OFFICE OF ENVIRONMENT
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# Liechtenstein's Informative Inventory report 2020

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

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

Submission of 15 June 2020

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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 2019 and 2020 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 2018. 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 PM10 reductions flattened since the year 2004. The increased wood combustion has also an impact on CO emissions. After a considerable decline, the CO emissions are relatively stable since the year 2001.

The source category 1A3b Road transport showed in comparison to the year 1990 a decrease of $NO_2$-, CO-, PM10- and NMVOC-emissions. The reduction is due to more stringent emission standards for vehicles.

The PAH-, HCB- and Cd emissions are above the level of 1990 and show significant 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 1998 and 2018, the wood energy consumption increased from 27.4 TJ to 139.5 TJ and from 18.3 TJ to 101.6 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 2020. 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, no errors occurred.

# 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 - 2018.

## 1.2 Institutional Arrangements

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

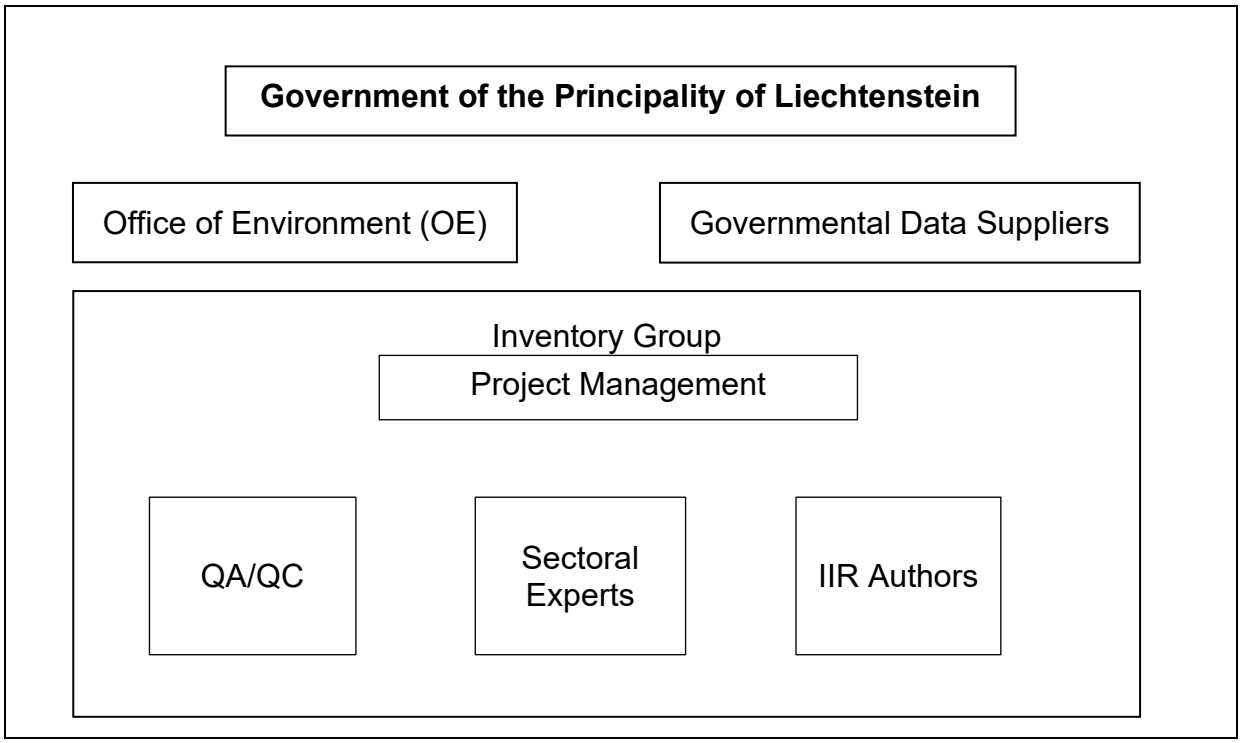



Figure 1.2-1: Informative Inventory Report: Institutional setting

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 2018 for the main pollutants which were identified by the approach 1 level assessment.

Table 1.5-1: Level assessment for pollutant $NO_2$ in 2018. Sorted by contribution in level.

| NFR Code | Source category | $NO_2$ [Gg] | Level ass. | ∑ |
|---|---|---|---|---|
| 1A3biii | Road transport: Heavy duty vehicles and buses | 0.0923 | 0.2757 | 27.6 |
| 1A3bi | Road transport: Passenger cars | 0.0722 | 0.2158 | 49.1 |
| 1A2gvii | Mobile Combustion in manufacturing industries and construction | 0.0700 | 0.2092 | 70.1 |
| 1A4ai | Commercial/institutional: Stationary | 0.0303 | 0.0905 | 79.1 |
| 1A3bii | Road transport: Light duty vehicles | 0.0201 | 0.0599 | 85.1 |

Table 1.5-2: Level assessment for pollutant CO in 2018. Sorted by contribution in level.

| NFR Code | Source category | CO [Gg] | Level ass. | ∑ |
|---|---|---|---|---|
| 1A4bi | Residential: Stationary | 0.2247 | 0.4014 | 40.1 |
| 1A3bi | Road transport: Passenger cars | 0.0964 | 0.1723 | 57.4 |
| 1A4ai | Commercial/institutional: Stationary | 0.0661 | 0.1181 | 69.2 |
| 1A3bii | Road transport: Light duty vehicles | 0.0603 | 0.1077 | 80.0 |
| 1A4aii | Commercial/institutional: Mobile | 0.0299 | 0.0534 | 85.3 |

Table 1.5-3: Level assessment for pollutant NMVOC in 2018. Sorted by contribution in level.

| NFR Code | Source category | NMVOC [Gg] | Level ass. | ∑ |
|---|---|---|---|---|
| 2D3a | Domestic solvent use including fungicides | 0.0486 | 0.1655 | 16.5 |
| 2D3d | Coating applications | 0.0459 | 0.1562 | 32.2 |
| 3B1a | Manure management - Dairy cattle | 0.0365 | 0.1245 | 44.6 |
| 2D3i | Other solvent use | 0.0327 | 0.1112 | 55.7 |
| 2D3g | Chemical products | 0.0154 | 0.0525 | 61.0 |
| 2D3h | Printing | 0.0131 | 0.0447 | 65.5 |
| 3B1b | Manure management - Non-dairy cattle | 0.0114 | 0.0389 | 69.4 |
| 2H2 | Food and beverages industry | 0.0103 | 0.0351 | 72.9 |
| 1A2gvii | Mobile Combustion in manufacturing industries and construction | 0.0102 | 0.0346 | 76.3 |
| 1A4bi | Residential: Stationary | 0.0086 | 0.0292 | 79.2 |
| 2D3e | Degreasing | 0.0065 | 0.0222 | 81.5 |

Table 1.5-4: Level assessment for pollutant $SO_x$ in 2018. Sorted by contribution in level.

| NFR Code | Source category | $SO_2$ [Gg] | Level ass. | ∑ |
|---|---|---|---|---|
| 1A4ai | Commercial/institutional: Stationary | 0.0045 | 0.4007 | 40.1 |
| 1A4bi | Residential: Stationary | 0.0022 | 0.1995 | 60.0 |
| 1A2gvii | Mobile Combustion in manufacturing industries and construction | 0.0020 | 0.1816 | 78.2 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: Other | 0.0011 | 0.1010 | 88.3 |

Table 1.5-5: Level assessment for pollutant $NH_3$ in 2018. Sorted by contribution in level.

| NFR Code | Source category | $NH_3$ [Gg] | Level ass. | ∑ |
|---|---|---|---|---|
| 3B1a | Manure management - Dairy cattle | 0.1294 | 0.6129 | 61.3 |
| 3B1b | Manure management - Non-dairy cattle | 0.0454 | 0.2148 | 82.8 |

Table 1.5-6: Level assessment for pollutant PM10 in 2018. Sorted by contribution in level.

| NFR Code | Source category | PM10 [Gg] | Level ass. | ∑ |
|---|---|---|---|---|
| 1A4bi | Residential: Stationary | 0.0093 | 0.2019 | 20.2 |
| 1A4ai | Commercial/institutional: Stationary | 0.0078 | 0.1685 | 37.0 |
| 3Dc | Farm-level agricultural operations including storage, handling and transport of agricultural products | 0.0073 | 0.1578 | 52.8 |
| 1A3bvi | Road transport: Automobile tyre and brake wear | 0.0044 | 0.0957 | 62.4 |
| 1A2gvii | Mobile Combustion in manufacturing industries and construction | 0.0033 | 0.0710 | 69.5 |
| 3B1a | Manure management - Dairy cattle | 0.0029 | 0.0618 | 75.7 |
| 2I | Wood processing | 0.0017 | 0.0365 | 79.3 |
| 1A3bvii | Road transport: Automobile road abrasion | 0.0015 | 0.0330 | 82.6 |

## 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 $NO_2$ from 1990 to 2018. Sorted by contribution in level.

| NFR Code | Source category | 1990 | 2018 | $T_{x,t}$ | % contrib | ∑ |
|---|---|---|---|---|---|---|
| 1A3biii | Road transport: Heavy duty vehicles and buses | 0.2684 | 0.0923 | 0.0879 | 37.9 | 37.9 |
| 1A2gvii | Mobile Combustion in manufacturing industries and construction | 0.0366 | 0.0700 | 0.0816 | 35.2 | 73.2 |
| 1A4cii | Agriculture/Forestry/Fishing: Off-road vehicles and other machinery | 0.0132 | 0.0172 | 0.0163 | 7.1 | 80.2 |

Table 1.5-8*:* Trend assessment for pollutant CO from 1990 to 2018. Sorted by contribution in level.

| NFR Code | Source category | 1990 | 2018 | $T_{x,t}$ | % contrib | ∑ |
|---|---|---|---|---|---|---|
| 1A3bi | Road transport: Passenger cars | 0.9084 | 0.0964 | 0.1575 | 40.5 | 40.5 |
| 1A4bi | Residential: Stationary | 0.0773 | 0.2247 | 0.1294 | 33.3 | 73.8 |
| 1A3bii | Road transport: Light duty vehicles | 0.2841 | 0.0603 | 0.0294 | 7.6 | 81.3 |

Table 1.5-9*:* Trend assessment for pollutant NMVOC from 1990 to 2018. Sorted by contribution in level.

| NFR Code | Source category | 1990 | 2018 | $T_{x,t}$ | % contrib | ∑ |
|---|---|---|---|---|---|---|
| 1A3bv | Road transport: Gasoline evaporation | 0.2118 | 0.0011 | 0.0365 | 19.2 | 19.2 |
| 2D3a | Domestic solvent use including fungicides | 0.0398 | 0.0486 | 0.0307 | 16.1 | 35.3 |
| 1A3bi | Road transport: Passenger cars | 0.1303 | 0.0022 | 0.0213 | 11.2 | 46.5 |
| 3B1a | Manure management - Dairy cattle | 0.0459 | 0.0365 | 0.0202 | 10.6 | 57.1 |
| 2D3g | Chemical products | 0.1210 | 0.0154 | 0.0094 | 4.9 | 62.0 |
| 2D3i | Other solvent use | 0.1002 | 0.0327 | 0.0076 | 4.0 | 66.0 |
| 1A2gvii | Mobile Combustion in manufacturing industries and construction | 0.0053 | 0.0102 | 0.0069 | 3.6 | 69.7 |
| 3B1b | Manure management - Non-dairy cattle | 0.0125 | 0.0114 | 0.0067 | 3.5 | 73.2 |
| 2H2 | Food and beverages industry | 0.0083 | 0.0103 | 0.0065 | 3.4 | 76.6 |
| 1B2av | Distribution of oil products | 0.0486 | 0.0029 | 0.0064 | 3.3 | 79.9 |
| 1A4bi | Residential: Stationary | 0.0042 | 0.0086 | 0.0059 | 3.1 | 83.0 |

Table 1.5-10*:* Trend assessment for pollutant $SO_x$ from 1990 to 2018. Sorted by contribution in level.

| NFR Code | Source category | 1990 | 2018 | $T_{x,t}$ | % contrib | ∑ |
|---|---|---|---|---|---|---|
| 1A2gvii | Mobile Combustion in manufacturing industries and construction | 0.0011 | 0.0020 | 0.0149 | 29.9 | 29.9 |
| 1A3biii | Road transport: Heavy duty vehicles and buses | 0.0155 | 0.0002 | 0.0091 | 18.1 | 48.0 |
| 1A3bi | Road transport: Passenger cars | 0.0131 | 0.0002 | 0.0068 | 13.6 | 61.6 |
| 1A4cii | Agriculture/Forestry/Fishing: Off-road vehicles and other machinery | 0.0006 | 0.0008 | 0.0056 | 11.1 | 72.7 |
| 1A4bi | Residential: Stationary | 0.0195 | 0.0022 | 0.0042 | 8.4 | 81.1 |

Table 1.5-11*:* Trend assessment for pollutant $NH_3$ from 1990 to 2018. Sorted by contribution in level.

| NFR Code | Source category | 1990 | 2018 | $T_{x,t}$ | % contrib | ∑ |
|---|---|---|---|---|---|---|
| 3B1b | Manure management - Non-dairy cattle | 0.0494 | 0.0454 | 0.0207 | 27.6 | 27.6 |
| 3B4gi | Manure mangement - Laying hens | 0.0016 | 0.0046 | 0.0128 | 17.0 | 44.7 |
| 3B2 | Manure management - Sheep | 0.0037 | 0.0053 | 0.0089 | 11.9 | 56.6 |
| 3B1a | Manure management - Dairy cattle | 0.1625 | 0.1294 | 0.0069 | 9.2 | 65.7 |
| 3B3 | Manure management - Swine | 0.0142 | 0.0101 | 0.0053 | 7.0 | 72.7 |
| 3B4f | Manure management - Mules and asses | 0.0006 | 0.0018 | 0.0052 | 7.0 | 79.7 |
| 3B4e | Manure management - Horses | 0.0013 | 0.0020 | 0.0034 | 4.6 | 84.2 |

Table 1.5-12*:* Trend assessment for pollutant PM10 from 1990 to 2018. Sorted by contribution in level.

| NFR Code | Source category | 1990 | 2018 | $T_{x,t}$ | % contrib | ∑ |
|---|---|---|---|---|---|---|
| 1A3biii | Road transport: Heavy duty vehicles and buses | 0.0153 | 0.0011 | 0.1469 | 23.0 | 23.0 |
| 1A4bi | Residential: Stationary | 0.0029 | 0.0093 | 0.1114 | 17.4 | 40.4 |
| 1A4ai | Commercial/institutional: Stationary | 0.0039 | 0.0078 | 0.0771 | 12.1 | 52.5 |
| 1A3bi | Road transport: Passenger cars | 0.0074 | 0.0006 | 0.0696 | 10.9 | 63.4 |
| 1A1a | Public electricity and heat production | 0.0036 | 0.0000 | 0.0384 | 6.0 | 69.4 |
| 1A3bvi | Road transport: Automobile tyre and brake wear | 0.0030 | 0.0044 | 0.0354 | 5.5 | 74.9 |
| 1A2gvii | Mobile Combustion in manufacturing industries and construction | 0.0017 | 0.0033 | 0.0316 | 4.9 | 79.9 |
| 1A3bii | Road transport: Light duty vehicles | 0.0033 | 0.0003 | 0.0304 | 4.8 | 84.6 |

### 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 $NO_2$

| NFR Code | Source category | L | T | Identification criteria |
|---|---|---|---|---|
| 1A3biii | Road transport: Heavy duty vehicles and buses | 27.6 | 37.9 | L1,T1 |
| 1A2gvii | Mobile Combustion in manufacturing industries and construction | 20.9 | 35.2 | L1,T1 |
| 1A3bi | Road transport: Passenger cars | 21.6 | | L1 |
| 1A4ai | Commercial/institutional: Stationary | 9.0 | | L1 |
| 1A4cii | Agriculture/Forestry/Fishing: Off-road vehicles and other machinery | | 7.1 | T1 |
| 1A3bii | Road transport: Light duty vehicles | 6.0 | | L1 |

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

| NFR Code | Source category | L | T | Identification criteria |
|---|---|---|---|---|
| 1A4bi | Residential: Stationary | 40.1 | 33.3 | L1,T1 |
| 1A3bi | Road transport: Passenger cars | 17.2 | 40.5 | L1,T1 |
| 1A3bii | Road transport: Light duty vehicles | 10.8 | 7.6 | L1,T1 |
| 1A4ai | Commercial/institutional: Stationary | 11.8 | | L1 |
| 1A4aii | Commercial/institutional: Mobile | 5.3 | | 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 | 16.5 | 16.1 | L1,T1 |
| 3B1a | Manure management - Dairy cattle | 12.4 | 10.6 | L1,T1 |
| 1A3bv | Road transport: Gasoline evaporation | | 19.2 | T1 |
| 2D3d | Coating applications | 15.6 | | L1 |
| 2D3i | Other solvent use | 11.1 | 4.0 | L1,T1 |
| 1A3bi | Road transport: Passenger cars | | 11.2 | T1 |
| 2D3g | Chemical products | 5.3 | 4.9 | L1,T1 |
| 3B1b | Manure management - Non-dairy cattle | 3.9 | 3.5 | L1,T1 |
| 1A2gvii | Mobile Combustion in manufacturing industries and construction | 3.5 | 3.6 | L1,T1 |
| 2H2 | Food and beverages industry | 3.5 | 3.4 | L1,T1 |
| 1A4bi | Residential: Stationary | 2.9 | 3.1 | L1,T1 |
| 2D3h | Printing | 4.5 | | L1 |
| 1B2av | Distribution of oil products | | 3.3 | T1 |
| 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 |
|---|---|---|---|---|
| 1A2gvii | Mobile Combustion in manufacturing industries and construction | 18.2 | 29.9 | L1,T1 |
| 1A4ai | Commercial/institutional: Stationary | 40.1 | | L1 |
| 1A4bi | Residential: Stationary | 19.9 | 8.4 | L1,T1 |
| 1A3biii | Road transport: Heavy duty vehicles and buses | | 18.1 | T1 |
| 1A3bi | Road transport: Passenger cars | | 13.6 | T1 |
| 1A4cii | Agriculture/Forestry/Fishing: Off-road vehicles and other machinery | | 11.1 | T1 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: Other | 10.1 | | L1 |

Table 1.5-17: Result of key category analysis for pollutant $NH_3$

| NFR Code | Source category | L | T | Identification criteria |
|---|---|---|---|---|
| 3B1a | Manure management - Dairy cattle | 61.3 | 9.2 | L1,T1 |
| 3B1b | Manure management - Non-dairy cattle | 21.5 | 27.6 | L1,T1 |
| 3B4gi | Manure mangement - Laying hens | | 17.0 | T1 |
| 3B2 | Manure management - Sheep | | 11.9 | T1 |
| 3B3 | Manure management - Swine | | 7.0 | T1 |
| 3B4f | Manure management – Mules and asses | | 7.0 | T1 |
| 3B4e | Manure management - Horses | | 4.6 | T1 |

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

| NFR Code | Source category | L | T | Identification criteria |
|---|---|---|---|---|
| 1A4bi | Residential: Stationary | 20.2 | 17.4 | L1,T1 |
| 1A4ai | Commercial/institutional: Stationary | 16.8 | 12.1 | L1,T1 |
| 1A3biii | Road transport: Heavy duty vehicles and buses | | 23.0 | T1 |
| 3Dc | Farm-level agricultural operations including storage, handling and transport of agricultural products | 15.8 | | L1 |
| 1A3bvi | Road transport: Automobile tyre and brake wear | 9.6 | 5.5 | L1,T1 |
| 1A2gvii | Mobile Combustion in manufacturing industries and construction | 7.1 | 4.9 | L1,T1 |
| 1A3bi | Road transport: Passenger cars | | 10.9 | T1 |
| 3B1a | Manure management - Dairy cattle | 6.2 | | L1 |
| 1A1a | Public electricity and heat production | | 6.0 | T1 |
| 1A3bii | Road transport: Light duty vehicles | | 4.8 | T1 |
| 2I | Wood processing | 3.6 | | L1 |
| 1A3bvii | Road transport: Automobile road abrasion | 3.3 | | 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 30th 2008 | LR 814.301.1 |
| Ordinance of September 6th, 2016 on the Major Incidents Act | LR 522.1 |
| Act of October 5th, 2014 on the environmental impact assessment | LR 814.03 |
| Ordinance of December 16th, 2008 on Inherited Waste | LR 814.011.2 |
| Act of December 16th, 2009 on Incentive Taxes on Volatile Organic Compounds | LR 814.061 |
| Ordinance of January 26th, 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 [LGBl 2010 Nr. 15] and a corresponding ordinance [LGBl 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 2018 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 1985-2018

| Pollutant | Unit | 1985 | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | Absolute diff. 2018 to Base 1990 | Relative diff. 2018 to Base 1990 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $NO_x$ | t | 660 | 614 | 570 | 542 | 510 | 425 | 389 | 364 | 350 | 335 | -279 | -46% |
| CO | t | 1819 | 1516 | 919 | 721 | 576 | 594 | 578 | 553 | 530 | 560 | -957 | -63% |
| NMVOC | t | 1509 | 1289 | 814 | 552 | 368 | 338 | 307 | 299 | 299 | 294 | -995 | -77% |
| $SO_x$ | t | 142 | 129 | 72 | 42 | 41 | 23 | 16 | 13 | 13 | 11 | -118 | -91% |
| $NH_3$ | t | 280 | 261 | 250 | 223 | 222 | 224 | 215 | 215 | 209 | 211 | -50 | -19% |
| TSP | t | 101 | 94 | 83 | 73 | 60 | 62 | 62 | 60 | 59 | 60 | -33 | -35% |
| PM10 | t | 71 | 66 | 61 | 57 | 48 | 48 | 48 | 46 | 45 | 46 | -19 | -30% |
| PM2.5 | t | 49 | 44 | 40 | 38 | 31 | 33 | 32 | 31 | 29 | 31 | -13 | -30% |
| Dioxin | mg | 133 | 125 | 98 | 68 | 61 | 95 | 102 | 96 | 90 | 101 | -24 | -19% |
| ICDP | kg | 3 | 3 | 2 | 4 | 3 | 4 | 3 | 3 | 3 | 3 | 0 | 7% |
| BKF | kg | 2 | 2 | 1 | 3 | 2 | 4 | 3 | 3 | 3 | 3 | 2 | 78% |
| BBF | kg | 5 | 5 | 4 | 7 | 5 | 7 | 5 | 5 | 5 | 5 | 0 | 8% |
| BAP | kg | 5 | 5 | 4 | 7 | 5 | 7 | 5 | 5 | 5 | 5 | 0 | 0.1% |
| PAH 1 - 4 | kg | 14 | 16 | 11 | 21 | 16 | 22 | 18 | 17 | 16 | 18 | 2 | 14% |
| Pb | kg | 897 | 649 | 265 | 35 | 29 | 25 | 25 | 24 | 23 | 24 | -625 | -96% |
| Cd | kg | 2 | 2 | 1 | 2 | 2 | 3 | 4 | 4 | 4 | 4 | 2 | 157% |
| Hg | kg | 0.6 | 0.6 | 0.6 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | -0.3 | -51% |
| HCB | g | 0.5 | 0.5 | 0.4 | 0.6 | 0.6 | 0.8 | 0.9 | 0.8 | 0.8 | 0.9 | 0.4 | 72% |

The main pollutant emissions show a downward trend between 1985 and 2018. 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 PAH-, HCB- and Cd 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: PAH-Emissions from 1985 to 2018

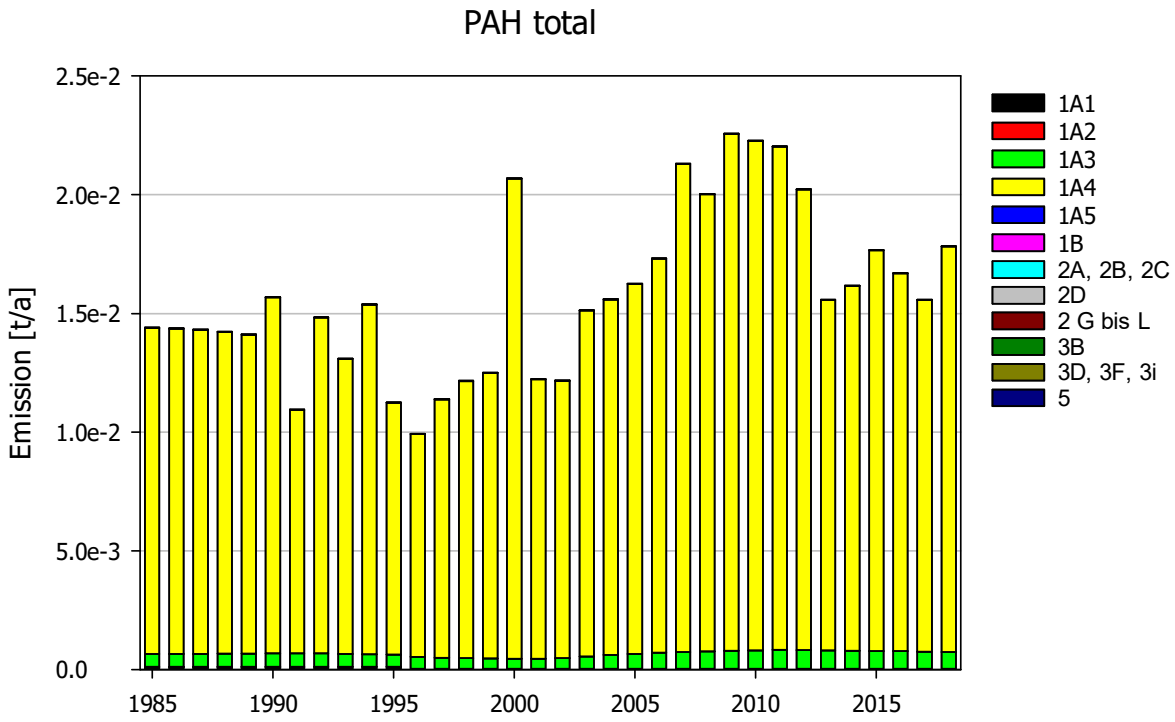



Figure 2.1-2: Cd-Emissions from 1985 to 2018

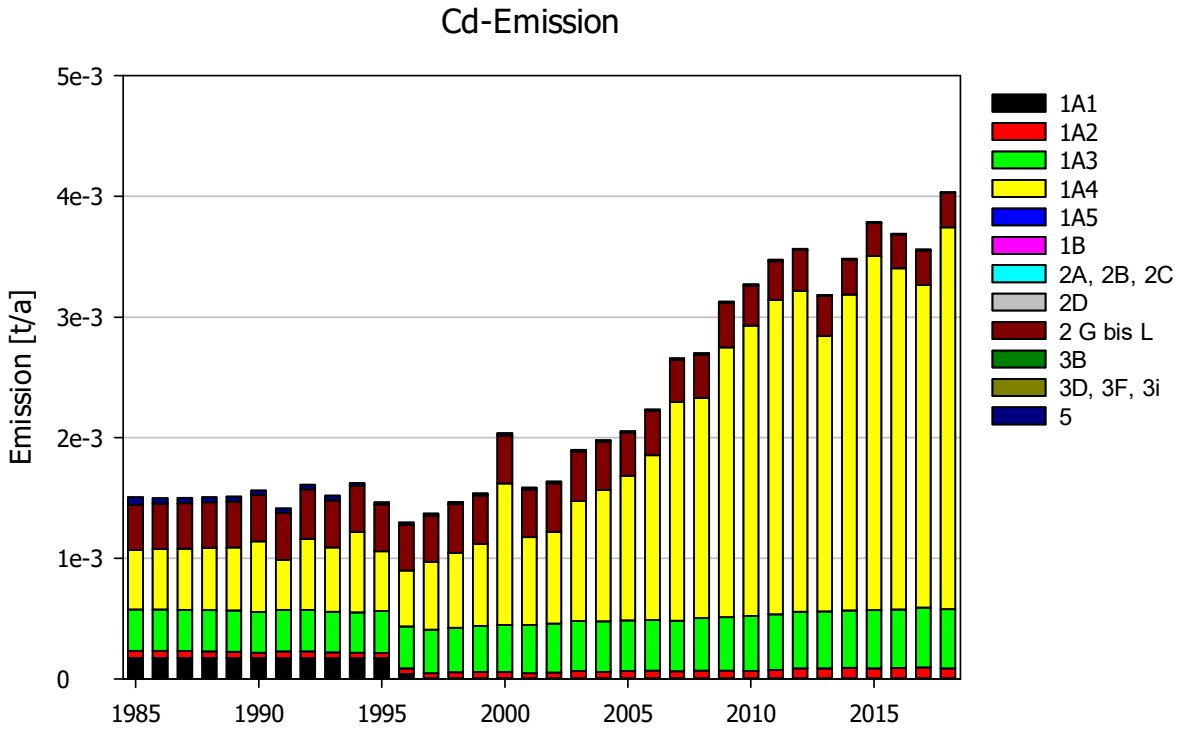


Figure 2.1-3: HCB-Emissions from 1985 to 2018

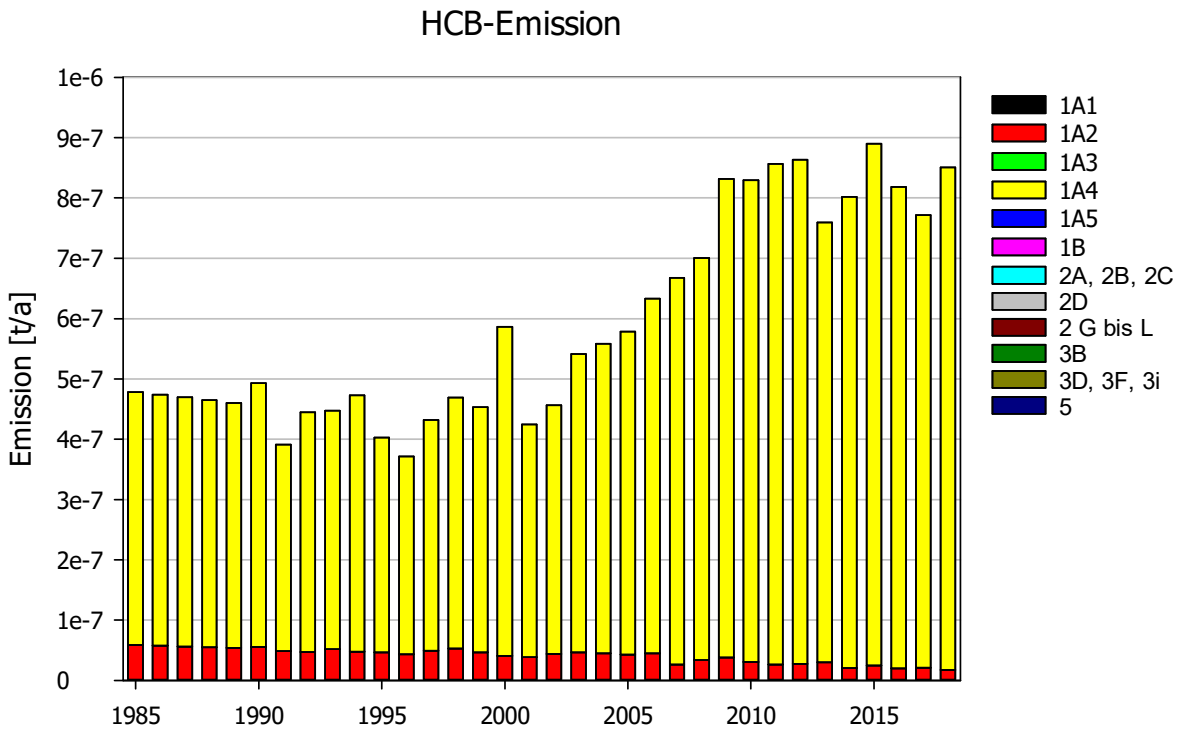



Figure 2.1-4: Wood as fuel from 1985 to 2018

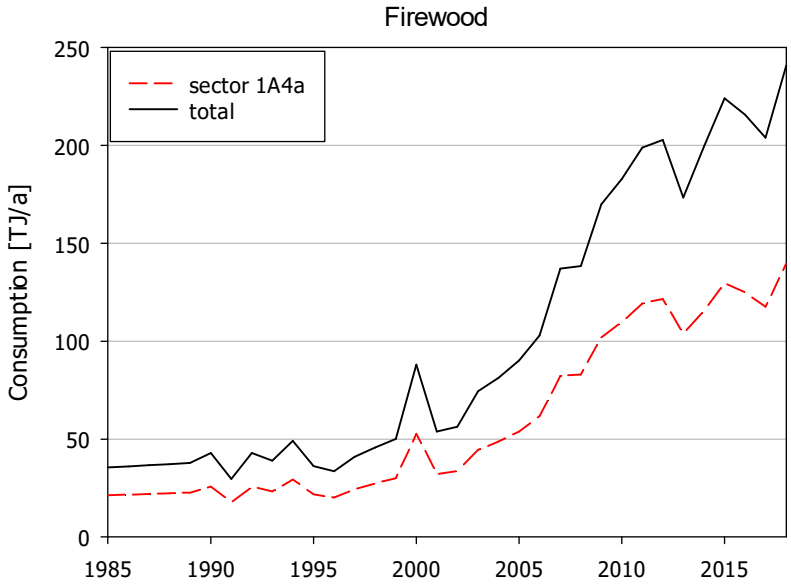



Table 2.1-1 displays the trends of the national total emissions per pollutant group. The reasons for the changes in the time series are given in the next paragraphs.

Figure 2.1-5: Change (Trend) for $NO_2$ in key sources from 1990 to 2018

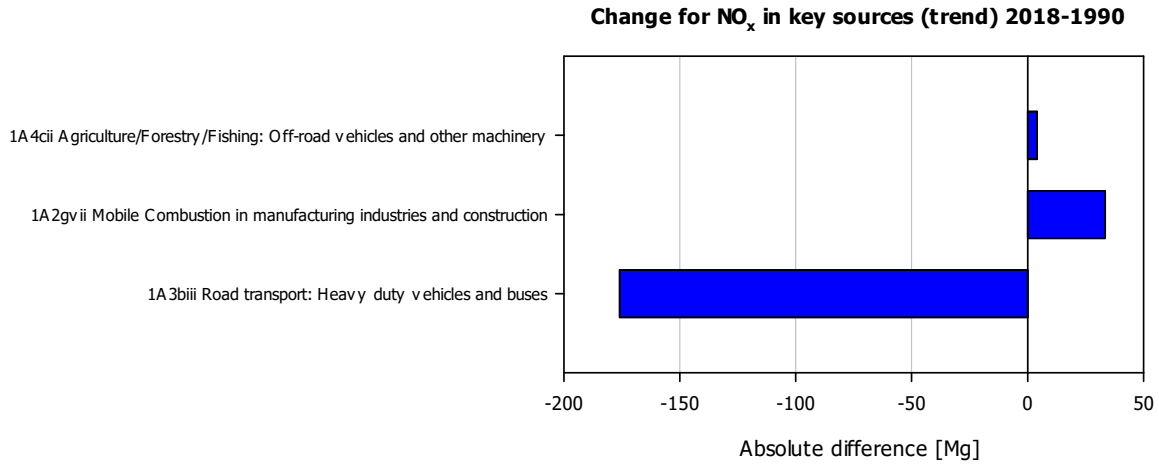
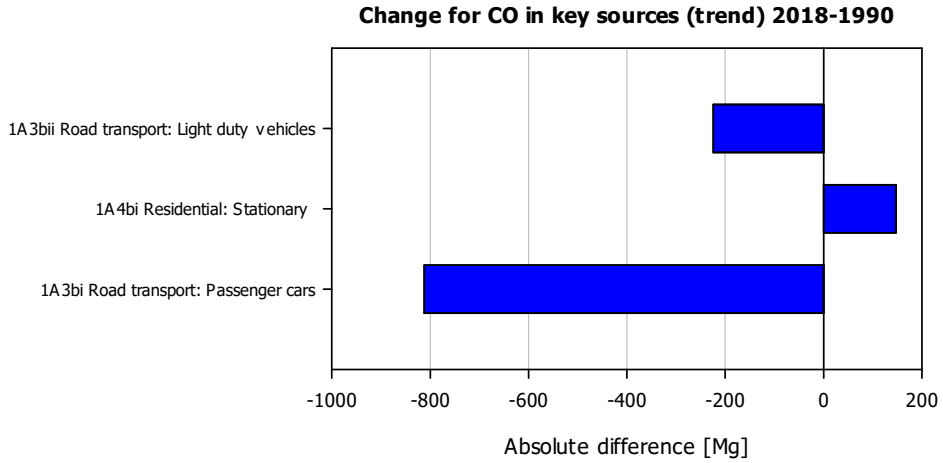


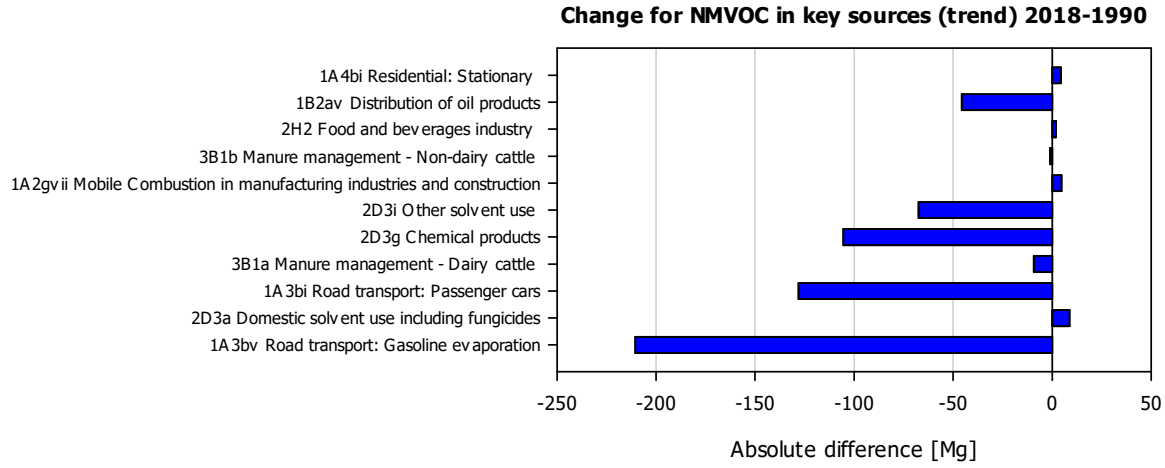

Figure 2.1-5 shows the absolute differences of key sources (trend) for $NO_x$ between 1990 and 2018. Obviously, the greatest difference occurred in source category 1A3biii Road transport: Heavy duty vehicles and buses. In the mentioned category, a decrease of over 170 Mg can be documented from 1990 to 2018. Regarding the source categories 1A2gvii and 1A4cii, increases of about 33 Mg and 4 Mg, respectively, were calculated.

Figure 2.1-6: Change (Trend) for CO in key sources from 1990 to 2018




The change of CO in the key source (trend) 1A3b Road transport is of great importance (see IIR 2013). A strong reduction of more than 1000 Mg was achieved in sub-categories passenger cars and light duty vehicles. In contrast, higher CO emissions in the key source 1A4bi Residential: Stationary can be observed.

Figure 2.1-7: Change (Trend) for NMVOC in key sources from 1990 to 2018




Regarding NMVOC, emissions from key sources (trend) increase from 1990 to 2018 in categories 1A4bi, 2H2, 1A2gvii and 2D3a. A decrease can be observed in key sources 1B2av, 3B1a & b, 2D3i & g and 1A3bi & bv.

Figure 2.1-8: Change (Trend) for $SO_x$ in key sources from 1990 to 2018

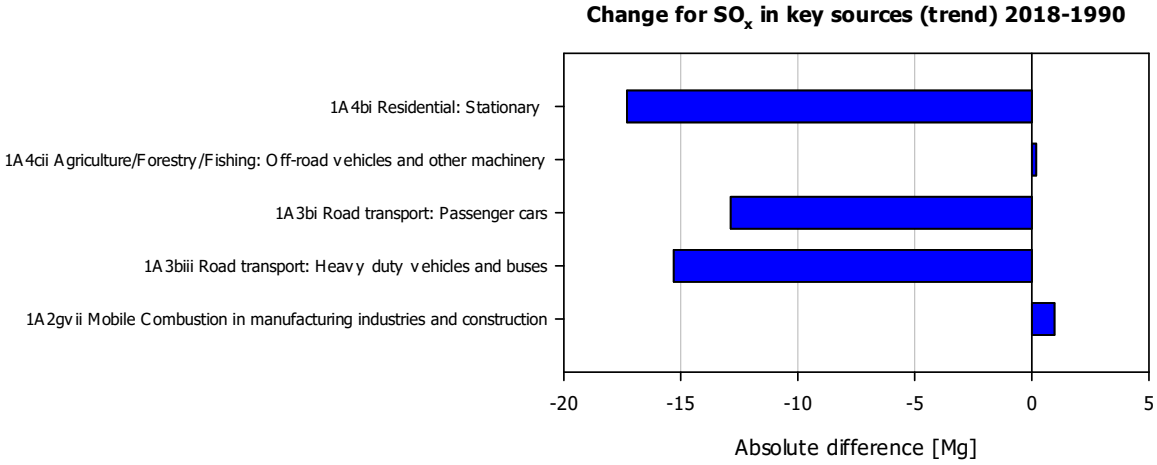
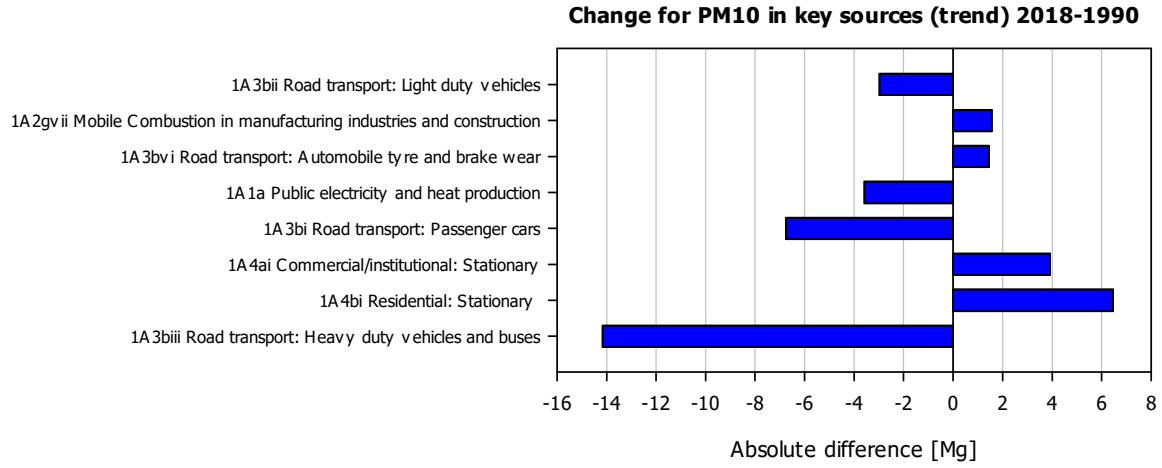


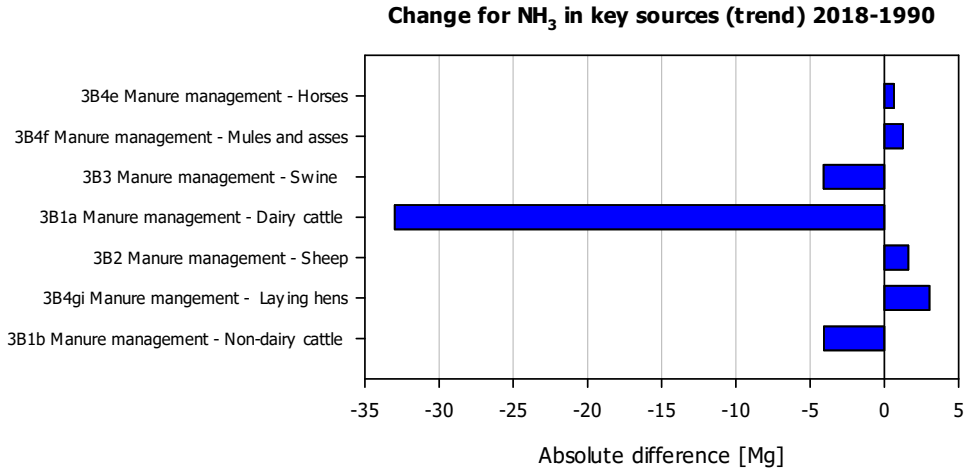

Figure 2.1-8: reveals decreases regarding $SO_x$ in source category 1A4bi Residential: Stationary as well as in 1A3bi Road transport: Passenger cars and 1A3biii Road Transport: Heavy duty vehicles and buses. On the other hand, the $SO_x$ emissions increased in source categories 1A4cii Agriculture/forestry/fishing: Off-road vehicles and other machinery and 1A2gvii Mobile combustion in manufacturing industries and construction.

Figure 2.1-9: Change (Trend) for PM10 in key sources from 1990 to 2018



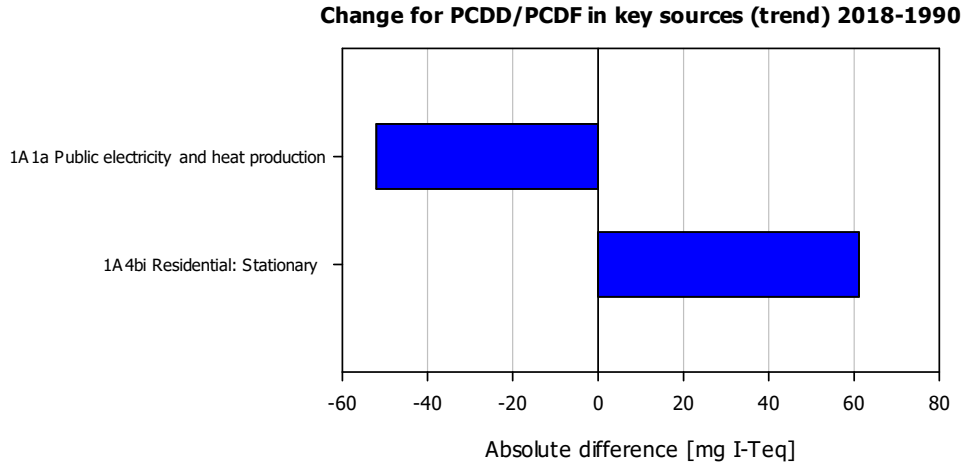

While the PM10 emissions decreased in key sources (trend) 1A3bii, 1A1a, 1A3bi and 1A3biii (in total almost 30 Mg), an increase in source categories 1A2gvii, 1A3bvi, 1A4ai and 1A4bi (in total about 13 Mg) can be observed.

Figure 2.1-10: Change (Trend) for $NH_3$ in key sources from 1990 to 2018



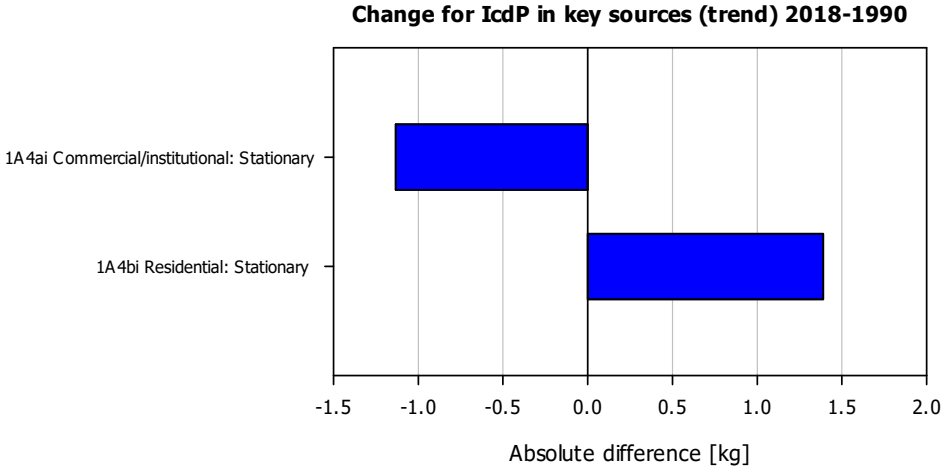

$NH_3$ emissions from key sources (trend) from 1990 to 2018 increased in source categories 3B4e-gi and 3B2. Decreases occur in categories 3B1 and 3B2, whereat the key category 3B1a Manure management – Dairy cattle showed the largest decrease (-33 Gg).

Figure 2.1-11: Change (Trend) for PCDD/PCDF in key sources from 1990 to 2018




The trend 2018 – 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 60 mg I-Teq).

Figure 2.1-12: Change (Trend) for IcdP in key sources from 1990 to 2018




The emissions of IcdP from 1990 to 2018 show the following trend: there is an increase of more than 1 kg in the key source (trend) 1A4bi Residential: Stationary. In source category 1A4ai Commercial/institutional: Stationary, a decrease of about 1 kg is reported.

Figure 2.1-13: Change (Trend) for BkF in key sources from 1990 to 2018

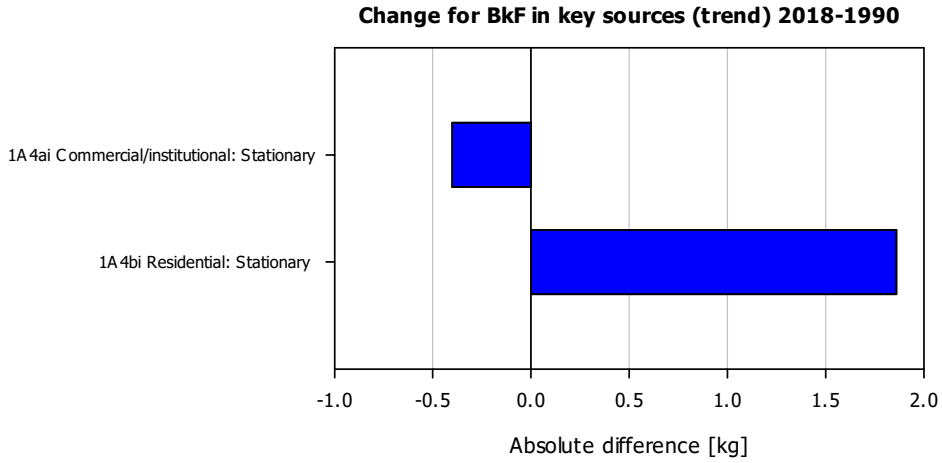
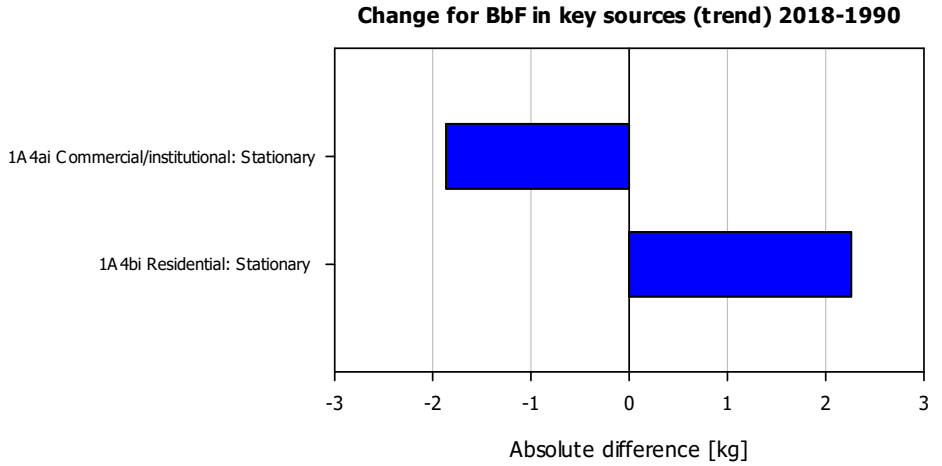
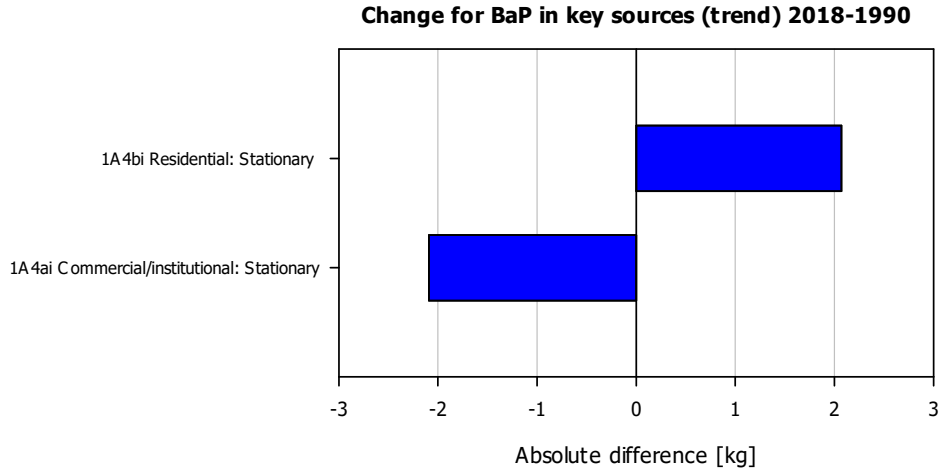



Figure 2.1-14: Change (Trend) for BbF in key sources from 1990 to 2018



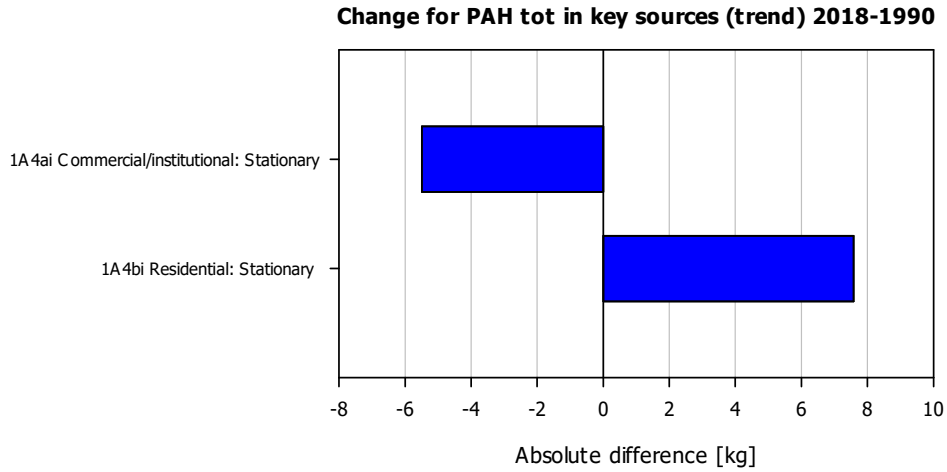

Like for IcdP, there is a decrease of the emissions of BkF (about 0.4 kg) and BbF (about 2 kg) from 1990 to 2018 in source category 1A4ai Commercial/institutional: Stationary. Like in the previous year's trend, there was an increase in 1A4bi Residential: Stationary (about 2 kg each).

Figure 2.1-15: Change (Trend) for BaP in key sources from 1990 to 2018



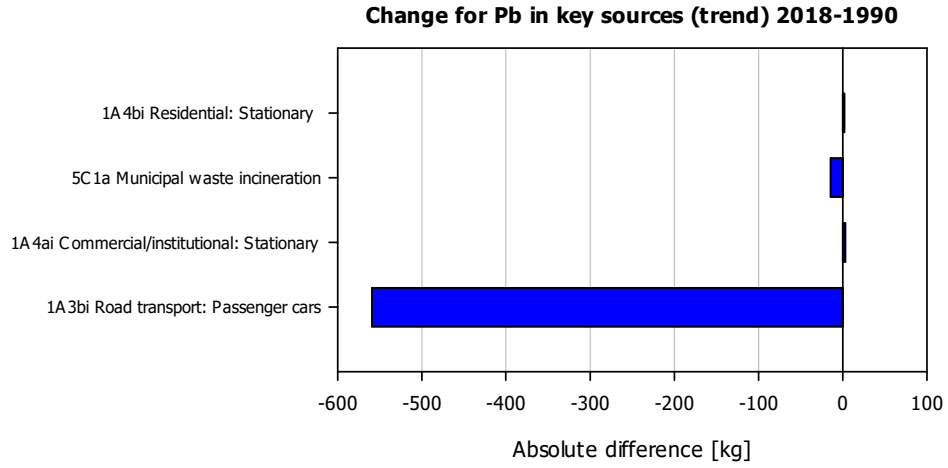

BaP emissions decreased from 1990 to 2018 in source category 1A4ai Commercial/institutional: Stationary (about 2 kg) and increased in 1A4bi Residential: Stationary (about 2 kg).

Figure 2.1-16: Change (Trend) for PAH's in key sources from 1990 to 2018



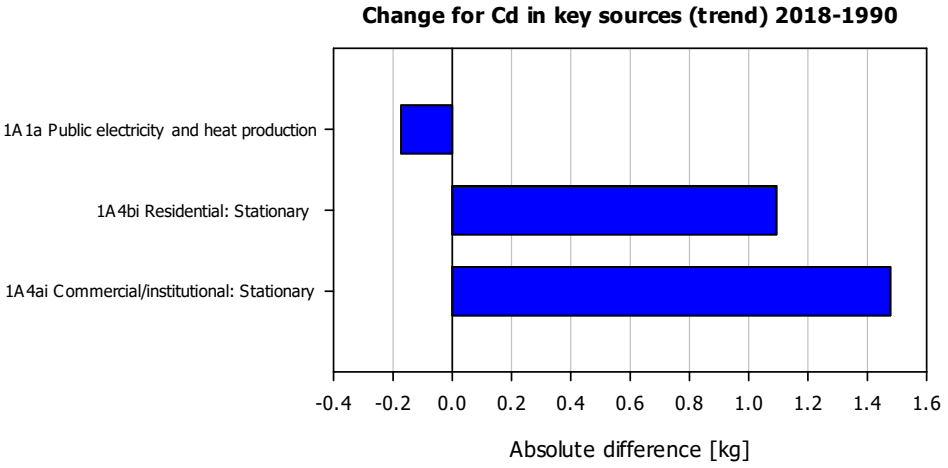

The sum of the PAH-emissions increased in source category 1A4bi Residential: Stationary (about 8 kg) from 1990 to 2018 and decreased in source category 1A4ai Commercial /institutional: Stationary (about 6 kg).

Figure 2.1-17: Change (Trend) for lead in key sources from 1990 to 2018



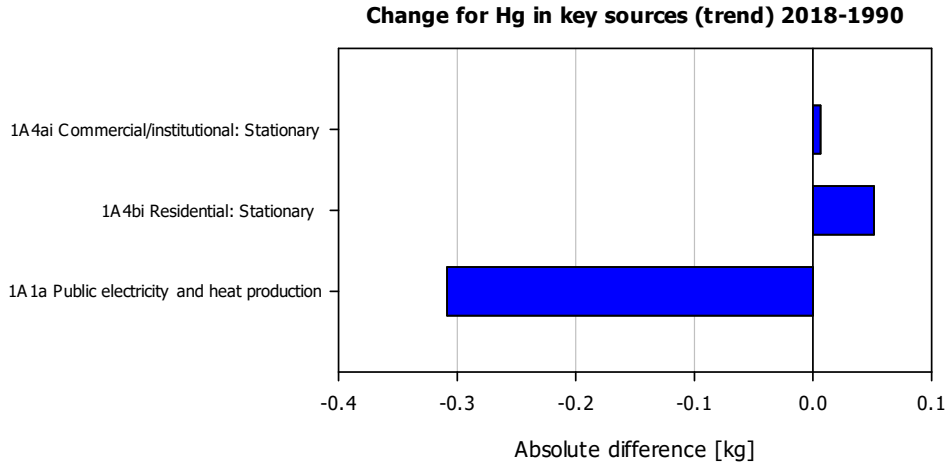

The change for Pb emissions shows a marginal increase of a few kg (absolute difference) in source categories 1A4ai Commercial/institutional: Stationary and 1A4bi Residential: Stationary. In the source category 5C1a Municipal waste incineration and particularly in category 1A3bi Road transport: Passenger cars lead emissions decreased significantly.

Figure 2.1-18: Change (Trend) for cadmium in key sources from 1990 to 2018



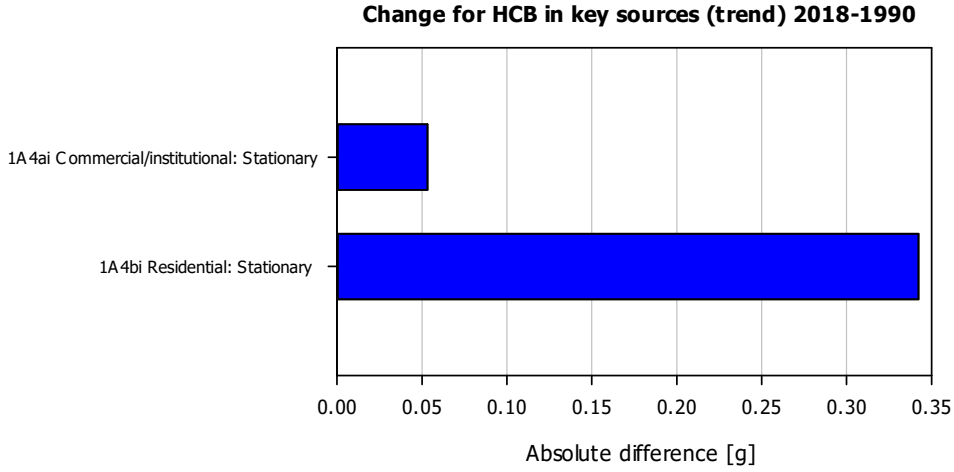

Regarding Cd emissions, increasing emissions can be observed in key sources (trend) 1A4bi Residential: Stationary and 1A4ai Commercial/institutional: Stationary. In key source 1A1a Public electricity and heat production, Cd emissions decreased between 1990 and 2018.

Figure 2.1-19: Change (Trend) for mercury in key sources from 1990 to 2018




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 2018




In the key sources (trend) 1A4ai Commercial/institutional: Stationary and 1A4bi Residential: Stationary, HCB emissions increased slightly (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 2018, almost 100 % of the national CO, $SO_2$ 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) consists 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. 1A2gvii mobile combustion in manufacturing industries and construction is a key source (level and trend) of $NO_2$, $SO_2$, PM10 and NMVOC emissions. The source category 1A2gviii Stationary combustion in manufacturing industries and construction is a key category (level) for $SO_2$ emissions.

## 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 1A3b is a key source for $NO_2$, CO, PM10 (level and trend), NMVOC and $SO_2$ (trend) emissions. In the following Table 3.3-1, main pollutants (level) and PM10 are imaged (% of national total in 2018):

Table 3.3-1: Category 1A3bi to 1A3bvii in % of national total in 1990 and 2018

| Pollutant | Level | |
|---|---|---|
| | 1990 | 2018 |
| $NO_x$ | 71 % | 55 % |
| CO | 85 % | 33 % |
| PM10 | 40 % | 5 % |

### 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 of PM10 (level & trend), $NO_2$ (level), CO (level) and $SO_2$ (level) and 1A4aii Commercial/institutional: Mobile is a key source (level) of CO emissions. Category 1A4bi Residential: Stationary is a key source (level & trend) of $SO_2$, PM10, NMVOC and CO emissions.

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 (2019).
The emission factors for TSP, $NO_x$, NMVOC, $SO_2$, $NH_3$ 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, PM2.5 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 2019 and OS 2018. 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 2019 with the numbers of inhabitants from population statistics [OS 2019].

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 | 2018 | 1990 | 2018 |
| Natural gas | $NO_x$ | 65.0 | 16.6 | 60.0 | 15.6 |
| | CO | 35.0 | 9.4 | 50.0 | 12.4 |
| | NMVOC | 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 |
| | PM10 | 0.2 | 0.1 | 0.2 | 0.1 |
| Fuel oil | $NO_x$ | 60.0 | 32.8 | 60.0 | 34 |
| | CO | 20.0 | 6.2 | 20.0 | 11.4 |
| | NMVOC | 8.0 | 6.0 | 8.0 | 6.0 |
| | $SO_2$ | 75.1 | 12.7 | 75.1 | 12.7 |
| | TSP | 0.3 | 0.2 | 0.3 | 0.2 |
| | PM10 | 0.3 | 0.2 | 0.3 | 0.2 |
| Wood | $NO_x$ | 149.5 | 142.1 | 85.0 | 85.0 |
| | CO | 1’825.0 | 452.6 | 3’875.0 | 2’151.8 |
| | NMVOC | 38.3 | 9.0 | 111.8 | 63.0 |
| | $SO_2$ | 10.0 | 10.0 | 10.0 | 10.0 |
| | TSP | 147.5 | 57.9 | 165.0 | 96.2 |
| | PM10 | 140.6 | 55.4 | 157.2 | 91.4 |

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 | 2018 | 1990 | 2018 |
| Natural gas | 140’840 | 158’493 | 41’225 | 424’069 |
| Fuel oil | 758’398 | 236’731 | 252’799 | 78’910 |
| Wood | 25’749 | 139’489 | 17’166 | 101’561 |

## 3.4.2 Agriculture/forestry/fishing (1A4cii)

Emissions are calculated by multiplying levels of activity with emission factors. Default emission factors from EMEP/CORINAIR 2016 are used for calculation. 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 | EF |
|---|---|
| $NO_x$ | 31.5 |
| CO | 3.8 |
| NMVOC | 1.0 |
| $SO_x$ | 1.4 |
| $NH_3$ | 0.01 |
| TSP | 0.5 |
| PM10 | 0.5 |
| PM2.5 | 0.5 |

This source category is a key category (trend) for $NO_2$ and $SO_2$.

### 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 NMVOC 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. In order to establish estimates of emissions for Liechtenstein, the emissions are calculated with emission factors per capita from EMIS 2019. The number of inhabitants in Liechtenstein is taken from population statistics [OS 2019].

Regarding NMVOC, the source category 2D3a is a key category (level and trend) and the main source for NMVOC in Liechtenstein (in 2018: 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. In order to establish estimates of emissions for Liechtenstein, the emissions are calculated with emission factors per capita from EMIS 2019. The number of inhabitants in Liechtenstein is taken from population statistics [OS 2019].

Source category 2D3d is a key category in level. Furthermore, this source account for the second largest proportion of NMVOC emissions in Liechtenstein (in 2018: 16 %).

### 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. In order to establish estimates of emissions for Liechtenstein, the emissions are calculated with emission factors per capita from EMIS 2019. The number of inhabitants in Liechtenstein is taken from population statistics [OS 2019].

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 2019. The number of inhabitants in Liechtenstein

is taken from population statistics [OS 2019]. The portion for NMVOC in Liechtenstein in 2018 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 2019. The number of inhabitants in Liechtenstein is taken from population statistics [OS 2019].

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 2019.

The source category 2D3i is a key category (level & trend) for NMVOC emissions (in 2018: 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 2019. The number of inhabitants in Liechtenstein is taken from population statistics [OS 2019].

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 PM10). The emissions are calculated with emission factors per capita from EMIS 2019. The number of inhabitants in Liechtenstein is taken from population statistics [OS 2019].

2H2 is a key category (level & trend) 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 2019. The number of inhabitants in Liechtenstein is taken from population statistics [OS 2019].

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 category 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 2007, 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 $NH_3$ emissions in Liechtenstein (in 2018: 83 %). 3B2 Manure management - Sheep, 3B3 Manure management – Swine, 3B4e Manure management – Horses, 3B4f Manure management – Mules and asses and 3B4gi Manure management – Laying hens are key sources for $NH_3$-emissions regarding trend. Furthermore, the source categories 3B1a and 3B1b 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 $NH_3$ in manure management [kg $NH_3$/animal and year]

| Animal category | EF |
|---|---|
| Dairy cattle | 28.5 |
| Other cattle | 14.3 |
| Fattening pigs | 6.4 |
| Sows | 16.4 |
| Sheep | 1.3 |
| Goats | 1.3 |
| Horses | 8 |
| Mules, asses | 8 |
| Laying hens | 0.4 |
| Broilers | 0.3 |
| Other poultry | 0.9 |
| Swine[1)] | 7.9 (1990) / 7.1 (2018) |

[1)] Time series

## 5.2 Crop production and agricultural soils (3D)

The source category 3D includes $NH_3$ and $NO_x$ emissions from inorganic N-fertilizers (3Da1), indirect NMVOC emissions from managed soils (3Db) and PM10 emissions from farm-level agricultural operations including storage, handling and transport of agricultural products (3Dc).

$NH_3$ 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 2019. The activity data were collected from the agricultural department of the OE.

NMVOC and PM10 emissions from source category 3Db and 3Dc, respectively, are calculated by multiplying the corresponding land area with emission factors from EMIS (2019) 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) 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 2019 with the bulk of composted organic waste. The activity data is provided by the OE.

The source category 5B is not a key category.

## 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. In order 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 2019].

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 (2020) various recalculations were made. The most relevant are listed below:

- Adjustment of emission factors for PM10, PM2.5 and TSP of source category 1A4aii Commercial/institutional: Mobile and 1A4bii Residential: Household and gardening (mobile)
- 1A3bv Road transport: Gasoline evaporation: Correction of a typing error in NMVOC calculation (led to "NO" classifications)
- 1A2gvii Mobile combustion in manufacturing industries: Correction of a formula error in activity calculation which led to an overestimation of activity in this source category
- Adjustment of emission factors for source categories 1A3bi – 1A3biv from HBEFA version 3.2 to HBEFA version 4.1 [HBEFA 2019]

## 8.2 First calculations

- Calculation of NMVOC emissions from source category 1B2b Fugitive emissions from natural gas
- Extension of emission sources in category 2G Other product use (so far, only emissions from firework and tobacco use were calculated)
- Extension of emission sources in category 1A1a from 1985 to 1996 (pyrolysis furnace; active until 1996) and generation of relating emission factors for the mentioned pyrolysis furnace based on fuel composition and corresponding emission factors from EMIS (2019)

## 8.3 Planned Improvements

For the next Submission, the following improvements are planned:

- Actualisation of activity data model in category 1A3b Road transport
- Re-evaluation of activity data and emission factors of off-road vehicles and other machinery in categories 1A2gvii and 1A4cii
- 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 emissions inventory guidebook – 2016

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

**EMIS 2019**: 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

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

**LGBl 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 2019**: Bevölkerungsstatistik 2019. Version 09.12.2019. Fürstentum Liechtenstein. Office of Statistics, Vaduz 2019

# Annex 1

Table 8.3-1: Definition of notation keys for the year 2018

| NFR Code | $NO_x$ | NMVOC | $SO_x$ | $NH_3$ | PM2.5 | PM10 | 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 | | | | | | | | | | | 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 | | | | | | | 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 | | | | | | | | | | | NA | NA | NA | NA | NA | NA | 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 | $NO_x$ | NMVOC | $SO_x$ | $NH_3$ | PM2.5 | PM10 | 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 | 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 | NA | 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 | NA | 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 | $NO_x$ | NMVOC | $SO_x$ | $NH_3$ | 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 |