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REPORT OF THE INDIVIDUAL REVIEW OF THE GREENHOUSE GAS INVENTORY OF CANADA SUBMITTED IN THE YEAR 2002[1]

Centralized review

I. OVERVIEW

A. Introduction

1. The Conference of the Parties (COP), by its decisions 6/CP.5 and 34/CP.7, requested the secretariat to conduct individual reviews of greenhouse gas (GHG) inventories submitted by Parties included in Annex I to the Convention (Annex I Parties) according to the "UNFCCC guidelines for the technical review of GHG inventories from Annex I Parties", hereinafter referred to as the UNFCCC review guidelines.[2] The principal objectives[3] of the review of the GHG inventories are to ensure that the COP has adequate information on GHG inventories and GHG emission trends, and to examine the information submitted by Annex I Parties in accordance with the UNFCCC reporting guidelines[4] for consistency with those guidelines.

2. The centralized review of Canada took place from 9 to 13 September 2002. It was carried out by a team of nominated experts from the roster of experts, working at the headquarters of the UNFCCC secretariat in Bonn. The assignments of the experts were as follows: generalists – Mr. Bernd Gugele (European Community) and Mr. Marius Taranu (Republic of Moldova); energy – Mr. Lambert Schneider (Germany) and Mr. Mohammad Soltanieh (Iran); industrial processes – Ms. Deborah Shafer (USA) and Mr. Mauro Meirelles de Oliveira Santos (Brazil); agriculture – Ms. Anna Romanovskaya (Russian Federation) and Mr. Tomoyuki Aizawa (Japan); land-use change and forestry (LUCF) – Mr. Aquiles Neuenschwander (Chile) and Mr. Daniel Martino (Uruguay); waste – Mr. Davor Vešligaj (Croatia) and Mr. Jens E. Frøiland Jensen (Norway). Mr. Jens E. Frøiland Jensen and Mr. Marius Taranu were the lead reviewers for this centralized review. The review was coordinated by Ms. Astrid Olsson and Ms. Sevdalina Todorova-Brankova (UNFCCC secretariat).

3. In accordance with the UNFCCC review guidelines, a draft version of this report was communicated to the Government of Canada, which provided comments that were considered and incorporated, as appropriate, in the final version of this report.

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[1] In the symbol for this document, 2002 refers to the year in which the inventory was submitted, and not to the year of publication. The number (3) indicates that this is a centralized review report.

[2] For the UNFCCC review guidelines and decision 6/CP.5 see document FCCC/CP/1999/7, pages 109 to 114 and 121 to 122, respectively.

[3] For the objectives of the review of GHG inventories see document FCCC/CP/1999/7, page 109, paragraph 2.

[4] The guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual inventories (FCCC/P/1999/7), are referred to in this report as the UNFCCC reporting guidelines.

B. Inventory submission and other sources of information

4. In its 2002 submission, Canada submitted common reporting format (CRF) tables for the years 1990–2000. Canada submitted a national inventory report (NIR) in 2002 providing information on methodologies, activity data and emission factors for each sector, as well as information on recalculations, emission trends, verification and quality control and assurance, the reference approach, the key source analysis and uncertainty estimates. The submission was received in the secretariat on 15 April 2002.

5. The 2002 status report and the draft 2002 synthesis and assessment (S&A) report, together with the previous status reports and S&A reports and the report of the centralized review of Canada's 2000 GHG inventory,[5] were made available to the review team. The country provided additional information and clarification during the review upon request from experts. The Party's responses are taken into consideration in this report. The full list of materials used during the review is provided in annex I to this report.

C. Emission profile, trends and key sources

6. In the year 2000, the most important GHG in Canada was carbon dioxide (CO_2), which in 2000 accounted for 78.7 per cent of total[6] national GHG emissions expressed in CO_2 equivalent, followed by methane (CH_4), 12.6 per cent and nitrous oxide (N_2O), 7.4 per cent. Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6) contributed 1.3 per cent of the overall GHG emissions in the country. By source, energy accounts for 80.9 per cent of the total emissions, agriculture 8.3 per cent, industrial processes 7.0 per cent, waste 3.3 per cent, and solvent and other product use 0.1 per cent.

7. Over the period 1990–2000, CO_2 emissions without LUCF increased by 21 per cent, because of the growth of emissions from energy industries (+33 per cent) and transport (+24 per cent). CH_4 emissions increased by 25 per cent between 1990 and 2000, mainly because of the growth of fugitive emissions from oil and natural gas (+46 per cent) and solid waste disposal on land (+22 per cent). N_2O emissions show almost the same level in 2000 as in 1990 (+1 per cent). Large emission decreases from chemical industry (–85 per cent) were offset by emission increases from agricultural soils (+23 per cent) and from transport (+43 per cent). HFCs[7] experienced significant growth from 1995 onwards (+91 per cent), PFCs showed almost the same level in 2000 as in 1990 (+3 per cent) and SF_6 in 2000 showed a decrease of 19 per cent in comparison with the 1990 level. Total GHG emissions (without CO_2 from LUCF) increased by 20 per cent between 1990 and 2000.

8. Canada used the IPCC tier 1 approach to identify its key sources using level and trend assessment as well as a qualitative approach in determining its key sources as part of its 2002 submission. It is noted that some minor differences were found, for both level and trend assessment, between the key source analysis provided by Canada and the independent preliminary key source analysis[8] of the secretariat. The reasons for the differences may be that Canada used a more detailed category split, but no fuel split. The key source analysis can be improved by providing the quantitative estimates in the NIR. In addition, the

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[5] See document FCCC/WEB/IRI(3)/2000/CAN.

[6] Total national GHG emissions refer to aggregate emissions of CO_2, CH_4, N_2O, PFCs, HFCs and SF_6, all expressed in terms of CO_2 equivalent, excluding CO_2 emissions/removals from LUCF.

[7] According to the NIR, HFCs were not used to any significant degree in Canada before 1995.

[8] The UNFCCC 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. They may differ from the key sources identified by the Party itself.

expert review team (ERT) recommends elaborating conclusions from the key source analysis as regards future improvements to the inventory.

D. General assessment of inventory

9. The national inventory submitted by Canada is generally in conformity with the UNFCCC reporting guidelines. The methodology used to estimate the GHG emissions is consistent with the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, hereinafter referred to as the IPCC Guidelines and the *IPCC good practice guidance and Uncertainty Management in National Greenhouse Gas Inventories*, hereinafter referred to as the IPCC good practice guidance. Areas for further improvement are identified for the general aspects of the inventory in paragraphs 16 and 17 below and in the sector sections for the sector-specific aspects.

1. Completeness

10. Canada submitted inventory data for the years 1990–2000 using the CRF of the UNFCCC reporting guidelines. The CRF was accompanied by the NIR. The CRF was found to be almost complete and included all tables requested. Notation keys were used appropriately in almost all the tables (except for the notation key not applicable (NA), which in many cases seems to be used to mean 'not available' instead of 'not applicable'). Data were provided for the whole time series (1990–2000) for CO_2, CH_4, N_2O, HFCs, PFCs and SF_6. Data availability on nitrogen oxide, non-methane volatile organic compound (NMVOC), carbon monoxide and sulphur dioxide is very limited. Gaps were found in activity data for HFCs, PFCs and SF_6 (F-gases) (table 2(II)).

2. Transparency

11. The NIR for Canada is very well documented and referenced. Methods and emission factors are generally described and models are discussed in detail, frequently with data on the specific parameter values provided. For LUCF and other categories where country-specific methods and practices are used, additional detailed documentation may improve transparency.

3. Recalculations

12. Canada provided major recalculations for 1998 and 1999 (a few minor changes or regroupings within sectors were also made for some other years). Tables 8(a) and 8(b) are provided for all years and some explanatory information is given in the NIR. The Party did not revise its 1990 total emission estimates, but recalculated its 1999 emissions (+2.10 per cent with LUCF and +0.67 per cent without LUCF). The main sectors for which recalculations were made were LUCF, industrial processes and energy; in 1999 the main gases were CO_2 (+2.66 per cent), CH_4 (+0.26 per cent) and N_2O (0.03 per cent); F-gases were not recalculated. The main reasons for recalculations were:

(a) Updates of fire data and of data for the production of and trade in wood commodities;

(b) Reallocation of CO_2 emissions from "other industrial processes" to chemical industry (ammonia production);

(c) Updating of fuel use data.

4. Uncertainties

13. Uncertainties associated with emissions and removal estimates were mentioned in the NIR with regard to a 1994 uncertainty analysis, conducted on the basis of 1990 inventory data, which used Monte Carlo simulations to determine source category uncertainty. Uncertainties are estimated to be about 4 per cent (CO_2), 30 per cent (CH_4) and 40 per cent (N_2O). A more recent uncertainty analysis of the inventory was not available, but in CRF table 7 quality estimate indicators for GHG source and sink categories were reported. The ERT supports Canada's plan to carry out further uncertainty studies in the near future. The NIR describes the use of a rounding protocol to approximate the level of uncertainty associated with each source category. The ERT recommends improving the transparency of the use of the rounding protocol.

5. Quality assurance/quality control

14. It was noted that Canada has begun scoping out its quality assurance/quality control **(**QA/QC) plan as required by the IPCC good practice guidance. This exercise has resulted in priority setting for improvements to the QA/QC performed on the national GHG inventory. Hitherto, the reference approach and expert review, a formal review process with industry, academia and government (both provincial and federal), have been used as the primary means of ensuring the quality of the inventory (appendix B of the NIR provides a description of the QA/QC and verification procedures used in the preparation of the GHG inventory). The activity data used in the GHG inventory are generally from published sources.

6. Issues relating to previous reviews

15. Canada addressed some of the issues and problems identified during previous reviews (e.g., an explanation was provided on the deviation in CO_2 emissions estimated with the reference and sectoral approach; for categories where country-specific methods and practices were used, some additional documentation was provided in the NIR). Some of the problems identified were not addressed. These concerned:

(a) The low implied emission factor (IEF) values calculated for gaseous fuels for stationary combustion sources;

(b) The use of gross calorific value (GCV) and the effect on the IEFs;

(c) The discrepancies between the reference approach energy data and International Energy Agency (IEA) energy data.

Fugitive emissions from oil refineries for the subcategory "Refining and storage" were not estimated, although Canada has large refinery throughput.

7. Areas for further improvement

16. Canada has noted the following areas for further improvement:

(a) Bringing the Canadian inventory more into line with IPCC good practice guidance; the priority areas have been identified as: improved documentation and archiving; the development of a QA/QC manual; a new uncertainty analysis with new QC procedures; and the development of tier 2 QC procedures for key sources;

(b) Canada intends to develop a method to estimate country-specific emission factors for crude oil, natural gas and coal to be used specifically in the reference approach, as the default IPCC factors do not provide the accuracy required.

17. The ERT recommends that in future inventories Canada should:

(a) Explain in the NIR the causes of the large annual and periodic fluctuations in both the GHGs (e.g., for F-gases and CO_2 emissions from LUCF sector) and IEF values calculated for fuels used at the stationary combustion sources;

(b) Explain the discrepancies found between international data concerning apparent consumption and the data provided using the Canadian reference approach;

(c) Improve the key source analysis by providing quantitative estimates;

(d) Elaborate conclusions and future improvements based on the findings of the key source analysis.

II. ENERGY

A. Sector overview

18. In 2000, the energy sector accounted for 80.9 per cent of total greenhouse gas emissions in Canada (without LUCF). In 2000, GHG emissions in the energy sector were 24.3 per cent above the 1990 level. With 90.8 per cent of emissions in the energy sector, fuel combustion is the main source, but fugitive emissions are also relatively important (9.2 per cent) as a result of significant mining and oil and gas exploration activities. Emissions from public electricity and heat production and from road transportation are by far the largest sources within the energy sector (both about 24 per cent).

19. The CRF tables in the energy sector are largely complete. In some cases, notation keys have not been used, for example for fuel combustion of biomass and other fuels (table 1.A(a)) and for some international bunker fuels (table 1.C). The NIR provides comprehensive and transparent information on methodologies, underlying assumptions, emission factors and emission trends. The use of emission factors is well explained in an appendix to the NIR and references to relevant literature are provided. The ERT also welcomes Canada's providing information on deficiencies, missing data and the allocation of emissions in IPCC categories in the NIR in a transparent manner.

20. In the energy sector, emissions for the year 1999 have been recalculated as energy statistics have been updated, resulting in 0.72 per cent higher emissions in the sector in 1999 compared with the previous submission. There are also some smaller recalculations for other years than 1999, which are reported in the CRF table 8(a) but not mentioned in the NIR, for example in the energy industries sector in 1994. In its final 2001 submission, Canada also recalculated for other years than 1999 some activity data in the Manufacturing Industries and Combustion sector, which was not done in the initial 2001 submission. However, only activity data were recalculated and emissions are not affected. As a consequence of this correction, the time series for most implied emission factors are more consistent. The ERT encourages Canada also to report in its NIR information on the recalculation of activity data and on minor changes in emissions.

B. Key sources

1. Stationary combustion

21. CO_2 emissions from combustion of solid fuels for public electricity and heat production together with road transport are the largest key source in the Canadian inventory, contributing about 14 per cent to overall Canadian greenhouse gas emissions. Canada explains in its NIR that quality and supply of coal vary over time. CO_2 emission factors for the period 1990–1994 are based on a fuel analysis from 1988, while those for the period 1995–2000 are based on a fuel analysis performed in 1998. The result is that emission factors vary significantly between these two analyses (e.g., the emission factor for

sub-bituminous coal in the Ontario region is 31 per cent lower during 1995–2000 than during 1990–1994). Since uncertainty CO_2 emission factors from coal combustion influences the whole GHG inventory significantly, the ERT recommends that Canada consider the possibility of basing CO_2 emission factors for coal combustion on more frequent fuel analyses.

22. The time series for some CO_2 implied emission factors appear to be inconsistent. In the subcategory 1.A.1.c (Manufacture of solid fuels and other energy industries) the CO_2 IEF for solid fuels amounts to 56 t/TJ during 1990–1994, to 68 t/TJ during 1995–1997 and to 79 t/TJ during 1998–2000. The CO_2 IEF for liquid fuels in the subcategory 1.A.2.c (Chemicals) in 1990 is significantly lower (50 t/TJ) than in all other reported years (74–77 t/TJ). In the subcategory 1.A.2.b (Non-ferrous metals) it is higher in 1998 (85 t/TJ) than in all other reported years (76–78 t/TJ), and in the subcategory 1.A.2.a (Iron and steal) in it is lower 1998 (63 t/TJ) than in all other reported years (73–77 t/TJ). In the subcategory 1.A.2.d (Pulp, paper and print), the CO_2 IEF for solid fuels is significantly higher in 1998 (122 t/TJ) than in all other reported years (86–90 t/TJ). The ERT recommends that these inconsistencies be checked and data recalculated where necessary.

2. Mobile combustion

23. To estimate emissions from transport, Canada uses a comprehensive model (M–GEM), which was updated in 2001. Emission factors and fleet data are taken from various sources. CO_2 emission factors for liquid fuels are based on a publication from 1992 and reported to be constant over the whole time series for each fuel type. Since CO_2 emissions from transport are a very large source in Canada's GHG inventory, and since the average quality of fuel may change over time (although this can be assumed to be less significant for liquid fuels than for solid fuels), the ERT encourages Canada to verify CO_2 emission factors for liquid fuels through additional measurements and calculations.

24. The time series for CO_2 implied emission factors for liquid fuels shows unsteadiness between 1997 and 1998 in most transport subcategories. For example, in the overall transport category 1.A.3, the CO_2 IEF for gasoline amounts to 68.3 t/TJ during 1990–1997 and to 67.5 t/TJ during 1998–2000, the CO_2 IEF for diesel amounts to 70.5 during 1990–1997 and to 71.0 during 1998–2000. The ERT recommends that these inconsistencies be checked and data recalculated where necessary.

3. Fugitive emissions

25. Canada recognizes in its NIR that emissions from flaring and venting of waste gases during refining have not been estimated because of lack of data. Also, emissions from the distribution of oil products are not estimated. The ERT encourages Canada to develop methodologies to estimate these emissions.

C. Non-key sources

1. Stationary combustion

26. Canada provides in its NIR (Appendix D, table D-4) CH_4 and N_2O emission factors for fuel combustion of solid fuels, as well as for liquid and gaseous fuels in a transparent manner. Implied emission factors of methane and nitrous oxide appear to have the same ratio in all years, while the values vary from year to year with overall variations of about 5 per cent. The ERT encourages Canada to provide explanations for the underlying variations for solid fuels in future NIRs.

2. Mobile combustion

27. In the road transportation category, the CH_4 IEF for gasoline is relatively low compared with that reported by other Parties and decreased significantly between 1990 and 2000. In its response to this draft report Canada states that the gasoline CH_4 emission factor (EF) has remained unchanged throughout the

period mentioned. The decrease in the CH_4 IEF is due to the effect that the changing fleet composition has. Newer vehicles with lower emission rates represent an increasing percentage of the overall fleet, and thus the overall emission per unit of activity (fuel consumed) should be declining. In contrast, the CH_4 IEF for natural gas is relatively high compared with that reported by other Parties. The ERT recommends that the appropriateness of CH_4 emission factors for gasoline and natural gas be checked.

D. Reference and sectoral approaches

28. CO_2 emissions from fuel combustion were calculated using the reference and the sectoral approaches. The difference between the two approaches amounts to 7.5–11.3 per cent for the years reported. The explanation provided by Canada for this relatively large difference is that several CO_2 emissions from industrial processes are not included in the sectoral approach. If CO_2 emissions from ammonia production, iron and steel production, aluminium production and the category "other" are added to the national approach, the difference is reduced from 7.5 to 1.4 per cent in 2000 (where the difference was lowest) and from 11.3 to 4.6 per cent in 1991 (where the difference was largest). However, no specific information is provided on the calculation of emissions from "other industrial processes". Canada explains the remaining difference mainly by the relatively inaccurate default emission factors applied in the reference approach. As suggested by Canada in the NIR, the ERT recommends, where possible, developing country-specific emission factors for the most important fuels (crude oil, natural gas etc.).

29. There are several discrepancies between the apparent fuel consumption reported to the IEA and that reported in the CRF. Data reported in the CRF for the year 2000 are 8.1 per cent higher for liquid fuels, 2.2 per cent lower for solid fuels and 3.2 per cent higher for natural gas compared with data reported to the IEA. Large differences can be noted in particular the cases of primary fuels, residual fuel oil, naphtha and refinery feedstocks. In its response to this draft report Canada states that at the moment the Party has had difficulty reviewing the discrepancies with IEA data because it is unclear specifically what IEA data is being used in the analyses and what methodology was used to equate the units of the data for comparison. However, the ERT encourages Canada to check the discrepancies and improve the consistency of data reported to the IEA and in the CRF.

E. Bunker fuels

30. According to the NIR, fuels sold to foreign-registered marine or aviation carriers are considered as international bunker fuels and separated from national fuels in the GHG inventory. This methodological approach to separating national emissions from international emissions from combustion of marine and aviation fuels is not in accordance with IPCC Guidelines and Canada recognises in its NIR that emissions are not allocated appropriately. The ERT recommends Canada to develop methodologies consistent with IPCC Guidelines to separate emissions from international bunker fuels.

31. Canada reports the consumption of gas/diesel oil and residual fuel oil as international bunkers in table 1.C, but not in table 1.A(b) in the reference approach. Canada recognizes this omission in its response to the draft 2002 S&A report and will correct this in future submissions.

F. Feedstocks and non-energy use of fuels

32. Canada estimates feedstocks and non-energy use of fuels. The specific methodologies (IPCC tier 1 default) and assumptions used in estimating carbon stored in products are documented in the NIR.

III. INDUSTRIAL PROCESSES AND SOLVENTS USE

A. Sector overview

33. In 2000, industrial processes emissions accounted for 7.0 per cent of the total CO_2 equivalent emissions (without LUCF), 8.7 per cent less than in 1990. Emissions of CO_2 represented 78.3 per cent of

the emissions in industrial processes in 2000, with metal production being responsible for 31.0 per cent (cement production 15.7 per cent). In the period 1990–2000, there was a decrease of industrial processes emissions of 3.4 per cent, mainly due to the decrease by 85.2 per cent in N_2O emissions in the period as a result of the installation of an emission abatement technology at the sole adipic acid plant in 1997, balanced by an increase of 22.9 per cent of the CO_2 emissions basically caused by increases in Other (non-energy uses of primary and secondary energy, and in ammonia, aluminium and iron production).

B. Key sources

1. Ammonia production – CO_2

34. The IEF varies over the period 1990–2000 and is lower than the IPCC default. In its response to this draft report Canada explained that it is due to the fact that some of the hydrogen produced for ammonia production originates from other chemical process by-products; there is no CO_2 generated for ammonia produced using this by-product hydrogen; a constant value of 500 kt of NH_3 produced from by-product hydrogen is subtracted from the total national NH_3 production value for each year prior to the application of the EF; if this 500 kt correction were not applied in the emission calculations there would be no fluctuation in the IEF and the IEF would be similar to the IPCC default factor. However, the ERT recommends the Party to provide in the NIR detailed information on the methodology used to estimate the emissions in order to clarify why the emission factor is changing over the time period in a transparent manner.

2. Adipic acid production – N_2O

35. Canada reports that emission estimates from 1997 and onwards are based on the producers' monitoring data. For the years 1990–1996 emission estimates were based on production data multiplied by an emission factor. The ERT recommends Canada to include more information regarding the installation of emission abatement technology as the emissions have decreased by 92 per cent from 1990 to 2000. The ERT also recommends Canada to show that the time series is consistent. Canada is encouraged to report the activity data.

3. Iron and steel production – CO_2

36. Canada reports only activity data for secondary coal consumption. The ERT recommends Canada to provide activity data and emissions for the other sub-sources in the iron and steel source category. Canada in its response to this draft report states that activity data for pig iron and steel production are available and will be included in future inventories.

4. Aluminium production – PFCs

37. Canada does not clarify whether its estimates of PFC emissions from aluminium smelting are based on:

(a) Production data and default emission factors;

(b) Production data, the frequency and duration of anode effects, and default slope factors; or

(c) Production, the frequency and duration of anode effects, and smelter-specific slope factors.

The ERT recommends Canada to explain its methodology and the reason why PFC emissions have declined over the past 10 years. The trend is probably correct; it is consistent with a worldwide trend toward reduced anode effect frequency and duration. In its response to this draft report Canada states that PFC emissions from aluminium production are estimated using production data and average emission rates for the varying smelting technologies. A recent study of PFC emissions from Canadian Aluminium

producers concluded that "Canadian (Aluminium) plants today are collectively controlling their anode effects more effectively and generating fewer perfluorocarbons than in 1993".

5. SF_6 used in magnesium foundries

38. Although Canada states in its NIR that emissions from "aluminium and magnesium foundries are not estimated", values appear in the CRF for the entire time series. In response to a request from the ERT, the Party clarified that these values apply to the primary production (smelting) of magnesium rather than casting. The ERT recommends that Canada clarify this in future NIRs by rewording the above statement to read "SF_6 emissions from aluminium production and magnesium casting are not estimated". In addition, the ERT recommends that Canada investigate emissions from casting. Magnesium casting is a fast-growing source of SF_6 in many countries and may be significant in Canada as well. The Party does not specify the method used to estimate SF_6 emissions from magnesium production and processing. In the sectoral background table 2(II)C, E, Canada states that its activity data are "point source SF_6 data", but does not supply these data. The ERT recommends the Party to explain its estimation method more clearly in both the NIR and the CRF.

6. Other industrial processes

39. CO_2 emissions from other and undifferentiated production were reported under "Other" but the specific sources were not further specified. Non-energy use of primary and secondary energy was reported for the activity data description, but no values were reported. The NIR provides discussion of the methodology used and general references to activity data sources. The ERT recommends that the information under 2.G (Other) be specified, for instance, the use of natural gas to produce hydrogen in the oil upgrading and refining industries, the use of petroleum coke for anodes in metal production, the use of natural gas liquids (NGLs) and feedstocks in the chemical industry, and the use of lubricants, as stated in the NIR.

C. Non-key sources

1. Limestone and dolomite use

40. The same activity data are reported for the years 1995 and 1996 (634 kt), and 1999 and 2000 (1,533 kt). Canada reports using the IPCC default emission factor but the emission factor in the CRF is 3 per cent higher (submission 2002 for 2000 and 1999) and the emission factor has varied over the years. The ERT recommends that Canada explain these matters in future inventories.

2. Consumption of halocarbons and SF_6, HFCs and PFCs

41. Although this is not classified as a key source category, the ERT believes that this is probably because Canada has underestimated emissions from it in recent years. First, in the absence of activity data from any year since 1998, the Party assumes that its HFC and PFC emissions from air conditioning and refrigeration equipment have remained constant since 1998. In reality, HFC and PFC emissions from this source are likely to have grown considerably as HFCs and PFCs have replaced the chlorofluorocarbons and hydrochlorofluorocarbons being phased out under the Montreal Protocol. HFC growth for other countries between 1998 and 2000 ranged from 20 per cent to 224 per cent, with an average growth of 76 per cent. Perhaps because it has not accounted for growth, Canada's 2000 per capita HFC emissions from air conditioning and refrigeration equipment are the lowest of any country undergoing this centralized review, despite the similarity of Canada's climate to those of the other countries reviewed (e.g., Sweden, Finland and Denmark). In view of these considerations, the ERT recommends that Canada find a way to account for growth (perhaps by applying the growth rate from 1995–1998 to generate the 1999–2000 time series) rather than assuming that emissions are constant. These comments and recommendations also apply to Canada's estimates of PFC emissions from

semiconductor manufacturing. In its response to this draft report Canada states that it will consider these emissions in its next inventory.

42. It was also noted that emission estimates from some sources are missing. Canada does not estimate emissions of SF_6 from electrical equipment, although they are likely to occur. Electrical equipment is the largest source of SF_6 emissions in the world, and the USA (whose electrical grid is presumably similar to Canada's) reports large emissions from it (14,400 Gg CO_2 equivalent). Although Canada, commendably, does present estimates of PFC emissions from electrical equipment, these are likely to be considerably smaller than the SF_6 emissions from the same source. Moreover, HFC emissions from fire extinguishers are shown in the CRF for the period 1995–1997, but not for later years. In response to a question from the ERT, Canada stated that its HFC survey indicated that there was no usage of HFCs in fire extinguishers in 1998. However, it seems more likely that 1998 was an unusual year than that usage of HFCs in this application came to a permanent halt. The ERT recommends that Party investigate these sources and, if possible, develop or revise emission estimates for them.

43. Canada's explanation of its emissions from consumption of halocarbons and SF_6 is fairly clear but could be made more transparent with the addition of estimates of new and total existing stocks (or other relevant activity data), both in the CRF background tables and in the NIR (perhaps as an appendix). Canada presents emission factors for ozone depleting substances (ODS) substitutes in appendix D under "Solvent and other product use" instead of under "Industrial processes". These emission factors (in table D–8) appear to be related to consumption rather than stock; while the emission factors in appendix A are related to stock. The ERT recommends that Canada move the emission factors in table D–8 to the "Industrial processes" section and that it clarify how and for what years both sets of emission factors are used.

44. The ratio of potential to actual emissions in 2000 for some HFCs and PFCs was less than 1: HFC–125 (0.3), HFC–152a (0.6), HFC–143a (0.4) and C_6F_{14} (0.9). The ERT recommends that Canada explain this atypical pattern. Canada, in its response to this draft report, stated that improvements to HFCs/PFCs emissions are ongoing. The atypical pattern mentioned in the paragraph will be further investigated.

D. Solvent and other product use

45. Emission estimates for CO_2 and N_2O are estimated as NA from 3.A Paint application and 3.B Degreasing and dry cleaning. The Party confirmed that these emissions have not been estimated, and "not estimated" (NE) should have been used for these gases. The ERT recommends that Canada try to estimate these emissions in future submissions.

IV. AGRICULTURE

A. Sector overview

46. The agriculture sector accounted for 8.3 per cent of total national GHG emissions in 2000, reaching 60,495 Gg equivalent. Over the period 1990–2000, emissions increased by 2.7 per cent. Consistent time series from 1990 to 2000 are reported. Canada reported GHG emissions using relevant tables (4.A, 4.B(a), 4.B(b) and 4.D). The category 4.E. Prescribed burning of savannas was reported as not occurring (NO). The emissions from 4.C. Rice cultivation and 4.F. Field burning of agricultural residues were assumed as negligible in the NIR, but reported as NO in the CRF. The ERT recommends Canada to indicate clearly if these sources are NO or very small. In the latter case the notation key NE[9] should be used. The NIR provides information on methodologies used, activity data and references for every source. The CRF includes information in footnotes and additional information boxes. The activity

[9] The revised reporting guidelines adopted by decision 18/CP.8 state that even if emission estimates are considered to be negligible, Parties should either report the emission estimate if calculated or use the notation key NE.

data are based on information from Statistics Canada. The methodology used is the IPCC Guidelines (tier 1), except for CO_2 emissions where a country-specific method was used. The CRF (table Summary 3) and the NIR state default emission factors, while Canada provided information on country-specific emission factors (EFs) used for enteric fermentation (CH_4 emissions) and manure management (N_2O emissions) sources (in its response to the 2000, 2001 and draft 2002 S&A reports). The ERT recommends Canada to include information on the emission factors used and how they are derived in future NIRs and the relevant CRF tables. No quantitative uncertainty estimates according to IPCC good practice guidance were provided for the agricultural sector. Qualitative uncertainty estimates were included in table 7. No QA/QC check according to the IPCC good practice guidance is performed for this sector. The Party may wish to develop country-specific emission factors for key source categories and implement tier 2 in accordance with the IPCC good practice guidance. In its response to this draft report Canada confirmed that the source categories Rice cultivation and Field burning of agricultural residues are negligible and that the notation key NE will be used in future CRFs. Canada further states that it generally followed the IPCC tier 1 methodology for estimating emissions from enteric fermentation, emission factors for a few cattle categories are country-specific. These emission factors are supposed to be generated following the IPCC tier 2 methodology, but the specific data that are required for adopting the tier 2 methodology are less certain. Nevertheless, Canada is working on adopting the IPCC tier 2 methodology for enteric fermentation. It is expected this process will take up to two years. Canada is also working on quantitative uncertainty estimates according to the IPCC good practice guidance for the agricultural sector. Canada is in the process of adopting the IPCC tier 2 methodology for enteric fermentation and manure management. Again, Canada hopes these higher tiered methodologies in accordance with the IPCC good practice guidance will be implemented within two years.

B. Key sources

1. Enteric fermentation – CH_4

47. The draft 2002 S&A report noted some differences between the livestock data reported in the CRF and the Food and Agriculture Organization (FAO) data. In its response to the draft 2002 S&A report, Canada states that for the CRF annual average census data are used, while data cited from FAO are probably based on census data collected in January. Annual fluctuations of sheep and goat populations were noted in the draft 2002 S&A report. Canada provided information, in its response to the draft 2002 S&A report, that some large changes are attributed to problems with allocation and separate reporting of data for goats and sheep for certain years. The country will attempt to resolve this problem in the 2003 submission. The draft 2002 S&A report noted large annual fluctuations of the horse population in 1995–1996. In its response to this draft report Canada explained that for horses, population data are collected once in five years, and reported in the general census (in Canada, the census years are 1991, 1996 and 2001); thus, large annual fluctuations of the horse population between 1995 and 1996 merely reflect the two census periods. The CRF (table Summary 3) and the NIR (p. 92) state default emission factors for estimation of CH_4 emissions, while Canada, in its responses to the 2001 S&A report and the draft 2002 S&A report, provided information on country-specific EFs for bulls, beef cows, dairy cows, dairy heifers and beef heifers. In addition, Canada reported that a non-dairy emission factor was applied for dairy heifers (response to the draft 2002 S&A report). The ERT recommends Canada to include information on the emission factors used and how they are derived in future NIRs. Canada is encouraged to correctly report methodologies and emission factors used in the relevant CRF tables.

2. Manure management – CH_4

48. The information on animal waste management system (AWMS) usage rates is based on the expert assumption. The ERT encourages the Party to develop annual or periodic data collection. Annual fluctuations in emission trend for goats and in IEFs for sheep and goats were noted in the draft 2002 S&A report. In its response to the draft 2002 S&A, report Canada explained that for the difficulties in allocating

CH_4 emissions between sheep and goats an attempt will be made to resolve this for the 2003 submission. The ERT encourages the Party to continue this work. There are no emissions reported for goats in 1999 (in its response to the draft 2002 centralized review report Canada states that this was an error which has been corrected in the 2003 inventory submission). The ERT recommends that Canada provide relevant information in the CRF for its next submission. Canada, in its response to this draft report, further explained that it is planning an in-depth study of AWMS usage rates and it is expected that this process along with implementation for NIR will take about two years.

3. Agricultural soils – direct N_2O

49. Some differences between the IEFs for synthetic fertilizers, animal wastes applied to soil and crop residues were noted with default emission factor (draft 2002 S&A report) which the Party reported using. In the response to the draft 2002 S&A report, Canada indicated that these differences are attributed to adjustment of activity data, such as volatilization of nitrogen from synthetic fertilizers and animal wastes, moisture content of grain crops and so on. The ERT suggests that Canada represent activity data on crop residues in accordance with the requirements of the IPCC Guidelines (kg dry biomass/yr). The Party may wish to include relevant information on the adjustment of activity data on synthetic fertilizers and animal wastes in the CRF and the NIR. Canada states in its response to this draft report that it will implement the ERT's suggestion in the 2004 inventory submission.

4. Agricultural soils – indirect N_2O

50. The IEF for leaching and run-off is the highest among reporting Parties and higher than the IPCC default value, which Canada reported using. The ERT suggests that Canada clearly show what emission factors are used and report in a consistent manner in the CRF and the NIR. In its response to this draft report Canada explained that this problem was corrected in the 2003 inventory submission.

C. Non-key sources

1. Manure management – N_2O

51. The CRF indicates default emission factors for estimation of N excretion rates, but the NIR provides information on additional research used for calculation (American Society of Agricultural Engineering, 1999). The ERT recommends that Canada indicate clearly what emission factors are used and reflect relevant background information in the NIR and the CRF. For sheep the N excreted by AWMS is 56 per cent higher that the N excreted by the sheep population. This was also noticed in the 2000 and 2001 S&A reports. In response to the draft 2002 S&A report, Canada explained that for the difficulties in allocating CH_4 emissions between sheep and goats an attempt will be made to try to resolve this for the 2003 submission. The ERT encourages the Party to continue this work. In its response to this draft report Canada states that it uses the US-based research for estimation of N excretion rates (American Society of Agricultural Engineering, 1999), as specified in the NIR, but still applies the IPCC default emission factors for various manure management systems.

2. Agricultural soils – CO_2

52. See the comments in the LUCF sector of this report.

V. LAND-USE CHANGE AND FORESTRY

A. Sector overview

53. The LUCF sector was a net sink of 14,009 Gg CO_2 equivalent in 2000, which represents 2.3 per cent of total greenhouse gas emissions of Canada (723,770 Gg CO_2 equivalent). During the period 1990–2000, removal of CO_2 by the LUCF sector shows a decreasing trend from 59,032 Gg CO_2

equivalent to 14,009 Gg CO_2 equivalent (from 9.8 per cent to 2.3 per cent of total GHG emissions). Non-CO_2 gas emissions by biomass burning are not estimated, which may lead to an underestimation of CO_2 equivalent emissions. The procedures used for determining carbon removal by non-forest agricultural trees, CO_2 emissions from post-harvest slash, and CO_2 emissions by forest and grassland conversion are not described. "Slash" burning was a particularly large source (19,645 Gg C) that was not properly documented. Recalculated data were provided for time series from 1990 to 2000, where important changes were made, mainly in years 1998 and 1999, compared with previous submissions, reporting a 52 per cent increase in CO_2 uptake for 1998 and a 47 per cent decrease in CO_2 uptake for 1999. The ERT recommends the Party to provide more detailed information on the above matters. No consistency problems were detected. In its response to this draft report Canada states that non-CO_2 gas emissions by biomass burning are estimated and reported in the case of wildfires. Information is not available on biomass burning practices upon forest conversion – hence non-CO_2 emissions are not reported. Efforts are underway to document forest conversion practices to support improved estimates. Burning practices of post-harvest biomass residues ('slash') are poorly documented. Estimates of biomass residues are derived from the difference between pre-harvest standing biomass and the biomass of merchantable timber + bark. It is assumed that these residues are oxidized as CO_2 during the harvest year (19,645 Gg C for the year 2000). Non-CO2 emissions from slash burning were derived from reported prescribed burn activities. Biomass densities pre and post forest conversion are not fully detailed in the NIR; however, the methodology is outlined and references are provided in p. 72–73 of the NIR. Recalculations made in the 2002 submission involved updates of harvest and fire data, but no methodological changes. Explanations were provided in the documentation box of table 8(b) for each recalculation year.

B. Sink and source categories

1. Changes in forest and other woody biomass stocks

54. The use of single values for growth rates (1.26 t dm/ha/yr) and conversion factor (0.5 t C/t dm) for diverse forest types may have impaired the accuracy of estimations. An effort should be made to develop different values for different tree species, age classes and geographic locations. Table 5.A reports an emission of 19,645 Gg C under the category "Other changes in carbon stocks". This was attributed to emissions from "slash", but no reference to methodology used was provided. Considering the relative importance of this source, the ERT recommends Canada to include a more detailed description of data sources, assumptions, emission factors and calculation procedures. However, in its response to this draft report Canada states that the Party does not use a single value for growth rates and the growth rate reported in the CRF is an aggregated, spatially-averaged value derived from mean annual volume increments (m.a.i) specific to species and ecological zones (the methodology used to derive growth rates is briefly outlined in the NIR, and the reference provided (Lowe et al., 1996b)). Efforts were made in the 2003 NIR to better document data sources and calculation procedures, and discuss areas for improvements.

2. Forest and grassland conversion

55. No emissions of non–CO_2 gases by biomass burning were reported in table 5.B. In the documentation box it is stated that no data are available to show how much biomass is lost through different paths, and all losses are assumed to be in the form of CO_2. This probably underestimates the total CO_2 equivalent emissions in this source category. An effort should be made in the future to estimate the fate of biomass lost due to forest and grassland conversion, in order to produce an estimation of non–CO_2 gas emissions mainly by biomass burning. Values derived from table 5.B indicate a loss of 40 and 102 t dm/ha for boreal and temperate forests, respectively. Values for grasslands and agricultural land were 1.1 and 10 t/ha, respectively. These figures differ markedly from IPCC Guidelines defaults, and the ERT recommends that Canada provide references to show their origin. In its response to this draft report Canada states that efforts are underway to document forest conversion practices to support

improved estimates, although pre-conversion biomass densities were estimated by the Canadian Forest Service (reference is provided in the NIR), while post-conversion biomass are taken from IPCC default values.

3. Abandonment of managed land

56. Lands abandoned between 40 and 100 years ago were not considered because of lack of statistical information. This underestimates the total amount of CO_2 removals. Some estimation of the amount of land abandoned between 40 and 100 years ago would have been helpful in enabling the ERT to assess the significance of this underestimation. In its response to this draft report Canada states that a compilation of national farmland data from the Census of Agriculture indicates that total farmland area has increased in all Canadian provinces up to the 1940s. In subsequent years, total farmland area in eastern Canadian provinces has decreased, while a steady increase has continued in the Prairies and in western Canada up to the 1990s. During the five decades between 1940 and 1990, total farmland areas, especially in eastern provinces, have declined by roughly 10 Mha; large tracks of this farmland would have been urbanized, however data are lacking to quantify these areas and efforts are underway to improve the estimates of urbanized land in Canada in the past decades.

4. Emissions and removals from soil

57. Emissions from agricultural soils were included in the agriculture sector and reported to be a net sink of 236.31 Gg CO_2 in 2000 (table Summary 1.A). Trend analysis of this source/sink reveals a continuous, marked change with time from a net source of 7,255 Gg CO_2 in 1990 to a current sink. Soil carbon emissions from land conversion are reported in another box attached to table 5.D. The result is expressed in Gg CO_2 over 25 years (2,709.46). Assuming linear carbon decay, the annual rate of carbon decay can be estimated as approximately 108 Gg CO_2/yr. This is the only source of CO_2 emissions from soils reported in the CRF. The value reported in table 5 for this category (9,934 Gg CO_2) does not match this figure. In its response to the draft 2002 centralized review report Canada states that table headings may have been misleading: soil C emissions from land conversion apply to the inventory year, although the column heading indicates that they represent soil C losses over 25 years; hence the figure 2,709.46 represents carbon (not CO_2) emissions from land conversion for the year 2000. The corresponding value in table 5 is 9,934 Gg CO_2, i.e. 2,709 multiplied by 3.667.

5. Other

58. The NIR includes emission sources additional to those required under the IPCC Guidelines, and these are reported in table Summary 1.A. They include five gases emitted by prescribed burning, other fires in wood production forests, and other fires. The methodology, information on emission factors and sources of activity data are provided as well in the NIR.

VI. WASTE

A. Sector overview

59. Emissions from the waste sector represented approximately 3.3 per cent of total GHG emissions in 2000, and there has been a 21 per cent increase since 1990. The NIR covers emissions from all source categories, that is, land disposal of solid waste, wastewater handling, waste incineration and human sewage. The First-Order Decay method (FOD, Scholl Canyon model) with country-specific parameters was used for estimating CH_4 emissions from solid waste disposal sites (SWDS). Emissions from other sources have been estimated using country-specific emission factors. Assumptions and methodologies used for estimating emissions are described in the NIR. There is a list of national references giving information additional to the NIR. Most of the activity data, IEFs and additional information in the CRF are indicated as NA and NE. Methodology and emission factors given in the CRF and the NIR are comparable to data from other Parties. All the CRF tables from 1990 to 2000 were submitted.

Methodologies used for estimating emissions in the period 1990–2000 are consistent with the IPCC Guidelines. Quantitative uncertainty assessments were not performed in the waste sector, but qualitative uncertainty indicators are reported in CRF table 7. Methane emissions from SWDS in 1999 were recalculated in the 2002 submission but not indicated in the related CRF table. However, in its response to this draft report Canada states that explanatory information is provided in table 8(b) of the CRF for the 1999 and 1998 recalculation of methane from Solid Waste Disposal on Land, where revised population data is the main reason for the emission update; as well in 1999, the quantity of methane recovered from managed landfills was also updated.

B. Key sources

1. Solid waste disposal on land

60. Solid waste disposal on land is the only key source in the waste sector. The main parameters being used in the FOD model are partially described in the NIR. Historical data on municipal solid waste (MSW) landfilled are estimated but not presented in the NIR. The half-life value used in the FOD model for wood waste landfills appears to be low in comparison to values given in the IPCC good practice guidance. The substantial decline (30 per cent) from 1989 of methane generation potential in waste reported by Canada does not reflect the trend in most developed countries. The report of the individual review of the greenhouse gas inventory of Canada submitted in 2000 addressed the issue of providing additional information. The draft 2002 S&A report pointed out that emissions reported in the 2002 submission differ from those in the 2001 submission for one particular year :1999. The ERT recommends that Canada present and briefly elaborate on all parameters used in the FOD model, particularly historical data on estimated quantities of MSW landfilled, waste composition and methane generation potential over time. All choices of emission factors which differ substantially from the IPCC Guidelines should be justified. The ERT also recommends that required additional information in the CRF table 6.A should be provided in future submissions.

C. Non-key sources

1. Waste incineration

61. Emissions from waste incineration are reported in the waste sector despite the fact that energy is utilized in almost all waste incineration plants in Canada. Activity data and IEFs are in most cases indicated as being not available. The report of the individual review of the greenhouse gas inventory of Canada submitted in 2000 and the draft 2002 S&A report addressed the issue of providing additional information. The ERT recommends that Canada report emissions from waste incineration in the energy sector when energy is recovered, and to cross-check emissions from waste incineration by using the methodology described in the IPCC good practice guidance.

ANNEX I: MATERIALS USED DURING THE REVIEW

A. Support materials on the CD ROM and the web page for the review

Sources of information used during the review include:

2000, 2001 and 2002 *Inventory submissions of Canada.* 2002 submissions including CRF for years 1990–2000 and an NIR.

UNFCCC secretariat (2001). *Report of the individual review of the greenhouse gas inventory of Canada submitted in the year 2000 (Centralized review)*. FCCC/WEB/IRI(3)/2000/CAN [available at http://unfccc.int/program/mis/ghg/countrep/cancentrev.pdf].

UNFCCC secretariat. *2000 Status reports for Canada* [available at http://unfccc.int/program/mis/ghg/statrep00/can00.pdf].

UNFCCC secretariat. *2001 Status report for Canada* [available at http://unfccc.int/program/mis/ghg/statrep01/can01.pdf].

UNFCCC secretariat. *2002 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 2000*. FCCC/WEB/SAI/2000 [available at http://unfccc.int/program/mis/ghg/sai2000.pdf].

UNFCCC secretariat. *Synthesis and assessment report of the greenhouse gas inventories submitted in 2001*. FCCC/WEB/SAI/2001 [available at http://unfccc.int/program/mis/ghg/sai2001.pdf].

UNFCCC secretariat. *Draft synthesis and assessment report of the greenhouse gas inventories submitted in 2002* (Part I 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 2002 [unpublished].

UNFCCC secretariat. *Key source analysis for the year 2000* [unpublished].

UNFCCC secretariat. *Handbook for review of national GHG inventories*. Draft 2002 [unpublished].

UNFCCC secretariat. *UNFCCC guidelines on reporting and review*. FCCC/CP/1999/7 [available at http://www.unfccc.int/resource/docs/cop5/07.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 provided by the Party

Responses to questions within the sectors Industrial Processes and Solvents use, Agriculture and LUCF during the review were received from Mr. Art Jaques (Air Pollution Prevention Directorate Canada) including additional material on the methodology and assumptions used.

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