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Report of the individual review of the greenhouse gas inventory of Liechtenstein submitted in 2006*

* In the symbol for this document, 2006 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 in-country review of the 2006 greenhouse gas (GHG) inventory submission of Liechtenstein, coordinated by the United Nations Framework Convention on Climate Change (UNFCCC) secretariat, in accordance with decision 19/CP.8. The review took place from 11 to 15 June 2007 in Vaduz, Liechtenstein, and was conducted by the following team of nominated experts from the roster of experts: generalist – Ms. Anna Romanovskaya (Russian Federation); energy, industrial processes – Mr. Hristo Vassilev (Bulgaria); agriculture, land use, land-use change and forestry (LULUCF) and waste – Mr. Sabin Guendehou (Benin). Ms. Anna Romanovkaya and Mr. Sabin Guendehou were the lead reviewers. The review was coordinated by Ms. Ruta Bubniene (UNFCCC secretariat).

2. In accordance with the "Guidelines for the technical review of greenhouse gas inventories from Parties included in Annex I to the Convention", (hereinafter referred to as UNFCCC review guidelines), a draft version of this report was communicated to the Government of Liechtenstein, which provided comments that were considered and incorporated, as appropriate, in this final version of the report.

B. Inventory submission and other sources of information

3. In its 2006 submission, Liechtenstein submitted a complete set of common reporting format (CRF) tables for the years 1990–2004 and a national inventory report (NIR). Liechtenstein submitted revised emission estimates for the years 1990 and 2004 on 27 July 2007 in response to questions raised by the expert review team (ERT) during the in-country visit; this report is based on these revised estimates. Where needed the ERT also used the previous (2005) submission, additional information provided during the review and other information. The full list of materials used during the review process is provided in the annex to this report.

C. Emission profiles and trends

4. In 2004, the most important GHG in Liechtenstein was carbon dioxide (CO_2), contributing 88.5 per cent to total[1] national GHG emissions expressed in CO_2 eq., followed by methane (CH_4), 5.3 per cent, and nitrous oxide (N_2O), 4.7 per cent. Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6) taken together contributed 1.5 per cent of the overall GHG emissions in the country. The energy sector accounted for 89.2 per cent of the total GHG emissions followed by agriculture, 8.3 per cent, waste, 0.6 per cent, and solvent and other product use, 0.4 per cent. Total GHG emissions amounted to 271.33 Gg CO_2 eq. and increased by 17.8 per cent from the base year to 2004. The trends for the different gases and sectors are clearly explained in the relevant section of the NIR and are reasonable.

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

[1] In this report, the term total emissions refers to the aggregated national GHG emissions expressed in terms of CO_2 eq. excluding LULUCF, unless otherwise specified.

Table 1. Greenhouse gas emissions by gas, 1990–2004

GHG emissions	Gg CO_2 equivalent								Change
	Base year Convention	1990	1995	2000	2001	2002	2003	2004	BY–2004 (%)
CO_2 (with LULUCF)	195.71	195.71	199.98	221.88	221.63	225.03	234.16	233.81	19.5
CO_2 (without LULUCF)	203.06	203.06	209.38	227.52	225.61	230.54	240.01	240.19	18.3
CH_4	13.40	13.40	12.49	12.22	12.94	13.52	13.91	14.34	7.0
N_2O	13.02	13.02	13.86	12.83	12.87	12.82	12.85	12.85	1.3
HFCs	0.00	0.00	0.39	2.31	2.92	3.16	3.44	3.95	$5*10^{-7}$
PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO
SF_6	NO	NO	NO	0.02	0.04	0.05	0.05	0.06	100.0

Note: BY = Base year, LULUCF = Land use, land use change and forestry, NA = Not applicable; NO = Not occurring.
Liechtenstein submitted revised estimates for the base year and 2004 in the course of the initial review on 27 July 2007. These estimates differ from the Party's GHG inventory submitted in 2006.

Table 2. Greenhouse gas emissions by sector, 1990–2004

Sectors	Gg CO_2 equivalent								Change
	Base year Convention	1990	1995	2000	2001	2002	2003	2004	BY–2004 (%)
Energy	203.47	203.47	210.63	229.41	227.34	232.24	241.80	242.09	19.0
Industrial processes	0.0	0.0	0.39	2.32	2.96	3.21	3.49	4.00	$5*10^{-7}$
Solvent and other product use	1.99	1.99	1.61	1.28	1.24	1.19	1.16	1.10	–44.7
Agriculture	22.48	22.48	22.09	20.22	21.32	21.72	22.08	22.44	–0.2
LULUCF	–7.35	–7.35	–9.33	–5.64	–3.97	–5.45	–5.82	–6.38	–13.2
Waste	1.55	1.55	1.40	1.66	1.52	1.73	1.73	1.74	12.3
Other	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (with LULUCF)	**222.14**	**222.14**	**226.79**	**249.26**	**250.40**	**254.63**	**264.44**	**264.99**	19.3
Total (without LULUCF)	**229.48**	**229.48**	**236.12**	**254.90**	**254.37**	**260.09**	**270.26**	**271.37**	18.3

Note: BY = Base year, LULUCF = Land use, land use change and forestry, NA = Not applicable.
Liechtenstein submitted revised estimates for the base year and 2004 in the course of the initial review on 27 July 2007. These estimates differ from the Party's GHG inventory submitted in 2006.

D. Key categories

6. Liechtenstein has reported tier 1 key category analyses, both level and trend assessment, as part of its 2006 submission. The key category analyses performed by the Party and the secretariat[2] produced some different results because Liechtenstein did not include the LULUCF sector in its key category analysis and used a different level of disaggregation for the most important categories in the energy sector. The key categories for other sectors identified by the secretariat are generally in agreement with those reported by the Party's level and trend assessments. The results of the key category analysis are a driving factor for the preparation of the inventory for all sectors, particularly in the prioritization of resources and the development of the higher tier methodologies. Most of the key categories are estimated using the tier 2 method.

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 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). However, during the in-country visit the ERT found that some descriptions of country-specific methodologies (e.g. estimation of carbon stock changes in the LULUCF sector), assumptions (e.g. interpolation for livestock populations) and emission factors (EFs) (e.g. for road transport and fugitive emissions in the energy sector) lack transparency. The ERT recommends that Liechtenstein improve transparency in the descriptions of these elements in its next inventory submission.

F. Cross-cutting topics

1. Completeness

8. The reporting in the Party's 2006 submission is complete in terms of years, sectors, categories and gases, including actual emissions of HFCs and SF_6 (the fluorinated gases (F-gases)), for the first time. However, emissions estimates for some categories (e.g. CH_4 emissions from managed waste disposal on land and CH_4 and N_2O emissions from biogas used to produce energy) were provided only during the review process. The CRF tables are generally complete. However, table 7 – summary overview for key categories, table 4B(a)s2 – CH_4 emissions from manure management and table 4Ds2 – agricultural soils in the CRF have not been completed. The ERT encourages Liechtenstein to properly complete all the CRF tables in the next submission. Liechtenstein reported some categories (e.g. emissions from nitrogen (N) fertilization and drainage of soils and from wild fires) as not occurring ("NO") and explained that these practices either do not occur or occur on a very small scale. The ERT encourages Liechtenstein to collect data and estimate all categories occurring in the country in the next submission in order to improve completeness. The ERT appreciates, and encourages Liechtenstein to continue, the reporting of subcategories additional to the IPCC methodology (e.g. composting of organic wastes, N-fixation on pastures).

[2] The secretariat identified, for each Party, those source 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 Foresty;* for the base year or base year period as well as the latest inventory year. Key categories according to the tier 1 trend assessment were also identified. 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.

2. Transparency

9. The Party's NIR provides much of the information required to assess the inventory. However, provision of some additional information could greatly improve transparency in the NIR and the CRF tables. The assumptions, country-specific methodologies, parameters and EFs as well as the uncertainty values used in Liechtenstein's inventory are mostly referenced to Swiss data. The ERT encourages Liechtenstein to report in the NIR the explanatory background information for these data for all sectors, but particularly the energy and LULUCF sectors. Providing additional information in the documentation boxes of the CRF background tables (e.g. for table 6.B – wastewater handling) would also increase overall transparency. The ERT recommends Liechtenstein to provide in a transparent manner in the NIR and the documentation boxes of the CRF tables of the next GHG inventory submission background information on all the assumptions and country-specific data used.

3. Recalculations and time-series consistency

10. The ERT noted that recalculations of the entire time series from the base year to 2004 had been undertaken by the Party in order to improve inventory estimates and provide the complete coverage of all sources and gases required in the IPCC methodologies. The major changes include: (1) revision of the activity data (AD) in the energy statistics; (2) revision of the EFs for direct N_2O emissions from agricultural soils (a default EF was used in this submission) and (3) inclusion of those categories that had not been estimated before. In general, the rationale for the recalculations is provided in the NIR and they have resulted in real improvements to the GHG inventory. The total effect of these recalculations is a 2.4 per cent increase in the estimate of total GHG emissions for 2003 and a 8.0 per cent decrease for the base year (1990).

11. The trends for GHG emissions reported in the Liechtenstein inventory in the period 1990 to 2004 are largely consistent. The ERT appreciates the fact that the analysis of the GHG emissions trends gives an indication of all the major drivers for fluctuations and that this information is clearly described in the NIR. However, the ERT noted that some rapid fluctuations in AD (e.g. poultry numbers) are not explained in the NIR. The ERT encourages Liechtenstein to add explanatory information on the AD trends in its next inventory submission.

4. Uncertainties

12. Liechtenstein provided a tier 1 uncertainty analysis for the non-LULUCF key categories and for the inventory in total, following the IPCC good practice guidance. The uncertainty analysis for all non-key categories was considered under one residual source and was undertaken using expert judgement. The ERT encourages Liechtenstein to add additional information on the expert judgement applied in the uncertainty analysis to its next GHG submission. Uncertainty values for country-specific parameters are not always clearly described in the NIR. The level of uncertainty associated with the estimates is in some cases based on a qualitative evaluation only (e.g. the NIR reports that the level of uncertainty in the inventory is assessed as low and medium). Correlations in uncertainty analysis are not considered, which might lead to the underestimation of total uncertainties. The ERT recommends Liechtenstein to include the LULUCF categories (in accordance with the level of disaggregation proposed in Table 5.4.1. of the IPCC good practice guidance for LULUCF) and to separate uncertainties for non-key categories (in accordance with the level of disaggregation proposed in Table 7.1. of the IPCC good practice guidance). The ERT encourages the Party to consider the possibility of implementing a tier 2 uncertainty assessment (Monte Carlo simulation) in order to estimate the correlation of the estimates of emissions.

5. Verification and quality assurance/quality control approaches

13. At the time of the in-country visit, on 11–15 June 2007, Liechtenstein had not provided a formal quality assurance/quality control (QA/QC) plan in accordance with the IPCC good practice guidance.

However, during the in-country review, Liechtenstein informed the ERT that an informal system for QA/QC checks had been developed and implemented during the preparation of the official GHG inventory submissions. The general QC procedures (tier 1) of the system include: (1) an annual plan for the preparation of GHG inventories; (2) double checks of all the GHG information during the review of the NIR by sectoral experts and checks on the emission estimates made by the NIR authors; (3) consistency checks of all the AD against the data for previous years; and (4) internal checking procedures (periodical surveys and censuses) for all data collected by the governmental offices that are providers of official statistical data. Liechtenstein provided a QA/QC plan in the course of the review, and the ERT recommends that Liechtenstein include this information in its next inventory submission. The ERT also recommends that Liechtenstein monitor the AD quality control checklists of the private companies involved in the preparation of the inventory and describe this procedure in the NIR of its next inventory submission.

14. Liechtenstein has implemented some QA procedures in accordance with IPCC good practice guidance requirements, including: (1) Swiss external expert peer review of all country-specific methodologies and EFs; and (2) internal QA by staff in the Office of Environmental Protection (OEP), the designated national entity that has a mandate from the Government of Liechtenstein to manage the national system for preparation of the GHG inventory, who are not directly involved in the compilation of the inventory.

6. Follow-up to previous reviews

15. The current review was the first review conducted of Liechtenstein's GHG inventory because, in the absence of an NIR, it was not possible to conduct a review in previous years.

G. Areas for further improvement

1. Identified by the Party

16. The NIR does not indicate clearly any areas for further improvement of the GHG inventory. The ERT recommends that Liechtenstein consider an approach of continuous improvement of the overall quality of its emission estimates, AD and EFs. In its response to the issues raised during the review, the Party indicated that it is working to improve its estimates of N_2O emissions from histosols, of CH_4 emissions from managed waste disposal on land and of N_2O and CH_4 emissions from wastewater handling.

2. Identified by the ERT

17. The ERT identified the following major cross-cutting issues for improvement. The Party should:

(a) Provide documentation on its QA/QC activities;

(b) Provide a key category analysis for 1990, include the LULUCF sector in the key category analysis for the entire time series and consider the possibility of using a tier 2 key category analysis;

(c) Include the LULUCF sector and non-key categories in the uncertainty assessment and consider the possibility of implementing a tier 2 uncertainty analysis;

(d) Provide thorough documentation on the expert judgements used to estimate uncertainty values for country-specific parameters;

(e) Provide more precise descriptions of any methodologies and parameters that differ from IPCC guidance;

(f) Provide the additional information requested in the documentation boxes of the CRF tables;

(g) Improve transparency in its explanation of AD trends.

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

II. Energy

A. Sector overview

19. In 2004, the energy sector in Liechtenstein accounted for 89.2 per cent (242.1 Gg CO_2) of total national GHG emissions. The most significant categories in the energy sector are other and transport, representing 46.2 per cent and 35.5 per cent of sectoral emissions, respectively.

20. In the period 1990–2004, emissions from the energy sector increased by 19.0 per cent, primarily because of a 25.9 per cent increase in emissions from other sectors and a 12.6 per cent increase in emissions from transport.

21. The CRF tables are largely complete. The estimates for most gases and sources are consistent with the requirements of the Revised 1996 IPCC Guidelines. However, "NO" is reported for AD for natural gas distribution. During the in-country visit, the Party provided additional explanations of the CO_2 fugitive emissions from natural gas distribution and corrected the notation keys from "NO" to included elsewhere ("IE") (table 1B.2.b – natural gas). The ERT commends this effort by the Party and recommends Liechtenstein to better document the use of notation keys in the future submissions.

22. Liechtenstein has improved its inventory considerably since its previous (2005) inventory submission. However, the ERT noted a lack of full documentation on the data sources used (e.g. the main part of the energy balance or the data files for national statistics), which reduces the transparency of the reporting. The ERT recommends that Liechtenstein provide more detail on the data sources in its next inventory submission.

23. Recalculations are reported in the CRF for the years from 1990 to 2003 In the base year, the recalculations have led to an increase in the estimates of CO_2 emissions and CH_4 emissions of 129.6 per cent and 66.8 per cent, respectively, and a decrease in the estimate of N_2O emissions by 73.1 per cent compared to the 2005 submission. The recalculations were based on improved AD for sectoral energy consumption and the elimination of inconsistencies in the statistical data. The ERT commends these improvements.

B. Reference and sectoral approaches

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

24. Liechtenstein forms a customs union with Switzerland and therefore has no specific statistics on the export and import of liquid fuels. Liechtenstein does not have a refinery industry. Liechtenstein therefore states that the reference approach and the sectoral approach are identical and that the reference approach has therefore not been reported explicitly in the 2006 submission. Nevertheless, the ERT encourages Liechtenstein to report the reference approach in its next inventory submission.

2. International bunker fuels

25. The single category reported under international bunker fuels is aviation bunkers, because there is a helicopter base in the country. Emissions of CO_2 from aviation bunkers decreased by 18.6 per cent from 1990 to 2004. In 2004, GHG emissions from aviation bunkers contributed 85.4 per cent of the total emissions from aviation. This reflects the national circumstances of the country.

3. Feedstocks and non-energy use of fuels

26. In 2004, Liechtenstein reported feedstock and non-energy use of fuels as "NO". Emissions of non-methane volatile organic compounds (NMVOC) from road paving with asphalt, however, are estimated and reported in the CRF, indicating that emissions from lubricants and bitumen do occur. The ERT recommends that Liechtenstein estimate emissions from lubricants and bitumen and report these estimates in its next inventory submission.

C. Key categories

1. Stationary combustion: liquid fuels – CO_2

27. Tier 1 and tier 2 methods have been used to calculate CO_2 emissions from stationary combustion. A tier 1 method is used to estimate emissions from agriculture/forestry/fisheries (1.A.4.c). EFs, AD and methodologies are satisfactorily described and explained in the NIR and the CRF tables. However, the ERT recommends Liechtenstein to apply a tier 2 method for all subcategories under this key category.

2. Stationary combustion: gaseous fuels – CH_4

28. The ERT noted that the Party's EFs for CH_4 from natural gas combustion in public electricity and heat production and in manufacturing industry and construction are higher than the IPCC default EFs (the IPCC default EF for gas equipment is 2.5 g/GJ and for boilers for natural gas is 1.4 g/GJ). In the course of the review, Liechtenstein explained that different parameters were used for the estimates. The specifications for a gas motor formed the basis for estimation of emissions from co-generation of electricity and heat (a country-specific EF of 25 g/GJ was used) and the specifications for a boiler formed the basis for estimations of emissions from generation of heat (a country-specific EF of 6 g/GJ was used). The ERT notes that the estimation is correct and recommends that Liechtenstein enhance transparency in the NIR by including this clarification in its next inventory submission.

3. Road transportation: liquid fuels – CO_2

29. In 2004, CO_2 emissions from road transportation accounted for 30.7 per cent of total national emissions. These emissions increased by 12.9 per cent from 1990 to 2004. Liechtenstein uses a tier 1 approach to estimate CO_2 emissions from combustion of gasoline and diesel oil. As this is a key category, the ERT recommends that Liechtenstein apply a tier 2 approach and country-specific EFs in its next inventory submission.

30. Liechtenstein calculates fuel consumption using the approach outlined in the Revised 1996 IPCC Guidance on the basis of the fuel sold in the country. During the in-country visit, Liechtenstein demonstrated that the emissions are also estimated, as a second approach, based on kilometres travelled. This approach is substantiated by a model which, as well as other parameters, includes transport statistics such as the distance travelled by vehicle. The ERT noted that the CO_2 emissions from gasoline and diesel oil estimated using the kilometres travelled approach resulted in estimates that were 45.6 per cent lower in the base year and 31.0 per cent lower in 2004. The ERT considers that the differences between the results obtained using the two different approaches are well explained (Austrian drivers buying fuel for their cars due to the lower gasoline prices in Liechtenstein) and that the reported level of CO_2 emissions estimated from gasoline and diesel fuel is accurate.

D. Non-key categories

Fugitive emissions: oil and natural gas – CH_4

31. Fugitive CH_4 emissions from oil and natural gas are estimated using a tier 3 IPCC method, which is also used to estimate such emissions in Switzerland. The method used is in line with the IPCC good practice guidance. However, the CH_4 implied emission factor (IEF) for the distribution of natural gas

(391.5 kg/unit) is much higher than the default IPCC EF (9.5 kg/unit). During the in-country visit, the Party explained that the difference was caused by a typing error in the CRF tables and that different units (m_3/h/km) for the CH_4 EF had been used for the calculations. Liechtenstein has revised the AD and corrected the IEF so that they are within the range of the IPCC default values. The ERT encourages the Party to add information on the length of gas pipelines for 1990–2004 and to explain any country-specific circumstances in its next inventory submission.

III. Industrial processes and solvent and other product use

A. Sector overview

32. In 2004, industrial processes, and solvent and other product use contributed 1.5 per cent (4 Gg CO_2 eq.) and 0.4 per cent (1.1 Gg CO_2 eq.) of the total national emissions, respectively. The only category reported under industrial processes is consumption of halocarbons and SF_6. The other categories in industrial processes are reported as "NO".

33. Liechtenstein reports carbon monoxide and NMVOC emissions from asphalt roofing and NMVOC emissions from road paving with asphalt, and uses Swiss country-specific emissions per inhabitant to estimate these emissions. The ERT encourages Liechtenstein to explain the method in more detail in its next inventory submission.

B. Key categories

Consumption of halocarbons and SF_6 – HFCs

34. The main source of AD for this category is actual emissions of HFCs. The ERT noted that actual HFC emissions are split between different types of equipment and that Liechtenstein has good statistics on stationary refrigeration and transport-related refrigeration, and on air-conditioners. Actual emissions increased by 4,000 per cent from 1993 to 2004. In the four-year period 2001–2004 the increase was 33.3 per cent. The ERT recommends that Liechtenstein explain this trend in the NIR of its next inventory submission.

IV. Agriculture

A. Sector overview

35. In 2004, agriculture accounted for 8.3 per cent (22.44 Gg CO_2 eq.) of the total national GHG emissions. Over the period 1990–2004, emissions in the sector decreased by 0.2 per cent. In 2004, the contributions of CH_4 and N_2O emissions to sectoral emissions were 54.0 per cent and 46.0 per cent, respectively. The main source of CH_4 emissions was enteric fermentation while agricultural soils were the most significant source of N_2O emissions during this period. Rice cultivation, prescribed burning of savannas and field burning of agricultural residues are reported as "NO".

36. The EFs for N_2O emissions from agricultural soils were revised and corresponding recalculations of the entire time series were made. In the 2006 submission the default value of the EF for direct N_2O emissions from agricultural soils was used, which resulted in an increase in estimates of sectoral emissions for 1990 and 2003 of 25.2 per cent and 17.0 per cent, respectively. Liechtenstein provided revised estimates of direct N_2O emissions from agricultural soils (4.D.1) in response to questions raised by the ERT about land area in the course of the review.

37. Liechtenstein reports complete estimates of all gases and categories from the agriculture sector, including their descriptions, as recommended by the IPCC good practice guidance. However, the uncertainty analysis for the agriculture sector is not clearly described in the NIR. The ERT recommends that Liechtenstein provide more explanatory information on uncertainties in the AD and the EFs in its next inventory submission.

38. In addition to the requirements of the IPCC good practice guidance, emissions from composting of organic wastes applied to soils are reported. The ERT appreciates the reporting of this additional category.

B. Key categories

1. Enteric fermentation – CH_4

39. The AD for the livestock categories used in the period 1990–2004 were obtained from different sources: the Office of Agriculture (LWA 2004) and the Office of Economic Affairs (AVW 1992). The NIR does not clearly state whether the methodologies for collecting these data from the two data sources are consistent. During the in-country review, Liechtenstein explained that the method of data collection was the same for both data sources and that the data are fully consistent. However, some of the AD (e.g. the numbers of some livestock) are not received annually but are interpolated. The ERT recommends that Liechtenstein provide explanations of the methodology for collecting and estimating the AD and of their consistency in its next inventory submission.

40. Poultry numbers have increased rapidly since 1996. The trend for poultry numbers is not explained in the NIR. In the course of the review, Liechtenstein explained that the reason for this trend was the establishment of two new poultry farms. The ERT encourages the Party to provide explanations of the rapid change in livestock numbers in the NIR of its next inventory submission.

2. Direct soil emissions – N_2O

41. The area of histosols reported under agriculture is higher than the area of organic soils reported in the LULUCF sector under category 21 (cropland). This leads to an overestimation of direct N_2O emissions from agricultural soils for the entire time series. During the in-country review, Liechtenstein noted that the area of histosols reported under direct soil emissions (4.D.1) might be incorrect. The ERT recommended that Liechtenstein revise its estimates of direct N_2O emissions from histosols. In the course of the review, following the recommendation of the ERT, Liechtenstein provided revised estimates for direct N_2O from histosols (0.62 Gg CO_2 eq. in 2004), which resulted in a decrease in emissions by 10.1 per cent compared with the emissions presented in the original 2006 submission.

42. In its NIR, Liechtenstein assumed that 60 per cent of the nitrogen in N-fixing crops comes from N-fixation. However, it is not clear from the NIR whether the remaining 40 per cent of the nitrogen in these types of crops was considered in the estimation of the total nitrogen input to soils. In the course of the review, Liechtenstein explained that all nitrogen from crop residues is included in the estimation, because the remaining 40 per cent comes from inputs of synthetic fertilizers and manure and is included under those categories. This is in line with the IPCC good practice guidance. The ERT recommends that Liechtenstein provide the relevant explanation in its next inventory submission.

43. Swiss standard values for crop production have been used for the Party's estimations of the amount of crop residues for 1990–2004. However, during the in-country visit, the ERT learned that annual national statistics on crop production are available in Liechtenstein. The Party might wish to consider the possibility of using these annual crop production statistics to estimate the amounts of crop residues in its next inventory submission.

V. Land use, land-use change and forestry

A. Sector overview

44. The LULUCF sector constituted a net sink of GHG in 1990–2004, which offset 7.35 Gg CO_2 eq. emissions in 1990 and 6.38 Gg CO_2 eq. in 2004. The amount offset decreased by 13.2 per cent between 1990 and 2004. The ERT encourages Liechtenstein to set out the reasons for this decrease in its next inventory submission.

45. The inventory in the LULUCF sector is in general complete since it covers all categories and gases. Liechtenstein also reports the categories wetlands and settlements. All the required CRF tables are provided for all the years from 1990 to 2004.

46. The information provided by Liechtenstein is in general transparent. However, the data collection techniques and the methodology applied in the base year required additional clarification, which was provided during the in-country review. The ERT recommends Liechtenstein to include these clarifications in its next inventory submission.

47. In general, the inventory methods are used consistently throughout the entire time series. In most cases, Liechtenstein applied Swiss methods, country-specific AD and some country-specific EFs. Liechtenstein has used interpolation and extrapolation techniques to address the land area data gap, using existing data from three national land statistical sources (aerial photographs of the whole country from 1984, 1996 and 2002) and a national forest inventory (NFI, Liechtensteinisches Landesforstinventar 1998) and developing a land-use change matrix. The ERT noted that the extrapolation has been applied for the entire 10-year period 2002–2012, which is not in line with the IPCC good practice guidance, as it is too long a period. Liechtenstein also used the NFI of Switzerland to derive some of the country-specific parameters required.

48. The ERT noted some inconsistencies between the NIR and the CRF tables, mainly with regard to the reporting of land use categories (e.g. land converted to forest land, land converted to cropland, and land converted to grassland are reported in the CRF tables but not in the NIR) and recommends Liechtenstein to improve the consistency between the NIR and the CRF tables in its next inventory submission. Furthermore, the ERT found it difficult to identify in the NIR the different land use categories (e.g. forest remaining forest, land converted to forest, cropland remaining cropland, land converted to cropland, grassland remaining grassland and land converted to grassland) and the different carbon pools (living biomass, dead organic matter and soil organic carbon) following the classification presented in the IPCC good practice guidance for LULUCF. The Party is encouraged to clearly distinguish these land use categories in the NIR of its next inventory submission.

49. None of the formal category-specific QA/QC procedures recommended by the IPCC good practice guidance has been implemented. The ERT recommends Liechtenstein to develop and implement such procedures for the preparation of its next inventory submission.

50. The LULUCF sector has not been included in the Party's key category analysis. The categories presented below were identified as key categories or non-key categories by the UNFCCC secretariat.

B. Key categories

1. Forest land remaining forest land – CO_2

51. During the in-country visit, Liechtenstein explained that "inaccessible forest" in the land-use change matrix corresponds to "unmanaged forest". The ERT found that the inclusion of this category in the inventory is not in line with the IPCC good practice guidance for LULUCF and might lead to an overestimation of sinks for the entire time series. Liechtenstein confirmed the finding and informed the ERT that it will correct the estimations in the future. The ERT recommends that Liechtenstein provide the revised estimates for forest land, including managed forest only, in its next inventory submission.

52. Liechtenstein used the Swiss country-specific method and AD from Liechtenstein to estimate removals from this category. The data on land area were based on interpolation and extrapolation. The NFIs of Switzerland were used to derive the EFs and the parameters required (e.g. biomass expansion factor, biomass density, biomass growth rate) for the estimation of the changes in carbon stocks. In response to questions raised by the ERT during the in-country visit, Liechtenstein explained how the data for the base year were derived, since none of the three NFIs (NFI I, 1983–1985; NFI II, 1993–1995; and

NFI III, 2000–2006) used in the estimations of removals from this category covers 1990. The spreadsheets used were analysed by the ERT, which concluded that the method is in line with the IPCC good practice guidance for LULUCF. The ERT recommends that Liechtenstein better document the methodology and data used to estimate the emissions and removals in the base year in its next inventory submission.

53. Liechtenstein has not reported any emissions from N fertilization and drainage of soils or from wild fires and has argued that these practices or events either do not occur or occur only on a very small scale. The ERT encourages Liechtenstein to report these categories if the data are available or can be obtained.

2. Cropland remaining cropland – CO_2

54. The estimation of living biomass in annual crops for the estimation of change in carbon stocks is not in line with the IPCC good practice guidance. This leads to an overestimation of the carbon stocks. During the in-country visit, Liechtenstein explained that the carbon stocks estimated for living biomass in annual crops are not included in the inventory and are considered only if land-use changes occur. The ERT confirms that the reporting of the Party is correct and recommends that Liechtenstein clarify in its next inventory submission that only perennial cropland is considered for the estimation of the changes in carbon stocks in living biomass in cropland remaining cropland, and that carbon stocks in annual crops are considered only in the case of conversion of land to grassland.

3. Settlements – CO_2

55. Liechtenstein used the IPCC default parameters and Swiss country-specific data to estimate the carbon stock changes in trees and soils. The ERT acknowledges the efforts made by the Party to report this category.

C. Non-key categories

1. Grassland remaining grassland – CO_2

56. In the course of the in-country visit, Liechtenstein confirmed that "unproductive grassland" identified in the land-use change matrix corresponds to "unmanaged grassland". The ERT identified that the inclusion of this category in the inventory is not in line with the IPCC good practice guidance for LULUCF and might lead to an overestimate of removals. The ERT recommends Liechtenstein to consider only managed grassland and to report it in its next inventory submission.

2. Wetlands converted to other land – CO_2

57. The classification by the Party of "unproductive wetlands" as "unmanaged wetlands" is not in line with the IPCC good practice guidance for LULUCF. During the in-country review, Liechtenstein clarified that the carbon stocks are to be considered only if a change in land-use category occurs and that they are not included in the inventory. The ERT recommends that Liechtenstein include this clarification and better document the consideration of unproductive wetlands in its next inventory submission.

VI. Waste

A. Sector overview

58. In 2004, emissions from the waste sector contributed 0.6 per cent (1.74 Gg CO_2 eq.) of the national total emissions. Emissions from the waste sector increased by 12.3 per cent from 1990 to 2004. Liechtenstein explained that the emissions have increased because of the growth of composting activities, thereby reducing the amount of municipal waste sent to Switzerland for incineration. The inventory of the waste sector is in general complete and it covers all categories and gases apart from estimates of CH_4

emissions from landfill and of CH_4 and N_2O emissions from biogas from wastewater treatment used to produce energy.

59. The information provided by Liechtenstein is in general transparent. However, Liechtenstein should improve the transparency of its cross-sectoral reporting by better documenting the clarifications provided during the review process in its next inventory submission; for example, clarifications of the reporting of emissions from biogas produced from wastewater treatment plant and burned to produce energy, which are reported in the energy sector, and reporting of emissions from compost applied to agricultural land, which are included in the agriculture sector. Furthermore, an explanation of the use of some notation keys in the CRF tables (e.g. "NE" and "IE" in wastewater handling) was only provided during the in-country visit. The ERT recommends that Liechtenstein provide this explanation of its use of notation keys in its next inventory submission.

60. In general, the inventory methods are used consistently throughout the entire time series. In most cases Liechtenstein applied Swiss methods together with the country-specific AD and some country-specific EFs. Some inconsistencies between the NIR and the CRF tables have been noted (e.g. in the NIR, a "non-biogenic" fraction of carbon is reported but in the CRF tables this fraction is reported under the "biogenic" fraction of carbon). The ERT recommends Liechtenstein to improve the consistency between the NIR and the CRF tables in its next inventory submission. Liechtenstein implements some QC checks, but none of the formal category-specific QA/QC procedures recommended by the IPCC good practice guidance is in place. The ERT recommends the Party to develop and implement category-specific QA/QC procedures.

B. Key categories

61. No key category has been identified in the waste sector.

C. Non-key categories

1. Managed waste disposal on land – CH_4

62. Liechtenstein reported managed waste disposal on land as "NO" assuming that, because its landfills had ceased operating 16 years before 1990, no emissions had occurred in the base year or in the entire time series. This is the eq. of the use of the mass balance approach, which underestimates such emissions. During the in-country visit and following the suggestion of the ERT, Liechtenstein provided estimates of CH_4 emissions from managed waste disposal on land using the first order decay (FOD) model and provided the AD (e.g. waste generation per capita and amount of waste landfilled) and the parameters (e.g. degradable organic carbon, decay rate constant and oxidation factor) as well as all the spreadsheets used for the estimates. These revisions resulted in estimates of CH_4 emissions of 0.22 Gg CO_2 eq. in the base year and 0.031 Gg CO_2 eq. in 2004. The ERT commends the provision of the estimates and recommends that Liechtenstein include these emissions in its future inventory submissions.

2. Wastewater handling – CH_4

63. In order to estimate CH_4 emissions from wastewater treatment plant (including domestic, commercial and industrial wastewater), Liechtenstein used parameters such as the volume of biogas produced and a leakage rate. Liechtenstein used plant-specific data on biogas as well as Swiss data on a leakage rate of 0.2 per cent and the CH_4 content in biogas of 65 per cent. During the in-country visit, the Party provided documentation on the parameters used and clarification of their use, which the ERT appreciated. During the in-country visit, Liechtenstein confirmed that CH_4 emissions from the use of biogas from wastewater handling to produce energy are not reported in the inventory. The ERT recommended Liechtenstein to estimate and report these emissions under the energy sector. Following this recommendation, Liechtenstein provided estimates of CH_4 emissions from biogas used to produce energy that were produced using well documented plant-specific data and EFs. These emissions,

estimated at 0.002 Gg CO_2 eq. in 1990 and 0.003 Gg CO_2 eq. in 2004, are reported in category 1.A.1a public electricity and heat production – biomass in the energy sector. The ERT recommends that Liechtenstein report these emissions in its future inventory submissions.

64. Liechtenstein also informed the ERT that biogenic CO_2 emissions from the biogas used for energy production are reported under the energy sector as a memo item and are not included in the total national GHG emissions. This is in line with the IPCC good practice guidance. The ERT recommends that Liechtenstein better document this information in its next inventory submission in order to enhance the transparency of the reporting.

3. Wastewater handling – N_2O

65. Liechtenstein used the IPCC default method to calculate N_2O emissions from wastewater handling. However, Liechtenstein used a constant value for protein consumption for the entire time series. The ERT recommends that Liechtenstein investigate the availability of annual statistics on protein consumption (e.g. the data from the United Nations Food and Agriculture Organization or data based on the well documented judgement of national experts) and estimate N_2O emissions from wastewater handling in its next inventory submission.

66. The ERT identified that Liechtenstein had not reported N_2O emissions from the combustion of biogas from wastewater handling to produce energy and recommended that Liechtenstein estimate and report these emissions under the energy sector. Following these recommendations, in the course of the review, Liechtenstein provided estimates of 0.053 Gg CO_2 eq. in 1990 and 0.074 Gg CO_2 eq. in 2004 reported under biomass in public electricity and heat production (1.A.1a.). Referenced plant-specific data and EFs have been used. The ERT recommends that Liechtenstein report these emissions in its next inventory submission.

4. Waste incineration – CO_2, CH_4, N_2O

67. In the NIR, Liechtenstein has reported that waste incineration does not occur, but a fraction of household waste is burned by the population and the emissions (CO_2 and non-CO_2) from this practice are calculated and reported by Liechtenstein using Switzerland's country-specific EFs. Liechtenstein confirmed, during the in-country visit, that the EF used for CO_2 includes only fossil carbon and that the EFs for non-CO_2 emissions are for both fossil and biogenic carbon. This is in line with the IPCC good practice guidance and the ERT recommends that Liechtenstein include this information in its next inventory submission. The ERT has identified that fossil carbon was misallocated in CRF table 6.C. Fossil carbon should be reported under "non-biogenic" and not under "biogenic". During the review process, Liechtenstein acknowledged the misallocation and added the CO_2 emissions from fossil carbon to the total national GHG emissions. The ERT recommends that Liechtenstein accurately allocate these emissions in its future inventory submissions.

5. Composting of organic waste – CH_4, N_2O

68. Liechtenstein used Swiss country-specific methods to estimate emissions of CH_4 and N_2O from composting of organic waste. The ERT appreciated the clarification provided by Liechtenstein on the distinction between the emissions reported under waste and those reported under the agriculture sector. The ERT encourages Liechtenstein to provide this clarification in its next inventory submission.

VII. Conclusions and recommendations

69. The 2006 submission by Liechtenstein is in general prepared in accordance with the Revised 1996 IPCC Guidelines, the IPCC good practice guidance and the IPCC good practice guidance for LULUCF and provides much of the information necessary to assess the quality of the inventory.

70. However, some additional information could greatly improve transparency in the NIR and the CRF tables, including background information on assumptions, country-specific methodologies, parameters and EFs as well as on the uncertainty values used for all sectors, particularly the energy and LULUCF sectors. The provision of additional information in the documentation boxes of the background tables in the CRF (e.g. for wastewater handling) could also increase transparency in the reporting.

71. The inventory is in general complete and covers all years and categories, except for some missing categories such as CH_4 emissions from landfills, and CH_4 and N_2O emissions from biogas used for energy. The ERT recommended Liechtenstein to provide the estimates for these categories for the base year and 2004 and, following the ERT recommendation, in the course of the review, Liechtenstein provided estimates for these categories for the base year and 2004 which are in line with the IPCC good practice guidance.

72. During the review process, the ERT formulated a number of recommendations related to QA/QC procedures and the transparency of the information presented in the 2006 submission. Most of the recommendations were addressed during the review process and those which referred to potential problems that could have led to an underestimation of emissions in 2004 have been resolved. The major remaining recommendations are presented below. Liechtenstein should:

- Improve documentation on the assumptions, country-specific data and methods used, particularly in the energy and LULUCF sectors;
- Provide a key category analysis for 1990, include the LULUCF sector in the key category analysis and use tier 2 methods for all key categories;
- Include LULUCF and non-key categories in the uncertainty assessment and consider the possibility of implementing a tier 2 uncertainty analysis;
- Provide thorough documentation of expert judgements used to estimate uncertainty values for country-specific parameters;
- Provide additional information in the documentation boxes of the CRF tables;
- Improve transparency in the explanations of AD trends.

Annex

Documents and information used during the review

A. Reference documents

IPCC. Good practice guidance and uncertainty management in national greenhouse gas inventories, 2000. Available at: <http://www.ipcc-nggip.iges.or.jp/public/gp/english/>.

IPCC. Good practice guidance for land use, land-use change and forestry, 2003. Available at: <http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.htm>.

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UNFCCC. 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/2004/8. Available at: <http://unfccc.int/resource/docs/2004/sbsta/08.pdf>.

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UNFCCC secretariat. Status report for Liechtenstein. 2006. Available at: <http://unfccc.int/resource/docs/2006/asr/lie.pdf>.

UNFCCC secretariat. Synthesis and assessment report on the greenhouse gas inventories submitted in 2006. FCCC/WEB/SAI/2006. Available at: <http://unfccc.int/resource/docs/webdocs/sai/sa_2006.pdf>.

B. Additional information provided by the Party

Responses to questions during the review were received from Mr. Helmut Kindle, Mr. Patrick Insinna, Mr. Sven Braden (Office of Environmental Protection), Mr. Jurg Heldstab, Ms. Myriam Steinemann (INFRAS Consulting), Mr. Jurg Fussler (EBP Ernst Basler and Partner), Mr. Jurgen Beckbissinger (Acontec AG Air Controlling, Consulting and Technics) including additional material on the methodology and assumptions used.

Emissionshandelsgesetz (EHG)Vaduz, 12. Juni 2007 / BrSv, Aktenplan-Nr. 864, Courtesy Translation of Articles related to the Preparation of Greenhous Gas Inventories within the Emission Trading Act.

Klimainventar und Inventory Report 2006 – Vorbereitung Initial Report. Vaduz, 12 Juni 2006. RA 2006/1528-8642 (in German).

Fuerstentum Liechtenstein, Amt fuer Volkswirtschaft, Statistisches Jahrbuch 2006, 2006 (in German).

Fuerstentum Liechtenstein, Betriebszahlung 1995, Landwirtschaft, Provisorische Ergebnisse, Amt fuer Volkswirschaft, Vaduz, 1995 (in German).

Regierung des Fuerstentum Liechtenstein, Klimainventar und Inventory Report 2006 – Vorbereitung Initial Report, RA 2006/1528-8642, 13 Juni, 2006 (in German).

References used in the energy sector

Arbeitsblatt Emissionsfaktoren Feuerungen (Stand Oktober 05), SAEFL 2005. Country specific NCV and EF for combustion emissions of GHG and GHG-precursors (in German).

INFRAS, Strassenverkehrsemissionen im Fuerstenturm Liechtenstein 1990, 2000, 2010, Schlussbericht 18.01.2002. Emissions from road transport in Liechtenstein 1990, 2000, 2010 Final report (in German).

References used in the land use, land-use change and forestry sector

Land-use change matrix 1984–2002, data matrix.

Relation between land-use categories, land-cover categories and the combined categories, data matrix.

Liechtensteinisches Landesgesetzblatt, Waldgesetz vom 25. Maerz 1991 (in German).

Waldordungen in Liechtenstein – Ablauf Bewilligungsverfahren, Juni 2007 (in German).

Amt fuer Wald, Natur und Landschaft, Rechenschaftsbericht des Amtes fuer Wald, Natur und Landschaft fuer das Jahr 2003 (in German).

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Amt fuer Wald, Natur und Landschaft, Rechenschaftsbericht des Amtes fuer Wald, Natur und Landschaft fuer das Jahr 2005 (in German).

References used in the waste sector

Bundesamt fuer Umwelt, Wald und Landschaft, Handbuch, Emissionfaktoren fur stationaere Quellen, Ausgabe 2000. Data for illegal waste burning by households (in German).

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