import - Export) of the above organic solvents were calculated by applying a compined Tier1/Tier3 methodology:

NMVOC emissions = ADxyl * EFxyl + Σ (ADi * Pi * EFi) where:

- ADxyl and ADi: Activity data for all organic solvents used derive from United Nation Statistics division (http://data.un.org/)
- EFxyl: emission factor for XYL derives from EMEP/EEA air pollutant emission inventory guidebook 2019 (Tier 1 method)

- Pi: percentage of the TRI, PER and MC (i) organic solvent used for degreasing applications derive from national studies.
- Efi: emissions factors for TRI, PER and MC (i) organic solvent derive from national studies.

Table 4-7 Percentage and Emission Factors of organic solvent use on degreasing

Organic Solvent	*Pi*	*EF (gr/kgsolvent)*
methylene chloride (MC)	0.8	550
tetrachloroethylene (PER)	0.4	600
trichloroethylene (TRI)	0.8	850
xylenes (XYL)	1	460

Below is presented the contribution of each organic solvent (used on degreasing) to NMVOC emissions through the examined years.

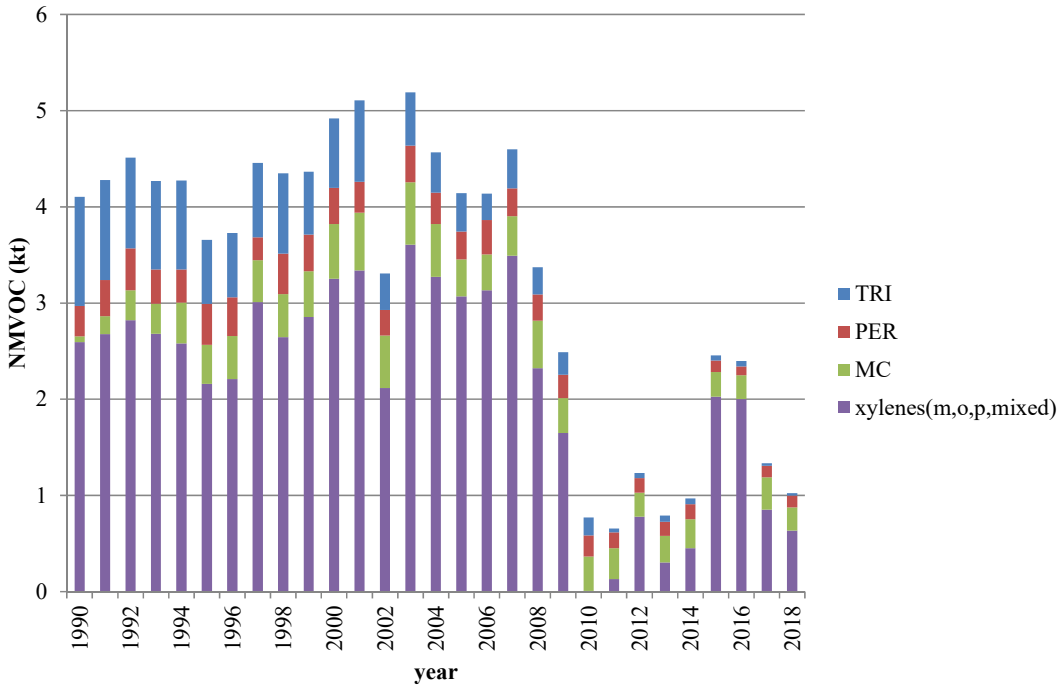

Figure 4-1 Contribution of organic solvents on NMVOC emissions due degreasing

4.5.6 NFR 2.D.3.f Dry cleaning

This category refers to the emissions from the cleaning process of textiles (furs, leathers, etc) in order to remove contamination. Due to national studies the main organic solvents used for dry cleaning are: methylene chloride (MC), tetrachloroethylene (PER) and trichloroethylene (TRI). Emissions of NMVOC associated to annual use (Product + Import - Export) of the above organic solvents were calculated by applying a Tier3 methodology:

NMVOC emissions = Σ (ADi * Pi * EFi) where:

- ADi: Activity data for all organic solvents used derive from United Nation Statistics division (http://data.un.org/)
- Pi: percentage of the TRI, PER and MC (i) organic solvent used for dry cleaning application derive from national studies.
- Efi: emissions factors for TRI, PER and MC (i) organic solvent derive from national studies.

Table 4-8 Percentage and Emission Factors of organic solvent use on dry cleaning

Organic Solvent	*Pi*	*EF (gr/kgsolvent)*
methylene chloride (MC)	0.2	550
tetrachloroethylene (PER)	0.6	600
trichloroethylene (TRI)	0.2	850

Total NMVOC emissions estimated below 1 kt per year with continous decrease after 2007 resulting to 0.214 kt for year 2016.

4.5.7 NFR 2.D.3.g Chemical products

This category refers to the emissions from the use of chemical products.

The following product groups and processes are taken into consideration under this category:

- Polysterene foam processing

- Polyurethane foam processing
- Polyvinylchloride processing
- Glues manufacturing
- Paints manufacturing
- Inks manufacturing
- Asphalt blowing (roofing materials)
- Rubber processing
- Shoes

Emissions from 'Fat, edible and non-edible oil extraction' estimated under 2.D.3.i category. Emissions for category 'Pharmaceutical products manufacturing' are zero.

Emissions of NMVOC, associated to total mass of products produced were calculated by applying Tier 2 methodology with EFs from EMEP/EEA air pollutant emission inventory guidebook 2019. Especially for the Glues manufacturing, Paints manufacturing and Inks, the EFs provided by the products' suppliers have been utilized varied from 11 g/kg product to 8 g/kg product.

Emissions of Benzo(α)pyrene, associated to the total mass of Asphalt blowing were calculated by applying Tier 1 methodology with EFs from EMEP/EEA air pollutant emission inventory guidebook 2019, i.e. 4000 g/Mg asphalt.

Activity data (see Table 4-9 (a) and (b)) derive from:

- The Prodcom database of the Hellenic Statistical Authority (www.statistics.gr) for asphalt blowing, paints and ink manufacturing.
- EUROSTAT database (http://ec.europa.eu/eurostat/data/database) for Polyurethane foam processing, Polysterene foam processing, Polyvinylchloride processing, Glues and adhesive manufacturing, paints and ink manufacturing.

Table 4-9 (a) Activity data (kg)

Year	Polysterene	polyvinylchloride	Polyurethane	Glues and adhesives	Paints
1990	49739243	118409307	6801282	40723201	82604889
1991	48763964	116087556	6667924	41134546	83833665
1992	47807808	113811329	6537180	41550047	85092043
1993	46870400	111579735	6409000	41969744	86380582
1994	45951372	109391897	6283334	42393681	97335783
1995	45050365	107246958	6160131	42821900	95781591
1996	46929770	108751322	6056021	44950910	97950785
1997	46815350	118565819	8932486	46496370	99316629
1998	50318280	127986450	6969751	51031610	104879640
1999	47633044	109741028	5449327	43039830	108059378
2000	51183687	91440818	6055863	47567996	111786860
2001	54115285	90685595	4221416	43885274	114836887
2002	50199961	97825071	4544709	70773387	147951496
2003	55662686	81606484	5950621	65477036	210603211
2004	58843552	78708884	5891386	84068699	190667095
2005	60193875	66669970	5894353	77730290	202640138
2006	59655543	108639459	6317537	84790950	193075393
2007	67488422	114299753	6986677	91639036	201850753
2008	59286065	136863159	7273385	74639372	228989486
2009	53390423	58026880	6415485	65260550	210393308
2010	50464862	45010560	5668085	77069052	213412012
2011	45602351	28360408	5633485	70941083	200424840
2012	40986490	23573306	2277085	44938339	137562693
2013	33613354	27369644	1146770	28916413	139944167
2014	34253564	32427547	1545386	28971948	144736588
2015	38241399	26405367	1786476	33590088	151866116
2016	42828836	29055232	2367389	32268826	148622909
2017	47775567	31320599	3140437	34737917	158002554
2018	47740467	29819209	1052441	37116835	160178173

Table 4-9 (b) Activity data (kg) and per of shoes

Year	Inks	asphalt blowing	Rubber	Per of shoes
1990	4630936	8228646	13799796	4417589
1991	5507373	8228646	13529211	4507744
1992	5365853	8228646	13263933	4599739
1993	11718071	8228646	13003856	4693611
1994	13350553	9874375	12748878	4789399
1995	15783707	11849250	12498900	4887142
1996	19230044	14219100	10358200	5431390
1997	14045407	17062920	11273000	4939546
1998	11110184	20475504	19851500	4327157
1999	10664034	24570605	12620400	4075680
2000	13324329	47256438	12915200	4114235
2001	13857649	40221328	11508500	5118861
2002	12610717	38680862	11799000	4561647
2003	14658497	37565953	15179400	4835283
2004	16007488	38480725	15978200	4437133
2005	17685510	36640636	15038000	4758276
2006	15992216	38997689	18273100	4170719
2007	15754041	42267894	20842400	4472760
2008	15608797	35640668	19895300	4443620
2009	14635381	24290897	17897700	5394300
2010	16494344	23117697	17891800	3341391
2011	19762982	23729629	15184400	2682696
2012	13224908	16598447	16441900	2289258
2013	13531993	21262159	17877300	3422816
2014	12033828	12854907	14530600	5033699
2015	11962484	15013100	16280300	4676297
2016	12170108	11914313	12723300	7441994
2017	13639491	11914313	12123900	5901192
2018	14144957	11914313	10764600	6483647

4.5.8 NFR 2.D.3.h Printing

This category refers to the emissions from the printing industry. Emissions of NMVOC associated to annual ink consumption in Greece (Product+Import-Export) were calculated by applying Tier 2 methodology with country specific emission factors based on data provided by the products' suppliers. Activity data derive from the Prodcom database of the Hellenic Statistical Authority (www.statistics.gr).

4.5.9 NFR 2.D.3.i Other solvent use

The following product groups and processes are taken into consideration under this category:

- Fat, edible and non-edible oil extraction
- Application of glues and adhesives
- Preservation of wood

The NMVOC emissions from the application of glues and adhesives account up to 85% of the emission from the category. Any sharp decrease / increase and variation in sub-sector is caused by this category.

For the estimation of glues and adhesives, Tier 2 approach is used with default EF, i.e. 522 g/kg and 76% abatement efficiencies, as per 2019 GB. Activity data derive from the Prodcom database of the Hellenic Statistical Authority. The trend of emissions just follows the trend of activity data, since the same EF is used for all years.

Emissions from the 'Underseal treatment and conservation of vehicles' and 'Vehicles dewaxing' are considered negligible, as it is indicated in the EMEP/EEA air pollutant emission inventory guidebook – 2019.

4.5.9.1 Fat, edible and non-edible oil extraction

The air pollutants NMVOC, TSP, PM10 and PM2.5 associated to oil extraction were calculated by applying Tier 2 methodology with EFs from EMEP/EEA air pollutant emission inventory guidebook 2016 for NMVOC and Tier 1 for the other emissions. Activity data derive from the FAOSTAT database (http://faostat.fao.org). Abatement efficiencies have been considered in accordance with EMEP/EEA air pollutant emission inventory guidebook 2019, approx. 80%. Activity data are provided in Table 4-9.

4.5.9.2 Application of glues and adhesives

NMVOC emissions associated to the application of adhesives were calculated by applying Tier 2 methodology with EFs from EMEP/EEA air pollutant emission inventory guidebook 2019. Abatement efficiencies have been considered in accordance with EMEP/EEA air pollutant emission inventory guidebook 2019, from 76% to 87%. Activity data derive from the Prodcom database of the Hellenic Statistical Authority (www.statistics.gr). Activity data are provided in Table 4-9.

4.5.9.3 Preservation of wood

The air pollutants NMVOC and PAHs associated to wood preservation were calculated by applying Tier 2 methodology with EFs from EMEP/EEA air pollutant emission inventory guidebook 2019 for NMVOC and Tier 1 for the other emissions. Abatement efficiencies have been considered in accordance with EMEP/EEA air pollutant emission inventory guidebook 2019, approximately 37%. Activity data derive from the FAOSTAT database (http://faostat.fao.org). Activity data are provided in Table 4-10.

Table 4-10 Activity data

Year	Oil extraction (t)	glue and adhesives (kg)	Preservation of wood (m^3)
1990	130010	51936829	748200
1991	116735	53663416	757500
1992	125978	55945347	665000
1993	127155	59967483	670000
1994	134034	63942055	670000
1995	127376	55802260	700000
1996	162407	60043100	700000
1997	141762	71382910	423000
1998	161230	70171690	528000
1999	156187	70777300	549500
2000	156696	62047214	835006
2001	170146	53317127	785006
2002	140394	108210158	992892
2003	139839	71473726	1057956
2004	125763	84717279	1032792
2005	126556	77013994	1032792
2006	122169	80845762	1026000
2007	118853	88240957	1026000
2008	133708	71044753	596000
2009	132978	57195921	1099946
2010	157446	70731735	1110254
2011	149804	66687749	1095779
2012	139757	40212012	444210
2013	162005	23032615	444200
2014	176091	21663861	444200
2015	169048	32500583	444200
2016	172570	31500162	444200
2017	170809	27397064	444200
2018	171689	27479056	444200

4.5.10 NFR 2.G Other product use

Category presents the emissions from the following activities from other uses of solvents:

- Use of fireworks
- Tobacco combustion
- Use of shoes

Below is presented the contribution of the above uses to NMVOC emissions through the examined years.

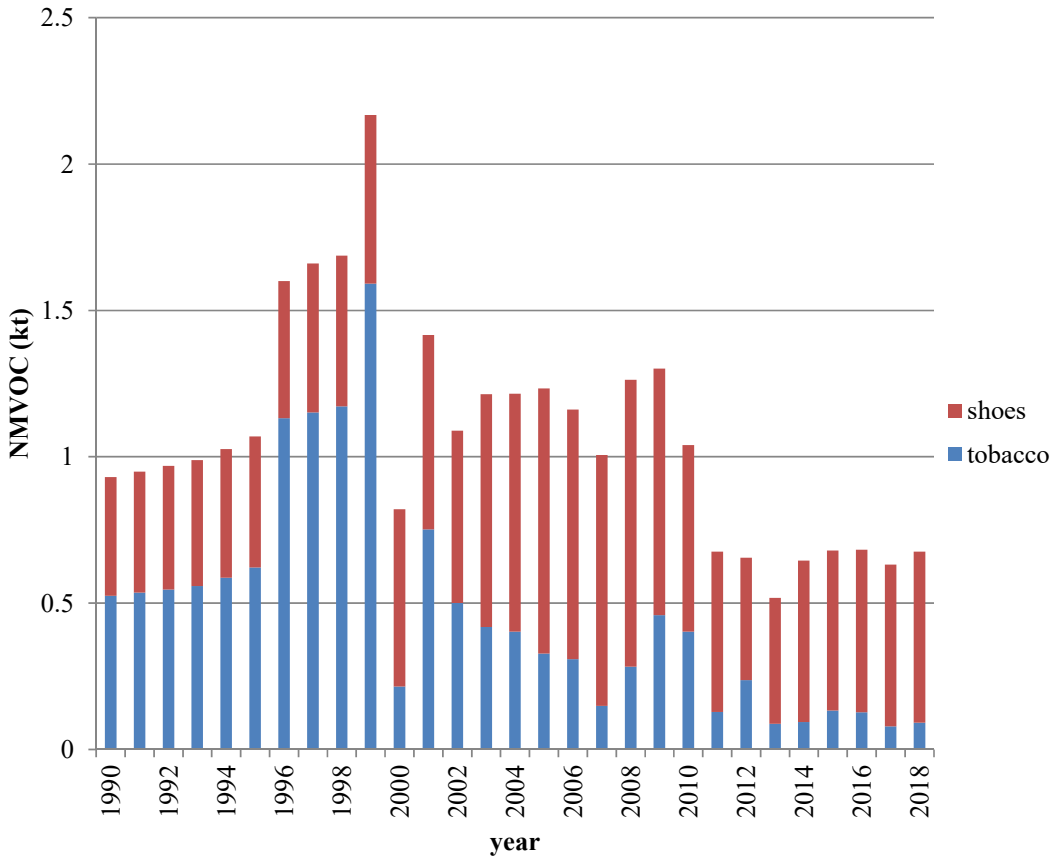

Figure 4-2 Contribution of other activities with solvent use on NMVOC emissions

4.5.10.1 Use of fireworks

Emissions of SO_2, CO, NOx, TSP, PM10, PM2.5, As, Cd, Cr, Cu, Hg, Ni, Pb and Zn associated to annual mass of fireworks used in Greece (Product+Import-Export) were calculated by applying Tier 2 methodology with EFs from EMEP/EEA air pollutant emission inventory guidebook 2019. Activity data derive from the EUROSTAT database (http://ec.europa.eu/eurostat/data/database).

4.5.10.2 Tobacco combustion

Emissions of NOx, CO, NMVOC, NH_3, TSP, PM10, PM2.5, BC, Cd, Ni, Zn, Cu, PCDD/F, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene associated to annual mass of tobacco smoked (combusted) were calculated by applying Tier 2 methodology with EFs from EMEP/EEA air pollutant emission inventory guidebook 2019. Activity data derive from the EUROSTAT database (http://ec.europa.eu/eurostat/data/database) as pieces of cigars and cigarettes (Product+Import-Export) assuming that all of them smoked annually. Due to EMEP/EEA air pollutant emission inventory guidebook 2019 in order to find the mass of tobacco smoked we assume that 'one cigarette contains 1 gr of tobacco and one cigar contains 5 gr of tobacco'.

4.5.10.3 Use of shoes

Emissions of NMVOC associated to annual amount of shoe pairs used in Greece (Product+Import-Export assuming 100% use) were calculated by applying Tier 2 methodology with EFs from EMEP/EEA air pollutant emission inventory guidebook 2019. Activity data derive from the EUROSTAT database (http://ec.europa.eu/eurostat/data/database).

4.6 NFR 2.H Other processes

4.6.1 NFR 2.H.1 Pulp and paper industry

Since there is no pulp production in Greece (pulp for paper production is imported), the emissions of air pollutants of this subcategory were reported as NO (not occurred).

4.6.2 NFR 2.H.2 Food and beverages industry

This category refers to the emissions from food and beverages manufacturing (except of vegetable oil extraction). The following products are taken into consideration under this category:

- Meat fish and poultry
- Sugar
- Margarine and solid cooking fats
- Bread
- Biscuits
- Animal feeds
- Coffee beans roast
- Wine

- Beer
- Spirits

Emissions of NMVOC, associated to total mass of products produced were calculated by applying Tier 2 methodology with EFs from EMEP/EEA air pollutant emission inventory guidebook 2019. Abatement efficiencies have been considered in accordance with EMEP/EEA air pollutant emission inventory guidebook 2019, 90%. Activity data derive from the Prodcom database of the Hellenic Statistical Authority (www.statistics.gr), see Table 4-11 (a) and (b).

Note that activity data for beverage manufacturing are given in 'lt' for beer and wine and 'lt alc 100%' for spirits. This data were converted to kg of products by multiplying with 1gr/ml and 0.789gr/ml respectively (density of each bevearage derived from bibliographic search).

Below is presented the contribution of food and beverage production to NMVOC emissions through the examined years.

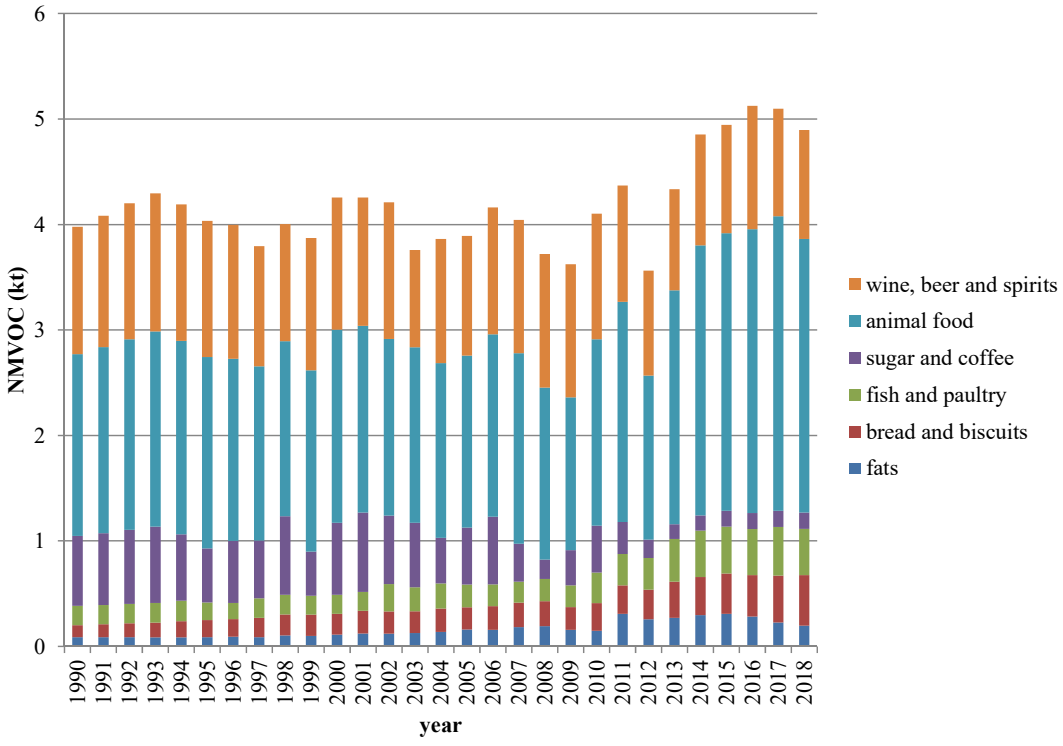

Figure 4-3 Contribution of food and beverage production on NMVOC emissions

Table 4-11 (a) Activity data

Year	Wine, Spirits (kg)	Poultry Meat (kg)	Meat Fish (kg)	Margarine and solid cooking fats (kg)	Bread (kg)
1990	602922178	76059407	15138406	43964605	30321858
1991	621515202	75959799	14973642	43994944	34262211
1992	644231348	76062034	14825626	44675651	38714810
1993	654770832	79441990	14644721	42556710	43746247
1994	647536762	82400870	14530391	43104503	46612390
1995	645439950	70699056	12054073	44456664	55796246
1996	634587904	63682040	12378240	46518469	58432934
1997	569919014	79891361	12440141	44706253	61904251
1998	555215688	80338105	12369127	51953637	70076435
1999	626648524	75162939	13830070	49867412	75755882
2000	627319326	76879913	13610393	55289037	73139407
2001	608629256	74260802	14946435	61755351	77901222
2002	647141317	111595563	17915166	59975382	74972400
2003	460915869	96443814	17528920	64067482	71035559
2004	588452015	101046700	17598365	68853766	81113933
2005	567173133	91532375	16118048	80155316	74329196
2006	600733553	85838016	16135450	79402209	78435374
2007	630606250	83067628	16931636	91536183	78328280
2008	633708262	85236082	19794301	96411727	82092666
2009	631571065	85438376	17691836	78934697	74634500
2010	595287447	113674842	31118314	74779626	97416166
2011	551366756	118490888	30335812	153618762	99468296
2012	498357456	130583251	20093649	128252722	106719653
2013	479373357	178156532	24789513	135488290	131241483
2014	525590662	193715794	27173452	148307108	138163970
2015	584874753	194487377	23308178	141943263	160775220
2016	509693108	203693978	26819592	113342164	183759343
2017	517436429	198869998	20284260	98066047	184473549
2018	584874753	194487377	23308178	141943263	160775220

Table 4-11 (b) Activity data

Year	Biscuits	Sugar	Coffee beans	Animal feeds	Beer
1990	27080385	322946159	7913301	862587787	453313000
1991	26714824	332934185	7950283	882883916	420768000
1992	27181558	343231119	8212224	903807761	448788000
1993	25976212	353846514	7306962	925378735	408835258
1994	29987508	306515703	8782030	915787594	437484306
1995	25541824	249079305	7475176	906472897	402284054
1996	24887017	286858166	7496363	863698784	376426998
1997	29515228	264820691	8207054	826358161	377039340
1998	30301126	363724110	8434112	829866283	370465992
1999	25590715	200064600	8878608	859636416	436175311
2000	26093267	332954320	8670771	914700103	442845142
2001	29466001	367603090	9195083	884727688	430606103
2002	30954498	314347260	10375704	837509520	448596370
2003	31348766	295590800	10185162	832144995	266714047
2004	30242822	205053340	10496600	828747506	378540117
2005	30951506	259301230	10563108	816128171	388790978
2006	33965878	310340192	11137570	864387866	389482727
2007	37410240	169610937	10227695	903438000	435016383
2008	35812661	78387590	13764844	815797735	441664385
2009	33456418	153371180	12960289	723998543	420335224
2010	33301808	211009655	11227827	883561286	401262976
2011	36289712	137276296	13823495	1043972941	375708061
2012	34151359	72961848	13961860	776626490	336358479
2013	40216484	55545116	13531439	1109261107	331069988
2014	42272255	59564201	11664080	1280352398	365019073
2015	40457763	63425100	11916562	1315822101	367339946
2016	35383234	63287715	13352264	1345380002	427449500
2017	38550140	62092339	14250753	1396818647	435998490
2018	56057959	63954096	13716494	1295236825	467213704

4.6.3 NFR 2.H.3 Other industrial processes

Emissions of air pollutants of this subcategory were reported as NO (not occurred) as it thought to be insignificant (EMEP/EEA air pollutant emission inventory guidebook 2019).

4.7 NFR 2.I Wood processing

This category refers to the emissions from wood processing.

The following wood products are taken into consideration under this category:

- Coniferous and non coniferous wood,
- Other wood products (crates, drums hand tools, handles etc)
- Wood boards (Fibreboard compressed or not, Hardboard, MDF/HDF, Particle board and OSB, Plywood, Veneer sheets, Sawlogs and veneer logs)

Emissions of TSP associated to annual mass of wood products in Greece were calculated by applying Tier 1 methodology with EFs from EMEP/EEA air pollutant emission inventory guidebook 2019.

Activity data derive from:

- The Prodcom database of the Hellenic Statistical Authority (www.statistics.gr) for coniferous and non coniferous wood and other wood products (in kg)
- The FAOSTAT database (http://faostat.fao.org) for wood boards (in m^3). This data were converted to kg of products by multiplying with an average density for every board derived from bibliographic search.

Table 4-12 Average wood board density values used

Wood Boards	Average density (kg/m³)
Fibreboard	650
Hardboard	1100
MDF/HDF	950
Other fibreboard	425
Particle board and OSB	650
Plywood	550
Veneer sheets	400
Sawlogs and veneer logs, coniferous	460
Sawlogs and veneer logs, non-coniferous	670

4.8 NFR 2.J Production of POPs

Emissions of air pollutants of this subcategory were reported as not estimated (NE) or not applicable (NA) as 'assumed to be negligible especially when compared to the use of POPs' (EMEP/EEA air pollutant emission inventory guidebook 2019).

4.9 NFR 2.K "Consumption of POPs and heavy metals (e.g. electrical and scientific equipment)"

Emissions of air pollutants of this subcategory were reported as not estimated (NE) or not applicable (NA) as assumed to be insignificant (EMEP/EEA air pollutant emission inventory guidebook 2019).

4.10 NFR 2.L Other production, consumption, storage, transportation or handling of bulk products

Emissions of air pollutants of this subcategory were reported as NO (not occurred) as it thought to be insignificant (EMEP/EEA air pollutant emission inventory guidebook 2019).

4.11 Planned improvements

Based on the findings of EU internal audits and UNECE reviews, actions will be planned and executed that may lead to recalculations / improvements of the inventory. Improvements that are associated to key categories will be prioritized.

4.12 Recalculations

Following EMEP/EEA air pollutant emission inventory guidebook 2019 revisions compared to 2016 version, Hg emissions removed from 2.D.3.a and PAH recalculated for 2.D.3.g based on the revised emission factor for the whole of period of 1990 to 2017. Moreover, NMVOC emissions were recalculated for 2017 for the categories 2.D.3.b, 2.D.3.g, 2.D.3.h, 2.G and 2.H.2 due to updated activity data.

5. Agriculture (CRF sector 3)

5.1 Sector Overview

This chapter includes information on the methodologies applied for estimating emissions of airpollutants, as well as references for activity data and emission factors concerning **Agriculture** sector from 1990 to 2018 in Greece, corresponding to the data reported in category 3 of the NFR format. Emissions addressed in this chapter include emissions from the subcategories:

- 3.B Manure Management,
- 3.D Agricultural Soils
- 3.F Field Burning of Agricultural Residues and
- 3.I Agriculture other.

5.2 General description

5.2.1 Completeness

Table 5-1 provides information on the status of emission estimates of all sub categories. A "✓" indicates that emissions from this sub category have been estimated. Emissions were not calculated (NA), only for categories and pollutants that there is no methodology included in the EMEP/EEA air pollutant emission inventory guidebook – 2016 and 2019.

Table 5-1 ***Overview of sub-categories of agriculture and status of estimation in Greece's agriculture inventory***

NFR Category		NEC gas				PM			Other (from 1990)	Heavy metals	POPs
		NO_x	NMVOC	SO_2	NH_3	TSP	PM_{10}	$PM_{2.5}$	CO	(Pb, Cd, Hg, As, etc)	(PCDD/PCDF, PAHs, etc)
3.B.	**MANURE MANAGEMENT**										
3.B.1	Cattle										
3.B.1.a	Dairy Cattle	✓	✓	NA	✓	✓	✓	✓	NA	NA	NA
3.B.1.b	Non-Dairy Cattle	✓	✓	NA	✓	✓	✓	✓	NA	NA	NA
3.B.2	Sheep	✓	✓	NA	✓	✓	✓	✓	NA	NA	NA
3.B.3	Swine	✓	✓	NA	✓	✓	✓	✓	NA	NA	NA
3.B.4	Other Livestock										
3.B.4.a	Buffalo	✓	✓	NA	✓	✓	✓	✓	NA	NA	NA
3.B.4.d	Goats	✓	✓	NA	✓	✓	✓	✓	NA	NA	NA
3.B.4.e	Horses	✓	✓	NA	✓	✓	✓	✓	NA	NA	NA
3.B.4.f	Mules and asses	✓	✓	NA	✓	✓	✓	✓	NA	NA	NA
3.B.4.g	Poultry										
.i	*Laying hens*	✓	✓	NA	✓	✓	✓	✓	NA	NA	NA
.ii	*Broilers*	✓	✓	NA	✓	✓	✓	✓	NA	NA	NA
.iii	*Turkeys*	✓	✓	NA	✓	✓	✓	✓	NA	NA	NA
.iv	*Other poultry*	✓	✓	NA	✓	✓	✓	✓	NA	NA	NA
3.B.4.h	Other Animals	✓	✓	NA	✓	✓	✓	✓	NA	NA	NA
3.D	**AGRICULTURAL SOILS**										
3.D.a.1	Inorganic N fertilizers	✓	NA	NA	✓	NA	NA	NA	NA	NA	NA
3.D.a.2	Organic N fertilizers										
.a	*Animal manure applied to soils*	✓	NA	NA	✓	NA	NA	NA	NA	NA	NA
.b	*Sewage sludge applied to soils*	✓	NA	NA	✓	NA	NA	NA	NA	NA	NA
.c	*Other organic fertilisers applied to soils (including compost)*	NO	NA	NA	NO	NA	NA	NA	NA	NA	NA
3.D.a.3	Urine and dung deposited by grazing animals	✓	NA	NA	✓	NA	NA	NA	NA	NA	NA
3.D.a.4	Crop residues	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.b	Indirect emissions from managed soils	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.c	Farm-level agricultural operations including storage, handling and transport of agricultural products	NA	NA	NA	NA	✓	✓	✓	NA	NO	NO
3.D.d	Off-farm storage, handling and transport of bulk agricultural products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.e	Cultivated crops	NA	✓	NA	NA	NA	NA	NA	NA	NA	NA
3.D.f	Use of pesticides	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.F	**FIELD BURNING OF AGRI-CULTURAL RESIDUES**	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
3.I	**AGRICULTURE OTHER**	NA	NA	NA	NO	NA	NA	NA	NA	NA	NA

5.2.2 Key Categories

Key category analysis is presented in Chapter 1.5. Key sources within this category are presented in Table 5-2.

Table 5-2 Key sources of NFR sector 3 Agriculture

NFR Category	Category Name	Pollutant	KS-assessment
3B1b	Manure management - Non-dairy cattle	NH3	L, T
3B2	Manure management – Sheep	NH3	L
3B3	Manure management - Swine	NH3	L
3B4gi	Manure mangement - Laying hens	NH3	T
3B4gii	Manure mangement - Broilers	NH3	L,T
3.D.a.1	Inorganic N-fertilizers (includes also urea application)	NH3	L,T
3.D.a.2.a	Animal manure applied to soils	NH3	L,T
3.D.a.3.	Urine and dung deposited by grazing animals	NH3	L,T
3.F	Field burning of agricultural residues	PM2.5	L

5.2.3 Uncertainty Assessment

The method used for the assessment of uncertainty is according to the EMEP/EEA air pollutant emission inventory guidebook 2019 (EEA 2019). Further information on the uncertainty assessment of activity data can be found in Greece`s National Inventory Report. Where no specific information on uncertainties of emission factors was available, an average of the default values, based on the definitions of the qualitative ratings given in the EMEP/EEA Emission Inventory Guidebook 2016 and 2019 is used. Please refer to Chapter 1.7 for further information about uncertainty.

5.2.4 Methodology

Table 5-3 summarizes the methodology that is applied per pollutant and category.

Table 5-3 Summary of methodologies used in Greece's agriculture inventory

NFR category						NH3	Other
3.B	**MANURE MANAGEMENT**						
3.B.1	*Cattle*	**3.B.1.a**	*Dairy Cattle*			Tier 2	Tier 1
		3.B.1.b	*Non-dairy Cattle*			Tier 2	Tier 1
3.B.2	*Sheep*					Tier 2	Tier 1
3.B.3	*Swine*					Tier 2	Tier 1
3.B.4	*Other livestock*	**3.B.4.a**	*Buffalo*			Tier 1	Tier 1
		3.B.4.d	*Goats*			Tier 1	Tier 1
		3.B.4.e	*Horses*			Tier 1	Tier 1
		3.B.4.f	*Mules & Asses*			Tier 1	Tier 1
		3.B.4.g	*Poultry*	**3.B.4.g.i**	*Laying hens*	Tier 2	Tier 1
				3.B.4.g.ii	*Broiler*	Tier 2	Tier 1
				3.B.4.g.iii	*Turkey*	Tier 1	Tier 1
				3.B.4.g.iv	*Ducks & Geese*	Tier 1	Tier 1
		3.B.4.h	*Other animal*			Tier 1	Tier 1
3.D	**AGRICULTURAL SOILS**						
3.D.a		**3.D.a.1**	Inorganic N fertilizers			Tier 2	Tier 1
		3.D.a.2	Organic N fertilizers	**3.D.a.2.a**	*Animal manure applied to soils*	Tier 1/2	Tier 1
				3.D.a.2.b	*Sewage sludge applied to soils*	Tier 1	Tier 1
				3.D.a.2.c	*Other organic fertilisers applied to soils (including compost)*	Tier 1	Tier 1
		3.D.a.3	Urine and dung deposited by grazing animals			Tier 1/2	Tier 1
		3.D.a.4	Crop residues			Tier 1	Tier 1
3.D.b	Indirect emissions from managed soils					Tier 1	Tier 1
3.D.c	Farm-level agricultural operations including storage, handling and transport of agricultural products					Tier 1	Tier 1
3.D.d	Off-farm storage, handling and transport of bulk agricultural products					Tier 1	Tier 1
3.D.e	Cultivated crops					Tier 1	Tier 1
3.D.f	Use of pesticides					Tier 1	Tier 1
3.F	**FIELD BURNING OF AGRI-CULTURAL RESIDUES**					Tier 1	Tier 1
3.I	**AGRICULTURE OTHER**					Tier 1	Tier 1

5.3 NFR 3.B Manure Management

5.3.1 Methodological Issues

The Tier 2 methodology was used for the calculation of NH_3 emissions from the high majority of animals, while Tier 1 methodology with default EFs from EMEP/EEA air pollutant emission inventory guidebook 2016 was used to calculate the other emissions from all subcategories.

The emissions for NH_3 calculated for Manure application and Grazed pastures are reported in subcategories 3Da2a and 3Da3, respectively, as proposed in EMEP/EEA air pollutant emission inventory guidebook 2016. Only NH_3 emissions from Housing, storage and yards are reported in 3B.

5.3.2 Activity data

If available, exactly the same data, which have been used for the estimation of GHG emissions for UNFCCC reporting, were used for the estimation of the emissions of air pollutants that are presented in this report and NFR tables. Other sources of activity data (mainly EUROSTAT) were used, in the cases of categories that the GHG inventory submission to UNFCCC did not include any relevant data. A description of the activity data is included in the National Inventory Report of Greece under the UNFCCC and in the following chapters.

5.3.3 Emissions from Cattle (3.B.1)

Cattle (dairy and non-dairy) is responsible for NH_3, NO_x, NMVOC, and Particulate Matter (TSP, PM10 and PM2.5) emissions. The air pollutants associated to Cattle were calculated by applying Tier 2 methodology for NH_3 emissions and Tier 1 methodology / EFs for the other emissions from EMEP/EEA air pollutant emission inventory guidebook 2016. Activity data (number of heads) and other parameters e.g. N Excretion kg, % TAN excr, Housed period and % excreta on yards, were obtained from CRF Tables from UNFCCC inventory submission. Please refer to the NIR (UNFCCC) for more details. The activity data were also reported in NFR tables.

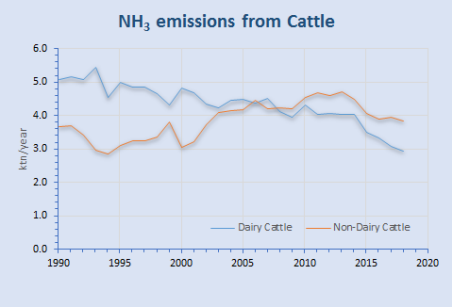

Figure 5-1 Calculated emissions for NH3 from 1990 till 2018 for Cattle in Greece.

For the estimation of NH_3 emissions from cattle, Tier 2 approach was developed following EMEP / EEA air pollutant emission inventory guidebook 2016, utilizing country specific data for the parameters which are avalaible as they are presented in Table 5-4 for 2018.

Table 5-4 Pameters for NH3 emissions estimation

	Nex (kg/yr)	Prop TAN	Livestock management practices	EF (kg a^{-1} AAP^{-1} NH3)
Dairy cattle	140	0.60	Pasture: 8% Liquid systems: 21% Solid storage and dry lot: 71%	31.7
Non-dairy cattle	54.3	0.60	Pasture: 33% Daily spread: 3% Solid storage and dry lot: 64	8.63

As it is obtained from this table, mean EF for both Dairy cattle and Non-Dairy cattle are estimated higher than the proposed figures from EEA air pollutant emission inventory guidebook since Nex figures for Greece are calculated higher than the default ones.

For the estimations of annual nitrogen excretion rate for dairy cattle, the proposed methodology Tier 2 IPCC 2006 Guidelines (EQUATION 10.31 and EQUATION 10.32) is utilized considering crude protein in diet percent (CP) by 16.5%. For the other cattle, annual nitrogen excretion rates were estimated following the Tier 1 approach proposed by 2006 IPCC Guidelines, considering Nrate 0.35 and TAM 425 kg.

NH_3 emissions from cattle have been revised considering the housing time for the adjusting the N in bedding material.

In Figure 5-1, the calculated emissions from 1990 till 2018 for NH_3 are presented.

5.3.4 Emissions from Sheep (3.B.2)

Sheep is responsible for NH_3, NO_x, NMVOC, and Particulate Matter (TSP, PM10 and PM2.5) emissions. The air pollutants associated to Sheep were calculated by applying Tier 2 methodology for NH_3 emissions and Tier 1 methodology / EFs for the other emissions from EMEP/EEA air pollutant emission inventory guidebook 2016 and 2019. Activity data (number of heads) and other parameters e.g. N Excretion kg, % TAN excr, Housed period and % excreta on yards, were obtained from CRF Tables from UNFCCC inventory submission. Please refer to the NIR (UNFCCC) for more details. The activity data were also reported in NFR tables. In Figure 5-2, the calculated emissions for NH_3 from 1990 till 2018 are presented.

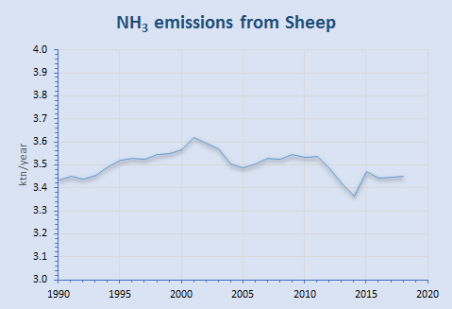

Figure 5-2 Calculated emissions for NH3 from 1990 till 2018 for Sheep in Greece.

For the estimation of NH_3 emissions from sheep, Tier 2 approach was developed following EMEP / EEA air pollutant emission inventory guidebook 2016, utilizing country specific data for the parameters which are avalaible as they are presented in Table 5-5 for 2018.

Table 5-5 Pameters for NH3 emissions estimation

	Nex (kg/yr)	Prop TAN	Livestock management practices	EF (kg a^{-1} AAP^{-1} NH3)
Swine	14.9	0.50	Solid storage and dry lot: 10% Pasture: 90%	0.4

As it is obtained from this table, mean EF for sheep is estimated equal to the proposed figures from EEA air pollutant emission inventory guidebook.

5.3.5 Emissions from Swine (3.B.3)

Swine is responsible for NH_3, NO_x, NMVOC, and Particulate Matter (TSP, PM10 and PM2.5) emissions. The air pollutants associated to Swine were calculated by applying Tier 2 methodology for NH_3 emissions and Tier 1 methodology / EFs for the other emissions from EMEP/EEA air pollutant emission inventory guidebook 2016 and 2019. Activity data (number of heads, distribution to fattening pigs, sows, weaners etc) and other parameters e.g. N Excretion kg, % TAN excr, Housed period and % excreta on yards, were obtained from NIR 2019.

For the estimation of NH_3 emissions from swine, Tier 2 approach was developed following EMEP / EEA air pollutant emission inventory guidebook 2016, utilizing country specific data for the parameters which are avalaible as they are presented in Table 5-6 for 2018.

Table 5-6 Pameters for NH3 emissions estimation

	Nex (kg/yr)	Prop TAN	Livestock management practices	EF (kg a^{-1} AAP^{-1} NH3)
Swine	13.5	0.70	Liquid systems: 90% Solid storage and dry lot: 10%	4.46

As it is obtained from this table, mean EF for swine is estimated in the range of the the proposed figures from EEA air pollutant emission inventory guidebook.

Regarding NMVOC emissions Tier 1 method presented in the 2019 EMEP/EEA Guidebook is utilized, i.e. 0.551 kg for fattening pigs and 1.704 kg for sows (kg NMVOC per animal and year). Taking into consideration that share of fattening pigs and sows population is varied from 75 to 86.6% and 13.1 to 25.1, respecivelly, NMVOC IEF changes from 0.702 kg to 0.84 kg. Since Tier 1 is utilized for the estimation of NMVOC emissions, no assumption is considered regarding manure management system (MMS) distribution. In Figure 5-3, the calculated emissions for NH_3 from 1990 till 2018 are presented.

For the NMVOC estimations, the proposed emission factors, i.e. 0.551 and 1.704 kg AAP^{-1} a^{-1}, for the total swine population, included Weaners, depending the manure management handling system. PM emissions are estimated for Fattening pigs, for Weaners and for Sows utilizing proposed figures of Table 3.5, 2019 EMEP/EEA Guidebook, i.e.:

Fattening pigs: EF for TSP: 1.05 kg AAP^{-1} a^{-1}, EF for PM10: 0.14 kg AAP^{-1} a^{-1} and EF for PM2.5: 0.006 kg AAP^{-1} a^{-1}

Weaners: EF for TSP: 0.27 kg AAP^{-1} a^{-1}, EF for PM10: 0.05 kg AAP^{-1} a^{-1} and EF for PM2.5: 0.002 kg AAP^{-1} a^{-1}

Sows: EF for TSP: 0.62 kg AAP^{-1} a^{-1}, EF for PM10: 0.17 kg AAP^{-1} a^{-1} and EF for PM2.5: 0.01 kg AAP^{-1} a^{-1}

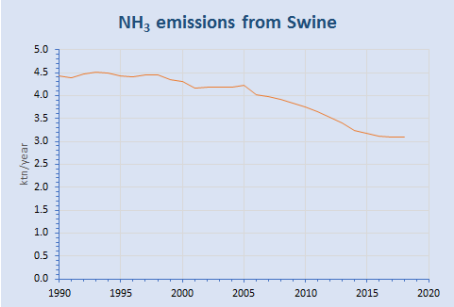

Figure 5-3 Calculated emissions for NH3 from 1990 till 2018 for Swine in Greece.

5.3.6 Emissions from Other livestoke (3.B.4.a, d, e, f and h)

Under the Other Livestoke category the following sub- categories are included.

- Buffalo
- Goats
- Horses
- Mules & Asses
- Other animal(fur)

Poultry is presented in a separated section.

These subcategories are responsible for NH_3, NO_x, NMVOC, and Particulate Matter (TSP, PM10 and PM2.5) emissions. The air pollutants were calculated by applying Tier 1 methodology / EFs from EMEP/EEA air pollutant emission inventory guidebook 2019. Activity data (number of heads) were obtained from CRF Tables from UNFCCC inventory submission. Please refer to the NIR (UNFCCC) for more details. The activity data were also reported in NFR tables. PM2.5, PM10 and TSP emissions were calculated in accordance with the Tier 1 method from the 2019 EMEP/EEA Guidebook following TERT for Horses and Mules & Asses.

5.3.7 Emissions from Poultry (3.B.4.g)

Poultry is responsible for NH_3, NO_x, NMVOC, and Particulate Matter (TSP, PM10 and PM2.5) emissions. The air pollutants associated to Laying hens and Broilers were calculated by applying Tier 2 methodology for NH_3 emissions and Tier 1 methodology / EFs for the other poultry emissions from EMEP/EEA air pollutant emission inventory guidebook 2016. Activity data (number of heads) and other parameters e.g. N Excretion kg, % TAN excr, Housed period and % excreta on yards, were obtained from CRF Tables from UNFCCC inventory submission while the distribution in hens, broilers, turkeys, etc were obtained from (EUROSTAT, 2018). The activity data are reported in Table 5-7.

In Figure 5-4, the calculated emissions for NH3 from 1990 till 2018 are presented.

For the estimation of NH_3 emissions from Laying hens and Broilers, Tier 2 approach was developed following EMEP / EEA air pollutant emission inventory guidebook 2016, utilizing country specific data for the parameters which are avalaible as they are presented in Table 5-8 for 2018.

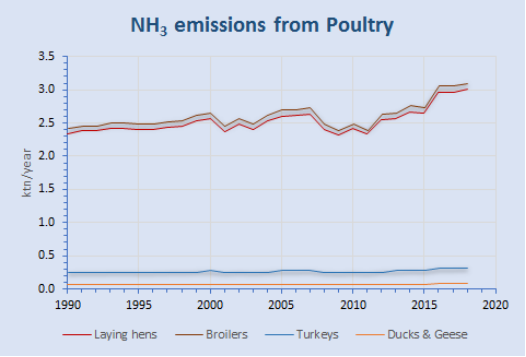

Figure 5-4 Calculated emissions for NH3 from 1990 till 2018 for Poultry in Greece.

Table 5-7 The population of Other livestock (Poultry) ((in 1000s) in Greece.

Year	Total	Laying hens (i)	Broilers (ii)	Others	Turkeys (iii)	Ducks & Geese (iv)
1990	**28282**	7495	20193	594	451	143
1991	**28843**	7643	20594	606	460	145
1992	**28818**	7637	20576	605	460	145
1993	**29256**	7753	20889	614	467	147
1994	**29379**	7785	20976	617	469	148
1995	**29059**	7701	20748	610	464	146
1996	**29157**	7727	20818	612	465	147
1997	**29583**	7840	21122	621	472	149
1998	**29704**	7872	21209	624	474	150
1999	**30727**	8143	21939	645	490	155
2000	**31010**	8218	22141	651	495	156
2001	**28714**	7609	20502	603	458	145
2002	**30088**	7973	21483	632	480	152
2003	**29134**	7721	20802	612	465	147
2004	**30587**	8106	21839	642	488	154
2005	**31566**	8365	22538	663	504	159
2006	**31599**	8374	22562	664	504	159
2007	**31949**	8466	22812	671	510	161
2008	**29141**	7722	20807	612	465	147
2009	**28022**	7426	20008	588	447	141
2010	**29209**	7740	20856	613	466	147
2011	**28262**	7489	20179	593	451	142
2012	**30804**	8163	21994	647	492	155
2013	**31078**	8236	22190	653	496	157
2014	**32362**	8576	23106	680	516	163
2015	**32111**	8509	22927	674	512	162
2016	**35857**	9502	25602	753	572	181
2017	**35823**	9493	25578	752	572	181
2018	**36369**	9638	25967	764	580	183

Table 5-8 Pameters for NH3 emissions estimation

	Nex (kg/yr)	Prop TAN	Livestock management practices	EF (kg a^{-1} AAP^{-1} NH3)
Laying hens	0.77	0.70	Solid storage and dry lot: 100%	0.31
Broilers	0.36	0.70	Solid storage and dry lot: 100%	0.12

As it is obtained from this table, mean EF for both Laying hens and Broilers are estimated in the range of the the proposed figures from EEA air pollutant emission inventory guidebook.

5.4 NFR 3.D Crop production and agricultural soils

5.4.1 Methodological Issues

The Tier 1 and Tier 2 methodology with default EFs from EMEP/EEA air pollutant emission inventory guidebook 2019 was used to calculate the emissions from all subcategories.

The emissions for NH_3 calculated for Manure application and Grazed pastures are reported in subcategories 3Da2a and 3Da3, respectively, as proposed in EMEP/EEA air pollutant emission inventory guidebook 2019.

5.4.2 Activity data

If available, exactly the same data, which have been used for the estimation of GHG emissions for UNFCCC reporting, were used for the estimation of the emissions of air pollutants that are presented in this report and NFR tables. Other sources of activity data (mainly EUROSTAT and Hellenic Fertilizer' Association[3]) were used, in the cases of categories that the GHG inventory submission to UNFCCC did not include any relevant data. A description of the activity data is included in the National Inventory Report of Greece under the UNFCCC and in the following chapters. **It should be noted that the development of the Tier 2 approach on the estimation of NH_3 emissions from inorganic fertilizers was based on activity data (i.e. annual nitrogen fertilizer consumption per fertilizer type) and the technical assistance on the footprint of existing conditions in Greece relevant to soil pH and urease inhibitors utilization, which was provided by the the Hellenic Fertilizer' Association.**

5.4.3 Emissions from Inorganic fertilizers (includes urea) (3.D.a.1)

Inorganic fertilizers are responsible for NH_3, NO_x and PM emissions. The air pollutants associated to Inorganic fertilizers were calculated by applying Tier 2 methodology for NH_3 emissions, with EFs from EMEP/EEA air pollutant emission inventory guidebook 2019 and Tier 1 methodology / EFs for the other emissions from EMEP/EEA air pollutant emission inventory guidebook 2019. Activity data (kg of Inorganic N fertilizers per fertilizer type, as it is required from the application of Tier 2 approach) were obtained from the Hellenic Fertilizer' Association.

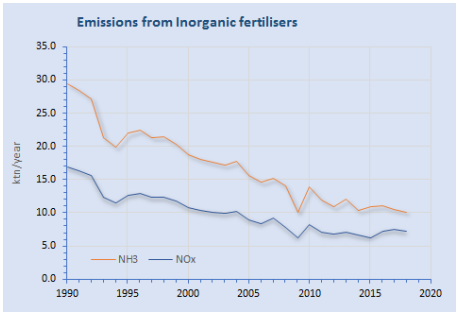

Figure 5-5 Calculated emissions for NH3 and NOx from 1990 till 2018 from Inorganic fertilizers in Greece.

[3] Former name of the association: Pan-Hellenic Association of Professional Fertilizers Producers & Dealers (PHAPFPD)

In accordance with Hellenic Fertilizer' Association, in Greece since 2012, urease inhibitors are utilized for some nitrogen fertilizer types in order to decrease the nitrogen emissions. In particular, for 2018, it is estimated that for approximately 45% of the total annual urea consumption, urease inhibitors are used resulting in approximately 80% reduction of relevant ammonia emissions. Similarly, for the other nitrogen fertilizers, it is estimated that for the 20% of the total amount, urease inhibitor is utilized.

For emissions estimation, proposed EFs for each N fertilizer type from 2016 EEA Guidebook, Chapter 3.D Crop production and agricultural soils, Page 17, Table 3.2 for Climate Temperate were utilized.

It must be clarified that in accordance with 2016 EEA Guidebook, Chapter 3.D Crop production and agricultural soils, Page 14, Table 3.1, Tier 1 default NH3 EFs is 0.05 kgNH3/kg N applied fertilizer, while in accordance with Table 3.2, EFs for NH3 emissions calculation with Tier 2 methodology for some fertilizer types EF is significantly higher. For example for AS, EF is between 0.092-0.17 kgNH3/kg N and for urea 0.159-0.168 kgNH3/kg N. Given the fact that the total applied N fertilizer in Greece contains more than 15% of these two types of fertilizers results on the calculation of a IEF approximately 0.56 kgNH3/kg N, i.e. 11% higher than the default one.

In Figure 5-5, the calculated emissions for NH_3 and NOx from 1990 till 2018 are presented.

The steep decrease observed for the years 1993 and 1994 is due to the cut backs in public incentives for the use of synthetic fertilizers.

The decrease in the use of synthetic nitrogen fertilizers could probably be attributed to an increase in non fertilized farming, the price of fertilizer and the impact of initiatives to promote good practice in fertilizer use. Additionally, the annual changes in the amount of fertilizers used and the agricultural production are the basic factors that account for the fluctuation of emissions during the period 1990 – 2018.

5.4.4 Emissions from Organic fertilizers (3.D.a.2)

Emissions for NH_3 and NO_x from Organic fertilizers are calculated in this chapter. The air pollutants associated to organic fertilizers were calculated by applying Tier 2 methodology for NH_3 emissions from cattle, sheep, swine and poultry manure applied to soils and Tier 1 methodology / EFs for the other categories and emissions from EMEP/EEA air pollutant emission inventory guidebook 2019. In this category, three subcategories are included.

- Livestock manure applied to soils (3.D.a.2.a). EFs for NH_3 (calculated in 3.B) and NO_x are available.
- Sewage sludge applied to soils (3.D.a.2.b). EFs only for NH_3 are available
- Other organic fertilisers applied to soils (including compost) (3.D.a.2.c). EFs for NH_3) and NO_x are available.

Activity data (kg of Organic N fertilizers per fertilizer type, as it is required from the application of Tier 2 approach) were obtained from the Hellenic Fertilizer' Association. The activity data were also reported in NFR tables and in Chapters 5.3.3, 5.3.5 and 5.3.7.. For Sewage sludge applied to soils (3.D.a.2.b), the country's population was utilised as obtained from EUROSTAT.

For 3.D.a.2.a, the total amount of NH_3 was calculated as the sum of NH_3 emissions calculated in each subcategory of 3.B. For 3.D.a.2.c, no amount of such fertilisers has been reported.

5.4.5 Emissions from Urine and dung deposited by grazing livestock (3.D.a.3)

Emissions for NH_3 and NO_x from Urine and dung deposited by grazing livestock are calculated in this chapter. The air pollutants associated to this subcategory were calculated by applying Tier 2 methodology for NH_3 emissions from cattle, sheep, swine and poultry manure applied to soils and Tier 1 methodology / EFs for the other categories and emissions EMEP/EEA air pollutant emission inventory guidebook 2019.

Activity data (kg of N excretion on pasture, range and paddock) were obtained from CRF Tables from UNFCCC inventory submission. The activity data were also reported in NFR tables.

For NH_3 emissions, the total amount of ammonia was calculated as the sum of NH_3 emissions calculated in each subcategory of 3.B. For NOx, the kg of N excretion on pasture, range and paddock were used.

In Figure 5-6, the calculated emissions for NH3 and NOx from 1990 till 2018 are presented.

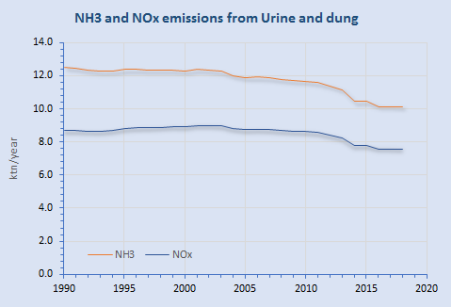

Figure 5-6 Calculated emissions for NH3 and NOx from 1990 till 2018 from Urine and dung deposited by grazing livestock in Greece.

5.4.6 Emissions from Crop residues applied to soils (3.D.a.4)

No emissions factors are available for this subcategory.

5.4.7 Indirect emissions from managed soils (3.D.b)

No emissions factors are available for this category.

5.4.8 Emissions from Farm-level agricultural operations including storage, handling and transport of agricultural products (3.D.c)

Emissions for PM from Farm-level agricultural operations including storage, handling and transport of agricultural products are calculated in this chapter. The air pollutants associated to this subcategory were calculated by applying Tier 1 methodology / EFs from EMEP/EEA air pollutant emission inventory guidebook 2019.

Activity data (ha of Croplands per year) were obtained from EUROSTAT.

5.4.9 Emissions from Off-farm storage, handling and transport of bulk agricultural products (3.D.d)

No emissions factors are available for this category.

5.4.10 Emissions from Cultivated crops (3.D.e)

Emissions for NMVOC from Cultivated crops are calculated in this chapter. The air pollutants associated to this subcategory were calculated by applying Tier 1 methodology / EFs from EMEP/EEA air pollutant emission inventory guidebook 2019.

Activity data (ha of Croplands per year) were obtained from EUROSTAT.

5.4.11 Emissions from the Use of pesticides (3.D.f)

No amounts of the specific pesticides have been reported.

5.5 NFR 3.F Field Burning of Agricultural Residues

5.5.1 Methodological Issues

The Tier 1 methodology with default EFs from EMEP/EEA air pollutant emission inventory guidebook 2019 was used to calculate the emissions from all subcategories.

5.5.2 Activity data

If available, exactly the same data, which have been used for the estimation of GHG emissions for UNFCCC reporting, were used for the estimation of the emissions of air pollutants that are presented in this report and NFR tables. A description of the activity data is included in the National Inventory Report of Greece under the UNFCCC and in the following chapters.

5.5.3 Emissions from Field burning of agricultural residues (3.F)

The air pollutants associated to Field burning of agricultural residues were calculated by applying Tier 1 methodology / EFs from EMEP/EEA air pollutant emission inventory guidebook 2019.

Activity data (kg of total biomass burned) were obtained from CRF Tables from UNFCCC inventory submission. The activity data were also reported in NFR tables.

5.6 NFR 3.I Agriculture other

No activity data have been reported.

5.7 Planned improvements

Based on the findings of EU internal audits and UNECE reviews, actions will be planned and executed that may lead to recalculations / improvements of the inventory. Imrpovements that are associated to key categories will be prioritized.

5.8 Recalculations

NH_3 emissions of categories Manure management for cattle (2.B.1.a and 2.B.1.b) and animal manure applied to soils (3.D.a.2.a) were recalculated for the whole of period of 1990 to 2017 due to adjusting of N in bedding which is applied in cattle manure considering the cattle housing days, following TERT 2019 recommendations. Moreover, emissions from swine were recalculated for

the whole of period of 1990 to 2017 due to updating of activity data to be consistent with the data used in UNFCCC inventory. Finally, emissions of category Indirect emissions from managed soils, 3.D.b, were recalculated for 2017 due to updating activity data.

6. WASTE (NFR SECTOR 5)

6.1 Sector Overview

This chapter includes information on and descriptions of methodologies applied for estimating emissions of airpollutants, as well as references for activity data and emission factors concerning waste management and treatment activities reported under NFR Category 5 Waste for the period from 1990 to 2018.

Emissions addressed in this chapter include emissions from the subcategories:

- Solid Waste Disposal on Land (NFR Sector 5.A);
- Composting (NRF Sector 5.B);
- Waste Incineration (NFR Sector 5.C);
- Wastewater Handling (NFR Sector 5.D); and
- Other waste ((NFR Sector 5.E).

6.1.1.1 Completeness

Table 6-1 provides information on the status of emission estimates of all sub categories. A "√" indicates that emissions from this sub category have been estimated. Emissions were not estimated (NE), only for categories and pollutants that there is no methodology included in the EMEP/EEA air pollutant emission inventory guidebook – 2019.

Emissions of subcategory 5.D.2 were reported under 5.D.1 (IE).

6.1.1.2 Key Categories

Key category analysis is presented in Chapter 1.5. Key sources within this category are presented in Table 6-2.

6.1.1.3 Uncertainty Assessment

The method used for the assessment of uncertainty is according to the EMEP/EEA air pollutant emission in-ventory guidebook 2019 (EEA 2019). Further information on the uncertainty

assessment of activity data can be found in Greece`s National Inventory Report. Where no specific information on uncertainties of emission factors was available, an average of the default values, based on the definitions of the qualitative ratings given in the EMEP/EEA Emission Inventory Guidebook 2019 is used. Please refer to chapter 1.7 for further information about uncertainty.

Table 6-1 Completeness of sub categories in NFR Sector 5 Waste.

NFR code	NOx (as NO2)	NMVOC	SOx (as SO2)	NH3	PM2.5	PM10	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/ PCDF (dioxins/ furans)	benzo(a) pyrene	benzo(b) fluoranthene	benzo(k) fluoranthene	Indeno (1,2,3-cd) pyrene	Total 1-4	HCB	PCBs
5A	NA	√	NA	NE	√	√	√	NA	NE	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5B1	NE	NE	NE	√	NE	NE	NE	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5B2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5C1a	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5C1bi	√	√	√	NE	√	√	√	√	√	√	√	√	√	NE	NE	√	NE	NE	√	NE	NE	NE	NE	√	√	NA
5C1bii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5C1biii	√	√	√	NE	NE	NE	√	√	√	√	√	√	√	√	√	√	NE	NE	√	NE	NE	NE	NE	√	√	√
5C1biv	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5C1bv	NE	NE	NE	NE	√	√	√	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5C1bvi	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5C2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5D1	NA	√	NA	NE	NE	NE	NE	NE	NA	NE	NE	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
5D2	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
5D3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5E	NE	NE	NE	NA	√	√	√	NE	NE	√	√	√	√	√	√	NE	NE	NE	√	NE	NE	NE	NE	NE	NE	NE

Table 6-2 Key sources of NFR sector 5 Waste.

NFR Category	Category Name	Pollutant	KS-assessment
5A	Biological treatment of waste - Solid waste disposal on land	NMVOC	L, T

L = Level Assessment 2018

T = Trend Assessment 2018/1990

6.1.2 Methodological issues

Methodology and emission factors

Table 6-3 summarizes the methodology that is applied per pollutant and category. Some clarifications about this table:

- ✓ T1 refers to Tier 1 methodology with default EFs from EMEP/EEA air pollutant emission in-ventory guidebook 2019.
- ✓ T2 refers to Tier 2 technology specific activity data and EFs. The source of technology specific Tier 2 EFs is the EMEP/EEA air pollutant emission inventory guidebook 2019.

Activity data

If available, exactly the same data, which have been used for the estimation of GHG emissions for UNFCCC reporting, were used for the estimation of the emissions of air pollutants that are presented in this report and NFR tables. Other sources of activity data (mainly the Hellenic Statistical Authority) were used, in the cases of categories that the GHG inventory submission to UNFCCC did not include any relevant data. A description of the activity data is included in the National Inventory Report of Greece under the UNFCCC and in the following chapters.

Table 6-3 Methodology that is applied per pollutant and category of sub categories in sector 5 Waste.

NFR code	NOx (as NO2)	NMVOC	SOx (as SO2)	NH3	PM2.5	PM10	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/ PCDF (dioxins/ furans)	benzo(a) pyrene	benzo(b) fluoranthene	benzo(k) fluoranthene	Indeno (1,2,3-cd) pyrene	Total 1-4	HCB	PCBs
5A	NA	T1	NA	NE	T1	T1	T1	NA	NE	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5B1	NE	NE	NE	T2	NE	NE	NE	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5B2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5C1a	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5C1bi	T1	T1	T1	NE	T1	T1	T1	T1	T1	T1	T1	T1	T1	NE	NE	T1	NE	NE	T1	NE	NE	NE	NE	T1	T1	NA
5C1bii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5C1biii	T1	T1	T1	NE	NE	NE	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	NE	NE	T3/T2	NE	NE	NE	NE	T1	T1	T1
5C1biv	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5C1bv	NE	NE	NE	NE	T2	T2	T2	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5C1bvi	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5C2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5D1	NA	T1	NA	NE	NE	NE	NE	NE	NA	NE	NE	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
5D2	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
5D3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5E	NE	NE	NE	NA	T2	T2	T2	NE	NE	T2	T2	T2	T2	T2	T2	NE	NE	NE	T2	NE	NE	NE	NE	NE	NE	NE

6.2 NFR 5.A Waste Disposal on Land

Solid waste disposal on land is responsible for NMVOC, TSP, PM10 and PM2.5 emissions. For the municipal solid waste, for the period 2001-2017 the official data provided by the MEEN (Ministry of Environment and Energy) was used. Concerning the data for the period 1960-2000 total quantities of generated waste were estimated according to studies by the Waste management sector of the MEEN.

The air pollutants associated to solid waste disposal on land were calculated by applying Tier 1 methodology / EFs from EMEP/EEA air pollutant emission inventory guidebook 2019. Activity data (i.e. annual amount of waste) were obtained from CRF Tables from UNFCCC inventory submission. Please refer to the NIR (UNFCCC) for more details. The activity data were also reported in NFR tables.

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6.3 NFR 5.B Composting

NH3 emissions associated to composting were calculated by applying Tier 2 methodology / EFs from EMEP/EEA air pollutant emission inventory guidebook 2019. Activity data (i.e. annual amount of waste) were obtained from CRF Tables from UNFCCC inventory submission. Please refer to the NIR (UNFCCC) for more details. The activity data were also reported in NFR tables.

6.4 NFR 5.C Incineration and open burning of waste

Incineration of municipal waste is not permitted in Greece. Emissions of air pollutants from the incineration of clinical waste were reported under this category. For the incineration of clinical waste, a central plant, the only existing in Greece, covers the total daily needs of hospitals in Athens (reported under category 5C1biii).

Moreover, emissions from the incineration of biogenic agricultural residues produced in slaughterhouses (reported under category 5C1bv) and from the incineration of small amounts of industrial chemical waste (reported under category 5C1bi) are estimated. For these estimations, data provided by the Hellenic Statistical Authority as waste incinerated without energy recovery in Greece. These data were obtained by individual researches of ELSTAT. Activity data (i.e. annual amount of waste) were obtained from CRF Tables from UNFCCC inventory submission. Please

refer to the NIR (UNFCCC) for more details. The activity data were also reported in NFR tables (categories 5C1bi, 5C1biii and 5C1biv).

The air pollutants associated to clinical and industrial waste incineration were calculated by applying Tier 1 methodology / EFs from EMEP/EEA air pollutant emission inventory guidebook 2019, with the exception of PCDD/ PCDF (dioxins/ furans) emissions from clinical waste incineration. These emissions were recalculated in the 2019 submission by applying a Tier 3/2 method. A combined use of Tier 3 facility data; and the development of country specific EFs based on these data, which are applied for the years that plant specific data are not available was followed. The air pollutants associated to the incineration of biogenic agricultural residues produced in slaughterhouses were calculated by applying Tier 2 methodology / EFs from EMEP/EEA air pollutant emission inventory guidebook 2019 (sheep burn).

6.5 NFR 5.D Wastewater handling

NMVOC emissions associated to wastewater handling were calculated by applying Tier 1 methodology / EFs from EMEP/EEA air pollutant emission inventory guidebook 2019. Activity data (i.e. annual amount of wastewater) were obtained from CRF Tables from UNFCCC inventory submission. Please refer to the NIR (UNFCCC) for more details. The activity data were also reported in NFR tables. These data have been estimated by using the total population of Greece (the population data reported in the CRF table 5.D) and the paremeter 0.15m3 wastewater per person per day (which is based on literature search and expert judgement). We consider that this estimation covers the volume of both domestic and industrial wastewater production in Greece (including latrines[4]). Concerning the EF of NMVOC, we applied the tier 1 method with default EF from the 2019 GB (i.e. 15mg/m3).

6.6 NFR 5.E Other waste

TSP, PM10, PM2.5, heavy metals and PCDD/PCDF emissions associated to car, residential and industrial buildings fires were reported under this category. Emissions were calculated by applying Tier 2 methodology / EFs from EMEP/EEA air pollutant emission inventory guidebook 2019. Activity data (i.e. annual fire events, type of fire) were obtained from fire service of Greece (Table 6-4) . The activity data were also reported in NFR tables.

Table 6-4 Activity data of category 5E (number of fire events)

Year	Car fire	Detached house fire	Undetached house fire	Appartment building fire	Industrial building fire	Total fire events

[4] A minor number of latrines exist in remote areas of Greece.

2013	119	73.5	176.5	133	301	803
2014	120	68	163	122	263	736
2015	118	79	190	144	339	870
2016	137	201	229	125	206	898
2017	155	140	259	147	275	976
2018	137	140	226	139	274	916

6.7 Planned improvements

Based on the findings of EU internal audits and UNECE reviews, actions will be planned and executed that may lead to recalculations / improvements of the inventory. Imrpovements that are associated to key categories will be prioritized.

6.8 Recalculations

No recalculation were made.

7. Recalculations and improvements

7.1 Explanations and justifications for recalculations

The recalculations made are driven by the results of the internal QA/QC checks and the recommendations of the 2019 NECD Comprehensive Review pursuant to the Directive on National Emissions Ceilings for certain Atmospheric Pollutants (Directive (EU) 2016/2284 or 'NECD'). Moreover, recalculations are also driven by internal QA/QC checks, ESD and UNFCCC reviews of the GHG inventory, in particular for the cases of air pollution emission source categories that are associated to the same activity data with GHG emission source categories.

The reasons for observed recalculations compared to previous submissions of NFR tables, can be classified as follows:

- ***Changes or refinements in methods***. A methodological change because of the use of the latest version of EMEP/EEA air pollutant emission inventory guidebook; a change in the Tier of the estimation method that was applied; use of plant facility data from E-PRTR or other source.
- ***Inclusion of new sources***. A new source is defined as a source for which estimates (all or some gases) did not exist in previous inventories either due to lack of data or because it has just been identified.
- ***Allocation***. Changes in allocation of emissions to different sectors or sources/sub-sources.
- ***Correction of errors***. This case concerns errors during calculating emissions (e.g. transcript errors) or while filling in the required information in the NFR tables. Inconsistencies resolving is also included in this category.
- ***Updated activity data***.

7.2 Recalculations, including in response to the review process, and planned improvements

An inventory improvement procedure is in place, which utilizes:

a) the recommendations from NECD review reports;

b) the findings of annual internal audits taken place by MEEN personnel; and

c) the output of key category analysis, uncertainty analysis and QA/QC procedures;

as a basis to prioritize, plan and materialize future improvements and recalculations. Details on the resulted recalculations and improvements planned per source/sink category have been presented in

the respective chapters (Chapters 3 – 6). Information regarding the implementation of 2019 NECD Review recommendations is presented in Table 7-1, Table 7-2 and Table 7-3.

Finally, it should be mentioned that the results and the proposals that will arise from the review of the present inventory, within the technical review process defined in NECD, will be integrated in the plan for the improvement of the NEC emissions inventory.

Table 7-1 Recommendations from the NECD Review 2018 for NOX, NMVOC, SO2, NH3, PM2.5 that have not been implemented in the inventory submission 2019

EMRT-NECD Observation	Recommendation	Improvement made/planned	Reference (Sections) into IIR
GR-2A1-2018-0001	For category 2A1 Cement Production and pollutant $PM_{2.5}$ for the whole time series, the TERT noted that for $PM_{2.5}$ in the 2019 IIR, Greece stated that a Tier 2/3 method had been applied. In response to a question raised by the TERT Greece replied that plant specific data had been applied, derived from E-PRTR data and applying the Tier 1 share of PM_{10}:$PM_{2.5}$ ratio from the 2016 EMEP/EEA Guidebook. This seems to correspond to a Tier 1 methodology for a key category. **The TERT recommends that Greece provide more detailed information in the IIR on the number of cement plants present in Greece, the number of plants reporting under the E-PRTR, the method used to calculate the EF.**	A country specific approach was applied, which is of higher tier compared to tier 1. PM2.5 EF was obtained based on PM10 plant specific data, derived from E-PRTR data and applying the Tier 1 share of PM_{10}:$PM_{2.5}$ ratio from the 2016 EMEP/EEA Guidebook.	4.2.1
GR-2D3i-2017-0002	The TERT noted that Greece had changed the calculation in the 2019 submission by including EFs taken from the EMEP/EEA Guidebook which take into account information on abatement technologies. The IIR does not provide transparent information on which abatement technologies have been used and why. **The TERT recommends that Greece increases the transparency of this sector in the IIR by providing more information on the EFs used, justification for the use of these EFs, and the reason for the increase of emissions in 2002 and decrease of emissions following 2012.**	Information is included in Chapter 4.5.9.	4.5.9
GR-3B3-2018-0002	For 3B3 Manure management – Swine, $PM_{2.5}$ emissions and years 2005, 2010, 2015, 2016 and 2017 the TERT noted that emissions from weaners might not be reported. This was raised during the 2018 NECD review. In response to a question raised during the 2018 review Greece indicated that the proposed EFs referred to in Table 3.5 of	Information is included in Chapter 5.3.5.	5.3.5

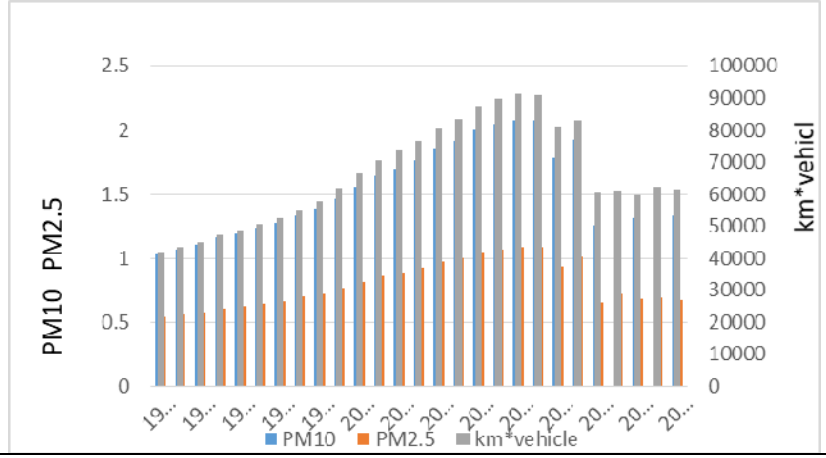
EMRT-NECD Observation	Recommendation	Improvement made/planned	Reference (Sections) into IIR
	the 2016 EMEP/EEA Guidebook for the calculation of PM emissions for fattening pigs, weaners, and sows are applied. The TERT noted that the issue does not relate to an under or overestimate of emissions. **The TERT recommends that Greece clearly indicates the Swine categories considered for each pollutant.**		

Table 7-2 Additional recommendations made during the NECD Review 2019 for NOX, NMVOC, SO2, NH3, PM2.5

EMRT-NECD Observation	Recommendation	Improvement made/planned	Reference (Sections) into IIR
GR-1A3dii-2019-0001	The TERT notes with reference to 1A3dii National navigation (shipping) for NO_X and $PM_{2.5}$ that a Tier 1 method is used for a key category. The TERT notes that using a Tier 1 method is not best practice and could result in an over and/or underestimate of emissions. This over/underestimate may have an impact on total emissions that is above the threshold of significance. Greece has not provided a revised estimate. It is currently not possible for the TERT to provide a numerical emission estimate based on a Tier 2 method, and therefore the issue will be flagged as Potential Technical Correction and will be assessed as a high priority item in future reviews. **The TERT recommends that Greece should calculate NO_X and $PM_{2.5}$ emissions from 1A3dii (national navigation - shipping) using a Tier 2 or Tier 3 method for inclusion in next year's inventory submission.**	Greece estimated and reported NOx, PM2.5 and PM10 emissions from 1A3Adii by using the Tier 2 method in the 2019 EMEP/EEA Guidebook.	3.2.5 and 3.2.8
GR-1A4bi-2019-0001	The TERT notes with reference to category 1A4bi Residential: Stationary, $PM_{2.5}$ and PAH that a Tier 1 method has been selected for a key category. (IIR table 3-3 and p.60) and that the contributions to the national total in 2017 are very high: $PM_{2.5}$=38.8 %, PAH=40.1%. The TERT notes that using a Tier 1 method is not best practice and could result in an over and/or underestimate of emissions. This over/underestimate may have an impact on total	A tier 2 method was developed and applied based on national statistics. Emissions were recalculated.	3.1.6 and 3.1.8

EMRT-NECD Observation	Recommendation	Improvement made/planned	Reference (Sections) into IIR
	emissions that is above the threshold of significance. Greece has not provided a revised estimate. In response to a question raised during the review, Greece responded that it plans to switch to a higher Tier methodology. It is currently not possible for the TERT to provide a numerical emission estimate based on a Tier 2 method, and therefore the issue will be flagged as Potential Technical Correction and will be assessed as a high priority item in future reviews. **The TERT recommends that Greece should calculate $PM_{2.5}$ (and where possible PAH) emissions from 1A4bi using a Tier 2 or Tier 3 method for inclusion in next years' inventory submission.**		
GR-1A2f-2019-0001	For category 1A2f Stationary combustion in manufacturing industries and construction: Non-metallic minerals, PM_{10}, $PM_{2.5}$ and 2000-2004 the TERT noted that $PM_{2.5}$ emissions are equal to PM_{10} emissions. The TERT would expect that for this category, PM_{10} estimates are higher than (rather than equal to) $PM_{2.5}$ estimates. In response to a question raised during the review, Greece responded that emissions from cement production are reported under category 2A1 and that 1A2f only includes $PM_{2.5}$ and PM_{10} emissions that are associated with other production except cement. Greece also responded, that the majority of solid fuels are used in the cement sector and that $PM_{2.5}$ emissions reported under 1A2f resulted from the combustion of gaseous and liquid fuels, which have identical Tier 1 emission factors for $PM_{2.5}$ and PM_{10}. The TERT agrees with the explanation	Text was added to the IIR indicating that emissions from cement production are reported under category 2A1 and that 1A2f only includes $PM_{2.5}$ and PM_{10} emissions that are associated with other production except cement. Further, the majority of solid fuels are used in the cement sector and that $PM_{2.5}$ emissions reported under 1A2f resulted from the combustion of gaseous and liquid fuels, which have identical Tier 1 emission factors for $PM_{2.5}$ and PM_{10}.	3.1.4

EMRT-NECD Observation	Recommendation	Improvement made/planned	Reference (Sections) into IIR
	provided by Greece. **The TERT recommends that Greece includes an explanation about the source and methodology of $PM_{2.5}$ and PM_{10} emission calculation of category 1A2f in its future IIR.**		
GR-1A3b-2019-0001	For 1A3b road transport, all pollutants, the TERT noted that there is a lack of transparency regarding whether biofuels are considered in the inventory. This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Greece explained that they use the COPERT model to estimate emissions arising from the road transport sector and this considers the use of biofuels, which amounted to 188.65 kt of biodiesel in 2017. **The TERT recommends that Greece provides the amount of biofuel consumed in the road transport sector and information how this is considered in the emission estimates in future IIRs.**	In 2018 the amount of biofuels, and more especially of biodiesel, in road transport was 7622,58 kt. Greece uses COPERT model to estimate the emissions arising from the road transport sector. COPERT takes into account diesel and biodiesel consumption. The emissions estimates include both diesel and biodiesel consumption.	3.2.1
GR-1A3bvi-2019-0002	For 1A3bvi brake and tyre wear, $PM_{2.5}$ emissions, all years, the TERT noted that there was a lack of transparency on how the emission estimates had been made and the trend in vehicle kilometres did not seem to follow the trend in emissions. In response to a question raised during the review, Greece provided graphs showing the trend in vehicle kilometres by vehicle type and the corresponding $PM_{2.5}$ emissions from brake & tyre wear. The graphs however did not follow the same trend in a few cases and therefore further work is required to understand the reasons for the discrepancy. The	PM2.5, PM10 and TSP were recalculated for the whole time series as a mistake was found in data processing. The chart below shows the trend in vehicle kilometres relatively to the trends of emissions which were recalculated	3.2.3 and 3.2.8

EMRT-NECD Observation	Recommendation	Improvement made/planned	Reference (Sections) into IIR
	TERT noted that the issue is likely to be below the threshold of significance for a technical correction. **The TERT recommends that Greece checks their PM emission estimates from brake and tyre wear and makes any amendments (if required) in their next inventory submission.**		
GR-2D3g-2019-0001	For category 2D3g and pollutants NMVOC for years 2000-2016 the TERT noted that the IIR stated that emissions from rubber processing, pharmaceutical products manufacturing and leather tanning were not calculated because of limited availability of data, which could lead to an underestimation. Emissions from rubber processing were included in the last NFR. In response to a question raised during the review, Greece explained that the information on rubber processing will be included in the next IIR, and that emissions from leather tanning and the production of pharmaceutical products are zero. The TERT agreed with the explanation provided by Greece. **The TERT recommends that Greece includes the information provided to the TERT into the next IIR.**	Information has been included, please see Chapter 4.5.7, NFR 2.D.3.g Chemical products.	4.5.7

EMRT-NECD Observation	Recommendation	Improvement made/planned	Reference (Sections) into IIR
GR-3B1a-2019-0001	**Recommendation** For categories 3B1a Manure management -Dairy cattle pollutant NH_3, the TERT noted that the N excretion rate is the second highest among Member States and high in relation to the milk yield (N excretion rate in 2017 is 138.93 kg/head, and milk yield 6253 kg/year). In response to a question raised during the review, Greece provided N excretion rate estimate for 2016, derived from the 2006 IPCC Guidelines methodology, based on Gross energy. Greece also indicated that crude protein in diet percent (CP) for dairy farming is based on http://www.clrtap-tfrn.org/sites/clrtap-tfrn.org/files/documents/AGD_final_file.pdf, as suggested by 2016 ESD review team. The value used for 2016 estimates is CP=16.5% and corresponds to "Medium ambition" in Table ES2 Indicative target protein levels (%) of dry feed with a standard dry matter content of 88% for housed animals as a function of animal category and for different ambition levels of the reference document. The TERT notes that the CP values in table ES2 are indicative targets only and that more research is needed when applying them to the national circumstances in Greece. **The TERT recommends that Greece improves the data for N excretion rates. The TERT also recommends that Greece includes further justification of the N excretion rates used in its next IIR, including the values for all the parameters used in the estimates (including those for estimating gross energy).**	Information has been included, please see Chapter 5.3.3, Emissions from Cattle (3.B.1). Improvement of N excretion rates is all time under investigation, however, it must be noted that the used figures have been concluded following TERT recommendations of GHGs inventory emissions the last five years.	5.3.3
GR-3B1b-2019-	For 3B1b Manure management - Non-dairy	Information has been included, please see Chapter 5.3.3, Emissions from Cattle	5.3.3

EMRT-NECD Observation	Recommendation	Improvement made/planned	Reference (Sections) into IIR
0001	cattle, NH_3 and 2000-2016 the TERT noted a lack of transparency regarding the recalculation. In response to a question raised during the review Greece indicated that, as stated in the 2019 IIR, recalculations are due to the change of Tier 1 method to Tier 2 method, and that after the update of N excretion rate (for example from 41kg/aap year to 54.64 kg/yr in year 2016) emissions showed an increase compared to previous submissions. Greece has also modified the housing period from the default 180 days to 208 days in 2016. Greece also provided a file with estimates for Non-dairy cattle for 2016. The TERT noted that in those estimates the amount of N in bedding applied is not adjusted considering the housing days as indicated in EMEP/EEA 2016 (text under table 3.7, page 23, chapter 3.B Manure management). The TERT notes that the issue is below the threshold of significance for a technical correction. **The TERT recommends that Greece revises the estimates considering the housing time for adjusting the N in bedding material. The TERT also recommends that when significant recalculations occur Greece further explains the drivers behind them, and that further information is provided in the IIR on the N excretion rates and livestock management practices.**	(3.B.1) and Chapter 5.8, Recalculations. Moreover, to be explained the differences between Tier 1 and Tier 2 emissions estimation, country specific information has been included, please see Chapter 5.3.3	
GR-3B3-2019-0001	For 3B3 Manure management – Swine, NH_3 emissions and years 2000-2016 the TERT noted that there is a lack of transparency regarding the recalculations. In response to a question raised during the review, Greece explained that, as	To be explained the differences between Tier 1 and Tier 2 emissions estimation, country specific information has been included, please see Chapter 5.3.5	5.3.5

EMRT-NECD Observation	Recommendation	Improvement made/planned	Reference (Sections) into IIR
	indicated in 2019 IIR, a Tier 2 approach has been applied for the first time, following the 2018 NECD Review recommendations. This does not relate to an over- or under-estimate of emissions. **The TERT recommends that Greece includes further description of the reasons behind this recalculation and the current emission estimates (for example, comparing the IEF, emissions/head, using Tier 1 and Tier 2 methods, and how the update of manure management system and the use of N excretion rate affects the emissions).**		
GR-3B4gii-2019-0001	For 3B4gii Manure management – Broilers, NH_3 emissions and years 2000-2016 the TERT noted that there is a lack of transparency regarding the recalculations. This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Greece explained that, as indicated in the 2019 IIR, a Tier 2 approach has been applied for the first time, following 2018 NECD Review recommendations. **The TERT recommends that Greece includes further description of the reasons behind this recalculation and the current emission estimates (for example, comparing the IEF, emissions/head, using Tier 1 and Tier 2 methods, and how the update of manure management system and the use of N excretion rate affects the emissions).**	To be explained the differences between Tier 1 and Tier 2 emissions estimation, country specific information has been included, please see Chapter 5.3.7	5.3.7
GR-3Da1-2019-0001	For 3Da1 Inorganic N-fertilizers (includes also urea application), NH_3 and the whole time series	Information has been included in Chapter 5.4.3. To be noted that specific information relevant to amounts of different type fertiliser is provided by Hellenic	5.4.3

EMRT-NECD Observation	Recommendation	Improvement made/planned	Reference (Sections) into IIR
	the TERT noted that there is a lack of transparency in the activity data and EF used. This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Greece indicated that, as stated in IIR page 124, "Activity data (kg of Inorganic N fertilizers per fertilizer type, as it is required from the application of Tier 2 approach) were obtained from the Hellenic Fertilizer' Association", but the values were not provided to the TERT. Greece also explained that the recalculations are due to the application of a Tier 2 method for the first time, and that Tier 1 default NH_3 EFs is 0.05 $kgNH_3$/kg N applied fertilizer and that because the total applied N fertilizer in Greece contains more than 15% of Ammonium sulphate and Urea types of fertilizers the IEF using Tier 2 is higher than the default EF for Tier1. **The TERT recommends that Greece includes the amount of fertiliser by type and EF used (referring to climate and pH as needed for Tier 2) and the abatement techniques considered, indicating the years and uptake assumed, and their effect on the emissions.**	Fertilizer' Association and cannot be reported.	
GR-3Da2a-2019-0001	For 3Da2a Animal manure applied to soils, NH_3 and the whole time series the TERT noted that there is a lack of transparency regarding the impacts of the change in the method from Tier 1 to Tier 2. This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Greece explained that N excretion for cattle is calculated higher than the default one based on specific	To be explained the differences between Tier 1 and Tier 2 emissions estimation, country specific information has been included, please see Chapters 5.3.3, 5.3.5, 5.3.7 and 5.4.4.	5.3.3, 5.3.5, 5.3.7 and 5.4.4

EMRT-NECD Observation	Recommendation	Improvement made/planned	Reference (Sections) into IIR
	national parameters (see National Inventory Report 2019 for UNFCCC, Page 299-300) and therefore the emissions from 3Da2a show an increase compared to previous submissions. **The TERT recommends that when significant recalculations occur Greece includes further explanation of the drivers and how the changes affect different sources. .This is especially important when applying the N mass balance for N compounds emissions in agriculture.**		

Table 7-3 ***Recommendations from the NECD Review 2018 of POPs and heavy metals that have not been implemented in the inventory submission 2019***

EMRT-NECD Observation	Recommendation	Improvement made/planned	Reference (sections) into IIR
GR-2B10a-2018-0001	For 2B10a Chemical industry: Other, Hg, the TERT noted that Greece reported the notation key 'NE' until 2012, and 'NA' for the time series post 2012. The TERT had requested actual emissions to be reported. In a reply to a question posed by the TERT, Greece replied that they intend to include the notation key 'NO' for the time series after 2012 in the next submission, but also stated that obtaining information on emissions from that sector does not have a high priority for them. **The TERT recommends Greece to continue efforts in obtaining information on emissions for the time before 2012, and to include the correct notation key 'NO' post 2012.**	Due to the fact that this recommendation refers to years before 2012, it is planned for future submissions.	
GR-5E-2018-0001	The TERT noted that emissions from 5E are included in the inventory but the methodological description is very short, indicating that the default Tier 2 methodology proposed in the 2016 EMEP/EEA Guidebook is applied. The question was raised during the 2018 review. In response to a question raised during the 2019 review, Greece indicated that AD and a methodological description will be provided in the next submission. **The TERT recommends that Greece improves the transparency of the IIR, providing detailed AD allowing checking of the reported emissions.**	More information about AD and methodology were provided in the IIR of this year's submission.	6.6

Table 7-4 Recommendations from the NECD Review 2018 of POPs and heavy metals that have not been implemented in the inventory submission 2019

EMRT-NECD Observation	Recommendation	Improvement made/planned	Reference (Sections) into IIR
GR-1A1a-2019-0002	For category 1A1a and pollutant PCDD/F and all years, the TERT noted that the ratio of PCDD/F to $PM_{2.5}$ emissions is very high when compared to other countries. Greece reports 520 g of PCDD/F for the year 2017 while total emissions of other EU-countries sum up to about 55 g for category 1A1a. In response to a question raised during the review Greece responded that PCDD/F emissions from large lignite power plants are estimated by means of reported E-PRTR data. Greece also responded that the IEF of PCDD/F for lignite is 2.54E-6 kg/TJ, which is two order of magnitude higher than the Tier 2 emission factor for lignite in the 2016 EMEP/EEA Guidebook (i.e. 1E-8kg/TJ). The TERT noted that about 492 g of PCDD/F from four plants of IPPC activity "1.(c) Thermal power stations and other combustion installations" (source: https://prtr.eea.europa.eu) have been reported in 2017 and that the four plants report the usage of the EN 1948:2006 measurement standard for emission estimation. **The TERT recommends that Greece reviews the reporting of PCDD/F under E-PRTR and that it explains in its IIR, how such high emissions levels may occur, e.g. if this is due to specific fuel characteristic or if old measurement data have been used for E-PRTR emission estimates of recent years.**	Please refer to GR-1A1a-2019-0003.	
GR-1B2aiv-2019-0001	For category 1B2aiv Fugitive emissions oil: Refining / storage, PCDD/F and all years, the TERT notes that	Emissions were recalculated.	

EMRT-NECD Observation	Recommendation	Improvement made/planned	Reference (Sections) into IIR
	emissions are a factor of 1000 higher than expected (e.g. 137 g in 2017 which is about 20% of the national total). The TERT also notes that activity data reported in the NFR ANNEX I tables are a factor of 1000 too high (e.g. 24030 Mt in 2017). The TERT calculated 0.137 g of PCDD/F for the year 2017 when using 24030 kt of crude oil input as activity data and the Tier1 emission factor (0.0057µg/Mg crude oil input) from the 2016 EMEP/EEA Guidebook Chapter 1B2aiv table 3-1. In response to a question raised during the review, Greece responded that their calculation was erroneous and that a correct estimation would be result in a factor of 1000 PCDD/F emission from category 1B2aiv. **The TERT recommends that Greece revises 1B2aiv PCDD/F emission calculation for the whole time series and that it reports activity data in the correct unit in its next submission.**		
GR-1A1a-2019-0003	For category 1A1a, PCDD/F, HCB, PAH, PCB, Cd and Pb and all years the TERT noted that the trend in emissions correlates strongly with the trend in solid fuels (lignite) consumption. The TERT also notes that the trend of $PM_{2.5}$ emissions 1990 to 2009 correlates strongly with the trend in solid fuels consumption but that between 2009 and 2015 emissions decrease by 85%. The TERT would expect that PCDD/F, HCB, PAH, PCB, Cd and Pb emissions would also decrease to a similar extent like $PM_{2.5}$ emissions do, because $PM_{2.5}$ abatement technologies would also reduce emissions of these substances. In response to a question raised during the review, Greece responded that $PM_{2.5}$ emissions between 2010 to 2017 are estimated by means of E-PRTR data and that old power plants were closed between 2009 to 2015. Greece also responded that it plans to revise PCDD/F emission calculation in order to reflect the effect of abatement technologies. **The TERT recommends that Greece reviews reported E-PRTR data which are used for emission estimation or that**	Emissions were recalculated based on the ratio of the Tier 2 EF of the pollutants: PCDD/F, HCB, PAH, PCB, Cd and Pb compared to PM2.5.	3.1.3.1 and 3.1.8

EMRT-NECD Observation	Recommendation	Improvement made/planned	Reference (Sections) into IIR
	is uses a higher Tier methodology for 1A1a and PCDD/F, HCB, PAH, PCB, Cd and Pb emissions estimation which reflect the abatement technologies applied.		
GR-1A1a-2019-0004	For category 1A1a, Cd and year 2014 the TERT noted that emission levels show a high peak while fuel consumption does not indicate this trend. In response to a question raised during the review, Greece responded that the peak in 2014 Cd emissions is due to an error in calculation. **The TERT recommends that Greece revises the calculation of 1A1a Cd emissions for 2014 in their next submission.**	Emissions were recalculated.	
GR-1A1a-2019-0005	For category 1A1a, Hg and years 2008-2013 the TERT noted that emission levels are a factor of two higher than for adjacent years 2007 and 2014 while fuel consumption does not indicate this trend. The TERT also notes that 1A1a is the major key source for Hg emissions in Greece (e.g. contributing 67% in 2014 to the national total). In response to a question raised during the review, Greece responded that it identified a time-series inconsistency in their working-files. **The TERT recommends that Greece corrects any inconsistencies in their next submission and that it explains the methodology of 1A1a Hg emission calculation in its future IIR.**	Emissions were recalculated.	3.1.3.1 and 3.1.8
GR-1A2f-2019-0004	For category 1A2f, PM_{10}, $PM_{2.5}$ and 2000-2004 the TERT noted that $PM_{2.5}$ emissions are equal to PM_{10} emissions. The TERT would expect that for this category, PM_{10} estimates are higher than (rather than equal to) $PM_{2.5}$ estimates. In response to a question raised during the review, Greece responded that emissions from cement production are reported under category 2A1 and that 1A2f only includes $PM_{2.5}$ and PM_{10} emissions that are associated with other	The following information was added to the IIR: "Emissions from cement production are reported under category 2A1. 1A2f only includes $PM_{2.5}$ and PM_{10} emissions that are associated with other production except cement. Moreover, the majority of solid fuels are used in the cement sector.The $PM_{2.5}$ emissions reported under 1A2f resulted from the combustion of gaseous and liquid fuels, which have identical Tier 1 emission factors for $PM_{2.5}$ and	3.1.4

EMRT-NECD Observation	Recommendation	Improvement made/planned	Reference (Sections) into IIR
	production except cement. Greece also responded, that the majority of solid fuels are used in the cement sector and that $PM_{2.5}$ emissions reported under 1A2f resulted from the combustion of gaseous and liquid fuels, which have identical Tier 1 emission factors for $PM_{2.5}$ and PM_{10}. The TERT agrees with the explanation provided by Greece. **The TERT recommends, that Greece includes an explanation about the source and methodology of $PM_{2.5}$ and PM_{10} emission calculation of category 1A2f in its future IIR.**	PM_{10}.""	
GR-1A4ciii-2019-0001	For 1A4cii and 1A4ciii, the TERT noted that Hg emissions in all years were outliers as a ratio of PM_{10} compared to other Member States. In response to a question raised during the review, Greece explained that an incorrect emission factor had been used and that in fact the guidebook does not provide any Hg emission factors for this source. They also stated that they would correct the emission estimates in the next submission and use the notation key NE. The TERT agreed with the response provided by Greece. **The TERT recommends that Greece use the notation key 'NE' for this source or use a correct emission factor in its 2020 NFR and IIR submission.**	Emissions were recalculated.	
GR-3F-2019-0001	For 3F Field burning of agricultural residues, PAHs and all years, the TERT noted that there is a lack of transparency regarding these emissions, since "Total 1-4" is reported as NA, while 2019 NRF presents emissions all PAHs categories, i.e. benzo(a) pyrene, benzo(b) fluoranthene , benzo(k) fluoranthene and Indeno (1,2,3-cd) pyrene . This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Greece explained that this is due to an error while compiling the NFR table and will be solved in the next submission. **The TERT recommends that Greece ensures consistent reporting of PAH emissions for 3F in the next submission.**	Emissions reporting Tables have been updated, see for all years cell AB123.	

EMRT-NECD Observation	Recommendation	Improvement made/planned	Reference (Sections) into IIR
GR-5-2019-0003	In its latest submission, Greece has moved to a Tier2/Tier 3 method for the estimation of emissions from the category Clinical waste incineration (5C1biii), which is welcomed as an improvement. However, the TERT noted that some zero values are reported e.g. in 2017 for the heavy metals Pb, Cd, Cu. In response to a question raised during the review, Greece confirmed that it has chosen to report zero values for Pb, Cd and Cu from Clinical waste incineration due to the application of an 100% abatement efficiency factor, as given by the 2016 EMEP/EEA Guidebook Table 3.4, chapter 5C1biii. Greece outlined that it considered this approach to be more applicable than reporting a notation key. **The TERT acknowledges Greece's response, but recommends that Greece removes zero values in its next submission, and reports the most applicable notation key, in this case "NA" (not applicable), where emissions of Pb, Cd and Cu are considered to be abated with 100% efficiency due to the application of exhaust cleaning units. In addition, Greece is recommended to include this justification within its next IIR submission.**	"NA" was wased for zero values.	

REFERENCES

EEA – European Environment Agency (2016): EMEP/EEA air pollutant emission inventory guidebook – 2016. EEA Technical report No. 21/2016.

http://www.eea.europa.eu/publications/emep-eea-guidebook-2019

EEA – European Environment Agency (2016): EMEP/EEA air pollutant emission inventory guidebook – 2016. EEA Technical report No. 21/2016.

http://www.eea.europa.eu/publications/emep-eea-guidebook-2016

ELSTAT – Hellenic Statistical Authority, PRODCOM database

http://www.statistics.gr/el/home

EPA – U.S. Environmental Protection Agency (1999): AP-42. Compilation of Air Pollutant Emission Factors, 5th edition. Chapter 13.2 fugitive dust sources. U.S. Environmental Protection Agency, Research Triangle Park, NC.

http://www.epa.gov/otaq/ap42.htm

EUROSTAT, PRODOM database, livestock population database

http://ec.europa.eu/eurostat/web/prodcom/data/database

FAOSTAT, Statistics Division, Food and Agriculture Organization of the United Nations.

http://www.fao.org/faostat/en/#home

MEEN – Ministry of Environment and Energy (2018): Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol. National Inventory Report for the Greek Greenhouse Gas Inventory 1990-2016.

http://ypeka.gr/Default.aspx?tabid=470&language=el-GR

MEEN – Ministry of Environment and Energy (2019): Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol. National Inventory Report for the Greek Greenhouse Gas Inventory 1990-2017.

http://ypeka.gr/Default.aspx?tabid=470&language=el-GR

MEEN – Ministry of Environment and Energy (2019): SUBMISSION OF THE INFORMATION UNDER THE ARTICLES 12, 13 AND 14 OF THE MONITORING MECHANISM REGULATION (EU) 525/2013.

https://cdr.eionet.europa.eu/gr/eu/mmr/art04-13-14_lcds_pams_projections/projections/envwteyjw/

ANNEXES

Annex I: Key categories

Table I-0-1 KCA level assessment for NOx (with key categories in bold)

NFR Code	Longname	Latest year, kt	Level assessment Lx,t	Cumulative total
1A1a	**Public electricity and heat production**	**77.06**	**30%**	**30%**
1A3biii	**Road transport: Heavy duty vehicles and buses**	**47.48**	**19%**	**49%**
1A3dii	**National navigation (shipping)**	**39.89**	**16%**	**65%**
1A3bi	**Road transport: Passenger cars**	**13.14**	**5%**	**70%**
1A3bii	**Road transport: Light duty vehicles**	**9.56**	**4%**	**74%**
1A2f	**Stationary combustion in manufacturing industries and construction: Non-metallic minerals**	**8.56**	**3%**	**77%**
3Da3	Urine and dung deposited by grazing animals	7.60	3%	80%
3Da1	Inorganic N-fertilizers (includes also urea application)	7.18	3%	83%
1A1b	Petroleum refining	6.13	2%	85%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	5.35	2%	87%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	4.72	2%	89%
1A4bi	Residential: Stationary	4.65	2%	91%
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	4.15	2%	93%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	3.56	1%	94%
1A4ai	Commercial/institutional: Stationary	2.08	1%	95%
3Da2a	Animal manure applied to soils	1.99	1%	96%
1A3ai(i)	International aviation LTO (civil)	1.81	1%	96%
1A3biv	Road transport: Mopeds & motorcycles	1.63	1%	97%
1A3c	Railways	1.55	1%	97%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	1.03	0%	98%
3F	Field burning of agricultural residues	0.87	0%	98%
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.69	0%	98%
1A5b	Other, Mobile (including military, land based and recreational boats)	0.62	0%	99%
1A3aii(i)	Domestic aviation LTO (civil)	0.57	0%	99%
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	0.55	0%	99%
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	0.41	0%	99%

NFR Code	Longname	Latest year, kt	Level assessment Lx,t	Cumulative total
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.31	0%	99%
2B2	Nitric acid production	0.27	0%	100%
2C1	Iron and steel production	0.19	0%	100%
2C3	Aluminium production	0.18	0%	100%
2C2	Ferroalloys production	0.18	0%	100%
2B1	Ammonia production	0.15	0%	100%
3B2	Manure management - Sheep	0.07	0%	100%
1A1c	Manufacture of solid fuels and other energy industries	0.07	0%	100%
3B1b	Manure management - Non-dairy cattle	0.06	0%	100%
3B4gii	Manure mangement - Broilers	0.05	0%	100%
3B4gi	Manure mangement - Laying hens	0.05	0%	100%
2G	Other product use (please specify in the IIR)	0.03	0%	100%
3B4d	Manure management - Goats	0.03	0%	100%
3Da2b	Sewage sludge applied to soils	0.02	0%	100%
3B1a	Manure management - Dairy cattle	0.02	0%	100%
5C1biii	Clinical waste incineration	0.01	0%	100%
3B4giii	Manure mangement - Turkeys	0.00	0%	100%
3B3	Manure management - Swine	0.00	0%	100%
3B4e	Manure management - Horses	0.00	0%	100%
3B4f	Manure management - Mules and asses	0.00	0%	100%
3B4giv	Manure management - Other poultry	0.00	0%	100%
3B4a	Manure management - Buffalo	0.00	0%	100%
5C1bi	Industrial waste incineration	0.00	0%	100%

Table I-0-2 KCA trend assessment for NOx (with key categories in bold)

NFR Code	Longname	1990, kt	Latest year, kt	Trend assessment Tx,t	% Contribution to trend	Cumulative total
1A1a	**Public electricity and heat production**	**69.69**	**77.06**	**0.08**	**25%**	**25%**
1A3bi	**Road transport: Passenger cars**	**55.20**	**13.14**	**0.05**	**17%**	**42%**
1A3dii	**National navigation (shipping)**	**40.33**	**39.89**	**0.04**	**11%**	**53%**
1A4cii	**Agriculture/Forestry/Fishing: Off-road vehicles and other machinery**	**28.30**	**3.56**	**0.04**	**11%**	**64%**
1A2f	**Stationary combustion in manufacturing industries and construction: Non-metallic minerals**	**26.48**	**8.56**	**0.02**	**6%**	**71%**
1A2gviii	**Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)**	**17.87**	**5.35**	**0.01**	**5%**	**75%**
1A3bii	**Road transport: Light duty vehicles**	**22.59**	**9.56**	**0.01**	**4%**	**79%**

NFR Code	Longname	1990, kt	Latest year, kt	Trend assessment Tx,t	% Contribution to trend	Cumulative total
1A1b	Petroleum refining	3.12	6.13	0.01	3%	82%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	1.40	4.72	0.01	3%	85%
3Da1	Inorganic N-fertilizers (includes also urea application)	16.96	7.18	0.01	3%	88%
3Da3	Urine and dung deposited by grazing animals	8.67	7.60	0.01	2%	89%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	4.81	1.03	0.00	2%	91%
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	3.81	0.55	0.00	1%	92%
1A4bi	Residential: Stationary	4.77	4.65	0.00	1%	94%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	2.98	0.31	0.00	1%	95%
1A3biv	Road transport: Mopeds & motorcycles	0.63	1.63	0.00	1%	96%
1A3ai(i)	International aviation LTO (civil)	0.97	1.81	0.00	1%	97%
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	2.01	0.41	0.00	1%	97%
1A4ai	Commercial/institutional: Stationary	2.10	2.08	0.00	1%	98%
3Da2a	Animal manure applied to soils	2.34	1.99	0.00	0%	98%
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	5.79	4.15	0.00	0%	99%
1A3aii(i)	Domestic aviation LTO (civil)	0.42	0.57	0.00	0%	99%
2B2	Nitric acid production	0.83	0.27	0.00	0%	99%
3F	Field burning of agricultural residues	1.00	0.87	0.00	0%	99%
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.73	0.69	0.00	0%	99%
1A3biii	Road transport: Heavy duty vehicles and buses	75.58	47.48	0.00	0%	100%
2C1	Iron and steel production	0.13	0.19	0.00	0%	100%
2C3	Aluminium production	0.15	0.18	0.00	0%	100%
2G	Other product use (please specify in the IIR)	0.20	0.03	0.00	0%	100%
2B1	Ammonia production	0.31	0.15	0.00	0%	100%
1A3c	Railways	2.51	1.55	0.00	0%	100%
1A1c	Manufacture of solid fuels and other energy industries	0.15	0.07	0.00	0%	100%
3B4gii	Manure mangement - Broilers	0.04	0.05	0.00	0%	100%
3B2	Manure management - Sheep	0.07	0.07	0.00	0%	100%
3B4gi	Manure mangement - Laying hens	0.04	0.05	0.00	0%	100%
3B4f	Manure management - Mules and asses	0.04	0.00	0.00	0%	100%

NFR Code	Longname	1990, kt	Latest year, kt	Trend assessment Tx,t	% Contribution to trend	Cumulative total
3B1b	Manure management - Non-dairy cattle	0.07	0.06	0.00	0%	100%
2C2	Ferroalloys production	0.30	0.18	0.00	0%	100%
5C1biii	Clinical waste incineration	0.00	0.01	0.00	0%	100%
3B1a	Manure management - Dairy cattle	0.05	0.02	0.00	0%	100%
3Da2b	Sewage sludge applied to soils	0.02	0.02	0.00	0%	100%
3B4d	Manure management - Goats	0.04	0.03	0.00	0%	100%
3B4e	Manure management - Horses	0.01	0.00	0.00	0%	100%
3B4giii	Manure mangement - Turkeys	0.00	0.00	0.00	0%	100%
3B4giv	Manure management - Other poultry	0.00	0.00	0.00	0%	100%
3B4a	Manure management - Buffalo	0.00	0.00	0.00	0%	100%
3B3	Manure management - Swine	0.01	0.00	0.00	0%	100%
5C1bi	Industrial waste incineration	0.00	0.00	0.00	0%	100%

Table I-0-3 KCA level assessment for NMVOC (with key categories in bold)

NFR Code	Longname	Latest year, kt	Level assessment Lx,t	Cumulative total
2D3a	**Domestic solvent use including fungicides**	**20.31**	**14%**	**14%**
2D3d	**Coating applications**	**14.77**	**10%**	**23%**
1A3bi	**Road transport: Passenger cars**	**14.41**	**10%**	**33%**
1A4bi	**Residential: Stationary**	**13.02**	**9%**	**42%**
1A3bv	**Road transport: Gasoline evaporation**	**10.93**	**7%**	**49%**
1B1a	**Fugitive emission from solid fuels: Coal mining and handling**	**7.57**	**5%**	**54%**
5A	**Biological treatment of waste - Solid waste disposal on land**	**6.96**	**5%**	**59%**
1A3biv	**Road transport: Mopeds & motorcycles**	**6.64**	**4%**	**63%**
1A3bii	**Road transport: Light duty vehicles**	**5.68**	**4%**	**67%**
1A1b	**Petroleum refining**	**5.39**	**4%**	**70%**
2D3g	**Chemical products**	**4.89**	**3%**	**74%**
1A3biii	**Road transport: Heavy duty vehicles and buses**	**3.43**	**2%**	**76%**
1B2av	**Distribution of oil products**	**2.99**	**2%**	**78%**
3B4gii	Manure mangement - Broilers	2.80	2%	80%
2D3h	Printing	2.77	2%	82%
3De	Cultivated crops	2.74	2%	83%
2D3i	Other solvent use (please specify in the IIR)	2.56	2%	85%
3B4d	Manure management - Goats	2.44	2%	87%
1A3dii	National navigation (shipping)	1.72	1%	88%
3B1a	Manure management - Dairy cattle	1.67	1%	89%

NFR Code	Longname	Latest year, kt	Level assessment Lx,t	Cumulative total
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	1.65	1%	90%
3B1b	Manure management - Non-dairy cattle	1.60	1%	91%
3B4gi	Manure mangement - Laying hens	1.59	1%	92%
1A1a	Public electricity and heat production	1.48	1%	93%
3B2	Manure management - Sheep	1.47	1%	94%
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	1.21	1%	95%
2D3e	Degreasing	1.02	1%	96%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.97	1%	96%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.69	0%	97%
2G	Other product use (please specify in the IIR)	0.68	0%	97%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.56	0%	98%
3B3	Manure management - Swine	0.49	0%	98%
2H2	Food and beverages industry	0.39	0%	98%
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.39	0%	99%
3B4giii	Manure mangement - Turkeys	0.28	0%	99%
2D3f	Dry cleaning	0.25	0%	99%
1A4ai	Commercial/institutional: Stationary	0.23	0%	99%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.19	0%	99%
3F	Field burning of agricultural residues	0.19	0%	99%
1A3c	Railways	0.18	0%	99%
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	0.13	0%	99%
1A5b	Other, Mobile (including military, land based and recreational boats)	0.13	0%	100%
1A3ai(i)	International aviation LTO (civil)	0.11	0%	100%
3B4giv	Manure management - Other poultry	0.09	0%	100%
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	0.07	0%	100%
2C1	Iron and steel production	0.07	0%	100%
3B4e	Manure management - Horses	0.06	0%	100%
3B4a	Manure management - Buffalo	0.04	0%	100%
1B2ai	Fugitive emissions oil: Exploration, production, transport	0.04	0%	100%
1A3aii(i)	Domestic aviation LTO (civil)	0.04	0%	100%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.04	0%	100%
2D3c	Asphalt roofing	0.02	0%	100%

NFR Code	Longname	Latest year, kt	Level assessment Lx,t	Cumulative total
2B1	Ammonia production	0.01	0%	100%
3B4f	Manure management - Mules and asses	0.01	0%	100%
2D3b	Road paving with asphalt	0.01	0%	100%
5D1	Domestic wastewater handling	0.01	0%	100%
5C1biii	Clinical waste incineration	0.00	0%	100%
1A1c	Manufacture of solid fuels and other energy industries	0.00	0%	100%
1B2b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)	0.00	0%	100%
5C1bi	Industrial waste incineration	0.00	0%	100%

Table I-0-4 KCA trend assessment for NMVOC (with key categories in bold)

NFR Code	Longname	1990, kt	Latest year, kt	Trend assessment Tx,t	% Contribution to trend	Cumulative total
1A3bi	**Road transport: Passenger cars**	**87.16**	**14.41**	**0.08**	**28%**	**28%**
2D3a	**Domestic solvent use including fungicides**	**22.79**	**20.31**	**0.03**	**10%**	**38%**
1A3bii	**Road transport: Light duty vehicles**	**29.42**	**5.68**	**0.03**	**9%**	**47%**
5A	**Biological treatment of waste - Solid waste disposal on land**	**2.10**	**6.96**	**0.02**	**6%**	**53%**
2D3d	**Coating applications**	**20.07**	**14.77**	**0.02**	**6%**	**59%**
1A3bv	**Road transport: Gasoline evaporation**	**32.85**	**10.93**	**0.01**	**5%**	**64%**
1A4bi	**Residential: Stationary**	**18.06**	**13.02**	**0.01**	**5%**	**68%**
1A4cii	**Agriculture/Forestry/Fishing: Off-road vehicles and other machinery**	**9.04**	**0.97**	**0.01**	**3%**	**72%**
1A1b	**Petroleum refining**	**5.88**	**5.39**	**0.01**	**3%**	**75%**
1B1a	**Fugitive emission from solid fuels: Coal mining and handling**	**10.77**	**7.57**	**0.01**	**3%**	**77%**
2D3g	**Chemical products**	**5.49**	**4.89**	**0.01**	**2%**	**80%**
2D3i	Other solvent use (please specify in the IIR)	9.79	2.56	0.01	2%	82%
2D3h	Printing	1.80	2.77	0.01	2%	84%
3B4gii	Manure mangement - Broilers	2.18	2.80	0.01	2%	86%
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.33	1.65	0.00	2%	87%
3De	Cultivated crops	3.39	2.74	0.00	1%	88%
3B4gi	Manure mangement - Laying hens	1.24	1.59	0.00	1%	90%
1A3dii	National navigation (shipping)	1.58	1.72	0.00	1%	91%

NFR Code	Longname	1990, kt	Latest year, kt	Trend assessment Tx,t	% Contribution to trend	Cumulative total
2D3e	Degreasing	4.10	1.02	0.00	1%	92%
3B4d	Manure management - Goats	3.33	2.44	0.00	1%	92%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	3.23	0.69	0.00	1%	93%
1A1a	Public electricity and heat production	1.40	1.48	0.00	1%	94%
3B2	Manure management - Sheep	1.46	1.47	0.00	1%	95%
3B1b	Manure management - Non-dairy cattle	1.75	1.60	0.00	1%	96%
1B2av	Distribution of oil products	4.90	2.99	0.00	1%	97%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.15	0.56	0.00	1%	97%
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.04	0.39	0.00	0%	97%
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	3.22	1.21	0.00	0%	98%
2G	Other product use (please specify in the IIR)	0.93	0.68	0.00	0%	98%
1A3biv	Road transport: Mopeds & motorcycles	13.60	6.64	0.00	0%	98%
3B4giii	Manure mangement - Turkeys	0.22	0.28	0.00	0%	98%
1A4ai	Commercial/institutional: Stationary	0.12	0.23	0.00	0%	99%
2H2	Food and beverages industry	0.48	0.39	0.00	0%	99%
3B3	Manure management - Swine	0.75	0.49	0.00	0%	99%
3B4f	Manure management - Mules and asses	0.27	0.01	0.00	0%	99%
2D3f	Dry cleaning	0.77	0.25	0.00	0%	99%
3B1a	Manure management - Dairy cattle	3.77	1.67	0.00	0%	99%
1A3ai(i)	International aviation LTO (civil)	0.01	0.11	0.00	0%	99%
3F	Field burning of agricultural residues	0.22	0.19	0.00	0%	99%
1A3biii	Road transport: Heavy duty vehicles and buses	7.12	3.43	0.00	0%	100%
3B4giv	Manure management - Other poultry	0.07	0.09	0.00	0%	100%
2C1	Iron and steel production	0.05	0.07	0.00	0%	100%
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	0.19	0.13	0.00	0%	100%
1A3c	Railways	0.30	0.18	0.00	0%	100%
3B4a	Manure management - Buffalo	0.01	0.04	0.00	0%	100%
1A3aii(i)	Domestic aviation LTO (civil)	0.00	0.04	0.00	0%	100%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.15	0.04	0.00	0%	100%
1B2ai	Fugitive emissions oil: Exploration, production, transport	0.15	0.04	0.00	0%	100%

NFR Code	Longname	1990, kt	Latest year, kt	Trend assessment Tx,t	% Contribution to trend	Cumulative total
3B4e	Manure management - Horses	0.19	0.06	0.00	0%	100%
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	0.10	0.07	0.00	0%	100%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.37	0.19	0.00	0%	100%
2D3c	Asphalt roofing	0.01	0.02	0.00	0%	100%
2D3b	Road paving with asphalt	0.01	0.01	0.00	0%	100%
5D1	Domestic wastewater handling	0.01	0.01	0.00	0%	100%
1B2b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)	0.01	0.00	0.00	0%	100%
5C1biii	Clinical waste incineration	0.00	0.00	0.00	0%	100%
1A1c	Manufacture of solid fuels and other energy industries	0.00	0.00	0.00	0%	100%
5C1bi	Industrial waste incineration	0.00	0.00	0.00	0%	100%
2B1	Ammonia production	0.03	0.01	0.00	0%	100%

Table I-0-5 KCA level assessment for SOx (with key categories in bold)

NFR Code	Longname	Latest year, kt	Level assessment Lx,t	Cumulative total
1A1a	**Public electricity and heat production**	**40.35**	**62%**	**62%**
1A1b	**Petroleum refining**	**9.01**	**14%**	**76%**
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	7.21	11%	88%
1A4bi	Residential: Stationary	2.47	4%	91%
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	1.32	2%	93%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	1.00	2%	95%
2C3	Aluminium production	0.83	1%	96%
2C2	Ferroalloys production	0.71	1%	97%
1A4ai	Commercial/institutional: Stationary	0.24	0%	98%
3F	Field burning of agricultural residues	0.19	0%	98%
1A3dii	National navigation (shipping)	0.18	0%	98%
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	0.17	0%	99%
2B10a	Chemical industry: Other (please specify in the IIR)	0.16	0%	99%

NFR Code	Longname	Latest year, kt	Level assessment Lx,t	Cumulative total
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.14	0%	99%
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.13	0%	99%
1A3ai(i)	International aviation LTO (civil)	0.11	0%	99%
2C1	Iron and steel production	0.09	0%	100%
1A3c	Railways	0.08	0%	100%
2C5	Lead production	0.06	0%	100%
1A3aii(i)	Domestic aviation LTO (civil)	0.04	0%	100%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.03	0%	100%
1A3bi	Road transport: Passenger cars	0.03	0%	100%
1A3biii	Road transport: Heavy duty vehicles and buses	0.02	0%	100%
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	0.01	0%	100%
1A3bii	Road transport: Light duty vehicles	0.01	0%	100%
1A5b	Other, Mobile (including military, land based and recreational boats)	0.01	0%	100%
1A3biv	Road transport: Mopeds & motorcycles	0.00	0%	100%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.00	0%	100%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.00	0%	100%
5C1biii	Clinical waste incineration	0.00	0%	100%
2G	Other product use (please specify in the IIR)	0.00	0%	100%
1A1c	Manufacture of solid fuels and other energy industries	0.00	0%	100%
5C1bi	Industrial waste incineration	0.00	0%	100%

Table I-0-6 KCA trend assessment for SOx (with key categories in bold)

NFR Code	Longname	1990, kt	Latest year, kt	Trend assessment Tx,t	% Contribution to trend	Cumulative total
1A1b	**Petroleum refining**	**19.51**	**9.01**	**0.01**	**26%**	**26%**
1A2gviii	**Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)**	**34.45**	**1.00**	**0.01**	**15%**	**41%**
1A2f	**Stationary combustion in manufacturing industries and construction: Non-metallic minerals**	**34.67**	**7.21**	**0.01**	**11%**	**51%**
1A3biii	**Road transport: Heavy duty vehicles and buses**	**12.53**	**0.02**	**0.00**	**7%**	**58%**
1A1a	**Public electricity and heat production**	**314.08**	**40.35**	**0.00**	**6%**	**65%**

NFR Code	Longname	1990, kt	Latest year, kt	Trend assessment Tx,t	% Contribution to trend	Cumulative total
1A2b	**Stationary combustion in manufacturing industries and construction: Non-ferrous metals**	**9.57**	**0.01**	**0.00**	**5%**	**70%**
1A4bi	**Residential: Stationary**	**9.70**	**2.47**	**0.00**	**5%**	**75%**
1A2a	**Stationary combustion in manufacturing industries and construction: Iron and steel**	**7.31**	**0.03**	**0.00**	**4%**	**78%**
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	8.07	0.14	0.00	4%	82%
2C3	Aluminium production	0.68	0.83	0.00	3%	85%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	4.91	0.00	0.00	3%	88%
1A3bi	Road transport: Passenger cars	4.65	0.03	0.00	2%	90%
2C2	Ferroalloys production	1.02	0.71	0.00	2%	93%
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	4.46	0.17	0.00	2%	94%
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	11.94	1.32	0.00	1%	96%
1A3bii	Road transport: Light duty vehicles	1.42	0.01	0.00	1%	96%
3F	Field burning of agricultural residues	0.22	0.19	0.00	1%	97%
1A3dii	National navigation (shipping)	0.21	0.18	0.00	1%	98%
2B10a	Chemical industry: Other (please specify in the IIR)	2.02	0.16	0.00	0%	98%
1A3ai(i)	International aviation LTO (civil)	0.06	0.11	0.00	0%	98%
2C1	Iron and steel production	0.06	0.09	0.00	0%	99%
1A4ai	Commercial/institutional: Stationary	1.27	0.24	0.00	0%	99%
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.44	0.13	0.00	0%	99%
1A3c	Railways	0.13	0.08	0.00	0%	100%
1A3aii(i)	Domestic aviation LTO (civil)	0.02	0.04	0.00	0%	100%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.26	0.00	0.00	0%	100%
1A3biv	Road transport: Mopeds & motorcycles	0.14	0.00	0.00	0%	100%
5C1biii	Clinical waste incineration	0.00	0.00	0.00	0%	100%
2G	Other product use (please specify in the IIR)	0.00	0.00	0.00	0%	100%
1A1c	Manufacture of solid fuels and other energy industries	0.00	0.00	0.00	0%	100%
5C1bi	Industrial waste incineration	0.00	0.00	0.00	0%	100%

Table I-0-7 KCA level assessment for NH3 (with key categories in bold)

NFR Code	Longname	Latest year, kt	Level assessment Lx,t	Cumulative total
3Da2a	**Animal manure applied to soils**	**14.72**	**23%**	**23%**
3Da3	**Urine and dung deposited by grazing animals**	**10.14**	**16%**	**39%**
3Da1	**Inorganic N-fertilizers (includes also urea application)**	**10.13**	**16%**	**56%**
3B1b	**Manure management - Non-dairy cattle**	**3.84**	**6%**	**62%**
3B2	**Manure management - Sheep**	**3.45**	**5%**	**67%**
3B4gii	**Manure mangement - Broilers**	**3.10**	**5%**	**72%**
3B3	**Manure management - Swine**	**3.09**	**5%**	**77%**
3B4gi	Manure mangement - Laying hens	3.00	5%	82%
3B1a	Manure management - Dairy cattle	2.94	5%	86%
2B10a	Chemical industry: Other (please specify in the IIR)	1.95	3%	90%
1A4bi	Residential: Stationary	1.58	3%	92%
3B4d	Manure management - Goats	1.57	2%	95%
1A3bi	Road transport: Passenger cars	1.28	2%	97%
3F	Field burning of agricultural residues	0.91	1%	98%
3B4giii	Manure mangement - Turkeys	0.33	1%	98%
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.18	0%	99%
3B4e	Manure management - Horses	0.11	0%	99%
1A3bii	Road transport: Light duty vehicles	0.09	0%	99%
3B4giv	Manure management - Other poultry	0.08	0%	99%
2G	Other product use (please specify in the IIR)	0.08	0%	99%
3Da2b	Sewage sludge applied to soils	0.07	0%	99%
3B4f	Manure management - Mules and asses	0.06	0%	100%
5B1	Biological treatment of waste - Composting	0.06	0%	100%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.05	0%	100%
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.04	0%	100%
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	0.03	0%	100%
1B2aiv	Fugitive emissions oil: Refining / storage	0.03	0%	100%
1A3biii	Road transport: Heavy duty vehicles and buses	0.02	0%	100%
3B4a	Manure management - Buffalo	0.02	0%	100%
1A3biv	Road transport: Mopeds & motorcycles	0.02	0%	100%
2B1	Ammonia production	0.01	0%	100%
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	0.00	0%	100%

NFR Code	Longname	Latest year, kt	Level assessment Lx,t	Cumulative total
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.00	0%	100%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.00	0%	100%
1A3c	Railways	0.00	0%	100%

Table I-0-8 KCA trend assessment for NH3 (with key categories in bold)

NFR Code	Longname	1990, kt	Latest year, kt	Trend assessment Tx,t	% Contribution to trend	Cumulative total
3Da1	**Inorganic N-fertilizers (includes also urea application)**	**29.48**	**10.13**	**0.11**	**42%**	**42%**
3Da2a	**Animal manure applied to soils**	**17.14**	**14.72**	**0.03**	**11%**	**53%**
3B4gii	**Manure mangement - Broilers**	**2.41**	**3.10**	**0.02**	**6%**	**59%**
3Da3	**Urine and dung deposited by grazing animals**	**12.54**	**10.14**	**0.02**	**6%**	**64%**
3B4gi	**Manure mangement - Laying hens**	**2.34**	**3.00**	**0.02**	**6%**	**70%**
3B1b	**Manure management - Non-dairy cattle**	**3.68**	**3.84**	**0.01**	**5%**	**75%**
1A3bi	**Road transport: Passenger cars**	**0.05**	**1.28**	**0.01**	**5%**	**80%**
1A3biii	Road transport: Heavy duty vehicles and buses	1.73	0.02	0.01	5%	85%
3B2	Manure management - Sheep	3.44	3.45	0.01	4%	89%
3B4f	Manure management - Mules and asses	1.31	0.06	0.01	3%	93%
3B1a	Manure management - Dairy cattle	5.09	2.94	0.01	2%	95%
2G	Other product use (please specify in the IIR)	0.45	0.08	0.00	1%	96%
3F	Field burning of agricultural residues	1.04	0.91	0.00	1%	97%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.30	0.05	0.00	1%	97%
3B4giii	Manure mangement - Turkeys	0.25	0.33	0.00	1%	98%
3B4e	Manure management - Horses	0.32	0.11	0.00	0%	98%
1A4bi	Residential: Stationary	2.12	1.58	0.00	0%	99%
1A3bii	Road transport: Light duty vehicles	0.01	0.09	0.00	0%	99%
3B4d	Manure management - Goats	2.13	1.57	0.00	0%	100%
3B4giv	Manure management - Other poultry	0.06	0.08	0.00	0%	100%
3Da2b	Sewage sludge applied to soils	0.07	0.07	0.00	0%	100%
3B4a	Manure management - Buffalo	0.00	0.02	0.00	0%	100%
1B2aiv	Fugitive emissions oil: Refining / storage	0.02	0.03	0.00	0%	100%

NFR Code	Longname	1990, kt	Latest year, kt	Trend assessment Tx,t	% Contribution to trend	Cumulative total
1A3biv	Road transport: Mopeds & motorcycles	0.00	0.02	0.00	0%	100%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.01	0.00	0.00	0%	100%
2B1	Ammonia production	0.02	0.01	0.00	0%	100%
3B3	Manure management - Swine	4.44	3.09	0.00	0%	100%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.00	0.00	0.00	0%	100%
1A3c	Railways	0.00	0.00	0.00	0%	100%

Table I-0-9 KCA level assessment for PM2.5 (with key categories in bold)

NFR Code	Longname	Latest year, kt	Level assessment Lx,t	Cumulative total
1A4bi	**Residential: Stationary**	**16.65**	**50%**	**50%**
1A3dii	**National navigation (shipping)**	**2.32**	**7%**	**58%**
1A1a	**Public electricity and heat production**	**2.20**	**7%**	**64%**
3F	**Field burning of agricultural residues**	**2.05**	**6%**	**70%**
1A3biii	**Road transport: Heavy duty vehicles and buses**	**1.48**	**4%**	**75%**
2A5b	**Construction and demolition**	**0.95**	**3%**	**78%**
1A2e	**Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco**	**0.81**	**2%**	**80%**
1A3bvi	Road transport: Automobile tyre and brake wear	0.72	2%	82%
2D3i	Other solvent use (please specify in the IIR)	0.52	2%	84%
2G	Other product use (please specify in the IIR)	0.51	2%	86%
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	0.44	1%	87%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.38	1%	88%
1A3bvii	Road transport: Automobile road abrasion	0.35	1%	89%
1A1b	Petroleum refining	0.34	1%	90%
2D3b	Road paving with asphalt	0.30	1%	91%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.28	1%	92%
1B1a	Fugitive emission from solid fuels: Coal mining and handling	0.23	1%	93%
1A3bii	Road transport: Light duty vehicles	0.22	1%	93%

NFR Code	Longname	Latest year, kt	Level assessment Lx,t	Cumulative total
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.21	1%	94%
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	0.19	1%	94%
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.19	1%	95%
3B2	Manure management - Sheep	0.17	1%	96%
2A5a	Quarrying and mining of minerals other than coal	0.17	1%	96%
2B10a	Chemical industry: Other (please specify in the IIR)	0.13	0%	96%
2C2	Ferroalloys production	0.12	0%	97%
2C3	Aluminium production	0.11	0%	97%
2A1	Cement production	0.11	0%	97%
1A3bi	Road transport: Passenger cars	0.10	0%	98%
1A3biv	Road transport: Mopeds & motorcycles	0.10	0%	98%
3B1b	Manure management - Non-dairy cattle	0.08	0%	98%
3B4d	Manure management - Goats	0.08	0%	99%
1A4ai	Commercial/institutional: Stationary	0.06	0%	99%
3B4gii	Manure mangement - Broilers	0.05	0%	99%
5E	Other waste (please specify in IIR)	0.05	0%	99%
1A3c	Railways	0.04	0%	99%
3B1a	Manure management - Dairy cattle	0.04	0%	99%
2C1	Iron and steel production	0.03	0%	99%
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	0.03	0%	99%
3B4gi	Manure mangement - Laying hens	0.03	0%	100%
2A3	Glass production	0.03	0%	100%
5C1bv	Cremation	0.03	0%	100%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.02	0%	100%
1A3ai(i)	International aviation LTO (civil)	0.02	0%	100%
3B4giii	Manure mangement - Turkeys	0.01	0%	100%
2D3c	Asphalt roofing	0.01	0%	100%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.01	0%	100%
2A2	Lime production	0.01	0%	100%
1A3aii(i)	Domestic aviation LTO (civil)	0.01	0%	100%
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	0.01	0%	100%
3B4giv	Manure management - Other poultry	0.00	0%	100%
3B3	Manure management - Swine	0.00	0%	100%
3B4e	Manure management - Horses	0.00	0%	100%
3B4a	Manure management - Buffalo	0.00	0%	100%
3B4f	Manure management - Mules and asses	0.00	0%	100%
1A1c	Manufacture of solid fuels and other energy industries	0.00	0%	100%

NFR Code	Longname	Latest year, kt	Level assessment Lx,t	Cumulative total
5A	Biological treatment of waste - Solid waste disposal on land	0.00	0%	100%
2C5	Lead production	0.00	0%	100%
5C1bi	Industrial waste incineration	0.00	0%	100%

Table I-0-10 KCA trend assessment for PM2.5 (with key categories in bold)

NFR Code	Longname	1990, kt	Latest year, kt	Trend assessment Tx,t	% Contribution to trend	Cumulative total
1A1a	**Public electricity and heat production**	**11.64**	**2.20**	**0.08**	**27%**	**27%**
1A4bi	**Residential: Stationary**	**23.46**	**16.65**	**0.05**	**16%**	**43%**
1A3dii	**National navigation (shipping)**	**1.80**	**2.32**	**0.02**	**7%**	**50%**
2G	**Other product use (please specify in the IIR)**	**2.93**	**0.51**	**0.02**	**7%**	**57%**
1A3biii	**Road transport: Heavy duty vehicles and buses**	**4.16**	**1.48**	**0.02**	**6%**	**63%**
1A4cii	**Agriculture/Forestry/Fishing: Off-road vehicles and other machinery**	**1.66**	**0.21**	**0.01**	**4%**	**67%**
1A2gviii	**Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)**	**1.79**	**0.38**	**0.01**	**4%**	**71%**
3F	**Field burning of agricultural residues**	**2.35**	**2.05**	**0.01**	**4%**	**75%**
1A2e	**Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco**	**0.29**	**0.81**	**0.01**	**4%**	**79%**
1A3bi	Road transport: Passenger cars	0.97	0.10	0.01	3%	82%
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	0.05	0.44	0.01	2%	84%
1A3bvi	Road transport: Automobile tyre and brake wear	0.54	0.72	0.01	2%	86%
2D3i	Other solvent use (please specify in the IIR)	0.39	0.52	0.01	2%	88%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.09	0.28	0.00	1%	89%
1A3bvii	Road transport: Automobile road abrasion	0.26	0.35	0.00	1%	90%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.36	0.02	0.00	1%	91%
1A3bii	Road transport: Light duty vehicles	0.06	0.22	0.00	1%	92%
2D3b	Road paving with asphalt	0.22	0.30	0.00	1%	93%

NFR Code	Longname	1990, kt	Latest year, kt	Trend assessment Tx,t	% Contribution to trend	Cumulative total
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.04	0.19	0.00	1%	94%
1A1b	Petroleum refining	0.31	0.34	0.00	1%	95%
2B10a	Chemical industry: Other (please specify in the IIR)	0.00	0.13	0.00	1%	96%
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	0.15	0.01	0.00	0%	97%
2C2	Ferroalloys production	0.33	0.12	0.00	0%	97%
3B2	Manure management - Sheep	0.17	0.17	0.00	0%	97%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.12	0.01	0.00	0%	98%
2C3	Aluminium production	0.09	0.11	0.00	0%	98%
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	0.24	0.19	0.00	0%	98%
1B1a	Fugitive emission from solid fuels: Coal mining and handling	0.33	0.23	0.00	0%	99%
3B1b	Manure management - Non-dairy cattle	0.09	0.08	0.00	0%	99%
3B4gii	Manure mangement - Broilers	0.04	0.05	0.00	0%	99%
5C1bv	Cremation	0.01	0.03	0.00	0%	99%
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	0.09	0.03	0.00	0%	99%
2C1	Iron and steel production	0.02	0.03	0.00	0%	99%
3B4gi	Manure mangement - Laying hens	0.02	0.03	0.00	0%	99%
3B4d	Manure management - Goats	0.11	0.08	0.00	0%	99%
2A1	Cement production	0.21	0.11	0.00	0%	100%
3B1a	Manure management - Dairy cattle	0.09	0.04	0.00	0%	100%
1A3ai(i)	International aviation LTO (civil)	0.01	0.02	0.00	0%	100%
3B4f	Manure management - Mules and asses	0.02	0.00	0.00	0%	100%
2A3	Glass production	0.03	0.03	0.00	0%	100%
1A3biv	Road transport: Mopeds & motorcycles	0.15	0.10	0.00	0%	100%
3B4giii	Manure mangement - Turkeys	0.01	0.01	0.00	0%	100%
2D3c	Asphalt roofing	0.01	0.01	0.00	0%	100%
1A3aii(i)	Domestic aviation LTO (civil)	0.00	0.01	0.00	0%	100%
1A4ai	Commercial/institutional: Stationary	0.11	0.06	0.00	0%	100%
3B4giv	Manure management - Other poultry	0.00	0.00	0.00	0%	100%
3B4a	Manure management - Buffalo	0.00	0.00	0.00	0%	100%
1A3c	Railways	0.06	0.04	0.00	0%	100%
3B4e	Manure management - Horses	0.01	0.00	0.00	0%	100%
2A2	Lime production	0.01	0.01	0.00	0%	100%
3B3	Manure management - Swine	0.01	0.00	0.00	0%	100%

NFR Code	Longname	1990, kt	Latest year, kt	Trend assessment Tx,t	% Contribution to trend	Cumulative total
1A1c	Manufacture of solid fuels and other energy industries	0.00	0.00	0.00	0%	100%
5A	Biological treatment of waste - Solid waste disposal on land	0.00	0.00	0.00	0%	100%
5C1bi	Industrial waste incineration	0.00	0.00	0.00	0%	100%

Annex II: Uncertainty analysis

Table II-0-1 Uncertainty analysis of NOx emissions

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
NFR sector	Pollutant	Base year emissions	Year t emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions	Emission factor quality indicator	Activity data quality indicator
		kt	kt	%	%	%	%	%	%	%	%	%		
1A1a	NOx	70	77	3%	20%	0.2	0.0612	0.0819	0.1910	1.64%	0.81%	1.83%	A	R
1A1b	NOx	3	6	3%	20%	0.2	0.0049	0.0103	0.0152	0.21%	0.06%	0.22%	A	R
1A1c	NOx	0	0	3%	200%	2.0	0.0005	0.0001	0.0002	0.02%	0.00%	0.02%	D	R
1A2a	NOx	3	0	3%	200%	2.0	0.0025	0.0039	0.0008	0.78%	0.00%	0.78%	D	R
1A2b	NOx	4	1	3%	200%	2.0	0.0043	0.0046	0.0014	0.92%	0.01%	0.92%	D	R
1A2c	NOx	5	1	3%	200%	2.0	0.0081	0.0050	0.0025	1.00%	0.01%	1.00%	D	R
1A2d	NOx	2	0	3%	200%	2.0	0.0032	0.0021	0.0010	0.43%	0.00%	0.43%	D	R
1A2e	NOx	6	4	3%	200%	2.0	0.0326	0.0012	0.0103	0.25%	0.04%	0.25%	D	R
1A2f	NOx	26	9	3%	200%	2.0	0.0672	0.0202	0.0212	4.04%	0.09%	4.04%	D	R
1A2gvii	NOx	1	5	3%	200%	2.0	0.0371	0.0095	0.0117	1.90%	0.05%	1.90%	D	R
1A2gviii	NOx	18	5											
1A3ai(i)	NOx	1	2	3%	20%	0.2	0.0014	0.0030	0.0045	0.06%	0.02%	0.06%	A	R
1A3aii(i)	NOx	0	1	3%	20%	0.2	0.0005	0.0008	0.0014	0.02%	0.01%	0.02%	A	R
1A3bi	NOx	55	13	3%	20%	0.2	0.0104	0.0536	0.0326	1.07%	0.14%	1.08%	A	R
1A3bii	NOx	23	10	3%	20%	0.2	0.0076	0.0116	0.0237	0.23%	0.10%	0.25%	A	R

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1A3biii	NOx	76	47	3%	20%	0.2	0.0377	0.0005	0.1177	0.01%	0.50%	0.50%	A	R
1A3biv	NOx	1	2	3%	20%	0.2	0.0013	0.0031	0.0040	0.06%	0.02%	0.06%	A	R
1A3bv	NOx	NE	NE											
1A3bvi	NOx	NE	NE											
1A3bvii	NOx	NE	NE											
1A3c	NOx	3	2	3%	200%	2.0	0.0122	0.0001	0.0038	0.02%	0.02%	0.02%	D	R
1A3di(ii)	NOx	NO	NO											
1A3dii	NOx	40	40	3%	200%	2.0	0.3135	0.0358	0.0989	7.16%	0.42%	7.17%	D	R
1A3ei	NOx	NO	IE											
1A3eii	NOx	NO	NO											
1A4ai	NOx	2	2	3%	200%	2.0	0.0163	0.0019	0.0051	0.37%	0.02%	0.37%	D	R
1A4aii	NOx	IE	IE											
1A4bi	NOx	5	5	3%	200%	2.0	0.0366	0.0041	0.0115	0.81%	0.05%	0.82%	D	R
1A4bii	NOx	IE	IE											
1A4ci	NOx	1	1	3%	200%	2.0	0.0054	0.0006	0.0017	0.11%	0.01%	0.11%	D	R
1A4cii	NOx	28	4	3%	200%	2.0	0.0280	0.0354	0.0088	7.08%	0.04%	7.08%	D	R
1A4ciii	NOx	IE	IE											
1A5a	NOx	IE	IE											
1A5b	NOx	IE	1											
1B1a	NOx	NA	NA											
1B1b	NOx	NO	NO											
1B1c	NOx	NO	NO											
1B2ai	NOx	NA	NA											
1B2aiv	NOx	IE	IE											
1B2av	NOx	NA	NA											
1B2b	NOx	NA	NA											
1B2c	NOx	IE	IE											
1B2d	NOx	NO	NO											
2A1	NOx	IE	IE											
2A2	NOx	IE	IE											
2A3	NOx	IE	IE											

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
2A5a	NOx	NA	NA											
2A5b	NOx	NA	NA											
2A5c	NOx	NE	NE											
2A6	NOx	NO	NO											
2B1	NOx	0	0	3%	40%	0.4	0.0002	0.0001	0.0004	0.00%	0.00%	0.01%	B	R
2B2	NOx	1	0	3%	20%	0.2	0.0002	0.0006	0.0007	0.01%	0.00%	0.01%	A	R
2B3	NOx	NO	NO											
2B5	NOx	NO	NO											
2B6	NOx	NO	NO											
2B7	NOx	NO	NO											
2B10a	NOx	NA	NA											
2B10b	NOx	NO	NO											
2C1	NOx	0	0	3%	40%	0.4	0.0003	0.0003	0.0005	0.01%	0.00%	0.01%	B	R
2C2	NOx	0	0	3%	40%	0.4	0.0003	0.0000	0.0004	0.00%	0.00%	0.00%	B	R
2C3	NOx	0	0	3%	200%	2.0	0.0015	0.0002	0.0005	0.04%	0.00%	0.04%	D	R
2C4	NOx	NO	NO											
2C5	NOx	NO	NE											
2C6	NOx	NO	NO											
2C7a	NOx	NO	NO											
2C7b	NOx	NO	NO											
2C7c	NOx	NO	NO											
2C7d	NOx	NO	NO											
2D3a	NOx	NA	NA											
2D3b	NOx	NE	NE											
2D3c	NOx	NE	NE											
2D3d	NOx	NA	NA											
2D3e	NOx	NA	NA											
2D3f	NOx	NA	NA											
2D3g	NOx	NE	NE											
2D3h	NOx	NA	NA											
2D3i	NOx	NA	NA											
2G	NOx	0	0	5%	200%	2.0	0.0003	0.0002	0.0001	0.04%	0.00%	0.04%	D	R

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
2H1	NOx	NA	NA											
2H2	NOx	NA	NA											
2H3	NOx	NO	NO											
2I	NOx	NE	NE											
2J	NOx	NE	NE											
2K	NOx	NA	NA											
2L	NOx	NO	NO											
3B1a	NOx	0	0	5%	200%	2.0	0.0002	0.0000	0.0001	0.00%	0.00%	0.00%	D	R
3B1b	NOx	0	0	5%	200%	2.0	0.0005	0.0000	0.0002	0.01%	0.00%	0.01%	D	R
3B2	NOx	0	0	5%	200%	2.0	0.0005	0.0001	0.0002	0.01%	0.00%	0.01%	D	R
3B3	NOx	0	0	5%	200%	2.0	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%	D	R
3B4a	NOx	0	0	5%	200%	2.0	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%	D	R
3B4d	NOx	0	0	5%	200%	2.0	0.0002	0.0000	0.0001	0.00%	0.00%	0.00%	D	R
3B4e	NOx	0	0	5%	200%	2.0	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%	D	R
3B4f	NOx	0	0	5%	200%	2.0	0.0000	0.0001	0.0000	0.01%	0.00%	0.01%	D	R
3B4gi	NOx	0	0	5%	200%	2.0	0.0004	0.0001	0.0001	0.01%	0.00%	0.01%	D	R
3B4gii	NOx	0	0	5%	200%	2.0	0.0004	0.0001	0.0001	0.01%	0.00%	0.01%	D	R
3B4giii	NOx	0	0	5%	200%	2.0	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%	D	R
3B4giv	NOx	0	0	5%	200%	2.0	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%	D	R
3B4h	NOx	NA	NA											
3Da1	NOx	17	7	5%	200%	2.0	0.0564	0.0087	0.0178	1.74%	0.13%	1.75%	D	R
3Da2a	NOx	2	2	5%	200%	2.0	0.0157	0.0013	0.0049	0.26%	0.03%	0.26%	D	R
3Da2b	NOx	0	0	5%	200%	2.0	0.0002	0.0000	0.0001	0.00%	0.00%	0.00%	D	R
3Da2c	NOx	NO	NO											
3Da3	NOx	9	8	5%	200%	2.0	0.0597	0.0053	0.0188	1.06%	0.13%	1.07%	D	R
3Da4	NOx	NA	NA											
3Db	NOx	NA	NA											
3Dc	NOx	NA	NA											
3Dd	NOx	NA	NA											
3De	NOx	NA	NA											
3Df	NOx	NA	NA											
3F	NOx	1	1	5%	200%	2.0	0.0069	0.0006	0.0022	0.12%	0.02%	0.12%	D	R

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
3I	NOx	NA	NA											
5A	NOx	NA	NA											
5B1	NOx	NO	NE											
5B2	NOx	NO	NO											
5C1a	NOx	NO	NO											
5C1bi	NOx	0	0	5%	200%	2.0	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%	D	R
5C1bii	NOx	NO	NO											
5C1biii	NOx	0	0	5%	200%	2.0	0.0001	0.0000	0.0000	0.00%	0.00%	0.00%	D	R
5C1biv	NOx	NO	NO											
5C1bv	NOx	NE	NE											
5C1bvi	NOx	NO	NO											
5C2	NOx	NO	NO											
5D1	NOx	NA	NA											
5D2	NOx	IE	IE											
5D3	NOx	NO	NO											
5E	NOx	NE	NE											
6A	NOx	NO	NO											
Total	NOx	404	255				34.68%					11.58%		

Table II-0-2 Uncertainty analysis of NMVOC emissions

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
NFR sector	Pollutant	Base year emissions	Year t emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions	Emission factor quality indicator	Activity data quality indicator
		kt	kt	%	%	%	%	%	%	%	%	%		
1A1a	NMVOC	1	1	3%	100%	1.0	0.0098	0.0026	0.0046	0.26%	0.02%	0.26%	C	R
1A1b	NMVOC	6	5	3%	100%	1.0	0.0359	0.0082	0.0170	0.82%	0.07%	0.83%	C	R
1A1c	NMVOC	0	0	3%	200%	2.0	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%	D	R
1A2a	NMVOC	0	0	3%	200%	2.0	0.0005	0.0001	0.0001	0.02%	0.00%	0.02%	D	R
1A2b	NMVOC	0	0	3%	200%	2.0	0.0018	0.0001	0.0004	0.03%	0.00%	0.03%	D	R
1A2c	NMVOC	0	0	3%	200%	2.0	0.0026	0.0001	0.0006	0.01%	0.00%	0.01%	D	R
1A2d	NMVOC	0	0	3%	200%	2.0	0.0009	0.0001	0.0002	0.01%	0.00%	0.01%	D	R
1A2e	NMVOC	0	2	3%	200%	2.0	0.0220	0.0047	0.0052	0.94%	0.02%	0.94%	D	R
1A2f	NMVOC	3	1	3%	200%	2.0	0.0161	0.0010	0.0038	0.20%	0.02%	0.20%	D	R
1A2gvii	NMVOC	0	1	3%	200%	2.0	0.0074	0.0015	0.0018	0.31%	0.01%	0.31%	D	R
1A2gviii	NMVOC	3	1											
1A3ai(i)	NMVOC	0	0	3%	20%	0.2	0.0001	0.0003	0.0003	0.01%	0.00%	0.01%	A	R
1A3aii(i)	NMVOC	0	0	3%	20%	0.2	0.0001	0.0001	0.0001	0.00%	0.00%	0.00%	A	R
1A3bi	NMVOC	87	14	3%	20%	0.2	0.0194	0.0841	0.0454	1.68%	0.19%	1.69%	A	R
1A3bii	NMVOC	29	6	3%	20%	0.2	0.0077	0.0259	0.0179	0.52%	0.08%	0.52%	A	R
1A3biii	NMVOC	7	3	3%	20%	0.2	0.0046	0.0002	0.0108	0.00%	0.05%	0.05%	A	R
1A3biv	NMVOC	14	7	3%	20%	0.2	0.0089	0.0007	0.0209	0.01%	0.09%	0.09%	A	R
1A3bv	NMVOC	33	11	3%	20%	0.2	0.0147	0.0145	0.0344	0.29%	0.15%	0.32%	A	R
1A3bvi	NMVOC	NE	NE											

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1A3bvii	NMVOC	NE	NE											
1A3c	NMVOC	0	0	3%	200%	2.0	0.0024	0.0001	0.0006	0.03%	0.00%	0.03%	D	R
1A3di(ii)	NMVOC	NO	NO											
1A3dii	NMVOC	2	2	3%	200%	2.0	0.0229	0.0031	0.0054	0.61%	0.02%	0.61%	D	R
1A3ei	NMVOC	NO	IE											
1A3eii	NMVOC	NO	NO											
1A4ai	NMVOC	0	0	3%	200%	2.0	0.0031	0.0006	0.0007	0.11%	0.00%	0.11%	D	R
1A4aii	NMVOC	IE	IE											
1A4bi	NMVOC	18	13	3%	200%	2.0	0.1735	0.0141	0.0410	2.82%	0.17%	2.83%	D	R
1A4bii	NMVOC	IE	IE											
1A4ci	NMVOC	0	0	3%	200%	2.0	0.0052	0.0012	0.0012	0.23%	0.01%	0.23%	D	R
1A4cii	NMVOC	9	1	3%	200%	2.0	0.0130	0.0104	0.0031	2.08%	0.01%	2.08%	D	R
1A4ciii	NMVOC	IE	IE			0.0								
1A5a	NMVOC	IE	IE			0.0								
1A5b	NMVOC	IE	0											
1B1a	NMVOC	11	8	3%	200%	2.0	0.1009	0.0078	0.0238	1.56%	0.10%	1.57%	D	R
1B1b	NMVOC	NO	NO											
1B1c	NMVOC	NO	NO											
1B2ai	NMVOC	0	0	3%	200%	2.0	0.0006	0.0001	0.0001	0.02%	0.00%	0.02%	D	R
1B2aiv	NMVOC	IE	IE											
1B2av	NMVOC	5	3	3%	200%	2.0	0.0398	0.0021	0.0094	0.42%	0.04%	0.42%	D	R
1B2b	NMVOC	0	0	3%	200%	2.0	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%	D	R
1B2c	NMVOC	IE	IE											
1B2d	NMVOC	NO	NO											
2A1	NMVOC	IE	IE											
2A2	NMVOC	IE	IE											
2A3	NMVOC	IE	IE											
2A5a	NMVOC	NA	NA											
2A5b	NMVOC	NA	NA											
2A5c	NMVOC	NE	NE											
2A6	NMVOC	NO	NO											

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
2B1	NMVOC	0	0	3%	100%	1.0	0.0001	0.0000	0.0000	0.00%	0.00%	0.00%	C	R
2B2	NMVOC	NA	NA											
2B3	NMVOC	NO	NO											
2B5	NMVOC	NO	NO											
2B6	NMVOC	NO	NO											
2B7	NMVOC	NO	NO											
2B10a	NMVOC	0	NO											
2B10b	NMVOC	NO	NO											
2C1	NMVOC	0	0	3%	100%	1.0	0.0004	0.0001	0.0002	0.01%	0.00%	0.01%	C	R
2C2	NMVOC	NE	NE											
2C3	NMVOC	NE	NE											
2C4	NMVOC	NO	NO											
2C5	NMVOC	NO	NE											
2C6	NMVOC	NO	NO											
2C7a	NMVOC	NO	NO											
2C7b	NMVOC	NO	NO											
2C7c	NMVOC	NO	NO											
2C7d	NMVOC	NO	NO											
2D3a	NMVOC	23	20	5%	200%	2.0	0.2707	0.0300	0.0639	6.00%	0.45%	6.02%	D	R
2D3b	NMVOC	0	0	5%	200%	2.0	0.0002	0.0000	0.0000	0.01%	0.00%	0.01%	D	R
2D3c	NMVOC	0	0	5%	200%	2.0	0.0002	0.0000	0.0001	0.01%	0.00%	0.01%	D	R
2D3d	NMVOC	20	15	5%	200%	2.0	0.1968	0.0166	0.0465	3.32%	0.33%	3.34%	D	R
2D3e	NMVOC	4	1	5%	200%	2.0	0.0136	0.0029	0.0032	0.58%	0.02%	0.58%	D	R
2D3f	NMVOC	1	0	5%	200%	2.0	0.0033	0.0004	0.0008	0.07%	0.01%	0.07%	D	R
2D3g	NMVOC	5	5	5%	200%	2.0	0.0652	0.0072	0.0154	1.45%	0.11%	1.45%	D	R
2D3h	NMVOC	2	3	5%	200%	2.0	0.0369	0.0060	0.0087	1.20%	0.06%	1.21%	D	R
2D3i	NMVOC	10	3	5%	200%	2.0	0.0341	0.0065	0.0080	1.31%	0.06%	1.31%	D	R
2G	NMVOC	1	1	5%	200%	2.0	0.0090	0.0007	0.0021	0.15%	0.02%	0.15%	D	R
2H1	NMVOC	NA	NA											
2H2	NMVOC	0	0	5%	200%	2.0	0.0052	0.0005	0.0012	0.11%	0.01%	0.11%	D	R
2H3	NMVOC	NO	NO											
2I	NMVOC	NE	NE											

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
2J	NMVOC	NE	NE											
2K	NMVOC	NA	NA											
2L	NMVOC	NO	NO											
3B1a	NMVOC	4	2	5%	200%	2.0	0.0222	0.0004	0.0052	0.07%	0.04%	0.08%	D	R
3B1b	NMVOC	2	2	5%	200%	2.0	0.0214	0.0024	0.0050	0.49%	0.04%	0.49%	D	R
3B2	NMVOC	1	1	5%	200%	2.0	0.0196	0.0024	0.0046	0.49%	0.03%	0.49%	D	R
3B3	NMVOC	1	0	5%	200%	2.0	0.0066	0.0004	0.0016	0.09%	0.01%	0.09%	D	R
3B4a	NMVOC	0	0	5%	200%	2.0	0.0006	0.0001	0.0001	0.03%	0.00%	0.03%	D	R
3B4d	NMVOC	3	2	5%	200%	2.0	0.0326	0.0027	0.0077	0.55%	0.05%	0.55%	D	R
3B4e	NMVOC	0	0	5%	200%	2.0	0.0009	0.0001	0.0002	0.02%	0.00%	0.02%	D	R
3B4f	NMVOC	0	0	5%	200%	2.0	0.0002	0.0004	0.0000	0.07%	0.00%	0.07%	D	R
3B4gi	NMVOC	1	2	5%	200%	2.0	0.0212	0.0032	0.0050	0.63%	0.04%	0.63%	D	R
3B4gii	NMVOC	2	3	5%	200%	2.0	0.0374	0.0056	0.0088	1.12%	0.06%	1.12%	D	R
3B4giii	NMVOC	0	0	5%	200%	2.0	0.0038	0.0006	0.0009	0.11%	0.01%	0.11%	D	R
3B4giv	NMVOC	0	0	5%	200%	2.0	0.0012	0.0002	0.0003	0.04%	0.00%	0.04%	D	R
3B4h	NMVOC	NA	NA											
3Da1	NMVOC	NA	NA											
3Da2a	NMVOC	NA	NA											
3Da2b	NMVOC	NA	NA											
3Da2c	NMVOC	NA	NA											
3Da3	NMVOC	NA	NA											
3Da4	NMVOC	NA	NA											
3Db	NMVOC	NA	NA											
3Dc	NMVOC	NA	NA											
3Dd	NMVOC	NA	NA											
3De	NMVOC	3	3	5%	200%	2.0	0.0366	0.0036	0.0086	0.72%	0.06%	0.72%	D	R
3Df	NMVOC	NA	NA											
3F	NMVOC	0	0	5%	200%	2.0	0.0025	0.0003	0.0006	0.05%	0.00%	0.05%	D	R
3I	NMVOC	NA	NA											
5A	NMVOC	2	7	5%	200%	2.0	0.0928	0.0188	0.0219	3.76%	0.16%	3.76%	D	R
5B1	NMVOC	NO	NE											
5B2	NMVOC	NO	NO											

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
5C1a	NMVOC	NO	NO											
5C1bi	NMVOC	0	0	5%	200%	2.0	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%	D	R
5C1bii	NMVOC	NO	NO											
5C1biii	NMVOC	0	0	5%	200%	2.0	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%	D	R
5C1biv	NMVOC	NO	NO											
5C1bv	NMVOC	NE	NE											
5C1bvi	NMVOC	NO	NO											
5C2	NMVOC	NO	NO											
5D1	NMVOC	0.0	0.0	5%	200%	2.0	0.0001	0.0000	0.0000	0.00%	0.00%	0.00%	D	R
5D2	NMVOC	IE	IE											
5D3	NMVOC	NO	NO											
5E	NMVOC	NE	NE											
6A	NMVOC	NO	NO											
Total	NMVOC	318	150				42.30%					9.52%		

Table II-0-3 Uncertainty analysis of SOx emissions

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
NFR sector	Pollutant	Base year emissions	Year t emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions	Emission factor quality indicator	Activity data quality indicator
		kt	kt	%	%	%	%	%	%	%	%	%		
1A1a	SOx	314	40	3%	20%	0.2	0.1263	0.0032	0.0834	0.06%	0.35%	0.36%	A	R
1A1b	SOx	20	9	3%	20%	0.2	0.0282	0.0132	0.0186	0.26%	0.08%	0.28%	A	R
1A1c	SOx	0	0	3%	200%	2.0	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%	D	R
1A2a	SOx	7	0	3%	40%	0.4	0.0002	0.0020	0.0001	0.08%	0.00%	0.08%	B	R
1A2b	SOx	10	0	3%	40%	0.4	0.0001	0.0026	0.0000	0.10%	0.00%	0.10%	B	R
1A2c	SOx	8	0	3%	40%	0.4	0.0009	0.0019	0.0003	0.08%	0.00%	0.08%	B	R
1A2d	SOx	4	0	3%	40%	0.4	0.0010	0.0009	0.0003	0.04%	0.00%	0.04%	B	R
1A2e	SOx	12	1	3%	40%	0.4	0.0082	0.0006	0.0027	0.02%	0.01%	0.03%	B	R
1A2f	SOx	35	7	3%	40%	0.4	0.0448	0.0053	0.0149	0.21%	0.06%	0.22%	B	R
1A2gvii	SOx	0	0	3%	40%	0.4	0.0000	0.0001	0.0000	0.00%	0.00%	0.00%	B	R
1A2gviii	SOx	34	1											
1A3ai(i)	SOx	0	0	3%	40%	0.4	0.0007	0.0002	0.0002	0.01%	0.00%	0.01%	B	R
1A3aii(i)	SOx	0	0	3%	40%	0.4	0.0002	0.0001	0.0001	0.00%	0.00%	0.00%	B	R
1A3bi	SOx	5	0	3%	40%	0.4	0.0002	0.0012	0.0001	0.05%	0.00%	0.05%	B	R
1A3bii	SOx	1	0	3%	40%	0.4	0.0001	0.0004	0.0000	0.01%	0.00%	0.01%	B	R
1A3biii	SOx	13	0	3%	40%	0.4	0.0001	0.0034	0.0000	0.14%	0.00%	0.14%	B	R
1A3biv	SOx	0	0	3%	40%	0.4	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%	B	R
1A3bv	SOx	NE	NE											

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1A3bvi	SOx	NE	NE											
1A3bvii	SOx	NE	NE											
1A3c	SOx	0	0	3%	40%	0.4	0.0005	0.0001	0.0002	0.01%	0.00%	0.01%	B	R
1A3di(ii)	SOx	NO	NO											
1A3dii	SOx	0	0	3%	40%	0.4	0.0011	0.0003	0.0004	0.01%	0.00%	0.01%	B	R
1A3ei	SOx	NO	NO											
1A3eii	SOx	NO	NO											
1A4ai	SOx	1	0	3%	40%	0.4	0.0015	0.0002	0.0005	0.01%	0.00%	0.01%	B	R
1A4aii	SOx	IE	IE											
1A4bi	SOx	10	2	3%	40%	0.4	0.0153	0.0024	0.0051	0.10%	0.02%	0.10%	B	R
1A4bii	SOx	IE	IE											
1A4ci	SOx	0	0	3%	40%	0.4	0.0008	0.0001	0.0003	0.01%	0.00%	0.01%	B	R
1A4cii	SOx	5	0	3%	40%	0.4	0.0000	0.0014	0.0000	0.05%	0.00%	0.05%	B	R
1A4ciii	SOx	IE	IE											
1A5a	SOx	IE	IE											
1A5b	SOx	IE	0											
1B1a	SOx	NA	NA											
1B1b	SOx	NO	NO											
1B1c	SOx	NO	NO											
1B2ai	SOx	NE	NE											
1B2aiv	SOx	IE	IE											
1B2av	SOx	NE	NE											
1B2b	SOx	NE	NE											
1B2c	SOx	IE	IE											
1B2d	SOx	NO	NO											
2A1	SOx	IE	IE											
2A2	SOx	IE	IE											
2A3	SOx	IE	IE											
2A5a	SOx	NA	NA											
2A5b	SOx	NA	NA											
2A5c	SOx	NE	NE											

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
2A6	SOx	NO	NO											
2B1	SOx	NA	NA											
2B2	SOx	NA	NA											
2B3	SOx	NO	NO											
2B5	SOx	NO	NO											
2B6	SOx	NO	NO											
2B7	SOx	NO	NO											
2B10a	SOx	2	0	3%	20%	0.2	0.0005	0.0002	0.0003	0.00%	0.00%	0.00%	A	R
2B10b	SOx	NO	NO											
2C1	SOx	0	0	3%	100%	1.0	0.0014	0.0002	0.0002	0.02%	0.00%	0.02%	C	R
2C2	SOx	1	1	3%	100%	1.0	0.0110	0.0012	0.0015	0.12%	0.01%	0.12%	C	R
2C3	SOx	1	1	3%	200%	2.0	0.0258	0.0015	0.0017	0.31%	0.01%	0.31%	D	R
2C4	SOx	NO	NO											
2C5	SOx	NO	0											
2C6	SOx	NO	NO											
2C7a	SOx	NO	NO											
2C7b	SOx	NO	NO											
2C7c	SOx	NO	NO											
2C7d	SOx	NO	NO											
2D3a	SOx	NA	NA											
2D3b	SOx	NE	NE											
2D3c	SOx	NA	NA											
2D3d	SOx	NA	NA											
2D3e	SOx	NA	NA											
2D3f	SOx	NA	NA											
2D3g	SOx	NE	NE											
2D3h	SOx	NA	NA											
2D3i	SOx	NA	NA											
2G	SOx	0	0	5%	200%	2.0	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%	D	R
2H1	SOx	NA	NA											
2H2	SOx	NA	NA											
2H3	SOx	NO	NO											

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
2I	SOx	NE	NE											
2J	SOx	NE	NE											
2K	SOx	NA	NA											
2L	SOx	NO	NO											
3B1a	SOx	NA	NA											
3B1b	SOx	NA	NA											
3B2	SOx	NA	NA											
3B3	SOx	NA	NA											
3B4a	SOx	NA	NA											
3B4d	SOx	NA	NA											
3B4e	SOx	NA	NA											
3B4f	SOx	NA	NA											
3B4gi	SOx	NA	NA											
3B4gii	SOx	NA	NA											
3B4giii	SOx	NA	NA											
3B4giv	SOx	NA	NA											
3B4h	SOx	NA	NA											
3Da1	SOx	NA	NA											
3Da2a	SOx	NA	NA											
3Da2b	SOx	NA	NA											
3Da2c	SOx	NA	NA											
3Da3	SOx	NA	NA											
3Da4	SOx	NA	NA											
3Db	SOx	NA	NA											
3Dc	SOx	NA	NA											
3Dd	SOx	NA	NA											
3De	SOx	NA	NA											
3Df	SOx	NA	NA											
3F	SOx	0	0	5%	200%	2.0	0.0059	0.0003	0.0004	0.07%	0.00%	0.07%	D	R
3I	SOx	NA	NA											
5A	SOx	NA	NA											
5B1	SOx	NO	NE											

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
5B2	SOx	NO	NO											
5C1a	SOx	NO	NO											
5C1bi	SOx	0	0	5%	200%	2.0	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%	D	R
5C1bii	SOx	NO	NO											
5C1biii	SOx	0	0	5%	200%	2.0	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%	D	R
5C1biv	SOx	NO	NO											
5C1bv	SOx	NE	NE											
5C1bvi	SOx	NO	NO											
5C2	SOx	NO	NO											
5D1	SOx	NA	NA											
5D2	SOx	IE	IE											
5D3	SOx	NO	NO											
5E	SOx	NE	NE											
6A	SOx	NO	NO											
Total		484	65				**14.10%**					**0.65%**		

Table II-0-4 Uncertainty analysis of NH3 emissions

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
NFR sector	Pollutant	Base year emissions	Year t emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions	Emission factor quality indicator	Activity data quality indicator
		kt	kt	%	%	%	%	%	%	%	%	%		
1A1a	NH3	NE	NE											
1A1b	NH3	NE	NE											
1A1c	NH3	NE	NE											
1A2a	NH3	NE	NE											
1A2b	NH3	NE	NE											
1A2c	NH3	NE	NE											
1A2d	NH3	NE	0											
1A2e	NH3	NE	0											
1A2f	NH3	0	0	3%	200%	2.0	0.0010	0.0004	0.0004	0.07%	0.00%	0.07%	D	R
1A2gvii	NH3	0	0	3%	200%	2.0	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%	D	R
1A2gviii	NH3	0	0											
1A3ai(i)	NH3	NE	NE											
1A3aii(i)	NH3	NE	NE											
1A3bi	NH3	0	1	3%	20%	0.2	0.0041	0.0138	0.0141	0.28%	0.06%	0.28%	A	R
1A3bii	NH3	0	0	3%	20%	0.2	0.0003	0.0009	0.0010	0.02%	0.00%	0.02%	A	R
1A3biii	NH3	2	0	3%	20%	0.2	0.0001	0.0131	0.0002	0.26%	0.00%	0.26%	A	R
1A3biv	NH3	0	0	3%	20%	0.2	0.0001	0.0002	0.0002	0.00%	0.00%	0.00%	A	R
1A3bv	NH3	NE	NE											
1A3bvi	NH3	NE	NE											

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1A3bvii	NH3	NE	NE											
1A3c	NH3	0	0	3%	200%	2.0	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%	D	R
1A3di(ii)	NH3	NO	NO											
1A3dii	NH3	NE	NE											
1A3ei	NH3	NO	NE											
1A3eii	NH3	NO	NO											
1A4ai	NH3	NO	NO											
1A4aii	NH3	IE	IE											
1A4bi	NH3	2	2	3%	200%	2.0	0.0502	0.0012	0.0175	0.23%	0.07%	0.24%	D	R
1A4bii	NH3	IE	IE											
1A4ci	NH3	NO	0											
1A4cii	NH3	0	0	3%	200%	2.0	0.0000	0.0000	0.0000	0.01%	0.00%	0.01%	D	R
1A4ciii	NH3	IE	IE											
1A5a	NH3	IE	IE											
1A5b	NH3	IE	NE											
1B1a	NH3	NA	NA											
1B1b	NH3	NO	NO											
1B1c	NH3	NO	NO											
1B2ai	NH3	NA	NA											
1B2aiv	NH3	0	0	3%	200%	2.0	0.0009	0.0002	0.0003	0.03%	0.00%	0.03%	D	R
1B2av	NH3	NA	NA											
1B2b	NH3	NA	NA											
1B2c	NH3	IE	IE											
1B2d	NH3	NO	NO											
2A1	NH3	IE	IE											
2A2	NH3	IE	IE											
2A3	NH3	IE	IE											
2A5a	NH3	NA	NA											
2A5b	NH3	NA	NA											
2A5c	NH3	NE	NE											
2A6	NH3	NO	NO											

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
2B1	NH3	0	0	3%	100%	1.0	0.0001	0.0000	0.0001	0.00%	0.00%	0.00%	C	R
2B2	NH3	NA	NA											
2B3	NH3	NO	NO											
2B5	NH3	NO	NO											
2B6	NH3	NO	NO											
2B7	NH3	NO	NO											
2B10a	NH3	NE	2											
2B10b	NH3	NO	NO											
2C1	NH3	NE	NE											
2C2	NH3	NE	NE											
2C3	NH3	NE	NE											
2C4	NH3	NO	NO											
2C5	NH3	NO	NE											
2C6	NH3	NO	NO											
2C7a	NH3	NO	NO											
2C7b	NH3	NO	NO											
2C7c	NH3	NO	NO											
2C7d	NH3	NO	NO											
2D3a	NH3	NA	NA											
2D3b	NH3	NA	NA											
2D3c	NH3	NA	NA											
2D3d	NH3	NA	NA											
2D3e	NH3	NA	NA											
2D3f	NH3	NA	NA											
2D3g	NH3	NE	NE											
2D3h	NH3	NA	NA											
2D3i	NH3	NA	NA											
2G	NH3	0	0	5%	200%	2.0	0.0025	0.0026	0.0009	0.52%	0.01%	0.52%	D	R
2H1	NH3	NA	NA											
2H2	NH3	NA	NA											
2H3	NH3	NO	NO											
2I	NH3	NE	NE											

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
2J	NH3	NE	NE											
2K	NH3	NA	NA											
2L	NH3	NO	NO											
3B1a	NH3	5	3	5%	200%	2.0	0.0935	0.0066	0.0325	1.33%	0.23%	1.35%	D	R
3B1b	NH3	4	4	5%	200%	2.0	0.1221	0.0142	0.0425	2.84%	0.30%	2.86%	D	R
3B2	NH3	3	3	5%	200%	2.0	0.1096	0.0117	0.0381	2.34%	0.27%	2.35%	D	R
3B3	NH3	4	3	5%	200%	2.0	0.0982	0.0000	0.0342	0.00%	0.24%	0.24%	D	R
3B4a	NH3	0	0	5%	200%	2.0	0.0006	0.0002	0.0002	0.04%	0.00%	0.04%	D	R
3B4d	NH3	2	2	5%	200%	2.0	0.0498	0.0009	0.0173	0.18%	0.12%	0.22%	D	R
3B4e	NH3	0	0	5%	200%	2.0	0.0033	0.0013	0.0012	0.26%	0.01%	0.26%	D	R
3B4f	NH3	1	0	5%	200%	2.0	0.0019	0.0094	0.0006	1.89%	0.00%	1.89%	D	R
3B4gi	NH3	2	3	5%	200%	2.0	0.0954	0.0152	0.0332	3.04%	0.23%	3.05%	D	R
3B4gii	NH3	2	3	5%	200%	2.0	0.0985	0.0157	0.0343	3.14%	0.24%	3.15%	D	R
3B4giii	NH3	0	0	5%	200%	2.0	0.0103	0.0016	0.0036	0.33%	0.03%	0.33%	D	R
3B4giv	NH3	0	0	5%	200%	2.0	0.0026	0.0004	0.0009	0.08%	0.01%	0.08%	D	R
3B4h	NH3	NA	NA											
3Da1	NH3	29	10	5%	200%	2.0	0.3218	0.1146	0.1120	22.92%	0.79%	22.93%	D	R
3Da2a	NH3	17	15	5%	200%	2.0	0.4676	0.0307	0.1627	6.15%	1.15%	6.26%	D	R
3Da2b	NH3	0	0	5%	200%	2.0	0.0022	0.0003	0.0008	0.05%	0.01%	0.05%	D	R
3Da2c	NH3	NO	NO											
3Da3	NH3	13	10	5%	200%	2.0	0.3222	0.0155	0.1121	3.10%	0.79%	3.20%	D	R
3Da4	NH3	NA	NA											
3Db	NH3	NA	NA											
3Dc	NH3	NA	NA											
3Dd	NH3	NA	NA											
3De	NH3	NA	NA											
3Df	NH3	NA	NA											
3F	NH3	1	1	5%	200%	2.0	0.0289	0.0020	0.0101	0.41%	0.07%	0.41%	D	R
3I	NH3	NO	NO											
5A	NH3	NE	NE											
5B1	NH3	NO	0											
5B2	NH3	NO	NO											

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
5C1a	NH3	NO	NO											
5C1bi	NH3	NE	NE											
5C1bii	NH3	NO	NO											
5C1biii	NH3	NE	NE											
5C1biv	NH3	NO	NO											
5C1bv	NH3	NE	NE											
5C1bvi	NH3	NO	NO											
5C2	NH3	NO	NO											
5D1	NH3	NE	NE											
5D2	NH3	IE	IE											
5D3	NH3	NO	NO											
5E	NH3	NA	NA											
6A	NH3	NO	NO											
Total		90	63				**70.43%**					**24.79%**		

Table II-0-5 Uncertainty analysis of PM2.5 emissions

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
NFR sector	Pollutant	Base year emissions	Year t emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions	Emission factor quality indicator	Activity data quality indicator
		kt	kt	%	%	%	%	%	%	%	%	%		
1A1a	PM2.5	12	2	3%	200%	2.0	0.1334	0.0835	0.0394	16.69%	0.17%	16.69%	D	R
1A1b	PM2.5	0	0	3%	200%	2.0	0.0204	0.0028	0.0060	0.55%	0.03%	0.55%	D	R
1A1c	PM2.5	0	0	3%	200%	2.0	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%	D	R
1A2a	PM2.5	0	0	3%	200%	2.0	0.0006	0.0011	0.0002	0.21%	0.00%	0.21%	D	R
1A2b	PM2.5	0	0	3%	200%	2.0	0.0003	0.0015	0.0001	0.29%	0.00%	0.29%	D	R
1A2c	PM2.5	0	0	3%	200%	2.0	0.0011	0.0034	0.0003	0.69%	0.00%	0.69%	D	R
1A2d	PM2.5	0	0	3%	200%	2.0	0.0018	0.0004	0.0005	0.08%	0.00%	0.08%	D	R
1A2e	PM2.5	0	1	3%	200%	2.0	0.0489	0.0114	0.0144	2.28%	0.06%	2.28%	D	R
1A2f	PM2.5	0	0	3%	200%	2.0	0.0265	0.0073	0.0078	1.45%	0.03%	1.45%	D	R
1A2gvii	PM2.5	0	0	3%	200%	2.0	0.0167	0.0040	0.0049	0.79%	0.02%	0.79%	D	R
1A2gviii	PM2.5	2	0											
1A3ai(i)	PM2.5	0	0	3%	20%	0.2	0.0001	0.0002	0.0003	0.00%	0.00%	0.00%	A	R
1A3aii(i)	PM2.5	0	0	3%	20%	0.2	0.0000	0.0001	0.0001	0.00%	0.00%	0.00%	A	R
1A3bi	PM2.5	1	0	3%	20%	0.2	0.0006	0.0085	0.0018	0.17%	0.01%	0.17%	A	R
1A3bii	PM2.5	0	0	3%	20%	0.2	0.0014	0.0033	0.0040	0.07%	0.02%	0.07%	A	R
1A3biii	PM2.5	4	1	3%	20%	0.2	0.0091	0.0174	0.0265	0.35%	0.11%	0.37%	A	R
1A3biv	PM2.5	0	0	3%	20%	0.2	0.0006	0.0001	0.0017	0.00%	0.01%	0.01%	A	R
1A3bv	PM2.5	NE	NE											

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1A3bvi	PM2.5	1	1	3%	20%	0.2	0.0044	0.0072	0.0129	0.14%	0.05%	0.15%	A	R
1A3bvii	PM2.5	0	0	3%	20%	0.2	0.0022	0.0035	0.0063	0.07%	0.03%	0.08%	A	R
1A3c	PM2.5	0	0	3%	200%	2.0	0.0024	0.0000	0.0007	0.01%	0.00%	0.01%	D	R
1A3di(ii)	PM2.5	NO	NO											
1A3dii	PM2.5	2	2	3%	200%	2.0	0.1409	0.0226	0.0416	4.52%	0.18%	4.52%	D	R
1A3ei	PM2.5	NO	IE											
1A3eii	PM2.5	NO	NO											
1A4ai	PM2.5	0	0	3%	200%	2.0	0.0037	0.0001	0.0011	0.01%	0.00%	0.01%	D	R
1A4aii	PM2.5	IE	IE											
1A4bi	PM2.5	23	17	3%	200%	2.0	1.0101	0.0500	0.2980	10.00%	1.26%	10.08%	D	R
1A4bii	PM2.5	IE	IE											
1A4ci	PM2.5	0	0	3%	200%	2.0	0.0116	0.0030	0.0034	0.61%	0.01%	0.61%	D	R
1A4cii	PM2.5	2	0	3%	200%	2.0	0.0125	0.0138	0.0037	2.76%	0.02%	2.76%	D	R
1A4ciii	PM2.5	IE	IE											
1A5a	PM2.5	IE	IE											
1A5b	PM2.5	IE	NE											
1B1a	PM2.5	0	0	3%	200%	2.0	0.0139	0.0007	0.0041	0.13%	0.02%	0.13%	D	R
1B1b	PM2.5	NO	NO											
1B1c	PM2.5	NO	NO											
1B2ai	PM2.5	NA	NA											
1B2aiv	PM2.5	IE	IE											
1B2av	PM2.5	NA	NA											
1B2b	PM2.5	NA	NA											
1B2c	PM2.5	IE	IE											
1B2d	PM2.5	NO	NO											
2A1	PM2.5	0	0	3%	200%	2.0	0.0067	0.0002	0.0020	0.05%	0.01%	0.05%	D	R
2A2	PM2.5	0	0	3%	100%	1.0	0.0002	0.0000	0.0001	0.00%	0.00%	0.00%	C	R
2A3	PM2.5	0	0	3%	200%	2.0	0.0017	0.0002	0.0005	0.03%	0.00%	0.03%	D	R
2A5a	PM2.5	NE	0											
2A5b	PM2.5	NE	1											
2A5c	PM2.5	NE	NE											

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
2A6	PM2.5	NO	NO											
2B1	PM2.5	NA	NA											
2B2	PM2.5	NA	NA											
2B3	PM2.5	NO	NO											
2B5	PM2.5	NO	NO											
2B6	PM2.5	NO	NO											
2B7	PM2.5	NO	NO											
2B10a	PM2.5	0	0	3%	100%	1.0	0.0039	0.0023	0.0023	0.23%	0.01%	0.23%	C	R
2B10b	PM2.5	NO	NO											
2C1	PM2.5	0	0	3%	100%	1.0	0.0009	0.0003	0.0006	0.03%	0.00%	0.03%	C	R
2C2	PM2.5	0	0	3%	100%	1.0	0.0036	0.0014	0.0021	0.14%	0.01%	0.14%	C	R
2C3	PM2.5	0	0	3%	200%	2.0	0.0067	0.0010	0.0020	0.21%	0.01%	0.21%	D	R
2C4	PM2.5	NO	NO											
2C5	PM2.5	NO	0											
2C6	PM2.5	NO	NO											
2C7a	PM2.5	NO	NO											
2C7b	PM2.5	NO	NO											
2C7c	PM2.5	NO	NO											
2C7d	PM2.5	NO	NO											
2D3a	PM2.5	NE	NE											
2D3b	PM2.5	0	0	5%	200%	2.0	0.0183	0.0031	0.0054	0.62%	0.04%	0.62%	D	R
2D3c	PM2.5	0	0	5%	200%	2.0	0.0006	0.0001	0.0002	0.02%	0.00%	0.02%	D	R
2D3d	PM2.5	NA	NA											
2D3e	PM2.5	NE	NE											
2D3f	PM2.5	NE	NE											
2D3g	PM2.5	NE	NE											
2D3h	PM2.5	NE	NE											
2D3i	PM2.5	0	1	5%	200%	2.0	0.0313	0.0051	0.0092	1.02%	0.07%	1.02%	D	R
2G	PM2.5	3	1	5%	200%	2.0	0.0311	0.0218	0.0092	4.35%	0.06%	4.35%	D	R
2H1	PM2.5	NA	NA											
2H2	PM2.5	NE	NE											
2H3	PM2.5	NO	NO											

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
2I	PM2.5	NE	NE											
2J	PM2.5	NE	NE											
2K	PM2.5	NA	NA											
2L	PM2.5	NO	NO											
3B1a	PM2.5	0	0	5%	200%	2.0	0.0023	0.0002	0.0007	0.05%	0.00%	0.05%	D	R
3B1b	PM2.5	0	0	5%	200%	2.0	0.0049	0.0005	0.0014	0.10%	0.01%	0.10%	D	R
3B2	PM2.5	0	0	5%	200%	2.0	0.0105	0.0013	0.0031	0.26%	0.02%	0.26%	D	R
3B3	PM2.5	0	0	5%	200%	2.0	0.0002	0.0000	0.0001	0.00%	0.00%	0.00%	D	R
3B4a	PM2.5	0	0	5%	200%	2.0	0.0001	0.0000	0.0000	0.01%	0.00%	0.01%	D	R
3B4d	PM2.5	0	0	5%	200%	2.0	0.0048	0.0003	0.0014	0.05%	0.01%	0.06%	D	R
3B4e	PM2.5	0	0											
3B4f	PM2.5	0	0											
3B4gi	PM2.5	0	0	5%	200%	2.0	0.0018	0.0003	0.0005	0.06%	0.00%	0.06%	D	R
3B4gii	PM2.5	0	0	5%	200%	2.0	0.0032	0.0005	0.0009	0.10%	0.01%	0.10%	D	R
3B4giii	PM2.5	0	0	5%	200%	2.0	0.0007	0.0001	0.0002	0.02%	0.00%	0.02%	D	R
3B4giv	PM2.5	0	0	5%	200%	2.0	0.0002	0.0000	0.0001	0.01%	0.00%	0.01%	D	R
3B4h	PM2.5	NA	NA											
3Da1	PM2.5	NA	NA											
3Da2a	PM2.5	NA	NA											
3Da2b	PM2.5	NA	NA											
3Da2c	PM2.5	NA	NA											
3Da3	PM2.5	NA	NA											
3Da4	PM2.5	NA	NA											
3Db	PM2.5	NA	NA											
3Dc	PM2.5	0	0	5%	200%	2.0	0.0116	0.0009	0.0034	0.19%	0.02%	0.19%	D	R
3Dd	PM2.5	NA	NA											
3De	PM2.5	NA	NA											
3Df	PM2.5	NA	NA											
3F	PM2.5	2	2	5%	200%	2.0	0.1243	0.0118	0.0367	2.37%	0.26%	2.38%	D	R
3I	PM2.5	NA	NA											
5A	PM2.5	0	0	5%	200%	2.0	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%	D	R
5B1	PM2.5	NO	NE											

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
5B2	PM2.5	NO	NO											
5C1a	PM2.5	NO	NO											
5C1bi	PM2.5	0	0	5%	200%	2.0	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%	D	R
5C1bii	PM2.5	NO	NO											
5C1biii	PM2.5	NE	NE											
5C1biv	PM2.5	NO	NO											
5C1bv	PM2.5	0	0.03	5%	200%	2.0	0.0017	0.0004	0.0005	0.09%	0.00%	0.09%	D	R
5C1bvi	PM2.5	NO	NO											
5C2	PM2.5	NO	NO											
5D1	PM2.5	NE	NE											
5D2	PM2.5	IE	IE											
5D3	PM2.5	NO	NO											
5E	PM2.5	NE	0											
6A	PM2.5	NO	NO											
Total		56	33				**103.95%**					**21.08%**		