LUXEMBOURG'S INFORMATIVE INVENTORY REPORT 1990-2022

ADMINISTRATION DE L'ENVIRONNEMENT

D'ËMWELTVERWALTUNG

ENVIRONMENT AGENCY

LE GOUVERNEMENT
DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère de l'Environnement, du Climat
et de la Biodiversité

Administration de l'environnement

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

Project Management

Dr Marc Schuman – Environment Agency

Authors

Nora Becker – Environment Agency

Ermin Hadzic – Environment Agency

Marie-Josée Mangen – Service d'Economie rurale

Tim Mirgain – Environment Agency

Marc Schuman – Environment Agency

Fabien Wahl – Environment Agency

Thomas Weiβ – Environment Agency

Max Wolter – Environment Agency

With contributions by:

Manou Pfeiffenschneider and al. (EFOR-ERSA)

Romain Molitor and al. (Komobile)

Nora Schintgen – Environment Agency

Michael Schwingshackl and al. (IVT-TU Graz)

The authors of this report want to express their thanks to all experts from other institutions involved in the preparation of the Air Emission Inventory of Luxembourg for their contribution to the continuous improvement of the inventory.

Questions and comments should be addressed to:

Administration de l’Environnement

Unité Surveillance et Evaluation de l’Environnement

Groupe Inventaires et Statistiques

1 Avenue du Rock’n’Roll

L-4361 Esch-sur-Alzette

contactUSEE@aev.etat.lu

2024 - Ministère de l’Environnement, du Climat et de la Biodiversité – Administration de l’environnement

Version 2.0 – (27.05.2024)

Tables

Figures

This report was compiled by Dr Marc Schuman (Environment Agency).

Specific responsibilities for this Informative Inventory Report have been as follows:

Executive Summary:	Marc Schuman
Chapter 1:	Marc Schuman
Chapter 2:	Marc Schuman, Nora Becker, Max Wolter
Chapter 3:	Marc Schuman, Nora Becker, Max Wolter
Chapter 4:	Ermin Hadzic, Thomas Weiβ, Marc Schuman
Chapter 5:	Marie-Josée Mangen
Chapter 6:	Tim Mirgain, Marc Schuman
Chapter 7:	Marc Schuman
Chapter 8:	Marc Schuman, Nora Becker, Max Wolter
Chapter 9:	Marc Schuman
Chapter 10:	Marc Schuman
Chapter 11:	Marc Schuman
Appendix 1 & 2:	Marc Schuman
Layout:	Nora Schintgen

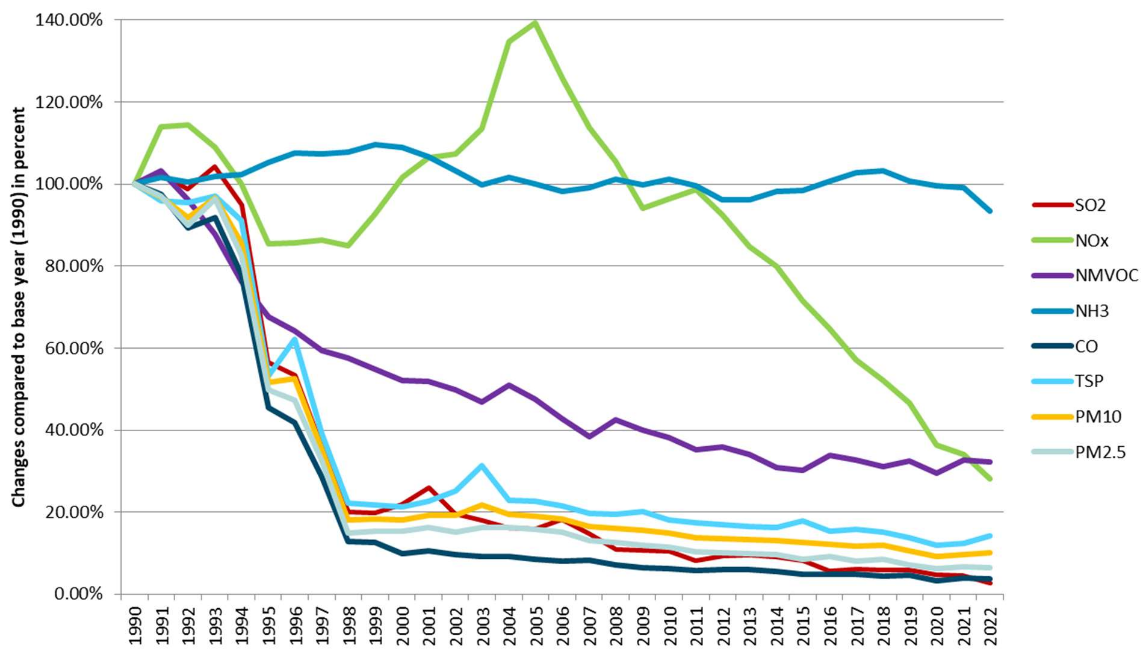
The present IIR contains information on anthropogenic emissions for NO_X, SO_2, NMVOC, NH_3, CO, TSP, PM_{10}, $PM_{2.5}$, HMs (Cd, Pb, Hg) and POPs and covers the period 1990-2022.

1 Executive Summary

This Informative Inventory Report (IIR) contains information on Luxembourg's air pollution inventory from 1990 (base year) up to two years prior to the current year (*i.e.* in 2024, emissions until 2022 are reported). The inventory data are reported under both the Geneva Convention on Long-Range Transboundary Air Pollution of the United Nations Economic Commission for Europe (UNECE/CLRTAP) and the Directive 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants. The report includes descriptions of methods, data sources, and carried out QA/QC activities as well as a comprehensive trend analysis. The report follows the requirements of the 2023 Reporting Guidelines as adopted for application in 2022 and subsequent years at the fourty-second session of the Executive Body for the LRTAP Convention (ECE/EB.AIR/150/Add.1, Decisions 2022/1).

Air pollution in Luxembourg declined in recent years (Figure 1). Emissions decreased significantly for most pollutants monitored since 1990, although progress varies depending on the pollutant.

Figure 1 – Air pollution trends in Luxembourg based on fuel sold



Sulphur dioxide (SO_2), carbon monoxide (CO), total suspended particles (TSP) and particulate matter (PM_{10}, $PM_{2.5}$) emissions saw a rapid decline in the early 1990s due to the technological switch, from blast furnaces to electric arc furnaces in the iron and steel industry, while the decrease of emissions of the remaining pollutants developed in a more irregular way.

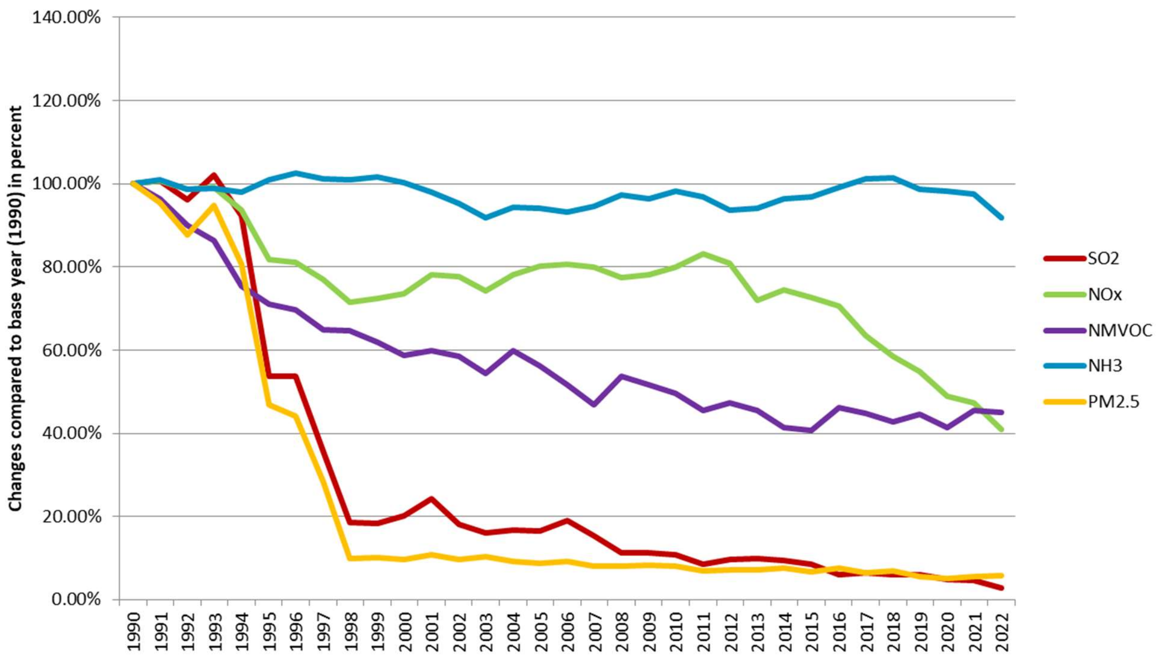
Emissions of non-methane volatile organic compounds (NMVOC) decreased almost continuously due to the reduced use of solvents and solvent containing products, as well as the reduction of solvent contents.

Nevertheless, the above figure also illustrates the fact that for certain pollutants, only moderate progress can be observed since 1998. This particularly holds true for the development of ammonia (NH_3) emissions, for which a relatively stable evolution is observed. Drivers are mostly animal numbers, milk production, changes in the common agricultural policy (abolishment of milk quotas) as well as use of fertilizers.

For nitrogen oxides (NO_X), the trend is mainly driven by emissions from the transport sector and the quantities of fuel sold. Indeed, more than 40% of NO_X emissions are due to fuel export in the vehicle tank. The reduction observed from 2011 onwards is mainly due to reduced activity and installation of more efficient abatement technologies in the manufacturing and construction industry as well as the combined effect of a steady decrease in fuel sales and more efficient abatement technologies in road transportation.

When considering the emission trends without the fuel export in the vehicle tank, *i.e* the fuel used on Luxembourg's territory, the emission trends have a very similar progress. Only NO_X and, in a less pronounced manner, NMVOC emissions illustrate the large contributing effect of the transport sector to the emission of these two pollutants (Figure 2).

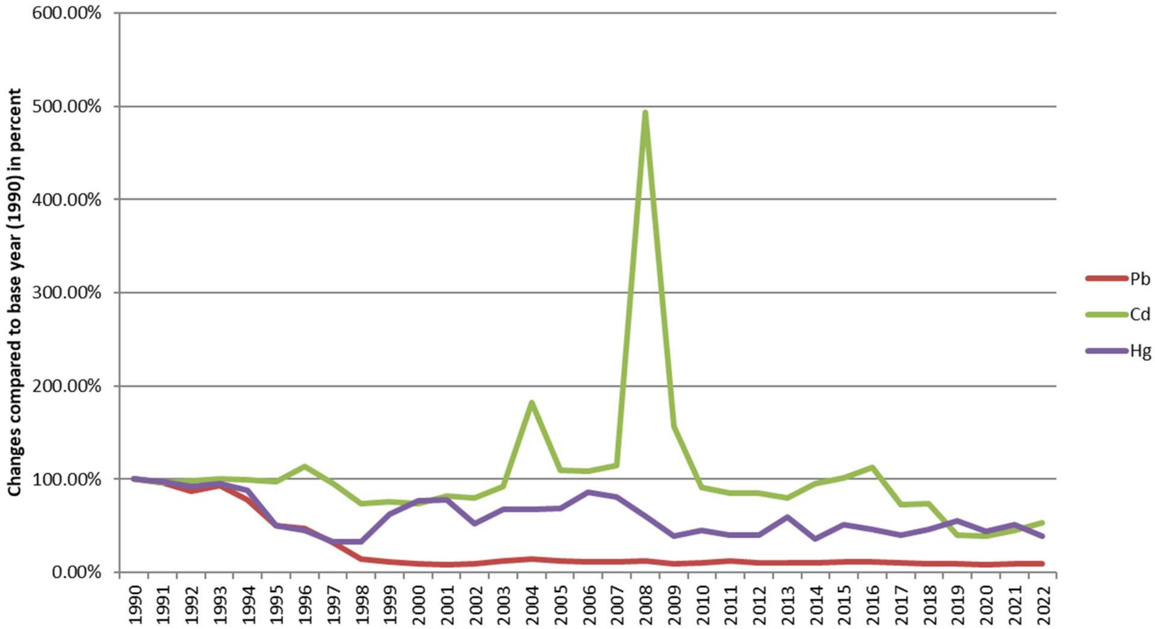
Figure 2 – Air pollution trends in Luxembourg based on fuel used



All trends are analysed and explained in detail in the chapter on emission trends.

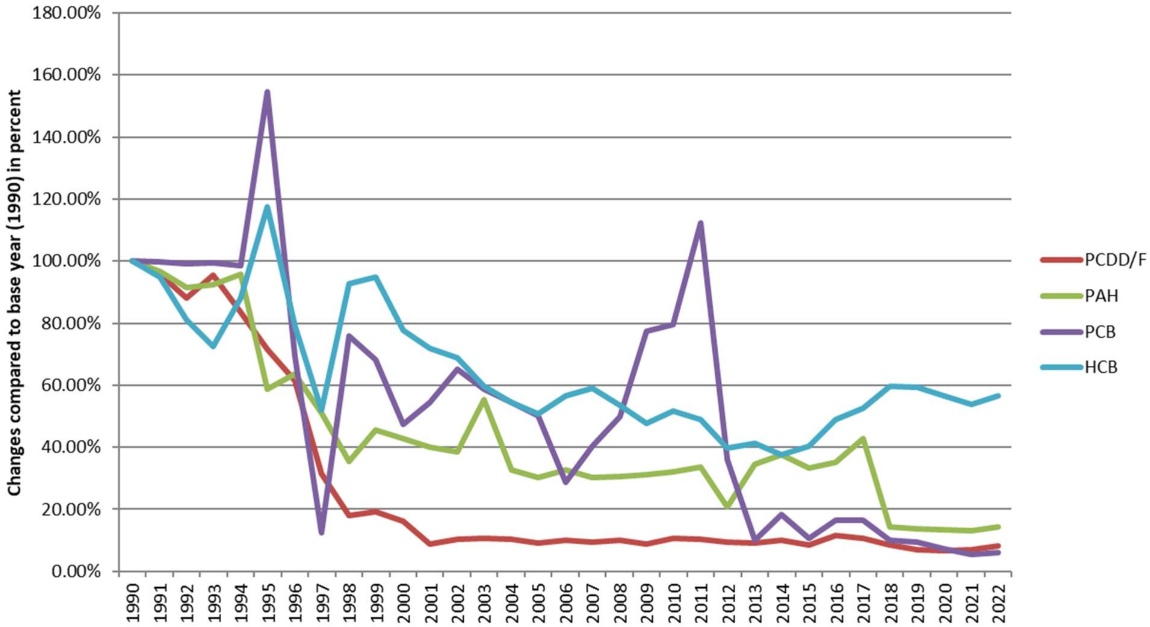
For heavy metals (Figure 3), decreasing trend over the entire timseries (1990 -2022) can be observed. While the general trend for lead and mercury emissions since 1990 is pretty clear with reductions of 91% and 60%, respectively, a detailed analysis shows that the tendency especially for cadmium is less obvious with several increases and drops of emitted quantities during the considered period. In relative figures, these variations can be substantial from one year to the next. In this context, it is important to consider that, because of the small size of the country and the small number of sources of emissions, a change within one production site can have a substantial effect on national emissions. The trend for cadmium emissions over the same period also shows some variations from one year to the next with a general trend that is less clear than for the other metals and a less pronounced emission reduction of 47% since 1990 is observed.

Figure 3 – Heavy metal emission trends in Luxembourg based on fuel sold



Similarly to heavy metals, emission trends for Persistent Organic Pollutants (POPs) are also quite heterogeneous (Figure 4). Major sources of POP emissions in Luxembourg are the steel and aluminium production as well as residential heating. Other important sources for POPs are municipal waste incineration, road transport and cement production. Between 1990 and 2021, the highest emission reduction was achieved for PCDD/F emissions (- 92 %). PAH and PCB emissions were reduced by 86 and 94 percent respectively, whereas HCB emissions decreased by 43 percent within the same period. HCB emissions are fluctuating from one year to the next with no steady trend over the past three decades. The erratic trend between 1995 and 2005 is mostly due to the introduction of the secondary iron and steel production. After a slight downward trend in the years 2005 – 2015, emissions rose again until 2018 and seem to have stablaised since then.

Figure 4 – Persistant organic pollutant emission trends in Luxembourg based on fuel sold



Finally, please be aware that this report does not provide a comprehensive discussion on air pollution or the policies and measures dealing with it. Instead, this report provides a detailed insight on the process of air pollution emission inventory preparation. The focus lies on the methods and assumptions used for Luxembourg's emission reporting. The report is intended to underpin the "technical" review of the emission data as reported under the CLRTAP and its protocols as well as under the "NEC" Directive (2016/2284/EU).

Also, this report is incrementally improved and extended, main differences are listed here for the specific submissions. They should be read as lists of improvements over their corresponding predecessor. Hence, since submission 2015, this is the tenth submission in which Luxembourg is providing an informative inventory report. The main improvements since the last submission include updated activity, updated methodology (including revised emission factors) for the energy, transport, agriculture and industrial processes and other product use and waste sectors. For full details on the recalculations and planned improvements, please refer to the respective sectoral chapters.

1 Introduction

1.1 Background information on the Air Emission Inventory and Climate Change

1.1.1 Background Information on Air Pollution

Air pollution, responsible for acidification, eutrophication and ground-level ozone pollution, travels over long distances and over national boundaries. Despite considerable improvements in past decades, air pollution is still responsible for more than 400 000 premature deaths in Europe each year. It also continues to damage vegetation and ecosystems. Continued improvements in air pollution levels are expected under current legislation, but beyond 2030 only slow progress is expected. Additional measures are needed if Europe is to achieve the long-term objective of air pollution levels that do not lead to unacceptable harm to human health and the environment.[1]

1.1.1.1 The Convention on Long-Range Transboundary Air Pollution

The 1972 United Nations Conference on the Human Environment in Stockholm signalled the start for active international cooperation to combat acidification. Between 1972 and 1977 several studies confirmed the hypothesis that air pollutants could travel several thousands of kilometres before deposition and damage occurred. This also implied that cooperation at the international level was necessary to solve problems such as acidification.

In response to these acute problems, a High-level Meeting within the Framework of the United Nations Economic Commission for Europe (UNECE) on the Protection of the Environment was held at ministerial level in November 1979 in Geneva. It resulted in the signature of the Convention on Long-Range Transboundary Air Pollution (CLRTAP) by 34 Governments and the European Community (EC). The Convention was the first international legally binding instrument to deal with problems of air pollution on a broad regional basis. Besides laying down the general principles of international cooperation for air pollution abatement, the Convention sets up an institutional framework bringing together research and policy.

The Convention on Long-Range Transboundary Air Pollution entered into force in 1983. It has been extended by eight specific protocols. Luxembourg signed the Convention in 1979. The Convention's obligations as well as information regarding the status of ratification are listed in Table 1-1.

Table 1-1 – Protocols of the UNECE Convention on Long-Range Transboundary Air Pollution

Tools of UNECE Convention on Long-Range Transboundary Air Pollution (LRTAP)		entered into force	signed/ratified by Luxembourg
1979	Geneva Convention on Long-Range Transboundary Air Pollution	16.03.1983	13.11.1979 (S) 15.07.1982 (R)
1984	Geneva Protocol on Long-term Financing of the Cooperative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe (EMEP)	28.01.1988	21.11.1984 (S) 24.08.1987 (R)

[1] The European Environment State and Outlook 2015 (Explore SOER 2015 online: eea.europa.eu/soer)

	Tools of UNECE Convention on Long-Range Transboundary Air Pollution (LRTAP)	entered into force	signed/ratified by Luxembourg
1985	Helsinki Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 per cent	02.09.1987	09.07.1985 (S) 24.08.1987 (R)
1988	Sofia Protocol concerning the Control of Emissions of Nitrogen Oxides or their Transboundary Fluxes	14.02.1991	1.11.1988 (S) 4.10.1990 (R)
1991	Geneva Protocol concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes	29.09.1997	19.11.1991 (S) 11.11.1993 (R)
1994	Oslo Protocol on Further Reduction of Sulphur Emissions	05.08.1998	14.6.1994 (S) 14.6.1996 (R)
1998	Aarhus Protocol on Heavy Metals	29.12.2003	24.6.1998 (S) 1.5.2000 (R)
	Aarhus Protocol on Heavy Metals, as amended on 13 December 2012	8.02.2022	14.5.2015 (A)
1998	Aarhus Protocol on Persistent Organic Pollutants (POPs)	23.10.2003	24.06.1998 (S) 1.5.2000 (R)
	Aarhus Protocol on Persistent Organic Pollutants, as amended on 18 December 2009[2]	20.01.2022	17.08.2011 (A)
1999	Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone	17.05.2005	1.12.1999 (S) 7.8.2001 (R)
	Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone, as amended on 4 May 2012[3]	07.10.2019	09. 07.2019 (A)

Abbreviation: signed (S), ratified (R), accession (AC), acceptance (A), Footnote: (2) with declaration upon ratification
Source: https://unece.org/protocols

1.1.2 Background Information on the Air Emission Inventory

As a Party to the UNECE-CLRTAP, Luxembourg is required to annually report data on emissions of the air pollutants covered by the Convention and its Protocols. The main pollutants covered are NO_X, SO_2, NMVOC, NH_3 and CO, Particulate Matter (TSP, PM_{10}, $PM_{2.5}$), Persistent Organic Pollutants (POPs) and Heavy Metals (HM). In order to meet the reporting requirements, Luxembourg compiles an Air Emission Inventory.

Responsible for the preparation of Luxembourg's National Air Emission Inventory as well as for the preparation of the informative inventory report (IIR) is the Environment Agency (AEV), under the political responsibility of the Ministry for the Environment, Climate and Biodiversity (MECB).

The present IIR follows the regulations under the UNECE-CLRTAP and its Protocols that define standards for national emission inventories. In 2014, the Executive Body adopted the "Guidelines for Reporting Emissions and Projections Data under the Convention on

[2] http://www.unece.org/fileadmin/DAM/env/lrtap/full%20text/ece.eb.air.104.e.pdf
[3] http://www.unece.org/fileadmin/DAM/env/documents/2013/air/eb/ECE.EB.AIR.114_ENG.pdf

Long-Range Transboundary Air Pollution" (ECE/EB.AIR/97)[4], which are necessary to ensure the transparency, accuracy, consistency, comparability, and completeness (TACCC) of reported emissions. The emission data presented in this report were compiled according to these guidelines for estimating and reporting emission data, which also define the format of reporting emission data (Nomenclature for Reporting – NFR of which the latest version of the template is coded 'NFR 2014-2') as well as standards for providing supporting documentation which should ensure the transparency of the inventory.[5]

The IIR 2024, at hand, complements the reported emission data by providing background information. It follows the "Recommended Structure for the Informative Inventory Report (IIR)[6]" as elaborated by the LRTAP Convention's "Task Force on Emission Inventories and Projections – TFEIP".

1.2 Institutional Arrangement for Inventory Preparation including the Legal and Procedural Arrangements for Inventory Planning, Preparation and Management

1.2.1 Overview of Institutional, Legal and Procedural Arrangements for Compiling the Air Emission Inventory

1.2.1.1 Overview of Luxembourg's Obligations

Luxembourg has to comply with the following air emission related obligations:

- Annual obligations under the 1979 UNECE Convention on Long-Range Transboundary Air Pollution (*CLRTAP*) and its Protocols comprising the annual reporting of national emission data on SO_2, NO_X, NMVOCs, NH_3, CO, TSP, PM_{10}, and $PM_{2.5}$ as well as on the heavy metals Pb, Cd and Hg and persistent organic hydrocarbons (*PAHs*), dioxins and furans and hexachlorobenzene (*HCB*).
- Annual obligations under Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC, known as the "NEC Directive" (NECD) comprising the annual reporting of national emission data on SO_2, NO_X, NMVOC, NH_3 and $PM_{2.5}$, among others.
- Annual obligation under Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on Industrial Emissions[7] (Integrated Pollution Prevention and Control) which sets out the main principles for the permitting and control of installations based on an integrated approach and the application of best available techniques (BAT). BAT is the most effective techniques to achieve a high level of environmental protection, taking into account the costs and benefits.
  On 7 January 2014, the Industrial Emissions Directive (IED) repealed and replaced Directive 2008/1/EC on Integrated Pollution Prevention and Control (IPPC), Directive 2000/76/EC on waste incineration, Directive 1999/13/EC on activities using organic solvents and Directives 78/176/EEC, 82/883/EEC and 92/112/EEC, concerning titanium dioxide production.

---

4 The Revised 2014 Reporting guidelines (ECE/EB.AIR.125) were adopted for application in 2015 and subsequent years. The document is a revised version of the 2009 Guidelines for Reporting Emission data under the Convention (ECE/EB.AIR/97), which were approved by the Executive Body in 2008 (ECE/EB.AIR/96, para. 83 (b))
www.ceip.at/fileadmin/inhalte/emep/2014_Guidelines/ece.eb.air.125_ADVANCE_VERSION_reporting_guidelines_2013.pdf

5 http://www.ceip.at/ms/ceip_home1/ceip_home/reporting_instructions/annexes_to_guidelines/

6 www.ceip.at/fileadmin/inhalte/emep/2014_Guidelines/Annex_II_Informative_Inventory_Report.pdf

7 http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32010L0075

- Obligations according to Article 15 of the European IPPC Directive 1996/61/EC to implement a European Pollutant Emission Register (EPER). EPER was displaced and upgraded by Regulation (EC) 166/2006 of the European Parliament and of the Council of 18 January 2006 concerning the establishment of a European Pollutant Release and Transfer Register (E-PRTR). EPER and E-PRTR are associated with Article 6 of the Aarhus Convention (United Nations: Aarhus, 1998) which refers to the right of the public to access environmental information and to participate in the decision-making process of environmental issues.
- Obligation under Directive 2001/80/EC of the European Parliament and of the Council of 23 October 2001 on the limitation of emissions of certain pollutants into the air from large combustion plants (Directive 2001/80/EC on large combustion plants (LCP)) which sets emission limit values for SO_2, NO_X and dust from combustion plants with a rated thermal input of 50 MW or more. The LCP Directive was repealed and replaced by the IED from 1 January 2016.[8]

Furthermore, Luxembourg has to comply with the following ambient air quality related obligations:

- Council Directive 96/62/EC on ambient air quality assessment and management (Air Quality Framework Directive).
- Council Directive 1999/30/EC relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air (First Daughter Directive).
- Directive 2000/69/EC of the European Parliament and of the Council relating to limit values for benzene and carbon monoxide in ambient air (Second Daughter Directive).
- Directive 2002/3/EC of the European Parliament and of the Council relating to ozone in ambient air (Third Daughter Directive).
- Directive 2004/107/EC of the European Parliament and of the Council relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air (Fourth Daughter Directive).

Some obligations are directly linked with greenhouse gas (GHG) emission reporting:

- Annual obligations under Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council;
- Obligations under the United Nations Framework Convention on Climate Change (UNFCCC):
    - Decision 3/CP.5 – Guidelines for the preparation of National Communications by Parties included in Annex I to the Convention, Part I: UNFCCC Reporting Guidelines on Annual Inventories (referring to Document FCCC/CP/1999/7) revised with Decision 18/CP.8 (referring to Document FCCC/CP/2002/8);
    - Decision 4/CP.5 – Guidelines for the preparation of National Communications by Parties included in Annex I to the Convention, Part II: UNFCCC Reporting Guidelines on National Communications (referring to Document FCCC/CP/1999/7) revised with Decision 19/CP.8 (referring to Document FCCC/CP/2002/8);
    - Document FCCC/CP/1999/7 – Review of the Implementation of Commitments and of other Provisions of the Convention – UNFCCC Guidelines on Reporting and Review revised with Document FCCC/CP/2002/8;
    - Decision 11/CP.4 – National communications from Parties included in Annex I to the Convention;

[8] http://ec.europa.eu/environment/industry/stationary/index.htm

- Document FCCC/CP/2001/13/Add.3 – Report of the Conference of the Parties on its seventh session, held at Marrakech from 29 October to 10 November 2001, Addendum, Part two: Action taken by the Conference of the Parties, Volume III (Decision 20/CP.7: Guidelines for national systems under Article 5, paragraph 1, of the Kyoto Protocol; Decision 21/CP.7: Good practice guidance and adjustments under Article 5, paragraph 2, of the Kyoto Protocol; Decision 22/C.7: Guidance for the preparation of the information required under Article 7 of the Kyoto Protocol; Decision 23/CP.7: Guidelines for review under Article 8 of the Kyoto Protocol).

1.2.1.2 Luxembourg's National Inventory System

In the following lines, Luxembourg's National Inventory System, as it has been established for the GHG emission inventory and as it is described in Luxembourg's latest National Inventory Report, will be reported.

A new Grand-Ducal Regulation (GDR, 04/2017) - hereafter the "Regulation" - of April 2017 designates a Single National Entity, the National Inventory Compiler and the National Inventory Focal Point. It also defines and allocates specific responsibilities for the realization of the air emission inventory both within the Single National Entity and within the other administrations and/or services that are involved in the inventory preparation. This Regulation also sets up a system for reporting on emissions of certain atmospheric pollutants under Directive (EU) 2016/2284, and more largely under the UNECE LRTAP Convention (CLRTAP). Consequently, the system put in place aims at reporting under both the UNFCCC and UNECE CLRTAP. Moreover, the Regulation proposes a national system for reporting on policies and measures and for reporting on projections of anthropogenic GHG emissions by sources and removals by sinks as required by European Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action. Consequently, the submission of the NFR tables and the informative inventory report at hand were realized under the new Regulation.

1.2.1.2.1 Single National Entity and other Cross-Cutting Roles

The Grand-Ducal Regulation designates the Minister having environment in his or her attributions as the "Single National Entity" (SNE). The SNE designates both the UNFCCC and CLRTAP National Focal Points (NFPs), but also the Inventory and Projections Focal Points as well as the Inventory and Projections Sectoral Experts. With regard to GHG inventory reporting under the UNFCCC and the MMR Regulation, the overall management of the SNE is assigned to the Inventory Focal Point that is presently located at the Environment Agency – Unité surveillance et évaluation de l'environnement – and which also acts as National Inventory Compiler (NIC) compiling and checking the information and air emission estimates coming from sector experts working in other administrations or services (Figure 5). The Inventory Focal Point and the NIC are actually the same person.[9]

The Environment Agency has therefore the "technical" knowledge and responsibility for the air emission inventory, but the "political" responsibility is staying with the Ministry for the Environment, Climate and Biodiversity – hereafter designated as MECB – acting as National Focal Point (NFP) to the UNFCCC and the CLRTAP. Thus, it is the MECB that officially submits the inventories and their related reports to the UNFCCC and UNECE-CLRTAP Secretariats and to the EC (see Article 11 of the Regulation).

[9] Luxembourg being a small country, its administrations and public services are small too. Hence, it is frequent that its staff members wear different hats. Nevertheless, this conjunction of responsibilities makes sense. The Environment Agency is also the Inventory Focal Point for reporting under the CLRTAP and Directive (EU) 2016/2284.

Thus, Luxembourg has adopted an integrated approach to avoid redundant and overlapping activities in different administrative services. This concentration of air emissions reporting in one department also allows an improved consistency between different reporting schemes.

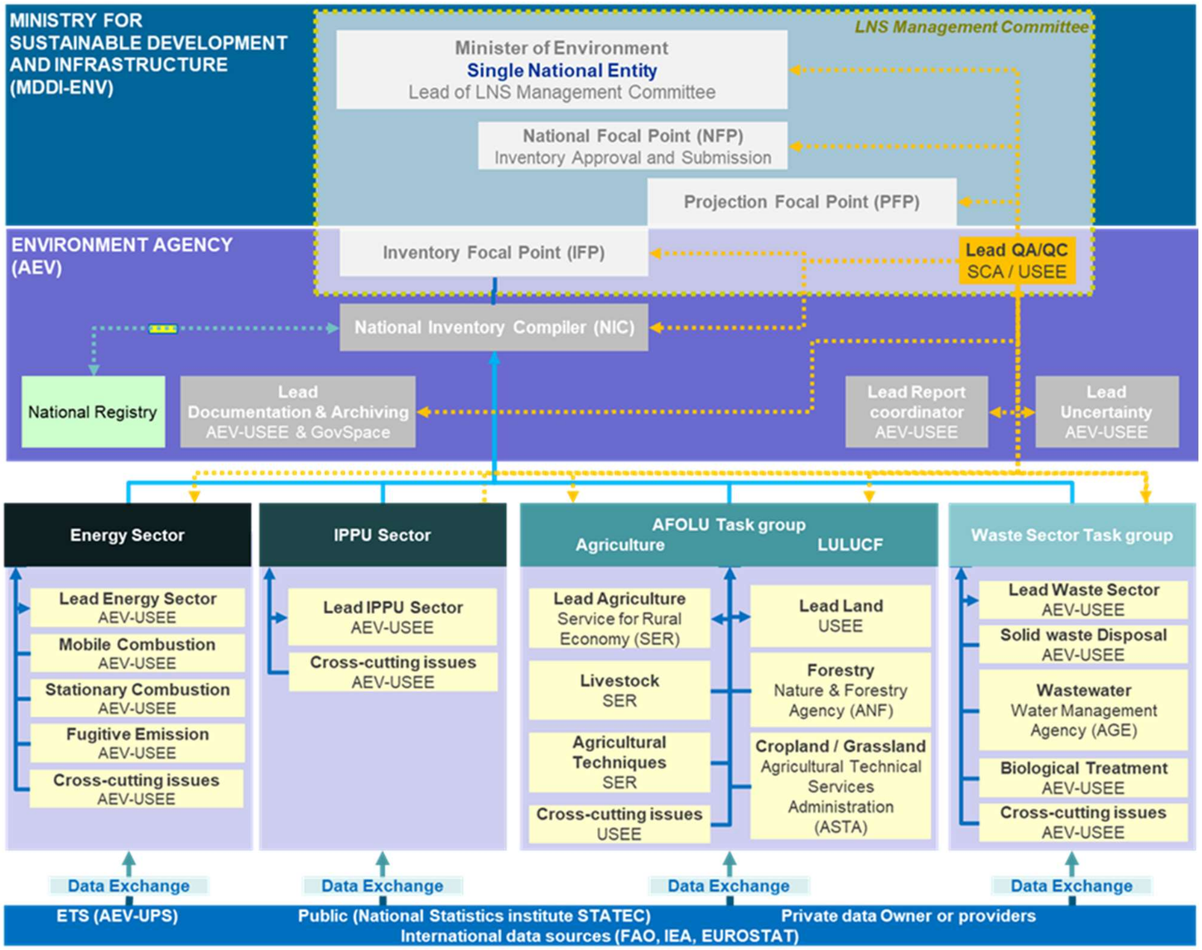
With regard to inputs for the monitoring of air emissions, having E-PRTR managed by the Unité surveillance et évaluation de l'environnement of the Environment Agency (and EU ETS also within the Environment Agency) ensures easy access to facilities' reported fuel and/or emissions that are subsequently integrated in air emission calculations. The Environment Agency also gathers information from facilities and installations subordinated to operational permits to carry out certain activities, the so-called "établissements classés". There, too, valuable information for the inventory is found. More details on these AD and, sometimes, EF sources are presented in Section 1.4.

With regards to outputs from the Unité surveillance et évaluation de l'environnement, not only are they used for the various inventory reporting obligations (GHG, CLRTAP, NEC), but also for other reporting activities, such as those linked to Spatial Data Information (such as the EC INSPIRE Directive[10]) and under the Shared Environmental Information System.[11] Of course, these are also used for various national publications, as well as, for defining policies and measures (PaMs).

Figure 5 summarizes the organisation of the air emission reporting in Luxembourg in accordance with the national Regulation for setting-up a National Inventory System (NIS), as well as the data flow process that is implied by the setting-up of the NIS. The *Unité surveillance et évaluation de l'environnement* of the Environment Agency not only collects and validates AD, EFs, parameters and emission estimates from sector experts, but also produces emission estimates. This flexibility is introduced in Luxembourg's system to ensure a better quality for the reporting of air emissions.

[10] http://inspire.jrc.it/
[11] http://ec.europa.eu/environment/seis/index.htm

Figure 5 – Luxembourg's NIS and data flow process according to the regulation of April 2017



1.2.1.2.2 Specific Responsibilities for the Air Emission Inventory Compilation and Development Process

Article 4 of the Regulation indicates that the Single National Entity designates sectoral experts. Articles 6 and 8 describe the tasks of the Inventory Focal Point and of the Sectoral Experts. In a few words, the Inventory Focal Point – i.e. the Environment Agency – provides sector experts for all the NFR categories except Agriculture and Wastewater Handling (seeTable 1-2). It is also the Agency that:

- manages the NIS and coordinates the work on air emission inventories by informing the experts of any changes and evolutions in the Guidelines;
- as National Inventory Compiler (NIC), compiles the air emission estimates produced by sector experts;
- prepares the National inventory report (NIR) and Informative Inventory Report (IIR) (notably on the basis of chapters received from the sector experts), including the Key Category Analysis (KCA) and the calculation of the uncertainties;
- prepares and defines work plans to secure timely data supply;
- assists sector experts in their assignments and their training;
- defines and approves, together with sector experts, activity/background data (AD), emission factors (EF), methods to estimate air emissions;
- archives the relevant information on the inventories and the NIS;
- implements recommendations from the quality assurance/quality control (QA/QC) annual exercise (section 1.6).

Article 8 describes the tasks that fall to sector experts, among others:

- choice of the best methods to evaluate air emissions, using IPCC Guidelines, respectively the most recent EMEP/EEA Guidebook (these methods have to be approved by the Single National Entity as indicated above);
- collection of the necessary AD and EFs;
- calculation of emission estimates;
- recalculation of emission estimates when possible and desirable: new AD sources, new parameters, new methods, etc.;
- proceeding with first quality checks (completeness and consistency);
- preparation of the NIR/IIR relevant chapters.

Finally, Article 10 indicates that activity/background data providers have to transmit quality AD using formats, and respecting the deadlines, defined by the Single National Entity.

Table 1-2 – NFR Sector responsibilities within the NIS

NFR Sector	AD	Choice of EFs	Emissions Estimation Methods
Energy, excl. Road Transportation – NFR 1 except 1A3b	AEV – STATEC	AEV	AEV
Road Transportation – NFR 1A3b	AEV – STATEC – SNCT	AEV	AEV
Industrial Processes – NFR 2	AEV	AEV	AEV
Non-energy Products from Fuels and Solvent Use – NFR 2D	AEV	AEV	AEV
Agriculture – NFR 3	SER - ASTA	SER	SER
Waste – NFR 5A, 5B & 5D	AEV	AEV	AEV
Wastewater Handling –NFR 5B	AGE	AGE	AGE

Abbreviations used:

Ministry of Agriculture:

ASTA = Agriculture Technical Services Administration (*Administration des Services Techniques de l'Agriculture*): http://www.asta.etat.lu/

SER = Agriculture Economic Service (*Service d'Economie Rurale*): http://www.ser.public.lu/

Ministry of Economic Affairs & External Trade:

STATEC = National Statistical Institute: http://www.statec.public.lu/fr/index.html

Ministry of the Environment, Climate and Biodiversity (MECB): http://www.emwelt.lu/:

AEV = Environment Agency (*Administration de l'Environnement*)

AGE = Water Agency (*Administration de la Gestion de l'Eau*): http://www.eau.public.lu/

Ministry of Transport:

SNCT = Vehicle Check Administration (*Société Nationale de Contrôle Technique*): http://www.snct.lu/snct/home.nsf

1.2.1.3 Revision of Luxembourg's National Inventory System

No revisions to the National Inventory System were operated since the last submission.

1.2.2 Overview of Inventory Planning

The main planning of Luxembourg's air emission inventory is performed once a year during summer at the so-called *Decision-Making Body* meeting: a meeting between the Director of the Environment Agency, the head of unit responsible for compiling the air emission inventory, the quality manager, and the national inventory compiler.

During the meeting, the quality manager and the national inventory compiler present an overview of the activities, from the previous reporting year, including information on audits and fulfilments of last year's improvement plan. On the basis of this report, the quality management system (QMS) is judged by the director and the head of the Air/Noise Division, in collaboration with the quality manager and the national inventory compiler. If required, measures to optimize the QMS are defined. Finally, the improvement plan is elaborated on the basis of the previously conducted discussions. It consists of two parts:

- Quality management improvement plan: is based on findings of internal and external audits; and also includes a training plan for sector experts.
- Inventory improvement plan: is based on particular findings of reviews of the air pollutant emissions inventory.

The Decision-Making Body prioritises the recommended improvements (including a timeline and responsibilities) and cares for associated resources.

1.2.3 Overview of inventory Preparation and Management

Table gives an overview on the tasks of inventory preparation together with a typical timeline.

Table 1-3 – Inventory Preparation Timeline

Task	Description	Deadline
Decision Making Body meeting	Evaluation of the fulfilment of the previous improvement plan Preparation of a plan for QMS and inventory improvement*, i.a.* based on audit and review findings.	Summer
Kick-Off	Meeting of sector experts, quality manager and national inventory compiler; definition of a work plan	Summer
Activity Data Collection	Collection of activity data, including contracting out studies.	November 1st
Inventory Preparation	Estimation of emissions for all sources, including collection of background data.	December 1st
Compilation of National Inventory	Stocking the database and transfer to NFR ; key category analysis and uncertainty assessment	December 31
Quality Checks	Tier 1 and Tier 2 QA/QC activities	December
Preparation of IIR	Compilation of the Informative Inventory Report	January – February
EC & CLRTAP Submission NFR	Submission of NFR tables to the EC and the UNECE/CLRTAP	February 15
EC & CLRTAP Submission IIR	Submission of the Informative Inventory Report to the EC & UNECE/CLRTAP	March 15
EC & CLRTAP Submission gridded data, LPS	Submission of gridded data and Large Point Sources (LPS)	May 1 (2017 & every 4 years)
Archive Submission	All relevant calculation and documentation files as well as the IIR are archived on Sharepoint	May

Finally, an official approval process has been established between the Single National Entity (SNE, Environment Agency) and the National Focal Point (NFP, MECB). Thus, the SNE notifies the NFP, in writing, that the inventory has been compiled according to the rules established by the UNECE and uploads the submission onto the Sharepoint data archive (see Section 1.3). The NFP accordingly informs the Minister in charge of the Environment accordingly. Upon acceptance, the NFP uploads the submission from Sharepoint archive onto the UNECE submission portal and onto the European central data repository hosted by the EEA.

1.3 Inventory Preparation

1.3.1 Air Emission Inventory

Luxembourg's air pollutant emissions inventory, at hand, has been prepared in accordance with the 2023 Reporting Guidelines for Reporting Emissions and Projections Data under the Convention on Long-Range Transboundary Air Pollution (ECE/EB.AIR.150/add.1) [12]).

During the inventory preparation process, sector experts collect activity data, emission factors and all relevant information needed for estimating the emissions. The sector experts also have specific responsibilities regarding the choice of methods, data processing and archiving and for contracting studies, if needed. Default methods and emission factors are usually derived directly from the latest version of the EMEP/EEA Air Pollutant Emission Inventory Guidebook — currently version 2023.[13] As part of the quality management system, the national inventory compiler approves the methodological choices. Sector experts are also responsible for performing Quality Control (QC) activities that are incorporated in the Quality Management System (QMS). All data collected together with emission estimates are archived on a central archiving system (see below), together with the well documented data sources in order to be able to perform future reconstructions of the inventory.

1.3.2 Data Collection, Processing and Storage

For estimating the emissions, Luxembourg mostly used Microsoft Excel™ spreadsheets (Table 1-4).

Table 1-4 – Programs and software used for generating emission estimates

CRF Sector	Emissions calculated using …
Energy, excl. Road Transportation – NFR 1 except 1A3b & Off-road	MS Excel 2016
Road Transportation – NFR 1A3b	NEMO IV and MS Excel 2016
Off-road (1A2vii, 1A3c, 1A3d, 1A4bii, 1A4cii, 1A5b)	GEORG and MS Excel 2016
Industrial Processes and Product Use (IPPU) – NFR 2	MS Excel 2016
Agriculture – NFR 3	MS Excel 2016 and the add-in software Palisade @Risk 7.5
Waste – NFR 5	MS Excel 2016

This way of proceeding offers a very flexible system that can be easily adjusted to new requirements. Only for the estimation of road transportation emissions a dedicated model is used:

NEMO (*Network Emission Model*) [14] developed at the Institute for Internal Combustion Engines and Thermodynamics (IVT) at the Graz University of Technology (TUG) is a software tool for the calculation of emissions from road transport and combines a detailed calculation of the fleet composition and simulation of energy consumption and emission output on a vehicle level. It is fully capable to depict

[12] https://www.ceip.at/fileadmin/inhalte/ceip/00_pdf_other/2022/emissions_reporting_guidelines_2023_final.pdf

[13] EEA Report N0 13/2019 available at: https://www.eea.europa.eu/publications/emep-eea-guidebook-2023

[14] Dippold, M.; Rexeis, M.; Hausberger, S.: NEMO - A universal and flexible model for assessment of emissions on road networks. - in: 19th International Transport and Air Pollution Conference 2012 (2012), S. 11 – 11, International Symposium Transport and Air Pollution; 2012; HAUSBERGER/ SCHWINGSHACKL/ REXEIS 2015a, 2015b).

the upcoming variety of possible combinations of propulsion systems (internal combustion engine, hybrid, plug-in-hybrid, electric propulsion, fuel cell …) and alternative fuels (CNG, biogas, FAME, Ethanol, GTL, BTL, H_2, …). The model calculates vehicle mileages, passenger-km, ton-km, fuel consumption, exhaust gas emissions, evaporative emissions and suspended TSP, PM_{10}, $PM_{2.5}$, PM_1 and $PM_{0.1}$ exhaust and non-exhaust emissions of road traffic. The balances use the vehicle stock and functions of the km driven per vehicle and year to assess the total traffic volume of each vehicle category.

GEORG (*Grazer Emissionsmodell für Off-Road Geräte*) developed at the TU Graz is a software tool for the calculation of air pollutant emissions from off-road vehicles and other machinery. This model has been developed within a study about off-road emissions in Austria (PISCHINGER 2000). Relevant country specific information has been adapted to Luxembourg's situation. The used methodology conforms to the requirements of the EMEP/EEA Tier 3 methodology. Input data to the model are:

- Machinery stock data (obtained through inquiries and statistical extrapolation);
- Assumptions on drop-out rates of machinery (broken down machinery will be replaced);
- Operating time (obtained through inquiries), related to age of machinery.

Emission estimates produced by the sector experts are then being centralized and verified by the Single National Entity (*i.e.* the National Inventory Compiler at the Environment Agency).

A centralised data management and archiving system (Sharepoint) has been implemented. This system is hosted by the National IT Administration, and access is password protected. This system enables sector experts to quickly and easily exchange and store data between administrations, which are not connected through a single network. The data stored on this system are backed up daily for the needs of data security. Furthermore, as part of the QMS, backups of the entire inventory information are made regularly on write-protected DVDs. This ensures the necessary documentation and archiving for future reconstruction of the inventory and for the timely response to requests during the review process.

For the generation of the CRF/NFR tables and the XML submission file, Luxembourg used the latest version of the CRF reporter / UNECE's NFR-reporting template. As a large number of source categories are only occurring in Luxembourg only around a hundred values per inventory year – other than notation keys – need to be transferred to the CRF-Reporter / NFR-reporting template.

1.3.3 Quality Assurance/Quality Control (QA/QC) Procedures and Extensive Review of Air Emission Inventory

QA/QC procedures are performed as defined in the QMS plan (see section 1.6).

Quality assurance, control and plausibility assessments of the estimates are being performed through internal audits covering all sectors, by the SNE in collaboration with the QA/QC manager.

The IIR is circulated after publication to experts that are involved in the estimation on greenhouse gas and air pollutant emissions in Luxembourg as identified by the National Inventory Compiler and the QA/QC manager. Comments received from experts are considered for the inventory improvement plan.

1.4 Methodologies and Data Sources Used

The following table briefly presents the AD sources for estimating the emissions reported in this submission.

Table 1-5 – Data sources and EFs used by Luxembourg – main NFR Sectors

NFR Sector	*Activity Data and Relevant Parameters*
Energy – NFR 1 A 1	• National Statistics • Plant Specific Data • Country Specific Data • Specific Questionnaire / Survey / Annual Reports
Energy – NFR 1 A 2	• National Statistics • Plant Specific Data • Country Specific Data • Specific Questionnaire / Survey / Annual Reports • TÜV Rheinland, *Emissionskataster für das Großherzogtum Luxemburg*, Köln, 1990
Energy – NFR 1 A 3 excl. Road Transportation	• National Statistics • Specific Questionnaire / Survey / Annual Reports
Energy – Road Transportation – NFR 1 A 3 b	• National Statistics • Country Specific Data • Specific Questionnaire / Survey / Annual Reports • Expert Judgement
Energy – NFR 1 A 4	• National Statistics • Country Specific Data
Industrial Processes and Product Use – NFR 2	• National Statistics • Plant Specific Data • Specific Questionnaire / Survey / Annual Reports
Agriculture – NFR 3	• National Statistics • Country Specific Data / Survey / Annual Reports • Expert Judgement
Waste – NFR 5	• National Statistics • Annual Reports • Plant Specific Data

For each category (1A1 – 1A5), the methods applied and emission factors (EF) used as well as coverage of energy consumption are provided in the relevant chapter.

EMEP/EEA Tier 3 approach

- For point sources, emission measurements of NO_X, SO_2, NMVOC, CO and TSP respectively particulate matter (PM) are the basis for the reported emissions. Hence, no emission factors per se are used, but rather implied emission factors are derived by dividing the emission with the activity data.

EMEP/EEA Tier 2 approach

- Where no PS data was available for SO_2, the EMEP/EEA Tier 2 approach has been applied using a CS EF based on fuel sulphur content.
- Area sources, for which no measured (plant-specific) emission data or plant specific activity data was available, were estimated using the EMEP/EEA Tier 2 by multiplying the fuel consumption taken from the national energy balance with the default emission factor taking into account the abatement technology.

EMEP/EEA Tier 1 approach

- Area sources, for which no measured (plant-specific) emission data, or plant specific activity data or information on the abatement technology was available, were estimated using the EMEP/EEA Tier 1 by multiplying the fuel consumption taken from the national energy balance with the default emission factor.

The following tables give a brief overview of the types of EFs and methods applied for estimating the emissions reported in this submission. For more details please consult the respective NFR sub-category chapters.

Table 1-6 – Summary of methodologies applied for estimating emissions in category - *1 A 1 Energy Industries*

1A1a - Public Electricity & Heat Production							
Pollutant	**Method**	**EF used**	**AD covered**	***Pollutant***	**Method**	**EF used**	**AD covered**
NO_X	T3	PS	42.1%	**$PM_{2.5}$**	T3	PS	42.1%
	T2	D	57.9%		T2	D	57.9%
NMVOC	T3	PS	26.4%	**PM_{10}**	T3	PS	42.1%
	T2	D	73.6%		T2	D	57.9%
SO_X	T3	PS	27.4%	**TSP**	T3	PS	42.1%
	T2	CS	0.2%		T2	D	57.9%
	T2	D	72.4%				
CO	T3	PS	42.1%				
	T2	D	57.9%				

Table 1-7 – Summary of methodologies applied for estimating emissions in category - *1 A 2 Manufacturing Industries and Construction*

Pollutant	**1 A 2 a Iron and steel**			**1 A 2 b Non-ferrous metals**			**1 A 2 c Chemicals**			**1 A 2 d Pulp, Paper and Print**		
	Method	**EF used**	**AD covered**	**Method**	**EF used**	**AD covered**	**Method**	**EF used**	**AD covered**	**Method**	**EF used**	**AD covered**
NO_X	T3	PS	88.5%	T3	PS	72.6%	T3	PS	86.9%	T3	PS	0.0%
	T2/T1	D	11.5%	T1	D	27.4%	T1	D	13.1%	T1	D	100.0%
NMVOC	T3	PS	88.5%	T3	PS	72.6%	T3	PS	0.0%	T3	PS	0.0%
	T2/T1	D	11.5%	T1	D	27.4%	T1	D	100.0%	T1	D	100.0%
SO_X	T3	PS	88.5%	T3	PS	72.6%	T3	PS	57.3%	T3	PS	0.0%
	T2	CS	1.0%	T2	CS	0.0%	T2	CS	2.2%	T2	CS	8.0%
	T1	D	10.4%	T1	D	27.4%	T1	D	40.4%	T1	D	92.0%
CO	T3	PS	88.5%	T3	PS	72.6%	T3	PS	86.9%	T3	PS	0.0%
	T2/T1	D	11.5%	T1	D	27.4%	T1	D	13.1%	T1	D	100.0%
$PM_{2.5}$	T3	PS	88.5%	T3	PS	72.6%	T3	PS	37.9%	T3	PS	0.0%
	T2/T1	D	11.5%	T1	D	27.4%	T1	D	62.1%	T2	D	100.0%
PM_{10}	T3	PS	88.5%	T3	PS	72.6%	T3	PS	37.9%	T3	PS	0.0%
	T2/T1	D	11.5%	T1	D	27.4%	T1	D	62.1%	T1	D	100.0%
TSP	T3	PS	88.5%	T3	PS	72.6%	T3	PS	37.9%	T3	PS	0.0%
	T2/T1	D	11.5%	T1	D	27.4%	T1	D	62.1%	T1	D	100.0%

Pollutant	1 A 2 e Food processing, beverages and tobacco			1 A 2 f Non-metallic minerals			1 A 2 g vii Mobile Combustion in manufacturing industries and			1 A 2 g viii Other		
	Method	EF used	AD covered	Method	EF used	AD covered	Method	EF used	AD covered	Method	EF used	AD covered
NO_X	T3	PS	39.6%	T3	PS	97.9%	T3	CS	100.0%	T3	PS	44.0%
	T1	D	60.4%	T1	D	2.1%	T1	D	0.0%	T2/T1	D	56.0%
NMVOC	T3	PS	0.0%	T3	PS	51.8%	T3	CS	100.0%	T3	PS	44.0%
	T1	D	100.0%	T1	D	48.2%	T1	D	0.0%	T2/T1	D	56.0%
SO_X	T3	PS	0.0%	T3	PS	97.9%	T3	CS	100.0%	T3	PS	14.9%
	T2	CS	93.2%	T2	CS	2.1%	T2	NO	NO	T2	CS	27.0%
	T1	D	6.8%	T1	D	0.0%	T1	D	0.0%	T1	D	58.0%
CO	T3	PS	39.6%	T3	PS	97.9%	T3	CS	100.0%	T3	PS	44.0%
	T1	D	60.4%	T1	D	2.1%	T1	D	0.0%	T2/T1	D	56.0%
$PM_{2.5}$	T3	PS	39.6%	T3	PS	97.9%	T3	CS	100.0%	T3	PS	44.0%
	T1	D	60.4%	T1	D	2.1%	T1	D	0.0%	T2/T1	D	56.0%
PM_{10}	T3	PS	39.6%	T3	PS	97.9%	T3	CS	100.0%	T3	PS	44.0%
	T1	D	60.4%	T1	D	2.1%	T1	D	0.0%	T2/T1	D	56.0%
TSP	T3	PS	39.6%	T3	PS	97.9%	T3	CS	100.0%	T3	PS	44.0%
	T1	D	60.4%	T1	D	2.1%	T1	D	0.0%	T2/T1	D	56.0%

Table 1-8 – Summary of methodologies applied for estimating emissions in category - *1 A 3 Transport*

		SO_2		NO_X		NMVOC		NH_3		CO		PM	
		Method	EF used	Method	EF used	Method	EF used	Method	EF used	Method	EF used	Method	EF used
1 A 3 a ii (i)	Civil Aviation - International - LTO	T1	D	T1	D	T1	D	T1	D	T1	D	T1	D
1 A 3 a i (i)	Civil Aviation - Domestic - LTO	T1	D	T1	D	T1	D	T1	D	T1	D	T1	D
1 A 3 b i	Road Transport, Passenger cars	T3	CS	T3	CS	T3	CS	T3	CS	T3	CS	T3	CS
1 A 3 b ii	Road Transport, Light duty vehicles	T3	CS	T3	CS	T3	CS	T3	CS	T3	CS	T3	CS
1 A 3 b iii	Road Transport, Heavy duty vehicles	T3	CS	T3	CS	T3	CS	T3	CS	T3	CS	T3	CS
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	T3	CS	T3	CS	T3	CS	T3	CS	T3	CS	T3	CS
1 A 3 b v	Road Transport, Gasoline evaporation	T3	CS	T3	CS	T3	CS	T3	CS	T3	CS	T3	CS
1 A 3 b vi	Road Transport, Automobile tyre and break wear	T3	CS	T3	CS	T3	CS	T3	CS	T3	CS	T3	CS
1 A 3 b vii	Road Transport, Automobile road abrasion	T3	CS	T3	CS	T3	CS	T3	CS	T3	CS	T3	CS
1 A 3 c	Railways	T3	CS	T3	D	T3	D	T3	D	T3	D	T3	D
1 A 3 d i (ii)	International inland waterways	T3	CS	T3	D	T3	D	T3	D	T3	D	T3	D
1 A 3 d ii	National Navigation (Shipping)	T3	CS	T3	D	T3	D	T3	D	T3	D	T3	D
1 A 3 e i	Pipeline compressors												
1 A 3 e ii	Other transportation												

Table 1-9– Summary of methodologies applied for estimating emissions in category - *1 A 4 Other Sectors*

Pollutant	1 A 4 a i Commercial / institutional: Stationary			1 A 4 b i Residential: Stationary			1 A 4 b ii Residential: Household and gardening (mobile)			1 A 4 c i Agriculture/Forestry/Fishing:			1 A 4 c ii Agriculture/Forestry/Fishing: Off-		
	Method	EF used	AD covered	Method	EF used	AD covered	Method	EF used	AD covered	Method	EF used	AD covered	Method	EF used	AD covered
NO_X	T2	D, CS	100.0%	T2	D, CS	100.0%	T3	CS	100.0%	T2	D	100.0%	T3	CS	100.0%
	T1	D	0.0%	T1	D	0.0%	T1	D	0.0%	T1	D	0.0%	T1	D	0.0%
NMVOC	T2	D	100.0%	T2	D	100.0%	T3	CS	100.0%	T2	D	100.0%	T3	CS	100.0%
	T1	D	0.0%	T1	D	0.0%	T1	D	0.0%	T1	D	0.0%	T1	D	0.0%
SO_X	T2	CS	53.2%	T2	CS	30.6%	T3	CS	100.0%	T2	CS	0.0%	T3	CS	100.0%
	T2	D	46.8%	T2	D	69.4%	T2	NO	NO	T2	D	100.0%	T2	NO	NO
	T1	D	0.0%	T1	D	0.0%	T1	D	0.0%	T1	D	0.0%	T1	D	0.0%
CO	T2	D	100.0%	T2	D	100.0%	T3	CS	100.0%	T2	D	100.0%	T3	CS	100.0%
	T1	D	0.0%	T1	D	0.0%	T1	D	0.0%	T1	D	0.0%	T1	D	0.0%
$PM_{2.5}$	T2	D	100.0%	T2	D	100.0%	T3	CS	100.0%	T2	D	100.0%	T3	CS	100.0%
	T1	D	0.0%	T1	D	0.0%	T1	D	0.0%	T1	D	0.0%	T1	D	0.0%
PM_{10}	T2	D	100.0%	T2	D	100.0%	T3	CS	100.0%	T2	D	100.0%	T3	CS	100.0%
	T1	D	0.0%	T1	D	0.0%	T1	D	0.0%	T1	D	0.0%	T1	D	0.0%
TSP	T2	D	100.0%	T2	D	100.0%	T3	CS	100.0%	T2	D	100.0%	T3	CS	100.0%
	T1	D	0.0%	T1	D	0.0%	T1	D	0.0%	T1	D	0.0%	T1	D	0.0%

Table 1-10 – Summary of methodologies applied for estimating emissions in category - *1 A 5 Other*

Pollutant	1 A 5 a Other stationary (including military)			1 A 5 b Other, Mobile (including military)		
	Method	EF used	AD covered	Method	EF used	AD covered
NO_X	T2	D	NO	T3	CS	100.0%
	T1	D	NO			
NMVOC	T2	D	NO	T3	CS	100.0%
	T1	D	NO			
SO_X	T2	CS	NO	T3	CS	100.0%
	T2	D	NO			
	T1	D	NO			
CO	T2	D	NO	T3	CS	100.0%
	T1	D	NO			
$PM_{2.5}$	T2	D	NO	T3	CS	100.0%
	T1	D	NO			
PM_{10}	T2	D	NO	T3	CS	100.0%
	T1	D	NO			
TSP	T2	D	NO	T3	CS	100.0%
	T1	D	NO			

Table 1-11 – Summary of methodologies applied for estimating emissions in category - *1 B Fugitive Emissions*

		NMVOC		PM2.5		PM10		TSP	
		Method	EF used	Method	EF used	Method	EF used	Method	EF used
1 B 1 a	Solid Fuels			T2	D	T2	D	T2	D
1 B 2 a v	Distribution of Oil Products	T2/T1	D						
1 B 2 b	Natural Gas	T3	D						

Table 1-12 – Summary of methodologies applied for estimating emissions in category - *2 Industrial Processes and Product Use*

Category		SO_2		NO_X		NMVOC		NH_3		CO		PM	
		Method	EF used	Method	EF used	Method	EF used	Method	EF used	Method	EF used	Method	EF used
2 A 5 b	Construction and demolition											T1	D
2 D 3 a	Domestic solvent use including fungicides					CS	CS						
2 D 3 b	Road paving with asphalt					CS	CS						
2 D 3 c	Asphalt roofing					CS	CS						
2 D 3 d	Coating application					CS	CS						
2 D 3 e	Degreasing					CS	CS						
2 D 3 f	Dry cleaning					CS	CS						
2 D 3 g	Chemical products					CS	CS						
2 D 3 h	Printing					CS	CS						
2 D 3 i	Other solvent use					CS	CS						
2 H 2	Food and beverages					T1	D						
2 G	Other product use	T1	D	T1	D	T1	D	T1	D	T1	D	T1	D

Table 1-13 – Summary of methodologies applied for estimating emissions in category - *3 B Manure Management*

Livestock category		NH_3		PM		NO_X		NMVOC	
		Method	EF used	Method	EF used	Method	EF used	Method	EF used
3 B 1 a	Cattle - Dairy Cattle	T2	CS	T1	D	T2	CS	T2	D
3 B 1 b	Non-dairy cattle	T2	CS	T1	D	T2	CS	T2	D
3 B 2	Sheep	T2	CS	T1	D	T2	CS	T2	D
3 B 3	Swines - fattening pigs	T2	CS	T1	D	T2	CS	T2	D
3 B 3	Swines - reproducing pigs	T2	CS	T1	D	T2	CS	T2	D
3 B 4 a	Buffalo	NO	NO	NO	NO	NO	NO	NO	NO
3 B 4 d	Goats	T2	CS	T1	D	T2	CS	T2	D
3 B 4 e	Horses	T2	CS	T1	D	T2	CS	T2	D
3 B 4 f	Mules & Asses	IE	IE	IE	IE	IE	IE	IE	IE
3 B 4 g i	Poultry: Laying hens	T2	CS	T1	D	T2	CS	T2	D
3 B 4 g ii	Poultry: Broilers	T2	CS	T1	D	T2	CS	T2	D
3 B 4 g iii	Poultry: Turkeys	IE	IE	IE	IE	IE	IE	IE	IE
3 B 4 g iv	Other Poultry	T2	CS	T1	D	T2	CS	T2	D
3 B 4 h	Other animals: Ostriches	T2	CS	T1	D	T2	CS	T2	D
3 B 4 h	Other animals: Rabbits	T2	CS	T1	D	T2	CS	T2	D
3 B 4 h	Other animals: Cervidae species	T2	CS	T1	D	T2	CS	T1	D

Table 1-14 – Summary of methodologies applied for estimating emissions in category - *3 D Agricultural Soils*

Categories		NH_3		NO_X		NMVOC		PM	
		Method	EF used	Method	EF used	Method	EF used	Method	EF used
3 D a 1	Inorganic N-fertilizers (includes also urea application)	T2	D	T1	D				
3 D a 2 a	Animal manure applied to soils	T2	CS	T1	D	T2	D/CS		
3 D a 2 b	Sewage sludge applied to soils	T2	CS	T1	D				
3 D a 2 c	Other organic fertilisers applied to soils	T2	CS	T1	D				
3 D a 3	Urine and dung deposited by grazing animals	T1	D	T1	D	T2	D/CS		
3 D a 4	Crop residues applied to soils			T1	D				
3 D b	Indirect emissions from managed soils								
3 D c	Farm-level agricultural operations including storage, handling and transport of agricultural products							T1	D
3 D d	Off-farm storage, handling and transport of								
3 D e	Cultivated crops					T1	D		
3 D f	Use of pesticides								

Table 1-15 – Summary of methodologies applied for estimating emissions in category – *5 Waste*

		NMVOC		NH_3		PM	
		Method	EF used	Method	EF used	Method	EF used
5 A	Solid waste disposal on land	T1	D			T1	D
5 B 1	Composting			T1	D		
5 B 2	Anaerobic digestion at biogas facilities			T2	D/CS		
5 D 1	Domestic wastewater handling	T1	D	T1	D		
5 D 2	Industrial wastewater handling	T1	D				
5 E	Other waste (accidental fires)					T1	D

1.5 Brief Description of Key Categories

The identification of key categories is described in Chapter 2 of the EMEP/EEA Emission Inventory Guidebook. It stipulates that a key category is a category which is prioritised within the National System because its estimate has a significant influence on a country's total emission of air pollutants in terms of the absolute level of emissions, the trend in emissions, or both. As stated in the guidebook, 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 every single year (level) and the change in emission from year to year (trend) of each category's emissions compared to the total national emissions.*

All notations, descriptions of identification and results for key categories included in this Chapter are based on the Guidebook Guidance.

The identification includes all NFR categories and all reported gases:

- SO_2, NO_X, NMVOC, NH_3,
- CO,
- PM: TSP, PM_{10}, $PM_{2.5}$,
- Pb, Cd, Hg
- PCDD/F, PCB, HCB, PAH (total 1-4)

1.5.1 Methodology – Approach 1

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

1.5.2 Identification of Key Categories

This is an important step in terms of correlation of input data, which could otherwise falsify results of a key category analysis which usually assumes that input data are not dependent on each other.

Depending on the level of aggregation in the NFR, many categories might result with the same source of (correlating) input data, in a detailed analysis, while a high level of aggregation could mask some information.

The suggested aggregation level of analysis for Approach 1 provided in Table 2-1 of Chapter 2 of the EMEP/EEA Emission Inventory Guidebook was used. No special considerations like disaggregation to main fuel types have been made.

For reasons of transparency, the following level of aggregation for the main pollutants was used:

Sector	Level of aggregation
1A - Combustion Activities	As "*1A - Combustion Activities*" is the most important sector in terms of emissions, and to help prioritising improvement efforts, this sector was analysed in greater detail. A split following the third level of the NFR categories was used (1 A 2, 1 A 4) for stationary sources. For mobile sources, the different means of transport were considered separately and, additionally, category Road Transport was further disaggregated as it is an important source for many pollutants.
1B - Fugitive Emissions	A split following the third level of the NFR categories was used for fugitive emissions
2 - Industrial Processes and Product use	A split following the second/third level of the NFR was used for sources categories from Industrial Processes
3 - Agriculture	Level two of the NFR was used for the agriculture sector; only the subcategory 3 B was further disaggregated as it is an important source of NH_3 and the methodology is different for the animal categories.
5 - Waste	Level two of the NFR was used for the waste sector.

1.5.3 Results of the Level and Trend Assessment

As the analysis was made for all different pollutants reported to the UNECE and as these pollutants differ in their way of formation, most of the identified categories are key categories for one pollutant or more. The following tables present the key category analysis for the main pollutants, heavy metals and persitant organic pollutants (fuel sold) and their ranking number for the year 2022, on the basis of fuel sold. The key category analysis for the main pollutants based on fuel used can be provided upon request.

Table 1-16 – Key Category Analysis - Fuel sold - Ranking per number – for the year 2022

Key Source Analysis (FUEL SOLD): Ranking per number		SO2		NOX		NMVOC		NH3		CO		TSP		PM10		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
1 A 1 a	Energy Industries - Public Electricity and Heat Production		5	8	5											6	
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	1	1		2					2	1		1		1		1
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	5	4									7		7		7	
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	6		5						3	4						
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction			4	4												
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	3	3			9						6		6		3	4
1 A 3 a i (i)	Civil Aviation - International - LTO	2	2	3	3												
1 A 3 b i	Road Transport, Passenger cars			1		8	1		2	1	3						
1 A 3 b ii	Road Transport, Light duty vehicles			7	7												
1 A 3 b iii	Road Transport, Heavy duty vehicles			2	1					6							
1 A 3 b v	Road Transport, Gasoline evaporation						3										
1 A 3 b vi	Road Transport, Automobile tyre and break wear											2	3	2	2	2	3
1 A 3 b vii	Road Transport, Automobile road abrasion											3	4	4	5	4	
1 A 4 a i	Commercial/Institutional: Stationary			9													
1 A 4 b i	Residential: stationary	4		6	6					4	2	4	5	1	3	1	2
1 A 4 b ii	Residential: Household and gardening (mobile)									5	5						
2 A 5 b	Construction and demolition											1	2	5	6		
2 D 3 a	Domestic solvent use including fungicides					1	2										
2 D 3 b	Road paving with asphalt											8					
2 D 3 d	Coating application					5											
2 D 3 g	Chemical products					7	6										
2 D 3 i	Other solvent use					4											
3 B 1 a	Manure management - Dairy cattle					2	4	3									
3 B 1 b	Manure management - Non-dairy cattle					3	5	2									
3 D a 1	Inorganic N-fertilizers (includes also urea application)								1								
3 D a 2 a	Animal manure applied to soils					6	7	1	4								
3 D a 2 b	Sewage sludge applied to soils								6								
3 D a 2 c	Other organic fertilisers applied to soils (including compost)								3								
3 D a 3	Urine and dung deposited by grazing animals							4	7								
3 D c	Farm-level agricultural operations including storage, handling and transport of agricultural products											5	6	3	4		
5 B 2	Anaerobic digestion at biogas facilities								5								
5 E	Other waste (please specify in IIR)															5	

Source: Environment Agency

Notes: LA = Level Assessment, TA = Trend Assessment; number in table indicates the rank in the specific analysis (1…biggest KC; 2… second biggest KC, …)

Table 1-17 – Key Categories for SO_2 - fuel sold - for 2022

Level Assessment

NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [kt]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	SO2	0.16	35.6%	35.6%
1 A 3 a i (i)	Civil Aviation - International - LTO	SO2	0.05	11.6%	47.2%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	SO2	0.05	11.1%	58.3%
1 A 4 b i	Residential: stationary	SO2	0.04	7.9%	66.3%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	SO2	0.03	7.8%	74.0%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	SO2	0.03	6.5%	80.5%

Trend Assessment

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2022) Estimate [kt]	Trend Assessment	% Contribution to the trend	Cumulative Total of $L_{x,t}$
			$E_{x,0}$	$E_{x,t}$	$L_{x,t}$		
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	SO2	12.14	0.16	14.193	43.1%	43.1%
1 A 3 a i (i)	Civil Aviation - International - LTO	SO2	0.03	0.05	4.200	12.7%	55.8%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	SO2	0.20	0.05	3.666	11.1%	66.9%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	SO2	0.03	0.03	2.795	8.5%	75.4%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	SO2	0.00	0.03	2.078	6.3%	81.7%

Table 1-18 – Key Categories for NO_X - fuel sold - for 2022

Level Assessment

NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [kt]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
1 A 3 b i	Road Transport, Passenger cars	NOX	3.25	28.3%	28.3%
1 A 3 b iii	Road Transport, Heavy duty vehicles	NOX	1.49	13.0%	41.3%
1 A 3 a i (i)	Civil Aviation - International - LTO	NOX	1.03	9.0%	50.3%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	NOX	0.90	7.8%	58.1%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	NOX	0.73	6.4%	64.5%
1 A 4 b i	Residential: stationary	NOX	0.60	5.3%	69.7%
1 A 3 b ii	Road Transport, Light duty vehicles	NOX	0.49	4.3%	74.0%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	NOX	0.48	4.2%	78.2%
1 A 4 a i	Commercial/Institutional: Stationary	NOX	0.43	3.8%	82.0%

Trend Assessment							
NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2022) Estimate [kt]	Trend Assessment	% Contribution to the trend	Cumulative Total of $L_{x,t}$
			$E_{x,0}$	$E_{x,t}$	$L_{x,t}$		
1 A 3 b iii	Road Transport, Heavy duty vehicles	NOX	14.48	1.49	0.798	29.4%	29.4%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	NOX	6.93	0.39	0.484	17.8%	47.2%
1 A 3 a i (i)	Civil Aviation - International - LTO	NOX	0.34	1.03	0.290	10.7%	57.8%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	NOX	0.63	0.90	0.223	8.2%	66.1%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	NOX	0.03	0.48	0.146	5.4%	71.4%
1 A4 b i	Residential: stationary	NOX	0.62	0.60	0.133	4.9%	76.3%
1 A 3 b ii	Road Transport, Light duty vehicles	NOX	0.30	0.49	0.127	4.7%	81.0%

Table 1-19 – Key Categories for NH_3 - fuel sold - for 2022

Level Assessment					
NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [kt]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
3 D a 2 a	Animal manure applied to soils	NH3	2.03	34.1%	34.1%
3 B 1 b	Manure management - Non-dairy cattle	NH3	1.43	24.0%	58.1%
3 B 1 a	Manure management - Dairy cattle	NH3	0.96	16.2%	74.3%
3 D a 3	Urine and dung deposited by grazing animals	NH3	0.46	7.8%	82.1%

Trend Assessment							
NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2022) Estimate [kt]	Trend Assessment	% Contribution to the trend	Cumulative Total of $L_{x,t}$
			$E_{x,0}$	$E_{x,t}$	$L_{x,t}$		
3 D a 1	Inorganic N-fertilizers (includes also urea application)	NH3	0.67	0.34	0.051	31.7%	31.7%
1 A3 b i	Road Transport, Passenger cars	NH3	0.01	0.15	0.025	15.4%	47.1%
3 D a 2 c	Other organic fertilisers applied to soils (including compost)	NH3	NO	0.14	0.025	15.4%	62.5%
3 D a 2 a	Animal manure applied to soils	NH3	2.23	2.03	0.010	6.5%	68.9%
5 B 2	Anaerobic digestion at biogas facilities	NH3	NO	0.05	0.010	6.1%	75.0%
3 D a 2 b	Sewage sludge applied to soils	NH3	0.05	0.01	0.007	4.4%	79.4%
3 D a 3	Urine and dung deposited by grazing animals	NH3	0.54	0.46	0.007	4.3%	83.7%

Table 1-20 – Key Categories for NMVOC - fuel sold - for 2022

Level Assessment					
NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [kt]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
2 D 3 a	Domestic solvent use including fungicides	NMVOC	2.01	20.1%	20.1%
3 B 1 a	Manure management - Dairy cattle	NMVOC	1.60	15.9%	36.0%
3 B 1 b	Manure management - Non-dairy cattle	NMVOC	1.08	10.8%	46.8%
2 D 3 i	Other solvent use	NMVOC	0.87	8.7%	55.6%
2 D 3 d	Coating application	NMVOC	0.69	6.9%	62.4%
3 D a 2 a	Animal manure applied to soils	NMVOC	0.64	6.4%	68.8%
2 D 3 g	Chemical products	NMVOC	0.51	5.1%	73.9%
1 A 3 b i	Road Transport, Passenger cars	NMVOC	0.37	3.7%	77.6%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	NMVOC	0.34	3.4%	81.0%

Trend Assessment							
NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2022) Estimate [kt]	Trend Assessment	% Contribution to the trend	Cumulative Total of $L_{x,t}$
			$E_{x,0}$	$E_{x,t}$	$L_{x,t}$		
1 A 3 b i	Road Transport, Passenger cars	NMVOC	12.04	0.37	1.089	33.0%	33.0%
2 D 3 a	Domestic solvent use including fungicides	NMVOC	1.86	2.01	0.439	13.3%	46.4%
1 A 3 b v	Road Transport, Gasoline evaporation	NMVOC	4.00	0.06	0.379	11.5%	57.9%
3 B 1 a	Manure management - Dairy cattle	NMVOC	1.28	1.60	0.367	11.1%	69.0%
3 B 1 b	Manure management - Non-dairy cattle	NMVOC	1.24	1.08	0.211	6.4%	75.4%
2 D 3 g	Chemical products	NMVOC	0.28	0.51	0.130	3.9%	79.3%
3 D a 2 a	Animal manure applied to soils	NMVOC	0.87	0.64	0.112	3.4%	82.7%

Table 1-21 – Key Categories for CO - fuel sold - for 2022

Level Assessment					
NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [kt]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
1 A 3 b i	Road Transport, Passenger cars	CO	4.81	27.0%	27.0%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	CO	3.40	19.0%	46.0%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	CO	2.67	15.0%	61.0%
1 A 4 b i	Residential: stationary	CO	1.98	11.1%	72.1%
1 A 4 b ii	Residential: Household and gardening (mobile)	CO	0.99	5.6%	77.7%
1 A 3 b iii	Road Transport, Heavy duty vehicles	CO	0.69	3.9%	81.6%

Trend Assessment							
NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2022) Estimate [kt]	Trend Assessment	% Contribution to the trend	Cumulative Total of $L_{x,t}$
			$E_{x,0}$	$E_{x,t}$	$L_{x,t}$		
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	CO	346.46	3.40	14.414	50.0%	50.0%
1 A 4 b i	Residential: stationary	CO	3.99	1.98	2.701	9.4%	59.4%
1 A 3 b i	Road Transport, Passenger cars	CO	80.25	4.81	2.601	9.0%	68.4%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	CO	30.17	2.67	2.250	7.8%	76.2%
1 A 4 b ii	Residential: Household and gardening (mobile)	CO	1.24	0.99	1.391	4.8%	81.0%

Table 1-22 – Key Categories for TSP - fuel sold - for 2022

Level Assessment					
NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [kt]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
2 A 5 b	Construction and demolition	TSP	0.48	18.9%	18.9%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	TSP	0.41	16.1%	35.0%
1 A 3 b vii	Road Transport, Automobile road abrasion	TSP	0.37	14.5%	49.5%
1 A 4 b i	Residential: stationary	TSP	0.34	13.5%	63.0%
3 D c	Farm-level agricultural operations including storage, handling and transport of agricultural products	TSP	0.20	7.8%	70.8%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	TSP	0.13	5.0%	75.8%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	TSP	0.10	4.1%	80.0%
2 D 3 b	Road paving with asphalt	TSP	0.06	2.6%	82.5%

Trend Assessment							
NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2022) Estimate [kt]	Trend Assessment	% Contribution to the trend	Cumulative Total of $L_{x,t}$
			$E_{x,0}$	$E_{x,t}$	$L_{x,t}$		
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	TSP	13.77	0.02	5.388	46.6%	46.6%
2 A 5 b	Construction and demolition	TSP	0.40	0.48	1.161	10.0%	56.6%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	TSP	0.20	0.41	1.046	9.0%	65.6%
1 A 3 b vii	Road Transport, Automobile road abrasion	TSP	0.17	0.37	0.948	8.2%	73.8%
1 A 4 b i	Residential: stationary	TSP	0.63	0.34	0.697	6.0%	79.9%
3 D c	Farm-level agricultural operations including storage, handling and transport of agricultural products	TSP	0.20	0.20	0.467	4.0%	83.9%

Table 1-23 – Key Categories for PM_{10} - fuel sold - for 2022

Level Assessment

NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [kt]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
1 A4 b i	Residential: stationary	PM10	0.33	19.3%	19.3%
1 A3 b vi	Road Transport, Automobile tyre and break wear	PM10	0.30	17.9%	37.2%
3 D c	Farm-level agricultural operations including storage, handling and transport of agricultural products	PM10	0.20	11.7%	48.9%
1 A3 b vii	Road Transport, Automobile road abrasion	PM10	0.18	10.9%	59.8%
2 A5 b	Construction and demolition	PM10	0.14	8.5%	68.3%
1 A2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	PM10	0.13	7.5%	75.8%
1 A2 b	Manufacturing Industries and Construction - Non-ferrous Metals	PM10	0.07	4.4%	80.2%

Trend Assessment

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2022) Estimate [kt]	Trend Assessment	% Contribution to the trend	Cumulative Total of $L_{x,t}$
			$E_{x,0}$	$E_{x,t}$	$L_{x,t}$		
1 A2 a	Manufacturing Industries and Construction - Iron and Steel	PM10	13.77	0.02	8.041	47.4%	47.4%
1 A3 b vi	Road Transport, Automobile tyre and break wear	PM10	0.15	0.30	1.702	10.0%	57.4%
1 A4 b i	Residential: stationary	PM10	0.59	0.33	1.572	9.3%	66.7%
3 D c	Farm-level agricultural operations including storage, handling and transport of agricultural products	PM10	0.20	0.20	1.048	6.2%	72.9%
1 A3 b vii	Road Transport, Automobile road abrasion	PM10	0.09	0.18	1.034	6.1%	79.0%
2 A5 b	Construction and demolition	PM10	0.12	0.14	0.772	4.6%	83.5%

Table 1-24 – Key Categories for $PM_{2.5}$ - fuel sold - for 2022

Level Assessment

NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [kt]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
1 A 4 b i	Residential: stationary	PM2.5	0.32	30.4%	30.4%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	PM2.5	0.17	15.9%	46.3%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	PM2.5	0.13	12.2%	58.5%
1 A 3 b vii	Road Transport, Automobile road abrasion	PM2.5	0.10	9.5%	68.0%
5 E	Other waste (please specify in IIR)	PM2.5	0.06	5.4%	73.4%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	PM2.5	0.04	3.8%	77.2%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	PM2.5	0.03	2.9%	80.1%

Trend Assessment

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2022) Estimate [kt]	Trend Assessment	% Contribution to the trend	Cumulative Total of $L_{x,t}$
			$E_{x,0}$	$E_{x,t}$	$L_{x,t}$		
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	PM2.5	13.77	0.02	12.887	48.5%	48.5%
1 A 4 b i	Residential: stationary	PM2.5	0.57	0.32	4.129	15.6%	64.1%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	PM2.5	0.08	0.17	2.367	8.9%	73.0%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	PM2.5	0.00	0.13	1.868	7.0%	80.0%

Table 1-25 – Key Categories for Pb - Fuel sold - for the year 2022

Level Assessment

NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [t]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
1 A 3 b vi	Road Transport, Automobile tyre and break wear	Pb	0.99	55.8%	55.8%
2 C 1	Iron and steel production	Pb	0.23	12.9%	68.7%
1 A 3 a ii (i)	Civil Aviation - Domestic - LTO	Pb	0.15	8.2%	76.9%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	Pb	0.14	7.7%	84.6%

Trend Assessment

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [t]	Latest Year (2022) Estimate [t]	Trend Assessment	% Contribution to the trend	Cumulative Total of $L_{x,t}$
			$E_{x,0}$	$E_{x,t}$	$L_{x,t}$		
2 C 1	Iron and steel production	Pb	16.39	0.23	7.850	43.7%	43.7%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	Pb	0.48	0.99	5.844	32.5%	76.2%
1 A 3 b i	Road Transport, Passenger cars	Pb	1.89	0.00	1.064	5.9%	82.1%

Table 1-26 – Key Categories for Cd - Fuel sold - for the year 2022

Level Assessment

NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [t]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
1 A 4 b i	Residential: stationary	Cd	0.0118	25.5%	25.5%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	Cd	0.0114	24.7%	50.3%
2 C 1	Iron and steel production	Cd	0.0083	17.9%	68.1%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	Cd	0.0047	10.1%	78.2%
2 G	Other product manufacture and use	Cd	0.0037	8.0%	86.2%

Trend Assessment

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [t]	Latest Year (2022) Estimate [t]	Trend Assessment	% Contribution to the trend	Cumulative Total of $L_{x,t}$
			$E_{x,0}$	$E_{x,t}$	$L_{x,t}$		
2 A 3	Glass production	Cd	0.0257	0.0010	0.515	26.3%	26.3%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	Cd	0.0001	0.0114	0.461	23.5%	49.8%
2 C 1	Iron and steel production	Cd	0.0325	0.0083	0.368	18.8%	68.6%
1 A 4 b i	Residential: stationary	Cd	0.0089	0.0118	0.285	14.5%	83.1%

Table 1-27 – Key Categories for Hg - Fuel sold - for the year 2022

Level Assessment

NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [t]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	Hg	0.10	53.8%	53.8%
2 C 3	Aluminum production	Hg	0.03	17.5%	71.3%
2 C 1	Iron and steel production	Hg	0.02	8.2%	79.5%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	Hg	0.01	5.1%	84.6%

Trend Assessment							
NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [t]	Latest Year (2022) Estimate [t]	Trend Assessment	% Contribution to the trend	Cumulative Total of $L_{x,t}$
			$E_{x,0}$	$E_{x,t}$	$L_{x,t}$		
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	Hg	0.01	0.10	1.297	39.0%	39.0%
2 C 1	Iron and steel production	Hg	0.28	0.02	1.230	37.0%	75.9%
2 C 3	Aluminum production	Hg	0.01	0.03	0.387	11.6%	87.5%

Table 1-28 – Key Categories for PCDD/F - Fuel sold - for the year 2022

Level Assessment					
NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [g I-Teq]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
2 C 3	Aluminum production	PCDD_PCDF	1.75	51.4%	51.4%
5 E	Other waste (please specify in IIR)	PCDD_PCDF	0.58	16.9%	68.2%
1 A 4 b i	Residential: stationary	PCDD_PCDF	0.37	10.8%	79.1%
2 C 1	Iron and steel production	PCDD_PCDF	0.31	9.1%	88.1%

Trend Assessment							
NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [g I-Teq]	Latest Year (2022) Estimate [g I-Teq]	Trend Assessment	% Contribution to the trend	Cumulative Total of $L_{x,t}$
			$E_{x,0}$	$E_{x,t}$	$L_{x,t}$		
2 C 1	Iron and steel production	PCDD_PCDF	36.59	0.31	9.615	50.0%	50.0%
2 C 3	Aluminum production	PCDD_PCDF	3.56	1.75	5.199	27.0%	77.0%
5 E	Other waste (please specify in IIR)	PCDD_PCDF	0.31	0.58	1.960	10.2%	87.2%

Table 1-29 – Key Categories for PCB - Fuel sold - for the year 2022

Level Assessment					
NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [kg]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
2 K	Consumption of POPs and heavy metals (e.g. electrical and scientific equipment)	PCB	0.82	59.2%	59.2%
2 C 1	Iron and steel production	PCB	0.51	36.6%	95.9%

Trend Assessment							
NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kg]	Latest Year (2022) Estimate [kg]	Trend Assessment	% Contribution to the trend	Cumulative Total of $L_{x,t}$
			$E_{x,0}$	$E_{x,t}$	$L_{x,t}$		
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	PCB	16.29	0.02	11.389	49.7%	49.7%
2 C 1	Iron and steel production	PCB	1.82	0.51	8.997	39.3%	88.9%

Table 1-30 – Key Categories for HCB - Fuel sold - for the year 2022

Level Assessment

NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [kg]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
2 C 1	Iron and steel production	HCB	0.46	56.5%	56.5%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	HCB	0.21	25.6%	82.1%

Trend Assessment

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kg]	Latest Year (2022) Estimate [kg]	Trend Assessment	% Contribution to the trend	Cumulative Total of $L_{x,t}$
			$E_{x,0}$	$E_{x,t}$	$L_{x,t}$		
3 D f	Use of pesticides	HCB	0.54	0.00	0.664	50.0%	50.0%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	HCB	0.10	0.21	0.335	25.2%	75.3%
2 C 3	Aluminum production	HCB	0.08	0.11	0.136	10.2%	85.5%

Table 1-31 – Key Categories for PAH - Fuel sold - for the year 2022

Level Assessment

NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [t]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	PAH	0.19	31.4%	31.4%
1 A4 b i	Residential: stationary	PAH	0.16	27.1%	58.5%
1 A4 a i	Commercial/Institutional: Stationary	PAH	0.09	14.8%	73.3%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	PAH	0.09	14.6%	87.8%

Trend Assessment

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [t]	Latest Year (2022) Estimate [t]	Trend Assessment	% Contribution to the trend	Cumulative Total of $L_{x,t}$
			$E_{x,0}$	$E_{x,t}$	$L_{x,t}$		
2 C 1	Iron and steel production	PAH	2.54	0.00	4.215	49.9%	49.9%
1 A4 b i	Residential: stationary	PAH	0.44	0.16	1.162	13.8%	63.6%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	PAH	0.04	0.09	0.951	11.3%	74.9%
1 A4 a i	Commercial/Institutional: Stationary	PAH	0.16	0.09	0.770	9.1%	84.0%

1.6 Information on the QA/QC Plan including Verification and Treatment of Confidentiality Issues where relevant

The overall responsibility for the establishment and existence of a Quality Management System (QMS), in order to prepare the National Air Emission Inventory lies within the Environment Agency (AEV). Political responsibility lies within the Ministry for the Environment, Climate and Biodiversity (MECB). Within the AEV, the *Unité surveillance et évaluation de l'environnement* is responsible for the following tasks:

The National Inventory Compiler (NIC):

- supervises the inventory preparation process for various obligations as outlined below;
- is the national inventory focal point to the Ministry (MECB).

The national, European and international obligations are:

- UNECE Convention on Long Range Transboundary Air Pollution and its protocols
- UNFCCC & Kyoto Protocol;
- European Union:
  - EU Regulation on the Governance of the Energy Union and Climate Action (2018/1999)
  - NEC Directive (2284/2016);
  - Ambient Air Quality Directive (2008/50/EC).

1.6.1 Quality Policy

The quality policy is the central aspect of a Quality Management System. It defines the understanding of quality in relation to all topics of inventory preparation and specifies its basic principles.

The single national entity has:

- to establish and maintain the quality policy and quality objectives regarding air emission inventory;
- to promote the quality policy and quality objectives regarding air emission inventory throughout the organisation to increase awareness, motivation and involvement;
- to ensure that appropriate processes are implemented to enable requirements the EMEP/EEA Emission Inventory Guidebook Chapter 6 - Inventory Management, Improvement and QA/QC to be fulfilled and quality objectives to be achieved;
- to ensure that an effective and efficient QMS is established, implemented and maintained in order to achieve these quality objectives;
- to ensure the availability of necessary resources;
- to review the Quality Management System periodically;
- to decide on actions regarding the quality policy and quality objectives regarding air emission inventory;
- to decide on actions for the improvement of the Quality Management System;
- to decide on actions for the improvement of National Air Emission Inventory.

1.6.2 Quality Management System Build-up

The build-up of the Quality Management System (*QMS*) of the air emission reporting is currently outsourced and supervised by SEG Umwelt-Service GmbH[15]. Since 2018, the QMS has been internalized within AEV in collaboration with Umweltbundesamt Vienna.

Luxembourg's QMS follows a Plan-Do-Check-Act-Cycle (PDCA-cycle)[16], which is an accepted model for pursuing a continual improvement of performance according to international standards.

Due to Luxembourg's clear extent, its QMS deals with a manageable quantity of documents. The specifications of Luxembourg's Quality Management System are the following:

- Firm build-up with a quality manual consisting of a chart with all relevant documents, handling instructions and deadlines for check (Figure 5);
- Good manageability (instead of a complex system);
- Usable and effective quality control procedures (user-friendly, clearly arranged).

Since the implementation of the QMS, it has evolved continuously and many improvements have already been realised.

The QMS shall ensure and continuously improve the quality (measured by transparency, accuracy consistency, comparability, completeness (TACCC) and timeliness) of Luxembourg's air emission Inventory. The QMS therefore supplies procedures to:

- check the integrity, correctness and completeness of data;
- identify potential errors and omissions;
- reduce uncertainties of emission estimates;
- document and archive the inventory calculation sheets and background data.

1.6.3 QMS Structure

Luxembourg's Quality Management System (QMS) of the Air Emission Inventory is organised in three layers (Figure 6):

a) Performance processes

Performance processes directly concern the compilation of the Air Emission Inventory. They comprise input data, data acquisition, calculations, and generation of NFR tables and IIR as well as quality control checks and the outcomes of the IIR and NFR-tables.

b) Management processes

Management processes control the system's performance by defining quality objectives, responsibilities, quality assurance procedures, improvement plans and the personnel's qualifications and obligations.

c) Supporting processes

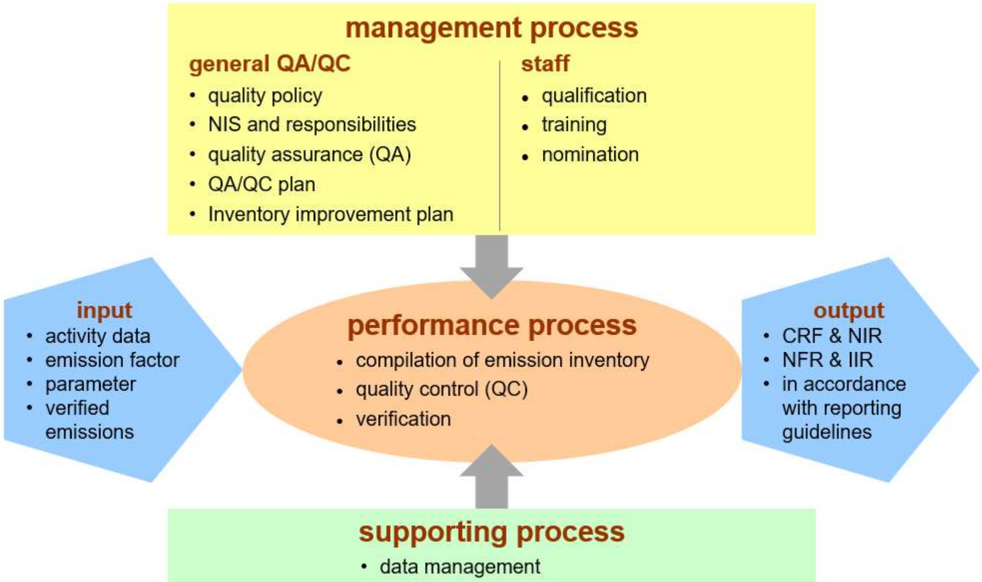
Supporting processes assist the system's performance by providing technical requirements and standards.

---

15 SEG Umwelt-Service GmbH, Auf der Haardt 2, D – 66693 Mettlach, http://www.seg-online.de

16 http://www.asq.org/learn-about-quality/project-planning-tools/overview/pdsa-cycle.html

Figure 6 – QMS structure



1.6.4 Quality Manual

The applied quality manual adopts the structure of the QMS and is divided in management, performance and supporting processes.

For each process, a list of related documents exists with information on content, handling, interval of document check and planned improvement.

1.6.5 Inventory Timetable

The inventory timetable gives several schedules to control the performance of inventory compilation, quality control and quality assurance procedures, implementation of inventory improvements and inventory publication (see Table 1-3 in Section 1.2.3). In addition, summaries of deadlines regarding UNFCCC and UNECE/LRTAP as well as EU submissions are outlined.

1.6.5.1 Timetable for Inventory Planning and Preparation

This schedule refers to general inventory work:

- Yearly meetings of the inventory work group and the decision making body;
- Key category analysis;
- Generation of NFR tables;
- NFR submission;
- IIR preparation and finalisation;
- IIR submission (and NFR re-submission);
- Publication and archiving of IIR;
- Consideration and implementation of review recommendations;

- Internal and external training; and
- Documentation and archiving.

1.6.5.2 Sector-specific Timetable for Inventory Planning and Preparation

This schedule refers to sector specific compilation work and quality control checks:

- Collection of activity data, emission factors and other parameters;
- Calculation of emissions;
- Quality check of data, comparison with previous years, documentation of calculations and assumptions;
- Uncertainty analysis;
- Completion of checklists and other QC activities; and
- Documentation and archiving;

1.6.5.3 QA/QC Timetable

This schedule especially refers to QA procedures:

- Internal audit;
- Implementation of internal review recommendations;
- Yearly meetings of the Inventory Work Group and the Decision Making Body;
- QA/QC training for the National Inventory Compiler and the sector experts.

1.6.6 Quality Control and Quality Assurance Procedures

The first steps to implement quality control and quality assurance procedures have already been undertaken but need further improvement. The current status and planned improvements are described in the following sub-sections.

Figure 7 – QA/QC Procedures

<table>
<tr><td>Does NOT require knowledge of the emission source category</td><td>Requires knowledge of the emission source category</td></tr>
<tr><td>general</td><td>source specific</td></tr>
<tr><td colspan="2">QC procedures
Sector experts (1st party) performed throughout preparation of inventory</td></tr>
<tr><td>TIER 1</td><td>TIER 2</td></tr>
<tr><td>Data validation, calculation sheet (check of formal aspects)</td><td>Preparation of NIR, comparision with Guidelines (check of applicability, comparisions)</td></tr>
<tr><td colspan="2">QA procedures
Quality manager (2nd or 3rd party; staff not directly involved, preferably independent) performed after inventory work was finished</td></tr>
<tr><td colspan="2">TIER 1
Basic, before submission</td></tr>
<tr><td></td><td>Internal audit /EU 'initial check `
(Expert Peer Review)</td></tr>
<tr><td></td><td>Evaluate if TIER 2 QC is effectively performed (check if methodologies are applicable)</td></tr>
<tr><td colspan="2">TIER 2
extensive</td></tr>
<tr><td>System audit by Umweltbundesamt (Audit)</td><td>ICR by UNFCCC (Expert Peer Review)</td></tr>
<tr><td>Evaluate if TIER 2 QC is effectively performed</td><td>Evaluate if TIER 2 QC is effectively performed (Check if methodologies are applicable)</td></tr>
</table>

Sources: Umweltbundesamt Austria, SEG Umwelt-Service GmbH and Environment Agency.

1.6.6.1 Quality Control Procedures

Quality Control procedures are conducted as follows:

a) Yearly meeting of the Decision Making Body (the Decision Making Body consists of the head of the AEV, the National Inventory Compiler and the quality manager) in order to appoint responsibilities, priorities and schedules for inventory work;

b) Checklists for Data Supplier that have to be completed by external suppliers of input data in order to assure the reliability of reported data;

c) Checklists for validation of data that have to be completed by sector experts until data are transmitted to the National Inventory Compiler;

d) Checks for validation of data include:

- Checks of activity data (trend checks, time series consistency, completeness, check of assumptions and criteria for activity data, check for transcription errors in data input and reference);
- Checks of emission factors (trend checks, time series consistency, completeness, check of correct recording of units and the use of appropriate conversion factors, check of documentation of assumptions and criteria for the selection of emission factors, check for transcription errors in data input and reference);

- Checks of emissions (trend checks, time series consistency, completeness, check of documentation of assumptions and criteria for emissions, check for transcription errors in data input and reference, check of correct recording of units and the use of appropriate conversion factors);

e) Checklists for verification of methods, activity data and emission factors that have to be completed by sector experts;

f) Checklist for survey of sectoral work (completeness and compliance of IIR Chapter and NFR-tables, implementation of planned improvements, transmission of sector-specific QC checklists) that has to be completed by NIC;

g) Checklist for the monitoring of internal and external reviews that has to be completed by the quality manager.

1.6.6.2 Quality Assurance procedures

The following Quality Assurance procedures are conducted:

- Compliance of inventory work and the inventory with the Emission Reporting Guidelines under the UNECE LRTAP Convention;
- Handling of data acquisition, calculation, referencing and archiving according to the defined methods;
- Sufficiency of resources for inventory work;
- Availability of relevant data and guaranteed reliability of external data ;
- Necessary improvement of the QMS system ;
- Consideration and implementation of recommendations from reviews and previous internal audits .

1.6.6.3 Improvement Plan

The results from internal and external audits are merged in the improvement plan. This plan lists the relevant sector, recommendations for improvement, responsibilities, and deadlines and gives opportunity for attestation.

The improvement plan is segmented in a QA/QC plan, that contains recommendations for the improvement of the QMS and an inventory improvement plan that contains recommendations for inventory improvement.

The Decision Making Body prioritises the recommended improvements and cares for associated resources.

1.6.7 Archiving and Documentation

Within the inventory system, a system for transparent documentation of inventory data and related information (special circumstances, assumptions *etc*.) is implemented. Archiving takes place on the Sharepoint server, where the data is secure for at least fifteen years.

As a principle every file shall be named clearly, shall be write/delete protected and supply relevant information concerning its validity in the footer.

1.6.8 Treatment of Confidentiality Issues

In this submission, there is no data reported using the notation key C (confidential).

1.7 General Uncertainty Evaluation

A quantitative uncertainty evaluation (Tier 1) is first published in Luxembourg's IIR 2024. It includes a level assessment for the inventory year 2022 as well as a trend assessment for the period 1990-2022 and covers the main pollutants NO_x, NH_3, NMVOC, SO_x and $PM_{2.5}$. The assessment of activity data and emission factor uncertainties is done according to the methodology described in the EMEP/EEA emission inventory Guidebook 2023 (Chapter A.5 Uncertainties, tables 2-1, 2-2 and 2-3). For some subcategories and pollutants, expert judgements were made to estimate AD or EF uncertainties. For the agriculture sector, uncertainties by subcategory and by pollutant were obtained by a sector-specific Monte Carlo analysis. For each pollutant, the inventory uncertainty was obtained by the error propagation method as described in on EMEP/EEA Guidebook 2023 (Chapter A.5 Uncertainties, Chapter 3).

The results of the uncertainty evaluation for the year 2022 are presented in Table 1-32, and Table 1-33 to Table 1-37 show the uncertainties at sectoral level for each pollutant.

Table 1-32 – Results of the Tier 1 uncertainty evaluation for 2022

Pollutant	Emissions 2022 (kt)	Level uncertainty 2022	Trend uncertainty 2022
NO_x	11.5	19.7%	3.3%
NH_3	5.9	8.8%	11.6%
NMVOC	10.0	49.6%	13.1%
SO_x	0.4	17.5%	0.2%
$PM_{2.5}$	1.0	54.8%	2.5%

Table 1-33 - Uncertainty estimation of NO_x emissions 1990 and 2022

NFR	Gas	Base year emissions	Year 2022 emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions	Comments (optional)
		kt	kt	%	%								
		input data	input data	input data Note A	input data Note A			Note B		I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2	
1A - Stationary Combustion	NOx	12.17	3.17	2%	50%	0.5004	0.0191	0.0060	0.0776	0.0030	0.0022	1.37E-05	
1A - other mobile machinery	NOx	0.97	1.06	2%	20%	0.2010	0.0003	0.0193	0.0259	0.0039	0.0007	1.54E-05	1A2gvii, 1A4bii, 1A4cii, 1A5b
1A3a - Transport - Civil Aviation	NOx	0.34	1.03	10%	100%	1.0050	0.0082	0.0229	0.0253	0.0229	0.0036	5.37E-04	
1A3b - Road Transportation	NOx	25.75	5.24	2%	20%	0.2010	0.0084	0.0483	0.1283	0.0097	0.0036	1.06E-04	
1A3c - Railways	NOx	0.26	0.04	2%	20%	0.2010	0.0000	0.0007	0.0011	0.0001	0.0000	1.98E-08	
1A3d - Navigation	NOx	0.02	0.01	20%	20%	0.2828	0.0000	0.0000	0.0001	0.0000	0.0000	1.51E-09	
2G - Other Product Manufacture and Use	NOx	0.00	0.00	20%	100%	1.0198	0.0000	0.0000	0.0000	0.0000	0.0000	4.97E-10	
3B - Manure management	NOx	0.02	0.02	100%		1.0000	0.0000	0.0002	0.0004	0.0000	0.0005	2.96E-07	total subcategory uncertainty
3D - Agricultural soils	NOx	1.35	0.90	65%		0.6500	0.0026	0.0128	0.0221	0.0000	0.0203	4.12E-04	total subcategory uncertainty
						Total Inventory Uncertainty	**19.67%**				**Trend uncertainty**	**3.29%**	

Table 1-34 - Uncertainty estimation of NH_3 emissions 1990 and 2022

NFR	Gas	Base year emissions	Year 2022 emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions	Comments (optional)
		kt	kt	%	%								
		input data	input data	input data Note A	input data Note A			Note B		I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2	
1A - Stationary Combustion	NH3	0.01	0.01	2%	100%	1.0002	0.0000	0.0009	0.0016	0.0009	0.0000	7.69E-07	
1A - other mobile machinery	NH3	0.00	0.00	2%	20%	0.2010	0.0000	0.0000	0.0001	0.0000	0.0000	2.75E-11	1A2gvii, 1A4bii, 1A4cii, 1A5b
1A3b - Road Transportation	NH3	0.01	0.18	2%	20%	0.2010	0.0000	0.0266	0.0287	0.0053	0.0008	2.90E-05	
1A3c - Railways	NH3	0.00	0.00	2%	20%	0.2010	0.0000	0.0000	0.0000	0.0000	0.0000	4.11E-12	
1A3d - Navigation	NH3	0.00	0.00	20%	20%	0.2828	0.0000	0.0000	0.0000	0.0000	0.0000	2.38E-14	
2G - Other Product Manufacture and Use	NH3	0.00	0.00	20%	200%	2.0100	0.0000	0.0002	0.0004	0.0003	0.0001	1.09E-07	
3B - Manure management	NH3	2.86	2.71	10%		0.1000	0.0021	0.0063	0.4259	0.0000	0.0602	3.63E-03	total subcategory uncertainty
3D - Agricultural soils	NH3	3.49	2.98	15%		0.1500	0.0056	0.0440	0.4671	0.0000	0.0991	9.82E-03	total subcategory uncertainty
5B1 - Composting	NH3	0.00	0.01	5%	50%	0.5025	0.0000	0.0017	0.0017	0.0008	0.0001	7.26E-07	
5B2 - Anaerobic Digestion at Biogas Facilities	NH3	0.00	0.05	60%		0.6000	0.0000	0.0086	0.0086	0.0000	0.0073	5.27E-05	total subcategory uncertainty
						Total Inventory Uncertainty	**8.82%**				**Trend uncertainty**	**11.63%**	

Table 1-35 - Uncertainty estimation of NMVOC emissions 1990 and 2022

NFR	Gas	Base year emissions	Year 2022 emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions	Comments (optional)
		kt	kt	%	%								
		input data	input data	input data Note A	input data Note A			Note B		I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2	
1A - Stationary Combustion	NMVOC	1.41	0.93	2%	100%	1.0002	0.0086	0.0152	0.0299	0.0152	0.0008	2.33E-04	
1A - other mobile machinery	NMVOC	0.47	0.14	2%	20%	0.2010	0.0000	0.0004	0.0044	0.0001	0.0001	2.25E-08	
1A3a - Transport - Civil Aviation	NMVOC	0.04	0.07	10%	100%	1.0050	0.0000	0.0018	0.0022	0.0018	0.0003	3.37E-06	
1A3b - Road Transportation	NMVOC	17.05	0.62	2%	20%	0.2010	0.0002	0.1558	0.0200	0.0312	0.0006	9.71E-04	
1A3c - Railways	NMVOC	0.05	0.00	2%	20%	0.2010	0.0000	0.0004	0.0001	0.0001	0.0000	5.63E-09	
1A3d - Navigation	NMVOC	0.02	0.00	20%	20%	0.2828	0.0000	0.0001	0.0001	0.0000	0.0000	1.48E-09	
1B2 - Fugitive Emissions	NMVOC	0.63	0.45	2%	100%	1.0002	0.0020	0.0079	0.0145	0.0079	0.0004	6.31E-05	
2D3 - solvent use	NMVOC	7.71	4.14	50%	100%	1.1180	0.2144	0.0533	0.1334	0.0533	0.0943	1.17E-02	
2G - Other Product Manufacture and Use	NMVOC	0.00	0.00	20%	100%	1.0198	0.0000	0.0001	0.0001	0.0001	0.0000	5.86E-09	
2H2 - Food and beverages industry	NMVOC	0.12	0.16	50%	100%	1.1180	0.0003	0.0038	0.0050	0.0038	0.0036	2.72E-05	
3B - Manure management	NMVOC	2.56	2.71	50%		0.5000	0.0183	0.0607	0.0872	0.0000	0.0617	3.80E-03	total subcategory uncertainty
3D - Agricultural soils	NMVOC	1.01	0.77	55%		0.5500	0.0018	0.0145	0.0249	0.0000	0.0194	3.76E-04	total subcategory uncertainty
5A - Solid Waste disposal on Land	NMVOC	0.02	0.01	8%	50%	0.5064	0.0000	0.0001	0.0002	0.0000	0.0000	1.35E-09	
5D - Wastewater treatment and discharge	NMVOC	0.00	0.00	10%	50%	0.5099	0.0000	0.0000	0.0000	0.0000	0.0000	2.69E-11	
						Total Inventory Uncertainty	49.57%				Trend uncertainty	13.12%	

Table 1-36 - Uncertainty estimation of SO_x emissions 1990 and 2022

NFR	Gas	Base year emissions	Year 2022 emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions	Comments (optional)
		kt	kt	%	%								
		input data	input data	input data Note A	input data Note A			Note B		I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2	
1A - Stationary Combustion	SOx	15.19	0.36	2%	20%	0.2010	0.0271	0.0029	0.0222	0.0006	0.0006	7.34E-07	
1A - other mobile machinery	SOx	0.06	0.00	2%	20%	0.2010	0.0000	0.0000	0.0001	0.0000	0.0000	3.75E-11	
1A3a - Transport - Civil Aviation	SOx	0.03	0.05	10%	50%	0.5099	0.0035	0.0031	0.0031	0.0015	0.0004	2.59E-06	
1A3b - Road Transportation	SOx	1.07	0.02	2%	20%	0.2010	0.0001	0.0003	0.0015	0.0001	0.0000	4.86E-09	
1A3c - Railways	SOx	0.02	0.00	2%	20%	0.2010	0.0000	0.0001	0.0001	0.0000	0.0000	3.71E-10	
1A3d - Navigation	SOx	0.00	0.00	20%	20%	0.2828	0.0000	0.0000	0.0000	0.0000	0.0000	6.46E-14	
2G - Other Product Manufacture and Use	SOx	0.00	0.00	20%	50%	0.5385	0.0000	0.0000	0.0000	0.0000	0.0000	9.20E-14	
						Total Inventory Uncertainty	**17.53%**				**Trend uncertainty**	**0.18%**	

Table 1-37 - Uncertainty estimation of $PM_{2.5}$ emissions 1990 and 2022

NFR	Gas	Base year emissions	Year 2022 emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	Combined uncertainty	Contribution to variance by category in year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions	Comments (optional)
		kt	kt	%	%								
		input data	input data	input data Note A	input data Note A			Note B		I*F Note C	J*E*sqrt(2) Note D	K^2 + L^2	
1A - Stationary Combustion	PM2.5	14.70	0.57	2%	100%	1.0002	0.2923	0.0241	0.0351	0.0241	0.0010	5.80E-04	
1A - other mobile machinery	PM2.5	0.18	0.02	2%	20%	0.2010	0.0000	0.0006	0.0013	0.0001	0.0000	1.53E-08	
1A3a - Transport - Civil Aviation	PM2.5	0.00	0.01	10%	100%	1.0050	0.0000	0.0003	0.0003	0.0003	0.0000	1.01E-07	
1A3b - Road Transportation	PM2.5	1.03	0.32	2%	20%	0.2010	0.0038	0.0158	0.0199	0.0032	0.0006	1.03E-05	
1A3c - Railways	PM2.5	0.06	0.00	2%	20%	0.2010	0.0000	0.0001	0.0002	0.0000	0.0000	1.68E-10	
1A3d - Navigation	PM2.5	0.00	0.00	20%	20%	0.2828	0.0000	0.0000	0.0000	0.0000	0.0000	2.21E-11	
1B1a - Fugitive emission from solid fuels: Coal mining and handling	PM2.5	0.00	0.00	2%	200%	2.0001	0.0000	0.0000	0.0000	0.0000	0.0000	1.00E-11	
2A5b - Construction and demolition	PM2.5	0.01	0.01	1%	100%	1.0000	0.0002	0.0008	0.0009	0.0008	0.0000	7.06E-07	
2D3b - Road paving with asphalt	PM2.5	0.01	0.00	2%	100%	1.0002	0.0000	0.0002	0.0002	0.0002	0.0000	2.72E-08	
2G - Other Product Manufacture and Use	PM2.5	0.01	0.02	20%	100%	1.0198	0.0002	0.0009	0.0010	0.0009	0.0003	9.70E-07	
3B - Manure management	PM2.5	0.03	0.03	45%		0.4500	0.0002	0.0018	0.0020	0.0000	0.0013	1.59E-06	total subcategory uncertainty
3Dc - Farm-level agricultural operations including storage, handling and transport of agricultural products	PM2.5	0.01	0.01	200%		2.0000	0.0002	0.0004	0.0005	0.0000	0.0013	1.78E-06	total subcategory uncertainty
5A - Solid Waste disposal on Land	PM2.5	0.00	0.00	8%	100%	1.0032	0.0000	0.0000	0.0000	0.0000	0.0000	1.03E-11	
5E- Other waste	PM2.5	0.03	0.06	1%	100%	1.0000	0.0030	0.0034	0.0035	0.0034	0.0001	1.17E-05	
						Total Inventory Uncertainty	**54.76%**				**Trend uncertainty**	**2.46%**	

1.8 General Assessment of Completeness

1.8.1 Air Emission Inventory

The emission data presented in this report were compiled according to the 2023 Guidelines for Reporting Emissions and Projections Data under the Convention on Long-Range Transboundary (see Chapter 1.8.1.4).

1.8.1.1 Sources

Notation keys are used according to the 2023 Guidelines for Reporting Emissions and Projections Data under the Convention on Long-Range Transboundary (see Chapter 1.8.1.4) to indicate in which categories *(i)* emissions are not occurring in Luxembourg, *(ii)* emissions have not been estimated or *(iii)* have been included elsewhere as suggested by EMEP/EEA Emission Inventory Guidebook. The main reason for different allocations to categories are the allocation in national statistics, insufficient information on the national statistics, national methods, and the impossibility to disaggregate emission declarations. Explanations for each case is given in the NFR Table under “Additional Information”.

1.8.1.2 Pollutants

In accordance with the reporting obligations, all relevant pollutants are covered by the Air Emission Inventory and emissions are reported for the years 1990–2022 for the four main pollutants, CO, TSP as well as PM_{10}, POPs and HMs.

1.8.1.3 Geographic Coverage

The geographic coverage is complete. There is no part of the national territory which is not covered by the inventory.

1.8.1.4 Notation Keys

The sources not considered in the inventory but included in the 2023 Guidelines for Reporting Emissions and Projections Data under the Convention on Long-Range Transboundary are clearly indicated. The reasons for such exclusions are explained. In addition, the notation keys presented below are used to fill in the blanks in the NFR tables.

Notation keys used in the IIR are consistent with those reported in the NFR tables. Notation keys used are those defined in Section II.C of Annex I to the Reporting Guidelines[17].

Allocations to categories may differ from Party to Party. The main reasons for different category allocations are different allocations in national statistics, insufficient information in national statistics and/or national methods, and the impossibility to disaggregate emission declarations.

IE (included elsewhere)

[17] http://www.ceip.at/ms/ceip_home1/ceip_home/reporting_instructions/

The notation key IE is used for emissions for the respective source that are estimated and included in the inventory but not presented separately for this source. The source which includes these emissions should be indicated.

NE (not estimated)

The notation key NE is used for occurring emissions, but which have not been estimated or reported.

NA (not applicable)

The notation key NA is used for activities or processes in a given source/sink category that do not produce emissions or lead to removals of a specific gas. As part of the improvement programme of the inventory, it is planned to revise all the NA notation keys to confirm whether they are indeed NA, NE or rather NO.

NO (not occurring)

The notation key NO is used for activities or processes in a given source/sink category that do not occur within Luxembourg.

C (confidential)

The notation key C is used for emissions, which could lead to the disclosure of confidential information if reported at the most dis-aggregated level. In this case, a minimum of aggregation is required to protect business information.

2 Explanation of Key Trends

2.1 National Circumstances

2.1.1 The Grand-Duchy of Luxembourg

The Grand-Duchy of Luxembourg has been an independent sovereign state since the Treaty of London was signed on 19 April 1839. The country is a parliamentary democracy in the form of a constitutional monarchy and is the second smallest Member State of the EU-28, after Malta. For many years, it has been characterized by high economic and demographic growth rates. The country is located in the heart of North-Western Europe and has direct borders with Belgium, Germany and France (Figure 8). It is therefore a crossroad for international trade and related transport flows, the most dynamic source of its GHG emissions.

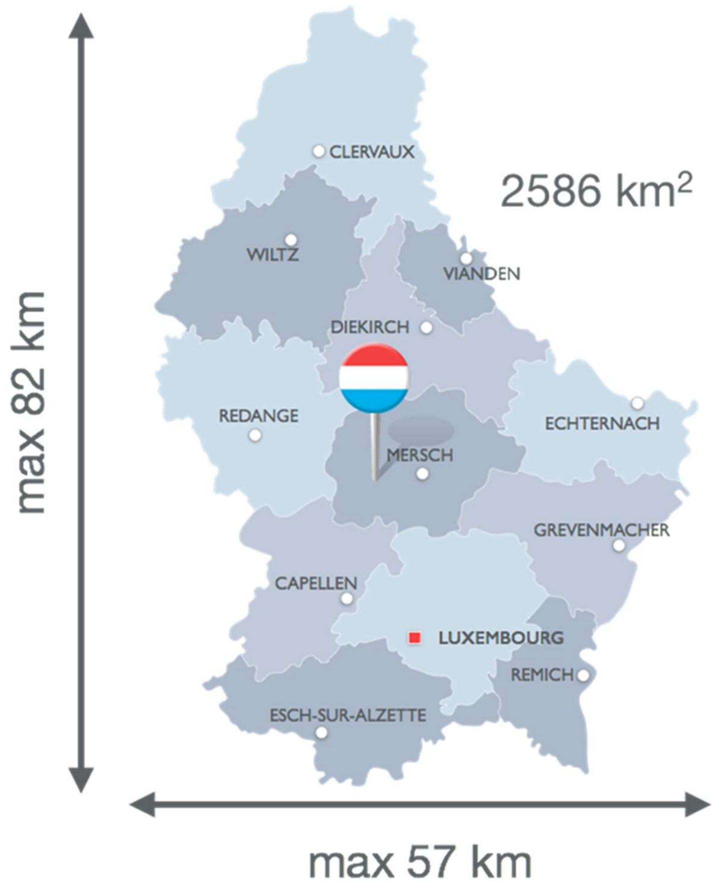
Luxembourg has a territory of 2 586 km². The maximum distance from North to South is some 82 km, from West to East about 57 km (Figure 9). In 2022, 84.5% of the total area of Luxembourg was agricultural land and land under forest. The built-up areas occupied 10.3% of the total surface while land covered by water and transport infrastructure covered about 5.2% (Table & Figure 10).

The North of Luxembourg is a part of the Ardennes and is called "Ösling". Its altitude is at an average of 400 to 500 meters above sea level. The "Ösling" landscape is affected by hills and deep river valleys, as for instance the Sure (Sauer) river. With 560 m, the highest elevation is called the "Kneiff" in Wilwerdange. In the South of Luxembourg lies the rank "Gutland", which belongs to the "Lothringer Stufenland". This area has higher population and industrial densities than "Ösling". The lowest point in the country, called "Spatz" (129 m above sea level), is located at the confluence of the Moselle and the Sure rivers in Wasserbillig. The most important rivers are the Moselle, the Sure, the Our – all three delimiting the border with Germany – and the Alzette.

Figure 8 – GEOGRAPHIC LOCATION OF LUXEMBOURG

Source: Google Maps.

Figure 9 – LUXEMBOURG SIZE



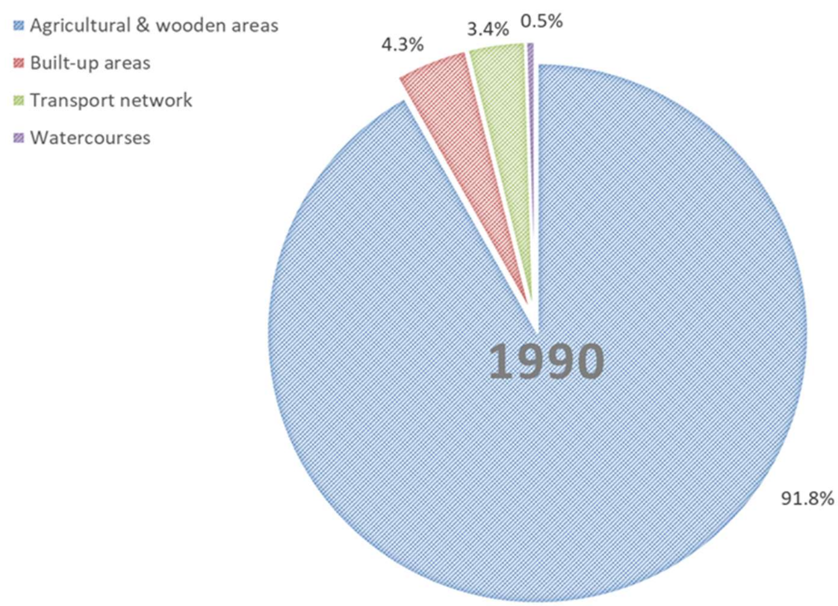
Source: Google Maps.

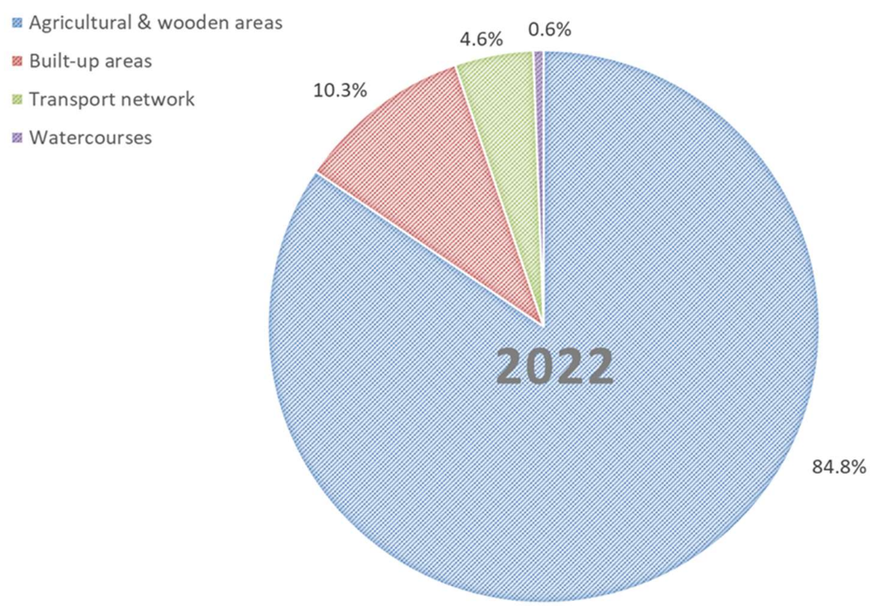
Table 2-1 – Land use in Luxembourg: 1972-2022

Percentages	1972	1990	2000	2010	2015	2016	2017	2018	2019	2020	2021	2022
Total land	100	100	100	100	100	100	100	100	100	100	100	100
Agriculture & wooden area	93.2	91.8	87.4	85.7	85.3	85.1	85.1	85.2	84.8	84.7	84.6	84.5
Built-up area	3.1	4.3	8.1	9.3	9.7	9.8	9.8	9.7	10.1	10.1	10.2	10.3
of which industrial area & other	NA	NA	2.7	3.0	3.0	3.1	3.1	3.0	3.1	3.1	3.2	3.2
Transport network & sheets of water	3.2	3.4	3.9	4.4	4.4	4.5	4.5	4.5	4.5	4.5	4.5	4.6
Watercourses	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6

Source: STATEC (accessed 3 April 2024):

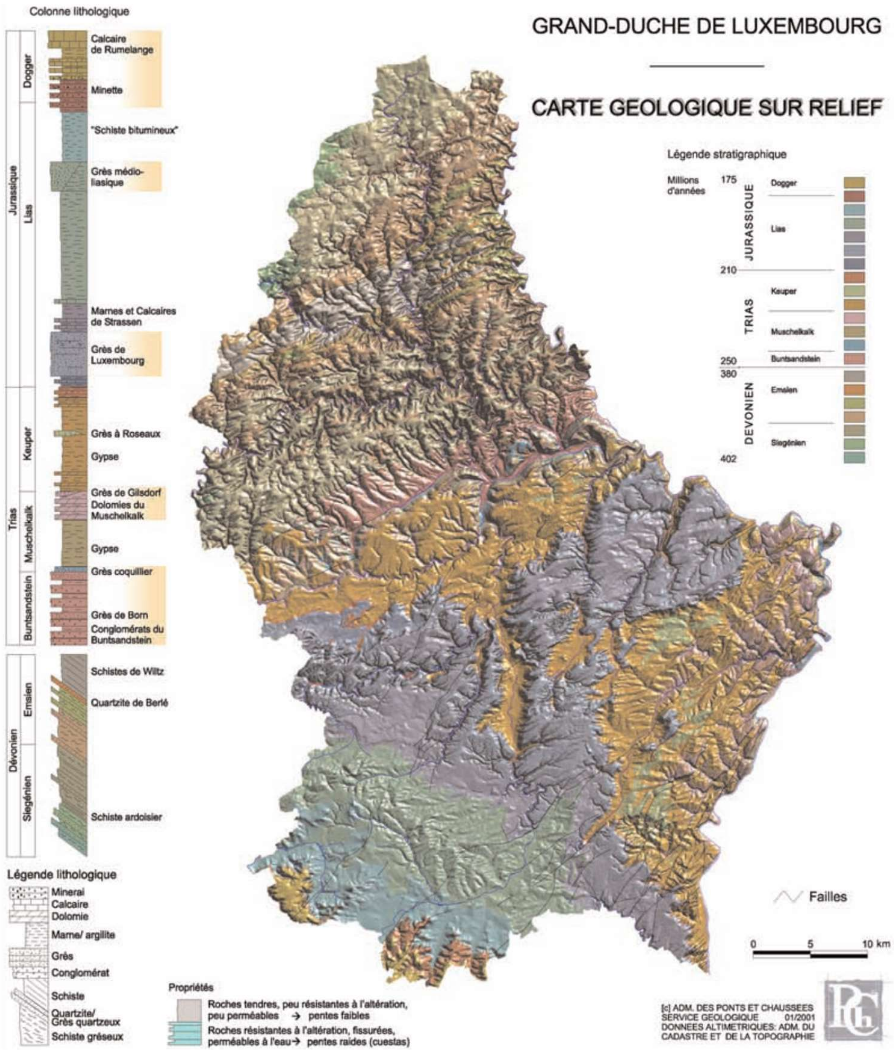
Figure 10 – Land use: 1990 & 2022





Source: STATEC, (updated 3 April 2024):

Figure 11 – Geological map of Luxembourg's territory



Source: STATEC, *Annuaire statistique du Luxembourg 2012*, page 39: http://www.statistiques.public.lu/fr/publications/series/annuaire-stat-lux/index.html.

2.1.2 Population and Workforce

2.1.2.1 A strong population growth driven by immigration

At the beginning of 2022, the population of Luxembourg was estimated to 645 397 inhabitants. Since 1960, the residential population has grown by some 330 000 inhabitants or about 96% – or 68% since 1990 (Table 2-2). The average annual growth rate of the resident population of Luxembourg is elevated compared to the rates of its neighbouring regions: between 1990 and 2015, the average annual growth rate for Luxembourg (1.64%) was about 4 times higher than its equivalent for the *Grande Région*.[18] It even reached 1.79% p. a. since 2000 (Figure 12).

[18] Refer to Box 2-1 for a presentation of the *Grande Région*.

Demographic growth in Luxembourg is actually dominated by immigration. Nationals themselves saw their number stagnating, and without immigrants taking the citizenship of Luxembourg they would even have fallen. At the end of 2021, 47.1% of the residential population did not have the citizenship of Luxembourg. This percentage was only around 28.7% in 1990, as depicted in Figure 13. The main driver behind these demographic trends is the economic restructuring and development of the country towards the tertiary sector coupled with attractive wages, which is presented in Section 2.1.4.

Since population projections are based on scenarios derived from past statistical data, population forecasts a continuation of the demographic trend in Luxembourg. Projections calculated by STATEC in 2017 forecast, under the assumption of a 3% annual gross domestic product increase, that almost 980 000 inhabitants could be living in Luxembourg by 2050 (Figure 12).[19] As it is the case for any forecasts, these predictions should be treated with caution because they cannot predict radical changes in the economic structure or demographics of a country, especially a small one whose economy relies heavily on a few economic sectors. However, since population growth is one of the key drivers for domestic energy use, mainly in the housing and transportation sector, these forecasts illustrate the scale of one of the many challenges Luxembourg is facing in the definition of measures aiming at reducing its GHG emissions.

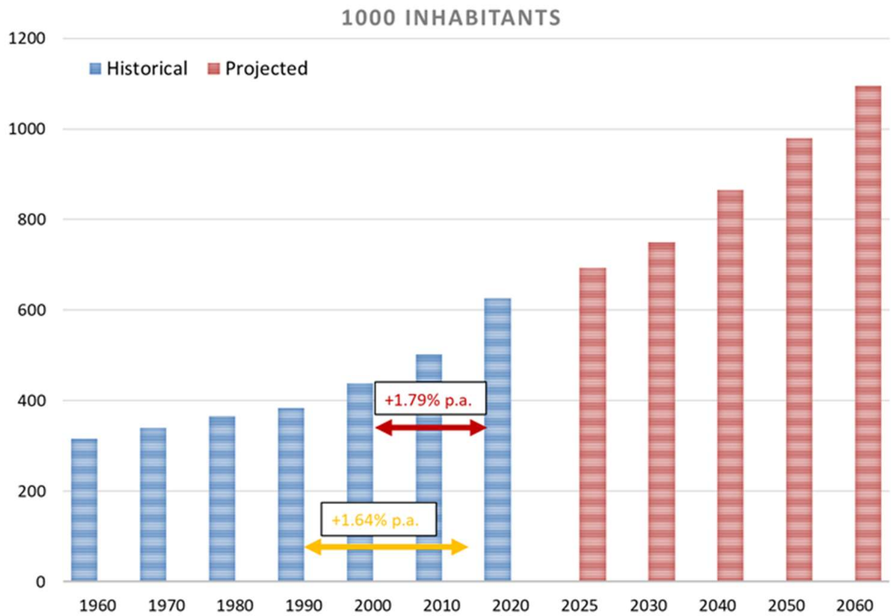
Table 2-2 – Population: 1960-2022

Calculated on 31st December	1960	1990	1995	2000	2005	2010	2015	2017	2018	2019	2020	2021	2022
Resident population (x 1000)	314.9	384.4	411.6	439.0	461.2	502.1	563.0	590.7	602.0	613.9	626.1	634.7	645.4

Source: STATEC, (updated 21 March 2023): https://lustat.statec.lu/vis?fs[0]=Th%C3%A8mes%2C1%7CPopulation%20et%20emploi%23B%23%7CEtat%20de%20la%20population%23B1%23&pg=0&fc=Th%C3%A8mes&df[ds]=ds-release&df[id]=DF_B1115&df[ag]=LU1&df[vs]=1.0&pd=1990%2C2022&dq=.A

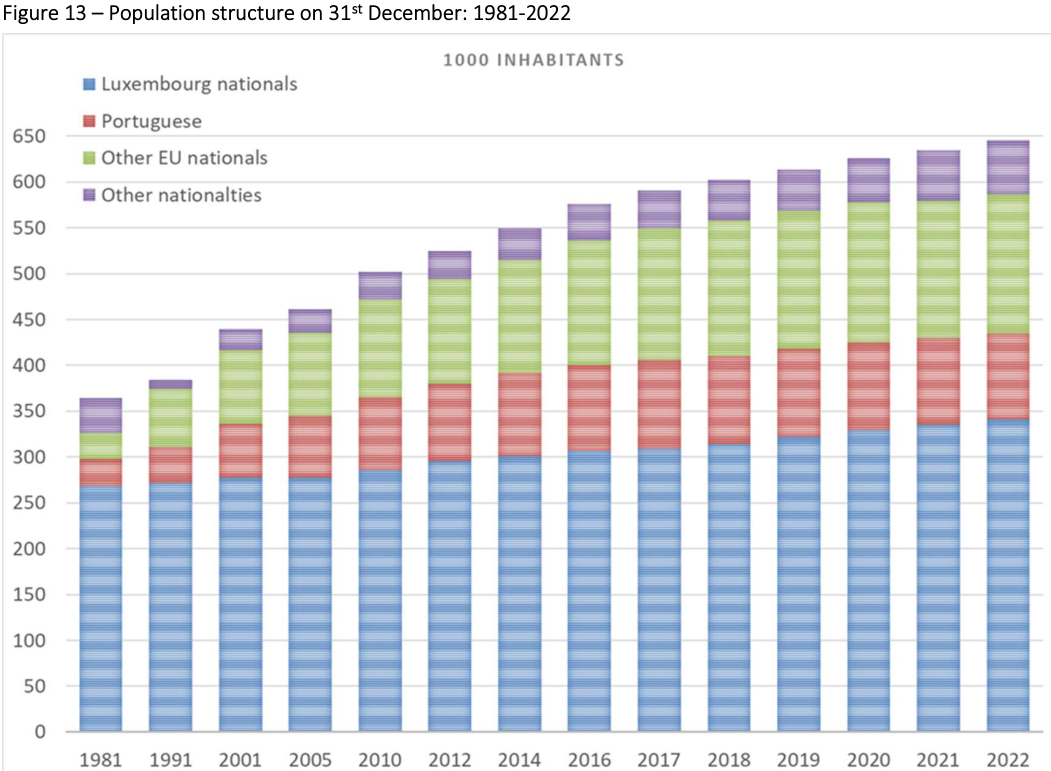
[19] For details, see STATEC (2012), *Projections socio-économiques 2010-2060*, Bulletin du STATEC N° 5/2010, Luxembourg, pages 262-272 (http://www.statistiques.public.lu/fr/publications/series/bulletin-statec/2010/05-10-Projpop/index.html). Other projections, which are a bit lower than STATEC's baseline scenario, are also produced in the framework of the European Commission Ageing Working Group: http://europa.eu/epc/working_groups/ageing_en.htm and http://europa.eu/epc/pdf/2012_ageing_report_en.pdf, as well as http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Population_projections.

Figure 12 – Population growth on 31st December: 1960-2060



Sources:STATEC, *Statistical Yearbook*, Table B.1101 (updated 16.03.2022):
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12856&IF_Language=fra&MainTheme=2&FldrName=1.
STATEC, Projections macroéconomiques et démographiques de long terme : 2017-2060 :
https://statistiques.public.lu/catalogue-publications/bulletin-Statec/2017/PDF-Bulletin3-2017.pdf.

Figure 13 – Population structure on 31st December: 1981-2022



Source: STATEC, (updated 21 March 2023):
https://lustat.statec.lu/vis?fs[0]=Th%C3%A8mes%2C1%7CPopulation%20et%20emploi%23B%23%7CEtat%20de%20la%20population%23B1%23&pg=0&fc=Th%C3%A8mes&df[ds]=ds-release&df[id]=DF_B1113&df[ag]=LU1&df[vs]=1.0&pd=2015%2C2022&dq=.A
Note:1981, 1991, 2001 and 2011 data are coming from population censuses held every decade, other years are calculated by STATEC.

Box 2-1 – The *Grande Région*

The *Grande Région* is the geographic unit that includes Luxembourg, the Region of Wallonia in Belgium, Lorraine in France and two German *Länder*: Saarland and Rheinland-Pfalz.

Today, this structure is more a cooperative space than an effective integrated region defining and modelling its own policies and development. This is the result of the diversity of the territories constituting the *Grande Région*, of its dimension and of the barriers created by institutional and administrative structures in each country. De facto, being a sovereign state amongst country regions, Luxembourg has a special status in this cooperative space: it is the main driving force behind the *Grande Région*, a position re-enforced by its demographic and economic development as shown by the figures in the table below.

Grande Région entity	Population change (1st January)	Population annual average growth rate (1st January)	GDP at current price annual average growth rate	Total employment in 2015
	% 1990-2015	*% 1990-2015*	*% 1990-2015*	*1990=100*
BE-Wallonia	10.67%	0.41%	3.57%	116
DE-Rheinland-Pfalz	8.37%	0.32%	2.35%	117
DE-Saarland	-7.12%	-0.29%	2.48%	116
FR-Lorraine	1.51%	0.06%	2.06%	102
Luxembourg	**48.42%**	**1.59%**	**7.23%**	**201**

More information on the *Grande Région* can be found on line:
http://www.granderegion.net/fr/index.html
http://www.grande-region.lu/eportal/pages/HomeTemplate.aspx

2.1.2.2 Workforce: the importance of cross-border commuters

The economic restructuring and development of Luxembourg led to a doubling of the workforce in the last 20 years. The resident population of Luxembourg nationality was unable to meet this increasing demand for labour. How, therefore, could this urgent economic need be satisfied? The initial response was to resort to **immigration**. The number of foreign employees living and working in Luxembourg rose from 56 900 in 1995 to 122 339 in 2020 - but, this was not enough. So, the **cross-border commuters** came into play. Between 1995 and 2022, the number of cross-border workers increased from 56 834 to 220 200 (Figure 14).[20]

For 2022, among the commuters employed in Luxembourg, 53.3% came from France, 23.1% from Germany and 23.5% from Belgium. In total, the commuters accounted for 46% of the total workforce in Luxembourg and for 33% of the residential population (Figure 14).[21] The commuting flows amongst the various regions of the *Grande Région* clearly show the economic attraction of Luxembourg (Figure 15).

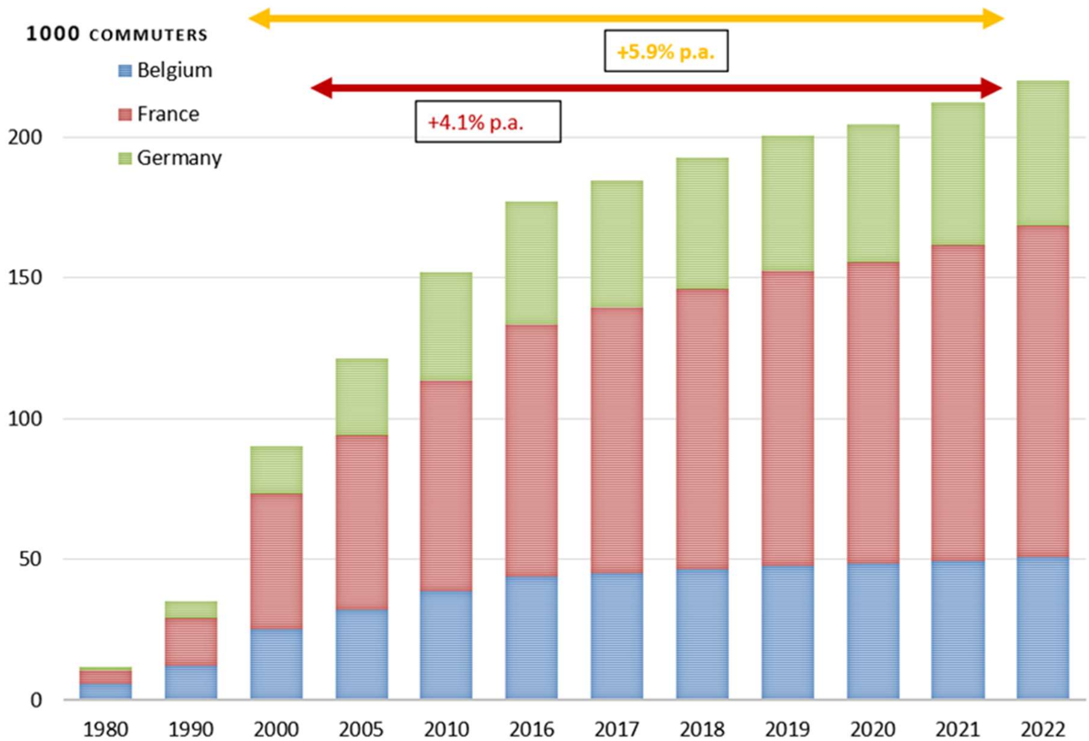
A vast majority of workers from abroad commute by car.[22] However, in order to alter the current modal split of home-work journeys, Luxembourg invests predominantly and jointly with the neighbouring regions into the public transport offer. Since 2020, public transportation services are free of charge in Luxembourg.

20 Figures indicated in this paragraph are annual cumulative averages.

21 Calculated from STATEC: https://lustat.statec.lu/vis?pg=0&df[ds]=ds-release&df[id]=DF_B3107&df[ag]=LU1&df[vs]=1.0&pd=2015%2C2021&dq=.A&tm=frontaliers

22 According to a recent study, for 2010, it was estimated that 86% of the cross-border commuters were only using their car for their home-work journeys. This percentage was 91% in 2007: http://www.ceps.lu/?type=module&id=104&tmp=1900.

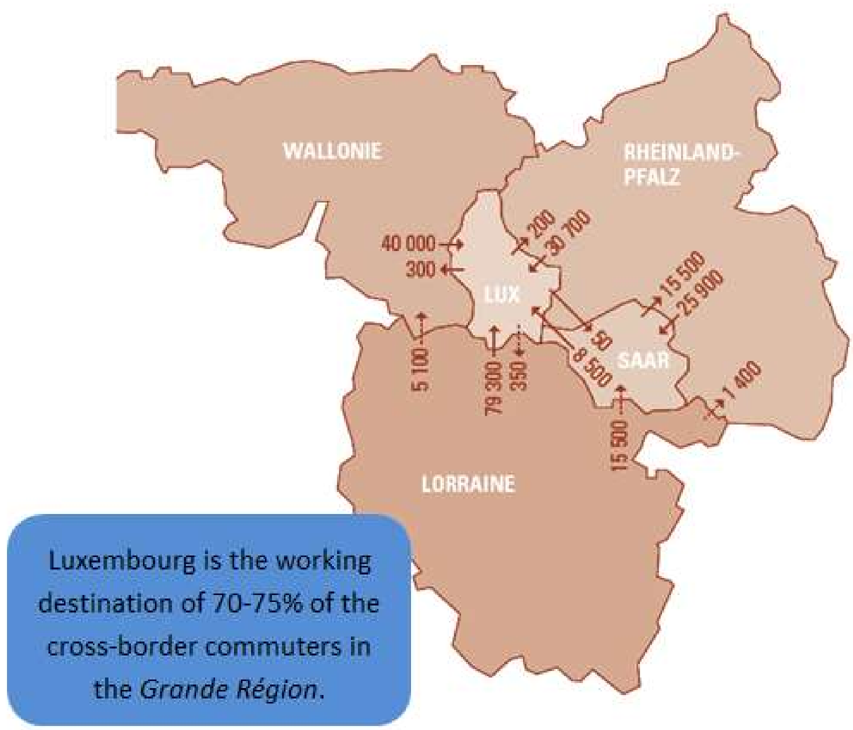
Figure 14 – Cross-border commuters' growth: annual cumulative averages 1980-2022



Source: STATEC (updated 03.04.2024):

https://lustat.statec.lu/vis?pg=0&df[ds]=ds-release&df[id]=DF_B3107&df[ag]=LU1&df[vs]=1.0&pd=2015%2C2021&dq=.A&tm=frontaliers

Figure 15 – Commuting flows 2015



Source: INSEE, IGSS, STATEC, IWEPS, Statistisches Amt Saarland, Statistisches Landesamt Rheinland-Pfalz: http://www.statistiques.public.lu/stat/TableViewer/document.aspx?ReportId=498&IF_Language=fra&MainTheme=2&FldrName=3&RFPath=92..

2.1.3 Economic Profile

One of the main characteristics of economic growth in Luxembourg is its volatility. Generally speaking, the economic cycle in Luxembourg follows that of other European countries, but the amplitude of the GDP variations is more pronounced. This is a common feature of small economies, open to the outside world, and therefore more vulnerable to external shocks. It would however appear that over the past ten years the amplitude of GDP variations in Luxembourg has diminished, as has the gap in relation to the European cycle.

The economic restructuring and development of the country towards the tertiary sector from the 1960s-70s, led to the following economic cycles since 1990:

- up to 1992, the continuation of the exceptional growth initiated around 1985;
- the effects of the economic slowdown in Luxembourg during the period between 1992 and 1996 and the economic downturn in 2001 – as well as the less impressive growth in 2002-2004 – which is mirrored by a stagnation of the GDP level per inhabitant in Luxembourg in comparison with the EU-15;
- the good economic performance of Luxembourg between 2005 and 2008;
- the financial and economic crisis that started at the end of 2008 and that has been particularly pronounced in the first semester of 2009;
- from 2010 onwards, a very slow recovery could be observed, though it flattened quickly for the industry and commercial sectors.

Nowadays, **gross value added** is mainly generated in the financial intermediation (banking and insurances), real estate and services to business sector. The share of total gross value added in this branch has increased from about 37.9% in 1995 to 48.4% in 2021.[23] While the commercial sector has maintained a relatively constant share at about 15 to 19%, the share of the industry sector has decreased significantly from 15% in 1995 to 6.6% in 2021. Other service activities ranged between a share of 18 to 26% and construction kept a rather constant share in total gross value added around 6%. The contribution of the agricultural sector is negligible with less than 1% (Table & Figure 16).

Nevertheless, emissions trends in Luxembourg are not so much influenced by the economic profile of the country, but for the most part by:

- the energy-mix for both production and consumption of fuels (liquid, solid, gaseous, biomass): more on this in the next section;
- due to its size and the size of its energy and industrial sector, structural changes in these sectors that could be initiated by a single entity;
- road transportation related fuel sales: more on this in Section 2.1.6

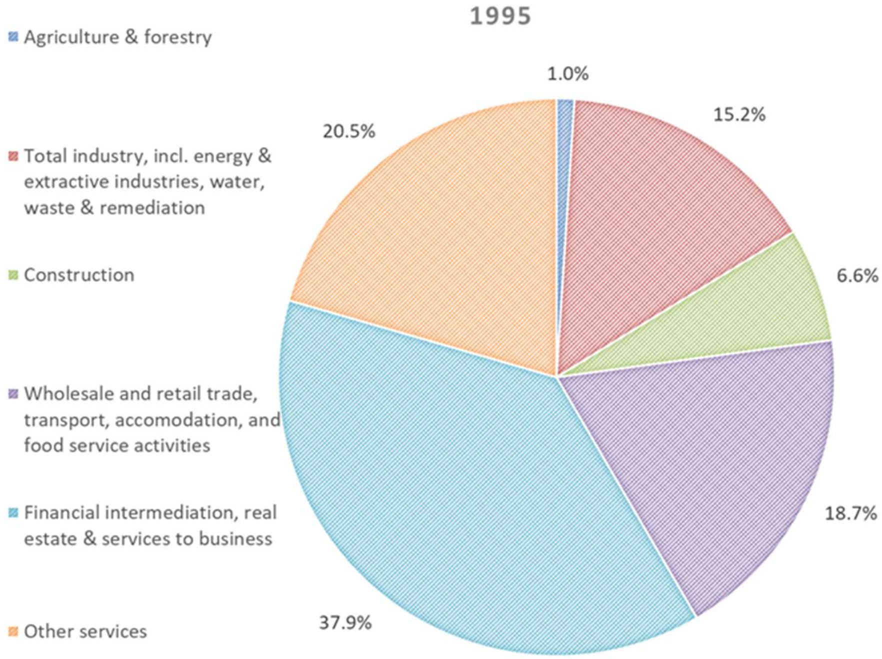
[23] Data prior to 1995 are and will not be translated into the new European System of Accounts (ESA).

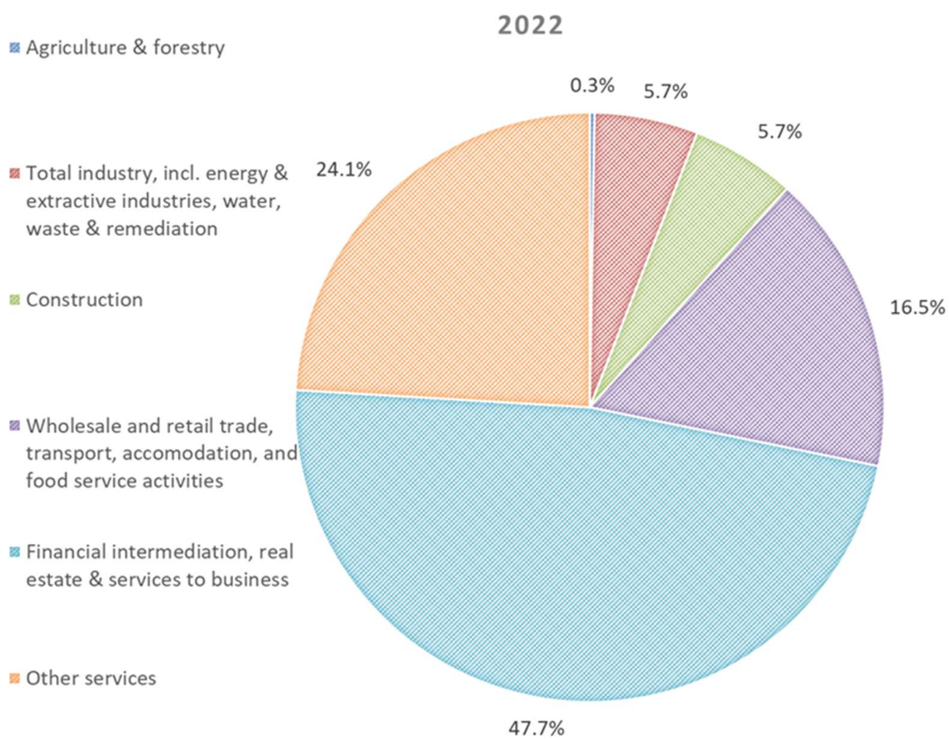
Table 2-3 – Sectoral gross value added at current prices: 1995-2022

mio. EUR		1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Agriculture, forestry & fishing (A)		142	137	108	107	137	123	91	114	111	134	129	150	121	120	136	141	134	128	138	187
	%	1.0%	0.7%	0.4%	0.3%	0.4%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.2%	0.2%	0.3%	0.3%	0.2%	0.2%	0.2%	0.3%
Total industry, including extractive industries, energy production & distribution, water supply, sewerage, waste		2087	2571	2857	2946	3528	3169	2381	2657	2701	2652	2837	3122	3663	4001	3487	3703	3913	3975	4199	4008
management and remediation activities (B to E)	%	15.2%	12.5%	10.6%	9.6%	10.5%	8.8%	6.8%	6.9%	6.8%	6.4%	6.4%	6.7%	7.4%	7.8%	6.6%	6.8%	6.9%	6.7%	6.4%	5.7%
Construction (F)		908	1257	1524	1675	1921	1954	1917	2007	2046	2199	2290	2477	2585	2798	2806	2898	3328	3324	3559	4053
	%	6.6%	6.1%	5.7%	5.5%	5.7%	5.4%	5.5%	5.2%	5.1%	5.3%	5.2%	5.4%	5.2%	5.4%	5.3%	5.3%	5.9%	5.6%	5.4%	5.7%
Wholesale and retail trade, transport,		2569	3524	4236	4707	4757	5743	5446	6112	7191	6930	7303	7559	7613	7903	8418	8593	8789	9068	10448	11654
accomodation (G-I)	%	18.7%	17.2%	15.7%	15.3%	14.1%	16.0%	15.5%	16.0%	18.1%	16.6%	16.6%	16.3%	15.4%	15.4%	15.9%	15.7%	15.5%	15.4%	15.9%	16.5%
Financial and insurance activities; real estate activities; professional, scientific and technical activities;		5196	8593	11879	14537	16082	17307	16845	18445	18332	19728	21142	22151	24172	25114	26007	26304	26719	27868	31611	33684
administrative and support service activities (K to N)	%	37.9%	41.9%	44.2%	47.4%	47.8%	48.1%	48.0%	48.2%	46.1%	47.3%	48.0%	47.9%	48.8%	48.9%	49.1%	48.1%	47.1%	47.3%	48.0%	47.7%
Other services: information and communication; public administration, defence, education, human health and social work activities; arts, entertainment and recreation;		2820	4420	6291	6713	7233	7701	8436	8901	9421	10040	10320	10796	11384	11450	12157	12992	13887	14526	15916	16982
Oher service activities; activities of household (J & O to P)	%	20.5%	21.6%	23.4%	21.9%	21.5%	21.4%	24.0%	23.3%	23.7%	24.1%	23.4%	23.3%	23.0%	22.3%	22.9%	23.8%	24.5%	24.7%	24.2%	24.1%
Total: all NACE rev2 branches		**13722**	**20502**	**26894**	**30684**	**33658**	**35998**	**35117**	**38236**	**39801**	**41683**	**44019**	**46255**	**49537**	**51386**	**53011**	**54632**	**56771**	**58889**	**65870**	**70568**
Annual growth rate - current prices					**13.8%**	**9.7%**	**2.8%**	**-3.1%**	**9.1%**	**7.2%**	**1.7%**	**5.4%**	**6.9%**	**5.1%**	**3.5%**	**3.9%**					
Annual growth rate - constant prices/in volume					**5.7%**	**8.5%**	**-1.5%**	**-4.6%**	**5.0%**	**2.0%**	**-0.8%**	**3.6%**	**3.9%**	**4.1%**	**2.5%**	**1.7%**					

Source: STATEC (updated 3 April 2024): https://lustat.statec.lu/vis?pg=0&tm=E2304&hc[dataflowId]=DF_E2304&df[ds]=ds-release&df[id]=DF_E2304&df[ag]=LU1&df[vs]=1.0&pd=2015%2C2022&dq=.A

Figure 16 – Sectoral gross value added at current prices: 1995 & 2022





Source: STATEC (updated 3 April 2024):

2.1.4 Energy

2.1.4.1 A total change in Luxembourg's energy-mix

Primary and final energy consumption in Luxembourg experienced dramatic changes since 1990. Overall primary energy consumption increased by 19.6% between 1990 and 2022. Whereas solid fuels and coal declined by 96.6% over the period, liquid fuels (incl. kerosene) and natural gas consumptions increased by 47.8% and 22.8% respectively (Table & Figure 17).

Table 2-4 – Primary energy consumption: 1990-2022

TJ	1990 (base year)	1991	1992	1993	1994	1995	1996	1997	1998
Solid fuels & coal	49939.83	45812.91	43145.01	44770.76	38726.29	22010.21	20893.02	13306.17	4861.42
	33.23%	28.98%	27.20%	27.75%	24.76%	15.90%	14.78%	9.57%	3.57%
Liquid fuels (incl. kerosene)	66030.62	76910.67	79078.34	78994.97	78578.11	72455.60	74715.90	77882.37	82209.79
	43.94%	48.66%	49.86%	48.97%	50.24%	52.35%	52.85%	56.00%	60.30%
Natural gas (1)	19925.91	20717.94	21593.35	22427.07	22593.81	25819.65	28324.39	29023.46	29305.68
	13.26%	13.11%	13.61%	13.90%	14.45%	18.65%	20.03%	20.87%	21.50%
Electricity	13256.15	13464.58	13631.32	14006.50	15423.82	17083.75	16644.80	17889.96	18859.16
	8.82%	8.52%	8.59%	8.68%	9.86%	12.34%	11.77%	12.86%	13.83%
Heat	NO	NO	NO	NO	NO	NO	NO	NO	NO
	NA	NA	NA	NA	NA	NA	NA	NA	NA
Renewable energy sources & waste	1125.52	1167.21	1167.21	1125.52	1083.84	1042.15	808.71	964.61	1100.93
Incineration (with heat recovery) (2)	0.75%	0.74%	0.74%	0.70%	0.69%	0.75%	0.57%	0.69%	0.81%
Total	**150278.03**	**158073.31**	**158615.23**	**161324.82**	**156405.87**	**138411.36**	**141386.82**	**139066.58**	**136336.98**

TJ	1999	2000	2001	2002	2003	2004	2005	2006	2007
Solid fuels & coal	4814.73	4594.52	4957.84	3083.62	2369.15	3328.54	3248.87	3876.79	3280.32
	3.33%	2.96%	3.02%	1.79%	1.31%	1.65%	1.58%	1.91%	1.65%
Liquid fuels (incl. kerosene)	87715.26	96236.54	102063.69	104261.62	111789.85	126709.57	130884.49	124310.30	121227.03
	60.72%	61.99%	62.27%	60.42%	61.74%	62.91%	63.82%	61.24%	60.92%
Natural gas (1)	30397.85	31231.01	34718.00	49629.00	50238.00	55632.00	54720.18	57237.24	53426.14
	21.04%	20.12%	21.18%	28.76%	27.74%	27.62%	26.68%	28.20%	26.85%
Electricity	19580.75	21059.69	19649.82	12952.77	13931.02	12698.58	12323.47	13490.64	14981.85
	13.55%	13.56%	11.99%	7.51%	7.69%	6.30%	6.01%	6.65%	7.53%
Heat	NO	0.03	1.21	4.04	6.43	8.86	11.54	14.48	19.65
	NA	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%	0.01%
Renewable energy sources & waste	1946.32	2128.82	2520.68	2630.06	2736.22	3041.45	3883.23	4049.26	6063.63
Incineration (with heat recovery) (2)	1.35%	1.37%	1.54%	1.52%	1.51%	1.51%	1.89%	1.99%	3.05%
Total	**144454.91**	**155250.60**	**163911.23**	**172561.09**	**181070.66**	**201419.00**	**205071.80**	**202978.71**	**198998.62**

TJ	2008	2009	2010	2011	2012	2013	2014	2015	2016
Solid fuels & coal	3136.57	2801.27	2745.48	2475.56	2295.39	2200.64	2180.81	2060.54	2132.32
	1.57%	1.48%	1.37%	1.26%	1.20%	1.19%	1.21%	1.16%	1.19%
Liquid fuels (incl. kerosene)	122653.44	114781.92	120101.37	122553.58	118269.72	116290.12	112065.91	110129.11	109970.55
	61.51%	60.83%	60.08%	62.57%	61.77%	62.65%	62.11%	61.77%	61.60%
Natural gas (1)	50856.70	51751.75	55665.22	48021.10	48894.89	41398.28	39223.62	35770.96	32988.07
	25.51%	27.43%	27.85%	24.52%	25.54%	22.30%	21.74%	20.06%	18.48%
Electricity	16412.67	12987.43	15290.40	16677.00	15567.70	18791.88	18634.28	21238.39	23821.51
	8.23%	6.88%	7.65%	8.51%	8.13%	10.12%	10.33%	11.91%	13.34%
Heat	26.29	36.03	50.68	63.92	80.70	98.72	116.07	141.14	166.65
	0.01%	0.02%	0.03%	0.03%	0.04%	0.05%	0.06%	0.08%	0.09%
Renewable energy sources & waste	6310.98	6320.76	6052.85	6067.59	6363.53	6846.43	8208.16	8956.07	9453.39
Incineration (with heat recovery) (2)	3.17%	3.35%	3.03%	3.10%	3.32%	3.69%	4.55%	5.02%	5.30%
Total	**199396.66**	**188679.15**	**199905.99**	**195858.76**	**191471.93**	**185626.07**	**180428.85**	**178296.21**	**178532.49**

TJ	2017	2018	2019	2020	2021	2022
Solid fuels & coal	1972.66	1748.41	1915.81	1609.51	1761.99	1719.63
	1.07%	0.91%	0.99%	0.95%	0.98%	1.06%
Liquid fuels (incl. kerosene)	115043.66	121479.76	122897.51	99811.13	107180.82	97620.46
	62.45%	63.55%	63.68%	59.17%	59.67%	60.18%
Natural gas (1)	32244.57	31802.53	31822.35	28901.45	31159.23	24469.59
	17.50%	16.64%	16.49%	17.13%	17.35%	15.08%
Electricity	23785.11	23858.70	23030.57	21847.96	22761.51	22173.88
	12.91%	12.48%	11.93%	12.95%	12.67%	13.67%
Heat	198.33	233.02	262.38	305.56	347.26	393.33
	0.11%	0.12%	0.14%	0.18%	0.19%	0.24%
Renewable energy sources & waste	10981.21	12030.51	13068.76	16222.48	16423.53	15847.67
Incineration (with heat recovery) (2)	5.96%	6.29%	6.77%	9.62%	9.14%	9.77%
Total	**184225.53**	**191152.94**	**192997.38**	**168698.09**	**179634.33**	**162224.55**

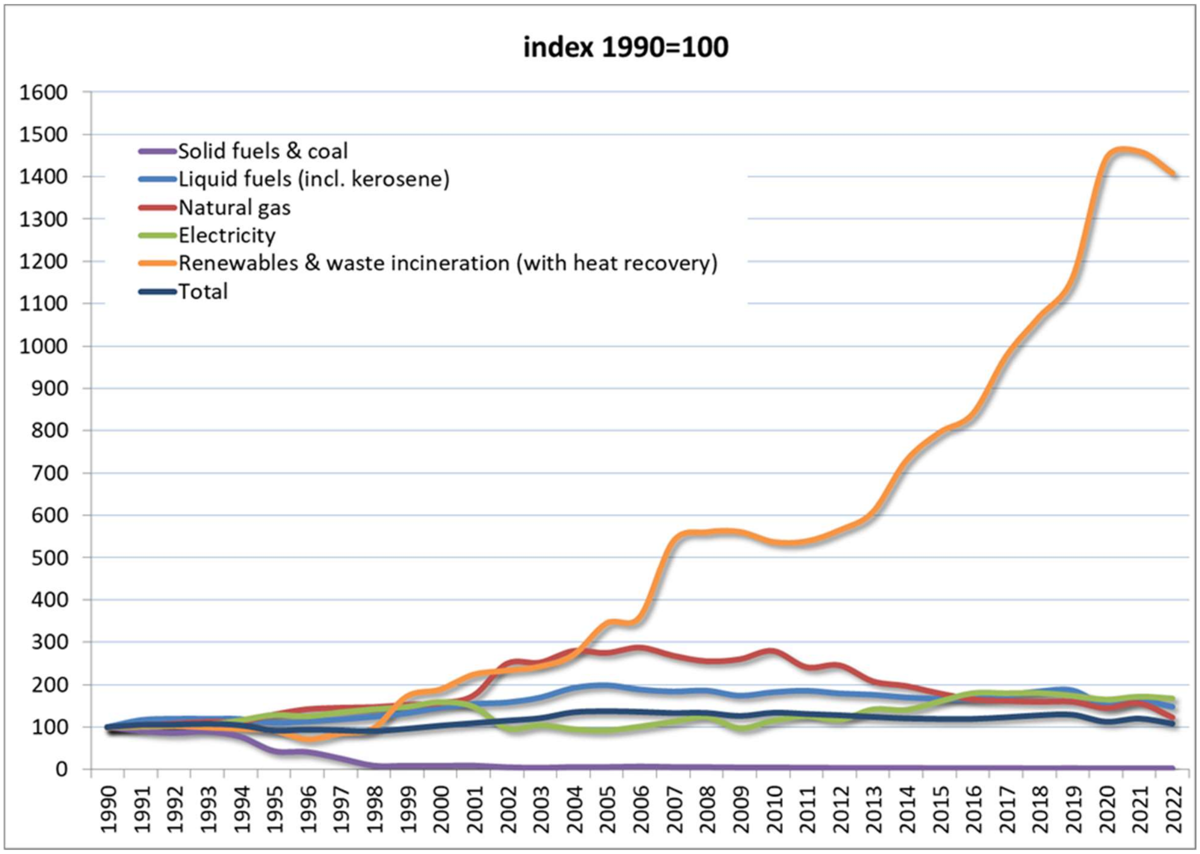
Source: STATEC, STATEC, Table A.4200 (updated 3 April 2024):

https://lustat.statec.lu/vis?pg=0&tm=a%204200&hc[dataflowId]=DF_A4200&hc[dimensions]=Sp%C3%A9cification&hc[Fr%C3%A9quence]=Annuelle&df[ds]=ds-release&df[id]=DF_A4200&df[ag]=LU1&df[vs]=1.0&pd=2015%2C2021&dq=.A.A01&ly[cl]=TIME_PERIOD&ly[rw]=SPECIFICATION

Notes: (1) Natural gas is expressed in GCV;

(2) Only the organic fraction of waste is counted. The biogas included as renewable energy source is expressed in GCV that also comprises blended biofuels. There is a break in the time-series between 1999 & 2000 (II).

Figure 17 –Primary energy consumption: 1990-2022



Source: STATEC, Table A.4200 (updated 3 April 2024):

https://lustat.statec.lu/vis?pg=0&tm=a%204200&hc[dataflowId]=DF_A4200&hc[dimensions]=Sp%C3%A9cification&hc[Fr%C3%A9quence]=Annuelle&df[ds]=ds-release&df[id]=DF_A4200&df[ag]=LU1&df[vs]=1.0&pd=2015%2C2021&dq=.A.A01&ly[cl]=TIME_PERIOD&ly[rw]=SPECIFICATION

Final energy consumption increased by 8.4% between 1990 and 2022. As for primary energy consumption, all the energy sources have seen their consumption increase over the period, except solid fuels and coal and blast furnace gases (Table & Figure 18).

Over the period 1990-2022, the final energy-mix of Luxembourg changed considerably with a dropping share for solid fuels – for which the main part was used in the iron and steel industry – in favour of liquid fuels and natural gas and, to a lesser extent, to new energy sources based on biomass. Indeed, in 2022, 77.3% of the final energy consumption was covered by fossil fuels – 62.1% by liquid fuels including the important volume of road fuels as well as kerosene,[24] 14.2% by natural gas and 1.1% by solid fuels and coal. The remaining

[24] Diesel being the first liquid fuel in terms of volumes sold. The liquid fuel consumption in Luxembourg is much lower than the level of fuel sales, because large amounts of road fuels are bought by foreign commuters and transit traffic passing through Luxembourg: see section 2.1.6 below.

22.7% of the consumption were either electricity (14.2%) and heat (3.5%) or renewable energy sources, including organic waste incineration with energy recovery, biogas, and biofuels (5.0%). Going back to 1990, 23.8% of the final energy consumption was stemming from solid fuels and coal, 46.0% from liquid fuels, 13.5% from natural gas and 10.4% from electricity (Table & Figure 18). The following elements caused the shift from 1990 to 2021 in terms of final energy consumption.

- Regarding solid fuels and coal, the important decline (-95.0%) is the result of a change in production processes in the steel industry sector: the production process was moved from blast furnaces to electric arc furnaces between 1994 and 1998 and, therefore, solid fuels (mainly imported coke, but also imported anthracite) were replaced, to a very large extent, by electricity and natural gas;
- Liquid fuels increase (+46.5%) was driven by road fuel sales and kerosene, but with the former being 4 to 5 times higher in quantity than the latter. This is especially "road fuel sales to non-residents" that explains a great deal of the sharp increase (see Section 2.1.6);
- The 13.7% increase in natural gas final consumption followed the continuous extension of the natural gas network in Luxembourg so that this fuel ranked second after the consumption of liquid fuels in 2022 – and even first if "road fuel sales to non-residents" and kerosene are not considered.

Due to the COVID-19 pandemic, the fuels that are used in the industry and for transportation saw a strong decrease from 2019 to 2020. The strongest decline, however, was observed for liquid fuels (incl. kerosene) where the 2020 consumption was 18.7% lower than in 2019. In 2021, all fossil fuels saw an increase again, but their consumption remained below the 2019 levels. In 2022, all fossil fuels decreased again due to the high energy prices.

Table 2-5 – Final energy consumption: 1990-2022

TJ	1990 (base year)	1991	1992	1993	1994	1995	1996	1997	1998
Solid fuels & coal	34331.76	30814.85	29475.07	30689.24	27268.21	16035.03	15670.77	10422.20	4882.65
	23.83%	20.38%	19.46%	19.85%	18.05%	11.91%	11.35%	7.64%	3.60%
Liquid fuels (incl. kerosene)	66193.31	76911.52	78669.97	78837.44	78753.71	72682.85	74734.38	78046.98	82554.07
	45.95%	50.87%	51.93%	51.00%	52.14%	53.99%	54.13%	57.20%	60.90%
Natural gas (1)	19426.75	20389.72	21227.08	22064.44	21989.91	23906.63	26251.24	27155.58	27436.94
	13.49%	13.49%	14.01%	14.27%	14.56%	17.76%	19.01%	19.90%	20.24%
Blast furnaces gas	8'457.34	7'234.79	6'196.46	6'514.24	5'503.55	2'731.89	2'511.66	1'347.31	NO
	5.87%	4.79%	4.09%	4.21%	3.64%	2.03%	1.82%	0.99%	NA
Electricity	14988.74	15198.08	15281.82	15826.10	16747.20	18045.11	17710.16	18254.45	19091.81
	10.41%	10.05%	10.09%	10.24%	11.09%	13.40%	12.83%	13.38%	14.08%
Heat (2)	NO	NO	NO	NO	125.60	586.15	547.21	563.54	949.98
	NA	NA	NA	NA	0.08%	0.44%	0.40%	0.41%	0.70%
Renewable energy sources & waste	644.77	644.77	644.77	644.77	644.77	644.77	644.77	644.77	644.77
Incineration (with heat recovery) (3)	0.45%	0.43%	0.43%	0.42%	0.43%	0.48%	0.47%	0.47%	0.48%
Total	**144042.67**	**151193.72**	**151495.17**	**154576.24**	**151032.95**	**134632.42**	**138070.20**	**136434.83**	**135560.21**

TJ	1999	2000	2001	2002	2003	2004	2005	2006	2007
Solid fuels & coal	4835.75	4594.52	4957.84	3083.62	2369.15	3328.54	3248.87	3876.79	3280.32
	3.39%	3.07%	3.16%	1.95%	1.41%	1.78%	1.71%	2.07%	1.77%
Liquid fuels (incl. kerosene)	88082.74	94660.74	100748.47	103139.16	110837.88	125735.24	130190.32	123620.38	120557.57
	61.67%	63.27%	64.30%	65.18%	65.84%	67.37%	68.35%	65.86%	65.22%
Natural gas (1)	28435.91	28125.74	27997.84	28258.28	28673.98	29942.32	29338.04	30622.60	29822.71
	19.91%	18.80%	17.87%	17.86%	17.03%	16.04%	15.40%	16.32%	16.13%
Blast furnaces gas	NO	NO	NO	NO	NO	NO	NO	NO	NO
	NA	NA	NA	NA	NA	NA	NA	NA	NA
Electricity	19835.80	20790.21	21033.19	21260.54	22252.42	23007.38	22149.43	23806.48	24097.50
	13.89%	13.90%	13.42%	13.44%	13.22%	12.33%	11.63%	12.68%	13.04%
Heat (2)	986.41	503.93	623.54	1084.56	2815.05	3031.39	3050.00	3203.55	2572.81
	0.69%	0.34%	0.40%	0.69%	1.67%	1.62%	1.60%	1.71%	1.39%
Renewable energy sources & waste	644.77	929.70	1321.31	1405.98	1406.76	1586.77	2489.86	2562.50	4518.54
Incineration (with heat recovery) (3)	0.45%	0.62%	0.84%	0.89%	0.84%	0.85%	1.31%	1.37%	2.44%
Total	**142821.40**	**149604.80**	**156682.20**	**158232.10**	**168355.20**	**186631.70**	**190466.50**	**187692.30**	**184849.50**

TJ	2008	2009	2010	2011	2012	2013	2014	2015	2016
Solid fuels & coal	3136.57	2801.27	2745.48	2475.56	2295.39	2200.64	2180.81	2060.54	2132.32
	1.68%	1.61%	1.49%	1.36%	1.29%	1.25%	1.28%	1.21%	1.24%
Liquid fuels (incl. kerosene)	121629.35	113546.50	118873.18	121286.04	116795.34	114971.98	110843.99	108958.23	108686.97
	65.13%	65.37%	64.50%	66.46%	65.80%	65.49%	65.13%	64.14%	63.16%
Natural gas (1)	30616.00	28658.82	31411.99	27916.40	28262.17	27789.82	26536.40	27791.20	29226.32
	16.40%	16.50%	17.04%	15.30%	15.92%	15.83%	15.59%	16.36%	16.98%
Blast furnaces gas	NO	NO	NO	NO	NO	NO	NO	NO	NO
	NA	NA	NA	NA	NA	NA	NA	NA	NA
Electricity	23750.44	22004.89	23734.71	23343.11	22449.55	22315.52	22256.43	22406.96	22922.20
	12.72%	12.67%	12.88%	12.79%	12.65%	12.71%	13.08%	13.19%	13.32%
Heat (2)	2907.26	2457.70	3002.57	3059.72	2993.01	3167.93	2445.50	2288.41	2367.73
	1.56%	1.42%	1.63%	1.68%	1.69%	1.80%	1.44%	1.35%	1.38%
Renewable energy sources & waste	4697.03	4219.33	4540.66	4414.70	4700.14	5103.19	5938.31	6360.25	6742.48
Incineration (with heat recovery) (3)	2.52%	2.43%	2.46%	2.42%	2.65%	2.91%	3.49%	3.74%	3.92%
Total	**186736.65**	**173688.50**	**184308.58**	**182495.52**	**177495.59**	**175549.07**	**170201.43**	**169865.59**	**172078.03**

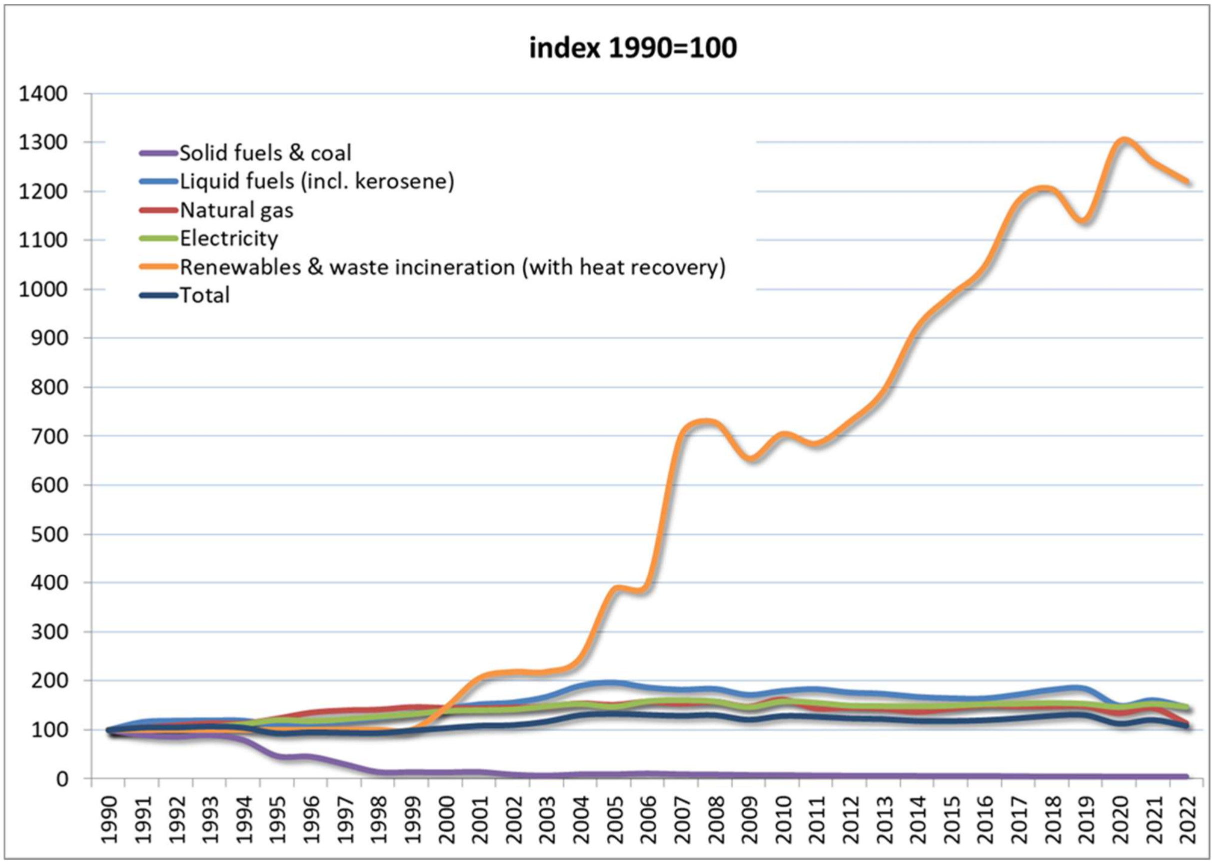
TJ	2017	2018	2019	2020	2021	2022
Solid fuels & coal	1972.66	1748.41	1915.81	1609.51	1761.99	1719.63
	1.11%	0.95%	1.03%	0.99%	1.02%	1.10%
Liquid fuels (incl. kerosene)	113904.45	120388.23	121854.08	99061.70	106364.91	96941.56
	64.02%	65.09%	65.21%	60.97%	61.43%	62.09%
Natural gas (1)	28751.14	28761.50	28845.58	26020.92	28074.40	22092.54
	16.16%	15.55%	15.44%	16.02%	16.21%	14.15%
Blast furnaces gas	NO	NO	NO	NO	NO	NO
	NA	NA	NA	NA	NA	NA
Electricity	23015.79	23251.37	23029.02	22030.23	23014.29	22115.27
	12.94%	12.57%	12.32%	13.56%	13.29%	14.16%
Heat (2)	2668.88	3028.45	3844.64	5353.81	5826.51	5390.91
	1.50%	1.64%	2.06%	3.30%	3.36%	3.45%
Renewable energy sources & waste	7599.27	7766.05	7361.13	8387.12	8117.97	7869.54
Incineration (with heat recovery) (3)	4.27%	4.20%	3.94%	5.16%	4.69%	5.04%
Total	**177912.18**	**184944.00**	**186850.25**	**162463.28**	**173160.07**	**156129.45**

Source: STATEC, Table A.4300 (updated 3 April 2024):

https://lustat.statec.lu/vis?pg=0&tm=a%204300&hc[dataflowId]=DF_A4300&hc[dimensions]=Sp%C3%A9cifica-tion&hc[Fr%C3%A9quence]=Annuelle&df[ds]=ds-release&df[id]=DF_A4300&df[ag]=LU1&df[vs]=1.0&pd=2015%2C2021&dq=A.A01.

Notes: (1) Natural gas is expressed in GCV;
(2) from 2000 onwards, heat that is consumed by the cogeneration power plants themselves is no longer included, hence there is a break in the time series (II);
(3) only the organic fraction of waste is counted. The biogas included as renewable energy source is expressed in GCV that also comprises blended
biofuels. There is a break in the time series between 1999 & 2000 (II).

Figure 18 – Final energy consumption: 1990-2022



Natural gas has also become the main energy source of Luxembourg's national electricity production capacity. In 1990, more than 90% of Luxembourg's electric energy consumption was imported and one medium size power plant of about 70 MW was run by the iron and steel company Arbed.[25] That power plant was mainly run on blast furnace gas – a side product of the blast furnaces in the steel industry – and was phased out in 1998 after the last blast furnace went out of service. In the early 1990s, small combined heat-power (CHP) installations (or cogeneration) plants appeared. Their installation was encouraged financially by the Government. This development was followed later by some industrial companies which installed gas turbines to produce electricity and heat simultaneously. In mid-2002, the ultra-modern TWINerg power plant started its commercial operation. Located in Esch-sur-Alzette, TWINerg is a gas and steam turbine power station running on natural gas, with an electrical output of 376 MWel (efficiency 55.7%).[26] If almost all of these cogeneration plants run on natural gas, gas oil remains the emergency fuel in case of a natural gas supply disruption.

25 Then Arcelor and now, ArcelorMittal.
26 http://www.twinerg.lu/en_index.html, "Environment" tab and http://www.ilr.public.lu/gaz/documents/statistiques/rapport2011.pdf, p. 29.

The impact of TWINerg on the primary energy consumption mix is clearly visible in Table 2-6 and its associated Figure 19 : electricity imports dropped and natural gas primary consumption increased in 2002, while in 2015 they reverted back to similar values than in 2001. After a few years of reduced activity, the TWINerg plant was finally shut down in 2016. To complement this analysis, an energy balance for electric power is provided (Table 2-6 & Figure 19).

Table 2-6 – Energy balance for electrical energy: 1990-2022

GWh	1990 (base year)	1991	1992	1993	1994	1995	1996	1997	1998
Net import	4665.46	4718.45	4523.56	4440.97	5015.24	5693.47	5712.33	6026.52	6366.60
Net national production	1322.04	1327.54	1144.30	1019.29	1150.11	1236.06	1251.78	1243.99	1311.39
Net inland consumption	4163.54	4221.69	4244.95	4396.14	4652.00	5012.53	4919.49	5070.68	5303.28

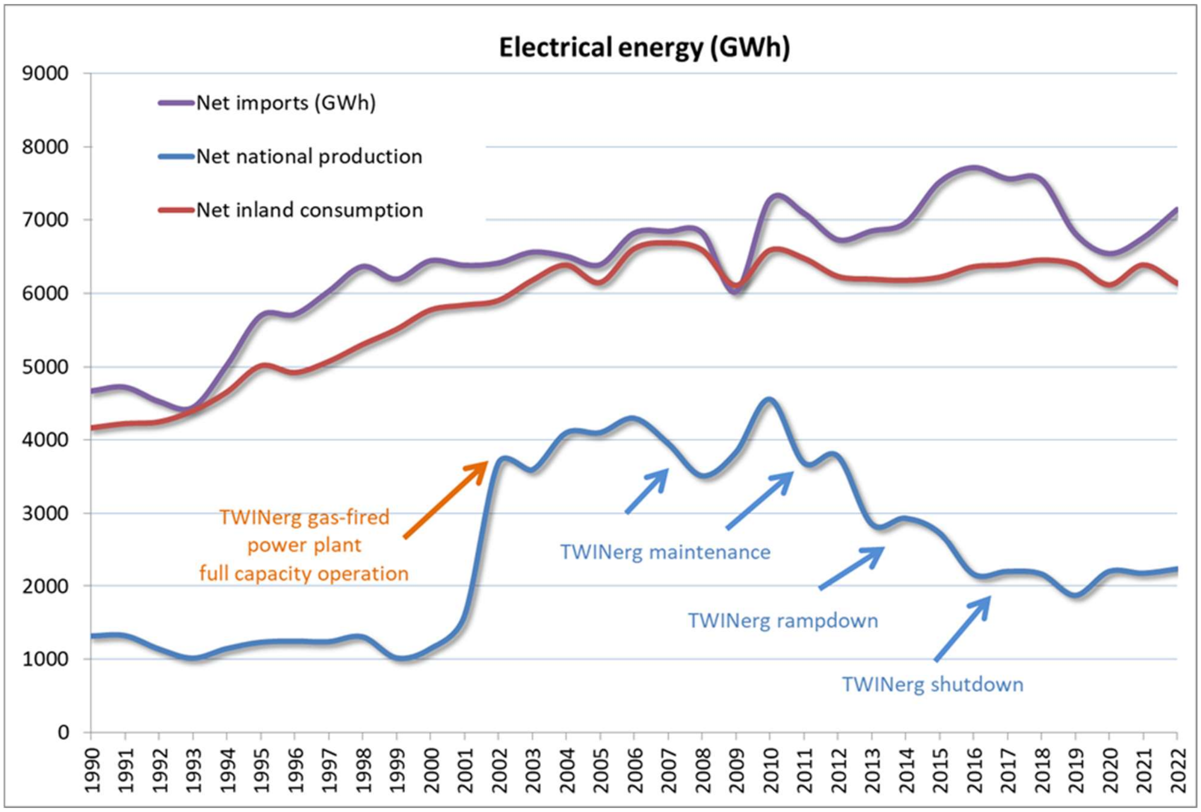
GWh	1999	2000	2001	2002	2003	2004	2005	2006	2007
Net import	6193.53	6445.38	6383.25	6413.64	6562.18	6506.31	6391.61	6823.54	6846.58
Net national production	1311.39	1022.59	1148.34	1591.96	3687.51	3597.10	4102.05	4104.41	4301.31
Net inland consumption	5509.95	5775.06	5842.55	5905.71	6181.23	6390.94	6152.62	6612.91	6693.75

GWh	2008	2009	2010	2011	2012	2013	2014	2015	2016
Net import	6829.87	6022.47	7279.51	7096.34	6732.10	6851.52	6961.18	7518.76	7718.39
Net national production	3516.43	3835.95	4560.28	3693.17	3786.31	2859.81	2937.81	2737.71	2167.69
Net inland consumption	6597.35	6112.47	6592.97	6484.20	6235.99	6198.76	6182.34	6224.16	6367.28

GWh	2017	2018	2019	2020	2021	2022
Net import	7566.69	7553.01	6817.52	6543.49	6758.47	7146.09
Net national production	2204.81	2170.45	1877.38	2205.48	2179.71	2238.26
Net inland consumption	6393.27	6458.71	6396.95	6119.51	6392.86	6143.13

Source: STATEC, Tables A.4203, A.4208, A.4300 (updated 3 April 2024)

Figure 19 –Energy balance for electric power: 1990-2022



Sources: Compiled by the Environment Agency on 3 April 2024 using data published by the Ministry of the Economy – Energy Department, the Institut Luxembourgeois de Régulation and STATEC (Tables A.4203, A.4208, A.4300).

Notes: (1) The net national production is the difference between the national production and the conversion process uses and losses.

2.1.5 Road Transportation - Diverse Inland and Cross-border Road Transport Flows

Luxembourg's location and its economic development have made it a focal point for international road traffic. Luxembourg is located at the heart of the main traffic axes for Western Europe and, therefore, has traditionally had a high volume of road transit traffic for both goods (freight transport) and passengers (tourists on their way to or back from southern Europe). The latter has increased even further by the high number of commuter journeys observed every working day. In comparison with international traffic, domestic traffic plays only a relatively small role since it is responsible for approx. only one quarter of the total road fuels sold in Luxembourg.

Road traffic is also the largest source of emissions in Luxembourg. Fuel quantities sold at Luxembourg’s petrol stations, are much larger than the quantities of fuel consumed by vehicles driving on the territory of Luxembourg. Hence, a large amount of air pollutant emissions is actually emitted mostly abroad. This phenomenon is referred to as “road fuel sales to non-residents”, whether they are in transit or commuting for work or leisure, or as “road fuel export in the vehicle tank”. Indeed, due to a policy of low taxed fuel (gasoline and diesel), Luxembourg is an attractive “fuelling station” for daily commuters from neighbouring countries and cross-border shoppers, but, in first instance, for international road transit traffic crossing its territory (mainly freight transport). “Road fuel sales to non-residents” is briefly defined in Box 2-2.

With numerous trucks transiting through Luxembourg, as well as a passenger cars market dominated by diesel vehicles in at least two of its neighbouring countries – namely Belgium and France – it is not surprising that diesel oil is the first liquid fuel in terms of volumes sold.

The allocation of fuel used on Luxembourg's territory (fuel used) and the fuel exported (fuel export) to neighbouring countries is not made on the basis of statistics or counting, but well using a specific transport model (NEMO). The sum of "fuel used" and "fuel export" gives the amount of "fuel sold" in Luxembourg as reported by most energy statistics. Details are provided in Chapter 3 in the specific section of Road Transportation.

Box 2-2 – "Road fuel sales to non-residents" or "Road fuel exports"

It covers fuel sales to non-residents, *i.e.*:

1. Road vehicles in transit: freight trucks, buses & coaches, passenger cars, whose an important share fills up in Luxembourg because of lower fuel prices;
2. Cross-border commuters who are also benefiting of the cheaper fuel prices;
3. "Fuel tourism", known as "*Tanktourismus*" in Luxembourg: people driving especially to Luxembourg for benefiting of lower fuel prices, as well as lower prices on other commodities such as non-alcoholic & alcoholic drinks, tobacco, *etc.* (Luxembourg usually applies the lower taxation rates adopted at EU levels).

2.1.6 Air Pollutant Emission Reductions: a Demanding Challenge for Luxembourg

2.1.6.1 The Road Transportation Dilemma

Since Luxembourg is a small open economy integrated in the European internal market **where mobility of tax bases are likely to be high**, only marginal variations in the price differentials for petrol and diesel can be initiated by the authorities. Indeed, if Luxembourg's rates of taxation and prices were higher than those in the surrounding countries, it would be rather easy for any citizen of Luxembourg to avoid domestic taxation and to practise arbitrage: no location in Luxembourg is further than a maximum of 25-30 km away from a border with a neighbouring country. Lower taxation rates for certain goods – such as fuels, e.g. – have therefore always been part of Luxembourg fiscal policy and will remain crucial in the future, because of the country's geographical location and its small area. Whereas in larger neighbouring states, increasing certain tax rates would result in a slight shift in demand and in arbitrage deals at the outer fringes of their national territory – with a corresponding relatively slight reduction in tax revenues – this would not be the case for Luxembourg where such a policy may result in big losses in tax incomes. However, since road transportation, and more precisely "road fuel sales to non-residents", is the main contributor to GHG emissions in Luxembourg, as underlined in the second national "Action Plan for reducing CO_2 emissions"[27], Luxembourg will use a policy mix of instruments with the aim of progressively reducing road transport related emissions.

[27] http://www.developpement-durableinfrastructures.
public.lu/fr/actualites/articles/2013/05/presentation_plan_action_climat/2_Nationaler-Aktionsplan-Klimaschutz.pdf

With regard to the instrument of excise duties, Luxembourg will gradually increase road fuels excise rates following a cautious approach based on a better knowledge of the factors determining road fuel sales in Luxembourg that also takes into account the impact on the public finances of the country. Furthermore, in its programme, the actual Government that took office early December 2013 underlines that a feasibility study on the progressive way out of “fuel tourism” – and more generally of “road fuel sales to non-residents” – should be realized so to evaluate the economic impacts of such a decision on the medium and long terms[28]. This study has been released in November 2016.[29] Its outcomes led to the setting-up of an inter-ministerial working group with the aim to inform the Government on possible venues to reduce the weight of road fuel sales in the GHG balance of Luxembourg, as well as making public finances less dependent from that source of income. In parallel, STATEC is working on evaluating price-elasticities of road fuel sales.

With regard to other instruments, the Luxembourg Government considers the organization of transport and the necessity to overcome existing problems linked to the traffic intensity as primary objectives. In this context, it promotes sustainable ways of transport consisting of public and non-motorized modes of transport. The re-organisation is intended to encompass both the national territory and the neighbouring regions of Germany, France and Belgium where many commuters come from, leading to a doubling of the workforce in Luxembourg during the day. All this is done in a conceptual way where new modes of transport such as electro-mobility and car sharing are promoted.

2.1.6.2 Country and economy sizes

Special attention must also be made for the small size of the country's economy in a different context: it is a contributory factor to the fact that, in spite of the healthy economic situation, the courses of the overall development of the country, of the demand for energy and of the emissions balance are often affected by a single plant which is starting its activities, closing them down or changing its production processes. This became particularly clear when the steel industry switch from blast furnaces to electric arc furnaces was completed during the 1990s.

Furthermore, the construction of a single power station, the TWINerg gas and steam plant, represents a further illustrative example as depicted in Section 2.1.5. When TWINerg started its operation in mid-2002, Luxembourg, which did not have so far any substantial electricity generating capacity, saw, at once, its emissions of GHG, increasing significantly per year. Air pollutant emissions, and in particular NO_X emissions, were also affected.

The impact that single industrial projects might have, plays also the other way round when a production unit or a plant is closed down. After a few years of reduced activity, the TWINerg power plant was finally shut down in 2016, which has a very high impact on Luxembourg’s total GHG and air pollutant emissions. Also, a sufficiently long breakdown in one of the main industrial unit of the country could have impacts on the total emissions, such as the long maintenance operations of the TWINerg plant in 2008 and 2011 demonstrated (cf. Figure 19).

If these issues might not be a major concern for large economies, it is for Luxembourg, as shown by the examples discussed above.

---

[28] http://www.gouvernement.lu/3322796/Programme-gouvernemental.pdf

[29] Ermittlung und Bewertung der positiven und negativen Wirkungen des Treibstoffverkaufs unter besonderer Berücksichtigung negativer externer Umwelt-und Gesundheitseffekte – Status quo 2012 und maßnahmeninduzierte Veränderungen, Bericht für das Ministerium für Nachhaltige Entwicklung und Infrastrukturen des Großherzogtums Luxemburg, Königswinter, 2016. (http://environnement.public.lu/fr/actualites/2016/11/etude_tt.html)

2.1.6.3 Limited Emission Reduction Potentials

As of today, Luxembourg **does not have those significant technical potentials** which exist in other countries where residual "old-technology" industrial and power plants still operate. In Luxembourg, there were almost none, and there still only very few of those air pollutant reduction potentials stemming from the modernisation or the replacement of existing industrial or power plants. In fact, with the move from blast to electric arc furnaces in the steel sector during the 1990s, Luxembourg very soon exhausted its only major technical potential for air pollutant emissions reduction. With the process change in the steel industry, total emissions from industry and electricity generation decreased significantly.

Also, any ultramodern fossil fuel-based electricity generating plant that Luxembourg might decide to construct will automatically lead to an increase of its national air pollutant emissions, since there are no existing power plants which can be stopped in return. Thus, those highly efficient CHP installations and the ultramodern gas and steam power station (TWINerg, shut down in 2016) that have been promoted and are operating in Luxembourg since 1998, and that use natural gas and, sometimes, gas oil as inputs, have led to an additional amount of air pollutant emissions. It is therefore clear that any new power generating installation or manufacturing industry that might be constructed will inevitably lead to a deterioration of Luxembourg's GHG or air pollutant balance.

2.1.7 National Circumstances: Overview

Key points that play a role on air pollutant emissions trends in the past and in the future are:

- a country characterized by both **high demographic** and **high economic growth** in a stagnating region, hence an **attractive economic destination**;
- **strong population growth** due to immigration and that is expected to go on;
- **even stronger cross-border commuters growth** that is expected as well to go on once the financial and economic crisis will be over;
- **increase of built-up areas** (housing, offices, services, infrastructures) as a consequence of the previous statements;
- location at the **heart** of the main Western Europe **transit routes** for both **goods and passengers**;
- **increase of transport flows** as a consequence of the previous statements;
- **small size** and open economy: a new industrial project, a technological change, a closure or a breakdown of a production unit might have significant impacts on the air pollutant emissions;
- **limitations in taxation policies** due to short distances to neighbouring countries;
- a country that **needs to co-operate and to interact with its neighbours** since environmental issues become quickly cross-border issues;
- **limited national** emission reduction potential.

2.2 Description of Emission Trends

The evolution of emissions during the last 30 years can essentially be explained by **changes in production techniques and abatement technologies**, as well as by **changes in the final "energy-mix" consumption, energy efficiency** and **economic and demographic growth**. Of course, **increasing or decreasing activities** for certain source categories also played a crucial role in Luxembourg's air pollutant emissions trend. During the last years, **the financial, sanitary, geopolitical and economic crisises and their aftermaths** also played a part.

A good example for a **technological change** in production took place in the iron and steel industry, where the steel production process was moved from blast furnaces to electric arc furnaces between 1994 and 1998 and, therefore, solid fuels (coke) were replaced, to a very large extent, by electricity and natural gas. Due to that technological change, the total energy consumption in the steel industry was significantly reduced and the "energy-mix" greatly modified. This process change was the main driver for the reduction in all emissions observed between 1994 and 1998. Changes also occurred in the industrial and residential/commercial/institutional sectors, where the consumption of liquid fuels (residual oil, gasoil) was reduced in favour of natural gas in conjunction with the extension of the natural gas network in Luxembourg. Lately, and due to climate change mitigation, the demand for renewable energy has increased substantially, impacting also air pollutant emissions.

The road transport sector, on the other hand, is a clear example on **how the interaction between activity levels of a source category can influence the overall emission trend**. Indeed, the upward trend for air pollutant emissions recorded from 1999 to 2004 was merely justified by increasing energy consumption and fuel sales in the transport sector. The stabilisation spotted for the inventory years 2004 to 2006 was largely the result of relatively steady sales of road fuels that peaked in 2005. Finally, the decrease in total emissions from 2006 to 2007 and the period of relative stability that followed was driven by a "road fuel sales to non-residents" related emissions reduction, which reached its lower level in 2009 (financial and economic crisis), combined with a diminution of air pollutant emissions from the power generation sector, the latter being exceptionally important for the years 2008, 2011 and 2012 when the main power plant of the country experienced maintenance or reduced activities which resulted in several months without substantial production.

A fundamental point worth mentioning when analysing Luxembourg's air pollutant emission trends and their composition over time, is **the small size of Luxembourg**, and therefore, the special nature of its economy. Indeed, the structure of the economy, the related energy demand and the energy and emission balances may vary significantly, whether a new economic activity starts its operations or an existing one ceases them. This characteristic explains, for instance, the reduction of emissions pertaining to the industrial sector– mainly after the re-organisation of the iron and steel industry which took place in the mid-90s and, more recently the closure of one of the steel production sites, or the closure of one of the flat glass production sites.

The following paragraphs, tables and figures describe the emission trends of the main pollutants.

2.2.1 SO_2 Emissions

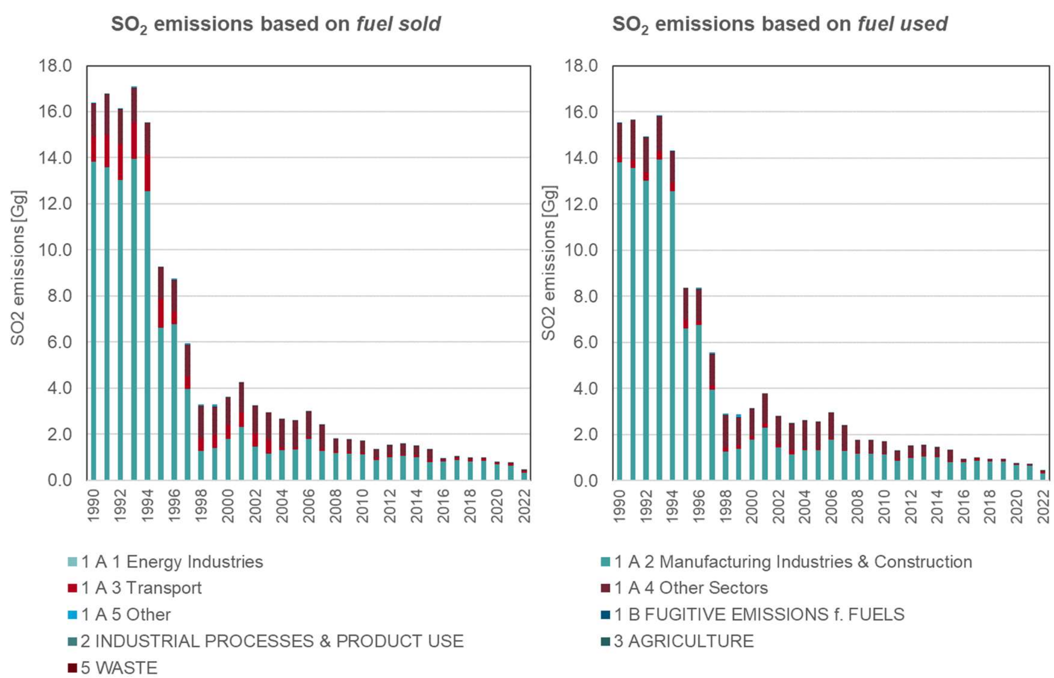
National total SO_2 emissions, based on fuel sold, amounted to 16.37 Gg in 1990 (Figure 20 and Table 2-7). Since then, emissions have decreased quite significantly in the period 1994-1998, due to the re-organisation in the *Iron and Steel Industry* (move from blast furnaces to electrical arc furnaces). In the year 2022, emissions were down by 97.3% compared to 1990 to 0.444 Gg, which was mainly due to lower emissions from combustion in manufacturing industries (*1A2*, especially *Iron and Steel industry*) and *1A4 Other Sectors*. In the period 2005 to 2022, SO_2 emissions decreased by 83.9%, which was mainly due to lower emissions from combustion in industries (especially *Non-metallic Minerals*) and residential heating. From 2021 to 2022, emissions decreased by 40.6% due to the fact that the remaining flat glass production facility was shut down for furnace renovation.

The main source for SO_2 emissions in Luxembourg, with a share of 35.6% in 2022, is *1A2a Iron and Steel Industry*, followed by the *1A3ai(i) Civil aviation – international LTO*, with a share of 11.6%. Other contributors to SO_2 emissions are category *1A2gviii Stationary combustion in manufacturing industries and construction: Other* with a share of 11.2% and category *1A4bi Residential stationary heating* with a share of 7.9% in 2022.

The constant decrease in emissions from all sectors is mainly due to:

- process changes in the iron and steel industry;
- lowering of the sulphur content in mineral oil products and fuels;
  - ⇨ implementation of the Fuel Quality Directive[30]
  - ⇨ since 2016, Belgium lowered the sulphur content in heating oil to a maximum of 50 ppm, and as Luxembourg is solely supplied by Belgium for heating oil, this low sulphur content is also observed in Luxembourg.
- fuel-switch from high sulphur fuels (*e.g.* solid and liquid) to low-sulphur fuels or to even sulphur free fuel (*e.g.* natural gas);
- installation of abatement techniques such as systems for purification of waste gases and desulphurisation facilities in industrial facilities;
  - ⇨ implementation of the Industrial Emissions Directive (IED)[31]

Figure 20 – SO_2 emission trend and share by category based on fuel sold and fuel used



[30] Directive 2009/30/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EEC; http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009L0030

[31] Directive 2010/75/EC of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (IED) https://eur-lex.europa.eu/legal-content/FR/ALL/?uri=CELEX%3A32010L0075

Table 2-7 – SO_2 emissions for 1990, 2005, 2021, 2022, Trend & Share in National Total based on fuel sold and fuel used

	SOx													
NFR Code	**Emissions**				**Trend**			**FUEL USED Share in National Total**			**FUEL SOLD Share in National Total**			**Fuel option**
	1990	**2005**	**2021**	**2022**	**1990 - 2022**	**2005 - 2022**	**2021 - 2022**	**1990**	**2005**	**2022**	**1990**	**2005**	**2022**	
1 A 1 a	0.004	0.010	0.027	0.025	535.6%	149.4%	-8.2%	0.03%	0.39%	5.86%	0.02%	0.39%	5.66%	fuel sold
1 A 1 b	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 1 c	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 2 a	12.136	0.200	0.185	0.158	-98.7%	-20.8%	-14.6%	78.10%	7.82%	36.90%	74.14%	7.70%	35.63%	fuel sold
1 A 2 b	0.029	0.063	0.034	0.034	19.2%	-44.9%	0.5%	0.19%	2.45%	8.04%	0.18%	2.41%	7.76%	fuel sold
1 A 2 c	0.643	0.003	0.001	0.006	-99.0%	91.5%	586.4%	4.14%	0.13%	1.45%	3.93%	0.13%	1.40%	fuel sold
1 A 2 d	IE	0.000	0.000	0.000	0.0%	-52.0%	-39.3%	IE	0.01%	0.02%	IE	0.01%	0.02%	fuel sold
1 A 2 e	0.010	0.012	0.018	0.018	82.6%	46.4%	-1.2%	0.06%	0.49%	4.26%	0.06%	0.48%	4.11%	fuel sold
1 A 2 f	0.758	0.988	0.277	0.029	-96.2%	-97.1%	-89.6%	4.88%	38.69%	6.74%	4.63%	38.11%	6.50%	fuel sold
1 A 2 g vii	0.042	0.001	0.002	0.002	-95.4%	105.6%	3.1%	0.27%	0.04%	0.46%	0.26%	0.04%	0.44%	fuel sold
1 A 2 g viii	0.197	0.055	0.098	0.050	-74.8%	-9.3%	-49.6%	1.27%	2.14%	11.55%	1.20%	2.11%	11.15%	fuel sold
1 A 3 a i (i)	0.027	0.045	0.036	0.051	87.3%	13.7%	43.7%	0.18%	1.77%	11.97%	0.17%	1.74%	11.56%	fuel sold
1 A 3 a ii (i)	0.000	0.000	0.000	0.000	150.1%	-12.5%	-10.2%	0.00%	0.00%	0.02%	0.00%	0.00%	0.02%	fuel sold
1 A 3 b i	0.259	0.014	0.010	0.010	-96.1%	-28.9%	1.7%				1.58%	0.55%	2.28%	fuel sold
	0.079	0.005	0.005	0.006	-92.7%	13.2%	5.1%	0.51%	0.20%	1.34%				fuel used
1 A 3 b ii	0.026	0.001	0.001	0.001	-96.1%	20.8%	-9.6%				0.16%	0.03%	0.23%	fuel sold
	0.026	0.001	0.001	0.001	-96.1%	20.8%	-9.6%	0.16%	0.03%	0.24%				fuel used
1 A 3 b iii	0.785	0.032	0.018	0.013	-98.3%	-58.9%	-26.3%				4.80%	1.25%	3.00%	fuel sold
	0.135	0.002	0.002	0.002	-98.2%	2.7%	7.3%	0.87%	0.09%	0.57%				fuel used
1 A 3 b iv	0.000	0.000	0.000	0.000	-86.9%	44.9%	4.9%				0.00%	0.00%	0.01%	fuel sold
	0.000	0.000	0.000	0.000	-86.9%	44.9%	4.9%	0.00%	0.00%	0.01%				fuel used
1 A 3 b v	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 b vi	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 b vii	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 c	0.020	0.003	0.003	0.002	-89.6%	-25.7%	-19.4%	0.13%	0.11%	0.49%	0.12%	0.11%	0.47%	fuel sold
1 A 3 d i (ii)	0.000	0.000	0.000	0.000	-99.8%	-87.5%	55.9%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
1 A 3 d ii	0.001	0.000	0.000	0.000	-99.6%	-64.9%	28.4%	0.01%	0.00%	0.00%	0.01%	0.00%	0.00%	fuel sold
1 A 3 e i	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 3 e ii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 4 a i	0.578	0.234	0.010	0.008	-98.6%	-96.6%	-21.7%	3.72%	9.15%	1.83%	3.53%	9.01%	1.76%	fuel sold
1 A 4 a ii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
1 A 4 b i	0.823	0.931	0.027	0.035	-95.7%	-96.2%	30.9%	5.30%	36.47%	8.19%	5.03%	35.92%	7.91%	fuel sold
1 A 4 b ii	0.000	0.000	0.000	0.000	-96.0%	-11.9%	0.2%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
1 A 4 c i	0.010	0.000	0.000	0.000	-98.7%	-25.5%	467.6%	0.06%	0.01%	0.03%	0.06%	0.01%	0.03%	fuel sold
1 A 4 c ii	0.021	0.000	0.000	0.000	-99.3%	-19.6%	3.2%	0.13%	0.01%	0.04%	0.13%	0.01%	0.03%	fuel sold
1A 4 c iii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 5 a	0.000	NO	NO	NO	NO	NO	NO	0.00%	NO	NO	0.00%	NO	NO	fuel sold
1 A 5 b	0.000	0.000	0.000	0.000	-99.3%	-19.0%	0.0%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
1 B	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	fuel sold
2	0.000	0.000	0.000	0.000	328.7%	-81.1%	-14.7%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
3	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	fuel sold
5	IE/NA/NO/NE	IE/NA/NO/NE	IE/NA/NO/NE	IE/NA/NO/NE	IE/NA/NO/NE	IE/NA/NO/NE	IE/NA/NO/NE	IE/NA/NO/NE	IE/NA/NO/NE	IE/NA/NO/NE	IE/NA/NO/NE	IE/NA/NO/NE	IE/NA/NO/NE	fuel sold
6 A	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
National total (fuel sold)	**16.369**	**2.593**	**0.748**	**0.444**	**-97.3%**	**-82.9%**	**-40.6%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**15.539**	**2.554**	**0.728**	**0.429**	**-97.2%**	**-83.2%**	**-41.1%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

2.2.2 NOX Emissions

National total NO_X emissions, based on fuel sold, amounted to 40.9 Gg in 1990 (Figure 21 and Table 2-8). Since then, emissions have decreased until 1998 but then increased again. In 2005, total NO_X emissions amounted to 56.9 Gg. In the year 2022, emissions were down by 71.9%, compared to 1990, to 11.5 Gg, which was mainly due to lower emissions from combustion in manufacturing industries. In the period 2005 to 2022, NO_X emissions decreased by 79.8%, which was mainly due to lower emissions from road transport (lower fuel sales combined with better abatement technologies) an lower emissions from manufacturing industries (closure of one of the flat glass production facilities in 2021, and shut down of the remaining facility for furnace renovation in 2022). From 2021 to 2022 emissions further decreased by 17.7%.

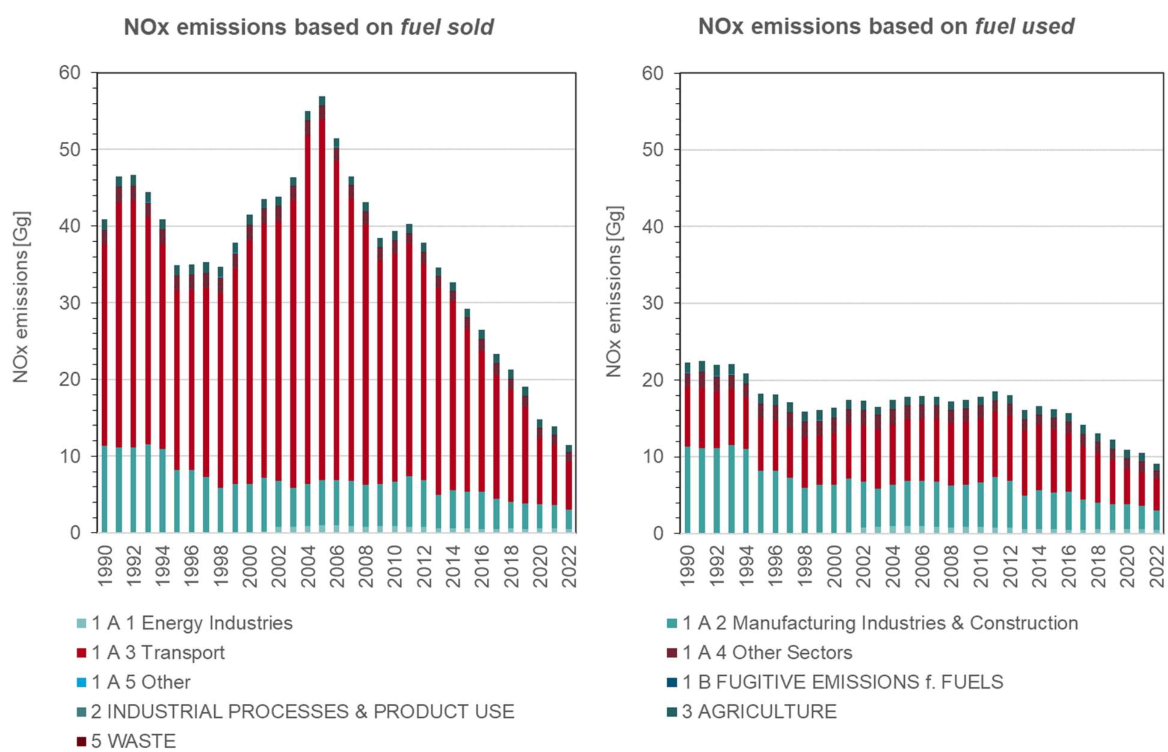
As shown in Figure 21 and Table 2-8, the main source for NO_X emissions in Luxembourg, with a share of 63% in 1990, 81% in 2005 and 46% in 2022, is *1A3b Road Transport*. In the past, a further major contributor to NO_X emissions was category *1A2a Iron and Steel*

Industry with a share of 17% in 1990 but only 2.7% in 2005 and 3.4% in 2022. Nowadays the second major contributor is category *1A3ai(i) Civil Aviation- International LTO* with a share of 1.3% in 2005 and 9.0% in 2022.

The decrease in emissions from all sectors is mainly due to:

- Implementation of advanced automotive technologies (petrol cars, heavy duty vehicles);
  - ⇨ implementation of the "EURO" Standard legislations[32]
- Continuous fleet renewal;
- Implementation of abatement techniques in industrial facilities like flue-gas abatement techniques (*e.g.* NO_X scrubbers and selective catalytic and non-catalytic reduction techniques – SCR and SNCR);
  - ⇨ implementation of the Industrial Emissions Directive (IED)[33]
- Introduction of combustion modification technologies (*e.g.* the use of low NO_X burners, which reduce formation of NO_X in combustion);
- Fuel switch from coal to gas (which has significantly lower NO_X emissions per unit energy).

Figure 21 – NO_X emission trend and share by category based on fuel sold and fuel used



---

[32] Light-duty vehicles, Directive 98/70/EC, Heavy-duty vehicles: Directive 2005/55/EC (agreed in co-decision) and Directive 2005/78/EC (implementing provisions).Motor vehicle emissions have originally been regulated by Directive 70/220/EEC (light-duty vehicles) and 88/77/EC (heavy-duty vehicles) and amendments to those directives. A whole series of amendments have been issued to stepwise tighten the limit values. The Auto-Oil Programme focused on the emissions of carbon monoxide (CO), volatile organic compounds (VOC), nitrogen oxides (NOx) and particles. It resulted in the Euro 3 and Euro 4 stages for light-duty vehicles as laid down in Directive 98/70/EC and in the Euro III and IV standards for heavy duty vehicles (Directive 1999/96/EC, now repealed), as well as the fuel quality Directive 98/70/EC.
http://ec.europa.eu/environment/air/transport/road.htm

[33] Directive 2010/75/EC of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (IED) https://eur-lex.europa.eu/legal-content/FR/ALL/?uri=CELEX%3A32010L0075

Table 2-8 – NO_X emissions for 1990, 2005, 2021, 2022, Trend & Share in National Total based on fuel sold and fuel used

	NOx													
NFR Code	**Emissions**				**Trend**			**FUEL USED Share in National Total**			**FUEL SOLD Share in National Total**			**Fuel option**
	1990	**2005**	**2021**	**2022**	**1990 - 2022**	**2005 - 2022**	**2021 - 2022**	**1990**	**2005**	**2022**	**1990**	**2005**	**2022**	
1 A 1 a	0.0314	0.9650	0.6059	0.4783	1424%	-50%	-21%	0.14%	5.40%	5.23%	0.08%	1.70%	4.17%	fuel sold
1 A 1 b	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 1 c	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 2 a	6.9339	1.5350	0.5155	0.3875	-94%	-75%	-25%	31.11%	8.59%	4.24%	16.97%	2.70%	3.38%	fuel sold
1 A 2 b	0.0604	0.0869	0.0753	0.0815	35%	-6%	8%	0.27%	0.49%	0.89%	0.15%	0.15%	0.71%	fuel sold
1 A 2 c	0.1859	0.1946	0.0804	0.0608	-67%	-69%	-24%	0.83%	1.09%	0.66%	0.45%	0.34%	0.53%	fuel sold
1 A 2 d	IE	0.0274	0.0217	0.0132	1%	-52%	-39%	IE	0.15%	0.14%	IE	0.05%	0.11%	fuel sold
1 A 2 e	0.0048	0.0154	0.0133	0.0199	319%	29%	50%	0.02%	0.09%	0.22%	0.01%	0.03%	0.17%	fuel sold
1 A 2 f	3.3758	2.7201	0.9252	0.7309	-78%	-73%	-21%	15.14%	15.23%	7.99%	8.26%	4.78%	6.37%	fuel sold
1 A 2 g vii	0.6331	1.2571	0.9642	0.8967	42%	-29%	-7%	2.84%	7.04%	9.81%	1.55%	2.21%	7.81%	fuel sold
1 A 2 g viii	0.0941	0.0889	0.4650	0.3576	280%	302%	-23%	0.42%	0.50%	3.91%	0.23%	0.16%	3.12%	fuel sold
1 A 3 a i (i)	0.3412	0.7372	0.9536	1.0314	202%	40%	8%	1.53%	4.13%	11.28%	0.83%	1.30%	8.99%	fuel sold
1 A 3 a ii (i)	0.0002	0.0007	0.0007	0.0006	150%	-12%	-10%	0.00%	0.00%	0.01%	0.00%	0.00%	0.01%	fuel sold
1 A 3 b i	10.9611	9.8923	3.7283	3.2468	-70%	-67%	-13%				26.82%	17.38%	28.29%	fuel sold
	4.5779	3.5538	2.1733	1.9410	-58%	-45%	-11%	20.54%	19.90%	21.22%				fuel used
1 A 3 b ii	0.2993	0.7115	0.6360	0.4927	65%	-31%	-23%				0.73%	1.25%	4.29%	fuel sold
	0.2993	0.7115	0.6360	0.4927	65%	-31%	-23%	1.34%	3.98%	5.39%				fuel used
1 A 3 b iii	14.4798	35.5533	2.3539	1.4949	-90%	-96%	-36%				35.43%	62.47%	13.03%	fuel sold
	2.2883	2.8375	0.5122	0.4697	-79%	-83%	-8%	10.27%	15.89%	5.14%				fuel used
1 A 3 b iv	0.0058	0.0110	0.0095	0.0095	63%	-13%	0%				0.01%	0.02%	0.08%	fuel sold
	0.0058	0.0110	0.0095	0.0095	63%	-13%	0%	0.03%	0.06%	0.10%				fuel used
1 A 3 b v	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 b vi	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 b vii	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 c	0.2577	0.0989	0.0566	0.0443	-83%	-55%	-22%	1.16%	0.55%	0.48%	0.63%	0.17%	0.39%	fuel sold
1 A 3 d i (ii)	0.0013	0.0021	0.0001	0.0002	-84%	-90%	50%	0.01%	0.01%	0.00%	0.00%	0.00%	0.00%	fuel sold
1 A 3 d ii	0.0144	0.0169	0.0044	0.0053	-63%	-68%	22%	0.06%	0.09%	0.06%	0.04%	0.03%	0.05%	fuel sold
1 A 3 e i	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 3 e ii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 4 a i	0.8431	0.5295	0.5739	0.4320	-49%	-18%	-25%	3.78%	2.96%	4.72%	2.06%	0.93%	3.76%	fuel sold
1 A 4 a ii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
1 A 4 b i	0.6219	1.0338	0.6433	0.6034	-3%	-42%	-6%	2.79%	5.79%	6.60%	1.52%	1.82%	5.26%	fuel sold
1 A 4 b ii	0.0052	0.0078	0.0086	0.0086	65%	11%	0%	0.02%	0.04%	0.09%	0.01%	0.01%	0.08%	fuel sold
1 A 4 c i	0.0107	0.0093	0.0012	0.0070	-35%	-25%	468%	0.05%	0.05%	0.08%	0.03%	0.02%	0.06%	fuel sold
1 A 4 c ii	0.3284	0.2687	0.1568	0.1534	-53%	-43%	-2%	1.47%	1.50%	1.68%	0.80%	0.47%	1.34%	fuel sold
1A 4 c iii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 5 a	0.0033	NO	NO	NO	NO	NO	NO	0.01%	NO	NO	0.01%	NO	NO	fuel sold
1 A 5 b	0.0014	0.0014	0.0003	0.0002	-83%	-83%	-14%	0.01%	0.01%	0.00%	0.00%	0.00%	0.00%	fuel sold
1 B	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	fuel sold
2	0.0007	0.0007	0.0010	0.0010	59%	44%	2%	0.00%	0.00%	0.01%	0.00%	0.00%	0.01%	fuel sold
3 B	0.0197	0.0157	0.0159	0.0157	-20%	0%	-1%	0.09%	0.09%	0.17%	0.05%	0.03%	0.14%	fuel sold
3 D a	1.3516	1.1340	1.1306	0.9024	-33%	-20%	-20%	6.06%	6.35%	9.87%	3.31%	1.99%	7.86%	fuel sold
3 D b	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	fuel sold
3 D c	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
3 D d	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
3 D e	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	fuel sold
3 D f	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	fuel sold
3 F	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
3 I	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
5	IE/NA/NO/NE	IE/NA/NO/NE	IE/NA/NO/NE	IE/NA/NO/NE	IE/NA/NO/NE	IE/NA/NO/NE	IE/NA/NO/NE	IE/NA/NO/NE	IE/NA/NO/NE	IE/NA/NO/NE	IE/NA/NO/NE	IE/NA/NO/NE	IE/NA/NO/NE	fuel sold
6 A	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
National total (fuel sold)	**40.866**	**56.915**	**13.941**	**11.476**	**-71.9%**	**-79.8%**	**-17.7%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**22.291**	**17.861**	**10.545**	**9.145**	**-59.0%**	**-48.8%**	**-13.3%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

2.2.4 NMVOC Emissions

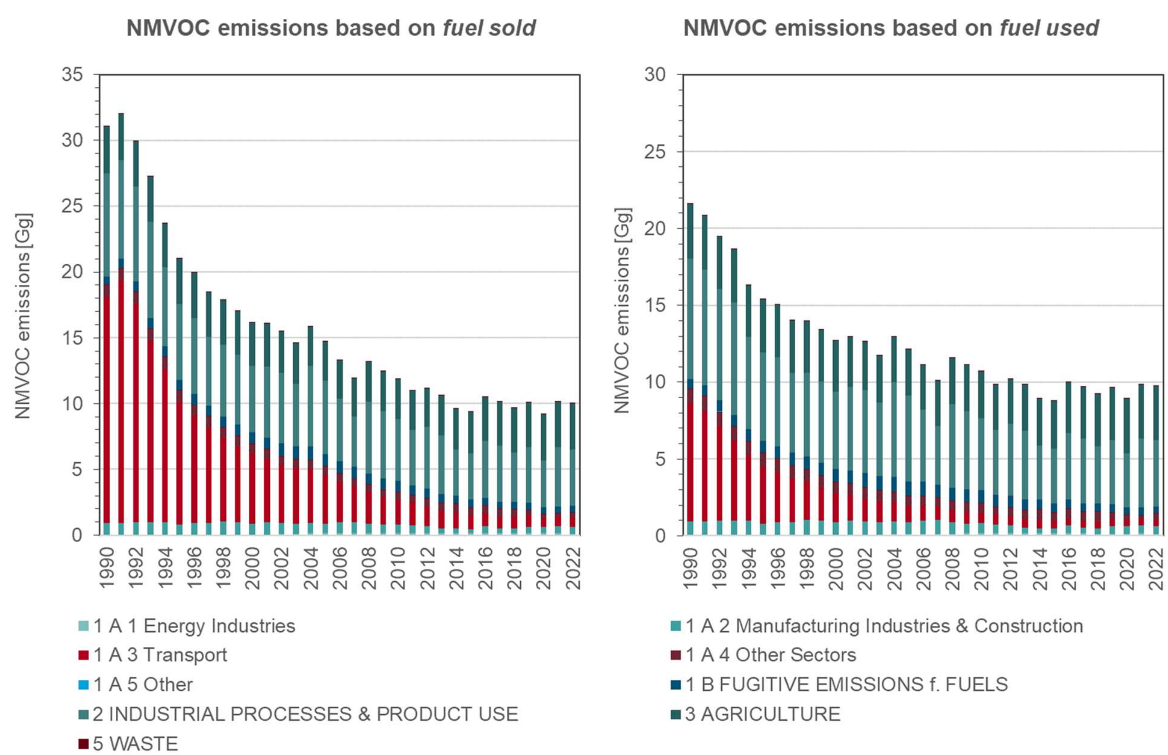
National total NMVOC emissions, based on fuel sold, amounted to 31.1 Gg in 1990 (Figure 22 and Table). Since then emissions have decreased steadily. In 2005 national total NMVOC emissions amounted to 14.7 Gg. In the year 2022, emissions were down by 67.8% compared to 1990 to 10.0 Gg, which was mainly due to lower emissions from solvent use (*2D3*) and due to lower emissions from road transport (*1A3b*). In the period 2005 to 2022, NMVOC emissions decreased by 32.1%. From 2021 to 2022 emissions increased by 1.7%.

As shown in Figure 22 and Table 2-9, the main source for NMVOC emissions in Luxembourg, with a share of 41.4% in 2022 is *2D3 Non-Energy Products from Fuels and Solvent Use* (24.8% in 1990 and 37.3% in 2005). A second contributor to NMVOC emissions, with a share of 27.1% in 2022, is *3B Manure management* (8.2% in 1990, 14.9% in 2005). Another major contributor to NMVOC emissions in Luxembourg, with a share of 6.2% in 2022, is *1A3b Road Transport* (54.9% in 1990 and 24.2% in 2005).

Although a certain stagnation in NMVOC emissions is observed in recent years, the decrease in emissions compared to 1990 is mainly due to:

- Implementation of advanced automotive technologies (petrol cars);
    - ⇨ implementation of the “EURO” Standard legislations[34]
- Implementation of limits and measures according to Solvent Directive and Paints Directive[35].

Figure 22 – NMVOC emission trend and share by category based on fuel sold and fuel used



[34] EU Directive 91/441/EC, Directive 94/12/EC (98/69/EC) 2005/55/EC and 2005/78/EC.
[35] VOC Solvents Directive (1999/13/EC) and Paints Directive (2004/42/EC).

Table 2-9 – NMVOC emissions for 1990, 2005, 2021, 2022, Trend & Share in National Total based on fuel sold and fuel used

NMVOC														
NFR Code	**Emissions**				**Trend**			**FUEL USED Share in National Total**			**FUEL SOLD Share in National Total**			**Fuel option**
	1990	**2005**	**2021**	**2022**	**1990 - 2022**	**2005 - 2022**	**2021 - 2022**	**1990**	**2005**	**2022**	**1990**	**2005**	**2022**	
1 A 1 a	0.001	0.137	0.152	0.102	9163.7%	-25.6%	-33.0%	0.01%	1.13%	1.05%	0.00%	0.93%	1.02%	fuel sold
1 A 1 b	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 1 c	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 2 a	0.593	0.253	0.100	0.089	-85.0%	-64.8%	-11.3%	2.74%	2.09%	0.92%	1.91%	1.72%	0.89%	fuel sold
1 A 2 b	0.133	0.197	0.060	0.068	-49.1%	-65.6%	13.6%	0.62%	1.62%	0.70%	0.43%	1.33%	0.68%	fuel sold
1 A 2 c	0.009	0.015	0.008	0.006	-33.1%	-58.2%	-22.1%	0.04%	0.12%	0.06%	0.03%	0.10%	0.06%	fuel sold
1 A 2 d	IE	0.007	0.006	0.003	0.3%	-52.0%	-39.3%	IE	0.06%	0.04%	IE	0.05%	0.03%	fuel sold
1 A 2 e	0.000	0.002	0.001	0.001	335.2%	-49.0%	-27.2%	0.00%	0.02%	0.01%	0.00%	0.01%	0.01%	fuel sold
1 A 2 f	0.074	0.059	0.011	0.010	-86.0%	-82.5%	-7.2%	0.34%	0.49%	0.11%	0.24%	0.40%	0.10%	fuel sold
1 A 2 g vii	0.104	0.155	0.026	0.025	-76.2%	-83.9%	-5.0%	0.48%	1.27%	0.26%	0.34%	1.05%	0.25%	fuel sold
1 A 2 g viii	0.010	0.048	0.336	0.341	3255.7%	604.3%	1.6%	0.05%	0.40%	3.51%	0.03%	0.33%	3.41%	fuel sold
1 A 3 a i (i)	0.034	0.056	0.045	0.064	87.3%	13.7%	43.7%	0.16%	0.46%	0.66%	0.11%	0.38%	0.64%	fuel sold
1 A 3 a ii (i)	0.001	0.004	0.004	0.004	150.1%	-12.5%	-10.2%	0.01%	0.03%	0.04%	0.00%	0.03%	0.04%	fuel sold
1 A 3 b i	12.044	2.000	0.377	0.369	-96.9%	-81.6%	-2.1%				38.76%	13.56%	3.69%	fuel sold
	5.210	0.546	0.159	0.165	-96.8%	-69.8%	3.8%	24.09%	4.50%	1.70%				fuel used
1 A 3 b ii	0.127	0.029	0.005	0.004	-96.6%	-85.4%	-15.9%				0.41%	0.20%	0.04%	fuel sold
	0.127	0.029	0.005	0.004	-96.6%	-85.4%	-15.9%	0.59%	0.24%	0.04%				fuel used
1 A 3 b iii	0.736	1.106	0.078	0.059	-92.0%	-94.7%	-24.5%				2.37%	7.50%	0.59%	fuel sold
	0.346	0.156	0.014	0.015	-95.8%	-90.6%	1.6%	1.60%	1.28%	0.15%				fuel used
1 A 3 b iv	0.142	0.162	0.130	0.126	-11.2%	-22.1%	-2.7%				0.46%	1.10%	1.26%	fuel sold
	0.142	0.162	0.130	0.126	-11.2%	-22.1%	-2.7%	0.66%	1.33%	1.30%				fuel used
1 A 3 b v	3.996	0.279	0.064	0.065	-98.4%	-76.9%	1.4%				12.86%	1.89%	0.65%	fuel sold
	1.776	0.078	0.029	0.031	-98.2%	-59.8%	7.1%	8.21%	0.64%	0.32%				fuel used
1 A 3 b vi	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 b vii	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 c	0.049	0.015	0.005	0.004	-91.4%	-71.6%	-21.5%	0.23%	0.12%	0.04%	0.16%	0.10%	0.04%	fuel sold
1 A 3 d i (ii)	0.001	0.001	0.000	0.000	-89.4%	-91.8%	49.5%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	fuel sold
1 A 3 d ii	0.021	0.018	0.003	0.003	-85.2%	-81.9%	26.8%	0.10%	0.14%	0.03%	0.07%	0.12%	0.03%	fuel sold
1 A 3 e i	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 3 e ii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 4 a i	0.093	0.038	0.067	0.052	-43.3%	38.6%	-21.7%	0.43%	0.31%	0.54%	0.30%	0.26%	0.52%	fuel sold
1 A 4 a ii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
1 A 4 b i	0.498	0.417	0.093	0.255	-48.7%	-38.8%	174.4%	2.30%	3.43%	2.62%	1.60%	2.83%	2.55%	fuel sold
1 A 4 b ii	0.258	0.170	0.072	0.072	-72.1%	-57.6%	0.2%	1.19%	1.40%	0.74%	0.83%	1.15%	0.72%	fuel sold
1 A 4 c i	0.002	0.000	0.000	0.000	-97.9%	-25.5%	467.6%	0.01%	0.00%	0.00%	0.01%	0.00%	0.00%	fuel sold
1 A 4 c ii	0.102	0.071	0.040	0.040	-61.0%	-44.2%	-1.7%	0.47%	0.59%	0.41%	0.33%	0.48%	0.40%	fuel sold
1A 4 c iii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 5 a	0.000	NO	NO	NO	NO	NO	NO	0.00%	NO	NO	0.00%	NO	NO	fuel sold
1 A 5 b	0.000	0.000	0.000	0.000	-85.1%	-73.1%	-2.5%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
1 B 1	NE/NO	NE/NO	NE/NO	NE/NO	NE/NO	NE/NO	NE/NO	NE/NO	NE/NO	NE/NO	NE/NO	NE/NO	NE/NO	fuel sold
1 B 2 a	0.409	0.293	0.172	0.184	-54.9%	-37.1%	6.9%	1.89%	2.41%	1.89%	1.32%	1.99%	1.84%	fuel sold
1 B 2 b	0.221	0.601	0.341	0.265	20.2%	-55.9%	-22.2%	1.02%	4.95%	2.72%	0.71%	4.08%	2.65%	fuel sold
1 B 2 c	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 B 3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
2 A	IE/NA/NO	IE/NA/NO	IE/NA/NO	IE/NA/NO	IE/NA/NO	IE/NA/NO	IE/NA/NO	IE/NA/NO	IE/NA/NO	IE/NA/NO	IE/NA/NO	IE/NA/NO	IE/NA/NO	fuel sold
2 B	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
2 C	IE/NO	IE/NO	IE/NO	IE/NO	IE/NO	IE/NO	IE/NO	IE/NO	IE/NO	IE/NO	IE/NO	IE/NO	IE/NO	fuel sold
2 D 3 a	1.856	1.652	2.090	2.012	8.4%	21.8%	-3.7%	8.58%	13.61%	20.68%	5.97%	11.20%	20.10%	fuel sold
2 D 3 b	0.009	0.005	0.031	0.030	228.8%	533.5%	-4.5%	0.04%	0.04%	0.31%	0.03%	0.03%	0.30%	fuel sold
2 D 3 c	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
2 D 3 d	2.118	1.446	0.759	0.686	-67.6%	-52.6%	-9.7%	9.79%	11.91%	7.05%	6.82%	9.81%	6.85%	fuel sold
2 D 3 e	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
2 D 3 f	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
2 D 3 g	0.280	0.438	0.398	0.508	81.2%	16.0%	27.7%	1.30%	3.61%	5.22%	0.90%	2.97%	5.08%	fuel sold
2 D 3 h	0.073	0.074	0.040	0.035	-51.6%	-52.3%	-10.8%	0.34%	0.61%	0.36%	0.23%	0.50%	0.35%	fuel sold
2 D 3 i	3.375	1.886	1.001	0.874	-74.1%	-53.7%	-12.7%	15.61%	15.53%	8.99%	10.86%	12.79%	8.73%	fuel sold
2 H	0.119	0.127	0.156	0.159	33.2%	25.4%	2.0%	0.55%	1.04%	1.64%	0.38%	0.86%	1.59%	fuel sold
2 I	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	fuel sold
2 J	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
2 K	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
2 L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	fuel sold
2 G	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
3 B	2.556	2.192	2.718	2.710	6.0%	23.6%	-0.3%	11.82%	18.05%	27.86%	8.23%	14.86%	27.08%	fuel sold
3 D a	0.900	0.669	0.671	0.666	-26.1%	-0.6%	-0.8%	4.16%	5.51%	6.84%	2.90%	4.54%	6.65%	fuel sold
3 D b	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	fuel sold
3 D c	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	fuel sold
3 D d	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	fuel sold
3 D e	0.108	0.111	0.109	0.109	0.6%	-2.5%	-0.2%	0.50%	0.92%	1.12%	0.35%	0.76%	1.09%	fuel sold
3 D f	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
3 F	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
3 I	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
5	0.016	0.014	0.008	0.007	-55.7%	-46.4%	-8.8%	0.08%	0.11%	0.07%	0.05%	0.09%	0.07%	fuel sold
6 A	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
National total (fuel sold)	**31.072**	**14.749**	**10.176**	**10.008**	**-67.8%**	**-32.1%**	**-1.7%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**21.628**	**12.143**	**9.860**	**9.727**	**-55.0%**	**-19.9%**	**-1.4%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

2.2.5 NH_3 Emissions

National total NH_3 emissions, based on fuel sold, amounted to 6.4 Gg in 1990. In 2005, national total NH_3 emissions amounted to 6.4 Gg. In the year 2022, emissions were down by 6.6% compared to 1990 to 5.9 Gg, which was mainly due to lower emissions from synthetic fertilizer use in agriculture in 2022. In the period 2005 to 2022, NH_3 emissions decreased by 6.7%. From 2021 to 2022 emissions decreased by 5.7%.

As shown in Figure 23 and Table 2-10, the two main sources for NH_3 emissions in Luxembourg were *3B1 Manure Management (dairy and non-dairy cattle),* with a share of 40.2% in 2022, and *3Da2a Animal Manure Applied to Soils*, with a share of 34.1%..

Figure 23 – NH_3 emission trends and shares by category based on fuel sold and fuel used

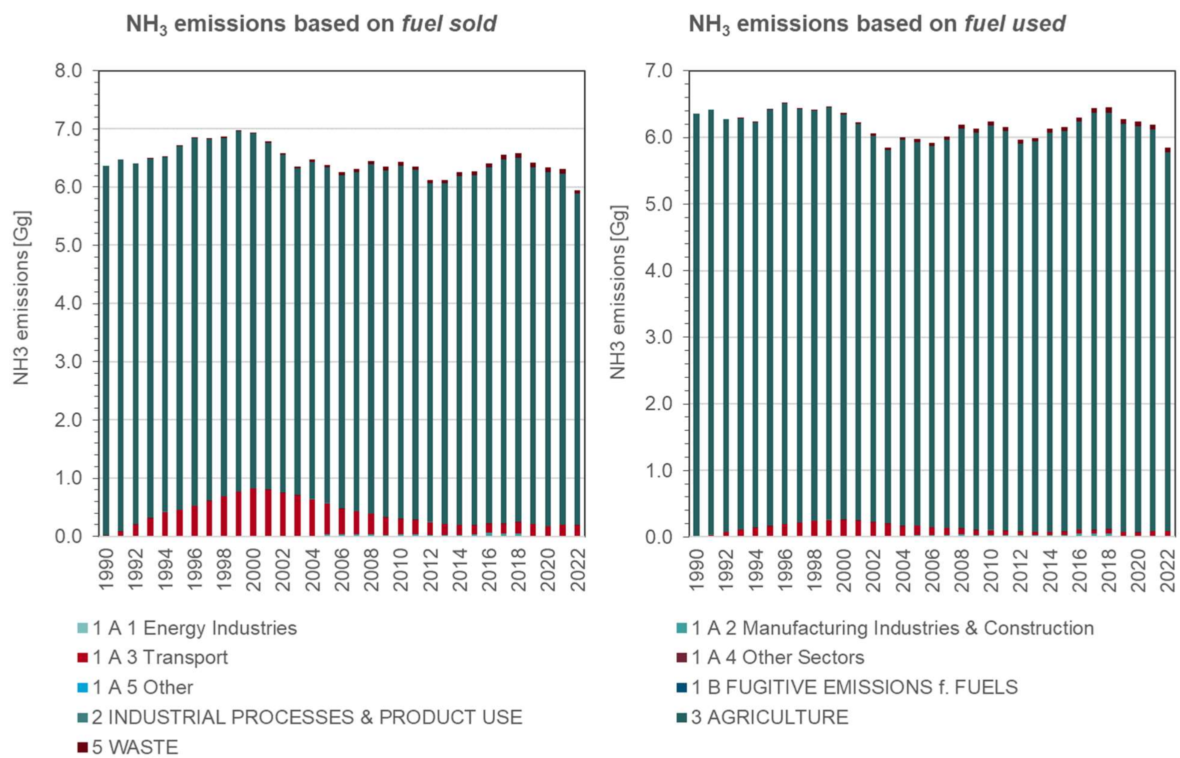


Table 2-10 – NH_3 emissions for 1990, 2005, 2021, 2022, Trend & Share in National Total based on fuel sold and fuel used

NH3														
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
1 A 1 a	NO	0.000	0.001	0.001	0.1%	2535.8%	-9.8%	NO	0.00%	0.02%	NO	0.00%	0.02%	fuel sold
1 A 1 b	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 1 c	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 2 a	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 2 b	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 2 c	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 2 d	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 2 e	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 2 f	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 2 g vii	0.000	0.000	0.000	0.000	90.0%	11.8%	2.8%	0.00%	0.01%	0.01%	0.00%	0.01%	0.01%	fuel sold
1 A 2 g viii	NO	0.034	0.012	0.006	0.6%	-83.4%	-51.8%	NO	0.57%	0.10%	NO	0.53%	0.09%	fuel sold
1 A 3 a i (i)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	fuel sold
1 A 3 a ii (i)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	fuel sold
1 A 3 b i	0.012	0.520	0.143	0.150	1100.7%	-71.2%	4.5%				0.20%	8.15%	2.52%	fuel sold
	0.005	0.133	0.063	0.071	1256.4%	-46.8%	11.2%	0.08%	2.22%	1.21%				fuel used
1 A 3 b ii	0.000	0.001	0.004	0.004	1611.2%	222.7%	-2.5%				0.00%	0.02%	0.07%	fuel sold
	0.000	0.001	0.004	0.004	1611.2%	222.7%	-2.5%	0.00%	0.02%	0.07%				fuel used
1 A 3 b iii	0.002	0.011	0.039	0.029	1655.9%	164.6%	-24.8%				0.03%	0.17%	0.49%	fuel sold
	0.000	0.001	0.005	0.006	1325.2%	480.6%	9.0%	0.01%	0.02%	0.10%				fuel used
1 A 3 b iv	0.000	0.000	0.000	0.000	171.0%	48.9%	5.0%				0.00%	0.00%	0.00%	fuel sold
	0.000	0.000	0.000	0.000	171.0%	48.9%	5.0%	0.00%	0.00%	0.00%				fuel used
1 A 3 b v	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 b vi	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 b vii	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 c	0.000	0.000	0.000	0.000	-85.1%	-55.6%	-20.6%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
1 A 3 d i (ii)	0.000	0.000	0.000	0.000	-83.8%	-89.5%	52.8%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
1 A 3 d ii	0.000	0.000	0.000	0.000	-73.8%	-72.7%	25.6%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
1 A 3 e i	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 3 e ii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 4 a i	NO	0.000	0.000	0.000	0.0%	53.9%	-16.4%	NO	0.00%	0.00%	NO	0.00%	0.00%	fuel sold
1 A 4 a ii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
1 A 4 b i	0.005	0.005	0.001	0.004	-31.6%	-31.9%	152.3%	0.08%	0.09%	0.06%	0.08%	0.08%	0.06%	fuel sold
1 A 4 b ii	0.000	0.000	0.000	0.000	-26.2%	-21.4%	0.2%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
1 A 4 c i	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 4 c ii	0.000	0.000	0.000	0.000	-57.3%	-42.6%	1.2%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
1A 4 c iii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 5 a	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 5 b	0.000	0.000	0.000	0.000	-83.8%	-89.5%	52.8%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
1 B	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	fuel sold
2	0.002	0.002	0.002	0.002	58.8%	45.1%	1.7%	0.02%	0.03%	0.04%	0.02%	0.03%	0.04%	fuel sold
3 B 1 a	1.053	0.719	0.980	0.962	-8.6%	33.9%	-1.9%	16.55%	12.01%	16.45%	16.53%	11.26%	16.17%	fuel sold
3 B 1 b	1.533	1.500	1.456	1.431	-6.7%	-4.6%	-1.8%	24.10%	25.07%	24.47%	24.07%	23.51%	24.05%	fuel sold
3 B 2	0.004	0.005	0.005	0.005	28.9%	-1.6%	3.5%	0.07%	0.09%	0.09%	0.07%	0.09%	0.09%	fuel sold
3 B 3	0.225	0.289	0.231	0.211	-6.3%	-27.2%	-8.8%	3.53%	4.83%	3.60%	3.53%	4.53%	3.54%	fuel sold
3 B 4 a	NO	NO	IE	IE	IE	IE	IE	NO	NO	IE	NO	NO	IE	fuel sold
3 B 4 d	0.000	0.007	0.015	0.016	3024.2%	127.6%	4.2%	0.01%	0.11%	0.27%	0.01%	0.11%	0.26%	fuel sold
3 B 4 e	0.028	0.066	0.060	0.061	118.9%	-6.9%	2.7%	0.44%	1.10%	1.05%	0.44%	1.03%	1.03%	fuel sold
3 B 4 f	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
3 B 4 g i	0.011	0.010	0.018	0.020	89.3%	95.3%	9.7%	0.17%	0.17%	0.34%	0.16%	0.16%	0.33%	fuel sold
3 B 4 g ii	0.001	0.002	0.006	0.006	381.8%	165.7%	5.9%	0.02%	0.04%	0.11%	0.02%	0.04%	0.10%	fuel sold
3 B 4 g iii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
3 B 4 g iv	0.000	0.000	0.000	0.000	-74.5%	-48.7%	-5.0%	0.01%	0.00%	0.00%	0.01%	0.00%	0.00%	fuel sold
3 B 4 h	0.006	0.003	0.001	0.001	-78.5%	-61.8%	-14.5%	0.09%	0.05%	0.02%	0.09%	0.05%	0.02%	fuel sold
3 D a 1	0.668	0.577	0.546	0.340	-49.1%	-41.0%	-37.7%	10.50%	9.64%	5.82%	10.49%	9.04%	5.72%	fuel sold
3 D a 2 a	2.233	1.993	2.095	2.028	-9.2%	1.8%	-3.2%	35.10%	33.31%	34.68%	35.06%	31.24%	34.08%	fuel sold
3 D a 2 b	0.048	0.021	0.005	0.006	-87.9%	-71.8%	16.8%	0.76%	0.35%	0.10%	0.76%	0.32%	0.10%	fuel sold
3 D a 2 c	NO	0.046	0.150	0.138	13.8%	198.9%	-8.0%	NO	0.77%	2.36%	NO	0.72%	2.32%	fuel sold
3 D a 3	0.537	0.522	0.462	0.463	-13.8%	-11.2%	0.4%	8.45%	8.72%	7.92%	8.44%	8.18%	7.79%	fuel sold
3 D a 4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	fuel sold
3 D b	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	fuel sold
3 D c	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	fuel sold
3 D d	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	fuel sold
3 D e	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	fuel sold
3 D f	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	fuel sold
3 F	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
3 I	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
5	0.000	0.046	0.077	0.065	6.5%	42.0%	-14.8%	0.00%	0.38%	0.67%	0.00%	0.31%	0.65%	fuel sold
6 A	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
National total (fuel sold)	**6.369**	**6.379**	**6.310**	**5.949**	**-6.6%**	**-6.7%**	**-5.7%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**6.361**	**5.982**	**6.197**	**5.847**	**-8.1%**	**-2.3%**	**-5.6%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

2.2.6 CO Emissions

National total CO emissions, based on fuel sold, amounted to 469 Gg in 1990 (Figure 24 and Table 2-11). Since then emissions have decreased significantly until 1998 due to shut down of the pig iron production. In 2005, national total CO emissions amounted to 39.7 Gg. In the year 2022, emissions were down by 96.2% compared to 1990 to 17.8 Gg, which was mainly due to lower emissions from iron and steel industry. In the period 2005 to 2022, CO emissions decreased by 55.1%, mainly due to decreasing emissions from road transport (catalytic converters). From 2021 to 2022 emissions decreased by 2.0% due to the decreased fuel combustion activities.

As shown in Figure 24 and Table 2-11, the main sources for CO emissions in Luxembourg are *1A2a Iron and Steel* - with a share of 19.0% in 2022 (73.8% in 1990 and 11.1% in 2005) and *1A3bi Road Transport – Passenger Cars* - with a share of 27.0% in 2022 (17.1% in 1990 and 42.8% in 2005). Another major contributor to CO emissions in Luxembourg is *1A4b Other Sectors – Residential* - with a share of 16.7% in 2022 (1.1% in 1990 and 10.0% in 2005).

The overall decrease of emissions is mainly due to:

- The switch from blast to electric arc furnaces in the iron and steel production during the 1990s;
- The abatement techniques and improved combustion efficiency in all sub-sectors;
- The ooptimized combustion processes in the engine and the introduction of the catalytic converters in road transportation;
- The switch to improved technologies and decreased use of coke.

Figure 24 – CO emission trends based on fuel sold

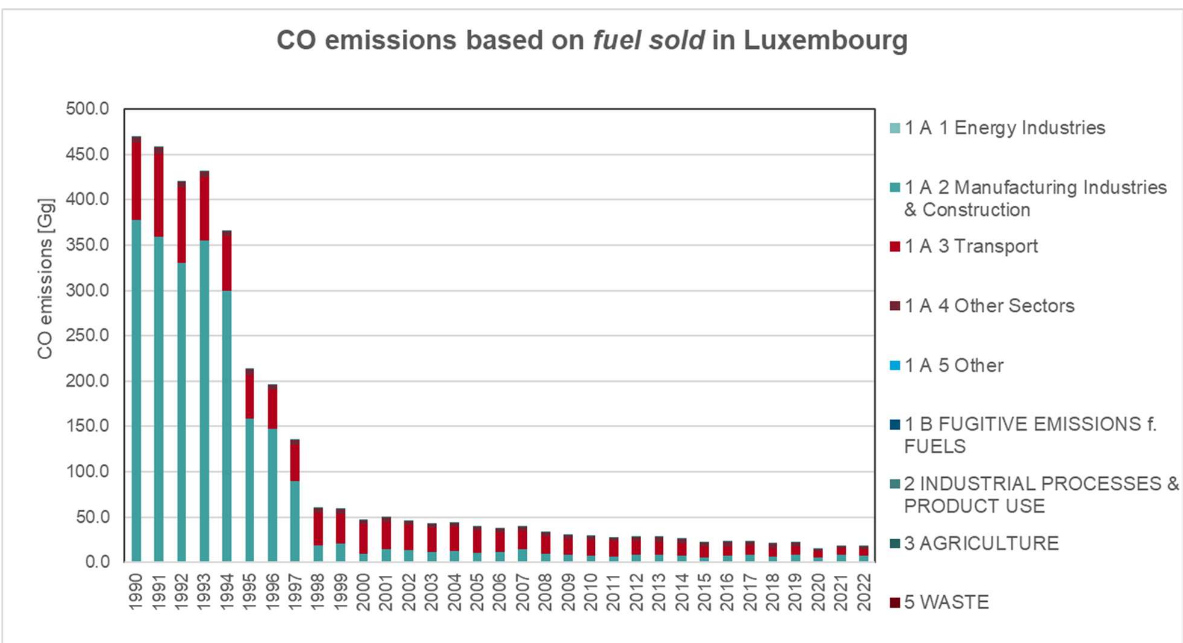


Table 2-11 – CO emissions for 1990, 2005, 2021, 2022, Trend & Share in National Total based on fuel sold and fuel used

CO														
NFR Code	**Emissions**				**Trend**			**FUEL USED Share in National Total**			**FUEL SOLD Share in National Total**			**Fuel option**
	1990	**2005**	**2021**	**2022**	**1990 - 2022**	**2005 - 2022**	**2021 - 2022**	**1990**	**2005**	**2022**	**1990**	**2005**	**2022**	
1 A 1 a	0.007	0.295	0.568	0.450	6161.0%	52.5%	-20.8%	0.00%	1.33%	3.05%	0.00%	0.74%	2.52%	fuel sold
1 A 1 b	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 1 c	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 2 a	346.461	4.425	4.366	3.395	-99.0%	-23.3%	-22.2%	82.03%	19.97%	23.05%	73.82%	11.13%	19.03%	fuel sold
1 A 2 b	0.323	0.588	0.127	0.158	-51.2%	-73.2%	24.1%	0.08%	2.65%	1.07%	0.07%	1.48%	0.88%	fuel sold
1 A 2 c	0.088	0.096	0.012	0.012	-86.9%	-88.0%	-7.6%	0.02%	0.43%	0.08%	0.02%	0.24%	0.06%	fuel sold
1 A 2 d	IE	0.008	0.006	0.004	0.4%	-52.0%	-39.3%	IE	0.03%	0.03%	IE	0.02%	0.02%	fuel sold
1 A 2 e	0.003	0.008	0.004	0.003	19.5%	-55.6%	-9.9%	0.00%	0.03%	0.02%	0.00%	0.02%	0.02%	fuel sold
1 A 2 f	30.167	4.353	2.580	2.672	-91.1%	-38.6%	3.6%	7.14%	19.64%	18.14%	6.43%	10.95%	14.98%	fuel sold
1 A 2 g vii	0.668	0.927	0.501	0.519	-22.2%	-43.9%	3.8%	0.16%	4.18%	3.53%	0.14%	2.33%	2.91%	fuel sold
1 A 2 g viii	0.174	0.115	0.519	0.472	172.1%	310.6%	-9.0%	0.04%	0.52%	3.21%	0.04%	0.29%	2.65%	fuel sold
1 A 3 a i (i)	0.318	0.524	0.414	0.595	87.3%	13.7%	43.7%	0.08%	2.36%	4.04%	0.07%	1.32%	3.34%	fuel sold
1 A 3 a ii (i)	0.063	0.179	0.174	0.156	150.1%	-12.5%	-10.2%	0.01%	0.81%	1.06%	0.01%	0.45%	0.88%	fuel sold
1 A 3 b i	80.250	17.002	4.915	4.814	-94.0%	-71.7%	-2.1%				17.10%	42.77%	26.99%	fuel sold
	34.879	4.484	2.089	2.171	-93.8%	-51.6%	3.9%	8.26%	20.23%	14.74%				fuel used
1 A 3 b ii	1.595	0.410	0.159	0.136	-91.5%	-66.8%	-14.7%				0.34%	1.03%	0.76%	fuel sold
	1.595	0.410	0.159	0.136	-91.5%	-66.8%	-14.7%	0.38%	1.85%	0.92%				fuel used
1 A 3 b iii	2.450	5.694	1.110	0.695	-71.6%	-87.8%	-37.4%				0.52%	14.32%	3.89%	fuel sold
	0.839	0.623	0.256	0.226	-73.0%	-63.7%	-11.5%	0.20%	2.81%	1.54%				fuel used
1 A 3 b iv	0.376	0.493	0.339	0.337	-10.4%	-31.7%	-0.6%				0.08%	1.24%	1.89%	fuel sold
	0.376	0.493	0.339	0.337	-10.4%	-31.7%	-0.6%	0.09%	2.23%	2.29%				fuel used
1 A 3 b v	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 b vi	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 b vii	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 c	0.280	0.089	0.039	0.031	-88.9%	-65.0%	-20.8%	0.07%	0.40%	0.21%	0.06%	0.22%	0.17%	fuel sold
1 A 3 d i (ii)	0.001	0.001	0.000	0.000	-74.4%	-86.1%	53.9%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
1 A 3 d ii	0.100	0.060	0.012	0.016	-83.6%	-72.8%	33.8%	0.02%	0.27%	0.11%	0.02%	0.15%	0.09%	fuel sold
1 A 3 e i	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 3 e ii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 4 a i	0.321	0.198	0.301	0.232	-27.7%	16.9%	-23.0%	0.08%	0.90%	1.57%	0.07%	0.50%	1.30%	fuel sold
1 A 4 a ii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
1 A 4 b i	3.988	2.962	0.901	1.983	-50.3%	-33.0%	120.0%	0.94%	13.36%	13.46%	0.85%	7.45%	11.12%	fuel sold
1 A 4 b ii	1.244	1.012	0.989	0.991	-20.4%	-2.1%	0.2%	0.29%	4.56%	6.73%	0.27%	2.54%	5.55%	fuel sold
1 A 4 c i	0.004	0.003	0.000	0.002	-46.3%	-25.5%	467.6%	0.00%	0.01%	0.02%	0.00%	0.01%	0.01%	fuel sold
1 A 4 c ii	0.445	0.290	0.135	0.133	-70.2%	-54.2%	-1.6%	0.11%	1.31%	0.90%	0.09%	0.73%	0.74%	fuel sold
1A 4 c iii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 5 a	0.001	NO	NO	NO	NO	NO	NO	0.00%	NO	NO	0.00%	NO	NO	fuel sold
1 A 5 b	0.001	0.001	0.000	0.000	-67.9%	-49.0%	-0.1%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
1 B	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	fuel sold
2	0.020	0.022	0.032	0.032	58.9%	44.5%	1.7%	0.09%	0.18%	0.33%	0.06%	0.15%	0.32%	fuel sold
3	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	fuel sold
5	IE/NA/NO	IE/NA/NO	NE	NE	NE	NE	NE	IE/NA/NO	IE/NA/NO	NE	IE/NA/NO	IE/NA/NO	NE	fuel sold
6 A	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
National total (fuel sold)	**469.347**	**39.753**	**18.203**	**17.838**	**-96.2%**	**-55.1%**	**-2.0%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**422.365**	**22.163**	**14.524**	**14.727**	**-96.5%**	**-33.6%**	**1.4%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

2.2.7 $PM_{2.5}$ Emissions

National total $PM_{2.5}$ emissions, based on fuel sold, amounted to 16.1 Gg in 1990 (Figure 25 and Table). Since then, emissions have decreased significantly. In 2005 national total $PM_{2.5}$ emissions amounted to 2.5 Gg. In the year 2022, emissions were down by 93.5% compared to 1990 to 1.1 Gg, which was mainly due to lower emissions from *1A2a Iron and Steel* and from *1A3b Road Transport Sector*. In the period 2005 to 2022, $PM_{2.5}$ emissions decreased by 58.8%. From 2021 to 2022 emissions decreased by 7.5%, mainly due to reduced combustion activities across all sectors.

As shown in Figure 25 and Table 2-12, the main source, in the past, for $PM_{2.5}$ emissions in Luxembourg, with a share of 85.6% in 1990, 1.3% in 2005 and 1.8% in 2022, was *1A2a Iron and Steel Industry*. Nowadays, the major contributors to $PM_{2.5}$ emissions in Luxembourg are, with a share of 30.4% in 2022, *1A4bi Residential Heating* (3.6% in 1990 and 19.9% in 2005) and, with a share of 30.7% in 2022, *1A3b Road Transport* (6.4% in 1990 and 63.0% in 2005).

The decrease of emissions is mainly due to:

- move from blast furnaces to electric arc furnaces in the iron and steel industry during the 1990s;
- abatement techniques and improved combustion efficiency in most combustion activities;

- optimised combustion processes in the engine and the introduction of particulate filters;
- switch in the energy mix from solid fuels to gaseous fuels in stationary combustion;

Figure 25 – $PM_{2.5}$ emission trends and shares by category based on fuel sold and fuel used

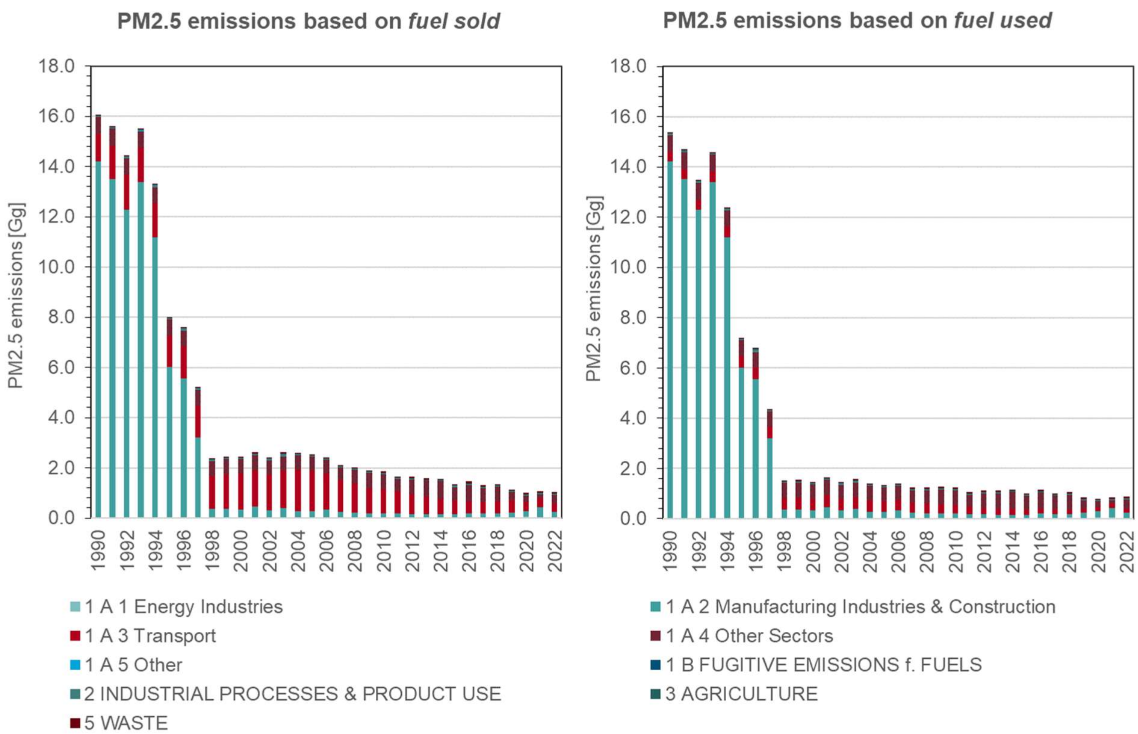


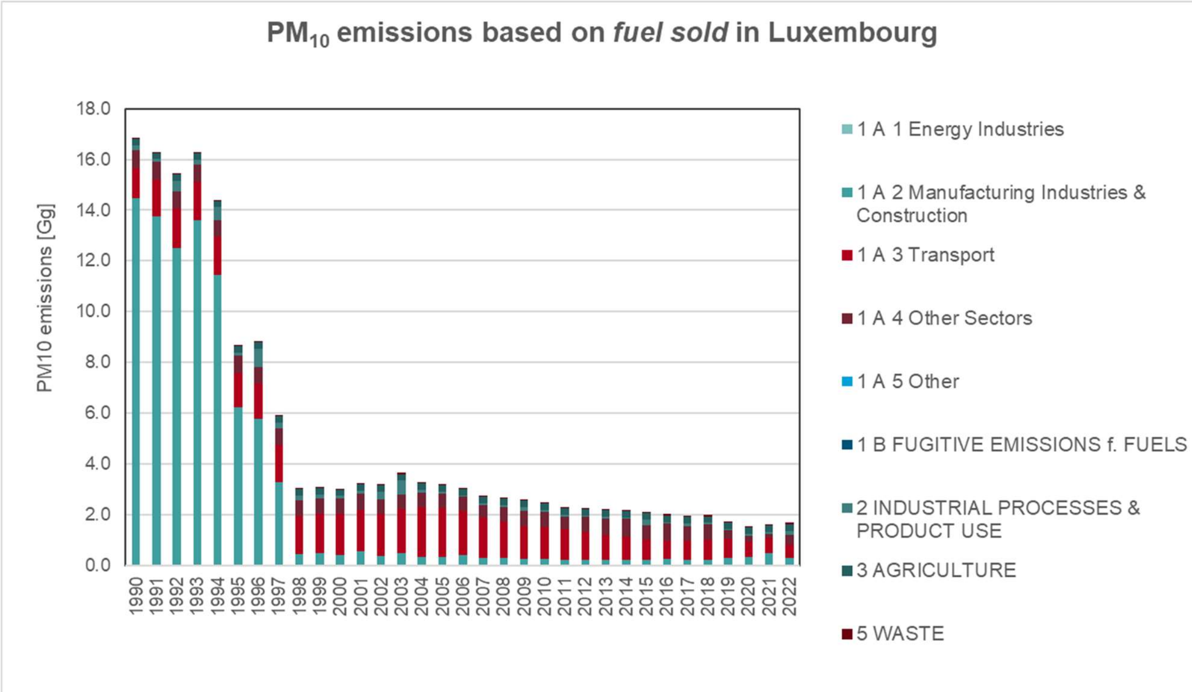
Table 2-12 – $PM_{2.5}$ emissions for 1990, 2005, 2021, 2022, Trend & Share in National Total based on fuel sold and fuel used

PM2.5														
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
1 A 1 a	0.000	0.004	0.044	0.040	210044.1%	937.8%	-8.7%	0.00%	0.29%	4.57%	0.00%	0.15%	3.84%	fuel sold
1 A 1 b	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 1 c	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 2 a	13.765	0.032	0.022	0.019	-99.9%	-41.0%	-12.5%	89.55%	2.37%	2.15%	85.60%	1.26%	1.80%	fuel sold
1 A 2 b	0.056	0.036	0.033	0.030	-46.3%	-17.0%	-7.5%	0.37%	2.70%	3.44%	0.35%	1.43%	2.88%	fuel sold
1 A 2 c	0.044	0.001	0.001	0.007	-83.4%	422.7%	650.1%	0.29%	0.10%	0.84%	0.28%	0.06%	0.70%	fuel sold
1 A 2 d	IE	0.000	0.000	0.000	0.0%	-52.0%	-39.3%	IE	0.02%	0.01%	IE	0.01%	0.01%	fuel sold
1 A 2 e	0.001	0.001	0.001	0.001	73.0%	7.8%	-2.0%	0.00%	0.08%	0.13%	0.00%	0.04%	0.11%	fuel sold
1 A 2 f	0.235	0.082	0.022	0.010	-95.7%	-87.7%	-53.6%	1.53%	6.06%	1.14%	1.46%	3.21%	0.96%	fuel sold
1 A 2 g vii	0.112	0.109	0.013	0.012	-89.4%	-89.1%	-8.9%	0.73%	8.11%	1.35%	0.69%	4.30%	1.14%	fuel sold
1 A 2 g viii	0.001	0.002	0.301	0.127	11040.4%	5520.9%	-57.8%	0.01%	0.17%	14.48%	0.01%	0.09%	12.15%	fuel sold
1 A 3 a i (i)	0.003	0.005	0.004	0.005	87.3%	13.7%	43.7%	0.02%	0.34%	0.59%	0.02%	0.18%	0.50%	fuel sold
1 A 3 a ii (i)	0.000	0.000	0.000	0.000	150.1%	-12.5%	-10.2%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
1 A 3 b i	0.308	0.477	0.018	0.017	-94.6%	-96.5%	-6.9%				1.92%	18.75%	1.60%	fuel sold
	0.087	0.183	0.009	0.009	-89.6%	-95.1%	-4.7%	0.56%	13.58%	1.03%				fuel used
1 A 3 b ii	0.030	0.056	0.011	0.009	-69.0%	-83.2%	-13.6%				0.19%	2.20%	0.90%	fuel sold
	0.030	0.056	0.011	0.009	-69.0%	-83.2%	-13.6%	0.20%	4.14%	1.07%				fuel used
1 A 3 b iii	0.559	0.702	0.030	0.020	-96.5%	-97.2%	-35.0%				3.47%	27.62%	1.87%	fuel sold
	0.153	0.081	0.007	0.007	-95.7%	-91.9%	-11.0%	0.99%	5.99%	0.74%				fuel used
1 A 3 b iv	0.006	0.008	0.010	0.010	59.6%	27.2%	1.5%				0.04%	0.30%	0.93%	fuel sold
	0.006	0.008	0.010	0.010	59.6%	27.2%	1.5%	NO	NO	1.10%				fuel used
1 A 3 b v	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 b vi	0.080	0.223	0.183	0.166	108.5%	-25.4%	-9.4%				0.50%	8.76%	15.88%	fuel sold
	0.028	0.051	0.070	0.075	167.3%	47.2%	6.9%	0.18%	3.79%	8.57%				fuel used
1 A 3 b vii	0.046	0.136	0.112	0.099	114.9%	-27.0%	-11.0%				0.29%	5.35%	9.49%	fuel sold
	0.016	0.029	0.040	0.043	160.6%	45.9%	7.2%	0.11%	2.17%	4.87%				fuel used
1 A 3 c	0.059	0.017	0.004	0.003	-95.1%	-82.8%	-22.3%	0.38%	1.24%	0.33%	0.37%	0.66%	0.28%	fuel sold
1 A 3 d i (ii)	0.000	0.000	0.000	0.000	-86.8%	-91.0%	49.9%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	fuel sold
1 A 3 d ii	0.002	0.002	0.000	0.000	-88.8%	-84.9%	19.1%	0.01%	0.12%	0.03%	0.01%	0.06%	0.02%	fuel sold
1 A 3 e i	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 3 e ii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 4 a i	0.020	0.009	0.016	0.012	-38.4%	31.1%	-22.1%	0.13%	0.69%	1.38%	0.12%	0.36%	1.16%	fuel sold
1 A 4 a ii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
1 A 4 b i	0.575	0.505	0.125	0.318	-44.6%	-37.0%	154.3%	3.74%	37.45%	36.25%	3.57%	19.87%	30.42%	fuel sold
1 A 4 b ii	0.000	0.000	0.000	0.000	-21.8%	5.5%	0.2%	0.00%	0.03%	0.04%	0.00%	0.01%	0.04%	fuel sold
1 A 4 c i	0.000	0.000	0.000	0.000	-86.6%	-25.5%	467.6%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
1 A 4 c ii	0.071	0.039	0.009	0.009	-87.2%	-76.4%	-3.5%	0.46%	2.87%	1.04%	0.44%	1.52%	0.87%	fuel sold
1A 4 c iii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 5 a	0.000	NO	NO	NO	NO	NO	NO	0.00%	NO	NO	0.00%	NO	NO	fuel sold
1 A 5 b	0.000	0.000	0.000	0.000	-96.5%	-91.5%	-12.6%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	fuel sold
1 B	0.001	0.000	0.000	0.000	-95.7%	-45.7%	-2.7%	0.01%	0.01%	0.01%	0.01%	0.00%	0.00%	fuel sold
2	0.035	0.023	0.019	0.034	-3.3%	47.2%	76.1%	0.23%	1.69%	3.83%	0.22%	0.90%	3.21%	fuel sold
3 B 1 a	0.018	0.012	0.017	0.017	-4.7%	42.5%	0.5%	0.12%	0.90%	1.97%	0.11%	0.48%	1.65%	fuel sold
3 B 1 b	0.014	0.013	0.013	0.013	-10.7%	-4.1%	-1.2%	0.09%	1.00%	1.47%	0.09%	0.53%	1.23%	fuel sold
3 B 2	0.000	0.000	0.000	0.000	29.1%	-2.2%	3.4%	0.00%	0.00%	0.01%	0.00%	0.00%	0.01%	fuel sold
3 B 3	0.000	0.000	0.000	0.000	8.4%	-22.8%	-7.6%	0.00%	0.03%	0.04%	0.00%	0.02%	0.03%	fuel sold
3 B 4 a	NO	NO	IE	IE	IE	IE	IE	NO	NO	IE	NO	NO	IE	fuel sold
3 B 4 d	0.000	0.000	0.000	0.000	2738.9%	114.5%	0.6%	0.00%	0.00%	0.01%	0.00%	0.00%	0.01%	fuel sold
3 B 4 e	0.000	0.001	0.001	0.001	140.3%	-4.0%	2.5%	0.00%	0.05%	0.07%	0.00%	0.02%	0.06%	fuel sold
3 B 4 f	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
3 B 4 g i	0.000	0.000	0.000	0.000	108.2%	90.8%	8.8%	0.00%	0.01%	0.04%	0.00%	0.01%	0.03%	fuel sold
3 B 4 g ii	0.000	0.000	0.000	0.000	381.8%	165.7%	5.9%	0.00%	0.00%	0.01%	0.00%	0.00%	0.01%	fuel sold
3 B 4 g iii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
3 B 4 g iv	0.000	0.000	0.000	0.000	-74.5%	-48.7%	-5.0%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
3 B 4 h	0.000	0.000	0.000	0.000	-76.7%	-62.3%	-16.4%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
3 D a	0.000	0.000	0.000	0.000	0.0%	0.0%	0.0%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
3 D b	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	fuel sold
3 D c	0.008	0.008	0.008	0.008	0.6%	-2.5%	-0.2%	0.05%	0.58%	0.86%	0.05%	0.31%	0.73%	fuel sold
3 D d	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	fuel sold
3 D e	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
3 D f	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	fuel sold
3 F	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
3 I	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
5	0.031	0.038	0.045	0.057	86.0%	48.6%	25.6%	0.20%	2.84%	6.49%	0.19%	1.51%	5.44%	fuel sold
6 A	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
National total (fuel sold)	**16.081**	**2.541**	**1.062**	**1.046**	**-93.5%**	**-58.8%**	**-1.5%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**15.372**	**1.348**	**0.846**	**0.878**	**-94.3%**	**-34.9%**	**3.8%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

2.2.8 PM_{10} Emissions

National total PM_{10} emissions, based on fuel sold, amounted to 16.8 Gg in 1990 (Figure 26 and Table 2-13). Since then emissions have decreased significantly. In 2005, national total PM_{10} emissions amounted to 3.2 Gg. In the year 2022, emissions were down by 90.0% compared to 1990 to 1.7 Gg, which was mainly due to lower emissions from *1A2a Iron and Steel Industry* and from *1A3b Road Transport*. In the period 2005 to 2022, PM_{10} emissions decreased by 47.5%. From 2021 to 2022, emissions increased by 4.2%.

Figure 26 – PM_{10} emission trends based on fuel sold



As shown in Figure 26 and Table 2-13 the main source for PM_{10} emissions in Luxembourg, in the past, was, with a share of 81.8% in 1990, *1A2a Iron and Steel Industry*. In 2022, the main sources of PM_{10} emissions were, with a share of 19.3% and 32.1%, categories *1A4bi Residential Heating* and *1A3b Road Transport*, respectively.

The decrease in emissions from all sectors is mainly due to:

- move from blast furnaces to electric arc furnaces in the iron and steel industry during the 1990s;
- abatement techniques and improved combustion efficiency in all sub-sectors;
- optimised combustion processes in the engine and the introduction of particulate filters;
- switch in the energy mix from solid fuels to gaseous fuels in stationary combustion;

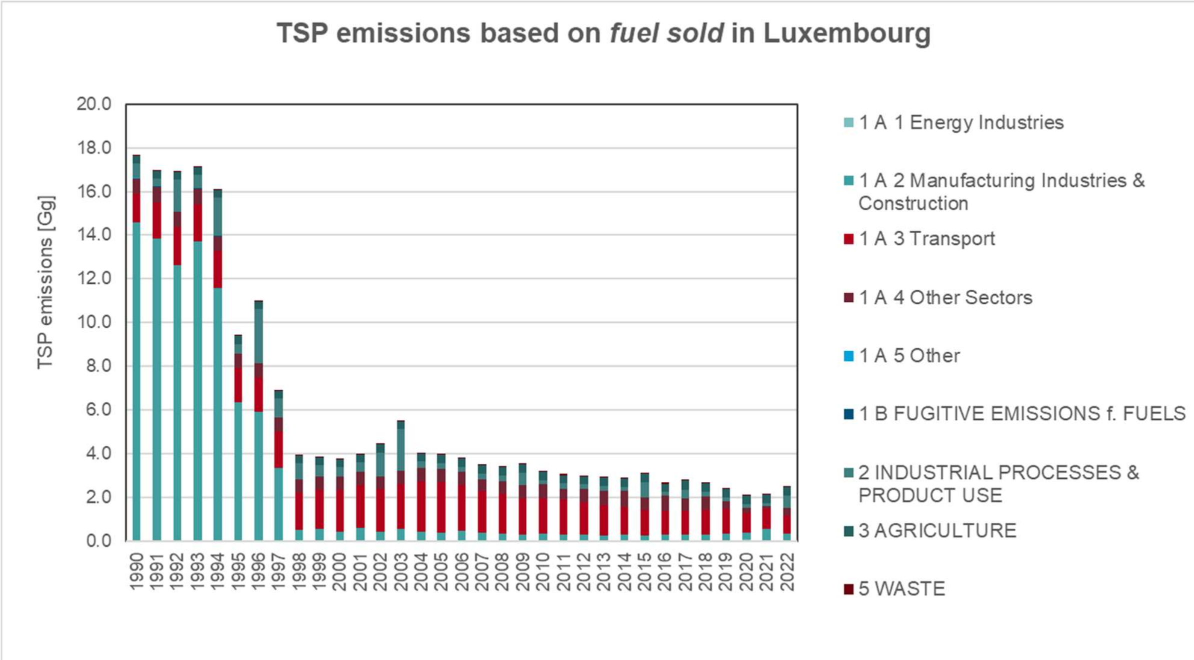
Table 2-13 – PM_{10} emissions for 1990, 2005, 2021, 2022, Trend & Share in National Total based on Fuel sold and Fuel used

PM10														
NFR Code	**Emissions**				**Trend**			**FUEL USED Share in National Total**			**FUEL SOLD Share in National Total**			**Fuel option**
	1990	**2005**	**2021**	**2022**	**1990 - 2022**	**2005 - 2022**	**2021 - 2022**	**1990**	**2005**	**2022**	**1990**	**2005**	**2022**	
1 A 1 a	0.000	0.004	0.045	0.041	144852.7%	941.7%	-8.7%	0.00%	0.22%	2.94%	0.00%	0.12%	2.44%	fuel sold
1 A 1 b	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 1 c	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 2 a	13.766	0.032	0.022	0.019	-99.9%	-41.0%	-12.5%	85.76%	1.78%	1.34%	81.81%	0.99%	1.11%	fuel sold
1 A 2 b	0.143	0.085	0.080	0.074	-48.5%	-13.3%	-7.4%	0.89%	4.73%	5.26%	0.85%	2.64%	4.36%	fuel sold
1 A 2 c	0.059	0.001	0.001	0.008	-86.8%	443.2%	691.5%	0.37%	0.08%	0.56%	0.35%	0.04%	0.46%	fuel sold
1 A 2 d	IE	0.000	0.000	0.000	0.0%	-52.0%	-39.3%	IE	0.01%	0.01%	IE	0.01%	0.01%	fuel sold
1 A 2 e	0.001	0.001	0.002	0.002	73.5%	10.0%	-1.8%	0.01%	0.08%	0.11%	0.01%	0.04%	0.09%	fuel sold
1 A 2 f	0.380	0.111	0.035	0.018	-95.3%	-84.0%	-49.0%	2.37%	6.20%	1.27%	2.26%	3.46%	1.05%	fuel sold
1 A 2 g vii	0.112	0.109	0.013	0.012	-89.4%	-89.1%	-8.9%	0.70%	6.09%	0.85%	0.66%	3.40%	0.70%	fuel sold
1 A 2 g viii	0.001	0.002	0.301	0.127	10411.6%	5520.9%	-57.8%	0.01%	0.13%	9.08%	0.01%	0.07%	7.53%	fuel sold
1 A 3 a i (i)	0.003	0.005	0.004	0.005	87.3%	13.7%	43.7%	0.02%	0.26%	0.37%	0.02%	0.14%	0.31%	fuel sold
1 A 3 a ii (i)	0.000	0.000	0.000	0.000	150.1%	-12.5%	-10.2%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
1 A 3 b i	0.308	0.477	0.018	0.017	-94.6%	-96.5%	-6.9%				1.83%	14.83%	0.99%	fuel sold
	0.087	0.183	0.009	0.009	-89.6%	-95.1%	-4.7%	0.54%	10.19%	0.65%				fuel used
1 A 3 b ii	0.030	0.056	0.011	0.009	-69.0%	-83.2%	-13.6%				0.18%	1.74%	0.56%	fuel sold
	0.030	0.056	0.011	0.009	-69.0%	-83.2%	-13.6%	0.19%	3.11%	0.67%				fuel used
1 A 3 b iii	0.559	0.702	0.030	0.020	-96.5%	-97.2%	-35.0%				3.32%	21.83%	1.16%	fuel sold
	0.153	0.081	0.007	0.007	-95.7%	-91.9%	-11.0%	0.95%	4.50%	0.47%				fuel used
1 A 3 b iv	0.006	0.008	0.010	0.010	59.6%	27.2%	1.5%				0.04%	0.24%	0.57%	fuel sold
	0.006	0.008	0.010	0.010	59.6%	27.2%	1.5%	NO	NO	0.69%				fuel used
1 A 3 b v	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 b vi	0.146	0.402	0.332	0.303	107.4%	-24.5%	-8.8%				0.87%	12.50%	17.95%	fuel sold
	0.053	0.095	0.131	0.140	165.9%	47.3%	6.9%	0.33%	5.31%	10.02%				fuel used
1 A 3 b vii	0.086	0.252	0.207	0.184	114.9%	-27.0%	-11.0%				0.51%	7.83%	10.89%	fuel sold
	0.030	0.054	0.074	0.079	160.6%	45.9%	7.2%	0.19%	3.02%	5.65%				fuel used
1 A 3 c	0.059	0.017	0.004	0.003	-95.1%	-82.8%	-22.3%	0.37%	0.93%	0.21%	0.35%	0.52%	0.17%	fuel sold
1 A 3 d i (ii)	0.000	0.000	0.000	0.000	-86.8%	-91.0%	49.9%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	fuel sold
1 A 3 d ii	0.002	0.002	0.000	0.000	-88.8%	-84.9%	19.1%	0.01%	0.09%	0.02%	0.01%	0.05%	0.01%	fuel sold
1 A 3 e i	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 3 e ii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 4 a i	0.020	0.009	0.016	0.012	-38.4%	31.2%	-22.0%	0.12%	0.52%	0.87%	0.12%	0.29%	0.72%	fuel sold
1 A 4 a ii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
1 A 4 b i	0.591	0.518	0.127	0.326	-44.9%	-37.2%	155.7%	3.68%	28.86%	23.26%	3.51%	16.12%	19.29%	fuel sold
1 A 4 b ii	0.000	0.000	0.000	0.000	-21.8%	5.5%	0.2%	0.00%	0.02%	0.03%	0.00%	0.01%	0.02%	fuel sold
1 A 4 c i	0.000	0.000	0.000	0.000	-86.6%	-25.5%	467.6%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
1 A 4 c ii	0.071	0.039	0.009	0.009	-87.2%	-76.4%	-3.5%	0.44%	2.15%	0.65%	0.42%	1.20%	0.54%	fuel sold
1A 4 c iii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 5 a	0.000	NO	NO	NO	NO	NO	NO	0.00%	NO	NO	0.00%	NO	NO	fuel sold
1 A 5 b	0.000	0.000	0.000	0.000	-96.5%	-91.5%	-12.6%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	fuel sold
1 B	0.012	0.001	0.001	0.001	-95.7%	-45.7%	-2.7%	0.07%	0.05%	0.04%	0.07%	0.03%	0.03%	fuel sold
2	0.185	0.086	0.049	0.174	-6.2%	101.3%	254.6%	1.15%	4.81%	12.42%	1.10%	2.69%	10.30%	fuel sold
3 B 1 a	0.028	0.019	0.026	0.027	-4.7%	42.5%	0.5%	0.17%	1.04%	1.90%	0.17%	0.58%	1.57%	fuel sold
3 B 1 b	0.022	0.020	0.020	0.020	-10.6%	-3.8%	-1.3%	0.14%	1.14%	1.41%	0.13%	0.64%	1.17%	fuel sold
3 B 2	0.000	0.000	0.000	0.000	29.1%	-2.2%	3.4%	0.00%	0.01%	0.01%	0.00%	0.01%	0.01%	fuel sold
3 B 3	0.007	0.010	0.009	0.008	14.4%	-21.0%	-7.3%	0.04%	0.57%	0.58%	0.04%	0.32%	0.48%	fuel sold
3 B 4 a	NO	NO	IE	IE	IE	IE	IE	NO	NO	IE	NO	NO	IE	fuel sold
3 B 4 d	0.000	0.000	0.000	0.000	2738.9%	114.5%	0.6%	0.00%	0.01%	0.02%	0.00%	0.00%	0.02%	fuel sold
3 B 4 e	0.000	0.001	0.001	0.001	140.3%	-4.0%	2.5%	0.00%	0.06%	0.07%	0.00%	0.03%	0.06%	fuel sold
3 B 4 f	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
3 B 4 g i	0.002	0.003	0.004	0.005	108.2%	90.8%	8.8%	0.01%	0.14%	0.34%	0.01%	0.08%	0.29%	fuel sold
3 B 4 g ii	0.000	0.000	0.001	0.001	381.8%	165.7%	5.9%	0.00%	0.02%	0.08%	0.00%	0.01%	0.06%	fuel sold
3 B 4 g iii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
3 B 4 g iv	0.000	0.000	0.000	0.000	-74.5%	-48.7%	-5.0%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	fuel sold
3 B 4 h	0.000	0.000	0.000	0.000	-55.5%	-54.5%	-26.1%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	fuel sold
3 D a	0.000	0.000	0.000	0.000	0.0%	0.0%	0.0%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
3 D b	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	fuel sold
3 D c	0.196	0.202	0.198	0.197	0.6%	-2.5%	-0.2%	1.22%	11.26%	14.08%	1.17%	6.29%	11.68%	fuel sold
3 D d	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	fuel sold
3 D e	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
3 D f	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	fuel sold
3 F	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
3 I	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
5	0.031	0.039	0.046	0.057	85.7%	46.5%	25.3%	0.19%	2.18%	4.09%	0.18%	1.22%	3.39%	fuel sold
6 A	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
National total (fuel sold)	**16.827**	**3.214**	**1.621**	**1.689**	**-90.0%**	**-47.5%**	**4.2%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**16.051**	**1.796**	**1.256**	**1.400**	**-91.3%**	**-22.0%**	**11.5%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

2.2.9 TSP Emissions

National total TSP emissions, based on fuel sold, amounted to 17.7 Gg in 1990 (Figure 27). Since then emissions have decreased steadily. In 2005 national total TSP emissions amounted to 4.0 Gg. In the year 2022, emissions were down by 85.7% compared to 1990 to 2.5 Gg, which was mainly due to lower emissions in the *1A2a Iron and Steel Industry*. In the period 2005 to 2022, TSP emissions decreased by 36.7%. From 2021 to 2022 emissions increased by 15.9%.

Figure 27 – TSP emission trends based on fuel sold



As shown in Figure 27 and Table 2-14, the main source, in the past, for TSP emissions in Luxembourg, with a share of 77.8% in 1990, was *1A2a Iron and Steel Industry*. In 2022, the main sources of TSP emissions, with a share of 32.8% and 22.1%, were categories *1A3b Road Transport* and *2 Industrial proccesses and product use*, respectively.

The decrease in emissions from all sectors is mainly due to:

- move from blast furnaces to electric arc furnaces in the iron and steel industry during the 1990s;
- abatement techniques and improved combustion efficiency in all sub-sectors;
- optimised combustion processes in the engine and the introduction of particulate filters;
- switch in the energy mix from solid fuels to gaseous fuels in stationary combustion;

Table 2-14 – TSP emissions for 1990, 2005, 2021, 2022, Trend & Share in National Total based on Fuel sold and Fuel used

TSP														
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
1 A 1 a	0.000	0.004	0.047	0.043	113883.9%	966.7%	-8.7%	0.00%	0.18%	2.08%	0.00%	0.10%	1.71%	fuel sold
1 A 1 b	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 1 c	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 2 a	13.766	0.032	0.022	0.019	-99.9%	-41.0%	-12.5%	81.83%	1.41%	0.91%	77.83%	0.80%	0.74%	fuel sold
1 A 2 b	0.204	0.120	0.113	0.105	-48.7%	-12.9%	-7.4%	1.21%	5.30%	5.04%	1.15%	3.01%	4.14%	fuel sold
1 A 2 c	0.073	0.001	0.001	0.008	-88.8%	462.9%	732.7%	0.44%	0.06%	0.39%	0.42%	0.04%	0.32%	fuel sold
1 A 2 d	IE	0.000	0.000	0.000	0.0%	-52.0%	-39.3%	IE	0.01%	0.01%	IE	0.01%	0.00%	fuel sold
1 A 2 e	0.001	0.002	0.002	0.002	73.8%	11.5%	-1.7%	0.01%	0.08%	0.09%	0.01%	0.04%	0.08%	fuel sold
1 A 2 f	0.420	0.122	0.039	0.020	-95.3%	-83.7%	-48.7%	2.50%	5.36%	0.95%	2.37%	3.04%	0.78%	fuel sold
1 A 2 g vii	0.112	0.109	0.013	0.012	-89.4%	-89.1%	-8.9%	0.66%	4.82%	0.57%	0.63%	2.74%	0.47%	fuel sold
1 A 2 g viii	0.001	0.002	0.301	0.127	9969.5%	5520.9%	-57.8%	0.01%	0.10%	6.12%	0.01%	0.06%	5.02%	fuel sold
1 A 3 a i (i)	0.003	0.005	0.004	0.005	87.3%	13.7%	43.7%	0.02%	0.20%	0.25%	0.02%	0.11%	0.21%	fuel sold
1 A 3 a ii (i)	0.000	0.000	0.000	0.000	150.1%	-12.5%	-10.2%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
1 A 3 b i	0.308	0.477	0.018	0.017	-94.6%	-96.5%	-6.9%				1.74%	11.92%	0.66%	fuel sold
	0.087	0.183	0.009	0.009	-89.6%	-95.1%	-4.7%	0.52%	8.07%	0.44%				fuel used
1 A 3 b ii	0.030	0.056	0.011	0.009	-69.0%	-83.2%	-13.6%				0.17%	1.40%	0.37%	fuel sold
	0.030	0.056	0.011	0.009	-69.0%	-83.2%	-13.6%	0.18%	2.46%	0.45%				fuel used
1 A 3 b iii	0.559	0.702	0.030	0.020	-96.5%	-97.2%	-35.0%				3.16%	17.56%	0.77%	fuel sold
	0.153	0.081	0.007	0.007	-95.7%	-91.9%	-11.0%	0.91%	3.56%	0.31%				fuel used
1 A 3 b iv	0.006	0.008	0.010	0.010	59.6%	27.2%	1.5%				0.03%	0.19%	0.38%	fuel sold
	0.006	0.008	0.010	0.010	59.6%	27.2%	1.5%	0.04%	0.34%	0.47%				fuel used
1 A 3 b v	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 b vi	0.195	0.544	0.448	0.407	108.3%	-25.3%	-9.3%				1.10%	13.62%	16.07%	fuel sold
	0.069	0.125	0.173	0.185	167.2%	47.2%	6.9%	0.41%	5.53%	8.88%				fuel used
1 A 3 b vii	0.171	0.503	0.413	0.368	114.9%	-27.0%	-11.0%				0.97%	12.60%	14.53%	fuel sold
	0.061	0.108	0.148	0.158	160.6%	45.9%	7.2%	0.36%	4.78%	7.61%				fuel used
1 A 3 c	0.059	0.017	0.004	0.003	-95.1%	-82.8%	-22.3%	0.35%	0.74%	0.14%	0.33%	0.42%	0.11%	fuel sold
1 A 3 d i (ii)	0.000	0.000	0.000	0.000	-86.8%	-91.0%	49.9%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
1 A 3 d ii	0.002	0.002	0.000	0.000	-88.8%	-84.9%	19.1%	0.01%	0.07%	0.01%	0.01%	0.04%	0.01%	fuel sold
1 A 3 e i	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 3 e ii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 4 a i	0.001	0.002	0.003	0.002	36.2%	-2.4%	-24.4%	0.01%	0.09%	0.09%	0.01%	0.05%	0.08%	fuel sold
1 A 4 a ii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
1 A 4 b i	0.628	0.545	0.133	0.342	-45.5%	-37.2%	156.9%	3.73%	24.05%	16.47%	3.55%	13.65%	13.52%	fuel sold
1 A 4 b ii	0.000	0.000	0.000	0.000	-21.8%	5.5%	0.2%	0.00%	0.02%	0.02%	0.00%	0.01%	0.01%	fuel sold
1 A 4 c i	0.000	0.000	0.000	0.000	-86.6%	-25.5%	467.6%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
1 A 4 c ii	0.071	0.039	0.009	0.009	-87.2%	-76.4%	-3.5%	0.42%	1.71%	0.44%	0.40%	0.97%	0.36%	fuel sold
1A 4 c iii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 5 a	0.000	NO	NO	NO	NO	NO	NO	0.00%	NO	NO	0.00%	NO	NO	fuel sold
1 A 5 b	0.000	0.000	0.000	0.000	-96.5%	-91.5%	-12.6%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
1 B	0.029	0.002	0.001	0.001	-95.7%	-45.7%	-2.7%	0.17%	0.10%	0.06%	0.16%	0.06%	0.05%	fuel sold
2	0.650	0.288	0.128	0.559	-14.1%	94.1%	337.3%	3.86%	12.70%	26.89%	3.68%	7.21%	22.08%	fuel sold
3 B 1 a	0.061	0.041	0.058	0.058	-4.7%	42.5%	0.5%	0.36%	1.80%	2.80%	0.35%	1.02%	2.30%	fuel sold
3 B 1 b	0.048	0.044	0.043	0.043	-10.7%	-3.9%	-1.3%	0.28%	1.96%	2.06%	0.27%	1.11%	1.69%	fuel sold
3 B 2	0.000	0.000	0.000	0.000	29.1%	-2.2%	3.4%	0.00%	0.02%	0.02%	0.00%	0.01%	0.02%	fuel sold
3 B 3	0.046	0.071	0.063	0.059	28.9%	-16.7%	-6.5%	0.27%	3.11%	2.83%	0.26%	1.77%	2.32%	fuel sold
3 B 4 a	NO	NO	IE	IE	IE	IE	IE	NO	NO	IE	NO	NO	IE	fuel sold
3 B 4 d	0.000	0.000	0.001	0.001	2738.9%	114.5%	0.6%	0.00%	0.01%	0.03%	0.00%	0.01%	0.03%	fuel sold
3 B 4 e	0.001	0.002	0.002	0.002	140.3%	-4.0%	2.5%	0.01%	0.10%	0.10%	0.00%	0.05%	0.08%	fuel sold
3 B 4 f	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
3 B 4 g i	0.011	0.012	0.021	0.023	108.2%	90.8%	8.8%	0.07%	0.53%	1.10%	0.06%	0.30%	0.90%	fuel sold
3 B 4 g ii	0.000	0.001	0.002	0.002	381.8%	165.7%	5.9%	0.00%	0.04%	0.10%	0.00%	0.02%	0.09%	fuel sold
3 B 4 g iii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
3 B 4 g iv	0.000	0.000	0.000	0.000	-74.5%	-48.7%	-5.0%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	fuel sold
3 B 4 h	0.000	0.000	0.000	0.000	-71.0%	-59.6%	-20.3%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	fuel sold
3 D a	0.000	0.000	0.000	0.000	0.0%	0.0%	0.0%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
3 D b	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	fuel sold
3 D c	0.196	0.202	0.198	0.197	0.6%	-2.5%	-0.2%	1.17%	8.92%	9.49%	1.11%	5.06%	7.79%	fuel sold
3 D d	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	fuel sold
3 D e	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
3 D f	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	fuel sold
3 F	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
3 I	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
5	0.031	0.040	0.046	0.058	85.5%	43.8%	24.9%	0.18%	1.77%	2.77%	0.18%	1.00%	2.28%	fuel sold
6 A	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
National total (fuel sold)	**17.687**	**3.996**	**2.184**	**2.531**	**-85.7%**	**-36.7%**	**15.9%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**16.823**	**2.268**	**1.612**	**2.078**	**-87.6%**	**-8.4%**	**28.9%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

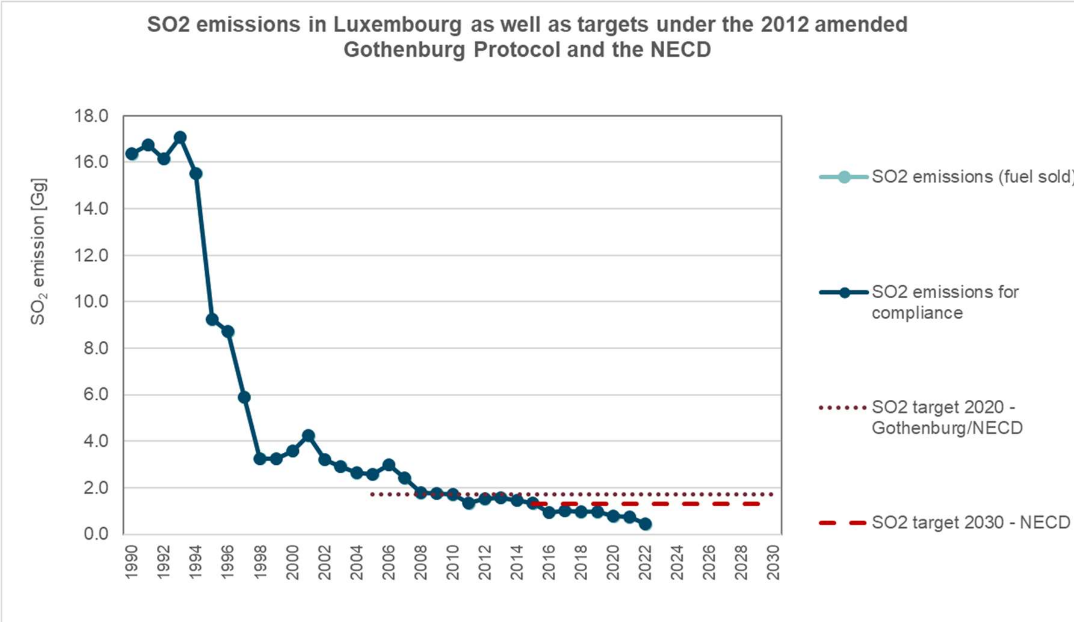
2.3 Compliance Assessment

2.3.1 SO_2

SO_2 emissions from Luxembourg are well below the 2020 emission reduction commitment (-34% compared to 2005, fuel sold) as defined under the 1999 Gothenburg Protocol, as amended in 2012, and the NECD. Indeed, SO_2 emissions have been reduced by -82.9% in 2022 compared to 2005.

Concerning the future emission reduction commitment for 2030 (-50% compared to 2005, fuel sold) as defined under the NECD, this target seems already to be reached in 2022, and is expected to be held in the future (Figure 28).

Figure 28 – SO_2 emissions and 2020 and 2030 targets under the 2012 amended Gothenburg Protocol and the NECD

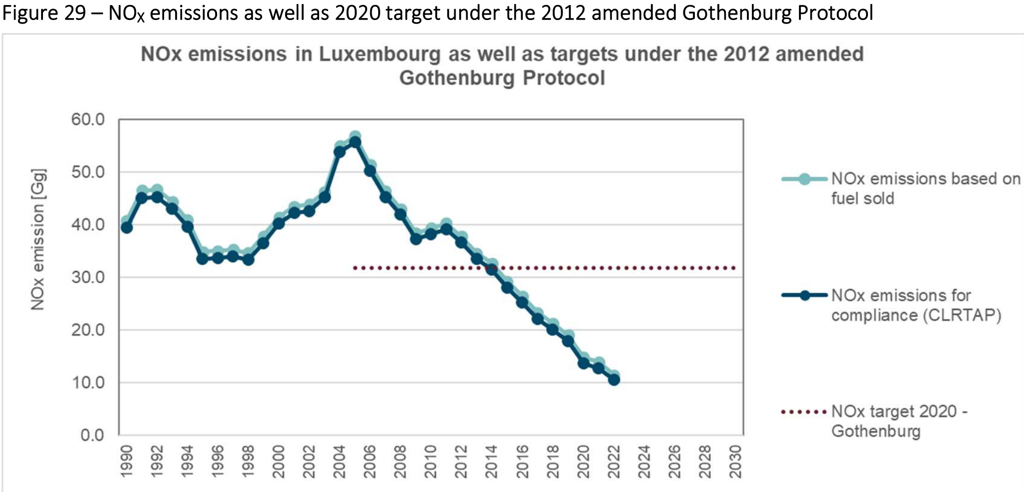


Note: National total SO_2 emissions based on fuel sold are identical to SO_2 emissions for compliance.

2.3.2 NO_X

NO_X emissions in Luxembourg are well below the 2020 emission reduction commitment (-43% compared to 2005, fuel sold) as defined under the 1999 Gothenburg Protocol, as amended in 2012, and the NECD. Indeed, NO_X emissions have been reduced by 81.0% in 2022 compared to 2005 under the accounting rules of the 2012 amended Gothenburg Protocol (Figure 29) and by 81.1% in 2022 compared to 2005 under the accounting rules of the NECD (Figure 30).

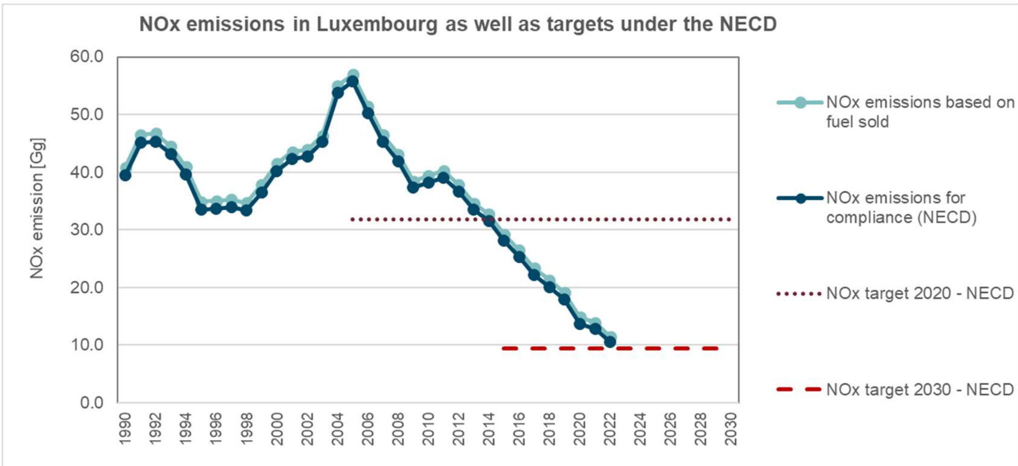
Figure 29 – NO_X emissions as well as 2020 target under the 2012 amended Gothenburg Protocol



Note: National total NO_X emissions based on fuel sold are higher than NO_X emissions for compliance due to the fact that NO_X emission from agricultural soils (3D) are excluded from compliance assessment (Table 3 of Annex II of the amended Gothenburg Protocol).

Concerning the future emission reduction commitment for 2030 (-84% compared to 2005, fuel sold) as defined under the NECD, this reduction target is expected to be reached by 2030 by a consequent implementation of the policies and measures as detailed in the national air pollution control programm (NAPCP) (Figure 30).

Figure 30 – NO_X emissions as well as 2020 and 2030 targets under the NECD

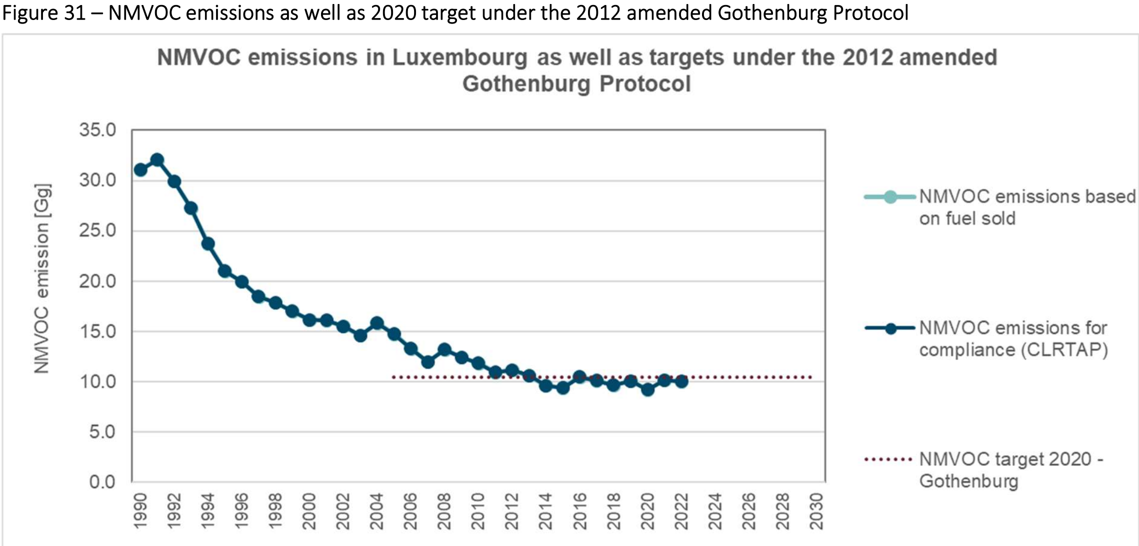


Note: National total NO_X emissions based on fuel sold are higher than NO_X emissions for compliance due to the fact that NO_X emission from agriculture are excluded from compliance assessment (Article 4 of the NECD).

2.3.3 NMVOC

NMVOC emissions from Luxembourg are just below the 2020 emission reduction commitment (-29% compared to 2005, fuel sold) as defined under the 1999 Gothenburg Protocol, as amended in 2012. For 2020, NMVOC emissions have been below (-37.6% compared to 2005) the reduction target, hence, compliance was observed for 2020. NMVOC emissions have been reduced by 32.1% in 2022 compared to 2005 under the accounting rules of the 2012 amended Gothenburg Protocol (Figure 31).

Figure 31 – NMVOC emissions as well as 2020 target under the 2012 amended Gothenburg Protocol

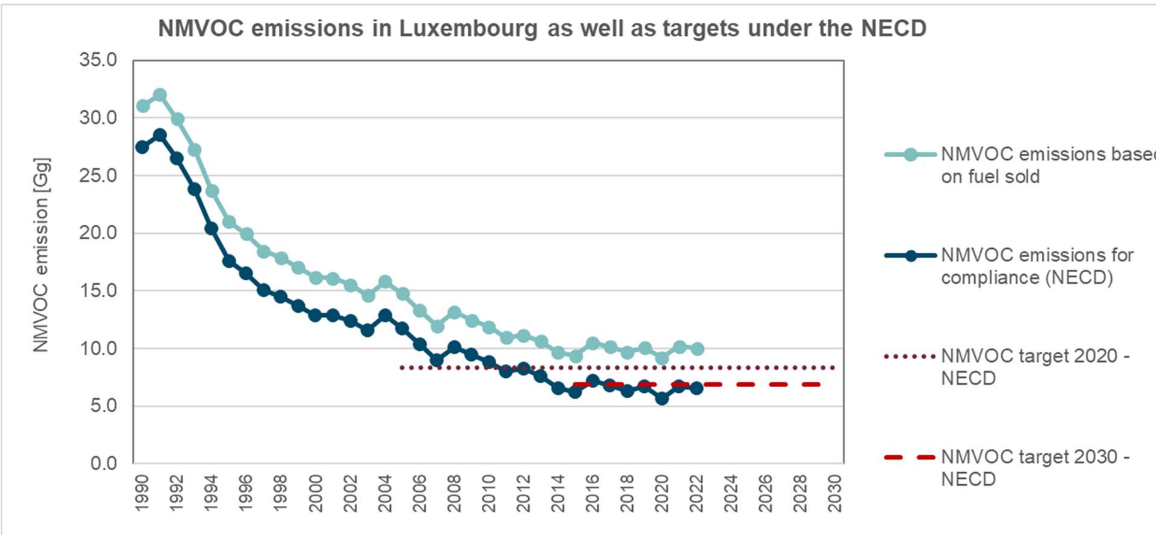


Note: National total NMVOC emissions based on fuel sold are identical to NMVOC emissions for compliance under the accounting rules of the 2012 amended Gothenburg Protocol (no exclusion of NMVOC emissions from agriculture).

NMVOC emissions from Luxembourg are below the 2020 emission reduction commitment (-29% compared to 2005, fuel sold) as defined under the NECD. Indeed, NMVOC emissions have been reduced by 44.6% in 2022 compared to 2005 under the accounting rules of the NECD (Figure 32).

Concerning the future emission reduction commitment for 2030 (-42% compared to 2005, fuel sold) as defined under the NECD, the reduction target is expected to be reached by 2030 by a consequent implememtation of the policies and measures as detailed in the national air pollution control programm (NAPCP) (Figure 32).

Figure 32 – NMVOC emissions as well as 2020 and 2030 targets under the NECD



Note: National total NMVOC emissions based on fuel sold are higher than NMVOC emissions for compliance due to the fact that NMVOC emissions from agriculture (3B & 3D) are excluded from compliance assessment (Article 4 of the NECD).

2.3.4 NH_3

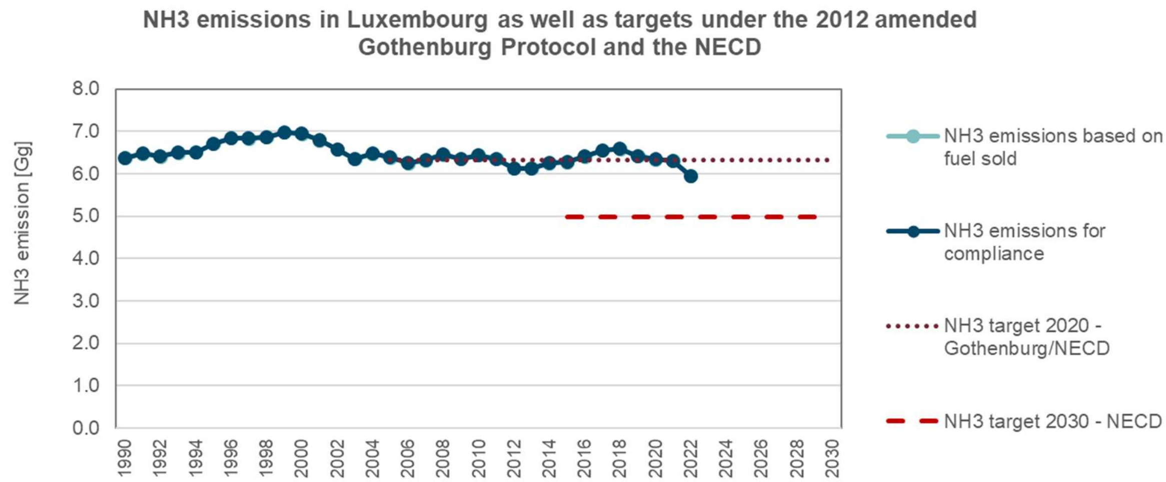
Luxembourg's NH_3 emissions are below the 2020 emission reduction commitment (-1% compared to 2005, fuel sold) as defined under the 2012 amended Gothenburg Protocol and the NECD. Indeed, NH_3 emissions have decreased by 6.7% in 2022 compared to 2005. Hence, the non-compliance as reported in the last submissions seems to be resolved for the moment. Indeed, as prices for agricultural products and especially synthetic fertilizers have soared in 2022 due to the Russian invasion in Ukraine, far less synthetic fertiliser was used in 2022. It remains to bee seen if this decrease in synthetic fertiliser can be stabilised or even increased in future years. Nevertheless, since 2022, Luxembourg worked on an update of its policies and measures in agriculture to ensure compliance for future years as well as for 2030. For further details please also consult the update to the NAPCP.[36]

Concerning the future emission reduction commitment for 2030 (-22% compared to 2005, fuel sold) as defined under the NECD, the reduction target might be reached by 2030, by a consequent implementation of the policies and measures as detailed in the national

[36] https://environnement.public.lu/content/dam/environnement/documents/air/plans-strategies/2023-napcp-aev-update.pdf

air pollution control programme (NAPCP) (Figure 33) However, it is not excluded that additional measures might be needed to guarantee compliance for 2030.

Figure 33 – NH_3 emissions as well as 2020 and 2030 targets under the 2012 amended Gothenburg Protocol and the NECD



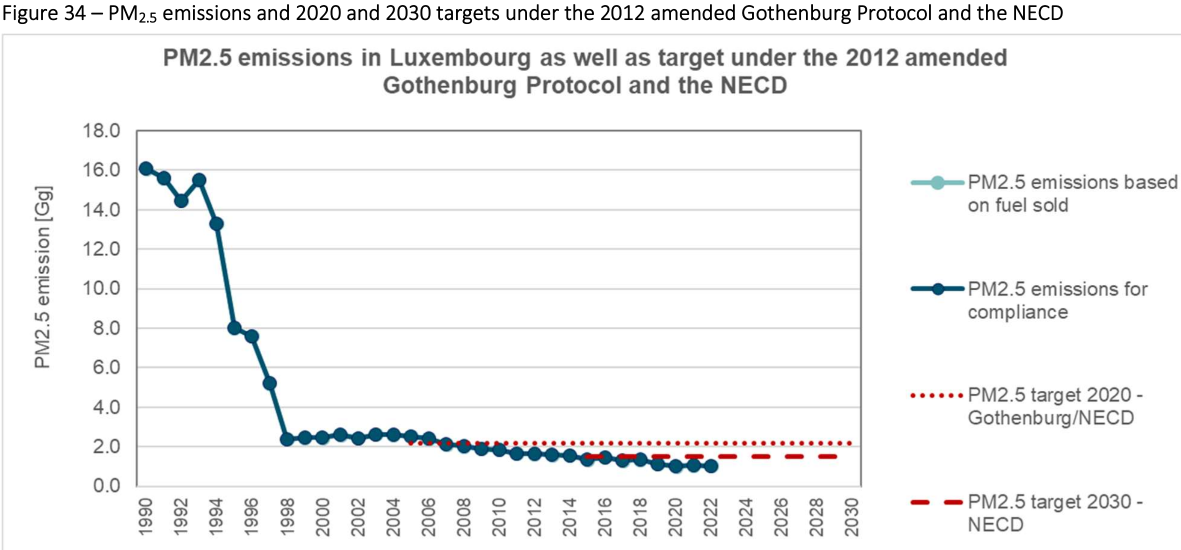
Note: National total NH_3 emissions based on fuel sold are identical to NH_3 emissions for compliance.

2.3.5 $PM_{2.5}$

Luxembourg's $PM_{2.5}$ emissions are well below the 2020 emission reduction commitment (-15% compared to 2005, fuel sold) as defined under the 1999 Gothenburg Protocol, as amended in 2012, and the NECD. Indeed, $PM_{2.5}$ emissions have been reduced by -58.9% in 2022 compared to 2005.

Concerning the future reduction commitment for 2030 (-40% compared to 2005, fuel sold) as defined under the NECD, the target seems to be already reached in 2020, and is expected to be held in the future (Figure 34).

Figure 34 – $PM_{2.5}$ emissions and 2020 and 2030 targets under the 2012 amended Gothenburg Protocol and the NECD

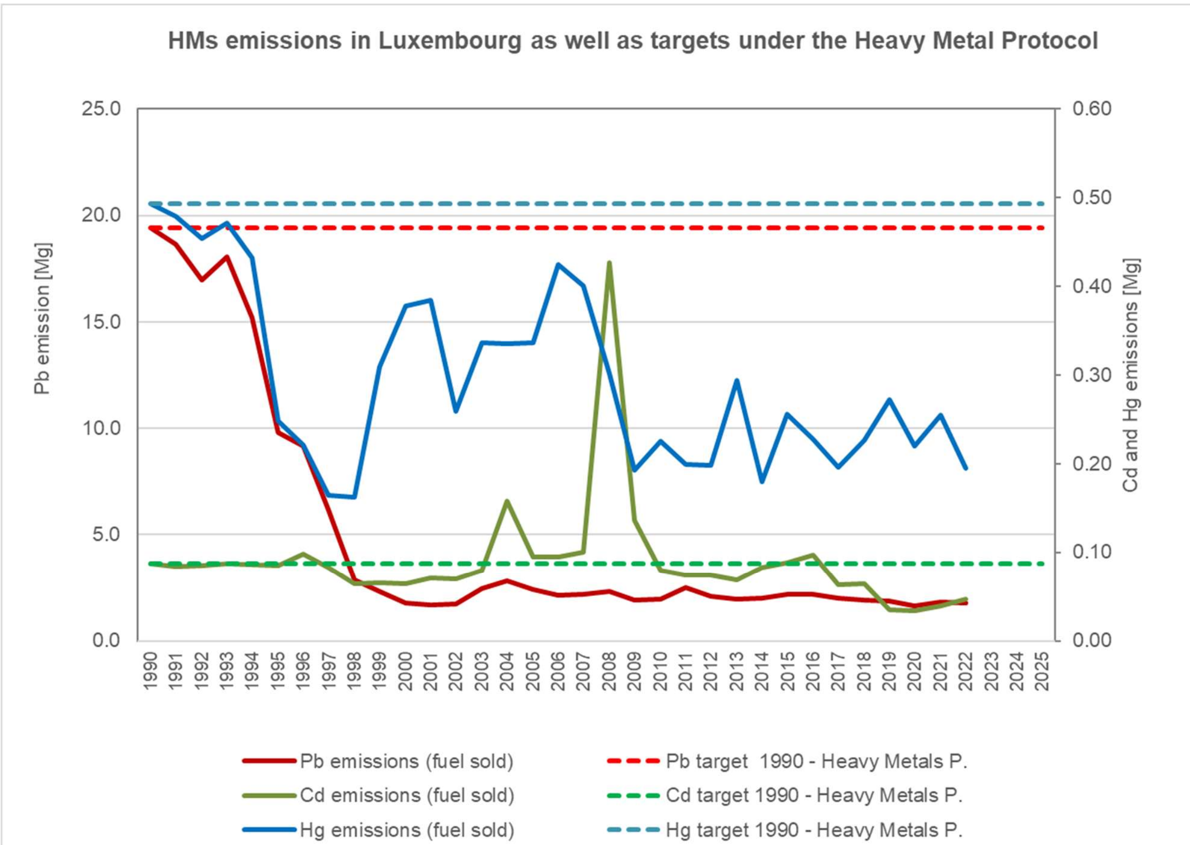


Note: National total $PM_{2.5}$ emissions based on fuel sold are identical to $PM_{2.5}$ emissions for compliance.

2.3.6 Heavy metals

Pb, Cd, and Hg emissions from Luxembourg are well below the emission target as defined under the 1998 Protocol on Heavy Metals and its 2012 amended version (emission reduction below the 1990 level for the thre metals) (Figure 35).

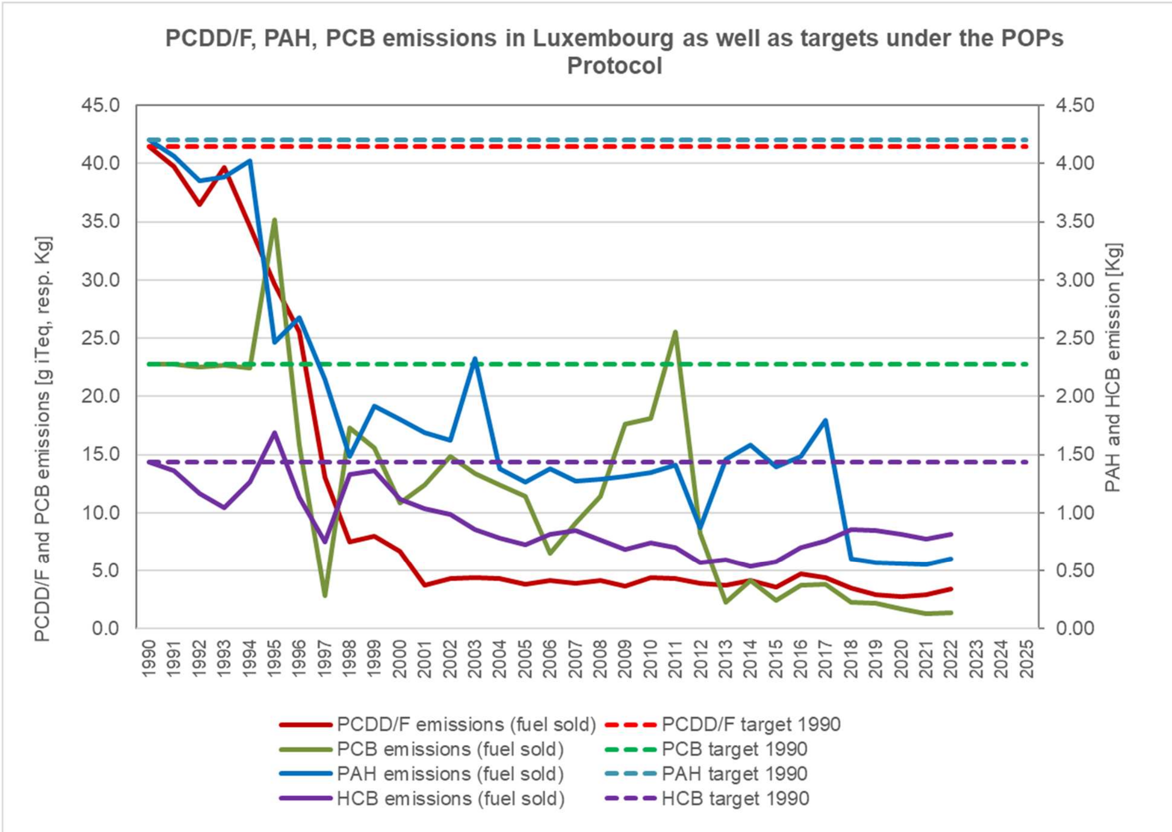
Figure 35 – HMs emissions and targets under the Heavy Metals Protocol



2.3.7 Persistent organic pollutants

Emissions of dioxins (PCDD), furans (PCDF), polycyclic aromatic hydrocarbons (PAHs), PCBs and HCB are below the emission target as defined under the 1998 Protocol on Persistent Organic Pollutants (POPs) and its 2009 amended version (emission reduction below the 1990 level for the afore mentioned POPs) (see Figure 36).

Figure 36 – PCDD/F, PAH, and PCB emissions and targets under the POPs Protocol



3 Energy

3.1 Sector Overview

Emissions from this sector comprise emissions from fuel combustion activities and fugitive emissions from fuels. This chapter also includes information on and description of methodologies used for estimating air pollutant emissions as well as references to activity data and emission factors reported under categories *1A – Fuel Combustion Activities* and *1B – Fugitive Emissions from Fuels* for the period 1990 to 2022.

Air pollutant emissions related to waste incineration are allocated to category *1A1a – Fuel Combustion Activities – Energy Industries – Public Electricity and Heat Production* (see Section 3.2.1.3.2 of this chapter) since energy is recovered and injected into the public electricity and district heating networks.

Process related emissions from industrial activities are included, for specific cases, in category *1A2 –Manufacturing Industries and Construction* (see section 3.2.3).

For more details on categories where no emissions occur and categories that are not estimated or that are included elsewhere, please refer to section 3.1.2 on completeness.

3.1.1 Emission Trends

In 1990, 2005 and 2022, 100% of total SO_2 and CO emissions and 92-98% of total NO_X emissions arose from category *1A – Fuel Combustion* (see Table 3-1). In 1990, about 93%-99% of national total $PM_{2.5}$, PM_{10} and TSP emissions arose from category *1A – Fuel Combustion*, whereas in 2022, the share diminished to 88%, 71% and 60%, respectively. In 1990, about 61% of national total NMVOC emissions arose from category *1A – Fuel Combustion*, the share diminished to 36% in 2005 and 18% in 2022. In 1990, 0.3% of national total NH_3 emissions arose from category *1A – Fuel Combustion*, and the share increased to about 9% in 2005 and fell agsain to 3% in 2022.

Table 3-1 – Emission, trend and share of air pollutant emissions for category *1A - Fuel Combustion Activities*

1 A FUEL COMBUSTION ACTIVITIES													
Pollutants	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total		Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
SOx	16.37	2.59	0.75	0.44	-97.3%	-82.9%	-40.6%				100.0%	100.0%	100.0%	fuel sold
	15.54	2.55	0.73	0.43	-97.2%	-83.2%	-41.1%	100.0%	100.0%	100.0%				fuel used
NOx	39.49	55.76	12.79	10.56	-73%	-81%	-17%				97%	98%	92%	fuel sold
	20.92	16.71	9.40	8.23	-60.7%	-50.8%	-12.5%	93.8%	93.6%	89.9%				fuel used
NMVOC	19.03	5.24	1.68	1.76	-90.7%	-66.3%	4.8%				61.2%	35.5%	17.6%	fuel sold
	9.59	2.63	1.37	1.48	-84.5%	-43.7%	8.4%	44.3%	21.7%	15.2%				fuel used
NH3	0.02	0.57	0.20	0.19	866.2%	-66.1%	-3.6%				0.3%	9.0%	3.3%	fuel sold
	0.01	0.17	0.09	0.09	691.1%	-47.8%	3.9%	0.2%	2.9%	1.6%				fuel used
CO	469.33	39.73	18.17	17.81	-96.2%	-55.2%	-2.0%				100.0%	99.9%	99.8%	fuel sold
TSP	16.61	3.29	1.62	1.53	-90.8%	-53.6%	-5.8%				93.9%	82.4%	60.4%	fuel sold
PM10	16.34	2.83	1.27	1.20	-92.7%	-57.7%	-5.3%				97.1%	88.1%	70.9%	fuel sold
PM2.5	15.97	2.44	0.96	0.92	-94.3%	-62.5%	-4.4%				99.3%	96.2%	87.6%	fuel sold

Source: Environment Agency.

In 1990, combustion in industry (*1A2 – Manufacturing Industries and Construction*) represented the most important source, with a share of more than 80% of each air pollutant emission within category *1A* except for $NO_{X,}$ NMVOC and NH_3 emissions (Table 3-2). The transport sector (*1A3 – Transport*) was the second largest source of air pollutant emissions*,* followed by the energy sector (*1A1 – Energy*) and combustion in the commercial and residential sector (*1A4 – Other Sectors*). Sub-category *1A5 – Other* is a minor source within category *1A.*

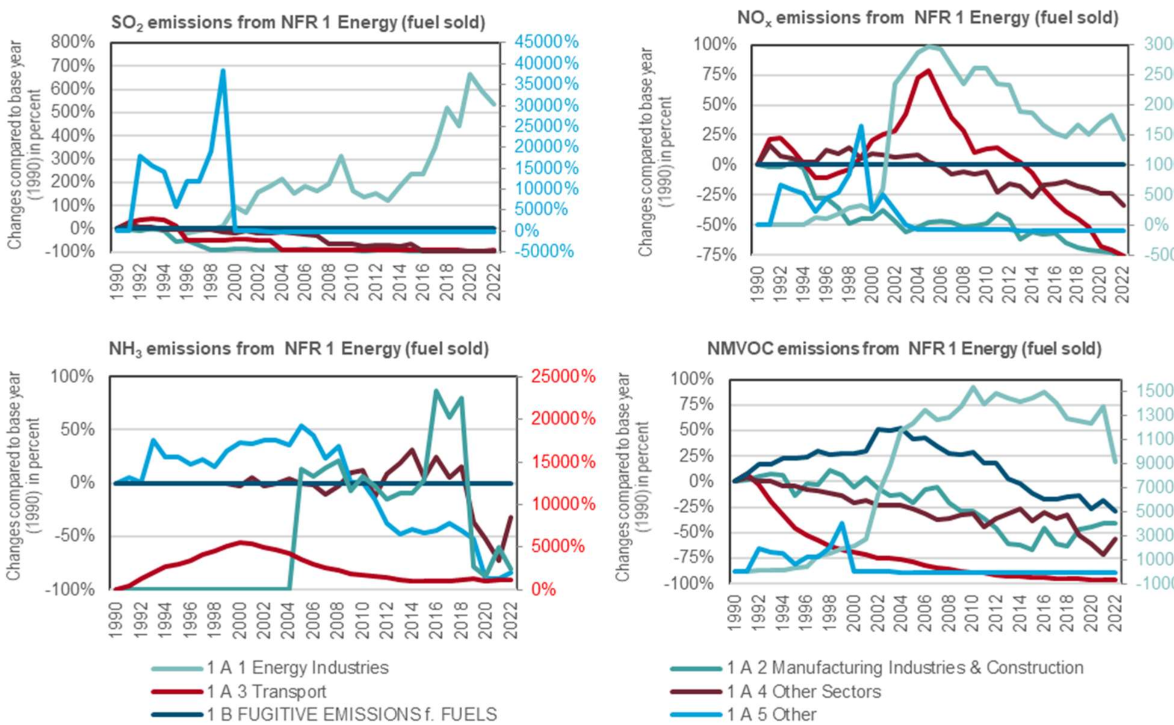
In 2005 and 2022, the transport sector (*1A3 – Transport*) represented the most important source, with the highest share of each air pollutant emission within category *1A* except for SO_2 and $PM_{2.5}$ (2022) emissions. The industrial sector (*1A2 – Manufacturing Industries and Construction*) was the second largest source of air pollutants*,* followed by combustion in the commercial and residential sector (*1A4 – Other Sectors*), the energy production category (*1A1 – Energy*) and category *1A5 – Other*, which includes emissions from other non-specified sources (mainly mobile military machinery).

As presented in Table , in 2022, a reduction of more than 92% of SO_2 emissions compared to the base year (1990) could be achieved by almost all sub-categories except for energy production (*1A1 – Energy Production*). In the period 2005 – 2022, an increase of 149.4% of SO_2 emissions was observed in the energy producing sector (*1A1 – Energy Production*), whereas in the same period a reduction of 77.5%, 18.4% and 96.3% could be achieved by the industrial sector (*1A2 – Manufacturing Industries and Construction*), the transport sector (*1A3 – Transport*), and the commercial and residential sector (*1A4 – Other Sectors*), respectively. These emission reductions could be realised by (a) strengthening of the laws and regulation regarding sulphur content in fuels and in waste gas, (b) further implementation of abatement technologies, and (c) fuel switch, and (d) process changes in the manufacturing industry.

As shown in Figure 37, Figure 39 and Table 3-2, in 2022, a reduction of about 73.3% of NO_X emissions compared to the base year (1990) could be achieved by the industrial sector (*1A2 – Manufacturing Industries and Construction*). The transport sector (*1A3 – Transport*) achieved a reduction of 76.0% in the same period, and combustion emissions in the commercial and residential sector (*1A4 – Other Sectors*) were reduced by 33.4%. These emission reductions could be realised by (a) enforcement of specific laws and regulation regarding nitrogen in waste gas, (b) implementation of extensive abatement technologies, (c) fuel switch, and (d) technological changes in industry. However, an increase in NO_x emissions of 1423.5% in heat and electricity production (*1A1 – Energy Industries*) is observed. This large increase is partially due to the increasing demand of electricity and heat in the commercial and residential sector as a consequence of the increasing population and work force in Luxembourg.

In the period 2005 – 2022, a reduction of NO_X emissions could be achieved in all sub-categories of the energy sector. The energy producing sector (*1A1 – Energy Production*) saw its NO_x emissions decrease by 50.4%. The NO_X emissions of the industrial sector (*1A2 – Manufacturing Industries and Construction*) could be reduced by 57.0% due to enforcement and strengthening of laws and regulation with implementation of measures (e.g. abatement technologies, waste gas treatment, etc.). The NO_X emission of the transport sector (*1A3 – Transport*) showed only in the last years a reduction compared to 1990 after a significant increase until 2005 (fuel sold). The increase of NO_x emissions was mainly due to increasing activities (mileage and vehicle fleet) in the transport sector. After the peak in 2005, the observed decrease (86.5% from 2005 to 2022) of NO_x emissions in the transport sector is due to (a) less fuel sold in Luxembourg and hence a reduction of the fuel export in the vehicle tank, and (b) to the implementation of efficient abatement technologies mainly for heavy duty vehicles, and to a lesser extent for passenger cars.

Figure 37 – SO_2, NO_X, NMVOC and NH_3 emission trends (compared to base year (1990) based on fuel sold) for category *1-Energy*

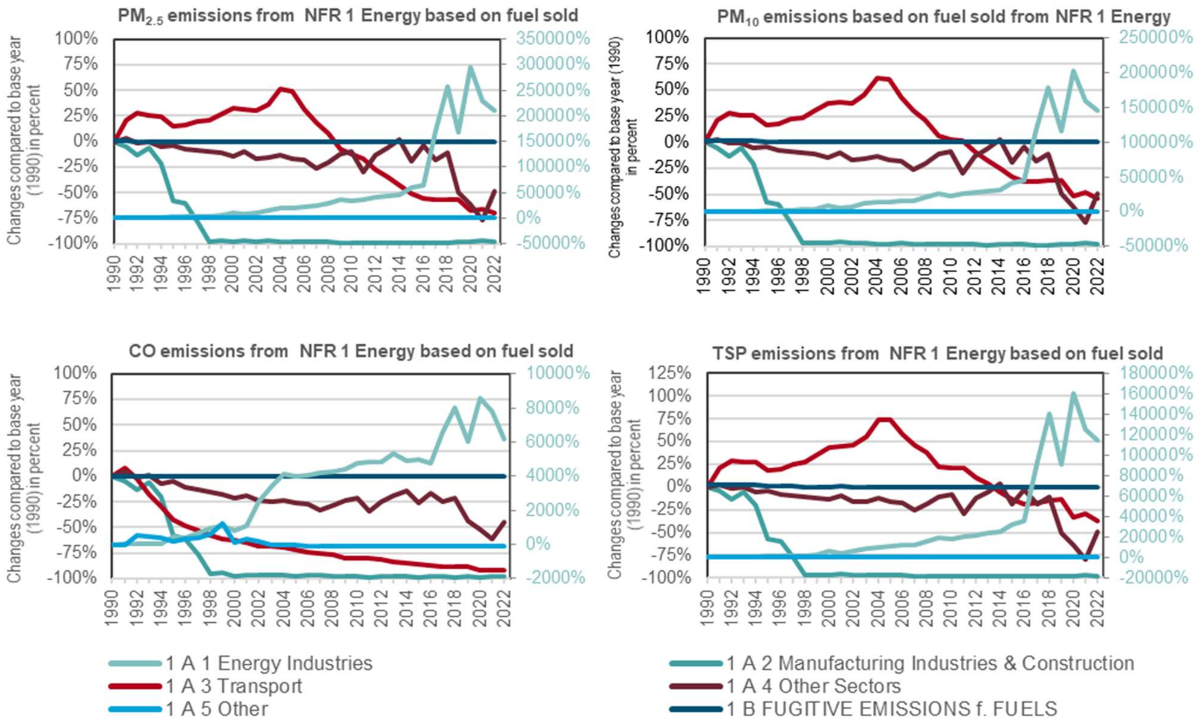


Source: Environment Agency.

The significant reduction of TSP, PM_{10} and $PM_{2.5}$ emissions compared to the base year (1990) could be mainly achieved in industry (*1A2 – Manufacturing Industries and Construction*) mainly due to fuel switch and change from pig iron to electric arc steel production in the iron and steel industry (Figure 38, Table). The overall reduction trend was partially absorbed by increasing PM emission in the transport sector (*1A3 – Transport*).

The overall reduction of about 96.2% of CO emissions compared to the base year (1990) could be achieved mainly through reduction of CO emissions by the industrial sector (*1A2 – Manufacturing Industries and Construction*) (-98.1%) in the 1990s through closing down the pig iron production sites. In the period 1990 – 2022, a reduction (-92.1%) of CO emissions could be achieved by the transport sector (*1A3 – Transport*) due to the introduction of catalytic converters in gasoline-powered vehicles and the diesel fleet.

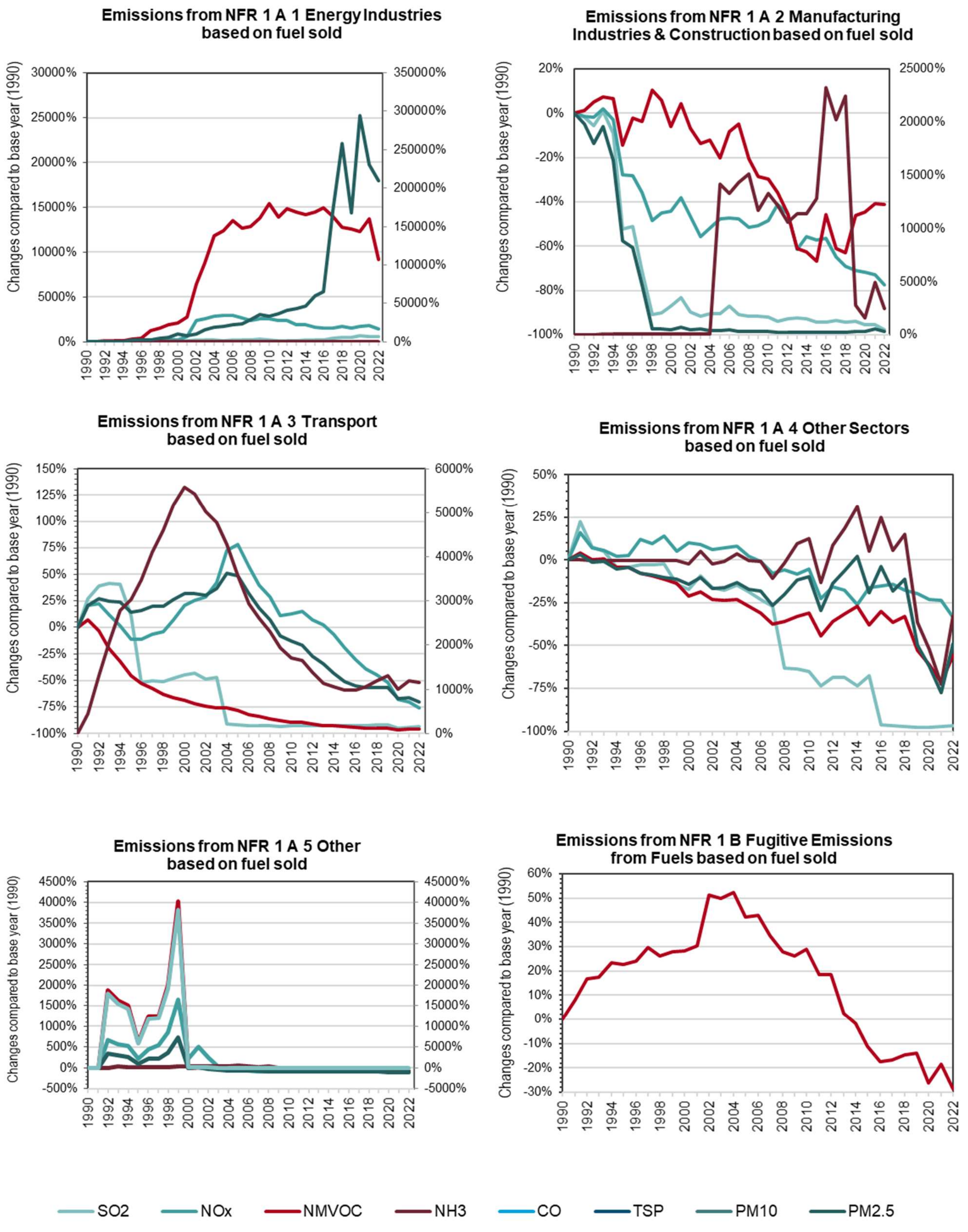
Figure 38 – Changes of Emissions of CO, $PM_{2.5}$, PM_{10} and TSP compared to base year (1990) based on fuel sold for category *1-Energy*



Source: Environment Agency.

Figure 39 presents the emission trends of the air pollutant emissions compared to the base year (1990) per category. The increasing emissions in category *1A1 Energy Industries* were due to the start-up of the gas turbine and other energy producing facilities. In category *1A2 Manufacturing Industries and Construction*, the emission reduction of the main pollutants SO_2, NO_x and CO as well as PM could be achieved due to the above mentioned changes in the iron and steel industry and through the introduction of modern production technologies following the "Best Available Technologies" (BAT) recommendations. In the transport sector, category *1A3*, a reduction of the combustion related emissions (NO_x, SO_2, NH_3, CO) could be observed. These reductions could be managed mainly through the implementation of improved technology standards and to a fluctuating diminution of the fuel export in the verhicle tank.

Figure 39 – Changes of Emissions compared to base year (1990) based on fuel sold per sub-category of category *1A - Fuel Combustion Activities*



Source: Environment Agency.

Table 3-2 – Emissions, Trends and Shares for category *1A - Fuel Combustion Activities* and sub-categories

1 A FUEL COMBUSTION ACTIVITIES																
Pollutants	NFR	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
		1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
SOx	**1 A**	**16.37**	**2.59**	**0.75**	**0.44**	**-97.3%**	**-82.9%**	**-40.6%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**fuel sold**
	1 A 1	0.00	0.01	0.03	0.03	535.6%	149.4%	-8.2%	0.0%	0.4%	5.9%	0.0%	0.4%	5.7%	fuel sold
	1 A 2	13.81	1.32	0.62	0.30	-97.8%	-77.5%	-51.7%	88.9%	51.8%	69.4%	84.4%	51.0%	67.0%	fuel sold
	1 A 3	1.12	0.10	0.07	0.08	-93.0%	-18.4%	15.4%	1.9%	2.2%	14.6%	6.8%	3.7%	17.6%	fuel sold
	1 A 4	1.43	1.17	0.04	0.04	-97.0%	-96.3%	16.9%	9.2%	45.6%	10.1%	8.7%	44.9%	9.7%	fuel sold
	1 A 5	0.00	0.00	0.00	0.00	-99.5%	-19.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
NOx	**1 A**	**39.49**	**55.76**	**12.79**	**10.56**	**-73.3%**	**-81.1%**	**-17.5%**	**93.8%**	**93.6%**	**89.9%**	**96.6%**	**98.0%**	**92.0%**	**fuel sold**
	1 A 1	0.03	0.97	0.61	0.48	1423.5%	-50.4%	-21.1%	0.1%	5.4%	5.2%	0.1%	1.7%	4.2%	fuel sold
	1 A 2	11.29	5.93	3.06	2.55	-77.4%	-57.0%	-16.7%	50.6%	33.2%	27.9%	27.6%	10.4%	22.2%	fuel sold
	1 A 3	26.36	47.02	7.74	6.33	-76.0%	-86.5%	-18.3%	34.9%	44.6%	43.7%	64.5%	82.6%	55.1%	fuel sold
	1 A 4	1.81	1.85	1.38	1.20	-33.4%	-34.9%	-13.0%	8.1%	10.4%	13.2%	4.4%	3.2%	10.5%	fuel sold
	1 A 5	0.00	0.00	0.00	0.00	-95.0%	-82.9%	-13.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
NMVOC	**1 A**	**19.03**	**5.24**	**1.68**	**1.76**	**-90.7%**	**-66.3%**	**4.8%**	**44.3%**	**21.7%**	**15.2%**	**61.2%**	**35.5%**	**17.6%**	**fuel sold**
	1 A 1	0.00	0.14	0.15	0.10	9163.7%	-25.6%	-33.0%	0.0%	1.1%	1.0%	0.0%	0.9%	1.0%	fuel sold
	1 A 2	0.92	0.74	0.55	0.54	-41.1%	-26.2%	-0.8%	4.3%	6.1%	5.6%	3.0%	5.0%	5.4%	fuel sold
	1 A 3	17.15	3.67	0.71	0.70	-95.9%	-81.0%	-1.7%	35.6%	8.8%	4.3%	55.2%	24.9%	7.0%	fuel sold
	1 A 4	0.95	0.70	0.27	0.42	-55.9%	-39.7%	54.0%	4.4%	5.7%	4.3%	3.1%	4.7%	4.2%	fuel sold
	1 A 5	0.00	0.00	0.00	0.00	-86.1%	-73.1%	-2.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
NH3	**1 A**	**0.02**	**0.57**	**0.20**	**0.19**	**866.2%**	**-66.1%**	**-3.6%**	**0.2%**	**2.9%**	**1.6%**	**0.3%**	**9.0%**	**3.3%**	**fuel sold**
	1 A 1	NO	0.00	0.00	0.00	0.1%	2535.8%	-9.8%	NO	0.0%	0.0%	NO	0.0%	0.0%	fuel sold
	1 A 2	0.00	0.03	0.01	0.01	2433.6%	-82.3%	-49.8%	0.0%	0.6%	0.1%	0.0%	0.5%	0.1%	fuel sold
	1 A 3	0.01	0.53	0.19	0.18	1161.8%	-65.6%	-1.7%	0.1%	2.3%	1.4%	0.2%	8.3%	3.1%	fuel sold
	1 A 4	0.01	0.01	0.00	0.00	-32.3%	-32.1%	144.3%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	fuel sold
	1 A 5	0.00	0.00	0.00	0.00	-83.8%	-89.5%	52.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
CO	**1 A**	**469.33**	**39.73**	**18.17**	**17.81**	**-96.2%**	**-55.2%**	**-2.0%**	**100.0%**	**99.9%**	**99.8%**	**100.0%**	**99.9%**	**99.8%**	**fuel sold**
	1 A 1	0.01	0.29	0.57	0.45	6161.0%	52.5%	-20.8%	0.0%	1.3%	3.1%	0.0%	0.7%	2.5%	fuel sold
	1 A 2	377.88	10.52	8.11	7.23	-98.1%	-31.2%	-10.8%	89.5%	47.5%	49.1%	80.5%	26.5%	40.6%	fuel sold
	1 A 3	85.43	24.45	7.16	6.78	-92.1%	-72.3%	-5.3%	9.1%	31.0%	24.9%	18.2%	61.5%	38.0%	fuel sold
	1 A 4	6.00	4.46	2.33	3.34	-44.3%	-25.2%	43.6%	1.4%	20.1%	22.7%	1.3%	11.2%	18.7%	fuel sold
	1 A 5	0.00	0.00	0.00	0.00	-82.2%	-49.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
TSP	**1 A**	**16.61**	**3.29**	**1.62**	**1.53**	**-90.8%**	**-53.6%**	**-5.8%**	**93.6%**	**68.9%**	**51.7%**	**93.9%**	**82.4%**	**60.4%**	**fuel sold**
	1 A 1	0.00	0.00	0.05	0.04	113883.9%	966.7%	-8.7%	0.0%	0.2%	2.1%	0.0%	0.1%	1.7%	fuel sold
	1 A 2	14.58	0.39	0.49	0.29	-98.0%	-24.7%	-40.4%	86.7%	17.1%	14.1%	82.4%	9.7%	11.6%	fuel sold
	1 A 3	1.33	2.31	0.94	0.84	-37.2%	-63.8%	-10.6%	2.8%	25.8%	18.6%	7.5%	57.9%	33.1%	fuel sold
	1 A 4	0.70	0.59	0.15	0.35	-49.6%	-39.7%	142.9%	4.2%	25.9%	17.0%	4.0%	14.7%	14.0%	fuel sold
	1 A 5	0.00	0.00	0.00	0.00	-96.8%	-91.5%	-12.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
PM10	**1 A**	**16.34**	**2.83**	**1.27**	**1.20**	**-92.7%**	**-57.7%**	**-5.3%**	**97.0%**	**78.7%**	**65.0%**	**97.1%**	**88.1%**	**70.9%**	**fuel sold**
	1 A 1	0.00	0.00	0.05	0.04	144852.7%	941.7%	-8.7%	0.0%	0.2%	2.9%	0.0%	0.1%	2.4%	fuel sold
	1 A 2	14.46	0.34	0.45	0.26	-98.2%	-24.6%	-42.9%	90.1%	19.1%	18.5%	85.9%	10.7%	15.3%	fuel sold
	1 A 3	1.20	1.92	0.61	0.55	-54.1%	-71.3%	-10.4%	2.6%	27.8%	18.7%	7.1%	59.7%	32.6%	fuel sold
	1 A 4	0.68	0.57	0.15	0.35	-49.1%	-38.7%	127.4%	4.3%	31.5%	24.8%	4.1%	17.6%	20.6%	fuel sold
	1 A 5	0.00	0.00	0.00	0.00	-96.8%	-91.5%	-12.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
PM2.5	**1 A**	**15.97**	**2.44**	**0.96**	**0.92**	**-94.3%**	**-62.5%**	**-4.4%**	**99.3%**	**92.9%**	**85.2%**	**99.3%**	**96.2%**	**87.6%**	**fuel sold**
	1 A 1	0.00	0.00	0.04	0.04	210044.1%	937.8%	-8.7%	0.0%	0.3%	4.6%	0.0%	0.2%	3.8%	fuel sold
	1 A 2	14.21	0.26	0.39	0.21	-98.5%	-21.8%	-47.3%	92.5%	19.6%	23.5%	88.4%	10.4%	19.8%	fuel sold
	1 A 3	1.09	1.62	0.37	0.33	-69.9%	-79.7%	-11.3%	2.5%	31.9%	18.3%	6.8%	63.9%	31.5%	fuel sold
	1 A 4	0.67	0.55	0.15	0.34	-49.0%	-38.6%	125.7%	4.3%	41.0%	38.7%	4.1%	21.8%	32.5%	fuel sold
	1 A 5	0.00	0.00	0.00	0.00	-96.8%	-91.5%	-12.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold

Source: Environment Agency.

3.1.2 Completeness

Table gives an overview of the sub-categories included under category *1A – Fuel Combustion* and provides information on the status of emission estimates of all subcategories.

Table 3-3 – Overview of subcategories of category *1A – Fuel Combustion*: status of emission estimates

NFR Code	FUEL COMBUSTION ADTIVITIES	NO_X	NMVOC	SO_X	NH_3	CO	TSP	PM_{10}	$PM_{2.5}$	Fuel option
1 A 1 a	Public Electricity and Heat Production	X	X	X	X	X	X	X	X	fuel sold
1 A 1 b	Petroleum refining	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 1 c	Manufacture of Solid fuels and Other Energy Industries	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 2 a	Iron and Steel	X	X	X	NO	X	X	X	X	fuel sold
1 A 2 b	Non-ferrous Metals	X	X	X	NO	X	X	X	X	fuel sold
1 A 2 c	Chemicals	X	X	X	NO	X	X	X	X	fuel sold
1 A 2 d	Pulp, Paper and Print	X	X	X	NO	X	X	X	X	fuel sold
1 A 2 e	Food Processing, Beverages and Tobacco	X	X	X	NO	X	X	X	X	fuel sold
1 A 2 f	Non-metallic Minerals	X	X	X	NO	X	X	X	X	fuel sold
1 A 2 g vii	Mobile Combustion in Manufacturing Industries and Construction	X	X	X	X	X	X	X	X	fuel sold
1 A 2 g viii	Other Stationary Combustion in Manufacturing Industries and Construction	X	X	X	X	X	X	X	X	fuel sold
1 A 3 a ii (i)	Civil Aviation - International - LTO	X	X	X	NE	X	X	X	X	fuel sold
1 A 3 a i (i)	Civil Aviation - Domestic - LTO	X	X	X	NE	X	X	X	X	fuel sold
1 A 3 b i	R.T., Passenger cars	X	X	X	X	X	X	X	X	fuel sold
		X	X	X	X	X	X	X	X	fuel used
1 A 3 b ii	R.T., Light duty vehicles	X	X	X	X	X	X	X	X	fuel sold
		X	X	X	X	X	X	X	X	fuel used
1 A 3 b iii	R.T., Heavy duty vehicles	X	X	X	X	X	X	X	X	fuel sold
		X	X	X	X	X	X	X	X	fuel used
1 A 3 b iv	R.T., Mopeds & Motorcycles	X	X	X	X	X	X	X	X	fuel sold
		X	X	X	X	X	X	X	X	fuel used
1 A 3 b v	R.T., Gasoline evaporation	NA	X	NA	NA	NA	NA	NA	NA	fuel sold
		NO	X	NO	NO	NO	NO	NO	NO	fuel used
1 A 3 b vi	R.T., Automobile tyre and break wear	NA	NA	NA	NA	NA	X	X	X	fuel sold
		NO	NO	NO	NO	NO	X	X	X	fuel used
1 A 3 b vii	R.T., Automobile road abrasion	NA	NA	NA	NA	NA	X	X	X	fuel sold
		NO	NO	NO	NO	NO	X	X	X	fuel used
1 A 3 c	Railways	X	X	X	X	X	X	X	X	fuel sold
1 A 3 d i (ii)	International inland waterways	X	X	X	X	X	X	X	X	fuel sold
1 A 3 d ii	National Navigation (Shipping)	X	X	X	X	X	X	X	X	fuel sold
1 A 3 e i	Pipeline compressors	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 3 e ii	Other transportation	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 4 a i	Commercial/Institutional: Stationary	X	X	X	X	X	X	X	X	fuel sold
1 A 4 a ii	Commercial/Institutional: Mobile	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
1 A 4 b i	Residential: stationary	X	X	X	X	X	X	X	X	fuel sold
1 A 4 b ii	Residential: Household and gardening (mobile)	X	X	X	X	X	X	X	X	fuel sold
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	X	X	X	NO	X	X	X	X	fuel sold
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	X	X	X	X	X	X	X	X	fuel sold
1A 4 c iii	Agriculture/Forestry/Fishing: National Fishing	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 5 a	Other, Stationary (including Military)	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 5 b	Other, Mobile (including Military)	X	X	X	X	X	X	X	X	fuel sold

<u>Source:</u> Environment Agency.

3.2 Fuel Combustion Activities (1A)

The present section provides more specific information and detailed methodological descriptions on the following NFR categories and their corresponding subcategories:

- *1A1 Energy Industries*
- *1A2 Manufacturing Industries and Construction*
- *1A3 Transport*
- *1A4 Other Sectors (commercial and residential)*
- *1A5 Other*

Emission trends for category *1A Fuel Combustion Activities* are described in section 3.1.1 of this chapter.

Table presents the key category analysis for *1A – Fuel Combustion Activities*. Due to the intensity of combustion activities most air pollutants are present among the key categories as well as most subcategories. Hence, on the basis of fuel sold, it is not surprising that road transport emissions are ranking among the top category for NO_x and PM, whereas for the other pollutants, the industrial and residential categories seem to share the top position.

Table 3-4 – Key category analysis of *1 A – Fuel Combustion Activities* – Fuel sold and fuel used

Key Source Analysis (FUEL SOLD): Ranking per number		SO2		NOX		NMVOC		NH3		CO		TSP		PM10		PM2.5	
NFR Code	**NFR Category**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**
1 A 1 a	Energy Industries - Public Electricity and Heat Production		5	8	5											6	
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	1	1		2					2	1		1		1		1
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	5	4									7		7		7	
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	6		5						3	4						
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction			4	4												
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	3	3			9						6		6		3	4
1 A 3 a i (i)	Civil Aviation - International - LTO	2	2	3	3												
1 A 3 b i	Road Transport, Passenger cars			1		8	1		2	1	3						
1 A 3 b ii	Road Transport, Light duty vehicles			7	7												
1 A 3 b iii	Road Transport, Heavy duty vehicles			2	1					6							
1 A 3 b v	Road Transport, Gasoline evaporation						3										
1 A 3 b vi	Road Transport, Automobile tyre and break wear											2	3	2	2	2	3
1 A 3 b vii	Road Transport, Automobile road abrasion											3	4	4	5	4	
1 A 4 a i	Commercial/Institutional: Stationary			9													
1 A 4 b i	Residential: stationary	4		6	6					4	2	4	5	1	3	1	2
1 A 4 b ii	Residential: Household and gardening (mobile)									5	5						

Key Source Analysis (FUEL USED): Ranking per number		SO2		NOX		NMVOC		NH3		PM2.5	
NFR Code	**NFR Category**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**
1 A 1 a	Energy Industries - Public Electricity and Heat Production		5	7	6					6	
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	1	1	10	1					8	1
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	5	4							7	
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	6		4	3						
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction			3	4						
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	3	3			8	8			2	3
1 A 3 a i (i)	Civil Aviation - International - LTO	2	2	2	2						
1 A 3 b i	Road Transport, Passenger cars			1			1		3		
1 A 3 b ii	Road Transport, Light duty vehicles			6	7						
1 A 3 b iii	Road Transport, Heavy duty vehicles			8	5						
1 A 3 b v	Road Transport, Gasoline evaporation						4				
1 A 3 b vi	Road Transport, Automobile tyre and break wear									3	4
1 A 3 b vii	Road Transport, Automobile road abrasion									5	
1 A 4 a i	Commercial/Institutional: Stationary			9							
1 A 4 b i	Residential: stationary	4		5						1	2

Sources: Environment Agency

Notes: LA = Level Assessment, TA = Trend Assessment

Number in Table = indicates the rank in the specific analysis (1…biggest KC; 2… second biggest KC, …)

Table presents the key category analysis for heavy metals and persistent organic pollutants for *1A – Fuel Combustion Activities*. For Heavy metals, it is not surprising that emisisnons from brake and tyre wear in road transportation are ranking among the top categories, whereas for fuel combustion activities, POP emissions from stationary combustion in manufacturing industries and residential heating are ranking among the highest positions.

Table 3-5 – Key category analysis of HMs and POPs for *1 A – Fuel Combustion Activities* – Fuel sold

Key Source Analysis (FUEL SOLD): Ranking per number		Pb		Cd		Hg		PCDD/F		PCB		HCB		PAH	
NFR Code	**NFR Category**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**
1 A 1 a	Energy Industries - Public Electricity and Heat Production	4		2	2	4						2	3		
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel					1	1								
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals										1				
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction													4	3
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction													1	
1 A 3 a ii (i)	Civil Aviation - Domestic - LTO	3													
1 A 3 b i	Road Transport, Passenger cars		3												
1 A 3 b vi	Road Transport, Automobile tyre and break wear	1	2	4											
1 A 4 a i	Commercial/Institutional: Stationary													3	4
1 A 4 b i	Residential: stationary			1	4			3						2	2

Legend **LA** Level Assessment **TA** Trend assessment
number in Table indicates the rank in the specific analysis (1…biggest KC; 2… second biggest KC, …)

3.2.1 Country specific issues

3.2.1.1 Activity data

Activity data are taken from the energy balance (1990-2021) as compiled by the national statistics institute (STATEC), or obtained directly from plant operators. Energy balance data covering 1990 to 1999 originates from the Ministry of Economic Affairs (Energy Directorate). Activity data obtained through the Emission Trading System (ETS) are used for QA/QC procedures by comparing the data to the data reported by the plant operators.

For the industrial sector (including energy production), most of the activity data is plant specific. Indeed, many combustion installations are located in major facilities and activity and emission data for individual plants are mostly available through the pollutant release and transfer registry (PRTR) or other national emission reporting schemes. If extrapolation is needed to cover all activity in the country either the implied emission factors for the facilities that did report, or the default emission factors as provided in the EMEP/EEA Guidebook are used.

As Luxembourg's industrial sector is relatively small compared to larger countries, one has to keep in mind, that, when analysing trends in activity data, relatively large fluctuations may occur in between years simply due to the fact that a facility was temporally switched off for maintenance reasons, or shut-down for good. This may then be reflected by a sharp decrease in the activity data. On the other hand, the bringing into service of a single installation may lead to a sharp increase of activity data in a source category, and consequently also an increase in emissions (e.g. in 2001, when the Twinerg gas turbine began operating).

3.2.1.2 Methodological choices

In general, the *EMEP/EEA Guidebook* methodologies were applied for sector *1-Energy*, except for road transportation where the NEMO calculation model and for off-road vehicles and machinery where the GEORG model were used.

Methodologies used were mostly Tier 2 or Tier 1, except if plant specific data was available based on emission measurements which are to be considered as Tier 3. For road transportation and off-road machinery, the NEMO and GEORG models are considered as a Tier 3 methodology.

Emissions are estimated by multiplying each activity, according to its fuel input or production data, by an emission factor.

Default emission factors are taken in their majority from the *EMEP/EEA air pollutant emission inventory guidebook 2019*, or an older version if none were available in the most recent version.

3.2.1.3 Country specific parameters

3.2.1.3.1 Net Calorific Values

Net calorific values (NCV) used for conversion of fuel activity data from physical units into energy units were fixed to national values in agreement with national statistics (STATEC). These are mostly country-specific values, however, were no such values were available; defaults from the 2006 IPCC Guidelines or the European Directive on Statistics (2006/32/EC) were used (see Table 3-6).

Table 3-6 – Fuel Properties for 2022

Fuel Characteristics for 2022 ***Country-specific Net Calorific Values and Densities***						
Fuel	**Net calorific value**			**Density**		
	NCV	***Unit***	***Source***	***Density***	***Unit***	***Source***
Anthracite	26.70	GJ/t	*2006 IPCC GL*			
Bituminous Coal & Coking Coal	24.40	GJ/t	*ETS*			
Patent Fuel ("boulets")	28.20	GJ/t	*2006 IPCC GL*			
Brown Coal Briquettes (incl. Lignite dust)	22.20	GJ/t	*ETS*			
Coke Oven Coke	28.50	GJ/t	*EU-2006/32/EC*			
Tires	28.20	GJ/t	*ETS*			
Dry sewage sludge	11.67	GJ/t	*ETS*			
Humid sewage sludge	2.04	GJ/t	*ETS*			
Fluff	23.05	GJ/t	*ETS*			
Waste solvents	20.42	GJ/t	*ETS*			
Residual Fuel Oil (low / high sulphur)	40.00	GJ/t	*EU-2006/32/EC*	0.92 / 0.96	kg/l	*Fuel Providers*
Gas Oil	42.49	GJ/t	*Fuel Providers*	0.85	kg/l	*Fuel Providers*
Diesel Oil	42.49	GJ/t	*Fuel Providers*	0.85	kg/l	*Fuel Providers*
Gasoline	43.05	GJ/t	*Fuel Providers*	0.76	kg/l	*Fuel Providers*
Liquefied Petroleum Gas (LPG)	46.00	GJ/t	*EU-2006/32/EC*	0.53	kg/l	*Fuel Providers*
Aviation Gasoline	43.50	GJ/t	*Fuel Provider*	0.71	kg/l	*Fuel Provider*
Jet Kerosene	43.11	GJ/t	*Fuel Provider*			
Other Kerosene	43.80	GJ/t	*2006 IPCC GL*			
Wood	7.15	GJ/m^3	*Statec*	0.69	t/m^3	*Statec*
Pellets	11.00	GJ/m^3	*Statec*	0.65	t/m^3	*Statec*
Wood chips	7.81	GJ/m^3	*Statec*	0.69	t/m^3	*Statec*
Biogas	0.02	GJ/m^3	*Statec*			
Biodiesel (pure)	39.76	GJ/t	*Fuel Providers*			
Biogasoline (pure)	26.80	GJ/t	*Fuel Providers*			
Lubricants	40.20	GJ/t	*2006 IPCC GL*			
Bitumen	40.20	GJ/t	*2006 IPCC GL*			

Source: Environment Agency

Natural Gas

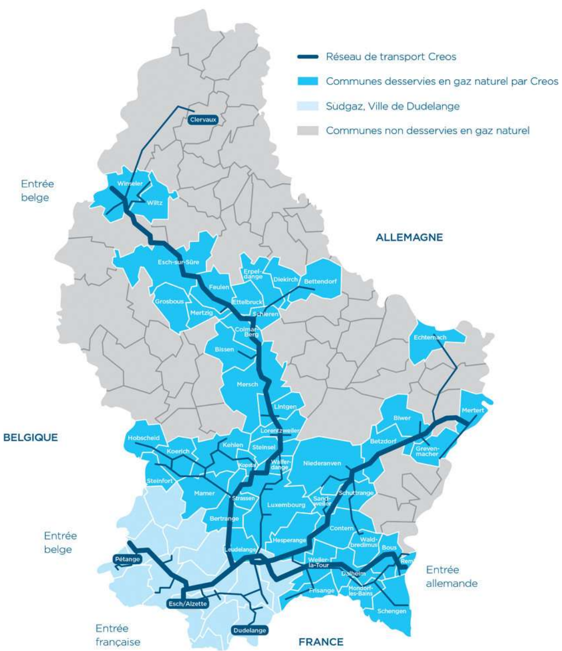
In Luxembourg, one operator, CREOS S.A. (formerly SOTEG S.A.)[37], operates the national natural gas network (Figure 40). There are four entry points, from where natural gas is imported: two with Belgium (Braz and Pétange) with a capacity of 0.16 and 0.06 Mio Nm^3/h, respectively, one with Germany (Remich) with a capacity of 0.19 Mio Nm^3/h and one with France (Esch/Alzette) with a capacity of 0.02 Mio Nm^3/h.

For the calculation of the country-specific NCV for natural gas, the operator provides the following parameters for each entry point and for each month of a given year:

- physical properties: density (kg/Nm^3) and gross calorific value (GCV: MJ/Nm^3);
- monthly import/consumption (Mio Nm^3). [38]

The monthly consumption is converted into energy units (TJ) using the respective NCV, which is calculated by multiplying the GCV with a conversion factor of 0.90 [39]. The CS-NCV is then derived by dividing the yearly consumption expressed in TJ by the yearly consumption expressed in Nm^3.

Figure 40 – Natural gas network



Source: Creos

A country-specific NCV has, thus, been obtained for the years 1991, 1995, 2000, 2005-2021 (Table 3-7). For the years in-between, the values have been interpolated.

[37] http://www.creos.lu

[38] Nm^3 is defined at a pressure of 1035 mbar and 0 degree Celsius.

[39] IEA Energy Statistics Manual, 2005, Table A3.12, p.183

Table 3-7 – Country-specific NCV for Natural Gas

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NCV (MJ/Nm^3)	36.58	36.67	36.62	36.64	36.66	36.75	36.85	36.92	36.99	37.06
Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
NCV (MJ/Nm^3)	37.10	37.01	36.96	36.91	36.86	36.85	36.72	36.64	36.48	36.72
Year	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
NCV (MJ/Nm^3)	36.73	36.56	36.38	36.19	36.30	36.81	36.93	36.98	36.76	36.78
Year	**2020**	**2021**	**2022**							
NCV (MJ/Nm^3)	36.98	37.05	37.39							

Source: Environment Agency

3.2.1.3.2 Sulphur Content

Fuel sulphur content has been determined either by applying the maximum legally authorised sulphur content per fuel, or by using the sulphur content obtained by measurements. Hence, for gasoil, measurements are available for the years 2010 to 2022. For diesel oil and motor gasoline, for the period 2001-2022, data (based on measurements) was taken from the Fuel Quality Monitoring System reporting obligation[40]. Sulphur contents are then derived into SO_2 emission factors. Table lists the SO_2 emissions factors used per fuel and year.

Table 3-8 – Country-specific SO_2 Emission Factors per liquid fuel (g SO_2/GJ)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Residual Oil	499.52	499.52	499.52	499.52	499.52	499.52	499.52	499.52	499.52	499.52
Gas Oil	94.06	94.06	94.06	94.06	94.06	94.06	94.06	94.06	94.06	94.06
Diesel Oil	94.06	94.06	94.06	94.06	94.06	94.06	23.52	23.52	23.52	23.52
Motor Gasoline	46.42	46.42	46.42	46.42	46.42	46.42	46.42	46.42	46.42	46.42
LPG	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Residual Oil	499.52	499.52	499.52	499.52	499.52	499.52	499.52	499.52	499.52	499.52
Gas Oil	94.06	94.06	94.06	94.06	94.06	94.06	94.06	94.06	47.03	47.03
Diesel Oil	16.46	11.85	1.55	1.98	2.12	1.50	1.28	1.06	0.83	0.61
Motor Gasoline	46.42	0.84	1.76	2.04	1.44	0.51	0.47	0.43	0.39	0.35
LPG	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Year	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Residual Oil	499.52	365.85	374.64	422.10	437.92	469.55	469.55	444.58	365.65	394.62
Gas Oil	45.41	39.90	42.99	42.28	41.26	41.26	1.02	0.83	0.72	0.45
Diesel Oil	0.38	0.34	0.36	0.37	0.31	0.35	0.35	0.33	0.34	0.36
Motor Gasoline	0.31	0.21	0.26	0.23	0.21	0.19	0.19	0.19	0.23	0.21
LPG	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Year	**2020**	**2021**	**2022**							
Residual Oil	449.57	489.53	489.53							
Gas Oil	0.55	0.60	0.67							
Diesel Oil	0.34	0.32	0.36							
Motor Gasoline	0.22	0.18	0.18							
LPG	0.50	0.50	0.50							

Source: Environment Agency

[40] http://ec.europa.eu/environment/air/transport/fuel.htm

3.2.2 Energy Industries (1A1): Public Electricity and Heat Production (1A1a)

3.2.2.1 Source category description

This section describes air pollutant emissions resulting from fuel combustion activities in energy industries, which, in Luxembourg, only originate from public electricity and heat production plants. There is no manufacturing of solid fuels, nor petroleum refining in Luxembourg. Hence, category *1A1 – Energy Industries* equals sub-category *1A1a – Public Electricity and Heat Production*.

In this category, the emissions of air pollutants SO_2, NO_X, NMVOC, NH_3 and CO as well as PM from combustion activities for electricity and heat production are reported, as well as emissions from municipal waste incineration. In Luxembourg, municipal waste is combusted with energy recovery at the sole waste incineration plant (SIDOR) where recovered heat and electricity are distributed to the urban district network. Therefore, the emissions are reported under fuel combustion activities.

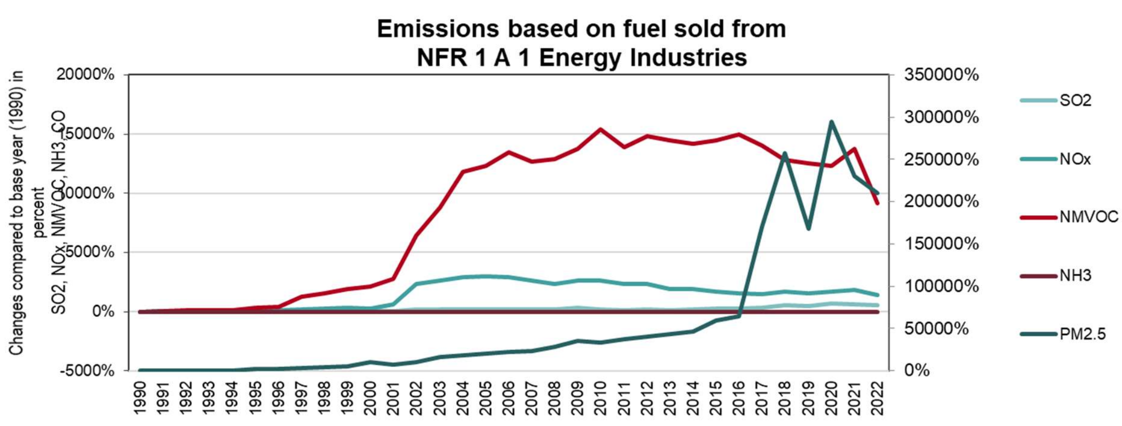
Table summarizes emissions of air pollutants for sub-category *1A1a*, Figure 41 and Table presents the emission trends for the period 1990 – 2022.

Table 3-9 – Emissions, trend and share of air pollutants for category *1A1a - Public Electricity and Heat Production*

1 A 1 a Energy Industries - Public Electricity and Heat Production														
Pollutants	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
SO_X	0.00	0.01	0.03	0.03	535.6%	149.4%	-8.2%	0.0%	0.4%	5.9%	0.0%	0.4%	5.7%	fuel sold
NOx	0.03	0.97	0.61	0.48	1424%	-50.4%	-21.1%	0.1%	5.4%	5.2%	0.1%	1.7%	4.2%	fuel sold
NMVOC	0.00	0.14	0.15	0.10	9163.7%	-25.6%	-33.0%	0.0%	1.1%	1.0%	0.0%	0.9%	1.0%	fuel sold
NH3	NO	0.00	0.00	0.00	0.1%	2535.8%	-9.8%	NO	0.0%	0.0%	NO	0.0%	0.0%	fuel sold
CO	0.01	0.29	0.57	0.45	6161.0%	52.5%	-20.8%	0.0%	1.3%	3.1%	0.0%	0.7%	2.5%	fuel sold
TSP	0.00	0.00	0.05	0.04	113883.9%	966.7%	-8.7%	0.0%	0.2%	2.1%	0.0%	0.1%	1.7%	fuel sold
PM10	0.00	0.00	0.05	0.04	144852.7%	941.7%	-8.7%	0.0%	0.2%	2.9%	0.0%	0.1%	2.4%	fuel sold
PM2.5	0.00	0.00	0.04	0.04	210044.1%	937.8%	-8.7%	0.0%	0.3%	4.6%	0.0%	0.2%	3.8%	fuel sold

Source: Environment Agency.

Figure 41 – Changes of emissions compared to base year (1990) for *1A1 – Energy Industries.*



Note: The vertical axis on the right corresponds to $PM_{2.5}$.

Source: Environment Agency.

In 2022, this source category represented, based on fuel sold:

- 5.7% of national total SO_x emissions,
- 4.2% of national total NO_X emissions,
- 1.0% of national total NMVOC emissions,
- 0.0% of national total NH_3 emissions,
- 3.8% of national total $PM_{2.5}$ emissions.

Compared to 2021, emissions of all pollutants decreased. NO_X emissions decreased by 21.1% while $PM_{2.5}$ emissions decreased by 8.7%. In the years prior to 2022, Luxembourg saw an increase in emissions due to increased activity in wood combustion. Indeed, since 2017, a new medium combustion plant, combusting pellets, became operational, and wood combustion activity at several other medium combustion plants and one industrial emissions plant were further increased in 2019, 2020 and continued to increase in 2021.

Table 3-10 – Emission trends for category *1A1a - Public electricity and heat production*

1A1 - Energy Industries *Emissions of air pollutants (Gg)*								
Year	1A1a - Public Electricity & Heat Production							
	SO2	*NOx*	*NMVOC*	*NH3*	*CO*	*TSP*	*PM10*	*PM2.5*
1990	0.004	0.031	0.001	NO	0.007	0.000	0.000	0.000
1991	0.004	0.033	0.001	NO	0.008	0.000	0.000	0.000
1992	0.004	0.035	0.003	NO	0.008	0.000	0.000	0.000
1993	0.004	0.033	0.003	NO	0.008	0.000	0.000	0.000
1994	0.004	0.033	0.003	NO	0.008	0.000	0.000	0.000
1995	0.004	0.073	0.005	NO	0.039	0.001	0.001	0.001
1996	0.003	0.067	0.006	NO	0.038	0.001	0.001	0.001
1997	0.004	0.089	0.015	NO	0.054	0.001	0.001	0.001
1998	0.004	0.118	0.018	NO	0.077	0.001	0.001	0.001
1999	0.004	0.134	0.022	0.000	0.088	0.001	0.001	0.001
2000	0.008	0.106	0.024	0.000	0.067	0.002	0.002	0.002
2001	0.007	0.219	0.032	0.000	0.086	0.002	0.002	0.001
2002	0.010	0.771	0.072	0.000	0.188	0.002	0.002	0.002
2003	0.011	0.846	0.098	0.000	0.254	0.003	0.003	0.003
2004	0.013	0.935	0.130	0.000	0.301	0.004	0.004	0.004
2005	0.010	0.965	0.137	0.000	0.295	0.004	0.004	0.004
2006	0.011	0.956	0.149	0.000	0.297	0.005	0.005	0.004
2007	0.010	0.863	0.140	0.000	0.308	0.005	0.005	0.005
2008	0.012	0.772	0.142	0.000	0.313	0.006	0.006	0.006
2009	0.016	0.850	0.152	0.000	0.322	0.007	0.007	0.007
2010	0.010	0.850	0.170	0.000	0.347	0.007	0.007	0.006
2011	0.009	0.772	0.154	0.000	0.353	0.008	0.007	0.007
2012	0.010	0.763	0.164	0.000	0.355	0.008	0.008	0.008
2013	0.009	0.623	0.160	0.000	0.390	0.009	0.009	0.008
2014	0.011	0.621	0.157	0.001	0.360	0.009	0.009	0.009
2015	0.013	0.555	0.160	0.001	0.362	0.012	0.012	0.011
2016	0.013	0.511	0.166	0.001	0.350	0.013	0.013	0.012
2017	0.018	0.496	0.155	0.001	0.482	0.036	0.034	0.033
2018	0.024	0.557	0.142	0.001	0.581	0.053	0.051	0.049
2019	0.022	0.506	0.139	0.001	0.440	0.035	0.033	0.032
2020	0.030	0.566	0.136	0.002	0.623	0.061	0.058	0.056
2021	0.027	0.606	0.152	0.001	0.568	0.047	0.045	0.044
2022	0.025	0.478	0.102	0.001	0.450	0.043	0.041	0.040
Trend 1990-2022	*535.56%*	*1423.53%*	*9163.69%*	*NA*	*6161.03%*	*113883.87%*	*144852.72%*	*210044.07%*
2005-2022	*149.41%*	*-50.43%*	*-25.55%*	*2535.75%*	*52.50%*	*966.74%*	*941.68%*	*937.80%*
2021-2022	*-8.18%*	*-21.06%*	*-33.05%*	*-9.81%*	*-20.85%*	*-8.72%*	*-8.72%*	*-8.71%*

Source: Environment Agency.

Category *1A1a – Public electricity and heat production* is a key category for NO_X, SO_X and $PM_{2.5}$ emissions (LA & TA) in 2022 (see Table 3-11 and also Table 3-4 in Section 3.2 and Chapter 1.5).

Table 3-11 – Key Categories (fuel sold & fuel used) for category – *1A1a - Public electricity and heat production*

Key Source Analysis (FUEL SOLD): Ranking per number		SO2		NOX		NMVOC		NH3		CO		TSP		PM10		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
1 A 1 a	Energy Industries - Public Electricity and Heat Production		5	8	5											6	

Key Source Analysis (FUEL USED): Ranking per number		SO2		NOX		NMVOC		NH3		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
1 A 1 a	Energy Industries - Public Electricity and Heat Production		5	7	6					6	

Sources: Environment Agency
Notes: LA = Level Assessment, TA = Trend Assessment
Number in Table = indicates the rank in the specific analysis (1…biggest KC; 2… second biggest KC, …)

For heavy metals and persistent organic pollutants, category *1A1a – Public electricity and heat production* is a key category for Cd and HCB (LA & TA) and Pb and Hg, (LA) in 2022 (see Table 3-12 and also Table 3-4 in Section 3.2 and Chapter 1.5).

Table 3-12 – HM and POP key categories for category – *1A1a - Public electricity and heat production*

Key Source Analysis (FUEL SOLD): Ranking per number		Pb		Cd		Hg		PCDD/F		PCB		HCB		PAH	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
1 A 1 a	Energy Industries - Public Electricity and Heat Production	4		2	2	4						2	3		

Legend **LA** Level Assessment **TA** Trend assessment
number in Table indicates the rank in the specific analysis (1…biggest KC; 2… second biggest KC, …)

3.2.2.2 Methodological issues

3.2.2.2.1 Activity data

Activity data of the various installations considered in *1A1a*:

- combined heat and power (*CHP*) installations, which have appeared at the beginning of the 1990s. Those installations generally use combustion engines, and are operated with natural gas and/or gasoil and to a smaller extent with biogas or wood & wood wastes. The activity rates are based on information received from the operators and from the energy balance as compiled by the national statistics institute (STATEC).
- combustion plants with a thermal capacity ranging between 100 KWth and 50MWth which are mostly operated either with natural gas or wood & wood wastes. The activity rates are based on information received from the operators and from the energy balance as compiled by the national statistics institute (STATEC)
- a CHP gas turbine (350 MW) running on natural gas and operated since 2001 by Twinerg S.A. Since heat was not recovered from 2002 to 2010, this unit was counted as a thermal power plant and not as a cogeneration plant in official statistics. After 2011 however, heat recovery was done and the installation was considered as a cogeneration plant. However, this classification change has no impact on the air pollutant emission estimates since it is the fuel(s) used and the technology (-ies) that matter. During 2015, electricity and heat production from this facility was at a very low level due to unfavourable economic reasons, and the facility was finally shut down in 2016 and decommissioned in 2018. There are several smaller CHP gas turbines, which are operated on industrial sites, but which produce heat and electricity mainly for the respective industries. Emissions related to these are accounted for in *1A2-Manufacturing Industries and Construction*, as these installations are considered as auto-producers.
- One waste incinerator (SIDOR) is fed with natural gas, gas oil, fluff, and waste (composed of municipal solid waste and bulky waste). The incinerated waste is composed of 14 waste categories: paper/cardboard, textiles, food waste, wood, garden & park waste,

nappies, rubber & leather, plastics, multilayer composite material, metal, glass, other inert waste, 0-8 sieve fraction, and 9-40 sieve fraction. The sieve fractions were added to the twelve previous MSW categories following the re-cent publication of an extensive study (ECO-Conseil s.à.r.l., "Laboranalytische Untersuchung ausgewählter Sor-tierfraktionen der landesweiten Restab-fallanalyse 2022", Luxembourg, 2022). In fact, the sieve fractions consist of fine waste elements with a size between 0 and 8 mm and between 9 and 40 mm. These waste categories have always been analyzed and documented in Luxembourg's waste analyses but their combustion properties were unknown, which is why their activity data were previously allocated to the waste categories "food waste" and "other, inert waste". With the abovementioned study, their combustion properties (net calorific value, dry matter content, total carbon content, and biogenic carbon fraction) have been identified by laboratory analysis. The municipal solid waste (MSW) and bulky waste (BW) are provided by the three syndicates SIDEC, SIDOR, and SIGRE. Both SIDOR and SIGRE deliver the waste directly to the incinerator while the waste from SIDEC first undergoes a pre-treatment at a different facility before arriving at the incinerator (some part is not taken to the incinerator after treatment but deposited on land[41]). No industrial and hazardous wastes are incinerated because they are exported. The MSW, delivered from SIDOR and SIGRE to the incinerator, is split into the fourteen MSW fractions mentioned above according to the following studies. The years for which the studies have been done act as pillar years. For the years in-between, a linear interpolation was carried out.

- ECO-Conseil s.à.r.l., "Restabfallanalyse 1992/1994", Luxembourg, 2002;
- ECO-Conseil s.à.r.l., "Restabfallanalyse 2001 im SIDOR", Luxembourg, 2002;
- ECO-Conseil s.à.r.l., "Restabfallanalyse 2004/05 im Großherzogtum Luxemburg, Band 1: Kompendium", Luxembourg, 2005;
- ECO-Conseil s.à.r.l., "Restabfallanalyse 2009/10 im Großherzogtum Luxemburg, Band 1: Kompendium", Luxembourg, 2010;
- ECO-Conseil s.à.r.l., "Restabfallanalyse 2013/14 im Großherzogtum Luxemburg, Band 1: Kompendium", Luxembourg, 2016;
- ECO-Conseil s.à.r.l., "Restabfallanalyse 2018/2019 im Großherzogtum Luxemburg, Endbericht", Luxembourg, 2019;
- ECO-Conseil s.à.r.l., "Nationale Restabfallanalyse 2021/2022 im Großherzogtum Luxemburg", Luxembourg, 2022.

The BW, delivered from SIDOR and SIGRE to the incinerator, is split into the twelve MSW fractions (i.e. all but the sieve fractions) according to the following studies. The years for which the studies have been done act as pillar years. For the years in-between, a linear interpolation was carried out.

- ECO-Conseil s.à.r.l., "Sperrmüllanalyse 2009 im Großherzogtum", Luxembourg, 2010;
- ECO-Conseil s.à.r.l., "Sperrmüllanalyse 2015 im Großherzogtum", Luxembourg, 2016;
- ECO-Conseil s.à.r.l., "Sperrmüllanalyse 2020 im Großherzogtum", Luxembourg, 2020.

The part of the waste that originates from the pre-treatment plant (MBA Fridhaff), consisting of both MSW and BW, is split into the twelve fractions according to the study

- ECO-Conseil s.à.r.l., "Abschätzung emittierter Klimagase durch die über die MBA Fridhaff abgeschiedene und verbrannte heizwertreiche Fraktion", Luxembourg, 2009

[41] For the different waste treatment schemes, see IIR chapter on waste.

Total fuel consumption data, for subcategory *1A1a – Public Electricity and Heat Production*, is taken from the energy balance (STATEC). The remaining fuel consumption (= total consumption minus reported bottom-up consumption) is the activity data of plants < 50 MWth used for emission calculation with the EMEP methodology using TIER 2 emission factors.

Table gives an overview of the energy consumption by fuel type in *1A1a – Public Electricity and Heat Production.* For biomass, a significant increase is observed from 2012 to 2015 and between 2016 and 2020. This is due to a significant increase in the consumption of wood & wood wastes combusted in CHP and medium combustion plants as reported by the national energy balance.

Table 3-13 – Activity data for category *1A1a – Public Electricity and Heat Production*

1A1 - Energy Industries *Activity Data by fuel type (GJ)* *1A1a - Public Electricity & Heat Production*						
Year	Activity Total (incl. biomass)	Liquid *Gas Oil*	Solid *Brown coal, BKB, etc.*	Gaseous *Natural Gas*	Biomass *Biogas, Wood & MSW (biogenic fraction)*	Other *MSW (fossil fraction)*
1990	1 245 232	NO	NO	NO	916 172	329'059
1991	1 302 864	NO	NO	NO	958 575	344'289
1992	1 316 100	NO	NO	NO	972 806	343'294
1993	1 306 187	NO	NO	NO	935 410	370'777
1994	1 330 484	NO	NO	NO	923 657	406'827
1995	2 366 317	NO	NO	1'043'100	891 878	431'339
1996	2 052 066	900	NO	984'600	699 211	367'355
1997	2 333 909	18'919	NO	1'013'400	825 997	475'594
1998	3 055 356	30'783	NO	1'709'100	809 104	506'368
1999	3 468 726	31'593	NO	1'883'700	927 169	626'264
2000	2 556 891	60'414	NO	920'854	921 527	654'097
2001	5 483 630	55'018	NO	3'808'343	928 835	691'434
2002	18 684 618	48'220	NO	17'031'071	934 387	670'939
2003	18 718 894	46'054	NO	17'102'526	939 592	630'722
2004	22 592 490	46'606	NO	20'850'220	1 016 819	678'845
2005	22 238 796	24'344	NO	20'647'091	982 911	584'450
2006	23 326 024	24'981	NO	21'624'432	1 043 724	632'887
2007	21 243 684	23'409	NO	19'508'383	1 082 681	629'211
2008	18 027 496	49'325	NO	16'205'838	1 138 134	634'200
2009	21 466 425	76'261	NO	19'534'163	1 194 170	661'832
2010	21 957 495	19'416	NO	20'082'942	1 223 237	631'901
2011	18 512 240	18'530	NO	16'344'441	1 360 114	789'155
2012	19 356 558	19'756	NO	17'071'478	1 408 597	856'727
2013	13 305 935	15'040	NO	10'853'489	1 487 571	949'834
2014	13 363 992	13'595	NO	10'369'609	2 054 402	926'386
2015	9 891 252	18'944	NO	6'533'034	2 351 666	987'608
2016	6 344 624	32'034	NO	2'687'859	2 494 471	1'130'260
2017	6 659 719	23'553	NO	2'496'982	2 998 002	1'141'181
2018	6 806 000	17'868	NO	2'090'227	3 563 510	1'134'395
2019	6 140 996	17'469	NO	1'801'657	3 169 793	1'152'077
2020	6 734 421	11'324	NO	1'878'222	3 785 195	1'059'680
2021	7 397 806	5'040	NO	2'752'847	3 579 986	1'059'933
2022	6 669 829	28'503	NO	2'116'932	3 400 642	1'123'751
Trend 1990-2022	*435.63%*	*NA*	*NA*	*NA*	*271.18%*	*241.50%*
2005-2022	*-70.01%*	*17.08%*	*NA*	*-89.75%*	*245.98%*	*92.27%*
2021-2022	*-9.84%*	*465.50%*	*NA*	*-23.10%*	*-5.01%*	*6.02%*

Source: Environment Agency.

3.2.2.2.2 Methodological choices

For point sources of this category, emission measurements of NO_X, SO_2, NMVOC, CO and TSP are the basis for the reported emissions (EMEP/EEA Tier 3 approach).

The remaining point or area sources, for which no measured (plant-specific) emission data but plant specific activity data or other information on the abatement technology was available, were estimated using the EMEP/EEA Tier 2 by multiplying the fuel consumption taken from the national energy balance with the default emission factors.

The methods applied in relation to the coverage of energy consumption for 2022 are presented in Table 3-14.

3.2.2.2.3 Emission factors

For point sources of this category, emission measurements of NO_X, SO_2, NMVOC, CO and TSP are the basis for the reported emissions (EMEP/EEA Tier 3 approach). Hence, no emission factors per se are used, but rather implied emission factors are derived by dividing the emission with the activity data.

The point or area sources, for which no measured (plant-specific) emission data but plant specific activity data or information on the abatement technology was available, were estimated using the EMEP/EEA Tier 2 default emission factors.

The remaining point or area sources, for which no measured (plant-specific) emission data, nor plant specific activity data or information on the abatement technology was available, were estimated using the EMEP/EEA Tier 1 default emission factors.

Emission factors (EF) used as well as coverage of energy consumption for 2022 are presented in Table 3-14. Implied emission factors are presented in Table . These may vary over time for the following reasons:

- The chemical characteristics of a fuel category varies, e.g. sulphur content.
- The mix of fuels of a fuel category changes over time. If the different fuels of a fuel category have different calorific values and their share in the fuel category changes, the calorific value of the fuel category might change over time. If emission factors are in the unit kg/t the transformation to kg/TJ induces a different emission factor due to varying net calorific values.
- The production or abatement technology of a facility – or of facilities – changes over time. Indeed, due to the final shutdown of the low-NO_x Twinerg Gas turbine in 2016, and consequently the increase in the share of technologies emitting more NO_x, the NO_x-IEF has increased by 15% compared to 2015.
- Since 2016, an increase in biomass combustion is observed, hence, this change in fuel mix is reflected by an increase of the implied emission factors for PM and NO_X ans SO_X, due to higher emission factors for wood combustion activities.

Table 3-14 – Methods and Emission Factors used in relation to the coverage of energy consumption in 2022 for category *1A1a - Public Electricity and Heat Production*

1A1a - Public Electricity & Heat Production				
Pollutant	**Method**	**EF used**	**Coverage of energy consumption**	**Source**
NOx	T3	PS	51.1%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2	D	48.9%	IEF: PS, EMEP/EEA GB 2019 (Chap1A1, Tab3.20, p35), IEF
NMVOC	T3	PS	31.5%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2	D	68.5%	IEF: PS, IEF: PS, EMEP/EEA GB 2019 (Chap1A1, Tab3.20, p35), EMEP/EEA GB 2019 (Chap1A1, Tab3.17, p31), EMEP/EEA GB 2019 (Chap1A4, Tab3.25, p56), IEF
SOx	T3	PS	33.7%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2	CS	0.0%	CS based on fuel sulfur content; determined by AEV
	T1	D	66.3%	EMEP/EEA GB 2019 (Chap1A1, Tab3.17, p31), EMEP/EEA GB 2019 (Chap1A1, Tab3.20, p35), IEF
CO	T3	PS	51.1%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2	D	48.9%	EMEP/EEA GB 2016(Chap1A1, Tab3.20, p36), EMEP/EEA GB 2016(Chap1A1, Tab3.17, p33), EMEP/EEA GB 2016(Chap1A4, Tab3.27, p62), EMEP/EEA GB 2016(Chap1A4, Tab3.25, p66), IEF
PM2.5	T3	PS	51.1%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV PM measured assumed to be TSP = PM10 = PM2.5
	T2	D	48.9%	EMEP/EEA GB 2016(Chap1A1, Tab3.20, p36), EMEP/EEA GB 2016(Chap1A1, Tab3.17, p33), EMEP/EEA GB 2016(Chap1A4, Tab3.27, p62), EMEP/EEA GB 2016(Chap1A4, Tab3.25, p66), IEF
PM10	T3	PS	51.1%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV PM measured assumed to be TSP = PM10 = PM2.5
	T2	D	48.9%	EMEP/EEA GB 2016(Chap1A1, Tab3.20, p36), EMEP/EEA GB 2016(Chap1A1, Tab3.17, p33), EMEP/EEA GB 2016(Chap1A4, Tab3.27, p62), EMEP/EEA GB 2016(Chap1A4, Tab3.25, p66), IEF
TSP	T3	PS	51.1%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV PM measured assumed to be TSP = PM10 = PM2.5
	T2	D	48.9%	EMEP/EEA GB 2016(Chap1A1, Tab3.20, p36), EMEP/EEA GB 2016(Chap1A1, Tab3.17, p33), EMEP/EEA GB 2016(Chap1A4, Tab3.27, p62), EMEP/EEA GB 2016(Chap1A4, Tab3.25, p66), IEF

Source: Environment Agency.

Table 3-15 – Implied emission factors for category *1A1a - Public Electricity and Heat Production*

1A1 - Energy Industries Implied Emission Factor (IEF) of air pollutants (g/GJ)								
Year	1A1a - Public Electricity & Heat Production							
	SO2	NOx	NMVOC	NH3	CO	TSP	PM10	PM2.5
1990	3.18	25.21	0.88	NA	5.77	0.03	0.02	0.02
1991	3.18	25.21	0.88	NA	5.77	0.03	0.02	0.02
1992	3.14	26.63	2.02	NA	6.42	0.06	0.05	0.04
1993	3.01	25.61	1.99	NA	6.19	0.05	0.05	0.04
1994	2.89	24.64	1.94	NA	5.96	0.05	0.05	0.04
1995	1.69	31.02	2.03	NA	16.49	0.23	0.23	0.22
1996	1.53	32.60	2.80	NA	18.42	0.25	0.25	0.24
1997	1.58	38.22	6.48	NA	23.22	0.25	0.24	0.24
1998	1.25	38.74	5.96	NA	25.19	0.28	0.28	0.28
1999	1.27	38.72	6.26	0.00	25.51	0.31	0.30	0.30
2000	3.04	41.58	9.43	0.00	26.12	0.92	0.91	0.75
2001	1.21	39.88	5.75	0.00	15.71	0.31	0.30	0.26
2002	0.55	41.28	3.86	0.00	10.07	0.12	0.12	0.11
2003	0.60	45.21	5.23	0.00	13.56	0.18	0.18	0.17
2004	0.56	41.40	5.77	0.00	13.34	0.17	0.17	0.16
2005	0.45	43.39	6.14	0.00	13.26	0.18	0.18	0.17
2006	0.48	40.96	6.40	0.00	12.73	0.20	0.19	0.19
2007	0.49	40.62	6.61	0.00	14.48	0.23	0.22	0.21
2008	0.64	42.84	7.89	0.00	17.36	0.33	0.32	0.31
2009	0.76	39.60	7.10	0.00	14.98	0.35	0.34	0.32
2010	0.48	38.72	7.75	0.00	15.80	0.31	0.30	0.29
2011	0.51	41.70	8.32	0.01	19.04	0.41	0.39	0.38
2012	0.52	39.44	8.47	0.01	18.32	0.43	0.42	0.40
2013	0.66	46.83	12.00	0.01	29.32	0.68	0.65	0.62
2014	0.84	46.44	11.71	0.05	26.91	0.70	0.68	0.66
2015	1.35	56.08	16.20	0.08	36.61	1.25	1.20	1.15
2016	2.09	80.54	26.10	0.13	55.17	2.13	2.04	1.95
2017	2.66	74.42	23.31	0.18	72.45	5.34	5.07	4.89
2018	3.59	81.82	20.82	0.22	85.35	7.82	7.44	7.23
2019	3.50	82.39	22.60	0.17	71.69	5.66	5.39	5.23
2020	4.49	84.09	20.23	0.25	92.55	9.02	8.59	8.35
2021	3.70	81.91	20.54	0.18	76.80	6.41	6.11	5.94
2022	2.26	43.03	9.15	0.11	40.46	3.90	3.71	3.61
Trend 1990-2022	*-28.80%*	*70.68%*	*937.80%*	*NA*	*601.42%*	*12669.48%*	*16138.89%*	*23442.20%*
2005-2022	*399.01%*	*-0.83%*	*48.95%*	*5173.46%*	*205.12%*	*2034.27%*	*1984.14%*	*1976.36%*
2021-2022	*-38.89%*	*-47.46%*	*-55.44%*	*-39.97%*	*-47.32%*	*-39.25%*	*-39.25%*	*-39.24%*

Source: Environment Agency.

3.2.2.3 Methodological issues for heavy metals and POPs

Category *1A1a - Public Electricity and Heat Production* includes HM and POP emissions from combustion processes associated with industrial heat and energy production as well as emissions originating from waste-to-energy processes (WTE). Apart from three large point sources (WTE plant in Leudelange, gas vapour turbine Twinerg in Esch/Alzette, and Luxenergie combustion plant in Luxembourg-Kirchberg), this category includes several diffuse emissions from a range of industrial combustion plants at different locations in the country.

3.2.2.3.1 Activity Data

WTE plant: Annual operating hours and volumetric flow taken from emission control measurement protocols. Where measurement data were lacking, annual fuel consumption (natural gas, gas oil) and amount of incinerated waste (municipal wastes, biomass), both taken from the national energy balance.

Twinerg plant, Luxenergie plant and diffuse sources: annual fuel consumption (natural gas, gas oil) taken from the national energy balance.

3.2.2.3.2 Methodological Choices

The calculation of emissions originating from the WTE plant was based on data from emission control measurements (tier 3). Projection of annual emissions was carried out using these measurement data in combination with annual operating hours and volumetric flow measurements. Where measurement data for the WTE plant were lacking, emissions were calculated based on annual consumption of fuels (natural gas, gas oil) and the amount of incinerated waste (municipal wastes, biomass) in combination with tier 1 emission factors. To obtain more realistic values, emission calculations based on annual fuel consumption were offset with a correction factor based on actual measurements of a reference year (ratio of the measured emission value to the appropriate value based on fuel consumption; both of the closest year with measurements).

The calculation of emissions from public electricity and heat production (any other than WTE) was based on total fuel consumption in combination with tier 1 emission factors.

Fuel consumption data were obtained from the national energy balance.

3.2.2.3.3 Emission Factors

Sources for Tier 1 emission factors are given in the following table:

Table 3-16 – Sources for Tier 1 HM and POP emission factors for category *1A1a - Public Electricity and Heat Production*

Fuel	Pollutants	Source	Page	Table
Hard coal	Pb, Hg, Cd, PCDD/F, PCB, HCB, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2023) – Chapter 1.A.1.a Energy industries	15	3-2
Brown coal	Pb, Hg, Cd, PCDD/F, PCB, HCB, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2023) – Chapter 1.A.1.a Energy industries	16	3-3
Natural gas	Pb, Hg, Cd	EEA (2023) – Chapter 1.A.1.a Energy industries (PCDD/F, PCB, HCB, B(a)P, B(b)F, B(k)F, I(cd)P are NA)	17	3-4
Gas oil	Pb, Hg, Cd, PCDD/F, I(cd)P *(B(a)P, B(b)F, B(k)F)*	EEA (2023) – Chapter 1.A.1.a Energy industries *Note: EF for B(a)P, B(b)F, B(k)F not estimated, thus assumed these to be equal to EF for I(cd)P*	19	3-7
Gas oil	PCB	EF not stated in EEA (2023), thus custom EF derived from EMEP/Corinair Guidebook (2007): 1 TEP= 1,170 l and density (gas oil) = 0,84 kg/l → 1 TEP= 983 kg EF: EMEP/Corinair Guidebook (2007), Draft Chapter on PCB emissions: 250 ug/t (gas oil) conversion: 1 TEP = 41,9 GJ (250 ug/t * 0,983 t)/ 41,9 GJ = 5,87 ug PCB/GJ gasoil	N/A	N/A
Biomass	Pb, Hg, Cd, PCDD/F, PCB, HCB, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2023) – Chapter 1.A.1.a Energy industries	20	3-8

3.2.2.4 Uncertainties and time-series consistency

The assessment of activity data and emission factor uncertainties is done according to the methodology described in the EMEP/EEA emission inventory Guidebook 2023 (Chapter A.5 Uncertainties, tables 2-1, 2-2 and 2-3), covering the main pollutants NO_x, NH_3, NMVOC, SO_x and $PM_{2.5}$. For some subcategories and pollutants, expert judgements were made to estimate AD or EF uncertainties. For

CO, PM10, heavy metzals and persistent organic pollutants, no uncertainty estimates are currently made. Details on uncertainty of the activity data can also be checked in the Luxembourg's National Inventory report (NIR). Please also refer to Table 1-33 to Table 1-37 of section 1.7 for caterogory specific uncertainties on activity data and emission factors.

The time-series are considered to be consistent with the data reported in the energy balance. The annual fluctuations in fuel consumption, especially for natural gas, and the resulting fluctuations of emissions, are explained by the fluctuations of electricity and heat production levels of the plants covering the sector. Indeed, a sharp increase in the natural gas consumption was observed in 2002, with the operational start of a 350 MWe gas turbine (Twinerg). In the following years, maintenance stops (2009, 2011) of the 350 MWe gas turbine, sometimes during several months, greatly influenced the energy demand of this category. Also, rotation of the gasoil stocks (used as emergency fuel) can cause fluctuations in the emissions. This was the case in 2008-2009. Since 2013, the activity was dramatically reduced, as a consequence of the low economic profitability of gas-fired plants. The facility was finally shut down in 2016. The dip of MSW incineration in 1996, was due to a fire in the incineration plant, followed by a shut-down for several months. Since 2014, several small to medium combustion plants fired with wood and wood wastes were put in operation.

3.2.2.5 Source-specific QA/QC and verification

Activity data for large facilities that are under the European Union Emission Trading Scheme (EU-ETS) is cross-checked from two sources: reports obtained directly from the operator under its operational permit obligations and the EU-ETS registry operator. Both are hosted at the Environment Agency. A list with the large energy consuming facilities along with their respective fuel consumption has been compiled and enables the Single National Entity to quickly cross-check this data with the EU-ETS data. Thus, completeness can be checked on a more systematic basis.

Additionally, cross checks with other relevant sectors, mainly *6 – Waste*, are performed to avoid double counting.

Finally, consistency and completeness checks are performed.

3.2.2.6 Category-specific recalculations including changes made in response to the review process

Table presents the main revisions and recalculations done since submission 2023 for category *1A1a – Public Electricity and Heat Production*.

Table 3-17 – Recalculations done since last submission for category *1A1a - Public Electricity and Heat Production*

Source category	Revisions 2023 → 2024	Type of revision
1A1a	Revision of the natural gas and biogas activity data due to changes in the national energy balance for 2021 (+733 TJ for natural gas compared to the previous submission and +62 TJ for biogas compared to the previous submission).	AD
1A1a	Error correction: emissions from the combustion of natural gas and wood were double counted in sectors 1A1a and 1A2gviii for 2018-2021 in the previous submissions. This error has been corrected.	AD error correction
1A1a	Revision of NH_3 emissions for 2017-2021 from medium sized wood boilers due to a change of the Tier 2 EF in the new 2023 EMEP/EEA Guidebook (from 37 g/GJ to NE in Chapter 1A4, Table 3-45, p.86).	NH_3 EF
1A1a	Revision of NH_3 emissions for 1999-2021 from automatic boilers burning wood due to a change of the Tier 2 EF in the new 2023 EMEP/EEA Guidebook (from 37 g/GJ to 1 g/GJ in Chapter 1A4, Table 3-48, p.90).	NH_3 EF

1A1a	Revision of TSP emissions for 2017-2021 from medium sized wood boilers due to a change of the Tier 2 EF in the new 2023 EMEP/EEA Guidebook (from 36 g/GJ to 40 g/GJ in Chapter 1A4, Table 3-45, p.86).	TSP EF
1A1a	Revision of TSP emissions for 1999-2021 from automatic boilers burning wood due to a change of the Tier 2 EF in the new 2023 EMEP/EEA Guidebook (from 36 g/GJ to 40 g/GJ in Chapter 1A4, Table 3-48, p.90).	TSP EF
1A1a	Revision of PM_{10} emissions for 2017-2021 from medium sized wood boilers due to a change of the Tier 2 EF in the new 2023 EMEP/EEA Guidebook (from 34 g/GJ to 38 g/GJ in Chapter 1A4, Table 3-45, p.86).	PM_{10} EF
1A1a	Revision of PM_{10} emissions for 1999-2021 from automatic boilers burning wood due to a change of the Tier 2 EF in the new 2023 EMEP/EEA Guidebook (from 34 g/GJ to 38 g/GJ in Chapter 1A4, Table 3-48, p.90).	PM_{10} EF
1A1a	Revision of $PM_{2.5}$ emissions for 2017-2021 from medium sized wood boilers due to a change of the Tier 2 EF in the new 2023 EMEP/EEA Guidebook (from 33 g/GJ to 37 g/GJ in Chapter 1A4, Table 3-45, p.86).	$PM_{2.5}$ EF
1A1a	Revision of $PM_{2.5}$ emissions for 1999-2021 from automatic boilers burning wood due to a change of the Tier 2 EF in the new 2023 EMEP/EEA Guidebook (from 33 g/GJ to 37 g/GJ in Chapter 1A4, Table 3-48, p.90).	$PM_{2.5}$ EF

3.2.2.7 Category-specific planned improvements including those in response to the review process

The following improvements are planned for the next submission.

Table 3-18 – Planned improvements for category *1.A.1. – Energy Industries*

Source category	Planned improvements	Type of revision
	none	

3.2.3 Manufacturing Industries and Construction (1A2)

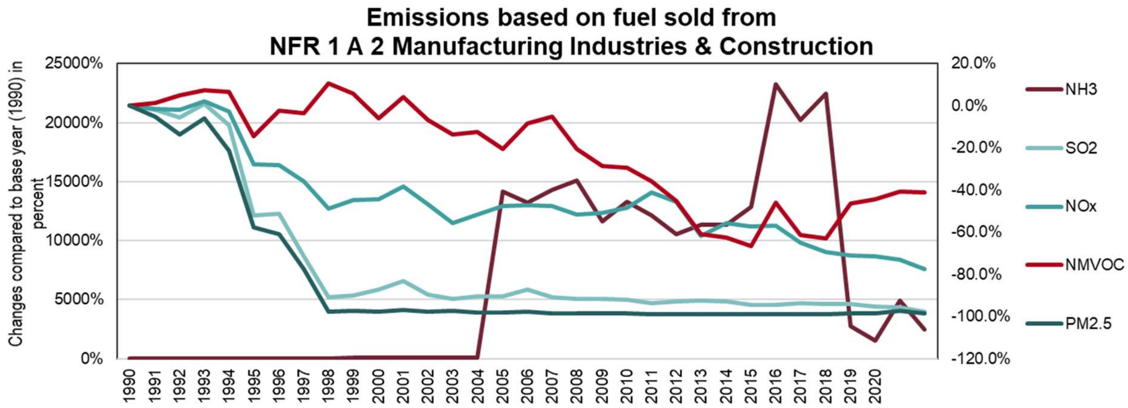
3.2.3.1 Source category description

This section describes air pollutant emissions resulting from fuel combustion activities in manufacturing industries and construction.

The 2022 air pollutant emission inventory includes emissions from categories *1A2a – Iron and Steel*, *1A2b – Non-Ferrous Metals*, *1A2c – Chemicals*, *1A2d – Pulp, Paper and Print, 1A2e – Food Processing, Beverages and Tobacco, 1A2f – Non-Metallic Minerals, 1A2g vii - Mobile Combustion in manufacturing industries and construction, 1A2g viii – Other Stationary.*

Figure 42 and Table 3-19 (and in more detail, Table and Table) present the emission trends of the air pollutants compared to the base year (1990). The emission reduction of the main pollutants SO_2, NO_x and CO as well as PM could be achieved mainly due to a change in the iron and steel industry and fuel switch but also by introduction of modern production and abatement technologies. For NMVOC and NH_3, the trend is dominated by the combustion in mobile machinery (*1A2g vii - Mobile Combustion in manufacturing industries and construction*).

Figure 42 – Changes of emissions compared to base year (1990) based on fuel sold for *1A2 - Manufacturing Industries and Construction.*



Note: The vertical axis on the left corresponds to NH_3 only.

Source: Environment Agency.

Table 3-19 – Emissions, Trends and Shares based on fuel sold and fuel used – *1A2- Manufacturing Industries and Construction*

1 A 2 Manufacturing Industries and Construction														
Pollutants	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
SO2	13.81	1.32	0.62	0.30	-98%	-77%	-52%	89%	52%	69%	84%	51%	67%	fuel sold
NOx	11.29	5.93	3.06	2.55	-77%	-57%	-17%	51%	33%	28%	28%	10%	22%	fuel sold
NMVOC	0.92	0.74	0.55	0.54	-41%	-26%	-1%	4%	6%	6%	3%	5%	5%	fuel sold
NH3	0.00	0.03	0.01	0.01	2434%	-82%	-50%	0%	1%	0%	0%	1%	0%	fuel sold
CO	377.88	10.52	8.11	7.23	-98%	-31%	-11%	89%	47%	49%	81%	26%	41%	fuel sold
TSP	14.58	0.39	0.49	0.29	-98%	-25%	-40%	87%	17%	14%	82%	10%	12%	fuel sold
PM10	14.46	0.34	0.45	0.26	-98%	-25%	-43%	90%	19%	18%	86%	11%	15%	fuel sold
PM2.5	14.21	0.26	0.39	0.21	-99%	-22%	-47%	92%	20%	24%	88%	10%	20%	fuel sold

Source: Environment Agency.

Table 3-20 – NO_X, NMVOC, SO_2, and NH_3 emissions, trends and shares based on fuel sold and fuel used – *1A2 - Manufacturing Industries and Construction*

NOx

NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
1 A 2	**11.29**	**5.93**	**3.06**	**2.55**	**-77%**	**-57%**	**-17%**	**51%**	**33%**	**28%**	**28%**	**10%**	**22%**	**fuel sold**
1 A 2 a	6.93	1.53	0.52	0.39	-94%	-75%	-25%	31.1%	8.6%	4.2%	17.0%	2.7%	3.4%	fuel sold
1 A 2 b	0.06	0.09	0.08	0.08	35%	-6%	8%	0.3%	0.5%	0.9%	0.1%	0.2%	0.7%	fuel sold
1 A 2 c	0.19	0.19	0.08	0.06	-67%	-69%	-24%	0.8%	1.1%	0.7%	0.5%	0.3%	0.5%	fuel sold
1 A 2 d	IE	0.03	0.02	0.01	1%	-52%	-39%	IE	0.2%	0.1%	IE	0.0%	0.1%	fuel sold
1 A 2 e	0.00	0.02	0.01	0.02	319%	29%	50%	0.0%	0.1%	0.2%	0.0%	0.0%	0.2%	fuel sold
1 A 2 f	3.38	2.72	0.93	0.73	-78%	-73%	-21%	15.1%	15.2%	8.0%	8.3%	4.8%	6.4%	fuel sold
1 A 2 g vii	0.63	1.26	0.96	0.90	42%	-29%	-7%	2.8%	7.0%	9.8%	1.5%	2.2%	7.8%	fuel sold
1 A 2 g viii	0.09	0.09	0.46	0.36	280%	302%	-23%	0.4%	0.5%	3.9%	0.2%	0.2%	3.1%	fuel sold
National total (fuel sold)	**40.866**	**56.915**	**13.941**	**11.476**	**-71.9%**	**-79.8%**	**-17.7%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**22.291**	**17.861**	**10.545**	**9.145**	**-59.0%**	**-48.8%**	**-13.3%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

NMVOC

NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
1 A 2	**0.924**	**0.737**	**0.548**	**0.544**	**-41.1%**	**-26.2%**	**-0.8%**	**4.3%**	**6.1%**	**5.6%**	**3.0%**	**5.0%**	**5.4%**	**fuel sold**
1 A 2 a	0.593	0.253	0.100	0.089	-85.0%	-64.8%	-11.3%	2.7%	2.1%	0.9%	1.9%	1.7%	0.9%	fuel sold
1 A 2 b	0.133	0.197	0.060	0.068	-49.1%	-65.6%	13.6%	0.6%	1.6%	0.7%	0.4%	1.3%	0.7%	fuel sold
1 A 2 c	0.009	0.015	0.008	0.006	-33.1%	-58.2%	-22.1%	0.0%	0.1%	0.1%	0.0%	0.1%	0.1%	fuel sold
1 A 2 d	IE	0.007	0.006	0.003	0.3%	-52.0%	-39.3%	IE	0.1%	0.0%	IE	0.0%	0.0%	fuel sold
1 A 2 e	0.000	0.002	0.001	0.001	335.2%	-49.0%	-27.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 2 f	0.074	0.059	0.011	0.010	-86.0%	-82.5%	-7.2%	0.3%	0.5%	0.1%	0.2%	0.4%	0.1%	fuel sold
1 A 2 g vii	0.104	0.155	0.026	0.025	-76.2%	-83.9%	-5.0%	0.5%	1.3%	0.3%	0.3%	1.0%	0.2%	fuel sold
1 A 2 g viii	0.010	0.048	0.336	0.341	3255.7%	604.3%	1.6%	0.0%	0.4%	3.5%	0.0%	0.3%	3.4%	fuel sold
National total (fuel sold)	**31.072**	**14.749**	**10.176**	**10.008**	**-67.8%**	**-32.1%**	**-1.7%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**21.628**	**12.143**	**9.860**	**9.727**	**-55.0%**	**-19.9%**	**-1.4%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

SO_2

NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
1 A 2	**13.814**	**1.322**	**0.616**	**0.298**	**-97.8%**	**-77.5%**	**-51.7%**	**88.9%**	**51.8%**	**69.4%**	**84.4%**	**51.0%**	**67.0%**	**fuel sold**
1 A 2 a	12.136	0.200	0.185	0.158	-98.7%	-20.8%	-14.6%	78.1%	7.8%	36.9%	74.1%	7.7%	35.6%	fuel sold
1 A 2 b	0.029	0.063	0.034	0.034	19.2%	-44.9%	0.5%	0.2%	2.5%	8.0%	0.2%	2.4%	7.8%	fuel sold
1 A 2 c	0.643	0.003	0.001	0.006	-99.0%	91.5%	586.4%	4.1%	0.1%	1.5%	3.9%	0.1%	1.4%	fuel sold
1 A 2 d	IE	0.000	0.000	0.000	0.0%	-52.0%	-39.3%	IE	0.0%	0.0%	IE	0.0%	0.0%	fuel sold
1 A 2 e	0.010	0.012	0.018	0.018	82.6%	46.4%	-1.2%	0.1%	0.5%	4.3%	0.1%	0.5%	4.1%	fuel sold
1 A 2 f	0.758	0.988	0.277	0.029	-96.2%	-97.1%	-89.6%	4.9%	38.7%	6.7%	4.6%	38.1%	6.5%	fuel sold
1 A 2 g vii	0.042	0.001	0.002	0.002	-95.4%	105.6%	3.1%	0.3%	0.0%	0.5%	0.3%	0.0%	0.4%	fuel sold
1 A 2 g viii	0.197	0.055	0.098	0.050	-74.8%	-9.3%	-49.6%	1.3%	2.1%	11.5%	1.2%	2.1%	11.1%	fuel sold
National total (fuel sold)	**16.369**	**2.593**	**0.748**	**0.444**	**-97.3%**	**-82.9%**	**-40.6%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**15.539**	**2.554**	**0.728**	**0.429**	**-97.2%**	**-83.2%**	**-41.1%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

NH3

NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
1 A 2	**0.000**	**0.034**	**0.012**	**0.006**	**2433.6%**	**-82.3%**	**-49.8%**	**0.0%**	**0.6%**	**0.1%**	**0.0%**	**0.5%**	**0.1%**	**fuel sold**
1 A 2 a	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 2 b	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 2 c	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 2 d	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 2 e	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 2 f	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 2 g vii	0.000	0.000	0.000	0.000	90.0%	11.8%	2.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 2 g viii	NO	0.034	0.012	0.006	0.6%	-83.4%	-51.8%	NO	0.6%	0.1%	NO	0.5%	0.1%	fuel sold
National total (fuel sold)	**6.369**	**6.379**	**6.310**	**5.949**	**-6.6%**	**-6.7%**	**-5.7%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**6.361**	**5.982**	**6.197**	**5.847**	**-8.1%**	**-2.3%**	**-5.6%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

Source: Environment Agency.

Table 3-21 – CO, TSP, PM_{10}, and $PM_{2.5}$ emissions, trends and shares based on fuel sold and fuel used – *1A2 - Manufacturing Industries and Construction*

CO

NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
1 A 2	**377.883**	**10.519**	**8.114**	**7.235**	**-98.1%**	**-31.2%**	**-10.8%**	**89.5%**	**47.5%**	**49.1%**	**80.5%**	**26.5%**	**40.6%**	**fuel sold**
1 A 2 a	346.461	4.425	4.366	3.395	-99.0%	-23.3%	-22.2%	82.0%	20.0%	23.1%	73.8%	11.1%	19.0%	fuel sold
1 A 2 b	0.323	0.588	0.127	0.158	-51.2%	-73.2%	24.1%	0.1%	2.7%	1.1%	0.1%	1.5%	0.9%	fuel sold
1 A 2 c	0.088	0.096	0.012	0.012	-86.9%	-88.0%	-7.6%	0.0%	0.4%	0.1%	0.0%	0.2%	0.1%	fuel sold
1 A 2 d	IE	0.008	0.006	0.004	0.4%	-52.0%	-39.3%	IE	0.0%	0.0%	IE	0.0%	0.0%	fuel sold
1 A 2 e	0.003	0.008	0.004	0.003	19.5%	-55.6%	-9.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 2 f	30.167	4.353	2.580	2.672	-91.1%	-38.6%	3.6%	7.1%	19.6%	18.1%	6.4%	11.0%	15.0%	fuel sold
1 A 2 g vii	0.668	0.927	0.501	0.519	-22.2%	-43.9%	3.8%	0.2%	4.2%	3.5%	0.1%	2.3%	2.9%	fuel sold
1 A 2 g viii	0.174	0.115	0.519	0.472	172.1%	310.6%	-9.0%	0.0%	0.5%	3.2%	0.0%	0.3%	2.6%	fuel sold
National total (fuel sold)	**469.347**	**39.753**	**18.203**	**17.838**	**-96.2%**	**-55.1%**	**-2.0%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**422.365**	**22.163**	**14.524**	**14.727**	**-96.5%**	**-33.6%**	**1.4%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

TSP

NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
1 A 2	**14.578**	**0.389**	**0.490**	**0.293**	**-98.0%**	**-24.7%**	**-40.4%**	**86.7%**	**17.1%**	**14.1%**	**82.4%**	**9.7%**	**11.6%**	**fuel sold**
1 A 2 a	13.766	0.032	0.022	0.019	-99.9%	-41.0%	-12.5%	81.8%	1.4%	0.9%	77.8%	0.8%	0.7%	fuel sold
1 A 2 b	0.204	0.120	0.113	0.105	-48.7%	-12.9%	-7.4%	1.2%	5.3%	5.0%	1.2%	3.0%	4.1%	fuel sold
1 A 2 c	0.073	0.001	0.001	0.008	-88.8%	462.9%	732.7%	0.4%	0.1%	0.4%	0.4%	0.0%	0.3%	fuel sold
1 A 2 d	IE	0.000	0.000	0.000	0.0%	-52.0%	-39.3%	IE	0.0%	0.0%	IE	0.0%	0.0%	fuel sold
1 A 2 e	0.001	0.002	0.002	0.002	73.8%	11.5%	-1.7%	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%	fuel sold
1 A 2 f	0.420	0.122	0.039	0.020	-95.3%	-83.7%	-48.7%	2.5%	5.4%	1.0%	2.4%	3.0%	0.8%	fuel sold
1 A 2 g vii	0.112	0.109	0.013	0.012	-89.4%	-89.1%	-8.9%	0.7%	4.8%	0.6%	0.6%	2.7%	0.5%	fuel sold
1 A 2 g viii	0.001	0.002	0.301	0.127	9969.5%	5520.9%	-57.8%	0.0%	0.1%	6.1%	0.0%	0.1%	5.0%	fuel sold
National total (fuel sold)	**17.687**	**3.996**	**2.184**	**2.531**	**-85.7%**	**-36.7%**	**15.9%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**16.823**	**2.268**	**1.612**	**2.078**	**-87.6%**	**-8.4%**	**28.9%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

PM10

NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
1 A 2	**14.461**	**0.3429**	**0.453**	**0.259**	**-98.2%**	**-24.6%**	**-42.9%**	**90.1%**	**19.1%**	**18.5%**	**85.9%**	**10.7%**	**15.3%**	**fuel sold**
1 A 2 a	13.766	0.032	0.022	0.019	-99.9%	-41.0%	-12.5%	85.8%	1.8%	1.3%	81.8%	1.0%	1.1%	fuel sold
1 A 2 b	0.143	0.085	0.080	0.074	-48.5%	-13.3%	-7.4%	0.9%	4.7%	5.3%	0.8%	2.6%	4.4%	fuel sold
1 A 2 c	0.059	0.001	0.001	0.008	-86.8%	443.2%	691.5%	0.4%	0.1%	0.6%	0.3%	0.0%	0.5%	fuel sold
1 A 2 d	IE	0.000	0.000	0.000	0.0%	-52.0%	-39.3%	IE	0.0%	0.0%	IE	0.0%	0.0%	fuel sold
1 A 2 e	0.001	0.001	0.002	0.002	73.5%	10.0%	-1.8%	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%	fuel sold
1 A 2 f	0.380	0.111	0.035	0.018	-95.3%	-84.0%	-49.0%	2.4%	6.2%	1.3%	2.3%	3.5%	1.1%	fuel sold
1 A 2 g vii	0.112	0.109	0.013	0.012	-89.4%	-89.1%	-8.9%	0.7%	6.1%	0.8%	0.7%	3.4%	0.7%	fuel sold
1 A 2 g viii	0.001	0.002	0.301	0.127	10411.6%	5520.9%	-57.8%	0.0%	0.1%	9.1%	0.0%	0.1%	7.5%	fuel sold
National total (fuel sold)	**16.827**	**3.214**	**1.621**	**1.689**	**-90.0%**	**-47.5%**	**4.2%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**16.051**	**1.796**	**1.256**	**1.400**	**-91.3%**	**-22.0%**	**11.5%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

PM2.5

NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
1 A 2	**14.213**	**0.264**	**0.392**	**0.207**	**-98.5%**	**-21.8%**	**-47.3%**	**92.5%**	**19.6%**	**23.5%**	**88.4%**	**10.4%**	**19.8%**	**fuel sold**
1 A 2 a	13.765	0.032	0.022	0.019	-99.9%	-41.0%	-12.5%	89.5%	2.4%	2.1%	85.6%	1.3%	1.8%	fuel sold
1 A 2 b	0.056	0.036	0.033	0.030	-46.3%	-17.0%	-7.5%	0.4%	2.7%	3.4%	0.3%	1.4%	2.9%	fuel sold
1 A 2 c	0.044	0.001	0.001	0.007	-83.4%	422.7%	650.1%	0.3%	0.1%	0.8%	0.3%	0.1%	0.7%	fuel sold
1 A 2 d	IE	0.000	0.000	0.000	0.0%	-52.0%	-39.3%	IE	0.0%	0.0%	IE	0.0%	0.0%	fuel sold
1 A 2 e	0.001	0.001	0.001	0.001	73.0%	7.8%	-2.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%	fuel sold
1 A 2 f	0.235	0.082	0.022	0.010	-95.7%	-87.7%	-53.6%	1.5%	6.1%	1.1%	1.5%	3.2%	1.0%	fuel sold
1 A 2 g vii	0.112	0.109	0.013	0.012	-89.4%	-89.1%	-8.9%	0.7%	8.1%	1.4%	0.7%	4.3%	1.1%	fuel sold
1 A 2 g viii	0.001	0.002	0.301	0.127	11040.4%	5520.9%	-57.8%	0.0%	0.2%	14.5%	0.0%	0.1%	12.2%	fuel sold
National total (fuel sold)	**16.081**	**2.541**	**1.062**	**1.046**	**-93.5%**	**-58.8%**	**-1.5%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**15.372**	**1.348**	**0.846**	**0.878**	**-94.3%**	**-34.9%**	**3.8%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

Source: Environment Agency.

3.2.3.2 Iron and Steel (1A2a)

3.2.3.2.1 Source category description

One sinter plant, two blast furnaces (*B*F) and three basic oxygen furnace steel plants (*BOF*) were operated in Luxembourg in 1990. The shift from BOF steel production to the EAF steel production occurred between 1993 and 1997. Three electric arc furnaces were operated between 1998 and 2011. One advanced multiple-heath furnace followed by a specially designed electric arc furnace (PRIMUS process) was operated between 2003 and 2009. In 2020, only two of the three electric arc furnaces (*EAF*) remained, following the shutdown of one in 2012.

Emissions from fuel combustion as well as process emissions are reported in category *1A2a – Iron and steel* as the data used is based on measurements from which it is not possible to clearly separate combustion and process emissions. The following plants are considered:

Sinter Plant (SP)

The sintering process is a pre-treatment step in the production of iron in which metal ores, coke and other materials are roasted under burners (using gaseous fuels derived from other activities in the iron production). Agglomeration of the fine particles is necessary to increase the passageway for the gases during the blast furnace process. The strength of the particles is also increased by agglomeration.

CO_2 process emissions occur from the oxidation of the carbonates in the iron ore. Dust (PM) process emissions occur through the handling, crushing, screening and conveying of sinter feedstock and products, as well as during the roasting and agglomeration process (combustion emissions).

Combustion emissions occur from the burning of fuels. Sulphur oxides (mainly SO_2) in the waste gas originate from the combustion of sulphur compounds in the sinter feed (mainly coke breeze). The contribution from iron ore is normally about ten times smaller.

Nitrogen oxides (NO_X) form mainly at the flame front in the sinter bed. This NO_X can be formed in three ways: combustion of organic nitrogen compounds in the sinter feed ('fuel NO_X'); the reaction of decomposing components with molecular nitrogen (N_2) in the combustion zone ('prompt NO_X'); and the reaction of molecular oxygen (O_2) with molecular nitrogen (N_2) in the combustion air ('thermal NO_X'). Fuel NO_X can be the most important, representing about 80 % of the total, but also thermal NO_X can dominate by 60 – 70 %.

Blast furnace (BF)

The blast furnace operates as a counter current process. Mainly sinter (iron oxides), coke and other fuels, and sometimes limestone, are charged as necessary into the top of the furnace. Preheated air is introduced through a large number of water-cooled nozzles at the bottom of the furnace and passes through the descending charge. Carbon monoxide is produced, which reacts with the heated charge to form molten high-carbon iron, slag and blast furnace gas. The molten iron and slag are periodically discharged.

Coke and other fuels serve not only as reducing agent but also to produce blast furnace gas as energy source which is recovered and used as fuel within the plant and in other steel industry processes and in a power station.

CO_2 process emissions are associated with the use of carbon to convert iron oxide to pig iron. An energy balance serves to exclude double-counting of carbon from the consumption as reducing agent if this is already accounted for as fuel consumption in category *1A – Fuel Combustion Activities*.

Basic oxygen furnace steel production (BOF)

In the basic oxygen furnace, pig iron (4% C) is transformed to steel (0.13% C).

During the process, the reduced carbon is released as CO_2. During oxygen blowing, converter gas is released from the converter. This gas contains carbon monoxide (CO) and large amounts of dust (mainly consisting of metal oxides, including heavy metals), relatively small amounts of sulphur oxides (SO_2) and nitrogen oxides (NO_X). In addition, very small amounts of PCDD/F and PAH are emitted. The process also generates considerable quantities of dust during the charging of scrap and hot metal, blowing, and during the tapping of slag and liquid steel.

Electric arc furnace steel production (EAF)

The major feedstock for the EAF is ferrous scrap, which may be comprised of scrap from inside the steelworks, cut-offs from steel product manufacturers (e.g. vehicle builders) and capital or post-consumer scrap (e.g. end-of-life products). EAF emissions contain dust, metals, nitrogen and sulphur oxides and organic matter (e.g. VOC, chlorobenzenes, PCB, PAH and PCDD/F). The SO_2 emissions mainly depend on the quantity of coal and oil input but are not of high relevance. NO_x emissions also do not need special consideration.

VOC emissions may result from organic substances adhering to the raw materials (e.g. solvents, paints) charged to the furnace. In the case of the use of natural coal (anthracite), compounds such as benzene may degas before being burnt off.

In the electric arc furnaces, anthracite and carbon, including the consumption of the electrodes, are used as reducing agent with the result of CO_2 process emissions.

The combustion of natural gas in the EAF is accounted for as energy consumption and, consequently, corresponding emissions of air pollutants are reported in category *1A2a – Iron and Steel*.

PRIMUS® process (PRIMUS)

The PRIMUS process consists of a combination of an advanced multiple-heath furnace and a specially designed electric arc furnace. Steelmaking dust is transformed into iron. CO_2 process emissions occur from raw material (steelmaking dust) and reducing agents (anthracite, carbon and the consumption of the electrodes).

In general, activity data for the iron production (*BF*) and steel production (*BOF & EAF*) are collected from national statistics (STATEC). However, if available, they are supplemented by information received directly from the operator. This is the case for sinter production (*SP*) and for the steel production breakdown between BOF between 1993 and 1997. Production data for the EAF (in operation since 1995 and 1998, the activity data is obtained directly from the operator.

Table 3-22 summarizes emissions of air pollutants for category *1A2a – Iron and steel*.

In 2022, this source category represented:

- 35.6% of national total SO_2 emissions, whereas in 1990, this source category represented 74.1% of national total SO_2 emissions.
- 19.0% of national total CO emissions, whereas in 1990, this source category represented 73.8% of national total CO emissions.
- 3.4% of national total NO_X emissions, whereas in 1990, this source category represented 17.0% of national total NO_X emissions.
- 1.8% of national total $PM_{2.5}$ emissions, whereas in 1990, this source category represented 85.6% of national total $PM_{2.5}$ emissions.

Table 3-22 – Emissions, Trends and Shares based on fuel sold and fuel used – *1A2a - Iron and Steel*

1 A 2 Stationary combustion in manufacturing industries and construction														
Emissions, Trends and Shares in National Totals of air pollutants based on fuel sold and fuel used														
1 A 2 a Iron and steel														
Pollutants	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
SO2	12.14	0.20	0.19	0.16	-98.7%	-20.8%	-14.6%	78.1%	7.8%	36.9%	74.1%	7.7%	35.6%	fuel sold
NOx	6.93	1.53	0.52	0.39	-94.4%	-74.8%	-24.8%	31.1%	8.6%	4.2%	17.0%	2.7%	3.4%	fuel sold
NMVOC	0.59	0.25	0.10	0.09	-85.0%	-64.8%	-11.3%	2.7%	2.1%	0.9%	1.9%	1.7%	0.9%	fuel sold
NH3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
CO	346.46	4.43	4.37	3.40	-99.0%	-23.3%	-22.2%	82.0%	20.0%	23.1%	73.8%	11.1%	19.0%	fuel sold
TSP	13.77	0.03	0.02	0.02	-99.9%	-41.0%	-12.5%	81.8%	1.4%	0.9%	77.8%	0.8%	0.7%	fuel sold
PM10	13.77	0.03	0.02	0.02	-99.9%	-41.0%	-12.5%	85.8%	1.8%	1.3%	81.8%	1.0%	1.1%	fuel sold
PM2.5	13.77	0.03	0.02	0.02	-99.9%	-41.0%	-12.5%	89.5%	2.4%	2.1%	85.6%	1.3%	1.8%	fuel sold

Source: Environment Agency.

In the period 1990 – 2022, all emissions of air pollutants decreased significantly. Compared to 1990, SO_2 emissions decreased by 98.7% and NO_X emissions decreased by 94.4%, mainly due the production switch from blast furnaces to electric arc furnaces completed during the late 1990s. In fact, with the move from blast to electric arc furnaces in the steel sector during the 1990s, Luxembourg very soon exhausted its only major technical potential for air pollutant emission reductions. Compared to 2021, SO_2, NO_X, NMVOC ,CO, TSP, PM_{10} and $PM_{2.5}$ emissions of category *1A2a - Iron and Steel* decreased by 14.6%, 24.8%, 11.3%, 22.2%, 12.5%, 12.5%, and 12.5%, respectively. The reason for these changes in emissions is to be seen in the reduced energy consumption due to high global energy prices. However, slight changes in the production or scrap quality, as well as in the fuels used (tires are sometimes used as secondary fuel) might cause interannual variations in emissions, although all operating permit conditions (based on best available techniques for abatement technologies) are respected.

Table 3-23 presents the emission trends in category *1A2a -Iron and Steel.*

Table 3-23 – Emission trends – *1A2a - Iron and Steel*

1 A 2 Stationary combustion in manufacturing industries and construction								
Emissions of air pollutants (Gg)								
Year	**1 A 2 a Iron and steel**							
	SO2	***NOx***	***NMVOC***	***NH3***	***CO***	***TSP***	***PM10***	***PM2.5***
1990	12.136	6.934	0.593	NO	346.461	13.766	13.766	13.765
1991	11.744	6.602	0.542	NO	329.212	13.045	13.045	13.044
1992	11.111	6.268	0.532	NO	299.127	11.788	11.787	11.787
1993	11.990	6.746	0.548	NO	328.424	12.902	12.902	12.901
1994	9.928	5.690	0.472	NO	269.869	10.604	10.604	10.603
1995	5.019	3.281	0.338	NO	143.347	5.588	5.588	5.588
1996	4.797	3.109	0.390	NO	131.656	5.100	5.100	5.100
1997	2.650	2.114	0.390	NO	74.336	2.849	2.849	2.849
1998	0.330	0.928	0.262	NO	3.880	0.030	0.030	0.030
1999	0.332	0.965	0.318	NO	4.618	0.032	0.032	0.032
2000	0.310	1.164	0.360	NO	6.060	0.033	0.033	0.033
2001	0.397	1.340	0.389	NO	7.662	0.040	0.040	0.040
2002	0.396	1.226	0.370	NO	6.868	0.036	0.036	0.036
2003	0.280	0.988	0.321	NO	5.010	0.030	0.030	0.030
2004	0.273	0.992	0.304	NO	5.759	0.025	0.025	0.025
2005	0.200	1.535	0.253	NO	4.425	0.032	0.032	0.032
2006	0.254	1.113	0.262	NO	4.519	0.043	0.043	0.043
2007	0.411	0.970	0.403	NO	5.068	0.031	0.031	0.031
2008	0.230	0.906	0.318	NO	4.417	0.032	0.032	0.032
2009	0.292	0.887	0.250	NO	5.346	0.024	0.024	0.024
2010	0.157	0.924	0.196	NO	4.847	0.028	0.028	0.028
2011	0.137	0.935	0.198	NO	3.123	0.026	0.026	0.026
2012	0.293	0.953	0.178	NO	4.878	0.020	0.020	0.020
2013	0.422	0.767	0.150	NO	4.489	0.017	0.017	0.017
2014	0.273	0.659	0.140	NO	5.163	0.016	0.016	0.016
2015	0.153	0.778	0.132	NO	3.275	0.023	0.023	0.023
2016	0.156	0.595	0.147	NO	3.934	0.021	0.021	0.021
2017	0.209	0.699	0.103	NO	4.341	0.017	0.017	0.017
2018	0.138	0.639	0.109	NO	3.878	0.017	0.017	0.017
2019	0.207	0.633	0.069	NO	4.084	0.017	0.017	0.017
2020	0.190	0.521	0.094	NO	2.760	0.013	0.013	0.013
2021	0.185	0.515	0.100	NO	4.366	0.022	0.022	0.022
2022	0.158	0.387	0.089	NO	3.395	0.019	0.019	0.019
Trend 1990-2022	*-98.70%*	*-94.41%*	*-84.97%*	*NA*	*-99.02%*	*-99.86%*	*-99.86%*	*-99.86%*
2005-2022	*-20.78%*	*-74.76%*	*-64.81%*	*NA*	*-23.28%*	*-41.01%*	*-41.01%*	*-41.01%*
2021-2022	*-14.57%*	*-24.84%*	*-11.29%*	*NA*	*-22.22%*	*-12.50%*	*-12.50%*	*-12.50%*

Sources: Environment Agency

With regard to SO_2, NO_X, CO, TSP, PM_{10} and $PM_{2.5}$ emissions, *1A2a – Iron and Steel* is a key category (either for LA or TA or both) in 2022 (see Table 3-24 and also Table in Section 3.2 and Chapter 1.5).

Table 3-24 – Key Categories (fuel sold & fuel used) of category – *1A2a - Iron and steel*

Key Source Analysis (FUEL SOLD): Ranking per number		**SO2**		**NOX**		**NMVOC**		**NH3**		**CO**		**TSP**		**PM10**		**PM2.5**	
NFR Code	**NFR Category**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	1	1		2					2	1		1		1		1

Key Source Analysis (FUEL USED): Ranking per number		**SO2**		**NOX**		**NMVOC**		**NH3**		**PM2.5**	
NFR Code	**NFR Category**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	1	1	10	1					8	1

Sources: Environment Agency

Notes: LA = Level Assessment , TA = Trend Assessment

Number in Table = indicates the rank in the specific analysis (1…biggest KC; 2… second biggest KC, …)

With regard to heavy metal and persistent organic pollutant emissions, *1A2a – Iron and Steel* is a key category for Hg (LA & TA) emissions in 2022.

3.2.3.2.2 Methodological issues

3.2.3.2.2.1 Activity Data

The iron and steel industry has been among the most important industrial activities in Luxembourg, both in terms of energy consumption and in terms of added value. As already stressed earlier in this report, important technological changes took place between 1993 and 1997 with the move from blast furnaces to electric arc furnaces. This led to considerable changes in air pollutant emissions. Today, the iron and steel industry has a specific energy consumption which is much lower than it was in 1990 but the activity being relatively emission intensive at Luxembourg's scale, hence the presence of this activity among the key categories.

Emissions from fuel combustion activities and process related emissions in the iron and steel industry are accounted for under category *1A2a – Iron and Steel*, due to the fact that reported emissions have been mostly measured at the stack, which does not allow separation between process and combustion emissions.

Blast furnace gas is a side product of the iron produced in blast furnaces and can be used as fuel for combustion purposes. This was the case in Luxembourg until 1997, when the last blast furnace was blown out. Blast furnace gas was used by the iron and steel industry for heating purposes and for electricity production. Thus, blast furnace gas is to be considered as a secondary fuel. This has to be taken into account when comparing official energy balances (as published by the national statistics institute) with the energy balance used to prepare the emission inventory.

Table 3-25 gives a summary of which combustion activities are included for estimating air pollutant emissions pertaining to sub-category *1A2a*.

Table 3-25 – Iron and steel combustion activities included in the air emission inventory

Combustion activity	SNAP[42] code
Combustion plants 50-300 MW	030102
Combustion plants <50 MW	030103
Blast Furnace Cowper's	030203
Sinter and pelletizing plants	030301
Reheating furnaces steel and iron	030302
Grey iron foundries	030303
Electric furnace steel plants	040207
Mobile Sources and Machinery in Industry	080800
Blast furnace gas distribution losses and flaring	NA

[42] technology oriented Standardized Nomenclature for Air Pollutants (SNAP)

Combustion plants 50-300 MW

One power plant, operated until 1997 by the iron and steel industry, located on a site called *Terres Rouges,* and fed with blast furnace gas, residual fuel oil and/or natural gas. The activity an emission rates are based on information received from the plant operator[43] and from a study (TÜV (1990)). The electricity produced was used in the installations of the iron and steel industry (autoproducer). Overproduction was fed into the public electricity network.

Combustion plants <50 MW

Various combustion plants were operated mainly for heating purposes until 1997, when the last blast furnace was shut down. They were fed with blast furnace gas, residual fuel oil and/or natural gas. After 1997, these combustion plants were replaced by installations running on natural gas or gasoil. The related fuel consumption and emission data were and still are received directly from the operator and from a study (TÜV (1990)).

Blast furnace cowpers

Blast furnace cowpers have been used until 1997. They were fed with blast furnace gas and with natural gas. The related fuel consumption and emission data were received directly from the operator and from a study (TÜV (1990)).

Sinter and pelletizing plants

The sole sinter plant has been used until 1997. Its activity data, i.e. fuel consumption (coke oven coke, coal, blast furnace gas and natural gas) and production have been established in detail for the year 1990 based on information received from the operator. The fuel consumptions of the following years have been extrapolated based on the consumption data of 1990 and on the sintered ore production from 1990 – 1997. Emission data was taken from a study (TÜV (1990)).

Reheating furnaces steel and iron

The reheating furnaces have been used during the whole period 1990 – 2014. Their operation is directly related to steel rolling. Their activity data (natural gas consumption) and emission data were received from the operator and from a study (TÜV (1990)). In 2012, as a consequence of the economic crisis, the steel rolling facilities as well as the electric arc furnace on the site in Schifflange were temporarily switched off. In 2015, it was decided to finally close these facilities.

Grey iron foundries

The activity data (coking coke consumption) of those foundries have been estimated in the early 1990s (TÜV 1990), and no new data has been received since. Therefore, the values in the inventories have been kept rather constant. In 1997, grey iron production was stopped simultaneously with the last blast furnace.

Electric furnace steel plants

The first electric furnace steel plant appeared in 1994. Beside electric energy, natural gas is used for the fusion of scrap. The related fuel consumption and emission data were received directly from the operator.

43 Later Arcelor-Arbed, and now Arcelor-Mittal.

Blast Furnace Gas Distribution Losses and Flaring

A certain amount of blast furnace gas (BFG) is either lost during distribution or vented to avoid over-pressurization of the pipes or flared. The amount of BFG lost, vented or flared was obtained from the national statistics institute (STATEC). Emission data was taken from a study (TÜV (1990)).

Mobile Sources and Machinery in Industry

Activity data on the consumption of diesel oil, used in mobile sources and machinery were derived from energy balance as produced by the national statistics institute (STATEC). Since submission 2015, emissions of mobile machinery are reported under category *1.A.2.g.vii – Off-road vehicles and other machinery* (see section 3.2.3.8.1 Mobile Combustion in Manufacturing Industries and Construction (1A2g vii)).

In general, the fuel consumption data obtained by the operators (bottom-up) were matched with the top-down data obtained from the national statistics institute's energy balance (STATEC), to avoid double counting or underestimation.

Table 3-26 gives a summary of the amount of energy used in category *1A2a – Iron and steel*.

Table 3-26 – Activity data for category – *1A2a - Iron and Steel*

1 A 2 Stationary combustion in manufacturing industries and construction						
Activity Data by fuel type (GJ)						
1 A 2 a Iron and steel						
Year	**Activity Total (incl. biomass)**	**Liquid** *Residual Fuel Oil, Gas Oil, Diesel Oil*	**Solid** *Blast Furnace Gas, Coke Oven Coke, Coking*	**Gaseous** *Natural Gas*	**Biomass**	**Other**
1990	31 648 648	478'498	24'297'184	6'872'966	NO	NO
1991	29 685 953	906'447	23'212'906	5'566'599	NO	NO
1992	27 921 510	1'389'836	21'153'539	5'378'135	NO	NO
1993	28 772 086	1'171'733	22'278'448	5'321'905	NO	NO
1994	24 472 090	1'052'284	18'169'300	5'250'505	NO	NO
1995	15 910 541	432'350	9'509'657	5'968'535	NO	NO
1996	15 109 545	320'254	8'471'037	6'318'253	NO	NO
1997	11 167 216	266'846	4'700'381	6'199'989	NO	NO
1998	5 031 569	235'131	NO	4'796'437	NO	NO
1999	5 431 288	167'328	NO	5'263'960	NO	NO
2000	5 436 967	NO	NO	5'436'967	NO	NO
2001	6 483 752	NO	NO	6'483'752	NO	NO
2002	6 202 490	NO	NO	6'202'490	NO	NO
2003	6 129 185	NO	NO	6'129'185	NO	NO
2004	6 603 080	NO	NO	6'603'080	NO	NO
2005	6 527 604	NO	NO	6'527'604	NO	NO
2006	7 649 731	NO	NO	7'649'731	NO	NO
2007	7 353 192	NO	NO	7'353'192	NO	NO
2008	7 048 451	NO	NO	7'048'451	NO	NO
2009	5 726 715	NO	NO	5'726'715	NO	NO
2010	6 578 058	NO	NO	6'578'058	NO	NO
2011	5 767 862	NO	NO	5'767'862	NO	NO
2012	5 216 652	NO	NO	5'216'652	NO	NO
2013	4 814 169	NO	NO	4'814'169	NO	NO
2014	4 786 104	NO	NO	4'786'104	NO	NO
2015	4 865 850	NO	NO	4'865'850	NO	NO
2016	4 724 974	NO	NO	4'724'974	NO	NO
2017	4 708 060	NO	NO	4'708'060	NO	NO
2018	5 464 344	NO	NO	5'464'344	NO	NO
2019	5 239 252	NO	NO	5'239'252	NO	NO
2020	4 713 705	NO	NO	4'713'705	NO	NO
2021	4 864 157	NO	NO	4'864'157	NO	NO
2022	4 105 284	NO	NO	4'105'284	NO	NO
Trend 1990-2022	*-87.03%*	*NA*	*NA*	*-40.27%*	*NA*	*NA*
2005-2022	*-37.11%*	*NA*	*NA*	*-37.11%*	*NA*	*NA*
2021-2022	*-15.60%*	*NA*	*NA*	*-15.60%*	*NA*	*NA*

Source: Environment Agency

Methodological choices

For almost all (large and small) sources of this category emission measurements of NO_X, SO_2, NMVOC, CO and TSP are the basis for the reported emissions (EMEP/EEA Tier 3 approach).

The remaining point or area sources, for which no measured (plant-specific) emission data but plant specific activity data or information on the abatement technology was available, were estimated using the EMEP/EEA TIER 2 default emission factors.

In Table 3-27, the methods and emission factors used in relation to the coverage of energy consumption for 2022 are described.

3.2.3.2.2.2 Emission factors

For point sources of this source category, emission measurements of NO_X, SO_2, NMVOC, CO and TSP are the basis for the reported emissions (EMEP/EEA Tier 3 approach). Hence, no emission factors per se are used, but rather implied emission factors are derived by dividing the emission with the activity data. $PM_{2.5}$ and PM_{10} emissions were based on TSP measurements (TSP considered equivalent to "dust" under IED monitoring rueles) by using the default ratio between the default Tier 2 EMEP/EEA emission factors for TSP, PM_{10} and $PM_{2.5}$.

The point or area sources, for which no measured (plant-specific) emission data but plant specific activity data or information on the abatement technology was available, were estimated using the EMEP/EEA Tier 2 default emission factors.

The remaining point or area sources, for which no measured (plant-specific) emission data, nor plant specific activity data or information on the abatement technology was available, were estimated using the EMEP/EEA Tier 1 default emission factors.

Emission factors (EF) used as well as coverage of energy consumption for 2022 are presented in Table 3-27.

Implied emission factors are presented in Table . These may vary over time for the following reasons:

- The chemical characteristic of a fuel varies, e.g. sulphur content.
- The mix of fuels changes over time. If the different fuels of a fuel category have different calorific values and their share in the fuel category changes, the calorific value of the fuel category might change over time. If emission factors are in the unit kg/t the transformation to kg/TJ induces a different emission factor due to varying net calorific values.
- The production- or abatement technology of a facility – or of facilities – changes over time.
- The scrap quality varies. Indeed, some scraps may contain paints, oils and other organic substances.

Table 3-27 – Methods and Emission Factors used in relation to the energy consumption in 2022 for category – *1A2a - Iron and Steel*

1 A 2 Stationary combustion in manufacturing industries and construction *Method applied and Emission factor (EF) used as well as coverage of energy consumption* 1 A 2 a Iron and steel				
Pollutant	**Method**	**EF used**	**Coverage of energy consumption**	**Source**
NOx	T3	PS	57.7%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2/T1	D	42.3%	EMEP/EEA GB 2019 (Chap1A2, Tab3.2, p15), EMEP/EEA GB 2019 (Chap1A2, Tab3.2, p15), EMEP/EEA GB 2019 (Chap1A2, Tab3.2 p15), EMEP/EEA GB 2019 (Chap1A2, Tab3.4 p17), EMEP/EEA GB 2019 (Chap1A2, Tab3.4 p17)
NMVOC	T3	PS	57.7%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2/T1	D	42.3%	EMEP/EEA GB 2019 (Chap1A2, Tab3.2, p15), EMEP/EEA GB 2019 (Chap1A2, Tab3.2, p15), EMEP/EEA GB 2019 (Chap1A1, Tab3.12, p26), EMEP/EEA GB 2019 (Chap1A2, Tab3.4 p17), EMEP/EEA GB 2019 (Chap1A2, Tab3.4 p17)
SOx	T3	PS	57.7%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2	CS	0.0%	CS based on fuel sulfur content; determined by AEV
	T1	D	42.3%	IEF: PS, EMEP/EEA GB 2019 (Chap1A2, Tab3.2, p15), EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16), EMEP/EEA GB 2019 (Chap1A2, Tab3.2 p15), CS based on maximum allowed suphur content, EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16)
CO	T3	PS	89.8%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2/T1	D	10.2%	EMEP/EEA GB 2009(PartB, Chap1A1, Tab3.3, p15), EMEP/EEA GB 2016(PartB, Chap1A1, Tab3.12, p27), EMEP/EEA GB 2009(PartB, Chap1A1, Tab3.7, p19), EMEP/EEA GB 2009(PartB, Chap1A1, Tab3.8, p20)
PM2.5	T3	PS	89.8%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV PM measured assumed to be TSP = PM10 = PM2.5
	T2/T1	D	10.2%	EMEP/EEA GB 2019 (Chap1A2, Tab3.2, p15) EMEP/EEA GB 2019 (Chap1A1, Tab3.12, p26) EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16) EMEP/EEA GB 2019 (Chap1A2, Tab3.4, p17)
PM10	T3	PS	89.8%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV PM measured assumed to be TSP = PM10 = PM2.5
	T2/T1	D	10.2%	EMEP/EEA GB 2019 (Chap1A2, Tab3.2, p15) EMEP/EEA GB 2019 (Chap1A1, Tab3.12, p26) EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16) EMEP/EEA GB 2019 (Chap1A2, Tab3.4, p17)
TSP	T3	PS	14.0%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV PM measured assumed to be TSP = PM10 = PM2.5
	T2/T1	D	86.0%	EMEP/EEA GB 2019 (Chap1A2, Tab3.2, p15), EMEP/EEA GB 2019 (Chap1A1, Tab3.12, p26), EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16), EMEP/EEA GB 2019 (Chap1A2, Tab3.4, p17)

Source: Environment Agency.

Table 3-28 – Implied emission factors for category – *1A2a - Iron and Steel*

1 A 2 Stationary combustion in manufacturing industries and construction *Implied Emission Factor (IEF) of air pollutants (g/GJ)*								
Year	**1 A 2 a Iron and steel**							
	SO2	***NOx***	***NMVOC***	***NH3***	***CO***	***TSP***	***PM10***	***PM2.5***
1990	383.47	219.09	18.73	NA	10947.11	434.97	434.95	434.93
1991	395.59	222.40	18.25	NA	11089.84	439.44	439.43	439.40
1992	397.95	224.48	19.07	NA	10713.14	422.18	422.16	422.14
1993	416.74	234.47	19.03	NA	11414.69	448.42	448.41	448.38
1994	405.68	232.50	19.27	NA	11027.61	433.31	433.29	433.26
1995	315.45	206.20	21.25	NA	9009.58	351.21	351.20	351.20
1996	317.46	205.76	25.78	NA	8713.43	337.57	337.56	337.55
1997	237.31	189.33	34.93	NA	6656.65	255.10	255.09	255.08
1998	65.58	184.39	52.08	NA	771.13	5.97	5.97	5.97
1999	61.11	177.73	58.63	NA	850.17	5.86	5.86	5.86
2000	56.96	214.09	66.29	NA	1114.51	6.04	6.04	6.04
2001	61.20	206.73	59.93	NA	1181.72	6.11	6.11	6.11
2002	63.80	197.73	59.63	NA	1107.31	5.86	5.86	5.86
2003	45.73	161.24	52.35	NA	817.41	4.84	4.84	4.84
2004	41.41	150.29	46.07	NA	872.14	3.77	3.77	3.77
2005	30.60	235.15	38.80	NA	677.95	4.89	4.89	4.89
2006	33.26	145.52	34.31	NA	590.69	5.58	5.58	5.58
2007	55.83	131.97	54.87	NA	689.26	4.20	4.20	4.20
2008	32.62	128.60	45.15	NA	626.63	4.53	4.53	4.53
2009	51.03	154.92	43.72	NA	933.46	4.24	4.24	4.24
2010	23.81	140.46	29.82	NA	736.85	4.31	4.31	4.31
2011	23.68	162.05	34.40	NA	541.52	4.43	4.43	4.43
2012	56.23	182.77	34.09	NA	935.07	3.86	3.86	3.86
2013	87.59	159.41	31.17	NA	932.55	3.45	3.45	3.45
2014	56.96	137.61	29.35	NA	1078.79	3.43	3.43	3.43
2015	31.38	159.97	27.08	NA	673.07	4.63	4.63	4.63
2016	32.92	125.98	31.12	NA	832.61	4.46	4.46	4.46
2017	44.30	148.50	21.93	NA	922.03	3.63	3.63	3.63
2018	25.24	116.95	20.02	NA	709.65	3.13	3.13	3.13
2019	39.58	120.79	13.24	NA	779.55	3.31	3.31	3.31
2020	40.30	110.62	19.86	NA	585.44	2.70	2.70	2.70
2021	38.08	105.98	20.65	NA	897.48	4.42	4.42	4.42
2022	38.55	94.38	21.71	NA	827.06	4.59	4.59	4.59
Trend 1990-2022	*-89.95%*	*-56.92%*	*15.86%*	*NA*	*-92.44%*	*-98.95%*	*-98.95%*	*-98.95%*
2005-2022	*25.96%*	*-59.86%*	*-44.05%*	*NA*	*21.99%*	*-6.21%*	*-6.21%*	*-6.21%*
2021-2022	*1.22%*	*-10.94%*	*5.11%*	*NA*	*-7.85%*	*3.68%*	*3.68%*	*3.68%*

Source: Environment Agency.

3.2.3.2.3 Methodological issues for heavy metals and POPs

Point sources considered in this category consist of a sintering plant in Esch-Belval and two blast furnaces at the same site. Diffuse emissions related to combustion processes in iron and steel production originate from combustion plants, reheating furnaces, and other stationary machinery used in this sector.

Note: emissions from three electric arc furnaces (EAFs) in Esch-Belval, Schifflange and Differdange, as well as emissions from the Primorec plant in Differdange (operational from 2003 to 2009) are treated under "Industrial processes" in category 2.C.1 Iron and steel.

3.2.3.2.3.1 Activity Data

Sintering plant, blast furnaces and diffuse sources: annual fuel consumption (natural gas, gas oil).

3.2.3.2.3.2 Methodological Choices

The sintering plant in Esch-Belval was operational until 1996 and thus considered a large point source from 1990 to 1996. Calculations of emissions were based on annual fuel consumption taken from the national energy balance. Emissions were calculated separately for different types of fuel (natural gas, blast furnace gas, coke oven coke, anthracite) using tier 1 emission factors.

Process-related emissions were based on activity data (tons of sinter per year) which in turn were back-calculated on basis of the total amount of energy used per year. This back-calculation was conducted conservatively using the maximum amount of energy per ton of sinter stated in EEA (2023) (1,92 GJ/Mg; cf. chapter 2.C.1, p. 17).

Both blast furnace cowpers were also operated until 1996. Calculation of emissions was carried out in the same manner as described above for the sintering plant. Back-calculation of activity data as a basis for process-related emissions was conducted using the gross amount of energy input in pig iron production stated in EEA (2023) (18,67 GJ/Mg; cf. chapter 2.C.1, p. 14).

Calculation of diffuse emissions was based on data from the national energy balance in combination with appropriate tier 1 emission factors.

Fuel consumption data were obtained from the national energy balance.

3.2.3.2.3.3 Emission Factors

Emissions related to combustion processes from point sources and diffuse emissions – Tier 1 emission factors:

Table 3-29 – Sources for HM and POP Tier 1 emission factors for category *1A2a - Iron and Steel*

Fuel	Pollutants	Source	Page	Table
Solid fuels	Pb, Hg, Cd, PCDD/F, PCB, HCB, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2023) – Chapter 1.A.2 Manufacturing industries and construction	15	3-2
Gaseous fuels	Pb, Hg, Cd, PCDD/F, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2023) – Chapter 1.A.2 Manufacturing industries and construction (PCDD/F, PCB, HCB, B(a)P, B(b)F, B(k)F, I(cd)P are NA)	16	3-3
Liquid fuels	Pb, Hg, Cd, PCDD/F, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2023) – Chapter 1.A.2 Manufacturing industries and construction	17	3-4
Liquid fuels	PCB	EF not stated in EEA (2019), thus custom EF derived from EMEP/Corinair Guidebook (2007): 1 TEP= 1,170 l and density (gas oil) = 0,84 kg/l → 1 TEP= 983 kg gas oil EF: EMEP/Corinair Guidebook (2007), Draft Chapter on PCB emissions: 250 ug/t (gas oil) conversion: 1 TEP = 41,9 GJ (250 ug PCB/t * 0,983 t)/41,9 GJ = 5,87 ug PCB/GJ	N/A	N/A

Process-related emissions from point sources – Tier 2 emission factors:

Table 3-30 – Sources for HM and POP Tier 2 emission factors for category *1A2a - Iron and Steel*

Process	Pollutants	Source	Page	Table
Sinter production	Pb, Hg, Cd, PCDD/F, PCB, HCB, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2023) – Chapter 2.C.1 Iron and steel production	27	3.2

Process	Pollutants	Source	Page	Table
Pig iron production (heat recovery)	Pb, Hg, Cd, PCDD/F, PCB, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2023) – Chapter 2.C.1 Iron and steel production	34	3.9

3.2.3.2.4 Uncertainties and time-series consistency

The assessment of activity data and emission factor uncertainties is done according to the methodology described in the EMEP/EEA emission inventory Guidebook 2023 (Chapter A.5 Uncertainties, tables 2-1, 2-2 and 2-3), covering the main pollutants NO_x, NH_3, NMVOC, SO_x and $PM_{2.5}$. For some subcategories and pollutants, expert judgements were made to estimate AD or EF uncertainties. For CO, PM10, heavy metzals and persistent organic pollutants, no uncertainty estimates are currently made. Details on uncertainty of the activity data can also be checked in the Luxembourg's National Inventory report (NIR). Please also refer to Table 1-33 to Table 1-37 of section 1.7 for caterogory specific uncertainties on activity data and emission factors.

Time-series are considered to be consistent, also in comparison with energy data as reported by the national statistics institute.

3.2.3.2.5 Source-specific QA/QC and verification

Activity data for large facilities that are under the European Union Emission Trading Scheme (EU-ETS) are cross-checked using two sources: reports obtained directly from the operator under its operational permit obligations and the EU-ETS registry operator. Both are hosted at the Environment Agency. A list with the large energy consuming facilities along with their respective fuel consumption has been compiled and enables the Single National Entity to quickly cross-check these data with the EU-ETS data. Thus, completeness can be checked on a more systematic basis.

Emission data are also cross-checked using two sources: reports obtained directly from the operator under its operational permit obligations and PRTR.

Finally, consistency and completeness checks are performed.

3.2.3.2.6 Category-specific recalculations including changes made in response to the review process

Table 3-31 presents the main revisions and recalculations done since the last submission for sub-category *1A2a – Iron and Steel*.

Table 3-31 – Recalculations done since last submission in category – *1A2a - Iron and Steel*

Source category	Revisions 2023 ➔ 2024	Type of revision
1A2a/c/d/e/f/gviii	In the latest national energy balance, changes were made to the allocation method of natural gas to the different sectors for the year 2021. Consequently, the natural gas AD for the sector 1A2a decreased by 577 TJ.	AD
1A2a	Revision of SO_X emissions for 2003-2009 from boilers using natural gas due to a change of the Tier 2 EF in the new 2023 EMEP/EEA Guidebook (from 0.281 g/GJ to 0.244 g/GJ in Chapter 1A1, Table 3-14, p.26).	SO_X EF
1A2a	Revision of TSP, PM_{10}, and $PM_{2.5}$ emissions for 2003-2009 from boilers using natural gas due to a change of the Tier 2 EF in the new 2023 EMEP/EEA Guidebook (from 0.89 g/GJ to 0.14 g/GJ in Chapter 1A1, Table 3-14, p.26).	TSP, PM_{10}, $PM_{2.5}$ EF

3.2.3.2.7 Category-specific planned improvements including those in response to the review process

The following improvements are planned for the next submission.

Table 3-32 – Planned improvements for category *1A2a – Iron and Steel*

Source category	Planned improvements	Type of revision
1A2a & 2C1	Reallocate process emissions (PM & TSP from raw material handling, blast furnace charging, etc.) from 1A2a to 2C1 for which separate data is available.	Emission reallocation

3.2.3.3 Non-Ferrous Metals (1A2b)

3.2.3.3.1 Source category description

In Luxembourg, non-ferrous metals activities cover mainly secondary aluminium production from aluminium scrap (3 plants) and secondary copper production (1 plant).

There are potential emissions to air of dust, metal compounds, chlorides, HCl and products of poor combustion such as dioxins and other organic compounds from the melting and treatment furnaces. The formation of dioxins in the combustion zone and in the cooling part of the off-gas treatment system (de-novo synthesis) may be possible. A significant proportion of the emission of these substances is produced by the fuel used and by contamination of the feed material. Some dust is produced by fine dusty scrap and by salt fume. Poor combustion of fuel or the organic content of the feed material can result in the emission of organic materials (VOC, dioxins) and CO. The provision of effective burner and furnace to controls is used to optimise combustion.

From 1990 through 2022, source category *1A2b – Non-Ferrous Metals* was a small source. In 2022, this emission source represented less than 7.8 % of national total for each air pollutant (based on fuel sold). In the period 1990 – 2022, the emissions of SO_2, NO_X increased, whereas all other air pollutants (NMVOC, CO, and PM) decreased.

Table 3-33 summarizes emissions of air pollutants for category *1A2b – Non-Ferrous Metals* and Table 3-34 presents the emission trends.

Table 3-33 – Emissions, Trends and Shares on fuel sold and fuel used for *1A2b - Non-Ferrous Metals*

1 A 2 Stationary combustion in manufacturing industries and construction														
Emissions, Trends and Shares in National Totals of air pollutants based on fuel sold and fuel used														
1 A 2 b Non-ferrous metals														
Pollutants	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
SO2	0.03	0.06	0.03	0.03	19.2%	-44.9%	0.5%	0.19%	2.45%	8.04%	0.18%	2.41%	7.76%	fuel sold
NOx	0.06	0.09	0.08	0.08	35.1%	-6.2%	8.2%	0.27%	0.49%	0.89%	0.15%	0.15%	0.71%	fuel sold
NMVOC	0.13	0.20	0.06	0.07	-49.1%	-65.6%	13.6%	0.62%	1.62%	0.70%	0.43%	1.33%	0.68%	fuel sold
NH3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
CO	0.32	0.59	0.13	0.16	-51.2%	-73.2%	24.1%	0.08%	2.65%	1.07%	0.07%	1.48%	0.88%	fuel sold
TSP	0.20	0.12	0.11	0.10	-48.7%	-12.9%	-7.4%	1.21%	5.30%	5.04%	1.15%	3.01%	4.14%	fuel sold
PM10	0.14	0.08	0.08	0.07	-48.5%	-13.3%	-7.4%	0.89%	4.73%	5.26%	0.85%	2.64%	4.36%	fuel sold
PM2.5	0.06	0.04	0.03	0.03	-46.3%	-17.0%	-7.5%	0.37%	2.70%	3.44%	0.35%	1.43%	2.88%	fuel sold

Source: Environment Agency.

Table 3-34 – Emission trends of category – *1A2b - Non-Ferrous Metals*

1 A 2 Stationary combustion in manufacturing industries and construction								
Emissions of air pollutants by source category (Gg)								
Year	1 A 2 b Non-ferrous metals							
	SO2	*NOx*	*NMVOC*	*NH3*	*CO*	*TSP*	*PM10*	*PM2.5*
1990	0.029	0.060	0.133	NO	0.323	0.204	0.143	0.056
1991	0.029	0.062	0.143	NO	0.347	0.204	0.143	0.056
1992	0.029	0.062	0.145	NO	0.546	0.204	0.143	0.056
1993	0.029	0.061	0.140	NO	0.535	0.204	0.143	0.056
1994	0.039	0.077	0.154	NO	0.573	0.273	0.191	0.075
1995	0.040	0.080	0.161	NO	0.610	0.279	0.195	0.077
1996	0.100	0.104	0.198	NO	0.670	0.296	0.208	0.086
1997	0.067	0.072	0.191	NO	0.648	0.069	0.049	0.023
1998	0.070	0.078	0.192	NO	0.648	0.095	0.068	0.031
1999	0.071	0.076	0.183	NO	0.631	0.095	0.067	0.031
2000	0.075	0.076	0.166	NO	0.599	0.097	0.069	0.031
2001	0.082	0.080	0.180	NO	0.659	0.098	0.070	0.032
2002	0.074	0.077	0.184	NO	0.639	0.105	0.075	0.034
2003	0.065	0.082	0.184	NO	0.606	0.108	0.077	0.034
2004	0.092	0.095	0.204	NO	0.739	0.132	0.094	0.042
2005	0.063	0.087	0.197	NO	0.588	0.120	0.085	0.036
2006	0.052	0.096	0.215	NO	0.570	0.133	0.094	0.039
2007	0.050	0.081	0.174	NO	0.515	0.128	0.090	0.037
2008	0.034	0.088	0.172	NO	0.508	0.108	0.076	0.031
2009	0.031	0.052	0.190	NO	0.516	0.090	0.063	0.026
2010	0.055	0.107	0.249	NO	0.515	0.141	0.099	0.040
2011	0.041	0.101	0.225	NO	0.529	0.134	0.094	0.038
2012	0.036	0.100	0.186	NO	0.580	0.125	0.088	0.036
2013	0.041	0.119	0.070	NO	0.486	0.144	0.101	0.041
2014	0.040	0.126	0.074	NO	0.487	0.134	0.094	0.038
2015	0.031	0.090	0.054	NO	0.198	0.109	0.076	0.031
2016	0.032	0.081	0.078	NO	0.117	0.101	0.071	0.029
2017	0.045	0.094	0.084	NO	0.118	0.128	0.090	0.036
2018	0.035	0.072	0.079	NO	0.082	0.111	0.078	0.032
2019	0.033	0.071	0.075	NO	0.104	0.110	0.078	0.032
2020	0.036	0.059	0.059	NO	0.107	0.107	0.075	0.031
2021	0.034	0.075	0.060	NO	0.127	0.113	0.080	0.033
2022	0.034	0.082	0.068	NO	0.158	0.105	0.074	0.030
Trend 1990-2022	*19.24%*	*35.06%*	*-49.09%*	*NA*	*-51.17%*	*-48.72%*	*-48.48%*	*-46.30%*
2005-2022	*-44.91%*	*-6.17%*	*-65.60%*	*NA*	*-73.17%*	*-12.87%*	*-13.32%*	*-17.01%*
2021-2022	*0.50%*	*8.24%*	*13.58%*	*NA*	*24.08%*	*-7.37%*	*-7.39%*	*-7.52%*

Source: Environment Agency.

With regard to TSP, PM_{10}, and $PM_{2.5}$ emissions, *1A2b – Non-Ferrous Metals* is a key category (LA) as well as for SO_2 (LA, TA) in 2022 (see Table 3-35 and also see Table 3-4 in Section 0 and Chapter 1.5).

Table 3-35 – Key Categories (fuel sold & fuel used) of category – 1A2b – Non-ferrous metals

Key Source Analysis (FUEL SOLD): Ranking per number		SO2		NOX		NMVOC		NH3		CO		TSP		PM10		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	5	4									7		7		7	

Key Source Analysis (FUEL USED): Ranking per number		SO2		NOX		NMVOC		NH3		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	5	4							7	

Sources: Environment Agency
Notes: LA = Level Assessment, TA = Trend Assessment
Number in Table = indicates the rank in the specific analysis (1…biggest KC; 2… second biggest KC, …)

With regard to PCB emissions, *1A2b – Non-Ferrous Metals* is a key category (TA only) in 2021 (see Table 3-5 in Section 0).

3.2.3.3.2 Methodological issues

3.2.3.3.2.1 Activity data

Liquefied petroleum gas (*LPG*) was an important fuel used in the secondary aluminium production. It was slowly substituted by natural gas. Generally, the fuel consumption data were obtained from the operators. The fuel consumption activity data for secondary aluminium and copper production are listed in Table 3-36.

The fuel consumption activity data reported here is the data reported by the operators to the Environment Agency through their annual reporting obligations. This bottom-up data could sometimes not be matched with top-down data from the national statistics institute as no such data is reported for this category. Due to confidentiality reasons, this data is reported under the iron & steel industry by national statistics. However, to avoid double counting, the bottom-up data was subtracted from the top-down data from official statistics reported for category *1A2a – Iron and Steel*.

Secondary aluminium and secondary copper production data is also reported by the operators. However, due to confidentiality reasons, this data can not be published in this report.

Table 3-36 – Activity data for category – *1A2b - Non-Ferrous Metals*

1 A 2 Stationary combustion in manufacturing industries and construction						
Activity Data by fuel type (GJ)						
1 A 2 b Non-ferrous metals						
Year	Activity Total (incl. biomass)	Liquid *LPG*	Solid	Gaseous *Natural Gas*	Biomass	Other
1990	462 005	230'000	NO	232'005	NO	NO
1991	480 174	230'000	NO	250'174	NO	NO
1992	484 471	230'000	NO	254'471	NO	NO
1993	474 992	230'000	NO	244'992	NO	NO
1994	574 091	307'372	NO	266'719	NO	NO
1995	593 787	314'594	NO	279'193	NO	NO
1996	983 700	314'594	NO	669'106	NO	NO
1997	724 596	56'951	NO	667'645	NO	NO
1998	757 076	87'447	NO	669'629	NO	NO
1999	740 541	86'796	NO	653'745	NO	NO
2000	722 935	88'251	NO	634'683	NO	NO
2001	733 199	86'796	NO	646'403	NO	NO
2002	715 027	NO	NO	715'027	NO	NO
2003	818 250	NO	NO	818'250	NO	NO
2004	928 110	NO	NO	928'110	NO	NO
2005	1 025 041	NO	NO	1'025'041	NO	NO
2006	1 073 850	NO	NO	1'073'850	NO	NO
2007	1 004 376	NO	NO	1'004'376	NO	NO
2008	979 207	NO	NO	979'207	NO	NO
2009	857 430	NO	NO	857'430	NO	NO
2010	987 086	NO	NO	987'086	NO	NO
2011	943 399	NO	NO	943'399	NO	NO
2012	958 750	NO	NO	958'750	NO	NO
2013	938 733	NO	NO	938'733	NO	NO
2014	906 812	NO	NO	906'812	NO	NO
2015	877 014	NO	NO	877'014	NO	NO
2016	896 259	NO	NO	896'259	NO	NO
2017	951 239	NO	NO	951'239	NO	NO
2018	915 753	NO	NO	915'753	NO	NO
2019	845 966	NO	NO	845'966	NO	NO
2020	763 317	NO	NO	763'317	NO	NO
2021	860 169	NO	NO	860'169	NO	NO
2022	844 043	NO	NO	844'043	NO	NO
Trend 1990-2022	*82.69%*	*NA*	*NA*	*263.80%*	*NA*	*NA*
2005-2022	*-17.66%*	*NA*	*NA*	*-17.66%*	*NA*	*NA*
2021-2022	*-1.87%*	*NA*	*NA*	*-1.87%*	*NA*	*NA*

Source: Environment Agency.

3.2.3.3.2.2 Methodological choices and emission factors

For point sources of this source category for which emission measurements were availaible, emissions of NO_X, SO_2, NMVOC, CO and TSP for most secondary aluminum plants, and NOx for the secondary copper plant were the basis for the reported emissions (EMEP/EEA Tier 3 approach). Hence, no emission factors per se are used, but rather implied emission factors are derived by dividing the emission with the activity data. $PM_{2.5}$ and PM_{10} emissions were based on TSP measurements (TSP considered equivalent to "dust" under IED monitoring rules) by using the default ratio between the default Tier 2 EMEP/EEA emission factors for TSP, PM_{10} and $PM_{2.5}$.

The point or area sources, for which no measured (plant-specific) emission data but plant specific production or fuel consumption activity data in relation with information on the abatement technology was available, were estimated using the EMEP/EEA Tier 2 default emission factors (EMEP/EEA Guidebook 2019, Chapters 2C3 (table 3.4) and 2C7a (table 3.3), or 1A2 (table 3-18 (secondary Al), table 3-13 (secondary Cu))).

The remaining point or area sources, for which no measured (plant-specific) emission data, nor plant specific activity data or information on the abatement technology was available, were estimated using the EMEP/EEA Tier 1 default emission factors (EMEP/EEA Guidebook 2019, Chapter 1A2 (table 3-3)).

The methods and emission factors used in relation to the coverage of energy consumption in consumption for 2022 are presented in Table 3-37.

Table 3-37 – Methods and Emission Factors used in relation to the energy consumption in 2022 for category – *1A2b – Non-Ferrous Metals*

1 A 2 Stationary combustion in manufacturing industries and construction				
Method applied and Emission factor (EF) used as well as coverage of energy consumption				
1 A 2 b Non-ferrous metals				
Pollutant	Method	EF used	Coverage of energy consumption	Source
NOx	T3	PS	68.7%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	31.3%	IEF: EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16 & Tab3.4, p.17)
NMVOC	T3	PS	68.7%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	31.3%	IEF: EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16 & Tab3.4, p.17)
SOx	T3	PS	68.7%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2	CS	0.0%	CS based on fuel sulfur content; determined by AEV
	T1	D	31.3%	IEF: EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16 & Tab3.4, p.17)
CO	T3	PS	68.7%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	31.3%	IEF: EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16 & Tab3.4, p.17)
PM2.5	T3	PS	68.7%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	31.3%	IEF: EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16 & Tab3.4, p.17)
PM10	T3	PS	68.7%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	31.3%	IEF: EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16 & Tab3.4, p.17)
TSP	T3	PS	68.7%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	31.3%	IEF: EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16 & Tab3.4, p.17)

Source: Environment Agency.

Table 3-38 gives an overview of the evolution of the implied emission factors. These may vary over time for the following reasons:

- The mix of fuels may change over time.
- The quality of scrap may change (i.e. quantities of coated scrap, etc.).

Table 3-38 – Implied emission factors for category – *1A2b - Non-Ferrous Metals*

1 A 2 Stationary combustion in manufacturing industries and construction *Implied Emission Factor (IEF) of air pollutants by source category (g/GJ)*								
Year	**1 A 2 b Non-ferrous metals**							
	SO2	***NOx***	***NMVOC***	***NH3***	***CO***	***TSP***	***PM10***	***PM2.5***
1990	62.57	130.67	287.94	NA	698.58	441.99	309.40	121.55
1991	60.21	128.73	297.85	NA	722.30	425.54	297.88	117.02
1992	59.68	128.30	300.14	NA	1127.93	421.83	295.28	116.00
1993	60.86	129.32	295.10	NA	1125.70	430.10	301.07	118.28
1994	67.28	134.53	268.14	NA	997.41	474.82	332.37	130.58
1995	66.58	133.89	271.16	NA	1028.14	469.93	328.95	129.23
1996	101.91	105.62	201.24	NA	681.08	300.73	211.70	87.38
1997	92.46	99.82	263.15	NA	893.62	94.74	67.91	32.30
1998	91.96	102.77	253.41	NA	855.62	125.69	89.47	40.42
1999	95.31	103.11	246.82	NA	852.34	127.86	91.06	41.28
2000	103.10	104.99	229.12	NA	828.43	134.00	95.50	43.50
2001	112.39	108.58	245.13	NA	899.10	133.66	95.46	44.23
2002	103.78	107.80	257.53	NA	893.54	146.63	104.33	46.94
2003	79.66	99.87	225.10	NA	740.50	132.58	94.01	41.17
2004	98.65	102.25	220.28	NA	796.31	142.06	101.04	45.33
2005	61.04	84.77	192.07	NA	573.16	117.24	82.88	35.45
2006	48.67	89.59	200.04	NA	531.08	123.95	87.28	36.12
2007	49.39	80.31	173.67	NA	512.35	127.54	89.79	37.09
2008	34.65	90.05	175.40	NA	519.12	110.60	77.79	31.85
2009	36.28	60.08	221.62	NA	601.29	104.63	73.66	30.42
2010	55.88	108.25	252.49	NA	521.69	142.96	100.46	40.83
2011	43.24	107.34	238.80	NA	560.37	142.00	99.78	40.55
2012	37.77	104.30	194.34	NA	604.48	130.51	91.65	37.06
2013	43.83	126.80	74.18	NA	517.89	153.23	107.57	43.33
2014	44.62	139.10	81.49	NA	537.24	148.22	104.12	42.18
2015	35.50	102.45	61.33	NA	225.56	123.73	87.01	35.58
2016	35.23	90.01	87.20	NA	130.32	113.02	79.50	32.61
2017	47.41	99.02	88.28	NA	123.79	134.09	94.24	38.37
2018	38.35	79.04	85.74	NA	90.00	121.45	85.40	34.92
2019	39.26	83.93	89.05	NA	123.50	130.39	91.70	37.52
2020	47.45	77.36	76.85	NA	139.59	140.39	98.77	40.55
2021	39.87	87.58	69.31	NA	147.67	131.42	92.45	37.91
2022	40.84	96.60	80.23	NA	186.73	124.06	87.25	35.73
Trend								
1990-2022	*-34.73%*	*-26.07%*	*-72.14%*	*NA*	*-73.27%*	*-71.93%*	*-71.80%*	*-70.61%*
2005-2022	*-33.10%*	*13.95%*	*-58.23%*	*NA*	*-67.42%*	*5.82%*	*5.27%*	*0.79%*
2021-2022	*2.42%*	*10.30%*	*15.75%*	*NA*	*26.45%*	*-5.60%*	*-5.62%*	*-5.76%*

Source: Environment Agency.

3.2.3.3.3 Methodological issues for heavy metal and POPs

Heavy metal and POP emissions related to secondary aluminium production are treated under “Industrial processes” in category 2.C.3 Aluminium production.

3.2.3.3.4 Uncertainties and time-series consistency

The assessment of activity data and emission factor uncertainties is done according to the methodology described in the EMEP/EEA emission inventory Guidebook 2023 (Chapter A.5 Uncertainties, tables 2-1, 2-2 and 2-3), covering the main pollutants NO_x, NH_3, NMVOC, SO_x and $PM_{2.5}$. For some subcategories and pollutants, expert judgements were made to estimate AD or EF uncertainties. For CO, PM10, heavy metzals and persistent organic pollutants, no uncertainty estimates are currently made. Details on uncertainty of the activity data can also be checked in the Luxembourg’s National Inventory report (NIR). Please also refer to Table 1-33 to Table 1-37 of section 1.7 for caterogory specific uncertainties on activity data and emission factors.

Time-series are considered consistent, also in comparison with energy data as reported by the national statistics institute.

3.2.3.3.5 Source-specific QA/QC and verification

Activity data are cross-checked with both reports obtained directly from the operators under their operational permit obligations and PRTR or ETS, if available.

Finally, consistency and completeness checks are performed.

3.2.3.3.6 Category-specific recalculations including changes made in response to the review process

Table 3-39 presents the main revisions and recalculations done since submission 2023 for sub-category *1A2b – Non-ferrous metals*.

Table 3-39 – Recalculations done since last submission for category – *1A2b - Non-ferrous metals*

Source category	Revisions 2023 → 2024	Type of revision
1A2b	Revision of SO_X emissions for 1996-2021 from secondary copper production due to an error correction of the Tier 2 EF (from 1320 g/t to 1230 g/t).	SO_X EF error correction

3.2.3.3.7 Category-specific planned improvements including those in response to the review process

The following improvements are planned for the next submission.

Table 3-40 – Planned improvements for category – *1A2b - Non-ferrous metals*

Source category	Planned improvements	Type of revision
1A2b	Update methodological table by including Tier 2 EFs	Transparency
1A2b	Reallocate process specific emissions (PM, HMs, POPs) to 2C3 and 2C7a respectively	

3.2.3.4 Chemicals (1A2c)

3.2.3.4.1 Source category description

In Luxembourg, chemical activities cover mainly the production of tyres, various plastic films and synthetic non-woven textiles. Also included in this category are the emissions of two gas turbines operated by the chemical industry for heat and electricity production (auto-producers).

This source category is a small source. In 1990 through 2022, this source category represented about 1.4% or less of the national total for each air pollutant (based on fuel sold and based on fuel used).

In the period 1990 – 2022, the emissions of all air pollutants decreased significantly due to changes in the fuel mix (switch from residual oil to natural gas) and the installation of more energy efficient combustion technologies.

Table 3-41 summarizes emissions of air pollutants for category *1A2c – Chemicals* and Table 3-42 presents the emission trends.

In 2022, category *1A2c – Chemicals* has not been identified as a key category, neither for the main pollutants, nor for heavy metals and persistent organic pollutants (see also Table 3-4 in Section 0 and Chapter 1.5).

Table 3-41 - Emissions, Trends and Shares based on fuel sold and fuel used – *1A2c – Chemicals*

1 A 2 Stationary combustion in manufacturing industries and construction														
Emissions, Trends and Shares in National Totals of air pollutants based on fuel sold and fuel used														
1 A 2 c Chemicals														
Pollutants	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
SO2	0.64	0.00	0.00	0.01	-99.0%	91.5%	586.4%	4.1%	0.1%	1.5%	3.9%	0.1%	1.4%	fuel sold
NOx	0.19	0.19	0.08	0.06	-67.3%	-68.8%	-24.4%	0.8%	1.1%	0.7%	0.5%	0.3%	0.5%	fuel sold
NMVOC	0.01	0.01	0.01	0.01	-33.1%	-58.2%	-22.1%	0.0%	0.1%	0.1%	0.0%	0.1%	0.1%	fuel sold
NH3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
CO	0.09	0.10	0.01	0.01	-86.9%	-88.0%	-7.6%	0.0%	0.4%	0.1%	0.0%	0.2%	0.1%	fuel sold
TSP	0.07	0.00	0.00	0.01	-88.8%	462.9%	732.7%	0.4%	0.1%	0.4%	0.4%	0.0%	0.3%	fuel sold
PM10	0.06	0.00	0.00	0.01	-86.8%	443.2%	691.5%	0.4%	0.1%	0.6%	0.3%	0.0%	0.5%	fuel sold
PM2.5	0.04	0.00	0.00	0.01	-83.4%	422.7%	650.1%	0.3%	0.1%	0.8%	0.3%	0.1%	0.7%	fuel sold

Source: Environment Agency.

Table 3-42 – Emission trends of category – *1A2c - Chemicals*

1 A 2 Stationary combustion in manufacturing industries and construction								
Emissions of air pollutants by source category (Gg)								
Year	1 A 2 c Chemicals							
	SO2	*NOx*	*NMVOC*	*NH3*	*CO*	*TSP*	*PM10*	*PM2.5*
1990	0.643	0.186	0.009	NO	0.088	0.073	0.059	0.044
1991	0.900	0.258	0.013	NO	0.097	0.096	0.078	0.059
1992	0.639	0.193	0.010	NO	0.090	0.073	0.058	0.044
1993	0.718	0.289	0.014	NO	0.094	0.074	0.060	0.046
1994	0.662	0.328	0.013	NO	0.103	0.072	0.058	0.044
1995	0.350	0.280	0.009	NO	0.093	0.044	0.035	0.027
1996	0.343	0.373	0.009	NO	0.096	0.043	0.035	0.026
1997	0.184	0.430	0.009	NO	0.086	0.024	0.020	0.015
1998	0.023	0.335	0.007	NO	0.079	0.003	0.002	0.002
1999	0.031	0.254	0.007	NO	0.080	0.003	0.002	0.002
2000	0.003	0.226	0.014	NO	0.089	0.001	0.001	0.001
2001	0.003	0.195	0.014	NO	0.101	0.001	0.001	0.001
2002	0.003	0.202	0.014	NO	0.101	0.001	0.001	0.001
2003	0.003	0.204	0.015	NO	0.116	0.002	0.002	0.001
2004	0.003	0.198	0.014	NO	0.110	0.001	0.001	0.001
2005	0.003	0.195	0.015	NO	0.096	0.001	0.001	0.001
2006	0.003	0.173	0.012	NO	0.102	0.002	0.001	0.001
2007	0.003	0.168	0.009	NO	0.088	0.001	0.001	0.001
2008	0.002	0.158	0.010	NO	0.065	0.001	0.001	0.001
2009	0.001	0.117	0.008	NO	0.030	0.001	0.001	0.001
2010	0.002	0.168	0.010	NO	0.056	0.001	0.001	0.001
2011	0.002	0.142	0.017	NO	0.059	0.003	0.003	0.003
2012	0.002	0.137	0.018	NO	0.055	0.002	0.002	0.002
2013	0.002	0.136	0.023	NO	0.050	0.003	0.003	0.003
2014	0.002	0.114	0.016	NO	0.066	0.002	0.002	0.002
2015	0.001	0.102	0.014	NO	0.027	0.006	0.006	0.006
2016	0.001	0.119	0.017	NO	0.027	0.007	0.007	0.007
2017	0.001	0.095	0.012	NO	0.020	0.004	0.004	0.004
2018	0.001	0.081	0.008	NO	0.016	0.011	0.011	0.011
2019	0.001	0.074	0.008	NO	0.012	0.011	0.011	0.011
2020	0.001	0.073	0.008	NO	0.011	0.011	0.011	0.011
2021	0.001	0.080	0.008	NO	0.012	0.001	0.001	0.001
2022	0.006	0.061	0.006	NO	0.012	0.008	0.008	0.007
Trend 1990-2022	-99.03%	-67.31%	-33.14%	NA	-86.92%	-88.83%	-86.77%	-83.36%
2005-2022	91.48%	-68.78%	-58.23%	NA	-88.01%	462.91%	443.16%	422.72%
2021-2022	586.41%	-24.39%	-22.12%	NA	-7.55%	732.74%	691.48%	650.09%

Source: Environment Agency.

3.2.3.4.2 Methodological issues & time-series consistency

3.2.3.4.2.1 Activity data

Annual fuel consumption data of residual fuel oil, gas oil, diesel oil and natural gas were obtained from the operators. Diesel oil is mainly used by mobile sources and machinery, whereas the remaining fuels are mainly combusted in stationary units for heating purposes.

The activity data reported here are the data reported by the operators to the Environment Agency through their annual reporting obligations. The bottom-up data on natural gas, between 1990 and 1999, could not be matched to the top-down data from the national statistics institute as no such data is reported for this category. To avoid double counting, the bottom-up data for this period were subtracted from the top-down data from official statistics reported for category *1A2g viii – Other*. For natural gas (2000-2010) and liquid fuels (residual fuel oil, gas oil, diesel oil) the matching exercise was done within the category *1A2c – Chemicals* as top-down data is reported for this sub-category by the national statistics institute. Activity data for the chemical industry are listed in Table 3-43.

Fluctuations in activity data may occur, due to temporal shutdown of installations (e.g. for maintenance). This may then be reflected in the activity data by a sharp decrease as happened in 2007 in comparison to the year 2006: a decrease of about 11% occurred due to maintenance on one of the gas turbines operated by the chemical industry. The dip in 2009 is explained by the global economic downturn due to the financial and economic crisis. 2010 showed a slight recovery, with a stabilisation in 2013. The decrease observed in 2014 is mainly due to the phase out of one of the gas turbines, being replaced by energy efficient boilers.

Table 3-43- Activity data for category – *1A2c – Chemicals*

1 A 2 Stationary combustion in manufacturing industries and construction						
Activity Data by fuel type (GJ)						
1 A 2 c Chemicals						
Year	Activity Total (incl. biomass)	Liquid *Residual Fuel Oil, Gas Oil, Diesel Oil*	Solid	Gaseous *Natural Gas*	Biomass	Other
1990	2 455 706	1'460'983	NO	994'723	NO	NO
1991	2 563 192	1'975'924	NO	587'269	NO	NO
1992	2 520 181	1'453'902	NO	1'066'279	NO	NO
1993	2 597 533	1'595'269	NO	1'002'264	NO	NO
1994	2 964 983	1'490'527	NO	1'474'456	NO	NO
1995	3 063 188	862'520	NO	2'200'668	NO	NO
1996	3 109 185	847'838	NO	2'261'347	NO	NO
1997	3 066 885	502'535	NO	2'564'350	NO	NO
1998	3 179 058	41'363	NO	3'137'695	NO	NO
1999	3 061 094	49'809	NO	3'011'284	NO	NO
2000	3 404 315	4'192	NO	3'400'122	NO	NO
2001	3 531 748	2'667	NO	3'529'081	NO	NO
2002	3 528 026	4'436	NO	3'523'590	NO	NO
2003	3 754 091	5'824	NO	3'748'267	NO	NO
2004	3 828 433	1'658	NO	3'826'775	NO	NO
2005	3 807 920	2'801	NO	3'805'119	NO	NO
2006	3 714 993	5'822	NO	3'709'171	NO	NO
2007	3 307 014	854	NO	3'306'160	NO	NO
2008	3 313 135	420	NO	3'312'715	NO	NO
2009	2 479 771	724	NO	2'479'048	NO	NO
2010	2 916 153	1'185	NO	2'914'968	NO	NO
2011	3 815 425	1'403	NO	3'814'023	NO	NO
2012	3 573 491	1'295	NO	3'572'197	NO	NO
2013	3 728 780	3'356	NO	3'725'424	NO	NO
2014	2 988 616	1'156	NO	2'987'460	NO	NO
2015	2 433 025	850	NO	2'432'175	NO	NO
2016	2 600 928	494	NO	2'600'434	NO	NO
2017	2 323 667	701	NO	2'322'966	NO	NO
2018	2 130 375	487	NO	2'129'888	NO	NO
2019	2 078 618	466	NO	2'078'151	NO	NO
2020	1 957 022	131	NO	1'956'891	NO	NO
2021	2 153 111	170	NO	2'152'941	NO	NO
2022	1 929 945	42'016	NO	1'887'929	NO	NO
Trend 1990-2022	*-21.41%*	*-97.12%*	*NA*	*89.79%*	*NA*	*NA*
2005-2022	*-49.32%*	*1399.98%*	*NA*	*-50.38%*	*NA*	*NA*
2021-2022	*-10.36%*	*24670.92%*	*NA*	*-12.31%*	*NA*	*NA*

Source: Environment Agency.

3.2.3.4.2.2 Methodological issues

For all large point sources of this category, emission measurements of NO_X, SO_2, CO and TSP are the basis for the reported emissions (EMEP/EEA Tier 3 approach).

The point or area sources, for which no measured (plant-specific) emission data but plant specific activity data or information on the abatement technology was available, were estimated using the EMEP/EEA Tier 2 default emission factors. The remaining point or area sources, for which no measured (plant-specific) emission data, nor plant specific activity data or information on the abatement technology was available, were estimated using the EMEP/EEA Tier 1 default emission factors.

The methods applied in relation to the energy consumption for 2022 are presented in Table 3-44.

3.2.3.4.2.3 Emission factors

For point sources of this sub-category, emission measurements of NO_X, SO_2, CO and TSP are the basis for the reported emissions (EMEP/EEA Tier 3 approach). Hence, no emission factors per se are used, but rather implied emission factors are derived by dividing the emission with the activity data. $PM_{2.5}$ and PM_{10} emissions were based on TSP measurements (TSP considered equivalent to "dust" under IED monitoring rueles) by using the default ratio between the default Tier 2 EMEP/EEA emission factors for TSP, PM_{10} and $PM_{2.5}$.

The point or area sources, for which no measured (plant-specific) emission data but plant specific activity data or information on the abatement technology was available, were estimated using the EMEP/EEA Tier 2 default emission factors.

The remaining point or area sources, for which no measured (plant-specific) emission data, nor plant specific activity data or information on the abatement technology was available, were estimated using the EMEP/EEA Tier 1 default emission factors (Table 3-44).

Table 3-45 gives an overview of the evolution of the implied emission factors. Implied emission factors may vary over time for the following reasons:

- The chemical characteristic of a fuel varies, e.g. sulphur content in residual oil.
- The mix of fuels changes over time. Indeed, a switch from mainly residual fuel oil in the 1990s to natural gas in the latest years occurred in this sub-category.
- The production- and/or abatement technology of a facility – or of facilities – changes over time.

Table 3-44 – Methods and Emission Factors used in relation to the energy consumption in 2022 for category – *1A2c - Chemicals*

1 A 2 Stationary combustion in manufacturing industries and construction *Method applied and Emission factor (EF) used as well as coverage of energy consumption* 1 A 2 c Chemicals				
Pollutant	Method	EF used	Coverage of energy consumption	Source
NOx	T3	PS	91.9%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	8.1%	EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16), EMEP/EEA GB 2019 (Chap1A2, Tab3.34 p17)
NMVOC	T3	PS	0.0%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	100.0%	EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16), EMEP/EEA GB 2019 (Chap1A2, Tab3.4 p17)
SOx	T3	PS	59.3%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2	CS	0.0%	CS based on fuel sulfur content; determined by AEV
	T1	D	40.7%	EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16)
CO	T3	PS	91.9%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	8.1%	EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.4, p16)
PM2.5	T3	PS	40.3%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV PM measured assumed to be TSP = PM10 = PM2.5
	T1	D	59.7%	EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16), EMEP/EEA GB 2019 (Chap1A2, Tab3.4, p17)
PM10	T3	PS	40.3%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV PM measured assumed to be TSP = PM10 = PM2.5
	T1	D	59.7%	EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16), EMEP/EEA GB 2019 (Chap1A2, Tab3.4, p17)
TSP	T3	PS	40.3%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV PM measured assumed to be TSP = PM10 = PM2.5
	T1	D	59.7%	EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16), EMEP/EEA GB 2019 (Chap1A2, Tab3.4, p17)

Source: Environment Agency.

Table 3-45 – Implied emission factors for category – *1A2c - Chemicals*

	1 A 2 Stationary combustion in manufacturing industries and construction *Implied Emission Factor (IEF) of air pollutants by source category (g/GJ)*							
Year	**1 A 2 c Chemicals**							
	SO2	***NOx***	***NMVOC***	***NH3***	***CO***	***TSP***	***PM10***	***PM2.5***
1990	261.68	75.70	3.78	NA	35.95	29.93	23.98	18.03
1991	351.28	100.73	5.01	NA	37.71	37.60	30.24	22.88
1992	253.55	76.61	3.83	NA	35.77	28.89	23.17	17.45
1993	276.42	111.14	5.50	NA	36.14	28.39	23.08	17.77
1994	223.18	110.79	4.28	NA	34.84	24.21	19.56	14.92
1995	114.31	91.33	2.84	NA	30.52	14.40	11.59	8.77
1996	110.40	119.83	2.92	NA	30.83	13.80	11.13	8.45
1997	59.87	140.06	2.99	NA	28.10	7.77	6.38	4.99
1998	7.38	105.24	2.09	NA	24.99	0.86	0.76	0.66
1999	10.28	83.05	2.36	NA	26.15	0.84	0.78	0.73
2000	0.76	66.32	4.15	NA	26.11	0.41	0.39	0.38
2001	0.88	55.08	3.82	NA	28.63	0.38	0.38	0.37
2002	0.89	57.12	4.01	NA	28.67	0.40	0.39	0.38
2003	0.91	54.30	4.00	NA	30.91	0.43	0.41	0.40
2004	0.74	51.63	3.63	NA	28.86	0.36	0.36	0.36
2005	0.85	51.11	3.91	NA	25.28	0.38	0.38	0.37
2006	0.94	46.45	3.16	NA	27.37	0.40	0.39	0.38
2007	0.91	50.72	2.75	NA	26.65	0.31	0.31	0.31
2008	0.55	47.73	3.15	NA	19.54	0.32	0.32	0.32
2009	0.60	47.03	3.21	NA	12.06	0.34	0.34	0.33
2010	0.66	57.46	3.28	NA	19.26	0.36	0.36	0.35
2011	0.51	37.25	4.40	NA	15.58	0.68	0.68	0.68
2012	0.53	38.33	5.02	NA	15.49	0.69	0.68	0.68
2013	0.60	36.38	6.16	NA	13.42	0.76	0.75	0.74
2014	0.52	38.19	5.45	NA	22.07	0.81	0.81	0.81
2015	0.56	41.93	5.91	NA	11.06	2.67	2.67	2.66
2016	0.55	45.89	6.60	NA	10.52	2.61	2.61	2.60
2017	0.49	40.93	5.15	NA	8.40	1.73	1.73	1.72
2018	0.49	37.97	3.93	NA	7.60	5.02	5.02	5.02
2019	0.45	35.57	4.08	NA	5.87	5.14	5.14	5.14
2020	0.44	37.44	3.87	NA	5.81	5.45	5.45	5.45
2021	0.42	37.33	3.71	NA	5.80	0.46	0.46	0.46
2022	3.22	31.49	3.22	NA	5.98	4.25	4.04	3.82
Trend 1990-2022	*-98.77%*	*-58.40%*	*-14.93%*	*NA*	*-83.36%*	*-85.79%*	*-83.17%*	*-78.83%*
2005-2022	*277.81%*	*-38.39%*	*-17.59%*	*NA*	*-76.34%*	*1010.66%*	*971.69%*	*931.37%*
2021-2022	*665.79%*	*-15.65%*	*-13.11%*	*NA*	*3.14%*	*829.03%*	*783.01%*	*736.83%*

Source: Environment Agency.

3.2.3.4.3 Methodological issues for heavy metal and POPs

Emissions in this category originate from four point sources (DuPont de Nemours, Goodyear, Ceduco, Cegyco) and a range of smaller facilities at different locations in the country. Emissions in this category are generated during the production of process heat and electricity.

3.2.3.4.3.1 Methodological Choices

Since HM or POP emission measurements were not available for any of the abovementioned facilities, calculation of emissions originating from chemical industries were based on total fuel consumption in combination with tier 1 emission factors.

Fuel consumption data were obtained from the national energy balance.

3.2.3.4.3.2 Emission Factors

Sources of default Tier 1 HM and POP emission factors are given in the following table:

Table 3-46 – Sources of Tier 1 HM and POP emission factors for category *1A2c - Chemicals*

Fuel	Pollutants	Source	Page	Table
Solid fuels	Pb, Hg, Cd, PCDD/F, PCB, HCB, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2023) – Chapter 1.A.2 Manufacturing industries and construction	15	3-2
Natural gas	Pb, Hg, Cd	EEA (2023) – Chapter 1.A.2 Manufacturing industries and construction PCDD/F, PCB, HCB, B(a)P, B(b)F, B(k)F, I(cd)P considered as NA	16	3-3
Liquid fuels	Pb, Hg, Cd, PCDD/F, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2023) – Chapter 1.A.2 Manufacturing industries and construction	17	3-4
Liquid fuels	PCB	EF not stated in EEA (2023), thus custom EF derived from EMEP/Corinair Guidebook (2007): 1 TEP= 1,170 l and density (gas oil) = 0,84 kg/l → 1 TEP= 983 kg EF: EMEP/Corinair Guidebook (2007), Draft Chapter on PCB emissions: 250 ug/t (gas oil) conversion: 1 TEP = 41,9 GJ (250 ug/t * 0,983 t)/41,9 GJ=5,87 ug/GJ	N/A	N/A

3.2.3.4.4 Uncertainties and time-series consistency

The assessment of activity data and emission factor uncertainties is done according to the methodology described in the EMEP/EEA emission inventory Guidebook 2023 (Chapter A.5 Uncertainties, tables 2-1, 2-2 and 2-3), covering the main pollutants NO_x, NH_3, NMVOC, SO_x and $PM_{2.5}$. For some subcategories and pollutants, expert judgements were made to estimate AD or EF uncertainties. For CO, PM10, heavy metzals and persistent organic pollutants, no uncertainty estimates are currently made. Details on uncertainty of the activity data can also be checked in the Luxembourg's National Inventory report (NIR). Please also refer to Table 1-33 to Table 1-37 of section 1.7 for caterogory specific uncertainties on activity data and emission factors.

Time-series are considered to be consistent, also in comparison with energy data as reported by the national statistics institute.

3.2.3.4.5 Source-specific QA/QC and verification

Activity data for large facilities that are under the European Union Emission Trading Scheme (EU-ETS) are cross-checked from two sources: reports obtained directly from the operator under its operational permit obligations and the EU-ETS registry operator. Both are hosted at the Environment Agency. A list with the large energy consuming facilities along with their respective fuel consumption have been compiled and enable the Single National Entity to quickly cross-check this data with the EU-ETS data. Thus, completeness can be checked on a more systematic basis.

Finally, consistency and completeness checks are performed.

3.2.3.4.6 Category-specific recalculations including changes made in response to the review process

Table 3-47 presents the main revisions and recalculations done since submission 2023 for category *1A2c – Chemicals*.

Table 3-47 – Recalculations done since last submission for category – *1A2c - Chemicals*

Source category	Revisions 2023 → 2024	Type of revision
1A2a/c/d/e/f/gviii	In the latest national energy balance, changes were made to the allocation method of natural gas to the different sectors for the year 2021. Consequently the natural gas in the sector 1A2c decreased by 100 TJ.	AD

3.2.3.4.7 Category-specific planned improvements including those in response to the review process

The following improvements are planned for the next submission.

Table 3-48 – Planned improvements for category – *1A2c - Chemicals*

Source category	Planned improvements	Type of revision
1A2c	No further improvements planned	n/a

3.2.3.5 Pulp, Paper and Print (1A2d)

3.2.3.5.1 Source category description

In Luxembourg, this source category only covers the printing industry. No pulp or paper production occurs in Luxembourg. Included in this category are the emissions from combustion plants (<50 MW). Mobile machinery operated by the printing industry is reported under category *1A2gvii - Mobile Combustion in manufacturing industries and construction*.

Fuel combustion from the paper and print industry is a small source of air pollutant emissions. In 2022, this source category represented less than 0.11% of national total for each air pollutant (based on fuel sold and based on fuel used).

Category *1A2d – Pulp, Paper and Print* is not a key category in 2022, neither for the main pollutants, nor for heavy metals and persistent organic pollutants (see also Table and Table 3-5 in Section 0 and Chapter 1.5).

Table 3-49 summarizes emissions of air pollutants for category *1A2d – Pulp, Paper and Print* and Table 3-50 presents the emission trends. From 1990-1999, no emissions could be estimated due to the lack of activity data for this source category in the energy balance. However, these emissions are included in category *1A2gviii - Stationary combustion in manufacturing industries and construction: Other*.

Table 3-49 – Emissions, Trends and Shares based on fuel sold and fuel used – *1A2d - Pulp, Paper and Print*

1 A 2 Stationary combustion in manufacturing industries and construction														
Emissions, Trends and Shares in National Totals of air pollutants based on fuel sold and fuel used														
1 A 2 d Pulp, Paper and Print														
Pollutants	1990	2005	2021	2022	Trend 1990 - 2022	Trend 2005 - 2022	Trend 2021 - 2022	FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
								1990	2005	2022	1990	2005	2022	
SO2	IE	0.00	0.00	0.00	0.0%	-52.0%	-39.3%	IE	0.01%	0.02%	IE	0.01%	0.02%	fuel sold
NOx	IE	0.03	0.02	0.01	1.3%	-52.0%	-39.3%	IE	0.15%	0.14%	IE	0.05%	0.11%	fuel sold
NMVOC	IE	0.01	0.01	0.00	0.3%	-52.0%	-39.3%	IE	0.06%	0.04%	IE	0.05%	0.03%	fuel sold
NH3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
CO	IE	0.01	0.01	0.00	0.4%	-52.0%	-39.3%	IE	0.03%	0.03%	IE	0.02%	0.02%	fuel sold
TSP	IE	0.00	0.00	0.00	0.0%	-52.0%	-39.3%	IE	0.01%	0.01%	IE	0.01%	0.00%	fuel sold
PM10	IE	0.00	0.00	0.00	0.0%	-52.0%	-39.3%	IE	0.01%	0.01%	IE	0.01%	0.01%	fuel sold
PM2.5	IE	0.00	0.00	0.00	0.0%	-52.0%	-39.3%	IE	0.02%	0.01%	IE	0.01%	0.01%	fuel sold

Source: Environment Agency.

Table 3-50 – Emission trends of category – *1A2d - Pulp and Paper*

1 A 2 Stationary combustion in manufacturing industries and construction *Emissions of air pollutants by source category (Gg)*								
Year	**1 A 2 d Pulp, Paper and Print**							
	SO2	***NOx***	***NMVOC***	***NH3***	***CO***	***TSP***	***PM10***	***PM2.5***
1990	IE	IE	IE	NO	IE	IE	IE	IE
1991	IE	IE	IE	NO	IE	IE	IE	IE
1992	IE	IE	IE	NO	IE	IE	IE	IE
1993	IE	IE	IE	NO	IE	IE	IE	IE
1994	IE	IE	IE	NO	IE	IE	IE	IE
1995	IE	IE	IE	NO	IE	IE	IE	IE
1996	IE	IE	IE	NO	IE	IE	IE	IE
1997	IE	IE	IE	NO	IE	IE	IE	IE
1998	IE	IE	IE	NO	IE	IE	IE	IE
1999	IE	IE	IE	NO	IE	IE	IE	IE
2000	0.000	0.018	0.005	NO	0.005	0.000	0.000	0.000
2001	0.000	0.021	0.005	NO	0.006	0.000	0.000	0.000
2002	0.000	0.027	0.007	NO	0.008	0.000	0.000	0.000
2003	0.000	0.032	0.008	NO	0.009	0.000	0.000	0.000
2004	0.000	0.028	0.007	NO	0.008	0.000	0.000	0.000
2005	0.000	0.027	0.007	NO	0.008	0.000	0.000	0.000
2006	0.000	0.017	0.004	NO	0.005	0.000	0.000	0.000
2007	0.000	0.011	0.003	NO	0.003	0.000	0.000	0.000
2008	0.000	0.015	0.004	NO	0.004	0.000	0.000	0.000
2009	0.000	0.012	0.003	NO	0.003	0.000	0.000	0.000
2010	0.000	0.008	0.002	NO	0.002	0.000	0.000	0.000
2011	0.000	0.011	0.003	NO	0.003	0.000	0.000	0.000
2012	0.000	0.015	0.004	NO	0.004	0.000	0.000	0.000
2013	0.000	0.019	0.005	NO	0.005	0.000	0.000	0.000
2014	0.000	0.009	0.002	NO	0.003	0.000	0.000	0.000
2015	0.000	0.008	0.002	NO	0.002	0.000	0.000	0.000
2016	0.000	0.008	0.002	NO	0.002	0.000	0.000	0.000
2017	0.000	0.008	0.002	NO	0.002	0.000	0.000	0.000
2018	0.000	0.002	0.001	NO	0.001	0.000	0.000	0.000
2019	0.000	0.003	0.001	NO	0.001	0.000	0.000	0.000
2020	0.000	0.001	0.000	NO	0.000	0.000	0.000	0.000
2021	0.000	0.022	0.006	NO	0.006	0.000	0.000	0.000
2022	0.000	0.013	0.003	NO	0.004	0.000	0.000	0.000
Trend 1990-2022	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005-2022	*-51.97%*	*-51.97%*	*-51.97%*	*NA*	*-51.97%*	*-51.97%*	*-51.97%*	*-51.97%*
2021-2022	*-39.32%*	*-39.32%*	*-39.32%*	*NA*	*-39.32%*	*-39.32%*	*-39.32%*	*-39.32%*

Source: Environment Agency.

3.2.3.5.2 Methodological issues & time-series consistency

3.2.3.5.2.1 Activity data

Annual fuel consumption data for gas oil, diesel oil and natural gas were derived from national statistics for the period 2000-2022. Diesel oil is mainly used by mobile sources and machinery and hence, related emissions are reported in category *1A2gvii - Mobile Combustion in manufacturing industries and construction*. The remaining fuels are mainly combusted in stationary units for heating purposes. For 1990-1999, no activity data are available from national statistics, hence the notation key IE was used in the NFR tables. For these years, emissions are included in category *1A2g - Combustion in manufacturing industries and construction - Other*. Activity data for the pulp, paper and print industry are listed in Table 3-51.

Table 3-51 – Activity data for category – *1A2d - Pulp, Paper and Print*

1 A 2 Stationary combustion in manufacturing industries and construction						
Activity Data by fuel type (GJ)						
1 A 2 d Pulp, Paper and Print						
Year	Activity Total (incl. biomass)	Liquid *Gas Oil, Diesel Oil*	Solid	Gaseous *Natural Gas*	Biomass	Other
1990	NO	IE	NO	IE	NO	NO
1991	NO	IE	NO	IE	NO	NO
1992	NO	IE	NO	IE	NO	NO
1993	NO	IE	NO	IE	NO	NO
1994	NO	IE	NO	IE	NO	NO
1995	NO	IE	NO	IE	NO	NO
1996	NO	IE	NO	IE	NO	NO
1997	NO	IE	NO	IE	NO	NO
1998	NO	IE	NO	IE	NO	NO
1999	NO	IE	NO	IE	NO	NO
2000	202 968	NO	NO	202'968	NO	NO
2001	236 843	NO	NO	236'843	NO	NO
2002	301 055	NO	NO	301'055	NO	NO
2003	360 488	NO	NO	360'488	NO	NO
2004	309 314	NO	NO	309'314	NO	NO
2005	308 222	NO	NO	308'222	NO	NO
2006	193 171	NO	NO	193'171	NO	NO
2007	124 403	NO	NO	124'403	NO	NO
2008	173 495	NO	NO	173'495	NO	NO
2009	136 285	NO	NO	136'285	NO	NO
2010	87 812	NO	NO	87'812	NO	NO
2011	126 426	NO	NO	126'426	NO	NO
2012	165 172	NO	NO	165'172	NO	NO
2013	210 341	NO	NO	210'341	NO	NO
2014	101 720	NO	NO	101'720	NO	NO
2015	94 968	NO	NO	94'968	NO	NO
2016	92 645	NO	NO	92'645	NO	NO
2017	87 269	NO	NO	87'269	NO	NO
2018	22 624	NO	NO	22'624	NO	NO
2019	33 584	NO	NO	33'584	NO	NO
2020	7 117	NO	NO	7'117	NO	NO
2021	243 968	NO	NO	243'968	NO	NO
2022	148 029	NO	NO	148'029	NO	NO
Trend 1990-2022	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005-2022	*-51.97%*	*NA*	*NA*	*-51.97%*	*NA*	*NA*
2021-2022	*-39.32%*	*NA*	*NA*	*-39.32%*	*NA*	*NA*

Source: Environment Agency.

3.2.3.5.2.2 Methodological choices

The EMEP/EEA Tier 1 approach was applied for gas oil, diesel oil and natural gas (see Table 3-52).

3.2.3.5.2.3 Emission factors

As neither measured (plant-specific) emission data nor technology specific activity data was available for this category, all emission sources were estimated using the EMEP/EEA Tier 1 default emission factors and multiplying them with the fuel consumption taken from the national energy balance.

The methods applied and emission factors (EF) used, in relation to the energy consumption, for 2022, are presented in Table 3-52.

Table 3-52 – Methods and Emission Factors used in relation to the energy consumption in 2022 for category – *1A2d - Pulp, Paper and Print*

1 A 2 Stationary combustion in manufacturing industries and construction *Method applied and Emission factor (EF) used as well as coverage of energy consumption* 1 A 2 d Pulp, Paper and Print				
Pollutant	**Method**	**EF used**	**Coverage of energy consumption**	**Source**
NOx	T3	PS	0.0%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	100.0%	EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16), EMEP/EEA GB 2019 (Chap1A2, Tab3.4 p17)
NMVOC	T3	PS	0.0%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	100.0%	EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16), EMEP/EEA GB 2019 (Chap1A2, Tab3.4 p17)
SOx	T3	PS	0.0%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2	CS	0.0%	CS based on fuel sulfur content; determined by AEV
	T1	D	100.0%	EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16)
CO	T3	PS	0.0%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	100.0%	EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.4, p16)
PM2.5	T3	PS	0.0%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2	D	100.0%	EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16), EMEP/EEA GB 2019 (Chap1A2, Tab3.4, p17)
PM10	T3	PS	0.0%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	100.0%	EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16), EMEP/EEA GB 2019 (Chap1A2, Tab3.4, p17)
TSP	T3	PS	0.0%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	100.0%	EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16), EMEP/EEA GB 2019 (Chap1A2, Tab3.4, p17)

Source: Environment Agency

Table 3-53 gives an overview of the evolution of the implied emission factors. These may vary over time due to:

- Changes in the energy mix. There is a general trend to natural gas combustion instead of liquid fuels.
- Changes in the activity rate. Please keep in mind that this is a very small sub-category in terms of emissions, and that changes in activity rates of one plant may have a large effect on the entire sub-category.

Table 3-53 – Implied emission factors for category – *1A2d - Pulp, Paper and Print*

1 A 2 Stationary combustion in manufacturing industries and construction *Implied Emission Factor (IEF) of air pollutants by source category (g/GJ)*								
Year	**1 A 2 d Pulp, Paper and Print**							
	SO2	***NOx***	***NMVOC***	***NH3***	***CO***	***TSP***	***PM10***	***PM2.5***
1990	NA	NA	NA	NA	NA	NA	NA	NA
1991	NA	NA	NA	NA	NA	NA	NA	NA
1992	NA	NA	NA	NA	NA	NA	NA	NA
1993	NA	NA	NA	NA	NA	NA	NA	NA
1994	NA	NA	NA	NA	NA	NA	NA	NA
1995	NA	NA	NA	NA	NA	NA	NA	NA
1996	NA	NA	NA	NA	NA	NA	NA	NA
1997	NA	NA	NA	NA	NA	NA	NA	NA
1998	NA	NA	NA	NA	NA	NA	NA	NA
1999	NA	NA	NA	NA	NA	NA	NA	NA
2000	0.67	89.00	23.00	NA	25.00	0.78	0.78	0.78
2001	0.67	89.00	23.00	NA	25.00	0.78	0.78	0.78
2002	0.67	89.00	23.00	NA	25.00	0.78	0.78	0.78
2003	0.67	89.00	23.00	NA	25.00	0.78	0.78	0.78
2004	0.67	89.00	23.00	NA	25.00	0.78	0.78	0.78
2005	0.67	89.00	23.00	NA	25.00	0.78	0.78	0.78
2006	0.67	89.00	23.00	NA	25.00	0.78	0.78	0.78
2007	0.67	89.00	23.00	NA	25.00	0.78	0.78	0.78
2008	0.67	89.00	23.00	NA	25.00	0.78	0.78	0.78
2009	0.67	89.00	23.00	NA	25.00	0.78	0.78	0.78
2010	0.67	89.00	23.00	NA	25.00	0.78	0.78	0.78
2011	0.67	89.00	23.00	NA	25.00	0.78	0.78	0.78
2012	0.67	89.00	23.00	NA	25.00	0.78	0.78	0.78
2013	0.67	89.00	23.00	NA	25.00	0.78	0.78	0.78
2014	0.67	89.00	23.00	NA	25.00	0.78	0.78	0.78
2015	0.67	89.00	23.00	NA	25.00	0.78	0.78	0.78
2016	0.67	89.00	23.00	NA	25.00	0.78	0.78	0.78
2017	0.67	89.00	23.00	NA	25.00	0.78	0.78	0.78
2018	0.67	89.00	23.00	NA	25.00	0.78	0.78	0.78
2019	0.67	89.00	23.00	NA	25.00	0.78	0.78	0.78
2020	0.67	89.00	23.00	NA	25.00	0.78	0.78	0.78
2021	0.67	89.00	23.00	NA	25.00	0.78	0.78	0.78
2022	0.67	89.00	23.00	NA	25.00	0.78	0.78	0.78
Trend								
1990-2022	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005-2022	*0.00%*	*0.00%*	*0.00%*	*NA*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
2021-2022	*0.00%*	*0.00%*	*0.00%*	*NA*	*0.00%*	*0.00%*	*0.00%*	*0.00%*

Source: Environment Agency

3.2.3.5.3 Methodological issues for heavy metals and POPs

In this category, all emissions originate from diffuse sources.

3.2.3.5.3.1 Methodological Choices

The calculation of emissions related to pulp, paper, and print were based on total fuel consumption in combination with tier 1 emission factors.

Fuel consumption data were obtained from the national energy balance.

3.2.3.5.3.2 Emission Factors

Sources for default Tier 1 HM and POP emission factors are given in the following table:

Table 3-54 – Sources of Tier 1 HM and POP emission factors for category *1A2d - Pulp, Paper and Print*

Fuel	Pollutants	Source	Page	Table
Solid fuels	Pb, Hg, Cd, PCDD/F, PCB, HCB, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2023) – Chapter 1.A.2 Manufacturing industries and construction	15	3-2
Natural gas	Pb, Hg, Cd	EEA (2023) – Chapter 1.A.2 Manufacturing industries and construction PCDD/F, PCB, HCB, B(a)P, B(b)F, B(k)F, I(cd)P considered as NA	16	3-3
Liquid fuels	Pb, Hg, Cd, PCDD/F, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2023) – Chapter 1.A.2 Manufacturing industries and construction	17	3-4
Liquid fuels	PCB	EF not stated in EEA (2019), thus custom EF derived from EMEP/Corinair Guidebook (2007): 1 TEP= 1,170 l and density (gas oil) = 0,84 kg/l → 1 TEP= 983 kg EF: EMEP/Corinair Guidebook (2007), Draft Chapter on PCB emissions: 250 ug/t (gas oil) conversion : 1 TEP = 41,9 GJ (250 ug/t * 0,983 t)/41,9 GJ=5,87 ug/GJ	N/A	N/A

3.2.3.5.4 Uncertainties and time-series consistency

The assessment of activity data and emission factor uncertainties is done according to the methodology described in the EMEP/EEA emission inventory Guidebook 2023 (Chapter A.5 Uncertainties, tables 2-1, 2-2 and 2-3), covering the main pollutants NO_x, NH_3, NMVOC, SO_x and $PM_{2.5}$. For some subcategories and pollutants, expert judgements were made to estimate AD or EF uncertainties. For CO, PM10, heavy metzals and persistent organic pollutants, no uncertainty estimates are currently made. Details on uncertainty of the activity data can also be checked in the Luxembourg's National Inventory report (NIR). Please also refer to Table 1-33 to Table 1-37 of section 1.7 for caterogory specific uncertainties on activity data and emission factors.

Time-series are considered to be consistent, also in comparison with energy data as reported by the national statistics institute.

3.2.3.5.5 Source-specific QA/QC and verification

As no plant-specific data are available, activity data could not be cross-checked with reports obtained directly from the operator under its operational permit obligations or the PRTR reporting. However, consistency and completeness checks were performed, to make sure that emission data is correctly linked and calculated.

3.2.3.5.6 Category-specific recalculations including changes made in response to the review process

Table 3-55 presents the main revisions and recalculations done since submission 2023 for category *1A2d – Pulp, Paper and Print*.

Table 3-55 – Recalculations done since the last submission for category – *1A2d - Pulp, Paper and Print*

Source category	Revisions 2023 → 2024	Type of revision
1A2a/c/d/e/f/gviii	In the latest national energy balance, changes were made to the allocation method of natural gas to the different sectors for the year 2021. Consequently, the natural gas AD in the sector 1A2d increased by 235 TJ.	AD

3.2.3.5.7 Category-specific planned improvements including those in response to the review process

The following improvements are planned for the next submission.

Table 3-56 – Planned improvements for category – *1A2d - Pulp, Paper and Print*

Source category	Planned improvements	Type of revision
1A2d	No further improvements planned	n/a

3.2.3.6 Food Processing, Beverages and Tobacco (1A2e)

3.2.3.6.1 Source category description

In Luxembourg, this source category covers mainly the production of milk, milk products, and tobacco products. Included in this category are the emissions from combustion plants (<50 MW) operated by the food processing, beverages and tobacco industry.

Fuel combustion from *1A2e – Food Processing, Beverages and Tobacco* is a small source of air pollutant emissions. In 2022, this source category represented less than 4.1% of national total emissions of air pollutants (based on fuel sold and based on fuel used).

Table 3-57 summarizes emissions for category *1A2e – Food Processing, Beverages and Tobacco* and Table 3-58 presents the emission trends.

Category *1A2e – Food Processing, Beverages and Tobacco* is not a key category in 2022, neither for the main pollutants, nor for heavy metals and persistent organic pollutants (see also Table and Table 3-5 in Section 0 and Chapter 1.5).

Table 3-57 – Emissions, Trends and Shares based on fuel sold and fuel used of category – *1A2e - Food Processing, Beverages and Tobacco*

1 A 2 Stationary combustion in manufacturing industries and construction														
Emissions, Trends and Shares in National Totals of air pollutants based on fuel sold and fuel used														
1 A 2 e Food processing, beverages and tobacco														
Pollutants	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
SO2	0.010	0.012	0.018	0.018	82.6%	46.4%	-1.2%	0.06%	0.49%	4.26%	0.06%	0.48%	4.11%	fuel sold
NOx	0.005	0.015	0.013	0.020	318.9%	29.5%	50.0%	0.02%	0.09%	0.22%	0.01%	0.03%	0.17%	fuel sold
NMVOC	0.000	0.002	0.001	0.001	335.2%	-49.0%	-27.2%	0.00%	0.02%	0.01%	0.00%	0.01%	0.01%	fuel sold
NH3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
CO	0.003	0.008	0.004	0.003	19.5%	-55.6%	-9.9%	0.00%	0.03%	0.02%	0.00%	0.02%	0.02%	fuel sold
TSP	0.001	0.002	0.002	0.002	73.8%	11.5%	-1.7%	0.01%	0.08%	0.09%	0.01%	0.04%	0.08%	fuel sold
PM10	0.001	0.001	0.002	0.002	73.5%	10.0%	-1.8%	0.01%	0.08%	0.11%	0.01%	0.04%	0.09%	fuel sold
PM2.5	0.001	0.001	0.001	0.001	73.0%	7.8%	-2.0%	0.00%	0.08%	0.13%	0.00%	0.04%	0.11%	fuel sold

Source: Environment Agency.

Table 3-58 – Emission trends for category – *1A2e - Food Processing, Beverages and Tobacco*

1 A 2 Stationary combustion in manufacturing industries and construction *Emissions of air pollutants by source category (Gg)*								
Year	**1 A 2 e Food processing, beverages and tobacco**							
	SO2	***NOx***	***NMVOC***	***NH3***	***CO***	***TSP***	***PM10***	***PM2.5***
1990	0.010	0.005	0.000	NO	0.003	0.001	0.001	0.001
1991	0.011	0.006	0.000	NO	0.004	0.001	0.001	0.001
1992	0.007	0.006	0.000	NO	0.004	0.001	0.001	0.001
1993	0.004	0.005	0.000	NO	0.003	0.001	0.000	0.000
1994	0.004	0.005	0.000	NO	0.003	0.001	0.001	0.000
1995	0.005	0.006	0.000	NO	0.004	0.001	0.001	0.001
1996	0.005	0.005	0.000	NO	0.004	0.001	0.000	0.000
1997	0.004	0.006	0.000	NO	0.004	0.001	0.001	0.000
1998	0.006	0.006	0.000	NO	0.004	0.001	0.001	0.000
1999	0.004	0.007	0.000	NO	0.004	0.002	0.002	0.001
2000	0.002	0.024	0.005	NO	0.009	0.001	0.001	0.001
2001	0.013	0.028	0.005	NO	0.011	0.002	0.002	0.002
2002	0.013	0.032	0.006	NO	0.013	0.002	0.002	0.002
2003	0.012	0.016	0.002	NO	0.008	0.002	0.002	0.001
2004	0.011	0.013	0.001	NO	0.007	0.002	0.001	0.001
2005	0.012	0.015	0.002	NO	0.008	0.002	0.001	0.001
2006	0.014	0.013	0.001	NO	0.007	0.002	0.001	0.001
2007	0.015	0.012	0.001	NO	0.007	0.002	0.002	0.001
2008	0.016	0.014	0.001	NO	0.007	0.003	0.002	0.002
2009	0.017	0.017	0.002	NO	0.007	0.004	0.003	0.003
2010	0.021	0.013	0.001	NO	0.004	0.002	0.002	0.001
2011	0.016	0.021	0.003	NO	0.006	0.002	0.002	0.001
2012	0.016	0.016	0.002	NO	0.005	0.002	0.002	0.001
2013	0.017	0.016	0.002	NO	0.005	0.002	0.002	0.001
2014	0.018	0.026	0.005	NO	0.007	0.002	0.002	0.001
2015	0.020	0.020	0.003	NO	0.005	0.002	0.002	0.001
2016	0.018	0.026	0.004	NO	0.006	0.002	0.002	0.001
2017	0.016	0.022	0.003	NO	0.005	0.002	0.002	0.001
2018	0.014	0.011	0.001	NO	0.003	0.002	0.002	0.001
2019	0.018	0.012	0.001	NO	0.003	0.002	0.002	0.001
2020	0.018	0.011	0.001	NO	0.003	0.002	0.002	0.001
2021	0.018	0.013	0.001	NO	0.004	0.002	0.002	0.001
2022	0.018	0.020	0.001	NO	0.003	0.002	0.002	0.001
Trend 1990-2022	*82.62%*	*318.94%*	*335.20%*	*NA*	*19.51%*	*73.78%*	*73.48%*	*72.97%*
2005-2022	*46.41%*	*29.47%*	*-48.99%*	*NA*	*-55.61%*	*11.46%*	*10.04%*	*7.77%*
2021-2022	*-1.22%*	*50.00%*	*-27.22%*	*NA*	*-9.91%*	*-1.69%*	*-1.82%*	*-2.03%*

Source: Environment Agency.

3.2.3.6.2 Methodological issues & time-series consistency

3.2.3.6.2.1 Activity data

Annual fuel consumption data of residual fuel oil, gas oil, diesel oil and natural gas were obtained from the operators. Diesel oil is mainly used by mobile sources and machinery and hence, related emissions are reported in category *1A2gvii - Mobile Combustion in manufacturing industries and construction*. The remaining fuels are mainly combusted in stationary units for heating purposes. The use of residual fuel oil stopped in 2002.

Activity data for the food processing, beverages and tobacco industry are listed in Table 3-59.

The activity data reported here are the data reported by the operators to the Environment Agency through their annual reporting obligations. The bottom-up data on natural gas, for 1990-1999, could not be matched to the top-down data from national statistics as no such data are reported for this category. To avoid double counting, the bottom-up data on natural gas were subtracted from the top-down data from national statistics reported for category *1A2g viii – Manufacturing Industry and Construction: Other*. For natural gas (2000-2021) and liquid fuels (residual fuel oil, gas oil, diesel oil), the matching exercise was done within category *1A2e* as top-down data are available for this category from national statistics.

Table 3-59 – Activity data for category – *1A2e - Food Processing, Beverages and Tobacco*

1 A 2 Stationary combustion in manufacturing industries and construction						
Activity Data by fuel type (GJ)						
1 A 2 e Food processing, beverages and tobacco						
Year	Activity Total (incl. biomass)	Liquid *Residual fuel oil, Gas Oil, Diesel Oil*	Solid	Gaseous *Natural Gas*	Biomass	Other
1990	87 063	21'250	NO	65'812	NO	NO
1991	118 180	22'725	NO	95'455	NO	NO
1992	116 494	16'026	NO	100'468	NO	NO
1993	108 002	9'271	NO	98'731	NO	NO
1994	112 220	11'486	NO	100'734	NO	NO
1995	124 161	19'791	NO	104'369	NO	NO
1996	113 556	10'391	NO	103'164	NO	NO
1997	118 927	12'459	NO	106'468	NO	NO
1998	124 863	13'987	NO	110'877	NO	NO
1999	132 660	36'560	NO	96'100	NO	NO
2000	331 573	14'797	NO	316'776	NO	NO
2001	397 361	44'100	NO	353'262	NO	NO
2002	441 896	43'133	NO	398'763	NO	NO
2003	259 337	41'178	NO	218'159	NO	NO
2004	239 611	29'151	NO	210'460	NO	NO
2005	254 250	31'604	NO	222'646	NO	NO
2006	217 756	34'435	NO	183'321	NO	NO
2007	212 486	36'309	NO	176'177	NO	NO
2008	228 536	50'825	NO	177'712	NO	NO
2009	230 932	82'440	NO	148'492	NO	NO
2010	202 766	43'189	NO	159'577	NO	NO
2011	297 342	43'837	NO	253'505	NO	NO
2012	250 766	44'115	NO	206'651	NO	NO
2013	257 067	39'713	NO	217'354	NO	NO
2014	353 024	42'850	NO	310'175	NO	NO
2015	295 610	41'909	NO	253'701	NO	NO
2016	329 991	38'150	NO	291'842	NO	NO
2017	284 954	36'492	NO	248'462	NO	NO
2018	197 569	39'645	NO	157'924	NO	NO
2019	206 414	45'163	NO	161'251	NO	NO
2020	204 711	39'468	NO	165'243	NO	NO
2021	242 913	37'632	NO	205'281	NO	NO
2022	211 952	37'200	NO	174'752	NO	NO
Trend 1990-2022	*143.45%*	*75.05%*	*NA*	*165.53%*	*NA*	*NA*
2005-2022	*-16.64%*	*17.71%*	*NA*	*-21.51%*	*NA*	*NA*
2021-2022	*-12.75%*	*-1.15%*	*NA*	*-14.87%*	*NA*	*NA*

Source: Environment Agency.

3.2.3.6.2.2 Methodological choices

For point sources of this sub-category where plant-specific data was available, emission measurements of NO_X, SO_2, CO and TSP were the basis for the reported emissions (see Table 3-60).

Where no plant-specific data was available, EMEP/EEA Tier 2 approach was used if specific technological information was available.

The remaining sources, for which no measured (plant-specific) emission data, plant specific activity data or information on the abatement technology was available, were estimated using the EMEP/EEA Tier 1 by multiplying the fuel consumption taken from the national energy balance with the default emission factor (see Table 3-60).

Table 3-60 – Methods and Emission Factors used in relation to the energy consumption in 2022 for category – *1A2e - Food Processing, Beverages and Tobacco*

1 A 2 Stationary combustion in manufacturing industries and construction				
Method applied and Emission factor (EF) used as well as coverage of energy consumption				
1 A 2 e Food processing, beverages and tobacco				
Pollutant	Method	EF used	Coverage of energy consumption	Source
NOx	T3	PS	67.1%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	32.9%	EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16), EMEP/EEA GB 2019 (Chap1A2, Tab3.4 p17)
NMVOC	T3	PS	0.0%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	100.0%	EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16), EMEP/EEA GB 2019 (Chap1A2, Tab3.4 p17)
SOx	T3	PS	0.0%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2	CS	83.9%	CS based on fuel sulfur content; determined by AEV
	T1	D	16.1%	EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16)
CO	T3	PS	67.1%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	32.9%	EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.4, p16)
PM2.5	T3	PS	67.1%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV PM measured assumed to be TSP = PM10 = PM2.5
	T1	D	32.9%	EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16), EMEP/EEA GB 2019 (Chap1A2, Tab3.4, p17)
PM10	T3	PS	67.1%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV
	T1	D	32.9%	EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16), EMEP/EEA GB 2019 (Chap1A2, Tab3.4, p17)
TSP	T3	PS	67.1%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV PM measured assumed to be TSP = PM10 = PM2.5
	T1	D	32.9%	EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16), EMEP/EEA GB 2019 (Chap1A2, Tab3.4, p17)

Source: Environment Agency

3.2.3.6.2.3 Emission factors

For point sources of this sub-category where plant-specific data were available, emission measurements of NO_X, SO_2, CO and TSP were the basis for the reported emissions (EMEP/EEA Tier 3 approach) (Table 3-60). Hence, no emission factors per se were used, but rather implied emission factors were derived by dividing the emission with the activity data.

The remaining sources, for which neither measured (plant-specific) emission data, nor plant specific activity data or information on the abatement technology was available, were estimated using the EMEP/EEA Tier 1 default emission factors.

The methods applied and emission factors (EF) used, in relation to the energy consumption, for 2022, are presented in Table 3-60.

Table gives an overview of the evolution of the implied emission factors.

Table 3-61 – Implied emission factors for category – *1A2e - Food Processing, Beverages and Tobacco*

1 A 2 Stationary combustion in manufacturing industries and construction *Implied Emission Factor (IEF) of air pollutants by source category (g/GJ)*								
Year	**1 A 2 e Food processing, beverages and tobacco**							
	SO2	***NOx***	***NMVOC***	***NH3***	***CO***	***TSP***	***PM10***	***PM2.5***
1990	114.92	54.64	2.73	NA	32.44	12.54	10.10	7.66
1991	89.89	51.54	2.58	NA	31.92	9.98	8.06	6.13
1992	58.24	48.25	2.41	NA	31.38	7.27	5.89	4.52
1993	37.33	45.15	2.26	NA	30.86	4.70	3.85	2.99
1994	37.78	46.14	2.31	NA	31.02	5.52	4.50	3.47
1995	40.45	49.56	2.48	NA	31.59	8.35	6.75	5.16
1996	40.63	45.49	2.27	NA	30.92	4.98	4.07	3.15
1997	34.76	46.29	2.31	NA	31.05	5.64	4.59	3.55
1998	48.10	46.72	2.34	NA	31.12	6.00	4.88	3.76
1999	28.55	56.54	2.83	NA	32.76	14.11	11.35	8.59
2000	5.67	71.94	14.68	NA	27.46	2.86	2.41	1.97
2001	33.88	71.30	12.89	NA	28.60	6.12	5.01	3.90
2002	29.56	72.18	13.57	NA	28.29	5.46	4.49	3.51
2003	48.06	61.28	7.51	NA	30.39	8.40	6.81	5.22
2004	46.03	56.15	6.16	NA	30.31	6.54	5.32	4.10
2005	49.09	60.55	7.98	NA	29.91	6.70	5.45	4.21
2006	63.97	57.61	5.96	NA	30.75	8.34	6.76	5.18
2007	70.18	56.60	5.23	NA	31.06	8.96	7.25	5.54
2008	70.54	59.68	5.38	NA	31.58	11.51	9.29	7.06
2009	74.29	74.05	8.48	NA	32.28	18.22	14.65	11.08
2010	103.24	63.76	6.70	NA	19.63	10.74	8.64	6.55
2011	53.56	70.20	11.36	NA	20.58	7.76	6.29	4.82
2012	63.52	64.48	8.60	NA	18.83	9.09	7.33	5.57
2013	64.23	64.18	9.36	NA	18.35	8.04	6.49	4.95
2014	50.76	73.46	12.96	NA	20.20	6.50	5.29	4.07
2015	66.28	65.99	10.23	NA	18.30	7.43	6.01	4.59
2016	54.27	79.24	11.17	NA	18.71	6.16	5.01	3.85
2017	56.74	78.86	9.41	NA	17.64	6.69	5.42	4.14
2018	73.20	53.63	4.87	NA	15.99	10.14	8.14	6.15
2019	85.54	59.48	5.05	NA	16.58	11.07	8.89	6.70
2020	86.81	54.43	4.91	NA	14.60	9.77	7.84	5.92
2021	76.15	54.70	5.86	NA	15.42	7.95	6.40	4.85
2022	86.21	94.04	4.88	NA	15.93	8.95	7.20	5.44
Trend								
1990-2022	*-24.99%*	*72.09%*	*78.76%*	*NA*	*-50.91%*	*-28.62%*	*-28.74%*	*-28.95%*
2005-2022	*75.63%*	*55.31%*	*-38.81%*	*NA*	*-46.75%*	*33.70%*	*32.00%*	*29.28%*
2021-2022	*13.20%*	*71.91%*	*-16.58%*	*NA*	*3.25%*	*12.67%*	*12.52%*	*12.28%*

Source: Environment Agency

The higher IEF in the (early) 1990s is due to the partial use of residual fuel oil in combustion plants. Residual fuel oil was then mainly phased out, which is reflected in a decreasing IEF. The increase of IEFs between 2016 and 2019 is due to an increased consumption of gasoil in this category, as reported by the energy balance.

3.2.3.6.3 Methodological issues for heavy metals and POPs

This category consists of two point sources (Heintz Van Landewyck cigarette factory and Luxlait dairy plant) and a range of smaller facilities at different locations in the country.

3.2.3.6.3.1 Activity Data

Annual fuel consumption taken from the national energy balance.

3.2.3.6.3.2 Methodological Choices

Since emission measurements were not available for these facilities, calculation of emissions originating from food processing, beverages, and tobacco were based on total fuel consumption in combination with tier 1 emission factors.

Fuel consumption data were obtained from the national energy balance.

3.2.3.6.3.3 Emission Factors

Sources of default Tier 1 HM and POP emission factors are given in the following table:

Table 3-62 - Sources of Tier 1 HM and POP emission factors for category *1A2e - Food Processing, Beverages and Tobacco*

Fuel	Pollutants	Source	Page	Table
Solid fuels	Pb, Hg, Cd, PCDD/F, PCB, HCB, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2023) – Chapter 1.A.2 Manufacturing industries and construction	15	3-2
Natural gas	Pb, Hg, Cd	EEA (2023) – Chapter 1.A.2 Manufacturing industries and construction PCDD/F, PCB, HCB, B(a)P, B(b)F, B(k)F, I(cd)P considered as NA	16	3-3
Liquid fuels	Pb, Hg, Cd, PCDD/F, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2023) – Chapter 1.A.2 Manufacturing industries and construction	17	3-4
Liquid fuels	PCB	EF not stated in EEA (2023), thus custom EF derived from EMEP/Corinair Guidebook (2007): 1 TEP= 1,170 l and density (gas oil) = 0,84 kg/l → 1 TEP= 983 kg EF: EMEP/Corinair Guidebook (2007), Draft Chapter on PCB emissions: 250 ug/t (gas oil) conversion : 1 TEP = 41,9 GJ (250 ug/t * 0,983 t)/41,9 GJ = 5,87 ug/GJ	N/A	N/A

3.2.3.6.4 Uncertainties and time-series consistency

The assessment of activity data and emission factor uncertainties is done according to the methodology described in the EMEP/EEA emission inventory Guidebook 2023 (Chapter A.5 Uncertainties, tables 2-1, 2-2 and 2-3), covering the main pollutants NO_x, NH_3, NMVOC, SO_x and $PM_{2.5}$. For some subcategories and pollutants, expert judgements were made to estimate AD or EF uncertainties. For CO, PM10, heavy metzals and persistent organic pollutants, no uncertainty estimates are currently made. Details on uncertainty of the activity data can also be checked in the Luxembourg's National Inventory report (NIR). Please also refer to Table 1-33 to Table 1-37 of section 1.7 for caterogory specific uncertainties on activity data and emission factors.

Time-series are considered to be consistent, also in comparison with energy data as reported by the national statistics institute.

3.2.3.6.5 Source-specific QA/QC and verification

Activity data for large facilities that are under the European Union Emission Trading Scheme (EU-ETS) are cross-checked from two sources: reports obtained directly from the operator under its operational permit obligations and the EU-ETS registry operator. Both are hosted at the Environment Agency. A list with the large energy consuming facilities along with their respective fuel consumption has been compiled and enables the Single National Entity to quickly cross-check this data with the EU-ETS data. Thus, completeness can be checked on a more systematic basis.

Emission data are also cross-checked with data reported under PRTR reporting obligation.

Finally, consistency and completeness checks are performed.

3.2.3.6.6 Category-specific recalculations including changes made in response to the review process

Table 3-63 presents the main revisions and recalculations done since submission 2023 for sub-category *1A2e – Food Processing, Beverages and Tobacco Industry*.

Table 3-63 – Recalculations done since the last submission for category – *1A2e - Food Processing, Beverages and Tobacco*

Source category	Revisions 2023 → 2024	Type of revision
1A2a/c/d/e/f/gviii	In the latest national energy balance, changes were made to the allocation method of natural gas to the different sectors for the year 2021. Consequently, the natural gas AD in the sector 1A2e increased by 12 TJ.	AD

3.2.3.6.7 Category-specific planned improvements including those in response to the review process

The following improvements are planned for the next submission.

Table 3-64 – Planned improvements for category – *1A2e - Food Processing, Beverages and Tobacco*

Source category	Planned improvements	Type of revision
1A2e	No further improvements planned	n/a

3.2.3.7 Non-Metallic Minerals (1A2f)

3.2.3.7.1 Source category description

Included in this category are the emissions from combustion plants (<50 MW) of the cement industry, glass industry and the industry of fine ceramic materials.

In 2022, this source category represented:

- 6.5% of national total SO_2 emissions (based on fuel sold), whereas in 1990, this source category represented 4.6% of national total SO_2 emissions (based on fuel sold).

- 6.4% of national total NO_X emissions (based on fuel sold), whereas in 1990, this source category represented 8.3% of national total NO_X emissions.
- 1.0% of national total $PM_{2.5}$ emissions (based on fuel sold), whereas in 1990, this source category represented 1.5% of national total $PM_{2.5}$ emissions.

Compared to 1990, emissions of all air pollutants decreased significantly mainly due the implementation of specific abatement technologies and substitution of solid fuels. Hence, the implementation of a selective catalytic reduction (SCR) in the glass production industry led to a significant reduction of NO_X emissions. Further improvements are due to the optimisation of the clinker burning process in the cement industry (choice of fuels and raw materials, use of wastes as fuels, techniques to prevent channelled and diffuse dust emissions, etc.). Compared to 2021, emissions of all pollutants, except CO, decreased. The strong decrease of SO_2 (-89.6%) is due to the temporary shutdown of Luxembourg's second flat glass plant (the first plant shut down in 2020) for maintenance purposes. The plant is expected to resume activity in 2024 and beyond.

Table 3-65 summarizes emissions of air pollutants for category *1A2f – Non-Metallic Minerals* and Table 3-66 presents the emission trends.

Table 3-65 – Emissions, Trends and Shares based on fuel sold and fuel used – *1A2f - Non-Metallic Minerals*

1 A 2 Stationary combustion in manufacturing industries and construction														
Emissions, Trends and Shares in National Totals of air pollutants based on fuel sold and fuel used														
1 A 2 f Non-metallic minerals														
Pollutants	**Emissions**				**Trend**			**FUEL USED Share in National Total**			**FUEL SOLD Share in National Total**			**Fuel option**
	1990	**2005**	**2021**	**2022**	**1990 - 2022**	**2005 - 2022**	**2021 - 2022**	**1990**	**2005**	**2022**	**1990**	**2005**	**2022**	
SO2	0.76	0.99	0.28	0.03	-96.2%	-97.1%	-89.6%	4.9%	38.7%	6.7%	4.6%	38.1%	6.5%	fuel sold
NOx	3.38	2.72	0.93	0.73	-78.3%	-73.1%	-21.0%	15.1%	15.2%	8.0%	8.3%	4.8%	6.4%	fuel sold
NMVOC	0.07	0.06	0.01	0.01	-86.0%	-82.5%	-7.2%	0.3%	0.5%	0.1%	0.2%	0.4%	0.1%	fuel sold
NH3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
CO	30.17	4.35	2.58	2.67	-91.1%	-38.6%	3.6%	7.1%	19.6%	18.1%	6.4%	11.0%	15.0%	fuel sold
TSP	0.42	0.12	0.04	0.02	-95.3%	-83.7%	-48.7%	2.5%	5.4%	1.0%	2.4%	3.0%	0.8%	fuel sold
PM10	0.38	0.11	0.03	0.02	-95.3%	-84.0%	-49.0%	2.4%	6.2%	1.3%	2.3%	3.5%	1.1%	fuel sold
PM2.5	0.23	0.08	0.02	0.01	-95.7%	-87.7%	-53.6%	1.5%	6.1%	1.1%	1.5%	3.2%	1.0%	fuel sold

Source: Environment Agency.

Table 3-66 – Emission trends for category – *1A2f - Non-Metallic Minerals*

1 A 2 Stationary combustion in manufacturing industries and construction – Emissions of air pollutants by source category (Gg)								
Year	1 A 2 f Non-metallic minerals							
	SO2	*NOx*	*NMVOC*	*NH3*	*CO*	*TSP*	*PM10*	*PM2.5*
1990	0.758	3.376	0.074	NO	30.167	0.420	0.380	0.235
1991	0.589	3.126	0.060	NO	28.710	0.383	0.347	0.209
1992	0.982	3.472	0.090	NO	29.351	0.439	0.398	0.255
1993	0.972	3.230	0.078	NO	24.456	0.384	0.349	0.227
1994	1.512	3.574	0.135	NO	28.072	0.492	0.449	0.307
1995	0.935	3.194	0.073	NO	13.079	0.269	0.245	0.167
1996	1.234	3.217	0.102	NO	13.226	0.308	0.282	0.202
1997	0.808	3.151	0.063	NO	13.222	0.255	0.232	0.154
1998	0.651	2.906	0.056	NO	13.217	0.236	0.214	0.138
1999	0.710	3.223	0.055	NO	13.833	0.249	0.226	0.146
2000	1.058	3.178	0.085	NO	1.846	0.147	0.135	0.103
2001	1.537	3.697	0.142	NO	5.256	0.305	0.283	0.233
2002	0.716	2.791	0.053	NO	4.460	0.132	0.121	0.087
2003	0.555	2.095	0.048	NO	3.933	0.268	0.246	0.193
2004	0.863	2.639	0.062	NO	4.439	0.120	0.110	0.079
2005	0.988	2.720	0.059	NO	4.353	0.122	0.111	0.082
2006	1.414	3.226	0.118	NO	4.898	0.192	0.178	0.144
2007	0.744	3.229	0.053	NO	7.350	0.103	0.094	0.063
2008	0.828	2.977	0.049	NO	3.734	0.108	0.098	0.067
2009	0.758	3.104	0.038	NO	1.327	0.104	0.095	0.064
2010	0.763	3.172	0.013	NO	1.414	0.094	0.086	0.062
2011	0.609	3.945	0.019	NO	1.715	0.061	0.056	0.044
2012	0.583	3.398	0.013	NO	1.564	0.076	0.069	0.050
2013	0.537	1.732	0.013	NO	2.462	0.053	0.048	0.033
2014	0.654	2.568	0.024	NO	0.967	0.096	0.087	0.056
2015	0.564	2.292	0.014	NO	1.303	0.071	0.064	0.042
2016	0.536	2.662	0.014	NO	2.077	0.064	0.058	0.040
2017	0.553	1.678	0.014	NO	2.458	0.058	0.053	0.035
2018	0.565	1.198	0.016	NO	0.859	0.051	0.046	0.030
2019	0.518	1.134	0.018	NO	3.081	0.047	0.042	0.026
2020	0.351	1.241	0.015	NO	1.207	0.035	0.031	0.020
2021	0.277	0.925	0.011	NO	2.580	0.039	0.035	0.022
2022	0.029	0.731	0.010	NO	2.672	0.020	0.018	0.010
Trend 1990-2022	*-96.19%*	*-78.35%*	*-85.95%*	*NA*	*-91.14%*	*-95.29%*	*-95.32%*	*-95.73%*
2005-2022	*-97.08%*	*-73.13%*	*-82.51%*	*NA*	*-38.62%*	*-83.74%*	*-84.01%*	*-87.73%*
2021-2022	*-89.56%*	*-21.00%*	*-7.16%*	*NA*	*3.57%*	*-48.72%*	*-48.98%*	*-53.56%*

Source: Environment Agency

With regard to CO emissions (LA & TA) as well as SO_2 and NO_X (LA), *1A2f Non-Metallic Minerals* is a key category in 2022 (see Table and also Table 3-4 and Table 3-5 in Section 0 and Chapter 1.5). For heavy metals, *1A2f Non-Metallic Minerals* is a key category in 2022 for Cd (LA). For persistent organic prollutants, *1A2f Non-Metallic Minerals* is not a key category.

Table 3-67 – Key Category Analysis for category – *1A2f - Non-Metallic Minerals*

Key Source Analysis (FUEL SOLD): Ranking per number		SO2		NOX		NMVOC		NH3		CO		TSP		PM10		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	6		5						3	4						

Key Source Analysis (FUEL USED): Ranking per number		SO2		NOX		NMVOC		NH3		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	6		4	3						

Sources: Environment Agency
Notes: LA = Level Assessment, TA = Trend Assessment
Number in Table = indicates the rank in the specific analysis (1…biggest KC; 2… second biggest KC, …)

3.2.3.7.2 Methodological issues

3.2.3.7.2.1 Activity Data

Cement (Clinker)

One industrial site produces clinker in Luxembourg. Its major fuel is hard coal (other bituminous coal), but use is also made of residual oil, natural gas and special types of waste: shredded tyres, fluff and sewage sludge. These waste types contain a certain biogenic fraction, which is annually reported by the operator. This is taken into consideration when estimating the emissions. The consumption data of these fuels are transmitted annually to the Environment Agency by the operator.

Flat glass

There where two flat glass plants in Luxembourg, one of which was closed in 2020 due to economic reasions. Their main fuel is natural gas. LPG was used in the past, but only on a small scale. In 2022, the second flat glass plant went into a temporary shutdown. It is expected to resume activity in 2024 and beyond.

Fine ceramic materials

One major production site of ceramic materials existed in Luxembourg (Villeroy & Boch) using natural gas as fuel. However, the production site was closed in 2010.

The activity data, as described above, are the data reported by the different operators to the Environment Agency through the annual reporting obligations as laid down in their operational permits.

Activity data for category *1A2f - Non-Metallic Minerals* are listed in Table 3-68.

Table 3-68 – Activity data by fuel type for category – *1A2f - Non-Metallic Minerals*

1 A 2 Stationary combustion in manufacturing industries and construction						
Activity Data by fuel type (GJ)						
1 A 2 f Non-metallic minerals						
Year	Activity Total (incl. biomass)	Liquid *Residual fuel oil, Gas Oil, Diesel Oil, Gasoline,*	Solid *Other Bituminous Coal, Brown Coal*	Gaseous *Natural Gas*	Biomass *Sewage sludge,Tyres (bio. frac.), Fluff*	Other *Tyres (fossil frac.), Fluff (fossil frac.)*
1990	7 102 444	317'025	3'302'589	3'482'830	NO	NO
1991	6 241 197	122'474	3'028'845	3'089'878	NO	NO
1992	6 653 792	149'903	3'404'630	3'099'259	NO	NO
1993	6 130 253	132'335	2'850'457	3'147'461	NO	NO
1994	7 228 121	111'640	3'840'609	3'275'872	NO	NO
1995	6 480 937	117'786	3'000'573	3'362'578	NO	NO
1996	6 809 456	107'233	3'303'931	3'398'292	NO	NO
1997	6 337 530	190'101	2'886'032	3'261'397	NO	NO
1998	5 896 561	93'449	2'674'118	2'949'422	48 484	131'088
1999	6 516 553	75'713	2'819'127	3'446'649	47 267	127'797
2000	7 049 927	97'743	3'127'895	3'555'847	72 479	195'963
2001	7 318 338	71'600	3'119'891	3'543'132	157 603	426'112
2002	6 338 760	60'817	2'093'325	3'482'189	197 108	505'321
2003	5 490 992	72'920	1'793'790	2'956'142	202 949	465'191
2004	6 233 605	91'078	2'070'876	3'310'857	252 132	508'662
2005	6 365 698	67'920	2'190'698	3'333'205	236 807	537'068
2006	6 772 959	67'200	2'577'804	3'286'321	263 980	577'654
2007	6 309 554	62'920	1'989'234	3'372'178	296 661	588'562
2008	6 123 579	58'034	1'805'356	3'340'782	259 929	659'478
2009	6 072 757	37'557	2'043'207	3'314'606	198 932	478'455
2010	5 963 639	23'877	1'794'620	3'222'306	283 272	639'565
2011	5 953 493	29'527	1'819'386	3'252'680	260 635	591'265
2012	5 830 526	32'119	1'742'721	3'181'655	270 977	603'054
2013	5 061 164	27'785	1'674'635	2'370'687	278 593	709'464
2014	5 555 332	57'737	1'673'730	2'917'527	265 670	640'669
2015	5 482 985	50'199	1'588'151	2'960'631	245 290	638'714
2016	5 815 751	40'131	1'640'442	3'014'023	227 998	893'158
2017	5 739 989	48'057	1'696'898	2'810'867	234 611	949'555
2018	5 883 493	29'566	1'485'137	3'030'472	232 079	1'106'239
2019	6 079 025	36'293	1'663'002	2'940'627	286 563	1'152'540
2020	5 206 630	37'928	1'357'956	2'067'947	392 765	1'350'034
2021	4 661 430	49'985	1'471'562	1'657'621	266 549	1'215'713
2022	3 319 902	97'455	1'536'416	236'017	314 091	1'135'923
Trend 1990-2022	-53.26%	-69.26%	-53.48%	-93.22%	NA	NA
2005-2022	-47.85%	43.49%	-29.87%	-92.92%	32.64%	111.50%
2021-2022	-28.78%	94.97%	4.41%	-85.76%	17.84%	-6.56%

Source: Environment Agency

3.2.3.7.2.2 Methodological choices

For point sources of this sub-category where plant-specific data were available, emission measurements of NO_X, SO_2, CO and TSP were the basis for the reported emissions (EMEP/EEA Tier 3 approach) (Table 3-69). The remaining sources, for which no measured (plant-specific) emission data, plant specific activity data or information on the abatement technology was available, were estimated using the EMEP/EEA Tier 1 by multiplying the fuel consumption taken from the national energy balance with the default emission factor.

The methods applied for 2022 in relation to the energy consumption are presented in Table 3-69.

Table 3-69 – Methods and Emission Factors used in relation to the energy consumption in 2022 for category – *1A2f - Non-Metallic Minerals*

1 A 2 Stationary combustion in manufacturing industries and construction *Method applied and Emission factor (EF) used as well as coverage of energy consumption* **1 A 2 f Non-metallic minerals**				
Pollutant	**Method**	**EF used**	**Coverage of energy consumption**	**Source**
NOx	T3	PS	92.2%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	7.8%	EMEP/EEA GB 2019 (Chap1A2, Tab3.2, p15), EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16), EMEP/EEA GB 2019 (Chap1A2, Tab3.4 p17), EMEP/EEA GB 2019 (Chap1A2, Tab3.5, p17)
NMVOC	T3	PS	0.0%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	100.0%	EMEP/EEA GB 2019 (Chap1A2, Tab3.2, p15), EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16), EMEP/EEA GB 2019 (Chap1A2, Tab3.4 p17), EMEP/EEA GB 2019 (Chap1A2, Tab3.5, p17)
SOx	T3	PS	92.2%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2	CS	0.0%	CS based on fuel sulfur content; determined by AEV
	T1	D	7.8%	EMEP/EEA GB 2016(PartB, Chap1A2, Tab3.2, p15), EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16)
CO	T3	PS	92.2%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	7.8%	EMEP/EEA GB 2016(PartB, Chap1A2, Tab3.2, p15), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.4, p16), EMEP/EEA GB 2009(PartB,
PM2.5	T3	PS	92.2%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV PM measured assumed to be TSP = PM10 = PM2.5
	T1	D	7.8%	EMEP/EEA GB 2019 (Chap1A2, Tab3.2, p15), EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16), EMEP/EEA GB 2019 (Chap1A2, Tab3.4, p17), EMEP/EEA GB 2019 (Chap1A2, Tab3.5, p17)
PM10	T3	PS	92.2%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV
	T1	D	7.8%	EMEP/EEA GB 2019 (Chap1A2, Tab3.2, p15), EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16), EMEP/EEA GB 2019 (Chap1A2, Tab3.4, p17), EMEP/EEA GB 2019 (Chap1A2, Tab3.5, p17)
TSP	T3	PS	92.2%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV PM measured assumed to be TSP = PM10 = PM2.5
	T1	D	7.8%	EMEP/EEA GB 2019 (Chap1A2, Tab3.2, p15), EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16), EMEP/EEA GB 2019 (Chap1A2, Tab3.4, p17), EMEP/EEA GB 2019 (Chap1A2, Tab3.5, p17)

Source: Environment Agency

3.2.3.7.2.3 Emission factors

For point sources of this sub-category, where plant-specific data were available, NO_X, SO_2, NMVOC, CO and TSP emission measurements were the basis of the reported emissions (EMEP/EEA Tier 3 approach (Table 3-70). Hence, no emission factors per se are used, but rather implied emission factors are derived by dividing the emissions by the activity data. $PM_{2.5}$ and PM_{10} emissions were based on TSP measurements (TSP considered equivalent to “dust” under IED monitoring rueles) by using the default ratio between the default Tier 2 EMEP/EEA emission factors for TSP, PM_{10} and $PM_{2.5}$.

The point or area sources, for which no measured (plant-specific) emission data but plant specific activity data or information on the abatement technology was available, were estimated using the EMEP/EEA Tier 2 default emission factors.

The remaining sources, for which no measured (plant-specific) emission data, nor plant specific activity data or information on the abatement technology was available, were estimated using the EMEP/EEA Tier 1 default emission factors.

Implied emission factors are presented in Table . These may vary over time for the following reasons:

- The chemical caracteristics of a fuel varies, e.g. sulphur content.
- The mix of fuels used changes over time.
- The production and/or abatement technology of a facility – or of facilities – changes over time. In 2017, the second flat glass plant was equipped with SCR technology to reduce NO_X emissions.

Table 3-70 – Implied emission factors for category – *1A2f - Non-Metallic Minerals*

1 A 2 Stationary combustion in manufacturing industries and construction *Implied Emission Factor (IEF) of air pollutants by source category (g/GJ)*								
Year	1 A 2 f Non-metallic minerals							
	SO2	*NOx*	*NMVOC*	*NH3*	*CO*	*TSP*	*PM10*	*PM2.5*
1990	106.67	475.29	10.40	NA	4247.39	59.10	53.51	33.02
1991	94.40	500.84	9.64	NA	4600.00	61.43	55.52	33.48
1992	147.53	521.86	13.49	NA	4411.13	65.93	59.86	38.26
1993	158.51	526.95	12.70	NA	3989.42	62.71	57.00	37.01
1994	209.22	494.52	18.63	NA	3883.73	68.00	62.11	42.52
1995	144.25	492.86	11.20	NA	2018.06	41.46	37.80	25.74
1996	181.15	472.49	14.99	NA	1942.35	45.25	41.45	29.66
1997	127.52	497.24	9.90	NA	2086.26	40.19	36.55	24.25
1998	110.35	492.80	9.52	NA	2241.45	40.01	36.31	23.41
1999	108.92	494.58	8.44	NA	2122.81	38.26	34.71	22.37
2000	150.07	450.77	12.12	NA	261.87	20.79	19.13	14.54
2001	210.05	505.12	19.35	NA	718.20	41.67	38.65	31.81
2002	112.92	440.38	8.31	NA	703.60	20.87	19.06	13.67
2003	101.09	381.58	8.69	NA	716.34	48.79	44.83	35.07
2004	138.44	423.42	9.88	NA	712.14	19.31	17.67	12.73
2005	155.21	427.31	9.32	NA	683.87	19.10	17.49	12.83
2006	208.71	476.32	17.50	NA	723.21	28.29	26.24	21.29
2007	117.99	511.69	8.37	NA	1164.98	16.32	14.84	9.91
2008	135.29	486.08	8.07	NA	609.71	17.58	16.01	11.01
2009	124.80	511.20	6.25	NA	218.58	17.21	15.65	10.52
2010	127.94	531.92	2.13	NA	237.16	15.72	14.36	10.33
2011	102.21	662.56	3.16	NA	288.03	10.31	9.46	7.35
2012	99.97	582.84	2.16	NA	268.27	12.98	11.86	8.57
2013	106.08	342.31	2.48	NA	486.47	10.39	9.46	6.46
2014	117.74	462.18	4.36	NA	174.02	17.19	15.59	10.01
2015	102.81	418.04	2.56	NA	237.72	12.91	11.73	7.72
2016	92.15	457.72	2.39	NA	357.21	10.94	9.97	6.90
2017	96.30	292.31	2.48	NA	428.17	10.14	9.21	6.07
2018	95.95	203.62	2.75	NA	145.99	8.63	7.83	5.09
2019	85.13	186.58	3.00	NA	506.76	7.65	6.93	4.26
2020	67.32	238.29	2.84	NA	231.91	6.65	6.02	3.78
2021	59.39	198.48	2.40	NA	553.42	8.27	7.49	4.63
2022	8.70	220.17	3.13	NA	804.81	5.95	5.36	3.02
Trend 1990-2022	*-91.84%*	*-53.68%*	*-69.95%*	*NA*	*-81.05%*	*-89.93%*	*-89.98%*	*-90.86%*
2005-2022	*-94.39%*	*-48.48%*	*-66.46%*	*NA*	*17.69%*	*-68.83%*	*-69.34%*	*-76.47%*
2021-2022	*-85.35%*	*10.93%*	*30.36%*	*NA*	*45.43%*	*-28.00%*	*-28.36%*	*-34.80%*

Source: Environment Agency

3.2.3.7.3 Methodoological issues for heavy metals and POPs

With the Cimalux cement kiln in Rumelange and the two Luxguard glass production sites in Bascharage and Dudelange, this category includes three point sources. Apart from these sources, several smaller facilities at different locations in the country are considered in this category.

3.2.3.7.3.1 Methodological Choices

Cement kiln:

For the cement kiln, emission measurements were available from several years and for all POPs and HMs. Where available, the quantity of emitted pollutants was taken directly from the company's emission declarations. For other years, calculation of emissions based on measured data were carried out using annual operating hours (stated in some of the measurement protocols) and technology-specific emission factors from EEA (tier 2 approach). Where measurement data for the kiln were lacking, emissions were calculated based on annual consumption of different fuels used (natural gas, residual fuel oil, gas oil, coal, tires, fluff, sewage sludge) employing emission factors from EEA (2023) (combustion in manufacturing industries and construction; all tier 1 approach). Since emission factors for cement production in the guidebook are stated in relation to production volume, the amount of clinker produced had to be backcalculated on basis of the total amount of energy used per year. For this back-calculation the average value of the possible range for energy demand per tonne of clinker produced was employed (4.75 GJ/Mg; cf. EEA (2023), chapter 2.A.1, p. 4). To obtain more realistic values, emissions calculated based on annual fuel consumption were offset with a correction factor based on actual measurements of a reference year (ratio of the measured emission value to the appropriate value based on fuel consumption; both of the closest year with measurements).

Since HM and POP emissions from cement production are assumed to originate mainly from combustion processes, process-related emissions were not necessary to be considered (cf. EEA (2023), chapter 2.A.1, p. 6).

Glass production:

Since no measurement data for this facility were available, emissions were calculated based on annual fuel consumption and the appropriate emission factors (combustion in manufacturing industries and construction; tier 1 approach).

Note: Regarding glass production, emissions due to combustion processes are reported under the current category, whereas process-related emissions are reported under category 2.A.3 (glass production).

Smaller facilities: Annual fuel consumption in combination with tier 1 emission factors.

Fuel consumption data were obtained from the national energy.

3.2.3.7.3.2 Emission Factors

Sources for default Tier 1 HM and POP emission factors applied are given in the following table:

Table 3-71 – Souces of Tier 1 HM and POP emission factors for category *1A2f - Non-Metallic Minerals*

Fuel	Pollutants	Source	Page	Table
Solid fuels	Pb, Hg, Cd, PCDD/F, PCB, HCB, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2023) – Chapter 1.A.2 Manufacturing industries and construction	15	3-2
Natural gas	Pb, Hg, Cd,	EEA (2019) – Chapter 1.A.2 Manufacturing industries and construction PCDD/F, PCB, HCB, B(a)P, B(b)F, B(k)F, I(cd)P are considered as NA	16	3-3
Liquid fuels	Pb, Hg, Cd, PCDD/F, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2023) – Chapter 1.A.2 Manufacturing industries and construction	17	3-4
Liquid fuels	PCB	EF not stated in EEA (2019), thus custom EF derived from EMEP/Corinair Guidebook (2007): 1 TEP= 1,170 l and density (gas oil) = 0,84 kg/l → 1 TEP= 983 kg EF: EMEP/Corinair Guidebook (2007), Draft Chapter on PCB emissions: 250 ug/t (gas oil) conversion: 1 TEP = 41,9 GJ (250 ug/t * 0,983 t)/41,9 GJ = 5,87 ug/GJ	N/A	N/A

Sources for default Tier 2 HM and POP emission factors applied are given in the following table:

Table 3-72 - Souces of Tier 2 HM and POP emission factors for category *1A2f - Non-Metallic Minerals*

Fuel	Pollutants	Source	Page	Table
Coke/gas/oil/recovered wastes	Pb, Hg, Cd, PCDD/F, PCB, HCB, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2023) – Chapter 1.A.2 Manufacturing industries and construction	32	3-25

3.2.3.7.4 Uncertainties and time-series consistency

The assessment of activity data and emission factor uncertainties is done according to the methodology described in the EMEP/EEA emission inventory Guidebook 2023 (Chapter A.5 Uncertainties, tables 2-1, 2-2 and 2-3), covering the main pollutants NO_x, NH_3, NMVOC, SO_x and $PM_{2.5}$. For some subcategories and pollutants, expert judgements were made to estimate AD or EF uncertainties. For CO, PM10, heavy metzals and persistent organic pollutants, no uncertainty estimates are currently made. Details on uncertainty of the activity data can also be checked in the Luxembourg's National Inventory report (NIR). Please also refer to Table 1-33 to Table 1-37 of section 1.7 for caterogory specific uncertainties on activity data and emission factors.

Generally, the time-series, as reported in category *1A2f – Non-Metallic Minerals* are considered to be consistent.

3.2.3.7.5 Source-specific QA/QC and verification

Activity data for large facilities that have reporting obligations under the European Union Emission Trading System (EU-ETS) are cross-checked between two sources: reports obtained directly from (1) the operator under its operational permit obligations and (2) the EU-ETS registry operator. Both are hosted at the Environment Agency. A list with the large energy consuming facilities along with their respective fuel consumption has been compiled and enables the Single National Entity to quickly cross-check this data with the EU-ETS data. Thus, completeness can be checked on a more systematic basis.

Finally, consistency and completeness checks are performed.

3.2.3.7.6 Category-specific recalculations including changes made in response to the review process

Table 3-73 presents the main revisions and recalculations done since submission 2023 and relevant to category *1A2f – Non-Metallic Minerals*.

Table 3-73 – Recalculations done since the last submission for category – *1A2f - Non-Metallic Minerals*

Source category	Revisions 2023 ➔ 2024	Type of revision
1A2a/c/d/e/f/gviii	In the latest national energy balance, changes were made to the allocation method of natural gas to the different sectors for the year 2021. Consequently, the natural gas AD in the sector 1A2f increased by 46 TJ.	AD

3.2.3.7.7 Category-specific planned improvements including those in response to the review process

The following improvements are planned for the next submission.

Table 3-74– Planned improvements for category – *1A2f - Non-Metallic Minerals*

Source category	Planned improvements	Type of revision
1A2f	No further improvement planned	n/a

3.2.3.8 Other Manufacturing Industries and Construction (1A2g): Mobile (1A2g vii) and Stationary (1A2g viii)

3.2.3.8.1 Mobile Combustion in Manufacturing Industries and Construction (1A2g vii)

3.2.3.8.1.1 Source category description

In Luxembourg, this source category covers mobile combustion in manufacturing industries and construction.

In 2022, this source category represented:

- 7.8% of national total NO_X emissions (based on fuel sold) and 9.8% of national total NO_X emissions (based on fuel used).
- 1.1% of national total $PM_{2.5}$ emissions (based on fuel sold) and 1.4% of national total $PM_{2.5}$ emissions (based on fuel used).

In the period 1990 – 2022, SO_2 and $PM_{2.5}$ emission decreased by 95.4% and 89.4%, respectively. Emissions of the other air pollutants also decreased, except for NO_x and NH_3, for which an increase of 41.6% and 90.0%, respectively, was observed. From 2021 to 2022, NO_x and $PM_{2.5,}$ decreased by 7.0% and 8.9%, respectively.

Category *1A2g vii Mobile Combustion in manufacturing industries and construction* is a key category in 2022 for NO_x, in the level and trend assessments based on fuel sold and fuel used (see Table 3-75 and also Table 3-4 and Table 3-5 in Section 0 and Chapter 1.5). For heavy metals and persistent organic pollutants, *1A2g vii Mobile Combustion in manufacturing industries and construction* was only a key category for PAHs (LA & TA) in 2022.

Table 3-75 – Key Category Analysis for category – *1A2g vii - Mobile Combustion in manufacturing industries and construction*

Key Source Analysis (FUEL SOLD): Ranking per number		SO2		NOX		NMVOC		NH3		CO		TSP		PM10		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction			4	4												

Key Source Analysis (FUEL USED): Ranking per number		SO2		NOX		NMVOC		NH3		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction			3	4						

Sources: Environment Agency
Notes: LA = Level Assessment, TA = Trend Assessment
Number in Table = indicates the rank in the specific analysis (1…biggest KC; 2… second biggest KC, …)

Table 3-76 summarizes emissions of air pollutants for category *1A2g vii - Mobile Combustion in manufacturing industries and construction* and Table 3-77 presents the emission trends.

Table 3-76 – Emissions, Trends and Shares based on fuel sold and fuel used – *1A2g vii - Mobile Combustion in manufacturing industries and construction*

1 A 2 Stationary combustion in manufacturing industries and construction														
Emissions, Trends and Shares in National Totals of air pollutants based on fuel sold and fuel used														
1 A 2 g viii Other														
Pollutants	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
SO2	0.20	0.05	0.10	0.05	-74.8%	-9.3%	-49.6%	1.3%	2.1%	11.5%	1.2%	2.1%	11.1%	fuel sold
NOx	0.09	0.09	0.46	0.36	280.2%	302.1%	-23.1%	0.4%	0.5%	3.9%	0.2%	0.2%	3.1%	fuel sold
NMVOC	0.01	0.05	0.34	0.34	3255.7%	604.3%	1.6%	0.0%	0.4%	3.5%	0.0%	0.3%	3.4%	fuel sold
NH3	NO	0.03	0.01	0.01	0.6%	-83.4%	-51.8%	NO	0.6%	0.1%	NO	0.5%	0.1%	fuel sold
CO	0.17	0.11	0.52	0.47	172.1%	310.6%	-9.0%	0.0%	0.5%	3.2%	0.0%	0.3%	2.6%	fuel sold
TSP	0.00	0.00	0.30	0.13	9969.5%	5520.9%	-57.8%	0.01%	0.1%	6.1%	0.01%	0.1%	5.0%	fuel sold
PM10	0.00	0.00	0.30	0.13	10411.6%	5520.9%	-57.8%	0.01%	0.1%	9.1%	0.01%	0.1%	7.5%	fuel sold
PM2.5	0.00	0.00	0.30	0.13	11040.4%	5520.9%	-57.8%	0.01%	0.2%	14.5%	0.01%	0.1%	12.2%	fuel sold

Source: Environment Agency.

Table 3-77 – Emission trends for category – *1A2g vii - Mobile Combustion in manufacturing industries and construction*

1 A 2 Stationary combustion in manufacturing industries and construction								
Emissions of air pollutants by source category (Gg)								
Year	1 A 2 g vii Mobile Combustion in manufacturing industries and construction							
	SO2	*NOx*	*NMVOC*	*NH3*	*CO*	*TSP*	*PM10*	*PM2.5*
1990	0.042	0.633	0.104	0.000	0.668	0.112	0.112	0.112
1991	0.048	0.721	0.118	0.000	0.756	0.126	0.126	0.126
1992	0.052	0.784	0.127	0.000	0.819	0.135	0.135	0.135
1993	0.057	0.852	0.138	0.000	0.888	0.146	0.146	0.146
1994	0.059	0.906	0.143	0.000	0.925	0.150	0.150	0.150
1995	0.054	0.985	0.148	0.000	0.969	0.152	0.152	0.152
1996	0.019	0.967	0.141	0.000	0.928	0.143	0.143	0.143
1997	0.019	1.047	0.147	0.000	0.976	0.147	0.147	0.147
1998	0.018	1.093	0.147	0.000	0.983	0.144	0.144	0.144
1999	0.018	1.214	0.155	0.000	1.053	0.148	0.148	0.148
2000	0.017	1.295	0.159	0.000	1.090	0.149	0.149	0.149
2001	0.017	1.340	0.160	0.000	1.108	0.148	0.148	0.148
2002	0.016	1.416	0.169	0.000	1.131	0.147	0.147	0.147
2003	0.015	1.372	0.165	0.000	1.054	0.133	0.133	0.133
2004	0.001	1.347	0.164	0.000	1.011	0.124	0.124	0.124
2005	0.001	1.257	0.155	0.000	0.927	0.109	0.109	0.109
2006	0.001	1.243	0.156	0.000	0.896	0.101	0.101	0.101
2007	0.001	1.386	0.157	0.000	0.899	0.092	0.092	0.092
2008	0.001	1.237	0.126	0.000	0.736	0.070	0.070	0.070
2009	0.001	1.288	0.121	0.000	0.709	0.064	0.064	0.064
2010	0.001	1.345	0.111	0.000	0.677	0.055	0.055	0.055
2011	0.001	1.416	0.101	0.000	0.635	0.048	0.048	0.048
2012	0.001	1.447	0.090	0.000	0.609	0.042	0.042	0.042
2013	0.001	1.431	0.080	0.000	0.585	0.036	0.036	0.036
2014	0.001	1.403	0.070	0.000	0.571	0.031	0.031	0.031
2015	0.001	1.360	0.061	0.000	0.553	0.026	0.026	0.026
2016	0.001	1.299	0.053	0.000	0.548	0.023	0.023	0.023
2017	0.002	1.225	0.045	0.000	0.523	0.019	0.019	0.019
2018	0.002	1.161	0.038	0.000	0.511	0.017	0.017	0.017
2019	0.002	1.099	0.034	0.000	0.533	0.016	0.016	0.016
2020	0.002	1.028	0.029	0.000	0.504	0.014	0.014	0.014
2021	0.002	0.964	0.026	0.000	0.501	0.013	0.013	0.013
2022	0.002	0.897	0.025	0.000	0.519	0.012	0.012	0.012
***Trend* 1990-2022**	*-95.37%*	*41.65%*	*-76.19%*	*90.01%*	*-22.25%*	*-89.35%*	*-89.35%*	*-89.35%*
2005-2022	*105.56%*	*-28.67%*	*-83.94%*	*11.79%*	*-43.95%*	*-89.13%*	*-89.13%*	*-89.13%*
2021-2022	*3.07%*	*-6.99%*	*-5.00%*	*2.82%*	*3.76%*	*-8.88%*	*-8.88%*	*-8.88%*

Source: Environment Agency.

3.2.3.8.1.2 Methodological issues

3.2.3.8.1.2.1 Activity Data

Under Mobile Sources and Machinery in Industry and Other Mobile Equipment the following activities have been considered:

- other mobile sources and machinery in industry (Snap code 080800).
- other mobile equipment (SNAP code 081000).

Activity data are based on the stock data of mobile machinery used in industry and construction equipment, as well as on economic indicators such as the gross value added for the industrial sector.

The total amounts of gasoline, diesel oil, bioethanol and biodiesel sold in Luxembourg are obtained from the national energy balance, and the activity data are then allocated to the different road and offroad subcategories with the NEMO and GEORG models developed by TU Graz. Since submission 2022v1, the version HBEFA4.2 was implemented.

Activity data for category *1A2g vii - Mobile Combustion in manufacturing industries and construction* are listed in Table 3-78.

Table 3-78 – Activity data by fuel type of category – *1A2g vii - Mobile Combustion in manufacturing industries and construction*

1 A 2 Stationary combustion in manufacturing industries and construction						
Activity Data by fuel type (GJ)						
1 A 2 g vii Mobile Combustion in manufacturing industries and construction						
Year	**Activity Total (incl. biomass)**	**Liquid** *Gas Oil, Diesel*	**Solid**	**Gaseous**	**Biomass**	**Other**
1990	706 269	706'269	NO	NO	NO	NO
1991	801 699	801'699	NO	NO	NO	NO
1992	869 993	869'993	NO	NO	NO	NO
1993	944 354	944'354	NO	NO	NO	NO
1994	992 028	992'028	NO	NO	NO	NO
1995	1 055 789	1'055'789	NO	NO	NO	NO
1996	1 022 208	1'022'208	NO	NO	NO	NO
1997	1 088 871	1'088'871	NO	NO	NO	NO
1998	1 113 260	1'113'260	NO	NO	NO	NO
1999	1 211 086	1'211'086	NO	NO	NO	NO
2000	1 271 815	1'271'815	NO	NO	NO	NO
2001	1 303 910	1'303'910	NO	NO	NO	NO
2002	1 459 067	1'459'067	NO	NO	NO	NO
2003	1 527 918	1'527'918	NO	NO	NO	NO
2004	1 618 534	1'618'534	NO	NO	IE	NO
2005	1 626 085	1'626'085	NO	NO	IE	NO
2006	1 759 809	1'759'809	NO	NO	IE	NO
2007	2 152 722	2'152'722	NO	NO	IE	NO
2008	2 006 457	2'006'457	NO	NO	IE	NO
2009	2 148 201	2'148'201	NO	NO	IE	NO
2010	2 289 508	2'289'508	NO	NO	IE	NO
2011	2 431 039	2'431'039	NO	NO	IE	NO
2012	2 571 398	2'571'398	NO	NO	IE	NO
2013	2 713 765	2'713'765	NO	NO	IE	NO
2014	2 856 110	2'856'110	NO	NO	IE	NO
2015	3 009 723	3'009'723	NO	NO	IE	NO
2016	3 171 785	3'171'785	NO	NO	IE	NO
2017	3 325 376	3'325'376	NO	NO	IE	NO
2018	3 496 191	3'496'191	NO	NO	IE	NO
2019	3 674 743	3'674'743	NO	NO	IE	NO
2020	3 837 056	3'837'056	NO	NO	IE	NO
2021	4 024 669	4'024'669	NO	NO	IE	NO
2022	4 146 691	4'146'691	NO	NO	IE	NO
Trend 1990-2022	*487.13%*	*487.13%*	*NA*	*NA*	*NA*	*NA*
2005-2022	*155.01%*	*155.01%*	*NA*	*NA*	*NA*	*NA*
2021-2022	*3.03%*	*3.03%*	*NA*	*NA*	*NA*	*NA*

Note: Activity data for biomass (bioethanol, biodiesel) is included in liquid fuels. Only blended fuels are used.
Source: Environment Agency

3.2.3.8.1.2.2 Methodological choices

For emissions of air pollutants from off-road vehicles and other machinery, the GEORG model (Grazer Emissionsmodell für Off-Road Geräte) developed by the TU Graz was used. This model has been developed within a study about off-road emissions in Austria (PISCHINGER 2000). Relevant country-specific information has been adapted to Luxembourg's situation. The used methodology conforms to the requirements of the EMEP/EEA Tier 3 methodology. Input data to the model are:

- Machinery stock data (obtained through inquiries and statistical extrapolation);
- Assumptions on drop-out rates of machinery (broken down machinery will be replaced);
- Operating time (obtained through inquiries), related to age of machinery.

From machinery stock data and drop-out rates an age structure of the off-road machinery was obtained by GEORG. Four categories of engine types were considered. Depending on the fuel consumption of the engine the ratio power of the engine was calculated. Emissions were calculated by multiplying an engine specific emission factor (expressed in g/kWh) by the average engine power, the operating time and the number of vehicles.

3.2.3.8.1.2.3 Emission factors

For mobile combustion (diesel oil and motor gasoline), country-specific values, derived from the GEORG model, have been applied. Furthermore, the country-specific Sulphur content of the fuel was used. For the $PM_{2.5}$ and PM_{10} emission factors, the condensable component is included.

The methods applied and emission factors (EF) used in relation to the energy consumption for 2022 are presented in Table 3-79.

Table 3-79 – Methods and Emission Factors used in relation to the energy consumption in 2022 for category – *1A2g vii - Mobile Combustion in manufacturing industries and construction*

1 A 2 Stationary combustion in manufacturing industries and construction *Method applied and Emission factor (EF) used as well as coverage of energy consumption*				
1 A 2 g vii Mobile Combustion in manufacturing industries and construction				
Pollutant	**Method**	**EF used**	**Coverage of energy**	**Source**
NOx NMVOC CO TSP PM10 PM2.5	T3	CS	100.0%	GEORG
	T1	D	0.0%	EMEP/EEA GB
SOx	T3	CS	100.0%	GEORG using national fuel sulfur contents
	T1	D	0.0%	EMEP/EEA GB

Source: Environment Agency

Table 3-80 gives an overview of the evolution of the implied emission factors.

Table 3-80 – Implied emission factors for category – *1A2g vii - Mobile Combustion in manufacturing industries and construction*

1 A 2 Stationary combustion in manufacturing industries and construction *Implied Emission Factor (IEF) of air pollutants by source category (g/GJ)*								
Year	**1 A 2 g vii Mobile Combustion in manufacturing industries and construction**							
	SO2	***NOx***	***NMVOC***	***NH3***	***CO***	***TSP***	***PM10***	***PM2.5***
1990	59.93	896.35	147.72	0.34	945.74	157.96	157.96	157.96
1991	59.93	898.74	147.07	0.34	943.54	156.64	156.64	156.64
1992	59.93	900.77	146.54	0.34	941.89	155.52	155.52	155.52
1993	59.93	902.20	146.18	0.34	940.74	154.76	154.76	154.76
1994	59.93	913.09	144.09	0.34	932.50	151.04	151.04	151.04
1995	50.80	933.34	140.30	0.33	917.41	144.41	144.41	144.41
1996	18.74	945.75	137.98	0.33	907.83	140.35	140.35	140.35
1997	17.47	961.64	135.18	0.32	896.71	135.37	135.37	135.37
1998	16.21	982.05	131.63	0.31	883.10	129.05	129.05	129.05
1999	14.94	1002.44	127.95	0.31	869.06	122.56	122.56	122.56
2000	13.67	1018.58	124.84	0.30	857.34	117.17	117.17	117.17
2001	12.97	1027.90	122.84	0.30	849.53	113.82	113.82	113.82
2002	11.03	970.51	115.58	0.29	775.19	101.01	101.01	101.01
2003	9.96	897.73	107.80	0.28	689.99	87.22	87.22	87.22
2004	0.67	832.50	101.06	0.26	624.50	76.37	76.37	76.37
2005	0.59	773.06	95.11	0.25	569.79	67.23	67.23	67.23
2006	0.52	706.08	88.50	0.24	509.35	57.12	57.12	57.12
2007	0.47	643.93	72.94	0.21	417.65	42.69	42.69	42.69
2008	0.47	616.38	62.96	0.19	366.78	34.83	34.83	34.83
2009	0.47	599.35	56.53	0.18	330.23	29.83	29.83	29.83
2010	0.47	587.62	48.46	0.16	295.49	24.12	24.12	24.12
2011	0.47	582.60	41.62	0.15	261.33	19.85	19.85	19.85
2012	0.47	562.57	35.13	0.14	236.67	16.26	16.26	16.26
2013	0.47	527.41	29.38	0.14	215.46	13.28	13.28	13.28
2014	0.47	491.34	24.61	0.13	199.80	10.78	10.78	10.78
2015	0.47	451.97	20.32	0.13	183.85	8.76	8.76	8.76
2016	0.47	409.44	16.66	0.12	172.68	7.13	7.13	7.13
2017	0.47	368.27	13.41	0.12	157.25	5.85	5.85	5.85
2018	0.47	332.17	10.94	0.12	146.18	4.93	4.93	4.93
2019	0.47	298.95	9.23	0.11	145.07	4.23	4.23	4.23
2020	0.47	267.91	7.54	0.11	131.23	3.67	3.67	3.67
2021	0.47	239.56	6.50	0.11	124.37	3.24	3.24	3.24
2022	0.47	216.25	5.99	0.11	125.24	2.86	2.86	2.86
Trend								
1990-2022	*-99.21%*	*-75.87%*	*-95.94%*	*-67.64%*	*-86.76%*	*-98.19%*	*-98.19%*	*-98.19%*
2005-2022	*-19.39%*	*-72.03%*	*-93.70%*	*-56.16%*	*-78.02%*	*-95.74%*	*-95.74%*	*-95.74%*
2021-2022	*0.04%*	*-9.73%*	*-7.80%*	*-0.20%*	*0.70%*	*-11.56%*	*-11.56%*	*-11.56%*

Source: Environment Agency

3.2.3.8.1.3 Methodological issues for heavy metals and POPs

HM and POP emissions from mobile combustion in manufacturing industries and construction were estimated based on total fuel sold. The same methodologies and models as for the main pollutants were applied.

3.2.3.8.1.4 Uncertainties and time-series consistency

The assessment of activity data and emission factor uncertainties is done according to the methodology described in the EMEP/EEA emission inventory Guidebook 2023 (Chapter A.5 Uncertainties, tables 2-1, 2-2 and 2-3), covering the main pollutants NO_x, NH_3, NMVOC, SO_x and $PM_{2.5}$. For some subcategories and pollutants, expert judgements were made to estimate AD or EF uncertainties. For CO, PM10, heavy metzals and persistent organic pollutants, no uncertainty estimates are currently made. Details on uncertainty of the activity data can also be checked in the Luxembourg's National Inventory report (NIR). Please also refer to Table 1-33 to Table 1-37 of section 1.7 for caterogory specific uncertainties on activity data and emission factors.

Generally, the time-series, as reported in category *1A2g vii Mobile Combustion in manufacturing industries and construction* are considered to be consistent.

3.2.3.8.1.5 Source-specific QA/QC and verification

Consistency and completeness checks are performed.

3.2.3.8.1.6 Category-specific recalculations including changes made in response to the review process

Table 3-81 presents the main revisions and recalculations done since submission 2023 and relevant to category *1A2g vii Mobile Combustion in manufacturing industries and construction*.

Table 3-81 – Recalculations done since the last submission for category – *1A2g vii - Mobile Combustion in manufacturing industries and construction*

Source category	Revisions 2023 → 2024	Type of revision
1A2g vii	No recalculations	

3.2.3.8.1.7 Category-specific planned improvements including those in response to the review process

The following improvements are planned for the next submission.

Table 3-82 – Planned improvements for sub-category – *1A2g vii - Mobile Combustion in manufacturing industries and construction*

Source category	Planned improvements	Type of revision
1A2g vii	No further improvements are planned	n/a

3.2.3.8.2 Other Stationary Combustion (1A2g viii)

3.2.3.8.2.1 Source category description

Source category *1A2g viii Other Stationary Combustion* covers all the remaining stationary industrial activities not previously mentioned, such as:

- Transport Equipment
- Machinery
- Mining (excluding fuels) and Quarrying
- Wood and Wood Products
- Construction (including asphalt concrete plants, however, NMVOC, TSP and PM emissions of these plants are reported under category *2D3b Road paving with asphalt*)
- Textile and Leather
- Non-specified Industry

In 2022, this source category represented:

- 11.1% of national total SO_2 emissions (based on fuel sold) and 11.5% of national total SO_2 emissions (based on fuel used), whereas in 1990, this source category represented 1.2% of national total SO_2 emissions (based on fuel sold) and 1.3% of national total SO_2 emissions (based on fuel used).
- 3.1% of national total NO_X emissions (based on fuel sold) and 3.9% of national total NO_X emissions (based on fuel used), whereas in 1990, this source category represented 0.2%, respectively, 0.4% of national total NO_X emissions (based on fuel sold/based on fuel used).
- 12.2% of national total $PM_{2.5}$ emissions (based on fuel sold) and 14.5% of national total $PM_{2.5}$ emissions (based on fuel used), whereas in 1990, this source category represented 0.01% of national total $PM_{2.5}$ emissions (based on fuel sold and fuel used).

The significant reduction of SO_2 emissions (-74.8%) in the period 1990-2022 was mainly due to the reduction of the sulphur content in the fuels. The emissions of all other air pollutants were increased due to the fact that since 2015 one plant producing wood products switched from gas-fired combustion technology to wood residue combustion, implying higher emissions, although the plant applies best available abatement technology.

Table 3-83 summarizes emissions of air pollutants for category *1A2g viii Other Stationary* and Table 3-84 presents the emission trends.

Table 3-83 – Emissions, Trends and Shares based on fuel sold and fuel used of category – *1A2g viii - Other Stationary*

1 A 2 Stationary combustion in manufacturing industries and construction														
Emissions, Trends and Shares in National Totals of air pollutants based on fuel sold and fuel used														
1 A 2 g viii Other														
Pollutants	**Emissions**				**Trend**			**FUEL USED Share in National Total**			**FUEL SOLD Share in National Total**			**Fuel option**
	1990	**2005**	**2021**	**2022**	**1990 - 2022**	**2005 - 2022**	**2021 - 2022**	**1990**	**2005**	**2022**	**1990**	**2005**	**2022**	
SO2	0.20	0.05	0.10	0.05	-74.8%	-9.3%	-49.6%	1.3%	2.1%	11.5%	1.2%	2.1%	11.1%	fuel sold
NOx	0.09	0.09	0.46	0.36	280.2%	302.1%	-23.1%	0.4%	0.5%	3.9%	0.2%	0.2%	3.1%	fuel sold
NMVOC	0.01	0.05	0.34	0.34	3255.7%	604.3%	1.6%	0.0%	0.4%	3.5%	0.0%	0.3%	3.4%	fuel sold
NH3	NO	0.03	0.01	0.01	0.6%	-83.4%	-51.8%	NO	0.6%	0.1%	NO	0.5%	0.1%	fuel sold
CO	0.17	0.11	0.52	0.47	172.1%	310.6%	-9.0%	0.0%	0.5%	3.2%	0.0%	0.3%	2.6%	fuel sold
TSP	0.00	0.00	0.30	0.13	9969.5%	5520.9%	-57.8%	0.01%	0.1%	6.1%	0.01%	0.1%	5.0%	fuel sold
PM10	0.00	0.00	0.30	0.13	10411.6%	5520.9%	-57.8%	0.01%	0.1%	9.1%	0.01%	0.1%	7.5%	fuel sold
PM2.5	0.00	0.00	0.30	0.13	11040.4%	5520.9%	-57.8%	0.01%	0.2%	14.5%	0.01%	0.1%	12.2%	fuel sold

Source: Environment Agency.

Table 3-84 – Emission trends of category – *1A2g viii - Other Stationary*

1 A 2 Stationary combustion in manufacturing industries and construction *Emissions of air pollutants by source category (Gg)*								
Year	**1 A 2 g viii Other (Please specify in the IIR)**							
	SO2	***NOx***	***NMVOC***	***NH3***	***CO***	***TSP***	***PM10***	***PM2.5***
1990	0.197	0.094	0.010	NO	0.174	0.001	0.001	0.001
1991	0.254	0.333	0.059	NO	0.210	0.005	0.005	0.005
1992	0.211	0.312	0.065	NO	0.229	0.003	0.003	0.003
1993	0.170	0.338	0.073	NO	0.204	0.004	0.004	0.004
1994	0.346	0.386	0.069	NO	0.309	0.005	0.005	0.005
1995	0.216	0.337	0.063	NO	0.193	0.005	0.005	0.005
1996	0.271	0.336	0.064	NO	0.255	0.004	0.004	0.004
1997	0.216	0.410	0.090	NO	0.265	0.004	0.004	0.003
1998	0.178	0.457	0.358	NO	0.284	0.011	0.011	0.011
1999	0.214	0.489	0.259	NO	0.356	0.011	0.011	0.011
2000	0.307	0.294	0.076	NO	0.274	0.011	0.011	0.011
2001	0.255	0.271	0.070	NO	0.243	0.010	0.010	0.010
2002	0.220	0.243	0.058	NO	0.228	0.007	0.007	0.007
2003	0.211	0.230	0.056	NO	0.325	0.005	0.005	0.005
2004	0.060	0.129	0.054	NO	0.126	0.003	0.003	0.003
2005	0.055	0.089	0.048	0.034	0.115	0.002	0.002	0.002
2006	0.050	0.074	0.078	0.032	0.108	0.004	0.004	0.004
2007	0.052	0.066	0.077	0.034	0.132	0.003	0.003	0.003
2008	0.052	0.087	0.052	0.036	0.124	0.003	0.003	0.003
2009	0.047	0.062	0.046	0.028	0.103	0.006	0.006	0.006
2010	0.121	0.075	0.069	0.032	0.092	0.005	0.005	0.005
2011	0.054	0.082	0.027	0.029	0.104	0.005	0.005	0.005
2012	0.055	0.082	0.015	0.025	0.101	0.006	0.006	0.006
2013	0.019	0.110	0.018	0.027	0.090	0.006	0.006	0.006
2014	0.013	0.094	0.015	0.027	0.103	0.005	0.005	0.005
2015	0.010	0.159	0.027	0.031	0.176	0.018	0.018	0.018
2016	0.043	0.102	0.186	0.056	0.108	0.062	0.062	0.062
2017	0.041	0.152	0.096	0.048	0.563	0.026	0.026	0.026
2018	0.048	0.314	0.089	0.054	0.138	0.026	0.026	0.026
2019	0.036	0.266	0.289	0.006	0.223	0.096	0.096	0.096
2020	0.054	0.274	0.308	0.004	0.245	0.146	0.146	0.146
2021	0.098	0.465	0.336	0.012	0.519	0.301	0.301	0.301
2022	0.050	0.358	0.341	0.006	0.472	0.127	0.127	0.127
Trend 1990-2022	*-74.81%*	*280.16%*	*3255.67%*	*NA*	*172.11%*	*9969.54%*	*10411.59%*	*11040.37%*
2005-2022	*-9.31%*	*302.07%*	*604.32%*	*-83.41%*	*310.57%*	*5520.95%*	*5520.95%*	*5520.95%*
2021-2022	*-49.56%*	*-23.09%*	*1.64%*	*-51.79%*	*-9.04%*	*-57.79%*	*-57.79%*	*-57.79%*

Source: Environment Agency.

Category *1A2g viii Other Stationary* was a key category for SO_2 (LA, TA), NMVOC (LA), TSP (LA), PM_{10} (LA) and $PM_{2.5}$ (LA, TA) in 2022 (see Table 3-85 and also see Table 3-4 in Section 0 and Chapter 1.5). For heavy metlas and persistent organic pollutants, *1A2g viii Other Stationary* was a key category, in 2022, only for PAHs (LA) (see Table 3-5 in Section 0).

Table 3-85 – Key Category Analysis for category – *1A2g viii - Stationary Combustion in manufacturing industries and construction*

Key Source Analysis (FUEL SOLD): Ranking per number		**SO2**		**NOX**		**NMVOC**		**NH3**		**CO**		**TSP**		**PM10**		**PM2.5**	
NFR Code	**NFR Category**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	3	3			9						6		6		3	4

Key Source Analysis (FUEL USED): Ranking per number		**SO2**		**NOX**		**NMVOC**		**NH3**		**PM2.5**	
NFR Code	**NFR Category**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	3	3			8	8			2	3

Sources: Environment Agency
Notes: LA = Level Assessment, TA = Trend Assessment
Number in Table = indicates the rank in the specific analysis (1…biggest KC; 2… second biggest KC, …)

3.2.3.8.2.2 Methodological issues

3.2.3.8.2.2.1 Activity data

Under other manufacturing industries and construction, the following activities have been considered:

Combustion plants <50 MW

This source includes all kind of smaller combustion installations for heat or steam production. As the number of this kind of boilers is quite important, they have not always been treated individually. Various types of fuel were and still are used: anthracite, residual fuel oil, gas oil, LPG, natural gas. Where information about the fuel combustion in these boilers was available, it was received directly from the operator.

Gas Turbines

This source includes one gas turbine used in the wood processing industry for heat and electricity production running on natural gas. The information about the fuel combustion is received directly from the operator.

Asphalt concrete plants

There are three asphalt concrete plants in Luxembourg. Their main fuel is lignite (brown coal briquettes) followed by natural gas and gas oil. Fuel consumption data were obtained by the operators. NOx and CO emissions are estimated based on fuel consumption. However, as NMVOC, TSP, PM_{10} and $PM_{2.5}$ emissions are mainly due to the production process and to a minor extent from combustion, these emissions are reported under category *2D3b Road paving with asphalt*.

Activity data for category *1A2g viii - Other Stationary* are listed in Table 3-86.

Table 3-86 – Activity data by fuel type of category – *1A2g viii - Other Stationary*

1 A 2 Stationary combustion in manufacturing industries and construction						
Activity Data by fuel type (GJ)						
1 A 2 g viii Other (Please specify in the IIR)						
Year	Activity Total (incl. biomass)	Liquid *Gas Oil*	Solid *Brown coal, BKB, etc.*	Gaseous *Natural Gas*	Biomass *Biogas, Wood*	Other
1990	618 872	NO	206'140	412'733	NO	NO
1991	2 740 221	126'073	199'769	2'414'378	NO	NO
1992	3 035 343	5'465	217'880	2'811'997	NO	NO
1993	3 321 203	29'967	161'445	3'129'790	NO	NO
1994	3 304 907	81'196	320'437	2'903'274	NO	NO
1995	2 869 037	123'730	160'119	2'585'188	NO	NO
1996	3 004 718	54'382	254'976	2'695'360	NO	NO
1997	4 139 562	34'300	225'135	3'880'127	NO	NO
1998	4 356 223	263'426	183'946	3'908'852	NO	NO
1999	4 886 549	547'121	218'107	4'121'322	NO	NO
2000	2 298 701	693'793	232'377	1'372'530	NO	NO
2001	2 145 204	661'165	168'958	1'315'081	NO	NO
2002	1 944 655	643'317	138'204	1'163'134	NO	NO
2003	1 934 290	662'206	145'892	1'126'193	NO	NO
2004	1 901 981	499'347	147'911	1'254'724	NO	NO
2005	2 673 103	401'520	144'819	1'208'763	918 000	NO
2006	2 587 036	304'837	136'831	1'288'369	857 000	NO
2007	2 483 266	359'156	142'414	1'056'706	924 990	NO
2008	2 457 806	431'129	139'665	907'342	979 670	NO
2009	2 009 874	206'309	156'912	891'832	754 820	NO
2010	1 933 153	97'598	211'674	760'510	863 371	NO
2011	1 891 686	98'904	171'154	821'715	799 912	NO
2012	1 862 880	73'699	191'369	839'412	758 400	NO
2013	1 961 940	63'835	138'667	948'903	795 938	14'597
2014	1 932 873	52'874	147'760	775'777	941 678	14'784
2015	1 810 274	42'860	128'089	716'768	911 066	11'491
2016	2 601 701	63'963	151'902	790'342	1 550 555	44'939
2017	2 344 221	99'735	110'221	730'607	1 364 151	39'507
2018	2 269 465	110'358	114'247	497'298	1 495 980	51'582
2019	4 396 942	55'052	100'914	830'065	3 267 179	143'733
2020	5 682 991	20'709	112'032	626'139	4 703 625	220'486
2021	6 389 863	26'921	168'861	517'835	5 475 985	200'261
2022	5 706 584	15'106	77'376	191'925	5 230 013	192'164
Trend 1990-2022	*822.09%*	*NA*	*-62.46%*	*-53.50%*	*NA*	*NA*
2005-2022	*113.48%*	*-96.24%*	*-46.57%*	*-84.12%*	*469.72%*	*NA*
2021-2022	*-10.69%*	*-43.89%*	*-54.18%*	*-62.94%*	*-4.49%*	*-4.04%*

Source: Environment Agency

3.2.3.8.2.2.2 Methodological choices

For point sources of this sub-category, emission measurements of NO_X, SO_2, NMVOC, CO and PM are the basis for the reported emissions (EMEP/EEA Tier 3 approach).

The point or area sources, for which no measured (plant-specific) emission data but plant specific activity data or information on the abatement technology was available, were estimated using the EMEP/EEA Tier 2 approach by multiplying the fuel consumption taken from the national energy balance with the default emission factors.

The remaining area sources, for which no measured (plant-specific) emission data, nor plant specific activity data or information on the abatement technology was available, were estimated using the EMEP/EEA Tier 1 by multiplying the fuel consumption taken from the national energy balance with the default emission factors.

The methods applied in relation to the energy consumption are presented in Table 3-87.

3.2.3.8.2.2.3 Emission factors

For point sources of this sub-category, emission measurements of NO_X, SO_2, NMVOC, CO and PM are the basis for the reported emissions (EMEP/EEA Tier 3 approach). Hence, no emission factors per se are used, but rather implied emission factors are derived by dividing the emission with the activity data.

The remaining point or area sources, for which no measured (plant-specific) emission data but plant specific activity data or information on the abatement technology was available, were estimated using the EMEP/EEA Tier 2 default emission factors. This includes NH_3 emissions from wood burning, where energy input was directly obtained from the plant operator. NH_3 emissions from wood burning were calculated using the default EF (37.0 g NH_3/GJ) for combustion plants with a heat capacity of 1-50 MWth from the EMEP/EEA GB 2019 (chapter 1A4, Tab 3.45., p.86).

NO_X, SO_2, NMVOC, CO, TSP, PM_{10} and $PM_{2.5}$ emission factors used in relation to the energy consumption are presented in Table 3-88 and may vary over time for the following reasons:

- The chemical characteristic of a fuel varies, e.g. sulphur content.
- The mix of fuels of a fuel category changes over time.
- The production and/or abatement technology of a facility – or of facilities – changes over time.

Table 3-87 – Methods and Emission Factors used in relation to the energy consumption in 2022 for category – *1A2g viii – Other Stationary*

1 A 2 Stationary combustion in manufacturing industries and construction

Method applied and Emission factor (EF) used as well as coverage of energy consumption

1 A 2 g viii Other

Pollutant	Method	EF used	Coverage of energy consumption	Source
NOx	T3	PS	39.4%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2/T1	D	60.6%	EMEP/EEA GB 2019 (Chap1A2, Tab3.2, p15), EMEP/EEA GB 2019 (Chap1A2, Tab3.4 p17), EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16)
NMVOC	T3	PS	39.4%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2/T1	D	60.6%	EMEP/EEA GB 2019 (Chap1A2, Tab3.2, p15), EMEP/EEA GB 2019 (Chap1A2, Tab3.4 p17), EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16)
SOx	T3	PS	39.4%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2	CS	0.0%	CS based on fuel sulfur content; determined by AEV
	T1	D	60.6%	EMEP/EEA GB 2016(PartB, Chap1A2, Tab3.2, p15)
CO	T3	PS	39.4%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2/T1	D	60.6%	EMEP/EEA GB 2019 (Chap1A2, Tab3.2 p15), EMEP/EEA GB 2019 (Chap1A2, Tab3.34 p17), EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16)
PM2.5	T3	PS	39.4%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV PM measured assumed to be TSP = PM10 = PM2.5
	T2/T1	D	60.6%	EMEP/EEA GB 2019 (Chap1A2, Tab3.2, p15), EMEP/EEA GB 2019 (Chap1A2, Tab3.4, p17), EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16)
PM10	T3	PS	39.4%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV PM measured assumed to be TSP = PM10 = PM2.5
	T2/T1	D	60.6%	EMEP/EEA GB 2019 (Chap1A2, Tab3.2, p15), EMEP/EEA GB 2019 (Chap1A2, Tab3.4, p17), EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16)
TSP	T3	PS	39.4%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV PM measured assumed to be TSP = PM10 = PM2.5
	T2/T1	D	60.6%	EMEP/EEA GB 2019 (Chap1A2, Tab3.2, p15), EMEP/EEA GB 2019 (Chap1A2, Tab3.4, p17), EMEP/EEA GB 2019 (Chap1A2, Tab3.3, p16)

Source: Environment Agency

Table 3-88 – Implied emission factors for category – *1A2g viii – Other Stationary*

1 A 2 Stationary combustion in manufacturing industries and construction *Implied Emission Factor (IEF) of air pollutants by source category (g/GJ)*								
Year	**1 A 2 g viii Other**							
	SO2	***NOx***	***NMVOC***	***NH3***	***CO***	***TSP***	***PM10***	***PM2.5***
1990	317.64	152.00	16.43	NA	280.36	2.04	1.95	1.84
1991	92.60	121.51	21.61	NA	76.80	1.89	1.87	1.85
1992	69.52	102.63	21.53	NA	75.60	1.01	0.99	0.98
1993	51.32	101.80	22.08	NA	61.36	1.17	1.16	1.14
1994	104.75	116.87	21.00	NA	93.60	1.43	1.42	1.40
1995	75.17	117.59	22.02	NA	67.28	1.87	1.85	1.83
1996	90.05	111.91	21.27	NA	84.94	1.31	1.30	1.28
1997	52.25	98.93	21.84	NA	64.03	0.86	0.85	0.84
1998	40.81	104.89	82.19	NA	65.28	2.50	2.49	2.48
1999	43.84	99.97	53.05	NA	72.84	2.19	2.19	2.18
2000	133.59	127.69	32.97	NA	119.32	4.70	4.70	4.70
2001	119.02	126.42	32.53	NA	113.25	4.44	4.44	4.44
2002	112.91	124.93	29.68	NA	117.27	3.72	3.72	3.72
2003	108.93	119.13	28.98	NA	167.79	2.78	2.78	2.78
2004	31.62	67.83	28.25	NA	66.33	1.56	1.56	1.56
2005	20.43	33.27	18.12	12.71	43.02	0.85	0.85	0.85
2006	19.30	28.50	30.01	12.26	41.57	1.65	1.65	1.65
2007	20.95	26.39	30.85	13.78	53.24	1.16	1.16	1.16
2008	21.17	35.23	21.28	14.75	50.51	1.34	1.34	1.34
2009	23.30	31.04	23.00	13.90	51.45	3.13	3.13	3.13
2010	62.52	38.92	35.54	16.43	47.70	2.52	2.52	2.52
2011	28.68	43.19	14.06	15.37	54.86	2.89	2.89	2.89
2012	29.53	44.24	8.18	13.57	54.33	3.04	3.04	3.04
2013	9.59	56.18	8.97	13.88	46.00	3.17	3.17	3.17
2014	6.68	48.87	7.86	14.06	53.53	2.57	2.57	2.57
2015	5.36	87.58	14.87	16.97	97.12	9.93	9.93	9.93
2016	16.54	39.12	71.52	21.46	41.61	23.80	23.80	23.80
2017	17.35	64.94	41.07	20.66	240.11	11.00	11.00	11.00
2018	20.95	138.14	39.35	23.73	60.91	11.43	11.43	11.43
2019	8.10	60.52	65.79	1.48	50.66	21.73	21.73	21.73
2020	9.51	48.27	54.16	0.62	43.15	25.64	25.64	25.64
2021	15.36	72.77	52.53	1.83	81.23	47.13	47.13	47.13
2022	8.68	62.67	59.78	0.99	82.73	22.27	22.27	22.27
Trend								
1990-2022	*-97.27%*	*-58.77%*	*263.92%*	*NA*	*-70.49%*	*992.03%*	*1039.97%*	*1108.16%*
2005-2022	*-57.52%*	*88.34%*	*229.92%*	*-92.23%*	*92.32%*	*2532.99%*	*2532.99%*	*2532.99%*
2021-2022	*-43.52%*	*-13.88%*	*13.81%*	*-46.02%*	*1.85%*	*-52.74%*	*-52.74%*	*-52.74%*

Source: Environment Agency

3.2.3.8.2.3 Methodological issues for heavy metals and POPs

With the asphalt plants in Leudelange (Cajot), Schifflange (Lisé), Wasserbillig (Wickler) and the City of Luxembourg (Karp-Kneip) this category includes four point sources. In addition to these sources, several smaller facilities and diffuse sources are considered in this category. These include transport equipment, machinery, mining and quarrying, wood and wood products, construction, and other non-specified industry.

3.2.3.8.2.3.1 Activity Data

Asphalt plants: emission measurements, annual operating hours and volumetric flow taken from emission control measurement protocols. Where measurement data were lacking, annual fuel consumption taken from the national energy balance was used instead.

Data about fuel consumption related to other sources of emissions in this sector were obtained from the national energy balance.

3.2.3.8.2.3.2 Methodological Choices

Asphalt plants:

Calculation of emissions was based on data from emission control measurements or annual emission reports (tier 3). Projection of annual emissions was carried out using measurement data in combination with annual operating hours and volumetric flow measurements. In contrast to annual energy consumption, which is available for the entire time series, emission measurements were not available for all years. For years without emission measurements, emission levels were therefore obtained using correction factors. These correction factors were calculated from the last available measurement data of the respective previous years (emissions per hour x activity hours per year) and the corresponding annual energy consumption in combination with tier 1 emission factors. For years without emission measurements, annual energy consumption was offset with these correction factors to obtain source-specific and most realistic emission values. Since measurements of Hg-emissions were not available for the Karp-Kneip and Lisé asphalt plants, correction factors from the Cajot plant were also employed for these plants. Process-related HM and POPs emissions from asphalt production were assumed to be negligible and thus not considered.

Smaller facilities:

Annual fuel consumption in combination with tier 1 emission factors.

Fuel consumption data were obtained from the national energy balance compiled by STATEC.

3.2.3.8.2.3.3 Emission Factors

Sources of default Tier 1 HM and POP emission factors applied are given in the following table:

Table 3-89 - Souces of Tier 1 HM and POP emission factors for category *1A2g viii – Other Stationary*

Fuel	Pollutants	Source	Page	Table
Solid fuels	Pb, Hg, Cd, PCDD/F, PCB, HCB, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2023) – Chapter 1.A.2 Manufacturing industries and construction	15	3-2
Gaseous fuels	Pb, Hg, Cd	EEA (2023) – Chapter 1.A.2 Manufacturing industries and construction PCDD/F, PCB, HCB, B(a)P, B(b)F, B(k)F, I(cd)P are considered as NA	16	3-3
Liquid fuels	Pb, Hg, Cd, PCDD/F, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2019) – Chapter 1.A.2 Manufacturing industries and construction	17	3-4
Liquid fuels	PCB	EF not stated in EEA (2023), thus custom EF derived from EMEP/Corinair Guidebook (2007): 1 TEP= 1,170 l and density (gas oil) = 0,84 kg/l → 1 TEP= 983 kg EF: EMEP/Corinair Guidebook (2007), Draft Chapter on PCB emissions: 250 ug/t (gas oil) conversion : 1 TEP = 41,9 GJ (250 ug/t * 0,983 t)/41,9 GJ = 5,87 ug/GJ	N/A	N/A

3.2.3.8.2.4 Uncertainties and time-series consistency

The assessment of activity data and emission factor uncertainties is done according to the methodology described in the EMEP/EEA emission inventory Guidebook 2023 (Chapter A.5 Uncertainties, tables 2-1, 2-2 and 2-3), covering the main pollutants NO_x, NH_3, NMVOC, SO_x and $PM_{2.5}$. For some subcategories and pollutants, expert judgements were made to estimate AD or EF uncertainties. For CO, PM10, heavy metzals and persistent organic pollutants, no uncertainty estimates are currently made. Details on uncertainty of the activity data can also be checked in the Luxembourg's National Inventory report (NIR). Please also refer to Table 1-33 to Table 1-37 of section 1.7 for caterogory specific uncertainties on activity data and emission factors.

Generally, the time-series, as reported in category *1A2g viii – Other Stationary* are considered consistent.

3.2.3.8.2.5 Source-specific QA/QC and verification

Activity data for large facilities that have reporting obligations under the European Union Emission Trading System (EU-ETS) are cross-checked between two sources: reports obtained directly from (1) the operator under its operational permit obligations and (2) the EU-ETS registry operator. Both are hosted at the Environment Agency. A list with the large energy consuming facilities along with their respective fuel consumption has been compiled and enables the Single National Entity to quickly cross-check this data with the EU-ETS data. Thus, completeness can be checked on a more systematic basis.

Consistency and completeness checks are performed.

3.2.3.8.2.6 Category-specific recalculations including changes made in response to the review process

Table 3-90 presents the main revisions and recalculations done since submission 2023 and relevant to category *1A2g viii Other Stationary*.

Table 3-90 – Recalculations done since the last submission for category – *1A2g viii – Other Stationary*

Source category	Revisions 2023 → 2024	Type of revision
1A2g viii	Revision of the residual fuel oil, liquid petroleum gas, and biogas activity data due to changes in the national energy balance for 2021 (+7728 GJ for RFO, +47 GJ for LPG, and +2993 GJ for biogas compared to the previous submission).	AD
1A2a/c/d/e/f/gv iii	In the latest national energy balance, changes were made to the allocation method of natural gas to the different sectors for the year 2021. Consequently, the natural gas AD in the sector 1A2gviii increased by 110 TJ.	AD
1A2g viii	Error correction: emissions from the combustion of natural gas and wood were double counted in sectors 1A1a and 1A2gviii for 2018-2021 in the previous submissions. This error has been corrected.	AD Error correction
1A2g viii	Revision of the NH_3 emissions for 2019-2021 due to a switch from Tier 2 to Tier 3.	Change of methodology
1A2g viii	Error correction of the AD for residual fuel oil from the national energy balance for the year 2005.	AD error correction

3.2.3.8.2.7 Category-specific planned improvements including those in response to the review process

The following improvements are planned for the next submission.

Table 3-91 – Planned improvements for category – *1A2g viii – Other Stationary*

Source category	Planned improvements	Type of revision
1A2g viii	Revision of SO_2 (and potentially other pollutants) emitted from a big wood construction and processing operator based on a combined Tier 2 and Tier 3 approach.	Emissions

3.2.4 Transport (1A3)

3.2.4.1 Category description

This section describes air pollutant emissions resulting from fuel combustion activities in the transport sector. The transport sector was and still remains (1990-2022) an important source of NO_x and CO emissions. But also, PM emissions from transport became an important source, on the one hand because of increasing activities (vehicle fleet, annual mileage, traffic performance, etc.) and on the other hand due to PM emission reduction in other sectors.

Table 3-92 – Emissions, Trends and Shares based on fuel sold and fuel used of category *1A3 - Transport*

1 A 3 Transport														
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
SOx	1.119	0.096	0.068	0.078	-93.0%	-18.4%	15.4%				6.8%	3.7%	17.6%	fuel sold
	0.288	0.056	0.047	0.063	-78.2%	11.3%	32.6%	1.9%	2.2%	14.6%				fuel used
NOx	26.361	47.024	7.743	6.326	-76.0%	-86.5%	-18.3%				64.5%	82.6%	55.1%	fuel sold
	7.786	7.970	4.346	3.995	-48.7%	-49.9%	-8.1%	34.9%	44.6%	43.7%				fuel used
NMVOC	17.153	3.670	0.710	0.698	-95.9%	-81.0%	-1.7%				55.2%	24.9%	7.0%	fuel sold
	7.708	1.065	0.394	0.417	-94.6%	-60.9%	5.8%	35.6%	8.8%	4.3%				fuel used
NH3	0.014	0.532	0.186	0.183	1161.8%	-65.6%	-1.7%				0.2%	8.3%	3.1%	fuel sold
	0.006	0.135	0.073	0.080	1245.7%	-40.5%	10.2%	0.1%	2.3%	1.4%				fuel used
CO	85.431	24.451	7.163	6.781	-92.1%	-72.3%	-5.3%				18.2%	61.5%	38.0%	fuel sold
	38.450	6.862	3.483	3.670	-90.5%	-46.5%	5.4%	9.1%	31.0%	24.9%				fuel used
TSP	1.334	2.313	0.938	0.838	-37.2%	-63.8%	-10.6%				7.5%	57.9%	33.1%	fuel sold
	0.470	0.584	0.365	0.386	-17.9%	-34.0%	5.7%	2.8%	25.8%	18.6%				fuel used
PM10	1.199	1.918	0.615	0.551	-54.1%	-71.3%	-10.4%				7.1%	59.7%	32.6%	fuel sold
	0.423	0.500	0.250	0.262	-38.0%	-47.5%	5.0%	2.6%	27.8%	18.7%				fuel used
PM2.5	1.093	1.623	0.371	0.329	-69.9%	-79.7%	-11.3%				6.8%	63.9%	31.5%	fuel sold
	0.385	0.431	0.155	0.161	-58.2%	-62.6%	3.8%	2.5%	31.9%	18.3%				fuel used

Source: Environment Agency

As presented in Table 3-92, in 2022, this source category represented 55.1% of national total NO_x emissions (based on fuel sold) and 43.7% of national total NO_x emissions (based on fuel used), whereas in 1990, this source category represented 64.5% of national total NO_x emissions (based on fuel sold) and 34.9% of national total NO_x emissions (based on fuel used). The most important sources of NO_x emissions based on fuel sold were category *1A3bi - Passenger cars* (1990: 26.8%, 2005: 17.4%, 2022: 28.3% of national total NO_x emissions) and category *1A3biii - Heavy Duty Vehicles and Buses* (1990: 35.4%, 2005: 62.5%, 2022: 13.0% of national total NO_x emissions) (see Table). A similar assessment can be made based on fuel used. The fuel export in the vehicle tank of diesel contributes significantly to national NO_x emissions based on fuels sold.

As presented in Table 3-92 and Table 3-93, from 1990 to 2022, NO_x emissions from transportation based on fuel sold decreased by 76.0% and NO_x emissions based on fuel used decreased by 48.7% due to fleet renewal, implementation of EURO standards, etc. In the period 1990-2022, NO_x emissions (based on fuel sold) from category *1A3bi - Passenger cars*, category *1A3biii – Heavy duty vehicles* and category *1A3c - Railways* were decreasing by more than 70% (see Table). NO_x emissions of category *1A3ai(i) Civil aviation – International LTO* showed, with 202.3%, the highest relative increase. In the period 1990-2022, NO_x emissions (based on fuel used) of category *1A3bi - Passenger cars* decreased by 57.6%. NO_X emissions of category *1A3biii - Heavy duty vehicles and Buses* decreased by 79.5% from 1990-2022.

Table 3-93 – NO_x, Emissions, Trends and Shares based on fuel sold and fuel used of category *1A3 - Transport*

NOx														
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
1 A 3	**26.361**	**47.024**	**7.743**	**6.326**	**-76.0%**	**-86.5%**	**-18.3%**				**64.5%**	**82.6%**	**55.1%**	**fuel sold**
	7.786	**7.970**	**4.346**	**3.995**	**-48.7%**	**-49.9%**	**-8.1%**	**34.9%**	**44.6%**	**43.7%**				**fuel used**
1 A 3 a i (i)	0.341	0.737	0.954	1.031	202.3%	39.9%	8.2%	1.5%	4.1%	11.3%	0.8%	1.3%	9.0%	fuel sold
1 A 3 a ii (i)	0.000	0.001	0.001	0.001	150.1%	-12.5%	-10.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 b i	10.961	9.892	3.728	3.247	-70.4%	-67.2%	-12.9%				26.8%	17.4%	28.3%	fuel sold
	4.578	3.554	2.173	1.941	-57.6%	-45.4%	-10.7%	20.5%	19.9%	21.2%				fuel used
1 A 3 b ii	0.299	0.711	0.636	0.493	64.6%	-30.7%	-22.5%				0.7%	1.3%	4.3%	fuel sold
	0.299	0.711	0.636	0.493	64.6%	-30.7%	-22.5%	1.3%	4.0%	5.4%				fuel used
1 A 3 b iii	14.480	35.553	2.354	1.495	-89.7%	-95.8%	-36.5%				35.4%	62.5%	13.0%	fuel sold
	2.288	2.837	0.512	0.470	-79.5%	-83.4%	-8.3%	10.3%	15.9%	5.1%				fuel used
1 A 3 b iv	0.006	0.011	0.009	0.010	63.3%	-13.2%	0.5%				0.0%	0.0%	0.1%	fuel sold
	0.006	0.011	0.009	0.010	63.3%	-13.2%	0.5%	0.0%	0.1%	0.1%				fuel used
1 A 3 b v	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 b vi	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 b vii	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 c	0.258	0.099	0.057	0.044	-82.8%	-55.2%	-21.8%	1.2%	0.6%	0.5%	0.6%	0.2%	0.4%	fuel sold
1 A 3 d i (ii)	0.001	0.002	0.000	0.000	-83.9%	-90.0%	50.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 d ii	0.014	0.017	0.004	0.005	-62.8%	-68.3%	22.2%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	fuel sold
1 A 3 e i	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 3 e ii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
National total (fuel sold)	**40.866**	**56.915**	**13.941**	**11.476**	**-71.9%**	**-79.8%**	**-17.7%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**22.291**	**17.861**	**10.545**	**9.145**	**-59.0%**	**-48.8%**	**-13.3%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

Source: Environment Agency

As presented in Table 3-92 and in more detail in Table 3-94, in 2022, source category *1A3 Transport* represented 17.6% of national total SO_2 emissions (based on fuel sold) and 14.6% of national total SO_2 emissions (based on fuel used), whereas in 1990, this source category represented 6.8% of national total SO_2 emissions (based on fuel sold) and 1.9% of national total SO_2 emissions (based on fuel used). In 2022, the most important source of SO_2 emissions based on fuel sold was category *1A3ai(i) Civil aviation - International LTO* (1990: 0.2%, 2005: 1.7%, 2022: 11.6% of national total SO_2 emissions) followed by category *1A3biii - Heavy Duty Vehicles and Buses* (1990: 4.8%, 2005: 1.3%, 2022: 3.0% of national total SO_2 emissions). The significant reduction of SO_2 emissions of category *1A3 Transport* of about 93.0% (based on fuel sold) and 78.2% (based on fuel used), in the period 1990-2022, was mainly due to the decreasing fuel sulphur content.

In 2022, the transport sector represented 7.0% of national total NMVOC emissions (based on fuel sold) and 4.3% of national total NMVOC emissions (based on fuel used), whereas in 1990, this source category represented 55.2% of national total NMVOC emissions (based on fuel sold) and 35.6% of national total NMVOC emissions (based on fuel used) (see Table). The most important source of NMVOC emissions based on fuel sold, by far, was category *1A3bi - Passenger cars* (1990: 38.8%, 2005: 13.6%, 2022: 3.7% of national total NMVOC emissions) (see Table). Other important sources of NMVOC emissions were category *1A3biii - Heavy duty vehicles and Buses* (1990: 2.4%, 2005: 7.5%, 2022: 0.6% of national total NMVOC emissions) and category *1A3bv - Evaporation* (1990: 12.9%, 2005: 1.9%, 2022: 0.6% of national total NMVOC emissions). The most important source of NMVOC emissions based on fuel used was category *1A3bi - Passenger cars* (1990: 24.1%, 2005: 4.5%, 2022: 1.7% of national total NMVOC emissions). Compared to 1990, NMVOC emissions from transport decreased by 95.9%.

In 2022, category *1A3 - Transport* represented 3.1% of national total NH_3 emissions (based on fuel sold) and 1.4% of national total NH_3 emissions (based on fuel used), whereas in 1990, this source category represented 0.2% of national total NH_3 emissions (based on fuel sold) and 0.1% of national total NH_3 emissions (based on fuel used). The most important source of NH_3 emissions based on fuel sold was category *1A3bi - Passenger cars* (1990: 0.2%, 2005: 8.1%, 2021: 2.5% of national total NH_3 emissions). Due to the increased diesel consumption and the installation of three-way catalytic converters in the vehicle fleet, NH_3 emissions increased overall by 1162% in the period 1990-2022.

Table 3-94 – SO_2, NMVOC and NH_3 Emissions, Trends and Shares based on fuel sold and fuel used for sub-category 1A3 - Transport

SOx														
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
1 A 3	**1.119**	**0.096**	**0.068**	**0.078**	**-93.0%**	**-18.4%**	**15.4%**				**6.8%**	**3.7%**	**17.6%**	**fuel sold**
	0.288	**0.056**	**0.047**	**0.063**	**-78.2%**	**11.3%**	**32.6%**	**1.9%**	**2.2%**	**14.6%**				**fuel used**
1 A 3 a i (i)	0.027	0.045	0.036	0.051	87.3%	13.7%	43.7%	0.2%	1.8%	12.0%	0.2%	1.7%	11.6%	fuel sold
1 A 3 a ii (i)	0.000	0.000	0.000	0.000	150.1%	-12.5%	-10.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 b i	0.259	0.014	0.010	0.010	-96.1%	-28.9%	1.7%				1.6%	0.5%	2.3%	fuel sold
	0.079	0.005	0.005	0.006	-92.7%	13.2%	5.1%	0.5%	0.2%	1.3%				fuel used
1 A 3 b ii	0.026	0.001	0.001	0.001	-96.1%	20.8%	-9.6%				0.2%	0.0%	0.2%	fuel sold
	0.026	0.001	0.001	0.001	-96.1%	20.8%	-9.6%	0.2%	0.0%	0.2%				fuel used
1 A 3 b iii	0.785	0.032	0.018	0.013	-98.3%	-58.9%	-26.3%				4.8%	1.3%	3.0%	fuel sold
	0.135	0.002	0.002	0.002	-98.2%	2.7%	7.3%	0.9%	0.1%	0.6%				fuel used
1 A 3 b iv	0.000	0.000	0.000	0.000	-86.9%	44.9%	4.9%				0.0%	0.0%	0.0%	fuel sold
	0.000	0.000	0.000	0.000	-86.9%	44.9%	4.9%	0.0%	0.0%	0.0%				fuel used
1 A 3 b v	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 b vi	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 b vii	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 c	0.020	0.003	0.003	0.002	-89.6%	-25.7%	-19.4%	0.1%	0.1%	0.5%	0.1%	0.1%	0.5%	fuel sold
1 A 3 d i (ii)	0.000	0.000	0.000	0.000	-99.8%	-87.5%	55.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 d ii	0.001	0.000	0.000	0.000	-99.6%	-64.9%	28.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 e i	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 3 e ii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
National total (fuel sold)	**16.369**	**2.593**	**0.748**	**0.444**	**-97.3%**	**-82.9%**	**-40.6%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**15.539**	**2.554**	**0.728**	**0.429**	**-97.2%**	**-83.2%**	**-41.1%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

NMVOC														
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
1 A 3	**17.153**	**3.670**	**0.710**	**0.698**	**-95.9%**	**-81.0%**	**-1.7%**				**55.2%**	**24.9%**	**7.0%**	**fuel sold**
	7.708	**1.065**	**0.394**	**0.417**	**-94.6%**	**-60.9%**	**5.8%**	**35.6%**	**8.8%**	**4.3%**				**fuel used**
1 A 3 a i (i)	0.034	0.056	0.045	0.064	87.3%	13.7%	43.7%	0.2%	0.5%	0.7%	0.1%	0.4%	0.6%	fuel sold
1 A 3 a ii (i)	0.001	0.004	0.004	0.004	150.1%	-12.5%	-10.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 b i	12.044	2.000	0.377	0.369	-96.9%	-81.6%	-2.1%				38.8%	13.6%	3.7%	fuel sold
	5.210	0.546	0.159	0.165	-96.8%	-69.8%	3.8%	24.1%	4.5%	1.7%				fuel used
1 A 3 b ii	0.127	0.029	0.005	0.004	-96.6%	-85.4%	-15.9%				0.4%	0.2%	0.0%	fuel sold
	0.127	0.029	0.005	0.004	-96.6%	-85.4%	-15.9%	0.6%	0.2%	0.0%				fuel used
1 A 3 b iii	0.736	1.106	0.078	0.059	-92.0%	-94.7%	-24.5%				2.4%	7.5%	0.6%	fuel sold
	0.346	0.156	0.014	0.015	-95.8%	-90.6%	1.6%	1.6%	1.3%	0.2%				fuel used
1 A 3 b iv	0.142	0.162	0.130	0.126	-11.2%	-22.1%	-2.7%				0.5%	1.1%	1.3%	fuel sold
	0.142	0.162	0.130	0.126	-11.2%	-22.1%	-2.7%	0.7%	1.3%	1.3%				fuel used
1 A 3 b v	3.996	0.279	0.064	0.065	-98.4%	-76.9%	1.4%				12.9%	1.9%	0.6%	fuel sold
	1.776	0.078	0.029	0.031	-98.2%	-59.8%	7.1%	8.2%	0.6%	0.3%				fuel used
1 A 3 b vi	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 b vii	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 c	0.049	0.015	0.005	0.004	-91.4%	-71.6%	-21.5%	0.2%	0.1%	0.0%	0.2%	0.1%	0.0%	fuel sold
1 A 3 d i (ii)	0.001	0.001	0.000	0.000	-89.4%	-91.8%	49.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 d ii	0.021	0.018	0.003	0.003	-85.2%	-81.9%	26.8%	0.1%	0.1%	0.0%	0.1%	0.1%	0.0%	fuel sold
1 A 3 e i	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 3 e ii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
National total (fuel sold)	**31.072**	**14.749**	**10.176**	**10.008**	**-67.8%**	**-32.1%**	**-1.7%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**21.628**	**12.143**	**9.860**	**9.727**	**-55.0%**	**-19.9%**	**-1.4%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

NH3														
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
1 A 3	**0.014**	**0.532**	**0.186**	**0.183**	**1161.8%**	**-65.6%**	**-1.7%**				**0.2%**	**8.3%**	**3.1%**	**fuel sold**
	0.006	**0.135**	**0.073**	**0.080**	**1245.7%**	**-40.5%**	**10.2%**	**0.1%**	**2.3%**	**1.4%**				**fuel used**
1 A 3 a i (i)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	fuel sold
1 A 3 a ii (i)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	fuel sold
1 A 3 b i	0.012	0.520	0.143	0.150	1100.7%	-71.2%	4.5%				0.2%	8.1%	2.5%	fuel sold
	0.005	0.133	0.063	0.071	1256.4%	-46.8%	11.2%	0.1%	2.2%	1.2%				fuel used
1 A 3 b ii	0.000	0.001	0.004	0.004	1611.2%	222.7%	-2.5%				0.0%	0.0%	0.1%	fuel sold
	0.000	0.001	0.004	0.004	1611.2%	222.7%	-2.5%	0.0%	0.0%	0.1%				fuel used
1 A 3 b iii	0.002	0.011	0.039	0.029	1655.9%	164.6%	-24.8%				0.0%	0.2%	0.5%	fuel sold
	0.000	0.001	0.005	0.006	1325.2%	480.6%	9.0%	0.0%	0.0%	0.1%				fuel used
1 A 3 b iv	0.000	0.000	0.000	0.000	171.0%	48.9%	5.0%				0.0%	0.0%	0.0%	fuel sold
	0.000	0.000	0.000	0.000	171.0%	48.9%	5.0%	0.0%	0.0%	0.0%				fuel used
1 A 3 b v	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 b vi	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 b vii	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 c	0.000	0.000	0.000	0.000	-85.1%	-55.6%	-20.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 d i (ii)	0.000	0.000	0.000	0.000	-83.8%	-89.5%	52.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 d ii	0.000	0.000	0.000	0.000	-73.8%	-72.7%	25.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 e i	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 3 e ii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
National total (fuel sold)	**6.369**	**6.379**	**6.310**	**5.949**	**-6.6%**	**-6.7%**	**-5.7%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**6.361**	**5.982**	**6.197**	**5.847**	**-8.1%**	**-2.3%**	**-5.6%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

Source: Environment Agency

In 2022, source category *1A3-Transport* represented 38.0% of national total CO emissions (based on fuel sold) and 24.9% of national total CO emissions (based on fuel used), whereas in 1990, this source category represented 18.2% of national total CO emissions (based on fuel sold) and 9.1% of national total CO emissions (based on fuel used). In 2005, the transport sector covered a share of 61.5% of national total CO emissions based on fuel sold, and a share of 31.0% of national total CO emissions based on fuel used. In the period 1990-2022, a reduction of 92.1% of CO emissions based on fuel sold and a reduction of 90.5%, based on fuel used, could be achieved (see Table 3-92 and for more detail, Table 3-95).

In 2022, source category *1A3-Transport* represented 31.5% of national total $PM_{2.5}$ emissions (based on fuel sold) and 18.3% of national total $PM_{2.5}$ emissions (based on fuel used), whereas in 1990, this source category represented 6.8% of national total $PM_{2.5}$ emissions (based on fuel sold) and 2.5% of national total $PM_{2.5}$ emissions (based on fuel used). For the period 1990-2022, a decrease of 69.9% could be observed, based on fuel sold (58.2% based on fuel used), and for the period 2005-2022, a decrease of 79.7% could be noted (based on fuel sold, 62.6% based on fuel used) (see Table 3-92 and for more detail, Table 3-95).

The most important source of $PM_{2.5}$ emissions based on fuel sold was category *1A3bvi - Automobile tyre and break wear* (1990: 0.5%, 2005: 8.8%, 2022: 15.9% of national total $PM_{2.5}$ emissions). The other important sources of $PM_{2.5}$ emissions, based on fuel sold, were category *1A3bvii - Automobile road abrasion* (1990: 0.3%, 2005: 5.3%, 2022: 9.5% of national total $PM_{2.5}$ emissions), *1A3biii - Heavy duty vehicles and buses* (1990: 3.5%, 2005: 27.6%, 2022: 1.9% of national total $PM_{2.5}$ emissions) and category *1A3bi - Passenger cars* (1990: 1.9%, 2005: 18.8%, 2022: 1.6% of national total $PM_{2.5}$ emissions) (see Table 3-95).

In 2022, source category *1A3-Transport* represented 32.6% of national total PM_{10} emissions (based on fuel sold) and 18.7% of national total PM_{10} emissions (based on fuel used), whereas in 1990, this source category represented 7.1% of national total PM_{10} emissions (based on fuel sold) and 2.6% of national total PM_{10} emissions (based on fuel used).

In 2022, source category *1A3-Transport* represented 33.1% of national total TSP emissions (based on fuel sold) and 18.6% of national total TSP emissions (based on fuel used), whereas in 1990, this source category represented 7.5% of national total TSP emissions (based on fuel sold) and 2.8% of national total TSP emissions (based on fuel used).

Table 3-95 – CO, $PM_{2.5}$, PM_{10}, TSP Emissions, Trends and Shares based on fuel sold and fuel used for category *1A3 - Transport*

CO

NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
1 A 3	**85.431**	**24.451**	**7.163**	**6.781**	**-92.1%**	**-72.3%**	**-5.3%**				**18.2%**	**61.5%**	**38.0%**	**fuel sold**
1 A 3	**38.450**	**6.862**	**3.483**	**3.670**	**-90.5%**	**-46.5%**	**5.4%**	**9.1%**	**31.0%**	**24.9%**				**fuel used**
1 A 3 a i (i)	0.318	0.524	0.414	0.595	87.3%	13.7%	43.7%	0.1%	2.4%	4.0%	0.1%	1.3%	3.3%	fuel sold
1 A 3 a ii (i)	0.063	0.179	0.174	0.156	150.1%	-12.5%	-10.2%	0.0%	0.8%	1.1%	0.0%	0.4%	0.9%	fuel sold
1 A 3 b i	80.250	17.002	4.915	4.814	-94.0%	-71.7%	-2.1%				17.1%	42.8%	27.0%	fuel sold
	34.879	4.484	2.089	2.171	-93.8%	-51.6%	3.9%	8.3%	20.2%	14.7%				fuel used
1 A 3 b ii	1.595	0.410	0.159	0.136	-91.5%	-66.8%	-14.7%				0.3%	1.0%	0.8%	fuel sold
	1.595	0.410	0.159	0.136	-91.5%	-66.8%	-14.7%	0.4%	1.8%	0.9%				fuel used
1 A 3 b iii	2.450	5.694	1.110	0.695	-71.6%	-87.8%	-37.4%				0.5%	14.3%	3.9%	fuel sold
	0.839	0.623	0.256	0.226	-73.0%	-63.7%	-11.5%	0.2%	2.8%	1.5%				fuel used
1 A 3 b iv	0.376	0.493	0.339	0.337	-10.4%	-31.7%	-0.6%				0.1%	1.2%	1.9%	fuel sold
	0.376	0.493	0.339	0.337	-10.4%	-31.7%	-0.6%	0.1%	2.2%	2.3%				fuel used
1 A 3 b v	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 b vi	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 b vii	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 c	0.280	0.089	0.039	0.031	-88.9%	-65.0%	-20.8%	0.1%	0.4%	0.2%	0.1%	0.2%	0.2%	fuel sold
1 A 3 d i (ii)	0.001	0.001	0.000	0.000	-74.4%	-86.1%	53.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 d ii	0.100	0.060	0.012	0.016	-83.6%	-72.8%	33.8%	0.0%	0.3%	0.1%	0.0%	0.2%	0.1%	fuel sold
1 A 3 e i	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 3 e ii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
National total (fuel sold)	**469.347**	**39.753**	**18.203**	**17.838**	**-96.2%**	**-55.1%**	**-2.0%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**422.365**	**22.163**	**14.524**	**14.727**	**-96.5%**	**-33.6%**	**1.4%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

PM2.5

NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
1 A 3	**1.093**	**1.623**	**0.371**	**0.329**	**-69.9%**	**-79.7%**	**-11.3%**				**6.8%**	**63.9%**	**31.5%**	**fuel sold**
	0.385	**0.431**	**0.155**	**0.161**	**-58.2%**	**-62.6%**	**3.8%**	**2.5%**	**31.9%**	**18.3%**				**fuel used**
1 A 3 a i (i)	0.003	0.005	0.004	0.005	87.3%	13.7%	43.7%	0.0%	0.3%	0.6%	0.0%	0.2%	0.5%	fuel sold
1 A 3 a ii (i)	0.000	0.000	0.000	0.000	150.1%	-12.5%	-10.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 b i	0.308	0.477	0.018	0.017	-94.6%	-96.5%	-6.9%				1.9%	18.8%	1.6%	fuel sold
	0.087	0.183	0.009	0.009	-89.6%	-95.1%	-4.7%	0.6%	13.6%	1.0%				fuel used
1 A 3 b ii	0.030	0.056	0.011	0.009	-69.0%	-83.2%	-13.6%				0.2%	2.2%	0.9%	fuel sold
	0.030	0.056	0.011	0.009	-69.0%	-83.2%	-13.6%	0.2%	4.1%	1.1%				fuel used
1 A 3 b iii	0.559	0.702	0.030	0.020	-96.5%	-97.2%	-35.0%				3.5%	27.6%	1.9%	fuel sold
	0.153	0.081	0.007	0.007	-95.7%	-91.9%	-11.0%	1.0%	6.0%	0.7%				fuel used
1 A 3 b iv	0.006	0.008	0.010	0.010	59.6%	27.2%	1.5%				0.0%	0.3%	0.9%	fuel sold
	0.006	0.008	0.010	0.010	59.6%	27.2%	1.5%	NO	NO	1.1%				fuel used
1 A 3 b v	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 b vi	0.080	0.223	0.183	0.166	108.5%	-25.4%	-9.4%				0.5%	8.8%	15.9%	fuel sold
	0.028	0.051	0.070	0.075	167.3%	47.2%	6.9%	0.2%	3.8%	8.6%				fuel used
1 A 3 b vii	0.046	0.136	0.112	0.099	114.9%	-27.0%	-11.0%				0.3%	5.3%	9.5%	fuel sold
	0.016	0.029	0.040	0.043	160.6%	45.9%	7.2%	0.1%	2.2%	4.9%				fuel used
1 A 3 c	0.059	0.017	0.004	0.003	-95.1%	-82.8%	-22.3%	0.4%	1.2%	0.3%	0.4%	0.7%	0.3%	fuel sold
1 A 3 d i (ii)	0.000	0.000	0.000	0.000	-86.8%	-91.0%	49.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 d ii	0.002	0.002	0.000	0.000	-88.8%	-84.9%	19.1%	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%	fuel sold
1 A 3 e i	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 3 e ii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
National total (fuel sold)	**16.081**	**2.541**	**1.062**	**1.046**	**-93.5%**	**-58.8%**	**-1.5%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**15.372**	**1.348**	**0.846**	**0.878**	**-94.3%**	**-34.9%**	**3.8%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

PM10

NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
1 A 3	**1.199**	**1.918**	**0.615**	**0.551**	**-54.1%**	**-71.3%**	**-10.4%**				**7.1%**	**59.7%**	**32.6%**	**fuel sold**
	0.423	**0.500**	**0.250**	**0.262**	**-38.0%**	**-47.5%**	**5.0%**	**2.6%**	**27.8%**	**18.7%**				**fuel used**
1 A 3 a i (i)	0.003	0.005	0.004	0.005	87.3%	13.7%	43.7%	0.0%	0.3%	0.4%	0.0%	0.1%	0.3%	fuel sold
1 A 3 a ii (i)	0.000	0.000	0.000	0.000	150.1%	-12.5%	-10.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 b i	0.308	0.477	0.018	0.017	-94.6%	-96.5%	-6.9%				1.8%	14.8%	1.0%	fuel sold
	0.087	0.183	0.009	0.009	-89.6%	-95.1%	-4.7%	0.5%	10.2%	0.6%				fuel used
1 A 3 b ii	0.030	0.056	0.011	0.009	-69.0%	-83.2%	-13.6%				0.2%	1.7%	0.6%	fuel sold
	0.030	0.056	0.011	0.009	-69.0%	-83.2%	-13.6%	0.2%	3.1%	0.7%				fuel used
1 A 3 b iii	0.559	0.702	0.030	0.020	-96.5%	-97.2%	-35.0%				3.3%	21.8%	1.2%	fuel sold
	0.153	0.081	0.007	0.007	-95.7%	-91.9%	-11.0%	1.0%	4.5%	0.5%				fuel used
1 A 3 b iv	0.006	0.008	0.010	0.010	59.6%	27.2%	1.5%				0.0%	0.2%	0.6%	fuel sold
	0.006	0.008	0.010	0.010	59.6%	27.2%	1.5%	NO	NO	0.7%				fuel used
1 A 3 b v	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 b vi	0.146	0.402	0.332	0.303	107.4%	-24.5%	-8.8%				0.9%	12.5%	17.9%	fuel sold
	0.053	0.095	0.131	0.140	165.9%	47.3%	6.9%	0.3%	5.3%	10.0%				fuel used
1 A 3 b vii	0.086	0.252	0.207	0.184	114.9%	-27.0%	-11.0%				0.5%	7.8%	10.9%	fuel sold
	0.030	0.054	0.074	0.079	160.6%	45.9%	7.2%	0.2%	3.0%	5.6%				fuel used
1 A 3 c	0.059	0.017	0.004	0.003	-95.1%	-82.8%	-22.3%	0.4%	0.9%	0.2%	0.4%	0.5%	0.2%	fuel sold
1 A 3 d i (ii)	0.000	0.000	0.000	0.000	-86.8%	-91.0%	49.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 d ii	0.002	0.002	0.000	0.000	-88.8%	-84.9%	19.1%	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%	fuel sold
1 A 3 e i	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 3 e ii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
National total (fuel sold)	**16.827**	**3.214**	**1.621**	**1.689**	**-90.0%**	**-47.5%**	**4.2%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**16.051**	**1.796**	**1.256**	**1.400**	**-91.3%**	**-22.0%**	**11.5%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

TSP

NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
1 A 3	**1.334**	**2.313**	**0.938**	**0.838**	**-37.2%**	**-63.8%**	**-10.6%**				**7.5%**	**57.9%**	**33.1%**	**fuel sold**
1 A 3	**0.470**	**0.584**	**0.365**	**0.386**	**-17.9%**	**-34.0%**	**5.7%**	**2.8%**	**25.8%**	**18.6%**				**fuel used**
1 A 3 a i (i)	0.003	0.005	0.004	0.005	87.3%	13.7%	43.7%	0.0%	0.2%	0.3%	0.0%	0.1%	0.2%	fuel sold
1 A 3 a ii (i)	0.000	0.000	0.000	0.000	150.1%	-12.5%	-10.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 b i	0.308	0.477	0.018	0.017	-94.6%	-96.5%	-6.9%				1.7%	11.9%	0.7%	fuel sold
	0.087	0.183	0.009	0.009	-89.6%	-95.1%	-4.7%	0.5%	8.1%	0.4%				fuel used
1 A 3 b ii	0.030	0.056	0.011	0.009	-69.0%	-83.2%	-13.6%				0.2%	1.4%	0.4%	fuel sold
	0.030	0.056	0.011	0.009	-69.0%	-83.2%	-13.6%	0.2%	2.5%	0.5%				fuel used
1 A 3 b iii	0.559	0.702	0.030	0.020	-96.5%	-97.2%	-35.0%				3.2%	17.6%	0.8%	fuel sold
	0.153	0.081	0.007	0.007	-95.7%	-91.9%	-11.0%	0.9%	3.6%	0.3%				fuel used
1 A 3 b iv	0.006	0.008	0.010	0.010	59.6%	27.2%	1.5%				0.0%	0.2%	0.4%	fuel sold
	0.006	0.008	0.010	0.010	59.6%	27.2%	1.5%	0.0%	0.3%	0.5%				fuel used
1 A 3 b v	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO				fuel used
1 A 3 b vi	0.195	0.544	0.448	0.407	108.3%	-25.3%	-9.3%				1.1%	13.6%	16.1%	fuel sold
	0.069	0.125	0.173	0.185	167.2%	47.2%	6.9%	0.4%	5.5%	8.9%				fuel used
1 A 3 b vii	0.171	0.503	0.413	0.368	114.9%	-27.0%	-11.0%				1.0%	12.6%	14.5%	fuel sold
	0.061	0.108	0.148	0.158	160.6%	45.9%	7.2%	0.4%	4.8%	7.6%				fuel used
1 A 3 c	0.059	0.017	0.004	0.003	-95.1%	-82.8%	-22.3%	0.4%	0.7%	0.1%	0.3%	0.4%	0.1%	fuel sold
1 A 3 d i (ii)	0.000	0.000	0.000	0.000	-86.8%	-91.0%	49.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 d ii	0.002	0.002	0.000	0.000	-88.8%	-84.9%	19.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 e i	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 3 e ii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
National total (fuel sold)	**17.687**	**3.996**	**2.184**	**2.531**	**-85.7%**	**-36.7%**	**15.9%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**16.823**	**2.268**	**1.612**	**2.078**	**-87.6%**	**-8.4%**	**28.9%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

Source: Environment Agency

Table 3-96 presents the key categories for the main pollutans, and Table presents the key categories for the heavy metals and persistant organic pollutants of *1A3 – Transport* (see also Table 3-4 in Section 3.2 and Chapter 1.5).

Table 3-96 – Key Category Analysis of category *1A3 - Transport*

Key Source Analysis (FUEL SOLD): Ranking per number		SO2		NOX		NMVOC		NH3		CO		TSP		PM10		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
1 A 3 a i (i)	Civil Aviation - International - LTO	2	2	3	3												
1 A 3 b i	Road Transport, Passenger cars			1		8	1		2	1	3						
1 A 3 b ii	Road Transport, Light duty vehicles			7	7												
1 A 3 b iii	Road Transport, Heavy duty vehicles			2	1					6							
1 A 3 b v	Road Transport, Gasoline evaporation						3										
1 A 3 b vi	Road Transport, Automobile tyre and break wear											2	3	2	2	2	3
1 A 3 b vii	Road Transport, Automobile road abrasion											3	4	4	5	4	

Key Source Analysis (FUEL USED): Ranking per number		SO2		NOX		NMVOC		NH3		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
1 A 3 a i (i)	Civil Aviation - International - LTO	2	2	2	2						
1 A 3 b i	Road Transport, Passenger cars			1			1		3		
1 A 3 b ii	Road Transport, Light duty vehicles			6	7						
1 A 3 b iii	Road Transport, Heavy duty vehicles			8	5						
1 A 3 b v	Road Transport, Gasoline evaporation						4				
1 A 3 b vi	Road Transport, Automobile tyre and break wear									3	4
1 A 3 b vii	Road Transport, Automobile road abrasion									5	

Sources: Environment Agency

Notes: LA = Level Assessment, TA = Trend Assessment

Number in Table = indicates the rank in the specific analysis (1…biggest KC; 2… second biggest KC, …)

Table 3-97 – Key Category Analysis for heavy metals and POPs and category *1A3 - Transport*

Key Source Analysis (FUEL SOLD): Ranking per number		Pb		Cd		Hg		PCDD/F		PCB		HCB		PAH	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
1 A 3 a ii (i)	Civil Aviation - Domestic - LTO	3													
1 A 3 b i	Road Transport, Passenger cars		3												
1 A 3 b vi	Road Transport, Automobile tyre and break wear	1	2	4											
Legend	**LA** Level Assessment	**TA** Trend assessment													
	number in Table indicates the rank in the specific analysis (1…biggest KC; 2… second biggest KC, …)														

3.2.4.2 Civil Aviation (1A3a)

3.2.4.2.1 Source category description

In Luxembourg, civil aviation is a rather small activity. There is only one airport for commercial aviation in Luxembourg (Findel) operated by Lux-Airport. Therefore, all commercial flights either inbound or outbound, are international flights. Private flights with Luxembourg as a start and return point are considered as domestic flights. These are mainly leisure or emergency (medical, police) flights made with small-sized propeller planes or helicopters.

Hence, source category *1A3a – Civil aviation* includes emissions from:

- *1A3a i (i) - Civil Aviation – International - LTO:* only landing and take-off. Emissions from cruise is excluded and reported under memo-items.
- *1A3a ii(i) - Civil Aviation – Domestic:* all other flights.

Table 3-98 and Table 3-99 present the emissions of air pollutants for 1990, 2005, 2020 and 2022 as well as the trends and shares based on fuel sold for categories *1A3ai(i) - Civil Aviation – International – LTO* and *1A3aii(i) - Civil Aviation – Domestic*.

In 2022, the source categories *1A3ai(i)* and *1A3aii(i)* represented less than 12% of national total for each air pollutant. Since 1990, all air pollutants increased significantly due to increased international aviation activities (see Table 3-100 and Table 3-101). Compared to 2020, the emissions rebounded in 2021 due to the partial lift of the COVID-19 restrictions the year prior. The high energy prices in 2022 did not have an effect on category *1A3ai(i)* as SO_2 and NO_X emissions increased by 43.7% and 8.2% respectively.

1A3ai(i) - Civil Aviation – International – LTO is a key category in 2022 for NO_X and SO_2 (LA & TA) emissions (see Table 3-96 and also Table 3-4in Section 3.2 and Chapter 1.5).

1A3aii(i) - Civil Aviation – Domestic – LTO is a key category in 2022 for Pb (LA) emissions from (see Table 3-97 and also Table 3-4 in Section 3.2 and Chapter 1.5).

Table 3-98 – Emissions, Trends and Shares based on fuel sold and fuel used for category *1A3a i(i) - Civil Aviation – International – LTO*

1 A Mobile Fuel Combustion

Emissions [Gg], Trend and Share in National Totals of air pollutants based on fuel sold and fuel used

1 A 3 a i (i) International aviation LTO (civil)

Pollutant	Emissions				Trend			FUEL USED			FUEL SOLD			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
SO2	0.0274	0.0452	0.0357	0.0514	87.3%	13.7%	43.7%	0.176%	1.768%	11.974%	0.168%	1.742%	11.562%	fuel sold
NOx	0.3412	0.7372	0.9536	1.0314	202.3%	39.9%	8.2%	1.531%	4.127%	11.279%	0.835%	1.295%	8.988%	fuel sold
NMVOC	0.0342	0.0563	0.0445	0.0640	87.3%	13.7%	43.7%	0.158%	0.463%	0.658%	0.110%	0.382%	0.640%	fuel sold
NH3	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	fuel sold
CO	0.3179	0.5236	0.4143	0.5954	87.3%	13.7%	43.7%	0.075%	2.362%	4.043%	0.068%	1.317%	3.338%	fuel sold
TSP	0.0028	0.0046	0.0036	0.0052	87.3%	13.7%	43.7%	0.017%	0.202%	0.251%	0.016%	0.115%	0.206%	fuel sold
PM10	0.0028	0.0046	0.0036	0.0052	87.3%	13.7%	43.7%	0.017%	0.255%	0.372%	0.017%	0.143%	0.309%	fuel sold
PM2.5	0.0028	0.0046	0.0036	0.0052	87.3%	13.7%	43.7%	0.018%	0.340%	0.594%	0.017%	0.180%	0.498%	fuel sold

Sources: Environment Agency

Table 3-99 – Emissions, Trends and Shares based on fuel sold and fuel used for category *1A3a ii(i) - Civil Aviation – Domestic*

1 A Mobile Fuel Combustion

Emissions [Gg], Trend and Share in National Totals of air pollutants based on fuel sold and fuel used

1 A 3 a ii (i) Domestic aviation

Pollutant	Emissions				Trend			FUEL USED			FUEL SOLD			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
SO2	0.0000	0.0001	0.0001	0.0001	150.1%	-12.5%	-10.2%	0.000%	0.004%	0.019%	0.000%	0.004%	0.019%	fuel sold
NOx	0.0002	0.0007	0.0007	0.0006	150.1%	-12.5%	-10.2%	0.001%	0.004%	0.007%	0.001%	0.001%	0.005%	fuel sold
NMVOC	0.0015	0.0042	0.0041	0.0037	150.1%	-12.5%	-10.2%	0.007%	0.035%	0.038%	0.005%	0.029%	0.037%	fuel sold
NH3	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	fuel sold
CO	0.0626	0.1787	0.1742	0.1565	150.1%	-12.5%	-10.2%	0.015%	0.806%	1.062%	0.013%	0.450%	0.877%	fuel sold
TSP	0.0000	0.0000	0.0000	0.0000	150.1%	-12.5%	-10.2%	0.000%	0.002%	0.001%	0.000%	0.001%	0.001%	fuel sold
PM10	0.0000	0.0000	0.0000	0.0000	150.1%	-12.5%	-10.2%	0.000%	0.002%	0.002%	0.000%	0.001%	0.002%	fuel sold
PM2.5	0.0000	0.0000	0.0000	0.0000	150.1%	-12.5%	-10.2%	0.000%	0.003%	0.003%	0.000%	0.001%	0.003%	fuel sold

Sources: Environment Agency

Table 3-100 – Emission trends for category *1A3ai(i) - Civil Aviation – International – LTO*

	1 A Mobile Fuel Combustion							
	Emissions of air pollutants by source category (Gg)							
Year	1 A 3 a i (i) International aviation LTO (civil)							
	SO_2	NO_X	NMVOC	NH_3	CO	TSP	PM_{10}	$PM_{2.5}$
1990	0.027	0.341	0.034	NE	0.318	0.003	0.003	0.003
1991	0.028	0.345	0.035	NE	0.329	0.003	0.003	0.003
1992	0.030	0.374	0.038	NE	0.352	0.003	0.003	0.003
1993	0.029	0.371	0.036	NE	0.338	0.003	0.003	0.003
1994	0.032	0.405	0.040	NE	0.373	0.003	0.003	0.003
1995	0.032	0.419	0.040	NE	0.376	0.003	0.003	0.003
1996	0.033	0.453	0.042	NE	0.388	0.003	0.003	0.003
1997	0.036	0.492	0.045	NE	0.415	0.004	0.004	0.004
1998	0.037	0.531	0.047	NE	0.433	0.004	0.004	0.004
1999	0.041	0.617	0.051	NE	0.474	0.004	0.004	0.004
2000	0.042	0.657	0.053	NE	0.490	0.004	0.004	0.004
2001	0.042	0.675	0.053	NE	0.489	0.004	0.004	0.004
2002	0.041	0.665	0.051	NE	0.474	0.004	0.004	0.004
2003	0.042	0.679	0.052	NE	0.487	0.004	0.004	0.004
2004	0.043	0.687	0.054	NE	0.500	0.004	0.004	0.004
2005	0.045	0.737	0.056	NE	0.524	0.005	0.005	0.005
2006	0.045	0.722	0.056	NE	0.517	0.005	0.005	0.005
2007	0.044	0.787	0.054	NE	0.506	0.004	0.004	0.004
2008	0.044	0.757	0.055	NE	0.510	0.004	0.004	0.004
2009	0.040	0.645	0.050	NE	0.466	0.004	0.004	0.004
2010	0.040	0.643	0.049	NE	0.460	0.004	0.004	0.004
2011	0.041	0.671	0.052	NE	0.480	0.004	0.004	0.004
2012	0.041	0.646	0.051	NE	0.478	0.004	0.004	0.004
2013	0.042	0.682	0.052	NE	0.486	0.004	0.004	0.004
2014	0.043	0.708	0.054	NE	0.498	0.004	0.004	0.004
2015	0.045	0.743	0.056	NE	0.521	0.005	0.005	0.005
2016	0.048	0.820	0.060	NE	0.557	0.005	0.005	0.005
2017	0.051	0.915	0.064	NE	0.596	0.005	0.005	0.005
2018	0.055	0.981	0.068	NE	0.633	0.006	0.006	0.006
2019	0.056	1.009	0.069	NE	0.644	0.006	0.006	0.006
2020	0.030	0.803	0.038	NE	0.349	0.003	0.003	0.003
2021	0.036	0.954	0.045	NE	0.414	0.004	0.004	0.004
2022	0.051	1.031	0.064	NE	0.595	0.005	0.005	0.005
Trend 1990-2022	*87.28%*	*202.31%*	*87.28%*	*NA*	*87.28%*	*87.28%*	*87.28%*	*87.28%*
2005-2022	*13.72%*	*39.92%*	*13.72%*	*NA*	*13.72%*	*13.72%*	*13.72%*	*13.72%*
2021-2022	*43.70%*	*8.16%*	*43.70%*	*NA*	*43.70%*	*43.70%*	*43.70%*	*43.70%*

Sources: Environment Agency

Table 3-101 – Emission trends for category *1A3aii(i) - Civil Aviation – Domestic*

	1 A Mobile Fuel Combustion							
	Emissions of air pollutants by source category (Gg)							
Year	1 A 3 a ii (i) Domestic aviation							
	SO_2	NO_X	NMVOC	NH_3	CO	TSP	PM_{10}	$PM_{2.5}$
1990	0.00003	0.00025	0.00148	NE	0.063	0.00001	0.00001	0.00001
1991	0.00005	0.00037	0.00225	NE	0.095	0.00002	0.00002	0.00002
1992	0.00007	0.00053	0.00317	NE	0.134	0.00003	0.00003	0.00003
1993	0.00009	0.00068	0.00410	NE	0.174	0.00003	0.00003	0.00003
1994	0.00011	0.00081	0.00485	NE	0.205	0.00004	0.00004	0.00004
1995	0.00012	0.00087	0.00523	NE	0.221	0.00004	0.00004	0.00004
1996	0.00012	0.00089	0.00534	NE	0.226	0.00004	0.00004	0.00004
1997	0.00012	0.00090	0.00541	NE	0.229	0.00004	0.00004	0.00004
1998	0.00010	0.00078	0.00466	NE	0.197	0.00004	0.00004	0.00004
1999	0.00011	0.00079	0.00476	NE	0.202	0.00004	0.00004	0.00004
2000	0.00010	0.00076	0.00454	NE	0.192	0.00004	0.00004	0.00004
2001	0.00010	0.00075	0.00451	NE	0.191	0.00004	0.00004	0.00004
2002	0.00009	0.00070	0.00418	NE	0.177	0.00003	0.00003	0.00003
2003	0.00011	0.00081	0.00486	NE	0.206	0.00004	0.00004	0.00004
2004	0.00009	0.00071	0.00427	NE	0.180	0.00003	0.00003	0.00003
2005	0.00009	0.00070	0.00423	NE	0.179	0.00003	0.00003	0.00003
2006	0.00008	0.00060	0.00360	NE	0.152	0.00003	0.00003	0.00003
2007	0.00008	0.00063	0.00381	NE	0.161	0.00003	0.00003	0.00003
2008	0.00008	0.00061	0.00365	NE	0.154	0.00003	0.00003	0.00003
2009	0.00008	0.00062	0.00373	NE	0.158	0.00003	0.00003	0.00003
2010	0.00008	0.00061	0.00368	NE	0.156	0.00003	0.00003	0.00003
2011	0.00009	0.00065	0.00391	NE	0.166	0.00003	0.00003	0.00003
2012	0.00008	0.00057	0.00340	NE	0.144	0.00003	0.00003	0.00003
2013	0.00007	0.00054	0.00325	NE	0.138	0.00003	0.00003	0.00003
2014	0.00008	0.00058	0.00346	NE	0.146	0.00003	0.00003	0.00003
2015	0.00009	0.00069	0.00416	NE	0.176	0.00003	0.00003	0.00003
2016	0.00009	0.00070	0.00419	NE	0.177	0.00003	0.00003	0.00003
2017	0.00009	0.00066	0.00400	NE	0.169	0.00003	0.00003	0.00003
2018	0.00009	0.00065	0.00389	NE	0.164	0.00003	0.00003	0.00003
2019	0.00008	0.00058	0.00349	NE	0.148	0.00003	0.00003	0.00003
2020	0.00008	0.00057	0.00340	NE	0.144	0.00003	0.00003	0.00003
2021	0.00009	0.00069	0.00412	NE	0.174	0.00003	0.00003	0.00003
2022	0.00008	0.00062	0.00370	NE	0.156	0.00003	0.00003	0.00003
Trend 1990-2022	*150.10%*	*150.10%*	*150.10%*	*NA*	*150.10%*	*150.10%*	*150.10%*	*150.10%*
2005-2022	*-12.46%*	*-12.46%*	*-12.46%*	*NA*	*-12.46%*	*-12.46%*	*-12.46%*	*-12.46%*
2021-2022	*-10.20%*	*-10.20%*	*-10.20%*	*NA*	*-10.20%*	*-10.20%*	*-10.20%*	*-10.20%*

Sources: Environment Agency

3.2.4.2.2 Methodological issues & time-series consistency

3.2.4.2.2.1 Activity data

There is only one company selling aviation fuels in Luxembourg.

Activity data for aviation gasoline is obtained directly from sole vendor. A country-specific NCV (also obtained from the sole vendor) of 43.5 GJ/t for aviation gasoline has been applied for converting physical activity data into energy units.

Expert judgement has been made for determining the share of aviation gasoline that is being exported – outbound flights – and the share that is addressed to the domestic consumption – inbound flights. Based on information obtained from the airport authorities, and from the aviation sport clubs registered in Luxembourg, it can be assumed that 90% of aviation gasoline sales are directed towards domestic flights.

Fuel consumption activity data for jet kerosene were obtained from the national energy balance compiled by the national statistics institute. The entire jet kerosene consumption in Luxembourg is attributed to international flights due to Luxembourg's specific circumstances, as explained in section 3.2.4.2.1. In order to split the fuel consumption between international landing and take-off cycles (LTOs) and the cruise flight mode, data on the number of international LTOs were obtained from both the national statistics institute and Eurostat. The LTO fuel consumption factor as well as the NO_X emission factor follow a Tier 2 methodology, which is explained in section 3.2.4.2.2.2 and is based on aircraft-specific LTO data from Eurostat. However, since the Eurostat data are only available for the period 2004-2021, the data had to be extrapolated to estimate the corresponding data for the period 1990-2003.

The fuel related data for category *1A3a – Civil Aviation* are listed in Table 3-102.

Table 3-102 – Activity data for category – *1A3a - Civil Aviation*

Activity Data by fuel type (GJ)			
Year	**Activity Total (incl. biomass)**	**1 A 3 a i (i) International aviation LTO (civil)** **Liquid Kerosene**	**1 A 3 a ii (i) Domestic aviation** **Liquid Aviation gasoline**
1990	993 940	990'530	3'410
1991	1 008 687	1'003'507	5'180
1992	1 094 016	1'086'706	7'310
1993	1 087 977	1'078'517	9'460
1994	1 187 635	1'176'445	11'190
1995	1 225 072	1'213'022	12'050
1996	1 316 836	1'304'528	12'308
1997	1 426 939	1'414'460	12'480
1998	1 532 523	1'521'782	10'742
1999	1 761 982	1'750'996	10'986
2000	1 865 444	1'854'979	10'465
2001	1 907 272	1'896'878	10'393
2002	1 871 904	1'862'271	9'633
2003	1 912 457	1'901'240	11'217
2004	1 929 142	1'919'309	9'834
2005	2 069 261	2'059'518	9'742
2006	2 036 425	2'028'129	8'296
2007	2 179 965	2'171'183	8'782
2008	2 120 279	2'111'861	8'417
2009	1 825 675	1'817'075	8'599
2010	1 825 857	1'817'361	8'496
2011	1 901 952	1'892'930	9'022
2012	1 835 134	1'827'291	7'844
2013	1 933 470	1'925'970	7'499
2014	2 011 003	2'003'030	7'974
2015	2 099 632	2'090'043	9'589
2016	2 294 933	2'285'274	9'659
2017	2 517 655	2'508'442	9'212
2018	2 669 926	2'660'962	8'965
2019	2 746 477	2'738'435	8'042
2020	2 028 331	2'020'494	7'836
2021	2 371 993	2'362'495	9'498
2022	2 747 995	2'739'467	8'528
Trend 1990-2022	*176.47%*	*176.57%*	*150.10%*
2005-2022	*32.80%*	*33.01%*	*-12.46%*
2021-2022	*15.85%*	*15.96%*	*-10.20%*

Source: Environment Agency

3.2.4.2.2.2 Methodological choices

To calculate both the LTO fuel consumption and LTO NO_X emissions, the EMEP/EEA Guidebook 2019 Tier 2 approach was taken by using data from the national statistics institute concerning the total number of international LTOs and data from Eurostat detailing the number of international LTOs per aircraft model. Using the EMEP/EEA Guidebook 2019 Master and LTO emissions calculators, the LTO fuel consumption factor and LTO NO_X emission factor are determined for each aicraft model. By multiplying the LTO fuel consumption factor and NO_X emission factor for each aircraft model by their number of LTOs, the total amount of LTO fuel consumption and NO_X emissions are calculated.

The total LTO jet kerosene consumption is shown in Table 3-102. The jet kerosene cruise consumption is calculated as the difference between the total amount of jet kerosene sold (as taken from the national statistics institute) and the total LTO jet kerosene consumption.

The LTO emissions of the pollutants NMVOC, SO_2, $PM_{2.5}$, PM_{10}, and CO were calculated by mutiplying the total LTO number by the pollutant-specific emission factors for a B737 aircraft model from the EMEP/EEA Guidebook (2019, Chap. 1A3a Aviation, Table 3.4, p. 22). The B737 aircraft model was chosen as it is representative of the aircraft fleet that operates to and from Luxembourg. The estimations of the pollutant emissions other than NO_X follow thus a Tier 1 approach.

The cruise emissions of the pollutants NO_X, NMVOC, SO_2, $PM_{2.5}$, PM_{10}, and CO were calculated by multiplying the jet kerosene cruise consumption by the pollutant-specific emission factors as taken from the EMEP/EEA Master emissions calculator for the B737 aircraft model. This approach thus also follows a Tier 1 approach.

Regarding the emissions from domestic flights using aviation gasoline, a Tier 1 approach has been taken by multiplying the total aviation gasoline fuel consumption activty data by the emission factors in Table 3-105.

3.2.4.2.2.3 Emission factors

The provenance of the NO_X emissions factors for jet kerosene are explained in section 3.2.4.2.2.2. The NO_X LTO implied emission factors are shown in Table while the NO_X cruise emission factor is shown in Table 3-103.

Table 3-103 – Implied LTO NO_X emission factor for jet kerosene

Pollutant	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
NO_X	t/LTO	0.009	0.008	0.008	0.009	0.009	0.009	0.009	0.009	0.010	0.010	0.011

Pollutant	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
NO_X	t/LTO	0.011	0.011	0.011	0.011	0.011	0.011	0.012	0.012	0.011	0.011	0.011

Pollutant	Unit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
NO_X	t/LTO	0.011	0.011	0.011	0.011	0.012	0.012	0.012	0.013	0.018	0.018	0.014

For the remaining pollutants, default LTO emission factors for jet kerosene, from the EMEP/EEA Guidebook (2019, Chap. 1A3a Aviation, Table 3.4, p.22) were used to calculate the emissions from *1A3ai (i) – International Aviation – LTO* assuming that aircraft type corresponds in average to a Boeing 737 (see Table 3-104). The cruise emissions factors for jet kerosene are taken from the EMEP/EEA Master emissions calculator for the Boeing 737 aircraft model (see Table 3-104 as well).

Table 3-104 – Emission factors for jet kerosene

Pollutants	activity	EF	Unit	Pollutants	activity	EF	Unit
NO_X	Cruise	0.0139	t/t Fuel	$PM_{2.5}$	LTO	0.00007	t/LTO
					Cruise	0.0001	t/t Fuel
NMVOC	LTO	0.00086	t/LTO	PM_{10}	LTO	0.00007	t/LTO
	Cruise	0.0002	t/t Fuel		Cruise	0.0001	t/t Fuel
SO_2	LTO	0.00069	t/LTO	CO	LTO	0.008	t/LTO
	Cruise	0.0008	t/t Fuel		Cruise	0.0043	t/t Fuel

Default NO_X, NMVOC, SO_2, and CO EMEP/EEA Guidebook emission factors for aviation gasoline combusted in piston-engined aircrafts were used to calculate the emissions for category *1A3aii(i) –Domestic Aviation* (see Table 3-105). Due to the lack of relevant emission factors, the emissions factors for $PM_{2.5}$, PM_{10}, and TSP were taken from the Austrian study *Österreichische Emissionsinventur für Staub, Winiwarter et al., 2001, Sei-bersdorf research, Anhang 4*.

Table 3-105 – Emission factors for aviation gasoline

Pollutants	Unit	EF aviation gasoline	Source
NO_X	g/kg fuel	3.14	EMEP/EEA 2019 GB, Chapter 1A3a Aviation, Table 3.10, p.28
NMVOC	g/kg fuel	18.867	
SO_2	g/kg fuel	0.42	
CO	g/kg fuel	798	
$PM_{2.5}$	g/kg fuel	3.5	Österreichische Emissionsinventur für Staub, Winiwarter et al., 2001, Seibersdorf research, Anhang 4.
PM_{10}	g/kg fuel	3.5	
TSP	g/kg fuel	3.5	

3.2.4.2.3 Methodological issues for heavy metals and POPs

3.2.4.2.3.1 Activity Data

Annual fuel consumption taken from the national energy balance.

3.2.4.2.3.2 Methodological Choices

Since EEA (2023) does not state an emission factor for Pb emissions from aviation gasoline, a custom tier 1 emission factor was derived (see Table 3-106).

Other HM and POPs emissions from this sector were considered negligible.

3.2.4.2.3.3 Emission Factors

Sources of custom Tier 1 emission factors are given in the following table:

Table 3-106 – Sources of Tier 1 HM and POP emission factors for category *1A3a - Civil Aviation*

Fuel	Pollutants	Source	Page	Table
Aviation gasoline	Pb	Since EEA (2019) does not state an emission factor for Pb emissions from aviation gasoline, a custom emission fac-tor was derived as follows: Aviation gasoline characteristics: Energy density: 0.0435 GJ/kg Density: 0.755 kg/L Lead content: 0.52 g/L Energy density per L = 0.0435 GJ/kg x 0.755 kg/L = 0.0328425 GJ/L = 30.448351983 L/GJ Lead content per GJ = 30.448351983 L/GJ x 0.52 g/L = 15.83314303116 g/GJ	N/A	N/A

3.2.4.2.4 Uncertainties and time-series consistency

The assessment of activity data and emission factor uncertainties is done according to the methodology described in the EMEP/EEA emission inventory Guidebook 2023 (Chapter A.5 Uncertainties, tables 2-1, 2-2 and 2-3), covering the main pollutants NO_x, NH_3, NMVOC, SO_x and $PM_{2.5}$. For some subcategories and pollutants, expert judgements were made to estimate AD or EF uncertainties. For CO, PM10, heavy metzals and persistent organic pollutants, no uncertainty estimates are currently made. Details on uncertainty of the activity data can also be checked in the Luxembourg's National Inventory report (NIR). Please also refer to Table 1-33 to Table 1-37 of section 1.7 for caterogory specific uncertainties on activity data and emission factors.

The time-series are considered to be consistent, although the split between domestic and international flights, combusting aviation gasoline, is kept constant over the entire time-series, due to a lack of specific annual information.

3.2.4.2.5 Source-specific QA/QC and verification

Consistency and completeness checks are performed.

3.2.4.2.6 Category-specific recalculations including changes made in response to the review process

Table 3-107 presents the main revisions and recalculations done since submission 2023.

Table 3-107 – Recalculations done since the last submission for category – *1A3a - Civil Aviation*

Source category	Revisions 2023 ➔ 2024	Type of revision
1A3a	No recalculations	

Source: Environment Agency

3.2.4.2.7 Category-specific planned improvements including those in response to the review process

The following improvements are planned for the next submission.

Table 3-108 – Planned improvements for category – *1A3a - Civil Aviation*

Source category	Planned improvements	Type of revision
1A3a	No further improvements are planned	

Source: Environment Agency

3.2.4.3 Road transport (1A3b)

3.2.4.3.1 Source category description

As already explained in a previous section of the IIR (please refer to chapter 2 on emission trends), Luxembourg's situation regarding emissions from *1A3b – Road Transportation* is quite unique, due to the high share of fuel export in the vehicles' tank.

In 2022, this source category represented:

- 45.7% of national total NO_X emissions (based on fuel sold) and 31.9% of national total NO_X emissions (based on fuel used).
- 5.5% of national total SO_2 emissions (based on fuel sold) and 2.2% of national total SO_2 emissions (based on fuel used).
- 6.2% of national total NMVOC emissions (based on fuel sold) and 3.5% of national total NMVOC emissions (based on fuel used).

- 3.1% of national total NH_3 emissions (based on fuel sold) and 1.4% of national total NH_3 emissions (based on fuel used).
- 33.5% of national total CO emissions (based on fuel sold) and 19.5% of national total CO emissions (based on fuel used).
- 32.8% of national total TSP emissions (based on fuel sold) and 18.2% of national total TSP emissions (based on fuel used).
- 32.1% of national total PM_{10} emissions (based on fuel sold) and 18.1% of national total PM_{10} emissions (based on fuel used).
- 30.7% of national total $PM_{2.5}$ emissions (based on fuel sold) and 17.4% of national total $PM_{2.5}$ emissions (based on fuel used).

Table 3-109 gives a general overview of the emissions, trends and shares for category 1*A3b - Road transport* for the years 1990, 2005, 2021 and 2022.

Table 3-109 – Emissions, Trends and Shares based on fuel sold and fuel used for category 1*A3b - Road transport*

	1 A 3 b Road Transport													
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
SOx	1.07	0.05	0.03	0.02	-97.7%	-48.4%	-16.1%				6.5%	1.8%	5.5%	fuel sold
	0.24	0.01	0.01	0.01	-96.1%	11.0%	3.8%	1.5%	0.3%	2.2%				fuel used
NOx	25.75	46.17	6.73	5.24	-79.6%	-88.6%	-22.1%				63.0%	81.1%	45.7%	fuel sold
	7.17	7.11	3.33	2.91	-59.4%	-59.1%	-12.5%	32.2%	39.8%	31.9%				fuel used
NMVOC	17.05	3.58	0.65	0.62	-96.3%	-82.6%	-4.7%				54.9%	24.3%	6.2%	fuel sold
	7.60	0.97	0.34	0.34	-95.5%	-64.8%	1.2%	35.1%	8.0%	3.5%				fuel used
NH3	0.01	0.53	0.19	0.18	1169.5%	-65.6%	-1.7%				0.2%	8.3%	3.1%	fuel sold
	0.01	0.13	0.07	0.08	1265.8%	-40.5%	10.2%	0.1%	2.3%	1.4%				fuel used
CO	84.67	23.60	6.52	5.98	-92.9%	-74.7%	-8.3%				18.0%	59.4%	33.5%	fuel sold
	37.69	6.01	2.84	2.87	-92.4%	-52.2%	1.0%	8.9%	27.1%	19.5%				fuel used
TSP	1.27	2.29	0.93	0.83	-34.7%	-63.8%	-10.8%				7.2%	57.3%	32.8%	fuel sold
	0.41	0.56	0.36	0.38	-7.0%	-32.7%	5.6%	2.4%	24.7%	18.2%				fuel used
PM10	1.13	1.90	0.61	0.54	-52.2%	-71.4%	-10.7%				6.7%	59.0%	32.1%	fuel sold
	0.36	0.48	0.24	0.25	-29.3%	-46.7%	4.9%	2.2%	26.5%	18.1%				fuel used
PM2.5	1.03	1.60	0.36	0.32	-68.8%	-80.0%	-11.7%				6.4%	63.0%	30.7%	fuel sold
	0.32	0.41	0.15	0.15	-52.4%	-62.6%	3.5%	2.1%	30.2%	17.4%				fuel used

Source: Environment Agency.

Category *1A3b – Road transport* is a key category with regard to NO_X, NMVOC, CO, TSP, PM_{10} and $PM_{2.5}$ emissions for both level and trend assessments and NH_3 in the trend assessment (see Table 3-110 and also Table 3-4 in Section 3.2 and Chapter 1.5).

Table 3-110 – Key Category Analysis of category – *1A3b - Road Transport*

Key Source Analysis (FUEL SOLD): Ranking per number		SO2		NOX		NMVOC		NH3		CO		TSP		PM10		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
1 A 3 b i	Road Transport, Passenger cars			1		8	1		2	1	3						
1 A 3 b ii	Road Transport, Light duty vehicles			7	7												
1 A 3 b iii	Road Transport, Heavy duty vehicles			2	1					6							
1 A 3 b v	Road Transport, Gasoline evaporation						3										
1 A 3 b vi	Road Transport, Automobile tyre and break wear											2	3	2	2	2	3
1 A 3 b vii	Road Transport, Automobile road abrasion											3	4	4	5	4	

Key Source Analysis (FUEL USED): Ranking per number		SO2		NOX		NMVOC		NH3		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
1 A 3 b i	Road Transport, Passenger cars			1			1		3		
1 A 3 b ii	Road Transport, Light duty vehicles			6	7						
1 A 3 b iii	Road Transport, Heavy duty vehicles			8	5						
1 A 3 b v	Road Transport, Gasoline evaporation						4				
1 A 3 b vi	Road Transport, Automobile tyre and break wear									3	4
1 A 3 b vii	Road Transport, Automobile road abrasion									5	

Sources: Environment Agency

Notes: LA = Level Assessment, TA = Trend Assessment

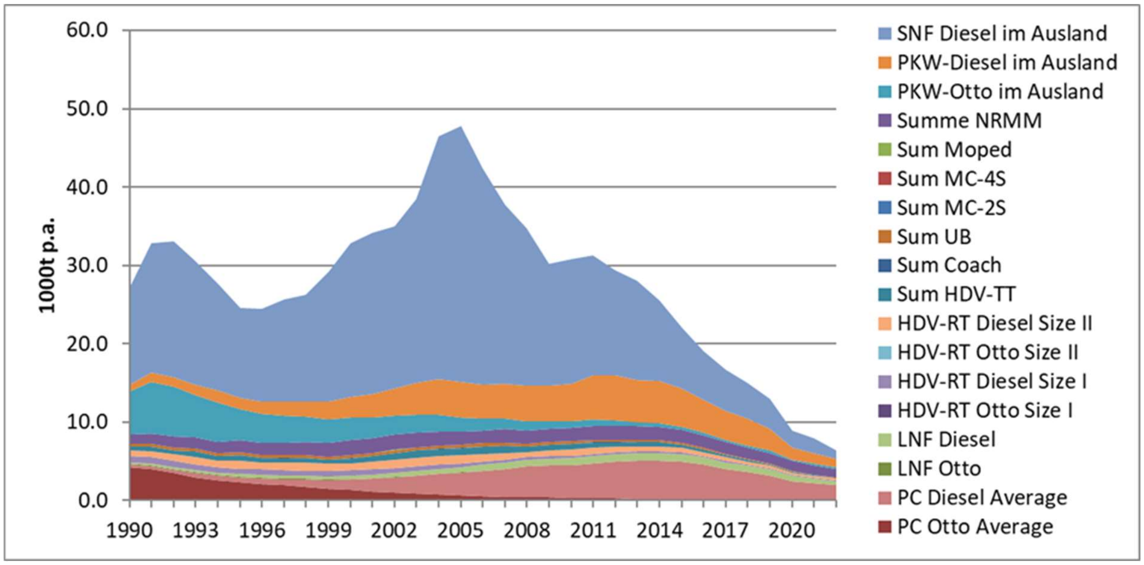
Number in Table = indicates the rank in the specific analysis (1…biggest KC; 2… second biggest KC, …)

With regard to heavy metals and persistent organic pollutant emissions, 1A3b – Road transport is a key category for Pb (TA) and Cd (TA) in 2022 (see Table 3-97 and also Table 3-5 in Section 3.2 and Chapter 1.5).

Figure 43 presents the evolution of NO_x emissions from *1A3b - Road transport* in Luxembourg (including fuel export). NO_x emissions based on fuel used declined from 7.17 Gg in 1990 to 2.91 Gg in 2022, whereas NO_x emissions based on fuel sold declined from 25.75 Gg in 1990 to 5.24 Gg in 2022.

The large fluctuations of emissions from heavy duty vehicles over the years are mainly due to the fuel sales, whereas a new increase of NO_x emissions from 2011 onwards could be avoided by extensive implementation of SCR exhaust emission reduction technology in heavy duty vehicles with low vehicle specific NO_x emission.

Figure 43 – Trend of NO_x emissions based on fuel used and fuel sold per vehicle category



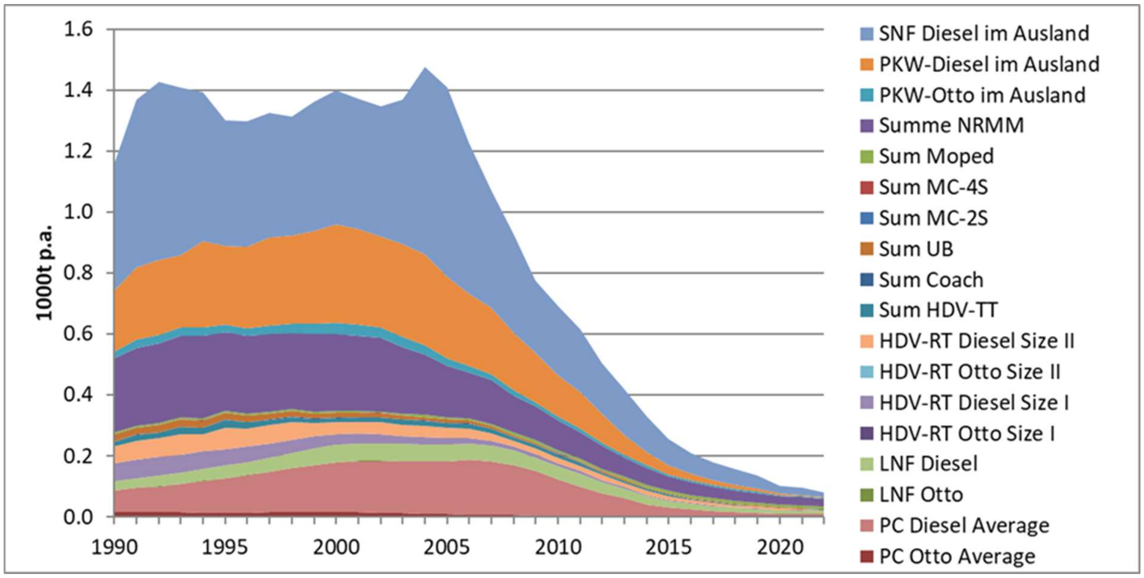
Sources: Environment Agency

Notes: vehicle categories, "Ausland" = fuel export

PKW	PC: Passenger car		
UB	Bus, urban bus, public transport bus		
LNF	LDV: Light commercial vehicle <3,5t (small buses, trucks, camper vans, other motor vehicles)	SNF	=HDV, Heavy goods vehicles {= general term for trucks (HDV-RT), truck trailers (HDV-TT) and articulated trucks (LSZ)}
MC-2S, MC-4S	Motorcycles	2S	2 stroke petrol engines
		4S	4 stroke petrol engines
NRMM	Non-road mobile machinery; sum of off-road emissions (navigation, railways, off-road machinery in industry, households, agriculture and forestry, military). Although the emissions are included in the above figure they are discussed and exported in their respective NFR categories.		

Figure 44 shows the evolution of PM_{10} emissions (exhaust and non-exhaust) for *1A3b - Road transport* (including fuel export) in Luxembourg. PM_{10} emissions based on fuel used decreased from 0.36 Gg in 1990 to 0.25 Gg in 2022, whereas PM_{10} emissions based on fuel sold decreased from 1.13 Gg in 1990 to 0.54 Gg in 2022. Diesel driven vehicles are by far the main source of PM_{10} emissions. Implemented improvements such as diesel particle filters within Luxembourg were counterbalanced by high portion of fuel export.

Figure 44 – Trend of PM_{10} emissions (exhaust and non-exhaust) based on fuel used and fuel sold per vehicle category



Sources: Environment Agency

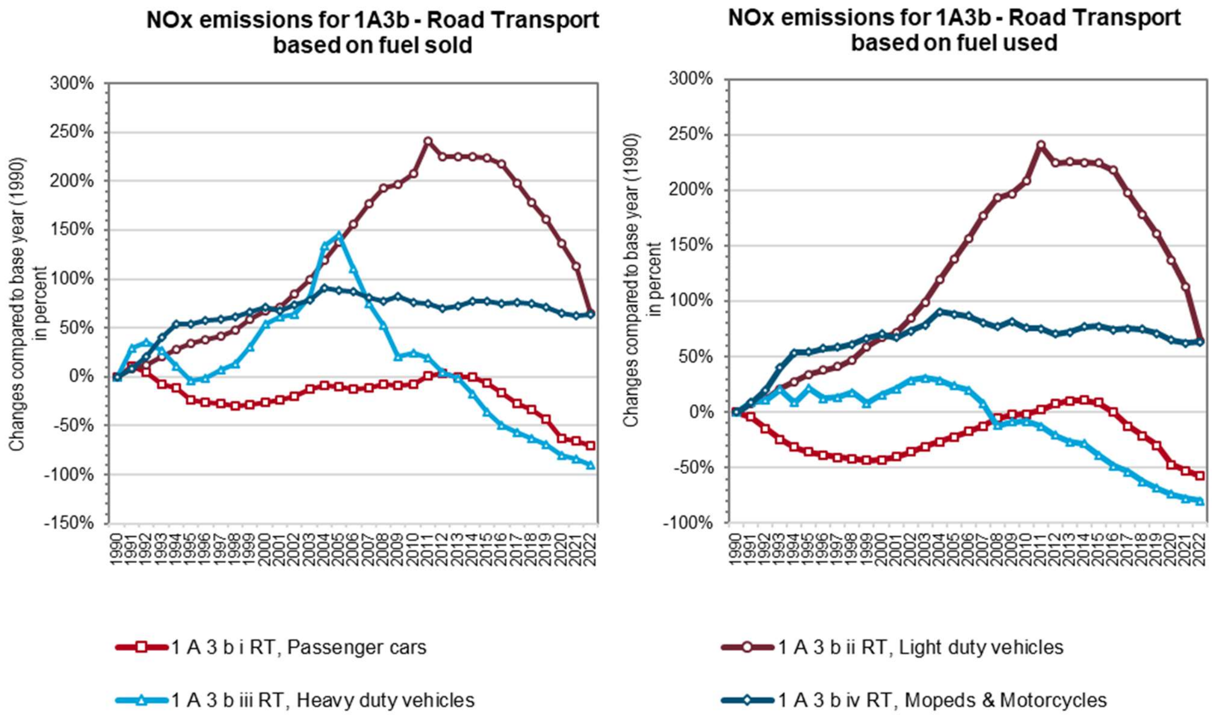
Notes: vehicle categories

PKW	PC: Passenger car		
UB	Bus, urban bus, public transport bus		
LNF	LDV: Light commercial vehicle <3,5t (small buses, trucks, camper vans, other motor vehicles)	SNF	=HDV, Heavy goods vehicles {= general term for trucks (HDV-RT), truck trailers (HDV-TT) and articulated trucks (LSZ)}
MC-2S, MC-4S	Motorcycles	2S	2 stroke petrol engines
		4S	4 stroke petrol engines
NRMM	Non-road mobile machinery; sum of off-road emissions (navigation, railways, off-road machinery in industry, households, agriculture and forestry, military). Although the emissions are included in the above figure they are discussed and exported in their respective NFR categories.		

The $PM_{2.5}$ emissions from *1A3b - Road transport* based on fuel used decreased from 0.32 Gg in 1990 to 0.15 Gg in 2022, whereas $PM_{2.5}$ emissions from *1A3b - Road transport* based on fuel sold decreased from 1.03 Gg in 1990 to 0.32 Gg in 2022. Diesel driven vehicles are by far the main source of $PM_{2.5}$ emissions. Implemented improvements such as diesel particle filters within Luxembourg were counterbalanced by high portion of fuel export.

Figure 45 illustrates the changes of NO_x emissions compared to the base year.

Figure 45 – Changes of Emissions of NO_x compared to base year (1990) based on fuel sold and fuel used for category – *1A3b - Road Transport*



Source: Environment Agency

On the following pages, Table 3-111 presents the emission trends for category *1A3b i –Passenger Cars*, Table 3-112 presents the emission trends for category *1A3b ii – Light duty vehicles (LDV)*, Table 3-113 presents the emission trends for category *1 A 3 b iii – Heavy duty vehicles and buses (HDV)*, Table 3-114 presents the emission trends for category *1 A 3 b iv – Mopeds & motorcycles*, Table 3-115 presents the emission trends for category *1 A 3 b v – Gasoline evaporation* and Table 3-116 presents the emission trends for category *1 A 3 b vi – Automobile tyre and brake wear*.

Table 3-111 – Emission trends of category – *1A3b i - Road transport - passenger cars*

1 A Mobile Fuel Combustion													
Emissions of air pollutants by source category (Gg)													
Year	**1 A 3 b i Road transport: Passenger cars - FUEL SOLD**								**1 A 3 b i Passenger cars - FUEL USED**				
	SO_2	**NO_X**	**NMVOC**	**NH_3**	**CO**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**NOx**	**NMVOC**	**NH_3**	**$PM_{2.5}$**
1990	0.259	10.961	12.044	0.012	80.250	0.308	0.308	0.308	0.079	4.578	5.210	0.005	0.087
1991	0.328	12.130	12.892	0.076	85.956	0.358	0.358	0.358	0.091	4.382	4.816	0.028	0.095
1992	0.371	11.487	11.568	0.201	77.233	0.374	0.374	0.374	0.104	3.907	4.060	0.071	0.100
1993	0.389	10.153	9.542	0.308	63.980	0.369	0.369	0.369	0.116	3.469	3.348	0.109	0.108
1994	0.459	9.663	8.122	0.413	54.677	0.431	0.431	0.431	0.128	3.127	2.729	0.140	0.119
1995	0.385	8.423	6.442	0.451	43.619	0.410	0.410	0.410	0.121	2.935	2.318	0.164	0.127
1996	0.185	8.060	5.598	0.515	38.114	0.430	0.430	0.430	0.061	2.826	2.026	0.188	0.137
1997	0.186	7.993	5.000	0.605	34.404	0.463	0.463	0.463	0.061	2.723	1.748	0.213	0.148
1998	0.180	7.766	4.322	0.678	30.522	0.479	0.479	0.479	0.060	2.663	1.504	0.237	0.160
1999	0.178	7.823	3.870	0.759	28.024	0.510	0.510	0.510	0.059	2.598	1.283	0.251	0.170
2000	0.178	8.124	3.535	0.815	26.250	0.538	0.538	0.538	0.059	2.623	1.114	0.255	0.179
2001	0.176	8.376	3.137	0.794	23.965	0.533	0.533	0.533	0.061	2.750	0.970	0.242	0.184
2002	0.163	8.747	2.780	0.736	21.877	0.517	0.517	0.517	0.058	2.934	0.848	0.219	0.183
2003	0.165	9.547	2.593	0.697	21.008	0.520	0.520	0.520	0.058	3.159	0.747	0.194	0.182
2004	0.017	10.053	2.340	0.624	19.460	0.510	0.510	0.510	0.006	3.354	0.635	0.161	0.182
2005	0.014	9.892	2.000	0.520	17.002	0.477	0.477	0.477	0.005	3.554	0.546	0.133	0.183
2006	0.013	9.589	1.699	0.428	14.733	0.446	0.446	0.446	0.005	3.774	0.481	0.111	0.187
2007	0.013	9.785	1.546	0.377	13.634	0.418	0.418	0.418	0.005	4.004	0.433	0.096	0.181
2008	0.013	10.066	1.389	0.327	12.392	0.375	0.375	0.375	0.005	4.341	0.406	0.086	0.169
2009	0.013	10.027	1.215	0.276	10.924	0.325	0.325	0.325	0.006	4.469	0.365	0.074	0.150
2010	0.013	10.096	1.066	0.237	9.800	0.269	0.269	0.269	0.006	4.502	0.320	0.064	0.123
2011	0.014	11.119	1.032	0.223	9.841	0.232	0.232	0.232	0.006	4.685	0.288	0.056	0.099
2012	0.014	11.391	0.890	0.185	8.938	0.182	0.182	0.182	0.006	4.916	0.256	0.048	0.079
2013	0.013	10.991	0.736	0.148	7.720	0.135	0.135	0.135	0.006	5.049	0.231	0.043	0.061
2014	0.013	10.929	0.680	0.135	7.365	0.091	0.091	0.091	0.006	5.075	0.219	0.041	0.041
2015	0.013	10.248	0.595	0.124	6.758	0.067	0.067	0.067	0.006	4.967	0.204	0.041	0.031
2016	0.012	9.127	0.526	0.123	6.231	0.051	0.051	0.051	0.006	4.576	0.192	0.045	0.025
2017	0.012	7.956	0.486	0.128	5.968	0.041	0.041	0.041	0.006	3.998	0.183	0.049	0.020
2018	0.013	7.319	0.481	0.142	6.091	0.035	0.035	0.035	0.006	3.611	0.179	0.054	0.016
2019	0.012	6.272	0.468	0.153	6.048	0.028	0.028	0.028	0.006	3.201	0.176	0.059	0.014
2020	0.009	4.124	0.332	0.119	4.322	0.018	0.018	0.018	0.005	2.428	0.152	0.056	0.010
2021	0.010	3.728	0.377	0.143	4.915	0.018	0.018	0.018	0.005	2.173	0.159	0.063	0.009
2022	0.010	3.247	0.369	0.150	4.814	0.017	0.017	0.017	0.006	1.941	0.165	0.071	0.009
Trend 1990-2022	*-96.09%*	*-70.38%*	*-96.94%*	*1100.74%*	*-94.00%*	*-94.58%*	*-94.58%*	*-94.58%*	*-92.71%*	*-57.60%*	*-96.83%*	*1256.36%*	*-89.56%*
2005-2022	*-28.87%*	*-67.18%*	*-81.56%*	*-71.19%*	*-71.69%*	*-96.50%*	*-96.50%*	*-96.50%*	*13.18%*	*-45.38%*	*-69.77%*	*-46.79%*	*-95.05%*
2021-2022	*1.69%*	*-12.91%*	*-2.08%*	*4.52%*	*-2.06%*	*-6.94%*	*-6.94%*	*-6.94%*	*5.08%*	*-10.69%*	*3.80%*	*11.17%*	*-4.65%*

Source: Environment Agency

Table 3-112 – Emission trends of category – *1A3b ii – Road transport – Light duty vehicles (LDV)*

1 A Mobile Fuel Combustion *Emissions of air pollutants by source category (Gg)*														
Year	**1 A 3 b ii Road transport:Light duty vehicles - FUEL SOLD**								**1 A 3 b ii Light duty vehicles - FUEL USED**					
	SO_2	**NO_X**	**NMVOC**	**NH_3**	**CO**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**NOx**	**NMVOC**	**NH_3**	**$PM_{2.5}$**
1990	0.026	0.299	0.127	0.000	1.595	0.030	0.030	0.030	0.026	0.299	0.127	0.000	0.030
1991	0.029	0.323	0.126	0.000	1.585	0.033	0.033	0.033	0.029	0.323	0.126	0.000	0.033
1992	0.032	0.335	0.118	0.000	1.484	0.034	0.034	0.034	0.032	0.335	0.118	0.000	0.034
1993	0.037	0.362	0.113	0.000	1.430	0.037	0.037	0.037	0.037	0.362	0.113	0.000	0.037
1994	0.041	0.382	0.109	0.000	1.379	0.040	0.040	0.040	0.041	0.382	0.109	0.000	0.040
1995	0.037	0.402	0.106	0.001	1.353	0.042	0.042	0.042	0.037	0.402	0.106	0.001	0.042
1996	0.014	0.412	0.105	0.001	1.437	0.043	0.043	0.043	0.014	0.412	0.105	0.001	0.043
1997	0.015	0.422	0.088	0.002	1.251	0.046	0.046	0.046	0.015	0.422	0.088	0.002	0.046
1998	0.015	0.441	0.080	0.001	1.139	0.049	0.049	0.049	0.015	0.441	0.080	0.001	0.049
1999	0.015	0.476	0.077	0.002	1.107	0.054	0.054	0.054	0.015	0.476	0.077	0.002	0.054
2000	0.016	0.500	0.068	0.002	0.990	0.058	0.058	0.058	0.016	0.500	0.068	0.002	0.058
2001	0.016	0.514	0.058	0.002	0.847	0.058	0.058	0.058	0.016	0.514	0.058	0.002	0.058
2002	0.014	0.552	0.048	0.002	0.712	0.058	0.058	0.058	0.014	0.552	0.048	0.002	0.058
2003	0.013	0.595	0.041	0.002	0.598	0.057	0.057	0.057	0.013	0.595	0.041	0.002	0.057
2004	0.001	0.657	0.034	0.001	0.485	0.057	0.057	0.057	0.001	0.657	0.034	0.001	0.057
2005	0.001	0.711	0.029	0.001	0.410	0.056	0.056	0.056	0.001	0.711	0.029	0.001	0.056
2006	0.001	0.767	0.027	0.001	0.366	0.055	0.055	0.055	0.001	0.767	0.027	0.001	0.055
2007	0.001	0.829	0.024	0.001	0.324	0.053	0.053	0.053	0.001	0.829	0.024	0.001	0.053
2008	0.001	0.877	0.021	0.001	0.285	0.050	0.050	0.050	0.001	0.877	0.021	0.001	0.050
2009	0.001	0.888	0.018	0.001	0.239	0.046	0.046	0.046	0.001	0.888	0.018	0.001	0.046
2010	0.001	0.923	0.016	0.001	0.210	0.043	0.043	0.043	0.001	0.923	0.016	0.001	0.043
2011	0.001	1.020	0.015	0.001	0.195	0.044	0.044	0.044	0.001	1.020	0.015	0.001	0.044
2012	0.001	0.971	0.012	0.001	0.158	0.037	0.037	0.037	0.001	0.971	0.012	0.001	0.037
2013	0.001	0.974	0.011	0.001	0.134	0.031	0.031	0.031	0.001	0.974	0.011	0.001	0.031
2014	0.001	0.972	0.011	0.001	0.173	0.027	0.027	0.027	0.001	0.972	0.011	0.001	0.027
2015	0.001	0.971	0.009	0.001	0.142	0.022	0.022	0.022	0.001	0.971	0.009	0.001	0.022
2016	0.001	0.951	0.008	0.001	0.138	0.019	0.019	0.019	0.001	0.951	0.008	0.001	0.019
2017	0.001	0.890	0.007	0.002	0.144	0.016	0.016	0.016	0.001	0.890	0.007	0.002	0.016
2018	0.001	0.833	0.006	0.002	0.159	0.014	0.014	0.014	0.001	0.833	0.006	0.002	0.014
2019	0.001	0.780	0.006	0.003	0.165	0.012	0.012	0.012	0.001	0.780	0.006	0.003	0.012
2020	0.001	0.709	0.005	0.004	0.163	0.011	0.011	0.011	0.001	0.709	0.005	0.004	0.011
2021	0.001	0.636	0.005	0.004	0.159	0.011	0.011	0.011	0.001	0.636	0.005	0.004	0.011
2022	0.001	0.493	0.004	0.004	0.136	0.009	0.009	0.009	0.001	0.493	0.004	0.004	0.009
Trend 1990-2022	*-96.06%*	*64.65%*	*-96.62%*	*1611.22%*	*-91.47%*	*-68.99%*	*-68.99%*	*-68.99%*	*-96.06%*	*64.65%*	*-96.62%*	*1611.22%*	*-68.99%*
2005-2022	*20.84%*	*-30.75%*	*-85.35%*	*222.68%*	*-66.81%*	*-83.16%*	*-83.16%*	*-83.16%*	*20.84%*	*-30.75%*	*-85.35%*	*222.68%*	*-83.16%*
2021-2022	*-9.59%*	*-22.53%*	*-15.93%*	*-2.51%*	*-14.69%*	*-13.65%*	*-13.65%*	*-13.65%*	*-9.59%*	*-22.53%*	*-15.93%*	*-2.51%*	*-13.65%*

Source: Environment Agency

Table 3-113 – Emission trends of category – *1A3b iii - Road transport: Heavy duty vehicles (HDV) and buses*

1 A Mobile Fuel Combustion *Emissions of air pollutants by source category (Gg)*													
Year	**1 A 3 b iii Road transport: Heavy duty vehicles and buses - FUEL SOLD**								**1 A 3 b iii Heavy duty vehicles and buses - FUEL USED**				
	SO_2	**NO_X**	**NMVOC**	**NH_3**	**CO**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**NOx**	**NMVOC**	**NH_3**	**$PM_{2.5}$**
1990	0.785	14.480	0.736	0.002	2.450	0.559	0.559	0.559	0.135	2.288	0.346	0.000	0.153
1991	1.017	18.805	0.894	0.002	3.057	0.708	0.708	0.708	0.147	2.493	0.374	0.000	0.166
1992	1.100	19.695	0.933	0.002	3.230	0.745	0.745	0.745	0.152	2.533	0.372	0.000	0.167
1993	1.110	18.431	0.924	0.003	3.205	0.719	0.719	0.719	0.170	2.759	0.376	0.001	0.174
1994	1.018	15.975	0.829	0.003	2.891	0.637	0.637	0.637	0.158	2.488	0.334	0.001	0.157
1995	0.773	13.993	0.776	0.002	2.647	0.574	0.574	0.574	0.152	2.790	0.356	0.001	0.171
1996	0.297	14.277	0.753	0.003	2.617	0.558	0.558	0.558	0.053	2.571	0.318	0.001	0.153
1997	0.309	15.447	0.763	0.003	2.695	0.552	0.552	0.552	0.051	2.600	0.300	0.001	0.145
1998	0.312	16.346	0.760	0.003	2.719	0.528	0.528	0.528	0.050	2.694	0.284	0.001	0.138
1999	0.344	18.986	0.793	0.004	2.930	0.537	0.537	0.537	0.043	2.479	0.238	0.001	0.116
2000	0.380	22.262	0.850	0.005	3.219	0.545	0.545	0.545	0.043	2.642	0.216	0.001	0.106
2001	0.392	23.285	0.851	0.006	3.342	0.528	0.528	0.528	0.044	2.777	0.202	0.001	0.100
2002	0.352	23.728	0.851	0.006	3.473	0.524	0.524	0.524	0.041	2.951	0.199	0.001	0.099
2003	0.367	26.401	0.916	0.007	3.914	0.569	0.569	0.569	0.039	2.993	0.186	0.001	0.094
2004	0.033	33.888	1.122	0.009	5.060	0.704	0.704	0.704	0.003	2.951	0.174	0.001	0.089
2005	0.032	35.553	1.106	0.011	5.694	0.702	0.702	0.702	0.002	2.837	0.156	0.001	0.081
2006	0.027	30.409	0.886	0.012	5.486	0.569	0.569	0.569	0.002	2.744	0.141	0.001	0.074
2007	0.023	25.351	0.683	0.015	5.356	0.450	0.450	0.450	0.002	2.480	0.118	0.001	0.064
2008	0.023	22.137	0.538	0.019	5.570	0.370	0.370	0.370	0.002	2.014	0.089	0.002	0.049
2009	0.020	17.531	0.402	0.020	4.967	0.284	0.284	0.284	0.002	2.093	0.084	0.002	0.048
2010	0.023	18.023	0.373	0.025	5.636	0.273	0.273	0.273	0.002	2.102	0.076	0.003	0.045
2011	0.024	17.344	0.323	0.029	5.870	0.244	0.244	0.244	0.002	2.003	0.065	0.003	0.040
2012	0.022	15.113	0.258	0.029	5.444	0.200	0.200	0.200	0.002	1.822	0.054	0.003	0.034
2013	0.023	14.296	0.226	0.031	5.425	0.179	0.179	0.179	0.002	1.676	0.045	0.003	0.030
2014	0.021	11.892	0.184	0.032	4.775	0.145	0.145	0.145	0.002	1.637	0.041	0.004	0.028
2015	0.019	9.207	0.143	0.032	3.899	0.110	0.110	0.110	0.002	1.408	0.034	0.004	0.023
2016	0.019	7.385	0.119	0.033	3.250	0.088	0.088	0.088	0.002	1.187	0.028	0.004	0.019
2017	0.020	6.299	0.111	0.037	2.851	0.075	0.075	0.075	0.002	1.056	0.025	0.005	0.016
2018	0.022	5.382	0.107	0.043	2.489	0.064	0.064	0.064	0.002	0.863	0.020	0.005	0.013
2019	0.023	4.517	0.104	0.047	2.122	0.055	0.055	0.055	0.002	0.731	0.018	0.005	0.011
2020	0.018	2.847	0.078	0.037	1.354	0.036	0.036	0.036	0.002	0.603	0.016	0.005	0.009
2021	0.018	2.354	0.078	0.039	1.110	0.030	0.030	0.030	0.002	0.512	0.014	0.005	0.007
2022	0.013	1.495	0.059	0.029	0.695	0.020	0.020	0.020	0.002	0.470	0.015	0.006	0.007
Trend 1990-2022	*-98.30%*	*-89.68%*	*-91.99%*	*1655.88%*	*-71.64%*	*-96.50%*	*-96.50%*	*-96.50%*	*-98.18%*	*-79.47%*	*-95.77%*	*1325.20%*	*-95.74%*
2005-2022	*-58.86%*	*-95.80%*	*-94.67%*	*164.58%*	*-87.80%*	*-97.21%*	*-97.21%*	*-97.21%*	*2.72%*	*-83.45%*	*-90.62%*	*480.57%*	*-91.93%*
2021-2022	*-26.30%*	*-36.49%*	*-24.52%*	*-24.80%*	*-37.39%*	*-34.97%*	*-34.97%*	*-34.97%*	*7.33%*	*-8.30%*	*1.62%*	*9.01%*	*-10.98%*

Source: Environment Agency

Table 3-114 – Emission trends of -category – *1A3b iv - Road transport: Mopeds & motorcycles*

	1 A Mobile Fuel Combustion												
	Emissions of air pollutants by source category (Gg)												
Year	**1 A 3 b iv Road transport: Mopeds & motorcycles - FUEL SOLD**								**1 A 3 b iv Mopeds & motorcycles FUEL USED**				
	SO_2	**NO_X**	**NMVOC**	**NH_3**	**CO**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**NOx**	**NMVOC**	**NH_3**	**$PM_{2.5}$**
1990	0.000	0.006	0.142	0.000	0.376	0.006	0.006	0.006	0.000	0.006	0.142	0.000	0.006
1991	0.000	0.006	0.144	0.000	0.396	0.006	0.006	0.006	0.000	0.006	0.144	0.000	0.006
1992	0.000	0.007	0.149	0.000	0.422	0.006	0.006	0.006	0.000	0.007	0.149	0.000	0.006
1993	0.000	0.008	0.154	0.000	0.464	0.006	0.006	0.006	0.000	0.008	0.154	0.000	0.006
1994	0.000	0.009	0.157	0.000	0.488	0.007	0.007	0.007	0.000	0.009	0.157	0.000	0.007
1995	0.000	0.009	0.157	0.000	0.485	0.007	0.007	0.007	0.000	0.009	0.157	0.000	0.007
1996	0.000	0.009	0.158	0.000	0.490	0.007	0.007	0.007	0.000	0.009	0.158	0.000	0.007
1997	0.000	0.009	0.159	0.000	0.489	0.007	0.007	0.007	0.000	0.009	0.159	0.000	0.007
1998	0.000	0.009	0.161	0.000	0.493	0.007	0.007	0.007	0.000	0.009	0.161	0.000	0.007
1999	0.000	0.010	0.153	0.000	0.491	0.006	0.006	0.006	0.000	0.010	0.153	0.000	0.006
2000	0.000	0.010	0.152	0.000	0.496	0.006	0.006	0.006	0.000	0.010	0.152	0.000	0.006
2001	0.000	0.010	0.150	0.000	0.484	0.006	0.006	0.006	0.000	0.010	0.150	0.000	0.006
2002	0.000	0.010	0.150	0.000	0.494	0.006	0.006	0.006	0.000	0.010	0.150	0.000	0.006
2003	0.000	0.010	0.150	0.000	0.497	0.006	0.006	0.006	0.000	0.010	0.150	0.000	0.006
2004	0.000	0.011	0.168	0.000	0.520	0.008	0.008	0.008	0.000	0.011	0.168	0.000	0.008
2005	0.000	0.011	0.162	0.000	0.493	0.008	0.008	0.008	0.000	0.011	0.162	0.000	0.008
2006	0.000	0.011	0.160	0.000	0.479	0.008	0.008	0.008	0.000	0.011	0.160	0.000	0.008
2007	0.000	0.011	0.157	0.000	0.459	0.008	0.008	0.008	0.000	0.011	0.157	0.000	0.008
2008	0.000	0.010	0.155	0.000	0.443	0.008	0.008	0.008	0.000	0.010	0.155	0.000	0.008
2009	0.000	0.011	0.155	0.000	0.443	0.008	0.008	0.008	0.000	0.011	0.155	0.000	0.008
2010	0.000	0.010	0.154	0.000	0.426	0.008	0.008	0.008	0.000	0.010	0.154	0.000	0.008
2011	0.000	0.010	0.153	0.000	0.417	0.009	0.009	0.009	0.000	0.010	0.153	0.000	0.009
2012	0.000	0.010	0.154	0.000	0.404	0.009	0.009	0.009	0.000	0.010	0.154	0.000	0.009
2013	0.000	0.010	0.154	0.000	0.399	0.009	0.009	0.009	0.000	0.010	0.154	0.000	0.009
2014	0.000	0.010	0.154	0.000	0.401	0.010	0.010	0.010	0.000	0.010	0.154	0.000	0.010
2015	0.000	0.010	0.151	0.000	0.394	0.010	0.010	0.010	0.000	0.010	0.151	0.000	0.010
2016	0.000	0.010	0.148	0.000	0.382	0.010	0.010	0.010	0.000	0.010	0.148	0.000	0.010
2017	0.000	0.010	0.146	0.000	0.378	0.010	0.010	0.010	0.000	0.010	0.146	0.000	0.010
2018	0.000	0.010	0.138	0.000	0.369	0.009	0.009	0.009	0.000	0.010	0.138	0.000	0.009
2019	0.000	0.010	0.136	0.000	0.360	0.009	0.009	0.009	0.000	0.010	0.136	0.000	0.009
2020	0.000	0.010	0.133	0.000	0.346	0.009	0.009	0.009	0.000	0.010	0.133	0.000	0.009
2021	0.000	0.009	0.130	0.000	0.339	0.010	0.010	0.010	0.000	0.009	0.130	0.000	0.010
2022	0.000	0.010	0.126	0.000	0.337	0.010	0.010	0.010	0.000	0.010	0.126	0.000	0.010
Trend 1990-2022	*-86.92%*	*63.29%*	*-11.25%*	*171.01%*	*-10.35%*	*59.60%*	*59.60%*	*59.60%*	*-86.92%*	*63.29%*	*-11.25%*	*171.01%*	*59.60%*
2005-2022	*44.92%*	*-13.19%*	*-22.08%*	*48.92%*	*-31.71%*	*27.17%*	*27.17%*	*27.17%*	*44.92%*	*-13.19%*	*-22.08%*	*48.92%*	*27.17%*
2021-2022	*4.89%*	*0.48%*	*-2.66%*	*4.97%*	*-0.59%*	*1.54%*	*1.54%*	*1.54%*	*4.89%*	*0.48%*	*-2.66%*	*4.97%*	*1.54%*

Source: Environment Agency

Table 3-115 – Emission trends of category – *1A3b v Road transport: Gasoline evaporation*

1 A 3 b v Road transport: Gasoline evaporation *Emissions of air pollutants by source category (Gg)*													
Year	**FUEL SOLD**								**FUEL USED**				
	SO_2	**NO_X**	**NMVOC**	**NH_3**	**CO**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**NOx**	**NMVOC**	**NH_3**	**$PM_{2.5}$**
1990	NA	NA	3.996	NA	NA	NA	NA	NA	NO	NO	1.776	NO	NO
1991	NA	NA	4.222	NA	NA	NA	NA	NA	NO	NO	1.623	NO	NO
1992	NA	NA	3.706	NA	NA	NA	NA	NA	NO	NO	1.341	NO	NO
1993	NA	NA	2.930	NA	NA	NA	NA	NA	NO	NO	1.062	NO	NO
1994	NA	NA	2.328	NA	NA	NA	NA	NA	NO	NO	0.816	NO	NO
1995	NA	NA	1.737	NA	NA	NA	NA	NA	NO	NO	0.655	NO	NO
1996	NA	NA	1.406	NA	NA	NA	NA	NA	NO	NO	0.537	NO	NO
1997	NA	NA	1.156	NA	NA	NA	NA	NA	NO	NO	0.426	NO	NO
1998	NA	NA	0.909	NA	NA	NA	NA	NA	NO	NO	0.335	NO	NO
1999	NA	NA	0.742	NA	NA	NA	NA	NA	NO	NO	0.263	NO	NO
2000	NA	NA	0.622	NA	NA	NA	NA	NA	NO	NO	0.210	NO	NO
2001	NA	NA	0.511	NA	NA	NA	NA	NA	NO	NO	0.168	NO	NO
2002	NA	NA	0.423	NA	NA	NA	NA	NA	NO	NO	0.137	NO	NO
2003	NA	NA	0.375	NA	NA	NA	NA	NA	NO	NO	0.113	NO	NO
2004	NA	NA	0.327	NA	NA	NA	NA	NA	NO	NO	0.092	NO	NO
2005	NA	NA	0.279	NA	NA	NA	NA	NA	NO	NO	0.078	NO	NO
2006	NA	NA	0.242	NA	NA	NA	NA	NA	NO	NO	0.069	NO	NO
2007	NA	NA	0.226	NA	NA	NA	NA	NA	NO	NO	0.063	NO	NO
2008	NA	NA	0.207	NA	NA	NA	NA	NA	NO	NO	0.059	NO	NO
2009	NA	NA	0.184	NA	NA	NA	NA	NA	NO	NO	0.054	NO	NO
2010	NA	NA	0.162	NA	NA	NA	NA	NA	NO	NO	0.047	NO	NO
2011	NA	NA	0.161	NA	NA	NA	NA	NA	NO	NO	0.044	NO	NO
2012	NA	NA	0.140	NA	NA	NA	NA	NA	NO	NO	0.040	NO	NO
2013	NA	NA	0.118	NA	NA	NA	NA	NA	NO	NO	0.037	NO	NO
2014	NA	NA	0.112	NA	NA	NA	NA	NA	NO	NO	0.037	NO	NO
2015	NA	NA	0.099	NA	NA	NA	NA	NA	NO	NO	0.035	NO	NO
2016	NA	NA	0.089	NA	NA	NA	NA	NA	NO	NO	0.034	NO	NO
2017	NA	NA	0.082	NA	NA	NA	NA	NA	NO	NO	0.032	NO	NO
2018	NA	NA	0.081	NA	NA	NA	NA	NA	NO	NO	0.032	NO	NO
2019	NA	NA	0.078	NA	NA	NA	NA	NA	NO	NO	0.031	NO	NO
2020	NA	NA	0.055	NA	NA	NA	NA	NA	NO	NO	0.027	NO	NO
2021	NA	NA	0.064	NA	NA	NA	NA	NA	NO	NO	0.029	NO	NO
2022	NA	NA	0.065	NA	NA	NA	NA	NA	NO	NO	0.031	NO	NO
Trend 1990-2022	*NA*	*NA*	*-98.38%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*-98.24%*	*NA*	*NA*
2005-2022	*NA*	*NA*	*-76.86%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*-59.80%*	*NA*	*NA*
2021-2022	*NA*	*NA*	*1.36%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*7.15%*	*NA*	*NA*

Source: Environment Agency

Table 3-116 – Emission trends of category – *1A3b vi - Road transport: Automobile tyre and brake wear*

1 A 3 b vi Road transport: Automobile tyre and brake wear *Emissions of air pollutants by source category (Gg)*				
Year	**FUEL SOLD**			**FUEL USED**
	TSP	**PM_{10}**	**$PM_{2.5}$**	**$PM_{2.5}$**
1990	0.195	0.146	0.080	0.028
1991	0.239	0.179	0.098	0.030
1992	0.261	0.195	0.107	0.031
1993	0.266	0.199	0.109	0.033
1994	0.276	0.206	0.113	0.033
1995	0.260	0.195	0.106	0.035
1996	0.269	0.202	0.110	0.036
1997	0.291	0.218	0.119	0.038
1998	0.306	0.229	0.125	0.040
1999	0.338	0.252	0.138	0.040
2000	0.378	0.281	0.154	0.043
2001	0.399	0.297	0.163	0.045
2002	0.415	0.309	0.170	0.047
2003	0.456	0.339	0.186	0.049
2004	0.521	0.386	0.213	0.050
2005	0.544	0.402	0.223	0.051
2006	0.522	0.385	0.214	0.053
2007	0.517	0.382	0.211	0.055
2008	0.527	0.389	0.216	0.058
2009	0.494	0.366	0.202	0.060
2010	0.520	0.384	0.213	0.061
2011	0.555	0.410	0.227	0.063
2012	0.536	0.397	0.219	0.064
2013	0.526	0.389	0.215	0.064
2014	0.512	0.379	0.209	0.066
2015	0.487	0.361	0.199	0.067
2016	0.476	0.353	0.195	0.068
2017	0.492	0.364	0.201	0.070
2018	0.525	0.388	0.215	0.071
2019	0.539	0.398	0.221	0.072
2020	0.419	0.310	0.171	0.066
2021	0.448	0.332	0.183	0.070
2022	0.407	0.303	0.166	0.075
Trend 1990-2022	*108.35%*	*107.42%*	*108.48%*	*167.34%*
2005-2022	*-25.30%*	*-24.54%*	*-25.41%*	*47.22%*
2021-2022	*-9.34%*	*-8.80%*	*-9.42%*	*6.88%*

Source: Environment Agency

3.2.4.3.2 Methodological issues

3.2.4.3.2.1 Activity Data

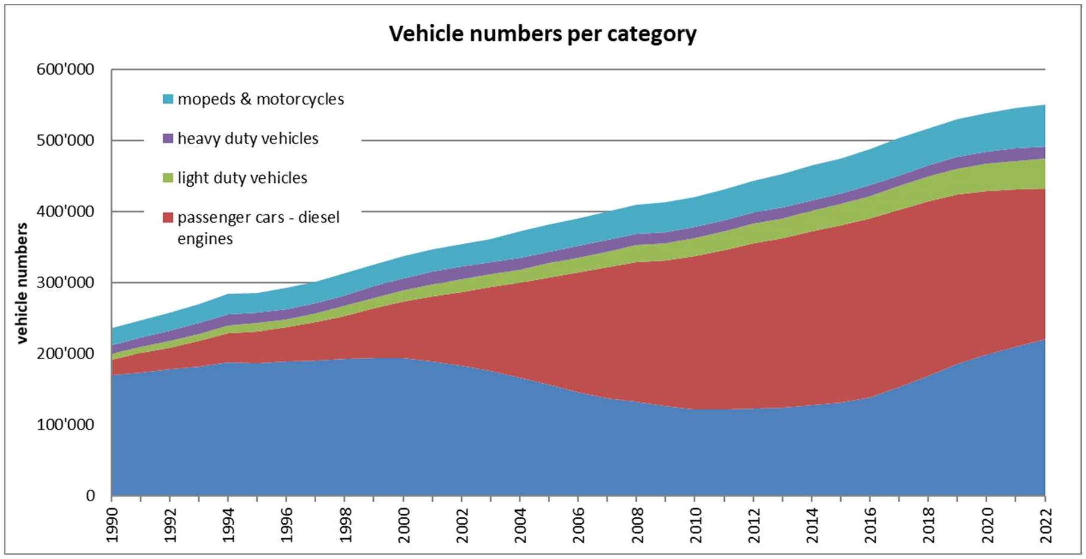
Table 3-117 (p. 243) shows blended fuel consumption for category *1A3b – Road Transportation* by fuel (motor gasoline, diesel oil, LPG) based on fuel used within the country's borders, as well as the quantities of fuel exported in the vehicle tank.

The total amounts of fuel sold were taken from the national energy balance provided by the national statistics institute, and the share of fuel used in Luxembourg was determined with the method described in section 3.2.4.3.2.2 on page 245.

Table 3-118 (p. 244) shows blended fuel consumption per vehicle category, as determined by the NEMO model based on vehicle stocks and driven mileage.

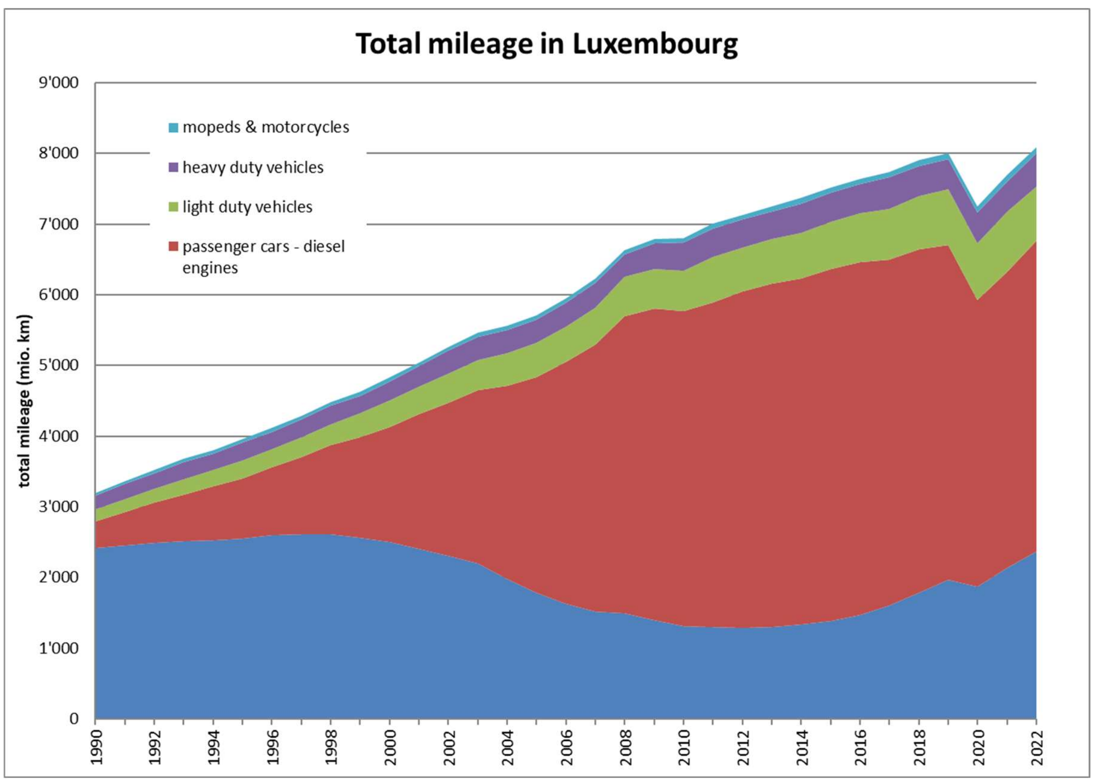
Figure 46 shows the evolution of the vehicle numbers per category since 1990 circulation on Luxembourg's territory. The number of diesel-fuelled passenger cars has strongly increased, whereas the vehicle numbers in the other categories show a less pronounced rise or even a decrease as in the case of passenger cars with motor gasoline engines. The same trends are observed for the total mileage driven in Luxembourg (Figure 47).

Figure 46 – Vehicle numbers per category (national fleet)



Source: Environment Agency

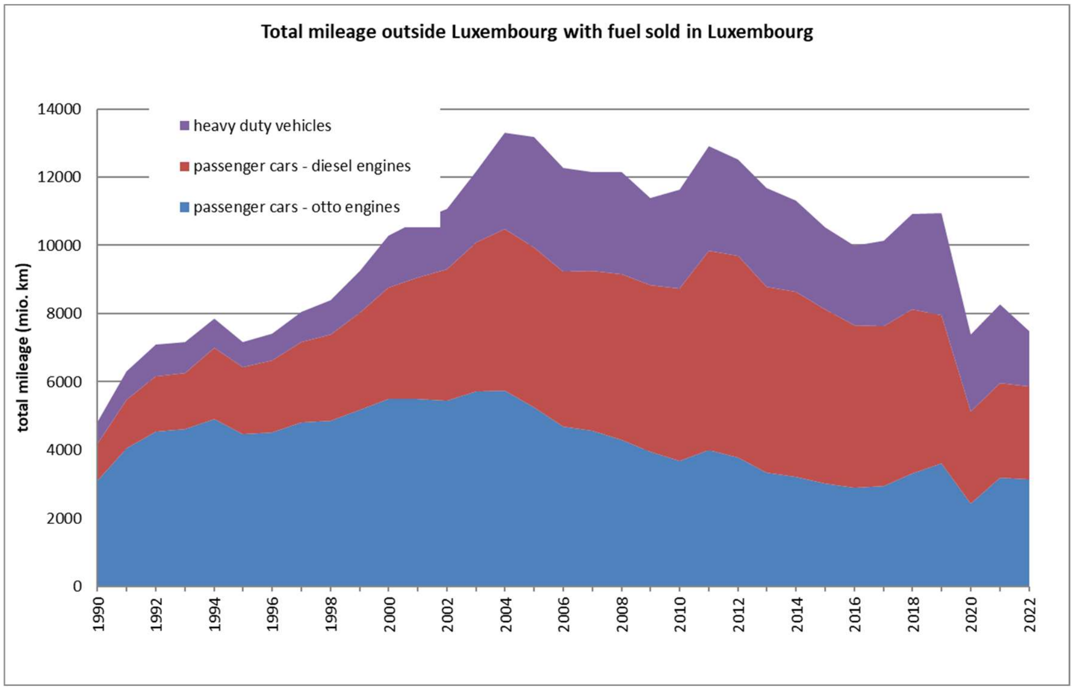
Figure 47 – Total mileage in Luxembourg



Source: Environment Agency

Figure 48 shows that the total mileage driven outside Luxembourg with fuel purchased in Luxembourg has more than doubled from 1990 to 2019, followed by a sharp decrease in 2020 due to the onset of the pandemic and only a mild rebound in 2021. While the mileage driven with gasoline exported in passenger car tanks has remained relatively stable, the mileage driven with diesel exported from Luxembourg in the tanks of passenger cars and heavy-duty vehicles has significantly increased.

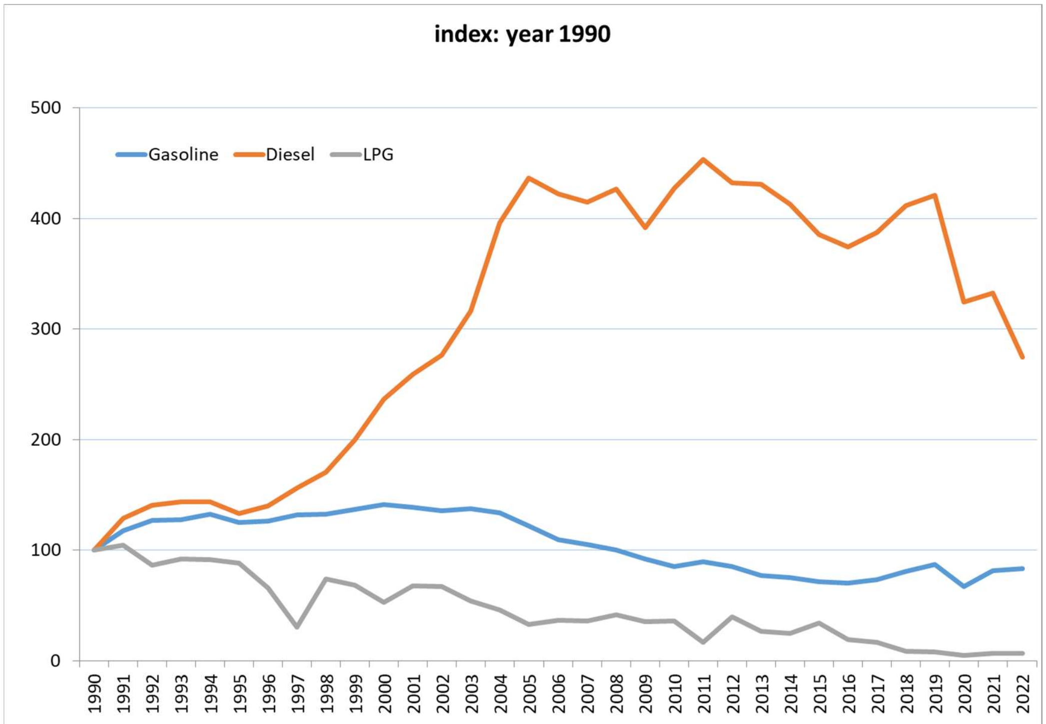
Figure 48 – Total mileage outside Luxembourg with fuel sold in Luxembourg



Source: Environment Agency

Figure 49 shows the evolution of fuel sold (*i.e.* blended fuel) in Luxembourg. Diesel oil is by far the most fuel sold and has seen a sharp decrease since 2020.

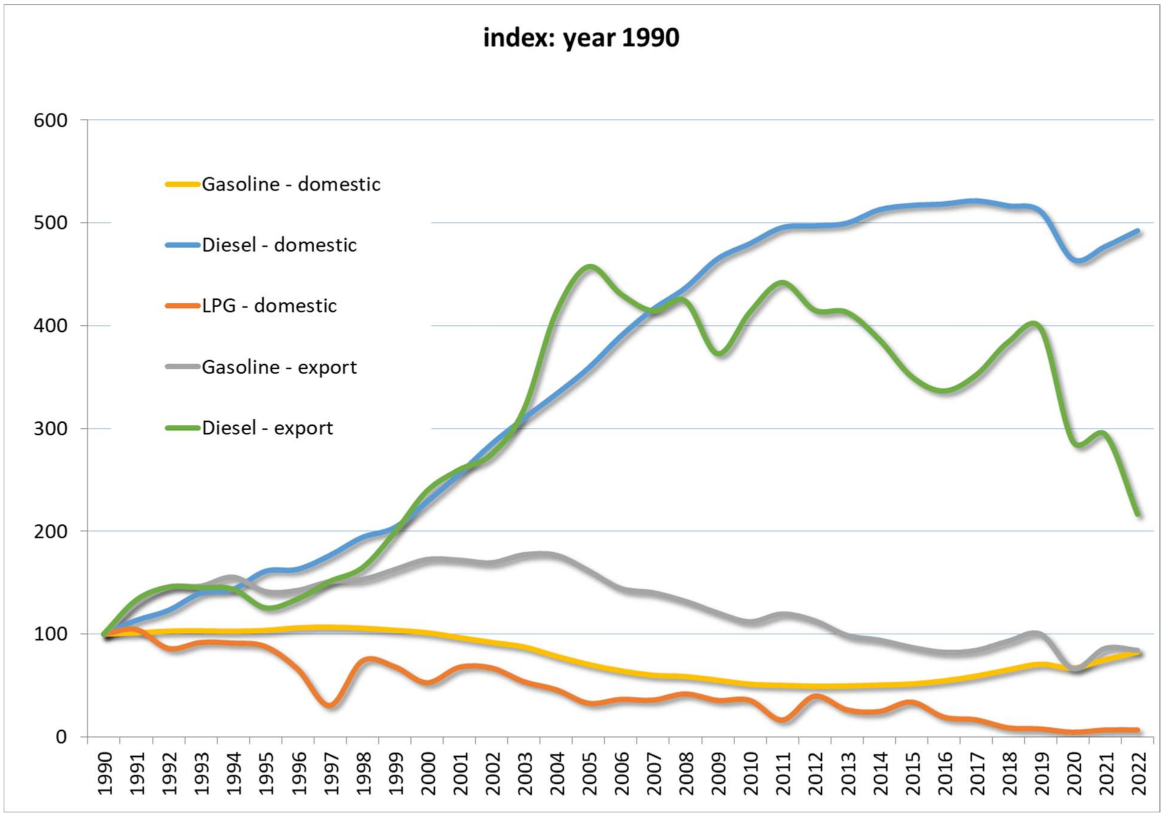
Figure 49 – Fuel sold trends for 1A3b – Road Transportation by fuel type



Source: Environment Agency

Figure 50 details the quantities of blended fuel used on the national territory and the amount of fuel exported. While the domestic and exported diesel fuel consumption saw a strong decrease in 2020 and a small rebound in 2021, the domestic and exported gasoline and LPG (only domestic) stayed relatively constant over the past years. Furthermore, exported diesel consumption has continued its decreasing trend in 2022.

Figure 50 – Domestic and exported fuel sold trends - indexes - for 1A3b – Road Transportation by fuel type



Source: Environment Agency

Table 3-117 – Activity data per fuel type for category *1A3b - Road transport*

1A3b - Road Transportation Blended Fuels (t)											
		domestic road fuel use					road fuel export				
Year	National Total	Total	share (%)	Blended Gasoline	Blended Diesel	LPG	Total	share (%)	Blended Gasoline	Blended Diesel	LPG
1990	822'233	270'160	32.86%	180'809	85'561	3'790	552'073	67.14%	229'538	322'535	NO
1991	1'011'095	283'771	28.07%	182'898	96'905	3'968	727'324	71.93%	298'399	428'925	NO
1992	1'099'277	294'503	26.79%	186'014	105'223	3'266	804'773	73.21%	334'763	470'010	NO
1993	1'114'499	309'524	27.77%	186'439	119'599	3'486	804'975	72.23%	337'014	467'961	NO
1994	1'132'564	311'968	27.55%	185'720	122'784	3'464	820'596	72.45%	357'264	463'332	NO
1995	1'057'850	328'330	31.04%	187'235	137'757	3'338	729'521	68.96%	324'923	404'598	NO
1996	1'093'429	333'739	30.52%	191'780	139'454	2'505	759'690	69.48%	327'550	432'140	NO
1997	1'180'162	345'103	29.24%	192'934	151'012	1'158	835'058	70.76%	347'270	487'788	NO
1998	1'241'930	359'995	28.99%	191'239	165'955	2'802	881'935	71.01%	351'823	530'112	NO
1999	1'379'495	364'279	26.41%	187'583	174'102	2'594	1'015'216	73.59%	374'009	641'206	NO
2000	1'548'438	380'834	24.59%	183'319	195'516	1'998	1'167'604	75.41%	396'631	770'973	NO
2001	1'629'303	395'985	24.30%	174'788	218'627	2'570	1'233'318	75.70%	395'278	838'040	NO
2002	1'687'290	412'447	24.44%	166'377	243'520	2'549	1'274'843	75.56%	389'279	885'564	NO
2003	1'858'471	425'410	22.89%	158'412	264'958	2'040	1'433'060	77.11%	407'138	1'025'923	NO
2004	2'166'253	429'016	19.80%	142'143	285'126	1'746	1'737'237	80.20%	406'193	1'331'044	NO
2005	2'282'567	435'785	19.09%	127'770	306'770	1'245	1'846'783	80.91%	371'545	1'475'237	NO
2006	2'172'749	451'419	20.78%	116'670	333'365	1'385	1'721'329	79.22%	331'923	1'389'406	NO
2007	2'124'443	466'024	21.94%	108'888	355'777	1'358	1'658'419	78.06%	322'317	1'336'102	NO
2008	2'152'606	481'802	22.38%	106'689	373'526	1'587	1'670'803	77.62%	303'232	1'367'571	NO
2009	1'978'275	499'384	25.24%	100'234	397'800	1'349	1'478'892	74.76%	277'178	1'201'713	NO
2010	2'095'197	505'030	24.10%	93'242	410'436	1'352	1'590'167	75.90%	257'490	1'332'677	NO
2011	2'216'244	515'782	23.27%	91'295	423'863	624	1'700'461	76.73%	274'989	1'425'472	NO
2012	2'115'132	516'495	24.42%	89'771	425'221	1'503	1'598'637	75.58%	259'820	1'338'817	NO
2013	2'078'068	518'699	24.96%	90'189	427'511	999	1'559'369	75.04%	227'199	1'332'170	NO
2014	1'994'891	531'320	26.63%	91'737	438'648	936	1'463'571	73.37%	216'571	1'247'000	NO
2015	1'868'168	537'251	28.76%	93'670	442'294	1'287	1'330'917	71.24%	200'287	1'130'630	NO
2016	1'817'829	543'278	29.89%	99'076	443'471	731	1'274'551	70.11%	189'460	1'085'091	NO
2017	1'882'382	554'107	29.44%	107'402	446'074	632	1'328'275	70.56%	193'535	1'134'740	NO
2018	2'014'203	560'765	27.84%	118'559	441'871	336	1'453'438	72.16%	214'375	1'239'063	NO
2019	2'077'680	565'952	27.24%	128'372	437'286	294	1'511'727	72.76%	229'784	1'281'943	NO
2020	1'598'103	518'891	32.47%	121'417	397'300	174	1'079'213	67.53%	153'058	926'155	NO
2021	1'691'870	544'694	32.19%	136'340	408'097	257	1'147'176	67.81%	198'282	948'895	NO
2022	1'462'930	570'614	39.00%	149'136	421'220	257	892'316	61.00%	193'722	698'594	NO
Trend 1990-2022	77.92%	111.21%	18.71%	-17.52%	392.30%	-93.21%	61.63%	-9.16%	-15.60%	116.59%	NA
Trend 2021-2022	-13.53%	4.76%	21.15%	9.39%	3.22%	-0.04%	-22.22%	-10.04%	-2.30%	-26.38%	NA
Share 1990	NA	32.86%	NA	21.99%	10.41%	0.46%	67.14%	NA	27.92%	39.23%	NA
Share 2022	NA	39.00%	NA	10.19%	28.79%	0.02%	61.00%	NA	13.24%	47.75%	NA

Source: Environment Agency

Table 3-118 – Activity data – Fuel sold and Fuel used – per sub-category for *1A3b - Road transport*

1 A Mobile Fuel Combustion Activity Data by fuel type (GJ)										
	1 A 3 b Road transport - FUEL SOLD					1 A 3 b Road transport - FUEL USED				
Year	Activity Total (incl. biomass)	1 A 3 b i Passenger cars	1 A 3 b ii LDV	1 A 3 b iii HDV and buses	1 A 3 b iv Mopeds & motorcycles	Activity Total (incl. biomass)	1 A 3 b i Passenger cars	1 A 3 b ii LDV	1 A 3 b iii HDV and buses	1 A 3 b iv Mopeds & motorcycles
1990	35 176 077	21'502'103	582'351	13'050'825	40'798	11 592 482	8'728'968	582'351	2'240'365	40'798
1991	43 240 313	25'655'122	639'639	16'901'549	44'002	12 172 544	9'050'053	639'639	2'438'851	44'002
1992	47 006 400	28'011'264	673'367	18'273'501	48'269	12 627 814	9'382'641	673'367	2'523'538	48'269
1993	47 655 388	28'420'645	740'292	18'439'036	55'416	13 266 976	9'642'322	740'292	2'828'946	55'416
1994	48 433 767	30'667'142	790'750	16'914'931	60'943	13 370 304	9'892'747	790'750	2'625'863	60'943
1995	45 241 829	29'182'645	837'089	15'161'172	60'923	14 065 869	10'179'888	837'089	2'987'969	60'923
1996	46 754 482	30'009'047	877'034	15'805'139	63'263	14 295 290	10'560'179	877'034	2'794'814	63'263
1997	50 446 299	31'841'152	926'503	17'614'618	64'027	14 774 026	10'902'913	926'503	2'880'584	64'027
1998	53 077 916	32'852'652	984'668	19'175'248	65'348	15 411 535	11'317'127	984'668	3'044'393	65'348
1999	58 932 008	34'858'947	1'090'022	22'915'699	67'340	15 590 753	11'573'478	1'090'022	2'859'913	67'340
2000	66 117 768	37'206'426	1'189'954	27'652'357	69'030	16 289 593	11'905'446	1'189'954	3'125'162	69'030
2001	69 549 776	38'145'684	1'243'034	30'093'246	67'813	16 930 507	12'223'999	1'243'034	3'395'661	67'813
2002	72 005 180	38'846'097	1'312'058	31'776'934	70'092	17 625 087	12'504'553	1'312'058	3'738'384	70'092
2003	79 281 580	41'180'831	1'362'155	36'666'536	72'057	18 169 605	12'807'742	1'362'155	3'927'650	72'057
2004	92 345 553	42'030'187	1'433'723	48'804'421	77'222	18 312 353	12'801'706	1'433'723	3'999'703	77'222
2005	97 257 849	40'541'331	1'490'124	55'150'221	76'174	18 590 102	12'968'259	1'490'124	4'055'546	76'174
2006	92 564 332	38'832'193	1'556'393	52'098'986	76'760	19 248 601	13'393'512	1'556'393	4'221'937	76'760
2007	90 342 807	39'301'811	1'640'618	49'324'378	75'999	19 829 680	13'905'285	1'640'618	4'207'777	75'999
2008	91 537 366	39'913'664	1'717'211	49'830'611	75'880	20 501 201	14'889'558	1'717'211	3'818'552	75'880
2009	84 125 086	39'008'802	1'724'307	43'312'354	79'622	21 242 559	15'060'432	1'724'307	4'378'197	79'622
2010	89 078 059	38'189'116	1'786'819	49'023'440	78'684	21 480 234	14'810'577	1'786'819	4'804'154	78'684
2011	94 087 190	40'793'995	1'974'975	51'238'450	79'771	21 899 564	14'916'765	1'974'975	4'928'054	79'771
2012	89 895 092	40'593'872	1'891'336	47'330'100	79'784	21 958 005	15'245'004	1'891'336	4'741'881	79'784
2013	88 295 801	38'209'059	1'909'084	48'095'229	82'429	22 048 473	15'418'492	1'909'084	4'638'468	82'429
2014	84 658 139	37'645'194	1'960'639	44'965'339	86'966	22 554 452	15'491'486	1'960'639	5'015'361	86'966
2015	79 141 735	36'303'246	1'993'602	40'755'418	89'470	22 763 842	15'716'448	1'993'602	4'964'323	89'470
2016	76 943 886	35'219'652	2'095'519	39'538'196	90'519	22 996 592	15'896'402	2'095'519	4'914'152	90'519
2017	79 672 836	35'290'348	2'159'628	42'128'494	94'366	23 458 107	16'026'496	2'159'628	5'177'617	94'366
2018	85 189 640	36'814'478	2'245'252	46'032'520	97'389	23 717 980	16'380'335	2'245'252	4'995'004	97'389
2019	87 717 221	36'432'257	2'310'385	48'876'113	98'466	23 880 622	16'510'662	2'310'385	4'961'109	98'466
2020	67 336 298	27'404'082	2'341'903	37'491'325	98'989	21 849 499	14'594'613	2'341'903	4'813'995	98'989
2021	71 277 871	30'461'376	2'450'789	38'263'756	101'950	22 932 966	15'557'056	2'450'789	4'823'171	101'950
2022	61 537 640	31'033'319	2'212'969	28'184'744	106'608	23 993 319	16'499'329	2'212'969	5'174'412	106'608
Trend 1990-2022	74.94%	44.33%	280.01%	115.96%	161.30%	106.97%	89.02%	280.01%	130.96%	161.30%
2005-2022	-36.73%	-23.45%	48.51%	-48.89%	39.95%	29.07%	27.23%	48.51%	27.59%	39.95%
2021-2022	-13.67%	1.88%	-9.70%	-26.34%	4.57%	4.62%	6.06%	-9.70%	7.28%	4.57%

Source: Environment Agency

3.2.4.3.2.2 Methodological choices

The model NEMO and its application to Luxembourg's road transport situation

The model NEMO (Network Emission Model) was developed at the Institute for Internal Combustion Engines and Thermodynamics (IVT)[44] at the Graz University of Technology (TUG) as tool for the simulation of traffic related emissions in road networks. Typical applications reach from emission inventories for cities, regions and countries to complex measures like environmental zones or promotion of alternative propulsion systems. An interface to macro scale traffic models, such as VISUM[45] and to air quality modelling is available.

NEMO combines both detailed calculation of the vehicle fleet composition and simulation of emission factors on a vehicle level (see Figure 51). NEMO calculates the percentages of different vehicle layers on the overall traffic volume as a function of year and considered road type based on data on vehicle stock, composition of new registrations and vehicle usage. The simulation of the emissions of the different vehicle layers is based on the correlation of the specific engine emission behaviour (emissions in grams per kilowatt-hour engine work) with the cycle average engine power in a normalised format. The calculation of the required engine power is based on average speed and additional kinematic parameters for the description of the cycle dynamics for a given road section. Compared to more detailed instantaneous emission models – which are usually based on simulation in 1Hz time resolution – this simplified approach gives no disadvantage for the modelling of emissions on large street networks as in most of the cases 1Hz data for vehicle operation are not available. An additional benefit of the NEMO simulation approach is the short computing time.

The parameterisation of NEMO is based on data from European in-use measurements which are also used for the Handbook Emission Factors of Road Transport Road Transport (HBEFA)[46]. NEMO is updated regularly according to recent data on emission behaviour and vehicle technologies. For the present submission, HBEFA 4.2 (released in May 2023, the latest reference database including all available in-use emission tests and recent forecasts for up-coming vehicle technology) was used. All on-road vehicle categories are covered; a tool for the transport sectors rail and inland waterway shipping is also available. NEMO is equipped with a Graphical User Interface which allows for efficient data editing, scenario handling and display of model results.

A crucial point in emission modelling is the characterisation of driving behaviour on the single road sections. For NEMO a method was developed, which allows for automatized derivation of driving behaviour based on a link with common traffic models. These models use the peak hour driving time between knots of the street work as resistance parameter for allocation of traffic volumes to the single road sections. NEMO imports this data together with the parameters of the capacity-restraint functions and calculates the daily average velocity for each road section. Based on functions derived from the driving cycles used in the HBEFA then the kinematic parameters needed for emission simulation (vehicle stop time and average brake deceleration) are assessed.

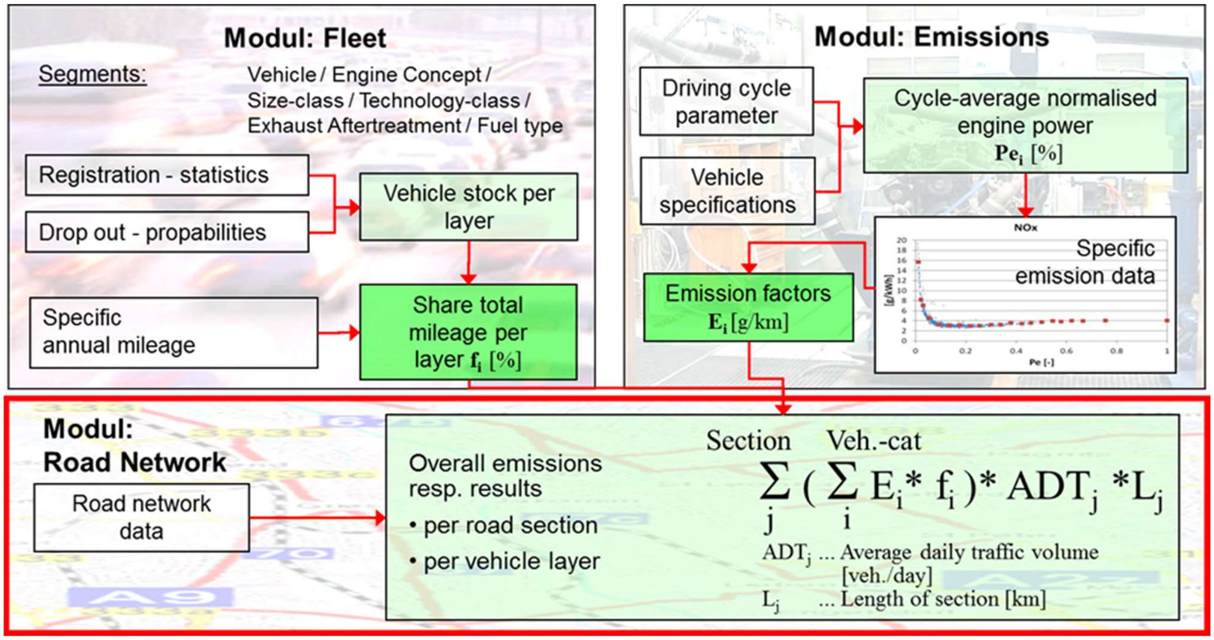
---

[44] http://portal.tugraz.at/portal/page/portal/TU_Graz/Einrichtungen/Institute/oe_123

[45] Information- and forecasting system for private and public transport VISUM: Comprehensive software for advanced transportation planning; http://irdata.sk/en/ptv-softver-2/

[46] Handbook emission factors for road transport (HBEFA) http://www.hbefa.net/

Figure 51 – Schematic picture of the model NEMO



NEMO calculates the emissions for all regulated pollutants (NO_X, THC[47], CO, PM exhaust) for hot vehicle operation. Fuel consumption is simulated based on a slightly extended method which also considers the energy content of the applied fuel type. The emissions of CO_2 and SO_2 are simulated based on fuel consumption and fuel specifications. The non-regulated pollutants N_2O, NH_3 CH_4, NMHC[48] and C_6H_6 are calculated with an approach similar to the HBEFA 4.2 based on fixed emission factors for certain vehicle categories and driving situations.

Additional influencing mechanisms on the emission output of road traffic implemented in NEMO are:

- Cold start effects for each vehicle class (data and approach compatible to the HBEFA 4.2), cold start of HDV vehicles according to [49].
- Influence of mileage and maintenance on the emissions of gasoline vehicles (method and data compatible to the HBEFA 4.2).[50]
- Calibration of fuel consumption based on statistics of g/km CO_2 of new registered vehicles in the NEDC[51] type approval and literature on the discrepancies between NEDC and real world CO_2 reduction rates (HBEFA 4.2).[52]
- Evaporation from gasoline emissions (data and approach compatible to the HBEFA 4.2).
- Ambient temperature influence on NO_x emission of Diesel passenger cars and LCV (method and data compatible to the HBEFA 4.2)

[47] THC - total hydrocarbon
[48] NMHC - non-methane hydrocarbons
[49] Rexeis, M; Schwingshackl, M; Dippold, M; Hausberger, S. (2013) Emissions aus Kalt- und Kühlstarts sowie aus aus AdBlue-Verwendung in SCR-Katalysatoren von Lkw, LNF, 2-Rädern sowie von mobilen Maschinen.
[50] Samaras, Z. (2004). Artemis Subtask 3123: Investigation of the emission degradation of gasoline vehicles, Aristotle University of Thessaloniki - Lab of Applied Thermodynamics
[51] NEDC - New European Driving Cycle
[52] Mock P., German J., Bandivadekar A., Riemersma I. (2012), ICCT working paper 2012-02: Discrepancies between type-approval and „real-world" fuel-consumption and CO_2 values

- Consideration of electrified propulsion systems like hybrid electric vehicles (HEV), plug-in hybrid electric vehicles (PHEV) and battery electric vehicles (BEV) (data and approach compatible to the HBEFA 4.2).

Particle emissions due to vehicle induced abrasion processes ("PM non-exhaust") are taken into account by NEMO in addition to the PM-exhaust emissions. The calculation of the PM non-exhaust emissions is based on the values published in [53] and [54].

Determination of the amounts of fuel used and fuel export

As already mentioned above, the major part of the fuel sold in Luxembourg is exported inside vehicle tanks. The split of the total fuel into domestic fuel use and exported fuel is thus a key element of the calculation of Luxembourg's total air pollutant emissions. This split is performed in several steps:

(i) determination of the domestic fuel consumption with the NEMO model,

(ii) calculation of the amount of exported fuel by subtracting the amount obtained in step (i) from the total national fuel consumption (fuel sold) obtained from national statistics (Statec),

(iii) the entire amount of exported gasoline is attributed to passenger cars,

(iv) the amount of diesel exported by passenger cars is determined by taking into account the result of step (iii) and the share of diesel-fuelled cars in the trans-border fleet,

(v) the amount of diesel exported by heavy duty vehicles is obtained by subtracting the amount of diesel exported by passenger cars from the total amount of exported diesel,

(vi) now the mileages of the passenger cars and heavy-duty vehicles responsible for the fuel export can be determined based on their fuel consumption,

(vii) finally, the emissions caused by domestic fuel use and exported fuel are calculated separately by NEMO.

Due to the lack of solid data on the commuting and transit vehicle fleets, the previous calculations, assume that the composition of the commuting and transit vehicle fleets is identical to the domestic fleet. Hence, emissions reported based on fuel used cover all emissions produced on Luxembourg's territory, i.e. include transit and commuter traffic.

3.2.4.3.2.3 Emission factors

The emission factors used by the NEMO model are derived from the Handbook of Emission Factors for road transport (HBEFA) version 4.2 (please also refer to the previous section for more details on the NEMO model).

As these emission factors are based on real-world emission measurements, emissions from lubricant consumption in vehicles with 2-stroke and 4-stroke engines are thus included in the exhaust emissions from the different vehicle classes (sectors 1A3bi-1A3biv).

---

[53] Schmidt W., Düring I., Lohmeyer A., (2011) Einbindung des HBEFA 3.1 in das FIS Umwelt und Verkehr sowie Neufassung der Emissionsfaktoren für Aufwirbelung und Abrieb des Straßenverkehrs

[54] B. Notter; M. Keller; B. Cox (2019) Handbuch Emissionsfaktoren des Strassenverkehrs 4.1 Quick Reference

For the $PM_{2.5}$ and PM_{10} emission factors, the condensable component is included.

Since submission 2018, NMVOC emissions from sector *1A3 v – Gasoline evaporation* include parking, running losses, and hot soak. A Tier 3 methodology based on the NEMO model and compatible with the EMEP/EEA Guidebook 2023 was applied. In Luxembourg's previous submissions, only evaporation emissions during parking were considered in *1A3bv*, and evaporations occurring during driving were included in categories 1*A3b i* to *1A3b iv*.

Since submission 2018, emissions from road abrasion are explicitly reported in sub-category *1A3b vii – Road abrasion*, while they were included in *1A3b vi – Automobile tyre and brake wear* in Luxembourg's previous submissions.

The following tables present the implied emission factors for each vehicle category. Changes of these factors throughout the time series are due to developments in vehicle technology and vehicle fleet composition. Table 3-119 gives an overview of the evolution of the implied emission factors for category *1A3bi – Passenger cars*, Table 3-120 gives an overview of the evolution of the implied emission factors for category *1A3bii – Light duty vehicles (LDV)*, Table 3-121 gives an overview of the evolution of the implied emission factors for category *1A3biii – Heavy duty vehicles (HDV) and buses*, Table 3-122 gives an overview of the evolution of the implied emission factors for category *1A3biv – Mopeds & motorcycles*, Table 3-123 gives an overview of the evolution of the implied emission factors for category *1A3v – Gasoline evaporation* and Table 3-124 gives an overview of the evolution of the implied emission factors for sub-category *1A3bvi – Automobile tyre and brake wear*.

Table 3-119 – Implied emission factors for category 1*A3b i – Road transport – passenger cars*

1 A Mobile Fuel Combustion Implied Emission Factor (IEF) of air pollutants by source category (g/GJ)													
Year	1 A 3 b i Passenger cars - FUEL SOLD								1 A 3 b i Passenger cars - FUEL USED				
	SO_2	NO_X	NMVOC	NH_3	CO	TSP	PM_{10}	$PM_{2.5}$	SO_2	NOx	NMVOC	NH3	$PM_{2.5}$
1990	12.036	509.768	560.138	0.580	3732.180	14.329	14.329	14.329	9.034	524.454	596.861	0.596	9.941
1991	12.793	472.798	502.497	2.944	3350.460	13.974	13.974	13.974	10.091	484.142	532.199	3.124	10.445
1992	13.253	410.090	412.979	7.173	2757.214	13.335	13.335	13.335	11.038	416.377	432.733	7.566	10.707
1993	13.678	357.242	335.725	10.840	2251.175	12.992	12.992	12.992	12.043	359.774	347.263	11.283	11.179
1994	14.979	315.089	264.831	13.479	1782.923	14.059	14.059	14.059	12.987	316.141	275.868	14.169	11.981
1995	13.187	288.619	220.744	15.469	1494.702	14.054	14.054	14.054	11.880	288.344	227.692	16.083	12.496
1996	6.165	268.592	186.557	17.163	1270.080	14.323	14.323	14.323	5.768	267.578	191.834	17.793	12.957
1997	5.851	251.022	157.033	18.993	1080.496	14.533	14.533	14.533	5.576	249.706	160.280	19.515	13.587
1998	5.473	236.376	131.570	20.632	929.067	14.580	14.580	14.580	5.337	235.314	132.924	20.924	14.115
1999	5.111	224.410	111.012	21.761	803.936	14.627	14.627	14.627	5.123	224.456	110.820	21.712	14.671
2000	4.778	218.337	95.000	21.912	705.513	14.472	14.472	14.472	4.937	220.308	93.537	21.443	14.999
2001	4.620	219.577	82.225	20.819	628.254	13.979	13.979	13.979	4.965	224.971	79.360	19.807	15.015
2002	4.200	225.167	71.565	18.940	563.164	13.309	13.309	13.309	4.637	234.654	67.796	17.543	14.647
2003	4.018	231.840	62.975	16.931	510.144	12.625	12.625	12.625	4.558	246.676	58.332	15.177	14.248
2004	0.407	239.184	55.670	14.835	463.001	12.137	12.137	12.137	0.440	261.981	49.635	12.578	14.189
2005	0.351	244.006	49.337	12.822	419.363	11.754	11.754	11.754	0.392	274.042	42.136	10.227	14.113
2006	0.332	246.929	43.747	11.013	379.409	11.489	11.489	11.489	0.370	281.742	35.913	8.319	13.972
2007	0.319	248.975	39.334	9.593	346.910	10.639	10.639	10.639	0.356	287.982	31.130	6.892	13.046
2008	0.327	252.197	34.803	8.191	310.466	9.395	9.395	9.395	0.364	291.552	27.254	5.788	11.370
2009	0.336	257.055	31.142	7.068	280.044	8.324	8.324	8.324	0.372	296.771	24.212	4.935	9.951
2010	0.342	264.369	27.908	6.214	256.627	7.032	7.032	7.032	0.377	303.966	21.596	4.329	8.281
2011	0.348	272.557	25.294	5.465	241.247	5.678	5.678	5.678	0.381	314.092	19.281	3.763	6.629
2012	0.348	280.619	21.936	4.556	220.172	4.489	4.489	4.489	0.380	322.475	16.807	3.173	5.163
2013	0.350	287.660	19.253	3.864	202.047	3.530	3.530	3.530	0.380	327.480	14.973	2.764	3.980
2014	0.351	290.309	18.075	3.573	195.642	2.420	2.420	2.420	0.378	327.600	14.136	2.637	2.667
2015	0.354	282.302	16.390	3.428	186.157	1.849	1.849	1.849	0.378	316.011	12.981	2.630	2.002
2016	0.354	259.134	14.934	3.489	176.912	1.455	1.455	1.455	0.377	287.877	12.076	2.802	1.554
2017	0.350	225.454	13.772	3.629	169.100	1.149	1.149	1.149	0.372	249.487	11.402	3.032	1.217
2018	0.346	198.813	13.052	3.862	165.443	0.939	0.939	0.939	0.367	220.423	10.929	3.296	0.990
2019	0.339	172.143	12.857	4.200	166.018	0.781	0.781	0.781	0.363	193.891	10.640	3.579	0.823
2020	0.339	150.489	12.110	4.342	157.731	0.675	0.675	0.675	0.358	166.350	10.382	3.843	0.701
2021	0.327	122.394	12.365	4.704	161.345	0.589	0.589	0.589	0.352	139.696	10.230	4.081	0.611
2022	0.326	104.623	11.885	4.826	155.110	0.538	0.538	0.538	0.348	117.639	10.012	4.277	0.549
Trend 1990-2022	-97.29%	-79.48%	-97.88%	731.96%	-95.84%	-96.25%	-96.25%	-96.25%	-96.14%	-77.57%	-98.32%	617.58%	-94.48%
2005-2022	-7.08%	-57.12%	-75.91%	-62.36%	-63.01%	-95.42%	-95.42%	-95.42%	-11.05%	-57.07%	-76.24%	-58.18%	-96.11%
2021-2022	-0.19%	-14.52%	-3.89%	2.60%	-3.86%	-8.65%	-8.65%	-8.65%	-0.92%	-15.79%	-2.13%	4.82%	-10.10%

Source: Environment Agency

Table 3-120 – Implied emission factors for category – *1A3bii - Road transport – Light duty vehicles (LDV)*

1 A Mobile Fuel Combustion Implied Emission Factor (IEF) of air pollutants by source category (g/GJ)													
Year	**1 A 3 b ii Light duty vehicles - FUEL SOLD**								**1 A 3 b ii Light duty vehicles - FUEL USED**				
	SO_2	**NO_X**	**NMVOC**	**NH_3**	**CO**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**NOx**	**NMVOC**	**NH3**	**$PM_{2.5}$**
1990	44.013	513.868	218.891	0.398	2738.494	52.053	52.053	52.053	44.013	513.868	218.891	0.398	52.053
1991	45.926	505.297	197.413	0.443	2477.592	50.973	50.973	50.973	45.926	505.297	197.413	0.443	50.973
1992	48.027	496.847	174.994	0.491	2203.758	50.537	50.537	50.537	48.027	496.847	174.994	0.491	50.537
1993	50.202	488.952	152.742	0.537	1931.012	50.640	50.640	50.640	50.202	488.952	152.742	0.537	50.640
1994	51.603	483.437	137.214	0.584	1743.868	50.569	50.569	50.569	51.603	483.437	137.214	0.584	50.569
1995	44.662	479.771	126.479	0.626	1616.627	50.536	50.536	50.536	44.662	479.771	126.479	0.626	50.536
1996	16.518	469.751	120.190	1.328	1638.287	48.994	48.994	48.994	16.518	469.751	120.190	1.328	48.994
1997	15.924	455.870	94.617	1.646	1350.217	49.980	49.980	49.980	15.924	455.870	94.617	1.646	49.980
1998	15.143	447.744	81.381	1.507	1156.895	50.144	50.144	50.144	15.143	447.744	81.381	1.507	50.144
1999	14.182	436.837	71.038	1.381	1015.316	49.396	49.396	49.396	14.182	436.837	71.038	1.381	49.396
2000	13.219	420.595	57.365	1.367	831.988	48.407	48.407	48.407	13.219	420.595	57.365	1.367	48.407
2001	12.598	413.239	46.315	1.382	681.492	46.625	46.625	46.625	12.598	413.239	46.315	1.382	46.625
2002	10.680	420.635	36.872	1.268	543.026	44.206	44.206	44.206	10.680	420.635	36.872	1.268	44.206
2003	9.570	437.170	29.927	1.131	439.012	41.755	41.755	41.755	9.570	437.170	29.927	1.131	41.755
2004	0.651	457.940	23.663	0.944	337.967	39.675	39.675	39.675	0.651	457.940	23.663	0.944	39.675
2005	0.561	477.462	19.766	0.824	274.963	37.459	37.459	37.459	0.561	477.462	19.766	0.824	37.459
2006	0.490	492.755	17.129	0.754	234.965	35.036	35.036	35.036	0.490	492.755	17.129	0.754	35.036
2007	0.444	505.078	14.631	0.689	197.495	32.197	32.197	32.197	0.444	505.078	14.631	0.689	32.197
2008	0.440	510.813	12.448	0.643	166.128	28.986	28.986	28.986	0.440	510.813	12.448	0.643	28.986
2009	0.437	514.768	10.618	0.599	138.746	26.506	26.506	26.506	0.437	514.768	10.618	0.599	26.506
2010	0.436	516.292	9.082	0.567	117.752	24.304	24.304	24.304	0.436	516.292	9.082	0.567	24.304
2011	0.436	516.245	7.705	0.531	98.691	22.038	22.038	22.038	0.436	516.245	7.705	0.531	22.038
2012	0.436	513.499	6.546	0.478	83.382	19.323	19.323	19.323	0.436	513.499	6.546	0.478	19.323
2013	0.439	510.346	5.542	0.412	70.095	16.412	16.412	16.412	0.439	510.346	5.542	0.412	16.412
2014	0.441	495.936	5.395	0.452	88.069	13.568	13.568	13.568	0.441	495.936	5.395	0.452	13.568
2015	0.440	487.018	4.392	0.453	71.382	11.050	11.050	11.050	0.440	487.018	4.392	0.453	11.050
2016	0.440	453.813	3.717	0.587	65.822	9.051	9.051	9.051	0.440	453.813	3.717	0.587	9.051
2017	0.444	412.142	3.225	0.841	66.805	7.449	7.449	7.449	0.444	412.142	3.225	0.841	7.449
2018	0.449	371.119	2.893	1.105	70.850	6.168	6.168	6.168	0.449	371.119	2.893	1.105	6.168
2019	0.453	337.460	2.541	1.317	71.420	5.256	5.256	5.256	0.453	337.460	2.541	1.317	5.256
2020	0.458	302.905	2.292	1.506	69.780	4.731	4.731	4.731	0.458	302.905	2.292	1.506	4.731
2021	0.456	259.498	2.094	1.659	65.050	4.442	4.442	4.442	0.456	259.498	2.094	1.659	4.442
2022	0.457	222.645	1.950	1.791	61.459	4.248	4.248	4.248	0.457	222.645	1.950	1.791	4.248
Trend 1990-2022	-98.96%	-56.67%	-99.11%	350.31%	-97.76%	-91.84%	-91.84%	-91.84%	-98.96%	-56.67%	-99.11%	350.31%	-91.84%
2005-2022	-18.63%	-53.37%	-90.14%	117.28%	-77.65%	-88.66%	-88.66%	-88.66%	-18.63%	-53.37%	-90.14%	117.28%	-88.66%
2021-2022	0.13%	-14.20%	-6.90%	7.97%	-5.52%	-4.37%	-4.37%	-4.37%	0.13%	-14.20%	-6.90%	7.97%	-4.37%

Source: Environment Agency

Table 3-121 – Implied emission factors for category – *1A3biii - Road transport – Heavy duty vehicles (HDV) and busses*

1 A Mobile Fuel Combustion Implied Emission Factor (IEF) of air pollutants by source category (g/GJ)														
Year	1 A 3 b iii Heavy duty vehicles and buses - FUEL SOLD								1 A 3 b iii Heavy duty vehicles and buses - FUEL USED					
	SO_2	NO_X	NMVOC	NH_3	CO	TSP	PM_{10}	$PM_{2.5}$	SO_2	NOx	NMVOC	NH3	$PM_{2.5}$
1990	60.181	1109.491	56.363	0.127	187.742	42.812	42.812	42.812	60.181	1021.375	154.319	0.177	68.259
1991	60.181	1112.635	52.906	0.125	180.872	41.900	41.900	41.900	60.181	1022.269	153.548	0.176	68.053
1992	60.181	1077.782	51.058	0.131	176.781	40.746	40.746	40.746	60.181	1003.898	147.242	0.182	66.117
1993	60.181	999.584	50.129	0.145	173.811	39.018	39.018	39.018	60.181	975.226	132.869	0.185	61.643
1994	60.181	944.451	49.007	0.155	170.888	37.681	37.681	37.681	60.181	947.484	127.026	0.195	59.757
1995	51.013	922.940	51.176	0.160	174.567	37.873	37.873	37.873	51.013	933.801	119.157	0.193	57.272
1996	18.807	903.300	47.622	0.164	165.568	35.331	35.331	35.331	18.807	919.989	113.908	0.201	54.878
1997	17.537	876.955	43.318	0.169	153.018	31.313	31.313	31.313	17.537	902.611	104.287	0.207	50.278
1998	16.268	852.442	39.623	0.174	141.774	27.534	27.534	27.534	16.268	885.059	93.318	0.212	45.169
1999	14.998	828.519	34.605	0.179	127.839	23.434	23.434	23.434	14.998	866.899	83.284	0.226	40.507
2000	13.729	805.068	30.744	0.183	116.400	19.718	19.718	19.718	13.729	845.382	69.023	0.231	33.944
2001	13.024	773.769	28.283	0.185	111.067	17.531	17.531	17.531	13.024	817.893	59.600	0.233	29.403
2002	11.072	746.708	26.781	0.186	109.287	16.504	16.504	16.504	11.072	789.399	53.267	0.233	26.480
2003	10.005	720.024	24.984	0.186	106.735	15.508	15.508	15.508	10.005	762.013	47.465	0.232	23.966
2004	0.672	694.356	22.992	0.186	103.671	14.431	14.431	14.431	0.672	737.885	43.388	0.232	22.177
2005	0.588	644.664	20.054	0.199	103.252	12.724	12.724	12.724	0.588	699.654	38.400	0.240	19.928
2006	0.517	583.682	17.006	0.226	105.306	10.921	10.921	10.921	0.517	650.032	33.425	0.262	17.606
2007	0.471	513.963	13.845	0.296	108.591	9.124	9.124	9.124	0.471	589.300	28.049	0.325	15.144
2008	0.471	444.249	10.797	0.389	111.774	7.433	7.433	7.433	0.471	527.460	23.260	0.420	12.954
2009	0.471	404.760	9.291	0.452	114.684	6.559	6.559	6.559	0.471	478.020	19.089	0.491	11.024
2010	0.471	367.648	7.614	0.510	114.963	5.567	5.567	5.567	0.471	437.451	15.793	0.558	9.400
2011	0.471	338.493	6.311	0.565	114.554	4.766	4.766	4.766	0.471	406.393	13.260	0.621	8.145
2012	0.471	319.301	5.448	0.607	115.024	4.228	4.228	4.228	0.471	384.238	11.393	0.679	7.233
2013	0.471	297.243	4.703	0.650	112.797	3.728	3.728	3.728	0.471	361.263	9.758	0.730	6.420
2014	0.471	264.472	4.083	0.710	106.197	3.226	3.226	3.226	0.471	326.440	8.240	0.784	5.557
2015	0.472	225.897	3.504	0.773	95.666	2.709	2.709	2.709	0.472	283.571	6.865	0.848	4.675
2016	0.472	186.784	3.020	0.833	82.201	2.216	2.216	2.216	0.472	241.506	5.711	0.905	3.870
2017	0.472	149.514	2.635	0.887	67.672	1.772	1.772	1.772	0.472	203.870	4.791	0.952	3.187
2018	0.472	116.926	2.321	0.932	54.079	1.395	1.395	1.395	0.472	172.734	4.083	0.995	2.643
2019	0.472	92.410	2.129	0.965	43.406	1.128	1.128	1.128	0.472	147.268	3.600	1.026	2.228
2020	0.473	75.937	2.074	0.991	36.105	0.956	0.956	0.956	0.473	125.251	3.224	1.055	1.848
2021	0.473	61.518	2.041	1.009	29.003	0.786	0.786	0.786	0.473	106.189	2.982	1.074	1.518
2022	0.473	53.040	2.091	1.031	24.651	0.694	0.694	0.694	0.473	90.769	2.824	1.092	1.260
Trend 1990-2022	-99.21%	-95.22%	-96.29%	713.05%	-86.87%	-98.38%	-98.38%	-98.38%	-99.21%	-91.11%	-98.17%	517.07%	-98.15%
2005-2022	-19.49%	-91.77%	-89.57%	417.72%	-76.13%	-94.55%	-94.55%	-94.55%	-19.49%	-87.03%	-92.64%	355.03%	-93.68%
2021-2022	0.05%	-13.78%	2.47%	2.10%	-15.01%	-11.71%	-11.71%	-11.71%	0.05%	-14.52%	-5.28%	1.61%	-17.02%

Source: Environment Agency

Table 3-122 – Implied emission factors for category – *1A3biv - Road transport – Mopeds & motorcycles*

1 A Mobile Fuel Combustion

Implied Emission Factor (IEF) of air pollutants by source category (g/GJ)

Year	1 A 3 b iv Mopeds & motorcycles - FUEL SOLD								1 A 3 b iv Mopeds & motorcycles - FUEL USED				
	SO_2	NO_X	NMVOC	NH_3	CO	TSP	PM_{10}	$PM_{2.5}$	SO_2	NOx	NMVOC	NH3	$PM_{2.5}$
1990	4.705	142.858	3483.564	1.224	9211.197	148.829	148.829	148.829	4.705	142.858	3483.564	1.224	148.829
1991	4.705	144.155	3278.468	1.224	8994.399	139.070	139.070	139.070	4.705	144.155	3278.468	1.224	139.070
1992	4.705	145.194	3096.059	1.226	8746.024	130.918	130.918	130.918	4.705	145.194	3096.059	1.226	130.918
1993	4.705	147.307	2772.355	1.226	8365.935	115.835	115.835	115.835	4.705	147.307	2772.355	1.226	115.835
1994	4.176	147.008	2572.025	1.218	8005.282	107.115	107.115	107.115	4.176	147.008	2572.025	1.218	107.115
1995	3.712	147.674	2572.371	1.222	7967.130	107.736	107.736	107.736	3.712	147.674	2572.371	1.222	107.736
1996	3.248	145.195	2501.546	1.204	7740.861	104.702	104.702	104.702	3.248	145.195	2501.546	1.204	104.702
1997	2.784	144.443	2483.872	1.200	7642.711	104.328	104.328	104.328	2.784	144.443	2483.872	1.200	104.328
1998	2.320	143.872	2457.861	1.196	7546.071	103.504	103.504	103.504	2.320	143.872	2457.861	1.196	103.504
1999	1.856	144.083	2266.385	1.189	7288.946	94.504	94.504	94.504	1.856	144.083	2266.385	1.189	94.504
2000	1.392	144.063	2206.996	1.186	7181.919	91.947	91.947	91.947	1.392	144.063	2206.996	1.186	91.947
2001	0.868	143.739	2209.044	1.185	7139.495	92.359	92.359	92.359	0.868	143.739	2209.044	1.185	92.359
2002	0.687	143.917	2147.006	1.183	7048.225	89.539	89.539	89.539	0.687	143.917	2147.006	1.183	89.539
2003	0.589	144.677	2079.201	1.181	6891.935	86.976	86.976	86.976	0.589	144.677	2079.201	1.181	86.976
2004	0.311	143.922	2179.409	1.187	6733.524	97.417	97.417	97.417	0.311	143.922	2179.409	1.187	97.417
2005	0.227	143.925	2125.160	1.193	6476.218	100.040	100.040	100.040	0.227	143.925	2125.160	1.193	100.040
2006	0.227	141.747	2081.952	1.191	6241.194	101.168	101.168	101.168	0.227	141.747	2081.952	1.191	101.168
2007	0.228	138.673	2065.462	1.194	6037.798	103.710	103.710	103.710	0.228	138.673	2065.462	1.194	103.710
2008	0.228	135.872	2043.725	1.196	5838.463	105.788	105.788	105.788	0.228	135.872	2043.725	1.196	105.788
2009	0.228	133.072	1942.459	1.195	5566.323	102.688	102.688	102.688	0.228	133.072	1942.459	1.195	102.688
2010	0.228	130.460	1951.591	1.200	5419.088	106.352	106.352	106.352	0.228	130.460	1951.591	1.200	106.352
2011	0.230	127.925	1922.437	1.200	5233.016	107.494	107.494	107.494	0.230	127.925	1922.437	1.200	107.494
2012	0.228	124.353	1935.478	1.205	5058.476	112.681	112.681	112.681	0.228	124.353	1935.478	1.205	112.681
2013	0.228	121.500	1865.578	1.212	4846.553	112.540	112.540	112.540	0.228	121.500	1865.578	1.212	112.540
2014	0.229	118.511	1769.676	1.217	4609.174	109.736	109.736	109.736	0.229	118.511	1769.676	1.217	109.736
2015	0.231	115.730	1689.295	1.222	4403.405	107.110	107.110	107.110	0.231	115.730	1689.295	1.222	107.110
2016	0.232	112.361	1638.678	1.227	4221.043	106.930	106.930	106.930	0.232	112.361	1638.678	1.227	106.930
2017	0.230	108.443	1542.327	1.234	4010.365	103.283	103.283	103.283	0.230	108.443	1542.327	1.234	103.283
2018	0.231	104.585	1417.015	1.240	3786.552	95.890	95.890	95.890	0.231	104.585	1417.015	1.240	95.890
2019	0.234	101.135	1381.578	1.252	3652.780	95.582	95.582	95.582	0.234	101.135	1381.578	1.252	95.582
2020	0.234	97.139	1345.499	1.258	3499.602	95.756	95.756	95.756	0.234	97.139	1345.499	1.258	95.756
2021	0.235	92.904	1271.116	1.265	3324.104	93.613	93.613	93.613	0.235	92.904	1271.116	1.265	93.613
2022	0.235	89.270	1183.229	1.269	3160.133	90.901	90.901	90.901	0.235	89.270	1183.229	1.269	90.901
Trend 1990-2022	-95.00%	-37.51%	-66.03%	3.71%	-65.69%	-38.92%	-38.92%	-38.92%	-95.00%	-37.51%	-66.03%	3.71%	-38.92%
2005-2022	3.55%	-37.97%	-44.32%	6.41%	-51.20%	-9.14%	-9.14%	-9.14%	3.55%	-37.97%	-44.32%	6.41%	-9.14%
2021-2022	0.30%	-3.91%	-6.91%	0.39%	-4.93%	-2.90%	-2.90%	-2.90%	0.30%	-3.91%	-6.91%	0.39%	-2.90%

Source: Environment Agency

Table 3-123 – Implied emission factors for category – *1A3b v - Road transport – Gasoline evaporation*

1 A 3 b v Road transport: Gasoline evaporation Implied Emission Factor (IEF) of air pollutants by source category (g/GJ)													
Year	FUEL SOLD								FUEL USED				
	SO_2	NO_X	NMVOC	NH_3	CO	TSP	PM_{10}	$PM_{2.5}$	SO_2	NOx	NMVOC	NH3	$PM_{2.5}$
1990	NA	NA	226.236	NA	NA	NA	NA	NA	NA	NA	228.146	NA	NA
1991	NA	NA	203.808	NA	NA	NA	NA	NA	NA	NA	206.148	NA	NA
1992	NA	NA	165.339	NA	NA	NA	NA	NA	NA	NA	167.446	NA	NA
1993	NA	NA	130.018	NA	NA	NA	NA	NA	NA	NA	132.389	NA	NA
1994	NA	NA	99.592	NA	NA	NA	NA	NA	NA	NA	102.120	NA	NA
1995	NA	NA	78.776	NA	NA	NA	NA	NA	NA	NA	81.242	NA	NA
1996	NA	NA	62.910	NA	NA	NA	NA	NA	NA	NA	65.054	NA	NA
1997	NA	NA	49.726	NA	NA	NA	NA	NA	NA	NA	51.323	NA	NA
1998	NA	NA	38.869	NA	NA	NA	NA	NA	NA	NA	40.667	NA	NA
1999	NA	NA	30.687	NA	NA	NA	NA	NA	NA	NA	32.542	NA	NA
2000	NA	NA	24.932	NA	NA	NA	NA	NA	NA	NA	26.607	NA	NA
2001	NA	NA	20.813	NA	NA	NA	NA	NA	NA	NA	22.339	NA	NA
2002	NA	NA	17.687	NA	NA	NA	NA	NA	NA	NA	19.061	NA	NA
2003	NA	NA	15.385	NA	NA	NA	NA	NA	NA	NA	16.634	NA	NA
2004	NA	NA	13.851	NA	NA	NA	NA	NA	NA	NA	15.069	NA	NA
2005	NA	NA	12.981	NA	NA	NA	NA	NA	NA	NA	14.159	NA	NA
2006	NA	NA	12.516	NA	NA	NA	NA	NA	NA	NA	13.723	NA	NA
2007	NA	NA	12.187	NA	NA	NA	NA	NA	NA	NA	13.392	NA	NA
2008	NA	NA	11.773	NA	NA	NA	NA	NA	NA	NA	12.911	NA	NA
2009	NA	NA	11.346	NA	NA	NA	NA	NA	NA	NA	12.450	NA	NA
2010	NA	NA	10.740	NA	NA	NA	NA	NA	NA	NA	11.823	NA	NA
2011	NA	NA	10.336	NA	NA	NA	NA	NA	NA	NA	11.363	NA	NA
2012	NA	NA	9.338	NA	NA	NA	NA	NA	NA	NA	10.332	NA	NA
2013	NA	NA	8.628	NA	NA	NA	NA	NA	NA	NA	9.520	NA	NA
2014	NA	NA	8.524	NA	NA	NA	NA	NA	NA	NA	9.429	NA	NA
2015	NA	NA	7.950	NA	NA	NA	NA	NA	NA	NA	8.817	NA	NA
2016	NA	NA	7.281	NA	NA	NA	NA	NA	NA	NA	8.045	NA	NA
2017	NA	NA	6.401	NA	NA	NA	NA	NA	NA	NA	7.111	NA	NA
2018	NA	NA	5.732	NA	NA	NA	NA	NA	NA	NA	6.402	NA	NA
2019	NA	NA	5.216	NA	NA	NA	NA	NA	NA	NA	5.851	NA	NA
2020	NA	NA	4.808	NA	NA	NA	NA	NA	NA	NA	5.393	NA	NA
2021	NA	NA	4.566	NA	NA	NA	NA	NA	NA	NA	5.140	NA	NA
2022	NA	NA	4.530	NA	NA	NA	NA	NA	NA	NA	5.050	NA	NA
Trend 1990-2022	NA	NA	-98.00%	NA	NA	NA	NA	NA	NA	NA	-97.79%	NA	NA
2005-2022	NA	NA	-65.10%	NA	NA	NA	NA	NA	NA	NA	-64.33%	NA	NA
2021-2022	NA	NA	-0.78%	NA	NA	NA	NA	NA	NA	NA	-1.75%	NA	NA

Source: Environment Agency

Table 3-124 – Implied emission factors for category – *1A3b vi - Road transport – Automobile tyre and brake wear*

1 A 3 b vi Road transport: Automobile tyre and brake wear Implied Emission Factor (g/km)				
Year	FUEL SOLD			FUEL USED
	TSP	PM_{10}	$PM_{2.5}$	$PM_{2.5}$
1990	0.024	0.018	0.010	0.009
1991	0.025	0.018	0.010	0.009
1992	0.025	0.018	0.010	0.009
1993	0.025	0.018	0.010	0.009
1994	0.024	0.018	0.010	0.009
1995	0.023	0.018	0.010	0.009
1996	0.023	0.018	0.010	0.009
1997	0.024	0.018	0.010	0.009
1998	0.024	0.018	0.010	0.009
1999	0.024	0.018	0.010	0.009
2000	0.025	0.019	0.010	0.009
2001	0.025	0.019	0.010	0.009
2002	0.025	0.019	0.010	0.009
2003	0.026	0.019	0.011	0.009
2004	0.028	0.020	0.011	0.009
2005	0.029	0.021	0.012	0.009
2006	0.029	0.021	0.012	0.009
2007	0.028	0.021	0.011	0.009
2008	0.028	0.021	0.011	0.009
2009	0.027	0.020	0.011	0.009
2010	0.028	0.021	0.012	0.009
2011	0.028	0.021	0.011	0.009
2012	0.027	0.020	0.011	0.009
2013	0.028	0.021	0.011	0.009
2014	0.027	0.020	0.011	0.009
2015	0.027	0.020	0.011	0.009
2016	0.027	0.020	0.011	0.009
2017	0.027	0.020	0.011	0.009
2018	0.028	0.021	0.011	0.009
2019	0.028	0.021	0.012	0.009
2020	0.029	0.021	0.012	0.009
2021	0.028	0.021	0.011	0.009
2022	0.026	0.019	0.010	0.009
Trend 1990-2022	5.14%	4.67%	5.21%	2.05%
2005-2022	-10.98%	-10.07%	-11.11%	0.42%
2021-2022	-8.17%	-7.62%	-8.25%	-0.66%

Source: Environment Agency

3.2.4.3.3 Methodological issues for heavy metals and POPs

3.2.4.3.3.1 Activity Data

HM and POPs emissions from road transport were estimated based on total fuel sold.

3.2.4.3.3.2 Methodological Choices

Emission values for the following categories were calculated with the same methodology and model as for the main pollutants:

- 1.A.3.b.i Passenger cars
- 1.A.3.b.ii Light duty vehicles
- 1.A.3.b.iii Heavy duty vehicles
- 1.A.3.b.iv Mopeds & motorcycles

Apart from fuel combustion, HM emissions of road traffic originate from tyre wear, brake wear and corrosion. The corresponding emissions were calculated with the same methodology and model as for the main pollutants.

Since road surface wear does not generate HM emissions, calculations in relation to this potential source of air pollution were not performed.

HCB emissions from road transport are no longer estimated as the EMEP/EEA Guidebook does not provide any emission factors.

3.2.4.3.4 Uncertainties and time-series consistency

Regarding time-series consistency, the air pollutants emissions from road transportation were calculated with the NEMO model for the time-series 1990-2022.

The assessment of activity data and emission factor uncertainties is done according to the methodology described in the EMEP/EEA emission inventory Guidebook 2023 (Chapter A.5 Uncertainties, tables 2-1, 2-2 and 2-3), covering the main pollutants NO_x, NH_3, NMVOC, SO_x and $PM_{2.5}$. For some subcategories and pollutants, expert judgements were made to estimate AD or EF uncertainties. For CO, PM10, heavy metzals and persistent organic pollutants, no uncertainty estimates are currently made. Details on uncertainty of the activity data can also be checked in the Luxembourg's National Inventory report (NIR). Please also refer to Table 1-33 to Table 1-37 of section 1.7 for caterogory specific uncertainties on activity data and emission factors.

The following parameters are qualified with relatively high uncertainties:

- Recently, a significant number of Luxembourg citizens moved to neighbouring countries but keeping their passenger cars registered in Luxembourg. However, as no reliable statistical data on the vehicle fleet of those citizens exists, this effect has not been considered. However, its magnitude is judged to be minor.
- The number of cars and light duty vehicles (LDV) registered as company cars is unknown as well as the number of cross border commuters, using the company car for the way home and for private purposes abroad. Due to missing data and the chosen approach, the domestic mileage driven by passenger cars registered in Luxembourg might be slightly overestimated.
- The data for the calculation of driving performance in cross-border traffic (without border commuters) is very poor. This must be based essentially on data of automatic counting systems. From these devices, only two categories of vehicles "car and truck-like vehicles" can be distinguished. This relatively rough distinction, in only two classes of vehicles, involves uncertainty in the classification of passenger cars, LDV, and HDV, which in turn affects greatly on the modeled fuel consumption and emissions.
- By changing the definition of the two vehicles at the counting systems in a process that extends over several years, additional uncertainties arise in the formation of the time series.
- Due to the existing data situation, the domestic traffic of people living in Luxembourg is calculated based on the total mileage of cars registered in Luxembourg and, on the basis of tourism statistics, estimated driving performance of these vehicles abroad. On the one hand, the tourism statistics show gaps, and, on the other hand, the values collected for the modal choice involve certain inaccuracies. Due to the missing data on the actual way frequencies and travel distances abroad, the necessary assessments taken induce additional uncertainties.
- As the road freight transport statistics are incomplete, the number of cross-border journeys for road freight transport must be estimated using the data of the automatic counting systems at the country borders. In addition, assumptions about the

distances within the country must be taken. The resilience of the results of this method is directly related to the quality and resolution of data accuracy of automatic counting systems.

- The data on transport performance with LDV is poor in many European countries and in Luxembourg, in particular on the loads and distances. The impact on the overall results is considered to be low.
- For the modelling of energy use and emissions from domestic transport, the composition of the domestic fleet of Luxembourg is used. It is assumed that the resulting error is less than the uncertainty in the calculation of domestic driving performance.

3.2.4.3.5 Source-specific QA/QC and verification

Consistency and completeness checks are performed.

3.2.4.3.6 Category-specific recalculations including changes made in response to the review process

Table 3-125 and Table 3-126 present the main revisions and recalculations done since submission 2023 for category *1A3b – Road transport*.

Table 3-125 – Recalculations done since the last submission for category – *1A3b – Road transport*

Source category	Revisions 2023 ➔ 2024	Type of revision
1A3b	Due to an error correction, the total activity data for diesel oil for the entire timeseries was revised, which impacts several mobile combustion sub-categories (1A2gvii, 1A3b, 1A3c, 1A3d, 1A4cii, 1A5b). As the fuel consumptions in mobile combustion are allocated to different vehicle categories by the NEMO and GEORG models, the change in total diesel activity data also impacts the allocations of gasoline, biomass and other fossil fuels (the total activity data of these three fuel types remains unchanged)	AD

Table 3-126 - Activity data recalculations in category 1A3b road transportation

AD changes in GJ	1A3bi Diesel Oil	1A3bi Biomass	1A3bi Other Fossil Fuels	1A3bi Gasoline	1A3bii Gasoline	1A3bii Diesel Oil	1A3bii Biomass	1A3bii Other Fossil Fuels	1A3biii Diesel Oil	1A3biii Biomass	1A3biii Other Fossil Fuels	1A3biv Gasoline	1A3biv Biomass
1990	45.3195	-	-	8.9334	-7.6474	-13.9403	-	-	-59473.4056	-	-	-1.2860	-
1991	36.6918	-	-	8.6947	-6.9609	-15.4538	-	-	-171912.8572	-	-	-1.7339	-
1992	28.9313	-	-	7.8025	-5.7841	-16.8495	-	-	-154236.7522	-	-	-2.0185	-
1993	21.9989	-	-	7.5982	-5.4448	-18.0535	-	-	-158112.1607	-	-	-2.1534	-
1994	25.1328	-	-	6.6031	-4.4004	-20.0339	-	-	-220101.1745	-	-	-2.2027	-
1995	19.4778	-	-	5.6158	-3.5591	-21.6630	-	-	-229346.0850	-	-	-2.0567	-
1996	12.8981	-	-	-7.8188	9.8620	-33.1708	-	-	-238385.5558	-	-	-2.0432	-
1997	18.1566	-	-	12.1997	-10.2430	4.0709	-	-	-176265.1148	-	-	-1.9568	-
1998	45.4287	-	-	85.3699	-84.6763	77.5696	-	-	-79236.5483	-	-	-0.6936	-
1999	40.8230	-	-	83.3169	-82.6145	57.5466	-	-	31494.5407	-	-	-0.7024	-
2000	30.4542	-	-	71.4363	-71.9259	59.9511	-	-	20597.7249	-	-	0.4896	-
2001	26.5787	-	-	65.3676	-65.6979	72.6177	-	-	35078.6853	-	-	0.3303	-
2002	-17.8785	-	-	57.5391	-57.7904	60.5433	-	-	29531.5707	-	-	0.2513	-
2003	-27.2196	-	-	49.3342	-49.6046	54.6835	-	-	19510.9967	-	-	0.2705	-
2004	-42.9165	-1.5873	-0.0906	40.5764	-40.6088	31.1060	-0.1070	-0.0061	20636.2489	1.8772	0.1072	0.0324	-
2005	-81.1894	-1.4340	-0.0819	36.4467	-36.4130	31.5067	-0.0969	-0.0055	20867.9323	1.6846	0.0962	-0.0337	-
2006	-64.6846	-1.1001	-0.0628	67.4581	-67.3411	36.1910	-0.0733	-0.0042	15540.8794	1.2946	0.0739	-0.1170	-
2007	119.9566	-118.7464	-6.7974	114.7493	-114.5951	92.6569	-7.3062	-0.3980	16959.0803	140.9581	8.0462	-0.1542	-0.0004
2008	66.4418	-117.3948	-6.7179	133.6323	-133.4789	112.2810	-6.4349	-0.3507	16352.1319	136.9253	7.8160	-0.1535	-0.0003
2009	-368.4700	209.9679	11.9637	202.0765	-204.5557	130.5908	18.9731	1.1051	-26685.7335	-253.6852	-14.4810	2.4791	0.0047
2010	-143.6759	6.8633	0.3468	243.1618	-246.0028	220.2622	5.3074	0.3149	-1470.3841	-13.3218	-0.7239	2.8410	0.0056
2011	-169.3598	52.1070	2.4650	314.4813	-319.8830	320.1013	5.0375	0.5589	-7818.7298	-62.9374	-3.3249	5.4017	0.0936
2012	-173.4285	11.1763	0.4755	347.1674	-352.5315	318.9535	8.0611	0.4455	-1835.6133	-20.9352	-1.0012	5.3641	0.0191
2013	-199.2528	-69.0714	-3.2740	358.9358	-365.5859	392.9394	6.2825	0.3285	6469.8229	70.6289	3.3140	6.6501	0.0131
2014	-1353.2977	208.5650	10.4115	-12.2072	2.5930	174.6824	27.3296	1.3622	-19143.5919	-269.7530	-13.4582	9.6141	0.0948
2015	-1969.7206	-152.6859	-8.7653	189.9096	-199.6740	369.4083	7.2830	0.6777	5584.4217	153.9138	8.5751	9.7644	0.2387
2016	-3137.5712	-295.7781	-16.6121	223.0522	-232.4378	541.8466	8.0653	0.8392	10676.0080	308.0665	16.9059	9.3855	0.2918
2017	-4619.2366	-506.8432	-28.6951	332.1795	-342.2327	566.1872	10.9358	1.0368	13598.8053	527.2574	29.4201	10.0532	0.2246
2018	-7283.1749	-598.8287	-34.0107	331.7136	-341.4257	592.0733	17.0375	1.5323	12786.8259	601.3308	33.5863	9.7121	0.2957
2019	91316.1137	5961.5821	332.5913	343.9735	-353.0529	564.6917	12.3226	1.6744	-88167.6690	-5962.1968	-333.5854	9.0796	0.4527
2020	-10270.0563	-1083.7087	-48.1196	427.6165	-436.1706	614.0394	26.9786	2.1856	12560.5291	1074.8942	46.7437	8.5542	0.4566
2021	-7444.3312	-698.4069	-25.8086	1459.3353	-476.5031	688.8434	21.3110	1.5936	14581.2161	1098.1121	36.2976	7.9245	0.4473

3.2.4.3.7 Category-specific planned improvements including those in response to the review process

The following improvements are planned for the next submission.

Table 3-127 – Planned improvements for category – *1A3b – Road transport*

Source category	Planned improvements	Type of revision
1A3b i-v	In order to improve transparency, values for biomass activity data will be provided instead of the notation key IE.	NA

3.2.4.4 Railways (1A3c)

3.2.4.4.1 Source category description

Railways related air pollutant emissions are quite low in Luxembourg. The reason stems from the fact that Luxembourg's national railway company, *CFL (Chemins de Fer Luxembourgeois*), uses, almost exclusively, locomotives powered by electricity.

Since the restructuring and liberalisation activities in the mid-2000s, less diesel driven locomotives were used. Since 2007, the number of diesel driven locomotives has stabilised between 70 and 80 units being operated per year.

In 1990 and 2022, this source category represented about 0.63% and 0.39% of national total NO_X emissions (based on fuel sold). All other pollutants had a share of less than 0.4 % of the national totals in these 2 years.

In the period 1990 – 2022, SO_2 emission decreased by 89.6%, NO_x emissions by 82.8% and PM emissions by 95.1% (see Table 3-128 and in more detail Table 3-129).

Air pollutant emissions (main pollutants, heavy metals and perisitent organic pollutants) from railways are not a key category in 2022 (see Table 3-96 and Table 3-97 and also Table 3-4 and Table 3-5 in Section 3.2 and Chapter 1.5).

Table 3-128 – Emissions, Trends and Shares based on fuel sold and fuel used for category *1A3c - Railways*

1 A Mobile Fuel Combustion

Emissions [Gg], Trend and Share in National Totals of air pollutants based on fuel sold and fuel used

1 A 3 c Railways

Pollutant	Emissions				Trend			FUEL USED			FUEL SOLD			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
SO2	0.0202	0.0028	0.0026	0.0021	-89.6%	-25.7%	-19.4%	0.13%	0.11%	0.49%	0.12%	0.11%	0.47%	fuel sold
NOx	0.2577	0.0989	0.0566	0.0443	-82.8%	-55.2%	-21.8%	1.16%	0.55%	0.48%	0.63%	0.17%	0.39%	fuel sold
NMVOC	0.0494	0.0150	0.0054	0.0043	-91.4%	-71.6%	-21.5%	0.23%	0.12%	0.04%	0.16%	0.10%	0.04%	fuel sold
NH3	0.0001	0.0000	0.0000	0.0000	-85.1%	-55.6%	-20.6%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	fuel sold
CO	0.2796	0.0887	0.0392	0.0310	-88.9%	-65.0%	-20.8%	0.07%	0.40%	0.21%	0.06%	0.22%	0.17%	fuel sold
TSP	0.0590	0.0167	0.0037	0.0029	-95.1%	-82.8%	-22.3%	0.35%	0.74%	0.14%	0.33%	0.42%	0.11%	fuel sold
PM10	0.0590	0.0167	0.0037	0.0029	-95.1%	-82.8%	-22.3%	0.37%	0.93%	0.21%	0.35%	0.52%	0.17%	fuel sold
PM2.5	0.0590	0.0167	0.0037	0.0029	-95.1%	-82.8%	-22.3%	0.38%	1.24%	0.33%	0.37%	0.66%	0.28%	fuel sold

Source: Environment Agency

Table 3-129 – Emission trends of category – *1A3c - Railways*

	1 A Mobile Fuel Combustion							
	Emissions of air pollutants by source category (Gg)							
Year	**1 A 3 c Railways**							
	SO_2	**NO_X**	**NMVOC**	**NH_3**	**CO**	**TSP**	**PM_{10}**	**$PM_{2.5}$**
1990	0.020	0.258	0.049	0.00008	0.280	0.059	0.059	0.059
1991	0.020	0.259	0.049	0.00008	0.279	0.059	0.059	0.059
1992	0.020	0.259	0.049	0.00008	0.279	0.058	0.058	0.058
1993	0.020	0.260	0.049	0.00008	0.278	0.058	0.058	0.058
1994	0.020	0.255	0.047	0.00008	0.269	0.056	0.056	0.056
1995	0.013	0.208	0.038	0.00006	0.217	0.045	0.045	0.045
1996	0.007	0.235	0.042	0.00007	0.242	0.049	0.049	0.049
1997	0.007	0.233	0.041	0.00007	0.237	0.048	0.048	0.048
1998	0.007	0.235	0.041	0.00007	0.236	0.047	0.047	0.047
1999	0.007	0.237	0.041	0.00007	0.235	0.047	0.047	0.047
2000	0.007	0.237	0.040	0.00007	0.231	0.045	0.045	0.045
2001	0.007	0.258	0.043	0.00007	0.248	0.048	0.048	0.048
2002	0.006	0.230	0.037	0.00006	0.215	0.041	0.041	0.041
2003	0.006	0.200	0.031	0.00006	0.184	0.035	0.035	0.035
2004	0.004	0.158	0.025	0.00004	0.144	0.027	0.027	0.027
2005	0.003	0.099	0.015	0.00003	0.089	0.017	0.017	0.017
2006	0.002	0.073	0.011	0.00002	0.064	0.012	0.012	0.012
2007	0.003	0.101	0.014	0.00003	0.086	0.015	0.015	0.015
2008	0.003	0.113	0.015	0.00003	0.093	0.016	0.016	0.016
2009	0.003	0.106	0.014	0.00003	0.084	0.014	0.014	0.014
2010	0.004	0.111	0.013	0.00003	0.084	0.013	0.013	0.013
2011	0.004	0.108	0.012	0.00003	0.078	0.012	0.012	0.012
2012	0.003	0.095	0.011	0.00002	0.068	0.010	0.010	0.010
2013	0.003	0.078	0.008	0.00002	0.054	0.007	0.007	0.007
2014	0.003	0.085	0.009	0.00002	0.057	0.007	0.007	0.007
2015	0.002	0.057	0.006	0.00001	0.037	0.004	0.004	0.004
2016	0.002	0.051	0.005	0.000	0.034	0.004	0.004	0.004
2017	0.002	0.054	0.005	0.000	0.036	0.004	0.004	0.004
2018	0.002	0.056	0.005	0.000	0.038	0.004	0.004	0.004
2019	0.002	0.053	0.005	0.000	0.036	0.004	0.004	0.004
2020	0.002	0.054	0.005	0.000	0.037	0.004	0.004	0.004
2021	0.003	0.057	0.005	0.000	0.039	0.004	0.004	0.004
2022	0.002	0.044	0.004	0.000	0.031	0.003	0.003	0.003
Trend 1990-2022	*-89.61%*	*-82.81%*	*-91.37%*	*-85.07%*	*-88.90%*	*-95.12%*	*-95.12%*	*-95.12%*
2005-2022	*-25.69%*	*-55.20%*	*-71.65%*	*-55.63%*	*-65.04%*	*-82.76%*	*-82.76%*	*-82.76%*
2021-2022	*-19.43%*	*-21.78%*	*-21.51%*	*-20.63%*	*-20.85%*	*-22.25%*	*-22.25%*	*-22.25%*

Source: Environment Agency

3.2.4.4.2 Methodological issues & time-series consistency

3.2.4.4.2.1 Activity data

Diesel oil consumption, operating hours, engine power and age per locomotive type was obtained directly from the national railway company (CFL, see Table 3-130 for fuel consumption). Activity data is consistent with the data reported by the national statistics institute in their energy balance (2000-2022). For the years 1990-1999, the energy balance (based on the IEA Questionnaire) does not report any consumption data for railways. Hence, the inventory fully relies on the data as reported by the national railway company, which were available for the years 1993-1995 and 2001. The consumption for the years from 1996-2000 was interpolated based on the numbers of diesel driven locomotives running in the respective year. Similarly, for 1990-1992, the data was extrapolated based on the number of diesel driven locomotives.

Table 3-130 – Activity data for category – *1A3c - Railways*

1 A Mobile Fuel Combustion						
Activity Data by fuel type (GJ)						
1 A 3 c Railways						
Year	Activity Total (incl. biomass)	Liquid	Solid	Gaseous	Biomass	Other
1990	334 678	334'678	NO	NA	NO	NA
1991	334 678	334'678	NO	NA	NO	NA
1992	334 678	334'678	NO	NA	NO	NA
1993	334 678	334'678	NO	NA	NO	NA
1994	324 884	324'884	NO	NA	NO	NA
1995	263 059	263'059	NO	NA	NO	NA
1996	293 972	293'972	NO	NA	NO	NA
1997	288 989	288'989	NO	NA	NO	NA
1998	288 989	288'989	NO	NA	NO	NA
1999	288 989	288'989	NO	NA	NO	NA
2000	285 971	285'971	NO	NA	NO	NA
2001	308 159	308'159	NO	NA	NO	NA
2002	272 319	272'319	NO	NA	NO	NA
2003	237 417	237'417	NO	NA	NO	NA
2004	188 732	188'732	NO	NA	IE	NA
2005	119 836	119'836	NO	NA	IE	NA
2006	89 357	89'357	NO	NA	IE	NA
2007	126 934	126'934	NO	NA	IE	NA
2008	145 790	145'790	NO	NA	IE	NA
2009	140 389	140'389	NO	NA	IE	NA
2010	151 142	151'142	NO	NA	IE	NA
2011	151 343	151'343	NO	NA	IE	NA
2012	137 692	137'692	NO	NA	IE	NA
2013	119 028	119'028	NO	NA	IE	NA
2014	136 764	136'764	NO	NA	IE	NA
2015	93 847	93'847	NO	NA	IE	NA
2016	86 211	86'211	NO	NA	IE	NA
2017	94 923	94'923	NO	NA	IE	NA
2018	100 898	100'898	NO	NA	IE	NA
2019	97 460	97'460	NO	NA	IE	NA
2020	100 708	100'708	NO	NA	IE	NA
2021	109 884	109'884	NO	NA	IE	NA
2022	88 486	88'486	NO	NA	IE	NA
***Trend* 1990-2022**	*-73.56%*	*-73.56%*	*NA*	*NA*	*NA*	*NA*
2005-2022	*-26.16%*	*-26.16%*	*NA*	*NA*	*NA*	*NA*
2021-2022	*-19.47%*	*-19.47%*	*NA*	*NA*	*NA*	*NA*

Source: Environment Agency

3.2.4.4.2.2 Methodology

For emissions of air pollutants from off-road vehicles and other machinery, the GEORG (Grazer Emissionsmodell für Off-Road Geräte) model developed by the TU Graz was used. Input data to the model are:

- Machinery stock data (obtained through inquiries and statistical extrapolation);
- Assumptions on drop-out rates of machinery (broken down machinery will be replaced);
- Operating time (obtained through inquiries), related to age of machinery.

From machinery stock data and drop-out rates an age structure of the off-road machinery was obtained by GEORG. Four categories of engine types were considered. Depending on the fuel consumption of the engine the ratio power of the engine was calculated. Emissions were calculated by multiplying an engine specific emission factor (expressed in g/kWh) by the average engine power, the operating time and the number of vehicles.

See Table 3-131 and section *3.2.3.8.1 - Mobile Combustion in Manufacturing Industries and Construction (1A2g vii)*.

3.2.4.4.2.3 Emission factors

For mobile combustion (diesel oil), country-specific values, derived from the GEORG model, have been applied. For the $PM_{2.5}$ and PM_{10} emission factors, the condensable component is included.

Table 3-131 – Methods and Emission Factors used in relation to the energy consumption in 2022 for category *1A3c – Railways*

1 A Mobile Fuel Combustion				
Method applied and Emission factor (EF) used as well as coverage of energy consumption				
1 A 3 c Railways				
Pollutant	**Method**	**EF used**	**Coverage of energy**	**Source**
NOx	T3	CS	100.0%	GEORG
NMVOC **CO** **TSP** **PM10** **PM2.5**	T1	D	0.0%	EMEP/EEA GB
SOx	T3	CS	100.0%	GEORG CS based on fuel sulfur content
	T1	D	0.0%	EMEP/EEA GB

Source: Environment Agency

An overview of the evolution of the implied emission factors is given in Table 3-132.

Table 3-132 – Implied emission factors for category – *1A3c - Railways*

1 A Mobile Fuel Combustion								
Implied Emission Factor (IEF) of air pollutants by source category (g/GJ)								
Year	1 A 3 c Railways							
	SO_2	NO_X	NMVOC	NH_3	CO	TSP	PM_{10}	$PM_{2.5}$
1990	60.26	770.05	147.58	0.25	835.39	176.24	176.24	176.24
1991	60.26	772.58	147.15	0.25	834.00	175.21	175.21	175.21
1992	60.26	775.15	146.73	0.25	832.58	174.16	174.16	174.16
1993	60.26	777.91	146.26	0.25	831.05	173.03	173.03	173.03
1994	60.26	784.76	145.42	0.25	828.18	171.17	171.17	171.17
1995	51.08	791.77	144.55	0.24	825.22	169.26	169.26	169.26
1996	23.54	798.68	143.70	0.24	822.30	167.37	167.37	167.37
1997	23.54	805.60	142.84	0.24	819.37	165.47	165.47	165.47
1998	23.54	812.83	141.94	0.24	816.30	163.47	163.47	163.47
1999	23.54	820.78	140.94	0.24	812.89	161.25	161.25	161.25
2000	23.54	829.15	139.88	0.24	809.30	158.90	158.90	158.90
2001	23.54	838.45	138.70	0.24	805.29	156.27	156.27	156.27
2002	23.54	846.03	134.79	0.24	788.24	150.24	150.24	150.24
2003	23.54	841.11	132.50	0.24	776.61	147.91	147.91	147.91
2004	23.54	836.40	130.24	0.23	765.19	145.59	145.59	145.59
2005	23.54	825.40	125.44	0.23	740.55	139.20	139.20	139.20
2006	23.54	814.49	120.51	0.23	715.28	132.60	132.60	132.60
2007	23.58	794.98	113.05	0.22	677.15	121.93	121.93	121.93
2008	23.58	774.05	105.22	0.21	637.01	110.79	110.79	110.79
2009	23.58	753.30	97.06	0.20	595.33	99.18	99.18	99.18
2010	23.58	732.19	89.13	0.20	554.64	87.81	87.81	87.81
2011	23.57	710.69	81.15	0.19	513.69	76.31	76.31	76.31
2012	23.58	688.83	76.95	0.18	490.31	69.54	69.54	69.54
2013	23.59	656.76	69.71	0.17	453.45	58.78	58.78	58.78
2014	23.60	624.14	62.26	0.16	415.59	47.67	47.67	47.67
2015	23.61	602.72	58.88	0.16	398.97	43.04	43.04	43.04
2016	23.62	592.31	58.14	0.15	396.17	42.63	42.63	42.63
2017	23.64	570.50	54.83	0.15	381.13	38.77	38.77	38.77
2018	23.64	558.13	53.41	0.15	375.13	37.41	37.41	37.41
2019	23.64	546.66	52.05	0.14	369.48	36.12	36.12	36.12
2020	23.69	531.46	50.77	0.14	363.42	34.91	34.91	34.91
2021	23.68	515.51	49.42	0.14	356.68	33.66	33.66	33.66
2022	23.69	500.74	48.17	0.14	350.59	32.50	32.50	32.50
Trend 1990-2022	*-60.69%*	*-34.97%*	*-67.36%*	*-43.53%*	*-58.03%*	*-81.56%*	*-81.56%*	*-81.56%*
2005-2022	*0.64%*	*-39.33%*	*-61.60%*	*-39.91%*	*-52.66%*	*-76.65%*	*-76.65%*	*-76.65%*
2021-2022	*0.05%*	*-2.87%*	*-2.53%*	*-1.43%*	*-1.71%*	*-3.45%*	*-3.45%*	*-3.45%*

Source: Environment Agency

3.2.4.4.3 Methodological issues for heavy metals and POPs

3.2.4.4.3.1 Methodological choices

The calculation of emissions related to railway transport were based on total fuel consumption in combination with tier 1 and tier 2 emission factors, respectively (see tables below).

Fuel consumption data were obtained from the national energy balance.

3.2.4.4.3.2 Emission Factors

Tier 1 emission factors:

Fuel	Pollutants	Source	Page	Table
Diesel oil	Cd, B(a)P, B(b)F	EEA (2023) – Chapter 1.A.3.c Railways	8	3.1

Tier 2 emission factors:

Fuel	Pollutants	Source	Page	Table
Diesel oil	Pb	EEA (2019) – Chapter 1.A.3.b.iii Heavy-duty vehicles including buses (road transport values used as a substitute, since EF for these pollutants are not stated in chapter 1.A.3.c Railways) EF adopted from HDV Diesel > 32t (conventional) Custom factor for conversion from g/km to g/GJ derived as follows: Assumed average fuel consumption: 3 l/km Density diesel oil: 0,84 kg/l Energy density diesel oil: 42,5 GJ/t 3 l/km * 0,48 kg/l = 2,52 kg/km 2,52 kg/km * 0,0425 GJ/km = 0,1071 GJ/km 1 / 0,1071 GJ/km = 9,3371 km/GJ	28	3-21
Diesel oil	B(k)F, I(cd)P	EEA (2023) – Chapter 1.A.3.b.iii Heavy-duty vehicles including buses (road transport values used as a substitute, since EF for these pollutants are not stated in chapter 1.A.3.c Railways) EF adopted from HDV Diesel > 32t (conventional) Custom factor for conversion from g/km to g/GJ derived as follows: Assumed average fuel consumption: 3 l/km Density diesel oil: 0,84 kg/l Energy density diesel oil: 42,5 GJ/t 3 l/km * 0,48 kg/l = 2,52 kg/km 2,52 kg/km * 0,0425 GJ/km = 0,1071 GJ/km 1 / 0,1071 GJ/km = 9,3371 km/GJ	30	3-22
Diesel oil	PCDD/F	EEA (2023) – Chapter 1.A.3.b.iii Heavy-duty vehicles including buses (road transport values used as a substitute, since EF for these pollutants are not stated in chapter 1.A.3.c Railways) PCDD/F = ∑ PCDD, PCDF Custom factor for conversion from g/km to g/GJ derived as follows: Assumed average fuel consumption: 3 l/km Density diesel oil: 0,84 kg/l Energy density diesel oil: 42,5 GJ/t 3 l/km * 0,48 kg/l = 2,52 kg/km 2,52 kg/km * 0,0425 GJ/km = 0,1071 GJ/km 1 / 0,1071 GJ/km = 9,3371 km/GJ	90	3-89

3.2.4.4.4 Uncertainties and time-series consistency

The assessment of activity data and emission factor uncertainties is done according to the methodology described in the EMEP/EEA emission inventory Guidebook 2023 (Chapter A.5 Uncertainties, tables 2-1, 2-2 and 2-3), covering the main pollutants NO_x, NH_3, NMVOC, SO_x and $PM_{2.5}$. For some subcategories and pollutants, expert judgements were made to estimate AD or EF uncertainties. For CO, PM10, heavy metzals and persistent organic pollutants, no uncertainty estimates are currently made. Details on uncertainty of the activity data can also be checked in the Luxembourg's National Inventory report (NIR). Please also refer to Table 1-33 to Table 1-37 of section 1.7 for caterogory specific uncertainties on activity data and emission factors.

The time-series are considered to be consistent.

3.2.4.4.5 Source-specific QA/QC and verification

Consistency and completeness checks are performed.

3.2.4.4.6 Category-specific recalculations including changes made in response to the review process

Table presents the main revisions and recalculations done since submission 2023.

Table 3-133 – Recalculations done since the last submission for category – *1A3c - Railways*

Source category	Revisions 2023 → 2024	Type of revision
1A3c	Due to an error correction, the total activity data for diesel oil for the entire timeseries was revised, which impacts several mobile combustion sub-categories (1A2gvii, 1A3b, 1A3c, 1A3d, 1A4cii, 1A5b). As the fuel consumptions in mobile combustion are allocated to different vehicle categories by the NEMO and GEORG models, the change in total diesel activity data also impacts the allocations of gasoline, biomass and other fossil fuels (the total activity data of these three fuel types remains unchanged)	AD

Table 3-134 - Activity data recalculations category 1A3c

AD changes in GJ	1A3c liquid	1A3c biomass	1A3c other
2004	0.0181	-0.0161	-0.0009
2005	0.0100	-0.0088	-0.0005
2006	0.0056	-0.0049	-0.0003
2007	0.8169	-0.7232	-0.0413
2008	0.8556	-0.7575	-0.0432
2009	-1.4771	1.3078	0.0747
2010	-0.0694	0.0616	0.0033
2011	-0.3304	0.2937	0.0155
2012	-0.0844	0.0754	0.0036
2013	0.3334	-0.2980	-0.0140
2014	-1.5672	1.3970	0.0697
2015	0.2706	-0.2399	-0.0134
2016	0.5610	-0.4978	-0.0273
2017	0.9040	-0.8014	-0.0447
2018	0.5748	-0.5095	-0.0285
2019	0.3271	-0.2899	-0.0162
2020	0.4921	-0.4414	-0.0192
2021	0.6706	-0.6075	-0.0201

3.2.4.4.7 Category-specific planned improvements including those in response to the review process

The following improvements are planned for the next submission.

Table 3-135 – Planned improvements for category – *1A3c - Railways*

Source category	Planned improvements	Type of revision
1A3c	In order to improve transparency, values for biomass activity data will be provided instead of the notation key IE.	NA

3.2.4.5 Navigation (1A3d)

3.2.4.5.1 Source category description

This sub-category includes

- *1A3di (ii) - International inland waterways*
- *1A3d ii - National navigation*

As Luxembourg has no direct access to the sea, there are no maritime activities taking place. Similarly, Luxembourg has only one river where shipping activities are allowed, the Moselle, a border river with Germany. Shipping activities are mainly passenger (leisure and tourism) and freight activities.

In 1990 and 2022, this source category represented less than 0.1% of the national total for each air pollutant based on fuel sold (Table 3-136 and Table 3-137). In the period 1990 – 2022, emissions of CO increased due to increased shipping activities. For SO_2 emissions, a significant decrease was noted due to lower sulphur content in the fuel. Detailed emission trends are reported in Table for category *1A3di (ii) - International inland waterways* and Table for category *1A3d ii - National navigation*.
Navigation related air pollutant emissions were not a key source in 2022 (see Table 3-96 and also Table 3-4 in Section 3.2 and Chapter 1.5).).

Table 3-136 – Emissions, Trends and Shares based on fuel sold and fuel used for category – *1A3di (ii) - International inland waterways*

1 A Mobile Fuel Combustion
Emissions [Gg], Trend and Share in National Totals of air pollutants based on fuel sold and fuel used
1 A 3 d i (ii) International inland waterways

Pollutant	Emissions				Trend			FUEL USED			FUEL SOLD			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
SO2	0.0001	0.0000	0.0000	0.0000	-99.8%	-87.5%	55.9%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	fuel sold
NOx	0.0013	0.0021	0.0001	0.0002	-83.9%	-90.0%	50.3%	0.006%	0.012%	0.002%	0.003%	0.004%	0.002%	fuel sold
NMVOC	0.0005	0.0007	0.0000	0.0001	-89.4%	-91.8%	49.5%	0.002%	0.006%	0.001%	0.002%	0.005%	0.001%	fuel sold
NH3	0.0000	0.0000	0.0000	0.0000	-83.8%	-89.5%	52.8%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	fuel sold
CO	0.0005	0.0010	0.0001	0.0001	-74.4%	-86.1%	53.9%	0.000%	0.004%	0.001%	0.000%	0.002%	0.001%	fuel sold
TSP	0.0001	0.0001	0.0000	0.0000	-86.8%	-91.0%	49.9%	0.000%	0.004%	0.000%	0.000%	0.002%	0.000%	fuel sold
PM10	0.0001	0.0001	0.0000	0.0000	-86.8%	-91.0%	49.9%	0.000%	0.005%	0.001%	0.000%	0.003%	0.000%	fuel sold
PM2.5	0.0001	0.0001	0.0000	0.0000	-86.8%	-91.0%	49.9%	0.000%	0.007%	0.001%	0.000%	0.004%	0.001%	fuel sold

Source: Environment Agency

Table 3-137 – Emissions, Trends and Shares based on fuel sold and fuel used for category *– 1A3d ii - National navigation (Shipping)*

1 A Mobile Fuel Combustion
Emissions [Gg], Trend and Share in National Totals of air pollutants based on fuel sold and fuel used
1 A 3 d ii National navigation (Shipping)

Pollutant	Emissions				Trend			FUEL USED			FUEL SOLD			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
SO2	0.0008	0.0000	0.0000	0.0000	-99.6%	-64.9%	28.4%	0.005%	0.000%	0.001%	0.005%	0.000%	0.001%	fuel sold
NOx	0.0144	0.0169	0.0044	0.0053	-62.8%	-68.3%	22.2%	0.064%	0.094%	0.058%	0.035%	0.030%	0.047%	fuel sold
NMVOC	0.0215	0.0175	0.0025	0.0032	-85.2%	-81.9%	26.8%	0.099%	0.144%	0.033%	0.069%	0.119%	0.032%	fuel sold
NH3	0.0000	0.0000	0.0000	0.0000	-73.8%	-72.7%	25.6%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	fuel sold
CO	0.1004	0.0604	0.0123	0.0164	-83.6%	-72.8%	33.8%	0.024%	0.273%	0.112%	0.021%	0.152%	0.092%	fuel sold
TSP	0.0022	0.0016	0.0002	0.0002	-88.8%	-84.9%	19.1%	0.013%	0.072%	0.012%	0.012%	0.041%	0.010%	fuel sold
PM10	0.0022	0.0016	0.0002	0.0002	-88.8%	-84.9%	19.1%	0.014%	0.091%	0.018%	0.013%	0.051%	0.015%	fuel sold
PM2.5	0.0022	0.0016	0.0002	0.0002	-88.8%	-84.9%	19.1%	0.014%	0.121%	0.028%	0.014%	0.064%	0.024%	fuel sold

Source: Environment Agency

Table 3-138 – Emission trends for category – *1A3di (ii) - International inland waterways*

Year	SO_2	NO_X	NMVOC	NH_3	CO	TSP	PM_{10}	$PM_{2.5}$
	1 A Mobile Fuel Combustion							
	Emissions of air pollutants by source category (Gg)							
	1 A 3 d i (ii) International inland waterways							
1990	0.00006	0.00131	0.00052	0.00000	0.00052	0.00006	0.00006	0.00006
1991	0.00006	0.00138	0.00055	0.00000	0.00055	0.00007	0.00007	0.00007
1992	0.00006	0.00132	0.00052	0.00000	0.00053	0.00006	0.00006	0.00006
1993	0.00008	0.00184	0.00073	0.00000	0.00074	0.00009	0.00009	0.00009
1994	0.00007	0.00163	0.00065	0.00000	0.00065	0.00008	0.00008	0.00008
1995	0.00006	0.00164	0.00065	0.00000	0.00066	0.00008	0.00008	0.00008
1996	0.00002	0.00155	0.00061	0.00000	0.00062	0.00007	0.00007	0.00007
1997	0.00002	0.00163	0.00063	0.00000	0.00065	0.00008	0.00008	0.00008
1998	0.00002	0.00154	0.00059	0.00000	0.00061	0.00007	0.00007	0.00007
1999	0.00002	0.00174	0.00066	0.00000	0.00069	0.00008	0.00008	0.00008
2000	0.00002	0.00186	0.00070	0.00000	0.00074	0.00009	0.00009	0.00009
2001	0.00002	0.00187	0.00070	0.00000	0.00075	0.00009	0.00009	0.00009
2002	0.00002	0.00191	0.00070	0.00000	0.00077	0.00009	0.00009	0.00009
2003	0.00001	0.00192	0.00069	0.00000	0.00078	0.00009	0.00009	0.00009
2004	0.00000	0.00186	0.00066	0.00000	0.00077	0.00009	0.00009	0.00009
2005	0.00000	0.00210	0.00067	0.00000	0.00096	0.00009	0.00009	0.00009
2006	0.00000	0.00198	0.00059	0.00000	0.00097	0.00008	0.00008	0.00008
2007	0.00000	0.00169	0.00050	0.00000	0.00084	0.00007	0.00007	0.00007
2008	0.00000	0.00184	0.00054	0.00000	0.00092	0.00008	0.00008	0.00008
2009	0.00000	0.00138	0.00040	0.00000	0.00070	0.00006	0.00006	0.00006
2010	0.00000	0.00139	0.00039	0.00000	0.00072	0.00006	0.00006	0.00006
2011	0.00000	0.00118	0.00033	0.00000	0.00062	0.00005	0.00005	0.00005
2012	0.00000	0.00087	0.00024	0.00000	0.00046	0.00004	0.00004	0.00004
2013	0.00000	0.00074	0.00020	0.00000	0.00040	0.00003	0.00003	0.00003
2014	0.00000	0.00080	0.00022	0.00000	0.00044	0.00003	0.00003	0.00003
2015	0.00000	0.00076	0.00020	0.00000	0.00042	0.00003	0.00003	0.00003
2016	0.00000	0.00079	0.00021	0.00000	0.00044	0.00003	0.00003	0.00003
2017	0.00000	0.00088	0.00023	0.00000	0.00050	0.00003	0.00003	0.00003
2018	0.00000	0.00078	0.00021	0.00000	0.00045	0.00003	0.00003	0.00003
2019	0.00000	0.00065	0.00017	0.00000	0.00039	0.00003	0.00003	0.00003
2020	0.00000	0.00014	0.00004	0.00000	0.00009	0.00001	0.00001	0.00001
2021	0.00000	0.00014	0.00004	0.00000	0.00009	0.00001	0.00001	0.00001
2022	0.00000	0.00021	0.00006	0.00000	0.00013	0.00001	0.00001	0.00001
Trend 1990-2022	*-99.77%*	*-83.92%*	*-89.36%*	*-83.85%*	*-74.42%*	*-86.79%*	*-86.79%*	*-86.79%*
2005-2022	*-87.52%*	*-89.96%*	*-91.81%*	*-89.49%*	*-86.08%*	*-90.97%*	*-90.97%*	*-90.97%*
2021-2022	*55.86%*	*50.26%*	*49.47%*	*52.80%*	*53.90%*	*49.86%*	*49.86%*	*49.86%*

Source: Environment Agency

Table 3-139 – Emission trends for category *1A3d ii - National navigation (Shipping)*

1 A Mobile Fuel Combustion								
Emissions of air pollutants by source category (Gg)								
Year	**1 A 3 d ii National navigation (Shipping)**							
	SO_2	**NO_X**	**NMVOC**	**NH_3**	**CO**	**TSP**	**PM_{10}**	**$PM_{2.5}$**
1990	0.0008	0.0144	0.0215	0.00001	0.1004	0.0022	0.0022	0.0022
1991	0.0009	0.0152	0.0271	0.00001	0.1169	0.0023	0.0023	0.0023
1992	0.0008	0.0141	0.0292	0.00001	0.1162	0.0021	0.0021	0.0021
1993	0.0009	0.0157	0.0296	0.00001	0.1126	0.0021	0.0021	0.0021
1994	0.0008	0.0148	0.0282	0.00001	0.1076	0.0019	0.0019	0.0019
1995	0.0006	0.0133	0.0229	0.00001	0.0862	0.0016	0.0016	0.0016
1996	0.0002	0.0133	0.0232	0.00001	0.0872	0.0016	0.0016	0.0016
1997	0.0002	0.0141	0.0221	0.00001	0.0812	0.0016	0.0016	0.0016
1998	0.0002	0.0135	0.0215	0.00001	0.0791	0.0016	0.0016	0.0016
1999	0.0002	0.0153	0.0225	0.00001	0.0814	0.0018	0.0018	0.0018
2000	0.0002	0.0142	0.0180	0.00000	0.0628	0.0015	0.0015	0.0015
2001	0.0002	0.0156	0.0200	0.00001	0.0706	0.0017	0.0017	0.0017
2002	0.0002	0.0168	0.0213	0.00001	0.0756	0.0019	0.0019	0.0019
2003	0.0002	0.0174	0.0216	0.00001	0.0758	0.0019	0.0019	0.0019
2004	0.0000	0.0162	0.0187	0.00001	0.0640	0.0017	0.0017	0.0017
2005	0.0000	0.0169	0.0175	0.00001	0.0604	0.0016	0.0016	0.0016
2006	0.0000	0.0152	0.0150	0.00001	0.0526	0.0014	0.0014	0.0014
2007	0.0000	0.0150	0.0149	0.00001	0.0536	0.0014	0.0014	0.0014
2008	0.0000	0.0166	0.0155	0.00001	0.0552	0.0015	0.0015	0.0015
2009	0.0000	0.0132	0.0126	0.00000	0.0462	0.0012	0.0012	0.0012
2010	0.0000	0.0141	0.0127	0.00000	0.0466	0.0012	0.0012	0.0012
2011	0.0000	0.0141	0.0108	0.00000	0.0378	0.0011	0.0011	0.0011
2012	0.0000	0.0140	0.0102	0.00000	0.0370	0.0010	0.0010	0.0010
2013	0.0000	0.0116	0.0088	0.00000	0.0361	0.0009	0.0009	0.0009
2014	0.0000	0.0123	0.0091	0.00000	0.0402	0.0008	0.0008	0.0008
2015	0.0000	0.0107	0.0081	0.00000	0.0401	0.0007	0.0007	0.0007
2016	0.0000	0.0115	0.0083	0.00000	0.0426	0.0007	0.0007	0.0007
2017	0.0000	0.0129	0.0084	0.00000	0.0419	0.0007	0.0007	0.0007
2018	0.0000	0.0119	0.0080	0.00000	0.0418	0.0007	0.0007	0.0007
2019	0.0000	0.0098	0.0068	0.00000	0.0366	0.0005	0.0005	0.0005
2020	0.0000	0.0046	0.0022	0.00000	0.0085	0.0002	0.0002	0.0002
2021	0.0000	0.0044	0.0025	0.00000	0.0123	0.0002	0.0002	0.0002
2022	0.0000	0.0053	0.0032	0.00000	0.0164	0.0002	0.0002	0.0002
Trend 1990-2022	*-99.56%*	*-62.79%*	*-85.18%*	*-73.79%*	*-83.64%*	*-88.76%*	*-88.76%*	*-88.76%*
2005-2022	*-64.90%*	*-68.28%*	*-81.86%*	*-72.68%*	*-72.81%*	*-84.88%*	*-84.88%*	*-84.88%*
2021-2022	*28.35%*	*22.23%*	*26.80%*	*25.59%*	*33.84%*	*19.07%*	*19.07%*	*19.07%*

Source: Environment Agency

3.2.4.5.2 Methodological issues & time-series consistency

3.2.4.5.2.1 Activity data

Due to the particular geographical situation of the Moselle River, freight shipping activities, which are executed on barges, which do not refuel in Luxembourg's sole commercial port (Mertert), are not accounted for in Luxembourg's air pollutant inventory. These activities are exclusively international, i.e. destination is always abroad.

For passenger shipping activities, the situation is different. There are two companies executing passenger shipping on the Moselle River. Fuel consumption data (gas oil), engine and engine power were obtained directly from the two national operators as no energy related data is available from the official statistics. They also communicated that in 2022 about 94% of their journeys are to be considered as domestic (from Luxembourg to Luxembourg), and the remaining 6% are to be considered international (from Luxembourg to an international destination, or vice versa). This information was used to be able to split the fuel consumption for passenger shipping activities between category *1A3d ii - National navigation* (95% of the journeys) and category *1A3di (ii) - International inland waterways* (5% of the journeys) (see Table 3-140 and Table 3-141).

Concerning the fuel consumption of leisure boats (yachts, jet-skis, etc), no data is available at this stage. However, only one (very) small marina exists on Luxembourg's side of the Moselle River: Schwebsange. This marina is equipped with a gasoline and diesel oil filling station. It is assumed that the quantities sold at this station are being combusted entirely on Luxembourg's side of the river. These fuel quantities are included in the total fuel consumption in the national energy balance, hence there is no risk of double-counting emissions from leisure boats. The amount of fuel sold at this station was obtained from the operator for the entire time-series, except for the years 2020 and 2021, where the station was out of service. For the year 2020, activity data for leisure boats was assumed to be 20% of th value from 2019, and the value for 2021 was estimated by interpolating between 2020 and 2022. The filling station in the Schwebsange marina was put back into operation in 2022 and activity data was again directly obtained from the operator.

Table 3-140 – Activity data for category – *1A3di (ii) - International inland waterways*

1 A Mobile Fuel Combustion						
Activity Data by fuel type (GJ)						
1 A 3 d i (ii) International inland waterways						
Year	**Activity Total (incl. biomass)**	**Liquid**	**Solid**	**Gaseous**	**Biomass**	**Other**
1990	992	992	NO	NA	NO	NA
1991	1 046	1'046	NO	NA	NO	NA
1992	1 001	1'001	NO	NA	NO	NA
1993	1 398	1'398	NO	NA	NO	NA
1994	1 238	1'238	NO	NA	NO	NA
1995	1 246	1'246	NO	NA	NO	NA
1996	1 178	1'178	NO	NA	NO	NA
1997	1 234	1'234	NO	NA	NO	NA
1998	1 165	1'165	NO	NA	NO	NA
1999	1 316	1'316	NO	NA	NO	NA
2000	1 411	1'411	NO	NA	NO	NA
2001	1 415	1'415	NO	NA	NO	NA
2002	1 462	1'462	NO	NA	NO	NA
2003	1 490	1'490	NO	NA	NO	NA
2004	1 473	1'473	NO	NA	IE	NA
2005	1 887	1'887	NO	NA	IE	NA
2006	1 932	1'932	NO	NA	IE	NA
2007	1 661	1'661	NO	NA	IE	NA
2008	1 832	1'832	NO	NA	IE	NA
2009	1 403	1'403	NO	NA	IE	NA
2010	1 439	1'439	NO	NA	IE	NA
2011	1 239	1'239	NO	NA	IE	NA
2012	932	932	NO	NA	IE	NA
2013	801	801	NO	NA	IE	NA
2014	881	881	NO	NA	IE	NA
2015	851	851	NO	NA	IE	NA
2016	903	903	NO	NA	IE	NA
2017	1 037	1'037	NO	NA	IE	NA
2018	941	941	NO	NA	IE	NA
2019	820	820	NO	NA	IE	NA
2020	181	181	NO	NA	IE	NA
2021	188	188	NO	NA	IE	NA
2022	293	293	NO	NA	IE	NA
Trend 1990-2022	*-70.52%*	*-70.52%*	*NA*	*NA*	*NA*	*NA*
2005-2022	*-84.50%*	*-84.50%*	*NA*	*NA*	*NA*	*NA*
2021-2022	*55.79%*	*55.79%*	*NA*	*NA*	*NA*	*NA*

Source: Environment Agency

Table 3-141 – Activity data for category – *1A3d ii - National navigation (Shipping)*

1 A Mobile Fuel Combustion						
Activity Data by fuel type (GJ)						
1 A 3 d ii National navigation (Shipping)						
Year	Activity Total (incl. biomass)	Liquid	Solid	Gaseous	Biomass	Other
1990	17 748	17'748	NA	NO	NO	NA
1991	19 366	19'366	NA	NO	NO	NA
1992	18 419	18'419	NA	NO	NO	NA
1993	19 273	19'273	NA	NO	NO	NA
1994	18 300	18'300	NA	NO	NO	NA
1995	15 754	15'754	NA	NO	NO	NA
1996	15 901	15'901	NA	NO	NO	NA
1997	16 200	16'200	NA	NO	NO	NA
1998	15 753	15'753	NA	NO	NO	NA
1999	17 351	17'351	NA	NO	NO	NA
2000	15 260	15'260	NA	NO	NO	NA
2001	17 107	17'107	NA	NO	NO	NA
2002	18 741	18'741	NA	NO	NO	NA
2003	19 600	19'600	NA	NO	NO	NA
2004	18 094	18'094	NA	NO	IE	NA
2005	19 250	19'250	NA	NO	IE	NA
2006	17 893	17'893	NA	NO	IE	NA
2007	18 293	18'293	NA	NO	IE	NA
2008	20 451	20'451	NA	NO	IE	NA
2009	17 113	17'113	NA	NO	IE	NA
2010	18 578	18'578	NA	NO	IE	NA
2011	18 027	18'027	NA	NO	IE	NA
2012	18 229	18'229	NA	NO	IE	NA
2013	15 886	15'886	NA	NO	IE	NA
2014	17 050	17'050	NA	NO	IE	NA
2015	15 223	15'223	NA	NO	IE	NA
2016	16 058	16'058	NA	NO	IE	NA
2017	17 664	17'664	NA	NO	IE	NA
2018	17 132	17'132	NA	NO	IE	NA
2019	14 749	14'749	NA	NO	IE	NA
2020	5 725	5'725	NA	NO	IE	NA
2021	6 218	6'218	NA	NO	IE	NA
2022	7 997	7'997	NA	NO	IE	NA
Trend ***1990-2022***	*-54.94%*	*-54.94%*	*NA*	*NA*	*NA*	*NA*
2005-2022	*-58.46%*	*-58.46%*	*NA*	*NA*	*NA*	*NA*
2021-2022	*28.60%*	*28.60%*	*NA*	*NA*	*NA*	*NA*

Source: Environment Agency

3.2.4.5.2.2 Methodology

For emissions of air pollutants from off-road vehicles and other machinery, the GEORG (Grazer Emissionsmodell für Off-Road Geräte) model developed by the TU Graz was used. Input data to the model are:

- Machinery stock data (obtained through inquiries and statistical extrapolation);
- Assumptions on drop-out rates of machinery (broken down machinery will be replaced);
- Operating time (obtained through inquiries), related to age of machinery.

From machinery stock data and drop-out rates an age structure of the off-road machinery was obtained by GEORG. Four categories of engine types were considered. Depending on the fuel consumption of the engine the ratio power of the engine was calculated. Emissions were calculated by multiplying an engine specific emission factor (expressed in g/kWh) by the average engine power, the operating time and the number of vehicles.

See Table 3-142 and section *3.2.3.8.1 - Mobile Combustion in Manufacturing Industries and Construction (1A2g vii)*.

3.2.4.5.2.3 Emission factors

For mobile combustion (diesel oil, gasoil, motor gasoline), country-specific values, derived from the GEORG model, have been applied (Table 3-142). For the $PM_{2.5}$ and PM_{10} emission factors, the condensable component is included.

Table 3-142 – Methods and Emission Factors used in relation to the energy consumption in 2022 for category – *1A3d – Navigation*

1 A Mobile Fuel Combustion *Method applied and Emission factor (EF) used as well as coverage of energy consumption* 1 A 3 d Navigation				
Pollutant	**Method**	**EF used**	**Coverage of energy**	**Source**
NOx	T3	CS	100.0%	GEORG
NMVOC **CO** **TSP** **PM10** **PM2.5**	T1	D	0.0%	EMEP/EEA GB
SOx	T3	CS	100.0%	GEORG
				CS based on fuel sulfur content
	T1	D	0.0%	EMEP/EEA GB

Source: Environment Agency

An overview of the evolution of the implied emission factors is given in Table 3-143 and Table 3-144.

Table 3-143 – Implied emission factors for – *1 A 3 d i (ii) International inland waterways*

1 A Mobile Fuel Combustion								
Implied Emission Factor (IEF) of air pollutants by source category (g/GJ)								
Year	**1 A 3 d i (ii) International inland waterways**							
	SO_2	**NO_X**	**NMVOC**	**NH_3**	**CO**	**TSP**	**PM_{10}**	**$PM_{2.5}$**
1990	60.26	1319.38	523.26	0.32	527.75	63.33	63.33	63.33
1991	60.26	1319.38	523.27	0.32	527.75	63.33	63.33	63.33
1992	60.26	1319.38	523.27	0.32	527.75	63.33	63.33	63.33
1993	60.26	1319.38	523.28	0.32	527.75	63.33	63.33	63.33
1994	60.26	1319.38	521.82	0.32	527.75	63.21	63.21	63.21
1995	51.08	1319.38	518.79	0.31	527.75	62.96	62.96	62.96
1996	18.83	1319.38	515.10	0.31	527.75	62.66	62.66	62.66
1997	17.56	1319.38	510.76	0.31	527.75	62.31	62.31	62.31
1998	16.29	1319.38	508.37	0.31	527.75	62.11	62.11	62.11
1999	15.02	1319.38	504.93	0.31	527.75	61.83	61.83	61.83
2000	13.75	1319.38	498.90	0.31	527.75	61.34	61.34	61.34
2001	13.04	1319.38	492.66	0.31	527.75	60.83	60.83	60.83
2002	11.09	1308.47	480.70	0.30	526.45	60.36	60.36	60.36
2003	10.02	1288.19	463.93	0.30	524.04	59.95	59.95	59.95
2004	0.67	1261.95	446.14	0.29	521.60	58.65	58.65	58.65
2005	0.59	1111.71	357.38	0.26	509.84	48.72	48.72	48.72
2006	0.52	1026.77	307.35	0.24	503.18	43.12	43.12	43.12
2007	0.47	1017.18	301.37	0.23	503.15	42.51	42.51	42.51
2008	0.47	1003.17	293.94	0.23	502.12	41.70	41.70	41.70
2009	0.47	982.87	283.30	0.22	500.74	40.51	40.51	40.51
2010	0.47	963.30	273.05	0.22	499.33	39.37	39.37	39.37
2011	0.47	949.12	265.95	0.21	498.36	38.58	38.58	38.58
2012	0.47	935.75	259.15	0.21	497.65	37.83	37.83	37.83
2013	0.47	922.26	252.21	0.21	496.92	37.07	37.07	37.07
2014	0.47	907.60	245.34	0.20	495.79	36.28	36.28	36.28
2015	0.47	890.28	238.40	0.20	493.62	35.43	35.43	35.43
2016	0.47	870.04	231.35	0.19	490.25	34.49	34.49	34.49
2017	0.47	848.33	224.72	0.19	486.23	33.54	33.54	33.54
2018	0.47	823.41	217.92	0.19	480.72	32.54	32.54	32.54
2019	0.47	797.72	211.27	0.18	474.72	31.56	31.56	31.56
2020	0.47	774.01	205.25	0.18	469.71	30.66	30.66	30.66
2021	0.47	746.28	196.91	0.18	463.51	29.49	29.49	29.49
2022	0.47	719.79	188.92	0.17	457.89	28.37	28.37	28.37
Trend 1990-2022	*-99.21%*	*-45.44%*	*-63.90%*	*-45.21%*	*-13.24%*	*-55.20%*	*-55.20%*	*-55.20%*
2005-2022	*-19.49%*	*-35.25%*	*-47.14%*	*-32.21%*	*-10.19%*	*-41.76%*	*-41.76%*	*-41.76%*
2021-2022	*0.05%*	*-3.55%*	*-4.06%*	*-1.92%*	*-1.21%*	*-3.80%*	*-3.80%*	*-3.80%*

Source: Environment Agency

Table 3-144 – Implied emission factors for – *1 A 3 d ii National navigation (Shipping)*

1 A Mobile Fuel Combustion								
Implied Emission Factor (IEF) of air pollutants by source category (g/GJ)								
Year	**1 A 3 d ii National navigation (Shipping)**							
	SO_2	**NO_X**	**NMVOC**	**NH_3**	**CO**	**TSP**	**PM_{10}**	**$PM_{2.5}$**
1990	46.19	810.02	1209.36	0.34	5655.96	124.01	124.01	124.01
1991	44.73	782.94	1401.53	0.33	6034.24	119.65	119.65	119.65
1992	43.54	766.72	1587.07	0.32	6310.37	113.81	113.81	113.81
1993	44.75	813.32	1535.87	0.32	5844.84	107.22	107.22	107.22
1994	44.40	807.71	1543.35	0.32	5879.32	106.46	106.46	106.46
1995	38.61	842.42	1455.89	0.32	5469.20	102.32	102.32	102.32
1996	14.69	833.66	1456.25	0.32	5485.21	102.63	102.63	102.63
1997	14.00	870.26	1366.19	0.32	5014.38	100.11	100.11	100.11
1998	12.91	858.78	1364.66	0.32	5018.71	101.86	101.86	101.86
1999	12.06	880.54	1296.87	0.32	4690.37	100.96	100.96	100.96
2000	11.34	928.93	1180.02	0.32	4117.52	97.68	97.68	97.68
2001	10.66	913.60	1171.01	0.32	4128.98	100.48	100.48	100.48
2002	9.10	898.99	1135.54	0.32	4035.79	101.34	101.34	101.34
2003	8.28	888.73	1102.43	0.32	3865.25	98.62	98.62	98.62
2004	0.61	897.56	1032.01	0.32	3535.79	93.06	93.06	93.06
2005	0.53	876.21	911.41	0.30	3138.45	85.01	85.01	85.01
2006	0.48	848.27	837.89	0.29	2940.61	79.57	79.57	79.57
2007	0.44	822.60	817.19	0.29	2929.50	77.93	77.93	77.93
2008	0.44	811.52	759.13	0.28	2701.17	73.96	73.96	73.96
2009	0.44	771.13	738.09	0.28	2698.05	71.87	71.87	71.87
2010	0.44	757.91	682.69	0.27	2509.25	67.28	67.28	67.28
2011	0.45	783.93	597.18	0.26	2098.56	61.15	61.15	61.15
2012	0.45	765.40	558.10	0.25	2028.98	57.50	57.50	57.50
2013	0.45	731.57	554.40	0.24	2273.69	53.61	53.61	53.61
2014	0.44	719.96	531.60	0.23	2358.69	49.59	49.59	49.59
2015	0.44	705.88	533.09	0.22	2635.92	45.84	45.84	45.84
2016	0.44	714.64	517.71	0.22	2653.58	42.76	42.76	42.76
2017	0.45	730.23	477.46	0.21	2371.74	40.55	40.55	40.55
2018	0.45	696.79	468.88	0.21	2437.04	38.05	38.05	38.05
2019	0.45	667.48	459.62	0.20	2481.03	35.56	35.56	35.56
2020	0.46	806.04	380.96	0.21	1476.36	37.64	37.64	37.64
2021	0.45	703.86	403.56	0.20	1973.72	33.42	33.42	33.42
2022	0.45	669.01	397.91	0.20	2054.20	30.94	30.94	30.94
Trend 1990-2022	*-99.02%*	*-17.41%*	*-67.10%*	*-41.84%*	*-63.68%*	*-75.05%*	*-75.05%*	*-75.05%*
2005-2022	*-15.51%*	*-23.65%*	*-56.34%*	*-34.23%*	*-34.55%*	*-63.60%*	*-63.60%*	*-63.60%*
2021-2022	*-0.19%*	*-4.95%*	*-1.40%*	*-2.34%*	*4.08%*	*-7.41%*	*-7.41%*	*-7.41%*

Source: Environment Agency

3.2.4.5.3 Methodological issues for heavy metals and POPs

3.2.4.5.3.1 Activity Data

Activity data is the same as for the emission calculation of the main pollutants. Please rever to section 3.2.4.5.2.1 for more details.

3.2.4.5.3.2 Methodological Choices

The calculation of emissions related to fluvial transport were based on the above-mentioned activity data in combination with tier 1 and tier 2 emission factors, respectively (see tables below).

3.2.4.5.3.3 Emission Factors

Tier 1 emission factors:

Fuel	Pollutants	Source	Page	Table
Diesel oil	Cd, Hg	EEA (2019) – Chapter 1.A.3.d Navigation (shipping)	17	3-2
Motor gasoline	Pb	Country-specific: 0.15g Pb/l motor gasoline, based on measurements. Equals to 4.6g Pb/GJ (density motor gasoline: 0.775 kg/l, NCV motor gasoline: 23.17 GJ/kg)		

3.2.4.5.4 Uncertainties and time-series consistency

The assessment of activity data and emission factor uncertainties is done according to the methodology described in the EMEP/EEA emission inventory Guidebook 2023 (Chapter A.5 Uncertainties, tables 2-1, 2-2 and 2-3), covering the main pollutants NO_x, NH_3, NMVOC, SO_x and $PM_{2.5}$. For some subcategories and pollutants, expert judgements were made to estimate AD or EF uncertainties. For CO, PM10, heavy metzals and persistent organic pollutants, no uncertainty estimates are currently made. Details on uncertainty of the activity data can also be checked in the Luxembourg's National Inventory report (NIR). Please also refer to Table 1-33 to Table 1-37 of section 1.7 for caterogory specific uncertainties on activity data and emission factors.

The time-series are considered to be consistent.

3.2.4.5.5 Source-specific QA/QC and verification

Consistency and completeness checks are performed.

3.2.4.5.6 Category-specific recalculations including changes made in response to the review process

Table presents the main revisions and recalculations done since submission 2023.

Table 3-145– Recalculations done since the last submission for category – *1A3d - Navigation*

Source category	Revisions 2023 ➔ 2024	Type of revision
1A3di(ii), 1A3dii	Due to an error correction, the total activity data for diesel oil for the entire timeseries was revised, which impacts several mobile combustion sub-categories (1A2gvii, 1A3b, 1A3c, 1A3d, 1A4cii, 1A5b). As the fuel consumptions in mobile combustion are allocated to different vehicle categories by the NEMO and GEORG models, the change in total diesel activity data also impacts the allocations of gasoline, biomass and other fossil fuels (the total activity data of these three fuel types remains unchanged	AD
1A3d	Updated AD (liquid fuels, biomass, and other fossil fuels) for leisure boats for 2021 (interpolation between 2020 and 2022)	AD

The combined effect of the activity data recalculations is shown in Table 3-146.

Table 3-146 - Activity data recalculations in category 1A3d

AD changes in GJ	1A3d liquid	1A3d biomass	1A3d other
2004	0.0014	-0.0013	-0.0001
2005	0.0014	-0.0012	-0.0001
2006	0.0010	-0.0009	0.0000
2007	0.1014	-0.0897	-0.0051
2008	0.1048	-0.0928	-0.0053
2009	-0.1569	0.1390	0.0079
2010	-0.0075	0.0067	0.0004
2011	-0.0356	0.0317	0.0017
2012	-0.0101	0.0091	0.0004
2013	0.0397	-0.0355	-0.0017
2014	-0.1736	0.1548	0.0077
2015	0.0384	-0.0340	-0.0019
2016	0.0913	-0.0810	-0.0044
2017	0.1496	-0.1326	-0.0074
2018	0.0864	-0.0766	-0.0043
2019	0.0437	-0.0388	-0.0022
2020	0.0264	-0.0236	-0.0010
2021	-4726.2173	-396.9381	-11.2719

3.2.4.5.7 Category-specific planned improvements including those in response to the review process

The following improvements are planned for the next submission.

Table 3-147 – Planned improvements for category – *1A3d - Navigation*

Source category	Planned improvements	Type of revision
1A3d	In order to improve transparency, values for biomass activity data will be provided instead of the notation key IE.	NA

3.2.4.6 Other Transportation (1A3e)

No activities have been identified for Luxembourg, hence notation key NO is reported for the following sub-categories:

- *1A3e i – Pipeline Transport*
- *1A3e ii - Other*

Luxembourg reports emissions from vehicles and mobile machinery, such as agricultural tractors, chain saws, forklifts, mowers, harvesters etc., used within the agriculture, forestry, industry (including construction and maintenance), residential and commercial/institutional sectors in the relevant categories as follows:

- *1A2g vii Mobile combustion in manufacturing industry and construction*
- *1A4a ii Commercial/Institutional: Mobile*: included in *1A2g vii Mobile combustion in manufacturing industry and construction*
- *1A4b ii Residential: Household and gardening*
- *1A4c ii Agriculture: Off-road vehicles and other machinery*

3.2.5 Other Sectors (1A4)

3.2.5.1 Source category description

This section describes emissions of air pollutants resulting from fuel combustion activities in the “other sectors” category. *1A4 – Other sectors* covers combustion activities from stationary combustion and mobile combustion of the following categories:

- *1A4a i – Commercial/Institutional*
- *1A4a ii Commercial/institutional: Mobile*
- *1A4b i – Residential*
- *1A4b ii Residential: Household and gardening*
- *1A4c i – Agriculture/Forestry – stationary*
- *1A4c ii – Agriculture/Forestry – Off-road vehicles and other machinery*

Emissions of air pollutants for category *1A4 – Other Sectors* are summarized Table 3-148. In 2022, this source category represented 9.7% of national total SO_2 emissions (based on fuel sold) and 10.1% of national total SO_2 emissions (based on fuel used), whereas in 1990, this source category represented 8.7% of national total SO_2 emissions (based on fuel sold) and 9.2% of national total SO_2 emissions (based on fuel used). The significant decrease of 97% in SO_2 emissions between 1990 and 2022 is the result of the increased use of low sulphur fuels and the reduction of the sulphur content in the fuels.

In 2022, this source category represented 10.5% of national total NO_X emissions (based on fuel sold) and 13.2% of national total NO_X emissions (based on fuel used), whereas in 1990, this source category represented 4.4% of national total NO_X emissions (based on fuel sold) and 8.1% of national total NO_X emissions (based on fuel used). The decrease of 33% in NO_X emissions compared to 1990 is mainly due to the implementation of low NO_X combustion technology in commercial/institutional and residential heating.

Further, this source category represented in 2022 4.2% of national total NMVOC emissions (based on fuel sold) and 4.3% of national total NMVOC emissions (based on fuel used), whereas in 1990, this source category represented 3.1% of national total NMVOC emissions (based on fuel sold) and 4.4% of national total NMVOC emissions (based on fuel used).

In 2022 and 1990, this source category represented less than 1% of national total NH_3 emissions (based on fuel sold) and less than 1% of national total NH_3 emissions (based on fuel used). NH_3 resulted from fuel combustion in mobile devices and wood combustion in stationary devices.

Carbon monoxide emissions of this source category represented, in 2022, 18.7% of national total CO emissions (based on fuel sold) and 22.7% of national total CO emissions (based on fuel used) whereas in 1990, this source category represented 1.3% of national total CO emissions (based on fuel sold) and 1.4% of national total CO emissions (based on fuel used).

Table 3-148 – Emissions, Trends and Shares of category *1A4 - Other Sectors*

1 A 4 Other Sectors														
NFR Code	**Emissions**				**Trend**			**FUEL USED Share in National Total**			**FUEL SOLD Share in National Total**			**Fuel option**
	1990	**2005**	**2021**	**2022**	**1990 - 2022**	**2005 - 2022**	**2021 - 2022**	**1990**	**2005**	**2022**	**1990**	**2005**	**2022**	
SO2	1.43	1.17	0.04	0.04	-97%	-96%	17%	9.2%	45.6%	10.1%	8.7%	44.9%	9.7%	fuel sold
NOx	1.81	1.85	1.38	1.20	-33%	-35%	-13%	8.1%	10.4%	13.2%	4.4%	3.2%	10.5%	fuel sold
NMVOC	0.95	0.70	0.27	0.42	-56%	-40%	54%	4.4%	5.7%	4.3%	3.1%	4.7%	4.2%	fuel sold
NH3	0.01	0.01	0.00	0.00	-32%	-32%	144%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	fuel sold
CO	6.00	4.46	2.33	3.34	-44%	-25%	44%	1.4%	20.1%	22.7%	1.3%	11.2%	18.7%	fuel sold
TSP	0.70	0.59	0.15	0.35	-50%	-40%	143%	4.2%	25.9%	17.0%	4.0%	14.7%	14.0%	fuel sold
PM10	0.68	0.57	0.15	0.35	-49%	-39%	127%	4.3%	31.5%	24.8%	4.1%	17.6%	20.6%	fuel sold
PM2.5	0.67	0.55	0.15	0.34	-49%	-39%	126%	4.3%	41.0%	38.7%	4.1%	21.8%	32.5%	fuel sold

Source: Environment Agency

Regarding PM emissions, this source category represented in 2022:

- 32.5% of national total $PM_{2.5}$ emissions (based on fuel sold) and 38.7% of national total $PM_{2.5}$ emissions (based on fuel used), whereas in 1990, this source category represented 4.1% of national total $PM_{2.5}$ emissions (based on fuel sold) and 4.3% of national total $PM_{2.5}$ emissions (based on fuel used).
- 20.6% of national total PM_{10} emissions (based on fuel sold) and 24.8% of national total PM_{10} emissions (based on fuel used), whereas in 1990, this source category represented 4.1% of national total PM_{10} emissions (based on fuel sold) and 4.3% of national total PM_{10} emissions (based on fuel used).
- 14.0% of national total TSP emissions (based on fuel sold) and 17.0% of national total TSP emissions (based on fuel used), whereas in 1990, this source category represented 4.0% of national total TSP emissions (based on fuel sold) and 4.2% of national total TSP emissions (based on fuel used).

All air pollutant emissions (except for NH_3) decreased in the period 1990 – 2022 due to the implementation of more efficient heating devices although a rising demand in heat in the commercial and residential sectors, due to the rising resident population and workforce, was observed. For NH_3, the increase in emissions is mainly due to the increased use of fuel wood, in recent year, a direct consequence of the high energy prices, and climate mitigation activities.

Table 3-149 – NO_x, SO_2, NMVOC and NH_3 Emissions, Trends and Shares of category *1A4 - Other Sectors*

NOx														
NFR Code	**Emissions**				**Trend**			**FUEL USED Share in National Total**			**FUEL SOLD Share in National Total**			**Fuel option**
	1990	**2005**	**2021**	**2022**	**1990 - 2022**	**2005 - 2022**	**2021 - 2022**	**1990**	**2005**	**2022**	**1990**	**2005**	**2022**	
1 A 4	**1.81**	**1.85**	**1.38**	**1.20**	**-33%**	**-35%**	**-13%**	**8%**	**10%**	**13%**	**4%**	**3%**	**10%**	**fuel sold**
1 A 4 a i	0.843	0.530	0.574	0.432	-49%	-18%	-25%	4%	3%	5%	2%	1%	4%	fuel sold
1 A 4 a ii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
1 A 4 b i	0.622	1.034	0.643	0.603	-3%	-42%	-6%	3%	6%	7%	2%	2%	5%	fuel sold
1 A 4 b ii	0.005	0.008	0.009	0.009	65%	11%	0%	0%	0%	0%	0%	0%	0%	fuel sold
1 A 4 c i	0.011	0.009	0.001	0.007	-35%	-25%	468%	0%	0%	0%	0%	0%	0%	fuel sold
1 A 4 c ii	0.328	0.269	0.157	0.153	-53%	-43%	-2%	1%	2%	2%	1%	0%	1%	fuel sold
1A 4 c iii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold

SO_2														
NFR Code	**Emissions**				**Trend**			**FUEL USED Share in National Total**			**FUEL SOLD Share in National Total**			**Fuel option**
	1990	**2005**	**2021**	**2022**	**1990 - 2022**	**2005 - 2022**	**2021 - 2022**	**1990**	**2005**	**2022**	**1990**	**2005**	**2022**	
1 A 4	**1.43**	**1.17**	**0.04**	**0.04**	**-97.0%**	**-96.3%**	**16.9%**	**9.2%**	**45.6%**	**10.1%**	**8.7%**	**44.9%**	**9.7%**	**fuel sold**
1 A 4 a i	0.578	0.234	0.010	0.008	-98.6%	-96.6%	-21.7%	3.7%	9.1%	1.8%	3.5%	9.0%	1.8%	fuel sold
1 A 4 a ii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
1 A 4 b i	0.823	0.931	0.027	0.035	-95.7%	-96.2%	30.9%	5.3%	36.5%	8.2%	5.0%	35.9%	7.9%	fuel sold
1 A 4 b ii	0.000	0.000	0.000	0.000	-96.0%	-11.9%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 4 c i	0.010	0.000	0.000	0.000	-98.7%	-25.5%	467.6%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	fuel sold
1 A 4 c ii	0.021	0.000	0.000	0.000	-99.3%	-19.6%	3.2%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	fuel sold
1A 4 c iii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold

NMVOC														
NFR Code	**Emissions**				**Trend**			**FUEL USED Share in National Total**			**FUEL SOLD Share in National Total**			**Fuel option**
	1990	**2005**	**2021**	**2022**	**1990 - 2022**	**2005 - 2022**	**2021 - 2022**	**1990**	**2005**	**2022**	**1990**	**2005**	**2022**	
1 A 4	**0.95**	**0.70**	**0.27**	**0.42**	**-55.9%**	**-39.7%**	**54.0%**	**4.4%**	**5.7%**	**4.3%**	**3.1%**	**4.7%**	**4.2%**	**fuel sold**
1 A 4 a i	0.093	0.038	0.067	0.052	-43.3%	38.6%	-21.7%	0.4%	0.3%	0.5%	0.3%	0.3%	0.5%	fuel sold
1 A 4 a ii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
1 A 4 b i	0.498	0.417	0.093	0.255	-48.7%	-38.8%	174.4%	2.3%	3.4%	2.6%	1.6%	2.8%	2.5%	fuel sold
1 A 4 b ii	0.258	0.170	0.072	0.072	-72.1%	-57.6%	0.2%	1.2%	1.4%	0.7%	0.8%	1.2%	0.7%	fuel sold
1 A 4 c i	0.002	0.000	0.000	0.000	-97.9%	-25.5%	467.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 4 c ii	0.102	0.071	0.040	0.040	-61.0%	-44.2%	-1.7%	0.5%	0.6%	0.4%	0.3%	0.5%	0.4%	fuel sold
1A 4 c iii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold

NH3														
NFR Code	**Emissions**				**Trend**			**FUEL USED Share in National Total**			**FUEL SOLD Share in National Total**			**Fuel option**
	1990	**2005**	**2021**	**2022**	**1990 - 2022**	**2005 - 2022**	**2021 - 2022**	**1990**	**2005**	**2022**	**1990**	**2005**	**2022**	
1 A 4	**0.01**	**0.01**	**0.00**	**0.00**	**-32.3%**	**-32.1%**	**144.3%**	**0.1%**	**0.1%**	**0.1%**	**0.1%**	**0.1%**	**0.1%**	**fuel sold**
1 A 4 a i	NO	0.000	0.000	0.000	0.0%	53.9%	-16.4%	NO	0.0%	0.0%	NO	0.0%	0.0%	fuel sold
1 A 4 a ii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
1 A 4 b i	0.005	0.005	0.001	0.004	-31.6%	-31.9%	152.3%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	fuel sold
1 A 4 b ii	0.000	0.000	0.000	0.000	-26.2%	-21.4%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 4 c i	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
1 A 4 c ii	0.000	0.000	0.000	0.000	-57.3%	-42.6%	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1A 4 c iii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold

Source: Environment Agency

Table 3-150 – CO, TSP, PM_{10} and $PM_{2.5}$ Emissions, Trends and Shares of category *1A4a - Other Sectors*

CO														
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
1 A 4	**6.00**	**4.46**	**2.33**	**3.34**	**-44.3%**	**-25.2%**	**43.6%**	**1.4%**	**20.1%**	**22.7%**	**1.3%**	**11.2%**	**18.7%**	**fuel sold**
1 A 4 a i	0.321	0.198	0.301	0.232	-27.7%	16.9%	-23.0%	0.1%	0.9%	1.6%	0.1%	0.5%	1.3%	fuel sold
1 A 4 a ii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
1 A 4 b i	3.988	2.962	0.901	1.983	-50.3%	-33.0%	120.0%	0.9%	13.4%	13.5%	0.8%	7.4%	11.1%	fuel sold
1 A 4 b ii	1.244	1.012	0.989	0.991	-20.4%	-2.1%	0.2%	0.3%	4.6%	6.7%	0.3%	2.5%	5.6%	fuel sold
1 A 4 c i	0.004	0.003	0.000	0.002	-46.3%	-25.5%	467.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 4 c ii	0.445	0.290	0.135	0.133	-70.2%	-54.2%	-1.6%	0.1%	1.3%	0.9%	0.1%	0.7%	0.7%	fuel sold
1A 4 c iii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold

TSP														
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
1 A 4	**0.70**	**0.59**	**0.15**	**0.35**	**-49.6%**	**-39.7%**	**142.9%**	**4.2%**	**25.9%**	**17.0%**	**4.0%**	**14.7%**	**14.0%**	**fuel sold**
1 A 4 a i	0.001	0.002	0.003	0.002	36.2%	-2.4%	-24.4%	0.0%	0.1%	0.1%	0.0%	0.1%	0.1%	fuel sold
1 A 4 a ii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
1 A 4 b i	0.628	0.545	0.133	0.342	-45.5%	-37.2%	156.9%	3.7%	24.0%	16.5%	3.6%	13.6%	13.5%	fuel sold
1 A 4 b ii	0.000	0.000	0.000	0.000	-21.8%	5.5%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 4 c i	0.000	0.000	0.000	0.000	-86.6%	-25.5%	467.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 4 c ii	0.071	0.039	0.009	0.009	-87.2%	-76.4%	-3.5%	0.4%	1.7%	0.4%	0.4%	1.0%	0.4%	fuel sold
1A 4 c iii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold

PM10														
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
1 A 4	**0.68**	**0.57**	**0.15**	**0.35**	**-49.1%**	**-38.7%**	**127.4%**	**4.3%**	**31.5%**	**24.8%**	**4.1%**	**17.6%**	**20.6%**	**fuel sold**
1 A 4 a i	0.020	0.009	0.016	0.012	-38.4%	31.2%	-22.0%	0.1%	0.5%	0.9%	0.1%	0.3%	0.7%	fuel sold
1 A 4 a ii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
1 A 4 b i	0.591	0.518	0.127	0.326	-44.9%	-37.2%	155.7%	3.7%	28.9%	23.3%	3.5%	16.1%	19.3%	fuel sold
1 A 4 b ii	0.000	0.000	0.000	0.000	-21.8%	5.5%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 4 c i	0.000	0.000	0.000	0.000	-86.6%	-25.5%	467.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 4 c ii	0.071	0.039	0.009	0.009	-87.2%	-76.4%	-3.5%	0.4%	2.2%	0.7%	0.4%	1.2%	0.5%	fuel sold
1A 4 c iii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold

PM2.5														
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
1 A 4	**0.67**	**0.55**	**0.15**	**0.34**	**-49.0%**	**-38.6%**	**125.7%**	**4.3%**	**41.0%**	**38.7%**	**4.1%**	**21.8%**	**32.5%**	**fuel sold**
1 A 4 a i	0.020	0.009	0.016	0.012	-38.4%	31.1%	-22.1%	0.1%	0.7%	1.4%	0.1%	0.4%	1.2%	fuel sold
1 A 4 a ii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
1 A 4 b i	0.575	0.505	0.125	0.318	-44.6%	-37.0%	154.3%	3.7%	37.5%	36.3%	3.6%	19.9%	30.4%	fuel sold
1 A 4 b ii	0.000	0.000	0.000	0.000	-21.8%	5.5%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 4 c i	0.000	0.000	0.000	0.000	-86.6%	-25.5%	467.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 4 c ii	0.071	0.039	0.009	0.009	-87.2%	-76.4%	-3.5%	0.5%	2.9%	1.0%	0.4%	1.5%	0.9%	fuel sold
1A 4 c iii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold

Source: Environment Agency

The following table provides an overview of the key categories in sub-category *1A4 – Other Sectors* (see Table 3-151 and also Table 3-4 in Section 3.2 and Chapter 1.5).

Table 3-151 – Key Category Analysis of category of *1A4 - Other sectors*

Key Source Analysis (FUEL SOLD): Ranking per number		SO2		NOX		NMVOC		NH3		CO		TSP		PM10		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
1 A 4 a i	Commercial/Institutional: Stationary			9													

Key Source Analysis (FUEL USED): Ranking per number		SO2		NOX		NMVOC		NH3		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
1 A 4 a i	Commercial/Institutional: Stationary			9							

Key Source Analysis (FUEL SOLD): Ranking per number		SO2		NOX		NMVOC		NH3		CO		TSP		PM10		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
1 A 4 b i	Residential: stationary	4		6	6					4	2	4	5	1	3	1	2
1 A 4 b ii	Residential: Household and gardening (mobile)									5	5						

Key Source Analysis (FUEL USED): Ranking per number		SO2		NOX		NMVOC		NH3		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
1 A 4 b i	Residential: stationary	4		5						1	2

Source: Environment Agency

Notes: LA = Level Assessment, TA = Trend Assessment

Number in Table = indicates the rank in the specific analysis (1…biggest KC; 2… second biggest KC, …)

With regard to heavy metals and persistent organic pollutant emissions, *1A4 – Other sectors* is a key category for Cd (LA & TA), PCDD/F (LA) and PAH (LA&TA) (see and Table 3-152 also Table 3-5 in Section 3.2 and Chapter 1.5).

Table 3-152 – Key Category Analysis for heavy metals and POPs of category – 1A4 – Other Sectors

Key Source Analysis (FUEL SOLD): Ranking per number		Pb		Cd		Hg		PCDD/F		PCB		HCB		PAH	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
1 A 4 a i	Commercial/Institutional: Stationary													3	4
1 A 4 b i	Residential: stationary			1	4			3						2	2

Source: Environment Agency

Notes: LA = Level Assessment, TA = Trend Assessment

Number in Table = indicates the rank in the specific analysis (1…biggest KC; 2… second biggest KC, …)

3.2.5.2 Commercial/Institutional (1A4a i)

3.2.5.2.1 Source category description

This source category includes all kind of smaller combustion plants (< 50 MW (boilers)) for heat production, stationary engines and other stationary equipment. As the number of this kind of boilers is quite important, they have not been treated individually. Various types of fuel were and still are used: gas oil, LPG, natural gas, biogas and solid biomass (wood).

Table 3-153 summarizes emissions of air pollutants for category *1A4a i – Commercial/Institutional* and Table 3-154 presents the emission trends.

Table 3-153 – Emissions, Trends and Shares of category *1A4a i - Commercial/ Institutional*

1 A 4 a *i* Other Sectors - Commercial/Institutional														
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
SO2	0.58	0.23	0.01	0.01	-99%	-97%	-22%	3.7%	9.1%	1.8%	3.5%	9.0%	1.8%	fuel sold
NOx	0.84	0.53	0.57	0.43	-49%	-18%	-25%	3.8%	3.0%	4.7%	2.1%	0.9%	3.8%	fuel sold
NMVOC	0.09	0.04	0.07	0.05	-43%	39%	-22%	0.4%	0.3%	0.5%	0.3%	0.3%	0.5%	fuel sold
NH3	NO	0.00	0.00	0.00	0%	54%	-16%	NO	0.0%	0.0%	NO	0.0%	0.0%	fuel sold
CO	0.32	0.20	0.30	0.23	-28%	17%	-23%	0.1%	0.9%	1.6%	0.1%	0.5%	1.3%	fuel sold
TSP	0.00	0.00	0.00	0.00	36%	-2%	-24%	0.0%	0.1%	0.1%	0.0%	0.1%	0.1%	fuel sold
PM10	0.02	0.01	0.02	0.01	-38%	31%	-22%	0.1%	0.5%	0.9%	0.1%	0.3%	0.7%	fuel sold
PM2.5	0.02	0.01	0.02	0.01	-38%	31%	-22%	0.1%	0.7%	1.4%	0.1%	0.4%	1.2%	fuel sold

Source: Environment Agency

The most important air pollutant of this source category was NO_X. In 2022, this source category represented about 3.8% of national total NO_X emissions (based on fuel sold) and 4.7% of national total NO_X emissions (based on fuel used), whereas in 1990, this source category represented 2.1% of national total NO_X emissions (based on fuel sold) and 3.8% of national total NO_X emissions (based on fuel used). The decrease of about 49% in NO_X emissions from 0.84 Gg in 1990 to 0.43 Gg in 2022 is mainly due to a fuel switch from liquid fuels to gaseous fuels, as well as due to the introduction of low NO_X combustion technology.

Further important air pollutants of this source category were SO_2 and $PM_{2.5}$. In 2022, this source category represented:

- about 1.8% of national total SO_2 emissions (based on fuel sold) and 1.8% of national total SO_2 emissions (based on fuel used), whereas in 1990, this source category represented 3.5% of national total SO_2 emissions (based on fuel sold) and 3.7% of national total SO_2 emissions (based on fuel used). The significant decrease of 99% in SO_2 emissions, in the period 1990-2022, is the result of the introduction of low-sulphur containing fuels.

- about 1.2% of national total $PM_{2.5}$ emissions (based on fuel sold) and 1.4% of national total $PM_{2.5}$ emissions (based on fuel used), whereas in 1990, this source category represented less than 0.1% of national total $PM_{2.5}$ emissions (based on fuel sold and based on fuel used). The decrease of about 38% in $PM_{2.5}$ emissions in the period 1990-2022 was the result of a fuel switch from liquid fuels to gaseous fuels, as well as due to the introduction of low PM combustion technology.

As presented in Table , *1A4a i – Commercial/Institutional* is a key category for NO_X (LA) in 2022 (see Table 3-151 in section 3.2.5.1 and Table 3-4 in Section 3.2 and Chapter 1.5).

Table 3-154 – Emission trends of category *1A4a i - Commercial/Institutional*

1 A 4 Other Sectors *Emissions of air pollutants by source category (Gg)*								
Year	**1 A 4 a i Commercial / institutional: Stationary**							
	SO2	***NOx***	***NMVOC***	***NH3***	***CO***	***TSP***	***PM10***	***PM2.5***
1990	0.578	0.843	0.093	NO	0.321	0.001	0.020	0.020
1991	0.718	1.016	0.115	NO	0.388	0.002	0.024	0.024
1992	0.638	0.935	0.102	NO	0.355	0.002	0.022	0.022
1993	0.615	0.924	0.099	NO	0.350	0.002	0.021	0.021
1994	0.589	0.890	0.094	NO	0.337	0.002	0.020	0.020
1995	0.573	0.896	0.092	NO	0.338	0.002	0.020	0.020
1996	0.627	1.001	0.101	NO	0.376	0.002	0.022	0.022
1997	0.628	0.975	0.101	NO	0.368	0.002	0.022	0.022
1998	0.648	1.020	0.104	NO	0.384	0.002	0.023	0.023
1999	0.554	0.912	0.089	NO	0.342	0.002	0.020	0.020
2000	0.250	0.712	0.041	0.000	0.256	0.003	0.011	0.011
2001	0.307	0.650	0.050	0.000	0.242	0.002	0.012	0.012
2002	0.285	0.649	0.046	0.000	0.244	0.003	0.012	0.012
2003	0.259	0.639	0.042	0.000	0.237	0.003	0.011	0.011
2004	0.254	0.591	0.041	0.000	0.220	0.002	0.010	0.010
2005	0.234	0.530	0.038	0.000	0.198	0.002	0.009	0.009
2006	0.142	0.488	0.023	0.000	0.179	0.002	0.007	0.007
2007	0.134	0.418	0.022	0.000	0.160	0.002	0.006	0.006
2008	0.057	0.426	0.018	0.000	0.170	0.003	0.006	0.006
2009	0.055	0.413	0.017	0.000	0.172	0.003	0.006	0.006
2010	0.102	0.534	0.033	0.000	0.231	0.003	0.009	0.009
2011	0.066	0.331	0.024	0.000	0.142	0.002	0.006	0.006
2012	0.081	0.429	0.028	0.000	0.190	0.003	0.008	0.008
2013	0.097	0.457	0.034	0.000	0.208	0.003	0.009	0.009
2014	0.086	0.394	0.031	0.000	0.185	0.003	0.009	0.009
2015	0.127	0.499	0.046	0.000	0.234	0.003	0.011	0.011
2016	0.011	0.511	0.044	0.000	0.247	0.003	0.012	0.012
2017	0.009	0.558	0.064	0.000	0.268	0.002	0.014	0.014
2018	0.009	0.564	0.065	0.000	0.278	0.002	0.015	0.015
2019	0.009	0.643	0.078	0.000	0.323	0.002	0.018	0.018
2020	0.007	0.532	0.072	0.000	0.272	0.002	0.016	0.016
2021	0.010	0.574	0.067	0.000	0.301	0.003	0.016	0.016
2022	0.008	0.432	0.052	0.000	0.232	0.002	0.012	0.012
Trend 1990-2022	*-98.64%*	*-48.77%*	*-43.29%*	*NA*	*-27.68%*	*36.25%*	*-38.36%*	*-38.38%*
2005-2022	*-96.65%*	*-18.42%*	*38.63%*	*53.92%*	*16.89%*	*-2.40%*	*31.16%*	*31.15%*
2021-2022	*-21.75%*	*-24.73%*	*-21.68%*	*-16.38%*	*-23.05%*	*-24.37%*	*-22.05%*	*-22.05%*

Source: Environment Agency

With regard to heavy metals and persistent organic pollutant emissions, *1A4a i – Commercial/Institutional* is a key category for PAH (LA & TA) (see Table 3-152 and also Table 3-5 in Section 3.2 and Chapter 1.5).

3.2.5.2.2 Methodological issues & time-series consistency

3.2.5.2.2.1 Activity data

Under *1A4a – Commercial/Institutional*, emissions from non-industrial commercial and institutional combustion plants (<50 MW) are accounted, thus covering numerous small combustion units, mainly for the heating purpose of buildings.

For the period 2000-2022, annual fuel combustion data for this category was extracted from the national energy balance established by the national statistics institute. However, for the period 1990-1999, fuel consumption data is only reported under the so-called "*domestic sector"* by the national energy balance, covering consumption data for commercial and institutional as well as for residential combustion units. Consequently, data was distributed arbitrarily, i.e. 50% is reported under *1A4a – Commercial/Institutional* and 50% under *1A4b – Residential*. Top-down activity data per fuel type is given in Table 3-155.

Table 3-155 – Activity data for category *1A4a i - Commercial/Institutional*

1 A 4 Other Sectors						
Activity Data by fuel type (GJ)						
1 A 4 a i Commercial / institutional: Stationary						
Year	Activity Total (incl. biomass)	Liquid *Gas Oil, LPG*	Solid	Gaseous *Natural Gas*	Biomass *Fuel Wood, Pellets, Wood chips*	Other
1990	9 296 234	6'359'553	NO	2'936'681	NO	NO
1991	11 122 560	7'822'330	NO	3'300'231	NO	NO
1992	10 323 786	6'985'232	NO	3'338'554	NO	NO
1993	10 259 447	6'708'868	NO	3'550'579	NO	NO
1994	9 898 224	6'406'937	NO	3'491'287	NO	NO
1995	10 042 374	6'223'973	NO	3'818'401	NO	NO
1996	11 278 090	6'794'806	NO	4'483'284	NO	NO
1997	10 906 999	6'718'170	NO	4'188'829	NO	NO
1998	11 463 250	6'954'434	NO	4'506'816	2 000	NO
1999	10 387 398	5'942'758	NO	4'441'640	3 000	NO
2000	8 915 370	2'673'823	NO	6'220'885	20 662	NO
2001	7 837 822	3'312'877	NO	4'491'584	33 361	NO
2002	7 957 180	3'009'270	NO	4'902'833	45 078	NO
2003	7 974 408	2'693'297	NO	5'243'119	37 993	NO
2004	7 357 752	2'685'214	NO	4'642'785	29 753	NO
2005	6 615 090	2'495'701	NO	4'091'000	28 389	NO
2006	6 505 067	1'498'922	NO	4'977'905	28 240	NO
2007	5 730 623	1'383'477	NO	4'319'537	27 609	NO
2008	6 344 565	1'090'665	NO	5'220'321	33 579	NO
2009	6 397 614	1'079'899	NO	5'275'683	42 033	NO
2010	8 175 626	2'428'020	NO	5'710'750	36 856	NO
2011	4 853 677	1'927'682	NO	2'883'496	42 499	NO
2012	6 669 545	2'112'874	NO	4'487'880	68 791	NO
2013	7 054 527	2'531'362	NO	4'437'823	85 342	NO
2014	6 142 035	2'307'949	NO	3'742'627	91 459	NO
2015	7 672 687	3'285'685	NO	4'301'932	85 070	NO
2016	8 182 788	3'213'441	NO	4'850'245	119 101	NO
2017	8 359 671	4'568'878	NO	3'711'297	79 496	NO
2018	8 765 997	4'529'937	NO	4'160'463	75 598	NO
2019	10 029 547	5'494'764	NO	4'465'689	69 094	NO
2020	8 181 169	4'999'213	NO	3'118'489	63 466	NO
2021	9 596 777	4'786'782	NO	4'778'259	31 737	NO
2022	7 338 077	3'737'051	NO	3'541'702	59 323	NO
Trend 1990-2022	*-21.06%*	*-41.24%*	*NA*	*20.60%*	*NA*	*NA*
2005-2022	*10.93%*	*49.74%*	*NA*	*-13.43%*	*108.96%*	*NA*
2021-2022	*-23.54%*	*-21.93%*	*NA*	*-25.88%*	*86.92%*	*NA*

Source: Environment Agency

For the estimation of NO_x emissions from natural gas and gasoil combustion, the top-down activity data was further split into more detailed activity data using country-specific technology ratios as illustrated in Table 3-156. The ratios for 2005 to 2011 were derived from a national study.[55] For the years before 2005 and after 2012, trend extrapolation was used.

Table 3-156 – Technology ratio by fuel type for NO_x emission estimation of category *1A4a i - Commercial/Institutional*

1 A 4 Other Sectors									
Technology ratio by fuel type (%)									
1 A 4 a i Commercial / institutional: Stationary									
Year	Natural Gas			Gasoil			Automatic Boilers (< 1 MW)		
	Conventional boilers	*New conventional Boilers*	*Condensing boilers*	*Conventional boilers*	*New conventional Boilers*	*Condensing boilers*	*Fuel wood (log)*	*Wood Pellets*	*Wood chips*
1990	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%
1991	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%
1992	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%
1993	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%
1994	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%
1995	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%
1996	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%
1997	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%
1998	99.44%	0.56%	0.00%	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%
1999	98.44%	0.75%	0.81%	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%
2000	97.44%	0.75%	1.81%	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%
2001	96.44%	0.75%	2.81%	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%
2002	95.44%	0.75%	3.81%	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%
2003	94.44%	0.75%	4.81%	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%
2004	93.44%	0.75%	5.81%	99.05%	0.95%	0.00%	100.00%	0.00%	0.00%
2005	92.44%	0.75%	6.81%	98.05%	1.58%	0.37%	100.00%	0.00%	0.00%
2006	90.45%	2.21%	7.35%	97.21%	2.72%	0.06%	100.00%	0.00%	0.00%
2007	85.65%	0.30%	14.05%	96.06%	3.73%	0.21%	100.00%	0.00%	0.00%
2008	77.72%	2.70%	19.58%	94.28%	4.88%	0.83%	100.00%	0.00%	0.00%
2009	73.10%	2.55%	24.35%	92.60%	5.54%	1.87%	100.00%	0.00%	0.00%
2010	65.68%	2.20%	32.11%	90.54%	6.51%	2.95%	100.00%	0.00%	0.00%
2011	66.43%	1.58%	31.99%	85.61%	9.49%	4.90%	100.00%	0.00%	0.00%
2012	64.43%	1.58%	33.99%	83.61%	9.49%	6.90%	100.00%	0.00%	0.00%
2013	62.43%	1.58%	35.99%	81.61%	9.49%	8.90%	100.00%	0.00%	0.00%
2014	60.43%	1.58%	37.99%	79.61%	9.49%	10.90%	100.00%	0.00%	0.00%
2015	58.43%	1.58%	39.99%	77.61%	9.49%	12.90%	100.00%	0.00%	0.00%
2016	56.43%	1.58%	41.99%	75.61%	9.49%	14.90%	100.00%	0.00%	0.00%
2017	54.43%	1.58%	43.99%	73.61%	9.49%	16.90%	100.00%	0.00%	0.00%
2018	52.43%	1.58%	45.99%	71.61%	9.49%	18.90%	100.00%	0.00%	0.00%
2019	50.43%	1.58%	47.99%	69.61%	9.49%	20.90%	100.00%	0.00%	0.00%
2020	48.43%	1.58%	49.99%	67.61%	9.49%	22.90%	100.00%	0.00%	0.00%
2021	46.43%	1.58%	51.99%	65.61%	9.49%	24.90%	100.00%	0.00%	0.00%
2022	44.43%	1.58%	53.99%	63.61%	9.49%	26.90%	100.00%	0.00%	0.00%

[55] Country specific emission calculation approach for small combustion plants in residential and commercial sector, A. Takagi, *et al.*, 2014, Tudor, Centre de Ressources des technologies pour l'Environnement, unpublished results.

Source: Environment Agency

3.2.5.2.2.2 Methodology

The EMEP/EEA Tier 2 approach has been applied for all fuels and all air pollutants.

For SO_2, EMEP/EEA Tier 2 approach has been applied using a country-specific emission factor based on the sulfur content of the fuel.

3.2.5.2.2.3 Emission factors

For the main air pollutants (NO_X (from wood burning), SO_2, NMVOC, NH_3, CO, TSP, PM_{10}, $PM_{2.5}$), the Tier 2 default emission factors for medium-sized (> 50 kWth to ≤ 1 MWth) boilers burning natural gas, for medium-sized (> 50 kWth to ≤ 1 MWth) boilers burning gasoil and for automatic boilers burning wood, from the EMEP/EEA Guidebook 2019 (Chapter 1A4 Small Combustion, Tables 3.26, 3.24, 3.48, respectively), have been applied.

For NO_X emissions, fuel combustion activity data was split according to specific combustion technology and Tier 2 emission factors were taken from the following sources:

- conventional boilers: medium-sized (> 50 kWth to ≤ 1 MWth) boilers burning natural gas: EMEP/EEA Guidebook 2019 (Chapter 1A4 Small Combustion, Tables 3.26) ; medium-sized (> 50 kWth to ≤ 1 MWth) boilers burning gasoil: EMEP/EEA Guidebook 2019 (Chapter 1A4 Small Combustion, Tables 3.24)
- new conventional boilers: Small (single household scale, capacity <=50 kWth) boilers burning natural gas: EMEP/EEA Guidebook 2019 (Chapter 1A4 Small Combustion, Tables 3.16); small (single household scale, capacity <=50 kWth) boilers burning gasoil: EMEP/EEA Guidebook 2019 (Chapter 1A4 Small Combustion, Tables 3.18)
- condensing boilers: no default emission factor for this technology and for neither natural gas, nor gasoil is available in the EMEP/EEA Guidebook 2019. The NO_x emission factor for natural gas and gasoil was derived from the Austrian emission inventory (AT IIR 2016, Table 114, p.168).

For LPG, Tier 2 default emission factors from the EMEP/EEA Guidebook 2019 (Chapter 1A4, Table 3.26) have been applied. For Biogas, Tier 2 default emission factors from the EMEP/EEA Guidebook 2019 have been applied, assuming that biogas is equivalent to natural gas (and usually blended with natural gas when entering the natural gas distribution network).

The methods applied and emission factors (EF) used as well as coverage of energy consumption for 2022 are presented in Table 3-157.

Table 3-157 – Methods and Emission Factors used in relation to the energy consumption in 2022 for category *1A4a i - Commercial/Institutional*

1 A 4 Other Sectors *Method applied and Emission factor (EF) used as well as coverage of energy consumption* 1 A 4 a i Commercial / institutional: Stationary				
Pollutant	Method	EF used	Coverage of energy consumption	Source
NOx	T2	D, CS	100.0%	EMEP/EEA GB 2019 (Chap 1A4, Table 3-48) ; EMEP/EEA GB 2019 (Chap 1A4, Tables 3-26 & 3-16) ; IIR AT 2016 (Table 114, p168) ; EMEP/EEA GB 2019 (Chap 1A4, Tables 3-24 & 3-18)
	T1	D	0.0%	
NMVOC CO TSP PM10 PM2.5	T2	D	100.0%	EMEP/EEA GB 2019 (Chap 1A4, Table 3-48) ; EMEP/EEA GB 2019 (Chap 1A4, Table 3-26) ; EMEP/EEA GB 2019 (Chap 1A4, Table 3-24)
	T1	D	0.0%	
SOx	T2	CS	45.2%	CS based on maximum allowed suphur content
	T2	D	54.8%	EMEP/EEA GB 2019 (Chap 1A4, Table 3-48) ; EMEP/EEA GB 2019 (Chap 1A4, Table 3-26)
	T1	D	0.0%	

Source: Environment Agency

Table 3-158 gives an overview of the evolution of the implied emission factors. The slight increase in the IEF which is observed for NMVOC and PM in recent years is mainly due to the increased use of biogas, LPG and, to a lower extend, wood.

Table 3-158 – Implied emission factors for category *1A4a i - Commercial/Institutional*

Year	1 A 4 Other Sectors *Implied Emission Factor (IEF) of air pollutants by source category (g/GJ)* 1 A 4 a i Commercial / institutional: Stationary							
	SO2	*NOx*	*NMVOC*	*NH3*	*CO*	*TSP*	*PM10*	*PM2.5*
1990	62.14	90.70	9.96	NA	34.49	0.16	2.12	2.12
1991	64.51	91.39	10.33	NA	34.90	0.14	2.19	2.19
1992	61.83	90.61	9.91	NA	34.43	0.16	2.11	2.11
1993	59.93	90.05	9.61	NA	34.11	0.17	2.06	2.06
1994	59.47	89.92	9.53	NA	34.03	0.17	2.05	2.05
1995	57.08	89.22	9.16	NA	33.61	0.18	1.98	1.98
1996	55.55	88.78	8.92	NA	33.35	0.19	1.94	1.94
1997	57.55	89.36	9.23	NA	33.70	0.18	2.00	2.00
1998	56.53	89.00	9.07	NA	33.52	0.18	1.97	1.97
1999	53.36	87.84	8.57	NA	32.97	0.20	1.88	1.88
2000	27.99	79.87	4.57	0.00	28.70	0.34	1.20	1.20
2001	39.21	82.98	6.35	0.00	30.85	0.31	1.53	1.53
2002	35.87	81.60	5.83	0.00	30.71	0.39	1.50	1.50
2003	32.43	80.10	5.27	0.00	29.69	0.35	1.35	1.35
2004	34.57	80.32	5.61	0.00	29.87	0.31	1.38	1.38
2005	35.32	80.05	5.72	0.00	29.99	0.30	1.40	1.40
2006	21.82	75.01	3.59	0.00	27.58	0.36	1.02	1.02
2007	23.35	72.94	3.83	0.00	27.86	0.35	1.06	1.06
2008	9.01	67.22	2.81	0.00	26.83	0.40	0.90	0.90
2009	8.54	64.56	2.66	0.00	26.84	0.43	0.89	0.89
2010	12.49	65.37	4.05	0.00	28.23	0.36	1.12	1.12
2011	13.69	68.16	5.04	0.00	29.26	0.33	1.29	1.28
2012	12.13	64.26	4.15	0.00	28.47	0.38	1.15	1.15
2013	13.74	64.73	4.80	0.00	29.50	0.41	1.31	1.31
2014	13.98	64.16	5.01	0.00	30.13	0.47	1.40	1.40
2015	16.60	64.98	5.95	0.00	30.46	0.33	1.47	1.47
2016	1.30	62.43	5.39	0.00	30.24	0.41	1.43	1.42
2017	1.11	66.70	7.71	0.00	32.06	0.23	1.73	1.73
2018	1.08	64.38	7.37	0.00	31.70	0.24	1.68	1.68
2019	0.91	64.15	7.82	0.00	32.17	0.22	1.75	1.75
2020	0.91	65.04	8.78	0.00	33.26	0.20	1.92	1.92
2021	1.04	59.80	6.98	0.00	31.40	0.27	1.63	1.62
2022	1.07	58.87	7.15	0.00	31.60	0.27	1.66	1.66
Trend 1990-2022	-98.28%	-35.09%	-28.16%	NA	-8.38%	72.61%	-21.91%	-21.94%
2005-2022	-96.98%	-26.46%	24.97%	38.75%	5.37%	-12.02%	18.23%	18.23%
2021-2022	2.34%	-1.56%	2.43%	9.36%	0.64%	-1.09%	1.94%	1.94%

Source: Environment Agency

3.2.5.2.3 Methodological issues for heavy metals and POPs

3.2.5.2.3.1 Methodological Choices

Tier 2 approach based on fuels used, percentage of different installed heating systems, and the appropriate tier 2 emission factors.

Fuel consumption data were obtained from the national energy balance compiled by the National Statistics Institute (STATEC).

3.2.5.2.3.2 Emission Factors

Tier 2 emission factors:

Fuel	Pollutants	Source	Page	Table
Liquid fuels	Pb, Hg, Cd, PCDD/F, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2023) – Chapter 1.A.4 Small combustion	55	3.24
Natural gas	Pb, Hg, Cd, PCDD/F, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2023) – Chapter 1.A.4 Small combustion	57	3.26
Wood	Pb, Hg, Cd, PCDD/F, PCB, HCB, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2023) – Chapter 1.A.4 Small combustion	90	3.48

3.2.5.3 Commercial/Institutional: Mobile (1A4a ii)

Source category *1A4a ii Commercial / Institutional: Mobile* is reported as included elsewhere in source category *1A2gvii – Mobile combustion in manufacturing industries and construction* (notation key: IE). Indeed, although mobile machinery such as fork lifts, etc. are used in this category, the national energy balance does not report diesel oil or gasoline consumption for this category. In addition, no data on the type of machinery, operating hours and power exists for this category in Luxembourg. Hence, in order to ensure completeness, it was decided to report this category as included elsewhere, rather than not occurring. LPG, reported by the energy balance for this category, is supposed to be entirely burnt in stationary combustion units.

3.2.5.4 Residential (1A4b i)

3.2.5.4.1 Source category description

This source category covers numerous smaller combustion units and other equipment (stoves, fireplaces, cooking etc.) mainly for heating purposes.

Table 3-159 summarizes the annual emissions of air pollutants for category *1A4b i Residential* and Table 3-161 presents the emission trends.

In 2022, $PM_{2.5}$ emissions of this source category represented 30.4% of national total $PM_{2.5}$ emissions (based on fuel sold) and 36.3% of national total $PM_{2.5}$ emissions (based on fuel used), whereas in 1990, this source category represented about 3.6% to 3.7% of national total $PM_{2.5}$ emissions (based on fuel sold/based on fuel used). For 2022 $PM_{2.5}$ emissions have decreased by about 45% compared to 1990, due to a shift from fuel wood to wood pellets in recent years, a trend fuelled by climate mitigation politics. However, compared to 2021, $PM_{2.5}$ emissions have increased by 154% in 2022. This increase is due to an increased combustion activity of fuel wood and wood chips (+253% and +594%, respectively) due to the high fossil fuel energy prices.

In 2022, NMVOC emissions of this source category represented 2.5% of national total NMVOC emissions (based on fuel sold) and 2.6% of national total NMVOC emissions (based on fuel used), whereas in 1990, this source category represented about 1.6% to 2.6% of national total NMVOC emissions (based on fuel sold/based on fuel used). NMVOC emissions have decreased by about 49% compared to 1990 due to an increased use of wood pellet combustion. However, compared to 2021, NMVOC emissions have increased by 174% in 2022. This increase is due to an increased combustion activity of fuel wood and wood chips (+253% and +594%, respectively) due to the high fossil fuel energy prices.

In 2022, SO_2 emissions of this source category represented 7.9% of national total SO_2 emissions (based on fuel sold) and 8.2% of national total SO_2 emissions (based on fuel used), whereas in 1990, this source category represented about 5.0%/5.3% of national total SO_2 emissions (based on fuel sold/based on fuel used). The significant decrease of about 96%, compared to 1990, in SO_2 emissions was the result of the introduction of low-sulphur containing fuels, and a general switch form liquid fuels to gaseous fuels or biomass.

In 2022, NO_X emissions of this source category represented 5.3% of national total NO_X emissions (based on fuel sold) and 6.6% of national total NO_X emissions (based on fuel used), whereas in 1990, this source category represented about 1.5% to 2.8% of national total NO_X emissions (based on fuel sold/based on fuel used). Compared to 1990, NO_X emissions decreased by 3% in 2022 despite an increasing population in Luxembourg, and thus an increased heating demand. In recent years emissions have decreased more sharply by 42% compared to 2005, illustrating the effect of increased low NO_x combustion technology installations (condensing boilers). In 2022, the NO_X emissions decreased by 6.0% compared to 2021.

Table 3-159 – Emissions, Trends and Shares based on fuel sold and fuel used for category *1A4bi - Residential*

1 A 4 b *i* Other Sectors - Residential														
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
SO2	0.82	0.93	0.03	0.04	-96%	-96%	31%	5.3%	36.5%	8.2%	5.0%	35.9%	7.9%	fuel sold
NOx	0.62	1.03	0.64	0.60	-3%	-42%	-6%	2.8%	5.8%	6.6%	1.5%	1.8%	5.3%	fuel sold
NMVOC	0.50	0.42	0.09	0.26	-49%	-39%	174%	2.3%	3.4%	2.6%	1.6%	2.8%	2.5%	fuel sold
NH3	0.01	0.01	0.00	0.00	-32%	-32%	152%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	fuel sold
CO	3.99	2.96	0.90	1.98	-50%	-33%	120%	0.9%	13.4%	13.5%	0.8%	7.4%	11.1%	fuel sold
TSP	0.63	0.55	0.13	0.34	-46%	-37%	157%	3.7%	24.0%	16.5%	3.6%	13.6%	13.5%	fuel sold
PM10	0.59	0.52	0.13	0.33	-45%	-37%	156%	3.7%	28.9%	23.3%	3.5%	16.1%	19.3%	fuel sold
PM2.5	0.57	0.50	0.13	0.32	-45%	-37%	154%	3.7%	37.5%	36.3%	3.6%	19.9%	30.4%	fuel sold

Source: Environment Agency

Further important sources of air pollutants of this source category were NH_3, CO and PM_{10}. In 2022, this source category represented:

- 0.1% of national total NH_3 emissions (based on fuel sold/fuel used).
- 11.1% of national total CO emissions (based on fuel sold) and 13.5% of national total CO emissions (based on fuel used).
- 19.3% of national total PM_{10} emissions (based on fuel sold) and 23.3% of national total PM_{10} emissions (based on fuel used).

As presented in Table 3-160, with regard to SO_2, NO_x, CO, TSP, PM_{10} and $PM_{2.5}$, 1A4b i Residential is a key category (LA & TA) in 2022 (see also Table 3-4 in Section 3.2 and Chapter 1.5).

Table 3-160 – Key Categories (fuel sold & fuel used) of sub-category *1A4bi - Residential*

Key Source Analysis (FUEL SOLD): Ranking per number		SO2		NOX		NMVOC		NH3		CO		TSP		PM10		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
1 A 4 b i	Residential: stationary	4		6	6					4	2	4	5	1	3	1	2
1 A 4 b ii	Residential: Household and gardening (mobile)									5	5						

Key Source Analysis (FUEL USED): Ranking per number		SO2		NOX		NMVOC		NH3		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
1 A 4 b i	Residential: stationary	4		5						1	2

Sources: Environment Agency

Notes: LA = Level Assessment , TA = Trend Assessment

Number in Table = indicates the rank in the specific analysis (1…biggest KC; 2… second biggest KC, …)

With regard to heavy metals and persistent organic pollutant emissions, *1A4bi – Residential* is a key category for Cd (LA & TA), PCDD/F (LA) and PAH (LA & TA) (see Table 3-161 and also Table 3-5 in Section 3.2 and Chapter 1.5).

Table 3-161 – Emission trends for category *1A4b i - Residential*

1 A 4 Other Sectors *Emissions of air pollutants by source category (Gg)*								
Year	1 A 4 b i Residential: Stationary							
	SO2	*NOx*	*NMVOC*	*NH3*	*CO*	*TSP*	*PM10*	*PM2.5*
1990	0.823	0.622	0.498	0.005	3.988	0.628	0.591	0.575
1991	1.003	0.744	0.516	0.005	4.219	0.647	0.608	0.591
1992	0.869	0.680	0.493	0.005	3.923	0.623	0.586	0.571
1993	0.862	0.673	0.500	0.005	4.016	0.630	0.592	0.576
1994	0.753	0.639	0.464	0.005	3.561	0.594	0.561	0.546
1995	0.769	0.645	0.478	0.005	3.739	0.607	0.572	0.557
1996	0.749	0.701	0.448	0.005	3.362	0.578	0.546	0.532
1997	0.741	0.685	0.444	0.005	3.304	0.574	0.543	0.528
1998	0.731	0.709	0.431	0.005	3.147	0.561	0.532	0.518
1999	0.632	0.635	0.429	0.005	3.111	0.557	0.528	0.514
2000	0.932	0.952	0.418	0.005	3.021	0.545	0.517	0.504
2001	0.990	1.030	0.444	0.005	3.181	0.582	0.553	0.538
2002	0.909	0.972	0.409	0.005	2.918	0.535	0.508	0.495
2003	0.918	1.004	0.414	0.005	2.929	0.542	0.515	0.502
2004	0.967	1.067	0.431	0.005	3.050	0.565	0.537	0.523
2005	0.931	1.034	0.417	0.005	2.962	0.545	0.518	0.505
2006	0.958	1.027	0.411	0.005	2.908	0.540	0.513	0.500
2007	0.913	0.974	0.371	0.005	2.629	0.487	0.463	0.451
2008	0.472	0.982	0.406	0.005	2.861	0.532	0.506	0.493
2009	0.468	0.955	0.452	0.006	3.171	0.593	0.564	0.550
2010	0.396	0.892	0.468	0.006	3.296	0.609	0.579	0.564
2011	0.315	0.797	0.364	0.005	2.593	0.472	0.449	0.437
2012	0.371	0.822	0.448	0.006	3.140	0.588	0.558	0.544
2013	0.353	0.801	0.492	0.006	3.457	0.644	0.612	0.596
2014	0.295	0.713	0.538	0.007	3.746	0.706	0.671	0.653
2015	0.338	0.795	0.421	0.005	3.052	0.551	0.524	0.511
2016	0.044	0.806	0.503	0.007	3.591	0.663	0.630	0.614
2017	0.034	0.786	0.424	0.006	3.065	0.558	0.530	0.517
2018	0.027	0.718	0.459	0.006	3.267	0.608	0.578	0.564
2019	0.022	0.620	0.255	0.003	1.904	0.330	0.314	0.307
2020	0.023	0.672	0.185	0.002	1.472	0.242	0.231	0.226
2021	0.027	0.643	0.093	0.001	0.901	0.133	0.127	0.125
2022	0.035	0.603	0.255	0.004	1.983	0.342	0.326	0.318
Trend 1990-2022	*-95.73%*	*-2.97%*	*-48.75%*	*-31.58%*	*-50.28%*	*-45.51%*	*-44.86%*	*-44.63%*
2005-2022	*-96.23%*	*-41.64%*	*-38.79%*	*-31.89%*	*-33.05%*	*-37.25%*	*-37.15%*	*-36.99%*
2021-2022	*30.94%*	*-6.20%*	*174.39%*	*152.27%*	*120.02%*	*156.89%*	*155.74%*	*154.27%*

Source: Environment Agency

3.2.5.4.2 Methodological issues & time-series consistency

3.2.5.4.2.1 Activity data

This source category covers numerous smaller combustion units, mainly for heating purposes.

For the period 2000-2022, annual fuel combustion data (coal products (coke, other bituminous coal, brown coal briquettes, patent fuels), wood, gas oil, LPG and natural gas), for this category was extracted from the national energy balance established by the national statistics institute. However, for the period 1990-1999, fuel consumption data is only reported under the so-called "*domestic sector"* by the national energy balance, covering consumption data for commercial and institutional as well as for residential combustion units.

Consequently, data was distributed arbitrarily, i.e. 50% is reported under *1A4a – Commercial/Institutional* and 50% under *1A4b – Residential*. Top-down activity data per fuel type is given in Table 3-162.

Table 3-162 – Activity data for category *1A4b i - Residential*

1 A 4 Other Sectors						
Activity Data by fuel type (GJ)						
1 A 4 b i Residential: Stationary						
Year	**Activity Total (incl. biomass)**	**Liquid** *Gas Oil, LPG*	**Solid** *Coke Oven Coke, Brown Coal Briquettes, Other Bituminous Coal*	**Gaseous** *Natural Gas*	**Biomass** *Wood and similar wood wastes*	**Other**
1990	10 209 975	6'359'553	268'741	2'936'681	645 000	NO
1991	12 080 805	7'822'330	313'244	3'300'231	645 000	NO
1992	11 221 978	6'985'232	253'192	3'338'554	645 000	NO
1993	11 175 946	6'708'868	271'499	3'550'579	645 000	NO
1994	10 722 365	6'406'937	179'141	3'491'287	645 000	NO
1995	10 901 600	6'223'973	214'226	3'818'401	645 000	NO
1996	12 056 737	6'794'806	133'647	4'483'284	645 000	NO
1997	11 675 576	6'718'170	123'577	4'188'829	645 000	NO
1998	12 196 003	6'954'434	89'753	4'506'816	645 000	NO
1999	11 113 040	5'942'758	83'642	4'441'640	645 000	NO
2000	16 573 771	9'317'222	63'651	6'560'642	632 256	NO
2001	18 026 431	10'051'202	51'351	7'241'170	682 708	NO
2002	17 224 203	9'232'409	40'632	7'320'304	630 859	NO
2003	17 929 987	9'399'832	29'511	7'856'398	644 245	NO
2004	19 196 454	9'966'251	27'390	8'516'240	686 572	NO
2005	18 806 933	9'582'913	30'074	8'536'993	656 953	NO
2006	18 490 496	9'906'170	25'786	7'899'632	658 908	NO
2007	17 906 737	9'436'033	21'523	7'861'031	588 151	NO
2008	18 551 040	9'478'018	19'861	8'407'485	645 676	NO
2009	18 357 007	9'392'016	21'702	8'226'956	716 333	NO
2010	18 442 389	8'072'239	25'322	9'602'707	742 120	NO
2011	16 831 628	7'192'446	22'774	9'027'820	588 588	NO
2012	17 110 617	8'001'850	18'751	8'315'615	774 401	NO
2013	17 205 223	7'527'325	26'584	8'797'046	854 268	NO
2014	15 823 829	6'413'604	20'855	8'443'674	945 695	NO
2015	17 571 952	7'338'323	25'796	9'195'335	1 012 498	NO
2016	18 285 375	7'348'704	24'557	9'781'925	1 130 189	NO
2017	18 822 613	6'545'503	15'951	11'216'019	1 045 140	NO
2018	17 358 300	6'112'745	9'964	10'152'875	1 082 717	NO
2019	15 842 437	4'863'684	10'421	10'271'325	697 008	NO
2020	17 119 816	5'658'884	11'148	10'716'604	733 180	NO
2021	16 343 728	5'590'726	14'581	10'001'857	736 563	NO
2022	15 282 246	5'387'413	20'989	8'903'941	969 902	NO
Trend 1990-2022	*49.68%*	*-15.29%*	*-92.19%*	*203.20%*	*50.37%*	*NA*
2005-2022	*-18.74%*	*-43.78%*	*-30.21%*	*4.30%*	*47.64%*	*NA*
2021-2022	*-6.49%*	*-3.64%*	*43.94%*	*-10.98%*	*31.68%*	*NA*

Source: Environment Agency

For the estimation of NO_x emissions, the top-down activity data were further split into more detailed activity data using country-specific technology ratios as illustrated in Table 3-163. The ratios for 2005 to 2011 were derived from a national study.[56] For the years before 2005 and after 2012, trend extrapolation was used.

[56] Country specific emission calculation approach for small combustion plants in residential and commercial sector, A. Takagi, *et al.*, 2014, Tudor, Centre de Ressources des technologies pour l'Environnement, unpublished results.

Table 3-163 – Technology ratio by fuel type for NO_x emission estimation of category *1A4b i - Residential*

1 A 4 Other Sectors *Technology ratio by fuel type (%)* 1 A 4 b i Residential: Stationary											
Year	**Coal products**		**Natural Gas**			**Gasoil**			**Fuel wood (log)**	**Wood Pellets**	**Wood chips**
	Conventional stoves	***Conventional boilers <50kW***	***Conventional boilers***	***New conventional Boilers***	***Condensing boilers***	***Conventional boilers***	***New conventional Boilers***	***Condensing boilers***	***Closed fireplace, conventional traditional stoves, domestic cooking***	***Pellet stoves and boilers: Modern pellet stoves, automatic wood boilers (pellets / chips)***	***Advanced combustion stoves, catalytic combustor stoves, advanced combustion boilers***
1990	50.00%	50.00%	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%	100.00%	100.00%
1991	50.00%	50.00%	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%	100.00%	100.00%
1992	50.00%	50.00%	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%	100.00%	100.00%
1993	50.00%	50.00%	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%	100.00%	100.00%
1994	50.00%	50.00%	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%	100.00%	100.00%
1995	50.00%	50.00%	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%	100.00%	100.00%
1996	50.00%	50.00%	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%	100.00%	100.00%
1997	50.00%	50.00%	100.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%	100.00%	100.00%
1998	50.00%	50.00%	99.44%	0.56%	0.00%	100.00%	0.00%	0.00%	100.00%	100.00%	100.00%
1999	50.00%	50.00%	98.44%	0.75%	0.81%	100.00%	0.00%	0.00%	100.00%	100.00%	100.00%
2000	50.00%	50.00%	97.44%	0.75%	1.81%	100.00%	0.00%	0.00%	100.00%	100.00%	100.00%
2001	50.00%	50.00%	96.44%	0.75%	2.81%	100.00%	0.00%	0.00%	100.00%	100.00%	100.00%
2002	50.00%	50.00%	95.44%	0.75%	3.81%	100.00%	0.00%	0.00%	100.00%	100.00%	100.00%
2003	50.00%	50.00%	94.44%	0.75%	4.81%	100.00%	0.00%	0.00%	100.00%	100.00%	100.00%
2004	50.00%	50.00%	93.44%	0.75%	5.81%	99.05%	0.95%	0.00%	100.00%	100.00%	100.00%
2005	50.00%	50.00%	92.44%	0.75%	6.81%	98.05%	1.58%	0.37%	100.00%	100.00%	100.00%
2006	50.00%	50.00%	90.45%	2.21%	7.35%	97.21%	2.72%	0.06%	100.00%	100.00%	100.00%
2007	50.00%	50.00%	85.65%	0.30%	14.05%	96.06%	3.73%	0.21%	100.00%	100.00%	100.00%
2008	50.00%	50.00%	77.72%	2.70%	19.58%	94.28%	4.88%	0.83%	100.00%	100.00%	100.00%
2009	50.00%	50.00%	73.10%	2.55%	24.35%	92.60%	5.54%	1.87%	100.00%	100.00%	100.00%
2010	50.00%	50.00%	65.68%	2.20%	32.11%	90.54%	6.51%	2.95%	100.00%	100.00%	100.00%
2011	50.00%	50.00%	66.43%	1.58%	31.99%	85.61%	9.49%	4.90%	100.00%	100.00%	100.00%
2012	50.00%	50.00%	64.43%	1.58%	33.99%	83.61%	9.49%	6.90%	100.00%	100.00%	100.00%
2013	50.00%	50.00%	62.43%	1.58%	35.99%	81.61%	9.49%	8.90%	100.00%	100.00%	100.00%
2014	50.00%	50.00%	60.43%	1.58%	37.99%	79.61%	9.49%	10.90%	100.00%	100.00%	100.00%
2015	50.00%	50.00%	58.43%	1.58%	39.99%	77.61%	9.49%	12.90%	100.00%	100.00%	100.00%
2016	50.00%	50.00%	56.43%	1.58%	41.99%	75.61%	9.49%	14.90%	100.00%	100.00%	100.00%
2017	50.00%	50.00%	54.43%	1.58%	43.99%	73.61%	9.49%	16.90%	100.00%	100.00%	100.00%
2018	50.00%	50.00%	52.43%	1.58%	45.99%	71.61%	9.49%	18.90%	100.00%	100.00%	100.00%
2019	50.00%	50.00%	50.43%	1.58%	47.99%	69.61%	9.49%	20.90%	100.00%	100.00%	100.00%
2020	50.00%	50.00%	48.43%	1.58%	49.99%	67.61%	9.49%	22.90%	100.00%	100.00%	100.00%
2021	50.00%	50.00%	46.43%	1.58%	51.99%	65.61%	9.49%	24.90%	100.00%	100.00%	100.00%
2022	50.00%	50.00%	44.43%	1.58%	53.99%	63.61%	9.49%	26.90%	100.00%	100.00%	100.00%

Source: Environment Agency

3.2.5.4.2.2 Methodology

The EMEP/EEA Tier 2 approach has been applied for all fuels and all air pollutants.

3.2.5.4.2.3 Emission factors

Tier 2 default emissions factors from the EMEP/EEA Guidebook 2019 have been applied for the main air pollutants.

For the main air pollutants (NO_X, SO_2, NMVOC, NH_3, CO, TSP, PM_{10}, $PM_{2.5}$), the Tier 2 default emission factors for conventional radiating stoves burning coal, for conventional under-fire boilers (<50kW) burning coal, for small (single household scale, capacity <=50 kWth) boilers burning natural gas, for small (single household scale, capacity <=50 kWth) boilers burning gasoil, for closed fireplaces, conventional traditional stoves and domestic cooking burning wood (log wood), for advanced combustion stoves, catalytic combustor stoves and advanced combustion boilers burning wood (wood chips) and for modern pellet stoves, automatic wood boilers burning wood (pellets), from the EMEP/EEA Guidebook 2019 (Chapter 1A4 Small Combustion, Tables 3.14, 3.15, 3.16, 3.18, 3.40, 3.42, 3.44, respectively), have been applied.

For NO_X emissions, fuel combustion activity data was split according to specific combustion technology and Tier 2 emission factors were taken from the following sources:

- conventional boilers: small (single household scale, capacity <=50 kWth) boilers burning natural gas: EMEP/EEA Guidebook 2019 (Chapter 1A4 Small Combustion, Tables 3.16) ; small (single household scale, capacity <=50 kWth) boilers burning gasoil: EMEP/EEA Guidebook 2019 (Chapter 1A4 Small Combustion, Tables 3.18)
- new conventional boilers burning natural gas or gasoil: 36 g NO_X/GJ for natural gas, 44 g NO_X/GJ for gasoil. NO_X emission factors were taken from a national study[56] with reference to a German study[57]
- condensing boilers: 16 g NO_X/GJ for natural gas, 20 g NO_X/GJ for gasoil; no default emission factor for this technology and for neither natural gas, nor gasoil is available in the EMEP/EEA Guidebook 2019. The NO_x emission factor for natural gas and gasoil was derived from the Austrian emission inventory (AT IIR 2016, Table 114, p.168).

LPG was assumed to be equal to natural gas such that Tier 2 default emission factors from the EMEP/EEA Guidebook 2019 (Chapter 1A4 Small Combustion, Tables 3.16) have been applied.

The methods applied and emission factors (EF) used as well as coverage of energy consumption for 2021 are presented in Table 3-164.

Table 3-164 – Methods and Emission Factors used in relation to the energy consumption in 2022 for category *1A4b i – Residential: Stationary*

1 A 4 Other Sectors *Method applied and Emission factor (EF) used as well as coverage of energy consumption* 1 A 4 b i Residential: Stationary				
Pollutant	**Method**	**EF used**	**Coverage of energy consumption**	**Source**
NOx	T2	D, CS	100.0%	EMEP/EEA GB 2019 (Chap 1A4, Tables 3-14 & 3-15) ; EMEP/EEA GB 2019 (Chap 1A4, Tables 3-40, 3-42, 3-44) ; EMEP/EEA GB 2019 (Chap 1A4, Table 3-16) ; CRTE (German Study: UBA 2008) ; IIR AT 2016, table 114, p168 ; EMEP/EEA GB 2019 (Chap 1A4, Table 3-18)
	T1	D	0.0%	
NMVOC **CO** **TSP** **PM10** **PM2.5**	T2	D	100.0%	EMEP/EEA GB 2019 (Chap 1A4, Tables 3-14 & 3-15) ; EMEP/EEA GB 2019 (Chap 1A4, Tables 3-40, 3-42, 3-44) ; EMEP/EEA GB 2019 (Chap 1A4, Table 3-16) ; EMEP/EEA GB 2019 (Chap 1A4, Table 3-18)
	T1	D	0.0%	
SOx	T2	CS	34.3%	CS based on maximum allowed suphur content
	T2	D	65.7%	EMEP/EEA GB 2019 (Chap 1A4, Tables 3-14 & 3-15) ; EMEP/EEA GB 2019 (Chap 1A4, Tables 3-40, 3-42, 3-44) ; EMEP/EEA GB 2019 (Chap 1A4, Table 3-16)
	T1	D	0.0%	

Source: Environment Agency

Table 3-165 gives an overview of the evolution of the implied emission factors.

[57] Effiziente Bereitstellung aktueller Emissionsdaten für die Luftreinhaltung, Umweltbundesamt, Germany, 2008 (UBA-FB-001217)

Table 3-165 – Implied emission factors for category *1A4b i - Residential*

Year	1 A 4 Other Sectors — Implied Emission Factor (IEF) of air pollutants by source category (g/GJ) — 1 A 4 b i Residential: Stationary							
	SO2	*NOx*	*NMVOC*	*NH3*	*CO*	*TSP*	*PM10*	*PM2.5*
1990	80.62	60.91	48.76	0.51	390.61	61.51	57.85	56.27
1991	83.00	61.61	42.70	0.43	349.23	53.58	50.33	48.95
1992	77.47	60.62	43.90	0.46	349.57	55.53	52.26	50.84
1993	77.14	60.23	44.74	0.46	359.32	56.35	53.00	51.55
1994	70.22	59.56	43.28	0.48	332.10	55.42	52.29	50.89
1995	70.51	59.13	43.86	0.47	342.96	55.71	52.50	51.08
1996	62.10	58.15	37.18	0.43	278.81	47.91	45.30	44.09
1997	63.49	58.65	38.00	0.44	282.96	49.14	46.48	45.25
1998	59.92	58.15	35.36	0.42	258.00	46.02	43.59	42.45
1999	56.83	57.17	38.56	0.46	279.96	50.16	47.52	46.27
2000	56.22	57.43	25.19	0.31	182.30	32.89	31.20	30.39
2001	54.95	57.12	24.65	0.30	176.45	32.29	30.65	29.86
2002	52.79	56.45	23.75	0.29	169.44	31.08	29.52	28.76
2003	51.19	55.98	23.08	0.29	163.38	30.24	28.74	28.00
2004	50.39	55.57	22.44	0.28	158.86	29.44	27.98	27.26
2005	49.52	54.97	22.16	0.28	157.47	29.00	27.55	26.85
2006	51.84	55.55	22.22	0.28	157.29	29.22	27.77	27.06
2007	51.01	54.42	20.72	0.26	146.80	27.19	25.85	25.19
2008	25.43	52.93	21.86	0.27	154.20	28.68	27.26	26.56
2009	25.49	52.05	24.62	0.31	172.74	32.33	30.72	29.93
2010	21.48	48.39	25.36	0.32	178.74	33.05	31.40	30.59
2011	18.73	47.37	21.63	0.27	154.05	28.06	26.67	25.98
2012	21.66	48.04	26.19	0.33	183.49	34.34	32.64	31.80
2013	20.51	46.56	28.61	0.36	200.92	37.43	35.56	34.64
2014	18.63	45.09	34.02	0.43	236.74	44.61	42.38	41.28
2015	19.25	45.24	23.95	0.31	173.67	31.35	29.80	29.06
2016	2.41	44.07	27.49	0.36	196.41	36.24	34.45	33.58
2017	1.79	41.77	22.53	0.29	162.86	29.62	28.17	27.47
2018	1.58	41.35	26.44	0.35	188.22	35.02	33.30	32.47
2019	1.37	39.15	16.09	0.21	120.20	20.86	19.84	19.36
2020	1.37	39.27	10.79	0.14	85.96	14.16	13.49	13.18
2021	1.64	39.36	5.69	0.09	55.14	8.15	7.79	7.66
2022	2.30	39.48	16.70	0.23	129.75	22.40	21.31	20.82
Trend 1990-2022	*-97.15%*	*-35.18%*	*-65.76%*	*-54.29%*	*-66.78%*	*-63.59%*	*-63.16%*	*-63.01%*
2005-2022	*-95.36%*	*-28.17%*	*-24.68%*	*-16.19%*	*-17.60%*	*-22.77%*	*-22.66%*	*-22.46%*
2021-2022	*40.04%*	*0.31%*	*193.45%*	*169.79%*	*135.30%*	*174.73%*	*173.50%*	*171.93%*

Source: Environment Agency

3.2.5.4.3 Methodological issues for heavy metals and POPs

3.2.5.4.3.1 Methodological Choices

Tier 2 approach based on fuels used, percentage of different installed heating systems, and the appropriate tier 2 emission factors.

Fuel consumption data were obtained from the national energy balance.

3.2.5.4.3.2 Emission Factors

Tier 2 emission factors:

Fuel	Pollutants	Source	Page	Table
Solid fuels (without biomass)	Pb, Hg, Cd, PCDD/F, PCB, HCB, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2023) – Chapter 1.A.4 Small combustion	45	3.14
Liquid fuels	Pb, Hg, Cd, PCDD/F, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2023) – Chapter 1.A.4 Small combustion	49	3.18
Natural gas	Pb, Hg, Cd, PCDD/F, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2023) – Chapter 1.A.4 Small combustion	47	3.16
Wood	Pb, Hg, Cd, PCDD/F, PCB, HCB, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2023) – Chapter 1.A.4 Small combustion	79	3.40

3.2.5.5 Residential: Household and gardening (mobile) (1A4b ii)

3.2.5.5.1 Source category description

This source category covers numerous mobile fuel combustion units in non-commercial mobile machinery such as for gardening, and other off-road vehicles. Table 3-166 summarizes the annual emissions of air pollutants for category *1A4b ii Residential (mobile)*.

In 2022, emissions are generally very low and only represent less than 1% of the national total emissions, except for CO (5.6%/6.7% on national total CO emissions for fuel sold/fuel used). Compared to 1990, emissions generally decreased by between 96% (SO_2) and 20% (CO) except for NO_X, for which emissions increased by 65%.

Table 3-166 – Emissions, Trends and Shares based on fuel sold and fuel used for category *1A4b ii – Residential (mobile)*

1 A 4 b *ii* Other Sectors - Household and Gardening (mobile)														
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
SO2	0.0003	0.0000	0.0000	0.0000	-96%	-12%	0.21%	0.002%	0.001%	0.003%	0.002%	0.001%	0.003%	fuel sold
NOx	0.0052	0.0078	0.0086	0.0086	65%	11%	0.21%	0.024%	0.044%	0.094%	0.013%	0.014%	0.075%	fuel sold
NMVOC	0.2584	0.1701	0.0720	0.0722	-72%	-58%	0.21%	1.195%	1.400%	0.742%	0.832%	1.153%	0.721%	fuel sold
NH3	0.0000	0.0000	0.0000	0.0000	-26%	-21%	0.21%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	fuel sold
CO	1.2442	1.0117	0.9885	0.9906	-20%	-2%	0.21%	0.295%	4.565%	6.726%	0.265%	2.545%	5.553%	fuel sold
TSP	0.0005	0.0004	0.0004	0.0004	-22%	6%	0.21%	0.003%	0.016%	0.018%	0.003%	0.009%	0.015%	fuel sold
PM10	0.0005	0.0004	0.0004	0.0004	-22%	6%	0.21%	0.003%	0.020%	0.027%	0.003%	0.011%	0.022%	fuel sold
PM2.5	0.0005	0.0004	0.0004	0.0004	-22%	6%	0.21%	0.003%	0.026%	0.043%	0.003%	0.014%	0.036%	fuel sold

Source: Environment Agency

Emission trends for the main air pollutants are given in Table 3-167.

Table 3-167 – Emission trends for category *1A4b ii – Residential: Household and gardening (mobile)*

	1 A 4 Other Sectors							
	Emissions of air pollutants by source category (Gg)							
Year	**1 A 4 b ii Residential: Household and gardening (mobile)**							
	SO2	***NOx***	***NMVOC***	***NH3***	***CO***	***TSP***	***PM10***	***PM2.5***
1990	0.00031	0.00524	0.25843	0.00000	1.24424	0.00048	0.00048	0.00048
1991	0.00031	0.00527	0.25937	0.00000	1.24785	0.00048	0.00048	0.00048
1992	0.00031	0.00530	0.26076	0.00000	1.25420	0.00048	0.00048	0.00048
1993	0.00031	0.00532	0.26144	0.00000	1.25730	0.00049	0.00049	0.00049
1994	0.00028	0.00544	0.25679	0.00000	1.24269	0.00048	0.00048	0.00048
1995	0.00024	0.00565	0.24764	0.00000	1.21297	0.00046	0.00046	0.00046
1996	0.00021	0.00586	0.23844	0.00000	1.18303	0.00044	0.00044	0.00044
1997	0.00018	0.00607	0.22910	0.00000	1.15256	0.00042	0.00042	0.00042
1998	0.00015	0.00629	0.21965	0.00000	1.12166	0.00040	0.00040	0.00040
1999	0.00012	0.00655	0.21201	0.00000	1.09988	0.00039	0.00039	0.00039
2000	0.00009	0.00678	0.20538	0.00000	1.08123	0.00037	0.00037	0.00037
2001	0.00006	0.00698	0.20049	0.00000	1.06835	0.00036	0.00036	0.00036
2002	0.00004	0.00721	0.19682	0.00000	1.05236	0.00035	0.00035	0.00035
2003	0.00004	0.00746	0.19531	0.00000	1.03752	0.00035	0.00035	0.00035
2004	0.00002	0.00766	0.18637	0.00000	1.02615	0.00036	0.00036	0.00036
2005	0.00001	0.00780	0.17007	0.00000	1.01167	0.00036	0.00036	0.00036
2006	0.00001	0.00796	0.15423	0.00000	1.00025	0.00036	0.00036	0.00036
2007	0.00001	0.00809	0.13786	0.00000	0.98815	0.00036	0.00036	0.00036
2008	0.00001	0.00822	0.12154	0.00000	0.97775	0.00036	0.00036	0.00036
2009	0.00001	0.00832	0.10619	0.00000	0.97082	0.00036	0.00036	0.00036
2010	0.00001	0.00841	0.09302	0.00000	0.96725	0.00037	0.00037	0.00037
2011	0.00001	0.00849	0.08318	0.00000	0.97367	0.00037	0.00037	0.00037
2012	0.00001	0.00854	0.07620	0.00000	0.97936	0.00037	0.00037	0.00037
2013	0.00001	0.00860	0.07375	0.00000	0.98537	0.00037	0.00037	0.00037
2014	0.00001	0.00872	0.07366	0.00000	1.00010	0.00038	0.00038	0.00038
2015	0.00001	0.00878	0.07360	0.00000	1.00598	0.00038	0.00038	0.00038
2016	0.00001	0.00875	0.07317	0.00000	1.00253	0.00038	0.00038	0.00038
2017	0.00001	0.00869	0.07265	0.00000	0.99644	0.00038	0.00038	0.00038
2018	0.00001	0.00866	0.07239	0.00000	0.99322	0.00038	0.00038	0.00038
2019	0.00001	0.00866	0.07231	0.00000	0.99222	0.00038	0.00038	0.00038
2020	0.00001	0.00864	0.07214	0.00000	0.98987	0.00038	0.00038	0.00038
2021	0.00001	0.00862	0.07203	0.00000	0.98850	0.00038	0.00038	0.00038
2022	0.00001	0.00864	0.07219	0.00000	0.99058	0.00038	0.00038	0.00038
Trend 1990-2022	*-95.95%*	*64.86%*	*-72.07%*	*-26.22%*	*-20.39%*	*-21.81%*	*-21.81%*	*-21.81%*
2005-2022	*-11.93%*	*10.78%*	*-57.55%*	*-21.38%*	*-2.08%*	*5.55%*	*5.55%*	*5.55%*
2021-2022	*0.21%*	*0.21%*	*0.21%*	*0.21%*	*0.21%*	*0.21%*	*0.21%*	*0.21%*

Source: Environment Agency

1A4b ii–Residential: Household and gardening (mobile) is a key category for CO (LA & TA) in 2022 (see Table 3-151 in section 3.2.5.4 and Table 3-4 in Section 3.2 and Chapter 1.5).

With regard to heavy metals and persistent organic pollutant emissions*, 1A4b ii–Residential: Household and gardening (mobile)* has not been identified as a key category (see Table 3-152 and also Table 3-5 in Section 3.2 and Chapter 1.5).

3.2.5.5.2 Methodological issues

Emissions are reported for the entire time series and were estimated using the GEORG model which conforms to the requirements of a Tier 3 methodology. The methodology is described in section 3.2.3.8.2 Other Stationary Combustion (1A2g viii). As no reliable activity data on fuel combustion from mobile sources was obtained from the national statistics institute, the machinery stock was estimated using Austrian data in relation to Luxembourg's population. Hence, an average of 0.57 garden machinery per household was estimated to be in operation. Fuel consumption activity data used for estimating air pollutant emissions are given in Table 3-168.

Table 3-168 – Activity data for category *1A4b ii – Residential: Household and gardening (mobile)*

1 A 4 Other Sectors						
Activity Data by fuel type (GJ)						
1 A 4 b ii Residential: Household and gardening (mobile)						
Year	**Activity Total (incl. biomass)**	**Liquid** *Gasoline*	**Solid**	**Gaseous**	**Biomass**	**Other**
1990	65 387	65'387	NA	NA	NO	NA
1991	65 628	65'628	NA	NA	NO	NA
1992	65 981	65'981	NA	NA	NO	NA
1993	66 152	66'152	NA	NA	NO	NA
1994	66 017	66'017	NA	NA	NO	NA
1995	65 618	65'618	NA	NA	NO	NA
1996	65 207	65'207	NA	NA	NO	NA
1997	64 779	64'779	NA	NA	NO	NA
1998	64 338	64'338	NA	NA	NO	NA
1999	64 409	64'409	NA	NA	NO	NA
2000	64 504	64'504	NA	NA	NO	NA
2001	64 692	64'692	NA	NA	NO	NA
2002	64 603	64'603	NA	NA	NO	NA
2003	64 344	64'344	NA	NA	NO	NA
2004	63 620	63'620	NA	NA	IE	NA
2005	62 213	62'213	NA	NA	IE	NA
2006	60 964	60'964	NA	NA	IE	NA
2007	59 407	59'407	NA	NA	IE	NA
2008	57 939	57'939	NA	NA	IE	NA
2009	56 644	56'644	NA	NA	IE	NA
2010	55 583	55'583	NA	NA	IE	NA
2011	54 661	54'661	NA	NA	IE	NA
2012	54 797	54'797	NA	NA	IE	NA
2013	54 844	54'844	NA	NA	IE	NA
2014	55 194	55'194	NA	NA	IE	NA
2015	54 924	54'924	NA	NA	IE	NA
2016	54 483	54'483	NA	NA	IE	NA
2017	54 403	54'403	NA	NA	IE	NA
2018	53 972	53'972	NA	NA	IE	NA
2019	53 345	53'345	NA	NA	IE	NA
2020	53 119	53'119	NA	NA	IE	NA
2021	52 959	52'959	NA	NA	IE	NA
2022	52 910	52'910	NA	NA	IE	NA
Trend 1990-2022	*-19.08%*	*-19.08%*	*NA*	*NA*	*NA*	*NA*
2005-2022	*-14.95%*	*-14.95%*	*NA*	*NA*	*NA*	*NA*
2021-2022	*-0.09%*	*-0.09%*	*NA*	*NA*	*NA*	*NA*

Source: Environment Agency

Default air pollutant emission factors from the GEORG model have been applied. For the $PM_{2.5}$ and PM_{10} emission factors, the condensable component is included. Implied emission factors are given in Table 3-169.

Table 3-169 – Implied emission factors for category *1A4b ii – Residential: Household and gardening (mobile)*

1 A 4 Other Sectors *Implied Emission Factor (IEF) of air pollutants by source category (g/GJ)*								
Year	**1 A 4 b ii Residential: Household and gardening (mobile)**							
	SO2	***NOx***	***NMVOC***	***NH3***	***CO***	***TSP***	***PM10***	***PM2.5***
1990	4.71	80.17	3952.25	0.07	19028.72	7.36	7.36	7.36
1991	4.71	80.31	3952.14	0.07	19014.00	7.35	7.35	7.35
1992	4.71	80.37	3952.10	0.07	19008.45	7.35	7.35	7.35
1993	4.71	80.39	3952.08	0.07	19006.37	7.35	7.35	7.35
1994	4.18	82.40	3889.83	0.07	18823.83	7.22	7.22	7.22
1995	3.72	86.13	3774.01	0.07	18485.34	6.98	6.98	6.98
1996	3.25	89.90	3656.76	0.07	18142.86	6.74	6.74	6.74
1997	2.79	93.76	3536.72	0.07	17792.31	6.49	6.49	6.49
1998	2.32	97.70	3413.99	0.06	17433.93	6.23	6.23	6.23
1999	1.86	101.64	3291.56	0.06	17076.43	5.98	5.98	5.98
2000	1.39	105.10	3183.90	0.06	16762.08	5.76	5.76	5.76
2001	0.87	107.82	3099.14	0.06	16514.58	5.58	5.58	5.58
2002	0.69	111.63	3046.59	0.06	16289.82	5.49	5.49	5.49
2003	0.59	115.92	3035.38	0.06	16124.71	5.51	5.51	5.51
2004	0.31	120.41	2929.49	0.06	16129.39	5.59	5.59	5.59
2005	0.23	125.38	2733.60	0.07	16261.29	5.73	5.73	5.73
2006	0.23	130.49	2529.80	0.07	16407.37	5.88	5.88	5.88
2007	0.23	136.24	2320.59	0.07	16633.51	6.06	6.06	6.06
2008	0.23	141.82	2097.77	0.07	16875.46	6.25	6.25	6.25
2009	0.23	146.95	1874.77	0.07	17139.10	6.42	6.42	6.42
2010	0.23	151.23	1673.47	0.07	17401.99	6.58	6.58	6.58
2011	0.23	155.33	1521.81	0.07	17812.75	6.76	6.76	6.76
2012	0.23	155.89	1390.60	0.06	17872.49	6.79	6.79	6.79
2013	0.23	156.73	1344.64	0.06	17966.85	6.83	6.83	6.83
2014	0.23	158.07	1334.56	0.06	18119.88	6.89	6.89	6.89
2015	0.23	159.78	1340.08	0.06	18315.96	6.96	6.96	6.96
2016	0.23	160.53	1342.92	0.06	18400.77	6.99	6.99	6.99
2017	0.23	159.78	1335.46	0.06	18315.84	6.96	6.96	6.96
2018	0.23	160.54	1341.30	0.06	18402.48	6.99	6.99	6.99
2019	0.23	162.26	1355.51	0.06	18599.93	7.07	7.07	7.07
2020	0.23	162.57	1358.00	0.06	18635.05	7.08	7.08	7.08
2021	0.24	162.83	1360.19	0.06	18665.47	7.09	7.09	7.09
2022	0.24	163.33	1364.31	0.06	18722.13	7.12	7.12	7.12
Trend								
1990-2022	*-95.00%*	*103.74%*	*-65.48%*	*-8.82%*	*-1.61%*	*-3.37%*	*-3.37%*	*-3.37%*
2005-2022	*3.55%*	*30.26%*	*-50.09%*	*-7.55%*	*15.13%*	*24.11%*	*24.11%*	*24.11%*
2021-2022	*0.30%*	*0.30%*	*0.30%*	*0.30%*	*0.30%*	*0.30%*	*0.30%*	*0.30%*

Source: Environment Agency

The methods applied and emission factors (EF) used as well as coverage of energy consumption for 2022 are presented in Table 3-170.

Table 3-170 – Methods and Emission Factors used in relation to the energy consumption in 2022 for category *1A4b ii – Residential: Household and gardening (mobile)*

1 A 4 Other Sectors *Method applied and Emission factor (EF) used as well as coverage of energy consumption* 1 A 4 b ii Residential: Household and gardening (mobile)				
Pollutant	**Method**	**EF used**	**Coverage of energy consumption**	**Source**
NOx NMVOC CO TSP PM10 PM2.5	T3	CS	100.0%	GEORG model
	T1	D	0.0%	EMEP/EEA Guidebook
SOx	T3	CS	100.0%	GEORG using national fuel sulfur contents
	T1	D	0.0%	EMEP/EEA GB

Source: Environment Agency

3.2.5.5.3 Methodological issues for heavy metals and POPs

Emission values for HM and POPs emissions from mobile combustion in household and gardening were calculated using the same methodology and models as for the main pollutants.

3.2.5.6 Agriculture/Forestry/Fishing (1A4c)

3.2.5.6.1 Source category description

This source category includes non-industrial combustion plants in agriculture, forestry and aquaculture as well as tractors and harvesters used in agriculture.

1A4c - Agriculture/Forestry/Fishing covers combustion activities from stationary combustion and mobile combustion in sub-categories:

- *1A4c i – Agriculture/Forestry/Fishing – stationary*
- *1A4c ii – Agriculture/Forestry/Fishing – Off-road vehicles and other machinery*

In 2022, fuel combustion activities from category *1 A 4 c i Other Sectors – Agriculture / Forestry / Fishing – stationary* were responsible for less than 1% of the emissions for each of the main air pollutants.

In 2022, fuel combustion activities from category *1 A 4 c ii Other Sectors – Agriculture / Forestry / Fishing – Off-road vehicles and other machinery*, were responsible for less than 1% of the emissions for each of the main air pollutants, apart for NO_X where this category was responsable for 1.3%, and 1.7% respectively, of total NO_X emissions (based on fuel sold, and fuel used respectively).

In 2022, neither category *1A4c ii Agriculture/Forestry/Fishing – Off-road vehicles and other machinery* nor category *1A4c i – Agriculture/Forestry/Fishing – stationary* were a key category (see Table 3-4 (main pollutants) and Table 3-5 (heavy metals and POPs) in Section 3.2 and Chapter 1.5).

Table 3-171 summarizes emissions of air pollutants for category *1A4c - Agriculture/Forestry/Fishing* while Table 3-172 and Table 3-173 present the emission trends for categories *1A4c i* and *1A4c ii*, respectively.

Table 3-171 – Emissions, Trends and Shares based on fuel sold and fuel used in category *1A4c – Agriculture/Forestry/Fishing*

1 A 4 c *i* Other Sectors - Agriculture/Forestry/Fishing – stationary

NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
SO2	0.010	0.000	0.000	0.000	-99%	-25%	468%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	fuel sold
NOx	0.011	0.009	0.001	0.007	-35%	-25%	468%	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%	fuel sold
NMVOC	0.002	0.000	0.000	0.000	-98%	-25%	468%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
NH3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
CO	0.004	0.003	0.000	0.002	-46%	-25%	468%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
TSP	0.000	0.000	0.000	0.000	-87%	-25%	468%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
PM10	0.000	0.000	0.000	0.000	-87%	-25%	468%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
PM2.5	0.000	0.000	0.000	0.000	-87%	-25%	468%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold

1 A 4 c *ii* Other Sectors - Agriculture/Forestry/Fishing – Off-road vehicles and other machinery

NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
SO2	0.021	0.000	0.000	0.000	-99%	-20%	3%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	fuel sold
NOx	0.328	0.269	0.157	0.153	-53%	-43%	-2%	1.5%	1.5%	1.7%	0.8%	0.5%	1.3%	fuel sold
NMVOC	0.102	0.071	0.040	0.040	-61%	-44%	-2%	0.5%	0.6%	0.4%	0.3%	0.5%	0.4%	fuel sold
NH3	0.000	0.000	0.000	0.000	-57%	-43%	1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
CO	0.445	0.290	0.135	0.133	-70%	-54%	-2%	0.1%	1.3%	0.9%	0.1%	0.7%	0.7%	fuel sold
TSP	0.071	0.039	0.009	0.009	-87%	-76%	-3%	0.4%	1.7%	0.4%	0.4%	1.0%	0.4%	fuel sold
PM10	0.071	0.039	0.009	0.009	-87%	-76%	-3%	0.4%	2.2%	0.7%	0.4%	1.2%	0.5%	fuel sold
PM2.5	0.071	0.039	0.009	0.009	-87%	-76%	-3%	0.5%	2.9%	1.0%	0.4%	1.5%	0.9%	fuel sold

Source: Environment Agency

Table 3-172 – Emission trends for category *1A4c i – Agriculture/Forestry/Fishing – stationary*

Year	SO2	NOx	NMVOC	NH3	CO	TSP	PM10	PM2.5
	1 A 4 Other Sectors *Emissions of air pollutants by source category (Gg)* 1 A 4 c i Agriculture/Forestry/Fishing: Stationary							
1990	0.010	0.011	0.002	NO	0.004	0.00032	0.00032	0.00032
1991	0.012	0.013	0.002	NO	0.005	0.00038	0.00038	0.00038
1992	0.012	0.013	0.002	NO	0.005	0.00038	0.00038	0.00038
1993	0.010	0.011	0.002	NO	0.004	0.00032	0.00032	0.00032
1994	0.012	0.013	0.002	NO	0.005	0.00038	0.00038	0.00038
1995	0.010	0.011	0.002	NO	0.004	0.00032	0.00032	0.00032
1996	0.012	0.013	0.002	NO	0.005	0.00038	0.00038	0.00038
1997	0.014	0.015	0.002	NO	0.006	0.00045	0.00045	0.00045
1998	0.014	0.015	0.002	NO	0.006	0.00045	0.00045	0.00045
1999	0.036	0.038	0.006	NO	0.015	0.00115	0.00115	0.00115
2000	0.000	0.001	0.000	NO	0.000	0.00000	0.00000	0.00000
2001	0.000	0.002	0.000	NO	0.001	0.00001	0.00001	0.00001
2002	0.000	0.002	0.000	NO	0.001	0.00001	0.00001	0.00001
2003	0.000	0.004	0.000	NO	0.001	0.00003	0.00003	0.00003
2004	0.000	0.006	0.000	NO	0.002	0.00004	0.00004	0.00004
2005	0.000	0.009	0.000	NO	0.003	0.00006	0.00006	0.00006
2006	0.000	0.011	0.000	NO	0.004	0.00007	0.00007	0.00007
2007	0.000	0.013	0.000	NO	0.004	0.00008	0.00008	0.00008
2008	0.000	0.016	0.000	NO	0.005	0.00010	0.00010	0.00010
2009	0.000	0.019	0.000	NO	0.006	0.00012	0.00012	0.00012
2010	0.000	0.015	0.000	NO	0.005	0.00009	0.00009	0.00009
2011	0.000	0.014	0.000	NO	0.005	0.00008	0.00008	0.00008
2012	0.000	0.014	0.000	NO	0.005	0.00009	0.00009	0.00009
2013	0.000	0.012	0.000	NO	0.004	0.00008	0.00008	0.00008
2014	0.000	0.009	0.000	NO	0.003	0.00005	0.00005	0.00005
2015	0.000	0.009	0.000	NO	0.003	0.00005	0.00005	0.00005
2016	0.000	0.011	0.000	NO	0.004	0.00007	0.00007	0.00007
2017	0.000	0.012	0.000	NO	0.004	0.00007	0.00007	0.00007
2018	0.000	0.011	0.000	NO	0.004	0.00007	0.00007	0.00007
2019	0.000	0.008	0.000	NO	0.003	0.00005	0.00005	0.00005
2020	0.000	0.005	0.000	NO	0.002	0.00003	0.00003	0.00003
2021	0.000	0.001	0.000	NO	0.000	0.00001	0.00001	0.00001
2022	0.000	0.007	0.000	NO	0.002	0.00004	0.00004	0.00004
Trend 1990-2022	*-98.67%*	*-34.61%*	*-97.85%*	*NA*	*-46.25%*	*-86.56%*	*-86.56%*	*-86.56%*
2005-2022	*-25.47%*	*-25.47%*	*-25.47%*	*NA*	*-25.47%*	*-25.47%*	*-25.47%*	*-25.47%*
2021-2022	*467.57%*	*467.57%*	*467.57%*	*NA*	*467.57%*	*467.57%*	*467.57%*	*467.57%*

Source: Environment Agency

Table 3-173 – Emission trends for category *1A4c ii – Agriculture/Forestry/Fishing – Off-road vehicles and other machinery*

	1 A 4 Other Sectors							
	Emissions of air pollutants by source category (Gg)							
Year	**1 A 4 c ii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery**							
	SO2	***NOx***	***NMVOC***	***NH3***	***CO***	***TSP***	***PM10***	***PM2.5***
1990	0.021	0.328	0.102	0.000	0.445	0.071	0.071	0.071
1991	0.020	0.320	0.100	0.000	0.436	0.069	0.069	0.069
1992	0.019	0.301	0.097	0.000	0.416	0.064	0.064	0.064
1993	0.019	0.295	0.095	0.000	0.409	0.062	0.062	0.062
1994	0.019	0.305	0.096	0.000	0.413	0.063	0.063	0.063
1995	0.016	0.303	0.094	0.000	0.404	0.061	0.061	0.061
1996	0.006	0.304	0.092	0.000	0.397	0.059	0.059	0.059
1997	0.006	0.303	0.090	0.000	0.388	0.057	0.057	0.057
1998	0.005	0.312	0.089	0.000	0.388	0.057	0.057	0.057
1999	0.005	0.311	0.087	0.000	0.379	0.056	0.056	0.056
2000	0.005	0.317	0.086	0.000	0.377	0.055	0.055	0.055
2001	0.004	0.280	0.079	0.000	0.340	0.048	0.048	0.048
2002	0.003	0.293	0.079	0.000	0.341	0.049	0.049	0.049
2003	0.003	0.285	0.076	0.000	0.323	0.046	0.046	0.046
2004	0.000	0.287	0.075	0.000	0.314	0.044	0.044	0.044
2005	0.000	0.269	0.071	0.000	0.290	0.039	0.039	0.039
2006	0.000	0.264	0.070	0.000	0.278	0.036	0.036	0.036
2007	0.000	0.253	0.067	0.000	0.262	0.033	0.033	0.033
2008	0.000	0.271	0.067	0.000	0.266	0.034	0.034	0.034
2009	0.000	0.268	0.065	0.000	0.255	0.032	0.032	0.032
2010	0.000	0.266	0.063	0.000	0.241	0.029	0.029	0.029
2011	0.000	0.250	0.059	0.000	0.222	0.025	0.025	0.025
2012	0.000	0.249	0.057	0.000	0.213	0.023	0.023	0.023
2013	0.000	0.210	0.052	0.000	0.187	0.019	0.019	0.019
2014	0.000	0.210	0.051	0.000	0.182	0.018	0.018	0.018
2015	0.000	0.205	0.049	0.000	0.173	0.016	0.016	0.016
2016	0.000	0.195	0.047	0.000	0.163	0.014	0.014	0.014
2017	0.000	0.189	0.046	0.000	0.157	0.013	0.013	0.013
2018	0.000	0.189	0.045	0.000	0.154	0.013	0.013	0.013
2019	0.000	0.176	0.043	0.000	0.146	0.011	0.011	0.011
2020	0.000	0.170	0.042	0.000	0.141	0.011	0.011	0.011
2021	0.000	0.157	0.040	0.000	0.135	0.009	0.009	0.009
2022	0.000	0.153	0.040	0.000	0.133	0.009	0.009	0.009
Trend 1990-2022	*-99.26%*	*-53.28%*	*-61.03%*	*-57.29%*	*-70.20%*	*-87.16%*	*-87.16%*	*-87.16%*
2005-2022	*-19.64%*	*-42.90%*	*-44.17%*	*-42.58%*	*-54.22%*	*-76.40%*	*-76.40%*	*-76.40%*
2021-2022	*3.22%*	*-2.16%*	*-1.68%*	*1.17%*	*-1.63%*	*-3.46%*	*-3.46%*	*-3.46%*

Source: Environment Agency

3.2.5.6.2 Methodological issues & time-series consistency

3.2.5.6.2.1 Activity data

Under *1A4c – Agriculture/Forestry/Fishing*, the following combustion activities have been considered:

Non-industrial combustion plants in agriculture, forestry and aquaculture

The fuel consumption data of this activity is derived from the national energy balance as prepared by the national statistics institute. The consumption of gas oil is reported from 1990 to 1999. Natural gas is reported from 2000 onwards, but its consumption is very small (not exceeding 1400 GJ per year), and Biogas consumption is reported from 1998 onwards. Indeed, some of the farms have installed anaerobic digesters, and the produced biogas is combusted for heat and/or electricity production.

Activity data for stationary combustion sources are listed in Table 3-174.

Table 3-174 – Activity data for category *1A4c i – Agriculture/Forestry/Fishing – stationary*

1 A 4 Other Sectors						
Activity Data by fuel type (GJ)						
1 A 4 c i Agriculture/Forestry/Fishing: Stationary						
Year	Activity Total (incl. biomass)	Liquid *Gasoil*	Solid	Gaseous *Natural gas*	Biomass *Biogas*	Other
1990	106 529	106'529	NA	NO	NO	NA
1991	127 683	127'683	NA	NO	NO	NA
1992	127 432	127'432	NA	NO	NO	NA
1993	106 233	106'233	NA	NO	NO	NA
1994	127 463	127'463	NA	NO	NO	NA
1995	106 232	106'232	NA	NO	NO	NA
1996	127 158	127'158	NA	NO	NO	NA
1997	148 755	148'755	NA	NO	NO	NA
1998	149 736	148'736	NA	NO	1 000	NA
1999	385 614	382'614	NA	NO	3 000	NA
2000	9 387	NO	NA	1'045	8 342	NA
2001	22 216	NO	NA	693	21 523	NA
2002	28 292	NO	NA	676	27 616	NA
2003	57 507	NO	NA	1'125	56 381	NA
2004	88 967	NO	NA	1'183	87 784	NA
2005	128 042	NO	NA	1'068	126 974	NA
2006	156 723	NO	NA	1'399	155 323	NA
2007	179 555	NO	NA	1'133	178 422	NA
2008	216 510	NO	NA	1'187	215 323	NA
2009	265 166	NO	NA	1'117	264 049	NA
2010	209 195	NO	NA	1'344	207 852	NA
2011	187 642	NO	NA	NO	187 642	NA
2012	189 008	NO	NA	NO	189 008	NA
2013	167 367	NO	NA	NO	167 367	NA
2014	119 986	NO	NA	21	119 965	NA
2015	118 267	NO	NA	24	118 243	NA
2016	147 687	NO	NA	42	147 645	NA
2017	159 751	NO	NA	32	159 720	NA
2018	148 249	NO	NA	11	148 238	NA
2019	109 006	NO	NA	34	108 973	NA
2020	71 293	NO	NA	37	71 256	NA
2021	16 814	NO	NA	NO	16 814	NA
2022	95 430	NO	NA	178	95 252	NA
Trend 1990-2022	*-10.42%*	*NA*	*NA*	*NA*	*NA*	*NA*
2005-2022	*-25.47%*	*NA*	*NA*	*-83.31%*	*-24.98%*	*NA*
2021-2022	*467.57%*	*NA*	*NA*	*NA*	*466.51%*	*NA*

Source: Environment Agency

Tractors, harvesters and other machinery (chain saws, …) used in agriculture and forestry

In this category, tractors, combined harvesters, motor mowers, and other harvesting machines, chain saws and choppers are considered. The vehicle stock for tractors was derived from national statistics. For combined harvesters, motor mowers and other harvesting machines, no suitable data was available in Luxembourg. The stock of this machinery was estimated based on the Austrian vehicle stock and put into relation with the ratio between Austria's and Luxembourg's agricultural area (approx. 3.5%). Production hours were estimated based on the annual change of cereal production in Luxembourg and based on agro-economic indicators. For the stock of chain saws and choppers a similar method was applied but this time based on the ratio of forest land (approx. 2%) between the two countries. Motor gasoline and Diesel oil fuel consumption has been estimated, based on the above-mentioned activity, using the GEORG model (HBEFA 4.2).

Activity data for mobile sources are listed in Table 3-175.

Table 3-175 – Activity data for category *1A4c ii – Agriculture/Forestry/Fishing – Off-road vehicles and other machinery*

1 A 4 Other Sectors						
Activity Data by fuel type (GJ)						
1 A 4 c ii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery						
Year	**Activity Total (incl. biomass)**	**Liquid** *Gasoline, Diesel*	**Solid**	**Gaseous**	**Biomass**	**Other**
1990	352 499	352'499	NO	NO	NO	NO
1991	343 402	343'402	NO	NO	NO	NO
1992	322 264	322'264	NO	NO	NO	NO
1993	315 402	315'402	NO	NO	NO	NO
1994	325 060	325'060	NO	NO	NO	NO
1995	322 913	322'913	NO	NO	NO	NO
1996	323 292	323'292	NO	NO	NO	NO
1997	320 845	320'845	NO	NO	NO	NO
1998	329 415	329'415	NO	NO	NO	NO
1999	328 413	328'413	NO	NO	NO	NO
2000	333 926	333'926	NO	NO	NO	NO
2001	295 172	295'172	NO	NO	NO	NO
2002	314 918	314'918	NO	NO	NO	NO
2003	318 854	318'854	NO	NO	NO	NO
2004	337 349	337'349	NO	NO	IE	NO
2005	331 328	331'328	NO	NO	IE	NO
2006	338 597	338'597	NO	NO	IE	NO
2007	332 918	332'918	NO	NO	IE	NO
2008	361 475	361'475	NO	NO	IE	NO
2009	363 906	363'906	NO	NO	IE	NO
2010	366 358	366'358	NO	NO	IE	NO
2011	350 373	350'373	NO	NO	IE	NO
2012	353 383	353'383	NO	NO	IE	NO
2013	302 999	302'999	NO	NO	IE	NO
2014	311 809	311'809	NO	NO	IE	NO
2015	320 792	320'792	NO	NO	IE	NO
2016	319 564	319'564	NO	NO	IE	NO
2017	320 044	320'044	NO	NO	IE	NO
2018	332 223	332'223	NO	NO	IE	NO
2019	321 628	321'628	NO	NO	IE	NO
2020	323 623	323'623	NO	NO	IE	NO
2021	319 934	319'934	NO	NO	IE	NO
2022	329 986	329'986	NO	NO	IE	NO
Trend 1990-2022	*-6.39%*	*-6.39%*	*NA*	*NA*	*NA*	*NA*
2005-2022	*-0.41%*	*-0.41%*	*NA*	*NA*	*NA*	*NA*
2021-2022	*3.14%*	*3.14%*	*NA*	*NA*	*NA*	*NA*

Source: Environment Agency

3.2.5.6.2.2 Methodological issues

For emissions of air pollutants from off-road vehicles and other machinery, the GEORG (Grazer Emissionsmodell für Off-Road Geräte) model developed by the TU Graz was used. Input data to the model are:

- Machinery stock data (obtained through inquiries and statistical extrapolation);
- Assumptions on drop-out rates of machinery (broken down machinery will be replaced);
- Operating time (obtained through inquiries), related to age of machinery.

From machinery stock data and drop-out rates an age structure of the off-road machinery was obtained by GEORG. Four categories of engine types were considered. Depending on the fuel consumption of the engine the ratio power of the engine was calculated. Emissions were calculated by multiplying an engine specific emission factor (expressed in g/kWh) by the average engine power, the operating time and the number of vehicles.

See also section 3.2.3.8.1 - Mobile Combustion in Manufacturing Industries and Construction (1A2g vii).

3.2.5.6.2.3 Emission factors

For stationary combustion, Tier 2 default emission factors from the EMEP/EEA Guidebook 2019 have been applied, as illustrated in Table 3-176. For natural gas and biogas combustion, the technology used in category *1A4ci* was assumed to be equivalent to medium-sized (>50 kWth to ≤ 1 MWth) boilers.

Table 3-176 – Methods and Emission Factors used in relation to the energy consumption in 2022 for category *1A4c i – Agriculture/Forestry/Fishing – stationary*

1 A 4 Other Sectors				
Method applied and Emission factor (EF) used as well as coverage of energy consumption				
1 A 4 c i Agriculture/Forestry/Fishing: Stationary				
Pollutant	Method	EF used	Coverage of energy consumption	Source
NOx NMVOC CO TSP PM10 PM2.5	T2	D	100.0%	EMEP/EEA GB 2019 (Chap 1A4, Table 3-26, p57), EMEP/EEA GB 2019 (Chap 1A4, Table 3-24, p55)
	T1	D	0.0%	
SOx	T2	CS	0.0%	CS based on maximum allowed suphur content
	T2	D	100.0%	EMEP/EEA GB 2019 (Chap 1A4, Table 3-26, p57)

Source: Environment Agency

For mobile combustion (diesel oil and motor gasoline), country-specific values, derived from the GEORG model (HBEFA 4.2), have been applied, as listed in Table 3-177. For the $PM_{2.5}$ and PM_{10} emission factors, the condensable component is included.

Table 3-177 – Methods and Emission Factors used in relation to the energy consumption in 2022 for category *1A4c ii – Agriculture/Forestry/Fisheries – Off-road vehicles and other machinery*

1 A 4 Other Sectors				
Method applied and Emission factor (EF) used as well as coverage of energy consumption				
1 A 4 c ii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery				
Pollutant	Method	EF used	Coverage of energy consumption	Source
NOx NMVOC CO TSP PM10 PM2.5	T3	CS	100.0%	GEORG model
	T1	D	0.0%	EMEP/EEA Guidebook
SOx	T3	CS	100.0%	GEORG using national fuel sulfur contents
	T1	D	0.0%	EMEP/EEA GB

Source: Environment Agency

Table 3-178 and Table 3-179 give an overview of the evolution of the implied emission factors.

Table 3-178 – Implied emission factors for category *1A4ci – Agriculture/Forestry/Fishing – stationary*

1 A 4 Other Sectors *Implied Emission Factor (IEF) of air pollutants by source category (g/GJ)*								
Year	**1 A 4 c i Agriculture/Forestry/Fishing: Stationary**							
	SO2	***NOx***	***NMVOC***	***NH3***	***CO***	***TSP***	***PM10***	***PM2.5***
1990	94.06	100.00	15.00	NA	40.00	3.00	3.00	3.00
1991	94.06	100.00	15.00	NA	40.00	3.00	3.00	3.00
1992	94.06	100.00	15.00	NA	40.00	3.00	3.00	3.00
1993	94.06	100.00	15.00	NA	40.00	3.00	3.00	3.00
1994	94.06	100.00	15.00	NA	40.00	3.00	3.00	3.00
1995	94.06	100.00	15.00	NA	40.00	3.00	3.00	3.00
1996	94.06	100.00	15.00	NA	40.00	3.00	3.00	3.00
1997	94.06	100.00	15.00	NA	40.00	3.00	3.00	3.00
1998	93.44	99.82	14.90	NA	39.89	2.98	2.98	2.98
1999	93.34	99.79	14.89	NA	39.88	2.98	2.98	2.98
2000	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
2001	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
2002	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
2003	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
2004	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
2005	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
2006	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
2007	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
2008	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
2009	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
2010	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
2011	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
2012	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
2013	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
2014	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
2015	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
2016	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
2017	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
2018	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
2019	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
2020	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
2021	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
2022	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
Trend 1990-2022	*-98.51%*	*-27.00%*	*-97.60%*	*NA*	*-40.00%*	*-85.00%*	*-85.00%*	*-85.00%*
2005-2022	*0.00%*	*0.00%*	*0.00%*	*NA*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
2021-2022	*0.00%*	*0.00%*	*0.00%*	*NA*	*0.00%*	*0.00%*	*0.00%*	*0.00%*

Source: Environment Agency

Table 3-179 – Implied emission factors for category *1A4c ii – Agriculture/Forestry/Fishing – Off-road vehicles and other machinery*

1 A 4 Other Sectors								
Implied Emission Factor (IEF) of air pollutants by source category (g/GJ)								
Year	**1 A 4 c ii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery**							
	SO2	***NOx***	***NMVOC***	***NH3***	***CO***	***TSP***	***PM10***	***PM2.5***
1990	59.47	931.60	289.77	0.46	1261.59	201.67	201.67	201.67
1991	59.45	933.11	292.36	0.46	1269.19	200.40	200.40	200.40
1992	59.39	933.38	299.94	0.46	1291.25	199.16	199.16	199.16
1993	59.38	934.98	302.06	0.46	1297.43	197.77	197.77	197.77
1994	59.40	937.94	294.41	0.46	1271.72	193.88	193.88	193.88
1995	50.35	939.71	289.58	0.45	1251.36	188.21	188.21	188.21
1996	18.59	941.86	283.82	0.44	1228.24	182.75	182.75	182.75
1997	17.33	943.94	279.41	0.43	1208.90	177.64	177.64	177.64
1998	16.08	946.26	270.36	0.42	1177.32	173.28	173.28	173.28
1999	14.82	947.97	264.59	0.42	1155.28	169.22	169.22	169.22
2000	13.57	949.38	257.23	0.41	1129.83	165.98	165.98	165.98
2001	12.84	948.83	267.00	0.41	1150.51	163.65	163.65	163.65
2002	10.93	928.88	251.03	0.40	1083.38	155.89	155.89	155.89
2003	9.88	893.31	239.52	0.39	1013.81	143.32	143.32	143.32
2004	0.67	851.60	222.98	0.38	930.16	129.46	129.46	129.46
2005	0.58	810.98	215.16	0.36	873.79	116.71	116.71	116.71
2006	0.51	780.25	205.53	0.35	821.65	107.24	107.24	107.24
2007	0.47	761.07	200.42	0.34	787.61	99.80	99.80	99.80
2008	0.47	749.05	186.40	0.33	735.00	93.45	93.45	93.45
2009	0.47	736.90	179.24	0.32	699.59	86.87	86.87	86.87
2010	0.47	724.87	171.08	0.31	659.06	79.20	79.20	79.20
2011	0.47	714.64	168.24	0.29	634.62	72.51	72.51	72.51
2012	0.47	704.40	161.41	0.28	601.75	66.38	66.38	66.38
2013	0.47	693.38	171.47	0.27	616.55	62.42	62.42	62.42
2014	0.47	673.66	163.18	0.27	582.84	57.25	57.25	57.25
2015	0.47	640.49	152.79	0.25	539.60	50.34	50.34	50.34
2016	0.47	609.41	146.67	0.24	510.27	44.76	44.76	44.76
2017	0.47	591.06	142.53	0.24	491.28	41.38	41.38	41.38
2018	0.47	568.24	134.79	0.23	462.86	37.85	37.85	37.85
2019	0.47	548.12	134.11	0.23	454.41	35.17	35.17	35.17
2020	0.47	524.47	129.83	0.22	436.99	32.51	32.51	32.51
2021	0.47	490.19	126.53	0.21	421.14	29.55	29.55	29.55
2022	0.47	464.99	120.61	0.21	401.67	27.66	27.66	27.66
Trend 1990-2022	*-99.21%*	*-50.09%*	*-58.38%*	*-54.37%*	*-68.16%*	*-86.28%*	*-86.28%*	*-86.28%*
2005-2022	*-19.31%*	*-42.66%*	*-43.94%*	*-42.35%*	*-54.03%*	*-76.30%*	*-76.30%*	*-76.30%*
2021-2022	*0.07%*	*-5.14%*	*-4.68%*	*-1.91%*	*-4.62%*	*-6.40%*	*-6.40%*	*-6.40%*

Source: Environment Agency

3.2.5.6.3 Methodological issues for heavy metals and POPs

3.2.5.6.3.1 1.A.4.c i – Agriculture/Forestry/Fishing: Stationary

3.2.5.6.3.1.1 Methodological Choices

The calculation of emissions related to stationary combustion processes in agriculture, forestry and fishing were based on total fuel consumption in combination with tier 1 emission factors.

Concerning the fuel consumption data, the same data was used as derived for the main pollutants.

3.2.5.6.3.1.2 Emission Factors

Tier 1 emission factors:

Fuel	Pollutants	Source	Page	Table
Gaseous fuels	Pb, Hg, Cd, PCDD/F, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2019) – Chapter 1.A.4 Small combustion	37	3.8
Liquid fuels	Pb, Hg, Cd, PCDD/F, PCB, HCB, B(a)P, B(b)F, B(k)F, I(cd)P	EEA (2019) – Chapter 1.A.4 Small combustion	38	3.9

3.2.5.6.3.2 1.A.4.c ii – Agriculture/Forestry/Fishing: Off-road vehicles and other machinery

Emission values for HM and POPs emissions from mobile combustion in agriculture, forestry and fishing were calculated using the same methodology and models as for the main pollutants.

3.2.5.7 Uncertainties and time-series consistency

The assessment of activity data and emission factor uncertainties is done according to the methodology described in the EMEP/EEA emission inventory Guidebook 2023 (Chapter A.5 Uncertainties, tables 2-1, 2-2 and 2-3), covering the main pollutants NO_x, NH_3, NMVOC, SO_x and $PM_{2.5}$. For some subcategories and pollutants, expert judgements were made to estimate AD or EF uncertainties. For CO, PM10, heavy metzals and persistent organic pollutants, no uncertainty estimates are currently made. Details on uncertainty of the activity data can also be checked in the Luxembourg's National Inventory report (NIR). Please also refer to Table 1-33 to Table 1-37 of section 1.7 for caterogory specific uncertainties on activity data and emission factors.

The time series reported under *1A4 – Other Sectors*, are considered to be consistent, to the best of data availability. Further investigations will be needed, in collaboration with STATEC, to see whether, for the years 1990-1999, the arbitrary 50/50 split between 1A4a and 1A4b could be replaced by a more accurate split.

3.2.5.8 Source-specific QA/QC and verification

Standard QA/QC procedures were executed according to the QA/QC policy.

Consistency and completeness checks have been performed.

3.2.5.9 Category-specific recalculations including changes made in response to the review process

Table 3-180 presents the main revisions and recalculations done since submission 2023 relevant to category *1A4 – Other Sectors*.

Table 3-180 – Recalculations done since the last submission for category *1A4 – Other Sectors*

Source category	Revisions 2023 → 2024	Type of revision
1A4cii	Due to an error correction, the total activity data for diesel oil for the entire timeseries was revised, which impacts several mobile combustion sub-categories (1A2gvii, 1A3b, 1A3c, 1A3d, 1A4cii, 1A5b). As the fuel consumptions in mobile combustion are allocated to different vehicle categories by the NEMO and GEORG models, the change in total diesel activity data also impacts the allocations of gasoline, biomass and other fossil fuels (the total activity data of these three fuel types remains unchanged)	AD
1A4	Revision of the liquid petroleum gas and biogas activity data due to changes in the national energy balance for 2021 (-47 GJ for LPG and +39 TJ for biogas compared to the previous submission).	AD
1A4	In the latest national energy balance, changes were made to the allocation method of natural gas to the different sectors for the year 2021. Consequently, the total amount of natural gas consumed by the 1A4 sector in 2021 decreased by 458 TJ.	AD
1A4a	Revision of NH_3 emissions for 2000-2021 from automatic boilers burning wood due to a change of the Tier 2 EF in the new 2023 EMEP/EEA Guidebook (from 37 g/GJ to 1 g/GJ in Chapter 1A4, Table 3-48, p. 90).	NH_3 EF
1A4b	Revision of NH_3 emissions for 1990-2021 from wood combustion in conventional stoves due to a change of the Tier 2 EF in the new 2023 EMEP/EEA Guidebook (from 70 g/GJ to 8 g/GJ in Chapter 1A4, Table 3-40, p. 78).	NH_3 EF

1A4b	Revision of NH_3 emissions for 1990-2021 from wood combustion in advanced / eco-labelled stoves and boilers due to a change of the Tier 2 EF in the new 2023 EMEP/EEA Guidebook (from 37 g/GJ to 4 g/GJ in Chapter 1A4, Table 3-42, p. 81).	NH_3 EF
1A4b	Revision of NH_3 emissions for 1990-2021 from wood combustion in pellet stoves and boilers due to a change of the Tier 2 EF in the new 2023 EMEP/EEA Guidebook (from 12 g/GJ to 1 g/GJ in Chapter 1A4, Table 3-44, p. 84).	NH_3 EF

3.2.5.10 Category-specific planned improvements including those in response to the review process

The following improvements are planned for the next submission.

Table 3-181 – Planned improvements for category *1A4 – Other Sectors*

Source category	Planned improvements	Type of revision
1A4ai, 1A4bi	1990-1999: collect information helping to refine the fuel consumption split between the commercial/institutional sectors, on the one hand, and the residential sector, on the other hand.	Update AD

3.2.6 Other (1.A.5)

3.2.6.1 Source category description

This section describes emissions of air pollutants resulting from fuel combustion activities in sub-category *1A5 – Other*. It covers combustion activities from stationary combustion and mobile combustion in sub-categories:

- *1A5a – Other Stationary*: Building and Plant Site Fuel Powered Machinery
- *1A5b – Other Mobile*: Off-road Vehicles and Other Machinery, Airport and Military Vehicles

In 2022, less than 0.01% of total national emissions of air pollutants occurred in category *1A5 – Other*, based on fuel sold and on fuel used. In 1990, this category was responsible for less than 0.012% of air pollutant emissions from fuel combustion activities, based on fuel sold (0.022% based on fuel used). Table 3-182 gives an overview of the emissions occurring in category *1A5 – Other* as well as of its sub-categories.

Table 3-182 – Emissions, Trends and Shares for category *1A5 - Other*

1 A 5 Other														
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
SO2	0.0002	0.0000	0.0000	0.0000	-100%	-19%	0%	0.0011%	0.0000%	0.0002%	0.0010%	0.0000%	0.0002%	fuel sold
NOx	0.0048	0.0014	0.0003	0.0002	-95%	-83%	-14%	0.0214%	0.0079%	0.0026%	0.0117%	0.0025%	0.0021%	fuel sold
NMVOC	0.0003	0.0001	0.0000	0.0000	-86%	-73%	-3%	0.0012%	0.0011%	0.0004%	0.0008%	0.0009%	0.0004%	fuel sold
NH3	0.0000	0.0000	0.0000	0.0000	-84%	-89%	53%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	fuel sold
CO	0.0025	0.0009	0.0004	0.0004	-82%	-49%	0%	0.0006%	0.0039%	0.0030%	0.0005%	0.0022%	0.0025%	fuel sold
TSP	0.0003	0.0001	0.0000	0.0000	-97%	-91%	-13%	0.0016%	0.0046%	0.0004%	0.0016%	0.0026%	0.0004%	fuel sold
PM10	0.0003	0.0001	0.0000	0.0000	-97%	-91%	-13%	0.0017%	0.0058%	0.0006%	0.0016%	0.0032%	0.0005%	fuel sold
PM2.5	0.0003	0.0001	0.0000	0.0000	-97%	-91%	-13%	0.0018%	0.0077%	0.0010%	0.0017%	0.0041%	0.0008%	fuel sold

1A5a – Other Stationary: Building and Plant Site Fuel Powered Machinery														
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
SO2	0.0001	NO	NO	NO	NO	NO	NO	0.0004%	NO	NO	0.0004%	NO	NO	fuel sold
NOx	0.0033	NO	NO	NO	NO	NO	NO	0.0150%	NO	NO	0.0082%	NO	NO	fuel sold
NMVOC	0.0000	NO	NO	NO	NO	NO	NO	0.0001%	NO	NO	0.0001%	NO	NO	fuel sold
NH3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
CO	0.0011	NO	NO	NO	NO	NO	NO	0.0003%	NO	NO	0.0002%	NO	NO	fuel sold
TSP	0.0000	NO	NO	NO	NO	NO	NO	0.0001%	NO	NO	0.0001%	NO	NO	fuel sold
PM10	0.0000	NO	NO	NO	NO	NO	NO	0.0001%	NO	NO	0.0001%	NO	NO	fuel sold
PM2.5	0.0000	NO	NO	NO	NO	NO	NO	0.0001%	NO	NO	0.0001%	NO	NO	fuel sold

1A5b – Other Mobile: Off-road Vehicles and Other Machinery, Airport and Military Vehicles														
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
SO2	0.0001	0.0000	0.0000	0.0000	-99%	-19%	0%	0.0007%	0.0000%	0.0002%	0.0006%	0.0000%	0.0002%	fuel sold
NOx	0.0014	0.0014	0.0003	0.0002	-83%	-83%	-14%	0.0064%	0.0079%	0.0026%	0.0035%	0.0025%	0.0021%	fuel sold
NMVOC	0.0002	0.0001	0.0000	0.0000	-85%	-73%	-3%	0.0011%	0.0011%	0.0004%	0.0008%	0.0009%	0.0004%	fuel sold
NH3	0.0000	0.0000	0.0000	0.0000	-84%	-89%	53%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	fuel sold
CO	0.0014	0.0009	0.0004	0.0004	-68%	-49%	0%	0.0003%	0.0039%	0.0030%	0.0003%	0.0022%	0.0025%	fuel sold
TSP	0.0003	0.0001	0.0000	0.0000	-97%	-91%	-13%	0.0015%	0.0046%	0.0004%	0.0014%	0.0026%	0.0004%	fuel sold
PM10	0.0003	0.0001	0.0000	0.0000	-97%	-91%	-13%	0.0016%	0.0058%	0.0006%	0.0015%	0.0032%	0.0005%	fuel sold
PM2.5	0.0003	0.0001	0.0000	0.0000	-97%	-91%	-13%	0.0017%	0.0077%	0.0010%	0.0016%	0.0041%	0.0008%	fuel sold

Source: Environment Agency

3.2.6.2 Other Stationary (1A5a)

3.2.6.2.1 Source category description

In 2022, no emissions from fuel combustion activities from *1A5a – Other Stationary* were reported (notation key NO). In 1990, this category was responsible for less than 0.02% of air pollutant emissions from fuel combustion activities. Indeed, only emissions from 1990 to 2003 are reported. Since 2004, no fuel consumption is reported by the national energy balance for this category. Table 3-183 gives an overview of the emissions occurring in category *1A5a – Other Stationary*.

1A5a – Other Stationary related air pollutant emissions were not a key category in 2022 (see Table 3-4 and Table 3-5Table in Section 3.2 and Chapter 1.5).

Table 3-183 – Emission trends for category *1A5a – Other Stationary*

Year	1 A 5 Other *Emissions of air pollutants by source category (Gg)* 1 A 5 a Other stationary (including military)							
	SO2	*NOx*	*NMVOC*	*NH3*	*CO*	*TSP*	*PM10*	*PM2.5*
1990	0.00006	0.00334	0.00002	NO	0.00110	0.00002	0.00002	0.00002
1991	0.00006	0.00334	0.00002	NO	0.00110	0.00002	0.00002	0.00002
1992	0.03003	0.03520	0.00480	NO	0.01384	0.00098	0.00098	0.00098
1993	0.02604	0.03096	0.00416	NO	0.01215	0.00085	0.00085	0.00085
1994	0.02404	0.02883	0.00384	NO	0.01129	0.00079	0.00079	0.00079
1995	0.01005	0.01371	0.00161	NO	0.00526	0.00034	0.00034	0.00034
1996	0.01999	0.02417	0.00319	NO	0.00946	0.00065	0.00065	0.00065
1997	0.02014	0.02922	0.00323	NO	0.01112	0.00069	0.00069	0.00069
1998	0.03217	0.04376	0.00515	NO	0.01681	0.00108	0.00108	0.00108
1999	0.06425	0.08186	0.01027	NO	0.03176	0.00213	0.00213	0.00213
2000	0.00026	0.01354	0.00007	NO	0.00445	0.00008	0.00008	0.00008
2001	0.00052	0.02703	0.00013	NO	0.00889	0.00017	0.00017	0.00017
2002	0.00029	0.01503	0.00007	NO	0.00494	0.00009	0.00009	0.00009
2003	0.00007	0.00352	0.00002	NO	0.00116	0.00002	0.00002	0.00002
2004	NO	NO	NO	NO	NO	NO	NO	NO
2005	NO	NO	NO	NO	NO	NO	NO	NO
2006	NO	NO	NO	NO	NO	NO	NO	NO
2007	NO	NO	NO	NO	NO	NO	NO	NO
2008	NO	NO	NO	NO	NO	NO	NO	NO
2009	NO	NO	NO	NO	NO	NO	NO	NO
2010	NO	NO	NO	NO	NO	NO	NO	NO
2011	NO	NO	NO	NO	NO	NO	NO	NO
2012	NO	NO	NO	NO	NO	NO	NO	NO
2013	NO	NO	NO	NO	NO	NO	NO	NO
2014	NO	NO	NO	NO	NO	NO	NO	NO
2015	NO	NO	NO	NO	NO	NO	NO	NO
2016	NO	NO	NO	NO	NO	NO	NO	NO
2017	NO	NO	NO	NO	NO	NO	NO	NO
2018	NO	NO	NO	NO	NO	NO	NO	NO
2019	NO	NO	NO	NO	NO	NO	NO	NO
2020	NO	NO	NO	NO	NO	NO	NO	NO
2021	NO	NO	NO	NO	NO	NO	NO	NO
2022	NO	NO	NO	NO	NO	NO	NO	NO
Trend 1990-2022	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005-2022	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2021-2022	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*

Source: Environment Agency

3.2.6.2.2 Methodological issues & time-series consistency:

3.2.6.2.2.1 Activity data

Fuel consumption data (gas oil, LPG) is obtained from the national energy balance as compiled by the national statistics institute and was attributed to this category based on expert judgement.

Table 3-184 – Activity data for category *1A5a – Other Stationary*

1 A 5 Other						
Activity Data by fuel type (GJ)						
1 A 5 a Other stationary (including military)						
Year	Activity Total (incl. biomass)	Liquid *Gasoil, LPG*	Solid	Gaseous	Biomass	Other
1990	45 728	45'728	NO	NO	NO	NA
1991	45 728	45'728	NO	NO	NO	NA
1992	364 308	364'308	NO	NO	NO	NA
1993	321 934	321'934	NO	NO	NO	NA
1994	300 654	300'654	NO	NO	NO	NA
1995	148 456	148'456	NO	NO	NO	NA
1996	252 683	252'683	NO	NO	NO	NA
1997	321 685	321'685	NO	NO	NO	NA
1998	473 779	473'779	NO	NO	NO	NA
1999	869 847	869'847	NO	NO	NO	NA
2000	185 497	185'497	NO	NO	NO	NA
2001	370 223	370'223	NO	NO	NO	NA
2002	205 847	205'847	NO	NO	NO	NA
2003	48 158	48'158	NO	NO	NO	NA
2004	NO	NO	NO	NO	NO	NA
2005	NO	NO	NO	NO	NO	NA
2006	NO	NO	NO	NO	NO	NA
2007	NO	NO	NO	NO	NO	NA
2008	NO	NO	NO	NO	NO	NA
2009	NO	NO	NO	NO	NO	NA
2010	NO	NO	NO	NO	NO	NA
2011	NO	NO	NO	NO	NO	NA
2012	NO	NO	NO	NO	NO	NA
2013	NO	NO	NO	NO	NO	NA
2014	NO	NO	NO	NO	NO	NA
2015	NO	NO	NO	NO	NO	NA
2016	NO	NO	NO	NO	NO	NA
2017	NO	NO	NO	NO	NO	NA
2018	NO	NO	NO	NO	NO	NA
2019	NO	NO	NO	NO	NO	NA
2020	NO	NO	NO	NO	NO	NA
2021	NO	NO	NO	NO	NO	NA
2022	NO	NO	NO	NO	NO	NA
Trend 1990-2022	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005-2022	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2021-2022	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*

Source: Environment Agency

3.2.6.2.2.2 Methodological issues

The EMEP/EEA Guidebook Tier 1 approach has been applied for all air pollutants.

3.2.6.2.2.3 Emission factors

Default emission factors have been applied, while country-specific SO_2 emission factors were used for liquid fuels.

Table 3-185 – Methods and Emission Factors used for category *1A5 a – Other Stationary*

1 A 5 Other				
Method applied and Emission factor (EF) used as well as coverage of energy consumption				
1 A 5 a Other stationary (including military)				
Source	Method	EF used	Coverage of energy consumption	Source
NOx NMVOC CO TSP PM10 PM2.5	T2	D	NO	EMEP/EEA GB 2019 (Chap 1A4, Table 3-24, p55) EMEP/EEA GB 2019 (Chap 1A4, Table 3-26, p57)
SOx	T2	D	NO	EMEP/EEA GB 2019 (Chap 1A4, Table 3-26, p57)
	T2	CS	NO	CS based on maximum allowed suphur content

Source: Environment Agency

An overview of the evolution of the implied emission factors is given in Table 3-186.

Table 3-186 – Implied Emission Factors for category *1A5a – Other Stationary*

Year	1 A 5 Other *Implied Emission Factor (IEF) of air pollutants by source category (g/GJ)* 1 A 5 a Other stationary (including military)							
	SO2	*NOx*	*NMVOC*	*NH3*	*CO*	*TSP*	*PM10*	*PM2.5*
1990	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
1991	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
1992	82.43	96.61	13.16	NA	37.99	2.68	2.68	2.68
1993	80.90	96.16	12.92	NA	37.73	2.64	2.64	2.64
1994	79.97	95.89	12.77	NA	37.57	2.61	2.61	2.61
1995	67.71	92.32	10.84	NA	35.45	2.27	2.27	2.27
1996	79.12	95.65	12.64	NA	37.42	2.59	2.59	2.59
1997	62.61	90.84	10.03	NA	34.57	2.13	2.13	2.13
1998	67.89	92.37	10.87	NA	35.48	2.28	2.28	2.28
1999	73.86	94.11	11.81	NA	36.51	2.44	2.44	2.44
2000	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
2001	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
2002	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
2003	1.40	73.00	0.36	NA	24.00	0.45	0.45	0.45
2004	NA	NA	NA	NA	NA	NA	NA	NA
2005	NA	NA	NA	NA	NA	NA	NA	NA
2006	NA	NA	NA	NA	NA	NA	NA	NA
2007	NA	NA	NA	NA	NA	NA	NA	NA
2008	NA	NA	NA	NA	NA	NA	NA	NA
2009	NA	NA	NA	NA	NA	NA	NA	NA
2010	NA	NA	NA	NA	NA	NA	NA	NA
2011	NA	NA	NA	NA	NA	NA	NA	NA
2012	NA	NA	NA	NA	NA	NA	NA	NA
2013	NA	NA	NA	NA	NA	NA	NA	NA
2014	NA	NA	NA	NA	NA	NA	NA	NA
2015	NA	NA	NA	NA	NA	NA	NA	NA
2016	NA	NA	NA	NA	NA	NA	NA	NA
2017	NA	NA	NA	NA	NA	NA	NA	NA
2018	NA	NA	NA	NA	NA	NA	NA	NA
2019	NA	NA	NA	NA	NA	NA	NA	NA
2020	NA	NA	NA	NA	NA	NA	NA	NA
2021	NA	NA	NA	NA	NA	NA	NA	NA
2022	NA	NA	NA	NA	NA	NA	NA	NA
Trend								
1990-2022	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005-2022	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2021-2022	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*

Source: Environment Agency

3.2.6.3 Other Mobile (1A5b)

3.2.6.3.1 Source category description

Source category *1A5b – Other Mobile* covers emissions of air pollutants from mobile military machinery in Luxembourg. In 2022, emissions from fuel combustion activities in category *1A5b – Other Mobile* represented less than 0.003% of the national total emissions, based on fuel sold and on fuel based. In 1990, this category was responsible for less than 0.004% of air pollutant emissions based on fuel sold (less than 0.007% based on fuel used). Table 3-187Table gives an overview of the emissions occurring in category *1A5b – Other Mobile*.

Table 3-187 – Emission trends of category *1A5b - Other Mobile*

Year	1 A 5 Other *Emissions of air pollutants by source category (Gg)* 1 A 5 b Other, Mobile (including military, land based and recreational boats)							
	SO2	*NOx*	*NMVOC*	*NH3*	*CO*	*TSP*	*PM10*	*PM2.5*
1990	0.000103	0.001435	0.000238	0.000000	0.001370	0.000256	0.000256	0.000256
1991	0.000103	0.001441	0.000236	0.000000	0.001363	0.000252	0.000252	0.000252
1992	0.000103	0.001446	0.000234	0.000000	0.001357	0.000248	0.000248	0.000248
1993	0.000103	0.001450	0.000233	0.000000	0.001351	0.000245	0.000245	0.000245
1994	0.000102	0.001478	0.000227	0.000000	0.001330	0.000235	0.000235	0.000235
1995	0.000086	0.001521	0.000219	0.000000	0.001299	0.000220	0.000220	0.000220
1996	0.000032	0.001559	0.000212	0.000000	0.001270	0.000206	0.000206	0.000206
1997	0.000029	0.001598	0.000205	0.000000	0.001243	0.000192	0.000192	0.000192
1998	0.000027	0.001637	0.000198	0.000000	0.001215	0.000179	0.000179	0.000179
1999	0.000025	0.001672	0.000191	0.000000	0.001189	0.000167	0.000167	0.000167
2000	0.000022	0.001696	0.000187	0.000000	0.001172	0.000158	0.000158	0.000158
2001	0.000021	0.001712	0.000184	0.000000	0.001160	0.000153	0.000153	0.000153
2002	0.000018	0.001685	0.000174	0.000000	0.001111	0.000144	0.000144	0.000144
2003	0.000016	0.001618	0.000158	0.000000	0.001027	0.000131	0.000131	0.000131
2004	0.000001	0.001522	0.000144	0.000000	0.000945	0.000118	0.000118	0.000118
2005	0.000001	0.001402	0.000131	0.000000	0.000862	0.000104	0.000104	0.000104
2006	0.000001	0.001281	0.000118	0.000000	0.000779	0.000090	0.000090	0.000090
2007	0.000001	0.001148	0.000107	0.000000	0.000704	0.000076	0.000076	0.000076
2008	0.000001	0.001022	0.000100	0.000000	0.000653	0.000066	0.000066	0.000066
2009	0.000001	0.000917	0.000096	0.000000	0.000619	0.000058	0.000058	0.000058
2010	0.000001	0.000834	0.000092	0.000000	0.000593	0.000052	0.000052	0.000052
2011	0.000001	0.000768	0.000090	0.000000	0.000575	0.000048	0.000048	0.000048
2012	0.000001	0.000712	0.000084	0.000000	0.000554	0.000043	0.000043	0.000043
2013	0.000001	0.000669	0.000076	0.000000	0.000529	0.000038	0.000038	0.000038
2014	0.000001	0.000630	0.000068	0.000000	0.000505	0.000033	0.000033	0.000033
2015	0.000001	0.000587	0.000060	0.000000	0.000484	0.000028	0.000028	0.000028
2016	0.000001	0.000540	0.000053	0.000000	0.000466	0.000023	0.000023	0.000023
2017	0.000001	0.000488	0.000046	0.000000	0.000452	0.000019	0.000019	0.000019
2018	0.000001	0.000431	0.000042	0.000000	0.000445	0.000016	0.000016	0.000016
2019	0.000001	0.000374	0.000039	0.000000	0.000442	0.000014	0.000014	0.000014
2020	0.000001	0.000322	0.000038	0.000000	0.000440	0.000012	0.000012	0.000012
2021	0.000001	0.000277	0.000036	0.000000	0.000440	0.000010	0.000010	0.000010
2022	0.000001	0.000239	0.000035	0.000000	0.000440	0.000009	0.000009	0.000009
Trend 1990-2022	*-99.25%*	*-83.33%*	*-85.10%*	*-83.85%*	*-67.89%*	*-96.53%*	*-96.53%*	*-96.53%*
2005-2022	*-19.01%*	*-82.94%*	*-73.08%*	*-89.49%*	*-48.99%*	*-91.49%*	*-91.49%*	*-91.49%*
2021-2022	*0.00%*	*-13.57%*	*-2.54%*	*52.80%*	*-0.06%*	*-12.63%*	*-12.63%*	*-12.63%*

Source: Environment Agency

1A5b – Other Mobile related air pollutant emissions were not a key category in 2022 (see Table 3-4 and Table 3-5 in Section 3.2 and Chapter 1.5).

3.2.6.3.2 Methodological issues & time-series consistency

3.2.6.3.2.1 Activity data

Fuel consumption data (diesel oil) was modelled using the GEORG model (see below). Due to missing vehicle stock data, military vehicle stock data was derived from the Austrian military vehicle stock data (excluding aviation) in relation with the population ratio between Luxembourg and Austria (approx. 6%). Estimated fuel consumption is given in Table 3-188.

Table 3-188 – Activity data for category *1A5b – Other Mobile*

1 A 5 Other						
Activity Data by fuel type (GJ)						
1 A 5 b Other, Mobile (including military, land based and recreational boats)						
Year	**Activity Total (incl. biomass)**	**Liquid**	**Solid**	**Gaseous**	**Biomass**	**Other**
1990	1 715	1'715	NA	NA	NO	NA
1991	1 712	1'712	NA	NA	NO	NA
1992	1 710	1'710	NA	NA	NO	NA
1993	1 707	1'707	NA	NA	NO	NA
1994	1 699	1'699	NA	NA	NO	NA
1995	1 686	1'686	NA	NA	NO	NA
1996	1 675	1'675	NA	NA	NO	NA
1997	1 664	1'664	NA	NA	NO	NA
1998	1 653	1'653	NA	NA	NO	NA
1999	1 643	1'643	NA	NA	NO	NA
2000	1 636	1'636	NA	NA	NO	NA
2001	1 631	1'631	NA	NA	NO	NA
2002	1 626	1'626	NA	NA	NO	NA
2003	1 620	1'620	NA	NA	NO	NA
2004	1 619	1'619	NA	NA	NO	NA
2005	1 621	1'621	NA	NA	NO	NA
2006	1 624	1'624	NA	NA	NO	NA
2007	1 624	1'624	NA	NA	NO	NA
2008	1 628	1'628	NA	NA	NO	NA
2009	1 632	1'632	NA	NA	NO	NA
2010	1 634	1'634	NA	NA	NO	NA
2011	1 636	1'636	NA	NA	NO	NA
2012	1 636	1'636	NA	NA	NO	NA
2013	1 636	1'636	NA	NA	NO	NA
2014	1 635	1'635	NA	NA	NO	NA
2015	1 635	1'635	NA	NA	NO	NA
2016	1 634	1'634	NA	NA	NO	NA
2017	1 633	1'633	NA	NA	NO	NA
2018	1 633	1'633	NA	NA	NO	NA
2019	1 634	1'634	NA	NA	NO	NA
2020	1 631	1'631	NA	NA	NO	NA
2021	1 632	1'632	NA	NA	NO	NA
2022	1 631	1'631	NA	NA	NO	NA
Trend 1990-2022	*-4.92%*	*-4.92%*	*NA*	*NA*	*NA*	*NA*
2005-2022	*0.60%*	*0.60%*	*NA*	*NA*	*NA*	*NA*
2021-2022	*-0.04%*	*-0.04%*	*NA*	*NA*	*NA*	*NA*

Source: Environment Agency

3.2.6.3.2.2 Methodology

For emissions of air pollutants from off-road vehicles and other machinery, the GEORG (Grazer Emissionsmodell für Off-Road Geräte) model developed by the TU Graz was used the first time. Input data to the model are:

- Machinery stock data (obtained through inquiries and statistical extrapolation);
- Assumptions on drop-out rates of machinery (broken down machinery will be replaced);
- Operating time (obtained through inquiries), related to age of machinery.

From machinery stock data and drop-out rates an age structure of the off-road machinery was obtained by GEORG. Four categories of engine types were considered. Depending on the fuel consumption of the engine the ratio power of the engine was calculated. Emissions were calculated by multiplying an engine specific emission factor (expressed in g/kWh) by the average engine power, the operating time and the number of vehicles.

See also section 3.2.3.8.1 - Mobile Combustion in Manufacturing Industries and Construction (1A2g vii).

3.2.6.3.2.3 Emission factors

For mobile combustion (diesel oil), country-specific values, derived from the GEORG model, have been applied. For the $PM_{2.5}$ and PM_{10} emission factors, the condensable component is included.

Table 3-189 – Methods and Emission Factors used in relation to the energy consumption in 2022 for category *1A5b – Other Mobile*

1 A 5 Other				
Method applied and Emission factor (EF) used as well as coverage of energy consumption				
1 A 5 b Other, Mobile (including military, land based and recreational boats)				
Pollutant	Method	EF used	Coverage of energy consumption	Source
NOx NMVOC CO TSP PM10 PM2.5	T3	CS	100.0%	GEORG
SOx	T3	CS	100.0%	GEORG using national fuel sulfur contents

Source: Environment Agency

An overview of the evolution of the implied emission factors is given in Table 3-190.

Table 3-190 – Implied Emission Factors for category *1A5b – Other Mobile*

1 A 5 Other								
Implied Emission Factor (IEF) of air pollutants by source category (g/GJ)								
Year	1 A 5 b Other, Mobile (including military)							
	SO2	*NOx*	*NMVOC*	*NH3*	*CO*	*TSP*	*PM10*	*PM2.5*
1990	60.26	836.61	138.46	0.18	798.61	149.02	149.02	149.02
1991	60.26	841.19	137.69	0.19	796.08	147.14	147.14	147.14
1992	60.26	845.83	136.90	0.19	793.52	145.25	145.25	145.25
1993	60.26	849.55	136.27	0.26	791.46	143.72	143.72	143.72
1994	60.26	869.75	133.79	0.23	783.10	138.38	138.38	138.38
1995	51.08	901.74	129.98	0.23	770.22	130.29	130.29	130.29
1996	18.83	931.08	126.51	0.22	758.47	122.93	122.93	122.93
1997	17.56	960.27	123.08	0.23	746.85	115.68	115.68	115.68
1998	16.29	990.36	119.56	0.22	734.92	108.27	108.27	108.27
1999	15.02	1018.19	116.31	0.25	723.91	101.42	101.42	101.42
2000	13.75	1037.06	114.10	0.27	716.41	96.76	96.76	96.76
2001	13.04	1049.71	112.61	0.26	711.36	93.60	93.60	93.60
2002	11.09	1036.17	107.03	0.27	683.14	88.29	88.29	88.29
2003	10.02	998.31	97.75	0.27	633.82	81.07	81.07	81.07
2004	0.67	939.78	89.16	0.26	583.44	73.15	73.15	73.15
2005	0.59	864.96	81.09	0.30	531.92	64.26	64.26	64.26
2006	0.52	788.98	72.96	0.28	479.86	55.26	55.26	55.26
2007	0.47	706.82	65.85	0.24	433.44	46.94	46.94	46.94
2008	0.47	627.65	61.39	0.26	401.34	40.45	40.45	40.45
2009	0.47	561.72	58.64	0.19	379.56	35.52	35.52	35.52
2010	0.47	510.18	56.40	0.19	362.95	31.85	31.85	31.85
2011	0.47	469.70	54.80	0.16	351.42	29.24	29.24	29.24
2012	0.47	435.39	51.49	0.12	338.70	26.36	26.36	26.36
2013	0.47	408.87	46.39	0.10	323.04	23.04	23.04	23.04
2014	0.47	385.45	41.43	0.11	308.68	19.93	19.93	19.93
2015	0.47	359.36	36.67	0.10	295.98	16.95	16.95	16.95
2016	0.47	330.62	32.13	0.11	284.93	14.11	14.11	14.11
2017	0.47	299.08	28.22	0.12	276.62	11.59	11.59	11.59
2018	0.47	264.07	25.70	0.11	272.21	9.71	9.71	9.71
2019	0.47	228.83	24.12	0.09	270.41	8.29	8.29	8.29
2020	0.47	197.35	23.01	0.02	270.11	7.15	7.15	7.15
2021	0.47	169.61	22.25	0.02	269.73	6.22	6.22	6.22
2022	0.47	146.66	21.70	0.03	269.70	5.44	5.44	5.44
Trend 1990-2022	*-99.21%*	*-82.47%*	*-84.33%*	*-83.01%*	*-66.23%*	*-96.35%*	*-96.35%*	*-96.35%*
2005-2022	*-19.49%*	*-83.04%*	*-73.25%*	*-89.56%*	*-49.30%*	*-91.54%*	*-91.54%*	*-91.54%*
2021-2022	*0.05%*	*-13.53%*	*-2.50%*	*52.87%*	*-0.01%*	*-12.59%*	*-12.59%*	*-12.59%*

Source: Environment Agency

3.2.6.3.2.4 Methodological issues for heavy metals and POPs

Emission values for HM and POPs emissions from mobile combustion in Other Mobile were calculated using the same methodology and models as for the main pollutants.

3.2.6.4 Uncertainties and time-series consistency

The assessment of activity data and emission factor uncertainties is done according to the methodology described in the EMEP/EEA emission inventory Guidebook 2023 (Chapter A.5 Uncertainties, tables 2-1, 2-2 and 2-3), covering the main pollutants NO_x, NH_3, NMVOC, SO_x and $PM_{2.5}$. For some subcategories and pollutants, expert judgements were made to estimate AD or EF uncertainties. For CO, PM10, heavy metzals and persistent organic pollutants, no uncertainty estimates are currently made. Details on uncertainty of the activity data can also be checked in the Luxembourg's National Inventory report (NIR). Please also refer to Table 1-33 to Table 1-37 of section 1.7 for caterogory specific uncertainties on activity data and emission factors.

The time series reported under *1A5 – Other* are considered consistent.

3.2.6.5 Source-specific QA/QC and verification

Standard QA/QC procedures were followed.

Consistency and completeness checks have been performed.

3.2.6.6 Category-specific recalculations including changes made in response to the review process

Table 3-191 presents the main revisions and recalculations done since submission 2023 relevant to category *1A5 – Other*.

Table 3-191 – Recalculations done since the last submission for category *1A5 – Other*

Source category	Revisions 2023 ➔ 2024	Type of revision
1A5b	Due to an error correction, the total activity data for diesel oil for the entire timeseries was revised, which impacts several mobile combustion sub-categories (1A2gvii, 1A3b, 1A3c, 1A3d, 1A4cii, 1A5b). As the fuel consumptions in mobile combustion are allocated to different vehicle categories by the NEMO and GEORG models, the change in total diesel activity data also impacts the allocations of gasoline, biomass and other fossil fuels (the total activity data of these three fuel types remains unchanged)	AD

3.2.6.7 Category-specific planned improvements including those in response to the review process

The following improvements are planned for the next submission.

Table 3-192 – Planned improvements for category *1A5 – Other*

Source category	Planned improvements	Type of revision
1A5	No planned improvements	

3.3 FUGITIVE EMISSIONS (1B)

An overview of the categories included under *1B Fugitive emissions* is provided in *Table 3-193*, as well as information on the status of emission estimates for all sub-categories.

Table 3-193 – Status of emission reporting for category *1B – Fugitive emissions*

NFR Code	FUGITIVE EMISSIONS FROM FUELS	NO_X	NMVOC	SO_X	NH_3	CO	TSP	PM_{10}	$PM_{2.5}$
1 B 1 a	Coal Mining and Handling	NA	NE	NA	NA	NA	X	X	X
1 B 1 b	Solid fuel transformation	NO	NO	NO	NO	NO	NO	NO	NO
1 B 1 c	Other fugitive emissions from solid fuels	NO	NO	NO	NO	NO	NO	NO	NO
1 B 2 a i	Exploration, Production, Transport	NO	NO	NO	NO	NO	NO	NO	NO
1 B 2 a iv	Refining / Storage	NO	NO	NO	NO	NO	NO	NO	NO
1 B 2 a v	Distribution of oil products	NA	X	NA	NA	NA	NA	NA	NA
1 B 2 b	Natural gas (exploration, production, processing, transmission, storage, distribution and other)	NA	X	NA	NA	NA	NA	NA	NA
1 B 2 c	Venting and flaring (Oil and natural gas)	NO	NO	NO	NO	NO	NO	NO	NO
1 B 3	Other fugitive emissions from energy production	NO	NO	NO	NO	NO	NO	NO	NO

Source: Environment Agency

3.3.1 Solid Fuels (1.B.1)

3.3.1.1 Source category description

In Luxembourg, fugitive emissions, in category 1.B.1, only occur from the handling of coal products (category *1B1a – Coal Mining and Handling)*. The emissions covered in this category are PM emissions from the handling of coal. Other fugitive emissions – because they are closely linked to production, processing or exploration – are not occurring in Luxembourg. Indeed, Luxembourg does not have any coal mines on its territory. All coal products are imported. Coal products are mainly used in the iron & steel, cement and asphalt production facilities. NMVOC emissions from coal storage and handling are not estimated as no emission factors are provided in the EMEP/EEA Guidebook 2019 (Chapter 1B1a, Tables 3-4 to 3-6, p.11-12).

With regard to PM emissions, category 1B1 is not a key category in 2022, neither in the level, nor in the trend assessments, and has never been.

Table 3-194 presents the emission trends of this category, aswell as the recalculations operated compared to submission 2023.

Table 3-194 - Emission trends and recalculations for category *1B1 – Fugitive emissions – Solid Fuels*

Year	1B1a - Fugitive emissions from coal storage and handling (Gg)			Recalculations (last-previous submission) 1B1a (Gg)		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
1990	0.0012	0.0116	0.0291	-	-	-
1991	0.0011	0.0111	0.0277	-	-	-
1992	0.0011	0.0105	0.0263	-	-	-
1993	0.0011	0.0108	0.0271	-	-	-
1994	0.0009	0.0094	0.0235	-	-	-
1995	0.0005	0.0053	0.0133	-	-	-
1996	0.0005	0.0051	0.0126	-	-	-
1997	0.0003	0.0032	0.0081	-	-	-
1998	0.0001	0.0012	0.0029	-	-	-
1999	0.0001	0.0012	0.0029	-	-	-
2000	0.0001	0.0013	0.0033	-	-	-
2001	0.0001	0.0014	0.0036	-	-	-
2002	0.0001	0.0009	0.0022	-	-	-
2003	0.0001	0.0007	0.0017	-	-	-
2004	0.0001	0.0010	0.0024	-	-	-
2005	0.0001	0.0009	0.0023	-	-	-
2006	0.0001	0.0011	0.0028	-	-	-
2007	0.0001	0.0009	0.0023	-	-	-
2008	0.0001	0.0009	0.0022	-	-	-
2009	0.0001	0.0008	0.0020	-	-	-
2010	0.0001	0.0008	0.0020	-	-	-
2011	0.0001	0.0007	0.0018	-	-	-
2012	0.0001	0.0007	0.0017	-	-	-
2013	0.0001	0.0006	0.0016	-	-	-
2014	0.0001	0.0006	0.0016	-	-	-
2015	0.0001	0.0006	0.0015	-	-	-
2016	0.0001	0.0006	0.0015	-	-	-
2017	0.0001	0.0006	0.0014	-	-	-
2018	0.0001	0.0005	0.0013	-	-	-
2019	0.0001	0.0006	0.0014	-	-	-
2020	0.0000	0.0005	0.0012	-	-	-
2021	0.0001	0.0005	0.0013	-	-	-
2022	0.0001	0.0005	0.0013			
Trend 1990-2022	-95.68%	-95.68%	-95.68%			
2005-2022	-45.73%	-45.73%	-45.73%			
2021-2022	-2.66%	-2.66%	-2.66%			

Source: Environment Agency

3.3.1.2 Methodological issues

3.3.1.2.1 Activity data

Activity data on national coal consumption (which is equal to import) are obtained from the national statistics institute's energy balance and is listed in Table 3-195.

Table 3-195 – Activity data for category *1B1a – Coal Mining and Handling*

Coal Import (t)								
1990	1991	1992	1993	1994	1995	1996	1997	1998
1'640'777	1'563'092	1'479'566	1'524'807	1'324'604	750'656	712'408	456'838	163'992
1999	2000	2001	2002	2003	2004	2005	2006	2007
165'767	187'248	201'520	124'179	95'573	134'962	130'639	155'415	130'709
2008	2009	2010	2011	2012	2013	2014	2015	2016
125'646	113'350	110'828	100'511	93'615	89'466	88'798	83'994	87'225
2017	2018	2019	2020	2021	2022			

81'093	71’900	78’756	66’317	72’831	70’894

Source: STATEC.

3.3.1.2.2 Methodology & Emission factors

The EMEP/EEA Tier 2 approach has been applied for estimating PM emissions from storage and handling of coal products in Luxembourg. As the PM emission factor for storage is based on the amount of coal stored per hectare and, as this amount is not known in Luxembourg, it was assumed that up to 100’000 tonnes of coal could be stored on one hectare.

An overview of the parameters applied and emission factors (EF) used for estimating PM emissions for category *1B1a – Coal Mining and Handling* is given in Table 3-196.

Table 3-196 – Method applied and Emission factor (EF) used for category *1B1a – Coal Mining and Handling*

Parameter / emission factor	Source	Value	Unit
Average stock per area	http://www.geometrica.com/en/coal-storage-domes	10^5	Mg coal/ha
EF Handling - $PM_{2.5}$	EEA/EMEP GB 2023 (Chap. 1B1a, Tab 3-7, p13)	0.3	g/Mg coal
EF controlled storage – $PM_{2.5}$	EEA/EMEP GB 2023 (Chap. 1B1a, Tab 3-6, p13)	0.041	Mg/ha/year
EF Handling - PM_{10}	EEA/EMEP GB 2023 (Chap. 1B1a, Tab 3-7, p13)	3	g/Mg coal
EF controlled storage – PM_{10}	EEA/EMEP GB 2019 (Chap. 1B1a, Tab 3-6, p13)	0. 41	Mg/ha/year
EF Handling – TSP	EEA/EMEP GB 2023 (Chap. 1B1a, Tab 3-7, p13)	7.5	g/Mg coal
EF controlled storage – TSP	EEA/EMEP GB 2019 (Chap. 1B1a, Tab 3-6, p13)	1.025	Mg/ha/year

3.3.2 Oil and Natural Gas (1.B.2)

3.3.2.1 Source category description

In Luxembourg, fugitive emissions in category 1.B.2 only occur from the distribution and transmission of natural gas and from the distribution of refined oil products (categories *1B2b - Fugitive emissions from natural gas* and *1B2a v - Distribution of oil products*, respectively). Other fugitive emissions – because they are closely linked to production, processing or exploration – are not occurring in Luxembourg.

As presented in Table 3-197, with regard to NMVOC emission, 1B2 – Oil and Natural Gas is a key category (LA) in 2022 (see also Chapter 1.5).

Table 3-197 – Key Categories of category *1B2 – Oil and Natural Gas*

Key Source Analysis (FUEL SOLD): Ranking per number		SO2		NOX		NMVOC		NH3		CO		TSP		PM10		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA

Key Source Analysis (FUEL USED): Ranking per number		SO2		NOX		NMVOC		NH3		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
1 B 2 b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)					9					

Source: Environment Agency

Notes: LA = Level Assessment, TA = Trend Assessment

Number in Table = indicates the rank in the specific analysis (1…biggest KC; 2… second biggest KC, …)

Table 3-198 presents the emission trends of this category, aswell as the recalculations operated compared to submission 2023 (v1).

Table 3-198 – Emission trends and recalculations for category *1B2 – Fugitive emissions – Oil & Natural Gas*

Year	1B2av - Distribution of oil products	1B2b - Fugitive emissions from natural gas	Recalculations (last-previous submissions)	
	NMVOC (Gg)	NMVOC (Gg)	1B2av - NMVOC (Gg)	1B2b - NMVOC (Gg)
1990	0.409	0.221	-	-
1991	0.451	0.229	-	-
1992	0.497	0.239	-	-
1993	0.491	0.248	-	-
1994	0.526	0.250	-	-
1995	0.487	0.285	-	-
1996	0.470	0.311	-	-
1997	0.497	0.318	-	-
1998	0.474	0.321	-	-
1999	0.474	0.332	-	-
2000	0.466	0.341	-	-
2001	0.441	0.379	-	-
2002	0.408	0.543	-	-
2003	0.392	0.550	-	-
2004	0.349	0.611	-	-
2005	0.293	0.601	-	-
2006	0.268	0.631	-	-
2007	0.256	0.591	-	-
2008	0.241	0.565	-	-
2009	0.222	0.571	-	-
2010	0.198	0.614	-	-
2011	0.214	0.532	-	-
2012	0.202	0.544	-	-
2013	0.181	0.464	-	-
2014	0.181	0.438	-	-
2015	0.166	0.394	-	-
2016	0.159	0.362	-	-
2017	0.168	0.356	-	-
2018	0.186	0.350	-	-
2019	0.191	0.351	-	-
2020	0.148	0.317	-	-
2021	0.172	0.341	-	-
2022	0.184	0.265		
Trend 1990-2022	*-54.94%*	*20.15%*		
2005-2022	*-37.15%*	*-55.94%*		
2021-2022	*6.91%*	*-22.17%*		

Source: Environment Agency

3.3.2.2 Methodological issues

3.3.2.2.1 Activity data

Activity data on national natural gas consumption as well as on the distribution of refined oil products (gasoil, diesel oil, LPG and motor gasoline) are obtained from the national statistics institute. Activity data for natural gas consumption is listed in Table 3-199.

Table 3-199 – Activity data for category *1B2 - Oil and Natural Gas*

Natural Gas Consumption (GJ)					
1990	1991	1992	1993	1994	1995
17 933 319	18 646 146	19 434 015	20 184 363	20 334 429	23 237 685
1996	1997	1998	1999	2000	2001
25 491 951	26 121 114	26 375 112	27 358 065	28 119 435	31 177 039
2002	2003	2004	2005	2006	2007
44 596 356	45 132 516	50 018 454	49 248 164	51 513 517	48 083 276

2008	2009	2010	2011	2012	2013
45 774 534	46 592 327	50 108 059	43 235 365	44 010 941	37 284 498
2014	**2015**	**2016**	**2017**	**2018**	**2019**
35 310 029	32 201 184	29 685 081	29 283 800	28 621 878	28 667 601
2020	**2021**	**2022**			
26 013 711	28'035'090	22’021’952			

Source: STATEC.

3.3.2.2.2 Methodology & Emission factors

The EMEP/EEA Tier 1 approach has been applied.

An overview of the method applied and emission factor (EF) used in category *1B2a v - Distribution of Oil Products* and category *1B2 - Oil and Natural Gas* are given, respectively, in Table 3-200 and Table 3-201.

Table 3-200 – Method applied and Emission factor (EF) used for category *1B2a v - Distribution of Oil Products*

Gasoline	Source	Value	Unit
EF – NMVOC – Gasoline Storage Tank	EEA/EMEP GB 2019 (Chap. 1B2av, Tab3-12, p22)	0.06	kg/t
Abatement efficiency	-	0.00	%
EF ServStat – storage tank – filling	EEA/EMEP GB 2019 (Chap. 1B2av, Tab3-8, p17)	24.00	g/m³/kPa
Abatement efficiency	EEA/EMEP GB 2019 (Chap. 1B2av, Tab3-14, p23)	0.95	%
EF ServStat – storage tank – breathing	EEA/EMEP GB 2019 (Chap. 1B2av, Tab3-9, p19)	3.00	g/m³/kPa
Abatement efficiency	-	0.00	%
EF ServStat – Car Refuelling	EEA/EMEP GB 2019 (Chap. 1B2av, Tab3-10, p19)	37.00	g/m³/kPa
Abatement efficiency	EEA/EMEP GB 2009 (Chap. 1B2av, Tab3-15, p19) EEA/EMEP GB 2019 (Chap. 1B2av, Tab3-15, p24)	0.60 (1990-96) Linear interpol. (1997-2004) 0.85 (2005-22)	% %
EF ServStat – Car Refuelling – Drips & minor spillage	EEA/EMEP GB 2019 (Chap. 1B2av, Tab3-11, p20)	2.00	g/m³/kPa
Abatement efficiency	-	0.00	%
Method	EEA/EMEP GB 2019 (Chap. 1B2av, eq2, p14)	T2	
EF used	EEA/EMEP GB 2019 (Chap. 1B2av, 3.3.2, p15)	D	
Diesel	**Source**	**Value**	**Unit**
Emission Factor – NMVOC	2006 IPCC Guidelines (Vol2, NMVOC, Tab4.2.4, p4.50)	ND	Gg/10³m³
Method	2006 IPCC Guidelines (Vol,2 NMVOC, p4.41)	T1	
EF used	2006 IPCC Guidelines (Vol2, NMVOC, Tab4.2.4, p4.50)	D	
Aviation Gasoline	**Source**	**Value**	**Unit**
Emission Factor – NMVOC	2006 IPCC Guidelines (Vol2, NMVOC, Tab4.2.4, p4.50)	ND	Gg/10³m³
Method	2006 IPCC Guidelines (Vol,2 NMVOC, p4.41)	T1	
EF used	2006 IPCC Guidelines (Vol2, NMVOC, Tab4.2.4, p4.50)	D	
Kerosene	**Source**	**Value**	**Unit**
Emission Factor – NMVOC	2006 IPCC Guidelines (Vol2, NMVOC, Tab4.2.4, p4.50)	ND	Gg/103m3
Method	2006 IPCC Guidelines (Vol2, NMVOC, p4.41)	T1	
EF used	2006 IPCC Guidelines (Vol2, NMVOC, Tab4.2.4, p4.50)	D	

Source: Environment Agency

For car-refuelling, an abatement efficiency of up to 85% was applied on the uncontrolled NMVOC emission factor as given in the EMEP/EEA Guidebook 2019, depending on the advancement of the Stage II implementation for petrol stations. Indeed, Luxembourg’s regulation[58] on the implementation of abatement technologies at service stations requires that all petrol stations are equipped with Stage II controls from January 2005 onwards. Implementation started around 1996 for the large petrol stations.[59] Hence in the inventory, it was assumed that before 1996, pre-Stage II technology was implemented, with an efficiency of 60% emission reduction, as described in the EMEP/EEA GB. As no data exists on the implementation rate of Stage II between 1997 and 2004, a linear implementation was assumed between these years. From 2005 onwards, full implementation of Stage II was assumed, as legally required.

Table 3-201 – Method applied and Emission factor (EF) used for category *1B2b - Natural Gas*

Natural Gas	Source	Value	Unit
Emission Factor – NMVOC	EEA/EMEP GB 2019 (Chap. 1B2b, Tab3-17, p23)	0.45	$Gg/10^3m^3$
Method	EEA/EMEP GB 2019 (Chap. 1B2b, 3.4, p17) EEA/EMEP GB 2019 (Chap. 1B2b, eq. 5, p18)	T3	
EF used	EEA/EMEP GB 2019 (Chap. 1B2b, 3.4, p17)	CS	

Source: Environment Agency

3.3.3 Uncertainties and time-series consistency

The assessment of activity data and emission factor uncertainties is done according to the methodology described in the EMEP/EEA emission inventory Guidebook 2023 (Chapter A.5 Uncertainties, tables 2-1, 2-2 and 2-3), covering the main pollutants NO_x, NH_3, NMVOC, SO_x and $PM_{2.5}$. For some subcategories and pollutants, expert judgements were made to estimate AD or EF uncertainties. For CO, PM10, heavy metzals and persistent organic pollutants, no uncertainty estimates are currently made. Details on uncertainty of the activity data can also be checked in the Luxembourg's National Inventory report (NIR). Please also refer to Table 1-33 to Table 1-37 of section 1.7 for caterogory specific uncertainties on activity data and emission factors.

The time series reported under *1B1 – Solid fuels* and *1B2 – Oil and Natural Gas* are considered to be consistent. Fluctuations in the time series occur due to maintenance stops of large industrial plants such as the 350 MW CHP gas turbine (Twinerg), the closure of iron and steel facilities (2012- Arcelor-Mittal Schifflange) or more heat demand due to colder winters. Although the population grows rapidly in Luxembourg, this does not necessarily induce a growth in natural gas demand as buildings get more and more energy efficient through better insulation.

3.3.4 Source-specific QA/QC and verification

Standard QA/QC procedures were followed.

Consistency and completeness checks have been performed.

3.3.5 Category-specific recalculations including changes made in response to the review process

Table 3-202 presents the main revisions and recalculations done to category *1B – Fugitive Emissions*.

[58] Règlement grand-ducal du 16 octobre 1996 relatif à la lutte contre les émissions de composés organiques volatils résultant du stockage de l'essence de la distribution de l'essence des terminaux aux stations-service et du ravitaillement en essence auprès des stations-service.
[59] European Commission & Entec UK Limited, Stage II Petrol Vapour Recovery – Final Report, (2005), p. XXXIV.

Table 3-202 – Recalculations done for category *1B - Fugitive Emissions*

Source category	Revisions 2023 ➔ 2024	Type of revision
1B	NO.	NA

For the calculated effect on the emissions through recalculations, please refer to Table and Table .

3.3.6 Category-specific planned improvements including those in response to the review process

No further improvements are planned for the moment.

4 INDUSTRIAL PROCESSES AND OTHER PRODUCT USE (IPPU)

This chapter covers air pollutant emissions occurring from industrial processes, from the use of products, from non-energy uses of fuels, and solvent use.

4.1 Sector Overview

Emissions from this sector comprise emissions from the following categories:

- Mineral Products (2.A)
- Solvent use (2.D.3)
- Other product use (2.G)
- Other production (2.H)

Only process related emissions are considered in this sector; emissions due to fuel combustion in manufacturing industries are allocated to category *1.A.2 Fuel Combustion – Manufacturing Industries and Construction*.

Table 4-1 gives an overview of the categories included under sector *2 - Industrial Processes and Other Product Use (IPPU)* and provides information on the status of emission estimates of all categories. Categories marked with notation key “NO” do not exist in Luxembourg. Explanations on notation key “IE” are given in Table 4-2.

Eissions of heavy metals in this sector result directly from industrial production processes. Combustion processes related to industrial energy and heat production are included in the NFR categories 1A2a to 1A2g and not considered in this section. Deviating from that, process-related emissions originating from sinter and pig iron production, as well as from secondary aluminium production were included in NFR categories 1A2a and 1A2b for practical reasons.

Table 4-1 – Status of emission reporting for category *2 – Industrial Processes and Other Product Use (IPPU)*

NFR Code	INDUSTRIAL PROCESSES AND OTHER PRODUCT USE	NO_X	NMVOC	SO_X	NH_3	CO	TSP	PM_{10}	$PM_{2.5}$
2 A 1	Cement Production	IE	IE	IE	IE	IE	IE	IE	IE
2 A 2	Lime Production	NO	NO	NO	NO	NO	NO	NO	NO
2 A 3	Glass production	IE	IE	IE	IE	IE	IE	IE	IE
2 A 5 a	Quarrying and mining of minerals other than coal	NO	NO	NO	NO	NO	NO	NO	NO
2 A 5 b	Construction and demolition	NA	NA	NA	NA	NA	X	X	X
2 A 5 c	Storage, handling and transport of mineral products	NO	NO	NO	NO	NO	NO	NO	NO
2 A 5 d	Other Mineral products	NO	NO	NO	NO	NO	NO	NO	NO
2 B 1	Ammonia Production	NO	NO	NO	NO	NA	NO	NO	NO
2 B 2	Nitric ADid Production	NO	NO	NO	NO	NO	NO	NO	NO
2 B 3	Adipic ADid Production	NO	NO	NO	NO	NO	NO	NO	NO
2 B 5	Carbide production	NO	NO	NO	NO	NO	NO	NO	NO
2 B 6	Titanium dioxide production	NO	NO	NO	NO	NO	NO	NO	NO
2 B 7	Soda ash production	NA	NO	NO	NO	NO	NO	NO	NO
2 B 10 a	Other chemical industry	NO	NO	NO	NO	NO	NO	NO	NO
2 B 10 b	Storage, handling and transport of chemical products	NO	NO	NO	NO	NO	NO	NO	NO
2 C 1	Iron and Steel Production	IE	IE	IE	NO	IE	IE	IE	IE
2 C 2	Ferroalloys Production	IE	IE	IE	NO	IE	IE	IE	IE
2 C 3	Aluminium production	IE	IE	IE	NO	IE	IE	IE	IE
2 C 4	Magnesium production	NO	NO	NO	NO	NO	NO	NO	NO
2 C 5	Lead Production	NO	NO	NO	NO	NO	NO	NO	NO
2 C 6	Zinc production	NO	NO	NO	NO	NO	NO	NO	NO
2 C 7 a	Copper production	NO	NO	NO	NO	NO	IE	IE	IE
2 C 7 b	Nickel production	NO	NO	NO	NO	NO	NO	NO	NO
2 C 7 c	Other metals	NO	NO	NO	NO	NO	NO	NO	NO
2 C 7 d	Storage, handling and transport of metal products	NO	NO	NO	NO	NO	NO	NO	NO
2 D 3 a	Domestic solvent use including fungicides	NA	X	NA	NA	NA	NA	NA	NA
2 D 3 b	Road paving with asphalt	IE	X	IE	IE	IE	X	X	X
2 D 3 c	Asphalt roofing	NO	NO	NO	NO	NO	NO	NO	NO
2 D 3 d	Coating applications	NA	X	NA	NA	NA	NA	NA	NA
2 D 3 e	Degreasing	NA	X	NA	NA	NA	NA	NA	NA
2 D 3 f	Dry cleaning	NA	X	NA	NA	NA	NA	NA	NA
2 D 3 g	Chemical products	NA	X	NA	NA	NA	NA	NA	NA
2 D 3 h	Printing	NA	X	NA	NA	NA	NA	NA	NA
2 D 3 i	Other solvent use	NA	X	NA	NA	NA	NA	NA	NA
2 G	Other product use	X	X	X	X	X	X	X	X
2 H 1	Pulp and paper industry	NO	NO	NO	NO	NO	NO	NO	NO
2 H 2	Food and beverages industry	NA	X	NA	NA	NA	NA	NA	NA
2 H 3	Other industrial processes	NA	NA	NA	NA	NA	NA	NA	NA
2 I	Wood processing	IE	IE	IE	IE	IE	IE	IE	IE
2 J	Production of POPs	NO	NO	NO	NO	NO	NO	NO	NO
2 K	Consumption of POPs and heavy metals (e.g. electrical and scientific equipment)	NA	NA	NA	NA	NA	NA	NA	NA
2 L	Other production, consumption, storage, transportation or handling of bulk products	NO	NO	NO	NO	NO	NO	NO	NO

Source: Environment Agency

Table 4-2 – Explanations on the use of notation key "IE"

Emissions of category	Pollutant(s)	Included in category	Explanation
2 A 1 Cement production	NO_X, SO_2, NMVOC, CO, TSP, PM_{10}, $PM_{2.5}$	1A2f	Emission estimation based on plant specific measurement data (only one plant), hence combustion and process emissions cannot be separated. According to EMEP/EEA GB, combustion emissions are to be reported under 1A Combustion activities, while process emissions are to be reported under 2 IPPU. As TSP, PM_{10}, and $PM_{2.5}$ are to be considered as process emissions, these will be reallocated to category 2A1 in the next submission.
2 A 3 Glass production	NO_X, SO_2, NMVOC, NH_3, CO, TSP, PM_{10}, $PM_{2.5}$	1A2f	Emission estimation based on plant specific measurement data (only one plant), hence combustion and process emissions cannot be separated. According to EMEP/EEA GB, combustion emissions are to be reported under 1A Combustion activities, while process emissions are to be

Emissions of category	Pollutant(s)	Included in category	Explanation
			reported under 2 IPPU. As TSP, PM10, and PM2.5 are to be considered as process emissions, these will be reallocated to category 2A3 in the next submission.
2 C 1 Iron and steel production	NO_X, SO_2, NMVOC, CO, TSP, PM_{10}, $PM_{2.5}$	1A2a	Emission estimation based on plant specific measurement data, hence combustion and process emissions cannot be separated. According to EMEP/EEA GB, combustion emissions are to be reported under 1A Combustion activities, while process emissions are to be reported under 2 IPPU. As TSP, PM10, and PM2.5 are to be considered as process emissions, these will be reallocated to category 2C1 in the next submission.
2 C 2 Ferroalloys production	NO_X, SO_2, NMVOC, CO, TSP, PM_{10}, $PM_{2.5}$	1A2a	Emission estimation based on plant specific measurement data, hence combustion and process emissions cannot be separated. According to EMEP/EEA GB, combustion emissions are to be reported under 1A Combustion activities, while process emissions are to be reported under 2 IPPU. As TSP, PM10, and PM2.5 are to be considered as process emissions, and should be reported under category 2C2. However, as only one plant is producing Ferroalloys in Luxembourg, and to preserve statistical secrecy, these will be reallocated to category 2C1 in the next submission.
2 C 3 Aluminium production	NO_X, SO_2, NMVOC, CO, TSP, PM_{10}, $PM_{2.5}$	1A2b	Emission estimation based on plant specific measurement data, hence combustion and process emissions cannot be separated. According to EMEP/EEA GB, combustion emissions are to be reported under 1A Combustion activities, while process emissions are to be reported under 2 IPPU. As TSP, PM10, and PM2.5 are to be considered as process emissions, these will be reallocated to category 2C3 in the next submission.
2 C 7 a Copper production	NO_X, SO_2, NMVOC, CO, TSP, PM_{10}, $PM_{2.5}$	1A2b	Emission estimation based on plant specific measurement data, hence combustion and process emissions cannot be separated. According to EMEP/EEA GB, combustion emissions are to be reported under 1A Combustion activities, while process emissions are to be reported under 2 IPPU. As TSP, PM10, and PM2.5 are to be considered as process emissions, and should be reported under category 2C7a. However, as only one plant is producing secondary copper sheets in Luxembourg, and to preserve statistical secrecy, these will be reallocated to category 2C3 in the next submission.
2 D 3 b Road paving with asphalt	NO_X, SO_2, CO	1 A 2 g viii	Emission estimation based on plant specific measurement data (3 plants), hence combustion and process emissions cannot be separated. According to EMEP/EEA GB, combustion emissions are to be reported under 1A Combustion activities, while process emissions are to be reported under 2 IPPU. As NMVOC, TSP, PM10, and PM2.5 are to be considered as process emissions, these are allocated to category 2D3b, whereas NOx, SO2 and CO are considered as combustion emissions and are allocated to category 1A2g viii.
2 I Wood processing	NO_X, SO_2, NMVOC, CO, TSP, PM_{10}, $PM_{2.5}$	1 A 2 g viii	Emission estimation based on plant specific measurement data, hence combustion and process emissions cannot be separated.

4.2 Glass production (2.A.3)

4.2.1 Source category description

Emissions (Pd, Cd, and Hg) associated with the glass production activities are assigned to category 2A3. Two flat glass production units have been operating in the past in Luxembourg in Dudelange (until 2021) and Bascharge, With the Luxguard production site in Bascharage, one single point source remains. POP emissions from this sector were considered negligible.

4.2.2 Methodological issues & time-series consistency

Since emission measurements for Luxguard were not available, the calculations of HM emissions originating from glass production were based on annual energy demand taken from the national energy balance. Process related emissions were based on activity data (tons of glass per year) which in turn were backcalculated on basis of the total amount of energy used per year and an assumed energy demand of 8 GJ/tonne (as stated in EEA 2023). Emissions originating from combustion processes in relation to glass production were reported under category 1.A.2.f (non-metallic minerals).

4.2.3 Source-specific QA/QC and verification

Along the general QA/QC procedures as embedded in in the overall QA/QC-system of Luxembourg's air emission inventory (see Chapter 1.6), no further source-specific QA/QC was operated.

4.2.4 Category-specific recalculations including changes made in response to the review process

No recalculations were operated since the last submission.

4.2.5 Category-specific planned improvements including those in response to the review process

No further improvements are planned.

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

4.3.1 Source category description

Emissions ($PM_{2.5}$, PM_{10} and TSP) associated with the activities of quarrying and mining of minerals other than coal are to be assigned to category 2A5a.

However, this activity does not occur in Luxembourg. Although clinker/cement production activity is occurring in Luxembourg (1 plant), quarrying and mining of raw materials is occurring in France. Indeed, the mine used by the clinker production facility (located in Rumelange) is situated in France (Ottange) just on the other side of the border. Raw materials are transported via covered conveyor belts (length approx. 1km) to the clinker production facility. In addition, national statistics do not publish data on quarrying of raw materials such as limestone or dolomite. Only import/export data is reported, also justifying the use of “NO”.

4.4 Construction and demolition (2.A.5.b)

4.4.1 Source category description

Emissions ($PM_{2.5}$, PM_{10} and TSP) associated with the construction and demolition activities are assigned to category 2A5b.

Table 4-3 gives an overview of the PM_{10} and $PM_{2.5}$ emission trends per construction type (residential - or non-residential buildings and road construction). Emissions from construction and demolition activities generally depend directly on the level of construction in Luxembourg. For residential buildings, emissions are increasing over the last decade due to the increasing population over the last decades. For non-residential buildings the trend is less clear although a recent increase is being observed mainly due to a favourable economic situation. Emissions from road construction are very variable due to the fact that road construction is only punctual due to the small size of Luxembourg.

Table 4-3 – PM_{10} and $PM_{2.5}$ emission trends per construction activity

PM10 (t)				
year	residential	non-residential	road construction	Total
1990	14.38	19.18	87.02	120.58
1991	14.35	24.79	0.00	39.14
1992	15.58	31.28	317.14	364.00
1993	17.65	24.79	93.28	135.72
1994	14.18	15.64	391.77	421.59
1995	14.27	22.13	37.31	73.71
1996	11.39	15.05	630.20	656.64
1997	10.94	14.46	152.57	177.97
1998	13.47	23.02	109.25	145.74
1999	15.10	28.63	0.00	43.73
2000	9.42	16.23	0.00	25.65
2001	12.33	27.15	0.00	39.48
2002	10.42	22.43	205.21	238.05
2003	12.26	21.54	391.77	425.57
2004	13.29	14.76	20.70	48.74
2005	11.61	15.05	18.66	45.32
2006	11.59	20.07	0.00	31.66
2007	15.19	14.76	0.00	29.95
2008	22.02	19.48	0.00	41.49
2009	22.59	13.28	93.28	129.15
2010	14.50	8.26	0.00	22.77
2011	12.95	9.74	0.00	22.69
2012	11.77	10.33	0.00	22.10
2013	14.48	8.56	0.00	23.03
2014	18.39	14.17	0.00	32.56
2015	15.74	12.39	167.90	196.03
2016	18.93	15.35	0.00	34.27
2017	20.76	11.80	74.62	107.19
2018	19.91	10.33	20.70	50.94
2019	18.43	12.69	0.00	31.12
2020	21.97	9.50	0.00	31.47
2021	21.30	10.74	0.00	32.04
2022	21.50	7.61	113.85	142.96
Trend 2021-2022	0.95%	-29.12%	NA	346.19%
2005-2022	85.21%	-49.41%	510.27%	215.49%
1990-2022	49.54%	-60.31%	30.84%	18.57%

PM2.5 (t)				
year	residential	non-residential	road construction	Total
1990	1.44	1.92	8.70	12.06
1991	1.44	2.48	0.00	3.91
1992	1.56	3.13	31.71	36.40
1993	1.77	2.48	9.33	13.57
1994	1.42	1.56	39.18	42.16
1995	1.43	2.21	3.73	7.37
1996	1.14	1.51	63.02	65.66
1997	1.09	1.45	15.26	17.80
1998	1.35	2.30	10.93	14.57
1999	1.51	2.86	0.00	4.37
2000	0.94	1.62	0.00	2.56
2001	1.23	2.72	0.00	3.95
2002	1.04	2.24	20.52	23.81
2003	1.23	2.15	39.18	42.56
2004	1.33	1.48	2.07	4.87
2005	1.16	1.51	1.87	4.53
2006	1.16	2.01	0.00	3.17
2007	1.52	1.48	0.00	2.99
2008	2.20	1.95	0.00	4.15
2009	2.26	1.33	9.33	12.91
2010	1.45	0.83	0.00	2.28
2011	1.30	0.97	0.00	2.27
2012	1.18	1.03	0.00	2.21
2013	1.45	0.86	0.00	2.30
2014	1.84	1.42	0.00	3.26
2015	1.57	1.24	16.79	19.60
2016	1.89	1.53	0.00	3.43
2017	2.08	1.18	7.46	10.72
2018	1.99	1.03	2.07	5.09
2019	1.84	1.27	0.00	3.11
2020	2.20	0.95	0.00	3.15
2021	2.13	1.07	0.00	3.20
2022	2.15	0.76	11.39	14.30
Trend 2021-2022	0.95%	-29.12%	NA	346.19%
2005-2022	85.21%	-49.41%	510.27%	215.49%
1990-2022	49.54%	-60.31%	30.84%	18.57%

Category *2A5b - Construction and demolition* is a key category in 2022 with regard to TSP emissions (LA) as presented in Table 4-4 (and also Chapter 1.5).

Table 4-4 – Key category analysis for category *2A5b - Construction and demolition*

Key Source Analysis (FUEL SOLD): Ranking per number		SO2		NOX		NMVOC		NH3		CO		TSP		PM10		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
2 A 5 b	Construction and demolition											7					

Sources: Environment Agency

Notes: LA = Level Assessment, TA = Trend Assessment

Number in Table = indicates the rank in the specific analysis (1…biggest KC; 2… second biggest KC, …)

4.4.2 Methodological issues & time-series consistency

4.4.2.1 Activity data

Activity data was based on official statistics as available from the national statistics institute (Statec) for the construction of residential and non-residential buildings, as well as for the construction of roads (Table 4-5). Constructed road length was converted to constructed road surface using the following assumptions:

- Municipal roads width: 18 m
- State roads: 20.25 m
- Highway with 4 side strips: 36.5 m

Please note that annual construction of new roads is very variable in Luxembourg, due to its small size.

Table 4-5 – Activity data: number of constructed buildings and roads per year

	Activity data buildings (number)			Activity data constructed roads (m2)		
year	**single family house**	**apartments**	**non-residential buildings**	**Municipal roads**	**State roads**	**Motorway (2x2)**
1990	1'427	168	65	0	60'750	109'500
1991	1'337	177	84	0	0	0
1992	1'311	207	106	0	0	620'500
1993	1'359	248	84	0	0	182'500
1994	1'159	192	53	0	0	766'500
1995	1'121	198	75	0	0	73'000
1996	1'018	145	51	1'233'000	0	0
1997	1'018	135	49	189'000	0	109'500
1998	1'001	193	78	72'000	141'750	0
1999	1'098	219	97	0	0	0
2000	897	114	55	0	0	0
2001	924	176	92	0	0	0
2002	786	148	76	0	0	401'500
2003	898	177	73	0	0	766'500
2004	841	206	50	0	40'500	0
2005	725	181	51	0	0	36'500
2006	665	187	68	0	0	0
2007	882	244	50	0	0	0
2008	1'236	358	66	0	0	0
2009	1'074	388	45	0	0	182'500
2010	747	243	28	0	0	0
2011	846	198	33	0	0	0
2012	1'013	154	35	0	0	0
2013	1'080	207	29	0	0	0
2014	1'278	273	48	0	0	0
2015	1'194	223	42	0	0	328'500
2016	1'183	295	52	0	0	0
2017	1'303	323	40	0	0	146'000
2018	1'106	325	35	0	40'500	0
2019	1'136	289	43	0	0	0
2020	1'119	369	32	0	0	0
2021	1'107	356	36	0	0	0
2022	1'051	366	26	0	222'750	0
Trend 2021-2022	-5.03%	2.92%	-29.12%	NA	NA	NA
2005-2022	44.98%	102.32%	-49.41%	NA	NA	-100.00%
1990-2022	-26.34%	117.98%	-60.31%	NA	266.67%	-100.00%

4.4.2.2 Methodology

The methodology used is the Tier 1 method as described in the EMEP/EEA Guidebook 2023. Default parameters, such as construction duration, control efficiency, soil moisture and soil silt content were either derived from the Guidebook or from the German inventory (Table 4-6).

Table 4-6 – Default parameters for construction in Luxembourg

Parameter	Unit	single family house	apartments	non-residential buildings	roads
construction duration	year	0.50	0.75	0.83	1.00
control efficiency		0.00	0.00	0.00	0.50
correction soil moisture		120.00	120.00	120.00	120.00
correction silt content		0.20	0.20	0.20	0.20

4.4.2.3 Emission factors

For the main air pollutants (TSP, PM_{10}, $PM_{2.5}$), the Tier 1 default emission factors from the EMEP/EEA Guidebook 2023 have been applied (Table 4-7).

Table 4-7 – Emission factors for construction of buildings and roads

Emission Factor	Unit	single family house	apartments	non-residential buildings	roads
TSP	kg/(m2*year)	0.29	1.00	3.30	7.70
PM_{10}	kg/(m2*year)	0.09	0.30	1.00	2.30
$PM_{2.5}$	kg/(m2*year)	0.01	0.03	0.10	0.23

4.4.3 Source-specific QA/QC and verification

The calculations of the data for this category are embedded in the overall QA/QC-system of Luxembourg's air emission inventory (see Chapter 1.6) of which important elements include:

- Are the correct values used (check for transcription errors, …)?
- Check of plausibility of input data (time-series, order of magnitude, …)
- Is the data set complete for the whole time series?
- Check of calculations, units ...
- Check of plausibility of results (time-series, order of magnitude, …)
- Correct transformation/transcription into NFR
- Where possible, data is checked with data from other sources, order of magnitude checks, …
- Are all references clearly made?
- Are all assumptions documented?

4.4.4 Category-specific recalculations including changes made in response to the review process

For buildings, emissions factors (EFs) were updated to match EMEP/EEA GB 2023 version, updated GB references, Efs were changed over entire timeseries, in total emissions were slightly lowered.

4.4.5 Category-specific planned improvements including those in response to the review process

The following improvements are planned for the next submission.

Table 4-8 – Planned improvements for category *2A5b - Construction and demolition*

Source category	Planned improvements	Type of revision
2A5b	No improvements are planned	

4.5 Iron and Steel production (2C1)

4.5.1 Source category description

Emissions (Pd, Cd, and Hg as well as POPs) associated with the iron and steel production activities are assigned to category 2C1. Four large point sources contribute to HM and POP emissions in this category (three electric arc furnaces in Esch-Belval, Esch-Schifflange (until 2014) and Differdange, as well as the Primorec plant in Differdange (from 2003 to 2009)).

4.5.2 Methodological issues & time-series consistency

4.5.2.1 Activity data

Annual operating hours and volumetric flow were taken from emission control measurement protocols; where measurement data were lacking: the annual fuel consumption was taken from the national energy balance.

4.5.2.2 Methodological Choices

Where appropriate data were available, HM and POP emissions were either taken directly from the official declaration of the respective plant or calculated based on annual emission control measurements and activity data obtained from the operating company.

Regarding the three electric arc furnaces, gaps lacking measured data were filled using energy consumption data from the national energy balance. Since process-related emissions in EEA (2023) are stated in relation to production volumes, energy consumption data had to be transformed into tons of steel produced. For this purpose, we employed the average energy demand per ton of steel produced stated in the EEA (2023). In order to obtain a transformation factor only for fuel consumption (electric energy as a secondary source of energy is not included in the energy balance) we subtracted the proportion of electrical energy included in total energy consumption (about 60 percent) from the initial value (cf. EEA 2023, chapter 2.C.1, p. 19). Finally, this transformation leads to a demand for combustibles of 0.975 GJ per ton of electrically produced steel. Emission factors employed here are technology-specific (tier 2 approach). In order to obtain most realistic values, emissions calculated on the basis of annual fuel consumption were offset with a correction factor based on actual measurements of a reference year (ratio of the measured emission value to the appropriate value based on fuel consumption; both of the closest year with measurements).

Measurements of HM emissions for the Primorec plant were only available from 2009. For all other years (2003 – 2008), HM emissions were calculated on the basis of total annual fuel consumption taken from the national energy balance. The Primorec plant consisted of several facilities with different production techniques (doghouse and MHF/MF) but in contrast to that, fuel consumption in the national energy balance is given as a single value without accounting for different production processes. For this reason, technology-specific emission factors could not be employed. Instead, we transformed measured emissions proportionally to the ratio of energy consumption of the year with measurements and the year in question (rule of three). In this approach, we could only consider total energy consumption without being able to account for the different types of fuel used.

Regarding HCB and for the years 1990 - 1997, emission factors from Austria were used: 138 ug/t steel for Basic Oxygen Furnace and 30 ug/t for Blast Furnace Charging, respectively. IEFs were used for the electric arc furnaces. To smooth out the large interannual fluctuations, the IEFs were averaged over 5 years. For the years 2016 - 2020, HCB emissions were calculated based on the share of HCB in the total load of heavy chlorobenzenes from the detailed measurement reports of the electric steel plants.

For the Primorec plant, measurements of PCDD/F, PCB, and PAH emissions were only available from 2009. These values were used to extrapolate emissions for the other years (proportional to energy consumption).

Fuel consumption data were obtained from the national energy balance.

4.5.2.3 Emission Factors

Tier 2 emission factors for process-related emissions:

Process	Pollutants	Source	Page	Table
Steel production (electr. arc furnace)	PCDD/F, PCB, PAH	EEA (2023) – Chapter 2.C.1 Iron and steel production	40	3.15

4.5.3 Source-specific QA/QC and verification

Along the general QA/QC procedures as embedded in in the overall QA/QC-system of Luxembourg's air emission inventory (see Chapter 1.6), no further source-specific QA/QC was operated.

4.5.4 Category-specific recalculations including changes made in response to the review process

No recalculations were operated since the last submission.

4.5.5 Category-specific planned improvements including those in response to the review process

No further improvements are planned.

4.6 Aluminium production (2C3)

4.6.1 Source category description

Emissions (Pd, Cd, and Hg) associated with the aluminium production activities are assigned to category 2C3. Process related emissions of three large point sources were considered in this category: two secondary aluminium melts in Clervaux (Hydro Aluminium and

Alcuilux) and an aluminium melt in Dudelange (Novelis/Eurofoil). The Novelis and Alcuilux melts were operational during the entire timeseries, whereas the Hydro Aluminium plant was put into service in 1996 as a spin-off from Alcuilux.

4.6.2 Methodological issues & time-series consistency

4.6.2.1 Activity data

Annual operating hours and volumetric flow were taken from emission control measurement protocols; where measurement data were lacking: the annual fuel consumption was taken from the national energy balance.

4.6.2.2 Methodological Choices

Where appropriate data were available, HM emissions were taken directly from the official declaration of the respective plant or calculated based on annual emission control measurements and activity data obtained from the operating company.

For the three secondary aluminium melts, emission measurements were available for the following years:

	Pb	Cd	Hg
Alcuilux	1994, 2009 2012, 2015, 2018 - 2020	1994, 2009 2012, 2015, 2018 - 2020	1994, 2015
Hydro Aluminium	2005, 2009 - 2011, 2015 – 2022	2005, 2009 - 2011, 2015 – 2022	2015
Novelis/Eurofoil	2009 - 2022	2009 - 2022	2014, 2015

Emission values were taken directly from the official declaration of the respective plant or calculated based on measured data, annual operating hours (stated in some of the measurement protocols) and technology-specific emission factors from the EEA guidebooks (tier 2 approach). Where measurement data were lacking, emissions were calculated on the basis of annual consumption of different fuels (natural gas, LPG) using the appropriate emission factors from the EEA guidebooks (combustion in manufacturing industries and construction; all tier 1 approach). In order to obtain most realistic values, emissions calculated on the basis of annual fuel consumption were offset with a correction factor based on actual measurements of a reference year (ratio of the measured emission value to the appropriate value based on fuel consumption; both of the closest year for which measured data were available).

Regarding PCDD/F and PCB emissions the same approach as described above was used. Hence, emission values were taken directly from the official declaration of the respective plant or calculated based on measured data and annual operating hours (stated in some of the measurement protocols). Where measurement data were lacking, emissions were calculated based on the annual fuel consumption or production data and using either technology-specific emission factors from the UNEP POPs toolkit[60] (tier 2 approach), or implied emission factors for which measurements were available for at least one year.

HCB emissions were calculated based on the Tier 2 emission factor from the UNEP POPs toolkit and plant-specific production data.

Fuel consumption data were obtained from the national energy balance and production data was obtained through the reporting obligations of the different plants.

[60] Thermal Al processing, scrap pre-treatment, well-controlled, fabric filters with lime injection: https://toolkit.pops.int/Publish/Downloads/UNEP-POPS-TOOLKIT-2012-En.pdf

4.6.2.3 Emission Factors

Tier 2 emission factors for process-related emissions:

Process	Pollutants	Source	Page	Table
Secondary aluminium production	PCDD/F PCB HCB	UNEP POPs toolkit 2012	57 242 242	II.2.7 III.20.1 III.20.2

4.6.3 Source-specific QA/QC and verification

Along the general QA/QC procedures as embedded in in the overall QA/QC-system of Luxembourg's air emission inventory (see Chapter 1.6), no further source-specific QA/QC was operated.

4.6.4 Category-specific recalculations including changes made in response to the review process

No recalculations were operated since the last submission.

4.6.5 Category-specific planned improvements including those in response to the review process

No further improvements are planned.

4.7 Non-energy products from fuels and solvent use (2.D.3)

4.7.1 Source category description

Solvents are chemical compounds, which are used to dissolve substances as paint, glues, ink, rubber, plastic, pesticides or for cleaning purposes (degreasing). Solvents used in products such as coatings, inks, and consumer products generally emit substances classified as VOCs (Volatile Organic Compounds). Because solvents consist mainly of NMVOC, solvent use is a major source for anthropogenic NMVOC emissions in Luxembourg. Once released into the atmosphere NMVOCs react with reactive molecules (mainly HO-radicals) or high energetic light to finally form CO_2.

As presented in Table 4-9, with regard to NMVOC emissions, 2D3 - Non-energy products from fuels and solvent use is a key category (LA & TA) in 2022 .

Table 4-9 – Key category analysis for category *2D3 - Non-energy products from fuels and solvent use: Other*

Key Source Analysis (FUEL SOLD): Ranking per number		SO2		NOX		NMVOC		NH3		CO		TSP		PM10		PM2.5	
NFR Code	**NFR Category**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**
2 D 3 a	Domestic solvent use including fungicides					1	2										
2 D 3 b	Road paving with asphalt											8					
2 D 3 d	Coating application					5											
2 D 3 g	Chemical products					7	6										
2 D 3 i	Other solvent use					4											

Key Source Analysis (FUEL USED): Ranking per number		SO2		NOX		NMVOC		NH3		PM2.5	
NFR Code	**NFR Category**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**	**LA**	**TA**
2 D 3 a	Domestic solvent use including fungicides					1	2				
2 D 3 d	Coating application					5					
2 D 3 g	Chemical products					7	7				
2 D 3 i	Other solvent use					4	5				

Sources: Environment Agency

Notes: LA = Level Assessment, TA = Trend Assessment

Number in Table = indicates the rank in the specific analysis (1…biggest KC; 2… second biggest KC, …)

NMVOC emissions (Table 4-10 & Figure 52) in category *2D3 - Non-energy products from fuels and solvent use* decreased by 46.25% between 1990 and 2022. While the Luxembourgish population has seen a 75% increase in the same time span, the reduced solvent use can partially be related to the positive impact of the enforced laws and regulations in Luxembourg:

- Solvent Ordinance: for limitation of emission of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products in order to combat acidification and ground-level ozone[61];
- Ordinance for paint finishing system (surface technology systems): for limitation of emission of volatile organic compounds due to the use of organic solvents by activities such as surface coating, painting or varnishing of different materials and products along the entire chain in the painting process in order to combat acidification and ground-level ozone[62]

[61] Règlement grand-ducal du 7 avril 2011 remplaçant l'annexe III du règlement grand-ducal modifié du 25 janvier 2006 relatif à la réduction des émissions de composés organiques volatils dues à l'utilisation de solvants organiques dans certains vernis et peintures et dans les produits de retouche de véhicules. (implementation of European Council Directive 2004/42/CE and European Council Directive 2010/79/EC).

[62] Règlement grand-ducal du 20 décembre 1995 relatif à certaines modalités d'application et à la sanction du règlement CE N° 3093/94 du Conseil du 15 décembre 1994 relatif à des substances qui appauvrissent la couche d'ozone.

- Ordinance for industrial facilities and installations applying chlorinated hydrocarbon: for limitation of emission of chlorinated organic solvents from industrial facilities and installations applying chlorinated hydrocarbon;
- Convention on Long-Range Transboundary Air Pollution (LRTAP)[63], extended by eight protocols from which the following have relevance:
    - The 1988 Protocol concerning the Control of Nitrogen Oxides or their Transboundary Fluxes;[64]
    - The 1991 Protocol concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes;[65]
    - The 1998 Protocol on Persistent Organic Pollutants (POPs);[66]
    - The 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone; 21 Parties.[67]
- Ordinance for volatile organic compounds (VOC) due to the use of organic solvents in certain activities and installations;[68]
- European Council Directive 1999/13/EC of March 1999 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations;
- European Council 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;
- Regulation on the limitation of emission during the use of solvents containing lightly volatile halogenated hydrocarbons in industrial facilities and installations.[69]

---

63 Loi du 18 juin 1981 portant approbation de la Convention sur la pollution atmosphérique transfrontière à longue distance, en date à Genève, du 13 novembre 1979. (Convention entered into force 16 March 1983; ratified by Luxembourg 15 July 1982)

64 Loi du 31 juillet 1990 portant approbation du Protocole à la Convention sur la pollution atmosphérique transfrontière à longue distance de 1979, relatif à la lute contre les émissions d'oxydes d'azote ou leurs flux transfrontières, fait à Sofia, le 31 octobre 1988. (Protocol entered into force 14 February 1991; ratified by Luxembourg 4 October 1990)

65 Loi du 29 juillet 1993 portant approbation du Protocole à la Convention sur la pollution atmosphérique transfrontière à longue distance, de 1979, relatif à la lutte contre les émissions de composés organiques volatils ou de leurs flux transfrontières, fait à Genève, le 18 novembre 1991. (Protocol entered into force 29 September 1997; ratified by Luxembourg 11.11.1993)

66 Loi du 24 décembre 1999 portant approbation du Protocole à la Convention sur la pollution atmosphérique transfrontière à longue distance, de 1979, relatif aux polluants organiques persistants, fait à Aarhus (Danemark), le 24 juin 1998. (Protocol entered into force on 23 October 2003; ratified by Luxembourg 01.05.2000)

67 Loi du 14 juin 2001 portant approbation du Protocole à la Convention de 1979 sur la pollution atmosphérique transfrontière à longue distance, relatif à la réduction de l'acidification, de l'eutrophisation et de l'ozone troposphérique, fait à Göteborg, le 30 novembre 1999. (Protocol entered into force on 17 May 2005; ratified by Luxembourg 07.08.2001)

68 Règlement grand-ducal du 3 décembre 2010 modifiant le règlement grand-ducal modifié du 4 juin 2001 portant - application de la directive 1999/13/CE du Conseil du 11 mars 1999 relative à la réduction des émissions de composés organiques volatils dues à l'utilisation de solvants organiques dans certaines activités et installations; - modification du règlement grand-ducal modifié du 16 juillet 1999 portant nomenclature et classification des établissements classes;.

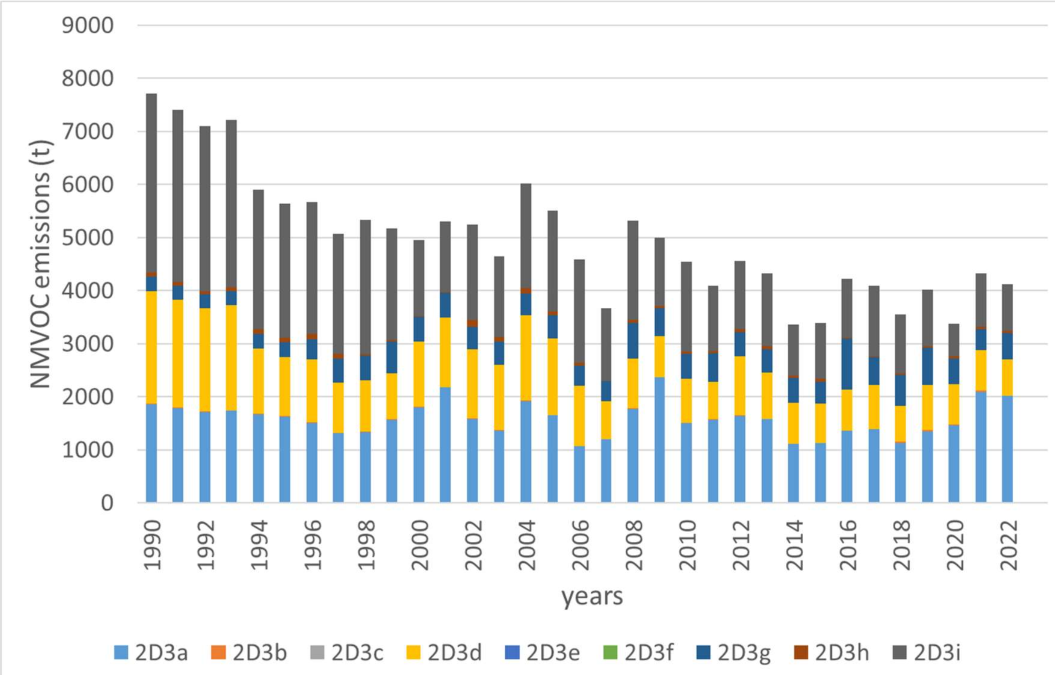
69 Règlement grand-ducal du 12 juillet 1995, relatif aux générateurs d'aérosols.

Table 4-10 – NMVOC emission trends for category *2D3 - Non-energy products from fuels and solvent use: Other*

2D3 - Solvent and Product Use										
NMVOC emissions (Gg)										
Year	2D3 TOTAL	2D3a Dometics solvent use including fungicides	2D3b Road paving with asphalt	2D3c Asphalt roofing	2D3d Coating applications	2D3e Degreasing	2D3f Dry cleaning	2D3g Chemical products	2D3h Printing	2D3i Other solvent use
1990	7.71	1.86	0.01	NO	2.12	IE	IE	0.28	0.07	3.38
1991	7.41	1.78	0.01	NO	2.03	IE	IE	0.27	0.07	3.24
1992	7.10	1.71	0.01	NO	1.95	IE	IE	0.26	0.07	3.11
1993	7.21	1.74	0.01	NO	1.98	IE	IE	0.26	0.07	3.16
1994	5.90	1.67	0.01	NO	1.23	IE	IE	0.27	0.09	2.63
1995	5.65	1.63	0.01	NO	1.11	IE	IE	0.28	0.08	2.54
1996	5.66	1.51	0.01	NO	1.18	IE	IE	0.38	0.10	2.48
1997	5.07	1.31	0.01	NO	0.95	IE	IE	0.45	0.09	2.27
1998	5.33	1.33	0.01	NO	0.96	IE	IE	0.48	0.02	2.52
1999	5.17	1.57	0.01	NO	0.86	IE	IE	0.60	0.03	2.10
2000	4.96	1.79	0.01	NO	1.24	IE	IE	0.46	0.02	1.44
2001	5.30	2.17	0.01	NO	1.31	IE	IE	0.46	0.02	1.33
2002	5.25	1.59	0.01	NO	1.30	IE	IE	0.42	0.13	1.80
2003	4.65	1.36	0.02	NO	1.22	IE	IE	0.44	0.08	1.53
2004	6.02	1.92	0.00	NO	1.60	IE	IE	0.42	0.10	1.97
2005	5.50	1.65	0.00	NO	1.45	IE	IE	0.44	0.07	1.89
2006	4.59	1.07	0.00	NO	1.13	IE	IE	0.38	0.06	1.94
2007	3.67	1.20	0.00	NO	0.71	IE	IE	0.38	0.01	1.38
2008	5.32	1.78	0.00	NO	0.94	IE	IE	0.67	0.05	1.87
2009	5.00	2.37	0.00	NO	0.77	IE	IE	0.53	0.04	1.29
2010	4.55	1.50	0.00	NO	0.83	IE	IE	0.47	0.03	1.70
2011	4.09	1.57	0.00	NO	0.70	IE	IE	0.53	0.05	1.23
2012	4.56	1.64	0.00	NO	1.11	IE	IE	0.46	0.05	1.29
2013	4.33	1.58	0.00	NO	0.87	IE	IE	0.45	0.05	1.38
2014	3.36	1.11	0.01	NO	0.78	IE	IE	0.45	0.05	0.96
2015	3.38	1.12	0.00	NO	0.75	IE	IE	0.40	0.06	1.05
2016	4.22	1.36	0.00	NO	0.77	IE	IE	0.96	0.02	1.10
2017	4.09	1.39	0.00	NO	0.83	IE	IE	0.53	0.02	1.32
2018	3.56	1.13	0.03	NO	0.67	IE	IE	0.59	0.02	1.12
2019	4.01	1.34	0.03	NO	0.85	IE	IE	0.70	0.02	1.07
2020	3.38	1.46	0.02	NO	0.75	IE	IE	0.49	0.04	0.62
2021	4.32	2.09	0.03	NO	0.76	IE	IE	0.40	0.04	1.00
2022	4.14	2.01	0.03	NO	0.69	IE	IE	0.51	0.04	0.87
Trend 1990-2022	-46.25%	8.36%	228.77%	NA	-67.62%	NA	NA	81.21%	-51.56%	-74.10%
2005-2022	-24.66%	21.76%	533.51%	NA	-52.58%	NA	NA	15.96%	-52.31%	-53.65%
2021-2022	-4.03%	-3.75%	-3.14%	NA	-9.65%	NA	NA	27.72%	-10.81%	-12.72%

Source: Environment Agency.

Figure 52 – NMVOC emissions for subcategory *2D3 - Non-energy products from fuels and solvent use: Other*



Source : Environment Agency

Particulate matter emissions (PM_{10} and $PM_{2.5}$) occur during the production of asphalt for road paving and are reported under category *2D3b - Road paving with asphalt*. In 2022, PM_{10} emissions of this category had a share of 0.88% of the national total PM_{10} emissions (fuel sold) and $PM_{2.5}$ a share of 0.33% of the national total $PM_{2.5}$ emissions (fuel sold). Compared to 1990, emissions decreased by 73%, due to more effective abatement technology used and a switch from coal-based production processes (drum heating) to more gas fired road paving asphalt production (Table 4-11). Methodological issues for category *2D3b - Road paving with asphalt* are described in section 4.7.3.

Category *2D3c - Asphalt roofing* does not exist in Luxembourg, hence, notation key "NO" is used.

Table 4-11 –Particulate matter emissions for category *2D3b - Road paving with asphalt*

	Activity Data (kt)	Emissions (t)		
year	Asphalt produced	TSP	PM_{10}	$PM_{2.5}$
1990	608.880	0.237	0.055	0.013
1991	529.120	0.206	0.048	0.011
1992	583.052	0.227	0.052	0.012
1993	455.934	0.178	0.041	0.010
1994	864.349	0.337	0.078	0.018
1995	452.471	0.176	0.041	0.010
1996	684.634	0.267	0.062	0.014
1997	623.154	0.243	0.056	0.013
1998	555.976	0.217	0.050	0.012
1999	859.039	0.335	0.077	0.018
2000	827.880	0.323	0.075	0.017
2001	740.321	0.289	0.067	0.016
2002	722.684	0.282	0.065	0.015
2003	1200.022	0.468	0.108	0.025
2004	539.700	0.123	0.028	0.007
2005	560.490	0.125	0.029	0.007
2006	564.883	0.119	0.027	0.006
2007	630.567	0.137	0.032	0.007
2008	606.886	0.121	0.028	0.007
2009	688.418	0.140	0.032	0.008
2010	627.093	0.120	0.028	0.006
2011	783.181	0.151	0.035	0.008
2012	703.165	0.126	0.029	0.007
2013	607.814	0.103	0.024	0.006
2014	690.515	0.058	0.013	0.003
2015	607.760	0.044	0.010	0.002
2016	768.686	0.040	0.009	0.002
2017	685.024	0.030	0.007	0.002
2018	671.173	0.022	0.005	0.001
2019	642.210	0.040	0.009	0.002
2020	626.732	0.019	0.004	0.001
2021	711.414	0.005	0.001	0.000
2022	631.074	0.065	0.015	0.003
Trend 2021-2022	-11.29%	1112.27%	1112.27%	1112.27%
2005-2022	12.59%	-48.04%	-48.04%	-48.04%
1990-2022	3.65%	-72.75%	-72.75%	-72.75%

Source : Environment Agency

4.7.2 Methodology overview for categories 2D3a and 2D3d-i

NMVOC emissions from solvent containing substances and products are calculated as follows:

a) The starting point is the import statistics of solvent-containing substances and products provided by the national statistics office. Approximately 500 different products and substances are listed according to their combined nomenclature (CN) code.

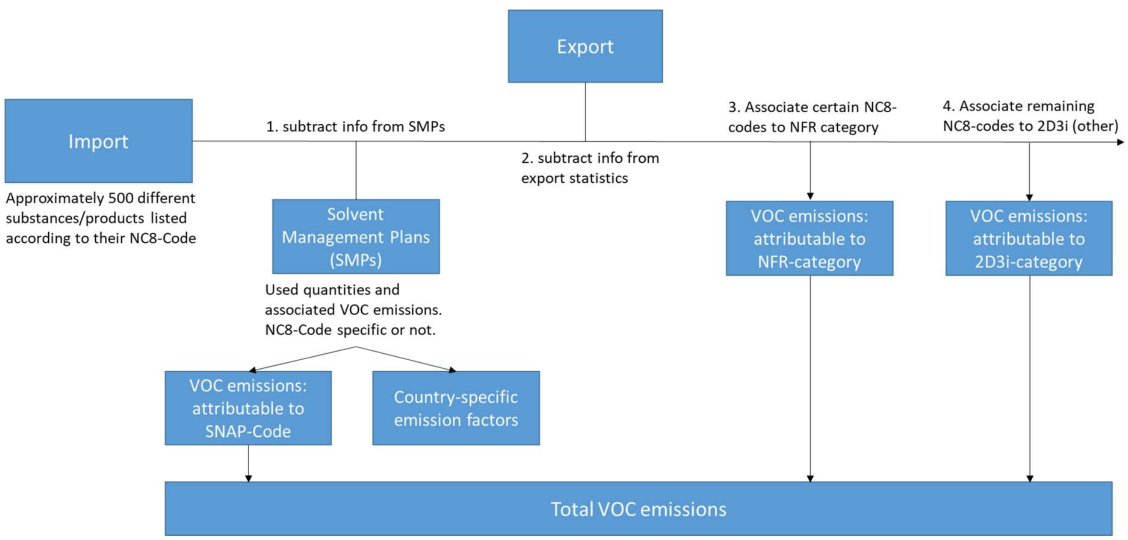
b) Next, solvent management plans (SMPs) from companies are analyzed, which are yearly submitted to the Environmental Administration according to the Directive 2010/75/EU of the European parliament and of the council of 24 November 2010 on industrial emissions (integrated pollution prevention and control). SMPs provide information about the consumption of certain solvent-containing substances and products as well as the resulting NMVOC emissions. Thus, country specific emission factors (kg NMVOC / kg substance/product) can be determined for the utilized substances/products. Finally, the quantities are subtracted from the import statistics.

c) Then, the export statistics are used to account for the exported quantities. However, quantities are set to 0 in case that quantities become negative after subtraction.

d) Subsequently, certain substances and products are linked to be used under certain NFR categories. This attribution links the emissions, calculated in the next step, to a certain NFR category as well.

e) Finally, NMVOC emissions for all remaining CN-code specific quantities are calculated. Emission factors are used based on the former model of Luxembourg, which itself is based on the Austrian inventory calculations. Emissions are attributed to previously attributed NFR-categories. In case that a certain substance or product cannot be attributed to a NFR-category, emissions are allocated under category 2D3i (Other solvent and product use).

It is noted that the SMPs are first account for prior to subtracting the export statistics. The reasoning is that these quantities are judged to be more accurate.



The approach is motivated as follows:

- Data from the European Solvents Industry Group (ESIG) is not available solely for Luxembourg due to confidentially reasons and is thus only available in aggregated form with the Belgian statistics.
- No other federations exist in Luxembourg, who gather statistics covering solvent-containing products.
- Thus, the only source of activity data is the national statistics on import and export of solvent-containing substances and products, which are disaggregated according to their CN-code provided by the national statistics agency.
- Additional data is gathered from solvent management plans (SMPs). Only a few sufficiently large companies exist in Luxembourg. However, the SMPs cover already a large portion of the imported solvent-containing products and substances. The reported emissions can directly by associated with a SNAP code and thus a NFR category.

It is noted that no statistics are available, which cover the production of solvent-containing substances and products. However, as Luxembourg is a small country and a major contribution to NMVOC emissions arises from a few international companies, the error is assumed to be small when treating the production within the export statistics.

The following issues arise for the approach described above.

- Some SMPs do not give details about which substances/products are used, but only specify the quantity of NMVOC input. In these cases, quantities and emissions cannot be associated to a specific CN-code. Nevertheless, the information of the SNAP-code is used, which is attributed to the company. Consequently, the emissions can also be attributed to that SNAP-Code. Thus, the emissions are subtracted from the previously calculated category 2D3i and added to the NFR-category corresponding to the given SNAP-code of the company.

- SMPs are not available for the entire timeline starting from 1990. Thus, for each company the NC8-code specific information is extrapolated towards the past until the year where the company is founded. If T is the year of the earliest available SMP for a certain company, the relative amount $p_{SMP,NC8,T}$ with respect to the total import $IMP_{NC8,T}$ is calculated. For earlier years $T-x$, the used quantities by this company are determined by $q_{PGS,NC\ ,T-x} = IMP_{NC8,T-x}\ p_{PGS,NC8,T}$.

In case that a subset of the used quantities cannot be related to a CN-code in the earliest available SMP, extrapolation is still performed for these quantities. In that case, extrapolation is carried out after the extrapolation of items with a CN-code is completed according to:

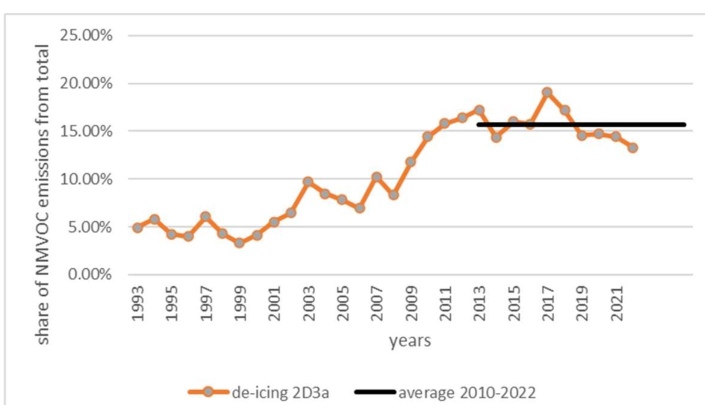
$$q_{NC8=None,T-x} = q_{NC8=None,T} \times \frac{q_{NC8,T-x}}{q_{NC8,T}}$$

Thus, these quantities without a NC8-code scale the same way as the quantities having a NC8-code.

In case that no quantities of a company's SMP can be related to a NC8-code, no extrapolation is carried out.

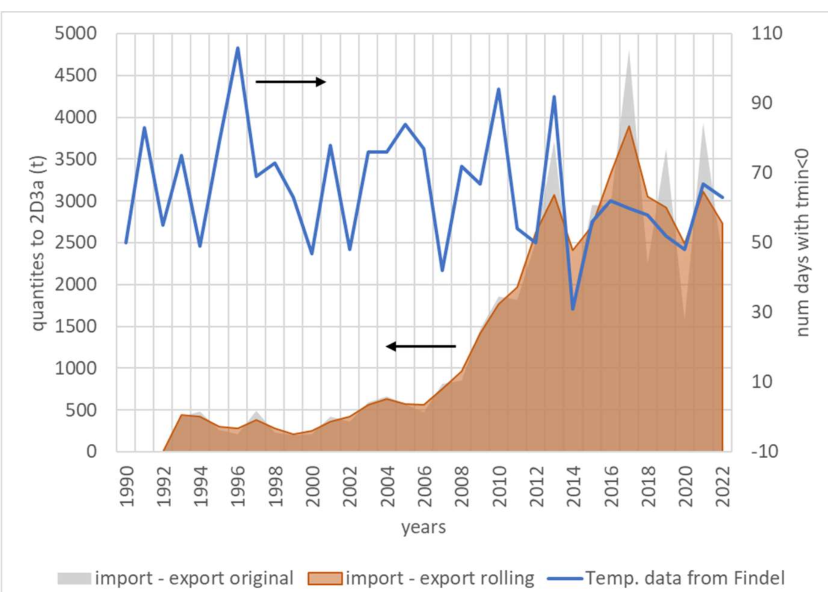
4.7.2.1 De-icing products

As can be seen below, a major contribution to the national NMVOC emissions in the category 2D3 are de-icing products allocated to the 2D3a (domestic solvent use including fungicides) category. Between 2010 and 2022, emissions of de-icing products in the category 2D3a amount to an average of 15.7 % of the total 2D3 emissions.



In order to account for emissions from de-icing products in general, the following steps are taken:

- De-icing products (single CN-code) are split into two categories with allocations to the NFR categories 2D3a and 2D3i. According to the EMEP/EEA Guidebook, 50 % of the total de-icing products should be allocated to each of these two NFR categories. However, in Luxembourg the transport sector has a major contribution due to the relatively large amount of commuters, suggesting that a larger portion than 50 % should be allocated to the category 2D3a. Second, in Luxembourg only a single airport exists from which the amount of used de-icing quantities are available to the Environment Administration. Consequently, the quantities provided by the Luxembourgish Airport are allocated to 2D3i, whereas the rest of the de-icing products are allocated to 2D3a.
- Second, the year-to-year import statistic of de-icing products varies significantly. Those products are generally utilized in the winter months, i.e. at a time where the statistics for one year are concluded and the statistics for the next year commence. However, storage is not taken into account in the statistics. Therefore, a rolling average is calculated for the import of de-icing products, which are allocated to the 2D3a category. For the rolling average, the window-size is 3, the center-point is weighted with 100 %, whereas the neighbouring points are weighted with 35 %. With these parameters, the shape of the import is maintained, while the peaks are flattened slightly. Indeed, the Figure below shows a decent correlation between the amount of de-icing products allocated to 2D3a and the temperatures - more precisely the number of days where temperatures fall between 0 °C. In particular, a better match is observed when using the rolling average (red area) instead of the original data (gray area).
- In addition, a strong increase in de-icing products allocated to 2D3a is observed since 2007. It is assumed that the solvent-content of de-icing products is reduced over time, so that ready-to-use solutions are directly available to the consumers and no additional dilution is necessary (i.e. de-icing fluids with a freezing point of -10 or -5 °C). Consequently, the emission factor (kg NMVOC / kg product) is reduced from 50% in 2007 to 20 % in 2014. The year 2014 is chosen because since then the quantity of de-icing products allocated to 2D3a does not show a trend anymore but only fluctuations.



4.7.2.2 Rolling average for other products

A relatively strong variation in import and export is also observed for some other products allocated to the 2D3a category. For those items, a rolling average is calculated the same way as for de-icing products described above. Table 4-12 gives an overview of all products, for which such a rolling average is calculated.

Table 4-12 - Product categories with rolling average

CN-Code	Short description
38200000998	domestic_Préparations antigel et liquides préparés…
33072000	Personal deodorants and antiperspirants
33074900	Preparations for perfuming or deodorising rooms, i…
33053000	Hair lacquers
33071000	Shaving preparations, incl. pre-shave and aftersha…
34029090	Washing preparations, incl. auxiliary washing prep…

4.7.2.3 Items allocated to NFR categories

The items listed in Table 4-13 are allocated to NRF categories. It is noted that the NC8-code 38140090 is split to be allocated to category 2D3d and 2D3a with a share of 70 % and 30 % respectively. Therefore, the NC8-code is extended to distinguish between these two in the calculations. Similarly, de-icing products are split. Here, only the de-icing products allocated to 2D3a are listed, while the de-icing products used by the airport are contained in the information of the SMPs (thus not listed in Table 4-13). It is noted that all items starting with the NC8-code 3808 are allocated to 2D3a as well and in the calculations an emission factor (kg NMVOC / kg product) of 0.15 is used according to the EMEP/EEA guidebook (Chapter: 2.D.3.a Domestic solvent use including fungicides).

Table 4-13 – Product codes and NFR category allocation

CN-Code	NRF category	Abbreviated description
32064970	2D3g	Matières colorantes inorganiques ou minérales, n.d…
32081090	2D3d	Paints and varnishes, incl. enamels and lacquers, …
32082090	2D3d	Paints and varnishes, incl. enamels and lacquers, …
32089091	2D3d	Paints and varnishes, incl. enamels and lacquers, …
32089099	2D3d	Paints and varnishes, incl. enamels and lacquers, …
32091000	2D3d	Paints and varnishes, incl. enamels and lacquers, …
32099000	2D3d	Paints and varnishes, incl. enamels and lacquers, …
32100010	2D3d	Oil paints and varnishes, incl. enamels and lacque…
32100090	2D3d	Paints and varnishes, incl. enamels, lacquers and …
32141090	2D3d	Painter's fillings
32151100	2D3h	Black printing ink, whether or not concentrated or…
32151900	2D3h	Printing ink, whether or not concentrated or solid…
32159020	2D3a	Cartouches d'encre pour imprimantes/photocopieurs,…
33030010	2D3a	Perfumes (excl. aftershave lotions and personal de…

33030090	2D3a	Toilet waters (excl. aftershave lotions, deodorant…
33049900	2D3a	Beauty or make-up preparations and preparations fo…
33052000	2D3a	Preparations for permanent waving or straightening…
33053000	2D3a	Hair lacquers
33059000	2D3a	Preparations for use on the hair (excl. shampoos, …
33059010	2D3a	Hair lotions
33059090	2D3a	Preparations for use on the hair (excl. shampoos, …
33071000	2D3a	Shaving preparations, incl. pre-shave and aftersha…
33072000	2D3a	Personal deodorants and antiperspirants
33074900	2D3a	Preparations for perfuming or deodorising rooms, i…
33079000	2D3a	Depilatories and other perfumery, toilet or cosmet…
34029090	2D3a	Washing preparations, incl. auxiliary washing prep…
34051000	2D3a	Polishes, creams and similar preparations, for foo…
34052000	2D3a	Polishes, creams and similar preparations, for the…
34053000	2D3a	Polishes and similar preparations for coachwork, w…
34059010	2D3a	Metal polishes, whether or not in the form of pape…
38063000	2D3g	Ester gums
3808*	2D3a	Pesticides
38140090998	2D3d	2D3d_Organic composite solvents and thinners and p…
38140090999	2D3a	2D3a_Organic composite solvents and thinners and p…
38200000998	2D3a	domestic_Anti-freezing preparations and prepared d…

4.7.2.4 Activity data and implied emission factor

Finally, combining the information from the SMPs and the import and export statistics, the following activity (Table 4-14) and NMVOC emissions (Table 4-15) per NFR category is obtained.

Table 4-14 – Solvent and product use activity data

2D3 - Solvent and Product Use										
Activity Data (Gg)										
Year	2D3 TOTAL	2D3a Dometics solvent use including fungicides	2D3b Road paving with asphalt	2D3c Asphalt roofing	2D3d Coating applications	2D3e Degreasing	2D3f Dry cleaning	2D3g Chemical products	2D3h Printing	2D3i Other solvent use
1990	68.08	8.76	N/A	NO	5.92	IE	IE	3.14	1.25	49.01
1991	65.40	8.42	N/A	NO	5.69	IE	IE	3.01	1.20	47.08
1992	62.72	8.07	N/A	NO	5.45	IE	IE	2.89	1.15	45.16
1993	63.69	8.20	N/A	NO	5.54	IE	IE	2.94	1.16	45.86
1994	84.31	8.31	N/A	NO	4.10	IE	IE	3.80	1.46	66.64
1995	71.27	8.47	N/A	NO	3.99	IE	IE	4.06	1.33	53.43
1996	55.72	6.19	N/A	NO	4.62	IE	IE	7.72	1.54	35.65
1997	60.76	6.89	N/A	NO	3.67	IE	IE	9.79	1.54	38.87
1998	47.62	7.35	N/A	NO	3.58	IE	IE	9.62	0.44	26.63
1999	74.17	9.45	N/A	NO	3.63	IE	IE	13.66	0.57	46.86
2000	79.96	10.95	N/A	NO	3.83	IE	IE	11.44	0.27	53.47
2001	70.51	13.31	N/A	NO	3.46	IE	IE	13.31	0.27	40.15
2002	71.14	9.16	N/A	NO	5.09	IE	IE	13.45	2.56	40.88
2003	70.97	8.21	N/A	NO	4.98	IE	IE	15.16	1.72	40.91
2004	80.43	7.24	N/A	NO	7.08	IE	IE	21.31	2.22	42.58
2005	79.01	5.92	N/A	NO	7.50	IE	IE	24.94	1.72	38.92
2006	73.98	7.15	N/A	NO	8.07	IE	IE	23.33	1.55	33.88
2007	66.08	8.82	N/A	NO	4.53	IE	IE	23.41	0.16	29.16
2008	81.23	11.24	N/A	NO	7.70	IE	IE	28.40	1.34	32.56
2009	68.07	12.11	N/A	NO	6.91	IE	IE	26.62	1.12	21.30
2010	65.19	9.04	N/A	NO	7.51	IE	IE	19.45	1.00	28.18
2011	79.01	9.50	N/A	NO	8.24	IE	IE	31.06	1.52	28.69
2012	77.47	10.33	N/A	NO	8.56	IE	IE	28.95	1.72	27.91
2013	83.35	11.12	N/A	NO	8.25	IE	IE	32.49	1.85	29.64
2014	76.00	8.95	N/A	NO	7.60	IE	IE	31.32	1.97	26.17
2015	79.09	8.43	N/A	NO	8.31	IE	IE	34.15	2.59	25.60
2016	78.57	9.11	N/A	NO	7.77	IE	IE	36.64	0.92	24.13
2017	92.60	9.91	N/A	NO	8.51	IE	IE	47.59	0.81	25.78
2018	88.07	8.67	N/A	NO	7.74	IE	IE	47.01	0.92	23.74
2019	96.61	9.50	N/A	NO	7.31	IE	IE	46.53	1.02	32.26
2020	94.41	9.79	N/A	NO	6.94	IE	IE	48.79	1.12	27.77
2021	107.32	10.74	N/A	NO	8.53	IE	IE	51.96	1.19	34.90
2022	100.92	9.62	N/A	NO	8.19	IE	IE	49.32	0.82	32.97
Trend 1990-2022	48.25%	9.77%	NA	NA	38.43%	NA	NA	1471.88%	-34.09%	-32.74%
2005-2022	27.74%	62.45%	NA	NA	9.19%	NA	NA	97.77%	-52.29%	-15.30%
2021-2022	-5.97%	-10.45%	NA	NA	-3.90%	NA	NA	-5.08%	-31.06%	-5.55%

Table 4-15 – Solvent and product use NMVOC emissions

2D3 - Solvent and Product Use										
NMVOC emissions (Gg)										
Year	2D3 TOTAL	2D3a Dometics solvent use including fungicides	2D3b Road paving with asphalt	2D3c Asphalt roofing	2D3d Coating applications	2D3e Degreasing	2D3f Dry cleaning	2D3g Chemical products	2D3h Printing	2D3i Other solvent use
1990	7.71	1.86	0.01	NO	2.12	IE	IE	0.28	0.07	3.38
1991	7.41	1.78	0.01	NO	2.03	IE	IE	0.27	0.07	3.24
1992	7.10	1.71	0.01	NO	1.95	IE	IE	0.26	0.07	3.11
1993	7.21	1.74	0.01	NO	1.98	IE	IE	0.26	0.07	3.16
1994	5.90	1.67	0.01	NO	1.23	IE	IE	0.27	0.09	2.63
1995	5.65	1.63	0.01	NO	1.11	IE	IE	0.28	0.08	2.54
1996	5.66	1.51	0.01	NO	1.18	IE	IE	0.38	0.10	2.48
1997	5.07	1.31	0.01	NO	0.95	IE	IE	0.45	0.09	2.27
1998	5.33	1.33	0.01	NO	0.96	IE	IE	0.48	0.02	2.52
1999	5.17	1.57	0.01	NO	0.86	IE	IE	0.60	0.03	2.10
2000	4.96	1.79	0.01	NO	1.24	IE	IE	0.46	0.02	1.44
2001	5.30	2.17	0.01	NO	1.31	IE	IE	0.46	0.02	1.33
2002	5.25	1.59	0.01	NO	1.30	IE	IE	0.42	0.13	1.80
2003	4.65	1.36	0.02	NO	1.22	IE	IE	0.44	0.08	1.53
2004	6.02	1.92	0.00	NO	1.60	IE	IE	0.42	0.10	1.97
2005	5.50	1.65	0.00	NO	1.45	IE	IE	0.44	0.07	1.89
2006	4.59	1.07	0.00	NO	1.13	IE	IE	0.38	0.06	1.94
2007	3.67	1.20	0.00	NO	0.71	IE	IE	0.38	0.01	1.38
2008	5.32	1.78	0.00	NO	0.94	IE	IE	0.67	0.05	1.87
2009	5.00	2.37	0.00	NO	0.77	IE	IE	0.53	0.04	1.29
2010	4.55	1.50	0.00	NO	0.83	IE	IE	0.47	0.03	1.70
2011	4.09	1.57	0.00	NO	0.70	IE	IE	0.53	0.05	1.23
2012	4.56	1.64	0.00	NO	1.11	IE	IE	0.46	0.05	1.29
2013	4.33	1.58	0.00	NO	0.87	IE	IE	0.45	0.05	1.38
2014	3.36	1.11	0.01	NO	0.78	IE	IE	0.45	0.05	0.96
2015	3.38	1.12	0.00	NO	0.75	IE	IE	0.40	0.06	1.05
2016	4.22	1.36	0.00	NO	0.77	IE	IE	0.96	0.02	1.10
2017	4.09	1.39	0.00	NO	0.83	IE	IE	0.53	0.02	1.32
2018	3.56	1.13	0.03	NO	0.67	IE	IE	0.59	0.02	1.12
2019	4.01	1.34	0.03	NO	0.85	IE	IE	0.70	0.02	1.07
2020	3.38	1.46	0.02	NO	0.75	IE	IE	0.49	0.04	0.62
2021	4.32	2.09	0.03	NO	0.76	IE	IE	0.40	0.04	1.00
2022	4.14	2.01	0.03	NO	0.69	IE	IE	0.51	0.04	0.87
Trend 1990-2022	-46.25%	8.36%	228.77%	NA	-67.62%	NA	NA	81.21%	-51.56%	-74.10%
2005-2022	-24.66%	21.76%	533.51%	NA	-52.58%	NA	NA	15.96%	-52.31%	-53.65%
2021-2022	-4.03%	-3.75%	-3.14%	NA	-9.65%	NA	NA	27.72%	-10.81%	-12.72%

From this data, the following implied emission factors (g NMVOC / kg product or substance) are obtained (see Table 4-16).

Table 4-16 – Sovent and product use implied emission factors

2D3 - Solvent and Product Use										
Implied Emission Factors (g NMVOC / kg product or substance)										
Year	2D3 AVERAGE	2D3a Dometics solvent use including fungicides	2D3b Road paving with asphalt	2D3c Asphalt roofing	2D3d Coating applications	2D3e Degreasing	2D3f Dry cleaning	2D3g Chemical products	2D3h Printing	2D3i Other solvent use
1990	113.28	211.87	N/A	N/A	357.79	N/A	N/A	89.33	58.55	68.86
1991	113.26	211.87	N/A	N/A	357.79	N/A	N/A	89.33	58.55	68.86
1992	113.28	211.87	N/A	N/A	357.79	N/A	N/A	89.33	58.55	68.86
1993	113.25	211.87	N/A	N/A	357.79	N/A	N/A	89.33	58.55	68.86
1994	69.98	200.82	N/A	N/A	300.22	N/A	N/A	70.59	62.38	39.42
1995	79.21	192.22	N/A	N/A	279.41	N/A	N/A	68.87	61.12	47.46
1996	101.65	244.17	N/A	N/A	256.29	N/A	N/A	49.01	61.70	69.70
1997	83.50	190.53	N/A	N/A	257.67	N/A	N/A	45.73	57.31	58.41
1998	111.84	181.68	N/A	N/A	269.30	N/A	N/A	49.39	54.26	94.63
1999	69.72	166.17	N/A	N/A	236.72	N/A	N/A	43.58	59.84	44.81
2000	62.00	163.82	N/A	N/A	323.01	N/A	N/A	40.10	68.58	26.87
2001	75.16	163.15	N/A	N/A	377.63	N/A	N/A	34.80	65.43	33.06
2002	73.81	173.20	N/A	N/A	256.10	N/A	N/A	31.36	49.50	44.08
2003	65.51	165.70	N/A	N/A	245.87	N/A	N/A	28.76	47.95	37.37
2004	74.87	265.13	N/A	N/A	226.77	N/A	N/A	19.57	45.48	46.37
2005	69.63	279.02	N/A	N/A	192.72	N/A	N/A	17.56	43.04	48.46
2006	62.01	149.58	N/A	N/A	140.40	N/A	N/A	16.33	40.65	57.14
2007	55.59	136.13	N/A	N/A	155.87	N/A	N/A	16.10	49.18	47.24
2008	65.44	158.03	N/A	N/A	121.76	N/A	N/A	23.72	37.49	57.58
2009	73.47	195.29	N/A	N/A	110.85	N/A	N/A	20.06	36.53	60.60
2010	69.77	166.15	N/A	N/A	110.42	N/A	N/A	24.41	34.19	60.49
2011	51.76	165.39	N/A	N/A	85.50	N/A	N/A	17.19	30.88	42.83
2012	58.85	159.08	N/A	N/A	130.01	N/A	N/A	15.76	28.87	46.32
2013	51.91	141.66	N/A	N/A	105.52	N/A	N/A	13.79	27.41	46.51
2014	44.22	123.61	N/A	N/A	102.86	N/A	N/A	14.50	25.05	36.86
2015	42.79	133.09	N/A	N/A	90.03	N/A	N/A	11.73	22.60	41.03
2016	53.70	149.37	N/A	N/A	98.83	N/A	N/A	26.32	21.73	45.67
2017	44.13	140.36	N/A	N/A	96.99	N/A	N/A	11.13	21.13	51.16
2018	40.38	130.66	N/A	N/A	86.08	N/A	N/A	12.56	23.88	47.15
2019	41.54	141.62	N/A	N/A	116.50	N/A	N/A	15.03	23.28	33.02
2020	35.77	149.17	N/A	N/A	108.19	N/A	N/A	9.97	36.41	22.19
2021	40.24	194.56	N/A	N/A	89.02	N/A	N/A	7.65	33.26	28.69
2022	41.07	209.13	N/A	N/A	83.70	N/A	N/A	10.30	43.03	26.51
Trend 1990-2022	-63.74%	-1.29%	NA	NA	-76.61%	NA	NA	-88.47%	-26.50%	-61.50%
:005-2022	-41.02%	-25.05%	NA	NA	-56.57%	NA	NA	-41.37%	-0.03%	-45.28%
:021-2022	2.06%	7.49%	NA	NA	-5.99%	NA	NA	34.56%	29.38%	-7.59%

4.7.3 Methodological issues for categories 2D3b and 2D3c

Activity data, i.e. annual production of road paving asphalt, was obtained directly from the 4 plants via the operators' reporting obligations.

For the period 1990-2003, NMVOC emissions were estimated using the Tier 2 method from the EMEP/EEA GB, due to a lack of plant specific measurement data. The 4 plants in Luxembourg operate using the drum mix / hot mix technology, hence, the corresponding

Tier 2 emissions factors of the EMEP/EEA GB were used. Since 2004, total organic carbon (TOC) emissions are measured at the stacks. It has been assumed that TOC emissions equal NMVOC emissions. Activity data, emissions and IEFs are given in Table 4-17.

Table 4-17 – Activity data, NMVOC emissions and IEFs for category *2D3b – Road Paving with Asphalt*

year	Activity Data (kt) Asphalt produced	Emissions (t) NMVOC	Implied Emission Factors (kg NMVOC/t asphalt)
1990	608.880	0.009	15.000
1991	529.120	0.008	15.000
1992	583.052	0.009	15.000
1993	455.934	0.007	15.000
1994	864.349	0.013	15.000
1995	452.471	0.007	15.000
1996	684.634	0.010	15.000
1997	623.154	0.009	15.000
1998	555.976	0.008	15.000
1999	859.039	0.013	15.000
2000	827.880	0.012	15.000
2001	740.321	0.011	15.000
2002	722.684	0.011	15.000
2003	1200.022	0.018	15.000
2004	539.700	0.004	8.259
2005	560.490	0.005	8.457
2006	564.883	0.005	8.249
2007	630.567	0.005	7.211
2008	606.886	0.004	7.076
2009	688.418	0.003	4.197
2010	627.093	0.003	4.281
2011	783.181	0.005	5.836
2012	703.165	0.004	6.217
2013	607.814	0.004	6.208
2014	690.515	0.005	7.377
2015	607.760	0.004	6.832
2016	768.686	0.005	6.086
2017	685.024	0.005	6.639
2018	671.173	0.026	39.003
2019	642.210	0.028	43.426
2020	626.732	0.020	31.540
2021	711.414	0.031	44.214
2022	631.074	0.030	47.581
Trend 2021-2022	-11.29%	-4.54%	7.62%
2005-2022	12.59%	533.51%	462.66%
1990-2022	3.65%	228.77%	217.21%

Source: Environment Agency.

TSP, PM_{10} and $PM_{2.5}$ emissions were estimated using the Tier 2 method from the EMEP/EEA GB for the period 1990-2003. The corresponding Tier 2 default emission factors for drum mix/hot mix plants were used. As abatement technology, the lowest confidentiality level for wet scrubber was applied (97%). Since 2004, "dust" emissions are measured at the stacks under the industrial emissions directive monitoring. As effective abatement technology is installed at the 4 plants it is assumen that "dust" emissions equal to $PM_{2.5}$ emissions. TSP and PM_{10} emissions where then back calculated by applying the fraction of $PM_{2.5}$ in TSP or PM_{10} as derived from the defauilt Tier 2 emisison factors from the EMEP/EEA Guidebook to the $PM_{2.5}$ emission derived from the measurements. Activity data, emissions and IEFs are given in Table 4-18.

Table 4-18 - Activity data, PM emissions and IEFs for category *2D3b – Road Paving with Asphalt*

	Activity Data (kt)	Emissions (t)			IEF (kg/t asphalt)		
year	Asphalt produced	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
1990	608.880	0.237	0.055	0.013	390.000	90.000	21.000
1991	529.120	0.206	0.048	0.011	390.000	90.000	21.000
1992	583.052	0.227	0.052	0.012	390.000	90.000	21.000
1993	455.934	0.178	0.041	0.010	390.000	90.000	21.000
1994	864.349	0.337	0.078	0.018	390.000	90.000	21.000
1995	452.471	0.176	0.041	0.010	390.000	90.000	21.000
1996	684.634	0.267	0.062	0.014	390.000	90.000	21.000
1997	623.154	0.243	0.056	0.013	390.000	90.000	21.000
1998	555.976	0.217	0.050	0.012	390.000	90.000	21.000
1999	859.039	0.335	0.077	0.018	390.000	90.000	21.000
2000	827.880	0.323	0.075	0.017	390.000	90.000	21.000
2001	740.321	0.289	0.067	0.016	390.000	90.000	21.000
2002	722.684	0.282	0.065	0.015	390.000	90.000	21.000
2003	1200.022	0.468	0.108	0.025	390.000	90.000	21.000
2004	539.700	0.123	0.028	0.007	227.606	52.525	12.256
2005	560.490	0.125	0.029	0.007	222.166	51.269	11.963
2006	564.883	0.119	0.027	0.006	210.075	48.479	11.312
2007	630.567	0.137	0.032	0.007	217.838	50.270	11.730
2008	606.886	0.121	0.028	0.007	199.404	46.016	10.737
2009	688.418	0.140	0.032	0.008	203.316	46.919	10.948
2010	627.093	0.120	0.028	0.006	191.651	44.227	10.320
2011	783.181	0.151	0.035	0.008	192.798	44.492	10.381
2012	703.165	0.126	0.029	0.007	179.599	41.446	9.671
2013	607.814	0.103	0.024	0.006	169.790	39.182	9.143
2014	690.515	0.058	0.013	0.003	83.430	19.253	4.492
2015	607.760	0.044	0.010	0.002	71.578	16.518	3.854
2016	768.686	0.040	0.009	0.002	51.625	11.913	2.780
2017	685.024	0.030	0.007	0.002	44.398	10.246	2.391
2018	671.173	0.022	0.005	0.001	32.751	7.558	1.764
2019	642.210	0.040	0.009	0.002	62.850	14.504	3.384
2020	626.732	0.019	0.004	0.001	30.269	6.985	1.630
2021	711.414	0.005	0.001	0.000	7.503	1.731	0.404
2022	631.074	0.065	0.015	0.003	102.531	23.661	5.521
Trend 2021-2022	-11.29%	1112.27%	1112.27%	1112.27%	1266.60%	1266.60%	1266.60%
2005-2022	12.59%	-48.04%	-48.04%	-48.04%	-53.85%	-53.85%	-53.85%
1990-2022	3.65%	-72.75%	-72.75%	-72.75%	-73.71%	-73.71%	-73.71%

Source: Environment Agency.

4.7.4 Uncertainties and time-series consistency

The assessment of activity data and emission factor uncertainties is done according to the methodology described in the EMEP/EEA emission inventory Guidebook 2023 (Chapter A.5 Uncertainties, tables 2-1, 2-2 and 2-3), covering the main pollutants NO_x, NH_3, NMVOC, SO_x and $PM_{2.5}$. For some subcategories and pollutants, expert judgements were made to estimate AD or EF uncertainties. For CO, PM10, heavy metzals and persistent organic pollutants, no uncertainty estimates are currently made. Details on uncertainty of the activity data can also be checked in the Luxembourg's National Inventory report (NIR). Please also refer to Table 1-33 to Table 1-37 of section 1.7 for caterogory specific uncertainties on activity data and emission factors.

The time series reported under *2D3b – Road Paving with Asphalt* are considered to be consistent. Fluctuations in the time series occur due to variations in the demand of road paving asphalt. Indeed, road paving asphalt is mostly used in Luxembourg for road surface renovation. Construction of new roads is very limited in Luxembourg (see Table on page 326). In 2003, for example, a section of a newly built motorway was pawed with asphalt, hence, nearly a doubling in asphalt production was observed.

4.7.5 Source specific QA/QC and verification

The calculations of the data for category 2D3 are embedded in the overall QA/QC-system of Luxembourg's air emission inventory (see Chapter 1.6) of which important elements include:

- Are the correct values used (check for transcription errors, …)?
- Check of plausibility of input data (time-series, order of magnitude, …)
- Is the data set complete for the whole time series?
- Check of calculations, units ...
- Check of plausibility of results (time-series, order of magnitude, …)
- Correct transformation/transcription to reporting tables
- Where possible, data is checked with data from other sources, order of magnitude checks, …
- Are all references clearly made?
- Are all assumptions documented?

Source-specific elements of QA/QC for Solvent and Other Product Use include:

Input data and emission factors:

- check for the plausibility of the activity data and their trend and check for plausibility of the emission factors as well as the related input data and their trends
- check documentation of the most important reasons for changes and non-changes of activity data
- check if these changes or non-changes of activity data fit to trends of underlying conditions
- if checks do not allow any explanation, further check of the used statistics and their estimates and/or communication with the data providers
- check of input data for completeness
- Comparison of the used activity data with those from other statistics: STATEC publication and EUROSTAT database.
- Comparison of the used activity data with those from relevant plant operators and SMPs

Emissions:

- check the correctness of all equations in the calculation files
- check the correctness of all intermediate results
- check the plausibility of the results and their trends related to activity data and emission factors
- check the correctness of the transfer of all data and results
- Comparison of the used emission factors and underlying input data with those of other data sources (*e.g.* from literature, results in NIRs of other comparable regions, IPCC default values).

4.7.6 Category-specific recalculations including changes made in response to the review process

The following table presents the main revisions and recalculations done since submission 2023 relevant to category *2D3 - Non-energy products from fuels and solvent use: Other*.

Table 4-19 – Recalculations done since the last submission for category *2D3 - Non-energy products from fuels and solvent use: Other*

Source category	Revisions 2023 ➔ 2024	Type of revision
2D3a, 2D3d – 2D3i	The solvent model was completely revised	Updated AD, EF, methodology

4.7.7 Category-specific planned improvements including those in response to the review process

The following improvements are planned for the next submission.

Table 4-20 – Planned improvements for category *2D3 - Non-energy products from fuels and solvent use*

Source category	Planned improvements	Type of revision
2D3	Punctual refinement of the new solvent and product use model	Methodology

4.8 Food and Beverages Industry (2.H.2)

4.8.1 Source category description

Emissions (NMVOC) associated with activities in the food and beverages industry are assigned to category *2H2 – Food and beverages industry*.

Table 4-21 gives an overview of the activity in the food and beverages industry in Luxembourg, as well as the associated NMVOC emissions.

Table 4-21 – NMVOC emission trends per activity in the food and beverages industry

2H2 - Food and Beverages Industry									
Activity Data and Emissions									
Year	**Total**	**Meat**		**Wine**		**Beer**		**Bread**	
	NMVOC	***AD***	***NMVOC***	***AD***	***NMVOC***	***AD***	***NMVOC***	***AD***	***NMVOC***
	Gg	*t*	*Gg*	*hl*	*Gg*	*hl*	*Gg*	*t*	*Gg*
1990	0.118	22'517	0.007	151'120	0.012	599'839	0.021	17'306	0.078
1991	0.113	23'170	0.007	85'713	0.007	572'333	0.020	17'538	0.079
1992	0.129	23'827	0.007	271'227	0.022	569'126	0.020	17'776	0.080
1993	0.121	24'483	0.007	169'268	0.014	557'873	0.020	18'010	0.081
1994	0.122	25'137	0.008	174'998	0.014	531'117	0.019	18'259	0.082
1995	0.121	24'487	0.007	149'654	0.012	518'400	0.018	18'508	0.083
1996	0.120	27'829	0.008	127'617	0.010	483'453	0.017	18'779	0.085
1997	0.117	27'273	0.008	74'708	0.006	480'546	0.017	19'019	0.086
1998	0.124	27'020	0.008	159'711	0.013	468'519	0.016	19'256	0.087
1999	0.127	29'648	0.009	184'277	0.015	449'597	0.016	19'498	0.088
2000	0.124	29'248	0.009	131'931	0.011	438'423	0.015	19'783	0.089
2001	0.122	25'295	0.008	134'826	0.011	396'676	0.014	20'029	0.090
2002	0.124	22'720	0.007	153'872	0.012	386'021	0.014	20'260	0.091
2003	0.123	23'533	0.007	123'085	0.010	390'694	0.014	20'454	0.092
2004	0.126	22'397	0.007	155'828	0.012	377'272	0.013	20'759	0.093
2005	0.125	21'098	0.006	135'366	0.011	373'651	0.013	21'042	0.095
2006	0.125	19'485	0.006	123'652	0.010	360'921	0.013	21'403	0.096
2007	0.127	19'421	0.006	141'972	0.011	348'190	0.012	21'727	0.098
2008	0.127	19'414	0.006	129'669	0.010	335'460	0.012	22'073	0.099
2009	0.129	19'507	0.006	134'786	0.011	322'730	0.011	22'516	0.101
2010	0.129	19'455	0.006	110'248	0.009	310'000	0.011	22'907	0.103
2011	0.132	19'131	0.006	131'988	0.011	302'000	0.011	23'353	0.105
2012	0.131	19'500	0.006	85'035	0.007	292'000	0.010	23'946	0.108
2013	0.134	19'492	0.006	100'888	0.008	281'000	0.010	24'502	0.110
2014	0.139	21'047	0.006	124'936	0.010	271'000	0.009	25'079	0.113
2015	0.141	21'959	0.007	110'694	0.009	287'000	0.010	25'685	0.116
2016	0.142	23'827	0.007	82'947	0.007	290'000	0.010	26'291	0.118
2017	0.145	22'920	0.007	81'248	0.006	290'000	0.010	26'949	0.121
2018	0.152	23'183	0.007	135'907	0.011	293'000	0.010	27'466	0.124
2019	0.149	23'602	0.007	76'045	0.006	288'000	0.010	28'009	0.126
2020	0.150	23'155	0.007	96'858	0.008	200'000	0.007	28'566	0.129
2021	0.153	23'744	0.007	99'716	0.008	225'000	0.008	28'960	0.130
2022	0.156	23'313	0.007	88'095	0.007	279'000	0.010	29'446	0.133
Trend 1990-2022	*32.79%*	*3.54%*	*3.54%*	*-41.71%*	*-41.71%*	*-53.49%*	*-53.49%*	*70.16%*	*70.16%*
2005-2022	*25.13%*	*10.50%*	*10.50%*	*-34.92%*	*-34.92%*	*-25.33%*	*-25.33%*	*39.94%*	*39.94%*
2021-2022	*1.97%*	*-1.82%*	*-1.82%*	*-11.65%*	*-11.65%*	*24.00%*	*24.00%*	*1.68%*	*1.68%*

4.8.2 Methodological issues & time-series consistency

The Tier 2 method, as described in the EMEP/EEA Guidebook 2023, was used to estimate NMVOC emissions from activities in the food and beverages industry. Activity data concerning the production of meat, wine, beer and bread were collected from various sources, as described below. The corresponding emission factors are all taken from the EMEP/EEA Guidebook 2023.

4.8.2.1 Meat

Regarding meat production, the activity data was obtained from STATEC. No data was available for the years 1991, 1992, 1993 and 1994, as previously to 1995, data were only collected in 5-year intervals. As such, yearly data collection only started in 1995. Additionally, data regarding goat, equine, sheep and poultry meat were only collected from the year 2001 onwards, resulting in a lack of data for the previous years. In both cases, the lacking data was generated using various methods of extrapolation based on the available data.

The NMVOC emissions were calculated using the Tier 2 approach / emission factor for meat frying / curing, as it is assumed that all meat produced and consumed in Luxembourg is either cooked or fried by the industry (food manufacturing, large restaurants, …) or by households. It has to be noted that after slaughter, most meat-based foods produced in Luxembourg for consumption, are of fresh or frozen nature (no exact data available), which in the EMEP/EEA Guidebook 2019 are described as having negligible emissions. As such Luxembourg assumes that the Tier 2 approach might still lead to an overestimation of emissions.

4.8.2.2 Wine

Regarding the production of wine, the activity data was obtained from the *National Statistical Institute (STATEC)*. A complete data set regarding the production of wine was obtained for the years 1990-2021. NMVOC emissions were calculated using a Tier 2 approach described in the EMEP/EEA Guidebook 2023. Similarly, the corresponding emission factor was taken from the same document.

4.8.2.3 Beer

To calculate NMVOC emissions associated with beer production, data regarding the yearly amounts of beer production were salvaged from the now defunct *Fédération des Brasseurs Luxembourgeois*. The acquired data set compromises the years 1990-2005. From 2010 onwards, data on beer production in Luxembourg was obtained from the *Brewers of Europe* association (www.brewersofeurope.org). For the years between 2005 and 2010, data was generated by linear interpolation. The NMVOC emissions were determined using a Tier 2 approach based on a corresponding emission factor taken from the EMEP/EEA Guidebook 2023.

4.8.2.4 Bread

Activity data regarding the production of bread could, for now, not be obtained and the existence of a comprehensive data set is currently questionable. To remedy to this problem, a factor corresponding to the daily produced bread quantity per Belgian habitant was taken from the Belgium IIR 2017 (125 g/hab/day, constant over the entire timeseries). A Tier 2 approach was used to determine the corresponding NMVOC emissions. The employed emission factor was derived from the EMEP/EEA Guidebook 2023.

4.8.3 Source-specific QA/QC and verification

The calculations of the data for this category are embedded in the overall QA/QC-system of Luxembourg’s air emission inventory (see Chapter 1.6) of which important elements include:

- Are the correct values used (check for transcription errors, …)?
- Check of plausibility of input data (time-series, order of magnitude, …)
- Is the data set complete for the whole time series?
- Check of calculations, units ...
- Check of plausibility of results (time-series, order of magnitude, …)
- Correct transformation/transcription into CRF
- Where possible, data is checked with data from other sources, order of magnitude checks, …
- Are all references clearly made?
- Are all assumptions documented?

4.8.4 Category-specific recalculations including changes made in response to the review process

The following table presents the main revisions and recalculations done since submission 2023 relevant to category *2H2 – Food and Beverages Industry*.

Table 4-22 – Recalculations done since the last submission for category *2H2 – Food and Beverages Industry*

Source category	Revisions 2023 → 2024	Type of revision
2H2	No recalculations	NA

4.8.5 Category-specific planned improvements including those in response to the review process

The following improvements are planned for the next submission.

Table 4-23 – Planned improvements for category *2H2 – Food and Beverages Industry*

Source category	Planned improvements	Type of revision
2H2	No further improvements planned	

4.9 Other product use (2G)

4.9.1 Sector Overview

Emissions associated with fireworks use, tobacco consumption and the use of shoes are assigned to category *2G – Other product use*. The emissions can compromise, depending on the emission source, $PM_{2.5}$, PM_{10}, TSP and NMVOC.

Table 4-24 and Table 4-25 give an overview of *fireworks and tobacco use*, respectively as well as the associated emissions. Although emissions from tobacco use seem to be relatively stable over the entire time-series, emissions from fireworks seem to have dramatically increased in the first decade of the 21st century. This increase can be explained by the relatively wealthy economic situation of Luxembourg, as well as by its increasing population.

Concerning NMVOC emissions from the *use of shoes*, it is not clear from the EMEP/EEA Guidebook, whether these emissions occur during production of shoes (use of adhesives/glues) or only from the use of shoes. In Luxembourg's understanding, it is more likely that these emissions mostly occur during production, especially as the EMEP/EEA Guidebook also provides abatement factors per type of glue and abatement technology used. In Luxembourg, there is no manufacturing of shoes, hence, not estimating the emissions from shoes as well as the use of notation key “NO” seems justified.

Table 4-24 – Emissions and activity data for category *2G – Tobacco Use*

2G - Tobacco Use Activity data, emissions										
Year	**AD** t of tobacco	**NOx** *t*	**NMVOC** *t*	**NH3** *t*	**TSP** *t*	**PM10** *t*	**PM2.5** *t*	**Cd** *kg*	**Pb** *kg*	**Hg** *kg*
1990	365.76	0.66	1.77	1.52	9.88	9.88	9.88	1.975	NE	NE
1991	370.67	0.67	1.79	1.54	10.01	10.01	10.01	2.002	NE	NE
1992	375.69	0.68	1.82	1.56	10.14	10.14	10.14	2.029	NE	NE
1993	380.66	0.69	1.84	1.58	10.28	10.28	10.28	2.056	NE	NE
1994	385.91	0.69	1.87	1.60	10.42	10.42	10.42	2.084	NE	NE
1995	391.17	0.70	1.89	1.62	10.56	10.56	10.56	2.112	NE	NE
1996	396.90	0.71	1.92	1.65	10.72	10.72	10.72	2.143	NE	NE
1997	401.97	0.72	1.95	1.67	10.85	10.85	10.85	2.171	NE	NE
1998	406.98	0.73	1.97	1.69	10.99	10.99	10.99	2.198	NE	NE
1999	412.09	0.74	1.99	1.71	11.13	11.13	11.13	2.225	NE	NE
2000	418.12	0.75	2.02	1.74	11.29	11.29	11.29	2.258	NE	NE
2001	423.33	0.76	2.05	1.76	11.43	11.43	11.43	2.286	NE	NE
2002	428.19	0.77	2.07	1.78	11.56	11.56	11.56	2.312	NE	NE
2003	475.52	0.86	2.30	1.97	12.84	12.84	12.84	2.568	NE	NE
2004	453.38	0.82	2.19	1.88	12.24	12.24	12.24	2.448	NE	NE
2005	400.26	0.72	1.94	1.66	10.81	10.81	10.81	2.161	NE	NE
2006	376.96	0.68	1.82	1.56	10.18	10.18	10.18	2.036	NE	NE
2007	382.66	0.69	1.85	1.59	10.33	10.33	10.33	2.066	NE	NE
2008	388.77	0.70	1.88	1.61	10.50	10.50	10.50	2.099	NE	NE
2009	380.70	0.69	1.84	1.58	10.28	10.28	10.28	2.056	NE	NE
2010	387.31	0.70	1.87	1.61	10.46	10.46	10.46	2.091	NE	NE
2011	361.95	0.65	1.75	1.50	9.77	9.77	9.77	1.955	NE	NE
2012	388.02	0.70	1.88	1.61	10.48	10.48	10.48	2.095	NE	NE
2013	362.50	0.65	1.75	1.50	9.79	9.79	9.79	1.958	NE	NE
2014	371.04	0.67	1.80	1.54	10.02	10.02	10.02	2.004	NE	NE
2015	380.00	0.68	1.84	1.58	10.26	10.26	10.26	2.052	NE	NE
2016	370.45	0.67	1.79	1.54	10.00	10.00	10.00	2.000	NE	NE
2017	398.70	0.72	1.93	1.65	10.77	10.77	10.77	2.153	NE	NE
2018	406.36	0.73	1.97	1.69	10.97	10.97	10.97	2.601	NE	NE
2019	532.78	0.96	2.58	2.21	14.38	14.38	14.38	3.410	NE	NE
2020	523.25	0.94	2.53	2.17	14.13	14.13	14.13	3.349	NE	NE
2021	571.26	1.03	2.76	2.37	15.42	15.42	15.42	3.656	NE	NE
2022	580.87	1.05	2.81	2.41	15.68	15.68	15.68	3.718	NE	NE
Trend 1990-2022	*58.81%*	*58.81%*	*58.81%*	*58.81%*	*58.81%*	*58.81%*	*58.81%*	*88.22%*	*NA*	*NA*
2005-2022	*45.12%*	*45.12%*	*45.12%*	*45.12%*	*45.12%*	*45.12%*	*45.12%*	*72.00%*	*NA*	*NA*
2021-2022	*1.68%*	*1.68%*	*1.68%*	*1.68%*	*1.68%*	*1.68%*	*1.68%*	*1.68%*	*NA*	*NA*

Source: Environment Agency.
Note: for emissions marked as NE, no emission factors are given in the EMEP/EEA Guidebook 2023.

Table 4-25 – Emissions and activity data for category *2G – Fireworks Use*

2G - Fireworks Use *Activity data, emissions*									
Year	AD	NOx	SO2	TSP	PM10	PM2.5	Cd	Pb	Hg
	t of fireworks	*t*	*t*	*t*	*t*	*t*	*kg*	*kg*	*kg*
1990	0.67	0.00	0.00	0.07	0.07	0.03	0.000993	0.526	0.000038
1991	0.81	0.00	0.00	0.09	0.08	0.04	0.001198	0.635	0.000046
1992	0.98	0.00	0.00	0.11	0.10	0.05	0.001446	0.766	0.000056
1993	1.18	0.00	0.00	0.13	0.12	0.06	0.001745	0.924	0.000067
1994	1.42	0.00	0.00	0.16	0.14	0.07	0.002107	1.116	0.000081
1995	1.72	0.00	0.01	0.19	0.17	0.09	0.002543	1.347	0.000098
1996	2.08	0.00	0.01	0.23	0.21	0.11	0.003073	1.628	0.000118
1997	2.50	0.00	0.01	0.28	0.25	0.13	0.003706	1.963	0.000143
1998	3.02	0.00	0.01	0.33	0.30	0.16	0.004469	2.367	0.000172
1999	6.10	0.00	0.02	0.67	0.61	0.32	0.009028	4.782	0.000348
2000	4.30	0.00	0.01	0.47	0.43	0.22	0.006364	3.371	0.000245
2001	3.50	0.00	0.01	0.38	0.35	0.18	0.005180	2.744	0.000200
2002	7.10	0.00	0.02	0.78	0.71	0.37	0.010508	5.566	0.000405
2003	8.30	0.00	0.03	0.91	0.83	0.43	0.012284	6.507	0.000473
2004	15.20	0.00	0.05	1.67	1.52	0.79	0.022496	11.917	0.000866
2005	15.20	0.00	0.05	1.67	1.52	0.79	0.022496	11.917	0.000866
2006	7.20	0.00	0.02	0.79	0.72	0.37	0.010656	5.645	0.000410
2007	36.30	0.01	0.11	3.99	3.63	1.89	0.053724	28.459	0.002069
2008	43.30	0.01	0.13	4.76	4.33	2.25	0.064084	33.947	0.002468
2009	39.40	0.01	0.12	4.33	3.94	2.05	0.058312	30.890	0.002246
2010	27.00	0.01	0.08	2.97	2.70	1.40	0.039960	21.168	0.001539
2011	48.10	0.01	0.15	5.28	4.81	2.50	0.071188	37.710	0.002742
2012	52.80	0.01	0.16	5.80	5.28	2.74	0.078144	41.395	0.003010
2013	73.70	0.02	0.22	8.09	7.36	3.83	0.109076	57.781	0.004201
2014	47.20	0.01	0.14	5.18	4.72	2.45	0.069856	37.005	0.002690
2015	82.10	0.02	0.25	9.02	8.20	4.26	0.121508	64.366	0.004680
2016	54.60	0.01	0.16	6.00	5.46	2.84	0.080808	42.806	0.003112
2017	43.50	0.01	0.13	4.78	4.35	2.26	0.064380	34.104	0.002480
2018	30.60	0.01	0.09	3.36	3.06	1.59	0.045288	23.990	0.001744
2019	19.50	0.01	0.06	2.14	1.95	1.01	0.028860	15.288	0.001112
2020	6.10	0.00	0.02	0.67	0.61	0.32	0.009028	4.782	0.000348
2021	3.37	0.00	0.01	0.37	0.34	0.18	0.004991	2.644	0.000192
2022	2.88	0.00	0.01	0.32	0.29	0.15	0.004256	2.255	0.000164
Trend 1990-2022	*328.75%*	*328.75%*	*328.75%*	*328.75%*	*328.75%*	*328.75%*	*328.75%*	*328.75%*	*328.75%*
2005-2022	*-81.08%*	*-81.08%*	*-81.08%*	*-81.08%*	*-81.08%*	*-81.08%*	*-81.08%*	*-81.08%*	*-81.08%*
2021-2022	*-14.71%*	*-14.71%*	*-14.71%*	*-14.71%*	*-14.71%*	*-14.71%*	*-14.71%*	*-14.71%*	*-14.71%*

4.9.2 Methodological issues & time-series consistency

For tobacco use, emission calculation is based on a Luxembourgish study (carried out by *Fondation Cancer*), which estimates the yearly % of the population consuming tobacco as well as the consumed quantities. As no data is available prior to 2001, the data regarding the years 1990-2000 were extrapolated by keeping the % of the population consuming tobacco as well as the consumed quantities constant relative to the year 2001. The emission factors used are taken from the relevant chapter in the EMEP/EEA Guidebook 2023. (see Table 4-26).

For fireworks use, emissions are based on yearly purchased quantities of fireworks per habitant. The number of habitants and the quantity of fireworks were obtained from Eurostat. As no data was available for the years 1990-1998, an extrapolation, based on an exponential function considering the purchased quantities of fireworks for the years 1999-2015, was applied to generate the missing data. The emission factors used are taken from the relevant chapter in the EMEP/EEA Guidebook 2023 (see Table).

Table 4-26 – Emission factors used for category 2G

Process	Pollutants	Source	Page	Table
Combustion of tobacco	NOx, NMVOC, NH3, TSP, PM10, PM2.5, CO, Cd, PCDD/F, PAH	EEA (2023) – Chapter 2.D.3.i, 2.G Other solvent and product use	22	3-15
Use of fireworks	NOx, SO2, TSP, PM10, PM2.5, CO, Pb, Hg, Cd	EEA (2023) – Chapter 2.D.3.i, 2.G Other solvent and product use	22	3-14

4.9.3 Source-specific QA/QC and verification

The calculations of the data for this category are embedded in the overall QA/QC-system of Luxembourg's air emission inventory (see Chapter 1.6) of which important elements include:

- Are the correct values used (check for transcription errors, …)?
- Check of plausibility of input data (time-series, order of magnitude, …)
- Is the data set complete for the whole time series?
- Check of calculations, units ...
- Check of plausibility of results (time-series, order of magnitude, …)
- Correct transformation/transcription into CRF
- Where possible, data is checked with data from other sources, order of magnitude checks, …
- Are all references clearly made?
- Are all assumptions documented?

4.9.4 Category-specific recalculations including changes made in response to the review process

The following table presents the main revisions and recalculations done since submission 2023 relevant to category *2G – Other Product Use*.

Table 4-27 – Recalculations done since the last submission for category *2G – Other Product Use*

Source category	Revisions 2023 ➔ 2024	Type of revision
2G	No recalculations	NA

4.9.5 Category-specific planned improvements including those in response to the review process

The following improvements are planned for the next submission.

Table 4-28 – Planned improvements for category *2G – Other Product Use*

Source category	Planned improvements	Type of revision
2G	No further improvements planned	

4.10 Consumption of POPs and heavy metals (2K)

4.10.1 Source category description

In this category, Hg emissions originating from the use of batteries and lighting (fluorescent tubes), as well as PCB emissions from disposal of electrical equipment are reported.

4.10.2 Methodological issues & time-series consistency

Calculations of Hg emissions from the use of batteries and fluorescent lighting were based on the Tier 1 approach. Emissions were estimated by offsetting population size with the appropriate emission factors (see Table 4-29).

Calculations of PCB emissions from PCB containing electrical equipment were based on the Tier 3 approach Indeed, disposal and fragmentizer operations do not occur in Luxembourg. Dismantled equipment is exported for these operations. The quantity of disposed PCB containing electrical equpment (tons per year) was offset with the appropriate emission factor stated in the tier 3 emission model (see Table 4-29). In this context, only PCB emissions were considered.

Population size and the quantity of dismantled electrical generators were obtained from the national statistics (STATEC).

Table 4-29 – Emissions factors used for category 2K

Process	Pollutants	Source	EF	Unit
2K	Hg	EMEP/EEA (2023) – Chapter 2.K Consumption of persistent organic pollutants and heavy metals, p. 6, Table 3-1.	0.01	g/capita
2K	PCB	EMEP/EEA (2023) – Chapter 2.K Consumption of persistent organic pollutants and heavy metals, p. 8, Table 3-4.	0.06	kg/tonne

4.10.3 Source-specific QA/QC and verification

Along the general QA/QC procedures as embedded in in the overall QA/QC-system of Luxembourg's air emission inventory (see Chapter 1.6), no further source-specific QA/QC was operated.

4.10.4 Category-specific recalculations including changes made in response to the review process

No recalculations were operated since the last submission.

4.10.5 Category-specific planned improvements including those in response to the review process

No further improvements are planned.

5 Agriculture

5.1 Sector Overview

This chapter includes information on and description of methodologies used for estimating emissions as well as references to activity data and emission factors reported under category *3 -Agriculture* for the period 1990 to 2022.

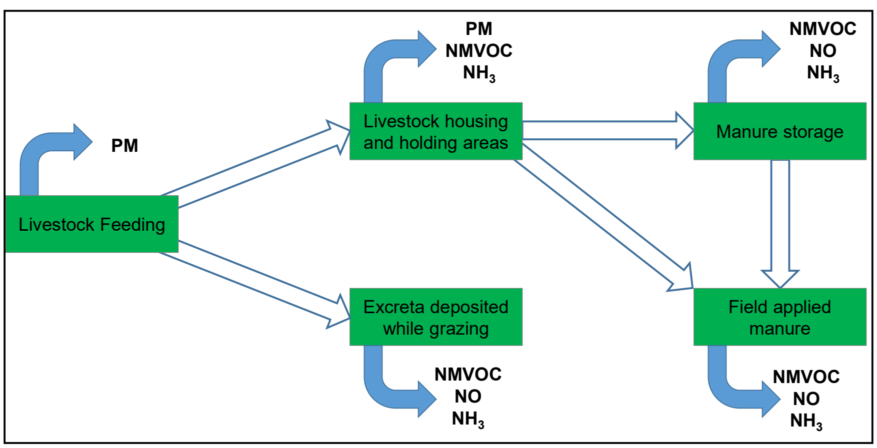
Emissions from this category comprise emissions from the following sub-categories:

- *3B - Manure Management*
- *3D - Crop production and Agricultural Soils*.

There are five main sources of emissions from animal husbandry and manure management (see Figure 53):

- livestock feeding (PM)
- livestock housing and holding areas (NH_3, PM, NMVOCs)
- manure storage (NH_3, NO, NMVOCs)
- field-applied manure (NH_3, NO, NMVOCs) to be reported under NRF 3Da2a
- manure deposited during grazing (NH_3, NO_x, NMVOCs) to be reported under NRF 3Da3

Figure 53 – Process scheme for source category 3.B - Animal husbandry and manure management



Source: EMEP/EEA air pollutant emission inventory guidebook – 2013 (EMEP/EEA 2013).

For more details on categories where emissions are not occurring and categories that are not estimated or included elsewhere, see Table 5-3. More details are presented under each source category in the following sections.

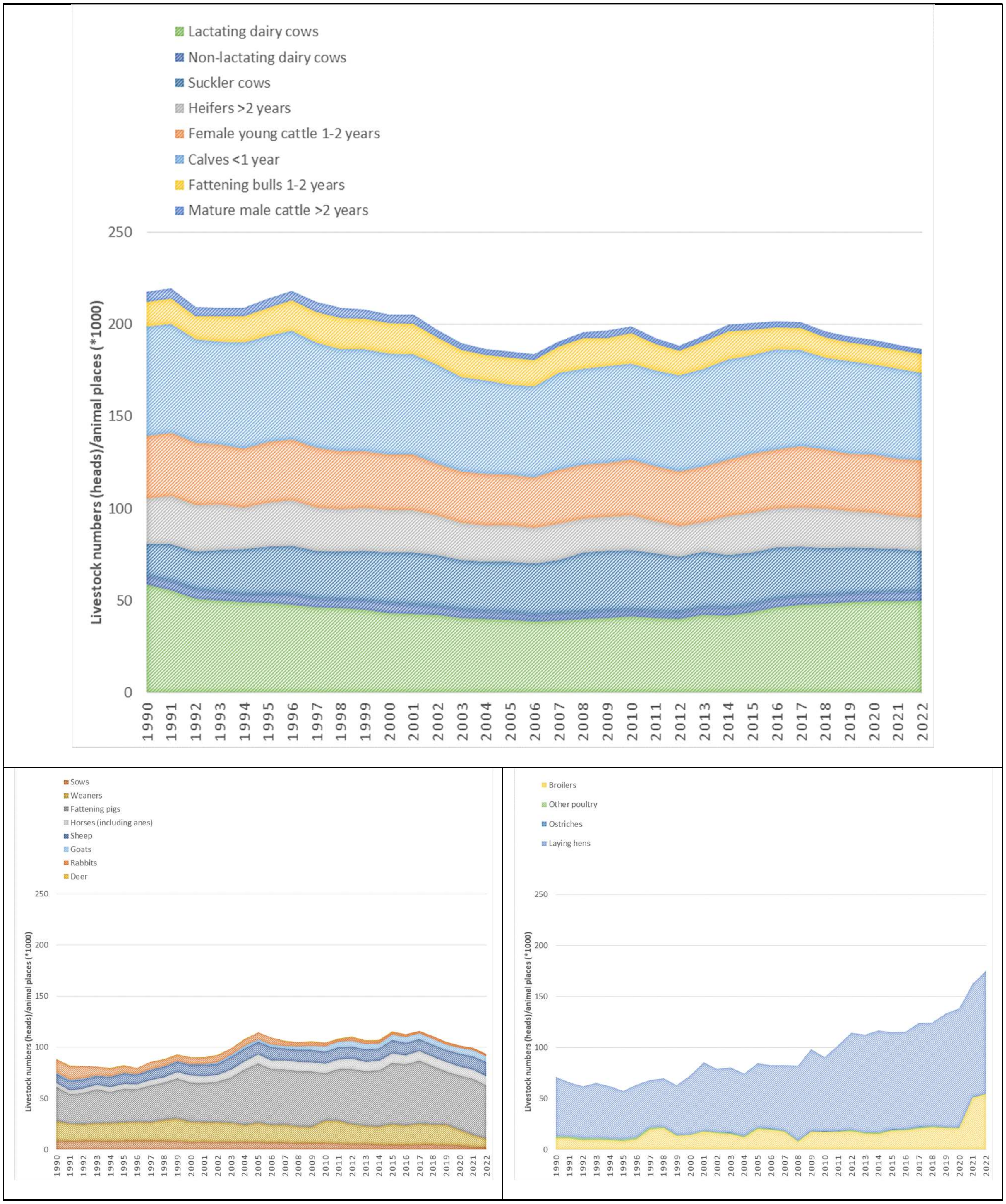
Hereafter a short overview of the Luxemburgish agricultural sector.

The country of Luxembourg is lying in a cool climate region, with both moderate winters and summers. 1 843 farms were managed in Luxembourg in 2022 (STATEC, 2023) , and the agricultural area comprised 126 394 hectare (see Figure 55). More than 50% of the used agriculture surface in Luxembourg was permanent grassland (STATEC, 2020). Cattle, and in particularly dairy cattle, was and is therefore the most important livestock sector in Luxembourg. With the introduction of the milk quota system in 1983 in the European Union (i.e. a restriction on milk production), and an increasing milk yield per dairy cow over time, the number of dairy cows had decreased over the years, although partly compensated by a parallel increase in the number of suckler cows. However, this trend has changed with the abolishment of the milk quota system in Europe in spring 2015, and the number of dairy cows is increasing since then, with an accelerated increase in the first 2-3 years, and is slowing down in the last years. Suckler cows and fattening bulls have decreased since then, see Figure 54.

Swine and poultry are in Luxembourg of far less importance than cattle and are now-a-days for most of the production in the hands of a few very professional farmers. Although, in recent years, cattle farmers tend to install mobile laying hen stables, resulting in a sharp increase of laying hens (Note: the produced eggs are sold on a deficitary local market). Furthermore, the market introduction of a new label resulted in a significant increase of broilers in 2021. Sheep, goats, and other livestock was and is a niche production in Luxemburg (Figure 58).

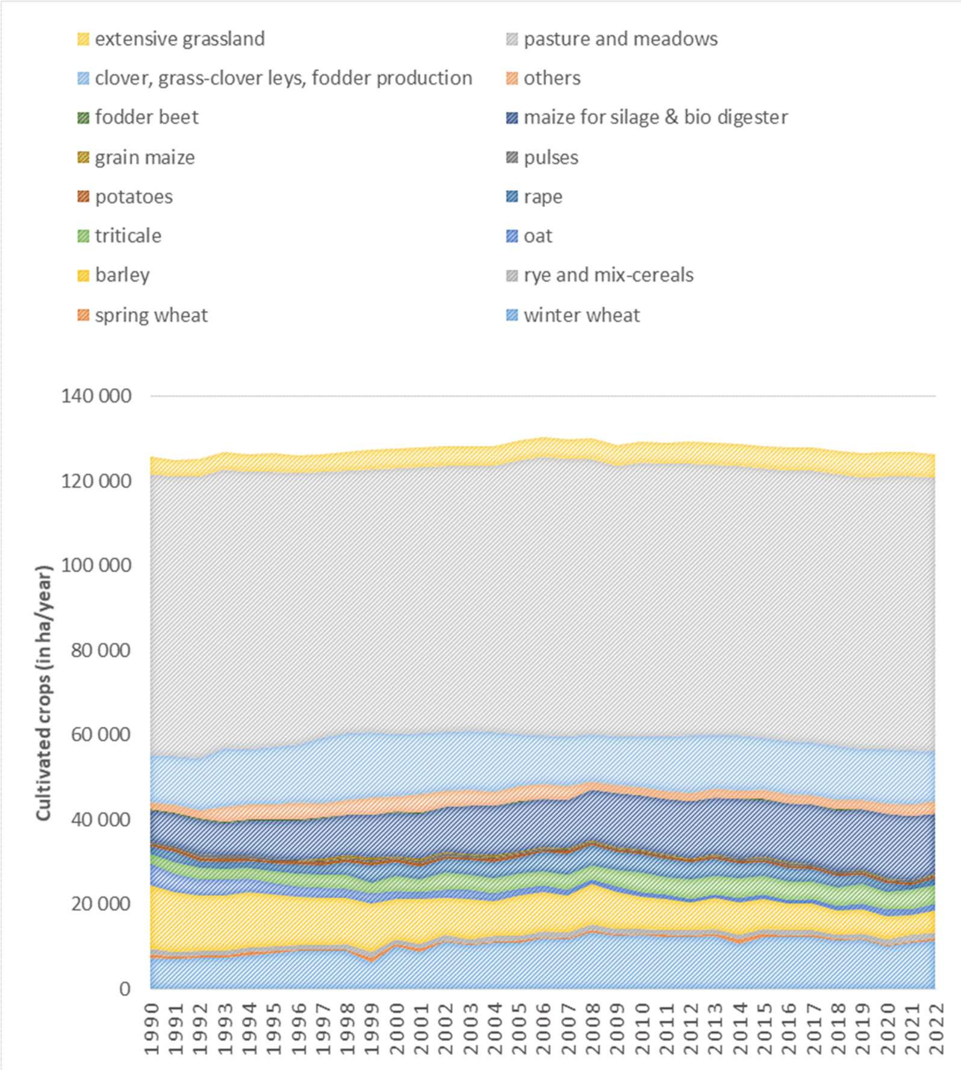
Permanent grassland was with more than 50% of the used agriculture surface predominant in Luxembourg. Grass, cover-grass, and maize for silage (whole plant) are and were the main forage crops grown in Luxembourg, see Figure 55. Grains such as wheat, barley, and triticale, but also rapeseed were the major cash crops cultivated in Luxembourg. In particularly the cultivated area for wheat and maize increased over the years, whereas barley and oat decreased.

Figure 54 – Average animal population (heads/animal places) per year for the different livestock categories for the period 1990-2022



Source: Compiled by SER using data by STATEC (published data) and SER (unpublished data).

Figure 55 – Cultivated crops (ha/year) for the period 1990-2022



5.1.1 Emission Trends

This section briefly describes the emission trends from 1990 to 2022 for each of the categories under Agriculture for which emissions are reported – i.e. categories 3B and 3D.

In 2022, source category *3-Agriculture* was responsible for:

- 5.69 Gg of NH_3 emissions from the agriculture sector, representing 95.60% of the national total NH_3 emissions (fuel sold).
- 0.92 Gg of NO_x emissions from the agricultural sector, representing 8.00% of the national total NO_x emissions (fuel sold).
- 3.48 Gg NMVOC emissions from the agriculture sector, representing 34.81% of the national total NMVOC emissions (fuel sold).
- 0.039 Gg $PM_{2.5}$ emissions from the agriculture sector, representing 3.77% of the national total $PM_{2.5}$ emissions (fuel sold).
- 0.26 Gg PM_{10} emissions from the agriculture sector, representing 15.34% of the national total PM_{10} emissions (fuel sold).
- 0.39 Gg TSP emissions from the agriculture sector, representing 15.23% of the national total TSP emissions (fuel sold).

- 0.0003 kg HCB emissions from the agriculture sector, representing 0.04% of the national total HCB emissions.

As shown in Table 5-1, total ammonia emissions related to agricultural activities decreased by about 10% in the period 1990-2022. Ammonia emissions decreased by 5% in category *3B – Manure Management* and by 15% in category *3D - Agricultural soils*. Figure 56 provides an overview of the ammonia emissions by origin in category *3 –Agriculture* for the period 1990-2022.

The emissions of nitrogen oxides related to agricultural activities decreased by 33% between 1990 and 2022, see Table 5-1. In category *3B – Manure Management*, NO_x decreased by 20% and in category *3D – Crop production and agricultural soils*, NO_x decreased by 33% between 1990 and 2022.

NMVOC emissions in 2022 are slightly lower (-2%) to the one in 1990, see Table 5-1

PM_{10}, TSP emissions related to agricultural activities increased by 1% and 6% between 1990 and 2022, whereas $PM_{2.5}$ had decreased by 4%, Table 5-1.

HCB emissions have decrease by 91% compared to 2021 and by 99.9% since 1990. In 2022, emissions were particularly low, on the basis of a simple 5-year trend extrapolation, as no statistical data were available (see section 5.4.3.3.5).

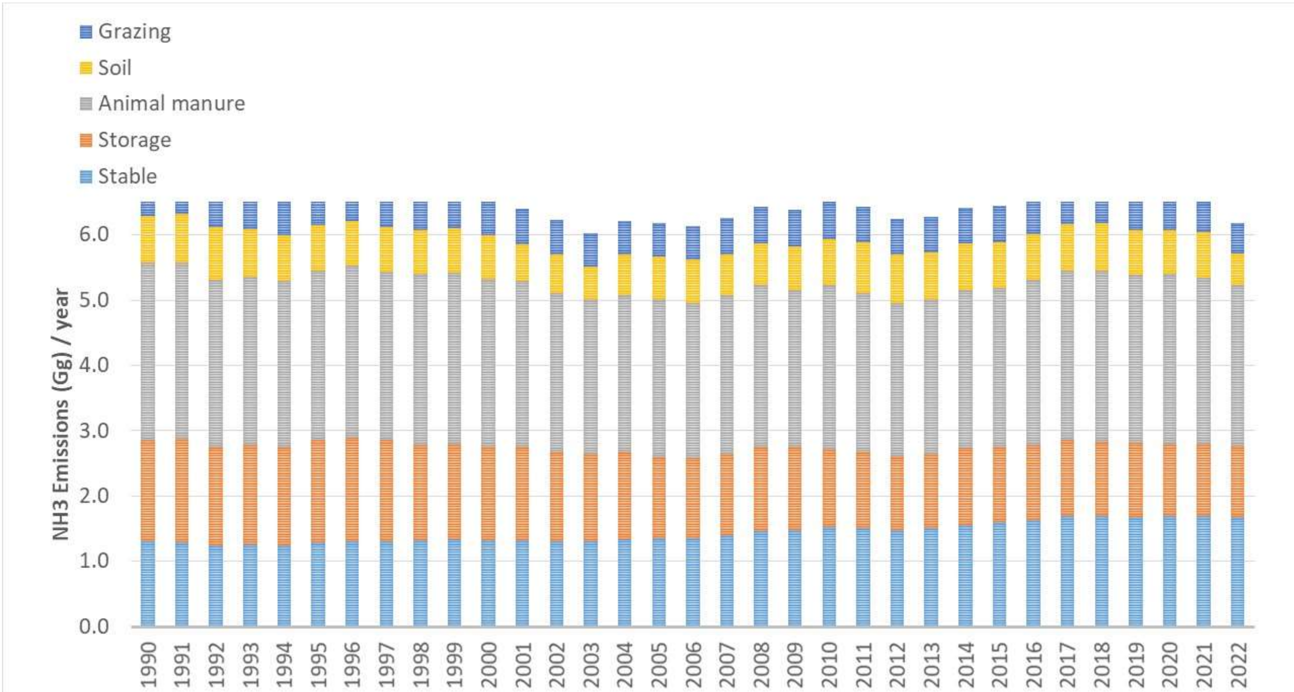
Table 5-1– Emission trends for category *3 – Agriculture*: 1990-2022

3 - Agriculture

Emissions by air pollutants (Gg)

	Total						3B. Manure management						3D. Crop production and agricultural soils					
Year	NH_3	NOx	NMVOC	$PM_{2.5}$	PM_{10}	TSP	NH_3	NOx	NMVOC	$PM_{2.5}$	PM_{10}	TSP	NH_3	NOx	NMVOC	$PM_{2.5}$	PM_{10}	TSP
1990	6.35	1.37	3.56	0.041	0.26	0.36	2.86	0.02	2.56	0.034	0.06	0.17	3.49	1.35	1.01	0.008	0.20	0.20
1991	6.39	1.41	3.51	0.041	0.25	0.35	2.87	0.02	2.53	0.033	0.06	0.16	3.52	1.39	0.98	0.007	0.19	0.19
1992	6.19	1.44	3.40	0.039	0.25	0.35	2.75	0.02	2.45	0.031	0.06	0.15	3.44	1.42	0.95	0.008	0.20	0.20
1993	6.17	1.38	3.45	0.039	0.25	0.36	2.78	0.02	2.50	0.031	0.06	0.16	3.39	1.36	0.95	0.008	0.20	0.20
1994	6.08	1.33	3.33	0.038	0.25	0.35	2.76	0.02	2.41	0.031	0.06	0.15	3.33	1.31	0.92	0.008	0.20	0.20
1995	6.24	1.34	3.42	0.039	0.25	0.35	2.85	0.02	2.49	0.031	0.06	0.16	3.39	1.32	0.94	0.008	0.20	0.20
1996	6.32	1.35	3.43	0.039	0.25	0.35	2.90	0.02	2.50	0.031	0.06	0.16	3.42	1.33	0.93	0.008	0.20	0.20
1997	6.21	1.33	3.39	0.038	0.25	0.36	2.86	0.02	2.47	0.031	0.06	0.16	3.35	1.31	0.91	0.008	0.20	0.20
1998	6.16	1.31	3.36	0.038	0.25	0.36	2.79	0.02	2.46	0.030	0.06	0.16	3.37	1.29	0.91	0.008	0.20	0.20
1999	6.19	1.33	3.33	0.038	0.25	0.36	2.80	0.02	2.43	0.030	0.06	0.16	3.39	1.32	0.89	0.008	0.20	0.20
2000	6.09	1.31	3.27	0.037	0.25	0.36	2.75	0.02	2.40	0.030	0.05	0.16	3.34	1.29	0.87	0.008	0.20	0.20
2001	5.96	1.20	3.26	0.037	0.25	0.36	2.75	0.02	2.40	0.030	0.06	0.16	3.20	1.19	0.86	0.008	0.20	0.20
2002	5.80	1.21	3.14	0.036	0.25	0.36	2.67	0.02	2.31	0.028	0.05	0.16	3.13	1.20	0.83	0.008	0.20	0.20
2003	5.61	1.09	3.05	0.035	0.25	0.36	2.64	0.02	2.25	0.027	0.05	0.16	2.97	1.07	0.80	0.008	0.20	0.20
2004	5.79	1.24	2.94	0.035	0.25	0.37	2.67	0.02	2.17	0.027	0.05	0.17	3.13	1.22	0.78	0.008	0.20	0.20
2005	5.76	1.15	2.97	0.035	0.26	0.37	2.60	0.02	2.19	0.027	0.05	0.17	3.16	1.13	0.78	0.008	0.20	0.20
2006	5.72	1.14	2.91	0.034	0.26	0.37	2.58	0.02	2.15	0.027	0.05	0.17	3.14	1.13	0.76	0.008	0.20	0.20
2007	5.82	1.13	2.96	0.035	0.26	0.37	2.65	0.02	2.20	0.027	0.05	0.17	3.17	1.11	0.75	0.008	0.20	0.20
2008	6.00	1.15	3.03	0.036	0.26	0.37	2.75	0.02	2.27	0.028	0.05	0.17	3.24	1.13	0.76	0.008	0.20	0.20
2009	5.95	1.15	3.01	0.036	0.26	0.37	2.75	0.02	2.26	0.028	0.06	0.17	3.20	1.13	0.74	0.008	0.20	0.20
2010	6.07	1.16	3.03	0.036	0.26	0.37	2.73	0.02	2.29	0.029	0.05	0.17	3.34	1.15	0.75	0.008	0.20	0.20
2011	6.00	1.17	2.93	0.036	0.26	0.37	2.67	0.02	2.21	0.028	0.05	0.17	3.33	1.16	0.72	0.008	0.20	0.20
2012	5.82	1.14	2.90	0.035	0.26	0.38	2.61	0.02	2.19	0.028	0.06	0.17	3.21	1.12	0.71	0.008	0.20	0.20
2013	5.86	1.13	3.00	0.036	0.26	0.38	2.65	0.02	2.28	0.029	0.06	0.18	3.21	1.12	0.72	0.008	0.20	0.20
2014	5.99	1.13	3.08	0.037	0.26	0.38	2.73	0.02	2.36	0.029	0.06	0.18	3.25	1.12	0.73	0.008	0.20	0.20
2015	6.01	1.13	3.15	0.038	0.26	0.39	2.76	0.02	2.42	0.030	0.06	0.19	3.25	1.12	0.73	0.008	0.20	0.20
2016	6.12	1.17	3.29	0.038	0.26	0.39	2.79	0.02	2.53	0.031	0.06	0.19	3.33	1.16	0.76	0.008	0.20	0.20
2017	6.25	1.19	3.33	0.039	0.26	0.40	2.85	0.02	2.56	0.031	0.06	0.20	3.40	1.17	0.77	0.008	0.20	0.20
2018	6.25	1.16	3.40	0.039	0.26	0.39	2.83	0.02	2.62	0.031	0.06	0.19	3.41	1.14	0.78	0.008	0.20	0.20
2019	6.12	1.16	3.38	0.039	0.26	0.39	2.81	0.02	2.62	0.032	0.06	0.19	3.31	1.14	0.77	0.008	0.20	0.20
2020	6.09	1.12	3.53	0.040	0.26	0.39	2.80	0.02	2.74	0.032	0.06	0.19	3.29	1.11	0.79	0.008	0.20	0.20
2021	6.03	1.15	3.50	0.039	0.26	0.39	2.77	0.02	2.72	0.032	0.06	0.19	3.26	1.13	0.78	0.008	0.20	0.20
2022	5.69	0.92	3.48	0.039	0.26	0.39	2.71	0.02	2.71	0.032	0.06	0.19	2.98	0.90	0.77	0.008	0.20	0.20
Trend 1990 -2022	-10%	-33%	-2%	-4%	1%	6%	-5%	-20%	6%	-5%	2%	12%	-15%	-33%	-23%	1%	1%	1%
Trend 2005 -2022	-1%	-20%	17%	13%	1%	3%	4%	0%	24%	17%	15%	9%	-6%	-20%	-1%	-2%	-2%	-2%
Trend 2021 -2022	-6%	-20%	0%	0%	0%	-1%	-2%	-1%	0%	0%	0%	-1%	-9%	-20%	-1%	0%	0%	0%

Figure 56 – NH_3 emission trend for 1990-2022 by origin



5.1.2 Key categories

The methodology and results of the key category analysis are presented in Chapter 1.5. Table 5-2 presents the key categories for category *3 - Agriculture*.

Table 5-2 – Key category analysis for category *3 – Agriculture*

Key Source Analysis (FUEL SOLD): Ranking per number		SO2		NOX		NMVOC		NH3		CO		TSP		PM10		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
3 B 1 a	Manure management - Dairy cattle					2	4	3									
3 B 1 b	Manure management - Non-dairy cattle					3	5	2									
3 D a 1	Inorganic N-fertilizers (includes also urea application)								1								
3 D a 2 a	Animal manure applied to soils					6	7	1	4								
3 D a 2 b	Sewage sludge applied to soils								6								
3 D a 2 c	Other organic fertilisers applied to soils (including compost)								3								
3 D a 3	Urine and dung deposited by grazing animals							4	7								
3 D c	Farm-level agricultural operations including storage, handling and transport of agricultural products											5	6	3	4		

Key Source Analysis (FUEL USED): Ranking per number		SO2		NOX		NMVOC		NH3		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
3 B 1 a	Manure management - Dairy cattle					2	3	3			
3 B 1 b	Manure management - Non-dairy cattle					3	6	2			
3 B 4 e	Manure management - Horses								6		
3 D a 1	Inorganic N-fertilizers (includes also urea application)								1		
3 D a 2 a	Animal manure applied to soils					6		1			
3 D a 2 b	Sewage sludge applied to soils								5		
3 D a 2 c	Other organic fertilisers applied to soils (including compost)								2		
3 D a 3	Urine and dung deposited by grazing animals							4	7		

Source: Environment Agency

Notes: LA = Level Assessment, TA = Trend Assessment, number in table indicates the rank in the specific analysis (1…biggest KC; 2… second biggest KC, …)

5.1.3 Completeness

Table 5-3 gives an overview of the categories included Agriculture and provides information on the status of emission estimates of all subcategories.

Table 5-3 – Status of emission reporting for category *3 – Agriculture*

NFR Code	Agriculture	NO_x	NMVOC	NH_3	TSP	PM_{10}	$PM_{2.5}$	HCB
3B1a	Manure management – Dairy cattle	x&	x&	x&	x*	x*	x*	NA
3B1a	Manure management – Non-dairy cattle	x&	x&	x&	x*	x*	x*	NA
3B2	Manure management – Sheep	x&	x&	x&	x*	x*	x*	NA
3B3	Manure management – Swine	x&	x&	x&	x*	x*	x*	NA
3B4a	Manure management – Buffalo	NO	NO	NO	NO	NO	NO	NA
3B4d	Manure management – Goats	x&	x&	x&	x*	x*	x*	NA
3B4e	Manure management – Horses	x&	x&	x&	x*	x*	x*	NA
3B4f	Manure management – Mules and asses[1]	IE	IE	IE	IE	IE	IE	NA
3B4gi	Manure management – Laying hens	x&	x&	x&	x*	x*	x*	NA
3B4gii	Manure management – Broilers	x&	x&	x&	x*	x*	x*	NA
3B4giii	Manure management – Turkeys[2]	IE	IE	IE	IE	IE	IE	NA
3B4giv	Manure management – Other poultry[2]	x&	x&	x&	x*	x*	x*	NA
3B4h	Manure management – Other animals[3]	x&	x&	x&	x*	x*	x*	NA
3Da1	Inorganic N-fertilizer	x*	NA	x&	NA	NA	NA	NA
3Da2a	Animal manure (including digestate originating from animal manure)	x*	x&	x&	NA	NA	NA	NA
3Da2b	Sewage sludge	x*	NA	x*	NA	NA	NA	NA
3Da2c	Other organic fertilisers (i.e.compost and digestate originating from engery crops and other waste)	x*	NA	X *,&	NA	NA	NA	NA
3Da3	Urine and dung deposited by grazing animals	x*	x&	x&	NA	NA	NA	NA
3Da4	Crop residues applied to soils	x*	NA	NE	NA	NA	NA	NA
3Db	Indirect emissions from managed soils	NE	NA	NA	NA	NA	NA	NA
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	NO	NA	NA	x*	x*	x*	NA
3Dd	Off-farm storage, handling and transport of bulk agricultural products	NO	NA	NA	NA	NA	NA	NA
3De	Cultivated crops	NA	x*	NA	NO	NO	NO	NA
3Df	Use of pesticide	NE	NO	NE	NE	NE	NE	x*
3F	Field burning of agricultural residues	NO	NO	NO	NO	NO	NO	NO
3I	Agriculture other	NO	NO	NO	NO	NO	NO	NO

Notes:
(1) the number of mules & asses where recorded together with horses (category 3B4e); (2) Turkeys are included in category Other Poultry (3B4giv); (3) the sub-category "Other animals" – ostriches is not occurring (NO) from 1990 to 2002 included. It further includes rabbits and deer.
* using Tier 1; &using Tier 2 and Default EF; # using Tier 2 and Country-specific EF.

5.2 General aspects

Animal categories, livestock numbers, manure management system (MMS), N excretion (N.ex) and the N flows in the manure management system are used in several categories in the emission calculations and were therefore described in this chapter. Other required information is presented under each source category review.

5.2.1 Animal categories

Cattle was and is the major livestock in Luxemburg. In the emission calculations seven categories were distinguished:

Calves	Comprising calves <1 year, from both dairy and suckler herds. Where necessary, further distinguishing between male and female calves.
Female young cattle 1-2 years	Comprising 1-2 years old female cattle from both dairy and suckler herds.
Fattening bulls 1-2 years	Comprising 1-2 years old male cattle from both dairy and suckler herds. Most of them fattening bulls kept and fed inside stables. The remaining animals were growing breeding males and young oxes, but for simplicity reasons treated in the agricultural emission calculations as being 100% fattening bulls.
Heifers >2 years	Comprising heifers >2 years from both dairy and suckler herds. Most of the heifers were kept for breeding purposes. Heifers for slaughtering were/are raised, fed, and kept in the same way as breeding heifers, why no further distinction was made.
Mature male cattle >2 years	Comprising male cattle >2 years from both dairy and suckler herds. Mostly breeding animals; a few fattening bulls who took longer than the useable 20-24 months for finishing; and a few fattening oxes. For simplicity all animals in this category were treated as being mature male breeding cattle.
Lactating dairy cows	Comprising ***only*** lactating dairy cows. In the census up to the year 2007 there were three "cow" categories distinguished, namely dairy cows comprising only "*lactating* dairy cows"; "*non-lactating* dairy cows" kept for fattening purposes and "suckler cows". Since 2008, however, both lactating and non-lactating dairy cows are reported together in one single category. For 1990-2007 non-lactating dairy cows accounted on average for 9.15% (range 7.1%-10.8%) of the total consisting of lactating dairy cows and non-lactating dairy cows ($P_{\text{cull cows}}$).(STATEC 2019d) Assuming the same distribution of lactating and non-lactating dairy cows for the year 2008 and onwards, the number of lactating dairy cows ($N_{\text{lactating dairy cows}}=N_{\text{dairy cows (total)}} - N_{\text{non-lactating dairy cows}}$) and the number of non-lactating dairy cows ($N_{\text{non-lactating dairy cows}} =[N_{\text{dairy cows (total)}} * P_{\text{non-lactating dairy cows}}]$) was estimated.
Non-lactating dairy cows	Comprising *only* non-lactating dairy cows kept for fattening purposes (i.e. cull cows). Numbers of non-lactating dairy cows were partly based on statistics (1990-2007), partly estimated (2008-and onwards), for more details see livestock category "lactating dairy cows".
Suckler cows	Comprising suckler cows.

In the NFR tables emission calculations were summarized and reported as “dairy cattle” (i.e. lactating dairy cows) and as “non-dairy cattle” (i.e all other cattle categories, excluding lactating dairy cows).

For sheep (reported in the NFR tables as one category) two categories were distinguished in the emissions calculations, namely:

Mature sheep	Comprising all sheep ≥1 year; in the majority breeding females (~90%) (STATEC 2019d). The remaining animals are other mature sheep, but for simplicity reasons treated in the agricultural emission calculations as being 100% female breeding animals.
Sheep lambs	Comprising only lambs <1 year. Sheep lambs are in born in early spring. The majority of the lambs are fattened and slaughtered at the age of 5-7 months, (Kirchgessner 2014) and remaining animals are raised as replacement stock. Approximately 80% (range 75%-85% (Vaessen Personal communication; December 2018)) of the fattening lambs were assumed to be slaughtered at the age of 6 months. The average animal population was corrected accordingly following IPCC guidelines.(IPCC 2006a)[70]

For swine (reported in the NFR tables as one category) three categories were distinguished in the emission calculations, these were:

Sows[71]	Comprising mated sows, sows with piglets and mated young sows
Fattening pigs	Comprising fattening pigs >30 kg (>90%) (STATEC 2019d) and growing not mated female breeding swines >30 kg and all male breeding swines >30 kg. For simplicity reason, all treated in the emission calculations as being fattening pigs.
Weaners	Comprising all weaners, i.e. piglets with a weight between 10-30 kg.

Note: Emissions from piglets <10 kg were considered within the “sow” category.

For goats (reported in the NFR tables as one category) two categories were distinguished in the current emission calculations, these were:

Mature goats	Comprising all goats ≥1 year, mostly goat ewes.(STATEC 2019d) The remaining animals were other mature goats, but for simplicity reasons treated in the agricultural emission calculations as being 100% goat ewes.
Goat kids	Comprising goat kids <1 year. Goat kids are born in early spring. However, the male goat kids (assumption to be 50%) are fattened and slaughtered at the age of 5-7 weeks. The female goat kids are raised as replacement stock (own survey)[72]. For the emission calculations it was assumed that

[70] Annual average population = (Number of lambs raised * 20%) + ((6*30) * ((Number of lambs raised * 80%)/365)). Note the number of sheep lambs raised was derived from the number of mature sheep.
[71] Emissions from piglets with a weight < 10 kg were accounted in the category “sows”.
[72] Own survey conducted in November 2018 between goat famers keeping in 2017 approximately 70% of all female dairy goats, and confirmed by unpublished data collected at the Luxemburgish Farm accounting data network (FADN)-partner (http://ec.europa.eu/agriculture/rica/) (Pers. communication Marc Schmit and Paul Jacqué, SER - Comptabilité, December 2018).

50% of the goat kids would be slaughtered at the age of 6 weeks. The average animal population was corrected accordingly, following IPCC guidelines.(IPCC 2006a)[73]

Horses consisted of one category and include mules and asses:

Horses	Comprising horses, mules and asses. Whereby further distinguishing between heavy agriculture horses, riding horses and ponies. Mules and asses were considered together with the ponies.

Note emissions from mules and asses were considered together with horses, why using in the NRF tables the key notification "IE".

For poultry three categories were distinguished in the current emissions calculations, namely:

Laying hens	Comprising laying hens and chicks up to 6 months
Broilers	Comprising only broilers
Other poultry	Comprising all other poultry categories, including turkeys, but excluding ostriches. Ostriches are included in "other animals" (see next category).

Note emissions from turkeys were considered together with "other poultry", why using in the NRF tables the key notification "IE".

The other animal category (reported in the NFR tables as one category (NFR 3B4h)) consisted of ostriches, rabbits, and deer, namely:

Breeding female rabbits[74]	Comprising breeding female rabbits only. Including the emissions for raising young stock but excluding the emissions for fattening the young stock.
Other rabbits	Comprising all other rabbits
Ostriches	Comprising all registered ostriches
Deer	All other registered animals are considered in this category, the majority (>90%) are deer.

[73] Annual average population = (Number of kids raised * 50%) + ((6*7) * ((Number of kids raised * 50%)/365)). Note the number of goat kids raised was derived from the number of mature goats.

[74] In the current emission calculations, a distinction was made between breeding female rabbits and other rabbits (no distinction in previous emission calculations) to better fit the available country-specific N excretion estimates.

5.2.2 Activity data - Livestock numbers

5.2.2.1 Livestock numbers - General

Activity data on animals' numbers are summarized in Table 5-4. Activity data were in general based on the agricultural census conducted annually in spring[75] by STATEC (Institut national de la statistique et des études économiques du Grand-Duché de Luxembourg).[76] In later years in collaboration with SER (Service d'Economie Rurale)),(STATEC 2018) and since 2017 only by SER. In the Agriculture census, all farms situated in Luxemburg with either ≥10 horses, or ≥10 cattle, or ≥20 small ruminants, or ≥50 fattening pigs, or ≥10 breeding female pigs (>50 kg), or ≥1000 poultry birds or ≥ 1000 rabbits were taken into account. The response rate was ~95%. The number of animals as counted on the reference data in spring was assumed to represent the animal numbers at any other possible reference data in the same year, except for:

- cattle from 2014 onwards;
- swine from 2020 onwards;
- laying hens from 2020 onwards.

In addition, were adjustement made to account for the fact that some animals are kept outside agricultural holdings, and hence not covered by the agricultural census. This was done for Equidae and for small ruminants.

Cattle

Agriculture census data was used for the period 1990-2013, and from 2014 onwards were average numbers as extracted from the "SANITEL" database used. In Luxemburg each single cattle must be registered and is followed from birth or import until end of life (slaughter or natural death) or export, whatever comes first. All those movements are registered in the "SANITEL" dataase, hence a 100% coverage of the cattle population and their evaluation throughout the year.

Swine

Agriculture census data was used for the period 1990-2019; and from 2020 onwards were data from the agricultural census in spring and the swine census on the 1st of December[77] used for estimating the "average population".

Laying hens

Agriculture census data was used for the period 1990-2019, and from 2020 onwards were data used from the agricultural census in spring and the laying hens survey on the 31th December, and on 31th December from previous year[78]. The median of this three data points was used to obtain the "average population" in year *x*. For all other poultry categories was the agriculture census data the only data source used.

---

[75] Reference date: Until 2010 15th Max; 2011-2021: 1st April and from 2022 onwards 1st February.

[76] https://lustat.statec.lu/vis?fs[0]=Th%C3%A8mes%2C1%7CEntreprises%23D%23%7CAgriculture%20et%20for-esterie%23D2%23&pg=0&fc=Th%C3%A8mes&df[ds]=release&df[id]=DF_D2107&df[ag]=LU1&pd=1990%2C2021&dq=.A

[77] Ministère de l'Agriculture, de la Viticulture et du Développement rural, Service d'économie rurale, Division des statistiques agricoles, des relations extérieures et des marchés agricoles. Data is available on : https://agriculture.public.lu/de/agrarstatistik/production-animale/animaux/tiere-jahr.html

[78] Ministère de l'Agriculture, de la Viticulture et du Développement rural, Service d'économie rurale, Division des statistiques agricoles, des relations extérieures et des marchés agricoles.

Horses, mules and anes

In the agricultural census in spring was data collected on the number of horses, mules and anes ***kept on agricultural holdings***. However, the data collection had changed over the years, and adjustement were necessary for:

- the number of horses in pension on agricultural holdings were missing for the period 1990-1998, a trend estimate based on the years 1999-2021 was used;
- the number of mules and anes kept on agricultural holdings were missing for the years 1990-2004, a trend estimate based on the years 2005-2009 was used;
- and further were heavy horses, riding horses and ponys not always collected as separate categories, hence a splitting of the collected data was required for some years, using the observed trend of the following years.

There were no data available on the number of equidae ***kept off-farms***. Presuming that half of the equidae in Luxembourg would be kept on agricultural holdings, the number of equidae kept on agricultural holdings was multiplied by two to obtain the total equidae population in Luxemburg.

Small ruminants

In the agricultural census were data collected on sheep and on goats ***kept on agricultural holdings***. Due to the large fluctuations of the number of sheep lambs and goat kits over the years, was the number of sheep lambs and goat kits born and raised estimated assuming 1.165 sheep lambs raised per sheep ewe for non-dairy breeds, 1.5 sheep lambs raised per sheep ewe for dairy breeds and 0.81 goat kits raised per goat ewe.[79]

Data on the number of small ruminants ***kept off-farms*** are missing. In 2020-2021 the veterinary authority counted roughly 1000 small ruminant holders. The agricultural census however counted <400 holders, hence roughly 600 holders keeping small ruminants off-farms. Assuming that agricultural holdings with less than 50 small ruminants would be comparable to small ruminants' herds off-farms (i.e. median was 7 small ruminants including lambs and kits in 2020), estimates of the number of sheep and goats kept off-farms were made for 2020. And for all other years (1990-2019 and 2021), it was assumed that the number of small ruminants kept off-farms were comparable to 2020.

[79] Estimates were based on farms within the LTBN (Source: SER) and validated by comparing the so estimated numbers of lambs/kits with the agricultural census data. They were considered as being valid, as the estimates would have been in all the years (1990-2021) higher than the census data.

Table 5-4– Annual average population (heads/animal places per year) per livestock category for the period 1990-2022

3 - Agriculture

Activity data - annual average population (heads/animal places per year (* 1000))[a]

Year	Calves < 1 year	Female young cattle 1-2 years	Heifers >2 years	Fattening bulls 1-2 years	Mature male cattle > 2 years	Lactating dairy cows[a]	Non lactating dairy cows[a]	Suckler cows	Sows	Fattening pigs[b]	Weaners[b,c]	Mature sheep[d]	Sheep lambs <1 year[d]	Mature goats[d,e]	Goat kids <1 year[d]	Horses[e]	Broilers	Laying hens[g]	Other poultry[h]	Ostriches	Rabbits - Breeding animals[i]	Other rabbits[i]	Deer
1990	59.6	34.0	24.6	13.0	5.4	58.8	4.5	17.6	9.0	33.2	19.2	3.7	2.0	0.46	0.26	3.6	11.2	57.8	2.26	0.00	2.31	11.2	0.09
1991	59.3	34.4	25.7	13.6	5.6	55.6	5.1	20.2	8.5	28.4	17.0	3.9	2.0	0.50	0.28	3.8	10.9	52.7	2.06	0.00	1.83	11.7	0.16
1992	56.2	33.8	25.0	12.7	4.7	51.1	4.8	20.9	8.6	30.6	16.4	3.8	2.0	0.41	0.24	3.8	9.5	50.8	1.82	0.00	1.65	10.4	0.13
1993	55.7	32.3	25.0	13.7	4.7	50.2	4.3	23.0	8.6	33.6	16.9	3.3	2.0	0.48	0.27	4.0	9.9	53.6	1.62	0.00	1.48	7.1	0.13
1994	58.0	31.9	22.6	14.1	4.2	49.0	4.3	24.6	8.6	30.9	17.0	4.1	2.1	0.40	0.21	4.4	9.3	51.1	1.52	0.00	1.34	6.4	0.18
1995	57.6	33.0	23.7	15.3	4.9	48.6	4.8	26.0	8.9	33.0	17.8	4.1	2.1	0.32	0.18	4.5	8.5	47.1	1.80	0.00	1.39	5.8	0.18
1996	59.1	33.0	24.6	16.2	5.1	48.0	5.1	26.8	8.6	31.6	18.7	3.8	2.1	0.26	0.14	4.6	10.3	51.6	1.59	0.00	1.13	4.8	0.14
1997	57.0	32.7	23.2	16.7	5.6	46.3	4.7	26.2	8.7	36.1	18.1	4.0	2.1	0.32	0.18	4.8	19.6	46.7	1.94	0.00	1.27	6.0	0.17
1998	55.3	31.4	23.0	17.1	5.3	46.0	4.7	26.0	8.7	36.6	20.3	4.5	2.2	0.26	0.14	4.9	21.3	47.1	1.39	0.00	1.07	5.7	0.28
1999	55.4	30.8	23.1	16.6	4.8	45.1	5.1	27.0	8.3	39.2	22.0	4.3	2.2	0.22	0.12	5.9	13.5	48.6	0.98	0.00	0.97	5.2	0.33
2000	54.8	30.6	22.6	16.4	4.4	43.3	5.3	27.6	7.6	38.5	19.7	4.3	2.2	0.27	0.15	6.6	14.2	57.6	0.85	0.00	1.44	5.2	0.38
2001	54.3	30.3	22.7	16.7	4.8	42.9	5.0	28.4	7.8	38.4	18.9	4.8	2.2	0.28	0.16	6.5	17.6	66.7	1.00	0.00	1.00	5.5	0.34
2002	53.7	28.1	21.4	15.0	4.2	42.1	4.9	27.9	7.6	39.7	19.1	4.7	2.2	0.30	0.14	6.5	16.0	61.9	0.96	0.00	1.13	5.9	0.32
2003	51.3	28.0	20.1	14.3	3.8	40.6	4.4	27.1	7.4	44.4	18.9	5.6	2.2	0.42	0.17	7.2	15.3	64.0	1.01	0.20	0.97	5.5	0.24
2004	50.8	27.7	19.8	13.8	3.6	39.9	4.1	27.1	7.2	54.7	16.6	5.6	2.2	0.45	0.20	7.7	12.2	60.9	1.08	0.27	0.86	5.7	0.29
2005	49.2	27.6	19.6	14.5	3.4	39.3	4.1	27.6	7.4	58.0	18.9	5.2	2.3	0.45	0.17	9.0	20.3	63.1	1.12	0.21	0.92	5.6	0.25
2006	49.5	27.8	19.0	14.0	3.2	38.6	3.6	28.0	7.1	54.7	16.9	5.8	2.3	0.45	0.17	8.6	19.3	62.0	1.15	0.17	0.88	6.0	0.25
2007	52.7	29.1	20.0	14.4	2.8	39.0	4.0	28.9	6.9	54.2	17.4	5.2	2.3	0.69	0.15	8.5	17.5	64.4	0.81	0.18	0.77	4.0	0.19
2008	52.1	29.3	18.4	16.5	3.2	40.0	3.6	32.6	6.6	54.0	16.0	5.0	2.3	0.67	0.17	8.9	8.1	73.3	0.63	0.21	0.68	3.4	0.34
2009	52.4	29.4	18.3	15.4	3.8	40.6	3.7	32.8	6.6	54.2	15.7	5.1	2.4	0.48	0.18	9.0	17.3	80.1	0.83	0.23	0.76	3.4	0.34
2010	52.2	30.3	18.6	16.5	3.7	41.3	3.7	32.5	6.5	46.2	21.9	5.1	2.3	0.67	0.24	9.1	17.2	72.4	0.54	0.20	0.67	2.8	0.33
2011	52.3	29.7	17.2	14.3	3.2	40.5	3.7	31.7	6.0	50.8	22.2	5.2	2.4	0.55	0.19	9.1	17.5	84.1	0.68	0.33	0.65	2.1	0.43
2012	52.5	29.8	16.3	13.1	2.8	39.8	3.6	30.5	5.7	54.3	19.1	4.9	2.3	0.73	0.20	9.7	17.8	95.0	1.54	0.21	0.71	2.9	0.38
2013	53.3	30.2	16.3	14.4	3.1	42.1	4.1	30.2	5.4	53.7	17.5	5.2	2.4	0.60	0.18	9.3	15.6	95.7	0.85	0.34	0.73	2.7	0.27
2014	54.1	31.0	20.9	15.4	3.3	41.9	4.1	28.8	5.3	54.8	17.4	5.2	2.3	0.67	0.20	9.3	15.4	100.1	1.01	0.18	0.74	2.3	0.27
2015	53.6	32.0	21.8	13.9	3.5	43.4	4.3	28.4	4.9	60.0	19.9	5.6	2.3	0.78	0.24	9.3	18.4	95.3	0.96	0.26	0.76	2.0	0.24
2016	54.4	32.0	21.0	12.2	3.1	46.5	4.6	27.9	4.9	60.0	18.5	5.2	2.3	0.65	0.21	9.0	18.9	95.3	0.87	0.25	0.61	2.2	0.17
2017	52.3	33.1	21.1	12.0	3.1	47.6	4.7	27.2	5.3	61.8	19.9	5.1	2.3	0.72	0.19	9.3	20.9	101.7	1.26	0.20	0.54	1.9	0.12
2018	49.9	31.9	21.8	11.2	3.1	48.0	4.7	25.6	5.2	57.1	19.2	5.1	2.3	0.79	0.23	9.3	22.1	101.4	0.77	0.21	0.57	2.2	0.15
2019	50.2	31.0	19.8	10.3	3.0	49.0	4.8	25.1	4.5	51.9	20.0	5.1	2.3	0.93	0.30	9.3	21.4	110.7	0.60	0.24	0.60	1.8	0.05
2020	49.4	31.6	18.9	10.1	2.9	49.5	4.9	24.3	4.0	53.0	15.2	5.7	2.3	0.93	0.28	8.8	20.9	116.5	0.55	0.22	0.51	1.6	0.04
2021	49.1	31.1	18.1	9.7	2.8	49.7	4.9	23.3	3.1	55.2	11.1	5.9	2.3	0.93	0.29	8.5	51.1	110.6	0.61	0.20	0.47	1.8	0.04
2022	47.7	31.4	17.7	9.9	2.9	50.0	4.9	22.3	2.4	52.5	8.2	6.2	2.3	1.13	0.29	8.7	54.1	120.3	0.58	0.13	0.40	1.7	0.04
Trend 1990 -2022	-20%	-8%	-28%	-24%	-48%	-15%	9%	27%	-74%	58%	-57%	67%	14%	146%	11%	142%	382%	108%	-75%	NA	-83%	-85%	-53%
Trend 2005-2022	-3%	14%	-10%	-32%	-17%	27%	20%	-19%	-68%	-10%	-57%	19%	2%	150%	69%	-3%	166%	91%	-49%	-40%	-56%	-69%	-83%
Trend 2021 -2022	-3%	1%	-2%	2%	2%	1%	1%	-4%	-23%	-5%	-26%	5%	0%	21%	-1%	2%	6%	9%	-5%	-35%	-14%	-3%	16%

a) Up to 2007 were dairy cows registered in two categories, i) lactating dairy cows, and ii) non-lactating dairy cows with the purpose to be fattened and slaughtered, but no further distinction since 2008. From 1990-2007, did non-lactating dairy cows account on average for 9.15% of the total dairy cow population (range 7.1%-10.8%). Presuming that the percentage of non-lactating dairy cows remained the same, the number of non-lactating dairy cows were estimated for the years 2008 and onwards and subtracted from the total number of dairy cows in order to obtain the number of "lactating dairy cows". Non-lactating dairy cows were considered together with all other cattle in the category "non-dairy".

b) For the period 1990-2009 there was a subcategory of fattening pigs from 20 kg-50 kg. To suit our animal categories, this category was split up and it was assumed that 2/3 would have been fattening pigs >30 kg and 1/3 would have been weaners. From 2010 onwards, statistics are collected accordingly to the live weights used in the current inventory, i.e. fattening pigs >30 kg and weaners 10-30 kg. Note the number of pig farmers and the number of pigs is relatively low in Luxemburg compared to our neighboring countries. This fact together with a strong reorientation of the sector in the whole period, and the fact that some of the pig famers work on contract basis - in particularly those raising weaners and fattening pigs – is an explication for the observed fluctuations between years.

c) Piglets staying with the sow up to 10 kg weight were not considered as a separate category in the emission calculation - a category also registered in the census. Since 2010 were those registered as a separate category. For the period 1990-2009, it was assumed that 50% of the piglets <20 kg would be weaners, and the other 50% would be newborn piglets <10 kg staying with the sows. The total for swine from the inventory differs therefore from the one reported by STATEC, and other international statistical institutes such as EUROSTAT.
d) The total of sheep and goats reported in this inventory varies from the one reported by STATEC, and other international statistical institutes because a) including also small rumiants kept off-farms; and b) most sheep lambs and goat kids are fattened and sold previous to one year of age. Following the IPPC guidelines from 2006,(IPCC 2006a) the average number of animals were corrected.
e) From 2007 onwards there were three categories, namely goat-ewes; goat kits and other mature goats (i.e. mainly breeding males and other goats older than 1 year). Before 2007, there exist only two categories, namely goat-ewes and “others”. This latter category was split into lambs and others. Based on the data from 2007-2018 (for the Source see footnote a), we assumed that on average 18% (range: 7%-30%) would have been “other mature goats” and the remaining would have been goat kits. Note in the CRF table goats are reported as one category.
f) The total of horses reported in this inventory varies from the one reported by STATEC, and other international statistical institutes because a) including also horses kept off-farms; and b) due to adjustment made to correct for adapted data collection over time; Mules and asses are included in the category “horses”.
g) There were two categories, namely laying hens and chicks older than 6 months up to 2004. Since 2005, however are chicks older than 6 months and laying hens considered as one category.
h) In the published statistics were ostriches included in “other poultry”. Ostriches were considered as a separate category and therefore subtracted from this category.
i) In the NRF tables reported together with deer and ostriches as one category, but for the emission calculations a distinction between breeding females’ rabbits and other rabbits (i.e. fattening rabbits) were made.

5.2.2.2 Temporary net export of grazing animals

A part of the utilized agriculture surface cultivated by luxemburgish farmers were situated in neighbouring countries. During summer months were the animals grazing on these fields “temporary” exported to neighbouring countries, see Table 5-5. The same applied the other way around, so where grazing animals fromof German, Belgium or France imported, see Table 5-5for grazing in Luxemburg on fields cultivated by German, Belgium and/or French farmers. In the inventories were only animals grazing in Luxemburg considered.

The temporary transfers had to be notified to the Luxemburgish animal health authorities, who published annually since 2001 annually the number of transferred animals.[80] The majority of these transfers were cattle. Transfers from other animal categories were rather seldom and included only very few animals, why ignored in the inventories. Having no data for the period 1990-2000, a trend estimate was used, based on the years 2001-2006. The number of exported and imported animals is reported in Table 5-5.

Detailed information on the age of the exported and imported livestock were not available, but as mostly female cattle was the assumption made that 50% of the cattle would have been young female cattle 1-2 years old, and 50% would have been heifers >2 years old.

Table 5-5– Tempory export, import and net export of grazing cattle (heads) for the period 1990-2022

3 - Agriculture					
Activity data - Temporary exported and imported grazing cattle (head/year)				Activity data - Correction factor for net exported grazing livestock category *i* (i.e. percentage of net exported animals in comparison to average number of animals in livestock category *i*)	
Year	Exported number of cattle	Imported number of cattle	Net export of cattle	Female young cattle 1-2 years	Heifers >2 years
	heads	heads	heads	%	%
1990	*5 451*	*649*	*4 803*	*0.07*	*0.10*
1991	*5 383*	*610*	*4 772*	*0.07*	*0.09*
1992	*5 314*	*572*	*4 742*	*0.07*	*0.09*
1993	*5 245*	*533*	*4 712*	*0.07*	*0.09*
1994	*5 176*	*494*	*4 682*	*0.07*	*0.10*
1995	*5 107*	*456*	*4 652*	*0.07*	*0.10*
1996	*5 039*	*417*	*4 622*	*0.07*	*0.09*
1997	*4 970*	*378*	*4 591*	*0.07*	*0.10*
1998	*4 901*	*340*	*4 561*	*0.07*	*0.10*
1999	*4 832*	*301*	*4 531*	*0.07*	*0.10*
2000	*4 763*	*263*	*4 501*	*0.07*	*0.10*
2001	4 800	108	4 692	0.08	0.10
2002	4 423	318	4 105	0.07	0.10
2003	4 401	98	4 303	0.08	0.11
2004	4 740	240	4 500	0.08	0.11
2005	4 669	-	4 669	0.08	0.12
2006	4 103	-	4 103	0.07	0.11
2007	3 776	12	3 764	0.06	0.09
2008	4 191	59	4 132	0.07	0.11
2009	4 297	28	4 269	0.07	0.12
2010	4 102	39	4 063	0.07	0.11
2011	4 818	8	4 810	0.08	0.14
2012	5 421	90	5 331	0.09	0.16
2013	5 359	44	5 315	0.09	0.16
2014	4 497	120	4 377	0.07	0.10
2015	4 637	507	4 130	0.06	0.09
2016	4 668	151	4 517	0.07	0.11
2017	4 312	741	3 571	0.05	0.08
2018	4 460	629	3 831	0.06	0.09
2019	3 932	25	3 907	0.06	0.10
2020	3 735	-	3 735	0.06	0.10
2021	5 725	386	5 339	0.09	0.15
2022	3 558	817	2 741	0.04	0.08

Source: For 2001 and onwards: annual reports of the Ministry of Agriculture.
Note: In italic estimations for the years 1990-2000.

[80] Publication in the annual activity reports (“Rapport d’activité”) from the ministry of agriculture later years are available online at https://agriculture.public.lu/de.html. The responsible animal health authority was the Administration des services veterinäires (ASV) for the years 1990-2021; and since 2022 Administration luxembourgeoise vétérinaire et alimentaire (ALVA) https://ma.gouvernement.lu/fr/administrations/alva.html.

5.2.3 Manure management system

5.2.3.1 General

For the emission calculations were for the different animal categories information required on:

- the fraction (or proportion) of the year that animals spend in:
  - grazing ($x_{grazing(i)}$);
  - on yards ($x_{yards(i)}$) (i.e. not occurring in Luxembourg);
  - buildings ($x_{build(i)} = (1- x_{grazing(i)})$[81];
- the proportion of livestock manure handled as:
  - slurry ($x_{slurry(i)}$), whereby, depending on animal category different housing systems were further distinguished (for more details see 5.2.3.2).
  - and as solid ($x_{solid(i)} = (1- x_{slurry(i)})$, whereby, depending on animal category different housing systems were further distinguished (for more details see see 5.2.3.2);
- for slurry further was required, what proportion of slurry:
  - was spread directly ($x_{spread\_direct\_slurry(i)}$) (i.e. not occurring in Luxembourg);
  - was used as feedstocks in biogas facilities ($x_{feed\_slurry(i)}$);
  - was stored before application ($x_{store\_slurry(i)} = (1 - x_{feed\_slurry(i)})$. Please note, in the inventories a further distinction was made on how slurry was stored (for more details see 5.2.3.5);
- for solid manure was further required, what proportion of solid manure:
  - was spread directly ($x_{spread\_direct\_solid(i)}$) (i.e. not occurring in Luxembourg);
  - was used as feedstocks in biogas facilities ($x_{feed\_solid(i)}$);
  - was stored before application ($x_{store\_solid} = (1 - x_{feed\_solid(i)})$. Please note, in the inventories a further distinction was made on how solid manures was stored (for more details see 5.2.3.5.2).

Please note:

- yards are uncommon in Luxembourg, and where then existing, integrated in the building with similar liquid/slurry management system as the rest of the housing. Yards were therefore not considered in the emission calculations as a separate category, but as building;
- direct spreading of slurry is not occurring in Luxembourg;
- direct spreading of solid manure is not occurring in Luxembourg.

The different manure management systems (MMS) were then calculated using the following formulas:

MMS- pasture$_{(i)}$ $= x_{grazing(i)}$; i.e. the proportion of excreta deposited during grazing for animal category i, see Table 5-6 including livestock grazing in neighbouring countries.

[81] Note: Yards, where than existing, are integrated in the building, and therefore not considered in the emission calculations as a separate category, but in xbuild.

MMS-feed_slurry$_{(i)}$ = ($x_{digester\_slurry\ i}$ / ($x_{building\ i}$)); i.e.the proportion of excreta deposited during housing in stables with a liquid/slurry management system, whereby slurry is used as feeding material for bio digester, see Table 5-7 .

MMS-liquid$_{(i)}$ = ($x_{store\_slurry\ i}$ / ($x_{building\ i}$)). i.e. the proportion of excreta deposited during housing in stables with a liquid/slurry management system, whereby slurry is stored on the farm, see Table 5-8.

MMS-feed_solid$_{(i)}$ = ($x_{digester\_solid\ i}$ / ($x_{building\ i}$)). i.e.the proportion of excreta deposited during housing in stables with livestock i kept on solid manure, whereby solid manure is used as feeding material for bio digester, see Table 5-9.

MMS-solid$_{(i)}$ = ($x_{store\_solid\ i}$ / ($x_{building\ i}$)). i.e. the proportion of excreta deposited during housing in stables with livestock i kept on solid manure and solid manure is stored on the farm, see Table 5-10.

with *i* = for animal category *i*.

Table 5-6– Manure management system - pasture (MMS-pasture) for all animal categories: 1990-2022

3 -Agriculture

Manure management system - pasture (MMS-pasture) for animal category *i*
(i.e. the proportion of excreta deposited during grazing)

Year	Calves < 1 year	Female young cattle 1-2 years	Heifers > 2 years	Fattening bulls 1-2 years	Mature male cattle > 2 years	Lactating dairy cows	Non-lactating dairy cows	Suckler cows	Sows	Fattening pigs	Weaners	Sheep	Goats	Horses	Broilers	Laying hens	Other poultry	Ostriches	Rabbits	Deer
1990	37%	49%	49%	0%	16%	25%	25%	49%	0%	0%	0%	75%	75%	49%	0%	0%	0%	NO	0%	75%
1991	37%	49%	49%	1%	17%	25%	25%	49%	0%	0%	0%	75%	75%	49%	0%	0%	0%	NO	0%	75%
1992	37%	49%	49%	1%	18%	25%	25%	49%	0%	0%	0%	75%	75%	49%	0%	0%	0%	NO	0%	75%
1993	37%	49%	49%	1%	19%	25%	25%	49%	0%	0%	0%	75%	75%	49%	0%	0%	0%	NO	0%	75%
1994	37%	49%	49%	2%	20%	25%	25%	49%	0%	0%	0%	75%	75%	49%	0%	0%	0%	NO	0%	75%
1995	37%	49%	49%	2%	20%	25%	25%	49%	0%	0%	0%	75%	75%	49%	0%	0%	0%	NO	0%	75%
1996	37%	49%	49%	2%	21%	25%	25%	49%	0%	0%	0%	75%	75%	49%	0%	0%	0%	NO	0%	75%
1997	37%	49%	49%	4%	19%	25%	25%	49%	0%	0%	0%	75%	75%	49%	0%	0%	0%	NO	0%	75%
1998	37%	49%	49%	3%	22%	25%	25%	49%	0%	0%	0%	75%	75%	49%	0%	0%	0%	NO	0%	75%
1999	37%	49%	49%	3%	21%	25%	25%	49%	0%	0%	0%	75%	75%	49%	0%	0%	0%	NO	0%	75%
2000	37%	49%	49%	3%	23%	25%	25%	49%	0%	0%	0%	75%	75%	49%	0%	0%	0%	NO	0%	75%
2001	37%	49%	49%	3%	23%	25%	25%	49%	0%	0%	0%	75%	75%	49%	0%	0%	0%	NO	0%	75%
2002	37%	49%	49%	3%	26%	25%	25%	49%	0%	0%	0%	75%	0%	49%	0%	0%	0%	NO	0%	75%
2003	37%	49%	49%	3%	27%	25%	25%	49%	0%	0%	0%	75%	0%	49%	0%	0%	0%	75%	0%	75%
2004	37%	49%	49%	2%	30%	25%	25%	49%	0%	0%	0%	75%	0%	49%	0%	0%	0%	75%	0%	75%
2005	37%	49%	49%	3%	29%	25%	25%	49%	0%	0%	0%	75%	0%	49%	0%	0%	0%	75%	0%	75%
2006	37%	49%	49%	3%	32%	25%	25%	49%	0%	0%	0%	75%	0%	49%	0%	0%	0%	75%	0%	75%
2007	37%	49%	49%	8%	35%	25%	25%	49%	0%	0%	0%	75%	0%	49%	0%	0%	0%	75%	0%	75%
2008	37%	49%	49%	8%	35%	25%	25%	49%	0%	0%	0%	75%	0%	49%	0%	0%	0%	75%	0%	75%
2009	37%	49%	49%	8%	33%	25%	25%	49%	0%	0%	0%	75%	0%	49%	0%	0%	0%	75%	0%	75%
2010	37%	49%	49%	10%	36%	25%	25%	49%	0%	0%	0%	75%	0%	49%	0%	0%	0%	75%	0%	75%
2011	36%	49%	49%	8%	32%	24%	24%	50%	0%	0%	0%	75%	0%	51%	0%	0%	0%	76%	0%	73%
2012	34%	49%	49%	8%	36%	23%	23%	51%	0%	0%	0%	75%	0%	52%	0%	0%	0%	76%	0%	72%
2013	33%	48%	49%	9%	40%	23%	23%	52%	0%	0%	0%	75%	0%	54%	0%	0%	0%	76%	0%	70%
2014	32%	48%	48%	10%	37%	22%	22%	53%	0%	0%	0%	75%	0%	55%	0%	0%	0%	77%	0%	68%
2015	30%	48%	48%	10%	37%	21%	21%	54%	0%	0%	0%	75%	0%	56%	0%	0%	0%	77%	0%	66%
2016	29%	47%	48%	9%	38%	20%	20%	55%	0%	0%	0%	75%	0%	58%	0%	0%	0%	77%	0%	64%
2017	28%	47%	48%	9%	41%	19%	19%	55%	0%	0%	0%	76%	4%	56%	0%	0%	0%	78%	0%	62%
2018	26%	47%	47%	9%	38%	18%	18%	54%	0%	0%	0%	77%	7%	54%	0%	0%	0%	78%	0%	60%
2019	25%	46%	47%	8%	42%	17%	17%	54%	0%	0%	0%	78%	10%	52%	0%	0%	0%	78%	0%	58%
2020	23%	46%	47%	8%	41%	16%	16%	54%	0%	0%	0%	79%	14%	50%	0%	0%	0%	79%	0%	56%
2021	23%	46%	47%	8%	41%	16%	16%	54%	0%	0%	0%	79%	14%	50%	0%	0%	0%	79%	0%	56%
2022	23%	46%	47%	8%	41%	16%	16%	54%	0%	0%	0%	79%	14%	50%	0%	0%	0%	79%	0%	56%

Table 5-7– Manure management system – digester-liquid (MMS-digester-liquid) for all animal categories: 1990-2022.

3 -Agriculture

Manure management system - digester-liquid (MMS-digester-liquid) for animal category *i*

(i.e. the proportion of excreta deposited during housing in stables with a liquid/slurry management system and slurry being used as feeding material for bio digesters)

Year	Calves < 1 year	Female young cattle 1-2 years	Heifers > 2 years	Fattening bulls 1-2 years	Mature male cattle > 2 years	Lactating dairy cows	Non-lactating dairy cows	Suckler cows	Sows	Fattening pigs	Weaners	Sheep	Goats	Horses	Broilers	Laying hens	Other poultry	Ostriches	Rabbits	Deer
1990	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1991	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1992	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1993	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1994	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1995	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1996	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1997	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1998	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1999	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	NO	0%	0%
2000	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%	0%	0%	0%	0%	0%	0%	NO	0%	0%
2001	0%	0%	0%	0%	0%	0%	0%	0%	2%	2%	2%	0%	0%	0%	0%	0%	0%	NO	0%	0%
2002	0%	0%	0%	0%	0%	0%	0%	0%	2%	3%	2%	0%	0%	0%	0%	0%	0%	NO	0%	0%
2003	0%	0%	0%	1%	0%	1%	1%	0%	3%	4%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2004	1%	1%	1%	2%	1%	2%	2%	0%	9%	10%	10%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2005	1%	2%	2%	3%	1%	4%	4%	1%	14%	16%	15%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2006	1%	2%	2%	4%	1%	5%	5%	1%	18%	20%	19%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2007	2%	3%	2%	4%	1%	5%	5%	1%	21%	23%	23%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2008	2%	3%	3%	5%	2%	6%	6%	1%	21%	24%	24%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2009	2%	3%	3%	5%	2%	7%	7%	1%	22%	25%	25%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2010	2%	4%	4%	5%	2%	8%	8%	1%	25%	29%	28%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2011	2%	4%	4%	6%	2%	9%	9%	1%	23%	26%	26%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2012	2%	4%	4%	6%	2%	9%	9%	1%	21%	24%	24%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2013	2%	5%	4%	6%	2%	10%	10%	1%	21%	25%	24%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2014	3%	5%	4%	6%	2%	10%	10%	1%	20%	24%	23%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2015	3%	5%	5%	6%	3%	11%	11%	1%	19%	22%	21%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2016	3%	6%	5%	6%	3%	13%	13%	1%	20%	24%	24%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2017	3%	6%	5%	6%	3%	13%	13%	1%	16%	19%	19%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2018	3%	6%	6%	7%	3%	14%	14%	1%	14%	17%	17%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2019	3%	6%	6%	6%	3%	14%	14%	1%	14%	16%	16%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2020	3%	6%	6%	6%	3%	14%	14%	1%	16%	19%	19%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2021	3%	6%	6%	6%	3%	15%	15%	1%	12%	14%	14%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2022	3%	6%	5%	5%	2%	13%	13%	1%	15%	18%	18%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Table 5-8– Manure management system - liquid (MMS-liquid) for all animal categories: 1990-2022.

3 -Agriculture

Manure management system - liquid (MMS-liquid) for animal category *i*
(i.e. the proportion of excreta deposited during housing in stables with a liquid/slurry management system and manure being stored on the farm)

Year	Calves < 1 year	Female young cattle 1-2 years	Heifers > 2 years	Fattening bulls 1-2 years	Mature male cattle > 2 years	Lactating dairy cows	Non-lactating dairy cows	Suckler cows	Sows	Fattening pigs	Weaners	Sheep	Goats	Horses	Broilers	Laying hens	Other poultry	Ostriches	Rabbits	Deer
1990	19%	27%	22%	56%	19%	52%	52%	12%	78%	78%	74%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1991	19%	27%	22%	56%	19%	52%	52%	12%	78%	79%	74%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1992	19%	27%	22%	55%	18%	52%	52%	12%	78%	80%	75%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1993	19%	27%	22%	55%	18%	52%	52%	12%	78%	80%	76%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1994	19%	27%	22%	55%	18%	51%	51%	12%	78%	81%	77%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1995	19%	27%	22%	55%	18%	51%	51%	12%	78%	82%	78%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1996	19%	27%	22%	55%	17%	51%	51%	12%	79%	82%	78%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1997	19%	27%	22%	53%	18%	51%	51%	12%	79%	83%	79%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1998	19%	29%	24%	52%	19%	56%	56%	12%	79%	83%	80%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1999	19%	29%	24%	52%	19%	56%	56%	12%	79%	84%	80%	0%	0%	0%	0%	0%	0%	NO	0%	0%
2000	19%	29%	24%	51%	19%	57%	57%	12%	78%	84%	80%	0%	0%	0%	0%	0%	0%	NO	0%	0%
2001	19%	29%	24%	51%	19%	56%	56%	11%	78%	84%	81%	0%	0%	0%	0%	0%	0%	NO	0%	0%
2002	19%	29%	24%	50%	17%	56%	56%	11%	77%	84%	81%	0%	0%	0%	0%	0%	0%	NO	0%	0%
2003	19%	28%	24%	50%	17%	55%	55%	11%	76%	83%	81%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2004	18%	28%	23%	48%	16%	54%	54%	11%	70%	77%	75%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2005	17%	28%	24%	47%	17%	56%	56%	10%	65%	72%	70%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2006	17%	28%	24%	45%	16%	55%	55%	10%	62%	69%	67%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2007	16%	27%	23%	42%	14%	53%	53%	10%	59%	66%	65%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2008	16%	26%	23%	41%	14%	52%	52%	9%	59%	66%	64%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2009	15%	26%	22%	40%	14%	51%	51%	9%	58%	65%	64%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2010	15%	26%	24%	35%	14%	55%	55%	8%	55%	63%	62%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2011	15%	26%	24%	34%	14%	56%	56%	7%	57%	65%	64%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2012	14%	27%	24%	34%	14%	56%	56%	7%	60%	68%	67%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2013	14%	27%	24%	32%	13%	57%	57%	6%	59%	69%	68%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2014	14%	27%	24%	31%	13%	57%	57%	6%	60%	70%	69%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2015	14%	27%	24%	30%	13%	57%	57%	6%	62%	73%	72%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2016	13%	26%	23%	29%	13%	57%	57%	5%	61%	71%	71%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2017	13%	26%	23%	28%	12%	57%	57%	5%	65%	77%	76%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2018	13%	26%	23%	27%	12%	58%	58%	5%	67%	80%	79%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2019	13%	26%	24%	27%	12%	59%	59%	4%	68%	81%	80%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2020	12%	27%	24%	26%	12%	60%	60%	4%	66%	79%	79%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2021	12%	27%	24%	26%	12%	60%	60%	4%	69%	83%	83%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2022	13%	27%	25%	27%	12%	62%	62%	4%	66%	79%	79%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Table 5-9– Manure management system – digester-solid (MMS-digester-solid) for all animal categories: 1990-2022.

3 -Agriculture

Manure management system - digester-solid (MMS-digester-solid) for animal category *i*

(i.e. the proportion of excreta deposited during housing in stables with a solid manure management system and solid manure being used as feeding material for bio digesters)

Year	Calves < 1 year	Female young cattle 1-2 years	Heifers > 2 years	Fattening bulls 1-2 years	Mature male cattle > 2 years	Lactating dairy cows	Non-lactating dairy cows	Suckler cows	Sows	Fattening pigs	Weaners	Sheep	Goats	Horses	Broilers	Laying hens	Other poultry	Ostriches	Rabbits	Deer
1990	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1991	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1992	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1993	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1994	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1995	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1996	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1997	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1998	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	NO	0%	0%
1999	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	NO	0%	0%
2000	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	NO	0%	0%
2001	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	NO	0%	0%
2002	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	NO	0%	0%
2003	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2004	1%	0%	0%	1%	1%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2005	1%	0%	1%	1%	1%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	46%	0%	0%	0%	0%
2006	1%	1%	1%	1%	2%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	40%	0%	0%	0%	0%
2007	2%	1%	1%	2%	2%	1%	1%	1%	0%	0%	0%	0%	0%	0%	0%	48%	0%	0%	0%	0%
2008	2%	1%	1%	2%	2%	1%	1%	1%	0%	0%	0%	0%	0%	0%	0%	42%	0%	0%	0%	0%
2009	2%	1%	1%	2%	2%	1%	1%	2%	0%	0%	0%	0%	0%	0%	0%	45%	0%	0%	0%	0%
2010	2%	1%	1%	2%	2%	1%	1%	2%	0%	0%	0%	0%	0%	0%	0%	66%	0%	0%	0%	0%
2011	2%	1%	1%	3%	3%	1%	1%	2%	0%	0%	0%	0%	0%	0%	0%	57%	0%	0%	0%	0%
2012	3%	1%	1%	3%	3%	1%	1%	2%	0%	0%	0%	0%	0%	0%	0%	51%	0%	0%	0%	0%
2013	3%	1%	1%	3%	3%	1%	1%	2%	0%	0%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%
2014	3%	1%	1%	3%	2%	1%	1%	2%	0%	0%	0%	0%	0%	0%	0%	48%	0%	0%	0%	0%
2015	4%	1%	2%	4%	3%	1%	1%	3%	0%	0%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%
2016	4%	1%	2%	4%	3%	1%	1%	3%	0%	0%	0%	0%	0%	0%	0%	47%	0%	0%	0%	0%
2017	4%	2%	2%	4%	3%	1%	1%	3%	0%	0%	0%	0%	0%	0%	0%	44%	0%	0%	0%	0%
2018	5%	2%	2%	5%	4%	1%	1%	3%	0%	0%	0%	0%	0%	0%	0%	44%	0%	0%	0%	0%
2019	5%	2%	2%	4%	3%	1%	1%	3%	0%	0%	0%	0%	0%	0%	0%	41%	0%	0%	0%	0%
2020	5%	2%	2%	5%	4%	1%	1%	3%	0%	0%	0%	0%	0%	0%	0%	39%	0%	0%	0%	0%
2021	5%	2%	2%	5%	3%	1%	1%	3%	0%	0%	0%	0%	0%	0%	0%	41%	0%	0%	0%	0%
2022	5%	2%	2%	5%	4%	1%	1%	3%	0%	0%	0%	0%	0%	0%	0%	37%	0%	0%	0%	0%

Table 5-10– Manure management system - solid (MMS-solid) for all animal categories: 1990-2022.

3 -Agriculture

Manure management system - solid (MMS-solid) for animal category *i*

(i.e. the proportion of excreta deposited during housing in stables with livestock kept on solid manure and manure being stored on the farm)

Year	Calves < 1 year	Female young cattle 1-2 years	Heifers > 2 years	Fattening bulls 1-2 years	Mature male cattle > 2 years	Lactating dairy cows	Non-lactating dairy cows	Suckler cows	Sows	Fattening pigs	Weaners	Sheep	Goats	Horses	Broilers	Laying hens	Other poultry	Ostriches	Rabbits	Deer
1990	44%	23%	29%	44%	66%	24%	24%	38%	22%	22%	26%	25%	25%	51%	100%	100%	100%	NO	100%	25%
1991	44%	23%	29%	44%	65%	24%	24%	38%	22%	21%	26%	25%	25%	51%	100%	100%	100%	NO	100%	25%
1992	44%	23%	29%	44%	64%	24%	24%	38%	22%	20%	25%	25%	25%	51%	100%	100%	100%	NO	100%	25%
1993	44%	23%	29%	43%	63%	24%	24%	38%	22%	20%	24%	25%	25%	51%	100%	100%	100%	NO	100%	25%
1994	44%	23%	29%	43%	63%	24%	24%	38%	22%	19%	23%	25%	25%	51%	100%	100%	100%	NO	100%	25%
1995	44%	23%	29%	43%	62%	24%	24%	38%	22%	18%	22%	25%	25%	51%	100%	100%	100%	NO	100%	25%
1996	44%	23%	29%	43%	61%	24%	24%	38%	21%	18%	22%	25%	25%	51%	100%	100%	100%	NO	100%	25%
1997	44%	23%	29%	42%	63%	24%	24%	38%	21%	17%	21%	25%	25%	51%	100%	100%	100%	NO	100%	25%
1998	44%	22%	27%	45%	59%	20%	20%	39%	21%	16%	20%	25%	25%	51%	100%	100%	100%	NO	100%	25%
1999	44%	22%	26%	45%	60%	20%	20%	39%	21%	16%	19%	25%	25%	51%	100%	100%	100%	NO	100%	25%
2000	44%	21%	26%	46%	58%	19%	19%	39%	21%	15%	18%	25%	25%	51%	100%	100%	100%	NO	100%	25%
2001	44%	22%	26%	46%	59%	19%	19%	39%	21%	15%	18%	25%	25%	51%	100%	100%	100%	NO	100%	25%
2002	44%	22%	26%	46%	56%	19%	19%	39%	21%	14%	17%	25%	100%	51%	100%	100%	100%	NO	100%	25%
2003	44%	22%	26%	47%	56%	19%	19%	39%	21%	13%	16%	25%	100%	51%	100%	100%	100%	25%	100%	25%
2004	44%	22%	26%	47%	53%	19%	19%	39%	20%	13%	15%	25%	100%	51%	100%	100%	100%	25%	100%	25%
2005	44%	20%	24%	47%	52%	15%	15%	39%	20%	12%	14%	25%	100%	51%	100%	54%	100%	25%	100%	25%
2006	44%	20%	24%	47%	50%	16%	16%	39%	20%	11%	14%	25%	100%	51%	100%	60%	100%	25%	100%	25%
2007	44%	20%	24%	45%	47%	16%	16%	39%	20%	11%	13%	25%	100%	51%	100%	52%	100%	25%	100%	25%
2008	44%	20%	24%	45%	47%	16%	16%	39%	20%	10%	12%	25%	100%	51%	100%	58%	100%	25%	100%	25%
2009	44%	21%	25%	45%	49%	17%	17%	39%	20%	9%	11%	25%	100%	51%	100%	55%	100%	25%	100%	25%
2010	44%	19%	22%	48%	46%	11%	11%	40%	20%	9%	10%	25%	100%	51%	100%	34%	100%	25%	100%	25%
2011	45%	19%	22%	49%	48%	11%	11%	39%	20%	8%	10%	25%	100%	49%	100%	43%	100%	24%	100%	27%
2012	46%	19%	22%	50%	46%	11%	11%	39%	19%	7%	9%	25%	100%	48%	100%	49%	100%	24%	100%	28%
2013	48%	19%	22%	50%	43%	10%	10%	38%	19%	7%	8%	25%	100%	46%	100%	50%	100%	24%	100%	30%
2014	49%	19%	22%	51%	45%	10%	10%	38%	19%	6%	7%	25%	100%	45%	100%	52%	100%	23%	100%	32%
2015	50%	19%	22%	51%	45%	10%	10%	37%	19%	5%	6%	25%	100%	44%	100%	50%	100%	23%	100%	34%
2016	51%	19%	22%	52%	43%	10%	10%	36%	19%	5%	6%	25%	100%	42%	100%	53%	100%	23%	100%	36%
2017	52%	19%	22%	52%	41%	10%	10%	37%	19%	4%	5%	24%	96%	44%	100%	56%	100%	22%	100%	38%
2018	53%	19%	22%	52%	43%	9%	9%	37%	19%	4%	4%	23%	93%	46%	100%	56%	100%	22%	100%	40%
2019	55%	19%	22%	54%	41%	9%	9%	37%	19%	3%	3%	22%	90%	48%	100%	59%	100%	22%	100%	42%
2020	56%	19%	22%	55%	41%	9%	9%	38%	18%	2%	2%	21%	86%	50%	100%	61%	100%	21%	100%	44%
2021	57%	19%	22%	55%	41%	9%	9%	38%	18%	2%	2%	21%	86%	50%	100%	59%	100%	21%	100%	44%
2022	56%	19%	22%	55%	41%	9%	9%	38%	18%	2%	2%	21%	86%	50%	100%	63%	100%	21%	100%	44%

5.2.3.2 Grazing

Data on the length of the grazing period were available from surveys on agricultural production methods for the years 2010 (Gargano et al. 2014), 2016 and 2020[82]. For the ninties estimates based on expert judgment (Administration des service technique de l'agriculture (ASTA) 19 June 2007), whereby assuming that grazing animals are in general 6 months/year on pasture. Interpolated manure management system for the years 2000-2011 were produced by using the shares as derived from the 2010 SAPM (Gargano et al. 2014).

In 2016 data on animal grazing was collected for dairy cows, for suckler cows, for horses and for small ruminants (i.e. sheep and goats) and linked at the level of individual herd sizes[83] to estimate average grazing time (MMS-pasturei) for animal category i in year 2016. Based on the results, interpolated MMS-pasture for dairy cows, suckler cows, horses and sheep were estimated for the years 2011-2015, assuming a linear decrease/increase between 2010 and 2016. For goats, it was for simplicity reason assumed that the 2016 data would apply from 2002 onwards (i.e. MMS- pasture being 0.3%) corresponding with the installation of the first professional dairy farmer with a few hundred dairy goats in 2001/2002 and a few additional farmers to follow.

In 2020 data on animal grazing was collected for all animal categories in the agriculture census [84] and linked at the level of individual herd sizes to estimate average grazing time (MMS-pasturei) for animal category i in the year 2020. An interpolation was applied for the period between the last two available measurements (i.e. 2016 for dairy cows, suckler cows, horses, goats and sheep; and 2010 for calves, female youngstock, including heifers >2 years and other grazing animals).

MMS pasture for 1-2 year old young bulls were based on the 2020 agricultural census observation on animal grazing and additional data allowing to distinguish for both animal categories between "animals kept for fattening purpose" and "other males" [85] (more details were presented in the NIR 2022 in Annex 3: B).

Without new data, the 2020 data were adopted in the following years.

The proportion of excreta deposited during grazing ($x_{grazing(i)}$), also referred as manure management system (MMS) – pasture (MMS-pasture$_{(ij)}$) for animal category *i* are summarized in Table 5-6 for the whole period.

5.2.3.3 Housing system

5.2.3.3.1 Cattle

In the emissions calculations, the distinction is made between eight housing systems, whereof four housing systems with predominantly liquid manure, and four housing systems with predominantly solid manure.

The four housing systems with slurry were:

- Tied systems, predominantly slurry based;
- Cubicle housing, predominantly slurry based

[82] Service d'économie rurale (SER), Division des statistiques agri-coles, des relations extérieures et des marchés agricoles.
[83] Opposite to EUROSTAT where data are linked to the agricultural holding https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Farm_structure_survey_(FSS)
[84] Service d'économie rurale (SER) – Division des statistiques agricoles, des relations extérieures et des marches agricoles.
[85] Service d'économie rurale (SER) – Division des statistiques agricoles, des relations extérieures et des marches agricoles.

- Loose housing systems, predominantly slurry based
- Others

The four housing systems with solid manure were:

- Tied systems, predominantly solid manure based;
- Deep beeding system;
- Sloped floor systems with bedding;
- Others.

Frequency distributions of housing systems expressed in animal places for different cattle categories were available from surveys on agricultural production methods for the years 1998 (STATEC, Le recensement agricole 1998, 1999), 2000 (STATEC, Le recensement agricoles 2000, 2001), 2005 (STATEC, Le recensement agricole en 2005, 2006), 2010 (Gargano et al. 2014) and 2020[86]. For 1998, 2000 and 2005 frequency distributions were only available for cattle in general. For 2010, frequency distribution was available for calves <6 months; fattening bulls >8 months; male cattle >2 years; dairy cows; suckler cows; and for female cattle >6 months including also young male cattle 6-8 months: For 2020 frequency distribution were available for all cattle catego-ries, namely calves <1 year; female youngstock 1-2 years; heifers>2 years; young bulls 1-2 years; male cattle >2 years; dairy cows and suckler cows. In case of missing information, the splitting of categories was derived from existing frequency distibutions of 2020, and where available of 2010. For 1990 a trend estimate was made, and compared with published data on housing systems, expressed as number of stables (STATEC, Le recensement de l'agriculture 1989, 1990). The frequencies of cattle were estimated for the years 1990, 1998, 2000, 2005, 2010 and 2020, see Table 5-11 , and by linear interpolation between those years. Without new data, the 2020 data were adopted in the following years.

In addition, in 2020 it was stated whether the animals had adcess to an exercise yard or not. This information is not used for the time being.

[86] Service d'économie rurale (SER) – Division des statistiques agricoles, des relations extérieures et des marches agricoles.

Table 5-11– Frequency distribution of housing systems for cattle category i.

3 -Agriculture Housing system$_{(i)}$ for cattle category *i*														
		Slurry based systems							Solid manure based systems					
Animal category		1990	1998	2000	2005	2010	2020		1990	1998	2000	2005	2010	2020
Calves < 1 year														
	Tied systems	*21%*	*15%*	*14%*	*10%*	2%	1%	Tied systems	*31%*	*23%*	*21%*	*14%*	7%	2%
	Cubicle loose housing	*55%*	*59%*	*60%*	*62%*	60%	64%	Deep bedding	*67%*	*68%*	*65%*	*70%*	54%	62%
	Fully slatted floor	*25%*	*26%*	*27%*	*28%*	17%	24%	Sloped floor	*2%*	*10%*	*14%*	*16%*	33%	32%
	Others	*0%*	*0%*	*0%*	*0%*	20%	10%	Others	*0%*	*0%*	*0%*	*0%*	6%	5%
Female young cattle 1-2 years														
	Tied systems	*24%*	*17%*	*16%*	*11%*	*5%*	2%	Tied systems	*73%*	*61%*	*57%*	*44%*	*18%*	8%
	Cubicle loose housing	*56%*	*60%*	*61%*	*65%*	*70%*	71%	Deep bedding	*25%*	*29%*	*28%*	*36%*	*32%*	39%
	Fully slatted floor	21%	22%	23%	*24%*	*21%*	23%	Sloped floor	*1%*	*10%*	*15%*	*20%*	*44%*	47%
	Others	*0%*	*0%*	*0%*	*0%*	*5%*	4%	Others	*0%*	*0%*	*0%*	*0%*	*6%*	6%
Heifers > 2 years														
	Tied systems	*21%*	*15%*	*14%*	*10%*	*4%*	2%	Tied systems	*77%*	*66%*	*62%*	*50%*	*22%*	10%
	Cubicle loose housing	*62%*	*66%*	*67%*	*70%*	*75%*	77%	Deep bedding	*22%*	*26%*	*25%*	*33%*	*34%*	42%
	Fully slatted floor	*17%*	*19%*	*19%*	*20%*	*16%*	18%	Sloped floor	*1%*	*8%*	*13%*	*17%*	*40%*	45%
	Others	*0%*	*0%*	*0%*	*0%*	*5%*	3%	Others	*0%*	*0%*	*0%*	*0%*	*3%*	3%
Fattening bulls 1-2 years														
	Tied systems	*15%*	*10%*	*9%*	*7%*	3%	4%	Tied systems	*36%*	*24%*	*20%*	*13%*	4%	3%
	Cubicle loose housing	*17%*	*17%*	*18%*	*18%*	19%	19%	Deep bedding	*60%*	*54%*	*49%*	*52%*	31%	32%
	Fully slatted floor	*69%*	*72%*	*73%*	*75%*	75%	74%	Sloped floor	*4%*	*22%*	*31%*	*35%*	55%	57%
	Others	*0%*	*0%*	*0%*	*0%*	3%	4%	Others	*0%*	*0%*	*0%*	*0%*	10%	8%
Mature male cattle > 2 years														
	Tied systems	*5%*	*3%*	*3%*	*2%*	*1%*	0%	Tied systems	*61%*	*47%*	*43%*	*31%*	*11%*	5%
	Cubicle loose housing	*56%*	*57%*	*58%*	*58%*	*59%*	58%	Deep bedding	*37%*	*40%*	*37%*	*44%*	*38%*	37%
	Fully slatted floor	*39%*	*39%*	*40%*	*40%*	*35%*	38%	Sloped floor	*2%*	*14%*	*20%*	*25%*	*47%*	54%
	Others	*0%*	*0%*	*0%*	*0%*	*5%*	4%	Others	*0%*	*0%*	*0%*	*0%*	*4%*	4%
Dairy cows														
	Tied systems	*10%*	*7%*	*6%*	*4%*	2%	1%	Tied systems	*83%*	*76%*	*74%*	*63%*	36%	13%
	Cubicle loose housing	*83%*	*86%*	*86%*	*88%*	91%	92%	Deep bedding	*17%*	*22%*	*22%*	*30%*	23%	38%
	Fully slatted floor	*7%*	*7%*	*8%*	*8%*	5%	5%	Sloped floor	*0%*	*3%*	*4%*	*6%*	19%	31%
	Others	*0%*	*0%*	*0%*	*0%*	3%	2%	Others	*0%*	*0%*	*0%*	*0%*	22%	19%
Suckler cows														
	Tied systems	*67%*	*58%*	*55%*	*46%*	24%	11%	Tied systems	*71%*	*59%*	*54%*	*42%*	17%	5%
	Cubicle loose housing	*20%*	*26%*	*28%*	*33%*	47%	57%	Deep bedding	*27%*	*31%*	*30%*	*37%*	31%	37%
	Fully slatted floor	*13%*	*16%*	*17%*	*21%*	17%	21%	Sloped floor	*1%*	*10%*	*16%*	*21%*	44%	52%
	Others	*0%*	*0%*	*0%*	*0%*	12%	12%	Others	*0%*	*0%*	*0%*	*0%*	8%	5%

Note: In Italic estimates

5.2.3.3.2 Swine

In the emissions calculations, the distinction is made between four housing systems, namely

- Fully slatted floors (slurry-based system);
- Partly slatted floors (slurry-based system);
- Non-slatted floors (predominantly slurry-based system);
- Deep bedding (solid manure-based system).

Frequency distributions of housing systems expressed in animal places for the three swine categories were available from surveys on agricultural production methods for the years 2010,(Gargano et al. 2014) and 2020[87]. For 1990 a trend estimate was made and compared with published data on housing systems, expressed as number of stables (STATEC, Le recensement de l'agriculture 1989, 1990). Deep bedding was assumed to be the only solid manure-based system. For the frequency distribution of the slurry-based housing system for swine category i, see Table 5-12. The frequencies of swine were estimated for the years 1990, 2010 and 2020, and by linear interpolation between those years. Without new data, the 2020 data were adopted in the following years.

Table 5-12– Frequency distribution of housing systems for swine category i.

3 -Agriculture Slurry based housing system$_{(i)}$ for swine category *i*				
		Slurry based systems		
Animal category		1990	2010	2020
Sows				
	Fully slatted floor	*22%*	54%	70%
	Partly slatted floor	*78%*	43%	28%
	Non-slatted floor		2%	2%
Fattening pigs				
	Fully slatted floor	*48%*	82%	99%
	Partly slatted floor	*52%*	18%	1%
	Non-slatted floor		0%	0%
Weaners				
	Fully slatted floor	*62%*	80%	89%
	Partly slatted floor	*38%*	20%	11%
	Non-slatted floor		0%	0%

Note: In Italic estimates

5.2.3.3.3 Poultry

Laying hens

In the emission calculation is the distinction for laying hens made between three housing systems, namely.

- Aviary/cages;
- Floor management (i.e. deep bedding) without outdoor access (hereafter referred to as “Deep beeding”);

[87] Service d’économie rurale (SER) – Division des statistiques agricoles, des relations extérieures et des marches agricoles.

- Free range/Floor management with outdoor access (i..e. deep beeding) with outdoor access/free range (hereafter referred to as “Free range”).

Frequency distributions of housing systems expressed in bird places for laying hens were available from surveys on price statistic for the year 2005[88] and on surveys on agricultural production methods for the years 2010,(Gargano et al. 2014) and 2020[89], see Table 5-13 . The 2005 data were assumed to apply also for the period 1990-2004, whereby it cannot be excluded that the 13% of laying hens kept in aviaries in 2005 might have been in earlier years kept in cages. The frequencies of laying hens were estimated for the years 2005, 2010 and 2020 by linear interpolation between those years. Without new data, the 2020 data were adopted in the following years.

Table 5-13– Frequency distribution of housing systems for poultry i.

3 -Agriculture Housing system$_{(i)}$ for poultry *i*						
Poultry category		1990	2005	2010	2020	2021
Laying hens						
	Aviary/cage	*13%*	13%	14%	40%	
	Deep beeding	*78%*	78%	73%	25%	
	Free range	*9%*	9%	14%	35%	
Broilers						
	Deep beeding	*80%*	80%	36%	25%	54%
	Free range	*20%*	20%	64%	75%	46%

Note: In Italic estimates

Broilers

In the emissions calculations the distinction is made between floor management without outdoor access, and floor management with outdoor access.

Frequency distributions of housing systems expressed in bird places for broilers were available from surveys on price statistic for the year 2005, 2010, 2020 and 2021[90], see Table 5-13 .The 2005 data were assumed to apply also for the period 1990-2004. The frequencies of broilers were estimated for the years 2005, 2010 and 2020 by linear interpolation between those years. The large difference between 2020 and 2021 is due to the initiative of offering a new product at the national market and hence a tripling of the broiler population within one year. Without new data, the 2021 data were adopted in the following years.

Other poultry and oostriches

In the emissions calculations the distinction is made between floor management without outdoor access and floor management with outdoor access.

[88] Service d’économie rurale (SER) – Division des statistiques agricoles, des relations extérieures et des marches agricoles.
[89] Service d’économie rurale (SER) – Division des statistiques agricoles, des relations extérieures et des marches agricoles.
[90] Service d’économie rurale (SER) – Division des statistiques agricoles, des relations extérieures et des marches agricoles.

Frequency distributions of housing systems expressed in bird places for turekys, oostriches and other poultry were available from surveys on agricultural production methods for the year 2020[91]. The 2020 data were assumed to apply also for the period 1990-2019. Without new data, the 2020 data were adopted in the following years.

5.2.3.3.4 For all other animal categories

No data was collected for other animal categories. Deep bedding (i.e. solid manure system) was the common housing system used.

5.2.3.4 Use of manure as feedstock in biogas facilities

5.2.3.4.1 Use of national produced manure as feedstock in biogas facilities

National annual quantities of locally produced slurry and solid manure were compared with quantities of slurry and solid manure used in biogas facilities and national production of slurry and solid manure for estimating the percentage of slurry and solid manure used in biogas facilities. The same livestock numbers and the same housing systems as used in the inventories were used for estimating national annual quantities of slurry and solid manure. The quantities of slurry and solid manure used as feed in biogas facilities was derived by compiling annual individual plant reports describing the feedstock input and submitted to AEV, and in recent years completed using data provided by ASTA. Unpublished plant individual electricity or gas production, available since 1993 from the Institute Luxembourgeois de Régulation (ILR)[92], were used to impute missing information on the use of manure. The imputed value was based on previous/following self-reported data on used manure but corrected for the ratio observed between electricity / gas pro-duction for the year with known data and the year with missing data. The so-obtained MMS are summarized in Table 5-7 and Table 5-9.

5.2.3.4.2 Use of imported manure as feedstock in biogas facilities

In addition to the national produced manure were also manure imported for being used as feedstock in biogas facilities. This occurred for the first time in 2016. The quantities of imported slurry and solid manure (expressed as kg N) for use as feedstock in biogas facilities is summarized in Table 5-14 and was derived by compiling annual individual plant reports describing the feedstock input and submitted to AEV. The percentage of TAN in the imported manure was assumed to be like locally produced manure when entering storage. The mix of separated swine manure and poultry manure was assumed to be 50% swine manure and the remainder would be poultry manure. For simplification it was assumed that poultry manure would originate 100% from laying hens; swine manure would originate 100% from fattening pigs and cattle manure would originate 100% from female young stock >1 year.

[91] Service d'économie rurale (SER) – Division des statistiques agricoles, des relations extérieures et des marches agricoles.
[92] Institute Luxembourgeois de Régulation (ILR); Christian Meyers ; personal communication October 2021 and following years.

Table 5-14– Imported quantities of manure to be used as feedstock in biogas facilities.

3 - Agriculture

Activity data - Imported quantities of manure to be used as feedstock in biogas facilities (kg N/year)

Year	Poultry manure	Separated swine manure & dry poultry manure	Separated cattle slurry / cattle manure	Separated swine manure
1990	*NO*	*NO*	*NO*	*NO*
1991	*NO*	*NO*	*NO*	*NO*
1992	*NO*	*NO*	*NO*	*NO*
1993	*NO*	*NO*	*NO*	*NO*
1994	*NO*	*NO*	*NO*	*NO*
1995	*NO*	*NO*	*NO*	*NO*
1996	*NO*	*NO*	*NO*	*NO*
1997	*NO*	*NO*	*NO*	*NO*
1998	*NO*	*NO*	*NO*	*NO*
1999	*NO*	*NO*	*NO*	*NO*
2000	*NO*	*NO*	*NO*	*NO*
2001	*NO*	*NO*	*NO*	*NO*
2002	*NO*	*NO*	*NO*	*NO*
2003	*NO*	*NO*	*NO*	*NO*
2004	*NO*	*NO*	*NO*	*NO*
2005	*NO*	*NO*	*NO*	*NO*
2006	*NO*	*NO*	*NO*	*NO*
2007	*NO*	*NO*	*NO*	*NO*
2008	*NO*	*NO*	*NO*	*NO*
2009	*NO*	*NO*	*NO*	*NO*
2010	*NO*	*NO*	*NO*	*NO*
2011	*NO*	*NO*	*NO*	*NO*
2012	*NO*	*NO*	*NO*	*NO*
2013	NO	NO	NO	NO
2014	NO	NO	NO	NO
2015	NO	NO	NO	NO
2016	57 065	0	14 045	0
2017	93 362	17 549	22 375	0
2018	194 891	4 780	21 824	0
2019	189 128	0	20 342	3 152
2020	157 482	4 249	2 453	39 543
2021	144 126	19 018	809	36 031
2022	68 857	22 666	0	4 219

5.2.3.5 Storage system

5.2.3.5.1 Slurry storage system

In the emissions calculations, the distinction is made between four slurry storage systems, namely:

- Open tanks without cover;
- Open tanks with floating cover (for example straw);
- Closed tanks with cover (plastic film or solid cover);
- Slurry stored underneath slatted floor.

The available data was collected in surveys on agricultural production methods in 2010 (Gargano et al. 2014) and in 2020[93]. In 2010 10.8% of the slurry was stored in slurry tanks without cover; 14.8% in slurry tank with cover (plastic film or solid cover), and 74.4% of the slurry was stored underneath slatted floor.(Gargano et al. 2014) In 2020 14.5% of liquid manure was stored in open tanks without

[93] Service d'économie rurale (SER) – Division des statistiques agricoles, des relations extérieures et des marches agricoles.

cover; 2.8% was stored in open tanks with a floating cover such as straw; 6.1% in open tanks with a fixed cover and 76.6% was stored underneath slatted floor. The frequencies apply to the cattle and pig liquid manure. For cattle liquid manure stored in tanks without cover it was assumed that 50% would have a natural crust and in 50% there would be no natural crust. Whereas swine liquid manure stored in tanks without cover would have no natural crust.

Based on expert judgment, it was assumed that in earlier years (i.e. 1990-2010), the frequency distributions would have been similar to the one found in 2010. An interpolation was applied for the period between the last two available measurements (i.e. 2010 and 2020). Without new data, the 2020 data were adopted in the following years.

5.2.3.5.2 Solid manure storage system

In the emissions calculations, the distinction is made, except for poultry, between two solid manure storage systems, namely:

- Solid manure stored in heaps;
- In-house deep litter/deep bedding.

The available data was collected in a survey on agricultural production methods in 2020[94]. In 2020 78% of the solid manure was stored in heaps and 22.4% in-house deep litter. Having no other information, it was assumed that in earlier years, the frequency distributions would have been like the one found in 2020. Without no data, the 2020 data were adopted in the following years.

For poultry the distinction is made between:

- Poultry manure with litter
- Poultry manure without litter.

Based on housing systems (see section 5.2.3.3.3) poultry manure from broilers and other poultry was assumed to be 100% with litter. Whereas for laying hens in 1990, 2010 and 2020 poultry manure with litter was equal to 87.5%, 86.4% and 60%, respectively. The remaining was poultry manure without litter. Interpolation was applied for the periods between two measurements. Without new data, the 2020 data were adopted in the following years.

5.2.3.5.3 Digestate storage system

In the emissions calculations, the distinction is made between three digestate storage systems, namely:

- Open takns without cover;
- Open tanks with floating cover;
- Closed tanks.

The available data was collected in a survey on agricultural production methods in 2020[95]. In 2020 18% of the digestate was stored in closed tanks, and the remaining digestate was stored in open tanks. Based on expert judgment, it was assumed that in earlier years, the frequency distributions would have been like the one found in 2020. A fact that could be confirmed when controlling ortho-photos from earlier years. Without new data, the 2020 data were adopted in the following years.

[94] Service d'économie rurale (SER) – Division des statistiques agricoles, des relations extérieures et des marches agricoles.
[95] Service d'économie rurale (SER) – Division des statistiques agricoles, des relations extérieures et des marches agricoles.

5.2.4 Nitrogen excretion

5.2.4.1 Dairy cows

For dairy cows the Nitrogen excretion (N.ex) in kg N per cow per year was calculated according to the following equation (DLG 2008) that was based on Bannink and Hindle, 2003:

$$N.ex = \left(320 * \left(124 + \left(1320 * milk\ urea\ N[\frac{g}{day}]\right) + \left(1.87 * milk\ N[\frac{g}{day}]\right) - (6.9 * daily\ milk\ yield))\right)\right) + (45 * 256)$$

with

- assuming that an average dairy cow is 320 days on lactation and 45 days dry;
- using country-specific data for milk urea (Engel 2019), see Table ; assuming an N-ratio in urea of 46% (DLG 2008);
- using country-specific milk protein, see Table 5-15;
- dividing milk protein by 6.38 to obtain N (DLG 2008);
- using a country-specific daily milk yield, see Table 5-15, which is calculated by dividing the annual milk production by the number of lactating dairy cows (see Table 5-4).

The annual milk production, see Table 5-15 consist of i) the official amount of milk delivered from the farms to dairy industries (>90%)[96]; ii) the amount of milk and milk products sold by the farmers and iii) estimates on milk used at the farm for the farmers family and for feeding the calves (SER 2018).

Data on milk urea were obtained from the *Administration des service technique de l'agriculture (ASTA) - Service d'analyse du lait* (Engel 2019) for the years 2001-2018. ASTA is the only organization in Luxembourg responsible to test the milk collected by the dairy industry. There were no data on milk urea for the years 1990-2000, why using the average as observed for the years 2001-2005. For the years 2001-2005 only average of the tested milk samples were available, and used as such, and for the years 2006-2018 weighted averages were used, i.e. weighted by the delivered amount of milk, and representing >80% of produced and delivered milk in Luxemburg (Engel 2019). For the year 2019 and onwards published weighted averages, as derived by ASTA, were used[97].

The estimated N.ex in kg N per lactating dairy cow and per year for the different years is summarized in Table 5-15.

[96] The dairy industry reports on a monthly basis the amount of milk collected at farm-gate, the milk fat and milk protein contain and the farm gate price to the SER – Statistiques agricoles, marches agricoles et relations extérieures on a monthly basis. Annual data are published at https://agriculture.public.lu/content/dam/agriculture/statistiques/production-animale/lait/milch-jahr-portail.pdf

[97] Publication in the annual activity reports ("Rapport d'activité") from the ministry of agriculture available online at https://agriculture.public.lu/de.html

Table 5-15– Annual milk production (*1000 tons), milk fat, milk protein, milk urea, daily milk yield and N.ex in kg N per lactating dairy cow per year

3 - Agriculture

Annual milk production (*1000 tons), milk fat, milk protein, milk urea, daily milk yield and N.ex in kg N per lactating dairy cow per year

Year	Annual milk production[a] (* 1000 tons)[a]	Milk fat (%)[a]	Milk protein (%)[a]	Milk urea (ppm)[b]	Daily milk yield (kg/day)[c]	N.ex (kg N per head per year[d])
1990	281.7	4.09	3.26	235	15.0	110.2
1991	265.1	4.16	3.33	235	14.9	111.1
1992	260.4	4.16	3.34	235	15.9	112.3
1993	268.2	4.22	3.35	235	16.7	113.1
1994	261.6	4.16	3.34	235	16.7	113.0
1995	268.6	4.20	3.35	235	17.3	113.8
1996	265.5	4.25	3.38	235	17.3	114.2
1997	263.9	4.23	3.36	235	17.8	114.4
1998	264.0	4.25	3.37	235	18.0	114.7
1999	266.6	4.20	3.38	235	18.5	115.4
2000	264.5	4.19	3.36	235	19.1	115.7
2001	269.7	4.17	3.37	219	19.7	113.2
2002	270.7	4.18	3.37	221	20.1	114.3
2003	267.1	4.20	3.38	237	20.6	118.0
2004	268.5	4.20	3.39	262	21.0	123.5
2005	269.7	4.19	3.40	237	21.4	119.1
2006	268.1	4.21	3.40	250	21.7	121.9
2007	274.2	4.19	3.41	257	22.0	123.9
2008	277.7	4.21	3.40	254	21.7	122.7
2009	283.9	4.18	3.37	231	21.8	117.8
2010	295.3	4.18	3.40	246	22.4	121.8
2011	292.2	4.15	3.37	252	22.6	122.5
2012	289.4	4.16	3.39	234	22.7	119.7
2013	295.9	4.13	3.36	222	22.0	116.0
2014	317.0	4.09	3.38	219	23.6	117.3
2015	346.3	4.11	3.37	211	24.9	116.9
2016	376.2	4.12	3.39	218	25.3	119.1
2017	387.2	4.11	3.41	226	25.4	121.4
2018	407.6	4.12	3.43	232	26.5	124.1
2019	421.3	4.16	3.44	221	26.8	122.7
2020	447.3	4.17	3.45	209	28.2	122.0
2021	443.3	4.22	3.46	213	27.9	122.7
2022	449.0	4.15	3.41	203	28.1	119.6

Notes:

a) Source: SER. Note: Since 1977 the annual milk production consist of i) the official amount of milk delivered by the producers to the dairy industry (>90% (Source: Fränk Steichen, personal communication December 2018; SER - Statistiques agricoles, marches agricoles et relations extérieures)); ii) the amount of milk and milk products sold by the farmers and iii) milk consumed at the farm by the farmers family and/or used for its animals as derived from unpublished LTBN data (SER 2018).

b) There were no data for the years 1990-2000, why using the average as observed for the years 2001-2005. For the years 2001-2005 only the average of all tested milk samples were available, and for the years 2006 and onwards weighted averages were used. ASTA is in Luxemburg the only institute responsible for testing milk that is delivered to dairy industries in Luxemburg and also for the majority of the milk produced in Luxemburg and delivered to dairy industries in Neighbouring countries. In 2017, ~95% of all delivered milk that was produced in Luxemburg was tested by ASTA. For >80% of the delivered milk was also the delivered quantity per tested sample known, allowing to estimate a weighted average representing >80% of the delivered milk in 2017 (Urea data: Source: (Engel 2019); Annual reports; Quantities : SER - Statistiques agricoles, marches agricoles et relations extérieures; Fränk Steichen, personal communication 11th January 2019)).

c) Calculated by dividing the milk production by the number of lactating dairy cows (see Table 5-4) and assuming 320 days in lactation

d) Calculated according to the equation shown above.

5.2.4.2 Other livestock categories than dairy cows

Having no own measurements, and having no information on feed diet for all other livestock categories that would allow to estimate the N.ex based on an N-balance, the N.ex data were taken from the technical literature from Germany, Belgium, the Netherlands and France and were summarized in Table 5-16.

Belgium, Germany and France (here in particular the Northern part) have direct borders with Luxembourg (Figure 8), and similar climate condition, feeding systems and animal husbandry systems as the one found in Luxembourg. And although the Netherlands does not have a direct border to Luxembourg, the distance between Wemperhardt (village in the North of Luxembourg) and Eijsden (village in the Sought of the Netherlands) is less than 100 km, and in particularly in the south-east of the Netherlands are climate condition, feeding systems and animal husbandry systems for certain livestock categories like one found in Luxembourg.

The starting point for this technical literature review were the corresponding emission inventories (NIR, IIR or both), respectively the underlying methodology reports (Lagerwerf, et al., 2019), (CITEPA, 2019), (Rösemann, et al., 2019), (Wever, et al., 2019) , (Ruyssenaars, et al., 2019), (Anonymous, 2019). According to the snowball methodology additional relevant literature were retrieved. Relevant findings were summarized in an Excel-file (available on request). Using this excel-file, the final selection was made by two animal specialist (RB and MJJM). A detailed description of the choices made was provided in section 8.1.1.1.1 in (Schuman, et al., 2020) the IIR 2020.

In 2021 was however, the N.ex for suckler cows revised, as the old value had been an underestimation (Haenel, et al., 2020). With 90.7 kg N/year per suckler cow, is the N.ex per suckler cow the same as in the German inventory (Haenel, et al., 2020) .

Table 5-16– N excretion per head/place per year for the different livestock categories for 1990-2022

Animal categories	N excretion (kg N per head/animal place per year)	Sources/Notes
Calves < 1 year	Calculated*	Based on the proportion of i) female calves and ii) males calves and the corresponding N.ex*
- Female calves < 1 year*	33	(CBS 2018, VLM 2019, 2018, 2017, 2016, 2015, 2014, 2013, 2012)
- Male calves < 1 year*	31.5	(CBS 2018)
Female young female cattle 1-2 years	58	(VLM 2019, 2018, 2017, 2016, 2015, 2014, 2013, 2012)
Heifers > 2 years	77	(VLM 2019, 2018, 2017, 2016, 2015, 2014, 2013, 2012); "Other cattle older than 2 years"
Fattening bulls 1-2 years	58	(VLM 2019, 2018, 2017, 2016, 2015, 2014, 2013, 2012)
Mature male cattle > 2 years	77	(VLM 2019, 2018, 2017, 2016, 2015, 2014, 2013, 2012); "Other cattle older than 2 years"
Non-lactating dairy cow	77	(VLM 2019, 2018, 2017, 2016, 2015, 2014, 2013, 2012); "Other cattle older than 2 years"
Suckler cows	90.7	(Haenel, et al., 2020)
Sows	23.5	(VLM 2017, 2016, 2015, 2014, 2013, 2012)
Fattening pigs	11.1	(Horlacher 2018) page 488-489
Weaners	3.6	(Horlacher 2018) page 488-489
Mature sheep	10.5	(VLM 2019, 2018, 2017, 2016, 2015, 2014, 2013, 2012)
Sheep lambs < 1 year	4.36	(VLM 2019, 2018, 2017, 2016, 2015, 2014, 2013, 2012)
Mature goats	18.7	(CBS 2018)
Goat kids < 1 year	-	Considered with does
Horses	Calculated*	Based on the proportion of i) agriculture horses; ii) riding horses and iii) horses<200 kg, anes and mules and the corresponding N.ex
- Agr. Horses > 6 months	65	(VLM 2019, 2018, 2017, 2016, 2015, 2014, 2013, 2012); Horses > 600 kg;
- Riding horses > 6 months	50	(VLM 2019, 2018, 2017, 2016, 2015, 2014, 2013, 2012); Horses 200-600 kg;
- Horses < 200 kg	33	(VLM 2019, 2018, 2017, 2016, 2015, 2014, 2013, 2012); Ponys; horses < 6 months; mules & anes;
Broilers	0.3	(CITEPA 2019)
Laying hens	0.81	(VLM 2019, 2018, 2017, 2016, 2015, 2014, 2013, 2012)
Other poultry	0.38	(CITEPA 2019) #
Ostriches	15.6	(Rösemann et al. 2019)
Rabbits - Breeding female animals	3.16	(VLM 2019, 2018, 2017, 2016, 2015, 2014, 2013, 2012); Breeding female animal, including raising of young stock (but no fattening);
Other rabbits (i.e. fattening rabbits)	0.658	(VLM 2019, 2018, 2017, 2016, 2015, 2014, 2013, 2012); Fattening rabbits
Deer	16	(Haenel et al. 2018, Rösemann et al. 2019)

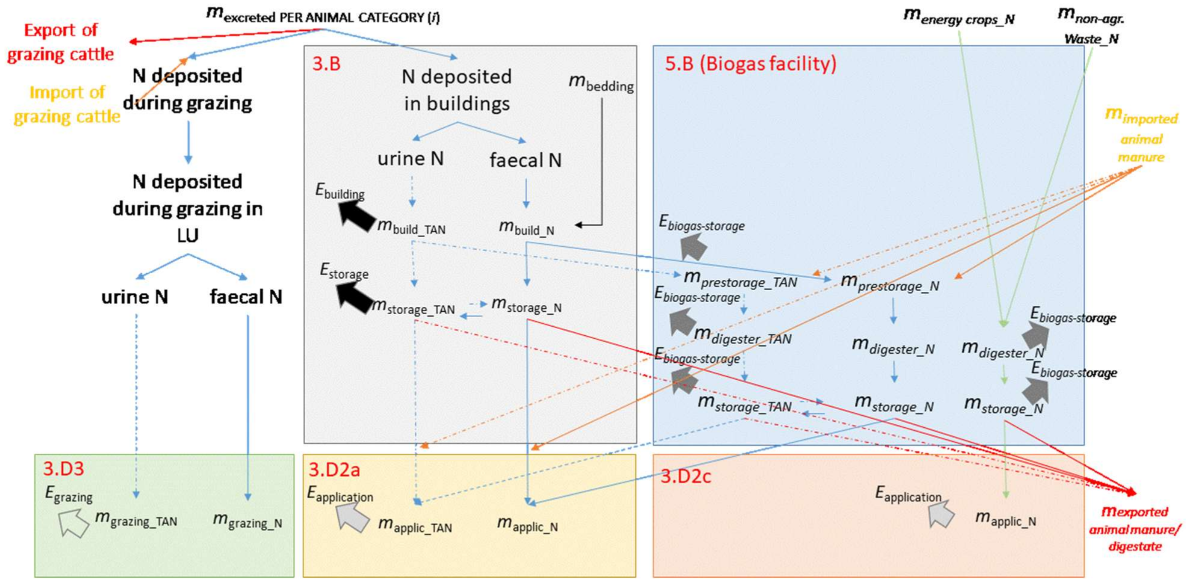
* Using more detailed statistics than the one provided in Table .

Using the French N.ex for ducks (0.4 kg n/ bird place/year), turkeys (1.0 kg N/bird place/year), geese (1.3 kg N/bird place/year) and broilers (as proxy for all other poultry, i.e. 0.3 kg N/bird place/year), assuming that places for ducks, turkeys and geese would only be occupied for half a year, and using the distribution as observed in 2005 (i.e. 25% ducks, 9% turkeys, 25% geese and 41% others), the N.ex for "other poultry" was calculated to be 0.38 kg N/bird place/year.

5.2.5 N flows in the manure management system

For the calculations of N emissions, a Tier 2 technological approach was taken. The Tier 2 uses a mass-flow approach based on the concept of a flow of total ammoniacal nitrogen (TAN) through the manure management and is schematically represented in Figure 57.

Figure 57 – N flow in the manure management systems



Note: *m*: mass from which emissions may occurr. Narrow broken arrows: TAN; narrow continous arrows: organic N. The horizontal arrows denote the process of immobilisation in systems with bedding occurring in the house; and the process of mineralisation during storage.Broad black hatched arrows denote emissions assigned to manure management: *E* emissions of N species ($E_{building}$ NH_3 emissions from buildings; $E_{storage}$ NH_3, N_2O, NO_x and N_2 emissions from storage); Broad grey hatched arrows denote emissions assigned to biogas facility: *E* emissions of N species ($E_{biogas\text{-}storage}$ NH_3 emissions from prestorage, from digester and from storage of the digestate; and N_2O emissions from digester/storage); Broad white arrows mark emissions from application application/from soil: ($E_{application}$ NH_3 emissions during and after spreading; N_2O, NO_x and N_2 emissions from soil resulting from manure input; $E_{grazing}$ NH_3, N_2O, NO_x and N_2 emissions during and after grazing).

The Tier 2 uses a mass-flow approach based on the concept of a flow of total ammoniacal nitrogen (TAN) through the manure management, which was determined following fifteen steps described in the 2023 guidelines (Amon H. D., 2023).

The first step is the definition of livestock subcategories "that are homogeneous with respect to feeding, excretion and age/weight range", (Amon H. D., 2023) , see section 5.2.1 for full details.

As second step, is the total annual N.ex for livestock category *i* ($N_{ex(i)}$), expressed in kg N per year per head, respectively per year per animal place determined, with *i* being the ith livestock category. For details see section 5.2.3.2.

In Step 3, the amount of the annual N excreted that is deposited within buildings in which livestock are housed ($m_{build\_N(i)}$) and during grazing ($m_{grazing\_N(i)}$), expressed in kg N per year per head/place for animal category *i*, was determined using the following equations (Amon H. D., 2023):

$$m_{grazing\_N(i)} = x_{grazing(i)} * N_{ex(i)}$$
$$m_{build\_N(i)} = x_{build(i)} * N_{ex(i)}$$

with $x_{grazing(i)}$ and $x_{build(i)}$ being defined in section 5.2.2.2

Note. Yards, where than existing in Luxembourg, are integrated in the building with same manure management system, and therefore not considered as a separate category, but as building.

Note. Not all animals owned by luxemburgish farmers were also grazing during the summer months in Luxemburg. Some were temporay exported to fields situated in neighbouring countries on fields cultivated by luxemburgish farmers. Whereas some Belgian, German and/or French owned animals were temporary imported for grazing during summer months in Luxemburg. For more details see section 5.2.2.2 and Table 5-5; In the inventories only animals grazing in Luxembourg were taken into consideration.

In Step 4 the proportion of the N excreted as TAN ($x_{TAN(i)}$) expressed as kg TAN per kg $N_{ex(i)}$ was calculated, whereby the amount of TAN deposited in buildings ($m_{build\_TAN(i)}$) and during grazing ($m_{grazing\_TAN(i)}$), expressed in kg TAN per year per head/place for animal category *i*, was calculated using the following equations (Amon H. D., 2023).

$$m_{grazing\_TAN(i)} = x_{TAN(i)} * m_{grazing\_N(i)}$$
$$m_{build\_TAN(i)} = x_{TAN(i)} * m_{build\_N(i)}$$

No national data was available on the proportion of TAN, why using the default values for $x_{TAN(i)}$ as provided in Table 3.9 in the EMEP guidelines (Amon H. D., 2023) and summarized in Table 5-17.

Table 5-17– TAN contents (xTAN) used for emission estimates, expressed as kg TAN per kg Nex(i)

Animal categories	$x_{TAN(i)}$	Notes
Calves < 1 year;	0.6	Default value for non-dairy cattle (Table 3.9; (Amon H. D., 2023))
Female young female cattle 1-2 years	0.6	Default value for non-dairy cattle (Table 3.9; (Amon H. D., 2023))
Heifers > 2 years	0.6	Default value for non-dairy cattle (Table 3.9; (Amon H. D., 2023))
Fattening bulls 1-2 years	0.6	Default value for non-dairy cattle (Table 3.9; (Amon H. D., 2023))
Mature male cattle > 2 years	0.6	Default value for non-dairy cattle (Table 3.9; (Amon H. D., 2023))
Dairy cows	0.6	Default value for dairy cattle (Table 3.9; (Amon H. D., 2023))
Suckler cows	0.6	Default value for non-dairy cattle (Table 3.9; (Amon H. D., 2023))
Sows	0.7	Default value for sows and piglets to 8 kg (Table 3.9; (Amon H. D., 2023))
Fattening pigs	0.7	Default value for fattening pigs, 8- 110 kg (Table 3.9; (Amon H. D., 2023))
Weaners	0.7	Default value for fattening pigs, 8-110 kg (Table 3.9; (Amon H. D., 2023))
Sheep (mature sheep and lambs)	0.5	Default value for sheep (Table 3.9; (Amon H. D., 2023))
Goats (mature goats and kids)	0.5	Default value for goats (Table 3.9; (Amon H. D., 2023))
Horses (including assess and mules)	0.6	Default value for horses (Table 3.9; (Amon H. D., 2023))
Broilers	0.7	Default value for broilers (Table 3.9; (Amon H. D., 2023))
Laying hens	0.7	Default value for laying hens (Table 3.9; (Amon H. D., 2023))
Other poultry	0.7	Default values for turkeys, ducks and geese (Table 3.9; (Amon H. D., 2023))

Animal categories	$x_{TAN(i)}$	Notes
Ostriches	0.7	Default value for geese (Table 3.9; (Amon H. D., 2023)), similar as (Haenel et al. 2018)
Rabbits (breeding female animals and other rabbits)	0.6	Default value for horses (Table 3.9; (Amon H. D., 2023)), similar as (Haenel et al. 2018)
Deer	0.5	Default value for sheep and goats (Table 3.9; (Amon H. D., 2023))

In Step 5 the amounts of TAN and total N deposited in buildings handled as liquid slurry ($m_{build\_slurry\_TAN(i)}$ and $m_{build\_slurry\_N(i)}$) or as solid manure ($m_{build\_solid\_TAN(i)}$ and $m_{build\_solid\_N(i)}$), expressed in kg TAN, respectively N per year per head/place for animal category *i*, were calculated using the following equations (Amon H. D., 2023):

$$m_{build\_slurry\_TAN(i)} = x_{slurry(i)} * m_{build\_TAN(i)}$$

$$m_{build\_slurry\_N(i)} = x_{slurry(i)} * m_{build\_N(i)}$$

$$m_{build\_solid\_TAN(i)} = (1 - x_{slurry(i)}) * m_{build\_TAN(i)}$$

$$m_{build\_solid\_N(i)} = (1 - x_{slurry(i)}) * m_{build\_N(i)}$$

with $x_{slurry(i)}$ being defined in section 5.2.2.2.

In step 6, the NH_3-N losses (in kg NH3-N per animal per year) from the livestock buildings is calculated, following equation 15 and equation 16 from the EMEP guidelines, (Amon H. D., 2023) namely:

$$E_{build\_slurry\_NH3-\quad(i)} = m_{build\_slurry\_TAN(i)} * EF_{build\_slurry\_NH3-N(i)}$$

$$E_{build\_solid\_NH3-N(i)} = m_{build\_solid\_TAN(i)} * EF_{build\_solid\_NH3-N(i)}$$

with

$E_{build\_slurry\_NH3\text{-}N(i)}$	Emissions of NH_3-N from livestock buildings with liquid manure system;
$E_{build\_solid\_NH3\text{-}N(i)}$	Emissions of NH_3-N from livestock buildings with solid manure system;
$EF_{build\_slurry\_NH3\text{-}N(i)}$	Emissions factors for NH_3-N emissions from livestock buildings with liquid manure system;
$EF_{build\_solid\_NH3\text{-}N(i)}$	Emissions factors for NH_3-N emissions from livestock buildings with solid manure system;

Additional information on methodology and Emission factors (EF) are provided in section 5.3.3. The emissions itself are reported in NFR category 3B.

In step 7, the N in animal bedding in litter-based housing systems, an additional N input applicable ***only*** to solid manure, is considered, whereby accounting for the consequent immobilisation of TAN (f_{imm}) in that bedding.

The mass of bedding ($m_{bedding(i)}$) expressed as kg fresh weight per year per head/animal place, and the mass of nitrogen in that bedding ($m_{bedding\_N(i)}$) were estimated using the figures provided in Table 3.7 in the EMEP guidelines (Amon H. D., 2023) and the country-specific housing period in days ($x_{housing(i)}$) and calculated by multiplying $x_{build(i)}$ with 365 (for $x_{build(i)}$ see section 5.2.2.2)), and is summarized in Table 5-18.

The estimates for N added straw in animal bedding for livestock category *i* in litter-based housing systems are summarized in Table 5-18. In the emission calculation itself, however, is only the N added in straw in animal bedding was only considered for the proportion of animals kept in litter-based housing systems.

Table 5-18– Estimated N added in straw in animal bedding ($_{mbedding\_N(i)}$) for livestock category i * (kg N / year / head or place)

3 - Agriculture Assumed N (kg N/head) in animal bedding for livestock category *i*															
Year	Calves < 1 year	Female young cattle 1-2 years	Heifers > 2 years	Fattening bulls 1-2 years	Mature male cattle > 2 years	Lactating dairy cows	Non-lactating dairy cows	Suckler cows	Sows	Fattening pigs	Weaners	Sheep	Goats	Horses	Deer
1990	1.77	0.94	1.16	1.78	2.66	2.89	0.96	1.55	0.53	0.17	0.21	0.24	0.24	2.05	0.24
1991	1.77	0.94	1.16	1.77	2.63	2.89	0.96	1.55	0.53	0.17	0.20	0.24	0.24	2.05	0.24
1992	1.77	0.94	1.16	1.77	2.60	2.89	0.96	1.55	0.53	0.16	0.20	0.24	0.24	2.05	0.24
1993	1.77	0.94	1.16	1.76	2.57	2.89	0.96	1.55	0.53	0.16	0.19	0.24	0.24	2.05	0.24
1994	1.77	0.94	1.16	1.76	2.54	2.90	0.97	1.55	0.52	0.15	0.19	0.24	0.24	2.05	0.24
1995	1.77	0.94	1.16	1.75	2.51	2.90	0.97	1.55	0.52	0.15	0.18	0.24	0.24	2.05	0.24
1996	1.78	0.94	1.16	1.75	2.48	2.90	0.97	1.55	0.52	0.14	0.17	0.24	0.24	2.05	0.24
1997	1.78	0.94	1.16	1.71	2.55	2.90	0.97	1.55	0.51	0.14	0.17	0.24	0.24	2.05	0.24
1998	1.78	0.88	1.08	1.81	2.40	2.39	0.80	1.57	0.51	0.13	0.16	0.24	0.24	2.05	0.24
1999	1.77	0.88	1.07	1.81	2.42	2.38	0.79	1.57	0.51	0.13	0.15	0.24	0.24	2.05	0.24
2000	1.77	0.87	1.06	1.86	2.35	2.26	0.75	1.58	0.50	0.12	0.15	0.24	0.24	2.05	0.24
2001	1.78	0.88	1.06	1.88	2.38	2.28	0.76	1.59	0.50	0.12	0.14	0.24	0.24	2.05	0.24
2002	1.78	0.88	1.07	1.89	2.28	2.31	0.77	1.59	0.50	0.11	0.13	0.24	0.97	2.05	0.24
2003	1.79	0.89	1.08	1.91	2.28	2.34	0.78	1.60	0.49	0.11	0.13	0.24	0.97	2.05	0.24
2004	1.80	0.89	1.08	1.92	2.19	2.37	0.79	1.60	0.49	0.10	0.12	0.24	0.97	2.05	0.24
2005	1.81	0.83	1.00	1.94	2.16	1.93	0.64	1.61	0.49	0.10	0.12	0.24	0.97	2.05	0.24
2006	1.82	0.84	1.01	1.95	2.08	1.97	0.66	1.62	0.49	0.09	0.11	0.24	0.97	2.05	0.24
2007	1.83	0.85	1.02	1.87	1.99	2.01	0.67	1.62	0.48	0.09	0.10	0.24	0.97	2.05	0.24
2008	1.84	0.86	1.03	1.89	1.99	2.05	0.68	1.63	0.48	0.08	0.10	0.24	0.97	2.05	0.24
2009	1.85	0.87	1.04	1.90	2.08	2.09	0.70	1.64	0.48	0.07	0.09	0.24	0.97	2.05	0.24
2010	1.87	0.82	0.94	2.04	1.97	1.39	0.46	1.69	0.47	0.07	0.08	0.24	0.97	2.05	0.24
2011	1.92	0.82	0.95	2.11	2.07	1.37	0.46	1.67	0.47	0.06	0.08	0.24	0.97	2.00	0.26
2012	1.98	0.82	0.95	2.15	1.97	1.35	0.45	1.66	0.47	0.06	0.07	0.24	0.97	1.94	0.28
2013	2.04	0.83	0.95	2.15	1.84	1.33	0.44	1.64	0.46	0.05	0.06	0.24	0.97	1.88	0.30
2014	2.10	0.83	0.95	2.17	1.92	1.32	0.44	1.62	0.46	0.05	0.06	0.24	0.97	1.83	0.31
2015	2.17	0.83	0.95	2.20	1.94	1.30	0.43	1.60	0.46	0.04	0.05	0.24	0.97	1.77	0.33
2016	2.23	0.84	0.95	2.26	1.89	1.28	0.43	1.58	0.45	0.04	0.04	0.24	0.97	1.71	0.35
2017	2.29	0.84	0.95	2.28	1.79	1.26	0.42	1.60	0.45	0.03	0.04	0.23	0.94	1.79	0.37
2018	2.36	0.84	0.95	2.32	1.89	1.25	0.42	1.62	0.45	0.03	0.03	0.22	0.91	1.87	0.39
2019	2.42	0.84	0.95	2.37	1.78	1.23	0.41	1.64	0.45	0.02	0.03	0.22	0.87	1.96	0.41
2020	2.49	0.85	0.95	2.41	1.80	1.22	0.41	1.66	0.44	0.02	0.02	0.21	0.84	2.04	0.42
2021	2.49	0.85	0.95	2.41	1.80	1.22	0.41	1.66	0.44	0.02	0.02	0.21	0.84	2.04	0.42
2022	2.49	0.85	0.95	2.41	1.80	1.22	0.41	1.66	0.44	0.02	0.02	0.21	0.84	2.04	0.42

*Note : Given the low numbers of poultry, ostriches and rabbits, and given that no data were provided in Table 3.7 in the EMEP guidelines (Amon H. D., 2023) for these categories, no estimates of additional N in animal bedding in litter-based housing systems were made for poultry, ostriches and rabbits. For deer data provided in Table 3.7 for sheep and goats were used.

The amounts of total-N and total-TAN in solid manure (expressed in kg TAN and N per year per head/place for animal category *i*) that were removed from buildings were calculated ($m_{ex\text{-}build\_solid\_TAN}$ and $m_{ex\text{-}build\_solid\_N}$), following equation 18 and equation 19 from the EMEP guidelines (Amon H. D., 2023), namely:

$$m_{ex-build\_solid\_TAN(i)} = \left\{m_{build\_solid\_TAN(i)} \quad - \left(E_{build\_solid\_NH3-N(i)} + \left(m_{bedding\_N(i)} + f_{imm}\right)\right)\right\}$$

$$m_{ex-build\_solid\_N(i)} = \left\{m_{build\_solid\_N(i)} + m_{bedding\_N(i)} - E_{build\_solid(i)}\right\}$$

with f_{imm} assumed to be 0.0067, according to the EMEP guidelines (Amon H. D., 2023).

In step 8, the amounts of total-N and TAN stored before application to land was estimated. Total manure was corrected for the proportion of manure that was used as feedstock for anaerobic digestions in biogas facilities ($x_{biogas\_slurry\ (i)}$, and $x_{biogas\_solid(i)}$, for details see section 5.2.2.2). Further was assumed that all manure (solid and liquid manure) would be stored before spreading (for details see section 5.2.2.2). The remainders, i.e. the proportion of slurry stored on farms ($x_{store\_slurry\ (i)}$) and the proportion of solid manure stored on farms ($x_{store\_solid(i)}$), which were presented in section 5.2.2.2, were used to estimate the amounts ($m_{storage}$) of total-N and TAN stored before application to land, following equation 20-23 and 26-29, respectively from the EMEP guidelines, (Amon H. D., 2023) namely:

whereby for liquid manure:

$$m_{storage\_slurry\_TAN(i)} = \{(m_{build\_slurry\_TAN(i)} - E_{build\_slurry\_NH3-N(i)})\} * x_{store\_slurry(i)}$$
$$m_{storage\_slurry\_N(i)} = \{(m_{build\_slurry\_N(i)} - E_{build\_slurry\_NH3-N(i)})\} * x_{store\_slurry(i)}$$

$$m_{biogas\_slurry\_TAN(i)} = \{(m_{build\_slurry\_TAN(i)} - E_{build\_slurry\_NH3-N(i)})\} * x_{biogas\_slurry(i)}$$
$$m_{biogas\_slurry\_N(i)} = \{(m_{build\_slurry\_N(i)} - E_{build\_slurry\_NH3-N(i)})\} * x_{biogas\_slurry(i)}$$

and for solid manure:

$$m_{storage\_solid\_TAN(i)} = m_{ex-build\_solid\_TAN(i)} * \ x_{store\_solid(i)}$$
$$m_{storage\_solid\_N(i)} = m_{ex-build\_solid\_N(i)} * \ x_{store\_solid(i)}.$$

$$m_{biogas\_solid\_TAN(i)} = m_{ex-build\_solid\_TAN(i)} * \ x_{biogas\_solid(i)}$$
$$m_{biogas\_solid\_N(i)} = m_{ex-build\_solid\_N(i)} * \ x_{bioga\ \ \_solid(i)}.$$

The masses of TAN and total N ($m_{biogas\_slurry\_TAN}$ and $m_{biogas\_slurry\_N}$) are used in a Tier 2 methodology for calculating NH_3 emission from anaerobic digestion facilities (biogas production) and reported in NFR Category 5B2.

Step 9 was applied only to liquid manure, with the aim to calculate the amount of TAN from which emissions will occur from liquid manure stores, whereby a fraction of the organic N is mineralised (f_{min}). The modified mass ($mm_{storage\_slurry}$), from which emissions were calculated (expressed in kg TAN per year per head/place for animal category *i*), was derived following equation 32 from the EMEP guidelines, (Amon H. D., 2023) namely:

$$mm_{storage\_slurry\_TAN(i)} = m_{storage\_slurry\_TAN(i)} + \{(m_{storage\_slurry\_N(i)} - m_{storage\_slurry\_TAN(i)}) * f_{min}\}$$

with f_{min} assumed to be 0.1, according to the EMEP guidelines. (Amon H. D., 2023)

In Step 10, the emissions of NH_3-N, N_2O-N, NO-N and N_2-N were calculated using the corresponding's emission factors (EFs) for storage and the amounts of total TAN stored before application to land, whereby following equation 33 and 34 from the EMEP guidelines, (Amon H. D., 2023) namely:

for liquid manure:

$$\begin{aligned} & E_{storage\_slurry(i)} \\ &= \ E_{storage\_slurry\_NH_{3-N}(i)} + E_{storage\_slurry\_N_2O-N(i)} + E_{storage\_slurry\_NO-N(i)} + E_{storage\_slurry\_N_2-N(i)} \\ &= \ mm_{storage\_slurry\_TAN(i)} * (EF_{storage_{slurr\ \ NH_{3-N}(i)}} + EF_{stora\ \ \ slurry_{N_2O}-N(i)} + EF_{storage_{slurry_{NO}}-N(i)} + EF_{storage_{slurry_{N_2}}-N(i)}) \end{aligned}$$

and for solid manure:

$$\begin{aligned} & E_{storage\_solid(i)} \\ &= \ E_{storage\_solid\_NH_3-N(i)} + E_{storage\_solid\_N_2O-N(i)} + E_{storage\_solid\_NO-N(i)} + E_{storage\_solid\_N_2-N(i)} \end{aligned}$$

$$= \ m_{storage\_slurry\_N(i)} * (EF_{storage\_solid\_NH_3-N(i)} + EF_{storage\_solid\_N_2O-N(i)} + EF_{storage\_solid\_NO-N(i)} + EF_{storage\_solid\_N_2-N(i)}$$

The N_2O EFs for the N_2O emissions were based on the 2019 Refinement to the 2006 IPCC guidelines (for details see section 5.4.3 in the national inventory report (NIR) 2024; but to derive EF's suitable to related to TAN, they were adapted following the example as provided in Annex 1 in the 2019 EMEP guidelines (Amon, Hutchings, Dämmgen, Sommer, & Webb, 2019). The N_2 EF for N_2 emissions from storage were assumed to be equal to $EF_{storage,N2}$ = 3 * $EF_{storage\_N2O\text{-}N}$, similar as (Rösemann, et al., 2019) . The used EF for NH_3 and NO_x are described in section 5.3.3 in the current report. The N_2O emissions are reported in CRF category 3B in the national inventory report 2024.

In Step 11, the total-N and TAN (m_{applic_N} and m_{applic_TAN}) that is applied to the field (expressed in kg TAN and N per year for animal category *i*) was calculated, according to equations 35-38 from the EMEP guidelines, (Amon H. D., 2023) namely:

for liquid manurey (excluding digestate from animal manure):

$$m_{applic\_slurry\_TAN(i)} = \left(mm_{storage\_slurry\_TAN(i)} - E_{storage\_slurry(i)}\right) * n_i$$
$$m_{applic\_slurry\_N(i)} = \left(mm_{storage\_slurry\_N(i)} - E_{storage\_slurry(i)}\right) * n_i$$

and for solid manure:

$$m_{applic\_solid\_TAN(i)} = \left(m_{storage\_slolid\_TAN(i)} - E_{storage\_solid(i)}\right) * n_i$$
$$m_{applic\_solid\_N(i)} = \left(m_{storage\_solid\_N(i)} - E_{storage\_solid(i)}\right) * n_i$$

with n_i number of animal places/animal (pl) for livestock category *i;*

as well as for digestate originating from animal manure, including imported animal manure used as feedstock:

$$m_{applic\_dig\_TAN(i)} = \left(mm_{dig\_TAN(i)} - E_{storage\_dig(i)}\right)$$
$$m_{applic\_dig\_N(i)} = \left(mm_{dig\_N(i)} - E_{storage\_dig(i)}\right)$$

Note 1: the added digestate created by the anaerobic digestion of manure, both liquid and solid manure, ($mm_{dig\_TAN(i)}$ and $mm_{dig\_N(i)}$), expressed in kg TAN and N per year for animal category *i*, is returned from NRF 5.B.2 (see section 6.4) and consisted of digestate originating of national animal manure from livestock category *i* and digestate originating from imported animal manure from livestock category *i*, both used as feedstock in luxemburgish biogas facilities;

Note 2: some of the national produced manure is exported and applied on fields in neighbouring countries, whereas other manure is imported and applied on fields in Luxemburg (see section 5.2.6).

The total-N and TAN (m_{applic_N} and m_{applic_TAN}), expressed in kg TAN and N per year for animal category *i* that is applied on field in Luxembourg was adapted accordingly, namely:

$$m_{applic\_slurry\_TAN\_LU(i)} = m_{applic\_slurry\_TAN(i)} + m_{applic\_slurry\_TAN\_IMPORTED(i)} - m_{applic\_slurry\_TAN\_EXPORTED(i)}$$
$$m_{applic\_slurry\_N\_LU(i)} = m_{applic\_slurry\_N(i)} + m_{applic\_slurry\_N\_IMPORTED(i)} - m_{applic\_slurry\_N\_EXPORTED(i)}$$
$$m_{applic\_dig\_TAN\_LU(i)} = m_{applic\_dig\_TAN(i)} + m_{applic\_dig\_TAN\_IMPORTED(i)} - m_{applic\_dig\_TAN\_EXPORTED(i)}$$
$$m_{applic\_dig\_N\_LU(i)} = m_{applic\_dig\_N(i)} + m_{applic\_dig\_N\_IMPORTED(i)} - m_{applic\_dig\_N\_EXPORTED(i)}$$
$$m_{applic\_solid\_TAN\_LU(i)} = m_{applic\_solid\_TAN(i)} + m_{applic\_solid\_TAN\_IMPORTED(i)} - m_{applic\_solid\_TAN\_EXPORTED(i)}$$
$$m_{applic\_solid\_N\_LU(i)} = m_{applic\_solid\_N(i)} + m_{applic\_solid\_N\_IMPORTED(i)} - m_{applic\_solid\_N\_EXPORTED(i)}$$

In Step 12, the emissions of NH_3-N during and immediately after field application, expressed in kg NH_3-N per year for animal category *i*, was calculated, according to equation 39 and 40 from the EMEP guidelines, (Amon H. D., 2023) namely:

for liquid manure (excluding digestate originating from animal manure):

$$E_{applic\_slurry\_NH3-N(i)} = m_{applic\_slurry\_TAN\_LU(i)} * EF_{applic\_slurry\_NH3-N(i)}$$

for digestate originating from animal manure:

$$E_{applic\_dig\_NH3-N(i)} = m_{applic\_dig\_TAN\_LU(i)} * EF_{applic\_dig\_NH3-N(i)}$$

and for solid manure:

$$E_{applic\_solid\_NH3-N(i)} = m_{applic\_solid\_TAN\_LU(i)} * EF_{applic\_solid\_NH3-N(i)}$$

Detailed information on the calculations and the used EFs are provided in section 0 in the current report. The NH_3 emissions are reported in NFR category 3Da2a.

In Step 13, the net amount of N returned to soil from manure ($m_{returned\_N}$ and $m_{returned\_TAN}$) after losses of NH_3-N were calculated, according to equations 41-44 from the EMEP guidelines, (Amon H. D., 2023) namely:

for liquid manure (excluding digestate originating from animal manure):

$$m_{returned\_slurry\_TAN(i)} = m_{applic\_slurry\_TAN\_LU(i)} - E_{applic\_slurry\_NH3-N(i)}$$
$$m_{returned\_slurry\_N(i)} = m_{applic\_slurry\_N\_LU(i)} - E_{applic\_slurry\_NH3-N(i)}$$

for digestate originating from animal manure:

$$m_{returned\_dig\_TAN(i)} = m_{applic\_dig\_TAN\_LU(i)} - E_{applic\_dig\_NH3-N(i)}$$
$$m_{returned\_dig\_N(i)} = m_{applic\_dig\_N\_LU(i)} - E_{applic\_dig\_NH3-N(i)}$$

and for solid manure:

$$m_{returned\_solid\_TAN(i)} = m_{applic\_solid\_TAN\_LU(i)} - E_{applic\_solid\_NH3-N(i)}$$
$$m_{returned\_solid\_N(i)} = m_{applic\_solid\_N\_LU(i)} - E_{applic\_solid\_NH3-N(i)}$$

Note: $m_{returned}$ does not account for NO and N_2O.

In Step 14, the NH3-N emissions from grazing ($E_{grazing\_NH3-N(i)}$) for livestock category *i* were calculated, using $m_{grazing\_TAN(i)}$ as estimated in Step 4 and following equation 45 from the EMEP guidelines, (Amon H. D., 2023), however, correcting for the fact of temporary imported and exported grazing animals namely:

$$E_{grazing_{NH3}-N\_LU(i)} = \left[m_{grazing_{TAN(i)}} * (n_i + n_{Temorary\ Imported\ GrazingAnimals(i)} - n_{Temporary\ Exported\ GrazingAnimals(i)}\right] * EF_{grazing_{NH}\ -N(i)}$$

with

n_i number of animals/animal places of livestock category *i;*

$n_{ITemporary\ Imported\_GrazingAnimals(i)}$ number of temporay imported grazing animals for grazing on fields in Luxemburg for livestock category *i* (see Table 5-5);

$n_{Temporary\ Exported\_GrazingAnimals(i)}$ number of temporary exported grazing animals for grazing on fields outside Luxemburg for livestock category *i* (see Table 5-5).

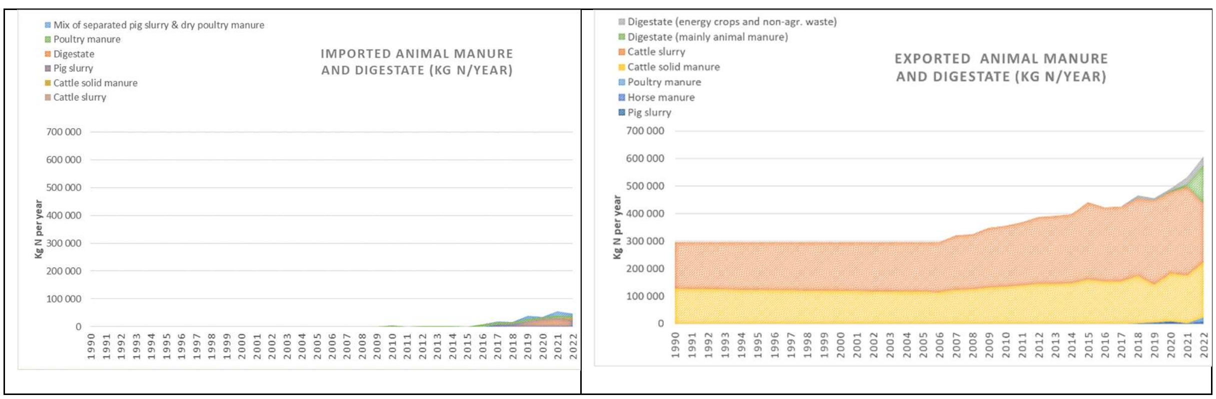
Detailed information on the calculations and the used EFs are provided in section 0 in the current report. The NH_3 emissions are reported in category 3Da3.

And as last step were all the emissions from the manure management system that are to be reported in the NFR category 3B summed and converted to the mass of the relevant compound.

5.2.6 Import and export of animal manure and digestate for application on fields

A part of the utilized agriculture surface cultivated by luxemburgish farmers were situated in neighbouring countries, and animal manure and digestate applied to those fields were exported, see Figure 58. But there were also animal manure and digestate imported to be applied on utilized agriculture surfaces in Luxembourg, see Figure 58. In the inventories only animal manure and digestate applied on fields in Luxemburg were considered.

Figure 58 – Imported and exported animal manure and digestate for application on fields, expressed in kg N/year



The import of animal manure and digstate for application on utilized agriculture surfaces in Luxembourg, although rather minor, had to be notidifed to Administration des Services techniques de l'Agriculture (ASTA). There were no imports in the years 2008 and 2009 and only minor imports in the years 2010-2015, allowing the assumption that imports were uncommon before 2008 and were therefore assumed not to occur. The percentage of TAN in the imported manure was assumed to be like nationally produced manure / digestate when leaving storage. The imported manure was, according to its origin, added to the specific livestock category i (see step 11 in section 5.2.6). Imported digestate was assumed to originate from cattle manure.

The export of animal manure and digestate from Luxembourg to utilized agriculture surfaces in Belgium had to be notified since 2013 to the Belgian authorities before their application[98]. The Beglian authorities transmitted the notified data to ASTA. The online notification to the Belgian authorities by Luxemburgish farmers had however some troughbacks in the early phase (2013-2016), and manure was often exported without notification. Reliable data were only available for 2017 and onwards. For ealier years, an estimate was made by using the median of exported/applied kg N per ha of utilized agricultural surface cultivated in Belgium by Luxemburgish farmers for the years 2017-2021, i.e. 86.7 kg N/ha and multiplied by the utilized agricultural surface cultivated in Belgium by Luxemburgish farmers (more details in the NIR 2024 in Annex 3:C), whereby assuming that only liquid and solid cattle manure would have been exported (both accounted for >99% in the years 2018-2021) whereby using the observed trend for the years 2018-2021. Data on export of manure and digestate to France and Germany were missing (except for one farmer, who had notifed his exports to France to ASTA), and were therefore assumed, except for this one case, not to occur. The percentage of TAN in the exported manure / digestate was assumed to be like nationally produced manure / digestate when leaving storage. The exported manure was, according to its origin, subtracted from the specific livestock category i (see step 11 in section 5.2.6). Exported digestate to France orginated from energy crops and non-agricultural waste, and the quantity of digestate originating from energy crops and non-agricultural waste applied in Luxemburg was corrected accordingly.

5.2.7 Category specific uncertainties

Monte Carlo simulation techniques were used for simulating the uncertainities w.r.t. CRF 3, NRF 3 and NRF 5.B.2. The stochastic model was built in MS Excel, using the add-in software Palisade @Risk 7.5. A probability distribution was chosen for most parameters to manage uncertainty. A value was drawn from such distributions iteratively using Latin Hypercube sampling with 50,000 iterations. The 95% uncertainty interval (95% UI), corresponding to the 2.5th and 97.5th percentiles of the results' distribution was computed to define the uncertainty, for the agriculture sector (i.e. sector 3), as well as for the separate CRF and NRF categories.

A detailed description of the parameters values used for the uncertainty analysis for livestock numbers, temporary import and export of grazing animals, manure management systems, housing systems, use of imported manure as feedstock in digester, storage of manure and digestate, N excretion rates and import and export of manure is provided in the national inventory report 2024 (section 5.2.7); in section 5.3.4 for NRF 3B related EF parameters and in the national inventory report 2024 (section 5.4.4) for manure management related N2O-EF parameters; in section 5.4.4 and in the national inventory report 2024 (section 5.6.4) for NRF 3D related parameters and in section 6.4.3 for NRF 5.B.2 related parameters.

5.2.8 Category specific QA/QC procedures

Consistency and completeness checks have been performed directly in the model.

[98] In recent years these notifications are made via the following link http://environnement.wallonie.be/sols, whereby choosing first "Je suis Agriculture" (in English: I'm a farmer) and second "Mouvements d'effluents" (In English: movement of manure). Access on 10-03-2023.

5.2.9 Category-specific recalculations including changes made in response to the review process

Table 5-19presents the main revisions and recalculations done since submission 2023.

Table 5-19– Recalculations done since the last submission for category – *3 – General aspects*

	Revisions 2023 ➔ 2024	Type of revision
3.B	Error correction of the number of laying hens in 2021; Used in 3.B and impacting 3.D influencing all N-, NMVOC- and PM-emissions.	Revised AD
3.B / 5.B.2	Revision of origin of solid manure to be used as feedstock in biogas facilities from 2005 onwards from laying hens and cattle rather than just cattle. Used in 3.B and 5.B.2 and impacting 3.D.	Revised AD
3.B / 5.B.2	Revision of the calculation methodology whereby the imported manure was split according to its origin and added to the corresponding livestock categories. Used in 3.B and 5.B.2 and impacting 3.D.	Revised calculation methodology and error correction
3.D	Having additional data w.r.t. export of digestate originating from energy crops and non-agricultural waste. AD was updated	Revised AD

The adapted AD and the revised MMS affected 3B and 3D, as well as 5B2. For recalculations see Table and Table .

5.2.10 Category-specific planned improvements including those made in response to the review process

Planned improvements, as listed in Table 5-20, will be explored, based on available resources and available data.

Table 5-20– Planned improvements for category – *3 – General aspects*

Source category	Planned improvements	Type of revision
3D	Continue the quest for additional data/information on exported quantities of nationally produced animal manure and digestate to France and Germany	AD

5.3 Manure Management (Category 3B)

This section describes the estimation of pollutant emissions resulting from manure management. In 2022, this source category was responsible for:

- 48% of the total NH_3 emissions of the agriculture sector.
- 1.7 % of the total NO_x emissions of the agricultural sector
- 78% of the total NMVOC emissions of the agricultural sector
- 81% of the total $PM_{2.5}$ and 24% of the total PM_{10} emissions of the agricultural sector
- 49% of the total TSP emissions of the agricultural sector.

5.3.1 Key categories

Ammonia emissions from cattle (category 3B1) as well as NMVOC emissions from cattle were a key category in 2022 (Table 5-21).

Table 5-21 – Key categories for category 3B – manure management.

Key Source Analysis (FUEL SOLD): Ranking per number		SO2		NOX		NMVOC		NH3		CO		TSP		PM10		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
3 B 1 a	Manure management - Dairy cattle					2	4	3									
3 B 1 b	Manure management - Non-dairy cattle					3	5	2									

Key Source Analysis (FUEL USED): Ranking per number		SO2		NOX		NMVOC		NH3		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
3 B 1 a	Manure management - Dairy cattle					2	3	3			
3 B 1 b	Manure management - Non-dairy cattle					3	6	2			

Sources: Environment Agency
Notes: LA = Level Assessment, TA = Trend Assessment, number in table = indicates the rank in the specific analysis (1…biggest KC; 2… second biggest KC, …)

5.3.2 Source category description

Ammonia volatilisation occurs when NH_3 in solution is exposed to the atmosphere. The source of NH_3 emission from manure management is the N excreted by livestock. Ammonia is emitted wherever manure is exposed to the atmosphere; in livestock housing, manure storage, after manure application to fields and from excreta deposited by grazing animals. Differences in agricultural practices such as housing and manure management, and differences in climate have significant impacts on emissions (Amon H. D., 2023).

Looking at <u>ammonia emissions</u> from manure management (Table 5-22), a decrease of 5% can be observed for the period 1990-2022. Goats, although a niche production in Luxembourg, have experienced the biggest increase in their population for the whole period 1990-2022 (Table 5-4), and consequently also the biggest increase in ammonia emissions from manure management for the same time period (3 024%), see Table 5-22. However, ammonia emission from manure management from goats represent <1% of the total ammonia emission from manure management in 2022 (see Table 5-22). Cattle as a whole group is over the whole period the main ammonia emitting animal category regarding manure management and was in 2022 responsible for 88% of the total ammonia emission from manure management (Table 5-22). Lactating dairy cows is the subgroup with the highest emission over the whole period, and in 2022 35% of the ammonia emission from manure management were from lactating dairy cows (Table 5-22). Swine are responsible for 7.8% of the ammonia emissions, and horses for 2.3%. For the other farm animal categories, ammonia emissions can be considered as negligible.

The following tables (Table 5-23 - Table 5-27) show the emission trends for NO_x, NMVOC, $PM_{2.5}$, PM_{10} and TSP by animal category over the time period 1990 - 2022. NO_x emissions (Table 5-23) had been reduced by 20%, which is mainly due to a decline in emissions from dairy cows (-34%). Decreasing numbers and different housing systems had been the driving forces. The NMVOC emissions in 2022 were 6% higher than in 1990 (Table 5-24). $PM_{2.5}$ emissions (Table 5-25) had been reduced by 5% whereas PM_{10} and TSP emissions had been increased by 2% (Table 5-26) and 12% (Table 5-27), respectively.

Regarding cattle, its total population and its evolution had been strongly influenced by changes in agricultural policy and, more precisely, in the Common Agricultural Policy of the EU (CAP). This was the case for dairy cows, as well as for suckler cows. Due to a quota system for milk production in place from 1983-31st March 2015, and an increasing milk yield per cow had the population of dairy cows declined over time, partly compensated by an increasing number of suckler cows. But at the end of the milk production system, this trend was reversed, and the population of dairy cows had sharply increased up to 2017, and a slower increase since then. Other factors who had influenced the cattle/livestock population is/was, availability of fodder, respectively high fodder prices, and /or low milk and8or meat prices.

Table 5-22 – NH_3 emission trends for category 3B – Manure Management: 1990-2022 by livestock category (Gg)

3 Agriculture														
NH_3 Emissions (in Gg)														
	3B. Manure management													
Year	Total	Dairy cows	Other cattle	Sheep	Swine	Buffalo	Goats	Horses[a]	Mules & asses[a]	Laying hens	Broilers	Turkey[b]	Other poultry[b]	Other animals
1990	2.86	1.05	1.53	0.0042	0.22	NO	0.0005	0.028	IE	0.011	0.0013	IE	0.0004	0.0057
1991	2.87	1.01	1.61	0.0043	0.20	NO	0.0005	0.030	IE	0.010	0.0012	IE	0.0003	0.0053
1992	2.75	0.94	1.56	0.0042	0.21	NO	0.0005	0.029	IE	0.009	0.0011	IE	0.0003	0.0047
1993	2.78	0.93	1.58	0.0038	0.22	NO	0.0005	0.031	IE	0.010	0.0011	IE	0.0003	0.0037
1994	2.76	0.91	1.59	0.0045	0.21	NO	0.0004	0.034	IE	0.009	0.0011	IE	0.0002	0.0034
1995	2.85	0.91	1.67	0.0046	0.22	NO	0.0004	0.034	IE	0.009	0.0010	IE	0.0003	0.0033
1996	2.90	0.90	1.73	0.0043	0.21	NO	0.0003	0.035	IE	0.009	0.0012	IE	0.0003	0.0027
1997	2.86	0.88	1.70	0.0045	0.23	NO	0.0004	0.036	IE	0.008	0.0022	IE	0.0003	0.0032
1998	2.79	0.84	1.66	0.0048	0.23	NO	0.0003	0.037	IE	0.009	0.0024	IE	0.0002	0.0030
1999	2.80	0.83	1.67	0.0047	0.24	NO	0.0002	0.044	IE	0.009	0.0015	IE	0.0002	0.0028
2000	2.75	0.79	1.66	0.0047	0.23	NO	0.0003	0.049	IE	0.010	0.0016	IE	0.0001	0.0034
2001	2.75	0.76	1.69	0.0050	0.23	NO	0.0003	0.048	IE	0.012	0.0020	IE	0.0002	0.0029
2002	2.67	0.76	1.60	0.0050	0.23	NO	0.0028	0.048	IE	0.011	0.0018	IE	0.0002	0.0031
2003	2.64	0.77	1.54	0.0057	0.25	NO	0.0049	0.053	IE	0.012	0.0017	IE	0.0002	0.0032
2004	2.67	0.79	1.51	0.0057	0.28	NO	0.0063	0.057	IE	0.011	0.0014	IE	0.0002	0.0033
2005	2.60	0.72	1.50	0.0054	0.29	NO	0.0069	0.066	IE	0.010	0.0023	IE	0.0002	0.0032
2006	2.58	0.73	1.49	0.0058	0.27	NO	0.0063	0.065	IE	0.010	0.0022	IE	0.0002	0.0032
2007	2.65	0.75	1.54	0.0054	0.26	NO	0.0076	0.063	IE	0.010	0.0020	IE	0.0001	0.0025
2008	2.75	0.77	1.63	0.0053	0.26	NO	0.0093	0.066	IE	0.012	0.0009	IE	0.0001	0.0025
2009	2.75	0.75	1.64	0.0054	0.26	NO	0.0099	0.067	IE	0.013	0.0020	IE	0.0001	0.0026
2010	2.73	0.74	1.65	0.0054	0.24	NO	0.0138	0.067	IE	0.011	0.0020	IE	0.0001	0.0023
2011	2.67	0.73	1.59	0.0055	0.25	NO	0.0146	0.065	IE	0.013	0.0020	IE	0.0001	0.0025
2012	2.61	0.71	1.54	0.0053	0.25	NO	0.0169	0.067	IE	0.015	0.0020	IE	0.0003	0.0024
2013	2.65	0.73	1.57	0.0055	0.25	NO	0.0147	0.062	IE	0.015	0.0018	IE	0.0001	0.0026
2014	2.73	0.74	1.64	0.0055	0.25	NO	0.0138	0.060	IE	0.016	0.0018	IE	0.0002	0.0022
2015	2.76	0.77	1.62	0.0058	0.27	NO	0.0156	0.058	IE	0.015	0.0021	IE	0.0002	0.0022
2016	2.79	0.84	1.58	0.0055	0.27	NO	0.0156	0.054	IE	0.015	0.0021	IE	0.0001	0.0020
2017	2.85	0.89	1.58	0.0052	0.28	NO	0.0154	0.059	IE	0.016	0.0024	IE	0.0002	0.0017
2018	2.83	0.93	1.54	0.0050	0.26	NO	0.0153	0.061	IE	0.016	0.0025	IE	0.0001	0.0019
2019	2.81	0.95	1.51	0.0048	0.24	NO	0.0142	0.064	IE	0.018	0.0024	IE	0.0001	0.0017
2020	2.80	0.97	1.49	0.0050	0.23	NO	0.0143	0.063	IE	0.019	0.0024	IE	0.0001	0.0015
2021	2.77	0.98	1.46	0.0052	0.23	NO	0.0150	0.060	IE	0.018	0.0058	IE	0.0001	0.0014
2022	2.71	0.96	1.43	0.0054	0.21	NO	0.0156	0.061	IE	0.020	0.0062	IE	0.0001	0.0012
Trend 1990 -2022	-5%	-9%	-7%	29%	-6%	NO	3024%	119%	IE	89%	382%	IE	-75%	-78%
Trend 2005 -2022	4%	34%	-5%	-2%	-27%	NO	128%	-7%	IE	95%	166%	IE	-49%	-62%
Trend 2021 -2022	-2%	-2%	-2%	4%	-9%	NO	4%	3%	IE	10%	6%	IE	-5%	-15%

Notes: a) Mules & asses are recorded together with horses, b) Turkey are recorded together with other poultry.

Table 5-23 – NOx emission trends for category 3B – Manure Management: 1990-2022 by livestock category (Gg NO_2)

3 Agriculture														
NOx Emissions (in Gg)														
	3B. Manure management													
Year	Total	Dairy cows	Other cattle	Sheep	Swine	Buffalo	Goats	Horses[a]	Mules & asses[a]	Laying hens	Broilers	Turkey[b]	Other poultry[b]	Other animals
1990	0.020	0.008	0.011	0.0001	0.0008	NO	0.0000	0.0003	IE	0.0000	0.0000	IE	0.0000	0.0000
1991	0.020	0.007	0.011	0.0001	0.0007	NO	0.0000	0.0003	IE	0.0000	0.0000	IE	0.0000	0.0000
1992	0.019	0.007	0.010	0.0001	0.0008	NO	0.0000	0.0003	IE	0.0000	0.0000	IE	0.0000	0.0000
1993	0.018	0.007	0.010	0.0001	0.0008	NO	0.0000	0.0003	IE	0.0000	0.0000	IE	0.0000	0.0000
1994	0.018	0.007	0.010	0.0001	0.0008	NO	0.0000	0.0004	IE	0.0000	0.0000	IE	0.0000	0.0000
1995	0.019	0.007	0.011	0.0001	0.0008	NO	0.0000	0.0004	IE	0.0000	0.0000	IE	0.0000	0.0000
1996	0.019	0.007	0.011	0.0001	0.0008	NO	0.0000	0.0004	IE	0.0000	0.0000	IE	0.0000	0.0000
1997	0.019	0.006	0.011	0.0001	0.0008	NO	0.0000	0.0004	IE	0.0000	0.0000	IE	0.0000	0.0000
1998	0.018	0.006	0.011	0.0001	0.0008	NO	0.0000	0.0004	IE	0.0000	0.0000	IE	0.0000	0.0000
1999	0.018	0.006	0.010	0.0001	0.0008	NO	0.0000	0.0005	IE	0.0000	0.0000	IE	0.0000	0.0000
2000	0.017	0.005	0.010	0.0001	0.0008	NO	0.0000	0.0005	IE	0.0000	0.0000	IE	0.0000	0.0000
2001	0.017	0.005	0.010	0.0001	0.0008	NO	0.0000	0.0005	IE	0.0000	0.0000	IE	0.0000	0.0000
2002	0.016	0.005	0.010	0.0001	0.0008	NO	0.0000	0.0005	IE	0.0000	0.0000	IE	0.0000	0.0000
2003	0.016	0.005	0.009	0.0001	0.0008	NO	0.0001	0.0006	IE	0.0000	0.0000	IE	0.0000	0.0000
2004	0.016	0.005	0.009	0.0001	0.0009	NO	0.0001	0.0006	IE	0.0000	0.0000	IE	0.0000	0.0000
2005	0.016	0.005	0.009	0.0001	0.0010	NO	0.0001	0.0007	IE	0.0000	0.0000	IE	0.0000	0.0000
2006	0.016	0.005	0.009	0.0001	0.0009	NO	0.0001	0.0007	IE	0.0000	0.0000	IE	0.0000	0.0000
2007	0.016	0.005	0.009	0.0001	0.0009	NO	0.0001	0.0007	IE	0.0000	0.0000	IE	0.0000	0.0000
2008	0.016	0.005	0.010	0.0001	0.0008	NO	0.0001	0.0007	IE	0.0000	0.0000	IE	0.0000	0.0000
2009	0.016	0.005	0.010	0.0001	0.0008	NO	0.0001	0.0007	IE	0.0000	0.0000	IE	0.0000	0.0000
2010	0.016	0.005	0.010	0.0001	0.0008	NO	0.0002	0.0007	IE	0.0000	0.0000	IE	0.0000	0.0000
2011	0.015	0.004	0.009	0.0001	0.0008	NO	0.0002	0.0007	IE	0.0000	0.0000	IE	0.0000	0.0000
2012	0.015	0.004	0.009	0.0001	0.0008	NO	0.0002	0.0007	IE	0.0000	0.0000	IE	0.0000	0.0000
2013	0.015	0.004	0.009	0.0001	0.0007	NO	0.0002	0.0007	IE	0.0000	0.0000	IE	0.0000	0.0000
2014	0.016	0.004	0.010	0.0001	0.0007	NO	0.0002	0.0007	IE	0.0000	0.0000	IE	0.0000	0.0000
2015	0.016	0.004	0.010	0.0001	0.0007	NO	0.0002	0.0006	IE	0.0000	0.0000	IE	0.0000	0.0000
2016	0.016	0.005	0.010	0.0001	0.0007	NO	0.0002	0.0006	IE	0.0000	0.0000	IE	0.0000	0.0000
2017	0.017	0.005	0.010	0.0001	0.0007	NO	0.0002	0.0007	IE	0.0000	0.0000	IE	0.0000	0.0000
2018	0.016	0.005	0.010	0.0001	0.0006	NO	0.0002	0.0007	IE	0.0000	0.0000	IE	0.0000	0.0000
2019	0.016	0.005	0.009	0.0001	0.0006	NO	0.0002	0.0007	IE	0.0000	0.0000	IE	0.0000	0.0000
2020	0.016	0.005	0.009	0.0001	0.0005	NO	0.0002	0.0007	IE	0.0000	0.0000	IE	0.0000	0.0000
2021	0.016	0.005	0.009	0.0001	0.0005	NO	0.0002	0.0007	IE	0.0000	0.0000	IE	0.0000	0.0000
2022	0.016	0.005	0.009	0.0001	0.0005	NO	0.0002	0.0007	IE	0.0000	0.0000	IE	0.0000	0.0000
Trend 1990 -2022	-20%	-34%	-14%	31%	-46%	NO	3087%	127%	IE	108%	382%	IE	-75%	-81%
Trend 2005 -2022	0%	9%	1%	0%	-53%	NO	132%	-5%	IE	91%	166%	IE	-49%	-63%
Trend 2021 -2022	-1%	-2%	-1%	4%	-9%	NO	4%	3%	IE	9%	6%	IE	-5%	-8%

Notes: a) Mules & asses are recorded together with horses, b) Turkey are recorded together with other poultry.

Table 5-24 – NMVOC emission trends for category *3B – Manure Management*: 1990-2022 by livestock category (Gg)

3 Agriculture

NMVOC Emissions (in Gg)

Year	3B. Manure management													
	Total	Dairy cows	Other cattle	Sheep	Swine	Buffalo	Goats	Horses[a]	Mules & asses[a]	Laying hens	Broilers	Turkey[b]	Other poultry[b]	Other animals
1990	2.556	1.284	1.236	0.0006	0.0287	NO	0.0000	0.0033	IE	0.0013	0.0005	IE	0.0003	0.0009
1991	2.526	1.202	1.291	0.0006	0.0262	NO	0.0000	0.0035	IE	0.0012	0.0005	IE	0.0002	0.0010
1992	2.453	1.186	1.233	0.0006	0.0271	NO	0.0000	0.0034	IE	0.0011	0.0005	IE	0.0002	0.0008
1993	2.496	1.218	1.243	0.0006	0.0280	NO	0.0000	0.0036	IE	0.0012	0.0005	IE	0.0002	0.0006
1994	2.407	1.129	1.244	0.0007	0.0272	NO	0.0000	0.0040	IE	0.0012	0.0004	IE	0.0002	0.0007
1995	2.485	1.141	1.309	0.0007	0.0286	NO	0.0000	0.0040	IE	0.0011	0.0004	IE	0.0002	0.0006
1996	2.497	1.111	1.352	0.0006	0.0277	NO	0.0000	0.0041	IE	0.0012	0.0005	IE	0.0002	0.0005
1997	2.473	1.104	1.332	0.0007	0.0291	NO	0.0000	0.0043	IE	0.0011	0.0009	IE	0.0002	0.0006
1998	2.455	1.102	1.315	0.0007	0.0293	NO	0.0000	0.0044	IE	0.0011	0.0010	IE	0.0002	0.0007
1999	2.433	1.084	1.310	0.0007	0.0295	NO	0.0000	0.0052	IE	0.0011	0.0006	IE	0.0001	0.0007
2000	2.398	1.063	1.298	0.0007	0.0277	NO	0.0000	0.0058	IE	0.0013	0.0007	IE	0.0001	0.0008
2001	2.398	1.051	1.309	0.0008	0.0281	NO	0.0000	0.0057	IE	0.0015	0.0008	IE	0.0001	0.0008
2002	2.308	1.041	1.229	0.0007	0.0280	NO	0.0002	0.0057	IE	0.0014	0.0008	IE	0.0001	0.0008
2003	2.249	1.035	1.174	0.0009	0.0289	NO	0.0003	0.0063	IE	0.0014	0.0007	IE	0.0001	0.0008
2004	2.165	0.978	1.146	0.0009	0.0312	NO	0.0004	0.0068	IE	0.0014	0.0006	IE	0.0001	0.0009
2005	2.192	0.996	1.151	0.0008	0.0324	NO	0.0005	0.0078	IE	0.0014	0.0010	IE	0.0001	0.0008
2006	2.149	0.977	1.129	0.0009	0.0305	NO	0.0004	0.0077	IE	0.0014	0.0009	IE	0.0001	0.0008
2007	2.203	0.999	1.162	0.0008	0.0298	NO	0.0005	0.0075	IE	0.0015	0.0008	IE	0.0001	0.0006
2008	2.271	1.016	1.214	0.0008	0.0292	NO	0.0006	0.0079	IE	0.0017	0.0004	IE	0.0001	0.0007
2009	2.263	1.014	1.206	0.0008	0.0292	NO	0.0007	0.0080	IE	0.0018	0.0008	IE	0.0001	0.0008
2010	2.286	1.022	1.224	0.0008	0.0270	NO	0.0010	0.0079	IE	0.0016	0.0008	IE	0.0001	0.0007
2011	2.211	1.007	1.163	0.0008	0.0275	NO	0.0010	0.0077	IE	0.0019	0.0008	IE	0.0001	0.0009
2012	2.193	1.029	1.122	0.0008	0.0279	NO	0.0012	0.0079	IE	0.0021	0.0009	IE	0.0002	0.0008
2013	2.276	1.077	1.159	0.0008	0.0271	NO	0.0010	0.0073	IE	0.0022	0.0007	IE	0.0001	0.0008
2014	2.359	1.099	1.221	0.0008	0.0272	NO	0.0009	0.0072	IE	0.0023	0.0007	IE	0.0001	0.0007
2015	2.415	1.164	1.210	0.0009	0.0284	NO	0.0011	0.0069	IE	0.0021	0.0009	IE	0.0001	0.0007
2016	2.528	1.309	1.179	0.0008	0.0283	NO	0.0011	0.0064	IE	0.0021	0.0009	IE	0.0001	0.0006
2017	2.559	1.334	1.182	0.0008	0.0300	NO	0.0010	0.0070	IE	0.0023	0.0010	IE	0.0001	0.0004
2018	2.621	1.430	1.150	0.0008	0.0285	NO	0.0010	0.0072	IE	0.0023	0.0011	IE	0.0001	0.0005
2019	2.617	1.460	1.118	0.0007	0.0258	NO	0.0009	0.0076	IE	0.0025	0.0010	IE	0.0001	0.0004
2020	2.736	1.587	1.111	0.0008	0.0248	NO	0.0010	0.0075	IE	0.0026	0.0010	IE	0.0001	0.0003
2021	2.718	1.602	1.078	0.0008	0.0235	NO	0.0010	0.0071	IE	0.0025	0.0025	IE	0.0001	0.0003
2022	2.710	1.596	1.078	0.0008	0.0209	NO	0.0010	0.0073	IE	0.0027	0.0026	IE	0.0001	0.0003
Trend 1990-2022	6%	24%	-13%	29%	-27%	NO	3923%	120%	IE	108%	382%	IE	-75%	-69%
Trend 2005-2022	24%	60%	-6%	-2%	-35%	NO	122%	-7%	IE	91%	166%	IE	-49%	-65%
Trend 2021-2022	0%	0%	0%	4%	-11%	NO	1%	3%	IE	9%	6%	IE	-5%	-10%

Notes: a) Mules & asses are recorded together with horses, b) Turkey are recorded together with other poultry.

Table 5-25 – PM 2.5 emission trends for category *3B – Manure Management*: 1990-2022 by livestock category (Gg)

3 Agriculture

PM25 Emissions (in Gg)

	3B. Manure management													
Year	**Total**	**Dairy cows**	**Other cattle**	**Sheep**	**Swine**	**Buffalo**	**Goats**	**Horses[a]**	**Mules & asses[a]**	**Laying hens**	**Broilers**	**Turkey[b]**	**Other poultry[b]**	**Other animals**
1990	0.034	0.018	0.014	0.0000	0.0003	NO	0.0000	0.0003	IE	0.0002	0.0000	IE	0.0000	0.0001
1991	0.033	0.017	0.015	0.0000	0.0003	NO	0.0000	0.0003	IE	0.0002	0.0000	IE	0.0000	0.0001
1992	0.031	0.016	0.014	0.0000	0.0003	NO	0.0000	0.0003	IE	0.0002	0.0000	IE	0.0000	0.0000
1993	0.031	0.015	0.015	0.0000	0.0003	NO	0.0000	0.0003	IE	0.0002	0.0000	IE	0.0000	0.0000
1994	0.031	0.015	0.015	0.0000	0.0003	NO	0.0000	0.0003	IE	0.0002	0.0000	IE	0.0000	0.0000
1995	0.031	0.015	0.015	0.0001	0.0003	NO	0.0000	0.0003	IE	0.0001	0.0000	IE	0.0000	0.0000
1996	0.031	0.015	0.016	0.0000	0.0003	NO	0.0000	0.0003	IE	0.0002	0.0000	IE	0.0000	0.0000
1997	0.031	0.014	0.015	0.0000	0.0003	NO	0.0000	0.0003	IE	0.0001	0.0000	IE	0.0000	0.0000
1998	0.030	0.014	0.015	0.0001	0.0003	NO	0.0000	0.0003	IE	0.0001	0.0000	IE	0.0000	0.0000
1999	0.030	0.014	0.015	0.0001	0.0004	NO	0.0000	0.0004	IE	0.0001	0.0000	IE	0.0000	0.0000
2000	0.030	0.013	0.015	0.0001	0.0003	NO	0.0000	0.0005	IE	0.0002	0.0000	IE	0.0000	0.0000
2001	0.030	0.013	0.015	0.0001	0.0003	NO	0.0000	0.0005	IE	0.0002	0.0000	IE	0.0000	0.0000
2002	0.028	0.013	0.014	0.0001	0.0004	NO	0.0000	0.0005	IE	0.0002	0.0000	IE	0.0000	0.0000
2003	0.027	0.013	0.014	0.0001	0.0004	NO	0.0000	0.0005	IE	0.0002	0.0000	IE	0.0000	0.0000
2004	0.027	0.012	0.013	0.0001	0.0004	NO	0.0000	0.0005	IE	0.0002	0.0000	IE	0.0000	0.0000
2005	0.027	0.012	0.013	0.0001	0.0005	NO	0.0000	0.0006	IE	0.0002	0.0000	IE	0.0000	0.0000
2006	0.027	0.012	0.013	0.0001	0.0004	NO	0.0000	0.0006	IE	0.0002	0.0000	IE	0.0000	0.0000
2007	0.027	0.012	0.014	0.0001	0.0004	NO	0.0000	0.0006	IE	0.0002	0.0000	IE	0.0000	0.0000
2008	0.028	0.012	0.014	0.0001	0.0004	NO	0.0001	0.0006	IE	0.0002	0.0000	IE	0.0000	0.0000
2009	0.028	0.013	0.014	0.0001	0.0004	NO	0.0001	0.0006	IE	0.0002	0.0000	IE	0.0000	0.0000
2010	0.029	0.013	0.014	0.0001	0.0004	NO	0.0001	0.0006	IE	0.0002	0.0000	IE	0.0000	0.0000
2011	0.028	0.013	0.014	0.0001	0.0004	NO	0.0001	0.0006	IE	0.0003	0.0000	IE	0.0000	0.0000
2012	0.028	0.013	0.013	0.0001	0.0004	NO	0.0001	0.0006	IE	0.0003	0.0000	IE	0.0000	0.0000
2013	0.029	0.013	0.014	0.0001	0.0004	NO	0.0001	0.0006	IE	0.0003	0.0000	IE	0.0000	0.0000
2014	0.029	0.013	0.014	0.0001	0.0004	NO	0.0001	0.0006	IE	0.0003	0.0000	IE	0.0000	0.0000
2015	0.030	0.014	0.014	0.0001	0.0004	NO	0.0001	0.0006	IE	0.0003	0.0000	IE	0.0000	0.0000
2016	0.031	0.015	0.014	0.0001	0.0004	NO	0.0001	0.0005	IE	0.0003	0.0000	IE	0.0000	0.0000
2017	0.031	0.016	0.014	0.0001	0.0005	NO	0.0001	0.0006	IE	0.0003	0.0000	IE	0.0000	0.0000
2018	0.031	0.016	0.014	0.0001	0.0004	NO	0.0001	0.0006	IE	0.0003	0.0000	IE	0.0000	0.0000
2019	0.032	0.017	0.013	0.0001	0.0004	NO	0.0001	0.0006	IE	0.0003	0.0000	IE	0.0000	0.0000
2020	0.032	0.017	0.013	0.0001	0.0004	NO	0.0001	0.0006	IE	0.0003	0.0000	IE	0.0000	0.0000
2021	0.032	0.017	0.013	0.0001	0.0004	NO	0.0001	0.0006	IE	0.0003	0.0001	IE	0.0000	0.0000
2022	0.032	0.017	0.013	0.0001	0.0004	NO	0.0001	0.0006	IE	0.0004	0.0001	IE	0.0000	0.0000
Trend 1990 -2022	-5%	-5%	-11%	29%	8%	NO	2739%	140%	IE	108%	382%	IE	-75%	-77%
Trend 2005 -2022	17%	42%	-4%	-2%	-23%	NO	114%	-4%	IE	91%	166%	IE	-49%	-62%
Trend 2021 -2022	0%	1%	-1%	3%	-8%	NO	1%	2%	IE	9%	6%	IE	-5%	-16%

Notes: a) Mules & asses are recorded together with horses, b) Turkey are recorded together with other poultry.

Table 5-26 – PM $_{10}$ emission trends for category *3B – Manure Management*: 1990-2022 by livestock category (Gg)

3 Agriculture

PM$_{10}$ Emissions (in Gg)

	3B. Manure management													
Year	**Total**	**Dairy cows**	**Other cattle**	**Sheep**	**Swine**	**Buffalo**	**Goats**	**Horses[a]**	**Mules & asses[a]**	**Laying hens**	**Broilers**	**Turkey[b]**	**Other poultry[b]**	**Other animals**
1990	0.061	0.028	0.022	0.0001	0.0071	NO	0.0000	0.0004	IE	0.0023	0.0002	IE	0.0002	0.0001
1991	0.059	0.026	0.023	0.0001	0.0063	NO	0.0000	0.0004	IE	0.0021	0.0002	IE	0.0002	0.0001
1992	0.056	0.024	0.022	0.0001	0.0066	NO	0.0000	0.0004	IE	0.0020	0.0002	IE	0.0002	0.0001
1993	0.056	0.024	0.022	0.0001	0.0070	NO	0.0000	0.0004	IE	0.0021	0.0002	IE	0.0002	0.0001
1994	0.055	0.023	0.022	0.0001	0.0066	NO	0.0000	0.0005	IE	0.0020	0.0002	IE	0.0002	0.0001
1995	0.056	0.023	0.023	0.0002	0.0070	NO	0.0000	0.0005	IE	0.0019	0.0002	IE	0.0002	0.0001
1996	0.057	0.023	0.024	0.0001	0.0068	NO	0.0000	0.0005	IE	0.0021	0.0002	IE	0.0002	0.0000
1997	0.056	0.022	0.023	0.0001	0.0074	NO	0.0000	0.0005	IE	0.0019	0.0004	IE	0.0002	0.0001
1998	0.056	0.022	0.023	0.0002	0.0076	NO	0.0000	0.0005	IE	0.0019	0.0004	IE	0.0002	0.0001
1999	0.056	0.021	0.023	0.0002	0.0080	NO	0.0000	0.0007	IE	0.0019	0.0003	IE	0.0001	0.0001
2000	0.055	0.021	0.023	0.0002	0.0077	NO	0.0000	0.0007	IE	0.0023	0.0003	IE	0.0001	0.0001
2001	0.055	0.020	0.023	0.0002	0.0077	NO	0.0000	0.0007	IE	0.0027	0.0004	IE	0.0001	0.0001
2002	0.053	0.020	0.022	0.0002	0.0078	NO	0.0001	0.0007	IE	0.0025	0.0003	IE	0.0001	0.0001
2003	0.053	0.019	0.021	0.0002	0.0084	NO	0.0001	0.0008	IE	0.0026	0.0003	IE	0.0001	0.0001
2004	0.053	0.019	0.020	0.0002	0.0097	NO	0.0001	0.0009	IE	0.0024	0.0002	IE	0.0001	0.0001
2005	0.054	0.019	0.020	0.0002	0.0103	NO	0.0001	0.0010	IE	0.0025	0.0004	IE	0.0001	0.0001
2006	0.053	0.018	0.020	0.0002	0.0097	NO	0.0001	0.0010	IE	0.0025	0.0004	IE	0.0001	0.0001
2007	0.053	0.018	0.021	0.0002	0.0096	NO	0.0001	0.0009	IE	0.0026	0.0003	IE	0.0001	0.0001
2008	0.055	0.019	0.022	0.0002	0.0095	NO	0.0002	0.0010	IE	0.0029	0.0002	IE	0.0001	0.0001
2009	0.055	0.019	0.022	0.0002	0.0095	NO	0.0002	0.0010	IE	0.0032	0.0003	IE	0.0001	0.0001
2010	0.055	0.020	0.022	0.0002	0.0087	NO	0.0003	0.0010	IE	0.0029	0.0003	IE	0.0001	0.0001
2011	0.055	0.019	0.021	0.0002	0.0092	NO	0.0003	0.0010	IE	0.0034	0.0003	IE	0.0001	0.0001
2012	0.055	0.019	0.020	0.0002	0.0095	NO	0.0003	0.0010	IE	0.0038	0.0004	IE	0.0002	0.0001
2013	0.057	0.021	0.021	0.0002	0.0093	NO	0.0003	0.0009	IE	0.0038	0.0003	IE	0.0001	0.0001
2014	0.058	0.021	0.022	0.0002	0.0094	NO	0.0003	0.0009	IE	0.0040	0.0003	IE	0.0001	0.0001
2015	0.060	0.022	0.022	0.0002	0.0102	NO	0.0003	0.0009	IE	0.0038	0.0004	IE	0.0001	0.0001
2016	0.061	0.023	0.022	0.0002	0.0102	NO	0.0003	0.0008	IE	0.0038	0.0004	IE	0.0001	0.0001
2017	0.062	0.024	0.022	0.0002	0.0106	NO	0.0003	0.0009	IE	0.0041	0.0004	IE	0.0001	0.0001
2018	0.062	0.025	0.021	0.0002	0.0098	NO	0.0003	0.0009	IE	0.0041	0.0004	IE	0.0001	0.0001
2019	0.062	0.026	0.021	0.0002	0.0090	NO	0.0003	0.0010	IE	0.0044	0.0004	IE	0.0001	0.0001
2020	0.062	0.026	0.020	0.0002	0.0089	NO	0.0003	0.0010	IE	0.0047	0.0004	IE	0.0001	0.0001
2021	0.062	0.026	0.020	0.0002	0.0088	NO	0.0003	0.0009	IE	0.0044	0.0010	IE	0.0001	0.0001
2022	0.062	0.027	0.020	0.0002	0.0082	NO	0.0003	0.0010	IE	0.0048	0.0011	IE	0.0001	0.0000
Trend 1990 -2022	2%	-5%	-11%	29%	14%	NO	2739%	140%	IE	108%	382%	IE	-75%	-55%
Trend 2005 -2022	15%	42%	-4%	-2%	-21%	NO	114%	-4%	IE	91%	166%	IE	-49%	-54%
Trend 2021 -2022	0%	1%	-1%	3%	-7%	NO	1%	2%	IE	9%	6%	IE	-5%	-26%

Notes: a) Mules & asses are recorded together with horses, b) Turkey are recorded together with other poultry.

Table 5-27 – TSP emission trends for category *3B – Manure Management*: 1990-2022 by livestock category (Gg)

3 Agriculture

TSP Emissions (in Gg)

Year	3B. Manure management													
	Total	Dairy cows	Other cattle	Sheep	Swine	Buffalo	Goats	Horses[a]	Mules & asses[a]	Laying hens	Broilers	Turkey[b]	Other poultry[b]	Other animals
1990	0.168	0.061	0.048	0.0003	0.0456	NO	0.0000	0.0009	IE	0.0110	0.0004	IE	0.0002	0.0002
1991	0.159	0.058	0.050	0.0003	0.0397	NO	0.0000	0.0009	IE	0.0100	0.0004	IE	0.0002	0.0002
1992	0.154	0.053	0.048	0.0003	0.0419	NO	0.0000	0.0009	IE	0.0097	0.0004	IE	0.0002	0.0002
1993	0.158	0.052	0.048	0.0003	0.0452	NO	0.0000	0.0010	IE	0.0102	0.0004	IE	0.0002	0.0002
1994	0.153	0.051	0.048	0.0003	0.0424	NO	0.0000	0.0011	IE	0.0097	0.0004	IE	0.0002	0.0001
1995	0.157	0.050	0.050	0.0004	0.0450	NO	0.0000	0.0011	IE	0.0089	0.0003	IE	0.0002	0.0001
1996	0.157	0.050	0.052	0.0003	0.0436	NO	0.0000	0.0011	IE	0.0098	0.0004	IE	0.0002	0.0001
1997	0.159	0.048	0.051	0.0003	0.0482	NO	0.0000	0.0012	IE	0.0089	0.0008	IE	0.0002	0.0001
1998	0.159	0.048	0.050	0.0004	0.0493	NO	0.0000	0.0012	IE	0.0089	0.0009	IE	0.0002	0.0001
1999	0.161	0.047	0.050	0.0004	0.0523	NO	0.0000	0.0014	IE	0.0092	0.0005	IE	0.0001	0.0001
2000	0.159	0.045	0.050	0.0004	0.0504	NO	0.0000	0.0016	IE	0.0109	0.0006	IE	0.0001	0.0001
2001	0.160	0.045	0.050	0.0004	0.0503	NO	0.0000	0.0016	IE	0.0127	0.0007	IE	0.0001	0.0001
2002	0.157	0.044	0.047	0.0004	0.0515	NO	0.0002	0.0016	IE	0.0118	0.0006	IE	0.0001	0.0001
2003	0.159	0.042	0.045	0.0004	0.0563	NO	0.0003	0.0018	IE	0.0122	0.0006	IE	0.0001	0.0002
2004	0.167	0.041	0.044	0.0004	0.0664	NO	0.0003	0.0019	IE	0.0116	0.0005	IE	0.0001	0.0002
2005	0.172	0.041	0.044	0.0004	0.0706	NO	0.0003	0.0022	IE	0.0120	0.0008	IE	0.0001	0.0002
2006	0.166	0.040	0.044	0.0005	0.0664	NO	0.0003	0.0021	IE	0.0118	0.0008	IE	0.0001	0.0002
2007	0.168	0.041	0.045	0.0004	0.0658	NO	0.0003	0.0021	IE	0.0122	0.0007	IE	0.0001	0.0001
2008	0.171	0.042	0.047	0.0004	0.0652	NO	0.0005	0.0022	IE	0.0139	0.0003	IE	0.0001	0.0001
2009	0.174	0.042	0.047	0.0004	0.0653	NO	0.0005	0.0022	IE	0.0152	0.0007	IE	0.0001	0.0001
2010	0.167	0.043	0.047	0.0004	0.0585	NO	0.0007	0.0022	IE	0.0138	0.0007	IE	0.0001	0.0001
2011	0.171	0.042	0.046	0.0004	0.0630	NO	0.0007	0.0021	IE	0.0160	0.0007	IE	0.0001	0.0001
2012	0.175	0.042	0.044	0.0004	0.0657	NO	0.0008	0.0022	IE	0.0180	0.0007	IE	0.0002	0.0001
2013	0.177	0.045	0.046	0.0004	0.0644	NO	0.0007	0.0021	IE	0.0182	0.0006	IE	0.0001	0.0002
2014	0.182	0.045	0.048	0.0004	0.0655	NO	0.0006	0.0020	IE	0.0190	0.0006	IE	0.0001	0.0001
2015	0.188	0.047	0.048	0.0004	0.0714	NO	0.0007	0.0020	IE	0.0181	0.0007	IE	0.0001	0.0001
2016	0.191	0.051	0.047	0.0004	0.0710	NO	0.0007	0.0018	IE	0.0181	0.0008	IE	0.0001	0.0001
2017	0.197	0.053	0.047	0.0004	0.0736	NO	0.0007	0.0020	IE	0.0193	0.0008	IE	0.0001	0.0001
2018	0.192	0.054	0.046	0.0004	0.0683	NO	0.0007	0.0021	IE	0.0193	0.0009	IE	0.0001	0.0001
2019	0.189	0.056	0.045	0.0004	0.0627	NO	0.0006	0.0022	IE	0.0210	0.0009	IE	0.0001	0.0001
2020	0.190	0.058	0.044	0.0004	0.0622	NO	0.0007	0.0021	IE	0.0221	0.0008	IE	0.0001	0.0001
2021	0.190	0.058	0.043	0.0004	0.0629	NO	0.0007	0.0020	IE	0.0210	0.0020	IE	0.0001	0.0001
2022	0.188	0.058	0.043	0.0004	0.0588	NO	0.0007	0.0021	IE	0.0229	0.0022	IE	0.0001	0.0001
Trend 1990-2022	12%	-5%	-11%	29%	29%	NO	2739%	140%	IE	108%	382%	IE	-75%	-71%
Trend 2005-2022	9%	42%	-4%	-2%	-17%	NO	114%	-4%	IE	91%	166%	IE	-49%	-60%
Trend 2021-2022	-1%	1%	-1%	3%	-6%	NO	1%	2%	IE	9%	6%	IE	-5%	-20%

Notes: a) Mules & asses are recorded together with horses, b) Turkey are recorded together with other poultry.

5.3.3 Methodological issues

5.3.3.1 Methodology

5.3.3.1.1 Ammonia emissions - Methodology issues

NH_3 emissions from Manure Management (E_{MMS_NH3}) were estimated using an Tier 2 mass-flow approach based on the concept of a flow of TAN through the manure management system, (Amon H. D., 2023) described in section 5.2.5 and schematically represented in Figure 57.

In the current category, ammonia emissions from livestock buildings and from the storage of manure were summed up and reported. The obtained emissions from the flow of TAN through the manure management system, expressed as kg NH_3-N per year per head/place for livestock category *i*, were summed, multiplied by the animal numbers and converted to kg NH_3 per year, following equation 46 of the 2023 guidelines (Amon H. D., 2023), namely:

$$E_{MMS\_NH_3(i)} = \left[\sum_i \left\{\left(E_{build\_slurry\_NH_3-N(i)} + E_{build\_solid\_NH_3-N(i)} + E_{storage\_slurry\_NH_3-N(i)} + E_{storage\_solid\_NH_3-N(i)}\right) * n_i\right\}\right] * \langle\frac{17}{14}\rangle$$

with i is the *i*th livestock category, pl=animal/animal place and:

$E_{build\_slurry\_NH3\text{-}N(i)}$	NH_3-N emissions from buildings with liquid manure system for livestock category *i* (in kg NH3-N pl^{-1} $year^{-1}$);
$E_{build\_solid\_NH3\text{-}N(i)}$	NH_3-N emissions from buildings with solid manure system for livestock category *i* (kg NH3-N pl^{-1} $year^{-1}$);
$E_{storage\_slurry\_NH3\text{-}N(i)}$	NH_3-N emissions from storage of liquid manure from livestock category *i* (kg NH3-N pl^{-1} $year^{-1}$);
$E_{storage\_silidy\_NH3\text{-}N(i)}$	NH_3-N emissions from storage of solid manure from livestock category *i* (kg NH3-N pl^{-1} $year^{-1}$);
n_i	number of animal places/animal (pl) for livestock category *i;*
17/14	the conversation factor according to the EMEP guidelines (Amon H. D., 2023).

Emissions from animal sub-categories were summed up to match NFR animal categories.

The NH_3-N emissions from buildings were calculated using the following formulas:

$$E_{build\_slurry\_NH3-N(i)} = m_{build\_slurry\_TAN(i)} * EF_{build\_slurry\_NH3-N(i)}$$
$$E_{build\_solid\_NH3-N(i)} = m_{build\_solid\_TAN(i)} * EF_{build\_solid\_NH3-N(i)}$$

with i is the *i*th livestock category, pl=animal/animal place and:

$EF_{build\_slurry\_NH3\text{-}N(i)}$	Emissions factors (EF) for NH_3-N emissions from livestock buildings with a liquid manure system (kg NH3-N kg^{-1}), and summarized in Table 5-30 for cattle, in Table 5-31 for swine and in Table 5-33 for all other categories.
$m_{build\_slurry\_N(i)}$	the amounts of total N deposited in buildings handled as liquid slurry (kg N pl^{-1} $year^{-1}$) and described in section 5.2.5, whereby, depending on livestock categories. Please note that for cattle and swine the amounts of N deposited in buildings handled as liquid was further split up according to housing systems, see section 5.2.3.3
$EF_{build\_solid\_NH3\text{-}N(i)}$	EFs for NH_3-N emissions from livestock buildings with a solid manure system (kg NH3-N kg^{-1}), and summarized in Table 5-30 for cattle, in Table 5-31 for swine and in Table 5-33 for all other categories.
$m_{build\_solid\_N(i)}$	the amounts of total N deposited in buildings handled as solid slurry (kg N pl^{-1} $year^{-1}$); and described in section 5.2.5. Please note that for cattle the amounts of N deposited in buildings with a solid manure was further split up according to housing systems, see section 5.2.3.3.

The NH_3-N emissions from storage were calculated using the following formulas:

$$E_{storage\_slurry\_NH_3-N(i)} = \left(mm_{storage\_slurry\_TAN(i)} * EF_{storage\_slurry\_NH_{3-N}(i)}\right)$$
$$E_{storage\_solid\_NH_3-N(i)} = \left(m_{storage\_solid\_TAN(i)} * EF_{storage\_solid\_NH_3-N(i)}\right)$$

with i is the *i*th livestock category, pl=animal/animal place and:

$EF_{storage\_slurry\_NH3-N(i)}$	Emissions factors (EF) for NH_3-N emissions from storage of liquid manure (kg NH3-N kg^{-1}), see Table 5-32.
$mm_{storage\_slurry\_TAN(i)}$	the modified amounts of total N stored before application to land (kg N pl^{-1} year^{-1}) and described in section 5.2.5. Please note that for slurry the amounts of N stored before application was further split up according to the storage system, see section 5.2.3.5.1.
$EF_{storage\_solid\_NH3-N(i)}$	EFs for NH_3-N emissions from storage of solid manure (kg NH3-N kg^{-1}), see Table 5-32 and Table 5-33.
$m_{storage\_solid\_TAN(i)}$	the amounts of total N stored before application to land (kg N pl^{-1} year^{-1}) and described in section 5.2.5.

5.3.3.1.2 Nitric oxide emissions - Methodology issues

Similarly to NH_3, NO_x emissions (expressed as NO_2) had been estimated using the Tier 2 mass-flow approach based on the concept of a flow of TAN through the manure management system (Amon H. D., 2023), see section 5.2.5. In the current category, only NO_x emissions from the storage of manure were considered. The sum of NO emissions from slurry and solid manure systems (expressed as kg NO-N per year per head/place for livestock category *i*) for livestock category *i*, were multiplied by the animal numbers, and converted to kg NO_2 per year by multiplication of the molar ration (NO_2/N =46/14), following equation 47 of the 2023 guidelines (Amon H. D., 2023), namely:

$$E_{MMS\_NO_x(i)} = \left[\sum_i \left\{\left(E_{storage\_slurry\_NO-N(i)} + E_{storage\_solid\_NO-N(i)}\right) * n_i\right\}\right] * \langle\frac{46}{14}\rangle$$

with i is the *i*th livestock category, pl=animal/animal place and:

$E_{storage\_slurry\_NO-N(i)}$	NO-N emissions from storage of liquid manure from livestock category *i* (in kg NO-N pl^{-1} year^{-1})*;*
$E_{storage\_silidy\_NO-N(i)}$	NO-N emissions from storage of solid manure from livestock category i (in kg NO-N pl^{-1} year^{-1})*;*
n_i	number of animals/animal places for livestock category *i;*
46/14	the conversation factor according to the EMEP guidelines (Amon H. D., 2023).

Emissions from animal sub-categories were summed up to match NFR animal categories.

The NO-N emissions from storage were calculated using the following formulas:

$$E_{storage\_slurry\_NO\ \ -N(i)} = \left(mm_{storage\_slurry\_TAN(i)} * \ EF_{storage\_slurry\_NO-N(i)}\right)$$
$$E_{storage\_solid\_NO\ \ -\ \ (i)} = \left(m_{storage\_solid\_TAN(i)} * \ EF_{storage\_solid\_NO\ \ -N(i)}\right)$$

with i is the *i*th livestock category, pl=animal/animal place and:

$EF_{storage\_slurry\_NO-N(i)}$	Emissions factors (EF) for NO-N emissions from storage of liquid manure/slurry (in kg NO-N kg^{-1}), see section 5.3.3.3.2.
$mm_{storage\_slurry\_TAN(i)}$	the modified amounts of total N stored before application to land (in kg N pl^{-1} year^{-1}) and described in section 5.2.5.
$EF_{storage\_solid\_NO-N(i)}$	EFs for NO-N emissions from storage of solid manure (in kg NO-N kg^{-1}), see section 5.3.3.3.2.
$m_{storage\_solid\_TAN(i)}$	the amounts of total N stored before application to land (in kg NO-N pl^{-1} year^{-1}) and described in section 5.2.5.

5.3.3.1.3 Non-methane volatile organic compounds emissions - Methodology issues

NMVOC emissions were estimated following the TIER 2 methodology from the EMEP guidelines (Amon H. D., 2023), and using two different methodologies, one for dairy cattle and other cattle, and another for all other remaining livestock categories.

NMVOC emissions ($E_{NMVOC(i)}$) arise from six different sources (Amon H. D., 2023), namely:

- silage stores ($E_{silage\_store\_NMVOC(i)}$);
- the feeding table if silage is used for feeding ($E_{silage\_feeding\_NMVOC(i)}$);
- livestock housing ($E_{build\_NMVOC(i)}$);
- outdoor manure stores ($E_{store\_NMVOC(i)}$);
- manure application ($E_{applic\_NMVOC(i)}$);
- and when grazing animals ($E_{grazing\_NMVOC(i)}$).

For dairy cattle and other cattle, NMVOC emissions ($E_{NMVOC(i)}$) were based on the estimated feed intake, whereby following equations 49-54 from the EMEP guidelines (Amon H. D., 2023), namely:

$$E_{silage\_store\_NMVOC(i)} = MJ_i * x_{build(i)} * \left(EF_{silage\_feeding\_NMVOC(i)} * Frac\_of\_max_{silage}\right) * Frac_{silage\_store(i)}$$

$$E_{silage\_feeding\_NMVOC(i)} = MJ_i * x_{build(i)} * \left(EF_{silage\_feeding\_NMVOC(i)} * Frac\_of\_max_{silage}\right)$$

$$E_{build\_NMOVC(i)} = MJ_i * x_{build(i)} * \left(EF_{build\_NMVOC(i)}\right)$$

$$E_{manure\_store\_NMOVC(i)} = E_{build\_NMOVC(i)} * \left(\frac{E_{storage\_\_NH3(i)}}{E_{build_{NH3}-N(i)}}\right)$$

$$E_{applic\_NMOVC(i)} = E_{build\_NMOVC(i)} * \left(\frac{E_{applic\_\_NH3(i)}}{E_{build\_NH\ \ (i)}}\right)$$

$$E_{grazing\_NMVOC(i)} = MJ_i * \left(1 - x_{build(i)}\right) * EF_{grazing\_NMVOC(i)}$$

with

$x_{build(i)}$	The proportion of time animals spend in the livestock building in a year (for details, see section 5.2.2.2)
$Frac\_of\_max_{silage}$	Being "0.5" for suckler cows, and "1", as silage feeding is dominant (Amon H. D., 2023) for all other cattle categories.
$Frac_{silage\_store}$	Using the default value of 0.25 for European conditions, according to the EMEP guidelines (Amon H. D., 2023).
$E_{build\_NH3(i)}$	= ($E_{build\_solid\_NH3-N(i)}$ + $E_{build\_slurry\_NH3-N(i)}$) in kg pl^{-1} year^{-1}; derived from the mass-flow of TAN through the manure management system (see section 5.2.5, setion 5.3.3.1.1 and section 5.3.3.3.1).
$E_{storage\_NH3(i)}$	= ($E_{storage\_solid\_NH3-N(i)}$ + $E_{storage\_slurry\_NH3-N(i)}$) in kg pl^{-1} year^{-1}; derived from the mass-flow of TAN through the manure management system (see section 5.2.5, section 5.3.3.1.1 and section 5.3.3.3.1).
$E_{applic\_NH3(i)}$	=($E_{applic\_solid\_NH3(i)}$ + $E_{applic\_slurry\_NH3(i)}$ + $E_{applic\_dig\_NH3(i)}$) in kg pl^{-1} year^{-1}; derived from the mass flow of TAN through the manure management system (see section 5.2.5, section 5.4.3.1.1 and section 5.4.3.3.1).
MJ_i	being the gross feed intake in megajoules (MJ) per animal place/animal per year, which were obtained by multiplying the estimated gross energy for livestock category *i* (GE_i) from the annual reporting of greenhouse gases by 365. The estimated daily GE_i values are described in detail in section 5.3 –Enteric Fermentation in national inventory report 2024 and are summarized in Table 5-28. Note, these values were corrected for the fact that over the summer months there was a temporary net export of grazing animals (see section 5.2.2.2).
i	is the *i*th livestock category.

Table 5-28 – Estimated gross energy (GE) per day for cattle and sheep categories for the years 1990-2022

3 - Agriculture

Activity data - Estimated gross energy (GE) in MJ per day per head

Year	Calves <1 year	Female young cattle 1-2 years	Heifers >2 years	Fattening bulls 1-2 years	Mature male cattle >2 years	Lactating dairy cows	Non-lactating dairy cows	Suckler cows
1990	66.8	136.4	125.6	185.5	201.2	272.0	203.7	249.0
1991	66.8	136.5	126.0	185.6	201.4	269.4	203.7	249.0
1992	66.8	136.4	125.8	185.6	201.7	289.3	203.7	249.0
1993	66.8	136.2	125.9	185.7	202.0	302.5	203.7	249.0
1994	66.8	136.2	125.2	185.8	202.2	287.3	203.7	249.0
1995	66.8	136.4	125.6	185.8	202.5	292.7	203.7	249.0
1996	66.8	136.4	125.9	185.9	202.7	288.8	203.7	249.0
1997	66.8	136.4	125.5	186.3	202.1	297.4	203.7	249.0
1998	66.8	136.2	125.5	186.1	202.8	299.0	203.7	249.0
1999	66.8	136.1	125.6	186.0	202.7	299.7	203.7	249.0
2000	66.8	136.1	125.5	186.0	203.3	305.6	203.7	249.0
2001	66.8	135.9	125.2	186.0	203.0	305.7	203.7	249.0
2002	66.8	136.2	125.7	186.0	204.0	308.6	203.7	249.0
2003	66.8	135.9	125.0	186.0	204.1	318.0	203.7	249.0
2004	66.8	135.6	124.5	185.9	205.0	306.0	203.7	249.0
2005	66.8	135.3	124.1	185.9	204.7	315.8	203.7	249.0
2006	66.8	136.1	124.9	186.1	205.5	316.0	203.7	249.0
2007	66.8	136.8	125.9	187.0	206.4	320.3	203.7	249.0
2008	66.8	136.4	124.6	187.0	206.5	317.9	203.7	249.0
2009	66.8	136.2	124.3	187.1	205.9	312.3	203.7	249.0
2010	66.8	136.6	124.8	187.3	206.6	309.4	203.7	249.0
2011	66.7	135.6	122.7	187.0	205.7	308.4	203.6	249.3
2012	66.6	135.0	121.0	187.0	206.6	316.8	203.5	249.5
2013	66.5	135.1	121.1	187.2	207.7	310.9	203.3	249.7
2014	66.4	136.3	125.1	187.3	207.0	315.4	203.2	250.0
2015	66.3	136.7	125.8	187.4	206.8	320.1	203.0	250.2
2016	66.2	136.3	124.9	187.2	207.2	332.7	202.9	250.5
2017	66.1	137.5	126.4	187.3	208.1	326.6	202.7	250.4
2018	66.0	137.0	126.2	187.2	207.2	341.6	202.4	250.3
2019	65.9	136.8	125.5	187.1	208.2	336.5	202.2	250.3
2020	65.8	137.0	125.5	187.1	208.0	357.1	202.0	250.2
2021	65.8	135.2	122.2	187.1	208.0	358.9	202.0	250.2
2022	65.8	138.1	126.9	187.1	208.0	355.5	202.0	250.2

Source: NIR Soubmission 2024

For livestock categories other than cattle, NMVOC emissions ($E_{NMVOC(i)}$) were based on the excreted volatile substances (VS), whereby following equations 55-60 from the EMEP guidelines (Amon H. D., 2023), namely:

$$E_{silage\_store\_NMVOC(i)} = VS_i * x_{build(i)} * \left(EF_{silage\_feeding\_NMVOC(i)} * Frac\_of\_max_{silage}\right) * Frac_{silage\_store(i)}$$

$$E_{silage\_feeding\_NMVOC(i)} = VS_i * x_{build(i)} * \left(EF_{silage\_feeding\_NMVOC(i)} * Frac\_of\_max_{sila}\right)$$

$$E_{build\_NMOVC(i)} = VS_i * x_{build(i)} * \left(EF_{build\_NMVOC(i)}\right)$$

$$E_{manure\_store\_NMOVC(i)} = E_{build\_NMOVC(i)} * \left(\frac{E_{storage\_NH\ (i)}}{E_{build_{NH3}-N(i)}}\right)$$

$$E_{applic\_NMOVC(i)} = E_{build\_NMOVC(i)} * \left(\frac{E_{applic\_NH\ (i)}}{E_{build\_NH3(i)}}\right)$$

$$E_{grazing\_NMVOC(i)} = VS_i * \left(1 - x_{build(i)}\right) * EF_{grazing\_NMVOC(i)}$$

with

$x_{build(i)}$ The proportion of time animals spend in the livestock building in a year (for details, see section 5.2.2.2)

$Frac\_of\_max_{silage}$ For all livestock categories defined as zero, as silage is not used as feed.

$Frac_{silage\_store}$ Being zero, as no silage is used as feed.

$E_{build\_NH3(i)}$ derived from the mass flow (see section 5.2.5); = ($E_{build\_solid\_NH3\text{-}N(i)} + E_{build\_slurry\_NH3\text{-}N(i)}$)

$E_{storage\_NH3(i)}$ derived from the mass flow (see section 5.2.5); = ($E_{storage\_solid\_NH3\text{-}N(i)} + E_{storage\_slurry\_NH3\text{-}N(i)}$)

$E_{applic\_NH3(i)}$ derived from the mass flow (see section 5.2.5); = ($E_{applic\_solid\_NH3(i)} + E_{applic\_slurry\_NH3(i)}$)

VS_i where kg VS_i is the excreted VS in kg per year for livestock category *I*, see Table 5-29. The annual VS_i for swine, small ruminants, horses and poultry were estimated according to equation 10.22a of the 2019 Refinement of the 2006 IPCC guidelines (Gavrilova, et al., 2019), for details see National Inventory Report 2024, and are summarized in Table 5-29; and for rabbits and ostrichs VS_i per day per head, as reported in Table 10.15 of the 2019 Refinement of the 2006 IPCC guidelines (Gavrilova, et al., 2019), multiplied by 365 were used.

i is the *i*th livestock category.

Table 5-29 – Annual excreted volatile substances (VS) for livestock category *i*

3 - Agriculture													
Activity data - Annual excreted volatile substances (VS) for livestock category *i* (in kg per year)													
Year	Sows	Fattening pigs	Weaners	Mature sheep	Sheep lamb	Mature goats	Goat kits	Horses	Broilers	Laying hens	Other poultry	Ostriches	Rabbits
1990	241	145	39	224	78	107	58	1128	5	4	20	423	37
1991	241	145	39	224	78	107	58	1121	5	4	20	423	37
1992	241	145	39	224	78	107	58	1100	5	4	20	423	37
1993	241	145	39	224	78	107	58	1108	5	4	20	423	37
1994	241	145	39	224	78	107	58	1099	5	4	20	423	37
1995	241	145	39	224	78	107	58	1097	5	4	20	423	37
1996	241	145	39	224	78	107	58	1096	5	4	20	423	37
1997	241	145	39	224	78	107	58	1097	5	4	20	423	37
1998	241	145	39	224	78	107	58	1091	5	4	20	423	37
1999	241	145	39	224	78	107	58	1075	5	4	20	423	37
2000	241	145	39	224	78	107	58	1079	5	4	20	423	37
2001	241	145	39	224	78	107	58	1070	5	4	20	423	37
2002	241	145	39	224	78	142	60	1069	5	4	20	423	37
2003	241	145	39	224	78	147	60	1064	5	4	20	423	37
2004	241	145	39	224	78	152	60	1071	5	4	20	423	37
2005	241	145	39	224	78	153	60	1066	5	4	20	423	37
2006	241	145	39	224	78	152	60	1095	5	4	20	423	37
2007	241	145	39	224	78	146	60	1084	5	4	20	423	37
2008	241	145	39	224	78	152	60	1080	5	4	20	423	37
2009	241	145	39	224	78	159	60	1083	5	4	20	423	37
2010	241	145	39	224	78	158	60	1061	5	4	20	423	37
2011	241	145	39	224	78	162	60	1065	5	4	20	423	37
2012	241	145	39	224	78	160	61	1061	5	4	20	423	37
2013	241	145	39	224	78	161	60	1054	5	4	20	423	37
2014	241	145	39	224	78	158	60	1054	5	4	20	423	37
2015	241	145	39	224	78	158	60	1050	5	4	20	423	37
2016	241	145	39	224	78	160	60	1050	5	4	20	423	37
2017	241	145	39	224	78	159	60	1053	5	4	20	423	37
2018	241	145	39	224	78	159	60	1043	5	4	20	423	37
2019	241	145	39	224	78	155	60	1050	5	4	20	423	37
2020	241	145	39	224	78	156	60	1043	5	4	20	423	37
2021	241	145	39	224	78	157	60	1031	5	4	20	423	37
2022	241	145	39	224	78	154	60	1033	5	4	20	423	37

The NMVOC emission associated with silage stores, the feeding table if silage is used for feeding, livestock housing and outdoor manure stores were reported in 3B, using the following formula

$$E_{NMVOC(i)} = \sum_i \left(E_{silage\_store\_NMVOC(i)} + E_{silage\_feeding\_NMVOC(i)} + E_{build\_NMOVC(i)} + E_{store\_NMVOC(i)}\right) * n_i$$

NMVOC emission associated with the manure application were reported in 3Da2a, using the following formula:

$$E_{NMVOC(i)} = \sum_i \left(E_{applic\_NMVOC(i)}\right) * n_i$$

and NMVOC emission associated with the dung and urine deposited by grazing animals were reported in 3Da3, using the following formula:

$$E_{NMVOC(i)} = \sum_i \left(E_{grazing\_NMVOC(i)}\right) * n_i$$

with

$n_{(i)}$ number of head/animal places of livestock category *i,*

i is the *i*th livestock category.

Emissions from animal sub-categories were summed up to match NFR animal categories.

5.3.3.1.4 Particles emissions - Methodology issues

A Tier 1 technology-specific approach was taken to estimate TSP, PM_{10} and $PM_{2.5}$ emissions from manure management (Amon H. D., 2023).

However, there is a lack of available emissions measurements for free-range livestock (Amon H. D., 2023), why only EFs for housed livestock are listed in the guidelines. However, as particular matter emissions from free-range poultry are expected to be in the same magnitude than housed poultry, the good practice advice from the guidelines were followed (Amon H. D., 2023), and the housed livestock EFs for estimating emissions were used for both housed and free-range poultry. Whereas for all other livestock categories, no emissions were estimated for free-range livestock.

Default emissions factors for the different livestock categories were used and multiplied by the number of animals, namely:

$$E_{PM(p)} = \left\{\sum_i \left[\left(EF_{PM(p,i)}\right) * x_{build(i)} * n_i\right]\right\}$$

with i is the *i*th livestock category and:

$E_{PM\,(p)}$ Emissions in kg/year for particle emissions *p*, with *p* being TSP, PM_{10} and $PM_{2.5}$, respectively;

$EF_{PM\,(p,i)}$ Default emission factor for particle emissions *p* for livestock category *i*, with *p* being TSP, PM_{10} and $PM_{2.5}$, respectively in kg *p* pl^{-1} $year^{-1}$;

$x_{build(i)}$ The proportion of time that animals spend inside livestock building in a year (for details, see section 5.2.2.2), except for poultry where $x_{buiild(i)}$ is defined to be 1 and the housed livestock EFs used for estimating emissions' from both housed and free-range poultry.

n_i number of animals (or places) for livestock category *i*

Emissions from animal sub-categories were summed up to match NFR animal categories.

5.3.3.2 Activity data

Livestock activity data used for the emission calculations had been extracted from national statistics/databases and are summarized in Table 5-4. For a detailed description of the different livestock categories and on livestock numbers see section 5.2.1 and section 5.2.2.

5.3.3.3 Emission factors

5.3.3.3.1 Ammonia emissions

By using the Tier 2 mass-flow approach based on the concept of a flow of TAN through the manure management system (Amon H. D., 2023) to estimate manure management NH_3 related emissions (see section 5.2.5), NH_3-N emission factors from manure had to be used for all animal categories. The used EFs for housing systems are presented in Table 5-30, in Table 5-31 and in Table 5-33 for cattle, swine and other livestock categories, respectively. EFs for cattle and swine, the two major animal categories, were based on the German inventory, due to similar climate and feeding conditions. (Vos, et al., Submission 2022) The EFs for all other livestock categories were based on Table 3.9 from the EMEP guidelines (Amon H. D., 2023). The used EFs for storage systems are presented in Table 5-32 for cattle and swine and in Table 5-33 for all other livestock categories. The EFs for storage were based on Table 3.9 from the EMEP guidelines (Amon H. D., 2023), except for the storage of slurry and cattle solid manure, where the EFs were based on the German inventory, due to similar climate and feeding conditions. (Vos, et al., Submission 2022) For cattle slurry stored in open tanks it was assumed that 50% would have a natural crust and 50% would have no natural crust. Whereas swine slurry stored in open tanks would have no natural crust.

Table 5-30– Used NH_3-N emissions factors (EF) for emissions for housing systems for cattle category *i*

	EF for buildings with slurry				EF for buildings with solid MS			
	Tied systems	Cubicle loose housing	Fully slatted floor	Others	Tied systems	Deep bedding	Sloped floor	Others
Non-dairy cattle (including calves, young female cattle, heifers, fattening bulls, mature male cattle and suckler cows)	0.066	0.197	0.197	0.197	0.066	0.197	0.213	0.197
Lactating dairy cows	0.066	0.197	0.197	0.197	0.066	0.197	0.213	0.197

Note: EFs were based on German inventory, due to similar climat and feeding conditions (Vos, et al., Submission 2022).

Table 5-31– Used NH_3-N emissions factors (EF) for emissions for housing systems for swine category *i*

	EF for buildings with slurry			EF for buildings with solid MS
	Fully slatted floor	Partly slatted floor	Non-slatted floor	Deep bedding
Sows	0.34	0.34	0.34	0.34
Fattening pigs / weaners	0.3	0.3	0.3	0.40

Note: EFs were based on German inventory, due to similar climat and feeding conditions (Vos, et al., Submission 2022).

Table 5-32– Used NH_3-N emissions factors (EF) for emissions from manure management for livestock category *i*

Livestock category	EF for storage of slurry [a]					EF for storage of solid manure
	Open tank	Open tank with natural crust	Floating cover	Covered tanks	Underneath slatted floor	
Non-dairy cattle (including calves, young female cattle, heifers, fattening bulls, mature male cattle and suckler cows)	0.15	0.045	0.023	0.015	0.045	0.6 [a]
Lactating dairy cows	0.15	0.045	0.023	0.015	0.045	0.6 [a]
Sows	0.15	N.A.	0.023	0.015	0.105	0.29 [b]
Fattening pigs / weaners	0.15	N.A.	0.023	0.015	0.105	0.29 [b]

Note:
a) EFs were based on German inventory, due to similar climat and feeding conditions (Vos, et al., Submission 2022).
b) EMEP guidelines default values as presented in Table 3.9 (Amon H. D., 2023)

Table 5-33– Used NH_3-N emissions factors (EF) for emissions from manure management for livestock category *i*

Livestock category	EF for buildings with solid MS [a]	EF for storage of solid manure [a]
Sheep (mature sheep and lambs)	0.22	0.32
Goats (mature goats and kids)	0.22	0.28
Horses (including assess and mules)	0.22	0.35
Broilers	0.21	0.30
Laying hens	0.20	0.08
Other poultry [b]	0.35	0.24
Ostriches [c]	0.57	0.16
Rabbits (breeding female animals and other rabbits) [d]	0.22	0.35
Deer [e]	0.22	0.32

Note:
a) EMEP guidelines default values as presented in Table 3.9 (Amon H. D., 2023)
b) As more than 50% were turkeys, the default value for Turkeys was used (Table 3.9; (Amon H. D., 2023));
c) Default value for geese (Table 3.9; (Amon H. D., 2023);
d) Default value for horses (Table 3.9; (Amon H. D., 2023); similar as (Haenel et al. 2018);
e) Default value for sheep and goat (Table 3.9; (Amon H. D., 2023)).

5.3.3.3.2 Nitric oxide emissions

The Tier 2 mass-flow approach based on the concept of a flow of TAN through the manure management system (Amon H. D., 2023) was used to estimate manure management NO_x related emissions for all animal categories.

For the storage of manure it was assumed that the EFs for storage for NO-N emissions from manure management is one tenth of the EFs for storage for N_2O-N emissions from manure management, similar as (Vos, et al., Submission 2022).

5.3.3.3.3 Non-methane volatile organic compounds emissions

NMVOC emissions were estimated using a Tier 2 methodology, whereby using the default emissions factors from the EMEP guidelines (Amon H. D., 2023) and provided in Table 3.11 for dairy cattle and non-dairy cattle, and in Table 3.12 for all other livestock categories than cattle. EFs are summarized in Table 5-34.

Note NMVOC emission associated with the manure application were reported in 3Da2a, and NMVOC emission associated with the dung and urine deposited by grazing animals were reported in 3Da3.

Table 5-34– NMVOC emission factors (EF) for silage feeding, building and grazing

Animal category	EF for silage feeding	EF for building	EF for grazing
Non-dairy cattle (including calves, young female cattle, heifers, fattening bulls, mature male cattle and suckler cows) [a]	0.0002002	0.0000353	0.0000069
Lactating dairy cows [a]	0.0002002	0.0000353	0.0000069
Sows [b]	NO	0.007042	NO
Fattening pigs and weaners [b]	NO	0.001703	NO
Sheep (mature sheep and lambs) [b]	NO	0.001614	0.00002349
Goats (mature goats and kids) [b]	NO	0.001614	0.00002349
Horses (including assess and mules) [b]	NO	0.001614	0.00002349
Broilers [b]	NO	0.009147	NO
Laying hens [b]	NO	0.005684	NO
Other poultry [c]	NO	0.005684	NO
Ostriches [d]	NO	0.005684	NO
Rabbits (breeding female animals and other rabbits) [b]	NO	0.001614	NO
Deer [e]	NO	0.001614	0.00002349

Note :
a) Based on Table 3.11 in the EMEP guidelines (Amon H. D., 2023)
b) Based on Table 3.12 in the EMEP guidelines (Amon H. D., 2023).
c) Default values for turkeys and other poultry (Table 3.12; (Amon H. D., 2023));
d) Using as proxy the default value for geese as there was no value for ostriches (Table 3.12; (Amon H. D., 2023));
e) Using as proxy the default value for sheep and goats (Table 3.12; (Amon H. D., 2023));

5.3.3.3.4 Particles emissions

For $PM_{2.5}$, PM_{10} and TSP the default Tier 1 emission factors from the EMEP guidelines (Amon H. D., 2023) were used and are summarized in Table 5-35.

Table 5-35– Particles emission factors (EF) used for the emissions from manure management [a]

Animal category	EF for TSP	EF for PM_{10}	EF for $PM_{2.5}$
Calves	0.34	0.16	0.10
Non-dairy cattle (including young female cattle, heifers, fattening bulls, mature male cattle and suckler cows)	0.59	0.27	0.18
Lactating dairy cows	1.38	0.63	0.41
Sows	0.62	0.17	0.01
Fattening pigs	1.05	0.14	0.006
Weaners	0.27	0.05	0.002
Sheep (mature sheep and lambs)	0.14	0.06	0.02
Goats (mature goats and kids)	0.14	0.06	0.02

Animal category	EF for TSP	EF for PM_{10}	EF for $PM_{2.5}$
Horses (including assess and mules)	0.48	0.22	0.14
Broilers	0.04	0.02	0.002
Laying hens	0.19	0.04	0.003
Other poultry[b]	0.11	0.11	0.02
Ostriches[c]	0.24	0.24	0.03
Rabbits (breeding female animals and other rabbits) [d]	0.018	0.008	0.004
Deer [e]	0.14	0.06	0.02

Note :
a) Based on Table 3.5 in the EMEP guidelines (Amon H. D., 2023).
b) As more than 50% are turkeys, the default value for turkeys were used (Table 3.5; (Amon H. D., 2023));
c) Using as proxy the default value for geese (Table 3.5; (Amon H. D., 2023));
d) Using as proxy the default value for fur animals (Table 3.5; (Amon H. D., 2023));
e) Using as proxy the default value for sheep and goats (Table 3.5 (Amon H. D., 2023)).

5.3.4 Category specific uncertainties

A description of the uncertainties for the activity data is provided in the national inventory report 2024 (section 5.2.7). The uncertainty w.r.t. the proportion of TAN was modelled by multiplying the proportion with an uncertainty factor to be most likely 100%, minimum 90% and maximum 110%, assuming a pert-distribution.

Uncertainties are required for the NH_3 EF for housing and for the NH_3 EF for storage for the different livestock categories. In the German inventory was uncertainty considered for “manure management” as a whole (i.e. housing plus storage) to be 36%. In a conservative way it is assumed for all livestock categories, that the uncertainty for the NH_3 EF for housing would be +-10% and the NH_3 EF for storage would be +- 10%, all modelled by multiplying the EF with an uncertainty factor to be most likely 100%, minimum 90% and maximum 110%, assuming a pert-distribution. The uncertainty for the NO_x EF for manure management is according to the EMEP guidelines -50% and +100% (Amon H. D., 2023), the EF for storage for NO-N emissions from manure management was assumed to be most likely one tenth of the EFs for storage for N_2O-N emissions (i.e. 0.1), minimum 0.05 and maximum 0.2, assuming a pert-distribution. The uncertainties for manure management related N_2O EF parameters were described in the national inventory report 2024 (section 5.4.4)

The EMEP guidelines highlight the large uncertainty for NMVOC and PM (Amon H. D., 2023), but without further quantification. As the uncertainty for NO_x was also considered to be large, a similar uncertainty factor was used for NMVOC and PM, and were the uncertainties modelled by multiypling the default values with an uncertainty factor to be most likely 100%, minimum 50% and maximum 200%, assuming a pert-distribution. This was applied for the NMVOC EFs summarized in Table 5-34, and the PM EFs summarized in Table 5-35.

5.3.5 Category specific QA/QC procedures

Consistency and completeness checks have been performed directly in the model.

5.3.6 Category-specific recalculations including changes made in response to the review process

Revision of livestock numbers and MMS since submission 2023v1 are described in Table . Additional revisions and relevant for 3B are described in Table 5-36.

Table 5-36– Recalculations done since the last submission for category – *3B – Manure management*

	Revisions 2023 ➔ 2024	Type of revision
3B	Revised Frac_of silage for suckler cows; revised Frac_of silage for horses and small rumiants. Revising VS_i for all livestock other than cattle following the 2019 Refinement of the 2006 IPCC guidelines (see NIR 2024)	EF / NMVOC emissions
3B	LU-3B-2023-001 - Error correction of the EF for PM for the livestock category “other poultry”. For all three PM2.5, PM10 and TSP, the used EF for other poultry was the one for ducks rather than for turkey. This error was corrected in the current submission	EF

The recalculations of the emissions in 3B due to the above updates in AD and EFs are detailed in Table 5-37. They were rather marginal, except for NMVOC where the revisions had resulted on average in a decrease of the NMVOC emissions by 5%.

Table 5-37– Recalculations for category *3B – Manure management* from submission 2023 to submission 2024

3 - Agriculture 3 B - Manure management Emissions of air pollutants (Gg)																		
	Submission 2024						Submission 2023						Difference					
Year	NH3	NOx	NMVOC	PM2.5	PM10	TSP	NH3	NOx	NMVOC	PM2.5	PM10	TSP	NH3	NOx	NMVOC	PM2.5	PM10	TSP
1990	2.9	0.020	2.6	0.034	0.061	0.168	2.9	0.020	2.6	0.034	0.061	0.168	0	0.0	-2.8	0.0	-0.1	0.0
1991	2.9	0.020	2.5	0.033	0.059	0.159	2.9	0.020	2.6	0.033	0.059	0.159	0	0.0	-3.2	0.0	-0.1	0.0
1992	2.8	0.019	2.5	0.031	0.056	0.154	2.8	0.019	2.5	0.031	0.056	0.155	0	0.0	-3.0	0.0	-0.1	0.0
1993	2.8	0.018	2.5	0.031	0.056	0.158	2.8	0.018	2.6	0.031	0.056	0.158	0	0.0	-3.2	0.0	-0.1	0.0
1994	2.8	0.018	2.4	0.031	0.055	0.153	2.8	0.018	2.5	0.031	0.055	0.153	0	0.0	-4.4	0.0	-0.1	0.0
1995	2.9	0.019	2.5	0.031	0.056	0.157	2.9	0.019	2.6	0.031	0.056	0.157	0	0.0	-4.5	0.0	-0.1	0.0
1996	2.9	0.019	2.5	0.031	0.057	0.157	2.9	0.019	2.6	0.031	0.057	0.157	0	0.0	-4.7	0.0	-0.1	0.0
1997	2.9	0.019	2.5	0.031	0.056	0.159	2.9	0.019	2.6	0.031	0.056	0.159	0	0.0	-4.4	0.0	-0.1	0.0
1998	2.8	0.018	2.5	0.030	0.056	0.159	2.8	0.018	2.6	0.030	0.056	0.159	0	0.0	-4.3	0.0	-0.1	0.0
1999	2.8	0.018	2.4	0.030	0.056	0.161	2.8	0.018	2.6	0.030	0.056	0.161	0	0.0	-4.8	0.0	-0.1	0.0
2000	2.7	0.017	2.4	0.030	0.055	0.159	2.7	0.017	2.5	0.030	0.055	0.159	0	0.0	-5.2	0.0	0.0	0.0
2001	2.8	0.017	2.4	0.030	0.055	0.160	2.8	0.017	2.5	0.030	0.055	0.160	0	0.0	-5.3	0.0	-0.1	0.0
2002	2.7	0.016	2.3	0.028	0.053	0.157	2.7	0.016	2.4	0.028	0.053	0.157	0	0.0	-5.5	0.0	-0.1	0.0
2003	2.6	0.016	2.2	0.027	0.053	0.159	2.6	0.016	2.4	0.027	0.053	0.159	0	0.0	-5.0	0.0	-0.1	0.0
2004	2.7	0.016	2.2	0.027	0.053	0.167	2.7	0.016	2.3	0.027	0.053	0.167	0	0.0	-6.0	0.0	-0.1	0.0
2005	2.6	0.016	2.2	0.027	0.054	0.172	2.6	0.016	2.3	0.027	0.054	0.172	0.01	0.000	-5.7	0.0	-0.1	0.0
2006	2.6	0.016	2.1	0.027	0.053	0.166	2.6	0.016	2.3	0.027	0.053	0.166	0.01	0.000	-6.1	0.0	-0.1	0.0
2007	2.6	0.016	2.2	0.027	0.053	0.168	2.6	0.016	2.3	0.027	0.053	0.168	0.01	0.000	-5.8	0.0	0.0	0.0
2008	2.8	0.016	2.3	0.028	0.055	0.171	2.8	0.016	2.4	0.028	0.055	0.171	0.01	0.000	-6.4	0.0	0.0	0.0
2009	2.7	0.016	2.3	0.028	0.055	0.174	2.7	0.016	2.4	0.028	0.055	0.174	0.01	0.000	-6.9	0.0	0.0	0.0
2010	2.7	0.016	2.3	0.029	0.055	0.167	2.7	0.016	2.5	0.029	0.055	0.167	0.02	0.000	-7.1	0.0	0.0	0.0
2011	2.7	0.015	2.2	0.028	0.055	0.171	2.7	0.015	2.4	0.028	0.055	0.171	0.02	0.000	-7.2	0.0	0.0	0.0
2012	2.6	0.015	2.2	0.028	0.055	0.175	2.6	0.015	2.4	0.028	0.055	0.175	0.02	0.000	-6.8	0.0	-0.1	0.0
2013	2.6	0.015	2.3	0.029	0.057	0.177	2.6	0.015	2.4	0.029	0.057	0.177	0.01	0.000	-6.3	0.0	0.0	0.0
2014	2.7	0.016	2.4	0.029	0.058	0.182	2.7	0.016	2.5	0.029	0.058	0.182	0.01	0.000	-5.9	0.0	-0.1	0.0
2015	2.8	0.016	2.4	0.030	0.060	0.188	2.8	0.016	2.6	0.030	0.060	0.189	0.01	0.000	-5.6	0.0	0.0	0.0
2016	2.8	0.016	2.5	0.031	0.061	0.191	2.8	0.016	2.7	0.031	0.061	0.191	0.02	0.000	-5.1	0.0	0.0	0.0
2017	2.9	0.017	2.6	0.031	0.062	0.197	2.9	0.017	2.7	0.031	0.062	0.197	0.02	0.000	-5.1	0.0	-0.1	0.0
2018	2.8	0.016	2.6	0.031	0.062	0.192	2.8	0.016	2.8	0.031	0.062	0.192	0.02	0.000	-4.8	0.0	0.0	0.0
2019	2.8	0.016	2.6	0.032	0.062	0.189	2.8	0.016	2.7	0.032	0.062	0.189	0.02	0.000	-4.8	0.0	0.0	0.0
2020	2.8	0.016	2.7	0.032	0.062	0.190	2.8	0.016	2.9	0.032	0.062	0.191	0.02	0.000	-4.5	0.0	0.0	0.0
2021	2.8	0.016	2.7	0.032	0.062	0.190	2.8	0.016	2.8	0.032	0.063	0.192	-0.03	-0.01	-4.3	-0.1	-0.5	-0.8
2022	2.7	0.016	2.7	0.032	0.062	0.188												

5.3.7 Category-specific planned improvements including those made in response to the review process

No further improvement planned.

5.4 Crop production and agricultural soils (category NRF 3.D)

The NFR sector *3.D Agricultural soils* include emissions of ammonia (NH_3), nitric oxide (NO_x), NMVOC and particulate matter (TSP, $PM_{2.5}$ and PM_{10}), as well as HCB emissions from the usage of pesticides.

In 2022, this source category was responsible for:

- 52% of agricultural ammonia emissions originating from the agriculture sector;
- 98% of the agricultural NOx emissions originating from the agriculture sector;
- 22% of the NMVOC emissions originating from the agriculture sector;
- 19% of $PM_{2.5}$ emissions originating from the agriculture sector;
- 76% of PM_{10} emissions originating from the agriculture sector;
- 51% of TSP emissions originating from the agriculture sector;
- and 0.3 g HCB emissions from the usage of pesticides.

5.4.1 Key categories

In 2022, category *3Da2a – Animal manure applied to soils* is a key categories (LA & TA) for NMVOC. Categories *3Da1 – Inorganic N-fertilizers*, *3Da2a – Animal manure applied to soils, 3Da2b – Sewage sludge applied to souls, 3Da2c – Other organic fertilisers applied to soils* and *3Da3 – Urine and dung deposited by grazing animals* are key for NH_3 emissions, whereas category *3Dc – Farm level agricultural operations* is a key category TSP and PM_{10} (Table 5-38).

Table 5-38 – Key categories for category *3D – Crop production and agricultural soils*.

Key Source Analysis (FUEL SOLD): Ranking per number		SO2		NOX		NMVOC		NH3		CO		TSP		PM10		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
3 D a 1	Inorganic N-fertilizers (includes also urea application)								1								
3 D a 2 a	Animal manure applied to soils					6	7	1	4								
3 D a 2 b	Sewage sludge applied to soils								6								
3 D a 2 c	Other organic fertilisers applied to soils (including compost)								3								
3 D a 3	Urine and dung deposited by grazing animals							4	7								
3 D c	Farm-level agricultural operations including storage, handling and transport of agricultural products											5	6	3	4		

Key Source Analysis (FUEL USED): Ranking per number		SO2		NOX		NMVOC		NH3		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
3 B 4 e	Manure management - Horses								6		
3 D a 1	Inorganic N-fertilizers (includes also urea application)								1		
3 D a 2 a	Animal manure applied to soils					6		1			
3 D a 2 b	Sewage sludge applied to soils								5		
3 D a 2 c	Other organic fertilisers applied to soils (including compost)								2		
3 D a 3	Urine and dung deposited by grazing animals							4	7		

Sources: Environment Agency

Notes: LA = Level Assessment, TA = Trend Assessment

Number in Table = indicates the rank in the specific analysis (1…biggest KC; 2… second biggest KC, …)

5.4.2 Source category description

An overview of shares and trends of NH_3, NO_x, NMVOC and particular matter originated from sector 3D – Crop production and agricultural soils is presented in Table 5-39.

Table 5-39 – Emissions (Gg) of main pollutants and particles from for category of *3D - Crop production and agricultural soils*

3 - Agriculture sector						
	Main pollutants (in Gg)			Particular matter (in Gg)		
	3D- Crop production and agricultural soils					
Year	**NH_3**	**NO_x**	**NMVOC**	**$PM_{2.5}$**	**PM_{10}**	**TSP**
1990	3.49	1.35	0.108	0.0075	0.196	0.196
1991	3.52	1.39	0.107	0.0075	0.195	0.195
1992	3.44	1.42	0.108	0.0075	0.195	0.195
1993	3.39	1.36	0.109	0.0076	0.198	0.198
1994	3.33	1.31	0.109	0.0076	0.197	0.197
1995	3.39	1.32	0.109	0.0076	0.197	0.197
1996	3.42	1.33	0.108	0.0076	0.197	0.197
1997	3.35	1.31	0.109	0.0076	0.197	0.197
1998	3.37	1.29	0.109	0.0076	0.198	0.198
1999	3.39	1.32	0.109	0.0076	0.198	0.198
2000	3.34	1.29	0.110	0.0077	0.199	0.199
2001	3.20	1.19	0.110	0.0077	0.199	0.199
2002	3.13	1.20	0.110	0.0077	0.200	0.200
2003	2.97	1.07	0.110	0.0077	0.200	0.200
2004	3.13	1.22	0.110	0.0077	0.200	0.200
2005	3.16	1.13	0.111	0.0078	0.202	0.202
2006	3.14	1.13	0.112	0.0078	0.203	0.203
2007	3.17	1.11	0.112	0.0078	0.203	0.203
2008	3.24	1.13	0.112	0.0078	0.203	0.203
2009	3.20	1.13	0.111	0.0077	0.200	0.200
2010	3.34	1.15	0.111	0.0078	0.202	0.202
2011	3.33	1.16	0.111	0.0077	0.201	0.201
2012	3.21	1.12	0.111	0.0078	0.202	0.202
2013	3.21	1.12	0.111	0.0077	0.201	0.201
2014	3.25	1.12	0.111	0.0077	0.201	0.201
2015	3.25	1.12	0.110	0.0077	0.200	0.200
2016	3.33	1.16	0.110	0.0077	0.200	0.200
2017	3.40	1.17	0.110	0.0077	0.199	0.199
2018	3.41	1.14	0.109	0.0076	0.198	0.198
2019	3.31	1.14	0.109	0.0076	0.197	0.197
2020	3.29	1.11	0.109	0.0076	0.198	0.198
2021	3.26	1.13	0.109	0.0076	0.198	0.198
2022	2.98	0.90	0.109	0.0076	0.197	0.197
Trend 1990 -2022	-15%	-33%	1%	1%	1%	1%
Trend 2005 -2022	-6%	-20%	-2%	-2%	-2%	-2%
Trend 2021 -2022	-9%	-20%	0%	0%	0%	0%

.

5.4.2.1 NH_3 emissions

As Table 5-39 and Table 5-40 show, NH3-emissions from soil decreased since 1990 by 15%. Within each of the agricultural soil categories, the main emitting activities were animal manure, in 2022 this category was responsible for 68%, N deposited by urine and manure by grazing animals was responsible for 16%, and N inputs from category *3Da1 - synthetic fertilizers application* were responsible for 11%.

5.4.2.2 NO_x

Agricultural soil NO_x emissions declined by 33% over the time series, see Table 5-39 and Table 5-41. Within each of the agricultural soil categories, the main emitting activities of the NO_x emissions emitting from soil in 2022 were: animal manure (37%), N input from synthetic fertilizers application (34%), and grazing (19%). Crop residues are responsible for 7% of the NO_x emissions from agricultural soil (Table 5-41).

5.4.2.3 NMVOC

NMVOC emissions related to agricultural soils decreased since 1990 by 23%, see Table 5-39 and Table 5-42. Livestock manure applied to soils was with 83% the main emitting activities of the NMVOC emissions emitting from soil in 2022 (Table 5-42).

5.4.2.4 Particle emissions

Particle emissions reported under source category 3D is a result from certain steps of farm work such as soil cultivation and harvesting (field operations) and are linked with the usage of machines on agricultural soils. They are considered in relationship with the treated areas and are dependent on climatic conditions. $PM_{2.5}$ and PM_{10} emissions rose by 1%, see Table 5-39. A similar increase was observed for TSP (total suspended particles). All three emissions were estimated using a Tier 1 methodology.

5.4.2.5 HCB emissions

Hexachlorobenzene (HCB) is one of the listed persistent organic pollutants. The application of HCB as a pesticide, in a pure form, had been probhibited since the early 1990's but can be present as an impurity or as a by-product in certain pesticides (Webb, Hutchings, & Amon, 2023). HCB emissions from the use of pesticides decreased since 1990 by > 99%, see Table 5-43.

Table 5-40 – NH_3 Emission trends for category *3D – Crop production and agricultural soils* (Gg): 1990-2022

3 - Agriculture sector

NH_3 emissions (in Gg)

Year	3D- Crop production and agricultural soils						
	Total	Inorganic N-fertilizer	Animal manure	Sewage sludge	Other organic	Grazing	Crop residue
1990	3.49	0.67	2.23	0.048	NO	0.54	NE
1991	3.52	0.70	2.22	0.048	NO	0.55	NE
1992	3.44	0.75	2.11	0.049	NO	0.53	NE
1993	3.39	0.69	2.12	0.051	NO	0.54	NE
1994	3.33	0.65	2.09	0.053	NO	0.54	NE
1995	3.39	0.64	2.14	0.053	NO	0.55	NE
1996	3.42	0.64	2.17	0.046	NO	0.56	NE
1997	3.35	0.63	2.12	0.048	NO	0.55	NE
1998	3.37	0.62	2.15	0.048	NO	0.54	NE
1999	3.39	0.64	2.15	0.048	NO	0.55	NE
2000	3.34	0.63	2.12	0.025	0.010	0.55	NE
2001	3.20	0.54	2.09	0.024	0.007	0.54	NE
2002	3.13	0.56	2.01	0.025	0.011	0.53	NE
2003	2.97	0.46	1.96	0.019	0.013	0.52	NE
2004	3.13	0.58	1.98	0.016	0.027	0.52	NE
2005	3.16	0.58	1.99	0.021	0.046	0.52	NE
2006	3.14	0.57	1.96	0.018	0.066	0.52	NE
2007	3.17	0.53	2.00	0.022	0.077	0.55	NE
2008	3.24	0.54	2.04	0.020	0.086	0.56	NE
2009	3.20	0.53	1.99	0.013	0.113	0.56	NE
2010	3.34	0.57	2.07	0.013	0.110	0.57	NE
2011	3.33	0.60	2.01	0.018	0.163	0.55	NE
2012	3.21	0.56	1.93	0.021	0.159	0.53	NE
2013	3.21	0.55	1.95	0.017	0.154	0.54	NE
2014	3.25	0.51	1.99	0.016	0.179	0.55	NE
2015	3.25	0.51	2.01	0.019	0.163	0.56	NE
2016	3.33	0.52	2.08	0.010	0.167	0.55	NE
2017	3.40	0.51	2.14	0.010	0.191	0.55	NE
2018	3.41	0.51	2.16	0.006	0.215	0.53	NE
2019	3.31	0.51	2.13	0.006	0.167	0.50	NE
2020	3.29	0.50	2.14	0.012	0.156	0.48	NE
2021	3.26	0.55	2.09	0.005	0.150	0.46	NE
2022	2.98	0.34	2.03	0.006	0.138	0.46	NE
Trend 1990 -2022	-15%	-49%	-9%	-88%		-14%	NE
Trend 2005 -2022	-6%	-41%	2%	-72%	199%	-11%	NE
Trend 2021 -2022	-9%	-38%	-3%	17%	-8%	0%	NE

Note: Other organic fertilizer includes compost and digestate originating from energy crops and non-agricultural waste.

Table 5-41 – NO_x Emission trends for category *3D – Crop production and agricultural soils* (Gg): 1990-2022

3 - Agriculture sector

NO_x emissions (in Gg)

Year	3D- Crop production and agricultural soils						
	Total	Inorganic N-fertilizer	Animal manure	Sewage sludge	Other organic	Grazing	Crop residue
1990	1.35	0.73	0.34	0.015	NO	0.21	0.06
1991	1.39	0.76	0.34	0.015	NO	0.21	0.06
1992	1.42	0.82	0.32	0.015	NO	0.20	0.06
1993	1.36	0.75	0.32	0.016	NO	0.21	0.06
1994	1.31	0.71	0.32	0.016	NO	0.20	0.06
1995	1.32	0.70	0.33	0.016	NO	0.21	0.06
1996	1.33	0.70	0.33	0.014	NO	0.21	0.07
1997	1.31	0.69	0.33	0.015	NO	0.21	0.07
1998	1.29	0.67	0.32	0.015	NO	0.21	0.07
1999	1.32	0.70	0.32	0.015	NO	0.21	0.07
2000	1.29	0.69	0.32	0.008	0.004	0.21	0.07
2001	1.19	0.59	0.32	0.007	0.002	0.21	0.07
2002	1.20	0.61	0.30	0.008	0.003	0.20	0.07
2003	1.07	0.50	0.30	0.006	0.003	0.20	0.07
2004	1.22	0.63	0.30	0.005	0.005	0.20	0.08
2005	1.13	0.55	0.30	0.006	0.010	0.19	0.07
2006	1.13	0.55	0.30	0.006	0.013	0.19	0.07
2007	1.11	0.51	0.30	0.007	0.015	0.20	0.07
2008	1.13	0.51	0.31	0.006	0.016	0.21	0.08
2009	1.13	0.51	0.31	0.004	0.021	0.21	0.08
2010	1.15	0.52	0.31	0.004	0.021	0.21	0.07
2011	1.16	0.55	0.31	0.005	0.029	0.20	0.06
2012	1.12	0.52	0.30	0.007	0.028	0.20	0.07
2013	1.12	0.51	0.31	0.005	0.028	0.20	0.08
2014	1.12	0.48	0.32	0.005	0.032	0.20	0.08
2015	1.12	0.49	0.32	0.006	0.030	0.21	0.07
2016	1.16	0.52	0.33	0.003	0.032	0.20	0.07
2017	1.17	0.51	0.35	0.003	0.037	0.20	0.07
2018	1.14	0.48	0.35	0.002	0.042	0.19	0.07
2019	1.14	0.51	0.35	0.002	0.033	0.18	0.06
2020	1.11	0.48	0.35	0.004	0.032	0.18	0.07
2021	1.13	0.51	0.35	0.002	0.029	0.17	0.07
2022	0.90	0.30	0.33	0.002	0.027	0.17	0.06
Trend 1990 -2022	-33%	-58%	-3%	-88%		-17%	11%
Trend 2005 -2022	-20%	-45%	11%	-72%	173%	-11%	-12%
Trend 2021 -2022	-20%	-40%	-4%	17%	-9%	0%	-12%

Note: Other organic fertilizer includes compost and digestate originating from energy crops and non-agricultural waste.

Table 5-42 – NMVOC Emission trends for category *3D – Crop production and agricultural soils* (Gg): 1990-2022

3 - Agriculture sector NMVOC emissions (in Gg)				
	3D- Crop production and agricultural soils			
Year	Total	Livestock manure applied to soils	Urine and dung deposited by grazing livestock	Cultivated crops
1990	1.01	0.87	0.03	0.11
1991	0.98	0.85	0.03	0.11
1992	0.95	0.81	0.03	0.11
1993	0.95	0.81	0.03	0.11
1994	0.92	0.78	0.03	0.11
1995	0.94	0.80	0.03	0.11
1996	0.93	0.79	0.03	0.11
1997	0.91	0.77	0.03	0.11
1998	0.91	0.77	0.03	0.11
1999	0.89	0.75	0.03	0.11
2000	0.87	0.73	0.03	0.11
2001	0.86	0.72	0.03	0.11
2002	0.83	0.69	0.03	0.11
2003	0.80	0.66	0.03	0.11
2004	0.78	0.64	0.03	0.11
2005	0.78	0.64	0.03	0.11
2006	0.76	0.62	0.03	0.11
2007	0.75	0.61	0.03	0.11
2008	0.76	0.62	0.03	0.11
2009	0.74	0.60	0.03	0.11
2010	0.75	0.60	0.03	0.11
2011	0.72	0.58	0.03	0.11
2012	0.71	0.57	0.03	0.11
2013	0.72	0.58	0.03	0.11
2014	0.73	0.58	0.03	0.11
2015	0.73	0.59	0.03	0.11
2016	0.76	0.62	0.03	0.11
2017	0.77	0.63	0.03	0.11
2018	0.78	0.64	0.03	0.11
2019	0.77	0.63	0.03	0.11
2020	0.79	0.66	0.03	0.11
2021	0.78	0.64	0.03	0.11
2022	0.77	0.64	0.03	0.11
Trend 1990 -2022	-23%	-26%	-14%	1%
Trend 2005 -2022	-1%	0%	-10%	-2%
Trend 2021 -2022	-1%	-1%	-1%	0%

Table 5-43 – HCB Emission trends for category *3.D.f – Use of pesticides* (g per year): 1990-2022

3 - Agriculture sector HBc Emissionen (in g per year)	
Year	3.D.f. - Use of pesticides HBc (in g per year)
1990	540
1991	488
1992	352
1993	184
1994	120
1995	115
1996	112
1997	94
1998	126
1999	117
2000	109
2001	35
2002	20
2003	21
2004	77
2005	122
2006	169
2007	159
2008	135
2009	125
2010	121
2011	121
2012	57
2013	102
2014	66
2015	60
2016	74
2017	78
2018	117
2019	105
2020	42
2021	4
2022	0.32
Trend 1990 -2022	-99.9%
Trend 2005 -2022	-99.7%
Trend 2021 -2022	-91%

5.4.3 Methodological issues

5.4.3.1 Methodology

5.4.3.1.1 Ammonia emissions - Methodology issues

A Tier 2 approach was used when estimating NH_3 emissions for the use of synthetic fertiliser whereby following the equation from the EMEP guidelines (Hutchings, Webb, & Amon, 2023), namely:

$$E_{fert_{NH_3}(f)} = \sum_{f} \left(m_{fert(f)} * EF_{NH_3(f)} \right)$$

with

$E_{fert\_NH3\,(f)}$ the amount of NH_3 emitted (in kg per year);

$m_{fert\,(f)}$ the mass (in kg) of fertiliser type f (in kg N per year);

$EF_{NH3\,(f)}$ emission factor for NH_3 for fertilizer type f (in kg NH_3 per kg N applied per year);

A Tier 1 approach was used when estimating NH_3 emissions for the use of sewage sludge and compost following equation 1 from the EMEP guidelines (Hutchings, Webb, & Amon, 2023), namely:

$$E_{NH_3(l)} = \left(AR_{N\_applied(l)} * EF_{NH_3(l)}\right)$$

with

$E_{NH3\ (l)}$	the amount of NH_3 emitted (in kg per year) for *l*, with *l* being sewage sludge and compost, respectively;
$AR_{N\_applied\ (l)}$	the amount of N applied (kg N/year) in *l*, with *l* being sewage sludge and compost, respectively;
$EF_{NH3\ (l)}$	emission factor for NH_3 for *l* application, with *l* being sewage sludge and compost, respectively.

The NH_3-N emissions during and immediately after field application of digestate originating from energy crops and other waste were calculated using the following formulas:

$$E_{applic\_dig-E\quad\_NH_3-N} = \left(m_{applic\_dig-E\quad\_TAN} * \ EF_{appli\ \_dig\_NH_{3-N}}\right)$$

with

$m_{applic\_dig-ECO\_TAN}$	the amounts of TAN that is applied to fields. Using total N in digestate as obtained from 5.B.2 and described in section 6.4; whereby assuming that 56% of total N is present as TAN, same as (Haenel, et al., 2020) .
$EF_{applic\_dig-NH3-N}$	Emissions factors (EF) for NH_3-N emissions during and immediately after field application of digestate (kg NH3-N kg^{-1}). Note: As the viscosity of untreated cattle slurry is similar to that of the digestate were the emission factors (EF) from cattle-slurry adopted, similar as (Haenel, et al., 2020), and summarized in Table 5-53.

The mass flow approach was used when estimating NH_3 emissions from animal manure and from dung and urine deposited by grazing animals.

The amount of NH_3 emitted (in kg per year) from N in dung and urine deposited from livestock during grazing were estimated following the EMEP guidelines (Amon H. D., 2023), namely:

$$E_{NH_3(grazing)} = \left[\sum_i \left\{\left(\ E_{grazing_{NH3}-N\_LU_{(i)}}\right)\right\}\right] * \langle\frac{17}{14}\rangle$$

with i is the *i*th livestock category and:

$E_{grazing\_NH3-N\_LU(i)}$	NH_3-N emissions from grazing in Luxemburg for livestock category *i* (in kg NH3-N per year) and described in step 14 in section 5.2.5. Please note, that only emissions from grazing animals kept on fields in Luxemburg were considered (see section 5.2.2.2).
17/14	the conversation factor according to the EMEP guidelines (Amon H. D., 2023).

The amount of NH_3 emitted (in kg per year) during and immediately after field application of animal manure, including digestate originated from animal manure, were estimated following the EMEP guidelines (Amon H. D., 2023), namely:

$$E_{NH_3(animal\ manure)} = \left[\sum_i \left\{\ E_{applic\_slurry\quad NH3-N_{(i)}} + \ E_{applic\_dig\quad NH\ -N_{(i)}} + \ E_{applic\_solid\quad NH\ -N_{(i)}}\right\}\right] * \langle\frac{17}{14}\rangle$$

with *i* is the *i*th livestock category and:

$E_{applic\_slurry\_NH3\text{-}N(i)}$	NH_3-N emissions during and immediately after field application of slurry/liquid manure in Luxemburg, for livestock category *i* (in kg NH3-N year^{-1}); and described in step 12 in section 5.2.5. Please note, that only emissions from manure applied to fields in Luxemburg were considered (see section 5.2.6).
$E_{applic\_dig\_NH3\text{-}N(i)}$	NH_3-N emissions during and immediately after field application of digestate originating from animal manure for livestock category *i* (in kg NH3-N year^{-1}), and described in step 12 in section 5.2.5 Please note, that only emissions from digestate applied to fields in Luxemburg were considered (see section 5.2.6).
$E_{applic\_solid\_NH3\text{-}N(i)}$	NH_3-N emissions during and immediately after field application of solid manure for livestock category *i* (in kg NH3-N year^{-1}); and described in step 12 in section 5.2.5. Please note, that only emissions from solid manure applied to fields in Luxemburg were considered (see section 5.2.6).
17/14	the conversation factor according to the EMEP guidelines (Amon H. D., 2023).

5.4.3.1.2 Nitrogen oxides emissions - Methodology issues

An Tier 1 approach was used when estimating NO_x emissions for the use of synthetic fertiliser, organic fertiliser (i.e. sewage sludge; compost; digestate originating from energy crops and other waste; animal manure including digestate originating from animal manure; and dung and urine deposited by grazing animals) and crop residues, respectively whereby following equation 1 from the EMEP guidelines (Hutchings, Webb, & Amon, 2023) , namely:

$$E_{NO_x(l)} = AR_{N\_applied(l)} * EF_{NO_x\,(l)}$$

with

$E_{NOx\,(l)}$	the amount of NO_x emitted (in kg per year) for *l*, with *l* being synthetic fertiliser; organic fertilisers (i.e. sewage sludge; compost; digestate originating from energy crops and other waste, animal manure including digestate originating from animal manure; and dung and urine deposited by grazing animals) and crop residues, respectively;
$AR_{N\_applied\,(l)}$	the amount of N applied (kg N/year) in *l*, with *l* synthetic fertiliser; organic fertilisers (i.e. sewage sludge; compost; digestate originating from energy crops and other waste; animal manure including digestate originating from animal manure; and dung and urine deposited by grazing animals) and crop residues, respectively;
$EF_{NOx\,(l)}$	emission factor for NO_x for *l* application, with *l* being synthetic fertiliser; organic fertilisers (i.e. sewage sludge; compost; digestate originating from energy crops and other waste; animal manure, including digestate originating from animal manure; and dung and urine deposited by grazing animals) and crop residues, respectively;

5.4.3.1.3 NMVOC emissions - Methodology issues

NMVOC emission associated with the manure application and NMVOC emission associated with the dung and urine deposited by grazing animals were estimated using a Tier 2 approach (see description in section 5.3.3.1.3) and were reported in 3Da2a and in 3Da3, respectively.

A Tier 1 approach was used to estimate NMVOC emissions from crop production and agricultural soils. Following equation 2 from the EMEP guidelines (Hutchings, Webb, & Amon, 2023), the equation used was:

$$E_{NMVOC} = AR_{area} * EF_{NMVOC}$$

with

E_{NMVOC} the amount of NMVOC emitted (in kg per year);

AR_{area} the utilised agricultural area in ha per year;

EF_{NMVOC} emission factor for the pollutant being NMVOC.

5.4.3.1.4 Particle emissions - Methodology issues

Using a Tier 1 approach to estimate particles emissions from crop production and agricultural soils, and following equation 2 from the EMEP guidelines (Hutchings, Webb, & Amon, 2023), the equation used was:

$$E_{PM\ (p)} = AR_{area} * EF_{PM\ (p)}$$

with

$E_{PM(p)}$ Emissions in kg/year for particle emissions *p*, with *p* being $PM_{2.5}$, PM_{10} and TSP, respectively;

AR_{area} the utilised agricultural area in ha per year;

$EF_{PM(p)}$ Emission factor for particle emissions *p*, with *p* being PM2.5, PM10 and TSP, respectively.

5.4.3.1.5 HCB emissions - Methodology issues

For the years 2012 and onwards, the emission of HCB is estimated using the Tier 1 method from the EMEP guidelines (Webb, Hutchings, & Amon, 2023), whereby the emission of HCB is calculated by summing up the product of the amount of each pesticide applied and the impurity factor (i.e. concentration of HCB in that pesticide), namely:

$$E_{pest} = \sum \left(m_{pest(p)} * IF_p\right)$$

with

E_{pest} the total emission of HCB (in mg per year);

$m_{pest(p)}$ mass of individual pesticide *p* applied (in kg per year);

IF_p impurity factor of HCB in the *p*th pesticides (in mg per kg);

For the years 1990-2011, due to a lack of activity data, were the emission of HCB from the use of pesticides derived from the German HCB emissions from the use of pesticides, whereby assuming that HCB emissions per ha arable land would have been similar in both countries as luxemburgish farmers used similar products to the one used in Germany. The German HCB emissions from the use of pesticides, as published in the 2023 IIR pesticides (Vos, Rösemann, Döring, & Gniffke, 2023), were divided by the area of arable land in Germany to obtain the HCB emissions per ha arable land in Germany. Although luxemburgish farmers used similar products in the same period as the German farmers, a 3-years average was used to reduce the observed fluctuations on the German market. The 3-year average German HCB emissions per ha arable land was therefore multiplied by the area of arable land cultivated in Luxemburg to obtain HCB emissions in Luxemburg, for details see Table .

Table 5-44– HCB emissions from used pesticides (in kg/year) for the years 1990-2011 derived from the German inventory

3 - Agriculture sector HBC emissions (in kg/year)						
	3Df- Use of pesticides					
Year	**Germany: HBC Emissions by used pesticides (kg/year)**	**Germany: Arable land ('1000) ha**	**Germany: HBC emissions (g/ha)**	**Germany: HBC emissions 3-year average (g/ha)**	**Luxembourg: Aable land ('1000 ha)**	**Luxembourg: HBC Emissions by used pesticides (kg/year)**
1988	114.77	11 089	0.0104			
1989	82.49	11 089	0.0074			
1990	109.30	11 089	0.0099	0.0097	55.4	0.540
1991	138.14	11 559	0.0120	0.0089	54.9	0.488
1992	55.87	11 468	0.0049	0.0065	54.5	0.352
1993	29.72	11 676	0.0025	0.0032	56.9	0.184
1994	26.74	11 805	0.0023	0.0021	56.6	0.120
1995	17.99	11 835	0.0015	0.0020	57.2	0.115
1996	26.60	11 832	0.0022	0.0019	57.7	0.112
1997	24.25	11 832	0.0020	0.0016	59.5	0.094
1998	5.01	11 879	0.0004	0.0021	60.4	0.126
1999	44.97	11 821	0.0038	0.0019	60.8	0.117
2000	18.58	11 804	0.0016	0.0018	60.1	0.109
2001	0.79	11 813	0.0001	0.0006	60.6	0.035
2002	1.00	11 791	0.0001	0.0003	60.8	0.020
2003	9.60	11 827	0.0008	0.0003	61.1	0.021
2004	1.59	11 899	0.0001	0.0013	60.7	0.077
2005	34.29	11 903	0.0029	0.0020	60.1	0.122
2006	36.32	11 866	0.0031	0.0028	59.9	0.169
2007	29.99	11 877	0.0025	0.0027	59.6	0.159
2008	28.87	11 932	0.0024	0.0022	60.3	0.135
2009	21.08	11 945	0.0018	0.0021	59.6	0.125
2010	24.92	11 847	0.0021	0.0020	59.7	0.121
2011	26.15	11 874	0.0022	0.0020	59.5	0.121

5.4.3.2 Activity data

5.4.3.2.1 Agricultural area used (AR_{area})

Information on the agricultural area used (AR_{area_LU}) in Luxemburg was derived from the databases of the Ministry of Agriculture,[99-100] set up to pay divers EU and national subsidies. Data were available from 2005 onwards. For the years 1990-2004 no reliable data were available why using data from the yearly Farm Structure Survey (FSS) collected by STATEC/SER.[101] FSS data were however corrected for the fact that 3.67% of the land (i.e. the portion in 2006) cultivated by luxemburgish farmers would have been situated in neighbouring countries. Note that Luxemburg farmers used to have always agricultural area in neighbouring countries. The agricultural area used in neighbouring countries was rather stable until 2005-2007. Changes of the luxemburgish agricultural policies in 2005-2007 increased the demand for agricultural area, and thus an increased demand for agricultural area abroad.

Not all AR_{area} is also utilized by farmers. The remaining AR_{area} is mostly extensive grassland with either ochard trees or grassland, without or with animals (for example small ruminants and horses kept off-farms). Reliable data on the AR_{area} cultivated by non-farmers were

---

[99] https://agriculture.public.lu/de/agrarpolitik-landliche-entwicklung/gemeinsame-agrarpolitik/direkte-einkommensbeihilfen.html; l
[100] https://agriculture.public.lu/de/betriebsfuhrung/gis.html
[101] https://lustat.statec.lu/vis?fs[0]=Th%C3%A8mes%2C1%7CEntreprises%23D%23%7CAgriculture%20et%20for-esterie%23D2%23&pg=0&fc=Th%C3%A8mes&df[ds]=release&df[id]=DF_D2100&df[ag]=LU1&pd=1990%2C2021&dq=.A

available since 2014[99] (Charel Perl, ASTA, personal communication 27-07-2022). For the period 1990-2013 a trend estimate was used. The total AR_{area} in Luxembourg is summarized in Table 5-45. Additional details are provided in Annex 3:B in NIR 2023.

Table 5-45 – Activity data for category *3D – Agriculture area and crop production* (ha): 1990-2022

3 - Agriculture

Activitiy data - Agriculture surface area, cash crop plants, fodder plants and pasture (in ha)

Year	agricultural area	winter wheat	spring wheat	rye and mix-cereals	barley	oat	triticale	rape	potatoes	pulses	grain maize	maize for silage & bio digester	fodder beet	clover, grass-clover leys, fodder production	pasture and meadows	extensive grassland	others
1990	125 671	7 373	943	1 209	15 120	4 962	2 191	1 881	796	518	NO	7 205	223	11 158	66 362	3 896	1 833
1991	124 927	7 071	599	1 107	14 227	4 338	2 574	2 502	828	570	NO	7 563	237	11 437	66 076	3 952	1 845
1992	125 246	7 303	553	1 067	13 169	3 957	2 620	1 466	912	734	NO	8 365	270	12 292	66 714	4 008	1 817
1993	126 722	7 430	638	891	13 254	3 682	2 570	1 626	804	805	NO	7 666	239	13 911	65 744	4 064	3 399
1994	126 344	8 062	644	1 058	13 078	3 398	2 336	1 605	756	592	NO	8 234	226	13 078	65 589	4 120	3 569
1995	126 497	8 598	403	1 055	12 227	2 690	2 771	1 884	773	457	NO	9 049	213	13 659	65 097	4 176	3 446
1996	126 075	9 025	417	894	11 391	2 502	2 923	2 355	768	390	NO	9 187	172	13 606	64 131	4 232	4 084
1997	126 381	8 966	427	938	11 169	2 427	2 984	2 169	812	406	441	9 665	159	15 500	62 638	4 287	3 392
1998	126 926	9 007	445	1 218	10 952	2 217	3 297	2 759	812	399	487	9 527	124	15 794	62 133	4 343	3 411
1999	127 241	6 392	1 126	1 190	11 461	2 368	2 657	3 923	810	537	484	10 116	102	15 657	62 071	4 399	3 948
2000	127 526	10 211	367	1 283	9 549	1 841	3 505	3 129	799	416	246	10 412	74	14 734	62 939	4 455	3 566
2001	127 870	8 740	733	1 268	10 545	1 663	2 956	2 974	708	668	459	10 839	59	14 628	62 782	4 511	4 338
2002	128 092	11 130	449	1 413	8 669	1 893	3 866	3 367	648	643	314	10 622	49	13 919	62 712	4 567	3 831
2003	128 189	10 353	433	1 097	9 422	2 086	3 591	3 542	601	579	325	11 205	41	14 018	62 506	4 623	3 767
2004	128 164	10 972	328	1 367	8 101	1 839	3 450	4 040	612	489	337	11 844	41	14 138	62 737	4 678	3 189
2005	129 619	10 967	600	1 129	9 499	1 637	3 390	3 956	608	477	221	11 733	61	12 118	64 749	4 734	3 741
2006	130 415	12 019	348	1 384	9 266	1 418	3 358	4 526	528	352	257	11 382	34	11 481	65 719	4 790	3 554
2007	129 943	11 748	291	1 348	8 836	1 347	3 327	5 136	573	350	268	11 518	30	11 793	65 490	4 846	3 041
2008	129 963	13 533	389	1 489	9 305	1 100	3 416	4 963	556	210	274	11 835	24	11 275	64 811	4 902	1 881
2009	128 499	12 563	426	1 238	8 794	1 264	3 854	4 356	535	292	324	12 654	33	11 398	63 949	4 958	1 860
2010	129 379	12 788	321	1 032	7 762	1 039	4 577	4 266	557	324	290	12 894	27	12 021	64 651	5 014	1 815
2011	129 089	12 438	460	1 112	7 354	995	4 106	4 244	582	264	232	13 186	32	12 658	64 500	5 069	1 855
2012	129 288	12 258	405	1 214	6 647	827	4 504	4 021	569	165	195	13 512	54	13 606	64 293	5 125	1 893
2013	128 986	12 663	437	1 075	7 311	990	4 298	4 022	565	253	242	13 432	65	12 544	63 943	5 181	1 964
2014	128 826	10 658	1 117	1 107	7 683	1 086	4 482	3 683	534	351	216	14 023	88	12 911	63 724	5 215	1 949
2015	128 103	12 351	723	1 030	7 143	1 078	4 347	3 388	506	549	153	13 503	129	12 119	63 595	5 225	2 263
2016	127 919	12 273	411	1 192	6 258	1 001	4 313	3 125	536	638	112	13 943	124	12 538	63 852	5 414	2 190
2017	127 821	12 377	439	1 132	6 134	1 129	4 233	2 890	561	581	82	13 927	106	12 505	64 046	5 442	2 236
2018	127 221	11 402	324	1 199	5 544	1 147	4 364	2 804	541	402	92	14 497	67	12 632	64 362	5 475	2 370
2019	126 489	11 722	256	1 285	5 625	1 240	4 653	2 256	501	386	125	14 442	71	11 931	64 241	5 534	2 221
2020	126 692	10 161	347	1 233	5 547	1 440	4 183	2 163	550	365	72	15 249	70	12 735	64 508	5 573	2 495
2021	126 692	10 989	211	1 568	4 766	1 415	4 420	1 285	578	331	63	15 289	89	12 738	64 868	5 581	2 500
2022	126 394	11 437	474	1 359	5 424	1 520	4 264	1 671	546	398	153	14 135	85	11 709	64 839	5 573	2 806

5.4.3.2.2 Synthetic N fertilizer

Only nitrogenous fertilizers ($AR_{N\_applied\ (synthetic\ N\ fertilizer)}$) have been considered as synthetic fertilizers since these are the ones generating nitrous oxide emissions and are summarized in Table 5-46.

Up to 1998 included, statistics were not recording fertilizer application, but fertilizer sales in Luxembourg. Therefore, for the years prior to 1999, the hypothesis that fertilizers consumption/application equals fertilizer sales (i.e. no stocks and stock changes) had been made. Thereafter, consumption data had been used. Synthetic N fertilizer, expressed as weighted average kg N per ha used agriculture surface, was based on data collected within the Luxemburgish "landwirtschaftliche Testbetriebsnetz (LTBN)"[102], using a nutrient balance methodology (in German the so-called "Feld – Stall Bilanz"), (Weckbecker 2018).

[102] Luxemburg has the obligation to collect data from agriculture farms for the Farm Accountancy Data Network (FADN). For details on the FADN see http://ec.europa.eu/agriculture/rica/, for the Luxemburgish "landwirtschaftliche Testbetriebsnetz (LTBN)" see https://agriculture.public.lu/de/betriebsfuhrung/buchfuhrung/testbetriebsnetz.html. The LTBN is situated in the division «Division de la gestion, de la comptabilité et de l'entraide agricoles», at the SER. This division gets from about 840 farms farm accountancy data (https://agriculture.public.lu/de/betriebsfuhrung/buchfuhrung.html). Out of these farms, a representative sample of 450 farms are selected to form the sample size shared with FADN (https://agriculture.public.lu/de/betriebsfuhrung/buchfuhrung/testbetriebsnetz.html).

National utilisation was obtained by multipling the weighted average kg N per ha with the used agriculture surface as summarized in Table 5-45, excluding the extensive grassland cultivated by non-farmers.

For the NH_3 emissions, a Tier 2 approach was implemented, requiring the mass of fertilizer type *f* (expressed in kg N per year). The national utilization of kg N used on agriculture surface was the basis for the estimation of the national utilization of synthetic N fertilizer *f*, being *f* anhydrous ammonia (AH); ammonium nitrate (AN); ammonium phosphate (AP); ammonium Sulphate (AS); calcium ammonium nitrate (CAN); NK mixtures; NPK mixtures; NP mixtures; N solutions, urea and other straight N compounds, respectively.

Starting with the national utilization of kg N, the estimated utilized N was redistributed over the different fertilizer in questions. The allocation of fertilizer types was based on the consumption of fertilizer of the farmers within the Luxemburgish "landwirtschaftliche Testbestriebsnetz" (LTBN). Since 2000 nearly every year, price statistics had been published on the used fertilizer types, presuming that at least 8 farmers had used them, and that total consumption was minimum 10,000 kg, if solid fertilizer, respectively 25 hl, if liquid fertilizer. Together with the price, was also the quantities published on which prices had been based (i.e. the quantities used by LTBN farmers) (Brücher & Jacqué, 2011-2013) (Conter, 2001-2007) (Hermes, Preisstatistik 2007 - 2008, 2008 - 2009) (Hermes, 2010) (Majerus, 2017-2019). There were no data for the years 1990-1999. But according to field experts[103] were the distribution of the used synthetic N-fertilizer like the one observed for the years 2000-2004, why assuming the same distribution for the years 1990-1999 as observed in 2000-2004. Given that prices are driving annual sales, multiannual sales data were more appropriate for the allocation of fertilizer type. The years chosen were 2000-2004, 2005-2009, 2010-2012 and 2016-2018. No information was available for the years 2013-2015, why using as proxy for the years 2013 and 2014 the 2010-2012 multiannual sales data and for the year 2015, the 2016-2018 multiannual sales data. For the year 2019 and ownards, information from all LTBN farmers were used, and the allocation was derived directly from the LTBN database[104]. But given that urea utilization is rather seldom in Luxembourg, and therefore showed only up in the period 2005-2009, and again in the 2019, an interpolation was made for the years 2010-2018 presuming a linear decrease from 1.9% in 2005-2009 to 0.3% in 2019. This correction was applied on the costs of the allocation of CAN, the major synthetic N-fertilizer used in Luxembourg. The annual amount of synthetic N applied to soil, total and split up into the different fertilizer types is summarized in Table 5-46.

103 Karl Weckbecker and Paul Jacqué, SER, Division de la gestion, de la comptabilité et de l'entraide agricoles; Simone Marx; ASTA, Service de pédologie; personal communications; July 2020

104 2019-2021 :Karl Weckbecker and Paul Jacqué, SER, Division de la gestion, de la comptabilité et de l'entraide agricoles, 2019 data: pers. com. 24-11-2020; 2020 data: pers. com. 29-11-2021; 2021 data: pers. com.23-11-2022; 2022 data: Paul Jacqué, pers. com. 27-11-2023

Table 5-46 – Activity data for category 3D1 synthetic N Fertilizer (kg N/year), total N and split up by fertilizer type.

3 - Agriculture sector										
Activity data - annual amount of N (in kg N/year) from different synthetic N fertilizers										
	3D- Crop production and agricultural soils									
Year	Total	Ammonium phosphate (AP)	Ammonium sulphate (AS)	Calcium ammonium nitrate (CAN)	NK mixtures	NPK mixtures	NP mixtures	N solutions	Other straight N compounds	Urea
1990	18 218 653	-	387 372	16 630 475	-	575 966	159 218	465 621	-	-
1991	18 983 396	-	403 633	17 328 553	-	600 143	165 902	485 166	-	-
1992	20 484 409	-	435 548	18 698 718	-	647 596	179 019	523 528	-	-
1993	18 687 016	-	397 331	17 058 009	-	590 773	163 311	477 592	-	-
1994	17 740 897	-	377 214	16 194 367	-	560 862	155 043	453 411	-	-
1995	17 407 501	-	370 125	15 890 033	-	550 322	152 129	444 890	-	-
1996	17 489 448	-	371 868	15 964 837	-	552 913	152 846	446 985	-	-
1997	17 220 060	-	366 140	15 718 932	-	544 396	150 491	440 100	-	-
1998	16 873 182	-	358 764	15 402 293	-	533 430	147 460	431 235	-	-
1999	17 400 520	-	369 977	15 883 661	-	550 101	152 068	444 712	-	-
2000	17 180 729	-	365 304	15 683 030	-	543 153	150 148	439 095	-	-
2001	14 655 099	-	311 603	13 377 567	-	463 307	128 075	374 546	-	-
2002	15 267 722	-	324 628	13 936 786	-	482 675	133 429	390 203	-	-
2003	12 443 168	-	264 572	11 358 458	-	393 379	108 745	318 015	-	-
2004	15 769 127	-	335 290	14 394 482	-	498 526	137 811	403 018	-	-
2005	13 762 308	53 913	716 202	11 926 891	269	231 542	56 546	511 549	-	265 397
2006	13 680 584	53 593	711 949	11 856 066	268	230 167	56 210	508 511	-	263 821
2007	12 722 328	49 839	662 080	11 025 608	249	214 045	52 273	472 893	-	245 342
2008	12 781 284	50 070	665 149	11 076 702	250	215 036	52 515	475 084	-	246 478
2009	12 644 457	49 534	658 028	10 958 123	247	212 734	51 953	469 998	-	243 840
2010	13 058 411	116 790	611 655	10 907 512	2 416	200 955	5 545	983 386	-	230 153
2011	13 642 135	122 010	638 996	11 417 727	2 524	209 938	5 793	1 027 344	-	217 802
2012	12 912 925	115 488	604 840	10 828 847	2 389	198 716	5 483	972 430	-	184 731
2013	12 628 048	112 941	591 497	10 610 903	2 337	194 332	5 362	950 977	-	159 700
2014	11 990 249	107 236	561 622	10 094 880	2 219	184 517	5 091	902 946	-	131 737
2015	12 164 881	126 180	530 483	10 412 922	1 125	161 536	2 583	816 584	-	113 468
2016	12 875 308	151 946	519 848	11 202 036	-	143 802	-	758 947	-	98 729
2017	12 666 185	141 163	603 648	11 006 084	-	104 583	-	734 601	-	76 106
2018	12 065 012	144 815	528 307	10 174 342	-	41 250	-	1 123 826	-	52 472
2019	12 679 772	152 049	821 768	10 948 586	-	3 586	79 361	620 662	19 656	34 104
2020	12 000 433	149 936	769 452	10 167 662	13 402	185 132	96 657	498 527	82 240	37 424
2021	12 704 561	152 447	852 164	10 575 767	7 816	284 182	158 048	594 941	38 335	40 860
2022	7 618 981	73 752	460 213	6 177 793	4 740	131 645	111 993	592 113	33 186	33 546

Note: Anhydrous ammonia and ammonium nitrate were not used as synthetic N fertilizer in the analyzed period.

5.4.3.2.3 Animal manure

N in animal manure, including digestate originating from animal manure, applied to soil was determined using a mass-flow approach based on the concept of a flow of total ammoniacal nitrogen (TAN) through the manure management, which was determined following the fifteen steps described in the EMEP guidelines (Amon H. D., 2023), which were described in section 5.2.5. Gross amounts are used throughout, i.e. emissions of various N substances from a given source are calculated using the same basic nitrogen amount. Only at the end of the calculation is the combined loss subtracted in order to yield the remaining N available for application.

This corresponds to step 11 described in section 5.2.5. The quantities are summarized in Table 5-50.

$$AR_{N_{applied}(AM)} = \left[\sum_{i}([m_{applic\_slurry\_N\_LU(i)} + m_{applic\_dig\_N\_LU(i)} + m_{applic\_solid\_N\_LU(i)}])\right]$$

with:

$m_{applic\_slurry\_N\_LU(i)}$ the net amount of N applied to soil from slurry in Luxemburg (expressed in kg N per year) for animal category *i* and defined in step 11 in section 5.2.5;

$m_{applic\_dig\_N\_LU(i)}$ the net amount of N applied to soil from digestate originating from animal manure (expressed in kg N per year) for animal category *i* and defined in step 11 in section 5.2.5;

$m_{applic\_solid\_N\_LU(i)}$ the net amount of N applied to soil from solid manure in Luxemburg (expressed in kg N per year) for animal category *i* and defined in step 11 in section 5.2.5;

Whereas for the amount of NH_3 emitted (in kg per year) the amount of the annual TAN that is applied to the field ($m_{applic\_slurry\_TAN\_LU(i)}$, $m_{applic\_digy\_TAN\_LU(i)}$ and $m_{applic\_solid\_TAN\_LU(i)}$), expressed in kg TAN per year for animal category *i*, was determined in step 11 in section 5.2.5.

$m_{applic\_slurry\_TAN}$ and $m_{applic\_dig\_TAN}$ was further split up whereby distinguishing:

- between the surface cover of the fields *c*, with *c* being grassland; arable land with vegetation and arable land without vegetation;
- according to technique used for spreading (*s*), with *s* being broadcast, training hose, training shoe, infecting techniques and slurry cultivator.
- and in case of arable land without cover, a further distinction was made, depending on the time span passed between spreading and incorporation (*t*), with *t* being <1 hour, <4 hours, <6 hours, <8 hours, >8/12 hours and no incorporation.

and $m_{applic\_solid\_TAN}$ was split up whereby distinguishing:

- between the surface cover of the fields *c*, with *c* being grassland; arable land with vegetation and arable land without vegetation;
- and in case of arable land without cover, a further distinction was made, depending on the time span passed between spreading and incorporation (*t*), with *t* being <1 hour, <4 hours, <8 hours, >8/12 hours and no incorporation;
- with broadcast being the used spreading technique.

Frequency distributions of liquid manure, digestate and solid were available from surveys on agricultural production methods for the years 2010 (Gargano et al. 2014), 2019[105] and 2021[106]. In 2001, the first environmentally friendly slurry spreading machine was bought by a group of three farmers, allowing to spread the slurry via trailing hose, injecting techniques or using a slurry cultivator.[107] For 1990 (liquid and solid manure) and 1998 (digestate) a trend estimate was made, presuming that broadcast was the only available technique at that moment in time.

The frequencies for solid manure was estimated for the years 1990, 2010, 2019 and 2021, see Table 5-47, and by linear interpolation between those years. The frequencies for slurry was estimated for 1990, 2001, 2010, 2019 and 2021, see Table 5-48, and for digestate for 1998, 2001, 2010, 2019 and 2021, see Table 5-49. Linear interpolation was assumed for the years between 1990/1998 and 2001 for slurry/digestate, as well as between 2019 and 2021. The increasing use of environmentally-friendly techniques for the application of liquid manure and digestate between 2001-2010 and 2010-2019 was based on the estimated ha as subsidied by the Ministry of Agriculture, using the year 2010 as reference point. In the first years, only the trailing hose was the available technique, and trailing shoe came later. (D. Rosseler August 2019, per-sonal communication). However, in the later years (from 2015 onwards), the trailing

[105] Service d'économie rurale (SER) – Division des statistiques agricoles, des relations extérieures et des marches agricoles. Data were collected for 1st April 2020 with reference period being the last 12 months (i.e. 2019).
[106] Service d'économie rurale (SER) – Division des statistiques agricoles, des relations extérieures et des marches agricoles. Provisional data. Data were collected for 1st February 2022 with reference period being the last 12 months (i.e. 2021).
[107] Highlighted by several Luxemburgish farmers in Februar 2019, and confirmed by Daniel Rosseler, one of the three farmers in question, who had bought the first well as by one of the three farmers who bought the first environmental-friendly manure trailer (Daniel Rosseler, August 2019; personal communication).

hose has been increasingly replaced by the trailing shoe and is slowly overtaken the trailing hose. It was therefore assumed that this was a smooth process. The progressive switch away from trailing hose towards trailing show was assumed, starting in 2011.

For the farmers participating in the program, it is an obligation of the program that liquid manure/digestate must be incorporated within less than 6 hours, if spreading on arable land without vegetation. Liquid manure and digestate being spread on arable land without vegetation by using a trailing shoe or trailing hose, was therefore assumed to have been incorporated within less than 6 hours.

Table 5-47 – Frequency distribution and times between application and incorporation of solid manure

3 – Agricultural sector

Activity data: Frequency distribution and times between application until incorporation of solid manure

3 D a 2 a Animal manure applied to soils

Year	1990	2010	2019	2021
Application of solid on … (in %)				
Grassland	*5%*	17%	23%	26%
Arable land with vegetation	*20%*	*11%*	7%	11%
Arable land without vegetation and				
with incorporation ≤ 1 h	*1%*	*2%*	2%	1.3%
with incorporation >1 h ≤ 4 h	*9%*	*11%*	13%	16%
with incorporation >4 h ≤ 8 h	*15%*	*19%*	21%	16%
with incorporation >8/12 h	*38%*	*33%*	30%	20%
without incorporation	*12%*	*7%*	4%	8%

Table 5-48 – Frequency distribution of spreading techniques and times between application until incorporation of liquid manure

3 – Agricultural sector

Activity data: Frequencies distribution of spreading techniques and times between application until incorporation of liquid manure

3 D a 2 a Animal manure applied to soils

Year	1990	2001	2010	2019	2021
Liquid manure applied on … (in %)					
Grassland using broadcast	62%	60%	54%	39%	35%
Grassland using trailing hose	NA	1%	6%	5%	6%
Grassland using trailing shoe	NA	NA	0.0%	14%	21%
Grassland using injecting techniques	NA	0.2%	1.2%	3%	3%
Arable land with vegetation and using broadcast	1%	3%	3%	3%	1%
Arable land with vegetation and using trailing hose	NA	0%	1%	1%	1%
Arable land with vegetation and using trailing shoe	NA	NA	0%	3%	2%
Arable land without vegetation, uinsg broadcast and					
with incorporation ≤ 1 h	4%	4%	3%	2%	1.1%
with incorporation >1 h ≤ 4 h	13%	13%	10%	6%	4.8%
with incorporation >4 h ≤ 6 h	7%	6%	5%	3%	1.3%
with incorporation >6 h ≤ 8 h	7%	6%	5%	3%	1.3%
with incorporation >8 h ≤12 h	6%	6%	5%	3%	3.0%

3 – Agricultural sector Activity data: Frequencies distribution of spreading techniques and times between application until incorporation of liquid manure 3 D a 2 a Animal manure applied to soils					
Year	1990	2001	2010	2019	2021
without / with incorporation > 12 h	0.1%	0.5%	0.8%	0.6%	0.8%
Arable land without vegetation, uinsg trailing hose and					
with incorporation ≤ 1 h	NA	0.1%	0.7%	0.8%	0.7%
with incorporation >1 h ≤ 4 h	NA	0.2%	0.9%	1.1%	1.1%
with incorporation >4 h ≤ 6 h	NA	0.1%	0.4%	0.1%	0.6%
with incorporation >6 h ≤ 8 h	NA	0.1%	0.4%	0.1%	0.6%
with incorporation >8 h ≤12 h	NA	0.0%	0.0%	0.7%	0.8%
without / with incorporation > 12 h	NA	0.1%	0.3%	0.3%	0.1%
Arable land without vegetation, uinsg trailing shoe and					
with incorporation ≤ 1 h	NA	NA	0%	1%	1.1%
with incorporation >1 h ≤ 4 h	NA	NA	0%	3%	3.5%
with incorporation >4 h ≤ 6 h	NA	NA	0%	1%	1.2%
with incorporation >6 h ≤ 8 h	NA	NA	0%	1%	1.2%
with incorporation >8 h ≤12 h	NA	NA	0%	1%	1.6%
without / with incorporation > 12 h	NA	NA	0%	1%	0.3%
Arable land using injecting techniques	NA	0.1%	0.7%	1.9%	1.1%
Arable land using slurry cultivator	NA	0.3%	1.8%	5.1%	3.3%

Table 5-49 – Frequency distribution of spreading techniques and times between application and incorporation of digestate

3 – Agricultural sector Activity data: Frequencies distribution of spreading techniques and times between application and incorporation of digestate 3 D a 2 a Animal manure applied to soils					
Year	1990	2001	2010	2019	2021
Digestate applied on … (in %)					
Grassland using broadcast	43%	39%	18%	7%	8%
Grassland using trailing hose	NA	4%	24%	11%	13%
Grassland using trailing shoe	NA	NA	0.0%	21.8%	27%
Grassland using injecting techniques	NA	0.5%	3.3%	7.0%	2.7%
Arable land with vegetation and using broad-cast	9%	8%	3%	3%	1.4%
Arable land with vegetation and using trailing hose	NA	1%	7%	3%	2.7%
Arable land with vegetation and using trailing shoe	NA	NA	0%	7%	10%
Arable land without vegetation, uinsg broadcast and					
with incorporation ≤ 1 h	4%	3%	2%	0%	0.6%
with incorporation >1 h ≤ 4 h	16%	15%	8%	2%	1.4%
with incorporation >4 h ≤ 6 h	13%	12%	7%	2%	0.3%
with incorporation >6 h ≤ 8 h	13%	12%	7%	2%	0.3%

3 – Agricultural sector Activity data: Frequencies distribution of spreading techniques and times between application and incorporation of digestate 3 D a 2 a Animal manure applied to soils					
Year	1990	2001	2010	2019	2021
with incorporation >8 h ≤12 h	3%	2%	1%	0%	0.7%
without / with incorporation > 12 h	0.6%	0.6%	0.2%	0.2%	0.0%
Arable land without vegetation, uinsg trailing hose and					
with incorporation ≤ 1 h	NA	1.4%	6.6%	3.6%	0.8%
with incorporation >1 h ≤ 4 h	NA	0.5%	2.3%	1.2%	3.4%
with incorporation >4 h ≤ 6 h	NA	0.1%	0.5%	0.2%	0.4%
with incorporation >6 h ≤ 8 h	NA	0.1%	0.5%	0.2%	0.4%
with incorporation >8 h ≤12 h	NA	0.0%	0.0%	0.1%	0.3%
without / with incorporation > 12 h	NA	0.2%	1.0%	0.5%	0.3%
Arable land without vegetation, uinsg trailing shoe and					
with incorporation ≤ 1 h	NA	NA	0%	1%	1.4%
with incorporation >1 h ≤ 4 h	NA	NA	0%	4%	2.9%
with incorporation >4 h ≤ 6 h	NA	NA	0%	1%	0.7%
with incorporation >6 h ≤ 8 h	NA	NA	0%	1%	0.7%
with incorporation >8 h ≤12 h	NA	NA	0%	1%	2.2%
without / with incorporation > 12 h	NA	NA	0%	0%	2.9%
Arable land using injecting techniques	NA	0.3%	1.9%	13%	11%
Arable land using slurry cultivator	NA	1.2%	6.8%	4%	3%

5.4.3.2.4 Sewage sludge ($AR_{N\_applied\ (sewage\ sludge)}$)

The annual amount of total sewage N applied to soils ($AR_{N\_applied\ (sewage\ sludge)}$), in kg per year (see Table 5-50) was estimated based on published statistics with respect to tonnage, N content and the destination use.

Sewage sludge data used in the emission calculations were derived from:

- estimates for the total sewage sludge produced in the various wastewater treatment plant (WWTP) of the country. These estimates have been prepared by the Environment Agency with some corrections for the years 2000 to 2004;
- annual reports on sewage sludge that are regularly issued since 2003.[108] These reports are based on a questionnaire sent to WWTPs with at least 2000 inhabitants-eq. The questionnaire requests, among other things, tonnage, N content and the destination.
- a five-year trend estimate was used to estimate the sewage sludge use in agriculture in 2022 as data collection was still on-going.

[108] See https://data.public.lu/en/datasets/boues-depuration/.

5.4.3.2.5 Compost applied to soils ($AR_{N\_applied (Compost)}$)

The annual amount of compost N applied to soils ($AR_{N\_applied (compost)}$), in kg per year, was estimated based on published statistics w.r.t. to tonnage, N content and the destination use, see Table .

Compost data used in the invenventory were derived from:

- estimates for the quantities of compost used in agriculture for the years 1993-1999 were derived using individual plant activity data of the total quantiy of compost (see Table 6-14) and presuming that a similar proportion of the compost production would be sold to agriculture, horticulture and viticulture sector as the median of the years 2001-2003. Further was the N-content in the compost in the years 1993-1999 assumed to be the same as the median observed for the years 2001-2003 using individual plant data;
- annual reports on compost statistics published by AEV for the year 2000 and onwards[109] .

5.4.3.2.6 Digestate originating from energy crops and other waste ($AR_{N\_applied (digestate\_engery crops)}$)

N in digestate after storage originating from energy crops and other waste ($m_{digN(ECO)}$) was obtained from 5B2 (see section 6.4.2.2.2), but was corrected for the quantities of digestate exported for application on fields outside Luxemburg ($m_{digN(ECO)\_EXPORT}$), see section 5.2.6) in order to obtain the quantities of digestate originating from energy crops and other waste for application on fields in Luxemburg and summarized in Table 5-50.

$$AR_{N_{applied}(digestate_{energy}crops)} = m_{dig_{N(ECO)\_LU}} = (m_{di\ \ N(ECO)} - m_{di\ \ N(ECO)\_EXPORT}\ \ )$$

By assuming that 56% of total-N is present as TAN, same as (Haenel, et al., 2020), was the amounts of TAN in digestate applied to fields in Luxemburg estimated ($m_{dig\_TAN(ECO)\_LU}$):

$$m_{dig\_TAN(ECO\_LU)} = (0.56 * m_{dig\_N(ECO)\_LU})$$

For the amount of NH_3 emitted (in kg per year), the amount of the annual TAN applied to the field was further split up between the surface cover of the fields *c*, with *c* being grassland; arable land with vegetation and arable land without vegetation; according to technique used for spreading (*s*), with *s* being broadcast, training hose, training shoe, infecting techniques and slurry cultivator; and in case of arable land without cover, a further distinction was made, depending on the time span passed between spreading and incorporation (*t*), with *t* being <1 hour, <4 hours, <6 hours, <8 hours, >8/12 hours and no incorporation. The used frequencies are summarized in Table 5-49.

5.4.3.2.7 Urine and dung deposited by grazing animals ($AR_{N\_applied (grazing)}$)

N in urine and dung deposited by grazing animals ($AR_{N\_applied (grazing)}$) was determined using a mass-flow approach based on the concept of a flow of total ammoniacal nitrogen (TAN) through the manure management, for a detailed description of the fifteen steps, see section 5.2.5.

[109] See https://data.public.lu/en/datasets/biodechets/#

The amount of the annual N excreted that is deposited during grazing ($m_{grazing\_N(i)}$), expressed in kg N per year per head/place for animal category *i*, and determined in step 3 section 5.2.5 was multiplied by the number of animals for livestock category *i* and summed over all livestock to determine $AR_{N\_applied\ (grazing)}$, in short:

$$AR_{N_{applied}}(grazing)\_LU = \sum_i([m_{grazing\_N(i)}] * (n_i + n_{Temporary\ Imported\ GrazingAnimals(i)} - n_{Temorary\ Exported\ GrazingAnimals(i)})$$

with

$m_{grazing\_N(i)}$	the amount of the annual N excreted that is deposited during grazing (expressed in kg N per year per head/place) for animal category *i*, and was determined in step 3 using a mass-flow approach (see section 5.2.5);
n_i	the number of animals for livestock category *i* and summarized in Table 5-4;
$n_{ITemporary\ Imported\_GrazingAnimals(i)}$	number of temporay imported grazing animals for grazing on fields in Luxemburg for livestock category *i* (see Table 5-5);
$n_{Temporary\ Exported\_GrazingAnimals(i)}$	number of temporary exported grazing animals for grazing on fields outside Luxemburg for livestock category *i* (see Table 5-5);

Whereas for the amount of NH_3 emitted (in kg per year) the amount of the annual TAN excreted and deposited during grazing, expressed in kg TAN per year for animal category *i* was used. For additional details see step 14 in section 5.2.5.

5.4.3.2.8 Crop residues applied to soils ($AR_{N\ applied\ (Crop\ residues)}$)

The annual amount of N in crop residues (above and below ground), including N-fixing crops and from forage/pasture renewal, returned to soils annually ($AR_{N\_applied\_Crop\ residuies}$), expressed in kg N per year is summarized in Table 5-50, and was estimated based on equation 11.6 the 2019 Refinement to the 2006 IPCC Guidelines (Hergoualc'h, et al., 2019):

$$AR_{N\_applied\_CR} = \sum_k\{[AGR_k * N_{AG(k)} * (1 - Frac_{Remove(k)})] + [BGR_k * N_{BG(k)}]\}$$

with:

$$AGR_k = AG_{DM(k)} * Area_k = (Crop_k * R_{AG(k)}) * Area_k$$

$$BGR_k = (Crop_k + AG_{DM(k)}) * RS_k * Area_k * Frac_{Renew(k)}$$

where

AGR_k	= annual total amount of above-ground crop residue for crop *k*, kg dry matter per year, with *k* = crop or forage type
$N_{AG(k)}$	= N content in above ground residues in kg N
$Frac_{Removed(k)}$	= fraction of above-ground residues of crop *k* removed annually for purposes as feed and bedding
BGR_k	= annual total amount of below ground crop residue for crop *k*, kg dry matter per year, with *k* = crop or forage type
$N_{BG(k)}$	= N content in below ground residues in kg N
$AG_{DM(k)}$	= above ground residues dry-matter for crop *k*, kg d.m. per ha
$Crop_k$	= harvested annual dry matter yield for crop *k*, ha d.m. per year

$R_{AG(k)}$ = ratio above ground residues dry-matter to harvested yield for crop *k*, kg dry matter per ha

$Area_k$ = total annual area harvested of crop k, ha per year

RS_k = ratio of below-ground root biomass to above-ground shoot biomass for crop *k*, kg dry matter per ha

$Frac_{Renew(k)}$ = fraction of total area under crop *k* that is renewed annually

Note: The above equation was slightly adapted as burning of crop residues is forbidden by law in Luxemburg, and therefore assumed to not occur. The cultivated crop area for 1990-2021 ($Area_k$) is summarized in Table 5-45 (see section 5.4.3.2.1). The used parameters for $Crop_k$,AGR_k, $N_{AG(k)}$, $Frac_{Removed(k)}$, BGR_k, $N_{BG(k)}$, $AG_{DM(k)}$, $R_{AG(k)}$, RS_k and $Frac_{Renew(k)}$ were presented in section 5-6-1-3 in the NIR 2024.

Table 5-50 – Activity data of N inputs for category *3D – Crop production and agricultural soils*: 1990-2022 (kg N)

3 - Agriculture

Activity data - Annual amount of N inputs to soil (kg N/year) from different sources

3D- Crop production and agricultural soils

Year	Synthetic fertilizer	Animal manure	Sewage sludge	Compost	Digestate (energy crops & non-agr. waste)	Grazing	Crop residues
1990	18 218 653	8 590 319	371 985	-	-	5 162 269	1 445 881
1991	18 983 396	8 530 126	372 205	-	-	5 285 211	1 524 344
1992	20 484 409	8 097 044	376 491	-	-	5 112 247	1 534 309
1993	18 687 016	8 122 177	391 126	10 513	-	5 138 502	1 570 548
1994	17 740 897	8 020 890	409 055	11 888	-	5 117 691	1 457 385
1995	17 407 501	8 235 827	406 178	15 130	-	5 280 713	1 584 870
1996	17 489 448	8 325 784	352 796	14 408	-	5 374 170	1 707 970
1997	17 220 060	8 155 938	369 747	29 637	-	5 232 189	1 730 836
1998	16 873 182	8 103 127	370 828	47 992	2 410	5 157 325	1 768 716
1999	17 400 520	8 098 349	368 839	49 670	5 846	5 185 761	1 825 360
2000	17 180 729	7 945 074	193 515	93 077	9 489	5 160 075	1 770 879
2001	14 655 099	7 884 850	181 353	43 384	14 775	5 138 146	1 780 267
2002	15 267 722	7 621 168	191 920	49 819	26 133	4 994 835	1 745 014
2003	12 443 168	7 480 533	146 205	25 282	42 979	4 877 587	1 715 055
2004	15 769 127	7 568 168	121 081	34 736	97 691	4 884 444	2 021 011
2005	13 762 308	7 526 856	159 100	84 921	158 714	4 833 017	1 825 602
2006	13 680 584	7 424 943	139 750	74 971	243 234	4 859 206	1 781 709
2007	12 722 328	7 588 316	165 609	77 357	286 615	5 089 680	1 867 114
2008	12 781 284	7 786 424	156 780	87 340	322 030	5 222 545	1 999 399
2009	12 644 457	7 689 769	103 488	82 833	442 939	5 214 667	2 050 516
2010	13 058 411	7 850 971	103 729	99 310	420 395	5 326 376	1 781 877
2011	13 642 135	7 688 187	137 317	70 731	660 733	5 100 221	1 621 660
2012	12 912 925	7 493 490	165 135	50 606	650 387	4 913 198	1 871 469
2013	12 628 048	7 655 113	132 854	43 191	645 886	4 943 999	1 902 688
2014	11 990 249	7 890 958	122 577	48 488	759 323	5 092 512	2 050 299
2015	12 164 881	8 016 481	144 931	59 767	696 079	5 127 788	1 726 056
2016	12 875 308	8 364 895	77 569	59 835	740 772	5 095 391	1 679 060
2017	12 666 185	8 680 694	78 285	72 794	858 412	5 052 824	1 834 096
2018	12 065 012	8 790 887	46 674	58 868	982 879	4 837 284	1 689 400
2019	12 679 772	8 765 799	45 038	63 245	766 835	4 609 340	1 623 480
2020	12 000 433	8 755 672	93 164	75 185	724 598	4 422 077	1 637 029
2021	12 704 561	8 682 309	38 486	87 125	646 136	4 273 893	1 831 652
2022	7 618 981	8 341 663	44 936	99 443	565 648	4 282 992	1 605 139

5.4.3.2.9 HCB emissions per ha arable land, respectively mass of individual pesticide *p* ($m_{pest(p)}$)

For the years 1990-2011, due to a lack of activity data, the emission of HCB from the use of pesticides were derived from the German HCB emissions from the use of pesticides, for details see section 5.4.3.1.5 and Table 5-44.

For the years 2012-2021 was for the mass of individual pesticide *p* applied, in kg per year, based on statistics derived from the Luxemburgish Farm accounting data network (LTBN) (SER, Utilisation de pesticides dans l'agriculture et la viticultre, 2023). However, as these statistics do represent the agricultural surface cultivated by luxemburgish farmers rather than the agricultural surface cultivated in Luxemburg, they were downwards corrected to fit the agricultural surface cultivated in Luxembourg.

Statistics for the mass of individual pesticide *p* applied for the year 2022 were not yet published, why using here a five-year trend.

5.4.3.3 Emission factors

5.4.3.3.1 Ammonia emissions

NH_3 emissions from the use of synthetic fertilizer were estimated using a Tier 2 methodology and default emissions factors as listed in Table 3.2 from the EMEP guidelines (Hutchings, Webb, & Amon, 2023). According to the field experts[110] were there are no differences with respect to utilized fertilizer and the soil pH. The used EF was therefore calculated by taking the proportion of fertilizer applied to used agriculture surfaces with a normal pH and to used agriculture surfaces with a high pH into account and is summarized in Table 5-51. The used map is available online at https://data.public.lu/fr/datasets/carte-du-statut-acido-basique-dans-les-sols-agricoles/. As a proxy to define if soil had a normal, respectively a high pH, the threshold of 6.5 pH CaCl2 was used, whereby 78.2% would be normal, and 21.8% would have a high pH.

Table 5-51– NH_3 Emissions factors used for the emissions from fertilizers (in g NH3 per kg N applied per year)

3 – Agriculture

NH3 Emission factors for emissions from fertilizer (in g NH3 / kg N applied per year)

Fertilizer type	Normal pH	High pH	Used EF
Anhydrous ammonia (AH)	20	20	20
Ammonium nitrate (AN)	24	52	30.1
Ammonium phosphate (AP)	84	187	106.5
Ammonium sulphate (AS)	84	187	106.5
Calcium Ammonium Nitrate (CAN)	24	50	30.1
NK mixtures	52	52	52.0
NPK mixtures	84	187	106.5
NP mixtures	84	187	106.5
N solutions	87	161	103.1
Other straight N compounds	84	187	106.5
Urea	195	206	197.4

Sources: 2023 EMEP guidelines (Hutchings, Webb, & Amon, 2023).

[110] Karl Weckbecker and Paul Jacqué, SER, Division de la gestion, de la comptabilité et de l'entraide agricoles; Simone Marx; ASTA, Service de pédologie; personal communications; July 2020

NH_3 emissions from the field application of animal manure and for the deposition of excreta when grazing was estimated following a mass-flow approach based on the concept of a flow of total ammoniacal nitrogen (TAN) through the manure management system (for details see section 5.2.5 step and step 14 for grazing, respectively).

The used emission factors to estimate kg NH_3-N per year for livestock category *i* for dung and urine deposited by grazing animals are summarized in Table 5-52 and were based on Table 3.9 from the EMEP guidelines (Amon H. D., 2023).

The used emission factors to estimate kg NH_3-N per year for livestock category *i* for the application of solid manure are different, depending on:

- the surface cover where solid manure would have been applied, whereby distinguishing between grassland, arable land with vegetation and arable land without vegetation;
- and in case of arable land without vegetation, it was further distinguished if incorporated within 1 hour, 1-4 hours; 4-8 hours; >8/12 hours and no incorporation
- whereby using always broadcast.

The used EFs were based on the German inventory, (Vos, et al., Submission 2022) (Haenel, et al., 2020), as climate condition, feeding condition and stable systems are similar, and are summarized in Table 5-52.

Table 5-52– NH_3-N Emissions factors used for the emissions from the field application of solid animal manure and for grazing

3 – Agriculture

NH_3-N Emission factors for emissions from the solid manure application and from deposition of dung and urine by grazing animals (in kg NH_3-N / kg TAN applied per year)

Animal category	$EF_{applic\_solid\_NH3-N(i)}$					$EF_{grazing\_NH3-N(i)}$
	Grassland / Arable land with vegetation / Arable land without vegetation and without incorporation	Arable land without vegetation and with incorporation within				
		≤ 1h	≤4h	≤ 8h	>12h	
Non-dairy cattle	0.90	0.09	0.45	0.72	0.9	0.14
Lactating dairy cows	0.90	0.09	0.45	0.72	0.9	0.14
Sows	0.90	0.09	0.45	0.72	0.9	0.31
Fattening pigs & weaners	0.90	0.09	0.45	0.72	0.9	NO
Sheep (mature sheep and lambs)	0.90	0.09	0.45	0.72	0.9	0.09
Goats (mature goats and kids)	0.90	0.09	0.45	0.72	0.9	0.09
Horses (including assess and mules)	0.90	0.09	0.45	0.72	0.9	0.35
Broilers	0.90 [a]	0.09	0.45	0.72	0.9	NO
Laying hens	0.90[a]	0.09	0.45	0.72	0.9	NO
Other poultry	0.90[a]	0.09	0.45	0.72	0.9	NO
Ostriches	0.90[a]	0.09	0.45	0.72	0.9	NE
Rabbits (breeding female animals and other rabbits)	0.90 [b]	0.09	0.45	0.72	0.9	NO
Deer	0.90 [c]	0.09	0.45	0.72	0.9	0.09[c]

Note: a) EF for poultry; b) Using the EF for horses as proxy for rabbits; c) Using the EFs for sheep as proxy for deers.

The used emission factors to estimate kg NH_3-N per year for livestock category *i* for the application of slurry are different, depending on:

- the used technique (i.e. broadcast, trailing hose, trailing shoe, injector and slurry cultivator);
- the surface cover where liquid manure would have been applied, whereby distinguishing between grassland, arable land vegetation and arable land without vegetation;
- and in case of arable land without vegetation, it was further distinguished if incorporated within 1 hour, 1-4 hours; 4-6 hours; 6-8 hours, >8/12 hours and no incorporation

The used EF's were based on the German inventory, as climate condition, feeding condition and stable systems (and consequently the consistence of slurry) are similar between both countries (Haenel, et al., 2020), (Vos, et al., Submission 2022) and are summarised in Table 5-53.

As the viscosity of untreated cattle slurry is similar to that of the digestate were the emission factors (EF) from cattle-slurry adopted (see Table 5-53), similar as in the German inventory (Haenel, et al., 2020), (Vos, et al., Submission 2022). However, the EFs differed, depending on i) the surface cover of the fields (i.e. grassland; arable land with plant cover; arable land without cover); ii) the technique used (i.e. broadcast, training hose, training shoe, infecting techniques and slurry cultivator), and iii) in case of arable land without cover, also the time span between spreading and incorporation. These EFs applied for digestate originating from animal manure, both national produced as well as imported manure being used as feedstock, as well as for digestate originating from energy crops and non-agricultural waste.

Table 5-53: NH_3-N Emissions factors used for the emissions during and immediately after field application of liquid animal manure/slurry

3 – Agriculture

NH_3-N Emission factors for emissions from the liquid manure application (in kg NH_3-N / kg TAN applied per year) using

Livestock category (i) / Spreading techniques	Broadcast	Trailing hose	Trailing shoe	Injection techniques	Slurry cultivator
Cattle (Dairy cattle / Non-dairy cattle) [a]					
Grassland	0.60	0.54	0.36	0.24	NA
Arable land with vegetation	0.50	0.35	0.30	0.24	NA
Arable land without vegetation					
& without incorporation (>12 hours)	0.50	0.46	0.36	NA	NA
& with incorporation ≤1 hour	0.10	0.004	0.004	0.24[b]	0.04[b]
& with incorporation ≤4 hour	0.26	0.15	0.15	NA	NA
& with incorporation ≤6 hour	0.35	0.20	0.20	NA	NA
& with incorporation ≤12 hour	0.43	0.30	0.30	NA	NA
Swine					
Grassland	0.30	0.21	0.12	0.06	NA

NH_3-N Emission factors for emissions from the liquid manure application (in kg NH_3-N / kg TAN applied per year) using

Livestock category (i) / Spreading techniques	Broadcast	Trailing hose	Trailing shoe	Injection techniques	Slurry cultivator
Arable land with vegetation	0.25	0.125	0.120	0.06	NA
Arable land without vegetation					
& without incorporation (>12 hours)	0.25	0.175	0.12	NA	NA
& with incorporation ≤1 hour	0.04	0.02	0.02	0.06[b]	0.02[b]
& with incorporation ≤4 hour	0.0[d]	0.06	0.06	NA	NA
& with incorporation ≤6 hour	0.11	0.08	0.08	NA	NA
& with incorporation ≤12 hour	0.16	0.11	0.11	NA	NA

Note:
a) As the viscosity of untreated cattle slurry is similar to that of the digestate were the emission factors (EF) from cattle-slurry adopted, similar as in the German inventory (Haenel, et al., 2020) .
b) Slurry cultivator and injection techniques are by definition immediate incorporation.

NH_3 emissions from the use of sewage sludge and compost, respectively were estimated using a Tier 1 methodology and default emissions factors as listed in Table 3.1 of the EMEP guidelines (Hutchings, Webb, & Amon, 2023), these were:

- 0.13 kg NH_3 per kg N of applied sewage sludge
- and 0.08 kg NH_3 per kg waste N applied, respectively.

5.4.3.3.2 Nitride oxides

NO_x emissions were estimated using a TIER 1 methodology and using the default emission factor provided in Table 3.1 of the EMEP guidelines (Hutchings, Webb, & Amon, 2023), namely 0.04 kg NO per kg N applied in synthetic fertiliser; animal manure including digestate originating from animal manure; sewage sludge; other organic fertilisers (i.e. compost and digestate originating from energy crops and other waste); and in crop residues.

5.4.3.3.3 NMVOC

NMVOC emission associated with the manure application and NMVOC emission associated with the dung and urine deposited by grazing animals reported in 3Da2a and in 3Da3, respectively, were estimated using a Tier 2 approach (see description in section 5.3.3.1.3).

NMVOC emissions from crop production and agricultural soils were estimated using a TIER 1 methodology and using the default emission factor of 0.86 kg NMVOC per ha per year related to the agricultural area, which was taken from Table 3.1 of the EMEP guidelines (Hutchings, Webb, & Amon, 2023).

5.4.3.3.4 Particle emissions

Particle emissions (i.e. $PM_{2.5}$, PM_{10} and TSP) were estimated using a TIER 1 methodology and using the default emission factors of 1.56 kg PM_{10}/ha/year, 0.06 kg $PM_{2.5}$/ha/year and 1.56 kg TSP/ha/year related to the agricultural area, which were taken from Table 3.1 of the EMEP guidelines (Hutchings, Webb, & Amon, 2023).

5.4.3.3.5 HCB emissions

For the years 1990-2011, due to a lack of activity data, the emission of HCB from the use of pesticides were derived from the German HCB emissions from the use of pesticides, for details see section 5.4.3.1.5 and Table 5-44.

For the years 2012 and onwards, HCB emissions were estimated using a TIER 1 methodology and using the default impurity factor of 40 mg/kg for Chlorothalonil, 50 mg/kg for Picloram and 2.5 mg/kg for Clopyralid, which were the three active substances used in Luxembourg in these years. These default values were taken from Table 7.3 of the EMEP guidelines (Webb, Hutchings, & Amon, 2023).

It is assumed that the HCB volatilisation of the impurity in HCB containing pesticides is 1 (Webb, Hutchings, & Amon, 2023). The use of an emission factor (EF_p) is therefore negligible for the calculation as it would be 1 or 100% (Webb, Hutchings, & Amon, 2023).

5.4.4 Category specific uncertainties

Uncertainty was model using Monte-Carlo techniques, see section 5.2.7 for more details. A detailed description of the assumed uncertainties for activity data and the used emission factors is provided hereafter.

5.4.4.1 Activity data

The uncertainty w.r.t. the activity data of the N in animal manure applied to soil and the N in urine and dung deposited to soils were both determined using a mass-flow approach (see section 5.2.5) and were described in section 5.2.7, in section 5.3.4, in section section 6.4.3 and in the national inventory report 2024 (section 5.2.7 and section 5.4.4).

A detailed description of the uncertainty w.r.t. activity data/parameters values used for activity data for the utilizsed agricultural area, synthetic fertilizer, sewage sludge, compost and crop residues is provided in the national inventory report 2024 (section 5.6.4.1) and for digestate originating from energy crops and other non-agricultural waste in section 6.4.3.

Uncertainty w.r.t. the used quantities of pesticides were assumed to be ±50% for the years 1990-2011, as derived from the German HCB emissions, respectively ±10% for 2012 and onwards when derived from the LTBN database. Uncertainty was modelled as pert-distribution using an uncertainty factor with most likely 100%, minimum 50%, respectively 90% and maximum 150%, respectively 110%.

5.4.4.2 Emission factors

EMEP guidelines quotes a UK study having estimated the NH_3 EF for spreading of slurry to be ±14% (Amon H. D., 2023), the uncertainty for the NH_3 EF for spreading manure and digestate was modelled using a pert-distribution and an uncertainty factor with most likely 100%, minimum 85% and maximum 115%. Further was for solid/liquid manure and digestate the distinction made between the surface cover of the fields; the technique used for spreading, and in case of arable land without cover, a further distinction was made, depending on the time span passed between spreading and incorporation, the 95% CI as obtained from the 2020 measurements were taken as minimum and maximum and assuming a pert-distribution to simulate this uncertainty factor. The NH_3 EF for grazing was modelled using a pert-distribution and an uncertainty factor with most likely 100%, minimum 30% and maximum 250%, according to the 95% confidence interval used in the German inventory (Vos, et al., Submission 2022). According to the EMEP guidelines is the accuracies of overall emissions estimates probably no better than 50% and are EFs the main factor for the uncertainty (Hutchings, Webb, & Amon, 2023). Taking a conservative estimation, uncertainties for NH3-EF for synthetic N-fertilizer, sewage sludge, compost and crop residues was modelled as pert-distribution using an uncertainty factor with most likely 100%, minimum 50% and maximum 150%.

According to the EMEP guidelines guidelines, Table 3-1 (Hutchings, Webb, & Amon, 2023) was the 95% confidence interval (C.I.) for the EF for NO-emission of N applied in fertilizer, compost, digestate originating from energy crops, manure and excreta 0.005 - 0.104; the 95% C.I. for the EF for NMVOC of standing crops (expressed in kg/ha) 0.22 - 3.44; the 95% C.I. for the EF for PM2.5; PM10 and TSP (expressed in kg/ha 0.78-7.8; 0.03-0.3 and 0.78-7.8 respectively. The values from the 95% C.I. were used as minimum and maximum and the default value as most likely value and modelled as pert-distribution.

5.4.5 Category-specific QA/QC procedures

Consistency and completeness checks have been performed directly in the model.

5.4.6 Category-specific recalculations

Revision of livestock numbers and MMS since submission 2023v1 affecting also NRF 3D are described in Table 5-19. Additional revisions and relevant for 3D are described in Table 5-54.

Table 5-54– Recalculations done since the last submission for category *3D – Crop production and agricultural soils*

Source category	Revisions 2023 ➔ 2024	Type of revision
3 D a 1	Revision of EF for inorganic N-fertilizers according to EMEP 2023 guidelines	EF
3 D a 2 a	Revision of the 2021 data on the application of slurry, digestate and solid manure, impacting N-emissions. Provisional data were replaced.	AD / N emissions
3 D a 2 a & 3 D a 3	Revision of GE and VS, according to 2019 Refinement of the 2006, and revision of pregnancy rate for suckler cows impacted NMVOC emissions	AD/EF
3 D a 2 b	The provisional activity data for sewage sludge for the year 2021 was replaced by published data	AD
3 D.f.	For the years: 1990-2011: Revision of estimated HCB emissions per ha, as the activitiy data in the German inventory had been revised (which is the base for the HCB emissions); For 2012 and onwards: new data source for activity data, hence new estimates according to Tier 1 methodology in the EMEP 2023 guidelines	Updated AD / Methodology

The recalculations of the emissions in 3.D.a due to the above updates in AD and EFs are detailed in Table 5-55 and for 3.D.f in Table 5-56.

There were significant increases for NH_3-emissions where the revisions had resulted in an average increase of NH_3-emissions by 9.6%. Whereas for NMVOC emissions the revision resulted in an average decrease of 2.4%, see Table 5-55.

The recalculations resulted in partly higher, partly lower HBC-emission with the median being -3% and a range from-68% to +450%.

Table 5-55– Recalculations for category *3Da – Crop production and agricultural soils* from submission 2023 to submission 2024

3 - Agriculture

3 D - Crop production and agricultural soils

Emissions of air pollutants (Gg)

	Submission 2024						Submission 2023						Difference					
Year	NH_3 [Gg]	NO_x [Gg]	NMVOC [Gg]	$PM_{2.5}$ [Gg]	PM_{10} [Gg]	TSP [Gg]	NH_3 [Gg]	NO_x [Gg]	NMVOC [Gg]	$PM_{2.5}$ [Gg]	PM_{10} [Gg]	TSP [Gg]	NH_3 [%]	NO_x [%]	NMVOC [%]	$PM_{2.5}$ [%]	PM_{10} [%]	TSP [%]
1990	3.5	1.35	1.0	0.008	0.196	0.196	3.1	1.35	1.0	0.008	0.196	0.196	11.9	0.0	-2.4	0.0	0.0	0.0
1991	3.5	1.39	1.0	0.007	0.195	0.195	3.1	1.39	1.0	0.007	0.195	0.195	12.4	0.0	-2.3	0.0	0.0	0.0
1992	3.4	1.42	0.9	0.008	0.195	0.195	3.0	1.42	1.0	0.008	0.195	0.195	13.8	0.0	-2.0	0.0	0.0	0.0
1993	3.4	1.36	1.0	0.008	0.198	0.198	3.0	1.36	1.0	0.008	0.198	0.198	12.7	0.0	-1.9	0.0	0.0	0.0
1994	3.3	1.31	0.9	0.008	0.197	0.197	3.0	1.31	0.9	0.008	0.197	0.197	12.2	0.0	-2.4	0.0	0.0	0.0
1995	3.4	1.32	0.9	0.008	0.197	0.197	3.0	1.32	1.0	0.008	0.197	0.197	11.7	0.0	-2.2	0.0	0.0	0.0
1996	3.4	1.33	0.9	0.008	0.197	0.197	3.1	1.33	1.0	0.008	0.197	0.197	11.7	0.0	-2.2	0.0	0.0	0.0
1997	3.4	1.31	0.9	0.008	0.197	0.197	3.0	1.31	0.9	0.008	0.197	0.197	11.7	0.0	-2.1	0.0	0.0	0.0
1998	3.4	1.29	0.9	0.008	0.198	0.198	3.0	1.29	0.9	0.008	0.198	0.198	11.4	0.0	-1.9	0.0	0.0	0.0
1999	3.4	1.32	0.9	0.008	0.198	0.198	3.0	1.32	0.9	0.008	0.198	0.198	11.7	0.0	-2.0	0.0	0.0	0.0
2000	3.3	1.29	0.9	0.008	0.199	0.199	3.0	1.29	0.9	0.008	0.199	0.199	11.7	0.0	-2.1	0.0	0.0	0.0
2001	3.2	1.19	0.9	0.008	0.199	0.199	2.9	1.19	0.9	0.008	0.199	0.199	10.3	0.0	-2.2	0.0	0.0	0.0
2002	3.1	1.20	0.8	0.008	0.200	0.200	2.8	1.20	0.8	0.008	0.200	0.200	11.1	0.0	-2.3	0.0	0.0	0.0
2003	3.0	1.07	0.8	0.008	0.200	0.200	2.7	1.07	0.8	0.008	0.200	0.200	9.3	0.0	-1.9	0.0	0.0	0.0
2004	3.1	1.22	0.8	0.008	0.200	0.200	2.8	1.22	0.8	0.008	0.200	0.200	11.5	0.0	-2.3	0.0	0.0	0.0
2005	3.2	1.13	0.8	0.008	0.202	0.202	2.9	1.13	0.8	0.008	0.202	0.202	9.2	0.0	-1.8	0.0	0.0	0.0
2006	3.1	1.13	0.8	0.008	0.203	0.203	2.9	1.13	0.8	0.008	0.203	0.203	9.2	0.0	-2.0	0.0	0.0	0.0
2007	3.2	1.11	0.8	0.008	0.203	0.203	2.9	1.11	0.8	0.008	0.203	0.203	8.4	0.0	-2.0	0.0	0.0	0.0
2008	3.2	1.13	0.8	0.008	0.203	0.203	3.0	1.13	0.8	0.008	0.203	0.203	8.2	0.0	-2.0	0.0	0.0	0.0
2009	3.2	1.13	0.7	0.008	0.200	0.200	3.0	1.13	0.8	0.008	0.200	0.200	8.2	0.0	-2.5	0.0	0.0	0.0
2010	3.3	1.15	0.7	0.008	0.202	0.202	3.1	1.15	0.8	0.008	0.202	0.202	7.8	0.0	-2.7	0.0	0.0	0.0
2011	3.3	1.16	0.7	0.008	0.201	0.201	3.1	1.16	0.7	0.008	0.201	0.201	8.2	0.0	-3.0	0.0	0.0	0.0
2012	3.2	1.12	0.7	0.008	0.202	0.202	3.0	1.12	0.7	0.008	0.202	0.202	8.0	0.0	-3.2	0.0	0.0	0.0
2013	3.2	1.12	0.7	0.008	0.201	0.201	3.0	1.12	0.7	0.008	0.201	0.201	7.8	0.0	-3.3	0.0	0.0	0.0
2014	3.3	1.12	0.7	0.008	0.201	0.201	3.0	1.12	0.8	0.008	0.201	0.201	7.2	0.0	-3.4	0.0	0.0	0.0
2015	3.3	1.12	0.7	0.008	0.200	0.200	3.0	1.12	0.8	0.008	0.200	0.200	7.4	0.0	-3.7	0.0	0.0	0.0
2016	3.3	1.16	0.8	0.008	0.200	0.200	3.1	1.16	0.8	0.008	0.200	0.200	7.8	0.0	-2.9	0.0	0.0	0.0
2017	3.4	1.17	0.8	0.008	0.199	0.199	3.2	1.17	0.8	0.008	0.199	0.199	7.4	0.0	-2.6	0.0	0.0	0.0
2018	3.4	1.14	0.8	0.008	0.198	0.198	3.2	1.14	0.8	0.008	0.198	0.198	6.8	0.0	-2.2	0.0	0.0	0.0
2019	3.3	1.14	0.8	0.008	0.197	0.197	3.1	1.14	0.8	0.008	0.197	0.197	7.6	0.0	-2.5	0.0	0.0	0.0
2020	3.3	1.11	0.8	0.008	0.198	0.198	3.1	1.11	0.8	0.008	0.198	0.198	7.6	-0.1	-2.8	0.0	0.0	0.0
2021	3.3	1.13	0.8	0.008	0.198	0.198	3.0	1.13	0.8	0.008	0.198	0.198	8.0	0.1	-3.3	0.0	0.0	0.0
2022	3.0	0.90	0.8	0.008	0.197	0.197												

Table 5-56– Recalculations for category *3Df –HBC emissions from the use of pesticieds* from submission 2023 to submission 2024

3 - Agriculture HCB - Emissions (g per year) 3.D.f - Agriculture other including use of pesticides			
Year	**NEW**	**OLD**	**Difference (in %)**
1990	*540*	*1 394*	-61.2
1991	*488*	*1 040*	-53.1
1992	*352*	*669*	-47.4
1993	*184*	*577*	-68.1
1994	*120*	*124*	-3.4
1995	*115*	*190*	-39.3
1996	*112*	*121*	-7.1
1997	*94*	*114*	-18.2
1998	*126*	*51*	148.2
1999	*117*	*152*	-22.8
2000	*109*	*59*	84.0
2001	*35*	*14*	147.9
2002	*20*	*13*	51.8
2003	*21*	*35*	-39.9
2004	*77*	*14*	449.9
2005	*122*	*97*	26.0
2006	*169*	*103*	64.0
2007	*159*	*90*	76.3
2008	*135*	*88*	52.6
2009	*125*	*67*	86.9
2010	*121*	*86*	39.7
2011	*121*	*85*	42.0
2012	57	*70*	-18.9
2013	102	*79*	30.1
2014	66	*125*	-47.0
2015	60	*99*	-40.1
2016	74	*148*	-49.7
2017	78	*199*	-60.9
2018	117	*64*	82.9
2019	105	*87*	20.2
2020	42	*87*	-51.8
2021	4	*87*	
2022	0.3		

5.4.7 Category-specific planned improvement

Planned improvements, as listed in Table 5-57, will be explored, based on available resources and available data.

Table 5-57– Planned improvements for category – *3D – Crop production and agricultural soils*

Source category	Planned improvements	Type of revision
3D	Countine the quest for data on quantities exported of locally produced animal manure and digestate to France and Germany	AD
3Dc	Quest for data on emitting practices necessary for refining PM emission calculations methodology in one of the next submissions	Update AD / Meth-odolgogy

5.5 Field Burning of Agricultural Residues (Category 3.F)

Article 14, indent 2 of the Law of August, 11 1982 concerning the protection of nature and natural resources (Climat 1982), later abrogated by (Climat 2004, 2018) forbids clearing and burning ("essartement") of fields, meadows, grasslands, roadsides, forests between the 1st of March and the 30th of September. According to this law, the clearing and burning of agricultural residues (such as straw) is not strictly forbidden. However, for economic reasons (residues can be used as litter, as feeding stuff for animals, as feedstock for biogas production or can be sold), field burning is not practiced in Luxembourg and, therefore, emission estimates have been recorded as not occurring (NO).

5.6 Other (Category 3.I)

The treatment of straw with ammonia, the other potential source of air pollutant listed in category 3.I. in the 2019 guidelines (EMEP/EEA 2019a), is not occurring in Luxembourg. According to experts from the field, the one or the other farmer had tried it in the eighties, but they were not very successful, and stopped it. Hence, the practice of treating straw with ammonia was never established as a common agricultural practice in Luxemburg, why the notification not occurring (NO).

6 WASTE

This chapter covers air pollutant emissions occurring during waste handling and waste treatment.

6.1 Source category overview

Emissions from the following categories are reported under category *5 - Waste*:

- *5A - Solid waste disposal on land*
- *5B1 – Composting*
- *5B2 – Anaerobic digestion at biogas facilities*
- *5C1bv – Cremation*
- *5C2 - Open burning of waste*
- *5D1 - Domestic wastewater*
- *5D2 - Industrial wastewater*
- *5E - Other waste handling*

For a more detailed overview on the status of air pollutant emission reporting for category *5 – Waste* please refer to section 6.1.5 on completeness. Sections 6.1.1 and 6.1.2 give an overview on the waste generation and management system in place in Luxembourg as well as an overview of the legislation in place, thus, helping to better understand specific nation circumstances in this category. Emission trends of category *5-Waste* are briefly described in section 6.1.3. For more details on emission trends, please refer to the respective category-specific descriptions.

6.1.1 Luxembourg's Waste Generation and Management System

The common basis for activity data to estimate emissions from categories *5A – Solid Waste disposal on land*, *5B – Biological Treatment of Solid Waste*, and *5C – Incineration and Open Burning of Waste* is the generation of municipal solid waste (MSW). MSW consists of waste collected from households, as well as refuses generated by small industries, retail shops and services (private or institutional). In other words, MSW corresponds to the totality of waste collected by municipalities [111] (Total MSW).

According to the modified Luxembourgish Law of March 21, 2012[112], the collection of MSW falls within the competence of municipalities. As a result, municipalities are joined together in different municipal waste management syndicates. There are four inter-municipal syndicates responsible for the management of municipal solid waste:

- SIDA regrouping the municipalities of Wiltz and others in the north of the country (integrated in SIDEC since 1994);
- SIDEC regrouping the municipalities of Diekirch, Ettelbruck and Colmar-Berg;
- SIDOR regrouping the municipalities of Luxembourg, Esch-sur-Alzette and Capellen;

---

[111] For details on municipal waste collection, see:
http://www.environnement.public.lu/dechets/statistiques_indicateurs/LUXUS_Daten/index.html (in German)
http://www.environnement.public.lu/dechets/statistiques_indicateurs/index.html, line "*Activité des parcs à conteneurs (recycling centres)*" (in French).

[112] Loi modifiée du 21 mars 2012 relative à la gestion des déchets, et modifiant la loi du 31 mai 1999 portant institution d'un fonds pour la protection de l'environnement; la loi du 25 mars 2005 relative au fonctionnement et au financement de l'action SuperDrecksKëscht; la loi du 19 décembre 2008 a) relative aux piles et accumulateurs ainsi qu'aux déchets de piles et d'accumulateurs; b) modifiant la loi modifiée du 17 juin 1994 relative à la prévention et à la gestion des déchets; la loi du 24 mai 2011 relative aux services dans le marché intérieur. http://www.legilux.public.lu/leg/a/archives/2012/0060/2012A0670A.html

- SIGRE regrouping the municipalities of Grevenmacher, Remich and Echternach.

The managed landfill sites of SIDEC and SIGRE opened in 1972 and 1979, respectively. Table 6-1 summarizes the situation for each waste management syndicate.

Table 6-1 – Municipal Solid Waste Syndicates in Luxembourg

Syndicate	Waste Elimination Scheme	Operating Years with Regard to the GHG Inventory
SIDA	Landfill	till 1993
SIDEC	Landfill	1972-2014
	+ Methane recovery system	*2002-ongoing*
	+ Biological treatment	*2007-ongoing*
SIDOR	Incineration	1976-ongoing
SIGRE	Landfill	1979-ongoing
	+ Aerobic treatment	*1993-2014*
	+ Methane recovery system	*2000-ongoing*

Source: Environment Agency.
Notes: SIDEC (www.sidec.lu), SIDOR (http://sidor.lu), and SIGRE (www.sigre.lu)

The waste management syndicates, listed in Table 6-1, exist since 1990 and have been managing their own dumping or incineration site. In 1994, the syndicate SIDA merged with SIDEC and its dumping site was subsequently closed. In 2014, there were two controlled landfill sites (one managed by SIDEC and one managed by SIGRE) and one incinerator (managed by SIDOR) in operation in Luxembourg. In 2015, the syndicates decided to use only one controlled landfill site in Muertendall, managed by SIGRE. The landfill site managed by SIDEC was subsequently closed.

A **methane recovery system** has been in operation at the SIGRE site since 2000, and at the SIDEC site since 2002. The **aerobic treatment** in heaps has been performed at SIGRE since 1993. Also, pre-treatment of solid waste prior landfilling of waste in tunnels has been fully operational since 2007 at SIDEC.

Figure 59 – Waste Flow in Luxembourg before 2015

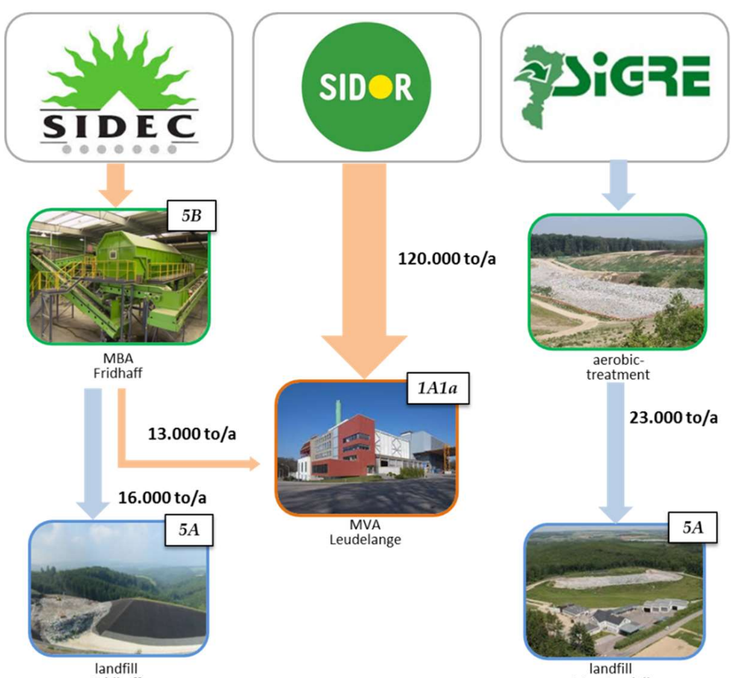
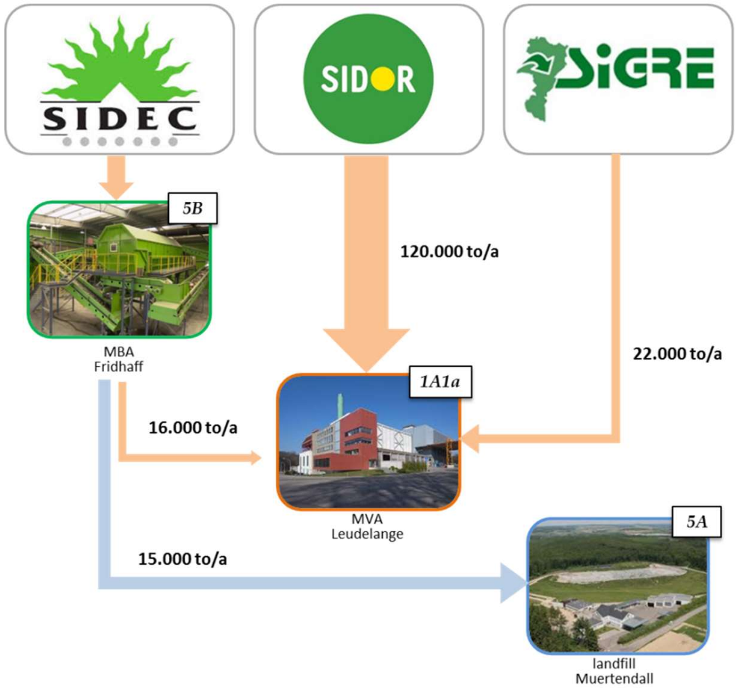


Figure 60 – Waste Flow in Luxembourg after 2015



The total municipal solid waste (Total MSW, municipal waste from households and similar household waste excluding recycling), accounted for in the inventory (Figure 60), is – upon collection – partly:

- landfilled – accounted under category *5A – Solid waste disposal on land* either directly[113] or indirectly after treatment (i.e. emissions occurring during biological treatment are accounted under category *5B – Biological Treatment of Solid Waste*), or
- incinerated (i.e. solid waste to be accounted for under category *1A1a – Public electricity and heat production* as energy is recovered from incineration).

6.1.2 Legislation

The most important legislative and regulatory measures, which have reduced the waste-related emissions from Luxembourg, are included in the :

(i) EU Waste Framework Directive 2008/98/EC,

(ii) Landfill Directive 1999/31/EC,

(iii) Waste Incineration Directive 2000/76/EC, and

(iv) *Loi du 9 juin 2022 modifiant :*

   a. *la loi modifiée du 21 mars 2021 relative aux déchets ;*
   b. *la loi modifiée du 31 mai 1999 portant insitution d'un fonds pour la protection de l'environnement*

[113] Direct landfilling of waste concerns waste with or without mechanical sorting. Direct landfilling was completely abandoned in 2015. Indirect landfilling of waste is referring to waste that is pre-treated.

b. *Règlement grand-ducal du 9 juin 2022 relatif aux avertissements taxés déterminant les modalités d'application de l'avertissement taxé et établissant un catalogue des contraventions soumises à l'avertissement taxé prévu par la loi modifiée du 21 mars 2012 relative aux déchets*.

The Waste Framework Directive mandates waste management as a priority to prevention (non-waste), re-use, recycling and recovery. The latter Directive, which also has introduced the "polluter pays principle", has been transposed on the national level by the Luxembourgish Law of March 21, 2012 [114].

The modern requirements for disposal sites, in order to reduce methane generation, of the Landfill Directive have been transposed into national legislation through the Grand-Ducal Regulation of February 24, 2003 [115], subsequently amended and rectified by the Grand-Ducal Regulation of June 9, 2022 [116].

The aim of the Waste Incineration Directive, transposed by the Grand-Ducal Regulation of May 9, 2014[117], is to prevent or to reduce emissions caused by the incineration of waste. This is to be achieved through the application of operational conditions, technical requirements, and emission limit values for incineration plants within the EU.

Even though the uncontrolled management of waste was already included in the law of 17 june 1994 ("Loi modifiée du 17 juin 1994 relative à la prévention et à la gestion des déchets (abrogée)") the Article 34 of the national law of 9 June 2022[118] states clearly that the abandonment, dumping or uncontrolled management of waste is prohibited. This statement includes the prohibition of open burning of waste, which is considered as an uncontrolled management of waste. This includes the ban on burning of green waste, household and non-domestic waste in the open air. Waste fines imposed for non-compliance with this provision are fixed in the Grand-Ducal Regulation of 9 June December 2022 [119]. Indeed, a fine of 500 € is imposed for open burning of waste and even 250 € for open burning of green waste. Many municipalities have also implemented this prohibition in their respective municipal regulations. However, emissions from accidental fires (cars and buildings) are estimated and reported under category 5E - Other waste handling.

---

[114] Loi modifiée du 21 mars 2012 relative à la gestion des déchets, et modifiant la loi du 31 mai 1999 portant institution d'un fonds pour la protection de l'environnement; la loi du 25 mars 2005 relative au fonctionnement et au financement de l'action SuperDrecksKëscht; la loi du 19 décembre 2008 a) relative aux piles et accumulateurs ainsi qu'aux déchets de piles et d'accumulateurs; b) modifiant la loi modifiée du 17 juin 1994 relative à la prévention et à la gestion des déchets; la loi du 24 mai 2011 relative aux services dans le marché intérieur.
http://www.legilux.public.lu/leg/a/archives/2012/0060/2012A0670A.html

[115] Règlement grand-ducal du 24 février 2003 concernant la mise en décharge des déchets, http://www.legilux.public.lu/leg/a/archives/2003/0034/2003A05461.html

[116] Règlement grand-ducal du 9 juin 2022 modifiant le règlement grand-ducal modifié du 24 février 2003 concernant la mise en décharge des déchets, https://legilux.public.lu/eli/etat/leg/rgd/2022/06/09/a273/jo
http://www.legilux.public.lu/leg/a/archives/2006/0051/2006A1124B.html

[117] Règlement grand-ducal du 9 mai 2014 abrogeant: 1) le règlement grand-ducal modifié du 9 mai 2003 portant application de la directive 2001/80/CE du Parlement européen et du Conseil du 23 octobre 2001 relative à la limitation des émissions de certains polluants dans l'atmosphère en provenance des grandes installations de combustion; 2) le règlement grand-ducal modifié du 4 juin 2001 portant - application de la directive 1999/13/CE du Conseil du 11 mars 1999 relative à la réduction des émissions de composés organiques volatils dues à l'utilisation de solvants organiques dans certaines activités et installations - modification du règlement grand-ducal modifié du 16 juillet 1999 portant nomenclature et classification des établissements classés; 3) le règlement grand-ducal du 19 décembre 1989 relatif aux déchets provenant de l'industrie du dioxyde de titane; 4) le règlement grand-ducal modifié du 19 décembre 2002 concernant l'incinération des déchets. http://legilux.public.lu/eli/etat/leg/rgd/2014/05/09/n1/jo

[118] Loi du 9 juin 2022 modifiant :
1° la loi modifiée du 21 mars 2012 relative aux déchets ;
2° la loi modifiée du 31 mai 1999 portant insitution d'un fonds pour la protection de l'environnement.

[119] Règlement grand-ducal du 9 juin 2022 relatif aux avertissements taxés déterminant les modalités d'application de l'avertissement taxé et établissant un catalogue des contraventions soumises à l'avertissement taxé prévu par la loi modifiée du 21 mars 2012 relative aux déchets. https://legilux.public.lu/eli/etat/leg/rgd/2022/06/09/a268/jo

6.1.3 Emission trends for category *5 – Waste*

This section briefly describes the emission trends from 1990 to 2021 for each of the categories under waste for which emissions are reported.

In 2022, this source category was responsible for:

- 0.007 Gg NMVOC emissions from the waste sector, representing 0.07% of the national total NMVOC emissions (fuel sold).
- 0.065 Gg of NH_3 emissions from the waste sector, representing 1.10% of the national total NH_3 emissions (fuel sold).
- 0.057 Gg $PM_{2.5}$ emissions from the waste sector, representing 5.44% of the national total $PM_{2.5}$ emissions (fuel sold).

As shown in Table 6-2, NMVOC emissions related to waste activities decreased by about 55.7% in the period 1990-2022, mainly due to the increased recovery of landfill gas, as well as the decreasing quantities of waste being landfilled. In category *5A – Solid waste disposal*, NMVOC emissions decreased by 57.2% and for category *5D - Wastewater treatment*, they increased by 7.9%. NH_3 emissions occur mostly in biological treatment of waste activities (*5B1 – Composting or 5B2 – Anaerobic digestion at biogas facilities*). Compared to 2005, NH_3 emissions increased by 42.0% and compared to 2022, emissions decreased by 14.8%. $PM_{2.5}$ emissions occur mostly in category *5E – Other waste* (accidental car and building fires). Due to a steady increase in population and dwellings, these emissions increased by 86.0% since 1990.

Table 6-2 – Emissions, emission trends and shares for category *5 - Waste*

5 - Waste														
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2021	2022	1990 - 2022	2005 - 2022	2021 - 2022	1990	2005	2022	1990	2005	2022	
SO2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
NOx	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
NMVOC	0.0164	0.0136	0.0080	0.0073	-56%	-46%	-9%	0.0759%	0.1117%	0.0747%	0.0529%	0.1117%	0.0726%	fuel sold
NH3	NO	0.0459	0.0766	0.0652	NO	42%	-15%	NO	0.7681%	1.1159%	NO	0.7203%	1.0966%	fuel sold
CO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
TSP	0.0311	0.0401	0.0462	0.0576	85%	44%	25%	0.1847%	1.7676%	2.7728%	0.1757%	1.0031%	2.2773%	fuel sold
PM10	0.0308	0.0391	0.0457	0.0572	86%	46%	25%	0.1920%	2.1758%	4.0867%	0.1831%	1.2157%	3.3894%	fuel sold
PM2.5	0.0306	0.0383	0.0453	0.0569	86%	49%	26%	0.1991%	2.8411%	6.4878%	0.1904%	1.5074%	5.4444%	fuel sold

6.1.4 Key category analysis

The methodology and results of the key category analysis are presented in Chapter 1. With regard to NH3 emissions, category *5B2 – Anaerobic disgistion at biogas facilities* is a key category in 2022, in the trend assessment. With regard to PM emissions, category *5E - Other Waste* is a key category in 2022, in the level assessment. Table 6-3 presents the key categories for category *5 - Waste*.

Table 6-3 - Key category analysis for category *5 - Waste*

Key Source Analysis (FUEL SOLD): Ranking per number		SO2		NOX		NMVOC		NH3		CO		TSP		PM10		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
5 B 2	Anaerobic digestion at biogas facilities								5								
5 E	Other waste (please specify in IIR)															5	

Key Source Analysis (FUEL USED): Ranking per number		SO2		NOX		NMVOC		NH3		PM2.5	
NFR Code	NFR Category	LA	TA	LA	TA	LA	TA	LA	TA	LA	TA
5 B 2	Anaerobic digestion at biogas facilities								4		
5 E	Other waste (please specify in IIR)									4	

Source: Environment Agency
Notes: LA = Level Assessment, TA = Trend Assessment, number in table indicates rank in the specific analysis (1=biggest KC; 2=second biggest KC, …)

6.1.5 Completeness

Table 6-4 gives an overview of the categories included under sector 5 - *Waste* and provides information on the status of emission estimates for all subcategories.

Table 6-4 – Status of reporting for category *5 – Waste*

NFR Code	WASTE	NO_X	NMVOC	SO_X	NH_3	CO	TSP	PM_{10}	$PM_{2.5}$
5 A	Solid waste disposal on land	NA	X	NA	NE	NE	X	X	X
5 B 1	Composting	NE	NE	NE	X	NE	NE	NE	NE
5 B 2	Anaerobic digestion at biogas facilities	NE	NE	NE	X	NE	NE	NE	NE
5 C 1 a	Municipal waste incineration	IE	IE	IE	IE	IE	IE	IE	IE
5 C 1 b i	Industrial waste	NO	NO	NO	NO	NO	NO	NO	NO
5 C 1 b ii	Hazardous waste	NO	NO	NO	NO	NO	NO	NO	NO
5 C 1 b iii	Clinical waste	NO	NO	NO	NO	NO	NO	NO	NO
5 C 1 b iv	Sewage sludge	IE	IE	IE	IE	IE	IE	IE	IE
5 C 1 b v	Cremation	IE	IE	IE	NE	IE	IE	IE	IE
5 C 1 b vi	Other waste	NO	NO	NO	NO	NO	NO	NO	NO
5 C 2	Open burning of waste	NO	NO	NO	NO	NO	NO	NO	NO
5 D 1	Domestic wastewater	NA	X	NA	NO	NA	NE	NE	NE
5 D 2	Industrial wastewater	NA	X	NA	NE	NA	NE	NE	NE
5 D 3	Other wastewater	NO	NO	NO	NO	NO	NO	NO	NO
5 E	Other waste handling	NE	NE	NE	NE	NE	X	X	X

Table 6-5 provides explanations to the use of notation key NE in category *5 - Waste*.

Table 6-5 – Explanations for notation key NE in category *5 - Waste*

	Substance(s)	Reason for not estimated
5C1bv Cremation	NH_3	No emission factor is provided in the EMEP/EEA Guidebook for this pollutant
5A Solid waste disposal on land	NH_3, CO	No emission factors are provided in the EMEP/EEA Guidebook for these pollutants
5B1 Composting	NO_X, SO_2, NMVOC, CO, TSP, PM_{10}, $PM_{2.5}$	No emission factors are provided in the EMEP/EEA Guidebook for these pollutants
5B2 Anaerobic digestion at biogas facilities	NO_X, SO_2, NMVOC, CO, TSP, PM_{10}, $PM_{2.5}$	No emission factors are provided in the EMEP/EEA Guidebook for these pollutants
5D1 Domestic wastewater & 5D2 Industrial wastewater	NH_3 (only for 5D2), TSP, PM_{10}, $PM_{2.5}$	No emission factors are provided in the EMEP/EEA Guidebook for these pollutants
5E Other waste handling (accidental fires)	NO_X, SO_2, NMVOC, NH_3, CO	No emission factors are provided in the EMEP/EEA Guidebook for these pollutants

Table 6-6 provides explanations to the use of notation key IE in category *5 - Waste*.

Table 6-6 – Explanations for notation key IE in category *5 - Waste*

NFR code	Substance(s)	Included in (IE) NFR code	Explanation
5 C 1 a Municipal waste incineration	NO_X, SO_2, NMVOC, NH_3, TSP, PM_{10}, $PM_{2.5}$	1A1a	Energy is recovered from the sole incinerator.
5 C 1 b iv Sewage sludge	NO_X, SO_2, NMVOC, NH_3, TSP, PM_{10}, $PM_{2.5}$	1A2f ; 3D	Sewage sludge, if not exported, is either incinerated or spread on fields

5C1bv Cremation	NO_X, SO_2, NMVOC, TSP, PM_{10}, $PM_{2.5}$	1A4ai	As only one plant exists in Luxembourg for cremation of human bodies, as no plant-specific natural gas consumption is known and inorder to avoid double counting with the energy-balance it was decided to report emissions as "IE" as the relative natural gas consumption, and hence the emissions are included under 1A4ai.

6.2 Solid waste disposal on land (5.A)

6.2.1 Source category description

Category *5A – Solid waste disposal on land* covers NMVOC emissions of municipal solid waste (MSW) disposal on landfills as well as PM emissions of the disposal of solid inert waste on landfills.

6.2.1.1 Key categories

With regard to NMVOC and PM emissions, category *5A – Solid waste disposal on land* is not a key category in 2022, neither in the level, nor in the trend assessments.

6.2.1.2 Emission trends

Table 6-7 presents the emission trends of this category. NMVOC emissions are generally decreasing, as less and less MSW is deposited on land as well as due to the pre-treatment of waste before landfilling. On the other hand, PM emissions are increasing due to the increasing building activities and the inheriting increase in earth excavation and inert construction waste.

Table 6-7 – Emission trends for category 5A – Solid waste disposal on land

5A - Solid waste disposal on land									
Emissions									
Year	NOx	NMVOC	NH3	TSP	PM10	PM2.5	Cd	Pb	Hg
	t	*t*	*t*	*t*	*t*	*t*	*t*	*t*	*t*
1990	NA	15.93	NE	0.50	0.23	0.04	NA	NA	NE
1991	NA	16.28	NE	0.50	0.23	0.04	NA	NA	NE
1992	NA	16.34	NE	0.50	0.23	0.04	NA	NA	NE
1993	NA	16.12	NE	0.42	0.20	0.03	NA	NA	NE
1994	NA	14.61	NE	0.35	0.16	0.02	NA	NA	NE
1995	NA	14.56	NE	0.62	0.30	0.04	NA	NA	NE
1996	NA	14.55	NE	0.37	0.17	0.03	NA	NA	NE
1997	NA	14.89	NE	1.08	0.51	0.08	NA	NA	NE
1998	NA	14.91	NE	1.37	0.65	0.10	NA	NA	NE
1999	NA	14.92	NE	1.80	0.85	0.13	NA	NA	NE
2000	NA	14.29	NE	2.03	0.96	0.15	NA	NA	NE
2001	NA	14.13	NE	1.75	0.83	0.12	NA	NA	NE
2002	NA	14.06	NE	1.49	0.70	0.11	NA	NA	NE
2003	NA	14.10	NE	1.92	0.91	0.14	NA	NA	NE
2004	NA	13.25	NE	1.88	0.89	0.13	NA	NA	NE
2005	NA	12.90	NE	1.92	0.91	0.14	NA	NA	NE
2006	NA	12.69	NE	1.67	0.79	0.12	NA	NA	NE
2007	NA	12.61	NE	2.31	1.09	0.16	NA	NA	NE
2008	NA	12.32	NE	2.82	1.34	0.20	NA	NA	NE
2009	NA	12.15	NE	3.02	1.43	0.22	NA	NA	NE
2010	NA	10.15	NE	2.84	1.34	0.20	NA	NA	NE
2011	NA	10.18	NE	3.03	1.43	0.22	NA	NA	NE
2012	NA	9.70	NE	1.60	0.76	0.11	NA	NA	NE
2013	NA	9.90	NE	2.04	0.96	0.15	NA	NA	NE
2014	NA	9.79	NE	1.49	0.71	0.11	NA	NA	NE
2015	NA	9.39	NE	1.84	0.87	0.13	NA	NA	NE
2016	NA	8.55	NE	1.94	0.92	0.14	NA	NA	NE
2017	NA	8.77	NE	1.48	0.70	0.11	NA	NA	NE
2018	NA	8.24	NE	1.12	0.53	0.08	NA	NA	NE
2019	NA	7.97	NE	0.86	0.41	0.06	NA	NA	NE
2020	NA	7.75	NE	0.88	0.42	0.06	NA	NA	NE
2021	NA	7.43	NE	0.87	0.41	0.06	NA	NA	NE
2022	NA	6.81	NE	0.75	0.35	0.05	NA	NA	NE
Trend 1990-2022	*NA*	*-57.22%*	*NA*	*51.32%*	*51.32%*	*51.32%*	*NA*	*NA*	*NA*
2005-2022	*NA*	*-47.16%*	*NA*	*-60.97%*	*-60.97%*	*-60.97%*	*NA*	*NA*	*NA*
2021-2022	*NA*	*-8.33%*	*NA*	*-13.66%*	*-13.66%*	*-13.66%*	*NA*	*NA*	*NA*

6.2.2 Methodological issues

6.2.2.1 NMVOC

For the calculation of NMVOC emissions from solid waste disposal on land, activity data was based on the quantity of methane in the generated landfill gas as calculated in the greenhouse gas emission inventory[120]. The amount of landfill gas generated was then back calculated based on the parameters shown in Table 6-8. The amount of methane emitted from landfilling is provided in Table 6-9. Finally, NMVOC emissions were calculated with the default NMVOC content in landfill gas, as provided in the EMEP/EEA Guidebook 2023 (see Table 6-8).

Table 6-8 – Conversion factor for the calculation of landfill gas

Parameter / emission factor	Source	Value	Unit
Methane content in landfill gas	EEA/EMEP GB 2023 (Chap. 5A, §3.3.2, p7)	50	%
Molar volume	at normal conditions of temperature (25°C) and pressure (1 atm): https://en.wikipedia.org/wiki/Molar_volume	0.0245	m^3/mol
NMVOC content in landfill gas	EEA/EMEP GB 2023 (Chap. 5A, Tab3-1 - Note, p5)	5.65	g NMVOC / m^3 LFG

Table 6-9 – Methane emitted from landfill gas

CH_4 (Gg)								
1990	1991	1992	1993	1994	1995	1996	1997	1998
3.69	3.77	3.78	3.73	3.38	3.37	3.37	3.45	3.45
1999	2000	2001	2002	2003	2004	2005	2006	2007
3.45	3.31	3.27	3.26	3.26	3.07	2.99	2.94	2.92
2008	2009	2010	2011	2012	2013	2014	2015	2016
2.85	2.81	2.35	2.36	2.24	2.29	2.27	2.17	1.98
2017	2018	2019	2020	2021	2022			
2.03	1.91	1.85	1.79	1.72	1.58			

Source: Luxembourg's greenhouse gas emission inventory 2024.

6.2.2.2 PM emissions

For the calculation of PM emissions from solid waste disposal on land, which consists mainly of inert construction and excavation waste, activity data was based on national statistics of inert waste (Table 6-10).

[120] for more details on the waste generation, and the calculation of methane released please refer to the National Inventory Report 2021, available at: https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/national-inventory-submissions-2021

Table 6-10 – Amount of inert waste landfilled

Inert waste landfilled (Gg)								
1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
1071	1071	1071	910	749	1349	789	2331	2968
1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
3887	4395	3773	3208	4149	4071	4152	3615	4997
2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
6097	6532	6129	6543	3465	4400	3220	3963	4196
2017	**2018**	**2019**	**2020**	**2021**	**2022**			
3203	2422	1867	1909	1877	1621			

Source: STATEC.

In a second step, the EMEP/EEA Tier 1 approach was then applied for estimating the corresponding PM emissions. An overview of the default emission factors (EF) used is given in Table 6-11.

Table 6-11 – PM emission factors used for category *5A – Solid waste disposal on land*

Gasoline	Source	Value	Unit
EF $PM_{2.5}$	EEA/EMEP GB 2023 (Chap. 5A, Tab3-1, p6)	0.033	g/Mg
EF PM_{10}	EEA/EMEP GB 2023 (Chap. 5A, Tab3-1, p6)	0.219	g/Mg
EF TSP	EEA/EMEP GB 2023 (Chap. 5A, Tab3-1, p6)	0.463	g/Mg

6.2.3 Uncertainties and time-series consistency

The assessment of activity data and emission factor uncertainties is done according to the methodology described in the EMEP/EEA emission inventory Guidebook 2023 (Chapter A.5 Uncertainties, tables 2-1, 2-2 and 2-3), covering the main pollutants NO_x, NH_3, NMVOC, SO_x and $PM_{2.5}$. For some subcategories and pollutants, expert judgements were made to estimate AD or EF uncertainties. For CO, PM10, heavy metzals and persistent organic pollutants, no uncertainty estimates are currently made. Details on uncertainty of the activity data can also be checked in the Luxembourg's National Inventory report (NIR). Please also refer to Table 1-33 to Table 1-37 of section 1.7 for caterogory specific uncertainties on activity data and emission factors.

The time series reported under *5A – Solid waste disposal on land* are considered to be consistent. Fluctuations in the time series may occur due to inter-annual changes in the generation of landfill gas, or the generation of inert waste (excavation and construction). In a small sized country, these fluctuations can be much more visible than in larger countries.

6.2.4 Source-specific QA/QC and verification

Standard QA/QC procedures were followed.

Consistency and completeness checks have been performed.

Category-specific recalculations including changes made in response to the review process Table 6-12 presents the main revisions and recalculations done since submission 2023.

Table 6-12 – Recalculations done since the last submission for category *5A – Solid waste disposal on land*

Source category	Revisions 2023 ➔ 2024	Type of revision
5A	NMVOC emissions from solid waste disposal on land were revised for the entire timeseries as the calculation is based on the molar volume of methane instead of the denisty of landfill gas following NECD review recommendation LU-5A-2023-0001. PM emissions from inert waste disposal on land were revised for 2020 to 2021 due to revised activity data from national statistics	AD

6.2.5 Category-specific planned improvements including those in response to the review process

No further improvements are planned for the moment.

6.3 Composting (5.B.1)

6.3.1 Source category description

Category *5B1 – Composting* covers NH_3 emissions from composting activities. These activities include composting activities of gardening wastes collected by municipalities and treated at regional composting facilities, as well as the pre-treatment of MSW at the SIDEC and SIGRE waste treatment sites.

With regard to NH_3 emissions, category *5B1 – Composting* was not a key category in 2022, neither in the level, nor in the trend assessments, and has never been.

NH_3 emissions generally increased from 1993 (start of composting operations) until 2010. Between 2010 and 2011, emissions dropped by approx. 250% due to the fact that one of the main composting facilities was equipped with bio-filter. Since then emissions remained more or less at a constant level. Table 6-13 presents the emission trends for this category.

Table 6-13 – Emission trends for category *5B1 – Composting*

5B1 - Composting									
Emissions									
Year	NOx	NMVOC	NH3	TSP	PM10	PM2.5	Cd	Pb	Hg
	t	t	t	t	t	t	t	t	t
1990	NE	NE	NO	NE	NE	NE	NA	NA	NA
1991	NE	NE	NO	NE	NE	NE	NA	NA	NA
1992	NE	NE	NO	NE	NE	NE	NA	NA	NA
1993	NE	NE	2.61	NE	NE	NE	NA	NA	NA
1994	NE	NE	3.14	NE	NE	NE	NA	NA	NA
1995	NE	NE	3.92	NE	NE	NE	NA	NA	NA
1996	NE	NE	3.35	NE	NE	NE	NA	NA	NA
1997	NE	NE	8.80	NE	NE	NE	NA	NA	NA
1998	NE	NE	16.28	NE	NE	NE	NA	NA	NA
1999	NE	NE	16.72	NE	NE	NE	NA	NA	NA
2000	NE	NE	22.47	NE	NE	NE	NA	NA	NA
2001	NE	NE	20.50	NE	NE	NE	NA	NA	NA
2002	NE	NE	23.37	NE	NE	NE	NA	NA	NA
2003	NE	NE	26.55	NE	NE	NE	NA	NA	NA
2004	NE	NE	27.78	NE	NE	NE	NA	NA	NA
2005	NE	NE	29.08	NE	NE	NE	NA	NA	NA
2006	NE	NE	29.55	NE	NE	NE	NA	NA	NA
2007	NE	NE	30.33	NE	NE	NE	NA	NA	NA
2008	NE	NE	30.36	NE	NE	NE	NA	NA	NA
2009	NE	NE	32.31	NE	NE	NE	NA	NA	NA
2010	NE	NE	30.91	NE	NE	NE	NA	NA	NA
2011	NE	NE	8.64	NE	NE	NE	NA	NA	NA
2012	NE	NE	10.25	NE	NE	NE	NA	NA	NA
2013	NE	NE	9.49	NE	NE	NE	NA	NA	NA
2014	NE	NE	10.13	NE	NE	NE	NA	NA	NA
2015	NE	NE	9.62	NE	NE	NE	NA	NA	NA
2016	NE	NE	11.58	NE	NE	NE	NA	NA	NA
2017	NE	NE	9.69	NE	NE	NE	NA	NA	NA
2018	NE	NE	9.98	NE	NE	NE	NA	NA	NA
2019	NE	NE	10.83	NE	NE	NE	NA	NA	NA
2020	NE	NE	11.45	NE	NE	NE	NA	NA	NA
2021	NE	NE	13.34	NE	NE	NE	NA	NA	NA
2022	NE	NE	10.75	NE	NE	NE	NA	NA	NA
Trend 1990-2022	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005-2022	*NA*	*NA*	*-63.04%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2021-2022	*NA*	*NA*	*-19.46%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*

6.3.2 Methodological issues

For the calculation of NH_3 emissions from composting activities, the same activity data as for the greenhouse gas emission inventory was used. Hence, the activity data was based on the total quantity of material composted as reported by national statistics, as well as based on the quantities as reported for the 3 main composting facility operators (Minett-Kompost, SIDEC and SIGRE). The total amount of composted material in Luxembourg is provided in Table 6-14.

Table 6-14 – Amount composted in Luxembourg

Organic waste composted (Mg)								
1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
NO	NO	NO	5'805	6'746	8'398	7'354	16'083	26'685
1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
27'729	37'169	34'088	38'424	53'310	51'692	54'817	57'242	58'196
2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
59'628	63'866	62'202	38'399	41'521	38'490	41'150	38'800	46'091
2017	**2018**	**2019**	**2020**	**2021**	**2022**			
43'512	44'690	46'377	49'374	56'501	48’284			

Source: Luxembourg’s greenhouse gas emission inventory 2024.

The EMEP/EEA Tier 2 approach was then applied for estimating the corresponding NH_3 emissions. Indeed, the plant specific information permitted to distinguish between three composting practices: (a) general compost production, (b) windrow composting and windrow composting with biofilter. An overview of the default emission factors (EF) used is given in Table 6-15.

Table 6-15 – NH_3 emission factors used for category *5B1 – Composting*

Emission Factor	Source	Value	Unit
EF NH_3 – general composting	EEA/EMEP GB 2023 (Chap. 5B1, Tab3-1, p5)	0.24	kg/Mg organic waste
EF NH_3 – windrow composting	EEA/EMEP GB 2023 (Chap. 5B1, Tab3-2, p6)	0.66	kg/Mg organic waste
EF NH_3 – windrow composting with biofil-ter	EEA/EMEP GB 2023 (Chap. 5B1, Tab3-2 & 3-3, p6)	0.066	kg/Mg organic waste

6.3.3 Uncertainties and time-series consistency

The assessment of activity data and emission factor uncertainties is done according to the methodology described in the EMEP/EEA emission inventory Guidebook 2023 (Chapter A.5 Uncertainties, tables 2-1, 2-2 and 2-3), covering the main pollutants NO_x, NH_3, NMVOC, SO_x and $PM_{2.5}$. For some subcategories and pollutants, expert judgements were made to estimate AD or EF uncertainties. For CO, PM10, heavy metzals and persistent organic pollutants, no uncertainty estimates are currently made. Details on uncertainty of the activity data can also be checked in the Luxembourg’s National Inventory report (NIR). Please also refer to Table 1-33 to Table 1-37 of section 1.7 for caterogory specific uncertainties on activity data and emission factors.

The time series reported under *5B1 – Composting* are considered to be consistent. Fluctuations in the time series may occur due to inter-annual changes in the quantities of organic waste being collected.

6.3.4 Source-specific QA/QC and verification

Standard QA/QC procedures were followed.

Consistency and completeness checks have been performed.

6.3.5 Category-specific recalculations including changes made in response to the review process

Table 6-16 presents the main revisions and recalculations done since submission 2023.

Table 6-16 – Recalculations done since the last submission for category *5B1 – Composting*

Source category	Revisions 2023 ➔ 2024	Type of revision
5B1	None	NA

6.3.6 Category-specific planned improvements including those in response to the review process

No further improvements are planned for the moment.

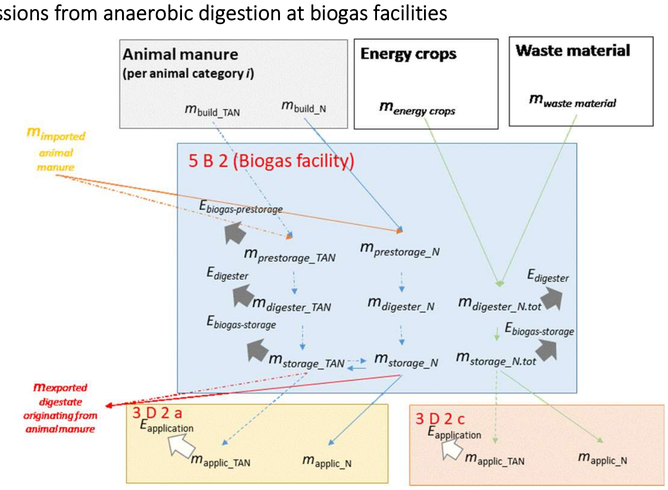
6.4 Anaerobic digestion at biogas facilities (5.B.2)

6.4.1 Source category description

Category *5B2 – Anaerobic digestation at biogas facilities* covers NH_3 emissions from pre-storage of feedstock, NH_3 emissions anaerobic digestation in the digester and NH_3 emissions from the storage of the digestate. NOx, TSP, PM and NMVOC emissions from biogas facilities were not covered, as at present no methods exist to calculate such emissions (Ramirez Garcia, et al., 2023).

It should be noted that most of the anaerobic digesters in Luxembourg are operated in a mixed mode, meaning that energy crops, non-agricultural waste materials (organic waste fraction from MSW or similar) and animal manure are mixed and used simultaneously in the digesters. Following the EMEP/EEA Guidelines (Ramirez Garcia, et al., 2023) the digestation of animal manures was calculated separately from the digestation of non-agricultural organic wastes and energy crops, allowing to report emissions from the application of digestate originating from animal manure under NFR 3D2a and from the application of digestate originating from energy crops and other waste under NFR 3D2c; as schematically presented in Figure 61.

Figure 61 – Reporting of emissions from anaerobic digestion at biogas facilities



Note:m: mass from which emissions may occurr. Narrow broken arrows: TAN; narrow continous arrows: total N. The horizontal arrows denote the process of immobilisation in systems with bedding occurring in the house; and the process of mineralisation during storage. Broad grey hatched arrows denote N emissions assigned to biogas facility and reported under 5.B.2 ($E_{biogas-prestorage}$ NH_3 emissions from prestorage; $E_{digester}$ NH_3 emissions from digester; $E_{biogas-storage}$ NH_3 emissions from biogas storage); Broad white arrows mark N emissions from application/from soil and reported under 3.D2a and 3.D2c.
Source: Derived from the EMEP/EEA Guidelines (Ramirez Garcia, et al., 2023).

With regard to NH_3 emissions, category *5B2 – Anaerobic digestation at biogas facilities* is a key category in 2022, in the trend assessment. Please refer to Table 6-3 which presents the key categories for category *5 - Waste*.

NH_3 emissions generally increased from 1998 (assumed start of biogas facilities operations in Luxembourg) until 2018. Since 2018, emissions are decrasing moderately.Table 6-17 presents the emission trends of this category.

Table 6-17 – Emission trends for category *5B2 – Anaerobic digestation at biogas facilities*

5 - Waste NH_3 emissions (in Gg)			
	5.B.2 - Anaerobic digesation at biogas facilities		
Year	Total	Originating from animal manure	Originating from energy crops and non-agr. waste
1990	NO	NO	NO
1991	NO	NO	NO
1992	NO	NO	NO
1993	NO	NO	NO
1994	NO	NO	NO
1995	NO	NO	NO
1996	NO	NO	NO
1997	NO	NO	NO
1998	0.000	0.000	0.000
1999	0.000	0.000	0.000
2000	0.001	0.001	0.000
2001	0.002	0.001	0.000
2002	0.003	0.002	0.001
2003	0.004	0.003	0.001
2004	0.010	0.007	0.003
2005	0.017	0.013	0.004
2006	0.022	0.016	0.007
2007	0.026	0.019	0.008
2008	0.029	0.020	0.009
2009	0.034	0.022	0.012
2010	0.038	0.027	0.011
2011	0.045	0.027	0.018
2012	0.045	0.027	0.018
2013	0.046	0.028	0.017
2014	0.050	0.029	0.021
2015	0.052	0.033	0.019
2016	0.059	0.039	0.020
2017	0.066	0.042	0.023
2018	0.073	0.046	0.027
2019	0.066	0.045	0.021
2020	0.065	0.045	0.020
2021	0.063	0.045	0.018
2022	0.054	0.038	0.016
Trend 1990 -2022	NA	NA	NA
Trend 2005 -2022	223%	205%	275%
Trend 2021 -2022	-14%	-15%	-11%

6.4.2 Methodological issues

6.4.2.1 Methodology

The EMEP/EEA Guidelines (Ramirez Garcia, et al., 2023) have been followed when estimating NH_3-emissions from biogas facilities. A Tier 2 approach was used to estimate the total emission, whereby NH_3 emissions (E_{NH3}) in kg NH_3 per year were estimated using the following formula:

$$E_{NH3} = AR_{Feedstock} * \sum_{s} EF_{NH3-N,\ stage\ s} * \frac{17}{14}$$

with

$AR_{Feedstock}$	is the total annual amount of N in feedstock, in kg N per year
$EF_{NH3\text{-}N\ stages\ s}$	is the NH_3-N emission factor (EF) for stage *s* (with *s* being the pre-storage, digester, and storage of digestate) related to the total N in feedstock.

The digestation of animal manures was calculated separately from the digestation of other organic wastes and of energy crops, see Figure 61.

6.4.2.2 Activity data

6.4.2.2.1 <u>Animal manure</u>

For digested manures, the TAN and total-N (TAN_{sub} and N_{tot} respectively, in kg per year) in the feedstock were:

$$TAN_{sub(i)} = \left[\left(m_{biogas\_slurry\_TA\ \ (i)} + m_{biogas\_solid\_TAN(i)}\right) * n_i\right] + m_{ImportedManureForFeedstock\_TAN(i)}$$

$$N_{sub(i)} = \left[\left(m_{biogas\_slurry\_N(i)} + m_{biogas\_soli\ \ \_N(i)}\right) * n_i\right] + m_{ImportedManureForFeedstock\_N(i)}$$

whereby $m_{biogas\_slurry\_TAN}$; $m_{biogas\_solid\_TAN}$, $m_{biogas\_slurry\_N}$ and $m_{biogas\_solid\_N}$ for livestock category *i* was obtained from the mass flow in 3B (for details see step 8 in section 5.2.5), multiplied by the number of livestock in category *i* (n_i);

and $m_{ImportedManureForFeedstock\ \_TAN}$ and $m_{ImportedManureForFeedstock\ \_N}$ for livestock category *i* are manure imported for being used as feedstock input in biogas facilities and is summarized in Table 5-14 (for details see section 5.2.3.4.2), whereby assuming that the percentage of TAN in the imported manure was similar to locally produced manure when entering storage.

Note as calculations in 3B are differentiated for different animal categories, TAN flow for digestion had also been calculated separately for the respective animal categories.

The TAN and the total-N in digestate originating from animal manure that was returned from 5.B.2 to 3B (see step 11 in section 5.2.5) was calculated according to the following equations:

$$mm_{dig\_TAN(i)} = TAN_{sub(i)} + f_{min} * \left(N_{tot(i)} - TAN_{sub(i)}\right) - (E_{NH3(i)} * \frac{14}{17})$$

$$mm_{dig\_N(i)} = \left(N_{tot\_dig(i)}\right) - (E_{NH\ \ (i)} * \frac{14}{17})$$

with

$TAN_{sub(i)}$	the TAN in the animal manure and being used as feedstock for the biogas facility, in kg TAN per year for animal category *i*
$N_{tot(i)}$	the total-N in the animal manure and being used as feedstock for the biogas facility, in kg N per year for animal category *i*
$mm_{dig\_TAN(i)}$	TAN in digestate after storage in kg per year for animal category *i*
f_{min}	relative share of organic N entering the digester that is mineralized to TAN in the digester; whereby using the default value provided in the EMEP guidelines, i.e. 0.32 (Ramirez Garcia, et al., 2023)
$E_{NH3(i)}$	NH_3 emitted in kg per year for animal category *i*.
$N_{tot\_dig(i)}$	the total-N in the digestate originating from animal manure after storage, in kg N per year for animal category *i*.

6.4.2.2.2 Energy crops and non-agricultural waste

The annual amount of N in energy crops and other waste used in biogas facilities was derived starting with activity data of the use of energy crops and other waste in biogas facilities from national statistics and transferred into N_{tot} flowing the EMEP guidelines (Ramirez Garcia, et al., 2023).

Those activity data were derived:

- for quantities of used energy crops and non-agriculture organic waste by compiling annual individual plant reports describing the feedstock input and submitted to AEV. Unpublished plant individual electricity or gas production, available since 1993 from the Institute Luxembourgeois de Régulation (ILR)[121] (Christian Meyers (ILR); personal communication October 2021), were used to impute missing information on the use of energy plants and on non-agriculture waste. The imputed value for biogas facility *x* was based on previous/following self-reported data on used non-agriculture waste and/or energy plants in the biogas facility *x* but corrected for the ratio observed between electricity / gas production of biogas facility *x* for the year with known data and the year with missing data.
- The composition of energy crops and of non-agriculture waste was based on available data derived from the annual individual plant reports, whereby presuming that biogas facilities with missing reports would have the same composition as their peers reporting. For energy crops there were detailed data available for the years 2014-2020, and for 2013 and earlier was the median from 2014-2020 used. For non-agriculture waste was the composition based on available data for the years 2007-2020 and for 2006 and earlier, was the median from the years 2007-2020 taken.

The N-content and dry matter content in maize silge (whole period), grass silage (whole time period) and fresh gras (from 2017 onwards) was derived from national statistics from the “Laboratoire de Contrôle et d'Essais de l'ASTA”. For fresh gras before 2017 and for all other energy crops standard reference values were used for dry matter content and N-concentration (DLG-Verlag, 1985). The non-agricultural waste was divided in different waste categories. For each of them was the dry matter content and the N-concentration

[121] https://web.ilr.lu/FR/ILR

based on the waste material composition as observed in the years 2007-2011, whereby using standard reference values (DLG-Verlag, 1985) (Ramirez Garcia, et al., 2023).

For digested energy crops and waste, the total-N in digestate after storage ($N_{tot\_dig(ECO)}$), in kg N per year that was returned from 5B2 to 3B was calculated according to the following equation:

$$m_{dig\_N(ECO)} = \left(N_{tot\_dig(ECO)}\right) = N_{tot(ECO)} - (E_{NH\ \ (ECO)} * \frac{14}{17})$$

6.4.2.3 Emission factors

6.4.2.3.1 Pre-storage

Most of the biogas plants in Luxembourg are modern. The used techniques were delivered and installed by German firms. It was therefore assumed that similar as in the German inventory, (Haenel, et al., 2020) the animal manure originating from Luxemburgish farmers to be either stored in covered pre-storage tanks, or directly fed from stable,[122]

The EF for NH_3 emissions from covered pre-storage tanks was assumed to be 0, according to (Haenel, et al., 2020) .

Agricultural crops used for biogas production are commonly stored as silage. Given the low pH of silage, and according to the EMEP guidelines are NH_3 emissions resulting from the storage of energy crops before anaerobic digestion negligible (Ramirez Garcia, et al., 2023).

There was no data, and hence no methode for NH_3 emissions for the storage of municipal waste before the use in the digester. But according to the EMEP guidelines are these emissions likely to be very small (Ramirez Garcia, et al., 2023).

<u>Digester</u>

As the digester is completely enclosed, no NH_3 emissions should occur. The only source would be the leakage losses, but the concentration of NH_3 in biogas is very low, and hence is this source considered to be negligible (Ramirez Garcia, et al., 2023). The EF for NH_3 emissions from digester was therefore assumed to be 0.

<u>Storage of the digestate</u>

The distinction is made between open tanks and closed tanks. The available data was collected in a survey on agricultural production methods in 2020[123]. In 2020 18% of the digestate was stored in closed tanks; and the remaining digestate was stored in open tanks. Based on expert judgment, it was assumed that in earlier years, the frequency distributions would have been like the one found in 2020. A fact that could be confirmed when controlling ortho-photos from earlier years. Without new data, the 2020 data were adopted in the following years.

The NH_3-N EFs for storage of digestate were based on EMEP guidelines (Ramirez Garcia, et al., 2023) and are summarized in Table 6-18.

---

[122] A fact confirmed by Jérôme Fries in November 2020 (Jérôme Fries used to be the chairman for "Biogas-Vereenigung", an association representing the different biogas facility plants);

[123] Service d'économie rurale (SER) – Division des statistiques agricoles, des relations extérieures et des marches agricoles.

Table 6-18 – Emission factors and uncertainties for NH_3 emission for category *5B2 – Anaerobic digestation at biogas facilities*

Emission Factor	Source	Value	Uncertainty range*	Unit
EF NH_3 – digestate (closed tanks)	(Ramirez Garcia, et al., 2023), p. 11	0	NA	kg NH_3-N per kg N in feedstock
EF NH_3 – digestate (open tanks): animal manure	(Ramirez Garcia, et al., 2023) Table 3-3	0.0266	0.0152-0.0465	kg NH_3-N per kg N in feedstock
EF NH_3 – digestate (open tanks): energy crops and non-agr. waste	(Ramirez Garcia, et al., 2023) Table 3-1	0.0275	0.0163-0.0501	kg NH_3-N per kg N in feedstock

*Uncertainty was modelled as a pert-distribution with the EF value as most likely value and using the uncertainty range as minimum and maximum value.

6.4.3 Uncertainties and time-series consistency

Uncertainty was model using Monte-Carlo techniques as explained in more detail in section 5.2.7. The uncertainty w.r.t. livestock numbers, N excretion rates, manure management systems and housing, as well as the import of manure to be used as feedstock in biogas facilities, all impacting the N in animal manure being used as feedstock for biogas facilities, were described in the national inventory report 2024 (section 5.2.7); in section 5.3.4 for NRF 3B related EF parameters and in the national inventory report 2024 (section 5.4.4) for manure management related N2O-EF parameters. The uncertainty w.r.t. quantities of energy crops (in kg fresh matter) and the quantities of other non-agricultural waste (in kg fresh matter) used as feedstock in biogas facilities was simulated by multiplying the quantities by an uncertainty factor to be uniformely distributed with minimum 75% and maximum 125%. The uncertainty w.r.t. the N-Content (in kg N/fresh matter) of the different energy crops and non-agricultural waste was modelled by multpyling the used values by an uncertainty factor with 100% as most likely value, 90% as minimum and 110% as maximum, assuming a pert-distribution.

The uncertainty for the used EF's in NRF 5.B.2 were modelled as pert-distributions and are summarized in Table 6-18.

6.4.4 Source-specific QA/QC and verification

Standard QA/QC procedures were followed.

Consistency and completeness checks have been performed.

6.4.5 Category-specific recalculations including changes made in response to the review process.

Revision of livestock numbers and MMS since submission 2023v1 affecting also NRF 5.B.2 are described in Table 5-19. There were no further revisions since submission 2023.

The recalculations of the emissions in the category 5B2 due to the above updates in AD are detailed in Table 6-19.

Table 6-19 – Recalculations done since the last submission for category *5B2 – Anaerobic digestion at biogas facilities*

5 B 2 - Anaerobic digestion at biogas facilities

Recalculations

Year	NH_3 [Gg] New	NH_3 [Gg] Old	Impact of recalculation %
1990	NO	NO	
1991	NO	NO	
1992	NO	NO	
1993	NO	NO	
1994	NO	NO	
1995	NO	NO	
1996	NO	NO	
1997	NO	NO	
1998	0.000	0.000	0.1
1999	0.000	0.000	0.1
2000	0.001	0.001	0.0
2001	0.002	0.002	0.1
2002	0.003	0.003	0.0
2003	0.004	0.004	0.1
2004	0.010	0.010	0.0
2005	0.017	0.016	2.5
2006	0.022	0.022	1.6
2007	0.026	0.026	1.7
2008	0.029	0.029	1.5
2009	0.034	0.034	1.5
2010	0.038	0.037	1.8
2011	0.045	0.045	1.5
2012	0.045	0.044	1.6
2013	0.046	0.045	1.5
2014	0.050	0.049	1.4
2015	0.052	0.051	1.3
2016	0.059	0.059	1.0
2017	0.066	0.065	0.9
2018	0.073	0.073	0.8
2019	0.066	0.065	0.9
2020	0.065	0.065	0.9
2021	0.063	0.060	4.6
2022	0.054		

6.4.6 Category-specific planned improvements including those in response to the review process

The following improvements are planned for the next submission.

Table 6-20 – Planned improvements for category – *5B2 – Anerobic digestation at biogas facilities*

Source category	Planned improvements	Type of revision
5B2	None	NA

6.5 Clinical waste incineration (5.C.1.b.ii)

6.5.1 Source category description

Clinical waste incineration took place in several small facilities (in 1990 approximately 11 facilities) until the mid-nineties. Since then, all facilities for clinical waste incineration in Luxemburg are shut down, hence notation key "NO" is used since 1996.

6.5.2 Methodological issues

6.5.2.1 Main pollutants

Emissions for the main pollutants are included in category *1A4ai – Commercial/Institutional: Stationary* to avoid double counting as no plant specific fuel consumption data was reported, and as the eneregy balance generally includes fuel consumption of such installations in category 1A4a.

6.5.2.2 Heavy metals and POPs

6.5.2.2.1 Activity data

No quantities of incinerated clinical waste from 1990 to 1995 is available, hence a proxy based on population size from national statistics was used.

6.5.2.2.2 Methodological Choices

Since emission measurements from clinical waste incineration were not available, POP (PCDD/F, PAH), and HM (Hg) emissions were estimated based on the total amount of incinerated biomedical waste in the USA in 1990 (GLASSER et al. 2012) and EF from the Guidebook (EEA 2023). To adapt the quantity of waste produced, values were transformed proportionally to population size assuming that generation of biomedical waste per capita is similar in both countries. One should be aware of the coarse character of these approximations but they were found acceptable, since the share of clinical waste incineration in total emissions is very small.

6.5.2.2.3 Emission factors

Table 6-21indicates the sources of Tier 1 emission factors used in the above methodological description:

Table 6-21 – Sources of Tier 1 default emission factors for HMs and POPs

Process	Pollutants	Source	Page	Table
Clinical waste incineration	Pb, Cd, Hg, PCB, PCDD/F, PAH, HCB	EMEP/EEA Guidebook (2023) – Chapter 5.C.1.b.iii Clinical waste	8	3-1

6.5.3 Category-specific recalculations including changes made in response to the review process

No recalculations occurred since the last submission.

6.5.4 Category-specific planned improvements including those in response to the review process

The following improvements are planned for the next submission.

Table 6-22 – Planned improvements for category *5C1biii – Clinical waste incineration*

Source category	Planned improvements	Type of revision
5C1biii	Estimate Pb, Cd, PCB, HCB emissions from clinical waste incineration as provided in EMEP/EEA Guidebook 2023	Completeness

6.6 Cremation (5.C.1.b.v)

6.6.1 Source category description

There is only one crematory in Luxembourg (Hamm) practicing the cremation of human bodies. It is considered as a small point source. Animal carcasses are not incinerated in Luxembourg, these are exported, mainly to Belgium for incineration.

6.6.2 Methodological issues

6.6.2.1 Main pollutants

Emissions for the main pollutants are included in category *1A4ai – Commercial/Institutional: Stationary* to avoid double counting as no plant specific fuel consumption data is reported, and as the eneregy balance generally includes fuel consumption of such installations in category 1A4a.

6.6.2.2 Heavy metals and POPs

6.6.2.2.1 Activity data

Operatinghours of the facility, used for estimating emissions based on control measurements, were estimated on a conservative basis (8 hours per day, 5 days per week, 52 weeks per year).

Data about the number of cremations per year, used for the Tier 1 emission calculation, were only available for 1995, 1996, 2000, 2005, 2020, 2015, 2017, 2019, 2021 and 2022. Years inbetween were lienraly interpolated (see Table 6-23).

Table 6-23 – Number of cremations per year

1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NO	NO	NO	NO	NO	178	1'130	1'427	1'724	2'021
2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
2'318	2'307	2'296	2'286	2'275	2'264	2'230	2'195	2'161	2'126
2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
2'092	2'167	2'242	2'317	2'392	2'467	2'542	2'617	2'714	2'810
2020	**2021**	**2022**							
2'965	3'119	3'120							

6.6.2.2.2 Methodological Choices

Control measurements of PCB, and PAH emissions from the crematory were available from 2011, measurements for PCDD/F from 1998, 2004, 2011, 2014 and 2018. HCB emissions are also known to occur during the cremation process but were not measured in the course of emission controls. For that reason, HCB emissions were calculated based on the number of cremations and the appropriate tier 1 emission factor from EEA (2023).

Control measurements of Hg emissions from the crematory were available from 1998, 2004, 2011, 2014 and 2018.

For the years without measurement data, Hg, PAH, PCB, and PCDD/F emissions were estimated by conversion of measured emission levels proportionally to the total number of cremations per year.

Measurements of Pb and Cd emissions were not available at all. Thus, Pb and Cd emissions were calculated based on the estimated total number of cremations per year and the appropriate tier 1 emission factors from EEA (2023).

6.6.2.2.3 Emission factors

Table 6-24 indicates the sources of Tier 1 emission factors used in the above methodological description:

Table 6-24 – Sources of Tier 1 default emission factors for HMs and POPs

Process	Pollutants	Source	Page	Table
Cremation of human bodies	Pb, Cd, HCB	EMEP/EEA Guidebook (2023) – Chapter 5.C.1.b.v Cremation	9	3-1

6.6.3 Category-specific recalculations including changes made in response to the review process

Table 6-25 presents the main revisions and recalculations done since submission 2023.

Table 6-25 – Recalculations done since the last submission for category *5C1bv – Cremation*

Source category	Revisions 2023 ➔ 2024	Type of revision
5C1bv	Number of incinerations were revised for the entire timeseries based on publicly available data.	AD
5C1bv	Tier 1 method from EMEP/EEA Guidebook was applied.	method

6.6.4 Category-specific planned improvements including those in response to the review process

The following improvements are planned for the next submission.

Table 6-26 – Planned improvements for category *5C1bv - Cremation*

Source category	Planned improvements	Type of revision
5C1bv	Estimate main pollutant emissions from cremation using the same activity data as for HMs and POPs, and reallocate from 1A4i to 5C1bv if double counting can be avoided.	Reallocation

6.7 Open burning of waste (5.C.2)

6.7.1 Source category description

Open burning of waste is banned by law since the early 1990's in Luxembourg, hence notation key "NO" is used for this category in the NFR tables. Hence, the practice of burning crop residues or forest residues never came up in Luxembourg.

In the following paragraphs the legal situation on the ban of open burning of waste in Luxembourg is explained: The law dated 26th June 1980 concerning the elimination of wastes, is the first Luxembourgish law defining wastes, and regulating its elimination. Article 1 defines what is meant by "waste". Article 6 states that "Waste must be disposed of by deposit in engineered landfills with a sufficient compaction of waste accumulated in superposed layers, by composting, by incineration or, by any other process recognized as equivalent by the competent minister following a prior request of the holder. The disposal of waste also includes sorting and treatment operations necessary for the recovery of reusable elements and materials or energy. The disposal must be carried out under conditions such as not to produce harmful effects on the soil, flora and fauna, to degrade sites or landscapes, to pollute the air or water, to generate noise and odours and in general to harm the health of humans and the environment." Hence, as this article is interpreted in a strict manner, it clearly classifies open burning of waste as a harmful procedure to the environment and to human health, which in the end is to be considered as prohibited. Article 7 regulates the installations for waste disposal, which covers also installations for waste incineration, again, implying that open burning of waste is forbidden.

The law dated 14 June 1994 on the prevention and management of waste, recalled the previous law and its subsequent modifications. In its first article, the law states that "Waste that does not lend itself to such recovery must be disposed of in an environmentally appropriate manner. The use of waste as an energy source is only conceivable for waste that does not lend itself to a valorisation other than thermal." Moreover, article 17, para 6 states that "Household waste, bulky waste or similar waste that cannot be recovered and in particular composted, must be either incinerated or landfilled. Incineration plants and landfills must apply best available technology at the time of disposal of waste and whose application does not entail excessive costs to ensure optimal energy recovery and a high level of environmental protection." Furthermore, in Article 19 on organic wastes (para 2 and 3), it is specified that "The organic fraction of household and similar waste must be recovered by composting or by another process adapted to the nature of the waste and to regional and local characteristics. The same applies to organic waste from maintenance work in parks, along the edges of roadways or green spaces." These dispositions, among others, again emphasize that open burning of waste is not an appropriate manner of disposing of waste (in general), and that, hence, open burning of waste is forbidden. In addition, it should be noted that besides landfilling of waste, waste collected by the SIDOR waste management syndicate is incinerated at the waste incinerator in Leudelange since 1976 when it began its operation. For further details on the waste management system in Luxembourg, please refer to the general description in section 6.1.1. Indeed, through the very early development of the centralised collection of all types of waste in the early 1980s, and the formation of waste management syndicates covering the entire country, the practice of open burning of waste never raised in Luxembourg.

Finally, and for completing the above information, the law dated 21 March 2012 on waste management, and recalling the law dated 14 June 1994, further emphasizes the waste management in Luxembourg as well as the protection of the environment and human health. Hence, Article 9(1) installs a waste hierarchy: "The following waste hierarchy applies in order of priority in waste prevention and management legislation and policy: (a) prevention; (b) preparation for re-use; (c) recycling; (d) any other recovery, including energy recovery; and (e) disposal." More details on this waste hierarchy is then given in the subsequent articles. It should also be noted that the above-mentioned waste hierarchy, although not explicitly mentioned in the 1994 law, the same principles already governed the philosophy of that law. Hence, article 15(2) on disposal states "Waste for which a recovery operation within the meaning of Article 13(1) is not carried out shall be subject to a duly authorised safe disposal operation which complies with the provisions of Article 10." and Article 10(a) on the protection of human health and the environment states: "Waste management must be carried out without endangering human health and without harming the environment, in particular: (a) without creating a risk to water, air, soil, fauna or flora; [...]". In addition, Article 42 on prohibited activities states: "The abandonment, discharge or uncontrolled management of waste is prohibited." From the preceding it is again clear that all open burning activity (including crops residue, pruning from orchard and forestry waste…) is prohibited in Luxembourg by law.

Finally, the well-established recycling centres all over the country, where private persons can dispose their “green” waste, recycle this kind of waste through composting activities, and for residues which cannot be composted (i.e. woody waste: forestry waste and pruning from orchard, …), these are valorised by combustion into heating energy. For large quantities, especially forestry waste and hedge cut, a special collection system is put in place by an agricultural association. This waste is generally chopped on site before being sorted into a composting fraction and a valorisation fraction for heat production (incineration in combustion plants).

6.7.2 Category-specific planned improvements including those in response to the review process

No further improvements are planned for the moment.

6.8 Domestic wastewater handling (5.D.1)

6.8.1 Source category description

Category *5D1 – Domestic wastewater handling* covers NMVOC emissions from domestic wastewater treatment activities. Domestic waste water treatment plants are mostly operated by municipalities and are organised in syndicates. Wastewater treatment plants are of two major types: (a) mechanical plants and (b) advanced biological plants with or without denitrification. A small part of the population is, however, still not connected to centralised wastewater treatment plants, mainly due to the remote location of the dwellings.

NH_3 emissions from domestic wastewater handling do not occur in Luxembourg as these generally only occur in latrines, which do not exist in Luxembourg. Dwellings not connected to wastewater treatment plants are connected to septic tanks which are regularly emptied and there contents transferred to advanced biological wastewater treatment plants via tank trucks to be further processed.

With regard to NMVOC emissions, category *5D1 – Domestic wastewater handling* is not a key category in 2022, neither in the level, nor in the trend assessments.

Table 6-27 presents the emission trends of this category. NMVOC emissions are increasing over the entire timeseries, due to the increasing population and workforce and due to the fact that more and more dwellings are connected to centralised wastewater treatment plants.

Table 6-27 – Emission trends for category *5D1 – Domestic wastewater handling*

5D1 - Domestic wastewater handling									
Emissions									
Year	NOx	NMVOC	NH3	TSP	PM10	PM2.5	Cd	Pb	Hg
	t	*t*	*t*	*t*	*t*	*t*	*t*	*t*	*t*
1990	NA	0.47	NO	NE	NE	NE	NE	NE	NE
1991	NA	0.48	NO	NE	NE	NE	NE	NE	NE
1992	NA	0.49	NO	NE	NE	NE	NE	NE	NE
1993	NA	0.50	NO	NE	NE	NE	NE	NE	NE
1994	NA	0.51	NO	NE	NE	NE	NE	NE	NE
1995	NA	0.52	NO	NE	NE	NE	NE	NE	NE
1996	NA	0.54	NO	NE	NE	NE	NE	NE	NE
1997	NA	0.55	NO	NE	NE	NE	NE	NE	NE
1998	NA	0.56	NO	NE	NE	NE	NE	NE	NE
1999	NA	0.57	NO	NE	NE	NE	NE	NE	NE
2000	NA	0.58	NO	NE	NE	NE	NE	NE	NE
2001	NA	0.60	NO	NE	NE	NE	NE	NE	NE
2002	NA	0.61	NO	NE	NE	NE	NE	NE	NE
2003	NA	0.62	NO	NE	NE	NE	NE	NE	NE
2004	NA	0.63	NO	NE	NE	NE	NE	NE	NE
2005	NA	0.64	NO	NE	NE	NE	NE	NE	NE
2006	NA	0.65	NO	NE	NE	NE	NE	NE	NE
2007	NA	0.65	NO	NE	NE	NE	NE	NE	NE
2008	NA	0.66	NO	NE	NE	NE	NE	NE	NE
2009	NA	0.66	NO	NE	NE	NE	NE	NE	NE
2010	NA	0.66	NO	NE	NE	NE	NE	NE	NE
2011	NA	0.66	NO	NE	NE	NE	NE	NE	NE
2012	NA	0.65	NO	NE	NE	NE	NE	NE	NE
2013	NA	0.64	NO	NE	NE	NE	NE	NE	NE
2014	NA	0.65	NO	NE	NE	NE	NE	NE	NE
2015	NA	0.70	NO	NE	NE	NE	NE	NE	NE
2016	NA	0.66	NO	NE	NE	NE	NE	NE	NE
2017	NA	0.61	NO	NE	NE	NE	NE	NE	NE
2018	NA	0.56	NO	NE	NE	NE	NE	NE	NE
2019	NA	0.51	NO	NE	NE	NE	NE	NE	NE
2020	NA	0.51	NO	NE	NE	NE	NE	NE	NE
2021	NA	0.52	NO	NE	NE	NE	NE	NE	NE
2022	NA	0.44	NO	NE	NE	NE	NE	NE	NE
Trend 1990-2022	*NA*	*-7.93%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005-2022	*NA*	*-31.92%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2021-2022	*NA*	*-16.06%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*

6.8.2 Methodological issues

In Luxembourg, domestic wastewater is treated in four different ways based on the location of the villages and municipalities. In the calculation method these four systems are considered separately:

- Septic tanks used in remote places where a connection to a wastewater treatment plant (WWTP) is not possible.
- Mechanical WWTPs, which in Luxembourg are to be considered as very basic installations with no sludge digesters and which are managed from a technical point of view in the same way as septic tanks. They consist of simple volumes with a baffle and no pre- or subsequent treatment (such as screen a grit compartment, or aerobic step). In addition, the management consists of simple regular emptying. Hence, it should also be noted, that the processes in these installations are very similar to septic

tanks (which is particularly important for the calculation of methane emissions). Also, all sludge, removed from these mechanical WWTPs (as well as from septic tanks), is transferred to biological WWTPs where it is further treated either aerobically, or anaerobically in a digester. This is not to be compared to modern mechanical wastewater treatment plants which might be operated in other European countries.

- Biological WWTPs without denitrification.
- Biological WWTPs with denitrification.

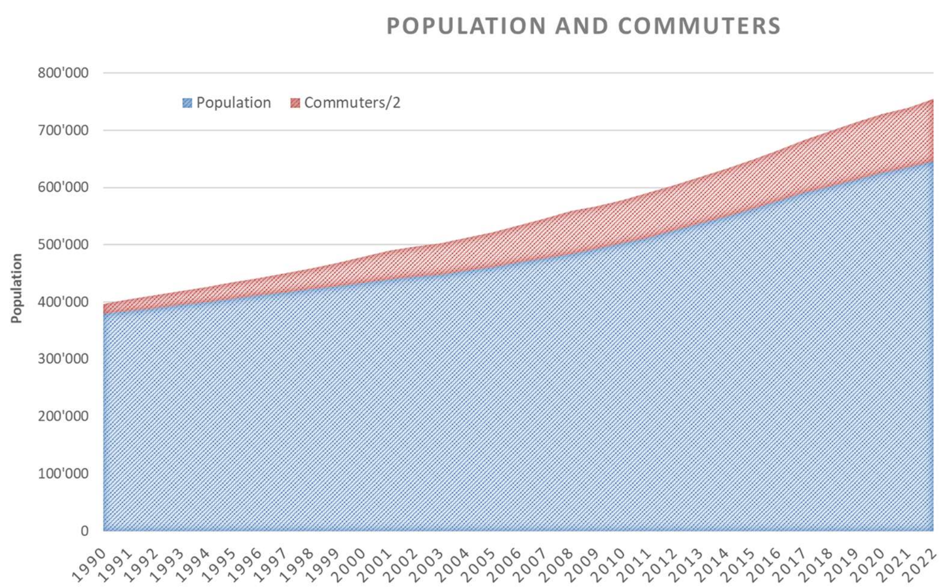
Emission estimates for domestic wastewater treatment activities are based on population data categorized into “not connected”, “connected to mechanical WWTP, “connected to biological WWTP without denitrification” and “connected to biological WWTP with denitrification”. Population (including commuters) per WWT type is given in Table 6-28

Table 6-28 – Population connected per WWT system

5.D.1 Domestic Wastewater					
	Share of population connected by WWT type				Total Population producing WW
Year	not connected	mec. wwtp	bio. wwtp - denitr.	bio. wwtp + denit.	
1990	7.84%	14.96%	77.20%	0.00%	396'950
1991	7.66%	15.05%	77.29%	0.00%	404'210
1992	7.48%	15.13%	77.39%	0.00%	411'570
1993	7.30%	15.21%	77.49%	0.00%	418'930
1994	7.13%	15.28%	77.59%	0.00%	426'490
1995	6.96%	12.57%	77.09%	3.38%	434'150
1996	6.78%	12.60%	70.45%	10.16%	442'300
1997	6.62%	12.65%	70.54%	10.18%	450'250
1998	6.47%	12.71%	70.62%	10.21%	458'850
1999	6.32%	12.75%	70.70%	10.23%	467'650
2000	6.16%	9.71%	73.86%	10.27%	478'750
2001	6.01%	9.72%	73.99%	10.27%	489'050
2002	5.88%	9.71%	63.59%	20.83%	496'450
2003	5.75%	9.73%	63.66%	20.85%	502'700
2004	5.60%	7.46%	66.16%	20.77%	512'200
2005	5.46%	7.19%	66.11%	21.24%	521'800
2006	5.30%	7.05%	66.53%	21.11%	533'600
2007	5.16%	7.05%	66.77%	21.02%	545'800
2008	5.02%	5.61%	59.26%	30.12%	558'500
2009	4.38%	5.08%	59.65%	30.90%	567'650
2010	4.23%	4.80%	59.55%	31.42%	578'050
2011	4.50%	4.76%	55.83%	34.91%	590'700
2012	4.33%	4.56%	34.93%	56.18%	604'450
2013	4.06%	4.35%	35.22%	56.37%	618'200
2014	3.90%	4.14%	35.59%	56.37%	632'350
2015	3.13%	3.98%	31.76%	61.13%	648'508
2016	2.69%	3.78%	32.13%	61.41%	664'849
2017	2.58%	2.93%	27.46%	67.02%	682'417
2018	2.35%	2.76%	25.75%	69.15%	698'055
2019	1.41%	2.60%	25.41%	70.59%	714'344
2020	1.29%	2.48%	16.84%	79.38%	728'558
2021	1.16%	2.39%	16.83%	79.62%	739'180
2022	1.02%	2.01%	14.53%	82.45%	754'273
Trend 1990-2022	-87.04%	-86.58%	-81%	NA	90.02%
2005-2022	-81.40%	-72.07%	-78%	288%	44.55%
2021-2022	-12.56%	-15.91%	-14%	4%	2.04%

Please note that, as Luxembourg's workforce is increased daily by about two hundred thousand commuters (from France, Belgium and Gemany), their impact on wastewater discharge had to be taken into account. Hence, as these daily commuters only spend their working hours in the country, their number was divided by half and added to Luxembourg's population. Hence, tha above mentioned population data includes half of the commuters. Figure 62 illustrates the population and cross-border commuters' growth between 1990 and 2022.

Figure 62 - Resident population and cross-border commuters



The EMEP/EEA Tier 2 approach was then applied for estimating the corresponding NMVOC emissions. An overview of the default emission factor (EF) used is given in Table 6-29.

Table 6-29 - NMVOC emission factors used for category *5D1 – Domestic wastewater handling*

Emission Factor	Source	Value	Unit
EF NMVOC (mechanical WWTP, biological WWTP without denitrification)	EEA/EMEP GB 2023 (Chap. 5D, Tab. 3-3, p. 9)	15	mg/m^3 wastewater handled
EF NMVOC (biological WWTP with denitrification)	EEA/EMEP GB 2023 (Chap. 5D, Tab. 3-3, p. 9)	15	mg/m^3 wastewater handled
Flow in (1990-2005)	AGE	236	l/person/day
Flow in (2006-)	AGE (annual values)	232 (2005) 125 (2022)	l/person/day

6.8.3 Uncertainties and time-series consistency

The assessment of activity data and emission factor uncertainties is done according to the methodology described in the EMEP/EEA emission inventory Guidebook 2023 (Chapter A.5 Uncertainties, tables 2-1, 2-2 and 2-3), covering the main pollutants NO_x, NH_3, NMVOC, SO_x and $PM_{2.5}$. For some subcategories and pollutants, expert judgements were made to estimate AD or EF uncertainties. For

CO, PM10, heavy metzals and persistent organic pollutants, no uncertainty estimates are currently made. Details on uncertainty of the activity data can also be checked in the Luxembourg's National Inventory report (NIR). Please also refer to Table 1-33 to Table 1-37 of section 1.7 for caterogory specific uncertainties on activity data and emission factors.

The time series reported under *5D1 – Domestic wastewater handling* are considered to be consistent. Fluctuations in the time series may occur due to inter-annual changes in flow in quantities or due to maintenance stops.

6.8.4 Source-specific QA/QC and verification

Standard QA/QC procedures were followed.

Consistency and completeness checks have been performed.

6.8.5 Category-specific recalculations including changes made in response to the review process

Table 6-30presents the main revisions and recalculations done since submission 2023.

Table 6-30 – Recalculations done since the last submission for category *5D1 – Domestic wastewater handling*

Source category	Revisions 2023 ➔ 2024	Type of revision
5D1	None	NA

6.8.6 Category-specific planned improvements including those in response to the review process

No further improvements are planned for the moment.

6.9 Industrial wastewater handling (5.D.2)

6.9.1 Source category description

Category *5D2 – Industrial wastewater handling* covers NMVOC emissions from industrial wastewater treatment activities, which comes down to two plants in Luxembourg. One plant is operated since 1990 by a chemical company, and the other one at a milk products production facility, since 2015.

With regard to NMVOC emissions, category *5D2 – Industrial wastewater handling* is not a key category in 2022, neither in the level, nor in the trend assessments.

Table 6-31 presents the emission trends of this category.

Table 6-31 – Emission trends for category *5D2 – Industrial wastewater handling*

5D2 - Industrial wastewater handling									
Emissions									
Year	NOx	NMVOC	NH3	TSP	PM10	PM2.5	Cd	Pb	Hg
	t	t	t	t	t	t	t	t	t
1990	NA	0.02	NE	NE	NE	NE	NE	NE	NE
1991	NA	0.02	NE	NE	NE	NE	NE	NE	NE
1992	NA	0.02	NE	NE	NE	NE	NE	NE	NE
1993	NA	0.02	NE	NE	NE	NE	NE	NE	NE
1994	NA	0.02	NE	NE	NE	NE	NE	NE	NE
1995	NA	0.02	NE	NE	NE	NE	NE	NE	NE
1996	NA	0.02	NE	NE	NE	NE	NE	NE	NE
1997	NA	0.02	NE	NE	NE	NE	NE	NE	NE
1998	NA	0.02	NE	NE	NE	NE	NE	NE	NE
1999	NA	0.02	NE	NE	NE	NE	NE	NE	NE
2000	NA	0.02	NE	NE	NE	NE	NE	NE	NE
2001	NA	0.02	NE	NE	NE	NE	NE	NE	NE
2002	NA	0.02	NE	NE	NE	NE	NE	NE	NE
2003	NA	0.02	NE	NE	NE	NE	NE	NE	NE
2004	NA	0.02	NE	NE	NE	NE	NE	NE	NE
2005	NA	0.02	NE	NE	NE	NE	NE	NE	NE
2006	NA	0.02	NE	NE	NE	NE	NE	NE	NE
2007	NA	0.02	NE	NE	NE	NE	NE	NE	NE
2008	NA	0.02	NE	NE	NE	NE	NE	NE	NE
2009	NA	0.01	NE	NE	NE	NE	NE	NE	NE
2010	NA	0.01	NE	NE	NE	NE	NE	NE	NE
2011	NA	0.01	NE	NE	NE	NE	NE	NE	NE
2012	NA	0.01	NE	NE	NE	NE	NE	NE	NE
2013	NA	0.01	NE	NE	NE	NE	NE	NE	NE
2014	NA	0.01	NE	NE	NE	NE	NE	NE	NE
2015	NA	0.02	NE	NE	NE	NE	NE	NE	NE
2016	NA	0.02	NE	NE	NE	NE	NE	NE	NE
2017	NA	0.02	NE	NE	NE	NE	NE	NE	NE
2018	NA	0.02	NE	NE	NE	NE	NE	NE	NE
2019	NA	0.02	NE	NE	NE	NE	NE	NE	NE
2020	NA	0.02	NE	NE	NE	NE	NE	NE	NE
2021	NA	0.02	NE	NE	NE	NE	NE	NE	NE
2022	NA	0.02	NE	NE	NE	NE	NE	NE	NE
Trend 1990-2022	*NA*	*-17.45%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005-2022	*NA*	*-5.60%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2021-2022	*NA*	*-3.61%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*

6.9.2 Methodological issues

The calculation of NMVOC emissions from industrial wastewater treatment activities is based on plant specific flow in data of the two plants as reported by the plant operators since 2002. For the years where no data is available an extrapolation was operated:

Year 1990 - 2002	Year 2002 – 2014	Since 2015
Flow in extrapolated by expert judgment of the water management administration. In 1998, the WWTP has been upgraded allowing also denitrification.	Flow in based on monitoring analyses.	Flow in based on monitoring analyses (for both industrial plants).

Table 6-32 provides the total annual industrial wastewater handeled in the two plants.

Table 6-32 – Amount of industrial wastewater handeled

(m³)								
1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
1'459'270	1'459'270	1'459'270	1'459'270	1'459'270	1'459'270	1'459'270	1'459'270	1'459'270
1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
1'459'270	1'459'270	1'459'270	1'459'270	1'352'225	1'365'830	1'276'040	1'215'888	1'036'094
2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
1'009'743	809'639	858'801	822'498	802'839	813'950	791'320	1'210'705	1'158'145
2017	**2018**	**2019**	**2020**	**2021**	**2022**			
1'187'856	1'212'413	1'192'280	1'125'091	1’249’745	1'204'631			

The EMEP/EEA Tier 2 approach was then applied for estimating the corresponding NMVOC emissions. An overview of the default emission factors (EF) used is given in Table 6-33.

Table 6-33 – NH_3 emission factors used for category *5D2 – Industrial wastewater handling*

Emission Factor	Source	Value	Unit
EF NMVOC	EEA/EMEP GB 2023 (Chap. 5D, Tab3-3, p9)	15	mg/m3 wastewater handled

6.9.3 Uncertainties and time-series consistency

The assessment of activity data and emission factor uncertainties is done according to the methodology described in the EMEP/EEA emission inventory Guidebook 2023 (Chapter A.5 Uncertainties, tables 2-1, 2-2 and 2-3), covering the main pollutants NO_x, NH_3, NMVOC, SO_x and $PM_{2.5}$. For some subcategories and pollutants, expert judgements were made to estimate AD or EF uncertainties. For CO, PM10, heavy metzals and persistent organic pollutants, no uncertainty estimates are currently made. Details on uncertainty of the activity data can also be checked in the Luxembourg’s National Inventory report (NIR). Please also refer to Table 1-33 to Table 1-37 of section 1.7 for caterogory specific uncertainties on activity data and emission factors.

The time series reported under *5D2 – Industrial wastewater handling* are considered to be consistent. Fluctuations in the time series may occur due to inter-annual changes in production quantities or due to maintenance stops.

6.9.4 Source-specific QA/QC and verification

Standard QA/QC procedures were followed.

Consistency and completeness checks have been performed.

6.9.5 Category-specific recalculations including changes made in response to the review process

Table 6-34 presents the main revisions and recalculations done since submission 2023.

Table 6-34 – Recalculations done since the last submission for category *5D2 – Industrial wastewater handling*

Source category	Revisions 2023 → 2024	Type of revision
5D2	none	na

6.9.6 Category-specific planned improvements including those in response to the review process

No further improvements are planned for the moment.

6.10 Other waste (5.E)

6.10.1 Source category description

This category covers PM, HM and POP emissions from accidental fires of buildings, dwellings and cars.

With regard to $PM_{2.5}$ emissions, category *5E – other waste* is a key category (LA) in 2022 (see Table 6-3 wich presents the key categories for category *5 - Waste*.)

PM, HM and POP emissions from accidental fires have generally increased since 1990. This increase is mainly due to the fact that the number of cars and dwellings have increased substantially in Luxembourg, due to a large increase in population and workforce (commuters). Table presents the emission trends of this category.

Table 6-35 – Emission trends for category *5E – Other waste*

5E - Other waste Emissions										
Year	**NOx**	**NMVOC**	**NH3**	**TSP**	**PM10**	**PM2.5**	**Cd**	**Pb**	**Hg**	**PCDD/F**
	t	*t*	*t*	*t*	*t*	*t*	*t*	*t*	*t*	*g iTeq*
1990	NE	NE	NE	30.58	30.58	30.58	0.178	0.088	0.18	309.85
1991	NE	NE	NE	31.37	31.37	31.37	0.183	0.091	0.18	317.84
1992	NE	NE	NE	27.12	27.12	27.12	0.158	0.078	0.16	274.83
1993	NE	NE	NE	26.90	26.90	26.90	0.157	0.078	0.16	272.55
1994	NE	NE	NE	26.13	26.13	26.13	0.152	0.076	0.15	264.74
1995	NE	NE	NE	30.88	30.88	30.88	0.180	0.089	0.18	312.89
1996	NE	NE	NE	33.41	33.41	33.41	0.195	0.097	0.19	338.59
1997	NE	NE	NE	32.68	32.68	32.68	0.190	0.095	0.19	331.17
1998	NE	NE	NE	34.15	34.15	34.15	0.199	0.099	0.20	346.01
1999	NE	NE	NE	39.82	39.82	39.82	0.232	0.115	0.23	403.49
2000	NE	NE	NE	37.94	37.94	37.94	0.221	0.110	0.22	384.46
2001	NE	NE	NE	38.75	38.75	38.75	0.226	0.112	0.23	392.64
2002	NE	NE	NE	41.92	41.92	41.92	0.244	0.121	0.24	424.81
2003	NE	NE	NE	51.01	51.01	51.01	0.297	0.148	0.30	516.92
2004	NE	NE	NE	40.51	40.51	40.51	0.236	0.117	0.24	410.53
2005	NE	NE	NE	38.17	38.17	38.17	0.222	0.110	0.22	386.74
2006	NE	NE	NE	44.07	44.07	44.07	0.256	0.127	0.26	447.43
2007	NE	NE	NE	38.76	38.76	38.76	0.225	0.112	0.23	393.94
2008	NE	NE	NE	45.77	45.77	45.77	0.267	0.133	0.27	463.02
2009	NE	NE	NE	45.77	45.77	45.77	0.267	0.133	0.27	463.02
2010	NE	NE	NE	41.56	41.56	41.56	0.242	0.120	0.24	420.72
2011	NE	NE	NE	45.02	45.02	45.02	0.262	0.130	0.26	456.03
2012	NE	NE	NE	42.80	42.80	42.80	0.250	0.124	0.25	433.64
2013	NE	NE	NE	38.25	38.25	38.25	0.222	0.110	0.22	388.59
2014	NE	NE	NE	37.89	37.89	37.89	0.220	0.109	0.22	384.78
2015	NE	NE	NE	43.53	43.53	43.53	0.254	0.126	0.25	440.96
2016	NE	NE	NE	79.06	79.06	79.06	0.463	0.230	0.46	796.89
2017	NE	NE	NE	44.49	44.49	44.49	0.259	0.129	0.26	450.56
2018	NE	NE	NE	43.40	43.40	43.40	0.253	0.126	0.25	439.42
2019	NE	NE	NE	42.98	42.98	42.98	0.251	0.124	0.25	435.05
2020	NE	NE	NE	43.12	43.12	43.12	0.251	0.125	0.25	436.50
2021	NE	NE	NE	45.28	45.28	45.28	0.264	0.131	0.26	458.45
2022	NE	NE	NE	56.88	56.88	56.88	0.332	0.165	0.33	575.84
Trend 1990-2022	*NA*	*NA*	*NA*	*86.01%*	*86.01%*	*86.01%*	*86.21%*	*86.17%*	*86.21%*	*85.85%*
2005-2022	*NA*	*NA*	*NA*	*49.03%*	*49.03%*	*49.03%*	*49.19%*	*49.15%*	*49.19%*	*48.90%*
2021-2022	*NA*	*NA*	*NA*	*25.60%*	*25.60%*	*25.60%*	*25.61%*	*25.60%*	*25.61%*	*25.61%*

6.10.2 Methodological issues

For the calculation of emissions from accidental fires, activity data on the number of fires per fire object from national statistics[124] was used. This data was categorized into the car fires, detached house fires, undetached house fires, apartment building fires and industrial building fires, as needed in the EMEP/EEA Tier 2 approach (see Table 6-36). For the main pollutants, heavy metals and POPs, default emission factors were taken from EMEP/EEA Guidebook 2019 as shown in Table 6-37.

[124] Published by „Corps Grand-Ducal Incendie & Secours" available at: https://112.public.lu

Table 6-36 – Activity data for accidental fires

5E - Other waste						
activity data : number of fires						
Year	**detached house fires #**	**undetached house fires #**	**appartement building fires #**	**industrial building fires #**	**car fires #**	**Total #**
1990	120	134	32	119	142	548
1991	124	138	33	122	146	562
1992	107	119	29	105	126	486
1993	106	118	29	104	125	482
1994	103	115	28	101	121	468
1995	122	136	33	120	143	553
1996	132	147	35	130	155	599
1997	129	144	35	127	152	585
1998	135	150	36	133	158	612
1999	157	175	42	155	185	713
2000	149	167	40	147	176	680
2001	153	170	41	150	180	694
2002	165	184	44	163	195	751
2003	201	224	54	198	237	914
2004	160	178	43	157	188	726
2005	150	168	40	148	177	684
2006	171	191	62	162	236	822
2007	154	172	33	146	226	732
2008	183	204	39	174	182	782
2009	183	204	39	174	182	782
2010	159	177	56	182	179	753
2011	180	200	29	188	206	803
2012	166	185	65	157	193	766
2013	151	169	50	125	216	711
2014	152	169	48	113	205	687
2015	181	202	45	94	187	710
2016	348	388	24	130	178	1069
2017	180	200	43	146	194	763
2018	176	196	41	141	185	738
2019	174	194	41	137	178	725
2020	175	195	41	136	180	727
2021	184	205	44	140	190	762
2022	232	259	53	169	237	951
Trend 1990-2022	*92.99%*	*92.99%*	*63.05%*	*42.68%*	*67.36%*	*73.68%*
)05-2022	*54.62%*	*54.62%*	*30.63%*	*14.32%*	*34.09%*	*39.15%*
)21-2022	*26.23%*	*26.23%*	*21.46%*	*21.27%*	*25.30%*	*24.82%*

Table 6-37 – Source of Tier 2 default emission factors for accidental fires

Process	Pollutants	Source	Page	Table
Detached house fire	TSP, PM_{10}, $PM_{2.5}$, Pb, Cd, Hg, PCCD/F	EEA (2023) – Chapter 5.E. Other Waste	6	3-2
Undetached house fire	TSP, PM_{10}, $PM_{2.5}$, Pb, Cd, Hg, PCCD/F	EEA (2023) – Chapter 5.E. Other Waste	6	3-3
Appartment building fire	TSP, PM_{10}, $PM_{2.5}$, Pb, Cd, Hg, PCCD/F	EEA (2023) – Chapter 5.E. Other Waste	7	3-4
Industrial building fire	TSP, PM_{10}, $PM_{2.5}$, Pb, Cd, Hg, PCCD/F	EEA (2023) – Chapter 5.E. Other Waste	7	3-5
Car fire	TSP, PM_{10}, $PM_{2.5}$, PCCD/F	EEA (2023) – Chapter 5.E. Other Waste	5	3-1

6.10.3 Uncertainties and time-series consistency

The assessment of activity data and emission factor uncertainties is done according to the methodology described in the EMEP/EEA emission inventory Guidebook 2023 (Chapter A.5 Uncertainties, tables 2-1, 2-2 and 2-3), covering the main pollutants NO_x, NH_3, NMVOC, SO_x and $PM_{2.5}$. For some subcategories and pollutants, expert judgements were made to estimate AD or EF uncertainties. For CO, PM10, heavy metzals and persistent organic pollutants, no uncertainty estimates are currently made. Details on uncertainty of the activity data can also be checked in the Luxembourg's National Inventory report (NIR). Please also refer to Table 1-33 to Table 1-37 of section 1.7 for caterogory specific uncertainties on activity data and emission factors.

The time series reported under *5E – Other waste* are considered to be consistent. Fluctuations in the time series may occur due to inter-annual changes in the number of accidental fires occurring.

6.10.4 Source-specific QA/QC and verification

Standard QA/QC procedures were followed.

Consistency and completeness checks have been performed.

6.10.5 Category-specific recalculations including changes made in response to the review process

Table 6-38 presents the main revisions and recalculations done since submission 2023.

Table 6-38 – Recalculations done since the last submission for category *5E – Other Waste*

Source category	Revisions 2023 → 2024	Type of revision
5E	1990-2021: error correction in the calculation method following review recommendation LU-5E-2023-0001. The recalcuation lowered PM, HM and POP emissions by approx. 10% in average.	method

6.10.6 Category-specific planned improvements including those in response to the review process

No further improvements are planned.

7 OTHER AND NATURAL EMISSIONS

Emissions from feedstock and non-energy use of fuel should be reported under sector 6 - *Other and Natural Emissions*.

Emissions from natural emissions should be reported under this sector.

Table 7-1 provides the explanation to the notation keys used in sector 6.

Table 7-1 – Status of reporting for category *6 - Other and Natural Emissions*

NFR Code	Other and Natural Emissions	Air pollutants
6A	Other (included in national total for entire territory) (please specify in IIR)	NO
6B	Other not included in national total of the entire territory (please specify in the IIR)	NO
11A	Volcanoes	NO
11B	Forest fires	NO
11C	Other natural emissions (please specify in the IIR)	NO

8 RECALCULATIONS AND IMPROVEMENTS

8.1 Recalculations

8.1.1 Recalculations per category

Table 8-1 presents the main revisions and recalculations done since submission 2023 for all categories.

Table 8-1 – Recalculations done since the last submission

Source category	Revisions 2023 → 2024	Type of revision
1A1a	Revision of the natural gas and biogas activity data due to changes in the national energy balance for 2021 (+733 TJ for natural gas compared to the previous submission and +62 TJ for biogas compared to the previous submission).	AD
1A1a	Error correction: emissions from the combustion of natural gas and wood were double counted in sectors 1A1a and 1A2gviii for 2018-2021 in the previous submissions. This error has been corrected.	AD error correction
1A1a	Revision of NH_3 emissions for 2017-2021 from medium sized wood boilers due to a change of the Tier 2 EF in the new 2023 EMEP/EEA Guidebook (from 37 g/GJ to NE in Chapter 1A4, Table 3-45, p.86).	NH_3 EF
1A1a	Revision of NH_3 emissions for 1999-2021 from automatic boilers burning wood due to a change of the Tier 2 EF in the new 2023 EMEP/EEA Guidebook (from 37 g/GJ to 1 g/GJ in Chapter 1A4, Table 3-48, p.90).	NH_3 EF
1A1a	Revision of TSP emissions for 2017-2021 from medium sized wood boilers due to a change of the Tier 2 EF in the new 2023 EMEP/EEA Guidebook (from 36 g/GJ to 40 g/GJ in Chapter 1A4, Table 3-45, p.86).	TSP EF
1A1a	Revision of TSP emissions for 1999-2021 from automatic boilers burning wood due to a change of the Tier 2 EF in the new 2023 EMEP/EEA Guidebook (from 36 g/GJ to 40 g/GJ in Chapter 1A4, Table 3-48, p.90).	TSP EF
1A2a/c/d/e/f/gviii	In the latest national energy balance, changes were made to the allocation method of natural gas to the different sectors for the year 2021. Consequently, the natural gas AD for the sector 1A2a decreased by 577 TJ.	AD
1A2a	Revision of SO_X emissions for 2003-2009 from boilers using natural gas due to a change of the Tier 2 EF in the new 2023 EMEP/EEA Guidebook (from 0.281 g/GJ to 0.244 g/GJ in Chapter 1A1, Table 3-14, p.26).	SO_X EF
1A2a	Revision of TSP, PM_{10}, and $PM_{2.5}$ emissions for 2003-2009 from boilers using natural gas due to a change of the Tier 2 EF in the new 2023 EMEP/EEA Guidebook (from 0.89 g/GJ to 0.14 g/GJ in Chapter 1A1, Table 3-14, p.26).	TSP, PM_{10}, $PM_{2.5}$ EF
1A2b	Revision of SO_X emissions for 1996-2021 from secondary copper production due to an error correction of the Tier 2 EF (from 1320 g/t to 1230 g/t).	SO_X EF error correction
1A2g viii	Revision of the residual fuel oil, liquid petroleum gas, and biogas activity data due to changes in the national energy balance for 2021 (+7728 GJ for RFO, +47 GJ for LPG, and +2993 GJ for biogas compared to the previous submission).	AD
1A2g viii	Error correction: emissions from the combustion of natural gas and wood were double counted in sectors 1A1a and 1A2gviii for 2018-2021 in the previous submissions. This error has been corrected.	AD Error correction
1A2g viii	Revision of the NH_3 emissions for 2019-2021 due to a switch from Tier 2 to Tier 3.	Change of methodology
1A2g viii	Error correction of the AD for residual fuel oil from the national energy balance for the year 2005.	AD error correction
1A3b	Due to an error correction, the total activity data for diesel oil for the entire timeseries was revised, which impacts several mobile combustion sub-categories (1A2gvii, 1A3b, 1A3c, 1A3d, 1A4cii, 1A5b). As the fuel consumptions in mobile combustion are allocated to different vehicle categories by the NEMO and GEORG mod-	AD

Source category	Revisions 2023 ➔ 2024	Type of revision
	els, the change in total diesel activity data also impacts the allocations of gasoline, biomass and other fossil fuels (the total activity data of these three fuel types remains unchanged)	
1A3c	Due to an error correction, the total activity data for diesel oil for the entire timeseries was revised, which impacts several mobile combustion sub-categories (1A2gvii, 1A3b, 1A3c, 1A3d, 1A4cii, 1A5b). As the fuel consumptions in mobile combustion are allocated to different vehicle categories by the NEMO and GEORG models, the change in total diesel activity data also impacts the allocations of gasoline, biomass and other fossil fuels (the total activity data of these three fuel types remains unchanged)	AD
1A3di(ii), 1A3dii	Due to an error correction, the total activity data for diesel oil for the entire timeseries was revised, which impacts several mobile combustion sub-categories (1A2gvii, 1A3b, 1A3c, 1A3d, 1A4cii, 1A5b). As the fuel consumptions in mobile combustion are allocated to different vehicle categories by the NEMO and GEORG models, the change in total diesel activity data also impacts the allocations of gasoline, biomass and other fossil fuels (the total activity data of these three fuel types remains unchanged	AD
1A3d	Updated AD (liquid fuels, biomass, and other fossil fuels) for leisure boats for 2021 (interpolation between 2020 and 2022)	AD
1A4cii	Due to an error correction, the total activity data for diesel oil for the entire timeseries was revised, which impacts several mobile combustion sub-categories (1A2gvii, 1A3b, 1A3c, 1A3d, 1A4cii, 1A5b). As the fuel consumptions in mobile combustion are allocated to different vehicle categories by the NEMO and GEORG models, the change in total diesel activity data also impacts the allocations of gasoline, biomass and other fossil fuels (the total activity data of these three fuel types remains unchanged)	AD
1A4	Revision of the liquid petroleum gas and biogas activity data due to changes in the national energy balance for 2021 (-47 GJ for LPG and +39 TJ for biogas compared to the previous submission).	AD
1A4	In the latest national energy balance, changes were made to the allocation method of natural gas to the different sectors for the year 2021. Consequently, the total amount of natural gas consumed by the 1A4 sector in 2021 decreased by 458 TJ.	AD
1A4a	Revision of NH_3 emissions for 2000-2021 from automatic boilers burning wood due to a change of the Tier 2 EF in the new 2023 EMEP/EEA Guidebook (from 37 g/GJ to 1 g/GJ in Chapter 1A4, Table 3-48, p. 90).	NH_3 EF
1A4b	Revision of NH_3 emissions for 1990-2021 from wood combustion in conventional stoves due to a change of the Tier 2 EF in the new 2023 EMEP/EEA Guidebook (from 70 g/GJ to 8 g/GJ in Chapter 1A4, Table 3-40, p. 78).	NH_3 EF
1A4b	Revision of NH_3 emissions for 1990-2021 from wood combustion in advanced / eco-labelled stoves and boilers due to a change of the Tier 2 EF in the new 2023 EMEP/EEA Guidebook (from 37 g/GJ to 4 g/GJ in Chapter 1A4, Table 3-42, p. 81).	NH_3 EF
1A4b	Revision of NH_3 emissions for 1990-2021 from wood combustion in pellet stoves and boilers due to a change of the Tier 2 EF in the new 2023 EMEP/EEA Guidebook (from 12 g/GJ to 1 g/GJ in Chapter 1A4, Table 3-44, p. 84).	NH_3 EF
1A5b	Due to an error correction, the total activity data for diesel oil for the entire timeseries was revised, which impacts several mobile combustion sub-categories (1A2gvii, 1A3b, 1A3c, 1A3d, 1A4cii, 1A5b). As the fuel consumptions in mobile combustion are allocated to different vehicle categories by the NEMO and GEORG models, the change in total diesel activity data also impacts the allocations of gasoline, biomass and other fossil fuels (the total activity data of these three fuel types remains unchanged)	AD
2A5a	For buildings, emissions factors (EFs) were updated to match EMEP/EEA GB 2023 over entire timeseries. In total, emissions were slightly lowered.	EF
2D3a, 2D3d – 2D3i	The solvent model was completely revised	Updated AD, EF, methodology
3.B	Error correction of the number of laying hens in 2021; Used in 3.B and impacting 3.D influencing all N-, NMVOC- and PM-emissions.	Revised AD

Source category	Revisions 2023 → 2024	Type of revision
3.B / 5.B.2	Revision of origin of solid manure to be used as feedstock in biogas facilities from 2005 onwards from laying hens and cattle rather than just cattle. Used in 3.B and 5.B.2 and impacting 3.D.	Revised AD
3.B / 5.B.2	Revision of the calculation methodology whereby the imported manure was split according to its origin and added to the corresponding livestock categories. Used in 3.B and 5.B.2 and impacting 3.D.	Revised calculation methodology and error correction
3B	Revised Frac_of silage for suckler cows; revised Frac_of silage for horses and small rumiants. Revising VS_i for all livestock other than cattle following the 2019 Refinement of the 2006 IPCC guidelines (see NIR 2024)	EF / NMVOC emissions
3B	LU-3B-2023-001 - Error correction of the EF for PM for the livestock category "other poultry". For all three PM2.5, PM10 and TSP, the used EF for other poultry was the one for ducks rather than for turkey. This error was corrected in the current submission	EF
3D	Having additional data w.r.t. export of digestate originating from energy crops and non-agricultural waste. AD was updated	Revised AD
3 D a 1	Revision of EF for inorganic N-fertilizers according to EMEP 2023 guidelines	EF
3 D a 2 a	Revision of the 2021 data on the application of slurry, digestate and solid manure, impacting N-emissions. Provisional data were replaced.	AD / N emissions
3 D a 2 a & 3 D a 3	Revision of GE and VS, according to 2019 Refinement of the 2006, and revision of pregnancy rate for suckler cows impacted NMVOC emissions	AD/EF
3 D a 2 b	The provisional activity data for sewage sludge for the year 2021 was replaced by published data	AD
3 D.f.	For the years: 1990-2011: Revision of estimated HCB emissions per ha, as the activitiy data in the German inventory had been revised (which is the base for the HCB emissions); For 2012 and onwards: new data source for activity data, hence new estimates according to Tier 1 methodology in the EMEP 2023 guidelines	Updated AD / Methodology
5A	NMVOC emissions from solid waste disposal on land were revised for the entire timeseries as the calculation is based on the molar volume of methane instead of the denisty of landfill gas following NECD review recommendation LU-5A-2023-0001. PM emissions from inert waste disposal on land were revised for 2020 to 2021 due to revised activity data from national statistics	AD
5C1bv	Number of incinerations were revised for the entire timeseries based on publicly available data.	AD
5C1bv	Tier 1 method from EMEP/EEA Guidebook was applied.	method
5E	1990-2021: error correction in the calculation method following review recommendation LU-5E-2023-0001. The recalcuation lowered PM, HM and POP emissions by approx. 10% in average.	method

8.2 Planned improvements

Table 8-2 presents the improvements which are planned for the next submission.

Table 8-2 – Planned improvements for the next submission

Source category	Planned improvements	Type of revision
1A2a & 2C1	Reallocate process emissions (PM & TSP from raw material handling, blast furnace charging, etc.) from 1A2a to 2C1 for which separate data is available.	Emission reallocation
1A2b	Update methodological table by including Tier 2 EFs	Transparency
1A2b	Reallocate process specific emissions (PM, HMs, POPs) to 2C3 and 2C7a respectively	
1A2g viii	Revision of SO_2 (and potentially other pollutants) emitted from a big wood construction and processing operator based on a combined Tier 2 and Tier 3 approach.	Emissions
1A3b i-v	In order to improve transparency, values for biomass activity data will be provided instead of the notation key IE.	NA
1A3c	In order to improve transparency, values for biomass activity data will be provided instead of the notation key IE.	NA
1A3d	In order to improve transparency, values for biomass activity data will be provided instead of the notation key IE.	NA
1A4ai, 1A4bi	1990-1999: collect information helping to refine the fuel consumption split between the commercial/institutional sectors, on the one hand, and the residential sector, on the other hand.	Update AD
2D3	Punctual refinement of the new solvent and product use model	Methodology
3D	Countine the quest for data on quantities exported of locally produced animal manure and digestate to France and Germany	Update AD
3Dc	Quest for data on emitting practices necessary for refining PM emission calculations methodology in one of the next submissions	Update AD/Methodology
5C1bv	Estimate main pollutant emissions from cremation using the same activity data as for HMs and POPs, and reallocate from 1A4i to 5C1bv if double counting can be avoided.	Reallocation

9 PROJECTIONS

As outlined in the 'Guidelines for Reporting Emission Data under the Convention on Long-Range Transboundary Air Pollution' (ECE/EB.AIR/125, Update on 13 March 2014)

> § 44 Parties to the Gothenburg Protocol within the scope of EMEP shall regularly update their projections and report every four years from 2015 onward their updated projections for the years 2020, 2025 and 2030 and, where available, also for 2040 and 2050. Parties to the Protocols are encouraged to regularly update their projections and report every four years from 2015.
>
> § 45 Projected emissions for substances listed in paragraph 7 (i.e. sulphur dioxide (SO2), nitrogen oxides (NOx), ammonia (NH3), PM2.5 and non-methane volatile organic compounds (NMVOCs etc.) and, where appropriate black carbon should be reported using the template within Annex IV to these Guidelines. Parties should complete the tables at the requested level of aggregation. Where values for individual categories or aggregated NFR categories are not available, the notation keys defined in paragraph 12 to these Guidelines should be used.
>
> § 46 Quantitative information on parameters underlying emission projections should be reported using the templates set out in annex IV to these Guidelines. These parameters should be reported for the projection target year and the historic year chosen as the starting year for the projections.

Projections are publicly available on the following website:

> http://cdr.eionet.europa.eu/lu/eu/nec_revised/projected/

10 REPORTING OF GRIDDED EMISSIONS AND LPS

10.1 Gridded Emissions

10.1.1 Introduction

The present chapter describes the different methods used in the 2021 reporting of the gridded emissions for 2019 of different pollutants (NOx (as NO_2), NMVOC, SOx (as SO_2), NH_3, $PM_{2.5}$, PM_{10}, BC, CO, Pb, Cd, Hg, PCDD/PCDF, PAHs, HCB, PCB) registered in Luxembourg.

The gridding is done using the EMEP grid 0.1° x 0.1°, as outlined in paragraph 47 of the 'Guidelines for Reporting Emission Data under the Convention on Long-Range Transboundary Air Pollution' (ECE/EB.AIR/125, Update on 13 March 2014). The emissions, which have to be disaggregated, correspond to the national NFR sector emissions for the 15 pollutants aforementioned. These NFR sectors are grouped into different GNFR sectors (Gridding NFR sectors).

Concerning the GNFR sector F_RoadTransport, the emissions are distributed in a first step according to fuel sold, and in a second step according to fuel used.

Figure 1 shows a map of the Grand-Duchy of Luxembourg and the 51 cells of the EMEP grid which are covering the country. The shapefiles containing this grid are provided by the European Environment Agency. The coordinates of the 51 cells are prescribed and correspond to the center of the cells, whereas the FIDs belonging to them can be freely chosen.

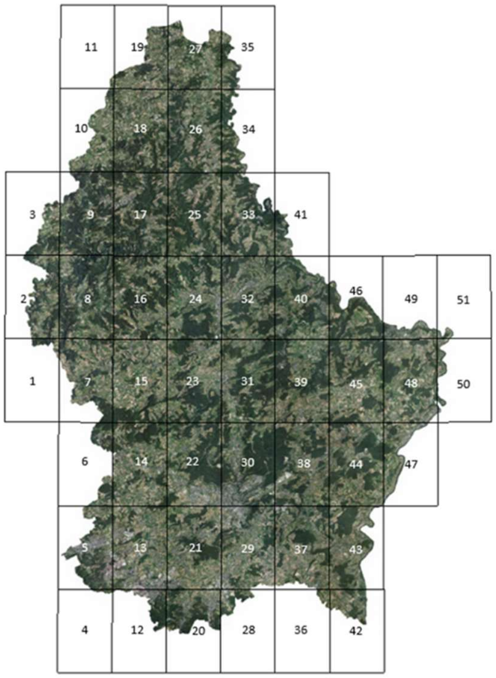
The software used to work with is the Gridding Emission Tool for ArcGIS (GRETA) from AVISO.

The disaggregated values, as finally reported to the CLRTAP and the European Commission, are summarized in the file LU_CLRTAP-NEC_2021v2_annex_v_gridded_emissions_210608_fuelsold.xlsx (according to fuel sold) an in the file LU_CLRTAP-NEC_2021v2_annex_v_gridded_emissions_210608_fuelused.xlsx (according to fuel used). The files are downloadable on the EEA's Central data repository under the following links:

a) Fuel sold : https://cdr.eionet.europa.eu/lu/un/clrtap/gridded/envyl83ja
b) Fuel used: https://cdr.eionet.europa.eu/lu/un/clrtap/gridded/envyl9hzg/

Please note that for air quality modeling purposes it is highly recommended to use the data set based on fuel used, as it only takes into account the emissions occurring on Luxembourg's territory. Emissions occurring in neighbouring countries due to fuel export (in the vehicle tank), and obtained by substracting emissions based on fuel used from emissions based on fuel sold, need to be considered by the modeler. Gridded emissions based on fuel sold are reported solely due to reporting obligations. Their spatial allocation (especially for GNFR category F_RoadTransport) has to be considered with special care.

Figure 63 – EMEP grid 0.1° x 0.1° for Luxembourg



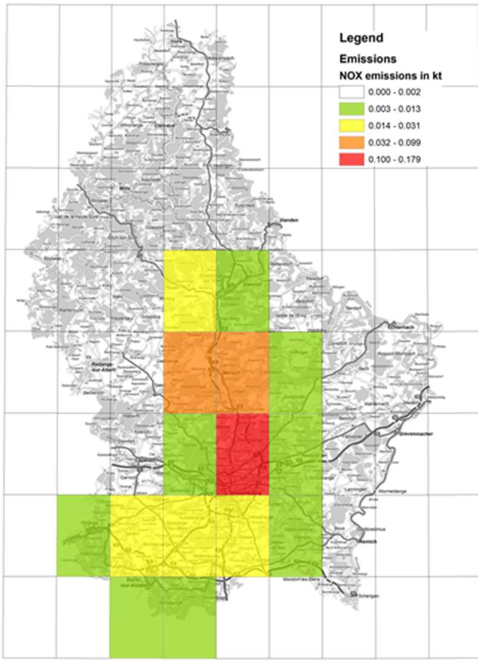
10.1.2 Methodology and results for the different GNFR sectors

10.1.2.1 A_PublicPower

The emissions of the GNFR sector A_PublicPower correspond to the emissions of the NFR sector 1A1a (Public electricity and heat production).

The disaggregation of the total emissions of this sector is carried out using E-PRTR (European Pollutant Release and Transfer Register) database. The emissions are assigned to the corresponding PRTR point sources. The remaining amount of emissions are distributed proportionally over the cantons in which the power plants reside.

Figure 64 – NO_X emission distribution of the GNFR sector A_PublicPower



10.1.2.2 B_Industry

The emissions of the GNFR sector B_Industry correspond to the sum of the emissions of the NFR sectors 1A2a (Stationary combustion in manufacturing industries and construction: Iron and steel), 1A2b (Stationary combustion in manufacturing industries and construction: Non-ferrous metals), 1A2c (Stationary combustion in manufacturing industries and construction: Chemicals), 1A2d (Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print), 1A2e (Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco), 1A2f (Stationary combustion in manufacturing industries and construction: Non-metallic minerals), 1A2gviii (Stationary combustion in manufacturing industries and construction: Other), 2A3 (Glass production), 2A5b (Construction and demolition), 2C1 (Iron and steel production), 2C3 (Aluminium production), 2D3b (Road paving with asphalt), 2H2 (Food and beverage industry), and 2K (Consumption of POPs and heavy metals (e.g. electrical and scientific equipment)).
There is a separate distribution for the pollutants in the above-mentioned NFR sectors.
The distribution for 2D3b is performed considering the geometry of the road network and the annual mileage in Luxembourg.
For all other above-mentioned NFR sectors, the emissions are firstly distributed via PRTR point sources. For each NFR sector, only the relevant companies are included in the distribution.

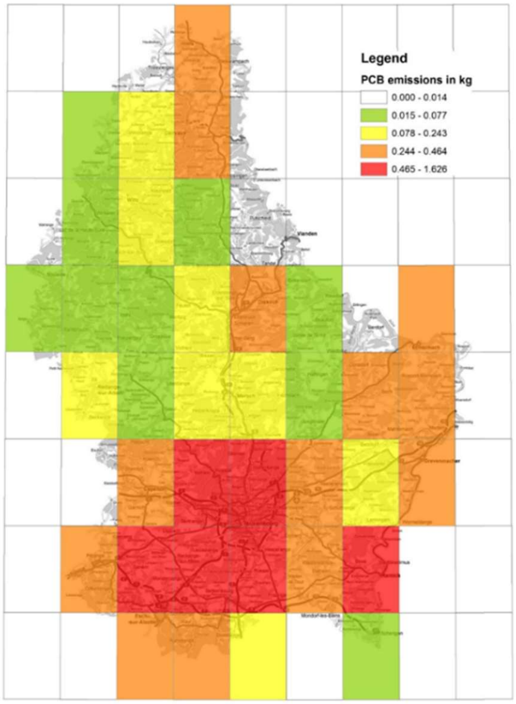
NFR sector	relevant NACE group
1A2a, 2A5b	1
1A2b, 2C3	2
1A2c	3
1A2d	4
1A2e, 2H2	5
1A2f	6
1A2gviii, 2K	1 to 12
2A3	7
2C1	8

Then, the number of companies per NACE sector is used at municipality level. Within the municipalities, emissions are allocated to the corresponding land use areas (OBS[125] 1.2.1.1.2, i.e. CLC[126] group 4 (mixed industrial and commercial areas, military, large buildings of public services)).

[125] Occupation Biophysique du Sol
[126] Corine Land Cover

The deciding factor for the emission distribution is less the area used than the number of resident companies.

Figure 65 – PCB emission distribution of the GNFR sector B_Industry



10.1.2.3 C_OtherStationaryComb

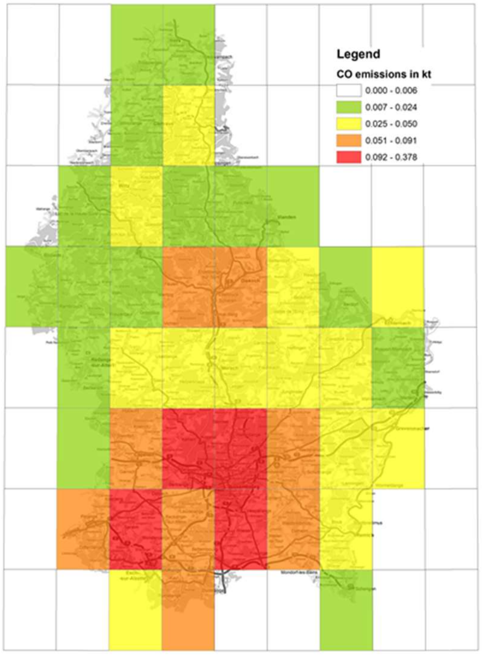
The emissions of the GNFR sector C_OtherStationaryComb correspond to the sum of the emissions of the NFR sectors 1A4ai (Commercial/institutional: Stationary), 1A4bi (Residential: Stationary) and 1A4ci (Agriculture/Forestry/Fishing: Stationary).

- The disaggregation of the total emissions of the sector 1A4ai is performed using the heating database. This heating database contains information about location and type of used heatings in Luxembourg. In addition to the type of use (private, commercial, public) and the municipality, the energy source used as well as the power of the heating is indicated. This database was aggregated at community level. As a result, the total output of all privately used and not privately used heating systems was available for each municipality. This information was used as primary distribution parameter for the NFR sector 1A4ai. In the case of NFR sector 1A4ai only the not privately used heatings were taken into account. The share of heating output (in kW) per municipality in the total output of all non-privately used heating systems forms the distribution key. Afterwards the final step of spatial distribution to suitable land use areas (OBS 1.2.1.1.2 and OBS 1.2.1.2, i.e. CLC groups 4 and 5) takes place.

- As described for NFR sector 1A4ai, the heating database is used as primary distribution key for the disaggregation of the total emissions of the sector 1A4bi. In contrast to NFR sector 1A4ai, only privately used heating systems are taken into account in determining the distribution parameter. The second part of the spatial distribution is the subdistribution on areas containing residential buildings (OBS 1.1.1 to OBS 1.1.2.4, i.e. CLC groups 1 and 2).

- The disaggregation of the total emissions of the sector 1A4ci is done using an evaluation of the agricultural plants and wine estates per municipality and canton. The deciding factor is not the agricultural area but the number of farms, as the focus here is on the heaters within the buildings. Therefore, this proportional count of farms/wineries per municipality is the distribution key. The subsequent spatial subdistribution takes place via OBS 1.2.1.4 areas (CLC group 7).

Figure 66 – CO emission distribution of the GNFR sector C_OtherStationaryComb



10.1.2.4 D_Fugitive

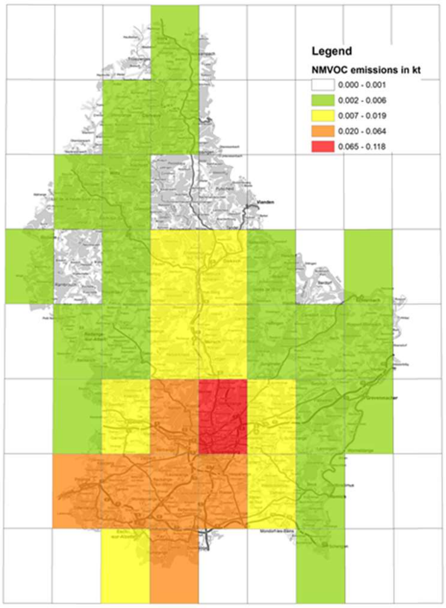
The emissions of the GNFR sector D_Fugitive correspond to the sum of the emissions of the NFR sectors 1B1a (Fugitive emission from solid fuels: Coal mining and handling), 1B2av (Distribution of oil products) and 1B2b (Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)).

- The disaggregation of the total emissions of the sector 1B1a is performed using the relevant NACE groups 13 and 14.

- The disaggregation of the total emissions of the sector 1B2av is done using two sources. 90 % of the emissions are distributed over the population per municipality (polygon of municipalities, CLC groups 2 to 5). Distribution of the remaining 10 % is based on the location of the filling stations (evenly distribution according to the point layer of petrol stations).

The disaggregation of the total emissions of the sector 1B2b is performed using the heating database. For this NFR sector, only entries of the energy source “natural gas” were evaluated. The sum of the heating output (kW) provided per municipality was set in relation to the total heating output of “natural gas”. This share per community is the main distribution parameter. Afterwards the final spatial distribution is done using OBS 1.1.1 to OBS 1.1.2.4 (CLC groups 1 and 2).

Figure 67 – NMVOC emission distribution of the GNFR sector D_Fugitive

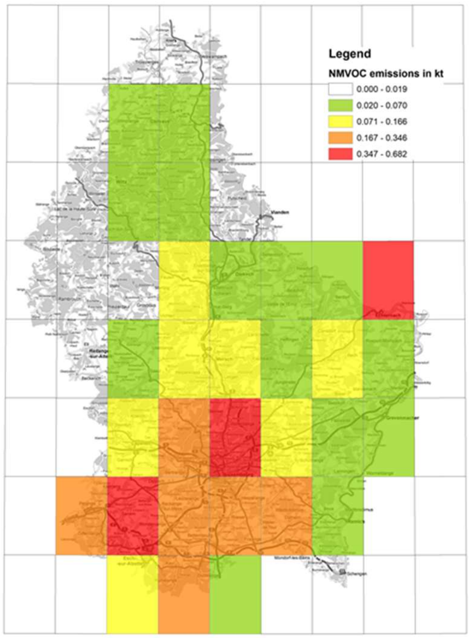


10.1.2.5 E_Solvents

The emissions of the GNFR sector E_Solvents correspond to the sum of the emissions of the NFR sectors 2D3a (Domestic solvent use including fungicides), 2D3d (Coating applications), 2D3e (Degreasing), 2D3f (Dry cleaning), 2D3g (Chemical products), 2D3h (Printing), 2D3i (Other solvent use) and 2G (Other product use).

Total emissions of the sectors 2D3a, 2D3d, 2D3e, 2D3f, 2D3g, 2D3h, 2D3i and 2G are disaggregated using two different sources. 50 % of the emissions are distributed over the population per municipality. The distribution of the remaining 50 % is based on the number of employees in companies emitting solvents. The database containing then number of employees in NACE sectors emitting solvents was aggregated to municipality level. For some companies, there was no information on the number of employees. In these cases, the minimum number of employees was assumed to ensure the spatial distribution. The second part of the spatial distribution is the subdistribution across all building areas (OBS 1.1.1 to OBS 1.2.1.4, i.e. CLC groups 1 - 7), as small businesses are often located in residential areas.

Figure 68 – NMVOC emission distribution of the GNFR sector E_Solvents



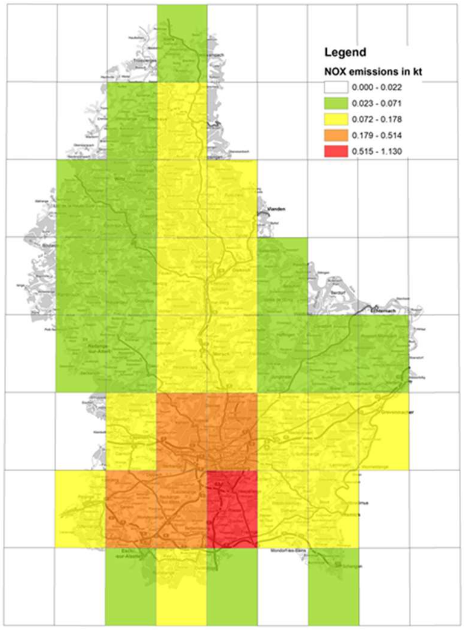
10.1.2.6 F_RoadTransport

The emissions of the GNFR sector F_RoadTransport correspond to the sum of the emissions of the NFR sectors 1A3bi (Road transport: Passenger cars), 1A3bii (Road transport: Light duty vehicles), 1A3biii (Road transport: Heavy duty vehicles and buses), 1A3biv (Road transport: Mopeds & motorcycles), 1A3bv (Road transport: Gasoline evaporation), 1A3bvi (Road transport: Automobile tyre and brake wear) and 1A3bvii (Road transport: Automobile road abrasion).

Total emissions in this sector are distributed according to the national road traffic model. Not only the geometry of the network is considered but also distribution parameters are derived using the average daily traffic per vehicle type.

- For the NFR sectors 1A3bi, 1A3bii, and 1A3biv, the mileage distribution of vehicle group “cars” is used for spatial distribution of the emissions.
- For the NFR sector 1A3biii, 1A3bvi, and 1A3bvii, the mileage distribution over yearly mileage of DTV (average daily traffic [Kfz/24h]) is used for spatial distribution of the emissions.
- For the NFR sector 1A3bv (Road transport: Gasoline Evaporation), the distribution is based on the number of inhabitants per municipality, as this serves as an indicator of the number of vehicles registered. Afterwards the final spatial distribution is done using CLC group 8 (OBS 1.2.2.1.1 and OBS 1.2.2.1.2).

Figure 69 – NO_X emission distribution of the GNFR sector F_RoadTransport

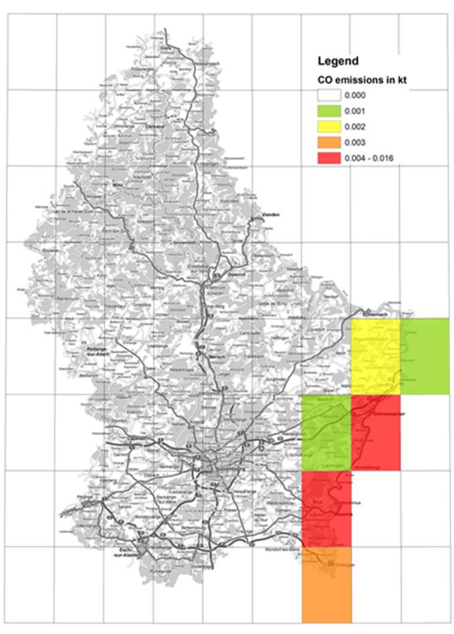


10.1.2.7 G_Shipping

The emissions of the GNFR sector G_Shipping correspond to the sum of the emissions of the NFR sectors 1A3di(ii) (International inland waterways) and 1A3dii (National navigation (shipping)).

The disaggregation of the total emissions of this sector is performed over the river Moselle. Therefore, the length of the river in the corresponding grid cells is determined. Based on the total length of the Moselle, the disaggregation of the total emissions of this sector can then be done.

Figure 70 – CO emission distribution of the GNFR sector G_Shipping

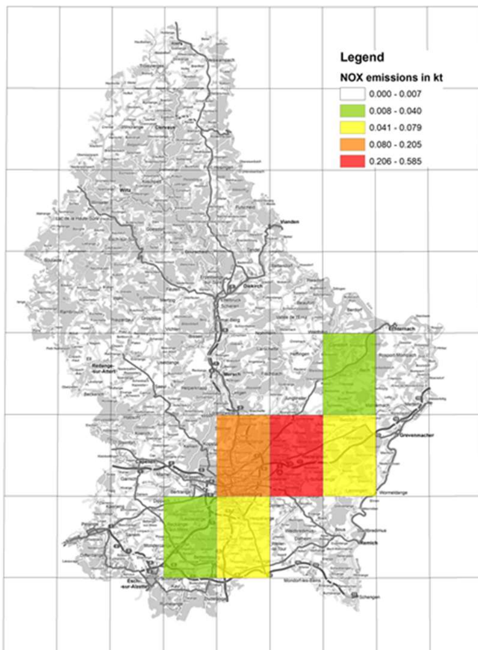


10.1.2.8 H_Aviation

The emissions of the GNFR sector H_Aviation correspond to the sum of the emissions of the NFR sectors 1A3ai(i) (International aviation LTO (civil)) and 1A3aii(i) (Domestic aviation LTO (civil)).

The disaggregation of the total emissions of this sector is done on the basis of the detailed radar flight traces for all take-offs and landings in 2016 on the national airport of Luxembourg (Findel), and the linkage of the data with the flight schedules proportionately to the corresponding approach/departure routes.
52.4 % of the emissions are distributed to the funnels (climb and approach); the remaining 47.6 % are allocated to the airport area (taxiing and take-off/landing). In addition, the average emission proportion per segment as well as the average emission height per segment is taken into account.

Figure 71 – NO_X emission distribution of the GNFR sector H_Aviation



10.1.2.9 I_Offroad

The emissions of the GNFR sector I_Offroad correspond to the sum of the emissions of the NFR sectors 1A2gvii (Mobile Combustion in manufacturing industries and construction), 1A3c (Railways), 1A4bii (Residential: Household and gardening (mobile)), 1A4cii (Agricul-ture/Forestry/Fishing: Off-road vehicles and other machinery) and 1A5b (Other, Mobile (including military, land based and recreational boats)).

- The disaggregation of the total emissions of the sector 1A2gvii is performed using the count of companies working in specific NACE sectors. Relevant NACE codes are the groups 13 and 14. The number of companies in groups 13 and 14 has been summed at the community level. This determines the proportionate distribution over affected communities. In the second step of the distribution, the allocation to the relevant OBS areas takes place. These are: industry (1.2.1.1.1), mining (1.3.1), earth deposit (1.3.2.1), heaps (1.3.2.2), industrial fallow (1.3.2.3) and construction sites (1.3.2.4). They are summarized to the previously defined CLC groups 3 and 12.

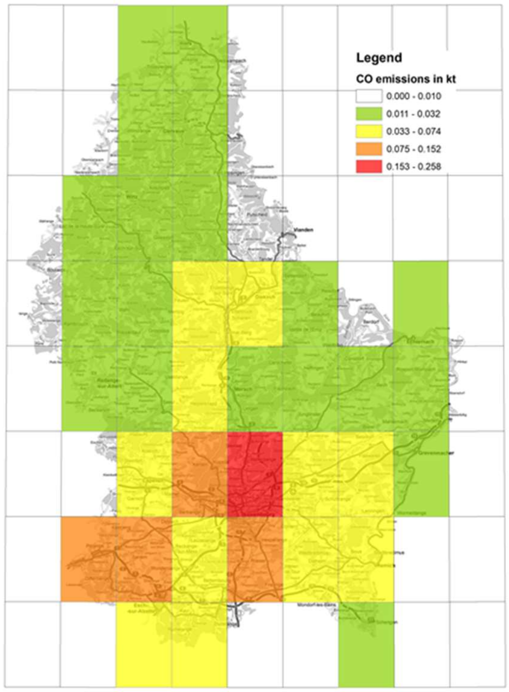
- The disaggregation of the total emissions of the sector 1A3c is done using the length proportion of the railway network for each grid.

- The disaggregation of the total emissions of the sector 1A4bii takes place in areas containing residential buildings. A measure of the level of emissions is the population of a municipality. Therefore, the distribution is based on the number of inhabitants. Sub-sequently, the spatial allocation to the relevant areas (OBS 1.1.1 to 1.1.2.4, i.e. CLC groups 1 and 2) is carried out.

- Total emissions of the sector 1A4cii are disaggregated over the number of agricultural holdings/wineries in line with the emissions of NFR sector 1A4ci (Agriculture/Forestry/ Fishing: Stationary). The subsequent spatial subdistribution takes place via OBS code 1.2.1.4 areas (CLC group 7).

- Total emissions of the sector 1A5b are evenly spread across all land use areas.

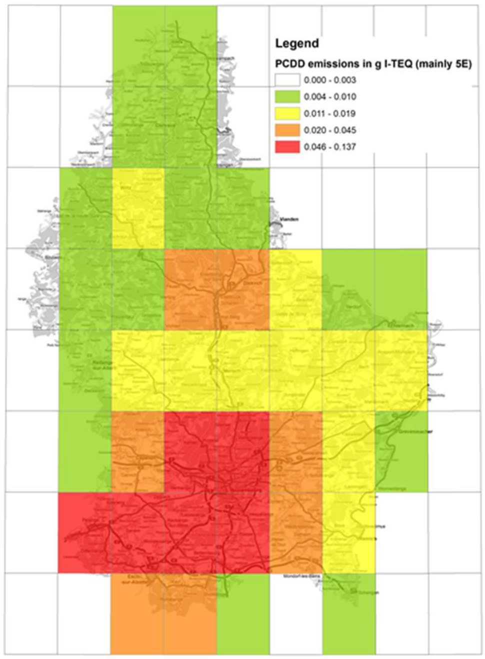
Figure 72 – CO emission distribution of the GNFR sector I_Offroad



10.1.2.10 J_Waste

The emissions of the GNFR sector J_Waste correspond to the emissions of the NFR sectors 5A (Biological treatment of waste - Solid waste disposal on land), 5B1 (Biological treatment of waste - Composting), 5B2 (Biological treatment of waste - Anaerobic digestion at biogas facilities), 5C1bv (Cremation), 5D1 (Domestic wastewater handling), 5D2 (Industrial wastewater handling) and 5E (Other waste).
Total emissions of this sector are disaggregated using the crematorium at Hamm as only point source. This crematorium is the only official source of emissions. The emission height is set to 10 m.

Figure 73 – PCDD emission distribution of the GNFR sector J_Waste



10.1.2.11 K_AgriLivestock

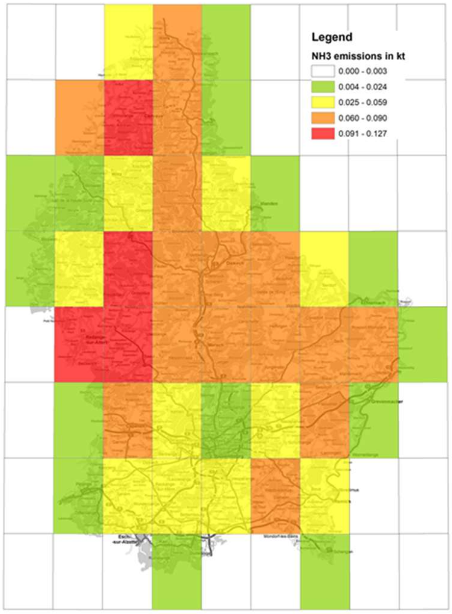
The emissions of the GNFR sector K_AgriLivestock correspond to the sum of the emissions of the NFR sectors 3B1a (Manure management - Dairy cattle), 3B1b (Manure management - Non-dairy cattle), 3B2 (Manure management - Sheep), 3B3 (Manure management - Swine), 3B4d (Manure management - Goats), 3B4e (Manure management - Horses), 3B4gi (Manure management - Laying hens), 3B4gii (Manure management - Broilers), 3B4giv (Manure management - Other poultry) and 3B4h (Manure management - Other animals).

- The disaggregation of the total emissions of the sectors 3B1a, 3B1b, 3B2, 3B3 and 3B4e is carried out on the municipalities using the livestock available at municipal level. The spatial distribution within a municipality then takes place over the CLC group 16 (humid and mesophilic grassland).

- The disaggregation of the total emissions of the sectors 3B4d, 3B4gi, 3B4gii, 3B4giv is performed only taking areas of the type commercial agriculture (OBS 1.2.1.4, i.e. CLC group 7) into account. Pre-distribution in municipalities takes place over the area share per municipality in relation to the total area of Luxembourg.

- The disaggregation of the total emissions of the sector 3B4h is performed only taking areas corresponding to the OBS classes 2.3.1.1 (humid grassland) and 2.3.1.2 (mesophilic grassland), i.e. CLC group 16. Pre-distribution in municipalities takes place over the area share per municipality in relation to the total area of Luxembourg

Figure 74 – NH_3 emission distribution of the GNFR sector K_AgriLivestock

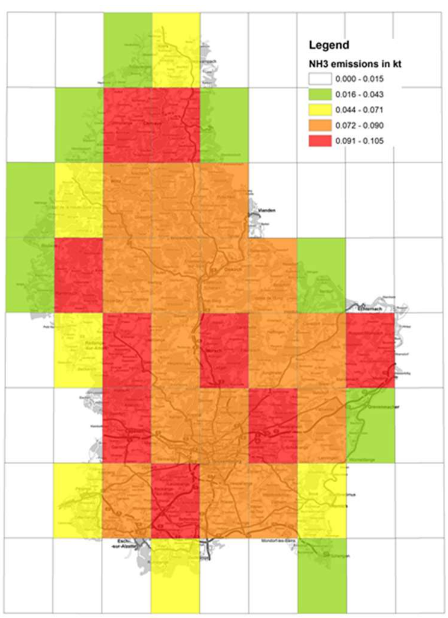


10.1.2.12 L_AgriOther

The emissions of the GNFR sector L_AgriOther correspond to the sum of the emissions of the NFR sectors 3Da1 (Inorganic N-fertilizers (includes also urea application)), 3Da2a (Animal manure applied to soils), 3Da2b (Sewage sludge applied to soils), 3Da2c (Other organic fertilizers applied to soils (including compost)), 3Da3 (Urine and dung deposited by grazing animals), 3Da4 (Crop residues applied to soils), 3Dc (Farm-level agricultural operations including storage, handling and transport of agricultural products) and 3De (Cultivated crops).

Total emissions of this sector are disaggregated over areas corresponding to OBS 2.1.1.1, i.e. CLC group 14. Pre-distribution in municipalities takes place over the area share per municipality in relation to the total area of Luxembourg.

Figure 75 – NH_3 emission distribution of the GNFR sector L_AgriOther



10.1.2.13 M_Other

The emissions of the GNFR sector M_Other are not applicable (NA) for Luxembourg.

10.2 Emissions of large point sources (LPS)

“Large point sources” (LPS) are defined as facilities whose combined emissions, within the limited identifiable area of the site premises, exceed at least one of the pollutant emission thresholds identified in Table 1 of the revised 2014 CLRTAP Reporting Guidelines. In its 2021 submission, Luxembourg reported LPS data for 2017 (14 facilities), 2018 (13 facilities) and 2019 (15 facilities) according to this definition, including information on stack height class. Please be aware that most facilities in Luxembourg are rather small, and that only a very limited number of pollutants exceed the threshold. Hence, there could be instances that LPS data is reported for one year but not for the next, as its emission might be lower than the above mentioned emission reporting threshold.

The data set is downloadable on the EEA’s Central data repository under the following link: https://cdr.eionet.europa.eu/lu/un/clrtap/lps/envymgp0g/.

10.2.1 Activity Data

In Table 10-1 an overview of the required information and the respective data source is presented.

Table 10-1 - Overview of data sources for LPS (required in ANNEX VI).

Activity data	Data source
LPS	Facility name, owner and (if necessary for distinguishability) parts of the address according to IED / E-PRTR reporting (Directive (EU) 2010/75 on industrial emissions and Regulation (EC) No 166/2006 on the establishment of a European Pollutant Release and Transfer Register)
GNFR	Expert judgement based on PRTR activities
PRTR Facility ID	IED (EU-Registry) / E-PRTR reporting
Stack Height Class (1-5)	LCP176 reporting according to directive 2010/75/EU on industrial emissions (integrated pollution prevention and control). If there were more than one height classes available, the upper value was taken
Longitude/latitude	IED (EU-Registry) / E-PRTR reporting
Emissions for 2008 and 2015	CLRTAP submission 2017 (IED (EU-Registry) / E-PRTR reporting, data set downloadable on the EEA’s Central data repository under the following link: https://cdr.eionet.europa.eu/lu/eu/nec_revised/lps/envwqmwha/
Emissions for 2017, 2018 and 2019	IED (EU-Registry) / E-PRTR reporting

10.2.2 Methodological Issues

The applied methodology is in accordance with the revised 2014 CLRTAP Reporting Guidelines. The LPS data is prepared in line with the list of pollutants to be reported if the applicable threshold value is exceeded as demonstrated in Table 1 of the CLRTAP Reporting Guidelines.

The LPS data is extracted from the PRTR data as reported by the relevant facilities and exceeding the emission threshold, as mentioned above. The same plant specific data (as reported by the PRTR reporting facilities, without appliying the LPS emission tresholds) is also integrated in the air emission inventory, after quality checks, except for agricultural facilities (GNFR K_AgriLivestock) for which the emissions calculated in the emission inventory are based on national livestock statistics. Indeed, the Environment Agency is both in charge of reporting under IED/PRTR and air emission inventory reporting obligations. Quality checks include comparison with facility specific annual reports, emission monitoring reports under the IED monitoring, plausibility checks. Also, the PRTR data only represents a more or less important share of the emission in a given NFR category.

10.3 Recalculations and planned improvements

For LPS and gridded emissions reported in the previous submission (2017), no recalculations have ben operated in this submission.

Currently, no further improvements are planned.

11 ADJUSTMENTS

Luxembourg has not requested any adjustments for the present submission.

12 REFERENCES

12.1 Chapter 3: Energy (NFR sector 1)

Administration de l'Environnement (AEV) - Division des Déchets (2005), *Restabfallanalyse 2004/05 im Großherzogtum Luxemburg, Band 1: Kompendium*, Luxembourg.

Administration de l'Environnement (AEV) - Division des Déchets (2002), *Restabfallanalyse 2001 im SIDOR*, Luxembourg.

Administration de l'Environnement (AEV) - Division des Déchets (2002), *Waste analysis 1992/1994*, Luxembourg.

ARBED (1990 – 1998): Annual communications from the operator to the Environment Agency Luxembourg. Luxembourg.

Handbook emission factors for road transport (HBEFA) http://www.hbefa.net/

Ministère de l'Economie et du Commerce Extérieur, Direction de l'Energie (1990 – 2008): Rapports d'Activité. Luxembourg.

Ministère de l'Environnement, L'Environnement en Chiffres 2002-2003 (2003).

Molitor R., Hausberger S., Obermayer C., Rexeis M., Schwingshackl M. 2015: Aktuali-sierung der Zeitreihen zum Kraftstoffexport und der Emissionen von klimarelevanten Gasen und Luftschadstoffen des Verkehrssektors in Luxemburg von 1990 – 2013, Er-stellt im Auftrag von: Le Gouvernement du Grand-Duché de Luxembourg Ministère du Développement durable et Infrastructures, Jänner 2015

Molitor R., Hausberger S., Obermayer C., Schwingshackl M. 2014: BAU-Prognose zum Kraftstoffexport und der zugehörigen Emissionen von klimarelevanten Gasen und Luftschadstoffen des Verkehrssektors in Luxemburg von 2015 – 2030 und Ausblick bis 2050, Erstellt im Auftrag von: Le Gouvernement du Grand-Duché de Luxembourg Mi-nistère du Développement durable et Infrastructures, Dezember 2014

Société Nationale de Contrôle Technique (SNCT) (1990-2013) : Stock of passenger cars, light duty vehicle, heavy duty vehicle, busses, motor cycles. Sandweiler, Luxembourg.

STATEC 1990 – 2013. Annuaires statistiques. Luxembourg.

TÜV Rheinland (1990): Emissionskataster für das Großherzogtum Luxemburg. Köln.

TÜV Rheinland (1992-1993) Impaktstudien für die ARBED-Werke Esch/Belval, Differdange und Esch-Schifflange für das Jahr 1990.

12.2 Chapter 4: INDUSTRIAL PROCESSES AND OTHER PRODUCT USE (IPPU) (NFR sector 2)

BARNERT (1998): ÖSTERREICHISCHES LACKINSTITUT: MÖGLICHKEITEN UND GRENZEN UMWELTVERTRÄGLICHER BESCHICHTUNG (LACKE, KLEBSTOFFE, BAUTENSCHUTZMITTEL, HOLZSCHUTZMITTEL), WIEN. AUSTRIA

EUROSTAT (2008): Enterprises and employees in Luxembourg (Industry, NACE Rev.1 Level-4), 1995-2005. http://epp.eurostat.ec.europa.eu.

SCHMIDT A., VITOVEC W., PUXBAUM H. & KNIERIDER R. (1998): TU Wien, Gesellschaft Österreichischer Chemiker: Die ökologischen Auswirkungen der Lösungsmittelverordnung 1991 und 1995. September 1998, Wien. Austria.

WINIWARTER, W.; KÖTHER, T (2008): UNCERTAINTY RELATED TO LUXEMBOURG'S NATIONAL GREENHOUSE GAS INVENTORY. AUSTRIAN RESEARCH CENTERS GMBH (ARC) DIVISION SYSTEMS RESEARCH. VIENNA. AUSTRIA.

WINDSPERGER, S.; STEINLECHNER, S.; SCHMIDT-STEJSKAL, H.; DRAXLER, S.; FISTER, G., SCHÖNSTEIN, R. & SCHÖRNER, G. (2002a): Gegenüberstellung und Abgleich der Daten von Top-down zu Bottom-up für Lösungsmittel im Jahr 2000. Institut für Industrielle Ökologie (IIÖ) und Forschungsinstitut für Energie und Umweltplanung, Wirtschaft- und Marktanalysen GmbH (FIEU). Studie im Auftrag des Lebensministeriums und Bundesministeriums für Wirtschaft und Arbeit. Wien.

WINDSPERGER, S.; STEINLECHNER, S.; SCHMIDT-STEJSKAL, H.; DRAXLER, S.; FISTER, G., SCHÖNSTEIN, R. & SCHÖRNER, G. (2002b): Verbesserung von Emissionsdaten (Inventur und Projektion bis 2010 für den Bereich Lösungsmittel in Österreich. Institut für Industrielle Ökologie (IIÖ) und Forschungsinstitut für Energie und Umweltplanung, Wirtschaft- und Marktanalysen GmbH (FIEU). Studie im Auftrag des Lebensministeriums und Bundesministeriums für Wirtschaft und Arbeit. Wien.

WINDSPERGER, S.; STEINLECHNER, S.; SCHMIDT-STEJSKAL, H.; DRAXLER, S.; FISTER, G., SCHÖNSTEIN, R. & SCHÖRNER, G. (2004): Studie zur Anpassung der Zeitreihe der Lösungsmittelemissionen der österreichischen Luftschadstoffinventur (OLI) 1980–2002. Institut für Industrielle Ökologie (IIÖ) und Forschungsinstitut für Energie und Umweltplanung, Wirtschaft- und Marktanalysen GmbH (FIEU). Studie im Auftrag des Umweltbundesamt. Wien.

WINDSPERGER, S.; STEINLECHNER, S. (2006) : Pooling and Analysis of Information on Materials with Complicated Pathways (WP 1) – Part: Survey on Solvents, Oils and Lubricants. Institute for Industrial Ecology (IIÖ), Continuation of the "International Network Non-energy use and CO2 emissions (NEU-CO2), Phase III. St.Pölten Austria.

12.3 Chapter 5: Agriculture (NFR Sector 3)

Administration des services vétérinaires, ASV. 2018. Rinder. Administration des services vétérinaires (ASV), 20/09/2018 2018 [cited 6-12-2018 2018]. Available from https://agriculture.public.lu/de/tierhaltung/nutztiere/identifizierung-ruckverfolgbarkeit/rinder.html.

CBS. 2009. Dierlijke mest en mineralen 1990-2008. Den Haag/Heerlen/Bonaire: Centraal Bureau voor de Statistiek (CBS).

CBS. 2018. Dierlijke mest en mineralen 2017. Den Haag/Heerlen/Bonaire: Centraal Bureau voor de Statistiek (CBS).

CITEPA. 2019. Inventaire des émissions de polluants atmosphériques en France métropolitaine, format CEE-NU. Paris: Centre Interprofessionnel Technique d'Etude de la Pollution Atmosphérique (CITEPA).

Climat, Environnement -. 1982. Loi du 11 août 1982 concernant la protection de la nature et des ressources naturelles. In A — N° 69 edited by MEMORIAL - Journal Officiel du Grand-Duché de Luxembourg. Luxembourg.

Climat, Environnement -. 2004. Loi du 19 janvier 2004 - concernant la protection de la nature et des ressources naturelles; - modifiant la loi modifiée du 12 juin 1937 concernant l'aménagement des villes et autres agglomérations importantes; - complétant la loi modifiée du 31 mai 1999 portant institution d'un fonds pour la protection de l'environnement. In A — N° 10 edited by MEMORIAL - Journal Officiel du Grand-Duché de Luxembourg. Luxembourg.

Climat, Environnement -. 2018. Loi du 15 mai 2018 relative à l'évaluation des incidences sur l'environnement et portant modification :1° de la loi modifiée du 25 mai 1964 concernant le remembrement des biens ruraux ; 2° de la loi modifiée du 10 juin 1999 relative aux établissements classés ; 3° de la loi modifiée du 19 janvier 2004 concernant la protection de la nature et des ressources naturelles ; 4° de la loi modifiée du 19 décembre 2008 relative à l'eau. In A398, edited by MEMORIAL - Journal Officiel du Grand-Duché de Luxembourg. Luxembourg.

DLG. 2008. Abschätzung der Stickstoffausscheidung bei der Milchkuh auf Basis von Milchharnstoffgehalt und Milchleistung - Ergänzung zur Broschüre „Bilanzierung der Nährstoffausscheidungen landwirtschaftlicher Nutztiere" – Arbeiten der DLG/Band 199. Frankfurt am Main: DLG-Arbeitskreises Futter und Fütterung.

EMEP/EEA. 2013. EMEP/EEA air pollutant emission inventory Guidebook 2013 - 3B Manure management. European Environmental Agency.

EMEP/EEA. 2016a. EMEP/EEA air pollutant emission inventory Guidebook 2016 - 3.D.f, 3.I Agriculture other including use of pesticides. European Environmental Agency.

EMEP/EEA. 2016b. EMEP/EEA air pollutant emission inventory Guidebook 2016 - 3B Manure management. European Environmental Agency.

EMEP/EEA. 2016c. EMEP/EEA air pollutant emission inventory Guidebook 2016 - 3D Crop production and agricultural soils. European Environmental Agency.

EMEP/EEA. 2019a. EMEP/EEA air pollutant emission inventory Guidebook 2019 - 3.D.f, 3.I Agriculture other including use of pesticides. European Environmental Agency.

EMEP/EEA. 2019b. EMEP/EEA air pollutant emission inventory Guidebook 2019 - 3B Manure management. European Environmental Agency.

EMEP/EEA. 2019c. EMEP/EEA air pollutant emission inventory Guidebook 2019 - 3D Crop production and agricultural soils. European Environmental Agency.

Engel, Tom. 2019. Milk urea - 2001-2005: average of the tested milk samples & 2006-2018: weighted averages Ettelbruck, 26th November 2019.

Gargano, Lucia , Georges Zangerlé, Jean Haupert, and Jean-Paul Hoffmann. 2014. "La structure des exploitations agricoles en 2012 et les méthodes de production agricole en 2010." Bulletin du statec no. 03/2013.

Haenel, Hans-Dieter, Claus Rösemann, Ulrich Dämmgen, Ulrike Döring, Sebastian Wulf, Brigitte Eurich-Menden, Annette Freibauer, Helmut Döhler, Carsten Schreiner, and Bernhard Osterburg. 2018. Calculations of gaseous and particulate emissions from German agriculture 1990-2016: Report on methods and data (RMD) Submission 2018. edited by Thünen Reports 57. Braunschweig: Johann Heinrich von Thünen Institute, Federal Research Institute for Rural Areas, Forestry and Fisheries.

Horlacher, Dieter. 2018. "IV Pflanzliche Erzeugung - 2.6 Kenngrössen, Eigenschaften, Nährstoff- und Mengenanfall von Wirtschaftsdüngern." In Faustzahlen für die Landwirtschaft, 485-513. Darmstadt: Kuratorium für Technik und Bauwesen in der Landwirtschaft e.V. (KTBL)

IPCC – Intergovernmental Panel on Climate Change, 2006a. 2006 IPCC Guidelines for National Greenhouse Gas Inventories - Chapter 10: Emissions from Livestock and Manure Management. Published by the Institute for Global Environmental Strategies (IGES), Kanagawa, Japan.

IPCC – Intergovernmental Panel on Climate Change, 2006b. 2006 IPCC Guidelines for National Greenhouse Gas Inventories - Chapter 11: N2O Emissions Emissions from Managed Soils and CO2 Emissions Lime and Urea Application. Published by the Institute for Global Environmental Strategies (IGES), Kanagawa, Japan.

Kirchgessner, Manfred. 2014. Kirchgessner Tierernährung: Leitfaden für Studium, Beratung und Praxis - 8 Schaffütterung. Vol. 14., neubearbeitete Auflage. Frankfurt (Main): DLG-Verlag.

KTBL. 2006. Betriebsplanung Landwirtschaft 2006/07. Vol. KTBL Datensammlung - 20. Auflage. Darmstadt: Kuratorium für Technik und Bauwesen in der Landwirtschaft e.V. (KTBL).

Lagerwerf, L.A. , A. Bannink, C. van Bruggen, C.M. Groenestein, J.F.M. Huijsmans, J.W.H. van der Kolk, H.H. Luesink, S.M. van der Sluis, G.L. Velthof, and J. Vonk. 2019. Methodology for estimating emissions from agriculture in the Netherlands – update 2019. Wageningen: Wageningen University & Research.

Protect'eau. 2017. Le PROGRAMME de GESTION DURABLE de l' AZOTE en agriculture (PGDA III) CENTRES D'ACTION DE PROTECT'EAU

Règlement_grand-ducal. 2015. Règlement grand-ducal du 30 juillet 2015 portant application, au Grand-Duché de Luxembourg, de règles communes relatives - aux paiements directs en faveur des agriculteurs au titre des régimes de soutien relevant de la politique agricole commune et - au soutien au développement rural et modifiant le règlement grand-ducal du 19 avril 2012 instituant une prime à l'entretien du paysage et de l'espace naturel et à l'encouragement d'une agriculture respectueuse de l'environnement. Luxembourg: MEMORIAL - Journal Officiel du Grand-Duché de Luxembourg.

Rösemann, Claus, Hans-Dieter Haenel, Ulrich Dämmgen, Ulrike Döring, Sebastian Wulf, Brigitte Eurich-Menden, Annette Freibauer, Helmut Döhler, Carsten Schreiner, Bernhard Osterburg, and Roland Fuß. 2019. Calculations of gaseous and particulate emissions from German agriculture 1990-2017: Report on methods and data (RMD) Submission 2019. edited by Thünen Reports 67. Braunschweig: Johann Heinrich von Thünen Institute, Federal Research Institute for Rural Areas, Forestry and Fisheries.

Schuman, Marc, Nora Becker, Ermin Hadzic, Marie-Josée Mangen, Tim Mirgain, and et al. 2020. Luxembourg's National Inventory Report 1990-2018 - Submission under the United Nations Framework Convention on Climate Change and under the Kyoto Protocol.

SER. Statistiken zur Milchproduktion und den Milchbetrieben in Luxemburg. Service d'Economie Rurale 2018 Available from https://agriculture.public.lu/dam-assets/statistiques/production-animale/lait/milch-jahr-portail.pdf.

STATEC 2018. Farm structure - 1.2 Presentation - Description of farm structures STATEC, 06-04-2016 2018 [cited 5-12-2018. Available from https://statistiques.public.lu/fr/methodologie/methodes/entreprises/Agriculture/agriculture/Agriculture_description.pdf.

STATEC. 2019a. Agriculture surface area by product (in ha) 1950 - 2018. Luxemburg: STATEC - Institut national de la statistique et des études économiques du Grand-Duché de Luxembourg.

STATEC. 2019b. Consommation d'engrais chimiques 1936 - 2018 - Consommation par ha cultivé (en kg d'éléments nutritifs par ha). Luxembourg: Institute.

STATEC. 2019c. Exploitations agricoles par classe de grandeur 1907 - 2019. Luxemburg: STATEC - Institut national de la statistique et des études économiques du Grand-Duché de Luxembourg.

STATEC. 2019d. Farm livestock 1950 - 2018. Luxemburg: STATEC - Institut national de la statistique et des études économiques du Grand-Duché de Luxembourg.

STATEC. 2019e. Quantities produced of main crop and fodder productions (in tonnes) 1960 - 2018. Luxemburg: STATEC - Institut national de la statistique et des études économiques du Grand-Duché de Luxembourg.

Vaessen, Marc. Personal communication; December 2018. Chairman of the Luxemburgish sheep farmers association "Lëtzebuerger Schéifergenossenschaft".

VLM. 2012. NORMEN EN RICHTWAARDEN 2012 – editie maart 2012. Brussels: Vlaamse Landmaatschappij (VLM)

VLM. 2013. NORMEN EN RICHTWAARDEN 2013 - december 2012. Brussels: Vlaamse Landmaatschappij (VLM)

VLM. 2014. NORMEN EN RICHTWAARDEN 2014 Brussels: Vlaamse Landmaatschappij (VLM)

VLM. 2015. NOG GEEN MAP 5: WAT ZIJN DE BEMESTINGSNORMEN IN 2015? Brussels: Vlaamse Landmaatschappij (VLM)

VLM. 2016. NORMEN EN RICHTWAARDEN 2016 versie januari 2016. Brussels: Vlaamse Landmaatschappij (VLM)

VLM. 2017. NORMEN EN RICHTWAARDEN 2017 versie januari 2017 Brussels: Vlaamse Landmaatschappij (VLM)

VLM. 2018. NORMEN EN RICHTWAARDEN 2018 versie januari 2018. Brussels: Vlaamse Landmaatschappij (VLM)

VLM. 2019. NORMEN EN RICHTWAARDEN 2019 versie juli 2019 – MAP6 Brussels: Vlaamse Landmaatschappij (VLM)

13 APPENDIX

13.1 Appendix 1: Key category analysis – Fuel sold

Annex Table 1 – Key Category analysis for SO_2: Level and Trend Assessment – Fuel Sold

Level Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [kt] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	SO2	0.1583	35.6326%	35.63%
1 A 3 a i (i)	Civil Aviation - International - LTO	SO2	0.0514	11.5620%	47.19%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	SO2	0.0495	11.1484%	58.34%
1 A 4 b i	Residential: stationary	SO2	0.0351	7.9108%	66.25%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	SO2	0.0345	7.7611%	74.01%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	SO2	0.0289	6.5049%	80.52%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	SO2	0.0251	5.6614%	86.18%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	SO2	0.0183	4.1140%	90.30%
1 A 3 b iii	Road Transport, Heavy duty vehicles	SO2	0.0133	3.0027%	93.30%
1 A 3 b i	Road Transport, Passenger cars	SO2	0.0101	2.2792%	95.58%
1 A 4 a i	Commercial/Institutional: Stationary	SO2	0.0078	1.7636%	97.34%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	SO2	0.0062	1.4009%	98.74%
1 A 3 c	Railways	SO2	0.0021	0.4719%	99.21%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	SO2	0.0020	0.4414%	99.65%
1 A 3 b ii	Road Transport, Light duty vehicles	SO2	0.0010	0.2276%	99.88%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	SO2	0.0002	0.0350%	99.92%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	SO2	0.0001	0.0301%	99.95%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	SO2	0.0001	0.0223%	99.97%
1 A 3 a ii (i)	Civil Aviation - Domestic - LTO	SO2	0.0001	0.0185%	99.99%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	SO2	0.0000	0.0057%	99.99%
1 A 4 b ii	Residential: Household and gardening (mobile)	SO2	0.0000	0.0028%	100.00%
2 H 1	Pulp and paper industry	SO2	0.0000	0.0020%	100.00%
1 A 3 d ii	National Navigation (Shipping)	SO2	0.0000	0.0008%	100.00%
1 A 5 b	Other, Mobile (including Military)	SO2	0.0000	0.0002%	100.00%
1 A 3 d i (ii)	International inland waterways	SO2	0.0000	0.0000%	100.00%

Trend Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt] $E_{x,0}$	Latest Year (2022) Estimate [kt] $E_{x,t}$	Trend Assessment $L_{x,t}$	% Contribution to the trend	Cumulative Total of $L_{x,t}$
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	SO2	12.1363	0.1583	14.1929	43.1%	43.1%
1 A 3 a i (i)	Civil Aviation - International - LTO	SO2	0.0274	0.0514	4.1996	12.7%	55.8%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	SO2	0.1966	0.0495	3.6663	11.1%	66.9%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	SO2	0.0289	0.0345	2.7953	8.5%	75.4%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	SO2	0.0040	0.0251	2.0777	6.3%	81.7%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	SO2	0.0100	0.0183	1.4937	4.5%	86.2%
1 A 4 b i	Residential: stationary	SO2	0.8231	0.0351	1.0624	3.2%	89.4%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	SO2	0.6426	0.0062	0.9306	2.8%	92.3%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	SO2	0.7576	0.0289	0.6916	2.1%	94.4%
1 A 3 b iii	Road Transport, Heavy duty vehicles	SO2	0.7854	0.0133	0.6617	2.0%	96.4%
1 A 4 a i	Commercial/Institutional: Stationary	SO2	0.5776	0.0078	0.6506	2.0%	98.3%
1 A 3 b i	Road Transport, Passenger cars	SO2	0.2588	0.0101	0.2573	0.8%	99.1%
1 A 3 c	Railways	SO2	0.0202	0.0021	0.1285	0.4%	99.5%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	SO2	0.0423	0.0020	0.0674	0.2%	99.7%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	SO2	0.0210	0.0002	0.0343	0.1%	99.8%
1 A 3 b ii	Road Transport, Light duty vehicles	SO2	0.0256	0.0010	0.0262	0.1%	99.9%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	SO2	0.0100	0.0001	0.0115	0.0%	99.9%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	SO2	IE	0.0001	0.0082	0.0%	100.0%
1 A 3 a ii (i)	Civil Aviation - Domestic - LTO	SO2	0.0000	0.0001	0.0068	0.0%	100.0%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	SO2	0.0002	0.0000	0.0017	0.0%	100.0%
1 A 3 d ii	National Navigation (Shipping)	SO2	0.0008	0.0000	0.0015	0.0%	100.0%
2 H 1	Pulp and paper industry	SO2	0.0000	0.0000	0.0007	0.0%	100.0%
1 A 4 b ii	Residential: Household and gardening (mobile)	SO2	0.0003	0.0000	0.0003	0.0%	100.0%
1 A 5 b	Other, Mobile (including Military)	SO2	0.0001	0.0000	0.0002	0.0%	100.0%
1 A 3 d i (ii)	International inland waterways	SO2	0.0001	0.0000	0.0001	0.0%	100.0%

Annex Table 2 – Key Category analysis for NO_X: Level and Trend Assessment – Fuel Sold.

Level Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [kt] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1 A 3 b i	Road Transport, Passenger cars	NOX	3.2468	28.2918%	28.29%
1 A 3 b iii	Road Transport, Heavy duty vehicles	NOX	1.4949	13.0263%	41.32%
1 A 3 a i (i)	Civil Aviation - International - LTO	NOX	1.0314	8.9878%	50.31%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	NOX	0.8967	7.8138%	58.12%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	NOX	0.7309	6.3693%	64.49%
1 A 4 b i	Residential: stationary	NOX	0.6034	5.2579%	69.75%
1 A 3 b ii	Road Transport, Light duty vehicles	NOX	0.4927	4.2933%	74.04%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	NOX	0.4783	4.1679%	78.21%
1 A 4 a i	Commercial/Institutional: Stationary	NOX	0.4320	3.7642%	81.97%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	NOX	0.3875	3.3762%	85.35%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	NOX	0.3576	3.1162%	88.46%
3 D a 2 a	Animal manure applied to soils	NOX	0.3337	2.9075%	91.37%
3 D a 1	Inorganic N-fertilizers (includes also urea application)	NOX	0.3048	2.6556%	94.03%
3 D a 3	Urine and dung deposited by grazing animals	NOX	0.1713	1.4928%	95.52%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	NOX	0.1534	1.3370%	96.86%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	NOX	0.0815	0.7105%	97.57%
3 D a 4	Crop residues applied to soils	NOX	0.0642	0.5595%	98.13%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	NOX	0.0608	0.5295%	98.66%
1 A 3 c	Railways	NOX	0.0443	0.3861%	99.04%
3 D a 2 c	Other organic fertilisers applied to soils (including compost)	NOX	0.0266	0.2318%	99.27%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	NOX	0.0199	0.1737%	99.45%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	NOX	0.0132	0.1148%	99.56%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	NOX	0.0095	0.0829%	99.65%
3 B 1 b	Manure management - Non-dairy cattle	NOX	0.0091	0.0792%	99.73%
1 A 4 b ii	Residential: Household and gardening (mobile)	NOX	0.0086	0.0753%	99.80%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	NOX	0.0070	0.0607%	99.86%
1 A 3 d ii	National Navigation (Shipping)	NOX	0.0053	0.0466%	99.91%
3 B 1 a	Manure management - Dairy cattle	NOX	0.0051	0.0447%	99.95%
3 D a 2 b	Sewage sludge applied to soils	NOX	0.0018	0.0157%	99.97%
2 H 1	Pulp and paper industry	NOX	0.0010	0.0091%	99.98%
3 B 4 e	Manure management - Horses	NOX	0.0007	0.0060%	99.98%
1 A 3 a ii (i)	Civil Aviation - Domestic - LTO	NOX	0.0006	0.0054%	99.99%
3 B 3	Manure management - Swine	NOX	0.0005	0.0040%	99.99%
1 A 5 b	Other, Mobile (including Military)	NOX	0.0002	0.0021%	100.00%
3 B 4 d	Manure management - Goats	NOX	0.0002	0.0019%	100.00%
1 A 3 d i (ii)	International inland waterways	NOX	0.0002	0.0018%	100.00%
3 B 2	Manure management - Sheep	NOX	0.0001	0.0007%	100.00%
3 B 4 g i	Manure management - Laying Hens	NOX	0.0000	0.0003%	100.00%
3 B 4 h	Manure management - Other animals (please specify in IIR)	NOX	0.0000	0.0001%	100.00%
3 B 4 g ii	Manure management - Broilers	NOX	0.0000	0.0000%	100.00%
3 B 4 g iv	Manure management - Other Poultry	NOX	0.0000	0.0000%	100.00%

Trend Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt] $E_{x,0}$	Latest Year (2022) Estimate [kt] $E_{x,t}$	Trend Assessment $L_{x,t}$	% Contribution to the trend	Cumulative Total of $L_{x,t}$
1 A 3 b iii	Road Transport, Heavy duty vehicles	NOX	14.4798	1.4949	0.7979	29.4%	29.4%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	NOX	6.9339	0.3875	0.4840	17.8%	47.2%
1 A 3 a i (i)	Civil Aviation - International - LTO	NOX	0.3412	1.0314	0.2903	10.7%	57.8%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	NOX	0.6331	0.8967	0.2231	8.2%	66.1%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	NOX	0.0314	0.4783	0.1457	5.4%	71.4%
1 A 4 b i	Residential: stationary	NOX	0.6219	0.6034	0.1330	4.9%	76.3%
1 A 3 b ii	Road Transport, Light duty vehicles	NOX	0.2993	0.4927	0.1268	4.7%	81.0%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	NOX	0.0941	0.3576	0.1028	3.8%	84.8%
3 D a 2 a	Animal manure applied to soils	NOX	0.3436	0.3337	0.0736	2.7%	87.5%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	NOX	3.3758	0.7309	0.0673	2.5%	89.9%
1 A 4 a i	Commercial/Institutional: Stationary	NOX	0.8431	0.4320	0.0606	2.2%	92.2%
1 A 3 b i	Road Transport, Passenger cars	NOX	10.9611	3.2468	0.0523	1.9%	94.1%
3 D a 3	Urine and dung deposited by grazing animals	NOX	0.2065	0.1713	0.0352	1.3%	95.4%
3 D a 1	Inorganic N-fertilizers (includes also urea application)	NOX	0.7287	0.3048	0.0311	1.1%	96.5%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	NOX	0.0604	0.0815	0.0200	0.7%	97.3%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	NOX	0.3284	0.1534	0.0190	0.7%	98.0%
3 D a 4	Crop residues applied to soils	NOX	0.0578	0.0642	0.0149	0.5%	98.5%
1 A 3 c	Railways	NOX	0.2577	0.0443	0.0087	0.3%	98.8%
3 D a 2 c	Other organic fertilisers applied to soils (including compost)	NOX	NO	0.0266	0.0083	0.3%	99.1%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	NOX	0.0048	0.0199	0.0058	0.2%	99.4%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	NOX	IE	0.0132	0.0041	0.2%	99.5%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	NOX	0.1859	0.0608	0.0027	0.1%	99.6%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	NOX	0.0058	0.0095	0.0024	0.1%	99.7%
1 A 4 b ii	Residential: Household and gardening (mobile)	NOX	0.0052	0.0086	0.0022	0.1%	99.8%
3 B 1 b	Manure management - Non-dairy cattle	NOX	0.0106	0.0091	0.0019	0.1%	99.8%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	NOX	0.0107	0.0070	0.0012	0.0%	99.9%
3 B 1 a	Manure management - Dairy cattle	NOX	0.0078	0.0051	0.0009	0.0%	99.9%
3 D a 2 b	Sewage sludge applied to soils	NOX	0.0149	0.0018	0.0007	0.0%	100.0%
1 A 3 d ii	National Navigation (Shipping)	NOX	0.0144	0.0053	0.0004	0.0%	100.0%
2 H 1	Pulp and paper industry	NOX	0.0007	0.0010	0.0003	0.0%	100.0%
3 B 4 e	Manure management - Horses	NOX	0.0003	0.0007	0.0002	0.0%	100.0%
1 A 3 a ii (i)	Civil Aviation - Domestic - LTO	NOX	0.0002	0.0006	0.0002	0.0%	100.0%
3 B 4 d	Manure management - Goats	NOX	0.0000	0.0002	0.0001	0.0%	100.0%
3 B 3	Manure management - Swine	NOX	0.0008	0.0005	0.0001	0.0%	100.0%
1 A 5 b	Other, Mobile (including Military)	NOX	0.0014	0.0002	0.0001	0.0%	100.0%
1 A 3 d i (ii)	International inland waterways	NOX	0.0013	0.0002	0.0000	0.0%	100.0%
3 B 2	Manure management - Sheep	NOX	0.0001	0.0001	0.0000	0.0%	100.0%
3 B 4 g i	Manure management - Laying Hens	NOX	0.0000	0.0000	0.0000	0.0%	100.0%
3 B 4 g ii	Manure management - Broilers	NOX	0.0000	0.0000	0.0000	0.0%	100.0%
3 B 4 h	Manure management - Other animals (please specify in IIR)	NOX	0.0000	0.0000	0.0000	0.0%	100.0%
3 B 4 g iv	Manure management - Other Poultry	NOX	0.0000	0.0000	0.0000	0.0%	100.0%

Annex Table 3 – Key Category analysis for NMVOC: Level and Trend Assessment – Fuel Sold.

Level Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [kt]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
2 D 3 a	Domestic solvent use including fungicides	NMVOC	2.0116	20.1003%	20.10%
3 B 1 a	Manure management - Dairy cattle	NMVOC	1.5960	15.9472%	36.05%
3 B 1 b	Manure management - Non-dairy cattle	NMVOC	1.0783	10.7743%	46.82%
2 D 3 i	Other solvent use	NMVOC	0.8741	8.7338%	55.56%
2 D 3 d	Coating application	NMVOC	0.6858	6.8521%	62.41%
3 D a 2 a	Animal manure applied to soils	NMVOC	0.6399	6.3944%	68.80%
2 D 3 g	Chemical products	NMVOC	0.5079	5.0754%	73.88%
1 A 3 b i	Road Transport, Passenger cars	NMVOC	0.3688	3.6853%	77.56%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	NMVOC	0.3411	3.4087%	80.97%
1 B 2 b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)	NMVOC	0.2650	2.6483%	83.62%
1 A 4 b i	Residential: stationary	NMVOC	0.2551	2.5494%	86.17%
1 B 2 a v	Distribution of oil products	NMVOC	0.1843	1.8416%	88.01%
2 H 3	Other industrial processes (please specify in the IIR)	NMVOC	0.1563	1.5619%	89.57%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	NMVOC	0.1261	1.2604%	90.83%
3 D e	Cultivated crops	NMVOC	0.1087	1.0861%	91.92%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	NMVOC	0.1017	1.0165%	92.94%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	NMVOC	0.0891	0.8904%	93.83%
1 A 4 b ii	Residential: Household and gardening (mobile)	NMVOC	0.0722	0.7213%	94.55%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	NMVOC	0.0677	0.6767%	95.22%
1 A 3 b v	Road Transport, Gasoline evaporation	NMVOC	0.0646	0.6452%	95.87%
1 A 3 a i (i)	Civil Aviation - International - LTO	NMVOC	0.0640	0.6395%	96.51%
1 A 3 b iii	Road Transport, Heavy duty vehicles	NMVOC	0.0589	0.5890%	97.10%
1 A 4 a i	Commercial/Institutional: Stationary	NMVOC	0.0525	0.5245%	97.62%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	NMVOC	0.0398	0.3977%	98.02%
2 D 3 h	Printing	NMVOC	0.0353	0.3528%	98.37%
2 D 3 b	Road paving with asphalt	NMVOC	0.0300	0.3000%	98.67%
3 D a 3	Urine and dung deposited by grazing animals	NMVOC	0.0257	0.2563%	98.93%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in	NMVOC	0.0248	0.2482%	99.18%
3 B 3	Manure management - Swine	NMVOC	0.0209	0.2088%	99.39%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	NMVOC	0.0104	0.1037%	99.49%
3 B 4 e	Manure management - Horses	NMVOC	0.0073	0.0726%	99.56%
5 A	Biological treatment of waste - Solid waste disposal on land	NMVOC	0.0068	0.0681%	99.63%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	NMVOC	0.0062	0.0621%	99.69%
1 A 3 b ii	Road Transport, Light duty vehicles	NMVOC	0.0043	0.0431%	99.74%
1 A 3 c	Railways	NMVOC	0.0043	0.0426%	99.78%
1 A 3 a ii (i)	Civil Aviation - Domestic - LTO	NMVOC	0.0037	0.0370%	99.82%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	NMVOC	0.0034	0.0340%	99.85%
1 A 3 d ii	National Navigation (Shipping)	NMVOC	0.0032	0.0318%	99.88%
2 H 1	Pulp and paper industry	NMVOC	0.0028	0.0281%	99.91%
3 B 4 g i	Manure management - Laying Hens	NMVOC	0.0027	0.0271%	99.94%
3 B 4 g ii	Manure management - Broilers	NMVOC	0.0026	0.0260%	99.96%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Bevera	NMVOC	0.0010	0.0103%	99.97%
3 B 4 d	Manure management - Goats	NMVOC	0.0010	0.0102%	99.98%
3 B 2	Manure management - Sheep	NMVOC	0.0008	0.0080%	99.99%
5 D 1	Domestic wastewater handling	NMVOC	0.0004	0.0044%	100.00%
3 B 4 h	Manure management - Other animals (please specify in IIR)	NMVOC	0.0003	0.0027%	100.00%
3 B 4 g iv	Manure management - Other Poultry	NMVOC	0.0001	0.0007%	100.00%
1 A 3 d i (ii)	International inland waterways	NMVOC	0.0001	0.0006%	100.00%
1 A 5 b	Other, Mobile (including Military)	NMVOC	0.0000	0.0004%	100.00%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	NMVOC	0.0000	0.0003%	100.00%
5 D 2	Industrial wastewater handling	NMVOC	0.0000	0.0002%	100.00%

Trend Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2022) Estimate [kt]	Trend Assessment	% Contribution to the trend	Cumulative Total of $L_{x,t}$
			$E_{x,0}$	$E_{x,t}$	$L_{x,t}$		
1 A 3 b i	Road Transport, Passenger cars	NMVOC	12.0441	0.3688	1.0890	33.043%	33.0%
2 D 3 a	Domestic solvent use including fungicides	NMVOC	1.8565	2.0116	0.4386	13.307%	46.4%
1 A 3 b v	Road Transport, Gasoline evaporation	NMVOC	3.9962	0.0646	0.3793	11.508%	57.9%
3 B 1 a	Manure management - Dairy cattle	NMVOC	1.2842	1.5960	0.3668	11.129%	69.0%
3 B 1 b	Manure management - Non-dairy cattle	NMVOC	1.2365	1.0783	0.2110	6.401%	75.4%
2 D 3 g	Chemical products	NMVOC	0.2803	0.5079	0.1296	3.931%	79.3%
3 D a 2 a	Animal manure applied to soils	NMVOC	0.8706	0.6399	0.1115	3.384%	82.7%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	NMVOC	0.0102	0.3411	0.1048	3.180%	85.9%
2 D 3 i	Other solvent use	NMVOC	3.3751	0.8741	0.0661	2.005%	87.9%
1 B 2 b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)	NMVOC	0.2206	0.2650	0.0602	1.826%	89.7%
1 A 3 b iii	Road Transport, Heavy duty vehicles	NMVOC	0.7356	0.0589	0.0552	1.675%	91.4%
2 H 3	Other industrial processes (please specify in the IIR)	NMVOC	0.1177	0.1563	0.0367	1.114%	92.5%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	NMVOC	0.5929	0.0891	0.0316	0.959%	93.5%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	NMVOC	0.0011	0.1017	0.0314	0.954%	94.4%
1 A 4 b i	Residential: stationary	NMVOC	0.4978	0.2551	0.0294	0.892%	95.3%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	NMVOC	0.1421	0.1261	0.0249	0.756%	96.1%
3 D e	Cultivated crops	NMVOC	0.1081	0.1087	0.0229	0.696%	96.8%
1 A 3 a i (i)	Civil Aviation - International - LTO	NMVOC	0.0342	0.0640	0.0164	0.499%	97.3%
1 B 2 a v	Distribution of oil products	NMVOC	0.4090	0.1843	0.0163	0.495%	97.8%
1 A 3 b ii	Road Transport, Light duty vehicles	NMVOC	0.1275	0.0043	0.0114	0.346%	98.1%
2 D 3 b	Road paving with asphalt	NMVOC	0.0091	0.0300	0.0084	0.255%	98.4%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	NMVOC	0.1330	0.0677	0.0077	0.234%	98.6%
1 A 4 a i	Commercial/Institutional: Stationary	NMVOC	0.0926	0.0525	0.0070	0.213%	98.8%
3 D a 3	Urine and dung deposited by grazing animals	NMVOC	0.0298	0.0257	0.0050	0.151%	99.0%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	NMVOC	0.0739	0.0104	0.0042	0.126%	99.1%
2 D 3 h	Printing	NMVOC	0.0729	0.0353	0.0037	0.111%	99.2%
3 B 3	Manure management - Swine	NMVOC	0.0287	0.0209	0.0036	0.110%	99.3%
1 A 3 c	Railways	NMVOC	0.0494	0.0043	0.0036	0.110%	99.4%
1 A 4 b ii	Residential: Household and gardening (mobile)	NMVOC	0.2584	0.0722	0.0034	0.104%	99.5%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	NMVOC	0.1043	0.0248	0.0027	0.082%	99.6%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	NMVOC	0.1021	0.0398	0.0021	0.065%	99.7%
3 B 4 e	Manure management - Horses	NMVOC	0.0033	0.0073	0.0019	0.058%	99.7%
1 A 3 d ii	National Navigation (Shipping)	NMVOC	0.0215	0.0032	0.0012	0.035%	99.8%
2 D 3 d	Coating application	NMVOC	2.1176	0.6858	0.0011	0.035%	99.8%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	NMVOC	IE	0.0034	0.0011	0.032%	99.8%
1 A 3 a ii (i)	Civil Aviation - Domestic - LTO	NMVOC	0.0015	0.0037	0.0010	0.030%	99.9%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	NMVOC	0.0093	0.0062	0.0010	0.030%	99.9%
3 B 4 g ii	Manure management - Broilers	NMVOC	0.0005	0.0026	0.0008	0.023%	99.9%
3 B 4 g i	Manure management - Laying Hens	NMVOC	0.0013	0.0027	0.0007	0.022%	99.9%
2 H 1	Pulp and paper industry	NMVOC	0.0018	0.0028	0.0007	0.021%	100.0%
5 A	Biological treatment of waste - Solid waste disposal on land	NMVOC	0.0159	0.0068	0.0005	0.016%	100.0%
3 B 4 d	Manure management - Goats	NMVOC	0.0000	0.0010	0.0003	0.010%	100.0%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Bevera	NMVOC	0.0002	0.0010	0.0003	0.009%	100.0%
3 B 2	Manure management - Sheep	NMVOC	0.0006	0.0008	0.0002	0.006%	100.0%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	NMVOC	0.0016	0.0000	0.0001	0.005%	100.0%
5 D 1	Domestic wastewater handling	NMVOC	0.0005	0.0004	0.0001	0.003%	100.0%
1 A 3 d i (ii)	International inland waterways	NMVOC	0.0005	0.0001	0.0000	0.001%	100.0%
1 A 5 b	Other, Mobile (including Military)	NMVOC	0.0002	0.0000	0.0000	0.000%	100.0%
3 B 4 g iv	Manure management - Other Poultry	NMVOC	0.0003	0.0001	0.0000	0.000%	100.0%
3 B 4 h	Manure management - Other animals (please specify in IIR)	NMVOC	0.0009	0.0003	0.0000	0.000%	100.0%
5 D 2	Industrial wastewater handling	NMVOC	0.0000	0.0000	0.0000	0.000%	100.0%

Annex Table 4 – Key Category analysis for NH_3: Level and Trend Assessment – Fuel Sold.

Level Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [kt]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
3 D a 2 a	Animal manure applied to soils	NH3	2.0279	34.0846%	34.08%
3 B 1 b	Manure management - Non-dairy cattle	NH3	1.4308	24.0486%	58.13%
3 B 1 a	Manure management - Dairy cattle	NH3	0.9620	16.1691%	74.30%
3 D a 3	Urine and dung deposited by grazing animals	NH3	0.4632	7.7852%	82.09%
3 D a 1	Inorganic N-fertilizers (includes also urea application)	NH3	0.3402	5.7185%	87.81%
3 B 3	Manure management - Swine	NH3	0.2105	3.5384%	91.34%
1 A 3 b i	Road Transport, Passenger cars	NH3	0.1498	2.5174%	93.86%
3 D a 2 c	Other organic fertilisers applied to soils (including compost)	NH3	0.1379	2.3186%	96.18%
3 B 4 e	Manure management - Horses	NH3	0.0613	1.0310%	97.21%
5 B 2	Anaerobic digestion at biogas facilities	NH3	0.0545	0.9160%	98.13%
1 A 3 b iii	Road Transport, Heavy duty vehicles	NH3	0.0290	0.4882%	98.62%
3 B 4 g i	Manure management - Laying Hens	NH3	0.0199	0.3343%	98.95%
3 B 4 d	Manure management - Goats	NH3	0.0156	0.2623%	99.21%
5 B 1	Composting	NH3	0.0107	0.1807%	99.39%
3 B 4 g ii	Manure management - Broilers	NH3	0.0062	0.1036%	99.50%
3 D a 2 b	Sewage sludge applied to soils	NH3	0.0058	0.0982%	99.59%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	NH3	0.0056	0.0947%	99.69%
3 B 2	Manure management - Sheep	NH3	0.0054	0.0901%	99.78%
1 A 3 b ii	Road Transport, Light duty vehicles	NH3	0.0040	0.0666%	99.85%
1 A 4 b i	Residential: stationary	NH3	0.0035	0.0593%	99.91%
2 H 1	Pulp and paper industry	NH3	0.0024	0.0405%	99.95%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	NH3	0.0012	0.0206%	99.97%
3 B 4 h	Manure management - Other animals (please specify in IIR)	NH3	0.0012	0.0206%	99.99%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	NH3	0.0005	0.0077%	99.99%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	NH3	0.0001	0.0023%	100.00%
3 B 4 g iv	Manure management - Other Poultry	NH3	0.0001	0.0016%	100.00%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	NH3	0.0001	0.0012%	100.00%
1 A 3 c	Railways	NH3	0.0000	0.0002%	100.00%
1 A 4 a i	Commercial/Institutional: Stationary	NH3	0.0000	0.0001%	100.00%
1 A 4 b ii	Residential: Household and gardening (mobile)	NH3	0.0000	0.0001%	100.00%
1 A 3 d ii	National Navigation (Shipping)	NH3	0.0000	0.0000%	100.00%
1 A 3 d i (ii)	International inland waterways	NH3	0.0000	0.0000%	100.00%
1 A 3 d i (ii)	International inland waterways	NH3	0.0000	0.0000%	100.00%

Trend Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2022) Estimate [kt]	Trend Assessment	% Contribution to the trend	Cumulative Total of $L_{x,t}$
			$E_{x,0}$	$E_{x,t}$	$L_{x,t}$		
3 D a 1	Inorganic N-fertilizærs (includes also urea application)	NH3	0.6682	0.3402	0.0511	31.670%	31.7%
1 A 3 b i	Road Transport, Passenger cars	NH3	0.0125	0.1498	0.0249	15.407%	47.1%
3 D a 2 c	Other organic fertilisers applied to soils (including compost)	NH3	NO	0.1379	0.0248	15.387%	62.5%
3 D a 2 a	Animal manure applied to soils	NH3	2.2329	2.0279	0.0104	6.459%	68.9%
5 B 2	Anaerobic digestion at biogas facilities	NH3	NO	0.0545	0.0098	6.079%	75.0%
3 D a 2 b	Sewage sludge applied to soils	NH3	0.0484	0.0058	0.0071	4.387%	79.4%
3 D a 3	Urine and dung deposited by grazing animals	NH3	0.5373	0.4632	0.0070	4.317%	83.7%
3 B 4 e	Manure management - Horses	NH3	0.0280	0.0613	0.0063	3.922%	87.6%
1 A 3 b iii	Road Transport, Heavy duty vehicles	NH3	0.0017	0.0290	0.0049	3.068%	90.7%
3 B 1 a	Manure management - Dairy cattle	NH3	1.0529	0.9620	0.0039	2.404%	93.1%
3 B 4 d	Manure management - Goats	NH3	0.0005	0.0156	0.0027	1.689%	94.8%
5 B 1	Composting	NH3	NO	0.0107	0.0019	1.199%	96.0%
3 B 4 g i	Manure management - Laying Hens	NH3	0.0105	0.0199	0.0018	1.124%	97.1%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	NH3	NO	0.0056	0.0010	0.629%	97.7%
3 B 4 g ii	Manure management - Broilers	NH3	0.0013	0.0062	0.0009	0.554%	98.3%
3 B 4 h	Manure management - Other animals (please specify in IIR)	NH3	0.0057	0.0012	0.0007	0.457%	98.8%
1 A 3 b ii	Road Transport, Light duty vehicles	NH3	0.0002	0.0040	0.0007	0.418%	99.2%
3 B 2	Manure management - Sheep	NH3	0.0042	0.0054	0.0003	0.165%	99.3%
1 A 4 b i	Residential: stationary	NH3	0.0052	0.0035	0.0002	0.144%	99.5%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	NH3	NO	0.0012	0.0002	0.137%	99.6%
3 B 1 b	Manure management - Non-dairy cattle	NH3	1.5328	1.4308	0.0002	0.116%	99.7%
2 H 1	Pulp and paper industry	NH3	0.0015	0.0024	0.0002	0.111%	99.8%
3 B 3	Manure management - Swine	NH3	0.2246	0.2105	0.0001	0.077%	99.9%
3 B 4 g iv	Manure management - Other Poultry	NH3	0.0004	0.0001	0.0000	0.028%	99.9%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	NH3	0.0002	0.0005	0.0000	0.026%	100.0%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	NH3	0.0000	0.0001	0.0000	0.010%	100.0%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	NH3	0.0002	0.0001	0.0000	0.009%	100.0%
1 A 3 c	Railways	NH3	0.0001	0.0000	0.0000	0.007%	100.0%
1 A 4 a i	Commercial/Institutional: Stationary	NH3	NO	0.0000	0.0000	0.001%	100.0%
1 A 3 d ii	National Navigation (Shipping)	NH3	0.0000	0.0000	0.0000	0.000%	100.0%
1 A 4 b ii	Residential: Household and gardening (mobile)	NH3	0.0000	0.0000	0.0000	0.000%	100.0%
1 A 3 d i (ii)	International inland waterways	NH3	0.0000	0.0000	0.0000	0.000%	100.0%
1 A 3 d i (ii)	International inland waterways	NH3	0.0000	0.0000	0.0000	0.000%	100.0%

Annex Table 5 – Key Category analysis for CO: Level and Trend Assessment – Fuel Sold.

Level Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [kt]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
1 A 3 b i	Road Transport, Passenger cars	CO	4.8136	26.9851%	26.99%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	CO	3.3953	19.0343%	46.02%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic	CO	2.6719	14.9788%	61.00%
1 A 4 b i	Residential: stationary	CO	1.9828	11.1158%	72.11%
1 A 4 b ii	Residential: Household and gardening (mobile)	CO	0.9906	5.5532%	77.67%
1 A 3 b iii	Road Transport, Heavy duty vehicles	CO	0.6948	3.8949%	81.56%
1 A 3 a i (i)	Civil Aviation - International - LTO	CO	0.5954	3.3377%	84.90%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion	CO	0.5193	2.9114%	87.81%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary	CO	0.4721	2.6468%	90.46%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	CO	0.4497	2.5213%	92.98%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	CO	0.3369	1.8886%	94.87%
1 A 4 a i	Commercial/Institutional: Stationary	CO	0.2319	1.2999%	96.17%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	CO	0.1576	0.8836%	97.05%
1 A 3 a ii (i)	Civil Aviation - Domestic - LTO	CO	0.1565	0.8771%	97.93%
1 A 3 b ii	Road Transport, Light duty vehicles	CO	0.1360	0.7625%	98.69%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other	CO	0.1325	0.7431%	99.43%
2 H 1	Pulp and paper industry	CO	0.0320	0.1795%	99.61%
1 A 3 c	Railways	CO	0.0310	0.1739%	99.79%
1 A 3 d ii	National Navigation (Shipping)	CO	0.0164	0.0921%	99.88%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	CO	0.0115	0.0647%	99.94%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	CO	0.0037	0.0207%	99.97%
1 A 2 e	Manufacturing Industries and Construction - Food Processing,	CO	0.0034	0.0189%	99.98%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	CO	0.0023	0.0128%	100.00%
1 A 5 b	Other, Mobile (including Military)	CO	0.0004	0.0025%	100.00%
1 A 3 d i (ii)	International inland waterways	CO	0.0001	0.0008%	100.00%

Trend Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2022) Estimate [kt]	Trend Assessment	% Contribution to the trend	Cumulative Total of $L_{x,t}$
			$E_{x,0}$	$E_{x,t}$	$L_{x,t}$		
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	CO	346.4613	3.3953	14.4145	50.0%	50.0%
1 A 4 b i	Residential: stationary	CO	3.9881	1.9828	2.7012	9.4%	59.4%
1 A 3 b i	Road Transport, Passenger cars	CO	80.2497	4.8136	2.6014	9.0%	68.4%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic	CO	30.1668	2.6719	2.2500	7.8%	76.2%
1 A 4 b ii	Residential: Household and gardening (mobile)	CO	1.2442	0.9906	1.3914	4.8%	81.0%
1 A 3 b iii	Road Transport, Heavy duty vehicles	CO	2.4502	0.6948	0.8875	3.1%	84.1%
1 A 3 a i (i)	Civil Aviation - International - LTO	CO	0.3179	0.5954	0.8604	3.0%	87.1%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion	CO	0.6679	0.5193	0.7286	2.5%	89.6%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary	CO	0.1735	0.4721	0.6867	2.4%	92.0%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	CO	0.0072	0.4497	0.6630	2.3%	94.3%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	CO	0.3758	0.3369	0.4759	1.7%	95.9%
1 A 4 a i	Commercial/Institutional: Stationary	CO	0.3206	0.2319	0.3240	1.1%	97.1%
1 A 3 a ii (i)	Civil Aviation - Domestic - LTO	CO	0.0626	0.1565	0.2273	0.8%	97.9%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	CO	0.3227	0.1576	0.2144	0.7%	98.6%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other	CO	0.4447	0.1325	0.1706	0.6%	99.2%
1 A 3 b ii	Road Transport, Light duty vehicles	CO	1.5948	0.1360	0.1112	0.4%	99.6%
2 H 1	Pulp and paper industry	CO	0.0202	0.0320	0.0461	0.2%	99.7%
1 A 3 c	Railways	CO	0.2796	0.0310	0.0301	0.1%	99.8%
1 A 3 d ii	National Navigation (Shipping)	CO	0.1004	0.0164	0.0186	0.1%	99.9%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	CO	0.0883	0.0115	0.0121	0.0%	100.0%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	CO	IE	0.0037	0.0055	0.0%	100.0%
1 A 2 e	Manufacturing Industries and Construction - Food Processing,	CO	0.0028	0.0034	0.0048	0.0%	100.0%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	CO	0.0043	0.0023	0.0031	0.0%	100.0%
1 A 5 b	Other, Mobile (including Military)	CO	0.0014	0.0004	0.0006	0.0%	100.0%
1 A 3 d i (ii)	International inland waterways	CO	0.0005	0.0001	0.0002	0.0%	100.0%

Annex Table 6 – Key Category analysis for TSP: Level and Trend Assessment – Fuel Sold.

Level Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [kt] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
2 A 5 b	Construction and demolition	TSP	0.4781	18.8945%	18.89%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	TSP	0.4066	16.0674%	34.96%
1 A 3 b vii	Road Transport, Automobile road abrasion	TSP	0.3677	14.5288%	49.49%
1 A 4 b i	Residential: stationary	TSP	0.3422	13.5244%	63.02%
3 D c	Farm-level agricultural operations including storage, handling and transport of agricultural products	TSP	0.1972	7.7917%	70.81%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	TSP	0.1271	5.0225%	75.83%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	TSP	0.1047	4.1379%	79.97%
2 D 3 b	Road paving with asphalt	TSP	0.0647	2.5569%	82.52%
3 B 3	Manure management - Swine	TSP	0.0588	2.3235%	84.85%
3 B 1 a	Manure management - Dairy cattle	TSP	0.0582	2.3013%	87.15%
5 E	Other waste (please specify in IIR)	TSP	0.0569	2.2476%	89.40%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	TSP	0.0433	1.7112%	91.11%
3 B 1 b	Manure management - Non-dairy cattle	TSP	0.0427	1.6887%	92.80%
3 B 4 g i	Manure management - Laying Hens	TSP	0.0229	0.9034%	93.70%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	TSP	0.0198	0.7811%	94.48%
1 A 3 b iii	Road Transport, Heavy duty vehicles	TSP	0.0196	0.7729%	95.25%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	TSP	0.0188	0.7439%	96.00%
1 A 3 b i	Road Transport, Passenger cars	TSP	0.0167	0.6595%	96.66%
2 H 1	Pulp and paper industry	TSP	0.0160	0.6322%	97.29%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	TSP	0.0119	0.4694%	97.76%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	TSP	0.0097	0.3829%	98.14%
1 A 3 b ii	Road Transport, Light duty vehicles	TSP	0.0094	0.3715%	98.51%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	TSP	0.0091	0.3607%	98.87%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	TSP	0.0082	0.3243%	99.20%
1 A 3 a i (i)	Civil Aviation - International - LTO	TSP	0.0052	0.2059%	99.40%
1 A 3 c	Railways	TSP	0.0029	0.1137%	99.52%
3 B 4 g ii	Manure management - Broilers	TSP	0.0022	0.0854%	99.60%
3 B 4 e	Manure management - Horses	TSP	0.0021	0.0826%	99.69%
1 A 4 a i	Commercial/Institutional: Stationary	TSP	0.0020	0.0776%	99.76%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	TSP	0.0019	0.0750%	99.84%
1 B 1 a	Coal Mining and Handling	TSP	0.0013	0.0497%	99.89%
5 A	Biological treatment of waste - Solid waste disposal on land	TSP	0.0008	0.0297%	99.92%
3 B 4 d	Manure management - Goats	TSP	0.0007	0.0277%	99.95%
3 B 2	Manure management - Sheep	TSP	0.0004	0.0164%	99.96%
1 A 4 b ii	Residential: Household and gardening (mobile)	TSP	0.0004	0.0149%	99.98%
1 A 3 d ii	National Navigation (Shipping)	TSP	0.0002	0.0098%	99.99%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	TSP	0.0001	0.0046%	99.99%
3 B 4 h	Manure management - Other animals (please specify in IIR)	TSP	0.0001	0.0028%	99.99%
3 B 4 g iv	Manure management - Other Poultry	TSP	0.0001	0.0025%	100.00%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	TSP	0.0000	0.0017%	100.00%
1 A 3 a ii (i)	Civil Aviation - Domestic - LTO	TSP	0.0000	0.0012%	100.00%
1 A 5 b	Other, Mobile (including Military)	TSP	0.0000	0.0004%	100.00%
1 A 3 d i (ii)	International inland waterways	TSP	0.0000	0.0003%	100.00%

Trend Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt] $E_{x,0}$	Latest Year (2022) Estimate [kt] $E_{x,t}$	Trend Assessment $L_{x,t}$	% Contribution to the trend	Cumulative Total of $L_{x,t}$
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	TSP	13.7662	0.0188	5.3879	46.6%	46.6%
2 A 5 b	Construction and demolition	TSP	0.4028	0.4781	1.1614	10.0%	56.6%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	TSP	0.1952	0.4066	1.0459	9.0%	65.6%
1 A 3 b vii	Road Transport, Automobile road abrasion	TSP	0.1711	0.3677	0.9478	8.2%	73.8%
1 A 4 b i	Residential: stationary	TSP	0.6280	0.3422	0.6971	6.0%	79.9%
3 D c	Farm-level agricultural operations including storage, handling and transport of agricultural products	TSP	0.1960	0.1972	0.4671	4.0%	83.9%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	TSP	0.0013	0.1271	0.3505	3.0%	86.9%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	TSP	0.2042	0.1047	0.2085	1.8%	88.7%
1 A 3 b iii	Road Transport, Heavy duty vehicles	TSP	0.5587	0.0196	0.1668	1.4%	90.2%
5 E	Other waste (please specify in IIR)	TSP	0.0306	0.0569	0.1450	1.3%	91.4%
3 B 3	Manure management - Swine	TSP	0.0456	0.0588	0.1444	1.2%	92.7%
3 B 1 a	Manure management - Dairy cattle	TSP	0.0611	0.0582	0.1367	1.2%	93.8%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	TSP	0.0000	0.0433	0.1196	1.0%	94.9%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	TSP	0.4198	0.0198	0.1113	1.0%	95.8%
3 B 1 b	Manure management - Non-dairy cattle	TSP	0.0478	0.0427	0.0991	0.9%	96.7%
2 D 3 b	Road paving with asphalt	TSP	0.2375	0.0647	0.0849	0.7%	97.4%
1 A 3 b i	Road Transport, Passenger cars	TSP	0.3081	0.0167	0.0757	0.7%	98.1%
3 B 4 g i	Manure management - Laying Hens	TSP	0.0110	0.0229	0.0588	0.5%	98.6%
2 H 1	Pulp and paper industry	TSP	0.0099	0.0160	0.0403	0.3%	98.9%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	TSP	0.0061	0.0097	0.0244	0.2%	99.1%
1 A 3 c	Railways	TSP	0.0590	0.0029	0.0154	0.1%	99.3%
1 A 3 b ii	Road Transport, Light duty vehicles	TSP	0.0303	0.0094	0.0140	0.1%	99.4%
1 A 3 a i (i)	Civil Aviation - International - LTO	TSP	0.0028	0.0052	0.0133	0.1%	99.5%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	TSP	0.1116	0.0119	0.0113	0.1%	99.6%
1 B 1 a	Coal Mining and Handling	TSP	0.0291	0.0013	0.0080	0.1%	99.7%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	TSP	0.0735	0.0082	0.0064	0.1%	99.7%
3 B 4 g ii	Manure management - Broilers	TSP	0.0004	0.0022	0.0058	0.1%	99.8%
3 B 4 e	Manure management - Horses	TSP	0.0009	0.0021	0.0054	0.0%	99.8%
1 A 4 a i	Commercial/Institutional: Stationary	TSP	0.0014	0.0020	0.0049	0.0%	99.9%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Bev	TSP	0.0011	0.0019	0.0048	0.0%	99.9%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machiner	TSP	0.0711	0.0091	0.0029	0.0%	99.9%
3 B 4 d	Manure management - Goats	TSP	0.0000	0.0007	0.0019	0.0%	100.0%
5 A	Biological treatment of waste - Solid waste disposal on land	TSP	0.0005	0.0008	0.0019	0.0%	100.0%
3 B 2	Manure management - Sheep	TSP	0.0003	0.0004	0.0010	0.0%	100.0%
1 A 4 b ii	Residential: Household and gardening (mobile)	TSP	0.0005	0.0004	0.0008	0.0%	100.0%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	TSP	IE	0.0001	0.0003	0.0%	100.0%
1 A 3 d ii	National Navigation (Shipping)	TSP	0.0022	0.0002	0.0002	0.0%	100.0%
3 B 4 h	Manure management - Other animals (please specify in IIR)	TSP	0.0002	0.0001	0.0001	0.0%	100.0%
1 A 3 a ii (i)	Civil Aviation - Domestic - LTO	TSP	0.0000	0.0000	0.0001	0.0%	100.0%
3 B 4 g iv	Manure management - Other Poultry	TSP	0.0002	0.0001	0.0001	0.0%	100.0%
1 A 5 b	Other, Mobile (including Military)	TSP	0.0003	0.0000	0.0001	0.0%	100.0%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	TSP	0.0003	0.0000	0.0000	0.0%	100.0%
1 A 3 d i (ii)	International inland waterways	TSP	0.0001	0.0000	0.0000	0.0%	100.0%

Annex Table 7 – Key Category analysis for PM_{10}: Level and Trend Assessment – Fuel Sold.

Level Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [kt] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1 A 4 b i	Residential: stationary	PM10	0.3257	19.2875%	19.29%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	PM10	0.3031	17.9475%	37.24%
3 D c	Farm-level agricultural operations including storage, handling and transport of agricultural products	PM10	0.1972	11.6769%	48.91%
1 A 3 b vii	Road Transport, Automobile road abrasion	PM10	0.1838	10.8867%	59.80%
2 A 5 b	Construction and demolition	PM10	0.1430	8.4665%	68.27%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	PM10	0.1271	7.5268%	75.79%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	PM10	0.0736	4.3613%	80.15%
5 E	Other waste (please specify in IIR)	PM10	0.0569	3.3683%	83.52%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	PM10	0.0412	2.4414%	85.96%
3 B 1 a	Manure management - Dairy cattle	PM10	0.0266	1.5745%	87.54%
3 B 1 b	Manure management - Non-dairy cattle	PM10	0.0197	1.1676%	88.71%
1 A 3 b iii	Road Transport, Heavy duty vehicles	PM10	0.0196	1.1582%	89.86%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	PM10	0.0188	1.1149%	90.98%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	PM10	0.0178	1.0545%	92.03%
1 A 3 b i	Road Transport, Passenger cars	PM10	0.0167	0.9883%	93.02%
2 H 1	Pulp and paper industry	PM10	0.0160	0.9458%	93.97%
2 D 3 b	Road paving with asphalt	PM10	0.0149	0.8843%	94.85%
1 A 4 a i	Commercial/Institutional: Stationary	PM10	0.0122	0.7200%	95.57%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	PM10	0.0119	0.7034%	96.27%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	PM10	0.0097	0.5739%	96.85%
1 A 3 b ii	Road Transport, Light duty vehicles	PM10	0.0094	0.5567%	97.41%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	PM10	0.0091	0.5406%	97.95%
3 B 3	Manure management - Swine	PM10	0.0082	0.4833%	98.43%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	PM10	0.0078	0.4612%	98.89%
1 A 3 a i (i)	Civil Aviation - International - LTO	PM10	0.0052	0.3085%	99.20%
3 B 4 g i	Manure management - Laying Hens	PM10	0.0048	0.2850%	99.48%
1 A 3 c	Railways	PM10	0.0029	0.1703%	99.65%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	PM10	0.0015	0.0904%	99.74%
3 B 4 g ii	Manure management - Broilers	PM10	0.0011	0.0640%	99.81%
3 B 4 e	Manure management - Horses	PM10	0.0010	0.0568%	99.87%
1 B 1 a	Coal Mining and Handling	PM10	0.0005	0.0298%	99.89%
1 A 4 b ii	Residential: Household and gardening (mobile)	PM10	0.0004	0.0223%	99.92%
5 A	Biological treatment of waste - Solid waste disposal on land	PM10	0.0004	0.0210%	99.94%
3 B 4 d	Manure management - Goats	PM10	0.0003	0.0178%	99.96%
1 A 3 d ii	National Navigation (Shipping)	PM10	0.0002	0.0147%	99.97%
3 B 2	Manure management - Sheep	PM10	0.0002	0.0106%	99.98%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	PM10	0.0001	0.0068%	99.99%
3 B 4 g iv	Manure management - Other Poultry	PM10	0.0001	0.0038%	99.99%
3 B 4 h	Manure management - Other animals (please specify in IIR)	PM10	0.0000	0.0029%	99.99%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	PM10	0.0000	0.0025%	100.00%
1 A 3 a ii (i)	Civil Aviation - Domestic - LTO	PM10	0.0000	0.0018%	100.00%
1 A 5 b	Other, Mobile (including Military)	PM10	0.0000	0.0005%	100.00%
1 A 3 d i (ii)	International inland waterways	PM10	0.0000	0.0005%	100.00%

Trend Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt] $E_{x,0}$	Latest Year (2022) Estimate [kt] $E_{x,t}$	Trend Assessment $L_{x,t}$	% Contribution to the trend	Cumulative Total of $L_{x,t}$
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	PM10	13.7657	0.0188	8.0411	47.4%	47.4%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	PM10	0.1461	0.3031	1.7020	10.0%	57.4%
1 A 4 b i	Residential: stationary	PM10	0.5907	0.3257	1.5722	9.3%	66.7%
3 D c	Farm-level agricultural operations including storage, handling and transport of agricultural products	PM10	0.1960	0.1972	1.0475	6.2%	72.9%
1 A 3 b vii	Road Transport, Automobile road abrasion	PM10	0.0856	0.1838	1.0342	6.1%	79.0%
2 A 5 b	Construction and demolition	PM10	0.1206	0.1430	0.7723	4.6%	83.5%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	PM10	0.0012	0.1271	0.7493	4.4%	87.9%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	PM10	0.1429	0.0736	0.3500	2.1%	90.0%
5 E	Other waste (please specify in IIR)	PM10	0.0306	0.0569	0.3176	1.9%	91.9%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	PM10	0.0000	0.0412	0.2433	1.4%	93.3%
1 A 3 b iii	Road Transport, Heavy duty vehicles	PM10	0.5587	0.0196	0.2155	1.3%	94.6%
3 B 1 a	Manure management - Dairy cattle	PM10	0.0279	0.0266	0.1404	0.8%	95.4%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	PM10	0.3801	0.0178	0.1200	0.7%	96.1%
3 B 1 b	Manure management - Non-dairy cattle	PM10	0.0221	0.0197	0.1033	0.6%	96.7%
2 H 1	Pulp and paper industry	PM10	0.0099	0.0160	0.0884	0.5%	97.2%
1 A 3 b i	Road Transport, Passenger cars	PM10	0.3081	0.0167	0.0840	0.5%	97.7%
1 A 4 a i	Commercial/Institutional: Stationary	PM10	0.0197	0.0122	0.0601	0.4%	98.1%
2 D 3 b	Road paving with asphalt	PM10	0.0548	0.0149	0.0557	0.3%	98.4%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	PM10	0.0061	0.0097	0.0536	0.3%	98.7%
3 B 3	Manure management - Swine	PM10	0.0071	0.0082	0.0439	0.3%	99.0%
1 A 3 b ii	Road Transport, Light duty vehicles	PM10	0.0303	0.0094	0.0375	0.2%	99.2%
1 A 3 a i (i)	Civil Aviation - International - LTO	PM10	0.0028	0.0052	0.0291	0.2%	99.4%
3 B 4 g i	Manure management - Laying Hens	PM10	0.0023	0.0048	0.0270	0.2%	99.5%
1 A 3 c	Railways	PM10	0.0590	0.0029	0.0180	0.1%	99.7%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	PM10	0.0711	0.0091	0.0118	0.1%	99.7%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	PM10	0.0589	0.0078	0.0111	0.1%	99.8%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	PM10	0.0009	0.0015	0.0085	0.1%	99.8%
3 B 4 g ii	Manure management - Broilers	PM10	0.0002	0.0011	0.0062	0.0%	99.9%
3 B 4 e	Manure management - Horses	PM10	0.0004	0.0010	0.0054	0.0%	99.9%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in	PM10	0.1116	0.0119	0.0040	0.0%	99.9%
1 B 1 a	Coal Mining and Handling	PM10	0.0116	0.0005	0.0039	0.0%	100.0%
5 A	Biological treatment of waste - Solid waste disposal on land	PM10	0.0002	0.0004	0.0020	0.0%	100.0%
1 A 4 b ii	Residential: Household and gardening (mobile)	PM10	0.0005	0.0004	0.0019	0.0%	100.0%
3 B 4 d	Manure management - Goats	PM10	0.0000	0.0003	0.0018	0.0%	100.0%
3 B 2	Manure management - Sheep	PM10	0.0001	0.0002	0.0010	0.0%	100.0%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	PM10	IE	0.0001	0.0007	0.0%	100.0%
3 B 4 g iv	Manure management - Other Poultry	PM10	0.0002	0.0001	0.0002	0.0%	100.0%
3 B 4 h	Manure management - Other animals (please specify in IIR)	PM10	0.0001	0.0000	0.0002	0.0%	100.0%
1 A 3 a ii (i)	Civil Aviation - Domestic - LTO	PM10	0.0000	0.0000	0.0002	0.0%	100.0%
1 A 3 d ii	National Navigation (Shipping)	PM10	0.0022	0.0002	0.0002	0.0%	100.0%
1 A 5 b	Other, Mobile (including Military)	PM10	0.0003	0.0000	0.0001	0.0%	100.0%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	PM10	0.0003	0.0000	0.0001	0.0%	100.0%
1 A 3 d i (ii)	International inland waterways	PM10	0.0001	0.0000	0.0000	0.0%	100.0%

Annex Table 8 – Key Category analysis for $PM_{2.5}$: Level and Trend Assessment – Fuel Sold.

Level Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [kt] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1 A 4 b i	Residential: stationary	PM2.5	0.3181	30.4239%	30.42%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	PM2.5	0.1661	15.8850%	46.31%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	PM2.5	0.1271	12.1546%	58.46%
1 A 3 b vii	Road Transport, Automobile road abrasion	PM2.5	0.0993	9.4933%	67.96%
5 E	Other waste (please specify in IIR)	PM2.5	0.0569	5.4393%	73.40%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	PM2.5	0.0401	3.8382%	77.23%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	PM2.5	0.0302	2.8838%	80.12%
1 A 3 b iii	Road Transport, Heavy duty vehicles	PM2.5	0.0196	1.8703%	81.99%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	PM2.5	0.0188	1.8003%	83.79%
3 B 1 a	Manure management - Dairy cattle	PM2.5	0.0173	1.6546%	85.44%
1 A 3 b i	Road Transport, Passenger cars	PM2.5	0.0167	1.5959%	87.04%
2 H 1	Pulp and paper industry	PM2.5	0.0158	1.5141%	88.55%
2 A 5 b	Construction and demolition	PM2.5	0.0143	1.3672%	89.92%
3 B 1 b	Manure management - Non-dairy cattle	PM2.5	0.0129	1.2338%	91.15%
1 A 4 a i	Commercial/Institutional: Stationary	PM2.5	0.0122	1.1621%	92.32%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	PM2.5	0.0119	1.1359%	93.45%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	PM2.5	0.0100	0.9585%	94.41%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	PM2.5	0.0097	0.9268%	95.34%
1 A 3 b ii	Road Transport, Light duty vehicles	PM2.5	0.0094	0.8990%	96.24%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	PM2.5	0.0091	0.8729%	97.11%
3 D c	Farm-level agricultural operations including storage, handling and transport of agricultural products	PM2.5	0.0076	0.7252%	97.83%
1 A 2 c		PM2.5	0.0074	0.7046%	98.54%
1 A 3 a i (i)	Civil Aviation - International - LTO	PM2.5	0.0052	0.4982%	99.04%
2 D 3 b	Road paving with asphalt	PM2.5	0.0035	0.3332%	99.37%
1 A 3 c	Railways	PM2.5	0.0029	0.2751%	99.65%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	PM2.5	0.0012	0.1104%	99.76%
3 B 4 e	Manure management - Horses	PM2.5	0.0006	0.0583%	99.81%
1 A 4 b ii	Residential: Household and gardening (mobile)	PM2.5	0.0004	0.0360%	99.85%
3 B 4 g i	Manure management - Laying Hens	PM2.5	0.0004	0.0345%	99.88%
3 B 3	Manure management - Swine	PM2.5	0.0004	0.0340%	99.92%
1 A 3 d ii	National Navigation (Shipping)	PM2.5	0.0002	0.0237%	99.94%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	PM2.5	0.0001	0.0110%	99.95%
3 B 4 g ii	Manure management - Broilers	PM2.5	0.0001	0.0103%	99.96%
3 B 4 d	Manure management - Goats	PM2.5	0.0001	0.0096%	99.97%
3 B 2	Manure management - Sheep	PM2.5	0.0001	0.0057%	99.98%
5 A	Biological treatment of waste - Solid waste disposal on land	PM2.5	0.0001	0.0051%	99.98%
1 B 1 a	Coal Mining and Handling	PM2.5	0.0001	0.0048%	99.99%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	PM2.5	0.0000	0.0041%	99.99%
1 A 3 a ii (i)	Civil Aviation - Domestic - LTO	PM2.5	0.0000	0.0029%	100.00%
3 B 4 h	Manure management - Other animals (please specify in IIR)	PM2.5	0.0000	0.0012%	100.00%
3 B 4 g iv	Manure management - Other Poultry	PM2.5	0.0000	0.0011%	100.00%
1 A 5 b	Other, Mobile (including Military)	PM2.5	0.0000	0.0008%	100.00%
1 A 3 d i (ii)	International inland waterways	PM2.5	0.0000	0.0008%	100.00%

Trend Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt] $E_{x,0}$	Latest Year (2022) Estimate [kt] $E_{x,t}$	Trend Assessment $L_{x,t}$	% Contribution to the trend	Cumulative Total of $L_{x,t}$
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	PM2.5	13.7650	0.0188	12.8869	48.5%	48.5%
1 A 4 b i	Residential: stationary	PM2.5	0.5746	0.3181	4.1292	15.6%	64.1%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	PM2.5	0.0797	0.1661	2.3666	8.9%	73.0%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	PM2.5	0.0011	0.1271	1.8681	7.0%	80.0%
1 A 3 b vii	Road Transport, Automobile road abrasion	PM2.5	0.0462	0.0993	1.4157	5.3%	85.4%
5 E	Other waste (please specify in IIR)	PM2.5	0.0306	0.0569	0.8072	3.0%	88.4%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	PM2.5	0.0000	0.0401	0.5902	2.2%	90.6%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	PM2.5	0.0562	0.0302	0.3898	1.5%	92.1%
1 A 3 b iii	Road Transport, Heavy duty vehicles	PM2.5	0.5587	0.0196	0.2467	0.9%	93.0%
3 B 1 a	Manure management - Dairy cattle	PM2.5	0.0182	0.0173	0.2371	0.9%	93.9%
2 H 1	Pulp and paper industry	PM2.5	0.0099	0.0158	0.2234	0.8%	94.8%
2 A 5 b	Construction and demolition	PM2.5	0.0121	0.0143	0.1987	0.7%	95.5%
3 B 1 b	Manure management - Non-dairy cattle	PM2.5	0.0145	0.0129	0.1759	0.7%	96.2%
1 A 4 a i	Commercial/Institutional: Stationary	PM2.5	0.0197	0.0122	0.1599	0.6%	96.8%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	PM2.5	0.0061	0.0097	0.1367	0.5%	97.3%
1 A 3 b ii	Road Transport, Light duty vehicles	PM2.5	0.0303	0.0094	0.1093	0.4%	97.7%
3 D c	Farm-level agricultural operations including storage, handling and transport of agricultural products	PM2.5	0.0075	0.0076	0.1043	0.4%	98.1%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	PM2.5	0.2345	0.0100	0.0769	0.3%	98.4%
1 A 3 a i (i)	Civil Aviation - International - LTO	PM2.5	0.0028	0.0052	0.0740	0.3%	98.7%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	PM2.5	0.1116	0.0119	0.0680	0.3%	98.9%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	PM2.5	0.0711	0.0091	0.0663	0.2%	99.2%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	PM2.5	0.0443	0.0074	0.0660	0.2%	99.4%
1 A 3 b i	Road Transport, Passenger cars	PM2.5	0.3081	0.0167	0.0492	0.2%	99.6%
2 D 3 b	Road paving with asphalt	PM2.5	0.0128	0.0035	0.0390	0.1%	99.8%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	PM2.5	0.0007	0.0012	0.0163	0.1%	99.8%
1 A 3 c	Railways	PM2.5	0.0590	0.0029	0.0141	0.1%	99.9%
3 B 4 e	Manure management - Horses	PM2.5	0.0003	0.0006	0.0087	0.0%	99.9%
3 B 4 g i	Manure management - Laying Hens	PM2.5	0.0002	0.0004	0.0051	0.0%	99.9%
1 A 4 b ii	Residential: Household and gardening (mobile)	PM2.5	0.0005	0.0004	0.0051	0.0%	99.9%
3 B 3	Manure management - Swine	PM2.5	0.0003	0.0004	0.0049	0.0%	100.0%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	PM2.5	IE	0.0001	0.0017	0.0%	100.0%
3 B 4 g ii	Manure management - Broilers	PM2.5	0.0000	0.0001	0.0016	0.0%	100.0%
1 A 3 d ii	National Navigation (Shipping)	PM2.5	0.0022	0.0002	0.0015	0.0%	100.0%
3 B 4 d	Manure management - Goats	PM2.5	0.0000	0.0001	0.0015	0.0%	100.0%
3 B 2	Manure management - Sheep	PM2.5	0.0000	0.0001	0.0008	0.0%	100.0%
5 A	Biological treatment of waste - Solid waste disposal on land	PM2.5	0.0000	0.0001	0.0008	0.0%	100.0%
1 A 3 a ii (i)	Civil Aviation - Domestic - LTO	PM2.5	0.0000	0.0000	0.0004	0.0%	100.0%
1 B 1 a	Coal Mining and Handling	PM2.5	0.0012	0.0001	0.0004	0.0%	100.0%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	PM2.5	0.0003	0.0000	0.0003	0.0%	100.0%
3 B 4 h	Manure management - Other animals (please specify in IIR)	PM2.5	0.0001	0.0000	0.0001	0.0%	100.0%
3 B 4 g iv	Manure management - Other Poultry	PM2.5	0.0000	0.0000	0.0001	0.0%	100.0%
1 A 5 b	Other, Mobile (including Military)	PM2.5	0.0003	0.0000	0.0001	0.0%	100.0%
1 A 3 d i (ii)	International inland waterways	PM2.5	0.0001	0.0000	0.0001	0.0%	100.0%

Annex Table 9 – Key Category analysis for Pb: Level and Trend Assessment – Fuel Sold.

1 A 3 b vi	Road Transport, Automobile tyre and break wear	Pb	0.9886	55.8497%	55.85%
2 C 1	Iron and steel production	Pb	0.2275	12.8514%	68.70%
1 A 3 a ii (i)	Civil Aviation - Domestic - LTO	Pb	0.1454	8.2156%	76.92%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	Pb	0.1364	7.7076%	84.62%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	Pb	0.0795	4.4929%	89.12%
1 A 4 a i	Commercial/Institutional: Stationary	Pb	0.0682	3.8506%	92.97%
2 C 3	Aluminum production	Pb	0.0659	3.7206%	96.69%
1 A 4 b i	Residential: stationary	Pb	0.0277	1.5627%	98.25%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	Pb	0.0202	1.1440%	99.40%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	Pb	0.0043	0.2410%	99.64%
2 A 3	Glass production	Pb	0.0027	0.1547%	99.79%
2 G	Other product manufacture and use	Pb	0.0023	0.1274%	99.92%
1 A 3 b i	Road Transport, Passenger cars	Pb	0.0007	0.0420%	99.96%
1 A 3 b iii	Road Transport, Heavy duty vehicles	Pb	0.0003	0.0189%	99.98%
5 E	Other waste (please specify in IIR)	Pb	0.0002	0.0093%	99.99%
5 C 1 b v	Cremation	Pb	0.0001	0.0049%	99.99%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	Pb	0.0000	0.0028%	100.00%
1 A 3 b ii	Road Transport, Light duty vehicles	Pb	0.0000	0.0015%	100.00%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	Pb	0.0000	0.0014%	100.00%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	Pb	0.0000	0.0003%	100.00%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	Pb	0.0000	0.0002%	100.00%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	Pb	0.0000	0.0002%	100.00%
1 A 4 b ii	Residential: Household and gardening (mobile)	Pb	0.0000	0.0001%	100.00%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	Pb	0.0000	0.0001%	100.00%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	Pb	0.0000	0.0001%	100.00%
1 A 3 d ii	National Navigation (Shipping)	Pb	0.0000	0.0000%	100.00%
1 A 5 b	Other, Mobile (including Military)	Pb	0.0000	0.0000%	100.00%
1 A 3 d i (ii)	International inland waterways	Pb	0.0000	0.0000%	100.00%
1 A 3 c	Railways	Pb	0.0000	0.0000%	100.00%

2 C 1	Iron and steel production	Pb	16.3868	0.2275	7.8502	43.7%	43.7%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	Pb	0.4846	0.9886	5.8441	32.5%	76.2%
1 A 3 b i	Road Transport, Passenger cars	Pb	1.8913	0.0007	1.0639	5.9%	82.1%
1 A 3 a ii (i)	Civil Aviation - Domestic - LTO	Pb	0.0581	0.1454	0.8671	4.8%	87.0%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	Pb	0.0005	0.1364	0.8440	4.7%	91.6%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	Pb	0.0453	0.0795	0.4665	2.6%	94.2%
1 A 4 a i	Commercial/Institutional: Stationary	Pb	0.1219	0.0682	0.3529	2.0%	96.2%
2 C 3	Aluminum production	Pb	0.1291	0.0659	0.3346	1.9%	98.1%
1 A 4 b i	Residential: stationary	Pb	0.0578	0.0277	0.1385	0.8%	98.8%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	Pb	0.0100	0.0202	0.1197	0.7%	99.5%
2 A 3	Glass production	Pb	0.1509	0.0027	0.0683	0.4%	99.9%
2 G	Other product manufacture and use	Pb	0.0005	0.0023	0.0137	0.1%	100.0%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	Pb	0.0507	0.0043	0.0022	0.0%	100.0%
1 A 3 b iii	Road Transport, Heavy duty vehicles	Pb	0.0002	0.0003	0.0020	0.0%	100.0%
5 E	Other waste (please specify in IIR)	Pb	0.0001	0.0002	0.0010	0.0%	100.0%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	Pb	0.0009	0.0000	0.0005	0.0%	100.0%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	Pb	0.0000	0.0000	0.0003	0.0%	100.0%
1 A 3 b ii	Road Transport, Light duty vehicles	Pb	0.0000	0.0000	0.0002	0.0%	100.0%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	Pb	0.0001	0.0000	0.0001	0.0%	100.0%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	Pb	0.0000	0.0000	0.0000	0.0%	100.0%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	Pb	0.0000	0.0000	0.0000	0.0%	100.0%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	Pb	0.0000	0.0000	0.0000	0.0%	100.0%
1 A 4 b ii	Residential: Household and gardening (mobile)	Pb	0.0000	0.0000	0.0000	0.0%	100.0%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	Pb	0.0000	0.0000	0.0000	0.0%	100.0%
1 A 3 d ii	National Navigation (Shipping)	Pb	0.0000	0.0000	0.0000	0.0%	100.0%
1 A 5 b	Other, Mobile (including Military)	Pb	0.0000	0.0000	0.0000	0.0%	100.0%
1 A 3 d i (ii)	International inland waterways	Pb	0.0000	0.0000	0.0000	0.0%	100.0%
1 A 3 c	Railways	Pb	0.0000	0.0000	0.0000	0.0%	100.0%

Annex Table 10 – Key Category analysis for Cd: Level and Trend Assessment – Fuel Sold.

Level Assessment (fuel sold)					
NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [t]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
1 A 4 b i	Residential: stationary	Cd	0.0118	25.5245%	25.52%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	Cd	0.0114	24.7322%	50.26%
2 C 1	Iron and steel production	Cd	0.0083	17.8652%	68.12%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	Cd	0.0047	10.0763%	78.20%
2 G	Other product manufacture and use	Cd	0.0037	8.0409%	86.24%
2 C 3	Aluminum production	Cd	0.0028	6.1291%	92.37%
1 A 4 a i	Commercial/Institutional: Stationary	Cd	0.0011	2.3427%	94.71%
2 A 3	Glass production	Cd	0.0010	2.1159%	96.83%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	Cd	0.0006	1.2115%	98.04%
5 E	Other waste (please specify in IIR)	Cd	0.0003	0.7167%	98.76%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	Cd	0.0002	0.4881%	99.24%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	Cd	0.0002	0.3934%	99.64%
1 A 3 b i	Road Transport, Passenger cars	Cd	0.0001	0.1899%	99.83%
1 A 3 b iii	Road Transport, Heavy duty vehicles	Cd	0.0000	0.0721%	99.90%
1 A 3 c	Railways	Cd	0.0000	0.0450%	99.94%
5 C 1 b v	Cremation	Cd	0.0000	0.0316%	99.98%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	Cd	0.0000	0.0108%	99.99%
1 A 3 b ii	Road Transport, Light duty vehicles	Cd	0.0000	0.0060%	99.99%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	Cd	0.0000	0.0042%	100.00%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	Cd	0.0000	0.0011%	100.00%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	Cd	0.0000	0.0009%	100.00%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	Cd	0.0000	0.0008%	100.00%
1 A 4 b ii	Residential: Household and gardening (mobile)	Cd	0.0000	0.0005%	100.00%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	Cd	0.0000	0.0003%	100.00%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	Cd	0.0000	0.0002%	100.00%
1 A 3 d ii	National Navigation (Shipping)	Cd	0.0000	0.0000%	100.00%
1 A 5 b	Other, Mobile (including Military)	Cd	0.0000	0.0000%	100.00%
1 A 3 d i (ii)	International inland waterways	Cd	0.0000	0.0000%	100.00%

Trend Assessment (fuel sold)							
NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [t]	Latest Year (2022) Estimate [t]	Trend Assessment	% Contribution to the trend	Cumulative Total of $L_{x,t}$
			$E_{x,0}$	$E_{x,t}$	$L_{x,t}$		
2 A 3	Glass production	Cd	0.0257	0.0010	0.5146	26.3%	26.3%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	Cd	0.0001	0.0114	0.4613	23.5%	49.8%
2 C 1	Iron and steel production	Cd	0.0325	0.0083	0.3683	18.8%	68.6%
1 A 4 b i	Residential: stationary	Cd	0.0089	0.0118	0.2846	14.5%	83.1%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	Cd	0.0023	0.0047	0.1395	7.1%	90.2%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	Cd	0.0043	0.0002	0.0837	4.3%	94.5%
2 G	Other product manufacture and use	Cd	0.0040	0.0037	0.0651	3.3%	97.8%
2 C 3	Aluminum production	Cd	0.0058	0.0028	0.0110	0.6%	98.4%
5 E	Other waste (please specify in IIR)	Cd	0.0002	0.0003	0.0096	0.5%	98.9%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	Cd	0.0006	0.0006	0.0094	0.5%	99.4%
1 A 4 a i	Commercial/Institutional: Stationary	Cd	0.0018	0.0011	0.0043	0.2%	99.6%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	Cd	0.0002	0.0002	0.0040	0.2%	99.8%
1 A 3 b i	Road Transport, Passenger cars	Cd	0.0001	0.0001	0.0017	0.1%	99.9%
1 A 3 b iii	Road Transport, Heavy duty vehicles	Cd	0.0000	0.0000	0.0010	0.1%	99.9%
1 A 3 c	Railways	Cd	0.0001	0.0000	0.0009	0.0%	100.0%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	Cd	0.0000	0.0000	0.0003	0.0%	100.0%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	Cd	0.0000	0.0000	0.0002	0.0%	100.0%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	Cd	0.0000	0.0000	0.0001	0.0%	100.0%
1 A 3 b ii	Road Transport, Light duty vehicles	Cd	0.0000	0.0000	0.0001	0.0%	100.0%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	Cd	0.0000	0.0000	0.0000	0.0%	100.0%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	Cd	0.0000	0.0000	0.0000	0.0%	100.0%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	Cd	0.0000	0.0000	0.0000	0.0%	100.0%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	Cd	0.0000	0.0000	0.0000	0.0%	100.0%
1 A 4 b ii	Residential: Household and gardening (mobile)	Cd	0.0000	0.0000	0.0000	0.0%	100.0%
1 A 3 d ii	National Navigation (Shipping)	Cd	0.0000	0.0000	0.0000	0.0%	100.0%
1 A 5 b	Other, Mobile (including Military)	Cd	0.0000	0.0000	0.0000	0.0%	100.0%
1 A 3 d i (ii)	International inland waterways	Cd	0.0000	0.0000	0.0000	0.0%	100.0%

Annex Table 11 – Key Category analysis for Hg: Level and Trend Assessment – Fuel Sold.

Level Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [t]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	Hg	0.1048	53.8224%	53.82%
2 C 3	Aluminum production	Hg	0.0340	17.4783%	71.30%
2 C 1	Iron and steel production	Hg	0.0159	8.1559%	79.46%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	Hg	0.0099	5.0993%	84.56%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	Hg	0.0080	4.0921%	88.65%
2 K	Consumption of POPs and heavy metals (e.g. electrical and scientific equipment)	Hg	0.0066	3.3932%	92.04%
1 A 3 b i	Road Transport, Passenger cars	Hg	0.0051	2.6066%	94.65%
1 A 3 b iii	Road Transport, Heavy duty vehicles	Hg	0.0035	1.8170%	96.46%
1 A 4 b i	Residential: stationary	Hg	0.0022	1.1081%	97.57%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	Hg	0.0014	0.7189%	98.29%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	Hg	0.0010	0.5261%	98.82%
1 A 4 a i	Commercial/Institutional: Stationary	Hg	0.0007	0.3579%	99.18%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	Hg	0.0005	0.2681%	99.44%
5 E	Other waste (please specify in IIR)	Hg	0.0003	0.1704%	99.61%
1 A 3 b ii	Road Transport, Light duty vehicles	Hg	0.0003	0.1443%	99.76%
5 C 1 b v	Cremation	Hg	0.0001	0.0755%	99.83%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	Hg	0.0001	0.0507%	99.88%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	Hg	0.0001	0.0410%	99.93%
2 A 3	Glass production	Hg	0.0001	0.0300%	99.96%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	Hg	0.0000	0.0214%	99.98%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	Hg	0.0000	0.0115%	99.99%
1 A 4 b ii	Residential: Household and gardening (mobile)	Hg	0.0000	0.0057%	99.99%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	Hg	0.0000	0.0049%	100.00%
1 A 3 d ii	National Navigation (Shipping)	Hg	0.0000	0.0005%	100.00%
1 A 5 b	Other, Mobile (including Military)	Hg	0.0000	0.0001%	100.00%
2 G	Other product manufacture and use	Hg	0.0000	0.0001%	100.00%
1 A 3 d i (ii)	International inland waterways	Hg	0.0000	0.0000%	100.00%

Trend Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [t]	Latest Year (2022) Estimate [t]	Trend Assessment	% Contribution to the trend	Cumulative Total of $L_{x,t}$
			$E_{x,0}$	$E_{x,t}$	$L_{x,t}$		
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	Hg	0.0129	0.1048	1.2970	38.966%	39.0%
2 C 1	Iron and steel production	Hg	0.2799	0.0159	1.2305	36.967%	75.9%
2 C 3	Aluminum production	Hg	0.0109	0.0340	0.3866	11.613%	87.5%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	Hg	0.0417	0.0080	0.1107	3.324%	90.9%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	Hg	0.0052	0.0099	0.1024	3.077%	93.9%
2 K	Consumption of POPs and heavy metals (e.g. electrical and scientific equipment)	Hg	0.0038	0.0066	0.0662	1.989%	95.9%
1 A 3 b i	Road Transport, Passenger cars	Hg	0.0040	0.0051	0.0454	1.365%	97.3%
1 A 3 b iii	Road Transport, Heavy duty vehicles	Hg	0.0016	0.0035	0.0377	1.131%	98.4%
1 A 4 b i	Residential: stationary	Hg	0.0029	0.0022	0.0134	0.401%	98.8%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	Hg	0.0007	0.0010	0.0097	0.290%	99.1%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	Hg	0.0001	0.0005	0.0063	0.190%	99.3%
2 A 3	Glass production	Hg	0.0011	0.0001	0.0051	0.152%	99.5%
1 A 4 a i	Commercial/Institutional: Stationary	Hg	0.0009	0.0007	0.0044	0.133%	99.6%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	Hg	0.0028	0.0014	0.0039	0.118%	99.7%
5 E	Other waste (please specify in IIR)	Hg	0.0002	0.0003	0.0034	0.102%	99.8%
1 A 3 b ii	Road Transport, Light duty vehicles	Hg	0.0001	0.0003	0.0032	0.096%	99.9%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	Hg	0.0000	0.0001	0.0011	0.033%	99.9%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	Hg	0.0000	0.0001	0.0010	0.031%	100.0%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	Hg	0.0000	0.0000	0.0003	0.009%	100.0%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	Hg	0.0000	0.0000	0.0002	0.007%	100.0%
1 A 4 b ii	Residential: Household and gardening (mobile)	Hg	0.0000	0.0000	0.0001	0.002%	100.0%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	Hg	0.0000	0.0000	0.0001	0.002%	100.0%
2 G	Other product manufacture and use	Hg	0.0000	0.0000	0.0000	0.000%	100.0%
1 A 5 b	Other, Mobile (including Military)	Hg	0.0000	0.0000	0.0000	0.000%	100.0%
1 A 3 d ii	National Navigation (Shipping)	Hg	0.0000	0.0000	0.0000	0.000%	100.0%
1 A 3 d i (ii)	International inland waterways	Hg	0.0000	0.0000	0.0000	0.000%	100.0%

Annex Table 12 – Key Category analysis for PCDD/F: Level and Trend Assessment – Fuel Sold.

Level Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [g I-Teq]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
2 C 3	Aluminum production	PCDD_PCDF	1.7532	51.3631%	51.36%
5 E	Other waste (please specify in IIR)	PCDD_PCDF	0.5758	16.8701%	68.23%
1 A 4 b i	Residential: stationary	PCDD_PCDF	0.3693	10.8189%	79.05%
2 C 1	Iron and steel production	PCDD_PCDF	0.3102	9.0877%	88.14%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	PCDD_PCDF	0.3062	8.9717%	97.11%
1 A 4 a i	Commercial/Institutional: Stationary	PCDD_PCDF	0.0345	1.0106%	98.12%
1 A 3 b i	Road Transport, Passenger cars	PCDD_PCDF	0.0268	0.7854%	98.91%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	PCDD_PCDF	0.0234	0.6855%	99.59%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	PCDD_PCDF	0.0061	0.1796%	99.77%
1 A 3 b ii	Road Transport, Light duty vehicles	PCDD_PCDF	0.0049	0.1439%	99.92%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	PCDD_PCDF	0.0014	0.0419%	99.96%
1 A 3 b iii	Road Transport, Heavy duty vehicles	PCDD_PCDF	0.0011	0.0324%	99.99%
5 C 1 b v	Cremation	PCDD_PCDF	0.0001	0.0032%	99.99%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	PCDD_PCDF	0.0001	0.0017%	100.00%
2 G	Other product manufacture and use	PCDD_PCDF	0.0001	0.0017%	100.00%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	PCDD_PCDF	0.0001	0.0015%	100.00%
1 A 3 c	Railways	PCDD_PCDF	0.0000	0.0009%	100.00%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	PCDD_PCDF	0.0000	0.0001%	100.00%

Trend Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [g I-Teq]	Latest Year (2022) Estimate [g I-Teq]	Trend Assessment	% Contribution to the trend	Cumulative Total of $L_{x,t}$
			$E_{x,0}$	$E_{x,t}$	$L_{x,t}$		
2 C 1	Iron and steel production	PCDD_PCDF	36.5907	0.3102	9.6153	49.967%	50.0%
2 C 3	Aluminum production	PCDD_PCDF	3.5609	1.7532	5.1992	27.018%	77.0%
5 E	Other waste (please specify in IIR)	PCDD_PCDF	0.3098	0.5758	1.9595	10.183%	87.2%
1 A 4 b i	Residential: stationary	PCDD_PCDF	0.7285	0.3693	1.1014	5.724%	92.9%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	PCDD_PCDF	0.0043	0.3062	1.0891	5.660%	98.6%
1 A 4 a i	Commercial/Institutional: Stationary	PCDD_PCDF	0.0609	0.0345	0.1050	0.545%	99.1%
1 A 3 b i	Road Transport, Passenger cars	PCDD_PCDF	0.1030	0.0268	0.0653	0.339%	99.4%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	PCDD_PCDF	0.0702	0.0234	0.0628	0.326%	99.8%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	PCDD_PCDF	0.0043	0.0061	0.0206	0.107%	99.9%
1 A 3 b ii	Road Transport, Light duty vehicles	PCDD_PCDF	0.0086	0.0049	0.0150	0.078%	99.9%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	PCDD_PCDF	0.0012	0.0014	0.0047	0.025%	100.0%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	PCDD_PCDF	0.0154	0.0000	0.0045	0.023%	100.0%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	PCDD_PCDF	0.0020	0.0001	0.0004	0.002%	100.0%
1 A 3 b iii	Road Transport, Heavy duty vehicles	PCDD_PCDF	0.0125	0.0011	0.0003	0.001%	100.0%
2 G	Other product manufacture and use	PCDD_PCDF	0.0000	0.0001	0.0002	0.001%	100.0%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	PCDD_PCDF	0.0000	0.0001	0.0002	0.001%	100.0%
1 A 3 c	Railways	PCDD_PCDF	0.0001	0.0000	0.0001	0.000%	100.0%

Annex Table 13 – Key Category analysis for PCB: Level and Trend Assessment – Fuel Sold.

Level Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [kg]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
2 K	Consumption of POPs and heavy metals	PCB	0.8226	59.2488%	59.25%
2 C 1	Iron and steel production	PCB	0.5087	36.6391%	95.89%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	PCB	0.0231	1.6643%	97.55%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	PCB	0.0170	1.2238%	98.78%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary	PCB	0.0134	0.9629%	99.74%
1 A 4 b i	Residential: stationary	PCB	0.0036	0.2597%	100.00%
1 A 3 b i	Road Transport, Passenger cars	PCB	0.0000	0.0008%	100.00%
5 C 1 b v	Cremation	PCB	0.0000	0.0003%	100.00%
1 A 3 b ii	Road Transport, Light duty vehicles	PCB	0.0000	0.0002%	100.00%
1 A 4 b ii	Residential: Household and gardening (mobile)	PCB	0.0000	0.0000%	100.00%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	PCB	0.0000	0.0000%	100.00%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion	PCB	0.0000	0.0000%	100.00%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other	PCB	0.0000	0.0000%	100.00%
1 A 3 b iii	Road Transport, Heavy duty vehicles	PCB	0.0000	0.0000%	100.00%
1 A 4 a i	Commercial/Institutional: Stationary	PCB	0.0000	0.0000%	100.00%
1 A 3 d ii	National Navigation (Shipping)	PCB	0.0000	0.0000%	100.00%
1 A 5 b	Other, Mobile (including Military)	PCB	0.0000	0.0000%	100.00%
1 A 3 d i (ii)	International inland waterways	PCB	0.0000	0.0000%	100.00%

Trend Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kg]	Latest Year (2022) Estimate [kg]	Trend Assessment	% Contribution to the trend	Cumulative Total of $L_{x,t}$
			$E_{x,0}$	$E_{x,t}$	$L_{x,t}$		
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	PCB	16.2903	0.0170	11.3889	49.7%	49.7%
2 C 1	Iron and steel production	PCB	1.8161	0.5087	8.9970	39.3%	88.9%
2 K	Consumption of POPs and heavy metals	PCB	20.6400	0.8226	1.7982	7.8%	96.8%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	PCB	0.0047	0.0231	0.4647	2.0%	98.8%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary	PCB	0.0574	0.0134	0.2295	1.0%	99.8%
1 A 4 b i	Residential: stationary	PCB	0.0457	0.0036	0.0401	0.2%	100.0%
1 A 3 b i	Road Transport, Passenger cars	PCB	0.0000	0.0000	0.0002	0.0%	100.0%
1 A 3 b ii	Road Transport, Light duty vehicles	PCB	0.0000	0.0000	0.0000	0.0%	100.0%
1 A 4 b ii	Residential: Household and gardening (mobile)	PCB	0.0000	0.0000	0.0000	0.0%	100.0%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion	PCB	0.0000	0.0000	0.0000	0.0%	100.0%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	PCB	0.0000	0.0000	0.0000	0.0%	100.0%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other	PCB	0.0000	0.0000	0.0000	0.0%	100.0%
1 A 3 b iii	Road Transport, Heavy duty vehicles	PCB	0.0000	0.0000	0.0000	0.0%	100.0%
1 A 4 a i	Commercial/Institutional: Stationary	PCB	0.0000	0.0000	0.0000	0.0%	100.0%
1 A 3 d ii	National Navigation (Shipping)	PCB	0.0000	0.0000	0.0000	0.0%	100.0%
1 A 3 d i (ii)	International inland waterways	PCB	0.0000	0.0000	0.0000	0.0%	100.0%
1 A 5 b	Other, Mobile (including Military)	PCB	0.0000	0.0000	0.0000	0.0%	100.0%

Annex Table 14 – Key Category analysis for HCB: Level and Trend Assessment – Fuel Sold.

Level Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [kg]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
2 C 1	Iron and steel production	HCB	0.4588	56.4934%	56.49%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	HCB	0.2081	25.6251%	82.12%
2 C 3	Aluminum production	HCB	0.1095	13.4776%	95.60%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	HCB	0.0269	3.3084%	98.90%
1 A 4 b i	Residential: stationary	HCB	0.0045	0.5588%	99.46%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	HCB	0.0036	0.4400%	99.90%
5 C 1 b v	Cremation	HCB	0.0004	0.0537%	99.96%
3 D f	Use of pesticides	HCB	0.0003	0.0400%	100.00%
1 A 4 a i	Commercial/Institutional: Stationary	HCB	0.0000	0.0030%	100.00%

Trend Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kg]	Latest Year (2022) Estimate [kg]	Trend Assessment	% Contribution to the trend	Cumulative Total of $L_{x,t}$
			$E_{x,0}$	$E_{x,t}$	$L_{x,t}$		
3 D f	Use of pesticides	HCB	0.5402	0.0003	0.6644	50.0%	50.0%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	HCB	0.0954	0.2081	0.3352	25.2%	75.3%
2 C 3	Aluminum production	HCB	0.0833	0.1095	0.1355	10.2%	85.5%
2 C 1	Iron and steel production	HCB	0.7073	0.4588	0.1270	9.6%	95.0%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	HCB	0.0002	0.0269	0.0582	4.4%	99.4%
1 A 4 b i	Residential: stationary	HCB	0.0034	0.0045	0.0057	0.4%	99.9%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	HCB	0.0048	0.0036	0.0018	0.1%	100.0%
1 A 4 a i	Commercial/Institutional: Stationary	HCB	0.0000	0.0000	0.0001	0.0%	100.0%

Annex Table 15 – Key Category analysis for PAH: Level and Trend Assessment – Fuel Sold.

Level Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Latest Year (2022) Estimate [t]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	PAH	0.1881	31.3523%	31.35%
1 A 4 b i	Residential: stationary	PAH	0.1629	27.1484%	58.50%
1 A 4 a i	Commercial/Institutional: Stationary	PAH	0.0886	14.7687%	73.27%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	PAH	0.0874	14.5719%	87.84%
1 A 3 b iii	Road Transport, Heavy duty vehicles	PAH	0.0285	4.7587%	92.60%
1 A 3 b i	Road Transport, Passenger cars	PAH	0.0222	3.6982%	96.30%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	PAH	0.0089	1.4759%	97.77%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	PAH	0.0086	1.4330%	99.21%
1 A 3 b ii	Road Transport, Light duty vehicles	PAH	0.0016	0.2686%	99.48%
2 C 1	Iron and steel production	PAH	0.0011	0.1755%	99.65%
1 A 4 b ii	Residential: Household and gardening (mobile)	PAH	0.0006	0.1030%	99.75%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	PAH	0.0004	0.0603%	99.81%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	PAH	0.0003	0.0516%	99.87%
1 A 3 d ii	National Navigation (Shipping)	PAH	0.0003	0.0515%	99.92%
1 A 3 c	Railways	PAH	0.0002	0.0288%	99.95%
2 G	Other product manufacture and use	PAH	0.0001	0.0238%	99.97%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	PAH	0.0001	0.0212%	99.99%
1 A 5 b	Other, Mobile (including Military)	PAH	0.0000	0.0061%	100.00%
1 A 3 d i (ii)	International inland waterways	PAH	0.0000	0.0020%	100.00%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	PAH	0.0000	0.0001%	100.00%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	PAH	0.0000	0.0001%	100.00%
5 C 1 b v	Cremation	PAH	0.0000	0.0000%	100.00%

Trend Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [t]	Latest Year (2022) Estimate [t]	Trend Assessment	% Contribution to the trend	Cumulative Total of $L_{x,t}$
			$E_{x,0}$	$E_{x,t}$	$L_{x,t}$		
2 C 1	Iron and steel production	PAH	2.5360	0.0011	4.2149	49.9%	49.9%
1 A 4 b i	Residential: stationary	PAH	0.4437	0.1629	1.1620	13.8%	63.6%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	PAH	0.0419	0.0874	0.9508	11.3%	74.9%
1 A 4 a i	Commercial/Institutional: Stationary	PAH	0.1584	0.0886	0.7703	9.1%	84.0%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	PAH	0.9422	0.1881	0.6255	7.4%	91.4%
1 A 3 b iii	Road Transport, Heavy duty vehicles	PAH	0.0114	0.0285	0.3142	3.7%	95.1%
1 A 3 b i	Road Transport, Passenger cars	PAH	0.0317	0.0222	0.2062	2.4%	97.6%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	PAH	0.0000	0.0089	0.1034	1.2%	98.8%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	PAH	0.0201	0.0086	0.0668	0.8%	99.6%
1 A 3 b ii	Road Transport, Light duty vehicles	PAH	0.0015	0.0016	0.0163	0.2%	99.8%
1 A 4 b ii	Residential: Household and gardening (mobile)	PAH	0.0017	0.0006	0.0044	0.1%	99.8%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	PAH	0.0005	0.0004	0.0034	0.0%	99.9%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	PAH	0.0001	0.0003	0.0034	0.0%	99.9%
1 A 3 d ii	National Navigation (Shipping)	PAH	0.0009	0.0003	0.0020	0.0%	100.0%
2 G	Other product manufacture and use	PAH	0.0001	0.0001	0.0015	0.0%	100.0%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	PAH	0.0001	0.0001	0.0013	0.0%	100.0%
1 A 3 c	Railways	PAH	0.0007	0.0002	0.0009	0.0%	100.0%
1 A 5 b	Other, Mobile (including Military)	PAH	0.0001	0.0000	0.0003	0.0%	100.0%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	PAH	0.0000	0.0000	0.0000	0.0%	100.0%
1 A 3 d i (ii)	International inland waterways	PAH	0.0001	0.0000	0.0000	0.0%	100.0%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	PAH	0.0000	0.0000	0.0000	0.0%	100.0%

13.2 Appendix 2: Summary Information on Condensable in PM

Table A6.1: Inclusion/exclusion of the condensable component from PM_{10} and $PM_{2.5}$ emission factors. Note: the percentages refer to the shares of activity data in the subcategories where more than one type of emission factor is used.

NFR	Source/sector name	PM emissions: the condensable component is			EF reference and comments
		included	excluded	unknown	
1A1a	Public electricity and heat production		50.6%	49.4%	Unknown for default EFs from EMEP/EEA Guidebook 2016 (Chap. 1.A.1 Tables 3-17, 3-20, 3-25, 3-27, 3-45); excluded for country-specific EFs (based on stack measurements)
1A2a	Iron and Steel		98.1%	1.9%	Unknown for default EFs from EMEP/EEA Guidebook 2016 (Chap 1A2, Table 3.2) & EMEP/EEA Guidebook 2009 (Chap. 1A1 Table 3.14, Chap. 1A2 tables 3.3 and 3.4); excluded for country-specific EFs (based on stack measurements)
1A2b	Non-ferrous metals			X	Unknown for default EFs EMEP/EEA 2016 (Chap. 1.A.2 Tables 3-3 and 3-4)
1A2c	Chemicals		32.7%	67.3%	Unknown for default EFs from EMEP/EEA 2016 (Chap. 1.A.2 Tables 3-3, 3-4 and 3-20); excluded for country-specific EFs (based on stack measurements)
1A2d	Pulp, Paper and Print			X	Unknown for default EFs from Guidebook 2009 (Chap. 1.A.2 Tables 3-3 and 3-4)
1A2e	Food processing, beverages and tobacco		39.4%	60.6%	Unknown for default EFs from EMEP/EEA 2016 (Chap. 1.A.2 Tables 3-3 and 3-4); excluded for country-specific EFs (based on stack measurements)
1A2f	Non-metallic minerals		99.2%	0.8%	PM2.5: Unknown for default EFs from EMEP/EEA 2016 (Chap. 1.A.2 Table 3-3). PM10: Unknown for default EFs from Guidebook 2016 (Chap. 1.A.2 Table 3-3); excluded for country-specific EFs (based on stack measurements)
1A2gviii	Other		11.9%	88.1%	Unknown for default EFs from Guidebook 2009 (Chap. 1.A.2 Tables 3-3 and 3-4); excluded for country-specific EFs (based on stack measurements)
1A2gvii	Mobile combustion in Manufacturing Industries and Construction	X			Country-specific EFs, Section 3.2.3.8.1.2.3
1A3a	Civil aviation			X	Unknown for default EFs from EMEP/EEA 2016 (chapter 1.A.3.a, tables 3-4 and 3-10)
1A3b	Road transport	X			Country-specific EFs, Section 3.2.4.3.2.3
1A3c	Railways	X			Country-specific EFs, Section 3.2.4.4.2.3
1A3d	Navigation	X			Country-specific EFs, Section 3.2.4.5.2.3
1A4ai	Commercial / institutional (stationary)			X	Unknown for default EFs from EMEP/EEA 2016 (Chap. 1.A.4 Tables 3-24, 3-26 and 3-48)
1A4bi	Residential (stationary)			X	Unknown for default EFs from EMEP/EEA 2016 (Chap. 1.A.4 Table 3-16)
1A4bii	Residential (mobile)	X			Country-specific EFs, Section 3.2.5.5.2
1A4ci	Agriculture/Forestry/Fishing (stationary)			X	Unknown for default EFs from EMEP/EEA 2016 (Chap. 1.A.4 Tables 3-24 and 3-26)
1A4cii	Agriculture/Forestry/Fishing (mobile)	X			Country-specific EFs, Section 3.2.5.6.2.3
1A5b	Other mobile	X			Country-specific EFs, Section 3.2.6.3.2.3
1B1a	Fugitive emissions			X	Unknown for default EFs from EMEP/EEA 2016
2A5b	Construction and demolition		n/a		Diffuse emissions.

2D3b	Road paving with asphalt		X		Default EFs from EMEP/EEA 2016 (Chap. 2.D.3.b Tables 3-17, 3-20, 3-25, 3-27, 3-45)
2G	Other product use			X	Unknown for default factors from EMEP/EEA Guidebook 2016 (Chap. 2D3i-2G, tables 3-13 and 3-14)
3B	Manure management	n/a			Diffuse emissions.
3D	Crop production and agricultural soils	n/a			Diffuse emissions. “The processes which result in particulate emissions are largely low-temperature mechanical activities, and emissions are unlikely to include substantial quantities of condensable particulate material.” EMEP/EEA 2016, Chapter 3D, page 9
5A	Biological treatment of waste - Solid waste disposal on land	n/a			Diffuse emissions.
5E	Other waste			X	Default EFs from EMEP/EEA 2016 (Chap. 5.E Tables 3-2 to 3-6)