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# Report for the Stage 3 in-depth review of emission inventories submitted under the UNECE LRTAP Convention and EU National Emissions Ceilings Directive for:

# LIECHTENSTEIN

# CONTENT

# INTRODUCTION

1. The mandate and overall objectives for the emission inventory review process under the LRTAP Convention is given by the UNECE document 'Updated methods and procedures for the technical reviews of air pollutant emission inventories reported under the Convention'(1) – hereafter referred to as the 'Review guidelines 2018'.

2. This annual review, has checked all pollutants covered by LRTAP Convention and its protocols ($SO_2$, NOx, NMVOC, $NH_3$, plus $PM_{10}$ $PM_{2.5}$, BC, 3 HMs and $POP_S$) for the time series years 1990 – 2019 reflecting current priorities from EMEP Steering Body and the Task Force on Emission Inventories and Projections (TFEIP). HMs and POPs have been reviewed to the extent possible.

3. This report covers the stage 3 centralised reviews of the UNECE LRTAP Convention of Liechtenstein coordinated by the EMEP emission centre CEIP acting as review secretariat. The review took place during May and June and was performed as desk review with virtual meetings. The following team of nominated experts from the roster of experts performed the review: generalist – Marion Pinterits (EU/Austria), Energy – Marion Pinterits (EU/Austria), Transport – Thamara Vieira da Rocha (France), IPPU Julien Jabot (Norway), Agriculture – Nicole Mandl (Austria), Waste – Zusana Jonáček (Slovakia).

4. Anne Misra was the lead reviewer. The review was coordinated by Katarina Marečková, (EMEP Centre on Emission Inventories and Projections - CEIP).

[1] Decision 2018/1 adopted by EB: *Updated methods and procedures for the technical review of air pollutant emission Inventories reported under the Convention*. ECE/EB.AIR/142/Add.1 http://www.unece.org/fileadmin/DAM/env/documents/2002/eb/air/EB%20Decisions/Decision_2018_1.pdf

# PART A: KEY REVIEW FINDINGS

5. The inventory is generally in line with the *EMEP EEA inventory guidebook* and UNECE Reporting Guidelines. However, the ERT noted that Liechtenstein are using the 2016 *EMEP EEA inventory guidebook*.

6. Liechtenstein's inventory is generally complete for the pollutants reviewed. Emissions of PCBs, BC and all voluntary pollutants (As, Cr, Cu, Ni, Se, Zn) and activity data in NFR tables are not reported for the entire time series.

7. The ERT further noted the need to increase capacity within the party for the compilation of the air emission inventory under the CLRTAP to further develop the quality and completeness of reporting in particular around uncertainty assessment (currently not provided), reporting of non-mandatory pollutants (currently missing), a more detailed description of QA/QC procedures, Key Category Analysis of all pollutants and reporting of activity data.

8. The ERT noted that emissions trends and recalculations have not been described in detail in the IIR.

9. ERT also noted that Liechtenstein applies Tier 1 methods and default parameters for some key categories (e.g. Solvent Use, Industry, Agriculture).

10. During the review the ERT did not identify possible technical corrections.

11. The ERT thanks Liechtenstein for participating actively in the Stage 3 review process by providing further information and data when requested. Based on that information, the ERT was able to review the inventory in detail and to provide several detailed recommendations.

## INVENTORY SUBMISSION

12. In their 2021 submission, Liechtenstein has reported emissions for its Protocol base years (1990) and a full time series to 2019 (the latest year) for its protocol pollutants in the NFR-14 format. In addition, the Party has also provided a full NFR 1990 - 2019 time series for CO and a 1990 - 2019 time series for $PM_{10}$ and $PM_{2.5}$., HM (mandatory metals only) and POPs (except PCB). Liechtenstein also submitted an IIR.

13. In 2021 Liechtenstein did not report gridded emissions for Gothenburg protocol pollutants nor LPS information or projections.

14. The CLRTAP inventory submitted by Liechtenstein is generally complete for the pollutants reviewed. The ERT noted the need to improve transparency and comparability of both the IIR and Annex I submission template, in particular providing more detailed information of applied methodologies, choice of emission factors and information on activity data used.

15. The ERT further noted the need to increase capacity within the party for the compilation of the air emission inventory under the CLRTAP to further develop the quality and completeness of reporting in particular around uncertainty assessment (currently not provided), reporting of non-mandatory pollutants (currently missing), a

more detailed description of QA/QC procedures, Key Category Analysis of all pollutants and reporting of activity data.

# KEY CATEGORIES

16. Liechtenstein has compiled and presented in its IIR a level and trend Key Source Category Analysis (KCA) for the following pollutants: $NO_2$, CO, NMVOC, $SO_X$, $NH_3$, TSP and $PM_{10}$ for the year 2019. A trend KCA is performed for the years 1990 and 2019 for $NO_2$, CO, NMVOC, $SO_X$, $NH_3$, TSP and $PM_{10}$. A KCA on trend and level for $PM_{2,5}$, BC, Pb, Cd, Hg and Dioxins, PAHs and PCBs is not provided by the Party. The ERT encourages Liechtenstein to conduct a KCA on trend and level also for all other pollutants.

# QUALITY

## Transparency

17. The ERT recognises the level of effort undertaken by Liechtenstein in providing an inventory including a significant level of detail and improvements undertaken in the last years to enhance transparency.

18. The ERT recommends Liechtenstein to include more detailed information on methodology, activity data and the use of emission factors in both key categories and non-key categories to further improve the transparency of the report.

19. The ERT noted that Liechtenstein applies the methodology from the EMEP/EEA Guidebook 2016. During this review, Liechtenstein has stated that it will progressively use the latest version of the EMEP/EEA Guidebook 2019 wherever possible. The Party also stated that scaling the emission data of Switzerland (EMIS) to Liechtenstein's population often gives a more realistic result. The ERT recommends Liechtenstein to use latest available 2019 EMEP/EEA air pollutant emission inventory guidebook, if more accurate methodology is not available.

20. The ERT noted that Liechtenstein is using the NFR tables 14-1. Liechtenstein clarified, that the most current version NFR tables 19-1 will be used in future submissions. The ERT recommends the use of the most current NFR tables 19-1 instead of NFR tables 14-1.

## Completeness

21. The ERT acknowledges the effort to which Liechtenstein has gone to provide estimates of emissions for all sub-sectors and all mandatory pollutants reviewed.

22. Liechtenstein’s inventory for the pollutants reviewed is generally complete. However, completeness was difficult to fully assess because of the limited information provided in the Party’s IIR. The ERT identified missing reporting for Memo items as well as missing estimations of PCB emissions for all sectors. The ERT reiterates its

recommendation from previous reviews to include information on Memo items and PCB emissions in future submissions.

23. Liechtenstein does not provide information on voluntary pollutants (BC, As, Cr, Cu, Ni, Se, Zn). The ERT encourages Liechtenstein to also provide emission data on those pollutants in order to enhance completeness of the inventory.

24. The ERT noted that Liechtenstein does not report gridded data nor information on LPS in in 2021 submission, which is a reporting year for both. The ERT is well aware that, under the original Gothenburg Protocol, Liechtenstein was not required to report such data. However, under the 2014 CLRTAP Reporting Guidelines the "EMEP grid" refers to a 0.1°×0.1° latitude-longitude projection in the geographic coordinate World Geodetic System (WGS) latest revision, WGS 84, which would be valid also for Liechtenstein. The 2014 CLRTAP Reporting Guidelines also state, that this information shall be reported every four years from 2017 onwards, therefore Liechtenstein is encouraged to include such data by the next appropriate deadline. The ERT therefore encourages Liechtenstein to include this information in future submissions.

25. The ERT noted that Liechtenstein does not report projections in its current inventory and encourages the Party to report this information in future submissions.

## Consistency, including recalculations and time-series

26. Liechtenstein has undertaken a number of recalculations for their 2021 submission in the energy, IPPU, agriculture and waste sectors for the whole time series. However, descriptions have only been provided for mayor recalculations in subcategories 1A2gvii, 1A4cii, 3B and 5B1. During the course of the review, the Party explained that from the 2022 submission onwards Liechtenstein aims to provide more detailed description of the recalculations. The ERT recommends Liechtenstein to provide additional detail on the rational for all key source recalculations as well as the impacts of the changes on the national estimates and time series in its future IIR submissions.

## Comparability

27. The ERT notes that the inventory of Liechtenstein is generally comparable with those of other reporting Parties. The allocation of source categories follows that of the EMEP/UNECE reporting Guidelines. The ERT encourages Liechtenstein to continue with this approach to national inventory calculation and provide information on methodologies, emission factors and activity data in future submissions as well as information on allocation of emissions to further improve comparability.

## Accuracy and uncertainties

28. Liechtenstein has not compiled uncertainty estimates for their UNECE submission. During the review, Liechtenstein indicated that it would investigate options for undertaking uncertainty evaluations and will evaluate the time and effort needed.

The ERT recommends Liechtenstein to compile at least a Tier 1 estimates for future submissions.

## Verification and quality assurance/quality control approaches

29. Liechtenstein has developed a quality assurance/quality control (QA/QC) plan in accordance with the United Nations Framework Convention on Climate Change (UNFCCC) and states in its IIR (p18) that the main part of the assessment area is also applicable for air pollutants. The ERT encourages Liechtenstein to provide detailed information on its QA/QC plan for its air emission inventory in future submissions.

30. The ERT commends Liechtenstein on its general quality assurance/quality control (QA/QC) activities. However, sector specific checks are not documented in the IIR. ERT encourages Liechtenstein to provide information on sector specific information on QA/QC procedures in future submissions.

## Reporting of Condensable

31. The Party did not provide information on condensable components in its IIR. The ERT recommends Liechtenstein to provide information on condensable in future submissions, following the structure of Annex II (Recommended Structure for Informative Inventory Report) of the reporting guidelines.

# FOLLOW-UP TO PREVIOUS REVIEWS

32. Liechtenstein did not provide responses in its IIR to the questions identified in previous reviews. During the review, the ERT noted that several recommendations were included since the last review in 2017. The ERT recommends Liechtenstein to further include recommendations resulting from reviews in its inventory and provide information on their implementation in its IIR.

# AREAS FOR IMPROVEMENTS IDENTIFIED BY LIECHTENSTEIN

33. The IIR identifies several areas for improvement. In its response to previous reviews and review stages this year, Liechtenstein indicates that it is working to improve its inventory. These include:

a. Correction of a formula error in $NH_3$ 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 $NH_3$ emissions).

b. Re-evaluation of activity data and emission factors of wood combustion in categories1A4ai & 1A4bi.

c. Re-evaluation of activity data and emission factors in sector 3 Agriculture.

## TECHNICAL CORRECTIONS CONSIDERED AND OR CALCULATED BY ERT

34. The IIR identified no significant inconsistencies in the inventories and does not propose technical corrections to the country.

# PART B: RECOMMENDATIONS FOR IMPROVEMENTS TO THE PARTY

## CROSS CUTTING IMPROVEMENTS IDENTIFIED BY THE ERT

35. The ERT identifies the following cross-cutting issues for improvement:

a) A detailed description of applied methodologies, data sources, choice of emission factors and activity data for all categories in the IIR.

b) Apply a Tier 2 or higher for all Key Categories.

c) The use of the latest available EMEP/EEA air pollutant emission inventory guidebook 2019.

d) The use of the latest NFR 19-1 tables for its submission.

e) The conduction of a key category analysis also for other pollutants, than for those presented in current inventory.

f) To perform and present an uncertainty analysis and use it to as a tool to focus on planned improvements to the key categories.

g) The provision of detailed information on its QA/QC plan for its air emission inventory in future submissions.

h) To provide information on condensable for all relevant categories.

i) The provision of projections, LPS – and gridded data.

j) The provision on information on recalculations throughout all sectors.

k) The increase of capacities for the air pollution inventory team in order to manage transparent, complete, comparable, consistent and accurate inventory within deadlines set up in the UNECE reporting Guidelines.

l) Recommended improvements relating to specific source categories are presented in the relevant sector sections of this report.

36. During the review Liechtenstein provided a response to the initial questions. Liechtenstein agreed that the IIR contains little information on the methods (activity data, emission factors, methodologies and assumptions used). Liechtenstein further explained, that due to the limited resources, Liechtenstein is not able to provide the detailed information in the IIR that would be required to conduct a comprehension review. Liechtenstein is planning to improve the IIR step by step for the upcoming submissions, also on the basis of the issues raised during the 2017 and 2021 reviews.

37. For the 2022 submission Liechtenstein plans to analyse and evaluate which improvements are possible to implement. The ERT welcomes the information of planned improvements and encourages Liechtenstein to ensure relevant resources are available in the future to implement all listed recommendations.

# SECTOR SPECIFIC RECOMMENDATIONS FOR IMPROVEMENTS IDENTIFIED BY ERT

# ENERGY

## Review Scope

| Pollutants Reviewed | | $SO_2$, $NO_x$, NMVOC, $NH_3$, $PM_{10}$ & $PM_{2.5}$, Cd, Hg, Pb, Dioxin, PAH | | |
|---|---|---|---|---|
| **Years** | | 1990 – 2019 | | |
| **Code** | **Name** | **Reviewed** | **Not Reviewed** | **Recommendation Provided** |
| 1A1a | Public electricity and heat production | x | | x |
| 1A1b | Petroleum refining | NO | | |
| 1A1c | Manufacture of solid fuels and other energy industries | NO | | |
| 1A2a | Iron and steel | NO | | |
| 1A2b | Non-ferrous metals | NO | | |
| 1A2c | Chemicals | NO | | |
| 1A2d | Pulp, Paper and Print | NO | | |
| 1A2e | Food processing, beverages and tobacco | x | | x |
| 1A2f | Stationary combustion in manufacturing industries and construction: Non-metallic minerals | x | | x |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: Other | x | | x |
| 1A3ei | Pipeline transport | NO | | |
| 1A3eii | Other | NO | | |
| 1A4ai | Commercial/institutional: Stationary | x | | x |
| 1A4bi | Residential: Stationary | x | | x |
| 1A4ci | Agriculture/Forestry/Fishing: Stationary | NO | | |
| 1A5a | Other stationary (including military) | NO | | |
| 1B1a | Fugitive emission from solid fuels: Coal mining and handling | NO | | |
| 1B1b | Fugitive emission from solid fuels: Solid fuel transformation | NO | | |
| 1B1c | Other fugitive emissions from solid fuels | NO | | |
| 1B2ai | Fugitive emissions oil: Exploration, production, transport | NO | | |
| 1B2aiv | Fugitive emissions oil: Refining / storage | NO | | |
| 1B2av | Distribution of oil products | x | | x |
| 1B2b | Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other) | x | | x |
| 1B2c | Venting and flaring (oil, gas, combined oil and gas) | NO | | |
| 1B2d | Other fugitive emissions from energy production | NO | | |
| Note: Where a sector has been partially reviewed (e.g. some of the NFR codes) please indicate which have and which have not in the respective columns. | | | | |

## General recommendations on cross cutting issues

### Transparency

38. Liechtenstein has provided a generally transparent emissions inventory. Estimates are provided at the most detailed level for all energy sectors. Liechtenstein's methodology, activity data and choice of emission factors are only described on a detailed level for subcategory 1A4 in the IIR. Information on methodology, activity data and choice of emission factors for all other subcategories of the Energy Sector are very limited, which does not allow a fully assessment of the inventory in course of the review. The ERT reiterates its recommendation from previous reviews to include more detail on methodology, activity data and emission factors to estimate emissions in order to improve transparency of its inventory.

39. The ERT noted that Liechtenstein uses notation keys in line with the EMEP/EEA Guidebook in cases, where no emissions from a subcategory are reported. However, a description on allocation of emissions (use of notation key 'IE') is not provided by the party. The ERT recommends Liechtenstein to transparently describe the allocation of emissions in its IIR.

### Completeness

40. The ERT considers the Energy sector to be generally complete and comprehensive for the years 1990 to 2019.During the review the ERT recognized that information on activity data is not provided by the Party. The ERT reiterates its recommendation from previous reviews to provide activity data in future submissions.

41. The ERT noted that Liechtenstein does not report PCB emissions, which would be expected to occur in categories such as 1A1a, 1A2f, 1A2gviii, 1A4ai and 1A4bi. Liechtenstein clarified during the review that due to limited personal resources the Party does not dispose of detailed statistical data on all sectors and will keep it on the planned improvements list. The ERT recommends Liechtenstein to calculate PCB emissions from these sources.

### Consistency including recalculation and time series

42. Liechtenstein has recalculated its inventory for almost all sectors in the year 2021. However, the IIR does only include information on major recalculations in subcategories 1A2gvii and 1A4cii. The ERT recommends Liechtenstein to provide more detailed explanation of recalculations, including the rational, the impact on the sector and implication to trends for the Energy sector in its IIR.

### Comparability

43. Although the methodology is not transparently described in Liechtenstein's IIR, the ERT assumes that Liechtenstein's inventory estimates for the Energy Sector have been calculated in a manner broadly consistent with the methodologies described in the EMEP/EEA Guidebook. Information on methodology for key categories is very limited or missing, the selection of emission factors for higher Tier methods are not clearly described nor justified. The ERT reiterates its recommendation from previous reviews, that Liechtenstein improves its description in the IIR of how the methods

applied are consistent with the EMEP/EEA Guidelines, specifically for higher tier methods applied to key categories, in order to demonstrate that the inventory submission is comparable to those of other Parties.

### Accuracy and uncertainties

44. The ERT encourages Liechtenstein to undertake uncertainty analysis for the Energy Sector to help inform the improvement process and to provide an indication of the reliability of the inventory data.

45. Liechtenstein references in its IIR to the QA/QC plan included in the Party's Greenhouse gas inventory. The NIR includes basic QA/QC checks, the use of checklists and the findings are documented and checked to confirm that checks have been performed by the Quality Manager in the Office of Environment. During the review, the Party clarified that annual data and informative inventory report are developed by a working group of 4 persons. Each year, last year's submission and planned improvements are discussed. Before submission, data and report are being checked from a person not involved in detailed compilation (four eyes principle). The ERT encourages the Party to implement sector specific OA/QC procedures for the Energy Sector and describe the process in the IIR on the wider QA/QC system, including roles and responsibilities and checks specific to the LRTAP submission.

### Condensable

46. The Party did not provide explanatory information on condensable component of PM for categories 1A1a, 1A2f, 1A2gviii, 1A4ai and 1A4bi. In the IIR, there is no information of whether $PM_{2.5}$ includes or excludes the condensable component. The ERT encourages Liechtenstein to include such information in its next submission.

### Improvement

47. The ERT commends Liechtenstein for its improvements undertaken since the last review. The description of methodology and choice of emission factors in subcategory 1A4 as well as the estimation of NMVOC emissions in subcategory 1B2av are implemented in the inventory. The ERT notes the Parties' intention to re-evaluate data and emission factors of wood combustion in categories 1A4ai & 1A4bi. During the review, the Party also indicated to provide information on allocation of emissions from subcategory 1A2e and evaluate the possibilities to estimate PCB emissions from various subcategories of the Energy sector in future submissions.

48. The ERT encourages Liechtenstein to implement planned improvements in future submissions.

## Sub-Sector Specific Recommendations

### Category issue 1: 1.A.1.a Public Electricity and Heat Production - All Pollutants

49. Category 1A1a is key category (trend) for $PM_{10}$-, DIOX-, Cd- and Hg-emissions. The IIR does not provide any further information on activity data, methodology or

applied EFs. During the review, Liechtenstein clarified, that activity data stems solely from gas use of combined heat and power plants [GJ/year]. EFs are based on EMIS. The Party was not able to provide further information on methodology, emission factors and activity data during the course of this review due to limited resources. The ERT reiterates its recommendation from the previous review to include information on activity data, choice of emission factors and methodology for this key category in upcoming submissions.

### Category issue 2: 1.A.2 Industrial Combustion - All Pollutants

50. As stated in the Liechtenstein IIR (p32), subcategory 1A2gviii is key category for NOx (trend) and SOx (level) emissions. The IIR does not provide any further information on methodology, choice of emission factors or activity data. The ERT reiterates its recommendation from the previous review to include this information in future submissions to enhance transparency.

51. The ERT noted that emissions from subcategory 1A2e are reported as included elsewhere (notation key 'IE'). The IIR does not provide information, in which subcategory emissions from 1A2e are included. During the review Liechtenstein clarified, that occurring emissions from this subcategory are included in subcategory 1A2gviii. The ERT recommends Liechtenstein to provide this information in its IIR.

### Category issue 3: 1.A.4.ai Commercial Combustion and 1.A.4.bi Residential Combustion – All Pollutants

52. The ERT identified that Liechtenstein states in its IIR (p34) that 'the emission factors for TSP, NOx, 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].' and '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.' The ERT compared the provided EFs for the year 2019 in Table 3.4-1 (LI IIR p34) with the range of EFs provided in Switzerland's IIR (CH IIR, Table 3-32 for 1A4ai and Table 3-33 for 1A4bi, p123f) and noted that applied EFs for wood combustion in Liechtenstein for the mentioned pollutants show a big difference to the EFs provided by Switzerland: For category 1A4ai, applied EF for NOx emissions from this source is 25% higher, EF for CO is 37% lower, EF for NMVOC is 81% lower, EF for $SO_2$ is 72% higher, EF for TSP is 42% higher, EF for $PM_{10}$ is 47% higher than EFs provided by Switzerland. For category 1A4bi, applied EFs for CO emissions are 48% higher, EF for NMVOC emissions are 671% higher, EF for TSP emissions is 48% higher and EF for $PM_{10}$ emissions is 53% higher than EFs provided by Switzerland. Liechtenstein clarified during the review that the mentioned differences in EF can occur due to disparities between the allocation of combustion units as well as firewood types (e.g. pellet, log wood) in Switzerland and Liechtenstein. It is planned to re-evaluate the activity data (including the share of combustion units and firewood types) and emission factors in the next submission. The ERT recommends Liechtenstein to provide explanations and justifications that underpin the choice of emission factors to calculate TSP, $PM_{10}$, NOx, NMVOC, $SO_2$, $NH_3$ and CO emissions from subcategories 1A4ai and 1A4bi in the IIR.

53. The ERT noted that subcategory 1A4ai is key category for Pb, Hg, Cd, DIOX, PAH and HCB emissions, subcategory 1A4bi is key category for Hg, Cd, DIOX, PAH and HCB emissions. The IIR does not provide any information on methodology, activity data nor the choice of emission factors. The ERT recommends Liechtenstein to include this information in its IIR to enhance transparency.

### Category issue 4: 1.B Fugitive emissions – NMVOC

54. As stated in Liechtenstein's IIR (p35), subcategory 1B2av is key category for NMVOC emissions. The Party does not provide any further information on methodology, activity data nor choice of emission factors. During the review, the ERT was not able to determine, whether a higher Tier method was being used to calculate NMVOC emissions from to this key category. The ERT recommends Liechtenstein to provide this information in its future submissions to enhance comparability of submissions with other Parties as well as to improve the transparency of the inventory.

55. Liechtenstein does report NMVOC emissions from subcategory 1B2b. The IIR does not provide further information on methodology, activity data nor applied emission factors to calculate NMVOC emissions from this source. The ERT encourages Liechtenstein to include this information in future submissions.

# TRANSPORT

## Review Scope

| Pollutants Reviewed | | All | | |
|---|---|---|---|---|
| Years | | 1990 – 2019 | | |
| **Code** | **Name** | **Reviewed** | **Not Reviewed** | **Recommendation Provided** |
| 1A2gvii | Mobile Combustion in manufacturing industries and construction | x | | |
| 1A3ai(i) | International aviation LTO (civil) | x | | x |
| 1A3ai(ii) | International aviation cruise (civil) | x | | x |
| 1A3aii(i) | Domestic aviation LTO (civil) | x | | x |
| 1A3aii(ii) | Domestic aviation cruise (civil) | x | | x |
| 1A3bi | Road transport: Passenger cars | x | | x |
| 1A3bii | Road transport: Light duty vehicles | x | | x |
| 1A3biii | Road transport: Heavy duty vehicles and buses | x | | x |
| 1A3biv | Road transport: Mopeds & motorcycles | x | | x |
| 1A3bv | Road transport: Gasoline evaporation | x | | x |
| 1A3bvi | Road transport: Automobile tyre and brake wear | x | | x |
| 1A3bvii | Road transport: Automobile road abrasion | x | | x |
| 1A3c | Railways | x | | |
| 1A3di(ii) | International inland waterways | x | | |
| 1A3dii | National navigation (shipping) | x | | |
| 1A4aii | Commercial/institutional: Mobile | x | | |
| 1A4bii | Residential: Household and gardening (mobile) | x | | |
| 1A4cii | Agriculture/Forestry/Fishing: Off-road vehicles and other machinery | x | | x |
| 1A4ciii | Agriculture/Forestry/Fishing: National fishing | x | | |
| 1A5b | Other, Mobile (including military, land based and recreational boats) | x | | |
| 1A3di(i) | International maritime navigation | x | | |
| 1A3 | Transport (fuel used) | x | | |
| Note: Where a sector has been partially reviewed (e.g. some of the NFR codes) please indicate which have and which have not in the respective columns. | | | | |

## General recommendations on cross cutting issues

### Transparency

56. The ERT noted that only limited information on the emission factors and activity data is provided in the 2021 IIR, as in previous IIR submissions. ERT welcomes the plan of the Party to provide activity calculations in the transport sector as an improvement. In general, providing more details on the methodology, emission factors,

and activity data used to calculate transport emissions is desirable to enhance the transparency of the transport sector emissions inventory.

### Completeness

57. The ERT considers the transport sector of Liechtenstein's inventory to generally be complete but there is still room for improvement with some recommendations for enhancing the completeness of the inventory provided below.

### Consistency including recalculation and time series

58. Liechtenstein provides explanations and descriptions of key trends in its IIR. Moreover, the Party also provided satisfactory explanations for most of the questions raise during the 2021 Stage 3 review process related to consistency of time series.

### Comparability

59. No activity data are provided either in the Annex I template or the IIR. Hence, it is not possible to calculate IEFs for comparison with other countries. Nevertheless, the ERT performed a comparison of the transport sector emissions of Liechtenstein to those of other countries.

### Accuracy and uncertainties

60. Liechtenstein has not provided a quantitative uncertainty assessment for any of the pollutants (IIR 2021, p. 18). The ERT encourages the Party to undertake an uncertainty analysis to help inform the improvement process and to provide an indication of the reliability of the inventory data.

61. Liechtenstein has performed QA/QC activities, which are presented in the NIR for the UNFCCC. Nevertheless, the ERT encourages the Party to describe QA/QC activities in the IIR as well as sector-specific QA/QC procedures.

### Improvement

62. The ERT encourages Liechtenstein to further improve its inventory by considering the recommendations of the previous 2017 and current Stage 3 reviews.

## Sub-Sector Specific Recommendations

### Category issue 1: 1A3aii(i) Domestic aviation LTO (civil) - All Pollutants

63. The ERT noted that no information on the emission factors and activity data is provided in IIR 2021, similar as in previous IIR submissions. Liechtenstein answered that the only emission source in this category is a heliport and it is planned to include this information in the IIR in the next submission. The ERT welcomes this plan and recommends including future planned improvements in IIR (IIR, p. 43).

### Category issue 2: 1A3b, 1A4cii, Road transport, Agriculture/Forestry/ Fishing: Off-road vehicles and other machinery - All Pollutants

64. The ERT noted that no information on the emission factors and activity data is provided in the IIR 2021, similar as in previous IIR submissions. Liechtenstein answered that due to limited resources the Part is not able to provide detailed information. The ERT recommends including this improvement in future IIR when possible.

### Category issue 3: 1A3b Road transport - All Pollutants

65. According to the 'Guidelines for Reporting Emissions and Projections Data under the Convention on Long-range Transboundary Air Pollution' (page 9, Footnote 12) Liechtenstein's Road transport emissions should be calculated based on fuels sold. During the current Stage 3 review process, Liechtenstein informed the ERT that those emissions are estimated based on fuel used and that a change to an estimation based on fuels sold will be analysed.

### Category issue 4: 1A3bi-iii, 1A3bvi-vii Road transport: Passenger cars, Light duty vehicles, Heavy duty vehicles and buses, Automobile tyre and brake wear, Automobile road abrasion - BC

66. In Liechtenstein's NFR tables, for 1A3bi-iii and 1A3bvi-vii, $PM_{2.5}$, $PM_{10}$ and TSP emissions are reported but BC emissions are reported using the Notation Key "NA" (Not Applicable). During the current Stage 3 review process, Liechtenstein informed the ERT that, as there are no BC emission factors listed in their source (HBEFA), the notation key NA is used. The ERT recommends using the information of BC fractions of PM given in the EMEP/EEA Guidebook (2019). For exhaust emissions, the Tier 2 values are presented in section "*1.A.3.b.i, 1.A.3.b.ii, 1.A.3.b.iii, 1.A.3.b.iv Passenger cars, light commercial trucks, heavy-duty vehicles including buses and motor cycles*", Table 3-92. For non-exhaust emissions, the values are presented in section "*1.A.3.b.vi Road transport: Automobile tyre and brake wear, 1.A.3.b.vii Road transport: Automobile road abrasion*", note of Table 3-4 for tyre wear and note of Table 3-6 for brake wear.

### Category issue 5: 1A3biv Road transport: Mopeds & motorcycles - $PM_{2.5}$, $PM_{10}$, TSP, BC

67. In Liechtenstein's NFR tables, it is mentioned $PM_{2.5}$, $PM_{10}$, TSP, BC emissions are "NA" (Not Applicable) for 1A3biv (Mopeds & motorcycles). During the current Stage 3 review process, Liechtenstein informed that it is planned to estimate related during the 2022 submission. The ERT welcomes this plan and recommends including future planned improvements in the IIR (IIR, p. 43).

# INDUSTRIAL PROCESSES

## Review Scope

| Pollutants Reviewed | | All pollutants | | |
|---|---|---|---|---|
| **Years** | | 1990 – 2019 + (Protocol Years) | | |
| **Code** | **Name** | **Reviewed** | **Not Reviewed** | **Recommendation Provided** |
| 2A1 | Cement production | NO | | |
| 2A2 | Lime production | NO | | |
| 2A3 | Glass production | NO | | |
| 2A5a | Quarrying and mining of minerals other than coal | NO | | |
| 2A5b | Construction and demolition | NO | | X |
| 2A5c | Storage, handling and transport of mineral products | NO | | |
| 2A6 | Other mineral products | NO | | |
| 2B1 | Ammonia production | NO | | |
| 2B2 | Nitric acid production | NO | | |
| 2B3 | Adipic acid production | NO | | |
| 2B5 | Carbide production | NO | | |
| 2B6 | Titanium dioxide production | NO | | |
| 2B7 | Soda ash production | NO | | |
| 2B10a | Chemical industry: Other | NO | | |
| 2B10b | Storage, handling and transport of chemical products | NO | | |
| 2C1 | Iron and steel production | NO | | |
| 2C2 | Ferroalloys production | NO | | |
| 2C3 | Aluminium production | NO | | |
| 2C4 | Magnesium production | NO | | |
| 2C5 | Lead production | NO | | |
| 2C6 | Zinc production | NO | | |
| 2C7a | Copper production | NO | | |
| 2C7b | Nickel production | NO | | |
| 2C7c | Other metal production | NO | | |
| 2C7d | Storage, handling and transport of metal products | NO | | |
| 2D3b | Road paving with asphalt | X | | X |
| 2D3c | Asphalt roofing | X | | |
| 2H1 | Pulp and paper industry | NO | | |
| 2H2 | Food and beverages industry | X | | X |
| 2H3 | Other industrial processes | X | | |
| 2I | Wood processing | X | | X |
| 2J | Production of POPs | NO | | |
| 2K | Consumption of POPs and heavy metals (e.g. electrical and scientific equipment) | NO | | |
| 2L | Other production, consumption, storage, transportation or handling of bulk products | NO | | |
| Note: Where a sector has been partially reviewed (e.g. some of the NFR codes please indicate which have and which have not in the respective columns. | | | | |

## General recommendations on cross cutting issues

### Transparency

68. Liechtenstein provided emission data for the whole period 1990-2019 for five source categories. Activity data have not been provided for any of those categories.

69. During the review, Liechtenstein did not provide the ERT with activity data as requested but rather referred to the Swiss inventory.

70. The IIR provided by Liechtenstein does not give enough information regarding the methodology used to estimate emissions.

71. Liechtenstein did not provide a detailed and generally transparent emission inventory for the industrial processes sector. Not enough information about methodologies used has been made available to the ERT before and during the review. Liechtenstein has only referred to the Swiss inventory when the ERT requested information about methodologies, AD and EF. The ERT recommends Liechtenstein to report a transparent IIR including detailed descriptions of methodologies, emission factors and activity data used to estimate emissions for all source categories for the next submission.

### Completeness

72. Liechtenstein did not provide any activity data in the NFR table I. Liechtenstein provided emission data for the whole period 1990-2019 for only five source categories.

73. The ERT considers the inventory for industrial processes sector reported by Liechtenstein to be incomplete.

### Consistency including recalculation and time series

74. Liechtenstein describes recalculations in the IIR. No recalculation has been made for the industrial processes sector.

75. Liechtenstein has reported emission data for five different source categories in the reported NFR tables. Liechtenstein uses the notation keys ‘NO’ for all other source categories. As not enough information regarding methodologies is provided in the IIR and as Liechtenstein did not provide the ERT with the necessary information during the review, the consistency of the inventory could not be assessed by the ERT.

### Comparability

76. Liechtenstein uses the Swiss inventory to estimate emissions from industrial processes based on emission factors per capita. As not enough information regarding methodologies has been provided by Liechtenstein to the ERT before and during the review, the ERT does not consider the inventory comparable with other countries.

### Accuracy and uncertainties

77. As not enough information regarding methodologies has been provided to the ERT before and during the review, the accuracy of the inventory of Liechtenstein could not be assessed by the ERT.

### Condensable

78. Liechtenstein did not provide any information on condensable component of PM for the industrial processes sector. The ERT did not find any information of whether $PM_{2.5}$ includes or excludes the condensable component in the IIR. The ERT recommends Liechtenstein to include such information in the next submission.

### Improvement

79. The ERT noted that Liechtenstein does not include specific improvement plan for the industrial sector. The ERT recommends Liechtenstein to implement a specific improvement plan for the industrial sector including recommendations from the ERT made during the 2017 and 2021 review.

## Sub-Sector Specific Recommendations

### Category issue 1: 2.A 5.b- Construction and demolition-TSP, $PM_{10}$, $PM_{2.5}$

80. The ERT noted that Liechtenstein uses the notation key NO to report emissions from the category 2A5b in the table NFR I. As this activity occurs in Liechtenstein, the notation key *Not Occurring* shall not be used. The ERT recommends Liechtenstein to estimate particle emissions from 2A5b or use the notation "NE", *Not Estimated*.

### Category issue 2: 2.D.3.b- Road paving with asphalt - NMVOC

81. The ERT noted in the NFR table Annex I reported by Liechtenstein that NMVOC emissions from road paving with asphalt have decreased by 99% between 1990 and 1991. During the review, Liechtenstein explained that it is due to an error in the estimation of NMVOC emissions which will be corrected in the next submission but did not provide the ERT with a corrected time series. The ERT recommends Liechtenstein to report a corrected time series with the next submission.

### Category issue 3: 2.H.2- Food and beverages industry – PCDD/PCDF, NMVOC

82. The ERT noted that Liechtenstein reported PCDD/PCDF emissions in the submitted NFR table Annex I for the source category 2H2. The ERT did not find any explanation in the IIR for emissions from these pollutants. The 2019 EMEP/EEA Guidebook does not provide any methodology for these pollutants. During the review, Liechtenstein explained to the ERT that emissions come from smokehouses and are calculated based on the Swiss inventory and an emission factor per capita. The ERT recommends Liechtenstein to include this information in the IIR for the next submission to improve the transparency of its inventory.

83. The ERT noted in that 2H2 is a key category for NMVOC emissions. Emissions have been estimated by Liechtenstein using the Swiss inventory and an emission factor per capita. The ERT recommends Liechtenstein to estimate NMVOC emissions using a higher Tier method since 2H2 is a key category for NMVOC emission.

## Category issue 4: 2.I- Wood processing – Particles

84. The ERT noted that Liechtenstein reported particle emissions in the submitted NFR table Annex I for the category 2I. The ERT noted in the IIR that particle emissions are estimated using the Swiss inventory based on emission factors per capita. The ERT noted also that emissions from $PM_{10}$, $PM_{2.5}$ and TSP follow different trends during the period 1990-2003 despite common activity data. During the review Liechtenstein explained the differences in EF trend by improvement technology but did not provide the ERT with information about these technologies as requested during the review but referred to the Swiss inventory. The ERT recommends Liechtenstein to justify the trend of particle emissions and to provide detailed technology specifications in the IIR for the next submission.

85. The ERT noted in that 2I is a key category for $PM_{10}$ emissions. Emissions have been estimated by Liechtenstein using the Swiss inventory and an emission factor per capita. The ERT recommends Liechtenstein to estimate $PM_{10}$ emissions using a higher Tier method since 2I is a key category for $PM_{10}$ emissions.

# SOLVENTS

## Review Scope

| Pollutants Reviewed | | $SO_2$, NOx, NMVOC, $NH_3$, $PM_{10}$ & $PM_{2.5}$ | | |
|---|---|---|---|---|
| **Years** | | 1990 – 2019 + (Protocol Years) | | |
| **Code** | **Name** | **Reviewed** | **Not Reviewed** | **Recommendation Provided** |
| 2D3a | Domestic solvent use including fungicides | X | | X |
| 2D3d | Coating applications | X | | X |
| 2D3e | Degreasing | X | | X |
| 2D3f | Dry cleaning | X | | X |
| 2D3g | Chemical products | X | | X |
| 2D3h | Printing | X | | X |
| 2D3i | Other solvent use | X | | X |
| 2G | Other product use | X | | |
| Note: Where a sector has been partially reviewed (e.g. some of the NFR codes please indicate which have and which have not in the respective columns. | | | | |

## General recommendations on cross cutting issues

### Transparency

86. Liechtenstein provided emission data for the whole period 1990-2019. Activity data have not been provided for any of the category within the solvent sector.

87. The IIR provided by Liechtenstein does not give enough information regarding the methodology used to estimate emissions.

88. During the review, Liechtenstein did not provide the ERT with more information regarding the methodology or the activity data as requested but rather referred to the Swiss inventory.

89. Liechtenstein did not provide a detailed and generally transparent emission inventory for the solvent sector. Not enough information about methodologies used has been made available to the ERT before and during the review. Liechtenstein has only referred to the Swiss inventory when the ERT requested information about methodologies, AD and EF. The ERT recommends Liechtenstein to report a transparent IIR including detailed descriptions of methodologies, emission factors and activity data used to estimate emissions for all source categories for the next submission.

### Completeness

90. Liechtenstein provided emission data for the whole period 1990-2019 for all source categories within the solvent sector. Liechtenstein did not provide any activity data in the NFR table I.

### Consistency including recalculation and time series

91. Liechtenstein describes recalculations in the IIR. No recalculation has been made for the solvent sector.

92. Liechtenstein did not provide the ERT with enough information regarding methodologies used to estimate emissions from the solvent sector before and during the review. The consistency of the inventory could therefore not be assessed by the ERT.

### Comparability

93. Liechtenstein uses the Swiss inventory to estimate emissions from the solvent sector based on emission factors per capita. As not enough information regarding methodologies has been provided by Liechtenstein to the ERT before and during the review, the ERT does not consider the inventory comparable.

### Accuracy and uncertainties

94. As not enough information regarding methodologies has been provided to the ERT before and during the review, the accuracy of the inventory of Liechtenstein could not be assessed by the ERT.

### Condensable

95. Liechtenstein did not provide any information on condensable component of PM for the industrial processes sector. The ERT did not find any information of whether $PM_{2.5}$ includes or excludes the condensable component in the IIR. The ERT recommends Liechtenstein to include such information in the next submission.

### Improvement

96. The ERT noted that Liechtenstein does not include specific improvement plan for the solvent sector. The ERT recommends Liechtenstein to implement a specific improvement plan for the solvent sector including recommendations from the ERT.

## Sub-Sector Specific Recommendations

### Category issue 1: 2.D.3.a- Domestic solvent use including fungicides, 2.D.3.d- Coating applications, 2.D.3.e- Degreasing, 2.D.3.f- Dry cleaning, 2.D.3.g- Chemical products, 2.D.3.h- Printing, 2.D.3.i- Other solvent use - NMVOC

97. The ERT noted that Liechtenstein reported NMVOC emissions in the submitted NFR table Annex I for the categories 2D3a, 2D3d, 2De, 2D3f, 2D3g, 2D3h, 2D3i. The ERT noted in the IIR that NMVOC emissions are estimated using the Swiss inventory based on emission factors per capita. The ERT noted also that these categories are key categories for NMVOC emissions. The ERT recommends Liechtenstein to estimate NMVOC emissions from these categories using a higher Tier method since they are key categories for NMVOC emissions.

# AGRICULTURE

## Review Scope

| Pollutants Reviewed | | $SO_2$, NOx, NMVOC, $NH_3$, $PM_{10}$ & $PM_{2.5}$ | | |
|---|---|---|---|---|
| **Years** | | 1990 – 2015 + (Protocol Years) | | |
| **Code** | **Name** | **Reviewed** | **Not Reviewed** | **Recommendation Provided** |
| 3B1a | Dairy cattle | x | | x |
| 3B1b | Non-dairy cattle | x | | x |
| 3B2 | Sheep | x | | x |
| 3B3 | Swine | x | | |
| 3B4a | Buffalo | | NO | |
| 3B4d | Goats | x | | x |
| 3B4e | Horses | x | | x |
| 3B4f | Mules and asses | x | | x |
| 3B4gi | Laying hens | x | | x |
| 3B4gii | Broilers | x | | x |
| 3B4giii | Turkeys | | NO | |
| 3B4giv | Other poultry | x | | x |
| 3B4h | Other animals | | NO | |
| 3Da1 | Inorganic N-fertilizers (includes also urea application) | x | | |
| 3Da2a | Animal manure applied to soils | | x | |
| 3Da2b | Sewage sludge applied to soils | | NO | |
| 3Da2c | Other organic fertilisers applied to soils (including compost) | | x | |
| 3Da3 | Urine and dung deposited by grazing animals | | x | |
| 3Da4 | Crop residues applied to soils | x | | |
| 3Db | Indirect emissions from managed soils | x | | x |
| 3Dc | Farm-level agricultural operations including storage, handling and transport of agricultural products | x | | |
| 3Dd | Off-farm storage, handling and transport of bulk agricultural products | | NO | |
| 3De | Cultivated crops | | NO | |
| 3Df | Use of pesticides | | NO | x |
| 3F | Field burning of agricultural residues | | NO | |
| 3I | Agriculture other | | NO | |
| 11A | Volcanoes | | NO | |
| 11B | Forest fires | | NO | |
| Note: Where a sector has been partially reviewed (e.g. some of the NFR codes please indicate which have and which have not in the respective columns. | | | | |

## General recommendations on cross cutting issues

### Transparency

98. The ERT noticed that the transparency of the agriculture inventory described in the IIR could be improved. The IIR only contains a short description of the methods, and emission factors used for the calculation of agriculture emissions. In the IIR, on page 39 emission factors used for NH3 manure management are shown but no other emission factors are mentioned in the text or in a table. Information on activity data is missing from the IIR and the reporting Annex I Tables while these data are available from the GHG National Inventory Report 2021. The ERT reiterates its recommendation from previous reviews to include more detail on methodology, activity data and emission factors to estimate emissions to improve transparency of the inventory.

99. The emission trends in the agriculture sector are not described in the IIR. The ERT recommends that Liechtenstein describes the emission trends to improve the quality and transparency of its inventory in its next submission.

### Completeness

100. The Party does not include AD used in the inventory in this submission. This limited information did not allow for a full assessment of the inventory during this review. The ERT reiterates its recommendation from previous reviews to provide AD for different animal categories and fertilizers used for estimating emissions of the agriculture sector for the whole time series in future reporting.

### Consistency including recalculation and time series

101. There is no reference to recalculations for the agriculture sector in the IIR. The ERT recommends Liechtenstein to include explanations for recalculations in its IIR.

### Comparability

102. As Liechtenstein does provide little information on methodologies and EFs it is not possible to check the accuracy of calculations and to compare EFs or IEFs with other countries. The ERT recommends Liechtenstein to provide more detailed information about the used methodologies and EF in the IIR in future submissions.

### Accuracy and uncertainties

103. The ERT recommends the Party to undertake uncertainty analysis for the Agriculture Sector and to describe the outcome in the IIR.

104. The Party indicates to have some basic QA/QC checks but no further information is given in the IIR. The ERT recommends Liechtenstein to implement sector specific OA/QC procedures for Agriculture and to describe the procedure in the IIR.

### Condensable

105. The Party did not provide explanatory information on condensable component of PM for Agriculture. The ERT encourages Liechtenstein to include such information in the next submission.

### Improvement

106. The ERT commends Liechtenstein for its improvement in reporting NOx and $NH_3$ emissions from 3Da1 in 2021.

107. Two planned improvements are mentioned for the Agriculture sector in Liechtenstein's IIR for the next submission:

- Correction of a formula error in $NH_3$ 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 $NH_3$ emissions)
- Re-evaluation of activity data and emission factors in sector 3 Agriculture

108. The ERT encourages Liechtenstein to plan improvements for the Agriculture sector regarding completeness and transparency of the inventory.

## Sub-Sector Specific Recommendations

### Category issue 1: 3.B Manure management - $NH_3$

109. NOx emissions from 3B are reported as "NO" with no explanation in the IIR as to why NOx emissions are not occurring in Liechtenstein. The EMEP/EEA Guidebook provides Tier 1 emission factors to estimate NOx emissions. During the review Liechtenstein explained that it is assumed that no NOx emissions are generated during manure management in Liechtenstein. They further indicated that this would be checked in more detail in the course of the 2022 submission. The ERT encourages Party to provide information on this check in its net IIR.

110. The ERT questioned the significant decrease of about 7 MG (> 50%) of $NH_3$ emissions between 2003 and 2004. Liechtenstein explained that the underlying reason behind this significant dip is a change in livestock number in 2004. The ERT recommends the Party to provide activity data in explain the reason for this significant decrease in the next submission.

111. The ERT noticed that several livestock categories of 3B are key categories but do not follow a Tier 2 approach yet. The EMEP/EEA Guidebook is clear about key categories in 3B: If proportions of livestock sub-categories on different manure management systems are available, a Tier 2 approach should be used to estimate emissions. If this information is not available, efforts to collect this data need to be undertaken. The ERT recommends the Party to clarify if data on different manure management systems is available and for all subcategories for which this is the case change the reporting to a Tier 2 approach. If the necessary data is not available, the ERT encourages the Party to include an explanation in future reporting.

112. Party is encouraged to use EMEP 2019 Guidebook emission factors for calculating emissions from NMVOC and $PM_{10}$ in sector 3B.

### Category issue 2: 3.D.1 Agricultural Soils - $NH_3$

113. The ERT recommends Liechtenstein to clarify the correctness of emission estimates for 3Db and adjust its calculations where necessary in future reporting.

114. The Party states in the IIR that they are calculating emissions from 3Db and 3Dc by multiplying the corresponding land area with emission factors from EMIS (2020) and EMEP/CORINAIR 2007. During the review, the Party further explained that it is planned to check and improve emission calculation in this category step by step in the following submissions. The ERT encourages the party to use the current 2019 EMEP/EEA Guidebook for estimating emission of these categories in future reporting.

115. During the review, the Party claimed that only about 5 to 15 % of Liechtenstein's agricultural land is cropland and consequently the use of pesticides is very low. The Party is encouraged to clarify the correctness of reporting the notation key “NO” for HCB emissions from 3Df. The appropriate notation key for not estimating insignificant emissions is “NE” and should rather be used instead of “NO”.

# WASTE

## Review Scope

| Pollutants Reviewed | | $SO_2$, NOx, NMVOC, $NH_3$, TSP, $PM_{10}$ & $PM_{2.5}$, BC, CO, Heavy metals, POPs | | |
|---|---|---|---|---|
| **Years** | | 1990 – 2019 + (Protocol Years) | | |
| **Code** | **Name** | **Reviewed** | **Not Reviewed** | **Recommendation Provided** |
| 5A | Solid waste disposal on land | X | | X |
| 5B1 | Biological treatment of waste - Composting | X | | X |
| 5B2 | Biological treatment of waste - Anaerobic digestion at biogas facilities | X | | X |
| 5C1a | Municipal waste incineration | X | | X |
| 5C1bi | Industrial waste incineration | X | | X |
| 5C1bii | Hazardous waste incineration | X | | X |
| 5C1biii | Clinical waste incineration | X | | X |
| 5C1biv | Sewage sludge incineration | X | | |
| 5C1bv | Cremation | X | | |
| 5C1bvi | Other waste incineration | X | | |
| 5C2 | Open burning of waste | X | | |
| 5D1 | Domestic wastewater handling | X | | X |
| 5D2 | Industrial wastewater handling | X | | X |
| 5D3 | Other wastewater handling | X | | |
| 5E | Other waste | X | | X |
| Note: Where a sector has been partially reviewed (e.g. some of the NFR codes please indicate which have and which have not in the respective columns. | | | | |

## General recommendations on cross cutting issues

### Transparency

116. Liechtenstein's IIR does not provide descriptions of emissions factors, activity data and methodologies used to estimate the emissions. The ERT recommends Liechtenstein to explain the calculation methods and provide information on emission factors and activity data sources in more detail.

### Completeness

117. The ERT notes that the waste sector is not complete, and the methodology descriptions are not comprehensive. Liechtenstein reports "NO" for the sub-sector 5E, other waste. In the 2019 EMEP/EEA Guidebook methodologies are described for sludge spreading, car fires and apartment/industrial building fires. The ERT recommends Liechtenstein to improve the completeness of its inventory and in sub-sectors where it is possible.

### Consistency, including recalculation and time series

118. Liechtenstein provided calculations for three subsectors that are consistent regarding emissions trends. As methodologies and EFs are not provided, it is not possible to check the correctness of calculations. Specific recalculations for the waste sector are not mentioned in IIR. The ERT encourages the Party to provide an explanation about time series and recalculations in the IIR.

### Comparability

119. As Liechtenstein does not provide methodologies and EFs in its IIR it is not possible to check the accuracy of calculations and to compare EFs or IEFs with other countries. The ERT recommends Liechtenstein to provide more detailed information about the used methodologies and EF in the IIR in future submissions.

### Accuracy and uncertainties

120. Liechtenstein does not describe specific QA/QC procedures and uncertainty analyses for the waste sector. The ERT encourages Liechtenstein to undertake an uncertainty analysis for the waste sector and to describe the outcome in the IIR.

### Condensable

121. Lichtenstein provides no information about the condensable compound of the PMs in the IIR. The ERT recommends the party involve this information in the next submission of the IIR.

### Improvement

122. There are no improvements mentioned for the waste sector in Liechtenstein's IIR. The ERT encourages Liechtenstein to plan improvements for the waste sector to improve the completeness and transparency of the inventory.

## Sub-Sector Specific Recommendations

### Category issue 1: 5.A. *Solid waste disposal on land* – All pollutants

123. The ERT notes that the description of emission calculations is not transparent. It is mentioned in the IIR that this category should include emissions from the managed landfills. But, according to the EMEP/EEA Guidebook, this category should include emissions from all landfills, managed or not managed.

124. Liechtenstein reports emissions of NOx, SOx, CO, Heavy metals and POPs in this category, but there is no information about the origin of these emissions as they are generally marked as combustion emissions. All the emissions of the main pollutants are calculated until 2008. From the year 2010 onwards, the notation key "NO" (Not Occurring) is reported in the NFR tables. The party stated that they will clarify this issue and include underlying information in future submission of the IIR

125. The ERT notes that the methodology, emission factors and activity data are not described in the IIR. The Party proclaims to have limited capacity to provide detailed

information regarding AD, EF and methodologies. The ERT strongly recommends the Party to prepare an improvement schedule with proposed methodology explanations in the IIR and to improve as many categories as possible.

### Category issue 2: 5.B. Biological treatment of waste– NMVOC, $NH_3$

126. It was noted by the ERT that Liechtenstein reports emissions from 5B1 Biological treatment of waste – Composting. There is no information available about methodology, EFs and activity data used in IIR and NFR tables. The ERT assumes that estimates of composted waste amounts are used for emission estimations. The Party responded that due to lack of capacity, the issue was not addressed in detail and the information will be included in the next submission of the IIR. The ERT strongly encourages the country to prepare a schedule of all planned implementation with clear explanation of the methodology for this category and include it in the next submission of the IIR.

127. The ERT notes that for NOx, SOx, CO and PMs, notation key NO is reported. According to reporting guidelines, when the activity occurs but the emissions are not expected to be released, notation key NA should be used. The Party responded that they would check the notation keys in the next submission. The ERT recommends Liechtenstein to revies the use of Notation Keys in the next submission and document it in the IIR.

128. The ERT notes that in the IIR in category 5C1b it is mentioned that there is biogas production in Liechtenstein, but it is not mentioned where the emissions are allocated. These emissions should be allocated to NFR 5B2 (biogas production using biogas in biogas station) and emissions from biogas burning in the energy sector (NFR1). Liechtenstein responded that only biogas from the wastewater treatment plant is upgraded to natural gas quality. There are no agricultural or other biogas plants in Liechtenstein. The ERT encourages the party that if the amount of N-flow entering the biogas facility is known (even from wastewater handling), to report emissions in the 5B2 category.

### Category issue 3: 5.C. Waste incineration – all pollutants

129. The ERT notes that Liechtenstein reports emissions only for the sub-sector 5C1a municipal waste incineration. In the IIR, the explanation is provided that only emissions from the illegal incineration of gardening and household wastes, as well as open burning of waste on construction sites, are included in 5C1a. Open burning of waste should be reported under category 5C2, similar to how it is reported in the GHG inventory. In addition, there is no information about activity data, emission factors and methodology used for the calculation. Liechtenstein responded that they will adjust their inventory following this recommendation, but due to lack of capacity, they will not be able to provide a detailed explanation of the methodology used in this category in the IIR. The ERT recommends the Party to reallocate the emissions from this category to category 5C2. The ERT strongly encourages the country to prepare a schedule of the planned implementation and explanation of the methodology used for this category and include it in the next submission of the IIR.

### Category issue 4: 5.D. Wastewater treatment – $NH_3$, NMVOC

130. The ERT notes that Liechtenstein calculates emissions only for the sub-sector 5D1 domestic wastewater handling, but no explanation is provided about methodologies, EFs and activity data. Also, no information about the usage of dry toilets was mentioned in the IIR. Liechtenstein responded that as stated in Liechtenstein's report on measures of water conservation for the International Water Protection Commission for the Bodensee, 99 % of the total wastewater is captured in wastewater treatment facilities and 90% in the central large wastewater treatment plant in Bendern. The ERT commends the Party for answering the question, but the issue of a detailed description of methodology and activity data stands still stands as well as the question round usage of dry toilets in the country. The ERT recommends the Party to include a detailed description of the methodology as well as information about the usage of dry toilets in the next submission of the IIR. If there is some dry toilets use recorded, the Party should report these emissions in the category 5D1.

### Category issue 5: 5.E. Other waste – all pollutants

131. The ERT notes that Liechtenstein uses the notation key “NO” for 5E. In the EMEP/EEA Guidebook 2019, this category contains emissions from accidental fires of houses, cars and industrial buildings as well as sludge spreading. In most European countries, fire and rescue services collect information about fires. Liechtenstein responded that they plan to check a progressive implementation of emission reporting from this source category. The ERT recommends the party provide a detailed time-schedule of implementation of this improvement task and expected finalisation in the IIR in the next submission.

## LIST OF MATERIALS PROVIDED TO ERT

1. Liechtenstein Annex I reporting template
2. Liechtenstein Stage 2 S&A report
3. Liechtenstein Stage 1 report 2021
4. Liechtenstein IIR 2020 and 2021
5. Liechtenstein NIR 2021
6. Repdab-Report
7. Extended checks

## LIST OF ADDITIONAL MATERIALS PROVIDED BY THE COUNTRY DURING THE REVIEW

1. Responses to the question raised by ERT during the review ("Clever space" platform at Umweltbundesamt website)
2. Material received from the Party during the Review
    - No additional information was provided by the Party either before or during the review.