



OFFICE OF ENVIRONMENT
PRINCIPALITY OF LIECHTENSTEIN

Liechtenstein's Informative Inventory report 2021

Submitted under the UNECE Convention on Long Range
Transboundary Air Pollution,
CLRTAP



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Submission of 28 April 2021

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Glossary

AD	Activity Data
CH ₄	Methane
CO	Carbon monoxide
CLRTAP	Geneva Convention on Long Range Transboundary Air Pollution
Dioxins	used almost exclusively to refer to the sum of compounds (as g I-Teq)
EF	Emission Factor
FOEN	Swiss Federal Office for the Environment (former name SAEFL)
Gg	Giga gram (10 ⁹ g = 1'000 tons = 1 kiloton)
GHG	Greenhouse gas
IIR	Informative Inventory Report (UNECE)
IPCC	Intergovernmental Panel on Climate Change
KC	Key Category
KP	Kyoto Protocol
LULUCF	Land-Use, Land-Use Change and Forestry
Mg	Mega gram (10 ⁶ g = 1 ton)
mg I-Teq	milligram (10 ⁻³ g) toxic equivalents
MJ	Mega Joule (10 ⁶ Joule = 1'000'000 Joule)
MSW	municipal solid waste
NFR	Nomenclature for reporting (IPCC code of categories)
NH ₃	Ammonia
NIR	National Inventory Report
NIS	National Inventory System
NMVOC	Non-methane volatile organic compounds
NO _x	Nitrogen oxides
OA	Office of Agriculture
OEA	Office of Economic Affairs
OE	Office of Environment
OEP	Office of Environmental Protection
OFNLM	Office of Forests, Nature and Land Management
OS	Office of Statistics
PAH	polycyclic aromatic hydrocarbons; comprises Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene
PBTs	persistent, bio accumulative and toxic substances
PCDDs	Polychlorinated Dibenzo-p-dioxins
PCDFs	Dibenzofurans
PM10	particulate matter; particles on the order of ~10 micrometres or less

PM2.5	particulate matter; particles on the order of ~ 2.5 micrometres or less
POP	persistent organic pollutants
QA/QC	Quality assurance/quality control: QA includes a system of review procedures conducted by persons not directly involved in the inventory development process. QC is a system of routine technical activities to control the quality of the inventory.
SC	Stockholm convention
SO ₂	Sulphur dioxide
SO _x	Sulphur oxides
TJ	Tera Joule (10 ¹² Joule = 1'000'000 Mega Joule)
UNECE	United Nations Economic Commission for Europe
VOC	volatile organic compounds

EXECUTIVE SUMMARY

Summary of the main differences in the inventory since the last submission

Differences between the inventories of the submissions 2020 and 2021 are described in chapter 8. The current submission was created in report format NFR14.

Explanation of significant changes in emission trends

The emissions of the main pollutants show a downward trend between 1990 and 2019. This is mainly a result of great emission reduction efforts made in industrial and transport sectors as well as the changeover to less polluting fuels. Due to the significantly increased wood consumption in heating systems, the CO reductions flattened since the year 2000.

The source category 1A3b Road transport showed in comparison to the year 1990 a decrease of NO₂-, CO-, SO₂-, PM10- and NMVOC-emissions. The reduction is due to more stringent emission standards for vehicles.

The HCB-, Cd- and Benzo(k)fluoranthene emissions are above the level of 1990 and show increases, particularly in the residential sector. The only relevant reason is the increased wood combustion in the source categories 1A4a and 1A4b. This is a direct result of increased wood combustion for providing heat and hot water. Between 1999 and 2019, the wood energy consumption increased from 30.1 TJ to 124.2 TJ and from 20.0 TJ to 82.8 TJ, respectively, in source categories 1A4a and 1A4b.

Incompleteness and timeseries inconsistencies

No relevant inconsistencies occurred for the estimates in timeseries chapter in Liechtenstein's IIR 2021. The activity data from 1985 to 1990 are based on extrapolation of the activity data from 1990 to 1995.

Recalculations

The recalculations are explained in chapter 8.1.

Error

In the current submission, a formula error in NH₃ emission factor calculation in category 3B3 occurred. This led to an underestimation of emissions in this category (lead to a difference of less than 0.1% of total NH₃ emissions). This error will be corrected in the next submission (see also chapter 8.1).

Improvement Priorities

The planned improvements are listed in chapter 8.2.

Acknowledgement

The Office of Environment (OE) highly appreciates the generous support by all members of the Inventory Core Group at the Swiss Federal Office for Environment (FOEN). The free use of methods and tools developed by the FOEN has been essential during the development of the IIR.

The OE also gratefully acknowledges the support of the personal and close contacts between the GHG specialists of Switzerland and Liechtenstein who provided the basis for a very promising and fruitful cooperation both on a technical and on a political level.

The OE also thanks the data suppliers in Liechtenstein: Office of Economic Affairs, Office of Statistics, the sectoral experts and the IIR authors. Their effort enabled the finalisation of the inventory and the IIR.

1 Introduction

1.1 National inventory background

The Geneva Convention on Long Range Transboundary Air Pollution (CLRTAP) was adopted in 1979 and entered into force in 1983. Signed by 34 Governments and the European Community, the Convention was the first international legally binding instrument to deal with the extensive problems of air pollution on a regional basis. Over the years, the Convention has been extended by 8 protocols, of which Liechtenstein has signed and ratified 7 protocols today.

Based on Article 8 of the Convention, parties shall exchange information on emissions, pollutants, changes in national policies and many others. The Informative Inventory Report (IIR) of Liechtenstein aims to comply with these requirements together with the Nomenclature for Reporting (NFR) tables.

The recent report includes all emissions covered by the ratified protocols of the period from the years 1985 - 2019.

1.2 Institutional Arrangements

Figure 1.2-1 gives a schematic overview of the institutional setting of the inventory preparation process within the NIS.

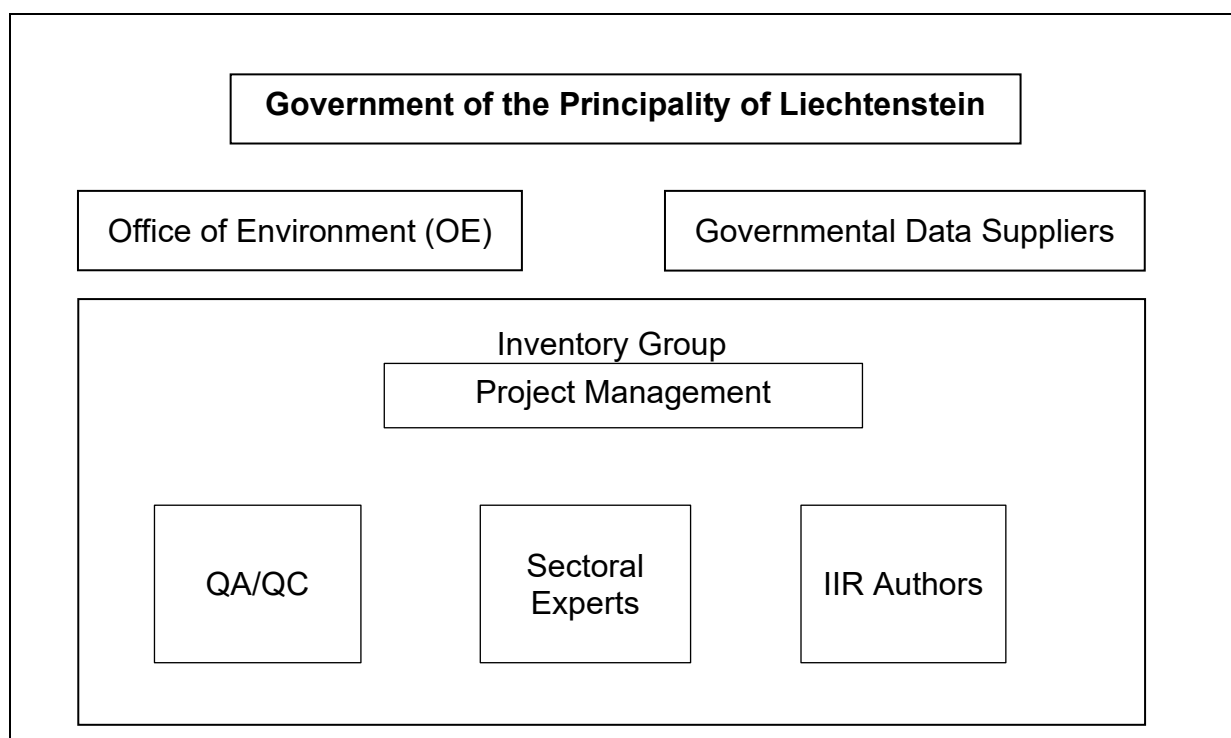


Figure 1.2-1: Informative Inventory Report: Institutional setting

The Government of the Principality of Liechtenstein bears the overall responsibility for the Informative Inventory Report (IIR) and mandated the Office of Environment (OE) with its implementation and supervision. This applies to the IIR under the Geneva Convention on Long

Range Transboundary Air Pollution (CLRTAP) as the well as the IIR under the Kyoto Protocol (KP).

The Inventory group consists of a project management team, which is responsible for the QA/QC activities, sectoral specialists for modelling the emissions and removals and the IIR authors.

1.3 Inventory preparation process

The required data for the inventory preparation is collected by various data suppliers. The individual data suppliers are responsible for the collection of activity data as well as for the selection of emission factors and methods.

Data processing is done using the software Excel and Access. The data storage is handled in the same way as in the Greenhouse Gas Inventory process. Data are kept in a bank safe and additionally in the OE.

Since the preparation of the inventory is closely linked to the preparation of the GHG inventory, a lot of working steps were done parallelly. Also, the editions of the Informative Inventory Report and of the National Inventory Report are processed simultaneously and, partly, by the same people. Therefore, both reports are structured similarly and complete each other.

The current submission was created in report format NFR14.

1.4 Methods and data sources

The bulk of the emission inventory was compiled by collecting activity data and appropriate emission factors. Especially, the collection of activity data went hand in hand with the GHG inventory.

The used activity data are mainly statistical data which were provided by the OS as well as other offices and public authorities. In addition, based on reporting obligations which are specified in emission permits, data were supplied directly by industrial installations.

The main data providers are:

- Office of Economic Affairs (OEA)
- Office of Statistics (OS)
- Office of Environment (OE)
- Swiss Federal Office for the Environment (FOEN)

1.5 Key categories

1.5.1 Level assessment

The level assessment relates to one year and consider the contribution of sectoral emissions to the absolute national emissions. The source categories are sorted in descending order of contribution magnitude and summed up.

The calculation is based on the Atmospheric Emissions Inventory Guidebook from 2016 [EMEP/CORINAIR 2016]. Source categories are identified as a „key category“ if 80 % of the national total emissions are covered. The following tables present the key categories identified by the level assessment for the year 2019 for the main pollutants which were identified by the approach 1 level assessment.

Table 1.5-1: Level assessment for pollutant NO₂ in 2019. Sorted by contribution in level.

NFR Code	Source category	NO ₂ [Gg]	Level ass.	Σ
1A3biii	Road transport: Heavy duty vehicles and buses	0.0826	0.3236	32.4
1A3bi	Road transport: Passenger cars	0.0683	0.2673	59.1
1A4ai	Commercial/institutional: Stationary	0.0295	0.1154	70.6
1A3bii	Road transport: Light duty vehicles	0.0188	0.0737	78.0
1A4bi	Residential: Stationary	0.0174	0.0681	84.8

Table 1.5-2: Level assessment for pollutant CO in 2019. Sorted by contribution in level.

NFR Code	Source category	CO [Gg]	Level ass.	Σ
1A4bi	Residential: Stationary	0.1812	0.3696	37.0
1A3bi	Road transport: Passenger cars	0.0966	0.1970	56.7
1A3bii	Road transport: Light duty vehicles	0.0577	0.1177	68.4
1A4ai	Commercial/institutional: Stationary	0.0574	0.1171	80.1

Table 1.5-3: Level assessment for pollutant NMVOC in 2019. Sorted by contribution in level.

NFR Code	Source category	NMVOC [Gg]	Level ass.	Σ
2D3a	Domestic solvent use including fungicides	0.0489	0.1685	16.8
2D3d	Coating applications	0.0444	0.1529	32.1
3B1a	Manure management - Dairy cattle	0.0375	0.1292	45.1
2D3i	Other solvent use	0.0326	0.1121	56.3
2D3g	Chemical products	0.0152	0.0524	61.5
2D3h	Printing	0.0128	0.0442	65.9
3B1b	Manure management - Non-dairy cattle	0.0119	0.0409	70.0
5B1	Biological treatment of waste - Composting	0.0107	0.0370	73.7
2H2	Food and beverages industry	0.0093	0.0322	76.9
1A4bi	Residential: Stationary	0.0075	0.0260	79.5
2D3e	Degreasing	0.0065	0.0222	81.7

Table 1.5-4: Level assessment for pollutant SO_x in 2019. Sorted by contribution in level.

NFR Code	Source category	SO ₂ [Gg]	Level ass.	Σ
1A4ai	Commercial/institutional: Stationary	0.0035	0.5199	52.0
1A4bi	Residential: Stationary	0.0018	0.2657	78.6
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	0.0008	0.1251	91.1

Table 1.5-5: Level assessment for pollutant NH₃ in 2019. Sorted by contribution in level.

NFR Code	Source category	NH ₃ [Gg]	Level ass.	Σ
3B1a	Manure management - Dairy cattle	0.1231	0.5703	57.0
3B1b	Manure management - Non-dairy cattle	0.0495	0.2293	80.0
3B3	Manure management - Swine	0.0102	0.0473	84.7

Table 1.5-6: Level assessment for pollutant PM10 in 2019. Sorted by contribution in level.

NFR Code	Source category	PM10 [Gg]	Level ass.	Σ
1A4bi	Residential: Stationary	0.0074	0.1811	18.1
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	0.0073	0.1774	35.9
1A4ai	Commercial/institutional: Stationary	0.0067	0.1627	52.1
1A3bvi	Road transport: Automobile tyre and brake wear	0.0045	0.1106	63.2
3B1a	Manure management - Dairy cattle	0.0029	0.0718	70.4
2I	Wood processing	0.0017	0.0417	74.5
1A3bvii	Road transport: Automobile road abrasion	0.0016	0.0381	78.3
1A3biii	Road transport: Heavy duty vehicles and buses	0.0010	0.0253	80.9

1.5.2 Trend assessment

A key category trend analysis evaluates the difference between the trend of a particular source category and the trend of Liechtenstein's total emissions. Key sources are those categories whose trend differences are, when summed up in descending order of magnitude, 80% of all source trend differences. The calculation is based on the Atmospheric Emissions Inventory Guidebook from 2016 [EMEP/CORINAIR 2016].

The following tables represent the key sources for main pollutants identified by the trend assessment ($t_{x,t}$).

Table 1.5-7: Trend assessment for pollutant NO₂ from 1990 to 2019. Sorted by contribution in level.

NFR Code	Source category	1990	2019	$T_{x,t}$	% contrib	Σ
1A3biii	Road transport: Heavy duty vehicles and buses	0.2684	0.0826	0.0454	37.8	37.8
1A3bi	Road transport: Passenger cars	0.1332	0.0683	0.0215	17.9	55.7
1A4bi	Residential: Stationary	0.0192	0.0174	0.0153	12.8	68.5
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	0.0300	0.0073	0.0082	6.8	75.4
1A4ai	Commercial/institutional: Stationary	0.0594	0.0295	0.0081	6.7	82.1

Table 1.5-8: Trend assessment for pollutant CO from 1990 to 2019. Sorted by contribution in level.

NFR Code	Source category	1990	2019	$T_{x,t}$	% contrib	Σ
1A3bi	Road transport: Passenger cars	0.9084	0.0966	0.1258	41.5	41.5
1A4bi	Residential: Stationary	0.0773	0.1812	0.1019	33.6	75.0
1A4ai	Commercial/institutional: Stationary	0.0676	0.0574	0.0233	7.7	82.7

Table 1.5-9: Trend assessment for pollutant NMVOC from 1990 to 2019. Sorted by contribution in level.

NFR Code	Source category	1990	2019	T _{x,t}	% contrib	Σ
1A3bv	Road transport: Gasoline evaporation	0.2118	0.0011	0.0359	19.0	19.0
2D3a	Domestic solvent use including fungicides	0.0398	0.0489	0.0309	16.4	35.4
1A3bi	Road transport: Passenger cars	0.1303	0.002	0.0211	11.2	46.6
3B1a	Manure management - Dairy cattle	0.0459	0.0375	0.0210	11.2	57.8
2D3g	Chemical products	0.121	0.0152	0.0092	4.9	62.7
2D3i	Other solvent use	0.1002	0.0326	0.0078	4.1	66.8
5B1	Biological treatment of waste - Composting	0.0069	0.0107	0.0071	3.8	70.6
3B1b	Manure management - Non-dairy cattle	0.0125	0.0119	0.0070	3.7	74.3
1B2av	Distribution of oil products	0.0486	0.0027	0.0064	3.4	77.6
2D3d	Coating applications	0.2314	0.0444	0.0058	3.1	80.7

Table 1.5-10: Trend assessment for pollutant SO_x from 1990 to 2019. Sorted by contribution in level.

NFR Code	Source category	1990	2019	T _{x,t}	% contrib	Σ
1A4bi	Residential: Stationary	0.0167	0.0018	0.0070	26.1	26.1
1A3biii	Road transport: Heavy duty vehicles and buses	0.0155	0.0002	0.0062	23.1	49.1
1A4ai	Commercial/institutional: Stationary	0.0489	0.0035	0.0059	21.8	70.9
1A3bi	Road transport: Passenger cars	0.0131	0.0002	0.0043	16.1	87.0

Table 1.5-11: Trend assessment for pollutant NH₃ from 1990 to 2019. Sorted by contribution in level.

NFR Code	Source category	1990	2019	T _{x,t}	% contrib	Σ
3B1b	Manure management - Non-dairy cattle	0.0519	0.0495	0.0222	20.7	20.7
3B4gi	Manure management - Laying hens	0.0020	0.0069	0.0204	19.0	39.8
3B1a	Manure management - Dairy cattle	0.1505	0.1231	0.016	15.0	54.7
3B4f	Manure management - Mules and asses	0.0012	0.0034	0.0097	9.0	63.8
3B3	Manure management - Swine	0.0147	0.0102	0.0086	8.0	71.8
3B2	Manure management - Sheep	0.0039	0.0054	0.0084	7.9	79.7
3B4e	Manure management - Horses	0.0026	0.0040	0.0069	6.5	86.1

Table 1.5-12: Trend assessment for pollutant PM₁₀ from 1990 to 2019. Sorted by contribution in level.

NFR Code	Source category	1990	2019	T _{x,t}	% contrib	Σ
1A3biii	Road transport: Heavy duty vehicles and buses	0.0153	0.0010	0.1192	21.8	21.8
1A4bi	Residential: Stationary	0.0029	0.0074	0.0833	15.2	37.0
1A4ai	Commercial/institutional: Stationary	0.0039	0.0067	0.0635	11.6	48.6
1A3bi	Road transport: Passenger cars	0.0074	0.0006	0.0562	10.3	58.8
1A3bvi	Road transport: Automobile tyre and brake wear	0.003	0.0045	0.0401	7.3	66.1
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	0.008	0.0073	0.0359	6.6	72.7
1A1a	Public electricity and heat production	0.0036	0.0000	0.0313	5.7	78.4
1A3bii	Road transport: Light duty vehicles	0.0033	0.0003	0.0246	4.5	82.9

1.5.3 Summary of key category analysis

Key sources are identified by means of their contribution to the national total emissions (level assessment) and according to the difference in their trend to the one of the total emissions (trend assessment). Key source categories identified by the approach 1 level (L1) assessment or trend assessment (T1) (or both (L1, T1)) are ranked according to the sum of their relative contributions in the level and trend assessment.

For the main pollutants and PM₁₀, the results of this key category analysis are summarized in the tables below.

Table 1.5-13: Result of key category analysis for pollutant NO₂

NFR Code	Source category	L	T	Identification criteria
1A3biii	Road transport: Heavy duty vehicles and buses	32.4	37.8	L1, T1
1A3bi	Road transport: Passenger cars	26.7	17.9	L1, T1
1A4bi	Residential: Stationary	6.8	12.8	L1, T1
1A4ai	Commercial/institutional: Stationary	11.5	6.7	L1, T1
1A3bii	Road transport: Light duty vehicles	7.4		L1
1A2gviii	Stationary combustion in manufacturing industries and construction: Other		6.8	T1

Table 1.5-14: Result of key category analysis for pollutant CO

NFR Code	Source category	L	T	Identification criteria
1A4bi	Residential: Stationary	37.0	33.6	L1, T1
1A3bi	Road transport: Passenger cars	19.7	41.5	L1, T1
1A4ai	Commercial/institutional: Stationary	11.7	7.7	L1, T1
1A3bii	Road transport: Light duty vehicles	11.8		L1

Table 1.5-15: Result of key category analysis for pollutant NMVOC

NFR Code	Source category	L	T	Identification criteria
2D3a	Domestic solvent use including fungicides	16.8	16.4	L1, T1
3B1a	Manure management - Dairy cattle	12.9	11.2	L1, T1
1A3bv	Road transport: Gasoline evaporation		19	T1
2D3d	Coating applications	15.3	3.1	L1, T1
2D3i	Other solvent use	11.2	4.1	L1, T1
1A3bi	Road transport: Passenger cars		11.2	T1
2D3g	Chemical products	5.2	4.9	L1, T1
3B1b	Manure management - Non-dairy cattle	4.1	3.7	L1, T1
5B1	Biological treatment of waste - Composting	3.7	3.8	L1, T1
2D3h	Printing	4.4		L1
1B2av	Distribution of oil products		3.4	T1
2H2	Food and beverages industry	3.2		L1
1A4bi	Residential: Stationary	2.6		L1
2D3e	Degreasing	2.2		L1

Table 1.5-16: Result of key category analysis for pollutant SO_x

NFR Code	Source category	L	T	Identification criteria
1A4ai	Commercial/institutional: Stationary	52.0	21.8	L1,T1
1A4bi	Residential: Stationary	26.6	26.1	L1,T1
1A3biii	Road transport: Heavy duty vehicles and buses		23.1	T1
1A3bi	Road transport: Passenger cars		16.1	T1
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	12.5		L1

Table 1.5-17: Result of key category analysis for pollutant NH₃

NFR Code	Source category	L	T	Identification criteria
3B1a	Manure management - Dairy cattle	57.0	15.0	L1,T1
3B1b	Manure management - Non-dairy cattle	22.9	20.7	L1,T1
3B4gi	Manure management - Laying hens		19	T1
3B3	Manure management - Swine	4.7	8.0	L1,T1
3B4f	Manure management - Mules and asses		9.0	T1
3B2	Manure management - Sheep		7.9	T1
3B4e	Manure management - Horses		6.5	T1

Table 1.5-18: Result of key category analysis for pollutant PM₁₀

NFR Code	Source category	L	T	Identification criteria
1A4bi	Residential: Stationary	18.1	15.2	L1,T1
1A4ai	Commercial/institutional: Stationary	16.3	11.6	L1,T1
1A3biii	Road transport: Heavy duty vehicles and buses	2.5	21.8	L1,T1
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	17.7	6.6	L1,T1
1A3bvi	Road transport: Automobile tyre and brake wear	11.1	7.3	L1,T1
1A3bi	Road transport: Passenger cars		10.3	T1
3B1a	Manure management - Dairy cattle	7.2		L1
1A1a	Public electricity and heat production		5.7	T1
1A3bii	Road transport: Light duty vehicles		4.5	T1
2l	Wood processing	4.2		L1
1A3bvii	Road transport: Automobile road abrasion	3.8		L1

1.6 QA/QC and verification methods

To be able to fulfil the obligations set out in the United Nations Framework Convention on Climate Change (UNFCCC), Liechtenstein has developed a QA/QC plan. Even though this plan is focused on Greenhouse Gas (GHG) emissions, the main part of the assessment criteria can also be applied for air pollutants.

1.7 General uncertainty evaluation

For the Liechtenstein's emission inventory pollutants, no quantitative uncertainty assessment has been made.

1.8 General assessment of completeness

The emission inventory covers all relevant sources which determine emissions to the atmosphere in Liechtenstein. It is not always possible to specify all subsectors in detail. Therefore, considering the above-mentioned facts, the listed notation keys are used in the emission tables (NFR).

Table 1.8-1: Description of the Notation keys used in the national inventory

Notation Key	UNECE/EMEP explanation
Not estimated (NE)	Emissions occur but have not been estimated or reported.
Included elsewhere (IE)	Emissions for this source are estimated and included in the inventory, but not presented separately for this source. The source where these emissions are included should be indicated.
Not applicable (NA)	The source exists, but relevant emissions are considered to never occur.
Not occurring (NO)	A source or process does not exist within a country.

Table 8.2-1 in Annex 1 displays the Notation keys of all reported pollutants.

1.8.1 Explanation of POP emissions

Liechtenstein signed (May 22nd, 2001) and ratified (December 3rd, 2004) the Stockholm Convention on Persistent Organic Pollutants (POP's) and elaborated the National Implementation Plan (NIP) to address the country's future compliance with the Convention's requirements. According to the NIP, Liechtenstein does not have any heavy and just an inconsiderable chemical industry. All waste produced in Liechtenstein is disposed in Switzerland. Thus, Liechtenstein does not have any waste incineration plant. None of the mentioned substances in the Convention have ever been produced in Liechtenstein. Furthermore, there is no intention to produce, import, export or use any of these substances in the future.

There is a small possibility to find unintentionally produced POPs. The illegal disposal or burning of waste in private or industrial combustions is controlled regularly. Therefore, the amount of unintentionally produced POPs can be qualified as marginal.

Regarding the elimination of POPs of the Stockholm Convention (SC), Liechtenstein is already in a highly advanced stage. To eliminate sources of unintentionally produced POPs, any effort to reduce other persistent, bioaccumulative and toxic substances (PBTs), is endeavoured.

1.8.2 General legislative framework

The relevant provisions are found in the individual sectoral policies. The Environmental protection act (LR 814.01) incorporates the Act on Waste, the Act on Soil Protection and the Act on Air Pollution Control and overruled them. Furthermore, it addresses the issue of contaminated sites and their remediation. EU Regulation (EC) No. 850/2004 on persistent organic pollutants (POP) has been incorporated into the EEA Agreement and therefore applicable as a national law in Liechtenstein.

Liechtenstein has implemented series of laws and ordinances covering the issue of POPs:

Name of Legislation	Number
Air Pollution Control Ordinance of September 30 th 2008	LR 814.301.1
Ordinance of September 6 th , 2016 on the Major Incidents Act	LR 522.1
Act of October 5 th , 2014 on the environmental impact assessment	LR 814.03
Ordinance of December 16 th , 2008 on Inherited Waste	LR 814.011.2
Act of December 16 th , 2009 on Incentive Taxes on Volatile Organic Compounds	LR 814.061
Ordinance of January 26 th , 2010 on Incentive Taxes on Volatile Organic Compounds	LR 814.061.1

Regarding volatile organic compounds (VOC) Liechtenstein has implemented a Law on the VOC levy in 2010 [LGBI 2010 Nr. 15] and a corresponding ordinance [LGBI 2010 Nr. 20].

Air pollution threshold values are also largely identical with those of Switzerland. In some areas, however, they have been adapted to the threshold values provided by relevant EU directives (pursuant to the EEA Agreement).

The following table - taken and updated from NIP Liechtenstein (2007) - shall strictly concentrate upon agreements or ordinances directly or indirectly mentioning persistent organic pollutants or the actual list of POPs and reflects only the Swiss legislation, which is applicable in Liechtenstein. Due to the customs treaty with Switzerland, the Swiss legislation is applicable in Liechtenstein. For further details, see the Swiss NIP chapter 2.2.4.

Table 1.8-2: Swiss law on POPs applicable in Liechtenstein

Name of Legislation	Number
Chemicals Ordinance	ChemO (SR 813.11)
Ordinance on the Reduction of Risks relating to the Use of Certain Particularly Dangerous Substances, Preparations and Articles	ORRChem (SR 814.81)
Ordinance on Biocidal Products	OBP (SR 813.12)
Ordinance on Plant Protection Products	OPPP (SR 916.161)
Ordinance on Waste	VVEA (SR 814.600)
Ordinance on Movements of Waste	OMW (SR 814.610)
Ordinance on the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Chemicals in International Trade	ChemPICO (SR 814.82)

2 Explanation of key trends

2.1 National total emission trends

For each year, Liechtenstein's total emissions per pollutant are summarized in Table 2.1-1. The absolute difference as well as the relative differences are calculated between 2019 and the base year. For all pollutants, the base year is 1990 as it is the base year for the Kyoto protocol. In addition, the data from 1985 to 1989 have a high uncertainty level.

Table 2.1-1: Total emissions and absolute and relative differences for the time series 1985-2019

Pollutant	Unit	1985	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	Absolute diff. 2019 to Base 1990	Relative diff. 2019 to Base 1990
NO _x	t	687	619	575	541	498	397	335	308	288	273	255	-364	-59%
CO	t	2136	1536	937	742	591	596	541	518	492	522	490	-1046	-68%
NM VOC	t	1506	1294	820	560	377	341	305	298	294	289	291	-1003	-78%
SO _x	t	169	117	72	45	34	20	9	8	7	7	7	-110	-94%
NH ₃	t	272	255	246	220	220	223	214	214	208	210	216	-39	-15%
TSP	t	106	96	85	75	62	62	58	56	55	57	55	-41	-42%
PM10	t	73	68	63	59	49	48	44	42	41	43	41	-27	-40%
PM2.5	t	51	47	42	41	33	32	29	27	26	28	26	-21	-45%
Dioxin	mg	137	124	97	67	60	93	91	86	79	90	81	-42	-34%
ICDP	kg	3	3	2	4	3	4	3	3	3	3	3	0	-12%
BKF	kg	2	2	1	3	2	4	3	3	3	3	3	1	46%
BBF	kg	5	5	4	7	5	7	5	5	4	5	5	-1	-11%
BAP	kg	5	5	4	7	6	7	5	5	4	5	4	-1	-18%
PAH 1 - 4	kg	16	16	11	21	16	22	16	15	14	16	15	-1	-7%
Pb	kg	1031	649	265	35	29	25	25	23	22	23	25	-624	-96%
Cd	kg	2	2	1	2	2	3	4	4	3	4	4	2	128%
Hg	kg	0.6	0.6	0.6	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	-0.3	-52%
HCB	g	0.5	0.5	0.4	0.6	0.6	0.8	0.8	0.8	0.7	0.8	0.7	0.2	49%

The main pollutant emissions show a downward trend between 1985 and 2019. This is mainly a result of great emission reduction efforts made in industrial and transport sectors as well as the changeover to less polluting fuels.

The HCB and Cd as well as the Benzo(k)fluoranthene emissions are above the level of 1990 (see Figure 2.1-1 to Figure 2.1-3). The only relevant reason is the mentioned increase of wood combustion in source categories 1A4ai Commercial/institutional: Stationary and 1A4bi Residential: Stationary (see Figure 2.1-4).

Figure 2.1-1: Cd-Emissions from 1985 to 2019

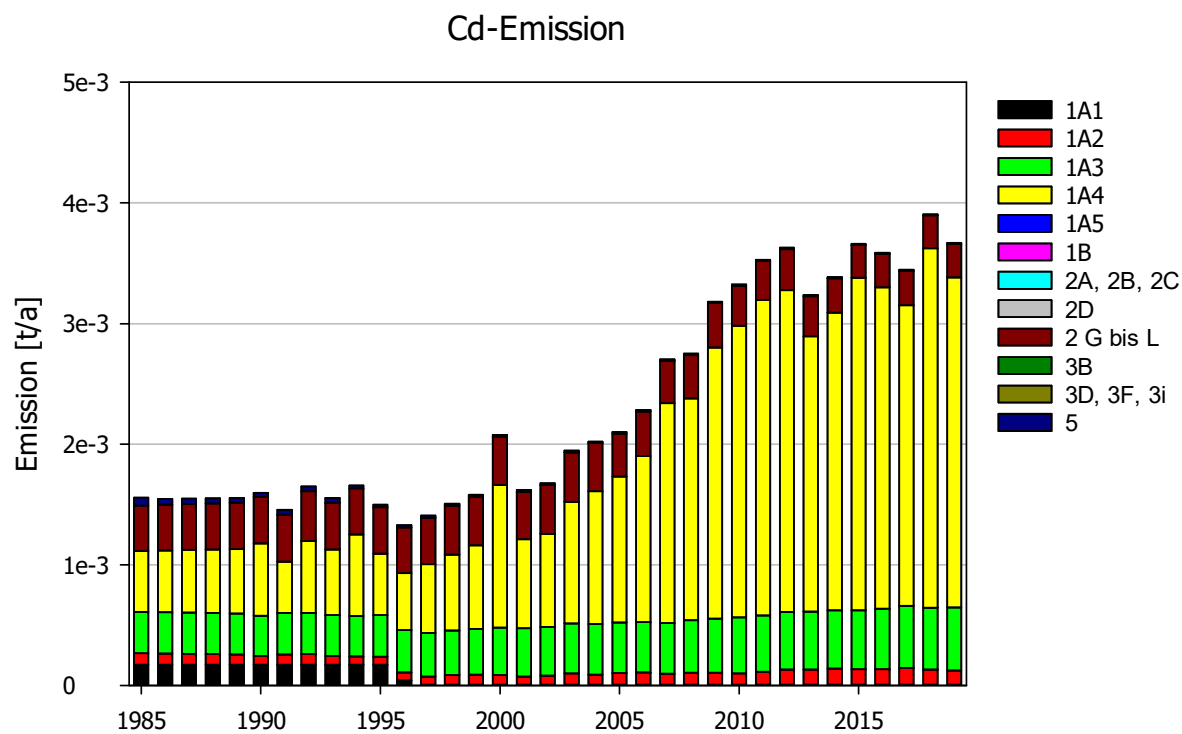


Figure 2.1-2: HCB-Emissions from 1985 to 2019

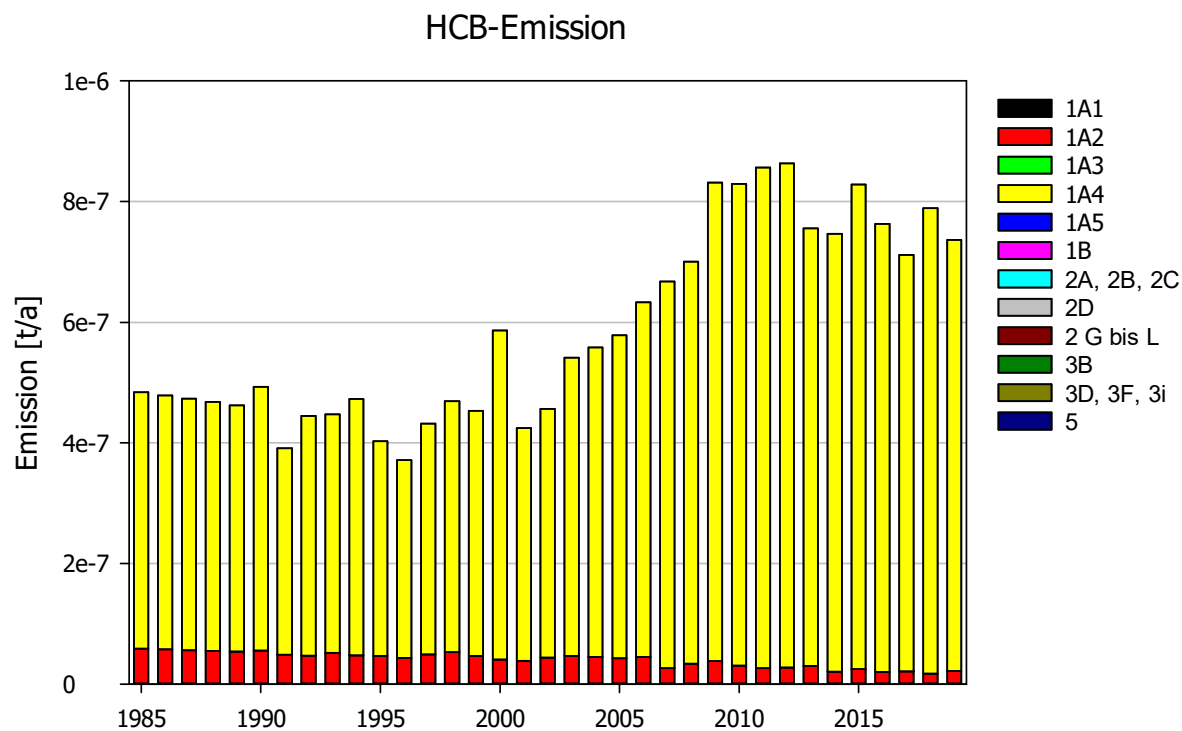


Figure 2.1-3: Benzo(k)fluoranthene-Emissions from 1985 to 2019

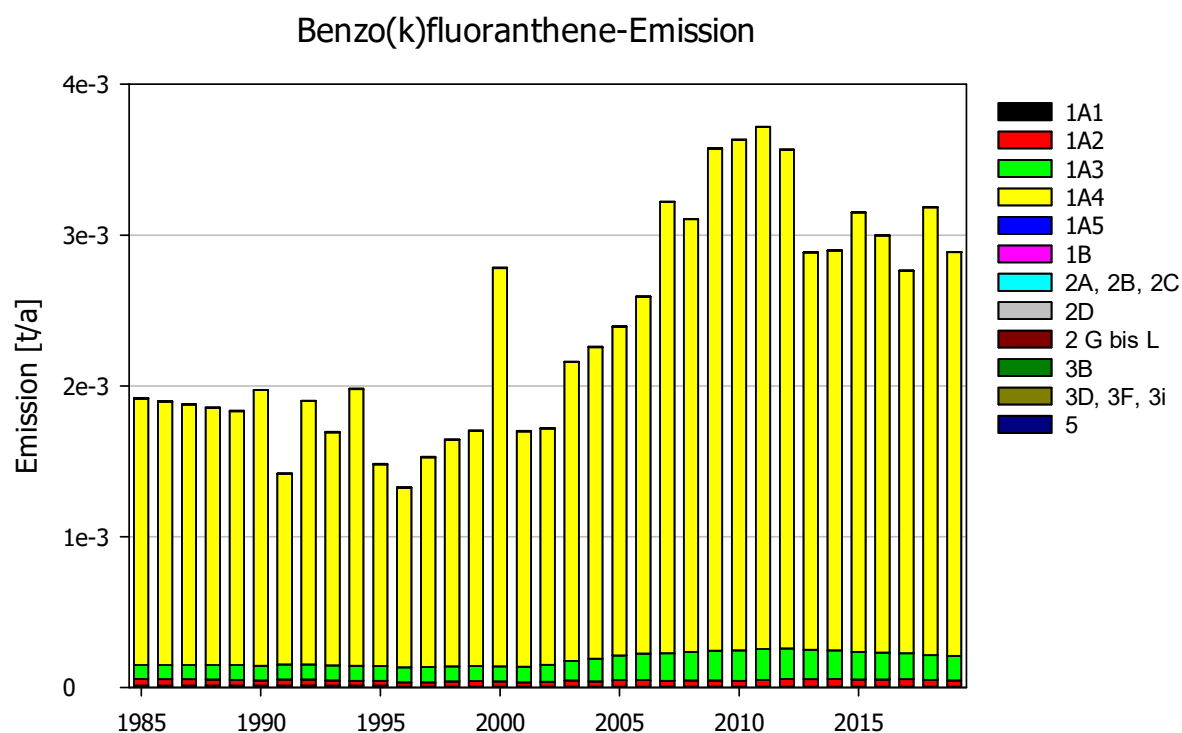


Figure 2.1-4: Wood as fuel from 1985 to 2019

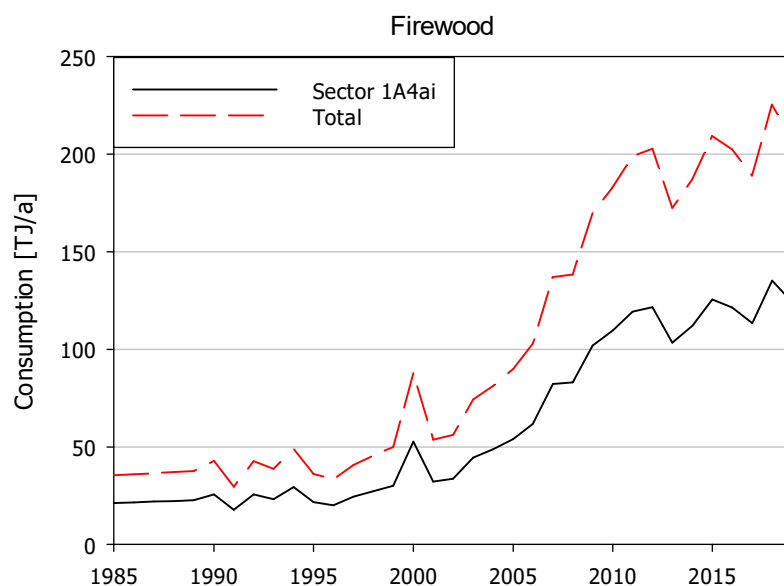


Table 2.1-1 displays the trends of the national total emissions per pollutant group. The reasons for the changes in the time series are given in the next paragraphs.

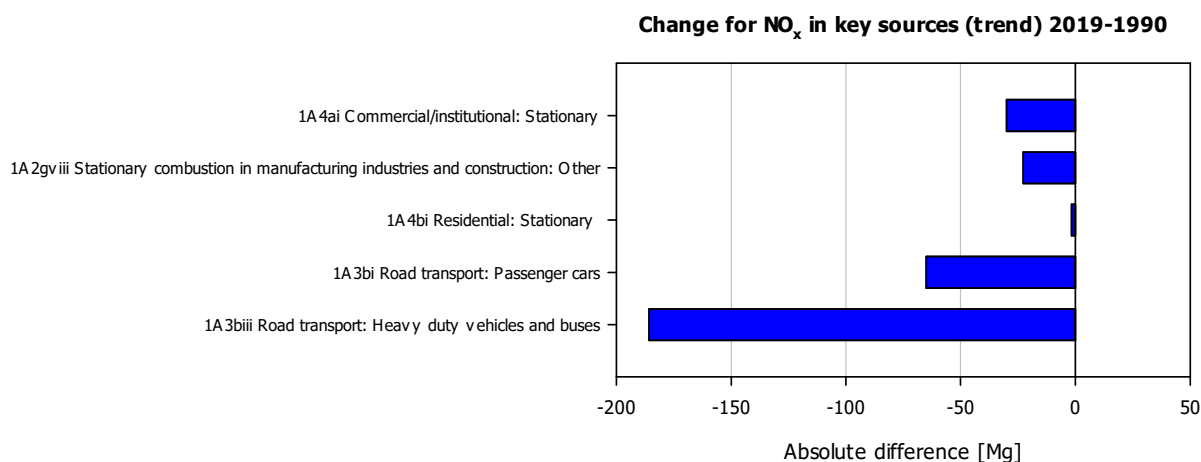
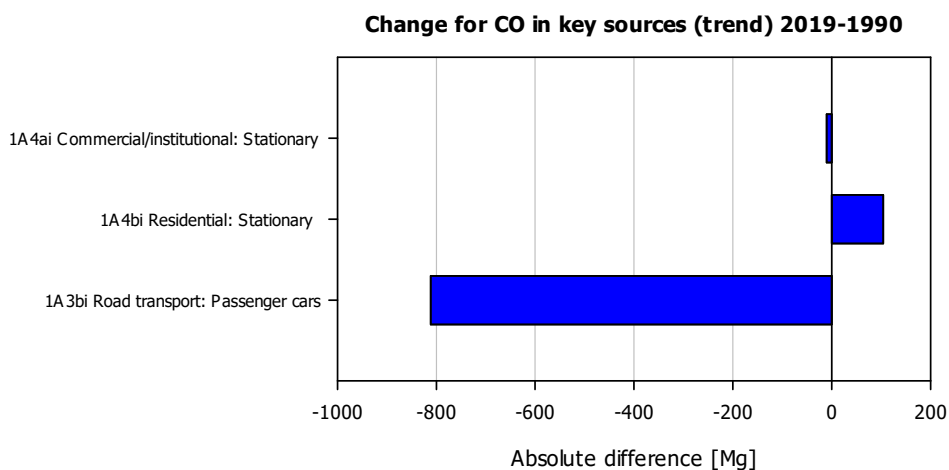
Figure 2.1-5: Change (Trend) for NO₂ in key sources from 1990 to 2019

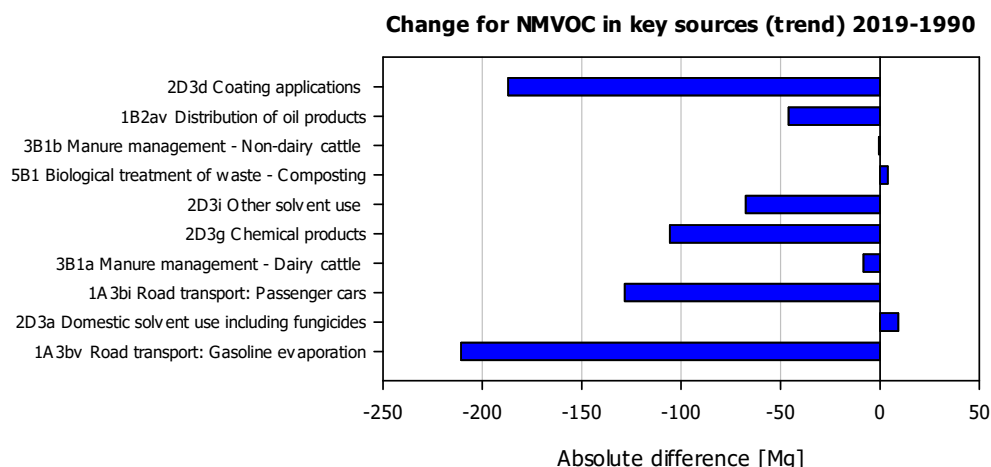
Figure 2.1-5 shows the absolute differences of key sources (trend) for NO_x between 1990 and 2019. The greatest difference occurred in source category 1A3biii Road transport: Heavy duty vehicles and buses. In this category, the NO_x emissions decreased by 180 Mg. Regarding the source categories 1A4ai, 1A2gviii, 1A4bi and 1A3bi, decreases between 2 Mg and 65 Mg were calculated.

Figure 2.1-6: Change (Trend) for CO in key sources from 1990 to 2019

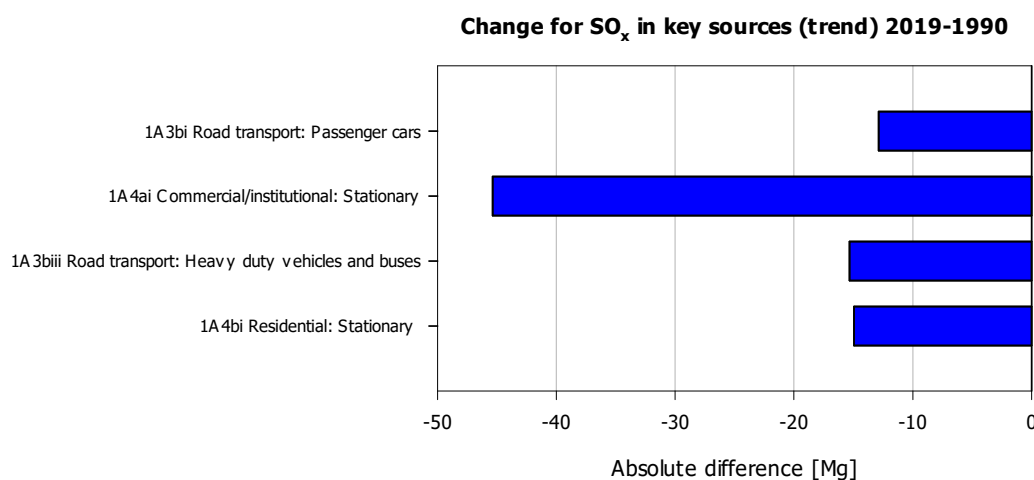


The change of carbon monoxide in the key source (trend) 1A3b Road transport is of great importance (see IIR 2013). A reduction of more than 800 Mg was achieved in sub-category 1A3bi passenger cars. In source category 1A4ai Commercial/institutional: stationary the CO emissions also decreased (-10 Mg). In contrast, higher CO emissions in the key source 1A4bi Residential: Stationary can be observed (+100 Mg).

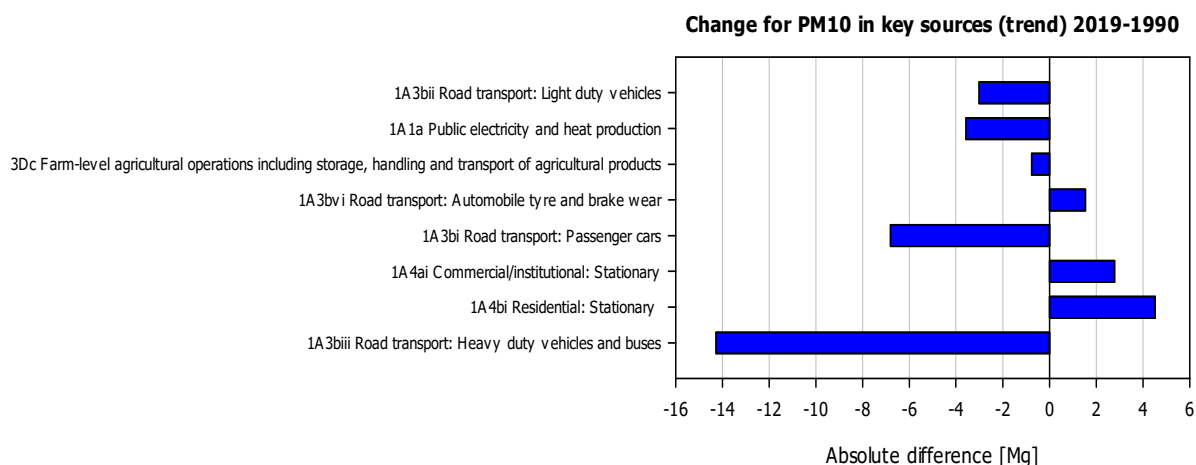
Figure 2.1-7: Change (Trend) for NMVOC in key sources from 1990 to 2019



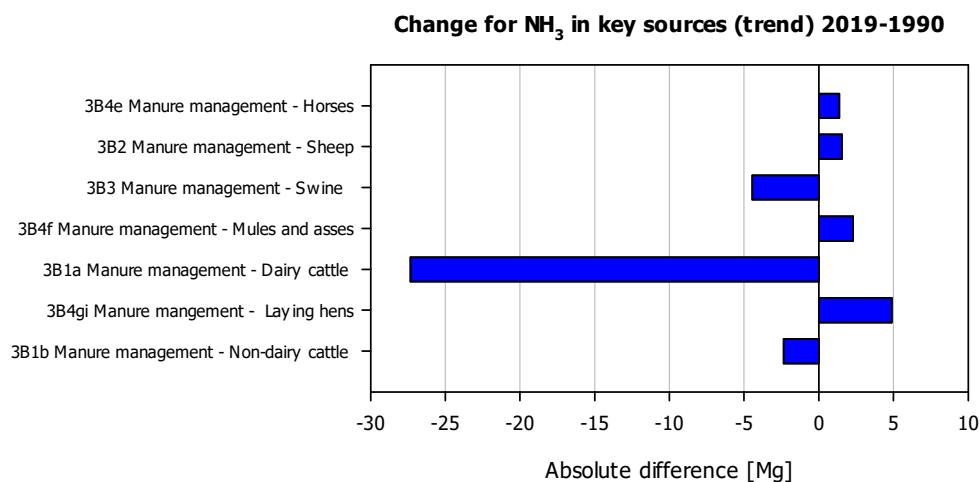
Regarding NMVOC, emissions from key sources (trend) decrease in categories 2D3d, 1B2av, 3B1b, 2D3i, 2D3g, 3B1a, 1A3bi and 1A3bv. An increase can be observed in key sources 5B1 and 2D3a.

Figure 2.1-8: Change (Trend) for SO_x in key sources from 1990 to 2019

Key sources (trend) concerning SO_x emissions are road transportation (1A3bi & 1A3biii) and small combustions (1A4ai & 1A4bi). Emissions decreased in all these categories between 13 and 45 Mg. One of the main reasons for this is the reduced sulphur content in fuels and heating oil.

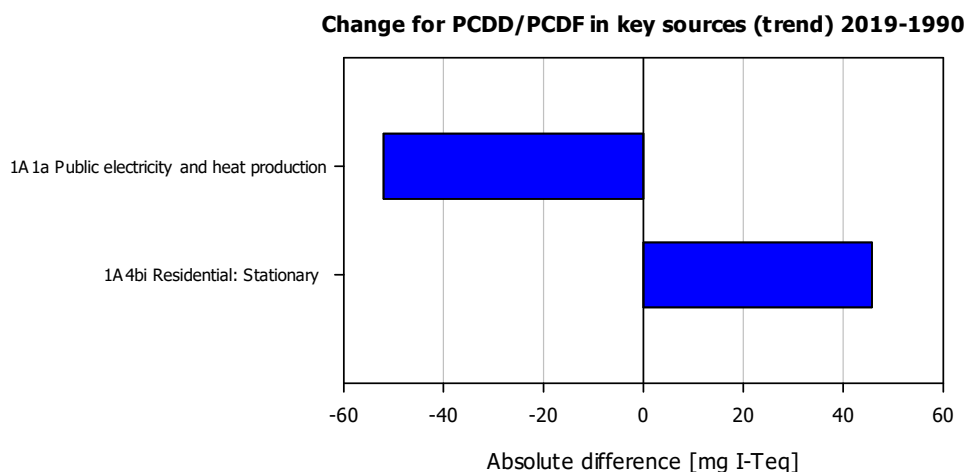
Figure 2.1-9: Change (Trend) for PM₁₀ in key sources from 1990 to 2019

While the PM₁₀ emissions decreased in key sources (trend) 1A1a, 1A3bi – biii and 3Dc (in total almost 30 Mg), an increase in source categories 1A3bvi, 1A4ai and 1A4bi (in total about 9 Mg) can be observed.

Figure 2.1-10: Change (Trend) for NH₃ in key sources from 1990 to 2019

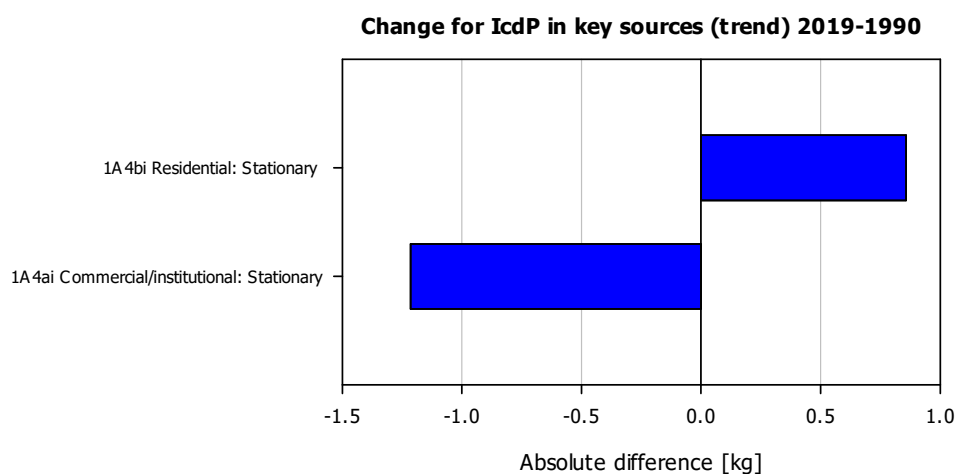
All key sources (trend) of NH₃ emissions stem from manure management. NH₃ emissions from 1990 to 2019 show an increase in source categories 3B2 and 3B4e-gi. In categories 3B1a, 3B1b and 3B2 the Emissions decreased.

Figure 2.1-11: Change (Trend) for PCDD/PCDF in key sources from 1990 to 2019



The trend 2019 – 1990 shows a decrease in key category (trend) 1A1a Public electricity and heat production (about 50 mg I-Teq) and an increase in key category 1A4bi Residential: Stationary (about 45 mg I-Teq).

Figure 2.1-12: Change (Trend) for IcdP in key sources from 1990 to 2019



The emissions of IcdP from 1990 to 2019 show the following trend: there is an increase of about 1 kg in the key source (trend) 1A4bi Residential: Stationary. In source category 1A4ai Commercial/institutional: Stationary, a decrease of more than 1 kg is reported.

Figure 2.1-13: Change (Trend) for BkF in key sources from 1990 to 2019

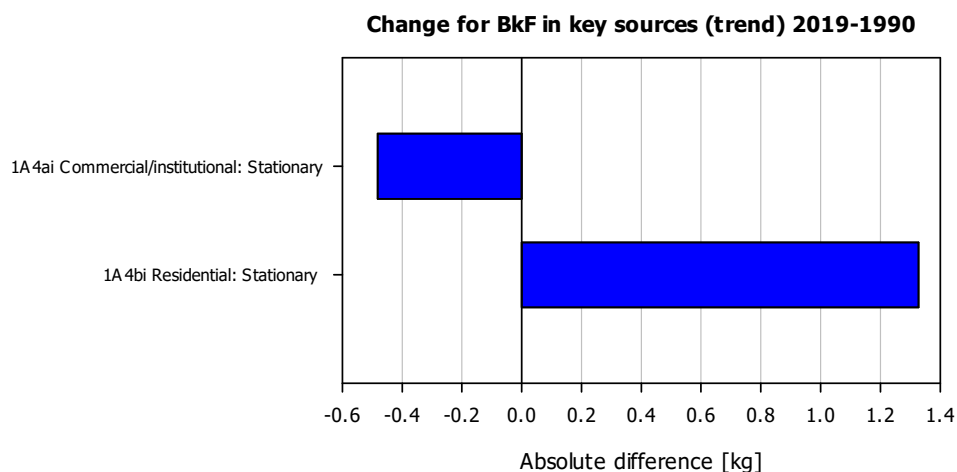
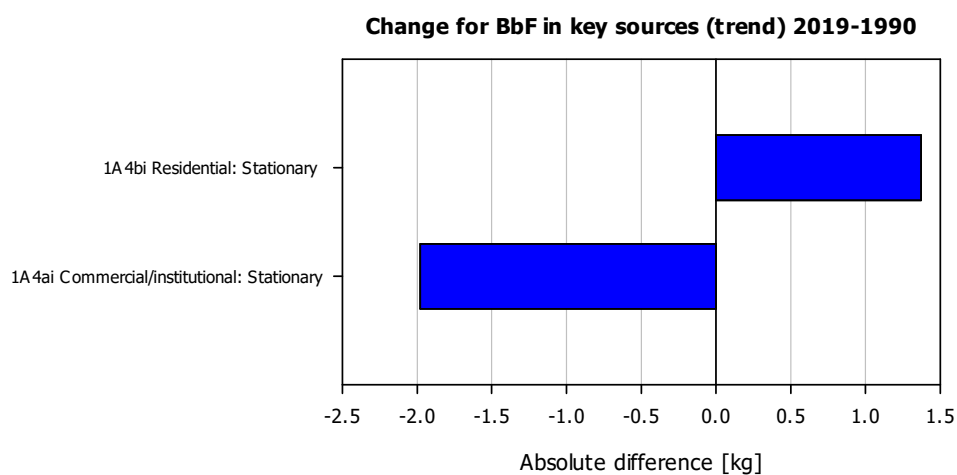
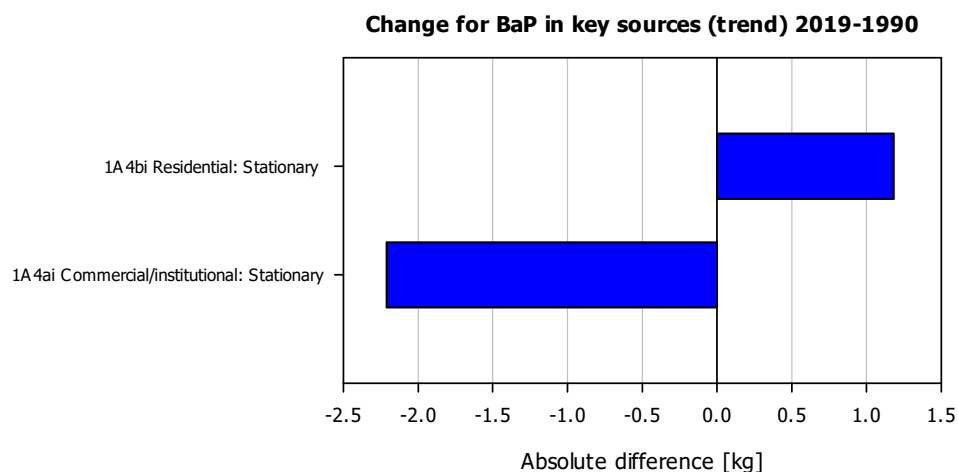


Figure 2.1-14: Change (Trend) for BbF in key sources from 1990 to 2019



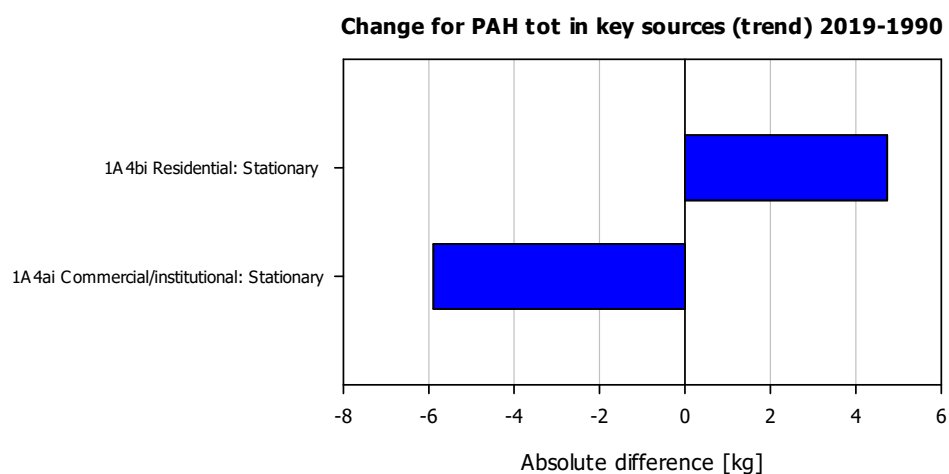
Like for IcdP, there is a decrease of the emissions of BkF (about 0.5 kg) and BbF (about 2 kg) from 1990 to 2019 in source category 1A4ai and an increase in category 1A4bi Residential: Stationary.

Figure 2.1-15: Change (Trend) for BaP in key sources from 1990 to 2019



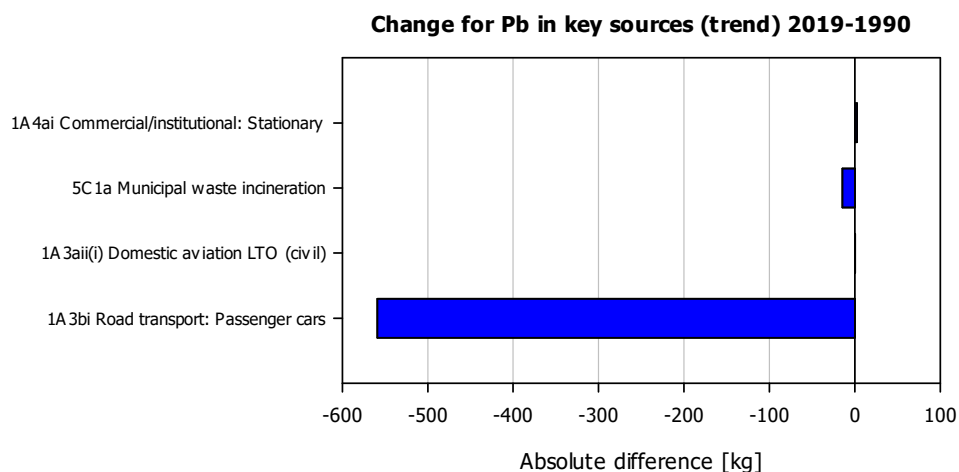
BaP emissions decreased from 1990 to 2019 in source category 1A4ai Commercial/institutional: Stationary (about 2 kg) and increased in 1A4bi Residential: Stationary (about 1 kg).

Figure 2.1-16: Change (Trend) for PAHs in key sources from 1990 to 2019



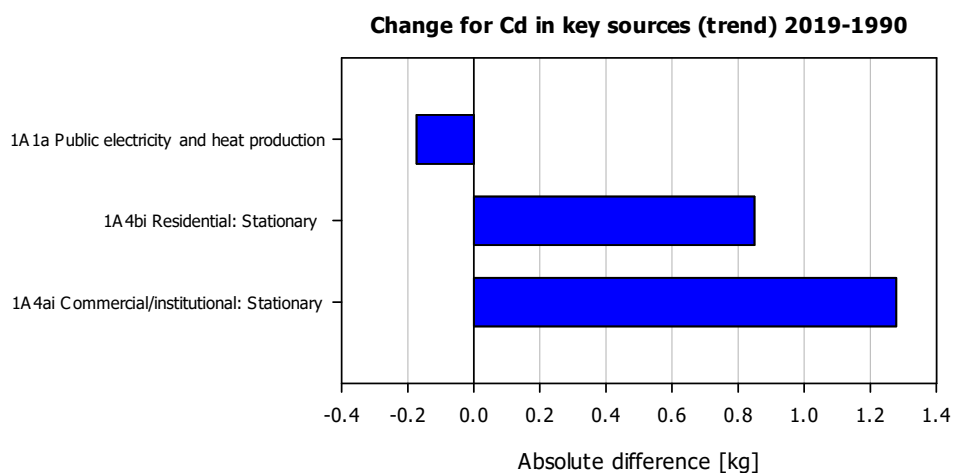
The sum of the PAH-emissions increased in source category 1A4bi Residential: Stationary (about 5 kg) from 1990 to 2019 and decreased in source category 1A4ai Commercial/institutional: Stationary (about 6 kg).

Figure 2.1-17: Change (Trend) for lead in key sources from 1990 to 2019



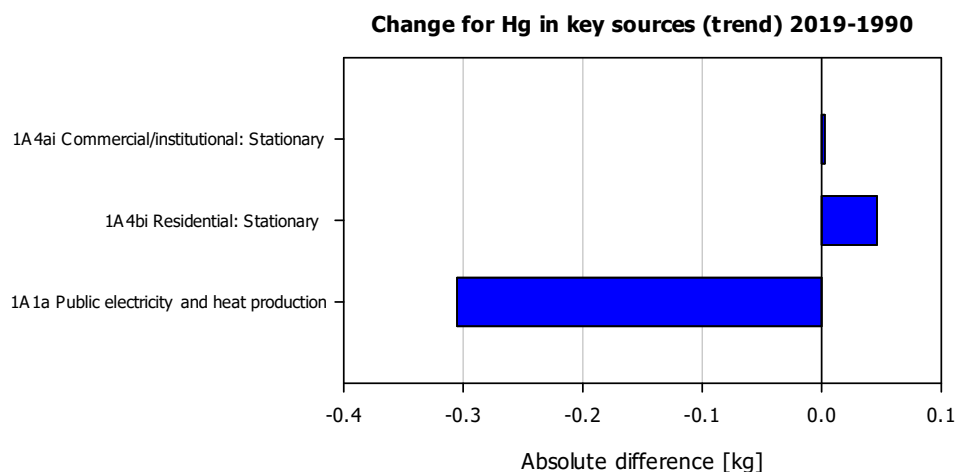
The change for Pb emissions shows a marginal increase of a few kg (absolute difference) in source categories 1A4ai Commercial/institutional: Stationary and 1A3aii(i). In the source category 5C1a Municipal waste incineration and particularly in category 1A3bi Road transport: Passenger cars lead emissions decreased significantly.

Figure 2.1-18: Change (Trend) for cadmium in key sources from 1990 to 2019



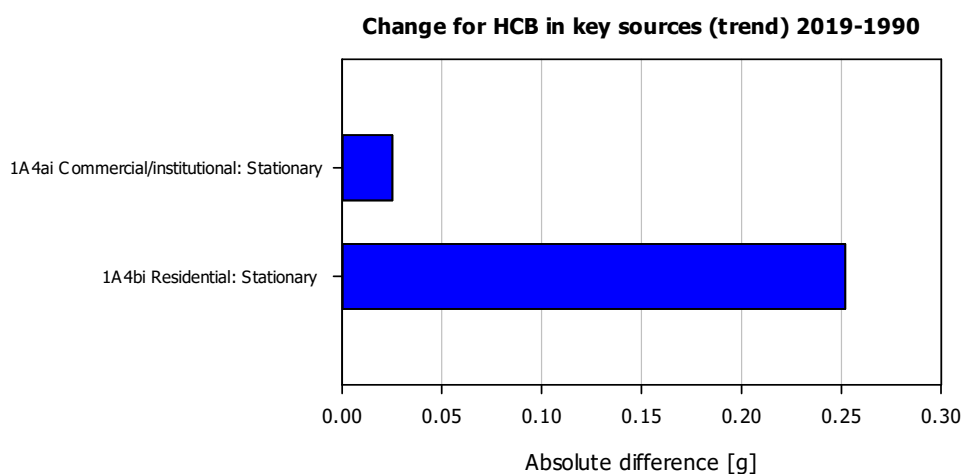
Regarding Cd emissions, increasing emissions can be observed in key sources (trend) 1A4ai Commercial/institutional: Stationary and 1A4bi Residential: Stationary. In key source 1A1a Public electricity and heat production, Cd emissions decreased between 1990 and 2019.

Figure 2.1-19: Change (Trend) for mercury in key sources from 1990 to 2019



The Hg emissions show an increase in key sources (trend) 1A4ai Commercial/institutional: Stationary and 1A4bi Residential: Stationary. In key source 1A1a Public electricity and heat production, mercury emissions decreased.

Figure 2.1-20: Change (Trend) for HCB in key sources from 1990 to 2019



In the key sources (trend) 1A4ai Commercial/institutional: Stationary and 1A4bi Residential: Stationary, HCB emissions increased slightly (less than 0.1 g and 0.3 g, respectively).

3 Energy (NFR Sector 1)

The energy sector is the major contributing part in Liechtenstein's national emission inventory. In the year 2019, almost 100 % of the national CO, SO₂ and NO_x emissions and about 60% of PM10 emissions arise in this sector. The emission data from this sector are mainly based on fuel input and emission factors according to the following formula:

$$E = Fc * Ef$$

E = Emission [g/year]

Fc = Fuel consumption [GJ/year]

Ef = Emission factor [g/GJ]

3.1 Energy industries (1A1)

At present, energy industries (source category 1A1) consist solely of natural gas and biogas fuelled public co-generation units in public electricity and heat production in 1A1a. This source category is a key category (trend) for PM10.

Petroleum refining (1A1b), production of solid fuels and other energy industries (1A1c) do not occur in Liechtenstein.

3.2 Manufacturing industries and construction (1A2)

Iron and steel, nonferrous metals industry, chemicals as well as pulp and paper production do not occur in Liechtenstein. All emissions related to manufacturing industries and construction are reported under 1A2f and 1A2g. The source category 1A2gviii Stationary combustion in manufacturing industries and construction is a key category (trend) for NO₂ and a key category (level) for SO₂.

3.3 Transport (1A3)

3.3.1 Aviation (1A3a)

In Liechtenstein, emissions occur only from source category 1A3ii(i) Domestic aviation LTO (one helicopter-base).

This source category is not a key category.

3.3.2 Exhaust emissions from road transport (1A3bi-vii)

Exhaust emissions of all pollutants in these source categories are dependent on fuel type, emission reduction technology, vehicle type and vehicle use. These emissions are calculated on the basis of traffic performance (vehicle kilometres) and specific emission factors for a variety of different vehicle classes and for three different road types. The emission factors are adopted from Switzerland [HBEFA 2019].

Category 1A3bi is a key source for NO₂, CO (level and trend) as well as for NMVOC, SO_x and PM10 (trend). Light duty vehicles (1A3bii) are key sources for NO₂, CO (level) and PM10 (trend). 1A3biii (heavy duty vehicles and buses) is a key category for NO₂, PM10 (level and

trend) and SO_x (trend). Gasoline evaporation (1A3bv) is a key category (trend) for NMVOC emissions. Regarding PM10 emissions, the categories 1A3bvi (level and trend) and 1A3bvii (level) are key categories besides the key categories 1A3bi-biii,

In the following Table 3.3-1, main pollutants (level) and PM10 are imaged (% of national total in 2019):

Table 3.3-1: Category 1A3bi to 1A3bvii in % of national total in 1990 and 2019

Pollutant	Level	
	1990	2019
NO _x	71 %	67 %
CO	84 %	37 %
PM10	44 %	20 %

3.3.3 Railways (1A3c)

There is a railway line crossing the country on which Austrian and Swiss trains run. Liechtenstein has no own railway. The railway line is owned and maintained by the Austrian Federal Railway. The Liechtenstein's part of the line is fully electrified.

This source category is not a key category.

3.3.4 Navigation (shipping) (1A3d)

Navigation does not occur in Liechtenstein, because there are no lakes, and the river Rhine is not navigable within Liechtenstein. Therefore, no emissions occur from this source category.

3.4 Other sectors (1A4)

3.4.1 Commercial/institutional and residential (1A4ai, 1A4aii, 1A4bi and 1A4bii)

1A4ai Commercial/institutional: Stationary is a key source (level and trend) of PM10, NO₂, CO and SO₂, and besides, the main source of SO₂ emissions in Liechtenstein. Category 1A4bi Residential: Stationary is a key source of NO₂, SO₂, CO, PM10 (level and trend) and NMVOC emissions (level). Furthermore, it is the main source of CO emissions since 2006.

A top-down method based on aggregated fuel consumption data from the energy statistics is applied to calculate emissions. The share of activity from 1A4ai and 1A4bi was estimated based on the national database "FEUKO" which includes a variety of information about combustion plants (oil and gas) in Liechtenstein. Furthermore, information from the national gas distributor were used. These sources are characterised by rather similar combustion processes. Therefore, similar emission factors are assumed for 1A4ai and 1A4bi. Emissions are calculated by multiplying levels of activity by emission factors from EMIS (2020).

The emission factors for TSP, NO_x, NMVOC, SO₂, NH₃ and CO from wood combustion are based on a country-specific (Switzerland) emission factor model for combustion processes [Nussbaumer & Hälg 2015]. The share of PM10 and PM2.5 on TSP rest on EMEP/EEA (2013). For wood combustion emission calculation, combustion units and combustion performance as well as firewood types (e.g., pellet, log wood) were considered.

The mentioned swiss emission factors were chosen because of the similar environmental legislation and legislation enforcement in Switzerland and Liechtenstein as well as the high

technical standards of combustion plants. An oxidation factor of 100% is assumed for all combustion processes and fuels. Table 3.4-1 presents the emission factors used in 1A4ai and 1A4bi. The activity data of main fuels used in these sources are imaged in Table 3.4-2.

The PM₁₀, PM_{2.5} and TSP emission calculation from source categories 1A4aii and 1A4bii was carried out with tier 1 emission factors from EMEP/CORINAIR 2019 and activity data (fuel consumption per capita and population numbers) from EMIS 2020 and OS 2020. The emission calculations of other pollutants from 1A4aii commercial/institutional: mobile and 1A4bii residential: household and gardening (mobile) are based on multiplication of emissions per capita from EMIS 2020 with the numbers of inhabitants from population statistics [OS 2020].

Table 3.4-1: Emission factors [g/GJ] for main fuels and pollutants used to calculate combustion emissions from the key source categories 1A4ai commercial/institutional and 1A4bi residential

Fuel	Pollutant	1A4ai		1A4bi	
		1990	2019	1990	2019
Natural gas	NO _x	65.0	16.3	60.0	15.3
	CO	35.0	9.2	50.0	12.2
	NM VOC	2.0	2.0	4.0	4.0
	SO ₂	0.5	0.5	0.5	0.5
	TSP	0.2	0.1	0.2	0.1
	PM ₁₀	0.2	0.1	0.2	0.1
Fuel oil	NO _x	60.0	32.4	60.0	33.5
	CO	20.0	6.1	20.0	11.2
	NM VOC	8.0	6	8.0	6
	SO ₂	64.0	7.4	64.0	7.4
	TSP	0.3	0.2	0.3	0.2
	PM ₁₀	0.3	0.2	0.3	0.2
Wood	NO _x	149.5	141.6	85.0	85.0
	CO	1825.0	437.0	3875.0	2107.9
	NM VOC	38.3	8.7	111.8	61.7
	SO ₂	10.0	10.0	10.0	10.0
	TSP	147.5	55.4	165.0	93.4
	PM ₁₀	140.6	53.0	157.2	88.8

Table 3.4-2: Activity data [GJ] for main fuels used to calculate combustion emissions from the key categories 1A4ai commercial/institutional and 1A4bi residential

Fuel	1A4ai		1A4bi	
	1990	2019	1990	2019
Natural gas	140'840	140'775	41'225	462'198
Fuel oil	758'398	294'697	252'799	98'232
Wood	25'749	124'165	17'166	82'777

3.4.2 Agriculture/forestry/fishing (1A4cii)

Emissions are calculated by multiplying levels of activity with emission factors from EMIS (2020). The activity data is derived from information provided by the OE.

Table 3.4-3: Emission factors [g/kg diesel] for the main pollutants (used to calculate combustion emissions from the source category agriculture/forestry/fishing)

Pollutant	1990	2019
NO _x	42.3	17.1
CO	30.2	9.9
NM VOC	6.1	2.0
SO _x	2.8	0.02
NH ₃	0.01	0.01
TSP	4.2	1.5
PM10	4.2	1.5
PM2.5	4.2	1.5

This source category is not a key category.

3.4.3 Other (1A5)

Emissions from source category 1A5a Other stationary (including military) and 1A5b Other, mobile (including military, land based and recreational boats) do not occur in Liechtenstein.

3.4.4 Fugitive emissions from fuels (1B)

In source category 1B, emissions occur only in sub-categories 1B2av Distribution of oil products and 1B2b Fugitive emissions from natural gas.

In source category 1B2av, the emissions caused by filling of gasoline powered cars at the petrol stations are reported.

1B2av is a key category (trend) for NM VOC emissions.

4 Industrial processes and product use (NFR Sector 2)

Only few source categories occur among the industrial processes sector in Liechtenstein. Sources in the categories 2A, 2B, 2C and 2J-2L do not occur at all. Emissions are reported from categories 2D3, 2G Other product use, 2H2 Food and beverages industry and 2I Wood processing.

4.1 Solvent and product use (2D)

Emissions within this source category comprise NMVOC emissions from solvent use and the use of other related compounds.

4.1.1 Domestic solvent use including fungicides, road paving with asphalt and asphalt roofing (2D3a-c)

Source category 2D3a-c comprises NMVOC emissions from domestic solvent use including fungicides, road paving with asphalt and asphalt roofing. Data availability is limited. To establish estimates of emissions for Liechtenstein, the emissions are calculated with emission factors per capita from EMIS 2020. The number of inhabitants in Liechtenstein is taken from population statistics [OS 2020].

Regarding NMVOC, the source category 2D3a is a key category (level and trend) and the main source for NMVOC in Liechtenstein (in 2019: 17 %).

4.1.2 Coating applications (2D3d)

Source category 2D3d Coating applications comprises NMVOC emissions from paints, lacquers, thinners and related materials used in coatings in industrial, commercial and household applications. Data availability is limited. To establish estimates of emissions for Liechtenstein, the emissions are calculated with emission factors per capita from EMIS 2020. The number of inhabitants in Liechtenstein is taken from population statistics [OS 2020].

Source category 2D3d is a key category in level and trend. Furthermore, this source account for the second largest proportion of NMVOC emissions in Liechtenstein (in 2019: 15 %).

4.1.3 Degreasing and dry cleaning (2D3e und 2D3f)

Source categories 2D3e Degreasing and 2D3f Dry cleaning comprises NMVOC emissions from degreasing, dry cleaning and cleaning in electronic industry. Data availability is limited. To establish estimates of emissions for Liechtenstein, the emissions are calculated with emission factors per capita from EMIS 2020. The number of inhabitants in Liechtenstein is taken from population statistics [OS 2020].

Source category 2D3e is a key category (level) for NMVOC.

4.1.4 Chemical products (2D3g)

Source category 2D3g Chemical products, manufacture and processing comprise NMVOC emissions from manufacturing and processing chemical products. Data availability is limited. In order to establish estimates of emissions for Liechtenstein, the emissions are calculated with emission factors per capita from EMIS 2020. The number of inhabitants in Liechtenstein

is taken from population statistics [OS 2020]. The portion from this category for NMVOC in Liechtenstein in 2019 is 5 %.

The source category 2D3g is a key category (level and trend) for NMVOC.

4.1.5 Printing (2D3h)

Source category 2D3h comprises NMVOC emissions from printing. Data availability is limited. In order to establish estimates of emissions for Liechtenstein, the emissions from printing are calculated with emission factors per capita from EMIS 2020. The number of inhabitants in Liechtenstein is taken from population statistics [OS 2020].

This source category is a key category (level) for NMVOC.

4.1.6 Other solvent use (2D3i)

Source category 2D3i Other solvent use comprises emissions from many different solvent applications.

In order to establish estimates of emissions for Liechtenstein, the emissions are calculated with emission factors per capita from EMIS 2020.

The source category 2D3i is a key category (level & trend) for NMVOC emissions (in 2019: 11 %).

4.2 Other product use (2G)

This source category includes emissions from product use like tobacco, adhesives, wood preservatives, underbody protection for vehicles and lubricants . The emissions are calculated with emission factors per capita from EMIS 2020. The number of inhabitants in Liechtenstein is taken from population statistics [OS 2020].

This source category is not a key category.

4.3 Pulp and paper industry, food and beverages industry (2H)

This source category comprises emissions from pulp and paper industry as well as food and beverages industry. In Liechtenstein, only in emissions from food and beverages industry (2H2) occur (NMVOC, CO and PM). The emissions are calculated with emission factors per capita from EMIS 2020. The number of inhabitants in Liechtenstein is taken from population statistics [OS 2020].

2H2 is a key category (level) for NMVOC emissions.

4.4 Wood processing (2I)

Emissions within this source category comprise emissions from wood processing. The emissions are calculated with emission factors per capita from EMIS 2020. The number of inhabitants in Liechtenstein is taken from population statistics [OS 2020].

2I Wood processing is a key category (level) for PM10.

4.5 Production of POPs, consumption of POPs and heavy metals and other production, consumption, storage, transportation or handling of bulk products (2J-L)

In Liechtenstein, no emissions occur from production of POPs, consumption of POPs and heavy metals and other production, consumption, storage, transportation or handling of bulk products.

5 Agriculture (NFR Sector 3)

The agricultural sector is a major source for ammonia emissions. For agricultural ammonia emissions, two different sources are distinguished: animal manure and synthetic fertilizer.

5.1 Manure management (3B)

Ammonia emissions from animal manure are calculated using the methodology described in EMEP/CORINAIR 2019, thus multiplying the activity data with the corresponding default Tier 1 emission factor. The emission factors used for the estimation of ammonia are presented in Table 5.1-1.

NMVOC and PM10 emissions from category 3B are calculated using emission factors from EMEP/EEA emission inventory Guidebook 2016 and livestock information. The activity data is provided by the OE.

3B1a Manure management – Dairy cattle and 3B1b Manure management – Non-dairy cattle are key categories (trend and level) and the largest sources for NH₃ emissions in Liechtenstein (in 2019: 80 %). 3B3 Manure management - Swine, too, is a key category (level and trend) for NH₃. 3B2 Manure management - Sheep, 3B4e Manure management – Horses, 3B4f Manure management – Mules and asses and 3B4gi Manure management – Laying hens are key sources for NH₃-emissions regarding trend. Furthermore, the source categories 3B1a and 3B1b and 3B3 are key categories (level and trend) for NMVOC. Regarding PM10, the source category 3B1a is a key category in level.

Table 5.1-1: Emission factors used for NH₃ in manure management [kg NH₃/animal and year]

Animal category	EF
Dairy cattle	26.4
Other cattle	15.0
Fattening pigs	6.5
Sows	17.7
Sheep	1.4
Goats	1.4
Horses	15.8
Mules, asses	15.8
Laying hens	0.48
Broilers	0.17
Other poultry	0.35
Swine ¹⁾	2.2 (1990) / 1.8 (2019)

¹⁾ Time series

5.2 Crop production and agricultural soils (3D)

The source category 3D includes NH₃ and NO_x emissions from inorganic N-fertilizers (3Da1), indirect NMVOC emissions from managed soils (3Db) as well as PM10 emissions from farm-level agricultural operations including storage, handling and transport of agricultural products (3Dc).

NH₃ and NO_x emissions from synthetic N-fertilizers (3Da1) are calculated by using the amount of applied nitrogen fertilizers multiplied by the corresponding emission factors from EMIS 2020. The activity data were collected from the agricultural department of the OE.

NM VOC and PM₁₀ emissions from source category 3Db and 3Dc, respectively, are calculated by multiplying the corresponding land area with emission factors from EMIS (2020) and EMEP/CORINAIR 2007. The activity data were collected from the agricultural department of the OE.

Source category 3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products is a key category (level and trend) for PM₁₀.

5.3 Field burning of agricultural wastes, agriculture other (3F, 3I)

Burning of savannas does not occur (NO) in Liechtenstein as this is not an agricultural practice. In addition, no emissions occur in source category 3I Agriculture other.

6 Waste (NFR Sector 5)

6.1 Biological treatment of waste: Solid waste disposal on land (5A)

The source category 5A Biological treatment of waste - Solid waste disposal on land comprises all emissions from solid waste handling on managed landfill sites.

Liechtenstein has historic unmanaged landfills. In the sixties, Liechtenstein stopped the disposal of municipal solid waste on landfill sites. Instead, it has been exported to Switzerland for incineration. This transition was completed in 1974, when the last municipality in the country stopped landfilling.

The landfills were not managed in Liechtenstein, because municipal solid waste (MSW) was disposed by users directly (only on 3 of over 30 landfill sites, a temporary control by landfill staff was executed). No mechanical compacting or levelling of waste was carried out. No collection or treatment of leachate took place which caused environmental pollution. All landfills are less than 5 m deep.

No landfill gas was collected for flaring or energy recovery.

There are no managed waste disposal sites reported in Liechtenstein. Therefore, emissions from the source category 5A do not occur.

6.2 Biological treatment of waste (5B)

The source category 5B Biological treatment of waste contains composting (5B1) and anaerobic digestion at biogas facilities (5B2). In Liechtenstein NH_3 and NMVOC emissions, specifically from central composting plants and backyard composting occur. The emissions are calculated by multiplying emission factors from EMIS 2020 with the bulk of composted organic waste. The activity data is provided by the OE.

The source category 5B1 is a key category (level and trend) for NMVOC emissions.

6.3 Municipal waste incineration (5C1a)

There are no waste incineration plants in Liechtenstein. Since the beginning of 1975, all municipal solid waste from Liechtenstein has been exported to Switzerland for incineration.

Therefore, the source category 5C1a includes only emissions from illegal incineration of gardening and household wastes, as well as of open burning of waste on construction sites.

This source category is not a key category.

6.4 Industrial waste incineration including hazardous waste and sewage sludge (5C1b)

In Liechtenstein, wastewater treatment plants are equipped to collect sewage sludge. The sludge is processed in a digester for biogas production. The biogas is used for co-generation of heat and power on-site. No emissions were calculated.

6.5 Wastewater handling (5D)

The category wastewater handling (5D) contains domestic, industrial and other wastewater handling. In Liechtenstein, only domestic wastewater handling (5D1) occurs. To establish estimates of emissions for Liechtenstein, the emissions are calculated with emission factors per capita from EMIS (2016). The number of inhabitants in Liechtenstein is taken from population statistics [OS 2020].

This source category is not a key category.

7 Other sources (NFR Sector 6)

There are no other or natural emissions reported in Liechtenstein's Informative Inventory Report.

8 Recalculations and improvements

8.1 Recalculations

In the current submission (2021) various recalculations were made. The most relevant are listed below:

- Re-evaluation and adjustment of emission factors of off-road vehicles and other machinery in categories 1A2gvii and 1A4cii
- Adjustment of NH₃ emission factors in sector 3B Manure management
- Adjustment of activity data in category 5B1 Biological treatment of waste – Composting according to GHG-Inventory (time series instead of default value)

8.2 First calculations

In the current submission, the following first calculations were performed:

- Calculation of Dioxin and PAH emissions in category 1A4cii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery

8.3 Planned Improvements

For the next Submission, the following improvements are planned:

- Correction of a formula error in NH₃ emission factor calculation in category 3B3 which led to an underestimation of emissions in this category (lead to a difference of less than 0.1 % of total NH₃ emissions)
- Re-evaluation of activity data and emission factors of wood combustion in categories 1A4ai & 1A4bi
- Re-evaluation of activity data and emission factors in sector 3 Agriculture

Main References (arranged in alphabetical order)

EMEP/CORINAIR 2007: Atmospheric Emissions Inventory Guidebook – 2007, Technical Report No. 30

EMEP/CORINAIR 2016: EMEP/EEA air pollutant emission inventory guidebook – 2016

EMEP/CORINAIR 2019: EMEP/EEA air pollutant emission inventory guidebook – 2019

EMIS 2016: EMIS data base. Internal documents. Federal Office for the Environment, Bern

EMIS 2020: EMIS data base. Internal documents. Federal Office for the Environment, Bern

HBEFA 2019: Handbook Emission Factors for Road Transport; Version 4.1 Federal Office for the Environment, Bern; Umweltbundesamt, Berlin; Umweltbundesamt Wien

LGBI 2010 No. 15: Liechtensteinisches Landesgesetzblatt: Gesetz vom 16. Dezember 2009 über die Lenkungsabgabe auf flüchtigen organischen Verbindungen (VOCG), Vaduz, 1. Februar 2010

LGBI 2010 No. 20: Liechtensteinisches Landesgesetzblatt: Verordnung vom 26. Januar 2010 über die Lenkungsabgabe auf flüchtigen organischen Verbindungen (VOCV), Vaduz, 1. Februar 2010

NUSSBAUMER & HÄLG 2015: Emissionsfaktoren von Holzfeuerungen – Aktualisierung und Ergänzung 2014. Verenum im Auftrag des Bundesamtes für Umwelt (BAFU) 2015

OS 2020: Bevölkerungsstatistik - Vorläufige Ergebnisse 31. Dezember 2019. Version 17.03.2020. Fürstentum Liechtenstein. Office of Statistics, Vaduz 2020

Annex 1

Table 8.3-1: Definition of notation keys for the year 2019

NFR Code	NO _x	NM VOC	SO _x	NH ₃	PM _{2.5}	PM ₁₀	TSP	CO	Pb	Cd	Hg	PCDD/ PCDF	BaP	BbF	BkF	IcdP	PAH 1-4	HCB
1A1a				NO														NO
1A1b	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A1c	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A2a	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A2b	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A2c	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A2d	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A2e	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO
1A2f				NA									NA	NA	NA	NA	NA	NA
1A2gvii									NO		NA							NA
1A2gviii												NA	NA	NA	NA	NA	NA	
1A3ai(i)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A3aii(i)										NA	NA	NA	NA	NA	NA	NA	NA	NA
1A3bi											NA							NA
1A3bii									NA		NA							NA
1A3biii									NO		NA							NA
1A3biv					NA	NA	NA				NA	NO						NA
1A3bv	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A3bvi	NO	NO	NO	NO				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A3bvii	NO	NO	NO	NO				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A3c	NO	NO	NO	NO	NE	NE	NE	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A3di(ii)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A3dii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A3ei	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A3eii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A4ai																		
1A4aii										NA	NA	NA	NA	NA	NA	NA	NA	NA
1A4bi																		
1A4bii										NA	NA	NA	NA	NA	NA	NA	NA	NA
1A4ci	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A4cii									NO		NA							NA
1A4ciii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A5a	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A5b	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1B1a	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1B1b	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1B1c	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1B2ai	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1B2aiv	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1B2av	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1B2b	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1B2c	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1B2d	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2A1	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2A2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2A3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2A5a	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2A5b	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2A5c	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2A6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B1	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B5	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Annex 1

NFR Code	NO _x	NM VOC	SO _x	NH ₃	PM _{2.5}	PM ₁₀	TSP	CO	Pb	Cd	Hg	PCDD/ PCDF	BaP	BbF	BkF	IcdP	PAH 1-4	HCB
2B6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B7	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B10a	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B10b	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C1	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C4	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C5	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C7a	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C7b	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C7c	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C7d	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D3a	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D3b	NO		NO	NO	NO	NO	NO	NA	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D3c	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D3d	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D3e	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D3f	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D3g	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D3h	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D3i	NO		NO	NO	NO	NO	NO	NA	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2G				NO								NA						NO
2H1	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2H2	NO		NO	NO					NO	NO	NO		NO	NO	NO	NO	NO	NO
2H3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2I	NO	NO	NO	NO				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2J	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2K	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2L	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B1a	NE		NO					NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B1b	NE		NO					NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B2	NE		NO					NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B3	NE		NO					NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B4a	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B4d	NE		NO					NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B4e	NE		NO					NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B4f	NE		NO					NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B4gi	NE		NO					NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B4gii	NE		NO					NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B4giii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B4giv	NE		NO					NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B4h	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3Da1		NO	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3Da2a	NA	NO	NO	IE	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3Da2b	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3Da2c	NA	NO	NO	NA	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3Da3	NA	NO	NO	IE	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3Da4	NA	NO	NO	NA	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3Db	NO		NO	NA	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3Dc	NA	NA	NO	NO				NA	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3Dd	NA	NA	NO	NO	NO	NO	NO	NA	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3De	NA	NA	NO	NO	NO	NO	NO	NA	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3Df	NO	NA	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Annex 1

NFR Code	NO _x	NM VOC	SO _x	NH ₃	PM2.5	PM10	TSP	CO	Pb	Cd	Hg	PCDD/ PCDF	BaP	BbF	BkF	IcdP	PAH 1-4	HCB
3F	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3I	NO	NA	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5A	NO	NO	NO	NA	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NA
5B1	NO		NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5B2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5C1a				NA														NA
5C1bi	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5C1bii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5C1biii	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5C1biv	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5C1bv	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5C1bvi	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5C2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5D1			NO		NO	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5D2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5D3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5E	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6A	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO