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# Report of the individual review of the greenhouse gas inventories of Liechtenstein submitted in 2007 and 2008*

* In the symbol for this document, 2008 refers to the year in which the inventory was submitted, and not to the year of publication.

CONTENTS

# I. Overview

## A. Introduction

1. This report covers the centralized review of the 2007 and 2008 greenhouse gas (GHG) inventory submissions of Liechtenstein, coordinated by the UNFCCC secretariat, in accordance with decision 22/CMP.1. In accordance with the conclusions of the Subsidiary Body for Implementation at its twenty-seventh session,[1] the focus of the review is on the most recent (2008) submission. The review took place from 8 to 13 September 2008 in Bonn, Germany, and was conducted by the following team of nominated experts from the UNFCCC roster of experts: generalist – Ms. Hongmin Dong (China) and Ms. Lisa Hanle (United States of America); energy – Mr. Dario Gomez (Argentina) and Mr. Pavel Fott (Czech Republic); industrial processes – Mr. Domenico Gaudioso (Italy) and Mr. Kiyoto Tanabe (Japan); agriculture – Mr. Donald Kamdonyo (Malawi) and Mr. Rob Sturgiss (Australia); land use, land-use change and forestry (LULUCF) – Mr. Harry Vreuls (Netherlands) and Mr. Xiaoquan Zhang (China); and waste – Mr. Seungdo Kim (Korea) and Mr. Takashi Morimoto (Japan). Mr. Gomez and Mr. Tanabe were the lead reviewers. The review was coordinated by Mr. Javier Hanna and Mr. Tomoyuki Aizawa (UNFCCC secretariat).

2. In accordance with the "Guidelines for review under Article 8 of the Kyoto Protocol" (decision 22/CMP.1), a draft version of this report was communicated to the Government of Liechtenstein, which provided comments that were considered and incorporated, as appropriate, into this final version of the report.

## B. Inventory submission and other sources of information

3. The 2008 inventory was submitted on 29 February 2008. It contains a complete set of common reporting format (CRF) tables for the period 1990–2006 and a national inventory report (NIR). This is in line with decision 15/CMP.1. Liechtenstein indicated that the 2008 submission is also its voluntary submission under the Kyoto Protocol.[2] In its 2007 submission, which was submitted on 10 May 2007, Liechtenstein included a complete set of CRF tables for the period 1990–2005 and an NIR. The full list of materials used during the review is provided in the annex to this report.

## C. Emission profiles and trends

4. In 2006 (as reported in the 2008 annual inventory submission), the main GHG in Liechtenstein was carbon dioxide ($CO_2$), accounting for 88.5 per cent of total GHG emissions[3] expressed in $CO_2$ equivalent ($CO_2$ eq), followed by methane ($CH_4$) (5.3 per cent) and nitrous oxide ($N_2O$) (4.7 per cent). Hydrofluorocarbons (HFCs) and sulphur hexafluoride ($SF_6$) collectively accounted for 1.5 per cent of the overall GHG emissions in the country. Perfluorocarbons (PFCs) have been reported as not applicable ("NA") and not occurring ("NO"). The energy sector accounted for 89.2 per cent of the total GHG emissions, followed by agriculture (8.2 per cent), industrial processes (1.5 per cent), waste (0.7 per cent) and solvent and other product use (0.4 per cent). Total GHG emissions amounted to 273.05 Gg $CO_2$ eq and increased by 19.0 per cent between the base year[4] and 2006. According to the 2007 annual inventory submission, total GHG emissions in 2005 amounted to 270.52 Gg $CO_2$ eq. In the 2008 annual inventory

[1] FCCC/SBI/2007/34, paragraph 104.
[2] Parties may start reporting information under Article 7, paragraph 1, of the Kyoto Protocol from the year following the submission of the initial report, on a voluntary basis (decision 15/CMP.1).
[3] In this report, the term "total GHG emissions" refers to the aggregated national GHG emissions expressed in terms of $CO_2$ eq excluding LULUCF, unless otherwise specified.
[4] Base year refers to the base year under the Kyoto Protocol, which is 1990 for all gases. The base year emissions do not include any possible emissions from deforestation.

submission, total GHG emissions in 2005 have been recalculated and reported to be 270.68 Gg $CO_2$ eq. The shares of gases and sectors in 2006 (2008 annual inventory submission) were similar to those in 2005 (2007 annual inventory submission).

5. Tables 1 and 2 show GHG emissions by gas and by sector, respectively

## D. Key categories

6. Liechtenstein has reported a key category tier 1 analysis, both level and trend assessment, as part of its 2008 submission. The key category analysis performed by Liechtenstein and that performed by the secretariat[5] produced similar results. Liechtenstein has included the LULUCF sector in its key category analysis, which was performed in accordance with the Intergovernmental Panel on Climate Change (IPCC) *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (hereinafter referred to as the IPCC good practice guidance) and the IPCC *Good Practice Guidance for Land Use, Land-Use Change and Forestry* (hereinafter referred to as the IPCC good practice guidance for LULUCF). The same key categories were identified in the 2007 submission. A description of how the key category analyses were determined has been provided in the NIR.

## E. Main findings

7. The inventory is generally in line with the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (hereinafter referred to as the Revised 1996 IPCC Guidelines), the IPCC good practice guidance and the IPCC good practice guidance for LULUCF. However, the expert review team (ERT) identified a need for further improvements in terms of its transparency.

8. The methodologies, emission factors (EFs) and uncertainty values used in Liechtenstein's inventory are mostly drawn from Switzerland's inventory. This may delay use of the most up-to-date methodologies and EFs. The ERT noted that Liechtenstein's EFs would be very similar to those reported in Switzerland's inventory. The ERT recommends that Liechtenstein find a way to update the necessary parameters in the latest year of its annual submission.

## F. Cross-cutting issues

### 1. Completeness

9. The inventory is generally complete in terms of the years, sectors and gases covered. Some minor categories are missing from the 2008 submission, namely $CO_2$ emissions from unmanaged waste disposal on land and indirect GHGs and sulphur dioxide ($SO_2$) emissions in the energy sector.
In response to questions raised by the ERT, Liechtenstein explained that $CO_2$ emissions from unmanaged waste disposal on land should have been reported as "NO" instead of not estimated ("NE"), because

[5] The secretariat identified, for each Party, the categories that are key categories in terms of their absolute level of emissions, applying the tier 1 level assessment as described in the IPCC *Good Practice Guidance for Land Use, Land-Use Change and Forestry*. Key categories according to the tier 1 trend assessment were also identified for Parties that provided a full set of CRF tables for the base year period. Where the Party performed a key category analysis, the key categories presented in this report follow the Party's analysis. However, they are presented at the level of aggregation corresponding to a tier 1 key category assessment conducted by the secretariat.

## Table 1. Greenhouse gas emissions by gas, 1990–2006

| Greenhouse gas emissions | Gg $CO_2$ eq | | | | | | | | Change base year–2006 (%) |
|---|---|---|---|---|---|---|---|---|---|
| | Base year[a] | 1990 | 1995 | 2000 | 2003 | 2004 | 2005 | 2006 | |
| $CO_2$ | 203.06 | 203.06 | 209.39 | 227.53 | 240.02 | 240.18 | 239.96 | 241.61 | 19.0 |
| $CH_4$ | 13.40 | 13.40 | 12.60 | 12.27 | 13.35 | 13.47 | 13.99 | 14.38 | 7.4 |
| $N_2O$ | 13.07 | 13.07 | 13.15 | 12.50 | 12.52 | 12.52 | 12.61 | 12.85 | –1.7 |
| HFCs | 0.00 | 0.00 | 0.38 | 2.33 | 3.58 | 4.03 | 4.07 | 4.15 | 49 391 690.4 |
| PFCs | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | NA |
| $SF_6$ | 0.00 | 0.00 | 0.00 | 0.02 | 0.05 | 0.06 | 0.06 | 0.05 | NA |

*Abbreviation*: NA = not applicable.

[a] "Base year" refers to the base year under the Kyoto Protocol, which is 1990 for all gases. The base year emissions do not include any possible emissions from deforestation; however, if applicable, these are taken into account when the assigned amount is calculated.

## Table 2. Greenhouse gas emissions by sector, 1990–2006

| Sectors | Gg $CO_2$ eq | | | | | | | | Change base year–2006 (%) |
|---|---|---|---|---|---|---|---|---|---|
| | Base year[a] | 1990 | 1995 | 2000 | 2003 | 2004 | 2005 | 2006 | |
| Energy | 203.47 | 203.47 | 210.69 | 229.48 | 241.86 | 242.08 | 241.93 | 243.63 | 19.7 |
| Industrial processes | 0.00 | 0.00 | 0.38 | 2.35 | 3.63 | 4.09 | 4.12 | 4.20 | 50 003 598.3 |
| Solvent and other product use | 1.99 | 1.99 | 1.61 | 1.28 | 1.16 | 1.10 | 1.10 | 1.11 | –44.2 |
| Agriculture | 22.52 | 22.52 | 21.32 | 19.83 | 21.09 | 21.24 | 21.60 | 22.33 | –0.9 |
| LULUCF | NA | –8.32 | –8.46 | –4.90 | –6.47 | –6.48 | –6.50 | –6.55 | NA |
| Waste | 1.55 | 1.55 | 1.52 | 1.72 | 1.77 | 1.75 | 1.93 | 1.78 | 14.3 |
| Other | NO | NO | NO | NO | NO | NO | NO | NO | NA |
| **Total (with LULUCF)** | NA | 221.21 | 227.05 | 249.75 | 263.05 | 263.78 | 264.18 | 266.50 | NA |
| **Total (without LULUCF)** | 229.53 | 229.53 | 235.52 | 254.65 | 269.52 | 270.26 | 270.68 | 273.05 | 19.0 |

*Abbreviations*: LULUCF = land use, land-use change and forestry; NA = not applicable, NO = not occurring.

[a] "Base year" refers to the base year under the Kyoto Protocol, which is 1990 for all gases. The base year emissions do not include any possible emissions from deforestation; however, if applicable, these are taken into account when the assigned amount is calculated.

Liechtenstein has not disposed of municipal solid waste in landfill sites since 1974 and hence no $CO_2$ emissions from waste combustion at landfill sites are occurring. The ERT recommends that Liechtenstein use the correct notation keys in its next annual submission. The ERT also recommends that Liechtenstein include emission estimates for the categories that are currently reported as "NE", if data and methods are available or it is feasible to obtain them, in order to improve the completeness of the inventory.

10. The CRF tables have been filled with notation keys, as appropriate. However, Liechtenstein has not completed table 7 for the period 1990–2003 or table 8(b) for 1990–2005. The ERT recommends that Liechtenstein submit complete CRF tables in its next inventory submission.

### 2. Transparency

11. Most of the information required for the ERT to review the inventory was provided in the NIR. However, the transparency of Liechtenstein's submission could be improved by including some additional information, such as assumptions and rules of thumb in the agriculture sector, more detail on methodologies in the road transport sector, and land-use change matrices. The ERT recommends that Liechtenstein include background information on the assumptions and methodologies adopted in its next inventory submission, especially for the categories for which methodologies and/or EFs specific to Switzerland have been applied.

### 3. Recalculations and time-series consistency

12. The ERT noted that recalculations reported by Liechtenstein of the time series from 1990 to 2005 were undertaken following recommendations made in a previous review. The changes include: the correction of a transcription error concerning fuel consumption in transport; the improved estimation of $CH_4$ and $N_2O$ emissions from power generation based on biogas from sewage; the revision of the area of cultivated organic soils; and the adoption of a new definition of forest. The rationale for these recalculations is provided in the NIR.

13. Recalculating the estimates of total GHG emissions (excluding LULUCF) had an effect on the long-term trend, resulting in the reporting of a 17.9 per cent increase in emissions over the period 1990–2005, as opposed to the 17.4 per cent increase previously reported.

14. In the 2007 submission, emission estimates for the period 1990–2004 have been recalculated, owing to the revision of activity data (AD) for the industrial processes and agriculture sectors, the reallocation of $CO_2$ emissions from waste incineration and the revision of the EF for the waste sector. As a result of these recalculations, the emission trend for the period 1990–2004 has changed slightly, with the estimated total national emissions now showing an increase of 17.3 per cent between 1990 and 2004, as opposed to the 17.8 per cent increase reported in the 2006 submission.

### 4. Uncertainties

15. The uncertainty analysis for the key categories was conducted using tier 1 methodology. Uncertainty analyses for non-key categories and the LULUCF sector have not been included. The uncertainty of non-key categories has been accounted for in an additional category named "rest of sources" with a global combined uncertainty of 40 per cent to guarantee a complete and conservative uncertainty analysis (for all sources excluding LULUCF). The NIR explains that there are no available data on non-key categories and no estimates for uncertainties in the LULUCF sector. Liechtenstein informed the ERT that it plans to include the non-key categories in the uncertainty analysis in its 2009 submission, and include the LULUCF sector in the uncertainty analysis in its 2010 submission, provided that Switzerland supply LULUCF uncertainties that may be transferred to the national circumstances of

Liechtenstein. The ERT encourages Liechtenstein to make efforts to implement these improvements as planned.

16. The IPCC good practice guidance provides a tier 2 uncertainty analysis based on a key category analysis. The ERT noted that the uncertainty of both the AD and EFs used by Liechtenstein is given only at an aggregated level, which does not facilitate a tier 2 key category analysis. The ERT encourages Liechtenstein to consider the possibility of implementing the tier 2 uncertainty assessment following the disaggregation of the uncertainty analysis results.

17. According to the NIR, the estimated level uncertainty for total national emissions in $CO_2$ eq for 2006 is 11.1 per cent, while the trend uncertainty is 18.1 per cent. The overall uncertainty is determined by the high uncertainty of the AD for liquid fuels, owing to the fact that Liechtenstein has no statistics for customs on imports of oil products.

### 5. Verification and quality assurance/quality control approaches

18. Significant improvements have been achieved in Liechtenstein's quality assurance/quality control (QA/QC) activities. A detailed description of Liechtenstein's QA/QC plan, information on the implementation of QA/QC activities and a record of QC activities have been provided in the NIR. The ERT noted that the external review depends largely on the review of Switzerland's methodologies and EFs, but that there is not enough information in the NIR on how external experts are involved in the quality control of AD. During the review, Liechtenstein provided further information on its activities conducted both internally and externally in accordance with the QA/QC plan. The ERT recommends that Liechtenstein include this information in its next annual submission, particularly a description of the QA/QC activities conducted in connection with AD. During the review, Liechtenstein informed the ERT that the QA/QC system will be improved in 2009 and that it is planned that the resulting improvements will be reported in the 2010 submission.

### 6. Follow-up to previous reviews

19. The ERT recognized that, in response to recommendations made in the previous review, Liechtenstein has provided information on the QA/QC plan and QA/QC activity, included the LULUCF sector in its key category analysis and used the first order decay model of the IPCC good practice guidance to estimate $CH_4$ emissions from solid waste disposal sites (SWDS). The ERT commends Liechtenstein for these improvements. However, the ERT feels that the Party has not yet fully addressed the recommendation made in the previous review to improve transparency in the energy and LULUCF sectors; therefore, the ERT reiterates this recommendation.

## G. Areas for further improvement

### 1. Identified by the Party

20. The 2008 NIR does not identify any areas for further improvement. In response to the issues raised by the ERT during the review, Liechtenstein indicated that it is working on improving its uncertainty analysis and the implementation of QA/QC.

### 2. Identified by the expert review team

21. The ERT identified the following cross-cutting issues for improvement:

(a) Provide quantified uncertainty estimates for the non-key categories and the LULUCF sector;

(b) Improve the transparency of the descriptions in the NIR of the LULUCF, agriculture and energy sectors;

(c) Further improve the QA/QC plan;

(d) Provide a description of the implementation of QA/QC activities, particularly those conducted in connection with AD;

(e) Include background information on the assumptions and methodologies adopted, especially for the categories for which methodologies and/or EFs specific to Switzerland have been applied, in the next annual submission.

22. Recommended improvements relating to specific source/sink categories are presented in the relevant sector chapters of this report.

# II. Energy

## A. Sector overview

23. The energy sector is the main sector in the GHG inventory of Liechtenstein. In 2006, the energy sector accounted for 243.63 Gg $CO_2$ eq, or 89.2 per cent of total GHG emissions. Emissions from the sector increased by 19.7 per cent between 1990 and 2006. Within the sector, 47.7 per cent of emissions were from the category other sectors, followed by 33.9 per cent from transport and 15.4 per cent from the manufacturing industry. Other (off-road machinery) accounted for 1.5 per cent of emissions, while energy industries accounted for 1.1 per cent. The remaining 0.4 per cent consisted of fugitive emissions from oil and natural gas. Most of the emissions were from $CO_2$, which accounted for 98.8 per cent of the sectoral emissions, while $CH_4$ accounted for 0.7 per cent and $N_2O$ for 0.5 per cent.

24. Liechtenstein's CRF tables are largely complete. The estimates for direct GHGs and sources are consistent with the requirements of the Revised 1996 IPCC Guidelines, although indirect GHGs and $SO_2$ have not been estimated. The chapter in the NIR on energy is broadly transparent, with a small number of exceptions (e.g. the presentation of EFs and net calorific values (NCVs)). The time series presented is consistent, as the same methods have been used since 1990. No significant recalculations have been reported in the 2008 submission; only one small correction was made to the estimate of fuel consumed in transportation for 2005. The Party has paid special attention to its QC activities, by updating the AD used (i.e. on fuel sales data).

25. Liechtenstein's inventory is very closely connected to that of Switzerland; the methodologies used are usually the same or similar. These methodologies are in line with the Revised 1996 IPCC Guidelines and the IPCC good practice guidance. Liechtenstein does not have its own official energy balance but, for the purpose of the GHG inventory, all fuels consumed in Liechtenstein are reported separately from those consumed in Switzerland according to the Swiss energy balance. This connection with the Swiss energy balance has the potential to result in an over or underestimation of fuel consumption in Liechtenstein as a result of a corresponding under or overestimation of fuel consumption in Switzerland. The ERT recommends that Liechtenstein implement QA/QC activities for the AD used in the energy sector.

26. Almost all methods, AD and EFs used for the 2008 inventory are identical to those reported in the 2007 submission; only one small correction (to fuel consumption in transportation for 2005) appeared in the 2008 submission. Also in the 2008 submission, the reference approach has been reported separately from the sectoral approach for the entire time series 1990–2006 for the first time.

## B. Reference and sectoral approaches

### 1. Comparison of the reference approach with the sectoral approach and international statistics

27. Liechtenstein forms a customs union with Switzerland and, therefore, there are no statistics specific to Liechtenstein on the export and import of liquid fuels. Moreover, Liechtenstein has no

refinery industry. Therefore, Liechtenstein formerly stated that the reference approach and the sectoral approach are practically identical and, as such, the reference approach was not reported until the 2007 submission. However, as a follow-up to the previous review, in its 2008 submission Liechtenstein has reported the reference approach for the entire time series since 1990. In addition, for the aforementioned reasons, Liechtenstein does not submit energy data to the International Energy Agency; therefore, it is not possible to make any comparison with international statistics.

28. Gas oil is imported from Switzerland by oil transport companies, a proportion of which is stored in the "Liechtenstein main storage facility". However, in CRF table 1A(b), the relevant values of stock change for gas oil are positive throughout the entire 1990–2006 time series, with oil stock changes reported as "NO" only for 1996 and 2004. The ERT recommends that Liechtenstein check and revise its oil storage data and address this issue in its next inventory submission, if any problems are found.

#### 2. International bunker fuels

29. The only category reported under international bunker fuels is $CO_2$ emissions from jet kerosene for aviation bunkers, because there is a helicopter base in the country. In 2006, GHG emissions from aviation bunkers contributed 85.0 per cent of the total emissions from aviation. This reflects the national circumstances of the country. The possible uncertainty resulting from dividing the total amount of fuel used in aviation into the amounts for domestic and international use is not likely to have much impact on overall uncertainty, since aviation, which constitutes helicopters only, accounts for just 0.3 per cent of total emissions.

#### 3. Feedstocks and non-energy use of fuels

30. For all years up to and including 2006, Liechtenstein has reported GHG emissions from feedstocks and non-energy use of fuels as "NO". However, the previous review supposed that some bitumen and lubricants might be used in this sector. During the review, Liechtenstein informed the ERT that bitumen is used for road paving. The ERT recommends that Liechtenstein include this explanation in future NIRs.

### C. Key categories

#### 1. Stationary combustion: solid and gaseous fuels – $CO_2$

31. In order to calculate $CO_2$ emissions from stationary combustion, Liechtenstein uses a set of Swiss country-specific $CO_2$ EFs and NCVs, which have been presented in the NIR. Although the values presented are mostly within the range of the IPCC default values, some information on $CO_2$ EFs and NCVs about the primary data source (e.g. reference to the relevant report and a date of the edition) and about the uncertainty of individual sets of data is missing. Fixed values for $CO_2$ EFs and NCVs are used to make estimations for the whole time series; however, evidence for the time-series consistency of these values is missing. The ERT encourages Liechtenstein to provide more information on the $CO_2$ EFs and NCVs in the NIR, in order to ensure transparency.

32. The $CO_2$ EF for natural gas was identified as 55.0 t $CO_2$/TJ, one of the lowest among the reporting Parties (the IPCC default value is 56.1 t $CO_2$/TJ). The ERT encourages Liechtenstein to explain the difference between the EF used and the IPCC default value. During the review, Liechtenstein informed the ERT that this EF is based on the analysis of fuel samples undertaken by the Swiss Federal Laboratories for Materials Testing and Research.

#### 2. Road transportation: liquid fuels – $CO_2$

33. The estimation of $CO_2$ emissions from road transport is based on the amount of fuel sold in the country. This approach is in line with the IPCC good practice guidance. Liechtenstein assumed that the amount of fuel sold was higher than the amount actually consumed within the country, owing to "tank

tourism" (fuel prices are lower in Liechtenstein than in neighbouring Austria). The previous review indicated that Liechtenstein also has a calculation method in place based on transport statistics. For the sake of transparency and for the purpose of QA/QC, the ERT encourages Liechtenstein to also present the results of this second approach in its next NIR.

### D. Non-key categories

Stationary combustion: gaseous fuel – $CH_4$

34. In the previous review, two country-specific EFs for $CH_4$ were identified that were rather high in comparison with the IPCC default values. The first EF, for energy industries, was 25 kg/TJ (the IPCC default value is 1 kg/TJ) and the second, for boilers in manufacturing industries, construction and other sectors, was 6 kg/TJ (the IPCC default value is 1.4 kg/TJ). In accordance with the previous review, the ERT recommends that Liechtenstein enhance transparency by including an explanation for this in the NIR of its next annual submission.

## III. Industrial processes and solvent and other product use

### A. Sector overview

35. In 2006, the industrial processes sector accounted for 4.20 Gg $CO_2$ eq, or 1.5 per cent of total GHG emissions, and the solvent and other product use sector accounted for 1.11 Gg $CO_2$ eq, or 0.4 per cent of total GHG emissions.

36. GHG emissions in the industrial processes sector, which originate only from the consumption of halocarbons and $SF_6$, were equal to 0 in 1990. HFCs contributed 98.8 per cent of the total sectoral emissions, with $SF_6$ accounting for the remaining 1.2 per cent. HFCs emissions experienced steep growth between 1992 and 2003. In recent years, this increasing trend has almost come to a halt, with only a 15.6 per cent increase in emissions since 2003 and a 2.7 per cent increase since 2004, owing to the decline in the use of HFCs in commercial refrigeration. PFCs emissions have been reported as "NO", as have GHG emissions for categories other than the consumption of halocarbons and $SF_6$. Carbon monoxide emissions have been reported from asphalt roofing, and carbon monoxide and non-methane volatile organic compound (NMVOC) emissions have been reported from road paving with asphalt.

37. GHG emissions from solvent and other product use decreased by 44.2 per cent between 1990 and 2006, thanks to the control measures introduced to limit NMVOC emissions and to a decline in $N_2O$ consumption (e.g. for anaesthesia and aerosol cans).

38. Liechtenstein estimates emissions in accordance with the Revised 1996 IPCC Guidelines and the IPCC good practice guidance. The assumptions, methodologies, parameters and EFs, as well as the uncertainty values used in Liechtenstein's inventory are mostly drawn from Switzerland's inventory.

39. In the NIR, it states that an IPCC tier 1 uncertainty analysis has been performed; only a summary of the results of this analysis has been presented.

40. A description of the QA/QC and verification procedures used in the preparation of the GHG inventory has been provided in the NIR. No reference to source-specific tier 2 QC procedures has been made for industrial processes and solvent and other product use.

41. No recalculations for industrial processes and solvent and other product use have been reported in CRF table 8(a) for the period 1990–2005.

42. Liechtenstein's 2007 and 2008 inventory submissions are in line with the Revised 1996 IPCC Guidelines and the IPCC good practice guidance as concerns methodologies, AD and EFs used, and the presentation of the relevant information in the CRF tables and the NIR. In Liechtenstein's 2008

submission, the AD and EFs used to estimate emissions from the consumption of halocarbons and $SF_6$ are still based on those in the NIR submitted by Switzerland for 2007, as Switzerland's 2008 inventory submission was not available at that time. However, the ERT recommends that Liechtenstein include further explanation about this specific assumption in its next NIR, in order to enhance transparency of the submission, and that revised estimates are submitted once the Swiss AD for the same year of Liechtenstein's submission become available.

### B. Key categories

Consumption of halocarbons and $SF_6$ - (HFCs, $SF_6$)

43. An IPCC tier 2a bottom-up approach is used to estimate emissions for this source category. With regard to refrigeration and air conditioning equipment, the AD used by Liechtenstein are based on the assumption that they are equal to a certain proportion of Switzerland's AD. The EFs (leakage rates) are the same as those reported in Switzerland's NIR. However, the use of a tier 2a bottom-up approach may result in inaccuracies (especially considering that this is a key category), since it uses EFs referenced from literature. Therefore, the ERT encourages Liechtenstein to consider moving towards a tier 2b top-down approach, based on the annual sales of refrigerants.

44. Liechtenstein has reported HFCs emissions from foam blowing as "NO"; HFCs may be released from foam blowing applications (e.g. for insulating, cushioning and packaging). HFCs are never used as replacements for chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs). Liechtenstein could consider producing an estimate for these emissions on the basis of the data reported by neighbouring countries.

45. Liechtenstein has reported HFC emissions from aerosols in the CRF tables, but no information on this sub-category has been provided in the NIR. Liechtenstein is therefore encouraged to include this information in its next inventory submission.

## IV. Agriculture

### A. Sector overview

46. In 2006, the agriculture sector accounted for 22.33 Gg $CO_2$ eq, or 8.2 per cent of total GHG emissions. Emissions from this sector decreased by 0.9 per cent between 1990 and 2006. Within the sector, 45.9 per cent of emissions were from enteric fermentation of domestic livestock, followed by 39.3 per cent from agricultural soils and 14.9 per cent from manure management. $CH_4$ accounted for 53.6 per cent of emissions, while $N_2O$ accounted for 46.4 per cent. No $CO_2$ emissions have been reported in the agriculture sector.

47. The ERT considers that the chapter on the agriculture sector in Liechtenstein's NIR is not sufficiently transparent; it is lacking in information on the non-occurrence of agricultural residue and savanna burning.

48. The methodologies and EFs used by Liechtenstein are heavily dependent on those used by Switzerland and Liechtenstein has not reported any plans to make improvements to them.

49. There are no differences between the 2007 and 2008 submissions in terms of methodologies and the transparency of the NIR. For the 2007 submission, livestock data for the period 2002–2005 were further disaggregated and recalculations were done for the whole time series. For the 2008 submission, crop production data for non-leguminous crops were regrouped for 2003 and 2004, which also made recalculations necessary. While only Swiss EFs were used for the 2007 submission, for the 2008 submission EFs for dairy cattle specific to Liechtenstein were used in addition to the Swiss EFs.

## B. Key categories

### 1. Enteric fermentation – $CH_4$

50. Liechtenstein used tier 2 Swiss methodology, which is consistent with the IPCC tier 2 methodology, to calculate emissions for this key category, in line with the IPCC good practice guidance. The EFs used are a mixture of IPCC default factors and Swiss country-specific factors. The ERT recommends that Liechtenstein provide an explanation, reflecting its national circumstances, of the applicability of Swiss country-specific methodologies and EFs.

51. AD are obtained from the offices of Agriculture and of Economic Affairs and are published data. Since 2002, Liechtenstein has adopted a sophisticated livestock data collection system which generates few inaccuracies. The livestock data are well disaggregated and the data have been applied across all appropriate categories, which is in line with the IPCC good practice guidance.

### 2. Manure management – $N_2O$

52. Country-specific methodologies and default EFs were used to evaluate $N_2O$ emissions from manure management, based on the Swiss methodology. The ERT recommends that Liechtenstein provide an explanation, reflecting its national circumstances, of the applicability of Swiss country-specific methodologies and EFs in the NIR of its next annual submission. The ERT also recommends that Liechtenstein develop its own country-specific EFs in order to reflect its national circumstances and agricultural practices.

### 3. Manure management – $CH_4$

53. Country-specific methodologies and a combination of IPCC default and Swiss country-specific EFs were used to calculate $CH_4$ emissions from manure management. With this in mind, the ERT reiterates the recommendation given in paragraph 52 above.

54. $N_2O$ emissions increased slightly in 2006 owing to an increase in the poultry population, while $CH_4$ emissions decreased in 2006 owing to a reduction in the dairy cattle and swine populations. The trend in $CH_4$ emissions from manure management is different from the trend in $N_2O$ emissions, which may be due to differences in the manure management systems for each animal type. However, the NIR only provides information on the animal populations without details on the respective manure management systems. Therefore, the ERT recommends that Liechtenstein provide a sufficient and transparent explanation for this issue in the NIR of its next annual submission.

### 4. Direct soil emissions – $N_2O$

55. Direct $N_2O$ soil emissions have decreased slightly since 1990, mainly as a result of the reduced input of synthetic fertilizer. Emissions have been calculated using a combination of Swiss country-specific EFs, IPCC tier 1b methodology and IPCC default EFs. The ERT recommends that Liechtenstein provide an explanation, reflecting its national circumstances, of the applicability of Swiss country-specific methodologies and EFs in the NIR of its next annual submission. The ERT also recommends that Liechtenstein develop its own country-specific EFs for this key source category, in order to reflect its national circumstances and agricultural practices.

### 5. Indirect soil emissions – $N_2O$

56. Indirect $N_2O$ soil emissions have also decreased slightly since 1990, mainly as a result of the reduced input of synthetic fertilizer. In order to calculate these emissions, a combination of Swiss country-specific and IPCC tier 1b methodologies, and IPCC default EFs were used. The ERT reiterates the recommendations given in paragraph 55 above.

# V. Land use, land-use change and forestry

## A. Sector overview

57. In 2006, the LULUCF sector in Liechtenstein accounted for a net sink of 6.55 Gg $CO_2$ eq, offsetting 2.4 per cent of total GHG emissions. GHG net removals by sinks in the LULUCF sector decreased by 21.3 per cent from 1990 to 2006. The key driver for the fall in removals is the increase in emissions from land converted to grasslands, land converted to wetlands and land converted to other lands.

58. Within the LULUCF sector, 19.02 Gg $CO_2$ of net removals are from forest land remaining forest land, while 4.45 Gg $CO_2$, 3.47 Gg $CO_2$, 1.81 Gg $CO_2$ and 1.04 Gg $CO_2$ of net emissions are from cropland remaining cropland, land converted to settlements, grassland remaining grassland, and land converted to other lands, respectively.

59. For the LULUCF sector, the inventory is generally complete, since the CRF for 2006 includes estimates of $CO_2$ emissions/removals for all six land-use categories in the sector. Carbon stock changes in living biomass, dead organic matter (DOM) and soils have been reported under the relevant categories. Non-$CO_2$ emissions have been reported as "NO".

60. Land use and land-use change matrices for 18 land-use/cover types have been established for the entire time series 1990–2006 based on the land-use and land-cover categories of the Swiss land-use statistics and aerial photographs which were interpreted stereographically into a hectare grid. For the purpose of the inventory, the land-use/cover categories were further disaggregated into three altitudinal belts for forests and grasslands and two soil types for croplands and grasslands. Swiss procedures and methodologies, tier 2 methodologies from the IPCC good practice guidance for LULUCF, Swiss country-specific factors and AD from Liechtenstein were all used. For the sake of transparency, the ERT recommends that Liechtenstein report GHG emissions/removals in its CRF tables in disaggregated land-use/cover categories and provide matrices of land-use/cover changes for the entire time series in the NIR of its next annual submission.

61. The amount of net removals in the LULUCF sector as reported in the 2008 submission is higher than in the 2007 submission as a result of Liechtenstein reviewing the land-use/cover combination and its estimation of organic soil area. The ERT notes that Liechtenstein plans to improve its inventory by not accounting for removals/emissions from any land-use conversion between two categories of unmanaged land. If Liechtenstein implements this plan, the ERT strongly recommends that it provide sufficient and clear explanation in its future NIRs in order to demonstrate that such land-use conversion has taken place without human-induced effects.

62. Except for in organic soil in cropland and grassland, carbon stock changes in DOM and soils were assumed to be zero for [x] land remaining [x] land under all six land-use categories. The organic matter above mineral soil has been reported for mineral soils, which is inconsistent with the IPCC good practice guidance for LULUCF. Liechtenstein did not carry out formal category-specific QA/QC procedures and quantitative uncertainty analyses for categories in the LULUCF sector. The ERT recommends that Liechtenstein report organic matter above mineral soil for DOM, develop and implement QA/QC procedures and quantify the uncertainties of the key categories in its future annual submissions.

63. In the 2008 submission, emissions in the LULUCF sector have been recalculated for the entire time series owing to the revision of the definition of forest, the improved estimate of the area of organic soils, more precise interpolation of areas between 1990 and 1996, and between 1996 and 2002, and more precise extrapolation after 2002.

## B. Key categories

### 1. Forest land remaining forest land – $CO_2$

64. The annual net $CO_2$ removals for forest land remaining forest land in 2006 amounted to 19.02 Gg $CO_2$. The carbon stock changes in living biomass of unproductive forests are (conservatively) assumed to be zero.

65. The attribution of a conversion period of 1–12 years for land converted to forest land is inconsistent with the IPCC good practice guidance for LULUCF, which defines the default land-use conversion period as 20 years or more. Liechtenstein's current attribution of the conversion period tends to overestimate $CO_2$ removals for forest land remaining forest land, while underestimating $CO_2$ removals for land converted to forest land. The ERT recommends that Liechtenstein investigate whether the historical data available would support the use of a minimum 20-year conversion period in order to distinguish between the sub-categories under forest land.

### 2. Cropland remaining cropland – $CO_2$

66. Cropland remaining cropland in Liechtenstein accounted for a net source of 4.45 Gg $CO_2$ in 2006. The tier 2 methodology from the IPCC good practice guidance for LULUCF and Swiss country-specific factors are used to calculate $CO_2$ emissions from cultivated organic soil, but these emissions have been incorrectly allocated to mineral soil. Carbon stock changes in living biomass, DOM and mineral soils are assumed to be zero. The ERT recommends that Liechtenstein improve its estimations and reporting of carbon stock changes in soils for this category in its next annual submission. During the review, Liechtenstein informed the ERT that its reporting will be checked and corrected in its 2010 submission.

### 3. Grassland – $CO_2$

67. The tier 2 approach in the IPCC good practice guidance for LULUCF, Swiss methodologies and country-specific EFs were used to estimate $CO_2$ emissions from cultivated organic soil for grassland remaining grassland and for carbon stock change in land converted to grassland. Carbon stock changes in living biomass, DOM and mineral soils are assumed to be zero for grassland remaining grassland. $CO_2$ emissions from cultivated organic soil for grassland remaining grassland have been incorrectly allocated to mineral soils. The ERT recommends that Liechtenstein improve its estimations and reporting of carbon stock changes in soils for this category in its future annual submissions. During the review, Liechtenstein informed the ERT that its reporting will be checked and corrected in its 2010 submission.

### 4. Settlements – $CO_2$

68. Settlements in Liechtenstein accounted for a net source of 3.53 Gg $CO_2$ in 2006, mainly from $CO_2$ emissions from land converted to settlements. The tier 2 methodology in the IPCC good practice guidance for LULUCF and Swiss country-specific factors were used to calculate emission estimates.

## C. Non-key categories

### Land converted to forest land – $CO_2$

69. The annual increase in living biomass has been estimated and reported. Carbon stock changes owing to land being converted to forest land were conservatively assumed to be zero for all carbon pools. The attribution of a conversion period of 1–12 years for land converted to forest land meant that the AD for land converted to forest land were underestimated. As a result of these assumptions, $CO_2$ removals for this category tend to be underestimated, while $CO_2$ removals for forest land remaining forest land tend to be overestimated. The ERT recommends that Liechtenstein investigate whether the historical

data available would support the use of a minimum 20-year conversion period in order to distinguish between the sub-categories under forest land.

# VI. Waste

## A. Sector overview

70. In 2006, the waste sector accounted for 1.78 Gg $CO_2$ eq, or 0.7 per cent of total GHG emissions. Emissions from the sector increased by 14.3 per cent between 1990 and 2006, which is attributed to the increase in emissions from the category other (i.e. composting). Within the sector, 57.1 per cent of emissions were from wastewater handling, followed by 40.8 per cent from other, 1.3 per cent from solid waste disposal on land and 0.8 per cent from waste incineration.

71. In response to the recommendation made by the ERT in the initial review report, Liechtenstein has made considerable improvements to its inventory in the waste sector since its previous submission. The Party has included $CH_4$ emissions from managed waste disposal on land, and estimated and reported $CH_4$ and $N_2O$ emissions from biogas from wastewater treatment used to produce energy under the energy sector. The ERT appreciates these improvements.

72. A quantitative uncertainty analysis has not been implemented for the waste sector. The ERT recommends that Liechtenstein implement a quantitative uncertainty analysis in accordance with the IPCC good practice guidance in its future annual submissions.

73. Category-specific QA/QC procedures described in the IPCC good practice guidance have not been implemented. The ERT recommends that Liechtenstein develop and implement category-specific QA/QC procedures in the future.

74. According to the key category analysis, there is no key category in the waste sector.

## B. Non-key categories

### 1. Solid waste disposal on land – $CH_4$

75. Liechtenstein used the first order decay model of the IPCC good practice guidance to estimate $CH_4$ emissions from SWDS, following the recommendation made during the initial review. The ERT appreciates this improvement and encourages Liechtenstein to continue reporting $CH_4$ emissions from SWDS in its future submissions.

76. Liechtenstein used Switzerland's waste composition data to calculate the value for degradable organic carbon, on the assumption that these data are roughly representative of the situation in Liechtenstein. The ERT encourages Liechtenstein to provide the rationale for and a discussion of this assumption, in order to improve transparency.

### 2. Wastewater handling – $CH_4$

77. Biogas from wastewater treatment plants is used for the cogeneration of heat and power. Emissions from biogas have been reported under the energy sector (energy industries) in accordance with the Revised 1996 IPCC Guidelines and in response to the recommendation made during the initial review. The ERT appreciates this improvement and encourages Liechtenstein to continue reporting emissions from waste incineration with energy recovery in its future submissions.

78. In order to estimate the $CH_4$ emissions from wastewater treatment plants, Liechtenstein used the volume of biogas produced, as well as the leakage rate and $CH_4$ content of the biogas, which are derived from Switzerland's data. The ERT encourages Liechtenstein to provide evidence in the next inventory submission that the use of Switzerland's data is appropriate. The ERT also encourages Liechtenstein to develop and use country-specific parameters, where possible, in its future inventory submissions.

### 3. Wastewater handling – $N_2O$

79. Liechtenstein used the IPCC default methodology to estimate $N_2O$ emissions from wastewater handling for human sewage. In the calculation of these emissions, 36 kg/person/year was used as the value for protein consumption for the entire time series. The ERT encourages Liechtenstein to use year-specific values in order to improve accuracy in its future annual submissions.

### 4. Waste incineration – $CO_2$

80. There is no waste incineration plant in Liechtenstein and municipal waste is exported to Switzerland. Liechtenstein has reported emissions from illegal waste incineration only, using country-specific AD and CORINAIR EFs and assuming that 40 per cent of waste incinerated is non-biogenic, in reference to the waste composition of illegal waste in Switzerland. Although $CO_2$ emissions from illegal waste incineration are divided into biogenic and non-biogenic waste, the amount of waste incinerated has been reported only for non-biogenic waste, with the amount of biogenic waste reported as included elsewhere. The ERT recommends that Liechtenstein divide the amount of waste incinerated into biogenic and non-biogenic waste, consistent with its reporting of the $CO_2$ emissions from this waste incineration. During the review, Liechtenstein informed the ERT that it will follow this recommendation in its 2010 submission.

### 5. Other – $CH_4$ and $N_2O$

81. Liechtenstein has reported $CH_4$ and $N_2O$ emissions from composting. On the basis of expert judgment, the amount of composting in small compost sites was estimated as a proportion of the amount of composting in centralized compost plants, resulting in a proportion of 8 per cent for 1990 and 5 per cent for 2005. The ERT encourages Liechtenstein to provide more detailed information on the aforementioned expert judgement in its future inventory submissions.

## VII. Other issues

### 1. Changes to the national system

82. Liechtenstein has not reported any changes to its national system in its 2008 inventory submission. In response to questions raised by the ERT during the review, Liechtenstein confirmed that no changes to the national system had taken place. During the review, Liechtenstein also informed the ERT that changes to its national system have been included in its 2009 submission and that the relevant information will be updated annually.

### 2. Changes to the national registry

83. Liechtenstein has not reported any changes to its national registry in its 2008 inventory submission. In response to questions raised by the ERT during the review, Liechtenstein confirmed that no changes to the national registry had taken place. During the review, Liechtenstein also informed the ERT that changes to its national registry have been included in its 2009 submission and that the relevant information will be updated annually.

### 3. Commitment period reserve

84. Liechtenstein has not reported its commitment period reserve (CPR) in the 2008 submission. In response to questions raised by the ERT during the review, Liechtenstein reported its commitment period reserve to be 950,061 $CO_2$ eq based on the assigned amount, which is consistent with the initial review report (FCCC/IRR/2007/LIE). The ERT agrees with this figure. The ERT recommends that Liechtenstein include the information on its CPR in its future annual submissions. During the review, Lichtenstein informed the ERT that changes to its national registry has been included in the 2009 submissions and the associated information will be updated annually.

# VIII. Conclusions and recommendations

85. Liechtenstein submitted a complete set of CRF tables for the period 1990–2006 and an NIR by the deadline established in the "Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual inventories" (hereinafter referred to as the UNFCCC reporting guidelines). Liechtenstein has submitted a national GHG inventory that is generally complete in terms of the years, sectors and gases covered. However, some minor categories are missing from the 2008 submission, namely $CO_2$ emissions from unmanaged waste disposal on land and indirect GHGs and $SO_2$ emissions in the energy sector.

86. In general, the 2008 submission conforms with the UNFCCC reporting guidelines in terms of its completeness, consistency and comparability. However, transparency could be improved by describing more thoroughly in the NIR the data and methodologies used to calculate the GHG emission estimates.

87. The ERT has identified some areas for improvement, recommending that Liechtenstein:

(a) Provide quantified uncertainty estimates for the non-key categories and the LULUCF sector;

(b) Improve the transparency of the descriptions in the NIR of the LULUCF, agriculture and energy sectors;

(c) Further improve the QA/QC plan;

(d) Provide a description of the implementation of QA/QC activities, particularly those conducted in connection with AD;

(e) Provide explanations of the applicability of Switzerland's methodologies and EFs to its own national GHG inventory;

(f) Develop and use country-specific methods and EFs, where possible.

88. The ERT recommends that Liechtenstein report annually in the NIR a calculation of the commitment period reserve. The ERT also recommends that Liechtenstein provide information on any changes to its national system and national registry in its future inventory submissions under the Kyoto Protocol.

# IX. Questions of implementation

89. No questions of implementation were identified by the ERT during the review.

Annex

# Documents and information used during the review

## A. Reference documents

Intergovernmental Panel on Climate Change. *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*. Available at <http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm>.

Intergovernmental Panel on Climate Change. *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*. Available at <http://www.ipcc-nggip.iges.or.jp/public/gp/english/>.

Intergovernmental Panel on Climate Change. *Good Practice Guidance for Land Use, Land-Use Change and Forestry*. Available at <http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.htm>.

"Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual inventories". FCCC/SBSTA/2006/9. Available at <http://unfccc.int/resource/docs/2006/sbsta/eng/09.pdf>.

"Guidelines for the technical review of greenhouse gas inventories from Parties included in Annex I to the Convention". FCCC/CP/2002/8. Available at <http://unfccc.int/resource/docs/cop8/08.pdf>.

"Guidelines for national systems under Article 5, paragraph 1, of the Kyoto Protocol". Decision 19/CMP.1. Available at <http://unfccc.int/resource/docs/2005/cmp1/eng/08a03.pdf#page=14>.

"Guidelines for the preparation of the information required under Article 7 of the Kyoto Protocol". Decision 15/CMP.1. Available at <http://unfccc.int/resource/docs/2005/cmp1/eng/08a02.pdf#page=54>.

"Guidelines for review under Article 8 of the Kyoto Protocol". Decision 22/CMP.1. Available at <http://unfccc.int/resource/docs/2005/cmp1/eng/08a03.pdf#page=51>.

Status report for Liechtenstein 2007. Available at <http://unfccc.int/resource/docs/2007/asr/LIE.pdf>.

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Synthesis and assessment report on the greenhouse gas inventories submitted in 2007. Available at <http://unfccc.int/resource/webdocs/sai/2007.pdf>.

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FCCC/ARR/2006/LIE. Report of the individual review of the greenhouse gas inventory of Liechtenstein submitted in 2006. Available at <http://unfccc.int/resource/docs/2007/arr/LIE.pdf>.

FCCC/IRR/2007/LIE. Report of the review of the initial report of Liechtenstein. Available at <http://unfccc.int/resource/docs/2007/irr/LIE.pdf>.

## B. Additional information provided by the Party

Responses to questions during the review were received from Mr. Patrick Insinna (Office of Environmental Protection, Vaduz/Liechtenstein), including additional material on the methodology and assumptions used.

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