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Report of the individual review of the greenhouse gas inventory of Canada submitted in 2005*

* In the symbol for this document, 2005 refers to the year in which the inventory was submitted, and not to the year of publication.

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CONTENTS

I. Overview

A. Introduction

1. This report covers the centralized review of the 2005 greenhouse gas (GHG) inventory submission of Canada, coordinated by the United Nations Framework Convention on Climate Change (UNFCCC) secretariat, in accordance with decision 19/CP.8. The review took place from 3 October to 8 October 2005 in Bonn, Germany, and was conducted by the following team of nominated experts from the roster of experts: Generalists – Ms. Mirja Kosonen (Finland) and Mr. Jim Penman (United Kingdom); Energy – Ms. Sumana Bhattacharya (India), Mr. Christov Christo (Bulgaria) and Mr. Hugh Saddler (Australia); Industrial Processes – Mr. Jochen Harnisch (Germany) and Mr. Stanford Mwakasonda (Republic of South Africa); Agriculture – Mr. Samuel Adejuwon (Nigeria) and Mr. Leonard Brown (New Zealand); Land Use, Land-use Change and Forestry (LULUCF) – Mr. Hector Ginzo (Argentina) and Mr. Zoltan Somogyi (Hungary); Waste – Mr. Carlos Lopez (Cuba) and Mr. Takashi Morimoto (Japan). Mr. Carlos Lopez and Mr. Jim Penman were the lead reviewers. The review was coordinated by Mr. Matthew Dudley (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", a draft version of this report was communicated to the Government of Canada, 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 2005 submission, Canada submitted a complete set of common reporting format (CRF) tables for the years 1990–2003 and a national inventory report (NIR). Where needed the expert review team (ERT) also used previous years' submissions, additional information provided during the review and other information. The full list of materials used during the review is provided in the annex to this report.

C. Emission profiles and trends

4. In 2003, the most important GHG in Canada was carbon dioxide (CO_2), contributing 79.2 per cent to total[1] national GHG emissions expressed in CO_2 equivalent, followed by methane (CH_4), 12.7 per cent, and nitrous oxide (N_2O), 6.8 per cent. Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) taken together contributed 1.3 per cent of the overall GHG emissions in the country. The Energy sector accounted for 81.1 per cent of total GHG emissions, followed by Agriculture (8.4 per cent), Industrial Processes (7.0 per cent), Waste (3.4 per cent) and Solvents and Other Product Use (0.1 per cent). Total GHG emissions (excluding LULUCF) amounted to 740,214 Gg CO_2 equivalent and had increased by 24.2 per cent from 1990 to 2003.

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

D. Key categories

5. Canada has reported tier 1 level and trend assessments as part of its 2005 submission. They produced similar results to the analysis performed by the secretariat:[2] the two analyses produced respectively 21 and 22 key categories by level and trend (both excluding LULUCF). Canada identified pipeline transport as a separate key category. Canada has also provided a level and trend key category analysis including the LULUCF categories, which adds four LULUCF key categories by level and five by trend assessment. The LULUCF category Forest Land Remaining Forest Land, when included, dominates the key category analysis based on trends. Canada has used a key category analysis and quality assurance/quality control (QA/QC) in inventory improvement and has used uncertainties as an input to an inventory parameter sensitivity analysis. Revised CRF table 7 (Summary Overview for Key Categories) was not completed due to a problem with the CRF reporter software, and this was acknowledged by the secretariat.

E. Main findings

6. The Canadian submission contains an NIR which follows the 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" (hereinafter referred to as the revised UNFCCC reporting guidelines) and CRF tables including the revised tables for LULUCF. The inventory makes extensive use of 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 Canada has a substantial programme of development. The NIR uses methodological annexes to increase transparency. Canada has an innovative approach to QA/QC using "activity books" for documentation. Consolidation of the data archiving procedures will be very important. The review identifies areas for individual sectors where methodologies, transparency or completeness can be improved, but the priorities are in the oil and gas industry and the LULUCF sector, both of which have large programmes for improvement under way.

F. Cross-cutting topics

1. Completeness

7. The submission contains data for the years 1990–2003 apart from table 2(II).F (the sectoral background table for Industrial Processes: Consumption of Halocarbons and SF_6). Table 7 (Summary Overview for Key Categories) will be completed when the CRF software is rectified (see paragraph 4), and Annex 1 of the NIR contains a description of key categories. All gases except sulphur dioxide (SO_2) are reported. CH_4 from Industrial Processes is not estimated. The notation keys are used throughout the tables. Canada has provided the LULUCF reporting tables as required by decision 13/CP.9. There is an assessment of completeness in annex 5 to the NIR.

[2] The secretariat identified, for each individual Party, those source categories which are key categories in terms of their absolute level of emissions, applying the tier 1 level assessment as described in the Intergovernmental Panel on Climate Change *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*. Key categories according to the tier 1 trend assessment were also identified for those Parties providing a full CRF for the year 1990. Where the Party has 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

8. Subject to comments below, the inventory is transparent. The ERT welcomed the descriptions of the evolving national inventory system and of the progress being made in Canada's Quality Management Cycle.

3. Recalculations and time-series consistency

9. Major changes affecting the time series 1990–2003 include the reallocation of CO_2 emissions from agricultural soils from the Agriculture sector to LULUCF, and the reallocation of domestic and international aviation emissions. Other recalculations affect non-CO_2 emissions from forest fires, estimates of the PFC emissions from aluminium production, and the inclusion of electrical equipment as a new source of SF_6 emissions. The total effect is a reduction of 1.65 per cent in the estimates of total emissions in the base year (1990) and a reduction of 0.86 per cent in the estimates of total emissions in 2002. The ERT considered that the recalculations in general are correct and transparently documented. It should be noted that Canada has made use of the CRF Reporter software, which, owing to a bug, calculated the effect of the recalculations incorrectly. The changes reported here reflect the correct values.

4. Uncertainties

10. The Party provides tier 2 level and trend uncertainty estimates for all key categories and most non-key categories, based on data from 2001, but did not cover LULUCF. The results should be generally applicable to the estimates for year 2003. The ERT considered that the uncertainty analysis should be extended to include LULUCF, other non-key categories, and overall inventory trend uncertainties.

5. Verification and quality assurance/quality control approaches

11. The NIR describes the national inventory system and the process of inventory preparation. The Canadian Environment Protection Act (1999) is the legislative authority for Environment Canada (EC) to establish the National System, and to designate EC (Greenhouse Gas Division) as the single national entity with responsibility for the preparation and submission of the national inventory. QA/QC procedures, including verification, are part of a Quality Management Cycle. There are plans for the QA/QC coordinator to implement the quality management procedures, also covering the organizations which provide data to the inventory. There is a system for documenting QA/QC activities (called activity books). QA/QC checks applied to the calculation of CO_2 emissions in the Energy sector have revealed a number of labelling and referencing problems which will be rectified in future.

6. Follow-up to previous reviews

12. Estimates for the use of SF_6 in magnesium casting and the electrical industry have been added, and the estimates of emissions from HFC use have been extended. CH_4 emissions from enteric fermentation and manure management are now estimated using a tier 2 approach. Institutional and methodological work is continuing to address the major uncertainties in the Forest Land category, including geographical location of disturbances with respect to managed forests. The allocation of emissions between the Energy and Industrial Processes sectors has improved, and the allocation of emissions to domestic and international aviation is now based on flight data rather than nationality of airline. Better activity data (AD) have been incorporated in the estimation of emissions from solid waste disposal and the transparency of the reporting of parameter values has improved.

G. Areas for further improvement

1. Identified by the Party

13. The NIR anticipates improvements in QA/QC and data archiving as part of Canada's ongoing programme of inventory development. The ERT noted the very substantial programme which is under way in the Energy sector, in cooperation with stakeholders, to improve the estimates of emissions from the petroleum industry, and work is also under way on the carbon (C) contents of coal and national energy balances. The NIR anticipates a series of detailed improvements in estimating emissions from industrial processes. The use of tier 2 methods will be expanded in the Agriculture sector. An ambitious programme of improvement is under way on LULUCF.

2. Identified by the ERT

14. The ERT appreciates the resources that Canada is devoting to the work across all inventory sectors. The ERT believes that the highest priorities are probably consolidation of the QA/QC and data archiving functions, and improvements to the LULUCF estimates. Other recommended improvements are presented in the relevant sector sections of this report below.

II. Energy

A. Sector overview

15. In 2003, emissions from the Energy sector in Canada amounted to 600,159 Gg CO_2 equivalent, or 81 per cent of Canada's total national GHG emissions – an increase of 28 per cent since 1990. Emissions from the Energy Industries, Manufacturing and Construction, Transport and Other subsectors of Energy increased by 29 per cent, 5 per cent, 21 per cent and 17 per cent, respectively.

16. Although the reporting of the Energy sector is generally complete, the ERT noted that emissions from the combustion of waste as fuel (e.g. tyres, solvents, etc.) for the production of energy at industrial facilities (e.g. cement kilns) are not included in the inventory. Because the inventory of landfill gas recovery and utilization covers only a limited number of GHG inventory years, Canada has postponed the allocation to the Energy sector of the portion of captured landfill gas utilized for energy recovery. Flaring and fugitive emissions from industrial facilities, including petroleum refineries, chemical plants and metallurgical coke production, are at present missing, but a 2004 study of the petroleum refining industry may be useful in providing these estimates in the future.

B. Reference and sectoral approaches

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

17. The total emissions estimate using the reference approach is consistently larger than the total under the sectoral approach. In 2003, the difference between the approaches is of the order of +3.6 per cent. This falls (with sign reversal) to –2.6 per cent when emissions from feedstocks used in iron and steel, ammonia and ethylene production are added to the sectoral approach. The differences for individual fuels range from –11.8 per cent for solid fuels to +12.8 per cent for gaseous fuels. When the correction is made the range is between –5.6 per cent and +4.4 per cent.

18. NIR table 1.A(c) shows energy consumption for each fuel type before and after adjustment for feedstock use. After adjustment, the discrepancy is –6.1 per cent for total fossil fuel energy, and ranges between –22.8 per cent for solid fuels and +9.7 per cent for liquid fuels. These are large differences, particularly for solid fuels. The overall average implied emission factor (IEF) in the sectoral approach for gaseous fuels (rows 10 and 11 of table 1.A(a)s1) is 51.7 t CO_2/TJ, corresponding to 14.17 t C/TJ, whereas the emission factor (EF) used in the reference approach for gaseous fuels is 14.55 t C/TJ. There

appears to be a similar difference for solid fuels. It is understood that some of these apparent discrepancies arise from the use of sector specific EFs in the sectoral approach and a single national EF for each fuel type in the reference approach. Other causes of the discrepancies should be examined, in conjunction with the problems identified with lack of transparency in the reporting of treatment of feedstocks and non-energy use of fuels.

19. The documentation box of table 1.A(a)s4 states that a recalculation was undertaken after emissions from combustion of petroleum coke and catalytic coke had been moved from Liquid Fuels to Solid Fuels, but the NIR does not report this recalculation. According to the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (hereinafter referred to as the Revised 1996 IPCC Guidelines) and the IPCC good practice guidance, these emissions should have been retained in Liquid Fuels. A corresponding change has been made to the reference approach (table 1.A.(b)). This will affect the reconciliation of the reference and sectoral approaches, since petroleum coke is a secondary fuel produced from crude oil. The ERT recommends that this change be reversed.

2. International bunker fuels

20. Previously, any fuel sold to foreign-registered carriers was considered international, and fuel sold to domestic-registered carriers was considered domestic. Following the previous reviews, fuel sold to domestic airlines has been split into domestic and international. This is a significant improvement. The approach should be extended to fuel sold to foreign airlines, which is still considered as international by the Party. The ERT understands that a similar approach is under development for marine navigation.

3. Feedstocks and non-energy use of fuels

21. Canada reports substantial CO_2 emissions from the use of fossil fuel as a feedstock or reagent in the production of aluminium, ammonia, ethylene, iron and steel, and other materials. The emissions are summarized in table 3–8 of the NIR and in CRF tables 2(I)s1 and s2. These CO_2 emissions are excluded from the sectoral approach table 1.A(a)s2. By deduction, the associated quantities of fuel are also excluded from the table, because the CO_2 IEFs are all within the appropriate ranges. It is possible that these quantities of fuel may be those calculated by the differences between Apparent Energy Consumption and Apparent Energy Consumption (excluding non-energy use and feedstocks) in table 1.A(c). However, this cannot be confirmed and requires more detailed explanation.

22. Some of this fossil fuel is used in the production of ethylene, ammonia and some other chemical products. They give rise to industrial process CO_2 emissions, but should also relate directly to the quantities of fuels used as feedstocks reported in table 1.A(d). However, no such relationship is evident from the inventory data or from the methodological description in the NIR, so it is not clear whether the default carbon storage ratios in this table have been used to estimate the quantities of emitted CO_2 reported in the relevant Industrial Processes sector, or whether some other method has been used. Furthermore, while all the carbon stored, as shown in table 1.A(d), is included in the reference approach table 1.A(b), the latter table also includes an additional quantity of 1,720.25 Gg of carbon stored from natural gas liquids which is not shown in table 1.A(d). The ERT understands that Canada will clarify these points in future submissions. The absence of formulae linking data between tables in the new CRF made it more difficult for the ERT to determine the relationship between the data in these two tables.

23. A further refinement should be undertaken to increase the transparency of reporting emissions from the combustion of secondary fuels collected during industrial processes and used for energy production, such as blast furnace gas, in the Energy sector.

24. The ERT noted the need (identified on page 281 of the NIR) for research into EFs to ensure that there is no double counting of emissions from the non-energy use of fossil fuels between the Industrial Processes and Energy sectors. It is also possible that there is under-reporting of some emissions. The

ERT recommends that Canada provide more transparent descriptions of the data collection and estimation procedures.

4. Country-specific issues

25. Section 3.4.4 (page 89) of the NIR concerns the estimation of emissions associated with the production and processing of natural gas and crude oil that is exported to the USA.

26. Transparency in terms of comparability with other Parties' inventories would be improved by the use of net calorific values in the report (annex 13 to the NIR) and in the CRF tables, and by reporting in the NIR either energy-based EFs or data on the specific energy content by fuel type.

C. Key categories

1. Public electricity and heat production: Gas, solid, liquid

27. Co-generation (autoproduction) emissions at industrial facilities are reported here, rather than in the relevant subsectors of Manufacturing Industry, because Statistics Canada provides the relevant fuel use data in this format.

2. Manufacture of solid fuels and other energy industries

28. This subsector currently only reports non-commercial fuels used in the upstream oil and gas and coal-mining industries, although it should also cover commercial fuels used in these industries (including on-site transportation in coal mines), which are currently included in the Mining subsector (under 1.A.2 Manufacturing Industries and Construction). The ERT notes that the latter may not be possible because of limitations on the availability of reliable AD. The Party has advised that fuel use and emissions associated with the production of metallurgical coke are reported under 1.A.2a Iron and Steel. Ideally, these emissions should also be reported under 1.A.1c Manufacture of Solid Fuels and Other Energy Industries.

3. Fugitive emissions: Solid fuels and oil and natural gas

29. Fugitive emissions constituted 7.3 per cent of total national emissions in 2003, and contributed 11 per cent to the growth in national emissions between 1990 and 2003, an increase of about 42.3 per cent. Emissions from the Oil and Natural Gas category contributed 98 per cent of total fugitive emissions in 2003. Fugitive emissions from solid fuel transformation are not included in these estimates as they are considered to be insignificant. It would be helpful if Canada could provide quantification in order to demonstrate this.

30. The list of emission categories on pages 77–78 of the NIR should include Venting and Flaring, which are by far the largest sources of fugitive emissions from gas processing, not equipment leaks.

31. All emissions from conventional oil and gas production are calculated by extrapolating from the results of a 1999 study of 1996 emissions, using appropriate activity parameters for each emission category (see the NIR, pages 79–80). This method does not allow for variations in the characteristics of the different oil and gas fields (which affects venting and flaring), or for variations in transmission (the largest sources), or for technological improvements (which should tend to reduce emissions).

32. The ERT noted with appreciation that Canada has given this sector priority in its planned improvements and that these will be incorporated in future inventory submissions.

D. Non-key categories

Fugitive emissions: Coal mining:

33. The EFs used for estimating emissions from coal mining are based on work done as long ago as in 1994, and have been adjusted according to the coal extracted each year. The methodology for adjustment needs to be documented to provide greater transparency.

III. Industrial Processes and Solvent and Other Product Use

A. Sector overview

34. The CRF tables include estimates of most gases and emission sources in these sectors. In 2003, estimated emissions from the Industrial Processes sector in Canada amounted to 52,007 Gg CO_2 equivalent, or 7.0 per cent of total national emissions. Mineral Production accounted for 8,692 Gg CO_2 equivalent (16.7 per cent of industrial emissions), Chemical Industry for 8,060 Gg CO_2 equivalent (15.6 per cent), Metal Production for 16,591 Gg CO_2 equivalent (32.3 per cent), Consumption of Halocarbons and SF_6 for 4,702 Gg CO equivalent (9.0 per cent), and Other differentiated production for 13,961 Gg CO_2 equivalent (26.9 per cent). Sectoral emissions decreased by 4.4 per cent from 1990 to 2003. Emissions from the Solvent and Other Product Use sector totalled 480 Gg CO_2 equivalent in 2003, or 0.1 per cent of total national emissions. These emissions were from the use of N_2O in anaesthesia and from propellants.

35. The ERT notes that a number of category emission estimate improvement measures have been planned for subsequent inventory submissions.

B. Key categories

36. With two exceptions (Iron and Steel, and Other Industrial Processes), the NIR provides a thorough and transparent description of the methodologies applied.

1. Aluminium production – CO_2 and PFCs

37. CO_2 emissions in this source increased from 1990 to 2003 proportionally to the increase in the volume of aluminium production. CO_2 emissions have been estimated, mostly on the basis of a tier 3 method, using EFs which are slightly different from the IPCC default EFs. The previous uncertainty analysis is reported not to be applicable to the 2003 CO_2 estimates, but will be updated in future submissions. Recalculations of previous estimates have been carried out using the improved AD. PFC emissions have fallen by over 50 per cent since 1990 due to the incorporation of automated emission controls in aluminium production. Smelter-level process data have been used, with indications that the tier 3 method for emissions estimation was used. QA/QC has been incorporated and recalculations have been performed as a result of improved AD.

2. Iron and steel production – CO_2

38. Emissions from the iron and steel industry have been estimated from data on use of metallurgical coke from the national energy statistics. The ERT understands that coal is also used as a reductant, and is currently allocated to Other and Undifferentiated Production. The ERT suggests clarification and possible reallocation of these emissions and emissions. Treatment of emissions associated with the use of limestone and lime in the metallurgical industry should be clarified.

3. Adipic acid production – N_2O

39. Adipic acid production data are reported to be confidential. The associated N_2O emissions are relatively constant from 1990 to 1997, and then decrease sharply from 1998 to 2003. The Party reports on one production facility where an abatement system was installed in 1997. The plant provides emissions data, and it is reported that emissions are directly monitored.

4. Consumption of halocarbons – HFCs and PFCs

40. The NIR states that there is no known production of HFCs/PFCs, and that all consumption is from bulk or product imports. Emissions from ozone depleting substance (ODS) substitutes are reported from refrigeration and air conditioning equipment, foam blowing, fire extinguishers, and aerosols. The NIR states that consumption of HFCs was negligible between 1990 and 1994. Because of limited surveys, non-inclusion and non-reporting of the gases in the surveys conducted, HFCs currently have limited coverage in the time-series emissions.

41. Canada has started to apply a tier 2 method based on actual AD derived from surveys for products containing HFCs. The survey, however, is not repeated and updated on an annual basis. The process should be simplified so that the survey can be updated annually or appropriate growth factors should be used to account for the growth of the fluid banks. Canada refers to ranges of IPCC reference EFs, using the midpoint or average of these ranges as EFs for emission estimation. It was explained that efforts will be made to develop country-specific EFs for major sources, such as air conditioning or refrigeration.

5. Electrical equipment – SF_6

42. Since 1990 these emissions have been relatively constant, except for 2002, when they are reported to have decreased by about 50 per cent. In 2003 emissions increased again back to the trend figure. The NIR does not explain why. Potential emissions of SF_6 are not estimated. A top–down approach for emissions estimation has been used, assuming that all SF_6 purchased from gas distributors replaces SF_6 lost through leakage, and thus neglecting the additions to stock. It was explained that, although the Party does not collect any data that would allow the application IPCC good practice method, improvements are planned for future estimates, based on electric utility reported annual SF_6 purchases and stock changes.

6. Magnesium production – SF_6

43. Magnesium production increased from 1990 to 2003 by over 150 per cent, while the associated SF_6 emissions generally decreased due to the replacement of SF_6 with alternatives such as SO_2 as cover gas in magnesium production. Data have been collected directly from the magnesium-producing companies through a mandatory emissions reporting programme. Use of the tier 3 method is reported, but it is not documented and should be described in the NIR. No recalculations have been made for this key category, and there are source-specific plans to improve the estimation of emissions.

C. Non-key categories

1. Ammonia production – CO_2

44. Canada is encouraged to update periodically its national EF for ammonia production, and to collect data on urea exported in order to avoid an overestimation of its CO_2 emissions.

2. Nitric acid production – N_2O

45. The Party is encouraged to update periodically its country-specific EF based on the actual production mix of nitric acid in different plant types, and reflecting the application of any abatement technologies.

3. Soda ash production and use

46. The NIR reports a CO_2-neutral technology for soda ash production in Canada, which has now ceased, without stating which technology was used. The Solvay process is far from being CO_2-neutral since generally a substantial excess of CO_2 over the stochiometric requirement is required for the carbonation. Canada is therefore encouraged to provide information on the specific technology that was used. The Party reports that no recent data are available on soda ash consumption after 1995. Canada is encouraged to seek alternative sources of data or to develop an approach to provide the missing data, taking account of the approaches to the provision of missing data described in the IPCC good practice guidance.

4. Solvent and other product use

47. Emissions are estimated for the use of N_2O as an anaesthetic and as an aerosol propellant, and are in both cases fairly constant. Recalculations have been done for the years 1990–2002 based on revised demographic statistics. Canada should consider whether there are other areas of Solvent and Other Product Use that generate emissions.

IV. Agriculture

A. Sector overview

48. In 2003, the Agriculture sector in Canada produced emissions amounting to 62.1 Gg CO_2 equivalent, or 8.4 per cent of total national emissions. This represents an increase of 19 per cent from the 52.1 Gg CO_2 equivalent reported in 1990. The primary drivers for this increase are stated to be an expansion of the beef and swine industries and the increased use of nitrogenous fertilizers, up by 34 per cent since 1990.

49. The ERT noted some significant improvements in the Agriculture sector, for which Canada now uses a tier 2 method to estimate emissions from enteric fermentation and manure management for cattle. Annex 3 to the NIR gives a transparent explanation of the methodology and sources of data. The livestock characterization has also been improved by the inclusion of additional species, the revision of population data, and updated information on the allocation of livestock to animal waste management systems (AWMS). There are better data on N_2O from cultivated organic soils. As a result of these improvements, recalculations have been performed for the whole time series. Canada has reallocated CO_2 emissions from the Agriculture sector to LULUCF, to be consistent with the new reporting format adopted at COP 9. The NIR notes the recalculations and a number of further planned improvements across the Agriculture sector.

50. The ERT noted that there are apparent differences between the cattle population and sheep population data in the CRF and the corresponding Food and Agriculture Organization of the United Nations (FAO) data. These differences may be an artefact of different averaging periods, but the ERT recommends that this should be investigated. The ERT also noted inconsistencies, which should be resolved, between what appear to be the same variables in the Enteric Fermentation and Manure Management categories.

B. Key categories

1. Enteric fermentation – CH_4

51. CH_4 from enteric fermentation is dominated by the emissions from cattle (96 per cent of emissions from this category). In its 2005 submission, Canada has estimated emissions using a tier 2 methodology, country-specific EFs and population data from Statistics Canada, with characterization of animal types obtained mostly directly from specialists. The ERT noted that the IEF derived (126 kg CH_4/head/yr) is the second highest of all reporting Parties and is constant for the whole period 1990–2003, due to a single value for milk production and weight being used in the equations. The ERT recommends that Canada incorporate changes in the EFs over time to reflect changes in productivity, and encourages Canada to report the data and the results of any peer review in the NIR.

52. Feed digestibility reported in table 4.A is 68.9 per cent for dairy and 62.4 per cent for non-dairy beasts. In the category Manure Management, Canada reports digestibility values of 65 per cent and 60 per cent, respectively. Differences also occur for milk production, with values of 29 and 25 kg/hd/day, respectively. Different sources of milk production data are referenced for Enteric Fermentation and Manure Management. The ERT recommends that Canada ensure consistency between categories.

2. Direct N_2O from agricultural soils

53. Direct N_2O emissions accounted for 79.5 per cent of total emissions from agricultural soils and amounted to 81.82 Gg in 2003. N_2O from animal production on pasture and paddock (4.D.2) is included with direct emissions (4.D.1) for the key category analysis. For the sake of comparability with other Parties' inventories and the secretariat's analysis, Canada should consider separating the two.

54. For synthetic fertilizers, the NIR states that a tier 1 methodology is used. The CRF reports an IEF of 0.0112 not the IPCC default of 0.0125. The apparent discrepancy is caused by Canada reducing the direct emissions for volatisation but reporting the total amount of nitrogen (N) input. This also applies to N from AWMS applied onto soil. To improve comparability with other Parties in table 4D, Canada may consider reducing the reported N input from synthetic fertiliser and AWMS by $Frac_{GASF}$ and $Frac_{GASM}$.

55. In estimating N_2O emission from agricultural soils, Canada has adopted the tier 1 approach of the IPCC good practice guidance. Recalculations in Animal Manure Applied to Soils, Cultivation of Histosols and Pasture, Range and Paddock Manure were undertaken by Canada and reported in the 2003 NIR. Recalculations in Animal Manure Applied to Soils and Pasture, Range and Paddock Manure were undertaken because of the addition of buffaloes, a revision of the data on goat population for the period 1990–1995, an increase in the estimated poultry population, and a change in the estimated percentage of manure nitrogen handled by AWMS. Recalculations in the Cultivation of Histosols undertaken by Canada were due to changes in the area of cultivated organic solid as well as changes in EFs as contained in the IPCC good practice guidance. The recalculations decreased the estimated N_2O emissions slightly but have little impact on the long-term trend.

3. Indirect N_2O from agricultural soils

56. In 2003, indirect N_2O accounted for 20.5 per cent of emissions from agricultural soils in Canada. Indirect N_2O emissions increased by 18.3 per cent from 1990 to 2003. Canada has adopted a country-specific leaching factor (0.15) instead of the IPCC default value in estimating indirect N_2O emissions from leaching, erosion and run-off. Canada states that the use of the country-specific method reflects the low precipitation and high evaporation which characterize the Canadian prairies.

C. Non-key categories

1. Manure management – N_2O

57. Manure Management – N_2O was identified as a key category by the secretariat but not by Canada. The ERT noted that in the 2003 inventory, for dairy and non-dairy cattle, the sum of the AWMS did not equal the product of population and the nitrogen excretion rate/head/yr (Nex). There is a 48 per cent discrepancy for dairy cattle and the ERT recommends that this be investigated, clarified and corrected as necessary. The NIR states that the percentages of manure handled in the different AWMS are based on expert opinion and survey data. Canada should clarify the nature of the survey and whether the IPCC good practice guidance procedures for obtaining expert opinion were used. Canada uses Nex values from American Society of Agriculture because they are considered to be more representative of Canadian conditions than the IPCC default values. The NIR should document the basis for this decision.

2. Manure management – CH_4

58. In 2003, CH_4 emissions from manure management were estimated using the IPCC tier 2 methodology. Rather than use equation 4.11 of the IPCC good practice guidance, Canada uses a range of dry matter intake values obtained from expert opinion and published sources. For consistency between categories, the dry matter intake for cattle should be calculated from the gross energy requirements determined from the tier 2 methodology for Enteric Fermentation, and the ERT recommends that Canada adopt this approach.

V. Land Use, Land-use Change and Forestry

A. Sector overview

59. In 2003, net removals by the LULUCF sector in Canada accounted for 9 per cent of total national (non-LULUCF) emissions. CO_2 was the major gas exchanged; emissions of CH_4 and N_2O from forest land represented about 2 per cent and 0.7 per cent, respectively, of the 45,869 Gg CO_2 equivalent removed by the LULUCF sector. This amount results from –72,252 Gg CO_2 removed by forest land, and from cropland and settlements each remaining in the same land use, and 26,383 Gg CO_2 emitted from lands converted to cropland, settlements, and grassland. Emissions/removals from wetlands and other land are not estimated. Considerable efforts have been made to improve the inventory, although further work is needed, particularly on completeness and uncertainty analysis. Significant omissions include C stock changes in the belowground biomass, the effects of insect infestations or epidemics which result in replacement of forest stands, and the estimation of emissions and removals from forest soils, dead wood and litter. The most likely sources of uncertainties are identified and a partial sensitivity analysis for cropland has been undertaken, but there is no overall quantitative analysis of uncertainties. Qualitative estimates of uncertainties are provided (high/moderate/low), but the relationship of each of these categories to probability ranges is not given. Emissions from deforestation, which may be important, are only estimated on a preliminary basis.

60. The large spatial scale used in assessing net land-use changes is a major source of uncertainty. The uncertainties associated with managed forest area and CO_2 emissions from mineral soils appear to be high, and there is moderate uncertainty with the estimation of the area of cultivated organic soils. Mineral soils are an important source of emissions and would warrant further efforts to obtain more accurate estimates.

61. Inter-annual fluctuations in net GHG emissions (table 10) increased from 1990 to 2003, even setting aside of the extreme 1995 value.

B. Sink and source categories

1. Forest land – CO_2

62. Forest Land accounted for 97.7 per cent of the LULUCF CO_2 removals in 2003; Forest Land Remaining Forest Land in turn accounted for 98.6 per cent of CO_2 removals by forest land. Between 1990 and 2003, removals from Forest Land decreased by 38 per cent.

63. The ERT fully recognizes the efforts taken by Canada over the years to improve the Canadian GHG inventory concerning forest land. Some issues remain. For example, Canada intends to develop a harmonized definition of managed forest lands to replace the current proxy definition. This is important as it provides the basis for the identification of the area where emissions and removals are to be estimated. For example, the identification of areas with wildfires on managed lands is crucial to obtaining accurate estimates of GHG emissions from wildfires (see table A.3.2-4 in annex 3 to the NIR), and the intersection of areas from the forest inventory and from the fire database is only as good as the identification of the managed forest land.

64. With the current proxy definition, there is considerable uncertainty with respect to the area of managed forests. The estimated area of managed forests has been changed from 203 Mha to 214 Mha since the Party's last (2004) submission, and, according to the NIR, the possibility is still high that the forest area under direct human influence is significantly different from the 214 Mha reported. Also, the area of Forest Land Remaining Forest Land reported in the CRF tables does not represent the total area of managed forest land, but only the part of it which is sequestering carbon in the aboveground biomass pool. This clarification is given in the NIR, but should also be clarified in the documentation box for greater transparency. The identification of managed land could require revision e.g. due to the constant increase in the areas of land that are accessible by road. In short, the definition and identification of the total managed forest land is obviously an issue which requires clarification. The length of the period for which a clear-cut, but not deforested, area remains in the unstocked forest area (see the last sentence on page 255) should be specified. The assumption that the net accumulation of aboveground biomass in over mature stands is zero requires validation. Although stock changes, whether positive or negative, may be small per unit area, the total emissions could be significant due to the large areas involved.

65. The ERT notes that the biomass conversion/expansion factors (BCEF) of Table A3-18 are highly aggregated values. It is recommended that the BCEF be detailed by species, age class and site quality in future submissions to improve transparency. The ERT notes the importance of more transparent reporting of all steps and values applied in the estimation of emissions from harvesting.

2. Crop land and grassland– CO_2

66. Cropland remaining cropland is estimated to account for 2 per cent of the total LULUCF sink in 2003. Gains of CO_2 from the tillage of mineral soils in cropland remaining cropland were 1,511 Gg CO_2 (9.1 per cent of the total CO_2 loss for croplands) in 2003, and losses of CO_2 from the cultivation of organic soils represented about 1 per cent of the total CO_2 loss for the category Cropland. The estimates have been made using the Century model for mineral soils, and for organic soils by multiplying the area of cultivated histosols by a country-specific EF which, at 2.7 t C/ha/yr, lies between the IPCC default values of 1 t C/ha/yr for cold temperate climates and 10 t C/ha/yr for warm temperate climates. Canada has explained that the choice of a country-specific values for the emissions is that IPCC's defaults carry a very large uncertainty because no scientific references are provided for them. Although a literature reference is given, it would be useful for the NIR briefly to summarize the justification for the choice of this value. Annex 3.2 to the NIR describes qualitatively how the Century model has been applied to estimate emissions from mineral soils and identifies the need for further refinements to improve reliability on the basis of comparisons with field data; it would be useful to know what plans there are to undertake this work. Emissions of CO_2 from liming were about 2 per cent of subsector (5.B Cropland)

emissions in 2003. Estimated net emissions of CO_2 from cropland decreased by 37.4 per cent between 1990 and 2003.

67. Conversions of forest to cropland, grassland and settlements have been estimated, as have conversions of grassland to forest and cropland. Emissions of CO_2 from forest land and grassland conversion to cropland accounted for 61 per cent of the sectoral emissions in 2003. Conversion of forest land accounted for 54.1 per cent of the loss of CO_2 (of which 52.5 per cent was from biomass and 47.5 per cent from soil organic carbon), and grassland conversion accounted for the remaining 45.9 per cent (of which 14.8 per cent was from biomass and 85.2 per cent from soil organic carbon). The approach to estimating emissions from conversion is generally consistent with the method outlined in the IPCC *Good Practice Guidance for Land Use, Land-use Change and Forestry* (hereinafter referred to as the IPCC good practice guidance for LULUCF), and the approach to identifying the relevant land areas is described, although this should be done in a way that is closer to the descriptions in the IPCC good practice guidance for LULUCF; and transparency would be improved by the provision of summary tables giving key parameters and land-use data in a matrix form with a clearer reconciliation of areas over time. The ERT noted that Canada plans work of this type over the next five years.

68. Net emissions from grassland have been derived from the biomass of forest land converted to grassland. They represented 18 per cent of total CO_2 emissions in the LULUCF sector in 2003. The amount of 4,755 Gg CO_2 has been assigned to each one of the years between 1990 and 2003. The time trend is therefore "0". The interpolation method used to determine the areas converted should be refined to improve the temporal resolution of estimates. Emissions/removals of CO_2 from the conversion of cropland, wetlands, settlements and other land to grassland have not been estimated. CO_2 fixed by urban vegetation accounted for less than 1 per cent of the LULUCF CO_2 removals in 2003. Net emissions from settlements decreased by 0.33 per cent between 1990 and 2003.

VI. Waste

A. Sector overview

69. In 2003, the Waste sector in Canada accounted for 3.4 per cent of total national GHG emissions. From 1990 to 2003 total emissions in this sector increased by 26.8 per cent, mainly due to the increase of CH_4 emissions from solid waste disposal on land (by 27.9 per cent), despite an increase in landfill gas capture and combustion of almost 48.3 per cent over the same period. Emissions have not been estimated for the category Industrial Wastewater Handling, and N_2O emissions from sewage incineration and CH_4 emissions from incineration of municipal solid waste (MSW) are also missing. Canada informed the ERT that these emissions will be reported in the next submission. All the CRF tables for the Waste sector are filled in from 1990 to 2003. The rationale for the emissions estimates is well documented in the NIR, but the AD and other parameters used are not all provided, so that it was not possible for the ERT to replicate the emissions estimates. A number of recalculations have been performed as a result of regular updates to the underlying AD or the availability of new information on emission sources. Canada has introduced several improvements in this inventory submission compared to the 2004 submission, but it should continue to improve the information provided on AD and emission parameters used in the estimation, and ensure that the estimates are complete.

B. Key categories

1. Solid waste disposal sites – CH_4

70. In 2003, CH_4 emissions from this source category amounted to 1,128.7 Gg and it was identified as a key category by level, trend and qualitative assessment. CH_4 emissions have been estimated from MSW and wood waste landfills using the Scholl Canyon model (first-order decay (FOD) method). Most of the data used and references are provided in the NIR. Because the inventory of landfill gas recovery

and utilization only covers a limited number of GHG inventory years, the Party has postponed the allocation to the Energy Sector of the portion of captured landfill gas utilized for energy recovery. The ERT noted the planned improvements set out in the NIR, and encourages Canada to continue working on the precise quantity of captured landfill gas utilized for energy recovery and to make the corresponding recalculations for the whole time series. The ERT recommends that Canada clarify the number of years used to estimate CH_4 emissions from MSW, especially for wood waste on landfills, and improve the information provided on the values of the parameters which support the methane generation potential (Lo) value used, and on the quantity of sludge deposited in solid waste disposal sites (SWDS).

2. Waste-water handling – N_2O

71. N_2O emissions from the discharge of human sewage in aquatic environments amounted in 2003 to an estimated 3.2 Gg. This was selected as a key category by qualitative assessment because of the high uncertainty. Emissions have been estimated following the method in the Revised 1996 IPCC Guidelines. To clarify the N flow from sewage sludge, the information on N in sewage applied to soils in the form of sewage sludge should be included. The ERT encourages Canada to further improve the information provided on the fate of sludge and make efforts to estimate N_2O emissions from sewage sludge applied to soils.

3. Waste incineration – CO_2

72. In 2003, CO_2 emissions from this source amounted to 287.7 Gg, and it was selected as a key category by qualitative assessment because of the high uncertainty. A country-specific method has been used to estimate emissions of CO_2 from the incineration of fossil fuel-based waste in MSW. Canada plans to review its municipal incineration AD.

C. Non-key categories

1. Waste-water handling – CH_4

73. In 2003, CH_4 emissions from domestic and commercial waste water amounted to 19.3 Gg. Recovery is reported as "not estimated" in the CRF, and CH_4 emissions from aerobic systems in the country are considered negligible. However, table 6.B states that 63 per cent of domestic waste water was aerobically treated. No information is provided on the aerobic systems used. The emissions have been estimated using a method developed for Environment Canada (ORTECH Corporation, 1994). From the information provided it was impossible to determine whether any part of industrial waste water is released into the domestic sewer system. The information submitted in the NIR and the CRF is not very transparent and the check method provided in the IPCC good practice guidance has not been used. Emissions from the treatment of industrial waste water are not calculated because of lack of data. The ERT recommends that Canada improve the transparency of its reporting in both the NIR and the CRF, use the check method, and assess the completeness of the inventory.

2. Waste incineration – N_2O

74. N_2O emissions from this source amounted to 0.2 Gg in 2003, and have been estimated using the IPCC default method. An average factor was calculated assuming that the IPCC five stokers facility factors were most representative.

3. Waste incineration – CH_4

75. In 2003, CH_4 emissions from this source amounted 0.3 Gg. CH_4 emissions from sewage sludge incineration have been estimated. CH_4 emissions from MSW incineration are assumed by the Party to be negligible and have not been calculated.

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 secretariat. Synthesis and assessment report on the greenhouse gas inventories submitted in 2005. FCCC/WEB/SAI/2005. Available at <http://unfccc.int/files/national_reports/annex_i_ghg_inventories/inventory_review_reports/application/pdf/sa_2005_part_i_final.pdf>.

UNFCCC secretariat. Canada: Report of the individual review of the greenhouse gas inventory submitted in the year 2004. FCCC/WEB/IRI/2004/CAN. Available at <http://unfccc.int/files/national_reports/annex_i_ghg_inventories/inventory_review_reports/application/pdf/2004_irr_desk_review_canada.pdf>.

B. Additional information provided by the Party

Responses to questions during the review were received from Mr. Art Jaques (Environment Canada) and Ms. Pascale Collas (Environment Canada), and included additional material on the methodology and assumptions used, and uncertainty analysis.

FAOStat Agricultural data. Available at <http://faostat.fao.org/faostat/form?collection=Production.Livestock.Stocks&Domain=Production&servlet=1&hasbulk=0&version=ext&language=EN>.

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