UNITED NATIONS
NATIONS UNIES

FRAMEWORK CONVENTION ON CLIMATE CHANGE - Secretariat
CONVENTION - CADRE SUR LES CHANGEMENTS CLIMATIQUES - Secrétariat

FCCC/WEB/IRI(2)/2003/CAN 29 January 2004

CANADA

REPORT OF THE INDIVIDUAL REVIEW OF THE GREENHOUSE GAS INVENTORY SUBMITTED IN 2003[1]

(In-country review)

EXECUTIVE SUMMARY

1. This report covers the review of the 2003 inventory submission of Canada, coordinated by the United Nations Framework Convention on Climate Change (UNFCCC) secretariat in accordance with decision 19/CP.8 of the Conference of the Parties (COP). Canada submitted its annual inventory on 15 April 2003, consisting of common reporting format tables for the years 1990–2001 and the national inventory report.[2] The review took place from 29 September to 3 October 2003 in Ottawa, Canada, and was conducted by the following team of nominated experts from the roster of experts: Generalist – Mr. Simon Eggleston (United Kingdom); Energy – Mr. Christo Christov (Bulgaria); Industrial Processes – Mr. Newton Paciornik (Brazil); Agriculture – Mr. Tomoyuki Aizawa (Japan); Land-use Change and Forestry – Mr. Audun Rosland (Norway); Waste – Mr. Moussa Cisse (Mali). Mr. Newton Paciornik and Mr. Audun Rosland were the lead reviewers of this review. The review was coordinated by Ms. Clare Breidenich (UNFCCC secretariat).

2. In accordance with the "UNFCCC guidelines for the technical review of greenhouse gas inventories from Annex I Parties", 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.

3. In the year 2001, the most important greenhouse gas in Canada was carbon dioxide (CO_2), contributing 78.9 per cent to total[3] national greenhouse gas emissions expressed in CO_2 equivalent, followed by methane (CH_4) – 12.4 per cent, and nitrous oxide (N_2O) – 7.4 per cent. Perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6) contributed 1.3 per cent of the overall greenhouse gas emissions in the country. The Energy sector accounted for 81.1 per cent of total greenhouse gas emissions, followed by Agriculture (8.3 per cent), Industrial Processes (7.0 per cent) and Waste (3.4 per cent).

4. Total greenhouse gas emissions (excluding Land-use Change and Forestry) amounted to 720 Gg CO_2 equivalent in 2001 and increased by 18.5 per cent from 1990 to 2001. However, Canada experienced a decrease in the total CO_2 equivalent of 1.3 per cent in 2001 as compared with 2000, mainly as a result of a warmer winter, reduced energy use in some industrial sectors and a decline in transportation.

---

[1] In the symbol for this document, 2003 refers to the year in which the inventory was submitted, and not to the year of publication. The number (2) indicates that this is an in-country review report.

[2] Canada resubmitted the entire common reporting format on 2 June 2003.

[3] In this report, the term total emissions refers to the aggregated national GHG emissions expressed in terms of CO_2 equivalent excluding Land-use Change and Forestry, unless otherwise specified.

5. Tables 1 and 2 provide data on emissions by gas and by sector from 1990 to 2001. Over the period 1990–2001 CO_2 emissions increased by 20 per cent, mainly owing to increased emissions from electricity and heat generation and other energy industries. CH_4 emissions increased by 27 per cent during the same period, mainly because of increased fugitive emissions from oil and natural gas production and emissions from landfills; N_2O emissions decreased by 3.5 per cent over the same period, mainly as a result of a significant reduction in emissions from production of adipic acid. Emissions from PFCs increased by 3.3 per cent, while emissions from SF_6 decreased by 30 per cent because emissions from magnesium producers fell. HFC emissions increased significantly in 1995 and 1996, but have been relatively stable in the period 1996–2001.

Table 1. Greenhouse gas emissions by gas, 1990–2001

GHG emissions	CO_2 equivalent – M tonnes												Change from 1990–2001 %
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
Net CO_2 emissions/removals	365.2	369.3	389.8	405.0	446.0	488.3	473.4	475.7	499.9	524.1	523.4	529.8	45.1
CO_2 emissions (without LUCF)[(a)]	472.2	462.5	475.7	474.3	488.4	500.9	513.6	524.8	534.5	553.6	576.8	566.2	19.9
CH_4	73.4	76.1	78.7	80.7	83.9	87.4	88.8	88.7	89.7	89.8	90.7	93.5	27.4
N_2O	53.2	52.7	53.2	54.3	59.1	60.9	61.9	60.1	56.8	53.8	52.8	51.4	–3.5
HFCs	0.0	0.0	0.0	0.0	0.0	0.5	0.9	0.9	0.9	0.9	0.9	0.9	
PFCs	6.0	6.3	6.6	7.4	6.9	6.0	5.9	6.0	6.0	6.2	6.2	6.2	3.3
SF_6	2.9	3.3	2.2	2.0	2.0	1.9	1.4	1.4	1.5	1.7	2.3	2.0	–29.6
Total (with net CO_2 emissions/removals)	**500.6**	**507.7**	**530.4**	**549.5**	**597.9**	**644.9**	**632.3**	**632.6**	**654.9**	**676.5**	**676.3**	**683.8**	36.6
Total (without CO_2 from LUCF)	**607.6**	**600.9**	**616.3**	**618.7**	**640.3**	**657.6**	**672.5**	**681.8**	**689.5**	**706.0**	**729.7**	**720.1**	18.5

[a] LUCF = Land-use Change and Forestry

Table 2. Greenhouse gas emissions by sector, 1990–2001

GHG source and sink categories	CO_2 equivalent – M tonnes												Change from 1990–2001 %
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
Energy	472.7	464.1	481.6	481.5	497.9	513.1	528.1	539.5	548.9	567.7	592.6	583.8	23.5
Industrial Processes	52.9	53.7	52.5	54.0	56.4	56.2	58.4	57.2	53.3	51.5	50.9	49.0	–7.4
Solvent Use	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	12.2
Agriculture	59.2	58.1	58.2	58.4	60.7	61.1	61.7	61.3	60.9	61.1	60.8	60.0	1.3
LUCF[a]	–104.7	–89.3	–83.5	–66.5	–39.4	–8.0	–38.4	–48.4	–31.7	–28.1	–52.7	–34.3	–67.3
Waste	20.1	20.7	21.2	21.7	21.9	22.0	22.1	22.6	23.1	23.8	24.3	24.8	23.5
Other	–	–	–	–	–	–	–	–	–	–	–	–	–

[a] LUCF = Land-use Change and Forestry

6. In general the expert review team found the Canadian inventory to be complete: it covers all years from 1990 to 2001 and all six mandatory greenhouse gases. However, some sources are not included, for example, SF_6 from electrical equipment and magnesium foundries; some fugitive CH_4 emissions from refining and oil and gas production; a number of minor petrochemical products; some transport fuels such as bio-diesel and ethanol added to fuels after they leave refineries; and some Land-use Change and Forestry subsectors such as soil in forest, below-ground biomass and extraction of peat, recognizing that these are included as possible refinements in the 1996 Guidelines. While not mandatory, according to the UNFCCC reporting guidelines Annex I Parties should report on the ozone precursors (nitrogen oxides, non-methane volatile organic compounds, carbon monoxide) and are encouraged to report on sulphur dioxide (SO_2). Canada has not included information on these indirect greenhouse gases in its national inventory report. Further, the distinction between national and international emissions from aviation and shipping is based on sales of fuels to domestic and foreign

registered vessels, and is likely to result in misallocations of emissions. Canada should move to higher tier methods that, for aircraft, distinguish between landing and take-off cycles and in-flight emissions and for both marine and air, methodologies that track transport within and outside Canadian borders.

7. In general the inventory is transparent. The national inventory report describes each sector, the methods used, the emission factors and, where applicable, the sector quality assurance/quality control approaches, and gives a qualitative assessment of uncertainties. However, there are some areas where the transparency of Canada's reporting can be improved, as described below:

(a) The expert review team finds it difficult to compare Canadian emission factors from the Energy sector with those of other countries because Canada reports energy usage in gross calorific values, while most countries report net calorific values. While reporting in gross calorific values is permitted, insufficient information was provided to facilitate comparison. Conversion factors were not supplied in the documentation boxes as requested in the common reporting format. In addition, some of the calorific values in the common reporting format tables appear to be internally inconsistent, resulting in misleading implied emission factors and making international comparison impossible.

(b) The reference approach (Sectoral Background Table for Energy – table 1.A(b)) has been completed using net calorific values while the sectoral approach tables have been completed using gross calorific values. This complies with the guidelines (except the conversion factors from gross calorific values to net calorific values should also be supplied and are not). However, table 1.A(c), which compares the reference and sectoral approaches compares both carbon emissions and fuel use. Thus the fuel (not the carbon emission) comparison in this table is misleading.

(c) The energy data presented by the International Energy Agency are different from those used by Canada in preparing the inventory. While this does not reflect a problem with the quality of the inventory it does hinder the review team, and other users of the inventory, making international comparisons. The review team understands that Statistics Canada is taking measures to ensure consistency.

(d) The methodology used for the Land-use Change and Forestry sector is only partly described in the national inventory report and common reporting format. To increase transparency, the expert review team recommends that Canada give more complete documentation of the methodology in its future national inventory reports, including data sources, growth rates and other parameters relevant for the calculations.

(e) The landfill gas captured and combusted for energy purposes is not accounted for in the Energy sector as it should be according to the guidelines. It is reported as flared in the Waste sector.

8. Recalculations have been carried out for all sectors except Solvent Use and Waste. In general these recalculations have been described in the national inventory report and common reporting format. Some inconsistencies have been identified, for example, for carbon dioxide emissions for coal, a value for 1990 was used for each year until 1995, after which a revised emission factor was used. This resulted in a step change in the emission factor. A similar situation has been found for some subsectors in Industrial Processes. Explanations of these changes should be given in the national inventory report.

9. Currently Canada has not implemented formal quality assurance/quality control procedures. However, a variety of informal quality control checks and reviews are in place and are documented in the national inventory report. Further, the draft *Instruction Manual for the Preparation of Canada's Greenhouse Gas Inventory for the Land Use Change and Forestry Sector* provides a good outline of such assurance/quality control procedures. The expert review team also noted with appreciation that Canada is currently investing in improvements covering formal quality assurance/quality control procedures, a protocol to quantify uncertainties and sector studies to develop more accurate methodologies. In this regard the expert review team recommends that Canada implement a long-term plan that prioritizes areas

for improvement, guided by the key source analysis and the results of uncertainty analysis. The expert review team also encourages Canada to establish a centralized archiving system.

10. Environment Canada has the overall responsibility for the national inventory, which should make an important contribution to consistency across the inventory. However, the expert review team believes that an even closer relationship with other agencies, the establishment of formal agreements for data development and sharing and the reestablishment of formal groups, such as the Sources and Sinks Group (1990) with the ability to assist in data improvements, will be needed. Environment Canada is already working towards this with several Memorandums of Understanding, related to data development and data sharing on forestry, agriculture and energy and this is commended.

11. The expert review team had difficulty in reviewing the methodology used to calculate N_2O emissions from road traffic, for example, the fuel-based emission factors for new and older cars with three-way catalytic converters. It is recommended that Canada undertake verification of the data and emission factors used in the calculations. Canada is also encouraged, where possible and appropriate, to integrate and link its fuel driven greenhouse gas road transport model with its technology driven criteria air contaminants model.

12. Canada informed the expert review team that it plans to improve the inventory for the Industrial Processes sector by implementing a tier 2 methodology for all key categories. In this regard the expert review team recommends that Canada review the current allocation of emissions to the Other Industries subsector and to make an effort to allocate the emissions to the subsectors where they occur, including an assessment of the destination of the non-energy products and the emissions associated with their actual use. Canada should also explore means for obtaining data, for example, on fuels and feedstocks, production data, emission factors and emissions measurements, directly from industrial producers, and update the data provided by industry in the early 1990's.

13. CO_2 emissions and removals from agricultural soils are reported in 4.D. Agricultural soils, as opposed to 5.D Land-use Change and Forestry as allowed by the *Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories* (hereinafter referred to as the IPCC Guidelines). Canada has consistently reported in this way for the reason that agricultural CO_2 fluxes are related to agricultural practices that are documented in the agriculture sector of the national inventory. Regarding CH_4 emissions from enteric fermentation and manure management, the expert review team endorses Canada's plans to implement the Intergovernmental Panel on Climate Change tier 2 methodology for the inventory year 2003.

14. The expert review team recommends that Canada implement in the future, in accordance with the new good practice guidance on Land-use, Land-use Change and Forestry adopted at COP9, a more comprehensive approach. This would necessitate inclusion of growth rates differentiated by age classes and biomes. Further, Canada is encouraged to improve data for wildfires, including the most recent data, and to document the methodology used for calculating removals by woodlots located on agricultural lands and urban forest.

15. Canada informed the expert review team about its plans to improve the methodology, emission factors and activity data regarding the solid waste disposal inventory. In the implementation of these improvements, the expert review team recommends, among other things, that work is pursued with Statistics Canada to improve the collection of provincial and municipal solid waste data, and that emissions from waste incineration be reported in the Energy sector, according to the reporting guidelines.

I. OVERVIEW

A. Inventory submission and other sources of information

16. Canada submitted a national inventory report (NIR) on 15 April 2003. In its 2003 submission, Canada submitted a complete set of common reporting format (CRF) tables for the years 1990–2001.

17. During the review, Canada provided the expert review team (ERT) with additional information sources. These documents are not part of the inventory submission but are in many cases referenced in the NIR. The full list of materials used during the review is provided in annex 1 to this report.

B. Key sources

18. Canada has reported a key source tier 1 analysis, both level and trend assessment, as part of its 2003 submission. The key source analysis performed by the Party and the secretariat[4] produced similar results. The NIR gives a clear and transparent description of how the key sources have been determined.

19. The key source analysis has not been used to date to prioritize inventory developments. Several key sources in the Industrial Processes sector are currently estimated using a tier 1 approach and data that were determined for one year and have been used unchanged since then. The ERT believes that Canada should improve the estimation of emissions from key sources, particularly where they are currently estimated using tier 1 analysis. Key source analysis should be used to prioritize inventory improvements.

20. The ERT proposes that three additions be made to the key sources:

(a) Carbon dioxide (CO_2) for agricultural soils, because of its uncertainty and trend;

(b) CO_2 from domestic navigation as it has high uncertainties owing to the difficulty of distinguishing between domestic and international shipping;

(c) Sulphur hexafluoride (SF_6) from electrical equipment because of its uncertainty. It is not currently estimated, but initial estimates indicate that it could be a key source.

C. Cross-cutting topics

Completeness

21. In general the Canadian inventory is complete: it covers all years, for the whole of Canada, for the six mandatory GHGs. A few sources are not included, for example, SF_6 from electrical equipment (which may be a key source); SF_6 from magnesium foundries; a number of minor petrochemical products; some transport fuels such as bio-diesel and ethanol added to fuels after they leave refineries; and some Land-use Change and Forestry (LUCF) subsectors such as forest soils, underground biomass and the extraction of peat. These are discussed in the detailed discussions by sector below.

22. While not a mandatory reporting requirement, under the UNFCCC reporting guidelines, Annex I Parties should provide information on indirect GHGs. The ERT notes that no estimates were included for the precursors nitrogen oxide (NO_X), non-methane volatile organic compounds (NMVOC) and CO (carbon monoxide), nor for sulphur dioxide (SO_2). Canada also does not report emissions of CO_2 corresponding to atmospheric oxidation of NMVOCs and of methane (CH_4) emissions from non-

[4] The secretariat had identified, for each individual Party, those source categories which are key sources in terms of their absolute level of emissions, applying the tier 1 level assessment as described in the IPCC good practice guidance. Key sources 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 source analysis, the key sources presented in this report follow the Party's analysis. However, they are presented at the level of aggregation corresponding to a tier 1 key source assessment conducted by the secretariat.

combustion and from non-biogenic processes, such as solvent use, coal mining and handling, venting and leakages of fossil fuels.

Transparency

23. In general the inventory is transparent. The NIR describes each sector, the methods and emission factors (EFs) used, the sector quality assurance/quality control approach (QA/QC) (if any), and gives a qualitative assessment of uncertainties.

24. The ERT made a few minor comments on some of the notation keys used. The use of gross calorific values (GCV) is allowed under the guidelines; however, this does make comparison of the Canadian data with those of other countries more difficult, as most countries report using net calorific values (NCV). Conversion factors are not supplied in the documentation boxes as requested in the CRF (table 1.A(a)s4). In addition, some of the calorific values used to present the data in the CRF tables appear to be incorrect, leading to misleading implied emission factors (IEFs) and making meaningful international comparisons difficult. Canada should make efforts to clarify the fuel calorific values as soon as possible. The reference approach has been entered as NCV. Comparison table (table 1.A(c)) is thus misleading as both GCV and NCV are used in different columns.

25. The energy data presented by the International Energy Agency (IEA) are different from those used by Canada in preparing the inventory. While this does not reflect a problem with the quality of the inventory it does hinder the review team, and other users of the inventory, making international comparisons. The review team understands that Statistics Canada is aware of some differences in data sets submitted to international bodies and is taking measures to ensure consistency.

26. The data presented in the executive summary and the appendix illustrating the provincial summary tables in the NIR are rounded and the data in the CRF are not. A rounding protocol is used where the number of significant digits depends on the uncertainty of the data. The ERT appreciated this as it improves the clarity and transparency of the NIR, while the CRF preserves some of the detail needed for comparisons and checking of the data. However, the NIR should include a section explaining the rounding protocol, as was the case in earlier years.

27. Some of the data sources referenced in the NIR are data reviews and it is not entirely clear how the data used in the inventory are derived from the original data sources. (One example is the nitrous oxide (N_2O) emissions from light-duty gasoline automobiles.) Additional explanatory material explaining how data have been derived from original references would improve transparency.

Recalculations and time-series consistency

28. The ERT notes that recalculations reported by the Party of the time-series 1990–2001 for the years 1996–2000 have been made in order to take into account revisions to energy data supplied by Statistics Canada; activity data (AD) for limestone use in 2000; and AD for farmland 1996–2001. The major changes involve stationary combustion in energy industries and manufacturing industries, mineral products, agricultural soils and LUCF. The rationale for these recalculations is provided in the NIR. The recalculation due to changes in AD has been performed in a correct manner.

29. The ERT notes that recalculations have not always been handled in a way that is consistent with the *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (hereinafter referred to as the IPCC good practice guidance) and that Canada does not document the reasons for this. For example, for carbon emissions for coal and road transportation a value for 1990 was used for each year until 1995, when a revised factor was used. This resulted in a step change in the EF. It is not clear whether the change in the EF is simply an improved estimate of the factor or reflects a real change in the emission rates. If the former is the case, the new EF should be applied to all years; in the latter case some method of phasing in the change over a number of years should be adopted, interpolating between 1990 and 1995 as the good practice guidance advises. In either

case, the change of factor should be documented, with explanations of the methodological choices made. In other cases values used in the calculation have remained constant for several years. This should be documented in the NIR but is not.

Uncertainties

30. The only uncertainty analysis is a study performed in 1994 (McCann 1994). This was used in the key source analysis; however, some sources in the current inventory were not included then and there have been changes in other sources. Canada stated that it was tendering for a consultant to establish a protocol to estimate uncertainties (based on the IPCC good practice guidance) and to estimate emissions for the 2004 submission. This protocol would then be used by Environment Canada for subsequent years. This is a very short timescale and it is unlikely that probability distribution functions for all the sectors can be determined in time for the 2004 submission. It will be necessary to use the 1994 study and simplify the data for 2004. A more thorough assessment should be possible, however, for the 2005 submission. It should be possible to use this as an opportunity to review data which were collected for early inventories and are still being used. Future reviews should examine progress in this area.

31. In earlier NIRs Canada included a section on uncertainties which was useful in explaining the uncertainties numbers in the report. In this report, uncertainty is considered in a subsection in each emission sector. The uncertainties quoted are all based on McCann 1994, which looked at the 1990 inventory. This report will be increasingly unreliable for estimates of uncertainties in later years. Some of the uncertainties will have increased as the data were collected for 1990 and are assumed to be correct for later years. Other improvements in data and methodologies, meanwhile, should have reduced uncertainties.

32. Canada uses a rounding protocol in the NIR that the ERT thought improved the clarity and transparency of the report. The number of significant digits shown for each sector was based on the uncertainty assessed for that sector. Unfortunately the section of the report on uncertainties that explained this was omitted from the 2003 NIR, although it was included in the NIRs for earlier years.

Verification and quality assurance/quality control approaches

33. Currently Canada does not have formal QA/QC procedures in place in accordance with the IPCC good practice guidance. A variety of informal QC checks and reviews (including internal and governmental reviews) are in place and are documented in the NIR. However, Canada's current internal review deadlines are short and it is not possible to ensure that all feedback is received before the emissions inventory is submitted, so that incorporation of some feedback has to wait until submission of the next annual inventory. Opportunities for more timely review should now increase as energy data are becoming available earlier in the year. Canada has recognized the lack of a formal QA/QC procedure and is developing a QA/QC manual with formal procedures which are to be in place for the 2004 submission. When work is subcontracted to other organizations there is a requirement that it be performed in accordance with the IPCC good practice guidance, including the QA/QC guidance.

34. The draft *Instruction Manual for the Preparation of Canada's Greenhouse Gas Inventory for the Land Use Change and Forestry Sector* provides a good outline of the QA/QC procedures. It shows the methods to be used, the data sources and timings, responsibilities, QA/QC to be performed, data storage, and archiving and data outputs. Extending this approach to other sectors will improve the quality of the inventory.

35. In the development of its QA/QC manual and procedures Canada should ensure that their requirements meet the UNFCCC requirements in the IPCC good practice guidance.

36. N_2O emissions from the manufacture of adipic acid are currently based on monitored emissions data. While there is no reason to doubt these data, it would be good practice for Environment Canada to follow and document the QA/QC as described in the IPCC good practice guidance section 8.7.1.3 for

reported emissions based on emission measurements. In other cases where individual plant or enterprise-level data are received, there should be QA/QC and documentation in a similar manner.

Institutional arrangements

37. During the in-country visit, Canada explained the institutional arrangements for preparation of the inventory. The Department of the Environment (Environment Canada) has overall responsibility for the national inventory. Other organizations are also involved. All emissions are calculated by Environment Canada with other organizations collecting and preparing AD. Emission factors and data have been developed for the most part in an ad hoc fashion, although prior to the establishment of the IPCC. Environment Canada, working with industry, other federal departments and the provinces took a number of concerted steps to develop country-specific methods, EFs and appropriate AD. A number of comparison studies were also initiated, both with other OECD countries and with the provinces. The result of this work was used to establish the original 1990 estimates. Subsequently, a limited number of studies on specific topics have been commissioned from industry experts on an ad hoc basis.

38. Energy balance and energy consumption data, livestock numbers, crop production data and land statistics are collected by Statistics Canada and provided to Environment Canada for use in the inventory. Statistics Canada has legislative authority for collecting data, and by law, maintains company confidentiality in what they report to the public. This may lead to completeness problems in what is presented to the public, but this does not appear to affect the quality of the inventory primarily because Environment Canada has access to the confidential data records.

39. Natural Resources Canada provides mineral production and forestry statistics. Agriculture and Agri-Food Canada provides agricultural soil model results. A further agreement between Environment Canada and Natural Resources Canada clarifies their roles with respect to the production of the national inventory and the national GHG emissions forecast. Environment Canada collects data on perfluorocarbons (PFCs) and hydrofluorocarbons (HFCs) under mandatory requirements in the Canadian Environmental Protection Act.

40. Statistics Canada is a very important supplier of data to the national GHG inventories in Canada. To improve the quality of the inventory and its transparency it will be necessary to improve the quality of the AD, mainly for energy, received from Statistics Canada. Discussions over perceived problems in the data and input to improvement plans will help both Environment Canada and Statistics Canada. A closer working relationship combined with the ability to assist in data improvements will be needed. Environment Canada is already working towards this with a Memorandum of Understanding and this is commended.

41. Environment Canada is currently investing in GHG inventory improvements such as a QA/QC plan, uncertainty analysis and the inclusion of some additional sectors. While this is very commendable, it is a specific improvement to meet a current need. As knowledge improves and the economic and technical situation changes, inventories should always be undergoing improvements, review and revision. In order to achieve this, a long-term plan that prioritizes areas for improvement (guided by the key sources and results of uncertainty analysis) will ensure that the inventory remains up to date and accurate. The ERT recommends that Canada not lose sight of these longer-term goals while developing its QA/QC plan.

42. Currently, a separate inventory of criteria air pollutants (SO_2, NO_X, NMVOC etc.) is developed and maintained by Environment Canada, and housed within the same branch to foster linkages and efficiencies. Recognizing that each inventory has different reporting requirements (UNFCCC vs ECE), and that mapping emissions to similar categories is not a trivial task, the ERT encourages Canada to implement additional linkages to foster consistency in methods and data and efficient use of resources. In addition, mapping and reporting the data in the same categories, to the extent possible, will provide a means of verification for both inventories, as each inventory group performs quality assurance and

quality control. Although reporting of these pollutants under the UNFCCC is not mandatory, the ERT urges Canada to provide information on the ozone precursors in the UNFCCC inventory.

Record keeping and archiving

43. Canada does have a centralized archiving system. A list of documents contained in it was provided to the ERT. Some documents were missing, however, and the system should be improved and incorporated into the development of a formal QA/QC procedure. The plans presented to the ERT include extending this to archive electronic material. Some information and documentation of decisions appear to be kept by the individuals who develop a particular sector and there is concern by the ERT that information may be lost when they leave. The ERT was informed that as part of the QA/QC system all materials will be held in the central archive system.

44. When requested, Environment Canada was able to supply background information, reports and data to justify the EFs used and information provided in the NIR and the CRF.

Follow-up to previous reviews

45. Earlier reviews have highlighted the informal nature of the QA/QC system and the lack of current uncertainty estimates. Canada has indicated that funding is now available, and tendering under way, to address these problems. Problems identified with implied EFs appear to be due to erroneous calorific values for biomass fuels, and this is also being addressed. Work still needs to be done to resolve the issue of the omitted source, as described above and in the relevant sector discussions below.

D. Areas for further improvement

Identified by the Party

46. In its response to the issues raised during the review, Canada indicates that it is working to improve its estimates by:

(a) Producing a formal QA/QC plan, including centralized documentation and archiving;

(b) Provide quantified uncertainties estimates;

(c) Improving the archiving of data;

(d) Reassessing methodologies for key subsectors in Industrial Processes.

Identified by the ERT

47. The ERT identifies the following cross-cutting topics for improvement. Canada should:

(a) Provide quantified uncertainty estimates;

(b) Create a QA/QC management system, including documentation;

(c) Review methods used for recalculations in the past in line with the IPCC good practice guidance, especially where a constant data item is used over several years;

(d) Review the calorific values and carbon contents of fuels for 1990–2001 and reconsider the use of GCV and NCV in the CRF;

(e) Estimate emissions from omitted sources, use tier 2 methods for key sources and document its methodological choices.

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

II. ENERGY

A. Sector overview

49. Overall, fuel combustion and fugitive emissions accounted for 81 per cent of total Canadian GHG emissions in 2001 (529 Mt and 55 Mt, respectively). Between 1990 and 2001, fuel combustion-related emissions increased by 24.6 per cent, while fugitive emissions rose 44.4 per cent. Overall, the Energy sector is responsible for 98.7 per cent of the 112.5 Mt increase in total Canadian GHG emissions over the period 1990–2001. The greatest contributors to the increase in GHG emissions are: electricity and steam generation – 41.8 Mt (37.2 per cent of the increase); vehicles – 34.2 Mt (30.4 per cent of the increase); and fossil fuel industries – 15.8 Mt (14.1 per cent of the increase).

50. Growth in oil and gas exports, primarily to the United States, contributed significantly to the growth in emissions between 1990 and 2001. Overall, total energy exported has increased by 139 per cent between 1990 and 2001, while emissions associated with those exports have increased by 146 per cent, from 28 Mt in 1990 to 68 Mt in 2001.

51. Some subsectors showed declines between 1990 and 2001. For example, emissions from manufacturing industry declined by 5.6 Mt (–10.3 per cent), as a result of improvements in energy efficiency, and residential emissions decreased by almost 2.1 Mt (–4.7 per cent), showing the effects of a warmer than usual winter in 2000–2001.

52. From 2000 to 2001 total GHG emissions from the Energy sector declined by more than 8.7 Mt (1.5 per cent reduction). Almost half of this decrease can be found in the subsector Manufacturing Industries, while emissions from the Transport sector decreased by 2.9 Mt.

Completeness

53. The CRF includes estimates of all direct GHGs, as recommended by the IPCC Guidelines. Almost all emission sources from the Energy sector are included. However, the following sources are not included: fugitive emissions from post-mining activities (CO_2), fuel transformation, oil and gas refining and storage, distribution of oil products, and part of venting and flaring activities (N_2O); CO_2 and non-CO_2 emissions from bio-diesel and ethanol added to gasoline; and part of the emissions from producers' consumption in synthetic oil production. The omission of these sources does not affect the overall completeness of the inventory because their contribution is relatively small. Overall, the Energy section of the national inventory provides a full estimate of all significant sources.

54. The CRF tables are complete. The notation keys are largely used in proper way. However, in some instances "not applicable" ("NA") is used to indicate AD that have been included elsewhere ("IE").

Transparency

55. Mass-based EFs are used in the presentation of the NIR and in the emission calculations, according to the IPCC Guidelines. However, the CRF sectoral tables are filled in using energy units, expressed in GCV, while in part of the reference approach table NCV are used. Furthermore, the conversion factors used in converting from mass units into GCV and NCV are not presented in the NIR. The ERT therefore finds it very difficult to compare Canada's emissions from the Energy sector with those of other countries, since most other countries report energy data in NCV. The inclusion of both GCV and NCV and conversion factors used by Statistics Canada would enhance the comparability of the inventory.

56. However, additional materials were presented to the ERT during the review in order to improve transparency and facilitate the review (see annex 1 B – Additional materials).

57. The ERT's analyses of the NIR, the CRF tables and the additional materials and recalculations of the values presented indicate that many of the coal EFs used do not look reasonable when recalculated in energy units. They differ significantly from the IPCC defaults and are inconsistent with the respective

calorific values. (See paragraph 62. below for additional explanation.) In addition, Canada's IEFs are the highest among reporting Parties for liquid fuels and the lowest for gaseous and solid fuels. Canada indicates that it believes this was due to problems with the calorific values of the fuels rather than with the EFs. This is consistent with the data presented and reviewed by the ERT. It shows the necessity for clarification of the energy/carbon content of the fuels.

58. The collection of information by Statistics Canada about the calorific values of the fuels and the quantities produced or consumed should be improved. The ERT further recommends that Canada assess the carbon content, GCV and NCV of the fuel samples periodically at the production sites, if possible.

59. To improve transparency, the NIR should provide EFs in mass units, as well as the calorific values of the fuels. The ERT recommends that Canada use a consistent energy unit (NCV of GCV) throughout the CRF and NIR.

Methodology

60. The methodologies used are appropriate and in line with the IPCC good practice guidance. Country-specific methods, tier 2 and 3 approaches and country-specific EFs are applied for almost all key sources as well as for some of the non-key sources. The country-specific EFs are well documented in specialized studies. They need to be the subject of QA/QC procedures and regularly updated.

Recalculations

61. In the NIR Canada reported recalculated estimates for the Energy sector for the 2000 and 1999 inventories resulting from (a) revision of the energy supply and demand data published by Statistics Canada and (b) correction of wrong input data, identified during the previous review. The effect of the recalculations for the year 2000 (as reported in the CRF tables) was an increase in CO_2 emissions of 1 per cent, and decreases in CH_4 emissions of 0.89 per cent and in N_2O emissions of 2.07 per cent for the sector. The estimate of total emissions for the sector has increased by 0.5 per cent. The changes for 1999. They have no significant impact on the trend assessment. The recalculations have not caused any time-series inconsistencies.

Time-series consistency

62. The consistency of the time series is influenced by the different coal EFs that were used for the two periods 1990–1994 and 1995–2001. A revision of the coal EFs was done for 1995–2001. The revised information introduces significant, in some cases contradictory, changes in the fuel characteristics (calorific values and EFs) which could not be accounted for by changes in fuel quality alone. For example, the revision of the EF for Ontario and Manitoba sub-bituminous coals has changed the value from 2520 gCO_2/kg to 1733 gCO_2/kg, equivalent to a 31.2 per cent decrease of the carbon content of the coal. At the same time the GCV of the coal was changed from 18.3 TJ/kt to 19.15 TJ/kt, equivalent to a 4.6 per cent increase. It is well known that a reduction in carbon content results in a decrease of the calorific value, however, in this case the calorific value has increased. Expressed in energy units (GCV), the EF decreases from 137 $kgCO_2/GJ$ to 90.5 $kgCO_2/GJ$, equivalent to 34 per cent. While the value 137 is extremely high, the revised value of 90.5 is extremely low for sub-bituminous coal.

63. It is important to obtain a reasonable picture of the corrections to the coal EFs applied from 1995. The ERT recommends that a review of the specific coal calorific values and the EFs for the whole of the period 1990–2001 be performed in order to achieve time-series consistency and that recalculation for the period should avoid step changes in factors.

B. Reference and sectoral approaches

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

64. CO_2 emissions from fuel combustion have been calculated using both the reference and the sectoral approaches. Canada predominantly has used a complex procedure based on fuel specific densities in NCV, and to a much lesser degree, gross to net conversion factors and country-specific calorific values suggested by the IPCC to convert the reference AD from mass/volume units into NCV units. These recalculations introduce significant uncertainty into the reference AD reported in the CRF table 1.A(d). The ERT notes that the reference and sectoral approaches presented in the CRF use different units (GCV and NCV) so that the results cannot be compared (the comparison in table 1.A(c) is meaningless). Recalculations done by the ERT using simple transformation units (0.90 for natural gas and 0.95 for other fuels) showed that natural gas energy consumption really differs by about +3 per cent, not –7.25, as reported in the table, while coal consumption differs by about 13 per cent (7.68 in the table) and liquid fuel by about 17 per cent (11.93 in the table). The differences cannot be explained by non-energy fuel use only as reported in the NIR. An analysis by fuel type, excluding non-energy fuels, would be more meaningful to explain the differences.

65. The IEFs calculated for the reference approach data seem to be acceptable. However, the use of a country-specific EF for Canadian oil for the reference approach could be recommended. Quantity of carbon stored is indicated in table 1.A(d), while there are no AD in the row for ethane. The omission should be corrected.

66. The apparent consumption in the Canadian reference approach for 2001 is 4.0 per cent higher than that reported to the IEA. The figure given in the CRF is 5.0 per cent higher for liquid fuels, 5.6 per cent higher for solid fuels, and 2.1 per cent higher for natural gas. Specific differences include crude oil production, crude oil net exports, natural gas, exports of naphtha, coal stock and production of natural gas.

67. Canada has had difficulty reviewing the discrepancies with the IEA data because it is unclear what data were presented to the IEA and what methodology was used to equate the units for comparison. Proper coordination between the responsible Canadian agencies that present data to the IEA and the presentation of data in NCV units could be recommended to Canada. More transparency in presenting information on IEA data conversion and processing is recommended to the UNFCCC secretariat so that Parties can review discrepancies.

International bunker fuels and feedstocks and Non-energy use of fuels

68. Emissions have been estimated on the basis of fuel sales, which is the tier 1 method recommended in the IPCC Guidelines. Fuel deliveries are classified as national or international according to the flag of the carrier, not whether or not the journey is trans-boundary. This is inconsistent with the definition of national and international transport in the IPCC good practice guidance definition. This is likely to result in overestimation of domestic emissions and underestimation of emissions of international bunkers, because all domestic vessels reported as consuming fuels are included in domestic emissions. For aviation, this problem can be addressed somewhat by using a tier 2 method, but it is more difficult for shipping, where statistics for the Great Lakes area may not be available. The ERT recommends that Canada develop data and methodologies to allocate these emissions according to the IPCC definition of international and national transport.

69. The data for international bunker fuels and feedstocks and non-energy use of fuels are reported in a proper way. All the emissions from non-energy use are reported in the Industrial Processes sector. The secondary fuels collected during the processes (for example, blast gas) and used for energy production are not accounted for under Energy.

C. Key sources (fuel combustion and fugitive emissions)

Fuel combustion

70. For sector 1.A.1 Energy industries: gas, coal, oil – CO_2, the ERT has identified that:

(a) Auto producers' emissions were included in Public electricity and heat production, not in the corresponding manufacturing industries;

(b) The landfill gas captured and combusted for energy is not accounted for in the Energy sector. It is considered as flared in the Waste sector;

(c) On-site transportation activities emissions are excluded from the category Manufacture of solid fuels and other energy industries, and included in Off-road transportation. They should be reported in the former.

71. For sector 1.A.2 Manufacturing industries and construction: gas, coal, oil – CO_2, the ERT has identified that emissions from food processing, beverages and tobacco are included in the category Other. Canada indicates that this is due to the fact that the Quarterly Report on Energy Supply and Demand in Canada as published by Statistics Canada, which is currently, the only official source of AD for food processing, beverages and tobacco, groups these activities under Other Manufacturing. The ERT recommends that Canada review this sector, with a view to identifying additional data that could assist in the disaggretation of the data.

72. The subsector 1.A.3 Transportation incorporates six key sources; road transportation – CO_2 and N_2O; other transport – CO_2; civil aviation – CO_2; railway transportation – CO_2; and pipeline transport – CO_2. For road transportation a country-specific model, MGEM, is used to estimate the emissions. This model allocates fuel to vehicles of different types (vehicle type and technology) by province. Fuel-based EFs are then used to estimate emissions. Canada distinguishes between new and old "tier 1"[5] vehicles (older cars with three-way catalytic converters).

73. A review of road transport emission factors shows that some of the source material quotes EFs in g/mile and the inventory uses g/litre. The derivation of the g/litre data from the g/mile data is unclear and not well documented in the NIR. It is recommended that Canada check and critically review these factors and their conversion, clearly documenting their derivation from the original source material. This conversion is needed as the emissions are estimated according to fuel use in the MGEM model. Other countries use models that are based on distance traveled by vehicles (e.g., MOBILE5C and COPERT), where variables such as vehicle speed and road type can be included and, if necessary, adjusted to match fuel use. This approach would better match the EFs and potential future improvements in EFs when variables such as cold starts could be included (if measurement data appropriate to conditions in Canada become available).

74. On the basis of these findings, the ERT recommends that, if a fuel-based approach continues to be used (MGEM or a successor), then the derivation of g/litre EFs from g/mile measured data needs to be thoroughly documented.

75. Furthermore, to have comparable data for the motor fleet from all the provinces and territories an improvement of the database for the model is needed, and the vehicle population should be better assessed through the provinces. The ERT understands that this is planned.

76. In addition the ERT has identified the following issues that need to be considered in the future in the NIR and the CRF tables:

[5] "Tier 1" here refers to a level of exhaust control in Canada and should not be confused with IPCC tier 1 methodologies.

(a) On-site transportation in the Manufacturing of solid fuel and other energy industries subsections is included in off-road transportation. It should be in the Manufacturing of solid fuel subsection;

(b) Military aviation is included in Aviation and military transportation in Road transportation. They should be moved to the appropriate places;

(c) Ethanol used as additive to gasoline and bio-diesel were not accounted for in the fuel consumption and mileage distribution by the MGEM model, nor in the non-CO_2 emissions;

(d) A tier 1 approach is applied for Civil aviation. The Party should consider a more precise distinction between the fuel consumption for national and international flights and implementation of the tier 2 methodology.

Fugitive emissions

77. Canada informed the ERT that a new study on the fugitive emissions from oil and gas production is under way. It should considerably improve the presentation of this sector.

78. For subsectors 1.B.2.a Oil – CH_4 and 1.B.2.b natural gas – CH_4, the ERT has identified that:

(a) Emissions from refining, storage and distribution of oil products are not estimated ("NE");

(b) Emissions from synthetic oil production are considered constant for the period 1996–2001 (independent of the production volumes). This assumption should be proved.

79. In subsector 1.B.2.c. Oil and natural gas – venting and flaring – CH_4, only CO_2 emissions are reported from venting. Significant emissions of CH_4 could originate from the venting of all the equipment in the refineries, oil and gas production, transportation and distribution. These emissions should be estimated or separated from the leakages of the oil and natural gas systems if they are included there now.

D. Non-key sources (fuel combustion and fugitive emissions)

80. For subsector 1.A Stationary combustion the ERT has identified that:

(a) The non-CO_2 EFs for different coals expressed in mass units are considered as not fuel-specific. They should be fuel-specific. (They are not fuel-specific if expressed in energy units.)

(b) The CO_2 IEF for biomass shows unusual variation from year to year. It is also at the low end of the range of reporting Parties. The biomass data for all subsectors and categories within the stationary combustion section of the CRF (1.A, 1.A.2 and 1.A.4) were incorrectly entered.

81. The fuel spent on fisheries is included in 1.A.3.d Navigation – CO_2. It should be moved to Agriculture, forestry and fisheries.

III. INDUSTRIAL PROCESSES AND SOLVENT USE

A. Sector overview

82. The Industrial Processes and Solvent Use sectors accounted for 6.9 per cent of total emissions of GHG in 2001, reaching 49 Tg CO_2 equivalent. Total emissions from those two sectors decreased by 7.2 per cent over the period 1990–2001. The main reason for this reduction is the addition of abatement technology in the adipic acid production process, leading to a 54 per cent reduction in the Chemical industry subsector in this period. Emissions from Other production increased by 26 per cent in the period, but this trend will be revised if the recommendations of the ERT for the reassessment of the allocation of emissions to this subsector are implemented.

Completeness

83. The CRF and the NIR include estimates of and information on most sources of emissions of direct greenhouse gases from the Industrial Processes sector. Sources not included are SF_6 emissions from electrical equipment, believed to be a potential key source, emissions from SF_6 from magnesium foundries and emissions from production of petrochemicals such as carbon black, ethylene, dichroethylene, styrene and methanol.

84. Emissions from indirect sources are not included. Emissions from NMVOC are usually important in the Industrial Processes sector, particularly in the Food and beverage and Use of solvents subsectors. Efforts should be made to report them in future inventories.

Transparency

85. The NIR is transparent overall, with clear descriptions of the methodologies used together with the criteria adopted and limitations. Emissions based on confidential information are reported in some subsectors, such as Adipic acid production and Nitric acid production.

Recalculations and time series

86. Some industrial AD are released with a delay (e.g., data on limestone use). Thus emissions for the most recent year are reported as equal to the previous year and are recalculated in the following submission. For some information, such as HFC consumption or soda ash consumption, AD have not been available for some time, leading to a constant value being reported from that point on.

87. In some subsectors EFs are updated following new studies and applied from some point forward, leading to step changes in time series and inconsistencies. An assessment of the evolution of parameters over time based on studies and the causes (technology change or better estimation) of change should lead to a more consistent time series.

Verification and quality assurance/quality control approaches

88. QA/QC would be improved if verification of data received directly from the industrial producers could be increased. These data include input fuels and feedstocks, production data, EFs, and emissions measuring and monitoring.

B. Key sources

Cement production – CO_2

89. A tier 1 methodology is adopted for this subsector using an EF based on cement production. Also, all cement is assumed to be Portland cement. A tier 2 approach based on clinker production is recommended, as well as an assessment of the types and composition of cement. Canada has recently identified data for clinker production and envisages using it in future submissions.

Ammonia production – CO_2

90. A tier 1 methodology is adopted for this subsector using an EF based on ammonia production. An amount of ammonia is produced from by-product hydrogen instead of natural gas and does not generate CO_2 emissions. However, this amount is assumed to be fixed for all years reported in the inventory. A tier 2 methodology based on data for natural gas consumed by the industry to produce ammonia is recommended, if possible, together with annual data for by-product hydrogen consumed.

Adipic acid production – N_2O

91. Only one plant produces adipic acid in Canada. Total N_2O annual emissions are therefore reported directly by the producer and are treated as confidential information. Emissions have been reduced significantly in recent years, by 93 per cent, which is consistent with the reported installation of abatement equipment.

92. QA/QC procedures should be implemented to make it possible to verify the monitoring procedures implemented by the industry, and the confidential information should be provided.

Iron and steel production – CO_2

93. CO_2 emissions from coke used for the reduction process in coke ovens are correctly included in the Industry sector, as recommended by the IPCC good practice guidance. Nevertheless, emissions from the consumption of anodes made from petroleum coke in electrical furnaces are currently included in the Other industries subsector and should be included here.

Aluminium production – PFCs

94. The EFs for this sector depend both on the technology employed and on the managing procedures adopted to reduce the frequency of anodic effect. The EFs adopted by Canada are within the uncertainty range given in the good practice guidance but have been assumed to be constant from 1996 forward. A new study has recently been concluded and may be used to update those data and improve time-series consistency.

Other industries – CO_2

95. Emissions reported in this subsector are based on the Canadian energy balance data for non-energy use of energy products and use of non-energy products. In the Canadian energy balance, the use of non-energy products is allocated to several subsectors besides the Industry sector, including Mining, Transportation, Agriculture, Public administration, Commercial and Other institutional. The emissions associated with this consumption should be kept in the Energy sector instead of being included in Other Industries.

96. Within the Industrial Processes sector, only the consumption that can be associated with industrial processes should be included. To increase transparency as much as possible, the emissions should be reported in the individual subsectors (Iron and Steel, Ferroalloy Production), as is currently done for the ammonia production and aluminium production processes.

97. Emissions are estimated using the default values for oxidation provided by the IPCC for the reference approach in the Energy sector. Emissions already reported in the Ammonia production and Aluminium production sectors are subtracted to prevent duplication. However, the default values for oxidation (i.e., 33 per cent for natural gas) already have embedded assumptions about the use of non-energy products that may not accurately reflect Canada's circumstances. It is therefore recommended that the actual destination and use of the non-energy products should be assessed, together with assumptions about the associated emissions.

C. Non-key sources

Soda ash use

98. Emissions of CO_2 from soda ash use have been reported as constant from 1992 forward. The reason for that is that the information provided in a Statistics Canada report on the consumption of soda ash in the glass industry was discontinued in 1992.

99. One suggestion to overcome this problem is that Canada investigate the availability of data for its production, imports and exports of soda ash. As, by default, all consumption of soda ash generates CO_2 emissions, those data can provide a basis for the emissions estimate.

HFC and PFC consumption

100. The Canadian inventory includes both potential and actual emissions estimates, as recommended in the good practice guidance. However, the NIR could be improved with the inclusion of a comparison of the results of the two approaches.

101. Emissions are assumed to be constant after 1998, as no new information has been available since then. An effort to ensure a more consistent time series is recommended.

D. Areas for further improvement

Identified by the Party

102. Canada had already identified some of the problems highlighted by the ERT and has established plans for improvement of the inventory. Those include the implementation of a tier 2 methodology for cement, and using the information from recent studies related to the emission of PFCs in the aluminium industry and the use of HFCs and PFCs.

Identified by the ERT

103. The current allocation of emissions to the Other Industries sector should be revised and efforts made to allocate the emissions to the subsectors where they occur, including an assessment of the destination of the non-energy products and the emissions associated with their actual use.

104. Emissions of indirect gases should be reported, including those for asphalt roofing, road paving, food and beverages, and solvent use.

105. Time-series consistency should be improved. The current step changes in EFs and constant values for AD should be assessed and a more consistent, and realistic, time series adopted based on the studies available.

IV. AGRICULTURE

A. Sector overview

106. The Agriculture sector is the second-largest category and accounted for 8.4 per cent of total GHG emissions in 2001, amounting to 60 Mt CO_2 equivalent. Over the period 1990–2001, total GHG emissions from the sector increased by 1.3 per cent. Most sources in the sector, with the exception of CO_2 emissions and removals for agricultural soils, increased by over 15 per cent between 1990 and 2001. CO_2 emissions and removals for agricultural soils decreased independently.

Completeness

107. The CRF includes estimates of all gases and sources of emissions from the Agriculture sector, as recommended by the IPCC Guidelines. CO_2 emissions and removals for agricultural soils are reported under 4.D. Agricultural soils instead of LUCF. Emissions from 4.C. Rice cultivation and 4.F. Field burning of agricultural residues were assumed to be negligible in the NIR, but reported as "not occurring", "NO" in the CRF. The ERT recommends that Canada report emissions from 4.C. Rice cultivation and 4.F. Field burning of agricultural residues as "NE".

Transparency

108. The NIR provides information on the methodologies used, EFs and references for every source. The more detailed methodologies are provided in annex 3 of the NIR, which was not included in the previous NIR. Annex 3 includes detailed explanation, equations and EFs for all subcategories. The CRF includes information such as footnotes and additional information boxes. More disaggregated AD or coefficients are used in the estimation process in particular when deriving model estimates of CO_2 emissions/removals from arable lands. However, these data are not indicated in the NIR. The estimation methodologies are therefore not completely transparent.

Recalculations and time-series consistency

109. Consistent time-series data from 1990 to 2001 are reported. Canada reported its agricultural inventory of GHG emissions using the relevant tables (4, 4.A, 4.B(a), 4.B(b) and 4.D).

110. According to table 8(a)s1, recalculations were made for CO_2 for 4.D. Agricultural soils; however, the NIR states that no recalculation has been carried out. These recalculations were caused by the application of a new method for Cultivation of histosols, which is one of the subcategories of 4.D. Agricultural soils. The ERT recommends that Canada revise the description of the recalculation in the NIR.

Uncertainties

111. Three-year average emissions suggested by the Revised 1996 IPCC Guidelines have not been adopted. The uncertainties are caused by EFs, not AD, which are considered to be accurate. Canada therefore believes that three-year average emissions need not be adopted.

Verification and quality assurance/quality control approaches

112. QA/QC has been conducted, but this is not completely consistent with the IPCC good practice guidance. Canada is in the process of developing a formal QA/QC procedure. The ERT recommends that this be completed, implemented and documented in the NIR.

113. Some implied EFs are different from the IPCC default values, and these are pointed out in the Synthesis and Assessment (S&A) report. The ERT recommends that Canada include a comparison and explanation of the differences between the EFs and the IPCC default in the future QA/QC procedure.

B. Key sources

4.A. Enteric fermentation – CH_4

114. The tier 1 method was used, and default EFs were used for major subcategories. Research on tier 2 methods is being carried out, and Canada will adopt the tier 2 method in its 2005 submission. The ERT recommends that Canada apply the tier 2 method in the near future.

115. Country-specific EFs are used for some subcategories of Cattle (Bull, Beef cow, Dairy heifer, Beef heifer). However, the EF indicated in the summary 3 of the CRF is only "D" (for default). The ERT recommends that Canada fill in the cells in summary 3 of the CRF with "D/CS" (for default/country-specific) instead.

116. The population of goats tripled between 1995 and 1996 (from 21.9 k/head in 1995 to 73.3 k/head in 1996) even though in general there is a tendency for the livestock population to change only gradually. Data on the population of goats and horses are not collected annually but every five years (most recently in 1991, 1996 and 2001). The ERT recommends that Canada use the interpolation method for these livestock populations.

117. Some population data are different from those published by the Food and Agriculture Organization on the United Nations (FAO). During the review, an adequate explanation for this was provided. In Canada, livestock population statistics (except for goats and horses) are collected on a quarterly or a semi-annual basis. It is not clear whether the FAO data uses the quarterly data or the semi-annual data.

4.B. Manure management – CH_4

118. The tier 1 method and default EFs were used for this category. Research on tier 2 is being carried out, and Canada will adopt the tier 2 method in the 2005 submission in accordance with the research. The ERT recommends that Canada apply the tier 2 method in the near future.

119. The figures for the population of sheep used in this category were inconsistent with the population figures given in table 4.A. Enteric fermentation and for N_2O from 4.B. Manure management. Canada explained that in table 4.A and for N_2O from 4.B the population of lambs was allocated to 10. Other but, as there is no row for 10. Other in table 4.B(a) of the CRF, the population of lambs was

included in subcategory 3 Sheep of that table. The ERT recommends that Canada indicate the reason for this inconsistency in the NIR.

4.D. Agricultural soils – CO_2

120. Canada did not identify this as a key source category. However, according to analysis conducted by the ERT, it was identified as a key source category in the trend assessment. The ERT recommends that Canada include this source/sink as a key source category.

121. Canada reports CO_2 emissions from/removals by agricultural soils under 4.D. Agricultural soils because these emissions are related to agricultural practices that are documented in the Agriculture sector (the IPCC allows this source/sink in either the Agriculture or the LUCF sector). These emissions/removals have decreased from 7,553 Gg emissions in 1990 to 299 Gg removals in 2001. The NIR indicates that the decrease is mainly due to changes in farming practices, particularly the increased use of conservation tillage. Canada uses the CENTURY model to estimate these emissions, and its summary is described in the NIR. The ERT recommends that Canada report why this source/sink is reported under the Agriculture sector instead of LUCF in the NIR.

122. CO_2 emissions and removals for agricultural soils fall into three subcategories. Canada has reported only the aggregated total in the CRF. The methodology (CENTURY model) is described in the NIR; however, AD and some parameters are not provided. The ERT recommends that Canada report the disaggregated emissions from/removals by this category and give an example of the estimation process of the model in the NIR.

123. The ERT noted an inconsistency between the CRF, which shows 300 Gg CO_2 removals, and table S-1 of the NIR (Canada's GHG emissions by gas and sector, 2001) which shows 300 Gg CO_2 emissions. Canada has explained that the data in the CRF are correct. The ERT recommends that Canada report consistently between the CRF and the NIR.

124. AD for limestone and dolomite application to agricultural soils are available only for 1990 to 1996 and are held constant from 1997 on. Associated emissions estimates will be updated in the next submission.

4.D. Agricultural soils – N_2O

125. N_2O emissions from 4.D. Agricultural soils were identified as a key source category. The IPCC good practice guidance (table 7.1) recommends analysing direct N_2O emissions and indirect N_2O emissions separately in the key source category analysis. The ERT recommends that Canada conduct key source category analysis in accordance with the IPCC good practice guidance.

126. The additional information in the CRF ($Frac_{BURN}$, $Frac_{FUEL}$ and $Frac_{GASF}$, etc.) was provided from 1990 to 2000; however, it was not provided in the CRF for 2001. The ERT recommends that Canada provide additional information of the CRF for 2001 as well as for the previous years.

127. With regard to direct soil emissions, the IEF for synthetic fertilizers is 0.01125 kg N_2O-N/kg N, which is lower than the IPCC default value (0.0125). This is reasonable since 10 per cent of nitrogen (N) in applied fertilizer is assumed to be lost as ammonia (NH_3) and NO_X in line with the IPCC Guidelines.

128. The IEF for animal wastes is 0.009 kg N_2O-N/kg N, which is lower than the IPCC default value (0.0125). It is assumed that 20 per cent of N in applied fertilizer is lost as NH_3 and NO_X, and the IEF should therefore be 0.01. However, the reason for this disparity has not been made clear.

129. In Cultivation of organic soils, the uncertainty description of AD of the NIR was not provided.

130. The estimation of N_2O emissions from animal production was conducted consistently with the estimation of emissions from 4.B. Manure management.

C. Non-key sources

4.B. Manure management – N_2O

131. The tier 1 method and default EF are used; however, the nitrogen excretion rate for some livestock species is different from the IPCC default values, which was pointed out in the S&A report. The reason for this is that data based on research conducted in United States (ASAE, 1999) are used, which is appropriate for Canada.

132. The animal waste management systems (AWMS) data currently used in the NIR will be re-evaluated through a survey within the next few months. Detailed data on AWMS by major animal type and by province will be obtained. It is expected that the updated AWMS will be used for the inventory year 2003.

133. The population of horses and goats in 1999 and 2000 indicated in the CRF seems to be incorrect (517 (k/head) in 1998, 12,391 (k/head) in 1999, 12,295 (k/head) in 2000 and 552 (k/head) in 2001).

D. Areas for further improvement

Identified by the Party

134. Regarding 4.A. Enteric fermentation and CH_4 emissions from 4.B. Manure management, studies for adopting the IPCC tier 2 methodology are to be carried out. Canada plans to adopt the IPCC tier 2 method completely for the inventory year 2003.

135. Regarding N_2O emissions from 4.B. Manure management, the AWMS data currently used in the NIR are to be re-evaluated through a survey. Detailed data on AWMS by major animal type and by province will be obtained. Canada is expected to use the updated AWMS for the inventory year 2003.

Identified by the ERT

136. The ERT recommends that the NIR includes AD and coefficients at the highest degree of disaggregation possible, at least for the most recent year, in order to facilitate the review process.

V. LAND-USE CHANGE AND FORESTRY

A. Sector overview

137. Canada has reported a net sink for the LUCF sector for all years 1990–2001. In 2001 the net sink amounted to 34 Mt CO_2 equivalent, representing 5 per cent of total greenhouse gas emissions of Canada. It had declined from 105 Mt in 1990, a reduction of almost 70 per cent. However, there has been high inter-annual variability because of variation in the harvesting rate and forest fires.

138. The largest sinks in Canada are found in the forest management area (IPCC sector 5.A), accounting for 90 per cent of all CO_2 removals in the LUCF sector. The reported data for land-use changes (IPCC sectors 5.B, 5.C and 5.D) include CO_2 emission and removals from conversion of forest and other land, as well as carbon sequestration in vegetation and soils on abandoned agricultural lands reverting to natural vegetation. These two sources represented a net emission, including change in soil carbon, of 2.9 Mt in 2001. From 1990 to 2001 net emissions increased by 41 per cent, mainly because of increased emissions from conversion of forest land.

Completeness

139. The CRF includes estimates of all four LUCF sectors as recommended by the IPCC Guidelines.[6] Changes in soil carbon (reported under sector 5.D) include only emissions and removals from land-use

[6] These are: 5.A Changes in forest and other woody biomass stocks; 5.B Forest and grassland conversion; 5.C Abandonment of managed lands; and 5.D CO_2 emissions and removals from soils.

change (from IPCC sector 5.B and 5.C). Canada's inventory also includes carbon changes in agricultural soil. However, this net sink is reported under the Agriculture sector (4.D): see chapter IV.

140. As part of subsector 5.A, Canada has also included removals by woodlots located on agricultural land and urban forests. Further, the inventory covers emissions of CO_2, CH_4 and N_2O from wildfires and prescribed fires within the forest management area (called "wood production forest" in Canada's inventory). Emissions from anthropogenic fires outside the wood production forest have been excluded from the inventory until further guidance is offered by the IPCC good practice guidance for Land-use, Land-use Change and Forestry (LULUCF).

141. The inventory, however, does not include soils in forest, below-ground biomass, dead organic material above ground, CH_4 and N_2O emissions from forest and grassland conversion, drainage of wetlands or the extraction of peat. The ERT encourages Canada to consider including these sources in the future, in accordance with the new good practice guidance on LULUCF. The ERT was informed that such an approach is already part of Canada's plans for future improvements.

Transparency

142. The methodology used for calculating is only partly described in the NIR and the CRF. However, the review team was given a thorough description of all parts of the inventory during the in-country visit. To increase transparency, the ERT recommends that Canada provide more complete documentation of the methodology in its future NIRs, including data sources, growth rates and other parameters and assumptions relevant for the calculations. Some of this information may be Internet-based, if possible.

143. With regard to removals by woodlots located on agricultural lands and urban forests, the NIR does not give any description of the methodology used. Despite the fact that this sink represents a relatively small net removal (5 per cent of the net removals by the total LUCF sector), the ERT recommends that, because of the high uncertainty related to this category, Canada provide documentation of the methodology for this source in future NIRs. During the in-country visit the ERT was given a description of the methodology and growth rates used. The estimates are not based on direct data collection and measurements, rather assumption. The ERT has no reason to believe that the data are wrong, although the calculations should be regarded as highly uncertain. A more thorough assessment of these sources is recommended.

144. The ERT has identified some illogical use of notation keys in the CRF, for example, the use of "NA" in the lines for Temperate forest in table 5.A, as well as in table 5. These should probably be reported as "IE".

Recalculations and time-series consistency

145. Significant recalculations were conducted for the 2003 submission, particularly for forest management (IPCC sector 5.A). Explanations of these recalculations are provided in CRF table 8, as well as in the NIR.

146. Canada now accounts for all GHG emissions from wildfires and prescribed fires located in wood production forest (IPCC sector 5.A), whereas previously the calculations only included non-CO_2 emissions. However, the 2003 submission does not include emissions from anthropogenic fires outside wood production forest (the 2002 NIR included CO_2, CH_4 and N_2O emissions from these).

147. Further, in the 2003 inventory, forest areas that are temporarily unstocked due to anthropogenic or natural disturbances are excluded from the areas actively sequestering carbon until these areas are regenerated. However, emissions from fires and harvesting are included in the inventory. The ERT regards this new approach as an improvement compared to the previous estimation procedure, which assumed that the maturity-class distribution of the wood production forest had remained constant since 1990.

148. Both emissions and removals from conversion of forest and other land and abandonment of managed land have been recalculated for all annual estimates from 1990 to 2001, as new area data are now available from the 2001 edition of the Census of Agriculture. The previous census was from 1996, and the data for the period 1996–2000 were projected from the 1991–1996 trends. This has resulted in significant upward recalculations for the period 1996–2001, both for emissions and for removals.

149. Despite the significant recalculations both for forest management and for land-use change, the ERT has not identified any time-series inconsistencies that might be due to these recalculations.

Uncertainties

150. The main source of uncertainty, of a systematic nature, is probably the omission of important carbon pools, such as forest soils, dead organic biomass and below-ground biomass. There are also large uncertainties related to the use of highly aggregated forest activity and area data, annual average growth rate, and biomass expansion factors. Canada has concrete plans to address these methodological deficiencies in accordance with the implementation of the IPCC's new good practice guidance on LULUCF. As a tool to prioritize future improvements, the ERT recommends that Canada quantify the uncertainty levels and trends of the different sources and elements in the LUCF calculation.

Verification and quality assurance/quality control approaches

151. Canada has not currently established any formal procedure for the technical verification of the LUCF inventory. However, many informal verifications and QA/QC checks have been implemented, such as the use of data and parameters published in the scientific literature, double checks of manual data input, and comparison of emissions and removals estimates with previous submissions. The ERT also considers that the draft *Instruction Manual for the Preparation of Canada's Greenhouse Gas Inventory for the Land Use Change and Forestry Sector* provides a good outline of the QA/QC procedures.

B. Sink and source categories

152. When reviewing the methodology used by Canada for the LUCF inventory, the ERT has recognized the characteristics of Canada's forests. Canada has 10 per cent of the world's forest area (417 Mha), which consists primarily of slow-growing "natural" forest with many different biomes. The levels of natural disturbances are relatively high and harvesting takes place primarily on mature natural forests (harvest rate 1.0 Mha/yr).

Managed Forest

153. Canada follows the IPCC basic methodology for calculating emissions and removals in the category 5.A, which is the net CO_2 removals or emissions calculated as the difference between (a) the gross annual growth increment and (b) emissions resulting from harvesting, fuelwood and other biomass losses. However, Canada has developed a country-specific methodology to define its managed forest area, its growth rate, the amount of harvested wood and other biomass losses. The methodology is partly described in the NIR and the CRF, but could be better documented. On the basis of information given during the in-country visit, the different elements and steps of the methodology for calculating emissions and removals in the managed forest category are reviewed below.

Managed forest area

154. The managed forest area in Canada is defined as timber productive forest which is non-reserved, accessible and not subject to management restriction (148 Mha). Within these 148 Mha, the area considered to estimate carbon sequestration due to active forest growth excludes area which is temporarily non-stocked following harvesting and stand replacing wildfires, as well as non-growing "over-mature" forest area. Previously harvested area is included in the calculation when the areas are regenerated. The forest area considered as actively sequestering carbon was reduced from 127 Mha in 1990 to 115 Mha in 2001 as a result of the adjustments described above. This approach is rather unusual

but is regarded as reasonable way to avoid overestimation of Canada's CO_2 removals from managed forest areas. Canada also indicated that this approach was developed to make the most appropriate use of the mean volume increments published by the Canadian Forest Service (see below).

Annual gross growth rate

155. The mean annual gross growth rates are based on specific information from each province and territory, compiled by the Canadian Forest Service. These rates do not reflect changes in forest age structure and composition and they are derived from standing above-ground biomass at maturity. However, this is regarded as reasonable since Canada only includes forest land which is actively sequestering carbon: see above.

156. The average growth rate differs from 0.42 to 2.34 m^3/ha/yr, with a country average of 1.82 m^3/ha/yr. Taking into account that approximately 75 per cent of the forest area in Canada is boreal and 25 per cent temperate forest, this growth rate is higher than the IPCC default values (1.0 for boreal, 3.0 for temperate evergreen and 2.0 for temperate deciduous). However, since Canada's inventory is limited to forest land which is actively sequestering carbon (e.g., temporarily non-stocked forest areas are excluded), the average growth rate should be regarded as reasonable.

Harvest and other biomass losses

157. In conformity with the IPCC Guidelines, Canada assumes that all CO_2 from harvested wood is emitted immediately after harvesting. This includes all above-ground biomass. Canada also includes emissions from fuelwood harvesting. The amount of fuelwood includes only commercial and formal fuelwood. The ERT recommends that Canada consider including the informal harvesting of fuelwood outside the managed forest areas, even if this emission source could be minor.

158. Further, Canada has included emissions of CO_2, CH_4, N_2O, NO_X and CO from wildfires and prescribed fires within the managed forest area. The wildfires affect on average 2.6 Mha of forest every year (or 1 per cent of the forest area), but with large annual variations (from 0.6 to 7.1 Mha/yr). The EFs are country-specific, based on an assessment from 1996, and seem to be reasonable. Canada informed the ERT that data for areas affected by wildfires can only be compiled three years after the year under consideration. This implies that the CO_2 emissions from the latest reported year (e.g., the data for 2001 reported in the 2003 NIR) must be based on extrapolations, and thus are significantly more uncertain than previous years. The ERT encourages Canada, if possible, to obtain more accurate data for the last reported year.

159. The Mean Annual Increments already integrate growth reductions due to insects and diseases. However, the current inventory does not include stand-replacing infestations.

160. Total emissions from harvesting and other biomass losses have varied significantly over the last 10 years (a difference of 35 per cent between the highest and the lowest number). Canada explained that this fluctuation was caused by identified variation in international timber marketed.

Expansion factor and biomass conversion

161. In the calculation of total above-ground biomass both for growth increment and for harvested wood, Canada uses a combined factor for biomass conversion and biomass expansion. This approach reduces the transparency in its calculations. The ERT therefore recommends that Canada document the biomass conversion and biomass expansion factor separately.

162. The combined biomass conversion and biomass expansion factor is based on information from Canada's Forest Inventory and varies from 0.66 to 0.94 t dm/m^3, with a country average of 0.77 t dm/m^3. No explanation for this variation is given. The IPCC default value for biomass conversion is 0.65 t dm/m^3 for deciduous and 0.45 t dm/m^3 for conifers. The IPCC default expansion ratios are 1.75 for undisturbed forests and 1.90 for logged forests. These default values would lead to a combined

biomass conversion and biomass expansion factor of 0.79 to 1.23 t dm/m^3. Thus Canada's combined factor lies at the lower end compared to the IPCC default value. However, this could be regarded as reasonable as much of Canada's managed forest is predominantly coniferous.

Emission and removals by non-forest trees

163. Canada has also included removals by woodlots located on agricultural lands and urban forests: these removals are calculated to account for 2 per cent of the total gross growth increment in 2001. The NIR does not give a description of the methodology used. The ERT recommends that Canada provide documentation of the methodology used for this source in future NIRs. During the in-country visit the ERT was given a description of the methodology and growth rates used. The estimates are not based on direct data collection and measurements but rather on assumption. The ERT has no reason to believe that the data are wrong, although the calculation must be regarded as highly uncertain. A more thorough assessment of these sources is recommended.

Land-use change

164. The LUCF inventory includes CO_2 emissions and removals from conversion of forest and grassland to agricultural and urban land, and of agricultural land to urban land, as well as those from the abandonment or loss of agricultural land to other land uses. Both biomass and soil carbon stocks are included in the assessment. The inventory, however, does not include below-ground biomass, dead organic material above ground, CH_4 and N_2O emissions from forest and grassland conversion, drainage of wetland or extraction of peat. Further, it is unclear to the ERT whether conversions of other wooded land are included. Canada informed the ERT that the inclusion of these sources should be considered in accordance with the implementation of the new good practice guidance.

165. In general Canada follows the methodology recommended by the IPCC Guidelines. The AD from the Census of Agriculture probably underestimate the extent of land-use change in Canada because of the use of farmland area data aggregated at provincial levels. However, when used in a consistent way the data are considered to give relatively accurate time series. Because of the high uncertainty level it is recommended that Canada improve the data input, as it stated that it is doing during the in-country review. The results of an on-going study to look at more spatially disaggregated area data will be integrated in the next inventory submission, which should reduce the uncertainty.

166. The biomass conversion parameters are based on both domestic and IPCC default values. In general the ERT regards these as reasonable. However, the parameters for urban and other land are relatively uncertain and should be improved Canada is also recommended to implement biomass conversion parameters which are more differentiated with regard to age structure and biomes. In this regard Canada should consider the inclusion of a sigmoid growth rate instead of the linear rate currently used.

C. Areas for further improvement

Identified by the Party

167. In the 2003 NIR as well as during the in-country review the ERT was informed that Canada will put significant effort into improving the quality and availability of its land-use change data in the coming years. The planned improvements cover the inclusion of all relevant carbon pools, as well as improvements in the quality of AD and methodologies. Both short-term and long-term improvements were described.

168. Further, Canada anticipated that the IPCC report on Good Practice Guidance and Uncertainty Management for the LULUCF sector will have a significant impact on the planning of inventory enhancements.

Identified by the ERT

169. The ERT has identified the following issues for improvement (which in most cases are part of Canada's own improvement plan). The Party should:

(a) Implement, in accordance with the new good practice guidance on LULUCF adopted by COP9, a more comprehensive approach. This would necessitate inclusion of growth rates differentiated by age classes and biomes;

(b) Include, in accordance with the new good practice guidance on LULUCF, missing pools and emissions, such as forest soil, below-ground biomass, dead organic material above ground, CH_4 and N_2O emissions, drainage of wetland and extraction of peat;

(c) Include informal harvesting of fuel wood outside the managed forest areas;

(d) Improve data for wildfires, including the most recent data;

(e) Document the biomass conversion and biomass expansion factor separately;

(f) Document the methodology used for calculating removals by woodlots located on agricultural lands and urban forests;

(g) Implement biomass conversion parameters for land-use change which are more differentiated with regard to age structure and biomes, and consider inclusion of a sigmoid growth rate;

(h) Increase the transparency of the NIR by including more information on the methodology and data used (which could be Internet-based).

VI. WASTE

A. Sector overview

170. The Waste sector contributed approximately 3.4 per cent of total GHG emissions in 2001. CO_2 equivalent emissions increased by 23.4 per cent between 1990 and 2001. Over the same period population growth in Canada was 12.2 per cent. The sector is dominated by emissions from solid waste disposal on land (93 per cent of the total Waste sector), while waste-water handling (6 per cent) and waste incineration (1 per cent) are considered as non-key sources.

171. Although there was an increase of 33 per cent in the capture and combustion of landfill gases, methane emissions from landfills are estimated to have increased by 24.4 per cent. The per capita GHG emission trend for waste since 1990 increased slowly until 1993 and decreased from 1993 to 1996 as a result of CH_4 capture programmes at landfills. A high increase was noticed from 1996 to 2001. From 1990 to 2001, per capita emissions increased by 10 per cent due to increasing emissions from landfills. Emissions per capita from solid waste disposal (35 kg CH_4/capita) are the second-highest among the reporting Parties. The incineration rate from municipal solid waste (MSW) is low.

Completeness

172. The CRF covers emissions from the following source categories: solid waste disposal on land, waste-water handling, waste incineration and human sewage. Most of the gases from the Waste sector are included as recommended by the IPCC Guidelines. However, CO_2 emissions from decomposition of plastic and other substances containing fossil carbon are not included.

Transparency

173. The methodology is not adequately described in the NIR and the CRF, and hence does not allow independent verification, although the assumptions and methodologies used for estimating emissions are

described and national references are given. However, the information included in the Waste sector CRF is consistent with that provided in the NIR.

174. The first-order decay method (FOD, Scholl Canyon model) with country-specific parameters has been used for estimating CH_4 emissions from solid waste disposal sites (SWDS). Most of the AD, IEFs and additional information are indicated as "NA" and "NE". The ERT recommends that Canada give more comprehensive information on the time series of AD, the composition of waste, EFs and country-specific parameters in future NIRs.

175. The methodologies and EFs given in the CRF and the NIR are comparable to data from other Parties, and are consistent with the IPCC Guidelines and good practice guidance.

176. Except for population and emissions, the AD are reported as "NA" and "NE" in tables 6.A – 6.B – 6.C. The documentation box notes explains this by the fact that these data were not utilized in the national model.

Verification and quality assurance/quality control

177. The Waste section of the NIR provides information on key sources, methods, data sources, uncertainty estimates, QA/QC procedures, verification activities, recalculations and planned improvements. As this presentation follows the outline of the revised UNFCCC reporting guidelines adopted by decision 18/CP.8, no specific additional QA/QC was done and no recalculations were made for the 2003 submission.

Uncertainty estimates

178. According to the NIR, uncertainties in the Waste sector are reported qualitatively in CRF table 7 as well as in the NIR, except for the solid waste disposal category, where the Party refers to a study. The level of uncertainty of the estimates is considered to be high because of the lack of detailed data. The quality of estimates is considered to be low for all sources, except for the key source, for which they are considered to be of medium quality.

Recalculations

179. According to information given in table 8a, estimates in the Waste sector were not recalculated for the 2003 submission. However, it is noted that recalculation occurred every two years according to the data collection period in recovered emissions in landfills. Methane emissions from solid waste disposal on land were recalculated in 1998 and 1999 because population data had been revised and the quantity of methane recovered in 1999 updated. The ERT has not been able to determine whether this recalculation was made in a time-consistent manner.

B. Key sources

Solid waste disposal on land – CH_4

180. The only key source in the Waste sector is solid waste disposal from managed waste disposal on land, comprising MSW landfills and wood waste landfills. The main parameters used in the FOD model to estimate CH_4 emissions are partially described in the NIR

181. Historical data (1941–1989) on landfilled MSW have been estimated but not presented in the NIR. AD are not provided in the CRF tables nor the NIR due to the use of the model.

182. According to the CRF, data on the waste generation rate is decreasing year by year: it has fallen from 1.98 kg/capita/day in 1998 to 1.97 in 1999 and 1.93 in 2000, even though emissions are increasing. These levels are high compared to the IPCC Guidelines. Insofar as Canada indicates that these data are country-specific, they need to be assessed.

183. The notation key "NO" used for managed waste disposal on land – CO_2 (table 6) should be replaced by "NE" because of the presence of plastics in the solid waste. This issue should be investigated further.

184. Landfill gas recovered for energy purposes was reported in the Waste sector instead of the Energy sector.

185. Although the FOD model has been provided, the ERT recommends that Canada present and briefly elaborate on all parameters used in the FOD, particularly historical data on estimated quantities of MSW landfilled, waste composition and methane generation potential over time. All EFs that are different from the IPCC Guidelines should be justified. Additional information should be provided in CRF table 6.A.

C. Non-key sources

Waste-water handling – CH_4 and N_2O

186. Estimates of CH_4 and N_2O are related to municipal waste-water treatment and human sewage from domestic and commercial waste water. Because the data were not available, a country-specific method has been used for the CH_4 estimates for municipal waste-water treatment. N_2O from human sewage was estimated using the IPCC default method (IPCC 1997).

187. In table 6.B of CRF, except for population, the AD and other information were not provided and were considered as "NA". According to the presentation made during the in-country visit, these data are available, and they should be provided in CRF table 6.B to increase transparency (protein consumption, N fraction).

188. Industrial waste-water handling emissions were not estimated because of lack of data. The ERT recommends that more consideration should be given to Canada's industrial waste-water treatment estimates.

Waste incineration – CO_2

189. Estimates are based on CO_2 emissions from MSW incineration (fossil fuel-based carbon waste such as plastics and rubber) and CH_4 from sewage sludge incineration. For the estimates, detailed provincial MWS incineration data for 1992 have been used. The ERT recommends that the provincial MSW data for 1992 be updated. Additional information should be provided in CRF table 6.C.

190. Emissions from incineration are reported in the Waste sector despite the fact that energy is utilized in almost all waste incineration plants in Canada. The ERT recommends that emissions from waste incineration be reported in the Energy sector when energy is recovered and that emissions from waste incineration be cross-checked by using the methodology described in the IPCC good practice guidance.

D. Areas for further improvement

Identified by the Party

191. Canada has undertaken some current improvement activities related to the MSW landfill first-order decay model, for instance, regarding methane generation rate constants, methane generation potential, waste composition, historical CH_4 estimates, revision of waste incineration emission, estimation to account for energy recovery, and cross-checking of emissions from waste incineration using GPG methods.

192. Other additional areas are being considering by the Party, such as a review of other MSW landfill models, the updating of information on waste wood disposal, and a review of emission estimations for waste incineration and waste-water models.

Identified by ERT

193. In addition to these current and future improvements, the ERT recommends that Canada pay attention to:

(a) Improving transparency in reporting AD, relevant parameters, EFs and other information in the NIR and the CRF;

(b) Updating its provincial MSW data;

(c) Revising its waste incineration emissions and its landfill gas accounting for energy purposes;

(d) Estimating industrial waste-water handling emissions.

ANNEX 1: MATERIALS USED DURING THE REVIEW

A. Support materials used during the review

2002 and 2003 Inventory submissions of Canada. 2003 submissions including CRF for years 1990–2001 and an NIR.

UNFCCC secretariat (2003). "Report of the individual review of the greenhouse gas inventory of Canada submitted in the year 2002 (Centralized review)". FCCC/WEB/IRI(3)/2002/CAN (available at http://unfccc.int/program/mis/ghg/countrep/cancentrev02.pdf).

UNFCCC secretariat. "2003 Status report for Canada" (available at http://unfccc.int/program/mis/ghg/statrep02/can02.pdf).

UNFCCC secretariat. "Synthesis and assessment report of the greenhouse gas inventories submitted in 2003. Part I." FCCC/WEB/SAI/2003 (available at http://unfccc.int/program/mis/ghg/s_a2003.html) and Part II – the section on Canada) (unpublished).

Canada's comments on the draft "Synthesis and assessment report of the greenhouse gas inventories submitted in 2003" (unpublished).

UNFCCC secretariat. "Handbook for review of national GHG inventories." Draft 2003 (unpublished).

UNFCCC secretariat. "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/CP/1999/7 (available at http://www.unfccc.int/resource/docs/cop5/07.pdf).

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

UNFCCC secretariat. Database search tool – *Locator* (unpublished).

IPCC. *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, 2000* (available at http://www.ipcc-nggip.iges.or.jp/public/gp/gpgaum.htm).

IPCC/OECD/IEA. *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, volumes 1–3, 1997* (available at http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm).

B. Additional materials

CCME, "Solid waste: 23 per cent national reduction in solid waste from 1988 to 1994–98" (available at http://www. Mbnet.mb.ca/solid_waste.html)

Environment Canada 1996. *An Assessment of the Physical, Economic and Energy Dimensions of Solid Waste Management in Canada*. Volume I, PPEDDE, March 1996

Environment Canada 1998, *Fossil Fuel and Derivative, CO_2 per Unit of Fuel, Heating Values, Factors*. Prepared for the Pollution Data Branch, Environment Canada, by T. J. McCann and Associates Ltd. and Clearstone Engineering Ltd., edition March 2000

Environment Canada 1999. *Inventory of Landfill Gas Recovery and Utilization in Canada*, PPERDDE

Environment Canada 2001. *Inventory of Landfill Gas Recovery and Utilization in Canada*, PPERDDE

Environment Canada 2003. *Instruction Manual for the Preparation of Canada's Greenhouse Gas Inventory for the Land Use Change and Forestry Sector* (draft)

Gray, Stephen L. and Power, Katja 1997. *Canada's Forest Inventory 1991: the 1994 version – Technical Supplement.* Pacific Forestry Centre. Canadian Forest Service. Victoria, British Columbia. Info Report BC-X-363

Jaques, A. P. 1992. *Canada's GHG Emissions: Estimates for 1990.* Report EPS 5/AP.4, December

McCann T. J. 1994. *Uncertainties in Canada's 1990 Greenhouse Gas Emission Estimates: A Quantitative Assessment*, Prepared for Environment Canada by T. J. McCann and Associates, March.

Quarterly Report on Energy Supply/Demand in Canada, 2001 – IV

M-Landfill Corel Quatro Pro 8 Notebook

Waste 01 Corel Quatro Pro 8 Notebook

- - - - -