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Administration de l'environnement

Luxembourg's Informative Inventory Report 1990-2018

Submission under the UNECE Convention on
Long-Range Transboundary Air Pollution

DRAFT

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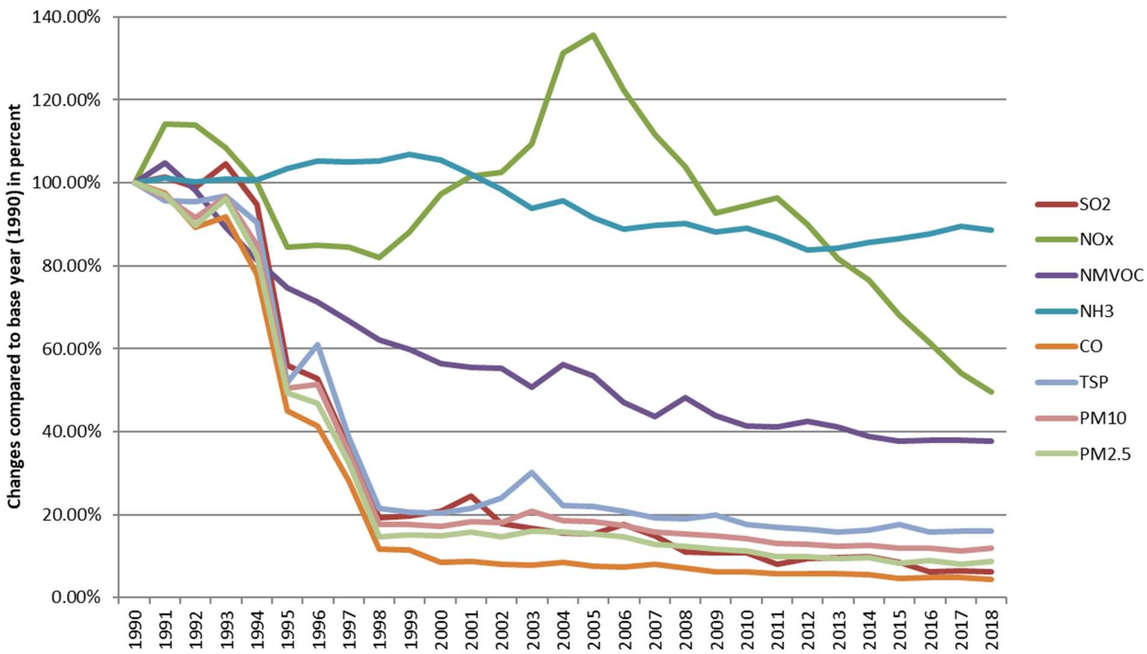
The present IIR contains information on anthropogenic emissions for NO_X, SO_2, NMVOC, NH_3, CO, TSP, PM_{10}, $PM_{2.5}$, HMs (Cd, Pb, Hg) and POPs and covers the period 1990-2018.

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 2020 emissions until 2018 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 2014 revised Reporting Guidelines (ECE/EB.AIR.125) as adopted for application in 2015 and subsequent years at the thirty-second session of the Executive Body for the LRTAP Convention (ECE/EB.AIR/122/Add.1, Decisions 2013/3 and 2013/4).

Air pollution in Luxembourg declined in recent years (Figure 0-1). Emissions decreased significantly for most pollutants monitored since 1990, although progress varies depending on the pollutant.

Figure 0-1 – Air pollution trends in Luxembourg based on fuel sold



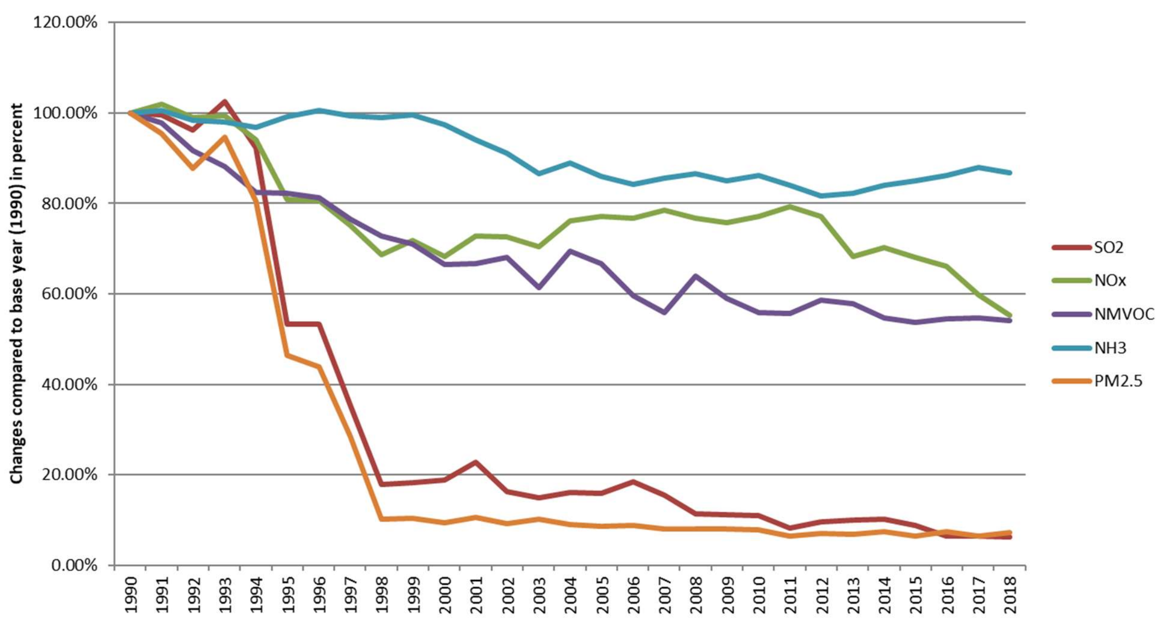
Sulphur dioxide (SO_2), carbon monoxide (CO), total suspended particles (TSP) and particulate matter (PM_{10}, $PM_{2.5}$) emissions saw a rapid decline in the early 1990s due to the technological switch, from blast furnaces to electric arc furnaces, in the iron and steel industry, while the decrease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

The emission 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, namely ammonia (NH_3), only moderate progress can be observed since 1998. This particularly holds true for the development of ammonia emissions, for which a relatively stable evolution, or even a steady increase since 2011 is observed, due to changes in the common agricultural policy (abolishment of milk quotas).

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 very similar pa. 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 0-2).

Figure 0-2 – Air pollution trends in Luxembourg based on fuel used



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

For POPs (Persistent Organic Pollutants) and heavy metal emissions, please refer to the separate reports, in the Annex, describing the methodology and emission trends for these air pollutants.

Finally, please be aware that this report does not provide a comprehensive discussion on air pollution or the measures and policies 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 sixth 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 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] The European Environment State and Outlook 2015 (Explore SOER 2015 online: eea.europa.eu/soer)

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

Tools of UNECE Convention on Long-Range Transboundary Air Pollution (LRTAP)		Parties	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)	44	28.01.1988	21.11.1984 (S) 24.08.1987 (R)
1985	Helsinki Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 per cent	25	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	34	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	24	29.09.1997	19.11.1991 (S) 11.11.1993 (R)
1994	Oslo Protocol on Further Reduction of Sulphur Emissions	29	05.08.1998	14.6.1994 (S) 14.6.1996 (R)
1998	Aarhus Protocol on Heavy Metals	31	29.12.2003	24.6.1998 (S) 1.5.2000 (R)
	Aarhus Protocol on Heavy Metals, as **amended on 13 December 2012**			14.5.2015 (A)
1998	Aarhus Protocol on Persistent Organic Pollutants (POPs)	33	23.10.2003	24.06.1998 (S) 1.5.2000 (R)
	Aarhus Protocol on Persistent Organic Pollutants, **as amended on 18 December 2009**[2]			17.08.2011 (A)
1999	Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone	31	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]	23	07.10.2019	09. 07.2019 (A)

Abbreviation: signed (S), ratified (R), accession (AC), acceptance (A), Footnote: (2) with declaration upon ratification

Source: http://www.unece.org/env/lrtap/status/lrtap_s.html

[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

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 of Sustainable Development and Infrastructures (MDDI).

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 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 2019, 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". However, it should be noted that currently, emissions of POPs and HMs are treated in separate reports which are included in the Appendix.

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

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.
- 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.

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

- 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 525/2013/EC of the European Parliament and of the Council of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change (known as Monitoring Mechanism Regulation (MMR)) and repealing Decision 280/2004/EC of the European Parliament and of the Council of 11 February 2004 concerning a mechanism for monitoring Community GHG emissions and for implementing the Kyoto Protocol and Commission Decision 2005/166/EC of 10 February 2005 laying down rules implementing Decision 280/2004/EC;
- 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

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

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;
- 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 Grand-Ducal Regulation[9] designates a Single National Entity, the National Inventory Compiler and the National GHG Inventory Focal Point. It also defines and allocates specific responsibilities for the realisation of the GHG emission inventory within the Single National Entity and within the other administrations and/or services that are, or will be, involved in the inventory preparation in the future.

The Single National Entity also covers the compilation of the air emission inventory other than GHG emissions, although this is not legally determined in the previously cited regulation. Currently the aforementioned regulation is being revised in order *(i)* to fulfil new UNFCCC, EU-MMR and CLRTAP reporting obligations and *(ii)* to unify the GHG emission inventory and the air pollutant emission inventory in one single system.

[9] Règlement grand-ducal du 1er août 2007 relatif à la mise en place d'un Système d'Inventaire National des émissions de gaz à effet de serre dans le cadre de la Convention-cadre des Nations Unies sur le Changement Climatique, Mémorial A-N° 130 du 7 août 2007, pp. 2318-2320: see http://www.legilux.public.lu/leg/a/archives/2007/1300708/1300708.pdf.

1.2.1.2.1 Single National Entity and other Cross-Cutting Roles

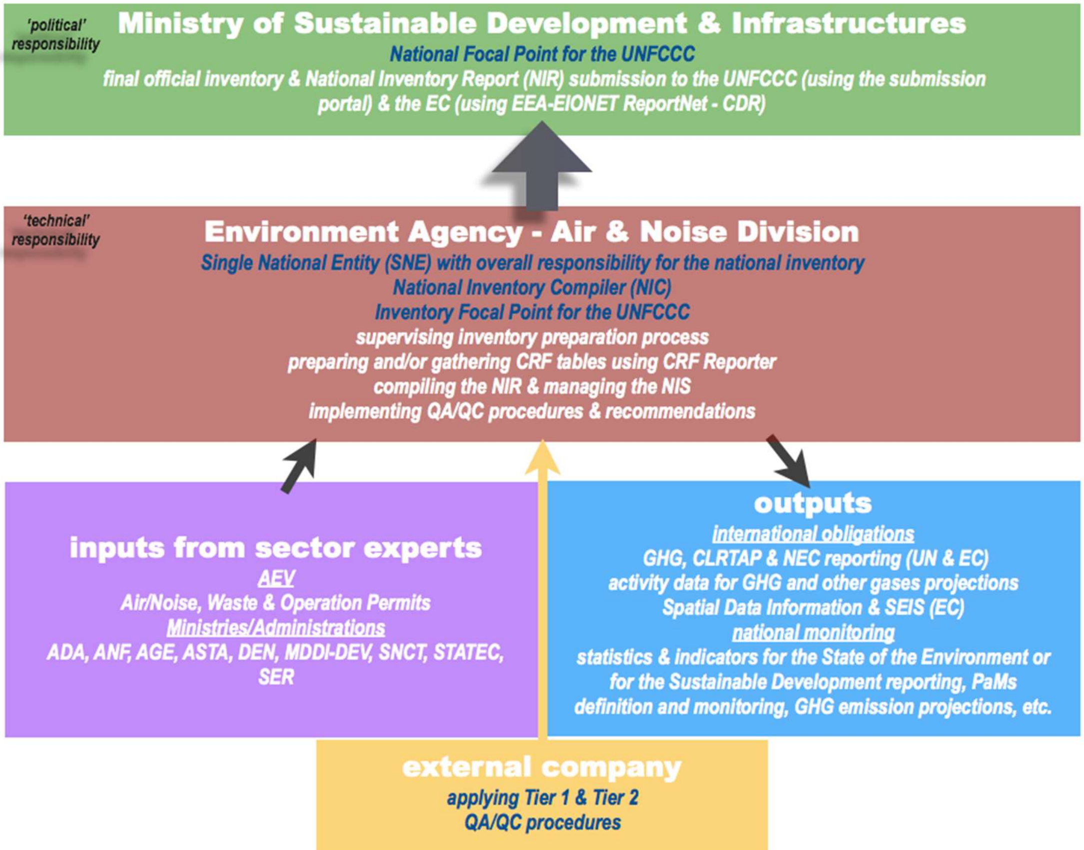
The previously cited regulation designates the Environment Agency (*Administration de l'Environnement, AEV*)[10] as the "Single National Entity with overall responsibility for the air emission inventory". Overall management of the Single National Entity is assigned to one staff member of the Environment Agency that is nominated Air Emission Inventory Focal Point. The Agency also acts as "National Inventory Compiler" compiling and checking the information and air emission estimates coming from sector experts working in other administrations or services.

The Environment Agency has therefore the "technical" knowledge and responsibility for the air emission inventory, but the "political" responsibility is staying with the Department of the Environment of the Ministry of Sustainable Development and Infrastructures – hereafter designated as MDDI-DEV – acting as UNFCCC National Focal Point and UNECE/LRTAP National Focal Point. Thus, it is the Ministry that officially submits the inventories and their related reports, prepared under the respective reporting obligations (UNFCCC, UNECE, and EC).

Figure 1-1 summarizes the organisation of the air emission reporting in Luxembourg in accordance with the national Regulation for the setting-up of a National Inventory System (NIS).

[10] The Environment Agency is directly linked to the Ministry of Sustainable Development and Infrastructures and works under its supervision: see http://www.environnement.public.lu/functions/apropos_du_site/mev/attributions_MEV/index.html and the assignments of the Environment Agency: http://www.environnement.public.lu/functions/apropos_du_site/aev/Missions_aev.html (in French).

Figure 1-1 – Luxembourg's NIS according to the Regulation of 1st August 2007



Luxembourg has, thus, adopted an "integrated approach" to avoid redundant and overlapping activities in different administrative services. This concentration of air emission reporting in one department also allows an improved consistency between different reporting schemes. As an example, indirect GHG and SO_2 emissions that are to be recorded in the GHG inventory are extracted and adapted from the CLRTAP/NEC reporting schemes.

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

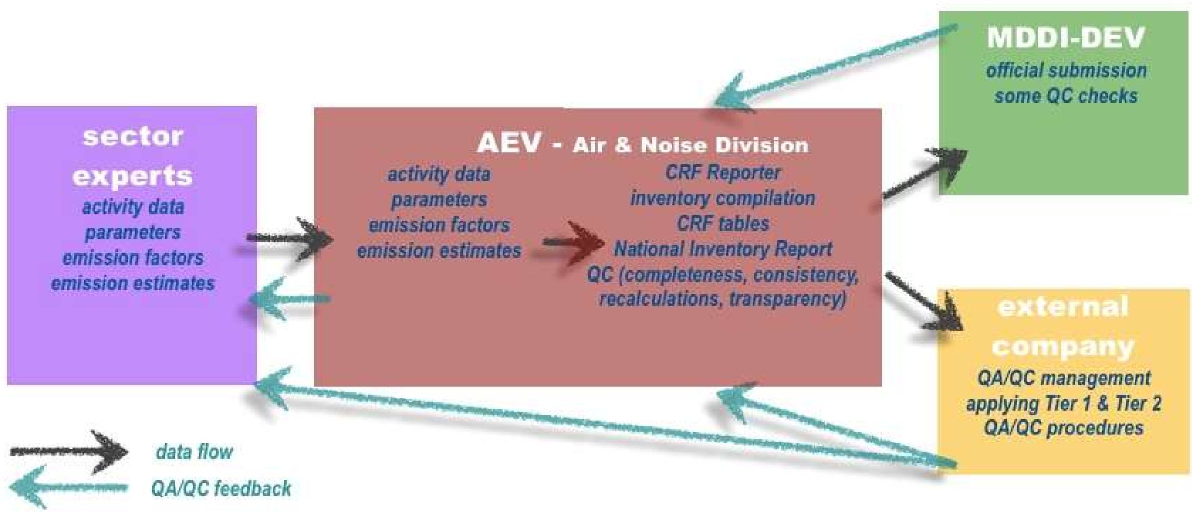
The outputs of the Environmnet Agency, are not only used for the various inventory reporting obligations (UNFCCC, CLRTAP, NECD), but also for other reporting activities, such as those linked to

Spatial Data Information (such as the EC INSPIRE Directive[11]) and under the Shared Environmental Information System.[12] Of course, these are also used for various national publications, as well as, for defining policies and measures (*PaMs*).

Finally, although the national regulation on setting up the NIS indicates that only an agent, belonging from to the Environment Agency should develop, implement and maintain a QA/QC plan, it has been decided that QA/QC activities should be performed by an external company so to guarantee an independent review process.

Figure 1-2 goes over the data flow process that is implied by the setting-up of the NIS. The Environment Agency not only collects and validates AD, EF, parameters and emission estimates from sector experts and compiles the inventories, but also produces emission estimates. This flexibility is introduced in Luxembourg's system to ensure a better quality for the reporting of air pollutant emissions.

Figure 1-2 – Theoretical data flow according to Luxembourg's NIS



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

Article 3 of the Regulation presents the tasks of the Single National Entity. In a few words, the Single National Entity – *i.e.* the Environment Agency – provides sector experts for all the IPCC/NFR Sectors except Agriculture and Wastewater Handling (see Table 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, compiles the air pollutant emissions estimates produced by the respective sector experts;

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

- prepares the IIR (notably on the basis of chapters received from the sector experts), including the Key Source Analysis (*KSA*) 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 pollutant emissions;
- archives the relevant information on the inventories and the NIS;
- implements recommendations from the quality assurance/quality control (*QA/QC*) annual exercise (see Section 0).

Article 4 of the Regulation describes the tasks that are assigned to sector experts:

- Choice of the best methods to evaluate air pollutant emissions, using 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;
- Preparation of the IIR relevant chapters.

Finally, Article 5 of the Regulation indicates that activity/background data providers have to transmit quality AD using formats, and respecting the deadlines, defined by the Single National Entity.

Table 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	ASTA – SER	ASTA – SER	ASTA – 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 Sustainable Development and Infrastructures (MDDI): 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

In order to accommodate the transposition of the NEC Directive into national law, the Grand-Ducal Regulation dated August 1st, 2007 relative to Luxembourg's National Inventory System has been recently revised and modernised. The new regulation, currently under official approval procedure, will accommodate for both the legal requirements under the NECD and under the MMR, as well as the corresponding international conventions. The new institutional arrangements and requirements will be presented in detail in the next informative inventory report in 2018.

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

Table 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

Task	Description	Deadline
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 CIRCALUX	May

Finally, an official approval process has been established between the Single National Entity (SNE, Environment Agency) and the National Focal Point (NFP, MDDI). 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 CIRCALUX data archive (see Section 1.3). The NFP accordingly informs the Minister in charge of Environmental Affairs accordingly. Upon acceptance, the NFP uploads the submission from the CIRCALUX archive onto the UNECE submission portal and onto the European central data repository hosted by the EEA.[13]

1.3 *Inventory Preparation*

1.3.1 Air Emission Inventory

Luxembourg's air pollutant emissions inventory for the period 1990 to 2018 has been prepared in accordance with the revised Guidelines for Reporting Emission Data under the Convention on Long-Range Transboundary Air Pollution (ECE/EB.AIR/97; 30th September 2009[14]).

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 2019.[15] 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

[13] See also Article 8 of the Grand-Ducal Regulation of August 1st, 2007 relative to the implementation of the NIS.
[14] http://www.ceip.at/fileadmin/inhalte/emep/reporting_2009/Rep_Guidelines_ECE_EB_AIR_97_e.pdf
[15] EEA Report N0 13/2019 available at: https://www.eea.europa.eu/publications/emep-eea-guidebook-2019

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 4).

Table 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
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*) [16] 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 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);

[16] 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).

- 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 Chapter 0).

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 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

NFR Sector	*Activity Data and Relevant Parameters*
	• 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 • Expert Judgement
Waste – NFR 5	• National Statistics • Plant Specific Data

For each sub-category (1 A 1 – 1 A 5) the methods applied and emission factors (EF) used as well as coverage of energy consumption for 2015 is provided in the relevant chapter.

EMEP/EEA Tier 3 approach

- For large point sources, emission measurements of NO_X, SO_2, NMVOC, CO and TSP 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 subcategory chapters.

Table 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	47.5%	$PM_{2.5}$	T3	PS	47.5%
	T2	D	52.5%		T2	D	52.5%
NMVOC	T3	PS	28.2%	PM_{10}	T3	PS	47.5%
	T2	D	71.8%		T2	D	52.5%
SO_X	T3	PS	29.9%	TSP	T3	PS	47.5%
	T2	CS	0.2%		T2	D	52.5%
	T1	D	70.0%				
CO	T3	PS	47.5%				
	T2	D	52.5%				

Table 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	97.1%	T3	PS	0.0%	T3	PS	80.7%	T3	PS	0.0%
	T2/T1	D	2.9%	T1	D	100.0%	T1	D	19.3%	T1	D	100.0%
NMVOC	T3	PS	97.1%	T3	PS	0.0%	T3	PS	0.0%	T3	PS	0.0%
	T2/T1	D	2.9%	T1	D	100.0%	T1	D	100.0%	T1	D	100.0%
SO_X	T3	PS	97.1%	T3	PS	0.0%	T3	PS	53.7%	T3	PS	0.0%
	T2	CS	0.9%	T2	CS	0.0%	T2	CS	1.6%	T2	CS	2.0%
	T1	D	2.0%	T1	D	100.0%	T1	D	44.7%	T1	D	98.0%
CO	T3	PS	97.1%	T3	PS	0.0%	T3	PS	80.7%	T3	PS	0.0%
	T2/T1	D	2.9%	T1	D	100.0%	T1	D	19.3%	T1	D	100.0%
$PM_{2.5}$	T3	PS	97.1%	T3	PS	0.0%	T3	PS	34.4%	T3	PS	0.0%
	T2/T1	D	2.9%	T1	D	100.0%	T1	D	65.6%	T2	D	100.0%
PM_{10}	T3	PS	97.1%	T3	PS	0.0%	T3	PS	34.4%	T3	PS	0.0%
	T2/T1	D	2.9%	T1	D	100.0%	T1	D	65.6%	T1	D	100.0%
TSP	T3	PS	97.1%	T3	PS	0.0%	T3	PS	34.4%	T3	PS	0.0%
	T2/T1	D	2.9%	T1	D	100.0%	T1	D	65.6%	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	34.7%	T3	PS	98.0%	T3	CS	100.0%	T3	PS	27.4%
	T1	D	65.3%	T1	D	2.0%	T1	D	0.0%	T2/T1	D	72.6%
NMVOC	T3	PS	0.0%	T3	PS	49.1%	T3	CS	100.0%	T3	PS	27.4%
	T1	D	100.0%	T1	D	50.9%	T1	D	0.0%	T2/T1	D	72.6%
SO_X	T3	PS	34.7%	T3	PS	98.0%	T3	CS	100.0%	T3	PS	11.2%
	T2	CS	29.9%	T2	CS	1.7%	T2	NO	NO	T2	CS	15.8%
	T1	D	35.5%	T1	D	0.3%	T1	D	0.0%	T1	D	73.0%
CO	T3	PS	34.7%	T3	PS	98.0%	T3	CS	100.0%	T3	PS	27.4%
	T1	D	65.3%	T1	D	2.0%	T1	D	0.0%	T2/T1	D	72.6%
$PM_{2.5}$	T3	PS	34.7%	T3	PS	98.0%	T3	CS	100.0%	T3	PS	16.2%
	T1	D	65.3%	T1	D	2.0%	T1	D	0.0%	T2/T1	D	83.8%
PM_{10}	T3	PS	34.7%	T3	PS	98.0%	T3	CS	100.0%	T3	PS	16.2%
	T1	D	65.3%	T1	D	2.0%	T1	D	0.0%	T2/T1	D	83.8%
TSP	T3	PS	34.7%	T3	PS	98.0%	T3	CS	100.0%	T3	PS	16.2%
	T1	D	65.3%	T1	D	2.0%	T1	D	0.0%	T2/T1	D	83.8%

Table 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 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: Stationary			1 A 4 c ii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery		
	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	49.1%	T2	CS	35.1%	T3	CS	100.0%	T2	CS	0.0%	T3	CS	100.0%
	T2	D	50.9%	T2	D	64.9%	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 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 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 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 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 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)	T1	D	T1	D				
3 D a 2 a	Animal manure applied to soils	T1	D	T1	D				
3 D a 2 b	Sewage sludge applied to soils	T1	D	T1	D				
3 D a 2 c	Other organic fertilisers applied to soils	T1	D	T1	D				
3 D a 3	Urine and dung deposited by grazing animals	T1	D	T1	D				
3 D a 4	Crop residues applied to soils								
3 D b	Indirect emissions from managed soils								
3 D c	Farm-level agricultural operations including storage, handling and transport of agricultural products								
3 D d	Off-farm storage, handling and transport of								
3 D e	Cultivated crops					T1	D	T1	D
3 D f	Use of pesticides								

Table 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						
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 (2016). 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}, $PM_{2.5}$.

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 same level of aggregation for all pollutants was used.

1 A Combustion Activities

"1 A Combustion Activities" is the most important sector for emissions reported to UNECE. To account for this fact and help prioritising efforts, this sector was analysed in greater detail.

Furthermore, for mobile sources the different means of transport were considered separately, and additionally the sub-category Road Transport was further disaggregated as it is an important source for many pollutants.

A split following the third level of the NFR was used (1 A 2, 1 A 4) for stationary sources.

1 B Fugitive Emissions

A split following the third level of the NFR 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 sub category 4 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 – Fuel sold & Fuel used**

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:

- Fuel sold - Ranking per number
- SO_2, NO_X, NH_3, NMVOC, CO, TSP, PM_{10}, $PM_{2.5}$ - Fuel sold - for the year 2016
- Fuel used - Ranking per number
- SO_2, NO_X, NH_3, NMVOC, CO, TSP, PM_{10}, $PM_{2.5}$ - Fuel used - for the year 2016

Table 16 – Key Category Analysis - Fuel sold - Ranking per number – for the year 2018

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				7							8		6		5	
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	2	1		1					2	1		1		1		1
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	1	2	3	8											7	
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction			5	5												
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	3															
1 A 3 a i (i)	Civil Aviation - Domestic - LTO			7	6												
1 A 3 b i	Road Transport, Passenger cars			1	3	7	1		2	1	3						
1 A 3 b ii	Road Transport, Light duty vehicles			4	4												
1 A 3 b iii	Road Transport, Heavy duty vehicles			2	2				6	4	4			7		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	3	2	3
1 A 3 b vii	Road Transport, Automobile road abrasion											3	4	4		3	
1 A 4 b i	Residential: stationary			6		6				3	2	1	2	1	2	1	2
1 A 4 b ii	Residential: Household and gardening (mobile)									5							
1 B 2 b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)					8											
2 A 5 b	Construction and demolition											6					
2 D 3 a	Domestic solvent use including fungicides					1	2										
2 D 3 b	Road paving with asphalt											4	5	8			
2 D 3 d	Coating application					5											
2 D 3 e	Degreasing					4	6										
2 D 3 g	Chemical products					9											
3 B 1 a	Manure management - Dairy cattle					2	4	3	4								
3 B 1 b	Manure management - Non-dairy cattle					3	5	2									
3 B 3	Manure management - Swine								5								
3 D a 1	Inorganic N-fertilizers (includes also urea application)							4	1								
3 D a 2 a	Animal manure applied to soils							1	3								
3 D a 3	Urine and dung deposited by grazing animals								7								
3 D c	Farm-level agricultural operations including storage, handling and transport of agricultural products											5		3	4		
5 E	Other waste (please specify in IIR)											7		5		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 17 – Key Categories for SO_2 - Fuel sold - for the year 2018

Level Assessment

NFR Category Code	NFR Category	Pollutant	Latest Year (2018) Estimate [kt]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	SO2	0.58	60.0%	60.0%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	SO2	0.14	14.3%	74.3%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	SO2	0.10	10.9%	85.2%

Trend Assessment

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2018) 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	12.15	0.14	10.283	44.0%	44.0%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	SO2	0.75	0.58	9.042	38.7%	82.6%

Table 18 – Key Categories for NO_X - Fuel sold - for the year 2018

Level Assessment

NFR Category Code	NFR Category	Pollutant	Latest Year (2018) 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	7.29	35.6%	35.6%
1 A 3 b iii	Road Transport, Heavy duty vehicles	NOX	4.93	24.1%	59.7%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	NOX	1.23	6.0%	65.7%
1 A 3 b ii	Road Transport, Light duty vehicles	NOX	0.89	4.3%	70.0%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	NOX	0.85	4.1%	74.2%
1 A 4 b i	Residential: stationary	NOX	0.72	3.5%	77.7%
1 A 3 a i (i)	Civil Aviation - Domestic - LTO	NOX	0.64	3.1%	80.8%

Trend Assessment

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2018) 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	NOX	7.01	0.62	0.281	24.6%	24.6%
1 A 3 b iii	Road Transport, Heavy duty vehicles	NOX	14.25	4.93	0.211	18.4%	43.1%
1 A 3 b i	Road Transport, Passenger cars	NOX	10.95	7.29	0.184	16.1%	59.1%
1 A 3 b ii	Road Transport, Light duty vehicles	NOX	0.30	0.89	0.073	6.4%	65.5%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	NOX	0.54	0.85	0.057	5.0%	70.5%
1 A 3 a i (i)	Civil Aviation - Domestic - LTO	NOX	0.14	0.64	0.056	4.9%	75.4%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	NOX	0.03	0.53	0.050	4.4%	79.8%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	NOX	3.37	1.23	0.044	3.8%	83.6%

Table 19 – Key Categories for NH_3 - Fuel sold - for the year 2018

Level Assessment

NFR Category Code	NFR Category	Pollutant	Latest Year (2018) 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	2.05	34.8%	34.8%
3 B 1 b	Manure management - Non-dairy cattle	NH3	1.21	20.5%	55.3%
3 B 1 a	Manure management - Dairy cattle	NH3	0.99	16.8%	72.1%
3 D a 1	Inorganic N-fertilizers (includes also urea application)	NH3	0.65	11.1%	83.1%

Trend Assessment

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2018) 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	0.94	0.65	0.035	21.4%	21.4%
1 A 3 b i	Road Transport, Passenger cars	NH3	0.01	0.14	0.025	15.3%	36.6%
3 D a 2 a	Animal manure applied to soils	NH3	2.46	2.05	0.025	15.1%	51.7%
3 B 1 a	Manure management - Dairy cattle	NH3	1.26	0.99	0.024	14.7%	66.4%
3 B 3	Manure management - Swine	NH3	0.19	0.24	0.014	8.4%	74.8%
1 A 3 b iii	Road Transport, Heavy duty vehicles	NH3	0.00	0.04	0.008	4.8%	79.6%
3 D a 3	Urine and dung deposited by grazing animals	NH3	0.28	0.29	0.008	4.8%	84.4%

Table 20 – Key Categories for NMVOC - Fuel sold - for the year 2018

Level Assessment

NFR Category Code	NFR Category	Pollutant	Latest Year (2018) 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	2.13	20.5%	20.5%
3 B 1 a	Manure management - Dairy cattle	NMVOC	1.58	15.2%	35.7%
3 B 1 b	Manure management - Non-dairy cattle	NMVOC	1.50	14.5%	50.2%
2 D 3 e	Degreasing	NMVOC	0.90	8.7%	58.9%
2 D 3 d	Coating application	NMVOC	0.80	7.7%	66.6%
1 A 4 b i	Residential: stationary	NMVOC	0.51	4.9%	71.5%
1 A 3 b i	Road Transport, Passenger cars	NMVOC	0.48	4.6%	76.1%
1 B 2 b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)	NMVOC	0.35	3.4%	79.5%
2 D 3 g	Chemical products	NMVOC	0.25	2.4%	81.9%

Trend Assessment

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2018) 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	0.48	1.039	33.9%	33.9%
2 D 3 a	Domestic solvent use including fungicides	NMVOC	1.04	2.13	0.446	14.5%	48.4%
1 A 3 b v	Road Transport, Gasoline evaporation	NMVOC	4.01	0.08	0.365	11.9%	60.3%
3 B 1 a	Manure management - Dairy cattle	NMVOC	1.48	1.58	0.262	8.5%	68.9%
3 B 1 b	Manure management - Non-dairy cattle	NMVOC	1.60	1.50	0.231	7.5%	76.4%
2 D 3 e	Degreasing	NMVOC	0.83	0.90	0.151	4.9%	81.3%

Table 21 – Key Categories for CO - Fuel sold - for the year 2018

Level Assessment

NFR Category Code	NFR Category	Pollutant	Latest Year (2018) 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	6.12	29.8%	29.8%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	CO	3.86	18.8%	48.6%
1 A 4 b i	Residential: stationary	CO	3.58	17.4%	66.0%
1 A 3 b iii	Road Transport, Heavy duty vehicles	CO	2.18	10.6%	76.6%
1 A 4 b ii	Residential: Household and gardening (mobile)	CO	1.04	5.0%	81.6%

Trend Assessment

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2018) 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	3.86	12.576	47.9%	47.9%
1 A 4 b i	Residential: stationary	CO	3.99	3.58	3.776	14.4%	62.3%
1 A 3 b i	Road Transport, Passenger cars	CO	80.21	6.12	2.895	11.0%	73.3%
1 A 3 b iii	Road Transport, Heavy duty vehicles	CO	2.42	2.18	2.300	8.8%	82.1%

Table 22 – Key Categories for TSP - Fuel sold - for the year 2018

Level Assessment

NFR Category Code	NFR Category	Pollutant	Latest Year (2018) Estimate [kt]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
1 A 4 b i	Residential: stationary	TSP	0.67	24.1%	24.1%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	TSP	0.38	13.6%	37.7%
1 A 3 b vii	Road Transport, Automobile road abrasion	TSP	0.37	13.2%	50.9%
2 D 3 b	Road paving with asphalt	TSP	0.26	9.4%	60.3%
3 D c	Farm-level agricultural operations including storage, handling and transport of agricultural products	TSP	0.21	7.4%	67.7%
2 A 5 b	Construction and demolition	TSP	0.19	6.9%	74.5%
5 E	Other waste (please specify in IIR)	TSP	0.08	3.0%	77.6%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	TSP	0.08	2.9%	80.5%

Trend Assessment

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2018) 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	4.912	48.4%	48.4%
1 A 4 b i	Residential: stationary	TSP	0.63	0.67	1.278	12.6%	61.0%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	TSP	0.14	0.38	0.803	7.9%	68.9%
1 A 3 b vii	Road Transport, Automobile road abrasion	TSP	0.12	0.37	0.777	7.7%	76.5%
2 D 3 b	Road paving with asphalt	TSP	0.24	0.26	0.502	4.9%	81.5%

Table 23 – Key Categories for PM_{10} - Fuel sold - for the year 2018

Level Assessment

NFR Category Code	NFR Category	Pollutant	Latest Year (2018) Estimate [kt]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
1 A 4 b i	Residential: stationary	PM10	0.64	32.1%	32.1%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	PM10	0.28	14.0%	46.1%
3 D c	Farm-level agricultural operations including storage, handling and transport of agricultural products	PM10	0.21	10.3%	56.5%
1 A 3 b vii	Road Transport, Automobile road abrasion	PM10	0.18	9.2%	65.7%
5 E	Other waste (please specify in IIR)	PM10	0.08	4.2%	70.0%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	PM10	0.08	3.9%	73.9%
1 A 3 b iii	Road Transport, Heavy duty vehicles	PM10	0.07	3.3%	77.1%
2 D 3 b	Road paving with asphalt	PM10	0.06	3.0%	80.2%

Trend Assessment

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2018) 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	PM10	13.77	0.02	6.868	49.5%	49.5%
1 A 4 b i	Residential: stationary	PM10	0.59	0.64	2.394	17.3%	66.7%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	PM10	0.10	0.28	1.125	8.1%	74.8%
3 D c	Farm-level agricultural operations including storage, handling and transport of agricultural products	PM10	0.20	0.21	0.768	5.5%	80.4%

Table 24 – Key Categories for $PM_{2.5}$ - Fuel sold - for the year 2018

Level Assessment

NFR Category Code	NFR Category	Pollutant	Latest Year (2018) 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	0.62	43.9%	43.9%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	PM2.5	0.16	11.0%	54.9%
1 A 3 b vii	Road Transport, Automobile road abrasion	PM2.5	0.10	7.0%	61.9%
5 E	Other waste (please specify in IIR)	PM2.5	0.08	6.0%	67.9%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	PM2.5	0.08	5.3%	73.2%
1 A 3 b iii	Road Transport, Heavy duty vehicles	PM2.5	0.07	4.6%	77.8%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	PM2.5	0.04	2.8%	80.5%

Trend Assessment

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2018) 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	9.602	49.9%	49.9%
1 A 4 b i	Residential: stationary	PM2.5	0.57	0.62	4.614	24.0%	73.9%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	PM2.5	0.06	0.16	1.217	6.3%	80.2%

Table 25 – Key Category Analysis - Fuel used - Ranking per number – for the year 2018

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			10	7					3	
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	2	1	8	1						1
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals									6	
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	1	2	2	4					4	
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction			4	6						
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	3								5	
1 A 3 a i (i)	Civil Aviation - Domestic - LTO			7	5						
1 A 3 b i	Road Transport, Passenger cars			1	2		1		5		
1 A 3 b ii	Road Transport, Light duty vehicles			3	3						
1 A 3 b iii	Road Transport, Heavy duty vehicles			5	8						
1 A 3 b v	Road Transport, Gasoline evaporation						3				
1 A 4 a i	Commercial/Institutional: Stationary			9							
1 A 4 b i	Residential: stationary			6		6	7			1	2
1 B 2 b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)					7	8				
2 D 3 a	Domestic solvent use including fungicides					1	2				
2 D 3 d	Coating application					5					
2 D 3 e	Degreasing					4	6				
2 D 3 g	Chemical products					8					
3 B 1 a	Manure management - Dairy cattle					2	4	3	2		
3 B 1 b	Manure management - Non-dairy cattle					3	5	2	7	7	
3 B 3	Manure management - Swine								4		
3 D a 1	Inorganic N-fertilizers (includes also urea application)							4	1		
3 D a 2 a	Animal manure applied to soils							1	3		
3 D a 3	Urine and dung deposited by grazing animals								6		
5 E	Other waste (please specify in IIR)									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)

Table 26 – Key Categories for SO_2 - Fuel used - for the year 2018

Level Assessment (fuel used)

NFR Category Code	NFR Category	Pollutant	Latest Year (2018) Estimate [kt]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	SO2_Fused	0.58	61.6%	61.6%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	SO2_Fused	0.14	14.7%	76.3%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	SO2_Fused	0.10	11.2%	87.5%

Trend Assessment (fuel used)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2018) 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_Fused	12.15	0.14	10.627	45.4%	45.4%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	SO2_Fused	0.75	0.58	9.030	38.6%	84.0%

Table 27 – Key Categories for NO_X - Fuel used - for the year 2018

Level Assessment (fuel used)

NFR Category Code	NFR Category	Pollutant	Latest Year (2018) 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_Fused	3.71	29.1%	29.1%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	NOx_Fused	1.23	9.6%	38.8%
1 A 3 b ii	Road Transport, Light duty vehicles	NOx_Fused	0.89	6.9%	45.7%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	NOx_Fused	0.85	6.7%	52.4%
1 A 3 b iii	Road Transport, Heavy duty vehicles	NOx_Fused	0.78	6.2%	58.5%
1 A 4 b i	Residential: stationary	NOx_Fused	0.72	5.6%	64.1%
1 A 3 a i (i)	Civil Aviation - Domestic - LTO	NOx_Fused	0.64	5.0%	69.2%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	NOx_Fused	0.62	4.9%	74.1%
1 A 4 a i	Commercial/Institutional: Stationary	NOx_Fused	0.59	4.6%	78.7%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	NOx_Fused	0.53	4.1%	82.8%

Trend Assessment (fuel used)							
NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2018) 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	NOx_Fused	7.01	0.62	0.462	34.0%	34.0%
1 A 3 b i	Road Transport, Passenger cars	NOx_Fused	4.72	3.71	0.157	11.6%	45.6%
1 A 3 b ii	Road Transport, Light duty vehicles	NOx_Fused	0.30	0.89	0.102	7.5%	53.1%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	NOx_Fused	3.37	1.23	0.090	6.6%	59.7%
1 A 3 a i (i)	Civil Aviation - Domestic - LTO	NOx_Fused	0.14	0.64	0.080	5.9%	65.6%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	NOx_Fused	0.54	0.85	0.078	5.7%	71.3%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	NOx_Fused	0.03	0.53	0.072	5.3%	76.7%
1 A 3 b iii	Road Transport, Heavy duty vehicles	NOx_Fused	2.26	0.78	0.066	4.8%	81.5%

Table 28 – Key Categories for NMVOC - Fuel used - for the year 2018

Level Assessment (fuel used)					
NFR Category Code	NFR Category	Pollutant	Latest Year (2018) 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_Fused	2.13	21.4%	21.4%
3 B 1 a	Manure management - Dairy cattle	NMVOC_Fused	1.58	15.9%	37.3%
3 B 1 b	Manure management - Non-dairy cattle	NMVOC_Fused	1.50	15.1%	52.4%
2 D 3 e	Degreasing	NMVOC_Fused	0.90	9.1%	61.5%
2 D 3 d	Coating application	NMVOC_Fused	0.80	8.1%	69.5%
1 A 4 b i	Residential: stationary	NMVOC_Fused	0.51	5.1%	74.6%
1 B 2 b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)	NMVOC_Fused	0.35	3.5%	78.2%
2 D 3 g	Chemical products	NMVOC_Fused	0.25	2.5%	80.6%

Trend Assessment (fuel used)							
NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2018) 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_Fused	5.37	0.18	0.507	29.4%	29.4%
2 D 3 a	Domestic solvent use including fungicides	NMVOC_Fused	1.04	2.13	0.291	16.9%	46.2%
1 A 3 b v	Road Transport, Gasoline evaporation	NMVOC_Fused	1.83	0.03	0.178	10.3%	56.6%
3 B 1 a	Manure management - Dairy cattle	NMVOC_Fused	1.48	1.58	0.144	8.4%	64.9%
3 B 1 b	Manure management - Non-dairy cattle	NMVOC_Fused	1.60	1.50	0.118	6.8%	71.7%
2 D 3 e	Degreasing	NMVOC_Fused	0.83	0.90	0.083	4.8%	76.6%
1 A 4 b i	Residential: stationary	NMVOC_Fused	0.50	0.51	0.044	2.6%	79.1%
1 B 2 b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)	NMVOC_Fused	0.22	0.35	0.043	2.5%	81.6%

Table 29 – Key Categories for NH_3 - Fuel used - for the year 2018

Level Assessment (fuel used)

NFR Category Code	NFR Category	Pollutant	Latest Year (2018) 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_Fused	2.05	35.5%	35.5%
3 B 1 b	Manure management - Non-dairy cattle	NH3_Fused	1.21	21.0%	56.5%
3 B 1 a	Manure management - Dairy cattle	NH3_Fused	0.99	17.2%	73.7%
3 D a 1	Inorganic N-fertilizers (includes also urea application)	NH3_Fused	0.65	11.3%	85.0%

Trend Assessment (fuel used)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2018) 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_Fused	0.94	0.65	0.034	24.1%	24.1%
3 B 1 a	Manure management - Dairy cattle	NH3_Fused	1.26	0.99	0.021	15.0%	39.1%
3 D a 2 a	Animal manure applied to soils	NH3_Fused	2.46	2.05	0.017	12.4%	51.6%
3 B 3	Manure management - Swine	NH3_Fused	0.19	0.24	0.015	10.9%	62.5%
1 A 3 b i	Road Transport, Passenger cars	NH3_Fused	0.01	0.06	0.010	7.3%	69.8%
3 D a 3	Urine and dung deposited by grazing animals	NH3_Fused	0.28	0.29	0.009	6.6%	76.4%
3 B 1 b	Manure management - Non-dairy cattle	NH3_Fused	1.35	1.21	0.007	4.9%	81.4%

Table 30 – Key Categories for $PM_{2.5}$ - Fuel used - for the year 2018

Level Assessment

NFR Category Code	NFR Category	Pollutant	Latest Year (2018) 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_Fused	0.62	55.8%	55.8%
5 E	Other waste (please specify in IIR)	PM2.5_Fused	0.08	7.6%	63.4%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	PM2.5_Fused	0.08	6.8%	70.1%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	PM2.5_Fused	0.04	3.5%	73.6%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	PM2.5_Fused	0.03	2.6%	76.2%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	PM2.5_Fused	0.03	2.4%	78.6%
3 B 1 b	Manure management - Non-dairy cattle	PM2.5_Fused	0.02	2.0%	80.6%

Trend Assessment

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2018) 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_Fused	13.77	0.02	12.164	50.0%	50.0%
1 A 4 b i	Residential: stationary	PM2.5_Fused	0.57	0.62	7.244	29.8%	79.7%
5 E	Other waste (please specify in IIR)	PM2.5_Fused	0.03	0.08	1.021	4.2%	83.9%

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).

Being designated by a Grand-Ducal Regulation[17] as the single national entity (SNE), the AEV, has the overall technical responsibility for the National Air Emission Inventory. Political responsibility lies within the Ministry of Sustainable Development and Infrastructures (MDDI). Within the AEV, the Air & Noise Division 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 (MDDI).

The national, European and international obligations are:

- UNECE Convention on Long Range Transboundary Air Pollution and its protocols
- UNFCCC & Kyoto Protocol;
- European Union:
    - EU GHG Monitoring Mechanism (525/2013/EC)
    - NEC Directive (2001/81/EC);
    - 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 the focus on the fulfilment of the Kyoto Protocol and the requirements of the IPCC GPG Chapter 8 QA/QC as well as the EMEP/EEA Emission Inventory Guidebook 2013 Chapter 6 Inventory Management, Improvement and QA/QC;

17 Grand-Ducal Regulation (règlement grand-ducal du 1 août 2007)

- to ensure that appropriate processes are implemented to enable requirements of the IPCC GPG Chapter 8 QA/QC and the EMEP/EEA Emission Inventory Guidebook 2013 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[18].

Luxembourg's QMS follows a Plan-Do-Check-Act-Cycle (PDCA-cycle)[19], 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 1-4);
- 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.

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

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

1.6.3 QMS Structure

Luxembourg's Quality Management System (QMS) of the Air Emission Inventory is organised in three layers (Figure 1-3):

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.

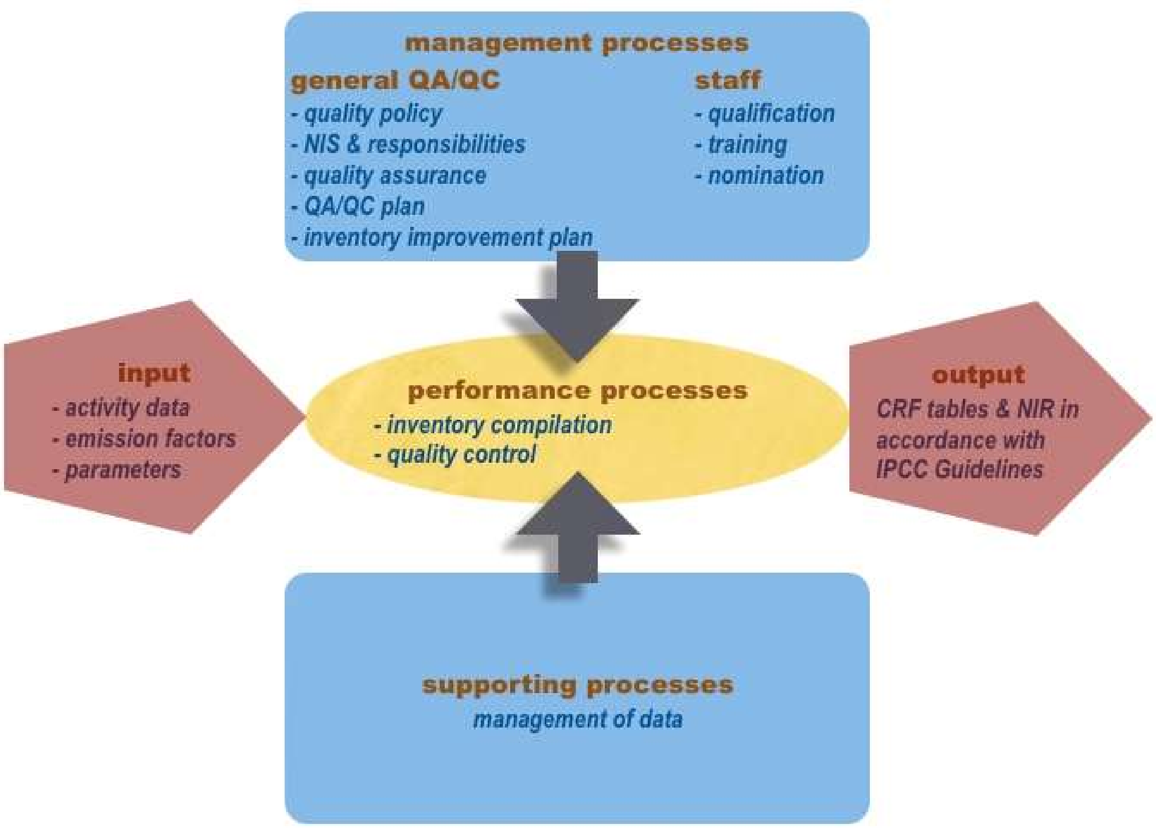
b) Management processes

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.

Figure 1-3 – 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 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 1-4 – QA/QC Procedures

does NOT require knowledge of the emission source category	requires knowledge of the emission source category
general	source specific
QC procedures sector experts (1st party) performed throughout preparation of inventory	
TIER 1	**TIER 2**
data validation, calculation sheet (check of formal aspects)	preparation of NIR, comparison with Guidelines (check of applicability, comparisons)
QA procedures quality manager (2nd or 3rd party; staff not directly involved, preferably independent) performed after inventory work has finished	
TIER 1 basic, before submission	
	Internal audit / EU 'Initial check' **(Expert Peer Review)**
	evaluate if TIER2 QC is effectively performed (check if methodologies are applicable)
TIER 2 extensive	
System audit by Umweltbundesamt (Audit)	**ICR by UNFCCC (Expert Peer Review)**
evaluate if TIER 2 QC is effectively performed	evaluate if TIER 2 QC is effectively performed (Check if methodologies are applicable)

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 server "CIRCALUX" within the folder "*Inventaires gaz à effet de serre*"[20]. 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, including Data on the Overall Uncertainty for the Inventory Totals*

No uncertainty estimates have been made.

Uncertainty on activity data can be consulted in Luxembourg's latest National Inventory Report (NIR).

1.8 *General Assessment of Completeness*

1.8.1 Air Emission Inventory

The emission data presented in this report were compiled according to the Revised 2014 Guidelines for Reporting Emissions and Projections Data under the Convention on Long-Range Transboundary (ECE/EB.AIR.125) (see Chapter 1.8.1.4).

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[20] https://circalux.etat.lu/Members/irc/public/invges/home (only for members)

1.8.1.1 **Sources**

Notation keys are used according to the Revised 2014 Guidelines for Reporting Emissions and Projections Data under the Convention on Long-Range Transboundary ((ECE/EB.AIR.125) (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 2016 (and older versions). 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 1990–2018 for the four main pollutants, CO as well as PM. For POPs and HMs, please consider the separate specific reports included in the Appendix.

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 Revised 2014 Guidelines for Reporting Emissions and Projections Data under the Convention on Long-Range Transboundary (ECE/EB.AIR.125), 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[21].

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.

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

IE (included elsewhere)

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 disaggregated 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 2-1). It is therefore a crossroad for international trade and related transport flows, the most dynamic source of its GHG emissions.

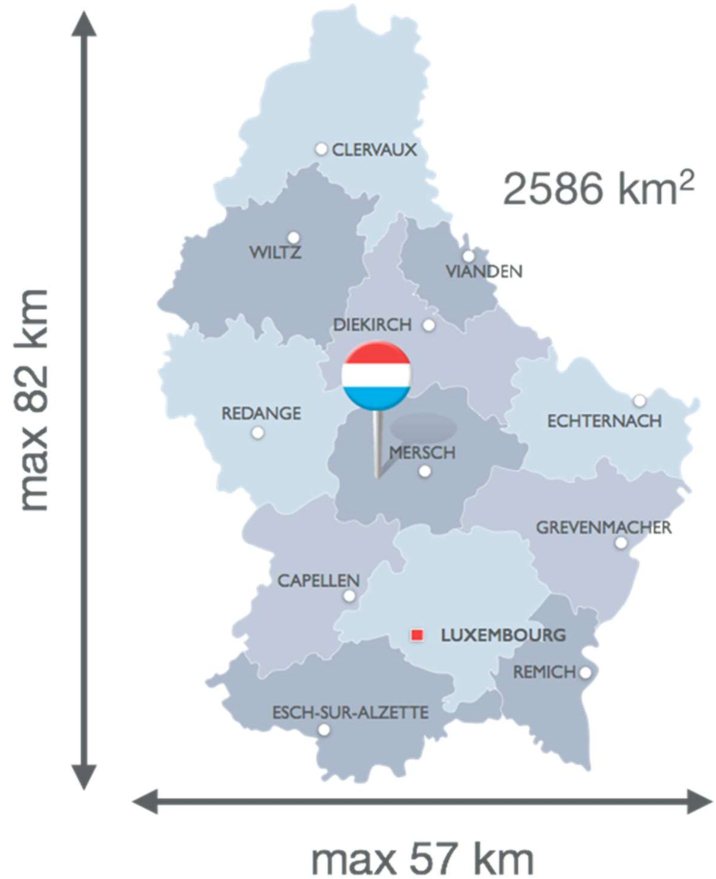
Luxembourg has a territory of 2 586 km². The maximum distance from North to South is some 82 km, from West to East about 57 km (Figure 2-2). In 2017, 85.1% of the total area of Luxembourg was agricultural land and land under forest – with around 51% for agriculture and 35% for forests. The built-up areas occupied 9.8% of the total surface and land covered by water and transport infrastructure about 4.5% (Table 2-1 & Figure 2-3).

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 2-1 – GEOGRAPHIC LOCATION OF LUXEMBOURG

Source: Google Maps.

Figure 2-2 – LUXEMBOURG SIZE



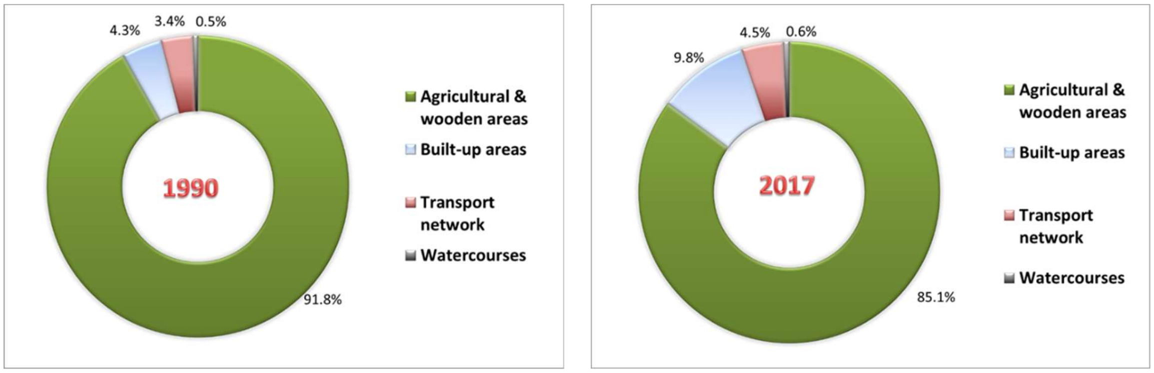
Source: Google Maps.

Table 31 – Land use in Luxembourg: 1972-2017

percentages	1972	1990	2000	2010	2015	2017
Total land	100.0	100.0	100.0	100.0	100.0	100.0
Agricultural & wooden area	93.2	91.8	87.4	85.7	85.3	85.1
Built-up area	3.1	4.3	8.1	9.3	9.7	9.8
of which industrial area & other	*n.a.*	*n.a.*	*2.7*	*3.0*	*3.0*	*3.1*
Transport network & sheets of water	3.2	3.4	3.9	4.4	4.4	4.5
Watercourses	0.5	0.5	0.6	0.6	0.6	0.6

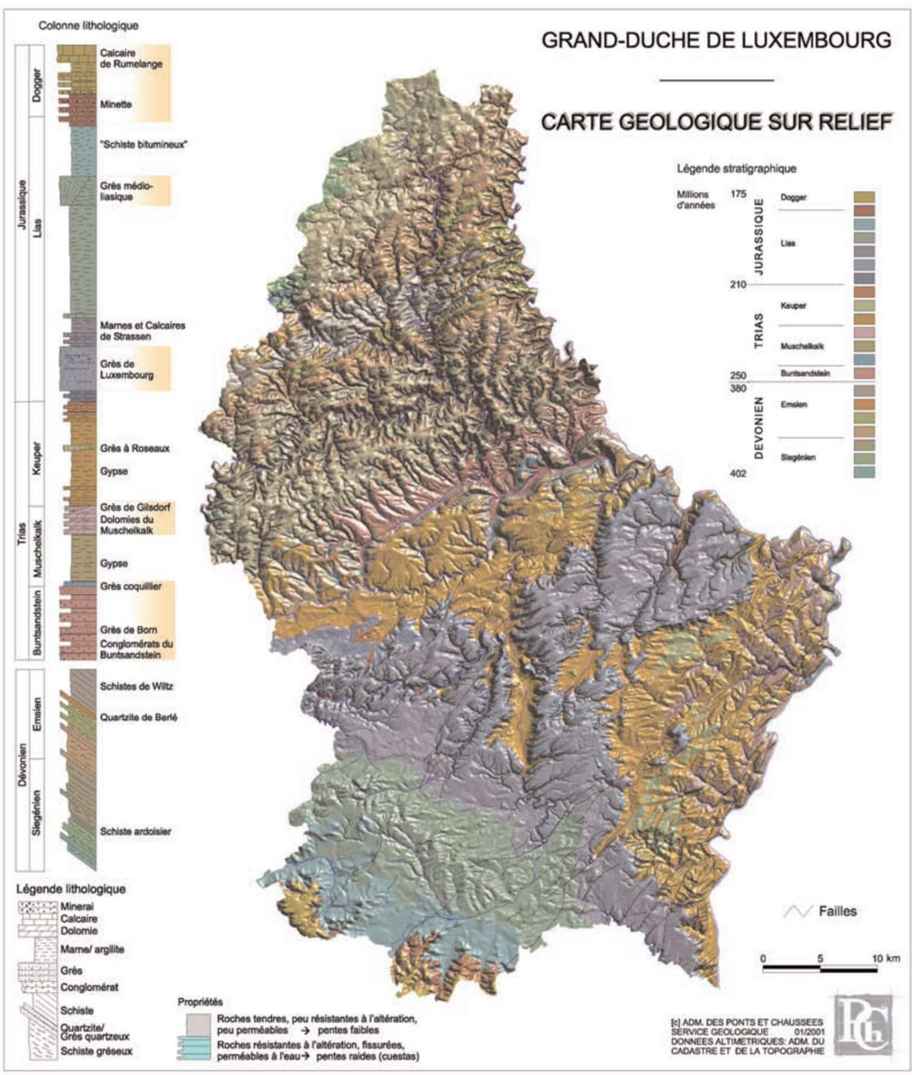
Source: STATEC, Statistical Yearbook, Table A.1101 (updated 3 April 2019): http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12695&IF_Language=fra&MainTheme=1&FldrName=1

Figure 2-3 – Land use: 1990 & 2017



Source: STATEC, Statistical Yearbook, Table A.1101 (updated 3 April 2019): http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12695&IF_Language=fra&MainTheme=1&FldrName=1

Figure 2-4 – 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 end of 2017, the **population of Luxembourg** was estimated to 602 005 inhabitants. Since 1960, the residential population has grown by some 287 100 inhabitants or about 91.2% – or 56.6% since 1990 (Table 2-4). 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 (1.59%) was about 4 times higher than its equivalent for the *Grande Région*.[22] It even reached 1.7% p. a. since 2000 (Figure 2-13).

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 2017, 51.4% of the residential population did not have the citizenship of Luxembourg. This percentage was only around 30% in 1990, as depicted in Figure 2-12. 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 2010 forecast, under the "baseline" scenario, that almost 750 000 inhabitants could be living in Luxembourg by 2050 (Figure 2-13).[23] 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 32 – Population: 1960-2017

calculated on 31st December	1960	1990	1995	2000	2005	2010	2015	2016	2017
Resident population (x 1000)	314.9	384.4	411.6	439.0	469.1	511.8	576.2	590.7	602.0

Source: STATEC, Statistical Yearbook, Table B.1100 (updated 3 April 2019): http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12856&IF_Language=fra&MainTheme=2&FldrName=1

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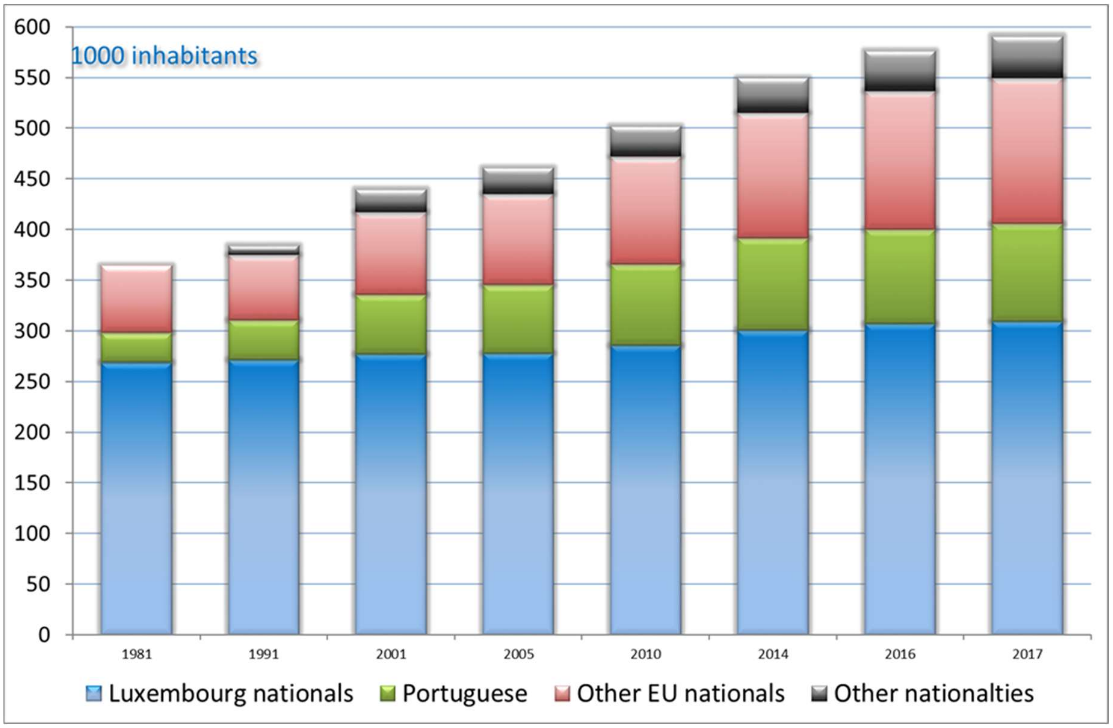
22 Refer to Box 2-1 for a presentation of the *Grande Région*.

23 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.

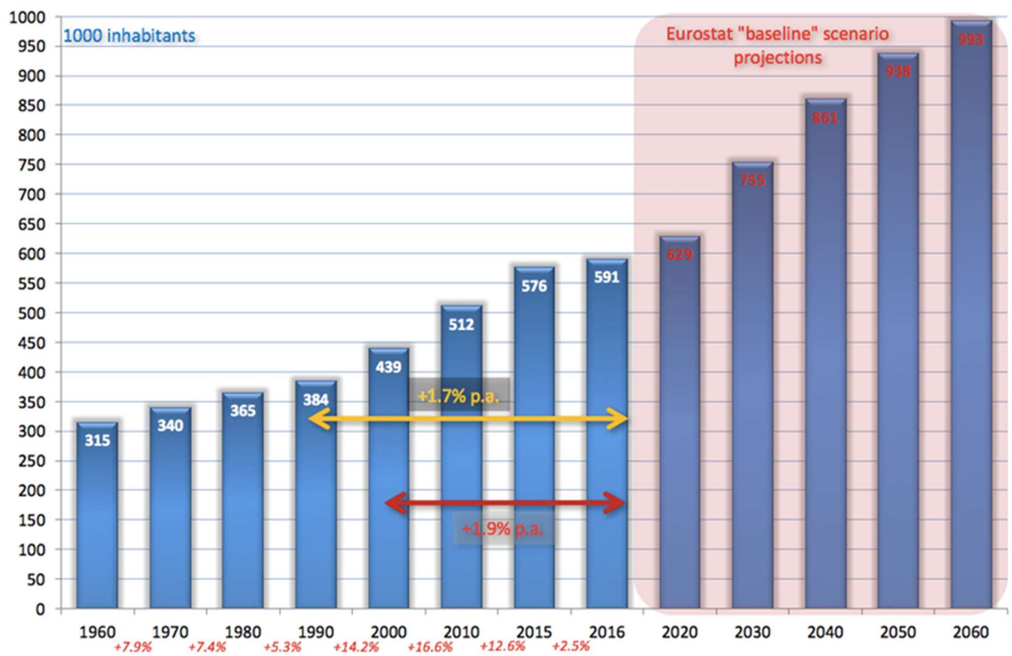
Figure 2-5 – Population structure on 31st December: 1981-2017



Source: STATEC, *Statistical Yearbook*, Table B.1101 ((updated 3 April 2019): http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12856&IF_Language=fra&MainTheme=2&FldrName=1.

Note: 1981, 1991, 2001 and 2011 data are coming from population censuses held every decade, other years are calculated by STATEC.

Figure 2-6 – Population growth on 31st December: 1960-2060



Sources: STATEC, *Statistical Yearbook*, Table B.1101 (updated 05.05.2017):
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12856&IF_Language=fra&MainTheme=2&FldrName=1.
Eurostat, *Population projections*, Table proj_15npms (updated 19.06.2017):
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=proj_15npms&lang=en.

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) % 1990-2015	Population annual average growth rate (1st January) % 1990-2015	GDP at current price annual average growth rate % 1990-2015	Total employment in 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. The number of Luxembourg nationals employed increased from some 103 700 units in 1995 to 140 770 in 2016, representing an average annual growth rate of only 1.5%. 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 54 900 in 1995 to 100 430 in 2016 – an average annual growth rate of 2.9%. But, this was not enough. So the **cross-border commuters** came into play. Between 1995 and 2017, the number of cross-border workers increased from 56 900 to 184 600, at an average annual growth rate of 4.3% (Table 2-5).[24]

For 2017, among the commuters employed in Luxembourg, 51.2% came from France, 24.4% from Germany and 24.3% from Belgium. In total, the commuters accounted for 42% of the total workforce in Luxembourg and for 30% of the residential population (Figure 2-14).[25] The commuting flows amongst the various regions of the *Grande Région* clearly show the economic attraction of Luxembourg (Figure 2-15).

[24] Figures indicated in this paragraph are annual cumulative averages.

[25] Calculated from STATEC, Statistical Yearbook, Table B.3107: http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12919&IF_Language=fra&MainTheme=2&FldrName=3&RFPath=92

A vast majority of workers from abroad commute by car.[26] 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.

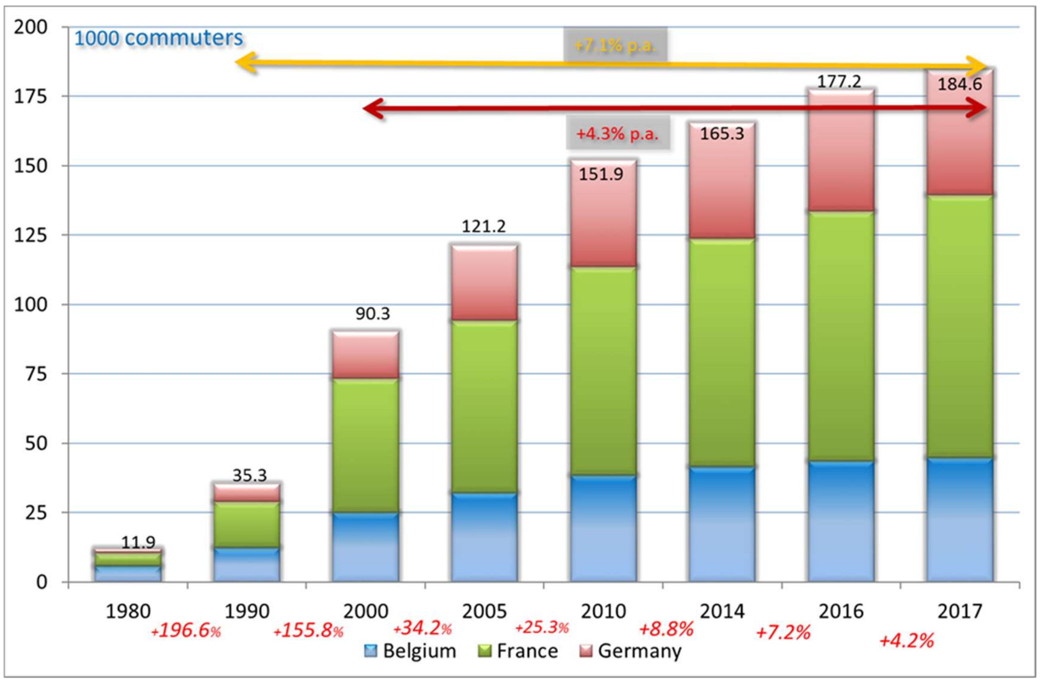
Table 33 – Persons employed: 1995-2016

in thousand persons	1995	2000	2005	2010	2015	2016
Resident workers – Lux. nationals (B.3106 & E.2309)	103.7	106.3	108.5	118.0	134.5	**140.8**
Resident workers – foreigners (B.3106 & B.3107)	54.9	67.2	77.9	89.7	100.5	**100.4**
Cross-border workers (B.3107)	56.9	90.3	121.2	151.9	171.1	**177.2**
Total workers/employment (B.3100)	**215.5**	**264.0**	**307.6**	**359.6**	**406.1**	**418.4**

Sources: MDDI-DEV calculations on the basis of STATEC, *Statistical Yearbook*, Tables B.3100 (updated 10.05.2017), B.3107 (updated 06.12.2017) & E.2309 (version 10.2017):
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12951&IF_Language=fra&MainTheme=2&FldrName=3&RFPath=92
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12928&IF_Language=fra&MainTheme=2&FldrName=3&RFPath=92
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=13161&IF_Language=fra&MainTheme=5&FldrName=2&RFPath=21

Notes: (1) due to revisions in the calculation of the various measures of employment, it is not possible to go back further than 1995. (2) this table presents the total employment, i.e. paid workers and self-employed workers. Figures are annual cumulative averages.

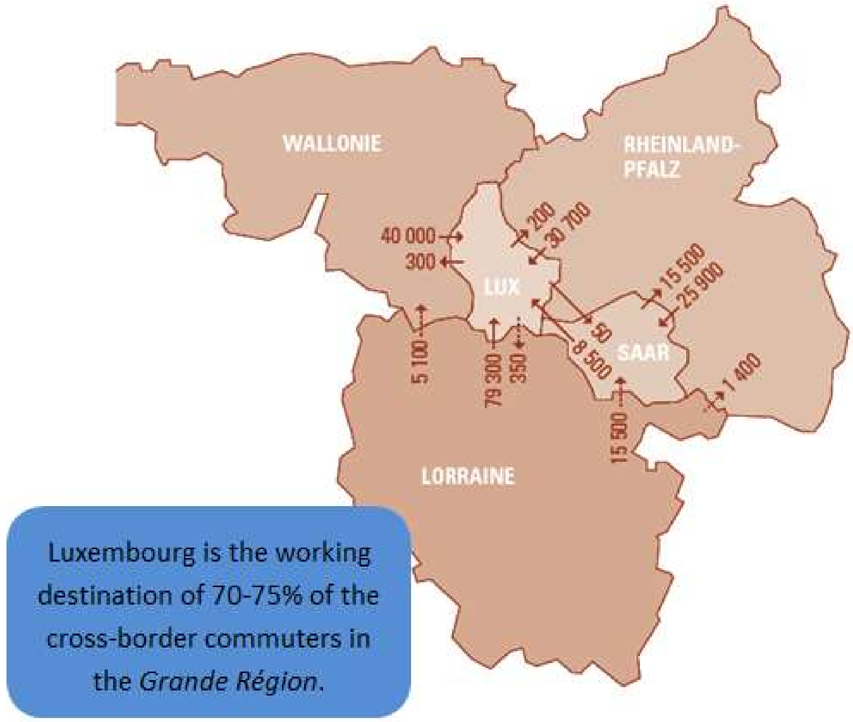
Figure 2-7 – Cross-border commuters' growth: annual cumulative averages 1980-2017



Source: STATEC, Statistical Yearbook, Table B.3107 (updated 04.04.2019):
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12919&IF_Language=fra&MainTheme=2&FldrName=3&RFPath=92

[26] 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 2-8 – 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 39% in 1995 to 48% in 2017.[27] 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 7% in 2017. Other service activities ranged between a share of 20 to 25% and construction kept a rather constant share in total gross value added between 5 and 6%. The contribution of the agricultural sector is negligible with less than 1% (Table 2-6 & Figure 2-16).

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.

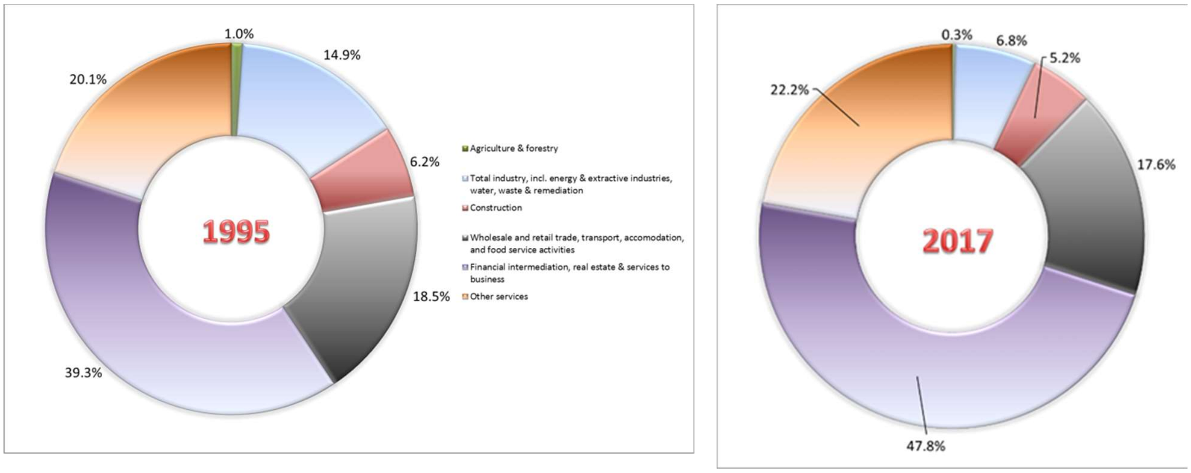
Table 34 – Sectoral gross value added at current prices: 1995-2017

mio. EUR		1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Agriculture, forestry & fishing (A)		144	144	107	115	152	119	94	99	109	159	129	145	119	119	147
	%	1.0%	0.7%	0.4%	0.4%	0.5%	0.3%	0.3%	0.3%	0.3%	0.4%	0.3%	0.3%	0.3%	0.2%	0.3%
Total industry, including extractive industries, energy production & distribution, water supply, sewerage, waste		2131	2594	2886	2948	3585	3185	2346	2661	2706	2673	2942	2729	3236	3624	3433
management and remediation activities (B to E)	%	14.9%	12.6%	10.8%	9.7%	10.8%	9.3%	7.1%	7.4%	7.0%	6.8%	7.1%	6.1%	6.9%	7.5%	6.8%
Construction (F)		892	1240	1527	1663	1943	1915	1914	1931	2124	2034	2129	2511	2550	2643	2612
	%	6.2%	6.0%	5.7%	5.5%	5.8%	5.6%	5.8%	5.3%	5.5%	5.2%	5.1%	5.7%	5.5%	5.5%	5.2%
Wholesale and retail trade, transport, accomodation		2636	3599	4257	4738	4910	5835	5374	6145	7262	7017	7699	8111	7522	8150	8832
and food service activities (G to I)	%	18.5%	17.5%	16.0%	15.6%	14.8%	17.1%	16.2%	17.0%	18.7%	17.8%	18.5%	18.3%	16.1%	16.9%	17.6%
Financial and insurance activities; real estate activities; professional, scientific and technical activities;		5603	8658	11745	14238	15514	15606	15346	16738	17436	17783	18614	20366	22140	22888	23984
administrative and support service activities (K to N)	%	39.3%	42.0%	44.0%	46.9%	46.6%	45.6%	46.3%	46.3%	45.0%	45.1%	44.8%	45.9%	47.5%	47.4%	47.8%
Other services: information and communication; public administration, defence, education, human health and social work activities; arts, entertainment and recreation;		2865	4385	6147	6637	7171	7542	8061	8563	9103	9721	10015	10533	11079	10859	11148
Oher service activities; activities of household (J & O to U)	%	20.1%	21.3%	23.0%	21.9%	21.6%	22.1%	24.3%	23.7%	23.5%	24.7%	24.1%	23.7%	23.8%	22.5%	22.2%
Total: all NACE rev2 branches		**14270**	**20619**	**26668**	**30339**	**33276**	**34203**	**33135**	**36137**	**38739**	**39386**	**41527**	**44396**	**46645**	**48284**	**50155**
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%

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

Source: STATEC, *Statistical Yearbook*, Tables E.2304 (current prices) & E.2305 (constant prices) (updated 4 April 2019): http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=13158&IF_Language=fra&MainTheme=5&FldrName=2&RFPath=21

Figure 2-9 – Sectoral gross value added at current prices: 1995 & 2017



Source: STATEC, *Statistical Yearbook*, Table E.2304 (updated 4 April 2019): http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=13157&IF_Language=fra&MainTheme=5&FldrName=2&RFPath=21

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 22.8% between 1990 and 2017. Whereas solid fuels and coal declined by 96% over the period, liquid fuels (incl. kerosene) and natural gas consumptions increased by 74% and 62% respectively (Table 2-7 & Figure 2-17).

Table 35 – Primary energy consumption: 1990-2017

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	2.02	6.47	9.85	13.60	17.53	21.62	28.95
	NA	0.00%	0.00%	0.00%	0.01%	0.01%	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**	**163912.04**	**172563.50**	**181074.05**	**201423.74**	**205077.57**	**202985.71**	**199007.74**

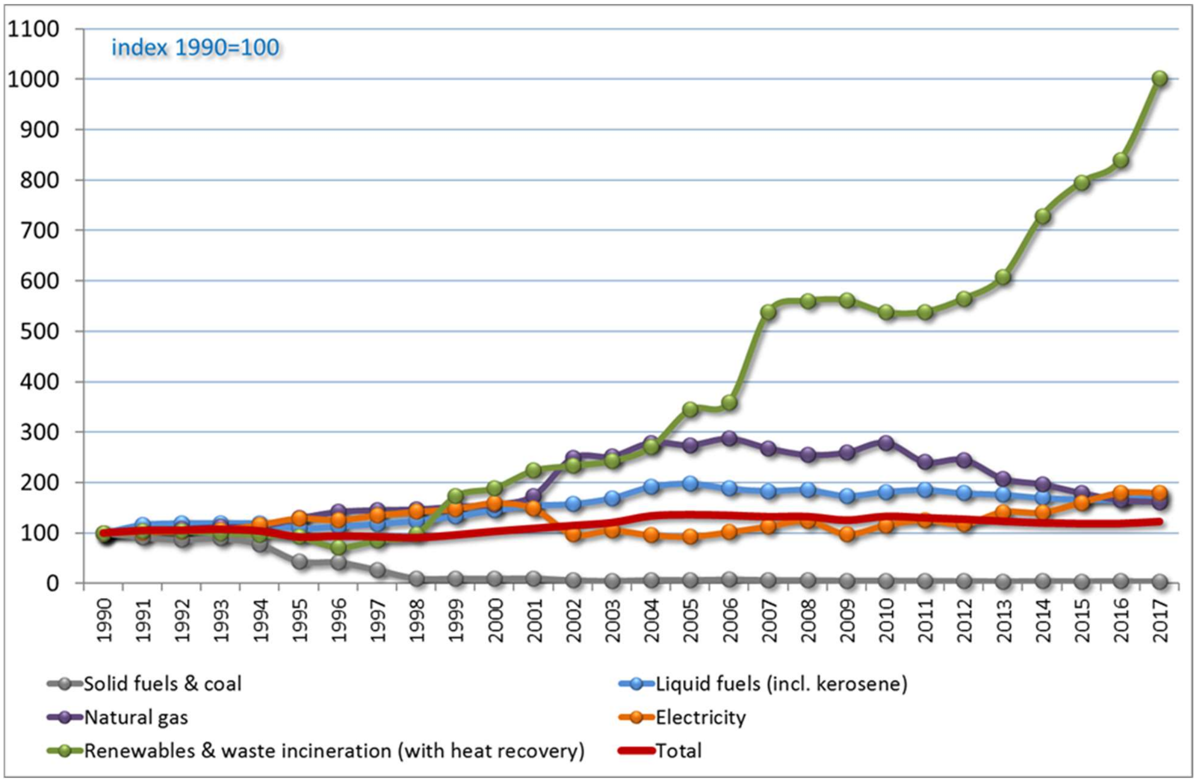
TJ	2008	2009	2010	2011	2012	2013	2014	2015	2016
Solid fuels & coal	3136.57	2801.27	2806.63	2443.45	2249.59	2005.86	2235.46	2057.27	2193.19
	1.57%	1.48%	1.40%	1.25%	1.17%	1.08%	1.24%	1.15%	1.23%
Liquid fuels (incl. kerosene)	122653.44	114781.92	120101.37	122553.58	118269.72	116297.53	112052.94	110128.94	109970.55
	61.51%	60.83%	60.05%	62.57%	61.77%	62.69%	62.07%	61.75%	61.55%
Natural gas (1)	50856.70	51751.75	55665.22	48021.10	48894.89	41398.28	39223.62	35770.96	32988.07
	25.50%	27.42%	27.83%	24.52%	25.54%	22.32%	21.73%	20.06%	18.46%
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%	10.13%	10.32%	11.91%	13.33%
Heat	41.42	62.14	84.70	106.64	133.07	160.91	182.47	208.17	231.67
	0.02%	0.03%	0.04%	0.05%	0.07%	0.09%	0.10%	0.12%	0.13%
Renewable energy sources & waste	6310.98	6320.76	6052.85	6067.60	6363.53	6846.43	8208.17	8956.12	9453.53
Incineration (with heat recovery) (2)	3.16%	3.35%	3.03%	3.10%	3.32%	3.69%	4.55%	5.02%	5.29%
Total	**199411.78**	**188705.27**	**200001.16**	**195869.37**	**191478.51**	**185500.90**	**180536.93**	**178359.85**	**178658.51**

TJ	2017
Solid fuels & coal	1897.95
	1.03%
Liquid fuels (incl. kerosene)	115043.66
	62.35%
Natural gas (1)	32244.57
	17.48%
Electricity	23785.11
	12.89%
Heat	257.20
	0.14%
Renewable energy sources & waste	11274.36
Incineration (with heat recovery) (2)	6.11%
Total	**184502.85**

Source: STATEC, *Statistical Yearbook*, Table A.4200 (updated 4 April 2019): http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12759&IF_Language=fra&MainTheme=1&FldrName=4&RFPath=54

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 (||).

Figure 2-10 –Primary energy consumption: 1990-2017



Source: STATEC, *Statistical Yearbook*, Table A.4200 (updated 4 April 2019): http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12759&IF_Language=fra&MainTheme=1&FldrName=4&RFPath=54

Final energy consumption increased by 23.6% between 1990 and 2017. 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 2-8 & Figure 2-18).

Over the period 1990-2017, 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 2017, 81.2% of the **final energy consumption** was covered by fossil fuels – 64.0% by liquid fuels including the important volume of road fuels as well as kerosene,[28] 16.1% by natural gas and 1.1% by coal. The remaining 18.8% of the consumption were either electricity (12.9%) and heat (1.6%) or renewable energy sources, including organic waste incineration with energy recovery, biogas, and biofuels (4.3%). Going back to 1990, 23.8% of the final energy consumption was stemming from solid fuels and coal, 46% from liquid fuels, 13.5% from natural gas and 10.4% from electricity (Table 2-8 & Figure 2-18). What happened?

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[28] 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.

- Regarding **solid fuels and coal**, the important decline (-94.5%) 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 (+72.0%) 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 48.0% 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 2017 – and even first if "road fuel sales to non-residents" and kerosene are not considered.

Table 36 – Final energy consumption: 1990-2017

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	**144043**	**151194**	**151495**	**154576**	**151033**	**134632**	**138070**	**136435**	**135560**

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	94644.90	100723.34	103120.21	110821.65	125715.23	130171.42	123605.43	120541.81
	61.67%	*63.27%*	*64.29%*	*65.18%*	*65.83%*	*67.37%*	*68.35%*	*65.86%*	*65.21%*
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%*	*13.43%*	*13.44%*	*13.22%*	*12.33%*	*11.63%*	*12.68%*	*13.04%*
Heat (2)	986.41	503.93	624.35	1086.98	2818.44	3036.13	3055.77	3210.55	2581.94
	0.69%	*0.34%*	*0.40%*	*0.69%*	*1.67%*	*1.63%*	*1.60%*	*1.71%*	*1.40%*
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**	**149589**	**156659**	**158216**	**168342**	**186616**	**190453**	**187684**	**184843**

TJ	2008	2009	2010	2011	2012	2013	2014	2015	2016
Solid fuels & coal	3136.57	2801.27	2806.63	2443.45	2249.59	2005.86	2235.46	2057.27	2193.19
	1.68%	*1.61%*	*1.52%*	*1.34%*	*1.27%*	*1.14%*	*1.31%*	*1.21%*	*1.27%*
Liquid fuels (incl. kerosene)	121613.03	113535.87	118859.54	121270.87	116787.74	114974.13	110826.74	108956.97	108684.56
	65.13%	*65.36%*	*64.46%*	*66.45%*	*65.80%*	*65.54%*	*65.08%*	*64.12%*	*63.11%*
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%*	*15.84%*	*15.58%*	*16.35%*	*16.97%*
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%*	*12.87%*	*12.79%*	*12.65%*	*12.72%*	*13.07%*	*13.19%*	*13.31%*
Heat (2)	2922.39	2483.81	3036.59	3102.44	3045.38	3230.12	2511.90	2355.44	2432.74
	1.56%	*1.43%*	*1.65%*	*1.70%*	*1.72%*	*1.84%*	*1.47%*	*1.39%*	*1.41%*
Renewable energy sources & waste	4697.03	4219.33	4540.66	4414.70	4700.15	5103.19	5938.32	6360.30	6742.58
Incineration (with heat recovery) (3)	*2.52%*	*2.43%*	*2.46%*	*2.42%*	*2.65%*	*2.91%*	*3.49%*	*3.74%*	*3.92%*
Total	**186735**	**173704**	**184390**	**182491**	**177495**	**175419**	**170305**	**169928**	**172202**

TJ	2017
Solid fuels & coal	1897.95
	1.07%
Liquid fuels (incl. kerosene)	113902.29
	63.95%
Natural gas (1)	28760.25
	16.15%
Blast furnaces gas	NO
	NA
Electricity	23015.53
	12.92%
Heat (2)	2782.06
	1.56%
Renewable energy sources & waste	7744.14
Incineration (with heat recovery) (3)	*4.35%*
Total	**178102**

Source: STATEC, *Statistical Yearbook*, Table A.4300.

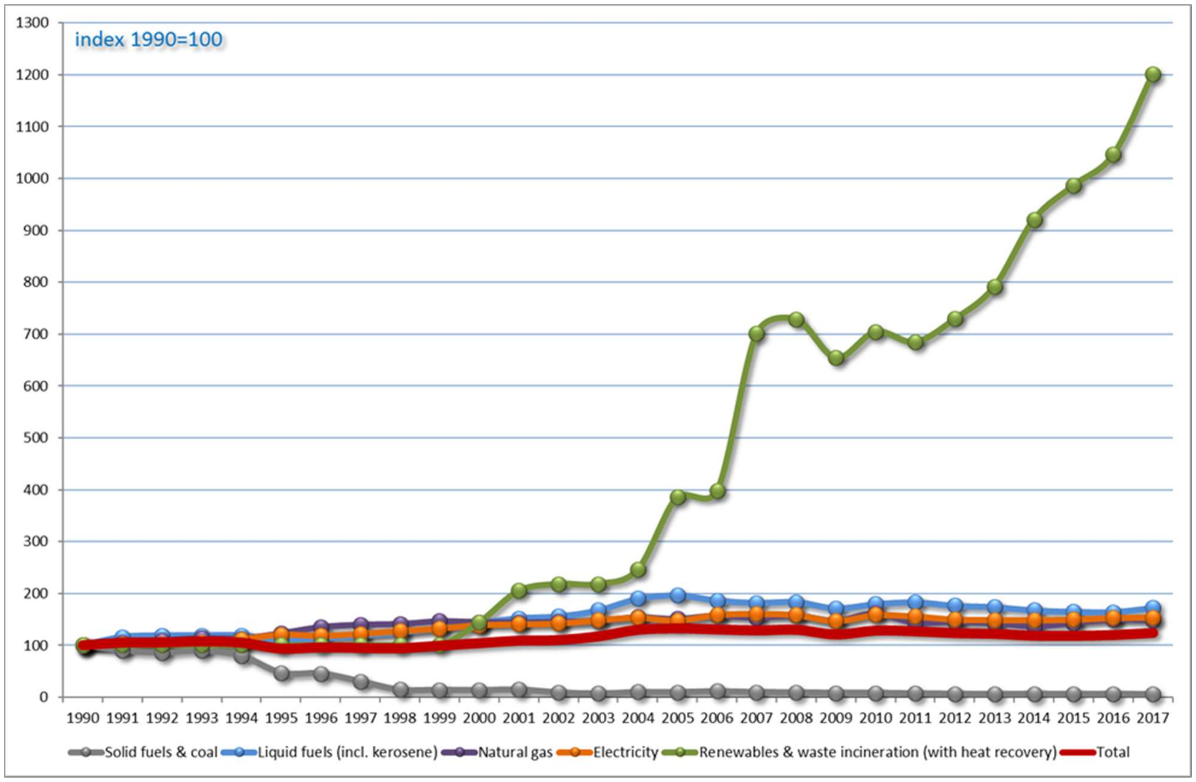
Notes:

(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 the break in the time-series.

(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.

Figure 2-11 – Final energy consumption: 1990-2017



Source: STATEC, *Statistical Yearbook*, Table A.4300 (updated 4 April 2019): http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12771&IF_Language=fra&MainTheme=1&FldrName=4&RFPath=51

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 (||);
(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 (||).

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.[29] 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%).[30] If almost all of these cogeneration

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29 Then Arcelor and now, ArcelorMittal.

30 http://www.twinerg.lu/en_index.html, "Environment" tab and http://www.ilr.public.lu/gaz/documents/statistiques/rapport2011.pdf, p. 29.

plants run on natural gas, gas oil remains the emergency fuel in case of a natural gas supply disruption.

The impact of TWINerg on the primary energy consumption mix is clearly visible in Table 37 and its associated Figure 2-12 : 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 37& Figure 2-12).

Table 37 – Energy balance for electric power: 1990-2017

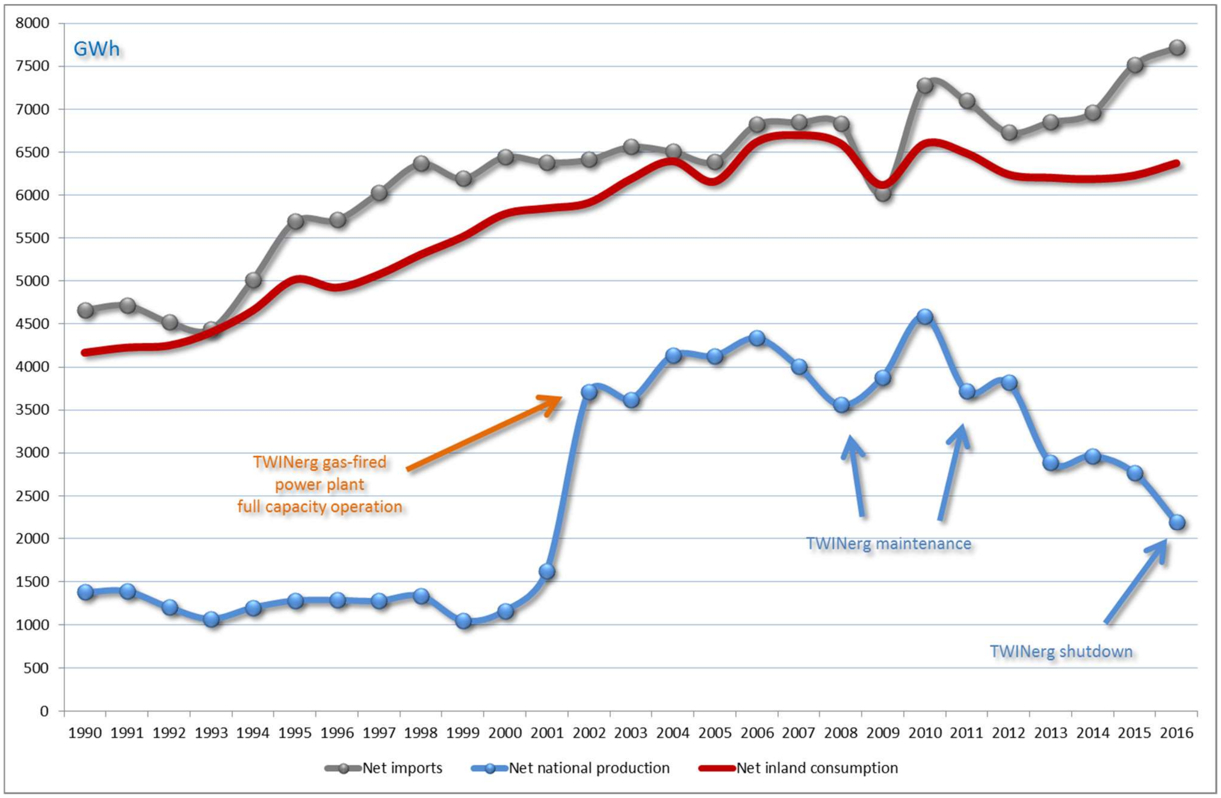
GWh	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Imports	**4665.46**	**4718.45**	**4523.56**	**4440.97**	**5015.24**	**5693.47**	**5712.33**	**6026.52**	**6366.60**	**6193.53**	**6445.38**	**6383.25**	**6413.64**
National production	**1322.04**	**1327.54**	**1144.30**	**1019.29**	**1150.11**	**1236.06**	**1251.78**	**1243.99**	**1311.39**	**1022.59**	**1148.34**	**1591.96**	**3687.51**
cogeneration	NO	NO	NO	NO	33.00	102.00	114.00	118.00	195.00	205.00	219.38	269.00	351.99
thermic power stations	558.72	622.11	594.14	607.83	538.96	448.53	420.24	331.96	299.76	256.62	270.88	726.25	2685.30
of which, TWINerg (2)	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
hydro-electricity	804.24	751.85	593.24	454.16	648.62	821.85	858.42	932.62	1022.16	765.80	872.99	857.97	977.93
wind	NO	NO	NO	NO	NO	NO	NO	3.00	11.00	17.00	25.00	24.00	24.00
biomass & biogas	554.00	617.00	590.00	604.00	491.00	399.00	380.00	320.00	240.00	257.00	271.00	725.00	2685.00
gas from WWTPs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
gas from landfill sites	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
photovoltaic	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total	**5987.50**	**6045.99**	**5667.85**	**5460.26**	**6165.36**	**6929.53**	**6964.11**	**7270.50**	**7678.00**	**7216.12**	**7593.72**	**7975.21**	**10101.15**
Exports	**0.75**	**0.72**	**0.54**	**0.39**	**0.57**	**0.74**	**0.81**	**0.85**	**0.92**	**0.65**	**0.74**	**1.07**	**2.94**
Conversion uses and losses	**389.32**	**395.43**	**334.28**	**318.06**	**364.83**	**434.15**	**431.95**	**418.98**	**428.05**	**340.97**	**359.49**	**414.82**	**450.53**
Net inland consumption	**4149.00**	**4211.00**	**4231.00**	**4385.00**	**4644.00**	**4996.00**	**4907.00**	**5057.00**	**5292.00**	**5495.00**	**5775.00**	**5843.00**	**5904.00**
Total	**4539.08**	**4601.04**	**4620.87**	**4774.72**	**5033.89**	**5386.07**	**5297.13**	**5447.17**	**5682.25**	**5884.98**	**6165.06**	**6233.39**	**6296.26**

Summary in GWh	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Net imports	**4665.46**	**4718.45**	**4523.56**	**4440.97**	**5015.24**	**5693.47**	**5712.33**	**6026.52**	**6366.60**	**6193.53**	**6445.38**	**6383.25**	**6413.64**
Net national production (1)	**1322.04**	**1327.54**	**1144.30**	**1019.29**	**1150.11**	**1236.06**	**1251.78**	**1243.99**	**1311.39**	**1022.59**	**1148.34**	**1591.96**	**3687.51**
Net inland consumption	**4149.00**	**4211.00**	**4231.00**	**4385.00**	**4644.00**	**4996.00**	**4907.00**	**5057.00**	**5292.00**	**5495.00**	**5775.00**	**5843.00**	**5904.00**
Net inland consumption in Mio. MJ (3)	14936.40	15159.60	15231.60	15786.00	16718.40	17985.60	17665.20	18205.20	19051.20	19782.00	20790.00	21034.80	21254.40
Net inland consumption in 1000 toe	356.75	362.08	363.80	377.04	399.31	429.58	421.93	434.82	455.03	472.48	496.56	502.41	507.65

GWh	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Imports	**6562.18**	**6506.31**	**6391.61**	**6823.54**	**6846.58**	**6829.87**	**6022.47**	**7279.51**	**7096.34**	**6732.10**	**6851.52**	**6961.18**	**7518.76**	**7718.39**
National production	**3597.10**	**4102.05**	**4104.41**	**4301.32**	**3959.54**	**3516.43**	**3835.95**	**4560.28**	**3693.17**	**3786.31**	**2859.81**	**2937.81**	**2938.81**	**2939.81**
cogeneration	397.41	441.91	445.15	470.69	398.98	422.18	390.45	439.66	447.05	437.88	417.32	381.36	349.89	355.05
thermic power stations	2682.89	3229.29	3181.75	3337.18	2997.85	2511.43	2961.88	3047.06	2495.80	2541.81	1574.22	1622.00	1029.80	467.66
of which, TWINerg (2)	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
hydro-electricity	902.91	842.98	867.65	906.31	906.12	951.92	820.53	1457.23	1124.76	1146.81	1145.22	1157.88	1158.88	1159.88
wind	26.00	39.00	52.00	58.00	64.00	61.00	63.00	55.00	64.00	77.00	83.00	80.00	102.00	101.00
biomass & biogas	2683.00	3230.00	3184.00	3339.00	2999.00	2513.00	2963.00	3046.00	2498.00	2543.00	1573.00	1622.00	1030.00	467.00
gas from WWTPs	NO	NO	NO	NO	NO	5.32	5.85	5.14	6.00	6.00	6.00	6.00	6.00	6.00
gas from landfill sites	NO	NO	NO	NO	NO	NO	0.26	0.41	0.00	1.00	1.00	1.00	1.00	1.00
photovoltaic	1.00	9.00	18.00	21.00	21.00	20.00	20.00	21.00	26.00	38.00	74.00	95.00	104.00	100.00
Total	**10159.28**	**10608.36**	**10496.01**	**11124.85**	**10806.12**	**10346.30**	**9858.42**	**11839.79**	**10789.51**	**10518.41**	**9711.33**	**9898.99**	**10457.57**	**10658.21**
Exports	**2.80**	**3.13**	**3.13**	**3.27**	**2.89**	**2.48**	**2.60**	**3.22**	**2.61**	**2.62**	**1.91**	**2.07**	**1.92**	**1.42**
Conversion uses and losses	**475.68**	**366.33**	**453.13**	**472.35**	**466.47**	**474.25**	**423.09**	**674.15**	**608.00**	**593.24**	**593.24**	**593.24**	**594.24**	**595.24**
Net inland consumption	**6182.00**	**6393.00**	**6150.00**	**6614.00**	**6695.00**	**6598.00**	**6114.00**	**6593.00**	**6485.00**	**6236.00**	**6201.00**	**6181.00**	**6225.00**	**6367.00**
Total	**6574.12**	**6785.46**	**6542.46**	**7006.59**	**7087.21**	**6989.81**	**6505.93**	**6985.54**	**6876.94**	**6627.95**	**6592.23**	**6572.39**	**6617.24**	**6759.74**

Summary in GWh	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Net imports	**6562.18**	**6506.31**	**6391.61**	**6823.54**	**6846.58**	**6829.87**	**6022.47**	**7279.51**	**7096.34**	**6732.10**	**6851.52**	**6961.18**	**7518.76**	**7718.39**
Net national production (1)	**3597.10**	**4102.05**	**4104.41**	**4301.32**	**3959.54**	**3516.43**	**3835.95**	**4560.28**	**3693.17**	**3786.31**	**2859.81**	**2937.81**	**2938.81**	**2939.81**
Net inland consumption	**6182.00**	**6393.00**	**6150.00**	**6614.00**	**6695.00**	**6598.00**	**6114.00**	**6593.00**	**6485.00**	**6236.00**	**6201.00**	**6181.00**	**6225.00**	**6367.00**
Net inland consumption in Mio. MJ (3)	22255.20	23014.80	22140.00	23810.40	24102.00	23752.80	22010.40	23734.80	23346.00	22449.60	22323.60	22251.60	22410.00	22921.20
Net inland consumption in 1000 toe	531.56	549.70	528.80	568.70	575.67	567.33	525.71	566.90	557.61	536.20	533.19	531.47	535.25	547.46

Figure 2-12 –Energy balance for electric power: 1990-2016



Sources: Compiled by the Environment Agency on 15 February 2018 using data published by the Ministry of the Economy – Energy Department, the *Institut Luxembourgeois de Régulation* and STATEC (Table A.4203).

Notes: (1) The net national production is the difference between the national production and the conversion process uses and losses.
(2) Net inland consumption expressed in TJ (Mio. MJ) differs slightly from the corresponding figures in Table II.6-2 – less than 2% – because data sources, units and calculations are not exactly the same.

2.1.5 **Road Transportation**

2.1.5.1 **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"[31], Luxembourg will use a policy mix of instruments with the aim of progressively reducing road transport related emissions.

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[32]. This study has been released in November 2016.[33] 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.

[31] http://www.developpement-durableinfrastructures.public.lu/fr/actualites/articles/2013/05/presentation_plan_action_climat/2_Nationaler-Aktionsplan-Klimaschutz.pdf
[32] http://www.gouvernement.lu/3322796/Programme-gouvernemental.pdf
[33] *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)

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 NOx 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 2-12).

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

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 28 years can essentially be explained by **changes in production techniques and abatement technologies**, as well as by **changes in the final "energy-mix" consumption**. 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 and economic crisis and its 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 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.

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 steel industry took place in the mid-90s and, more recently the closure of one of the steel 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 15.76 Gg in 1990 (Figure 2-13). 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 2018, emissions were down by 93.9% compared to 1990 to 0.96 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 2018, SO_2 emissions decreased by 60.2%, which was mainly due to lower emissions from combustion in industries (especially *Non-metallic Minerals*) and residential heating. From 2017 to 2018, emissions decreased by 3.8%, due to decreasing emissions in the iron and steel industry and the residential sector.

It should be noted that SO_2 emissions (fuel sold/fuel used) from Luxembourg are well below the emission targets for 2010 and 2020 as stipulated under the 1999 Gothenburg Protocol and amended in 2012 and the NECD, and also already reached the new reduction target for 2030 as defined under the NECD (Figure 2-13).

As shown in Figure 2-14 and Table 38, the main source for SO_2 emissions in Luxembourg, with a share of 60.0% in 2018, is *1A2f Non-metallic Minerals*, followed by the *1A2a Iron and Steel Industry*, with a share of 14.3%. Other contributors to SO_2 emissions are category *1A2gviii Other – stationary combustion in industry* with a share of 10.9% in 2018 and category *1A3ai(i) Civil Aviation – Domestic - LTO* with a share of 4.5% in 2018.

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[34]
    - ⇨ since 2016, Belgium lowered the sulphur content in heating oil to a maximum of 50 ppm, 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)[35]

[34] 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

[35] 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

Figure 2-13 – SO_2 emissions (national total) based on fuel sold and used as well as targets under the Gothenburg Protocol and the NECD

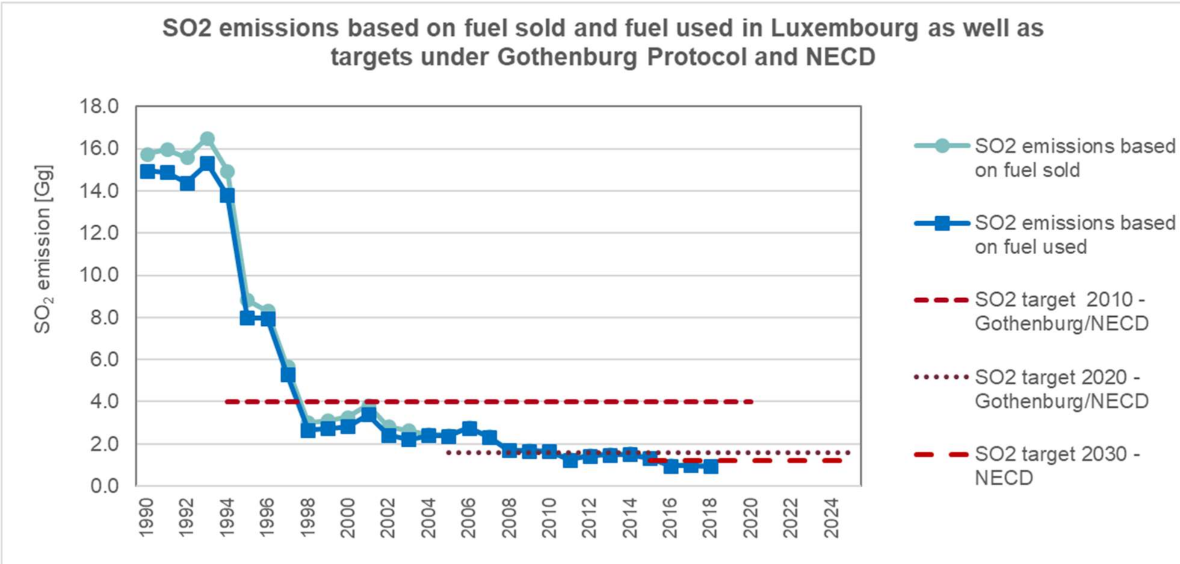
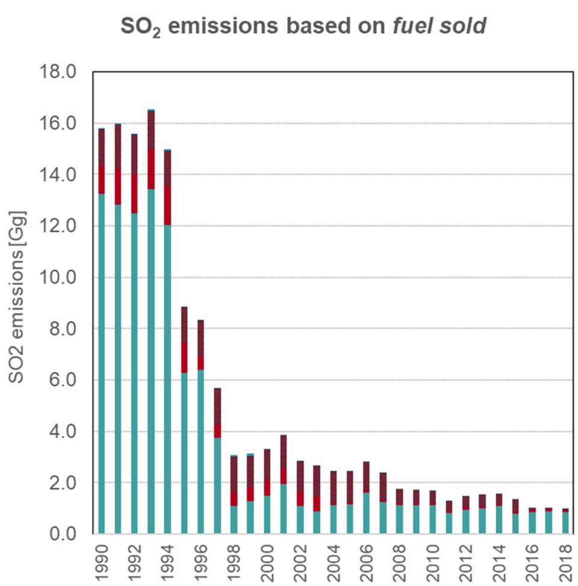
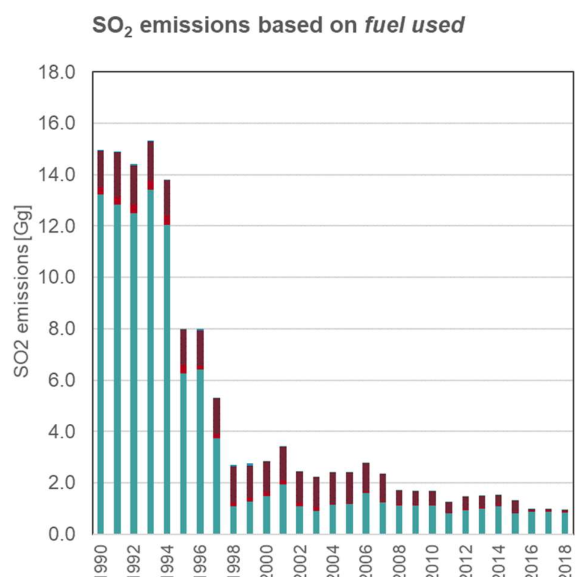


Figure 2-14 – SO_2 emission trend and share by category based on fuel sold and fuel used





- 1 A 1 Energy Industries
- 1 A 2 Manufacturing Industries & Construction
- 1 A 3 Transport
- 1 A 4 Other Sectors
- 1 A 5 Other
- 1 B FUGITIVE EMISSIONS f. FUELS
- 2 INDUSTRIAL PROCESSES & PRODUCT USE
- 3 AGRICULTURE
- 5 WASTE

Table 38 – SO_2 emissions for 1990, 2005, 2017, 2018, 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	2017	2018	1990 - 2018	2005 - 2018	2017 - 2018	1990	2005	2018	1990	2005	2018	
1 A 1 a	0.004	0.010	0.014	0.021	400.2%	103.3%	48.5%	0.0%	0.4%	2.2%	0.0%	0.4%	2.2%	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	12.151	0.054	0.209	0.138	-98.9%	154.0%	-34.0%	81.3%	2.3%	14.7%	77.1%	2.2%	14.3%	fuel sold
1 A 2 b	0.011	0.001	0.001	0.001	-94.6%	-35.9%	-8.8%	0.1%	0.0%	0.1%	0.1%	0.0%	0.1%	fuel sold
1 A 2 c	0.069	0.020	0.001	0.001	-98.3%	-93.9%	3.0%	0.5%	0.8%	0.1%	0.4%	0.8%	0.1%	fuel sold
1 A 2 d	NO	0.002	0.000	0.000	0.0%	-96.0%	13.6%	NO	0.1%	0.0%	NO	0.1%	0.0%	fuel sold
1 A 2 e	0.005	0.005	0.000	0.000	-95.7%	-96.4%	4.5%	0.0%	0.2%	0.0%	0.0%	0.2%	0.0%	fuel sold
1 A 2 f	0.754	0.986	0.549	0.577	-23.5%	-41.5%	5.1%	5.0%	41.4%	61.6%	4.8%	40.8%	60.0%	fuel sold
1 A 2 g vii	0.037	0.003	0.001	0.001	-96.9%	-64.6%	3.3%	0.2%	0.1%	0.1%	0.2%	0.1%	0.1%	fuel sold
1 A 2 g viii	0.214	0.085	0.106	0.105	-51.1%	22.8%	-1.1%	1.4%	3.6%	11.2%	1.4%	3.5%	10.9%	fuel sold
1 A 3 a i (i)	0.010	0.036	0.040	0.043	350.2%	20.8%	8.1%	0.1%	1.5%	4.6%	0.1%	1.5%	4.5%	fuel sold
1 A 3 a ii (i)	0.000	0.000	0.000	0.000	162.9%	-8.0%	-2.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 b i	0.258	0.014	0.012	0.013	-95.1%	-11.0%	2.4%				1.6%	0.6%	1.3%	fuel sold
	0.081	0.006	0.006	0.006	-92.4%	11.2%	-0.7%	0.5%	0.2%	0.7%				fuel used
1 A 3 b ii	0.026	0.001	0.001	0.001	-95.8%	22.4%	5.3%				0.2%	0.0%	0.1%	fuel sold
	0.026	0.001	0.001	0.001	-95.8%	22.4%	5.3%	0.2%	0.0%	0.1%				fuel used
1 A 3 b iii	0.773	0.032	0.020	0.022	-97.2%	-32.2%	9.6%				4.9%	1.3%	2.2%	fuel sold
	0.133	0.002	0.002	0.002	-98.2%	0.0%	-4.2%	0.9%	0.1%	0.3%				fuel used
1 A 3 b iv	0.000	0.000	0.000	0.000	-88.4%	30.2%	1.4%				0.0%	0.0%	0.0%	fuel sold
	0.000	0.000	0.000	0.000	-88.4%	30.2%	1.4%	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
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 b vi	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 b vii	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 c	0.020	0.003	0.002	0.002	-88.2%	-15.4%	6.3%	0.1%	0.1%	0.3%	0.1%	0.1%	0.2%	fuel sold
1 A 3 d i (ii)	0.000	0.000	0.000	0.000	-98.6%	-79.6%	-13.2%	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	-99.1%	-83.1%	-2.0%	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
1 A 4 a i	0.578	0.234	0.010	0.010	-98.3%	-95.8%	2.4%	3.9%	9.8%	1.0%	3.7%	9.7%	1.0%	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	0.823	0.931	0.034	0.028	-96.6%	-97.0%	-17.7%	5.5%	39.1%	3.0%	5.2%	38.5%	2.9%	fuel sold
1 A 4 b ii	0.000	0.000	0.000	0.000	-91.4%	-81.6%	0.7%	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	-97.4%	45.4%	11.7%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	fuel sold
1 A 4 c ii	0.021	0.001	0.000	0.000	-99.3%	-80.3%	1.4%	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
1 A 5 a	0.000	NO	NO	NO	NO	NO	NO	0.0%	NO	NO	0.0%	NO	NO	fuel sold
1 A 5 b	0.000	0.000	0.000	0.000	-99.3%	-79.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	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	4461.8%	101.3%	-29.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	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	NA	NA	NA	NA	NA	IE/NA/NO	IE/NA/NO	NA	IE/NA/NO	IE/NA/NO	NA	fuel sold
6 A	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
National total (fuel sold)	**15.764**	**2.418**	**1.000**	**0.962**	**-93.9%**	**-60.2%**	**-3.8%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**14.948**	**2.380**	**0.976**	**0.936**	**-93.7%**	**-60.7%**	**-4.1%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

2.2.2 NO_X Emissions

National total NO_X emissions, based on fuel sold, amounted to 41.3 Gg in 1990 (Figure 2-12). Since then emissions have decreased until 1998 but then increased again. In 2005, total NO_X emissions amounted to 56.0 Gg. In the year 2018, emissions were down by 50.4%, compared to 1990, to 20.5 Gg, which was mainly due to lower emissions from combustion in manufacturing industries (*1A2*, especially *Iron and Steel Industry* and *Glass Production*) and lower fuel sales in road transportation. In the period 2005 to 2018, NO_X emissions decreased by 63.4%, which was mainly due to lower emissions from road transport (lower fuel sales combined with better abatement technologies). From 2017 to 2018 emissions further decreased by 8.4%.

However, although NOx emissions have decreased compared to 1990, emissions (fuel sold/fuel used) in Luxembourg are well above the targets for 2010 and 2020 as stipulated under the Gothenburg Protocol and the NECD and the new 2030 target as fixed under the NECD (Figure 2-12).

As shown in Figure 2-16 and Table 39 the main source for NO_X emissions in Luxembourg, with a share of 62% in 1990, 82% in 2005 and 64% in 2018, 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% in 2005 and 3% in 2018. Nowadays the second major contributor is category *1A2f Mineral Products* with a share of 5% in 2005 and 6% in 2018.

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[36]
- 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)[37]
- 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).

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[36] 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

[37] 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

Figure 2-15 – NO_X emissions (national total) based on fuel sold and fuel used as well as targets under Gothenburg Protocol and the NECD

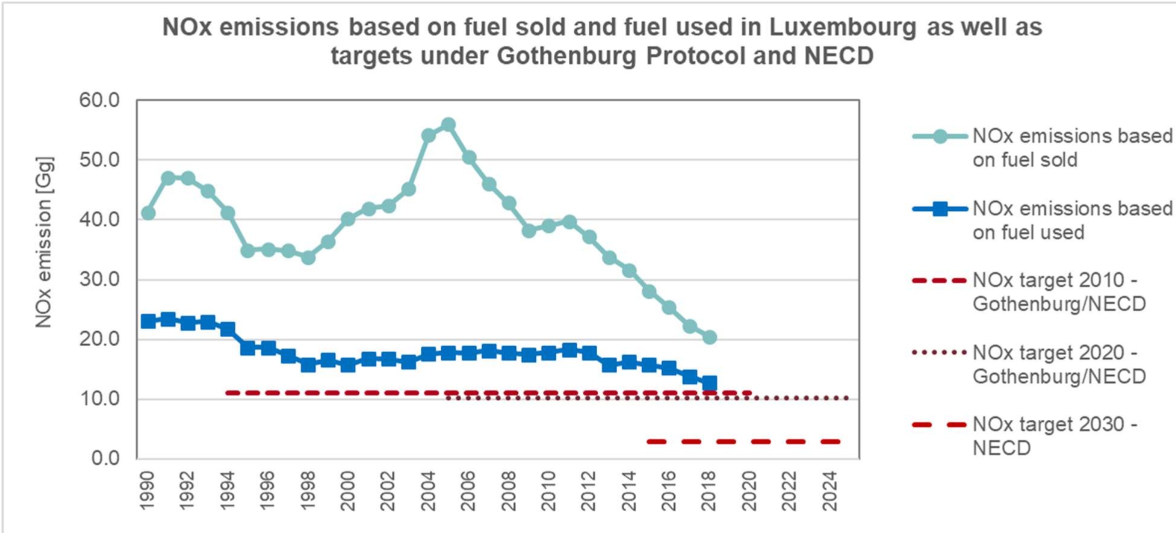


Figure 2-16 – NO_X emission trend and share by category based on fuel sold and fuel used

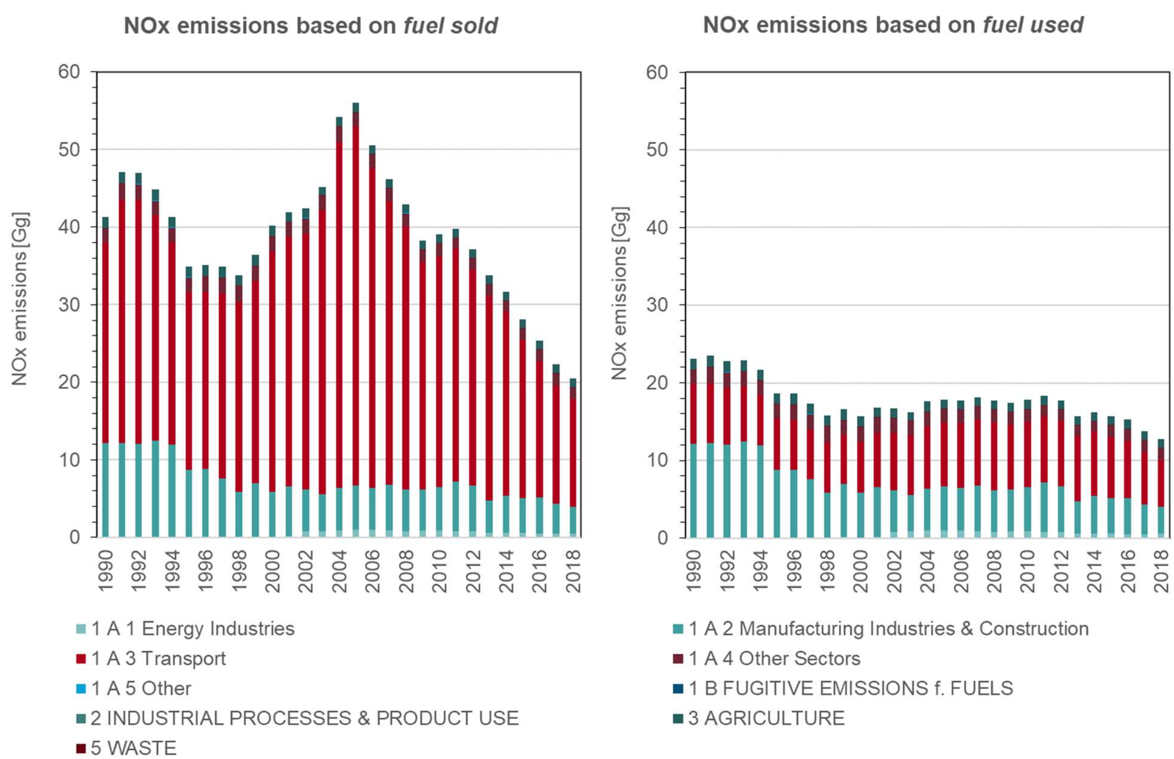


Table 39 – NO$_X$ emissions for 1990, 2005, 2017, 2018, Trend & Share in National Total based on fuel sold and fuel used

	NOx													
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2017	2018	1990 - 2018	2005 - 2018	2017 - 2018	1990	2005	2018	1990	2005	2018	
1 A 1 a	0.033	0.97	0.46	0.53	1501%	-45%	13%	0%	5%	4%	0%	2%	3%	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	7.013	1.14	0.72	0.62	-91%	-46%	-14%	30%	6%	5%	17%	2%	3%	fuel sold
1 A 2 b	0.135	0.08	0.07	0.06	-52%	-17%	-8%	1%	0%	1%	0%	0%	0%	fuel sold
1 A 2 c	0.823	0.33	0.12	0.12	-85%	-63%	5%	4%	2%	1%	2%	1%	1%	fuel sold
1 A 2 d	NO	0.04	0.01	0.01	1%	-73%	13%	NO	0%	0%	NO	0%	0%	fuel sold
1 A 2 e	0.035	0.05	0.08	0.08	134%	68%	-2%	0%	0%	1%	0%	0%	0%	fuel sold
1 A 2 f	3.370	2.72	1.71	1.23	-64%	-55%	-28%	15%	15%	10%	8%	5%	6%	fuel sold
1 A 2 g vii	0.544	1.09	0.88	0.85	56%	-22%	-3%	2%	6%	7%	1%	2%	4%	fuel sold
1 A 2 g viii	0.188	0.27	0.30	0.50	165%	86%	67%	1%	1%	4%	0%	0%	2%	fuel sold
1 A 3 a i (i)	0.143	0.53	0.60	0.64	350%	21%	8%	1%	3%	5%	0%	1%	3%	fuel sold
1 A 3 a ii (i)	0.000	0.00	0.00	0.00	163%	-8%	-3%	0%	0%	0%	0%	0%	0%	fuel sold
1 A 3 b i	10.951	9.97	7.86	7.29	-33%	-27%	-7%				27%	18%	36%	fuel sold
	4.721	3.91	4.12	3.71	-21%	-5%	-10%	20%	22%	29%				fuel used
1 A 3 b ii	0.301	0.75	0.94	0.89	195%	18%	-6%				1%	1%	4%	fuel sold
	0.301	0.75	0.94	0.89	195%	18%	-6%	1%	4%	7%				fuel used
1 A 3 b iii	14.251	34.96	5.80	4.93	-65%	-86%	-15%				35%	62%	24%	fuel sold
	2.255	2.84	0.99	0.78	-65%	-72%	-20%	10%	16%	6%				fuel used
1 A 3 b iv	0.006	0.01	0.01	0.01	72%	-7%	-3%				0%	0%	0%	fuel sold
	0.006	0.01	0.01	0.01	72%	-7%	-3%	0%	0%	0%				fuel used
1 A 3 b v	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 b vi	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 b vii	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 c	0.258	0.10	0.05	0.06	-78%	-43%	4%	1%	1%	0%	1%	0%	0%	fuel sold
1 A 3 d i (ii)	0.001	0.00	0.00	0.00	36%	-18%	-15%	0%	0%	0%	0%	0%	0%	fuel sold
1 A 3 d ii	0.012	0.01	0.01	0.01	-28%	-35%	-5%	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
1 A 4 a i	0.843	0.53	0.57	0.59	-30%	11%	3%	4%	3%	5%	2%	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	0.622	1.03	0.78	0.72	15%	-31%	-9%	3%	6%	6%	2%	2%	3%	fuel sold
1 A 4 b ii	0.005	0.01	0.01	0.01	73%	16%	1%	0%	0%	0%	0%	0%	0%	fuel sold
1 A 4 c i	0.011	0.01	0.01	0.01	28%	45%	12%	0%	0%	0%	0%	0%	0%	fuel sold
1 A 4 c ii	0.328	0.27	0.19	0.19	-43%	-30%	-2%	1%	2%	1%	1%	0%	1%	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	0.003	NO	NO	NO	NO	NO	NO	0%	NO	NO	0%	NO	NO	fuel sold
1 A 5 b	0.001	0.00	0.00	0.00	-70%	-69%	-12%	0%	0%	0%	0%	0%	0%	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	0.001	0.00	0.00	0.00	12%	2%	1%	0%	0%	0%	0%	0%	0%	fuel sold
3 B	0.115	0.07	0.08	0.08	-28%	14%	-2%	0%	0%	1%	0%	0%	0.41%	fuel sold
3 D a	1.298	1.05	1.07	1.05	-19%	0%	-3%	6%	6%	8%	3%	2%	5.11%	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	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
6 A	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
National total (fuel sold)	**41.290**	**55.985**	**22.340**	**20.465**	**-50.4%**	**-63.4%**	**-8.4%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**23.065**	**17.807**	**13.785**	**12.746**	**-44.7%**	**-28.4%**	**-7.5%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

2.2.3 **NMVOC Emissions**

National total NMVOC emissions, based on fuel sold, amounted to 27.6 Gg in 1990 (Figure 2-17). Since then emissions have decreased steadily. In 2005 national total NO_X emissions amounted to 14.7 Gg. In the year 2018, emissions were down by 62.4% compared to 1990 to 10.4 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 2018, NMVOC emissions decreased by 29.7%. From 2017 to 2018 emissions increased by 1.0%.

As presented in Figure 2-17, NMVOC emissions (fuel sold/fuel used) in Luxembourg are slightly above the targets for 2010 and 2020 as stipulated under the Gothenburg Protocol and the NECD, and further efforts are needed to comply with the target set for 2030 in the NECD.

As shown in Figure 2-18 and Table 40, the main source for NMVOC emissions in Luxembourg, with a share of 42.1% in 2018 is *2D3 Non-Energy Products from Fuels and Solvent Use* (16.7% in 1990 and 40.2% in 2005). A second contributor to NMVOC emissions, with a share of 30.4% in 2018, is *3B Manure management* (11.4% in 1990, 19.2% in 2005). Another major contributor to NMVOC emissions in Luxembourg, with a share of 7.8% in 2018, is *1A3b Road Transport* (61.8% in 1990 and 24.0% in 2005).

Although a certain increase 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[38]
- implementation of limits and measures according to Solvent Directive and Paints Directive[39].

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

Figure 2-17 – NMVOC emissions (national total) based on fuel sold and used as well as targets under the Gothenburg Protocol and the NECD

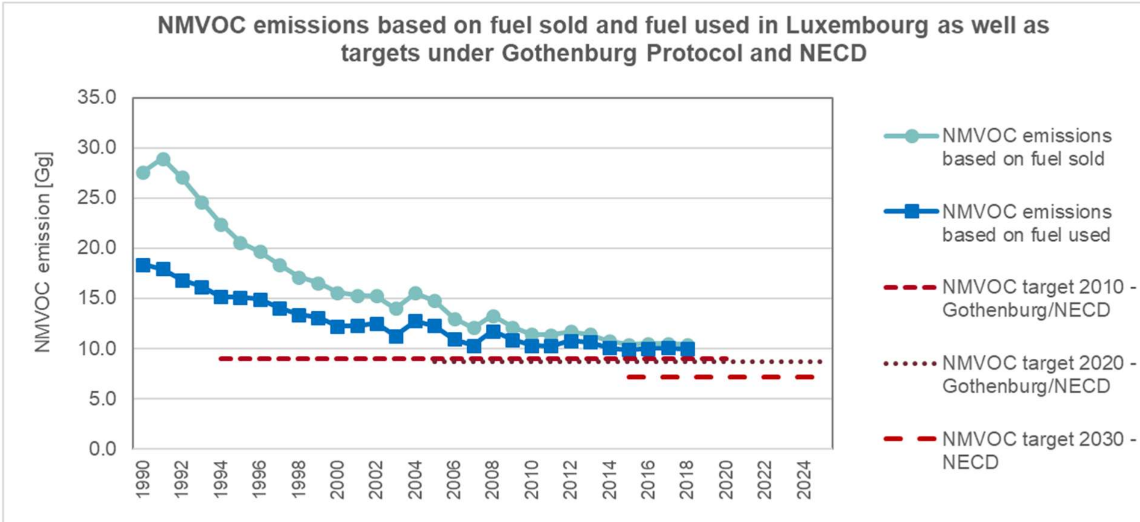


Figure 2-18 – NMVOC emission trend and share by category based on fuel sold and fuel used

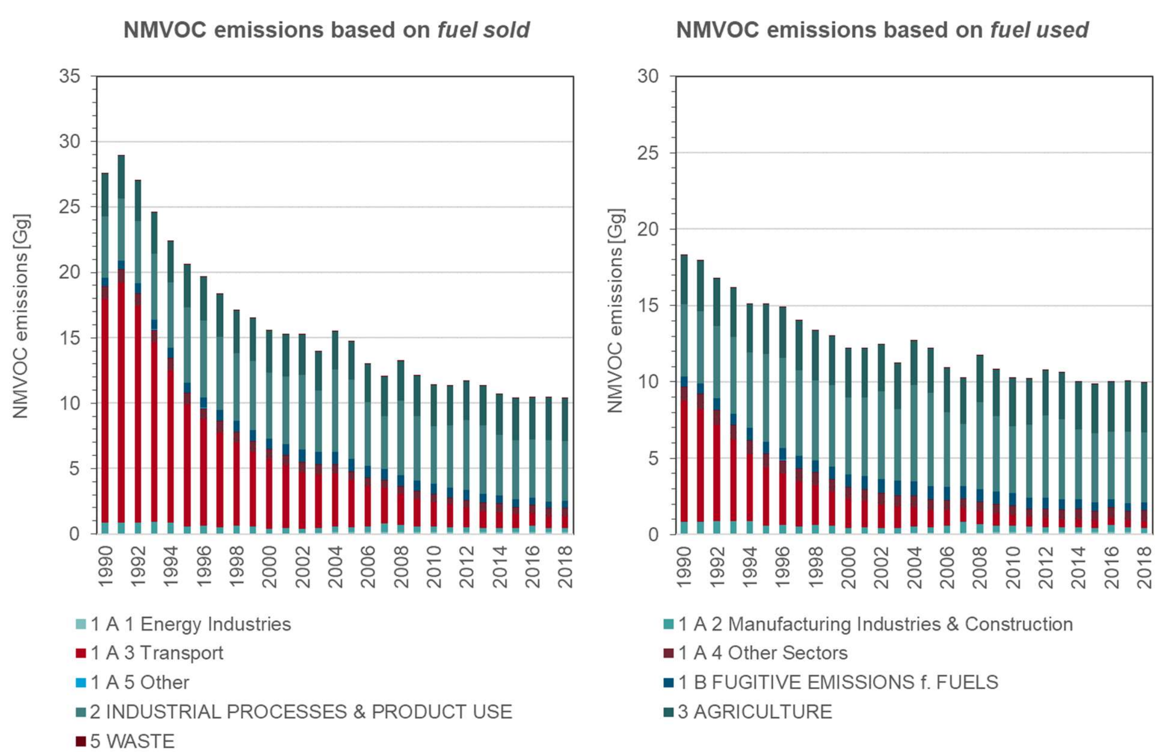


Table 40 – NMVOC emissions for 1990, 2005, 2017, 2018, Trend & Share in National Total based on fuel sold and fuel used

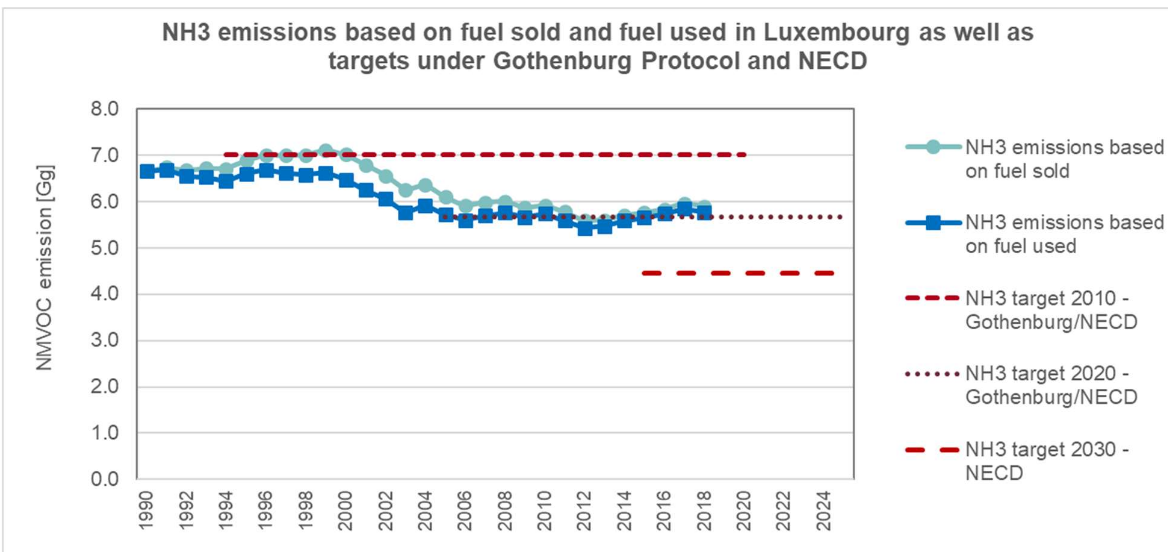
						NMVOC								
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2017	2018	1990 - 2018	2005 - 2018	2017 - 2018	1990	2005	2018	1990	2005	2018	
1 A 1 a	0.001	0.137	0.151	0.138	11898.8%	0.7%	-8.9%	0.0%	1.1%	1.4%	0.0%	0.9%	1.3%	fuel 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	0.597	0.057	0.104	0.100	-83.3%	76.2%	-4.1%	3.3%	0.5%	1.0%	2.2%	0.4%	1.0%	fuel sold
1 A 2 b	0.011	0.024	0.022	0.020	81.6%	-15.1%	-8.0%	0.1%	0.2%	0.2%	0.0%	0.2%	0.2%	fuel sold
1 A 2 c	0.059	0.045	0.041	0.041	-30.4%	-7.7%	1.3%	0.3%	0.4%	0.4%	0.2%	0.3%	0.4%	fuel sold
1 A 2 d	NO	0.007	0.002	0.002	0.2%	-70.3%	14.0%	NO	0.1%	0.0%	NO	0.1%	0.0%	fuel sold
1 A 2 e	0.003	0.007	0.009	0.009	206.0%	37.1%	4.6%	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%	fuel sold
1 A 2 f	0.073	0.059	0.014	0.014	-81.4%	-77.0%	-0.4%	0.4%	0.5%	0.1%	0.3%	0.4%	0.1%	fuel sold
1 A 2 g vii	0.090	0.098	0.026	0.024	-73.5%	-75.7%	-7.3%	0.5%	0.8%	0.2%	0.3%	0.7%	0.2%	fuel sold
1 A 2 g viii	0.012	0.065	0.099	0.097	687.2%	48.8%	-1.8%	0.1%	0.5%	1.0%	0.0%	0.4%	0.9%	fuel sold
1 A 3 a i (i)	0.012	0.044	0.050	0.054	350.2%	20.8%	8.1%	0.1%	0.4%	0.5%	0.0%	0.3%	0.5%	fuel sold
1 A 3 a ii (i)	0.001	0.004	0.004	0.004	162.9%	-8.0%	-2.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 b i	12.043	1.982	0.484	0.477	-96.0%	-76.0%	-1.5%				43.7%	13.4%	4.6%	fuel sold
	5.375	0.599	0.190	0.182	-96.6%	-69.6%	-4.0%	29.3%	4.9%	1.8%				fuel used
1 A 3 b ii	0.128	0.031	0.008	0.007	-94.4%	-77.0%	-6.3%				0.5%	0.2%	0.1%	fuel sold
	0.128	0.031	0.008	0.007	-94.4%	-77.0%	-6.3%	0.7%	0.3%	0.1%				fuel used
1 A 3 b iii	0.727	1.089	0.110	0.106	-85.4%	-90.2%	-3.7%				2.6%	7.4%	1.0%	fuel sold
	0.344	0.156	0.025	0.021	-93.9%	-86.6%	-17.7%	1.9%	1.3%	0.2%				fuel used
1 A 3 b iv	0.143	0.162	0.147	0.139	-3.1%	-14.5%	-5.6%				0.5%	1.1%	1.3%	fuel sold
	0.143	0.162	0.147	0.139	-3.1%	-14.5%	-5.6%	0.8%	1.3%	1.4%				fuel used
1 A 3 b v	4.005	0.282	0.083	0.082	-98.0%	-71.0%	-1.7%				14.5%	1.9%	0.8%	fuel sold
	1.833	0.086	0.034	0.033	-98.2%	-61.6%	-3.1%	10.0%	0.7%	0.3%				fuel used
1 A 3 b vi	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 b vii	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 c	0.049	0.015	0.005	0.005	-89.1%	-64.2%	3.5%	0.3%	0.1%	0.1%	0.2%	0.1%	0.1%	fuel sold
1 A 3 d i (ii)	0.000	0.000	0.000	0.000	10.8%	-24.8%	-15.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 d ii	0.020	0.016	0.006	0.006	-69.0%	-60.2%	-3.0%	0.1%	0.1%	0.1%	0.1%	0.1%	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
1 A 4 a i	0.093	0.038	0.067	0.069	-25.7%	81.6%	2.3%	0.5%	0.3%	0.7%	0.3%	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	0.498	0.417	0.424	0.508	2.0%	21.8%	19.8%	2.7%	3.4%	5.1%	1.8%	2.8%	4.9%	fuel sold
1 A 4 b ii	0.260	0.171	0.075	0.076	-70.8%	-55.7%	0.6%	1.4%	1.4%	0.8%	0.9%	1.2%	0.7%	fuel sold
1 A 4 c i	0.002	0.000	0.000	0.000	-95.8%	45.4%	11.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 4 c ii	0.105	0.069	0.045	0.044	-58.0%	-36.5%	-1.8%	0.6%	0.6%	0.4%	0.4%	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
1 A 5 a	0.000	NO	NO	NO	NO	NO	NO	0.0%	NO	NO	0.0%	NO	NO	fuel sold
1 A 5 b	0.000	0.000	0.000	0.000	-82.3%	-68.1%	-8.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 B 1	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	fuel sold
1 B 2 a	0.409	0.293	0.168	0.186	-54.4%	-36.4%	11.0%	2.2%	2.4%	1.9%	1.5%	2.0%	1.8%	fuel sold
1 B 2 b	0.221	0.601	0.356	0.352	59.8%	-41.4%	-1.1%	1.2%	4.9%	3.5%	0.8%	4.1%	3.4%	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	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 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	1.036	1.940	2.275	2.129	105.6%	9.8%	-6.4%	5.6%	15.9%	21.4%	3.8%	13.2%	20.5%	fuel sold
2 D 3 b	0.009	0.005	0.004	0.026	182.0%	443.5%	538.0%	0.0%	0.0%	0.3%	0.0%	0.0%	0.2%	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	1.331	1.455	0.806	0.802	-39.8%	-44.9%	-0.6%	7.3%	11.9%	8.1%	4.8%	9.9%	7.7%	fuel sold
2 D 3 e	0.835	1.133	0.907	0.901	8.0%	-20.4%	-0.6%	4.5%	9.3%	9.1%	3.0%	7.7%	8.7%	fuel sold
2 D 3 f	0.018	0.023	0.018	0.018	0.2%	-22.5%	-0.6%	0.1%	0.2%	0.2%	0.1%	0.2%	0.2%	fuel sold
2 D 3 g	0.739	0.674	0.248	0.246	-66.7%	-63.5%	-0.6%	4.0%	5.5%	2.5%	2.7%	4.6%	2.4%	fuel sold
2 D 3 h	0.488	0.527	0.106	0.106	-78.3%	-80.0%	-0.6%	2.7%	4.3%	1.1%	1.8%	3.6%	1.0%	fuel sold
2 D 3 i	0.145	0.173	0.143	0.143	-0.8%	-17.1%	0.1%	0.8%	1.4%	1.4%	0.5%	1.2%	1.4%	fuel sold
2 H	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 I	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	fuel sold
2 J	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
2 K	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	fuel sold
2 L	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
2 G	0.002	0.002	0.002	0.002	11.1%	1.5%	1.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
3 B	3.138	2.830	3.176	3.149	0.4%	11.3%	-0.8%	17.1%	23.1%	31.7%	11.4%	19.2%	30.4%	fuel sold
3 D 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
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	0.109	0.110	0.113	0.113	4.2%	3.0%	0.3%	0.6%	0.9%	1.1%	0.4%	0.7%	1.1%	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	0.032	0.026	0.018	0.014	-56.8%	-47.0%	-23.2%	0.2%	0.2%	0.1%	0.1%	0.2%	0.1%	fuel sold
6 A	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
National total (fuel sold)	**27.573**	**14.748**	**10.473**	**10.373**	**-62.4%**	**-29.7%**	**-1.0%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**18.350**	**12.235**	**10.045**	**9.945**	**-45.8%**	**-18.7%**	**-1.0%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

2.2.4 **NH_3 Emissions**

National total NH_3 emissions, based on fuel sold, amounted to 6.65 Gg in 1990. In 2005, national total NH_3 emissions amounted to 6.09 Gg. In the year 2018, emissions were down by 11.4% compared to 1990 to 5.9 Gg, which was mainly due to lower emissions from manure management. In the period 2005 to 2018, NH_3 emissions decreased by 3.3%. From 2017 to 2018 emissions decreased by 1.0%.

As presented in Figure 2-19, NH_3 emissions (fuel sold/fuel used) from Luxembourg are well below the targets for 2010 as stipulated under the Gothenburg Protocol and NECD. For the 2020 target, although already close to the target, the challenge remains to push ammonia emissions under the target. In order to reach the 2030 target, as set in the NECD, further, more stringent, efforts are needed to cut emissions.

Figure 2-19 – NH_3 emissions based on fuel sold and used in Luxembourg as well as targets under the Gothenburg Protocol and the NECD



As shown in Figure 2-20 and Table 41, the main source for NH_3 emissions in Luxembourg, with a share of 45.8% in 2018, was *3Da1 Inorganic N-Fertilizers* and *3Da2a Animal Manure Applied to Soils*, when considered together (51.2.2% in 1990 and 46.8% in 2005). Another contributor to NH_3 emissions in Luxembourg, with a share of 37.3% in 2018, are *3B1a Dairy Cattle* and *3B1b Non-dairy Cattle*, together (39.3% in 1990 and 32.5% in 2005).

Figure 2-20 – NH_3 emission trends and shares by category based on fuel sold and fuel used

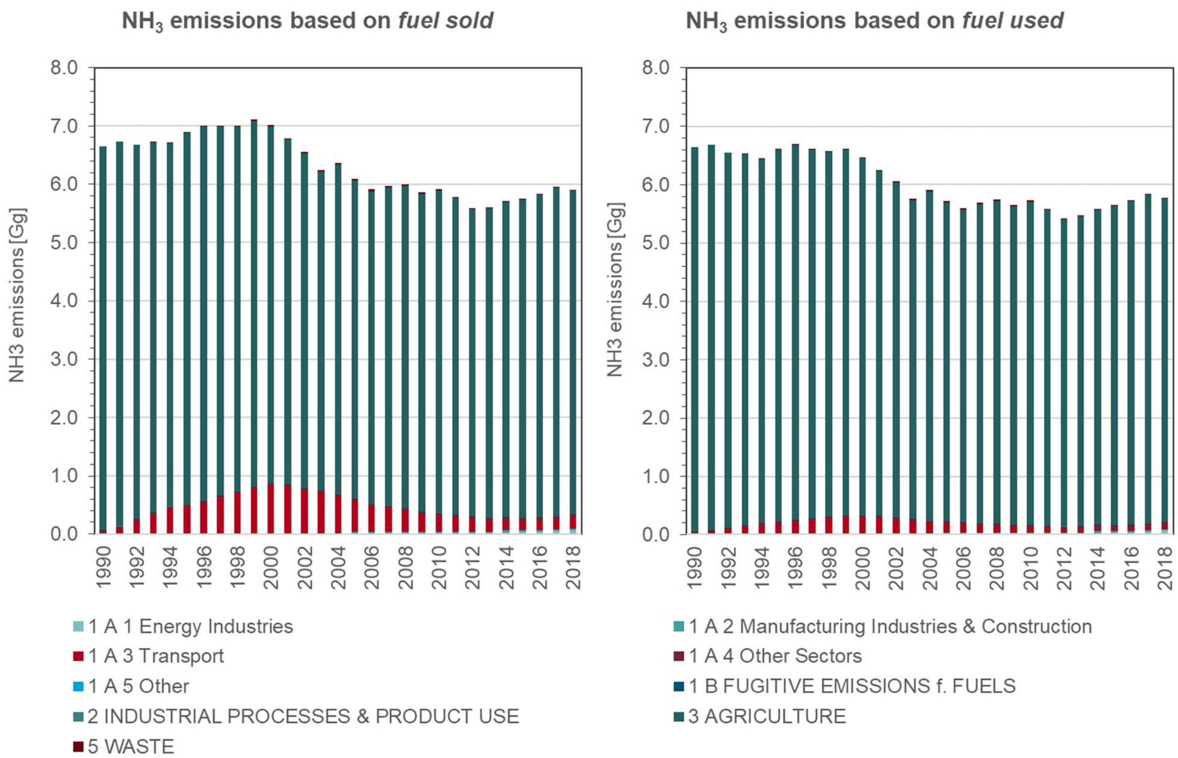


Table 41 – NH_3 emissions for 1990, 2005, 2017, 2018, Trend & Share in National Total based on fuel sold and fuel used

NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2017	2018	1990 - 2018	2005 - 2018	2017 - 2018	1990	2005	2018	1990	2005	2018	
1 A 1 a	NO	0.002	0.045	0.068	6.8%	3851.7%	51.3%	NO	0.0%	1.2%	NO	0.0%	1.2%	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	49.2%	-11.5%	1.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 2 g viii	NO	0.033	0.027	0.016	1.6%	-49.8%	-39.2%	NO	0.6%	0.3%	NO	0.5%	0.3%	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	0.513	0.129	0.143	1048.7%	-72.1%	11.4%				0.2%	8.4%	2.4%	fuel sold
	0.005	0.145	0.051	0.056	938.2%	-61.6%	9.6%	0.1%	2.5%	1.0%				fuel used
1 A 3 b ii	0.000	0.001	0.002	0.003	1038.4%	105.3%	37.1%				0.0%	0.0%	0.0%	fuel sold
	0.000	0.001	0.002	0.003	1038.4%	105.3%	37.1%	0.0%	0.0%	0.0%				fuel used
1 A 3 b iii	0.002	0.011	0.037	0.043	2536.1%	299.0%	15.6%				0.0%	0.2%	0.7%	fuel sold
	0.000	0.001	0.005	0.005	1178.5%	419.5%	0.3%	0.0%	0.0%	0.1%				fuel used
1 A 3 b iv	0.000	0.000	0.000	0.000	138.5%	33.0%	1.4%				0.0%	0.0%	0.0%	fuel sold
	0.000	0.000	0.000	0.000	138.5%	33.0%	1.4%	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
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 b vi	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 b vii	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 c	0.000	0.000	0.000	0.000	-81.9%	-46.3%	4.6%	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	32.4%	-15.1%	-13.9%	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	-43.8%	-40.7%	-3.9%	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
1 A 4 a i	NO	0.000	0.000	0.000	0.0%	-65.5%	38.2%	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	0.045	0.045	0.049	0.059	30.3%	29.6%	19.0%	0.7%	0.8%	1.0%	0.7%	0.7%	1.0%	fuel sold
1 A 4 b ii	0.000	0.000	0.000	0.000	-22.7%	-17.9%	0.6%	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	-53.5%	-37.6%	-1.4%	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
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	32.4%	-15.1%	-13.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	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	11.1%	1.5%	1.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
3 B 1 a	1.262	0.808	0.967	0.990	-21.5%	22.5%	2.4%	19.0%	14.1%	17.2%	19.0%	13.3%	16.8%	fuel sold
3 B 1 b	1.354	1.170	1.259	1.210	-10.6%	3.4%	-3.9%	20.4%	20.5%	21.0%	20.3%	19.2%	20.5%	fuel sold
3 B 2	0.003	0.004	0.004	0.004	29.4%	-7.7%	0.8%	0.0%	0.1%	0.1%	0.0%	0.1%	0.1%	fuel sold
3 B 3	0.192	0.263	0.261	0.243	26.5%	-7.6%	-6.7%	2.9%	4.6%	4.2%	2.9%	4.3%	4.1%	fuel sold
3 B 4 a	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
3 B 4 d	0.000	0.007	0.017	0.018	4736.0%	143.0%	2.5%	0.0%	0.1%	0.3%	0.0%	0.1%	0.3%	fuel sold
3 B 4 e	0.017	0.037	0.039	0.038	128.1%	2.4%	-1.5%	0.3%	0.7%	0.7%	0.3%	0.6%	0.6%	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	0.020	0.021	0.034	0.034	75.4%	60.8%	-0.3%	0.3%	0.4%	0.6%	0.3%	0.4%	0.6%	fuel sold
3 B 4 g ii	0.001	0.002	0.002	0.002	96.8%	8.6%	5.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	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	-66.0%	-31.6%	-39.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
3 B 4 h	0.006	0.003	0.002	0.002	-67.7%	-42.8%	11.2%	0.1%	0.1%	0.0%	0.1%	0.1%	0.0%	fuel sold
3 D a 1	0.945	0.704	0.679	0.652	-31.0%	-7.4%	-4.0%	14.2%	12.3%	11.3%	14.2%	11.6%	11.1%	fuel sold
3 D a 2 a	2.461	2.148	2.078	2.049	-16.7%	-4.6%	-1.4%	37.0%	37.6%	35.5%	37.0%	35.2%	34.8%	fuel sold
3 D a 2 b	0.048	0.021	0.010	0.008	-82.7%	-59.6%	-17.9%	0.7%	0.4%	0.1%	0.7%	0.3%	0.1%	fuel sold
3 D a 2 c	0.000	0.007	0.006	0.005	0.5%	-30.7%	-19.1%	0.0%	0.1%	0.1%	0.0%	0.1%	0.1%	fuel sold
3 D a 3	0.284	0.262	0.295	0.293	3.0%	11.8%	-0.6%	4.3%	4.6%	5.1%	4.3%	4.3%	5.0%	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	0.029	0.011	0.011	1.1%	-60.9%	3.7%	0.0%	0.2%	0.1%	0.0%	0.2%	0.1%	fuel sold
6 A	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
National total (fuel sold)	**6.655**	**6.094**	**5.954**	**5.895**	**-11.4%**	**-3.3%**	**-1.0%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**6.647**	**5.717**	**5.844**	**5.769**	**-13.2%**	**0.9%**	**-1.3%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

2.2.5 **CO Emissions**

National total CO emissions, based on fuel sold, amounted to 468 Gg in 1990 (Figure 2-21). 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 36.0 Gg. In the year 2018, emissions were down by 95.6% compared to 1990 to 20.5 Gg, which was mainly due to lower emissions from iron and steel industry. In the period 2005 to 2018, CO emissions decreased by 42.9%, mainly due to decreasing emissions from road transport (catalytic converters). From 2017 to 2018 emissions decreased by 8.9%.

As shown in Figure 2-21 and Table 42, the main sources for CO emissions in Luxembourg are *1A2a Iron and Steel* - with a share of 18.8% in 2018 (73.9% in 1990 and 4.6% in 2005) and *1A3bi Road Transport – Passenger Cars* - with a share of 29.8% in 2018 (17.1% in 1990 and 46.9% in 2005). Another major contributor to CO emissions in Luxembourg is *1A4bi Other Sectors – Residential* - with a share of 17.4% in 2018 (0.9% in 1990 and 8.2% in 2005).

The overall decrease of emissions is mainly due to:

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

Figure 2-21 – CO emission trends based on fuel sold

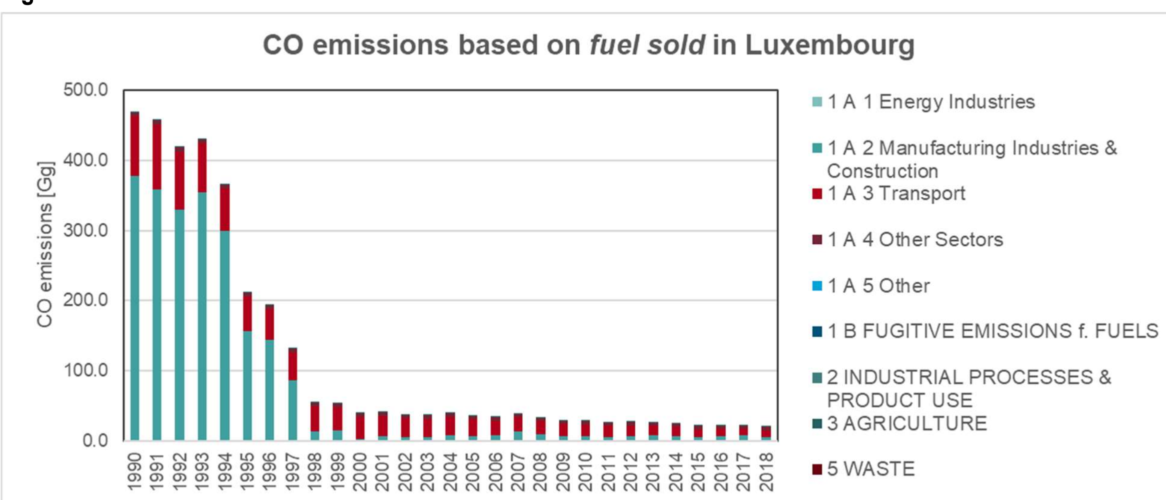


Table 42 – CO emissions for 1990, 2005, 2017, 2018, Trend & Share in National Total based on fuel sold and fuel used

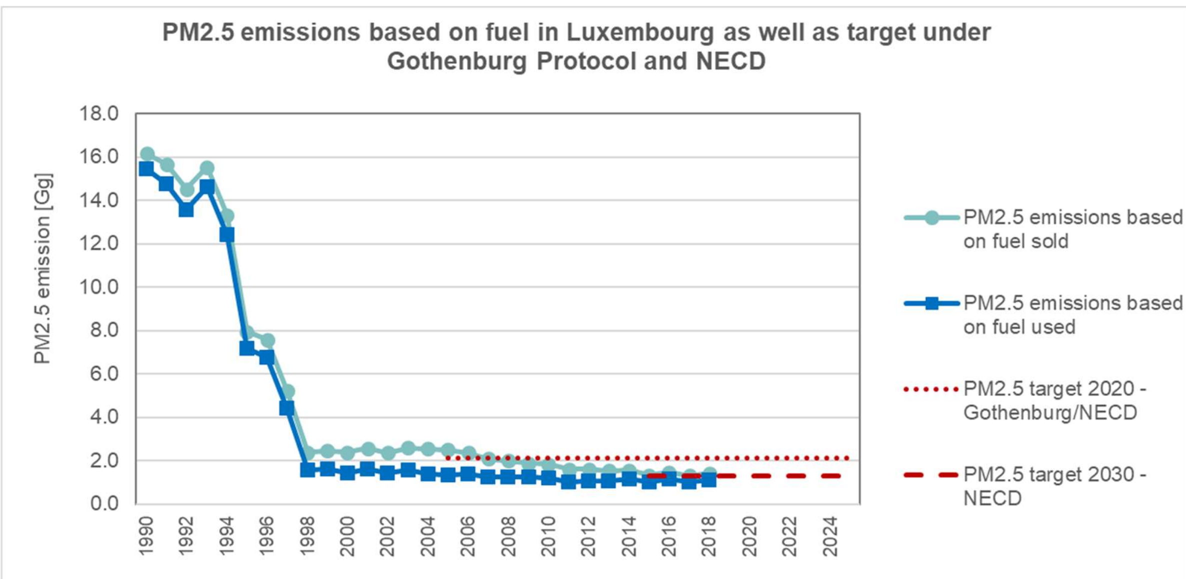
NFR Code	CO Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2017	2018	1990 - 2018	2005 - 2018	2017 - 2018	1990	2005	2018	1990	2005	2018	
1 A 1 a	0.008	0.295	0.380	0.480	6287.5%	62.7%	26.2%	0.0%	1.5%	3.2%	0.0%	0.8%	2.3%	fuel sold
1 A 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	346.464	1.655	4.339	3.860	-98.9%	133.2%	-11.0%	81.9%	8.7%	25.8%	73.9%	4.6%	18.8%	fuel sold
1 A 2 b	0.022	0.030	0.028	0.025	15.9%	-15.5%	-8.0%	0.0%	0.2%	0.2%	0.0%	0.1%	0.1%	fuel sold
1 A 2 c	0.125	0.102	0.021	0.023	-81.5%	-77.2%	9.7%	0.0%	0.5%	0.2%	0.0%	0.3%	0.1%	fuel sold
1 A 2 d	NO	0.008	0.002	0.002	0.2%	-70.7%	13.9%	NO	0.0%	0.0%	NO	0.0%	0.0%	fuel sold
1 A 2 e	0.005	0.009	0.008	0.009	89.9%	3.2%	8.8%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	fuel sold
1 A 2 f	30.108	4.283	2.402	0.824	-97.3%	-80.8%	-65.7%	7.1%	22.5%	5.5%	6.4%	11.9%	4.0%	fuel sold
1 A 2 g vii	0.589	0.821	0.480	0.473	-19.7%	-42.4%	-1.5%	0.1%	4.3%	3.2%	0.1%	2.3%	2.3%	fuel sold
1 A 2 g viii	0.181	0.132	0.580	0.163	-10.0%	23.0%	-71.9%	0.0%	0.7%	1.1%	0.0%	0.4%	0.8%	fuel sold
1 A 3 a i (i)	0.111	0.413	0.462	0.500	350.2%	20.8%	8.1%	0.0%	2.2%	3.3%	0.0%	1.1%	2.4%	fuel sold
1 A 3 a ii (i)	0.063	0.179	0.169	0.164	162.9%	-8.0%	-2.7%	0.0%	0.9%	1.1%	0.0%	0.5%	0.8%	fuel sold
1 A 3 b i	80.213	16.894	6.008	6.124	-92.4%	-63.7%	1.9%				17.1%	46.9%	29.8%	fuel sold
	35.969	4.932	2.335	2.330	-93.5%	-52.8%	-0.2%	8.5%	25.9%	15.6%				fuel used
1 A 3 b ii	1.601	0.432	0.159	0.176	-89.0%	-59.3%	10.3%				0.3%	1.2%	0.9%	fuel sold
	1.601	0.432	0.159	0.176	-89.0%	-59.3%	10.3%	0.4%	2.3%	1.2%				fuel used
1 A 3 b iii	2.418	5.602	2.485	2.178	-9.9%	-61.1%	-12.4%				0.5%	15.6%	10.6%	fuel sold
	0.833	0.624	0.455	0.369	-55.7%	-40.9%	-18.9%	0.2%	3.3%	2.5%				fuel used
1 A 3 b iv	0.384	0.498	0.389	0.373	-3.1%	-25.1%	-4.3%				0.1%	1.4%	1.8%	fuel sold
	0.384	0.498	0.389	0.373	-3.1%	-25.1%	-4.3%	0.1%	2.6%	2.5%				fuel used
1 A 3 b v	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 b vi	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 b vii	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 c	0.280	0.089	0.036	0.038	-86.5%	-57.3%	4.6%	0.1%	0.5%	0.3%	0.1%	0.2%	0.2%	fuel sold
1 A 3 d i (ii)	0.001	0.001	0.001	0.001	21.1%	-19.2%	-14.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 d ii	0.101	0.062	0.043	0.043	-58.0%	-31.5%	-0.5%	0.0%	0.3%	0.3%	0.0%	0.2%	0.2%	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	0.276	0.290	-9.4%	46.4%	5.1%	0.1%	1.0%	1.9%	0.1%	0.6%	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	3.988	2.962	3.063	3.577	-10.3%	20.8%	16.8%	0.9%	15.5%	23.9%	0.9%	8.2%	17.4%	fuel sold
1 A 4 b ii	1.244	1.015	1.030	1.037	-16.7%	2.2%	0.7%	0.3%	5.3%	6.9%	0.3%	2.8%	5.0%	fuel sold
1 A 4 c i	0.004	0.003	0.004	0.004	4.9%	45.4%	11.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 4 c ii	0.451	0.296	0.167	0.162	-64.1%	-45.4%	-2.9%	0.1%	1.6%	1.1%	0.1%	0.8%	0.8%	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	0.0%	NO	NO	0.0%	NO	NO	fuel sold
1 A 5 b	0.001	0.001	0.000	0.000	-67.5%	-48.5%	-1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	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	0.022	0.023	12.2%	2.0%	1.5%	0.1%	0.2%	0.2%	0.1%	0.2%	0.2%	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)	**468.704**	**36.001**	**22.557**	**20.549**	**-95.6%**	**-42.9%**	**-8.9%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**422.874**	**19.061**	**16.853**	**14.945**	**-96.5%**	**-21.6%**	**-11.3%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

2.2.6 $PM_{2.5}$ Emissions

National total $PM_{2.5}$ emissions, based on fuel sold, amounted to 16.1 Gg in 1990 (Figure 2-22). Since then emissions have decreased significantly. In 2005 national total $PM_{2.5}$ emissions amounted to 2.5 Gg. In the year 2018, emissions were down by 91.3% compared to 1990 to 1.3 Gg, which was mainly due to lower emissions from *1A2a Iron and Steel* and from *1A3b Road Transport Sector*. In the period 2005 to 2018, $PM_{2.5}$ emissions decreased by 43.1%. From 2017 to 2018 emissions increased by 9.4%, mainly due to increased wood burning activities in *1A4bi – Other sectors - Residential*.

As presented in Figure 2-22, $PM_{2.5}$ emissions (fuel sold) from Luxembourg are since the year 2010 below the target for 2020 as stipulated under the Gothenburg Protocol and the NECD and slightly above the 2030 target as set in the NECD.

Figure 2-22 – $PM_{2.5}$ emissions (national total) based on fuel sold and used as well as target under the Gothenburg Protocol and NECD



As shown in Figure 2-23 and Table 43, the main source, in the past, for $PM_{2.5}$ emissions in Luxembourg, with a share of 85.3% in 1990, 0.6% in 2005 and 1.2% in 2018, was *1A2a Iron and Steel Industry*. Nowadays, the major contributors to $PM_{2.5}$ emissions in Luxembourg are, with a share of 43.9% in 2018, *1A4bi Residential Heating* (3.6% in 1990 and 20.3% in 2005) and, with a share of 26.7% in 2018, *1A3b Road Transport* (6.1% in 1990 and 61.2% 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 2-23 – $PM_{2.5}$ emission trends and shares by category based on fuel sold and fuel used

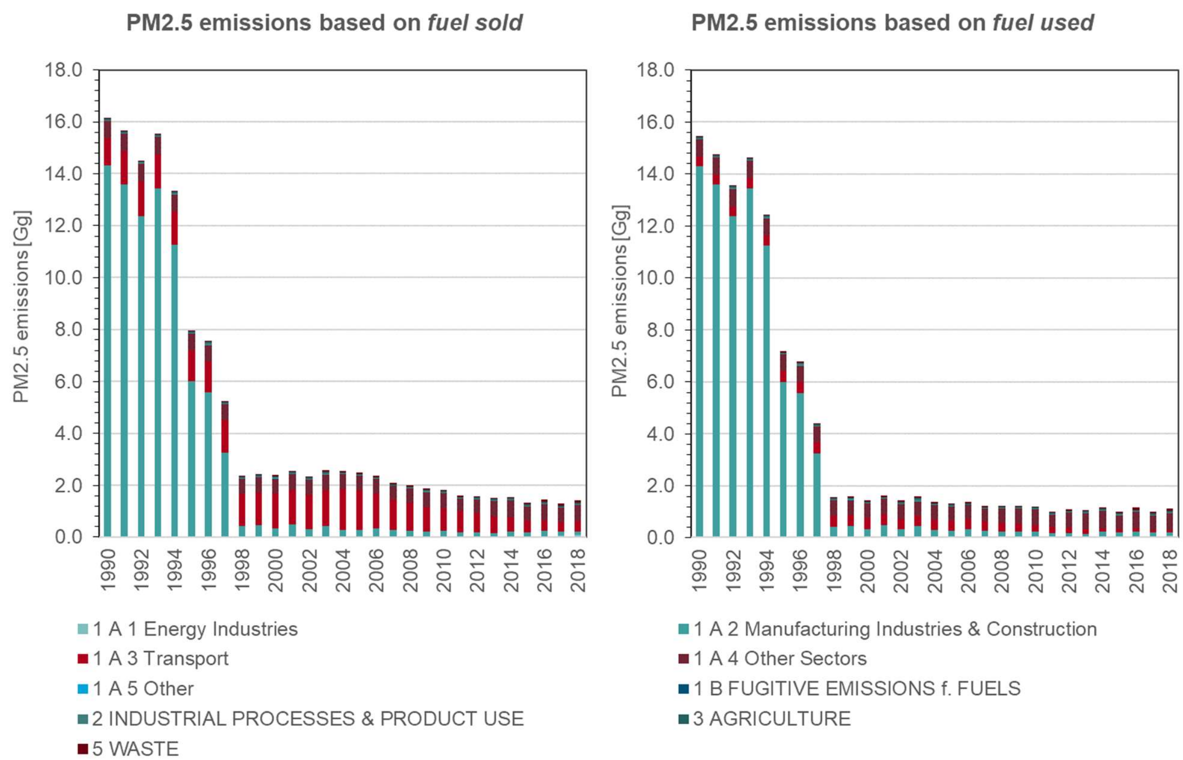


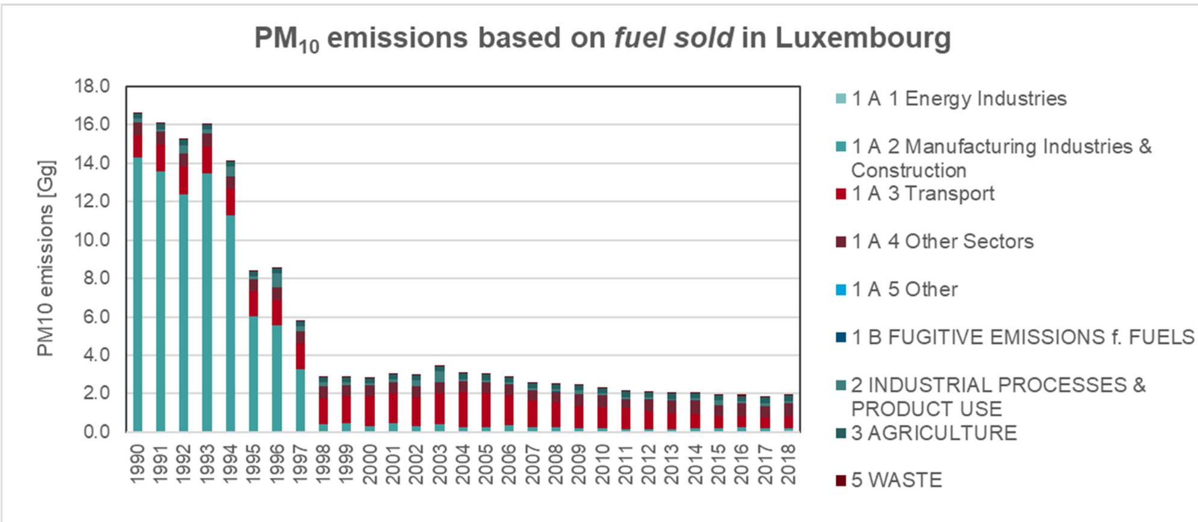
Table 43 – $PM_{2.5}$ emissions for 1990, 2005, 2017, 2018, Trend & Share in National Total based on fuel sold and fuel used

PM2.5														
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2017	2018	1990 - 2018	2005 - 2018	2017 - 2018	1990	2005	2018	1990	2005	2018	
1 A 1 a	0.000	0.004	0.048	0.075	190501.8%	1930.3%	56.4%	0.0%	0.3%	6.8%	0.0%	0.1%	5.3%	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	13.768	0.016	0.018	0.018	-99.9%	13.1%	-1.8%	89.1%	1.2%	1.6%	85.3%	0.6%	1.2%	fuel sold
1 A 2 b	0.005	0.034	0.031	0.026	448.7%	-22.6%	-16.5%	0.0%	2.6%	2.4%	0.0%	1.4%	1.9%	fuel sold
1 A 2 c	0.030	0.005	0.002	0.002	-93.0%	-57.2%	-9.3%	0.2%	0.4%	0.2%	0.2%	0.2%	0.1%	fuel sold
1 A 2 d	NO	0.001	0.000	0.000	0.0%	-79.1%	9.8%	NO	0.0%	0.0%	NO	0.0%	0.0%	fuel sold
1 A 2 e	0.001	0.001	0.003	0.003	118.0%	92.7%	2.9%	0.0%	0.1%	0.2%	0.0%	0.1%	0.2%	fuel sold
1 A 2 f	0.410	0.112	0.046	0.039	-90.5%	-65.4%	-15.1%	2.7%	8.5%	3.5%	2.5%	4.5%	2.8%	fuel sold
1 A 2 g vii	0.094	0.089	0.018	0.016	-83.0%	-82.1%	-11.6%	0.6%	6.7%	1.4%	0.6%	3.6%	1.1%	fuel sold
1 A 2 g viii	0.003	0.006	0.028	0.029	897.1%	377.7%	1.6%	0.0%	0.5%	2.6%	0.0%	0.2%	2.0%	fuel sold
1 A 3 a i (i)	0.001	0.004	0.004	0.004	350.2%	20.8%	8.1%	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	162.9%	-8.0%	-2.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 b i	0.307	0.479	0.040	0.034	-88.8%	-92.8%	-15.3%				1.9%	19.3%	2.4%	fuel sold
	0.090	0.200	0.020	0.017	-81.5%	-91.7%	-18.3%	0.6%	15.1%	1.5%				fuel used
1 A 3 b ii	0.030	0.059	0.017	0.015	-51.4%	-74.8%	-13.6%				0.2%	2.4%	1.0%	fuel sold
	0.030	0.059	0.017	0.015	-51.4%	-74.8%	-13.6%	0.2%	4.4%	1.3%				fuel used
1 A 3 b iii	0.551	0.691	0.075	0.065	-88.2%	-90.6%	-13.1%				3.4%	27.8%	4.6%	fuel sold
	0.152	0.081	0.017	0.013	-91.1%	-83.4%	-19.9%	1.0%	6.1%	1.2%				fuel used
1 A 3 b iv	0.006	0.008	0.010	0.009	54.1%	23.0%	-4.1%				0.0%	0.3%	0.7%	fuel sold
	0.006	0.008	0.010	0.009	54.1%	23.0%	-4.1%	NO	NO	0.8%				fuel used
1 A 3 b v	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 b vi	0.056	0.176	0.142	0.155	177.6%	-11.6%	9.3%				0.3%	7.1%	11.0%	fuel sold
	0.005	0.010	0.013	0.013	139.8%	35.7%	-2.5%	0.0%	0.7%	1.2%				fuel used
1 A 3 b vii	0.033	0.110	0.090	0.099	196.2%	-10.5%	9.4%				0.2%	4.4%	7.0%	fuel sold
	0.004	0.007	0.009	0.009	121.9%	31.3%	-2.7%	0.0%	0.5%	0.8%				fuel used
1 A 3 c	0.059	0.017	0.004	0.004	-93.6%	-77.4%	2.6%	0.4%	1.3%	0.3%	0.4%	0.7%	0.3%	fuel sold
1 A 3 d i (ii)	0.000	0.000	0.000	0.000	-7.4%	-33.8%	-16.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 d ii	0.003	0.002	0.001	0.001	-52.8%	-49.4%	-9.7%	0.0%	0.2%	0.1%	0.0%	0.1%	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
1 A 4 a i	0.020	0.009	0.015	0.016	-21.2%	67.7%	3.2%	0.1%	0.7%	1.4%	0.1%	0.4%	1.1%	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	0.575	0.505	0.517	0.621	8.0%	22.9%	20.0%	3.7%	38.1%	55.8%	3.6%	20.3%	43.9%	fuel sold
1 A 4 b ii	0.000	0.000	0.000	0.000	-18.2%	10.1%	0.7%	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	-73.8%	45.4%	11.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 4 c ii	0.071	0.039	0.014	0.013	-81.9%	-67.4%	-7.0%	0.5%	3.0%	1.2%	0.4%	1.6%	0.9%	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	0.0%	NO	NO	0.0%	NO	NO	fuel sold
1 A 5 b	0.000	0.000	0.000	0.000	-93.8%	-84.8%	-16.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	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	0.035	0.028	0.038	0.032	-6.9%	15.9%	-15.1%	0.2%	2.1%	2.9%	0.2%	1.1%	2.3%	fuel sold
3 B 1 a	0.024	0.016	0.020	0.020	-18.7%	21.6%	-0.1%	0.2%	1.2%	1.8%	0.1%	0.6%	1.4%	fuel sold
3 B 1 b	0.024	0.022	0.024	0.023	-4.2%	1.9%	-3.4%	0.2%	1.7%	2.0%	0.1%	0.9%	1.6%	fuel sold
3 B 2	0.000	0.000	0.000	0.000	23.3%	-12.4%	1.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
3 B 3	0.000	0.000	0.000	0.000	32.1%	-6.0%	-6.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
3 B 4 a	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
3 B 4 d	0.000	0.000	0.000	0.000	963.6%	134.7%	-3.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
3 B 4 e	0.000	0.001	0.001	0.001	170.7%	11.2%	-0.6%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	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	75.4%	60.8%	-0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
3 B 4 g ii	0.000	0.000	0.000	0.000	96.8%	8.6%	5.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	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	-66.0%	-31.6%	-39.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
3 B 4 h	0.000	0.000	0.000	0.000	-63.2%	-45.1%	15.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
3 D a	0.000	0.000	0.000	0.000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	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	4.2%	3.0%	0.3%	0.0%	0.6%	0.7%	0.0%	0.3%	0.6%	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	0.034	0.042	0.075	0.084	150.3%	100.1%	11.6%	0.2%	3.2%	7.6%	0.2%	1.7%	6.0%	fuel sold
6 A	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
National total (fuel sold)	**16.150**	**2.484**	**1.291**	**1.413**	**-91.3%**	**-43.1%**	**9.4%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**15.454**	**1.327**	**1.004**	**1.112**	**-92.8%**	**-16.2%**	**10.8%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

2.2.7 PM_{10} Emissions

National total PM_{10} emissions, based on fuel sold, amounted to 16.6 Gg in 1990 (Figure 2-24). Since then emissions have decreased significantly. In 2005, national total PM_{10} emissions amounted to 3.0 Gg. In the year 2018, emissions were down by 88.1% compared to 1990 to 2.0 Gg, which was mainly due to lower emissions from *1A2a Iron and Steel Industry* and from *1A3b Road Transport*. In the period 2005 to 2018, PM_{10} emissions decreased by 34.7%. From 2017 to 2018, emissions increased by 5.4%.

Figure 2-24 – PM_{10} emission trends based on fuel sold



As shown in Figure 2-24 and Table 44 the main source for PM_{10} emissions in Luxembourg, in the past, was, with a share of 83% in 1990, *1A2a Iron and Steel Industry*. In 2018, the main sources of PM_{10} emissions were, with a share of 32.1% and 29.5%, categories *1A4bi Residential – Stationary* 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.

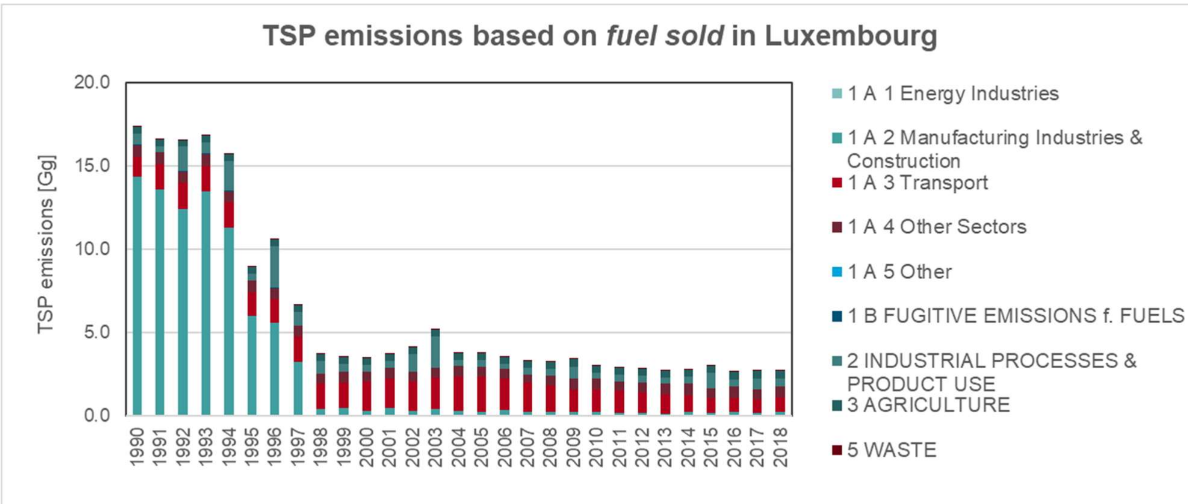
Table 44 – PM_{10} emissions for 1990, 2005, 2017, 2018, Trend & Share in National Total based on Fuel sold and Fuel used

	PM10													
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2017	2018	1990 - 2018	2005 - 2018	2017 - 2018	1990	2005	2018	1990	2005	2018	
1 A 1 a	0.000	0.004	0.049	0.077	196302.8%	1946.8%	56.4%	0.0%	0.2%	5.2%	0.0%	0.1%	3.9%	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	13.769	0.016	0.018	0.018	-99.9%	13.1%	-1.8%	86.8%	0.9%	1.2%	82.8%	0.5%	0.9%	fuel sold
1 A 2 b	0.005	0.034	0.031	0.026	448.7%	-22.6%	-16.5%	0.0%	2.0%	1.8%	0.0%	1.1%	1.3%	fuel sold
1 A 2 c	0.030	0.005	0.005	0.012	-60.0%	143.7%	133.7%	0.2%	0.3%	0.8%	0.2%	0.2%	0.6%	fuel sold
1 A 2 d	NO	0.001	0.000	0.000	0.0%	-79.1%	9.8%	NO	0.0%	0.0%	NO	0.0%	0.0%	fuel sold
1 A 2 e	0.001	0.001	0.003	0.003	118.0%	92.7%	2.9%	0.0%	0.1%	0.2%	0.0%	0.0%	0.1%	fuel sold
1 A 2 f	0.411	0.113	0.046	0.039	-90.5%	-65.6%	-14.8%	2.6%	6.8%	2.6%	2.5%	3.7%	2.0%	fuel sold
1 A 2 g vii	0.094	0.089	0.018	0.016	-83.0%	-82.1%	-11.6%	0.6%	5.4%	1.1%	0.6%	2.9%	0.8%	fuel sold
1 A 2 g viii	0.003	0.006	0.028	0.029	874.1%	377.7%	1.6%	0.0%	0.4%	1.9%	0.0%	0.2%	1.5%	fuel sold
1 A 3 a i (i)	0.001	0.004	0.004	0.004	350.2%	20.8%	8.1%	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	162.9%	-8.0%	-2.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 b i	0.307	0.479	0.040	0.034	-88.8%	-92.8%	-15.3%				1.8%	15.7%	1.7%	fuel sold
	0.090	0.200	0.020	0.017	-81.5%	-91.7%	-18.3%	0.6%	12.0%	1.1%				fuel used
1 A 3 b ii	0.030	0.059	0.017	0.015	-51.4%	-74.8%	-13.6%				0.2%	1.9%	0.7%	fuel sold
	0.030	0.059	0.017	0.015	-51.4%	-74.8%	-13.6%	0.2%	3.5%	1.0%				fuel used
1 A 3 b iii	0.551	0.691	0.075	0.065	-88.2%	-90.6%	-13.1%				3.3%	22.7%	3.3%	fuel sold
	0.152	0.081	0.017	0.013	-91.1%	-83.4%	-19.9%	1.0%	4.9%	0.9%				fuel used
1 A 3 b iv	0.006	0.008	0.010	0.009	54.1%	23.0%	-4.1%				0.0%	0.3%	0.5%	fuel sold
	0.006	0.008	0.010	0.009	54.1%	23.0%	-4.1%	NO	NO	0.6%				fuel used
1 A 3 b v	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 b vi	0.102	0.315	0.255	0.278	172.4%	-11.6%	9.2%				0.6%	10.4%	14.0%	fuel sold
	0.011	0.018	0.026	0.025	132.8%	35.3%	-2.4%	0.1%	1.1%	1.7%				fuel used
1 A 3 b vii	0.062	0.204	0.167	0.183	196.2%	-10.5%	9.4%				0.4%	6.7%	9.2%	fuel sold
	0.008	0.013	0.017	0.017	121.9%	31.3%	-2.7%	0.0%	0.8%	1.1%				fuel used
1 A 3 c	0.059	0.017	0.004	0.004	-93.6%	-77.4%	2.6%	0.4%	1.0%	0.3%	0.4%	0.5%	0.2%	fuel sold
1 A 3 d i (ii)	0.000	0.000	0.000	0.000	-7.4%	-33.8%	-16.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 d ii	0.003	0.002	0.001	0.001	-52.8%	-49.4%	-9.7%	0.0%	0.1%	0.1%	0.0%	0.1%	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
1 A 4 a i	0.020	0.009	0.015	0.016	-21.2%	67.7%	3.2%	0.1%	0.6%	1.0%	0.1%	0.3%	0.8%	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	0.591	0.518	0.530	0.637	7.8%	22.9%	20.1%	3.7%	31.2%	42.6%	3.6%	17.1%	32.1%	fuel sold
1 A 4 b ii	0.000	0.000	0.000	0.000	-18.2%	10.1%	0.7%	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	-73.8%	45.4%	11.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 4 c ii	0.071	0.039	0.014	0.013	-81.9%	-67.4%	-7.0%	0.4%	2.4%	0.9%	0.4%	1.3%	0.6%	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	0.0%	NO	NO	0.0%	NO	NO	fuel sold
1 A 5 b	0.000	0.000	0.000	0.000	-93.8%	-84.8%	-16.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	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	0.186	0.108	0.184	0.132	-29.1%	21.5%	-28.5%	1.2%	6.5%	8.8%	1.1%	3.6%	6.6%	fuel sold
3 B 1 a	0.037	0.025	0.030	0.030	-18.7%	21.6%	-0.1%	0.2%	1.5%	2.0%	0.2%	0.8%	1.5%	fuel sold
3 B 1 b	0.036	0.034	0.036	0.035	-4.5%	1.9%	-3.5%	0.2%	2.0%	2.3%	0.2%	1.1%	1.7%	fuel sold
3 B 2	0.000	0.000	0.000	0.000	23.3%	-12.4%	1.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
3 B 3	0.007	0.010	0.011	0.010	37.8%	-4.8%	-6.9%	0.0%	0.6%	0.7%	0.0%	0.3%	0.5%	fuel sold
3 B 4 a	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
3 B 4 d	0.000	0.000	0.000	0.000	963.6%	134.7%	-3.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
3 B 4 e	0.000	0.001	0.001	0.001	170.7%	11.2%	-0.6%	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%	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	0.004	75.4%	60.8%	-0.3%	0.0%	0.2%	0.3%	0.0%	0.1%	0.2%	fuel sold
3 B 4 g ii	0.000	0.000	0.000	0.000	96.8%	8.6%	5.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	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	-66.0%	-31.6%	-39.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
3 B 4 h	0.000	0.000	0.000	0.000	-27.9%	-30.7%	11.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
3 D a	0.000	0.000	0.000	0.000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
3 D b	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	fuel sold
3 D c	0.197	0.199	0.205	0.205	4.2%	3.0%	0.3%	1.2%	12.0%	13.7%	1.2%	6.6%	10.3%	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	0.034	0.043	0.076	0.085	151.4%	98.5%	11.6%	0.2%	2.6%	5.7%	0.2%	1.4%	4.3%	fuel sold
6 A	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
National total (fuel sold)	**16.629**	**3.039**	**1.881**	**1.983**	**-88.1%**	**-34.7%**	**5.4%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**15.867**	**1.663**	**1.423**	**1.495**	**-90.6%**	**-10.1%**	**5.0%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

2.2.8 **TSP Emissions**

National total TSP emissions, based on fuel sold, amounted to 17.4 Gg in 1990 (Figure 2-25). Since then emissions have decreased steadily. In 2005 national total TSP emissions amounted to 3.8 Gg. In the year 2018, emissions were down by 84% compared to 1990 to 2.8 Gg, which was mainly due to lower emissions in the *1A2a Iron and Steel Industry*. In the period 2005 to 2018, TSP emissions decreased by 26.8%. From 2017 to 2018 emissions increased by 0.2%.

Figure 2-25 – TSP emission trends based on fuel sold



As shown in Figure 2-25 and Table 45, the main source, in the past, for TSP emissions in Luxembourg, with a share of 79.3% in 1990, was *1A2a Iron and Steel Industry*. In 2018, the main sources of TSP emissions, with a share of 31.2% and 24.1%, were categories *1A3b Road Transport* and *1A4bi Residential – Stationary*, 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 45 – TSP emissions for 1990, 2005, 2017, 2018, Trend & Share in National Total based on Fuel sold and Fuel used

NFR Code	TSP Emissions 1990	Emissions 2005	Emissions 2017	Emissions 2018	Trend 1990 - 2018	Trend 2005 - 2018	Trend 2017 - 2018	FUEL USED Share in National Total 1990	FUEL USED 2005	FUEL USED 2018	FUEL SOLD Share in National Total 1990	FUEL SOLD 2005	FUEL SOLD 2018	Fuel option
1 A 1 a	0.000	0.004	0.052	0.081	205643.6%	1992.6%	56.1%	0.0%	0.2%	4.0%	0.0%	0.1%	2.9%	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	13.769	0.016	0.018	0.018	-99.9%	13.1%	-1.8%	83.4%	0.7%	0.9%	79.3%	0.4%	0.6%	fuel sold
1 A 2 b	0.005	0.034	0.031	0.026	448.7%	-22.6%	-16.5%	0.0%	1.6%	1.3%	0.0%	0.9%	0.9%	fuel sold
1 A 2 c	0.030	0.005	0.005	0.012	-60.0%	143.7%	133.7%	0.2%	0.2%	0.6%	0.2%	0.1%	0.4%	fuel sold
1 A 2 d	NO	0.001	0.000	0.000	0.0%	-79.1%	9.8%	NO	0.0%	0.0%	NO	0.0%	0.0%	fuel sold
1 A 2 e	0.001	0.001	0.003	0.003	118.0%	92.7%	2.9%	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%	fuel sold
1 A 2 f	0.412	0.114	0.046	0.039	-90.5%	-65.7%	-14.5%	2.5%	5.4%	1.9%	2.4%	3.0%	1.4%	fuel sold
1 A 2 g vii	0.094	0.089	0.018	0.016	-83.0%	-82.1%	-11.6%	0.6%	4.2%	0.8%	0.5%	2.4%	0.6%	fuel sold
1 A 2 g viii	0.003	0.006	0.028	0.029	857.0%	377.7%	1.6%	0.0%	0.3%	1.4%	0.0%	0.2%	1.0%	fuel sold
1 A 3 a i (i)	0.001	0.004	0.004	0.004	350.2%	20.8%	8.1%	0.0%	0.2%	0.2%	0.0%	0.1%	0.2%	fuel sold
1 A 3 a ii (i)	0.000	0.000	0.000	0.000	162.9%	-8.0%	-2.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 b i	0.307	0.479	0.040	0.034	-88.8%	-92.8%	-15.3%				1.8%	12.6%	1.2%	fuel sold
	0.090	0.200	0.020	0.017	-81.5%	-91.7%	-18.3%	0.5%	9.4%	0.8%				fuel used
1 A 3 b ii	0.030	0.059	0.017	0.015	-51.4%	-74.8%	-13.6%				0.2%	1.5%	0.5%	fuel sold
	0.030	0.059	0.017	0.015	-51.4%	-74.8%	-13.6%	0.2%	2.8%	0.7%				fuel used
1 A 3 b iii	0.551	0.691	0.075	0.065	-88.2%	-90.6%	-13.1%				3.2%	18.2%	2.3%	fuel sold
	0.152	0.081	0.017	0.013	-91.1%	-83.4%	-19.9%	0.9%	3.8%	0.7%				fuel used
1 A 3 b iv	0.006	0.008	0.010	0.009	54.1%	23.0%	-4.1%				0.0%	0.2%	0.3%	fuel sold
	0.006	0.008	0.010	0.009	54.1%	23.0%	-4.1%	0.0%	0.4%	0.5%				fuel used
1 A 3 b v	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 b vi	0.137	0.429	0.347	0.379	176.9%	-11.6%	9.3%				0.8%	11.3%	13.6%	fuel sold
	0.013	0.024	0.033	0.032	138.9%	35.6%	-2.5%	0.1%	1.1%	1.6%				fuel used
1 A 3 b vii	0.124	0.409	0.334	0.366	196.2%	-10.5%	9.4%				0.7%	10.8%	13.2%	fuel sold
	0.015	0.026	0.035	0.034	121.9%	31.3%	-2.7%	0.1%	1.2%	1.7%				fuel used
1 A 3 c	0.059	0.017	0.004	0.004	-93.6%	-77.4%	2.6%	0.4%	0.8%	0.2%	0.3%	0.4%	0.1%	fuel sold
1 A 3 d i (ii)	0.000	0.000	0.000	0.000	-7.4%	-33.8%	-16.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 d ii	0.003	0.002	0.001	0.001	-52.8%	-49.4%	-9.7%	0.0%	0.1%	0.1%	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
1 A 4 a i	0.001	0.002	0.002	0.002	47.6%	5.7%	10.8%	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	0.558	0.670	6.6%	22.8%	20.1%	3.8%	25.7%	33.0%	3.6%	14.4%	24.1%	fuel sold
1 A 4 b ii	0.000	0.000	0.000	0.000	-18.2%	10.1%	0.7%	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	-73.8%	45.4%	11.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 4 c ii	0.071	0.039	0.014	0.013	-81.9%	-67.4%	-7.0%	0.4%	1.9%	0.6%	0.4%	1.0%	0.5%	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	0.0%	NO	NO	0.0%	NO	NO	fuel sold
1 A 5 b	0.000	0.000	0.000	0.000	-93.8%	-84.8%	-16.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	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	0.652	0.383	0.641	0.467	-28.3%	21.9%	-27.2%	3.9%	18.1%	23.0%	3.8%	10.1%	16.8%	fuel sold
3 B 1 a	0.081	0.054	0.066	0.066	-18.7%	21.6%	-0.1%	0.5%	2.6%	3.2%	0.5%	1.4%	2.4%	fuel sold
3 B 1 b	0.079	0.074	0.078	0.075	-4.4%	1.9%	-3.5%	0.5%	3.5%	3.7%	0.5%	1.9%	2.7%	fuel sold
3 B 2	0.001	0.001	0.001	0.001	23.3%	-12.4%	1.5%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	fuel sold
3 B 3	0.046	0.071	0.074	0.068	49.8%	-3.3%	-7.2%	0.3%	3.3%	3.4%	0.3%	1.9%	2.5%	fuel sold
3 B 4 a	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
3 B 4 d	0.000	0.000	0.001	0.001	963.6%	134.7%	-3.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
3 B 4 e	0.001	0.002	0.002	0.002	170.7%	11.2%	-0.6%	0.0%	0.1%	0.1%	0.0%	0.1%	0.1%	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	0.019	0.019	75.4%	60.8%	-0.3%	0.1%	0.6%	0.9%	0.1%	0.3%	0.7%	fuel sold
3 B 4 g ii	0.000	0.001	0.001	0.001	96.8%	8.6%	5.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	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	-66.0%	-31.6%	-39.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
3 B 4 h	0.000	0.000	0.000	0.000	-52.3%	-40.0%	14.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
3 D a	0.000	0.000	0.000	0.000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
3 D b	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	fuel sold
3 D c	0.197	0.199	0.205	0.205	4.2%	3.0%	0.3%	1.2%	9.4%	10.1%	1.1%	5.2%	7.4%	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	0.034	0.044	0.077	0.086	152.8%	96.5%	11.5%	0.2%	2.1%	4.2%	0.2%	1.2%	3.1%	fuel sold
6 A	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
National total (fuel sold)	**17.365**	**3.797**	**2.775**	**2.781**	**-84.0%**	**-26.8%**	**0.2%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**16.517**	**2.121**	**2.083**	**2.032**	**-87.7%**	**-4.2%**	**-2.4%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

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 2018.

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 network.

Process related emissions from industrial activities are included 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 2018, 100% of total SO_2 and CO emissions and 94-98% of total NO_X emissions arose from category *1A – Fuel Combustion* (see Table 46). Whereas in 1990, about 93%-99% of national total $PM_{2.5}$, PM_{10} and TSP emissions arose from category *1A – Fuel Combustion*, in 2018, the share diminished to 88%, 75% and 64%, respectively. In 1990, about 69% of national total NMVOC emissions arose from category *1A – Fuel Combustion*, the share diminished to 33% in 2005 and 20% in 2018. In 1990, from category *1A – Fuel Combustion* was responsible of 1% of national total NH_3 emissions, the share increased to about 10% in 2005 and about 6% in 2018.

Table 46 – Emissions (1990, 2005, 2017 and 2018), Trend and Share of air pollutant emissions based on fuel sold and fuel used – *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	2017	2018	1990 - 2018	2005 - 2018	2017 - 2018	1990	2005	2018	1990	2005	2018	
SOx	15.76	2.42	1.00	0.96	-93.9%	-60.2%	-3.8%				100.0%	100.0%	100.0%	fuel sold
	14.95	2.38	0.98	0.94	-93.7%	-60.7%	-4.1%	100.0%	100.0%	100.0%				fuel used
NOx	39.88	54.86	21.18	19.33	-52%	-65%	-9%				97%	98%	94%	fuel sold
	21.65	16.68	12.63	11.62	-46.3%	-30.4%	-8.0%	93.9%	93.7%	91.1%				fuel used
NMVOC	18.93	4.82	1.98	2.02	-89.3%	-58.1%	2.3%				68.7%	32.7%	19.5%	fuel sold
	9.71	2.31	1.55	1.59	-83.6%	-31.0%	2.9%	52.9%	18.9%	16.0%				fuel used
NH3	0.06	0.61	0.29	0.33	454.7%	-45.0%	14.9%				0.9%	9.9%	5.6%	fuel sold
	0.05	0.23	0.18	0.21	301.3%	-9.0%	15.3%	0.8%	4.0%	3.6%				fuel used
CO	468.68	35.98	22.53	20.53	-95.6%	-43.0%	-8.9%				100.0%	99.9%	99.9%	fuel sold
TSP	16.23	2.95	1.61	1.79	-89.0%	-39.5%	11.1%				93.5%	77.8%	64.3%	fuel sold
PM10	16.12	2.61	1.33	1.48	-90.8%	-43.4%	11.1%				96.9%	86.0%	74.6%	fuel sold
PM2.5	16.02	2.37	1.12	1.24	-92.2%	-47.4%	10.6%				99.2%	95.3%	88.1%	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 47). 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 2018, 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 $PM_{2.5}$ 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 sub-category (*1A4 – Other Sectors*), the energy production sub-category (*1A1 – Energy*) and sub-category *1A5 – Other*, which includes emissions from other non-specified sources (mainly mobile military machinery).

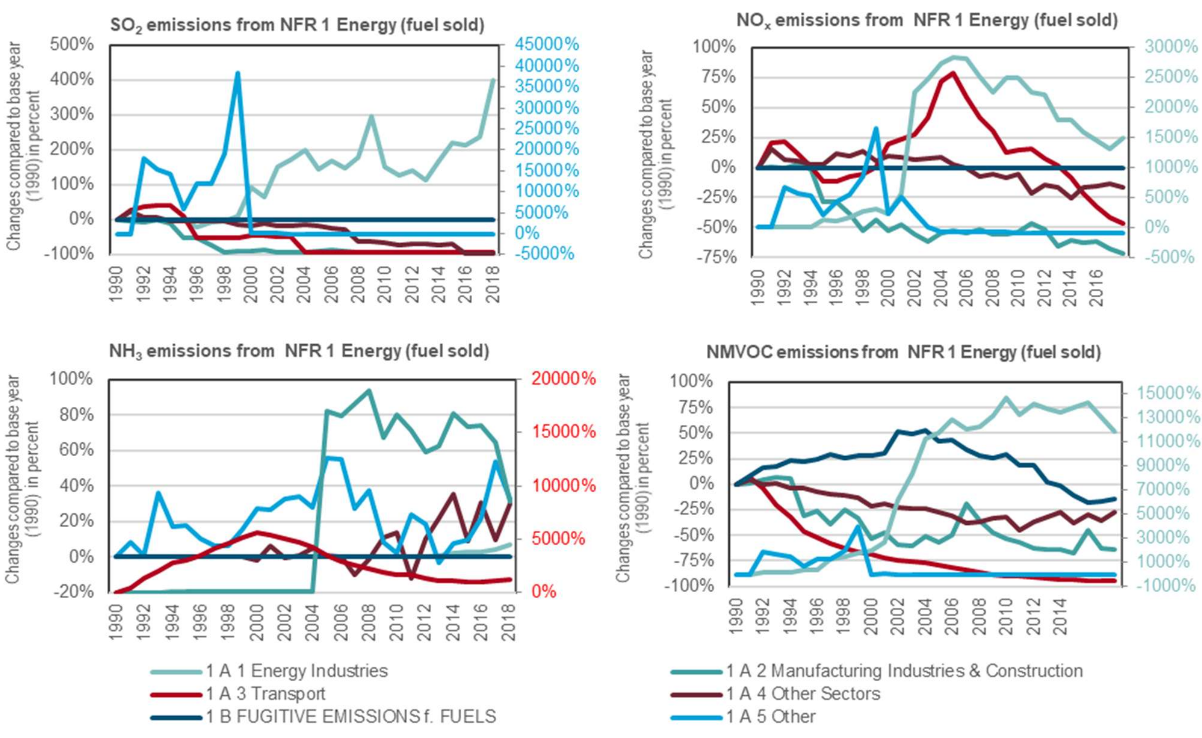
As presented in Table 47, in 2018, a reduction of more than 93% of SO_2 emissions compared to the base year (1990) could be achieved by almost all sub-categories except for energy production (*1A1 – Energy Production*) where an increase of 400% can be observed due to the installation of new centralised district heating and power plants during that period. The emission reductions could be realised by (a) enforcement of different laws and regulation regarding sulphur content in fuels and in waste gas, (b) implementation of extensive abatement technologies, (c) fuel switch, and (d) process changes in the manufacturing industry.

In the period 2005 – 2018, an increase of 103% of SO_2 emissions was observed in the energy producing sector (*1A1 – Energy Production*), whereas in the same period a reduction of 29%, 5.5% and 97% 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.

As shown in Figure 3-1, Figure 3-3 and Table 47, in 2018, a reduction of about 71% 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 47% in the same period, and combustion emissions in the commercial and residential sector (*1A4 – Other Sectors*) were reduced by 16%. 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 1501% 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 – 2018, 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 45.5%. The NO_X emissions of the industrial sector (*1A2 – Manufacturing Industries and Construction*) could be reduced by 39% 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 NOx emissions was mainly due to increasing activities (mileage and vehicle fleet) in the transport sector. After the peak in 2005, the observed decrease 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 3-1 – Changes of Emissions of SO_2, NO_X, NMVOC and NH_3 compared to base year (1990) based on fuel sold for NFR sector *1-Energy*



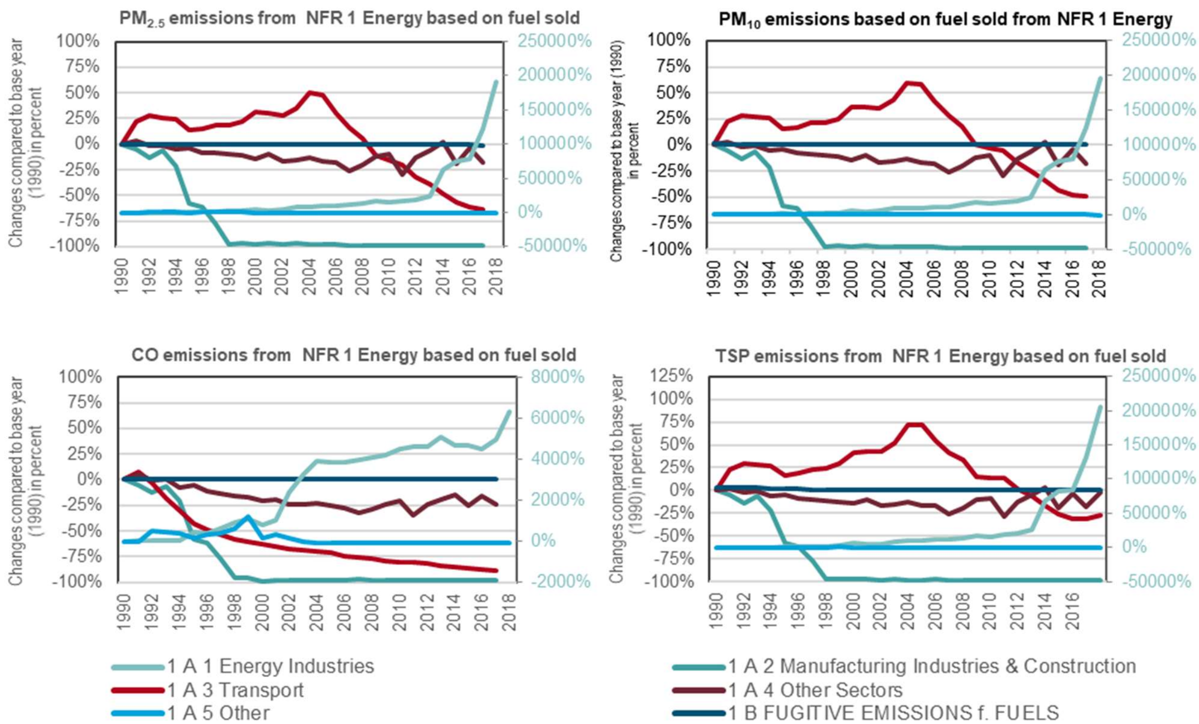
Source: Environment Agency.

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

3-2, Table 47). The overall reduction trend was partially absorbed by increasing PM emission in the transport sector (*1A3 – Transport*).

The overall reduction of about 96% 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*) (-98.6%) in the 1990s through closing down the pig iron production sites. In the period 1990 – 2018, a reduction (-88%) 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.

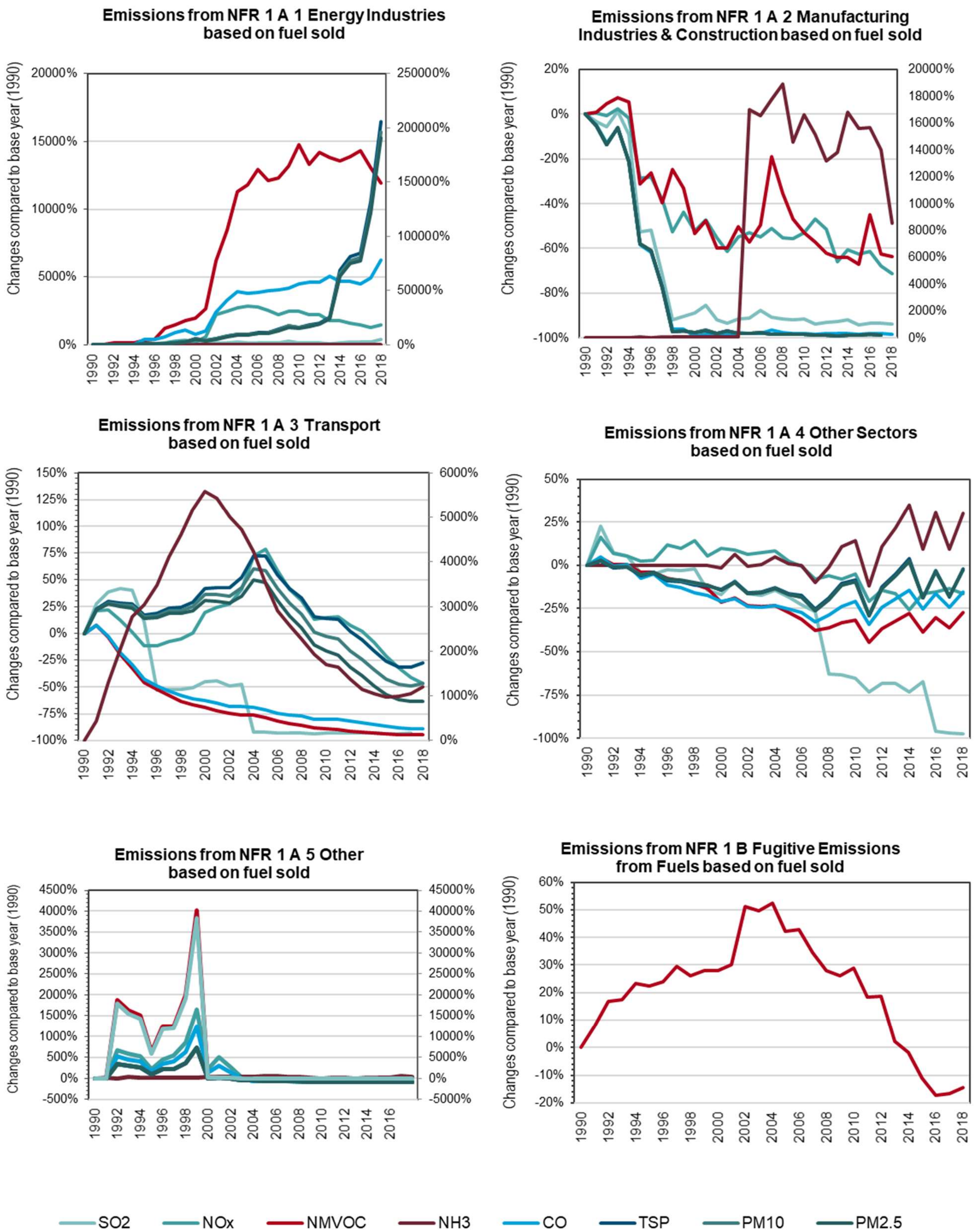
Figure 3-2 – Changes of Emissions of CO, $PM_{2.5}$, PM_{10} and TSP compared to base year (1990) based on fuel sold for NFR sector *1-Energy*



Source: Environment Agency.

Figure 3-3 presents the emission trends of the air pollutant emissions compared to the base year (1990) per category. The increasing emission in sub-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.

Figure 3-3 – Changes of Emissions compared to base year (1990) based on fuel sold per sub-category for category *1A - Fuel Combustion Activities*



Source: Environment Agency.

Table 47 – Emissions (1990, 2005, 2017 and 2018), 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	2017	2018	1990 - 2018	2005 - 2018	2017 - 2018	1990	2005	2018	1990	2005	2018	
SOx	**1 A**	**15.76**	**2.42**	**1.00**	**0.96**	**-93.9%**	**-60.2%**	**-3.8%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**fuel sold**
	1 A 1	0.00	0.01	0.01	0.02	400.2%	103.3%	48.5%	0.0%	0.4%	2.2%	0.0%	0.4%	2.2%	fuel sold
	1 A 2	13.24	1.16	0.87	0.82	-93.8%	-28.9%	-5.1%	88.6%	48.6%	87.8%	84.0%	47.8%	85.5%	fuel sold
	1 A 3	1.09	0.09	0.08	0.08	-92.6%	-5.5%	7.4%	1.8%	2.0%	5.9%	6.9%	3.5%	8.4%	fuel sold
	1 A 4	1.43	1.17	0.04	0.04	-97.4%	-96.8%	-13.0%	9.6%	49.0%	4.0%	9.1%	48.2%	3.9%	fuel sold
	1 A 5	0.00	0.00	0.00	0.00	-99.5%	-79.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
NOx	**1 A**	**39.88**	**54.86**	**21.18**	**19.33**	**-51.5%**	**-64.8%**	**-8.7%**	**93.9%**	**93.7%**	**91.1%**	**96.6%**	**98.0%**	**94.5%**	**fuel sold**
	1 A 1	0.03	0.97	0.46	0.53	1501.3%	-45.5%	13.4%	0.1%	5.4%	4.1%	0.1%	1.7%	2.6%	fuel sold
	1 A 2	12.11	5.71	3.88	3.47	-71.3%	-39.3%	-10.5%	52.5%	32.1%	27.2%	29.3%	10.2%	17.0%	fuel sold
	1 A 3	25.92	46.33	15.27	13.82	-46.7%	-70.2%	-9.5%	33.4%	45.8%	47.9%	62.8%	82.8%	67.5%	fuel sold
	1 A 4	1.81	1.85	1.57	1.52	-16.3%	-18.1%	-3.5%	7.8%	10.4%	11.9%	4.4%	3.3%	7.4%	fuel sold
	1 A 5	0.00	0.00	0.00	0.00	-91.0%	-69.2%	-11.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
NMVOC	**1 A**	**18.93**	**4.82**	**1.98**	**2.02**	**-89.3%**	**-58.1%**	**2.3%**	**52.9%**	**18.9%**	**16.0%**	**68.7%**	**32.7%**	**19.5%**	**fuel sold**
	1 A 1	0.00	0.14	0.15	0.14	11898.8%	0.7%	-8.9%	0.0%	1.1%	1.4%	0.0%	0.9%	1.3%	fuel sold
	1 A 2	0.85	0.36	0.32	0.31	-63.7%	-15.0%	-2.7%	4.6%	3.0%	3.1%	3.1%	2.5%	3.0%	fuel sold
	1 A 3	17.13	3.63	0.90	0.88	-94.9%	-75.7%	-2.0%	43.1%	9.1%	4.5%	62.1%	24.6%	8.5%	fuel sold
	1 A 4	0.96	0.70	0.61	0.70	-27.2%	0.2%	13.9%	5.2%	5.7%	7.0%	3.5%	4.7%	6.7%	fuel sold
	1 A 5	0.00	0.00	0.00	0.00	-83.5%	-68.1%	-8.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
NH3	**1 A**	**0.06**	**0.61**	**0.29**	**0.33**	**454.7%**	**-45.0%**	**14.9%**	**0.8%**	**4.0%**	**3.6%**	**0.9%**	**9.9%**	**5.6%**	**fuel sold**
	1 A 1	NO	0.00	0.04	0.07	6.8%	3851.7%	51.3%	NO	0.0%	1.2%	NO	0.0%	1.2%	fuel sold
	1 A 2	0.00	0.03	0.03	0.02	8553.8%	-49.4%	-38.8%	0.0%	0.6%	0.3%	0.0%	0.5%	0.3%	fuel sold
	1 A 3	0.01	0.53	0.17	0.19	1206.4%	-64.0%	12.6%	0.1%	2.6%	1.1%	0.2%	8.6%	3.2%	fuel sold
	1 A 4	0.05	0.05	0.05	0.06	30.1%	29.2%	19.0%	0.7%	0.8%	1.0%	0.7%	0.7%	1.0%	fuel sold
	1 A 5	0.00	0.00	0.00	0.00	32.4%	-15.1%	-13.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
CO	**1 A**	**468.68**	**35.98**	**22.53**	**20.53**	**-95.6%**	**-43.0%**	**-8.9%**	**99.9%**	**88.8%**	**90.6%**	**100.0%**	**99.9%**	**99.9%**	**fuel sold**
	1 A 1	0.01	0.30	0.38	0.48	6287.5%	62.7%	26.2%	0.0%	1.5%	3.2%	0.0%	0.8%	2.3%	fuel sold
	1 A 2	377.49	7.04	7.86	5.38	-98.6%	-23.6%	-31.6%	89.3%	36.9%	36.0%	80.5%	19.6%	26.2%	fuel sold
	1 A 3	85.17	24.17	9.75	9.60	-88.7%	-60.3%	-1.6%	9.3%	37.9%	26.7%	18.2%	67.1%	46.7%	fuel sold
	1 A 4	6.01	4.47	4.54	5.07	-15.6%	13.3%	11.7%	1.3%	12.4%	24.7%	1.3%	12.4%	24.7%	fuel sold
	1 A 5	0.00	0.00	0.00	0.00	-82.0%	-48.5%	-1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
TSP	**1 A**	**16.23**	**2.95**	**1.61**	**1.79**	**-89.0%**	**-39.5%**	**11.1%**	**92.9%**	**48.0%**	**42.0%**	**93.5%**	**77.8%**	**64.3%**	**fuel sold**
	1 A 1	0.00	0.00	0.05	0.08	205643.6%	1992.6%	56.1%	0.0%	0.2%	4.0%	0.0%	0.1%	2.9%	fuel sold
	1 A 2	14.31	0.27	0.15	0.14	-99.0%	-46.4%	-4.6%	86.7%	12.5%	7.0%	82.4%	7.0%	5.1%	fuel sold
	1 A 3	1.22	2.10	0.83	0.88	-27.9%	-58.1%	5.4%	2.2%	19.8%	6.4%	7.0%	55.2%	31.6%	fuel sold
	1 A 4	0.70	0.59	0.57	0.69	-2.3%	16.7%	19.4%	4.0%	15.5%	24.6%	4.0%	15.5%	24.6%	fuel sold
	1 A 5	0.00	0.00	0.00	0.00	-94.3%	-84.8%	-16.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
PM10	**1 A**	**16.12**	**2.61**	**1.33**	**1.48**	**-90.8%**	**-43.4%**	**11.1%**	**96.6%**	**59.0%**	**55.3%**	**96.9%**	**86.0%**	**74.6%**	**fuel sold**
	1 A 1	0.00	0.00	0.05	0.08	196302.8%	1946.8%	56.4%	0.0%	0.2%	5.2%	0.0%	0.1%	3.9%	fuel sold
	1 A 2	14.31	0.27	0.15	0.14	-99.0%	-46.3%	-4.7%	90.2%	15.9%	9.5%	86.1%	8.7%	7.2%	fuel sold
	1 A 3	1.12	1.78	0.57	0.59	-47.0%	-66.6%	3.6%	2.3%	24.1%	7.1%	6.7%	58.5%	30.0%	fuel sold
	1 A 4	0.68	0.57	0.56	0.67	-2.4%	17.3%	19.0%	4.1%	18.7%	33.6%	4.1%	18.7%	33.6%	fuel sold
	1 A 5	0.00	0.00	0.00	0.00	-94.3%	-84.8%	-16.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
PM2.5	**1 A**	**16.02**	**2.37**	**1.12**	**1.24**	**-92.2%**	**-47.4%**	**10.6%**	**99.2%**	**91.1%**	**84.8%**	**99.2%**	**95.3%**	**88.1%**	**fuel sold**
	1 A 1	0.00	0.00	0.05	0.08	190501.8%	1930.3%	56.4%	0.0%	0.3%	6.8%	0.0%	0.1%	5.3%	fuel sold
	1 A 2	14.31	0.26	0.15	0.13	-99.1%	-49.9%	-9.7%	92.6%	19.9%	11.9%	88.6%	10.6%	9.4%	fuel sold
	1 A 3	1.05	1.54	0.38	0.39	-63.0%	-74.9%	0.8%	2.3%	29.2%	7.7%	6.5%	62.2%	27.4%	fuel sold
	1 A 4	0.67	0.55	0.55	0.65	-2.5%	17.2%	18.9%	4.3%	41.8%	58.4%	4.1%	22.3%	46.0%	fuel sold
	1 A 5	0.00	0.00	0.00	0.00	-94.3%	-84.8%	-16.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold

Source: Environment Agency.

3.1.2 **Completeness**

Table 48 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 48 – 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
		NA	X	NA	NA	NA	NA	NA	NA	fuel used
1 A 3 b vi	R.T., Automobile tyre and break wear	NA	NA	NA	NA	NA	X	X	X	fuel sold
		NA	NA	NA	NA	NA	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
		NA	NA	NA	NA	NA	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

Source: 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 49 presents the key category analysis for *1A – Fuel Combustion Activities*. Due to the intensity of combustion activities most air pollutants are presented 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 49 – 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				7							8		6		5	
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	2	1		1					2	1		1		1		1
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	1	2	3	8											7	
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion i			5	5												
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Cor	3															
1 A 3 a i (i)	Civil Aviation - Domestic - LTO			7	6												
1 A 3 b i	Road Transport, Passenger cars			1	3	7	1		2	1	3						
1 A 3 b ii	Road Transport, Light duty vehicles			4	4												
1 A 3 b iii	Road Transport, Heavy duty vehicles			2	2				6	4	4			7		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	3	2	3
1 A 3 b vii	Road Transport, Automobile road abrasion											3	4	4		3	
1 A 4 b i	Residential: stationary			6		6				3	2	1	2	1	2	1	2
1 A 4 b ii	Residential: Household and gardening (mobile)									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			10	7					3	
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	2	1	8	1						1
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals									6	
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	1	2	2	4					4	
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction			4	6						
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	3								5	
1 A 3 a i (i)	Civil Aviation - Domestic - LTO			7	5						
1 A 3 b i	Road Transport, Passenger cars			1	2		1		5		
1 A 3 b ii	Road Transport, Light duty vehicles			3	3						
1 A 3 b iii	Road Transport, Heavy duty vehicles			5	8						
1 A 3 b v	Road Transport, Gasoline evaporation						3				
1 A 4 a i	Commercial/Institutional: Stationary			9							
1 A 4 b i	Residential: stationary			6		6	7			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, …)

3.2.1 Country specific issues

3.2.1.1 Activity data

Activity data are taken from the energy balance (2000-2017) 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). Customs and Excise Administration provide data on liquid fuels and biofuels which are used for QA/QC purposes. Activity data obtained through the Emission Trading System (ETS) are used for QA/QC procedures by comparing its 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. When the quality of such data is assured by a well-developed QA/QC system and the activity data and emission reports have been verified by an independent auditing scheme, it is good practice to use such data. 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 was 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 50).

Table 50 – Fuel Properties for 2018

Fuel Characteristics for 2018 *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	10.10	GJ/t	*ETS*			
Humid sewage sludge	2.15	GJ/t	*ETS*			
Fluff	22.50	GJ/t	*ETS*			
Waste solvents	29.86	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*
Biogaz	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.)[40], operates the national natural gas network (Figure 3-4). 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.

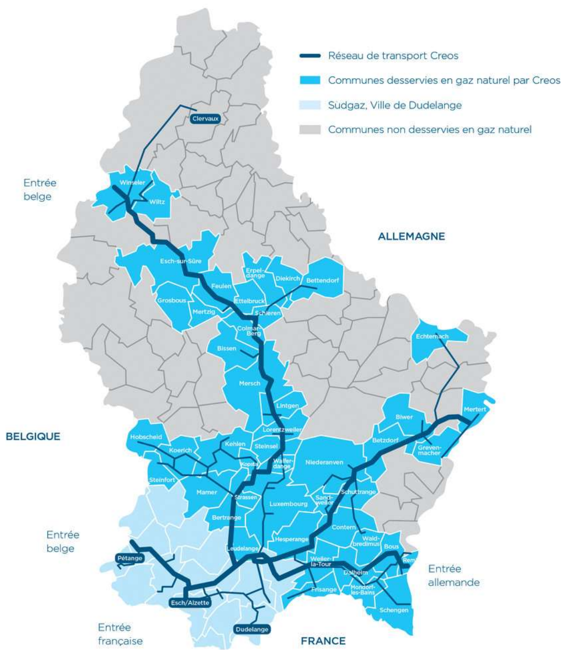
[40] http://www.creos.lu

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). [41]

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 [42]. The CS-NCV is then derived by dividing the yearly consumption expressed in TJ by the yearly consumption expressed in Nm^3.

Figure 3-4 – Natural gas network



Source: Creos

A country-specific NCV has, thus, been obtained for the years 1991, 1995, 2000, 2005-2017 (Table 51). For the years in-between, the values have been interpolated.

Table 51 – Country-specific NCV for Natural Gas: 1990-2018

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**	
NCV (MJ/Nm^3)	36.73	36.56	36.38	36.19	36.30	36.81	36.93	36.98	36.76	

Source: Environment Agency

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

42 IEA Energy Statistics Manual, 2005, Table A3.12, p.183

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 2018. For diesel oil and motor gasoline, for the period 2001-2018, data (based on measurements) was taken from the Fuel Quality Monitoring System reporting obligation[43]. Sulphur contents are then derived into SO_2 emission factors. Table 52 lists the SO_2 emissions factors used per fuel and year.

Table 52 – Country-specific SO_2 Emission Factors for the period 1990-2018 (gSO_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**	
Residual Oil	499.52	365.85	374.64	422.10	437.92	469.55	469.55	469.55	469.55	
Gas Oil	45.41	39.90	42.99	42.28	41.26	41.26	1.02	0.83	0.72	
Diesel Oil	0.38	0.34	0.36	0.37	0.31	0.35	0.35	0.33	0.34	
Motor Gasoline	0.31	0.21	0.26	0.23	0.21	0.19	0.19	0.19	0.23	
LPG	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	

Source: Environment Agency

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

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

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 53 – Emissions (1990, 2005, 2017 and 2018), Trend and Share of air pollutants based on fuel sold and fuel used – *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	2017	2018	1990 - 2018	2005 - 2018	2017 - 2018	1990	2005	2018	1990	2005	2018	
SO_X	0.00	0.01	0.01	0.02	400.2%	103.3%	48.5%	0.0%	0.4%	2.2%	0.0%	0.4%	2.2%	fuel sold
NOx	0.03	0.97	0.46	0.53	1501%	-45.5%	13.4%	0.1%	5.4%	4.1%	0.1%	1.7%	2.6%	fuel sold
NMVOC	0.00	0.14	0.15	0.14	11898.8%	0.7%	-8.9%	0.0%	1.1%	1.4%	0.0%	0.9%	1.3%	fuel sold
NH3	NO	0.00	0.04	0.07	6.8%	3851.7%	51.3%	NO	0.0%	1.2%	NO	0.0%	1.2%	fuel sold
CO	0.01	0.30	0.38	0.48	6287.5%	62.7%	26.2%	0.0%	1.5%	3.2%	0.0%	0.8%	2.3%	fuel sold
TSP	0.00	0.00	0.05	0.08	205643.6%	1992.6%	56.1%	0.0%	0.2%	4.0%	0.0%	0.1%	2.9%	fuel sold
PM10	0.00	0.00	0.05	0.08	196302.8%	1946.8%	56.4%	0.0%	0.2%	5.2%	0.0%	0.1%	3.9%	fuel sold
PM2.5	0.00	0.00	0.05	0.08	190501.8%	1930.3%	56.4%	0.0%	0.3%	6.8%	0.0%	0.1%	5.3%	fuel sold

Source: Environment Agency.

Table 53 summarizes emissions of air pollutants for sub-category *1A1a*, Table 55 presents the emission trends for the period 1990 – 2018.

In 2018, this source category represented, based on fuel sold:

- 2.2% of national total SO_x emissions,
- 2.6% of national total NO_X emissions,
- 1.3% of national total NMVOC emissions,
- 1.2% of national total NH_3 emissions,
- 5.3% of national total $PM_{2.5}$ emissions.

Compared to 2017, all pollutants, except for NMVOC, increased between 13% and 56%. NMVOC decreased by 9%. The increase in emissions is mainly 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 2018.

Category *1A1a – Public electricity and heat production* is a key category for NO_X emissions (LA & TA) in 2018 (see Table 54 and also Table 49 in Section 3.2 and Chapter 1.5).

Table 54 – 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				7							8		6		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			10	7					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, …)

Table 55 – Emission trends for category *1A1a - Public electricity and heat production*

Year	1A1 - Energy Industries. Emissions of air pollutants (Gg). 1A1a - Public Electricity & Heat Production							
	SO2	*NOx*	*NMVOC*	*NH3*	*CO*	*TSP*	*PM10*	*PM2.5*
1990	0.004	0.033	0.001	NO	0.008	0.000	0.000	0.000
1991	0.004	0.034	0.001	NO	0.008	0.000	0.000	0.000
1992	0.004	0.037	0.003	NO	0.009	0.000	0.000	0.000
1993	0.004	0.035	0.003	NO	0.008	0.000	0.000	0.000
1994	0.004	0.034	0.003	NO	0.008	0.000	0.000	0.000
1995	0.004	0.075	0.005	NO	0.039	0.001	0.001	0.001
1996	0.003	0.068	0.006	NO	0.038	0.001	0.001	0.001
1997	0.004	0.090	0.015	NO	0.054	0.001	0.001	0.001
1998	0.004	0.120	0.018	NO	0.077	0.001	0.001	0.001
1999	0.005	0.136	0.022	0.000	0.089	0.001	0.001	0.001
2000	0.008	0.108	0.024	0.000	0.067	0.002	0.002	0.002
2001	0.007	0.220	0.032	0.000	0.086	0.002	0.002	0.001
2002	0.010	0.773	0.072	0.000	0.188	0.002	0.002	0.002
2003	0.011	0.847	0.098	0.001	0.254	0.003	0.003	0.003
2004	0.012	0.935	0.130	0.001	0.301	0.004	0.004	0.004
2005	0.010	0.966	0.137	0.002	0.295	0.004	0.004	0.004
2006	0.011	0.956	0.149	0.002	0.297	0.004	0.004	0.004
2007	0.010	0.863	0.140	0.002	0.308	0.005	0.004	0.004
2008	0.012	0.772	0.142	0.003	0.313	0.006	0.005	0.005
2009	0.016	0.850	0.152	0.004	0.322	0.007	0.007	0.006
2010	0.010	0.850	0.170	0.004	0.347	0.006	0.006	0.006
2011	0.009	0.772	0.154	0.004	0.353	0.007	0.007	0.007
2012	0.010	0.763	0.164	0.004	0.355	0.008	0.008	0.007
2013	0.009	0.623	0.160	0.007	0.390	0.010	0.010	0.010
2014	0.011	0.621	0.157	0.025	0.360	0.027	0.026	0.025
2015	0.013	0.554	0.160	0.029	0.360	0.032	0.031	0.030
2016	0.013	0.509	0.165	0.030	0.345	0.033	0.032	0.031
2017	0.014	0.464	0.151	0.045	0.380	0.052	0.049	0.048
2018	0.021	0.527	0.138	0.068	0.480	0.081	0.077	0.075
Trend 1990-2018	*400.22%*	*1501.29%*	*11898.81%*	*NA*	*6287.54%*	*205643.62%*	*196302.77%*	*190501.79%*
2005-2018	*103.31%*	*-45.47%*	*0.73%*	*3851.69%*	*62.65%*	*1992.64%*	*1946.84%*	*1930.33%*
2017-2018	*48.46%*	*13.43%*	*-8.90%*	*51.33%*	*26.17%*	*56.14%*	*56.38%*	*56.39%*

Source: Environment Agency.

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 (350MWe) 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. Since 2011 however, heat recovery is done and the installation is 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 and/or gas oil and high calorific municipal solid waste (MSW). MSW incinerated is composed of paper/cardboard, textiles, food waste, wood, garden & park waste, nappies, rubber & leather, plastics, multilayer composite material, metal, glass, other inert waste. The MSW is untreated and partially split into a high calorific fraction which is incinerated and a low calorific fraction which is deposited on land.[44] No industrial and hazardous wastes are incinerated because they are exported. Activity data on municipal waste composition are taken from the following studies and for the years in-between a linear interpolation was carried out.

  For 1990-2001, the composition is calculated based on:

  - Waste Division of the Environment Agency, "Restabfallanalyse 2001 im SIDOR", Luxembourg, 2002;
  - Waste Division of the Environment Agency, "Restabfallanalyse 1992/1994", Luxembourg, 2002.

  For 2002-2018, MSW fractions are calculated similarly based on the following waste composition analysis:

  - Waste Division of the Environment Agency, "Restabfallanalyse 2013/14 im Großherzogtum Luxemburg, Band 1: Kompendium", Luxembourg, 2016;
  - Waste Division of the Environment Agency, "Restabfallanalyse 2009/10 im Großherzogtum Luxemburg, Band 1: Kompendium", Luxembourg, 2010;
  - Waste Division of the Environment Agency, "Restabfallanalyse 2004/05 im Großherzogtum Luxemburg, Band 1: Kompendium", Luxembourg, 2005;

  However, one part of the waste incinerated originates from a pre-treatment plant (MBA Fridhaff), where a high calorific fraction is sorted out for incineration. The rest is disposed of on landfill sites. The composition of the high calorific faction is calculated based on the following studies :

  - Air & Noise Division of the Environment Agency, " Estimation of emitted greenhouse gases by the selected high calorific fraction from SIDEC being incinerated ", Luxembourg, 2010
  - Air & Noise Division of the Environment Agency, "Estimation of emitted greenhouse gases by the selected high calorific fraction from SIDEC being incinerated", Luxembourg, 2016

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

[44] For the different waste treatment schemes, see NIR Chapter 8 on waste.

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 56 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 2018. 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 56 – 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	1 213 293	NO	NO	NO	877 003	336'290
1991	1 269 447	NO	NO	NO	917 593	351'854
1992	1 282 780	NO	NO	NO	931 942	350'838
1993	1 221 173	NO	NO	NO	887 411	333'762
1994	1 195 144	NO	NO	NO	868 596	326'548
1995	2 187 248	NO	NO	1'043'100	832 290	311'859
1996	1 874 986	900	NO	984'600	648 213	241'274
1997	2 078 487	18'919	NO	1'013'400	760 358	285'810
1998	3 011 697	30'783	NO	1'709'100	687 092	584'722
1999	3 367 501	31'593	NO	1'883'700	782 767	669'441
2000	2 369 052	20'688	NO	920'854	777 172	650'338
2001	5 268 396	35'178	NO	3'808'343	782 746	642'130
2002	18 514 236	29'574	NO	17'031'071	800 879	652'711
2003	18 652 612	19'538	NO	17'102'526	899 751	630'796
2004	22 494 535	20'625	NO	20'850'220	931 279	692'412
2005	22 257 043	20'818	NO	20'647'091	962 615	626'519
2006	23 315 217	15'513	NO	21'624'432	999 055	676'217
2007	21 267 604	17'189	NO	19'508'383	1 052 385	689'647
2008	18 040 937	31'857	NO	16'205'838	1 088 938	714'304
2009	21 348 712	43'194	NO	19'534'163	1 081 297	690'058
2010	21 842 385	14'154	NO	20'082'942	1 107 901	637'389
2011	18 239 520	16'067	NO	16'344'441	1 181 148	697'864
2012	18 985 474	10'790	NO	17'071'478	1 197 411	705'795
2013	12 781 154	7'389	NO	10'853'489	1 228 287	691'988
2014	13 005 879	8'516	NO	10'369'609	1 812 733	815'020
2015	9 435 909	3'994	NO	6'533'034	2 019 104	879'777
2016	5 860 991	8'104	NO	2'687'859	2 135 110	1'029'919
2017	6 084 024	9'581	NO	2'488'776	2 537 582	1'048'085
2018	6 392 359	6'118	NO	2'106'564	3 209 782	1'069'895
Trend 1990-2018	*426.86%*	*NA*	*NA*	*NA*	*265.99%*	*218.15%*
2005-2018	*-71.28%*	*-70.61%*	*NA*	*-89.80%*	*233.44%*	*70.77%*
2017-2018	*5.07%*	*-36.15%*	*NA*	*-15.36%*	*26.49%*	*2.08%*

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 2018 are presented in Table 57.

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 2018 are presented in Table 57. Implied emission factors are presented in Table 58. 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 40% compared to 2015.

Table 57 – Methods and Emission Factors used in relation to the coverage of energy consumption in 2018 for category *1A1a - Public Electricity and Heat Production*

1A1 - Energy Industries				
Method applied and Emission factor (EF) used as well as coverage of energy consumption				
1A1a - Public Electricity & Heat Production				
Pollutant	**Method**	**EF used**	**Coverage of energy consumption**	**Source**
NOx	T3	PS	47.5%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2	D	52.5%	IEF: PS, EMEP/EEA GB 2019 (Chap1A1, Tab3.20, p35), IEF
NMVOC	T3	PS	28.2%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2	D	71.8%	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	29.9%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2	CS	0.2%	CS based on fuel sulfur content; determined by AEV
	T1	D	70.0%	EMEP/EEA GB 2019 (Chap1A1, Tab3.17, p31), EMEP/EEA GB 2019 (Chap1A1, Tab3.20, p35), IEF
CO	T3	PS	47.5%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2	D	52.5%	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	47.5%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV PM measured assumed to be TSP = PM10 = PM2.5
	T2	D	52.5%	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	47.5%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV PM measured assumed to be TSP = PM10 = PM2.5
	T2	D	52.5%	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	47.5%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV PM measured assumed to be TSP = PM10 = PM2.5
	T2	D	52.5%	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 58 – Implied emission factors for category *1A1a - Public Electricity and Heat Production*

Year	SO2	NOx	NMVOC	NH3	CO	TSP	PM10	PM2.5
	1A1 - Energy Industries							
	Implied Emission Factor (IEF) of air pollutants (g/GJ)							
	1A1a - Public Electricity & Heat Production							
1990	3.42	27.11	0.95	NA	6.19	0.03	0.03	0.03
1991	3.42	27.11	0.95	NA	6.19	0.03	0.03	0.03
1992	3.38	28.54	2.11	NA	6.85	0.06	0.06	0.06
1993	3.38	28.62	2.17	NA	6.89	0.06	0.06	0.06
1994	3.38	28.65	2.20	NA	6.90	0.06	0.06	0.06
1995	1.91	34.20	2.21	NA	17.98	0.25	0.25	0.25
1996	1.75	36.25	3.08	NA	20.29	0.28	0.28	0.28
1997	1.86	43.53	7.30	NA	26.21	0.28	0.28	0.28
1998	1.33	39.71	6.06	NA	25.65	0.29	0.29	0.29
1999	1.36	40.30	6.46	0.03	26.37	0.31	0.31	0.31
2000	3.35	45.46	10.19	0.07	28.32	0.98	0.98	0.81
2001	1.30	41.77	6.00	0.03	16.41	0.32	0.31	0.28
2002	0.56	41.73	3.90	0.02	10.18	0.12	0.12	0.11
2003	0.61	45.43	5.25	0.04	13.62	0.18	0.18	0.16
2004	0.56	41.56	5.80	0.04	13.39	0.17	0.17	0.16
2005	0.46	43.40	6.14	0.08	13.26	0.17	0.17	0.17
2006	0.48	40.99	6.40	0.08	12.74	0.19	0.18	0.18
2007	0.49	40.57	6.60	0.11	14.46	0.21	0.21	0.20
2008	0.64	42.81	7.89	0.16	17.35	0.31	0.30	0.29
2009	0.77	39.82	7.14	0.17	15.07	0.33	0.32	0.30
2010	0.48	38.92	7.79	0.16	15.88	0.29	0.28	0.28
2011	0.51	42.33	8.45	0.23	19.33	0.39	0.38	0.37
2012	0.53	40.21	8.63	0.24	18.67	0.42	0.40	0.39
2013	0.69	48.76	12.49	0.51	30.52	0.80	0.77	0.75
2014	0.86	47.71	12.04	1.91	27.65	2.08	1.98	1.93
2015	1.41	58.72	16.98	3.10	38.17	3.40	3.24	3.14
2016	2.23	86.93	28.22	5.13	58.87	5.69	5.41	5.23
2017	2.30	76.34	24.84	7.40	62.53	8.53	8.13	7.89
2018	3.25	82.41	21.54	10.65	75.09	12.68	12.11	11.75
Trend 1990-2018	*-5.06%*	*203.93%*	*2177.42%*	*NA*	*1112.38%*	*38950.88%*	*37177.96%*	*36076.91%*
2005-2018	*607.90%*	*89.87%*	*250.72%*	*13659.08%*	*466.33%*	*7186.20%*	*7026.74%*	*6969.24%*
2017-2018	*41.30%*	*7.95%*	*-13.30%*	*44.03%*	*20.09%*	*48.61%*	*48.84%*	*48.85%*

Source: Environment Agency.

3.2.2.3 **Uncertainties and time-series consistency**

Currently no uncertainty estimates are made. Uncertainty of the activity data can be checked in the Luxembourg's National Inventory report (NIR).

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, some times 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.

3.2.2.4 **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.

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

Table 59 presents the main revisions and recalculations done since submission 2019 for category *1A1a – Public Electricity and Heat Production*.

Table 59 – Recalculations done since submission for category *1A1a - Public Electricity and Heat Production*

Source category	Revisions 2019 ➔ 2020	Type of revision
1A1a	Gasoil consumption in 1A1a for the year 2016 was revised in the national energy balance.	Updated AD
1A1a	Aligned Tier 1 and Tier 2 default EFs to EMEP/EEA Guidebook 2019, if necessary.	Updated EFs
1A1a	Incorporated plant specific activity and emission data for two medium combustion plants (wood & wood wastes)	Update EFs / methodology

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

The following improvements are planned for the next submission.

Table 60 – Planned improvements for category *1.A.1. – Energy Industries*

Source category	Planned improvements	Type of revision
	No further improvements planned	

3.2.3 **Manufacturing Industries and Construction (1A2)**

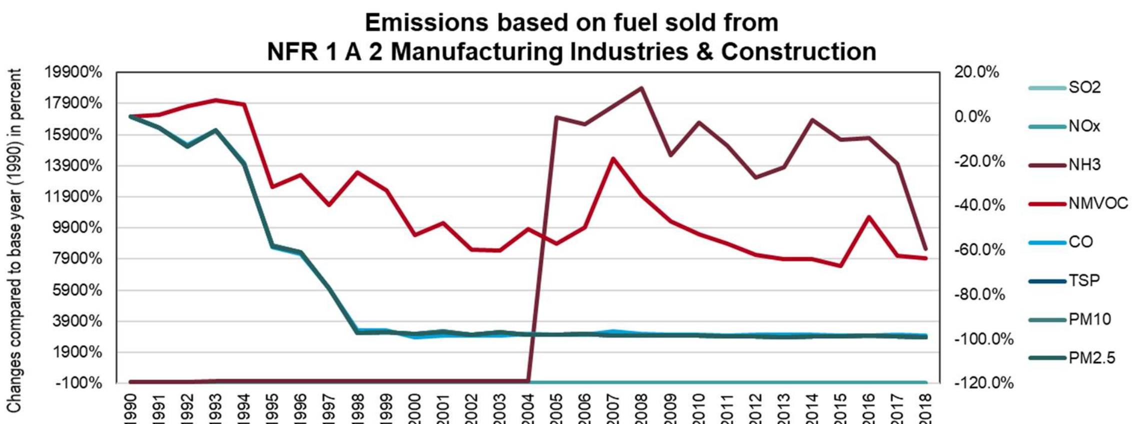
3.2.3.1 **Source category description**

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

The 2020 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 3-3 and Table 61 (and in more detail in Table 62 and Table 63) 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 3-5 – Changes of emissions compared to base year (1990) based on fuel sold for *1A2 - Manufacturing Industries and Construction*



Source: Environment Agency.

Table 61 – Emissions (1990, 2005, 2017 and 2018), 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	2017	2018	1990 - 2018	2005 - 2018	2017 - 2018	1990	2005	2018	1990	2005	2018	
SO2	13.24	1.16	0.87	0.82	-94%	-29%	-5%	89%	49%	88%	84%	48%	85%	fuel sold
NOx	12.11	5.71	3.88	3.47	-71%	-39%	-11%	52%	32%	27%	29%	10%	17%	fuel sold
NMVOC	0.85	0.36	0.32	0.31	-64%	-15%	-3%	5%	3%	3%	3%	2%	3%	fuel sold
NH3	0.00	0.03	0.03	0.02	8554%	-49%	-39%	0%	1%	0%	0%	1%	0%	fuel sold
CO	377.49	7.04	7.86	5.38	-99%	-24%	-32%	89%	37%	36%	81%	20%	26%	fuel sold
TSP	14.31	0.27	0.15	0.14	-99%	-46%	-5%	87%	13%	7%	82%	7%	5%	fuel sold
PM10	14.31	0.27	0.15	0.14	-99%	-46%	-5%	90%	16%	10%	86%	9%	7%	fuel sold
PM2.5	14.31	0.26	0.15	0.13	-99%	-50%	-10%	93%	20%	12%	89%	11%	9%	fuel sold

Source: Environment Agency.

Table 62 – NO_X, SO_2, NMVOC and NH_3 emissions (1990, 2005, 2017 and 2018), 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	2017	2018	1990 - 2018	2005 - 2018	2017 - 2018	1990	2005	2018	1990	2005	2018	
1 A 2	**12.11**	**5.71**	**3.88**	**3.47**	**-71%**	**-39%**	**-11%**	**52%**	**32%**	**27%**	**29%**	**10%**	**17%**	**fuel sold**
1 A 2 a	7.01	1.14	0.72	0.62	-91%	-46%	-14%	30%	6%	5%	17%	2%	3%	fuel sold
1 A 2 b	0.14	0.08	0.07	0.06	-52%	-17%	-8%	1%	0%	1%	0%	0%	0%	fuel sold
1 A 2 c	0.82	0.33	0.12	0.12	-85%	-63%	5%	4%	2%	1%	2%	1%	1%	fuel sold
1 A 2 d	NO	0.04	0.01	0.01	1%	-73%	13%	NO	0%	0%	NO	0%	0%	fuel sold
1 A 2 e	0.03	0.05	0.08	0.08	134%	68%	-2%	0%	0%	1%	0%	0%	0%	fuel sold
1 A 2 f	3.37	2.72	1.71	1.23	-64%	-55%	-28%	15%	15%	10%	8%	5%	6%	fuel sold
1 A 2 g vii	0.54	1.09	0.88	0.85	56%	-22%	-3%	2%	6%	7%	1%	2%	4%	fuel sold
1 A 2 g viii	0.19	0.27	0.30	0.50	165%	86%	67%	1%	1%	4%	0%	0%	2%	fuel sold
National total (fuel sold)	**41.290**	**55.985**	**22.340**	**20.465**	**-50.4%**	**-63.4%**	**-8.4%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**23.065**	**17.807**	**13.785**	**12.746**	**-44.7%**	**-28.4%**	**-7.5%**	**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	2017	2018	1990 - 2018	2005 - 2018	2017 - 2018	1990	2005	2018	1990	2005	2018	
1 A 2	**0.846**	**0.362**	**0.316**	**0.307**	**-63.7%**	**-15.0%**	**-2.7%**	**4.6%**	**3.0%**	**3.1%**	**3.1%**	**2.5%**	**3.0%**	**fuel sold**
1 A 2 a	0.597	0.057	0.104	0.100	-83.3%	76.2%	-4.1%	3.3%	0.5%	1.0%	2.2%	0.4%	1.0%	fuel sold
1 A 2 b	0.011	0.024	0.022	0.020	81.6%	-15.1%	-8.0%	0.1%	0.2%	0.2%	0.0%	0.2%	0.2%	fuel sold
1 A 2 c	0.059	0.045	0.041	0.041	-30.4%	-7.7%	1.3%	0.3%	0.4%	0.4%	0.2%	0.3%	0.4%	fuel sold
1 A 2 d	NO	0.007	0.002	0.002	0.2%	-70.3%	14.0%	NO	0.1%	0.0%	NO	0.1%	0.0%	fuel sold
1 A 2 e	0.003	0.007	0.009	0.009	206.0%	37.1%	4.6%	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%	fuel sold
1 A 2 f	0.073	0.059	0.014	0.014	-81.4%	-77.0%	-0.4%	0.4%	0.5%	0.1%	0.3%	0.4%	0.1%	fuel sold
1 A 2 g vii	0.090	0.098	0.026	0.024	-73.5%	-75.7%	-7.3%	0.5%	0.8%	0.2%	0.3%	0.7%	0.2%	fuel sold
1 A 2 g viii	0.012	0.065	0.099	0.097	687.2%	48.8%	-1.8%	0.1%	0.5%	1.0%	0.0%	0.4%	0.9%	fuel sold
National total (fuel sold)	**27.573**	**14.748**	**10.473**	**10.373**	**-62.4%**	**-29.7%**	**-1.0%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**18.350**	**12.235**	**10.045**	**9.945**	**-45.8%**	**-18.7%**	**-1.0%**	**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	2017	2018	1990 - 2018	2005 - 2018	2017 - 2018	1990	2005	2018	1990	2005	2018	
1 A 2	**13.240**	**1.156**	**0.867**	**0.822**	**-93.8%**	**-28.9%**	**-5.1%**	**88.6%**	**48.6%**	**87.8%**	**84.0%**	**47.8%**	**85.5%**	**fuel sold**
1 A 2 a	12.151	0.054	0.209	0.138	-98.9%	154.0%	-34.0%	81.3%	2.3%	14.7%	77.1%	2.2%	14.3%	fuel sold
1 A 2 b	0.011	0.001	0.001	0.001	-94.6%	-35.9%	-8.8%	0.1%	0.0%	0.1%	0.1%	0.0%	0.1%	fuel sold
1 A 2 c	0.069	0.020	0.001	0.001	-98.3%	-93.9%	3.0%	0.5%	0.8%	0.1%	0.4%	0.8%	0.1%	fuel sold
1 A 2 d	NO	0.002	0.000	0.000	0.0%	-96.0%	13.6%	NO	0.1%	0.0%	NO	0.1%	0.0%	fuel sold
1 A 2 e	0.005	0.005	0.000	0.000	-95.7%	-96.4%	4.5%	0.0%	0.2%	0.0%	0.0%	0.2%	0.0%	fuel sold
1 A 2 f	0.754	0.986	0.549	0.577	-23.5%	-41.5%	5.1%	5.0%	41.4%	61.6%	4.8%	40.8%	60.0%	fuel sold
1 A 2 g vii	0.037	0.003	0.001	0.001	-96.9%	-64.6%	3.3%	0.2%	0.1%	0.1%	0.2%	0.1%	0.1%	fuel sold
1 A 2 g viii	0.214	0.085	0.106	0.105	-51.1%	22.8%	-1.1%	1.4%	3.6%	11.2%	1.4%	3.5%	10.9%	fuel sold
National total (fuel sold)	**15.764**	**2.418**	**1.000**	**0.962**	**-93.9%**	**-60.2%**	**-3.8%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**14.948**	**2.380**	**0.976**	**0.936**	**-93.7%**	**-60.7%**	**-4.1%**	**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	2017	2018	1990 - 2018	2005 - 2018	2017 - 2018	1990	2005	2018	1990	2005	2018	
1 A 2	**0.000**	**0.033**	**0.027**	**0.017**	**8553.8%**	**-49.4%**	**-38.8%**	**0.0%**	**0.6%**	**0.3%**	**0.0%**	**0.5%**	**0.3%**	**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	49.2%	-11.5%	1.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 2 g viii	NO	0.033	0.027	0.016	1.6%	-49.8%	-39.2%	NO	0.6%	0.3%	NO	0.5%	0.3%	fuel sold
National total (fuel sold)	**6.655**	**6.094**	**5.954**	**5.895**	**-11.4%**	**-3.3%**	**-1.0%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**6.647**	**5.717**	**5.844**	**5.769**	**-13.2%**	**0.9%**	**-1.3%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

Source: Environment Agency.

Table 63 – CO, $PM_{2.5}$, PM_{10} and TSP emissions (1990, 2005, 2017 and 2018), 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	2017	2018	1990 - 2018	2005 - 2018	2017 - 2018	1990	2005	2018	1990	2005	2018	
1 A 2	**377.493**	**7.040**	**7.860**	**5.380**	**-98.6%**	**-23.6%**	**-31.6%**	**89.3%**	**36.9%**	**36.0%**	**80.5%**	**19.6%**	**26.2%**	**fuel sold**
1 A 2 a	346.464	1.655	4.339	3.860	-98.9%	133.2%	-11.0%	81.9%	8.7%	25.8%	73.9%	4.6%	18.8%	fuel sold
1 A 2 b	0.022	0.030	0.028	0.025	15.9%	-15.5%	-8.0%	0.0%	0.2%	0.2%	0.0%	0.1%	0.1%	fuel sold
1 A 2 c	0.125	0.102	0.021	0.023	-81.5%	-77.2%	9.7%	0.0%	0.5%	0.2%	0.0%	0.3%	0.1%	fuel sold
1 A 2 d	NO	0.008	0.002	0.002	0.2%	-70.7%	13.9%	NO	0.0%	0.0%	NO	0.0%	0.0%	fuel sold
1 A 2 e	0.005	0.009	0.008	0.009	89.9%	3.2%	8.8%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	fuel sold
1 A 2 f	30.108	4.283	2.402	0.824	-97.3%	-80.8%	-65.7%	7.1%	22.5%	5.5%	6.4%	11.9%	4.0%	fuel sold
1 A 2 g vii	0.589	0.821	0.480	0.473	-19.7%	-42.4%	-1.5%	0.1%	4.3%	3.2%	0.1%	2.3%	2.3%	fuel sold
1 A 2 g viii	0.181	0.132	0.580	0.163	-10.0%	23.0%	-71.9%	0.0%	0.7%	1.1%	0.0%	0.4%	0.8%	fuel sold
National total (fuel sold)	**468.704**	**36.001**	**22.557**	**20.549**	**-95.6%**	**-42.9%**	**-8.9%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**422.874**	**19.061**	**16.853**	**14.945**	**-96.5%**	**-21.6%**	**-11.3%**	**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	2017	2018	1990 - 2018	2005 - 2018	2017 - 2018	1990	2005	2018	1990	2005	2018	
1 A 2	**14.314**	**0.266**	**0.149**	**0.143**	**-99.0%**	**-46.4%**	**-4.6%**	**86.7%**	**12.5%**	**7.0%**	**82.4%**	**7.0%**	**5.1%**	**fuel sold**
1 A 2 a	13.769	0.016	0.018	0.018	-99.9%	13.1%	-1.8%	83.4%	0.7%	0.9%	79.3%	0.4%	0.6%	fuel sold
1 A 2 b	0.005	0.034	0.031	0.026	448.7%	-22.6%	-16.5%	0.0%	1.6%	1.3%	0.0%	0.9%	0.9%	fuel sold
1 A 2 c	0.030	0.005	0.005	0.012	-60.0%	143.7%	133.7%	0.2%	0.2%	0.6%	0.2%	0.1%	0.4%	fuel sold
1 A 2 d	NO	0.001	0.000	0.000	0.0%	-79.1%	9.8%	NO	0.0%	0.0%	NO	0.0%	0.0%	fuel sold
1 A 2 e	0.001	0.001	0.003	0.003	118.0%	92.7%	2.9%	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%	fuel sold
1 A 2 f	0.412	0.114	0.046	0.039	-90.5%	-65.7%	-14.5%	2.5%	5.4%	1.9%	2.4%	3.0%	1.4%	fuel sold
1 A 2 g vii	0.094	0.089	0.018	0.016	-83.0%	-82.1%	-11.6%	0.6%	4.2%	0.8%	0.5%	2.4%	0.6%	fuel sold
1 A 2 g viii	0.003	0.006	0.028	0.029	857.0%	377.7%	1.6%	0.0%	0.3%	1.4%	0.0%	0.2%	1.0%	fuel sold
National total (fuel sold)	**17.365**	**3.797**	**2.775**	**2.781**	**-84.0%**	**-26.8%**	**0.2%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**16.517**	**2.121**	**2.083**	**2.032**	**-87.7%**	**-4.2%**	**-2.4%**	**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	2017	2018	1990 - 2018	2005 - 2018	2017 - 2018	1990	2005	2018	1990	2005	2018	
1 A 2	**14.313**	**0.2651**	**0.149**	**0.142**	**-99.0%**	**-46.3%**	**-4.7%**	**90.2%**	**15.9%**	**9.5%**	**86.1%**	**8.7%**	**7.2%**	**fuel sold**
1 A 2 a	13.769	0.016	0.018	0.018	-99.9%	13.1%	-1.8%	86.8%	0.9%	1.2%	82.8%	0.5%	0.9%	fuel sold
1 A 2 b	0.005	0.034	0.031	0.026	448.7%	-22.6%	-16.5%	0.0%	2.0%	1.8%	0.0%	1.1%	1.3%	fuel sold
1 A 2 c	0.030	0.005	0.005	0.012	-60.0%	143.7%	133.7%	0.2%	0.3%	0.8%	0.2%	0.2%	0.6%	fuel sold
1 A 2 d	NO	0.001	0.000	0.000	0.0%	-79.1%	9.8%	NO	0.0%	0.0%	NO	0.0%	0.0%	fuel sold
1 A 2 e	0.001	0.001	0.003	0.003	118.0%	92.7%	2.9%	0.0%	0.1%	0.2%	0.0%	0.0%	0.1%	fuel sold
1 A 2 f	0.411	0.113	0.046	0.039	-90.5%	-65.6%	-14.8%	2.6%	6.8%	2.6%	2.5%	3.7%	2.0%	fuel sold
1 A 2 g vii	0.094	0.089	0.018	0.016	-83.0%	-82.1%	-11.6%	0.6%	5.4%	1.1%	0.6%	2.9%	0.8%	fuel sold
1 A 2 g viii	0.003	0.006	0.028	0.029	874.1%	377.7%	1.6%	0.0%	0.4%	1.9%	0.0%	0.2%	1.5%	fuel sold
National total (fuel sold)	**16.629**	**3.039**	**1.881**	**1.983**	**-88.1%**	**-34.7%**	**5.4%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**15.867**	**1.663**	**1.423**	**1.495**	**-90.6%**	**-10.1%**	**5.0%**	**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	2017	2018	1990 - 2018	2005 - 2018	2017 - 2018	1990	2005	2018	1990	2005	2018	
1 A 2	**14.311**	**0.264**	**0.147**	**0.132**	**-99.1%**	**-49.9%**	**-9.7%**	**92.6%**	**19.9%**	**11.9%**	**88.6%**	**10.6%**	**9.4%**	**fuel sold**
1 A 2 a	13.768	0.016	0.018	0.018	-99.9%	13.1%	-1.8%	89.1%	1.2%	1.6%	85.3%	0.6%	1.2%	fuel sold
1 A 2 b	0.005	0.034	0.031	0.026	448.7%	-22.6%	-16.5%	0.0%	2.6%	2.4%	0.0%	1.4%	1.9%	fuel sold
1 A 2 c	0.030	0.005	0.002	0.002	-93.0%	-57.2%	-9.3%	0.2%	0.4%	0.2%	0.2%	0.2%	0.1%	fuel sold
1 A 2 d	NO	0.001	0.000	0.000	0.0%	-79.1%	9.8%	NO	0.0%	0.0%	NO	0.0%	0.0%	fuel sold
1 A 2 e	0.001	0.001	0.003	0.003	118.0%	92.7%	2.9%	0.0%	0.1%	0.2%	0.0%	0.1%	0.2%	fuel sold
1 A 2 f	0.410	0.112	0.046	0.039	-90.5%	-65.4%	-15.1%	2.7%	8.5%	3.5%	2.5%	4.5%	2.8%	fuel sold
1 A 2 g vii	0.094	0.089	0.018	0.016	-83.0%	-82.1%	-11.6%	0.6%	6.7%	1.4%	0.6%	3.6%	1.1%	fuel sold
1 A 2 g viii	0.003	0.006	0.028	0.029	897.1%	377.7%	1.6%	0.0%	0.5%	2.6%	0.0%	0.2%	2.0%	fuel sold
National total (fuel sold)	**16.150**	**2.484**	**1.291**	**1.413**	**-91.3%**	**-43.1%**	**9.4%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**15.454**	**1.327**	**1.004**	**1.112**	**-92.8%**	**-16.2%**	**10.8%**	**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 2018, only two of the three electric arc furnaces (*EAF*) remained, following the shut-down 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 64 summarizes emissions of air pollutants for category *1A2a – Iron and steel*.

In 2018, this source category represented:

- 14.3% of national total SO_2 emissions (based on fuel sold) and 14.7% of national total SO_2 emissions (based on fuel used), whereas in 1990, this source category represented 77.1% of national total SO_2 emissions (based on fuel sold) and 81.3% of national total SO_2 emissions (based on fuel used).
- 18.8% of national total CO emissions (based on fuel sold) and 25.8% of national total CO emissions (based on fuel used), whereas in 1990, this source category represented 73.9% of national total CO emissions (based on fuel sold) and 81.9% of national total CO emissions (based on fuel used).
- 3.0% of national total NO_X emissions (based on fuel sold) and 4.9% of national total NO_X emissions (based on fuel used), whereas in 1990, this source category represented 17.0% of national total NO_X emissions (based on fuel sold) and 30.4% of national total NO_X emissions (based on fuel used).
- 1.2% of national total $PM_{2.5}$ emissions (based on fuel sold) and 1.6% of national total $PM_{2.5}$ emissions (based on fuel used), whereas in 1990, this source category represented 85.3% of national total $PM_{2.5}$ emissions (based on fuel sold) and 89.1% of national total $PM_{2.5}$ emissions (based on fuel used).

Table 64 – Emissions (1990, 2005, 2017 and 2018), 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	2017	2018	1990 - 2018	2005 - 2018	2017 - 2018	1990	2005	2018	1990	2005	2018	
SO2	12.15	0.05	0.21	0.14	-98.9%	154.0%	-34.0%	81.3%	2.3%	14.7%	77.1%	2.2%	14.3%	fuel sold
NOx	7.01	1.14	0.72	0.62	-91.2%	-45.8%	-13.9%	30.4%	6.4%	4.9%	17.0%	2.0%	3.0%	fuel sold
NMVOC	0.60	0.06	0.10	0.10	-83.3%	76.2%	-4.1%	3.3%	0.5%	1.0%	2.2%	0.4%	1.0%	fuel sold
NH3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
CO	346.46	1.65	4.34	3.86	-98.9%	133.2%	-11.0%	81.9%	8.7%	25.8%	73.9%	4.6%	18.8%	fuel sold
TSP	13.77	0.02	0.02	0.02	-99.9%	13.1%	-1.8%	83.4%	0.7%	0.9%	79.3%	0.4%	0.6%	fuel sold
PM10	13.77	0.02	0.02	0.02	-99.9%	13.1%	-1.8%	86.8%	0.9%	1.2%	82.8%	0.5%	0.9%	fuel sold
PM2.5	13.77	0.02	0.02	0.02	-99.9%	13.1%	-1.8%	89.1%	1.2%	1.6%	85.3%	0.6%	1.2%	fuel sold

Source: Environment Agency.

In the period 1990 – 2018, all emissions of air pollutants decreased significantly. Compared to 1990, SO_2 emissions decreased by 98.9% and NO_X emissions decreased by 91.2%, 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 2017, SO_2, NO_X, CO, NMVOC, TSP, PM_{10} and $PM_{2.5}$ emissions of category *1A2a - Iron and Steel* decreased by 34.0%, 13.9%, 11.0%, 4.1%, 1.8%, 1.8% and 1.8%, respectively. The reason for the decrease in emissions is not very clear as steel production has remained nearly constant compared to 2017. 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 variations in emissions, although all operating permit conditions (based on best available techniques for abatement technologies) are respected.

With regard to SO_2, NO_X, CO, TSP, PM_{10} and $PM_{2.5}$ emissions, *1A2a – Iron and Steel* is a key category (LA & TA) in 2018 (see Table 65 and also Table 49 in Section 3.2 and Chapter 1.5).

Table 65 – 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	2	1		1					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	2	1	8	1						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, …)

Table 66 presents the emission trends in category *1A2a -Iron and Steel.*

Table 66 – Emission trends – *1A2a - Iron and Steel*

Year	1 A 2 Stationary combustion in manufacturing industries and construction — Emissions of air pollutants (Gg) — 1 A 2 a Iron and steel							
	SO2	*NOx*	*NMVOC*	*NH3*	*CO*	*TSP*	*PM10*	*PM2.5*
1990	12.151	7.013	0.597	NO	346.464	13.769	13.769	13.768
1991	11.760	6.692	0.546	NO	329.215	13.049	13.048	13.048
1992	11.126	6.346	0.536	NO	299.129	11.791	11.790	11.790
1993	12.009	6.847	0.553	NO	328.427	12.906	12.906	12.905
1994	9.946	5.791	0.476	NO	269.872	10.608	10.607	10.607
1995	4.993	3.168	0.241	NO	142.490	5.583	5.583	5.583
1996	4.752	2.979	0.248	NO	130.438	5.093	5.093	5.093
1997	2.562	1.876	0.152	NO	72.310	2.836	2.835	2.835
1998	0.144	0.502	0.027	NO	0.037	0.015	0.015	0.015
1999	0.129	0.595	0.035	NO	0.047	0.018	0.018	0.018
2000	0.036	0.412	0.015	NO	0.024	0.012	0.012	0.012
2001	0.038	0.415	0.011	NO	0.016	0.012	0.012	0.012
2002	0.034	0.388	0.010	NO	0.015	0.011	0.011	0.011
2003	0.011	0.384	0.032	NO	0.064	0.008	0.008	0.008
2004	0.118	0.690	0.103	NO	2.982	0.011	0.011	0.011
2005	0.054	1.144	0.057	NO	1.655	0.016	0.016	0.016
2006	0.116	0.619	0.068	NO	1.912	0.024	0.024	0.024
2007	0.417	1.004	0.405	NO	5.069	0.032	0.032	0.032
2008	0.232	0.929	0.319	NO	4.416	0.033	0.033	0.033
2009	0.294	0.903	0.251	NO	5.345	0.025	0.025	0.025
2010	0.160	0.963	0.198	NO	4.845	0.030	0.030	0.030
2011	0.138	0.959	0.200	NO	3.125	0.026	0.026	0.026
2012	0.294	0.962	0.179	NO	4.878	0.020	0.020	0.020
2013	0.422	0.780	0.151	NO	4.490	0.017	0.017	0.017
2014	0.273	0.666	0.141	NO	5.163	0.017	0.017	0.017
2015	0.153	0.788	0.132	NO	3.274	0.023	0.023	0.023
2016	0.156	0.605	0.148	NO	3.933	0.021	0.021	0.021
2017	0.209	0.721	0.104	NO	4.339	0.018	0.018	0.018
2018	0.138	0.621	0.100	NO	3.860	0.018	0.018	0.018
Trend 1990-2018	-98.87%	-91.15%	-83.26%	NA	-98.89%	-99.87%	-99.87%	-99.87%
2005-2018	153.98%	-45.77%	76.16%	NA	133.25%	13.10%	13.10%	13.10%
2017-2018	-33.95%	-13.89%	-4.15%	NA	-11.04%	-1.76%	-1.76%	-1.76%

Sources: Environment Agency

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. However,

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

Table 67 – Iron and steel combustion activities included in the air emission inventory

Combustion activity	SNAP[45] 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

<u>Combustion plants 50-300 MW</u>

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[46] 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.

<u>Combustion plants <50 MW</u>

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)).

45 technology oriented Standardized Nomenclature for Air Pollutants (SNAP)

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

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 – 2012. 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)).

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 fuel consumption and emission data were received directly from the operator.

Blast Furnace Gas Distribution Losses and Flaring

A certain amount of blast furnace gas (BFG) is either lost during distribution or vented to avoid overpressurization 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

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) was matched with the top-down data obtained from the national statistics institute's energy balance (STATEC), in order to avoid double counting or underestimation.

Table 68 gives a summary of the amount of energy used in category *1A2a – Iron and steel*.

Table 68 – 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	8 115 008	161'389	3'392'205	4'561'414	NO	NO
1991	6 231 283	213'823	2'697'816	3'319'644	NO	NO
1992	6 455 111	518'762	2'582'675	3'353'674	NO	NO
1993	6 180 904	669'501	2'159'680	3'351'723	NO	NO
1994	6 045 491	760'507	1'796'360	3'488'624	NO	NO
1995	3 203 940	217'928	1'014'021	1'971'991	NO	NO
1996	3 519 326	238'810	992'197	2'288'319	NO	NO
1997	2 850 985	238'233	618'762	1'993'990	NO	NO
1998	1 098 867	498'093	NO	600'773	NO	NO
1999	1 412 387	634'967	NO	777'420	NO	NO
2000	597 506	360'167	NO	237'339	NO	NO
2001	385 452	385'452	NO	NO	NO	NO
2002	339 077	339'077	NO	NO	NO	NO
2003	1 314 828	91'251	NO	1'223'577	NO	NO
2004	541 847	153'569	NO	388'278	NO	NO
2005	103 627	103'627	NO	NO	NO	NO
2006	472 693	79'708	NO	392'985	NO	NO
2007	341 153	64'889	NO	276'264	NO	NO
2008	553 082	43'438	NO	509'644	NO	NO
2009	468 844	31'033	NO	437'811	NO	NO
2010	595 513	75'689	NO	519'824	NO	NO
2011	273 414	40'643	NO	232'771	NO	NO
2012	214 190	12'569	NO	201'621	NO	NO
2013	290 991	17'984	NO	273'007	NO	NO
2014	58 000	12'163	NO	45'836	NO	NO
2015	121 128	18'432	NO	102'696	NO	NO
2016	120 211	19'592	NO	100'618	NO	NO
2017	95 671	42'930	NO	52'741	NO	NO
2018	147 084	43'828	NO	103'256	NO	NO
Trend 1990-2018	*-98.19%*	*-72.84%*	*NA*	*-97.74%*	*NA*	*NA*
2005-2018	*41.94%*	*-57.71%*	*NA*	*NA*	*NA*	*NA*
2017-2018	*53.74%*	*2.09%*	*NA*	*95.78%*	*NA*	*NA*

Source: Environment Agency

3.2.3.2.2.2 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 69, the methods and emission factors used in relation to the coverage of energy consumption for 2017 are described.

3.2.3.2.2.3 Emission factors

For large point sources of this sub-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 2016 are presented in Table 69.

Implied emission factors are presented in Table 70. These may vary over time for the following reasons:

- The chemical characteristics 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 70 gives an overview of the evolution of the implied emission factors.

Table 69 – Methods and Emission Factors used in relation to the energy in consumption in 2018 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	97.1%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2/T1	D	2.9%	EMEP/EEA GB 2019 (Chap1A2, Tab3.2, p15), EMEP/EEA GB 2019 (Chap1A2, Tab3.2, p15), EMEP/EEA GB 2019 (Chap1A2,
NMVOC	T3	PS	97.1%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2/T1	D	2.9%	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	97.1%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2	CS	0.9%	CS based on fuel sulfur content; determined by AEV
	T1	D	2.0%	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
CO	T3	PS	97.1%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2/T1	D	2.9%	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	97.1%	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	2.9%	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	97.1%	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	2.9%	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	97.1%	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	2.9%	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 70 – 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	1497.32	864.18	73.54	NA	42694.18	1696.76	1696.70	1696.62
1991	1887.27	1073.98	87.65	NA	52832.63	2094.08	2094.00	2093.89
1992	1723.58	983.15	83.06	NA	46339.93	1826.60	1826.52	1826.42
1993	1942.91	1107.81	89.40	NA	53135.81	2088.05	2087.97	2087.86
1994	1645.27	957.88	78.81	NA	44640.14	1754.69	1754.61	1754.50
1995	1558.26	988.73	75.37	NA	44473.42	1742.60	1742.57	1742.54
1996	1350.38	846.51	70.57	NA	37063.40	1447.20	1447.18	1447.15
1997	898.57	657.91	53.46	NA	25363.23	994.58	994.55	994.51
1998	131.02	457.26	24.79	NA	34.05	13.24	13.24	13.24
1999	91.66	421.07	24.61	NA	33.50	12.44	12.44	12.44
2000	59.68	689.49	25.93	NA	40.33	19.72	19.72	19.72
2001	98.75	1077.78	27.82	NA	40.87	32.04	32.04	32.04
2002	99.31	1145.40	28.16	NA	43.97	33.48	33.48	33.48
2003	8.20	291.79	24.22	NA	48.73	5.71	5.71	5.71
2004	217.09	1273.43	190.32	NA	5503.59	20.90	20.90	20.90
2005	523.53	11043.63	547.21	NA	15968.30	150.46	150.46	150.46
2006	245.95	1309.87	143.42	NA	4044.32	49.74	49.74	49.74
2007	1221.28	2942.05	1187.50	NA	14857.43	94.75	94.75	94.75
2008	419.39	1679.19	577.37	NA	7984.07	59.33	59.33	59.33
2009	626.40	1926.22	535.62	NA	11400.29	53.29	53.29	53.29
2010	268.73	1616.75	332.58	NA	8135.84	50.13	50.13	50.13
2011	505.55	3507.93	732.89	NA	11430.14	96.47	96.47	96.47
2012	1372.15	4493.35	834.90	NA	22775.33	95.26	95.26	95.26
2013	1451.72	2678.83	519.84	NA	15430.74	58.39	58.39	58.39
2014	4708.96	11478.46	2430.85	NA	89012.43	287.12	287.12	287.12
2015	1267.00	6504.20	1091.57	NA	27029.39	189.12	189.12	189.12
2016	1293.92	5035.27	1227.10	NA	32721.39	178.53	178.53	178.53
2017	2180.61	7532.93	1089.31	NA	45349.12	187.62	187.62	187.62
2018	936.82	4219.37	679.17	NA	26241.18	119.89	119.89	119.89
Trend								
1990-2018	*-37.43%*	*388.25%*	*823.54%*	*NA*	*-38.54%*	*-92.93%*	*-92.93%*	*-92.93%*
2005-2018	*78.94%*	*-61.79%*	*24.12%*	*NA*	*64.33%*	*-20.32%*	*-20.32%*	*-20.32%*
2017-2018	*-57.04%*	*-43.99%*	*-37.65%*	*NA*	*-42.14%*	*-36.10%*	*-36.10%*	*-36.10%*

Source: Environment Agency.

3.2.3.2.3 Uncertainties and time-series consistency

Currently no uncertainty estimates are made. Uncertainty of the activity data can be checked in the Luxembourg's National Inventory report (NIR).

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

3.2.3.2.4 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 within 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 is also cross-checked within two sources: reports obtained directly from the operator under its operational permit obligations and PRTR.

Finally, consistency and completeness checks are performed.

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

Table 71 presents the main revisions and recalculations done since the last submission for sub-category *1A2a – Iron and Steel*.

Table 71 – Recalculations done since submission 2019 in category – *1A2a - Iron and Steel*

Source category	Revisions 2019 → 2020	Type of revision
1A2a	Fuel consumption (liquid, gaseous, 2014-2016) was revised due to revised energy balance from the national statistics institute	updated AD
1A2a	Aligned Tier 1 and Tier 2 default EFs to EMEP/EEA Guidebook 2019, if necessary.	Updated EFs

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

The following improvements are planned for the next submission.

Table 72 – 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.

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.

In 1990 and 2017, source category *1A2b – Non-Ferrous Metals* was a small source. In 2017, this emission source represented less than 2.3 % of national total for each air pollutant (based on fuel sold) and less than 2.9 % of national total for each air pollutant (based on fuel used). In the period 1990 –

2017, the emissions of SO_2, NOx decreased significantly due to changes in the fuel mix, whereas all other air pollutants (NMVOC, CO and PM) increased due to increased production activity (coated scrap).

Table 73 summarizes emissions of air pollutants for category *1A2b – Non-Ferrous Metals* and Table 75 presents the emission trends.

Table 73 – Emissions (1990, 2005, 2016 and 2017), 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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
SO2	0.01	0.00	0.00	0.00	-94.0%	-29.7%	3.6%	0.08%	0.04%	0.07%	0.07%	0.04%	0.06%	fuel sold
NOx	0.14	0.08	0.07	0.07	-47.8%	-10.1%	5.9%	0.59%	0.49%	0.57%	0.33%	0.14%	0.39%	fuel sold
NMVOC	0.01	0.02	0.02	0.02	97.4%	-7.7%	6.1%	0.06%	0.19%	0.19%	0.04%	0.16%	0.18%	fuel sold
NH3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
CO	0.02	0.03	0.03	0.03	26.0%	-8.2%	6.0%	0.01%	0.15%	0.16%	0.00%	0.08%	0.13%	fuel sold
TSP	0.00	0.03	0.03	0.03	557.4%	-7.3%	14.2%	0.03%	1.53%	1.36%	0.03%	0.87%	1.06%	fuel sold
PM10	0.00	0.03	0.03	0.03	557.4%	-7.3%	14.2%	0.03%	1.96%	1.99%	0.03%	1.10%	1.57%	fuel sold
PM2.5	0.00	0.03	0.03	0.03	557.4%	-7.3%	14.2%	0.03%	2.55%	2.91%	0.03%	1.38%	2.34%	fuel sold

Source: Environment Agency.

Since 1990, category *1A2b – Non-Ferrous Metals* has never been identified as a key category with regard to the following pollutants: SO_2, NO_X, CO, TSP and PM_{10}. With regard to $PM_{2.5}$ emissions, *1A2b – Non-Ferrous Metals* is a key category (LA, fuel used) in 2017 (see Table 74 and also Table 49 in Section 3.2 and Chapter 1.5).

Table 74 – 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

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									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, …)

Table 75 – 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	0.011	0.135	0.011	NO	0.022	0.005	0.005	0.005
1991	0.011	0.137	0.012	NO	0.022	0.005	0.005	0.005
1992	0.011	0.137	0.012	NO	0.033	0.005	0.005	0.005
1993	0.011	0.136	0.011	NO	0.033	0.005	0.005	0.005
1994	0.015	0.177	0.014	NO	0.039	0.006	0.006	0.006
1995	0.015	0.182	0.014	NO	0.041	0.007	0.007	0.007
1996	0.024	0.304	0.028	NO	0.052	0.035	0.035	0.035
1997	0.011	0.170	0.021	NO	0.035	0.030	0.030	0.030
1998	0.013	0.184	0.022	NO	0.037	0.031	0.031	0.031
1999	0.013	0.184	0.022	NO	0.036	0.031	0.031	0.031
2000	0.013	0.189	0.022	NO	0.037	0.032	0.032	0.032
2001	0.015	0.203	0.022	NO	0.039	0.032	0.032	0.032
2002	0.009	0.148	0.021	NO	0.033	0.027	0.027	0.027
2003	0.008	0.137	0.023	NO	0.034	0.032	0.032	0.032
2004	0.011	0.186	0.027	NO	0.042	0.038	0.038	0.038
2005	0.001	0.079	0.024	NO	0.030	0.034	0.034	0.034
2006	0.001	0.080	0.025	NO	0.031	0.038	0.038	0.038
2007	0.001	0.077	0.023	NO	0.029	0.036	0.036	0.036
2008	0.001	0.073	0.023	NO	0.028	0.034	0.034	0.034
2009	0.001	0.064	0.020	NO	0.025	0.027	0.027	0.027
2010	0.001	0.074	0.023	NO	0.029	0.034	0.034	0.034
2011	0.001	0.071	0.022	NO	0.028	0.031	0.031	0.031
2012	0.001	0.072	0.022	NO	0.028	0.030	0.030	0.030
2013	0.001	0.070	0.022	NO	0.027	0.030	0.030	0.030
2014	0.001	0.068	0.021	NO	0.026	0.030	0.030	0.030
2015	0.001	0.065	0.020	NO	0.025	0.027	0.027	0.027
2016	0.001	0.067	0.021	NO	0.026	0.028	0.028	0.028
2017	0.001	0.071	0.022	NO	0.028	0.031	0.031	0.031
Trend 1990-2017	*-94.04%*	*-47.78%*	*97.43%*	*NA*	*26.02%*	*557.40%*	*557.40%*	*557.40%*
2005-2017	*-29.72%*	*-10.11%*	*-7.67%*	*NA*	*-8.18%*	*-7.27%*	*-7.27%*	*-7.27%*
2016-2017	*3.62%*	*5.87%*	*6.09%*	*NA*	*6.05%*	*14.20%*	*14.20%*	*14.20%*

Source: Environment Agency.

3.2.3.3.2 Methodological issues & time series consistency

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 activity data for secondary aluminium production are listed in Table 76.

The 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*.

Table 76 – 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
Trend 1990-2017	*105.89%*	*NA*	*NA*	*310.01%*	*NA*	*NA*
2005-2017	*-7.20%*	*NA*	*NA*	*-7.20%*	*NA*	*NA*
2016-2017	*6.13%*	*NA*	*NA*	*6.13%*	*NA*	*NA*

Source: Environment Agency.

3.2.3.3.2.2 Methodological choices

As no plant-specific emission data for this category was available, emissions of air pollutants were estimated using the EMEP/EEA Guidebook Tier 1 approach for liquid (LPG) and gaseous fuels (natural gas).

The methods and emission factors used in relation to the coverage of energy consumption in consumption for 2017 are presented in Table 77.

Table 77 – Methods and Emission Factors used in relation to the energy in consumption in 2017 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	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)
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 2009(PartB, Chap1A2, Tab3.3, p16)
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%	IEF
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)
PM2.5	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)
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 2009(PartB, Chap1A2, Tab3.3, p16)
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 2009(PartB, Chap1A2, Tab3.3, p16)

Source: Environment Agency.

3.2.3.3.2.3 Emission factors

The EMEP/EEA default emission factors were used. Table 78 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 78 – 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	23.73	292.55	24.00	NA	47.42	10.35	10.35	10.35
1991	22.86	284.28	23.96	NA	46.72	9.99	9.99	9.99
1992	22.66	282.41	23.95	NA	69.15	9.90	9.90	9.90
1993	23.10	286.57	23.97	NA	70.04	10.09	10.09	10.09
1994	25.48	309.04	24.07	NA	68.34	11.07	11.07	11.07
1995	25.22	306.59	24.06	NA	69.47	10.96	10.96	10.96
1996	24.13	308.76	28.24	NA	52.97	35.96	35.96	35.96
1997	15.85	234.41	29.29	NA	48.11	41.63	41.63	41.63
1998	16.83	242.70	28.98	NA	48.45	40.55	40.55	40.55
1999	17.40	248.74	29.24	NA	49.20	41.52	41.52	41.52
2000	18.61	261.67	29.78	NA	50.77	44.38	44.38	44.38
2001	19.96	276.60	30.58	NA	52.76	43.38	43.38	43.38
2002	12.90	207.44	29.50	NA	46.17	37.07	37.07	37.07
2003	9.26	167.73	27.57	NA	41.06	39.52	39.52	39.52
2004	12.24	200.32	29.16	NA	45.25	41.46	41.46	41.46
2005	0.91	76.60	23.13	NA	29.33	33.07	33.07	33.07
2006	0.72	74.59	23.03	NA	29.08	35.46	35.46	35.46
2007	0.90	76.47	23.12	NA	29.32	36.24	36.24	36.24
2008	0.73	74.69	23.03	NA	29.09	34.72	34.72	34.72
2009	0.77	75.06	23.05	NA	29.14	31.47	31.47	31.47
2010	0.78	75.25	23.06	NA	29.16	34.80	34.80	34.80
2011	0.78	75.19	23.06	NA	29.15	32.81	32.81	32.81
2012	0.74	74.78	23.04	NA	29.10	31.79	31.79	31.79
2013	0.74	74.81	23.04	NA	29.10	31.90	31.90	31.90
2014	0.72	74.56	23.03	NA	29.07	32.78	32.78	32.78
2015	0.67	74.03	23.00	NA	29.00	30.43	30.43	30.43
2016	0.70	74.37	23.02	NA	29.05	30.71	30.71	30.71
2017	0.69	74.19	23.01	NA	29.02	33.04	33.04	33.04
Trend								
1990-2017	*-97.10%*	*-74.64%*	*-4.11%*	*NA*	*-38.79%*	*219.29%*	*219.29%*	*219.29%*
2005-2017	*-24.27%*	*-3.14%*	*-0.51%*	*NA*	*-1.05%*	*-0.07%*	*-0.07%*	*-0.07%*
2016-2017	*-2.37%*	*-0.24%*	*-0.04%*	*NA*	*-0.08%*	*7.60%*	*7.60%*	*7.60%*

Source: Environment Agency.

3.2.3.3.3 Uncertainties and time-series consistency

Currently no uncertainty estimates are made. Uncertainty of the activity data can be checked in the Luxembourg's National Inventory report (NIR).

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

3.2.3.3.4 Source-specific QA/QC and verification

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

Finally, consistency and completeness checks are performed.

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

Table 79 presents the main revisions and recalculations done since submission 2018 for sub-category *1A2b – Non-ferrous metals*.

Table 79 – Recalculations done since submission 2018 for category – *1A2b - Non-ferrous metals*

Source category	Revisions 2018 ➔ 2019	Type of revision
1A2b	Fuel consumption was revised due to revised energy balance from the national statistics institute	Updated AD
1A2b	Aligned Tier 1 and Tier 2 default EFs from EMEP/EEA Guidebook 2009 to EMEP/EEA Guidebook 2016, if necessary.	Updated EFs

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

The following improvements are planned for the next submission.

Table 80 – Planned improvements for category – *1A2b - Non-ferrous metals*

Source category	Planned improvements	Type of revision
1A2b	Add secondary copper production point source	Update AD

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 and 2017, this source category represented about 1% or less of the national total for each air pollutant (based on fuel sold and based on fuel used).

In the period 1990 – 2017, all emissions of 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 81 summarizes emissions of air pollutants for category *1A2c – Chemicals* and Table 82 presents the emission trends.

In 2017, category *1A2c – Chemicals* has not been identified as a key category (see also Table 49 in Section 3.2 and Chapter 1.5).

Table 81 - Emissions (1990, 2005, 2016 and 2017), 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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
SO2	0.07	0.02	0.00	0.00	-98.3%	-94.0%	-10.3%	0.5%	0.8%	0.1%	0.5%	0.8%	0.1%	fuel sold
NOx	0.82	0.25	0.11	0.10	-87.4%	-58.3%	-4.5%	3.6%	1.5%	0.8%	2.0%	0.5%	0.6%	fuel sold
NMVOC	0.06	0.04	0.03	0.03	-44.4%	-6.1%	-0.6%	0.3%	0.3%	0.3%	0.2%	0.2%	0.3%	fuel sold
NH3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
CO	0.13	0.10	0.03	0.02	-80.2%	-75.6%	-8.9%	0.0%	0.5%	0.1%	0.0%	0.3%	0.1%	fuel sold
TSP	0.03	0.01	0.01	0.00	-85.0%	-26.5%	-36.4%	0.2%	0.3%	0.2%	0.2%	0.2%	0.2%	fuel sold
PM10	0.03	0.01	0.01	0.00	-85.1%	-12.1%	-36.6%	0.2%	0.3%	0.3%	0.2%	0.2%	0.2%	fuel sold
PM2.5	0.03	0.00	0.00	0.00	-94.5%	-61.2%	10.5%	0.2%	0.3%	0.2%	0.2%	0.2%	0.1%	fuel sold

Source: Environment Agency.

Table 82 – 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	0.069	0.823	0.059	NO	0.125	0.030	0.030	0.030
1991	0.134	1.020	0.062	NO	0.145	0.041	0.040	0.040
1992	0.075	0.820	0.061	NO	0.127	0.030	0.030	0.030
1993	0.173	0.803	0.060	NO	0.129	0.034	0.033	0.032
1994	0.123	0.883	0.060	NO	0.138	0.031	0.031	0.030
1995	0.046	0.676	0.049	NO	0.116	0.019	0.019	0.019
1996	0.056	0.750	0.047	NO	0.119	0.020	0.019	0.019
1997	0.065	0.611	0.041	NO	0.097	0.012	0.012	0.011
1998	0.020	0.392	0.030	NO	0.083	0.005	0.004	0.004
1999	0.040	0.299	0.032	NO	0.086	0.007	0.006	0.005
2000	0.023	0.281	0.033	NO	0.096	0.007	0.006	0.005
2001	0.027	0.248	0.030	NO	0.110	0.008	0.007	0.005
2002	0.024	0.251	0.030	NO	0.109	0.007	0.006	0.005
2003	0.019	0.252	0.032	NO	0.121	0.006	0.005	0.004
2004	0.022	0.255	0.036	NO	0.117	0.007	0.006	0.005
2005	0.020	0.248	0.035	NO	0.102	0.006	0.005	0.004
2006	0.011	0.218	0.032	NO	0.104	0.003	0.003	0.003
2007	0.010	0.222	0.037	NO	0.089	0.003	0.003	0.002
2008	0.004	0.197	0.030	NO	0.065	0.002	0.002	0.002
2009	0.003	0.125	0.028	NO	0.031	0.002	0.002	0.002
2010	0.005	0.179	0.027	NO	0.059	0.003	0.003	0.002
2011	0.005	0.147	0.025	NO	0.064	0.004	0.004	0.002
2012	0.009	0.149	0.026	NO	0.064	0.007	0.006	0.004
2013	0.012	0.151	0.029	NO	0.061	0.009	0.007	0.005
2014	0.009	0.126	0.029	NO	0.074	0.007	0.006	0.004
2015	0.011	0.117	0.035	NO	0.036	0.013	0.012	0.005
2016	0.001	0.108	0.033	NO	0.027	0.007	0.007	0.001
2017	0.001	0.104	0.033	NO	0.025	0.004	0.004	0.002
Trend 1990-2017	*-98.29%*	*-87.41%*	*-44.41%*	*NA*	*-80.17%*	*-85.05%*	*-85.12%*	*-94.54%*
2005-2017	*-93.99%*	*-58.25%*	*-6.06%*	*NA*	*-75.61%*	*-26.54%*	*-12.08%*	*-61.22%*
2016-2017	*-10.27%*	*-4.48%*	*-0.63%*	*NA*	*-8.94%*	*-36.43%*	*-36.59%*	*10.52%*

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 is 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 was 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 83.

Fluctuations in activity data may occur, due to temporal shut-down 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 9% 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 83- 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	3 096 655	895'987	NO	2'200'668	NO	NO
1996	3 166 826	905'480	NO	2'261'347	NO	NO
1997	3 105 924	541'574	NO	2'564'350	NO	NO
1998	3 282 717	145'022	NO	3'137'695	NO	NO
1999	3 223 167	211'883	NO	3'011'284	NO	NO
2000	3 618 830	218'707	NO	3'400'122	NO	NO
2001	3 782 763	253'681	NO	3'529'081	NO	NO
2002	3 744 542	220'952	NO	3'523'590	NO	NO
2003	3 918 509	170'242	NO	3'748'267	NO	NO
2004	4 023 985	197'211	NO	3'826'775	NO	NO
2005	3 979 273	174'153	NO	3'805'119	NO	NO
2006	3 791 898	82'726	NO	3'709'171	NO	NO
2007	3 373 071	66'911	NO	3'306'160	NO	NO
2008	3 356 005	43'290	NO	3'312'715	NO	NO
2009	2 516 779	37'732	NO	2'479'048	NO	NO
2010	2 990 086	75'118	NO	2'914'968	NO	NO
2011	3 226 530	68'167	NO	3'158'363	NO	NO
2012	3 127 706	165'874	NO	2'961'833	NO	NO
2013	3 415 054	229'291	NO	3'185'763	NO	NO
2014	2 806 391	177'507	NO	2'628'884	NO	NO
2015	2 668 182	236'221	NO	2'431'961	NO	NO
2016	2 603 415	2'972	NO	2'600'443	NO	NO
2017	2 541 240	4'185	NO	2'537'055	NO	NO
Trend 1990-2017	*3.48%*	*-99.71%*	*NA*	*155.05%*	*NA*	*NA*
2005-2017	*-36.14%*	*-97.60%*	*NA*	*-33.33%*	*NA*	*NA*
2016-2017	*-2.39%*	*40.81%*	*NA*	*-2.44%*	*NA*	*NA*

Source: Environment Agency.

3.2.3.4.2.2 Methodological issues

For all large 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).

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 by multiplying the fuel consumption taken from the national energy balance with the default emission factors.

If no information was available, EMEP/EEA Tier 1 methodology was used.

The methods applied in relation to the energy consumption for 2017 are presented in Table 84.

3.2.3.4.2.3 Emission factors

For large 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.

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 84).

Table 85 gives an overview of the evolution of the implied emission factors. Implied emission factors may vary over time for the following reasons:

- The chemical characteristics 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 84 – Methods and Emission Factors used in relation to the energy in consumption in 2017 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	77.7%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	22.3%	EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.4, p16), EMEP/EEA GB
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 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.4, p16), EMEP/EEA GB 2009(PartB, Chap1A1, Tab3.20, p33), EMEP/EEA GB 2016(PartB, Chap1A1, Tab3.18, p34)
SOx	T3	PS	52.3%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2	CS	0.1%	CS based on fuel sulfur content; determined by AEV
	T1	D	47.6%	EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.6, p16)
CO	T3	PS	77.7%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	22.3%	EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.4, p16)
PM2.5	T3	PS	32.7%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV PM measured assumed to be TSP = PM10 = PM2.5
	T1	D	67.3%	EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.4, p16)
PM10	T3	PS	32.7%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV PM measured assumed to be TSP = PM10 = PM2.5
	T1	D	67.3%	EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.4, p16)
TSP	T3	PS	32.7%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV PM measured assumed to be TSP = PM10 = PM2.5
	T1	D	67.3%	EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.4, p16)

Source: Environment Agency.

Table 85 – Implied emission factors for category – *1A2c - Chemicals*

Year	SO2	NOx	NMVOC	NH3	CO	TSP	PM10	PM2.5
	1 A 2 Stationary combustion in manufacturing industries and construction – *Implied Emission Factor (IEF) of air pollutants by source category (g/GJ)* – 1 A 2 c Chemicals							
1990	28.23	335.18	24.19	NA	51.01	12.21	12.21	12.21
1991	52.24	397.94	24.02	NA	56.61	15.86	15.65	15.47
1992	29.58	325.27	24.08	NA	50.22	11.90	11.88	11.85
1993	66.70	309.32	22.98	NA	49.56	13.21	12.71	12.29
1994	41.61	297.74	20.17	NA	46.52	10.61	10.38	10.19
1995	14.98	218.35	15.74	NA	37.50	6.21	6.15	6.09
1996	17.73	236.81	14.91	NA	37.49	6.21	6.07	5.95
1997	21.09	196.72	13.10	NA	31.29	4.01	3.79	3.61
1998	6.00	119.32	9.27	NA	25.38	1.46	1.26	1.09
1999	12.28	92.81	9.97	NA	26.61	2.17	1.79	1.48
2000	6.37	77.62	9.15	NA	26.62	1.98	1.63	1.33
2001	7.12	65.58	7.87	NA	29.13	2.14	1.74	1.41
2002	6.33	67.12	7.96	NA	29.06	1.91	1.56	1.27
2003	4.89	64.23	8.16	NA	31.00	1.49	1.23	1.02
2004	5.36	63.44	8.90	NA	29.08	1.68	1.39	1.15
2005	4.95	62.38	8.83	NA	25.60	1.53	1.28	1.06
2006	2.86	57.55	8.49	NA	27.35	0.92	0.80	0.69
2007	2.87	65.72	11.02	NA	26.48	0.93	0.81	0.71
2008	1.25	58.73	8.90	NA	19.47	0.69	0.62	0.55
2009	1.29	49.76	10.97	NA	12.38	0.81	0.72	0.65
2010	1.78	59.98	8.94	NA	19.69	1.04	0.90	0.77
2011	1.41	45.50	7.73	NA	19.88	1.25	1.12	0.69
2012	2.85	47.64	8.19	NA	20.35	2.11	1.79	1.23
2013	3.43	44.11	8.37	NA	17.92	2.52	2.12	1.53
2014	3.12	44.80	10.23	NA	26.37	2.54	2.17	1.53
2015	4.11	43.73	13.16	NA	13.53	4.94	4.41	2.05
2016	0.51	41.67	12.76	NA	10.48	2.71	2.70	0.57
2017	0.47	40.78	13.00	NA	9.77	1.76	1.76	0.64
Trend 1990-2017	*-98.35%*	*-87.83%*	*-46.28%*	*NA*	*-80.84%*	*-85.55%*	*-85.62%*	*-94.73%*
2005-2017	*-90.59%*	*-34.63%*	*47.09%*	*NA*	*-61.82%*	*15.03%*	*37.68%*	*-39.27%*
2016-2017	*-8.07%*	*-2.14%*	*1.81%*	*NA*	*-6.71%*	*-34.87%*	*-35.04%*	*13.23%*

Source: Environment Agency.

3.2.3.4.3 Uncertainties and time-series consistency

Currently no uncertainty estimates are made. Uncertainty of the activity data can be checked in the Luxembourg's National Inventory report (NIR).

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

3.2.3.4.4 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.

Finally, consistency and completeness checks are performed.

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

Table 86 presents the main revisions and recalculations done since submission 2018 for category *1A2c – Chemicals*.

Table 86 – Recalculations done since submission 2018 for category – *1A2c - Chemicals*

Source category	Revisions 2018 ➔ 2019	Type of revision
1A2c	Fuel consumption data was revised due to revised energy balance from the national statistics institute	updated AD
1A2c	Aligned Tier 1 and Tier 2 default EFs from EMEP/EEA Guidebook 2009 to EMEP/EEA Guidebook 2016.	Updated EFs

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

The following improvements are planned for the next submission.

Table 87 – 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 2017, this source category represented less than 0.1% 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 2017, and has never been in the past (see also Table 49 in Section 3.2 and Chapter 1.5).

Table 88 summarizes emissions of air pollutants for category *1A2d – Pulp, Paper and Print* and Table 89 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 88 – Emissions (1990, 2005, 2016 and 2017), 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	2016	2017	Trend 1990 - 2017	Trend 2005 - 2017	Trend 2016 - 2017	FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
								1990	2005	2017	1990	2005	2017	
SO2	NO	0.00	0.00	0.00	0.0%	-96.9%	-0.6%	NO	0.06%	0.00%	NO	0.06%	0.00%	fuel sold
NOx	NO	0.02	0.01	0.01	0.7%	-71.4%	-0.3%	NO	0.14%	0.05%	NO	0.04%	0.04%	fuel sold
NMVOC	NO	0.00	0.00	0.00	0.0%	-73.2%	1.0%	NO	0.01%	0.00%	NO	0.01%	0.00%	fuel sold
NH3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
CO	NO	0.01	0.00	0.00	0.2%	-71.6%	-0.2%	NO	0.04%	0.01%	NO	0.02%	0.01%	fuel sold
TSP	NO	0.00	0.00	0.00	0.0%	-83.5%	16.5%	NO	0.03%	0.00%	NO	0.01%	0.00%	fuel sold
PM10	NO	0.00	0.00	0.00	0.0%	-82.5%	14.0%	NO	0.03%	0.01%	NO	0.02%	0.00%	fuel sold
PM2.5	NO	0.00	0.00	0.00	0.0%	-81.4%	11.6%	NO	0.03%	0.01%	NO	0.02%	0.01%	fuel sold

Source: Environment Agency.

Table 89 – 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	NO	NO	NO	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO	NO	NO	NO
1994	NO	NO	NO	NO	NO	NO	NO	NO
1995	NO	NO	NO	NO	NO	NO	NO	NO
1996	NO	NO	NO	NO	NO	NO	NO	NO
1997	NO	NO	NO	NO	NO	NO	NO	NO
1998	NO	NO	NO	NO	NO	NO	NO	NO
1999	NO	NO	NO	NO	NO	NO	NO	NO
2000	0.002	0.016	0.001	NO	0.006	0.001	0.001	0.000
2001	0.003	0.020	0.001	NO	0.007	0.001	0.001	0.001
2002	0.003	0.024	0.001	NO	0.009	0.001	0.001	0.001
2003	0.002	0.027	0.001	NO	0.010	0.001	0.001	0.000
2004	0.002	0.024	0.001	NO	0.009	0.001	0.001	0.000
2005	0.002	0.023	0.001	NO	0.008	0.001	0.000	0.000
2006	0.001	0.014	0.001	NO	0.005	0.000	0.000	0.000
2007	0.000	0.009	0.000	NO	0.003	0.000	0.000	0.000
2008	0.000	0.012	0.000	NO	0.004	0.000	0.000	0.000
2009	0.000	0.010	0.000	NO	0.004	0.000	0.000	0.000
2010	0.000	0.007	0.000	NO	0.002	0.000	0.000	0.000
2011	0.000	0.011	0.000	NO	0.004	0.000	0.000	0.000
2012	0.000	0.013	0.000	NO	0.005	0.000	0.000	0.000
2013	0.000	0.017	0.001	NO	0.006	0.000	0.000	0.000
2014	0.000	0.008	0.000	NO	0.003	0.000	0.000	0.000
2015	0.000	0.007	0.000	NO	0.002	0.000	0.000	0.000
2016	0.000	0.007	0.000	NO	0.002	0.000	0.000	0.000
2017	0.000	0.007	0.000	NO	0.002	0.000	0.000	0.000
Trend 1990-2017	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005-2017	*-96.94%*	*-71.42%*	*-73.19%*	*NA*	*-71.55%*	*-83.47%*	*-82.52%*	*-81.42%*
2016-2017	*-0.64%*	*-0.27%*	*1.05%*	*NA*	*-0.18%*	*16.48%*	*14.03%*	*11.59%*

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 2000-2017. 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 is 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 90.

Table 90 – 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	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO	NO
1994	NO	NO	NO	NO	NO	NO
1995	NO	NO	NO	NO	NO	NO
1996	NO	NO	NO	NO	NO	NO
1997	NO	NO	NO	NO	NO	NO
1998	NO	NO	NO	NO	NO	NO
1999	NO	NO	NO	NO	NO	NO
2000	222 948	19'980	NO	202'968	NO	NO
2001	266 625	29'781	NO	236'843	NO	NO
2002	331 511	30'456	NO	301'055	NO	NO
2003	378 444	17'956	NO	360'488	NO	NO
2004	329 795	20'482	NO	309'314	NO	NO
2005	323 026	14'804	NO	308'222	NO	NO
2006	199 751	6'580	NO	193'171	NO	NO
2007	128 782	4'379	NO	124'403	NO	NO
2008	176 705	3'210	NO	173'495	NO	NO
2009	138 620	2'335	NO	136'285	NO	NO
2010	91 754	3'941	NO	87'812	NO	NO
2011	154 293	2'195	NO	152'098	NO	NO
2012	189 025	1'217	NO	187'807	NO	NO
2013	236 517	1'603	NO	234'914	NO	NO
2014	111 331	663	NO	110'668	NO	NO
2015	95 849	876	NO	94'973	NO	NO
2016	93 858	1'213	NO	92'645	NO	NO
2017	93 394	1'707	NO	91'687	NO	NO
Trend 1990-2017	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005-2017	*-71.09%*	*-88.47%*	*NA*	*-70.25%*	*NA*	*NA*
2016-2017	*-0.49%*	*40.81%*	*NA*	*-1.03%*	*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 91).

3.2.3.5.2.3 Emission factors

Where no plant-specific data was available EMEP/EEA Tier 2 approach was used if specific technological information was available.

The remaining sources, where neither measured (plant-specific) emission data nor technology specific activity data 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 and emission factors (EF) used, in relation to the energy consumption, for 2017, are presented in Table 91.

Table 91 – Methods and Emission Factors used in relation to the energy in consumption in 2017 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 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.4, p16)
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 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.4, p16)
SOx	T3	PS	0.0%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2	CS	1.8%	CS based on fuel sulfur content; determined by AEV
	T1	D	98.2%	EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.6, 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 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.4, p16)
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 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.4, p16)
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 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.4, p16)

Source: Environment Agency

Table 92 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 92 – 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	8.88	72.69	3.17	NA	26.34	2.92	2.38	1.93
2001	10.95	73.35	3.34	NA	26.68	3.52	2.85	2.29
2002	9.10	72.76	3.19	NA	26.38	2.98	2.43	1.97
2003	4.94	71.42	2.86	NA	25.71	1.78	1.50	1.26
2004	6.31	71.86	2.97	NA	25.93	2.18	1.80	1.49
2005	4.79	71.37	2.84	NA	25.69	1.74	1.46	1.23
2006	3.58	70.99	2.75	NA	25.49	1.39	1.19	1.03
2007	3.68	71.02	2.76	NA	25.51	1.42	1.21	1.04
2008	1.35	70.54	2.64	NA	25.27	0.99	0.88	0.79
2009	1.28	70.51	2.63	NA	25.25	0.95	0.85	0.77
2010	2.43	71.29	2.82	NA	25.64	1.66	1.40	1.19
2011	1.06	70.43	2.61	NA	25.21	0.88	0.80	0.73
2012	0.77	70.19	2.55	NA	25.10	0.67	0.64	0.60
2013	0.78	70.20	2.55	NA	25.10	0.68	0.64	0.61
2014	0.74	70.18	2.54	NA	25.09	0.66	0.63	0.60
2015	0.87	70.27	2.57	NA	25.14	0.75	0.69	0.65
2016	0.51	70.39	2.60	NA	25.19	0.85	0.77	0.71
2017	0.51	70.55	2.64	NA	25.27	0.99	0.88	0.79
Trend								
1990-2017	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005-2017	*-89.43%*	*-1.16%*	*-7.27%*	*NA*	*-1.61%*	*-42.81%*	*-39.56%*	*-35.74%*
2016-2017	*-0.15%*	*0.23%*	*1.55%*	*NA*	*0.32%*	*17.06%*	*14.60%*	*12.14%*

Source: Environment Agency

3.2.3.5.3 Uncertainties and time-series consistency

Currently no uncertainty estimates are made. Uncertainty of the activity data can be checked in the Luxembourg's National Inventory report (NIR).

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

3.2.3.5.4 Source-specific QA/QC and verification

Activity data for large facilities is cross-checked from two sources: reports obtained directly from the operator under its operational permit obligations and ePRTR.

Finally, consistency and completeness checks are performed.

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

Table 93 presents the main revisions and recalculations done since submission 2018 for category *1A2d – Pulp, Paper and Print*.

Table 93 – Recalculations done since submission 2018 for category – *1A2d - Pulp, Paper and Print*

Source category	Revisions 2018 → 2019	Type of revision
1A2d	Fuel consumption data was revised due to revised energy balance from the national statistics institute	updated AD

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

The following improvements are planned for the next submission.

Table 94 – Planned improvements for category – *1A2d - Pulp, Paper and Print*

Source category	Planned improvements	Type of revision
1A2d	For the years 1990-1999, the notation key will be changed from NO to IE	Notation key correction
1A2d	Align Tier 1 and Tier 2 default EFs from EMEP/EEA Guidebook 2009 to EMEP/EEA Guidebook 2016.	Update EFs

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 2017, this source category represented less than 0.2 % of national total emissions of air pollutants (based on fuel sold and based on fuel used).

Table 95 summarizes emissions for category *1A2e – Food Processing, Beverages and Tobacco* and Table 96 presents the emission trends.

Category *1A2e – Food Processing, Beverages and Tobacco* is not a key category in 2017 (see also Table 49 in Section 3.2 and Chapter 1.5).

Table 95 – Emissions (1990, 2005, 2016 and 2017), 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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
SO2	0.005	0.005	0.000	0.000	-96.6%	-97.2%	-22.1%	0.03%	0.23%	0.02%	0.03%	0.22%	0.02%	fuel sold
NOx	0.019	0.026	0.026	0.024	24.5%	-5.6%	-7.8%	0.08%	0.16%	0.20%	0.05%	0.05%	0.13%	fuel sold
NMVOC	0.002	0.004	0.004	0.005	91.8%	4.0%	4.9%	0.01%	0.04%	0.04%	0.01%	0.03%	0.04%	fuel sold
NH3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
CO	0.005	0.009	0.007	0.007	53.8%	-16.4%	8.5%	0.00%	0.04%	0.04%	0.00%	0.02%	0.03%	fuel sold
TSP	0.001	0.002	0.002	0.002	47.4%	26.2%	38.1%	0.01%	0.08%	0.10%	0.01%	0.04%	0.07%	fuel sold
PM10	0.001	0.001	0.001	0.002	36.9%	21.4%	37.4%	0.01%	0.08%	0.11%	0.01%	0.05%	0.09%	fuel sold
PM2.5	0.001	0.001	0.001	0.001	25.0%	15.5%	36.4%	0.01%	0.09%	0.13%	0.01%	0.05%	0.10%	fuel sold

Source: Environment Agency.

Table 96 – 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	0.005	0.019	0.002	NO	0.005	0.001	0.001	0.001
1991	0.008	0.026	0.004	NO	0.007	0.003	0.002	0.002
1992	0.008	0.023	0.003	NO	0.007	0.002	0.002	0.002
1993	0.004	0.016	0.003	NO	0.005	0.001	0.001	0.001
1994	0.007	0.021	0.003	NO	0.007	0.002	0.002	0.002
1995	0.007	0.024	0.004	NO	0.007	0.002	0.002	0.002
1996	0.006	0.019	0.003	NO	0.006	0.002	0.001	0.001
1997	0.009	0.023	0.004	NO	0.008	0.003	0.002	0.002
1998	0.008	0.023	0.004	NO	0.007	0.002	0.002	0.002
1999	0.014	0.039	0.004	NO	0.011	0.004	0.004	0.003
2000	0.009	0.039	0.004	NO	0.013	0.003	0.002	0.002
2001	0.013	0.044	0.006	NO	0.014	0.003	0.003	0.002
2002	0.011	0.049	0.006	NO	0.016	0.003	0.003	0.002
2003	0.005	0.031	0.005	NO	0.009	0.002	0.002	0.001
2004	0.006	0.026	0.005	NO	0.009	0.002	0.002	0.001
2005	0.005	0.026	0.004	NO	0.009	0.002	0.001	0.001
2006	0.002	0.020	0.004	NO	0.007	0.001	0.001	0.001
2007	0.002	0.019	0.004	NO	0.006	0.001	0.001	0.001
2008	0.001	0.024	0.004	NO	0.006	0.001	0.001	0.001
2009	0.003	0.038	0.004	NO	0.008	0.001	0.001	0.001
2010	0.001	0.013	0.003	NO	0.003	0.001	0.001	0.001
2011	0.001	0.019	0.003	NO	0.006	0.001	0.000	0.000
2012	0.001	0.014	0.003	NO	0.004	0.001	0.001	0.000
2013	0.001	0.016	0.004	NO	0.004	0.001	0.001	0.001
2014	0.002	0.025	0.004	NO	0.007	0.001	0.001	0.001
2015	0.002	0.018	0.004	NO	0.005	0.001	0.001	0.001
2016	0.000	0.026	0.004	NO	0.007	0.002	0.001	0.001
2017	0.000	0.024	0.005	NO	0.007	0.002	0.002	0.001
Trend 1990-2017	*-96.63%*	*24.50%*	*91.84%*	*NA*	*53.79%*	*47.40%*	*36.94%*	*24.97%*
2005-2017	*-97.17%*	*-5.60%*	*3.96%*	*NA*	*-16.38%*	*26.17%*	*21.40%*	*15.51%*
2016-2017	*-22.12%*	*-7.77%*	*4.92%*	*NA*	*8.45%*	*38.09%*	*37.36%*	*36.39%*

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 97.

The activity data reported here is 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 is reported for this category. To avoid double counting, the bottom-up data on natural gas was subtracted from the top-down data from national statistics reported for category *1A2g viii – Manufacturing Industry and Construction: Other*. For natural gas (2000-2017) and liquid fuels (residual fuel oil, gas oil, diesel oil), the matching exercise was done within category *1A2e* as top-down data is available for this category from national statistics.

Table 97 – 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	123 939	58'127	NO	65'812	NO	NO
1991	193 080	97'625	NO	95'455	NO	NO
1992	190 024	89'556	NO	100'468	NO	NO
1993	144 772	46'041	NO	98'731	NO	NO
1994	185 088	84'354	NO	100'734	NO	NO
1995	188 732	84'363	NO	104'369	NO	NO
1996	169 396	66'232	NO	103'164	NO	NO
1997	209 521	103'053	NO	106'468	NO	NO
1998	199 012	88'135	NO	110'877	NO	NO
1999	266 940	170'840	NO	96'100	NO	NO
2000	414 541	97'766	NO	316'776	NO	NO
2001	499 227	145'965	NO	353'262	NO	NO
2002	518 726	119'963	NO	398'763	NO	NO
2003	282 284	64'125	NO	218'159	NO	NO
2004	299 949	89'488	NO	210'460	NO	NO
2005	282 624	59'979	NO	222'646	NO	NO
2006	238 614	55'292	NO	183'321	NO	NO
2007	227 830	51'653	NO	176'177	NO	NO
2008	228 492	50'780	NO	177'712	NO	NO
2009	230 932	82'440	NO	148'492	NO	NO
2010	232 193	72'615	NO	159'577	NO	NO
2011	337 278	61'839	NO	275'438	NO	NO
2012	275 554	63'516	NO	212'037	NO	NO
2013	290 831	68'843	NO	221'988	NO	NO
2014	406 318	82'381	NO	323'937	NO	NO
2015	331 255	77'550	NO	253'705	NO	NO
2016	384 262	92'420	NO	291'842	NO	NO
2017	401 130	112'973	NO	288'157	NO	NO
Trend 1990-2017	*223.65%*	*94.36%*	*NA*	*337.85%*	*NA*	*NA*
2005-2017	*41.93%*	*88.36%*	*NA*	*29.42%*	*NA*	*NA*
2016-2017	*4.39%*	*22.24%*	*NA*	*-1.26%*	*NA*	*NA*

Source: Environment Agency.

3.2.3.6.2.2 Methodological choices

For large point sources of this sub-category, emission measurements of NO_X, SO_2, CO and TSP are the basis for the reported emissions (see Table 98).

Where no plant-specific data was available, EMEP/EEA Tier 2 approach was used if specific technological information was available.

The remaining area 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 98).

Table 98 – Methods and Emission Factors used in relation to the energy in consumption in 2017 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	39.4%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	60.6%	EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.4, p16)
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 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.4, p16)
SOx	T3	PS	39.4%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2	CS	19.1%	CS based on fuel sulfur content; determined by AEV
	T1	D	41.5%	EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.6, p16), CS based on maximum allowed suphur content
CO	T3	PS	39.4%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	60.6%	EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.4, 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
	T1	D	60.6%	EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.4, 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
	T1	D	60.6%	EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.4, 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
	T1	D	60.6%	EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.4, p16)

Source: Environment Agency

3.2.3.6.2.3 Emission factors

For large 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) (Table 98). 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 by multiplying the fuel consumption taken from the national energy balance with the 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 and emission factors (EF) used, in relation to the energy consumption, for 2017, are presented in Table 98.

Table 99 gives an overview of the evolution of the implied emission factors.

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.

Table 99 – 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	36.40	157.01	19.47	NA	38.62	12.03	10.24	8.75
1991	42.35	135.75	18.19	NA	37.62	13.41	11.08	9.14
1992	40.72	121.08	18.14	NA	36.38	12.74	10.42	8.48
1993	27.36	108.72	19.83	NA	34.16	8.80	7.27	6.00
1994	40.31	111.48	18.01	NA	35.63	12.49	10.13	8.16
1995	37.48	128.93	18.76	NA	36.64	11.94	9.88	8.17
1996	34.30	109.50	18.84	NA	34.90	10.77	8.79	7.14
1997	43.81	111.35	17.50	NA	35.96	13.48	10.88	8.72
1998	38.72	114.54	18.30	NA	35.70	12.09	9.85	7.99
1999	53.99	147.20	16.73	NA	39.60	16.85	13.84	11.32
2000	20.93	92.96	10.68	NA	30.61	6.68	5.48	4.48
2001	26.09	88.81	11.20	NA	27.85	6.83	5.60	4.58
2002	20.25	95.25	11.23	NA	30.79	6.52	5.38	4.43
2003	18.48	108.59	16.60	NA	32.48	6.25	5.32	4.54
2004	20.76	86.70	15.93	NA	29.78	6.63	5.43	4.42
2005	19.05	90.81	15.76	NA	31.14	6.16	5.07	4.15
2006	10.33	82.69	16.30	NA	27.45	3.65	3.13	2.69
2007	8.50	81.70	16.87	NA	26.98	3.13	2.73	2.39
2008	4.73	103.24	17.49	NA	27.98	2.37	2.37	2.37
2009	11.21	164.65	15.26	NA	32.81	5.03	5.03	5.03
2010	6.12	54.18	13.77	NA	14.96	3.78	3.02	2.39
2011	2.47	55.75	10.33	NA	16.67	1.80	1.48	1.21
2012	3.41	52.00	12.69	NA	14.12	2.24	1.82	1.47
2013	4.55	53.33	12.33	NA	15.16	3.03	2.43	1.93
2014	4.55	62.17	9.76	NA	18.35	3.07	2.49	2.00
2015	4.68	54.16	11.90	NA	15.49	3.21	2.56	2.02
2016	0.51	68.36	11.49	NA	17.66	4.14	3.29	2.59
2017	0.38	60.40	11.54	NA	18.35	5.48	4.33	3.38
Trend								
1990-2017	*-98.96%*	*-61.53%*	*-40.73%*	*NA*	*-52.48%*	*-54.46%*	*-57.69%*	*-61.39%*
2005-2017	*-98.01%*	*-33.49%*	*-26.75%*	*NA*	*-41.08%*	*-11.10%*	*-14.46%*	*-18.62%*
2016-2017	*-25.39%*	*-11.65%*	*0.51%*	*NA*	*3.89%*	*32.29%*	*31.59%*	*30.66%*

Source: Environment Agency

3.2.3.6.3 Uncertainties and time-series consistency

Currently no uncertainty estimates are made. Uncertainty of the activity data can be checked in the Luxembourg's National Inventory report (NIR).

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

3.2.3.6.4 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.

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

Finally, consistency and completeness checks are performed.

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

Table 100 presents the main revisions and recalculations done since submission 2018 for sub-category *1A2e – Food Processing, Beverages and Tobacco Industry*.

Table 100 – Recalculations done since submission 2018 for category – *1A2e - Food Processing, Beverages and Tobacco*

Source category	Revisions 2018 ➔ 2019	Type of revision
1A2e	Fuel consumption data was revised due to revised energy balance from the national statistics institute	updated AD
1A2e	Aligned Tier 1 and Tier 2 default EFs from EMEP/EEA Guidebook 2009 to EMEP/EEA Guidebook 2016.	Updated EFs

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

The following improvements are planned for the next submission.

Table 101 – 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 2017, this source category represented

- 54.3% of national total SO_2 emissions (based on fuel sold) and 55.6% of national total SO_2 emissions (based on fuel used), whereas in 1990, this source category represented 5.1% of national total SO_2 emissions (based on fuel sold) and 5.4% of national total SO_2 emissions (based on fuel used).
- 10.9% of national total CO emissions (based on fuel sold) and 14.1% of national total CO emissions (based on fuel used) , whereas in 1990, this source category represented 6.5% of national total CO emissions (based on fuel sold) and 7.2% of national total CO emissions (based on fuel used).

- 9.1% of national total NO_X emissions (based on fuel sold) and 13.5% of national total NO_X emissions (based on fuel used), whereas in 1990, this source category represented 8.1% of national total CO emissions (based on fuel sold) and 14.6% of national total CO emissions (based on fuel used).

Compared to 1990, emissions of all air pollutants decreased significantly mainly due the implementation of specific abatement technology and substitution of solid fuels. But also the implementation of a selective catalytic reduction (SCR) in the glass production industry led to a reduction of the 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 2016, emissions of most air pollutants decreased by up to 50%.

Table 102 summarizes emissions of air pollutants for category *1A2f – Non-Metallic Minerals* and Table 104 presents the emission trends.

Table 102 – Emissions (1990, 2005, 2016 and 2017), 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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
SO2	0.75	0.99	0.66	0.55	-27.2%	-44.3%	-16.7%	5.4%	41.4%	55.6%	5.1%	40.8%	54.3%	fuel sold
NOx	3.37	2.71	2.67	1.67	-50.4%	-38.5%	-37.5%	14.6%	16.9%	13.5%	8.1%	5.0%	9.1%	fuel sold
NMVOC	0.07	0.06	0.02	0.01	-83.3%	-79.2%	-50.0%	0.4%	0.5%	0.1%	0.3%	0.4%	0.1%	fuel sold
NH3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold
CO	30.11	4.28	2.15	2.40	-92.0%	-43.9%	11.8%	7.2%	21.6%	14.1%	6.5%	11.2%	10.9%	fuel sold
TSP	0.41	0.11	0.07	0.05	-88.9%	-60.1%	-34.7%	2.5%	5.1%	2.0%	2.4%	2.9%	1.5%	fuel sold
PM10	0.41	0.11	0.07	0.05	-89.0%	-60.1%	-34.0%	2.6%	6.6%	2.9%	2.5%	3.7%	2.3%	fuel sold
PM2.5	0.41	0.11	0.07	0.05	-89.0%	-59.9%	-33.0%	2.7%	8.4%	4.2%	2.5%	4.6%	3.4%	fuel sold

Source: Environment Agency.

With regard to SO_2 and CO emissions (LA & TA) as well as NO_X and $PM_{2.5}$ emissions (LA), *1A2f Non-Metallic Minerals* is a key category in 2017 (see Table 103 and also Table 49 in Section 3.2 and Chapter 1.5).

Table 103 – 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	1	2	3						4	5					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 f	Manufacturing Industries and Construction - Non-metallic Minerals	1	2	2						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 104 – 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	0.754	3.370	0.073	NO	30.108	0.412	0.411	0.410
1991	0.600	3.135	0.061	NO	28.652	0.380	0.379	0.378
1992	0.995	3.484	0.091	NO	29.293	0.436	0.432	0.429
1993	0.987	3.244	0.079	NO	24.397	0.382	0.379	0.375
1994	1.533	3.594	0.136	NO	28.016	0.491	0.483	0.474
1995	0.955	3.213	0.074	NO	13.023	0.268	0.265	0.261
1996	1.254	3.237	0.104	NO	13.175	0.307	0.302	0.295
1997	0.829	3.171	0.065	NO	13.168	0.254	0.252	0.249
1998	0.671	2.925	0.058	NO	13.162	0.235	0.233	0.232
1999	0.742	3.254	0.058	NO	13.779	0.252	0.250	0.248
2000	1.057	3.174	0.085	NO	1.778	0.140	0.137	0.134
2001	1.537	3.694	0.141	NO	5.190	0.298	0.291	0.281
2002	0.715	2.788	0.052	NO	4.394	0.125	0.125	0.125
2003	0.553	2.086	0.046	NO	3.867	0.261	0.261	0.260
2004	0.861	2.635	0.061	NO	4.366	0.113	0.112	0.111
2005	0.986	2.715	0.059	NO	4.283	0.114	0.113	0.112
2006	1.410	3.219	0.118	NO	4.825	0.184	0.178	0.171
2007	0.740	3.221	0.052	NO	7.266	0.095	0.095	0.095
2008	0.823	2.968	0.048	NO	3.649	0.100	0.100	0.100
2009	0.753	3.095	0.037	NO	1.241	0.097	0.097	0.097
2010	0.812	3.173	0.017	NO	1.376	0.093	0.093	0.092
2011	0.602	3.932	0.017	NO	1.603	0.053	0.053	0.053
2012	0.577	3.387	0.011	NO	1.459	0.068	0.068	0.068
2013	0.531	1.722	0.011	NO	2.384	0.044	0.044	0.044
2014	0.784	2.583	0.036	NO	1.052	0.104	0.103	0.102
2015	0.558	2.276	0.012	NO	1.258	0.060	0.060	0.060
2016	0.660	2.672	0.024	NO	2.147	0.070	0.069	0.067
2017	0.549	1.670	0.012	NO	2.401	0.046	0.045	0.045
Trend 1990-2017	-27.17%	-50.42%	-83.32%	NA	-92.02%	-88.94%	-88.99%	-89.01%
2005-2017	-44.29%	-38.47%	-79.20%	NA	-43.93%	-60.14%	-60.09%	-59.94%
2016-2017	-16.74%	-37.47%	-50.02%	NA	11.83%	-34.73%	-34.03%	-32.97%

Source: Environment Agency.

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 are two flat glass plants in Luxembourg. Their main fuel is natural gas. LPG was used in the past, but only on a small scale.

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 down in 2010.

The activity data described here is the data reported by the operators to the Environment Agency through the annual reporting obligation in their operational permits.

Activity data for category *1A2f - Non-Metallic Minerals* are listed in Table 105.

Table 105 – 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	6 397 674	278'951	3'028'845	3'089'878	NO	NO
1992	6 835 989	332'101	3'404'630	3'099'259	NO	NO
1993	6 338 557	340'640	2'850'457	3'147'461	NO	NO
1994	7 488 467	371'987	3'840'609	3'275'872	NO	NO
1995	6 741 314	378'163	3'000'573	3'362'578	NO	NO
1996	7 069 180	366'957	3'303'931	3'398'292	NO	NO
1997	6 597 961	450'532	2'886'032	3'261'397	NO	NO
1998	6 156 959	353'846	2'674'118	2'949'422	48 484	131'088
1999	6 899 166	458'326	2'819'127	3'446'649	47 267	127'797
2000	7 085 633	133'449	3'127'895	3'555'847	72 479	195'963
2001	7 361 385	114'647	3'119'891	3'543'132	157 603	426'112
2002	6 376 036	100'703	2'093'325	3'482'189	197 108	502'711
2003	5 451 703	97'186	1'793'790	2'900'483	202 949	457'295
2004	6 248 831	122'662	2'070'876	3'310'857	252 132	492'303
2005	6 377 448	89'426	2'190'698	3'333'205	236 807	527'312
2006	6 770 822	77'093	2'577'804	3'286'321	263 980	565'623
2007	6 300 860	70'777	1'989'234	3'372'178	296 661	572'010
2008	6 113 270	58'034	1'805'356	3'340'782	259 929	649'169
2009	6 028 293	37'557	2'043'207	3'314'606	198 932	433'991
2010	5 986 404	23'877	1'855'755	3'222'306	283 272	601'195
2011	5 928 723	29'527	1'819'386	3'242'719	260 635	576'457
2012	5 818 715	32'119	1'742'721	3'181'655	270 977	591'243
2013	4 915 103	27'785	1'657'980	2'337'698	278 590	613'050
2014	5 613 473	57'737	1'792'071	2'892'559	265 698	605'407
2015	5 297 230	50'199	1'527'342	2'943'615	245 290	530'784
2016	5 473 478	67'561	1'699'332	2'982'705	227 998	495'883
2017	5 261 698	95'247	1'607'521	2'789'923	234 627	534'381
Trend 1990-2017	*-25.92%*	*-69.96%*	*-51.33%*	*-19.89%*	*NA*	*NA*
2005-2017	*-17.50%*	*6.51%*	*-26.62%*	*-16.30%*	*-0.92%*	*1.34%*
2016-2017	*-3.87%*	*40.98%*	*-5.40%*	*-6.46%*	*2.91%*	*7.76%*

Source: Environment Agency

3.2.3.7.2.2 Methodological choices

For large point sources of this sub-category, emission measurements of NO_X, SO_2, NMVOC, CO and TSP are the basis for the reported emissions (EMEP/EEA Tier 3 approach) (Table 106).

Where no plant-specific data was available EMEP/EEA Tier 2 approach was used if specific technological information was available.

The remaining area 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 2017 in relation to the energy consumption are presented in (Table 106).

Table 106 – Methods and Emission Factors used in relation to the energy in consumption in 2017 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	99.2%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	0.8%	EMEP/EEA GB 2016(PartB, Chap1A2, Tab3.2, p15), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB
NMVOC	T3	PS	50.4%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	49.6%	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, Chap1A2, Tab3.5, p17)
SOx	T3	PS	99.2%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2	CS	0.8%	CS based on fuel sulfur content; determined by AEV
	T1	D	0.0%	EMEP/EEA GB 2016(PartB, Chap1A2, Tab3.2, p15), 0, 0
CO	T3	PS	99.2%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T1	D	0.8%	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, Chap1A2, Tab3.5, p17)
PM2.5	T3	PS	99.2%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV PM measured assumed to be TSP = PM10 = PM2.5
	T1	D	0.8%	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, Chap1A2, Tab3.5, p17)
PM10	T3	PS	99.2%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV PM measured assumed to be TSP = PM10 = PM2.5
	T1	D	0.8%	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, Chap1A2, Tab3.5, p17)
TSP	T3	PS	99.2%	Measurement reports of all facilities; IEFs and CS EFs were determined by AEV PM measured assumed to be TSP = PM10 = PM2.5
	T1	D	0.8%	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, Chap1A2, Tab3.5, p17)

Source: Environment Agency

3.2.3.7.2.3 Emission factors

For large point sources of this sub-category, emission measurements of NO_X, SO_2, NMVOC, CO and TSP are the basis for the reported emissions (EMEP/EEA Tier 3 approach (Table 106). 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 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 taking into account the abatement.

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.

Implied emission factors are presented in Table 107. These may vary over time for the following reasons:

- The chemical characteristics 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 107 – 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	106.17	474.43	10.30	NA	4239.04	57.99	57.87	57.71
1991	93.79	490.00	9.53	NA	4478.44	59.36	59.22	59.10
1992	145.53	509.64	13.28	NA	4285.15	63.75	63.25	62.69
1993	155.76	511.82	12.49	NA	3849.04	60.31	59.77	59.18
1994	204.68	479.89	18.22	NA	3741.24	65.54	64.51	63.29
1995	141.72	476.66	11.03	NA	1931.78	39.75	39.27	38.75
1996	177.42	457.90	14.70	NA	1863.66	43.48	42.68	41.76
1997	125.61	480.56	9.79	NA	1995.84	38.49	38.13	37.77
1998	109.02	475.09	9.41	NA	2137.75	38.20	37.90	37.62
1999	107.50	471.66	8.41	NA	1997.27	36.52	36.18	35.91
2000	149.20	447.99	11.99	NA	250.90	19.71	19.38	18.96
2001	208.82	501.80	19.19	NA	705.05	40.51	39.51	38.23
2002	112.20	437.33	8.20	NA	689.08	19.68	19.64	19.61
2003	101.50	382.61	8.42	NA	709.30	47.81	47.78	47.76
2004	137.86	421.66	9.76	NA	698.71	18.14	17.98	17.78
2005	154.57	425.70	9.20	NA	671.53	17.92	17.79	17.63
2006	208.26	475.48	17.38	NA	712.55	27.18	26.36	25.32
2007	117.46	511.13	8.23	NA	1153.19	15.12	15.12	15.11
2008	134.69	485.47	7.91	NA	596.90	16.31	16.31	16.31
2009	124.85	513.48	6.12	NA	205.80	16.02	16.02	16.02
2010	135.69	530.02	2.84	NA	229.88	15.61	15.54	15.45
2011	101.50	663.22	2.91	NA	270.33	9.02	9.02	9.02
2012	99.08	582.14	1.95	NA	250.66	11.65	11.65	11.65
2013	108.13	350.29	2.30	NA	484.98	8.88	8.88	8.88
2014	139.59	460.09	6.46	NA	187.46	18.52	18.34	18.10
2015	105.34	429.63	2.32	NA	237.49	11.28	11.28	11.28
2016	120.50	488.10	4.46	NA	392.28	12.75	12.54	12.27
2017	104.37	317.48	2.32	NA	456.36	8.66	8.60	8.56
Trend 1990-2017	*-1.70%*	*-33.08%*	*-77.48%*	*NA*	*-89.23%*	*-85.07%*	*-85.13%*	*-85.17%*
2005-2017	*-32.48%*	*-25.42%*	*-74.79%*	*NA*	*-32.04%*	*-51.68%*	*-51.63%*	*-51.44%*
2016-2017	*-13.39%*	*-34.96%*	*-48.01%*	*NA*	*16.33%*	*-32.10%*	*-31.37%*	*-30.27%*

Source: Environment Agency

3.2.3.7.3 Uncertainties and time-series consistency

Currently no uncertainty estimates are made. Uncertainty of the activity data can be checked in the Luxembourg's National Inventory report (NIR).

Generally, the time-series, as reported in category *1A2f – Non-Metallic Minerals* are considered to be consistent.

3.2.3.7.4 Source-specific QA/QC and verification

Activity data for large facilities that have reporting obligations under the European Union Emission Trading System (EU-ETS) is 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.

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

Table 108 presents the main revisions and recalculations done since submission 2018 and relevant to category *1A2f – Non-Metallic Minerals*.

Table 108 –Recalculations done since submission 2018 for category – *1A2f - Non-Metallic Minerals*

Source category	Revisions 2018 ➔ 2019	Type of revision
1A2f	Fuel consumption was revised due to revised energy balance from the national statistics institute	Updated AD
1A2f	Aligned Tier 1 and Tier 2 default EFs from EMEP/EEA Guidebook 2009 to EMEP/EEA Guide-book 2016	Update EFs

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

The following improvements are planned for the next submission.

Table 109– Planned improvements for category – *1A2f - Non-Metallic Minerals*

Source category	Planned improvements	Type of revision
1A2f	No further improvements are 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 2017, this source category represented:

- 4.7% of national total NO_X emissions (based on fuel sold) and 6.9% of national total NO_X emissions (based on fuel used).
- 1.4% of national total $PM_{2.5}$ emissions (based on fuel sold) and 1.7% of national total $PM_{2.5}$ emissions (based on fuel used).

In the period 1990 – 2017, SO_2 and $PM_{2.5}$ emission decreased by, respectively, 97.1% and 80.5%, whereas, emissions of the other air pollutants also decreased, except for NO_x and NH_3, for which an increase of 56.9% and 40.2%, respectively, was observed. From 2016 to 2017, NO_x and $PM_{2.5,}$ decreased by 6.3% and 13.8%, respectively.

Category *1A2g vii Mobile Combustion in manufacturing industries and construction* was a key category in 2017 for NO_x, in the level and trend assessments based on fuel sold and fuel used(see Table 110 and also Table 49 in Section 3.2 and Chapter 1.5).

Table 110 – 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 111 summarizes emissions of air pollutants for category *1A2g vii - Mobile Combustion in manufacturing industries and construction* and Table 112 presents the emission trends.

Table 111 – Emissions (1990, 2005, 2016 and 2017), 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 vii Mobile Combustion in manufacturing industries and construction														
Pollutants	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
SO2	0.04	0.00	0.00	0.00	-97.1%	-67.6%	2.9%	0.3%	0.1%	0.1%	0.2%	0.1%	0.1%	fuel sold
NOx	0.54	1.09	0.91	0.85	56.9%	-21.7%	-6.3%	2.4%	6.8%	6.9%	1.3%	2.0%	4.7%	fuel sold
NMVOC	0.09	0.10	0.03	0.03	-71.5%	-73.9%	-9.7%	0.5%	0.8%	0.2%	0.3%	0.7%	0.2%	fuel sold
NH3	0.00	0.00	0.00	0.00	40.2%	-16.9%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
CO	0.59	0.82	0.48	0.46	-21.2%	-43.5%	-3.1%	0.1%	4.1%	2.7%	0.1%	2.1%	2.1%	fuel sold
TSP	0.09	0.09	0.02	0.02	-80.5%	-79.5%	-13.8%	0.6%	4.0%	0.8%	0.5%	2.3%	0.6%	fuel sold
PM10	0.09	0.09	0.02	0.02	-80.5%	-79.5%	-13.8%	0.6%	5.2%	1.2%	0.6%	2.9%	0.9%	fuel sold
PM2.5	0.09	0.09	0.02	0.02	-80.5%	-79.5%	-13.8%	0.6%	6.7%	1.7%	0.6%	3.7%	1.4%	fuel sold

Source: Environment Agency.

Table 112 – Emission trends for category – *1A2g vii - Mobile Combustion in manufacturing industries and construction*

Year	1 A 2 Stationary combustion in manufacturing industries and construction — Emissions of air pollutants by source category (Gg) — 1 A 2 g vii Mobile Combustion in manufacturing industries and construction							
	SO2	*NOx*	*NMVOC*	*NH3*	*CO*	*TSP*	*PM10*	*PM2.5*
1990	0.037	0.544	0.090	0.000	0.589	0.094	0.094	0.094
1991	0.042	0.618	0.101	0.000	0.666	0.106	0.106	0.106
1992	0.046	0.672	0.110	0.000	0.721	0.114	0.114	0.114
1993	0.049	0.731	0.119	0.000	0.782	0.123	0.123	0.123
1994	0.044	0.779	0.123	0.000	0.814	0.126	0.126	0.126
1995	0.017	0.852	0.127	0.000	0.852	0.127	0.127	0.127
1996	0.017	0.838	0.121	0.000	0.815	0.119	0.119	0.119
1997	0.018	0.911	0.126	0.000	0.857	0.122	0.122	0.122
1998	0.018	0.955	0.125	0.000	0.862	0.118	0.118	0.118
1999	0.017	1.065	0.132	0.000	0.922	0.121	0.121	0.121
2000	0.018	1.139	0.136	0.000	0.958	0.121	0.121	0.121
2001	0.019	1.179	0.138	0.000	0.975	0.121	0.121	0.121
2002	0.021	1.243	0.136	0.000	0.996	0.120	0.120	0.120
2003	0.022	1.200	0.122	0.000	0.930	0.109	0.109	0.109
2004	0.003	1.174	0.112	0.000	0.894	0.101	0.101	0.101
2005	0.003	1.092	0.098	0.000	0.821	0.089	0.089	0.089
2006	0.004	1.072	0.089	0.000	0.795	0.082	0.082	0.082
2007	0.001	1.176	0.080	0.000	0.795	0.074	0.074	0.074
2008	0.001	1.042	0.061	0.000	0.655	0.057	0.057	0.057
2009	0.001	1.027	0.055	0.000	0.621	0.051	0.051	0.051
2010	0.001	1.048	0.050	0.000	0.596	0.046	0.046	0.046
2011	0.001	1.097	0.046	0.000	0.580	0.041	0.041	0.041
2012	0.001	1.048	0.041	0.000	0.527	0.036	0.036	0.036
2013	0.001	1.059	0.039	0.000	0.529	0.033	0.033	0.033
2014	0.001	1.056	0.036	0.000	0.538	0.029	0.029	0.029
2015	0.001	0.947	0.031	0.000	0.488	0.024	0.024	0.024
2016	0.001	0.911	0.028	0.000	0.479	0.021	0.021	0.021
2017	0.001	0.854	0.026	0.000	0.464	0.018	0.018	0.018
Trend 1990-2017	-97.13%	56.94%	-71.51%	40.21%	-21.24%	-80.49%	-80.49%	-80.49%
2005-2017	-67.64%	-21.74%	-73.89%	-16.87%	-43.50%	-79.46%	-79.46%	-79.46%
2016-2017	2.91%	-6.25%	-9.65%	0.62%	-3.11%	-13.84%	-13.84%	-13.84%

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 (Table 113):

Table 113 – Combustion activities included in *1A2g vii*

Description	SNAP code
Other mobile sources and machinery in Industry	080800
Other mobile equipment	081000

Activity data is 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.

Activity data for category *1A2g vii - Mobile Combustion in manufacturing industries and construction* are listed in Table 114.

Table 114 – 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	618 365	618'365	NO	NO	IE	NO
1991	700 883	700'883	NO	NO	IE	NO
1992	760 284	760'284	NO	NO	IE	NO
1993	824 978	824'978	NO	NO	IE	NO
1994	866 765	866'765	NO	NO	IE	NO
1995	922 207	922'207	NO	NO	IE	NO
1996	892 581	892'581	NO	NO	IE	NO
1997	950 701	950'701	NO	NO	IE	NO
1998	971 738	971'738	NO	NO	IE	NO
1999	1 056 669	1'056'669	NO	NO	IE	NO
2000	1 111 339	1'111'339	NO	NO	IE	NO
2001	1 140 315	1'140'315	NO	NO	IE	NO
2002	1 268 813	1'268'813	NO	NO	IE	NO
2003	1 320 679	1'320'679	NO	NO	IE	NO
2004	1 393 672	1'393'672	NO	NO	IE	NO
2005	1 396 142	1'396'142	NO	NO	IE	NO
2006	1 505 844	1'505'844	NO	NO	IE	NO
2007	1 834 533	1'834'533	NO	NO	IE	NO
2008	1 708 547	1'708'547	NO	NO	IE	NO
2009	1 729 970	1'729'970	NO	NO	IE	NO
2010	1 796 956	1'796'956	NO	NO	IE	NO
2011	1 902 419	1'902'419	NO	NO	IE	NO
2012	1 818 424	1'818'424	NO	NO	IE	NO
2013	1 930 816	1'930'816	NO	NO	IE	NO
2014	2 192 502	2'192'502	NO	NO	IE	NO
2015	2 124 489	2'124'489	NO	NO	IE	NO
2016	2 187 224	2'187'224	NO	NO	IE	NO
2017	2 248 591	2'248'591	NO	NO	IE	NO
Trend 1990-2017	*263.63%*	*263.63%*	*NA*	*NA*	*NA*	*NA*
2005-2017	*61.06%*	*61.06%*	*NA*	*NA*	*NA*	*NA*
2016-2017	*2.81%*	*2.81%*	*NA*	*NA*	*NA*	*NA*

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 (Grazer Emissionsmodell für Off-Road Geräte) model 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 2017 are presented in Table 115.

Table 115 – Methods and Emission Factors used in relation to the energy in consumption in 2017 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 116 gives an overview of the evolution of the implied emission factors.

Table 116 – Implied emission factors for category – *1A2g vii - Mobile Combustion in manufacturing industries and construction*

Year	SO2	NOx	NMVOC	NH3	CO	TSP	PM10	PM2.5
	1 A 2 Stationary combustion in manufacturing industries and construction							
	Emissions of air pollutants by source category (Gg)							
	1 A 2 g vii Mobile Combustion in manufacturing industries and construction							
1990	0.037	0.544	0.090	0.000	0.589	0.094	0.094	0.094
1991	0.042	0.618	0.101	0.000	0.666	0.106	0.106	0.106
1992	0.046	0.672	0.110	0.000	0.721	0.114	0.114	0.114
1993	0.049	0.731	0.119	0.000	0.782	0.123	0.123	0.123
1994	0.044	0.779	0.123	0.000	0.814	0.126	0.126	0.126
1995	0.017	0.852	0.127	0.000	0.852	0.127	0.127	0.127
1996	0.017	0.838	0.121	0.000	0.815	0.119	0.119	0.119
1997	0.018	0.911	0.126	0.000	0.857	0.122	0.122	0.122
1998	0.018	0.955	0.125	0.000	0.862	0.118	0.118	0.118
1999	0.017	1.065	0.132	0.000	0.922	0.121	0.121	0.121
2000	0.018	1.139	0.136	0.000	0.958	0.121	0.121	0.121
2001	0.019	1.179	0.138	0.000	0.975	0.121	0.121	0.121
2002	0.021	1.243	0.136	0.000	0.996	0.120	0.120	0.120
2003	0.022	1.200	0.122	0.000	0.930	0.109	0.109	0.109
2004	0.003	1.174	0.112	0.000	0.894	0.101	0.101	0.101
2005	0.003	1.092	0.098	0.000	0.821	0.089	0.089	0.089
2006	0.004	1.072	0.089	0.000	0.795	0.082	0.082	0.082
2007	0.001	1.176	0.080	0.000	0.795	0.074	0.074	0.074
2008	0.001	1.042	0.061	0.000	0.655	0.057	0.057	0.057
2009	0.001	1.027	0.055	0.000	0.621	0.051	0.051	0.051
2010	0.001	1.048	0.050	0.000	0.596	0.046	0.046	0.046
2011	0.001	1.097	0.046	0.000	0.580	0.041	0.041	0.041
2012	0.001	1.048	0.041	0.000	0.527	0.036	0.036	0.036
2013	0.001	1.059	0.039	0.000	0.529	0.033	0.033	0.033
2014	0.001	1.056	0.036	0.000	0.538	0.029	0.029	0.029
2015	0.001	0.947	0.031	0.000	0.488	0.024	0.024	0.024
2016	0.001	0.911	0.028	0.000	0.479	0.021	0.021	0.021
2017	0.001	0.854	0.026	0.000	0.464	0.018	0.018	0.018
Trend 1990-2017	*-97.13%*	*56.94%*	*-71.51%*	*40.21%*	*-21.24%*	*-80.49%*	*-80.49%*	*-80.49%*
2005-2017	*-67.64%*	*-21.74%*	*-73.89%*	*-16.87%*	*-43.50%*	*-79.46%*	*-79.46%*	*-79.46%*
2016-2017	*2.91%*	*-6.25%*	*-9.65%*	*0.62%*	*-3.11%*	*-13.84%*	*-13.84%*	*-13.84%*

Source: Environment Agency

3.2.3.8.1.3 Uncertainties and time-series consistency

Currently no uncertainty estimates are made. Uncertainty of the activity data can be checked in the Luxembourg's National Inventory report (NIR).

Generally, the time-series, as reported in category *1A2g vii Mobile Combustion in manufacturing industries and construction* are considered to be consistent.

3.2.3.8.1.4 Source-specific QA/QC and verification

Consistency and completeness checks are performed.

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

Table 117 presents the main revisions and recalculations done since submission 2018 and relevant to category *1A2g vii Mobile Combustion in manufacturing industries and construction*.

Table 117 – Recalculations done since submission 2018 for category – *1A2g vii - Mobile Combustion in manufacturing industries and construction*

Source category	Revisions 2018 ➔ 2019	Type of revision
1A2g vii	Emission factors have been updated according to a recent study[47]	updated EFs
1A2g vii	Changed notation key for biomass activity data from NO to IE (included in liquid fuels)	Changed notation key

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

The following improvements are planned for the next submission.

Table 118 – 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:

- Transport Equipment
- Machinery
- Mining (excluding fuels) and Quarrying
- Wood and Wood Products
- Construction
- Textile and Leather
- Non-specified Industry

In 2017, this source category represented:

- 10.7% of national total SO_2 emissions (based on fuel sold) and 10.7% of national total SO_2 emissions (based on fuel used), whereas in 1990, this source category represented 1.4% of national total SO_2 emissions (based on fuel sold).
- 2.0% 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), whereas in 1990, this source category represented 0.02% of national total $PM_{2.5}$ emissions (based on fuel sold/based on fuel used).

47 FVT: Aktualisierung der Zeitreihen zum Kraftstoffexport und der Emissionen von klimarelevanten Gasen und Luftschadstoffen des Verkehrssektors in Luxemburg von 1990 – 2017„minimales Update“, Endbericht, Januar 2019, Graz

- 0.9% of national total NO_X emissions (based on fuel sold) and 1.3% of national total NO_X emissions (based on fuel used), whereas in 1990, this source category represented 0.3%, respectively, 0.5% of national total TSP emissions (based on fuel sold/based on fuel used).

The significant reduction of SO_2 emissions in the period 1990-2017 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.

Category *1A2g viii Other Stationary* was a key category for SO_2 (LA, fuel used and fuel sold) and $PM_{2.5}$ (LA, fuel used) in 2017 (see Table 119 and also see Table 49 in Section 3.2 and Chapter 1.5).

Table 119 – 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															

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								8	

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 120 summarizes emissions of air pollutants for category *1A2g viii Other Stationary* and Table 121 presents the emission trends.

Table 120 – Emissions (1990, 2005, 2016 and 2017), 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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
SO2	0.21	0.09	0.03	0.11	-50.6%	24.2%	273.0%	1.5%	3.6%	10.7%	1.4%	3.5%	10.4%	fuel sold
NOx	0.10	0.13	0.10	0.16	52.7%	25.8%	56.6%	0.5%	0.8%	1.3%	0.3%	0.2%	0.9%	fuel sold
NMVOC	0.00	0.06	0.18	0.09	3426.7%	60.9%	-49.3%	0.0%	0.4%	0.8%	0.0%	0.4%	0.8%	fuel sold
NH3	NO	0.03	0.03	0.03	2.7%	-17.4%	-10.5%	NO	0.6%	0.5%	NO	0.6%	0.5%	fuel sold
CO	0.18	0.13	0.11	0.58	220.1%	337.4%	423.1%	0.0%	0.7%	3.4%	0.0%	0.3%	2.6%	fuel sold
TSP	0.00	0.01	0.06	0.03	724.3%	241.7%	-54.3%	0.02%	0.4%	1.3%	0.02%	0.2%	1.0%	fuel sold
PM10	0.00	0.01	0.06	0.03	850.0%	268.6%	-55.5%	0.02%	0.4%	1.8%	0.02%	0.2%	1.4%	fuel sold
PM2.5	0.00	0.01	0.06	0.03	1009.9%	296.4%	-56.6%	0.02%	0.5%	2.5%	0.02%	0.3%	2.0%	fuel sold

Source: Environment Agency.

Table 121 – Emission trends of category – *1A2g viii - Other Stationary*

Year	SO2	NOx	NMVOC	NH3	CO	TSP	PM10	PM2.5
	1 A 2 Stationary combustion in manufacturing industries and construction *Emissions of air pollutants by source category (Gg)* **1 A 2 g viii Other (Please specify in the IIR)**							
1990	0.214	0.104	0.003	NO	0.181	0.004	0.003	0.002
1991	0.269	0.252	0.009	NO	0.217	0.009	0.007	0.006
1992	0.234	0.280	0.010	NO	0.239	0.008	0.007	0.006
1993	0.188	0.286	0.010	NO	0.212	0.007	0.006	0.005
1994	0.362	0.315	0.010	NO	0.316	0.007	0.006	0.005
1995	0.228	0.251	0.009	NO	0.199	0.008	0.007	0.005
1996	0.286	0.279	0.009	NO	0.262	0.007	0.006	0.005
1997	0.236	0.358	0.012	NO	0.274	0.007	0.006	0.005
1998	0.201	0.431	0.298	NO	0.295	0.016	0.015	0.014
1999	0.323	0.551	0.194	NO	0.402	0.030	0.026	0.023
2000	0.324	0.244	0.065	NO	0.281	0.018	0.016	0.015
2001	0.276	0.219	0.059	NO	0.251	0.017	0.015	0.013
2002	0.250	0.197	0.047	NO	0.237	0.015	0.013	0.011
2003	0.259	0.227	0.046	NO	0.341	0.012	0.011	0.009
2004	0.098	0.154	0.047	NO	0.142	0.009	0.008	0.007
2005	0.085	0.127	0.057	0.033	0.132	0.009	0.008	0.007
2006	0.057	0.092	0.073	0.032	0.115	0.007	0.007	0.007
2007	0.055	0.081	0.072	0.034	0.138	0.006	0.006	0.005
2008	0.045	0.095	0.043	0.036	0.128	0.006	0.006	0.005
2009	0.041	0.065	0.041	0.028	0.105	0.007	0.007	0.007
2010	0.120	0.071	0.067	0.032	0.100	0.008	0.007	0.006
2011	0.049	0.067	0.023	0.029	0.083	0.007	0.007	0.006
2012	0.053	0.072	0.011	0.025	0.083	0.008	0.007	0.007
2013	0.018	0.109	0.011	0.026	0.082	0.009	0.008	0.008
2014	0.008	0.092	0.011	0.032	0.098	0.006	0.006	0.006
2015	0.065	0.171	0.021	0.030	0.188	0.019	0.019	0.019
2016	0.028	0.102	0.180	0.030	0.111	0.064	0.064	0.063
2017	0.106	0.160	0.091	0.027	0.579	0.029	0.028	0.027
Trend 1990-2017	-50.56%	52.73%	3426.66%	NA	220.06%	724.27%	849.97%	1009.93%
2005-2017	24.16%	25.76%	60.92%	-17.40%	337.41%	241.74%	268.63%	296.41%
2016-2017	272.96%	56.62%	-49.31%	-10.53%	423.10%	-54.33%	-55.53%	-56.55%

Source: Environment Agency.

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 (Table 122):

Table 122 – Combustion activities included in *1A2g viii – Other Stationary*

Description	SNAP code
Combustion plants < 50 MW	030103
Gas Turbines	030104
Asphalt concrete plants	030313

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 was obtained by the operators.

Activity data for category *1A2g viii - Other Stationary* are listed in Table 123.

Table 123 – Activity data by fuel type of sub-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	801 141	182'270	206'140	412'732	NO	NO
1991	2 907 750	293'602	199'769	2'414'379	NO	NO
1992	3 281 600	251'723	217'880	2'811'997	NO	NO
1993	3 516 627	225'392	161'445	3'129'790	NO	NO
1994	3 474 848	251'136	320'437	2'903'275	NO	NO
1995	3 009 908	264'601	160'119	2'585'188	NO	NO
1996	3 169 734	219'399	254'976	2'695'358	NO	NO
1997	4 359 756	254'493	225'135	3'880'128	NO	NO
1998	4 594 935	502'140	183'946	3'908'850	NO	NO
1999	6 025 268	1'685'840	218'107	4'121'321	NO	NO
2000	2 454 457	849'550	232'377	1'372'530	NO	NO
2001	2 347 784	863'745	168'958	1'315'081	NO	NO
2002	2 159 148	857'810	138'204	1'163'134	NO	NO
2003	2 344 413	1'072'329	145'892	1'126'193	NO	NO
2004	2 284 468	881'834	147'911	1'254'724	NO	NO
2005	2 960 886	726'370	144'819	1'208'763	880 933	NO
2006	2 747 063	465'284	136'831	1'288'369	856 579	NO
2007	2 602 513	485'132	142'414	1'056'706	918 261	NO
2008	2 528 296	501'626	139'665	907'342	979 662	NO
2009	2 039 236	235'671	156'912	891'832	754 820	NO
2010	2 104 485	268'931	211'674	760'510	863 371	NO
2011	1 984 336	173'690	171'154	853'577	785 914	NO
2012	1 907 308	172'989	191'369	860'045	682 906	NO
2013	2 046 515	220'157	135'996	975'125	715 237	NO
2014	1 926 696	108'588	147'760	797'836	872 512	NO
2015	1 806 463	93'171	188'807	716'784	807 701	NO
2016	1 942 729	185'152	153'878	790'341	813 359	NO
2017	1 994 859	297'182	196'635	773'354	727 688	NO
Trend 1990-2017	*149.00%*	*63.05%*	*-4.61%*	*87.37%*	*NA*	*NA*
2005-2017	*-32.63%*	*-59.09%*	*35.78%*	*-36.02%*	*-17.40%*	*NA*
2016-2017	*2.68%*	*60.51%*	*27.79%*	*-2.15%*	*-10.53%*	*NA*

Source: Environment Agency

3.2.3.8.2.2.2 Methodological choices

For large point sources of this sub-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 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 124.

3.2.3.8.2.2.3 Emission factors

For large point sources of this sub-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 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.

Emission factors used in relation to the energy consumption are presented in Table 124.

Table 125 gives an overview of the evolution of the implied emission factors. These may vary over time for the following reasons:

- The chemical characteristics 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 124 – Methods and Emission Factors used in relation to the energy in consumption 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	22.9%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2/T1	D	77.1%	EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.4, p16), EMEP/EEA GB
NMVOC	T3	PS	22.9%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2/T1	D	77.1%	EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.4, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.5, p17), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.3, p16)
SOx	T3	PS	11.0%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2	CS	10.9%	CS based on fuel sulfur content; determined by AEV
	T1	D	78.1%	EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.6, p16), CS based on maximum allowed suphur content, 0, 0
CO	T3	PS	11.0%	Measurement reports of all facilities IEFs and CS EFs were determined by AEV
	T2/T1	D	89.0%	0, 0, IE above, EMEP/EEA GB 2016(Chap1A4, Tab3.25, p60), 0
PM2.5	T3	PS	0.0%	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	100.0%	EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.4, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.5, p17), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.3, p16), TSP, PM10, PM2.5 emissions based on Asphalt production -
PM10	T3	PS	11.9%	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	88.1%	EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.4, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.5, p17), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.3, p16), TSP, PM10, PM2.5 emissions based on Asphalt production -
TSP	T3	PS	11.9%	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	88.1%	EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.3, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.4, p16), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.5, p17), EMEP/EEA GB 2009(PartB, Chap1A2, Tab3.3, p16), TSP, PM10, PM2.5 emissions based on Asphalt production -

Source: Environment Agency

Table 125 – Implied emission factors for category – *1A2g viii – Other Stationary*

Year	SO2	NOx	NMVOC	NH3	CO	TSP	PM10	PM2.5
	1 A 2 Stationary combustion in manufacturing industries and construction – Implied Emission Factor (IEF) of air pollutants by source category (g/GJ) – 1 A 2 g viii Other							
1990	266.69	130.38	3.22	NA	225.67	4.44	3.71	3.08
1991	92.55	86.58	3.15	NA	74.68	3.11	2.56	2.10
1992	71.22	85.47	2.94	NA	72.92	2.40	2.01	1.68
1993	53.54	81.27	2.87	NA	60.17	2.00	1.70	1.44
1994	104.09	90.52	2.80	NA	90.98	2.13	1.80	1.51
1995	75.90	83.47	3.04	NA	66.00	2.60	2.17	1.81
1996	90.11	88.05	2.83	NA	82.60	2.13	1.79	1.51
1997	54.20	82.16	2.76	NA	62.82	1.62	1.39	1.20
1998	43.85	93.81	64.86	NA	64.12	3.39	3.17	2.98
1999	53.58	91.43	32.17	NA	66.64	4.94	4.29	3.74
2000	131.84	99.40	26.65	NA	114.59	7.30	6.56	5.94
2001	117.45	93.07	25.20	NA	106.93	7.35	6.47	5.73
2002	115.88	91.44	21.95	NA	109.70	7.06	6.10	5.30
2003	110.66	96.64	19.54	NA	145.52	5.13	4.50	3.96
2004	42.89	67.60	20.62	NA	62.26	3.97	3.47	3.05
2005	28.73	42.84	19.10	11.01	44.68	2.89	2.59	2.34
2006	20.81	33.53	26.70	11.54	41.70	2.68	2.52	2.39
2007	21.29	31.24	27.59	13.05	52.98	2.32	2.16	2.03
2008	17.96	37.40	17.00	14.34	50.46	2.28	2.20	2.13
2009	20.07	31.93	20.32	13.70	51.63	3.55	3.51	3.48
2010	57.09	33.62	31.60	15.18	47.39	3.83	3.40	3.03
2011	24.93	33.83	11.38	14.65	41.92	3.72	3.42	3.17
2012	27.61	37.78	5.58	13.25	43.39	4.04	3.73	3.47
2013	8.85	53.32	5.60	12.93	39.92	4.37	4.02	3.73
2014	4.08	47.88	5.51	16.76	50.81	3.23	3.06	2.92
2015	35.78	94.81	11.90	16.54	103.95	10.54	10.40	10.28
2016	14.58	52.43	92.42	15.49	56.94	33.01	32.72	32.47
2017	52.95	79.97	45.62	13.50	290.07	14.68	14.17	13.74
Trend 1990-2017	*-80.15%*	*-38.67%*	*1316.32%*	*NA*	*28.54%*	*231.03%*	*281.51%*	*345.75%*
2005-2017	*84.29%*	*86.66%*	*138.85%*	*22.61%*	*549.23%*	*407.23%*	*447.14%*	*488.37%*
2016-2017	*263.21%*	*52.53%*	*-50.64%*	*-12.87%*	*409.44%*	*-55.52%*	*-56.69%*	*-57.69%*

Source: Environment Agency

3.2.3.8.2.3 Uncertainties and time-series consistency

Currently no uncertainty estimates are made. Uncertainty of the activity data can be checked in the Luxembourg's National Inventory report (NIR).

Generally, the time-series, as reported in category *1A2g viii – Other Stationary* are considered to be consistent.

3.2.3.8.2.4 Source-specific QA/QC and verification

Activity data for large facilities that have reporting obligations under the European Union Emission Trading System (EU-ETS) is 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.

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

Table 126 presents the main revisions and recalculations done since submission 2018 and relevant to NFR category *1A2g viii Other Stationary*.

Table 126 – Recalculations done since submission 2018 for category – *1A2g viii – Other Stationary*

Source category	Revisions 2018 ➔ 2019	Type of revision
1A2g viii	Fuel consumption was revised due to revised energy balance from the national statistics institute	updated AD
1A2g viii	Aligned Tier 1 and Tier 2 default EFs from EMEP/EEA Guidebook 2009 to EMEP/EEA Guidebook 2016	Update EFs

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

The following improvements are planned for the next submission.

Table 127 – Planned improvements for category – *1A2g viii – Other Stationary*

Source category	Planned improvements	Type of revision
1A2g viii	No further improvements are planned	

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 (1990-2017) 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 128 – Emissions (1990, 2005, 2016 and 2017), 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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
SOx	1.084	0.085	0.071	0.075	-93.0%	-11.4%	5.8%				7.3%	3.5%	5.6%	fuel sold
	0.267	0.047	0.049	0.052	-80.5%	11.5%	6.9%	1.9%	2.0%	4.0%				fuel used
NOx	26.403	45.354	12.618	11.354	-57.0%	-75.0%	-10.0%				63.7%	83.0%	62.0%	fuel sold
	8.017	6.789	5.632	5.388	-32.8%	-20.6%	-4.3%	34.8%	42.2%	43.7%				fuel used
NMVOC	15.787	3.441	1.003	0.979	-93.8%	-71.6%	-2.5%				59.5%	22.9%	8.6%	fuel sold
	6.978	1.013	0.502	0.495	-92.9%	-51.2%	-1.5%	39.4%	8.0%	4.6%				fuel used
NH3	0.016	0.547	0.189	0.194	1132.2%	-64.5%	2.8%				0.2%	9.3%	3.5%	fuel sold
	0.006	0.155	0.070	0.072	1007.8%	-53.6%	2.9%	0.1%	2.8%	1.3%				fuel used
CO	82.574	26.493	9.472	8.971	-89.1%	-66.1%	-5.3%				17.7%	69.1%	43.0%	fuel sold
	36.758	7.962	3.994	3.921	-89.3%	-50.8%	-1.8%	8.7%	40.2%	27.2%				fuel used
TSP	1.226	2.227	1.060	1.048	-14.5%	-52.9%	-1.1%				7.1%	57.2%	32.2%	fuel sold
	0.411	0.553	0.392	0.391	-4.9%	-29.3%	-0.4%	2.5%	24.9%	15.4%				fuel used
PM10	1.089	1.812	0.712	0.697	-36.0%	-61.5%	-2.2%				6.6%	58.9%	33.1%	fuel sold
	0.364	0.464	0.275	0.271	-25.5%	-41.6%	-1.4%	2.3%	26.9%	16.6%				fuel used
PM2.5	0.982	1.508	0.456	0.437	-55.5%	-71.0%	-4.1%				6.1%	61.6%	31.9%	fuel sold
	0.325	0.391	0.178	0.173	-46.9%	-55.9%	-3.1%	2.1%	29.4%	16.3%				fuel used

Source: Environment Agency

As presented in Table 128, in 2017, this source category represented 62.0% 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 63.7% of national total NO_x emissions (based on fuel sold) and 34.8% of national total NO_x emissions (based on fuel used). The most important sources of NO_x emissions based on fuel sold were category *1A3biii - Heavy Duty Vehicles and Buses* (1990: 33.4%, 2005: 67.1%, 2017: 26.8% of national total NO_x emissions) and category *1A3bi - Passenger cars* (1990: 28.6%, 2005: 13.7%, 2017: 28.6% of national total NO_x emissions) (see Table 129). The most important source of NO_x emissions based on fuel used were category *1A3bi - Passenger cars* (1990: 21.7%, 2005: 18.9%, 2017: 27.5% of national total NO_x emissions) and category *1A3biii - Heavy Duty Vehicles and Buses* (1990: 10.1%, 2005: 15.7%, 2017: 6.3% of national total NO_x emissions). The fuel export in the vehicle tank of diesel contributes significantly to national NO_x emissions based on fuels sold.

As presented in Table 128, from 1990 to 2017, **NO_x** emissions from transportation based on fuel sold decreased by 57.0% and NO_x emissions based on fuel used decreased by 32.8% due to fleet renewal, implementation of EURO standards, etc. In the period 1990-2017, NO_x emissions (based on fuel sold) from category *1A3bi - Passenger cars*, category *1A3bi – Heavy duty vehicles* and category *1A3c - Railways* were decreasing by more than 50% (see Table 129). NO_x emissions of category *1A3a - Civil Aviation* showed, with 290%, the highest relative increase. In the period 1990-2017, NO_x emissions (based on fuel used) from category *1A3bi - Passenger cars* decreased by 32.0%. NO_X emissions of category *1A3biii - Heavy duty vehicles and Buses* decreased by 66.7% from 1990-2017.

Table 129 – NO_x, Emissions (1990, 2005, 2016 and 2017), 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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
1 A 3	**26.403**	**45.354**	**12.618**	**11.354**	**-57.0%**	**-75.0%**	**-10.0%**				**63.7%**	**83.0%**	**62.0%**	**fuel sold**
	8.017	**6.789**	**5.632**	**5.388**	**-32.8%**	**-20.6%**	**-4.3%**	**34.8%**	**42.2%**	**43.7%**				**fuel used**
1 A 3 a ii (i)	0.000	0.001	0.001	0.001	170.2%	-5.4%	-4.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 a i (i)	0.143	0.532	0.558	0.595	316.6%	11.8%	6.6%	0.6%	3.3%	4.8%	0.3%	1.0%	3.3%	fuel sold
1 A 3 b i	11.864	7.475	5.362	5.233	-55.9%	-30.0%	-2.4%				28.6%	13.7%	28.6%	fuel sold
	4.996	3.038	3.515	3.399	-32.0%	11.9%	-3.3%	21.7%	18.9%	27.5%				fuel used
1 A 3 b ii	0.280	0.572	0.568	0.528	88.7%	-7.7%	-7.1%				0.7%	1.0%	2.9%	fuel sold
	0.280	0.572	0.568	0.528	88.7%	-7.7%	-7.1%	1.2%	3.6%	4.3%				fuel used
1 A 3 b iii	13.851	36.657	6.058	4.908	-64.6%	-86.6%	-19.0%				33.4%	67.1%	26.8%	fuel sold
	2.333	2.529	0.919	0.777	-66.7%	-69.3%	-15.4%	10.1%	15.7%	6.3%				fuel used
1 A 3 b iv	0.006	0.017	0.019	0.018	184.0%	6.3%	-2.4%				0.0%	0.0%	0.1%	fuel sold
	0.006	0.017	0.019	0.018	184.0%	6.3%	-2.4%	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
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 b vi	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 b vii	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 c	0.258	0.099	0.051	0.069	-73.4%	-30.7%	34.2%	1.1%	0.6%	0.6%	0.6%	0.2%	0.4%	fuel sold
1 A 3 d i (ii)	0.001	0.001	0.001	0.001	59.5%	-3.7%	25.6%	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	-42.4%	-11.9%	-3.5%	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)	**41.456**	**54.656**	**20.342**	**18.305**	**-55.8%**	**-66.5%**	**-10.0%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**23.070**	**16.091**	**13.355**	**12.340**	**-46.5%**	**-23.3%**	**-7.6%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

Source: Environment Agency

As presented in Table 128 and in more detail in Table 130, in 2017, source category *1A3 Transport* represented 5.6% of national total **SO_2** emissions (based on fuel sold) and 4.0% of national total SO_2 emissions (based on fuel used), whereas in 1990, this source category represented 7.3% of national total SO_2 emissions (based on fuel sold) and 1.9% of national total SO_2 emissions (based on fuel used). In 2017, the most important source of SO_2 emissions based on fuel sold was category *1A3ai(i) Civil aviation - International LTO* (1990: 0.1%, 2005: 1.5%, 2017: 3.0% of national total SO_2 emissions) followed by category *1A3biii - Heavy Duty Vehicles and Buses* (1990: 5.2%, 2005: 1.4%, 2017: 1.6% of national total SO_2 emissions). The significant reduction of SO_2 emissions of category *1A3 Transport* of about 93% (based on fuel sold) and 80.5% (based on fuel used), in the period 1990-2017, was mainly due to the decreasing fuel sulphur content.

In 2017, this source category represented 8.6% of national total **NMVOC** emissions (based on fuel sold) and 4.6% of national total NMVOC emissions (based on fuel used), whereas in 1990, this source category represented 59.5% of national total NMVOC emissions (based on fuel sold) and 39.4% of national total NMVOC emissions (based on fuel used) (see Table 128). The most important source of NMVOC emissions based on fuel sold, by far, was sub-category *1A3bi - Passenger cars* (1990: 41.7%, 2005: 12.7%, 2017: 5.2% of national total NMVOC emissions) (see Table 130). Other important sources of NMVOC emissions were category *1A3biii - Heavy duty vehicles and Buses* (1990: 1.6%, 2005: 6.7%, 2017: 0.9% of national total NMVOC emissions) and category *1A3bv - Evaporation* (1990: 15.1%, 2005: 1.9%, 2017: 0.8% of national total NMVOC emissions). The most important source of NMVOC emissions based on fuel used was category *1A3bi - Passenger cars* (1990: 27.0%, 2005: 4.6%, 2017: 2.3% of national total NMVOC emissions).

In 2017, source category *1A3 - Transport* represented 3.5% of national total **NH_3** emissions (based on fuel sold) and 1.3% 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: 9.1%, 2017: 3.3% 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 1132% in the period 1990-2017.

Table 130 – SO_2, NMVOC and NH_3 Emissions (1990, 2005, 2016 and 2017), 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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
1 A 3	**1.084**	**0.085**	**0.071**	**0.075**	**-93.0%**	**-11.4%**	**5.8%**				**7.3%**	**3.5%**	**5.6%**	**fuel sold**
	0.267	**0.047**	**0.049**	**0.052**	**-80.5%**	**11.5%**	**6.9%**	**1.9%**	**2.0%**	**4.0%**				**fuel used**
1 A 3 a ii (i)	0.000	0.000	0.000	0.000	170.2%	-5.4%	-4.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 a i (i)	0.010	0.036	0.037	0.040	316.6%	11.8%	6.6%	0.1%	1.5%	3.0%	0.1%	1.5%	3.0%	fuel sold
1 A 3 b i	0.261	0.013	0.010	0.010	-96.2%	-21.3%	1.6%				1.8%	0.5%	0.7%	fuel sold
	0.085	0.005	0.006	0.006	-92.9%	13.9%	0.4%	0.6%	0.2%	0.5%				fuel used
1 A 3 b ii	0.021	0.001	0.001	0.001	-95.5%	23.5%	2.7%				0.1%	0.0%	0.1%	fuel sold
	0.021	0.001	0.001	0.001	-95.5%	23.5%	2.7%	0.1%	0.0%	0.1%				fuel used
1 A 3 b iii	0.772	0.033	0.021	0.022	-97.2%	-34.4%	3.2%				5.2%	1.4%	1.6%	fuel sold
	0.132	0.002	0.002	0.002	-98.2%	12.1%	2.3%	0.9%	0.1%	0.2%				fuel used
1 A 3 b iv	0.000	0.000	0.000	0.000	-85.1%	33.5%	-0.1%				0.0%	0.0%	0.0%	fuel sold
	0.000	0.000	0.000	0.000	-85.1%	33.5%	-0.1%	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
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 b vi	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 b vii	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 c	0.020	0.003	0.002	0.003	-85.9%	0.7%	39.4%	0.1%	0.1%	0.2%	0.1%	0.1%	0.2%	fuel sold
1 A 3 d i (ii)	0.000	0.000	0.000	0.000	-98.3%	-76.5%	27.3%	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	-95.7%	-86.1%	-4.1%	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)	**14.837**	**2.419**	**1.546**	**1.341**	**-91.0%**	**-44.6%**	**-13.3%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**14.020**	**2.381**	**1.520**	**1.318**	**-90.6%**	**-44.7%**	**-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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
1 A 3	**15.787**	**3.441**	**1.003**	**0.979**	**-93.8%**	**-71.6%**	**-2.5%**				**59.5%**	**22.9%**	**8.6%**	**fuel sold**
	6.978	**1.013**	**0.502**	**0.495**	**-92.9%**	**-51.2%**	**-1.5%**	**39.4%**	**8.0%**	**4.6%**				**fuel used**
1 A 3 a ii (i)	0.001	0.004	0.004	0.004	170.2%	-5.4%	-4.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 a i (i)	0.012	0.044	0.047	0.050	316.6%	11.8%	6.6%	0.1%	0.4%	0.5%	0.0%	0.3%	0.4%	fuel sold
1 A 3 b i	11.051	1.913	0.604	0.593	-94.6%	-69.0%	-1.8%				41.7%	12.7%	5.2%	fuel sold
	4.776	0.584	0.253	0.249	-94.8%	-57.3%	-1.7%	27.0%	4.6%	2.3%				fuel used
1 A 3 b ii	0.120	0.037	0.010	0.009	-92.3%	-75.0%	-9.1%				0.5%	0.2%	0.1%	fuel sold
	0.120	0.037	0.010	0.009	-92.3%	-75.0%	-9.1%	0.7%	0.3%	0.1%				fuel used
1 A 3 b iii	0.424	1.004	0.118	0.107	-74.7%	-89.3%	-8.9%				1.6%	6.7%	0.9%	fuel sold
	0.122	0.100	0.020	0.018	-85.1%	-81.8%	-11.0%	0.7%	0.8%	0.2%				fuel used
1 A 3 b iv	0.104	0.128	0.118	0.116	11.3%	-9.2%	-2.3%				0.4%	0.8%	1.0%	fuel sold
	0.104	0.128	0.118	0.116	11.3%	-9.2%	-2.3%	0.6%	1.0%	1.1%				fuel used
1 A 3 b v	4.007	0.282	0.092	0.087	-97.8%	-69.0%	-4.7%				15.1%	1.9%	0.8%	fuel sold
	1.774	0.087	0.038	0.037	-97.9%	-58.1%	-4.0%	10.0%	0.7%	0.3%				fuel used
1 A 3 b vi	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 b vii	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 c	0.050	0.015	0.005	0.007	-86.7%	-56.3%	31.3%	0.3%	0.1%	0.1%	0.2%	0.1%	0.1%	fuel sold
1 A 3 d i (ii)	0.000	0.000	0.000	0.000	30.3%	-11.6%	24.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 d ii	0.018	0.014	0.005	0.005	-72.2%	-63.0%	-7.1%	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)	**26.524**	**15.059**	**11.114**	**11.365**	**-57.2%**	**-24.5%**	**2.3%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**17.715**	**12.631**	**10.441**	**10.794**	**-39.1%**	**-14.5%**	**3.4%**	**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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
1 A 3	**0.016**	**0.547**	**0.189**	**0.194**	**1132.2%**	**-64.5%**	**2.8%**				**0.2%**	**9.3%**	**3.5%**	**fuel sold**
	0.006	**0.155**	**0.070**	**0.072**	**1007.8%**	**-53.6%**	**2.9%**	**0.1%**	**2.8%**	**1.3%**				**fuel used**
1 A 3 a ii (i)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	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 b i	0.013	0.532	0.177	0.182	1355.1%	-65.7%	2.8%				0.2%	9.1%	3.3%	fuel sold
	0.005	0.151	0.067	0.069	1213.7%	-54.5%	3.0%	0.1%	2.8%	1.3%				fuel used
1 A 3 b ii	0.000	0.002	0.001	0.001	164.6%	-33.6%	-0.6%				0.0%	0.0%	0.0%	fuel sold
	0.000	0.002	0.001	0.001	164.6%	-33.6%	-0.6%	0.0%	0.0%	0.0%				fuel used
1 A 3 b iii	0.003	0.012	0.010	0.010	293.7%	-17.2%	3.4%				0.0%	0.2%	0.2%	fuel sold
	0.001	0.001	0.001	0.001	118.6%	32.1%	2.1%	0.0%	0.0%	0.0%				fuel used
1 A 3 b iv	0.000	0.000	0.000	0.000	232.7%	34.6%	0.6%				0.0%	0.0%	0.0%	fuel sold
	0.000	0.000	0.000	0.000	232.7%	34.6%	0.6%	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
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 b vi	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 b vii	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 c	0.000	0.000	0.000	0.000	-78.1%	-35.0%	35.3%	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	53.7%	-1.4%	26.1%	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	-73.6%	-55.9%	-6.5%	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)	**6.344**	**5.874**	**5.545**	**5.597**	**-11.8%**	**-4.7%**	**0.9%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**6.335**	**5.482**	**5.406**	**5.471**	**-13.6%**	**-0.2%**	**1.2%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

Source: Environment Agency

In 2017, source category *1A3-Transport* represented 43.0% of national total **CO** emissions (based on fuel sold) and 27.2% of national total CO emissions (based on fuel used), whereas in 1990, this source category represented 17.7% of national total CO emissions (based on fuel sold) and 8.7% of national total CO emissions (based on fuel used). In 2005, the transport sector covers a share of 69%of national total CO emissions based on fuel sold, and a share of 40% of national total CO emissions based on fuel used. In the period 1990-2017, a reduction of 89.1% of CO emissions based on fuel sold and a reduction of 89.3%, based on fuel used, could be achieved (see Table 128 and for more detail, Table 131).

In 2016, source category *1A3-Transport* represented 31.9% of national total **$PM_{2.5}$** emissions (based on fuel sold) and 16.3% of national total $PM_{2.5}$ emissions (based on fuel used), whereas in 1990, this source category represented 6.1% of national total $PM_{2.5}$ emissions (based on fuel sold) and 2.1% of national total $PM_{2.5}$ emissions (based on fuel used). For the period 1990-2017, a decrease of 55.5% could be observed, based on fuel sold (46.9% based on fuel used), and for the period 2005-2017, a decrease of 71.0% could be noted (based on fuel sold, 55.9% based on fuel used) (see Table 128 and for more detail, Table 131).

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: 9.4%, 2017: 14.3% 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: 0.5%, 2005: 5.9%, 2017: 8.9% of national total $PM_{2.5}$ emissions), *1A3bvi - Heavy duty vehicles and buses* (1990: 2.7%, 2005: 27%, 2017: 4.2% of national total $PM_{2.5}$ emissions) and category *1A3bi - Passenger cars* (1990: 2%, 2005: 16.7%, 2017: 2.7% of national total $PM_{2.5}$ emissions) (see Table 131).

In 2017, source category *1A3-Transport* represented 33.1% of national total **PM_{10}** emissions (based on fuel sold) and 16.6% of national total PM_{10} emissions (based on fuel used), whereas in 1990, this source category represented 6.6% of national total PM_{10} emissions (based on fuel sold) and 2.3% of national total PM_{10} emissions (based on fuel used).

In 2017, source category *1A3-Transport* represented 32.2% of national total **TSP** emissions (based on fuel sold) and 15.4% of national total TSP emissions (based on fuel used), whereas in 1990, this source category represented 7.1% of national total TSP emissions (based on fuel sold) and 2.5% of national total TSP emissions (based on fuel used).

Table 131 – CO, $PM_{2.5}$, PM_{10}, TSP Emissions (1990, 2005, 2016 and 2017), 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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
1 A 3	**82.574**	**26.493**	**9.472**	**8.971**	**-89.1%**	**-66.1%**	**-5.3%**				**17.7%**	**69.1%**	**43.0%**	**fuel sold**
1 A 3	**36.758**	**7.962**	**3.994**	**3.921**	**-89.3%**	**-50.8%**	**-1.8%**	**8.7%**	**40.2%**	**27.2%**				**fuel used**
1 A 3 a ii (i)	0.063	0.179	0.177	0.169	170.2%	-5.4%	-4.6%	0.0%	0.9%	1.2%	0.0%	0.5%	0.8%	fuel sold
1 A 3 a i (i)	0.111	0.413	0.434	0.462	316.6%	11.8%	6.6%	0.0%	2.1%	3.2%	0.0%	1.1%	2.2%	fuel sold
1 A 3 b i	78.859	19.475	5.693	5.648	-92.8%	-71.0%	-0.8%				16.9%	50.8%	27.1%	fuel sold
	34.210	5.685	2.220	2.206	-93.6%	-61.2%	-0.6%	8.1%	28.7%	15.3%				fuel used
1 A 3 b ii	1.208	0.340	0.093	0.086	-92.9%	-74.7%	-7.6%				0.3%	0.9%	0.4%	fuel sold
	1.208	0.340	0.093	0.086	-92.9%	-74.7%	-7.6%	0.3%	1.7%	0.6%				fuel used
1 A 3 b iii	1.550	5.185	2.370	1.915	23.6%	-63.1%	-19.2%				0.3%	13.5%	9.2%	fuel sold
	0.382	0.444	0.366	0.308	-19.2%	-30.6%	-15.7%	0.1%	2.2%	2.1%				fuel used
1 A 3 b iv	0.415	0.761	0.633	0.608	46.7%	-20.0%	-3.9%				0.1%	2.0%	2.9%	fuel sold
	0.415	0.761	0.633	0.608	46.7%	-20.0%	-3.9%	0.1%	3.8%	4.2%				fuel used
1 A 3 b v	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 b vi	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 b vii	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 c	0.280	0.089	0.034	0.046	-83.6%	-48.4%	34.0%	0.1%	0.4%	0.3%	0.1%	0.2%	0.2%	fuel sold
1 A 3 d i (ii)	0.001	0.001	0.001	0.001	41.0%	-6.0%	25.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 d ii	0.090	0.050	0.036	0.035	-61.5%	-31.2%	-4.0%	0.0%	0.3%	0.2%	0.0%	0.1%	0.2%	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)	**466.106**	**38.325**	**24.806**	**20.881**	**-95.5%**	**-45.5%**	**-15.8%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**420.289**	**19.794**	**16.857**	**14.396**	**-96.6%**	**-27.3%**	**-14.6%**	**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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
1 A 3	**0.982**	**1.508**	**0.456**	**0.437**	**-55.5%**	**-71.0%**	**-4.1%**				**6.1%**	**61.6%**	**31.9%**	**fuel sold**
	0.325	**0.391**	**0.178**	**0.173**	**-46.9%**	**-55.9%**	**-3.1%**	**2.1%**	**29.4%**	**16.3%**				**fuel used**
1 A 3 a ii (i)	0.000	0.000	0.000	0.000	170.2%	-5.4%	-4.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 a i (i)	0.001	0.004	0.004	0.004	316.6%	11.8%	6.6%	0.0%	0.3%	0.4%	0.0%	0.1%	0.3%	fuel sold
1 A 3 b i	0.328	0.408	0.042	0.037	-88.7%	-90.9%	-11.7%				2.0%	16.7%	2.7%	fuel sold
	0.102	0.185	0.026	0.022	-78.3%	-88.1%	-13.9%	0.7%	13.9%	2.1%				fuel used
1 A 3 b ii	0.029	0.040	0.016	0.014	-53.5%	-66.1%	-16.2%				0.2%	1.6%	1.0%	fuel sold
	0.029	0.040	0.016	0.014	-53.5%	-66.1%	-16.2%	0.2%	3.0%	1.3%				fuel used
1 A 3 b iii	0.432	0.661	0.074	0.058	-86.6%	-91.3%	-21.8%				2.7%	27.0%	4.2%	fuel sold
	0.085	0.057	0.013	0.011	-87.1%	-80.9%	-18.3%	0.5%	4.3%	1.0%				fuel used
1 A 3 b iv	0.004	0.003	0.002	0.002	-48.5%	-40.6%	-4.6%				0.0%	0.1%	0.1%	fuel sold
	0.004	0.003	0.002	0.002	-48.5%	-40.6%	-4.6%	NO	NO	0.2%				fuel used
1 A 3 b v	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 b vi	0.081	0.230	0.194	0.196	142.2%	-14.8%	1.3%				0.5%	9.4%	14.3%	fuel sold
	0.029	0.055	0.073	0.074	158.8%	35.8%	1.8%	0.2%	4.1%	7.0%				fuel used
1 A 3 b vii	0.047	0.143	0.120	0.121	158.9%	-15.4%	1.0%				0.3%	5.9%	8.9%	fuel sold
	0.016	0.030	0.040	0.041	149.4%	34.2%	1.8%	0.1%	2.3%	3.9%				fuel used
1 A 3 c	0.059	0.017	0.004	0.005	-92.1%	-72.1%	26.7%	0.4%	1.3%	0.4%	0.4%	0.7%	0.3%	fuel sold
1 A 3 d i (ii)	0.000	0.000	0.000	0.000	10.2%	-21.2%	22.6%	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	-38.6%	-14.8%	-3.3%	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)	**16.082**	**2.447**	**1.597**	**1.370**	**-91.5%**	**-44.0%**	**-14.2%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**15.425**	**1.331**	**1.223**	**1.058**	**-93.1%**	**-20.5%**	**-13.5%**	**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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
1 A 3	**1.089**	**1.812**	**0.712**	**0.697**	**-36.0%**	**-61.5%**	**-2.2%**				**6.6%**	**58.9%**	**33.1%**	**fuel sold**
	0.364	**0.464**	**0.275**	**0.271**	**-25.5%**	**-41.6%**	**-1.4%**	**2.3%**	**26.9%**	**16.6%**				**fuel used**
1 A 3 a ii (i)	0.000	0.000	0.000	0.000	170.2%	-5.4%	-4.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 a i (i)	0.001	0.004	0.004	0.004	316.6%	11.8%	6.6%	0.0%	0.2%	0.2%	0.0%	0.1%	0.2%	fuel sold
1 A 3 b i	0.328	0.408	0.042	0.037	-88.7%	-90.9%	-11.7%				2.0%	13.3%	1.8%	fuel sold
	0.102	0.185	0.026	0.022	-78.3%	-88.1%	-13.9%	0.6%	10.7%	1.4%				fuel used
1 A 3 b ii	0.029	0.040	0.016	0.014	-53.5%	-66.1%	-16.2%				0.2%	1.3%	0.6%	fuel sold
	0.029	0.040	0.016	0.014	-53.5%	-66.1%	-16.2%	0.2%	2.3%	0.8%				fuel used
1 A 3 b iii	0.432	0.661	0.074	0.058	-86.6%	-91.3%	-21.8%				2.6%	21.5%	2.7%	fuel sold
	0.085	0.057	0.013	0.011	-87.1%	-80.9%	-18.3%	0.5%	3.3%	0.7%				fuel used
1 A 3 b iv	0.004	0.003	0.002	0.002	-48.5%	-40.6%	-4.6%				0.0%	0.1%	0.1%	fuel sold
	0.004	0.003	0.002	0.002	-48.5%	-40.6%	-4.6%	NO	NO	0.1%				fuel used
1 A 3 b v	NA	NA	NA	NA	NA	NA	NA				NA	NA	NA	fuel sold
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 b vi	0.148	0.412	0.348	0.353	138.1%	-14.5%	1.3%				0.9%	13.4%	16.7%	fuel sold
	0.054	0.102	0.135	0.138	156.7%	35.4%	1.8%	0.3%	5.9%	8.5%				fuel used
1 A 3 b vii	0.087	0.266	0.222	0.225	158.9%	-15.4%	1.0%				0.5%	8.6%	10.7%	fuel sold
	0.030	0.056	0.074	0.076	149.4%	34.2%	1.8%	0.2%	3.3%	4.6%				fuel used
1 A 3 c	0.059	0.017	0.004	0.005	-92.1%	-72.1%	26.7%	0.4%	1.0%	0.3%	0.4%	0.5%	0.2%	fuel sold
1 A 3 d i (ii)	0.000	0.000	0.000	0.000	10.2%	-21.2%	22.6%	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	-38.6%	-14.8%	-3.3%	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)	**16.593**	**3.074**	**2.204**	**2.108**	**-87.3%**	**-31.4%**	**-4.4%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**15.868**	**1.727**	**1.646**	**1.628**	**-89.7%**	**-5.7%**	**-1.1%**	**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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
1 A 3	**1.226**	**2.227**	**1.060**	**1.048**	**-14.5%**	**-52.9%**	**-1.1%**				**7.1%**	**57.2%**	**32.2%**	**fuel sold**
1 A 3	**0.411**	**0.553**	**0.392**	**0.391**	**-4.9%**	**-29.3%**	**-0.4%**	**2.5%**	**24.9%**	**15.4%**				**fuel used**
1 A 3 a ii (i)	0.000	0.000	0.000	0.000	170.2%	-5.4%	-4.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 3 a i (i)	0.001	0.004	0.004	0.004	316.6%	11.8%	6.6%	0.0%	0.2%	0.2%	0.0%	0.1%	0.1%	fuel sold
1 A 3 b i	0.328	0.408	0.042	0.037	-88.7%	-90.9%	-11.7%				1.9%	10.5%	1.1%	fuel sold
	0.102	0.185	0.026	0.022	-78.3%	-88.1%	-13.9%	0.6%	8.3%	0.9%				fuel used
1 A 3 b ii	0.029	0.040	0.016	0.014	-53.5%	-66.1%	-16.2%				0.2%	1.0%	0.4%	fuel sold
	0.029	0.040	0.016	0.014	-53.5%	-66.1%	-16.2%	0.2%	1.8%	0.5%				fuel used
1 A 3 b iii	0.432	0.661	0.074	0.058	-86.6%	-91.3%	-21.8%				2.5%	17.0%	1.8%	fuel sold
	0.085	0.057	0.013	0.011	-87.1%	-80.9%	-18.3%	0.5%	2.6%	0.4%				fuel used
1 A 3 b iv	0.004	0.003	0.002	0.002	-48.5%	-40.6%	-4.6%				0.0%	0.1%	0.1%	fuel sold
	0.004	0.003	0.002	0.002	-48.5%	-40.6%	-4.6%	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
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				fuel used
1 A 3 b vi	0.198	0.562	0.473	0.479	141.7%	-14.8%	1.3%				1.1%	14.4%	14.7%	fuel sold
	0.070	0.134	0.179	0.182	158.5%	35.7%	1.8%	0.4%	6.0%	7.2%				fuel used
1 A 3 b vii	0.174	0.531	0.445	0.449	158.9%	-15.4%	1.0%				1.0%	13.6%	13.8%	fuel sold
	0.061	0.113	0.149	0.151	149.4%	34.2%	1.8%	0.4%	5.1%	6.0%				fuel used
1 A 3 c	0.059	0.017	0.004	0.005	-92.1%	-72.1%	26.7%	0.4%	0.8%	0.2%	0.3%	0.4%	0.1%	fuel sold
1 A 3 d i (ii)	0.000	0.000	0.000	0.000	10.2%	-21.2%	22.6%	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	-38.6%	-14.8%	-3.3%	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)	**17.351**	**3.896**	**3.011**	**3.250**	**-81.3%**	**-16.6%**	**8.0%**				**100.0%**	**100.0%**	**100.0%**	**fuel sold**
National total (fuel used)	**16.536**	**2.221**	**2.190**	**2.531**	**-84.7%**	**14.0%**	**15.6%**	**100.0%**	**100.0%**	**100.0%**				**fuel used**

Source: Environment Agency

Table 132 presents the key categories of *1A3 – Transport* (see also Table 49 in Section 3.2 and Chapter 1.5).

Table 132 – 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 - Domestic - LTO				5												
1 A 3 b i	Road Transport, Passenger cars			1		6	1		2	1	3					8	
1 A 3 b ii	Road Transport, Light duty vehicles				7												
1 A 3 b iii	Road Transport, Heavy duty vehicles			2	2					5	4			8		5	
1 A 3 b v	Road Transport, Gasoline evaporation						2										
1 A 3 b vi	Road Transport, Automobile tyre and break wear											2	3	2	3	2	3
1 A 3 b vii	Road Transport, Automobile road abrasion											3	4	3	4	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 3 a i (i)	Civil Aviation - Domestic - LTO			8	5						
1 A 3 b i	Road Transport, Passenger cars			1	2		1		3		
1 A 3 b iii	Road Transport, Heavy duty vehicles			5	6						
1 A 3 b v	Road Transport, Gasoline evaporation						3				
1 A 3 b vi	Road Transport, Automobile tyre and break wear									3	4
1 A 3 b vii	Road Transport, Automobile road abrasion									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, …)

3.2.4.2 **Civil Aviation (1A3a)**

3.2.4.2.1 Source category description

In Luxembourg, civil aviation, excluding international flights, is a very 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.

In Table 133 and Table 134 are presented the emissions of air pollutants for 1990, 2005, 2016 and 2017 as well as the trends and shares based on fuel sold for categories *1A3aii(i) - Civil Aviation – Domestic* and category *1A3ai(i) - Civil Aviation – International – LTO*.

In 2017, the source categories *1A3aii(i)* and *1A3ai(i)* represented less than 4% of national total for each air pollutant. All air pollutants increased significantly due to increased international aviation activities (see Table 135 and Table 136).

Fuel consumption emissions from civil aviation are not key categories (see Table 132 and also Table 49 in Section 3.2 and Chapter 1.5).

Table 133 – Emissions (1990, 2005, 2016 and 2017), 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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
SO2	0.0000	0.0001	0.0001	0.0001	170.2%	-5.4%	-4.6%	0.000%	0.004%	0.007%	0.000%	0.004%	0.007%	fuel sold
NOx	0.0002	0.0007	0.0007	0.0007	170.2%	-5.4%	-4.6%	0.001%	0.004%	0.005%	0.001%	0.001%	0.004%	fuel sold
NMVOC	0.0015	0.0042	0.0042	0.0040	170.2%	-5.4%	-4.6%	0.008%	0.033%	0.037%	0.006%	0.028%	0.035%	fuel sold
NH3	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	fuel sold
CO	0.0626	0.1787	0.1772	0.1690	170.2%	-5.4%	-4.6%	0.015%	0.903%	1.174%	0.013%	0.466%	0.809%	fuel sold
TSP	0.0000	0.0000	0.0000	0.0000	170.2%	-5.4%	-4.6%	0.000%	0.002%	0.001%	0.000%	0.001%	0.001%	fuel sold
PM10	0.0000	0.0000	0.0000	0.0000	170.2%	-5.4%	-4.6%	0.000%	0.002%	0.002%	0.000%	0.001%	0.002%	fuel sold
PM2.5	0.0000	0.0000	0.0000	0.0000	170.2%	-5.4%	-4.6%	0.000%	0.003%	0.003%	0.000%	0.001%	0.002%	fuel sold

Sources: Environment Agency

Table 134 – Emissions (1990, 2005, 2016 and 2017), 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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
SO2	0.0096	0.0357	0.0374	0.0399	316.6%	11.8%	6.6%	0.068%	1.498%	3.026%	0.065%	1.474%	2.973%	fuel sold
NOx	0.1429	0.5322	0.5582	0.5952	316.6%	11.8%	6.6%	0.619%	3.307%	4.824%	0.345%	0.974%	3.252%	fuel sold
NMVOC	0.0119	0.0444	0.0466	0.0497	316.6%	11.8%	6.6%	0.067%	0.352%	0.460%	0.045%	0.295%	0.437%	fuel sold
NH3	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	fuel sold
CO	0.1110	0.4133	0.4336	0.4623	316.6%	11.8%	6.6%	0.026%	2.088%	3.211%	0.024%	1.079%	2.214%	fuel sold
TSP	0.0010	0.0036	0.0038	0.0040	316.6%	11.8%	6.6%	0.006%	0.163%	0.160%	0.006%	0.093%	0.124%	fuel sold
PM10	0.0010	0.0036	0.0038	0.0040	316.6%	11.8%	6.6%	0.006%	0.209%	0.248%	0.006%	0.118%	0.192%	fuel sold
PM2.5	0.0010	0.0036	0.0038	0.0040	316.6%	11.8%	6.6%	0.006%	0.272%	0.382%	0.006%	0.148%	0.295%	fuel sold

Sources: Environment Agency

Table 135 – 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
Trend 1990-2017	*170.16%*	*170.16%*	*170.16%*	*NA*	*170.16%*	*170.16%*	*170.16%*	*170.16%*
2005-2017	*-5.44%*	*-5.44%*	*-5.44%*	*NA*	*-5.44%*	*-5.44%*	*-5.44%*	*-5.44%*
2016-2017	*-4.62%*	*-4.62%*	*-4.62%*	*NA*	*-4.62%*	*-4.62%*	*-4.62%*	*-4.62%*

Sources: Environment Agency

Table 136 – 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	0.010	0.143	0.012	NE	0.111	0.001	0.001	0.001
1991	0.010	0.147	0.012	NE	0.115	0.001	0.001	0.001
1992	0.010	0.151	0.013	NE	0.117	0.001	0.001	0.001
1993	0.010	0.144	0.012	NE	0.112	0.001	0.001	0.001
1994	0.009	0.138	0.012	NE	0.107	0.001	0.001	0.001
1995	0.012	0.173	0.014	NE	0.134	0.001	0.001	0.001
1996	0.014	0.202	0.017	NE	0.157	0.001	0.001	0.001
1997	0.015	0.221	0.018	NE	0.172	0.002	0.002	0.002
1998	0.016	0.244	0.020	NE	0.190	0.002	0.002	0.002
1999	0.022	0.324	0.027	NE	0.252	0.002	0.002	0.002
2000	0.025	0.370	0.031	NE	0.287	0.003	0.003	0.003
2001	0.027	0.396	0.033	NE	0.308	0.003	0.003	0.003
2002	0.027	0.408	0.034	NE	0.317	0.003	0.003	0.003
2003	0.029	0.427	0.036	NE	0.331	0.003	0.003	0.003
2004	0.031	0.464	0.039	NE	0.360	0.003	0.003	0.003
2005	0.036	0.532	0.044	NE	0.413	0.004	0.004	0.004
2006	0.036	0.543	0.045	NE	0.422	0.004	0.004	0.004
2007	0.036	0.533	0.044	NE	0.414	0.004	0.004	0.004
2008	0.036	0.536	0.045	NE	0.416	0.004	0.004	0.004
2009	0.033	0.486	0.041	NE	0.377	0.003	0.003	0.003
2010	0.032	0.483	0.040	NE	0.375	0.003	0.003	0.003
2011	0.033	0.493	0.041	NE	0.383	0.003	0.003	0.003
2012	0.033	0.494	0.041	NE	0.384	0.003	0.003	0.003
2013	0.034	0.504	0.042	NE	0.391	0.003	0.003	0.003
2014	0.035	0.516	0.043	NE	0.401	0.004	0.004	0.004
2015	0.036	0.534	0.045	NE	0.415	0.004	0.004	0.004
2016	0.037	0.558	0.047	NE	0.434	0.004	0.004	0.004
2017	0.040	0.595	0.050	NE	0.462	0.004	0.004	0.004
Trend 1990-2017	*316.63%*	*316.63%*	*316.63%*	*NA*	*316.63%*	*316.63%*	*316.63%*	*316.63%*
2005-2017	*11.84%*	*11.84%*	*11.84%*	*NA*	*11.84%*	*11.84%*	*11.84%*	*11.84%*
2016-2017	*6.63%*	*6.63%*	*6.63%*	*NA*	*6.63%*	*6.63%*	*6.63%*	*6.63%*

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** was 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 was obtained from the national statistics institute. The LTO fuel consumption of international operations were estimated using a Tier 1 fuel consumption factor from the EMEP/EEA Guidebook 2016 of 824.65 kg/LTO and representative for an average fleet based on B737-400 short distance flight which is representative of modern aircrafts operating to and from Luxembourg. The cruise fuel consumption was then deduced by calculating the difference between the amount of fuel sold and the LTO fuel consumption.

Activity data for category *1A3a – Civil Aviation* are listed in Table 137.

Table 137 – Activity data for category – *1A3a - Civil Aviation*

1 A Mobile Fuel Combustion			
Activity Data by fuel type (GJ)			
Year	Activity Total (incl. biomass)	1 A 3 a ii (i) Domestic aviation Liquid Aviation gasoline	1 A 3 a i (i) International aviation LTO (civil) Liquid Kerosene
1990	496 440	3'410	493'030
1991	514 135	5'180	508'955
1992	528 209	7'310	520'899
1993	506 436	9'460	496'976
1994	486 909	11'190	475'719
1995	608 556	12'050	596'506
1996	710 513	12'308	698'205
1997	776 091	12'480	763'611
1998	854 190	10'742	843'448
1999	1 128 782	10'986	1'117'796
2000	1 286 230	10'465	1'275'765
2001	1 377 442	10'393	1'367'049
2002	1 417 880	9'633	1'408'247
2003	1 483 768	11'217	1'472'551
2004	1 611 276	9'834	1'601'443
2005	1 846 361	9'742	1'836'619
2006	1 883 873	8'296	1'875'578
2007	1 846 680	8'782	1'837'898
2008	1 857 442	8'417	1'849'024
2009	1 684 999	8'599	1'676'400
2010	1 675 521	8'496	1'667'025
2011	1 711 752	9'022	1'702'729
2012	1 713 734	7'844	1'705'890
2013	1 745 697	7'499	1'738'197
2014	1 788 671	7'974	1'780'697
2015	1 853 037	9'589	1'843'448
2016	1 936 068	9'659	1'926'409
2017	2 063 342	9'212	2'054'130
Trend 1990-2017	*315.63%*	*170.16%*	*316.63%*
2005-2017	*11.75%*	*-5.44%*	*11.84%*
2016-2017	*6.57%*	*-4.62%*	*6.63%*

Source: Environment Agency

3.2.4.2.2.2 Methodological choices

The EMEP/EEA Guidebook Tier 1 approach has been applied for domestic flights using aviation gasoline and international flights (LTO and cruise) using jet kerosene.

3.2.4.2.2.3 Emission factors

Default emission factors for kerosene, from the EMEP/EEA Guidebook (2016, Part B, Chap. 1A3 Aviation, Table 3-4, p.23) were used to calculate the emissions from *1A3ai (i) – International Aviation – LTO* (see Table 138).

Table 138 – Emission factors for jet kerosene

Pollutants	activity	EF	Unit	Pollutants	activity	EF	Unit
NO_X	LTO	0.0103	t/LTO	$PM_{2.5}$	LTO	0.00007	t/LTO
	Cruise	0.0139	t/t Fuel		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 emission factors for aviation gasoline, from the EMEP/EEA Guidebook (2016, Part B, Chap. 1A3 Aviation, Table 3-10, p.29) were used to calculate the emissions from category *1A3aii(i) –Domestic Aviation* (see Table 139).

Table 139 – Emission factors for aviation gasoline

Pollutants	Unit	EF aviation gasoline	Source
NO_X	g/kg fuel	3.14	EMEP/EEA 2016 GB Part B, Chap. 1A3 Aviation, Table 3-10, p.29
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	
PM_{10}	g/kg fuel	3.5	
TSP	g/kg fuel	3.5	

3.2.4.2.3 Uncertainties and time-series consistency

Currently no uncertainty estimates are made. Uncertainty of the activity data can be checked in the Luxembourg's National Inventory report (NIR).

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.

3.2.4.2.4 Source-specific QA/QC and verification

Consistency and completeness checks are performed.

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

Table 140 presents the main revisions and recalculations done since submission 2018.

Table 140 – Recalculations done since submission 2018 for category – *1A3a - Civil Aviation*

Source category	Revisions 2018 → 2019	Type of revision
1A3a	Aviation gasoline activity data for 2016 was revised by data provider	AD
1A3ai(i) and 1A3aii(i)	changed the notation key of NH_3 from 'NO' to 'NE'	Changed notation key

Source: Environment Agency

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

The following improvements are planned for the next submission.

Table 141 – Planned improvements for category – *1A3a - Civil Aviation*

Source category	Planned improvements	Type of revision
1A3ai(i)	Analyse LTO data per aircraft type from Eurostat for Luxembourg in order to upgrade the current Tier 1 methodology to Tier 2.	Update methodology

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 2017, this source category represented:

- 58% of national total NO_X emissions (based on fuel sold) and 38% of national total NO_X emissions (based on fuel used).
- 3.2% of national total SO_2 emissions (based on fuel sold) and 0.9% of national total SO_2 emissions (based on fuel used).
- 7.5% of national total NMVOC emissions (based on fuel sold) and 3.7% of national total NMVOC emissions (based on fuel used).
- 3.3% of national total NH_3 emissions (based on fuel sold) and 1.3% of national total NH_3 emissions (based on fuel used).
- 37% of national total CO emissions (based on fuel sold) and 19% of national total CO emissions (based on fuel used).
- 35% of national total TSP emissions (based on fuel sold) and 17% of national total TSP emissions (based on fuel used).
- 34% of national total PM_{10} emissions (based on fuel sold) and 17% of national total PM_{10} emissions (based on fuel used).
- 32% of national total $PM_{2.5}$ emissions (based on fuel sold) and 15% of national total $PM_{2.5}$ emissions (based on fuel used).

Table 142 gives a general overview of the emissions, tends and shares for category 1*A3b - Road transport* for the years 1990, 2005, 2016 and 2017.

Table 142 – Emissions (1990, 2005, 2016 and 2017), Trends and Shares based on fuel sold and fuel used for category 1*A3b - Road transport*

1 A 3 b Road Transport													
Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
1990	2005	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
1.05	0.05	0.03	0.03	-96.9%	-29.9%	2.7%				7.1%	1.9%	3.2%	fuel sold
0.24	0.01	0.01	0.01	-96.1%	14.3%	1.1%	1.7%	0.3%	0.9%				fuel used
26.00	44.72	12.01	10.69	-58.9%	-76.1%	-11.0%				62.7%	81.8%	58.4%	fuel sold
7.62	6.16	5.02	4.72	-38.0%	-23.3%	-5.9%	33.0%	38.3%	38.3%				fuel used
15.71	3.36	0.94	0.91	-94.2%	-72.9%	-3.1%				59.2%	22.3%	7.5%	fuel sold
6.90	0.94	0.44	0.43	-93.8%	-54.1%	-2.6%	38.9%	7.4%	3.7%				fuel used
0.02	0.55	0.19	0.19	1138.6%	-64.5%	2.8%				0.2%	9.3%	3.3%	fuel sold
0.01	0.15	0.07	0.07	1021.8%	-53.6%	2.9%	0.1%	2.8%	1.3%				fuel used
82.03	25.76	8.79	8.26	-89.9%	-67.9%	-6.1%				17.6%	67.2%	37.4%	fuel sold
36.21	7.23	3.31	3.21	-91.1%	-55.6%	-3.1%	8.6%	36.5%	18.9%				fuel used
1.17	2.21	1.05	1.04	-10.9%	-52.9%	-1.2%				6.7%	56.6%	35.1%	fuel sold
0.35	0.53	0.38	0.38	8.9%	-28.3%	-0.8%	2.1%	24.0%	16.6%				fuel used
1.03	1.79	0.70	0.69	-33.1%	-61.6%	-2.4%				6.2%	58.3%	34.3%	fuel sold
0.30	0.44	0.27	0.26	-13.6%	-40.9%	-1.9%	1.9%	25.7%	16.6%				fuel used
0.92	1.49	0.45	0.43	-53.6%	-71.2%	-4.5%				5.7%	60.8%	31.9%	fuel sold
0.26	0.37	0.17	0.16	-38.2%	-55.8%	-4.0%	1.7%	27.8%	15.2%				fuel used

Source: Environment Agency.

Fuel combustion in 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 (see Table 143 and also Table 49 in Section 3.2 and Chapter 1.5).

Table 143 – Key Category Analysis of category – *1A3b - Road Transport*

NFR 1A3b

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		6	1		2	1	3					8	
1 A 3 b ii	Road Transport, Light duty vehicles				7												
1 A 3 b iii	Road Transport, Heavy duty vehicles			2	2					5	4			8		5	
1 A 3 b v	Road Transport, Gasoline evaporation						2										
1 A 3 b vi	Road Transport, Automobile tyre and break wear											2	3	2	3	2	3
1 A 3 b vii	Road Transport, Automobile road abrasion											3	4	3	4	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 3 b i	Road Transport, Passenger cars			1	2		1		3		
1 A 3 b iii	Road Transport, Heavy duty vehicles			5	6						
1 A 3 b v	Road Transport, Gasoline evaporation						3				
1 A 3 b vi	Road Transport, Automobile tyre and break wear									3	4
1 A 3 b vii	Road Transport, Automobile road abrasion									6	

Sources: Environment Agency

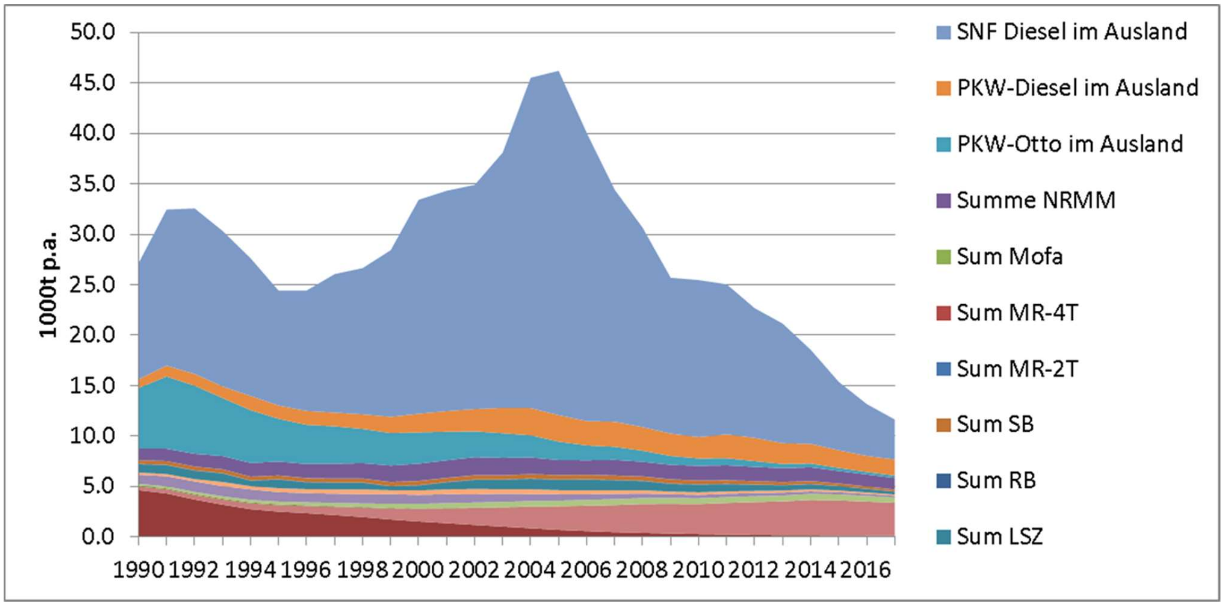
Notes: LA = Level Assessment, TA = Trend Assessment

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

Figure 3-6 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 7.62 Gg in 1990 to 4.72 Gg in 2017, whereas NO_x emissions based on fuel sold declined from 26.00 Gg in 1990 to 10.69 Gg in 2017.

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 3-6 – Trend of NO_x emissions based on fuel used and fuel sold per vehicle category



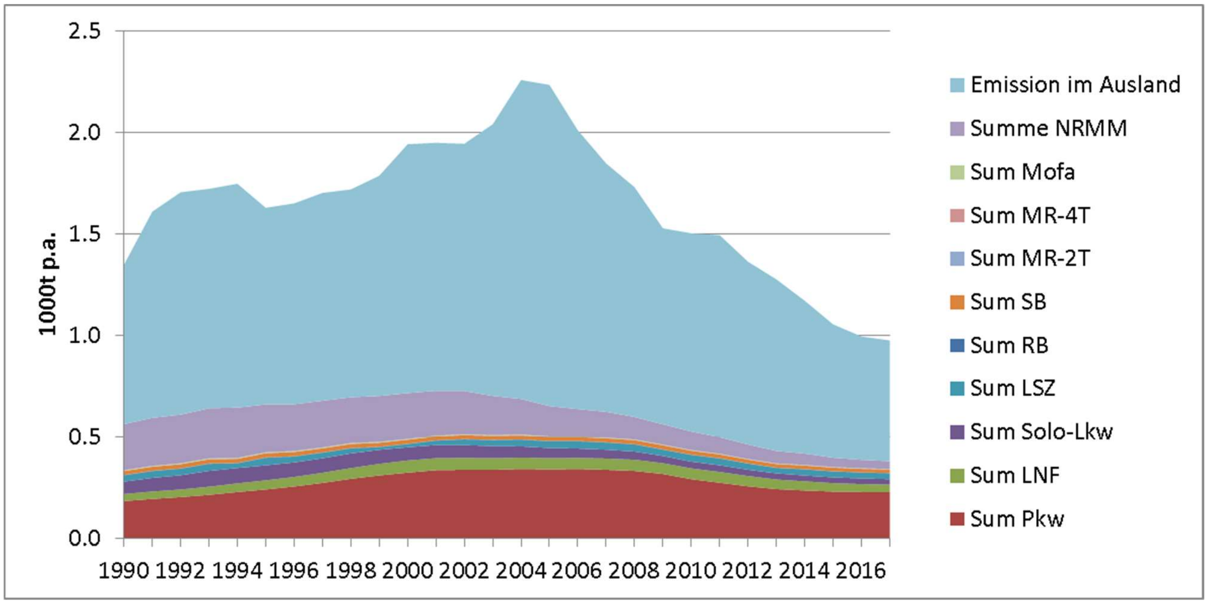
Sources: Environment Agency

Notes: vehicle categories, “Ausland” = fuel export

PKW	PC: Passenger car		
SB	Bus, urban bus, public transport bus (German: Linienbus)	RB	Coach (German: Reisebus)
LNF	LDV: Light commercial vehicle <3,5t (small buses, trucks, camper vans, other motor vehicles)	SNF, LSZ, solo-LKW	Heavy goods vehicles {= general term for trucks (Solo-LKW), truck trailers (SNF) and articulated trucks (LSZ)} = HDV
MR-2T, MR-4T	Motorcycle	2ST	2 stroke petrol engine
		4ST	4 stroke petrol engine
KKR	Moped (<50cc) (German: Kleinkraftrad)		
Off-Road	Sum of Offroad 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 3-7 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 0.30 Gg in 1990 to 0.26 Gg in 2017, whereas PM_{10} emissions based on fuel sold decreased from 1.03 Gg in 1990 to 0.69 Gg in 2017. 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 3-7 – Trend of PM_{10} emissions based on fuel used and fuel sold per vehicle category



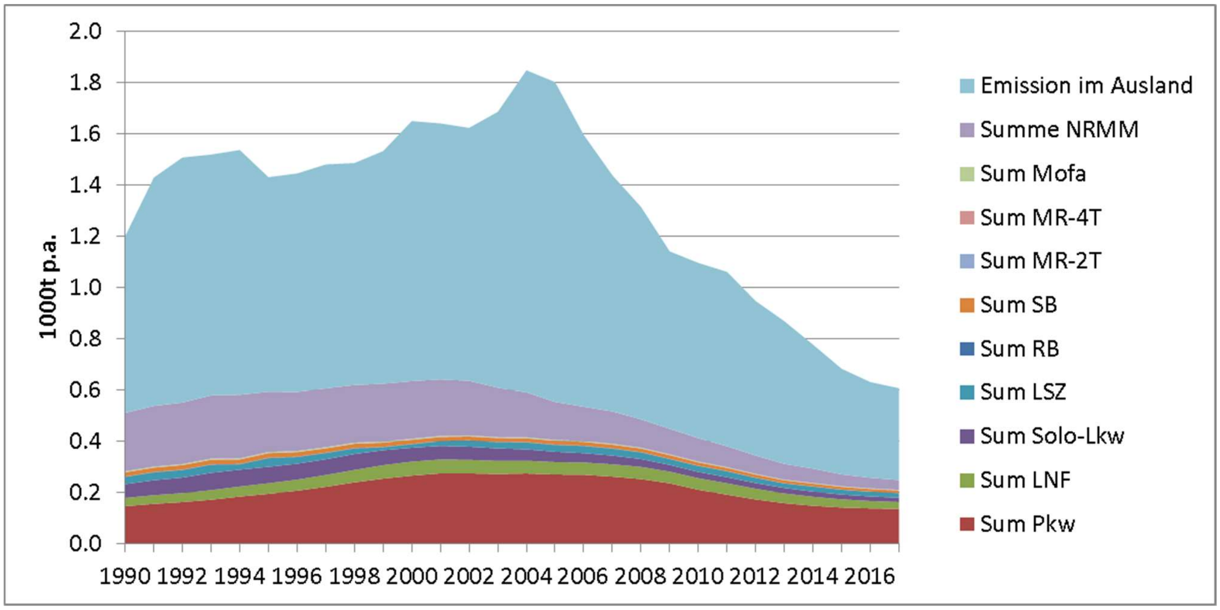
Sources: Environment Agency

Notes: vehicle categories

PKW	PC: Passenger car		
SB	Bus, urban bus, public transport bus (German: Linienbus)	RB	Coach (German: Reisebus)
LNF	LDV: Light commercial vehicle <3,5t (small buses, trucks, camper vans, other motor vehicles)	SNF, LSZ, solo-LKW	Heavy goods vehicles {= general term for trucks (Solo-LKW), truck trailers (SNF) and articulated trucks (LSZ)} = HDV
MR-2T, MR-4T	Motorcycle	2ST	2 stroke petrol engine
		4ST	4 stroke petrol engine
KKR	Moped (<50cc) (German: Kleinkraftrad)		
Off-Road	Sum of Offroad 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 3-8 presents the evolution of $PM_{2.5}$ emissions (exhaust and non-exhaust) from the transport sector (including fuel export) in Luxembourg. The $PM_{2.5}$ emissions from *1A3b - Road transport* based on fuel used decreased from 0.26 Gg in 1990 to 0.16 Gg in 2017, whereas $PM_{2.5}$ emissions from *1A3b - Road transport* based on fuel sold decreased from 0.92 Gg in 1990 to 0.43 Gg in 2017. 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 3-8 – Trend of $PM_{2.5}$ emissions based on fuel used and fuel sold per vehicle category



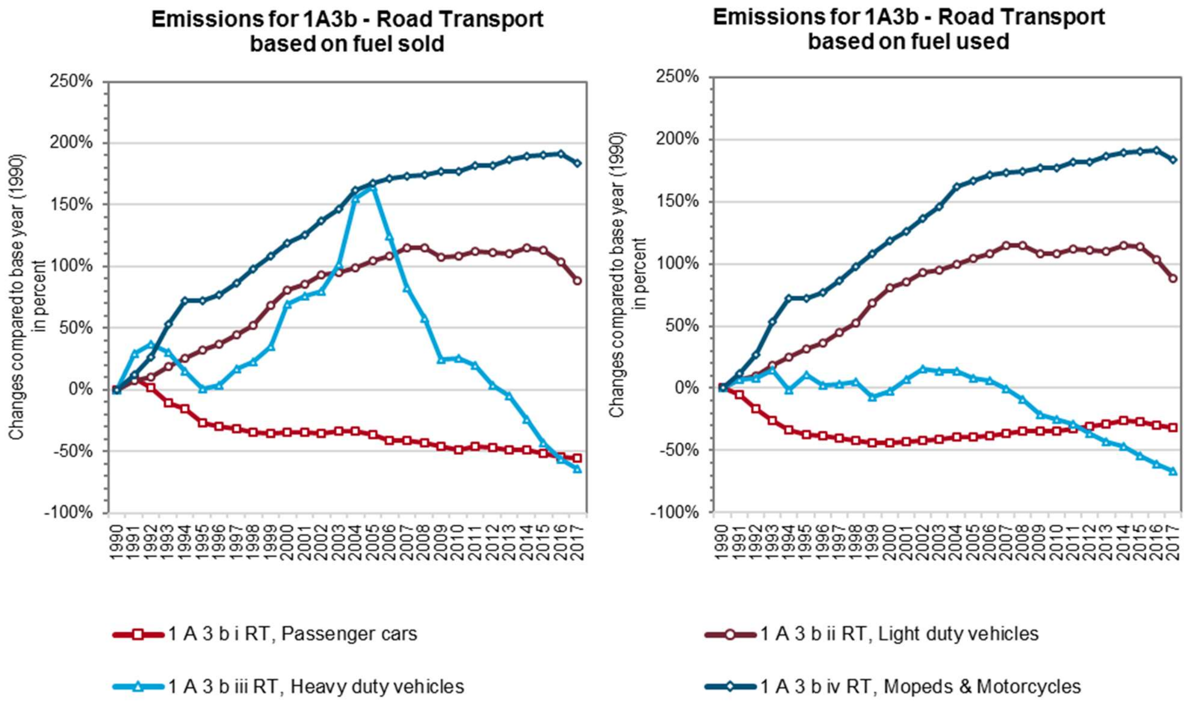
Sources: Environment Agency

Notes: vehicle categories

PKW	PC: Passenger car				
SB	Bus, urban bus, public transport bus (German: Linienbus)			RB	Coach (German: Reisebus)
LNF	LDV: Light commercial vehicle <3,5t (small buses, trucks, camper vans, other motor vehicles)			SNF, LSZ, solo-LKW	Heavy goods vehicles {= general term for trucks (Solo-LKW), truck trailers (SNF) and articulated trucks (LSZ)} = HDV
MR-2T, MR-4T	Motorcycle	2ST	2 stroke petrol engine		
		4ST	4 stroke petrol engine		
KKR	Moped (<50cc) (German: Kleinkraftrad)				
Off-Road	Sum of Offroad 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 3-9 illustrates the changes of NO_x emissions compared to the base year.

Figure 3-9 – 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

Table 144 presents the emission trends for sub-category *1A3b i –Passenger Cars* based on fuel sold and fuel used.

Table 145 presents the emission trends for sub-category *1A3b ii – Light duty vehicles (LDV)* based on fuel sold and fuel used.

Table 146 presents the emission trends for sub-category *1 A 3 b iii – Heavy duty vehicles and buses (HDV)* based on fuel sold and fuel used.

Table 147 presents the emission trends for sub-category *1 A 3 b iv – Mopeds & motorcycles* based on fuel sold and fuel used.

Table 148 presents the emission trends for sub-category *1 A 3 b v – Gasoline evaporation* based on fuel sold and fuel used.

Table 149 presents the emission trends for sub-category *1 A 3 b vi – Automobile tyre and brake wear* based on fuel sold and fuel used.

Table 144 – 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	NH3	$PM_{2.5}$
1990	0.261	11.864	11.051	0.013	78.859	0.328	0.328	0.328	0.085	4.996	4.776	0.005	0.102
1991	0.329	12.961	11.825	0.080	84.248	0.380	0.380	0.380	0.097	4.724	4.419	0.030	0.108
1992	0.369	12.086	10.637	0.214	75.823	0.393	0.393	0.393	0.108	4.167	3.754	0.076	0.113
1993	0.381	10.597	8.812	0.328	63.362	0.384	0.384	0.384	0.120	3.709	3.141	0.118	0.120
1994	0.444	9.975	7.545	0.441	54.903	0.441	0.441	0.441	0.132	3.338	2.594	0.153	0.130
1995	0.372	8.696	6.035	0.483	44.676	0.420	0.420	0.420	0.123	3.150	2.239	0.180	0.138
1996	0.177	8.330	5.290	0.548	39.945	0.434	0.434	0.434	0.062	3.067	1.993	0.208	0.147
1997	0.167	8.047	4.732	0.635	36.713	0.431	0.431	0.431	0.062	2.979	1.753	0.235	0.159
1998	0.162	7.745	4.125	0.702	33.256	0.448	0.448	0.448	0.062	2.911	1.530	0.259	0.174
1999	0.160	7.642	3.720	0.776	31.090	0.472	0.472	0.472	0.062	2.817	1.324	0.274	0.185
2000	0.159	7.727	3.416	0.829	29.689	0.496	0.496	0.496	0.062	2.782	1.157	0.276	0.194
2001	0.158	7.711	3.041	0.806	27.667	0.492	0.492	0.492	0.064	2.839	1.021	0.265	0.200
2002	0.144	7.651	2.692	0.746	25.614	0.469	0.469	0.469	0.061	2.888	0.893	0.240	0.197
2003	0.144	7.895	2.503	0.709	24.686	0.463	0.463	0.463	0.060	2.933	0.782	0.213	0.192
2004	0.015	7.918	2.248	0.636	22.680	0.449	0.449	0.449	0.006	3.016	0.682	0.183	0.191
2005	0.013	7.475	1.913	0.532	19.475	0.408	0.408	0.408	0.005	3.038	0.584	0.151	0.185
2006	0.011	6.982	1.621	0.442	16.505	0.367	0.367	0.367	0.005	3.101	0.513	0.129	0.180
2007	0.011	6.939	1.476	0.394	14.920	0.339	0.339	0.339	0.005	3.165	0.457	0.111	0.169
2008	0.011	6.710	1.322	0.347	13.216	0.293	0.293	0.293	0.005	3.271	0.419	0.098	0.154
2009	0.011	6.390	1.155	0.298	11.365	0.248	0.248	0.248	0.006	3.288	0.377	0.086	0.136
2010	0.011	6.112	1.013	0.263	9.914	0.198	0.198	0.198	0.006	3.266	0.338	0.078	0.111
2011	0.011	6.438	0.995	0.262	9.664	0.165	0.165	0.165	0.006	3.375	0.313	0.073	0.089
2012	0.011	6.333	0.882	0.237	8.540	0.126	0.126	0.126	0.006	3.465	0.287	0.068	0.069
2013	0.010	6.012	0.754	0.206	7.205	0.093	0.093	0.093	0.006	3.535	0.267	0.064	0.054
2014	0.010	6.002	0.718	0.195	6.754	0.067	0.067	0.067	0.006	3.684	0.269	0.065	0.039
2015	0.010	5.682	0.652	0.183	6.105	0.051	0.051	0.051	0.006	3.631	0.259	0.065	0.031
2016	0.010	5.362	0.604	0.177	5.693	0.042	0.042	0.042	0.006	3.515	0.253	0.067	0.026
2017	0.010	5.233	0.593	0.182	5.648	0.037	0.037	0.037	0.006	3.399	0.249	0.069	0.022
Trend 1990-2017	*-96.19%*	*-55.89%*	*-94.63%*	*1355.11%*	*-92.84%*	*-88.67%*	*-88.67%*	*-88.67%*	*-92.91%*	*-31.96%*	*-94.78%*	*1213.71%*	*-78.27%*
2005-2017	*-21.34%*	*-29.99%*	*-68.98%*	*-65.75%*	*-71.00%*	*-90.90%*	*-90.90%*	*-90.90%*	*13.86%*	*11.91%*	*-57.29%*	*-54.48%*	*-88.06%*
2016-2017	*1.56%*	*-2.39%*	*-1.75%*	*2.84%*	*-0.79%*	*-11.66%*	*-11.66%*	*-11.66%*	*0.44%*	*-3.29%*	*-1.66%*	*2.95%*	*-13.91%*

Source: Environment Agency

Table 145 – 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	NH3	$PM_{2.5}$
1990	0.021	0.280	0.120	0.000	1.208	0.029	0.029	0.029	0.021	0.280	0.120	0.000	0.029
1991	0.023	0.299	0.119	0.001	1.238	0.031	0.031	0.031	0.023	0.299	0.119	0.001	0.031
1992	0.025	0.308	0.113	0.002	1.209	0.031	0.031	0.031	0.025	0.308	0.113	0.002	0.031
1993	0.029	0.332	0.110	0.002	1.206	0.034	0.034	0.034	0.029	0.332	0.110	0.002	0.034
1994	0.031	0.350	0.106	0.003	1.188	0.035	0.035	0.035	0.031	0.350	0.106	0.003	0.035
1995	0.029	0.368	0.104	0.003	1.167	0.037	0.037	0.037	0.029	0.368	0.104	0.003	0.037
1996	0.012	0.382	0.100	0.003	1.131	0.039	0.039	0.039	0.012	0.382	0.100	0.003	0.039
1997	0.012	0.404	0.094	0.003	1.047	0.041	0.041	0.041	0.012	0.404	0.094	0.003	0.041
1998	0.012	0.426	0.088	0.003	0.963	0.043	0.043	0.043	0.012	0.426	0.088	0.003	0.043
1999	0.013	0.470	0.086	0.003	0.935	0.047	0.047	0.047	0.013	0.470	0.086	0.003	0.047
2000	0.013	0.506	0.077	0.003	0.811	0.049	0.049	0.049	0.013	0.506	0.077	0.003	0.049
2001	0.014	0.520	0.067	0.003	0.691	0.047	0.047	0.047	0.014	0.520	0.067	0.003	0.047
2002	0.012	0.539	0.058	0.003	0.585	0.046	0.046	0.046	0.012	0.539	0.058	0.003	0.046
2003	0.012	0.547	0.050	0.003	0.489	0.044	0.044	0.044	0.012	0.547	0.050	0.003	0.044
2004	0.001	0.557	0.042	0.002	0.398	0.042	0.042	0.042	0.001	0.557	0.042	0.002	0.042
2005	0.001	0.572	0.037	0.002	0.340	0.040	0.040	0.040	0.001	0.572	0.037	0.002	0.040
2006	0.001	0.583	0.033	0.002	0.302	0.039	0.039	0.039	0.001	0.583	0.033	0.002	0.039
2007	0.001	0.602	0.030	0.002	0.270	0.039	0.039	0.039	0.001	0.602	0.030	0.002	0.039
2008	0.001	0.602	0.026	0.002	0.232	0.038	0.038	0.038	0.001	0.602	0.026	0.002	0.038
2009	0.001	0.581	0.023	0.001	0.199	0.036	0.036	0.036	0.001	0.581	0.023	0.001	0.036
2010	0.001	0.582	0.020	0.001	0.174	0.035	0.035	0.035	0.001	0.582	0.020	0.001	0.035
2011	0.001	0.592	0.018	0.001	0.157	0.034	0.034	0.034	0.001	0.592	0.018	0.001	0.034
2012	0.001	0.591	0.017	0.001	0.143	0.031	0.031	0.031	0.001	0.591	0.017	0.001	0.031
2013	0.001	0.588	0.015	0.001	0.128	0.027	0.027	0.027	0.001	0.588	0.015	0.001	0.027
2014	0.001	0.602	0.013	0.001	0.111	0.024	0.024	0.024	0.001	0.602	0.013	0.001	0.024
2015	0.001	0.597	0.011	0.001	0.101	0.020	0.020	0.020	0.001	0.597	0.011	0.001	0.020
2016	0.001	0.568	0.010	0.001	0.093	0.016	0.016	0.016	0.001	0.568	0.010	0.001	0.016
2017	0.001	0.528	0.009	0.001	0.086	0.014	0.014	0.014	0.001	0.528	0.009	0.001	0.014
Trend 1990-2017	*-95.47%*	*88.70%*	*-92.29%*	*164.63%*	*-92.89%*	*-53.51%*	*-53.51%*	*-53.51%*	*-95.47%*	*88.70%*	*-92.29%*	*164.63%*	*-53.51%*
2005-2017	*23.50%*	*-7.67%*	*-74.98%*	*-33.59%*	*-74.72%*	*-66.08%*	*-66.08%*	*-66.08%*	*23.50%*	*-7.67%*	*-74.98%*	*-33.59%*	*-66.08%*
2016-2017	*2.70%*	*-7.12%*	*-9.15%*	*-0.63%*	*-7.64%*	*-16.15%*	*-16.15%*	*-16.15%*	*2.70%*	*-7.12%*	*-9.15%*	*-0.63%*	*-16.15%*

Source: Environment Agency

Table 146 – 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	NH3	$PM_{2.5}$
1990	0.772	13.851	0.424	0.003	1.550	0.432	0.432	0.432	0.132	2.333	0.122	0.001	0.085
1991	1.001	17.964	0.535	0.003	1.970	0.557	0.557	0.557	0.142	2.507	0.131	0.001	0.091
1992	1.080	18.910	0.587	0.004	2.131	0.598	0.598	0.598	0.145	2.516	0.135	0.001	0.092
1993	1.096	18.089	0.631	0.004	2.207	0.601	0.601	0.601	0.159	2.677	0.148	0.001	0.100
1994	1.009	15.928	0.604	0.004	2.056	0.550	0.550	0.550	0.139	2.294	0.135	0.001	0.088
1995	0.764	13.959	0.551	0.003	1.851	0.490	0.490	0.490	0.136	2.581	0.144	0.001	0.098
1996	0.294	14.314	0.558	0.003	1.890	0.485	0.485	0.485	0.047	2.385	0.135	0.001	0.089
1997	0.317	16.131	0.602	0.004	2.088	0.501	0.501	0.501	0.045	2.404	0.132	0.001	0.085
1998	0.316	16.953	0.609	0.004	2.157	0.477	0.477	0.477	0.043	2.461	0.131	0.001	0.082
1999	0.329	18.667	0.637	0.005	2.315	0.469	0.469	0.469	0.035	2.159	0.116	0.001	0.069
2000	0.388	23.462	0.749	0.006	2.824	0.514	0.514	0.514	0.035	2.267	0.112	0.001	0.065
2001	0.397	24.326	0.751	0.007	2.966	0.494	0.494	0.494	0.038	2.499	0.115	0.001	0.066
2002	0.359	24.908	0.756	0.007	3.114	0.492	0.492	0.492	0.037	2.688	0.117	0.001	0.067
2003	0.378	27.925	0.830	0.008	3.569	0.541	0.541	0.541	0.034	2.642	0.113	0.001	0.064
2004	0.033	35.389	1.019	0.011	4.604	0.666	0.666	0.666	0.002	2.655	0.108	0.001	0.062
2005	0.033	36.657	1.004	0.012	5.185	0.661	0.661	0.661	0.002	2.529	0.100	0.001	0.057
2006	0.028	31.054	0.802	0.012	5.011	0.535	0.535	0.535	0.002	2.485	0.092	0.001	0.053
2007	0.024	25.310	0.615	0.011	4.872	0.420	0.420	0.420	0.002	2.320	0.081	0.001	0.048
2008	0.025	21.876	0.496	0.012	5.131	0.351	0.351	0.351	0.002	2.127	0.069	0.001	0.043
2009	0.022	17.293	0.373	0.010	4.612	0.272	0.272	0.272	0.002	1.847	0.057	0.001	0.036
2010	0.025	17.313	0.346	0.012	5.153	0.259	0.259	0.259	0.002	1.750	0.049	0.001	0.032
2011	0.026	16.523	0.306	0.012	5.375	0.235	0.235	0.235	0.002	1.656	0.043	0.001	0.029
2012	0.025	14.330	0.249	0.012	4.986	0.196	0.196	0.196	0.002	1.480	0.036	0.001	0.025
2013	0.025	13.172	0.220	0.012	4.826	0.174	0.174	0.174	0.002	1.321	0.030	0.001	0.022
2014	0.024	10.569	0.177	0.011	4.016	0.136	0.136	0.136	0.002	1.245	0.027	0.001	0.019
2015	0.022	7.862	0.140	0.010	3.054	0.099	0.099	0.099	0.002	1.076	0.023	0.001	0.016
2016	0.021	6.058	0.118	0.010	2.370	0.074	0.074	0.074	0.002	0.919	0.020	0.001	0.013
2017	0.022	4.908	0.107	0.010	1.915	0.058	0.058	0.058	0.002	0.777	0.018	0.001	0.011
Trend 1990-2017	*-97.20%*	*-64.56%*	*-74.70%*	*293.66%*	*23.59%*	*-86.62%*	*-86.62%*	*-86.62%*	*-98.20%*	*-66.70%*	*-85.07%*	*118.61%*	*-87.09%*
2005-2017	*-34.44%*	*-86.61%*	*-89.32%*	*-17.20%*	*-63.06%*	*-91.25%*	*-91.25%*	*-91.25%*	*12.14%*	*-69.28%*	*-81.77%*	*32.12%*	*-80.86%*
2016-2017	*3.19%*	*-18.98%*	*-8.88%*	*3.45%*	*-19.20%*	*-21.77%*	*-21.77%*	*-21.77%*	*2.31%*	*-15.44%*	*-11.02%*	*2.12%*	*-18.34%*

Source: Environment Agency

Table 147 – 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	NH3	$PM_{2.5}$
1990	0.000	0.006	0.104	0.000	0.415	0.004	0.004	0.004	0.000	0.006	0.104	0.000	0.004
1991	0.000	0.007	0.106	0.000	0.449	0.004	0.004	0.004	0.000	0.007	0.106	0.000	0.004
1992	0.000	0.008	0.110	0.000	0.488	0.004	0.004	0.004	0.000	0.008	0.110	0.000	0.004
1993	0.000	0.010	0.114	0.000	0.558	0.004	0.004	0.004	0.000	0.010	0.114	0.000	0.004
1994	0.000	0.011	0.116	0.000	0.600	0.004	0.004	0.004	0.000	0.011	0.116	0.000	0.004
1995	0.000	0.011	0.116	0.000	0.593	0.004	0.004	0.004	0.000	0.011	0.116	0.000	0.004
1996	0.000	0.011	0.117	0.000	0.605	0.004	0.004	0.004	0.000	0.011	0.117	0.000	0.004
1997	0.000	0.012	0.119	0.000	0.628	0.004	0.004	0.004	0.000	0.012	0.119	0.000	0.004
1998	0.000	0.013	0.121	0.000	0.654	0.004	0.004	0.004	0.000	0.013	0.121	0.000	0.004
1999	0.000	0.013	0.116	0.000	0.672	0.004	0.004	0.004	0.000	0.013	0.116	0.000	0.004
2000	0.000	0.014	0.116	0.000	0.695	0.004	0.004	0.004	0.000	0.014	0.116	0.000	0.004
2001	0.000	0.015	0.116	0.000	0.708	0.004	0.004	0.004	0.000	0.015	0.116	0.000	0.004
2002	0.000	0.015	0.117	0.000	0.733	0.004	0.004	0.004	0.000	0.015	0.117	0.000	0.004
2003	0.000	0.016	0.117	0.000	0.746	0.004	0.004	0.004	0.000	0.016	0.117	0.000	0.004
2004	0.000	0.017	0.131	0.000	0.773	0.004	0.004	0.004	0.000	0.017	0.131	0.000	0.004
2005	0.000	0.017	0.128	0.000	0.761	0.003	0.003	0.003	0.000	0.017	0.128	0.000	0.003
2006	0.000	0.017	0.127	0.000	0.753	0.003	0.003	0.003	0.000	0.017	0.127	0.000	0.003
2007	0.000	0.018	0.125	0.000	0.740	0.003	0.003	0.003	0.000	0.018	0.125	0.000	0.003
2008	0.000	0.018	0.124	0.000	0.726	0.003	0.003	0.003	0.000	0.018	0.124	0.000	0.003
2009	0.000	0.018	0.124	0.000	0.715	0.003	0.003	0.003	0.000	0.018	0.124	0.000	0.003
2010	0.000	0.018	0.123	0.000	0.701	0.003	0.003	0.003	0.000	0.018	0.123	0.000	0.003
2011	0.000	0.018	0.124	0.000	0.694	0.003	0.003	0.003	0.000	0.018	0.124	0.000	0.003
2012	0.000	0.018	0.123	0.000	0.680	0.002	0.002	0.002	0.000	0.018	0.123	0.000	0.002
2013	0.000	0.018	0.123	0.000	0.674	0.002	0.002	0.002	0.000	0.018	0.123	0.000	0.002
2014	0.000	0.019	0.123	0.000	0.661	0.002	0.002	0.002	0.000	0.019	0.123	0.000	0.002
2015	0.000	0.019	0.120	0.000	0.645	0.002	0.002	0.002	0.000	0.019	0.120	0.000	0.002
2016	0.000	0.019	0.118	0.000	0.633	0.002	0.002	0.002	0.000	0.019	0.118	0.000	0.002
2017	0.000	0.018	0.116	0.000	0.608	0.002	0.002	0.002	0.000	0.018	0.116	0.000	0.002
Trend 1990-2017	*-85.07%*	*183.95%*	*11.29%*	*232.66%*	*46.72%*	*-48.53%*	*-48.53%*	*-48.53%*	*-85.07%*	*183.95%*	*11.29%*	*232.66%*	*-48.53%*
2005-2017	*33.55%*	*6.27%*	*-9.22%*	*34.56%*	*-20.05%*	*-40.60%*	*-40.60%*	*-40.60%*	*33.55%*	*6.27%*	*-9.22%*	*34.56%*	*-40.60%*
2016-2017	*-0.09%*	*-2.43%*	*-2.26%*	*0.63%*	*-3.92%*	*-4.56%*	*-4.56%*	*-4.56%*	*-0.09%*	*-2.43%*	*-2.26%*	*0.63%*	*-4.56%*

Source: Environment Agency

Table 148 – 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	NH3	$PM_{2.5}$
1990	NA	NA	4.007	NA	NA	NA	NA	NA	NA	NA	1.774	NA	NA
1991	NA	NA	4.228	NA	NA	NA	NA	NA	NA	NA	1.621	NA	NA
1992	NA	NA	3.710	NA	NA	NA	NA	NA	NA	NA	1.345	NA	NA
1993	NA	NA	2.936	NA	NA	NA	NA	NA	NA	NA	1.077	NA	NA
1994	NA	NA	2.333	NA	NA	NA	NA	NA	NA	NA	0.832	NA	NA
1995	NA	NA	1.744	NA	NA	NA	NA	NA	NA	NA	0.673	NA	NA
1996	NA	NA	1.412	NA	NA	NA	NA	NA	NA	NA	0.556	NA	NA
1997	NA	NA	1.165	NA	NA	NA	NA	NA	NA	NA	0.450	NA	NA
1998	NA	NA	0.919	NA	NA	NA	NA	NA	NA	NA	0.356	NA	NA
1999	NA	NA	0.754	NA	NA	NA	NA	NA	NA	NA	0.282	NA	NA
2000	NA	NA	0.634	NA	NA	NA	NA	NA	NA	NA	0.226	NA	NA
2001	NA	NA	0.521	NA	NA	NA	NA	NA	NA	NA	0.183	NA	NA
2002	NA	NA	0.431	NA	NA	NA	NA	NA	NA	NA	0.149	NA	NA
2003	NA	NA	0.380	NA	NA	NA	NA	NA	NA	NA	0.123	NA	NA
2004	NA	NA	0.332	NA	NA	NA	NA	NA	NA	NA	0.103	NA	NA
2005	NA	NA	0.282	NA	NA	NA	NA	NA	NA	NA	0.087	NA	NA
2006	NA	NA	0.244	NA	NA	NA	NA	NA	NA	NA	0.078	NA	NA
2007	NA	NA	0.229	NA	NA	NA	NA	NA	NA	NA	0.071	NA	NA
2008	NA	NA	0.212	NA	NA	NA	NA	NA	NA	NA	0.065	NA	NA
2009	NA	NA	0.189	NA	NA	NA	NA	NA	NA	NA	0.059	NA	NA
2010	NA	NA	0.165	NA	NA	NA	NA	NA	NA	NA	0.053	NA	NA
2011	NA	NA	0.164	NA	NA	NA	NA	NA	NA	NA	0.050	NA	NA
2012	NA	NA	0.142	NA	NA	NA	NA	NA	NA	NA	0.045	NA	NA
2013	NA	NA	0.120	NA	NA	NA	NA	NA	NA	NA	0.042	NA	NA
2014	NA	NA	0.115	NA	NA	NA	NA	NA	NA	NA	0.042	NA	NA
2015	NA	NA	0.102	NA	NA	NA	NA	NA	NA	NA	0.040	NA	NA
2016	NA	NA	0.092	NA	NA	NA	NA	NA	NA	NA	0.038	NA	NA
2017	NA	NA	0.087	NA	NA	NA	NA	NA	NA	NA	0.037	NA	NA
Trend 1990-2017	*NA*	*NA*	*-97.82%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*-97.94%*	*NA*	*NA*
2005-2017	*NA*	*NA*	*-69.00%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*-58.13%*	*NA*	*NA*
2016-2017	*NA*	*NA*	*-4.70%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*-4.05%*	*NA*	*NA*

Source: Environment Agency

Table 149 – 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	0.198	0.148	0.081	0.029
1991	0.243	0.181	0.099	0.030
1992	0.265	0.198	0.108	0.032
1993	0.273	0.203	0.111	0.034
1994	0.282	0.211	0.115	0.034
1995	0.266	0.199	0.109	0.036
1996	0.275	0.206	0.112	0.037
1997	0.296	0.221	0.121	0.039
1998	0.311	0.232	0.127	0.041
1999	0.338	0.251	0.138	0.042
2000	0.387	0.287	0.158	0.044
2001	0.408	0.302	0.167	0.047
2002	0.424	0.314	0.173	0.050
2003	0.466	0.345	0.191	0.051
2004	0.536	0.394	0.219	0.053
2005	0.562	0.412	0.230	0.055
2006	0.539	0.396	0.221	0.057
2007	0.533	0.391	0.218	0.060
2008	0.541	0.397	0.221	0.063
2009	0.504	0.371	0.206	0.063
2010	0.527	0.387	0.216	0.064
2011	0.560	0.410	0.229	0.066
2012	0.537	0.394	0.220	0.066
2013	0.526	0.386	0.215	0.067
2014	0.509	0.374	0.208	0.070
2015	0.482	0.355	0.197	0.071
2016	0.473	0.348	0.194	0.073
2017	0.479	0.353	0.196	0.074
Trend 1990-2017	*141.72%*	*138.09%*	*142.24%*	*158.78%*
2005-2017	*-14.80%*	*-14.51%*	*-14.84%*	*35.80%*
2016-2017	*1.28%*	*1.33%*	*1.27%*	*1.79%*

Source: Environment Agency

3.2.4.3.2 Methodological issues

3.2.4.3.2.1 Activity Data

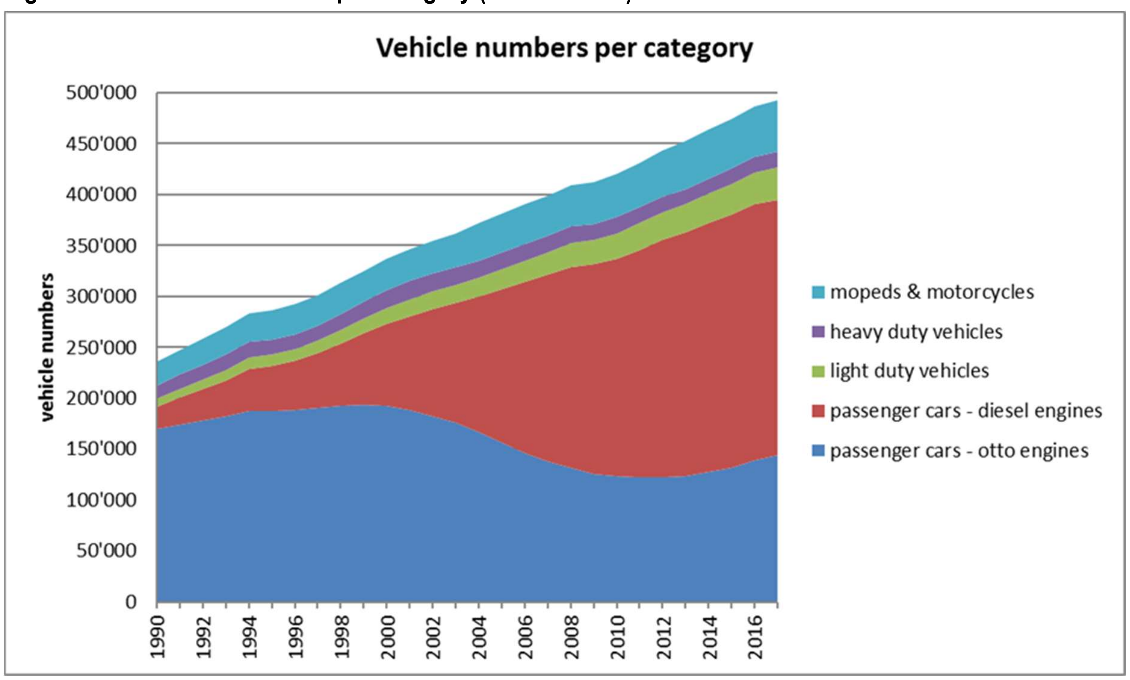
Table 150 (p. 231) shows blended fuel consumption for category *1A3b – Road Transportation* by fuel (motor gasoline, diesel oil, LPG) based on fuel used within the country's borders, as well as the quantities of fuel exported in the vehicle tank.

The 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 233.

Table 151 (p. 232) shows blended fuel consumption per vehicle category, as determined by the NEMO model based on vehicle stocks and driven mileage.

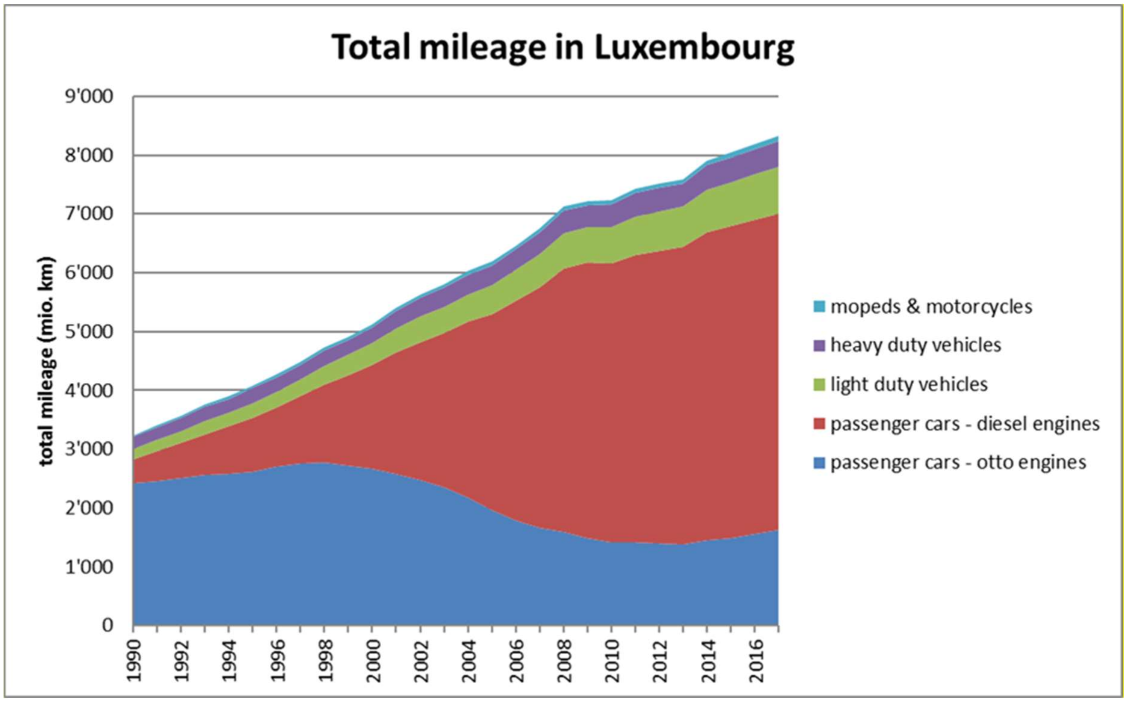
Figure 3-10 shows the evolution of the vehicle numbers per category since 1990 circulation on Luxembourg's territory. The number of diesel-fuelled passenger cars has strongly increased, whereas the vehicle numbers in the other categories show a less pronounced rise or even a decrease as in the case of passenger cars with motor gasoline engines. The same trends are observed for the total mileage driven in Luxembourg (Figure 3-11).

Figure 3-10 – Vehicle numbers per category (national fleet)



Source: Environment Agency

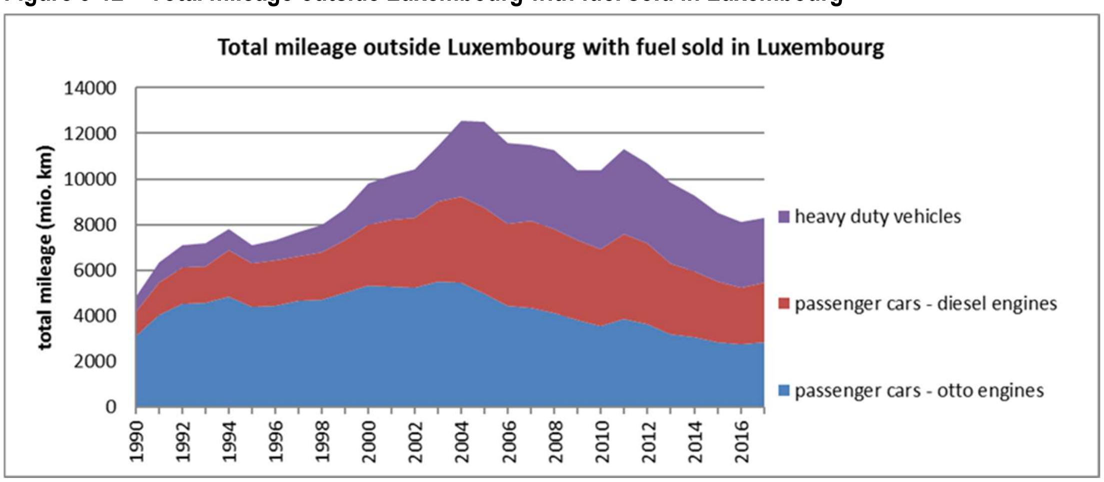
Figure 3-11 – Total mileage in Luxembourg



Source: Environment Agency

Figure 3-12 shows that the total mileage driven outside Luxembourg with fuel purchased in Luxembourg has approximately doubled since 1990. 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.

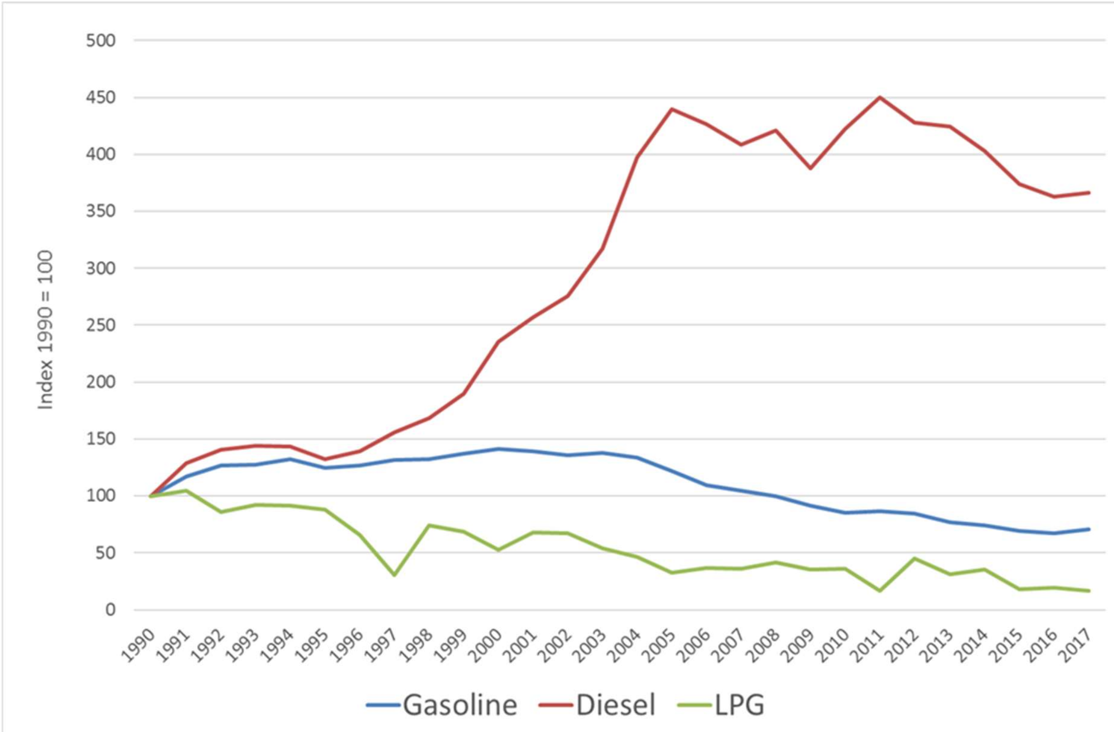
Figure 3-12 – Total mileage outside Luxembourg with fuel sold in Luxembourg



Source: Environment Agency

Figure 3-13 shows the evolution of fuel sold (*i.e.* blended fuel) in Luxembourg. Diesel oil is by far the most fuel sold, although during recent years the quantities sold seem to decrease significantly.

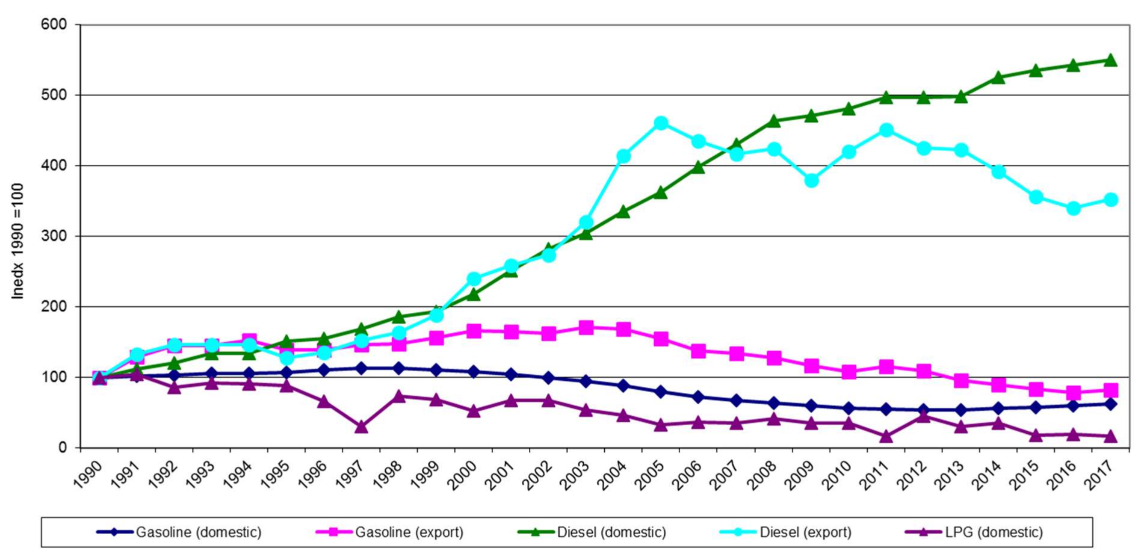
Figure 3-13 – Fuel sold trends for 1A3b – Road Transportation by fuel type: 1990-2017



Source: Environment Agency

Figure 3-14 detail the quantities of blended fuel used on the national territory and the amount of fuel exported.

Figure 3-14 – Domestic and exported fuel sold trends - indexes - for 1A3b – Road Transportation by fuel type: 1990-2017



Source: Environment Agency

Table 150 – Activity data per fuel type for category *1A3b - Road transport*

		1A3b - Road Transportation *Blended Fuels (t)*									
Year	National Total	domestic road fuel use					road fuel export				
		Total	share (%)	*Blended Gasoline*	*Blended Diesel*	*LPG*	Total	share (%)	*Blended Gasoline*	*Blended Diesel*	*LPG*
1990	**816'916**	**269'008**	32.93%	*179'298*	*85'919*	*3'790*	**547'909**	67.07%	*231'041*	*316'867*	*NO*
1991	**1'003'986**	**281'649**	28.05%	*181'696*	*95'985*	*3'968*	**722'337**	71.95%	*299'595*	*422'742*	*NO*
1992	**1'090'059**	**292'373**	26.82%	*186'032*	*103'075*	*3'266*	**797'686**	73.18%	*334'739*	*462'947*	*NO*
1993	**1'106'015**	**307'600**	27.81%	*188'543*	*115'571*	*3'486*	**798'414**	72.19%	*334'904*	*463'511*	*NO*
1994	**1'124'203**	**308'318**	27.43%	*189'254*	*115'600*	*3'464*	**815'885**	72.57%	*353'723*	*462'162*	*NO*
1995	**1'049'506**	**326'109**	31.07%	*192'455*	*130'317*	*3'338*	**723'396**	68.93%	*319'696*	*403'700*	*NO*
1996	**1'083'796**	**334'134**	30.83%	*198'611*	*133'018*	*2'505*	**749'662**	69.17%	*320'712*	*428'950*	*NO*
1997	**1'167'584**	**348'092**	29.81%	*202'513*	*144'420*	*1'158*	**819'492**	70.19%	*337'682*	*481'810*	*NO*
1998	**1'224'597**	**364'287**	29.75%	*201'794*	*159'690*	*2'802*	**860'310**	70.25%	*341'258*	*519'052*	*NO*
1999	**1'328'114**	**368'482**	27.74%	*199'336*	*166'552*	*2'594*	**959'633**	72.26%	*362'248*	*597'385*	*NO*
2000	**1'530'817**	**384'064**	25.09%	*194'842*	*187'225*	*1'998*	**1'146'752**	74.91%	*385'098*	*761'654*	*NO*
2001	**1'608'131**	**406'093**	25.25%	*187'910*	*215'612*	*2'570*	**1'202'038**	74.75%	*382'145*	*819'894*	*NO*
2002	**1'669'057**	**424'750**	25.45%	*179'208*	*242'993*	*2'549*	**1'244'307**	74.55%	*376'437*	*867'870*	*NO*
2003	**1'845'259**	**434'003**	23.52%	*170'042*	*261'921*	*2'040*	**1'411'256**	76.48%	*395'496*	*1'015'760*	*NO*
2004	**2'150'736**	**447'828**	20.82%	*157'837*	*288'245*	*1'746*	**1'702'908**	79.18%	*390'487*	*1'312'421*	*NO*
2005	**2'271'408**	**454'432**	20.01%	*142'146*	*311'041*	*1'245*	**1'816'976**	79.99%	*357'155*	*1'459'821*	*NO*
2006	**2'169'658**	**473'286**	21.81%	*130'219*	*341'683*	*1'385*	**1'696'372**	78.19%	*318'360*	*1'378'012*	*NO*
2007	**2'124'462**	**491'211**	23.12%	*120'433*	*369'420*	*1'358*	**1'633'252**	76.88%	*310'757*	*1'322'495*	*NO*
2008	**2'155'105**	**514'398**	23.87%	*114'657*	*398'155*	*1'587*	**1'640'707**	76.13%	*295'249*	*1'345'458*	*NO*
2009	**1'985'995**	**513'369**	25.85%	*107'485*	*404'535*	*1'349*	**1'472'626**	74.15%	*269'910*	*1'202'716*	*NO*
2010	**2'098'093**	**516'440**	24.61%	*101'655*	*413'433*	*1'352*	**1'581'653**	75.39%	*249'070*	*1'332'583*	*NO*
2011	**2'223'653**	**527'651**	23.73%	*99'691*	*427'335*	*624*	**1'696'002**	76.27%	*266'573*	*1'429'430*	*NO*
2012	**2'125'664**	**526'646**	24.78%	*97'443*	*427'497*	*1'705*	**1'599'018**	75.22%	*252'156*	*1'346'863*	*NO*
2013	**2'085'980**	**525'962**	25.21%	*96'565*	*428'229*	*1'169*	**1'560'017**	74.79%	*220'830*	*1'339'187*	*NO*
2014	**2'004'292**	**552'859**	27.58%	*100'265*	*451'245*	*1'348*	**1'451'433**	72.42%	*208'036*	*1'243'396*	*NO*
2015	**1'882'133**	**563'026**	29.91%	*102'204*	*460'146*	*676*	**1'319'106**	70.09%	*191'764*	*1'127'342*	*NO*
2016	**1'834'894**	**573'890**	31.28%	*106'465*	*466'694*	*731*	**1'261'004**	68.72%	*182'086*	*1'078'918*	*NO*
2017	**1'889'858**	**584'310**	30.92%	*111'299*	*472'379*	*632*	**1'305'548**	69.08%	*189'628*	*1'115'920*	*NO*
Trend 1990-2017	***131.34%***	***117.21%***	*-6.11%*	*-37.93%*	*449.79%*	*-83.33%*	***138.28%***	*3.00%*	*-17.92%*	*252.17%*	*NA*
Trend 2016-2017	***3.00%***	***1.82%***	*-1.15%*	*4.54%*	*1.22%*	*-13.55%*	***3.53%***	*0.52%*	*4.14%*	*3.43%*	*NA*
Share 1990	***NA***	***32.93%***	*NA*	*21.95%*	*10.52%*	*0.46%*	***67.07%***	*NA*	*28.28%*	*38.79%*	*NA*
Share 2017	***NA***	***30.92%***	*NA*	*5.89%*	*25.00%*	*0.03%*	***69.08%***	*NA*	*10.03%*	*59.05%*	*NA*

Source: Environment Agency

Table 151 – Activity data – Fuel sold and Fuel used – per sub-category for *1A3b - Road transport*

1 A Mobile Fuel Combustion										
Activity Data by vehicle category (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	34 950 217	21'604'061	476'935	12'835'255	33'966	11 542 702	8'839'340	476'935	2'192'461	33'966
1991	42 938 305	25'737'702	529'652	16'633'864	37'087	12 081 741	9'159'180	529'652	2'355'821	37'087
1992	46 614 793	28'057'819	564'376	17'951'523	41'074	12 537 306	9'525'055	564'376	2'406'801	41'074
1993	47 294 933	28'405'355	628'655	18'212'937	47'986	13 186 421	9'864'742	628'655	2'645'038	47'986
1994	48 078 551	30'573'119	679'217	16'773'429	52'785	13 217 237	10'168'365	679'217	2'316'870	52'785
1995	44 887 292	29'129'518	726'669	14'978'300	52'806	13 974 456	10'525'409	726'669	2'669'572	52'806
1996	46 345 206	29'886'707	764'543	15'639'828	54'128	14 315 894	10'999'276	764'543	2'497'947	54'128
1997	49 911 918	30'959'574	820'914	18'074'830	56'600	14 906 353	11'465'549	820'914	2'563'291	56'600
1998	52 341 502	31'954'800	877'962	19'449'340	59'400	15 599 771	11'990'557	877'962	2'671'853	59'400
1999	56 749 106	33'786'411	988'564	21'912'574	61'557	15 775 885	12'359'910	988'564	2'365'855	61'557
2000	65 369 123	35'962'840	1'087'008	28'255'160	64'115	16 433 309	12'730'911	1'087'008	2'551'275	64'115
2001	68 650 285	36'964'513	1'140'485	30'479'583	65'704	17 367 299	13'229'910	1'140'485	2'931'200	65'704
2002	71 230 571	37'540'574	1'201'776	32'419'830	68'391	18 155 018	13'574'414	1'201'776	3'310'437	68'391
2003	78 720 260	39'644'055	1'234'347	37'771'038	70'820	18 541 166	13'850'400	1'234'347	3'385'599	70'820
2004	91 686 325	40'516'557	1'270'910	49'822'060	76'797	19 120 391	14'222'004	1'270'910	3'550'680	76'797
2005	96 783 759	39'166'733	1'320'131	56'218'337	78'559	19 390 399	14'385'583	1'320'131	3'606'126	78'559
2006	92 433 016	37'511'182	1'373'628	53'467'944	80'262	20 185 202	14'845'291	1'373'628	3'886'021	80'262
2007	90 343 091	38'095'135	1'469'858	50'696'170	81'927	20 904 210	15'278'712	1'469'858	4'073'713	81'927
2008	91 643 030	37'807'773	1'536'146	52'215'899	83'211	21 888 169	15'970'377	1'536'146	4'298'434	83'211
2009	84 452 301	36'385'253	1'540'450	46'441'624	84'974	21 839 889	16'087'851	1'540'450	4'126'614	84'974
2010	89 200 320	34'839'895	1'592'132	52'681'964	86'329	21 968 949	15'890'769	1'592'132	4'399'718	86'329
2011	94 401 212	36'453'851	1'669'024	56'189'607	88'730	22 404 532	16'056'767	1'669'024	4'590'010	88'730
2012	90 341 905	35'554'805	1'709'751	52'986'767	90'582	22 393 265	16'182'566	1'709'751	4'410'365	90'582
2013	88 630 890	33'236'427	1'740'338	53'560'117	94'008	22 360 601	16'278'155	1'740'338	4'248'100	94'008
2014	85 057 218	32'784'421	1'825'746	50'349'952	97'099	23 471 957	16'868'047	1'825'746	4'681'065	97'099
2015	79 730 032	31'646'445	1'890'630	46'093'381	99'576	23 853 605	17'059'485	1'890'630	4'803'913	99'576
2016	77 665 447	31'133'664	1'938'658	44'490'003	103'123	24 291 860	17'326'555	1'938'658	4'923'525	103'123
2017	79 985 866	32'029'647	1'988'319	45'864'358	103'542	24 735 315	17'611'568	1'988'319	5'031'886	103'542
Trend 1990-2017	*128.86%*	*48.26%*	*316.90%*	*257.33%*	*204.84%*	*114.29%*	*99.24%*	*316.90%*	*129.51%*	*204.84%*

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)[48] 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[49] 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 3-15). 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[50]. NEMO is updated regularly according to recent data on emission behaviour and vehicle technologies. 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

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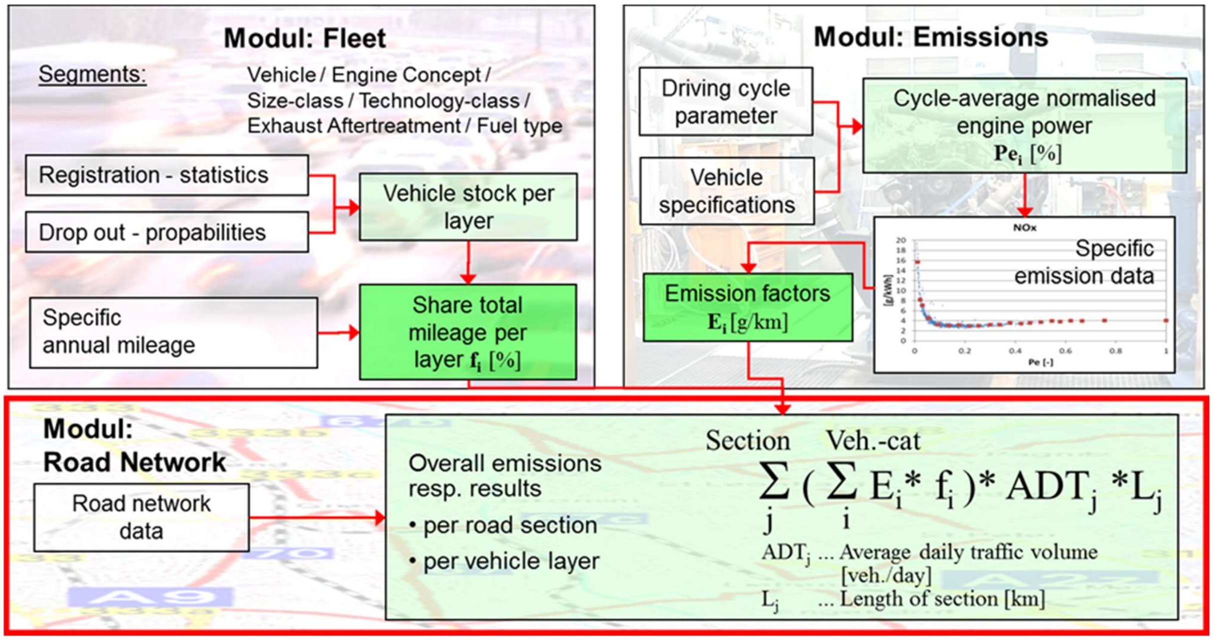
[48] http://portal.tugraz.at/portal/page/portal/TU_Graz/Einrichtungen/Institute/oe_123

[49] Information- and forecasting system for private and public transport VISUM: Comprehensive software for advanced transportation planning; http://irdata.sk/en/ptv-softver-2/

[50] Handbook emission factors for road transport (HBEFA) http://www.hbefa.net/

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.

Figure 3-15 – Schematic picture of the model NEMO



NEMO calculates the emissions for all regulated pollutants (NO_X, THC[51], 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[52] and C_6H_6 are calculated with an approach similar to the HBEFA 3.3 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:

[51] THC - total hydrocarbon
[52] NMHC - non-methane hydrocarbons

- Cold start effects for each vehicle class (data and approach compatible to the HBEFA 3.3).
- Influence of mileage and maintenance on the emissions of gasoline vehicles.[53]
- Calibration of fuel consumption based on statistics of g/km CO_2 of new registered vehicles in the NEDC[54] type approval and literature on the discrepancies between NEDC and real world CO_2 reduction rates.[55]
- Evaporation from gasoline emissions (data and approach compatible to the HBEFA 3.3).

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 *Schmidt W., Düring I., Lohmeyer A., (2011)*[56].

<u>*Determination of the amounts of fuel used and fuel export*</u>

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

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[53] Samaras, Z. (2004). Artemis Subtask 3123: Investigation of the emission degradation of gasoline vehicles, Aristotle University of Thessaloniki - Lab of Applied Thermodynamics

[54] NEDC - New European Driving Cycle

[55] 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

[56] 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

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 3.3 (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).

HBEFA does not provide emission factors for $PM_{2.5}$ exhaust emissions from mopeds and motorcycles. For this reason, $PM_{2.5}$ emissions from *1A3b iv – Mopeds & motorcycles* have been estimated by Tier 2 default emission factors for mopeds and motorcycles from the EMEP/EEA Guidebook 2016 in Luxembourg's submission 2019.

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 2016 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 paragraphs 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 152 gives an overview of the evolution of the implied emission factors for category *1A3b i – Passenger cars* based on fuel sold and fuel used.

Table 153 gives an overview of the evolution of the implied emission factors for category *1A3b ii – Light duty vehicles (LDV)* based on fuel sold and fuel used.

Table 154 gives an overview of the evolution of the implied emission factors for category *1A3b iii – Heavy duty vehicles (HDV) and buses* based on fuel sold and fuel used.

Table 155 gives an overview of the evolution of the implied emission factors for category *1A3b iv – Mopeds & motorcycles* based on fuel sold and fuel used.

Table 156 gives an overview of the evolution of the implied emission factors for category *1A3 v – Gasoline evaporation* based on fuel sold and fuel used.

Table 157 gives an overview of the evolution of the implied emission factors for sub-category *1A3b vi – Automobile tyre and brake wear* based on fuel sold and fuel used.

Table 152 – Implied emission factors for category *1A3b 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	12.097	549.158	511.513	0.580	3650.173	15.183	15.183	15.183	9.584	565.223	540.348	0.594	11.483
1991	12.776	503.575	459.458	3.098	3273.318	14.757	14.757	14.757	10.545	515.714	482.427	3.258	11.822
1992	13.141	430.764	379.124	7.617	2702.374	14.003	14.003	14.003	11.356	437.527	394.089	7.957	11.866
1993	13.414	373.060	310.216	11.562	2230.634	13.512	13.512	13.512	12.193	375.936	318.358	11.917	12.142
1994	14.513	326.271	246.794	14.435	1795.797	14.422	14.422	14.422	12.952	328.291	255.120	15.022	12.765
1995	12.760	298.526	207.180	16.570	1533.702	14.418	14.418	14.418	11.696	299.265	212.716	17.117	13.122
1996	5.913	278.716	176.990	18.351	1336.559	14.532	14.532	14.532	5.593	278.820	181.193	18.902	13.409
1997	5.393	259.913	152.850	20.523	1185.839	13.931	13.931	13.931	5.385	259.855	152.905	20.533	13.903
1998	5.071	242.374	129.102	21.956	1040.711	14.011	14.011	14.011	5.206	242.751	127.575	21.620	14.480
1999	4.733	226.171	110.089	22.958	920.179	13.975	13.975	13.975	5.034	227.875	107.107	22.136	15.002
2000	4.424	214.857	94.990	23.047	825.541	13.793	13.793	13.793	4.869	218.487	90.869	21.717	15.268
2001	4.271	208.613	82.275	21.792	748.478	13.317	13.317	13.317	4.866	214.572	77.180	19.996	15.094
2002	3.835	203.797	71.701	19.880	682.293	12.498	12.498	12.498	4.485	212.722	65.778	17.693	14.485
2003	3.631	199.151	63.134	17.886	622.700	11.687	11.687	11.687	4.361	211.746	56.444	15.354	13.860
2004	0.377	195.416	55.482	15.690	559.778	11.079	11.079	11.079	0.415	212.041	47.972	12.847	13.416
2005	0.323	190.854	48.844	13.593	497.239	10.427	10.427	10.427	0.367	211.150	40.567	10.524	12.837
2006	0.305	186.126	43.208	11.779	439.993	9.785	9.785	9.785	0.345	208.874	34.565	8.665	12.121
2007	0.295	182.152	38.752	10.352	391.649	8.897	8.897	8.897	0.331	207.155	29.936	7.258	11.048
2008	0.301	177.486	34.964	9.186	349.545	7.739	7.739	7.739	0.340	204.815	26.206	6.166	9.634
2009	0.307	175.624	31.737	8.196	312.343	6.820	6.820	6.820	0.347	204.359	23.423	5.369	8.435
2010	0.311	175.443	29.084	7.562	284.548	5.691	5.691	5.691	0.351	205.522	21.274	4.904	6.969
2011	0.315	176.613	27.291	7.194	265.105	4.536	4.536	4.536	0.355	210.217	19.465	4.529	5.545
2012	0.312	178.129	24.804	6.664	240.202	3.539	3.539	3.539	0.353	214.141	17.721	4.205	4.277
2013	0.314	180.890	22.694	6.193	216.775	2.784	2.784	2.784	0.353	217.170	16.377	3.957	3.293
2014	0.314	183.087	21.914	5.948	206.016	2.029	2.029	2.029	0.350	218.388	15.952	3.872	2.328
2015	0.316	179.558	20.605	5.777	192.920	1.617	1.617	1.617	0.349	212.850	15.194	3.819	1.807
2016	0.315	172.213	19.402	5.695	182.867	1.352	1.352	1.352	0.345	202.851	14.628	3.864	1.479
2017	0.311	163.389	18.529	5.693	176.352	1.161	1.161	1.161	0.341	193.010	14.153	3.913	1.252
Trend 1990-2017	*-97.43%*	*-70.25%*	*-96.38%*	*881.47%*	*-95.17%*	*-92.36%*	*-92.36%*	*-92.36%*	*-96.44%*	*-65.85%*	*-97.38%*	*559.36%*	*-89.09%*
2005-2017	*-3.81%*	*-14.39%*	*-62.07%*	*-58.12%*	*-64.53%*	*-88.87%*	*-88.87%*	*-88.87%*	*-6.99%*	*-8.59%*	*-65.11%*	*-62.81%*	*-90.24%*
2016-2017	*-1.28%*	*-5.12%*	*-4.50%*	*-0.04%*	*-3.56%*	*-14.13%*	*-14.13%*	*-14.13%*	*-1.18%*	*-4.85%*	*-3.25%*	*1.29%*	*-15.30%*

Source: Environment Agency

Table 153 – 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	43.117	586.540	251.177	1.035	2531.942	61.745	61.745	61.745	43.117	586.540	251.177	1.035	61.745
1991	43.657	564.945	225.158	2.106	2336.689	58.388	58.388	58.388	43.657	564.945	225.158	2.106	58.388
1992	44.312	545.286	200.464	3.017	2143.012	55.437	55.437	55.437	44.312	545.286	200.464	3.017	55.437
1993	45.435	528.187	175.364	3.618	1918.529	53.545	53.545	53.545	45.435	528.187	175.364	3.618	53.545
1994	46.204	515.417	156.691	4.030	1748.379	52.032	52.032	52.032	46.204	515.417	156.691	4.030	52.032
1995	39.988	506.850	142.614	4.181	1606.573	51.239	51.239	51.239	39.988	506.850	142.614	4.181	51.239
1996	15.431	500.142	130.851	4.199	1479.641	50.602	50.602	50.602	15.431	500.142	130.851	4.199	50.602
1997	14.769	492.726	114.324	3.937	1275.703	50.460	50.460	50.460	14.769	492.726	114.324	3.937	50.460
1998	13.995	484.697	99.849	3.718	1096.830	49.492	49.492	49.492	13.995	484.697	99.849	3.718	49.492
1999	13.117	475.601	87.295	3.525	945.611	47.284	47.284	47.284	13.117	475.601	87.295	3.525	47.284
2000	12.311	465.102	71.083	3.128	746.128	44.674	44.674	44.674	12.311	465.102	71.083	3.128	44.674
2001	11.856	455.913	59.034	2.807	606.049	41.455	41.455	41.455	11.856	455.913	59.034	2.807	41.455
2002	10.249	448.497	48.597	2.426	486.790	38.214	38.214	38.214	10.249	448.497	48.597	2.426	38.214
2003	9.379	442.764	40.466	2.095	396.474	35.326	35.326	35.326	9.379	442.764	40.466	2.095	35.326
2004	0.653	438.542	33.213	1.727	312.795	32.912	32.912	32.912	0.653	438.542	33.213	1.727	32.912
2005	0.571	433.079	27.952	1.490	257.265	30.572	30.572	30.572	0.571	433.079	27.952	1.490	30.572
2006	0.505	424.224	24.031	1.339	219.672	28.389	28.389	28.389	0.505	424.224	24.031	1.339	28.389
2007	0.462	409.467	20.369	1.185	183.655	26.354	26.354	26.354	0.462	409.467	20.369	1.185	26.354
2008	0.463	391.646	17.069	1.045	151.049	24.499	24.499	24.499	0.463	391.646	17.069	1.045	24.499
2009	0.464	377.360	14.758	0.957	129.252	23.083	23.083	23.083	0.464	377.360	14.758	0.957	23.083
2010	0.465	365.724	12.713	0.882	109.158	21.760	21.760	21.760	0.465	365.724	12.713	0.882	21.760
2011	0.465	354.939	11.066	0.825	94.056	20.251	20.251	20.251	0.465	354.939	11.066	0.825	20.251
2012	0.466	345.527	9.743	0.785	83.364	18.065	18.065	18.065	0.466	345.527	9.743	0.785	18.065
2013	0.466	337.962	8.532	0.740	73.549	15.445	15.445	15.445	0.466	337.962	8.532	0.740	15.445
2014	0.467	329.504	7.059	0.726	61.040	12.899	12.899	12.899	0.467	329.504	7.059	0.726	12.899
2015	0.468	315.747	5.993	0.699	53.651	10.376	10.376	10.376	0.468	315.747	5.993	0.699	10.376
2016	0.468	293.172	5.241	0.678	47.942	8.422	8.422	8.422	0.468	293.172	5.241	0.678	8.422
2017	0.469	265.488	4.643	0.657	43.175	6.885	6.885	6.885	0.469	265.488	4.643	0.657	6.885
Trend 1990-2017	*-98.91%*	*-54.74%*	*-98.15%*	*-36.52%*	*-98.29%*	*-88.85%*	*-88.85%*	*-88.85%*	*-98.91%*	*-54.74%*	*-98.15%*	*-36.52%*	*-88.85%*
2005-2017	*-18.00%*	*-38.70%*	*-83.39%*	*-55.91%*	*-83.22%*	*-77.48%*	*-77.48%*	*-77.48%*	*-18.00%*	*-38.70%*	*-83.39%*	*-55.91%*	*-77.48%*
2016-2017	*0.14%*	*-9.44%*	*-11.42%*	*-3.11%*	*-9.94%*	*-18.25%*	*-18.25%*	*-18.25%*	*0.14%*	*-9.44%*	*-11.42%*	*-3.11%*	*-18.25%*

Source: Environment Agency

Table 154 – 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	1079.141	33.011	0.202	120.743	33.695	33.695	33.695	60.181	1063.933	55.547	0.278	38.632
1991	60.181	1079.976	32.134	0.200	118.447	33.480	33.480	33.480	60.181	1064.130	55.612	0.280	38.585
1992	60.181	1053.408	32.699	0.203	118.710	33.288	33.288	33.288	60.181	1045.433	56.089	0.285	38.412
1993	60.181	993.211	34.669	0.208	121.155	33.026	33.026	33.026	60.181	1012.210	55.812	0.282	37.849
1994	60.181	949.595	36.036	0.214	122.576	32.800	32.800	32.800	60.181	990.009	58.431	0.300	38.062
1995	51.013	931.946	36.759	0.217	123.600	32.744	32.744	32.744	51.013	966.993	54.105	0.284	36.820
1996	18.807	915.252	35.660	0.218	120.860	31.008	31.008	31.008	18.807	954.959	54.057	0.290	35.717
1997	17.537	892.450	33.333	0.219	115.505	27.713	27.713	27.713	17.537	937.877	51.614	0.293	33.229
1998	16.268	871.637	31.288	0.221	110.902	24.543	24.543	24.543	16.268	920.945	48.958	0.295	30.667
1999	14.998	851.878	29.073	0.223	105.640	21.422	21.422	21.422	14.998	912.510	48.850	0.317	29.123
2000	13.729	830.354	26.522	0.222	99.951	18.182	18.182	18.182	13.729	888.726	43.716	0.310	25.440
2001	13.024	798.115	24.653	0.223	97.327	16.196	16.196	16.196	13.024	852.442	39.098	0.302	22.364
2002	11.072	768.305	23.308	0.223	96.044	15.190	15.190	15.190	11.072	812.099	35.274	0.291	20.155
2003	10.005	739.314	21.981	0.222	94.498	14.323	14.323	14.323	10.005	780.485	33.260	0.292	18.899
2004	0.672	710.307	20.452	0.220	92.401	13.375	13.375	13.375	0.672	747.632	30.553	0.283	17.439
2005	0.588	652.040	17.863	0.220	92.223	11.766	11.766	11.766	0.588	701.381	27.665	0.279	15.851
2006	0.517	580.804	14.991	0.220	93.725	10.001	10.001	10.001	0.517	639.347	23.595	0.272	13.746
2007	0.471	499.248	12.140	0.220	96.111	8.287	8.287	8.287	0.471	569.597	19.964	0.271	11.858
2008	0.471	418.954	9.503	0.220	98.271	6.729	6.729	6.729	0.471	494.847	16.158	0.268	9.923
2009	0.471	372.356	8.035	0.221	99.297	5.848	5.848	5.848	0.471	447.543	13.768	0.269	8.702
2010	0.471	328.634	6.560	0.221	97.819	4.922	4.922	4.922	0.471	397.731	11.135	0.266	7.305
2011	0.471	294.051	5.445	0.221	95.661	4.188	4.188	4.188	0.471	360.681	9.309	0.266	6.307
2012	0.471	270.439	4.704	0.221	94.095	3.695	3.695	3.695	0.471	335.599	8.053	0.269	5.631
2013	0.471	245.931	4.106	0.221	90.100	3.249	3.249	3.249	0.471	310.855	7.086	0.272	5.062
2014	0.471	209.908	3.525	0.221	79.760	2.699	2.699	2.699	0.471	266.064	5.699	0.266	4.121
2015	0.472	170.569	3.028	0.221	66.257	2.141	2.141	2.141	0.472	223.881	4.817	0.264	3.366
2016	0.472	136.174	2.645	0.222	53.281	1.662	1.662	1.662	0.472	186.606	4.151	0.265	2.721
2017	0.472	107.017	2.338	0.223	41.763	1.261	1.261	1.261	0.472	154.391	3.614	0.264	2.174
Trend 1990-2017	*-99.22%*	*-90.08%*	*-92.92%*	*10.17%*	*-65.41%*	*-96.26%*	*-96.26%*	*-96.26%*	*-99.22%*	*-85.49%*	*-93.49%*	*-4.75%*	*-94.37%*
2005-2017	*-19.64%*	*-83.59%*	*-86.91%*	*1.49%*	*-54.72%*	*-89.28%*	*-89.28%*	*-89.28%*	*-19.64%*	*-77.99%*	*-86.94%*	*-5.31%*	*-86.29%*
2016-2017	*0.10%*	*-21.41%*	*-11.61%*	*0.35%*	*-21.62%*	*-24.11%*	*-24.11%*	*-24.11%*	*0.10%*	*-17.26%*	*-12.94%*	*-0.08%*	*-20.10%*

Source: Environment Agency

Table 155 – 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	189.585	3062.140	1.252	12206.778	112.887	112.887	112.887	4.705	189.585	3062.140	1.252	112.887
1991	4.705	194.461	2856.892	1.263	12101.133	104.622	104.622	104.622	4.705	194.461	2856.892	1.263	104.622
1992	4.705	198.278	2678.305	1.275	11870.404	97.515	97.515	97.515	4.705	198.278	2678.305	1.275	97.515
1993	4.705	205.768	2370.281	1.294	11635.465	85.231	85.231	85.231	4.705	205.768	2370.281	1.294	85.231
1994	4.176	209.756	2201.966	1.305	11369.978	78.640	78.640	78.640	4.176	209.756	2201.966	1.305	78.640
1995	3.712	210.023	2195.486	1.307	11224.068	78.608	78.608	78.608	3.712	210.023	2195.486	1.307	78.608
1996	3.248	211.013	2162.042	1.309	11176.036	77.349	77.349	77.349	3.248	211.013	2162.042	1.309	77.349
1997	2.784	212.618	2101.242	1.312	11103.901	74.964	74.964	74.964	2.784	212.618	2101.242	1.312	74.964
1998	2.320	214.182	2040.601	1.316	11016.357	72.592	72.592	72.592	2.320	214.182	2040.601	1.316	72.592
1999	1.856	218.234	1882.635	1.325	10917.926	66.260	66.260	66.260	1.856	218.234	1882.635	1.325	66.260
2000	1.392	219.970	1815.398	1.330	10833.743	62.338	62.338	62.338	1.392	219.970	1815.398	1.330	62.338
2001	0.868	221.299	1765.703	1.333	10770.289	58.142	58.142	58.142	0.868	221.299	1765.703	1.333	58.142
2002	0.687	222.802	1710.308	1.336	10712.496	53.842	53.842	53.842	0.687	222.802	1710.308	1.336	53.842
2003	0.589	224.044	1650.543	1.340	10528.659	49.734	49.734	49.734	0.589	224.044	1650.543	1.340	49.734
2004	0.311	219.538	1704.929	1.336	10062.840	47.813	47.813	47.813	0.311	219.538	1704.929	1.336	47.813
2005	0.227	219.024	1623.017	1.338	9685.439	42.289	42.289	42.289	0.227	219.024	1623.017	1.338	42.289
2006	0.227	217.458	1576.914	1.339	9375.561	39.460	39.460	39.460	0.227	217.458	1576.914	1.339	39.460
2007	0.228	214.758	1531.175	1.340	9033.785	36.899	36.899	36.899	0.228	214.758	1531.175	1.340	36.899
2008	0.228	212.085	1496.161	1.341	8720.355	34.740	34.740	34.740	0.228	212.085	1496.161	1.341	34.740
2009	0.228	209.728	1453.888	1.342	8416.453	32.513	32.513	32.513	0.228	209.728	1453.888	1.342	32.513
2010	0.228	206.801	1429.917	1.343	8120.267	30.779	30.779	30.779	0.228	206.801	1429.917	1.343	30.779
2011	0.230	204.271	1394.144	1.344	7822.415	28.859	28.859	28.859	0.230	204.271	1394.144	1.344	28.859
2012	0.228	200.606	1363.087	1.345	7504.988	27.139	27.139	27.139	0.228	200.606	1363.087	1.345	27.139
2013	0.228	196.547	1313.264	1.348	7168.116	25.195	25.195	25.195	0.228	196.547	1313.264	1.348	25.195
2014	0.229	192.110	1265.358	1.351	6803.269	23.348	23.348	23.348	0.229	192.110	1265.358	1.351	23.348
2015	0.231	187.567	1207.609	1.357	6478.190	21.613	21.613	21.613	0.231	187.567	1207.609	1.357	21.613
2016	0.232	181.728	1148.444	1.363	6139.501	20.051	20.051	20.051	0.232	181.728	1148.444	1.363	20.051
2017	0.230	176.595	1117.906	1.366	5875.148	19.060	19.060	19.060	0.230	176.595	1117.906	1.366	19.060
Trend 1990-2017	*-95.10%*	*-6.85%*	*-63.49%*	*9.13%*	*-51.87%*	*-83.12%*	*-83.12%*	*-83.12%*	*-95.10%*	*-6.85%*	*-63.49%*	*9.13%*	*-83.12%*
2005-2017	*1.32%*	*-19.37%*	*-31.12%*	*2.09%*	*-39.34%*	*-54.93%*	*-54.93%*	*-54.93%*	*1.32%*	*-19.37%*	*-31.12%*	*2.09%*	*-54.93%*
2016-2017	*-0.49%*	*-2.82%*	*-2.66%*	*0.22%*	*-4.31%*	*-4.94%*	*-4.94%*	*-4.94%*	*-0.49%*	*-2.82%*	*-2.66%*	*0.22%*	*-4.94%*

Source: Environment Agency

Table 156 – 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	226.845	NA	NA	NA	NA	NA	NA	NA	229.869	NA	NA
1991	NA	NA	204.091	NA	NA	NA	NA	NA	NA	NA	207.250	NA	NA
1992	NA	NA	165.491	NA	NA	NA	NA	NA	NA	NA	167.980	NA	NA
1993	NA	NA	130.318	NA	NA	NA	NA	NA	NA	NA	132.736	NA	NA
1994	NA	NA	99.798	NA	NA	NA	NA	NA	NA	NA	102.154	NA	NA
1995	NA	NA	79.090	NA	NA	NA	NA	NA	NA	NA	81.248	NA	NA
1996	NA	NA	63.179	NA	NA	NA	NA	NA	NA	NA	65.028	NA	NA
1997	NA	NA	50.092	NA	NA	NA	NA	NA	NA	NA	51.621	NA	NA
1998	NA	NA	39.319	NA	NA	NA	NA	NA	NA	NA	40.991	NA	NA
1999	NA	NA	31.177	NA	NA	NA	NA	NA	NA	NA	32.874	NA	NA
2000	NA	NA	25.376	NA	NA	NA	NA	NA	NA	NA	26.893	NA	NA
2001	NA	NA	21.252	NA	NA	NA	NA	NA	NA	NA	22.662	NA	NA
2002	NA	NA	18.027	NA	NA	NA	NA	NA	NA	NA	19.338	NA	NA
2003	NA	NA	15.604	NA	NA	NA	NA	NA	NA	NA	16.832	NA	NA
2004	NA	NA	14.058	NA	NA	NA	NA	NA	NA	NA	15.225	NA	NA
2005	NA	NA	13.109	NA	NA	NA	NA	NA	NA	NA	14.268	NA	NA
2006	NA	NA	12.658	NA	NA	NA	NA	NA	NA	NA	13.854	NA	NA
2007	NA	NA	12.373	NA	NA	NA	NA	NA	NA	NA	13.628	NA	NA
2008	NA	NA	12.011	NA	NA	NA	NA	NA	NA	NA	13.256	NA	NA
2009	NA	NA	11.633	NA	NA	NA	NA	NA	NA	NA	12.860	NA	NA
2010	NA	NA	10.975	NA	NA	NA	NA	NA	NA	NA	12.192	NA	NA
2011	NA	NA	10.509	NA	NA	NA	NA	NA	NA	NA	11.704	NA	NA
2012	NA	NA	9.482	NA	NA	NA	NA	NA	NA	NA	10.745	NA	NA
2013	NA	NA	8.818	NA	NA	NA	NA	NA	NA	NA	10.013	NA	NA
2014	NA	NA	8.709	NA	NA	NA	NA	NA	NA	NA	9.776	NA	NA
2015	NA	NA	8.197	NA	NA	NA	NA	NA	NA	NA	9.195	NA	NA
2016	NA	NA	7.513	NA	NA	NA	NA	NA	NA	NA	8.465	NA	NA
2017	NA	NA	6.832	NA	NA	NA	NA	NA	NA	NA	7.731	NA	NA
Trend 1990-2017	*NA*	*NA*	*-96.99%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*-96.64%*	*NA*	*NA*
2005-2017	*NA*	*NA*	*-47.89%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*-45.81%*	*NA*	*NA*
2016-2017	*NA*	*NA*	*-9.07%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*-8.67%*	*NA*	*NA*

Source: Environment Agency

Table 157 – 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	0.025	0.018	0.010	0.009
1991	0.025	0.019	0.010	0.009
1992	0.025	0.018	0.010	0.009
1993	0.025	0.019	0.010	0.009
1994	0.024	0.018	0.010	0.009
1995	0.024	0.018	0.010	0.009
1996	0.024	0.018	0.010	0.009
1997	0.024	0.018	0.010	0.009
1998	0.025	0.018	0.010	0.009
1999	0.025	0.018	0.010	0.009
2000	0.026	0.019	0.011	0.009
2001	0.026	0.019	0.011	0.009
2002	0.026	0.020	0.011	0.009
2003	0.027	0.020	0.011	0.009
2004	0.029	0.021	0.012	0.009
2005	0.030	0.022	0.012	0.009
2006	0.030	0.022	0.012	0.009
2007	0.029	0.021	0.012	0.009
2008	0.029	0.022	0.012	0.009
2009	0.029	0.021	0.012	0.009
2010	0.030	0.022	0.012	0.009
2011	0.030	0.022	0.012	0.009
2012	0.030	0.022	0.012	0.009
2013	0.030	0.022	0.012	0.009
2014	0.030	0.022	0.012	0.009
2015	0.029	0.021	0.012	0.009
2016	0.029	0.021	0.012	0.009
2017	0.029	0.021	0.012	0.009
Trend 1990-2017	*17.14%*	*15.38%*	*17.39%*	*0.52%*
2005-2017	*-4.26%*	*-3.94%*	*-4.31%*	*0.88%*
2016-2017	*-0.78%*	*-0.74%*	*-0.79%*	*0.12%*

Source: Environment Agency

3.2.4.3.3 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 1990-2017.

Regarding uncertainties, no quantified estimates have been made yet. The following parameters are qualified with relatively high uncertainties:

- Recently, a significant number of Luxembourg citizens moved to neighbouring countries but keeping their, in Luxembourg, registered passenger cars. 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.

3.2.4.3.4 Source-specific QA/QC and verification

Consistency and completeness checks are performed.

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

Table 158 presents the main revisions and recalculations done since submission 2018 for category *1A3b – Road transport*.

Table 158 – Recalculations done since submission 2018 for category – *1A3b – Road transport*

Source category	Revisions 2018 ➔ 2019	Type of revision
1A3b i-v	Changed notation key for biomass activity data from NA to IE (included in liquid fuels)	Changed notation key

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

The following improvements are planned for the next submission.

Table 159 – 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.	

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 2017, this source category represented about 0.6% and 0.4% 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 the period 1990 – 2017, SO_2 emission decreased by 86%, NO_x emissions by 73% and PM emissions by 92% (see Table 160 and in more detail Table 161).

Air pollutant emissions from railways are not a key category in 2017 (see Table 132 and also Table 49 in Section 3.2 and Chapter 1.5).

Table 160 – Emissions (1990, 2005, 2016 and 2017), 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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
SO2	0.0202	0.0028	0.0020	0.0028	-85.9%	0.7%	39.4%	0.144%	0.118%	0.216%	0.136%	0.117%	0.212%	fuel sold
NOx	0.2577	0.0989	0.0511	0.0685	-73.4%	-30.7%	34.2%	1.117%	0.615%	0.555%	0.622%	0.181%	0.374%	fuel sold
NMVOC	0.0501	0.0153	0.0051	0.0067	-86.7%	-56.3%	31.3%	0.283%	0.121%	0.062%	0.189%	0.101%	0.059%	fuel sold
NH3	0.0001	0.0000	0.0000	0.0000	-78.1%	-35.0%	35.3%	0.001%	0.001%	0.000%	0.001%	0.000%	0.000%	fuel sold
CO	0.2796	0.0887	0.0342	0.0458	-83.6%	-48.4%	34.0%	0.067%	0.448%	0.318%	0.060%	0.232%	0.219%	fuel sold
TSP	0.0590	0.0167	0.0037	0.0047	-92.1%	-72.1%	26.7%	0.357%	0.751%	0.184%	0.340%	0.428%	0.143%	fuel sold
PM10	0.0590	0.0167	0.0037	0.0047	-92.1%	-72.1%	26.7%	0.372%	0.966%	0.286%	0.355%	0.543%	0.221%	fuel sold
PM2.5	0.0590	0.0167	0.0037	0.0047	-92.1%	-72.1%	26.7%	0.382%	1.253%	0.440%	0.367%	0.682%	0.340%	fuel sold

Source: Environment Agency

Table 161 – 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	0.050	0.00008	0.280	0.059	0.059	0.059
1991	0.020	0.259	0.050	0.00008	0.279	0.059	0.059	0.059
1992	0.020	0.259	0.050	0.00008	0.279	0.058	0.058	0.058
1993	0.020	0.260	0.050	0.00008	0.278	0.058	0.058	0.058
1994	0.020	0.255	0.048	0.00008	0.269	0.056	0.056	0.056
1995	0.013	0.208	0.039	0.00006	0.217	0.045	0.045	0.045
1996	0.007	0.235	0.043	0.00007	0.242	0.049	0.049	0.049
1997	0.007	0.233	0.042	0.00007	0.237	0.048	0.048	0.048
1998	0.007	0.235	0.042	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	0.041	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	0.032	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	0.015	0.00003	0.086	0.015	0.015	0.015
2008	0.003	0.113	0.016	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	0.014	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	0.003	0.069	0.007	0.000	0.046	0.005	0.005	0.005
Trend 1990-2017	*-85.92%*	*-73.41%*	*-86.69%*	*-78.12%*	*-83.63%*	*-92.11%*	*-92.11%*	*-92.11%*
2005-2017	*0.67%*	*-30.73%*	*-56.28%*	*-34.98%*	*-48.42%*	*-72.09%*	*-72.09%*	*-72.09%*
2016-2017	*39.45%*	*34.18%*	*31.28%*	*35.31%*	*34.02%*	*26.70%*	*26.70%*	*26.70%*

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 162 for fuel consumption). Activity data is consistent with the data reported by the national statistics institute in their energy balance (2000-2017). 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 162 – 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	IE	NA
1991	334 678	334'678	NO	NA	IE	NA
1992	334 678	334'678	NO	NA	IE	NA
1993	334 678	334'678	NO	NA	IE	NA
1994	324 884	324'884	NO	NA	IE	NA
1995	263 059	263'059	NO	NA	IE	NA
1996	293 972	293'972	NO	NA	IE	NA
1997	288 989	288'989	NO	NA	IE	NA
1998	288 989	288'989	NO	NA	IE	NA
1999	288 989	288'989	NO	NA	IE	NA
2000	285 971	285'971	NO	NA	IE	NA
2001	308 159	308'159	NO	NA	IE	NA
2002	272 319	272'319	NO	NA	IE	NA
2003	237 417	237'417	NO	NA	IE	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	126 933	126'933	NO	NA	IE	NA
2008	145 789	145'789	NO	NA	IE	NA
2009	140 389	140'389	NO	NA	IE	NA
2010	151 141	151'141	NO	NA	IE	NA
2011	151 343	151'343	NO	NA	IE	NA
2012	137 691	137'691	NO	NA	IE	NA
2013	119 026	119'026	NO	NA	IE	NA
2014	136 762	136'762	NO	NA	IE	NA
2015	93 846	93'846	NO	NA	IE	NA
2016	86 210	86'210	NO	NA	IE	NA
2017	120 093	120'093	NO	NA	IE	NA
Trend 1990-2017	*-64.12%*	*-64.12%*	*NA*	*NA*	*NA*	*NA*
2005-2017	*0.21%*	*0.21%*	*NA*	*NA*	*NA*	*NA*
2016-2017	*39.30%*	*39.30%*	*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 163 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 163 – Methods and Emission Factors used in relation to the energy consumption in 2017 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 164.

Table 164 – 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	149.74	0.25	835.39	176.24	176.24	176.24
1991	60.26	772.58	149.31	0.25	834.00	175.21	175.21	175.21
1992	60.26	775.15	148.87	0.25	832.58	174.16	174.16	174.16
1993	60.26	777.91	148.41	0.25	831.05	173.03	173.03	173.03
1994	60.26	784.76	147.55	0.25	828.18	171.17	171.17	171.17
1995	51.08	791.77	146.67	0.24	825.22	169.26	169.26	169.26
1996	23.54	798.68	145.80	0.24	822.30	167.37	167.37	167.37
1997	23.54	805.60	144.93	0.24	819.37	165.47	165.47	165.47
1998	23.54	812.83	144.02	0.24	816.30	163.47	163.47	163.47
1999	23.54	820.78	143.00	0.24	812.89	161.25	161.25	161.25
2000	23.54	829.15	141.93	0.24	809.30	158.90	158.90	158.90
2001	23.54	838.45	140.73	0.24	805.29	156.27	156.27	156.27
2002	23.54	846.03	136.77	0.24	788.24	150.24	150.24	150.24
2003	23.54	841.11	134.44	0.24	776.61	147.91	147.91	147.91
2004	23.54	836.40	132.15	0.23	765.19	145.59	145.59	145.59
2005	23.54	825.40	127.28	0.23	740.55	139.20	139.20	139.20
2006	23.54	814.49	122.28	0.23	715.28	132.60	132.60	132.60
2007	23.58	794.99	114.71	0.22	677.15	121.93	121.93	121.93
2008	23.58	774.05	106.77	0.21	637.01	110.79	110.79	110.79
2009	23.58	753.30	98.48	0.20	595.33	99.18	99.18	99.18
2010	23.58	732.20	90.43	0.20	554.65	87.81	87.81	87.81
2011	23.57	710.69	82.34	0.19	513.69	76.31	76.31	76.31
2012	23.58	688.84	78.07	0.18	490.31	69.54	69.54	69.54
2013	23.59	656.77	70.72	0.17	453.46	58.78	58.78	58.78
2014	23.60	624.14	63.14	0.16	415.59	47.67	47.67	47.67
2015	23.61	602.73	59.69	0.16	398.97	43.04	43.04	43.04
2016	23.62	592.32	58.93	0.15	396.18	42.63	42.63	42.63
2017	23.65	570.53	55.53	0.15	381.14	38.77	38.77	38.77
Trend 1990-2017	*-60.76%*	*-25.91%*	*-62.91%*	*-39.03%*	*-54.38%*	*-78.00%*	*-78.00%*	*-78.00%*
2005-2017	*0.45%*	*-30.88%*	*-56.37%*	*-35.12%*	*-48.53%*	*-72.15%*	*-72.15%*	*-72.15%*
2016-2017	*0.10%*	*-3.68%*	*-5.76%*	*-2.87%*	*-3.79%*	*-9.05%*	*-9.05%*	*-9.05%*

Source: Environment Agency

3.2.4.4.3 Uncertainties and time-series consistency

Currently no uncertainty estimates are made. Uncertainty of the activity data can be checked in the Luxembourg's National Inventory report (NIR).

The time-series are considered to be consistent.

3.2.4.4.4 Source-specific QA/QC and verification

Consistency and completeness checks are performed.

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

Table 165 presents the main revisions and recalculations done since submission 2018.

Table 165 – Recalculations done since submission 2018 for category – *1A3c - Railways*

Source category	Revisions 2018 ➔ 2019	Type of revision
1A3c	No recalculations were done.	

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

The following improvements are planned for the next submission.

Table 166 – 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 2017, this source category represented less than 0.02% of the national total for each air pollutant based on fuel sold (Table 167 and Table 168). In the period 1990 – 2017, emissions of NO_x, NMVOC and 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 169 for category *1A3di (ii) - International inland waterways* and Table 170 for category *1A3d ii - National navigation*.
Navigation related air pollutant emissions were not a key source in 2017 (see Table 132 and also Table 49 in Section 3.2 and Chapter 1.5).).

Table 167 – Emissions (1990, 2005, 2016 and 2017), Trends and Shares based on fuel sold and fuel used for category – *1A3di (ii) - International inland waterways*

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
	1990	2005	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	option
SO2	0.0001	0.0000	0.0000	0.0000	-98.3%	-76.5%	27.3%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	fuel sold
NOx	0.0008	0.0014	0.0011	0.0014	59.5%	-3.7%	25.6%	0.004%	0.009%	0.011%	0.002%	0.003%	0.007%	fuel sold
NMVOC	0.0002	0.0002	0.0002	0.0002	30.3%	-11.6%	24.1%	0.001%	0.002%	0.002%	0.001%	0.001%	0.002%	fuel sold
NH3	0.0000	0.0000	0.0000	0.0000	53.7%	-1.4%	26.1%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	fuel sold
CO	0.0009	0.0013	0.0010	0.0012	41.0%	-6.0%	25.6%	0.000%	0.007%	0.008%	0.000%	0.003%	0.006%	fuel sold
TSP	0.0002	0.0002	0.0002	0.0002	10.2%	-21.2%	22.6%	0.001%	0.011%	0.007%	0.001%	0.006%	0.006%	fuel sold
PM10	0.0002	0.0002	0.0002	0.0002	10.2%	-21.2%	22.6%	0.001%	0.014%	0.012%	0.001%	0.008%	0.009%	fuel sold
PM2.5	0.0002	0.0002	0.0002	0.0002	10.2%	-21.2%	22.6%	0.001%	0.018%	0.018%	0.001%	0.010%	0.014%	fuel sold

Source: Environment Agency

Table 168 – Emissions (1990, 2005, 2017 and 2017), 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
	1990	2005	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	option
SO2	0.0008	0.0000	0.0000	0.0000	-99.0%	-82.8%	8.3%	0.006%	0.002%	0.001%	0.005%	0.002%	0.001%	fuel sold
NOx	0.0124	0.0137	0.0085	0.0093	-24.6%	-31.8%	9.5%	0.054%	0.085%	0.076%	0.030%	0.025%	0.051%	fuel sold
NMVOC	0.0201	0.0157	0.0067	0.0064	-68.0%	-58.9%	-3.8%	0.113%	0.124%	0.060%	0.076%	0.104%	0.057%	fuel sold
NH3	0.0000	0.0000	0.0000	0.0000	-41.5%	-38.3%	6.9%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	fuel sold
CO	0.1014	0.0622	0.0435	0.0428	-57.8%	-31.2%	-1.5%	0.024%	0.314%	0.297%	0.022%	0.162%	0.205%	fuel sold
TSP	0.0026	0.0024	0.0012	0.0013	-47.7%	-44.0%	8.4%	0.016%	0.108%	0.053%	0.015%	0.061%	0.041%	fuel sold
PM10	0.0026	0.0024	0.0012	0.0013	-47.7%	-44.0%	8.4%	0.016%	0.139%	0.082%	0.015%	0.078%	0.064%	fuel sold
PM2.5	0.0026	0.0024	0.0012	0.0013	-47.7%	-44.0%	8.4%	0.017%	0.180%	0.127%	0.016%	0.098%	0.098%	fuel sold

Source: Environment Agency

Table 169 – Emission trends for category – *1A3di (ii) - International inland waterways*

1 A Mobile Fuel Combustion *Emissions of air pollutants by source category (Gg)*								
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	0.00006	0.00085	0.00015	0.00000	0.00086	0.00017	0.00017	0.00017
1991	0.00007	0.00092	0.00016	0.00000	0.00093	0.00018	0.00018	0.00018
1992	0.00006	0.00086	0.00015	0.00000	0.00087	0.00017	0.00017	0.00017
1993	0.00009	0.00116	0.00020	0.00000	0.00116	0.00023	0.00023	0.00023
1994	0.00006	0.00100	0.00018	0.00000	0.00101	0.00020	0.00020	0.00020
1995	0.00002	0.00101	0.00018	0.00000	0.00101	0.00020	0.00020	0.00020
1996	0.00002	0.00096	0.00017	0.00000	0.00095	0.00019	0.00019	0.00019
1997	0.00002	0.00093	0.00016	0.00000	0.00092	0.00018	0.00018	0.00018
1998	0.00002	0.00093	0.00016	0.00000	0.00092	0.00018	0.00018	0.00018
1999	0.00002	0.00102	0.00018	0.00000	0.00101	0.00020	0.00020	0.00020
2000	0.00002	0.00113	0.00019	0.00000	0.00111	0.00022	0.00022	0.00022
2001	0.00002	0.00114	0.00019	0.00000	0.00111	0.00022	0.00022	0.00022
2002	0.00002	0.00120	0.00020	0.00000	0.00115	0.00022	0.00022	0.00022
2003	0.00002	0.00121	0.00020	0.00000	0.00115	0.00022	0.00022	0.00022
2004	0.00000	0.00115	0.00019	0.00000	0.00109	0.00021	0.00021	0.00021
2005	0.00000	0.00141	0.00022	0.00000	0.00129	0.00024	0.00024	0.00024
2006	0.00000	0.00140	0.00022	0.00000	0.00125	0.00022	0.00022	0.00022
2007	0.00000	0.00115	0.00018	0.00000	0.00103	0.00018	0.00018	0.00018
2008	0.00000	0.00123	0.00019	0.00000	0.00111	0.00020	0.00020	0.00020
2009	0.00000	0.00097	0.00015	0.00000	0.00087	0.00015	0.00015	0.00015
2010	0.00000	0.00091	0.00014	0.00000	0.00082	0.00014	0.00014	0.00014
2011	0.00000	0.00110	0.00017	0.00000	0.00101	0.00018	0.00018	0.00018
2012	0.00000	0.00105	0.00017	0.00000	0.00096	0.00017	0.00017	0.00017
2013	0.00000	0.00086	0.00013	0.00000	0.00079	0.00014	0.00014	0.00014
2014	0.00000	0.00095	0.00015	0.00000	0.00087	0.00015	0.00015	0.00015
2015	0.00000	0.00097	0.00015	0.00000	0.00088	0.00014	0.00014	0.00014
2016	0.00000	0.00108	0.00016	0.00000	0.00097	0.00015	0.00015	0.00015
2017	0.00000	0.00135	0.00020	0.00000	0.00121	0.00019	0.00019	0.00019
Trend 1990-2017	*-98.34%*	*59.53%*	*30.33%*	*53.70%*	*41.01%*	*10.20%*	*10.20%*	*10.20%*
2005-2017	*-76.47%*	*-3.65%*	*-11.55%*	*-1.45%*	*-5.96%*	*-21.20%*	*-21.20%*	*-21.20%*
2016-2017	*27.25%*	*25.60%*	*24.08%*	*26.14%*	*25.56%*	*22.59%*	*22.59%*	*22.59%*

Source: Environment Agency

Table 170 – 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	0.0124	0.0201	0.00001	0.1014	0.0026	0.0026	0.0026
1991	0.0009	0.0131	0.0258	0.00001	0.1179	0.0027	0.0027	0.0027
1992	0.0008	0.0121	0.0279	0.00001	0.1173	0.0025	0.0025	0.0025
1993	0.0009	0.0129	0.0277	0.00001	0.1142	0.0026	0.0026	0.0026
1994	0.0007	0.0123	0.0265	0.00001	0.1090	0.0024	0.0024	0.0024
1995	0.0002	0.0107	0.0212	0.00000	0.0876	0.0021	0.0021	0.0021
1996	0.0002	0.0108	0.0215	0.00000	0.0886	0.0021	0.0021	0.0021
1997	0.0003	0.0114	0.0202	0.00000	0.0829	0.0022	0.0022	0.0022
1998	0.0002	0.0110	0.0198	0.00000	0.0805	0.0021	0.0021	0.0021
1999	0.0002	0.0124	0.0206	0.00001	0.0831	0.0024	0.0024	0.0024
2000	0.0002	0.0111	0.0160	0.00000	0.0646	0.0021	0.0021	0.0021
2001	0.0002	0.0126	0.0180	0.00001	0.0724	0.0024	0.0024	0.0024
2002	0.0003	0.0138	0.0194	0.00001	0.0774	0.0025	0.0025	0.0025
2003	0.0003	0.0143	0.0197	0.00001	0.0775	0.0026	0.0026	0.0026
2004	0.0000	0.0132	0.0168	0.00001	0.0658	0.0024	0.0024	0.0024
2005	0.0000	0.0137	0.0157	0.00001	0.0622	0.0024	0.0024	0.0024
2006	0.0000	0.0124	0.0134	0.00000	0.0541	0.0021	0.0021	0.0021
2007	0.0000	0.0126	0.0135	0.00001	0.0550	0.0021	0.0021	0.0021
2008	0.0000	0.0138	0.0139	0.00001	0.0569	0.0023	0.0023	0.0023
2009	0.0000	0.0112	0.0115	0.00000	0.0473	0.0018	0.0018	0.0018
2010	0.0000	0.0119	0.0114	0.00000	0.0480	0.0019	0.0019	0.0019
2011	0.0000	0.0111	0.0092	0.00000	0.0391	0.0018	0.0018	0.0018
2012	0.0000	0.0108	0.0085	0.00000	0.0381	0.0017	0.0017	0.0017
2013	0.0000	0.0090	0.0075	0.00000	0.0370	0.0014	0.0014	0.0014
2014	0.0000	0.0095	0.0076	0.00000	0.0412	0.0014	0.0014	0.0014
2015	0.0000	0.0081	0.0067	0.00000	0.0409	0.0012	0.0012	0.0012
2016	0.0000	0.0085	0.0067	0.00000	0.0435	0.0012	0.0012	0.0012
2017	0.0000	0.0093	0.0064	0.00000	0.0428	0.0013	0.0013	0.0013
Trend 1990-2017	*-99.05%*	*-24.56%*	*-68.02%*	*-41.50%*	*-57.77%*	*-47.69%*	*-47.69%*	*-47.69%*
2005-2017	*-82.77%*	*-31.83%*	*-58.94%*	*-38.26%*	*-31.17%*	*-44.00%*	*-44.00%*	*-44.00%*
2016-2017	*8.34%*	*9.50%*	*-3.81%*	*6.94%*	*-1.52%*	*8.37%*	*8.37%*	*8.37%*

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 was obtained directly from the two national operators as no energy related data is available from the official statistics. They also communicated that about 80% of their journeys are to be considered as domestic (from Luxembourg to Luxembourg), and the remaining 20% 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* (80% of the journeys) and category *1A3di (ii) - International inland waterways* (20% of the journeys) (see Table 171 and Table 172).

Concerning the fuel consumption of leisure boats (yachts, jet-skis, etc.) only one (very) small marina exists on Luxembourg’s side of the Moselle river at Schwebsange. This marina is equipped with a gasoline and diesel oil filling station. The amount of fuel sold at this station was obtained from the operator for the entire time-series. It is assumed that the quantities sold at this station are being combusted entirely on Luxembourg's side of the river. The boat stock was assumed to be about 800 units (expert judgement) per year over the entire timeseries. Operating hours per year were estimated based on the fuel consumption as reported by the marina.

Table 171 – 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	1 054	1'054	NO	NA	IE	NA
1991	1 139	1'139	NO	NA	IE	NA
1992	1 065	1'065	NO	NA	IE	NA
1993	1 430	1'430	NO	NA	IE	NA
1994	1 238	1'238	NO	NA	IE	NA
1995	1 245	1'245	NO	NA	IE	NA
1996	1 175	1'175	NO	NA	IE	NA
1997	1 134	1'134	NO	NA	IE	NA
1998	1 133	1'133	NO	NA	IE	NA
1999	1 242	1'242	NO	NA	IE	NA
2000	1 372	1'372	NO	NA	IE	NA
2001	1 372	1'372	NO	NA	IE	NA
2002	1 445	1'445	NO	NA	IE	NA
2003	1 471	1'471	NO	NA	IE	NA
2004	1 421	1'421	NO	NA	IE	NA
2005	1 901	1'901	NO	NA	IE	NA
2006	2 007	2'007	NO	NA	IE	NA
2007	1 653	1'653	NO	NA	IE	NA
2008	1 798	1'798	NO	NA	IE	NA
2009	1 441	1'441	NO	NA	IE	NA
2010	1 379	1'379	NO	NA	IE	NA
2011	1 697	1'697	NO	NA	IE	NA
2012	1 642	1'642	NO	NA	IE	NA
2013	1 360	1'360	NO	NA	IE	NA
2014	1 519	1'519	NO	NA	IE	NA
2015	1 565	1'565	NO	NA	IE	NA
2016	1 752	1'752	NO	NA	IE	NA
2017	2 227	2'227	NO	NA	IE	NA
Trend						
1990-2017	*111.27%*	*111.27%*	*NA*	*NA*	*NA*	*NA*
2005-2017	*17.12%*	*17.12%*	*NA*	*NA*	*NA*	*NA*
2016-2017	*27.12%*	*27.12%*	*NA*	*NA*	*NA*	*NA*

Source: Environment Agency

Table 172 – 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	17 686	17'686	NA	NO	IE	NA
1991	19 273	19'273	NA	NO	IE	NA
1992	18 355	18'355	NA	NO	IE	NA
1993	19 241	19'241	NA	NO	IE	NA
1994	18 300	18'300	NA	NO	IE	NA
1995	15 755	15'755	NA	NO	IE	NA
1996	15 903	15'903	NA	NO	IE	NA
1997	16 300	16'300	NA	NO	IE	NA
1998	15 785	15'785	NA	NO	IE	NA
1999	17 425	17'425	NA	NO	IE	NA
2000	15 300	15'300	NA	NO	IE	NA
2001	17 150	17'150	NA	NO	IE	NA
2002	18 758	18'758	NA	NO	IE	NA
2003	19 620	19'620	NA	NO	IE	NA
2004	18 147	18'147	NA	NO	IE	NA
2005	19 236	19'236	NA	NO	IE	NA
2006	17 819	17'819	NA	NO	IE	NA
2007	18 302	18'302	NA	NO	IE	NA
2008	20 485	20'485	NA	NO	IE	NA
2009	17 075	17'075	NA	NO	IE	NA
2010	18 638	18'638	NA	NO	IE	NA
2011	17 569	17'569	NA	NO	IE	NA
2012	17 519	17'519	NA	NO	IE	NA
2013	15 327	15'327	NA	NO	IE	NA
2014	16 412	16'412	NA	NO	IE	NA
2015	14 509	14'509	NA	NO	IE	NA
2016	15 209	15'209	NA	NO	IE	NA
2017	16 473	16'473	NA	NO	IE	NA
Trend 1990-2017	*-6.86%*	*-6.86%*	*NA*	*NA*	*NA*	*NA*
2005-2017	*-14.36%*	*-14.36%*	*NA*	*NA*	*NA*	*NA*
2016-2017	*8.31%*	*8.31%*	*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 163 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 173). For the $PM_{2.5}$ and PM_{10} emission factors, the condensable component is included.

Table 173 – Methods and Emission Factors used in relation to the energy in consumption in 2017 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 174 and Table 175.

Table 174 – Implied emission factors for category – *1 A 3 d i (ii) International inland waterways*

Year	1 A Mobile Fuel Combustion – Implied Emission Factor (IEF) of air pollutants by source category (g/GJ) – 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	805.56	143.72	0.25	815.77	161.72	161.72	161.72
1991	60.26	807.55	143.38	0.25	814.67	160.90	160.90	160.90
1992	60.26	808.09	143.29	0.25	814.37	160.69	160.69	160.69
1993	60.26	808.43	143.24	0.25	814.19	160.55	160.55	160.55
1994	51.08	810.50	142.99	0.25	813.35	160.03	160.03	160.03
1995	18.83	813.23	142.75	0.25	812.50	159.59	159.59	159.59
1996	18.83	816.10	142.52	0.25	811.67	159.21	159.21	159.21
1997	18.83	819.23	142.27	0.25	810.80	158.81	158.81	158.81
1998	18.83	818.78	142.48	0.25	811.43	159.40	159.40	159.40
1999	16.48	819.89	142.48	0.24	811.38	159.53	159.53	159.53
2000	16.48	824.84	141.98	0.24	809.65	158.55	158.55	158.55
2001	16.48	830.00	141.44	0.24	807.79	157.47	157.47	157.47
2002	16.48	827.96	139.51	0.24	798.33	155.45	155.45	155.45
2003	16.48	820.27	136.50	0.24	782.99	152.71	152.71	152.71
2004	2.35	808.05	133.79	0.24	768.01	149.63	149.63	149.63
2005	2.35	739.42	117.40	0.22	678.12	125.37	125.37	125.37
2006	2.35	697.57	107.43	0.20	623.42	110.61	110.61	110.61
2007	0.47	693.58	107.00	0.20	620.60	110.07	110.07	110.07
2008	0.47	685.16	106.14	0.20	615.45	108.94	108.94	108.94
2009	0.47	671.95	104.52	0.20	606.18	106.59	106.59	106.59
2010	0.47	659.23	102.94	0.19	597.16	104.30	104.30	104.30
2011	0.47	649.40	102.11	0.19	592.23	103.13	103.13	103.13
2012	0.47	639.80	100.89	0.19	586.87	101.84	101.84	101.84
2013	0.47	629.92	99.21	0.19	580.48	100.29	100.29	100.29
2014	0.47	626.92	96.18	0.19	569.64	95.52	95.52	95.52
2015	0.47	621.39	93.57	0.18	560.51	91.64	91.64	91.64
2016	0.47	615.67	90.84	0.18	551.25	87.47	87.47	87.47
2017	0.47	608.27	88.66	0.18	544.48	84.35	84.35	84.35
Trend 1990-2017	*-99.22%*	*-24.49%*	*-38.31%*	*-27.25%*	*-33.26%*	*-47.84%*	*-47.84%*	*-47.84%*
2005-2017	*-79.91%*	*-17.74%*	*-24.48%*	*-15.85%*	*-19.71%*	*-32.71%*	*-32.71%*	*-32.71%*
2016-2017	*0.10%*	*-1.20%*	*-2.39%*	*-0.78%*	*-1.23%*	*-3.57%*	*-3.57%*	*-3.57%*

Source: Environment Agency

Table 175 – Implied emission factors for category – *1 A 3 d ii National navigation (Shipping)*

Year	1 A Mobile Fuel Combustion – Implied Emission Factor (IEF) of air pollutants by source category (g/GJ) – 1 A 3 d ii National navigation (Shipping)							
	SO_2	NO_X	NMVOC	NH_3	CO	TSP	PM_{10}	$PM_{2.5}$
1990	46.14	699.66	1136.24	0.33	5734.75	145.01	145.01	145.01
1991	44.65	679.07	1336.27	0.32	6117.53	139.23	139.23	139.23
1992	43.48	659.64	1519.22	0.31	6389.35	134.01	134.01	134.01
1993	44.72	669.67	1437.57	0.30	5933.69	134.46	134.46	134.46
1994	37.97	670.04	1447.17	0.30	5956.58	132.66	132.66	132.66
1995	15.10	681.22	1342.78	0.30	5559.51	133.32	133.32	133.32
1996	15.06	682.03	1351.85	0.30	5569.82	132.22	132.22	132.22
1997	15.43	696.94	1240.96	0.29	5086.15	134.80	134.80	134.80
1998	15.40	698.75	1256.12	0.30	5100.49	134.21	134.21	134.21
1999	13.83	709.72	1180.28	0.30	4770.24	136.02	136.02	136.02
2000	14.18	725.90	1045.03	0.29	4223.65	139.62	139.62	139.62
2001	14.17	731.83	1052.21	0.30	4223.61	138.36	138.36	138.36
2002	14.22	735.10	1031.63	0.30	4125.52	135.78	135.78	135.78
2003	14.29	731.21	1004.03	0.30	3951.16	132.16	132.16	132.16
2004	2.35	725.79	923.92	0.30	3625.14	130.47	130.47	130.47
2005	2.35	711.91	813.67	0.29	3234.78	124.55	124.55	124.55
2006	2.35	697.78	753.11	0.28	3036.23	118.08	118.08	118.08
2007	0.47	687.21	738.83	0.28	3006.85	113.28	113.28	113.28
2008	0.47	674.37	679.27	0.27	2778.09	110.36	110.36	110.36
2009	0.47	655.09	673.62	0.27	2770.80	103.00	103.00	103.00
2010	0.47	639.33	614.13	0.26	2573.60	99.97	99.97	99.97
2011	0.47	631.45	521.39	0.25	2226.69	101.84	101.84	101.84
2012	0.47	613.79	487.96	0.24	2174.55	97.20	97.20	97.20
2013	0.47	588.71	488.74	0.23	2417.07	91.08	91.08	91.08
2014	0.47	576.99	462.62	0.23	2509.69	86.43	86.43	86.43
2015	0.47	561.41	464.37	0.22	2819.58	82.05	82.05	82.05
2016	0.47	560.54	439.33	0.21	2859.76	81.40	81.40	81.40
2017	0.47	566.71	390.17	0.21	2600.13	81.45	81.45	81.45
Trend 1990-2017	*-98.98%*	*-19.00%*	*-65.66%*	*-37.19%*	*-54.66%*	*-43.83%*	*-43.83%*	*-43.83%*
2005-2017	*-79.88%*	*-20.40%*	*-52.05%*	*-27.91%*	*-19.62%*	*-34.61%*	*-34.61%*	*-34.61%*
2016-2017	*0.03%*	*1.10%*	*-11.19%*	*-1.27%*	*-9.08%*	*0.06%*	*0.06%*	*0.06%*

Source: Environment Agency

3.2.4.5.3 Uncertainties and time-series consistency

Currently no uncertainty estimates are made. Uncertainty of the activity data can be checked in the Luxembourg's National Inventory report (NIR).

The time-series are considered to be consistent.

3.2.4.5.4 Source-specific QA/QC and verification

Consistency and completeness checks are performed.

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

Table 176 presents the main revisions and recalculations done since submission 2018.

Table 176– Recalculations done since submission 2018 for category – *1A3d - Navigation*

Source category	Revisions 2018 ➔ 2019	Type of revision
1A3d	No recalculations were done	

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

The following improvements are planned for the next submission.

Table 177 – 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.	

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*
- *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 178. In 2017, this source category represented 34% of national total SO_2 emissions (based on fuel sold) and 35% of national total SO_2 emissions (based on fuel used), whereas in 1990, this source category represented 10% of national total SO_2 emissions (based on fuel sold) and 10% of national total SO_2 emissions (based on fuel used). The significant decrease of 68% in SO_2 emissions between 1990 and 2017 is the result of the increased use of low sulphur fuels.

In 2017, this source category represented 7% of national total NO_X emissions (based on fuel sold) and 11% of national total NO_X emissions (based on fuel used), whereas in 1990, this source category represented 4% of national total NO_X emissions (based on fuel sold) and 8% of national total NO_X emissions (based on fuel used). The decrease of 17% in NO_X emissions compared to 1990 is mainly due to the implementation of low NOx combustion technology in commercial/institutional and residential heating.

Further, this source category represented in 2017, 5% of national total NMVOC emissions (based on fuel sold) and 5% of national total NMVOC emissions (based on fuel used), whereas in 1990, this source category represented 4% of national total NMVOC emissions (based on fuel sold) and 5% of national total NMVOC emissions (based on fuel used).

In 2017 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.

Table 178 – Emissions (1990, 2005, 2016 and 2017), 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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
SO2	1.43	1.17	0.38	0.46	-68%	-60%	21%	10%	49%	35%	10%	48%	34%	fuel sold
NOx	1.81	1.85	1.53	1.51	-17%	-18%	-2%	8%	11%	11%	4%	3%	7%	fuel sold
NMVOC	0.96	0.70	0.69	0.59	-39%	-16%	-15%	5%	6%	5%	4%	5%	5%	fuel sold
NH3	0.05	0.05	0.06	0.05	9%	8%	-19%	1%	1%	1%	1%	1%	1%	fuel sold
CO	6.01	4.47	5.13	4.48	-26%	0%	-13%	1%	23%	31%	1%	12%	21%	fuel sold
TSP	0.70	0.59	0.73	0.56	-20%	-4%	-23%	4%	26%	22%	4%	15%	17%	fuel sold
PM10	0.68	0.57	0.70	0.54	-20%	-4%	-22%	4%	33%	33%	4%	18%	26%	fuel sold
PM2.5	0.67	0.55	0.68	0.53	-20%	-4%	-22%	4%	42%	50%	4%	23%	39%	fuel sold

Source: Environment Agency

Carbon monoxide emissions of this source category represented, in 2017, 21% of national total CO emissions (based on fuel sold) and 31% of national total CO emissions (based on fuel used) whereas in 1990, this source category represented 1% of national total CO emissions (based on fuel sold) and 1% of national total CO emissions (based on fuel used).

Regarding PM emissions, this source category represented in 2017:

- 39% of national total $PM_{2.5}$ emissions (based on fuel sold) and 50% of national total $PM_{2.5}$ emissions (based on fuel used), whereas in 1990, this source category represented 4% of national total $PM_{2.5}$ emissions (based on fuel sold) and 4% of national total $PM_{2.5}$ emissions (based on fuel used).
- 26% of national total PM_{10} emissions (based on fuel sold) and 33% of national total PM_{10} emissions (based on fuel used), whereas in 1990, this source category represented 4% of national total PM_{10} emissions (based on fuel sold) and 4% of national total PM_{10} emissions (based on fuel used).
- 17% of national total TSP emissions (based on fuel sold) and 22% of national total TSP emissions (based on fuel used), whereas in 1990, this source category represented 4% of national total TSP emissions (based on fuel sold) and 4% of national total TSP emissions (based on fuel used).

All air pollutant emissions (except for NH_3) decreased in the period 1990 – 2017 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 179 – NO_x, SO_2, NMVOC and NH_3 Emissions (1990, 2005, 2016 and 2017), Trends and Shares of category *1A4 - Other Sectors*

	SO_2													
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
1 A 4	**1.43**	**1.17**	**0.38**	**0.46**	**-67.7%**	**-60.3%**	**21.3%**	**10.2%**	**49.0%**	**35.1%**	**9.7%**	**48.2%**	**34.5%**	**fuel sold**
1 A 4 a i	0.578	0.234	0.086	0.124	-78.5%	-46.9%	43.8%	4.1%	9.8%	9.4%	3.9%	9.7%	9.2%	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	0.823	0.931	0.295	0.338	-58.9%	-63.7%	14.7%	5.9%	39.1%	25.7%	5.5%	38.5%	25.2%	fuel sold
1 A 4 b ii	0.000	0.000	0.000	0.000	-91.6%	-82.1%	0.9%	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	-98.3%	-7.6%	-1.4%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	fuel sold
1 A 4 c ii	0.021	0.001	0.000	0.000	-99.3%	-80.6%	2.9%	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

	NOx													
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
1 A 4	**1.81**	**1.85**	**1.53**	**1.51**	**-17%**	**-18%**	**-2%**	**8%**	**11%**	**11%**	**4%**	**3%**	**7%**	**fuel sold**
1 A 4 a i	0.84	0.53	0.51	0.49	-42%	-7%	-3%	4%	3%	4%	2%	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	0.62	1.03	0.80	0.79	27%	-23%	-1%	3%	6%	6%	1%	2%	4%	fuel sold
1 A 4 b ii	0.01	0.01	0.01	0.01	68%	13%	-1%	0%	0%	0%	0%	0%	0%	fuel sold
1 A 4 c i	0.01	0.01	0.01	0.01	-19%	-8%	-20%	0%	0%	0%	0%	0%	0%	fuel sold
1 A 4 c ii	0.33	0.27	0.20	0.21	-37%	-23%	4%	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

	NMVOC													
NFR Code	Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
1 A 4	**0.96**	**0.70**	**0.69**	**0.59**	**-38.6%**	**-15.6%**	**-15.2%**	**5.4%**	**5.5%**	**5.4%**	**3.6%**	**4.6%**	**5.2%**	**fuel sold**
1 A 4 a i	0.093	0.038	0.031	0.044	-51.9%	17.5%	44.0%	0.5%	0.3%	0.4%	0.3%	0.3%	0.4%	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	0.498	0.417	0.538	0.421	-15.5%	0.9%	-21.8%	2.8%	3.3%	3.9%	1.9%	2.8%	3.7%	fuel sold
1 A 4 b ii	0.260	0.171	0.074	0.074	-71.4%	-56.7%	0.5%	1.5%	1.4%	0.7%	1.0%	1.1%	0.7%	fuel sold
1 A 4 c i	0.002	0.000	0.000	0.000	-97.3%	-7.6%	-1.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 4 c ii	0.105	0.069	0.049	0.047	-54.9%	-31.7%	-3.0%	0.6%	0.5%	0.4%	0.4%	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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
1 A 4	**0.05**	**0.05**	**0.06**	**0.05**	**9.2%**	**8.4%**	**-19.2%**	**0.7%**	**0.8%**	**0.9%**	**0.7%**	**0.8%**	**0.9%**	**fuel sold**
1 A 4 a i	NO	0.000	0.001	0.000	0.0%	216.2%	-59.1%	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	0.045	0.045	0.060	0.049	8.6%	8.0%	-18.7%	0.7%	0.8%	0.9%	0.7%	0.8%	0.9%	fuel sold
1 A 4 b ii	0.000	0.000	0.000	0.000	-23.8%	-19.0%	-0.8%	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	-49.6%	-32.2%	-1.8%	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 180 – CO, TSP, PM_{10} and $PM_{2.5}$ Emissions (1990, 2005, 2016 and 2017), 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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
1 A 4	**6.01**	**4.47**	**5.13**	**4.48**	**-25.5%**	**0.1%**	**-12.7%**	**1.4%**	**22.6%**	**31.1%**	**1.3%**	**11.7%**	**21.4%**	**fuel sold**
1 A 4 a i	0.321	0.198	0.191	0.230	-28.1%	16.2%	20.4%	0.1%	1.0%	1.6%	0.1%	0.5%	1.1%	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	3.988	2.962	3.745	3.050	-23.5%	3.0%	-18.6%	0.9%	15.0%	21.2%	0.9%	7.7%	14.6%	fuel sold
1 A 4 b ii	1.244	1.015	0.999	1.011	-18.7%	-0.4%	1.2%	0.3%	5.1%	7.0%	0.3%	2.6%	4.8%	fuel sold
1 A 4 c i	0.004	0.003	0.003	0.003	-33.4%	-7.6%	-1.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 4 c ii	0.451	0.296	0.190	0.182	-59.7%	-38.7%	-4.3%	0.1%	1.5%	1.3%	0.1%	0.8%	0.9%	fuel sold
1A 4 c iii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold

NFR Code	TSP Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
1 A 4	**0.70**	**0.59**	**0.73**	**0.56**	**-19.8%**	**-4.2%**	**-22.6%**	**4.2%**	**26.4%**	**22.2%**	**4.0%**	**15.1%**	**17.3%**	**fuel sold**
1 A 4 a i	0.001	0.002	0.003	0.002	72.9%	24.6%	-13.5%	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	0.705	0.543	-13.6%	-0.5%	-23.0%	3.8%	24.5%	21.4%	3.6%	14.0%	16.7%	fuel sold
1 A 4 b ii	0.000	0.000	0.000	0.000	-20.2%	7.4%	1.2%	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	-83.3%	-7.6%	-1.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 4 c ii	0.071	0.039	0.019	0.017	-76.4%	-57.5%	-9.4%	0.4%	1.8%	0.7%	0.4%	1.0%	0.5%	fuel sold
1A 4 c iii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold

NFR Code	PM10 Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
1 A 4	**0.68**	**0.57**	**0.70**	**0.54**	**-20.3%**	**-4.1%**	**-22.0%**	**4.3%**	**32.8%**	**33.4%**	**4.1%**	**18.4%**	**25.8%**	**fuel sold**
1 A 4 a i	0.020	0.009	0.009	0.011	-44.2%	18.9%	27.5%	0.1%	0.5%	0.7%	0.1%	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	0.591	0.518	0.670	0.515	-12.7%	-0.5%	-23.0%	3.7%	30.0%	31.6%	3.6%	16.8%	24.4%	fuel sold
1 A 4 b ii	0.000	0.000	0.000	0.000	-20.2%	7.4%	1.2%	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	-83.3%	-7.6%	-1.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 4 c ii	0.071	0.039	0.019	0.017	-76.4%	-57.5%	-9.4%	0.4%	2.3%	1.0%	0.4%	1.3%	0.8%	fuel sold
1A 4 c iii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	fuel sold

NFR Code	PM2.5 Emissions				Trend			FUEL USED Share in National Total			FUEL SOLD Share in National Total			Fuel option
	1990	2005	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
1 A 4	**0.67**	**0.55**	**0.68**	**0.53**	**-20.4%**	**-4.2%**	**-22.0%**	**4.3%**	**41.5%**	**50.1%**	**4.1%**	**22.6%**	**38.7%**	**fuel sold**
1 A 4 a i	0.020	0.009	0.009	0.011	-44.3%	18.8%	27.7%	0.1%	0.7%	1.0%	0.1%	0.4%	0.8%	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	0.575	0.505	0.652	0.502	-12.6%	-0.5%	-23.0%	3.7%	37.8%	47.4%	3.6%	20.6%	36.6%	fuel sold
1 A 4 b ii	0.000	0.000	0.000	0.000	-20.2%	7.4%	1.2%	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	-83.3%	-7.6%	-1.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
1 A 4 c ii	0.071	0.039	0.019	0.017	-76.4%	-57.5%	-9.4%	0.5%	3.0%	1.6%	0.4%	1.6%	1.2%	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 181 and also Table 49 in Section 3.2 and Chapter 1.5).

Table 181 – Key Categories (fuel sold & fuel used) 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 b i	Residential: stationary			5	6	7				3	2	1	2	1	2	1	2
1 A 4 b ii	Residential: Household and gardening (mobile)									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 4 a i	Commercial/Institutional: Stationary			9							
1 A 4 b i	Residential: stationary			4	7	6				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, …)

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 and biogas.

Table 182 summarizes emissions of air pollutants for category *1A4a i – Commercial/Institutional* and Table 183 presents the emission trends.

Table 182 – Emissions (1990, 2005, 2016 and 2017), Trends and Shares of sub-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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
SO2	0.58	0.23	0.09	0.12	-79%	-47%	44%	4.1%	9.8%	9.4%	3.9%	9.7%	9.2%	fuel sold
NOx	0.84	0.53	0.51	0.49	-42%	-7%	-3%	3.7%	3.3%	3.6%	2.0%	1.0%	2.2%	fuel sold
NMVOC	0.09	0.04	0.03	0.04	-52%	17%	44%	0.5%	0.3%	0.4%	0.3%	0.3%	0.4%	fuel sold
NH3	NO	0.00	0.00	0.00	0%	216%	-59%	NO	0.0%	0.0%	NO	0.0%	0.0%	fuel sold
CO	0.32	0.20	0.19	0.23	-28%	16%	20%	0.1%	1.0%	1.6%	0.1%	0.5%	1.1%	fuel sold
TSP	0.00	0.00	0.00	0.00	73%	25%	-13%	0.0%	0.1%	0.1%	0.0%	0.1%	0.1%	fuel sold
PM10	0.02	0.01	0.01	0.01	-44%	19%	27%	0.1%	0.5%	0.7%	0.1%	0.3%	0.5%	fuel sold
PM2.5	0.02	0.01	0.01	0.01	-44%	19%	28%	0.1%	0.7%	1.0%	0.1%	0.4%	0.8%	fuel sold

Source: Environment Agency

The most important air pollutant of this source category was SO_2. In 2017, this source category represented about 9% of national total SO_2 emissions (based on fuel sold/based on fuel used), whereas in 1990, this source category represented 3.9% of national total SO_2 emissions (based on fuel sold) and 4.1% of national total SO_2 emissions (based on fuel used). The significant decrease of about 79% in SO_2 emissions from 0.58 Gg in 1990 to 0.12 Gg in 2017 was the result of the introduction of low-sulphur containing fuels.

Further important air pollutants of this source category were NO_X and $PM_{2.5}$. In 2017, this source category represented:

- about 2.2% of national total NO_X emissions (based on fuel sold) and 3.6% of national total NO_X emissions (based on fuel used), whereas in 1990, this source category represented 2.0% of national total NO_X emissions (based on fuel sold) and 3.7% of national total NO_X emissions (based on fuel used). The decrease of about 42% in NO_X emissions is mainly due to a fuel switch from liquid fuels to gaseous fuels, as well as due to the introduction of low NOx combustion technology.
- about 0.8% of national total $PM_{2.5}$ emissions (based on fuel sold) and 1.0% of national total $PM_{2.5}$ emissions (based on fuel used), whereas in 1990, this source category represented less than 0.2% of national total $PM_{2.5}$ emissions (based on fuel sold/based on fuel used). The decrease of about 44% in $PM_{2.5}$ emissions 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 for wood combustion.

As presented in Table 181, *1A4a i – Commercial/Institutional* is not a key category (LA & TA) in 2017 (see Table 181 in section 3.2.5.1 and Table 49 in Section 3.2 and Chapter 1.5).

Table 183 – 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	0.001	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	0.067	0.360	0.025	0.000	0.155	0.002	0.006	0.006
2012	0.082	0.455	0.028	0.000	0.202	0.003	0.008	0.008
2013	0.098	0.478	0.034	0.001	0.218	0.003	0.009	0.009
2014	0.086	0.407	0.031	0.001	0.191	0.003	0.009	0.009
2015	0.124	0.492	0.044	0.000	0.230	0.002	0.011	0.011
2016	0.011	0.510	0.044	0.001	0.247	0.003	0.012	0.012
2017	0.010	0.580	0.061	0.000	0.280	0.002	0.014	0.014
Trend 1990-2017	*-98.20%*	*-31.18%*	*-34.23%*	*NA*	*-12.66%*	*61.16%*	*-28.36%*	*-28.37%*

Source: Environment Agency

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 2000-2017, 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 184.

Table 184 – 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	11 122 561	7'822'330	NO	3'300'231	NO	NO
1992	10 323 786	6'985'232	NO	3'338'553	NO	NO
1993	10 259 446	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	11 278 089	6'794'806	NO	4'483'283	NO	NO
1997	10 906 999	6'718'170	NO	4'188'829	NO	NO
1998	11 463 249	6'954'434	NO	4'506'815	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	5 383 896	1'927'682	NO	3'416'530	39 684	NO
2012	7 169 998	2'107'114	NO	5'018'938	43 946	NO
2013	7 474 883	2'527'936	NO	4'887'692	59 255	NO
2014	6 406 079	2'292'116	NO	4'045'292	68 671	NO
2015	7 593 241	3'236'283	NO	4'302'114	54 843	NO
2016	8 156 508	3'218'889	NO	4'850'237	87 382	NO
2017	9 035 060	4'307'377	NO	4'675'573	52 110	NO
Trend 1990-2017	*-2.81%*	*-32.27%*	*NA*	*59.21%*	*NA*	*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 185. The ratios for 2005 to 2011 were derived from a national study.[57] For the years before 2005 and after 2012, trend extrapolation was used.

[57] 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 185 – 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%

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 2016 (Chapter 1A4 Small Combustion, Tables 3.36, 3.30, 3.35, 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 tacken from the following sources:

- conventional boilers: medium-sized (> 50 kWth to ≤ 1 MWth) boilers burning natural gas: EMEP/EEA Guidebook 2016 (Chapter 1A4 Small Combustion, Tables 3.36) ; medium-sized (> 50 kWth to ≤ 1 MWth) boilers burning gasoil: EMEP/EEA Guidebook 2016 (Chapter 1A4 Small Combustion, Tables 3.30)
- new conventional boilers: Small (single household scale, capacity <=50 kWth) boilers burning natural gas: EMEP/EEA Guidebook 2016 (Chapter 1A4 Small Combustion, Tables 3.21) ; small (single household scale, capacity <=50 kWth) boilers burning gasoil: EMEP/EEA Guidebook 2016 (Chapter 1A4 Small Combustion, Tables 3.21)
- condensing boilers: no default emission factor for this technology and for neither natural gas, nor gasoil is available in the EMEP/EEA Guidebook 2016. 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 1 default emission factors from the EMEP/EEA Guidebook 2009 have been applied. For Biogas, Tier 1 default emission factors from the EMEP/EEA Guidebook 2009 have been applied, except for NOx for which a country-specific emission factor based on measurements has been used.

The methods applied and emission factors (EF) used as well as coverage of energy consumption for 2017 are presented in Table 186.

Table 186 – Methods and Emission Factors used in relation to the energy in consumption in 2017 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 2016 (Chap 1A4, Table 3-48) ; EMEP/EEA GB 2016 (Chap 1A4, Tables 3-26 & 3-19) ; IIR AT 2016 (Table 114, p168) ; EMEP/EEA GB 2016 (Chap 1A4, Tables 3-24 & 3-21)
	T1	D	0.0%	
NMVOC	T2	D	100.0%	EMEP/EEA GB 2016 (Chap 1A4, Table 3-48) ; EMEP/EEA GB 2016 (Chap 1A4, Table 3-26) ; EMEP/EEA GB 2016 (Chap 1A4,
	T1	D	0.0%	
SOx	T2	CS	43.6%	CS based on maximum allowed sulfur content
	T2	D	56.4%	EMEP/EEA GB 2016 (Chap 1A4, Table 3-48) ; EMEP/EEA GB 2016 (Chap 1A4, Table 3-26)
	T1	D	0.0%	
CO	T2	D	100.0%	EMEP/EEA GB 2016 (Chap 1A4, Table 3-48) ; EMEP/EEA GB 2016 (Chap 1A4, Table 3-26) ; EMEP/EEA GB 2016 (Chap 1A4,
	T1	D	0.0%	
PM2.5	T2	D	100.0%	EMEP/EEA GB 2016 (Chap 1A4, Table 3-48) ; EMEP/EEA GB 2016 (Chap 1A4, Table 3-26) ; EMEP/EEA GB 2016 (Chap 1A4, Table 3-24)
	T1	D	0.0%	
PM10	T2	D	100.0%	EMEP/EEA GB 2016 (Chap 1A4, Table 3-48) ; EMEP/EEA GB 2016 (Chap 1A4, Table 3-26) ; EMEP/EEA GB 2016 (Chap 1A4, Table 3-24)
	T1	D	0.0%	
TSP	T2	D	100.0%	EMEP/EEA GB 2016 (Chap 1A4, Table 3-48) ; EMEP/EEA GB 2016 (Chap 1A4, Table 3-26) ; EMEP/EEA GB 2016 (Chap 1A4, Table 3-24)
	T1	D	0.0%	

Source: Environment Agency

Table 187 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, in recent years.

Table 187 – Implied emission factors for category *1A4a - Commercial/Institutional*

1 A 4 Other Sectors								
Implied Emission Factor (IEF) of air pollutants by source category (g/GJ)								
Year	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	0.02	28.70	0.34	1.20	1.19
2001	39.21	82.98	6.35	0.04	30.85	0.31	1.53	1.53
2002	35.87	81.60	5.83	0.10	30.71	0.38	1.49	1.49
2003	32.43	80.10	5.27	0.05	29.69	0.34	1.34	1.34
2004	34.57	80.32	5.61	0.02	29.87	0.31	1.38	1.38
2005	35.32	80.05	5.72	0.02	29.99	0.30	1.40	1.40
2006	21.82	75.01	3.59	0.01	27.58	0.36	1.02	1.02
2007	23.35	72.94	3.83	0.01	27.86	0.35	1.06	1.06
2008	9.01	67.22	2.81	0.02	26.83	0.40	0.90	0.89
2009	8.54	64.56	2.66	0.05	26.84	0.42	0.89	0.89
2010	12.49	65.37	4.05	0.03	28.23	0.36	1.12	1.12
2011	12.48	66.79	4.58	0.02	28.74	0.34	1.20	1.20
2012	11.38	63.46	3.88	0.04	28.16	0.38	1.10	1.10
2013	13.05	64.01	4.55	0.09	29.19	0.40	1.25	1.25
2014	13.46	63.56	4.82	0.14	29.88	0.45	1.35	1.34
2015	16.34	64.84	5.86	0.05	30.35	0.33	1.45	1.45
2016	1.30	62.49	5.41	0.10	30.26	0.40	1.42	1.41
2017	1.15	64.22	6.74	0.00	30.99	0.26	1.56	1.56
Trend 1990-2017	*-98.15%*	*-29.19%*	*-32.32%*	*NA*	*-10.13%*	*65.82%*	*-26.29%*	*-26.30%*

Source: Environment Agency

3.2.5.3 **Commercial/Institutional: Mobile (1A4a ii)**

The source category *1A4a ii Commercial / Institutional: Mobile* is reported as not occurring in Luxembourg (notation key: NO), as no diesel oil consumption is reported by the national energy balance for this category. LPG is supposed to be burnt entirely 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 188 summarizes the annual emissions of air pollutants for category *1A4b i Residential* and Table 190 presents the emission trends.

In 2017, $PM_{2.5}$ emissions of this source category represented 36.6% of national total $PM_{2.5}$ emissions (based on fuel sold) and 47.4% 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).

In 2017, PM_{10} emissions of this source category represented 24.4% of national total PM_{10} emissions (based on fuel sold) and 31.6% of national total PM_{10} emissions (based on fuel used), whereas in 1990, this source category represented about 3.6% to 3.7% of national total PM_{10} emissions (based on fuel sold/based on fuel used). $PM_{2.5}$ and PM_{10} emissions have decreased by about 13% compared to 1990.

In 2017, SO_2 emissions of this source category represented 25.2% of national total SO_2 emissions (based on fuel sold) and 25.7% of national total SO_2 emissions (based on fuel used), whereas in 1990, this source category represented about 6% of national total SO_2 emissions (based on fuel sold/based on fuel used). The significant decrease of about 59%, compared to 1990, in SO_2 emissions was the result of the introduction of low-sulphur containing fuels.

In 2017, NO_X emissions of this source category represented 3.5% of national total NO_X emissions (based on fuel sold) and 5.8% of national total NO_X emissions (based on fuel used), whereas in 1990, this source category represented about 1.5% to 2.7% of national total NO_X emissions (based on fuel sold/based on fuel used). Compared to 1990, NO_X emissions increased by 27% due to the increasing population in Luxembourg, and thus an increased heating demand. However, in recent years emissions have decreased by 23% compared to 2005, illustrating the effect of increased low NOx combustion technology installations (condensing boilers).

Table 188 – Emissions (1990, 2005, 2016 and 2017), Trends and Shares based on fuel sold and fuel used for category *1A4b i - 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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
SO2	0.82	0.93	0.29	0.34	-59%	-64%	15%	5.9%	39.1%	25.7%	5.5%	38.5%	25.2%	fuel sold
NOx	0.62	1.03	0.80	0.79	27%	-23%	-1%	2.7%	6.4%	5.8%	1.5%	1.9%	3.5%	fuel sold
NMVOC	0.50	0.42	0.54	0.42	-15%	1%	-22%	2.8%	3.3%	3.9%	1.9%	2.8%	3.7%	fuel sold
NH3	0.05	0.05	0.06	0.05	9%	8%	-19%	0.7%	0.8%	0.9%	0.7%	0.8%	0.9%	fuel sold
CO	3.99	2.96	3.74	3.05	-24%	3%	-19%	0.9%	15.0%	21.2%	0.9%	7.7%	14.6%	fuel sold
TSP	0.63	0.55	0.70	0.54	-14%	0%	-23%	3.8%	24.5%	21.4%	3.6%	14.0%	16.7%	fuel sold
PM10	0.59	0.52	0.67	0.52	-13%	0%	-23%	3.7%	30.0%	31.6%	3.6%	16.8%	24.4%	fuel sold
PM2.5	0.57	0.50	0.65	0.50	-13%	0%	-23%	3.7%	37.8%	47.4%	3.6%	20.6%	36.6%	fuel sold

Source: Environment Agency

Further important sources of air pollutants of this source category were NMVOC, CO, and TSP. In 2017, this source category represented:

- 3.7% of national total NMVOC emissions (based on fuel sold) and 3.9% of national total NMVOC emissions (based on fuel used).
- 14.6% of national total CO emissions (based on fuel sold) and 21.2% of national total CO emissions (based on fuel used).
- 16.7% of national total TSP emissions (based on fuel sold) and 21.4% of national total TSP emissions (based on fuel used).

As presented in the following table, with regard to SO_2, NO_x, NMVOC, CO, TSP, PM_{10} and $PM_{2.5}$, *1A4b i Residential* is a key category (LA & TA) in 2017 (see Table 189 and also Table 49 in Section 3.2 and Chapter 1.5).

Table 189 – Key Categories (fuel sold & fuel used) of sub-category *1A4b i - 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			5	6	7				3	2	1	2	1	2	1	2
1 A 4 b ii	Residential: Household and gardening (mobile)									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 4 b i	Residential: stationary			4	7	6				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 190 – 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	0.045	3.988	0.628	0.591	0.575
1991	1.003	0.744	0.516	0.045	4.219	0.647	0.608	0.591
1992	0.869	0.680	0.493	0.045	3.923	0.623	0.586	0.571
1993	0.862	0.673	0.500	0.045	4.016	0.630	0.592	0.576
1994	0.753	0.639	0.464	0.045	3.561	0.594	0.561	0.546
1995	0.769	0.645	0.478	0.045	3.739	0.607	0.572	0.557
1996	0.749	0.701	0.448	0.045	3.362	0.578	0.546	0.532
1997	0.741	0.685	0.444	0.045	3.304	0.574	0.543	0.528
1998	0.731	0.709	0.431	0.045	3.147	0.561	0.532	0.518
1999	0.632	0.635	0.429	0.045	3.111	0.557	0.528	0.514
2000	0.932	0.952	0.418	0.044	3.021	0.545	0.517	0.504
2001	0.990	1.030	0.444	0.048	3.181	0.582	0.553	0.538
2002	0.909	0.972	0.409	0.044	2.918	0.535	0.508	0.495
2003	0.918	1.004	0.414	0.045	2.929	0.542	0.515	0.502
2004	0.967	1.067	0.431	0.047	3.050	0.565	0.537	0.523
2005	0.931	1.034	0.417	0.045	2.962	0.545	0.518	0.505
2006	0.958	1.027	0.411	0.045	2.908	0.540	0.513	0.500
2007	0.913	0.974	0.371	0.041	2.629	0.487	0.463	0.451
2008	0.472	0.982	0.406	0.045	2.861	0.532	0.505	0.492
2009	0.468	0.955	0.452	0.050	3.171	0.593	0.564	0.549
2010	0.396	0.892	0.468	0.051	3.296	0.609	0.579	0.564
2011	0.315	0.797	0.364	0.040	2.593	0.472	0.448	0.437
2012	0.371	0.820	0.448	0.050	3.138	0.587	0.558	0.544
2013	0.353	0.799	0.492	0.054	3.456	0.643	0.611	0.595
2014	0.295	0.711	0.538	0.060	3.745	0.705	0.670	0.652
2015	0.338	0.792	0.421	0.049	3.050	0.543	0.515	0.502
2016	0.044	0.803	0.503	0.058	3.590	0.655	0.622	0.606
2017	0.035	0.792	0.424	0.051	3.088	0.555	0.527	0.514
Trend 1990-2017	*-95.71%*	*27.36%*	*-14.77%*	*13.62%*	*-22.56%*	*-11.61%*	*-10.70%*	*-10.51%*

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 2000-2017, 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 191.

Table 191 – 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*	Gaseous *Natural Gas*	Biomass *Wood and similar wood wastes*	Other
1990	10 209 974	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	11 221 977	6'985'232	253'192	3'338'553	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	12 056 736	6'794'806	133'647	4'483'283	645 000	NO
1997	11 675 576	6'718'170	123'577	4'188'829	645 000	NO
1998	12 196 002	6'954'434	89'753	4'506'815	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	16 822 075	7'192'446	22'774	9'027'820	579 036	NO
2012	17 059 500	8'000'314	18'751	8'315'615	724 820	NO
2013	17 147 535	7'525'396	26'584	8'797'046	798 509	NO
2014	15 761 501	6'411'849	20'855	8'443'674	885 123	NO
2015	17 496 835	7'336'703	25'796	9'195'335	939 001	NO
2016	18 210 084	7'346'075	24'557	9'781'925	1 057 527	NO
2017	18 258 504	7'155'153	15'951	9'991'936	1 095 464	NO
Trend 1990-2017	*78.83%*	*12.51%*	*-94.06%*	*240.25%*	*69.84%*	*NA*

Source: Environment Agency

For the estimation of NO_x emissions, the top-down activity data was further split into more detailed activity data using country-specific technology ratios as illustrated in Table 192. The ratios for 2005 to 2011 were derived from a national study.[58] For the years before 2005 and after 2012, trend extrapolation was used.

Table 192 – 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%

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 Guideboook 2016 have been applied for the main air pollutants.

[58] 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.

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 fireplace, conventional traditional stoves and domestic cooking burning wood (log wood), for advanced combustion stoves, catalytic combustor stovesand advanced combustion boilers burning wood (wood chips) and for modern pellet stoves, automatic wood boilers burning wood (pellets), from the EMEP/EEA Guidebook 2016 (Chapter 1A4 Small Combustion, Tables 3.15, 3.16, 3.19, 3.21, 3.17, 3.24, 3.25, 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 tacken from the following sources:

- conventional boilers: small (single household scale, capacity <=50 kWth) boilers burning natural gas: EMEP/EEA Guidebook 2016 (Chapter 1A4 Small Combustion, Tables 3.19) ; small (single household scale, capacity <=50 kWth) boilers burning gasoil: EMEP/EEA Guidebook 2016 (Chapter 1A4 Small Combustion, Tables 3.31)
- new conventional boilers burning natural gas or gasoil : 36 g NOx/GJ for natural gas, 44 g NOx/GJ for gasoil. NOx emission factors were taken from a national study[58] with reference to a German study[59]
- condensing boilers: 16 g NOx/GJ for natural gas, 20 g NOx/GJ for gasoil ; no default emission factor for this technology and for neither natural gas, nor gasoil is available in the EMEP/EEA Guidebook 2016. 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 1 default emission factors from the EMEP/EEA Guidebook 2009 have been applied.

The methods applied and emission factors (EF) used as well as coverage of energy consumption for 2017 are presented in Table 193.

[59] Effiziente Bereitstellung aktueller Emissionsdaten für die Luftreinhaltung, Umweltbundesamt, Germany, 2008 (UBA-FB-001217)

Table 193 – Methods and Emission Factors used in relation to the energy in consumption in 2017 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 2016 (Chap 1A4, Tables 3-14 & 3-15) ; EMEP/EEA GB 2016 (Chap 1A4, Tables 3-40, 3-42, 3-44) ; EMEP/EEA GB 2016 (Chap 1A4, Table 3-16) ; CRTE (German Study: UBA 2008) ; IIR AT 2016, table 114, p168 ; EMEP/EEA GB 2016 (Chap 1A4, Table 3-18)
	T1	D	0.0%	
NMVOC CO TSP PM10 PM2.5	T2	D	100.0%	EMEP/EEA GB 2016 (Chap 1A4, Tables 3-14 & 3-15) ; EMEP/EEA GB 2016 (Chap 1A4, Tables 3-40, 3-42, 3-44) ; EMEP/EEA GB 2016 (Chap 1A4, Table 3-16) ; EMEP/EEA GB 2016 (Chap 1A4, Table 3-18)
	T1	D	0.0%	
SOx	T2	CS	39.1%	CS based on maximum allowed sulfur content
	T2	D	60.9%	EMEP/EEA GB 2016 (Chap 1A4, Tables 3-14 & 3-15) ; EMEP/EEA GB 2016 (Chap 1A4, Tables 3-40, 3-42, 3-44) ; EMEP/EEA GB 2016 (Chap 1A4, Table 3-16)
	T1	D	0.0%	

Source: Environment Agency

Table 194 gives an overview of the evolution of the implied emission factors.

Table 194 – Implied emission factors for category *1A4b i - Residential*

1 A 4 Other Sectors								
Implied Emission Factor (IEF) of air pollutants by source category (g/GJ)								
Year	1 A 4 b i Residential: Stationary							
	SO2	*NOx*	*NMVOC*	*NH3*	*CO*	*TSP*	*PM10*	*PM2.5*
1990	80.62	60.91	48.76	4.42	390.61	61.51	57.85	56.27
1991	83.00	61.61	42.70	3.74	349.23	53.58	50.33	48.95
1992	77.47	60.62	43.90	4.02	349.57	55.53	52.26	50.84
1993	77.14	60.23	44.74	4.04	359.32	56.35	53.00	51.55
1994	70.22	59.56	43.28	4.21	332.10	55.42	52.29	50.89
1995	70.51	59.13	43.86	4.14	342.96	55.71	52.50	51.08
1996	62.10	58.15	37.18	3.74	278.81	47.91	45.30	44.09
1997	63.49	58.65	38.00	3.87	282.96	49.14	46.48	45.25
1998	59.92	58.15	35.36	3.70	258.00	46.02	43.59	42.45
1999	56.83	57.17	38.56	4.06	279.96	50.16	47.52	46.27
2000	56.22	57.43	25.19	2.67	182.30	32.89	31.20	30.39
2001	54.95	57.12	24.65	2.65	176.45	32.29	30.65	29.86
2002	52.79	56.45	23.75	2.56	169.44	31.08	29.52	28.76
2003	51.19	55.98	23.08	2.52	163.38	30.24	28.74	28.00
2004	50.39	55.57	22.44	2.46	158.86	29.41	27.95	27.24
2005	49.52	54.97	22.16	2.41	157.47	28.98	27.54	26.83
2006	51.84	55.55	22.22	2.44	157.29	29.19	27.74	27.03
2007	51.01	54.42	20.72	2.27	146.80	27.17	25.83	25.17
2008	25.43	52.93	21.86	2.40	154.20	28.66	27.24	26.55
2009	25.49	52.05	24.62	2.72	172.74	32.32	30.72	29.93
2010	21.48	48.39	25.36	2.78	178.74	33.03	31.38	30.57
2011	18.74	47.37	21.64	2.35	154.12	28.05	26.65	25.97
2012	21.73	48.06	26.27	2.91	183.97	34.41	32.70	31.86
2013	20.58	46.58	28.70	3.18	201.53	37.51	35.64	34.71
2014	18.70	45.10	34.15	3.82	237.59	44.72	42.49	41.39
2015	19.33	45.25	24.05	2.80	174.32	31.01	29.46	28.71
2016	2.42	44.08	27.60	3.20	197.13	35.96	34.16	33.28
2017	1.93	43.38	23.24	2.81	169.15	30.41	28.89	28.16
Trend 1990-2017	-97.60%	-28.78%	-52.34%	-36.47%	-56.69%	-50.57%	-50.07%	-49.96%

Source: Environment Agency

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. Emission trends for the main air pollutants are given in Table 195.

1A4b ii–Residential: Household and gardening (mobile) is a key category for CO (LA) in 2017 (see Table 189 in section 3.2.5.4 and Table 49 in Section 3.2 and Chapter 1.5).

Table 195 – 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	0.25961	0.00000	1.24424	0.00048	0.00048	0.00048
1991	0.00031	0.00527	0.26050	0.00000	1.24755	0.00048	0.00048	0.00048
1992	0.00031	0.00530	0.26187	0.00000	1.25376	0.00048	0.00048	0.00048
1993	0.00031	0.00532	0.26254	0.00000	1.25686	0.00049	0.00049	0.00049
1994	0.00031	0.00544	0.25789	0.00000	1.24231	0.00048	0.00048	0.00048
1995	0.00030	0.00565	0.24874	0.00000	1.21279	0.00046	0.00046	0.00046
1996	0.00030	0.00586	0.23956	0.00000	1.18315	0.00044	0.00044	0.00044
1997	0.00030	0.00608	0.23025	0.00000	1.15303	0.00042	0.00042	0.00042
1998	0.00030	0.00629	0.22081	0.00000	1.12248	0.00040	0.00040	0.00040
1999	0.00030	0.00655	0.21319	0.00000	1.10100	0.00039	0.00039	0.00039
2000	0.00030	0.00679	0.20658	0.00000	1.08260	0.00037	0.00037	0.00037
2001	0.00030	0.00699	0.20172	0.00000	1.07001	0.00036	0.00036	0.00036
2002	0.00030	0.00722	0.19808	0.00000	1.05432	0.00036	0.00036	0.00036
2003	0.00030	0.00747	0.19663	0.00000	1.03979	0.00036	0.00036	0.00036
2004	0.00015	0.00768	0.18770	0.00000	1.02877	0.00036	0.00036	0.00036
2005	0.00014	0.00782	0.17135	0.00000	1.01470	0.00036	0.00036	0.00036
2006	0.00014	0.00798	0.15542	0.00000	1.00352	0.00036	0.00036	0.00036
2007	0.00003	0.00812	0.13898	0.00000	0.99175	0.00036	0.00036	0.00036
2008	0.00003	0.00825	0.12257	0.00000	0.98172	0.00036	0.00036	0.00036
2009	0.00003	0.00836	0.10714	0.00000	0.97521	0.00037	0.00037	0.00037
2010	0.00003	0.00845	0.09388	0.00000	0.97214	0.00037	0.00037	0.00037
2011	0.00003	0.00851	0.08368	0.00000	0.97539	0.00037	0.00037	0.00037
2012	0.00003	0.00854	0.07649	0.00000	0.97903	0.00037	0.00037	0.00037
2013	0.00003	0.00859	0.07395	0.00000	0.98420	0.00037	0.00037	0.00037
2014	0.00003	0.00872	0.07391	0.00000	0.99946	0.00038	0.00038	0.00038
2015	0.00003	0.00882	0.07427	0.00000	1.01111	0.00038	0.00038	0.00038
2016	0.00003	0.00888	0.07459	0.00000	1.01802	0.00039	0.00039	0.00039
2017	0.00003	0.00894	0.07503	0.00000	1.02493	0.00039	0.00039	0.00039
Trend 1990-2017	*-91.45%*	*70.58%*	*-71.10%*	*-23.53%*	*-17.63%*	*-19.10%*	*-19.10%*	*-19.10%*

Source: Environment Agency

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. For 2017, it was estimated that 125 242 garden machines were in operation for an average of 30 hours per machine and year. Fuel consumption activity data used for estimating air pollutant emissions are given in Table 196.

Table 196 – 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	65 612	65'612	NA	NA	NO	NA
1992	65 958	65'958	NA	NA	NO	NA
1993	66 128	66'128	NA	NA	NO	NA
1994	65 997	65'997	NA	NA	NO	NA
1995	65 608	65'608	NA	NA	NO	NA
1996	65 213	65'213	NA	NA	NO	NA
1997	64 805	64'805	NA	NA	NO	NA
1998	64 385	64'385	NA	NA	NO	NA
1999	64 475	64'475	NA	NA	NO	NA
2000	64 586	64'586	NA	NA	NO	NA
2001	64 792	64'792	NA	NA	NO	NA
2002	64 723	64'723	NA	NA	NO	NA
2003	64 484	64'484	NA	NA	NO	NA
2004	63 782	63'782	NA	NA	IE	NA
2005	62 400	62'400	NA	NA	IE	NA
2006	61 163	61'163	NA	NA	IE	NA
2007	59 624	59'624	NA	NA	IE	NA
2008	58 174	58'174	NA	NA	IE	NA
2009	56 900	56'900	NA	NA	IE	NA
2010	55 864	55'864	NA	NA	IE	NA
2011	54 758	54'758	NA	NA	IE	NA
2012	54 779	54'779	NA	NA	IE	NA
2013	54 779	54'779	NA	NA	IE	NA
2014	55 158	55'158	NA	NA	IE	NA
2015	55 204	55'204	NA	NA	IE	NA
2016	55 325	55'325	NA	NA	IE	NA
2017	55 959	55'959	NA	NA	IE	NA
Trend 1990-2017	*-14.42%*	*-14.42%*	*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 197.

Table 197 – 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	3970.36	0.07	19028.72	7.36	7.36	7.36
1991	4.71	80.31	3970.25	0.07	19014.00	7.35	7.35	7.35
1992	4.71	80.37	3970.20	0.07	19008.45	7.35	7.35	7.35
1993	4.71	80.39	3970.19	0.07	19006.37	7.35	7.35	7.35
1994	4.71	82.40	3907.65	0.07	18823.83	7.22	7.22	7.22
1995	4.65	86.13	3791.29	0.07	18485.34	6.98	6.98	6.98
1996	4.65	89.90	3673.49	0.07	18142.86	6.74	6.74	6.74
1997	4.65	93.76	3552.90	0.07	17792.31	6.49	6.49	6.49
1998	4.65	97.70	3429.60	0.06	17433.93	6.23	6.23	6.23
1999	4.65	101.64	3306.60	0.06	17076.43	5.98	5.98	5.98
2000	4.65	105.10	3198.45	0.06	16762.08	5.76	5.76	5.76
2001	4.65	107.82	3113.29	0.06	16514.58	5.58	5.58	5.58
2002	4.65	111.63	3060.50	0.06	16289.82	5.49	5.49	5.49
2003	4.65	115.92	3049.23	0.06	16124.72	5.51	5.51	5.51
2004	2.32	120.41	2942.82	0.06	16129.39	5.59	5.59	5.59
2005	2.32	125.38	2745.95	0.07	16261.28	5.73	5.73	5.73
2006	2.32	130.49	2541.14	0.07	16407.35	5.88	5.88	5.88
2007	0.47	136.24	2330.90	0.07	16633.46	6.06	6.06	6.06
2008	0.47	141.82	2106.98	0.07	16875.38	6.25	6.25	6.25
2009	0.47	146.95	1882.87	0.07	17139.00	6.42	6.42	6.42
2010	0.47	151.23	1680.56	0.07	17401.89	6.58	6.58	6.58
2011	0.47	155.33	1528.13	0.07	17812.64	6.76	6.76	6.76
2012	0.47	155.89	1396.26	0.06	17872.41	6.79	6.79	6.79
2013	0.47	156.73	1350.05	0.06	17966.84	6.83	6.83	6.83
2014	0.47	158.07	1339.90	0.06	18119.96	6.89	6.89	6.89
2015	0.47	159.79	1345.44	0.06	18316.07	6.96	6.96	6.96
2016	0.47	160.53	1348.30	0.06	18400.83	6.99	6.99	6.99
2017	0.47	159.78	1340.81	0.06	18315.87	6.96	6.96	6.96
Trend 1990-2017	*-90.01%*	*99.32%*	*-66.23%*	*-10.65%*	*-3.75%*	*-5.47%*	*-5.47%*	*-5.47%*

Source: Environment Agency

The methods applied and emission factors (EF) used as well as coverage of energy consumption for 2017 are presented in Table 198.

Table 198 – Methods and Emission Factors used in relation to the energy in consumption in 2017 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	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

3.2.5.6 **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 2017, fuel combustion activities in 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 2017, fuel combustion activities in sub-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.

In 2017, 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 also Table 49 in Section 3.2 and Chapter 1.5).

Table 199 summarizes emissions of air pollutants for category *1A4c - Agriculture/Forestry/Fishing* and Table 200 and Table 201 present the emission trends for categories *1A4c i* and *1A4c ii*, respectively.

Table 199 – Emissions (1990, 2005, 2016 and 2017), 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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
SO2	0.010	0.000	0.000	0.000	-98%	-8%	-1%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	fuel sold
NOx	0.011	0.009	0.011	0.009	-19%	-8%	-20%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	fuel sold
NMVOC	0.002	0.000	0.000	0.000	-97%	-8%	-1%	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	0.003	0.003	-33%	-8%	-1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
TSP	0.000	0.000	0.000	0.000	-83%	-8%	-1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
PM10	0.000	0.000	0.000	0.000	-83%	-8%	-1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
PM2.5	0.000	0.000	0.000	0.000	-83%	-8%	-1%	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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
SO2	0.021	0.001	0.000	0.000	-99%	-81%	3%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	fuel sold
NOx	0.328	0.269	0.199	0.206	-37%	-23%	4%	1.4%	1.7%	1.5%	0.8%	0.5%	0.9%	fuel sold
NMVOC	0.105	0.069	0.049	0.047	-55%	-32%	-3%	0.6%	0.5%	0.4%	0.4%	0.5%	0.4%	fuel sold
NH3	0.000	0.000	0.000	0.000	-50%	-32%	-2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	fuel sold
CO	0.451	0.296	0.190	0.182	-60%	-39%	-4%	0.1%	1.5%	1.3%	0.1%	0.8%	0.9%	fuel sold
TSP	0.071	0.039	0.019	0.017	-76%	-57%	-9%	0.4%	1.8%	0.7%	0.4%	1.0%	0.5%	fuel sold
PM10	0.071	0.039	0.019	0.017	-76%	-57%	-9%	0.4%	2.3%	1.0%	0.4%	1.3%	0.8%	fuel sold
PM2.5	0.071	0.039	0.019	0.017	-76%	-57%	-9%	0.5%	3.0%	1.6%	0.4%	1.6%	1.2%	fuel sold

Source: Environment Agency

Table 200 – Emission trends for category *1A4c i – Agriculture/Forestry/Fishing – stationary*

1 A 4 Other Sectors								
Emissions of air pollutants by source category (Gg)								
Year	1 A 4 c i Agriculture/Forestry/Fishing: Stationary							
	SO2	*NOx*	*NMVOC*	*NH3*	*CO*	*TSP*	*PM10*	*PM2.5*
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
Trend 1990-2017	*-97.77%*	*9.48%*	*-96.40%*	*NA*	*-10.02%*	*-77.50%*	*-77.50%*	*-77.50%*

Source: Environment Agency

Table 201 – 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	0.105	0.000	0.451	0.071	0.071	0.071
1991	0.020	0.320	0.103	0.000	0.442	0.069	0.069	0.069
1992	0.019	0.301	0.099	0.000	0.423	0.064	0.064	0.064
1993	0.019	0.295	0.098	0.000	0.416	0.062	0.062	0.062
1994	0.016	0.305	0.098	0.000	0.420	0.063	0.063	0.063
1995	0.006	0.303	0.096	0.000	0.411	0.061	0.061	0.061
1996	0.006	0.305	0.094	0.000	0.404	0.059	0.059	0.059
1997	0.006	0.303	0.092	0.000	0.395	0.057	0.057	0.057
1998	0.006	0.312	0.092	0.000	0.395	0.057	0.057	0.057
1999	0.005	0.311	0.090	0.000	0.386	0.056	0.056	0.056
2000	0.005	0.317	0.089	0.000	0.384	0.056	0.056	0.056
2001	0.005	0.280	0.082	0.000	0.346	0.048	0.048	0.048
2002	0.005	0.293	0.081	0.000	0.348	0.049	0.049	0.049
2003	0.005	0.285	0.077	0.000	0.330	0.046	0.046	0.046
2004	0.001	0.287	0.074	0.000	0.320	0.044	0.044	0.044
2005	0.001	0.269	0.069	0.000	0.296	0.039	0.039	0.039
2006	0.001	0.264	0.066	0.000	0.285	0.037	0.037	0.037
2007	0.000	0.253	0.063	0.000	0.269	0.034	0.034	0.034
2008	0.000	0.271	0.063	0.000	0.273	0.035	0.035	0.035
2009	0.000	0.268	0.061	0.000	0.262	0.033	0.033	0.033
2010	0.000	0.266	0.058	0.000	0.249	0.030	0.030	0.030
2011	0.000	0.250	0.055	0.000	0.230	0.026	0.026	0.026
2012	0.000	0.249	0.053	0.000	0.220	0.024	0.024	0.024
2013	0.000	0.210	0.050	0.000	0.195	0.020	0.020	0.020
2014	0.000	0.210	0.049	0.000	0.190	0.019	0.019	0.019
2015	0.000	0.206	0.047	0.000	0.182	0.017	0.017	0.017
2016	0.000	0.199	0.046	0.000	0.173	0.015	0.015	0.015
2017	0.000	0.193	0.045	0.000	0.166	0.014	0.014	0.014
Trend 1990-2017	*-99.26%*	*-41.31%*	*-57.34%*	*-52.48%*	*-63.12%*	*-80.70%*	*-80.70%*	*-80.70%*

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 classified:

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 202**Error! Reference source not found.**.

Table 202 – 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	NA	NO	NA
1991	127 683	127'683	NA	NA	NO	NA
1992	127 432	127'432	NA	NA	NO	NA
1993	106 233	106'233	NA	NA	NO	NA
1994	127 463	127'463	NA	NA	NO	NA
1995	106 232	106'232	NA	NA	NO	NA
1996	127 158	127'158	NA	NA	NO	NA
1997	148 755	148'755	NA	NA	NO	NA
1998	149 736	148'736	NA	NA	1 000	NA
1999	385 614	382'614	NA	NA	3 000	NA
2000	8 342	NO	NA	NA	8 342	NA
2001	21 523	NO	NA	NA	21 523	NA
2002	27 616	NO	NA	NA	27 616	NA
2003	56 381	NO	NA	NA	56 381	NA
2004	87 784	NO	NA	NA	87 784	NA
2005	126 974	NO	NA	NA	126 974	NA
2006	155 323	NO	NA	NA	155 323	NA
2007	178 422	NO	NA	NA	178 422	NA
2008	215 323	NO	NA	NA	215 323	NA
2009	264 049	NO	NA	NA	264 049	NA
2010	207 852	NO	NA	NA	207 852	NA
2011	187 642	NO	NA	NA	187 642	NA
2012	189 008	NO	NA	NA	189 008	NA
2013	167 367	NO	NA	NA	167 367	NA
2014	119 965	NO	NA	NA	119 965	NA
2015	118 243	NO	NA	NA	118 243	NA
2016	147 645	NO	NA	NA	147 645	NA
2017	159 720	NO	NA	NA	159 720	NA
Trend 1990-2017	*49.93%*	*NA*	*NA*	*NA*	*NA*	*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 Austia'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.

Activity data for mobile sources are listed in Table 203.

Table 203 – Activity data for category *1A4c – 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	352 748	352'748	NO	NO	NO	NO
1991	343 652	343'652	NO	NO	NO	NO
1992	322 515	322'515	NO	NO	NO	NO
1993	315 657	315'657	NO	NO	NO	NO
1994	325 319	325'319	NO	NO	NO	NO
1995	323 176	323'176	NO	NO	NO	NO
1996	323 562	323'562	NO	NO	NO	NO
1997	321 122	321'122	NO	NO	NO	NO
1998	329 700	329'700	NO	NO	NO	NO
1999	328 706	328'706	NO	NO	NO	NO
2000	334 228	334'228	NO	NO	NO	NO
2001	295 483	295'483	NO	NO	NO	NO
2002	315 237	315'237	NO	NO	NO	NO
2003	319 181	319'181	NO	NO	NO	NO
2004	337 685	337'685	NO	NO	IE	NO
2005	331 673	331'673	NO	NO	IE	NO
2006	338 950	338'950	NO	NO	IE	NO
2007	333 277	333'277	NO	NO	IE	NO
2008	361 845	361'845	NO	NO	IE	NO
2009	364 287	364'287	NO	NO	IE	NO
2010	366 747	366'747	NO	NO	IE	NO
2011	350 771	350'771	NO	NO	IE	NO
2012	353 793	353'793	NO	NO	IE	NO
2013	303 419	303'419	NO	NO	IE	NO
2014	312 239	312'239	NO	NO	IE	NO
2015	321 229	321'229	NO	NO	IE	NO
2016	324 610	324'610	NO	NO	IE	NO
2017	325 955	325'955	NO	NO	IE	NO
Trend 1990-2017	*-7.60%*	*-7.60%*	*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 mostly Tier 1 default emission factors from the EMEP/EEA Guidebook have been applied, as illustrated in Table 204.

Table 204 – Methods and Emission Factors used in relation to the energy in consumption in 2017 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	T2	CS	100.0%	EMEP/EEA GB 2016 (Chap 1A4, Table 3-26, p61)
	T1	D	0.0%	EMEP/EEA GB 2016 (Chap 1A4, Table 3-26, p61), EMEP/EEA GB 2016 (Chap 1A4, Table 3-24, p59)
NMVOC	T2	D	100.0%	EMEP/EEA GB 2016 (Chap 1A4, Table 3-26, p61)
	T1	D	0.0%	EMEP/EEA GB 2016 (Chap 1A4, Table 3-26, p61), EMEP/EEA GB 2016 (Chap 1A4, Table 3-24, p59)
SOx	T2	CS	0.0%	CS based on fuel sulfur content
	T2	D	100.0%	EMEP/EEA GB 2016 (Chap 1A4, Table 3-26, p61)
	T1	D	0.0%	EMEP/EEA GB 2016 (Chap 1A4, Table 3-26, p61)
CO	T2	D	100.0%	EMEP/EEA GB 2016 (Chap 1A4, Table 3-26, p61)
	T1	D	0.0%	EMEP/EEA GB 2016 (Chap 1A4, Table 3-26, p61), EMEP/EEA GB 2016 (Chap 1A4, Table 3-24, p59)
PM2.5	T2	D	100.0%	EMEP/EEA GB 2016 (Chap 1A4, Table 3-26, p61)
	T1	D	0.0%	EMEP/EEA GB 2016 (Chap 1A4, Table 3-26, p61), EMEP/EEA GB 2016 (Chap 1A4, Table 3-24, p59)
PM10	T3	CS	100.0%	EMEP/EEA GB 2016 (Chap 1A4, Table 3-26, p61)
	T1	D	0.0%	EMEP/EEA GB 2016 (Chap 1A4, Table 3-26, p61), EMEP/EEA GB 2016 (Chap 1A4, Table 3-24, p59)
TSP	T3	CS	100.0%	EMEP/EEA GB 2016 (Chap 1A4, Table 3-26, p61)
	T1	D	0.0%	EMEP/EEA GB 2016 (Chap 1A4, Table 3-26, p61), EMEP/EEA GB 2016 (Chap 1A4, Table 3-24, p59)

Source: Environment Agency

For mobile combustion (diesel oil and motor gasoline), country-specific values, derived from the GEORG model, have been applied, as listed in Table 205. For the $PM_{2.5}$ and PM_{10} emission factors, the condensable component is included.

Table 205 – Methods and Emission Factors used in relation to the energy in consumption in 2017 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	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 206 and Table 207 give an overview of the evolution of the implied emission factors.

Table 206 – 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	1.58	82.15	0.41	NA	27.01	0.51	0.51	0.51
2001	1.45	75.35	0.37	NA	24.77	0.46	0.46	0.46
2002	1.43	74.79	0.37	NA	24.59	0.46	0.46	0.46
2003	1.43	74.46	0.37	NA	24.48	0.46	0.46	0.46
2004	1.42	73.98	0.36	NA	24.32	0.46	0.46	0.46
2005	1.41	73.61	0.36	NA	24.20	0.45	0.45	0.45
2006	1.41	73.66	0.36	NA	24.22	0.45	0.45	0.45
2007	1.41	73.46	0.36	NA	24.15	0.45	0.45	0.45
2008	1.41	73.40	0.36	NA	24.13	0.45	0.45	0.45
2009	1.41	73.31	0.36	NA	24.10	0.45	0.45	0.45
2010	1.41	73.47	0.36	NA	24.16	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	73.01	0.36	NA	24.00	0.45	0.45	0.45
2015	1.40	73.01	0.36	NA	24.00	0.45	0.45	0.45
2016	1.40	73.02	0.36	NA	24.01	0.45	0.45	0.45
2017	1.40	73.02	0.36	NA	24.01	0.45	0.45	0.45
Trend 1990-2017	*-98.51%*	*-26.98%*	*-97.60%*	*NA*	*-39.98%*	*-85.00%*	*-85.00%*	*-85.00%*

Source: Environment Agency

Table 207 – 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	59.43	930.98	296.83	0.46	1279.42	201.71	201.71	201.71
1991	59.41	932.46	299.62	0.46	1287.53	200.44	200.44	200.44
1992	59.35	932.69	307.72	0.46	1310.94	199.21	199.21	199.21
1993	59.33	934.26	310.10	0.46	1317.80	197.83	197.83	197.83
1994	50.33	937.23	302.29	0.46	1291.54	193.94	193.94	193.94
1995	18.60	938.98	297.58	0.45	1271.21	188.28	188.28	188.28
1996	18.60	941.12	291.91	0.44	1248.02	182.82	182.82	182.82
1997	18.60	943.16	287.69	0.43	1228.86	177.72	177.72	177.72
1998	18.61	945.49	278.53	0.42	1196.72	173.37	173.37	173.37
1999	16.29	947.17	272.85	0.42	1174.62	169.31	169.31	169.31
2000	16.30	948.57	265.44	0.41	1148.84	166.07	166.07	166.07
2001	16.27	947.89	276.33	0.41	1171.89	163.77	163.77	163.77
2002	16.29	927.99	257.19	0.40	1103.36	156.46	156.46	156.46
2003	16.29	892.44	241.14	0.39	1033.57	144.66	144.66	144.66
2004	2.35	850.81	219.77	0.38	948.96	131.33	131.33	131.33
2005	2.35	810.19	208.41	0.36	893.12	118.90	118.90	118.90
2006	2.35	779.49	195.80	0.35	840.80	109.67	109.67	109.67
2007	0.47	760.31	189.45	0.34	807.42	102.36	102.36	102.36
2008	0.47	748.33	174.44	0.33	753.62	95.99	95.99	95.99
2009	0.47	736.18	167.25	0.32	718.50	89.36	89.36	89.36
2010	0.47	724.16	159.43	0.31	678.31	81.57	81.57	81.57
2011	0.47	713.89	157.50	0.29	655.26	74.77	74.77	74.77
2012	0.47	703.72	151.20	0.28	622.80	68.54	68.54	68.54
2013	0.47	692.66	163.38	0.27	641.75	64.55	64.55	64.55
2014	0.47	673.90	155.79	0.27	608.33	59.29	59.29	59.29
2015	0.47	642.84	146.91	0.25	565.69	52.22	52.22	52.22
2016	0.47	614.20	141.04	0.24	533.85	46.46	46.46	46.46
2017	0.47	591.31	137.03	0.24	510.70	42.14	42.14	42.14
Trend 1990-2017	*-99.20%*	*-36.49%*	*-53.83%*	*-48.57%*	*-60.08%*	*-79.11%*	*-79.11%*	*-79.11%*

Source: Environment Agency

3.2.5.7 **Uncertainties and time-series consistency**

Currently no uncertainty estimates are made. Uncertainty of the activity data can be checked in the Luxembourg's National Inventory report (NIR).

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 208 presents the main revisions and recalculations done since submission 2018 relevant to category *1A4 – Other Sectors*.

Table 208 – Recalculations done since submission 2018 for category *1A4 – Other Sectors*

Source category	Revisions 2018 ➔ 2019	Type of revision
1A4a, 1A4b, 1A4c	AD was revised due to a revised energy balance by the national statistics institute.	updated AD
1A4aii	NO_x, SO_2, NH_3, NMVOC, $PM_{2.5}$, PM_{10}, TSP, CO: Changed notation key from NO to IE (included in 1A2gvii)	Changed notation key
1A4ci	Aligned Tier 1 and Tier 2 default EFs from EMEP/EEA Guidebook 2009 to EMEP/EEA Guidebook 2016	Update EFs / methodology

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 209 – 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 2017, less than 0.003% of total national emissions of air pollutants occurred in category *1A5 – Other*, based on fuel sold (0.004% based on fuel used). In 1990, this category was responsible for less than 0.02% of air pollutant emissions from fuel combustion activities, based on fuel sold (0.03% based on fuel used). Table 210 gives an overview of the emissions occurring in category *1A5 – Other* as well as of its sub-categories.

Table 210 – Emissions (1990, 2005, 2016 and 2017), Trends and Shares of 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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
SO2	0.0002	0.0000	0.0000	0.0000	-100%	-80%	0%	0.0012%	0.0002%	0.0001%	0.0011%	0.0002%	0.0001%	fuel sold
NOx	0.0048	0.0014	0.0006	0.0006	-88%	-58%	-7%	0.0207%	0.0087%	0.0043%	0.0115%	0.0026%	0.0026%	fuel sold
NMVOC	0.0003	0.0001	0.0001	0.0001	-76%	-54%	-12%	0.0014%	0.0010%	0.0006%	0.0010%	0.0009%	0.0005%	fuel sold
NH3	0.0000	0.0000	0.0000	0.0000	10%	-30%	2%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	fuel sold
CO	0.0025	0.0009	0.0005	0.0005	-80%	-44%	-4%	0.0006%	0.0044%	0.0034%	0.0005%	0.0022%	0.0023%	fuel sold
TSP	0.0003	0.0001	0.0000	0.0000	-90%	-73%	-15%	0.0017%	0.0047%	0.0011%	0.0016%	0.0027%	0.0009%	fuel sold
PM10	0.0003	0.0001	0.0000	0.0000	-90%	-73%	-15%	0.0017%	0.0060%	0.0017%	0.0017%	0.0034%	0.0013%	fuel sold
PM2.5	0.0003	0.0001	0.0000	0.0000	-90%	-73%	-15%	0.0018%	0.0078%	0.0026%	0.0017%	0.0043%	0.0020%	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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
SO2	0.0001	NO	NO	NO	NO	NO	NO	0.0005%	NO	NO	0.0004%	NO	NO	fuel sold
NOx	0.0033	NO	NO	NO	NO	NO	NO	0.0145%	NO	NO	0.0080%	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	2016	2017	1990 - 2017	2005 - 2017	2016 - 2017	1990	2005	2017	1990	2005	2017	
SO2	0.0001	0.0000	0.0000	0.0000	-99%	-80%	0%	0.0007%	0.0002%	0.0001%	0.0007%	0.0002%	0.0001%	fuel sold
NOx	0.0014	0.0014	0.0006	0.0006	-59%	-58%	-7%	0.0062%	0.0087%	0.0043%	0.0035%	0.0026%	0.0026%	fuel sold
NMVOC	0.0002	0.0001	0.0001	0.0001	-75%	-54%	-12%	0.0013%	0.0010%	0.0006%	0.0009%	0.0009%	0.0005%	fuel sold
NH3	0.0000	0.0000	0.0000	0.0000	10%	-30%	2%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	fuel sold
CO	0.0014	0.0009	0.0005	0.0005	-65%	-44%	-4%	0.0003%	0.0044%	0.0034%	0.0003%	0.0022%	0.0023%	fuel sold
TSP	0.0003	0.0001	0.0000	0.0000	-89%	-73%	-15%	0.0015%	0.0047%	0.0011%	0.0015%	0.0027%	0.0009%	fuel sold
PM10	0.0003	0.0001	0.0000	0.0000	-89%	-73%	-15%	0.0016%	0.0060%	0.0017%	0.0015%	0.0034%	0.0013%	fuel sold
PM2.5	0.0003	0.0001	0.0000	0.0000	-89%	-73%	-15%	0.0017%	0.0078%	0.0026%	0.0016%	0.0043%	0.0020%	fuel sold

Source: Environment Agency

3.2.6.2 **Other Stationary (1A5a)**

3.2.6.2.1 Source category description

In 2017, 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 211 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 2017 (see also Table 49 in Section 3.2 and Chapter 1.5).

Table 211 – Emission trends of category *1A5 a – Other Stationary*

1 A 5 Other								
Emissions of air pollutants by source category (Gg)								
Year	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
Trend 1990-2017	*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 212 – 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
Trend 1990-2017	*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 213 – 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	Source
NOx NMVOC CO TSP PM10 PM2.5	T2	D	NO	EMEP/EEA GB 2016 (Chap 1A4, Table 3-24, p59) EMEP/EEA GB 2016 (Chap 1A4, Table 3-26, p61)
SOx	T2	D	NO	EMEP/EEA GB 2016 (Chap 1A4, Table 3-26, p61)
	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 214.

Table 214 – Implied Emission Factors for category *1A5a – Other Stationary*

1 A 5 Other								
Implied Emission Factor (IEF) of air pollutants by source category (g/GJ)								
Year	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
Trend 1990-2017	*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 2017, emissions from fuel combustion activities in category *1A5b – Other Mobile* represented less than 0.003% of the national total emissions, based on fuel sold (less than 0.005% base on fuel used). 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 215 gives an overview of the emissions occurring in category *1A5b – Other Mobile*.

1A5b – Other Mobile related air pollutant emissions were not a key category in 2017 (see also Table 49 in Section 3.2 and Chapter 1.5).

Table 215 – Emission trends of category *1A5b - Other Mobile*

1 A 5 Other								
Emissions of air pollutants by source category (Gg)								
Year	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	0.000087	0.001478	0.000227	0.000000	0.001330	0.000235	0.000235	0.000235
1995	0.000032	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	0.000031	0.001598	0.000205	0.000000	0.001243	0.000192	0.000192	0.000192
1998	0.000031	0.001637	0.000198	0.000000	0.001215	0.000179	0.000179	0.000179
1999	0.000027	0.001672	0.000191	0.000000	0.001189	0.000167	0.000167	0.000167
2000	0.000027	0.001696	0.000187	0.000000	0.001172	0.000158	0.000158	0.000158
2001	0.000027	0.001712	0.000184	0.000000	0.001160	0.000153	0.000153	0.000153
2002	0.000027	0.001685	0.000174	0.000000	0.001111	0.000144	0.000144	0.000144
2003	0.000027	0.001618	0.000158	0.000000	0.001027	0.000131	0.000131	0.000131
2004	0.000004	0.001522	0.000144	0.000000	0.000945	0.000118	0.000118	0.000118
2005	0.000004	0.001402	0.000132	0.000000	0.000862	0.000104	0.000104	0.000104
2006	0.000004	0.001281	0.000119	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
Trend 1990-2017	*-99.25%*	*-65.97%*	*-80.59%*	*53.70%*	*-67.03%*	*-92.60%*	*-92.60%*	*-92.60%*

Source: Environment Agency

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 216.

Table 216 – 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	1 634	1'634	NA	NA	NO	NA
2016	1 634	1'634	NA	NA	NO	NA
2017	1 633	1'633	NA	NA	NO	NA
Trend 1990-2017	*-4.81%*	*-4.81%*	*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 217 – Methods and Emission Factors used in relation to the energy in consumption in 2017 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	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 218.

Table 218 – 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	0.25	798.61	149.02	149.02	149.02
1991	60.26	841.19	137.69	0.27	796.08	147.14	147.14	147.14
1992	60.26	845.83	136.90	0.25	793.52	145.25	145.25	145.25
1993	60.26	849.55	136.27	0.32	791.46	143.72	143.72	143.72
1994	51.08	869.75	133.79	0.28	783.10	138.38	138.38	138.38
1995	18.83	901.74	129.98	0.27	770.22	130.29	130.29	130.29
1996	18.83	931.08	126.51	0.26	758.47	122.93	122.93	122.93
1997	18.83	960.27	123.08	0.24	746.85	115.68	115.68	115.68
1998	18.83	990.36	119.56	0.25	734.92	108.27	108.27	108.27
1999	16.48	1018.19	116.31	0.27	723.91	101.42	101.42	101.42
2000	16.48	1037.06	114.10	0.29	716.41	96.76	96.76	96.76
2001	16.48	1049.71	112.61	0.30	711.36	93.60	93.60	93.60
2002	16.48	1036.17	107.03	0.32	683.14	88.29	88.29	88.29
2003	16.48	998.31	97.75	0.32	633.82	81.07	81.07	81.07
2004	2.35	939.78	89.16	0.30	583.44	73.15	73.15	73.15
2005	2.35	864.96	81.09	0.38	531.92	64.26	64.26	64.26
2006	2.35	788.98	72.96	0.38	479.86	55.26	55.26	55.26
2007	0.47	706.82	65.85	0.32	433.45	46.94	46.94	46.94
2008	0.47	627.65	61.39	0.33	401.34	40.45	40.45	40.45
2009	0.47	561.72	58.64	0.26	379.56	35.52	35.52	35.52
2010	0.47	510.18	56.40	0.24	362.95	31.85	31.85	31.85
2011	0.47	469.71	54.81	0.28	351.42	29.24	29.24	29.24
2012	0.47	435.40	51.44	0.27	338.70	26.37	26.37	26.37
2013	0.47	408.87	46.25	0.22	323.05	23.04	23.04	23.04
2014	0.47	385.45	41.09	0.24	307.38	19.93	19.93	19.93
2015	0.47	359.36	35.96	0.24	290.96	16.95	16.95	16.95
2016	0.47	330.63	30.85	0.26	273.82	14.11	14.11	14.11
Trend 1990-2016	*-99.22%*	*-60.48%*	*-77.72%*	*3.26%*	*-65.71%*	*-90.53%*	*-90.53%*	*-90.53%*

Source: Environment Agency

3.2.6.4 **Uncertainties and time-series consistency**

Currently no uncertainty estimates are made. Uncertainty of the activity data can be checked in the Luxembourg's National Inventory report (NIR).

The time series reported under *1A5 – Other* are considered to be 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 219 presents the main revisions and recalculations done since submission 2018 relevant to category *1A5 – Other*.

Table 219 – Recalculations done since submission 2018 for category *1A5 – Other*

Source category	Revisions 2018 ➔ 2019	Type of revision
1A5a	Aligned Tier 1 and Tier 2 default EFs from EMEP/EEA Guidebook 2009 to EMEP/EEA Guidebook 2016	Update EFs / methodology

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 220 – 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 221, as well as information on the status of emission estimates for all sub-categories.

Table 221* – 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	NA	NO	NO	NO	NO	NO
1 B 1 c	Other fugitive emissions from solid fuels	NO	NO	NA	NO	NO	NO	NO	NO
1 B 2 a i	Exploration, Production, Transport	NA	NO	NA	NA	NA	NA	NA	NA
1 B 2 a iv	Refining / Storage	NA	NO	NA	NA	NA	NA	NA	NA
1 B 2 a v	Distribution of oil products	NA	X	NA	NA	NA	NA	NA	NA
1 B 2 b	Other	NA	X	NA	NA	NA	NA	NA	NA
1 B 2 c	Venting and flaring (Oil and natural gas)	NO	NO	NA	NO	NO	NO	NO	NO
1 B 3	Other fugitive emissions from energy production	NO	NO	NA	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 (categories *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 2018, neither in the level, nor in the trend assessments, and has never been.

Table 222 presents the emission trends of this category.

Table 222 - Emission trends for category *1B1 – Fugitive emissions – Solid Fuels*

Year	1B1a - Fugitive emissions from coal storage and handling (Gg)		
	$PM_{2.5}$	PM_{10}	TSP
1990	1.1650	11.6495	29.1238
1991	1.1098	11.0980	27.7449
1992	1.0505	10.5049	26.2623
1993	1.0826	10.8261	27.0653
1994	0.9405	9.4047	23.5117
1995	0.5330	5.3297	13.3241
1996	0.5058	5.0581	12.6452
1997	0.3244	3.2435	8.1089
1998	0.1164	1.1643	2.9109
1999	0.1177	1.1769	2.9424
2000	0.1329	1.3295	3.3236
2001	0.1431	1.4308	3.5770
2002	0.0882	0.8817	2.2042
2003	0.0679	0.6786	1.6964
2004	0.0958	0.9582	2.3956
2005	0.0928	0.9275	2.3188
2006	0.1103	1.1034	2.7586
2007	0.0928	0.9280	2.3201
2008	0.0892	0.8921	2.2302
2009	0.0805	0.8048	2.0120
2010	0.0805	0.8047	2.0117
2011	0.0704	0.7043	1.7607
2012	0.0651	0.6513	1.6284
2013	0.0576	0.5764	1.4409
2014	0.0644	0.6436	1.6091
2015	0.0595	0.5954	1.4885
2016	0.0635	0.6346	1.5865
2017	0.0554	0.5540	1.3850
2018	0.0515	0.5150	1.2875
Trend 1990-2018	-95.58%	-95.58%	-95.58%
2005-2018	-44.48%	-44.48%	-44.48%
2017-2018	-7.04%	-7.04%	-7.04%

3.3.1.2 **Methodological issues**

3.3.1.2.1 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 223.

Table 223 – 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	201'519	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	113'334	99'195	91'738	81'177	90'655	83'860	89'381
2017	**2018**							
78'031	72'536							

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 method applied and emission factor (EF) used in sub-category *1B1a – Coal Mining and Handling* is given in Table 224.

Table 224 – 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 2016 (Chap. 1B1a, Tab3-6, p12)	0.3	g/Mg coal
EF controlled storage – $PM_{2.5}$	EEA/EMEP GB 2016 (Chap. 1B1a, Tab3-5, p11)	0.041	Mg/ha/year
EF Handling - PM_{10}	EEA/EMEP GB 2016 (Chap. 1B1a, Tab3-6, p12)	3	g/Mg coal
EF controlled storage – PM_{10}	EEA/EMEP GB 2016 (Chap. 1B1a, Tab3-5, p11)	0. 41	Mg/ha/year
EF Handling – TSP	EEA/EMEP GB 2016 (Chap. 1B1a, Tab3-6, p12)	7.5	g/Mg coal
EF controlled storage – TSP	EEA/EMEP GB 2016 (Chap. 1B1a, Tab3-5, p11)	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 225, with regard to NMVOC emission, *1B2 – Oil and Natural Gas* is a key category (LA) in 2018 (see also Chapter 1.5).

Table 225 – 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
1 B 2 b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)					8											

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)					7	8				

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 226 presents the emission trends of this category.

Table 226 – Emission trends 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	0.012	-
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	-0.001	-
1996	0.470	0.311	0.000	-
1997	0.497	0.318	-0.024	-
1998	0.474	0.321	-0.048	-
1999	0.474	0.332	-0.075	-
2000	0.466	0.341	-0.105	-
2001	0.441	0.379	-0.110	-
2002	0.408	0.543	-0.156	-
2003	0.392	0.550	-0.164	-
2004	0.349	0.611	-0.203	-
2005	0.293	0.601	-0.207	-
2006	0.268	0.631	-0.189	-
2007	0.256	0.591	-0.185	-
2008	0.241	0.565	-0.170	-
2009	0.222	0.571	-0.156	-
2010	0.198	0.614	-0.153	-
2011	0.214	0.532	-0.144	-
2012	0.202	0.544	-0.148	-
2013	0.181	0.464	-0.138	-
2014	0.181	0.438	-0.124	-
2015	0.166	0.394	-0.119	-
2016	0.159	0.362	-0.118	-
2017	0.168	0.356	-0.124	-
2018	0.186	0.352		
Trend 1990-2018	*-54.42%*	*59.77%*		
2005-2018	*-36.42%*	*-41.41%*		
2017-2018	*10.97%*	*-1.09%*		

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 227.

Table 227 – Activity data for category *1B2 - Oil and Natural Gas*

Natural Gas Consumption (GJ)					
1990	**1991**	**1992**	**1993**	**1994**	**1995**
17 933 317	18 646 148	19 434 013	20 184 361	20 334 431	23 237 685
1996	**1997**	**1998**	**1999**	**2000**	**2001**
25 491 947	26 121 115	26 375 108	27 358 063	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**	
35 310 029	32 201 184	29 685 081	29 283 800	28 792 801	

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 sub-category *1B2a v - Distribution of Oil Products* and sub-category *1B2 - Oil and Natural Gas* are given, respectively, in Table 228 and Table 229.

Table 228 – 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 2016 (Chap. 1B2av, Tab3-12, p19)	0.06	kg/t
Abatement efficiency	-	0.00	%
EF ServStat – storage tank – filling	EEA/EMEP GB 2016 (Chap. 1B2av, Tab3-8, p17)	24.00	g/m3/kPa
Abatement efficiency	EEA/EMEP GB 2016 (Chap. 1B2av, Tab3-14, p20)	0.95	%
EF ServStat – storage tank – breathing	EEA/EMEP GB 2016 (Chap. 1B2av, Tab3-9, p17)	3.00	g/m3/kPa
Abatement efficiency	-	0.00	%
EF ServStat – Car Refuelling	EEA/EMEP GB 2016 (Chap. 1B2av, Tab3-10, p18)	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 (2005-18)	% %
EF ServStat – Car Refuelling – Drips & minor spillage	EEA/EMEP GB 2016 (Chap. 1B2av, Tab3-11, p17)	2.00	g/m3/kPa
Abatement efficiency	-	0.00	%
Method	EEA/EMEP GB 2016 (Chap. 1B2av, eq2, p13)	T2	
EF used	EEA/EMEP GB 2016 (Chap. 1B2av, 3.3, p13)	D	
Diesel	**Source**	**Value**	**Unit**
Emission Factor – NMVOC	2006 IPCC Guidelines (Vol2, NMVOC, Tab4.2.4, p4.50)	ND	Gg/10^3m3
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/10^3m3
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/10^3m3
Method	2006 IPCC Guidelines (Vol,2 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[60] 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.[61] 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 2009. As no data exists on the implementation rate of Stage II between 1997 and 2004, a linear implementation was assumed between these years. Form 2005 onwards, full implementation of Stage II was assumed, as legally required.

Table 229 – Method applied and Emission factor (EF) used for category *1B2b - Natural Gas*

Natural Gas	Source	Value	Unit
Emission Factor – NMVOC	EEA/EMEP GB 2016 (Chap. 1B2b, Tab3-17, p22)	0.45	Gg/10^3m3
Method	EEA/EMEP GB 2016 (Chap. 1B2b, 3.4, p16) EEA/EMEP GB 2016 (Chap. 1B2b, eq. 5, p17)	T3	
EF used	EEA/EMEP GB 2016 (Chap. 1B2b, Tab3-17, p22))	CS	

Source: Environment Agency

3.3.3 Uncertainties and time-series consistency

Currently no uncertainty estimates are made. Uncertainty of the activity data can be checked in the Luxembourg's National Inventory report (NIR).

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- ArcelorMittal 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.

[60] 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.

[61] European Commission & Entec UK Limited, Stage II Petrol Vapour Recovery – Final Report, (2005), p. XXXIV.

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 230 presents the main revisions and recalculations done to category *1B – Fugitive Emissions*.

Table 230 – Recalculations done since submission 2019 for category *1B - Fugitive Emissions*

Source category	Revisions 2019 ➔ 2020	Type of revision
1B1b, 1B1c, 1B2ai, 1B2aiv, 1B2c	notation key changed from NA to NO for various pollutants (recommendation LU-1B-2017-0001).	Change of notation key
1B1a	Updated description (implantation of recommendation LU-1B1a-2017-0001).	Updated methodological description
1B2av	updated timeseries on average temperature for Luxembourg city as needed for the calculation of the true vapour pressure (1990, 195-2017) ; updated abatement efficiency according to LU regulation: since 2005 (1st Jan.) all service stations must be equipped with Stage II abatement equipment. Hence, NMVOC emissions were reduced by up to 0.207 Gg.	Updated method

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 231 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 the following Table 232.

Table 231 – 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	NA	NA
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	NO	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	IE	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	NA	NO	NA	NA	NA	NA	NA	NA
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 232 – 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 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 *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, PM_{10}, and $PM_{2.5}$ 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, PM_{10}, and $PM_{2.5}$ are to be considered as process emissions, 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, PM_{10}, and $PM_{2.5}$ are to be considered as process emissions, 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, PM_{10}, and $PM_{2.5}$ are to be considered as process emissions, these are allocated to category *2D3b*, whereas NOx, SO_2 and CO are considered as combustion emissions and are allocated to category *1A2g viii*.
2 I Wood processing	NO_X, SO_2, NMVOC, NH_3, 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 ***2.A.5.a Quarrying and mining of minerals other than coal***

4.2.1 **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".

4.3 ***2.A.5.b Construction and demolition***

4.3.1 **Source category description**

Emissions ($PM_{2.5}$, PM_{10} and TSP) associated with the construction and demolition activities are assigned to category 2A5b.

Table 234 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.

Category *2A5b - Construction and demolition* is a key category in 2017 with regard to TSP emissions (LA&TA) and PM_{10} emissions (LA) as presented in Table 233 (and also Chapter 1.5).

Table 233 – 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											4	5	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 234 – PM_{10} and $PM_{2.5}$ emission trends per construction activity

		PM_{10} (t)					$PM_{2.5}$ (t)		
year	residential	non-residential	road construction	Total	year	residential	non-residential	road construction	Total
1990	14.28	19.61	87.02	120.91	1990	1.43	1.96	8.70	12.09
1991	14.25	25.34	0.00	39.59	1991	1.43	2.53	0.00	3.96
1992	15.46	31.98	317.14	364.58	1992	1.55	3.20	31.71	36.46
1993	17.51	25.34	93.28	136.13	1993	1.75	2.53	9.33	13.61
1994	14.07	15.99	391.77	421.82	1994	1.41	1.60	39.18	42.18
1995	14.15	22.62	37.31	74.09	1995	1.42	2.26	3.73	7.41
1996	11.31	15.38	630.20	656.89	1996	1.13	1.54	63.02	65.69
1997	10.86	14.78	152.57	178.21	1997	1.09	1.48	15.26	17.82
1998	13.35	23.53	109.25	146.13	1998	1.34	2.35	10.93	14.61
1999	14.97	29.26	0.00	44.23	1999	1.50	2.93	0.00	4.42
2000	9.35	16.59	0.00	25.94	2000	0.94	1.66	0.00	2.59
2001	12.23	27.75	0.00	39.98	2001	1.22	2.78	0.00	4.00
2002	10.33	22.93	205.21	238.47	2002	1.03	2.29	20.52	23.85
2003	12.15	22.02	391.77	425.94	2003	1.22	2.20	39.18	42.59
2004	13.17	15.08	20.70	48.95	2004	1.32	1.51	2.07	4.89
2005	11.50	15.38	18.66	45.54	2005	1.15	1.54	1.87	4.55
2006	11.48	20.51	0.00	31.99	2006	1.15	2.05	0.00	3.20
2007	15.05	15.08	0.00	30.13	2007	1.50	1.51	0.00	3.01
2008	21.80	19.91	0.00	41.71	2008	2.18	1.99	0.00	4.17
2009	22.36	13.57	93.28	129.21	2009	2.24	1.36	9.33	12.92
2010	14.36	8.45	0.00	22.81	2010	1.44	0.84	0.00	2.28
2011	12.83	9.95	0.00	22.79	2011	1.28	1.00	0.00	2.28
2012	11.68	10.56	0.00	22.24	2012	1.17	1.06	0.00	2.22
2013	14.35	8.75	0.00	23.10	2013	1.44	0.87	0.00	2.31
2014	18.23	14.48	0.00	32.71	2014	1.82	1.45	0.00	3.27
2015	15.61	12.67	167.90	196.18	2015	1.56	1.27	16.79	19.62
2016	18.75	15.69	0.00	34.44	2016	1.88	1.57	0.00	3.44
2017	20.34	16.68	74.62	111.65	2017	2.03	1.67	7.46	11.16
Trend 2016-2017	8.49%	6.35%	NA	224.20%	**Trend 2016-2017**	8.49%	6.35%	NA	224.20%
2005-2017	76.89%	8.43%	300.00%	145.16%	**2005-2017**	76.89%	8.43%	300.00%	145.16%
1990-2017	42.45%	-14.92%	-14.24%	-7.66%	**1990-2017**	42.45%	-14.92%	-14.24%	-7.66%

4.3.2 Methodological issues & time-series consistency

4.3.2.1 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 235). Constructed road length was converted to constructed road surface using the following assumptions:

a) Municipal roads width: 18 m
b) State roads: 20.25 m
c) Highway with 4 side strip: 36.5 m

Please note that annual construction of new roads is very variable in Luxembourg, due to its small size.

Table 235 – 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	Highway with 4 side strip
1990	1'427	168	65	60'750	109'500	0
1991	1'337	177	84	0	0	0
1992	1'311	207	106	0	620'500	0
1993	1'359	248	84	0	182'500	0
1994	1'159	192	53	0	766'500	0
1995	1'121	198	75	0	73'000	0
1996	1'018	145	51	0	0	1'233'000
1997	1'018	135	49	0	109'500	189'000
1998	1'001	193	78	141'750	0	72'000
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	401'500	0
2003	898	177	73	0	766'500	0
2004	841	206	50	40'500	0	0
2005	725	181	51	0	36'500	0
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	182'500	0
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	328'500	0
2016	1'183	295	52	0	0	0
2017	1'286	320	55	0	0	0
Trend 2016-2017	8.69%	8.41%	6.35%	NA	NA	NA
2005-2017	77.35%	76.69%	8.43%	NA	-100.00%	NA
1990-2017	-9.89%	90.36%	-14.92%	-100.00%	-100.00%	NA

4.3.2.2 **Methodology**

The methodology used is the Tier 1 method as described in the EMEP/EEA Guidebook 2016. 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 236).

Table 236 – 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

4.3.2.3 **Emission factors**

For the main air pollutants (TSP, PM_{10}, $PM_{2.5}$), the Tier 1 default emission factors from the EMEP/EEA Guidebook 2016 have been applied (Table 237).

Table 237 – 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	0.99	1.70	7.70
PM_{10}	kg/(m2*year)	0.09	0.30	0.51	2.30
$PM_{2.5}$	kg/(m2*year)	0.01	0.03	0.05	0.23

4.3.3 **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?

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

No recalculations were made.

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

No further improvements are planned.

4.4 *Non-energy products from fuels and solvent use (2.D)*

4.4.1 **Other – Solvent Use (2.D.3)**

4.4.1.1 **Sector Overview**

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 238, with regard to NMVOC emissions, *2D3 - Non-energy products from fuels and solvent use* is a key category (LA & TA) in 2017 and a key category with regard to TSP and PM_{10} (LA) (see Table 238 and also Chapter 1.5).

Table 238 – 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	3										
2 D 3 b	Road paving with asphalt											5		7			
2 D 3 d	Coating application					5											
2 D 3 e	Degreasing					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
2 D 3 a	Domestic solvent use including fungicides					1	2				
2 D 3 d	Coating application					5	7				
2 D 3 e	Degreasing					4	4				
2 D 3 g	Chemical products					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, …)

NMVOC emissions (Table 239) in category *2D3 - Non-energy products from fuels and solvent use* increased by 14.9% between 1990 and 2017. Although the Luxembourgish population has seen a 50% increase in the same time span, overall solvent use only shows a slight increase, which can be partially 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[62];

[62] 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).

- 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[63]
- 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)[64], extended by eight protocols from which the following have relevance:
    - The 1988 Protocol concerning the Control of Nitrogen Oxides or their Transboundary Fluxes;[65]
    - The 1991 Protocol concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes;[66]
    - The 1998 Protocol on Persistent Organic Pollutants (POPs);[67]
    - The 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone; 21 Parties.[68]
- Ordinance for volatile organic compounds (VOC) due to the use of organic solvents in certain activities and installations;[69]
- 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;

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[63] 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.

[64] 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)

[65] 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)

[66] 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)

[67] 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)

[68] 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)

[69] *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;.*

- Regulation on the limitation of emission during the use of solvents containing lightly volatile halogenated hydrocarbons in industrial facilities and installations.[70]

Table 239 – Emission trends for category *2D3 - Non-energy products from fuels and solvent use: Other*

NMVOC emissions (Gg)										
	2D3	2D3a	2D3b	2D3c	2D3d	2D3e	2D3f	2D3g	2D3h	2D3i
	TOTAL	Dometics solvent use including fungicides	Road paving with asphalt	Asphalt roofing	Coating applications	Degreasing	Dry cleaning	Chemical products	Printing	Other solvent use (please specify in the IR)
1990	5.02	1.13	0.01	NO	1.45	0.91	0.02	0.81	0.53	0.16
1991	5.02	1.13	0.01	NO	1.45	0.91	0.02	0.81	0.53	0.16
1992	5.02	1.13	0.01	NO	1.45	0.91	0.02	0.81	0.53	0.16
1993	5.01	1.13	0.01	NO	1.45	0.91	0.02	0.81	0.53	0.16
1994	4.98	1.12	0.01	NO	1.44	0.90	0.02	0.80	0.53	0.16
1995	5.66	1.28	0.01	NO	1.64	1.03	0.02	0.91	0.60	0.18
1996	5.83	1.37	0.01	NO	1.67	1.09	0.02	0.86	0.62	0.19
1997	5.60	1.37	0.01	NO	1.59	1.08	0.02	0.74	0.59	0.19
1998	5.13	1.31	0.01	NO	1.44	1.03	0.02	0.61	0.54	0.18
1999	5.23	1.39	0.01	NO	1.44	1.08	0.02	0.55	0.54	0.19
2000	4.95	1.37	0.01	NO	1.35	1.05	0.02	0.45	0.51	0.18
2001	5.14	1.41	0.01	NO	1.34	1.11	0.02	0.53	0.53	0.18
2002	5.66	1.54	0.01	NO	1.40	1.25	0.02	0.65	0.59	0.20
2003	4.74	1.27	0.02	NO	1.12	1.06	0.02	0.60	0.49	0.16
2004	6.32	1.73	0.00	NO	1.58	1.36	0.03	0.79	0.63	0.20
2005	6.10	1.70	0.00	NO	1.61	1.25	0.03	0.74	0.58	0.19
2006	4.87	1.41	0.00	NO	1.26	1.03	0.02	0.54	0.41	0.19
2007	4.05	1.23	0.00	NO	1.03	0.89	0.02	0.41	0.30	0.17
2008	5.70	1.80	0.00	NO	1.43	1.30	0.03	0.52	0.36	0.26
2009	4.97	1.64	0.00	NO	1.24	1.17	0.02	0.41	0.26	0.23
2010	4.06	1.39	0.00	NO	1.01	0.98	0.02	0.30	0.18	0.18
2011	4.51	1.59	0.00	NO	1.10	1.10	0.02	0.33	0.18	0.19
2012	5.10	1.84	0.00	NO	1.21	1.25	0.03	0.37	0.19	0.21
2013	5.41	2.00	0.00	NO	1.26	1.34	0.03	0.38	0.19	0.22
2014	4.58	1.73	0.00	NO	1.04	1.14	0.02	0.32	0.15	0.18
2015	5.06	1.95	0.00	NO	1.12	1.26	0.03	0.34	0.15	0.20
2016	5.11	1.97	0.00	NO	1.13	1.27	0.03	0.35	0.15	0.20
2017	5.77	2.23	0.00	NO	1.28	1.44	0.03	0.39	0.17	0.23
Trend 2016-2017 (%)	12.92	12.94	NA	NA	12.94	12.94	12.94	12.94	12.94	12.94
Trend 1990-2017 (%)	14.93	97.29	NA	NA	-11.95	57.96	46.48	-51.28	-68.33	44.05

Source: Environment Agency.

4.4.1.2 **Methodology Overview**

As a first step the quantity of solvents used and the solvent emissions were calculated. To determine the quantity of solvents used, in Luxembourg, in the various applications, a bottom up and a top down approach were combined. The following figures present an overview of the methodology.

70 Règlement grand-ducal du 12 juillet 1995, relatif aux générateurs d'aérosols.

The top down approach provides total quantities of solvents used in Luxembourg. The share of solvents used for the different applications and the solvent emission factors have been calculated on the basis of the bottom up approach. It was based on the economic structure in Luxembourg, applying solvent use and emission factors from the Austrian survey by linking the results of bottom up and top down approach, quantities of solvents annually used and solvent emissions for the different applications were obtained.

This model has been developed for Austria (WINDSPERGER et al. 2002a, 2004) and was in the meantime applied for different European countries within the network "non-energy use of fossils and CO_2 emissions" (WINDSPERGER & STEINLECHNER, 2006). The application for Luxembourg is suitable as both countries show similar situation regarding economic and technical structure, and moreover as members of the EU similar legal framework conditions.

Figure 4-1 – Top-down-Approach compared to Bottom-up-Approach.

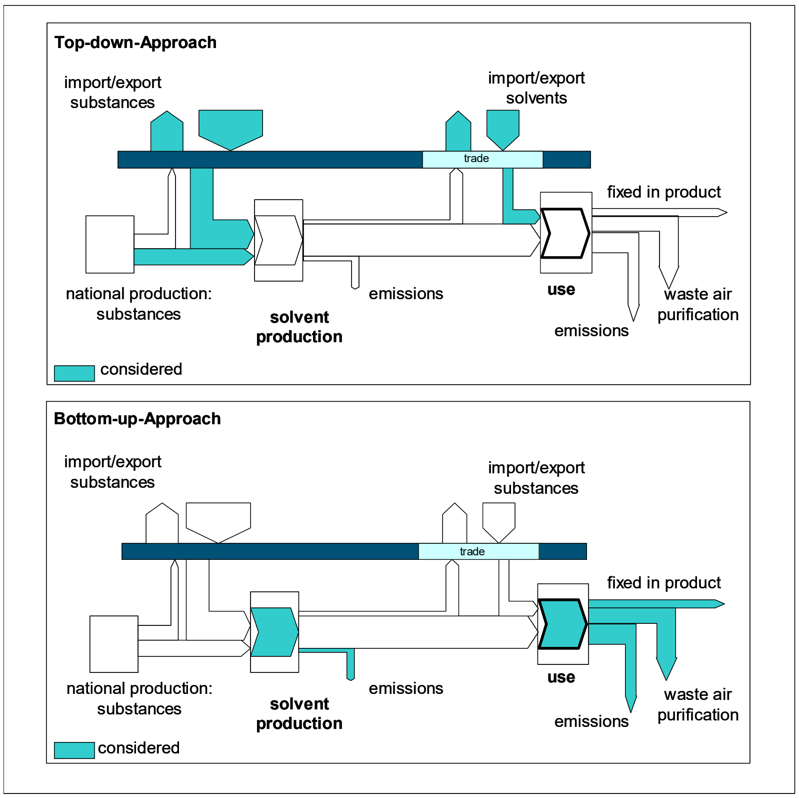


Figure 4-2 – Overview of the methodology for solvent emissions.

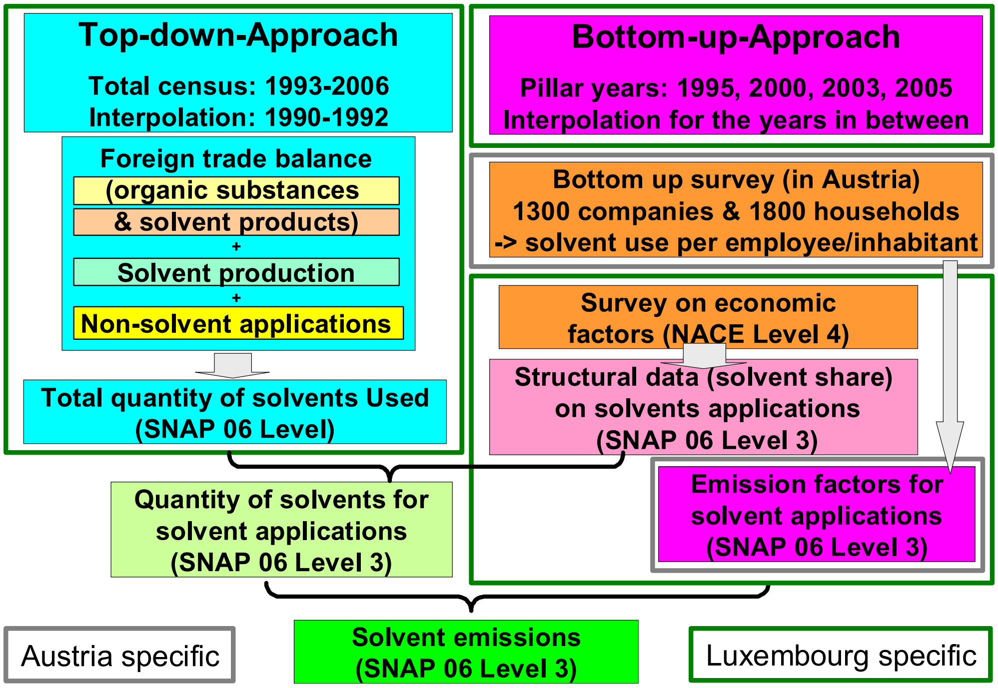


Figure 4-3 – Data of Top-down-Approach and Bottom-up-Approach for 2012.

Top-down: CRF Sector 3	
Imp/Exp Solvent products	2
Inland Solvent production	10
Imp/Exp Organic Substances	14
Non-solvent applications	-19
Substances used as solvents	-5
Solvents in applications	5
Solvent Activity	7

Bottom-up: CRF Sector 3A-3D	SNAP Level 3		Solvent Share CRF 3	Solvent Share CRF 3A-D	Solvent Share SNAP Lev 3	Solvent Emission Factor CRF 3	Solvent Emission Factor CRF 3A-D	Solvent Emission Factor SNAP Lev 3	Combination Top-down to Bottom-up: Solvent Activity CRF 3	Solvent Activity CRF 3A-D	Solvent Activity SNAP Lev 3	Solvent Emissions CRF 3	Solvent Emissions CRF 3A-D	Solvent Emissions SNAP Lev 3
3 A, Paint application	060101	Manufacture of automobiles	100%	26%	0.3%	68%	67%	64%	7.4	1.9	0.0	5.0	1.3	0.0
	060102	Car repairing			1.0%			86%			0.1			0.1
	060103	Construction and buildings			6.6%			89%			0.5			0.4
	060104	Domestic use			1.3%			89%			0.1			0.1
	060105	Coil coating			2.4%			52%			0.2			0.1
	060107	Wood coating			2.3%			90%			0.2			0.2
	060108	Other industrial paint application			11.9%			50%			0.9			0.4
3 B, Degreasing and Dry Cleaning	060201	Metal degreasing		31%	13.6%		51%	29%		2.3	1.0		1.2	0.3
	060202	Dry cleaning			0.3%			84%			0.0			0.0
	060203	Electronic components manufact.			0.0%			82%			0.0			0.0
	060204	Other industrial cleaning			16.7%			68%			1.2			0.8
3 C, Chemical Products, Manufacture and Processing	060305	Rubber processing		10%	6.3%		83%	93%		0.7	0.5		0.6	0.4
	060306	Pharmaceutical products manufact.			0.7%			26%			0.1			0.0
	060307	Paints manufacturing			0.5%			100%			0.0			0.0
	060308	Inks manufacturing			0.7%			100%			0.0			0.0
	060309	Glues manufacturing			0.0%			100%			0.0			0.0
	060310	Asphalt blowing			0.7%			1%			0.0			0.0
	060311	Adhesive, films & photographs			0.0%			94%			0.0			0.0
	060312	Textile finishing			0.0%			90%			0.0			0.0
	060314	Other manufacturing			0.9%			100%			0.1			0.1
3 D, Other	060403	Printing industry		34%	9.7%		79%	65%		2.5	0.7		2.0	0.5
	060404	Fat and oil extraction			0.3%			20%			0.0			0.0
	060405	Application of glues and adhesives			0.0%			63%			0.0			0.0
	060406	Preservation of wood			0.1%			99%			0.0			0.0
	060407	Treatment & conservation of vehicles			0.3%			85%			0.0			0.0
	060408	Domestic solvent use (other)			17.3%			84%			1.3			1.1
	060411	Domestic use of pharmac. products			4.0%			94%			0.3			0.3
	060412	Other (preservation of seeds,...)			2.1%			78%			0.2			0.1

A study compiled for Austria (WINDSPERGER et al. 2002a) showed huge overestimation of NMVOC emissions when emission estimates are based on a top down approach only because a large amount of substances is used for "non-solvent-applications". "Non-solvent applications" are applications where substances usually are used as feed stock in chemical, pharmaceutical or petrochemical industry (e.g. production of MTBE/ETBE, formaldehyde, polyester, biodiesel, pharmaceuticals etc.)

and where therefore no emissions from "solvent use" arise. However, there might be emissions from the use of the produced products, such as MTBE/ETBE which is used as fuel additive and finally combusted; these emissions are considered in the transport sector.

Additionally, the comparison of the top-down and the bottom-up approaches helped to identify several quantitatively important applications like windscreens wiper fluids, antifreeze, moonlighting, hospitals, de-icing agents of aeroplanes, tourism, which were not considered in the top-down approach.

4.4.1.2.1 Top down Approach

The top-down approach is based on:

1. import-export statistics on solvent substances and solvent containing products (foreign trade balance) (STATEC);
2. production statistics on solvents in Luxembourg;
3. a survey on non-solvent-applications in companies in Austria (Windsperger et al. 2004a);
4. survey on the solvent content in products and preparations at producers and retailers in Austria (Windsperger et al. 2002a).

ad (1) and (2): Total quantity of solvents used in Luxembourg were obtained from import-export statistics and production statistics provided by STATEC.

Nearly a full top down investigation of substances of the import-export statistics from 1993 to 2008 was carried out (data 1990 – 1992 were interpolated). One problem is that the methodology of the import-export statistics changed over the years. In case of severe deviations between some years smoothing the time series with the mean values was used.

In Luxembourg, there are only few facilities producing solvents. The production of solvents considerably decreased, especially in the last years.

ad (3): In a study on the comparison of top down and bottom up approach in Austria (WINDSPERGER et al. 2002a), the amount of solvents used in "non-solvent-applications" was identified. The most important companies in Austria were identified and asked to report the quantities of solvents they used over the considered time period in „non-solvent-applications". In combination with import-export statistic for these solvent substances the percentages of „non-solvent-applications" were calculated.

For Luxembourg, these percentages of "non-solvent-applications" were adapted to the country's specific situation according to information from companies in Luxembourg.

ad (4): Relevant producers and retailers provided data on solvent content in products and preparations in Austria. These data were also adapted to Luxembourg due to the country specific situation.

4.4.1.2.2 Bottom up Approach

In a first step, an extensive survey on the use of solvents in the year 2000 was carried out in 1 300 Austrian companies (WINDSPERGER et al. 2002b). In this extensive survey data about the solvent content of paints, cleaning agents etc. and on solvents used (both substances and substance categories) like acetone or alcohols were collected.

Furthermore, information was gathered on:

- type of application of the solvents: "final application", "cleaner" and "product preparation" as well as
- actual type of waste gas treatment: "open application", "waste gas collection" and "waste gas treatment".

For every category of application and waste gas treatment an emission factor was estimated to calculate solvent emissions in the year 2000 (see Table 240).

The survey in 1 300 Austrian companies in the year 2000 was carried out at all industrial branches with solvent applications at NACE-level-4. Within these NACE-levels data on solvent use distinguished in substance categories was collected from the companies and a factor of "solvent use per employee" was calculated. For the calculation of the total amounts within the SNAP-digit (level 3) the number of employees in the respective NACE-levels in 2000 was used (WINDSPERGER et al. 2002b). In accordance with statistics in other European countries the structural business statistics (number of employees (NACE Rev.1.1)) were taken from EUROSTAT 2008 [71].

Table 240 – Emission factors for NMVOC emissions.

Category	Factor
final application	1.00
cleaner	0.85
product preparation	0.05
open application	1.00
waste gas collection	0.50
waste gas treatment	0.20

In a second step a survey in 1 800 households was made (WINDSPERGER et al. 2002a) for estimating the domestic solvent use (37 categories in 5 main groups: cosmetic, do-it-yourself, household cleaning, car, fauna and flora). Also, solvent use in the context of moonlighting besides commercial work and do-it-yourself was calculated.

The comparison of top down and bottom up approach helped to identify several additional applications that make an important contribution to the total amount of solvents used. Thus in a third

[71] http://epp.eurostat.ec.europa.eu

step the quantities of solvents used in these applications such as windscreens wiper fluids, antifreeze, hospitals, de-icing agents of aeroplanes, tourism were estimated in surveys.

The outcome of these three steps was the total amount of solvents used for each application in the year 2000 (at SNAP level 3) in Austria (WINDSPERGER et al. 2002a).

To adapt the values for Luxembourg coefficients of the solvent consumption per employee (respective inhabitant) were used and applied to the employees of the industry sectors in Luxembourg (resp. Inhabitants). The outcome was the total amount of solvents for every application in the year 2000 in Luxembourg.

To achieve a time series, the development of the economic and technical situation in relation to the year 2000 was considered. It was distinguished between "general aspects" and "specific aspects". The information about these defined aspects were collected for two pillar years (1990 and 1995) and were taken from several studies (SCHMIDT et al. 1998, BARNERT 1998) and expert judgements from associations of industries (chemical industry, printing industry, paper industry) and other stakeholders. On the basis of this information calculation factors were estimated. With these factors and the data for solvent use and emission of 2000 data for the two pillar years was estimated. For the years in between, data was linearly interpolated. Since 2000, no new survey has been conducted so that the data remain constant since then.

For the pillar year 2005 and 2010 country specific data are used to update the bottom-up approach:

- update by of emission factors, type of waste gas treatment and solvent content by using information from solvents balances reported under the Solvent Ordinance.
- update of plant specific, information from associations of industries and statistical data for "general aspects" and "specific aspects".

Table 241 – General aspects and their development.

General aspects	1990	1995	2000	2005
efficiency factor solvent cleaning	150%	130%	100%	100%
efficiency factor application	110%	105%	100%	100%
solvent content of water-based paints	12%	10%	8%	8%
solvent content of solvent-based paints	58%	55%	55%	55%
efficiency of waste gas purification	75%	78%	80%	80%

Table 242 – Specific aspects and their development: distribution of the used paints (water based-paints – solvent-based paints) and part of waste gas purification (application – purification).

SNAP category	description	year	Distribution of used paints		Part of waste gas treatment	
			Solvent based paints	Water based paints	application	Purification
060101	manufacture of automobiles	2005	73%	27%	10%	0%
		2000	73%	27%	10%	0%
		1995	80%	20%	8%	0%
		1990	90%	10%	5%	0%
060102	car repairing	2005	51%	49%	62%	1%
		2000	51%	49%	62%	1%
		1995	55%	45%	60%	0%
		1990	75%	25%	10%	0%
060107	wood coating	2005	46%	54%	46%	3%
		2000	46%	54%	46%	3%
		1995	60%	40%	45%	2%
		1990	85%	15%	10%	0%
060108	Other industrial paint application	2005	97%	3%	90%	46%
		2000	97%	3%	90%	46%
		1995	99%	1%	87%	45%
		1990	100%	0%	26%	20%
060201	Metal degreasing	2005	92%	8%	75%	0%
		2000	92%	8%	75%	0%
		1995	95%	5%	65%	0%
		1990	100%	0%	10%	0%
060403	Printing industry	2005			44%	17%
		2000			44%	17%
		1995			29%	10%
		1990			10%	5%
060405	Application of glues and adhesives	2005			58%	0%
		2000			58%	0%
		1995			53%	0%
		1990			15%	0%
060103	Paint application : construction and buildings	2005	91%	9%	19%	4%
		2000	91%	9%	19%	4%
		1995	93%	7%	15%	2%
		1990	100%	0%	5%	0%
060105	Paint application : coil coating	2005	100%	0%	63%	0%
		2000	100%	0%	63%	0%
		1995	100%	0%	60%	0%
		1990	100%	0%	25%	0%
060406	Preservation of wood	2005	83%	17%	0%	0%
		2000	83%	17%	0%	0%
		1995	85%	15%	0%	0%
		1990	95%	5%	0%	0%
060412	Other (preservation of seeds,…)	2005	100%	0%	90%	0%
		2000	100%	0%	90%	0%
		1995	100%	0%	80%	0%
		1990	100%	0%	10%	0%

Table 243 – Specific aspects and their development: changes in the number of employees compared to the year 2000

SNAP	Description	Changes in the number of employees compared to the year 2000				
		1990	1995	2000	2003	2005
0601	Paint application					
060101	manufacture of automobiles	106%	106%	100%	134%	163%
060102	car repairing	93%	93%	100%	120%	125%
060103	construction and buildings	93%	93%	100%	120%	128%
060104	domestic use	separate analysis				
060105	coil coating	106%	106%	100%	32%	38%
060107	wood coating	93%	93%	100%	117%	126%
060108	industrial paint application	93%	93%	100%	100%	110%
0602	Degreasing, dry cleaning and electronics					
060201	Metal degreasing	117%	117%	100%	100%	88%
060202	Dry cleaning	94%	94%	100%	103%	106%
060203	Electronic components manufacturing	3%	3%	100%	96%	165%
060204	Other industrial cleaning	76%	76%	100%	134%	143%
0603	Chemical products manufacturing and processing					
060305	Rubber processing	190%	190%	100%	199%	198%
060306	Pharmaceutical products manufacturing	88%	88%	100%	194%	134%
060307	Paints manufacturing	133%	133%	100%	111%	111%
060308	Inks manufacturing	89%	89%	100%	94%	93%
060309	Glues manufacturing	NO	NO	NO	NO	NO
060310	Asphalt blowing	218%	218%	100%	103%	104%
060311	Adhesive, magnetic tapes, films and photographs	84%	84%	100%	70%	70%
060312	Textile finishing	119%	119%	100%	6%	7%
060314	Other	88%	88%	100%	87%	132%
0604	Other use of solvents and related activities					
060403	Printing industry	90%	90%	100%	111%	103%
060404	Fat, edible and non edible oil extraction	0%	0%	100%	155%	177%
060405	Application of glues and adhesives	NO	NO	NO	NO	NO
060406	Preservation of wood	91%	91%	100%	245%	125%
060407	Under seal treatment and conservation of vehicles	71%	71%	100%	102%	102%
060408	Domestic solvent use (other than paint application	analysed separately				
060411	Domestic use of pharmaceutical products (k)					
060412	Other (preservation of seeds,…)	32%	32%	100%	48%	24%

Because of the unavailability of data for employees in 1990 in the European database, the number of employees was taken out from 1995.

4.4.1.2.3 Combination Top-down – Bottom-up approach and updating

To verify and adjust the data, the solvents given in the top down approach and the results of the bottom up approach were differentiated in the pillar years (1995, 2000, 2003, 2005, 2010, 2015). The differences between the quantities of solvents from the top down approach and bottom up approach respectively are lower than 10%. Table 244 shows the range of the differences in the considered pillar years broken down to the 15 substance categories.

Table 244 – Differences between the results of the bottom up and the top down approach for Luxembourg.

Year	Differences [t/a]
2005	-760
2003	0
2000	54
1995	-549

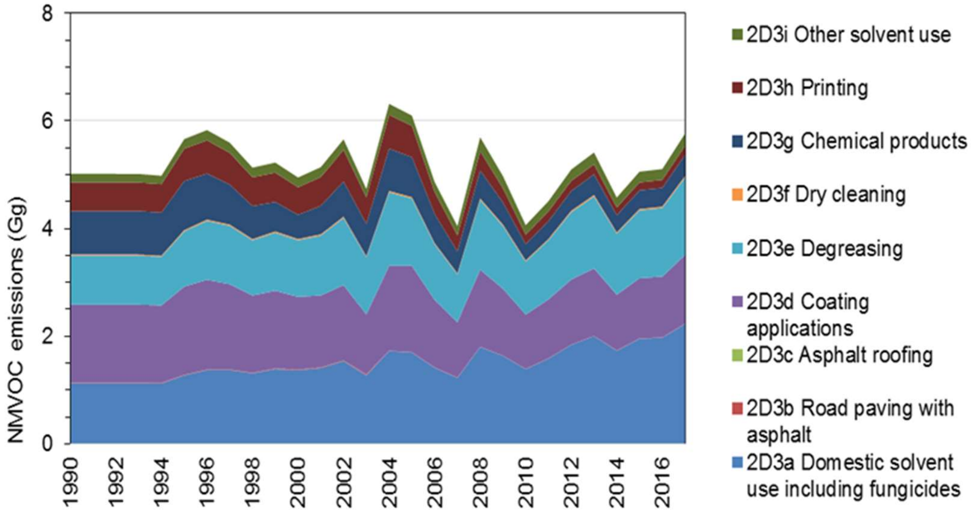
As the data of the top down approach were obtained from national statistics, they are assumed to be more reliable than the data of the bottom up approach. That's why the annual quantities of solvents used were taken from the top down approach while the share of the solvents for the different applications (on SNAP level 3) and the solvent emission factors have been calculated on the basis of the bottom up approach. The following tables present the activity data used and the implied emission factors for estimating NMVOC emissions.

Table 245 – Activity data of category *2D3 - Non-energy products from fuels and solvent use: Other*

	Solvents (Gg)									
	2D3	2D3a	2D3b	2D3c	2D3d	2D3e	2D3f	2D3g	2D3h	2D3i
	TOTAL	Dometics solvent use including fungicides	Road paving with asphalt	Asphalt roofing	Coating applications	Degreasing	Dry cleaning	Chemical products	Printing	Other solvent use (please specify in the IR)
1990	7.124	1.309	NE	NO	1.863	1.890	0.022	1.062	0.774	0.204
1991	7.124	1.309	NE	NO	1.863	1.890	0.022	1.062	0.774	0.204
1992	7.124	1.309	NE	NO	1.863	1.890	0.022	1.062	0.774	0.204
1993	7.124	1.309	NE	NO	1.863	1.890	0.022	1.062	0.774	0.204
1994	7.068	1.299	NE	NO	1.848	1.876	0.022	1.053	0.768	0.202
1995	8.045	1.478	NE	NO	2.103	2.135	0.025	1.199	0.874	0.230
1996	8.356	1.588	NE	NO	2.195	2.266	0.027	1.120	0.903	0.255
1997	8.102	1.591	NE	NO	2.139	2.245	0.026	0.965	0.871	0.263
1998	7.503	1.521	NE	NO	1.991	2.123	0.025	0.782	0.803	0.258
1999	7.711	1.611	NE	NO	2.056	2.227	0.026	0.689	0.820	0.280
2000	7.377	1.588	NE	NO	1.977	2.175	0.026	0.549	0.781	0.283
2001	7.618	1.635	NE	NO	1.940	2.280	0.026	0.647	0.814	0.276
2002	8.336	1.784	NE	NO	2.012	2.533	0.028	0.796	0.900	0.284
2003	6.922	1.477	NE	NO	1.578	2.136	0.023	0.734	0.754	0.221
2004	9.034	2.004	NE	NO	2.289	2.515	0.031	0.950	0.964	0.281
2005	8.553	1.970	NE	NO	2.384	2.124	0.030	0.892	0.894	0.258
2006	6.934	1.642	NE	NO	1.857	1.780	0.025	0.664	0.693	0.274
2007	5.856	1.425	NE	NO	1.504	1.552	0.022	0.510	0.559	0.285
2008	8.371	2.091	NE	NO	2.059	2.288	0.031	0.656	0.761	0.485
2009	7.417	1.901	NE	NO	1.743	2.089	0.028	0.517	0.641	0.498
2010	6.139	1.613	NE	NO	1.375	1.780	0.024	0.375	0.503	0.468
2011	6.743	1.839	NE	NO	1.484	1.963	0.026	0.405	0.519	0.507
2012	7.545	2.130	NE	NO	1.631	2.206	0.030	0.446	0.544	0.558
2013	7.932	2.315	NE	NO	1.684	2.328	0.032	0.461	0.534	0.578
2014	6.635	1.998	NE	NO	1.384	1.955	0.027	0.379	0.416	0.476
2015	7.264	2.254	NE	NO	1.488	2.148	0.030	0.408	0.422	0.514
2016	7.335	2.276	NE	NO	1.503	2.169	0.030	0.412	0.427	0.519
2017	8.284	2.570	NE	NO	1.697	2.449	0.034	0.465	0.482	0.586
Trend 2016-2017 (%)	12.94	12.94	NA	NA	12.94	12.94	12.94	12.94	12.94	12.94
Trend 1990-2017 (%)	16.27	96.28	NA	NA	-8.87	29.56	52.72	-56.17	-37.79	187.40

Source: Environment Agency

Figure 4-4 – NMVOC emissions and trend from 1990–2017 by subcategories of *2D3 - Non-energy products from fuels and solvent use: Other*



Source: Environment Agency

Table 246 – NMVOC implied emission factors

	NMVOC implied emission factor (g NMVOC/g solvents)									
	2D3	2D3a	2D3b	2D3c	2D3d	2D3e	2D3f	2D3g	2D3h	2D3i
	TOTAL	Dometics solvent use including fungicides	Road paving with asphalt	Asphalt roofing	Coating applications	Degreasing	Dry cleaning	Chemical products	Printing	Other solvent use (please specify in the IR)
1990	0.65	0.86	0.02	NO	0.78	0.48	0.88	0.76	0.69	0.77
1991	0.65	0.86	0.02	NO	0.78	0.48	0.88	0.76	0.69	0.77
1992	0.65	0.86	0.02	NO	0.78	0.48	0.88	0.76	0.69	0.77
1993	0.65	0.86	0.02	NO	0.78	0.48	0.88	0.76	0.69	0.77
1994	0.65	0.86	0.02	NO	0.78	0.48	0.88	0.76	0.69	0.77
1995	0.65	0.86	0.02	NO	0.78	0.48	0.88	0.76	0.69	0.77
1996	0.65	0.86	0.02	NO	0.76	0.48	0.87	0.76	0.68	0.75
1997	0.64	0.86	0.02	NO	0.74	0.48	0.87	0.77	0.68	0.72
1998	0.64	0.86	0.02	NO	0.72	0.48	0.86	0.78	0.67	0.69
1999	0.63	0.86	0.02	NO	0.70	0.48	0.86	0.79	0.66	0.67
2000	0.63	0.86	0.02	NO	0.68	0.48	0.85	0.82	0.66	0.64
2001	0.63	0.86	0.02	NO	0.69	0.49	0.85	0.82	0.66	0.67
2002	0.63	0.86	0.02	NO	0.70	0.49	0.85	0.82	0.65	0.69
2003	0.64	0.86	0.02	NO	0.71	0.50	0.84	0.82	0.65	0.71
2004	0.64	0.86	0.01	NO	0.69	0.54	0.84	0.83	0.65	0.73
2005	0.65	0.86	0.01	NO	0.67	0.59	0.84	0.83	0.65	0.74
2006	0.63	0.86	0.01	NO	0.68	0.58	0.84	0.81	0.59	0.68
2007	0.61	0.86	0.01	NO	0.68	0.57	0.84	0.80	0.53	0.61
2008	0.60	0.86	0.01	NO	0.70	0.57	0.84	0.79	0.47	0.53
2009	0.58	0.86	0.00	NO	0.71	0.56	0.84	0.79	0.41	0.46
2010	0.57	0.86	0.00	NO	0.74	0.55	0.84	0.81	0.35	0.38
2011	0.57	0.86	0.00	NO	0.74	0.56	0.84	0.81	0.35	0.37
2012	0.57	0.86	0.00	NO	0.74	0.57	0.84	0.82	0.35	0.38
2013	0.57	0.86	0.00	NO	0.75	0.57	0.84	0.83	0.35	0.38
2014	0.58	0.87	0.01	NO	0.75	0.58	0.84	0.84	0.35	0.38
2015	0.58	0.87	0.01	NO	0.75	0.59	0.84	0.84	0.35	0.39
2016	0.58	0.87	0.01	NO	0.75	0.59	0.84	0.84	0.35	0.39
2017	0.58	0.87	0.01	NO	0.75	0.59	0.84	0.84	0.35	0.39

Source: Environment Agency.

4.4.1.3 **Uncertainties and time-series consistency**

Consistency and completeness checks have been performed.

4.4.1.4 **Source specific QA/QC and verification**

The calculations of the data are embedded in the overall QA/QC-system of the air pollutant 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/NFR
- 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:

a) Bottom-up checks on:

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

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

b) Top-down checks include:

- 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.

- 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, default values).

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

The following table presents the main revisions and recalculations done since submission 2017 relevant to category *2D3 - Non-energy products from fuels and solvent use: Other*.

Table 247 –Recalculations done since submission 2018 for category *2D3 - Non-energy products from fuels and solvent use: Other*

Source category	Revisions 2018 → 2019	Type of revision
2D3	update of • data of production statistics, import and export statistics, • of plant specific information from associations of industries and statistical data for "general aspects" and "specific aspects" .	updated • AD • EF • parameter

Solvent content have been revised. Revised content has been applied to the years 2015-2017. In addition, for the years 2011-2014 solvent contents have been interpolated using the solvent contents of 2010 and 2015.

Solvent management reports from the major solvent consuming companies in Luxembourg were reviewed. Solvent based emissions from these companies were taken into account and the concerned solvent contents were adjusted accordingly.

European Directive 2004/42/CE 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 was taken into account to adjust various solvent contents of the aforementioned products.

Following the in country-review of 2018, several changes were made:

Notation key "IE" for categories 2D3b and 2D3c have been replaced by data and the annotations keys "NE" and "NO", respectively. For 2D3b, data was previously reported in 1A2gviii and has now been moved to 2D3b. More details about 2D3b are given in the section on road paving with asphalt.

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

The following improvements are planned for the next submission.

Table 248 – Planned improvements for category *2D3 - Non-energy products from fuels and solvent use*

Source category	Planned improvements	Type of revision
2D3	No further improvements are planned	n/a

4.5 *Other product use (2G)*

4.5.1 **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 249 and Table 250 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 249 – Emissions and activity data for category *2G – Tobacco Use*

2G - Tobacco Use										
Activity data, emissions										
Year	AD	NOx	NMVOC	NH3	TSP	PM10	PM2.5	Cd	Pb	Hg
	t of tobacco	t	t	t	t	t	t	t	t	t
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	379.72	0.68	1.84	1.58	10.25	10.25	10.25	2.050	NE	NE
Trend 1990-2017	*3.82%*	*3.82%*	*3.82%*	*3.82%*	*3.82%*	*3.82%*	*3.82%*	*3.82%*	*NA*	*NA*
2005-2017	*-5.13%*	*-5.13%*	*-5.13%*	*-5.13%*	*-5.13%*	*-5.13%*	*-5.13%*	*-5.13%*	*NA*	*NA*
2015-2017	*2.50%*	*2.50%*	*2.50%*	*2.50%*	*2.50%*	*-0.07%*	*2.50%*	*2.50%*	*NA*	*NA*

Source: Environment Agency.
Note: for emissions marked as NE, no emission factors are given in the EMEP/EEA Guidebook 2016.

Table 250 – 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*	*t*	*t*	*t*
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	43.60	0.01	0.13	4.79	4.36	2.26	0.064528	34.182	0.002485
Trend 1990-2017	*6400%*	*6400%*	*6400%*	*6400%*	*6400%*	*6400%*	*6400%*	*6400%*	*6400%*
2005-2017	*186.84%*	*186.84%*	*186.84%*	*186.84%*	*-100.00%*	*186.84%*	*186.84%*	*186.84%*	*186.84%*
2015-2017	*-20.15%*	*-20.15%*	*-20.15%*	*-20.15%*	*-20.15%*	*-20.15%*	*-20.15%*	*-20.15%*	*-20.15%*

4.5.2 **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 2016.

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 taking into account the purchased quantities of fireworks for the years 1999-2016, was applied to generate the missing data. The emission factors used are taken from the relevant chapter in the EMEP/EEA Guidebook 2016.

4.5.3 **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?

4.5.4 **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 *2.H.2 Food and Beverages Industry*

4.6.1 **Source category description**

Emissions (NMVOC) associated with activities in the food and beverages industry are assigned to category *2H2 – Food and beverages industry*.

Table 251 gives an overview of the activity in the food and beverages industry in Luxembourg, as well as the associated NMVOC emissions

Table 251 – 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*	*hl*	*Gg*
1990	0.231	59'256	0.119	151'120	0.012	599'839	0.021	17'538	0.079
1991	0.229	61'080	0.122	85'713	0.007	572'333	0.020	17'776	0.080
1992	0.248	62'908	0.126	271'227	0.022	569'126	0.020	18'013	0.081
1993	0.245	64'735	0.129	169'268	0.014	557'873	0.020	18'259	0.082
1994	0.249	66'559	0.133	174'998	0.014	531'117	0.019	18'510	0.083
1995	0.244	64'739	0.129	149'654	0.012	518'400	0.018	18'779	0.085
1996	0.261	74'080	0.148	127'617	0.010	483'453	0.017	19'021	0.086
1997	0.254	72'429	0.145	74'708	0.006	480'546	0.017	19'258	0.087
1998	0.260	71'692	0.143	159'711	0.013	468'519	0.016	19'500	0.088
1999	0.273	76'621	0.153	184'277	0.015	449'597	0.016	19'783	0.089
2000	0.268	75'951	0.152	131'931	0.011	438'423	0.015	20'029	0.090
2001	0.246	64'932	0.130	134'826	0.011	396'676	0.014	20'258	0.091
2002	0.228	55'166	0.110	153'872	0.012	386'021	0.014	20'454	0.092
2003	0.231	56'963	0.114	123'085	0.010	390'694	0.014	20'759	0.093
2004	0.229	54'508	0.109	155'828	0.012	377'272	0.013	21'042	0.095
2005	0.222	51'076	0.102	135'366	0.011	373'651	0.013	21'403	0.096
2006	0.215	47'391	0.095	123'652	0.010	360'921	0.013	21'727	0.098
2007	0.217	47'276	0.095	141'972	0.011	348'190	0.012	22'073	0.099
2008	0.218	47'387	0.095	129'669	0.010	335'460	0.012	22'516	0.101
2009	0.220	47'530	0.095	134'786	0.011	322'730	0.011	22'908	0.103
2010	0.220	47'738	0.095	110'248	0.009	310'000	0.011	23'351	0.105
2011	0.222	46'757	0.094	131'988	0.011	302'000	0.011	23'949	0.108
2012	0.221	47'048	0.094	85'035	0.007	292'000	0.010	24'501	0.110
2013	0.224	46'520	0.093	100'888	0.008	281'000	0.010	25'080	0.113
2014	0.235	50'176	0.100	124'936	0.010	271'000	0.009	25'687	0.116
2015	0.242	52'623	0.105	110'694	0.009	287'000	0.010	26'289	0.118
2016	0.251	56'660	0.113	82'947	0.007	290'000	0.010	26'951	0.121
2017	0.250	54'970	0.110	81'248	0.006	290'000	0.010	27'466	0.124
Trend									
1990-2017	*8.53%*	*-7.23%*	*-7.23%*	*-46.24%*	*-46.24%*	*-51.65%*	*-51.65%*	*56.61%*	*56.61%*
2005-2017	*12.51%*	*7.62%*	*7.62%*	*-39.98%*	*-39.98%*	*-22.39%*	*-22.39%*	*28.33%*	*28.33%*
2016-2017	*-0.48%*	*-2.98%*	*-2.98%*	*-2.05%*	*-2.05%*	*0.00%*	*0.00%*	*1.91%*	*1.91%*

4.6.2 **Methodological issues & time-series consistency**

The Tier 2 method, as described in the EMEP/EEA Guidebook 2016, 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 2016.

4.6.2.1 **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 2016 are described as having negligible emissions. As such Luxembourg assumes that the Tier 2 approach might still lead to an overestimation of emissions.

4.6.2.2 **Wine**

Regarding the production of wine, the activity data was obtained from the *Institut Viti-Vinicole*. A complete data set regarding the production of wine was obtained for the years 1990-2016. NMVOC emissions were calculated using a Tier 2 approach described in the EMEP/EEA Guidebook 2016. Similarly, the corresponding emission factor was taken from the same document.

4.6.2.3 **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. Data regarding the missing years were requested from the Luxembourgish customs, but have at the time of preparing this documentation not been delivered. As such, they will be included in the next inventory submission and have, for the time being, been replaced by an extrapolation. The NMVOC emissions were determined using a Tier 2 approach based on a corresponding emission factor taken from the EMEP/EEA Guidebook 2016.

4.6.2.4 **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. A Tier 2 approach was used to determine the corresponding NMVOC emissions. The employed emission factor was derived from the EMEP/EEA Guidebook 2016.

4.6.3 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?

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

No recalculations were done

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

The following improvements are planned for the next submission.

Table 252 – Planned improvements for category *2H2 – Food and Beverages Industry*

Source category	Planned improvements	Type of revision
2H2	Beer: collect beer production data for 2005-2018 from the Customs Administration, if available	Update AD

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 NFR category *3 - Agriculture* for the period 1990 to 2017.

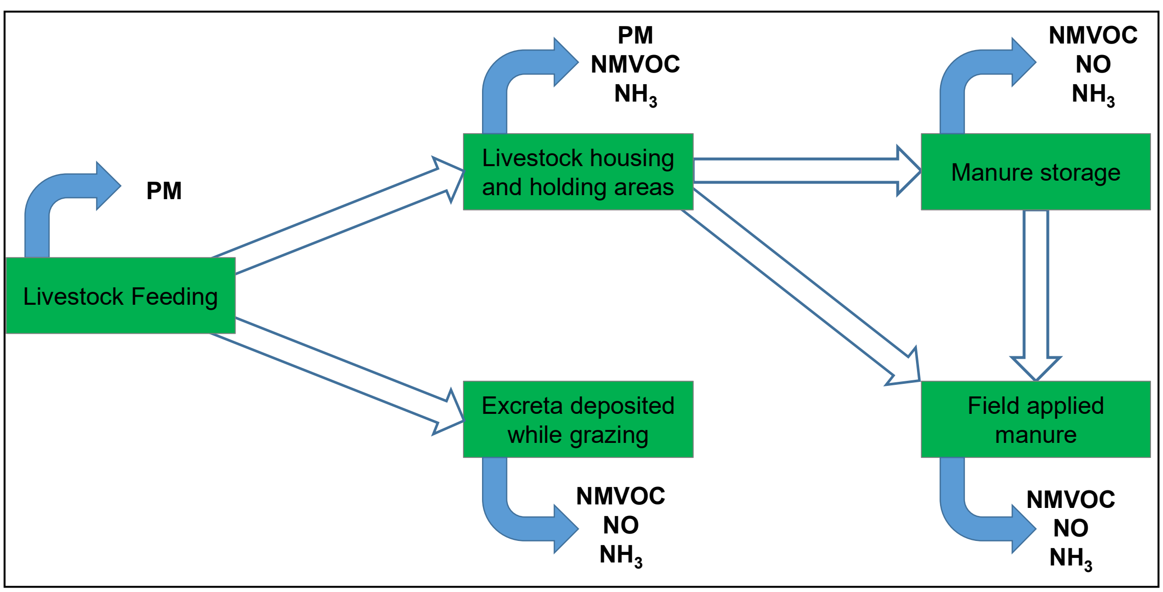
Emissions from this category comprise emissions from the following sub-categories:

- *3B - Manure Management*
- *3D - Crop production and Agricultural Soils*.

There are five main sources of emissions from animal husbandry and manure management (see Figure 5-1):

- 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)
- manure deposited during grazing (NH_3, NO_x, NMVOCs)

Figure 5-1 – Process scheme for source category 3.B - Animal husbandry and manure management



Source: EMEP/EEA air pollutant emission inventory guidebook – 2013 (EMEP/EEA 2013).

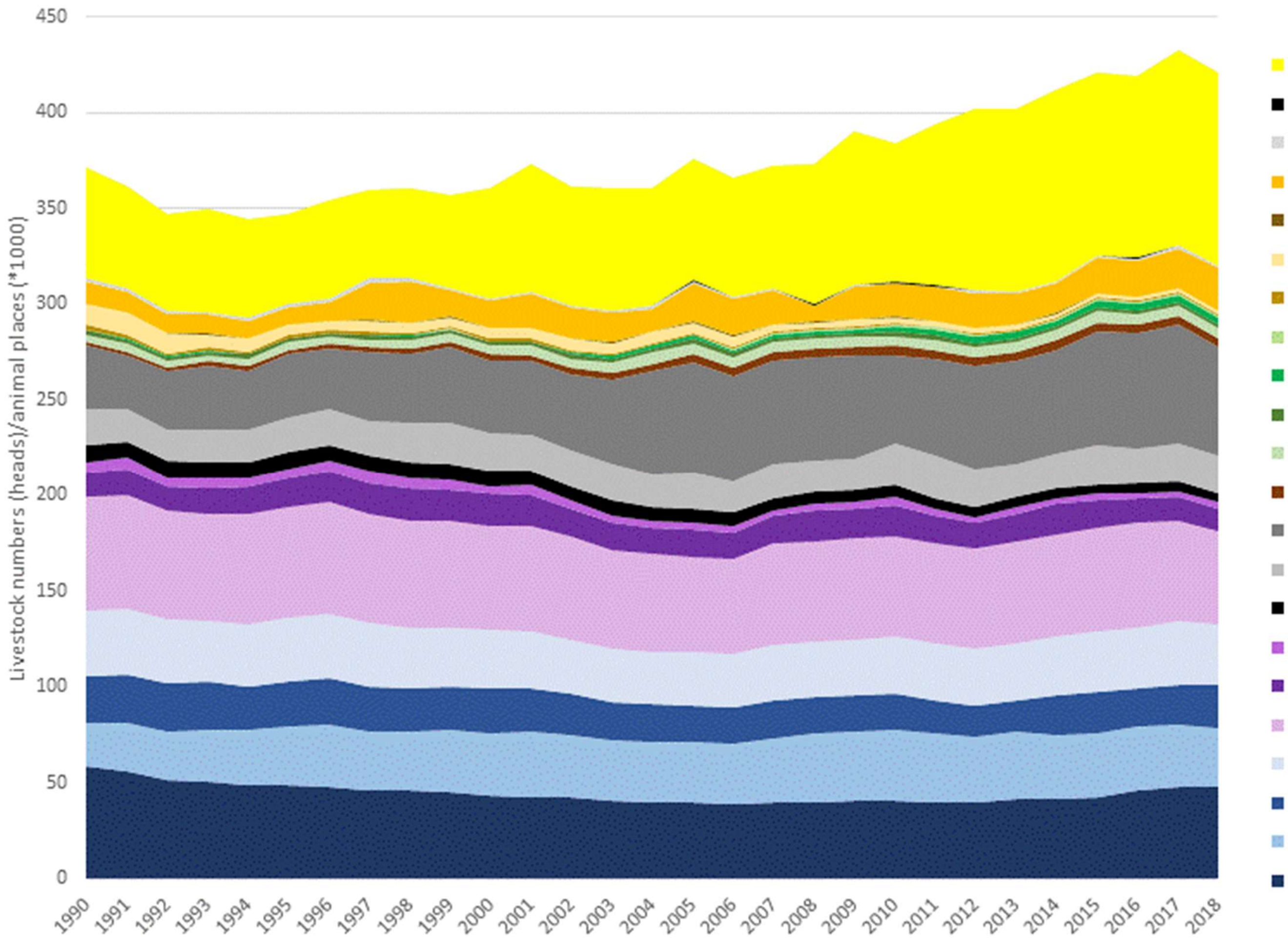
For more details on categories where emissions are not occurring and categories that are not estimated or included elsewhere, see Table 255 below. More details are presented under each source category in the following sections.

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. 1906 farms were managed in Luxembourg in 2018 (STATEC 2019c), and the agricultural area comprised 131,559 hectare. (STATEC 2019a) More than 50% of the used agriculture surface in Luxembourg was permanent grassland. (STATEC 2019a) Cattle, and in particularly dairy cattle, was and is therefore the most important livestock sector in Luxembourg. With the introduction of a dairy produce quota (also referred to as milk quota system) in 1983 within the European Union and the different member states, including Luxembourg, and an increasing milk yield per dairy cow over time, did the number of dairy cows decrease over the years. In the earlier years was this trend partly compensated by an increasing number of suckler cows. This trend was reversed with the abolishment of the milk quota system in Europe on 31st March 2015, with a sharp increase of dairy cows up to 2017, and slowing down since 2018, partly compensated by a decrease in suckler cows, see Figure 5-2. (STATEC 2019d)

Swine and poultry were in Luxembourg of far less importance than cattle, and are now-a-days for the majority of the production in the hands of a few very professional farmers. Sheep, goats and other livestock was and is in Luxembourg a niche production. (STATEC 2019d)

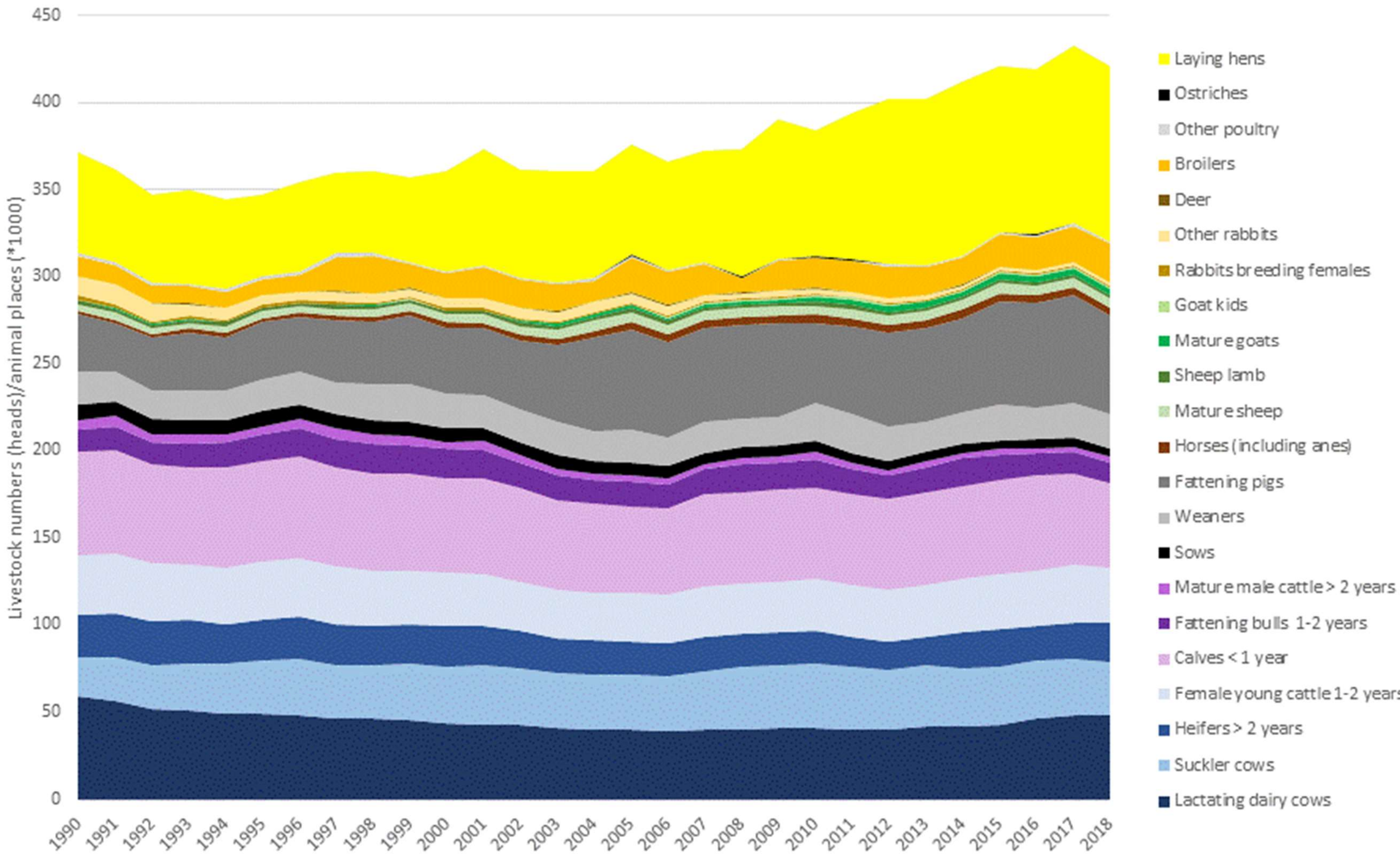
Permanent grassland was with more than 50% of the used agriculture surface predominant in Luxembourg. Grass, cover-grass and maize for silage (whole plant) are and were the main forage crops grown in Luxembourg, see Figure 5-2 – Average animal population (heads/animal places) per year for the different livestock categories for the period 1990-2018



Source: (STATEC 2019d)

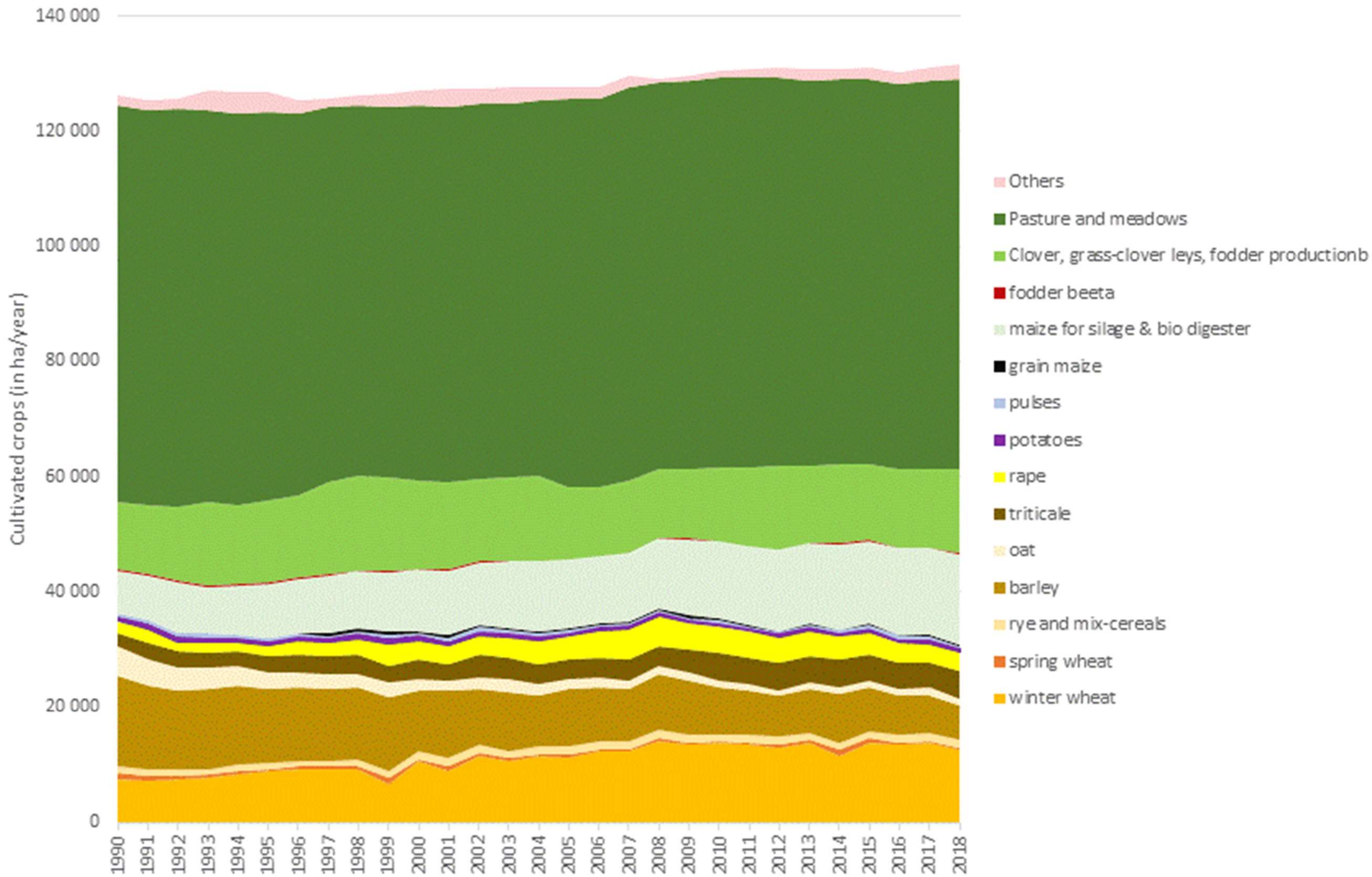
. (STATEC 2019a) Grains such as wheat, barley and triticale, but also rapeseed were the major cash crops cultivated in Luxembourg. In particularly the cultivated area for wheat and maize increased over the years, whereas barley and oat decreased.

Figure 5-2 – Average animal population (heads/animal places) per year for the different livestock categories for the period 1990-2018



Source: (STATEC 2019d)

Figure 5-3 – Cultivated crops (ha/year) for the period 1990-2018



Source: (STATEC 2019a)

5.1.1 **Emission Trends**

This section briefly describes the emission trends from 1990 to 2018 for each of the categories under Agriculture for which emissions are reported – i.e. categories 3B and 3D.

In 2018, this source category was responsible for:

- 5.55 Gg of NH_3 emissions from the agriculture sector, representing $$$95.8% of the national total NH_3 emissions (fuel used) and $$$93.8% of the national total NH_3 emissions (fuel sold).
- 1.13 Gg of NO_x emissions from the agricultural sector, representing $$$5.9% of the national total NO_x emissions.
- 3.26 Gg NMVOC emissions from the agriculture sector, representing $$$27.9% of the national total NMVOC emissions.
- 0.052 Gg $PM_{2.5}$ emissions from the agriculture sector, representing $$$3.3% of the national total $PM_{2.5}$ emissions.
- 0.29 Gg PM_{10} emissions from the agriculture sector, representing $$$3.9% of the national total PM_{10} emissions.
- 0.44 Gg TSP emissions from the agriculture sector, representing $$$6.6% of the national total TSP emissions.

As shown in Table 253, total ammonia emissions related to agricultural activities decreased by about 16% in the period 1990-2018. In category *3B – Manure Management*, ammonia emissions decreased by 11% and for category *3D - Agricultural soils*, they decreased by 20%. The reason for this decrease was the decreasing use of mineral fertilizers (3D), partly lower animal numbers than in 1990, and in recent years, more environmental friendly techniques when applying slurry to managed soils.

The emissions of nitrogen oxides related to agricultural activities decreased by 20% between 1990 and 2018. In category *3B – Manure Management*, they decreased by 28% and in category *3D – Crop production and agricultural soils*, they decreased by 19% between 1990 and 2018, Table 253.

NMVOC emissions in 2018 are similar to the one in 1990, Table 253.

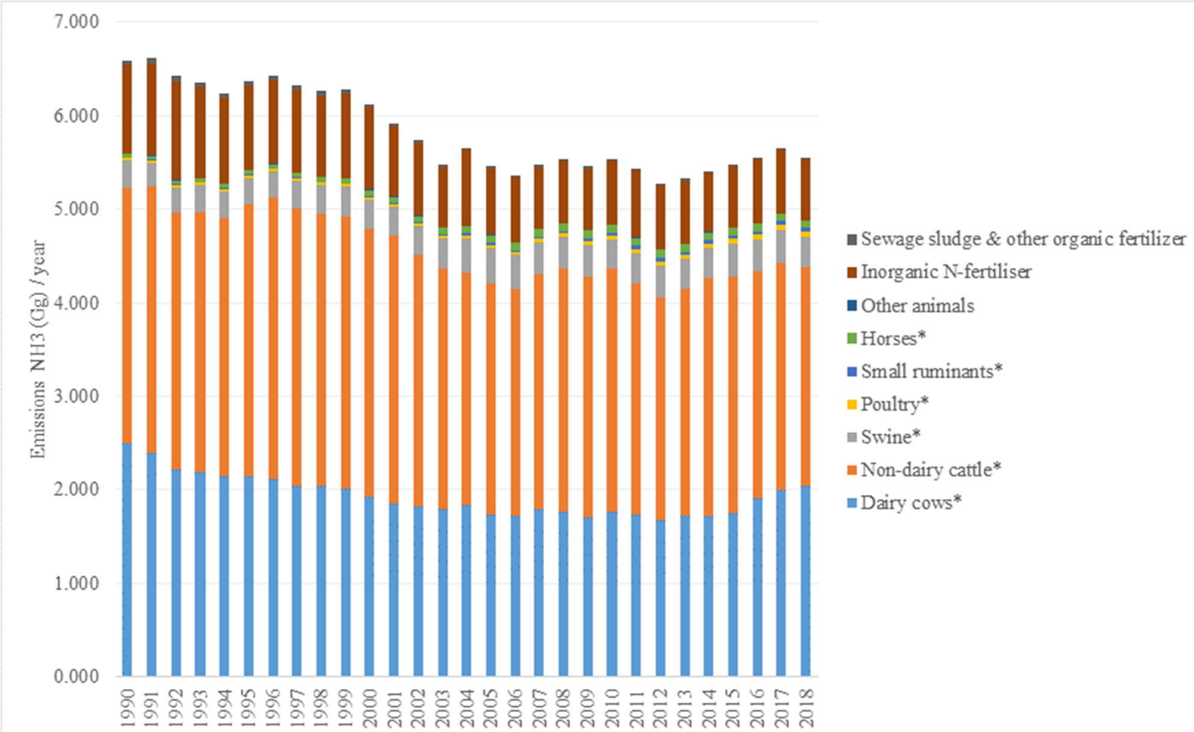
Figure 5-4 provides an overview of the NH_3 emissions in category *3 –Agriculture* for the period 1990-2018.

Table 253– Emission trends for category *3 – Agriculture*: 1990-2018

Year	Total (Gg)						Manure management (Gg)						Crop production and agricultural soils (Gg)					
	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	6.59	1.41	3.25	0.056	0.28	0.42	2.85	0.12	3.14	0.049	0.08	0.22	3.74	1.30	0.11	0.008	0.20	0.20
1991	6.61	1.44	3.27	0.056	0.28	0.41	2.73	0.10	3.16	0.049	0.08	0.21	3.88	1.34	0.11	0.008	0.20	0.20
1992	6.42	1.48	3.14	0.053	0.27	0.40	2.58	0.09	3.03	0.046	0.08	0.20	3.85	1.39	0.11	0.008	0.20	0.20
1993	6.36	1.41	3.18	0.053	0.28	0.41	2.59	0.09	3.07	0.046	0.08	0.21	3.77	1.32	0.11	0.008	0.20	0.20
1994	6.24	1.36	3.15	0.053	0.28	0.40	2.53	0.09	3.05	0.045	0.08	0.20	3.71	1.27	0.11	0.008	0.20	0.20
1995	6.38	1.37	3.26	0.054	0.28	0.40	2.59	0.09	3.15	0.046	0.08	0.21	3.78	1.28	0.11	0.008	0.20	0.20
1996	6.43	1.37	3.31	0.054	0.28	0.40	2.62	0.09	3.20	0.047	0.08	0.21	3.81	1.28	0.11	0.008	0.20	0.20
1997	6.33	1.36	3.26	0.053	0.27	0.40	2.57	0.09	3.16	0.045	0.08	0.21	3.76	1.27	0.11	0.008	0.20	0.20
1998	6.26	1.34	3.24	0.052	0.27	0.40	2.53	0.09	3.14	0.045	0.08	0.21	3.73	1.25	0.11	0.008	0.20	0.20
1999	6.28	1.36	3.25	0.052	0.28	0.41	2.45	0.08	3.14	0.044	0.08	0.21	3.83	1.28	0.11	0.008	0.20	0.20
2000	6.13	1.34	3.20	0.051	0.27	0.40	2.40	0.07	3.09	0.044	0.08	0.21	3.72	1.27	0.11	0.008	0.20	0.20
2001	5.92	1.22	3.21	0.051	0.28	0.41	2.39	0.07	3.10	0.044	0.08	0.21	3.52	1.15	0.11	0.008	0.20	0.20
2002	5.75	1.22	3.09	0.050	0.27	0.40	2.32	0.07	2.98	0.042	0.07	0.20	3.43	1.14	0.11	0.008	0.20	0.20
2003	5.47	1.07	2.99	0.048	0.27	0.40	2.29	0.07	2.88	0.041	0.07	0.20	3.18	1.00	0.11	0.008	0.20	0.20
2004	5.66	1.24	2.94	0.048	0.27	0.41	2.33	0.07	2.83	0.040	0.07	0.21	3.32	1.16	0.11	0.008	0.20	0.20
2005	5.46	1.12	2.94	0.048	0.27	0.41	2.32	0.07	2.83	0.040	0.07	0.22	3.14	1.05	0.11	0.008	0.20	0.20
2006	5.37	1.11	2.90	0.047	0.27	0.41	2.29	0.07	2.79	0.040	0.07	0.21	3.07	1.04	0.11	0.008	0.20	0.20
2007	5.48	1.11	2.98	0.049	0.28	0.42	2.38	0.08	2.87	0.041	0.07	0.21	3.10	1.04	0.11	0.008	0.20	0.20
2008	5.54	1.12	3.07	0.049	0.28	0.42	2.43	0.08	2.96	0.042	0.08	0.22	3.11	1.04	0.11	0.008	0.20	0.20
2009	5.46	1.12	3.08	0.050	0.28	0.42	2.43	0.08	2.96	0.042	0.08	0.22	3.03	1.04	0.11	0.008	0.20	0.20
2010	5.54	1.14	3.13	0.050	0.28	0.42	2.47	0.08	3.02	0.043	0.08	0.21	3.07	1.05	0.11	0.008	0.20	0.20
2011	5.44	1.14	3.02	0.049	0.28	0.42	2.41	0.08	2.90	0.041	0.08	0.22	3.03	1.06	0.11	0.008	0.20	0.20
2012	5.28	1.13	2.94	0.048	0.28	0.42	2.35	0.08	2.83	0.041	0.08	0.22	2.93	1.05	0.11	0.008	0.20	0.20
2013	5.32	1.12	3.03	0.050	0.28	0.43	2.39	0.08	2.91	0.042	0.08	0.22	2.93	1.04	0.11	0.008	0.20	0.20
2014	5.41	1.11	3.13	0.051	0.28	0.43	2.46	0.08	3.02	0.043	0.08	0.23	2.95	1.03	0.11	0.008	0.20	0.20
2015	5.48	1.11	3.20	0.051	0.28	0.44	2.49	0.08	3.08	0.043	0.08	0.23	2.99	1.03	0.11	0.008	0.20	0.20
2016	5.55	1.16	3.24	0.052	0.28	0.44	2.53	0.08	3.13	0.044	0.08	0.24	3.02	1.08	0.11	0.008	0.20	0.20
2017	5.65	1.16	3.29	0.053	0.29	0.45	2.59	0.08	3.18	0.045	0.08	0.24	3.07	1.07	0.11	0.008	0.20	0.20
2018	5.55	1.13	3.26	0.052	0.29	0.44	2.54	0.08	3.15	0.044	0.08	0.23	3.01	1.05	0.11	0.008	0.21	0.21
Trend 1990 -2018	-16%	-20%	0%	-8%	2%	5%	-11%	-28%	0%	-10%	-4%	7%	-20%	-19%	4%	4%	4%	4%
Trend 2017 -2018	-2%	-2%	-1%	-2%	-1%	-2%	-2%	-2%	-1%	-2%	-2%	-3%	-2%	-3%	0%	0%	0%	0%

Source: SER

Figure 5-4 – NH_3 emission trend for 1990-2018 by origin



*NH_3 emissions from stable, storage, manure & grazing originating from animal category *i* were added up, with *i* being dairy cows, non-dairy cattle, swine, poultry (laying hens, broilers and other poultry, including turkeys), small ruminants (sheep & goats), horses including asses and mules and other animals, including ostriches, rabbits and deer.

Source: SER.

5.1.2 Key sources$$$

The methodology and results of the key source analysis are presented in Chapter 1. Table 254 presents the key source categories in Agriculture.

Table 254 – 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					3	5	3	3								
3 B 1 b	Manure management - Non-dairy cattle					2	6	2				7					
3 B 3	Manure management - Swine								4								
3 B 4 e	Manure management - Horses								5								
3 D a 1	Inorganic N-fertilizers (includes also urea application)							4	1			6		4			
3 D a 2 a	Animal manure applied to soils							1									
3 D a 3	Urine and dung deposited by grazing animals								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
3 B 1 a	Manure management - Dairy cattle					3	5	3	2		
3 B 1 b	Manure management - Non-dairy cattle					2	6	2	7	9	
3 B 3	Manure management - Swine								4		
3 B 4 e	Manure management - Horses								6		
3 D a 1	Inorganic N-fertilizers (includes also urea application)							4	1		
3 D a 3	Urine and dung deposited by grazing animals								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, …)

5.1.3 **Completeness**

Table 255 gives an overview of the categories included Agriculture and provides information on the status of emission estimates of all subcategories.

Table 255 – Status of emission reporting for category *3 – Agriculture*

NFR Code	Agriculture	NO_x	NMVOC	SO_2	NH_3	CO	TSP	PM_{10}	$PM_{2.5}$
3B1a	Manure management – Dairy cattle	x	x	NA	x	NA	x	x	x
3B1a	Manure management – Non-dairy cattle	x	x	NA	x	NA	x	x	x
3B2	Manure management – Sheep	x	x	NA	x	NA	x	x	x
3B3	Manure management – Swine	x	x	NA	x	NA	x	x	x
3B4a	Manure management – Buffalo	NO	NO	NA	NO	NA	NO	NO	NO
3B4d	Manure management – Goats	x	x	NA	x	NA	x	x	x
3B4e	Manure management – Horses	x	x	NA	x	NA	x	x	x
3B4f	Manure management – Mules and asses[a]	IE	IE	NA	IE	NA	IE	IE	IE
3B4gi	Manure management – Laying hens	x	x	NA	x	NA	x	x	x
3B4gii	Manure management – Broilers	x	x	NA	x	NA	x	x	x
3B4giii	Manure management – Turkeys[b]	IE	IE	NA	IE	NA	IE	IE	IE
3B4giv	Manure management – Other poultry[c]	x	x	NA	x	NA	x	x	x
3B4h	Manure management – Other animals[d]	x	x	NA	x	NA	x	x	x
3Da1	Inorganic N-fertilizer	x	NA	NA	x	NA	NA	NA	NA
3Da2a	Animal manure	x	NA	NA	x	NA	NA	NA	NA
3Da2b	Sewage sludge	x	NA	NA	x	NA	NA	NA	NA
3Da2c	Other organic fertilisers (including compost)	x	NA	NA	x	NA	NA	NA	NA
3Da3	Urine and dung deposited by grazing animals	x	IE	NA	x	NA	IE	IE	IE
3Da4	Crop residues applied to soils	x	NA	NA	x	NA	NA	NA	NA
3Db	Indirect emissions from managed soils	NE	NA	NA	NA	NA	NA	NA	NA
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	NO	NA	NA	NA	NA	x	x	x
3Dd	Off-farm storage, handling and transport of bulk agricultural products	NO	NA	NA	NA	NA	NA	NA	NA
3De	Cultivated crops	NA	x	NA	NA	NA	NO	NO	NO
3Df	Use of pesticide	NE	NO	NA	NE	NE	NE	NE	NE
3F	Field burning of agricultural residues	NO	NO	NO	NO	NO	NO	NO	NO
3I	Agriculture other	NO	NO	NO	NO	NO	NO	NO	NO

Footnotes:

(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.

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 are presented under each source category review.

5.2.1 **Animal categories**

Cattle was and is the major livestock in Luxemburg. For 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. In the majority 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. The majority 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. In the nineties, the distribution might have been slightly other, but 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; “cull cows” comprising non-lactating dairy cows kept for fattening purposes and “suckler cows”. Since 2008, however, both lactating and non-lactating dairy cows (i.e. cull cows) are reported together in one single category. For 1990-2007 cull 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 ($P_{cull\ cows}$).(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 ($N_{lactating\ dairy}$

	cows$=N_{dairy\ cows\ (total)} - N_{cull\ cows}$) and the number of cull cows ($N_{non\text{-}lactating\ dairy\ cows} = [N_{dairy\ cows\ (total)} * P_{cull\ cows}]$) was estimated.
Suckler cows	Comprising suckler cows (>90%) and "cull cows" i.e. non-lactating dairy cows. Numbers of cull cows were partly based on statistics (1990-2007), partly estimated (2008-2018), see above.

In the NFR tables emission calculations are summarized and reported as dairy cattle (i.e. lactating dairy cows) and non-dairy cattle (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)[72]

For swine (reported in the NFR tables as one category) three categories were distinguished in the emission calculations, these were:

Sows	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.

[72] Annual average population = (Number of lambs reported in census * 20%) + ((6*30) * ((Number of lambs reported in census * 80%)/365)). Note the number of sheep lambs reported in the census is approximately the number of sheep lambs produced annually.

Note: Emissions from piglets with a weight < 10 kg were accounted in the category "sows".

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)[73]. For the emission calculations it was assumed that 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)[74]

Horses remained unchanged, in comparison to previous emission calculations and consisted of one category:

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 asses and mules were included in the category "horses (NFR 3B4e)".

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.

[73] 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).

[74] Annual average population = (Number of kids reported in census * 50%) + ((6*7) * ((Number of kids reported in census * 50%)/365)). Note the number of goat kids reported in the census is approximately the number of goat kids produced annually.

Note ostriches are in the NFR tables reported in the category "other animals (NFR 3B4h)" and "turkeys" were considered together with other poultry in the category "other poultry (NFR 3B4g iv)"

The other animal category (reported in the NFR tables as one category (NFR 3B4h)) consisted of ostriches, rabbits and deer, namely:

Breeding female animals	Comprising breeding female animals 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's.

Note: 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**

Activity data on animals numbers were based on the agricultural census conducted annually in spring by STATEC (Institut national de la statistique et des études économiques du Grand-Duché de Luxembourg);(STATEC 2019d) in later years in collaboration with SER (Service d'Economie Rurale)),(STATEC 2018) and since 2017 only by SER, and are summarized in Table 5. 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%. However, since 2012 is the number of cattle – the most important livestock category in Luxemburg – no longer self-reported by the farmers, but are these data extracted from the "SANITEL" database, whereby taking the number of cattle as registered on April 1st;; and hence a 100% coverage of farmers with ≥10 cattle. In Luxemburg each single cattle has to 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" database.(ASV,(2018)

Table 256– Average animal numbers (heads/animal places) per year per livestock category for the period 1990-2018[a]

Year	Calves < 1 year (* 1000)	Female young (* 1000)	Heifers >2 years (* 1000)	Fattening bulls 1-2 (* 1000)	Mature male (* 1000)	Lactating dairy cows[b] (* 1000)	Suckler cows[b] (* 1000)	Sows (* 1000)	Fattening pigs[c] (* 1000)	Weaners[cd] (* 1000)	Mature sheep (* 1000)	Sheep lambs < 1 (* 1000)	Mature goats[f] (* 1000)	Goat kids < 1 year[e,f] (* 1000)	Horses[g] (* 1000)	Broilers (* 1000)	Laying hens[h] (* 1000)	Other poultry[i] (* 1000)	Ostriches[i] (* 1000)	Rabbits - Breeding (* 1000)	Other rabbits[j] (* 1000)	Deer (* 1000)
1990	59.6	34.0	24.6	13.0	5.4	58.8	22.0	9.0	33.2	19.2	3.7	2.1	0.30	0.12	1.7	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	25.3	8.5	28.4	17.0	3.9	2.3	0.33	0.13	1.8	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	25.7	8.6	30.6	16.4	3.8	1.9	0.27	0.09	1.8	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	27.3	8.6	33.6	16.9	3.3	2.1	0.30	0.12	1.9	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	28.9	8.6	30.9	17.0	4.1	2.2	0.27	0.13	2.1	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	30.7	8.9	33.0	17.8	4.1	2.0	0.22	0.10	2.2	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	32.0	8.6	31.6	18.7	3.8	2.0	0.17	0.07	2.2	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	30.8	8.7	36.1	18.1	4.0	2.4	0.21	0.08	2.3	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	30.7	8.7	36.6	20.3	4.5	2.2	0.17	0.07	2.3	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	32.1	8.3	39.2	22.0	4.3	2.4	0.15	0.06	2.8	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	32.9	7.6	38.5	19.7	4.3	2.2	0.18	0.07	3.2	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	33.4	7.8	38.4	18.9	4.8	2.2	0.19	0.07	3.1	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	32.8	7.6	39.7	19.1	4.7	2.7	0.55	0.31	3.1	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	31.5	7.4	44.4	18.9	5.6	2.3	1.02	0.49	3.4	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	31.1	7.2	54.7	16.6	5.6	2.5	1.34	0.38	3.7	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	31.7	7.4	58.0	18.9	5.2	3.0	1.47	0.42	4.2	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	31.6	7.1	54.7	16.9	5.8	2.3	1.35	0.34	4.3	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	40.0	32.8	6.9	54.2	17.4	5.2	2.5	1.62	0.67	4.3	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	39.6	36.6	6.6	54.0	16.0	5.0	2.1	2.01	0.51	4.5	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	40.3	36.8	6.6	54.2	15.7	5.1	2.2	2.15	0.55	4.6	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	40.9	36.6	6.5	46.2	21.9	5.1	2.4	2.99	1.18	4.6	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	40.1	35.8	6.0	50.8	22.2	5.2	2.3	3.19	1.48	4.6	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	39.5	34.5	5.7	54.3	19.1	4.9	2.0	3.70	0.67	4.9	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	42.0	34.4	5.4	53.7	17.5	5.2	2.0	3.23	0.69	4.7	15.6	95.7	0.85	0.34	0.73	2.7	0.27
2014	53.3	30.6	20.5	15.7	3.5	42.0	33.3	5.3	54.8	17.4	5.2	2.1	3.01	0.74	4.7	15.4	100.1	1.01	0.18	0.74	2.3	0.27
2015	54.1	31.6	21.3	14.2	3.7	42.6	33.5	4.9	60.0	19.9	5.6	2.3	3.40	0.77	4.7	18.4	95.3	0.96	0.26	0.76	2.0	0.24
2016	54.7	31.5	20.1	12.5	3.1	46.4	33.2	4.9	60.0	18.5	5.2	2.2	3.40	0.97	4.5	18.9	95.3	0.87	0.25	0.61	2.2	0.17
2017	52.6	33.3	20.1	12.3	3.3	47.9	32.8	5.3	61.8	19.9	5.1	2.0	3.48	1.09	4.7	20.9	101.7	1.26	0.20	0.54	1.9	0.12
2018	49.0	31.8	22.1	11.3	3.3	47.8	30.9	5.2	57.1	19.2	5.1	2.2	3.56	0.85	4.7	22.1	101.4	0.77	0.21	0.57	2.2	0.15
Trend 1990 -2018	-18%	-6%	-10%	-13%	-40%	-19%	40%	-42%	72%	0%	36%	1%	1092%	634%	171%	97%	75%	-66%	NA	-75%	-80%	65%
Trend 2017 -2018	-7%	-4%	10%	-8%	-2%	0%	-6%	-2%	-8%	-3%	0%	5%	3%	-22%	-1%	6%	0%	-39%	7%	4%	20%	27%

d) Source: (STATEC 2019d), with additional unpublished information available at SER – Division des statistiques agricoles, des relations extérieurs et des marchés agricoles.

e) Up to 2007 were dairy cows registered in two categories, i) lactating dairy cows, and ii) cull cows (i.e. non-lactating dairy cows with the purpose to be fattened and slaughtered), but no further distinction since 2008 (STATEC 2019d). From 1990-2007, did cull cows account on average for 9.15% of the total dairy cow population (range 7.1%-10.8%). Assuming that the percentage of culled cows remained the same, the number of cull cows were estimated for the years 2008-2018 and subtracted from the total number of dairy cows in order to obtain the number of "lactating dairy cows". Cull cows were considered together with suckler cows in the animal category "suckler cows".

f) 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.

g) 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 time 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 (STATEC 2019d), and other international statistical institutes such as EUROSTAT.

h) The majority of 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, why the total for sheep, respectively for goats from the inventory differs from the one reported by STATEC (STATEC 2019d), and other international statistical institutes.

i) From 2007 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). Previous to 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.

j) Mules and asses are included in the category "horses".

k) 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.

l) In the published statistics were ostriches included in "other poultry". Ostriches were considered as a separate category and therefore subtracted from this category.

m) 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.

5.2.3 **Manure management system**

For the emission calculations information were required on:

a) the fraction (or proportion) of the year that animals spend in:
   a. buildings (x_{build}),
   b. on yards (x_{yards}),
   c. and grazing ($x_{grazing}$).
b) the proportion of livestock manure handled as:
   a. slurry (x_{slurry}),
   b. and as solid (x_{solid}).
c) for slurry further was required, what proportion of slurry:
   a. was spread directly ($x_{spread\_direct\_slurry}$)
   b. was stored before application (x_{store_slurry})
   c. was used as feedstocks in biogas facilities (x_{feed_slurry}).
d) for solid manure was further required, what proportion of solid manure:
   a. was spread directly ($x_{spread\_direct\_solid}$) (not occurring in Luxembourg)
   b. was stored before application (x_{store_solid})
   c. was used as feedstocks in biogas facilities (x_{feed_solid}) (not common practice, why considered as not occurring in Luxembourg).

The different fractions/proportions were derived from the manure management systems (MMS) developed for the greenhouse gas emissions (see Table 257 to Table 260), whereby:

$x_{grazing(i)}$ = MMS- pasture$_{(i)}$.

$x_{yard(i)}$ = 0 as not occurring in Luxembourg. Yards, where than existing, are integrated in the building with underneath a slatted floor, and therefore not considered in the emission calculations as a separate category, but as building.

$x_{build(i)}$ = (1 - $x_{grazing(i)}$).

$x_{slurry(i)}$ = ((MMS-liquid$_{(i)}$ + MMS-digest$_{(i)}$) / (MMS-liquid$_{(i)}$ + MMS-digest$_{(i)}$ + MMS-solid$_{(i)}$))

$x_{solid(i)}$ = (1 – $x_{slurry(i)}$).

$x_{feed\_slurry(i)}$ = ((MMS-digest$_{(i)}$) / (MMS-liquid$_{(i)}$ + MMS-digest$_{(i)}$)).

$x_{spread\_direct\_slurry(i)}$= 0 as not occurring in Luxembourg.

$X_{store\_slurry(i)}$ = (1 – $x_{feed\_slurry(i)}$ – $x_{spread\_direct\_slurry(i)}$)

$X_{feed\_solid(i)}$ = 0 as not common praxis, therefore assumed to be 0.

$x_{spread\_direct\_solid(i)}$= 0 as not occurring in Luxembourg.

$x_{store\_solid(i)}$ = MMS-solid$_{(i)}$.

with *i* = for animal category *i*

MMS- pasture$_{(i)}$ = manure management system – pasture for animal category *i*, i.e. the proportion of excreta deposited during grazing, see Table 257.

MMS-liquid$_{(i)}$	= manure management system – liquid for animal category *i*, i.e. the proportion of excreta deposited during housing in stables with a liquid/slurry manure management system with slurry being stored on the farm, see Table 259.
MMS-feed$_{(i)}$	= manure management system 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, see Table 260.
MMS-solid$_{(i)}$	= manure management system 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, see Table 260.

The first manure management systems were based on expert judgment. The percentage of each manure system had been estimated by Administration des service technique de l'agriculture (ASTA) on the basis of diverse unpublished in-house information and its knowledge on the agricultural practices in Luxembourg.

ASTA provided some additional information together with the manure management estimates:

a) liquid system: liquid manure storage was assumed to be present around 6 months/year – during the winter season – for a certain number of farms. It was present the whole year for porcine breeding;
b) solid storage: manure storage was present around 6 months/year – during the winter season – for a certain number of farms;
c) pasture: this system was present around 6 months/year when the animals were grazing (summer season);
d) anaerobic digester: since the end of the last century, biogas installations are more and more frequent at farms (and/or manure is more regularly collected to supply municipal or private bio-methanization units). Hence, if the percentages presented in Table 260 could be seen as reasonable for the latest years, this would not be the case for the early 1990s. Indeed, as most of the installations producing biogas from manure are operating in Luxembourg since around the year 2000, they are usually very efficient and a gas tight coverage is present (expert judgment).

The yearly agricultural census in 2010 has been completed by a dedicated survey on agricultural production methods (SAPM). Based on the results from the SAPM, 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) Without new data, the manure management systems for the years 2012-2018 were assumed to be the same as in 2011, except for goats. Up to 2001, the few goats kept on Luxemburgish farms (<200 mature goats in the whole country) were a kind of "backyard" animals. Those animals were kept, similar as sheep, for most of the year on pasture. With the installation of the first professional dairy farmer with a few hundred dairy goats in 2001/2002, and a few more professional dairy farmers following him, the vast majority of goats are dairy goats that are kept in buildings with a solid manure management system. For simplicity reason it was therefore assumed that since 2002, 100% of the goats would be kept in buildings on straw.

More recent data are expected to be published in the near future, also will be new data collected in 2020, allowing an update, and interpolation, of the manure management system in the next submissions.

5.2.4 **Slurry storage system**

In the emissions calculations, the distinction is made between three slurry storage systems, namely:

- Slurry tank without cover;
- Slurry tank with cover (plastic film or solid cover);
- Slurry stored underneath slatted floor.

The available data was collected in the 2010 SPAM for the year 2010. 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) The frequencies apply to the cattle and pig slurry as a whole. It was therefore assumed that cattle slurry stored in slurry tanks without cover would have a natural crust, and swine slurry stored in slurry tanks without would have no natural crust.

Based on expert judgment, it was assumed that in earlier years, the frequency distributions would have been similar to the one found in 2010. Without no data, the frequency distribution was kept constant for all following years. However, an update is planned in one of the following submissions, as these information will be collected again in the 2020 SPAM.

Table 257– Manure management system - pasture (MMS-pasture) for all animal categories: 1990-2018.

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	Suckler cows	Sows	Fattening pigs	Weaners	Sheep	Goats	Horses	Broilers	Laying hens	Other poultry	Ostriches	Rabbits	Cervidae
1990	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	75%	49%	0%	0%	0%	75%	0%	75%
1991	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	75%	49%	0%	0%	0%	75%	0%	75%
1992	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	75%	49%	0%	0%	0%	75%	0%	75%
1993	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	75%	49%	0%	0%	0%	75%	0%	75%
1994	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	75%	49%	0%	0%	0%	75%	0%	75%
1995	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	75%	49%	0%	0%	0%	75%	0%	75%
1996	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	75%	49%	0%	0%	0%	75%	0%	75%
1997	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	75%	49%	0%	0%	0%	75%	0%	75%
1998	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	75%	49%	0%	0%	0%	75%	0%	75%
1999	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	75%	49%	0%	0%	0%	75%	0%	75%
2000	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	75%	49%	0%	0%	0%	75%	0%	75%
2001	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	75%	49%	0%	0%	0%	75%	0%	75%
2002	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	0%	49%	0%	0%	0%	75%	0%	75%
2003	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	0%	49%	0%	0%	0%	75%	0%	75%
2004	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	0%	49%	0%	0%	0%	75%	0%	75%
2005	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	0%	49%	0%	0%	0%	75%	0%	75%
2006	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	0%	49%	0%	0%	0%	75%	0%	75%
2007	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	0%	49%	0%	0%	0%	75%	0%	75%
2008	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	0%	49%	0%	0%	0%	75%	0%	75%
2009	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	0%	49%	0%	0%	0%	75%	0%	75%
2010	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	0%	49%	0%	0%	0%	75%	0%	75%
2011	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	0%	49%	0%	0%	0%	75%	0%	75%
2012	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	0%	49%	0%	0%	0%	75%	0%	75%
2013	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	0%	49%	0%	0%	0%	75%	0%	75%
2014	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	0%	49%	0%	0%	0%	75%	0%	75%
2015	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	0%	49%	0%	0%	0%	75%	0%	75%
2016	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	0%	49%	0%	0%	0%	75%	0%	75%
2017	37%	49%	49%	0%	0%	25%	49%	0%	0%	0%	75%	0%	49%	0%	0%	0%	75%	0%	75%

Source: Expert judgement (ASTA) prepared on 19 June 2007, and SER & ASTA calculations based on partly unpublished data from the 2010 SAPM survey (Gargano et al. 2014).

Table 258– Manure management system - solid (MMS-solid) for all animal categories: 1990-2018.

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	Suckler cows	Sows	Fattening pigs	Weaners	Sheep	Goats	Horses	Broilers	Laying hens	Other poultry	Ostriches	Rabbits	Cervidae
1990	44%	32%	32%	81%	81%	52%	32%	5%	5%	5%	25%	25%	51%	100%	100%	100%	25%	100%	25%
1991	39%	27%	27%	77%	77%	46%	27%	5%	5%	5%	25%	25%	51%	100%	100%	100%	25%	100%	25%
1992	38%	26%	26%	75%	75%	45%	26%	5%	5%	5%	25%	25%	51%	100%	100%	100%	25%	100%	25%
1993	38%	26%	26%	75%	75%	44%	26%	5%	5%	5%	25%	25%	51%	100%	100%	100%	25%	100%	25%
1994	37%	25%	25%	74%	74%	43%	25%	5%	5%	5%	25%	25%	51%	100%	100%	100%	25%	100%	25%
1995	36%	24%	24%	73%	73%	42%	24%	5%	5%	5%	25%	25%	51%	100%	100%	100%	25%	100%	25%
1996	36%	24%	24%	73%	73%	42%	24%	5%	5%	5%	25%	25%	51%	100%	100%	100%	25%	100%	25%
1997	35%	23%	23%	73%	73%	41%	23%	5%	5%	5%	25%	25%	51%	100%	100%	100%	25%	100%	25%
1998	34%	22%	22%	72%	72%	40%	22%	5%	5%	5%	25%	25%	51%	100%	100%	100%	25%	100%	25%
1999	31%	19%	19%	68%	68%	35%	19%	5%	5%	5%	25%	25%	51%	100%	100%	100%	25%	100%	25%
2000	31%	19%	19%	68%	68%	35%	19%	5%	5%	5%	25%	25%	51%	100%	100%	100%	25%	100%	25%
2001	31%	19%	19%	68%	68%	35%	19%	5%	5%	5%	25%	25%	51%	100%	100%	100%	25%	100%	25%
2002	31%	19%	19%	68%	68%	35%	19%	5%	5%	5%	25%	100%	51%	100%	100%	100%	25%	100%	25%
2003	32%	20%	20%	69%	69%	36%	20%	5%	5%	5%	25%	100%	51%	100%	100%	100%	25%	100%	25%
2004	33%	20%	20%	69%	69%	36%	21%	5%	5%	5%	25%	100%	51%	100%	100%	100%	25%	100%	25%
2005	35%	20%	20%	69%	69%	36%	23%	5%	5%	5%	25%	100%	51%	100%	100%	100%	25%	100%	25%
2006	38%	19%	19%	69%	69%	35%	26%	5%	5%	5%	25%	100%	51%	100%	100%	100%	25%	100%	25%
2007	40%	19%	19%	68%	68%	34%	29%	5%	5%	5%	25%	100%	51%	100%	100%	100%	25%	100%	25%
2008	42%	18%	18%	68%	68%	33%	32%	5%	5%	5%	25%	100%	51%	100%	100%	100%	25%	100%	25%
2009	45%	18%	18%	68%	68%	32%	35%	5%	5%	5%	25%	100%	51%	100%	100%	100%	25%	100%	25%
2010	47%	18%	18%	67%	67%	31%	38%	5%	5%	5%	25%	100%	51%	100%	100%	100%	25%	100%	25%
2011	46%	18%	18%	66%	66%	31%	38%	5%	5%	5%	25%	100%	51%	100%	100%	100%	25%	100%	25%
2012	46%	18%	18%	67%	67%	31%	38%	5%	5%	5%	25%	100%	51%	100%	100%	100%	25%	100%	25%
2013	46%	18%	18%	67%	67%	31%	38%	5%	5%	5%	25%	100%	51%	100%	100%	100%	25%	100%	25%
2014	46%	18%	18%	67%	67%	31%	38%	5%	5%	5%	25%	100%	51%	100%	100%	100%	25%	100%	25%
2015	46%	18%	18%	67%	67%	31%	38%	5%	5%	5%	25%	100%	51%	100%	100%	100%	25%	100%	25%
2016	46%	18%	18%	67%	67%	31%	38%	5%	5%	5%	25%	100%	51%	100%	100%	100%	25%	100%	25%
2017	46%	18%	18%	67%	67%	31%	38%	5%	5%	5%	25%	100%	51%	100%	100%	100%	25%	100%	25%

Source: Expert judgement (ASTA) prepared on 19 June 2007, and SER & ASTA calculations based on partly unpublished data from the 2010 SAPM survey (Gargano et al. 2014).

Table 259– Manure management system - liquid (MMS-liquid) for all animal categories: 1990-2018.

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	Suckler cows	Sows	Fattening pigs	Weaners	Sheep	Goats	Horses	Broilers	Laying hens	Other poultry	Ostriches	Rabbits	Cervidae
1990	19%	19%	19%	19%	19%	23%	19%	95%	95%	95%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1991	24%	24%	24%	24%	24%	29%	24%	95%	95%	95%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1992	25%	25%	25%	25%	25%	31%	25%	95%	95%	95%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1993	25%	25%	25%	25%	25%	31%	25%	95%	95%	95%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1994	26%	26%	26%	26%	26%	32%	26%	95%	95%	95%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1995	27%	27%	27%	27%	27%	33%	27%	95%	95%	95%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1996	27%	27%	27%	27%	27%	33%	27%	95%	95%	95%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1997	28%	28%	28%	28%	28%	34%	28%	95%	95%	95%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1998	29%	29%	29%	29%	29%	36%	29%	95%	95%	95%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1999	32%	32%	32%	32%	32%	40%	32%	95%	95%	95%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2000	31%	31%	31%	31%	31%	40%	31%	93%	94%	94%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2001	31%	31%	31%	31%	31%	39%	31%	91%	93%	93%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2002	30%	30%	30%	30%	30%	38%	30%	89%	91%	91%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2003	29%	29%	29%	29%	29%	37%	29%	87%	90%	90%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2004	28%	28%	28%	28%	28%	36%	28%	85%	89%	89%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2005	25%	27%	27%	27%	27%	36%	24%	82%	88%	88%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2006	22%	27%	27%	27%	27%	36%	21%	80%	87%	87%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2007	19%	27%	27%	27%	27%	36%	17%	78%	86%	86%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2008	16%	27%	27%	26%	26%	36%	14%	76%	84%	84%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2009	13%	27%	27%	26%	26%	37%	11%	74%	83%	83%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2010	10%	27%	27%	26%	26%	37%	7%	72%	82%	82%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2011	11%	27%	27%	27%	27%	37%	7%	72%	82%	82%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2012	11%	26%	26%	26%	26%	37%	7%	72%	82%	82%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2013	11%	26%	26%	26%	26%	37%	7%	72%	82%	82%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2014	11%	26%	26%	26%	26%	37%	7%	72%	82%	82%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2015	11%	26%	26%	26%	26%	37%	7%	72%	82%	82%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2016	11%	26%	26%	26%	26%	37%	7%	72%	82%	82%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2017	11%	26%	26%	26%	26%	37%	7%	72%	82%	82%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Source: Expert judgement (ASTA) prepared on 19 June 2007, and SER & ASTA calculations based on partly unpublished data from the 2010 SAPM survey (Gargano et al. 2014).

Table 260– Manure management system - digester (MMS-digester) for all animal categories: 1990-2018.

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	Suckler cows	Sows	Fattening pigs	Weaners	Sheep	Goats	Horses	Broilers	Laying hens	Other poultry	Ostriches	Rabbits	Cervidae
1990	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1991	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1992	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1993	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1994	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1995	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1996	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1997	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1998	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1999	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2000	1%	1%	1%	1%	1%	1%	1%	2%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2001	1%	1%	1%	1%	1%	1%	1%	4%	2%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2002	2%	2%	2%	2%	2%	2%	2%	6%	4%	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2003	2%	2%	2%	2%	2%	3%	2%	8%	5%	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2004	3%	3%	3%	3%	3%	3%	3%	11%	6%	6%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2005	3%	3%	3%	4%	4%	4%	3%	13%	7%	7%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2006	4%	4%	4%	4%	4%	5%	4%	15%	8%	8%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2007	4%	5%	5%	5%	5%	5%	4%	17%	9%	9%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2008	5%	5%	5%	5%	5%	6%	5%	19%	11%	11%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2009	5%	6%	6%	6%	6%	6%	5%	21%	12%	12%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2010	6%	6%	6%	7%	7%	7%	6%	23%	13%	13%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2011	6%	6%	6%	7%	7%	7%	6%	23%	13%	13%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2012	6%	6%	6%	7%	7%	7%	6%	23%	13%	13%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2013	6%	6%	6%	7%	7%	7%	6%	23%	13%	13%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2014	6%	6%	6%	7%	7%	7%	6%	23%	13%	13%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2015	6%	6%	6%	7%	7%	7%	6%	23%	13%	13%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2016	6%	6%	6%	7%	7%	7%	6%	23%	13%	13%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2017	6%	6%	6%	7%	7%	7%	6%	23%	13%	13%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Source: Expert judgement (ASTA) prepared on 19 June 2007, and SER & ASTA calculations based on partly unpublished data from the 2010 SAPM survey (Gargano et al. 2014).

5.2.5 **Nitrogen excretion**

5.2.5.1 **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 261.
- assuming an N-ratio in urea of 46% (DLG 2008);
- using country-specific milk protein (SER 2018), see Table 261.
-
- dividing milk protein by 6.38 to obtain N (DLG 2008);
- using a country-specific daily milk yield, see Table 261, which is calculated by dividing the annual milk production (SER 2018) by the number of lactating dairy cows (see Table 256).

The annual milk production, see Table 261, consist of i) the official amount of milk delivered from the farms to dairy industries (>90%); 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) 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)

The estimated N.ex in kg N per lactating dairy cow and per year for the years 1990-2018 is summarized in Table 261.

Table 261– Annual milk production (*1000 tons), milk fat, milk protein, milk urea, daily milk yield and N.ex in kg N per dairy cow per year

	Annual milk production[a] (*1000 tons)	Milk fat (%)	Milk protein (%)	Milk urea (ppm)[b]	Daily milk yield[c] (kg/day)	N.ex (kg N per head)[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	21.4	123.3
2008	277.7	4.21	3.40	254	21.9	122.9
2009	283.9	4.18	3.37	231	22.0	118.0
2010	295.3	4.18	3.40	246	22.6	122.0
2011	292.2	4.15	3.37	252	22.8	122.7
2012	289.4	4.16	3.39	234	22.9	119.9
2013	295.9	4.13	3.36	222	22.0	116.1
2014	317.0	4.09	3.38	219	23.6	117.3
2015	346.3	4.11	3.37	211	25.4	117.4
2016	376.2	4.12	3.39	218	25.4	119.1
2017	387.2	4.11	3.41	226	25.3	121.2
2018	407.6	4.12	3.43	232	26.6	124.3
Trend 1990-2018	45%	1%	5%	-1%	78%	13%
Trend 2017-2018	5%	0%	1%	3%	5%	3%

a) Source: (SER 2018). Note: Until 1976 only milk delivered to dairy industries. 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) Note: 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 2006-2018 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 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); for confidential details of the delivered quantities to dairy industry: Source: 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 256) and assuming 320 days in lactation

d) Calculated according to the equation shown above.

5.2.5.2 **Other livestock categories than dairy cows**

Having no own measurements, and having no information on feed ration 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 262. Belgium, Germany and France (here in particular the Northern part) have direct borders with Luxembourg (Figure 2-1), 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 similar to one found in Luxembourg. A detailed description is provided in section 8.1.1.1.1.

Table 262– N excretion per head/place per year for the different livestock categories for 1990-2018

	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”
Suckler cows	82	(KTBL 2006) page 490
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)

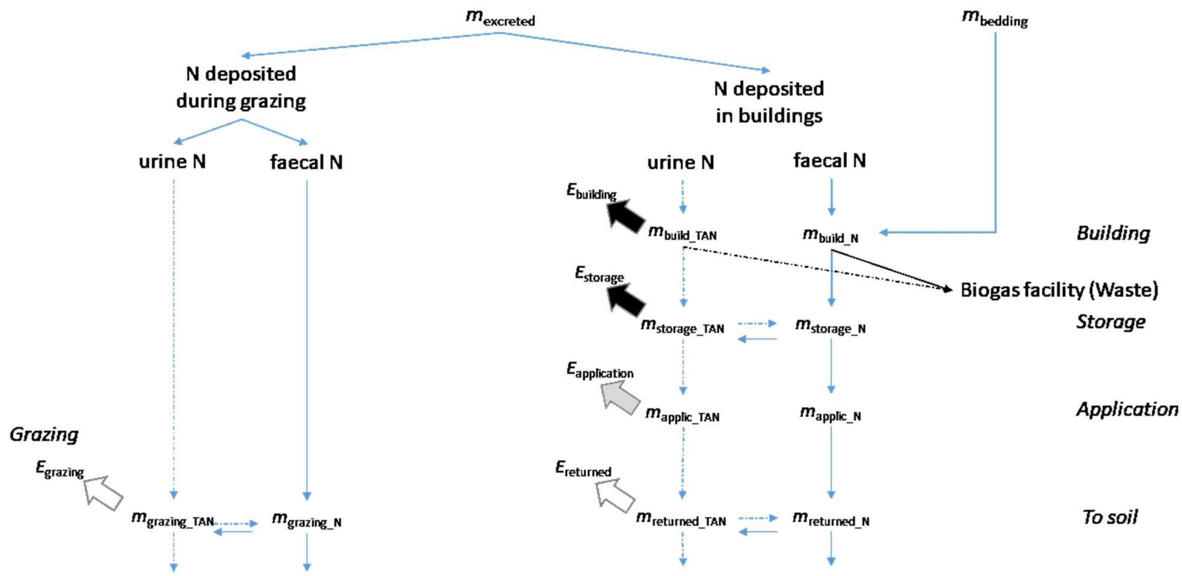
* Using more detailed statistics than the one provided in Table 256.

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.

5.2.6 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 5-5.

Figure 5-5 – N flow in the manure management systems



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 2016 guidelines.(EMEP/EEA 2016b)

The first step is the definition of livestock subcategories "that are homogeneous with respect to feed-ing, excretion and age/weight range", (EMEP/EEA 2016b), 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 5.2.5.

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 (EMEP/EEA 2016b):

$$m_{grazing\_N(i)} = x_{grazing(i)} * N_{ex(i)}$$
$$m_{build\_N(i)} = x_{build(i)} * N_{ex(i)}$$

with $x_{grazing(i)}$ and $x_{build(i)}$ being defined in section 5.2.3

Note. Yards, where than existing in Luxembourg, are integrated in the building with underneath a slat-ted floor, and therefore not considered as a separate category, but as building.

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 ($m_{grazing\_TAN(i)}$) was calculated using the following equations (EMEP/EEA 2016b):

$$m_{grazing\_TAN(i)} = x_{TAN(i)} * m_{grazing\_N(i)}$$

$$m_{build\_TAN(i)} = x_{TAN(i)} * m_{build\_N(i)}$$

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 2016 guidelines (EMEP/EEA 2016b) and summarized in Table 263.

Table 263– TAN contents (x_{TAN}) used for emission estimates, expressed as kg TAN per kg $N_{ex(i)}$

	$x_{TAN(i)}$	Notes
Calves < 1 year;	0.6	Default value for non-dairy cattle (Table 3.9; (EMEP/EEA 2016b))
Female young female cattle 1-2 years	0.6	Default value for non-dairy cattle (Table 3.9; (EMEP/EEA 2016b))
Heifers > 2 years	0.6	Default value for non-dairy cattle (Table 3.9; (EMEP/EEA 2016b))
Fattening bulls 1-2 years	0.6	Default value for non-dairy cattle (Table 3.9; (EMEP/EEA 2016b))
Mature male cattle > 2 years	0.6	Default value for non-dairy cattle (Table 3.9; (EMEP/EEA 2016b))
Lactating dairy cows	0.6	Default value for dairy cattle (Table 3.9; (EMEP/EEA 2016b))
Suckler cows	0.6	Default value for non-dairy cattle (Table 3.9; (EMEP/EEA 2016b))
Sows	0.7	Default value for sows and piglets to 8 kg (Table 3.9; (EMEP/EEA 2016b))
Fattening pigs	0.7	Default value for fattening pigs, 8- 110 kg (Table 3.9; (EMEP/EEA 2016b))
Weaners	0.7	Default value for fattening pigs, 8-110 kg (Table 3.9; (EMEP/EEA 2016b))
Sheep (mature sheep and lambs)	0.5	Default value for sheep (Table 3.9; (EMEP/EEA 2016b))
Goats (mature goats and kids)	0.5	Default value for goats (Table 3.9; (EMEP/EEA 2016b))
Horses (including assess and mules)	0.6	Default value for horses (Table 3.9; (EMEP/EEA 2016b))
Broilers	0.7	Default value for broilers (Table 3.9; (EMEP/EEA 2016b))
Laying hens	0.7	Default value for laying hens (Table 3.9; (EMEP/EEA 2016b))
Other poultry	0.7	Default values for turkeys, ducks and geese (Table 3.9; (EMEP/EEA 2016b))
Ostriches	0.7	Default value for geese (Table 3.9; (EMEP/EEA 2016b)), similar as (Haenel et al. 2018)
Rabbits (breeding female animals and other rabbits)	0.6	Default value for horses (Table 3.9; (EMEP/EEA 2016b)), similar as (Haenel et al. 2018)
Deer	0.5	Default value for sheep and goats (Table 3.9; (EMEP/EEA 2016b))

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 $m_{build\_solid\_N(i)}$) were calculated using the following equations (EMEP/EEA 2016b):

$$m_{build\_slurry\_TAN(i)} = x_{slurry(i)} * m_{build\_TAN(i)}$$

$$m_{build\_slurry\_N(i)} = x_{slurry(i)} * m_{build\_N(i)}$$

$$m_{build\_solid\_TAN(i)} = (1 - x_{slurry(i)}) * m_{build\_TAN(i)}$$
$$m_{build\_solid\_N(i)} = (1 - x_{slurry(i)}) * m_{build\_N(i)}$$

with $x_{slurry(i)}$ being defined in section 5.2.3.

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 2016 guidelines,(EMEP/EEA 2016b) namely:

$$E_{build\_slurry\_NH3-N(i)} = m_{build\_slurry\_TAN(i)} * EF_{buil\ \ \_slurry\_NH3-N(i)}$$
$$E_{build\_solid\_NH3-N(i)} = m_{build\_solid\_TAN(i)} * EF_{build\_solid\_NH3-N(i)}$$

with

$E_{build\_slurry\_NH3-N(i)}$	Emissions of NH_3-N from livestock buildings with liquid manure system;
$E_{build\_solid\_NH3-N(i)}$	Emissions of NH_3-N from livestock buildings with solid manure system;
$EF_{build\_slurry\_NH3-N(i)}$	Emissions factors for NH_3-N emissions from livestock buildings with liquid manure system;
$EF_{build\_solid\_NH3-N(i)}$	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, N in animal bedding ($m_{bedding(i)}$) in litter-based housing systems is added, whereby accounting for the consequent immobilisation of TAN (f_{imm}) in that bedding.

$m_{bedding(i)}$ was estimated using the figures provided in Table 3.7 in the 2016 guidelines (EMEP/EEA 2016b) 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 5.2.3)), and is summarized in Table 264.

Table 264– Estimated N added in straw in animal bedding ($m_{bedding(i)}$) for livestock category i * (kg N / year / head or place)

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	Suckler cows	Sows	Fattening pigs	Weaners	Sheep	Goats	Horses
1990	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.24	2.05
1991	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.24	2.05
1992	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.24	2.05
1993	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.24	2.05
1994	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.24	2.05
1995	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.24	2.05
1996	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.24	2.05
1997	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.24	2.05
1998	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.24	2.05
1999	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.24	2.05
2000	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.24	2.05
2001	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.24	2.05
2002	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.97	2.05
2003	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.97	2.05
2004	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.97	2.05
2005	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.97	2.05
2006	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.97	2.05
2007	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.97	2.05
2008	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.97	2.05
2009	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.97	2.05
2010	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.97	2.05
2011	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.97	2.05
2012	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.97	2.05
2013	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.97	2.05
2014	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.97	2.05
2015	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.97	2.05
2016	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.97	2.05
2017	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.97	2.05
2018	2.55	2.05	2.05	4.06	4.06	9.16	2.05	2.40	0.80	0.80	0.24	0.97	2.05

Note : Given the low numbers of poultry, ostriches, rabbits and deer, and given that no data were provided in Table 3.7 in the 2016 Guidelines (EMEP/EEA 2016a) for these categories, no estimates of additional N in animal bedding in litter-based housing systems were made for poultry, ostriches, rabbits and deer.

Further were the amounts of total-N and total-TAN in solid manure that are removed from buildings calculated ($m_{ex\text{-}build\_solid\_TAN}$ and $m_{ex\text{-}build\_solid\_N}$), following equation 18 and equation 19 from the 2016 guidelines (EMEP/EEA 2016b), namely:

$$m_{ex-build\_solid\_TAN(i)} = \{(m_{build\_solid\_TAN(i)} - E_{build\_solid\_NH3-N(i)}) * (1 - f_{imm})\}$$
$$m_{ex-build\_solid\_N(i)} = \{(m_{build\_solid\_N(i)} + m_{bedding\_N(i)} + f_{imm}) - E_{build\_solid(i)}\}$$

with f_{imm} assumed to be 0.0067, according to the 2016 guidelines.(EMEP/EEA 2016b)

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 ($x_{feed\_slurry\ (i)}$, assumed to be only slurry, for details see section 5.2.3) as emissions were calculated and reported in NFR Category 5B2. Further was assumed that all manure (solid manure and slurry) would be stored before spreading (for details see section 5.2.3). 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 5.2.3, were used to estimate the amounts ($m_{storage}$) of total-N and TAN stored before application to land, following equation 20, 21, 24 and 25, respectively from the 2016 guidelines,(EMEP/EEA 2016b) namely:

whereby for slurry:

$$m_{storage\_slurry\_TAN(i)} = \{(m_{build\_slurry\_TAN(i)} - E_{build\_slurry\_NH3-N(i)})\} * x_{store\_slurry(i)}$$
$$m_{storage\_slurry\_N(i)} = \{(m_{build\_slurry\_N(i)} - E_{build\_slurry\_NH3-N(i)})\} * x_{store\_slurry(i)}$$

and for solid manure:

$$m_{storage\_solid\_TAN(i)} = m_{ex-buil\ \ \_solid\_TAN(i)} *\ x_{store\_solid(i)}$$
$$m_{storage\_solid\_N(i)} = m_{ex-build\_solid\_N(i)} *\ x_{store\_solid(i)}.$$

Step 9 was applied only to slurry, with the aim to calculate the amount of TAN from which emissions will occur from slurry stores, whereby a fraction of the organic N is mineralised (f_{min}). The modified mass ($mm_{storage\_slurry}$), from which emissions were calculated, was derived following equation 28 from the 2016 guidelines,(EMEP/EEA 2016b) 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 2016 guidelines (EMEP/EEA 2016a).

In Step 10, the emissions of NH_3, N_2O, NO and N_2 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 29 and 30 from the 2016 guidelines,(EMEP/EEA 2016b) namely:

for slurry:

$$E_{storage\_slurry(i)} = E_{storage\_slurry\_NH_{3-N}(i)} + E_{storage\_slurry\_N_2O-N(i)} + E_{storage\_slurry\_NO-N(i)} + E_{storage\_slurry\_N_2-N(i)}$$

and for solid:

$$E_{storage\_solid(i)} = E_{storage\_solid\_NH_3-N(i)} + E_{storage\_solid\_N_2O-N(i)} + E_{storage\_solid\_NO-N(i)} + E_{storage\_solid\_N_2-N(i)}$$

Detailed information on the calculations and the EFs used for the N_2O emissions are provided in section 5.4.3 in the national inventory report (NIR) 2020 (Schuman et al. 2020), and for the other N emissions in section 5.3.3 in the current report. The N_2O emissions are reported in CRF category 3B, and the NH_3 and NO_x emissions are reported in NFR category 3B.

In Step 11, the total-N and TAN (m_{applic_N} and m_{applic_TAN}) that is applied to the field was calculated, according to equations 31-34 from the 2016 guidelines,(EMEP/EEA 2016b) namely:

for slurry:

$$m_{applic\_slurry\_TAN(i)} = mm_{storage\_slurry\_TAN(i)} - E_{storage\_slurry(i)}$$
$$m_{applic\_slurry\_N(i)} = mm_{storage\_slurry\_N(i)} - E_{storage\_slurry(i)}$$

and for solid:

$$m_{applic\_solid\_TAN(i)} = m_{storage\_slolid\_TAN(i)} - E_{storage\_solid(i)}$$
$$m_{applic\_solid\_N(i)} = m_{storage\_solid\_N(i)} - E_{storage\_solid(i)}$$

In Step 12, the emissions of NH_3-N during and immediately after field application was calculated, according to equation 35 and 36 from the 2016 guidelines,(EMEP/EEA 2016b) namely:

for slurry:

$$E_{applic\_slurry\_NH3-N(i)} = m_{applic\_slurry\_TAN(i)} * \ EF_{applic\_slurry\_NH3-N(i)}$$

and for solid:

$$E_{applic\_solid\_NH3-N(i)} = m_{applic\_solid\_TAN(i)} * \ EF_{applic\_solid\_NH3-N(i)}$$

Detailed information on the calculations and the used EFs are provided in section 5.4.3 in the current report. The NH_3 emissions are reported in NFR category 3D2.

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 37 - 40 from the 2016 guidelines,(EMEP/EEA 2016b) namely:

for slurry:

$$m_{returned\_slurry\_TAN(i)} = m_{applic\_slurry\_TAN(i)} - \ E_{applic\_slurry\_NH3-N(i)}$$
$$m_{returned\_slurry\_N(i)} = m_{applic\_slurry\_N(i)} - \ E_{applic\_slurry\_NH3-N(i)}$$

and for solid:

$$m_{returned\_solid\_TAN(i)} = m_{applic\_solid\_TAN(i)} - \ E_{applic\_solid\_NH3-N(i)}$$
$$m_{returned\_solid\_N(i)} = m_{applic\_solid\_N(i)} - \ E_{applic\_solid\_NH3-N(i)}$$

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 41 from the 2016 guidelines,(EMEP/EEA 2016b) namely:

$$E_{grazing_{NH3}-N(i)} = m_{grazing\_TAN(i)} * \ EF_{grazi \quad _{NH3}-N(i)}$$

Detailed information on the calculations and the used EFs are provided in section 5.4.3 in the current report. The NH_3 emissions are reported in NFR category 3D2.

In Step 15, all the emissions from the manure management system that are to be reported in the NFR category 3B were summed and converted to the mass of the relevant compound.

5.2.7 Category-specific recalculations including those made in response to the review process

Full details of the different changes are provided in chapter 8.1.1, including recalculations. Hereafter in short, a list of the revisions/changes applied that required recalculations:

- Updating of the provisional 2017 animal numbers, where applicable.
- Revision of the N.ex for dairy cows, due to an error in the calculation of the weighted average milk urea.
- On request of the reviewer, revision of all N.ex. values for all other animals than dairy cows.
- Distinguishing between different slurry storage system.

5.2.8 Category specific QA/QC procedures

Consistency and completeness checks have been performed directly in the model.

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

An update of the manure management system using more recent data is planned for the following submission. The N flow will be revised and updated, where applicable, following the 2019 EMEP/EEA guidelines.

5.3 *Manure Management (Category 3B)*

This section describes the estimation of pollutant emissions resulting from manure management. In 2018, this source category was responsible for:

- 46% of the total NH_3 emissions of the agriculture sector and represented $$$44.8% of the national total NH_3 emissions (fuel sold) and $$$45.8% of the national total NH_3 emissions (fuel used).
- 7 % of the total NO_x emissions of the agricultural sector
- 97% of the total NMVOC emissions of the agricultural sector
- 85% of the total $PM_{2.5}$ and 28% of the total PM_{10} emissions of the agricultural sector
- 53% of the total TSP emissions of the agricultural sector.

5.3.1 Key source$$$

Ammonia emissions from cattle (category 3B1) as well as NMVOC emissions from cattle were a key category in 2018 (Table 265). Ammonia emissions from swine (3B3) are a key category in the trend assessment.

Table 265 – Key categories for category 3B – manure management.

NFR 3B																	
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					3	5	3	3								
3 B 1 b	Manure management - Non-dairy cattle					2	6	2				7					
3 B 3	Manure management - Swine								4								
3 B 4 e	Manure management - Horses								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, …)

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 (EMEP/EEA 2016b) .

Looking at ammonia emissions from manure management (Table 266), a decrease of 11% can be observed for the period 1990-2018. Goats, although a niche production in Luxembourg, have experienced the biggest increase in their population for the whole period 1990-2018 (Table 256), and consequently also the biggest increase in ammonia emissions from manure management for the same time period (4736%), see Table 266. However, ammonia emission from manure management from goats represent <1% of the total ammonia emission from manure management in 2018 (see Table 266). Cattle as a whole group is over the whole period the main ammonia emitting animal category with regard to manure management, and was in 2018 responsible for 87% of the total ammonia emission from manure management (Table 266). Lactating dairy cows is the subgroup with the highest emission over the whole period, and in 2018 39% of the ammonia emission from manure management were from lactating dairy cows (Table 266). Swine are responsible for 10% of the ammonia emissions. For the other farm animal categories, ammonia emissions can be considered as negligible.

The following tables (Table 267 - Table 271) show the emission trends for NO_x, NMVOC, $PM_{2.5}$, PM_{10} and TSP by animal category over the time period 1990 - 2018. NO_x emissions (Table 267) had been reduced by 28%, which is mainly due to a decline in emissions from dairy cows (-44%). Decreasing numbers and different housing systems had been the driving forces. The NMVOC emissions in 2018 were of the same magnitude as in 1990 (Table 268). $PM_{2.5}$ emissions (Table 269) had been reduced by

10% and PM_{10} emissions by 4% (Table 270), whereas TSP emissions had been increased by 7% (Table 271).

With regard to 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. 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. But at the end of the milk production system, the population of dairy cows had sharply increased up to 2017, and was slowing down in 2018. Other factors who had influenced the cattle population were fodder and milk prices.

Table 266 – NH_3 emission trends for category *3B – Manure Management*: 1990-2018 by livestock category (Gg)

Year	Dairy cows	Other cattle	Sheep	Swine	Buffalo	Goats	Horses[a]	Mules & asses[a]	Laying hens	Broilers	Turkey[b]	Other poultry[b]	Other animals	TOTAL
1990	1.26	1.35	0.0032	0.19	NO	0.0004	0.017	IE	0.020	0.0011	IE	0.0004	0.0057	2.85
1991	1.16	1.36	0.0033	0.17	NO	0.0004	0.018	IE	0.018	0.0011	IE	0.0003	0.0053	2.73
1992	1.06	1.29	0.0031	0.18	NO	0.0003	0.017	IE	0.017	0.0010	IE	0.0003	0.0047	2.58
1993	1.05	1.31	0.0028	0.19	NO	0.0004	0.018	IE	0.018	0.0010	IE	0.0003	0.0037	2.59
1994	1.01	1.29	0.0034	0.18	NO	0.0003	0.020	IE	0.017	0.0010	IE	0.0002	0.0034	2.53
1995	1.01	1.35	0.0034	0.19	NO	0.0003	0.021	IE	0.016	0.0009	IE	0.0003	0.0033	2.59
1996	1.00	1.40	0.0032	0.18	NO	0.0002	0.021	IE	0.017	0.0011	IE	0.0003	0.0027	2.62
1997	0.96	1.37	0.0034	0.20	NO	0.0003	0.022	IE	0.016	0.0020	IE	0.0003	0.0032	2.57
1998	0.94	1.34	0.0037	0.20	NO	0.0002	0.022	IE	0.016	0.0022	IE	0.0002	0.0030	2.53
1999	0.90	1.29	0.0036	0.21	NO	0.0002	0.026	IE	0.016	0.0014	IE	0.0002	0.0028	2.45
2000	0.87	1.28	0.0036	0.20	NO	0.0002	0.030	IE	0.020	0.0014	IE	0.0001	0.0034	2.40
2001	0.84	1.29	0.0039	0.20	NO	0.0002	0.029	IE	0.023	0.0018	IE	0.0002	0.0030	2.39
2002	0.83	1.22	0.0040	0.20	NO	0.0027	0.029	IE	0.021	0.0016	IE	0.0002	0.0032	2.32
2003	0.83	1.18	0.0045	0.22	NO	0.0050	0.032	IE	0.022	0.0016	IE	0.0002	0.0032	2.29
2004	0.86	1.16	0.0045	0.25	NO	0.0066	0.034	IE	0.021	0.0012	IE	0.0002	0.0034	2.33
2005	0.81	1.17	0.0044	0.26	NO	0.0073	0.037	IE	0.021	0.0021	IE	0.0002	0.0032	2.32
2006	0.81	1.16	0.0046	0.25	NO	0.0067	0.037	IE	0.021	0.0020	IE	0.0002	0.0032	2.29
2007	0.84	1.22	0.0043	0.24	NO	0.0080	0.037	IE	0.022	0.0018	IE	0.0001	0.0025	2.38
2008	0.82	1.29	0.0040	0.24	NO	0.0100	0.038	IE	0.025	0.0008	IE	0.0001	0.0025	2.43
2009	0.80	1.30	0.0041	0.24	NO	0.0107	0.039	IE	0.027	0.0018	IE	0.0001	0.0026	2.43
2010	0.83	1.34	0.0042	0.22	NO	0.0148	0.039	IE	0.025	0.0018	IE	0.0001	0.0023	2.47
2011	0.82	1.27	0.0042	0.23	NO	0.0158	0.039	IE	0.028	0.0018	IE	0.0001	0.0025	2.41
2012	0.79	1.22	0.0039	0.24	NO	0.0184	0.041	IE	0.032	0.0018	IE	0.0003	0.0024	2.35
2013	0.81	1.25	0.0041	0.23	NO	0.0160	0.039	IE	0.032	0.0016	IE	0.0001	0.0026	2.39
2014	0.82	1.31	0.0042	0.23	NO	0.0149	0.039	IE	0.034	0.0016	IE	0.0002	0.0021	2.46
2015	0.83	1.31	0.0045	0.25	NO	0.0169	0.039	IE	0.032	0.0019	IE	0.0002	0.0022	2.49
2016	0.92	1.26	0.0042	0.25	NO	0.0169	0.037	IE	0.032	0.0019	IE	0.0001	0.0020	2.53
2017	0.97	1.26	0.0041	0.26	NO	0.0172	0.039	IE	0.034	0.0021	IE	0.0002	0.0017	2.59
2018	0.99	1.21	0.0041	0.24	NO	0.0177	0.038	IE	0.034	0.0023	IE	0.0001	0.0018	2.54
Trend 1990 -2018	-22%	-11%	29%	27%		4736%	128%		75%	97%		-66%	-68%	-11%
Trend 2017 -2018	2%	-4%	1%	-7%		3%	-2%		0%	6%		-39%	11%	-2%

a) Mules & asses are recorded together with horses, b) Turkey are recorded together with other poultry.

<u>Source:</u> SER

Table 267 – NO_x emission trends for category *3B – Manure Management*: 1990-2018 by livestock category (Gg NO_2)

Year	Dairy cows	Other cattle	Sheep	Swine	Buffalo	Goats	Horses[a]	Mules & asses[a]	Laying hens	Broilers	Turkey[b]	Other poultry[b]	Other animals	TOTAL
1990	0.054	0.058	0.00015	0.00079	NO	0.00002	0.0007	IE	0.00063	0.00006	IE	0.00001	0.00021	0.115
1991	0.046	0.054	0.00016	0.00070	NO	0.00002	0.0008	IE	0.00057	0.00005	IE	0.00001	0.00020	0.103
1992	0.042	0.050	0.00015	0.00073	NO	0.00002	0.0007	IE	0.00055	0.00005	IE	0.00001	0.00018	0.094
1993	0.041	0.050	0.00014	0.00078	NO	0.00002	0.0008	IE	0.00059	0.00005	IE	0.00001	0.00014	0.093
1994	0.039	0.049	0.00016	0.00074	NO	0.00002	0.0009	IE	0.00056	0.00005	IE	0.00001	0.00013	0.090
1995	0.038	0.051	0.00016	0.00078	NO	0.00001	0.0009	IE	0.00051	0.00004	IE	0.00001	0.00013	0.091
1996	0.038	0.052	0.00015	0.00076	NO	0.00001	0.0009	IE	0.00056	0.00005	IE	0.00001	0.00010	0.092
1997	0.035	0.051	0.00016	0.00082	NO	0.00001	0.0009	IE	0.00051	0.00010	IE	0.00001	0.00012	0.089
1998	0.034	0.048	0.00018	0.00083	NO	0.00001	0.0009	IE	0.00051	0.00011	IE	0.00001	0.00012	0.085
1999	0.030	0.043	0.00017	0.00087	NO	0.00001	0.0011	IE	0.00053	0.00007	IE	0.00001	0.00011	0.076
2000	0.029	0.042	0.00017	0.00082	NO	0.00001	0.0013	IE	0.00063	0.00007	IE	0.00000	0.00013	0.074
2001	0.028	0.044	0.00019	0.00082	NO	0.00001	0.0012	IE	0.00073	0.00009	IE	0.00001	0.00011	0.075
2002	0.028	0.041	0.00019	0.00083	NO	0.00013	0.0012	IE	0.00068	0.00008	IE	0.00001	0.00012	0.072
2003	0.028	0.040	0.00022	0.00088	NO	0.00024	0.0014	IE	0.00070	0.00008	IE	0.00001	0.00012	0.072
2004	0.029	0.040	0.00022	0.00099	NO	0.00032	0.0015	IE	0.00067	0.00006	IE	0.00001	0.00012	0.073
2005	0.027	0.041	0.00021	0.00105	NO	0.00035	0.0016	IE	0.00069	0.00010	IE	0.00001	0.00011	0.073
2006	0.027	0.042	0.00022	0.00098	NO	0.00032	0.0016	IE	0.00068	0.00010	IE	0.00001	0.00012	0.073
2007	0.027	0.045	0.00021	0.00097	NO	0.00039	0.0016	IE	0.00070	0.00009	IE	0.00000	0.00009	0.077
2008	0.026	0.049	0.00019	0.00095	NO	0.00048	0.0016	IE	0.00080	0.00004	IE	0.00000	0.00009	0.080
2009	0.025	0.051	0.00020	0.00095	NO	0.00051	0.0017	IE	0.00087	0.00009	IE	0.00000	0.00009	0.081
2010	0.026	0.053	0.00020	0.00086	NO	0.00071	0.0016	IE	0.00079	0.00008	IE	0.00000	0.00008	0.084
2011	0.025	0.051	0.00020	0.00091	NO	0.00076	0.0016	IE	0.00092	0.00009	IE	0.00000	0.00008	0.081
2012	0.024	0.049	0.00019	0.00093	NO	0.00088	0.0018	IE	0.00104	0.00009	IE	0.00001	0.00009	0.078
2013	0.025	0.050	0.00020	0.00091	NO	0.00077	0.0017	IE	0.00105	0.00008	IE	0.00000	0.00008	0.080
2014	0.025	0.052	0.00020	0.00092	NO	0.00072	0.0017	IE	0.00109	0.00008	IE	0.00001	0.00008	0.082
2015	0.026	0.052	0.00021	0.00099	NO	0.00081	0.0017	IE	0.00104	0.00009	IE	0.00001	0.00007	0.083
2016	0.029	0.050	0.00020	0.00098	NO	0.00081	0.0016	IE	0.00104	0.00009	IE	0.00000	0.00007	0.083
2017	0.030	0.050	0.00019	0.00102	NO	0.00083	0.0017	IE	0.00111	0.00010	IE	0.00001	0.00006	0.085
2018	0.031	0.047	0.00020	0.00095	NO	0.00085	0.0016	IE	0.00111	0.00011	IE	0.00000	0.00006	0.083
Trend 1990 -2018	-44%	-18%	29%	20%		4736%	128%		75%	97%		-66%	-71%	-28%
Trend 2017 -2018	2%	-5%	1%	-7%		3%	-2%		0%	6%		-39%	12%	-2%

a) Mules & asses are recorded together with horses, b) Turkey are recorded together with other poultry.

<u>Source</u>: SER.

Table 268 – NMVOC emission trends for category *3B – Manure Management*: 1990-2018 by livestock category (Gg)

Year	Dairy cows	Other cattle	Sheep	Swine	Buffalo	Goats	Horses[a]	Mules & asses[a]	Laying hens	Broilers	Turkey[b]	Other poultry[b]	Other animals	TOTAL
1990	1.48	1.60	0.0017	0.042	NO	0.0001	0.007	IE	0.0037	0.0007	IE	0.00014	0.00146	3.14
1991	1.41	1.69	0.0017	0.038	NO	0.0001	0.007	IE	0.0034	0.0007	IE	0.00012	0.00149	3.16
1992	1.34	1.64	0.0016	0.039	NO	0.0001	0.007	IE	0.0032	0.0006	IE	0.00011	0.00132	3.03
1993	1.35	1.66	0.0015	0.040	NO	0.0001	0.008	IE	0.0034	0.0006	IE	0.00010	0.00095	3.07
1994	1.31	1.68	0.0018	0.039	NO	0.0001	0.008	IE	0.0033	0.0006	IE	0.00009	0.00088	3.05
1995	1.33	1.77	0.0018	0.041	NO	0.0001	0.009	IE	0.0030	0.0005	IE	0.00011	0.00082	3.15
1996	1.31	1.83	0.0017	0.040	NO	0.0001	0.009	IE	0.0033	0.0006	IE	0.00010	0.00067	3.20
1997	1.29	1.81	0.0018	0.042	NO	0.0001	0.009	IE	0.0030	0.0012	IE	0.00012	0.00083	3.16
1998	1.29	1.79	0.0020	0.042	NO	0.0001	0.009	IE	0.0030	0.0013	IE	0.00008	0.00082	3.14
1999	1.28	1.80	0.0019	0.043	NO	0.0001	0.011	IE	0.0031	0.0008	IE	0.00006	0.00077	3.14
2000	1.25	1.78	0.0019	0.040	NO	0.0001	0.012	IE	0.0037	0.0009	IE	0.00005	0.00084	3.09
2001	1.25	1.79	0.0020	0.040	NO	0.0001	0.012	IE	0.0043	0.0011	IE	0.00006	0.00081	3.10
2002	1.24	1.69	0.0021	0.039	NO	0.0009	0.012	IE	0.0040	0.0010	IE	0.00006	0.00085	2.98
2003	1.20	1.61	0.0024	0.040	NO	0.0016	0.014	IE	0.0041	0.0010	IE	0.00006	0.00092	2.88
2004	1.19	1.58	0.0024	0.041	NO	0.0019	0.015	IE	0.0039	0.0008	IE	0.00006	0.00099	2.83
2005	1.18	1.58	0.0023	0.043	NO	0.0020	0.017	IE	0.0040	0.0013	IE	0.00007	0.00092	2.83
2006	1.17	1.55	0.0024	0.040	NO	0.0018	0.017	IE	0.0040	0.0012	IE	0.00007	0.00093	2.79
2007	1.20	1.60	0.0023	0.039	NO	0.0025	0.017	IE	0.0041	0.0011	IE	0.00005	0.00070	2.87
2008	1.20	1.69	0.0021	0.038	NO	0.0027	0.018	IE	0.0047	0.0005	IE	0.00004	0.00070	2.96
2009	1.22	1.68	0.0022	0.037	NO	0.0029	0.018	IE	0.0051	0.0011	IE	0.00005	0.00072	2.96
2010	1.25	1.70	0.0022	0.036	NO	0.0045	0.018	IE	0.0046	0.0011	IE	0.00003	0.00062	3.02
2011	1.23	1.61	0.0022	0.036	NO	0.0050	0.018	IE	0.0054	0.0011	IE	0.00004	0.00068	2.90
2012	1.22	1.55	0.0021	0.036	NO	0.0048	0.019	IE	0.0061	0.0011	IE	0.00009	0.00066	2.83
2013	1.26	1.59	0.0022	0.034	NO	0.0043	0.019	IE	0.0061	0.0010	IE	0.00005	0.00070	2.91
2014	1.30	1.65	0.0022	0.034	NO	0.0041	0.019	IE	0.0064	0.0010	IE	0.00006	0.00054	3.02
2015	1.38	1.64	0.0024	0.036	NO	0.0046	0.019	IE	0.0061	0.0012	IE	0.00006	0.00056	3.08
2016	1.49	1.57	0.0022	0.035	NO	0.0047	0.018	IE	0.0061	0.0012	IE	0.00005	0.00053	3.13
2017	1.53	1.57	0.0021	0.036	NO	0.0049	0.019	IE	0.0065	0.0013	IE	0.00008	0.00043	3.18
2018	1.58	1.50	0.0021	0.034	NO	0.0048	0.018	IE	0.0065	0.0014	IE	0.00005	0.00050	3.15
Trend 1990 -2018	7%	-6%	29%	-18%		4262%	171%		75%	97%		-66%	-66%	0%
Trend 2017 -2018	3%	-4%	1%	-6%		-2%	-1%		0%	6%		-39%	15%	-1%

a) Mules & asses are recorded together with horses, b) Turkey are recorded together with other poultry.

Source: SER.

Table 269 – PM $_{2.5}$ emission trends for category *3B – Manure Management*: 1990-2018 by livestock category (Gg)

Year	Dairy cows	Other cattle	Sheep	Swine	Buffalo	Goats	Horses[a]	Mules & asses[a]	Laying hens	Broilers	Turkey[b]	Other poultry[b]	Other animals	TOTAL
1990	0.024	0.024	0.000117	0.00033	NO	0.000008	0.00024	IE	0.00017	0.000022	IE	0.000045	0.000056	0.049
1991	0.023	0.025	0.000124	0.00029	NO	0.000009	0.00026	IE	0.00016	0.000022	IE	0.000041	0.000057	0.049
1992	0.021	0.024	0.000113	0.00030	NO	0.000007	0.00026	IE	0.00015	0.000019	IE	0.000036	0.000051	0.046
1993	0.021	0.024	0.000107	0.00032	NO	0.000008	0.00027	IE	0.00016	0.000020	IE	0.000032	0.000037	0.046
1994	0.020	0.024	0.000126	0.00031	NO	0.000008	0.00030	IE	0.00015	0.000019	IE	0.000030	0.000035	0.045
1995	0.020	0.025	0.000124	0.00032	NO	0.000006	0.00030	IE	0.00014	0.000017	IE	0.000036	0.000032	0.046
1996	0.020	0.026	0.000116	0.00031	NO	0.000005	0.00031	IE	0.00015	0.000021	IE	0.000032	0.000026	0.047
1997	0.019	0.025	0.000128	0.00034	NO	0.000006	0.00032	IE	0.00014	0.000039	IE	0.000039	0.000032	0.045
1998	0.019	0.025	0.000135	0.00035	NO	0.000005	0.00033	IE	0.00014	0.000043	IE	0.000028	0.000033	0.045
1999	0.018	0.025	0.000133	0.00036	NO	0.000004	0.00039	IE	0.00015	0.000027	IE	0.000020	0.000031	0.044
2000	0.018	0.025	0.000130	0.00035	NO	0.000005	0.00044	IE	0.00017	0.000028	IE	0.000017	0.000034	0.044
2001	0.018	0.025	0.000140	0.00035	NO	0.000005	0.00044	IE	0.00020	0.000035	IE	0.000020	0.000033	0.044
2002	0.017	0.024	0.000147	0.00035	NO	0.000017	0.00044	IE	0.00019	0.000032	IE	0.000019	0.000034	0.042
2003	0.017	0.023	0.000158	0.00038	NO	0.000030	0.00048	IE	0.00019	0.000031	IE	0.000020	0.000037	0.041
2004	0.016	0.022	0.000162	0.00043	NO	0.000034	0.00052	IE	0.00018	0.000024	IE	0.000022	0.000040	0.040
2005	0.016	0.022	0.000165	0.00046	NO	0.000038	0.00059	IE	0.00019	0.000041	IE	0.000022	0.000037	0.040
2006	0.016	0.022	0.000162	0.00043	NO	0.000034	0.00061	IE	0.00019	0.000039	IE	0.000023	0.000038	0.040
2007	0.016	0.023	0.000154	0.00043	NO	0.000046	0.00061	IE	0.00019	0.000035	IE	0.000016	0.000028	0.041
2008	0.016	0.024	0.000142	0.00042	NO	0.000050	0.00064	IE	0.00022	0.000016	IE	0.000013	0.000030	0.042
2009	0.017	0.024	0.000147	0.00042	NO	0.000054	0.00064	IE	0.00024	0.000035	IE	0.000017	0.000030	0.042
2010	0.017	0.024	0.000150	0.00039	NO	0.000083	0.00064	IE	0.00022	0.000034	IE	0.000011	0.000026	0.043
2011	0.016	0.023	0.000149	0.00041	NO	0.000093	0.00064	IE	0.00025	0.000035	IE	0.000014	0.000030	0.041
2012	0.016	0.023	0.000138	0.00042	NO	0.000087	0.00068	IE	0.00028	0.000036	IE	0.000031	0.000028	0.041
2013	0.017	0.023	0.000145	0.00041	NO	0.000078	0.00066	IE	0.00029	0.000031	IE	0.000017	0.000029	0.042
2014	0.017	0.024	0.000146	0.00042	NO	0.000075	0.00066	IE	0.00030	0.000031	IE	0.000020	0.000023	0.043
2015	0.017	0.024	0.000158	0.00045	NO	0.000083	0.00066	IE	0.00029	0.000037	IE	0.000019	0.000024	0.043
2016	0.019	0.024	0.000149	0.00045	NO	0.000087	0.00064	IE	0.00029	0.000038	IE	0.000017	0.000022	0.044
2017	0.020	0.024	0.000142	0.00046	NO	0.000091	0.00066	IE	0.00031	0.000042	IE	0.000025	0.000018	0.045
2018	0.020	0.023	0.000144	0.00043	NO	0.000088	0.00065	IE	0.00030	0.000044	IE	0.000015	0.000020	0.044
Trend 1990 -2018	-19%	-4%	23%	32%		964%	171%		75%	97%		-66%	-63%	-10%
Trend 2017 -2018	0%	-3%	2%	-7%		-3%	-1%		0%	6%		-39%	15%	-2%

a) Mules & asses are recorded together with horses, b) Turkey are recorded together with other poultry.

Source: SER.

Table 270 – PM $_{10}$ emission trends for category *3B – Manure Management*: 1990-2018 by livestock category (Gg)

Year	Dairy cows	Other cattle	Sheep	Swine	Buffalo	Goats	Horses[a]	Mules & asses[a]	Laying hens	Broilers	Turkey[b]	Other poultry[b]	Other animals	TOTAL
1990	0.037	0.036	0.0004	0.0071	NO	0.00002	0.0004	IE	0.0023	0.00022	IE	0.00032	0.00011	0.084
1991	0.035	0.038	0.0004	0.0063	NO	0.00003	0.0004	IE	0.0021	0.00022	IE	0.00029	0.00012	0.083
1992	0.032	0.037	0.0003	0.0066	NO	0.00002	0.0004	IE	0.0020	0.00019	IE	0.00026	0.00010	0.079
1993	0.032	0.037	0.0003	0.0070	NO	0.00003	0.0004	IE	0.0021	0.00020	IE	0.00023	0.00008	0.079
1994	0.031	0.037	0.0004	0.0066	NO	0.00002	0.0005	IE	0.0020	0.00019	IE	0.00021	0.00007	0.078
1995	0.031	0.038	0.0004	0.0070	NO	0.00002	0.0005	IE	0.0019	0.00017	IE	0.00025	0.00007	0.079
1996	0.030	0.039	0.0003	0.0068	NO	0.00001	0.0005	IE	0.0021	0.00021	IE	0.00022	0.00006	0.080
1997	0.029	0.039	0.0004	0.0074	NO	0.00002	0.0005	IE	0.0019	0.00039	IE	0.00027	0.00007	0.079
1998	0.029	0.038	0.0004	0.0076	NO	0.00001	0.0005	IE	0.0019	0.00043	IE	0.00019	0.00007	0.078
1999	0.028	0.038	0.0004	0.0080	NO	0.00001	0.0006	IE	0.0019	0.00027	IE	0.00014	0.00007	0.078
2000	0.027	0.038	0.0004	0.0077	NO	0.00001	0.0007	IE	0.0023	0.00028	IE	0.00012	0.00008	0.076
2001	0.027	0.038	0.0004	0.0077	NO	0.00002	0.0007	IE	0.0027	0.00035	IE	0.00014	0.00007	0.077
2002	0.027	0.036	0.0004	0.0078	NO	0.00005	0.0007	IE	0.0025	0.00032	IE	0.00013	0.00008	0.074
2003	0.026	0.035	0.0005	0.0084	NO	0.00009	0.0008	IE	0.0026	0.00031	IE	0.00014	0.00012	0.073
2004	0.025	0.034	0.0005	0.0097	NO	0.00010	0.0008	IE	0.0024	0.00024	IE	0.00015	0.00014	0.073
2005	0.025	0.034	0.0005	0.0103	NO	0.00011	0.0009	IE	0.0025	0.00041	IE	0.00016	0.00012	0.074
2006	0.024	0.034	0.0005	0.0097	NO	0.00010	0.0010	IE	0.0025	0.00039	IE	0.00016	0.00011	0.072
2007	0.025	0.035	0.0005	0.0096	NO	0.00014	0.0010	IE	0.0026	0.00035	IE	0.00011	0.00009	0.075
2008	0.025	0.036	0.0004	0.0095	NO	0.00015	0.0010	IE	0.0029	0.00016	IE	0.00009	0.00010	0.076
2009	0.025	0.036	0.0004	0.0095	NO	0.00016	0.0010	IE	0.0032	0.00035	IE	0.00012	0.00011	0.077
2010	0.026	0.037	0.0004	0.0087	NO	0.00025	0.0010	IE	0.0029	0.00034	IE	0.00008	0.00010	0.076
2011	0.025	0.035	0.0004	0.0092	NO	0.00028	0.0010	IE	0.0034	0.00035	IE	0.00010	0.00013	0.076
2012	0.025	0.034	0.0004	0.0095	NO	0.00026	0.0011	IE	0.0038	0.00036	IE	0.00022	0.00010	0.075
2013	0.026	0.035	0.0004	0.0093	NO	0.00024	0.0010	IE	0.0038	0.00031	IE	0.00012	0.00013	0.077
2014	0.026	0.036	0.0004	0.0094	NO	0.00022	0.0010	IE	0.0040	0.00031	IE	0.00014	0.00008	0.079
2015	0.027	0.037	0.0005	0.0102	NO	0.00025	0.0010	IE	0.0038	0.00037	IE	0.00013	0.00010	0.080
2016	0.029	0.036	0.0004	0.0102	NO	0.00026	0.0010	IE	0.0038	0.00038	IE	0.00012	0.00009	0.081
2017	0.030	0.036	0.0004	0.0106	NO	0.00027	0.0010	IE	0.0041	0.00042	IE	0.00018	0.00007	0.083
2018	0.030	0.035	0.0004	0.0098	NO	0.00026	0.0010	IE	0.0041	0.00044	IE	0.00011	0.00008	0.081
Trend 1990 -2018	-19%	-4%	23%	38%		964%	171%		75%	97%		-66%	-28%	-4%
Trend 2017 -2018	0%	-3%	2%	-7%		-3%	-1%		0%	6%		-39%	12%	-2%

a) Mules & asses are recorded together with horses, b) Turkey are recorded together with other poultry.

Source: SER.

Table 271 – TSP emission trends for category *3B – Manure Management*: 1990-2018 by livestock category (Gg)

Year	Dairy cows	Other cattle	Sheep	Swine	Buffalo	Goats	Horses[a]	Mules & asses[a]	Laying hens	Broilers	Turkey[b]	Other poultry[b]	Other animals	TOTAL
1990	0.081	0.079	0.0008	0.046	NO	0.00006	0.0008	IE	0.011	0.00045	IE	0.00032	0.00026	0.22
1991	0.077	0.082	0.0009	0.040	NO	0.00007	0.0009	IE	0.010	0.00044	IE	0.00029	0.00027	0.21
1992	0.071	0.079	0.0008	0.042	NO	0.00005	0.0009	IE	0.010	0.00038	IE	0.00026	0.00023	0.20
1993	0.069	0.080	0.0008	0.045	NO	0.00006	0.0009	IE	0.010	0.00039	IE	0.00023	0.00017	0.21
1994	0.068	0.080	0.0009	0.042	NO	0.00006	0.0010	IE	0.010	0.00037	IE	0.00021	0.00016	0.20
1995	0.067	0.083	0.0009	0.045	NO	0.00004	0.0010	IE	0.009	0.00034	IE	0.00025	0.00015	0.21
1996	0.066	0.086	0.0008	0.044	NO	0.00003	0.0011	IE	0.010	0.00041	IE	0.00022	0.00013	0.21
1997	0.064	0.084	0.0009	0.048	NO	0.00004	0.0011	IE	0.009	0.00079	IE	0.00027	0.00015	0.21
1998	0.063	0.082	0.0009	0.049	NO	0.00003	0.0011	IE	0.009	0.00085	IE	0.00019	0.00016	0.21
1999	0.062	0.082	0.0009	0.052	NO	0.00003	0.0014	IE	0.009	0.00054	IE	0.00014	0.00016	0.21
2000	0.060	0.082	0.0009	0.050	NO	0.00003	0.0015	IE	0.011	0.00057	IE	0.00012	0.00017	0.21
2001	0.059	0.082	0.0010	0.050	NO	0.00004	0.0015	IE	0.013	0.00071	IE	0.00014	0.00017	0.21
2002	0.058	0.078	0.0010	0.052	NO	0.00012	0.0015	IE	0.012	0.00064	IE	0.00013	0.00017	0.20
2003	0.056	0.075	0.0011	0.056	NO	0.00021	0.0017	IE	0.012	0.00061	IE	0.00014	0.00020	0.20
2004	0.055	0.074	0.0011	0.066	NO	0.00024	0.0018	IE	0.012	0.00049	IE	0.00015	0.00023	0.21
2005	0.054	0.074	0.0012	0.071	NO	0.00026	0.0020	IE	0.012	0.00081	IE	0.00016	0.00020	0.22
2006	0.053	0.073	0.0011	0.066	NO	0.00024	0.0021	IE	0.012	0.00077	IE	0.00016	0.00020	0.21
2007	0.055	0.076	0.0011	0.066	NO	0.00032	0.0021	IE	0.012	0.00070	IE	0.00011	0.00016	0.21
2008	0.055	0.079	0.0010	0.065	NO	0.00035	0.0022	IE	0.014	0.00032	IE	0.00009	0.00017	0.22
2009	0.056	0.079	0.0010	0.065	NO	0.00038	0.0022	IE	0.015	0.00069	IE	0.00012	0.00018	0.22
2010	0.056	0.080	0.0010	0.059	NO	0.00058	0.0022	IE	0.014	0.00069	IE	0.00008	0.00016	0.21
2011	0.055	0.077	0.0010	0.063	NO	0.00065	0.0022	IE	0.016	0.00070	IE	0.00010	0.00019	0.22
2012	0.054	0.075	0.0010	0.066	NO	0.00061	0.0023	IE	0.018	0.00071	IE	0.00022	0.00017	0.22
2013	0.058	0.076	0.0010	0.064	NO	0.00055	0.0022	IE	0.018	0.00062	IE	0.00012	0.00018	0.22
2014	0.058	0.079	0.0010	0.066	NO	0.00052	0.0023	IE	0.019	0.00062	IE	0.00014	0.00014	0.23
2015	0.059	0.080	0.0011	0.071	NO	0.00058	0.0023	IE	0.018	0.00074	IE	0.00013	0.00015	0.23
2016	0.064	0.078	0.0010	0.071	NO	0.00061	0.0022	IE	0.018	0.00075	IE	0.00012	0.00013	0.24
2017	0.066	0.078	0.0010	0.074	NO	0.00064	0.0023	IE	0.019	0.00084	IE	0.00018	0.00011	0.24
2018	0.066	0.075	0.0010	0.068	NO	0.00062	0.0022	IE	0.019	0.00088	IE	0.00011	0.00012	0.23
Trend 1990 -2018	-19%	-4%	23%	50%		964%	171%		75%	97%		-66%	-52%	7%
Trend 2017 -2018	0%	-3%	2%	-7%		-3%	-1%		0%	6%		-39%	14%	-3%

a) Mules & asses are recorded together with horses, b) Turkey are recorded together with other poultry.

Source: SER.

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,(EMEP/EEA 2016b) described in section 5.2.6 and schematically represented in Figure 5-5.

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 42 of the 2016 guidelines,(EMEP/EEA 2016b) namely:

$$E_{MMS\_NH_3(i)} = \left[\sum_i \{(E_{build\_slurry\_NH_3-N(i)} + E_{build\_solid\_NH_3-N(i)} + E_{storage\_slurry\_NH_3-N(i)} + E_{storage\_solid\_NH_3-N(i)}) * n_i\}\right] * \langle\frac{17}{14}\rangle$$

with i is the *i*th livestock category, pl=animal/animal place and:

$E_{build\_slurry\_NH3-N(i)}$	NH_3-N emissions from buildings with liquid manure system for livestock category *i* (in kg NH3-N pl^{-1} $year^{-1}$);
$E_{build\_solid\_NH3-N(i)}$	NH_3-N emissions from buildings with solid manure system for livestock category *i* (kg NH3-N pl^{-1} $year^{-1}$);
$E_{storage\_slurry\_NH3-N(i)}$	NH_3-N emissions from storage of liquid manure from livestock category *i* (kg NH3-N pl^{-1} $year^{-1}$);
$E_{storage\_silidy\_NH3-N(i)}$	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 2016 guidelines (EMEP/EEA 2016a).

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:

$EF_{build\_slurry\_NH3-N(i)}$	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 274.
$m_{build\_slurry\_N(i)}$	the amounts of total N deposited in buildings handled as liquid slurry (kg N pl^{-1} year^{-1}) and described in section 5.2.6.
$EF_{build\_solid\_NH3-N(i)}$	EFs for NH_3-N emissions from livestock buildings with a solid manure system (kg NH3-N kg^{-1}), and summarized in Table 274.
$m_{build\_solid\_N(i)}$	the amounts of total N deposited in buildings handled as solid slurry (kg N pl^{-1} year^{-1}); and described in section 5.2.6.

The NH_3-N emissions from storage were calculated using the following formulas:

$$E_{storage\_slurry\_NH_3-N(i)} = \left(mm_{storage\_slurry\_TAN(i)} * \ EF_{storage\_slurry\_NH_3-N}(i)\right)$$
$$E_{storage\_solid\_NH_3-N(i)} = \left(m_{storage\_solid\_TAN(i)} * \ EF_{stora\quad\_solid\_NH_3-N(i)}\right)$$

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 274.
$mm_{storage\_slurry\_TAN(i)}$	the modified amounts of total N stored before application to land (kg N pl^{-1} year^{-1}) and described in section 5.2.6.
$EF_{storage\_solid\_NH3-N(i)}$	EFs for NH_3-N emissions from storage of solid manure (kg NH3-N kg^{-1}), see Table 274.
$m_{storage\_solid\_TAN(i)}$	the amounts of total N stored before application to land (kg N pl^{-1} year^{-1}) and described in section 5.2.6.

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,(EMEP/EEA 2016b) see section 5.2.6. 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 43 of the 2016 guidelines,(EMEP/EEA 2016b) 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 2016 guidelines (EMEP/EEA 2016a).

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:

$$E_{storage\_slurry\_NO\ \ -N(i)} = \left(mm_{storage\_slurry\_TAN(i)} * EF_{storage\_slurry\_NO-N(i)}\right)$$
$$E_{storage\_solid\_NO\ \ -N(i)} = \left(m_{storage\_solid\_TAN(i)} * EF_{storage\_solid\_NO\ \ -N(i)}\right)$$

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 5.2.6.
$EF_{storage\_solid\_NO-N(i)}$	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 5.2.6.

5.3.3.1.3 Non-methane volatile organic compounds emissions - Methodology issues

NMVOC emissions were estimated following the TIER 2 methodology from the 2019 guidelines,(EMEP/EEA 2019b) 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,(EMEP/EEA 2019b) 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 48-54 from the 2019 guidelines,(EMEP/EEA 2019b) namely:

$$E_{NMVOC(i)} = \left[\sum_i \{ (E_{silage\_store\_NMVOC(i)} + E_{silage\_feeding\_NMVOC(i)} + E_{build\_NMOVC(i)} + E_{store\_NMVOC(i)} + E_{applic\_NMVOC(i)} + E_{grazing\_NMVOC(i)}) * n_i \} \right]$$

with i is the *i*th livestock category and:

$$E_{silage\_store\_NMVOC(i)} = MJ_i * x_{build(i)} * (EF_{silage\_feeding\_NMVOC(i)} * Frac_{silage}) * Frac_{silage\_store(i)}$$

$$E_{silage\_feeding\_NMVOC(i)} = MJ_i * x_{build(i)} * (EF_{silage\_feeding\_NMVOC(i)} * Frac_{silage})$$

$$E_{build\_NMOVC(i)} = MJ_i * x_{build(i)} * (EF_{build\_NMVOC(i)})$$

$$E_{manure\_store\_NMOVC(i)} = E_{build\_NMOVC(i)} * \left(\frac{E_{storage\_\_NH\ \ (i)}}{E_{build_{NH3}-N(i)}} \right)$$

$$E_{applic\_NMOVC(i)} = E_{build\_NMOVC(i)} * \left(\frac{E_{applic\_\_NH3(i)}}{E_{build\_NH3(i)}} \right)$$

$$E_{grazi\quad\_NMVOC(i)} = MJ_i * (1 - x_{build(i)}) * EF_{grazing\_NMVOC(i)}$$

with i is the *i*th livestock category, pl=animal/animal place and:

$x_{build(i)}$ The proportion of time animals spend in the livestock building in a year (for details, see section 5.2.3)

$Frac_{silage}$ Being "1", as silage feeding is dominant (EMEP/EEA, 2019a).

$Frac_{silage\_store}$ Using the default value of 0.25 for European conditions, according to the 2019 guidelines (EMEP/EEA, 2019a).

$E_{build\_NH3(i)}$ = ($E_{build\_solid\_NH3\text{-}N(i)}$ + $E_{build\_slurry\_NH3\text{-}N(i)}$) in kg pl^{-1} $year^{-1}$; derived from the mass-flow of TAN through the manure management system (see section 5.2.6, setion 5.3.3.1.1 and section 5.3.3.3.1);

$E_{storage\_NH3(i)}$ = ($E_{storage\_solid\_NH3\text{-}N(i)}$ + $E_{storage\_slurry\_NH3\text{-}N(i)}$) in kg pl^{-1} $year^{-1}$; derived from the mass-flow of TAN through the manure management system (see section 5.2.6, section 5.3.3.1.1 and section 5.3.3.3.1);

$E_{applic\_NH3(i)}$ =($E_{applic\_solid\_NH3(i)}$ + $E_{applic\_slurry\_NH3(i)}$) in kg pl^{-1} $year^{-1}$; derived from the mass flow of TAN through the manure management system (see section 5.2.6, section 5.4.3.1.1 and section 5.4.4.2.1);

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 the NIR 2020 (Schuman et al. 2020), and are summarized in Table 272.

Emissions from animal sub-categories were summed up to match NFR animal categories.

Table 272 – Estimated gross energy (GE) per day for cattle and sheep categories for the years 1990-2020

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	Suckler cows	Mature sheep	Sheep lambs <1 year
1990	66.8	141.5	132.4	185.4	184.5	263.3	228.3	22.3	12.6
1991	66.8	141.5	132.4	185.4	184.5	263.9	228.3	22.3	12.6
1992	66.8	141.5	132.4	185.4	184.5	271.4	228.3	22.3	12.6
1993	66.8	141.5	132.4	185.4	184.5	278.2	228.3	22.3	12.6
1994	66.8	141.5	132.4	185.4	184.5	277.2	228.3	22.3	12.6
1995	66.8	141.5	132.4	185.4	184.5	282.1	228.3	22.3	12.6
1996	66.8	141.5	132.4	185.4	184.5	283.2	228.3	22.3	12.6
1997	66.8	141.5	132.4	185.4	184.5	286.6	228.3	22.3	12.6
1998	66.8	141.5	132.4	185.4	184.5	288.1	228.3	22.3	12.6
1999	66.8	141.5	132.4	185.4	184.5	291.1	228.3	22.3	12.6
2000	66.8	141.5	132.4	185.4	184.5	295.3	228.3	22.3	12.6
2001	66.8	141.5	132.4	185.4	184.5	299.4	228.3	22.3	12.6
2002	66.8	141.5	132.4	185.4	184.5	302.9	228.3	22.3	12.6
2003	66.8	141.5	132.4	185.4	184.5	306.7	228.3	22.3	12.6
2004	66.8	141.5	132.4	185.4	184.5	310.2	228.3	22.3	12.6
2005	66.8	141.5	132.4	185.4	184.5	312.8	228.3	22.3	12.6
2006	66.8	141.5	132.4	185.4	184.5	315.3	228.3	22.3	12.6
2007	66.8	141.5	132.4	185.4	184.5	312.7	228.3	22.3	12.6
2008	66.8	141.5	132.4	185.4	184.5	316.9	228.3	22.3	12.6
2009	66.8	141.5	132.4	185.4	184.5	317.3	228.3	22.3	12.6
2010	66.8	141.5	132.4	185.4	184.5	321.2	228.3	22.3	12.6
2011	66.8	141.5	132.4	185.4	184.5	322.2	228.3	22.3	12.6
2012	66.8	141.5	132.4	185.4	184.5	323.4	228.3	22.3	12.6
2013	66.8	141.5	132.4	185.4	184.5	316.2	228.3	22.3	12.6
2014	66.8	141.5	132.4	185.4	184.5	326.9	228.3	22.3	12.6
2015	66.8	141.5	132.4	185.4	184.5	340.6	228.3	22.3	12.6
2016	66.8	141.5	132.4	185.4	184.5	340.6	228.3	22.3	12.6
2017	66.8	141.5	132.4	185.4	184.5	339.6	228.3	22.3	12.6
2018	66.8	141.5	132.4	185.4	184.5	349.9	228.3	22.3	12.6

Source: NIR 2020 (Schuman et al. 2020).

For livestock categories other than cattle, NMVOC emissions ($E_{NMVOC(i)}$) were based on the excreted volatile substances (VS), whereby following equations 48-55 from the 2019 guidelines,(EMEP/EEA 2019b) namely:

$$E_{NMVOC(i)} = \sum_i \big(E_{silage\_store\_NMVOC(i)} + E_{silag\ \ \_feeding\_NMVOC(i)} + E_{build\_NMOVC(i)} + E_{store\_NMVOC(i)} + E_{applic\_NMVOC(i)} + E_{grazing\_NMVOC(i)}\big) * n_i$$

with i is the *i*th livestock category, pl=animal/animal place and:

$$E_{silage\_store\_NMVOC(i)} = VS_i * \ x_{build(i)} * \ \big(EF_{silage\_feeding\_NMVOC(i)} * Frac_{silage}\big) * Frac_{silage\_store(i)}$$

$$E_{silage\_feeding\_NMVOC(i)} = VS_i * \ x_{build(i)} * \ \left(EF_{silage\_feeding\_NMVOC(i)} * Frac_{silage}\right)$$
$$E_{build\_NMOVC(i)} = VS_i * \ x_{build(i)} * \ \left(EF_{build\_NMVOC(i)}\right)$$
$$E_{manure\_store\_NMOVC(i)} = E_{build\_NMOVC(i)} * \left(\frac{E_{storage\_NH\ \ (i)}}{E_{buil\ \ _{NH}\ -N(i)}}\right)$$
$$E_{applic\_NMOVC(i)} = E_{build\_NMOVC(i)} * \left(\frac{E_{applic\_NH3(i)}}{E_{build\_NH\ \ (i)}}\right)$$
$$E_{grazing\_NMVOC(i)} = VS_i * \ (1 - x_{build(i)}) * \ EF_{grazing\_NMVOC(i)}$$

with

$x_{build(i)}$	The proportion of time animals spend in the livestock building in a year (for details, see section 5.2.3)
$Frac_{silage}$	For sheep, goats, deer and horses, assumed to be "0.5". For all other livestock categories defined as zero, as silage is not used as feed.
$Frac_{silage\_store}$	Using the default value of 0.25 for European conditions, according to the 2019 guidelines (EMEP/EEA; 2019a).
$E_{build\_NH3(i)}$	derived from the mass flow (see section 5.2.6); = ($E_{build\_solid\_NH3\text{-}N(i)}$ + $E_{build\_slurry\_NH3\text{-}N(i)}$)
$E_{storage\_NH3(i)}$	derived from the mass flow (see section 5.2.6); = ($E_{storage\_solid\_NH3\text{-}N(i)}$ + $E_{storage\_slurry\_NH3\text{-}N(i)}$)
$E_{applic\_NH3(i)}$	derived from the mass flow (see section 5.2.6); = ($E_{applic\_solid\_NH3(i)}$ + $E_{applic\_slurry\_NH3(i)}$)
VS_i	where kg VS_i is the excreted VS in kg per year for livestock category *i*. The used VS_i values were based on the 2006 IPCC guidelines,(IPCC 2006a) which are daily VS_i values (see Table 273) and were therefore multiplied by 365 to obtain annual excreted VS.

Table 273 – Daily excreted volatile substances (VS) for livestock category *i*

Animal category	VS_i	Source / Note
Sows	0.46	(IPCC 2006a) – Table 10A-8
Fattening pigs	0.3	(IPCC 2006a)– Table 10A-7
Weaners	0.3	(IPCC 2006a)– Table 10A-7
Goats	0.3	(IPCC 2006a) – Table 10A-9
Horses	2.13	(IPCC 2006a) – Table 10A-9
Broilers	0.01	(IPCC 2006a) – Table 10A-9
Laying hens	0.02	(IPCC 2006a) – Table 10A-9
Other poultry	0.02	(IPCC 2006a) – Table 10A-9, ducks as proxy
Ostriches	1.16	(IPCC 2006a) – Table 10A-9
Rabbits	0.1	(IPCC 2006a) – Table 10A-9

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.(EMEP/EEA 2019b) Default emissions factors for the different livestock categories were used and multiplied by the number of animals, namely:

$$E_{PM(p)} = \left\{\sum_i \left[\left(EF_{PM(p,i)}\right) * n_i\right]\right\}$$

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} $year^{-1}$;
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 and are summarized in Table 256. 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 (EMEP/EEA 2016b) to estimate manure management NH_3 related emissions (see section 5.2.6), NH_3-N emission factors from manure management emission factors from manure management had to be used for all animal categories. The used EFs are presented in Table 274 for the different livestock categories for NH3-N emissions during housing and during storage, and were based mainly based on Table 3.9 from the 2016 guidelines (EMEP/EEA 2016b), except for the storage of slurry, where the EFs were based on the German inventory, due to similar climate and feeding conditions.(Rösemann et al. 2019) For cattle slurry stored in open tanks it was assumed that a natural cover would be given, whereas for swine, this would not be the case.

Table 274– Used NH_3-N emissions factors (EF) for the emissions from manure management for livestock category *i*

Livestock category	EF for buildings with slurry [a]	EF for buildings with solid MS [a]	EF for storage of slurry [b]			EF for storage of solid manure [a]
			Open tanks	Covered tanks	Underneath slatted floor	
Non-dairy cattle (including calves, young female cattle, heifers, fattening bulls, mature male cattle and suckler cows)	0.2	0.19	0.045	0.013	0.045	0.27
Lactating dairy cows	0.2	0.19	0.045	0.013	0.045	0.27
Sows	0.22	0.25	0.15	0.015	0.105	0.45
Fattening pigs / weaners	0.28	0.27	0.15	0.015	0.105	0.45
Sheep (mature sheep and lambs)	NO	0.22	NO			0.28

Livestock category	EF for buildings with slurry [a]	EF for buildings with solid MS [a]	EF for storage of slurry [b]			EF for storage of solid manure [a]
			Open tanks	Covered tanks	Underneath slatted floor	
Goats (mature goats and kids)	NO	0.22	NO			0.28
Horses (including assess and mules)	NO	0.22	NO			0.35
Broilers	NO	0.28	NO			0.17
Laying hens	NO	0.41	NO			0.14
Other poultry [c]	NO	0.35	NO			0.24
Ostriches [d]	NO	0.57	NO			0.16
Rabbits (breeding female animals and other rabbits) [e]	NO	0.22	NO			0.35
Deer [f]	NO	0.22	NO			0.28

a) EMEP/EEA 2016 guidelines default values as presented in Table 3.9.(EMEP/EEA 2016b)
b) EFs were based on German inventory, due to similar climat and feeding conditions ((Rösemann et al. 2019); Table 4.5 for the EFs for cattle slurry, and Table 5.4 for the EFs for swine slurry);
c) As more than 50% were turkeys, the default value for Turkeys was used (Table 3.9; .(EMEP/EEA 2016b));
d) Default value for geese (Table 3.9; .(EMEP/EEA 2016b));
e) Default value for horses (Table 3.9; .(EMEP/EEA 2016b)); similar as (Haenel et al. 2018);
f) Default value for sheep and goat (Table 3.9; .(EMEP/EEA 2016b)).

5.3.3.3.2 Nitric oxide emissions

Since the Tier 2 mass-flow approach based on the concept of a flow of TAN through the manure management system (EMEP/EEA 2016b) was used to estimate manure management NO_x related emissions, NO-N emission factors from manure management were used for all animal categories.

The used EFs for storage of solid manure for NO-N were taken from Table 3.10 in the 2016 guidelines, (EMEP/EEA 2016b) and were 0.01 for the storage of solid manure. For the storage of liquid 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 N2O-N emissions from manure management, similar as (Rösemann et al. 2019). The used EFs for storage of cattle slurry for NO-N were 0.00045, 0.0015 and 0.00045 for slurry stored in an open tank, in a covered tanks and underneath a slatted floor, respectively. For swine slurry stored in an open tank, in a covered tank and underneath a slatted floor were the used EFs 0.015, 0.0015 and 0.0105, respectively.

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 2019 guidelines (EMEP/EEA 2019b) 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 275 .

Table 275– NMVOC emission factors (EF) for silage feeding, building and grazing

	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]	0.01076	0.001614	0.00002349
Goats (mature goats and kids) [b]	0.01076	0.001614	0.00002349
Horses (including assess and mules) [b]	0.01076	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]	0.01076[e]	0.001614	0.00002349

Note : a) Based on Table 3.11 in the 2019 guidelines.(EMEP/EEA 2019b)
b) Based on Table 3.12 in the 2019 guidelines.(EMEP/EEA 2019b)
c) Default values for turkeys and other poultry (Table 3.12; (EMEP/EEA 2019b));
d) Using as proxy the default value for geese as there was no value for ostriches (Table 3.12; (EMEP/EEA 2019b));
e) Using as proxy for EF for silage feeding the default value for sheep and goats as there was no value for deer (Table 3.12; (EMEP/EEA 2019b));.

5.3.3.3.4 Particles emissions

For $PM_{2.5}$, PM_{10} and TSP the default Tier 1 emission factors from the 2019 guidelines (EMEP/EEA 2019b) were used and are summarized in Table 276.

Table 276– Particles emission factors (EF) used for the emissions from manure management [a]

	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
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 2019 guidelines.(EMEP/EEA 2019b)
b) As more than 50% are turkeys, the default value for turkeys were used (Table 3.5; (EMEP/EEA 2019b));
c) Using as proxy the default value for geese (Table 3.5; (EMEP/EEA 2019b));
d) Using as proxy the default value for fur animals (Table 3.5; (EMEP/EEA 2019b));
e) Using as proxy the default value for sheep and goats (Table 3.5; (EMEP/EEA 2019b)).

5.3.4 Category specific QA/QC procedures

Consistency and completeness checks have been performed directly in the model.

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

- Provisional activity data for 2017 livestock data were updated, were necessary.
- The N extraction of the different animal categories revised, and adapted, and influenced all N emissions, as well as NMVOC emissions.
- Further was the distinction made between different slurry storage types, whereas in previous submission the default value was used.
- The EFs for swine and sheep to estimate particular matter emissions ($PM_{2.5}$; PM_{10} and TSP) were mismatched, this error was corrected.
- The 2019 EMEP/EEA guidelines were applied for NMVOC and particular matters.

A detailed descriptions of the different changes and the recalculations are provided in 8.1.1.

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

An update of the manure management system using more recent data is planned for the following submission. The N flow will be revised, according to the 2019 EMEP/EEA guidelines.

5.4 *Crop production and agricultural soils (category 3D)*

This section includes the estimation of ammonia and nitrogen oxide emissions linked to N-fertilisation of agricultural soils.

In 2018, this source category was responsible for 54% of agricultural ammonia and for 93% of the agricultural NOx emissions and for $$$49.0% of the national total ammonia emissions (fuel sold) and for $$$5.0% of the national total NOx emissions (fuel sold).

This section also includes emissions of NMVOC and particulate matter (TSP, PM_{10}, $PM_{2.5}$). In 2018, this source category was responsible for:

- 3% of the NMVOC emissions from the agriculture sector.
- 15% of $PM_{2.5}$ emissions and 72% of PM_{10} emissions from the agriculture sector.
- 47% of TSP emissions from agriculture.

5.4.1 **Key categories$$$$**

In 2018, categories *3Da1 – Inorganic N-fertilizers* and 3Da2A – Animal manure applied to soils are key categories for NH_3 emissions, whereas category *3Da1* is also a key category, in the level assessment, for TSP and PM_{10} (Table 277).

Table 277 – Key categories for sector 3D – Crop production and agricultural soils.

NFR 3D																	
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)							4	1			6		4			
3 D a 2 a	Animal manure applied to soils							1									
3 D a 3	Urine and dung deposited by grazing animals								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, …)

5.4.2 **Source category description**

An overview of shares and trends of pollutants that originated from sector 3D – Crop production and agricultural soils is presented in Table 278.

Table 278 – Emissions (Gg) of main pollutants and particles from for category of Crop production and agricultural soils (3D): 1990-2018

Year	Main pollutants			Particular matter		
	NH_3	NO_x	NMVOC	$PM_{2.5}$	PM_{10}	TSP
1990	3.74	1.30	0.109	0.0076	0.197	0.197
1991	3.88	1.34	0.108	0.0075	0.196	0.196
1992	3.85	1.39	0.108	0.0075	0.196	0.196
1993	3.77	1.32	0.109	0.0076	0.198	0.198
1994	3.71	1.27	0.109	0.0076	0.198	0.198
1995	3.78	1.28	0.109	0.0076	0.198	0.198
1996	3.81	1.28	0.108	0.0075	0.196	0.196
1997	3.76	1.27	0.108	0.0075	0.196	0.196
1998	3.73	1.25	0.109	0.0076	0.197	0.197
1999	3.83	1.28	0.109	0.0076	0.197	0.197
2000	3.72	1.27	0.109	0.0076	0.198	0.198
2001	3.52	1.15	0.109	0.0076	0.199	0.199
2002	3.43	1.14	0.110	0.0077	0.199	0.199
2003	3.18	1.00	0.110	0.0077	0.199	0.199
2004	3.32	1.16	0.110	0.0077	0.199	0.199
2005	3.14	1.05	0.110	0.0077	0.199	0.199
2006	3.07	1.04	0.110	0.0077	0.199	0.199
2007	3.10	1.04	0.112	0.0078	0.202	0.202
2008	3.11	1.04	0.111	0.0077	0.201	0.201
2009	3.03	1.04	0.112	0.0078	0.202	0.202
2010	3.07	1.05	0.112	0.0078	0.204	0.204
2011	3.03	1.06	0.112	0.0078	0.204	0.204
2012	2.93	1.05	0.113	0.0079	0.205	0.205
2013	2.93	1.04	0.112	0.0078	0.204	0.204
2014	2.95	1.03	0.112	0.0078	0.204	0.204
2015	2.99	1.03	0.113	0.0079	0.205	0.205
2016	3.02	1.08	0.112	0.0078	0.203	0.203
2017	3.07	1.07	0.113	0.0079	0.205	0.205
2018	3.01	1.05	0.113	0.0079	0.205	0.205
Trend 1990 -2018	-20%	-19%	4%	4%	4%	4%
Trend 2017 -2018	-2%	-3%	0%	0%	0%	0%

Source: SER.

5.4.2.1 **NH_3 emissions**

As Table 278 and Table 279 show, there was a decreasing trend of ammonia emissions during the period 1990-2018. Agricultural soil related NH_3-emissions declined by 20% over the time series. Within each of the agricultural soil categories, the main emitting activities were animal manure, in 2018 responsible for 68%, and N input from synthetic fertilizers application (sub-category 3Da1), in 2018 responsible for 22% of the NH_3 emissions emitting from soil.

5.4.2.2 **NO_x**

Agricultural soil NO_x emissions declined by 19% over the time series, see Table 278 and Table 280. Within each of the agricultural soil categories, the main emitting activities of the NO_x emissions emitting from soil in 2018 were: N input from synthetic fertilizers application (50%), animal manure (23%) and grazing (19%). Crop residue are responsible for 7% of the NO_x emissions from agricultural soil (Table 280).

5.4.2.3 **NMVOC**

NMVOC emissions related to agricultural soils increased since 1990 by 4%, see Table 278. This corresponds to the variation of the agricultural area over the period 1990-2018, Table 281.

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 4%, see Table 278, and hence in correlation with an increase of the agricultural surface area. A similar increase was observed for TSP (total suspended particles). All three emissions were estimated using a Tier 1 methodology.

Table 279 – NH_3 Emission trends for category *3D – Crop production and agricultural soils* (Gg): 1990-2018

Year	NH_3 inorganic N-	NH_3 animal manure	NH_3 sewage sludge	NH_3 other organic fertilizer	NH_3 grazing	NH_3 Crop residue	TOTAL
1990	0.94	2.46	0.048	NO	0.28	NA	3.74
1991	0.98	2.56	0.048	NO	0.29	NA	3.88
1992	1.06	2.46	0.049	NO	0.28	NA	3.85
1993	0.97	2.47	0.051	NO	0.28	NA	3.77
1994	0.92	2.46	0.053	NO	0.28	NA	3.71
1995	0.90	2.54	0.053	NO	0.28	NA	3.78
1996	0.90	2.58	0.046	NO	0.29	NA	3.81
1997	0.89	2.55	0.048	NO	0.28	NA	3.76
1998	0.87	2.54	0.048	NO	0.27	NA	3.73
1999	0.90	2.61	0.048	NO	0.28	NA	3.83
2000	0.89	2.53	0.025	0.007	0.28	NA	3.72
2001	0.76	2.47	0.024	0.003	0.27	NA	3.52
2002	0.79	2.35	0.025	0.004	0.27	NA	3.43
2003	0.64	2.25	0.019	0.002	0.26	NA	3.18
2004	0.81	2.23	0.016	0.003	0.26	NA	3.32
2005	0.70	2.15	0.021	0.007	0.26	NA	3.14
2006	0.70	2.09	0.018	0.006	0.26	NA	3.07
2007	0.66	2.14	0.022	0.006	0.27	NA	3.10
2008	0.66	2.14	0.020	0.007	0.28	NA	3.11
2009	0.66	2.07	0.013	0.007	0.28	NA	3.03
2010	0.69	2.08	0.013	0.008	0.28	NA	3.07
2011	0.72	2.01	0.018	0.006	0.27	NA	3.03
2012	0.68	1.95	0.021	0.004	0.27	NA	2.93
2013	0.67	1.97	0.017	0.003	0.27	NA	2.93
2014	0.63	2.02	0.016	0.004	0.28	NA	2.95
2015	0.65	2.03	0.019	0.005	0.28	NA	2.99
2016	0.69	2.03	0.010	0.005	0.29	NA	3.02
2017	0.68	2.08	0.010	0.006	0.29	NA	3.07
2018	0.65	2.05	0.008	0.005	0.29	NA	3.01
Trend 1990 -2018	-31%	-17%	-0.8		3%		-20%
Trend 2017 -2018	-4%	-1%	-0.2	-19%	-1%		-2%

Source: SER.

Table 280 – NO_x Emission trends for category *3D – Crop production and agricultural soils* (Gg): 1990-2018

Year	NO_x inorganic N-	NO_x animal manure	NO_x sewage sludge	NO_x other organic fertilizer	NO_x grazing	NO_x crop residue	TOTAL
1990	0.76	0.26	0.015	NO	0.20	0.07	1.30
1991	0.79	0.27	0.015	NO	0.20	0.07	1.34
1992	0.85	0.25	0.015	NO	0.20	0.07	1.39
1993	0.78	0.26	0.016	NO	0.20	0.08	1.32
1994	0.74	0.25	0.016	NO	0.20	0.07	1.27
1995	0.72	0.26	0.016	NO	0.20	0.08	1.28
1996	0.72	0.26	0.014	NO	0.20	0.08	1.28
1997	0.71	0.26	0.015	NO	0.20	0.09	1.27
1998	0.70	0.26	0.015	NO	0.19	0.09	1.25
1999	0.72	0.26	0.015	NO	0.20	0.09	1.28
2000	0.71	0.25	0.008	0.004	0.19	0.10	1.27
2001	0.60	0.25	0.007	0.002	0.19	0.09	1.15
2002	0.63	0.24	0.008	0.002	0.19	0.07	1.14
2003	0.51	0.23	0.006	0.001	0.18	0.06	1.00
2004	0.65	0.23	0.005	0.001	0.18	0.09	1.16
2005	0.56	0.23	0.006	0.003	0.18	0.07	1.05
2006	0.56	0.23	0.006	0.003	0.18	0.07	1.04
2007	0.53	0.23	0.007	0.003	0.19	0.08	1.04
2008	0.53	0.23	0.006	0.003	0.19	0.08	1.04
2009	0.53	0.23	0.004	0.003	0.19	0.08	1.04
2010	0.55	0.23	0.004	0.004	0.19	0.08	1.05
2011	0.58	0.22	0.005	0.003	0.19	0.06	1.06
2012	0.55	0.22	0.007	0.002	0.18	0.09	1.05
2013	0.53	0.22	0.005	0.002	0.19	0.09	1.04
2014	0.51	0.23	0.005	0.002	0.19	0.10	1.03
2015	0.52	0.23	0.006	0.002	0.20	0.07	1.03
2016	0.55	0.24	0.003	0.002	0.20	0.08	1.08
2017	0.54	0.25	0.003	0.003	0.20	0.08	1.07
2018	0.52	0.24	0.003	0.002	0.20	0.08	1.05
Trend 1990 -2018	-31%	-7%	-0.8		0%	17%	-19%
Trend 2017 -2018	-4%	-1%	-0.2	-19%	-1%	1%	-3%

Source: SER.

5.4.3 **Methodological issues**

5.4.3.1 **Methodology**

5.4.3.1.1 Ammonia emissions - Methodology issues

An Tier 1 approach was used when estimating NH_3 emissions for the use of synthetic fertiliser; sewage sludge, compost and crop residues, respectively whereby following equation 1 from the 2016 guidelines,(EMEP/EEA 2016c) 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 synthetic fertiliser; sewage sludge; compost or crop residues, respectively;

$AR_{N\_applied\,(l)}$ the amount of N applied (kg N/year) in *l*, with *l* being synthetic fertiliser; sewage sludge; compost; and in crop residues, respectively;

$EF_{NH3\,(l)}$ emission factor for NH_3 for *l* application, with *l* being synthetic fertiliser; sewage sludge; compost; and from crop residues, respectively;

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 2016 guidelines,(EMEP/EEA 2016b) namely:

$$E_{NH_3(grazing)} = \left[\sum_i \left\{\left(E_{grazing_{NH}} \; _{-N_{(i)}}\right) * n_i\right\}\right] * \langle\frac{17}{14}\rangle$$
$$= \left[\sum_i \left\{\left(m_{grazing\_TAN(i)} * \; EF_{grazing_{NH3}-N_{(i)}}\right) * n_i\right\}\right] * \langle\frac{17}{14}\rangle$$

with i is the *i*th livestock category, pl=animal/animal place and:

$E_{grazing\_NH3\text{-}N(i)}$ NH_3-N emissions from grazing for livestock category *i* (in kg NH3-N pl^{-1} $year^{-1}$); and described in step 14 in section 5.2.6

$m_{grazing\_TAN(i)}$ the amounts of TAN deposited during grazing (kg TAN pl^{-1} $year^{-1}$); and described in step 4 in section 5.2.6.

$EF_{grazing\_NH3\text{-}N(i)}$ Emissions factors (EF) for NH_3-N emissions from grazing (kg NH3-N kg^{-1}) for livestock category *i* see Table 284.

n_i number of animal places/animal (pl) for livestock category *i;*

17/14 the conversation factor according to the 2016 guidelines (EMEP/EEA 2016a).

The amount of NH_3 emitted (in kg per year) during and immediately after field application of animal manure were estimated following the 2016 guidelines,(EMEP/EEA 2016b) namely:

$$E_{NH_3(animal\ manure)} = \left[\sum_i \left\{ \left(E_{applic\_slurry\ \ NH3-N_{(i)}} + E_{applic\_solid\ \ NH\ -N_{(i)}} \right) * n_i \right\} \right] * \langle \frac{17}{14} \rangle$$

with i is the *i*th livestock category, pl=animal/animal place and:

$E_{applic\_slurry\_NH3\text{-}N(i)}$	NH_3-N emissions during and immediately after field application of slurry/liquid manure for livestock category *i* (in kg NH3-N pl^{-1} $year^{-1}$); and described in step 12 in 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 pl^{-1} $year^{-1}$); and described in step 12 in section 5.2.6
n_i	number of animal places/animal (pl) for livestock category *i;*
17/14	the conversation factor according to the 2016 guidelines (EMEP/EEA 2016a).

The NH_3-N emissions during and immediately after field application of animal manure were calculated using the following formulas:

$$E_{applic\_slurry\_NH_3-N(i)} = \left(m_{applic\_slurry\_TAN(i)} * EF_{applic\_slurry\_NH_{3-N}(i)} \right)$$
$$E_{applic\_solid\_NH_3-N(i)} = \left(m_{applic\_solid\_TAN(i)} * EF_{applic\_solid\_NH_3-N(i)} \right)$$

with i is the *i*th livestock category, pl=animal/animal place and:

$EF_{applic\_slurry\_NH3\text{-}N(i)}$	Emissions factors (EF) for NH_3-N emissions during and immediately after field application of slurry/liquid manure from livestock category *i* (kg NH3-N kg^{-1}). Note, there are several EFs for the application of slurry from livestock category *i* 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. The EFs are summarized in Table 285.
$m_{applic\_slurry\_TAN(i)}$	the amounts of TAN that is applied to fields (kg N pl^{-1} $year^{-1}$) and described in section 5.2.6 in step 11. Note, $m_{applic\_slurry\_TAN(i)}$ is split up whereby distinguishing: • between the surface cover of the fields *c*, with *c* being grassland; arable land with plant cover and arable land without cover, respectively. • 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 is made, depending on the time span passed between spreading and incorporation (*t*).
$EF_{applic\_solid\_NH3\text{-}N(i)}$	Emissions factors (EF) for NH_3-N emissions during and immediately after field application of slurry/liquid manure (kg NH3-N kg^{-1}), see Table 284.
$m_{applic\_solid\_TAN(i)}$	the amounts of TAN that is applied to fields (kg N pl^{-1} $year^{-1}$) and described in section 5.2.6 in step 11.

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; animal manure and dung and urine deposited by grazing animals) and crop residues, respectively whereby following equation 1 from the 2016 guidelines, (EMEP/EEA 2016c) 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; 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; 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; animal manure and dung and urine deposited by grazing animals) and crop residues, respectively;

5.4.3.1.3 NMVOC emissions - Methodology issues

Using a Tier 1 approach to estimate NMVOC emissions from crop production and agricultural soils, and following equation 2 from the 2019 guidelines,(EMEP/EEA 2019c) the general 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 2019 guidelines,(EMEP/EEA 2019c) the general 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.

5.4.3.2 **Activity data**

5.4.3.2.1 Agricultural area used (AR_{area})

Information on the agricultural area used AR_{area} were based on published and unpublished data from the agriculture census (Sources: (STATEC 2019a) and unpublished data: SER – Statistiques agricoles, marchés agricoles et relations extérieures;), and is summarized in Table 281.

5.4.3.2.2 Synthetic N fertilizer ($AR_{N\ applied\ (synthetic\ N\ fertilizer)}$)

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 is summarized in Table 282.

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) has 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)"[75], using a nutrient balance methodology (in German the so-called "Feld – Stall Bilanz"), (Weckbecker 2018).

National utilisation was obtained by multipling the weighted average kg N per ha used agriculture surface (STATEC 2019b) by the used agriculture surface (STATEC 2019a).

5.4.3.2.3 Animal manure

N in 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 from the 2016 guidelines (EMEP/EEA 2016a), which were described in section 5.2.6. 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.

[75] 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).

This corresponds to step 13 described in section 5.2.6 and summarized in Table 282.

$$AR_{N_{applied}}(AM) = \left[\sum_{i}\left(\left[m_{returned\_slurry\_N(i)} + m_{returned\_solid\_N(i)}\right] * n_i\right)\right]$$

with:

$m_{returned\_slurry\_N(i)}$	the net amount of N returned to soil from liquid manure/slurry (expressed in kg N per year per head/place) for animal category *i* and defined in step 13 in section 5.2.6;
$m_{returned\_solid\_N(i)}$	the net amount of N returned to soil from solid manure (expressed in kg N per year per head/place) for animal category *i* and defined in step 13 in section 5.2.6;
n_i	the number of animals for livestock category *i* and summarized in Table 256 ;

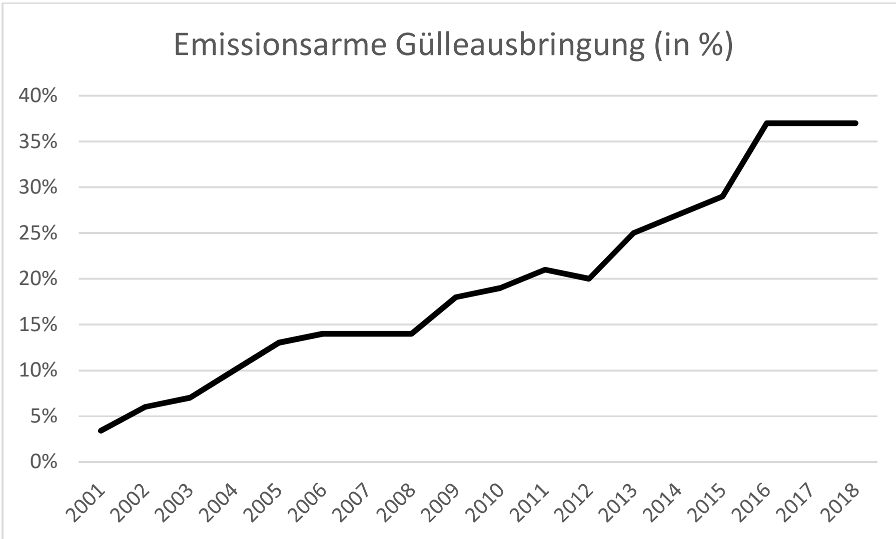
Whereas for the amount of NH_3 emitted (in kg per year) the amount of the annual TAN that is applied to the field ($m_{applic\_slurry\_TAN(i)}$ and $m_{applic\_solid\_TAN(i)}$), expressed in kg TAN per year per head/place for animal category i, was determined in step 11 in section 5.2.6. was used.

Note, $m_{applic\_slurry\_TAN(i)}$ was further split up whereby distinguishing:

- between the surface cover of the fields *c*, with *c* being grassland; arable land with plant cover and arable land without cover, respectively.
- 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 is made, depending on the time span passed between spreading and incorporation (*t*), with *t* being <1 hours, <4hours, <6 hours, <12 hours and >12 hours.

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.[76] There has been funding for low-emission manure spreading since 2002. Based on the premium paid, the proportion of slurry spread over the years using environmentally friendly technology had been estimated and was summarized in (see figure).

[76] Confirmed by several Luxemburgish farmers, as well as by one of the three farmers (Daniel Rosseler, August 2019; personal communication).



According to a survey of farmers using environmentally friendly technology, in 2019:

- 50% of the manure spread on grassland;
- 20% on arable land with vegetation cover;
- And 30% on arable land without vegetation.

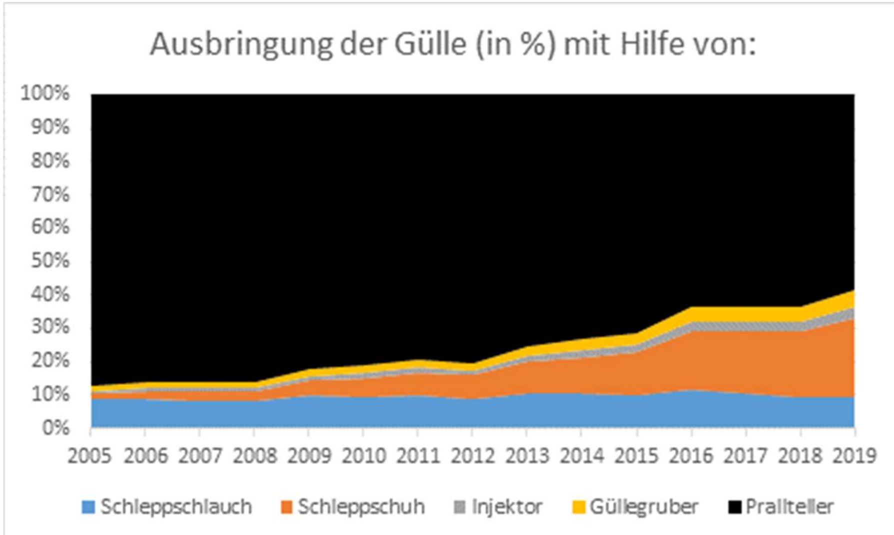
It was assumed that all other farmers would have a similar pattern. Due to a lack of data, it was further assumed that the distribution of manure over the areas has not changed significantly over time.

On grassland areas, 59% of farms use the trailing shoe, 29% the trailing hose and 12% use an injecting technique to spread the manure. On arable land with a plant cover, 66% of farms use the trailing shoe, 26% the trailing hose and 9% use an injecting technique to spread the manure. On arable land without a plant cover, 40% of the farms use the trailing shoe, 18% the trailing hose and 8% an injecting technique, 31% a slurry cultivator, and in 4% broadcast would have been used.[77]

In the first years only the trailing hose was the available technique, and no trailing shoe. (D. Rosseler August 2019, personal communication) However, the trailing hose had been increasingly replaced by the trailing shoe over time. It was assumed during the calculation that this was a smooth process (interpolation between the data from 2001 and 2019). Slurry cultivator are only used on uncultivated arable land. The use of the injecting techniques, although in 2001 and 2002, in relatively high demand for use on grassland and for arable land with vegetation cover, decreased rapidly to a level similar to 2019. Reason for the decrease were a) too expensive (billing per hour regardless of used technology, however, almost twice the number of hours per ha is incurred in the slit method compared to a trailing hose/shoe (D. Rosseler August 2019, personal communication) and problems in grassland with), and b) problems with the grassland (L. Boonen Dezember 2020, personal communication).

[77] Investigated in a survey conducted in spring 2019 between 262 farmers, all applying for subsidies of environmental friendly slurry spreading techniques. The 262 farmers corresponded to 96% of the farmers applying for the above mentioned subsidy.

Mit Hilfe von Interpolationen von den hier oben genannten Daten und von Experten, wurde die Verteilung zwischen Pralltellerund umweltschonender Technik für die verschiedenen Jahre geschätzt. Diese ist in der folgenden Figur zusammengefasst.



Die verwendeten EF's für NH3-N wurden den Deutschen Emissionsberechnungen entnommen [13, 14].

5.4.4 Einarbeitung von Gülle

Wegen fehlender Daten wurde bis Dato unterstellt, dass keine Einarbeitung erfolgte. Nur für die NEC Projektion hatte man versucht, mit Hilfe einiger Annahmen, die Einarbeitung von Gülle zu berücksichtigen, wobei man zu dem Zeitpunkt noch von 6 Stunden bei der Einarbeitung der Gülle auf Ackerflächen ohne Vegetation von teilnehmende Landwirte an umweltschonender Gülleausbringungsprogram ausging. Eine aktuelle Abänderung dieses Programmes hat dazu geführt, dass die Landwirte sich aktuell verpflichten die Gülle auf Ackerflächen ohne Vegetation innerhalb von 4 Stunden einzuarbeiten.

Beim Schlitzverfahren und beim Güllegruber erfolgt die Einarbeitung sofort. Beim Schleppschlauch und Schleppschuh ist ein zusätzlicher Arbeitsschritt erforderlich, wobei unterstellt wurde, dass dieser dann innerhalb von 4 Stunden erfolgt. Für alle andere Landwirte wurde Mangels an Daten unterstellt, dass 50% der Gülle innerhalb der ersten 12 Stunden nach der Ausbringung eingearbeitet wird, und die anderen 50% innerhalb der nächsten 12 Stunden (12-24 Stunden nach Ausbringung).

On

Those

$$$$$$$$$$$$$$

$$$$$

between 250 farmers

For additional details see section 5.4.3.1.1.

$$$$$ $$$$$$$$$$

$m_{applic\_slurry\_TAN(i)}$	the amounts of TAN that is applied to fields (kg N pl^{-1} $year^{-1}$) and described in section 5.2.6 in step 11. Note, $m_{applic\_slurry\_TAN(i)}$ is split up whereby distinguishing: • between the surface cover of the fields *c*, with *c* being grassland; arable land with plant cover and arable land without cover, respectively. • 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 is made, depending on the time span passed between spreading and incorporation (*t*).

5.4.4.1.1 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 282) was estimated based on published statistics w.r.t. 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 MDDI-AEV (Environment Agency) with some corrections performed by the MDDI-DEV for the years 2000 to 2004;
- annual reports on sewage sludge that are regularly issued since 2003-2017.[78] 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.
- Due to on-going data collection for the annual report for the year 2018, a five-year trend estimate was used to estimate the sewage sludge use in agriculture in 2018.

5.4.4.1.2 Other organic fertilizers applied to soils ($AR_{N\_applied\ (other\ organic\ fertilizers)}$)

[78] See https://data.public.lu/en/datasets/boues-depuration/.

The annual amount of compost N applied to soils ($AR_{N\_applied\ (other\ organic\ fertilizers)}$), in kg per year, was estimated based on published statistics w.r.t. to tonnage, N content and the destination use, see Table 282.

Recent compost statistics were obtained from annual reports[79]. Previously, data has been estimated by both the MDDI-DEV and the MDDI-AEV (Environment Agency) on the basis of annual reports and official statistics on wastewater treatment in Luxembourg.

5.4.4.1.1 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,(EMEP/EEA 2016b) for a detailed description of the fifteen steps, see section 5.2.6.

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 5.2.6 was multiplied by the number of animals for livestock category *i* and summed over all livestock to determing $AR_{N\_applied\ (grazing)}$, in short:

$$AR_{N_{applied}(grazing)} = \sum_i ([m_{grazing\_N(i)}] * n_i)$$

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 5.2.6);
n_i	the number of animals for livestock category *i* and summarized in Table 256 ;

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 per head/place for animal category *i*, and determined in step 4 in section 5.2.6. was used. For additional details see section 5.4.3.1.1.

[79] See https://data.public.lu/en/datasets/biodechets/#_ (accessed on 9-04-2019).

Table 281 – Activity data for category *3D – Agriculture area and crop production* (ha): 1990-2018

Year	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	Agricultural area
1990	7 647	978	1 255	15 682	5 146	2 272	1 951	826	537	NO	7 473	231	11 573	68 827	126 298
1991	7 334	621	1 147	14 755	4 499	2 670	2 595	859	591	NO	7 844	246	11 862	68 531	125 469
1992	7 574	574	1 107	13 658	4 104	2 717	1 520	946	761	NO	8 676	280	12 749	69 192	125 742
1993	7 706	662	923	13 746	3 819	2 665	1 686	834	835	NO	7 951	248	14 428	68 186	127 215
1994	8 361	668	1 097	13 564	3 524	2 423	1 665	784	614	NO	8 540	234	13 564	68 025	126 765
1995	8 917	418	1 094	12 681	2 790	2 874	1 954	802	474	NO	9 385	221	14 166	67 515	126 865
1996	9 360	432	927	12 836	2 595	3 032	2 443	797	404	NO	9 528	178	14 111	66 513	125 348
1997	9 299	443	973	12 584	2 517	3 095	2 250	842	421	457	10 024	165	16 075	64 965	125 629
1998	9 342	462	1 263	12 260	2 299	3 419	2 862	842	414	505	9 881	129	16 381	64 441	126 235
1999	6 629	1 168	1 234	12 798	2 456	2 756	4 069	840	557	502	10 491	106	16 238	64 377	126 494
2000	10 590	381	1 331	10 538	1 909	3 635	3 245	829	431	255	10 799	77	15 281	65 277	127 009
2001	9 065	760	1 315	11 622	1 725	3 066	3 084	734	693	476	11 241	61	15 171	65 114	127 257
2002	11 552	466	1 466	9 585	1 963	4 010	3 492	672	667	326	11 016	51	14 436	65 042	127 520
2003	10 738	449	1 142	10 355	2 163	3 724	3 674	623	601	337	11 621	43	14 539	64 828	127 574
2004	11 380	340	1 427	8 882	1 907	3 578	4 190	635	507	350	12 284	43	14 663	65 068	127 593
2005	11 296	630	1 309	9 938	1 696	3 411	4 061	608	467	215	12 100	51	12 288	67 504	127 789
2006	12 257	408	1 411	9 512	1 502	3 470	4 782	594	372	288	11 566	37	11 860	67 659	127 641
2007	12 246	340	1 431	9 226	1 443	3 546	5 394	628	367	281	11 985	39	12 480	68 290	129 791
2008	14 179	418	1 557	9 674	1 252	3 608	5 208	604	222	379	12 192	30	12 039	67 172	129 141
2009	13 369	472	1 343	9 370	1 383	4 055	4 629	604	305	409	13 261	32	12 221	67 367	129 726
2010	13 668	342	1 150	8 261	1 136	4 780	4 715	615	336	375	13 435	27	12 818	67 593	130 479
2011	13 367	511	1 206	7 940	1 123	4 340	4 674	635	268	300	13 690	32	13 653	67 638	130 797
2012	13 055	462	1 328	7 142	919	4 736	4 596	639	166	196	14 131	59	14 567	67 292	131 191
2013	13 740	511	1 148	7 740	1 130	4 561	4 496	593	282	243	13 996	75	13 493	66 897	130 800
2014	11 506	1 159	1 235	8 318	1 178	4 787	4 146	607	378	216	14 745	102	13 790	66 827	130 701
2015	13 698	796	1 141	7 714	1 194	4 604	3 975	570	588	141	14 448	137	13 089	66 923	131 159
2016	13 373	435	1 319	6 901	1 094	4 609	3 508	615	682	125	14 938	154	13 501	67 115	130 357
2017	13 696	488	1 243	6 594	1 309	4 520	3 267	622	621	108	15 194	111	13 647	67 413	131 163
2018	12 633	351	1 353	6 004	1 238	4 669	3 393	627	409	61	15 876	77	14 658	67 705	131 559

Sources: : Source: (STATEC 2019a) and unpublished data : SER – Statistiques agricoles, marchés agricole et relations extérieures.

Table 282 – Activity data for category *3D – Crop production and agricultural soils*: 1990-2018 (kg N)

Year	Synthetic fertilizer	Animal manure	Sewage sludge	Compost	Grazing	Crop residues
1990	18 895 444	6 559 364	371 985	NO	5 207 264	1 643 597
1991	19 688 595	6 638 404	372 205	NO	5 319 549	1 703 159
1992	21 245 368	6 354 803	376 491	NO	5 141 968	1 791 330
1993	19 381 205	6 394 848	391 126	NO	5 139 483	1 932 991
1994	18 399 940	6 336 139	409 055	NO	5 105 693	1 784 346
1995	18 054 158	6 527 127	406 178	NO	5 251 261	1 902 935
1996	17 992 452	6 593 282	352 796	NO	5 338 079	1 956 771
1997	17 718 714	6 515 561	369 747	NO	5 164 851	2 142 122
1998	17 375 970	6 486 975	370 828	NO	5 091 872	2 181 055
1999	17 917 875	6 574 032	368 839	NO	5 127 300	2 229 136
2000	17 730 456	6 374 215	193 515	93 077	5 092 607	2 501 279
2001	15 118 132	6 284 833	181 353	43 384	5 066 604	2 283 852
2002	15 761 472	6 043 771	191 920	49 819	4 905 811	1 846 480
2003	12 846 702	5 860 911	146 205	25 282	4 785 648	1 515 546
2004	16 293 626	5 869 806	121 081	34 736	4 786 944	2 190 137
2005	14 082 348	5 760 382	159 100	84 921	4 723 550	1 676 528
2006	13 900 105	5 627 562	139 750	74 971	4 714 227	1 771 669
2007	13 199 745	5 768 058	165 609	77 357	4 930 866	1 961 830
2008	13 198 210	5 789 488	156 780	87 340	5 005 268	2 054 186
2009	13 277 456	5 700 733	103 488	82 833	4 991 818	2 057 322
2010	13 700 295	5 738 061	103 729	99 310	5 075 891	1 876 481
2011	14 387 670	5 602 499	137 317	70 731	4 959 507	1 614 139
2012	13 643 864	5 451 856	165 135	50 606	4 830 312	2 317 347
2013	13 341 600	5 591 567	132 854	43 191	4 881 841	2 217 483
2014	12 677 997	5 758 394	122 577	48 488	5 018 048	2 385 921
2015	12 984 741	5 857 050	144 931	59 767	5 121 415	1 722 323
2016	13 700 554	6 014 734	77 569	59 835	5 186 513	2 091 599
2017	13 575 361	6 170 262	78 285	72 794	5 267 485	1 902 189
2018	13 037 517	6 098 513	64 282	58 868	5 213 230	1 921 389

Sources: Synthetic fertilizer (STATEC 2019b); Animal manure. SER: estimated values following the EMEP/EEA 2016 guidelines (EMEP/EEA 2016b) ; Sewage sludge: For recent years: Annual reports as published by the Administration of Environment to be found on the platform: https://data.public.lu/en/datasets/boues-depuration/ Other organic fertilizer: For recent years: Annual reports as published by the Administration of Environment to be found on the platform: https://data.public.lu/en/datasets/biodechets/ ; Grazing. SER: estimated values following the EMEP/EEA 2016 guidelines (EMEP/EEA 2016b); Crop residue. (Schuman et al. 2020) estimated values according to equation 11.6 on page 11.14 from the IPCC 2006 guidelines for crop residues (IPCC 2006b).

5.4.4.1.2 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 282, and was estimated based on equation 11.6 of the 2006 IPCC Guidelines (IPCC 2006b):

$$AR_{N\_applied\_CR} = \sum_{k} \{Crop_k * Frac_{Renew(k)} * \left(Area_k * R_{AG(k)} * N_{AG(k)} * \left(1 - Frac_{Renew(k)}\right) + Area_k * R_{BG(k)} * N_{BG(k)}\right)\}$$

with:

$Crop_k$	= harvested annual dry matter yield for crop *k*, kg dry matter per ha, with *k* = crop or forage type
$Area_k$	= total annual area harvested of crop *k*, ha per year, see Table 281
$Frac_{Renew(k)}$	= fraction of total area under crop *k* that is renewed annually
$R_{AG(k)}$	= ratio above ground residues dry-matter ($AG_{DM(k)}$) to harvested yield for crop *k*, kg dry matter, = $AG_{DM(k)}$ * 1000 / $Crop_{(k)}$
$N_{AG(k)}$	= 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
$R_{BG(k)}$	= ratio below ground residues to harvest yield for crop *k*, kg dry matter
$N_{BG(k)}$	= N content in below ground residues in kg N (values taken from Table 11.2 Guidelines (IPCC 2006b))

Note: Burning of crop residues is forbidden by law in Luxemburg, and therefore assumed to not occur, why not considered in the above equation.

The cultivated crop area for 1990-2018 ($Area_k$) is summarized in Table 281, and the harvest yield for the different crop cultivated ($Crop_k$) is summarized in Table 283. Area data were based on both, published and unpublished data from the agriculture census (Sources: (STATEC 2019a) & unpublished data: SER – Statistiques agricoles, marchés agricoles et relations extérieures). Official statistics were consulted for the harvest yield data (STATEC 2019e), whereby cash crops were mainly extracted from unpublished LTBN data and forage yields were based on measurements conducted by ASTA in different experimental fields through the country (for example for pasture http://www.grengland.lu/grunland-ticker). With the exception of clover, grass-clover and pasture and meadows are all crops annually renewed (see Table 283). Clover and grass-clover leys are renewed every 3 years, similar to Germany (Haenel et al. 2018). Whereas permanent grassland (i.e. pasture and meadows) is forbidden to plough (Règlement_grand-ducal 2015). For additional details see NIR 2020.(Schuman et al., 2020)

Table 283 – Activity data for category *3D – Crop harvest* (kg/ha): 1990-2018

Year	winter wheat	spring wheat	rye and mix-cereals	barley	oat	triticale	rape	potatoes	pulses	grain maize	maize for silage & bio digester[a,b,c]	fodder beet[a,b]	Clover, grass-clover leys, fodder production[a,b]	Pasture and meadows[a,d]
1990	5 186	3 941	3 604	4 439	3 645	4 612	2 741	27 800	2 533	NO	14 056	12 030	8 534	5 165
1991	5 630	4 849	4 477	4 980	4 330	4 990	2 562	22 700	3 092	NO	14 056	12 030	8 534	3 920
1992	5 720	4 880	4 031	5 153	4 200	4 946	1 520	28 400	2 870	NO	14 056	12 030	8 534	5 322
1993	5 870	4 985	3 617	4 951	4 480	5 220	2 669	30 760	2 610	NO	14 056	12 030	8 534	5 623
1994	5 130	3 519	3 316	4 415	3 510	4 804	2 160	22 779	2 990	NO	14 056	12 030	8 534	5 079
1995	5 715	4 269	3 534	4 954	4 355	5 077	2 614	28 500	2 911	NO	14 056	12 030	8 534	5 880
1996	6 644	5 129	4 588	5 645	5 117	5 980	3 124	25 400	4 745	NO	14 056	12 030	8 534	5 708
1997	5 904	4 688	4 460	5 454	5 263	4 994	3 496	27 100	3 636	5 000	14 056	12 030	8 534	6 957
1998	6 125	4 680	4 972	5 158	5 086	6 323	3 210	26 500	3 430	8 500	14 056	12 030	8 534	7 767
1999	6 001	5 178	5 113	5 452	4 986	6 282	3 334	30 600	4 141	6 200	14 056	12 030	8 534	5 959
2000	5 599	4 968	4 535	5 080	4 828	5 459	2 580	33 605	2 866	8 000	12 060	11 000	11 460	9 800
2001	5 563	4 730	5 301	4 609	4 521	5 429	2 847	31 022	3 285	9 099	14 050	11 000	9 970	8 530
2002	5 978	5 669	6 403	5 406	5 206	5 747	3 586	29 913	3 486	7 100	13 400	12 650	7 440	6 360
2003	6 178	5 129	5 786	5 343	5 278	5 369	3 412	29 425	3 571	5 649	15 400	12 000	5 020	4 290
2004	6 843	6 199	6 875	5 941	4 959	6 453	3 944	35 010	3 407	10 332	15 368	13 500	8 780	7 510
2005	6 070	5 021	5 677	5 318	4 561	5 433	3 621	31 784	3 184	9 576	15 980	13 770	6 940	5 940
2006	5 982	5 590	5 303	5 263	4 429	5 669	3 398	27 664	3 184	6 520	13 900	12 000	8 410	7 190
2007	5 622	4 762	5 420	4 838	3 905	4 983	3 393	31 828	2 247	7 540	17 110	12 500	8 890	7 600
2008	6 707	5 136	6 316	5 422	4 985	5 966	3 154	36 022	3 462	9 141	15 930	12 100	9 590	8 200
2009	6 575	6 369	5 970	5 806	5 200	6 268	3 917	33 185	3 954	9 289	16 340	10 375	9 120	7 800
2010	5 981	5 062	5 283	5 206	4 214	5 339	3 371	31 739	2 892	8 316	13 480	8 583	8 300	7 100
2011	5 578	4 451	4 529	4 843	3 595	5 138	3 332	30 991	2 328	7 787	12 790	7 610	6 300	5 383
2012	5 906	4 524	4 798	5 306	5 168	4 946	3 337	32 254	2 765	8 255	14 060	11 038	10 200	8 730
2013	6 402	6 062	5 376	5 489	4 898	5 645	3 394	29 594	3 303	8 930	13 460	10 528	10 220	8 739
2014	6 303	4 674	5 917	5 526	4 647	6 282	3 788	31 244	2 773	7 743	15 830	10 528	10 610	9 053
2015	6 324	5 567	5 772	5 754	4 923	5 946	3 482	22 750	2 662	6 578	12 350	8 376	7 200	6 154
2016	5 107	4 066	4 277	4 927	4 834	4 956	3 112	30 447	1 913	6 697	12 680	24 003	9 520	8 130
2017	5 501	4 979	4 588	5 300	4 522	5 242	3 464	34 237	2 593	8 597	16 750	8 231	7 640	6 520
2018	6 075	4 749	4 932	5 773	5 636	5 726	3 227	25 841	3 762	6 225	12 710	8 727	7 900	6 743

Notes: a) In kg/ha dry matter; b) No data were available on the harvest of silage maize, fodder beets, clover and grass-clover for the years 1990-1999. The average as observed for the years 2000-2004 was taken; c) No data were available on the harvest maize used to feed the bio-digester for the years 1990-2001. The same harvest as for maize for silage was taken; d) No data was available on the harvest of pasture and meadows for the year 1990. The average as observed for the years 1991-1995 was taken.

Sources: (STATEC 2019e). .

5.4.4.2 **Emission factors**

$$$$$$$$$$$$$$$$$$$

The used EFs for field application of slurry and solid manure ($EF_{applic\_slurry\_NH3(i)}$ and $EF_{applic\_solid\_NH3(i)}$) were taken from Table 3.9 from the 2016 guidelines (EMEP/EEA 2016a) and are summarized in Table 284. The emissions itself are reported in the NFR Category 3D2.

$$$$$$$$$$$$$

The used EFs for field application of slurry and solid manure ($EF_{applic\_slurry\_NH3(i)}$ and $EF_{applic\_solid\_NH3(i)}$) were taken from Table 3.9 from the 2016 guidelines (EMEP/EEA 2016a) and are summarized in Table 284. The emissions itself are reported in the NFR Category 3D2.

The used EFs for grazing ($EF_{grazing\_NH3\text{-}N(i)}$) were taken from Table 3.9 from the 2016 guidelines (EMEP/EEA 2016a) and are summarized in Table 284. The emissions itself are reported in the NFR Category 3D2.

5.4.4.2.1 Ammonia emissions

NH_3 emissions from the use of synthetic fertiliser; sewage sludge and compost, respectively were estimated using a Tier 1 methodology and default emissions factors as listed in Table 3.1 from the 2016 guidelines (EMEP/EEA 2016c), these were:

- 0.05 kg NH_3 (Table 3.1 from the 2016 guidelines (EMEP/EEA 2016c)) per kg synthetic N fertiliser applied;
- 0.13 kg NH_3 (Appendix A1 on page 30 from the 2016 guidelines (EMEP/EEA 2016c)) per kg N of applied sewage sludge
- and 0.08 kg NH_3 (Table 3.1 from the 2016 guidelines (EMEP/EEA 2016c)) per kg waste N applied, respectively.

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 5.2.6). The used emission factors to estimate kg NH_3-N per year per head/place for livestock category *i* are summarized in Table 284 and were based on Table 3.9 from the 2016 guidelines (EMEP/EEA 2016a), and multiplied with the conversation factor 17/14, according to the 2016 guidelines (EMEP/EEA 2016a), to obtain NH_3 kg per year per head for livestock category *i*. Emissions from animal sub-categories were then summed up to obtain total NH_3 emissions from the field application of animal manure and for the deposition of excreta when grazing.

Table 284– NH_3-N Emissions factors used for the emissions from the field application of solid animal manure and for grazing

	$EF_{applic\_slurry\_NH3-N(i)}$	$EF_{applic\_solid\_NH3-N(i)}$	$EF_{grazing\_NH3-N(i)}$
Non-dairy cattle	0.55	0.79	0.10
Lactating dairy cows	0.55	0.79	0.06
Sows	0.29	0.81	NO
Fattening pigs & weaners	0.40	0.81	NO
Sheep (mature sheep and lambs)	NO	0.90	0.09
Goats (mature goats and kids)	NO	0.90	0.09
Horses (including assess and mules)	NO	0.90	0.35
Broilers	NO	0.66	NO
Laying hens	NO	0.69	NO
Other poultry	NO	0.54[a]	NO
Ostriches	NO	0.45[b]	NE
Rabbits (breeding female animals and other rabbits)	NO	0.90 [c]	NO
Deer	NO	0.90 [d]	0.09[d]

Sources : Default value for turkeys and ducks (Table 3.9; (EMEP/EEA 2016a)) ; Default value for geese (Table 3.9; (EMEP/EEA 2016a)) ; Default value for horses (Table 3.9; (EMEP/EEA 2016a)) - No value for grazing, therefore not estimated ; Default value for sheep and goat (Table 3.9; (EMEP/EEA 2016a)).

In the current submission a distinction was made:

- for the used technique (i.e. broadcoast, trailing hose, trailing shoe, injector and slurry cultivator);
- where slurry was applied, whereby distinguishing between grassland, arable land with plant cover 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; 6-12 hours or >12 hours. The new 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.(Rösemann et al. 2019)
-

Table 285: NH_3-N Emissions factors used for the emissions during and immediately after field application of liquid animal manure/slurry

Livestock category (i) / Slurry storage system	Emission factor for NH3-N $EF_{applic\_slurry\_NH3-N(i)}$ for slurry application using … Broadcast	Trailing hose	Trailing shoe	Injection techniques	Slurry cultivator
Cattle (Dairy cattle / Non-dairy cattle)					
Grassland	0.60[a]	0.54[a]	0.36[a]	0.24[a]	NA
Arable land with vegetation	0.50[a]	0.35[a]	0.36[a]	0.24[a]	NA
Arable land without vegetation					
& without incorporation (>12 hours)	0.50[a]	0.46[a]	0.36[a]	0.24[a]	NA
& with incorporation ≤1 hour	0.10[a]	0.004[a]	0.004[a,c]	0.004[a,c]	0.04[a,b]
& with incorporation ≤4 hour	0.26[a]	0.15[a]	0.15[a,c]	0.15[a,c]	NA
& with incorporation ≤6 hour	0.35[a]	0.20[a]	0.20[a,c]	0.20[a,c]	NA
& with incorporation ≤12 hour	0.43[a]	0.30[a]	0.30[a,c]	0.24[a,c]	NA
Swine					
Grassland	0.30[d]	0.21[d]	0.12[d]	0.06[d]	NA
Arable land with vegetation	0.25[d]	0.13[d]	0.12[d]	0.06[d]	NA
Arable land without vegetation					
& without incorporation (>12 hours)	0.25[d]	0.18[d]	0.12[d]	0.06[d]	NA
& with incorporation ≤1 hour	0.04[d]	0.02[d]	0.02[d,b]	0.02[d,b]	0.02[d,b]
& with incorporation ≤4 hour	0.09[d]	0.06[d]	0.06[d.d]	0.06[d,b]	NA
& with incorporation ≤6 hour	0.11[d]	0.08[d]	0.08[d,b]	0.06[d,b]	NA

& with incorporation ≤12 hour	0.16[d]	0.11[d]	0.11[d,b]	0.06[d,b]	NA

a) Based on Table 4.7 in (Rösemann et al. 2019).
b) Slurry cultivator is by definition immediate incorporation.
c) No details were provided for trailing shoe and incorporation and infecting techniques and incorporation. It was therefore assumed that the EFs would be the same as for trailing hose, but could never been worse than without incorporation.
d) Based on Table 5.6 in (Rösemann et al. 2019).

5.4.4.2.2 Nitride oxides

NO_x emissions were estimated using a TIER 1 methodology and using the default emission factor provided in Table 3.1 from the 2016 guidelines (EMEP/EEA 2016c), namely 0.04 kg NO per kg N applied in fertiliser (synthetic and organic), manure, excreta or crop residues.

5.4.4.2.3 NMVOC

NMVOC emissions 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 from the 2019 guidelines (EMEP/EEA 2019c).

5.4.4.2.4 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 from the 2019 guidelines (EMEP/EEA 2019c).

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**

- The utilised agriculture surface area were revised, influencing further the use of synthetic N fertilizer, and the N in crop residues;
- The activity data for compost had to be revised as erroneously the fresh quantities were used, rather than the dry matter quantities.
- In the current submission the distinction was made on the methodology used for spreading slurry; where slurry was spread; and how quick slurry was incorporated, whereas in previous submission, the default values had been used.
- The 2019 EMEP/EEA guidelines were applied for NMVOC and particular matters.

A detailed description of the different changes and the recalculations are provided in chapter 8.1.1.

5.4.7 **Category-specific planned improvement**

An update of the manure management system using more recent data is planned for the following submission. As the area cultivated by Luxemburgish farmers, i.e. the area derived from the agriculture census, is - in particularly in recent years – strongly overestimating the agriculture area in Luxemburg (in 2018, 7% of the land cultivated by Luxemburgish farmers were situated in neighbouring countries, in total 8651 ha, versus only 342 ha land that was situated in Luxembourg and cultivated by neighbouring farmers (Jean-Paul Didier; SER – Division des paiements directs)), it is planned to investigate for alternative data sources, and if available, adapt emissions calculations accordingly. Further, is it planned to revise the N flow following the 2019 EMEP/EEA guidelines.

5.5 ***Agriculture - HCB emissions from pesticides (Category 3.D.f)***

In Luxemburg, the accreditation of pesticides is mandatory. Approved plant protection products are registered since 1997/1998 in a database, i.e. TAPES[80]. Responsible for the accreditation and for the TAPES database is the „Administration des services techniques de l'agriculture" (ASTA) namely the division "Service de la protection des végétaux"[81].

[80] Source: https://saturn.etat.lu/tapes/; accessed 10-01-2020
[81] Source: https://agriculture.public.lu/de/pflanzen-boden/pflanzenschutz/pflanzenschutzmittel.html; accessed 10-01-2020

According to the information collected in TAPES, none of the listed pesticides from Table 3.1 in the 2016 guidelines (EMEP/EEA 2016a) had been approved in Luxemburg for the years 1997-2018 (Source: Monique Faber; ASTA – Service de la protection des végétaux; personal communication 10 January 2020). However, some of the active substances with HCB impurities, listed in the Annex in the 2019 guidelines (EMEP/EEA 2019a), were and are used as plant protection products in Luxemburg[82,83]. There is on-going research to establish a complete list with the approved pesticides for the different years in question.

According to experts were in the years 1990-1997, HCB as "pure substances", except for Lindan, not approved in Luxemburg (Source: Monique Faber; ASTA – Service de la protection des végétaux; personnel communication; 10 January 2020). Lindan had been approved at one moment in Luxemburg, and was probably in use in the years 1990-1997. But further research is necessary, to determine a) for which years Lindan was approved, b) to determine the phasing-out phase and c) the quantities used.

ASTA is since 2017 responsible for the collection of selling data (Source: Jacques Engel; ASTA – Service de la protection des végétaux; personal communication 17 January 2020). In previous years, this data was collected by STATEC[84]. However, the data collection from STATEC does not cover the whole period. We therefore investigate other possible routes to obtain activity data, allowing us to cover the whole time period.

Hence in the current submission, the HCB emissions are reported as "NE", but there is on-going work, which should allow us to present HCB emissions from the agriculture sector in a next submission.

5.6 *Agriculture - 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

82 Source: List with current accredited pesticides: https://saturn.etat.lu/tapes/tapes_de_lst_pdt.jsp?sel=_; accessed 17-01-2020.
83 Source: List with phasing out pesticides: https://saturn.etat.lu/tapes/tapes_de_lst_sup.jsp; accessed 17-01-2020.
84 https://statistiques.public.lu/fr/methodologie/methodes/entreprises/pesticides/pesticides/index.html

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 or can be sold), field burning is not practiced in Luxembourg and, therefore, emission estimates have been recorded as not occurring (NO).

5.7 *Agriculture - 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 Luxemburg. 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

6.1 *Sector Overview*

Table 286 gives an overview of the categories included under sector 5 - *Waste* and provides information on the status of emission estimates for all subcategories.

Table 286 – 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	IE	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	NE	NE	NE	NE	NE	NE	NE	NE
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	X	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 287 provides explanations to the use of notation key NE in category *5 - Waste*.

Table 287 – Explanations for notation key NE in category *5 - Waste*

NFR code	Substance(s)	Reason for not estimated
5C1bv Cremation	NO_X, SO_2, NMVOC, NH_3, TSP, PM_{10}, $PM_{2.5}$	Only one plant in Luxembourg for cremation of human bodies, hence very small source. Further analysis of measurement data and extrapolation method needed.
5A Solid waste disposal on land	NH_3, CO	No emission factors are provided in the EMEP/EEA Guidebook 2016 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 2016 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 2016 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 2016 for these pollutants

Table 288 provides explanations to the use of notation key IE in category *5 - Waste*.

Table 288 – 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

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 Luxembourg's Waste Generation and Management System

In Luxembourg, the collection of MSW falls within the competence of municipalities[85]. As a result municipalities 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;
- SIGRE regrouping the municipalities of Grevenmacher, Remich and Echternach.

The managed landfill sites of SIDEC and SIGRE opened in 1972 and 1979, respectively. Table 289 summarizes the situation for each waste management syndicate.

[85] 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

Table 289 – 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*	*2002-2017*
	+ *Biological treatment*	*2007-2017*
SIDOR	Incineration	1976-2017
SIGRE	Landfill	1979-2017
	+ *Aerobic treatment*	*1993-2014*
	+ *Methane recovery system*	*2000-2017*

Source: Environment Agency.

Notes: SIDEC (www.sidec.lu), SIDOR (http://sidor.lu), and SIGRE (www.sigre.lu)

The waste management syndicates, listed in Table 289, 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 6-1 – Waste Flow in Luxembourg before 2015

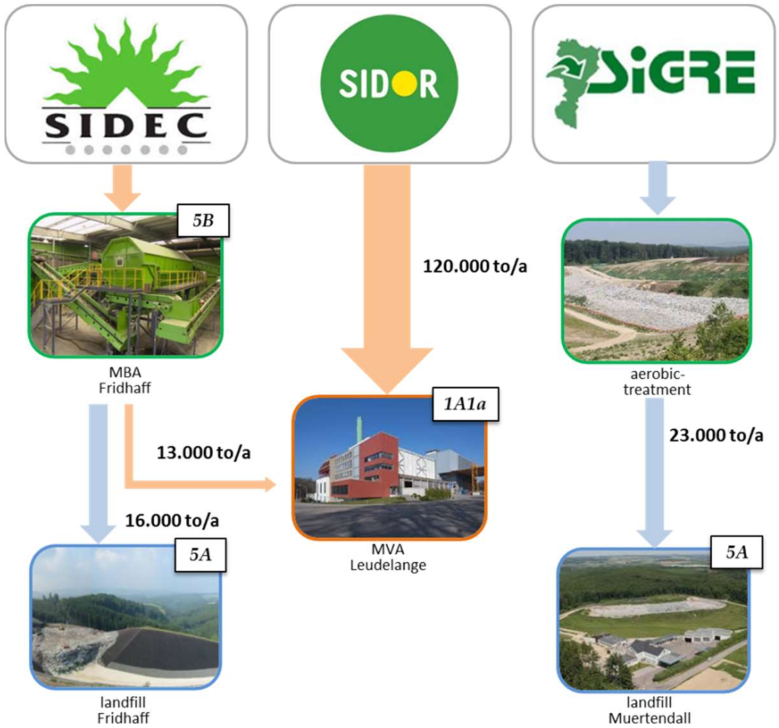
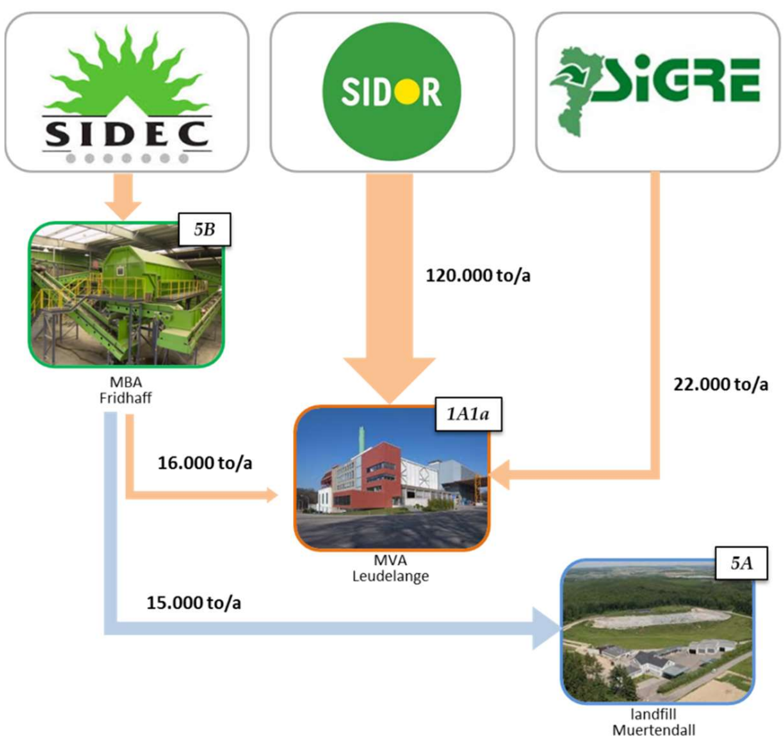


Figure 6-2 – Waste Flow in Luxembourg after 2015



The total municipal solid waste (Total MSW, municipal waste from households and similar household waste excluding recycling), accounted for in the inventory (Figure 6-2), is – upon collection – partly:

- landfilled – accounted under IPCC category 5A either directly or indirectly after treatment (i.e. emissions occurring during biological treatment are accounted under IPCC category 5B), or
- incinerated (i.e. solid waste to be accounted for under IPCC category 1A1a as energy is recovered from incineration).

6.2.1.2 **Key categories**

With regard to NMVOC and PM emissions, category *5A – Solid waste disposal on land* is not a key category in 2017, neither in the level, nor in the trend assessments, and has never been.

6.2.1.3 **Emission trends**

Table 290 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.

Table 290 – 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	31.81	NE	0.50	0.23	0.04	NA	NA	NE
1991	NA	32.51	NE	0.50	0.23	0.04	NA	NA	NE
1992	NA	32.64	NE	0.50	0.23	0.04	NA	NA	NE
1993	NA	32.20	NE	0.42	0.20	0.03	NA	NA	NE
1994	NA	29.18	NE	0.35	0.16	0.02	NA	NA	NE
1995	NA	29.08	NE	0.62	0.30	0.04	NA	NA	NE
1996	NA	29.06	NE	0.37	0.17	0.03	NA	NA	NE
1997	NA	29.74	NE	1.08	0.51	0.08	NA	NA	NE
1998	NA	29.78	NE	1.37	0.65	0.10	NA	NA	NE
1999	NA	29.79	NE	1.80	0.85	0.13	NA	NA	NE
2000	NA	28.54	NE	2.03	0.96	0.15	NA	NA	NE
2001	NA	28.22	NE	1.75	0.83	0.12	NA	NA	NE
2002	NA	28.08	NE	1.49	0.70	0.11	NA	NA	NE
2003	NA	28.15	NE	1.92	0.91	0.14	NA	NA	NE
2004	NA	26.46	NE	1.88	0.89	0.13	NA	NA	NE
2005	NA	25.76	NE	1.92	0.91	0.14	NA	NA	NE
2006	NA	25.34	NE	1.67	0.79	0.12	NA	NA	NE
2007	NA	25.18	NE	2.31	1.09	0.16	NA	NA	NE
2008	NA	24.60	NE	2.74	1.29	0.20	NA	NA	NE
2009	NA	24.26	NE	2.99	1.42	0.21	NA	NA	NE
2010	NA	20.28	NE	2.80	1.33	0.20	NA	NA	NE
2011	NA	20.34	NE	3.01	1.43	0.21	NA	NA	NE
2012	NA	19.36	NE	1.60	0.76	0.11	NA	NA	NE
2013	NA	19.78	NE	2.03	0.96	0.15	NA	NA	NE
2014	NA	19.55	NE	1.48	0.70	0.11	NA	NA	NE
2015	NA	18.75	NE	1.84	0.87	0.13	NA	NA	NE
2016	NA	17.13	NE	1.95	0.92	0.14	NA	NA	NE
2017	NA	17.61	NE	2.06	0.97	0.15	NA	NA	NE
Trend 1990-2017	*NA*	*-44.63%*	*NA*	*315.09%*	*315.09%*	*315.09%*	*NA*	*NA*	*NA*
2005-2017	*NA*	*-31.63%*	*NA*	*7.07%*	*7.07%*	*7.07%*	*NA*	*NA*	*NA*
2016-2017	*NA*	*2.81%*	*NA*	*5.73%*	*5.73%*	*5.73%*	*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[86]. The amount of landfill gas generated was then back calculated based on the parameters as shown in Table 291. The amount of methane emitted form landfilling is provided in Table 223.

[86] for more details on the waste generation, and the calculation of methane released please refer to the National Inventory Report 2019, section 8.2, p. 553, 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-2019

Table 291 – Conversion factor for the calculation of landfill gas

Parameter / emission factor	Source	Value	Unit
Methane content in landfill gas	EEA/EMEP GB 2016 (Chap. 3A, Tab3-1 - Note, p5)	50	%
Density	http://www.landfilldesign.com/cgi-bin/gaspressure.pl	1.31	kg LFG /m3
NMVOC content in landfill gas	EEA/EMEP GB 2016 (Chap. 3A, Tab3-1 - Note, p5)	0.041	g NMVOC / m3 LFG

Table 292 – 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	1.99
2017								
2.04								

Source: National Inventory Report 2019.

Finally, NMVOC emissions were calculated with the default NMVOC content in landfill gas, as provided in the EMEP/EEA Guidebook 2016 (see Table 291).

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 293).

Table 293 – Amount of 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**
5910	6468	6054	6507	3466	4395	3203	3964	4205
2017								
4446								

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 294.

Table 294 – PM emission factors used for category *5A – Solid waste disposal on land*

Gasoline	Source	Value	Unit
EF $PM_{2.5}$	EEA/EMEP GB 2016 (Chap. 5A, Tab3-1, p5)	0.033	g/Mg
EF PM_{10}	EEA/EMEP GB 2016 (Chap. 5A, Tab3-1, p5)	0.219	g/Mg
EF TSP	EEA/EMEP GB 2016 (Chap. 5A, Tab3-1, p5)	0.463	g/Mg

6.2.3 Uncertainties and time-series consistency

Currently no uncertainty estimates are made. Uncertainty of the activity data can be checked in the Luxembourg's National Inventory report (NIR).

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 of the number and size of construction/demolition sites. 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.

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

No recalculations were done since the last submission (2018).

6.2.6 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 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* is not a key category in 2017, 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 295 presents the emission trends of this category.

Table 295 – Emission trends for category *5B1 - Composting*

5B1 - Composting *Emissions*									
Year	NOx *t*	NMVOC *t*	NH3 *t*	TSP *t*	PM10 *t*	PM2.5 *t*	Cd *t*	Pb *t*	Hg *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	8.63	NE	NE	NE	NA	NA	NA
2012	NE	NE	10.23	NE	NE	NE	NA	NA	NA
2013	NE	NE	9.48	NE	NE	NE	NA	NA	NA
2014	NE	NE	10.11	NE	NE	NE	NA	NA	NA
2015	NE	NE	9.61	NE	NE	NE	NA	NA	NA
2016	NE	NE	12.00	NE	NE	NE	NA	NA	NA
2017	NE	NE	10.97	NE	NE	NE	NA	NA	NA
Trend 1990-2017	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005-2017	*NA*	*NA*	*-62.28%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2016-2017	*NA*	*NA*	*-8.61%*	*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 296.

Table 296 – Amount composted in Luxembourg

(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	38'192	41'244	38'210	40'852	38'528	47'631
2017								
48'639								

Source: National Inventory Report 2019.

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 297.

Table 297 – NH_3 emission factors used for category *5B1 – Composting*

Emission Factor	Source	Value	Unit
EF NH3 – general composting	EEA/EMEP GB 2016 (Chap. 5A, Tab3-1, p5)	0.24	kg/Mg organic waste
EF NH_3 – windrow composting	EEA/EMEP GB 2016 (Chap. 5A, Tab3-2, p6)	0.66	kg/Mg organic waste
EF NH_3 – windrow composting with biofilter	EEA/EMEP GB 2016 (Chap. 5A, Tab3-2 & 3-3, p6)	0.066	kg/Mg organic waste

6.3.3 **Uncertainties and time-series consistency**

Currently no uncertainty estimates are made. Uncertainty of the activity data can be checked in the Luxembourg's National Inventory report (NIR).

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**

No recalculations were done since the last submission (2018).

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 *Domestic wastewater handling (5.D.1)*

6.4.1 **Source category description**

Category *5D1 – Domestic wastewater handling* covers NH_3 and 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 type: (a) mechanical plants and (b) biological plants with or without denitrification. A small part of the population is, however, still not connected to centralised wastewater treatment plant, mainly due to the remote location of the dwellings.

With regard to NH_3 and NMVOC emissions, category *5D1 – Domestic wastewater handling* is not a key category in 2017, neither in the level, nor in the trend assessments.

Table 300 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. On the other hand, NH_3 emissions are decreasing due to a decreasing number of dwellings not connected to a WWT.

Table 298 – 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	0.38	48.00	NE	NE	NE	NE	NE	NE
1991	NA	0.39	46.93	NE	NE	NE	NE	NE	NE
1992	NA	0.40	45.87	NE	NE	NE	NE	NE	NE
1993	NA	0.40	44.80	NE	NE	NE	NE	NE	NE
1994	NA	0.41	43.74	NE	NE	NE	NE	NE	NE
1995	NA	0.42	42.67	NE	NE	NE	NE	NE	NE
1996	NA	0.42	41.61	NE	NE	NE	NE	NE	NE
1997	NA	0.43	40.00	NE	NE	NE	NE	NE	NE
1998	NA	0.43	43.91	NE	NE	NE	NE	NE	NE
1999	NA	0.44	41.41	NE	NE	NE	NE	NE	NE
2000	NA	0.45	41.41	NE	NE	NE	NE	NE	NE
2001	NA	0.45	41.31	NE	NE	NE	NE	NE	NE
2002	NA	0.46	40.01	NE	NE	NE	NE	NE	NE
2003	NA	0.47	37.44	NE	NE	NE	NE	NE	NE
2004	NA	0.48	33.61	NE	NE	NE	NE	NE	NE
2005	NA	0.48	32.42	NE	NE	NE	NE	NE	NE
2006	NA	0.49	37.04	NE	NE	NE	NE	NE	NE
2007	NA	0.50	36.97	NE	NE	NE	NE	NE	NE
2008	NA	0.50	38.84	NE	NE	NE	NE	NE	NE
2009	NA	0.52	34.56	NE	NE	NE	NE	NE	NE
2010	NA	0.53	34.00	NE	NE	NE	NE	NE	NE
2011	NA	0.54	36.93	NE	NE	NE	NE	NE	NE
2012	NA	0.55	36.36	NE	NE	NE	NE	NE	NE
2013	NA	0.56	34.85	NE	NE	NE	NE	NE	NE
2014	NA	0.58	34.30	NE	NE	NE	NE	NE	NE
2015	NA	0.45	28.17	NE	NE	NE	NE	NE	NE
2016	NA	0.46	24.77	NE	NE	NE	NE	NE	NE
2016	NA	0.47	24.36	NE	NE	NE	NE	NE	NE
Trend 1990-2017	*NA*	*23.56%*	*-49.26%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005-2017	*NA*	*-2.12%*	*-24.88%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2016-2017	*NA*	*2.62%*	*-1.69%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*

6.4.2 **Methodological issues**

Emission estimates for domestic wastewater treatment activities are based on population data categorized into "not connected", "connected to WWTP" and "connected to biological WWTP", as provided in the greenhouse gas emission inventory.

The EMEP/EEA Tier 2 approach was then applied for estimating the corresponding NMVOC and NH_3 emissions. An overview of the default emission factors (EF) used is given in Table 301. It should be noted that NH_3 emission are only calculated for the population not connected to a WWTP. The NH_3 emission factor used for the calculation is the one for latrines, as provided by the EMEP/EEA Guidebook, although there are no latrines in Luxembourg. Indeed, the dwellings not connected to a WWTP are connected to their septic tank. However no emission factor is provided for septic tanks in the EMEP/EEA Guidebook.

Table 299 – NH_3 and NMVOC emission factors used for category *5D1 – Domestic wastewater handling*

Emission Factor	Source	Value	Unit
EF NH_3 (latrines)	EEA/EMEP GB 2016 (Chap. 5D, Tab3-2, p8)	1.6	kg/person/year
EF NMVOC (mechanical WWTP)	EEA/EMEP GB 2016 (Chap. 5D, Tab3-3, p9)	15	mg/m3 wastewater handled
EF NMVOC (biological WWTP)	EEA/EMEP GB 2016 (Chap. 5D, Tab3-3, p9)	15	mg/m3 wastewater handled

6.4.3 Uncertainties and time-series consistency

Currently no uncertainty estimates are made. Uncertainty of the activity data can be checked in the Luxembourg's National Inventory report (NIR).

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.

6.4.4 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

No recalculations were done since the last submission (2018).

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

No further improvements are planned for the moment.

6.5 *Industrial wastewater handling (5.D.2)*

6.5.1 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 2017, neither in the level, nor in the trend assessments.

Table 300 presents the emission trends of this category.

Table 300 – 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
2016	NA	0.02	NE	NE	NE	NE	NE	NE	NE
Trend 1990-2017	*NA*	*-18.60%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2005-2017	*NA*	*-6.91%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2016-2017	*NA*	*2.57%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*

6.5.2 **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.

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 301.

Table 301 – NH_3 emission factors used for category *5D2 – Industrial wastewater handling*

Emission Factor	Source	Value	Unit
EF NMVOC	EEA/EMEP GB 2016 (Chap. 5D, Tab3-3, p9)	15	mg/m3 wastewater handled

6.5.3 **Uncertainties and time-series consistency**

Currently no uncertainty estimates are made. Uncertainty of the activity data can be checked in the Luxembourg's National Inventory report (NIR).

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.

6.5.4 **Source-specific QA/QC and verification**

Standard QA/QC procedures were followed.

Consistency and completeness checks have been performed.

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

No recalculations were done since the last submission (2018).

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

No further improvements are planned for the moment.

6.6 *Other waste (5.E)*

6.6.1 **Source category description**

This category covers PM, HM and POP emissions from accidental fires of buildings, dwellings and cars.

With regard to PM_{10} and $PM_{2.5}$ emissions, category *5E – other waste* is a key category (LA & TA) in 2017 (see Table 302 and also Chapter 1.5)

Table 302 - Key Categories (fuel sold & fuel used) category *5E – Other 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 E	Other waste (please specify in IIR)													6		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
5 E	Other waste (please specify in IIR)									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, …)

In general, PM, HM and POP emissions from accidental fires seem to have more or less doubled since 1990. This increase is mainly due to the fact the number of cars and dwellings have increased substantially in Luxembourg, due to a large increase in population and workforce (commuters). Table 303 presents the emission trends of this category.

Table 303 – Emission trends for category *5B1 - Composting*

					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	33.63	33.63	33.628344	0.196	0.097575	0.20	340.49
1991	NE	NE	NE	34.50	34.50	34.495905	0.201	0.100092	0.20	349.28
1992	NE	NE	NE	29.83	29.83	29.827597	0.174	0.086547	0.17	302.01
1993	NE	NE	NE	29.58	29.58	29.579722	0.173	0.085828	0.17	299.50
1994	NE	NE	NE	28.73	28.73	28.732817	0.168	0.083370	0.17	290.93
1995	NE	NE	NE	33.96	33.96	33.958843	0.198	0.098534	0.20	343.84
1996	NE	NE	NE	36.75	36.75	36.747434	0.215	0.106625	0.21	372.07
1997	NE	NE	NE	35.94	35.94	35.941841	0.210	0.104288	0.21	363.92
1998	NE	NE	NE	37.55	37.55	37.553027	0.219	0.108963	0.22	380.23
1999	NE	NE	NE	43.79	43.79	43.791209	0.256	0.127063	0.26	443.39
2000	NE	NE	NE	41.73	41.73	41.725586	0.244	0.121070	0.24	422.48
2001	NE	NE	NE	42.61	42.61	42.613804	0.249	0.123647	0.25	431.47
2002	NE	NE	NE	46.10	46.10	46.104707	0.269	0.133776	0.27	466.82
2003	NE	NE	NE	56.10	56.10	56.102323	0.328	0.162785	0.33	568.05
2004	NE	NE	NE	44.56	44.56	44.555490	0.260	0.129281	0.26	451.13
2005	NE	NE	NE	41.97	41.97	41.973461	0.245	0.121789	0.25	424.99
2006	NE	NE	NE	47.90	47.90	47.899791	0.279	0.138756	0.28	485.84
2007	NE	NE	NE	43.22	43.22	43.216950	0.252	0.125103	0.25	438.67
2008	NE	NE	NE	51.03	51.03	51.026643	0.298	0.148282	0.30	515.82
2009	NE	NE	NE	51.03	51.03	51.026643	0.298	0.148282	0.30	515.82
2010	NE	NE	NE	44.30	44.30	44.300902	0.259	0.128596	0.26	448.36
2011	NE	NE	NE	50.11	50.11	50.106527	0.293	0.145424	0.29	507.20
2012	NE	NE	NE	46.28	46.28	46.283733	0.270	0.134311	0.27	468.57
2013	NE	NE	NE	42.33	42.33	42.327002	0.247	0.122563	0.25	429.50
2014	NE	NE	NE	42.41	42.41	42.410071	0.247	0.122880	0.25	430.06
2015	NE	NE	NE	50.60	50.60	50.604669	0.296	0.147012	0.30	511.72
2016	NE	NE	NE	96.75	96.75	96.748908	0.568	0.282275	0.57	973.86
2016	NE	NE	NE	75.32	75.32	75.321207	0.442	0.219406	0.44	759.47
Trend 1990-2017	*NA*	*NA*	*NA*	*123.98%*	*123.98%*	*123.98%*	*124.86%*	*124.86%*	*124.86%*	*123.05%*
2005-2017	*NA*	*NA*	*NA*	*79.45%*	*79.45%*	*79.45%*	*80.15%*	*80.15%*	*80.15%*	*78.70%*
2016-2017	*NA*	*NA*	*NA*	*-22.15%*	*-22.15%*	*-22.15%*	*-22.27%*	*-22.27%*	*-22.27%*	*-22.01%*

6.6.2 **Methodological issues**

For the calculation of emissions from accidental fires, activity data on the number of fires per fire object from national statistics[87] was used. These data were then 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. Default emission factors were taken from EMEP/EEA Guidebook 2016 (Chapter 5.E, Tables 3-2 – 3-6, p. 6-8).

[87] Published by „Corps Grand-Ducal Incendie & Secours“ available at: https://112.public.lu

6.6.3 **Uncertainties and time-series consistency**

Currently no uncertainty estimates are made. Uncertainty of the activity data can be checked in the Luxembourg's National Inventory report (NIR).

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.

6.6.4 **Source-specific QA/QC and verification**

Standard QA/QC procedures were followed.

Consistency and completeness checks have been performed.

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

No recalculations were done since the last submission (2018).

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

No further improvements are planned for the moment.

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 304 provides the explanation to the notation keys used in sector 6.

Table 304 – 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

Table 305 presents the main revisions and recalculations done since submission 2018.

Table 305 – Recalculations done since submission 2018

Source category	Revisions 2018 → 2019	Type of revision
1A1a	Gasoil consumption in 1A1a for the year 2016 was revised in the national energy balance.	Updated AD
1A1a	Aligned Tier 1 and Tier 2 default EFs from EMEP/EEA Guidebook 2009 to EMEP/EEA Guidebook 2016, if necessary.	Updated EFs
1A2a	Fuel consumption (liquid, gaseous, 2014-2016) was revised due to revised energy balance from the national statistics institute	updated AD
1A2a	Aligned Tier 1 and Tier 2 default EFs from EMEP/EEA Guidebook 2009 to EMEP/EEA Guidebook 2016, if necessary.	Updated EFs
1A2b	Fuel consumption was revised due to revised energy balance from the national statistics institute	Updated AD
1A2b	Aligned Tier 1 and Tier 2 default EFs from EMEP/EEA Guidebook 2009 to EMEP/EEA Guidebook 2016, if necessary.	Updated EFs
1A2c	Fuel consumption data was revised due to revised energy balance from the national statistics insti-tute	updated AD
1A2c	Aligned Tier 1 and Tier 2 default EFs from EMEP/EEA Guidebook 2009 to EMEP/EEA Guidebook 2016.	Updated EFs
1A2d	Fuel consumption data was revised due to revised energy balance from the national statistics insti-tute	updated AD
1A2e	Fuel consumption data was revised due to revised energy balance from the national statistics insti-tute	updated AD
1A2e	Aligned Tier 1 and Tier 2 default EFs from EMEP/EEA Guidebook 2009 to EMEP/EEA Guidebook 2016.	Updated EFs
1A2f	Fuel consumption was revised due to revised energy balance from the national statistics institute	Updated AD
1A2f	Aligned Tier 1 and Tier 2 default EFs from EMEP/EEA Guidebook 2009 to EMEP/EEA Guidebook 2016	Update EFs
1A2g vii	Emission factors have been updated according to a recent study88	updated EFs
1A2g vii	Changed notation key for biomass activity data from NO to IE (included in liquid fuels)	Changed notation key
1A2g viii	Fuel consumption was revised due to revised energy balance from the national statistics institute	updated AD
1A2g viii	Aligned Tier 1 and Tier 2 default EFs from EMEP/EEA Guidebook 2009 to EMEP/EEA Guidebook 2016	Update EFs
1A3a	Aviation gasoline activity data for 2016 was revised by data provider	AD
1A3ai(i) and 1A3aii(i)	changed the notation key of NH3 from 'NO' to 'NE'	Changed notation key
1A3b i-v	Changed notation key for biomass activity data from NA to IE (included in liquid fuels)	Changed notation key
1A4a, 1A4b, 1A4c	AD was revised due to a revised energy balance by the national statistics institute.	updated AD

[88] FVT: Aktualisierung der Zeitreihen zum Kraftstoffexport und der Emissionen von klimarelevanten Gasen und Luftschadstoffen des Verkehrssektors in Luxemburg von 1990 – 2017„minimales Update“, Endbericht, Januar 2019, Graz

Source category	Revisions 2018 ➔ 2019	Type of revision
1A4aii	NOx, SO2, NH3, NMVOC, PM2.5, PM10, TSP, CO: Changed notation key from NO to IE (included in 1A2gvii)	Changed notation key
1A4ci	Aligned Tier 1 and Tier 2 default EFs from EMEP/EEA Guidebook 2009 to EMEP/EEA Guidebook 2016	Update EFs / methodology
1A5a	Aligned Tier 1 and Tier 2 default EFs from EMEP/EEA Guidebook 2009 to EMEP/EEA Guidebook 2016	Update EFs / methodology
1B1a	NOx emissions: notation key changed from NO to NE.	Change of notation key
1B1a	NH3, PM2.5, PM10 emissions: changed from notation key NO to emission estimates	New emission estimates
1B2aiv	CO, Pb, Cd, Zn, PCDD/PCDF, PAHs, HCB emissions: notation key changed from NA to NO	Change of notation key
2D3	update of • data of production statistics, import and export statistics, • of plant specific information from associations of industries and statistical data for "general aspects" and "specific aspects" .	updated • AD • EF • parameter

In the agriculture sector, major revisions have been done since submission 2018. The following section provides detailed information about these changes and their impact on emissions.

8.1.1 Detailed information on revised activity data, error corrections and recalculations for the different emissions from the Agriculture sector

This chapter describes in detail the revisions made for activity data used for Ammonia (NH3); particulate matter (PM), nitric oxide (NO) and non-methane volatile organic compounds (NMVOCs) emissions from Agriculture, and the error corrections in the calculations. **The methodology as such was not adapted.**

- Provisional activity data for 2017 livestock data were updated, were necessary.
- The N extraction of the different animal categories revised, and adapted, and influenced all N emissions, as well as NMVOC emissions. For more details see section 8.1.1.1 .
- Further was the distinction made between different slurry storage types, whereas in previous submission default EFs were used. The new EFs influenced the N emissions, as well as NMVOC emissions. For more details see section 8.1.1.2.
- The EFs of particular matter emissions ($PM_{2.5}$; PM_{10} and TSP) for swine and sheep had been mismatched, this error was corrected.
- There were no changes in the 2019 guidelines (EMEP/EEA 2019b, c) when comparing with the 2016 guidelines (EMEP/EEA 2016b, c), neither for the calculation methodology, nor for

the default EFs of NMVOC and particular matters. The 2019 EMEP/EEA guidelines were applied for NMVOC and particular matters emissions.

- The utilised agriculture surface area were revised, whereby using the latest published data, those updated activity influenced
  - the use of synthetic N fertilizer, and the N in crop residues;
  - the N emissions
  - the NMVOC emissions
  - and the particular matter emissions.
- The use of synthetic N fertilizer was revised, and obtained by multiplying the weighted average kg N/ha times the utilised agriculture surface area, rather than using the published sum, as this later is normally not updated when updating the utilised agriculture surface area.
- The activity data for compost had to be revised as erroneously the fresh quantities were used, rather than the dry matter quantities, when estimating the N quantities applied from compost to soils, resulting in lower quantities of N, and hence lower emissions in the current submission.
- In the current submission the distinction was made on a) what methodology is used to spread slurry; b) where is slurry spread; and c) how quick was slurry incorporated, where then applicable. In earlier submission, no distinction was made, and default values as provided in the guidelines were used. For more details see section 8.1.1.3.

8.1.1.1 **N excretion per head/place per year**

8.1.1.1.1 Revision of N.ex values for all livestock categories others than dairy cows

General

Based on the reviewers request N.ex values for the different livestock categories, other than dairy cows, were revised.

The old N.ex estimates were based on "fertilization units" (in German "Dungeinheit" (DE)), as published in Luxemburgish agro-environmental legislation (Règlement_grand-ducal 2015), multiplied by 85 (i.e. 85 kg N per UF (Règlement_grand-ducal 2015)) to obtain country-specific N.ex per head/place per year. According to the reviewer, the so-obtained country-specific N.ex might have be an underestimation of the true N.ex per head/animal place per year as N losses that might occur previous to the application of the manure to the soil, might not have been considered in these estimates. The N.ex for the different livestock categories were, except for dairy cows and cervidae therefore revised.

Having no own measurements, and having no information on feed ratio for the different livestock categories, which would allowing to estimate the N.ex based on an N-balance, the revised N.ex data were taken from the technical literature from Germany, Belgium, the Netherlands and France and are summarized in Table 306. Recalculations for N.ex in kg N for other cattle than dairy cows per year, for all other livestock categories and for the total livestock is summarized in Table 307, Table 308 and Table 309, respectively.

Detailed information for the different livestock species, others than dairy cows, are provided hereafter. To a large extent the literature cited herein dates the period that is covered by the inventory. Hence it is assumed that the details provided are representative of the time series from 1990 onwards and that the methodology based can be applied to all years since 1990.

Belgium, Germany and France (here in particular the Northern part) have direct borders with Luxembourg, 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 similar to one found in Luxembourg.

Table 306: The old and the revised N excretion per head/place per year for the different livestock categories

	N excretion (kg N per head/animal place per year)		Notes/Sources
	Old values	Revised values	
Calves (female calves) < 1 year	29.75*	33	(CBS 2018, VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019)
Calves (male calves) < 1 year	29.75*	31.5	(CBS 2018)
Female young female cattle 1-2 years	42.50*	58	(VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019)
Heifers > 2 years	68.00*	77	"Other cattle older than 2 years" (VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019)
Fattening bulls 1-2 years	42.50*	58	(VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019)
Mature male cattle > 2 years	68.00*	77	"Other cattle older than 2 years" (VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019)
Suckler cows	68.00*	82	(KTBL 2006) page 490

Sows	12.75*	23.5	(VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019)
Weaners	2.55*	3.6	(Horlacher 2018) page 488-489
Fattening pigs	7.65*	11.1	(Horlacher 2018) page 488-489
Mature sheep	5.60*	10.5	(VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019)
Sheep lambs < 1 year	-	4.36	(VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019)
Mature goats	5.60*	18.7	(CBS 2018)
Goat kids < 1 year	-	-	Considered with does
Horses (including anes & mules)	68.00*	calculated	
Agr. Horses > 6 months		65	Horses > 600 kg; (VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019)
Riding horses > 6 months		50	Horses 200-600 kg; (VLM 2017, 2016, 2015, 2014, 2013, 2012)
Horses < 200 kg		35	Ponys; horses < 6 months; mules & anes; (VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019)
Broilers	0.255*	0.3	(CITEPA 2019)
Laying hens	0.595*	0.81	(VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019)
Other poultry	0.85*	0.38	(CITEPA 2019)#
Ostriches	2.975*	15.6	(Rösemann et al. 2019)
Rabbits - Breeding female animals	3.6125*	3.16	Breeding female animal, including raising of young stock (but no fattening); (VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019)
Other rabbits	0.34*	0.658	Fattening rabbits; (VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019)
Cervidae	16.00	16	(Haenel et al. 2018, Rösemann et al. 2019)

Note:

* Using the fertilizer units as published in the (Règlement_grand-ducal 2015) and assuming 85 kg N per fertilizer unit (Règlement_grand-ducal 2015);

Using the French N extraction 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), N.ex for "other poultry" was calculated to be 0.38 kg N/bird place/year.

Table 307: Recalculation of N.ex in kg N per year for dairy cows, for other cattle than dairy cows and for the total cattle population for 1990-2018

years	N.ex in kg N for dairy cows per year New	N.ex in kg N for dairy cows per year Old	Impact of recalculation (%)	N.ex in kg N for other cattle than dairy cows per year New	N.ex in kg N for other cattle than dairy cows per year Old	Impact of recalculation (%)	N.ex in kg N for total cattle population per year New	N.ex in kg N for total cattle population per year Old	Impact of recalculation (%)
1990	6 484 139	6 508 237	-0.4	8 782 434	7 310 140	20.1	15 266 573	13 818 377	10.5
1991	6 179 745	6 202 313	-0.4	9 200 999	7 656 282	20.2	15 380 744	13 858 594	11.0
1992	5 737 933	5 758 676	-0.4	8 925 887	7 421 707	20.3	14 663 819	13 180 383	11.3
1993	5 676 762	5 696 971	-0.4	9 002 184	7 487 408	20.2	14 678 946	13 184 378	11.3
1994	5 532 452	5 552 330	-0.4	8 989 447	7 470 829	20.3	14 521 899	13 023 158	11.5
1995	5 531 048	5 550 670	-0.4	9 400 519	7 805 346	20.4	14 931 566	13 356 016	11.8
1996	5 477 847	5 497 082	-0.3	9 683 278	8 043 771	20.4	15 161 125	13 540 853	12.0
1997	5 298 977	5 317 600	-0.4	9 463 158	7 850 065	20.5	14 762 135	13 167 664	12.1
1998	5 269 824	5 288 256	-0.3	9 305 647	7 717 724	20.6	14 575 471	13 005 980	12.1
1999	5 203 193	5 221 403	-0.3	9 326 685	7 740 160	20.5	14 529 878	12 961 563	12.1
2000	5 014 528	5 032 052	-0.3	9 283 128	7 702 105	20.5	14 297 656	12 734 157	12.3
2001	4 850 635	4 884 114	-0.7	9 354 342	7 762 162	20.5	14 204 977	12 646 276	12.3
2002	4 807 497	4 832 432	-0.5	8 900 932	7 398 328	20.3	13 708 428	12 230 760	12.1
2003	4 788 712	4 805 786	-0.4	8 546 894	7 095 396	20.5	13 335 605	11 901 183	12.1
2004	4 923 480	4 932 677	-0.2	8 411 148	6 984 063	20.4	13 334 627	11 916 741	11.9
2005	4 684 969	4 684 841	0.0	8 410 506	6 973 192	20.6	13 095 475	11 658 033	12.3
2006	4 706 224	4 708 905	-0.1	8 328 232	6 903 551	20.6	13 034 456	11 612 457	12.2
2007	4 936 068	4 932 909	0.1	8 684 680	7 202 802	20.6	13 620 748	12 135 711	12.2
2008	4 868 207	4 825 910	0.9	9 010 733	7 453 149	20.9	13 878 940	12 279 059	13.0
2009	4 750 010	4 709 508	0.9	9 026 642	7 475 015	20.8	13 776 651	12 184 523	13.1
2010	4 988 464	4 887 183	2.1	9 129 676	7 549 077	20.9	14 118 140	12 436 260	13.5
2011	4 917 549	4 835 262	1.7	8 755 702	7 246 495	20.8	13 673 251	12 081 756	13.2
2012	4 730 299	4 645 293	1.8	8 492 185	7 029 428	20.8	13 222 484	11 674 721	13.3
2013	4 871 608	4 819 230	1.1	8 631 968	7 140 366	20.9	13 503 576	11 959 596	12.9
2014	4 924 131	4 903 514	0.4	8 990 099	7 445 647	20.7	13 914 230	12 349 161	12.7
2015	5 001 082	4 978 205	0.5	9 090 279	7 536 925	20.6	14 091 360	12 515 130	12.6
2016	5 522 615	5 445 477	1.4	8 838 543	7 331 933	20.5	14 361 159	12 777 410	12.4
2017	5 803 871	5 624 300	3.2	8 848 705	7 317 992	20.9	14 652 576	12 942 292	13.2
2018	5 943 281			8 577 549			14 520 831		

Source: SER

Note: In the previous submission only provisional data were available for the 2017 livestock numbers. Those were, where applicable, updated.

Table 308: Recalculation of N.ex in kg N per year for swine, poultry, small ruminants, horses and for others for 1990-2018

years	N.ex N in kg for swine per year		Impact of recalculation (%)	N.ex in kg N for poultry per year		Impact of recalculation (%)	N.ex in kg N for small ruminants (sheep & goats) per year		Impact of recalculation (%)	N.ex in kg N for horses, including mules and anes per year		Impact of recalculation (%)	N.ex in kg N for "others" (i.e. ostriches, rabbits, cervidae)		Impact of recalculation (%)
	New	Old		New	Old		New	Old		New	Old		New	Old	
1990	648 621	455 568	42.4	51 045	39 175	30.3	53 975	51 255	5.3	92 205	117 096	-21.3	16 102	13 597	18.4
1991	576 006	404 975	42.2	46 710	35 865	30.2	56 943	53 563	6.3	97 435	124 372	-21.7	15 988	13 087	22.2
1992	600 831	422 147	42.3	44 689	34 196	30.7	52 755	51 281	2.9	96 295	124 780	-22.8	14 089	11 536	22.1
1993	637 131	447 219	42.5	46 977	35 774	31.3	49 010	45 365	8.0	101 560	130 900	-22.4	11 325	9 740	16.3
1994	605 872	425 621	42.4	44 778	34 086	31.4	57 464	55 514	3.5	111 295	144 364	-22.9	11 372	9 944	14.4
1995	640 509	449 847	42.4	41 382	31 720	30.5	56 492	55 616	1.6	113 165	147 152	-23.1	11 084	9 879	12.2
1996	621 311	436 440	42.4	45 459	34 659	31.2	51 781	50 541	2.5	114 865	149 464	-23.1	8 879	7 874	12.8
1997	671 048	470 741	42.6	44 420	34 415	29.1	56 361	53 537	5.3	120 015	156 060	-23.1	10 725	9 402	14.1
1998	682 401	478 660	42.6	45 042	34 617	30.1	60 493	59 938	0.9	121 900	159 256	-23.5	11 668	10 335	12.9
1999	709 728	497 327	42.7	43 775	33 182	31.9	58 000	56 419	2.8	145 355	191 624	-24.1	11 785	10 581	11.4
2000	675 780	473 180	42.8	51 249	38 621	32.7	58 299	57 426	1.5	163 070	214 472	-24.0	14 091	13 088	7.7
2001	678 559	475 262	42.8	59 678	45 019	32.6	63 275	63 074	0.3	160 560	212 568	-24.5	12 238	10 931	12.0
2002	687 110	480 954	42.9	55 339	41 753	32.5	70 930	66 657	6.4	159 915	211 956	-24.6	12 504	11 147	12.2
2003	733 746	512 915	43.1	56 809	42 836	32.6	87 924	84 456	4.1	176 140	234 532	-24.9	13 737	9 837	39.6
2004	837 211	583 951	43.4	53 424	40 283	32.6	94 435	88 154	7.1	189 265	250 648	-24.5	15 401	10 501	46.7
2005	886 195	618 022	43.4	57 611	43 664	31.9	95 255	84 928	12.2	205 420	285 124	-28.0	13 845	9 805	41.2
2006	834 803	582 216	43.4	56 425	42 774	31.9	95 745	90 512	5.8	205 995	294 848	-30.1	13 423	9 756	37.6
2007	825 176	575 419	43.4	57 751	43 491	32.8	95 954	87 350	9.9	204 270	294 712	-30.7	10 998	7 772	41.5
2008	813 000	566 740	43.5	62 033	46 208	34.2	99 271	89 518	10.9	210 910	308 448	-31.6	13 156	9 746	35.0
2009	814 398	567 699	43.5	70 390	52 781	33.4	103 535	92 501	11.9	214 155	310 216	-31.0	13 673	10 075	35.7
2010	745 075	520 237	43.2	64 009	47 924	33.6	120 068	103 390	16.1	212 615	312 868	-32.0	12 338	9 223	33.8
2011	783 941	546 621	43.4	73 614	55 068	33.7	123 945	106 832	16.0	212 805	312 392	-31.9	15 463	10 881	42.1
2012	805 199	560 841	43.6	82 867	62 369	32.9	129 214	109 510	18.0	226 670	332 316	-31.8	13 563	10 274	32.0
2013	785 968	547 233	43.6	82 548	61 663	33.9	123 746	107 368	15.3	213 530	318 376	-32.9	13 701	8 849	54.8
2014	794 995	553 336	43.7	86 120	64 373	33.8	120 201	104 894	14.6	216 360	321 232	-32.6	11 033	8 333	32.4
2015	852 942	593 149	43.8	83 080	62 214	33.5	132 145	114 189	15.7	214 290	320 756	-33.2	11 617	8 020	44.9
2016	847 359	589 201	43.8	83 172	62 245	33.6	127 998	109 676	16.7	205 860	308 720	-33.3	9 914	6 393	55.1
2017	882 783	603 804	46.2	89 119	66 908	33.2	127 084	108 872	16.7	213 625	321 776	-33.6	7 870	5 062	55.5
2018	824 217			89 032			129 248			210 335			8 923		

Source: SER

Note: In the previous submission only provisional data were available for the 2017 livestock numbers. Those were, where applicable, updated.

Table 309: Recalculation of N.ex in kg N per year for all livestock for 1990-2018

years	N.ex in kg N for total livestock population New	Old	Impact of recalculation (%)
1990	16 128 520	14 495 068	11.3
1991	16 173 826	14 490 456	11.6
1992	15 472 478	13 824 323	11.9
1993	15 524 949	13 853 377	12.1
1994	15 352 680	13 692 686	12.1
1995	15 794 198	14 050 229	12.4
1996	16 003 420	14 219 831	12.5
1997	15 664 704	13 891 819	12.8
1998	15 496 975	13 748 786	12.7
1999	15 498 521	13 750 695	12.7
2000	15 260 146	13 530 943	12.8
2001	15 179 286	13 453 130	12.8
2002	14 694 227	13 043 227	12.7
2003	14 403 962	12 785 758	12.7
2004	14 524 364	12 890 277	12.7
2005	14 353 801	12 699 576	13.0
2006	14 240 846	12 632 562	12.7
2007	14 814 897	13 144 455	12.7
2008	15 077 309	13 299 718	13.4
2009	14 992 802	13 217 796	13.4
2010	15 272 246	13 429 901	13.7
2011	14 883 019	13 113 551	13.5
2012	14 479 997	12 750 032	13.6
2013	14 723 069	13 003 084	13.2
2014	15 142 940	13 401 328	13.0
2015	15 385 433	13 613 457	13.0
2016	15 635 462	13 853 645	12.9
2017	15 973 057	14 048 715	13.7
2018	15 782 585		

Source: SER

Note: The 2017 livestock numbers were provisional data, and were updated where applicable.

Revised N.ex for cattle categories others than dairy cows

Calves

We made, similar as the Netherlands and France, the distinction between male and female calves.(Lagerwerf et al. 2019, CITEPA 2019)

The N.ex for female calves < 1 year were based on the N.ex for dairy calves < 1 year as published for the years 2012-2017 for the region Flandern in Belgium (VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019) and for female dairy calves < 1 year for South-east Netherlands for 2017,(CBS 2018) namely 33 kg N/animal/year (see Table 306).

The assumed N.ex for male calves < 1 year was based on the value from the Netherlands,(CBS 2018) namely 31.7 kg N/animal/year (see Table 306).

The applied N.ex for calves are similar to Belgium and the Netherlands, and are slightly higher than the N.ex values used in the French emission calculations (i.e. 26.8 kg N/animal/year and 27.6 kg N/animal/year for female and male calves respectively).(CITEPA 2019)

Female young cattle 1-2 years

The N.ex for female young cattle 1-2 years was assumed to be 58 kg N/animal/year (see Table 306), based on the N.ex as published for the years 2012-2017 for the region Flandern in Belgium (VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019).

The applied N.ex for female young cattle 1-2 years is higher than the values used by the Wallonia region in Belgium (i.e. 48 kg N/animal/year)(Protect'eau 2017) and France (i.e. 51.1 kg N/animal/year and 53.5-53.3 kg N/animal/year for beef breed female heifers 1-2 years and for dairy breed female heifers 1-2 years, respectively),(CITEPA 2019) but lower than the values used in the Dutch emission calculations (93.2 kg N/animal/year in 1990 decreasing over time to 67.9 kg N/animal/year in 2017).(Lagerwerf et al. 2019, CBS 2018, 2009).

Fattening bulls 1-2 years

The N.ex for fattening bulls 1-2 years was assumed to be 58 kg N/animal/year (see Table 306), based on the N.ex as published for the years 2012-2017 for the region Flandern in Belgium.(VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019)

The applied N.ex for female young cattle 1-2 years is higher than the values used by the Wallonia region in Belgium (i.e. 40 kg N/animal/year),(Protect'eau 2017) but in the same range as used in French emissions calculations (i.e. 57.8-57.6 kg N/animal/year and 56.4-56.2 kg N/animal/year for beef breed young bulls 1-2 years and for dairy breed young bulls 1-2 years, respectively),(CITEPA 2019) and Dutch emission calculations (72.6 kg N/animal/year in 1990 decreasing to 50.3 kg N/animal/year in 2017).(CBS 2009, 2018)

Heifers > 2 years

The N.ex for heifers > 2 years was assumed to be 77 kg N/animal/year (see Table 306), based on the N.ex as published for the years 2012-2017 for the region Flandern in Belgium (VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019) for other cattle older than 2 years (in Dutch “andere runderen”), the only value provided by VLM for other cattle than suckler cows or dairy cows.

This is slightly higher than the values used by the Wallonia region in Belgium (i.e. 66 kg N/animal/year)(Protect'eau 2017) and France (i.e. 69.7 kg N/animal/year in 1990 and 69.1 kg N/animal/year in 2017 for dairy heifers > 2 years, respectively 67 kg N/animal/year in 1990 and 66.9 kg N/animal/year in 2017 for beef heifers >2 years), (CITEPA 2019) but similar to the Dutch emission calculations (94.2 kg N/animal/year in 1990 and decreasing to 69.3 kg N/animal/year for heifers > 2 years).(CBS 2009, 2018)

Male bulls > 2 years

The N.ex for heifers > 2 years was assumed to be 77 kg N/animal/year (see Table 306), based on the N.ex as published for the years 2012-2017 for the region Flandern in Belgium (VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019) for other cattle older than 2 years (in Dutch "andere runderen"), the only value provided by VLM for other cattle than suckler cows or dairy cows.

This is slightly higher than the values used by the Wallonia region in Belgium (i.e. 66 kg N/animal/year)(Protect'eau 2017) and in the Dutch emission calculations (72.6 kg N/animal/year in 1990 decreasing to 50.3 kg N/animal/year in 2017).(CBS 2009, 2018) But this value is in the same range as used in French emissions calculations (i.e. 77.8-77.7 kg N and 79.1-78.4 kg N for beef breed young bulls 1-2 years and for dairy breed young bulls 1-2 years, respectively),(CITEPA 2019) and lower than the value used in German emission calculations (84 kg N/animal/year).(Rösemann et al. 2019, KTBL 2006)

Suckler cows

The N.ex for heifers > 2 years was assumed to be 82 kg N/animal/year (see Table 306), based on the N.ex used in the German emission calculations. (Rösemann et al. 2019, KTBL 2006)

Although all other cattle N extraction were derived from the Flandern region emission calculations, the 65 kg N/suckler cow/year used in their emissions seems too low,(VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019) although that value is similar to the N.ex used for suckler cows in the Wallonia region (i.e. 66 kg N/suckler cow/year).(Protect'eau 2017) But with Limousin being the main breed in Luxembourg, opposite to the Belgian White and Blue breed used as main breed in Belgium, the values used in the German and the Dutch emission calculations (i.e. 81.5 kg N/suckler cow/year in 2017) seems more appropriated.(Rösemann et al. 2019, KTBL 2006, CBS 2018) The used value is slightly lower than the N.ex used in the French emission calculations, (i.e. 107.3 kg N/suckler cow/year),(CITEPA 2019) who have, next to the Limousin breed, also other heavier breeds for example the Charolais breed.

Revised N.ex for swine categories

The swine production in Luxemburg is in the hand of very few, but very professional farmers, and therefore more in line with the German, the Dutch or Flemish swine production.

Sows

The N.ex for sows (pregnant sows and sows with piglets < 8 kg) was assumed to be 23.5 kg N/animal place/year (see Table 306), based on the N.ex used for reduced N-feeding strategies for the years 2012-2017 for the region Flandern in Belgium.(VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019)

This value is in the same magnitude as used in the French emission calculations (CITEPA 2019), and as published by KTBL.(Horlacher 2018) The used value is higher than the one used in the Wallonia (B.) emission calculations, namely 15 kg N/sow place/year,(Protect'eau 2017) and lower than the value used in the Dutch emission calculations, (33.8 kg N/sow place/year in 1990 and decreasing to

30.2 kg N/sow place/year and including piglets < 20kg). The latter value is however, not comparable, as including piglets up to 20 kg with the sow emissions.(CBS 2009, 2018)

Weaners

The N.ex for weaners (8-30 kg) was assumed to be 3.6 kg N/animal place/year (see Table 306), based on the N.ex provided in KTBL for reduced N-feeding strategies.(Horlacher 2018)

This value is in the same order of magnitude as used in the French emission calculations (4.1 kg N/animal place/year in 2017).(CITEPA 2019)

In the Belgium emissions calculations, weaners are only considered up to 20 kg, and therefore not suitable for our purpose (i.e. 1.9 kg N/animal place/year in the Wallonia region, and 2.18 kg N/animal place/year in the Flanders region),(Protect'eau 2017, VLM 2017)lm and in the Dutch emission calculations, piglets up to 20 kg are included in the sow extraction.

Fattening pigs

The N.ex for fattening pigs (>30 kg) was assumed to be 11.1 kg N/animal place/year (see Table 306), based on the N.ex provided in KTBL for reduced N-feeding strategies.(Horlacher 2018)

This value is slightly lower than the value used in the French emission calculations (12.9 kg N/fattening animal place/year in 2017).(CITEPA 2019) The used value seems to be more in the magnitude of N extraction of Flemish and Dutch fattening pigs. Although in both emission calculations fattening pigs are considered from 20 kg onwards, and therefore is the used N extraction per animal place by definition slightly higher, but with 11.87 kg N/animal/place and 11.7 kg N/animal/place in 2017, respectively, comparable to the used value in the Luxembourgish emission calculations.(VLM 2017, CBS 2018) The extraction value used in the Wallonia region is with 7.8 kg N/animal place/year far below any other value used in neighbouring country.

Revised N.ex for poultry categories

Laying hens

Laying hens are in the hand of a few, very professional farmers. The N.ex for laying hens was assumed to be 0.81 kg N/animal place/year (see Table 306), based on the N.ex used for the Flanders region in Belgium.(VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019)

This used value is slightly higher than the values used in the French and Dutch emission calculations, namely in 2017 0.7 kg N/animal place/year and 0.76 kg N/animal place/year, respectively.(CITEPA 2019, CBS 2018)

Broilers

The broiler production is closer to “poulet de ferme” with a 80-day production cycle as more common in France than the typical 32 to 40 day broilers as produced in Flanders, the Netherlands and Germany. The N.ex for broilers was therefore assumed to be 0.3 kg N/animal place/year (see Table 306), based on the N.ex used in the French emission calculations.(CITEPA 2019)

This value is similar to the more extensive broiler production found in the Wallonia region in Belgium (i.e. 0.27 kg N/animal place/year).(Protect'eau 2017)

Other poultry

Turkey, duck, goose and other poultry are considered together in one category (varying over the years between 550-1500 birds/year). There is no large-scale production of any of these birds, the majority of the birds are kept as a kind of "backyard" and within the majority just one round per year. Using the French N extraction for ducks, turkeys, geese and broilers (as proxy for all other poultry), assuming that places for ducks, turkeys and geeses' would only be occupied for half a year, and using the distribution as observed in 2005, N.ex for "other poultry" was calculated to be 0.38 kg N/animal place/year.

This value is similar to the more extensive production found in the Wallonia region in Belgium (i.e. 0.43 kg N/animal place/year).(Protect'eau 2017)

Revised N.ex for small ruminants

Sheep > 1 year

The N.ex for sheep >1 year was assumed to be 10.5 kg N/animal place/year (see Table 306), based on the N.ex used for the years 2012-2017 for Flanders region in Belgium.(VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019)

This value is in the same magnitude as used in the German emission, 11 kg N/animal place/year.(Rösemann et al. 2019) The major sheep production in France is not situated in the Northern part of France, and also are the used breeds different, why these emissions cannot be compared. The Dutch emissions calculations consider emissions per ewe, including extractions from lambs why hard to compare. The used N.ex per ewe per year was decreasing from 25 kg N/ewe/year in 1990 to 13.7 kg N/ewe/year in 2017.(CBS 2009, 2018)

Sheep lambs < 1 year

The N.ex for sheep lambs <1 year was assumed to be 4.36 kg N/animal place/year (see Table 306), based on the N.ex used for the years 2012-2017 for Flanders region in Belgium.(VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019)

This value is in the same magnitude as used in the German emission, namely 4 kg N/animal place/year(Rösemann et al. 2019) The major sheep production in France is not situated in the Northern part of France, and are the used breeds different, why these emissions are hard to compare. In the Dutch emission calculations, the extraction from lambs are considered together with ewes.

Goats does > 1 year

The majority of goats are dairy goats. The initiator of this production in Luxembourg were second-generation Dutch immigrants, with good connections and relations to the Dutch dairy goat sector, which has not changed since then. Therefore the N.ex for mature goats, in the majority goat does, was based on goat does, including N.ex of raised goat kits < 1 year, and was assumed to be 18.7 kg

N/animal place/year (see Table 306) similar to the N.ex used for the years 2017 in the Dutch emission calculations.(CBS 2018)

The major goat production in France is not situated in the Northern part of France, and are the used breeds different, why these emissions are hard to compare. The Flemish emissions calculations consider emissions per doe and per kit, whereby using the same values as for sheep.(VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019)

Goat kits < 1 year

The N.ex for goat kits <1 year were included in the N.ex estimates for goat does, and therefore set at 0 kg N/animal place/year in the model (see Table 306).

Revised N.ex for "other animals"

Horses

The N.ex for horses was assumed to be 65 kg N/animal/year for agriculture horses >6 months (i.e. horses > 600 kg) where the major breed is Ardennes; 50 kg N/animal/year for riding horses >6 months (i.e. horses 200-600 kg); and 35 kg N/animal/year for light horses (i.e. horses < 200 kg) such as ponys and horses <6 months, but including also mules and anes (see Table 306), based on the N.ex used in Belgium.(VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, Protect'eau 2017)

This value is in the same magnitude as used in the French emission calculations, who also distinguish between tree different horse categories.(CITEPA 2019) The German and the Netherlands, do distinguish only between two categories, with similar values for ponys/"light" horses, and 53.6 kg N/horses 500-600 kg/year and 58.6 kg N/horse/year, respectively.(Rösemann et al. 2019, CBS 2018)

Ostriches

Belgium and Germany report N.ex for ostriches, whereby the German N.ex was based on Danish data.(Rösemann et al. 2019) The Flemish emission calculations used N.ex for different production stages (i.e. breeding adult bird (18 kg N/bird/year), fattening bird (8.6 kg N/bird/year), young bird 0-3 months (3.16 kg N/bird/year).(VLM 2017) But these detail information were not available in Luxembourg, and seen the low numbers (varying between 343-172 birds/year), will probably also not collected in the close future. The used N.ex for ostriches was therefore based on the N.ex used in the German emission calculations, namely 15.6 kg N/bird place/year (see Table 306).(Haenel et al. 2018, Rösemann et al. 2019)

Rabbits

The IPCC default value for N.ex for rabbits is 8.1 kg,(IPCC 2006a) and in the same magnitude is the value used in the French emission calculations (8.1 kg N/animal place/year in 1990 decreasing to 7.5 kg N/animal place),(CITEPA 2019) the Dutch emission calculations (8.7 kg N/animal place/year in 1990 decreasing to 8.3 kg N/animal place/year in 2017),(CBS 2009, 2018) and in the Flemish emission calculations for female breeding animals, including raising and fattening of rabbits (i.e. 7.42 kg N/animal place/year.(VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019)

The Flemish emission calculations however, foresees also N.ex for fattening rabbits (0.658 kg N/animal place/year) and for female breeding animals, including raising of young stock, ***but excluding*** the fattening of young stock (3.16 kg N/animal place/year).(VLM 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019) The German emission calculations foresees only N excretion for fattening rabbits (i.e. 0.8 kg N/animal place/year).(Rösemann et al. 2019)

The majority of rabbits are rather small-scale, often for self-consumption. To better fit the Luxemburgish conditions, N.ex were calculated for fattening places and for breeding animal, including raising of youngstock, ***but excluding*** fattening, separately, whereby using the same values as used in the Flemish emission calculations, namely 0.658 kg N/fattening place/year and 3.16 kg N/female breeding animal place including raising of youngstock/year, see Table 306.

Deer

The livestock categories "deer" are in the majority deer. Neither the IPCC guidelines,(IPCC 2006a) nor Belgium, nor France, nor the Netherlands calculate N emissions for deer. Only Germany report N excretions for deers, whereby the German N.ex was based on Danish data.(Haenel et al. 2018, Rösemann et al. 2019) Given that deer's in Luxembourg are kept under similar conditions w.r.t. climate, feeding situation and holding system (i.e. kept outdoor throughout the year) as found in Germany, the Luxemburg calculations have been based on the N excretion value used by Germany, i.e. 16 kg/animal place/year,(Haenel et al. 2018, Rösemann et al. 2019) see Table 306.

8.1.1.1.2 Updating N.ex values for dairy cows

When estimating the weighted average for milk urea in November 2018, an error had occurred. This mistake was noted in November 2019 and the Administration des service technique de l'agriculture (ASTA) - Service d'analyse du lait, corrected the error and provided the updated values (Engel 2019). The recalculated N.ex (in kg N per dairy cow per year) at national level for dairy cows are summarized in Table 307.

8.1.1.2 **Slurry storage system**

In earlier submissions no distinction was made between different slurry storage systems whereby using the default emission factors as provided in the 2016 guidelines (EMEP/EEA 2016b) in Table 3.8-3.10 to estimate NH_3-N, N_2O-N, NO-N and N_2-N emissions. In the current submission a distinction between three different slurry storage system was made (see section 5.2.4), namely a) slurry stored in a slurry tank without cover, b) slurry stored in a slurry tank with cover (plastic film or solid cover) and c) slurry stored underneath a slatted floor. The new EF's were based on the German inventory, as climate condition, feeding and holding systems are similar between both countries.(Rösemann et al. 2019)

Table 310: Old and new emission factors for slurry storage of different N emissions

	Emission factor for slurry storage ($EF_{slurry\ torage}$) for …			
Livestock category (i) / Slurry storage system	NH3-N(i)	N2O-N(i)	NO-N(i)	N2-N(i)
Cattle (Dairy cattle / Non-dairy cattle)				
Default value (old)	0.2[a]	0.1[d]	0.0001[g]	0.003[g]
Slurry tank without cover	0.045[b]	0.005[e]	0.0005[h]	0.015[i]
Slurry tank with cover	0.015[b]	0.005[e]	0.0005[h]	0.015[i]
Slurry stored underneath a slatted floor	0.045[b]	0.002[e]	0.0002[h]	0.006[i]
Swine (Sows, weaners, fattening pigs)				
Default value (old)	0.14 [a]	0[d]	0.0001[g]	0.003[g]
Slurry tank without cover	0.15[c]	0[f]	0[h]	0[i]
Slurry tank with cover	0.015[c]	0.005[f]	0.0005[h]	0.015[i]
Slurry stored underneath a slatted floor	0.105[c]	0.002[f]	0.0002[h]	0.006[i]

a) Default value in Table 3.9 in the 2016 guidelines (EMEP/EEA 2016b).
b) Based on Table 4.5 in (Rösemann et al. 2019) slurry tank with natural crust (0.045), slurry tank with solid cover (0.015) and slurry stored underneath a slatted floor (0.045), respectively.
c) Based on Table 5.4 in (Rösemann et al. 2019) slurry tank without natural crust (0.15), slurry tank with solid cover (0.015) and slurry stored underneath a slatted floor (0.105), respectively.
d) Default value in Table 3.8 in the 2016 guidelines (EMEP/EEA 2016b).
e) Based on Table 4.6 in (Rösemann et al. 2019) slurry tank with natural crust (0.005), slurry tank with solid cover (0.005) and slurry stored underneath a slatted floor (0.002), respectively.
f) Based on Table 5.5 in (Rösemann et al. 2019) slurry tank without natural crust (0), slurry tank with solid cover (0.005) and slurry stored underneath a slatted floor (0.002), respectively.
g) Default value in Table 3.10 in the 2016 guidelines (EMEP/EEA 2016b).
h) Assuming that $EF_{slurry\ storage,NO\text{-}N} = 0.1 * EF_{slurry\ storage,N2O\text{-}N}$ (Rösemann et al. 2019).
i) Assuming that $EF_{slurry\ storage,N2\text{-}N} = 3 * EF_{slurry\ storage,N2O\text{-}N}$ (Rösemann et al. 2019).

8.1.1.3 **Spreading slurry**

In earlier submissions no distinction was made, neither on the techniques used when spreading slurry, nor where slurry would have been applied, nor if slurry was incorporated or not. The default Tier 2 NH_3-N EFs, as provided in the 2016 guidelines (EMEP/EEA 2016b) in Table 3.9, had been used and are summarized in Table 311.

In the current submission a distinction was made:

- for the used technique (i.e. broadcoast, trailing hose, trailing shoe, injector and slurry cultivator);
- where slurry was applied, whereby distinguishing between grassland, arable land with plant cover 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; 6-12 hours or >12 hours.

The new 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,(Rösemann et al. 2019) and are summarized in Table 311.

Table 311: Old and new emission factors for NH_3-N from slurry application (in kg NH_3-N kg^{-1})

	Emission factor for NH3-N for slurry application using …				
Livestock category (i) / Slurry storage system	Broadcast	Trailing hose	Trailing shoe	Injection techniques	Slurry cultivator
Cattle (Dairy cattle / Non-dairy cattle)					
Default value (old)	0.55[a]				
Grassland	0.60[b]	0.54[b]	0.36[b]	0.24[b]	NA
Arable land with vegetation	0.50[b]	0.35[b]	0.36[b]	0.24[b]	NA
Arable land without vegetation					
& without incorporation (>12 hours)	0.50[b]	0.46[b]	0.36[b]	0.24[b]	NA
& with incorporation ≤1 hour	0.10[b]	0.004[b]	0.004[b,d]	0.004[b,d]	0.04[b,c]
& with incorporation ≤4 hour	0.26[b]	0.15[b]	0.15[b,d]	0.15[b,d]	NA
& with incorporation ≤6 hour	0.35[b]	0.20[b]	0.20[b,d]	0.20[b,d]	NA
& with incorporation ≤12 hour	0.43[b]	0.30[b]	0.30[b,d]	0.24[b,d]	NA
Swine					
Default value (old)	0.29/0.40[e]				
Grassland	0.30[f]	0.21[f]	0.12[f]	0.06[f]	NA
Arable land with vegetation	0.25[f]	0.13[f]	0.12[f]	0.06[f]	NA

Arable land without vegetation					
& without incorporation (>12 hours)	0.25[f]	0.18[f]	0.12[f]	0.06[f]	NA
& with incorporation ≤1 hour	0.04[f]	0.02[f]	0.02[f,d]	0.02[f,d]	0.02[f,c]
& with incorporation ≤4 hour	0.09[f]	0.06[f]	0.06[f,d]	0.06[f,d]	NA
& with incorporation ≤6 hour	0.11[f]	0.08[f]	0.08[f,d]	0.06[f,d]	NA
& with incorporation ≤12 hour	0.16[f]	0.11[f]	0.11[f,d]	0.06[f,d]	NA

e) Default value in Table 3.9 in the 2016 guidelines (EMEP/EEA 2016b).
f) Based on Table 4.7 in (Rösemann et al. 2019).
g) Slurry cultivator is by definition immediate incorporation.
h) No details were provided for trailing shoe and incorporation and infecting techniques and incorporation. It was therefore assumed that the EFs would be the same as for trailing hose, but could never been worse than without incorporation.
i) Default value in Table 3.9 in the 2016 guidelines (EMEP/EEA 2016b), whereby distinguishing between sows (EF=0.29) and fattening pigs/weaners (EF=0.40).
j) The new 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,(Rösemann et al. 2019) and are summarized in Table 311section 5.4.3.1.15.4.3.2.3

Underlying information necessary for the new estimations are summarized in section 5.4.3.1.1 5.4.3.2.3. $$$$CHECK IN WHICH SECTION and comprise:

- For grassland, arable land with and without vegetation the distribution over the different techniques suitable for spreading slurry;
- For arable land without vegetation, was further required the distribution over different incorporation times from the slurry after the field application had taken place.

8.1.1.4 **Recalculations**

Adapted livestock categories, revised activity data for both livestock and managed soil, adapted N.ex and error corrections of the N flow, resulted in lower NH_3 emissions from manure management (NRF 3B) than in the previous submission, but in increased NH_3 emissions from crop production and managed soil (NRF 3D), see Table 312.

Table 312: Recalculation of NH_3 emissions for category 3B (Manure management) and 3D (Crop production and agricultural soils) (Gg)

	3B		Impact of recalculation	3D		Impact of recalculation
Year	New	Old	%	New	Old	%
1990	2.9	2.9	-0.3	3.7	3.4	10.9
1991	2.7	2.8	-3.0	3.9	3.5	10.9
1992	2.6	2.7	-3.5	3.8	3.3	16.4
1993	2.6	2.7	-3.5	3.8	3.3	15.4
1994	2.5	2.6	-4.0	3.7	3.2	14.7
1995	2.6	2.7	-4.1	3.8	3.3	14.5
1996	2.6	2.7	-4.0	3.8	3.3	15.1
1997	2.6	2.7	-4.1	3.8	3.3	15.4
1998	2.5	2.7	-4.7	3.7	3.3	14.5
1999	2.4	2.6	-7.0	3.8	3.3	15.5
2000	2.4	2.6	-6.6	3.7	3.2	15.4
2001	2.4	2.5	-6.0	3.5	3.0	15.5
2002	2.3	2.5	-6.0	3.4	3.0	14.6
2003	2.3	2.4	-5.0	3.2	2.8	14.7
2004	2.3	2.4	-4.3	3.3	2.9	13.0
2005	2.3	2.4	-3.3	3.1	2.8	12.7
2006	2.3	2.4	-3.1	3.1	2.7	12.1
2007	2.4	2.4	-2.8	3.1	2.8	12.3
2008	2.4	2.5	-1.5	3.1	2.8	12.6
2009	2.4	2.4	-0.8	3.0	2.7	11.7
2010	2.5	2.5	-0.2	3.1	2.7	12.7
2011	2.4	2.4	-0.4	3.0	2.8	10.1
2012	2.3	2.4	-0.1	2.9	2.6	10.9
2013	2.4	2.4	-0.5	2.9	2.7	10.0
2014	2.5	2.5	-0.8	3.0	2.7	9.5
2015	2.5	2.5	-0.9	3.0	2.7	9.0
2016	2.5	2.6	-1.4	3.0	2.8	7.3
2017	2.6	2.6	-0.7	3.1	2.8	7.9
2018	2.5			3.0		

Source: SER.

Whereas, the NO_x emission increased compared to previous submission from both, manure management and crop production and managed soil, see Table 313.

Table 313: Recalculation of NO_x emissions for category 3B (Manure management) and 3D (Crop production and agricultural soils) (Gg)

	3B		Impact of recalculation	3D		Impact of recalculation
Year	New	Old	%	New	Old	%
1990	0.12	0.10	10.4	1.30	1.27	2.3
1991	0.10	0.09	11.3	1.34	1.34	0.2
1992	0.09	0.08	11.6	1.39	1.25	11.2
1993	0.09	0.08	11.9	1.32	1.22	8.6
1994	0.09	0.08	12.1	1.27	1.19	6.6
1995	0.09	0.08	12.5	1.28	1.21	5.3
1996	0.09	0.08	12.7	1.28	1.20	6.2
1997	0.09	0.08	13.0	1.27	1.19	6.6
1998	0.09	0.08	13.2	1.25	1.20	4.5
1999	0.08	0.07	13.6	1.28	1.21	5.5
2000	0.07	0.07	13.6	1.27	1.21	5.4
2001	0.07	0.07	13.6	1.15	1.08	6.0
2002	0.07	0.06	13.3	1.14	1.08	5.8
2003	0.07	0.06	13.1	1.00	0.94	6.4
2004	0.07	0.06	12.9	1.16	1.10	5.5
2005	0.07	0.06	13.2	1.05	0.99	5.7
2006	0.07	0.06	13.0	1.04	0.99	5.6
2007	0.08	0.07	13.1	1.04	0.98	5.9
2008	0.08	0.07	14.0	1.04	0.98	5.9
2009	0.08	0.07	14.1	1.04	0.98	5.9
2010	0.08	0.07	14.6	1.05	0.98	8.0
2011	0.08	0.07	14.2	1.06	1.02	4.3
2012	0.08	0.07	14.1	1.05	0.99	6.1
2013	0.08	0.07	13.9	1.04	0.98	6.3
2014	0.08	0.07	13.8	1.03	0.97	6.3
2015	0.08	0.07	13.6	1.03	0.96	6.8
2016	0.08	0.07	13.4	1.08	1.01	6.6
2017	0.08	0.07	14.1	1.07	1.00	7.2
2018	0.08			1.05		

Source: SER.

Adapted livestock categories and revised livestock numbers, resulted in:

- lower NMVOC emissions from manure management than in the previous submission (Table 314),
- higher emissions from manure management than in the previous submission (Table 315),
- lower $PM_{2.5}$ emissions from manure management than in the previous submission (Table 316)

- higher PM_{10} emissions from manure management than in the previous submission (Table 317).

Table 314: Recalculation of NMVOC emissions for category 3B (Manure management) (Gg)

	3B		Impact of recalculation	3D		Impact of recalculation
Year	New	Old	%	New	Old	%
1990	3.1	3.2	-1.1	0.11	0.11	0.0
1991	3.2	3.2	-1.4	0.11	0.11	0.0
1992	3.0	3.1	-1.5	0.11	0.11	0.0
1993	3.1	3.1	-1.5	0.11	0.11	0.0
1994	3.0	3.1	-1.5	0.11	0.11	0.0
1995	3.2	3.2	-1.6	0.11	0.11	0.0
1996	3.2	3.2	-1.6	0.11	0.11	-0.8
1997	3.2	3.2	-1.6	0.11	0.11	-0.8
1998	3.1	3.2	-1.7	0.11	0.11	-0.7
1999	3.1	3.2	-1.9	0.11	0.11	-0.7
2000	3.1	3.1	-1.9	0.11	0.11	-0.5
2001	3.1	3.2	-1.9	0.11	0.11	-0.5
2002	3.0	3.0	-2.0	0.11	0.11	-0.5
2003	2.9	2.9	-1.9	0.11	0.11	-0.5
2004	2.8	2.9	-2.0	0.11	0.11	-0.4
2005	2.8	2.9	-2.0	0.11	0.11	-1.0
2006	2.8	2.8	-2.0	0.11	0.11	-1.0
2007	2.9	2.9	-2.0	0.11	0.11	-0.8
2008	3.0	3.0	-1.9	0.11	0.11	-1.0
2009	3.0	3.0	-1.9	0.11	0.11	-0.8
2010	3.0	3.1	-1.9	0.11	0.11	-0.5
2011	2.9	3.0	-2.0	0.11	0.11	-0.4
2012	2.8	2.9	-2.0	0.11	0.11	-0.2
2013	2.9	3.0	-2.1	0.11	0.11	-0.2
2014	3.0	3.1	-2.2	0.11	0.11	-0.3
2015	3.1	3.2	-2.4	0.11	0.11	-0.2
2016	3.1	3.2	-2.7	0.11	0.11	-0.2
2017	3.2	3.3	-2.7	0.11	0.11	0.0
2018	3.1			0.11		

Source: SER.
Note: No changes for category 3D (Crop production and agricultural soils)

Table 315: Recalculation of TSP emissions for category 3B (Manure management) (Gg)

	3B		Impact of recalculation	3D		Impact of recalculation
Year	New	Old	%	New	Old	%
1990	0.219	0.197	11.0	0.197	0.197	0
1991	0.211	0.193	9.2	0.196	0.196	0
1992	0.204	0.184	10.6	0.196	0.196	0
1993	0.207	0.185	12.0	0.198	0.198	0
1994	0.202	0.183	10.8	0.198	0.198	0
1995	0.207	0.186	11.4	0.198	0.198	0
1996	0.208	0.187	11.0	0.196	0.197	-0.81
1997	0.208	0.184	12.9	0.196	0.198	-0.79
1998	0.207	0.183	13.2	0.197	0.198	-0.71
1999	0.209	0.182	14.6	0.197	0.199	-0.72
2000	0.206	0.180	14.6	0.198	0.199	-0.50
2001	0.208	0.182	14.1	0.199	0.200	-0.54
2002	0.203	0.176	15.1	0.199	0.200	-0.46
2003	0.204	0.173	17.4	0.199	0.200	-0.46
2004	0.211	0.173	21.9	0.199	0.200	-0.37
2005	0.215	0.175	23.2	0.199	0.201	-1.04
2006	0.209	0.171	22.1	0.199	0.201	-0.96
2007	0.214	0.176	21.5	0.202	0.204	-0.84
2008	0.217	0.179	21.2	0.201	0.203	-0.98
2009	0.220	0.182	20.9	0.202	0.204	-0.79
2010	0.214	0.181	18.0	0.204	0.205	-0.48
2011	0.216	0.180	20.2	0.204	0.205	-0.41
2012	0.218	0.179	21.8	0.205	0.205	-0.23
2013	0.221	0.183	21.0	0.204	0.204	-0.19
2014	0.226	0.187	21.0	0.204	0.204	-0.29
2015	0.233	0.190	22.9	0.205	0.205	-0.17
2016	0.236	0.192	22.6	0.203	0.204	-0.22
2017	0.242	0.196	23.2	0.205	0.205	0.01
2018	0.234			0.205		

Source: SER.
Note: No changes for category 3D (Crop production and agricultural soils)

Table 316: Recalculation of $PM_{2.5}$ emissions for category 3B (Manure management) (Gg)

	3B		Impact of recalculation	3D		Impact of recalculation
Year	New	Old	%	New	Old	%
1990	0.049	0.049	-0.2	0.008	0.008	0
1991	0.049	0.049	-0.2	0.008	0.008	0
1992	0.046	0.046	-0.2	0.008	0.008	0
1993	0.046	0.046	-0.2	0.008	0.008	0
1994	0.045	0.045	-0.2	0.008	0.008	0
1995	0.046	0.046	-0.2	0.008	0.008	0
1996	0.047	0.047	-0.3	0.008	0.008	-0.81
1997	0.045	0.045	-0.2	0.008	0.008	-0.79
1998	0.045	0.045	-0.3	0.008	0.008	-0.71
1999	0.044	0.045	-0.3	0.008	0.008	-0.72
2000	0.044	0.044	-0.2	0.008	0.008	-0.50
2001	0.044	0.044	-0.2	0.008	0.008	-0.54
2002	0.042	0.042	-0.2	0.008	0.008	-0.46
2003	0.041	0.041	-0.1	0.008	0.008	-0.46
2004	0.040	0.040	0.1	0.008	0.008	-0.37
2005	0.040	0.040	0.0	0.008	0.008	-1.04
2006	0.040	0.039	0.1	0.008	0.008	-0.96
2007	0.041	0.041	0.0	0.008	0.008	-0.84
2008	0.042	0.042	0.1	0.008	0.008	-0.98
2009	0.042	0.042	0.1	0.008	0.008	-0.79
2010	0.043	0.043	-0.3	0.008	0.008	-0.48
2011	0.041	0.041	-0.2	0.008	0.008	-0.41
2012	0.041	0.041	-0.1	0.008	0.008	-0.23
2013	0.042	0.042	0.0	0.008	0.008	-0.19
2014	0.043	0.043	0.0	0.008	0.008	-0.29
2015	0.043	0.043	0.0	0.008	0.008	-0.17
2016	0.044	0.044	0.0	0.008	0.008	-0.22
2017	0.045	0.045	0.0	0.008	0.008	0.01
2018	0.044			0.008		

Source: SER.
Note: No changes for category 3D (Crop production and agricultural soils).

Table 317: Recalculation of PM_{10} emissions for category 3B (Manure management) (Gg)

Year	3B New	3B Old	Impact of recalculation %	3D New	3D Old	Impact of recalculation %
1990	0.084	0.082	2.6	0.197	0.197	0
1991	0.083	0.081	2.1	0.196	0.196	0
1992	0.079	0.077	2.6	0.196	0.196	0
1993	0.079	0.077	3.0	0.198	0.198	0
1994	0.078	0.076	2.5	0.198	0.198	0
1995	0.079	0.077	2.7	0.198	0.198	0
1996	0.080	0.078	2.6	0.196	0.197	-0.81
1997	0.079	0.076	3.1	0.196	0.198	-0.79
1998	0.078	0.076	3.1	0.197	0.198	-0.71
1999	0.078	0.075	3.4	0.197	0.199	-0.72
2000	0.076	0.074	3.4	0.198	0.199	-0.50
2001	0.077	0.074	3.4	0.199	0.200	-0.54
2002	0.074	0.072	3.6	0.199	0.200	-0.46
2003	0.073	0.070	4.2	0.199	0.200	-0.46
2004	0.073	0.069	5.6	0.199	0.200	-0.37
2005	0.074	0.070	5.9	0.199	0.201	-1.04
2006	0.072	0.069	5.6	0.199	0.201	-0.96
2007	0.075	0.071	5.4	0.202	0.204	-0.84
2008	0.076	0.072	5.5	0.201	0.203	-0.98
2009	0.077	0.073	5.4	0.202	0.204	-0.79
2010	0.076	0.073	4.3	0.204	0.205	-0.48
2011	0.076	0.072	4.9	0.204	0.205	-0.41
2012	0.075	0.071	5.5	0.205	0.205	-0.23
2013	0.077	0.073	5.3	0.204	0.204	-0.19
2014	0.079	0.075	5.3	0.204	0.204	-0.29
2015	0.080	0.076	5.7	0.205	0.205	-0.17
2016	0.081	0.077	5.7	0.203	0.204	-0.22
2017	0.083	0.078	6.0	0.205	0.205	0.01
2018	0.081			0.205		

Source: SER.
Note: No changes for category 3D (Crop production and agricultural soils)

8.2 *Planned improvements*

Table 318 presents the improvements which are planned for the next submission.

Table 318 – Planned improvements for the next submission

Source category	Planned improvements	Type of revision
1A1a - Public Electricity and Heat Production	Incorporate plant specific activity and emission data for two medium combustion plants (wood & wood wastes)	Update EFs / methodology

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	Add secondary copper production point source	Update AD
1A2d	For the years 1990-1999, the notation key will be changed from NO to IE	Notation key correction
1A2d	Align Tier 1 and Tier 2 default EFs from EMEP/EEA Guidebook 2009 to EMEP/EEA Guidebook 2016.	Update EFs
1A3ai(i)	Analyse LTO data per aircraft type from Eurostat for Luxembourg in order to upgrade the current Tier 1 methodology to Tier 2.	Update methodology
1A3b i-v, 1A3c, 1A3d	In order to improve transparency, values for biomass activity data will be provided instead of the notation key IE.	Notation key
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
2H2	Beer: collect beer production data for 2005-2018 from the Customs Administration, if available	Update AD
3B/3D	Updating the manure management systems using more recent data	Update AD
3B/3D	Implementing the 2019 guidelines for the N-emissions	Update methodology
3D	Investigate for alternative data sources on the area cultivated by Luxemburgish farmers	Update AD
3D	Investigate for use of pesticides for estimating HCB emissions	

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

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)

> § 47. Every four years from 2017 onward, Parties shall report for the year x-2 updated aggregated sectoral (GNFR) gridded emissions and LPS emissions as defined in paragraphs 7, 9 and 14 and table 1 of these Guidelines. Gridded emissions in a grid of 0.1 x 0.1 degrees shall be reported for all substances referred to in paragraph 7 of these Guidelines. As an alternative, a Party may report gridded emissions in a grid of approximately 50 x 50 km² until it is technically and economically feasible to switch to a grid of 0.1 x 0.1 degrees. LPS emissions shall be reported for all substances referred to in table 1 of these Guidelines, taking into account the defined release thresholds. Parties are encouraged to update their gridded and LPS data and report annually where changes in spatial patterns have occurred, so that the EMEP models can represent the most up-to-date information.
>
> § 48. Gridded emissions for each GNFR aggregated sector (as defined in annex V to these Guidelines) shall be provided for the EMEP latitude-longitude coordinate resolution (as defined in paragraph 14 to these Guidelines) that overlie the Party's territory. As an alternative, a Party may report gridded emissions in a grid of approximately 50 x 50 km² until it is technically and economically feasible to switch to a grid of 0.1 x 0.1 degrees.

Gridded emissions are published on the following website

- Gridded emissions:
  http://cdr.eionet.europa.eu/lu/eu/nec_revised/gridded/
- Large point sources:
  http://cdr.eionet.europa.eu/lu/eu/nec_revised/lps/

11 ADJUSTMENTS

11.1 *Introduction*

Luxembourg signed and ratified the 1999 Protocol to Abate Acidification, Eutrophication and Ground-level ozone (Gothenburg Protocol) and committed itself to reduce its emissions for the four pollutants responsible for acidification, eutrophication and ground level ozone pollution (sulphur dioxide (SO_2), nitrogen oxides (NO_x), volatile organic compounds (VOC) and ammonia (NH_3)) to the agreed emission ceilings by 2010 based on fuel used and to respect these ceilings from 2010 onwards. Emission estimates are yearly reported according the recommendations of the Guidelines for Estimating and Reporting Emissions Data under CLRTAP (ECE/EB.AIR/97), revised in 2009 and in 2013 (ECE/EB.AIR/125)[89].

In the case of Luxembourg, *Directive 2001/81/EC of the European Parliament and the Council on National Emission Ceilings for certain pollutants* sets the same ceilings for the four above mentioned pollutants not to be exceeded from 2010 onwards.[90] Furthermore, *Directive 2016/2284 of the European Parliament and the Council on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC*[91] (NECD) sets new reduction targets for 2020 and 2030. Although article 21(1) repealed Directive 2001/81/EC with effect from 1st July 2018, articles 1 (Object) and 4 (National emission ceilings) and Annex I of Directive 2001/81/EC shall continue to apply until 31 December 2019, i.e. the absolute emission ceilings not to be exceeded from 2010 onwards remain in place until 2020, when they will be replaced by the new relative emission ceilings as set out in article 4 and Annex II of Directive 2016/2284. In addition, article 21(2) of Directive 2016/2284 sets out, until 31 December 2019, the possibility for Member States to apply article 5(1) of this Directive in relation to the ceilings under Article 4 of and Annex I to Directive 2001/81/EC.

Figure 11-1 summarizes the emission totals, based on fuel used for compliance under the NECD and the Gothenburg Protocol emission ceilings. Luxembourg exceeds its national emissions ceiling for NOx by 38% in 2010. The estimates for 2018 give an exceedance of 14%. For NMVOC, the emission ceiling is exceeded by 12% in 2010 and in 2018 by 10%. The emission ceilings for the other pollutants were met in 2010 or earlier.

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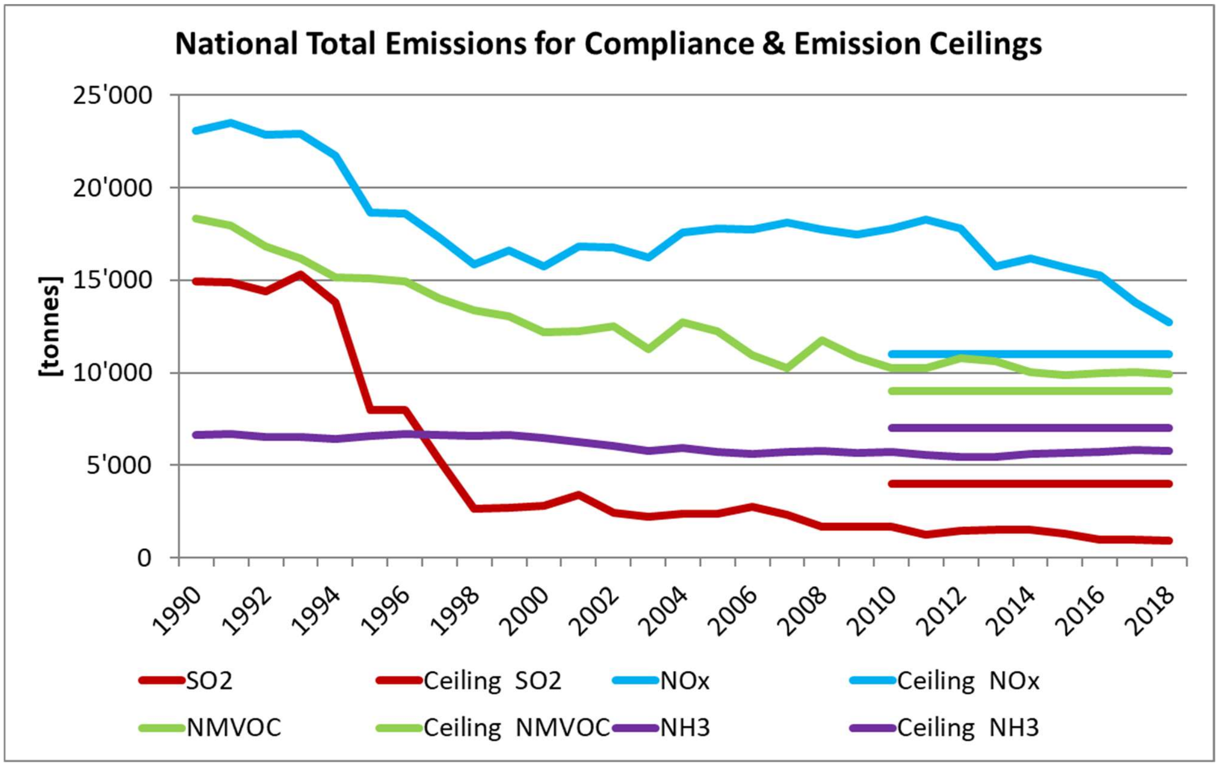
89 http://www.unece.org/fileadmin/DAM/env/documents/2013/air/eb/ece.eb.air.125_E_ODS.pdf

90 http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1429211483658&uri=CELEX:32001L0081

91 http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2016.344.01.0001.01.ENG

Figure 11-1 – National Total Emissions (fuel used, excluding adjustments) and Emission Ceilings



The limits set for Luxembourg not to be exceeded since 2010 are:

- NO_X : 11 Gg
- NMVOC : 9 Gg
- SO_2 : 4 Gg
- NH_3 : 7 Gg

The non-compliance for both NOx and NMVOC emissions up to 2018 are due to changes in the emission inventory, not foreseen at the time the emission ceilings were set. These changes include the partial failure of certain EURO vehicle emission standards, especially for diesel vehicles, as well as the inclusion of new source categories (NOx and NMVOC from manure management and agricultural soils).

Based on EB decision 2012/4[92] allowing the provisional application of article 3, paragraph 11 quinquies of the amended Gothenburg Protocol and on article 21(2) of Directive 2016/2284 setting out the possibility for Member States to apply article 5(1) of this Directive in relation to the ceilings under

[92] Decision 2012/4: Provisional Application of Amendment to the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone.
http://www.unece.org/fileadmin/DAM/env/documents/2013/air/ECE_EB.AIR_111_Add.1__ENG_DECISION_4.pdf

Article 4 of and Annex I to Directive 2001/81/EC, Luxembourg applies for making use of the adjustment procedure as described in Decision 2012/3[93] and according the Guidance in the consolidated version of the adapted Decision 2012/12[94] and additional Guidance[95] for its emission inventory for NOx for 2010 to 2018 and NMVOC for 2010 to 2018 in order to prove its compliance with the emission ceilings as set out in Directive 2001/80/EC and the Gothenburg Protocol ceilings.

For NOx, the adjustment application to the emission inventory is the result of two (aggregated) adjustments, both of them in accordance with one of the circumstances as described in Decision 2012/12, article 6:

1. Road transport (1A3bi-iv): Significant change in emission factors (article 6(b))
2. Agriculture (3B1a to 3B1h and 3Da1 to 3Da4): new source categories (article 6(a))

For NMVOC, the adjustment application to the emission inventory is due to the inclusion of the emissions from agricultural soils and manure management, two source categories that were not taken into account at the time the emission ceilings were set, and therefore in accordance with circumstance a) in Decision 2012/12:

Agriculture (3B1a to 3B1h and 3De): new source categories (article 6(a)).

This report describes the different adjustment applications in detail. Compared to the adjustment application introduced in 2016, this application includes no new application per se[96], but reintroduces the applications for adjustment for NOx and NMVOC for the above-mentioned categories due to the fact that certain revisions have been done to the certain activity data, emission factors and background parameters.

Table 319 summarizes the individual adjustments as well as the adjusted national total emissions. For compliance purposes, Luxembourg is allowed to use national total emissions based on fuel used.[97] With application of the adjustments, Luxembourg would be in compliance with its Gothenburg Protocol emission ceilings from 2013 onwards for NOx and from 2010 to 2018 for NMVOC.

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93 Decision 2012/3: Adjustments under the Gothenburg Protocol to emission reduction commitments or to inventories for the purposes of comparing total national emissions with them. http://www.unece.org/fileadmin/DAM/env/documents/2013/air/ECE_EB.AIR_111_Add.1__ENG_DECISION_3.pdf

94 Decision 2012/12: Guidance for adjustments under the 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone to emission reduction commitments or to inventories for the purposes of comparing total national emissions with them. URL: http://www.unece.org/fileadmin/DAM/env/documents/2012/EB/Decision_2012_12.pdf

95 Chris Dore (TFEIP Co-Chair), Yvonne Pang (UK), Leon Ntziachristos (Greece) Morten Winther (Denmark): Guidance on the Adjustments Process for Parties and Expert Reviewers, TFEIP/11K14/CD, draft version4, November2014.

96 Both adjustments for Road Transport (NOx) and Agriculture (NOx, NMVOC) have been recommended for approval in 2016: http://www.unece.org/fileadmin/DAM/env/documents/2016/AIR/EMEP/ECE_EB.AIR_GE.1_2016_10_E.pdf

97 Decision 2013/4 - Reporting of emissions and projections data under the Convention and its protocols in force: http://www.unece.org/fileadmin/DAM/env/documents/2013/air/eb/2013_4.pdf

Table 319 – Total Emissions and adjustments for NOx and NMVOC

NOx [kt]	2010	2011	2012	2013	2014	2015	2016	2017	2018	Gothenburg Emission ceiling 2010
National Total (fuel used)	17.795	18.288	17.771	15.737	16.186	15.708	15.266	13.785	12.746	11
Adjustment Road transport (1A3b)	-5.002	-5.288	-5.490	-5.582	-5.548	-5.387	-4.881	-4.167	-3.590	
Adjustment Agriculture - Manure Management (3B)	-0.084	-0.081	-0.078	-0.080	-0.082	-0.083	-0.083	-0.085	-0.083	
Adjustment Agriculture - Agricultural Soils (3D)	-1.055	-1.062	-1.050	-1.039	-1.031	-1.026	-1.076	-1.073	-1.046	
Adjusted national total for compliance	11.655	11.857	11.153	9.035	9.524	9.212	9.226	8.461	8.027	
NMVOC [kt]	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Gothenburg Emission ceiling 2010**
National Total (fuel used)	10.262	10.234	10.770	10.615	10.039	9.849	9.994	10.045	9.945	9
Adjustment Agriculture - Manure Management (3B)	-3.016	-2.904	-2.831	-2.913	-3.016	-3.085	-3.129	-3.176	-3.149	
Adjustment Agriculture - Agricultural Soils (3D)	-0.112	-0.112	-0.113	-0.112	-0.112	-0.113	-0.112	-0.113	-0.113	
Adjusted national total for compliance	7.133	7.218	7.827	7.590	6.911	6.652	6.753	6.756	6.682	

11.2 *Road Transportation (1A3b)*

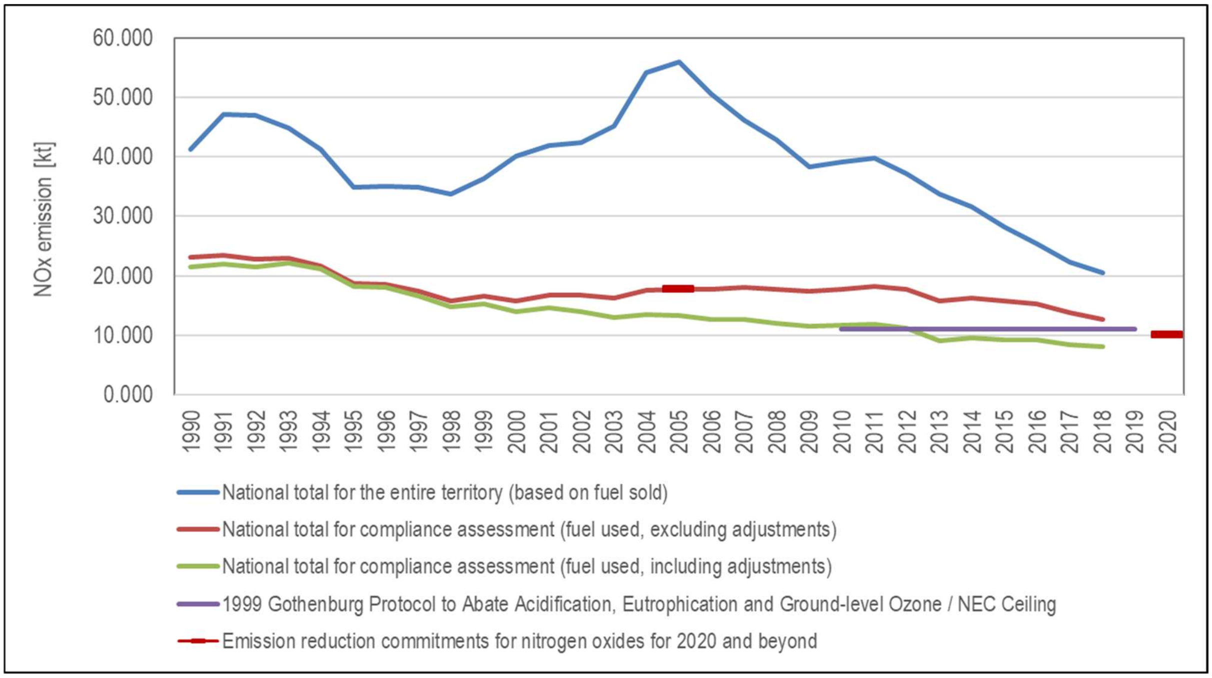
Please note that the adjustment for NO_X from road transportation (1A3b) has already been approved in 2015 to 2018 and 2019. However, since some changes in activity data and emission factors have been done in submission 2020, this chapter has been updated accordingly. Please also consider more background information on the methodology in the chapter on road transportation.

Background of the definition of Gothenburg Protocol and NECD targets were model calculations with the RAINS model[98] of the International Institute for Applied Systems Analysis in Laxenburg (IIASA)[99], which were based on the state of knowledge at the end of the 1990ies.[100] Concerning trend of vehicle specific emissions it was assumed that the emission levels will be reduced by the same ratio as the emission limits in the vehicle type approval. However, in the meantime it was found that the reductions in vehicle specific NO_X emissions in real world driving are much smaller than it was expected at the time when the targets were established, e.g. *Weiss M. et al. (2011), Bach C.& Lienin S. (2007), Lambrecht U. et al (2007)*. This has been shown especially for diesel passenger cars (PC) and light commercial vehicles (LCV) certified according to the emission standards EURO 2 to EURO 6[101] as well as for heavy duty vehicles (HDV) certified from EURO II to EURO V[102].

With respect to NO_X emissions, both the NECD and Gothenburg Protocol commitments have not been reached by Luxembourg yet[103]. Emissions from road transportation were responsible for about 58.4% of total NO_x emissions based on fuel sold and for about 38.3% of total NOx emissions based on fuel used in 2018. However, compliance should be established from the year 2013 onwards, depending on the status of the proposed adjustments. If these are accepted, Luxembourg's total NO_X emission will be below the ceilings for both regulations from the year 2013 onwards (Figure 11-2, green line).

[98] http://www.iiasa.ac.at/web/home/about/achievments/scientificachievementsandpolicyimpact/cleaningeuropeair/The-RAINS-Model.en.html
[99] http://www.iiasa.ac.at/
[100] For more detailed information see: Interim Reports to the European Commission for the Directive on National Emission Ceilings and the EU Ozone Strategy (http://www.iiasa.ac.at/~rains/interim_reports.html)
[101] European exhaust emissions regulations for passenger cars and light vehicles
[102] European exhaust emissions regulations for heavy vehicles
[103] www.unece.org/fileadmin/DAM/env/documents/2013/air/eb/2013_16.pdf

Figure 11-2 – NO_x Emissions including adjustment for Road Transportation only



According to ECE/EB.AIR/111/Add.1[104] Parties may apply to adjust their inventory data or emission reduction commitments if they are (or expect to be) in non-compliance with their emission reduction targets. However, in making an adjustment application, they must demonstrate that extraordinary circumstances have given rise to revisions to their emission estimates. These extraordinary circumstances fall into three broad categories:

a) Emission source categories are identified that were not accounted for at the time when the emission reduction commitments were set; or

b) For a particular source, the emission factors used to estimate emissions for the year in which emissions reduction commitments are to be attained are significantly different to those used when the emission reduction commitments were set; or

c) The methodologies used for determining emissions from specific source categories have undergone significant changes between the time when emission reduction commitments were set and the year they are to be attained.

[104] Decision 2012/3 Adjustments under the Gothenburg Protocol to emission reduction commitments or to inventories for the purposes of comparing total national emissions with them
www.ceip.at/fileadmin/inhalte/emep/Adjustments/ECE_EB.AIR_111_Add.1__ENG_DECISION_3.pdf

With respect to road transport, such an unexpected effect was the partial failure of several so-called "EURO norms"[105] set on the EU level to reduce emissions from road vehicles.

Luxembourg commissioned the study 'Assessment of transport emissions in Luxembourg based on emission factors from HBEFA1.2 and HBEFA4.1', prepared by TU Graz[106] where the amount of additional emissions is determined, which is caused by these higher emission factors compared to the data which the NECD/Gothenburg Protocol limits are based on. For this exercise emission factors have been taken from two different versions of the "Handbook emission factors for road transport" (HBEFA)[107]:

- HBEFA version 1.2[108] (released in January 1999) which was the basis for the definition of the NEC limits, and
- HBEFA version 4.1[109] (released in November 2019) which is the latest reference database including all available in-use emission tests and recent forecasts for upcoming vehicle technology.

The calculations were done in both scenarios with up-to-date data on vehicle mileage and fleet composition for Luxembourg. The allocation of vehicles year of first registration to EURO classes was done in the HBEFA 1.2 scenario based on original assumptions whereas in the HBEFA 4.1 scenario the latest available data as used in the Luxemburg national emission inventory has been used. For the year 2018, the following NO_X emissions have been determined:

	HBEFA 4.1	HBEFA 1.2	Difference (4.1-1.2)
Total transport (fuel sold, incl. non-road machinery, excl. aviation)	14.22 Gg	8.36 Gg	+ 5.87 Gg
Inland transport (fuel used, incl. non-road machinery, excl. aviation)	6.50 Gg	2.91 Gg	+ 3.59 Gg

The calculated additional emissions can be directly attributed to the European emission legislation and its test procedures, which cover vehicle operation in real world conditions very weakly. These emissions were not foreseeable at the time of definition of NECD/Gothenburg Protocol targets and could not be influenced by any national measures in Luxembourg.

[105] European exhaust emissions regulations

[106] Schwingshackl, Michael; Rexeis, Martin; Hausberger, Stefan (2020): Assessment of transport emissions in Luxembourg based on emission factors from HBEFA1.2 and HBEFA4.1 – year 2018. Institute for Internal Combustion Engines and Thermodynamics, TU Graz. Report No.: I-04/20 Schwi Em-20/01/679.

[107] http://www.hbefa.net/e/index.html

[108] www.hbefa.net/e/documents/HBEFA12DOKU.pdf

[109] https://www.hbefa.net/e/documents/HBEFA41_Development_Report.pdf

11.2.1 **Scope of the study**

The study determines the amount of additional emissions, which is caused by these higher emission factors compared to the data which the NECD/Gothenburg Protocol limits are based on. The calculations were done with up-to-date data on vehicle mileage and fleet composition for Luxembourg. The calculated additional emissions can be directly attributed to the European emission legislation and its test procedures, which cover vehicle operation in real world conditions very weakly. These emissions were not foreseeable at the time of definition of NECD/Gothenburg Protocol targets and could not be influenced by any national measures in Luxembourg.

11.2.2 **Methodology**

Starting point of the comparison is traffic and fleet data from the latest version of the Luxembourgian national emission inventory 1990-2018 (*Molitor M., Schwingshackl M., et al., 2020*) and data from the forecast scenario "BAU"[110] (*Molitor M., Schwingshackl M. et al, 2020*) until the year 2035.

For the comparison the Luxembourgian national transport emissions have been calculated for each year in the time period from 1990 to 2035 based on data from two different versions of the "Handbook emission factors for road transport" (HBEFA)[111]:

- HBEFA version 1.2 (released in January 1999) which was the basis for the definition of the NECD/Gothenburg Protocol limits, and
- HBEFA version 4.1 (released in November 2019) which is the latest reference database including all available in-use emission tests and up-to-date forecasts for upcoming vehicle technology.

For both considered HBEFA versions the emission factors have been imported into the model NEMO, which is the standard model used for modelling of road transport emissions in the Luxemburg national emission inventory.

The section below gives a short description of the model NEMO.

11.2.2.1 **The model NEMO**

The model NEMO (Network Emission Model) was developed at the Institute for Internal Combustion Engines and Thermodynamics (IVT)[112] at the Graz University of Technology (TUG) as tool for

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110 Business-As-Usual (BAU)

111 The HBEFA is the main data source for emission factors from road transport in Europe. Most other common used emission models (e.g. COPERT) are also based on HBEFA data.

112 http://portal.tugraz.at/portal/page/portal/TU_Graz/Einrichtungen/Institute/oe_123

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[113] and to air quality modelling is available.

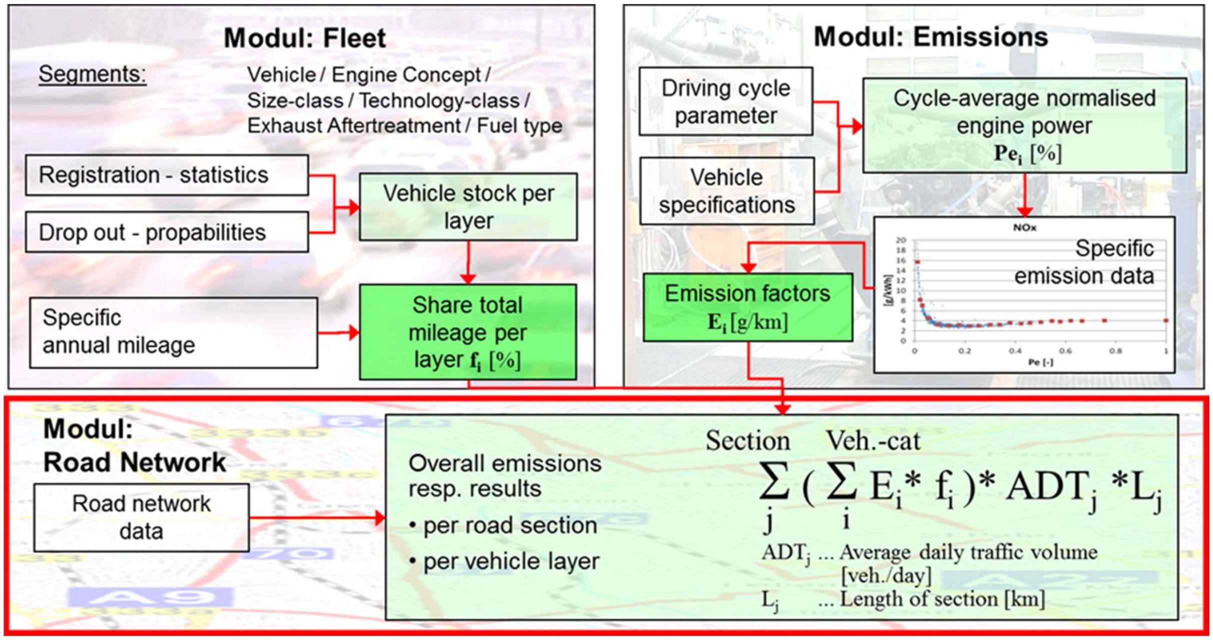
NEMO combines both detailed calculation of the vehicle fleet composition and simulation of emission factors on a vehicle level. NEMO calculates the percentages of different vehicle layers on the overall traffic volume as a function of year and considered road type based on data on vehicle stock, composition 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. NEMO is updated regularly according to recent data on emission behaviour and vehicle technologies. 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.

[113] Information- and forecasting system for private and public transport VISUM: Comprehensive software for advanced transportation planning; http://irdata.sk/en/ptv-softver-2/

Figure 11-3 – Schematic picture of the model NEMO



NEMO calculates the emissions for all regulated pollutants (NO_X, THC[114], 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[115] and C_6H_6 are calculated with an approach similar to the HBEFA 4.1 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 4.1)
- Influence of mileage and maintenance on the pollutant emission levels (method and data compatible to the HBEFA 4.1)
- Calibration of fuel consumption based on statistics of g/km CO2 of new registered vehicles in the NEDC type approval and literature on the discrepancies between NEDC and real-world CO_2 reduction rates [HBEFA4.1]
- Evaporation from gasoline emissions (data and approach compatible to the HBEFA 4.1)
- Ambient temperature influence on NOx emission of Diesel passenger cars and LCV (method and data compatible to the HBEFA 4.1)

[114] THC - total hydrocarbon
[115] NMHC - non-methane hydrocarbons

- 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 4.1)

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 based on the values published in *Schmidt W., Düring I., Lohmeyer A., (2011)* and *B. Notter, M. Keller, B. Cox., (2019).*

Furthermore, the model GEORG[116], e.g. *Schwingshackl M., Hausberger S. (2012)* – which is also part of the methodology for the Luxembourg transport emission inventory – has been applied in the current study for calculation of energy consumption and the emissions of the non-road machinery.

In both scenarios considered in this study (“HBEFA 1.2” and “HBEFA 4.1”) the emissions from non-road machinery were calculated according to the latest emission inventory (i.e. similar numbers for non-road emissions are used in both scenarios).

11.2.2.2 **Inventory 2019**

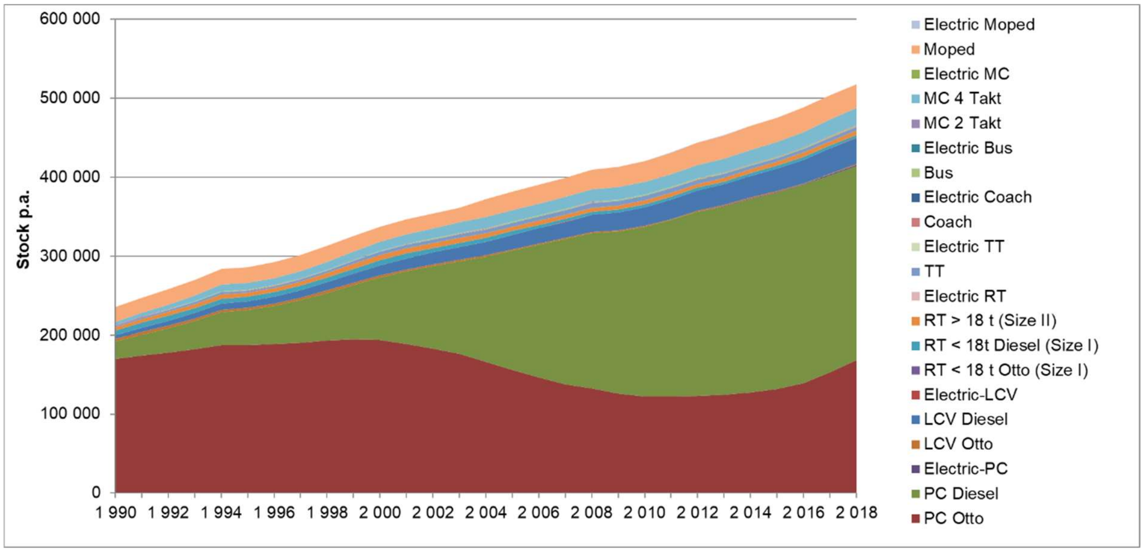
The Inventory 2019 includes a full update e.g. of the stock and activity data for 1990 to 2018. This chapter will give a short overview of the basic input parameter for NEMO. All details can be found in *Molitor M., Schwingshackl M., et al., (2020)*.

11.2.2.2.1 Vehicle Stock:

Figure 4 shows the trend of the Luxembourg vehicle fleet from 1990 to 2018. The increase in the share of diesel passenger cars from around 2000 onwards is due to lower diesel prices combined with lower fuel consumption of these vehicles. The total road vehicle fleet in 1990 was 235 868 vehicles and will grow to 517 633 vehicles by 2018.

[116] GEORG - Grazer Emissionsmodell für Off Road Geräte

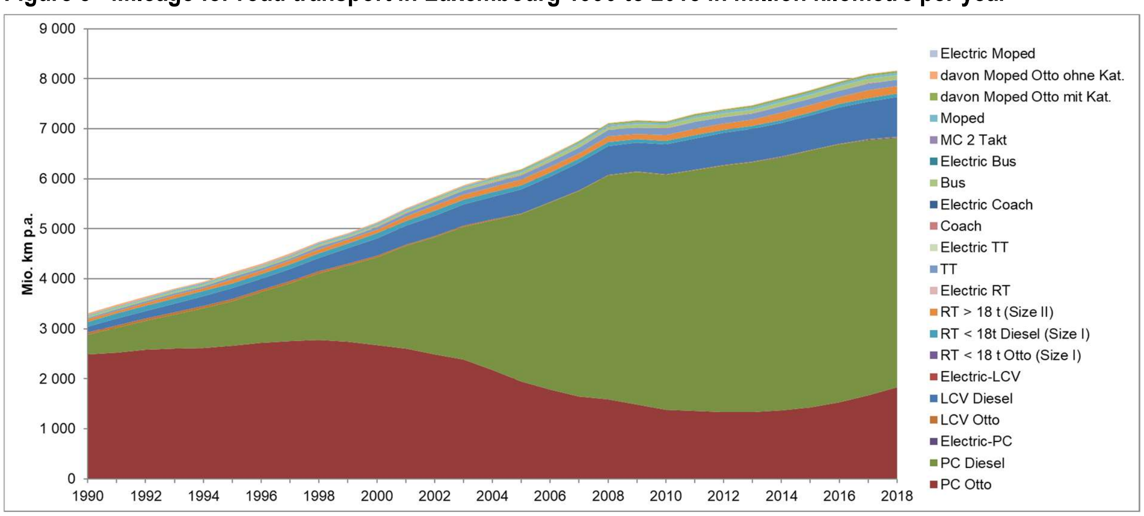
Figure 4 - Total vehicle stock in Luxembourg from 1990 to 2018



11.2.2.2.2 Mileage:

Figure 5 shows the development of domestic mileage in Luxembourg's road transport from 1990 to 2018, with passenger cars accounting for approximately 84% of domestic mileage in 2018. The increase in the share of diesel passenger cars from about 2000 onwards correlates with the development of the stock shares. The total mileage of road transport in 1990 amounts to 3,286 million vehicle kilometres and increases to 8,160 million vehicle kilometres by 2018.

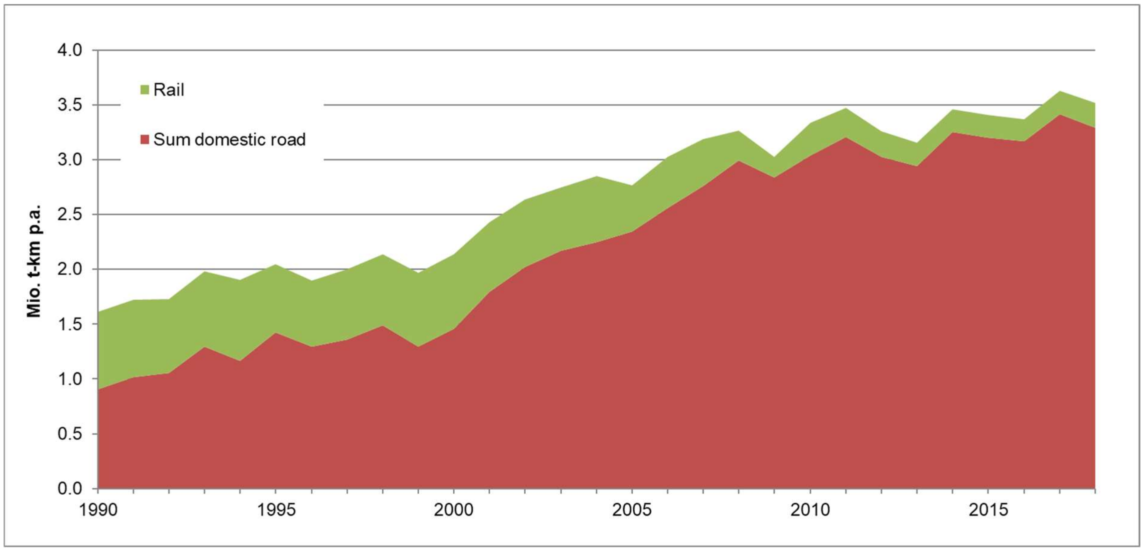
Figure 5 - Mileage for road transport in Luxembourg 1990 to 2018 in million kilometre per year



11.2.2.2.3 Freight transport performance:

Figure 6 shows the development of domestic freight transport performance (excluding flights) for Luxembourg from 1990 to 2018, which, due to the sharp reduction in rail transport performance, will be composed of 95% road transport and 5% rail transport in 2018. The total domestic freight transport performance increased from 1,611 million tkm in 1990 to 3,516 million tkm in 2018.

Figure 6 - Development of the inland freight transport performance in Luxembourg from 1990 to 2018 in million tkm per year



The calculations with NEMO including the activity data update and the implementation of HBEFA4.1 lead to the following **conclusions** for the Inventory 2019:

With regard to the calculated development of traffic and activity data, these are

- The growth in domestic car mileage since 2012 has slowed down compared to the population growth since 2012. The car fleet has grown faster than the population, which has increased the level of motorization. The specific mileage of passenger cars has continued to fall, as in previous years.
- Since 2012, the number of LCV vehicles in service and the associated mileage have grown much faster than the number of cars and their mileage.
- Due to the adjustment of the distance matrix and the modal shift towards more passengers, especially on commuting to work, it can be seen that the growth of cross-border commuters and the growth of mileage are diverging. This can be taken as an indication that the political measures to reduce car traffic on the way to work are beginning to have an effect.
- The number of holiday trips made by the Luxembourg population has increased, which has led to an increase in the proportion of kilometres travelled by Luxembourgers in connection with domestic and foreign holidays.
- Domestic road freight transport is dominated by international source and destination transport to and from Luxembourg and transit transport. Domestic transport accounts for only about a quarter of Luxembourg's road freight transport. However, the quality and reliability of the available data on international transport is limited due to the incomplete nature of transport statistics and some uncertainties in counting point data.

The following conclusions can be drawn with regard to energy consumption and fuel exports in vehicle tanks:

- Compared to the Inventory 2018 (1990 – 2017), domestic transport shows an increase in energy consumption [GWh] from 1990 to 2017 of 2.3% on average.

- In 2017 about 2.088 million tonnes of fuel were sold in Luxembourg. Of this, about 1.437 million tonnes, or about 68.8 %, were again exported in vehicle tanks.
- Of the exported fuel, approximately 962 kt or 66.9 % is caused by HDV. Conversely, this means that 475 kt or 33.1 % of the exported fuel was exported by car.

With regard to emissions from the transport sector, the following key points can be made:

- Total NOx emissions have increased from 26.7 kt in 1990 to a peak of 47.2 kt in 2005 and then decreased again to 14.2 kt in 2018. The share of NOx emissions emitted by domestic transport was about 45.7% in 2018. From the exported fuel, approximately 4.1 kt NOx is emitted by HDV and 3.6 kt NOx by passenger cars.
- Particulate emissions from transport (PM10, exhaust) have been decreasing since 2004 and reach around 158 tonnes in 2018; the domestic share is 56.1%.

11.2.3 **Implementation of HBEFA4.1 in NEMO**

In the work of *M. Schwingshackl, M. Rexeis (2019)* the method and emission factors of HBEFA 4.1 have been implemented in the dataset of Luxemburg.[117] This chapter will give a short overview of the main updates due to the adaptations of NEMO for HBEFA4.1, while the following chapter compares the emission factors of HBEFA version 1.2 and 4.1 in detail.

The main innovations of HBEFA4.1 which are implemented in NEMO are:

- Update of emission factors for "hot" operation conditions
    - New and more measurements
    - New version of emission model PHEM
- New traffic situations and driving cycles
    - New Heavy Stop&go traffic situation
    - Higher dynamic parameter for the driving cycles (in PHEM)
- Real energy consumption
    - Real energy consumption factors are in NEMO compatible with HBEFA4.1
    - The CO_2 calibration method of HBEFA4.1, is based on the already existed method in NEMO
- Alternative propulsion concepts
    - PHEV, BEV for passenger cars and LCV as well as CNG busses are implemented in NEMO and are compatible with HBEFA4.1
- Actualisation of emission factors
    - Updated cold start emission factors
    - Updated evaporation emission factors
    - Updated emission factors of non-regulated pollutants like e.g. HC, NO_2, N_2O, NH_3, non-exhaust particular matter
- Better fleet segmentation
    - Implementation of 3 size classes for LCV

[117] This work is also fully documented in the report for the Inventory 2019 **Error! Reference source not found.**.

    - Implementation of 2 size classes for motorcycles
- Software Updates
    - Includes the effects of the software updates according to "diesel gate"
- Ambient temperature effects
    - Update of the correction factors of NOx emissions for different ambient temperatures for passenger cars
    - Implementing correction factors of NOx emissions for different ambient temperatures for LCV
- Actualisation of vehicle data
    - Update of: Vehicle weights, Loads, power, driving resistances

11.2.4 **Emission factors**

This section gives a comparison of emission factors of the HBEFA versions 1.2 and 4.1 and describes how the model NEMO was parameterised to represent these two datasets.

11.2.4.1 **Passenger cars**

Table 320 and Table 321 give an overview on the Otto and Diesel passenger car emission standards covered in the two HBEFA versions and the associated introduction dates for new registrations. HBEFA1.2 includes emission measurements until EURO 1 (both for Ot-to and Diesel cars) and gives a prognosis for emission levels of passenger cars until EU-RO 4. HBEFA version 4.1 additionally includes measurements on cars certified from EURO 2 to EURO 6d-temp and a prognosis on the emission behaviour for EURO 6d technology.

Table 320 – Otto passenger car emission data in HBEFA 1.2 and HBEFA 4.1

emission standard	HBEFA1.2			HBEFA4.1		
	emission data	new registrations		emission data	new registrations	
		from	until		from	until
pre EURO 1	**meas.**	until	1993	**meas.**	until	1992
EURO 1	**meas.**	1994	1995	**meas.**	1993	1999
EURO 2	progn.	1996	1999	**meas.**	1995	2002
EURO 3	progn.	2000	2004	**meas.**	1999	2006
EURO 4	progn.	2005	and after	**meas.**	2003	2010
EURO 5	n.a.			**meas.**	2009	2015
EURO 6	n.a.			**meas.**	2013	2018
EURO 6c	n.a.			**meas.**	2017	2019
EURO 6d_temp	n.a.			**meas.**	2018	2021
EURO 6d	n.a.			progn.	2019	and after

Table 321 – Diesel passenger car emission data in HBEFA 1.2 and HBEFA 4.1

emission standard	HBEFA1.2			HBEFA4.1		
	emission data	new registrations from	new registrations until	emission data	new registrations from	new registrations until
pre EURO 1	**meas.**	until	1993	**meas.**	until	1992
EURO 1	**meas.**	1994	1995	**meas.**	1993	1999
EURO 2	progn.	1996	1999	**meas.**	1995	2002
EURO 3	progn.	2000	2004	**meas.**	1999	2006
EURO 4	progn.	2005	and after	**meas.**	2003	2010
EURO 5	n.a.			**meas.**	2009	2015
EURO 6a/b	n.a.			**meas.**	2013	2019
EURO 6c	n.a.			**meas.**	2017	2019
EURO 6d_temp	n.a.			**meas.**	2018	2021
EURO 6d	n.a.			progn.	2020	and after

Table 322 shows the details on allocation of Diesel passenger car first registration dates to EURO classes. Otto passenger cars have only marginal differences in HBEFA4.1. In the HBEFA 1.2 scenario, the original assumptions from in 1999 have been used without any modification whereas in the HBEFA 4.1 scenario actual data as used in the Luxemburg national emission inventory was applied. The HBEFA 4.1 scenario also makes use of the NEMO feature to split the first registrations of a certain year between two or more emission standards.[118]

[118] Reasons for splitting are: market entry in reality earlier (due to availability) or later (due to imports of used vehicles or registrations for a short time for selling the vehicles later; HDV chassis with finishing the truck type mounting later than the deadline for first registration) than the due date of an emission standard; For HBEFA 1.2 this information was not available.

Table 322 – Allocation of Diesel passenger car first registration years to EURO classes in the scenarios HBEFA 1.2 and HBEFA 4.1

	HBEFA1.2					HBEFA4.1										
	EURO 1	EURO 2	EURO 3	EURO 4a	EURO 4b	EURO 1	EURO 2	EURO 3	EURO 4a	EURO 4b	EURO 5	EURO 6a/b	EURO 6c	EURO 6d_temp	EURO 6d	EURO 6 PHEV
1993	0	0	0	0	0	1,00	0	0	0	0	0	0	0	0	0	0
1994	1,00	0	0	0	0	1,00	0	0	0	0	0	0	0	0	0	0
1995	1,00	0	0	0	0	0,99	0,01	0	0	0	0	0	0	0	0	0
1996	0	1,00	0	0	0	0,44	0,56	0	0	0	0	0	0	0	0	0
1997	0	1,00	0	0	0	0,22	0,78	0	0	0	0	0	0	0	0	0
1998	0	1,00	0	0	0	0,13	0,87	0	0	0	0	0	0	0	0	0
1999	0	1,00	0	0	0	0,01	0,97	0,02	0	0	0	0	0	0	0	0
2000	0	0	1,00	0	0	0	0,61	0,39	0	0	0	0	0	0	0	0
2001	0	0	1,00	0	0	0	0,11	0,89	0	0	0	0	0	0	0	0
2002	0	0	1,00	0	0	0	0,02	0,98	0	0	0	0	0	0	0	0
2003	0	0	1,00	0	0	0	0	0,97	0,03	0	0	0	0	0	0	0
2004	0	0	1,00	0	0	0	0	0,50	0,50	0	0	0	0	0	0	0
2005	0	0	0	0	1,00	0	0	0,11	0,89	0	0	0	0	0	0	0
2006	0	0	0	0	1,00	0	0	0,02	0,98	0	0	0	0	0	0	0
2007	0	0	0	0	1,00	0	0	0	0	1,00	0	0	0	0	0	0
2008	0	0	0	0	1,00	0	0	0	0	1,00	0	0	0	0	0	0
2009	0	0	0	0	1,00	0	0	0	0	0,60	0,40	0	0	0	0	0
2010	0	0	0	0	1,00	0	0	0	0	0,25	0,75	0	0	0	0	0
2011	0	0	0	0	1,00	0	0	0	0	0	1,00	0	0	0	0	0
2012	0	0	0	0	1,00	0	0	0	0	0	1,00	0	0	0	0	0,0001
2013	0	0	0	0	1,00	0	0	0	0	0	0,85	0,15	0	0	0	0,0001
2014	0	0	0	0	1,00	0	0	0	0	0	0,65	0,35	0	0	0	0,0002
2015	0	0	0	0	1,00	0	0	0	0	0	0,15	0,85	0	0	0	0,0000
2016	0	0	0	0	1,00	0	0	0	0	0	0	1,00	0	0	0	0,0007
2017	0	0	0	0	1,00	0	0	0	0	0	0	0,90	0,10	0	0	0,0010
2018	0	0	0	0	1,00	0	0	0	0	0	0	0,75	0,20	0,05	0	0,0006
2019	0	0	0	0	1,00	0	0	0	0	0	0	0	0,30	0,60	0	0,005
2020	0	0	0	0	1,00	0	0	0	0	0	0	0	0	0,79	0,20	0,008
2021	0	0	0	0	1,00	0	0	0	0	0	0	0	0	0,21	0,89	0,008

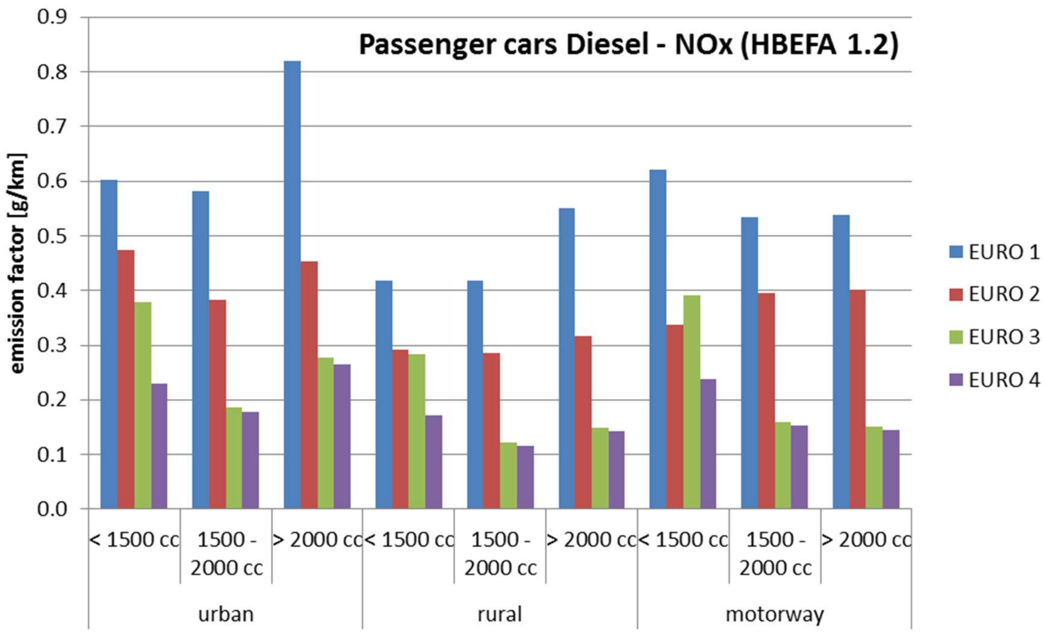
Besides the additional available emission tests also the methods of generation of emission factors have changed significantly over the different HBEFA versions (used models, underlying driving cycles). The main findings related to the updates of passenger cars emission factors from HBEFA 1.2 to 4.1 are documented in *B. Notter, M. Keller, B. Cox, (2019)*.

11.2.4.1.1 Emission factors for diesel cars

In the HBEFA 1.2 the emission factors for a certain driving condition are differentiated by the emission standard (the "EURO class") as well as the engine capacity class. Figure 7 shows the HBEFA 1.2

values for Diesel cars and the emission component NO_X for the average "urban", "rural" and "motorway" driving situation. About two out of three Diesel cars in Luxembourg fall within the capacity class from 1.5 to 2.0 litres.[119]

Figure 7 – Schematic HBEFA 1.2 NO_X emission factors for Diesel passenger cars by vehicle segment



In the following pictures weighted emission factors according to the Austrian fleet activity in 2010 are shown.[120]

Figure 11-8 gives a comparison of NO_X emission factors for diesel passenger cars. For EURO 1 vehicles (for which emission measurements were already available in the HBEFA 1.2) HBEFA 3.2 calculates about 20% higher NO_X levels. This difference can be attributed to additional emission data and to the change of methods in the prediction of real world emission levels. For emissions standards EURO 2 to EURO 4, HBEFA 1.2 predicts a stepwise NO_X reduction compared to EURO 1 which is related to the relative decrease of emission limits in the type approval. This – from today's point of knowledge very optimistic assumption – resulted in a prediction of real world NO_X levels which are by far lower than the related emission limit in the type approval (EURO 2: 0.7 g/km; EURO 3: 0.5 g/km, EURO 4: 0.25 g/km).

[119] In later HBEFA versions the differentiation of passenger car emission factors by capacity classes was neglected as no clear dependency of emission levels by engine size have been found in the emission test data.

[120] For other reference years or other countries the weighted emission factors can vary. The comparison shown here is based on Austrian numbers as Luxembourg fleet data is not included in the HBEFA software. Section 3.5 gives a description how the information on vehicle specific emission behaviour transferred from the HEBFA into NEMO to reflect Luxembourg conditions.

However, real world emission data for EURO 2 to EURO 5 diesel cars did not show any significant decrease of NO_X output compared to EURO 1 levels. The updated emission factors for EURO 2 exceed the HBEFA 1.2 prognosis by more than 100%, for EURO 3 and EURO 4 the HBEFA 4.1 value exceeds the prediction by about 300%. Main reasons for the high real world NO_X levels are shortcomings in the emission type approval, which – since the introduction of electronic engine control systems with EURO 2 technology – allow for different optimisations in the type approval cycle (low NO_X levels in the NEDC on the chassis dynamometer) and in real world driving (low fuel consumption, better drivability etc.).

With the introduction of the emission standard EURO 6d-temp the gap between real world NO_x emissions and type approval NO_x emissions of Diesel cars was observed to have nearly disappeared. Reason is that starting with provisions for the standard "EURO 6d-temp", emission tests driven on-road with PEMS equipment ("RDE tests", Real Drive Emissions) are part of the emission type approval.[121] As for EURO 6d the boundary conditions where the RDE limits have to be met are widened, a further decrease of real world NOx emissions is predicted.

Figure 11-8 – Average NO_X emission factors passenger cars - Diesel

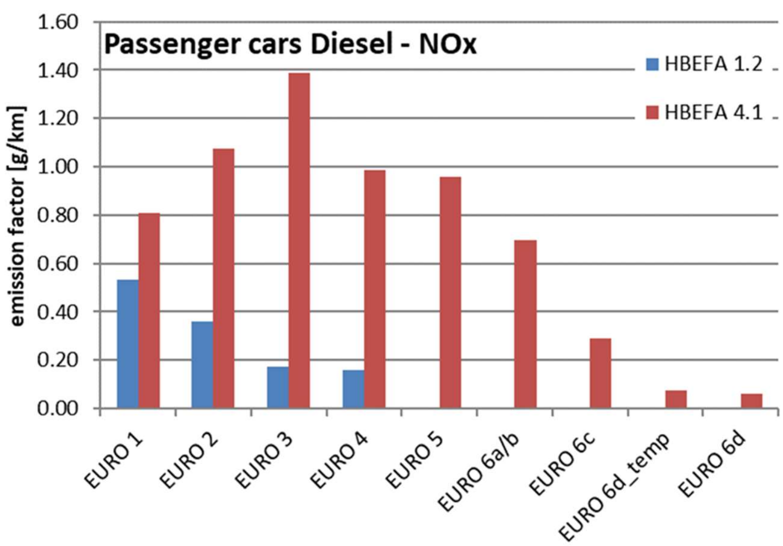


Table 323 compares the average emission factors for Diesel cars for all regulated pollutants. As for NO_x, the emission factors for HC and PM have been underestimated in the HBEFA1.2 compared to the latest status of knowledge. CO have been underestimated in the HBEFA1.2 for EURO 1 and overestimated for EURO 2 to 4 by about 25% to 60%.

[121] The downward trend in NOx emissions was already observed for EURO 6c vehicles. It is assumed that most of the vehicles certified under 6c have been designed to fulfil 6d-temp as well. The emission standard 6c was applicable only for a very short interim period.

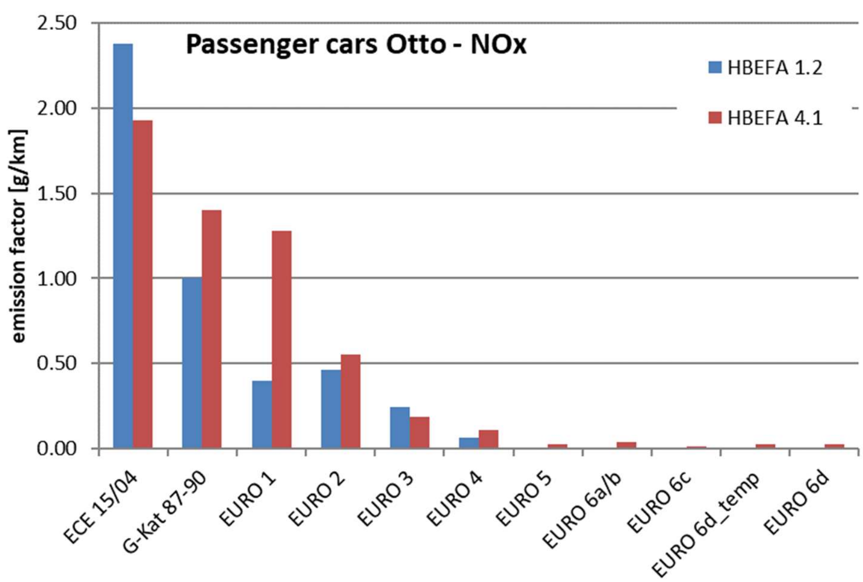
Table 323 – Average emission factors passenger cars - Diesel

PC Diesel [g/km]	HBEFA1.2				HBEFA4.1				ratio HBEFA4.1/HBEFA1.2			
	NO_x	HC	CO	PM	NO_x	HC	CO	PM	NO_x	HC	CO	PM
EURO 1	0,53	0,03	0,17	0,05	0,81	0,08	0,46	0,130	152%	257%	262%	283%
EURO 2	0,36	0,03	0,28	0,05	1,07	0,05	0,22	0,087	298%	162%	76%	187%
EURO 3	0,17	0,02	0,23	0,03	1,39	0,03	0,11	0,045	801%	166%	49%	178%
EURO 4	0,16	0,01	0,19	0,01	0,99	0,02	0,07	0,022	623%	111%	39%	253%
EURO 5	n.a.	n.a.	n.a.	n.a.	0,96	0,01	0,05	0,002	---	---	---	---
EURO 6a/b	n.a.	n.a.	n.a.	n.a.	0,70	0,02	0,14	0,001	---	---	---	---
EURO 6c	n.a.	n.a.	n.a.	n.a.	0,29	0,02	0,08	0,001	---	---	---	---
EURO 6d_temp	n.a.	n.a.	n.a.	n.a.	0,07	0,01	0,04	0,001	---	---	---	---
EURO 6d	n.a.	n.a.	n.a.	n.a.	0,06	0,01	0,03	0,001	---	---	---	---

11.2.4.1.2 Emission factors for otto cars

Figure 11-9 shows the average NO_x emission factors for Otto cars. In the recent HBEFA version lower emission levels for ECE 15/04 and EURO 3 but higher emissions levels for all other emission standards are specified than in version 1.2.[122]

Figure 11-9 – Average NO_X emission factors passenger cars - Otto



[122] The shown factors consider only emission output in “hot” operation conditions. Especially for Otto engines with Three-way catalyst also extra emissions in cold start conditions contribute to the overall emission amount. Cold start emissions are considered in the emission modelling separately (both in the HBEFA and NEMO). In this study only the standard settings for cold start emissions in NEMO have been used for both calculations. This does not significantly influence the comparison of emissions calculated for the two HBEFA versions as the update of cold start emissions from HBEFA1.2 to HBEFA4.1 did not significantly change the levels. Due to the aging and cold start emissions the up to date NEMO version is not 100% compatible to older versions. To show all the differences would implicate in a huge effort with no influence to the main conclusions of the study and therefore not fully presented here.

Table 324 shows the average emission factors for Otto cars for all regulated pollutants. Except from the above mentioned overestimated emission factors for NOx ECE 15/04 and EURO 3, NOx, HC and CO emissions from Otto cars are higher in the up-to-date HBEFA version.

Table 324 – Average emission factors passenger cars – Otto

	HBEFA1.2				HBEFA4.1				ratio HBEFA4.1/HBEFA1.2			
PC Otto [g/km]	**NO_x**	**HC**	**CO**	**PM**	**NO_x**	**HC**	**CO**	**PM**	**NO_x**	**HC**	**CO**	**PM**
ECE 15/04	2,38	1,33	12,01	n.a.	1.93	1.88	12.97	0.010	81%	142%	108%	---
G-Kat 87-90	1,01	0,13	2,24	n.a.	1.40	0.18	3.40	0.007	139%	135%	152%	---
EURO 1	0,40	0,10	2,06	n.a.	1.28	0.18	3.15	0.007	318%	179%	153%	---
EURO 2	0,46	0,11	2,21	n.a.	0.55	0.07	2.33	0.011	120%	60%	105%	---
EURO 3	0,25	0,06	1,56	n.a.	0.18	0.02	2.09	0.004	75%	37%	134%	---
EURO 4	0,06	0,03	0,92	n.a.	0.11	0.01	1.35	0.002	171%	41%	146%	---
EURO 5	n.a.	n.a.	n.a.	n.a.	0.02	0.01	1.06	0.002	---	---	---	---
EURO 6a/b	n.a.	n.a.	n.a.	n.a.	0.04	0.01	0.50	0.001	---	---	---	---
EURO 6c	n.a.	n.a.	n.a.	n.a.	0.01	0.00	0.39	0.000	---	---	---	---
EURO 6d_temp	n.a.	n.a.	n.a.	n.a.	0.03	0.01	0.38	0.001	---	---	---	---
EURO 6d	n.a.	n.a.	n.a.	n.a.	0.03	0.01	0.33	0.001	---	---	---	---

11.2.4.2 **Light duty vehicles**

Table 325 compares the average emission factors for Diesel driven light commercial vehicles (LCV). Similar to the findings for passenger cars also the predictions for NO_x and PM emissions made in the HBEFA1.2 were found to be too optimistic. HC and CO emission factors are in the up-to-date HBEFA version lower.

Table 325 – Average emission factors light commercial vehicles - diesel

	HBEFA1.2				HBEFA4.1				ratio HBEFA4.1/HBEFA1.2			
LCV Diesel [g/km]	**NO_x**	**HC**	**CO**	**PM**	**NO_x**	**HC**	**CO**	**PM**	**NO_x**	**HC**	**CO**	**PM**
EURO 1	0,83	0,07	0,74	0,08	1,64	0,06	0,75	0,199	198%	80%	102%	252%
EURO 2	0,71	0,05	0,29	0,07	1,43	0,03	0,26	0,158	201%	67%	90%	230%
EURO 3	0,53	0,03	0,16	0,03	2,10	0,02	0,08	0,101	394%	58%	48%	330%
EURO 4	0,30	0,02	0,15	0,02	1,86	0,01	0,07	0,052	627%	40%	44%	289%
EURO 5	n.a.	n.a.	n.a.	n.a.	1,66	0,01	0,03	0,002	---	---	---	---
EURO 6a/b	n.a.	n.a.	n.a.	n.a.	0,71	0,01	0,24	0,005	---	---	---	---
EURO 6c	n.a.	n.a.	n.a.	n.a.	0,51	0,02	0,09	0,012	---	---	---	---
EURO 6d_temp	n.a.	n.a.	n.a.	n.a.	0,12	0,02	0,05	0,014	---	---	---	---
EURO 6d	n.a.	n.a.	n.a.	n.a.	0,09	0,02	0,04	0,013	---	---	---	---

Table 326 shows the emission factors for LCVs with Otto engines. The emission factors are very uncertain, as no emission tests for such vehicles were available for the HBEFA. Thus the LCV Otto emission factors have been assessed taking into account the emission behaviour of Otto passenger cars and additionally taking into account the different emission limits and vehicle specifications of LCV. Anyhow, Otto driven LCVs have only minor influence on the fleet emissions as about 95% of the LCV fleet are equipped with Diesel engines.

Table 326 – Average emission factors light commercial vehicles - Otto

LCV Otto [g/km]	HBEFA1.2				HBEFA4.1				ratio HBEFA4.1/HBEFA1.2			
	NO_x	HC	CO	PM	NO_x	HC	CO	PM	NO_x	HC	CO	PM
Konv >81	2,77	1,28	16,94	n.a.	2,44	2,75	39,59	0,036	88%	215%	234%	---
G-Kat 87-90	1,12	0,13	4,57	n.a.	2,88	0,93	68,27	0,028	258%	696%	1495%	---
EURO 1	n.a.	n.a.	n.a.	n.a.	2,77	0,93	66,73	0,029	---	---	---	---
EURO 2	0,67	0,08	3,97	n.a.	0,85	0,37	25,40	0,044	127%	437%	640%	---
EURO 3	0,33	0,06	3,11	n.a.	0,27	0,11	11,64	0,013	82%	181%	374%	---
EURO 4	0,17	0,04	2,41	n.a.	0,12	0,08	8,32	0,011	72%	188%	345%	---
EURO 5	n.a.	n.a.	n.a.	n.a.	0,05	0,08	8,53	0,010	---	---	---	---
EURO 6a/b	n.a.	n.a.	n.a.	n.a.	0,04	0,07	5,87	0,010	---	---	---	---
EURO 6c	n.a.	n.a.	n.a.	n.a.	0,04	0,07	5,91	0,010	---	---	---	---
EURO 6d_temp	n.a.	n.a.	n.a.	n.a.	0,04	0,07	5,79	0,010	---	---	---	---
EURO 6d	n.a.	n.a.	n.a.	n.a.	0,03	0,07	5,07	0,010	---	---	---	---

11.2.4.3 **Heavy duty vehicles**

In the HBEFA1.2 the emission factors for heavy duty vehicles (HDV) have been based on measurements on engines certified to EURO I and earlier standards. A prognosis has been given for emission standards until EURO V based on the reductions in the type approval (Table 327). The recent HBEFA version 4.1 includes emission tests on engines and HDV of all emission standards including the latest stage EURO VI. In the last 15 years also the methods of derivation of emission factors for the different HDV classes based on the available emission test data (which are to a large extend data from the engine dynamometer) have been improved significantly.

Table 327 – Average Heavy duty vehicle emission data in HBEFA1.2 and HBEFA4.1

emission standard	HBEFA1.2			HBEFA4.1		
	emission data	new registrations from	new registrations until	emission data	new registrations from	new registrations until
pre EURO	**meas.**	until	1993	**meas.**	until	1993
EURO I	**meas.**	1994	1995	**meas.**	1994	1995
EURO II	progn.	1996	2000	**meas.**	1996	2000
EURO III	progn.	2001	2005	**meas.**	2000	2008
EURO IV	progn.	2006	2008	**meas.**	2004	2009
EURO V	progn.	2009	and after	**meas.**	2006	2013
EURO VI	n.a.			**meas.**	2012	and after

Table 328 shows the details on allocation of HDV first registration dates to EURO classes. In the HBEFA1.2 scenario the original assumptions from in 1999 have been used without any modification whereas in the HBEFA4.1 scenario actual data as used in the Luxemburg national emission inventory was applied. As for passenger cars the HBEFA4.1 scenario also makes use of the NEMO feature to split the first registrations of a certain year between two or more emission standards.

Table 328 – Allocation of heavy duty vehicle first registration years in the scenarios HBEFA 1.2 and HBEFA 4.1

LSZ	HBEFA1.2					HBEFA4.1							
	EURO I	EURO II	EURO III	EURO IV - EGR	EURO V - EGR	EURO I	EURO II	EURO III	EURO IV - EGR	EURO IV - SCR	EURO V - EGR	EURO V - SCR	EURO VI
1993	0	0	0	0	0	1,00	0	0	0	0	0	0	0
1994	1,00	0	0	0	0	1,00	0	0	0	0	0	0	0
1995	1,00	0	0	0	0	1,00	0	0	0	0	0	0	0
1996	0	1,00	0	0	0	0	1,00	0	0	0	0	0	0
1997	0	1,00	0	0	0	0	1,00	0	0	0	0	0	0
1998	0	1,00	0	0	0	0	1,00	0	0	0	0	0	0
1999	0	1,00	0	0	0	0	1,00	0	0	0	0	0	0
2000	0	1,00	0	0	0	0	0,93	0,07	0	0	0	0	0
2001	0	0	1,00	0	0	0	0	1,00	0	0	0	0	0
2002	0	0	1,00	0	0	0	0	1,00	0	0	0	0	0
2003	0	0	1,00	0	0	0	0	1,00	0	0	0	0	0
2004	0	0	1,00	0	0	0	0	0,70	0,30	0	0	0	0
2005	0	0	1,00	0	0	0	0	0,20	0,15	0,45	0	0,20	0
2006	0	0	0	1,00	0	0	0	0,31	0,12	0,32	0	0,26	0
2007	0	0	0	1,00	0	0	0	0,02	0,08	0,08	0,00	0,81	0
2008	0	0	0	1,00	0	0	0	0,01	0,05	0,05	0,03	0,87	0
2009	0	0	0	0	1,00	0	0	0	0,03	0	0,13	0,84	0
2010	0	0	0	0	1,00	0	0	0	0	0	0,29	0,71	0
2011	0	0	0	0	1,00	0	0	0	0	0	0,29	0,71	0
2012	0	0	0	0	1,00	0	0	0	0	0	0,29	0,71	0
2013	0	0	0	0	1,00	0	0	0	0	0	0,15	0,35	0,50
2014	0	0	0	0	1,00	0	0	0	0	0	0	0,25	0,75
2015	0	0	0	0	1,00	0	0	0	0	0	0	0,15	0,85
2016	0	0	0	0	1,00	0	0	0	0	0	0	0,05	0,95
2017ff	0	0	0	0	1,00	0	0	0	0	0	0	0	1,00

Below the comparison of HDV emission levels from the two HBEFA versions is done on a fuel specific basis (in "gram emissions per kilogram fuel"). This allows for a straight forward comparison which is not biased by the fact that the data on HDV fleet mix has changed over the different HBEFA versions significantly.[123]Figure 11-10 gives a comparison of fuel specific NO_x levels. For pre EURO and EURO I the data on both HBEFA versions give nearly similar numbers. From EURO II on the data on NO_x output from the HBEFA4.1 are significantly higher than the HBEFA1.2 forecast. The reasons are similar to the findings for Diesel passenger cars, i.e. the combination of type approval tests which are not representative for real world conditions and the possibilities of modern engine control systems.[124] With the coming into force of EURO VI the type approval procedures have been

[124] The updates of the HDV emission factors in the HBEFA are documented in **Error! Reference source not found.** (EURO II), **Error! Reference source not found.** (EURO III), **Error! Reference source not found.** (EURO IV and V) and **Error! Reference source not found.** (EURO V and VI).

significantly improved which – according to test results on new EURO VI vehicles and engines - resulted in real world NO_x emissions, which are are close to type approval limits. Recent emission tests however prevailed that current EURO VI technology is prone to deterioration effects. Thus the latest EURO VI emission factors as published in the HBEFA4.1 are some 20% to 50% higher than in the HBEFA 3.X versions.

Figure 11-10 – Average NO_X emissions per fuel consumption for HDV

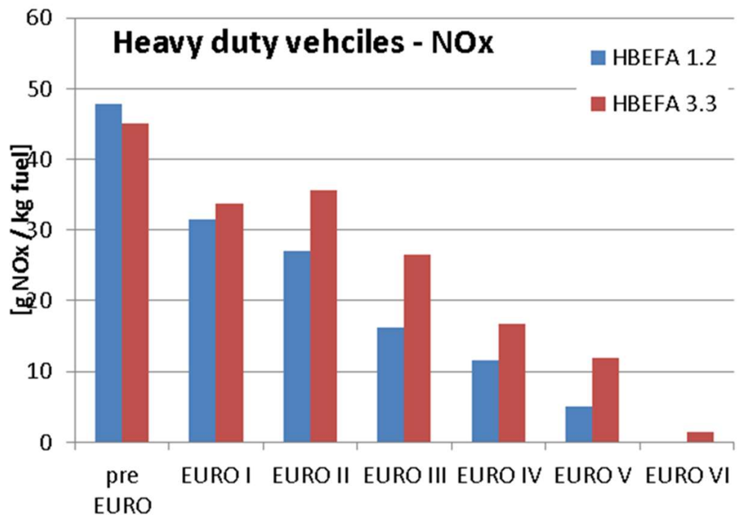


Table 329 gives the comparison of the fuel specific emission levels for all regulated pollutants. For CO and PM the HBEFA1.2 generally predicted lower emission output. The reason can be found in shortcomings in the former methods to model the influence of transient engine load conditions on the emission behaviour. For HC the HBEFA1.2 generally predicted higher emission output.

Table 329 – Average fuel specific emission levels for HDV

HDV Diesel [g Em/ kg Fuel]	HBEFA1.2				HBEFA4.1				ratio HBEFA4.1/HBEFA1.2			
	NO_x	HC	CO	PM	NO_x	HC	CO	PM	NO_x	HC	CO	PM
pre EURO	47,89	4,36	12,05	1,45	41,65	4,54	12,63	2,09	87%	104%	105%	144%
EURO I	31,57	2,81	4,35	0,94	30,43	1,80	6,78	1,28	96%	64%	156%	137%
EURO II	26,98	1,72	1,98	0,35	32,96	1,26	5,48	0,66	122%	73%	277%	186%
EURO III	16,17	1,25	1,43	0,23	25,82	1,16	6,24	0,60	160%	93%	435%	266%
EURO IV	11,59	1,05	1,02	0,06	18,23	0,15	5,56	0,16	157%	15%	545%	243%
EURO V	5,02	1,03	1,00	0,06	12,23	0,14	7,24	0,17	244%	13%	723%	272%
EURO VI	n.a.	n.a.	n.a.	n.a.	2,39	0,08	0,76	0,04	---	---	---	---

11.2.5 **Two Wheelers**

For two-wheelers the HBEFA1.2 includes emission factors for the emission standards "pre EURO" and EURO 1, in the HBEFA4.1 additionally the stages EURO 2 to EURO 5 are specified. The emission factors for "pre EURO" and EURO 1 have not been modified significantly in the updates from version 1.2 to 4.1. In general, in the HBEFA the data on two-wheeler emissions on are based on measurements in the type approval cycle only, so the representativeness for real world emissions is uncertain. However, due to the very small share on overall mileage two-wheeler this uncertainty does not significantly influence the Luxembourg emission inventory.

11.2.5.1 **Parametrisation of NEMO to represent emission factors from HBEFA 4.1 and HBEFA 1.2**

Since HBEFA version 3.1 (published in 2010) a standard method is available how the emission behaviour of the different vehicle segments is parameterised in NEMO to be fully compatible with the HBEFA data. This is done based on a two-stage approach:

- Compilation of characteristic curves for specific emission behaviour as a function of cycle average engine power
- Application of an overall calibration factor in a way that the weighted overall emission factor for a certain mix of traffic situations (e.g. the Luxembourgish mix) of NEMO and the HBEFA match.

For step 1.) the underlying data for all single traffic situations as specified in the HBEFA are used.[125] Based on the resulting characteristic curves NEMO is able to predict the emission behaviour in any kind of driving situation. Step 2.) then establishes full compatibility in terms of country specific emission results as applicable in an national emission inventory.

11.2.5.1.1 Dataset "HBEFA 4.1"

The parameterisation of NEMO referring to the recent 4.1 version of the HBEFA already was the baseline for the Luxembourgian national emission inventory 1990-2018 as published in *Molitor R., et al. (2019)*. As no Luxembourgian data on distribution of traffic situations is available in the HBEFA tool, the final parameterisation of NEMO has been performed by comparison of NEMO and HBEFA results for the Austrian mix of traffic situations. The Luxembourgian national emission inventory then has been simulated in NEMO based on the Luxembourgian fleet and Luxembourgian street net data. Besides the HBEFA4.1emission data - incorporated into NEMO based on the methods as described above - this dataset additionally considers the effects of cold start emissions from HDV according to the data elaborated in *Rexeis M., Schwingshackl M., (2013)*.

Due to this more comprehensive and from a scientific point of view more realistic modelling approach the Luxembourgian national emission inventory 1990-2018 as calculated in **Error! Reference**

[125] Since version 3.1 the emission factors in the HBEFA are based on simulation results of the model "PHEM". For step 1.) the underlying PHEM results including information on average engine power are required.

source not found. results in higher NO_x emissions as if calculated strictly with the data from the HBEFA4.1. For terms of simplicity this NEMO dataset is still referred to as "HBEFA4.1" in this report.

11.2.5.1.2 Dataset "HBEFA 1.2"

The structure of HBEFA version 1.2 differs significantly from the latest 4.1 version. Emission factors have been determined from baseline in-use emission test data by rather simple functions but not by a complex simulation model. Also much fewer traffic situations are specified in the HBEFA 1.2 (approx. 20 compared to 365 in HBEFA 4.1). As a consequence, step 1.) of the NEMO parametrisation was not applicable based on the HBEFA 1.2 data. Instead for each vehicle segment the characteristic curves for specific emission behaviour have been taken over from the comparable dataset from the HBEFA 3.3 parameterisation. The final calibration then has been performed based on the comparison of HBEFA 1.2 emission factors for the Austrian average traffic situation with the according NEMO result. Several plausibility checks have been performed to verify compatibility of the resulting NEMO model behaviour with the original HBEFA 1.2 data.

Then the Luxembourgish national emission inventory has been simulated in NEMO also with the HBEFA 1.2 parameters and based on the Luxembourgish fleet and Luxembourgish street net data.

11.2.6 Results for transport emissions

This chapter summarises the results for the Luxembourgish national transport emission inventory based on the emission factors of the two HBEFA versions. Detailed results for the main pollutants are also given in table form in the Annex. The full set of results is available as MS Excel files in the standard inventory format. This report especially focuses on NO_X emissions and the years 2010 to 2018 as well as the projections for 2020, 2030 and 2035.

11.2.6.1 Nitrogen oxide (NO_X) *emissions*

Figure 11-11 shows the time series from 1990 to 2035 for NO_x emissions of the main relevant vehicle categories passenger cars (PC) and heavy duty vehicles (HDV) calculated with the two sets of HBEFA emission factors. Figure 11-12 plots the differences between the two scenarios over the years for each vehicle category. Only emissions from inland mileage are shown (i.e. the numbers do not include emissions related to fuel export). According to the recent HBEFA version 4.1 emissions from Otto cars are since 1992 lower than predicted in the HBEFA1.2, especially until the end of the last decade. For the year 2018 the "4.1" calculation gives about 0.05 kt less NO_x from Otto cars than the "1.2" results. According to recent data NO_x emissions from Otto engines will even more be on a very low level in the future.

The situation for Diesel cars is completely different: The scenario based on the HBEFA1.2 forecast shows an amount of yearly NO_x of about 0.6 kt around the year 2000 with an increasing tendency to a quantity of 0.64 kt in the year 2018. Based on the measured emission factors for modern Diesel cars in the HBEFA4.1 yearly NO_x emissions rise up to about 3.55 kt in the year 2018 and reach a peak value of 4.91 kt in 2014. For the year 2018 the NO_x difference between the "4.1" and the "1.2" calculation is at 2.91 kt, i.e. the recent data show more than four times higher NO_x output than "1.2". An analogue situation to Diesel cars can be found for HDV. Since the coming into the fleet of EURO II vehicles in the mid of the 1990ies more NO_x was emitted by HDV than predicted by the HBEFA1.2. For the year 2018 0.06 kt extra NO_x are calculated in the "4.1" calculations. However, due the effectiveness of the EURO VI regulations for HDV the situation for NO_x from HDV is predicted to improve significantly from 2014 on. For the end of the decade lower NO_x from HDV are predicted based on the recent HBEFA4.1 than calculated with the HBEFA1.2 factors.

Figure 11-11 – Average NO_X emissions per vehicle category (inland mileage)

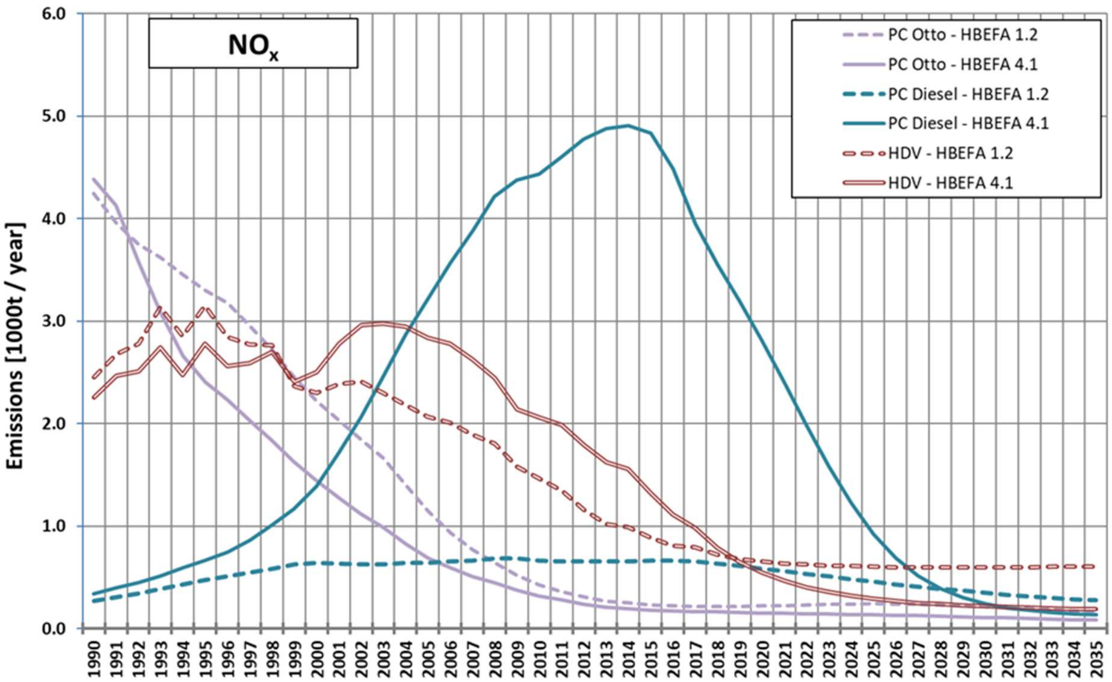


Figure 11-12 – Differences for NO_X emissions per vehicle category (inland mileage) between HBEFA 4.1 and 1.2

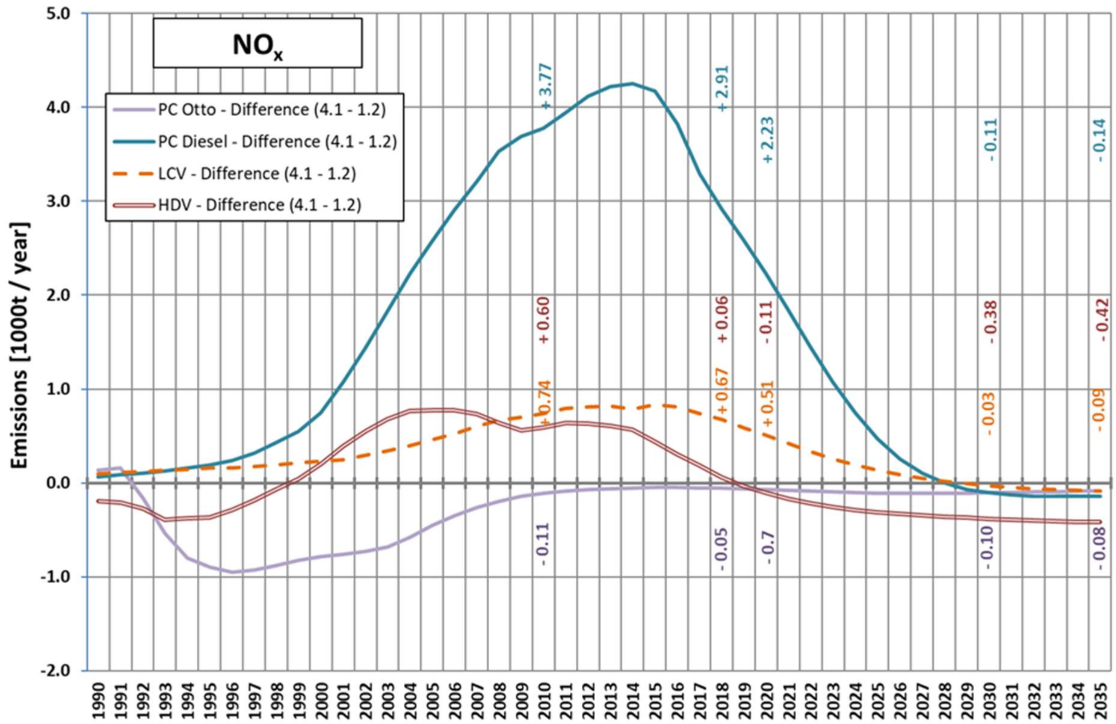
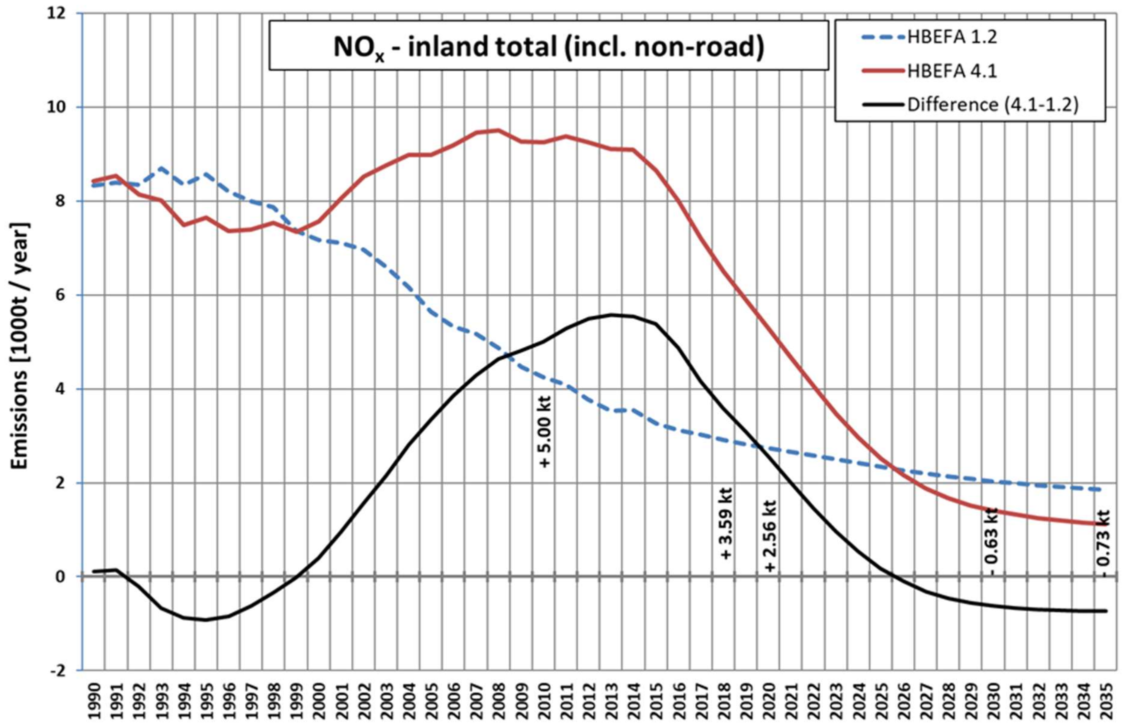


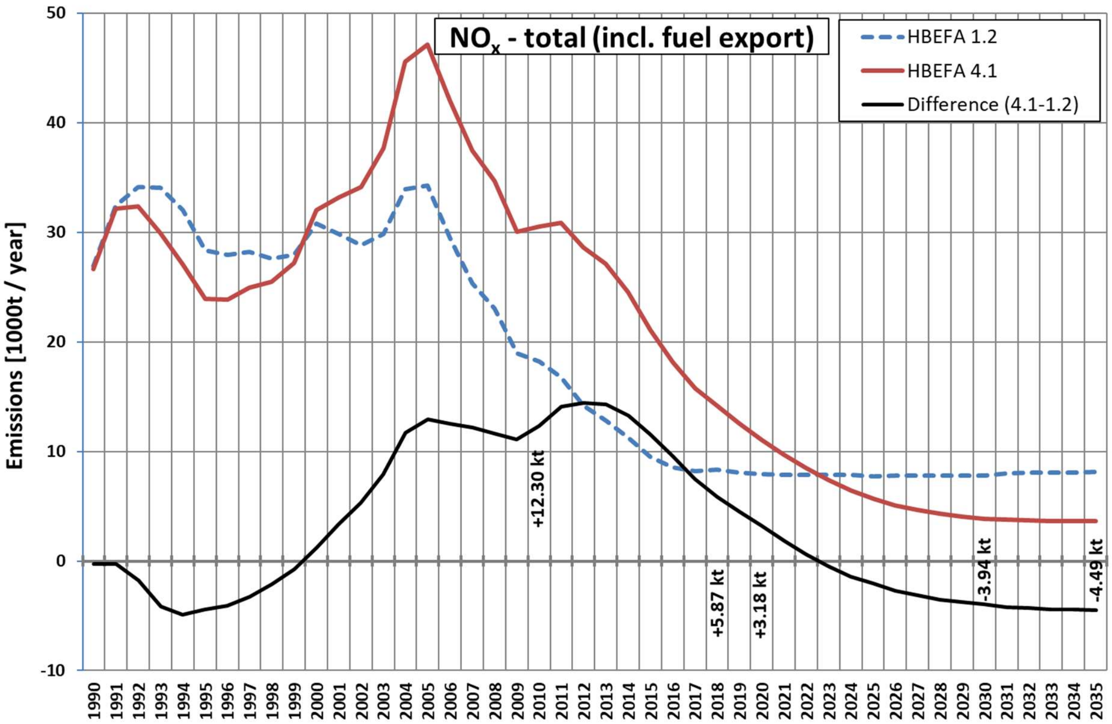
Figure 11-13 compares the time series for total inland NO_x from Luxembourgian transport including non-road machinery. Based on HBEFA4.1 the yearly NO_x emissions have been at a constant level of about 8 to 9 kt from 1990 until the end of the last decade. For the year 2018 3.59 kt higher NO_x emissions are determined in the HBEFA4.1 scenario compared to the "1.2" calculation. For the years after 2004 also the HBEFA4.1 scenario gives a decreasing NO_x trend, showing in 2020 still 2.56 kt more NO_x than the HBEFA1.2. In the following decade then the "4.1" NO_x prediction falls below the "1.2" forecast.

Figure 11-13 – NO_X emissions of the total inland transport including non-road machinery



The results for total NO_X emissions from Luxemburg transport including the emissions associated to the fuel sold in Luxemburg but used abroad are shown in Figure 11-14. For the year 2018 a value of 14.22 kt is calculated with the HBEFA4.1 emission factors which gives 5.87 kt more NO_x compared to the value of 8.357 kt from the HBEFA1.2. For the upcoming years the calculations with the recent set of emission factors predict a continuous decrease of NO_x emissions with 11.09 kt in the year 2020 and 3.86 kt in the year 2030. Besides the uncertainties in the development of transport demand and fuel prices this up-to-date forecast of course again contains some uncertainties regarding the real world emission factors of future generation of EURO 6 / VI vehicles and especially of EURO 7 / VII vehicles which can be expected to be on the road until the end of this decade.

Figure 11-14 – NO_X emissions of the total transport sector with fuel sold in Luxembourg



11.2.6.2 **Hydrocarbon (HC) emissions**

HC emissions from on-road transport are mostly determined by the data on emission behaviour of Otto cars. For hot operation conditions the HBEFA4.1 specifies higher emission factors from 1990ies cars and somewhat lower HC emissions for recent Otto vehicle generations than the HBEFA1.2. HC levels are also influenced by cold start behaviour. Here the model data has not been varied in this study in the two HBEFA scenarios (see footnote 122 on page 473). Anyway, since the last decade the overall HC emissions from transport are on a low absolute level and are dominated by the contribution of the non-road machinery with still increasing shares. Figure 11-15 and Figure 11-16 show the results for total HC emitted from Luxembourgish transport. The quantities do not differ significantly between the two calculation variants.

Figure 11-15 – HC emissions of the total inland transport including non-road machinery

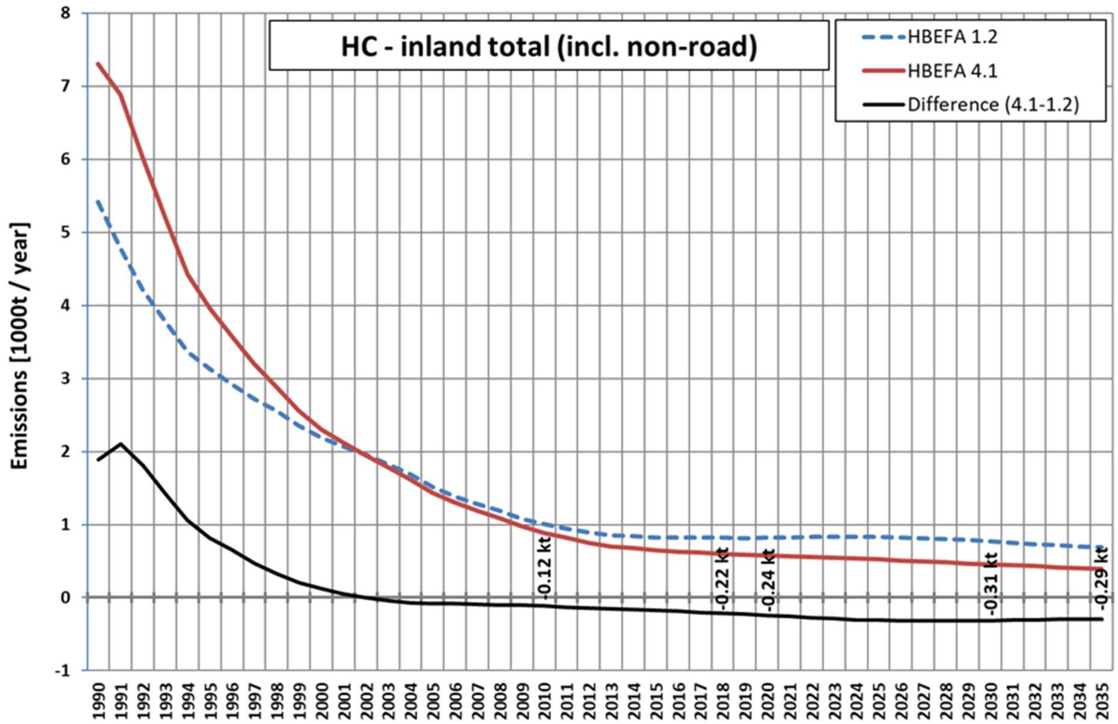
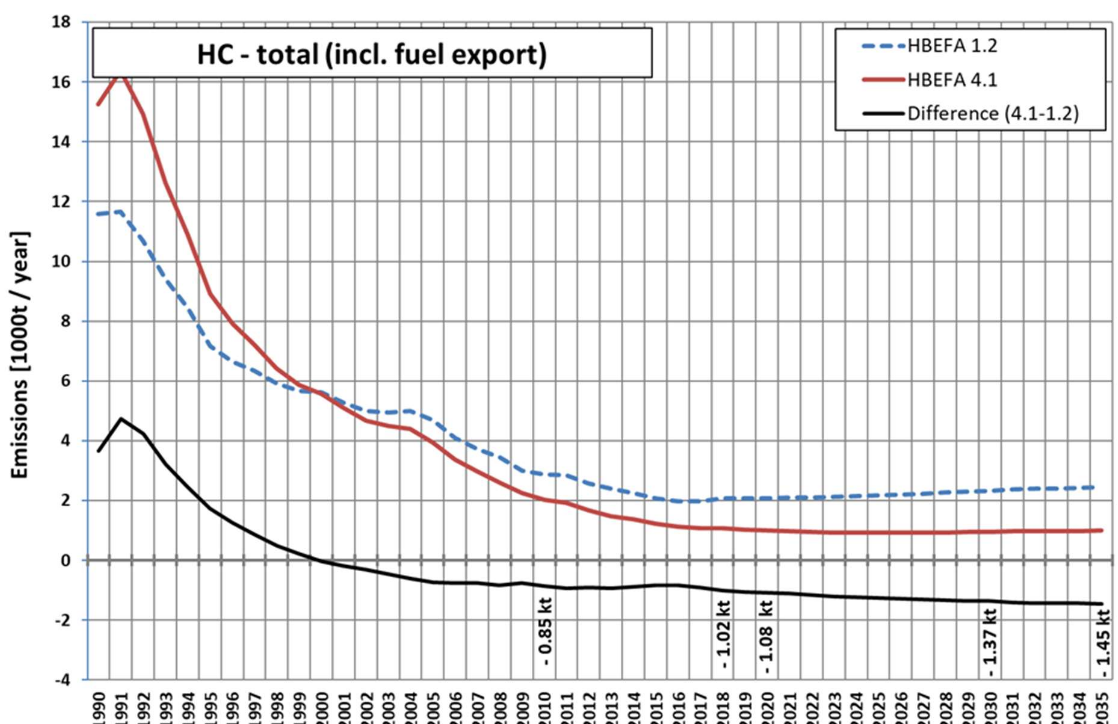


Figure 11-16 – HC emissions of the total transport sector with fuel sold in Luxembourg



11.2.6.3 **Particulate matter (PM) exhaust *emissions***

In Figure 11-17 the calculations for PM exhaust emissions (inland transport) are shown. For the year 2018 the HBEFA4.1 calculation results in 0.02 kt lower PM emissions than based on the HBEFA1.2. For the subsequent years the HBEFA4.1 predicts more reduction in PM exhaust emissions than the HBEFA1.2 due to the introduction of EURO5/6 and EURO VI vehicles equipped with DPF which were not foreseen in the HBEFA1.2.

Figure 11-17 – PM exhaust emissions of the total inland transport including non-road machinery

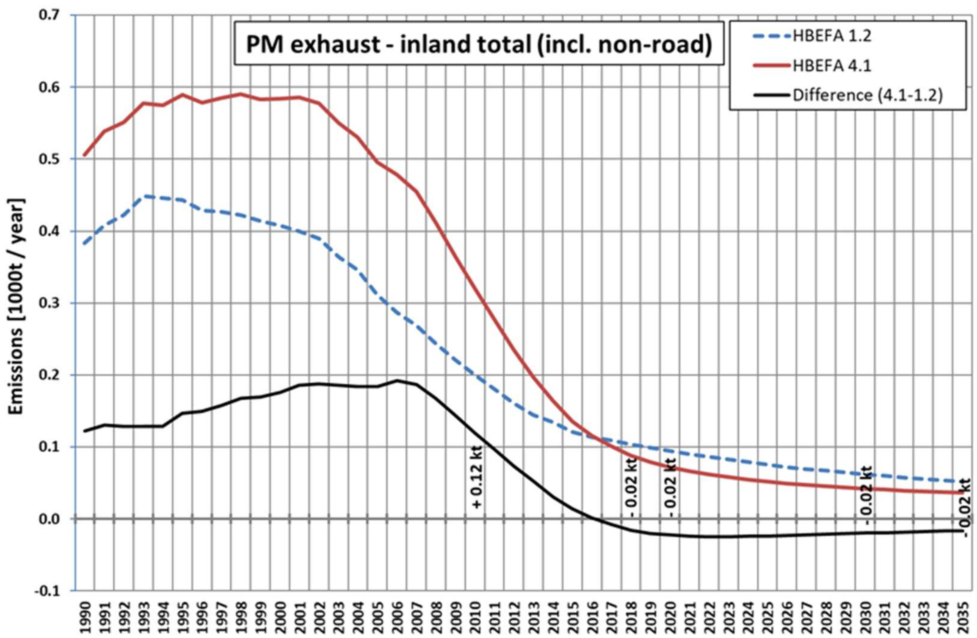
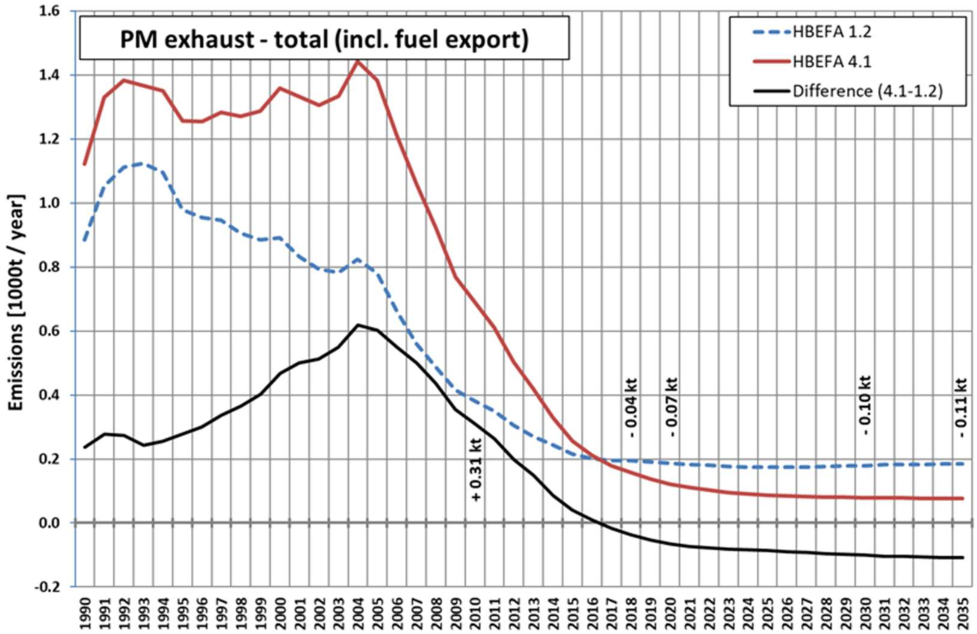


Figure 11-18 shows the trends for PM exhaust if the total fuel in Luxembourg is considered. For the year 2018 the "4.1" calculation shows 0.04 Gg lower PM exhaust than the values based on the old HBEFA.

Figure 11-18 – PM exhaust emissions of the total transport sector with fuel sold in Luxembourg



11.2.6.4 **Carbon monoxide (CO) *emissions***

The results for CO emissions are given in Figure 11-19 and Figure 11-20. Similar to HC the total CO amount is mainly determined by the emission factors of Otto cars (incl. cold start behaviour) and by the non-road machinery. The HBEFA4.1 calculations result in less CO emissions for inland transport (-0.89 kt) lower emissions (-0.88 kt) for total transport including fuel export compared to the HBEFA1.2 scenario for the year 2018.

Figure 11-19 – CO emissions of the total inland transport including non-road machinery

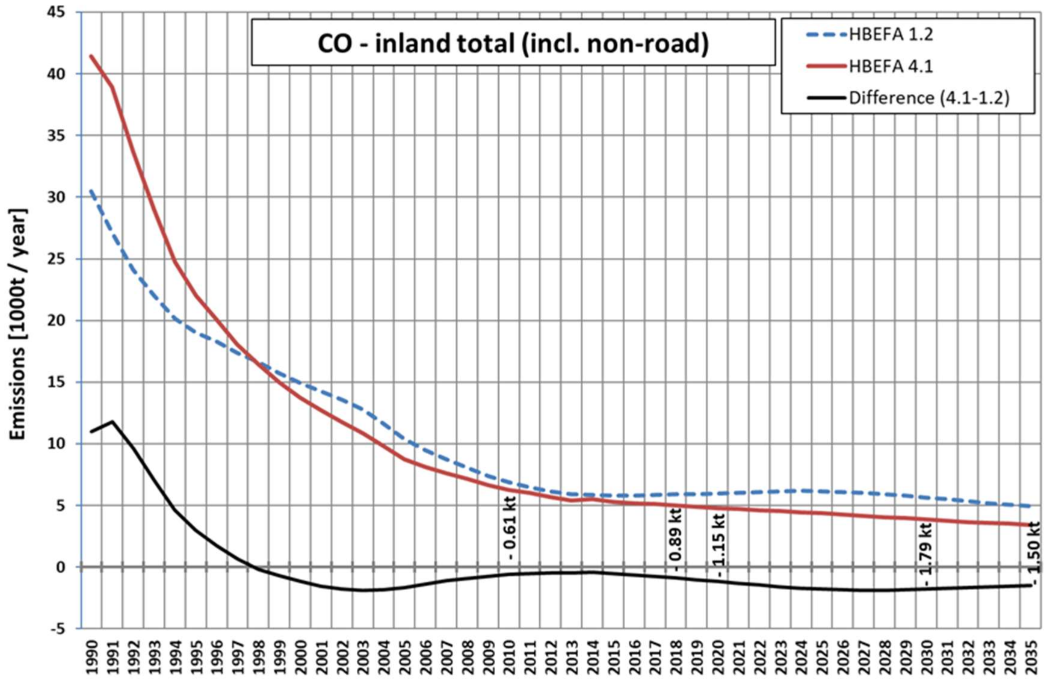
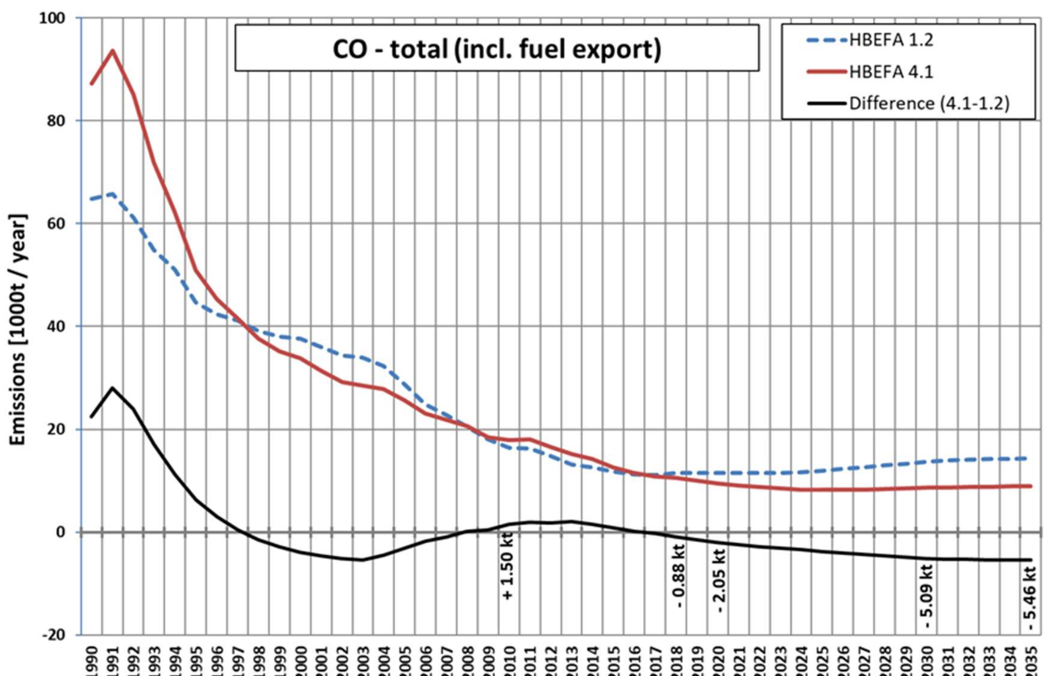


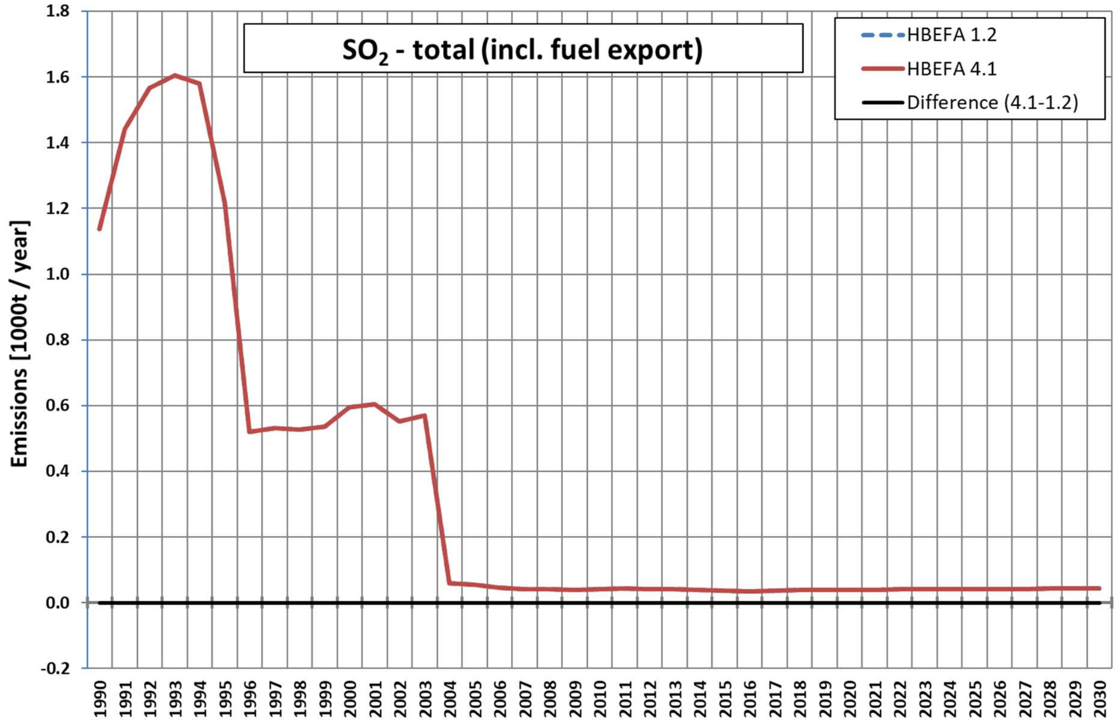
Figure 11-20 – CO emissions of the total transport sector with fuel sold in Luxembourg



11.2.6.5 **Sulphur dioxide (SO_2)** ***emissions***

For SO_2 in both scenarios similar emission quantities are calculated as the total consumed fuel and the sulphur content is identical (Figure 11-21).

Figure 11-21 – SO_2 emissions of the total transport sector with fuel sold in Luxembourg



11.3 *Agriculture (3B, 3D)*

Please note that the adjustments for NO_X and NMVOC from agriculture (3B, 3D) have already been approved in 2016-2017, 2018 and 2019. In this submission (2020), some changes in the methodology and activity data have been done, and the current chapter was updated. The methodology as such was not adapted for the 2020 submission. However, animal numbers for 2017 were revised. The N extraction of the different animal categories were revised, and adapted. Detailed information of slurry storage became available. Further the activity data for soil management such as agricultural surface area, synthetic fertilizer and compost was revised. N available from manure management and N deposited with urine and dung during grazing had to be revised due to the new N.ex. A detail description and the impact on the calculations is provided in section 11.3.3.

11.3.1 **NO_X emissions from Agriculture**

11.3.1.1 **Manure Management (3B)**

Nitric oxide (NO) is formed through nitrification in the surface layers of stored manure or in manure aerated to reduce odour or to promote composting. Nitric oxide emission from soils is generally considered to be a product of nitrification. Increased nitrification is likely to occur following application of manures and deposition of excreta during grazing (EMEP/EEA Guidebook 2016).

NOx emissions from 3B - manure management were reported for the first time to the CLRTAP/NECD in 2016, and were as such not yet included in Luxembourg's air pollutant emission inventory at the time the emission reduction commitments were set in 1999.

According to Decision 2012/12 2bis (a)(i) an emission source category will qualify as a new emission source category if emission estimates for that source category were introduced to the national emission inventory after the emission reduction commitment for that pollutant was set and where no methodology was provided in the EMEP/EEA air pollutant emission inventory guidebook for determining emissions from that source category at the time that the emission reduction commitment was set.

The emissions allocated in category 3B (Manure management from live stock) originate from manure management regarding organic compounds (included in the first and second edition of the EMEP/CORINAIR Emission Inventory Guidebook under SNAP code 100500, chapter 10 agriculture). This chapter considers the emission of ammonia (NH_3) but no methodology for NO emission estimation is provided.

Hence, it can be concluded that the available guidance material for the above mentioned category provided no methodology for estimating NO emissions from manure management. As a result, category 3B can be considered as new emission sources. Consequently, the proposed adjustments are simply the values of these new sources (Table 330).

Methodology

In this submission, **NO_X** emissions (expressed as NO_2) have been estimated using the Tier 2 mass-flow approach based on the on the concept of a flow of TAN through the manure management system (EMEP/EEA Guidebook 2016, 3.B Manure management, p.20-26). In the last of the 15 step calculation, the sum of NO emissions from slurry and solid manure systems (expressed as NO-N) are converted to NO_2 by multiplication of the molar ration (NO_2/N =46/14).

For detailed information on activity data and emission factors please refer to the chapter on Agriculture (section 3.B. Manure Management).

11.3.1.2 **Agricultural soils (3D)**

NO_X emissions from 3Da1 - Inorganic N-fertilizers were reported for the first time to the CLRTAP/EU (NECD) in 2011. In 2016, and due to a complete revision of the emission calculations for agriculture, emissions reported under 3Da1 - Inorganic N-fertilizers also included for the first time emissions from organic fertilizers (3Da2a – Animal Manure, 3Da2b – Sewage sludge, 3Da2c – Other Organic Fertilizer, 3Da3 – N-Deposit Grazing and 3Da4 – Crop Residues)[126]. Hence, these emissions were as such not included in Luxembourg's air pollutant emission inventory at the time the emission reduction commitments were set in 1999.

According to Decision 2012/12 2bis (a)(i) an emission source category will qualify as a new emission source category if emission estimates for that source category were introduced to the national emission inventory after the emission reduction commitment for that pollutant was set and where no methodology was provided in the EMEP/EEA air pollutant emission inventory guidebook for determining emissions from that source category at the time that the emission reduction commitment was set. According to Decision 2012/12 2bis (a)(iii) an emission source may also be qualified as a new source where a methodology was available in the EMEP/EEA air pollution emission inventory guidebook at the time that the emission reduction commitment was set, only if a Party can demonstrate that it was unable to apply the methodology due to a lack of relevant national statistical data or can provide another justification why it could not make use of this methodology.

The emissions allocated in the sector 3Da1 originate from inorganic N-fertilizer use (included in the first and second edition of the EMEP/CORINAIR Emission Inventory Guidebook under SNAP code 100100, chapter 10 agriculture). Version 2 of the EMEP/CORINAIR Atmospheric Emissions Inventory Guidebook (published in 1999) describes for the first time a methodology for the estimation of NO emissions from inorganic fertilizer use (SNAP 100100). Nevertheless it was too early to take these emissions into account at the time that the emission reduction commitment was set because first a thorough validation of the methodology by the national experts was required.

[126] Please refer to the methodological description on emissions used Agriculture

In fact, there was so much doubt about the reliability of this methodology that it was not until 2011 (for emissions from inorganic fertilizers) and until 2016 (for both inorganic and organic fertilizers) that these emissions were reported by Luxembourg.

These emissions are also not taken into account in the RAINS/GAINS model: not in the 1999 RAINS version, nor in the current 2015 GAINS version. As a result the sector 3Da1 can be considered as a new emission source. Consequently, the proposed adjustments are simply the values of these new sources (Table 330).

<u>*Methodology*</u>

Luxembourg uses the TIER 1 methodology for estimating NO_x emissions, i.e. emissions that arise directly as a result of N-fertiliser application. To estimate NO_x emissions, the total usage of mineral N-fertiliser in the country is required.

$$NO_x = N_{Fertilizer} * EF_{NO} * \frac{46}{40}$$

The default emission factor of 0.04 kg NO related to the input of fertilizer N was taken from the EMEP/EEA Guidebook 2016 (chapter 3.D, table 3.1, p. 14 and Annex 2 for sewage sludge).

For detailed information on activity data and emission factors please refer to the chapter on Agriculture (section 3.D. Agricultural soils).

Table 330 – NOx emissions from the agricultural sector

NFR code	Longname	2010	2011	2012	2013	2014	2015	2016	2017	2018
3 B 1 a	3 B 1 a Manure management - Dairy cattle	0.0257	0.0254	0.0244	0.0251	0.0254	0.0258	0.0285	0.0300	0.0307
3 B 1 b	3 B 1 b Manure management - Non-dairy cattle	0.0534	0.0506	0.0490	0.0503	0.0519	0.0518	0.0500	0.0496	0.0473
3 B 2	3 B 2 Manure management - Sheep	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
3 B 3	3 B 3 Manure Management - Swine	0.0009	0.0009	0.0009	0.0009	0.0009	0.0010	0.0010	0.0010	0.0010
3 B 4 a	3 B 4a Manure management - Buffalo	NO	NO	NO	NO	NO	NO	NO	NO	NO
3 B 4 d	3 B 4 d Manure management - Goats	0.0007	0.0008	0.0009	0.0008	0.0007	0.0008	0.0008	0.0008	0.0008
3 B 4 e	3 B 4 e Manure management - Horses	0.0016	0.0016	0.0018	0.0017	0.0017	0.0017	0.0016	0.0017	0.0016
3 B 4 f	3 B 4 f Manure management - Mules and asses	IE	IE	IE	IE	IE	IE	IE	IE	IE
3 B 4 g i	3 B 4 g i Manure management - Laying hens	0.0008	0.0009	0.0010	0.0010	0.0011	0.0010	0.0010	0.0011	0.0011
3 B 4 g ii	3 B 4 g ii Manure management - Broilers	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
3 B 4 g iii	3 B 4 g iii Manure management - Turkeys	IE	IE	IE	IE	IE	IE	IE	IE	IE
3 B 4 g iv	3 B 4 g iv Manure management - Other poultry	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3 B 4 h	3 B 4 h Manure management - Other animals	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
3 D a 1	3 D a 1 Inorganic N-fertilizers (includes also urea application)	0.5480	0.5755	0.5458	0.5337	0.5071	0.5194	0.5480	0.5430	0.5215
3 D a 2 a	3 D a 2 a Animal manure applied to soils	0.2295	0.2241	0.2181	0.2237	0.2303	0.2343	0.2406	0.2468	0.2440
3 D a 2 b	3 D a 2 b Sewage sludge applied to soils	0.0041	0.0055	0.0066	0.0053	0.0049	0.0058	0.0031	0.0031	0.0026
3 D a 2 c	3 D a 2 c Other organic fertilisers applied to soils (including compost)	0.0040	0.0028	0.0020	0.0017	0.0019	0.0024	0.0024	0.0029	0.0024
3 D a 3	3 D a 3 Urine and dung deposited by grazing animals	0.1938	0.1893	0.1843	0.1863	0.1916	0.1955	0.1980	0.2010	0.1989
3 D a 4	3 D a 4 Crop residues applied to soils	0.0751	0.0646	0.0927	0.0887	0.0954	0.0689	0.0837	0.0761	0.0769
Adjustment	**Total Agriculture**	**-1.138**	**-1.142**	**-1.128**	**-1.120**	**-1.113**	**-1.109**	**-1.159**	**-1.158**	**-1.129**

11.3.2 **NMVOC emissions from Agriculture**

11.3.2.1 **Manure Management (3B)**

According to the EMEP/EEA Guidebook, NMVOC emissions from animal husbandry originates from feed, especially silage, degradation of feed in the rumen, and from partly digested and undigested fat, carbohydrate and protein decomposition in the rumen and in manure. Sources of emission include livestock buildings, yards, and manure stores, fields to which manure is spread and fields grazed by livestock. Emissions take place from manure managed in solid form or as slurry.

NMVOC emissions from 3B - Manure management was reported for the first time to the CLRTAP/NECD in 2016, and was as such not included in the Luxembourgish emission inventory at the time the emission reduction commitments were set in 1999.

According to Decision 2012/12 2bis (a)(i) an emission source category will qualify as a new emission source category if emission estimates for that source category were introduced to the national emission inventory after the emission reduction commitment for that pollutant was set and where no methodology was provided in the EMEP/EEA air pollutant emission inventory guidebook for determining emissions from that source category at the time that the emission reduction commitment was set.

NMVOC emissions allocated in category 3B originate from animal manure, waste management systems (included in the first and second edition of the EMEP/CORINAIR Emission Inventory Guidebook under SNAP code 100500, chapter 10 agriculture). In the second edition of the Guidebook (published in 1999) no methodology for estimating NMVOC emissions from animal manure and waste was available. Hence, it can be concluded that the available guidance material for the above-mentioned sector provided no methodology for estimating NMVOC emissions from manure management. As a result, category 3B can be considered as a new emission source. Consequently, the adjustments are simply the values of these new sources (Table 331).

The current guidance recognises that there is still a high degree of uncertainty regarding NMVOC emissions from animal waste, and that available information requires review and improvement. But when a country includes NMVOC emissions from this source in their national emission inventory totals, emissions can be considered a valid case for an adjustment application as a "new" source (according to the appendix of the adjustment guidance document[127]).

[127] TFEIP 2014: Chris Dore (TFEIP Co-Chair), Yvonne Pang (UK), Leon Ntziachristos (Greece) Morten Winther (Denmark): Guidance for Parties Making Adjustment Applications and Guidance for the Expert Review of Adjustment Applications, TFEIP/11K14/CD, draft version4, November2014.

Methodology

NMVOC emissions for dairy and non-dairy cattle are estimated using the Tier 2 methodology; all other animal categories are calculated using the Tier 1 methodology from the EMEP/EEA Guidebook 2019.

For detailed information on activity data and emission factors please refer to the chapter on Agriculture (section 3.B. Manure Management).

11.3.2.2 **Agricultural soils (3D)**

NMVOC emissions from 3De – Cultivated cops were reported for the first time to the CLRTAP/NECD in 2011. In 2016, and due to a complete revision of the emission calculations for agriculture, emissions reported under 3De - Cultivated crops were completely revised. Hence, these emissions were as such not included in Luxembourg's air pollutant emission inventory at the time the emission reduction commitments were set in 1999.

According to Decision 2012/12 2bis (a)(i) an emission source category will qualify as a new emission source category if emission estimates for that source category were introduced to the national emission inventory after the emission reduction commitment for that pollutant was set and where no methodology was provided in the EMEP/EEA air pollutant emission inventory guidebook for determining emissions from that source category at the time that the emission reduction commitment was set. According to Decision 2012/12 2bis (a)(iii) an emission source may also be qualified as a new source where a methodology was available in the EMEP/EEA air pollution emission inventory guidebook at the time that the emission reduction commitment was set, only if a Party can demonstrate that it was unable to apply the methodology due to a lack of relevant national statistical data or can provide another justification why it could not make use of this methodology.

Emissions allocated in category 3De originate from crop production (included in the first and second edition of the EMEP/CORINAIR Emission Inventory Guidebook under SNAP code 100100, chapter 10 agriculture).

Version 2 of the EMEP/CORINAIR Atmospheric Emissions Inventory Guidebook (published in 1999) described for the first time a methodology to estimate NMVOC emissions from crops. Nevertheless it was too early to take these emissions into account at the time that the emission reduction commitment was set because first a thorough validation of the methodology by the national experts was required. In fact there was so much doubt about the reliability of this methodology that it was not until 2011 that these emissions were reported by Luxembourg.

These emissions are also not taken into account in the RAINS/GAINS model: not in the 1999 RAINS version, nor in the current 2015 GAINS version. As a result, category 3De can be considered as a new emission source for NMVOC. Consequently, the adjustment is simply the value of this new source (Table 331).

Methodology

Luxembourg uses the TIER 1 methodology for estimating NMVOC emissions from cultivated crops, i.e. emissions that arise from agricultural soils. To estimate NMVOC emissions, the total agricultural area of the country is required.

$$E_{NMVOC} = agricultural\ area * EF_{NMVOC}$$

The default emission factor of 0.86 kg NMVOC * ha^{-1} related to the agricultural area was taken from the EMEP/EEA Guidebook 2019 (chapter 3.D, table 3.1, p.14).

For detailed information on activity data and emission factors please refer to the chapter on Agriculture (section 3.D. Agricultural soils.

Table 331 – NMVOC emissions from the agricultural sector

NFR code	Longname	2010	2011	2012	2013	2014	2015	2016	2017	2018
3 B 1 a	3 B 1 a Manure management - Dairy cattle	1.2520	1.2296	1.2153	1.2608	1.3024	1.3758	1.4908	1.5349	1.5783
3 B 1 b	3 B 1 b Manure management - Non-dairy cattle	1.6970	1.6054	1.5456	1.5853	1.6464	1.6399	1.5706	1.5706	1.5025
3 B 2	3 B 2 Manure management - Sheep	0.0022	0.0022	0.0021	0.0022	0.0022	0.0024	0.0022	0.0021	0.0021
3 B 3	3 B 3 Manure Management - Swine	0.0361	0.0364	0.0359	0.0343	0.0342	0.0356	0.0346	0.0365	0.0344
3 B 4 a	3 B 4a Manure management - Buffalo	NO	NO	NO	NO	NO	NO	NO	NO	NO
3 B 4 d	3 B 4 d Manure management - Goats	0.0045	0.0050	0.0048	0.0043	0.0041	0.0046	0.0047	0.0049	0.0048
3 B 4 e	3 B 4 e Manure management - Horses	0.0182	0.0182	0.0193	0.0185	0.0187	0.0187	0.0180	0.0186	0.0184
3 B 4 f	3 B 4 f Manure management - Mules and asses	IE	IE	IE	IE	IE	IE	IE	IE	IE
3 B 4 g i	3 B 4 g i Manure management - Laying hens	0.0046	0.0054	0.0061	0.0061	0.0064	0.0061	0.0061	0.0065	0.0065
3 B 4 g ii	3 B 4 g ii Manure management - Broilers	0.0011	0.0011	0.0011	0.0010	0.0010	0.0012	0.0012	0.0013	0.0014
3 B 4 g iii	3 B 4 g iii Manure management - Turkeys	IE	IE	IE	IE	IE	IE	IE	IE	IE
3 B 4 g iv	3 B 4 g iv Manure management - Other poultry	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000
3 B 4 h	3 B 4 h Manure management - Other animals	0.0006	0.0007	0.0007	0.0007	0.0005	0.0006	0.0005	0.0004	0.0005
3 D e	3 D e Cultivated crops	NO	NO	NO	NO	NO	NO	NO	NO	NO
Adjustment	**Total Agriculture**	**-3.016**	**-2.904**	**-2.831**	**-2.913**	**-3.016**	**-3.085**	**-3.129**	**-3.176**	**-3.149**

11.3.3 **Recalculations affecting the adjustments**

For a detailed description of the revisions made for activity data used for nitric oxide (NO) and non-methane volatile organic compounds (NMVOC) emissions from agriculture, please refer to chapter 8 on recalculations, and specifically to section 8.1.1. **The methodology as such was not adapted.**

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<u>Agriculture:</u>

Please refer to the references provided for the chapter on agriculture (see above).

APPENDIX

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 (2017) Estimate [kt]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	SO2	0.549	54.308%	54.3%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	SO2	0.209	20.631%	74.9%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	SO2	0.106	10.446%	85.4%
1 A 3 a i (i)	Civil Aviation - Domestic - LTO	SO2	0.040	3.943%	89.3%
1 A 4 b i	Residential: stationary	SO2	0.035	3.493%	92.8%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	SO2	0.023	2.279%	95.1%
1 A 3 b iii	Road Transport, Heavy duty vehicles	SO2	0.022	2.142%	97.2%
1 A 4 a i	Commercial/Institutional: Stationary	SO2	0.010	1.029%	98.3%
1 A 3 b i	Road Transport, Passenger cars	SO2	0.010	0.984%	99.3%
1 A 3 c	Railways	SO2	0.003	0.281%	99.5%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	SO2	0.001	0.117%	99.7%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	SO2	0.001	0.105%	99.8%
1 A 3 b ii	Road Transport, Light duty vehicles	SO2	0.001	0.092%	99.9%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	SO2	0.001	0.065%	99.9%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	SO2	0.000	0.022%	99.9%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	SO2	0.000	0.015%	100.0%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	SO2	0.000	0.015%	100.0%
2 G	Other product manufacture and use	SO2	0.000	0.013%	100.0%
1 A 3 a ii (i)	Civil Aviation - International - LTO	SO2	0.000	0.009%	100.0%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	SO2	0.000	0.005%	100.0%
1 A 4 b ii	Residential: Household and gardening (mobile)	SO2	0.000	0.003%	100.0%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	SO2	0.000	0.002%	100.0%
1 A 3 d i (ii)	International inland waterways	SO2	0.00	0.0%	100.0%
1 A 3 d ii	National Navigation (Shipping)	SO2	0.00	0.0%	100.0%
1 A 5 b	Other, Mobile (including Military)	SO2	0.00	0.0%	100.0%

Trend Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2017) 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	11.23	0.21	8.076	42.6%	42.6%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	SO2	0.75	0.55	7.223	38.1%	80.8%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	SO2	0.21	0.11	1.321	7.0%	87.8%
1 A 3 a i (i)	Civil Aviation - Domestic - LTO	SO2	0.01	0.04	0.569	3.0%	90.8%
1 A 3 b iii	Road Transport, Heavy duty vehicles	SO2	0.77	0.02	0.450	2.4%	93.1%
1 A 4 a i	Commercial/Institutional: Stationary	SO2	0.58	0.01	0.420	2.2%	95.4%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	SO2	0.00	0.02	0.330	1.7%	97.1%
1 A 4 b i	Residential: stationary	SO2	0.82	0.04	0.301	1.6%	98.7%
1 A 3 b i	Road Transport, Passenger cars	SO2	0.26	0.01	0.114	0.6%	99.3%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	SO2	0.07	0.00	0.051	0.3%	99.6%
1 A 3 c	Railways	SO2	0.02	0.00	0.021	0.1%	99.7%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	SO2	0.04	0.00	0.021	0.1%	99.8%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	SO2	0.02	0.00	0.018	0.1%	99.9%
1 A 3 b ii	Road Transport, Light duty vehicles	SO2	0.02	0.00	0.007	0.0%	99.9%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	SO2	0.01	0.00	0.007	0.0%	100.0%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	SO2	0.00	0.00	0.002	0.0%	100.0%
2 G	Other product manufacture and use	SO2	0.00	0.00	0.002	0.0%	100.0%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	SO2	0.01	0.00	0.001	0.0%	100.0%
1 A 3 a ii (i)	Civil Aviation - International - LTO	SO2	0.00	0.00	0.001	0.0%	100.0%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	SO2	0.00	0.00	0.000	0.0%	100.0%
1 A 5 b	Other, Mobile (including Military)	SO2	0.00	0.00	0.000	0.0%	100.0%
1 A 4 b ii	Residential: Household and gardening (mobile)	SO2	0.00	0.00	0.000	0.0%	100.0%
1 A 3 d i (ii)	International inland waterways	SO2	0.00	0.00	0.000	0.0%	100.0%
1 A 3 d ii	National Navigation (Shipping)	SO2	0.00	0.00	0.000	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 (2017) 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	5.2333	28.5893%	28.6%
1 A 3 b iii	Road Transport, Heavy duty vehicles	NOX	4.9083	26.8136%	55.4%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	NOX	1.6705	9.1258%	64.5%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	NOX	0.8543	4.6669%	69.2%
1 A 4 b i	Residential: stationary	NOX	0.7920	4.3267%	73.5%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	NOX	0.7044	3.8482%	77.4%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	NOX	0.6959	3.8019%	81.2%
1 A 3 a i (i)	Civil Aviation - Domestic - LTO	NOX	0.5952	3.2516%	84.4%
1 A 4 a i	Commercial/Institutional: Stationary	NOX	0.5802	3.1697%	87.6%
3 D a 1	Inorganic N-fertilizers (includes also urea application)	NOX	0.5430	2.9664%	90.6%
1 A 3 b ii	Road Transport, Light duty vehicles	NOX	0.5279	2.8838%	93.4%
3 D a 2 a	Animal manure applied to soils	NOX	0.1980	1.0817%	94.5%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	NOX	0.1927	1.0529%	95.6%
3 D a 3	Urine and dung deposited by grazing animals	NOX	0.1768	0.9658%	96.5%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	NOX	0.1595	0.8715%	97.4%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	NOX	0.1036	0.5661%	98.0%
3 D a 4	Crop residues applied to soils	NOX	0.0752	0.4110%	98.4%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	NOX	0.0706	0.3855%	98.8%
1 A 3 c	Railways	NOX	0.0685	0.3743%	99.2%
3 B 1 b	Manure management - Non-dairy cattle	NOX	0.0409	0.2235%	99.4%
3 B 1 a	Manure management - Dairy cattle	NOX	0.0284	0.1552%	99.5%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	NOX	0.0242	0.1324%	99.7%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	NOX	0.0183	0.0999%	99.8%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	NOX	0.0117	0.0637%	99.8%
1 A 4 b ii	Residential: Household and gardening (mobile)	NOX	0.0089	0.0488%	99.9%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	NOX	0.0066	0.0360%	99.9%
3 D a 2 c	Other organic fertilisers applied to soils (including compost)	NOX	0.0047	0.0258%	99.9%
3 D a 2 b	Sewage sludge applied to soils	NOX	0.0031	0.0171%	100.0%
3 B 4 e	Manure management - Horses	NOX	0.0025	0.0136%	100.0%
1 A 3 d i (ii)	International inland waterways	NOX	0.0014	0.0074%	100.0%
3 B 4 g i	Manure management - Laying Hens	NOX	0.0008	0.0045%	100.0%
2 G	Other product manufacture and use	NOX	0.0007	0.0038%	100.0%
1 A 3 a ii (i)	Civil Aviation - International - LTO	NOX	0.0007	0.0036%	100.0%
3 B 3	Manure management - Swine	NOX	0.00	0.0%	100.0%
3 B 4 d	Manure management - Goats	NOX	0.00	0.0%	100.0%
1 A 5 b	Other, Mobile (including Military)	NOX	0.00	0.0%	100.0%
3 B 2	Manure management - Sheep	NOX	0.00	0.0%	100.0%
1 A 3 d ii	National Navigation (Shipping)	NOX	0.00	0.0%	100.0%
3 B 4 g ii	Manure management - Broilers	NOX	0	0.0%	100.0%
3 B 4 h	Manure management - Other animals (please specify in IIR)	NOX	0	0.0%	100.0%
3 B 4 g iv	Manure management - Other Poultry	NOX	0	0.0%	100.0%

Trend Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2017) 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	NOX	6.84	0.70	0.286	30.2%	30.2%
1 A 3 b iii	Road Transport, Heavy duty vehicles	NOX	13.85	4.91	0.149	15.8%	45.9%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	NOX	0.03	0.70	0.084	8.9%	54.8%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	NOX	0.54	0.85	0.076	8.0%	62.8%
1 A 3 a i (i)	Civil Aviation - Domestic - LTO	NOX	0.14	0.60	0.066	6.9%	69.8%
1 A 4 b i	Residential: stationary	NOX	0.62	0.79	0.064	6.7%	76.5%
1 A 3 b ii	Road Transport, Light duty vehicles	NOX	0.28	0.53	0.050	5.3%	81.8%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	NOX	0.82	0.10	0.032	3.4%	85.2%
1 A 4 a i	Commercial/Institutional: Stationary	NOX	0.84	0.58	0.026	2.7%	87.9%
3 D a 1	Inorganic N-fertilizers (includes also urea application)	NOX	0.79	0.54	0.024	2.5%	90.4%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	NOX	3.37	1.67	0.023	2.4%	92.8%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	NOX	0.10	0.16	0.014	1.5%	94.3%
3 D a 2 a	Animal manure applied to soils	NOX	0.22	0.20	0.012	1.3%	95.6%
3 D a 3	Urine and dung deposited by grazing animals	NOX	0.18	0.18	0.012	1.3%	96.9%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	NOX	0.33	0.19	0.006	0.6%	97.5%
3 D a 4	Crop residues applied to soils	NOX	0.06	0.08	0.006	0.6%	98.1%
1 A 3 c	Railways	NOX	0.26	0.07	0.006	0.6%	98.7%
3 B 1 b	Manure management - Non-dairy cattle	NOX	0.05	0.04	0.002	0.3%	99.0%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	NOX	0.02	0.02	0.002	0.2%	99.2%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	NOX	0.01	0.02	0.002	0.2%	99.4%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	NOX	0.14	0.07	0.001	0.1%	99.5%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	NOX	0.01	0.01	0.001	0.1%	99.6%
1 A 4 b ii	Residential: Household and gardening (mobile)	NOX	0.01	0.01	0.001	0.1%	99.7%
1 A 3 b i	Road Transport, Passenger cars	NOX	11.86	5.23	0.001	0.1%	99.8%
3 D a 2 c	Other organic fertilisers applied to soils (including compost)	NOX	0.00	0.00	0.001	0.1%	99.8%
3 B 1 a	Manure management - Dairy cattle	NOX	0.05	0.03	0.001	0.1%	99.9%
3 D a 2 b	Sewage sludge applied to soils	NOX	0.01	0.00	0.000	0.0%	99.9%
3 B 4 e	Manure management - Horses	NOX	0.00	0.00	0.000	0.0%	99.9%
1 A 3 d i (ii)	International inland waterways	NOX	0.00	0.00	0.000	0.0%	100.0%
3 B 4 g i	Manure management - Laying Hens	NOX	0.00	0.00	0.000	0.0%	100.0%
3 B 4 d	Manure management - Goats	NOX	0.00	0.00	0.000	0.0%	100.0%
1 A 3 a ii (i)	Civil Aviation - International - LTO	NOX	0.00	0.00	0.000	0.0%	100.0%
2 G	Other product manufacture and use	NOX	0.00	0.00	0.000	0.0%	100.0%
3 B 3	Manure management - Swine	NOX	0.00	0.00	0.000	0.0%	100.0%
1 A 5 b	Other, Mobile (including Military)	NOX	0.00	0.00	0.000	0.0%	100.0%
3 B 2	Manure management - Sheep	NOX	0.00	0.00	0.000	0.0%	100.0%
3 B 4 g ii	Manure management - Broilers	NOX	0.00	0.00	0.000	0.0%	100.0%
1 A 3 d ii	National Navigation (Shipping)	NOX	0.00	0.00	0.000	0.0%	100.0%
3 B 4 h	Manure management - Other animals (please specify in IIR)	NOX	0.00	0.00	0.000	0.0%	100.0%
3 B 4 g iv	Manure management - Other Poultry	NOX	0.00	0.00	0.000	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 (2017) 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	2.23	18.418%	18.4%
3 B 1 b	Manure management - Non-dairy cattle	NMVOC	1.60	13.215%	31.6%
3 B 1 a	Manure management - Dairy cattle	NMVOC	1.59	13.119%	44.8%
2 D 3 e	Degreasing	NMVOC	1.44	11.884%	56.6%
2 D 3 d	Coating application	NMVOC	1.28	10.568%	67.2%
1 A 3 b i	Road Transport, Passenger cars	NMVOC	0.59	4.905%	72.1%
1 A 4 b i	Residential: stationary	NMVOC	0.42	3.506%	75.6%
2 D 3 g	Chemical products	NMVOC	0.39	3.247%	78.9%
1 B 2 b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)	NMVOC	0.36	2.945%	81.8%
1 B 2 a v	Distribution of oil products	NMVOC	0.29	2.417%	84.2%
2 H 2	Food and beverages industry	NMVOC	0.25	2.068%	86.3%
2 D 3 i	Other solvent use	NMVOC	0.23	1.878%	88.2%
2 D 3 h	Printing	NMVOC	0.17	1.393%	89.6%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	NMVOC	0.16	1.342%	90.9%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	NMVOC	0.12	0.957%	91.9%
3 D e	Cultivated crops	NMVOC	0.11	0.932%	92.8%
1 A 3 b iii	Road Transport, Heavy duty vehicles	NMVOC	0.11	0.886%	93.7%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	NMVOC	0.10	0.846%	94.5%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	NMVOC	0.09	0.752%	95.3%
1 A 3 b v	Road Transport, Gasoline evaporation	NMVOC	0.09	0.722%	96.0%
1 A 4 b ii	Residential: Household and gardening (mobile)	NMVOC	0.08	0.620%	96.6%
1 A 4 a i	Commercial/Institutional: Stationary	NMVOC	0.06	0.503%	97.1%
1 A 3 a i (i)	Civil Aviation - Domestic - LTO	NMVOC	0.05	0.411%	97.5%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	NMVOC	0.04	0.369%	97.9%
3 B 3	Manure management - Swine	NMVOC	0.04	0.368%	98.3%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	NMVOC	0.03	0.273%	98.5%
2 D 3 f	Dry cleaning	NMVOC	0.03	0.237%	98.8%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in	NMVOC	0.03	0.212%	99.0%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	NMVOC	0.02	0.181%	99.2%
3 B 4 e	Manure management - Horses	NMVOC	0.02	0.154%	99.3%
5 A	Biological treatment of waste - Solid waste disposal on land	NMVOC	0.02	0.146%	99.5%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	NMVOC	0.01	0.101%	99.6%
1 A 3 b ii	Road Transport, Light duty vehicles	NMVOC	0.01	0.076%	99.6%
1 A 3 c	Railways	NMVOC	0.01	0.055%	99.7%
3 B 4 g i	Manure management - Laying Hens	NMVOC	0.01	0.054%	99.8%
1 A 3 d ii	National Navigation (Shipping)	NMVOC	0.00	0.041%	99.8%
3 B 4 d	Manure management - Goats	NMVOC	0.00	0.041%	99.8%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Bevera	NMVOC	0.00	0.038%	99.9%
1 A 3 a ii (i)	Civil Aviation - International - LTO	NMVOC	0.00	0.033%	99.9%
2 D 3 b	Road paving with asphalt	NMVOC	0.00	0.033%	99.9%
3 B 2	Manure management - Sheep	NMVOC	0.00	0.018%	100.0%
2 G	Other product manufacture and use	NMVOC	0.00	0.015%	100.0%
3 B 4 g ii	Manure management - Broilers	NMVOC	0.00	0.011%	100.0%
5 D 1	Domestic wastewater handling	NMVOC	0.00	0.004%	100.0%
3 B 4 h	Manure management - Other animals (please specify in IIR)	NMVOC	0.00	0.003%	100.0%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	NMVOC	0.00	0.002%	100.0%
1 A 3 d i (ii)	International inland waterways	NMVOC	0.00	0.002%	100.0%
3 B 4 g iv	Manure management - Other Poultry	NMVOC	0.00	0.001%	100.0%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	NMVOC	0.00	0.000%	100.0%
1 A 5 b	Other, Mobile (including Military)	NMVOC	0.00	0.000%	100.0%
5 D 2	Industrial wastewater handling	NMVOC	0.00	0.000%	100.0%

Trend Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2017) 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	11.05	0.59	0.806	33.901%	33.9%
1 A 3 b v	Road Transport, Gasoline evaporation	NMVOC	4.01	0.09	0.315	13.267%	47.2%
2 D 3 a	Domestic solvent use including fungicides	NMVOC	1.13	2.23	0.310	13.059%	60.2%
2 D 3 e	Degreasing	NMVOC	0.91	1.44	0.185	7.795%	68.0%
3 B 1 a	Manure management - Dairy cattle	NMVOC	1.49	1.59	0.164	6.906%	74.9%
3 B 1 b	Manure management - Non-dairy cattle	NMVOC	1.62	1.60	0.156	6.566%	81.5%
2 D 3 d	Coating application	NMVOC	1.45	1.28	0.112	4.697%	86.2%
1 B 2 b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)	NMVOC	0.22	0.36	0.046	1.949%	88.1%
1 A 4 b i	Residential: stationary	NMVOC	0.50	0.42	0.036	1.503%	89.6%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	NMVOC	0.00	0.16	0.029	1.233%	90.9%
2 D 3 i	Other solvent use	NMVOC	0.16	0.23	0.028	1.183%	92.1%
2 H 2	Food and beverages industry	NMVOC	0.23	0.25	0.026	1.105%	93.2%
1 B 2 a v	Distribution of oil products	NMVOC	0.40	0.29	0.020	0.849%	94.0%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	NMVOC	0.00	0.09	0.016	0.685%	94.7%
1 A 3 b iii	Road Transport, Heavy duty vehicles	NMVOC	0.42	0.11	0.016	0.656%	95.4%
2 D 3 h	Printing	NMVOC	0.53	0.17	0.013	0.566%	95.9%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	NMVOC	0.10	0.12	0.012	0.521%	96.4%
3 D e	Cultivated crops	NMVOC	0.11	0.11	0.011	0.482%	96.9%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	NMVOC	0.36	0.10	0.011	0.476%	97.4%
1 A 3 b ii	Road Transport, Light duty vehicles	NMVOC	0.12	0.01	0.008	0.346%	97.7%
1 A 3 a i (i)	Civil Aviation - Domestic - LTO	NMVOC	0.01	0.05	0.008	0.337%	98.1%
1 A 4 b ii	Residential: Household and gardening (mobile)	NMVOC	0.26	0.08	0.008	0.331%	98.4%
2 D 3 g	Chemical products	NMVOC	0.81	0.39	0.005	0.191%	98.6%
3 B 3	Manure management - Swine	NMVOC	0.05	0.04	0.004	0.174%	98.8%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	NMVOC	0.07	0.01	0.004	0.161%	98.9%
2 D 3 f	Dry cleaning	NMVOC	0.02	0.03	0.004	0.151%	99.1%
1 A 4 a i	Commercial/Institutional: Stationary	NMVOC	0.09	0.06	0.003	0.142%	99.2%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	NMVOC	0.01	0.02	0.003	0.128%	99.4%
1 A 3 c	Railways	NMVOC	0.05	0.01	0.003	0.123%	99.5%
3 B 4 e	Manure management - Horses	NMVOC	0.01	0.02	0.003	0.118%	99.6%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	NMVOC	0.09	0.03	0.003	0.117%	99.7%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	NMVOC	0.06	0.03	0.001	0.045%	99.8%
3 B 4 d	Manure management - Goats	NMVOC	0.00	0.00	0.001	0.037%	99.8%
3 B 4 g i	Manure management - Laying Hens	NMVOC	0.00	0.01	0.001	0.037%	99.8%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Bevera	NMVOC	0.00	0.00	0.001	0.027%	99.9%
1 A 3 a ii (i)	Civil Aviation - International - LTO	NMVOC	0.00	0.00	0.001	0.025%	99.9%
1 A 3 d ii	National Navigation (Shipping)	NMVOC	0.02	0.00	0.001	0.024%	99.9%
5 A	Biological treatment of waste - Solid waste disposal on land	NMVOC	0.03	0.02	0.001	0.024%	99.9%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	NMVOC	0.10	0.04	0.001	0.024%	100.0%
3 B 2	Manure management - Sheep	NMVOC	0.00	0.00	0.000	0.011%	100.0%
2 G	Other product manufacture and use	NMVOC	0.00	0.00	0.000	0.008%	100.0%
3 B 4 g ii	Manure management - Broilers	NMVOC	0.00	0.00	0.000	0.008%	100.0%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	NMVOC	0.00	0.00	0.000	0.005%	100.0%
5 D 1	Domestic wastewater handling	NMVOC	0.00	0.00	0.000	0.002%	100.0%
2 D 3 b	Road paving with asphalt	NMVOC	0.01	0.00	0.000	0.002%	100.0%
1 A 3 d i (ii)	International inland waterways	NMVOC	0.00	0.00	0.000	0.001%	100.0%
1 A 5 b	Other, Mobile (including Military)	NMVOC	0.00	0.00	0.000	0.000%	100.0%
3 B 4 h	Manure management - Other animals (please specify in IIR)	NMVOC	0.00	0.00	0.000	0.000%	100.0%
3 B 4 g iv	Manure management - Other Poultry	NMVOC	0.00	0.00	0.000	0.000%	100.0%
5 D 2	Industrial wastewater handling	NMVOC	0.00	0	0.000	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 (2017) 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	1.866	32.151%	32.2%
3 B 1 b	Manure management - Non-dairy cattle	NH3	1.168	20.126%	52.3%
3 B 1 a	Manure management - Dairy cattle	NH3	1.145	19.726%	72.0%
3 D a 1	Inorganic N-fertilizers (includes also urea application)	NH3	0.679	11.692%	83.7%
3 D a 3	Urine and dung deposited by grazing animals	NH3	0.278	4.785%	88.5%
3 B 3	Manure management - Swine	NH3	0.186	3.202%	91.7%
1 A 3 b i	Road Transport, Passenger cars	NH3	0.182	3.141%	94.8%
3 B 4 e	Manure management - Horses	NH3	0.058	1.005%	95.8%
1 A 4 b i	Residential: stationary	NH3	0.051	0.884%	96.7%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	NH3	0.051	0.871%	97.6%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	NH3	0.027	0.464%	98.0%
3 B 4 g i	Manure management - Laying Hens	NH3	0.025	0.436%	98.5%
5 D 1	Domestic wastewater handling	NH3	0.024	0.420%	98.9%
3 B 4 d	Manure management - Goats	NH3	0.012	0.202%	99.1%
5 B 1	Composting	NH3	0.011	0.189%	99.3%
1 A 3 b iii	Road Transport, Heavy duty vehicles	NH3	0.010	0.176%	99.5%
3 D a 2 b	Sewage sludge applied to soils	NH3	0.010	0.175%	99.6%
3 D a 2 c	Other organic fertilisers applied to soils (including compost)	NH3	0.009	0.163%	99.8%
3 B 2	Manure management - Sheep	NH3	0.004	0.073%	99.9%
3 B 4 g ii	Manure management - Broilers	NH3	0.002	0.031%	99.9%
2 G	Other product manufacture and use	NH3	0.002	0.027%	99.9%
1 A 3 b ii	Road Transport, Light duty vehicles	NH3	0.001	0.023%	100.0%
3 B 4 h	Manure management - Other animals (please specify in IIR)	NH3	0.001	0.021%	100.0%
3 B 4 g iv	Manure management - Other Poultry	NH3	0.000	0.008%	100.0%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	NH3	0.000	0.005%	100.0%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	NH3	0.000	0.002%	100.0%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	NH3	0.000	0.001%	100.0%
1 A 4 a i	Commercial/Institutional: Stationary	NH3	0.000	0.001%	100.0%
1 A 3 c	Railways	NH3	0.000	0.000%	100.0%
1 A 4 b ii	Residential: Household and gardening (mobile)	NH3	0.000	0.000%	100.0%
1 A 3 d i (ii)	International inland waterways	NH3	0.000	0.000%	100.0%
1 A 3 d i (ii)	International inland waterways	NH3	0.000	0.000%	100.0%
1 A 3 d ii	National Navigation (Shipping)	NH3	0.000	0.000%	100.0%

Trend Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2017) 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	0.98	0.68	0.042	26.467%	26.5%
1 A 3 b i	Road Transport, Passenger cars	NH3	0.01	0.18	0.032	20.373%	46.8%
3 B 1 a	Manure management - Dairy cattle	NH3	1.42	1.15	0.028	18.045%	64.9%
3 B 3	Manure management - Swine	NH3	0.14	0.19	0.012	7.313%	72.2%
3 B 4 e	Manure management - Horses	NH3	0.02	0.06	0.007	4.638%	76.8%
3 D a 3	Urine and dung deposited by grazing animals	NH3	0.26	0.28	0.007	4.499%	81.3%
3 D a 2 b	Sewage sludge applied to soils	NH3	0.05	0.01	0.006	4.062%	85.4%
3 D a 2 a	Animal manure applied to soils	NH3	2.08	1.87	0.006	3.946%	89.3%
5 D 1	Domestic wastewater handling	NH3	0.05	0.02	0.004	2.332%	91.7%
3 B 4 g i	Manure management - Laying Hens	NH3	0.01	0.03	0.002	1.448%	93.1%
3 B 1 b	Manure management - Non-dairy cattle	NH3	1.26	1.17	0.002	1.406%	94.5%
3 B 4 d	Manure management - Goats	NH3	0.00	0.01	0.002	1.374%	95.9%
1 A 4 b i	Residential: stationary	NH3	0.05	0.05	0.002	1.191%	97.1%
3 D a 2 c	Other organic fertilisers applied to soils (including compost)	NH3	0.00	0.01	0.002	1.125%	98.2%
1 A 3 b iii	Road Transport, Heavy duty vehicles	NH3	0.00	0.01	0.001	0.935%	99.2%
3 B 4 h	Manure management - Other animals (please specify in IIR)	NH3	0.00	0.00	0.001	0.374%	99.5%
3 B 2	Manure management - Sheep	NH3	0.00	0.00	0.000	0.165%	99.7%
3 B 4 g ii	Manure management - Broilers	NH3	0.00	0.00	0.000	0.111%	99.8%
1 A 3 b ii	Road Transport, Light duty vehicles	NH3	0.00	0.00	0.000	0.102%	99.9%
3 B 4 g iv	Manure management - Other Poultry	NH3	0.00	0.00	0.000	0.035%	99.9%
2 G	Other product manufacture and use	NH3	0.00	0.00	0.000	0.022%	100.0%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	NH3	0.00	0.00	0.000	0.012%	100.0%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion	NH3	0.00	0.00	0.000	0.011%	100.0%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	NH3	0.00	0.00	0.000	0.008%	100.0%
1 A 3 c	Railways	NH3	0.00	0.00	0.000	0.007%	100.0%
1 A 4 b ii	Residential: Household and gardening (mobile)	NH3	0.00	0.00	0.000	0.000%	100.0%
1 A 3 d ii	National Navigation (Shipping)	NH3	0.00	0.00	0.000	0.000%	100.0%
1 A 3 d i (ii)	International inland waterways	NH3	0.00	0.00	0.000	0.000%	100.0%
1 A 3 d i (ii)	International inland waterways	NH3	0.00	0.00	0.000	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 (2017) 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	5.65	25.6%	25.6%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	CO	4.34	19.7%	45.3%
1 A 4 b i	Residential: stationary	CO	3.09	14.0%	59.3%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic	CO	2.40	10.9%	70.2%
1 A 3 b iii	Road Transport, Heavy duty vehicles	CO	1.92	8.7%	78.8%
1 A 4 b ii	Residential: Household and gardening (mobile)	CO	1.02	4.6%	83.5%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	CO	0.66	3.0%	86.5%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	CO	0.61	2.8%	89.2%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary	CO	0.58	2.6%	91.9%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion	CO	0.46	2.1%	94.0%
1 A 3 a i (i)	Civil Aviation - Domestic - LTO	CO	0.46	2.1%	96.1%
1 A 4 a i	Commercial/Institutional: Stationary	CO	0.28	1.3%	97.3%
1 A 3 a ii (i)	Civil Aviation - International - LTO	CO	0.17	0.8%	98.1%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other	CO	0.17	0.8%	98.8%
1 A 3 b ii	Road Transport, Light duty vehicles	CO	0.09	0.4%	99.2%
1 A 3 c	Railways	CO	0.05	0.2%	99.4%
1 A 3 d ii	National Navigation (Shipping)	CO	0.03	0.2%	99.6%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	CO	0.03	0.1%	99.7%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	CO	0.02	0.1%	99.8%
2 G	Other product manufacture and use	CO	0.02	0.1%	99.9%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	CO	0.01	0.0%	100.0%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	CO	0.00	0.0%	100.0%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	CO	0.00	0.0%	100.0%
1 A 3 d i (ii)	International inland waterways	CO	0.00	0.0%	100.0%
1 A 5 b	Other, Mobile (including Military)	CO	0.00	0.0%	100.0%

Trend Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2017) 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	4.34	11.550	50.0%	50.0%
1 A 4 b i	Residential: stationary	CO	3.99	3.09	2.777	12.0%	62.0%
1 A 3 b i	Road Transport, Passenger cars	CO	78.86	5.65	1.835	7.9%	70.0%
1 A 3 b iii	Road Transport, Heavy duty vehicles	CO	1.55	1.92	1.764	7.6%	77.6%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic	CO	30.11	2.40	0.935	4.0%	81.7%
1 A 4 b ii	Residential: Household and gardening (mobile)	CO	1.24	1.02	0.925	4.0%	85.7%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	CO	0.01	0.66	0.632	2.7%	88.4%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	CO	0.41	0.61	0.564	2.4%	90.8%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary	CO	0.18	0.58	0.546	2.4%	93.2%
1 A 3 a i (i)	Civil Aviation - Domestic - LTO	CO	0.11	0.46	0.438	1.9%	95.1%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion	CO	0.59	0.46	0.418	1.8%	96.9%
1 A 4 a i	Commercial/Institutional: Stationary	CO	0.32	0.28	0.254	1.1%	98.0%
1 A 3 a ii (i)	Civil Aviation - International - LTO	CO	0.06	0.17	0.159	0.7%	98.7%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other	CO	0.45	0.17	0.139	0.6%	99.3%
1 A 3 c	Railways	CO	0.28	0.05	0.031	0.1%	99.4%
1 A 3 d ii	National Navigation (Shipping)	CO	0.09	0.03	0.029	0.1%	99.6%
1 A 3 b ii	Road Transport, Light duty vehicles	CO	1.21	0.09	0.027	0.1%	99.7%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	CO	0.02	0.03	0.025	0.1%	99.8%
2 G	Other product manufacture and use	CO	0.02	0.02	0.019	0.1%	99.9%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	CO	0.13	0.02	0.018	0.1%	99.9%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	CO	0.00	0.01	0.007	0.0%	100.0%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	CO	0.00	0.00	0.003	0.0%	100.0%
1 A 3 d i (ii)	International inland waterways	CO	0.00	0.00	0.001	0.0%	100.0%
1 A 5 b	Other, Mobile (including Military)	CO	0.00	0.00	0.000	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 (2017) Estimate [kt]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
1 A 4 b i	Residential: stationary	TSP	0.56	18.7%	18.7%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	TSP	0.48	16.2%	34.9%
1 A 3 b vii	Road Transport, Automobile road abrasion	TSP	0.45	15.2%	50.1%
2 A 5 b	Construction and demolition	TSP	0.37	12.6%	62.7%
2 D 3 b	Road paving with asphalt	TSP	0.26	8.9%	71.7%
3 D a 1	Inorganic N-fertilizers (includes also urea application)	TSP	0.20	6.9%	78.6%
3 B 1 b	Manure management - Non-dairy cattle	TSP	0.08	2.6%	81.2%
5 E	Other waste (please specify in IIR)	TSP	0.08	2.5%	83.7%
3 B 1 a	Manure management - Dairy cattle	TSP	0.07	2.2%	86.0%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	TSP	0.06	2.0%	88.0%
1 A 3 b iii	Road Transport, Heavy duty vehicles	TSP	0.06	2.0%	89.9%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	TSP	0.05	1.5%	91.5%
1 A 3 b i	Road Transport, Passenger cars	TSP	0.04	1.3%	92.7%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	TSP	0.03	1.1%	93.8%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	TSP	0.03	1.0%	94.8%
3 B 3	Manure management - Swine	TSP	0.02	0.8%	95.6%
3 B 4 g i	Manure management - Laying Hens	TSP	0.02	0.7%	96.2%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	TSP	0.02	0.6%	96.9%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	TSP	0.02	0.6%	97.5%
2 G	Other product manufacture and use	TSP	0.02	0.5%	98.0%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other	TSP	0.01	0.5%	98.4%
1 A 3 b ii	Road Transport, Light duty vehicles	TSP	0.01	0.5%	98.9%
1 A 3 c	Railways	TSP	0.00	0.2%	99.1%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	TSP	0.00	0.2%	99.2%
3 B 2	Manure management - Sheep	TSP	0.00	0.1%	99.4%
1 A 3 a i (i)	Civil Aviation - Domestic - LTO	TSP	0.00	0.1%	99.5%
1 A 4 a i	Commercial/Institutional: Stationary	TSP	0.00	0.1%	99.6%
3 B 4 e	Manure management - Horses	TSP	0.00	0.1%	99.7%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	TSP	0.00	0.1%	99.7%
5 A	Biological treatment of waste - Solid waste disposal on land	TSP	0.00	0.1%	99.8%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	TSP	0.00	0.1%	99.9%
1 B 1 a	Coal Mining and Handling	TSP	0.00	0.0%	99.9%
3 B 4 g ii	Manure management - Broilers	TSP	0.00	0.0%	99.9%
3 B 4 d	Manure management - Goats	TSP	0.00	0.0%	100.0%
1 A 4 b ii	Residential: Household and gardening (mobile)	TSP	0.00	0.0%	100.0%
1 A 3 d i (ii)	International inland waterways	TSP	0.00	0.0%	100.0%
3 B 4 g iv	Manure management - Other Poultry	TSP	0.00	0.0%	100.0%
3 B 4 h	Manure management - Other animals (please specify in IIR)	TSP	0.00	0.0%	100.0%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	TSP	0	0.0%	100.0%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	TSP	0	0.0%	100.0%
1 A 3 a ii (i)	Civil Aviation - International - LTO	TSP	0	0.0%	100.0%
1 A 3 d ii	National Navigation (Shipping)	TSP	0	0.0%	100.0%
1 A 5 b	Other, Mobile (including Military)	TSP	0	0.0%	100.0%

Trend Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2017) 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	4.615	48.6%	48.6%
1 A 4 b i	Residential: stationary	TSP	0.63	0.56	0.887	9.3%	57.9%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	TSP	0.20	0.48	0.881	9.3%	67.2%
1 A 3 b vii	Road Transport, Automobile road abrasion	TSP	0.17	0.45	0.831	8.7%	75.9%
2 A 5 b	Construction and demolition	TSP	0.40	0.37	0.602	6.3%	82.2%
2 D 3 b	Road paving with asphalt	TSP	0.24	0.26	0.444	4.7%	86.9%
3 D a 1	Inorganic N-fertilizers (includes also urea application)	TSP	0.20	0.20	0.338	3.6%	90.5%
5 E	Other waste (please specify in IIR)	TSP	0.03	0.08	0.138	1.4%	91.9%
3 B 1 b	Manure management - Non-dairy cattle	TSP	0.08	0.08	0.128	1.3%	93.3%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	TSP	0.00	0.06	0.117	1.2%	94.5%
3 B 1 a	Manure management - Dairy cattle	TSP	0.08	0.07	0.103	1.1%	95.6%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	TSP	0.00	0.03	0.061	0.6%	96.2%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	TSP	0.00	0.03	0.057	0.6%	96.8%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	TSP	0.41	0.05	0.049	0.5%	97.3%
3 B 3	Manure management - Swine	TSP	0.02	0.02	0.042	0.4%	97.8%
1 A 3 b i	Road Transport, Passenger cars	TSP	0.33	0.04	0.037	0.4%	98.2%
3 B 4 g i	Manure management - Laying Hens	TSP	0.01	0.02	0.035	0.4%	98.5%
1 A 3 b iii	Road Transport, Heavy duty vehicles	TSP	0.43	0.06	0.032	0.3%	98.9%
2 G	Other product manufacture and use	TSP	0.01	0.02	0.026	0.3%	99.1%
1 A 3 b ii	Road Transport, Light duty vehicles	TSP	0.03	0.01	0.017	0.2%	99.3%
1 A 3 c	Railways	TSP	0.06	0.00	0.011	0.1%	99.4%
1 A 3 a i (i)	Civil Aviation - Domestic - LTO	TSP	0.00	0.00	0.008	0.1%	99.5%
3 B 2	Manure management - Sheep	TSP	0.00	0.00	0.008	0.1%	99.6%
1 B 1 a	Coal Mining and Handling	TSP	0.03	0.00	0.007	0.1%	99.7%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	TSP	0.09	0.02	0.005	0.0%	99.7%
3 B 4 e	Manure management - Horses	TSP	0.00	0.00	0.004	0.0%	99.8%
1 A 4 a i	Commercial/Institutional: Stationary	TSP	0.00	0.00	0.004	0.0%	99.8%
5 A	Biological treatment of waste - Solid waste disposal on land	TSP	0.00	0.00	0.004	0.0%	99.8%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Bev	TSP	0.00	0.00	0.004	0.0%	99.9%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machiner	TSP	0.07	0.01	0.003	0.0%	99.9%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	TSP	0.00	0.00	0.003	0.0%	99.9%
3 B 4 g ii	Manure management - Broilers	TSP	0.00	0.00	0.002	0.0%	100.0%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	TSP	0.03	0.00	0.001	0.0%	100.0%
3 B 4 d	Manure management - Goats	TSP	0.00	0.00	0.001	0.0%	100.0%
1 A 4 b ii	Residential: Household and gardening (mobile)	TSP	0.00	0.00	0.001	0.0%	100.0%
1 A 3 d i (ii)	International inland waterways	TSP	0.00	0.00	0.000	0.0%	100.0%
3 B 4 g iv	Manure management - Other Poultry	TSP	0.00	0.00	0.000	0.0%	100.0%
3 B 4 h	Manure management - Other animals (please specify in IIR)	TSP	0.00	0.00	0.000	0.0%	100.0%
1 A 3 a ii (i)	Civil Aviation - International - LTO	TSP	0.00	0.00	0.000	0.0%	100.0%
1 A 5 b	Other, Mobile (including Military)	TSP	0.00	0.00	0.000	0.0%	100.0%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	TSP	0.00	0.00	0.000	0.0%	100.0%
1 A 3 d ii	National Navigation (Shipping)	TSP	0.00	0.00	0.000	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 (2017) Estimate [kt] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1 A 4 b i	Residential: stationary	PM10	0.53	26.3%	26.3%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	PM10	0.35	17.6%	43.9%
1 A 3 b vii	Road Transport, Automobile road abrasion	PM10	0.22	11.2%	55.1%
3 D a 1	Inorganic N-fertilizers (includes also urea application)	PM10	0.20	10.2%	65.3%
2 A 5 b	Construction and demolition	PM10	0.11	5.6%	70.9%
5 E	Other waste (please specify in IIR)	PM10	0.08	3.8%	74.7%
2 D 3 b	Road paving with asphalt	PM10	0.06	3.1%	77.7%
1 A 3 b iii	Road Transport, Heavy duty vehicles	PM10	0.06	2.9%	80.6%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	PM10	0.06	2.8%	83.4%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	PM10	0.05	2.3%	85.7%
1 A 3 b i	Road Transport, Passenger cars	PM10	0.04	1.9%	87.5%
3 B 1 b	Manure management - Non-dairy cattle	PM10	0.04	1.8%	89.3%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	PM10	0.03	1.6%	90.9%
3 B 1 a	Manure management - Dairy cattle	PM10	0.03	1.5%	92.4%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	PM10	0.03	1.4%	93.8%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	PM10	0.02	0.9%	94.7%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	PM10	0.02	0.9%	95.6%
2 G	Other product manufacture and use	PM10	0.01	0.7%	96.3%
1 A 4 a i	Commercial/Institutional: Stationary	PM10	0.01	0.7%	97.1%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	PM10	0.01	0.7%	97.7%
1 A 3 b ii	Road Transport, Light duty vehicles	PM10	0.01	0.7%	98.4%
3 B 3	Manure management - Swine	PM10	0.01	0.3%	98.7%
1 A 3 c	Railways	PM10	0.00	0.2%	98.9%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	PM10	0.00	0.2%	99.1%
3 B 4 g i	Manure management - Laying Hens	PM10	0.00	0.2%	99.3%
1 A 3 a i (i)	Civil Aviation - Domestic - LTO	PM10	0.00	0.2%	99.5%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	PM10	0.00	0.1%	99.6%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	PM10	0.00	0.1%	99.7%
3 B 2	Manure management - Sheep	PM10	0.00	0.1%	99.8%
3 B 4 e	Manure management - Horses	PM10	0.00	0.1%	99.8%
5 A	Biological treatment of waste - Solid waste disposal on land	PM10	0.00	0.0%	99.9%
1 B 1 a	Coal Mining and Handling	PM10	0.00	0.0%	99.9%
3 B 4 g ii	Manure management - Broilers	PM10	0.00	0.0%	99.9%
1 A 4 b ii	Residential: Household and gardening (mobile)	PM10	0.00	0.0%	100.0%
3 B 4 d	Manure management - Goats	PM10	0.00	0.0%	100.0%
1 A 3 d i (ii)	International inland waterways	PM10	0.00	0.0%	100.0%
3 B 4 g iv	Manure management - Other Poultry	PM10	0.00	0.0%	100.0%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	PM10	0.00	0.0%	100.0%
3 B 4 h	Manure management - Other animals (please specify in IIR)	PM10	0	0.0%	100.0%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	PM10	0	0.0%	100.0%
1 A 3 a ii (i)	Civil Aviation - International - LTO	PM10	0	0.0%	100.0%
1 A 3 d ii	National Navigation (Shipping)	PM10	0	0.0%	100.0%
1 A 5 b	Other, Mobile (including Military)	PM10	0	0.0%	100.0%

Trend Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt] $E_{x,0}$	Latest Year (2017) 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	13.77	0.02	6.798	49.7%	49.7%
1 A 4 b i	Residential: stationary	PM10	0.59	0.53	1.885	13.8%	63.5%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	PM10	0.15	0.35	1.383	10.1%	73.6%
1 A 3 b vii	Road Transport, Automobile road abrasion	PM10	0.09	0.22	0.885	6.5%	80.1%
3 D a 1	Inorganic N-fertilizers (includes also urea application)	PM10	0.20	0.20	0.747	5.5%	85.5%
2 A 5 b	Construction and demolition	PM10	0.12	0.11	0.401	2.9%	88.5%
5 E	Other waste (please specify in IIR)	PM10	0.03	0.08	0.295	2.2%	90.6%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	PM10	0.00	0.06	0.233	1.7%	92.3%
2 D 3 b	Road paving with asphalt	PM10	0.05	0.06	0.225	1.6%	94.0%
3 B 1 b	Manure management - Non-dairy cattle	PM10	0.04	0.04	0.130	1.0%	94.9%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	PM10	0.00	0.03	0.128	0.9%	95.8%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	PM10	0.00	0.03	0.115	0.8%	96.7%
3 B 1 a	Manure management - Dairy cattle	PM10	0.04	0.03	0.106	0.8%	97.5%
2 G	Other product manufacture and use	PM10	0.01	0.01	0.055	0.4%	97.9%
1 A 4 a i	Commercial/Institutional: Stationary	PM10	0.02	0.01	0.049	0.4%	98.2%
1 A 3 b ii	Road Transport, Light duty vehicles	PM10	0.03	0.01	0.042	0.3%	98.5%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	PM10	0.09	0.02	0.029	0.2%	98.7%
1 A 3 b iii	Road Transport, Heavy duty vehicles	PM10	0.43	0.06	0.023	0.2%	98.9%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	PM10	0.07	0.01	0.021	0.2%	99.1%
3 B 3	Manure management - Swine	PM10	0.00	0.01	0.019	0.1%	99.2%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	PM10	0.41	0.05	0.018	0.1%	99.3%
1 A 3 a i (i)	Civil Aviation - Domestic - LTO	PM10	0.00	0.00	0.016	0.1%	99.5%
3 B 4 g i	Manure management - Laying Hens	PM10	0.00	0.00	0.016	0.1%	99.6%
1 A 3 c	Railways	PM10	0.06	0.00	0.010	0.1%	99.6%
1 A 3 b i	Road Transport, Passenger cars	PM10	0.33	0.04	0.010	0.1%	99.7%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	PM10	0.00	0.00	0.007	0.0%	99.8%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	PM10	0.00	0.00	0.006	0.0%	99.8%
3 B 2	Manure management - Sheep	PM10	0.00	0.00	0.005	0.0%	99.8%
3 B 4 e	Manure management - Horses	PM10	0.00	0.00	0.004	0.0%	99.9%
5 A	Biological treatment of waste - Solid waste disposal on land	PM10	0.00	0.00	0.004	0.0%	99.9%
1 B 1 a	Coal Mining and Handling	PM10	0.01	0.00	0.004	0.0%	99.9%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	PM10	0.03	0.00	0.003	0.0%	100.0%
3 B 4 g ii	Manure management - Broilers	PM10	0.00	0.00	0.002	0.0%	100.0%
1 A 4 b ii	Residential: Household and gardening (mobile)	PM10	0.00	0.00	0.001	0.0%	100.0%
3 B 4 d	Manure management - Goats	PM10	0.00	0.00	0.001	0.0%	100.0%
1 A 3 d i (ii)	International inland waterways	PM10	0.00	0.00	0.001	0.0%	100.0%
3 B 4 g iv	Manure management - Other Poultry	PM10	0.00	0.00	0.001	0.0%	100.0%
3 B 4 h	Manure management - Other animals (please specify in IIR)	PM10	0.00	0.00	0.000	0.0%	100.0%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	PM10	0.00	0.00	0.000	0.0%	100.0%
1 A 3 a ii (i)	Civil Aviation - International - LTO	PM10	0.00	0.00	0.000	0.0%	100.0%
1 A 3 d ii	National Navigation (Shipping)	PM10	0.00	0.00	0.000	0.0%	100.0%
1 A 5 b	Other, Mobile (including Military)	PM10	0.00	0.00	0.000	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 (2017) 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	0.51	38.3%	38.3%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	PM2.5	0.20	14.6%	52.9%
1 A 3 b vii	Road Transport, Automobile road abrasion	PM2.5	0.12	9.0%	61.9%
5 E	Other waste (please specify in IIR)	PM2.5	0.08	5.6%	67.5%
1 A 3 b iii	Road Transport, Heavy duty vehicles	PM2.5	0.06	4.3%	71.8%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	PM2.5	0.05	4.1%	75.9%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	PM2.5	0.05	3.4%	79.2%
1 A 3 b i	Road Transport, Passenger cars	PM2.5	0.04	2.8%	82.0%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	PM2.5	0.03	2.3%	84.3%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	PM2.5	0.03	2.0%	86.4%
3 B 1 b	Manure management - Non-dairy cattle	PM2.5	0.02	1.8%	88.1%
3 B 1 a	Manure management - Dairy cattle	PM2.5	0.02	1.5%	89.6%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	PM2.5	0.02	1.4%	91.0%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	PM2.5	0.02	1.3%	92.3%
2 D 3 b	Road paving with asphalt	PM2.5	0.01	1.1%	93.3%
1 A 4 a i	Commercial/Institutional: Stationary	PM2.5	0.01	1.1%	94.4%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	PM2.5	0.01	1.0%	95.4%
1 A 3 b ii	Road Transport, Light duty vehicles	PM2.5	0.01	1.0%	96.4%
2 G	Other product manufacture and use	PM2.5	0.01	0.9%	97.4%
2 A 5 b	Construction and demolition	PM2.5	0.01	0.8%	98.2%
3 D a 1	Inorganic N-fertilizers (includes also urea application)	PM2.5	0.01	0.6%	98.8%
1 A 3 c		PM2.5	0.00	0.3%	99.1%
1 A 3 a i (i)	Civil Aviation - Domestic - LTO	PM2.5	0.00	0.3%	99.4%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	PM2.5	0.00	0.1%	99.6%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	PM2.5	0.00	0.1%	99.7%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	PM2.5	0.00	0.1%	99.8%
3 B 4 e	Manure management - Horses	PM2.5	0.00	0.0%	99.8%
3 B 3	Manure management - Swine	PM2.5	0.00	0.0%	99.9%
1 A 4 b ii	Residential: Household and gardening (mobile)	PM2.5	0.00	0.0%	99.9%
3 B 4 g i	Manure management - Laying Hens	PM2.5	0.00	0.0%	99.9%
1 A 3 d i (ii)	International inland waterways	PM2.5	0.00	0.0%	100.0%
5 A	Biological treatment of waste - Solid waste disposal on land	PM2.5	0.00	0.0%	100.0%
3 B 4 d	Manure management - Goats	PM2.5	0.00	0.0%	100.0%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	PM2.5	0.00	0.0%	100.0%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	PM2.5	0.00	0.0%	100.0%
3 B 2	Manure management - Sheep	PM2.5	0.00	0.0%	100.0%
1 B 1 a	Coal Mining and Handling	PM2.5	0.00	0.0%	100.0%
3 B 4 g ii	Manure management - Broilers	PM2.5	0.00	0.0%	100.0%
1 A 3 a ii (i)	Civil Aviation - International - LTO	PM2.5	0	0.0%	100.0%
3 B 4 g iv	Manure management - Other Poultry	PM2.5	0	0.0%	100.0%
1 A 3 d ii	National Navigation (Shipping)	PM2.5	0	0.0%	100.0%
1 A 5 b	Other, Mobile (including Military)	PM2.5	0	0.0%	100.0%
3 B 4 h	Manure management - Other animals (please specify in IIR)	PM2.5	0	0.0%	100.0%

Trend Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2017) 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	10.089	49.9%	49.9%
1 A 4 b i	Residential: stationary	PM2.5	0.57	0.51	4.153	20.6%	70.5%
1 A 3 b vi	Road Transport, Automobile tyre and break wear	PM2.5	0.08	0.20	1.686	8.3%	78.9%
1 A 3 b vii	Road Transport, Automobile road abrasion	PM2.5	0.05	0.12	1.046	5.2%	84.0%
5 E	Other waste (please specify in IIR)	PM2.5	0.03	0.08	0.646	3.2%	87.2%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	PM2.5	0.00	0.05	0.489	2.4%	89.7%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	PM2.5	0.00	0.03	0.276	1.4%	91.0%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	PM2.5	0.00	0.03	0.242	1.2%	92.2%
1 A 3 b iii	Road Transport, Heavy duty vehicles	PM2.5	0.43	0.06	0.193	1.0%	93.2%
3 B 1 b	Manure management - Non-dairy cattle	PM2.5	0.02	0.02	0.192	1.0%	94.1%
3 B 1 a	Manure management - Dairy cattle	PM2.5	0.02	0.02	0.157	0.8%	94.9%
2 D 3 b	Road paving with asphalt	PM2.5	0.01	0.01	0.118	0.6%	95.5%
1 A 4 a i	Commercial/Institutional: Stationary	PM2.5	0.02	0.01	0.111	0.6%	96.0%
2 G	Other product manufacture and use	PM2.5	0.01	0.01	0.104	0.5%	96.6%
1 A 3 b ii	Road Transport, Light duty vehicles	PM2.5	0.03	0.01	0.100	0.5%	97.1%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	PM2.5	0.41	0.05	0.096	0.5%	97.5%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	PM2.5	0.09	0.02	0.094	0.5%	98.0%
2 A 5 b	Construction and demolition	PM2.5	0.01	0.01	0.090	0.4%	98.4%
1 A 3 b i	Road Transport, Passenger cars	PM2.5	0.33	0.04	0.087	0.4%	98.9%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	PM2.5	0.07	0.01	0.069	0.3%	99.2%
3 D a 1	Inorganic N-fertilizers (includes also urea application)	PM2.5	0.01	0.01	0.064	0.3%	99.5%
1 A 3 a i (i)	Civil Aviation - Domestic - LTO	PM2.5	0.00	0.00	0.035	0.2%	99.7%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	PM2.5	0.00	0.00	0.015	0.1%	99.8%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	PM2.5	0.00	0.00	0.011	0.1%	99.8%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	PM2.5	0.03	0.00	0.008	0.0%	99.9%
3 B 4 e	Manure management - Horses	PM2.5	0.00	0.00	0.006	0.0%	99.9%
3 B 3	Manure management - Swine	PM2.5	0.00	0.00	0.005	0.0%	99.9%
1 A 4 b ii	Residential: Household and gardening (mobile)	PM2.5	0.00	0.00	0.003	0.0%	99.9%
3 B 4 g i	Manure management - Laying Hens	PM2.5	0.00	0.00	0.003	0.0%	100.0%
1 A 3 c	Railways	PM2.5	0.06	0.00	0.002	0.0%	100.0%
1 A 3 d i (ii)	International inland waterways	PM2.5	0.00	0.00	0.002	0.0%	100.0%
5 A	Biological treatment of waste - Solid waste disposal on land	PM2.5	0.00	0.00	0.001	0.0%	100.0%
3 B 4 d	Manure management - Goats	PM2.5	0.00	0.00	0.001	0.0%	100.0%
3 B 2	Manure management - Sheep	PM2.5	0.00	0.00	0.001	0.0%	100.0%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	PM2.5	0.00	0.00	0.000	0.0%	100.0%
1 B 1 a	Coal Mining and Handling	PM2.5	0.00	0.00	0.000	0.0%	100.0%
3 B 4 g ii	Manure management - Broilers	PM2.5	0.00	0.00	0.000	0.0%	100.0%
1 A 3 a ii (i)	Civil Aviation - International - LTO	PM2.5	0.00	0.00	0.000	0.0%	100.0%
3 B 4 g iv	Manure management - Other Poultry	PM2.5	0.00	0.00	0.000	0.0%	100.0%
1 A 3 d ii	National Navigation (Shipping)	PM2.5	0.00	0.00	0.000	0.0%	100.0%
3 B 4 h	Manure management - Other animals (please specify in IIR)	PM2.5	0.00	0.00	0.000	0.0%	100.0%
1 A 5 b	Other, Mobile (including Military)	PM2.5	0.00	0.00	0.000	0.0%	100.0%

Appendix 2: Key category analysis – Fuel used

Annex Table 9 – Key Category analysis for SO_2: Level and Trend Assessment – Fuel used.

Level Assessment (fuel used)

NFR Category Code	NFR Category	Pollutant	Latest Year (2017) Estimate [kt]	Level Assessment	Cumulative Total of $L_{x,t}$
			$E_{x,t}$	$L_{x,t}$	
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	SO2_Fused	0.549	55.6%	55.6%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	SO2_Fused	0.21	21.1%	76.7%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	SO2_Fused	0.11	10.7%	87.4%
1 A 3 a i (i)	Civil Aviation - Domestic - LTO	SO2_Fused	0.04	4.0%	91.4%
1 A 4 b i	Residential: stationary	SO2_Fused	0.04	3.6%	95.0%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	SO2_Fused	0.02	2.3%	97.3%
1 A 4 a i	Commercial/Institutional: Stationary	SO2_Fused	0.01	1.1%	98.4%
1 A 3 b i	Road Transport, Passenger cars	SO2_Fused	0.01	0.6%	99.0%
1 A 3 c	Railways	SO2_Fused	0.00	0.3%	99.3%
1 A 3 b iii	Road Transport, Heavy duty vehicles	SO2_Fused	0.00	0.2%	99.5%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	SO2_Fused	0.00	0.1%	99.6%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	SO2_Fused	0.00	0.1%	99.8%
1 A 3 b ii	Road Transport, Light duty vehicles	SO2_Fused	0.00	0.1%	99.8%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	SO2_Fused	0.00	0.1%	99.9%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	SO2_Fused	0.00	0.0%	99.9%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	SO2_Fused	0.00	0.0%	100.0%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	SO2_Fused	0.00	0.0%	100.0%
2 G	Other product manufacture and use	SO2_Fused	0.00	0.0%	100.0%
1 A 3 a ii (i)	Civil Aviation - International - LTO	SO2_Fused	0.00	0.0%	100.0%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	SO2_Fused	0.00	0.0%	100.0%
1 A 4 b ii	Residential: Household and gardening (mobile)	SO2_Fused	0.00	0.0%	100.0%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	SO2_Fused	0.00	0.0%	100.0%
1 A 3 d i (ii)	International inland waterways	SO2_Fused	0.00	0.0%	100.0%
1 A 3 d ii	National Navigation (Shipping)	SO2_Fused	0.00	0.0%	100.0%
1 A 5 b	Other, Mobile (including Military)	SO2_Fused	0.00	0.0%	100.0%

Trend Assessment (fuel used)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2017) 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_Fused	11.23	0.21	8.367	44.8%	44.8%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	SO2_Fused	0.75	0.55	7.125	38.1%	82.9%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	SO2_Fused	0.21	0.11	1.301	7.0%	89.9%
1 A 3 a i (i)	Civil Aviation - Domestic - LTO	SO2_Fused	0.01	0.04	0.563	3.0%	92.9%
1 A 4 a i	Commercial/Institutional: Stationary	SO2_Fused	0.58	0.01	0.435	2.3%	95.2%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	SO2_Fused	0.00	0.02	0.327	1.7%	97.0%
1 A 4 b i	Residential: stationary	SO2_Fused	0.82	0.04	0.326	1.7%	98.7%
1 A 3 b iii	Road Transport, Heavy duty vehicles	SO2_Fused	0.13	0.00	0.099	0.5%	99.3%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	SO2_Fused	0.07	0.00	0.053	0.3%	99.6%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	SO2_Fused	0.04	0.00	0.022	0.1%	99.7%
1 A 3 c	Railways	SO2_Fused	0.02	0.00	0.020	0.1%	99.8%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	SO2_Fused	0.02	0.00	0.019	0.1%	99.9%
1 A 3 b ii	Road Transport, Light duty vehicles	SO2_Fused	0.02	0.00	0.007	0.0%	99.9%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	SO2_Fused	0.01	0.00	0.007	0.0%	100.0%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	SO2_Fused	0.00	0.00	0.002	0.0%	100.0%
2 G	Other product manufacture and use	SO2_Fused	0.00	0.00	0.002	0.0%	100.0%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	SO2_Fused	0.01	0.00	0.002	0.0%	100.0%
1 A 3 a ii (i)	Civil Aviation - International - LTO	SO2_Fused	0.00	0.00	0.001	0.0%	100.0%
1 A 3 b i	Road Transport, Passenger cars	SO2_Fused	0.08	0.01	0.000	0.0%	100.0%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	SO2_Fused	0.00	0.00	0.000	0.0%	100.0%
1 A 5 b	Other, Mobile (including Military)	SO2_Fused	0.00	0.00	0.000	0.0%	100.0%
1 A 4 b ii	Residential: Household and gardening (mobile)	SO2_Fused	0.00	0.00	0.000	0.0%	100.0%
1 A 3 d i (ii)	International inland waterways	SO2_Fused	0.00	0.00	0.000	0.0%	100.0%
1 A 3 d ii	National Navigation (Shipping)	SO2_Fused	0.00	0.00	0.000	0.0%	100.0%

Annex Table 10 – Key Category analysis for NO_X: Level and Trend Assessment – Fuel used.

Level Assessment (fuel used)

NFR Category Code	NFR Category	Pollutant	Latest Year (2017) 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_Fused	3.40	27.5%	27.5%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	NOx_Fused	1.67	13.5%	41.1%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	NOx_Fused	0.85	6.9%	48.0%
1 A 4 b i	Residential: stationary	NOx_Fused	0.79	6.4%	54.4%
1 A 3 b iii	Road Transport, Heavy duty vehicles	NOx_Fused	0.78	6.3%	60.7%
1 A 2 a	Manufacturing Industries and Construction - Iron and Steel	NOx_Fused	0.70	5.7%	66.4%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	NOx_Fused	0.70	5.6%	72.1%
1 A 3 a i (i)	Civil Aviation - Domestic - LTO	NOx_Fused	0.60	4.8%	76.9%
1 A 4 a i	Commercial/Institutional: Stationary	NOx_Fused	0.58	4.7%	81.6%
3 D a 1	Inorganic N-fertilizers (includes also urea application)	NOx_Fused	0.54	4.4%	86.0%
1 A 3 b ii	Road Transport, Light duty vehicles	NOx_Fused	0.53	4.3%	90.3%
3 D a 2 a	Animal manure applied to soils	NOx_Fused	0.20	1.6%	91.9%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	NOx_Fused	0.19	1.6%	93.4%
3 D a 3	Urine and dung deposited by grazing animals	NOx_Fused	0.18	1.4%	94.9%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	NOx_Fused	0.16	1.3%	96.2%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	NOx_Fused	0.10	0.8%	97.0%
3 D a 4	Crop residues applied to soils	NOx_Fused	0.08	0.6%	97.6%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	NOx_Fused	0.07	0.6%	98.2%
1 A 3 c	Railways	NOx_Fused	0.07	0.6%	98.7%
3 B 1 b	Manure management - Non-dairy cattle	NOx_Fused	0.04	0.3%	99.1%
3 B 1 a	Manure management - Dairy cattle	NOx_Fused	0.03	0.2%	99.3%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	NOx_Fused	0.02	0.2%	99.5%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	NOx_Fused	0.02	0.1%	99.6%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	NOx_Fused	0.01	0.1%	99.7%
1 A 4 b ii	Residential: Household and gardening (mobile)	NOx_Fused	0.01	0.1%	99.8%
1 A 2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	NOx_Fused	0.01	0.1%	99.9%
3 D a 2 c	Other organic fertilisers applied to soils (including compost)	NOx_Fused	0.00	0.0%	99.9%
3 D a 2 b	Sewage sludge applied to soils	NOx_Fused	0.00	0.0%	99.9%
3 B 4 e	Manure management - Horses	NOx_Fused	0.00	0.0%	100.0%
1 A 3 d i (ii)	International inland waterways	NOx_Fused	0.00	0.0%	100.0%
3 B 4 g i	Manure management - Laying Hens	NOx_Fused	0.00	0.0%	100.0%
2 G	Other product manufacture and use	NOx_Fused	0.00	0.0%	100.0%
1 A 3 a ii (i)	Civil Aviation - International - LTO	NOx_Fused	0.00	0.0%	100.0%
3 B 3	Manure management - Swine	NOx_Fused	0.00	0.0%	100.0%
3 B 4 d	Manure management - Goats	NOx_Fused	0.00	0.0%	100.0%
1 A 5 b	Other, Mobile (including Military)	NOx_Fused	0.00	0.0%	100.0%
3 B 2	Manure management - Sheep	NOx_Fused	0.00	0.0%	100.0%
1 A 3 d ii	National Navigation (Shipping)	NOx_Fused	0.00	0.0%	100.0%
3 B 4 g ii	Manure management - Broilers	NOx_Fused	0	0.0%	100.0%
3 B 4 h	Manure management - Other animals (please specify in IIR)	NOx_Fused	0	0.0%	100.0%
3 B 4 g iv	Manure management - Other Poultry	NOx_Fused	0	0.0%	100.0%

Trend Assessment (fuel used)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt]	Latest Year (2017) 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	NOx_Fused	6.84	0.70	0.447	37.2%	37.2%
1 A 3 b i	Road Transport, Passenger cars	NOx_Fused	5.00	3.40	0.110	9.2%	46.4%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	NOx_Fused	0.03	0.70	0.103	8.6%	54.9%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	NOx_Fused	0.54	0.85	0.085	7.1%	62.0%
1 A 3 a i (i)	Civil Aviation - Domestic - LTO	NOx_Fused	0.14	0.60	0.079	6.5%	68.6%
1 A 3 b iii	Road Transport, Heavy duty vehicles	NOx_Fused	2.33	0.78	0.071	5.9%	74.5%
1 A 4 b i	Residential: stationary	NOx_Fused	0.62	0.79	0.070	5.8%	80.3%
1 A 3 b ii	Road Transport, Light duty vehicles	NOx_Fused	0.28	0.53	0.057	4.8%	85.1%
1 A 2 c	Manufacturing Industries and Construction - Chemicals	NOx_Fused	0.82	0.10	0.051	4.2%	89.3%
1 A 2 f	Manufacturing Industries and Construction - Non-metallic Minerals	NOx_Fused	3.37	1.67	0.020	1.7%	91.0%
1 A 4 a i	Commercial/Institutional: Stationary	NOx_Fused	0.84	0.58	0.020	1.6%	92.6%
3 D a 1	Inorganic N-fertilizers (includes also urea application)	NOx_Fused	0.79	0.54	0.018	1.5%	94.1%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	NOx_Fused	0.10	0.16	0.016	1.3%	95.4%
3 D a 3	Urine and dung deposited by grazing animals	NOx_Fused	0.18	0.18	0.012	1.0%	96.5%
3 D a 2 a	Animal manure applied to soils	NOx_Fused	0.22	0.20	0.012	1.0%	97.5%
1 A 3 c	Railways	NOx_Fused	0.26	0.07	0.011	0.9%	98.3%
3 D a 4	Crop residues applied to soils	NOx_Fused	0.06	0.08	0.006	0.5%	98.9%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	NOx_Fused	0.33	0.19	0.003	0.2%	99.1%
3 B 1 b	Manure management - Non-dairy cattle	NOx_Fused	0.05	0.04	0.002	0.2%	99.3%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	NOx_Fused	0.01	0.02	0.002	0.2%	99.5%
1 A 2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	NOx_Fused	0.02	0.02	0.002	0.2%	99.6%
1 A 4 b ii	Residential: Household and gardening (mobile)	NOx_Fused	0.01	0.01	0.001	0.1%	99.7%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	NOx_Fused	0.01	0.01	0.001	0.1%	99.8%
3 D a 2 b	Sewage sludge applied to soils	NOx_Fused	0.01	0.00	0.001	0.1%	99.8%
3 D a 2 c	Other organic fertilisers applied to soils (including compost)	NOx_Fused	0.00	0.00	0.001	0.1%	99.9%
3 B 4 e	Manure management - Horses	NOx_Fused	0.00	0.00	0.000	0.0%	99.9%
1 A 2 b	Manufacturing Industries and Construction - Non-ferrous Metals	NOx_Fused	0.14	0.07	0.000	0.0%	99.9%
1 A 3 d i (ii)	International inland waterways	NOx_Fused	0.00	0.00	0.000	0.0%	100.0%
3 B 1 a	Manure management - Dairy cattle	NOx_Fused	0.05	0.03	0.000	0.0%	100.0%
3 B 4 g i	Manure management - Laying Hens	NOx_Fused	0.00	0.00	0.000	0.0%	100.0%
3 B 4 d	Manure management - Goats	NOx_Fused	0.00	0.00	0.000	0.0%	100.0%
1 A 3 a ii (i)	Civil Aviation - International - LTO	NOx_Fused	0.00	0.00	0.000	0.0%	100.0%
3 B 3	Manure management - Swine	NOx_Fused	0.00	0.00	0.000	0.0%	100.0%
2 G	Other product manufacture and use	NOx_Fused	0.00	0.00	0.000	0.0%	100.0%
1 A 5 b	Other, Mobile (including Military)	NOx_Fused	0.00	0.00	0.000	0.0%	100.0%
3 B 2	Manure management - Sheep	NOx_Fused	0.00	0.00	0.000	0.0%	100.0%
3 B 4 g ii	Manure management - Broilers	NOx_Fused	0.00	0.00	0.000	0.0%	100.0%
3 B 4 h	Manure management - Other animals (please specify in IIR)	NOx_Fused	0.00	0.00	0.000	0.0%	100.0%
1 A 3 d ii	National Navigation (Shipping)	NOx_Fused	0.00	0.00	0.000	0.0%	100.0%
3 B 4 g iv	Manure management - Other Poultry	NOx_Fused	0.00	0.00	0.000	0.0%	100.0%

Annex Table 11 – Key Category analysis for NMVOC: Level and Trend Assessment – Fuel used.

Level Assessment (fuel used)

NFR Category Code	NFR Category	Pollutant	Latest Year (2017) Estimate [kt] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
2 D 3 a	Domestic solvent use including fungicides	NMVOC_Fused	2.23	19.2%	19.2%
3 B 1 b	Manure management - Non-dairy cattle	NMVOC_Fused	1.60	13.8%	33.0%
3 B 1 a	Manure management - Dairy cattle	NMVOC_Fused	1.59	13.7%	46.6%
2 D 3 e	Degreasing	NMVOC_Fused	1.44	12.4%	59.0%
2 D 3 d	Coating application	NMVOC_Fused	1.28	11.0%	70.0%
1 A4 b i	Residential: stationary	NMVOC_Fused	0.42	3.7%	73.7%
2 D 3 g	Chemical products	NMVOC_Fused	0.39	3.4%	77.0%
1 B 2 b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)	NMVOC_Fused	0.36	3.1%	80.1%
1 B 2 a v	Distribution of oil products	NMVOC_Fused	0.29	2.5%	82.6%
2 H 2	Food and beverages industry	NMVOC_Fused	0.25	2.2%	84.8%
1 A3 b i	Road Transport, Passenger cars	NMVOC_Fused	0.25	2.1%	86.9%
2 D 3 i	Other solvent use	NMVOC_Fused	0.23	2.0%	88.9%
2 D 3 h	Printing	NMVOC_Fused	0.17	1.5%	90.3%
1 A1 a	Energy Industries - Public Electricity and Heat Production	NMVOC_Fused	0.16	1.4%	91.7%
1 A3 b iv	Road Transport, Mopeds & Motorcycles	NMVOC_Fused	0.12	1.0%	92.7%
3 D e	Cultivated crops	NMVOC_Fused	0.11	1.0%	93.7%
1 A2 a	Manufacturing Industries and Construction - Iron and Steel	NMVOC_Fused	0.10	0.9%	94.6%
1 A2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	NMVOC_Fused	0.09	0.8%	95.4%
1 A4 b ii	Residential: Household and gardening (mobile)	NMVOC_Fused	0.08	0.6%	96.0%
1 A4 a i	Commercial/Institutional: Stationary	NMVOC_Fused	0.06	0.5%	96.5%
1 A3 a i (i)	Civil Aviation - Domestic - LTO	NMVOC_Fused	0.05	0.4%	97.0%
1 A4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	NMVOC_Fused	0.04	0.4%	97.3%
3 B 3	Manure management - Swine	NMVOC_Fused	0.04	0.4%	97.7%
1 A3 b v	Road Transport, Gasoline evaporation	NMVOC_Fused	0.04	0.3%	98.0%
1 A2 c	Manufacturing Industries and Construction - Chemicals	NMVOC_Fused	0.03	0.3%	98.3%
2 D 3 f	Dry cleaning	NMVOC_Fused	0.03	0.2%	98.6%
1 A2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	NMVOC_Fused	0.03	0.2%	98.8%
1 A2 b	Manufacturing Industries and Construction - Non-ferrous Metals	NMVOC_Fused	0.02	0.2%	99.0%
3 B 4 e	Manure management - Horses	NMVOC_Fused	0.02	0.2%	99.1%
1 A3 b iii	Road Transport, Heavy duty vehicles	NMVOC_Fused	0.02	0.2%	99.3%
5 A	Biological treatment of waste - Solid waste disposal on land	NMVOC_Fused	0.02	0.2%	99.5%
1 A2 f	Manufacturing Industries and Construction - Non-metallic Minerals	NMVOC_Fused	0.01	0.1%	99.6%
1 A3 b ii	Road Transport, Light duty vehicles	NMVOC_Fused	0.01	0.1%	99.6%
1 A3 c	Railways	NMVOC_Fused	0.01	0.1%	99.7%
3 B 4 g i	Manure management - Laying Hens	NMVOC_Fused	0.01	0.1%	99.7%
1 A3 d ii	National Navigation (Shipping)	NMVOC_Fused	0.00	0.0%	99.8%
3 B 4 d	Manure management - Goats	NMVOC_Fused	0.00	0.0%	99.8%
1 A2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	NMVOC_Fused	0.00	0.0%	99.9%
1 A3 a ii (i)	Civil Aviation - International - LTO	NMVOC_Fused	0.00	0.0%	99.9%
2 D 3 b	Road paving with asphalt	NMVOC_Fused	0.00	0.0%	99.9%
3 B 2	Manure management - Sheep	NMVOC_Fused	0.00	0.0%	100.0%
2 G	Other product manufacture and use	NMVOC_Fused	0.00	0.0%	100.0%
3 B 4 g ii	Manure management - Broilers	NMVOC_Fused	0.00	0.0%	100.0%
5 D 1	Domestic wastewater handling	NMVOC_Fused	0	0.0%	100.0%
3 B 4 h	Manure management - Other animals (please specify in IIR)	NMVOC_Fused	0	0.0%	100.0%
1 A2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	NMVOC_Fused	0	0.0%	100.0%
1 A3 d i (ii)	International inland waterways	NMVOC_Fused	0	0.0%	100.0%
3 B 4 g iv	Manure management - Other Poultry	NMVOC_Fused	0	0.0%	100.0%
1 A4 c i	Agriculture/Forestry/Fishing: Stationary	NMVOC_Fused	0	0.0%	100.0%
1 A5 b	Other, Mobile (including Military)	NMVOC_Fused	0	0.0%	100.0%
5 D 2	Industrial wastewater handling	NMVOC_Fused	0	0.0%	100.0%

Trend Assessment (fuel used)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt] $E_{x,0}$	Latest Year (2017) Estimate [kt] $E_{x,t}$	Trend Assessment $L_{x,t}$	% Contribution to the trend	Cumulative Total of $L_{x,t}$
1 A3 b i	Road Transport, Passenger cars	NMVOC_Fused	4.78	0.25	0.378	29.9%	29.9%
2 D 3 a	Domestic solvent use including fungicides	NMVOC_Fused	1.13	2.23	0.195	15.4%	45.3%
1 A3 b v	Road Transport, Gasoline evaporation	NMVOC_Fused	1.77	0.04	0.148	11.7%	57.0%
2 D 3 e	Degreasing	NMVOC_Fused	0.91	1.44	0.110	8.7%	65.7%
3 B 1 a	Manure management - Dairy cattle	NMVOC_Fused	1.49	1.59	0.080	6.3%	72.0%
3 B 1 b	Manure management - Non-dairy cattle	NMVOC_Fused	1.62	1.60	0.071	5.6%	77.6%
2 D 3 d	Coating application	NMVOC_Fused	1.45	1.28	0.043	3.4%	81.0%
1 B 2 b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)	NMVOC_Fused	0.22	0.36	0.028	2.2%	83.1%
2 D 3 h	Printing	NMVOC_Fused	0.53	0.17	0.024	1.9%	85.0%
1 A1 a	Energy Industries - Public Electricity and Heat Production	NMVOC_Fused	0.00	0.16	0.021	1.7%	86.7%
2 D 3 g	Chemical products	NMVOC_Fused	0.81	0.39	0.018	1.4%	88.1%
1 A2 a	Manufacturing Industries and Construction - Iron and Steel	NMVOC_Fused	0.36	0.10	0.018	1.4%	89.5%
2 D 3 i	Other solvent use	NMVOC_Fused	0.16	0.23	0.016	1.3%	90.8%
2 H 2	Food and beverages industry	NMVOC_Fused	0.23	0.25	0.013	1.0%	91.8%
1 A4 b i	Residential: stationary	NMVOC_Fused	0.50	0.42	0.013	1.0%	92.8%
1 A4 b ii	Residential: Household and gardening (mobile)	NMVOC_Fused	0.26	0.08	0.012	1.0%	93.8%
1 A2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	NMVOC_Fused	0.00	0.09	0.012	0.9%	94.7%
1 A3 b ii	Road Transport, Light duty vehicles	NMVOC_Fused	0.12	0.01	0.009	0.7%	95.4%
1 A3 b iii	Road Transport, Heavy duty vehicles	NMVOC_Fused	0.12	0.02	0.008	0.6%	96.1%
1 A3 b iv	Road Transport, Mopeds & Motorcycles	NMVOC_Fused	0.10	0.12	0.006	0.5%	96.6%
1 A3 a i (i)	Civil Aviation - Domestic - LTO	NMVOC_Fused	0.01	0.05	0.005	0.4%	97.0%
3 D e	Cultivated crops	NMVOC_Fused	0.11	0.11	0.005	0.4%	97.4%
1 A2 f	Manufacturing Industries and Construction - Non-metallic Minerals	NMVOC_Fused	0.07	0.01	0.005	0.4%	97.8%
1 A2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	NMVOC_Fused	0.09	0.03	0.004	0.3%	98.2%
1 B 2 a v	Distribution of oil products	NMVOC_Fused	0.40	0.29	0.004	0.3%	98.5%
1 A3 c	Railways	NMVOC_Fused	0.05	0.01	0.003	0.3%	98.8%
1 A4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	NMVOC_Fused	0.10	0.04	0.003	0.2%	99.0%
2 D 3 f	Dry cleaning	NMVOC_Fused	0.02	0.03	0.002	0.2%	99.2%
1 A2 b	Manufacturing Industries and Construction - Non-ferrous Metals	NMVOC_Fused	0.01	0.02	0.002	0.2%	99.3%
3 B 4 e	Manure management - Horses	NMVOC_Fused	0.01	0.02	0.002	0.1%	99.5%
3 B 3	Manure management - Swine	NMVOC_Fused	0.05	0.04	0.002	0.1%	99.6%
1 A3 d ii	National Navigation (Shipping)	NMVOC_Fused	0.02	0.00	0.001	0.1%	99.7%
1 A2 c	Manufacturing Industries and Construction - Chemicals	NMVOC_Fused	0.06	0.03	0.001	0.1%	99.7%
3 B 4 d	Manure management - Goats	NMVOC_Fused	0.00	0.00	0.001	0.1%	99.8%
3 B 4 g i	Manure management - Laying Hens	NMVOC_Fused	0.00	0.01	0.001	0.0%	99.8%
5 A	Biological treatment of waste - Solid waste disposal on land	NMVOC_Fused	0.03	0.02	0.000	0.0%	99.9%
1 A2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	NMVOC_Fused	0.00	0.00	0.000	0.0%	99.9%
1 A3 a ii (i)	Civil Aviation - International - LTO	NMVOC_Fused	0.00	0.00	0.000	0.0%	99.9%
2 D 3 b	Road paving with asphalt	NMVOC_Fused	0.01	0.00	0.000	0.0%	100.0%
3 B 2	Manure management - Sheep	NMVOC_Fused	0.00	0.00	0.000	0.0%	100.0%
1 A4 c i	Agriculture/Forestry/Fishing: Stationary	NMVOC_Fused	0.00	0.00	0.000	0.0%	100.0%
3 B 4 g ii	Manure management - Broilers	NMVOC_Fused	0.00	0.00	0.000	0.0%	100.0%
2 G	Other product manufacture and use	NMVOC_Fused	0.00	0.00	0.000	0.0%	100.0%
5 D 1	Domestic wastewater handling	NMVOC_Fused	0.00	0.00	0.000	0.0%	100.0%
3 B 4 h	Manure management - Other animals (please specify in IIR)	NMVOC_Fused	0.00	0.00	0.000	0.0%	100.0%
1 A4 a i	Commercial/Institutional: Stationary	NMVOC_Fused	0.09	0.06	0.000	0.0%	100.0%
1 A5 b	Other, Mobile (including Military)	NMVOC_Fused	0.00	0.00	0.000	0.0%	100.0%
1 A3 d i (ii)	International inland waterways	NMVOC_Fused	0.00	0.00	0.000	0.0%	100.0%
3 B 4 g iv	Manure management - Other Poultry	NMVOC_Fused	0.00	0.00	0.000	0.0%	100.0%
5 D 2	Industrial wastewater handling	NMVOC_Fused	0.00	0	0.000	0.0%	100.0%
#NUM!	#NUM!		#NUM!	#NUM!	#NUM!		

Annex Table 12 – Key Category analysis for NH_3: Level and Trend Assessment – Fuel used.

Level Assessment (fuel used)

NFR Category Code	NFR Category	Pollutant	Latest Year (2017) Estimate [kt] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
3 D a 2 a	Animal manure applied to soils	NH3_Fused	1.87	32.8%	32.8%
3 B 1 b	Manure management - Non-dairy cattle	NH3_Fused	1.17	20.6%	53.4%
3 B 1 a	Manure management - Dairy cattle	NH3_Fused	1.15	20.2%	73.6%
3 D a 1	Inorganic N-fertilizers (includes also urea application)	NH3_Fused	0.68	11.9%	85.5%
3 D a 3	Urine and dung deposited by grazing animals	NH3_Fused	0.28	4.9%	90.4%
3 B 3	Manure management - Swine	NH3_Fused	0.19	3.3%	93.7%
1 A 3 b i	Road Transport, Passenger cars	NH3_Fused	0.07	1.2%	94.9%
3 B 4 e	Manure management - Horses	NH3_Fused	0.06	1.0%	95.9%
1 A 4 b i	Residential: stationary	NH3_Fused	0.05	0.9%	96.8%
1 A 1 a	Energy Industries - Public Electricity and Heat Production	NH3_Fused	0.05	0.9%	97.7%
1 A 2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	NH3_Fused	0.03	0.5%	98.2%
3 B 4 g i	Manure management - Laying Hens	NH3_Fused	0.03	0.4%	98.6%
5 D 1	Domestic wastewater handling	NH3_Fused	0.02	0.4%	99.0%
3 B 4 d	Manure management - Goats	NH3_Fused	0.01	0.2%	99.2%
5 B 1	Composting	NH3_Fused	0.01	0.2%	99.4%
3 D a 2 b	Sewage sludge applied to soils	NH3_Fused	0.01	0.2%	99.6%
3 D a 2 c	Other organic fertilisers applied to soils (including compost)	NH3_Fused	0.01	0.2%	99.8%
3 B 2	Manure management - Sheep	NH3_Fused	0.00	0.1%	99.9%
3 B 4 g ii	Manure management - Broilers	NH3_Fused	0.00	0.0%	99.9%
2 G	Other product manufacture and use	NH3_Fused	0.00	0.0%	99.9%
1 A 3 b iii	Road Transport, Heavy duty vehicles	NH3_Fused	0.00	0.0%	99.9%
1 A 3 b ii	Road Transport, Light duty vehicles	NH3_Fused	0.00	0.0%	100.0%
3 B 4 h	Manure management - Other animals (please specify in IIR)	NH3_Fused	0.00	0.0%	100.0%
3 B 4 g iv	Manure management - Other Poultry	NH3_Fused	0.00	0.0%	100.0%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	NH3_Fused	0.00	0.0%	100.0%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	NH3_Fused	0.00	0.0%	100.0%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	NH3_Fused	0.00	0.0%	100.0%
1 A 4 a i	Commercial/Institutional: Stationary	NH3_Fused	0.00	0.0%	100.0%
1 A 3 c	Railways	NH3_Fused	0.00	0.0%	100.0%
1 A 4 b ii	Residential: Household and gardening (mobile)	NH3_Fused	0.00	0.0%	100.0%
1 A 3 d i (ii)	International inland waterways	NH3_Fused	0.00	0.0%	100.0%
1 A 3 d i (ii)	International inland waterways	NH3_Fused	0.00	0.0%	100.0%
1 A 3 d ii	National Navigation (Shipping)	NH3_Fused	0.00	0.0%	100.0%

Trend Assessment (fuel used)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt] $E_{x,0}$	Latest Year (2017) Estimate [kt] $E_{x,t}$	Trend Assessment $L_{x,t}$	% Contribution to the trend	Cumulative Total of $L_{x,t}$
3 D a 1	Inorganic N-fertilizers (includes also urea application)	NH3_Fused	0.98	0.68	0.040	29.9%	29.9%
3 B 1 a	Manure management - Dairy cattle	NH3_Fused	1.42	1.15	0.025	18.4%	48.4%
1 A 3 b i	Road Transport, Passenger cars	NH3_Fused	0.01	0.07	0.013	9.4%	57.8%
3 B 3	Manure management - Swine	NH3_Fused	0.14	0.19	0.013	9.3%	67.1%
3 D a 3	Urine and dung deposited by grazing animals	NH3_Fused	0.26	0.28	0.008	6.2%	73.3%
3 B 4 e	Manure management - Horses	NH3_Fused	0.02	0.06	0.008	5.8%	79.1%
3 B 1 b	Manure management - Non-dairy cattle	NH3_Fused	1.26	1.17	0.007	5.1%	84.2%
3 D a 2 b	Sewage sludge applied to soils	NH3_Fused	0.05	0.01	0.007	4.9%	89.0%
5 D 1	Domestic wastewater handling	NH3_Fused	0.05	0.02	0.004	2.7%	91.8%
3 B 4 g i	Manure management - Laying Hens	NH3_Fused	0.01	0.03	0.002	1.8%	93.6%
3 B 4 d	Manure management - Goats	NH3_Fused	0.00	0.01	0.002	1.7%	95.3%
1 A 4 b i	Residential: stationary	NH3_Fused	0.05	0.05	0.002	1.6%	96.8%
3 D a 2 c	Other organic fertilisers applied to soils (including compost)	NH3_Fused	0.00	0.01	0.002	1.4%	98.2%
3 D a 2 a	Animal manure applied to soils	NH3_Fused	2.08	1.87	0.001	0.6%	98.8%
3 B 4 h	Manure management - Other animals (please specify in IIR)	NH3_Fused	0.00	0.00	0.001	0.4%	99.3%
3 B 2	Manure management - Sheep	NH3_Fused	0.00	0.00	0.000	0.2%	99.5%
3 B 4 g ii	Manure management - Broilers	NH3_Fused	0.00	0.00	0.000	0.1%	99.6%
1 A 3 b ii	Road Transport, Light duty vehicles	NH3_Fused	0.00	0.00	0.000	0.1%	99.8%
1 A 3 b iii	Road Transport, Heavy duty vehicles	NH3_Fused	0.00	0.00	0.000	0.1%	99.9%
3 B 4 g iv	Manure management - Other Poultry	NH3_Fused	0.00	0.00	0.000	0.0%	99.9%
2 G	Other product manufacture and use	NH3_Fused	0.00	0.00	0.000	0.0%	100.0%
1 A 3 b iv	Road Transport, Mopeds & Motorcycles	NH3_Fused	0.00	0.00	0.000	0.0%	100.0%
1 A 2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	NH3_Fused	0.00	0.00	0.000	0.0%	100.0%
1 A 4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	NH3_Fused	0.00	0.00	0.000	0.0%	100.0%
1 A 3 c	Railways	NH3_Fused	0.00	0.00	0.000	0.0%	100.0%
1 A 4 b ii	Residential: Household and gardening (mobile)	NH3_Fused	0.00	0.00	0.000	0.0%	100.0%
1 A 3 d ii	National Navigation (Shipping)	NH3_Fused	0.00	0.00	0.000	0.0%	100.0%
1 A 3 d i (ii)	International inland waterways	NH3_Fused	0.00	0.00	0.000	0.0%	100.0%
1 A 3 d i (ii)	International inland waterways	NH3_Fused	0.00	0.00	0.000	0.0%	100.0%

Annex Table 13 – Key Category analysis for $PM_{2.5}$: Level and Trend Assessment – Fuel used.

Level Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Latest Year (2017) Estimate [kt] $E_{x,t}$	Level Assessment $L_{x,t}$	Cumulative Total of $L_{x,t}$
1 A4 b i	Residential: stationary	PM2.5_Fused	0.51	47.6%	47.6%
5 E	Other waste (please specify in IIR)	PM2.5_Fused	0.08	7.0%	54.6%
1 A3 b vi	Road Transport, Automobile tyre and break wear	PM2.5_Fused	0.07	6.9%	61.5%
1 A1 a	Energy Industries - Public Electricity and Heat Production	PM2.5_Fused	0.05	5.1%	66.6%
1 A2 f	Manufacturing Industries and Construction - Non-metallic Minerals	PM2.5_Fused	0.05	4.2%	70.8%
1 A3 b vii	Road Transport, Automobile road abrasion	PM2.5_Fused	0.04	3.8%	74.5%
1 A2 b	Manufacturing Industries and Construction - Non-ferrous Metals	PM2.5_Fused	0.03	2.9%	77.5%
1 A2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	PM2.5_Fused	0.03	2.5%	80.0%
3 B 1 b	Manure management - Non-dairy cattle	PM2.5_Fused	0.02	2.2%	82.2%
1 A3 b i	Road Transport, Passenger cars	PM2.5_Fused	0.02	2.0%	84.2%
3 B 1 a	Manure management - Dairy cattle	PM2.5_Fused	0.02	1.8%	86.0%
1 A2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	PM2.5_Fused	0.02	1.7%	87.7%
1 A2 a	Manufacturing Industries and Construction - Iron and Steel	PM2.5_Fused	0.02	1.6%	89.4%
2 D 3 b	Road paving with asphalt	PM2.5_Fused	0.01	1.3%	90.7%
1 A4 a i	Commercial/Institutional: Stationary	PM2.5_Fused	0.01	1.3%	92.0%
1 A4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	PM2.5_Fused	0.01	1.3%	93.3%
1 A3 b ii	Road Transport, Light duty vehicles	PM2.5_Fused	0.01	1.3%	94.5%
2 G	Other product manufacture and use	PM2.5_Fused	0.01	1.2%	95.7%
2 A5 b	Construction and demolition	PM2.5_Fused	0.01	1.0%	96.7%
1 A3 b iii	Road Transport, Heavy duty vehicles	PM2.5_Fused	0.01	1.0%	97.7%
3 D a 1	Inorganic N-fertilizers (includes also urea application)	PM2.5_Fused	0.01	0.7%	98.5%
1 A3 c		PM2.5_Fused	0.00	0.4%	98.9%
1 A3 a i (i)	Civil Aviation - Domestic - LTO	PM2.5_Fused	0.00	0.4%	99.3%
1 A3 b iv	Road Transport, Mopeds & Motorcycles	PM2.5_Fused	0.00	0.2%	99.5%
1 A2 c	Manufacturing Industries and Construction - Chemicals	PM2.5_Fused	0.00	0.2%	99.6%
1 A2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	PM2.5_Fused	0.00	0.1%	99.7%
3 B 4 e	Manure management - Horses	PM2.5_Fused	0.00	0.1%	99.8%
3 B 3	Manure management - Swine	PM2.5_Fused	0.00	0.1%	99.9%
1 A4 b ii	Residential: Household and gardening (mobile)	PM2.5_Fused	0.00	0.0%	99.9%
3 B 4 g i	Manure management - Laying Hens	PM2.5_Fused	0.00	0.0%	99.9%
1 A3 d i (ii)	International inland waterways	PM2.5_Fused	0.00	0.0%	99.9%
5 A	Biological treatment of waste - Solid waste disposal on land	PM2.5_Fused	0.00	0.0%	100.0%
3 B 4 d	Manure management - Goats	PM2.5_Fused	0.00	0.0%	100.0%
1 A2 d	Manufacturing Industries and Construction - Pulp, Paper and Print	PM2.5_Fused	0.00	0.0%	100.0%
1 A4 c i	Agriculture/Forestry/Fishing: Stationary	PM2.5_Fused	0.00	0.0%	100.0%
3 B 2	Manure management - Sheep	PM2.5_Fused	0.00	0.0%	100.0%
1 B 1 a	Coal Mining and Handling	PM2.5_Fused	0.00	0.0%	100.0%
3 B 4 g ii	Manure management - Broilers	PM2.5_Fused	0.00	0.0%	100.0%
1 A3 a ii (i)	Civil Aviation - International - LTO	PM2.5_Fused	0	0.0%	100.0%
3 B 4 g iv	Manure management - Other Poultry	PM2.5_Fused	0	0.0%	100.0%
1 A3 d ii	National Navigation (Shipping)	PM2.5_Fused	0	0.0%	100.0%
1 A5 b	Other, Mobile (including Military)	PM2.5_Fused	0	0.0%	100.0%
3 B 4 h	Manure management - Other animals (please specify in IIR)	PM2.5_Fused	0	0.0%	100.0%

Trend Assessment (fuel sold)

NFR Category Code	NFR Category	Pollutant	Base Year (1990) Estimate [kt] $E_{x,0}$	Latest Year (2017) Estimate [kt] $E_{x,t}$	Trend Assessment $L_{x,t}$	% Contribution to the trend	Cumulative Total of $L_{x,t}$
1 A2 a	Manufacturing Industries and Construction - Iron and Steel	PM2.5_Fused	13.77	0.02	12.524	50.0%	50.0%
1 A4 b i	Residential: stationary	PM2.5_Fused	0.57	0.51	6.279	25.1%	75.0%
5 E	Other waste (please specify in IIR)	PM2.5_Fused	0.03	0.08	0.967	3.9%	78.9%
1 A3 b vi	Road Transport, Automobile tyre and break wear	PM2.5_Fused	0.03	0.07	0.955	3.8%	82.7%
1 A1 a	Energy Industries - Public Electricity and Heat Production	PM2.5_Fused	0.00	0.05	0.728	2.9%	85.6%
1 A3 b vii	Road Transport, Automobile road abrasion	PM2.5_Fused	0.02	0.04	0.526	2.1%	87.7%
1 A2 b	Manufacturing Industries and Construction - Non-ferrous Metals	PM2.5_Fused	0.00	0.03	0.412	1.6%	89.3%
1 A2 g viii	Manufacturing Industries and Construction - Other Stationary Combustion in Manufacturing Industries and Construction	PM2.5_Fused	0.00	0.03	0.361	1.4%	90.8%
3 B 1 b	Manure management - Non-dairy cattle	PM2.5_Fused	0.02	0.02	0.290	1.2%	91.9%
3 B 1 a	Manure management - Dairy cattle	PM2.5_Fused	0.02	0.02	0.238	0.9%	92.9%
1 A2 f	Manufacturing Industries and Construction - Non-metallic Minerals	PM2.5_Fused	0.41	0.05	0.217	0.9%	93.8%
1 A3 b i	Road Transport, Passenger cars	PM2.5_Fused	0.10	0.02	0.198	0.8%	94.5%
2 D 3 b	Road paving with asphalt	PM2.5_Fused	0.01	0.01	0.177	0.7%	95.3%
1 A4 a i	Commercial/Institutional: Stationary	PM2.5_Fused	0.02	0.01	0.169	0.7%	95.9%
2 G	Other product manufacture and use	PM2.5_Fused	0.01	0.01	0.157	0.6%	96.5%
1 A2 g vii	Manufacturing Industries and Construction - Mobile Combustion in Manufacturing Industries and Construction	PM2.5_Fused	0.09	0.02	0.156	0.6%	97.2%
1 A3 b ii	Road Transport, Light duty vehicles	PM2.5_Fused	0.03	0.01	0.154	0.6%	97.8%
2 A5 b	Construction and demolition	PM2.5_Fused	0.01	0.01	0.137	0.5%	98.3%
1 A4 c ii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	PM2.5_Fused	0.07	0.01	0.116	0.5%	98.8%
3 D a 1	Inorganic N-fertilizers (includes also urea application)	PM2.5_Fused	0.01	0.01	0.097	0.4%	99.2%
1 A3 b iii	Road Transport, Heavy duty vehicles	PM2.5_Fused	0.08	0.01	0.066	0.3%	99.4%
1 A3 a i (i)	Civil Aviation - Domestic - LTO	PM2.5_Fused	0.00	0.00	0.053	0.2%	99.7%
1 A3 b iv	Road Transport, Mopeds & Motorcycles	PM2.5_Fused	0.00	0.00	0.023	0.1%	99.7%
1 A2 e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco	PM2.5_Fused	0.00	0.00	0.017	0.1%	99.8%
3 B 4 e	Manure management - Horses	PM2.5_Fused	0.00	0.00	0.009	0.0%	99.9%
1 A3 c	Railways	PM2.5_Fused	0.06	0.00	0.007	0.0%	99.9%
3 B 3	Manure management - Swine	PM2.5_Fused	0.00	0.00	0.007	0.0%	99.9%
1 A2 c	Manufacturing Industries and Construction - Chemicals	PM2.5_Fused	0.03	0.00	0.006	0.0%	99.9%
1 A4 b ii	Residential: Household and gardening (mobile)	PM2.5_Fused	0.00	0.00	0.005	0.0%	99.9%
3 B 4 g i	Manure management - Laying Hens	PM2.5_Fused	0.00	0.00	0.004	0.0%	100.0%
1 A3 d i (ii)	International inland waterways	PM2.5_Fused	0.00	0.00	0.002	0.0%	100.0%
5 A	Biological treatment of waste - Solid waste disposal on land	PM2.5_Fused	0.00	0.00	0.002	0.0%	100.0%
3 B 4 d	Manure management - Goats	PM2.5_Fused	0.00	0.00	0.001	0.0%	100.0%
3 B 2	Manure management - Sheep	PM2.5_Fused	0.00	0.00	0.001	0.0%	100.0%
1 A4 c i	Agriculture/Forestry/Fishing: Stationary	PM2.5_Fused	0.00	0.00	0.001	0.0%	100.0%
3 B 4 g ii	Manure management - Broilers	PM2.5_Fused	0.00	0.00	0.001	0.0%	100.0%
1 A3 a ii (i)	Civil Aviation - International - LTO	PM2.5_Fused	0.00	0.00	0.000	0.0%	100.0%
1 B 1 a	Coal Mining and Handling	PM2.5_Fused	0.00	0.00	0.000	0.0%	100.0%
3 B 4 g iv	Manure management - Other Poultry	PM2.5_Fused	0.00	0.00	0.000	0.0%	100.0%
1 A3 d ii	National Navigation (Shipping)	PM2.5_Fused	0.00	0.00	0.000	0.0%	100.0%
3 B 4 h	Manure management - Other animals (please specify in IIR)	PM2.5_Fused	0.00	0.00	0.000	0.0%	100.0%
1 A5 b	Other, Mobile (including Military)	PM2.5_Fused	0.00	0.00	0.000	0.0%	100.0%

Appendix 3: Adjustment Procedure

In the following tables and figures are presented the data and results inserted in the adjustment reporting templates.

Approved adjustments (Annex VII reporting template)

Annex VII: Reporting of approved adjustments, by NFR, year and pollutant

COUNTRY:	LU	(as ISO2 code)
DATE:	15.03.2020	(as DD.MM.YYYY)
YEAR:	2018	(as YYYY, year of Emissions and Activity Data)
Version:	v2.0	(as v1.0 for the initial submission)

Instructions

1. This template is for the reporting of approved adjustments only. Each approved adjustment should be identified by a unique reference number.
2. Enter values or text only in the cells shaded green.
3. For each adjustment, enter the calculated value for each pollutant/NFR combination in Table A **i.e. the difference (negative value) between the adjusted and unadjusted emission value.**
4. Where more than one application is approved then entries are identified by using different reference numbers. In this way, all data for all adjustments can be listed in Table A
5. Table B automatically calculates the total net adjustment from all individual lines in Table A.
6. The 'Aggregated sum of all Adjustments' should be entered in the main reporting template (Annex I) for the appropriate year.

Illustrative examples are included in the tables below

Table A **INDIVIDUAL ADJUSTMENT DETAILS**

Reference number	Pollutant	NFR	units	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
LU_1A3b_NOx	NOx	1A3b	ktonnes						-5.0019	-5.2879	-5.4903	-5.5824	-5.5484	-5.3867	-4.8811	-4.1671	-3.5900		
LU_3B_NOx	NOx	3B	ktonnes						-0.0835	-0.0805	-0.0784	-0.0802	-0.0821	-0.0825	-0.0832	-0.0846	-0.0829		
LU_3D_NOx	NOx	3D	ktonnes						-1.0545	-1.0618	-1.0495	-1.0394	-1.0313	-1.0263	-1.0757	-1.0730	-1.0461		
LU_3B_NMVOC	NMVOC	3B	ktonnes						-3.0163	-2.9039	-2.8311	-2.9133	-3.0158	-3.0848	-3.1288	-3.1759	-3.1490		
LU_3D_NMVOC	NMVOC	3D	ktonnes						-0.1122	-0.1125	-0.1128	-0.1125	-0.1124	-0.1128	-0.1121	-0.1128	-0.1131		
			ktonnes																
			ktonnes																

Table B **AGGREGATED SUM OF ADJUSTMENTS (use this value in the main emissions reporting template (Annex I)**

Pollutant		units	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NOx	**total**	ktonnes						-6.13992186	-6.43027481	-6.61825912	-6.70197299	-6.66176167	-6.49556297	-6.04009995	-5.32458429	-4.71907482		
SOx	**total**	ktonnes																
NH3	**total**	ktonnes																
NMVOC	**total**	ktonnes						-3.1285613	-3.01641558	-2.94388813	-3.02574322	-3.12821491	-3.19756679	-3.24092659	-3.2887438	-3.26217815		
PM2.5	**total**	ktonnes																
	total	ktonnes																
	total	ktonnes																
	total	ktonnes																

Newly applied adjustments (Annex VIII reporting template)

NA

Appendix 4: POPs emissions

PERSISTENT ORGANIC POLLUTANTS (POPS)

Final Report

Version 1.0

POPs Emissions in Luxembourg in 2017

2019

Contracting authority:
Administration de l'Environnement
1, avenue du Rock'n'Roll
L-4361 Esch-sur-Alzette

efor-ersa, ingénieurs-conseils
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Order
08.10.2018

Handover of the report
25.04.2019

Internal identification
AIR-POP-2017

Content

Glossary

I-TEQ & I-TEF

International Toxicity EQuivalents resp. International Toxicity Factors according to NATO/CCMS (1988).

WHO-TEQ & WHO-TEF

The World Health Organization (WHO) suggested modified Toxic Equivalency Factor (TEF) values. On average, the result of TEQ-calculations is about 10% higher when I-TEFs are used compared to when WHO-TEFs are used.

WHO-TEFs have been developed in 1998 and re-evaluated in 2005. WHO advises that the new WHO 2005 TEF values should be used as they replace the previous 1998 values.

Persistent Organic Pollutants (POPs)

Persistent organic pollutants (POPs) are organic compounds that are resistant to environmental degradation through chemical, biological, and photolytic processes. Because of this, they have been observed to persist in the environment, to be capable of long-range transport, bioaccumulate in human and animal tissue, biomagnify in food chains, and to have potential significant impacts on human health and the environment. There are a few natural sources of POPs, but most POPs are created by humans in industrial processes, either intentionally or as by-products.

Polycyclic Aromatic Hydrocarbons (PAH)

Polycyclic aromatic hydrocarbons (PAHs) are potent atmospheric pollutants that consist of fused aromatic rings and do not contain heteroatoms or carry substituents. PAHs occur in oil, coal, and tar deposits, and are produced as by-products of fuel burning (whether fossil fuel or biomass). As a pollutant, they are of concern because some compounds have been identified as carcinogenic, mutagenic, and teratogenic.

The United States Environmental Protection Agency (EPA) has designated 32 PAH compounds as priority pollutants. The original 16 are listed. They are naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo[*a*]anthracene, chrysene, benzo[*b*]fluoranthene, benzo[*k*]fluoranthene, benzo[*a*]pyrene, dibenz(ah)anthracene, benzo[*ghi*]perylene and indeno(1,2,3-cd)pyrene. This list of the 16 EPA priority PAHs is often targeted for measurement in environmental samples. In this report, if not stated otherwise, indications about total PAHs refer to the 16 priority PAHs as designated by the EPA.

Polychlorinated dibenzodioxins and dibenzofurans (PCDD/F)

Polychlorinated dibenzodioxins (PCDDs), or simply dioxins, are a group of organic polyhalogenated compounds that are significant environmental pollutants. Members of the PCDD family bioaccumulate in humans and wildlife due to their lipophilic properties, and may cause developmental disturbances and cancer.
Dioxins occur as by-products in the manufacture of some organochlorines, in incineration processes, in the chlorine bleaching of paper, and from natural sources such as volcanoes and forest fires.
Polychlorinated dibenzofurans (PCDFs) are a group of halogenated organic compounds which are toxic environmental pollutants. They are known teratogens, mutagens, and suspected human carcinogens. PCDFs tend to co-occur with polychlorinated dibenzodioxins (PCDDs). PCDFs can be formed by pyrolysis or incineration at temperatures below 1.200 °C of chlorine containing products, such as

PVC, PCBs, and other organochlorides, or of non-chlorine containing products in the presence of chlorine donors.
Dioxin and furan emissions are calculated using NATO I-TEF or WHO-TEF. In the present report, PCDD/F emissions are calculated according to NATO I-TEF and WHO-TEF (2005):

PCDD/F-congener	I-TEF (NATO)	WHO-TEF (2005)
2,3,7,8-TCDF	0,1	0,1
1,2,3,7,8-PeCDF	0,05	0,03
2,3,4,7,8-PeCDF	0,5	0,3
1,2,3,4,7,8-HxCDF	0,1	0,1
1,2,3,6,7,8-HxCDF	0,1	0,1
2,3,4,6,7,8-HxCDF	0,1	0,1
1,2,3,7,8,9-HxCDF	0,1	0,1
1,2,3,4,6,7,8-HpCDF	0,01	0,01
1,2,3,4,7,8,9-HpCDF	0,01	0,01
OCDF	0,001	0,0003
2,3,7,8-TCDD	1	1
1,2,3,7,8-PeCDD	0,5	1
1,2,3,4,7,8-HxCDD	0,1	0,1
1,2,3,6,7,8-HxCDD	0,1	0,1
1,2,3,7,8,9-HxCDD	0,1	0,1
1,2,3,4,6,7,8-HpCDD	0,01	0,01
OCDD	0,001	0,0003

Polychlorinated biphenyls (PCB)

A polychlorinated biphenyl (PCB) is any of the 209 configurations of organochlorides with 2 to 10 chlorine atoms attached to biphenyl, which is a molecule composed of two benzene rings. PCBs were widely used as dielectric and coolant fluids, for example in transformers, capacitors, and electric motors. Due to PCBs' toxicity and classification as a persistent organic pollutant, PCB production was banned by the Stockholm Convention on Persistent Organic Pollutants in 2001. Concerns about the toxicity of PCBs are largely based on compounds within this group that share a structural similarity and toxic mode of action with dioxin.

Because PCBs are almost invariably found in complex mixtures, the concept of toxic equivalency factors (TEFs) has been developed to facilitate risk assessment and regulatory control. Whereas some of the measurements for point sources indicated values for PCB-WHO and PCB-DIN, indications in the present report about PCB-TEFs concern the congeners PCB 28, 52, 101, 138, 153 and 180 (as defined by former DIN 515227):

	IUPAC-name	Congener number
PCB-WHO	3,4,4',5-Tetrachlorobiphenyl	PCB 81
	3,3',4,4'-Tetrachlorobiphenyl	PCB 77
	3,3',4,4',5-Pentachlorobiphenyl	PCB 126
	3,3',4,4',5,5'-Hexachlorobiphenyl	PCB 169
	2,3,3',4,4'-Pentachlorobiphenyl	PCB 105
	2,3,4,4',5-Pentachlorobiphenyl	PCB 114
	2,3',4,4',5-Pentachlorobiphenyl	PCB 118
	2,3',4,4',5'-Pentachlorobiphenyl	PCB 123
	2,3,3',4,4',5-Hexachlorobiphenyl	PCB 156
	2,3,3',4,4',5'-Hexachlorobiphenyl	PCB 157
	2,3',4,4',5,5'-Hexachlorobiphenyl	PCB 167
	2,3,3',4,4',5,5'-Heptachlorobiphenyl	PCB 189
PCB-DIN	2,4,4'-Trichlorobiphenyl	PCB 28
	2,2',5,5'-Tetrachlorobiphenyl	PCB 52
	2,2',4,5,5'-Pentachlorobiphenyl	PCB 101
	2,2',3,4,4',5'-Hexachlorobiphenyl	PCB 138
	2,2',4,4',5,5'-Hexachlorobiphenyl	PCB 153
	2,2',3,4,4',5,5'-Heptachlorobiphenyl	PCB 180

Hexachlorbenzene (HCB)

Hexachlorobenzene is a fully chlorinated industrial hydrocarbon chemical. It is insoluble in water, but is very soluble in fat, oils, and organic solvents. Hexachlorobenzene is one of the most persistent environmental pollutants, and bioaccumulates in the environment, in animals, and in humans. Hexachlorobenzene is produced as a byproduct or impurity for example in the manufacture of chlorinated solvents and other chlorinated compounds, including several pesticides. Chronic (long-term) oral exposure to hexachlorobenzene in humans results in a liver disease with associated skin lesions. EPA has classified hexachlorobenzene as a probable human carcinogen. Due to HCB's persistence in the environment, it has been banned globally under the Stockholm Convention (source: www.toxipedia.org).

1. INTRODUCTION

The present inventory of POPs emissions in Luxembourg was compiled in the context of the 1979 Geneva Convention on Long-Range Transboundary Air Pollution. The Geneva Convention is the first legally binding instrument for dealing with problems of air pollution on international scale.

As a party to the Convention, Luxembourg is obliged to annually submit data on emissions of air pollutants in order to comply with the protocols under the Convention. Parties are required to report on annual national emissions of SO_X, NO_X, NMVOC, CO, NH_3 and various heavy metals as well as on POPs.

The present report presents an estimation of POPs emissions in Luxembourg in 2017 and shows emission trends over the past three decades (1990 – 2017).

2. METHODOLOGY

Emission levels for POPs emissions were calculated using the latest available methodology (EEA 2016). Measurement data were used where available. Otherwise, calculations were based on activity data (i.e. fuel consumption) and the corresponding emission factors from EEA (2016).

2.1. Fuel Combustion Activities (NFR 1 A)

POPs emissions in this sector primarily result from fuel combustion. This includes combustion processes related to electricity and heat production, the heavy industries and other manufacturing industries, road, rail and waterway traffic, off road mobility, agriculture, as well as small commercial and residential heating systems.

For the whole period covered by this report, emission factors were taken from EEA (2016).

This chapter includes emissions from point sources as well as from diffuse sources.

2.1.1. NFR 1 A 1 Energy Industries

NFR 1 A 1 a Public electricity and heat production

This category includes emissions from combustion processes associated with industrial heat and energy production as well as emissions originating from waste-to-energy processes (WTE). Apart from two large point sources (WTE plant in Leudelange and TWIN ERG plant in Esch/Alzette), this category includes only diffuse emissions from a range of industrial combustion plants at different locations in the country.

Calculation of emissions originating from the WTE plant was based on data from emission control measurements. Projection of annual emissions was carried out using these measurement data in combination with annual operating hours and emission factors from EEA (2016). Where measurement data for the WTE plant were lacking, emissions were calculated on the basis of annual consumption of fuels (natural gas, gas oil) and the amount of incinerated wastes (municipal wastes, biomass) using the appropriate tier 1 emission factors from EEA (2016). In order to obtain more 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).

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 from EEA (2016). Fuel consumption data were obtained from the national energy balance compiled by the competent authority (*Administration de l′ environnement*).

2.1.2. NFR 1 A 2 Industries and Construction

NFR 1 A 2 a Iron and steel

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.

The sintering plant in Esch-Belval was operational until 1996 and thus considered a large point source from 1990 to 1996. Calculations of POPs 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 emission factors from EEA 2016 (combustion in manufacturing industries and construction; all tier 1 approach). 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 (2016) (1.92 GJ/Mg; cf. chapter 2.C.1, p. 16). Process-related emissions were calculated using tier 2 emission factors from EEA (2016).

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 (2016) (18.67 GJ/Mg; cf. chapter 2.C.1, p. 13). For calculation of process-related emissions, technology-specific emission factors from EEA (2016) were employed (tier 2 approach).

The POPs emissions of the three electric arc furnaces (EAFs) in Esch-Belval, Schifflange and Differdange are treated under chapter 2.2. "Industrial processes" NFR 2 C 1 Iron and steel.

Calculation of diffuse emissions was based on data from the national energy balance in combination with appropriate tier 1 emission factors from EEA (2016).

NFR 1 A 2 b Non-ferrous metals

In this category, three large point sources were considered: 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 whole period covered in this report, whereas the Hydro Aluminium plant was put into service in 1996 as a spin-off from Alcuilux. Emissions of these point sources are treated under chapter 2.2. "Industrial processes" NFR 2 C3 Aluminium production.

NFR 1 A 2 c Chemicals

Reported 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.

Since 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 emission factors. Fuel consumption data were obtained from the national energy balance. Appropriate tier 1 emission factors were taken from EEA (2016).

NFR 1 A 2 d Pulp, paper, and print

The calculation of emissions related to pulp, paper, and print were based on total fuel consumption in combination with emission factors. Fuel consumption data were obtained from the national energy balance. Appropriate tier 1 emission factors were taken from EEA (2016).

NFR 1 A 2 e Food processing, beverages, and tobacco

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.

Since emission measurements were not available for any of these facilities, calculation of emissions originating from food processing, beverages, and tobacco were based on total fuel consumption in combination with emission factors. Fuel consumption data were obtained from the national energy balance. Appropriate tier 1 emission factors were taken from EEA (2016).

NFR 1 A 2 f Non-metallic minerals

With the Cimalux cement kiln in Rumelange this category includes one large point source of POPs. Apart from these sources, several smaller facilities at different locations in the country are considered in this category.

For the cement kiln, emission measurements were available from several years and for all POPs. 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 the EEA guidebooks (tier 2 approach). Where measurement data for the kiln were lacking, emissions were calculated on the basis of annual consumption of different fuels used (natural gas, residual fuel oil, gas oil, coal, tires, fluff, sewage sludge) employing emission factors from the EEA guidebooks (combustion in manufacturing industries and construction; all tier 1 approach). Since emission factors for cement production in the guidebooks are stated in relation to production volume, the amount of clinker produced had to be back-calculated 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 (2016), chapter 2.A.1, p. 4). In order to obtain more 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).

Since POPs emissions from cement production are assumed to originate mainly from combustion processes, it was not necessary to take process-related emissions into account (cf. EEA (2016), chapter 2.A.1, p. 6).

POP emissions from glass production were calculated based on emission factors from EEA (2016) and fuel consumption data from the national energy balance.

NFR 1 A 2 gviii Other

With the asphalt plants in Leudelange (Cajot), Schifflange (Lisé), Wasserbillig (Wickler) and the City of Luxembourg (Karp-Kneip) this category includes four point sources of POPs.

Emission measurements for these asphalt plants were only available for Benzo(a)pyrene. Thus, calculations of POPs emissions originating from asphalt production were based on annual fuel consumption taken from the national energy balance. Emissions were calculated separately for different types of fuel used (brown coal, gas oil, natural gas) employing tier 1 emission factors from EEA (2016). Process-related POPs emissions from asphalt production were assumed to be negligible and thus not taken into account.

Data about fuel consumption related to other sources of emissions in this sector were obtained from the national energy balance. These include transport equipment, machinery, mining and quarrying, wood and wood products, construction, and other non-specified industry. Appropriate emission factors were taken from EEA (2016).

2.1.3. NFR 1 A 3 Transport

For the present report, POP emissions from transport were estimated on total fuel sales. This corresponds to a change compared to the method previously used where emissions were calculated based on the national car pool.

Emission values were taken from the Network emission model (NEMO) retroactively until 1990. This was done for the following NFR categories:

- 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

Until last report regarding POP emissions in Luxembourg, **HCB emissions from road transport** have been calculated based on the appropriate emission factors taken from the publication "Update of the Air Emissions Inventory Guidebook – Road Transport 2014 Update" rather than omitting HCB emissions from road transport completely. The guidebook from 2016 states that "With regard to HCB, emission factors are not given due to a complete lack of relevant data from road transport. An initial approach was to gather the emission factors from other sources (industrial, waste combustion, ship engines, etc.). However, due to the high variance of the emission factors from these sources, it was decided that more relevant testing is needed to develop emission factors that better represent road vehicles. [...] It was therefore decided to suspend the development of emission factors for HCB from road vehicles until more relevant data have become available. "

As this view has been confirmed under the Convention, HCB emissions from road transport are no longer included in this report.

NFR 1 A 3 c Railways

Calculation of POPs emissions from rail traffic were based on total fuel consumption per year obtained from the national energy balance. Appropriate emission factors were taken from EEA (2016). Since railway-specific emission factors are only given for B(a)P and B(b)F, emission factors for other POPs were adopted from road traffic (heavy duty vehicles). This approach is in line with the guidelines given in the current version of the guidebook (EEA 2016; tier 1, cf. p. 8).

NFR 1 A 3 cii Off-road Other

Calculations for PAH emissions from off-road mobility were based on Tier 1 emission factors taken from EEA (2016) (chap 1A4 Non road mobile machinery, table 3-1) combined with fuel consumption data obtained from the national energy balance: agriculture (tractors, harvesters) – diesel oil only - and other mobile equipment.

NFR 1A3d Navigation

Calculations for PCDD/F, PCB and HCB emissions from navigation shipping were based on Tier 1 emission factors taken from EEA (2016) (chap 1A3d navigation shipping table 3-1) combined with fuel consumption data obtained from the national energy balance (navigation on inland waterways). The same emission factors were uses for diesel and motor gasoline.

2.1.4. NFR 1 A 4 Small combustion

POPs emissions from small stationary combustion facilities were based on energy consumption data from the national energy balance. These data permit to differentiate between commercial, residential, and agricultural sources as well as between different types of used fuel. Tier 2 emission factors were taken from EEA (2016).

NFR 1 A 4 a i Commercial/institutionary: Stationary

Calculation of POPs emissions from small combustion in commercial/institutionary facilities were based on total fuel consumption (data from the national energy balance). With these data, separate calculations for different energy carriers (coke, brown coal, patent fuels, other bituminous coal, wood and wood wastes, biogas, natural gas, gas oil, LPG, diesel oil) were undertaken.

Appropriate tier 2 emission factors were taken from EEA (2016).

NFR 1 A 4 b i Residential: Stationary

Calculation of POPs emissions from small combustion in the residential sector were also based on total fuel consumption (data from the national energy balance). Separate calculations for different energy carriers (coke oven coke, brown coal briquettes, patent fuels, other bituminous coal, wood and wood wastes, natural gas, gas oil, LPG, gasoline) were undertaken.

Appropriate tier 2 emission factors were taken from EEA (2016).

NFR 1 A 4 c i Agriculture/Forestry/Fishing: Stationary

Calculation of POPs emissions from small combustion in the agricultural sector were also based on total fuel consumption (data from the national energy balance). Separate calculations for different energy carriers (biogas, natural gas, gas oil, diesel oil) were undertaken.

Appropriate tier 2 emission factors were taken from EEA (2016).

2.2. Industrial processes (NFR 2)

POPs emissions in this sector result directly from industrial production processes. This chapter only includes facilities for which emission control measurements were available. Combustion processes related to industrial energy and heat production are included in the NFR categories 1 A 2 a to 1 A 2 f i and not taken into account 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 1 A 2 a and 1 A 2 b for practical reasons.

For the whole period covered by this report, emission factors were taken from EEA (2016).

2.2.1. NFR 2 C Metal production

NFR 2 C 1 Iron and steel

Four large point sources contribute to POPs emissions in this category: Three electric arc furnaces in Esch-Belval, Schifflange (until 2011) and Differdange, as well as the Primorec plant in Differdange (until 2009).

Where appropriate data were available, calculations of POPs emissions were based on annual emission control measurements and activity data obtained from the operating company.

With regard to 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 (2016) 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 EEA (2016). 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. Finally, this transformation leads to a demand for combustibles of 0.975 GJ per ton of electrically produced steel (cf. EEA 2016, chapter 2.C.1, p. 18). 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).

However, for **HCB** emissions, the abovementioned approach for filling of measurement gaps could not be employed since emission factors for HCB in electric steel production are not provided by EEA (2016). For years without **HCB** measurements we thus approximated emission levels by converting the closest measured emission value proportionally to energy consumption in the year in question and in the year the measured value was taken from (rule of three).

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 the energy input).

Since no measured data of **HCB** emissions were available, emissions were calculated based on the average measured emissions of the three electric arc furnaces and the energy consumption of the Primorec plant as given by the national energy balance.

NFR 2 C 3 Aluminium production

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 whole period covered in this report, whereas the Hydro Aluminium plant was put into service in 1996 as a spin-off from Alcuilux.

For the Alcuilux melt, emission measurements were available for all POPs from several years. Calculation of emissions based on measured data were carried out using annual operating hours (stated in some of the measurement protocols) and tier 2 emission factors from EEA (2016). Where measurement data for the Alcuilux plant were lacking, emissions were calculated on the basis of annual consumption of different fuels (natural gas, LPG) using the appropriate emission factors from EEA (2016) (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).

Process related emissions were based on activity data (tons of aluminium per year) which in turn were back-calculated on basis of the total amount of energy used per year. For back-calculation, the mean value of the range for energy demand per ton of aluminium produced during electrolysis stage was calculated using the values stated in EEA (2016) (primary production: 15 MWh = 54 GJ, chapter 2.C.3, p. 8). Since production of aluminium from recycled material only uses about 5 percent of the energy of primary production (OSPARCOM 1997), this value was multiplied by 0.05 giving a result of 3.18 GJ/Mg for secondary aluminium production. The calculation of process-related emissions was based on this conversion using tier 2 emission factors from EEA (2016).

However, for **PCB** emissions, the abovementioned approach could not be employed since emission factors for this pollutant were not available from the EEA guidebooks. For years without **PCB** measurements we thus approximated emission levels by converting the closest measured emission value proportionally to energy consumption in the year in question and in the year the measured value was taken from (rule of three).

From the Hydro Aluminium melt measured data were only available for **PCCD/F** and **PCB**, from Novelis only for **PCCD/F** emissions. Here we employed the same approach as stated above for the Alcuilux melt. Other emissions for these melts had to be approximated on the basis of energy consumption (taking into account the different types of fuels used) and the abovementioned correction factors from the Alcuilux melt. However, this approach is based on the assumption that all three melts employ similar techniques in terms of production processes and emission abatement (i.e. all melts have the same ratio of emission levels to energy consumption).

Since an emission factor for **PCB** in aluminium production was not available, we had to approximate **PCB** emissions for the Hydro Aluminium and Novelis melts using calculated emission values from Alcuilux as a reference. Emissions from Alcuilux were transformed proportionally to the ratio of energy consumption of the Alcuilux melt to the other melt in question. In this approach, we could only consider total energy consumption without being able to account for the different types of fuel used.

HCB emissions were calculated based on the TIER 2 default emission factor from EEA (2016) and energy consumption as given by the national energy balance.

2.2.2. NFR 2 D Solvent and product use

NFR 2.D.3.g Chemical products

Asphalt blowing does not occur in Luxembourg.

Other products that might be relevant for this category have been included under 2 G “Other product use”. This concerns tobacco, fireworks, batteries and fluorescent light tubes.[128]

2.2.3. NFR 2 K Consumption of POPs and heavy metals

In this category, emissions originate from the dismantling of older electrical generators. Data about the amount of disposed generators (in tons per year until 2017) were compiled by the competent authority (*Administration de l’environnement*) and offset with the appropriate emission factors from EEA (2016). In this context, only PCB emissions were considered.

[128] cf. Observation LU-2D3g-2018-0001 from the NECD Review 2018

2.3. Waste (NFR 5)

2.3.1. NFR 5 C Waste incineration

NFR 5.C.1.a Municipal waste incineration

Waste incineration only takes place in the WTE plant in Leudelange where the produced energy is recovered. POPs emissions from this facility were thus included in NFR 1 A 1 a (public electricity and heat production).

NFR 5.C.1.b.iii Clinical waste incineration

Clinical waste incineration took place in a number of small facilities (in 1990 approx. 11 facilities) until the late nineties. Unfortunately, emission measurements or data about the amount of burned waste are not available. Thus, POPs emissions from clinical waste incineration had to be estimated. This was achieved on base of the UK National Atmospheric Emissions Inventory (NAEI). UK emission levels were adopted to Luxembourg in relation to population numbers in both countries. We are aware of the coarse character of this approximation but found it acceptable, since the share of clinical waste incineration in total POPs emissions is very small. Today, all facilities for clinical waste incineration in Luxemburg are shut down (DORNSEIFFER 2005).

NFR 5.C.1.b.v Cremation

The crematory in Luxemburg/Hamm is operational since 1995. It is considered a small point source of POPs emissions.

Control measurements of **PCB**, and **PAH** emissions from the crematory were available from 2011, measurements for **PCDD/F** from 1998, 2004, 2011, and 2014. **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 an emission factor taken from EEA (2016).

Operating hours of the facility were estimated on a conservative basis (8 hours per day, 5 days per week, 52 weeks per year).

For the years without measurement data, **PAH, PCB**, and **PCDD/F** emissions were estimated by conversion of measured emission levels proportionally to the total number of cremations per year. Since total numbers of cremations were not available for every year, we assumed a linear increase since 1995 in order to fill the gaps.

NFR 5.C.2 Open burning of waste

Open burning of waste is banned in Luxembourg by law. Emissions from this type of source don' t occur.[129]

[129] cf. Observation LU-5C2-2018-0001 from the NECD Review 2018

2.4. Methodology in relation to specific pollutants

2.4.1. Polycyclic Aromatic Hydrocarbons (PAH)

Where no measured data were available for the 16 PAHs, emissions were calculated using emission data of the four substances benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene) as specified by the guidelines for reporting emission data under the convention on long-range transboundary air pollution (United Nations 2009). The average of these four substances was multiplied by a factor sixteen assuming that emission levels are distributed evenly among the 16 substances. Emission factors were taken from EEA (2016). With regard to gas oil in NFR category 1A1a Energy Industries, EEA (2016) contains specifications only for indeno(1,2,3-cd)pyrene. Thus, the same emission factor was applied to the other PAHs.

2.4.2. Polychlorinated biphenyls (PCB)

Where no measured data were available, PCB emissions had to be calculated. For some NFR categories, emission factors for liquid fuels were not available in EEA (2016). Thus, emission factors for these categories were taken from the draft chapter about PCBs in the EMEP/Corinair Guidebook (EEA 2007). Emissions from gaseous fuels were considered negligible.

2.5. Key Category Analysis

Key category analysis (KCA) was performed according to the methodology given in EEA (2016). For **PCDD/F**, **PCB**, **HCB**, and **PAH (total 1-4)**, KCA approach 1 with level and trend assessment was carried out (chapter 3).

NFR categories identified as key categories by either level or trend assessment were regarded as key categories (cf. annexe 1 - 4).

3. EMISSION TRENDS

Emission trends for Persistent Organic Pollutants (POPs) in Luxembourg are heterogeneous. Nevertheless, POP emissions decreased remarkably between 1990 and 2017. The highest reductions were achieved with regard to PCDD/F emissions (- 95 percent). PAH and PCB emissions were reduced by 86 and 91 percent respectively, whereas HCB emissions increased by 5 percent within the same period (Tab. 3-1).

HCB emissions are fluctuating from one year to the next with no steady trend over the past three decades. The following years will show whether the downward trend of the last three years will continue.

After an important – though not always constant - decrease between 1990 and 2007 (-89%), PCDD/F emissions seem to level off at a value ranging from 1,4 to 2,4 g per year.

The trend for PCB emissions is similar (-91% from 1990 to 2017). The six years documented since 2012 have been amongst the eight years with national PCB emissions under 10 kg/year.

After an important reduction of PAH emissions during the nineties, the following years show minor fluctuations and PAH emissions seem to level off at 0.5 t/a - 0.7 t/a since then.

Emission reductions of PCDD/F and PCB are closely related to the restructuring seen foremost in the nineties in the iron and steel industry.

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.

Table 3-1: Emissions and emission trends for POPs 1990 – 2017.

Year	Emission			
	PAH	PCDD/F	HCB	PCB
	(total 1-4)	(I-TEQ)		(6 congeners)
	[t]	[g]	[kg]	[kg]
1990	4,515	43,4	0,422	39,912
1991	4,402	41,5	0,424	40,382
1992	4,036	38,1	0,413	40,309
1993	4,321	41,5	0,413	40,169
1994	3,742	35,4	0,421	43,331
1995	2,295	33,9	1,266	35,852
1996	2,177	23,4	0,713	16,717
1997	1,505	14,4	0,483	3,461
1998	0,712	8,4	1,137	17,720
1999	0,719	8,8	1,178	15,944
2000	0,635	6,1	0,558	11,255
2001	0,759	3,2	0,974	13,002
2002	0,578	3,0	0,453	15,285
2003	0,563	2,8	0,534	13,805
2004	0,582	2,5	0,541	13,346
2005	0,594	2,2	0,545	12,031
2006	0,658	2,3	0,747	8,004
2007	0,515	2,0	0,851	10,479
2008	0,529	2,4	0,608	12,372
2009	0,526	2,9	0,682	19,006
2010	0,602	2,4	0,613	18,709
2011	0,499	2,3	0,584	26,452
2012	0,545	1,7	0,388	9,080
2013	0,581	1,6	0,365	4,260
2014	0,623	1,8	0,400	5,131
2015	0,568	1,4	0,473	3,078
2016	0,635	2,3	0,458	3,805
2017	0,609	2,0	0,443	3,642
Trend 1990-1999	***-84,08%***	***-79,83%***	***+ 179,15%***	***-60,05%***
Trend 2000-2017	***-4,10%***	***-67,03%***	***-20,66%***	***-67,64%***
Trend 1990-2017	***-86,51%***	***-95,35%***	***+ 4,91%***	***-90,87%***

Note: Minor inconsistencies of emission values and calculated percentages are due to rounding errors.

3.1. Dioxins and furans (PCDD/F)

With regard to **PCDD/F** emissions, the KCA identified the following emission sources as key categories: **iron and steel production** (2C1) in level assessment, **residential heating** (1A4bi) in both level and trend assessment, **stationary combustion in manufacturing industries and construction** (1A2gviii) and **road transport with passenger cars** (1A3bi) in trend assessment (KCA cf. annexe 1, see also Fig. 3-1).

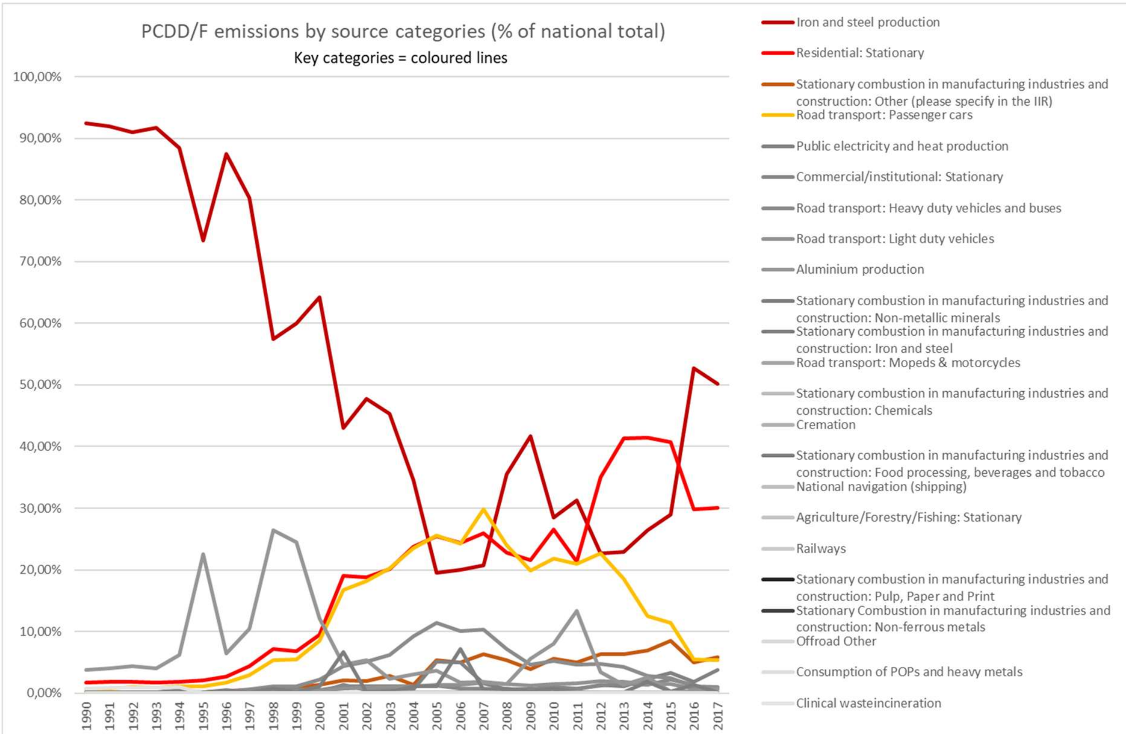

Figure 3-1: Evolution of PCDD/F emissions by different NFR categories. Key categories are shown as coloured lines.

Over the past twenty years, PCDD/F emissions have dropped dramatically. This decrease occurred mainly due to important changes in the iron and steel industry during the 1990s which resulted in a drop of emissions of over 95 percent between 1990 and 2017 (see Fig. 3-2 & Tab. 3-2).

In the recent past, PCDD/F emissions from steel production decreased remarkably (minus 42 percent from 2011 to 2015). One reason for this decrease was the decommissioning of a large steelworks in Schifflange. The increase emissions visible in 2016 and 2017 are the result of an important rise of emissions from the electric arc furnace in Differdange.

PCCD/F emissions from road transport (calculations based on fuel sold) increased dramatically until 2010. This rise is mainly due to an overall increase of the national car pool and higher yearly mileages. From 2010 on, PCCD/F emissions show a steady decrease due to modernised engine technologies and also a slight decrease in fuel quantities sold.

Due to the availability of measurement protocols for most facilities and most years, PCDD/F emissions given for the iron and steel and the aluminium industries are relatively accurate. Emissions for years without any available measurements were calculated based on energy balance, emission factors and a correction factor, which in turn was derived from measured data of other years. The same applies to other industrial sectors and the residential and commercial sector where emissions were calculated on the basis of activity data/energy balance and emission factors. Emissions from road traffic were taken from the Network emission model (NEMO) retroactively until 1990.

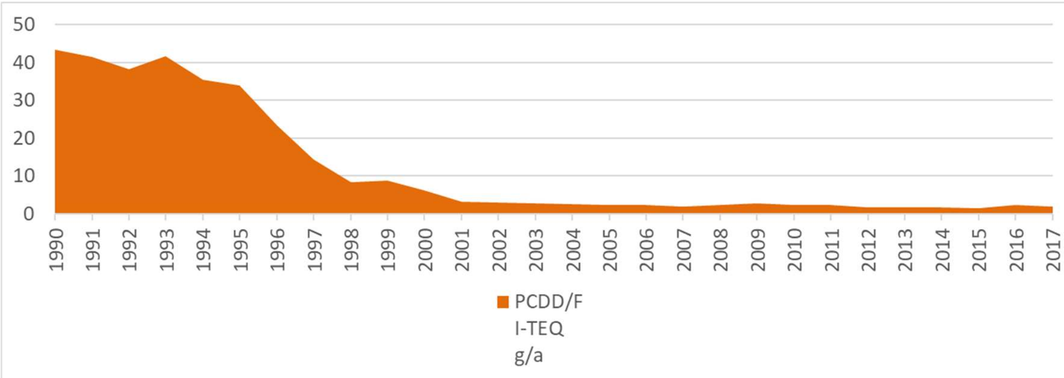

Figure 3-2: Evolution of total PCDD/F emissions in Luxembourg since 1990.

Table 3-2: PCDD/F emissions by NFR category 1990 and 2017 - Trends and shares in total emissions.

NFR Category		PCDD/F (ITEQ) emissions [g]		Trend	Share in National Total	
		1990	2017		1990	2017
1 A	**ENERGY - FUEL COMBUSTION ACTIVITIES**	**1,262**	**0,991**	**-21,5%**	**2,9%**	**49,1%**
1 A 1	***Energy Industries***	***0,005***	***0,077***	***+ 1440%***	***0,0%***	***3,8%***
1 A 1 a	Public electricity and heat production	0,005	0,077	+ 1440%	0,0%	3,8%
1 A 2	***Stationary combustion in manufacturing industries and construction***	***0,130***	***0,123***	***-5,4%***	***0,3%***	***6,1%***
1 A 2 a	Iron and steel	0,023	0,002	-91,3%	0,1%	0,1%
1 A 2 b	Non-ferrous metals	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 2 c	Chemicals	0,003	0,001	-66,7%	0,0%	0,0%
1 A 2 d	Pulp, paper and print	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 2 e	Food processing, beverages and tobacco	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 2 f	Non-metallic minerals	0,038	0,003	-92,1%	0,1%	0,1%
1 A 2 g viii	Other	0,066	0,117	+ 77,3%	0,2%	5,8%
1 A 3	***Transport***	***0,332***	***0,143***	***-56,9%***	***0,8%***	***7,1%***
1 A 3 b i	Passenger cars	0,267	0,107	-59,9%	0,6%	5,3%
1 A 3 b ii	Light duty vehicles	0,009	0,015	+ 66,7%	0,0%	0,7%
1 A 3 b iii	Heavy duty vehicles and buses	0,055	0,019	-65,5%	0,1%	0,9%
1 A 3 b iv	Mopeds & motorcycles	0,001	0,002	+ 100%	0,0%	0,1%
1 A 3 b vi	Road transport: Automobile tyre and brake wear	NA	NA	NA	NA	NA
1 A 3 c	Railways	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 3 d ii	National navigation (shipping)	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 3 e ii	Offroad Other	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 4	***Other***	***0,795***	***0,648***	***-18,5%***	***1,8%***	***32,1%***
1 A 4 a i	Commercial / institutional: Stationary	0,062	0,042	-32,3%	0,1%	2,1%
1 A 4 b i	Residential: Stationary	0,733	0,606	-17,3%	1,7%	30,0%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	0,000	0,000	± 0,0%	0,0%	0,0%
2 C	**INDUSTRIAL PROCESSES - METAL PRODUCTION**	**41,773**	**1,025**	**-97,5%**	**96,3%**	**50,8%**
2 C 1	Iron and steel production	40,126	1,012	-97,5%	92,5%	50,2%
2 C 3	Aluminium production	1,647	0,013	-99,2%	3,8%	0,6%
2 K	**INDUSTRIAL PROCESSES - CONSUMPTION OF POPS AND HEAVY METALS**	**0,000**	**0,000**	**± 0,0%**	**0,0%**	**0,0%**
2 K	Consumption of POPs and heavy metals	0,000	0,000	± 0,0%	0,0%	0,0%
5 C	**WASTE - INCINERATION**	**0,350**	**0,001**	**-99,7%**	**0,8%**	**0,0%**
5 C 1 b iii	Clinical wasteincineration (d)	0,350	NO	-100,0%	0,8%	NO
5 C 1 b v	Cremation	NO	0,001	+	NO	0,0%
	National total for the entire territory	**43,385**	**2,017**	**-95,4%**	**100,0%**	**100,0%**

3.2. Polycyclic Aromatic Hydrocarbons (PAH)

With regard to **PAH** emissions, the KCA identified **residential heating** (1A4bi), **commercial/institutional heating** (1A4ai) and **stationary combustion in manufacturing industries and construction** (1A2gviii) as key categories, both in level and trend assessment (KCA cf. annexe 1, see also Fig. 3-3).

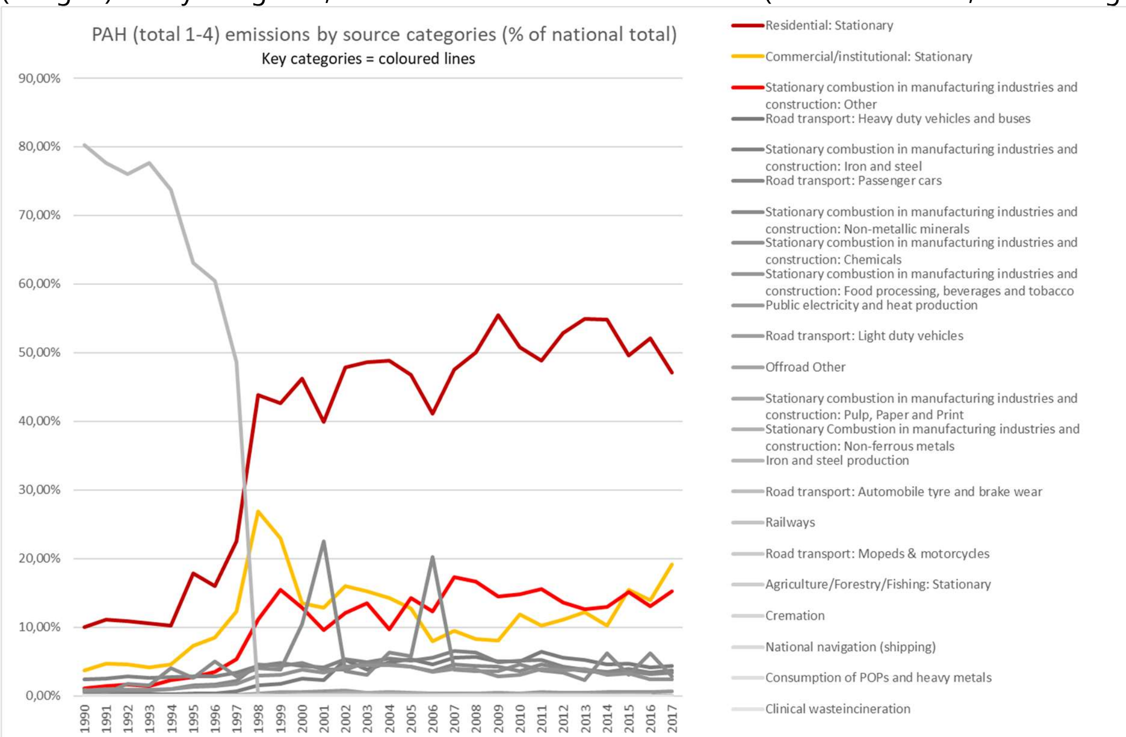

Figure 3-3: Evolution of PAH emissions by different NFR categories. Key categories are shown as coloured lines.

PAH form during incomplete combustion processes which mainly occur in older stoves and small heating plants. Based on the values for benzo[*b*]fluoranthene, benzo[*k*]fluoranthene, benzo[*a*]pyrene and indeno(1,2,3-cd)pyrene, some 66 percent of PAH emissions in Luxembourg originate from residential and commercial heating as well as from the use of biomass as fuel. Other sources of PAH emissions are industrial combustion processes and diesel-driven road transport (25 and 8 percent of total emissions, respectively). **PAH emissions originating from industrial combustion processes are mainly related to wood and wood products as well as to the construction sector.**

PAH emissions decreased by almost 87 percent from 1990 to 2017 (Fig. 3-4). **Most of that reduction occurred in the 1990s due to the replacement of fossil fuel intensive processes in iron and steel production (sintering plants and blast furnaces) by electrical arc furnaces (secondary production)[130].**

Emissions from the production of non-metallic minerals (primarily aluminium production, responsible for the increase observable from 2005 to 2010) and chemicals also decreased considerably. The grad-

[130] cf. Observation LU-2C1-2018-0002 from the NECD Review 2018

ual replacement of coal- and oil-burning heating systems by the increased use of natural gas for residential heating led to a further decrease of PAH emissions during the past two decades (Tab. 3-3). On the other hand, increasing numbers of diesel-driven vehicles led to a rise of PAH emissions in the transport sector.

However, the calculation of PAH emissions from residential heating is based on fuel consumption and emission factors. Particularly with regard to wood burning, calculated emission levels are rather coarse since detailed information (e.g. exact amount and quality of the burned firewood) were not available.

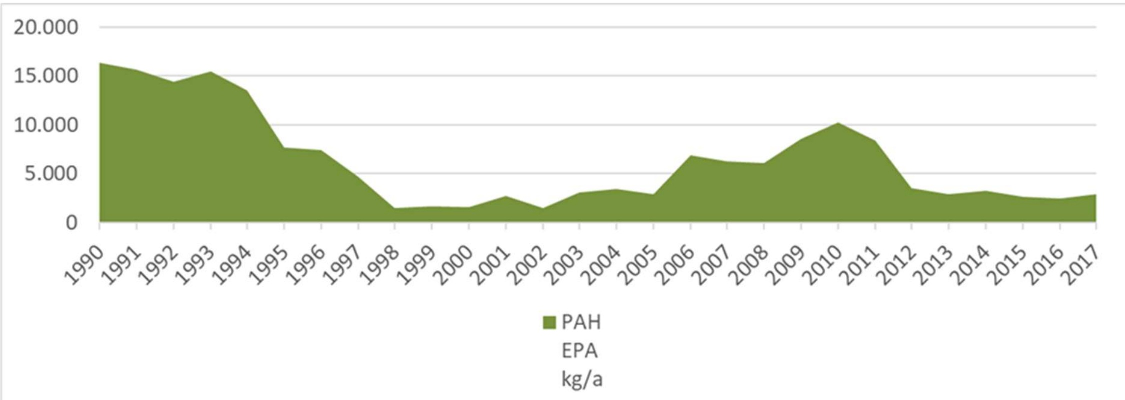

Figure 3-4 Evolution of selected PAH emissions in Luxembourg since 1990.

Table 3-3: PAH emissions by NFR category 1990 and 2017 - Trends and shares in total emissions.

NFR Category		PAH (total 1-4) emissions [t] 1990	2017	Trend	Share in National Total 1990	2017
1 A	**ENERGY - FUEL COMBUSTION ACTIVITIES**	**0,892**	**0,608**	**-31,8%**	**19,8%**	**100,0%**
1 A 1	***Energy Industries***	***0,000***	***0,002***	***+***	***0,0%***	***0,3%***
1 A 1 a	Public electricity and heat production	0,000	0,002	+	0,0%	0,3%
1 A 2	***Stationary combustion in manufacturing industries and construction***	***0,237***	***0,153***	***-35,4%***	***5,2%***	***25,1%***
1 A 2 a	Iron and steel	0,110	0,022	-80%	2,4%	3,6%
1 A 2 b	Non-ferrous metals	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 2 c	Chemicals	0,035	0,015	-57,1%	0,8%	2,5%
1 A 2 d	Pulp, paper and print	0,000	0,001	+	0,0%	0,2%
1 A 2 e	Food processing, beverages and tobacco	0,002	0,004	+ 100%	0,0%	0,7%
1 A 2 f	Non-metallic minerals	0,041	0,018	-56,1%	0,9%	3,0%
1 A 2 g vii	Other	0,049	0,093	+ 89,8%	1,1%	15,3%
1 A 3	***Transport***	***0,035***	***0,049***	***+ 40,5%***	***0,8%***	***8,1%***
1 A 3 b i	Passenger cars	0,026	0,020	-23,1%	0,6%	3,3%
1 A 3 b ii	Light duty vehicles	0,001	0,002	+ 100%	0,0%	0,3%
1 A 3 b iii	Heavy duty vehicles and buses	0,007	0,026	+ 271,4%	0,2%	4,3%
1 A 3 b iv	Mopeds & motorcycles	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 3 b vi	Road transport: Automobile tyre and brake wear	0,000	0,000	+ 151,2%	0,0%	0,1%
1 A 3 c	Railways	0,001	0,000	-100%	0,0%	0,0%
1 A 3 d ii	National navigation (shipping)	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 3 e ii	Offroad Other	0,000	0,001	+	0,0%	0,2%
1 A 4	***Other***	***0,620***	***0,404***	***-34,8%***	***13,7%***	***66,4%***
1 A 4 a i	Commercial / institutional: Stationary	0,167	0,117	-29,9%	3,7%	19,2%
1 A 4 b i	Residential: Stationary	0,453	0,287	-36,6%	10,0%	47,2%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	0,000	0,000	± 0,0%	0,0%	0,0%
2 C	**INDUSTRIAL PROCESSES - METAL PRODUCTION**	**3,622**	**0,000**	**-100%**	**80,2%**	**0,0%**
2 C 1	Iron and steel production	3,622	0,000	-100%	80,2%	0,0%
2 C 3	Aluminium production	IE	IE	IE	IE	IE
2 K	**INDUSTRIAL PROCESSES - CONSUMPTION OF POPS AND HEAVY METALS**	**0,000**	**0,000**	**± 0,0%**	**0,0%**	**0,0%**
2 K	Consumption of POPs and heavy metals	0,000	0,000	± 0,0%	0,0%	0,0%
5 C	**WASTE - INCINERATION**	**0,001**	**0,000**	**-100%**	**0,0%**	**0,0%**
5 C 1 b iii	Clinical wasteincineration (d)	0,001	NO	-100,0%	0,0%	NO
5 C 1 b v	Cremation	NO	0,000	+	NO	0,0%
	National total for the entire territory	**4,515**	**0,608**	**-86,5%**	**100,0%**	**100,0%**

3.3. Hexachlorobenzene (HCB)

With regard to **HCB** emissions, the KCA identified **iron and steel production** (2C1) and **public electricity and heat production** (1A1a), as key categories both in level and trend assessment (KCA cf. annexe 1, see also Fig. 3-5).

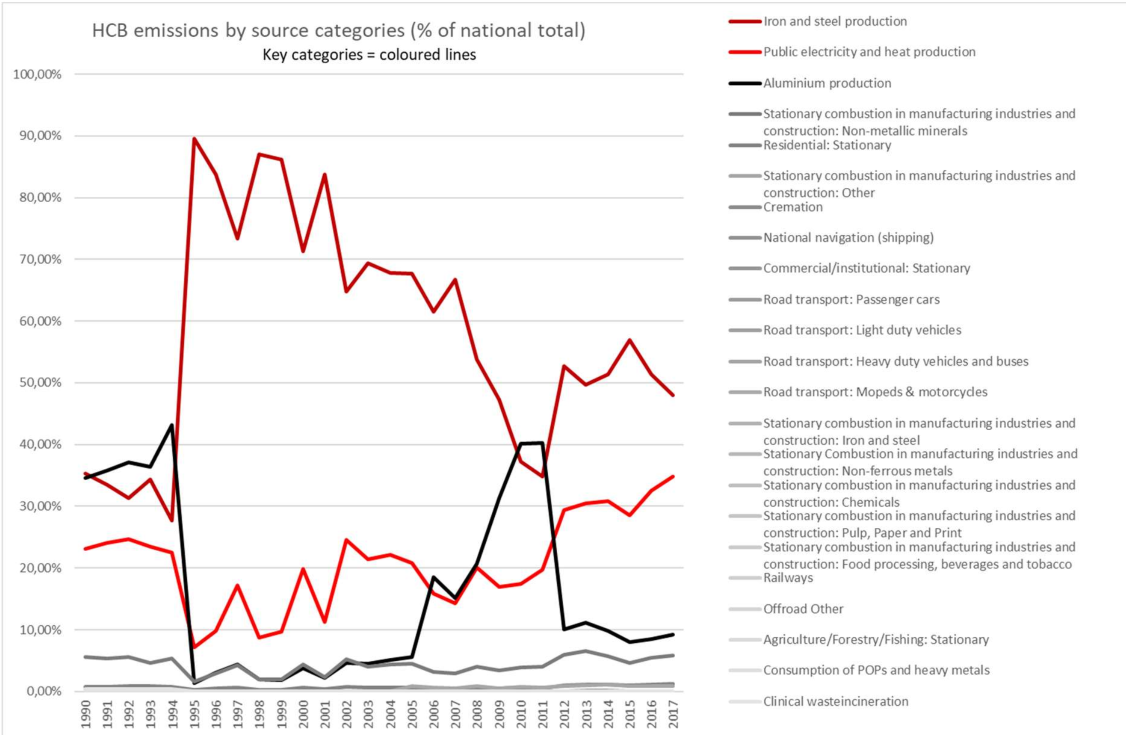

Figure 3-5: Evolution of HCB emissions by different NFR categories. Key categories are shown as coloured lines.

After a huge increase in the second half of the nineties and some ups and downs since 1999, HCB emissions in Luxembourg have been decreasing from 2009 to 2013 reaching more or less the level of the beginning of the 1990s (Fig. 3-6). The sharp increase and heavy fluctuations of HCB emissions between 1994 and 1999 were predominantly caused by the steel industry which put three new electrical steel plants into service.

From 2013 to 2015 emissions increased again by almost 30 percent due to higher discharges from the electric arc furnace in Belval, the WTE plant in Leudelange, and the secondary aluminium melt in Clervaux. This was followed by minor reductions of emissions in 2016 and 2017.

In 2017, iron and steel production made up for 52 percent of the national total (Tab. 3-4). Other important sources were the WTE plant in Leudelange as a large point source and the aluminium industry.

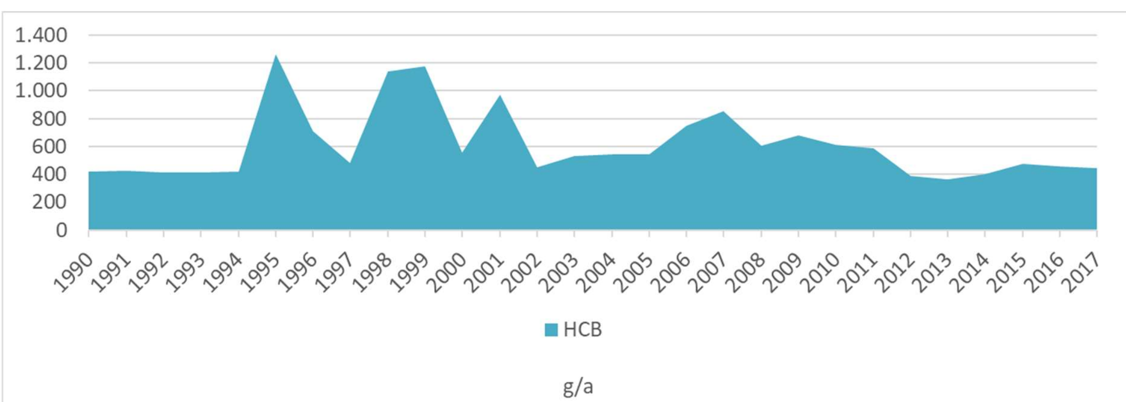

Figure 3-6: Evolution of HCB emissions in Luxembourg since 1990.

Table 3-4: HCB emissions by NFR category 1990 and 2017 - Trends and shares in total emissions.[131]

NFR Category		HCB emissions [kg]		Trend	Share in National Total	
		1990	2017		1990	2017
1 A	**ENERGY - FUEL COMBUSTION ACTIVITIES**	**0,125**	**0,189**	***+ 51,2%***	**29,6%**	**42,8%**
1 A 1	***Energy Industries***	***0,098***	***0,154***	***+ 57,1%***	***23,2%***	***34,8%***
1 A 1 a	Public electricity and heat production	0,098	0,154	+ 57,1%	23,2%	34,8%
1 A 2	***Stationary combustion in manufacturing industries and construction***	***0,024***	***0,030***	***+ 25%***	***5,7%***	***6,8%***
1 A 2 a	Iron and steel	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 2 b	Non-ferrous metals	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 2 c	Chemicals	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 2 d	Pulp, paper and print	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 2 e	Food processing, beverages and tobacco	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 2 f	Non-metallic minerals	0,024	0,026	+ 8,3%	5,7%	5,9%
1 A 2 g viii	Other	0,000	0,004	+	0,0%	0,9%
1 A 3	***Transport***	***0,000***	***0,000***	***± 0,0%***	***0,0%***	***0,0%***
1 A 3 b i	Passenger cars	NE	NE	NE	NE	NE
1 A 3 b ii	Light duty vehicles	NE	NE	NE	NE	NE
1 A 3 b iii	Heavy duty vehicles and buses	NE	NE	NE	NE	NE
1 A 3 b iv	Mopeds & motorcycles	NE	NE	NE	NE	NE
1 A 3 b vi	Road transport: Automobile tyre and brake wear	NE	NE	NE	NE	NE
1 A 3 c	Railways	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 3 d ii	National navigation (shipping)	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 3 e ii	Offroad Other	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 4	***Other***	***0,003***	***0,005***	***+ 66,7%***	***0,7%***	***1,1%***
1 A 4 a i	Commercial / institutional: Stationary	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 4 b i	Residential: Stationary	0,003	0,005	+ 66,7%	0,7%	1,1%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	0,000	0,000	± 0,0%	0,0%	0,0%
2 C	**INDUSTRIAL PROCESSES - METAL PRODUCTION**	**0,295**	**0,253**	***-14,2%***	**69,9%**	**57,2%**
2 C 1	Iron and steel production	0,149	0,212	+ 42,3%	35,3%	48,0%
2 C 3	Aluminium production	0,146	0,041	-71,9%	34,6%	9,3%
2 K	**INDUSTRIAL PROCESSES - CONSUMPTION OF POPS AND HEAVY METALS**	**0,000**	**0,000**	***± 0,0%***	**0,0%**	**0,0%**
2 K	Consumption of POPs and heavy metals	0,000	0,000	± 0,0%	0,0%	0,0%
5 C	**WASTE - INCINERATION**	**0,002**	**0,000**	***-100%***	**0,5%**	**0,0%**
5 C 1 b iii	Clinical wasteincineration (d)	0,002	NO	-100,0%	0,5%	NO
5 C 1 b v	Cremation	NO	0,000	+	NO	0,0%
	National total for the entire territory	**0,422**	**0,442**	**4,7%**	**100,0%**	**100,0%**

3.4. Polychlorinated Biphenyls (PCB)

With regard to **PCB** emissions, the KCA identified **iron and steel production** (2C1) as key category in both level and trend assessment, and **consumption of POPs and heavy metals** (2K) as key category in level assessment (KCA cf. annexe 1, see also Fig. 3-7).

[131] cf. Observation LU-2C1-2018-0001 from the NECD Review 2018

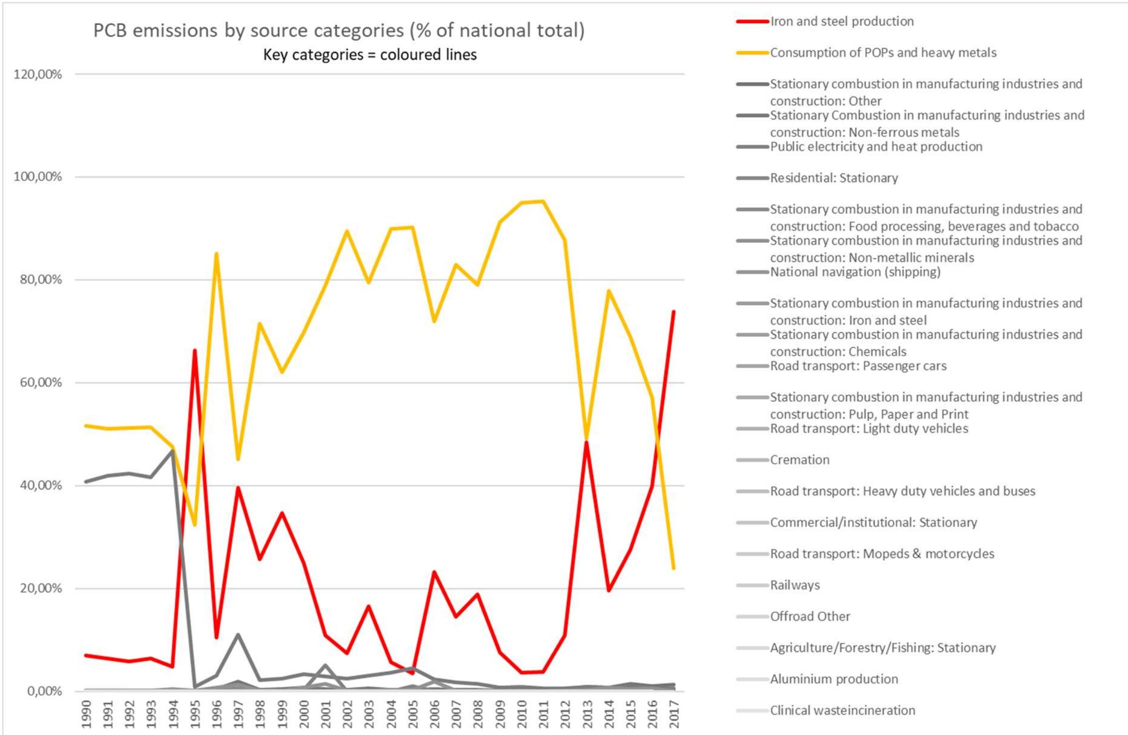

Figure 3-7: Evolution of PCB emissions by different NFR categories. Key categories are shown as coloured lines.

In 2016, PCB emissions predominantly originated from the dismantling of older electrical generators, while iron and steel production were responsible for over 70% of emissions in 2017. Minor sources of PCB are combustion processes in manufacturing industries and construction and WTE (see Tab. 3-5).

From 1990 to 1995, total PCB emissions stayed almost constant at high levels but dropped by 90 percent between 1995 and 1997. This drop was mainly caused by emission control efforts in aluminium production, waste incineration, and important changes in the steel industry. The fluctuations between 1997 and 2012 mainly reflect the amount of disposed material from older electrical generators (Fig. 3-8).

The peak of PCB emissions for category 2C1 in 1995 was due to the start-up of an electric arc furnace (Differdange) in that year where emissions were not yet fully in control, while in later years this problem was resolved.[132]

[132] cf. Observation LU-2C1-2018-0003 from the NECD Review 2018

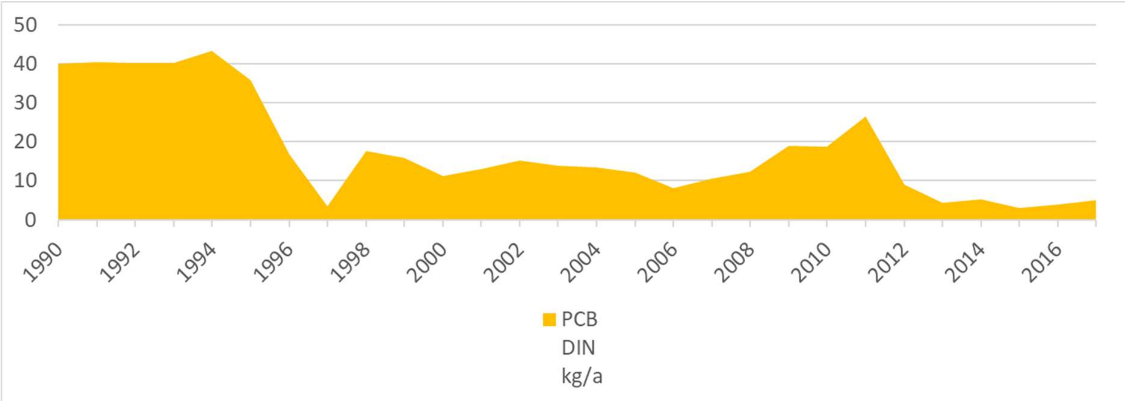

Figure 3-8: Evolution of PCB emissions in Luxembourg since 1990.

Table 3-5: PCB emissions by NFR category 1990 and 2017 - Trends and shares in total emissions.

NFR Category		PCB (6 congeners)[1] emission [kg] 1990	PCB (6 congeners)[1] emission [kg] 2017	Trend	Share in National Total 1990	Share in National Total 2017
1 A	**ENERGY - FUEL COMBUSTION ACTIVITIES**	**16,476**	**0,084**	***-99,5%***	**41,3%**	**2,3%**
1 A 1	***Energy Industries***	***0,005***	***0,011***	***+ 120%***	***0,0%***	***0,3%***
1 A 1 a	Public electricity and heat production	0,005	0,011	+ 120%	0,0%	0,3%
1 A 2	***Stationary combustion in manufacturing industries and construction***	***16,425***	***0,070***	***-99,6%***	***41,2%***	***1,9%***
1 A 2 a	Iron and steel	0,016	0,000	-100%	0,0%	0,0%
1 A 2 b	Non-ferrous metals	16,290	0,021	-99,9%	40,8%	0,6%
1 A 2 c	Chemicals	0,009	0,000	-100%	0,0%	0,0%
1 A 2 d	Pulp, paper and print	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 2 e	Food processing, beverages and tobacco	0,000	0,001	+	0,0%	0,0%
1 A 2 f	Non-metallic minerals	0,051	0,000	-100%	0,1%	0,0%
1 A 2 g viii	Other	0,059	0,048	-18,6%	0,1%	1,3%
1 A 3	***Transport***	***0,000***	***0,000***	***± 0,0%***	***0,0%***	***0,0%***
1 A 3 b i	Passenger cars	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 3 b ii	Light duty vehicles	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 3 b iii	Heavy duty vehicles and buses	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 3 b iv	Mopeds & motorcycles	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 3 b vi	Road transport: Automobile tyre and brake wear	NA	NA	NA	NA	NA
1 A 3 c	Railways	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 3 d ii	National navigation (shipping)	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 3 e ii	Offroad Other	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 4	***Other***	***0,046***	***0,003***	***-93,5%***	***0,1%***	***0,1%***
1 A 4 a i	Commercial / institutional: Stationary	0,000	0,000	± 0,0%	0,0%	0,0%
1 A 4 b i	Residential: Stationary	0,046	0,003	-93,5%	0,1%	0,1%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	0,000	0,000	± 0,0%	0,0%	0,0%
2 C	**INDUSTRIAL PROCESSES - METAL PRODUCTION**	**2,775**	**2,687**	***-3,2%***	7,0%	**73,8%**
2 C 1	Iron and steel production	2,775	2,687	-3,2%	7,0%	73,8%
2 C 3	Aluminium production	IE	IE	IE	IE	IE
2 K	**INDUSTRIAL PROCESSES - CONSUMPTION OF POPS AND HEAVY METALS**	**20,640**	**0,870**	***-95,8%***	***51,7%***	**23,9%**
2 K	Consumption of POPs and heavy metals	20,640	0,870	-95,8%	51,7%	23,9%
5 C	**WASTE - INCINERATION**	**0,020**	**0,000**	**-100%**	**0,1%**	**0,0%**
5 C 1 b iii	Clinical wasteincineration (d)	0,020	NO	-100,0%	0,1%	NO
5 C 1 b v	Cremation	NO	0,000	+	NO	0,0%
	National total for the entire territory	**39,911**	**3,641**	**-90,9%**	**100,0%**	**100,0%**

[1]: Congeners PCB 28, 52, 101, 138, 153, 180.

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Annexe 1 - 4: Key Category Analysis for sources of PCCD/F, PAH, HCB, and PCB.

NFR category code	NFR category	Pollutant	Last year estimate $E_{x,t}$	Level assessment $L_{x,t}$	Cumulative total of level assessment
2C1	**Iron and steel production**	**PCDD/F**	**1,01**	**0,50**	**0,50**
1A4bi	**Residential: Stationary**	**PCDD/F**	**0,61**	**0,30**	**0,80**
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	PCDD/F	0,12	0,06	0,86
1A3bi	Road transport: Passenger cars	PCDD/F	0,11	0,05	0,91
1A1a	Public electricity and heat production	PCDD/F	0,08	0,04	0,95
1A4ai	Commercial/institutional: Stationary	PCDD/F	0,04	0,02	0,97
1A3biii	Road transport: Heavy duty vehicles and buses	PCDD/F	0,02	0,01	0,98
1A3bii	Road transport: Light duty vehicles	PCDD/F	0,02	0,01	0,99
2C3	Aluminium production	PCDD/F	0,01	0,01	1,00
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	PCDD/F	0,00	0,00	1,00
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	PCDD/F	0,00	0,00	1,00
1A3biv	Road transport: Mopeds & motorcycles	PCDD/F	0,00	0,00	1,00
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	PCDD/F	0,00	0,00	1,00
5C1bv	Cremation	PCDD/F	0,00	0,00	1,00
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	PCDD/F	0,00	0,00	1,00
1A3dii	National navigation (shipping)	PCDD/F	0,00	0,00	1,00
1A4ci	Agriculture/Forestry/Fishing: Stationary	PCDD/F	0,00	0,00	1,00
1A3c	Railways	PCDD/F	0,00	0,00	1,00
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	PCDD/F	0,00	0,00	1,00
1A2b	Stationary Combustion in manufacturing industries and construction: Non-ferrous metals	PCDD/F	0,00	0,00	1,00
1A3eii	Offroad Other	PCDD/F	0,00	0,00	1,00
2K	Consumption of POPs and heavy metals	PCDD/F	0,00	0,00	1,00
5C1biii	Clinical wasteincineration	PCDD/F	NO	0,00	1,00

NFR category code	NFR category	Pollutant	Base year estimate $E_{x,0}$	Last year estimate $E_{x,t}$	Trend assessment $T_{x,t}$	% Contribution to trend	Cumulative total of trend assessment
1A4bi	**Residential: Stationary**	**PCDD/F**	**0,73**	**0,61**	**0,01**	**0,61**	**0,61**
1A2gviii	**Stationary combustion in manufacturing industries and construction: Other**	**PCDD/F**	**0,07**	**0,12**	**0,00**	**0,12**	**0,73**
1A3bi	**Road transport: Passenger cars**	**PCDD/F**	**0,27**	**0,11**	**0,00**	**0,10**	**0,84**
1A1a	Public electricity and heat production	PCDD/F	0,00	0,08	0,00	0,08	0,92
1A4ai	Commercial/institutional: Stationary	PCDD/F	0,06	0,04	0,00	0,04	0,96
1A3biii	Road transport: Heavy duty vehicles and buses	PCDD/F	0,05	0,02	0,00	0,02	0,98
1A3bii	Road transport: Light duty vehicles	PCDD/F	0,01	0,02	0,00	0,02	0,99
1A3biv	Road transport: Mopeds & motorcycles	PCDD/F	0,00	0,00	0,00	0,00	0,99
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	PCDD/F	0,04	0,00	0,00	0,00	1,00
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	PCDD/F	0,00	0,00	0,00	0,00	1,00
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	PCDD/F	0,02	0,00	0,00	0,00	1,00
5C1bv	Cremation	PCDD/F	NO	0,00	0,00	0,00	1,00
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	PCDD/F	0,00	0,00	0,00	0,00	1,00
1A3dii	National navigation (shipping)	PCDD/F	0,00	0,00	0,00	0,00	1,00
1A4ci	Agriculture/Forestry/Fishing: Stationary	PCDD/F	0,00	0,00	0,00	0,00	1,00
1A3c	Railways	PCDD/F	0,00	0,00	0,00	0,00	1,00
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	PCDD/F	0,00	0,00	0,00	0,00	1,00
2C1	Iron and steel production	PCDD/F	40,13	1,01	0,00	0,00	1,00
2C3	Aluminium production	PCDD/F	1,65	0,01	0,00	0,00	1,00
1A2b	Stationary Combustion in manufacturing industries and construction: Non-ferrous metals	PCDD/F	0,00	0,00	0,00	0,00	1,00
1A3eii	Offroad Other	PCDD/F	0,00	0,00	0,00	0,00	1,00
2K	Consumption of POPs and heavy metals	PCDD/F	0,00	0,00	0,00	0,00	1,00
5C1biii	Clinical wasteincineration	PCDD/F	0,35	NO	0,00	0,00	1,00

NFR category code	NFR category	Pollutant	Last year estimate $E_{x,t}$	Level assessment $L_{x,t}$	Cumulative total of level assessment
1A4bi	**Residential: Stationary**	**PAH (total 1-4)**	**0,29**	**0,47**	**0,47**
1A4ai	**Commercial/institutional: Stationary**	**PAH (total 1-4)**	**0,12**	**0,19**	**0,66**
1A2gviii	**Stationary combustion in manufacturing industries and construction: Other**	**PAH (total 1-4)**	**0,09**	**0,15**	**0,82**
1A3biii	Road transport: Heavy duty vehicles and buses	PAH (total 1-4)	0,03	0,04	0,86
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	PAH (total 1-4)	0,02	0,04	0,90
1A3bi	Road transport: Passenger cars	PAH (total 1-4)	0,02	0,03	0,93
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	PAH (total 1-4)	0,02	0,03	0,96
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	PAH (total 1-4)	0,01	0,02	0,98
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	PAH (total 1-4)	0,00	0,01	0,99
1A1a	Public electricity and heat production	PAH (total 1-4)	0,00	0,00	0,99
1A3bii	Road transport: Light duty vehicles	PAH (total 1-4)	0,00	0,00	0,99
1A3eii	Offroad Other	PAH (total 1-4)	0,00	0,00	1,00
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	PAH (total 1-4)	0,00	0,00	1,00
1A2b	Stationary Combustion in manufacturing industries and construction: Non-ferrous metals	PAH (total 1-4)	0,00	0,00	1,00
2C1	Iron and steel production	PAH (total 1-4)	0,00	0,00	1,00
1A3bvi	Road transport: Automobile tyre and brake wear	PAH (total 1-4)	0,00	0,00	1,00
1A3c	Railways	PAH (total 1-4)	0,00	0,00	1,00
1A3biv	Road transport: Mopeds & motorcycles	PAH (total 1-4)	0,00	0,00	1,00
1A4ci	Agriculture/Forestry/Fishing: Stationary	PAH (total 1-4)	0,00	0,00	1,00
5C1bv	Cremation	PAH (total 1-4)	0,00	0,00	1,00
1A3dii	National navigation (shipping)	PAH (total 1-4)	0,00	0,00	1,00
2K	Consumption of POPs and heavy metals	PAH (total 1-4)	0,00	0,00	1,00
5C1biii	Clinical waste incineration	PAH (total 1-4)	NO	0,00	1,00

NFR category code	NFR category	Pollutant	Base year estimate $E_{x,0}$	Last year estimate $E_{x,t}$	Trend assessment $T_{x,t}$	% Contribution to trend	Cumulative total of trend assessment
1A4bi	**Residential: Stationary**	**PAH (total 1-4)**	**0,45**	**0,33**	**0,06**	**0,52**	**0,52**
1A2gviii	**Stationary combustion in manufacturing industries and construction: Other**	**PAH (total 1-4)**	**0,05**	**0,08**	**0,02**	**0,15**	**0,67**
1A4ai	**Commercial/institutional: Stationary**	**PAH (total 1-4)**	**0,17**	**0,09**	**0,01**	**0,13**	**0,80**
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	PAH (total 1-4)	0,04	0,04	0,01	0,07	0,87
1A3biii	Road transport: Heavy duty vehicles and buses	PAH (total 1-4)	0,01	0,03	0,01	0,05	0,92
1A3bi	Road transport: Passenger cars	PAH (total 1-4)	0,03	0,02	0,00	0,03	0,95
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	PAH (total 1-4)	0,04	0,02	0,00	0,02	0,97
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	PAH (total 1-4)	0,11	0,02	0,00	0,01	0,98
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	PAH (total 1-4)	0,00	0,00	0,00	0,01	0,99
1A3bii	Road transport: Light duty vehicles	PAH (total 1-4)	0,00	0,00	0,00	0,00	0,99
1A3eii	Offroad Other	PAH (total 1-4)	0,00	0,00	0,00	0,00	0,99
1A1a	Public electricity and heat production	PAH (total 1-4)	0,00	0,00	0,00	0,00	1,00
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	PAH (total 1-4)	0,00	0,00	0,00	0,00	1,00
1A2b	Stationary Combustion in manufacturing industries and construction: Non-ferrous metals	PAH (total 1-4)	0,00	0,00	0,00	0,00	1,00
1A3bvi	Road transport: Automobile tyre and brake wear	PAH (total 1-4)	0,00	0,00	0,00	0,00	1,00
1A3biv	Road transport: Mopeds & motorcycles	PAH (total 1-4)	0,00	0,00	0,00	0,00	1,00
1A3c	Railways	PAH (total 1-4)	0,00	0,00	0,00	0,00	1,00
1A4ci	Agriculture/Forestry/Fishing: Stationary	PAH (total 1-4)	0,00	0,00	0,00	0,00	1,00
5C1bv	Cremation	PAH (total 1-4)	NO	0,00	0,00	0,00	1,00
1A3dii	National navigation (shipping)	PAH (total 1-4)	0,00	0,00	0,00	0,00	1,00
2C1	Iron and steel production	PAH (total 1-4)	3,62	0,00	0,00	0,00	1,00
2K	Consumption of POPs and heavy metals	PAH (total 1-4)	0,00	0,00	0,00	0,00	1,00
5C1biii	Clinical waste incineration	PAH (total 1-4)	0,00	NO	0,00	0,00	1,00

NFR category code	NFR category	Pollutant	Last year estimate $E_{x,t}$	Level assessment $L_{x,t}$	Cumulative total of level assessment
2C1	**Iron and steel production**	**HCB**	**0,21**	**0,48**	**0,48**
1A1a	**Public electricity and heat production**	**HCB**	**0,15**	**0,35**	**0,83**
2C3	Aluminium production	HCB	0,04	0,09	0,92
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	HCB	0,03	0,06	0,98
1A4bi	Residential: Stationary	HCB	0,01	0,01	0,99
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	HCB	0,00	0,01	1,00
5C1bv	Cremation	HCB	0,00	0,00	1,00
1A3dii	National navigation (shipping)	HCB	0,00	0,00	1,00
1A4ai	Commercial/institutional: Stationary	HCB	0,00	0,00	1,00
1A3bi	Road transport: Passenger cars	HCB	0,00	0,00	1,00
1A3bii	Road transport: Light duty vehicles	HCB	0,00	0,00	1,00
1A3biii	Road transport: Heavy duty vehicles and buses	HCB	0,00	0,00	1,00
1A3biv	Road transport: Mopeds & motorcycles	HCB	0,00	0,00	1,00
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	HCB	0,00	0,00	1,00
1A2b	Stationary Combustion in manufacturing industries and construction: Non-ferrous metals	HCB	0,00	0,00	1,00
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	HCB	0,00	0,00	1,00
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	HCB	0,00	0,00	1,00
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	HCB	0,00	0,00	1,00
1A3c	Railways	HCB	0,00	0,00	1,00
1A3eii	Offroad Other	HCB	0,00	0,00	1,00
1A4ci	Agriculture/Forestry/Fishing: Stationary	HCB	0,00	0,00	1,00
2K	Consumption of POPs and heavy metals	HCB	0,00	0,00	1,00
5C1biii	Clinical wasteincineration	HCB	NO	0,00	1,00

NFR category code	NFR category	Pollutant	Base year estimate $E_{x,0}$	Last year estimate $E_{x,t}$	Trend assessment $T_{x,t}$	% Contribution to trend	Cumulative total of trend assessment
2C1	**Iron and steel production**	**HCB**	**0,15**	**0,21**	**0,13**	**0,49**	**0,49**
1A1a	**Public electricity and heat production**	**HCB**	**0,10**	**0,15**	**0,12**	**0,45**	**0,94**
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	HCB	0,00	0,00	0,01	0,03	0,97
1A4bi	Residential: Stationary	HCB	0,00	0,01	0,00	0,02	0,99
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	HCB	0,02	0,03	0,00	0,01	1,00
5C1bv	Cremation	HCB	NO	0,00	0,00	0,00	1,00
1A4ai	Commercial/institutional: Stationary	HCB	0,00	0,00	0,00	0,00	1,00
1A3bi	Road transport: Passenger cars	HCB	0,00	0,00	0,00	0,00	1,00
1A3bii	Road transport: Light duty vehicles	HCB	0,00	0,00	0,00	0,00	1,00
1A3biii	Road transport: Heavy duty vehicles and buses	HCB	0,00	0,00	0,00	0,00	1,00
1A3biv	Road transport: Mopeds & motorcycles	HCB	0,00	0,00	0,00	0,00	1,00
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	HCB	0,00	0,00	0,00	0,00	1,00
1A2b	Stationary Combustion in manufacturing industries and construction: Non-ferrous metals	HCB	0,00	0,00	0,00	0,00	1,00
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	HCB	0,00	0,00	0,00	0,00	1,00
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	HCB	0,00	0,00	0,00	0,00	1,00
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	HCB	0,00	0,00	0,00	0,00	1,00
1A3c	Railways	HCB	0,00	0,00	0,00	0,00	1,00
1A3dii	National navigation (shipping)	HCB	0,00	0,00	0,00	0,00	1,00
1A3eii	Offroad Other	HCB	0,00	0,00	0,00	0,00	1,00
1A4ci	Agriculture/Forestry/Fishing: Stationary	HCB	0,00	0,00	0,00	0,00	1,00
2C3	Aluminium production	HCB	0,15	0,04	0,00	0,00	1,00
2K	Consumption of POPs and heavy metals	HCB	0,00	0,00	0,00	0,00	1,00
5C1biii	Clinical wasteincineration	HCB	0,00	0,00	0,00	0,00	1,00

NFR category code	NFR category	Pollutant	Last year estimate $E_{x,t}$	Level assessment $L_{x,t}$	Cumulative total of level assessment
2C1	**Iron and steel production**	**PCB**	**2,69**	**0,74**	**0,74**
2K	**Consumption of POPs and heavy metals**	**PCB**	**0,87**	**0,24**	**0,98**
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	PCB	0,05	0,01	0,99
1A2b	Stationary Combustion in manufacturing industries and construction: Non-ferrous metals	PCB	0,02	0,01	1,00
1A1a	Public electricity and heat production	PCB	0,01	0,00	1,00
1A4bi	Residential: Stationary	PCB	0,00	0,00	1,00
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	PCB	0,00	0,00	1,00
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	PCB	0,00	0,00	1,00
1A3dii	National navigation (shipping)	PCB	0,00	0,00	1,00
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	PCB	0,00	0,00	1,00
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	PCB	0,00	0,00	1,00
1A3bi	Road transport: Passenger cars	PCB	0,00	0,00	1,00
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	PCB	0,00	0,00	1,00
1A3bii	Road transport: Light duty vehicles	PCB	0,00	0,00	1,00
5C1bv	Cremation	PCB	0,00	0,00	1,00
1A3biii	Road transport: Heavy duty vehicles and buses	PCB	0,00	0,00	1,00
1A4ai	Commercial/institutional: Stationary	PCB	0,00	0,00	1,00
1A3biv	Road transport: Mopeds & motorcycles	PCB	0,00	0,00	1,00
1A3c	Railways	PCB	0,00	0,00	1,00
1A3eii	Offroad Other	PCB	0,00	0,00	1,00
1A4ci	Agriculture/Forestry/Fishing: Stationary	PCB	0,00	0,00	1,00
2C3	Aluminium production	PCB	IE	0,00	1,00
5C1biii	Clinical wasteincineration	PCB	NO	0,00	1,00

NFR category code	NFR category	Pollutant	Base year estimate $E_{x,0}$	Last year estimate $E_{x,t}$	Trend assessment $T_{x,t}$	% Contribution to trend	Cumulative total of trend assessment
2C1	**Iron and steel production**	**PCB**	**2,78**	**2,69**	**0,06**	**0,98**	**0,98**
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	PCB	0,06	0,05	0,00	0,02	1,00
1A1a	Public electricity and heat production	PCB	0,00	0,01	0,00	0,00	1,00
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	PCB	0,00	0,00	0,00	0,00	1,00
1A3dii	National navigation (shipping)	PCB	0,00	0,00	0,00	0,00	1,00
1A3bi	Road transport: Passenger cars	PCB	0,00	0,00	0,00	0,00	1,00
1A3biii	Road transport: Heavy duty vehicles and buses	PCB	0,00	0,00	0,00	0,00	1,00
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	PCB	0,00	0,00	0,00	0,00	1,00
1A3bii	Road transport: Light duty vehicles	PCB	0,00	0,00	0,00	0,00	1,00
5C1bv	Cremation	PCB	NO	0,00	0,00	0,00	1,00
1A4ai	Commercial/institutional: Stationary	PCB	0,00	0,00	0,00	0,00	1,00
1A3biv	Road transport: Mopeds & motorcycles	PCB	0,00	0,00	0,00	0,00	1,00
1A3c	Railways	PCB	0,00	0,00	0,00	0,00	1,00
2K	Consumption of POPs and heavy metals	PCB	20,64	0,87	0,00	0,00	1,00
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	PCB	0,05	0,00	0,00	0,00	1,00
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	PCB	0,01	0,00	0,00	0,00	1,00
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	PCB	0,02	0,00	0,00	0,00	1,00
1A2b	Stationary Combustion in manufacturing industries and construction: Non-ferrous metals	PCB	16,29	0,02	0,00	0,00	1,00
1A3eii	Offroad Other	PCB	0,00	0,00	0,00	0,00	1,00
1A4bi	Residential: Stationary	PCB	0,05	0,00	0,00	0,00	1,00
1A4ci	Agriculture/Forestry/Fishing: Stationary	PCB	0,00	0,00	0,00	0,00	1,00
2C3	Aluminium production	PCB	IE	0,00	0,00	0,00	1,00
5C1biii	Clinical wasteincineration	PCB	0,02	0,00	0,00	0,00	1,00

Appendix 5: Heavy metal (Cd, Pd, Hg) emissions

HEAVY METALS

Final Report

Emissions of cadmium, lead and mercury in Luxembourg in 2017

Version 1.1

2019

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Content

Glossary

Heavy metal

The term "heavy metal" summarizes a group of metals. There are a number of different definitions found for this group. Several sources evaluate a heavy metal as a metal whose density is higher than 5,0 g/cm³.

Cadmium

Cadmium is a chemical element with symbol **Cd** and atomic number 48.

Cadmium occurs as a minor component in most zinc ores and therefore is a by-product of zinc production. It was used for a long time as a pigment and for corrosion-resistant plating on steel, whereas cadmium compounds were used to stabilize plastic. The use of cadmium is generally decreasing due to its toxicity (it is specifically listed in the European Restriction of Hazardous Substances) and the replacement of nickel-cadmium batteries with nickel-metal hydride and lithium-ion batteries.

Cadmium is an environmental hazard. Human exposures to environmental cadmium are primarily the result of fossil fuel combustion, phosphate fertilizers, natural sources, iron and steel production, cement production and related activities, nonferrous metals production, and municipal solid waste incineration. Cadmium is one of six substances banned by the European Union's Restriction on Hazardous Substances (RoHS) directive, which bans certain hazardous substances in electrical and electronic equipment but allows for certain exemptions and exclusions from the scope of the law. The International Agency for Research on Cancer has classified cadmium and cadmium compounds as carcinogenic to humans.

Tobacco smoking is the most important single source of cadmium exposure in the general population. It has been estimated that about 10% of the cadmium content of a cigarette is inhaled through smoking. The absorption of cadmium from the lungs is much more effective than that from the gut, and as much as 50% of the cadmium inhaled via cigarette smoke may be absorbed. In the non-smoking part of the population food is the biggest source of exposure to cadmium. High quantities of cadmium can be found for example in crustaceans, molluscs and algal products. However, due to the higher consumption the most significant contributors to the dietary cadmium exposure are grains, vegetables, and starchy roots and tubers.

Source: http://en.wikipedia.org/wiki/Cadmium

Lead

Lead is a chemical element in the carbon group with symbol **Pb** and atomic number 82. Lead is a soft, malleable and heavy post-transition metal. It is the heaviest non-radioactive element.

Lead is used in building construction, lead-acid batteries, bullets and shot, weights, as part of solders, pewters, fusible alloys, and as a radiation shield.

Lead is a highly poisonous metal (whether inhaled or swallowed), affecting almost every organ and system in the body. The main target for lead toxicity is the nervous system, both in adults and children. Long-term exposure of adults can result in decreased performance in some tests that measure functions of the nervous system. Long-term exposure to lead or its salts can cause nephropathy, and colic-like abdominal pains. It may also cause weakness in fingers, wrists, or ankles. Lead exposure also causes small increases in blood pressure, particularly in middle-aged and older people and can cause anaemia. Exposure to high lead levels can severely damage the brain and kidneys in adults or children and ultimately cause death. In pregnant women, high levels of exposure to lead may cause miscarriage. Chronic, high-level exposure has been shown to reduce fertility in males. Lead also damages nervous connections (especially in young children) and causes blood and brain disorders. Lead poisoning typically results from ingestion of food or water contaminated with lead, but may also occur after accidental ingestion of contaminated soil, dust, or lead-based paint. It is rapidly absorbed into the bloodstream and is believed to have adverse effects on the central nervous system, the cardiovascular system, kidneys, and the immune system. The concern about lead's role in cognitive deficits in children has brought about widespread reduction in its use.

Source: http://en.wikipedia.org/wiki/Lead

Mercury

Mercury is a chemical element with symbol **Hg** and atomic number 80. Mercury is the only metallic element that is liquid at standard conditions for temperature and pressure.

Mercury occurs in deposits throughout the world mostly as mercuric sulphide. Mercury poisoning can result from exposure to water-soluble forms of mercury, inhalation of mercury vapour, or eating seafood contaminated with mercury.

Mercury is used in thermometers, barometers, manometers, sphygmomanometers; float valves, mercury switches, mercury relays, fluorescent lamps and other devices, though concerns about the element's toxicity have led to mercury thermometers and sphygmomanometers being largely phased out. Mercury remains in use in scientific research applications and in amalgam material for dental restoration.

Mercury and most of its compounds are extremely toxic and must be handled with care. Mercury can be absorbed through the skin and mucous membranes and mercury vapours can be inhaled. Mercury can cause both chronic and acute poisoning.

Natural sources, such as volcanoes, are responsible for approximately half of atmospheric mercury emissions. The human-generated half can be divided into the following estimated percentages:

- 65% from stationary combustion, of which coal-fired power plants are the largest aggregate source.
- 11% from gold production.
- 6.8% from non-ferrous metal production.
- 6.4% from cement production.
- 3.0% from waste disposal, including municipal and hazardous waste, crematoria, and sewage sludge incineration.
- 3.0% from caustic soda production.
- 1.4% from pig iron and steel production.
- 1.1% from mercury production, mainly for batteries.
- 2.0% from other sources.

The above percentages are estimates of the global human-caused mercury emissions in 2000, excluding biomass burning, an important source in some regions.

Source: http://en.wikipedia.org/wiki/Mercury_%28element%29

1. Introduction

The present inventory of heavy metal (HM) emissions in Luxembourg was compiled in the context of the 1979 Geneva Convention on Long-Range Transboundary Air Pollution.

The Geneva Convention is the first legally binding instrument for dealing with problems of air pollution on international scale. 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.

As a party to the Convention, Luxembourg is obliged to annually submit data on emissions of air pollutants in order to comply with the protocols under the Convention. Parties are required to report on annual national emissions of SO_X, NO_X, NMVOC, CO, NH_3, POPs and various HM.

The present report contains an estimation of air pollution by emissions of the three priority HM cadmium, lead and mercury in Luxembourg for 2017 and shows emission trends over the past three decades (1990 – 2017).

2. METHODOLOGY

Emission levels for HM emissions were calculated using the latest available methodology (EEA 2016). Measurement data were used where available. Otherwise, calculations were based on activity data (i.e. fuel consumption) and the corresponding emission factors from EEA (2016). For reasons of comparability, sectoral statistics have also been adapted to the new NFR-Categories in all years of the time series.

2.1. Fuel Combustion Activities (NFR 1 A)

Heavy metal (HM) emissions in this sector primarily result from fuel combustion processes. Apart from this, emissions from industrial processes related to sinter and pig iron production, as well as process-related emissions from secondary aluminium production were included in this category for practical reasons.

For the whole period covered by this report, emission factors were taken from EEA (2016).

This chapter includes emissions from point sources as well as from diffuse sources.

2.1.1. NFR 1 A 1 Energy Industries

NFR 1 A 1 a Public electricity and heat production

This category includes emissions from combustion processes associated with industrial heat and energy production as well as emissions originating from waste-to-energy processes (WTE). Apart from two single point sources (WTE plant in Leudelange and Gas Vapour Turbin Twinerg in Esch/Alzette), this category includes only diffuse emissions from a range of industrial combustion plants at different locations in the country.

Calculation of emissions originating from the WTE plant was based on data from emission control measurements. Projection of annual emissions was carried out using these measurement data in combination with annual operating hours and emission factors from EEA (2016). Where measurement data for the WTE plant were lacking, emissions were calculated on the basis of annual consumption of fuels (natural gas, gas oil) and the amount of incinerated wastes (municipal wastes, biomass) using the appropriate tier 1 emission factors from EEA (2016). In order to obtain more 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).

The calculation of emissions from public electricity and heat production was based on total fuel consumption in combination with tier 1 emission factors from EEA (2016). Fuel consumption data were obtained from the national energy balance compiled by the competent authority (*Administration de l’ environnement*).

2.1.2. NFR 1 A 2 Industries and Construction

NFR 1 A 2 a Iron and steel

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.

The sintering plant in Esch-Belval was operational until 1996 and thus considered a large point source from 1990 to 1996. Calculations of HM 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 emission factors from EEA 2016 (combustion in manufacturing industries and construction; all tier 1 approach). 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 (2016) (1.92 GJ/Mg; cf. chapter 2.C.1, p. 16). Process-related emissions were calculated using tier 2 emission factors from EEA (2016).

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 (2016) (18.67 GJ/Mg; cf. chapter 2.C.1, p. 13). For calculation of process-related emissions, technology-specific emission factors from EEA (2016) were employed (tier 2 approach).

HM emissions of the three electric arc furnaces (EAFs) in Esch-Belval, Esch-Schifflange (operational until 2014) and Differdange are treated under chapter 3.2. "Industrial processes" NFR 2 C 1 Iron and steel.

Calculation of diffuse emissions was based on data from the national energy balance in combination with appropriate tier 1 emission factors from EEA (2016).

NFR 1 A 2 b Non-ferrous metals

In this category, three large point sources were considered: two secondary aluminium melts in Clervaux (Hydro Aluminium and Alcuilux) and an aluminium melt in Dudelange (Novelis/Eurofoil). The Novelis/Eurofoil and Alcuilux melts were operational during the whole period covered in this report, whereas the Hydro Aluminium plant was put into service in 1996 as a spin-off from Alcuilux. Emissions of these point sources are treated under chapter 2.2. "Industrial processes" NFR 2 C3 Aluminium production.

NFR 1 A 2 c Chemicals

Reported 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.

Since emission measurements were not available for any of the abovementioned facilities, calculation of HM emissions originating from chemical industries were based on total fuel consumption in combination with emission factors. Fuel consumption data were obtained from the national energy balance. Appropriate emission factors were taken from EEA (2016).

NFR 1 A 2 d Pulp, paper, and print

The calculation of HM emissions related to pulp, paper, and print were based on total fuel consumption in combination with emission factors. Fuel consumption data were obtained from the national energy balance. Appropriate emission factors were taken from EEA (2016).

NFR 1 A 2 e Food processing, beverages, and tobacco

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.

Since HM emission measurements were not available for any of these facilities, calculation of emissions originating from food processing, beverages, and tobacco were based on total fuel consumption in combination with emission factors. Fuel consumption data were obtained from the national energy balance. Appropriate emission factors were taken from EEA (2016).

NFR 1 A 2 f Non-metallic minerals

With the Cimalux cement kiln in Rumelange and the Luxguard glass production site in Bascharage, this category includes two point sources of HM. Apart from these sources, several smaller facilities at different locations in the country are considered in this category.

For the cement kiln, emission measurements were available from several years and for all HM. 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 on the basis of annual consumption of different fuels used (natural gas, residual fuel oil, gas oil, coal, tires, fluff, sewage sludge) employing emission factors from EEA (2016) (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 back-calculated 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 (2016), chapter 2.A.1, p. 4). In order to obtain more 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).

Since HM emissions from cement production are assumed to originate mainly from combustion processes, process-related emissions were not necessary to be taken into account (cf. EEA (2016), chapter 2.A.1, p. 6).

With regard to glass production, emissions due to combustion processes were reported under the current category, whereas process-related emissions fall in category 2 A 3 (glass production). Since no measurement data for Luxguard were available, all emissions were calculated on the basis of annual fuel consumption and the appropriate emission factors from EEA (2016) (combustion in manufacturing industries and construction; tier 1 approach).

NFR 1 A 2 gviii Other

With the asphalt plants in Leudelange (Cajot), Schifflange (Lisé), Wasserbillig (Wickler) and the City of Luxembourg (Karp-Kneip) this category includes four point sources of HM.

Since emission measurements for the asphalt plants were not available, calculations of HM emissions originating from asphalt production were based on annual fuel consumption taken from the national energy balance. Emissions were calculated separately for different types of fuel used (brown coal, gas oil, natural gas) employing tier 1 emission factors from EEA (2016). Process-related HM emissions from asphalt production were assumed to be negligible and thus not taken into account.

Data about fuel consumption related to other sources of emissions in this sector were obtained from the national energy balance. These include transport equipment, machinery, mining and quarrying, wood and wood products, construction, and other non-specified industry. Appropriate emission factors were taken from EEA (2016).

2.1.3. NFR 1 A 3 Transport

2.1.3.1 Road transport

For the present report, HM emissions from transport were estimated on total fuel sales. This corresponds to a change compared to the method previously used where emissions were calculated based on the national car pool.

Emission values were taken from the Network emission model (NEMO) retroactively until 1990.

This was done for the following NFR categories:

- 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 also taken from the Network emission model.

Since road surface wear does not produce HM emissions, no calculations were undertaken in relation to that potential source of air pollution.

The calculations from the NEMO model underestimate lead emissions, since the model does not take the leaded fuel of the nineties into account. Corresponding improvements are planned for the next report.

2.1.3.2 Navigation

Emissions of HM resulting from national navigation were calculated using emission factors from EEA (2016) and fuel consumption data with the exception of emissions from motor gasoline. Since EEA (2016) provides no emission factors, lead emissions were calculated based on the density and calorific value of motor gasoline and an emission factor provided by the *Administration de l' environnement*. For cadmium and mercury, no emissions factors were available.

2.1.3.3 Civil aviation

Emissions of lead resulting from civil aviation were calculated using fuel consumption data and values for the density and the lead content of aviation fuel.

2.1.4. NFR 1 A 4 Small combustion

HM emissions from small stationary combustion facilities were based on energy consumption data from the national energy balance. These data permit to differentiate between commercial, residential, and agricultural sources as well as between different types of used fuel. Tier 2 emission factors were taken from EEA (2016).

NFR 1 A 4 a i Commercial/institutionary: Stationary

Calculation of HM emissions from small combustion in commercial/institutionary facilities were based on total fuel consumption (data from the national energy balance). With these data, separate calculations for different energy carriers (coke, brown coal, patent fuels, other bituminous coal, wood and wood wastes, biogas, natural gas, gas oil, LPG, diesel oil) were undertaken.

Appropriate tier 2 emission factors were taken from EEA (2016).

NFR 1 A 4 b i Residential: Stationary

Calculation of HM emissions from small combustion in the residential sector were also based on total fuel consumption (data from the national energy balance). Separate calculations for different energy carriers (coke oven coke, brown coal briquettes, patent fuels, other bituminous coal, wood and wood wastes, natural gas, gas oil, LPG, gasoline) were undertaken.

Appropriate tier 2 emission factors were taken from EEA (2016).

NFR 1 A 4 c i Agriculture/Forestry/Fishing: Stationary

Calculation of HM emissions from small combustion in the agricultural sector were also based on total fuel consumption (data from the national energy balance). Separate calculations for different energy carriers (biogas, natural gas, gas oil, diesel oil) were undertaken.

Appropriate tier 2 emission factors were taken from EEA (2016).

2.2. Industrial processes (NFR 2)

HM emissions in this sector result directly from industrial production processes. This chapter only includes facilities of which emission control measurements were available. Combustion processes related to industrial energy and heat production are included in the NFR categories 1 A 2 a to 1 A 2 f i and not taken into account 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 1 A 2 a and 1 A 2 b for practical reasons.

For the whole period covered by this report, emission factors were taken from EEA (2016).

2.2.1. NFR 2 A 3 b Glass production

With the Luxguard production site in Bascharage, one single point source was considered in this category. 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 back-calculated on basis of the total amount of energy used per year and an assumed energy demand of 8 GJ/tonne (as stated in EEA 2016). Emissions originating from combustion processes in relation to glass production were reported under category 1 A 2 f (non-metallic minerals).

2.2.2. NFR 2 C Metal production

NFR 2 C 1 Iron and steel

Four large point sources contribute to HM 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).

Where appropriate data were available, calculations of HM emissions were based on annual emission control measurements and activity data obtained from the operating company.

With regard to 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 (2016) 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 (2016). 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. Finally, this transformation leads to a demand for combustibles of 0.975 GJ per ton of electrically produced steel (cf. EEA 2016, chapter 2.C.1, p. 18). 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.

NFR 2 C 3 Aluminium production

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 whole period covered in this report, whereas the Hydro Aluminium plant was put into service in 1996 as a spin-off from Alcuilux.

For the three secondary aluminium melts, emission measurements were available for the following years:

	Pb	**Cd**	**Hg**
Alcuilux	1994, 2009 2012, 2015	1994, 2009 2012, 2015	1994, 2015
Hydro Aluminium	2005, 2009 - 2011, 2015 - 2017	2005, 2009 - 2011, 2015 - 2017	2015
Novelis/Eurofoil	2009 - 2017	2009 - 2017	2014, 2015

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 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).

Process related emissions were based on activity data (tons of aluminium per year) which in turn were back-calculated on basis of the total amount of energy used per year. For back-calculation, the mean value of the range for energy demand per ton of aluminium produced during electrolysis stage was calculated using the values stated in EEA (2016) (primary production: 15 MWh = 54 GJ, chapter 2.C.3, p. 8). Since production of aluminium from recycled material only uses about 5 percent of the energy of primary production (OSPARCOM 1997), this value was multiplied by 0.05 giving a result of 3.18 GJ/Mg for secondary aluminium production. The calculation of process-related emissions was based on this conversion using tier 2 emission factors from EEA (2016).

Data about fuel consumption related to diffuse sources of emissions in this sector were taken from the national energy balance. The appropriate tier 1 emission factors were taken from EEA (2016).

2.2.3. NFR 2 G Industrial processes – Other product use

In this category, emissions originate from the use of batteries and lighting (fluorescent tubes), tobacco and fireworks. Calculations were based on the Tier 1 approach with an emission of 0,01 g/capita (EEA 2016) (batteries and lighting) while data for tobacco and fireworks were calculated with a Tier 2 approach.

2.3. Waste (NFR 6)

2.3.1. NFR 6 C Waste incineration

NFR 6 C a Clinical waste incineration

Clinical waste incineration took place in a number of small facilities (in 1990 approx. 11 facilities) until the mid-nineties. Today, all facilities for clinical waste incineration in Luxemburg are shut down (DORNSEIFFER 2005).

Since emission measurements from clinical waste incineration were not available, HM emissions were estimated on the basis of the total amount of incinerated biomedical waste in the USA in 1990 (GLASSER et al. 2012). In order to adapt these data to the situation in Luxembourg, values were transformed proportionally to population size assuming that generation of biomedical waste per capita is similar in both countries. For 1991 to 1994, estimated HM emissions were carried over from 1990.

NFR 6 C Municipal waste incineration

Waste incineration only takes place for the purpose of energy recovery in the WTE plant in Leudelange. HM emissions from this facility were thus included in NFR 1 A 1 a (public electricity and heat production).

NFR 6 C d Cremation

The crematory in Luxembourg/Hamm is operational since 1995. It is considered a small point source of HM emissions.

Data about the number of cremations per year were only available for 1995 and 2012 (http://www.lessentiel.lu). Based on these values and assuming a linear relationship, a factor for the share of cremations in the total number of death cases per year was calculated. By applying this factor to the nationwide death cases per year taken from the national statistics, total numbers of cremations were estimated for all years apart from 1995 and 2012.

Control measurements of **mercury** emissions from the crematory were available from 1998, 2004, 2011 and 2014. For years without **mercury** measurements, we transformed measured emissions from the closest year with measurement data proportionally to the estimated number of cremations for the year in question (rule of three).

Measurements of **lead** and **cadmium** emissions were not available at all. Thus, cadmium and lead emissions were calculated based on the estimated total number of cremations per year and the appropriate tier 1 emission factors from EEA (2016).

3. Emission trends

While the general trend for lead and mercury emissions since 1990 is pretty clear with reductions of 93 respectively 85%, a detailed analysis shows that the tendency especially for mercury is less obvious with several increases and drops of emitted quantities during that 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 important sources of emissions, a change within one production site can have a substantial effect on national statistics.

The trend for cadmium emissions over the same period shows the same variations from one year to the next with a general trend that is less clear than for the other metals and an emission reduction of only 24% since 1990.

Table 3-1: Emissions and emission trends for heavy metals 1990 - 2017

Year	Emission		
	Pb	Cd	Hg
	[Mg]	[Mg]	[Mg]
1990	18,785	0,092	0,413
1991	17,930	0,086	0,397
1992	16,444	0,084	0,374
1993	17,985	0,086	0,392
1994	15,083	0,083	0,351
1995	8,954	0,067	0,228
1996	8,618	0,078	0,170
1997	5,528	0,071	0,125
1998	1,799	0,053	0,087
1999	1,465	0,054	0,209
2000	1,083	0,055	0,270
2001	1,054	0,061	0,285
2002	0,996	0,063	0,145
2003	1,641	0,067	0,204
2004	1,814	0,141	0,161
2005	1,388	0,080	0,200
2006	1,296	0,081	0,296
2007	1,242	0,081	0,270
2008	1,373	0,412	0,163
2009	1,040	0,124	0,064
2010	1,002	0,069	0,068
2011	1,508	0,065	0,059
2012	1,666	0,104	0,085
2013	1,123	0,056	0,162
2014	1,239	0,069	0,067
2015	1,322	0,076	0,082
2016	1,289	0,076	0,123
2017	1,365	0,070	0,063
Trend 1990-1999	***-92,20%***	***-41,30%***	***-49,39%***
Trend 2000-2017	***26,04%***	***27,27%***	***-76,67%***
Trend 1990-2017	***-92,73%***	***-23,91%***	***-84,75%***

Note: Minor inconsistencies of emission values and calculated percentages are due to rounding errors.

3.1. Cadmium (Cd)

With regard to **cadmium** emissions, the KCA identified **glass production** (2A3), **residential heating** (1A4bi), **iron and steel production** (2C1), and **stationary combustion in manufacturing industries and construction** (1A2gviii) as key categories in level assessment. **Stationary combustion in manufacturing industries and construction** (1A2gviii), **residential heating** (1A4bi) and **public electricity and heat production** (1A1a) contributed primarily to the observed emission trends (KCA cf. annexe, see also Fig. 3-1).

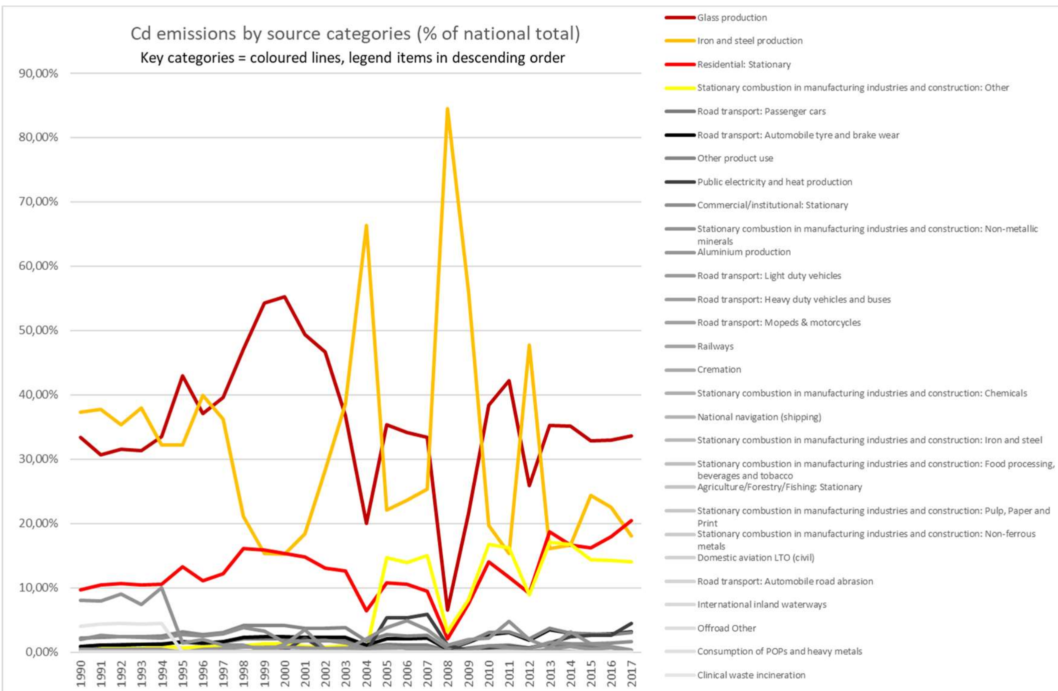

Fig. 3-1: Evolution of cadmium emissions by different NFR categories. Key categories are shown as coloured lines.

From the early nineties until their shutdown in 1997, the sintering plant and several blast furnaces in Esch-Belval constituted the main emitters of cadmium in Luxembourg. From 1990 to 1994 sinter and pig iron production contributed to about one third of nationwide cadmium emissions. However, from 1995 to 1997 the share of iron production in total cadmium emissions dropped to some 15 percent of total emissions.

With the launch of two electrical steel plants in Esch-Schifflange and Differdange in 1995 and a third one in 1998 in Esch-Belval, steel production in electrical arc furnaces became a major source of cadmium emissions in Luxembourg. 14 – 23% of national cadmium emissions originated from electrical arc furnaces between 1996 and 2007. In 2004, 2008, 2009 and 2012 this proportion was much higher (45 - 83%) and probably related to problems within one or more of these installations.

In a usual year, glass industry was and is still the most important emitter of cadmium in Luxembourg with between 30 and 50% of total emissions (34% in 2017).

There is no clear trend in cadmium emissions over the past 20 years. In general, cadmium emissions range between 50 and 90 kg/a with two outstanding peaks in 2004, 2008 and 2012 (see Fig. 3-2). All three peaks were a result of sharp rises of cadmium emissions in different electrical steel plants.

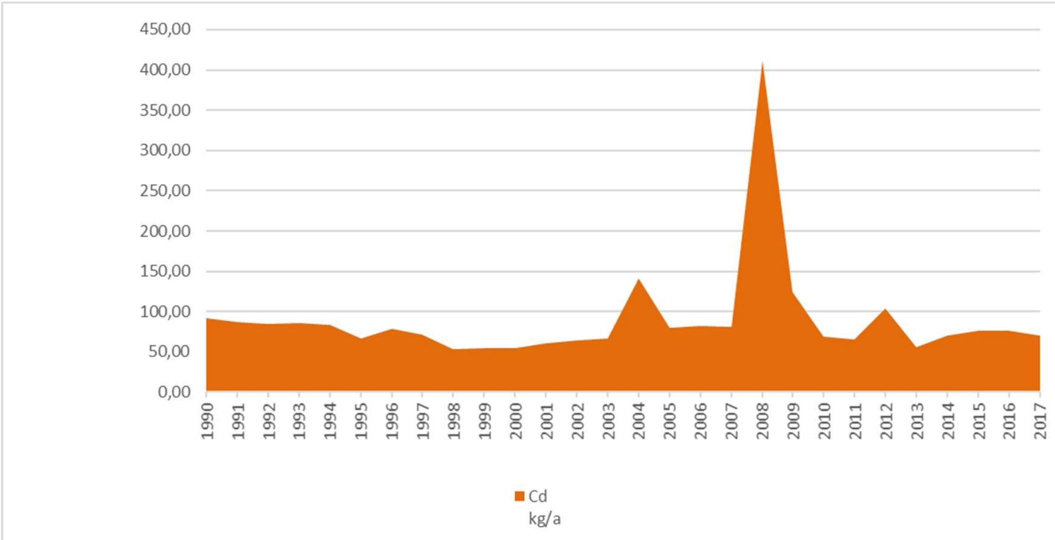

Fig. 3-2: Evolution of total cadmium-emissions in Luxembourg since 1990

Compared to 1990, total cadmium emissions in 2017 were cut by 24% (Tab. 3-2, next page). However, since there is no clear observable trend over the past twenty years, this evolution should be treated with caution.

Table 3-2: Cadmium emissions by NFR category 1990 and 2017 - Trends and shares in total emissions.

NFR Category		Cd [t]		Trend	Share in National Total	
		1990	2017		1990	2017
1 A	**ENERGY - FUEL COMBUSTION ACTIVITIES**	**0,021**	**0,032**	***+ 51,2%***	**22,8%**	**45,2%**
1 A 1	***Energy Industries***	***0,000***	***0,003***	***+ 4572,9%***	***0,1%***	***4,5%***
1 A 1 a	Public electricity and heat production	0,000	0,003	***+ 4572,9%***	0,1%	4,5%
1 A 2	***Stationary combustion in manufacturing industries and construction***	***0,008***	***0,010***	***+ 22,7%***	***9,0%***	***14,4%***
1 A 2 a	Iron and steel	0,000	0,000	***-97,6%***	0,2%	0,0%
1 A 2 b	Non-ferrous metals	0,000	0,000	***± 0,0%***	0,0%	0,0%
1 A 2 c	Chemicals	0,000	0,000	***-76,1%***	0,0%	0,0%
1 A 2 d	Pulp, paper and print	0,000	0,000	***+***	0,0%	0,0%
1 A 2 e	Food processing, beverages and tobacco	0,000	0,000	***+ 129,7%***	0,0%	0,0%
1 A 2 f	Non-metallic minerals	0,007	0,000	***-97%***	8,1%	0,3%
1 A 2 g viii	Other	0,001	0,010	***+ 1594,7%***	0,6%	14,1%
1 A 3	***Transport***	***0,002***	***0,003***	***+ 62,5%***	***2,0%***	***4,2%***
1 A 3 a ii(i)	Domestic aviation LTO (civil)	0,000	0,000	***± 0,0%***	0,0%	0,0%
1 A 3 b i	Passenger cars	0,001	0,001	***-24,3%***	0,9%	0,9%
1 A 3 b ii	Light duty vehicles	0,000	0,000	***-47,7%***	0,0%	0,0%
1 A 3 b iii	Heavy duty vehicles and buses	0,000	0,000	***+ 259%***	0,0%	0,1%
1 A 3 b iv	Mopeds & motorcycles	0,000	0,000	***+ 208,9%***	0,0%	0,0%
1 A 3 b vi	Road transport: Automobile tyre and brake wear	0,001	0,002	***+ 153,3%***	0,9%	3,1%
1 A 3 b vii	Road transport: Automobile road abrasion	0,000	0,000	***± 0,0%***	0,0%	0,0%
1 A 3 c	Railways	0,000	0,000	***-64,1%***	0,1%	0,0%
1 A 3 d i(ii)	International inland waterways	0,000	0,000	***± 0,0%***	0,0%	0,0%
1 A 3 d ii	National navigation (shipping)	0,000	0,000	***+ 17,5%***	0,0%	0,0%
1 A 3 e ii	Offroad Other	0,000	0,000	***-7,5%***	0,0%	0,0%
1 A 4	***Other***	***0,011***	***0,015***	***+ 43%***	***11,8%***	***22,2%***
1 A 4 a i	Commercial / institutional: Stationary	0,002	0,001	***-34,8%***	2,0%	1,7%
1 A 4 b i	Residential: Stationary	0,009	0,014	***+ 60%***	9,7%	20,5%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	0,000	0,000	***-99,8%***	0,1%	0,0%
2 A	**INDUSTRIAL PROCESSES - NON-METALLIC MINERALS**	**0,031**	**0,024**	***-23,4%***	**33,5%**	**33,7%**
2 A 3	Glass production	0,031	0,024	***-23,4%***	33,5%	33,7%
2 C	**INDUSTRIAL PROCESSES - METAL PRODUCTION**	**0,034**	**0,013**	***-63,2%***	**37,4%**	**18,1%**
2 C 1	Iron and steel production	0,034	0,013	***-63,2%***	37,4%	18,1%
2 C 3	Aluminium production	0,000	0,000	***-76,4%***	0,4%	0,1%
2 G	**INDUSTRIAL PROCESSES - OTHER PRODUCT USE**	**0,002**	**0,002**	***+ 7,3%***	**2,2%**	**3,0%**
2 G	Other product use	0,002	0,002	***+ 7,3%***	2,2%	3,0%
5 C	**WASTE - INCINERATION**	**0,004**	**0,000**	***-99,7%***	**4,1%**	**0,0%**
5 C 1 b iii	Clinical wasteincineration (d)	0,004	NO	***-100,0%***	4,1%	0,0%
5 C 1 b v	Cremation	NO	0,000	***-100,0%***	0,0%	0,0%
	National total for the entire territory	**0,092**	**0,070**	-23,8%	**100,0%**	**100,0%**

3.2. Lead (Pb)

With regard to **lead** emissions, the KCA identified **road transport: automobile tyre and brake wear** (1A3bvi) (level and trend), **iron and steel production** (2C1) (level), **glass production** (2A3) (level and trend), **aviation** (1A3aii(i)) (level), and **commercial/institutional heating** (1A4ai)(level and trend) as key categories (KCA cf. annexe, see also Fig. 3-3).

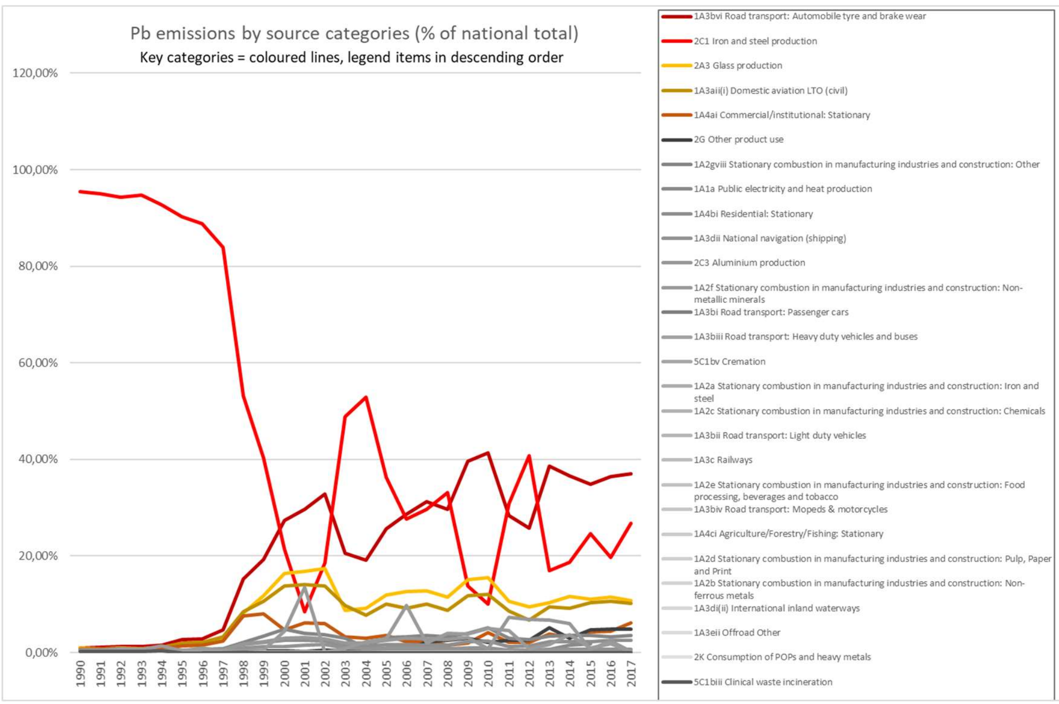

Fig. 3-3: Evolution of lead emissions by different NFR categories. Key categories are shown as coloured lines.

As stated above with regard to cadmium emissions, the sintering plant in Esch-Belval and several other blast furnaces at the same production site were also main sources of lead emissions during the early nineties. From 1990 to 1994, these facilities contributed to more than 40 percent of nationwide lead emissions, which ranged from 14 to 18 t/a. The other important source of lead emissions during that time was road transport. Combustion, brake and tyre wear were responsible for some 50% of total lead emissions. Emission values for road transport as given by the Network emission model (NEMO) and used for this report, don' t reflect that situation since it does not take into account the leaded fuel used in the nineties. Corresponding improvements are planned for the next report

After 1994, emissions from sinter and pig iron production were gradually cut by almost 75 percent. Thus, before the shutdown of the sintering plant in 1997, lead emissions from sinter and pig iron production summed up to 3.7 t/a which corresponded to some 32 percent of nationwide lead emissions.

Other sources of lead emissions are the production of non-ferrous metals, chemicals, cement, and asphalt as well as civil aviation and residential and commercial heating. Until 1994, incineration of medical wastes also constituted a small source of lead emissions. However, compared to lead emissions from iron production and road traffic, emissions from other sources appear almost insignificant. Thus, from 1990 to 1999 (after the shutdown of the sintering plant in 1997 and the end of leaded gasoline) total lead emissions dropped by more than 97 percent to a national total of 1.3 t/a.

From 1995 on, steel production in electrical arc furnaces became a major source of lead emissions. In 2017, electrical steel plants contributed some 25% of total lead emissions in Luxembourg. The main source of lead emissions is automobile tyre and break wear with around 35% of all emissions in 2017.

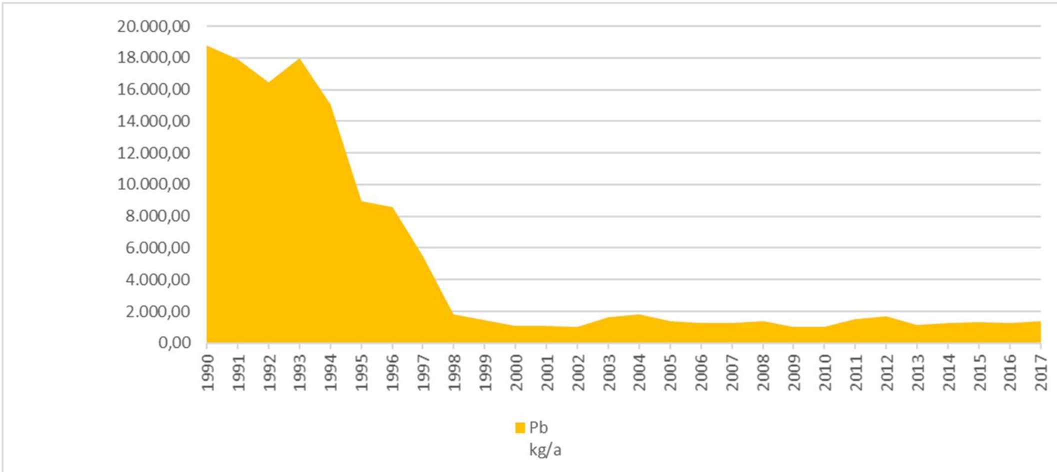

Fig. 3-4: Evolution of lead-emissions in Luxembourg since 1990

Over the past two decades, there is a clear downward trend of lead emissions in Luxembourg (Fig. 3-4). During this period, total lead emissions have been cut by over 90 percent between 1990 and 2017. The important difference of absolute figures between the reporting of 2016 and the present one is due to the above-mentioned limitation of the Network emission model. As stated above, this evolution was mainly influenced by structural changes in the heavy industries (iron and steel production) and the end of leaded gasoline. Since 2000, there is no clear trend anymore and lead emissions seem to level off between 1.3 and 2.0 t/a).

Table 3-3: Lead emissions by NFR category 1990 and 2017 - Trends and shares in total emissions.

NFR Category		Pb [t]		Trend	Share in National Total	
		1990	2017		1990	2017
1 A	**ENERGY - FUEL COMBUSTION ACTIVITIES**	**0,599**	**0,815**	*+ 36%*	**3,2%**	**59,7%**
1 A 1	***Energy Industries***	***0,001***	***0,036***	***+ 5970,1%***	***0,0%***	***2,6%***
1 A 1 a	Public electricity and heat production	0,001	0,036	***+ 5970,1%***	0,0%	2,6%
1 A 2	***Stationary combustion in manufacturing industries and construction***	***0,157***	***0,048***	***-69,3%***	***0,8%***	***3,5%***
1 A 2 a	Iron and steel	0,010	0,000	***-99,6%***	0,1%	0,0%
1 A 2 b	Non-ferrous metals	0,000	0,000	***± 0,0%***	0,0%	0,0%
1 A 2 c	Chemicals	0,000	0,000	***-77,9%***	0,0%	0,0%
1 A 2 d	Pulp, paper and print	0,000	0,000	***+***	0,0%	0,0%
1 A 2 e	Food processing, beverages and tobacco	0,000	0,000	***+ 127,2%***	0,0%	0,0%
1 A 2 f	Non-metallic minerals	0,104	0,002	***-98%***	0,6%	0,1%
1 A 2 g viii	Other	0,043	0,046	***+ 7,8%***	0,2%	3,4%
1 A 3	***Transport***	***0,261***	***0,620***	***+ 137,4%***	***1,4%***	***45,4%***
1 A 3 a ii(i)	Domestic aviation LTO (civil)	0,049	0,131	***+ 170,2%***	0,3%	9,6%
1 A 3 b i	Passenger cars	0,001	0,001	***+ 1,3%***	0,0%	0,1%
1 A 3 b ii	Light duty vehicles	0,000	0,000	***+ 160,2%***	0,0%	0,0%
1 A 3 b iii	Heavy duty vehicles and buses	0,000	0,001	***+ 259%***	0,0%	0,0%
1 A 3 b iv	Mopeds & motorcycles	0,000	0,000	***+ 208,9%***	0,0%	0,0%
1 A 3 b vi	Road transport: Automobile tyre and brake wear	0,191	0,478	***+ 150,6%***	1,0%	35,0%
1 A 3 b vii	Road transport: Automobile road abrasion	0,000	0,000	***± 0,0%***	0,0%	0,0%
1 A 3 c	Railways	0,000	0,000	***-64,1%***	0,0%	0,0%
1 A 3 d i(ii)	International inland waterways	0,000	0,000	***± 0,0%***	0,0%	0,0%
1 A 3 d ii	National navigation (shipping)	0,021	0,009	***-56,3%***	0,1%	0,7%
1 A 3 e ii	Offroad Other	0,000	0,000	***± 0,0%***	0,0%	0,0%
1 A 4	***Other***	***0,180***	***0,111***	***-38,4%***	***1,0%***	***8,1%***
1 A 4 a i	Commercial / institutional: Stationary	0,122	0,079	***-35,4%***	0,6%	5,8%
1 A 4 b i	Residential: Stationary	0,058	0,032	***-44,5%***	0,3%	2,4%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	0,000	0,000	***-99,2%***	0,0%	0,0%
2 A	**INDUSTRIAL PROCESSES - NON-METALLIC MINERALS**	**0,181**	**0,138**	***-23,4%***	**1,0%**	**10,1%**
2 A 3	Glass production	0,181	0,138	***-23,4%***	1,0%	10,1%
2 C	**INDUSTRIAL PROCESSES - METAL PRODUCTION**	**17,957**	**0,349**	***-98,1%***	**95,6%**	**25,6%**
2 C 1	Iron and steel production	17,936	0,345	***-98,1%***	95,5%	25,3%
2 C 3	Aluminium production	0,021	0,004	***-81,7%***	0,1%	0,3%
2 G	**INDUSTRIAL PROCESSES - OTHER PRODUCT USE**	**0,001**	**0,062**	***+ 11751,7%***	**0,0%**	**4,6%**
2 G	Other product use	0,001	0,062	***+ 11751,7%***	0,0%	4,6%
5 C	**WASTE - INCINERATION**	**0,049**	**0,000**	***-99,8%***	**0,3%**	**0,0%**
5 C 1 b iii	Clinical wasteincineration (d)	0,049	NO	***-100,0%***	0,3%	0,0%
5 C 1 b v	Cremation	NO	0,000	***-100,0%***	0,0%	0,0%
	National total for the entire territory	**18,785**	**1,365**	-92,7%	**100,0%**	**100,0%**

3.3. Mercury (Hg)

Concerning **mercury** emissions, the KCA identified **iron and steel production** (2C1), **stationary combustion in manufacturing industries and construction: Non-metallic minerals** (1A2f), **other product use** (2G), **road transport** (1A3bi, 1A3biii) and **public electricity and heat production** (1A1a) as key categories in level assessment. Regarding the trend assessment, **road transport** (1A3bi, 1A3biii), **other product use** (2G), **public electricity and heat production** (1A1a), **stationary combustion in**

manufacturing industries and construction: Other (1A2gviii), **residential heating** (1A4bi) and **stationary combustion in manufacturing industries and construction: Non-metallic minerals** (1A2f) are to be considered as key categories for mercury emissions (KCA cf. annexe, see also Fig. 3-5).

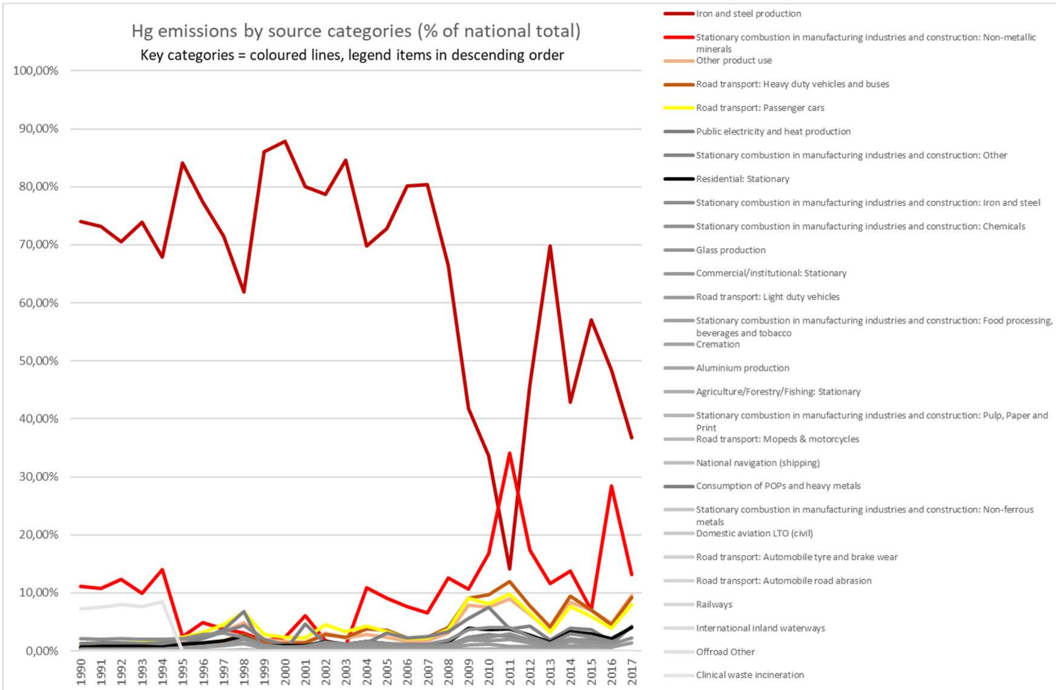

Figure 3-5: Evolution of mercury emissions by different NFR categories. Key categories are shown as coloured lines.

From 1990 to 1997, mercury emissions in Luxembourg originated mainly from iron production (sintering plant and blast furnaces). During this period, emissions from the heavy industries made up for 65 to 85 percent of nationwide mercury releases. Total emission levels lay between approx. 125 and 415 kg/a. Other important emitters of mercury in the early nineties were cement production, medical waste incineration, and, at much lower levels, commercial and residential heating.

During the nineties, nationwide mercury emissions were cut dramatically from over 400 kg/a in 1990 to 86 kg/a in 1998. This reduction was mainly due to changes in iron production (predominantly caused by reduced production volumes).

However, with the increase of steel production in electrical arc furnaces in the late nineties, mercury emissions form these facilities bounced up and peaked in 2006 with total mercury emissions reaching more than 250 kg/a again (Fig. 3-6).

Since that peak, mercury emissions showed a tendency to reduction mainly due to lower emissions from steel production. Since production volumes in the steel industry varied only slightly during this period, it can be assumed that better emission control was the main reason for the drop.

In recent years, mercury emissions showed a tendency to rise again and reached over 150 kg in 2013 before dropping to 62 kg in 2014. In 2015 and 2016 mercury emissions increased again reaching 127 kg in 2016, before dropping to 65 kg in 2017. These fluctuations originate mainly from rising or dropping emissions in the steel and non-metallic mineral industry (1A2f, 2C1).

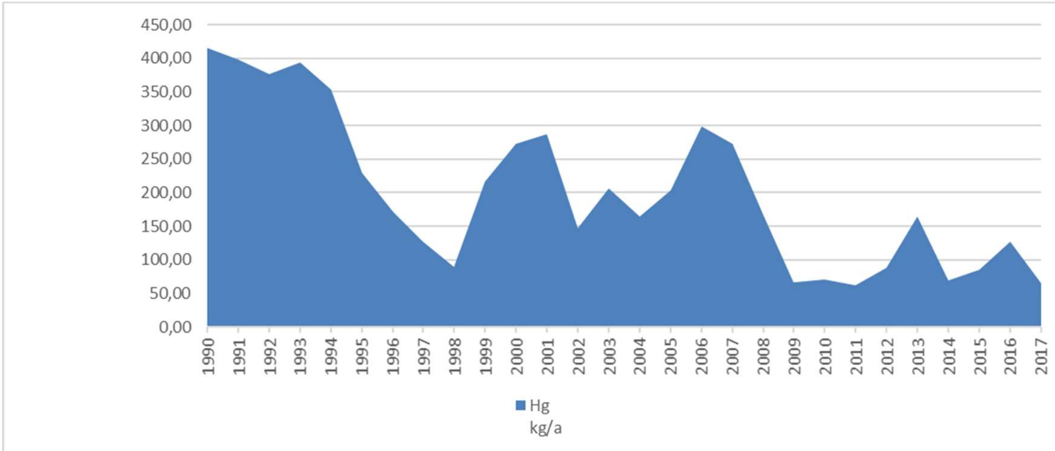

Fig. 3-6: Evolution of mercury emissions in Luxembourg since 1990

Table 3-4: Mercury emissions by NFR category 1990 and 2017 - Trends and shares in total

NFR Category		Hg [t] 1990	Hg [t] 2017	Trend	Share in National Total 1990	Share in National Total 2017
1 A	**ENERGY - FUEL COMBUSTION ACTIVITIES**	**0,072**	**0,032**	***-55,3%***	**17,5%**	**51,7%**
1 A 1	***Energy Industries***	***0,005***	***0,003***	***-38,5%***	***1,3%***	***5,1%***
1 A 1 a	Public electricity and heat production	0,005	0,003	***-38,5%***	1,3%	5,1%
1 A 2	***Stationary combustion in manufacturing industries and construction***	***0,058***	***0,015***	***-74,7%***	***13,9%***	***23,3%***
1 A 2 a	Iron and steel	0,009	0,002	***-76,7%***	2,1%	3,3%
1 A 2 b	Non-ferrous metals	0,000	0,000	***± 0,0%***	0,0%	0,0%
1 A 2 c	Chemicals	0,001	0,001	***+ 92,4%***	0,2%	2,2%
1 A 2 d	Pulp, paper and print	0,000	0,000	***+***	0,0%	0,1%
1 A 2 e	Food processing, beverages and tobacco	0,000	0,000	***+ 297,9%***	0,0%	0,3%
1 A 2 f	Non-metallic minerals	0,046	0,008	***-82%***	11,2%	13,2%
1 A 2 g viii	Other	0,002	0,003	***+ 33,8%***	0,5%	4,3%
1 A 3	***Transport***	***0,006***	***0,011***	***+ 93,3%***	***1,4%***	***17,7%***
1 A 3 a ii(i)	Domestic aviation LTO (civil)	0,000	0,000	***± 0,0%***	0,0%	0,0%
1 A 3 b i	Passenger cars	0,004	0,005	***+ 24,6%***	1,0%	8,0%
1 A 3 b ii	Light duty vehicles	0,000	0,000	***+ 255,2%***	0,0%	0,4%
1 A 3 b iii	Heavy duty vehicles and buses	0,002	0,006	***+ 259%***	0,4%	9,2%
1 A 3 b iv	Mopeds & motorcycles	0,000	0,000	***+ 208,9%***	0,0%	0,0%
1 A 3 b vi	Road transport: Automobile tyre and brake wear	0,000	0,000	***± 0,0%***	0,0%	0,0%
1 A 3 b vii	Road transport: Automobile road abrasion	0,000	0,000	***± 0,0%***	0,0%	0,0%
1 A 3 c	Railways	0,000	0,000	***± 0,0%***	0,0%	0,0%
1 A 3 d i(ii)	International inland waterways	0,000	0,000	***± 0,0%***	0,0%	0,0%
1 A 3 d ii	National navigation (shipping)	0,000	0,000	***+ 17,5%***	0,0%	0,0%
1 A 3 e ii	Offroad Other	0,000	0,000	***± 0,0%***	0,0%	0,0%
1 A 4	***Other***	***0,004***	***0,004***	***-8%***	***0,9%***	***5,6%***
1 A 4 a i	Commercial / institutional: Stationary	0,001	0,001	***-4,6%***	0,2%	1,4%
1 A 4 b i	Residential: Stationary	0,003	0,003	***-10,7%***	0,7%	4,1%
1 A 4 c i	Agriculture/Forestry/Fishing: Stationary	0,000	0,000	***+ 102,5%***	0,0%	0,1%
2 A	**INDUSTRIAL PROCESSES - NON-METALLIC MINERALS**	**0,001**	**0,001**	***-23,4%***	**0,3%**	**1,7%**
2 A 3	Glass production	0,001	0,001	***-23,4%***	0,3%	1,7%
2 C	**INDUSTRIAL PROCESSES - METAL PRODUCTION**	**0,306**	**0,023**	***-92,5%***	**74,0%**	**36,8%**
2 C 1	Iron and steel production	0,306	0,023	***-92,5%***	74,0%	36,8%
2 C 3	Aluminium production	0,000	0,000	***+***	0,0%	0,2%
2 G	**INDUSTRIAL PROCESSES - OTHER PRODUCT USE**	**0,004**	**0,006**	***+ 56,7%***	**0,9%**	**9,6%**
2 G	Other product use	0,004	0,006	***+ 56,7%***	0,9%	9,6%
5 C	**WASTE - INCINERATION**	**0,030**	**0,000**	***-99,6%***	**7,2%**	**0,2%**
5 C 1 b iii	Clinical wasteincineration (d)	0,030	NO	***-100,0%***	7,2%	0,0%
5 C 1 b v	Cremation	NO	0,000	***-100,0%***	0,0%	0,2%
	National total for the entire territory	**0,413**	**0,063**	**-84,9%**	**100,0%**	**100,0%**

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5. ANNEXE

Annexe 1 – 3: Key Category Analysis for sources of Cd, Pb and Hg.

NFR category code	NFR category	Pollutant	Last year estimate $E_{x,t}$	Level assessment $L_{x,t}$	Cumulative total of level assessment
2A3	**Glass production**	**Cd**	**0,02**	**0,34**	**0,34**
1A4bi	**Residential: Stationary**	**Cd**	**0,01**	**0,20**	**0,54**
2C1	**Iron and steel production**	**Cd**	**0,01**	**0,18**	**0,72**
1A2gviii	**Stationary combustion in manufacturing industries and construction: Other**	**Cd**	**0,01**	**0,14**	**0,86**
1A1a	Public electricity and heat production	Cd	0,00	0,04	0,91
1A3bvi	Road transport: Automobile tyre and brake wear	Cd	0,00	0,03	0,94
2G	Other product use	Cd	0,00	0,03	0,97
1A4ai	Commercial/institutional: Stationary	Cd	0,00	0,02	0,98
1A3bi	Road transport: Passenger cars	Cd	0,00	0,01	0,99
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	Cd	0,00	0,00	1,00
2C3	Aluminium production	Cd	0,00	0,00	1,00
1A3biii	Road transport: Heavy duty vehicles and buses	Cd	0,00	0,00	1,00
1A3c	Railways	Cd	0,00	0,00	1,00
5C1bv	Cremation	Cd	0,00	0,00	1,00
1A3biv	Road transport: Mopeds & motorcycles	Cd	0,00	0,00	1,00
1A3dii	National navigation (shipping)	Cd	0,00	0,00	1,00
1A3bii	Road transport: Light duty vehicles	Cd	0,00	0,00	1,00
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	Cd	0,00	0,00	1,00
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	Cd	0,00	0,00	1,00
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	Cd	0,00	0,00	1,00
1A4ci	Agriculture/Forestry/Fishing: Stationary	Cd	0,00	0,00	1,00
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	Cd	0,00	0,00	1,00
1A3eii	Offroad Other	Cd	0,00	0,00	1,00
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	Cd	0,00	0,00	1,00
1A3aii(i)	Domestic aviation LTO (civil)	Cd	0,00	0,00	1,00
1A3bvii	Road transport: Automobile road abrasion	Cd	0,00	0,00	1,00
1A3di(ii)	International inland waterways	Cd	0,00	0,00	1,00
2K	Consumption of POPs and heavy metals	Cd	0,00	0,00	1,00
5C1biii	Clinical waste incineration	Cd	0,00	0,00	1,00

NFR category code	NFR category	Pollutant	Base year estimate $E_{x,0}$	Last year estimate $E_{x,t}$	Trend assessment $T_{x,t}$	% Contribution to trend	Cumulative total of trend assessment
1A2gviii	**Stationary combustion in manufacturing industries and construction: Other**	**Cd**	**0,00**	**0,01**	**0,10**	**0,42**	**0,42**
1A4bi	**Residential: Stationary**	**Cd**	**0,01**	**0,01**	**0,08**	**0,34**	**0,76**
1A1a	**Public electricity and heat production**	**Cd**	**0,00**	**0,00**	**0,03**	**0,14**	**0,89**
1A3bvi	Road transport: Automobile tyre and brake wear	Cd	0,00	0,00	0,02	0,07	0,96
2G	Other product use	Cd	0,00	0,00	0,01	0,03	0,99
2A3	Glass production	Cd	0,03	0,02	0,00	0,01	1,00
1A3biii	Road transport: Heavy duty vehicles and buses	Cd	0,00	0,00	0,00	0,00	1,00
5C1bv	Cremation	Cd	0,00	0,00	0,00	0,00	1,00
1A3biv	Road transport: Mopeds & motorcycles	Cd	0,00	0,00	0,00	0,00	1,00
1A3dii	National navigation (shipping)	Cd	0,00	0,00	0,00	0,00	1,00
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	Cd	0,00	0,00	0,00	0,00	1,00
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	Cd	0,00	0,00	0,00	0,00	1,00
1A3eii	Offroad Other	Cd	0,00	0,00	0,00	0,00	1,00
2C3	Aluminium production	Cd	0,00	0,00	0,00	0,00	1,00
1A3bi	Road transport: Passenger cars	Cd	0,00	0,00	0,00	0,00	1,00
1A3bii	Road transport: Light duty vehicles	Cd	0,00	0,00	0,00	0,00	1,00
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	Cd	0,00	0,00	0,00	0,00	1,00
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	Cd	0,00	0,00	0,00	0,00	1,00
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	Cd	0,00	0,00	0,00	0,00	1,00
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	Cd	0,01	0,00	0,00	0,00	1,00
1A3aii(i)	Domestic aviation LTO (civil)	Cd	0,00	0,00	0,00	0,00	1,00
1A3bvii	Road transport: Automobile road abrasion	Cd	0,00	0,00	0,00	0,00	1,00
1A3c	Railways	Cd	0,00	0,00	0,00	0,00	1,00
1A3di(ii)	International inland waterways	Cd	0,00	0,00	0,00	0,00	1,00
1A4ai	Commercial/institutional: Stationary	Cd	0,00	0,00	0,00	0,00	1,00
1A4ci	Agriculture/Forestry/Fishing: Stationary	Cd	0,00	0,00	0,00	0,00	1,00
2C1	Iron and steel production	Cd	0,03	0,01	0,00	0,00	1,00
2K	Consumption of POPs and heavy metals	Cd	0,00	0,00	0,00	0,00	1,00
5C1biii	Clinical waste incineration	Cd	0,00	0,00	0,00	0,00	1,00

NFR category code	NFR category	Pollutant	Last year estimate $E_{x,t}$	Level assessment $L_{x,t}$	Cumulative total of level assessment
1A3bvi	**Road transport: Automobile tyre and brake wear**	**Pb**	**0,48**	**0,35**	**0,35**
2C1	**Iron and steel production**	**Pb**	**0,35**	**0,25**	**0,60**
2A3	**Glass production**	**Pb**	**0,14**	**0,10**	**0,70**
1A3aii(i)	**Domestic aviation LTO (civil)**	**Pb**	**0,13**	**0,10**	**0,80**
1A4ai	**Commercial/institutional: Stationary**	**Pb**	**0,08**	**0,06**	**0,86**
2G	Other product use	Pb	0,06	0,05	0,90
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	Pb	0,05	0,03	0,94
1A1a	Public electricity and heat production	Pb	0,04	0,03	0,96
1A4bi	Residential: Stationary	Pb	0,03	0,02	0,99
1A3dii	National navigation (shipping)	Pb	0,01	0,01	0,99
2C3	Aluminium production	Pb	0,00	0,00	1,00
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	Pb	0,00	0,00	1,00
1A3bi	Road transport: Passenger cars	Pb	0,00	0,00	1,00
1A3biii	Road transport: Heavy duty vehicles and buses	Pb	0,00	0,00	1,00
5C1bv	Cremation	Pb	0,00	0,00	1,00
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	Pb	0,00	0,00	1,00
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	Pb	0,00	0,00	1,00
1A3bii	Road transport: Light duty vehicles	Pb	0,00	0,00	1,00
1A3c	Railways	Pb	0,00	0,00	1,00
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	Pb	0,00	0,00	1,00
1A3biv	Road transport: Mopeds & motorcycles	Pb	0,00	0,00	1,00
1A4ci	Agriculture/Forestry/Fishing: Stationary	Pb	0,00	0,00	1,00
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	Pb	0,00	0,00	1,00
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	Pb	0,00	0,00	1,00
1A3bvii	Road transport: Automobile road abrasion	Pb	0,00	0,00	1,00
1A3di(ii)	International inland waterways	Pb	0,00	0,00	1,00
1A3eii	Offroad Other	Pb	0,00	0,00	1,00
2K	Consumption of POPs and heavy metals	Pb	0,00	0,00	1,00
5C1biii	Clinical waste incineration	Pb	0,00	0,00	1,00

NFR category code	NFR category	Pollutant	Base year estimate $E_{x,0}$	Last year estimate $E_{x,t}$	Trend assessment $T_{x,t}$	% Contribution to trend	Cumulative total of trend assessment
1A3bvi	**Road transport: Automobile tyre and brake wear**	**Pb**	**0,19**	**0,48**	**0,02**	**0,48**	**0,48**
1A3aii(i)	**Domestic aviation LTO (civil)**	**Pb**	**0,05**	**0,13**	**0,01**	**0,13**	**0,61**
2A3	**Glass production**	**Pb**	**0,18**	**0,14**	**0,01**	**0,13**	**0,74**
1A4ai	**Commercial/institutional: Stationary**	**Pb**	**0,12**	**0,08**	**0,00**	**0,07**	**0,81**
2G	Other product use	Pb	0,00	0,06	0,00	0,06	0,88
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	Pb	0,04	0,05	0,00	0,04	0,92
1A1a	Public electricity and heat production	Pb	0,00	0,04	0,00	0,04	0,96
1A4bi	Residential: Stationary	Pb	0,06	0,03	0,00	0,03	0,99
1A3dii	National navigation (shipping)	Pb	0,02	0,01	0,00	0,01	1,00
2C3	Aluminium production	Pb	0,02	0,00	0,00	0,00	1,00
1A3bi	Road transport: Passenger cars	Pb	0,00	0,00	0,00	0,00	1,00
1A3biii	Road transport: Heavy duty vehicles and buses	Pb	0,00	0,00	0,00	0,00	1,00
5C1bv	Cremation	Pb	0,00	0,00	0,00	0,00	1,00
1A3bii	Road transport: Light duty vehicles	Pb	0,00	0,00	0,00	0,00	1,00
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	Pb	0,00	0,00	0,00	0,00	1,00
1A3c	Railways	Pb	0,00	0,00	0,00	0,00	1,00
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	Pb	0,00	0,00	0,00	0,00	1,00
1A3biv	Road transport: Mopeds & motorcycles	Pb	0,00	0,00	0,00	0,00	1,00
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	Pb	0,00	0,00	0,00	0,00	1,00
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	Pb	0,10	0,00	0,00	0,00	1,00
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	Pb	0,01	0,00	0,00	0,00	1,00
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	Pb	0,00	0,00	0,00	0,00	1,00
1A3bvii	Road transport: Automobile road abrasion	Pb	0,00	0,00	0,00	0,00	1,00
1A3di(ii)	International inland waterways	Pb	0,00	0,00	0,00	0,00	1,00
1A3eii	Offroad Other	Pb	0,00	0,00	0,00	0,00	1,00
1A4ci	Agriculture/Forestry/Fishing: Stationary	Pb	0,00	0,00	0,00	0,00	1,00
2C1	Iron and steel production	Pb	17,94	0,35	0,00	0,00	1,00
2K	Consumption of POPs and heavy metals	Pb	0,00	0,00	0,00	0,00	1,00
5C1biii	Clinical waste incineration	Pb	0,05	0,00	0,00	0,00	1,00

NFR category code	NFR category	Pollutant	Last year estimate $E_{x,t}$	Level assessment $L_{x,t}$	Cumulative total of level assessment
2C1	**Iron and steel production**	**Hg**	**0,02**	**0,37**	**0,37**
1A2f	**Stationary combustion in manufacturing industries and construction: Non-metallic minerals**	**Hg**	**0,01**	**0,13**	**0,50**
2G	**Other product use**	**Hg**	**0,01**	**0,10**	**0,60**
1A3biii	**Road transport: Heavy duty vehicles and buses**	**Hg**	**0,01**	**0,09**	**0,69**
1A3bi	**Road transport: Passenger cars**	**Hg**	**0,01**	**0,08**	**0,77**
1A1a	**Public electricity and heat production**	**Hg**	**0,00**	**0,05**	**0,82**
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	Hg	0,00	0,04	0,86
1A4bi	Residential: Stationary	Hg	0,00	0,04	0,90
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	Hg	0,00	0,03	0,93
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	Hg	0,00	0,02	0,96
2A3	Glass production	Hg	0,00	0,02	0,97
1A4ai	Commercial/institutional: Stationary	Hg	0,00	0,01	0,99
1A3bii	Road transport: Light duty vehicles	Hg	0,00	0,00	0,99
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	Hg	0,00	0,00	0,99
5C1bv	Cremation	Hg	0,00	0,00	1,00
2C3	Aluminium production	Hg	0,00	0,00	1,00
1A4ci	Agriculture/Forestry/Fishing: Stationary	Hg	0,00	0,00	1,00
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	Hg	0,00	0,00	1,00
1A3biv	Road transport: Mopeds & motorcycles	Hg	0,00	0,00	1,00
1A3dii	National navigation (shipping)	Hg	0,00	0,00	1,00
2K	Consumption of POPs and heavy metals	Hg	0,00	0,00	1,00
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	Hg	0,00	0,00	1,00
1A3aii(i)	Domestic aviation LTO (civil)	Hg	0,00	0,00	1,00
1A3bvi	Road transport: Automobile tyre and brake wear	Hg	0,00	0,00	1,00
1A3bvii	Road transport: Automobile road abrasion	Hg	0,00	0,00	1,00
1A3c	Railways	Hg	0,00	0,00	1,00
1A3di(ii)	International inland waterways	Hg	0,00	0,00	1,00
1A3eii	Offroad Other	Hg	0,00	0,00	1,00
5C1biii	Clinical waste incineration	Hg	0,00	0,00	1,00

NFR category code	NFR category	Pollutant	Base year estimate $E_{x,0}$	Last year estimate $E_{x,t}$	Trend assessment $T_{x,t}$	% Contribution to trend	Cumulative total of trend assessment
1A3biii	**Road transport: Heavy duty vehicles and buses**	**Hg**	**0,00**	**0,01**	**0,01**	**0,20**	**0,20**
2G	**Other product use**	**Hg**	**0,00**	**0,01**	**0,01**	**0,20**	**0,39**
1A3bi	**Road transport: Passenger cars**	**Hg**	**0,00**	**0,01**	**0,01**	**0,16**	**0,55**
1A1a	**Public electricity and heat production**	**Hg**	**0,01**	**0,00**	**0,01**	**0,09**	**0,64**
1A2gviii	**Stationary combustion in manufacturing industries and construction: Other**	**Hg**	**0,00**	**0,00**	**0,01**	**0,09**	**0,72**
1A4bi	**Residential: Stationary**	**Hg**	**0,00**	**0,00**	**0,01**	**0,08**	**0,80**
1A2f	**Stationary combustion in manufacturing industries and construction: Non-metallic minerals**	**Hg**	**0,05**	**0,01**	**0,00**	**0,05**	**0,84**
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	Hg	0,00	0,00	0,00	0,05	0,89
2A3	Glass production	Hg	0,00	0,00	0,00	0,03	0,92
1A4ai	Commercial/institutional: Stationary	Hg	0,00	0,00	0,00	0,03	0,95
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	Hg	0,01	0,00	0,00	0,03	0,97
1A3bii	Road transport: Light duty vehicles	Hg	0,00	0,00	0,00	0,01	0,98
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	Hg	0,00	0,00	0,00	0,01	0,99
5C1bv	Cremation	Hg	0,00	0,00	0,00	0,00	0,99
2C3	Aluminium production	Hg	0,00	0,00	0,00	0,00	0,99
1A4ci	Agriculture/Forestry/Fishing: Stationary	Hg	0,00	0,00	0,00	0,00	1,00
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	Hg	0,00	0,00	0,00	0,00	1,00
1A3biv	Road transport: Mopeds & motorcycles	Hg	0,00	0,00	0,00	0,00	1,00
1A3dii	National navigation (shipping)	Hg	0,00	0,00	0,00	0,00	1,00
2K	Consumption of POPs and heavy metals	Hg	0,00	0,00	0,00	0,00	1,00
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	Hg	0,00	0,00	0,00	0,00	1,00
1A3aii(i)	Domestic aviation LTO (civil)	Hg	0,00	0,00	0,00	0,00	1,00
1A3bvi	Road transport: Automobile tyre and brake wear	Hg	0,00	0,00	0,00	0,00	1,00
1A3bvii	Road transport: Automobile road abrasion	Hg	0,00	0,00	0,00	0,00	1,00
1A3c	Railways	Hg	0,00	0,00	0,00	0,00	1,00
1A3di(ii)	International inland waterways	Hg	0,00	0,00	0,00	0,00	1,00
1A3eii	Offroad Other	Hg	0,00	0,00	0,00	0,00	1,00
2C1	Iron and steel production	Hg	0,31	0,02	0,00	0,00	1,00
5C1biii	Clinical waste incineration	Hg	0,03	0,00	0,00	0,00	1,00

Appendix 6: 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)