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Report on the individual review of the inventory submission of Canada submitted in 2019*

Note by the expert review team

Summary

Each Party included in Annex I to the Convention must submit an annual inventory of emissions and removals of greenhouse gases for all years from the base year (or period) to two years before the inventory due date (decision 24/CP.19). This report presents the results of the individual inventory review of the 2019 inventory submission of Canada, conducted by an expert review team in accordance with the "Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual greenhouse gas inventories". The review took place from 23 to 28 September 2019 in Bonn.

* In the symbol for this document, 2019 refers to the year in which the inventory was submitted, not to the year of publication.

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Abbreviations and acronyms

2006 IPCC Guidelines	*2006 IPCC Guidelines for National Greenhouse Gas Inventories*
AD	activity data
AWMS	animal waste management system(s)
BOD	biochemical oxygen demand
C_a	activity coefficient corresponding to animal's feeding situation
CH_4	methane
CO_2	carbon dioxide
CO_2 eq	carbon dioxide equivalent
Convention reporting adherence	adherence to the "Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual greenhouse gas inventories"
CRF	common reporting format
CSC	carbon stock change
DOC	degradable organic carbon
DOC_f	fraction of degradable organic carbon
ECCC	Environment and Climate Change Canada
EF	emission factor
ERT	expert review team
$Frac_{GASM}$	fraction of applied organic nitrogen fertilizer materials and urine and dung nitrogen deposited by grazing animals that volatilizes as ammonia and nitrogen oxides
$Frac_{GasMS}$	percentage of managed manure nitrogen for a livestock category that volatilizes as ammonia and nitrogen oxides in the manure management system
$Frac_{LeachMS}$	percentage of managed manure nitrogen losses for a livestock category due to run-off and leaching during solid and liquid storage of manure
$Frac_{LeachMS(T,AWMS)}$	percentage of managed manure nitrogen losses for a dairy livestock category due to run-off and leaching during solid and liquid storage of manure, animal waste management system
GCV	gross calorific value
GHG	greenhouse gas
HFC	hydrofluorocarbon
HWP	harvested wood products
IE	included elsewhere
IEF	implied emission factor
IPCC	Intergovernmental Panel on Climate Change
IPCC good practice guidance	*Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*
IPPU	industrial processes and product use
LKD	lime kiln dust
LULUCF	land use, land-use change and forestry
MCF	methane conversion factor
MSW	municipal solid waste
N	nitrogen
NA	not applicable
NCV	net calorific value
NE	not estimated
$N_{EX,T}$	nitrogen excretion rate for a livestock category or subcategory

$N_{i,AWMS}$	percentage of manure nitrogen handled by each animal waste management system in a province
NF_3	nitrogen trifluoride
NH_3	ammonia
NIR	national inventory report
NO	not occurring
NO_X	nitrogen oxides
N_2O	nitrous oxide
OX	oxidation factor
PFC	perfluorocarbon
QA/QC	quality assurance/quality control
Revised 1996 IPCC Guidelines	*Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*
SF_6	sulfur hexafluoride
SWDS	solid waste disposal site(s)
UNFCCC Annex I inventory reporting guidelines	"Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual greenhouse gas inventories"
UNFCCC review guidelines	"Guidelines for the technical review of information reported under the Convention related to greenhouse gas inventories, biennial reports and national communications by Parties included in Annex I to the Convention"
VS	volatile solid(s)
Wetlands Supplement	*2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands*

I. Introduction

1. This report covers the review of the 2019 inventory submission of Canada organized by the secretariat in accordance with the UNFCCC review guidelines, particularly part III thereof, namely the "UNFCCC guidelines for the technical review of greenhouse gas inventories from Parties included in Annex I to the Convention" (decision 13/CP.20). The review took place from 23 to 28 September 2019 in Bonn and was coordinated by Claudia do Valle, Javier Hanna and Peter Iversen (secretariat). Table 1 provides information on the composition of the ERT that conducted the review of Canada.

Table 1
Composition of the expert review team that conducted the review of Canada

Area of expertise	*Name*	*Party*
Generalist	Agita Gancone	Latvia
	Olia Glade	New Zealand
Energy	Leonidas Osvaldo Girardin	Argentina
	Gherghita Nicodim	Romania
	Peter Seizov	Bulgaria
IPPU	Kent Buchanan	South Africa
	Kakhaberi Mdivani	Georgia
	Jolanta Merkeliene	Lithuania
	Su Mingshan	China
Agriculture	Michael Anderl	Austria
	Juan José Rincón Cristóbal	Spain
LULUCF	Maria Fernanda Alcobé	Argentina
	Valentyna Slivinska	Ukraine
	Midori Yanagawa	Japan
Waste	Cristobal Felix Diaz Morejon	Cuba
	Gabor Kis-Kovacs	Hungary
	Martiros Tsarukyan	Armenia
Lead reviewers	Olia Glade	
	Kakhaberi Mdivani	

2. The basis of the findings in this report is the assessment by the ERT of the Party's 2019 inventory submission in accordance with the UNFCCC review guidelines. The ERT notes that the individual inventory review of Canada's 2018 inventory submission did not take place in 2018 owing to insufficient funding for the review process.

3. The ERT has made recommendations that Canada resolve the findings related to issues.[1] Other findings, and, if applicable, the encouragements of the ERT to Canada to resolve them, are also included.

4. A draft version of this report was communicated to the Government of Canada, which provided comments that were considered and incorporated, as appropriate, into this final version of the report.

5. Annex I shows annual GHG emissions for Canada, including totals excluding and including the LULUCF sector, indirect CO_2 emissions, and emissions by gas and by sector.

[1] Issues are defined in decision 13/CMP.20, annex, para. 81.

II. Summary and general assessment of the 2019 inventory submission

6. Table 2 provides the assessment by the ERT of the inventory submission with respect to the tasks undertaken during the review. Further information on the issues identified, as well as additional findings, may be found in tables 3 and 5.

Table 2
Summary of review results and general assessment of the inventory of Canada

Assessment			*Issue ID#(s) in table 3 and/or 5*[a]
Date of submission	Original submission: 15 April 2019 (NIR), 15 April 2019 (CRF tables) version 1		
Review format	Centralized		
Application of the requirements of the UNFCCC Annex I inventory reporting guidelines and Wetlands Supplement (if applicable)	Have any issues been identified in the following areas:		
	(a) Identification of key categories?	Yes	G.6, L.3
	(b) Selection and use of methodologies and assumptions?	Yes	E.1, A.6, A.14, A.20, L.11, L.12, L.19, L.22
	(c) Development and selection of EFs?	Yes	E.4, I.18, A.15, A.21, W.14
	(d) Collection and selection of AD?	Yes	I.22, I.28, I.33, L.9, L.18, W.12
	(e) Reporting of recalculations?	Yes	I.26
	(f) Reporting of a consistent time series?	No	
	(g) Reporting of uncertainties, including methodologies?	Yes	G.4, L.16
	(h) QA/QC?	Yes	G.5, A.7, W.3
	(i) Missing categories/completeness?[b]	Yes	I.2, I.4, I.9, I.34, I.35, A.2, A.8, A.9, A.12, A.18, L.1, L.2, L.7, L.10, L.13, W.16
	(j) Application of corrections to the inventory?	No	
Significance threshold	For categories reported as insignificant, has the Party provided sufficient information showing that the likely level of emissions meets the criteria in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines?	No	I.9
Description of trends	Did the ERT conclude that the description in the NIR of the trends for the different gases and sectors is reasonable?	Yes	
National inventory arrangements	Have any issues been identified with the effectiveness and reliability of the institutional, procedural and legal arrangements for estimating GHG emissions, including the changes to the national inventory arrangements since the previous annual submission?	No	
Response from the Party during the review	Has the Party provided the ERT with responses to the questions raised, including the data and information necessary for the assessment of conformity with the UNFCCC Annex I inventory reporting guidelines and any further guidance adopted by the Conference of the Parties?	Yes	

Assessment			*Issue ID#(s) in table 3 and/or 5[a]*
Recommendation for an exceptional in-country review	On the basis of the issues identified, does the ERT recommend that the next review be conducted as an in-country review?	No	

[a] The ERT identified additional issues in the energy, IPPU, agriculture, LULUCF and waste sectors as well as issues that are not listed in this table but are included in table 5.

[b] Missing categories for which methods are provided in the 2006 IPCC Guidelines may affect completeness and are listed in annex II.

III. Status of implementation of issues raised in the previous review report

7. Table 3 compiles all the recommendations made in previous review reports that were included in the previous review report, published on 26 January 2018.[2] For each issue, the ERT specified whether it believes the issue has been resolved by the conclusion of the review of the 2019 inventory submission and provided the rationale for its determination, which takes into consideration the publication date of the previous review report and national circumstances.

Table 3
Status of implementation of issues raised in the previous review report of Canada

ID#	*Issue classification[a, b]*	*Recommendation made in previous review report*	*ERT assessment and rationale*
General			
G.1	Key category analysis (G.3, 2017) (G.6, 2016) Transparency	Provide category-specific information on the aggregation of categories in the key category analysis.	Resolved. Canada included information on the details on aggregation of categories in the key category analysis in table A1-1 in its 2019 NIR (part 2, annex 1, p.2) and 2018 NIR (part 2, annex 1, p.3).
G.2	NIR (G.2, 2017) (G.3, 2016) Transparency	Include information that explains changes over the times series for the key AD, EFs and parameters used in the NIR for fuels combusted (at the level of CRF table 1.A(b)), and disaggregated animal number data where higher tiers are used. The AD, EFs and parameters should be reported in sufficient detail to facilitate (using both the CRF tables and the NIR) the understanding and replication of the calculations of the emission/removal estimates, where applicable.	Resolved. Canada included a summary of the development and selection of the EFs used to estimate GHG emissions in the NIR (annex 6, pp.220–245). Additional details on sector-specific methodologies for using these EFs are presented in annex 3 (NIR, pp.20–171). During the review, Canada stated that information on EFs is also published in a separate document on the Government's open data portal (https://open.canada.ca/en). The ERT noted that AD are well referenced throughout the NIR and links to reference documents are provided; for example, annex 3.1 includes tables (e.g. table A3-1) with clear references to the source of AD, including weblinks where available.
Energy			
E.1	1. General (energy sector) – gaseous fuels – CO_2, CH_4 and N_2O (E.1, 2017) (E.2, 2016) (E.4, 2015)	Take steps to ensure that the conversion of volumes of natural gas to energy units is completed appropriately for both marketable and non-marketable natural gas. Document the progress of efforts	Addressing. Canada stated during the review that work is under way to update the carbon content and energy conversion factors for natural gas. A presentation of progress as at February 2019 is included in the NIR (part 1, section 3.2.4.6). During the review, Canada informed the ERT that this is a multi-year

[2] FCCC/ARR/2017/CAN. The ERT notes that the report on the individual inventory review of Canada's 2018 inventory submission has not been published yet. As a result, the latest previously published inventory review report reflects the findings of the review of the Party's 2017 inventory submission.

ID#	*Issue classification*[a, b]	*Recommendation made in previous review report*	*ERT assessment and rationale*
	(19, 2014) Accuracy	in the improvement plan and in the NIR.	project requiring stakeholder involvement and that the inventory team and contractor had been developing approaches to identifying distribution points for the past year with the input of industry participants, who would start to gather the necessary data in the second half of 2019. Canada planned to have collected information on fuel composition and flow rates by early 2020. The Party further informed the ERT that ensuring a representative carbon composition of natural gas by region is a challenge given the multiple transmission and distribution networks associated with the production, supply, export and import of natural gas.
E.2	1. General (energy sector) – all fuels – CO_2 (E.2, 2017) (E.3, 2016) (E.11, 2015) Accuracy	Develop a plan that provides a timeline for updating the carbon content factors regularly, prioritizing fuels used in large quantities within Canada, as well as fuels with high carbon content variabilities.	Resolved. During the review, Canada informed the ERT that, following the recommendation from the previous review report, a review of the fuel properties of the two major fuels used for transportation (motor gasoline and diesel) was conducted by ECCC in 2017. On the basis of this review the carbon content factors were updated, and the updated factors were incorporated into the 2018 NIR (tables 8-3 and A6-12). The results of this review are documented in a report by Tobin (2017). In the NIR (part 1, section 3.2.4.6) Canada explained that EF improvements were prioritized for the fuels with the largest contribution to combustion emissions such as coal, gasoline, diesel and natural gas. In the past few years, CO_2 EF and heating value improvements were implemented for coal, gasoline and diesel.
E.3	1. General (energy sector) – all fuels – CO_2, CH_4 and N_2O (E.3, 2017) (E.25, 2016) Accuracy	Review and, where necessary, update calorific values for other fuels (i.e. other than natural gas as referenced in ID# E.2 in the 2016 inventory review report (see ID# E.1 above)).	Resolved. During the review, Canada informed the ERT that a review of the fuel properties of the two major fuels used for transportation (motor gasoline and diesel) was conducted by ECCC in 2017. On the basis of this review the calorific values were updated, and the updated values were incorporated into the 2018 NIR (tables 8-3 and A6-12). The results of this review are documented in a report by Tobin (2017).
E.4	1. General (energy sector) – all fuels – CO_2, CH_4 and N_2O (E.4, 2017) (E.25, 2016) Accuracy	Update CO_2 EFs where appropriate (following the plan referred to in ID# E.3 in the 2016 inventory review report (see ID# E.2 above)) and provide references for these in the NIR.	Addressing. In the NIR (part 1, section 3.2.4.6) Canada stated that the priority for EF improvements has been fuels with the largest contribution to combustion emissions, such as coal, gasoline, diesel and natural gas, and that the CO_2 EFs and heating values for coal, gasoline and diesel have improved in recent years. When comparing the EFs (part 2, tables A3-9, A6-1 to A6-12) in the 2018 NIR with those in the 2019 NIR (part 2, table A6-1 to A6-13), the ERT found that only the EFs for CO_2 emissions for petroleum coke for refineries and others in table A6-5 had changed. However, no information was provided as to whether this completes the work related to the improvements referred to in ID# E.2 above.

ID#	*Issue classification*[a, b]	*Recommendation made in previous review report*	*ERT assessment and rationale*
E.5	1. General (energy sector) – all fuels – CO_2, CH_4 and N_2O (E.5, 2017) (E.25, 2016) Transparency	Document all instances where the calorific values and/or the CO_2 EFs deviate from the ranges set out in the 2006 IPCC Guidelines, and provide concise explanations of the reasons for these deviations, where the reasons are understood; where the reasons are not understood, investigate them.	Addressing. During the review, Canada informed the ERT that a review of the fuel properties of the two major fuels used for transportation (motor gasoline and diesel) was conducted by ECCC in 2017. On the basis of this review the GCVs were updated and now accurately reflect the fuel properties of motor gasoline and diesel. The results of this review are documented in a report by Tobin (2017). However, no information was provided as to whether this completes the work on documentation of all instances of the GCVs or CO_2 EFs deviating from the ranges set out in the 2006 IPCC Guidelines, including concise explanations of such deviations.
E.6	1. General (energy sector) – all fuels – CO_2, CH_4 and N_2O (E.24, 2017) Transparency	Provide a comprehensive explanation of any recalculations performed in categories 1.A.2, 1.A.3 and 1.A.4.	Resolved. Canada provided a specific explanation of recalculations for categories where appropriate (e.g. for category 1.A.1 in section 3.2.4.5 of the NIR), and a general explanation for the remaining categories in section 3.1 of the NIR by type of recalculation, such as AD and methodological changes.
E.7	Feedstocks, reductants and other non-energy use of fuels – liquid fuels – CO_2 (E.23, 2017) Comparability	Report non-energy use of liquefied petroleum gas (propane and butane) using the correct notation key "IE" in CRF table 1.A(d).	Addressing. Canada continues to report "NO" for non-energy use of liquefied petroleum gas. During the review, Canada informed the ERT that it had started to examine this issue but further discussion is required. According to the *Report on Energy Supply and Demand in Canada* (Statistics Canada, 2016), the only source of propane and butane consumed as feedstock is from the natural gas stream and is currently reported in CRF table 1.A(d) under natural gas liquids. Canada explained that additional research and discussions with Statistics Canada are required to determine whether any propane and butane from the petroleum refinery stream (i.e. liquefied petroleum gas) are consumed or produced, in which case this fuel would be reported correctly as "IE".
E.8	1.A Fuel combustion – sectoral approach – solid fuels – CO_2 (E.25, 2017) Accuracy	Use the correct value for the EF for foreign sub-bituminous coal of between 1,739 and 1,865 kg CO_2/t.	Resolved. Canada used an EF of 1,865 kg CO_2/t for foreign sub-bituminous coal (see part 2, annex 6, table A6-8 of the NIR).
E.9	1.A Fuel combustion – sectoral approach – peat – CO_2, CH_4 and N_2O (E.7, 2017) (E.28, 2016) Transparency	Explain in the NIR that peat is extracted in Canada for agricultural purposes only.	Resolved. Canada stated in the NIR (part 1, section 3.1) that peat is not consumed as an energy source in the country.
E.10	1.A.1.c Manufacture of solid fuels and other energy industries – all fuels – CO_2, CH_4 and N_2O (E.8, 2017) (E.9,	Report the CO_2, CH_4 and N_2O emissions from the purchased fuels used in manufacture of solid fuels and other energy industries in that category.	Resolved. During the review, Canada informed the ERT that all fuel use, including both purchased and own-use fuels, and the associated emissions from fuel consumption that occur during the manufacture of solid fuels and other energy industries are now reported under this category. Canada recalculated CO_2, CH_4 and

ID#	*Issue classification*[a, b]	*Recommendation made in previous review report*	*ERT assessment and rationale*
	2016) (E.19, 2015) Comparability		N_2O emissions for this category accordingly (see part 1, section 3.2.4.5 of the NIR for more details).
E.11	1.A.2 Manufacturing industries and construction – all fuels – CO_2 (E.11, 2017) (E.30, 2016) Convention reporting adherence	Provide category-specific information on recalculations that relate to changes in the collection of AD and the choice of EF or method used, including information on the reasoning for the recalculations in the NIR.	Resolved. Canada provided specific information on why EFs changed between the 2017 and 2018 submissions in the 2018 NIR (part 1, section 3.1).
E.12	1.A.3 Transport – liquid fuels – CO_2 (E.26, 2017) Accuracy	Estimate CO_2 emissions from lubricants combusted in two-stroke engines separately using appropriate OXs and report them in the energy sector.	Not resolved. During the review, Canada explained that the model used to estimate these emissions is being reviewed and revised.
E.13	1.A.3 Transport – liquid fuels – CO_2, CH_4 and N_2O (E.27, 2017) Transparency	Finalize the update of the methodological documentation on the Motor Vehicle Emissions Simulator and Nonroad Engines, Equipment and Vehicles models and include a summary of the documentation in the NIR.	Not resolved. As at the 2019 submission, Canada has not implemented this recommendation. The Motor Vehicle Emissions Simulator and Nonroad Engines, Equipment and Vehicles models are being reviewed and revised, and the relevant documentation will be completed in time for the 2021 submission (see part 1, table 8-5 of the NIR).
E.14	1.A.3 Transport – liquid fuels – CO_2, CH_4 and N_2O (E.27, 2017) Transparency	Provide information on the verification of the Motor Vehicle Emissions Simulator and Nonroad Engines, Equipment and Vehicles models (e.g. comparison of the values estimated by the models with data from other sources) in the NIR, in accordance with paragraph 41 of the UNFCCC Annex I inventory reporting guidelines.	Resolved. Canada reported on its verification activities, which involve comparing outputs from the Motor Vehicle Emissions Simulator and Nonroad Engines, Equipment and Vehicles models with other data sources. Canada referred to the normalization values used to align the estimates from the Motor Vehicle Emissions Simulator and Nonroad Engines, Equipment and Vehicles models with those of the national energy balance for the on-road and off-road sectors. The normalization values for gasoline and diesel can be found in part 2, tables A3-7 and A3-8, respectively, of the NIR.
E.15	1.A.3.b Road transportation – gasoline – CO_2 (E.12, 2017) (E.12, 2016) (E.23, 2015) Transparency	Provide an explanation in the NIR that the low IEF for gasoline reported in the CRF tables is attributed to the outdated GCVs used to convert the AD and EFs from physical to energy units.	Resolved. Canada stated in the 2018 NIR (part 1, table 8.3, p.212) that it used new country-specific EFs that are based on a report on updated CO_2 EFs for gasoline and diesel fuel issued by the ECCC in 2017. The GCVs were updated and now accurately reflect the fuel properties of motor gasoline and diesel in Canada. Canada recalculated the relevant emissions for the 2017 and 2018 submissions, and the CO_2 IEF for gasoline is no longer low when compared with other Parties'. The results of this review are documented in a report by Tobin (2017).
E.16	1.A.3.b Road transportation – liquid fuels – CO_2 (E.13, 2017) (E.13, 2016) (E.7, 2015) (27, 2014) Accuracy	Carry out the analysis to evaluate the opportunities to repeat portions of the McCann (2000) study to investigate the evolution and current applicability of the final applied EF, and document progress made in this regard in the improvement plan and in the NIR.	Resolved. During the review, Canada informed the ERT that a review of the fuel properties of the two major fuels used for transportation (motor gasoline and diesel) was conducted by ECCC in 2017. On the basis of this review, portions of the McCann (2000) study were replicated using newer fuel samples. The results of the review are documented in a report by

ID#	*Issue classification*[a, b]	*Recommendation made in previous review report*	*ERT assessment and rationale*
			Tobin (2017) and were incorporated into the 2018 NIR (tables 8-3 and A6-12).
E.17	1.A.3.c Railways – solid fuels – CO_2, CH_4 and N_2O (E.14, 2017) (E.14, 2016) (E.24, 2015) Completeness	Either estimate and include in the inventory CO_2, CH_4 and N_2O emissions from steam trains, or provide a justification in the NIR, consistent with the UNFCCC Annex I inventory reporting guidelines, that these emissions are considered insignificant.	Resolved. Canada stated in the NIR (part 1, p.74) that an investigation into this activity showed that the 20 locomotives operating in Canada produced slightly more than 0.5 kt CO_2 eq, including CO_2 from biomass. Canada confirmed that, as this is less than 0.05 per cent of its total emissions and below the 500 kt CO_2 eq significance threshold specified in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines, this source can be considered insignificant.
E.18	1.A.4 Other sectors – all fuels – CH_4 and N_2O (E.16, 2017) (E.32, 2016) Convention reporting adherence	Provide category-specific information on recalculations that relate to changes in the collection of AD and the choice of EF or method used, including information on the reasoning for the recalculations in the NIR.	Resolved. Canada provided detailed information in its 2018 NIR (part 1, section 3.2.7.5) explaining the impact of recalculations due to revised AD and EFs. Canada also provided detailed information in its 2019 NIR (part 1, section 3.2.7.5) on the impact of the recalculations carried out between the 2018 and 2019 submissions.
E.19	1.B.1.a Coal mining and handling – solid fuels – CO_2 (E.17, 2017) (E.20, 2016) (E.29, 2015) Transparency	Report the CO_2 emissions from underground mines as "NA" and indicate in the NIR that no CO_2 emissions associated with flaring and drainage systems of underground mines occur in the country.	Addressing. The ERT noted that Canada reported "NA" in the CRF table 1.B.1, but the NIR text had not been modified accordingly.
E.20	1.B.1.a Coal mining and handling – solid fuels – CH_4 (E.29, 2017) Transparency	Include in the NIR the explanation regarding the Coal Industry Advisory Board methodology provided to the ERT during the 2016 and 2017 reviews.	Resolved. Canada stated during the review that the specific reports used for the coal mining emission methodology had been provided to in-country reviewers in previous review years. As these reports contain confidential industry data, they would require extensive editing before they could be fully included in the NIR. However, in the NIR (part 2, annex 3), Canada provided information on the method used for calculating the emissions for surface and underground coal mines using the Coal Industry Advisory Board method.
E.21	1.B.1.b Solid fuel transformation – solid fuels – CO_2, CH_4 and N_2O (E.19, 2017) (E.23, 2016) (E.34, 2015) Transparency	Verify that the emissions from all coke oven gas both consumed and flared at the four integrated iron and steel plants are included in the inventory and report accordingly in the NIR.	Resolved. Canada reported in the NIR (part 1, section 3.2.5.2) that there are currently three integrated iron and steel plants in the country, and that Statistics Canada reports all coke oven gas produced and consumed in the *Report on Energy Supply and Demand in Canada* (Statistics Canada, 2016). Determining the specific amount of coke oven gas flared is not feasible, but Statistics Canada included the amount of fuels flared in the consumption totals in the above-mentioned report.
E.22	1.B.1.b Solid fuel transformation – solid fuels – CO_2 and CH_4 (E.20, 2017) (E.33, 2016) Transparency	Report CO_2 and CH_4 emissions from briquette manufacturing under solid fuel transformation. If this cannot be done, use the correct notation key for solid fuel transformation ("IE" instead of	Addressing. In its 2019 submission, the Party reported CH_4 emissions from solid fuel transformation as "IE" (reported as "NE" in the 2017 submission). In CRF table 9 the Party explained that CH_4 emissions from solid fuel transformation are included under surface mines – mining activities. In the NIR (section 3.3.1.1), the Party also explained that emissions from

ID#	*Issue classification*[a, b]	*Recommendation made in previous review report*	*ERT assessment and rationale*
		"NE") and update the description in the NIR accordingly.	briquette manufacturing are included under coal mining, while other emissions from solid fuel transformation are considered negligible. During the review, the Party further explained that this aggregation of CH_4 emissions is done because it cannot disaggregate post-mining activity from activity associated with briquette manufacturing, and that it would include this explanation in its next NIR. The Party noted that total emissions from briquette manufacturing as a source account for less than 0.05 per cent of its total emissions and do not exceed the 500 kt CO_2 eq significance threshold. The Party therefore reported them as "NE" instead of "IE". In CRF table 9, the Party explained that CO_2 emissions from solid fuel transformation are reported as "NE" because the emission levels and AD are unknown.
E.23	1.B.1.b Solid fuel transformation – solid fuels – CO_2 and CH_4 (E.21, 2017) (E.33, 2016) Transparency	Document the methodology and data sources used to estimate emissions from briquette manufacturing in the NIR.	Not resolved. In the NIR (section 3.3.1.1), the Party explained that emissions from briquette manufacturing are included under coal mining but no further information was provided. During the review, Canada stated that emissions from briquette manufacturing as a source account for less than 0.05 per cent of its total emissions and do not exceed the 500 kt CO_2 eq significance threshold. Some of these emissions, specifically emissions associated with post-mining handling, are currently reported in CRF table 1.B.1. Canada stated that this is because it cannot disaggregate post-mining activity from activity associated with briquette manufacturing, and that it would include this information in its next NIR.
E.24	1.B.2.a Oil – liquid fuels – CH_4 (E.22, 2017) (E.24, 2016) (E.9, 2015) (29, 2014) Accuracy	Continue to explore ways to review and update the bitumen model to capture industry changes and document progress on this in the improvement plan and in the NIR.	Resolved. Canada provided information on the 2017 oil sands study by Clearstone for ECCC in the NIR (part 2, annex 3.2 section A3.2.2.5). This bitumen study provides a facility-based tier 3 emissions inventory for the oil sands and heavy oil upgrading industry for the 2015 reference year. It was used as the basis for extrapolating both forward and backward to obtain estimates for 2004–2017. Where facility emission reports were available from operators, extrapolation was not required and actual emission estimates were used.
E.25	1.C CO_2 transport and storage – all fuels – CO_2 (E.30, 2017) Transparency	Provide transparent information on the subcategories under which the fugitive CO_2 emissions from the two CO_2 enhanced oil recovery projects are reported and how the Party ensures comprehensive coverage of fugitive CO_2 emissions from these projects in the NIR.	Not resolved. Canada provided information in the NIR (section 3.4) on the allocation of fugitive emissions related to CO_2 capture. During the review, Canada informed the ERT that it is not yet possible to disaggregate fugitive emissions specific to the two enhanced oil recovery fields that use CO_2 from carbon capture and storage. These fugitive emissions are included in the estimates generated by the upstream oil and gas model (part 1, section 2.3.4.1) and reported in CRF table 1.B.2.

ID#	*Issue classification*[a, b]	*Recommendation made in previous review report*	*ERT assessment and rationale*
IPPU			
I.1	2.A.2 Lime production – CO_2 (I.1, 2017) (I.15, 2016) Accuracy	Improve the tier 2 method used by including the correction factor for LKD using the IPCC default value (2006 IPCC Guidelines, vol. 3, p.2.24), if a country-specific LKD correction factor is not available.	Resolved. Canada stated in the NIR (part 1, section 4.3.2, p.96) that a default LKD correction factor of 2 per cent from the 2006 IPCC Guidelines was applied throughout the time series since a country-specific LKD correction factor is not available.
I.2	2.A.4 Other process uses of carbonates – CO_2 (I.2, 2017) (I.2, 2016) (I.10, 2015) Completeness	Include CO_2 emissions from ceramics production in the inventory or demonstrate that the emissions are insignificant, as defined in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines.	Addressing. During the review, Canada explained that an assessment had demonstrated that CO_2 emissions from ceramics production for 2011–2018 account for less than 0.05 per cent of Canada's national total GHG emissions and did not exceed the 500 kt CO_2 eq threshold. This is not reported in the NIR; however, the Party stated that it will include this information in its next NIR. The Party intends to provide the information used to determine insignificance and the results of that assessment in the submission.
I.3	2.B.1 Ammonia production – CO_2 (I.19, 2017) Transparency	Include information from the fertilizer industry survey that was undertaken in 2005–2009 on the number of plants that provided information on feed fuel requirements for NH_3 production and the variability of the NH_3-to-feed fuel factor.	Resolved. Canada presented information from the fertilizer industry survey that was undertaken in 2005–2009 in the NIR (part 1, section 4.5.2, p.101). Nine plants were in operation during that period, two of which did not provide NH_3-to-feed fuel factors. A variability factor (0.0001 per cent) was also reported.
I.4	2. General (IPPU) – CO_2 (I.20, 2017) Completeness	Provide information to enable an evaluation of whether all CO_2 emissions from significant uses of urea are included in the inventory, including by providing an overview table in the NIR listing the use(s) of the CO_2 emissions recovered from NH_3 production, by the category in which they are reported in the GHG inventory.	Addressing. The inventory accounts for CO_2 emissions from uses of urea as a fertilizer in the agriculture sector reported under category 3.H and from the use of urea-based additives in catalytic converters, which are reported under category 2.D.3. In the NIR (part 1, section 4.5.1, p.101), Canada stated that other uses of urea and the significance of the emissions will be investigated for future inventories. During the review, Canada stated that emissions resulting from other uses of urea were found to be significant for certain years and it plans to include CO_2 estimates for uses of urea in its next submission.
I.5	2.B.2 Nitric acid production – N_2O (I.3, 2017) (I.16, 2016) Consistency	Investigate why there is such an inconsistency between the statistical data (showing decreasing nitric acid production in 2007–2008) and the data reported by facilities (showing increasing production in 2007–2008) and whether there could be any errors in the data reported by the facilities, and report on the results of such an investigation in the NIR, including information on the QA/QC activities undertaken in relation to the facility-level data received.	Resolved. Canada stated in the 2018 NIR (p.104) that it had investigated the inconsistency found between 2007 and 2008 data and concluded that there is likely an error in the data reported by companies. A facility was suspected of not reporting on its production to Statistics Canada for the reference year 2008. Canada has corrected the AD for 2008–2010 with a recalculation, and the IEF no longer peaks in 2008. Canada described in the 2018 NIR (p.104) the steps in its QC checklist for checking for errors in production data, including step 1.3 (comparing data with those from previous years), step 2.1 (checking for transcription errors) and step 2.2 (checking units).

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I.6	2.B.2 Nitric acid production – N_2O (I.21, 2017) Transparency	Include transparent information on the methodological tier used for the estimation of nitric acid production for each plant in the NIR.	Resolved. Canada provided an explanation for the combination of tiers used for the different facilities in the NIR (part 1, section 4.6.2). A tier 2 method was mostly used when plant-specific EFs were not available. The Party reported that all five facilities currently in operation in Canada applied a tier 2 method for almost all years. During the review and in the NIR (section 4.6.2), Canada stated that it was not possible to specifically attribute EFs to the plants for confidentiality reasons.
I.7	2.B.2 Nitric acid production – N_2O (I.21, 2017) Transparency	Provide more transparent information on the EFs used for nitric acid production in the NIR, including how EFs provided in the NIR are used for the estimation of emissions, and the years and number of plants for which they are used.	Addressing. Canada provided information on the EFs used for specific nitric acid production technology types in the NIR (part 1, section 4.6.2, and part 2, annex 6, table A6-16, p.228). The Party stated in the NIR that a tier 2 method was applied to all currently operating plants for almost all years; however, the specific years, number of plants and the EFs used were not presented in the NIR.
I.8	2.B.6 Titanium dioxide production – CO_2 (I.4, 2017) (I.17, 2016) Completeness	Confirm that the emissions from titanium dioxide production are included in the inventory and report the CO_2 emissions under category 2.B.6 (titanium dioxide production). If the emissions are reported under another subcategory, explain so in the NIR.	Resolved. The Party stated in the NIR (part 1, section 4.9.1, p.106) that, when applying the default EF, the emissions were found to account for less than 0.05 per cent of the national total and were below 500 kt CO_2 eq for 2009, which was the last year for which production data were available. This is in accordance with paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines. These emissions are reported as "NE" in the CRF table 2(I).A-Hs1.
I.9	2.B.8 Petrochemical and carbon black production – CO_2 and CH_4 (I.5, 2017) (I.3, 2016) (I.11, 2015) Completeness	Include CO_2 and CH_4 emissions from ethylene oxide production in the inventory or demonstrate that the emissions are insignificant, as defined in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines.	Not resolved. Canada continued to report CO_2 and CH_4 emissions from ethylene oxide production as "NE" in CRF table 2(I).A-Hs1, and explained in CRF table 9 that it is considering estimating these emissions. In the NIR (section 4.9.6), Canada stated in its comments on the draft review report that emissions related to ethylene oxide will be included in its 2020 NIR.
I.10	2.B.8 Petrochemical and carbon black production – CO_2 (I.6, 2017) (I.18, 2016) Comparability	Include in the inventory CO_2 emissions from carbon black production or justify its exclusion in accordance with paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines.	Resolved. Canada explained in the NIR (part 1, section 4.9.1) its justification for reporting CO_2 emissions from carbon black production as "IE", namely that CO_2 emissions are included under category 2.D (other). The Party stated that these data cannot be disaggregated.
I.11	2.C.1 Iron and steel production – CO_2 (I.7, 2017) (I.4, 2016) (I.5, 2015) (37, 2014) Transparency	Include the allocation of non-energy use of other reductants identified in this category in the improvement plan and implement steps to further disaggregate the energy statistics and other (industrial processes) category.	Addressing. Canada included in the NIR (part 1, section 4.10.6) its plan to include process emissions associated with natural gas and coal as reductants under category 2.C.1 as soon as supporting information becomes available. Canada reported that it is implementing steps to further disaggregate the energy statistics. During the review, Canada stated that it has been collecting information related to emissions, reductant use and carbon content directly from iron and steel facilities since 2017. The data collected are currently being reviewed to

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			determine their suitability for inclusion in future NIRs.
I.12	2.C.1 Iron and steel production – CO_2 (I.8, 2017) (I.19, 2016) Transparency	More transparently describe the allocation of emissions from ferroalloys production in the NIR.	Resolved. The allocation of emissions from ferroalloys production is reported in the NIR (part 2, annex 3, section A3.3.2, p.62). The Party reported that CO_2 emissions are included under category 2.C.1.b (pig iron production), since the production of specialty steel from iron ore using the electric arc furnace process uses reductants, whose emissions cannot be disaggregated.
I.13	2.C.3 Aluminium production – CO_2, PFCs and SF_6 (I.22, 2017) Transparency	Include information on the shares of process-related emissions from aluminium production estimated using different methodological tiers across the time series in the NIR.	Addressing. Canada did not include in the NIR the shares of process-related emissions from aluminium production estimated using different methodological tiers prior to 2015. However, the Party reported in the NIR (part 1, p.114) that all process-related emissions from this sector have been estimated using a tier 3 approach since 2015.
I.14	2.C.4 Magnesium production – SF_6 (I.10, 2017) (I.21, 2016) Consistency	Check the AD reported for 1999–2000 and revise them, if appropriate.	Resolved. The Party described in the NIR (part 1, p.115) the reasons for the increase in production in 1999–2000, namely that a new facility began operations in 2000 and the other two facilities increased their SF_6 use by more than 30 per cent in 1999–2000.
I.15	2.C.4 Magnesium production – SF_6 (I.23, 2017) Comparability	Reallocate emissions from magnesium casting from category 2.C.7 (other metal production) to 2.C.4 (magnesium production).	Resolved. Canada has reallocated SF_6 emissions from magnesium casting from category 2.C.7 to category 2.C.4 since its 2018 submission. The reporting is explained in the NIR (part 1, p.115).
I.16	2.C.4 Magnesium production – SF_6 (I.11, 2017) (I.21, 2016) Convention reporting adherence	Improve the QA/QC procedures in order to detect such fluctuations in IEFs and provide a corresponding explanation in the NIR.	Resolved. Canada included procedures for detecting fluctuations in IEFs in its QA/QC process and reported on the existence of these procedures in its 2018 NIR (part 1, section 4.12.4, p.117). During the review, the Party provided to the ERT its general QC checklist and guidelines. Both documents include relevant steps in detecting large fluctuations (step 1.3 in the guidelines and step 4.4 in the checklist).
I.17	2.D Non-energy products from fuels and solvents use – CO_2 and CH_4 (I.12, 2017) (I.8, 2016) (I.6, 2015) (37 and 41, 2014) (47, 2013) (78, 2012) (77, 2011) Transparency	Implement the scheduled improvements for this category, reporting on progress in future inventory submissions, and continue the improvements necessary to document the methods and sources of AD and EFs in the NIR.	Not resolved. Improvements under this category were not implemented. In the NIR (part 1, section 4.13.6, p.119), Canada reported that improvements will be made when supporting information that enables the disaggregation of fuel data and their allocation to the appropriate sources becomes available. Canada stated that it plans to evaluate whether the EFs are still valid and update them if necessary (see also ID#s I.18, I.20, I.21 and I.22 below and ID# I.32 in table 5).
I.18	2.D Non-energy products from fuels and solvents use – CO_2 (I.24, 2017) Accuracy	Investigate whether the subcategory other products corresponds to paraffin wax use as defined in the 2006 IPCC Guidelines and, if that is the case, reallocate the emissions from category 2.D.3 to category 2.D.2 (paraffin wax use) and estimate emissions using the default	Addressing. Canada explained that data on paraffin wax use are not available since they are aggregated with data on non-paraffin wax. During the review, Canada stated that the data from its energy statistics are only available in an aggregated format. However, Canada did not provide a transparent explanation in the NIR on the reason why the default oxidized-during-use

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		oxidized-during-use factor from the 2006 IPCC Guidelines rather than the default carbon storage factor from the Revised 1996 IPCC Guidelines. If the subcategory other products does not correspond to paraffin wax use, then explore whether the data on paraffin wax use (as defined in the 2006 IPCC Guidelines) can be identified within the AD for subcategory 2.D.3 to allow separate reporting of the associated emissions.	factor from the 2006 IPCC Guidelines was not used.
I.19	2.D Non-energy products from fuels and solvents use – CO_2 (I.24, 2017) Accuracy	Provide a transparent description in the NIR of the assumptions and approach used in the reporting, ensuring the completeness of the reporting of CO_2 emissions for category 2.D.3.	Resolved. Canada stated in the NIR (part 1, section 4.13, pp.117–118) that the AD are obtained from Statistics Canada. A description is provided in the NIR (annex 6) of what is included under category 2.D.3, including the EFs used for this category. For additional issues regarding the methods and AD used for this category, see ID#s I.18 above and I.20, I.21 and I.22 below, and ID# I.32 in table 5.
I.20	2.D.1 Lubricant use – CO_2 (I.13, 2017) (I.22, 2016) Accuracy	Implement the methodology provided in the 2006 IPCC Guidelines for this key category by applying a factor of 0.2 to the amount of lubricants oxidized during use.	Resolved. Canada indicated in the NIR (part 1, section 4.13.2, p.118) that a tier 1 approach applying the oxidized-during-use factor is used to estimate emissions associated with lubricants. In table A6-22 of the NIR (annex 6), the Party reported that a factor of 0.2 was applied to the amount of lubricants oxidized during use. The emissions are reported under category 2.D.3 for confidentiality reasons.
I.21	2.D.1 Lubricant use – CO_2 (I.14, 2017) (I.22, 2016) Transparency	Explain in the NIR how the emissions from oxidation of lubricants during their use and due to the end of their use are estimated and in which CRF categories the emissions are reported.	Resolved. The methodology for estimating emissions from oxidation of lubricants during use has been explained in the NIR (see ID# I.20 above) and information on the EFs used is reported in table A6-22 of the NIR (part 2, annex 6). The emissions are reported in CRF table 2(I).A-Hs2 under category 2.D.3 and not category 2.D.1 for confidentiality reasons.
I.22	2.D.3 Other (non-energy products from fuels and solvent use) – other (I.15, 2017) (I.23, 2016) Accuracy	Improve the consistency of the information provided in CRF table 1.A(d) and in the IPPU sector, in particular regarding categories 2.D.3 (non-energy products from fuels and solvent use – other) and 2.B.8 (petrochemical and carbon black production).	Not resolved. Canada stated during the review that efforts to address the issue are ongoing and that it plans to include in the NIR further explanations for the differences observed between the reporting in CRF table 1.A(d) and the CRF tables for the IPPU sector and how they can be addressed in future inventories.
I.23	2.F Product uses as substitutes for ozone-depleting substances – PFCs (I.25, 2017) Convention reporting adherence	Estimate all PFC emissions in category 2.F using the 2006 IPCC Guidelines, making appropriate revisions to the NIR to reflect the use of the updated methodologies.	Addressing. Canada stated in the NIR (part 1, section 4.16, pp.124–125) the methodology used to estimate PFC emissions for categories 2.F.1 (refrigeration and air conditioning), 2.F.2 (foam blowing agents) and 2.F.5 (solvents). Emissions for category 2.F.4 (aerosols) were assumed to be negligible (see ID# I.36 in table 5). The Party reported that it used the Revised 1996 IPCC Guidelines to estimate emissions for categories 2.F.1 and 2.F.5, while the 2006 IPCC

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			Guidelines (vol. 3, section 7.1.2.2) were used to estimate emissions for category 2.F.2.
I.24	2.G.4 Other (other product manufacture and use) – CO_2 (I.26, 2017) Comparability	Reallocate emissions from urea-based catalysts from category 2.G.4 to category 2.D.3 in the next submission.	Resolved. Canada reallocated emissions from urea-based catalysts from category 2.G.3 to category 2.D.3 and explained the reporting in the NIR (part 1, section 3.13.1, p.118).
Agriculture			
A.1	3. General (agriculture) (A.11, 2017) Transparency	Provide the correct references to the sources of N excretion rates for dairy and other cattle and of the EFs for CH_4 emissions from manure management for mules and asses in the NIR.	Addressing. Canada correctly referenced table 10.19 of the 2006 IPCC Guidelines (vol. 4) as the source of the N excretion rates for other cattle in the NIR (part 2, footnote 1 to table A3-46). A reference for dairy cattle is no longer needed as the N excretion rates for dairy cattle are currently estimated on the basis of the N intake from feed and using the tier 2 methodology from the 2006 IPCC Guidelines. However, the source of the EF for CH_4 emissions from manure management for mules and asses was not included in the NIR (part 2, table A3-44).
A.2	3.B Manure management – CH_4 and N_2O (A.3, 2017) (A.12, 2016) Accuracy	Provide in the NIR the reasons why emissions from anaerobic lagoon and daily spread have not been estimated, in accordance with paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines.	Addressing. Canada reported emissions from anaerobic lagoon and daily spread as "NE" in CRF tables 3.B(a)s2 and 3.B(b), without providing a justification for reporting them as such in accordance with paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines. While the Party explained in the NIR (part 2, section A3.4.3.4) that no specific data were available on anaerobic lagoons and daily spread and they were assumed to be part of other systems, the documentation boxes in CRF tables 3.B(a)s1 and 3.B(b) state that anaerobic lagoons and daily spread may exist in Canada. However, since they are not covered in Marinier et al. (2004), which is the source of data on allocation to AWMS for Canada, they were assumed to be negligible.
A.3	3.B.4 Other livestock – CH_4 (A.12, 2017) Transparency	Provide a more detailed explanation of and/or background documentation on the assumption regarding proxies for minor livestock categories as well as on the derivation of the EFs for CH_4 emissions from manure management in the NIR.	Not resolved. Canada did not provide in the NIR a more detailed explanation of or background documentation on the assumption about proxies or the derivation of EFs for CH_4 emissions from manure management. Neither did Canada include the source of the EF for CH_4 from manure management provided in table A3-44 of the NIR (part 2, section A3.4.3.7). During the review, Canada provided an explanation for the proxies.
A.4	3.B.4 Other livestock – CH_4 (A.13, 2017) Transparency	Provide a more detailed explanation in the NIR that the reason for the apparent inconsistency between the values of VS for llamas and alpacas compared with sheep and lambs reported in the NIR and the CRF tables (although the Party assumes the same mean value for VS for all these animals) is due to the fact that the values in the NIR and CRF	Resolved. Canada provided an explanation for the apparent inconsistency between the values of VS for llamas and alpacas compared with sheep and lambs reported in the NIR (part 2, footnote 1 to table A3-36) and CRF table 3.B(a)s1. The Party explained that it assumed the same mean VS values for llamas and alpacas as sheep and lambs at the provincial level. The VS values for llamas and alpacas and sheep and lambs presented in the NIR (part 2, table A3-36) and CRF table 3.B(b) are national values

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		tables are national values calculated by weighting the provincial VS values by the population of animals in each province.	calculated by weighting the provincial VS values by the population of animals in each province. The national VS values for these two livestock categories are thus different due to their different populations in different provinces.
A.5	3.B.4 Other livestock – N_2O (A.14, 2017) Transparency	Explain in the NIR that the calculated N excretion rate for camels in CRF table 3.B(b) is different from the default value for camels in the 2006 IPCC Guidelines because it reflects the N excretion rate from llamas and alpacas (which is assumed to have the same default N excretion rate as sheep).	Not resolved. During the review, Canada explained that, because CRF Reporter did not permit a separate livestock category for llamas and alpacas to be created, it had to report emissions from llamas and alpacas with those from camels. It included a note in the documentation box to CRF table 3.B(a)s1 to explain that the category camels represents camelids, which includes llamas and alpacas. The ERT noted that this was the same approach used in the 2017 submission but the Party did not include in the 2019 NIR the additional explanation requested in the previous review report.
A.6	3.B.5 Indirect N_2O emissions – N_2O (A.15, 2017) Accuracy	Estimate indirect N_2O emissions from manure management systems due to leaching and run-off by using a tier 2 approach and by developing the value of $Frac_{LeachMS}$ on the basis of country-specific data on N run-off and leaching from manure management systems.	Addressing. Canada explained that indirect N_2O emissions from manure management systems due to leaching and run-off were estimated for dairy cattle and swine, for which country-specific information on $Frac_{LeachMS}$ was available. During the review, Canada explained that work is ongoing to obtain country-specific information on the fraction of N loss due to leaching and run-off for the other major livestock categories (non-dairy cattle and poultry). Canada explained that the new estimates will be calculated over the medium term (three to five years) owing to the complexity of obtaining the data and integrating them into a new model structure.
A.7	3.B.5 Indirect N_2O emissions – N_2O (A.16, 2017) Convention reporting adherence	Use the correct table numbers in the descriptions of various parameters in equation A3-27 (part 2, p.112, of the 2017 NIR) in the NIR and improve the QA/QC procedures to prevent the occurrence of such errors.	Addressing. The ERT noted that equation A3-27 in the 2017 NIR corresponds to equation A3-28 (part 2, p.101) in the 2019 NIR. Canada provided the correct table references for the parameters $N_{i,AWMS,}$ $N_{EX,T}$ and $Frac_{LeachMS(T,AWMS)}$ in equation A3-28. However, the ERT noted that the references for the parameter $Frac_{LeachMS(T,AWMS)}$ do not include table A3-51. Similarly, the ERT noted that the reference for the parameter $N_{EX,T}$ did not include table A3-47. The ERT therefore concluded that the QA/QC procedures had not been sufficiently improved.
A.8	3.D Direct and indirect N2O emissions from agricultural soils – N_2O (A.6, 2017) (A.9, 2016) (A.16, 2015) Completeness	Report direct N_2O emissions from sewage sludge and other organic fertilizers applied to soils.	Addressing. Canada did not report N_2O emissions from the application of sewage sludge and other organic fertilizers to soils (they were reported as "NE"). In response to a question raised by the ERT during the review, the Party explained that it has been collecting data on soil N_2O fluxes since 1990, mainly from published literature, to identify key factors, including soil properties, climatic conditions and management practices, and that this work is ongoing. Furthermore, AD on sewage sludge were collected and the associated estimates are planned to be reported in the next submission.

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			Canada addressed this issue in its improvement plan (see part 1, section 8.3, table 8-5, p.216 of the NIR). The Party plans to complete its ongoing analysis of published literature to identify key factors, including soil properties, climatic conditions, N sources and management practices to explain N_2O emissions from agricultural soils, and to re-evaluate the empirical relationship between N_2O EFs and the increases in growing season precipitation and potential evapotranspiration.
A.9	3.D.b Indirect N_2O emissions from managed soils – N_2O (A.7, 2017) (A.15, 2016) Completeness	When estimating direct N_2O emissions from application of sewage sludge and other organic fertilizers to soils, also estimate the related indirect N_2O emissions.	Addressing. See ID# A.8 above.
A.10	3.D.b.1 Atmospheric deposition – N_2O (A.8, 2017) (A.16, 2016) Comparability	Correct the reporting of $Frac_{GASM}$ in the additional information table of CRF table 3.D to correspond to the $Frac_{GASM}$ value (0.2 kg NH_3-$N+NO_X$-N/kg N) provided in the 2006 IPCC Guidelines, which was used in the inventory.	Addressing. Canada reported country-specific $Frac_{GASM}$ values of 0.18 for 2017 and 0.19 for 1990 derived from its NH_3 emission model for dairy and swine manure (see part 1, section 5.4.2, p.151, and part 2, section A 3.4.5.2., p.113, of the NIR). Calculations include volatilization losses from inorganic and organic N inputs to soils. However, Canada explained in a comment in CRF table 3.D that the $Frac_{GASM}$ value also includes the volatilization losses during the storage of animal manure. This comment is not in line with the methodological description in the NIR. The ERT recommends that Canada correct or delete this comment.
A.11	3.H Urea application – CO_2 (A.17, 2017) Transparency	Provide transparent information to substantiate the significant inter-annual variability in the CO_2 emissions from urea application for 1993–1994, 2006–2007, 2011–2012, 2012–2013 and 2013–2014 in the NIR.	Addressing. The Party provided information on the significant inter-annual variability in CO_2 emissions from urea application in the NIR in the context of N fertilizer sales, and included a comment specific to the urea component of N sales in section 5.7.3, noting that urea consumption in Canada increased significantly from 1990 to 2017 with a relatively high inter-annual variability in a range of up to ±25 per cent annually. The Party confirmed during the review that the data on fertilizer sales provided by Statistics Canada vary. However, the ERT noted that the Party did not provide in the NIR specific information on the underlying reason for the significant inter-annual variability of the data.
LULUCF			
L.1	4. General (LULUCF) (L.1, 2017) (L.2, 2016) (L.4, 2015) (59, 2014) (9 and 63, 2013) Completeness	Improve the completeness of reporting of the pools in all mandatory categories currently reported as “NE” and include a description on how the notation keys have been used.	Addressing. Canada reported some mandatory pools. However, other mandatory categories were still missing from the reporting (e.g. wetlands converted to cropland, settlements converted to cropland, cropland converted to settlements, grassland remaining grassland and grassland converted to settlements). During the review, Canada provided detailed information on its progress in reporting the missing categories. Further, Canada stated that an explanation of the reporting of “NE” for CSC

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			and emissions and removals was provided in CRF Reporter, but that it did not appear in the tables generated by the software.
L.2	4. General (LULUCF) (L.2, 2017) (L.3, 2016) (L.13, 2015) Completeness	Improve the completeness of representing land areas in the LULUCF sector by amending the reporting (both the land-use change matrix and the estimates for category-specific emissions and removals in the CRF tables) by including all land areas and making it clear which categories and subcategories occur in Canada and whether the emissions/ removals are calculated or not. This includes both managed land areas where no emissions or removals are expected (e.g. grassland remaining grassland) as well as unmanaged areas.	Addressing. Canada included in the NIR the area of cropland converted to settlements in the land-use matrix. During the review, Canada described the progress of its plan to develop AD and estimation models, particularly for wetlands converted to settlements and cropland. However, the Party did not mention a clear timeline for completing the planned improvements.
L.3	4. General (LULUCF) (L.3, 2017) (L.14, 2016) Convention reporting adherence	Provide more details in the NIR on how the CRF categories are disaggregated in the Canadian key category analysis, in accordance with paragraph 50(d)(ii) of the UNFCCC Annex I inventory reporting guidelines, particularly in relation to where emissions from biomass burning are included.	Addressing. Canada added information in the NIR (part 2, annex 1, table A1-1) on the disaggregation of categories for the purpose of the key category analysis, including emissions from biomass burning, which are included under the land-use category under which they occur. However, the Party did not provide any information on its rationale for the disaggregation.
L.4	Land representation (L.4, 2017) (L.16, 2016) Transparency	Specify in the NIR that the total land area is included in the inventory and report the land area in CRF table 4.1 separately for unmanaged forest, unmanaged grassland and unmanaged wetlands.	Addressing. Canada reported the total land area in the NIR (part 1, section 6.2) and in CRF table 4.1, but did not provide estimates for the different unmanaged land uses in the table. During the review, Canada informed the ERT that unmanaged forest areas will be reported separately in the next inventory submission. Canada also explained that unmanaged grassland and unmanaged wetlands will be reported when more reliable data become available, but did not specify a timeline for completing the work.
L.5	Land representation (L.5, 2017) (L.17, 2016) Transparency	Include in the NIR the correction of the reporting in CRF table 4.1 (to include information on annual changes) as part of the planned improvement, along with any update on the status of implementation of other parts of the ongoing project to revise and improve the consistency and completeness of the land-transition matrix.	Addressing. Since its 2017 NIR, Canada has included information on annual area changes in CRF table 4.1. Canada stated in its 2019 NIR (part 1, table 8.5) that data analysis is ongoing, and explained during the review that efforts are being made to gradually integrate the missing land use and land-use change categories into the NIR. However, the Party did not provide a detailed plan or timeline for implementing this plan or information on other consistency improvements.
L.6	Land representation – CO_2, CH_4 and N_2O (L.15, 2017) Transparency	Correct the error in the reporting of the total land area of Canada in the land-use matrix reported in CRF table 4.1 that is owing to the inadvertent error made when calculating the areas of managed and unmanaged land in land	Resolved. Canada corrected the error and consistently reported the same total land area in CRF table 4.1 for the entire time series.

ID#	*Issue classification*[a, b]	*Recommendation made in previous review report*	*ERT assessment and rationale*
		remaining in the same land-use categories.	
L.7	4.A Forest land – CO_2 (L.16, 2017) Completeness	Estimate the CO_2 emissions from drained organic forest soils by developing the peatland module for the carbon budget model of the Canadian forest sector or any other country-specific methods. Pending the development of such methods, estimate and report the CO_2 emissions using the tier 1 methodology and the default EFs in the 2006 IPCC Guidelines together with AD derived from the new statistics.	Not resolved. Canada did not report on CO_2 emissions from drained forest soils. During the review, Canada informed the ERT that it will provide estimates in its next inventory submission using the peatland drainage statistics obtained for the province of Quebec.
L.8	4.A Forest land – CO_2, CH_4 and N_2O (L.7, 2017) (L.19, 2016) Accuracy	Disaggregate the CSC in mineral and organic soils to increase transparency and comparability and ensure that the emissions are neither under- nor overestimated.	Addressing. The NIR does not contain disaggregated data on CSC in mineral and organic soils. During the review, Canada informed the ERT that a study commissioned by ECCC determined that drainage in forest land was only conducted operationally in Quebec and a tier 1 estimate of forest drainage is currently being completed. Canada explained that CSC in organic soils for the province of Quebec will be reported in its next inventory submission.
L.9	4.A.2 Land converted to forest land – CO_2 (L.8, 2017) (L.7, 2016) (L.19, 2015) Accuracy	Provide additional information on why using zero for annual area conversions to forest land for 2009–2013 is considered reasonable compared with other alternative ways to construct the time series. Continue with efforts to acquire the missing AD for land converted to forest land.	Not resolved. Canada did not report the missing AD for land converted to forest land for 2009–2013 in the NIR. During the review, and in the NIR (part 1, section 6.3.2.6), Canada explained that efforts are under way to obtain the data from provincial and territorial resource management agencies; and improvements were made to the data from Ontario for 2009–2012. However, the Party did not report a clear timeline for obtaining and reporting the AD for other provinces and territories.
L.10	4.A.2.1 Cropland converted to forest land – CO_2 (L.17, 2017) Completeness	Include the loss of the biomass in cropland in the CSC in living biomass due to conversion of cropland to forest land for all types of cropland, including abandoned cropland. If these biomass losses are already accounted for under cropland in the Century model, then the Party should transparently document how these are already accounted for in the NIR.	Not resolved. Canada did not include the initial biomass losses prior to the transition from cropland to forest land in the estimates of CSC in living biomass. Canada explained during the review that there was no loss of biomass on the basis of the assumption that there was no perennial biomass on cropland prior to its conversion to forest (see also ID# L.22 in table 5).
L.11	4.D.2.2 Land converted to flooded land – CO_2 (L.18, 2017) Accuracy	Estimate the emissions from land converted to flooded land using either the level 2 approach (country-specific EFs) or the level 3 approach (country-specific methodology) given in appendix 2 to the 2006 IPCC Guidelines, applying a set of assumptions (e.g. regarding the steady-state transition period) that are appropriate to the approach selected.	Not resolved. Canada explained that it used a country-specific (level 3) approach to estimate emissions from land converted to flooded land. Moreover, Canada reported in the NIR (part 2, figure A3–28) a country-specific decay curve with a range of 20–40 years to reach natural background emission levels. However, the steady-state transition period applied to estimate land converted to flooded land was a 10-year period, which is related to the level 2 approach, as outlined in appendix 2 to the 2006 IPCC Guidelines.

ID#	*Issue classification*[a, b]	*Recommendation made in previous review report*	*ERT assessment and rationale*
L.12	4.D.2.2 Land converted to flooded land – CO_2 (L.18, 2017) Accuracy	Classify flooded land as land converted to flooded land or flooded land remaining flooded land using a transition period consistent with the assumptions regarding the steady-state transition period used in the methodological approach selected.	Not resolved. As Canada did not modify the approach selected (see ID# L.11 above), the necessary improvements to the classification of flooded land have not yet been made.
L.13	4(III) Direct N_2O emissions from N mineralization/ immobilization and 4(IV) indirect N_2O emissions from managed soils – N_2O (L.10, 2017) (L.10, 2016) (L.24, 2015) Completeness	Estimate all the direct N_2O emissions as well as the associated indirect N_2O emissions from N mineralization or immobilization associated with loss or gain of soil organic matter. Until the estimation is implemented, provide information on the planned improvement and assessment of the quantitative impact of this missing category in accordance with the provisions in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines.	Not resolved. Canada did not report estimates from direct N_2O from N mineralization or immobilization associated with loss or gain of soil organic matter on forest land, grassland remaining grassland and settlements. Canada explained that it had assessed the impact of the soil N_2O emissions from the net soil organic carbon losses in forest land and will report the results in its next GHG inventory submission. However, the Party did not report a plan or timeline for assessing the impact of the other missing categories. In CRF table 9, the Party provided information on the allocation of direct N_2O emissions from wetlands (table 4(III)), reported as "IE". Indirect N_2O emissions from managed soils in CRF table 4(IV) were all reported as "IE" with the explanation that they were included under the agriculture sector, while any N_2O emissions associated with N leaching and run-off of N mineralized in mineral soils as a result of loss of soil organic carbon in forest land remaining forest land are considered to be insignificant.
L.14	4(V) Biomass burning – CO_2 (L.11, 2017) (L.21, 2016) Accuracy	Include indirect CO_2 emissions from atmospheric oxidation of carbon monoxide emissions due to biomass burning in CRF table 6 and exclude them from CRF table 4(V) to correct the identified double counting of indirect CO_2 from carbon monoxide emissions.	Resolved. Canada included indirect CO_2 emissions from the atmospheric oxidation of carbon monoxide emissions due to biomass burning in CRF table 6 and excluded them from CRF table 4(V). Additional information was provided in the NIR (part 1, chap. 6, p.159).
L.15	4(V) Biomass burning – CO_2 (L.12, 2017) (L.21, 2016) Transparency	More clearly explain in the NIR which source emissions are considered as indirect CO_2 and how these indirect emissions have been calculated.	Resolved. Canada explained in the NIR the emissions sources considered as indirect CO_2 and how indirect emissions were calculated (part 2, p.126 and annex 7, and part 1, chap. 6, p.156).
L.16	4.G HWP – CO_2 (L.13, 2017) (L.13, 2016) (L.22, 2015) Transparency	Include data for 1900–1940 for estimating emissions from the category HWP, as part of the improvement work in relation to the category, and consider how the uncertainty may be affected.	Addressing. Canada reported in the NIR (part 2, section A3.5.4) that historical information for 1900–1940 was included in the HWP estimates. During the review, Canada explained that this assumption took into account how the uncertainty was affected by the inclusion of this historical information. However, the Party did not provide this information in the NIR.
L.17	4.G HWP – CO_2 (L.19, 2017) Transparency	Provide in the NIR the information provided during the review on the data (disaggregated by product category) and calculations for the HWP pool together with the information on carbon inputs, carbon losses and CO_2 emissions	Addressing. Canada improved the information provided in CRF table 4.G.s1, including the information in the documentation box, and added a line showing the carbon transferred from forests to the HWP pool in figure 6.2 of the NIR (p.163). However, this is not sufficient to ensure comparability with other Parties, as

ID#	*Issue classification*[a, b]	*Recommendation made in previous review report*	*ERT assessment and rationale*
		for CRF table 4.G.s1 so as to enable the ERT to assess the comparability of Canada's reporting on the HWP pool with that of other Parties.	Canada did not provide detailed information on data and calculations for the HWP pool, including carbon inputs, carbon losses and CO_2 emissions (see ID# L.26 in table 5).
Waste			
W.1	5.A.1 Managed waste disposal sites – CH_4 (W.10, 2017) Accuracy	Include in the NIR transparent information to substantiate the use of 0.6 as the value for DOC_f, including its applicability to MSW in various regions in Canada on the basis of the new study cited examining the applicability of this value.	Resolved. See ID# W.2 below.
W.2	5.A.1 Managed waste disposal sites – CH_4 (W.10, 2017) Accuracy	If the aforementioned study (see ID# W.1 above) cannot provide evidence to substantiate the use of 0.6 as the country-specific value for DOC_f, and until such time as the Party can develop a robust country-specific DOC_f value, use the default DOC_f value of 0.5 provided in the 2006 IPCC Guidelines.	Resolved. Canada switched to using the default DOC_f value of 0.5 provided in the 2006 IPCC Guidelines for its 2018 submission.
W.3	5.A.2 Unmanaged waste disposal sites – CH_4 (W.12, 2017) Transparency	Report the correct value for DOC_f in CRF table 5.A and implement QC measures so as to avoid such errors in future inventory submissions.	Resolved. Canada changed the value for DOC_f in CRF table 5.A under category 5.A.2 (unmanaged waste disposal sites) from 43 to 50 per cent as recommended in the previous review report.
W.4	5.B.2 Anaerobic digestion at biogas facilities – CH_4 (W.4, 2017) (W.22, 2016) Completeness	Include in the NIR the approximate estimate of CH_4 emissions from anaerobic digestion at biogas facilities, to justify that the emissions are below the threshold defined in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines.	Resolved. Canada provided in the NIR (part 1, section 7.3.2) an approximate estimate of CH_4 emissions from five large anaerobic digesters known to be operating in the country. The approximate level of emissions from these identified facilities was 7 kt CO_2 eq, or 0.001 per cent of the total national emissions, thus below the threshold specified in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines. Moreover, the Party explained during the review that it is currently developing an inventory of existing anaerobic digestion facilities.
W.5	5.C.1 Waste incineration (W.5, 2017) (W.10, 2016) (W.2, 2015) (73, 2014) (83, 2013) (53, 2012) (31, 2011) Comparability	Report all emissions related to energy recovery in the energy sector.	Resolved. Canada reported all emissions related to energy recovery in the energy sector in its latest submission. Moreover, the Party improved the methodology used for calculating the emissions.
W.6	5.C.1 Waste incineration – N_2O (W.6, 2017) (W.11, 2016) (W.22, 2015) Accuracy	Either justify the continued use of the default EF from the Revised 1996 IPCC Guidelines as appropriate to Canada's national circumstances, or update the EF to that provided in the 2006 IPCC Guidelines.	Resolved. Canada applied the default EFs from the 2006 IPCC Guidelines (vol. 5, table 5.6) for MSW incineration taking into account the operation type of the incinerators (continuous and semi-continuous versus batch-type incineration).

ID#	*Issue classification*[a, b]	*Recommendation made in previous review report*	*ERT assessment and rationale*
W.7	5.C.2 Open burning of waste – CO_2, CH_4 and N_2O (W.13, 2017) Transparency	Include in the NIR documentation to justify that the emissions from open burning of MSW are below the thresholds defined in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines.	Resolved. During the review, Canada referred the ERT to the 2018 NIR (part 2, section A3.6.3.6), where an estimate of 100 kt CO_2 eq, or 0.015 per cent of the total national emissions, for 2010 was provided, which is considered to be representative of the whole time series. The ERT considered that the justification was in accordance with paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines. The ERT noted that open burning of waste is banned through regulations in most provinces and territories, and that there is only anecdotal evidence that some open burning still occurs in rural areas of the country.
W.8	5.D.1 Domestic wastewater – CH_4 (W.14, 2017) Accuracy	Implement the planned improvement aimed at collecting data on the populations served by each type of anaerobic treatment (facultative lagoons, septic systems and collected-untreated) and recalculate the CH_4 emissions from domestic wastewater treatment for the entire time series by applying the population-specific CH_4 correction factor values.	Resolved. Canada implemented the planned improvement aimed at collecting data on the percentages of the population served by different treatment types, and recalculated the CH_4 emissions from domestic wastewater treatment for the entire time series. The relevant data are presented by province in figure 7-1 and figure A3-33 of the NIR (see also ID# W.18 in table 5).
W.9	5.D.1 Domestic wastewater – CH_4 (W.15, 2017) Accuracy	Implement the planned improvement aimed at revising the percentages of the population served by different treatment types and use this information to recalculate CH_4 emissions from domestic wastewater for the entire time series.	Resolved. See ID# W.8 above.
W.10	5.D.1 Domestic wastewater – CH_4 and N_2O (W.7, 2017) (W.17, 2016) (W.12, 2015) (82, 2014) Accuracy	Justify the assumption that there is 100 per cent efficient combustion and flaring at anaerobic wastewater treatment systems servicing urban municipalities.	Resolved. During the review, Canada explained that there was an error in the 2016 submission and the text was correct in the 2018 and 2019 submissions (part 2, section A3.6.4.1.1). The NIR (part 2, section A3.6.4.1.1) stated that Canada used a tier 2 approach from the 2006 IPCC Guidelines for estimating CH_4 emissions, using country-specific factors where available, and a tier 1 method from the 2006 IPCC Guidelines for estimating N_2O emissions from wastewater.
W.11	5.D.2 Industrial wastewater – CH_4 (W.17, 2017) Accuracy	Recalculate CH_4 emissions from industrial wastewater, including the CH_4 recovery reported by all facilities, for the entire time series.	Resolved. CH_4 emissions from industrial wastewater were recalculated taking into account CH_4 recovery consistently throughout the time series. However, the ERT noted that the Party reported the same CH_4 emissions for the third consecutive year (see ID# W.20 in table 5).

[a] References in parentheses are to the paragraph(s) and the year(s) of the previous review report(s) in which the issue was raised. Issues are identified in accordance with paras. 80–83 of the UNFCCC review guidelines and classified as per para. 81 of the same guidelines.

[b] The report on the review of the 2018 inventory submission of Canada was not available at the time of the review. Therefore, the previous recommendations reflected in table 3 are taken from the 2017 inventory review report. For the same reason, 2018 is excluded from the list of review years in which the issue could have been identified.

IV. Issues identified in three successive reviews and not addressed by the Party

8. In accordance with paragraph 83 of the UNFCCC review guidelines, the ERT noted that the issues included in table 4 have been identified in three successive reviews, including the review of the 2019 inventory submission of Canada, and have not been addressed by the Party.

Table 4
Issues identified in three successive reviews and not addressed by Canada

ID#	*Previous recommendation for the issue identified*	*Number of successive reviews issue not addressed*[a]
General	No issues identified	
Energy		
E.1	Take steps to ensure that the conversion of volumes of natural gas to energy units is completed appropriately for both marketable and non-marketable natural gas. Document the progress of efforts in the improvement plan and in the NIR	5 (2014–2019)
E.4	Update CO_2 EFs where appropriate (following the plan referred to in ID# E.3 in the 2016 inventory review report (see ID# E.2 above)) and provide references for these in the NIR	3 (2016–2019)
E.5	Document all instances where the calorific values and/or the CO_2 EFs deviate from the ranges set out in the 2006 IPCC Guidelines, and provide concise explanations of the reasons for these deviations, where the reasons are understood; where the reasons are not understood, investigate them	3 (2016–2019)
E.19	Report the CO_2 emissions from underground mines as "NA" and indicate in the NIR that no CO_2 emissions associated with flaring and drainage systems of underground mines occur in the country	4 (2015–2019)
E.22	Report CO_2 and CH_4 emissions from briquette manufacturing under solid fuel transformation. If this cannot be done, use the correct notation key for solid fuel transformation ("IE" instead of "NE") and update the description in the NIR accordingly	3 (2016–2019)
E.23	Document the methodology and data sources used to estimate emissions from briquette manufacturing in the NIR	3 (2016–2019)
IPPU		
I.2	Include CO_2 emissions from ceramics production in the inventory or demonstrate that the emissions are insignificant, as defined in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines	4 (2015–2019)
I.9	Include CO_2 and CH_4 emissions from ethylene oxide production in the inventory or demonstrate that the emissions are insignificant, as defined in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines	4 (2015–2019)
I.11	Include the allocation of non-energy use of other reductants identified in this category in the improvement plan and implement steps to further disaggregate the energy statistics and other (industrial processes) category	5 (2014–2019)
I.17	Implement the scheduled improvements for this category, reporting on progress in future inventory submissions, and continue the improvements necessary to document the methods and sources of AD and EFs in the NIR	8 (2011–2019)

ID#	*Previous recommendation for the issue identified*	*Number of successive reviews issue not addressed*[a]
I.22	Improve the consistency of the information provided in CRF table 1.A(d) and in the IPPU sector, in particular regarding categories 2.D.3 (non-energy products from fuels and solvent use – other) and 2.B.8 (petrochemical and carbon black production)	3 (2016–2019)
Agriculture		
A.2	Provide in the NIR the reasons why emissions from anaerobic lagoon and daily spread have not been estimated, in accordance with paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines	3 (2016–2019)
A.8	Report direct N_2O emissions from sewage sludge and other organic fertilizers applied to soils	4 (2015–2019)
A.9	When estimating direct N_2O emissions from application of sewage sludge and other organic fertilizers to soils, also estimate the related indirect N_2O emissions	3 (2016–2019)
LULUCF		
L.1	Improve the completeness of reporting of the pools in all mandatory categories currently reported as "NE" and include a description on how the notation keys have been used	6 (2013–2019)
L.2	Improve the completeness of representing land areas in the LULUCF sector by amending the reporting (both the land-use change matrix and the estimates for category-specific emissions and removals in the CRF tables) by including all land areas and making it clear which categories and subcategories occur in Canada and whether the emissions and removals are calculated or not. This includes both managed land areas where no emissions/removals are expected (e.g. grassland remaining grassland) as well as unmanaged areas	4 (2015–2019)
L.3	Provide more details in the NIR on how the CRF categories are disaggregated in the Canadian key category analysis, in accordance with paragraph 50(d)(ii) of the UNFCCC Annex I inventory reporting guidelines, particularly in relation to where emissions from biomass burning are included	3 (2016–2019)
L.4	Specify in the NIR that the total land area is included in the inventory and report the land area in CRF table 4.1 separately for unmanaged forest, unmanaged grassland and unmanaged wetlands	3 (2016–2019)
L.5	Include in the NIR the correction of the reporting in CRF table 4.1 (to include information on annual changes) as part of the planned improvement, along with any update on the status of implementation of other parts of the ongoing project to revise and improve the consistency and completeness of the land-transition matrix	3 (2016–2019)
L.8	Disaggregate the CSC in mineral and organic soils to increase transparency and comparability and ensure that the emissions are neither under- nor overestimated	3 (2016–2019)
L.9	Provide additional information on why using zero for annual area conversions to forest land for 2009–2013 is considered reasonable compared with other alternative ways to construct the time series. Continue with efforts to acquire the missing AD for land converted to forest land	4 (2015–2019)
L.13	Estimate all the direct N_2O emissions as well as the associated indirect N_2O emissions from N mineralization or immobilization associated with loss or gain of soil organic matter. Until the estimation is implemented, provide	4 (2015–2019)

ID#	*Previous recommendation for the issue identified*	*Number of successive reviews issue not addressed*[a]
	information on the planned improvement and assessment of the quantitative impact of this missing category in accordance with the provisions in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines	
L.16	Include data for 1900–1940 for estimating emissions for the category HWP as part of the improvement work in relation to the category, and consider how the uncertainty may be affected	4 (2015–2019)
Waste	No issues identified	

[a] The report on the review of the 2018 inventory submission of Canada has not yet been published. Therefore, 2018 was not included when counting the number of successive years in table 4.

V. Additional findings made during the individual review of the 2019 inventory submission

9. Table 5 contains findings made by the ERT during the individual review of the 2019 inventory submission of Canada that are additional to those identified in table 3.

Table 5
Additional findings made during the individual review of the 2019 inventory submission of Canada

ID#	*Finding classification*	*Description of the finding with recommendation or encouragement*	*Is finding an issue?*[a]
General			
G.3	CRF tables	For all sectors, Canada reported emissions of NO_X, non-methane volatile organic compounds and sulfur dioxide as "NE", "NA", "NO" or "IE" in the CRF tables, together with a reference to annex 7 to the NIR. According to the 2006 IPCC Guidelines (vol. 1, chap. 7.2), where the country already has inventories for precursors, the results should be reported in the inventory. During the review, the Party stated that it reported "IE" for these pollutants in the CRF tables as they are included in Canada's air pollutant emissions inventory (available at https://www.canada.ca/en/environment-climate-change/services/pollutants/air-emissions-inventory-overview.html), and reported to the United Nations Economic Commission for Europe under the Convention on Long-range Transboundary Air Pollution via the Centre on Emission Inventories and Projections. However, the ERT noted that, according to paragraph 37(d) of the UNFCCC Annex I inventory reporting guidelines, "IE" is to be used for emissions by sources and removals by sinks of GHGs that were estimated but not reported under the expected category but rather included elsewhere in the inventory. Therefore, the ERT concluded that the Party's use of "IE" for precursor gases is not in accordance with the UNFCCC Annex I inventory reporting guidelines. During the review, the Party stated that it plans to continue using this approach when reporting its ozone and aerosol precursors. The ERT reiterates the encouragement from the previous review report for Canada to report numerical values for emissions of precursor gases (as reported to the United Nations Economic Commission for Europe) in the appropriate CRF tables under the relevant sectors and to ensure that it uses the notation keys in accordance with the UNFCCC Annex I inventory reporting guidelines.	Not an issue
G.4	Uncertainty analysis	Canada performed a quantitative uncertainty assessment, applying approach 1 from the 2006 IPCC Guidelines (vol. 1, section 3.2.3). The uncertainty assessment provided in the NIR (part 2, annex 2, tables A2-1–A2-2) was performed for the latest inventory year (2017) and the trend between the base year and the latest inventory year. However, according to paragraph 15 of the UNFCCC Annex I inventory reporting guidelines, the quantitative uncertainty assessment is to be performed for at least the base year and the latest inventory year, as well as the trend between these two years. During the review, the Party noted that information on uncertainty is primarily used to prioritize efforts to improve the accuracy of inventories in the future and guide decisions on selecting a methodology. Canada informed the ERT that it had implemented an established, effective process for prioritizing improvement efforts that takes into consideration the results of the uncertainty assessment. This process for prioritizing improvements includes an inventory improvement plan (see section 8.3 of the NIR). While the Party recognized that the reporting guidelines state that a quantitative uncertainty assessment must be performed for the base year, it questioned the value of quantifying uncertainty for the base year in the context of its established and effective process for improving its inventory. The ERT recommends that Canada include a quantitative uncertainty assessment for the base year for all source and sink categories in its next submission.	Yes. Convention reporting adherence
G.5	QA/QC and verification	Canada did not provide correct information on the notation keys used for the energy and the IPPU sectors in CRF table 2(I).A-Hs1 (see ID# E.7 in table 3 and ID# I.26 below), consistent information on the notation keys	Yes. Convention reporting adherence

ID#	*Finding classification*	*Description of the finding with recommendation or encouragement*	*Is finding an issue?*[a]
		used for the energy sector in CRF table 1.B.1 and the NIR (see ID# E.19 in table 3), a consistent value for average VS excretion for the agriculture sector in the NIR and relevant CRF table 3.B(a)s1 (see ID# A.17 below) or consistent information on the amount of CH_4 flared under the waste sector in the NIR and relevant CRF table (see ID# W.21 below). The Party did not provide an explanation for all of the notation keys used, in particular for the reporting of "NE" for the LULUCF sector, in CRF table 9. The ERT recommends that the Party implement additional QA/QC procedures to ensure correct use of notation keys in the CRF tables and consistency of reporting across the CRF tables and the NIR. The ERT recommends that the Party justify its use of notation keys, particularly "NE" and "IE", in CRF table 9.	
G.6	Key category analysis	Canada's NIR (part 2, annex 1, p.2) states that the CRF categories provide the basis for identifying key categories, although some categories have been aggregated for the purpose of the key category analysis. For example, Canada indicated in its NIR (part 2, annex 1, table A1-1) the category under which emissions from biomass burning in the LULUCF sector were included (i.e. the land-use category in which they occur). However, no further details on the rationale for the key category aggregation for the purpose of the key category analysis was provided in the NIR (see ID# L.3 in table 3). The ERT noted a similar lack of information for the IPPU sector. During the review, the Party agreed that its NIR could include more comprehensive information on the aggregation of categories for the key category analysis. Canada noted that, in the key category analysis, categories for which the same EFs are used on the basis of a common assumption are aggregated before the analysis. For example, Canada aggregated categories 2.F.1, 2.F.2, 2.F.3, 2.F.4, 2.F.5 and 2.F.6 under 2.F (product uses as substitutes for ozone-depleting substances) in its key category analysis. The Party stated that this information would be added to table A1-1 in the next NIR. The ERT recommends that, to improve the transparency of the reporting, Canada include in its future submissions an explanation of how individual categories have been aggregated in each sector for the purpose of the key category analysis.	Yes. Transparency
Energy			
E.26	1.A.3.a Domestic aviation – jet kerosene – CH_4 and CO_2	The IEF values reported (in CH_4 kg/TJ) for jet kerosene in category 1.A.3.a (for 2013 (1.905), 2014 (1.991), 2015 (1.853), 2016 (1.389), 2017 (1.408) and the base year (1.387) are higher than the default value (0.5 CH_4 kg/TJ) given in the 2006 IPCC Guidelines (vol. 2, table 3.6.5), and the inter-annual change from 2015 to 2016 (–25.0 per cent) is significant compared with the changes occurring between the other years in the time series. The IEF value reported (in CO_2 t/TJ) for CO_2 for jet kerosene in category 1.A.3.a for 2013–2017 (80.392) is higher than the default value (71.5 CO_2 t/TJ) given in the 2006 IPCC Guidelines (vol. 2, table 3.6.4). They were also among the highest values reported among all Parties. During the review, Canada stated that, in both cases, the GCV was applied incorrectly in the time series and that this will be corrected in the next submission; this situation does not affect the national inventory totals. (The Party reports in GVC while the 2006 IPCC default is a net calorific value. For the purpose of this comparison, all values have been converted to net calorific values.) The ERT recommends that the Party correct the application of the GCV to CH_4 and CO_2 emissions from jet kerosene under category 1.A.3.a for the entire time series and report the correct values in CRF table 1.A(a)s(3), providing an explanation of the recalculations in the NIR.	Yes. Comparability

ID#	*Finding classification*	*Description of the finding with recommendation or encouragement*	*Is finding an issue?*[a]
E.27	1.B.1 Fugitive emissions – solid fuels – underground mines – coal – CH_4	The IEF values (in CH_4 kg/t) reported for category 1.B.1.a.1.i for 2013 (0.002), 2014 (0.002), 2015 (0.002) and the base year (0.012) are lower than the IPCC default values (6.7–16.75 CH_4 kg/t) and are the lowest such values among all reporting Parties. During the review, Canada explained that the production values reported for category 1.B.1.a.1.i are in kt, and not in Mt, which is the correct reporting unit in CRF table 1.B.1, but that the reported CH_4 emissions are correct. The inconsistency in production units results in an IEF that is incorrect by a factor of 1,000. Canada stated that it will correct the reporting units for production in its next submission. The ERT recommends that the Party report the production data for category 1.B.1.a.1.i in the correct unit of measurement in CRF table 1.B.1.	Yes. Comparability
IPPU			
I.25	2. General (IPPU) – CO_2, CH_4, N_2O, HFCs, PFCs and SF_6	The Party reported in the category-specific QA/QC and verification sections of the NIR (e.g. section 4.17.4) that informal QC checks were carried out. The NIR did not describe what these checks involved. In response to a question raised by the ERT during the review, Canada explained that informal QC checks include visual checks of AD and emission trends to detect fluctuations and outliers; checks to determine the cause(s) of such fluctuations; a peer review of the calculations to ensure that equations are entered correctly and the results thereof are correctly transcribed from one cell to another; and a check to ensure that data sources and methodologies are adequately documented and hard-coded inputs in the models are replaced with formulas. The ERT encourages the Party to improve the transparency of the documentation of its QA/QC procedures when preparing its inventory by explaining the specific QC checks carried out for each category in the respective category-specific QA/QC and verification section of the NIR.	Not an issue
I.26	2.B.3 Adipic acid production – CO_2	According to the NIR (p.104), adipic acid production ceased in Canada in 2009; N_2O and CO_2 are reported as "NO" in CRF table 2(I).A-Hs1 for 2010 onward. However, CO_2 emissions are reported as "NA" for the entire time series in CRF table 2(I).A-Hs1. The ERT asked the Party to clarify the discrepancy between the information in the NIR and the CRF table. During the review, Canada stated that the notation keys will be corrected from "NA" to "NO" in CRF table 2(I).A-Hs1 for 2010 onward in its next inventory submission. The ERT recommends that, for category 2.B.3 (adipic acid production), the Party report CO_2 emissions for 2010 onward as "NO" in both the NIR and in CRF table 2(I).A-Hs1 in its next inventory submission.	Yes. Convention reporting adherence
I.27	2.B.8 Petrochemical and carbon black production – CO_2, CH_4 and N_2O	Canada reported in the NIR (p.108) that four plants producing ethylene were in operation in the country during the years reported. However, only three are mentioned in the text as having participated in a study by Cheminfo Services (2010) to estimate emissions associated with ethylene production. The ERT noted that it was unclear whether all four plants were included in the reported GHG emissions. During the review, Canada confirmed that the emissions reported for this category include all four plants and therefore the emissions reported are complete. The Party clarified that the one facility that did not participate in the study accounts for around 10 per cent of ethylene-related emissions; its emissions were estimated by applying facility-level EFs derived from the study. The ERT encourages Canada to explain in the NIR that the emissions reported for ethylene production include all plants that were in operation in Canada during the years reported.	Not an issue
I.28	2.C.4 Magnesium production – SF_6	According to the NIR (part 1, section 4.12.2), SF_6 emissions associated with magnesium-casting facilities were calculated for 1990–2004 and 2008–2009 and the data were extrapolated for 2010–2017. In the NIR (section	Yes. Accuracy

ID#	*Finding classification*	*Description of the finding with recommendation or encouragement*	*Is finding an issue?*[a]
		4.12.6), Canada stated that it will make efforts to obtain up-to-date data on SF_6 emissions from magnesium casting. During the review, the Party informed the ERT that it is taking steps to address the lack of data and plans to include new emission data and AD in the 2020 NIR. The ERT welcomes these efforts to obtain up-to-date data on SF_6 emissions from magnesium casting. The ERT recommends that the Party carry out the planned improvement to recalculate SF_6 emissions using data from companies for 2010 onward to increase the accuracy of estimated SF_6 emissions from magnesium casting and that the Party explain the recalculation in the NIR.	
I.29	2.C.4 Magnesium production – CO_2	In the NIR (part 1, pp.48 and 116), Canada reported that primary magnesium production was halted in the country in 2009. However, CRF table 2.(I)A-H reported the associated CO_2 emissions from magnesium production as "NA" instead of "NO" for 2009 onward. Although magnesium casting exists in Canada and must be reported under magnesium production (see ID# I.15 in table 3), this process only results in SF_6 emissions and is unlikely to result in CO_2 emissions. According to paragraph 37 of the UNFCCC Annex I inventory reporting guidelines, "NO" is to be reported for categories or processes that do not occur. During the review, Canada confirmed that magnesium production has not taken place since 2008, and only magnesium casting is reported. Canada explained that, since magnesium casting is still taking place and reported under this category, it considers "NA" to be the correct notation key. However, the ERT considers that the correct notation key for CO_2 emissions from magnesium production (category 2.C.4) is "NO" for 2008 onward since primary magnesium metal production does not occur in the country and the description of magnesium-casting activities (in section 4.12 of the NIR) does not indicate the use of any carrier gas processing chain. The ERT recommends that Canada correct the notation key reported in CRF table 2(I).A-H for category 2.C.4 for CO_2 emissions from "NA" to "NO" for years during which primary magnesium production did not occur. The ERT welcomes the reporting of SF_6 emissions from magnesium casting under this category.	Yes. Comparability
I.30	2.C.5 Lead production – CO_2	The NIR did not include information on category 2.C.5 (lead production). In CRF table 2(I).A-H AD and CO_2 emissions for category 2.C.5 were reported as "IE". During the review, the Party explained that lead production occurs in Canada and the country has two lead smelters. It stated that the process emissions are currently included under category 2.D.3 other (non-energy products from fuels and solvent use) since the use of reductants cannot be disaggregated. According to paragraph 37 of the UNFCCC Annex 1 inventory reporting guidelines, if there are data gaps in inventories, information on these gaps should be presented in a transparent manner. The ERT recommends that the Party improve the transparency of its reporting on this category by including a description of lead production in Canada and clarifying where the process emissions from lead production are reported in the NIR.	Yes. Transparency
I.31	2.C.6 Zinc production – CO_2	The NIR did not include information on category 2.C.6 (zinc production). In CRF table 2(I).A-H "IE" was reported for AD and CO_2 emissions for the category. During the review, Canada explained that there are three zinc smelters in Canada and that the process emissions are currently included under category 2.D.3 other (non-energy products from fuels and solvent use). Canada reported that the use of reductants cannot be disaggregated. According to paragraph 37 of the UNFCCC Annex 1 inventory reporting guidelines, if there are data gaps in inventories, information on these gaps should be presented in a transparent manner.	Yes. Transparency

ID#	*Finding classification*	*Description of the finding with recommendation or encouragement*	*Is finding an issue?*[a]
		The ERT recommends that Canada improve the transparency of its reporting on this category by including a description of zinc production in Canada and clarifying where the process emissions from lead production are reported in the NIR.	
I.32	2.D.3 Other (non-energy products from fuels and solvent use) – CH_4 and N_2O	In CRF table 2(I).A-H, "NE", "IE" and "NA" are reported for CH_4 and N_2O emissions for category 2.D.3 (other – non-energy products from fuels and solvent use). The NIR does not provide any information on non-CO_2 estimates. During the review, Canada reported that "NE" is used for category 2.D.3 (road paving with asphalt and asphalt roofing) as there is no country-specific information and, in accordance with the 2006 IPCC Guidelines (vol. 3, chap. 5), CH_4 emissions for this category are assumed to be negligible. "NA" is reported for categories 2.D.1 (lubricant use), 2.D.2 (paraffin wax use) and 2.D.3 (other – use of urea in selective catalytic reduction vehicles). "IE" is reported for category 2.D.3 (other and undifferentiated). CH_4 emissions are included under category 2.B.8 (petrochemical and carbon black production), while N_2O emissions from methanol, carbon black and ethylene production are included under category 2.B.10 (other –chemical industry). Canada stated that it would indicate in its next submission where N_2O and CH_4 emissions under category 2.D.3 are allocated, and add a reference to the specific EFs for CH_4 and N_2O in the NIR (part 2, annex 6, table A6-17, p.228). The ERT welcomes the Party's proposal to improve the transparency of its reporting on this subsector by adding additional information in its next submission.	Yes. Transparency
		The ERT recommends that Canada include in the NIR an explanation of which CH_4 and N_2O emissions are estimated, where they are allocated and, if they are not estimated, indicate this in CRF table 2(I).A-Hs1.	
I.33	2.F Product uses as substitutes for ozone-depleting substances – PFCs	In the NIR (part 1, section 4.16.2) the Party reported data on PFC use for 2008 and 2009, and used the data to extrapolate values for 2010–2017. The NIR states (section 4.16.6) that there are plans to obtain up-to-date data on PFC use. During the review, Canada confirmed that the voluntary collection of PFC data (covering 2014–2018) would start in September 2019. It stated that the inclusion of these data in future submissions will depend on the findings of the data analysis. The ERT welcomes the collection of PFC data for 2014–2018 and the Party's proposal to include a transparent description thereof in future NIRs. The ERT noted that the Party did not clarify whether it plans to fill the data gaps for 2010–2013.	Yes. Accuracy
		The ERT recommends that Canada increase the accuracy of its emission estimates reported under this category by collecting and using data on PFC use for the entire time series, including 2010–2013.	
I.34	2.G.2 SF_6 and PFCs from other product use – PFCs and SF_6	The Party did not report on the use of SF_6 and PFCs under category 2.G.2 (SF_6 and PFCs from other product use) in the NIR and reported "NA" in CRF table 2(II). During the review, the Party stated that the disaggregated categories mentioned in the 2006 IPCC Guidelines (vol. 3, section 8.3) for category 2.G.2 were not included in previous surveys of gas producers and distributors. Canada reported that it conducted an Internet search and found that SF_6 and PFCs from other product use do not seem to exist at a detectable level.	Yes. Completeness
		The ERT recommends that the Party investigate whether the SF_6 and PFC uses mentioned in the 2006 IPCC Guidelines (vol. 3, section 8.3) occur in the country. If emissions from such uses do not occur, the ERT recommends that the Party report them as "NO". If such emissions do occur, the ERT recommends that the Party estimate and report them, or, if they are considered insignificant, report them as "NE", provide in the NIR a justification for the insignificance, in accordance with paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines, and explain in CRF table 9 why these emissions are reported as "NE".	

ID#	*Finding classification*	*Description of the finding with recommendation or encouragement*	*Is finding an issue?*[a]
I.35	2.G.4 Other (other product manufacture and use) – PFCs and SF_6	The Party reported on PFCs from other contained product uses in the NIR (part 1, section 4.17.2, p.127) and in CRF table 2(II).B-H. The NIR states that this category includes PFCs used as electronic insulators and a dielectric coolant for heat transfer in the electronics industry. The NIR also states that the tier 2 EFs from the IPCC good practice guidance were applied to the data on PFC use obtained from the PFC survey to estimate PFC emissions from contained sources (in line with equation 3.54 of the IPCC good practice guidance). During the review, Canada stated that only PFCs from other contained product uses are included under category 2.G.4 in CRF table 2(II).B-H and that it would include more information on the AD used to estimate emissions under category 2.G.4 in its next submission. The 2006 IPCC Guidelines state that emissions associated with heat transfer in the electronics industry should be reported under category 2.E.1. The ERT recommends that, in accordance with the 2006 IPCC Guidelines, Canada report on PFCs used in electronic insulators and for heat transfer in the electronics industry under category 2.E.1 instead of category 2.G.4 in its next submission.	Yes. Comparability
Agriculture			
A.12	3. General (agriculture) – CH_4	Canada estimated emissions from enteric fermentation and manure management for dairy cattle, non-dairy cattle and swine on the basis of a detailed national tier 2 model that takes into account the differences between regions, subcategories of animals and production subcategories, among other factors. Canada included some references and brief explanations for the methodologies used in the NIR (part 1, sections 5.2.2 and 5.3.1.2). However, the ERT noted that the information provided in the NIR does not sufficiently explain the model used to calculate these emissions and thus does not allow the calculations to be replicated. During the review, as requested by the ERT, Canada provided two spreadsheets (one for dairy cattle enteric fermentation and one for swine manure management) with detailed information on the parameters used. The ERT noted that the information on methodologies presented in the NIR is insufficient to replicate all of the values included in the spreadsheets. In addition, owing to the limited time available during the review and the amount of information received, it was not possible for the ERT to conduct a thorough review of the estimates. The ERT recommends that Canada provide in the NIR sufficient information and data on the categorization of animal used (subcategory list and a description of the subcategories used in the estimations), AD (number of animals per province and subcategory of animal), parameters (i.e. MCF, VS, biodegradability of manure, AWMS, N excretion weight, daily weight gain, mature weight, mean winter temperature, milk production, milk fat content, percentage of females that give birth in a year, number of offspring, feed digestibility and any other parameter used in the estimations), equations and EFs used for the estimates of enteric fermentation and manure management of dairy cattle, non-dairy cattle and swine in level of disaggregation used in the estimations and explicitly explaining changes along the time series (e.g. if weight changes between subcategories and provinces, the information is requested to be reported at subcategory and region level). In addition, the ERT recommends that Canada provide clear references for the sources of the data, parameters and EFs, as well as documentation on any assumption used in the calculations following the protocol for expert elicitation included in annex 2A.1, chapter 2, volume 1, of the 2006 IPCC Guidelines. Furthermore, the ERT recommends that Canada provide a clear explanation of the rationale for selecting the various parameters and assumptions. The information provided must be detailed enough to clearly follow any estimation included in the Excel estimation files of Canada.	Yes. Transparency

ID#	*Finding classification*	*Description of the finding with recommendation or encouragement*	*Is finding an issue?*[a]
		Where Canada uses a model to obtain any parameter or EF used in the above-mentioned estimates (e.g. swine growth model), the ERT recommends that the Party provide the following information, as suggested in the IPCC document *Use of Models and Facility-Level Data in Greenhouse Gas Inventories*, to assess the model: basis and type of model (statistical, deterministic, process-based, empirical, top-down, bottom-up, etc.); application and adaptation of the model; main equations and processes; key assumptions; domain of application; how the model parameters were estimated; description of key inputs and outputs; details of calibration and evaluation with calibration data and independent data; description of the approach to the uncertainty and sensitivity analyses, and the results of these analyses; QA/QC procedures adopted; and references to peer-reviewed literature. The ERT recommends that, if the information is too extensive to be included in the NIR, even as an annex, Canada publish all of the information requested in a public methodological report and reference that document in the NIR as a source of information.	
A.13	3.A.1 Cattle – CH_4	Canada reported the average and mature weight of dairy cattle in 2001 in table A3-30 of the NIR. However, Canada did not report on daily weight gain for dairy cattle in that table, as it did for calves and replacement heifers. During the review, Canada provided a spreadsheet containing the parameters used to estimate emissions from enteric fermentation for dairy cattle. The ERT noted that, in that file, information on daily weight gain (e.g. 0.348 kg/day in 2017 in the province of Ontario) was provided for mature dairy cows under the production subcategory dairy cow – lactating. In addition, the ERT noted that daily weight gain is not affected by the quality of the feed in the calculations (e.g. the daily weight gain is 0.302 kg/day under both production subcategories "dairy cow – dry low quality feed" and "dairy cow – dry high quality feed" in the province of British Colombia in 2017). The ERT also noted that it was not possible to replicate the values in the spreadsheets on the basis of the methodological explanations and data provided in the inventory submission and during the review. During the review, Canada provided a more detailed explanation of the methodology used to estimate the weight of dairy cattle, explaining that, as the quality of the feed was not taken into account, it was not possible to differentiate the effects of the quality of feed and herd age on the growth rate. Further, Canada explained that the average weight gain in the dairy cow production category is derived from the differential weight between the dairy herd and a fully mature dairy cow. The ERT noted that, on the basis of the information included in the spreadsheet provided by Canada, replacement heifers' (dairy heifers) final weight (i.e. initial weight plus the average weight gain in the category) is equal to the mature weight of the dairy cattle (mature dairy cows). Therefore, the ERT considers that, as the replacement heifers have already reached the final mature weight of the cows, the daily weight gain in mature dairy cattle included in the spreadsheet could lead to the double counting of weight gain and, consequently, of emissions associated with the energy requirements for that weight gain. The ERT recommends that Canada provide a clear description of the production subcategories of dairy cattle in the NIR to facilitate understanding their main characteristics. The ERT also recommends that Canada provide in the NIR a clear description of the AD, parameters and methodologies used to explain the weight values of dairy cattle and describe how these values can be replicated. The ERT further recommends that Canada provide in the NIR a transparent justification of the daily weight gain of mature dairy cows. Finally, the ERT recommends that Canada explain in the NIR why there is no change in the average daily weight gain linked to feed quality.	Yes. Transparency

ID#	*Finding classification*	*Description of the finding with recommendation or encouragement*	*Is finding an issue?*[a]
A.14	3.A.1 Cattle – CH_4	Canada did not report in the NIR the values of the parameters used in the tier 2 estimation of enteric fermentation for dairy and non-dairy cattle. During the review, Canada provided a spreadsheet with the values of the parameters used for estimating emissions from enteric fermentation for dairy cattle. The ERT noted that, in that file, the parameter C_a was reported using a different value for the same animal and production subcategory depending on the region (e.g. the C_a for "dairy heifers – pasture" for 2017 is 0.17 for New Brunswick, Newfoundland and Labrador, Prince Edward Island and Sakatchewan, and 0 for other regions). During the review, Canada stated that the C_a values used are taken from Boadi et al. (2004), but did not provide a reference to the exact source of the data in the NIR. It explained that a C_a of 0 in the pasture subcategory in the spreadsheets indicates that there were no animals in this production subcategory in the corresponding province. The ERT noted that the reference and explanations provided do not allow the emission estimates to be replicated. The ERT also noted that, according to the data in Boadi et al. (2004) (table 2, p.28), in Ontario 75 per cent of replacement heifers are located on pastures (four months), free stalls or tie stalls or are loose, but in the spreadsheets provided by Canada the C_a is reported as 0. However, the ERT noted that, also on the basis of the data in Boadi et al. (2004) (table 2, p.28), in Newfoundland replacement heifers are located in barns during winter and pastures during summer, but the C_a was reported as 0.17 in the spreadsheets provided. The ERT considers that the calculation procedure is not transparent or consistent. The ERT recommends that Canada provide a clear description of the production subcategories of cattle in the NIR to facilitate understanding their main characteristics. The ERT also recommends that Canada provide quantitative and qualitative information on the values used for all parameters involved in the tier 2 estimation of enteric fermentation at the regional level, including detailed references to the sources of the information and assumptions used. Finally, the ERT recommends that Canada ensure consistency when determining the parameters by region and animal type by developing a transparent protocol by which to assign the values and revise the estimates, when appropriate.	Yes. Accuracy
A.15	3.A.4 Other livestock – CH_4	Canada reported in the NIR (part 2, p.83) that the EF for enteric fermentation for sheep is used for llamas and alpacas. During the review, the Party explained that the EF for llamas and alpacas is the same value as that used for alpacas from table 10.10 of the 2006 IPCC Guidelines. Canada also explained that it does not have statistics on the proportion of llamas to alpacas, and therefore used the closest available default tier 1 EF. The ERT noted that, according to the footnote to table 10.10 of the 2006 IPCC Guidelines, approximate EFs should be developed using a tier 1 EF for an animal with a similar digestive system and then scaled using the ratio of the weight of the animal raised to the power of 0.75. The ERT also noted that, in table 10.10 of the 2006 IPCC Guidelines, the default live weight of alpacas in developed countries is 65 kg, but Canada reported a live weight of 122 kg for llamas and alpacas in table A3-48 (part 2, p.100) of the NIR. The ERT recommends that Canada estimate the enteric fermentation EF for llamas and alpacas on the basis of the proportion of llamas to alpacas (using statistics or expert judgment), using the EF for alpacas from table 10.10 of the 2006 IPCC Guidelines and estimating an approximate EF for llamas on the basis of the EF for alpacas and the weight of llamas.	Yes. Accuracy
A.16	3.B Manure management – CH_4	Canada reported the MCFs for dairy cattle and swine in table A6-33 (part 2, p.235) and for other animals in table A6-32 (part 2, p.234) of the NIR. The MCFs for dairy cattle and swine are based on the values included in table 10.17 of the 2006 IPCC Guidelines at a fixed average annual temperature of 12 °C (cool climate). The MCFs for other animals are based on tables 10A.5–10A.9 of the 2006 IPCC Guidelines at a fixed average	Yes. Accuracy

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		annual temperature of 12 °C (cool climate). During the review, Canada explained that this temperature was not used in the calculation, noting that, in all regions in Canada, the average annual temperature is below the range proposed in the 2006 IPCC Guidelines (10–28 °C). Canada did not provide average temperatures for each region for 1990–2017, as requested by the ERT during the review. The ERT noted that, according to the 2006 IPCC Guidelines (vol. 4, p.10.43), areas with extreme average annual temperatures outside the 10–28 °C range should utilize the end-of-range values (i.e. 10 or 28 °C) or consider developing country-specific values. The ERT noted that the approach used by the Party could result in an overestimation as the Party uses a temperature of 12 °C instead of 10 °C (i.e. the end-of-range value given in the 2006 IPCC Guidelines). The ERT recommends that Canada construct a time series of average temperatures for each region for 1990–2017 and use MCFs for all animals on the basis of those average annual temperatures and in line with the 2006 IPCC Guidelines (i.e. using the 10 °C value if the average annual temperature is below 10 °C).	
A.17	3.B.2 Sheep – CH_4	Canada reported 0.63 kg/head/day as the average VS daily excretion in 2017 for sheep and lambs in the NIR (part 2, table A3-36, p.88) and 0.6055 kg dry matter/head/day in CRF table 3.B(a)s1. During the review, Canada noted that the value in table A3-36 was incorrect and the value in CRF table 3.B(a)s1 was correct. The ERT recommends that Canada report the correct average VS daily excretion for sheep and lambs in the NIR.	Yes. Convention reporting adherence
A.18	3.B.3 Swine – N_2O	Canada reported in the NIR (part 2, section A3.4.4.1) that it uses the values in table 10.19 of the 2006 IPCC Guidelines and the mass of the animals to estimate the N excretion rate for swine. During the review, Canada provided a spreadsheet with the estimation parameters for N_2O emissions from manure management for swine. The ERT noted that, in that file, the value for the default N excretion rate for market swine is 0.53 kg N/1,000 kg animal mass/day. (Canada's subcategories are pig <20 kg, pig 20–60 kg and pig >60 kg.) However, the value given in table 10.19 of the 2006 IPCC Guidelines for market swine in North America is 0.42 kg N/1,000 kg animal mass/day. During the review, Canada explained that the excretion rate for market swine used was calculated using the values given in table 10.19 of the 2006 IPCC Guidelines for the market swine category (0.24 kg N/1,000 kg animal mass/day) and for total swine (0.50 kg N/1,000 kg animal mass/day) and weighting them using the proportion indicated in the footnote (i.e. 90 per cent market swine and 10 per cent breeding swine). The ERT noted that Canada did not justify why the value for breeding swine in table 10.19 of the 2006 IPCC Guidelines is considered appropriate, whereas the value for market swine is not. The ERT also noted that 0.24 kg N/1,000 kg animal mass/day is the value for breeding swine and not for market swine, as was stated by Canada in its response. Finally, the ERT considers that the methodology proposed by Canada is in line with the 2006 IPCC Guidelines for estimating the average N excretion for all categories of swine, but not for estimating market swine N excretion. The ERT recommends that Canada correct its estimates of the N excretion rate of market swine by using the appropriate value for market swine given in table 10.19 of the 2006 IPCC Guidelines, or provide documented and supported information for the assumptions regarding the erroneous values proposed in table 10.19 of the 2006 IPCC Guidelines.	Yes. Accuracy
A.19	3.B.3 Swine – CH_4	Canada explained in the NIR (part 2, p.87) that the VS for swine are estimated on the basis of the values in Marinier et al. (2004) using the tier 2 approach from the 2006 IPCC Guidelines. Canada explained that the typical animal mass was used to convert the temporally fixed VS into units of VS per 1,000 kg body weight (kg VS per 1,000 kg animal mass per day), which are applied to the full animal mass time series. During the	Yes. Transparency

ID#	Finding classification	Description of the finding with recommendation or encouragement	Is finding an issue?[a]
		review, Canada provided two spreadsheets containing the parameters used to estimate emissions from manure management for swine. The ERT noted that the values included in the spreadsheet for the VS per animal mass do not match the values included in the referenced document by Marinier et al. (2004). For example, for Alberta in 2017, the spreadsheet reports 0.103, 0.213 and 0.410 kg VS/1,000 kg animal mass/day for the production categories pig <20 kg, pig 20–60 kg and pig >60 kg, respectively, while Marinier et al. (2004) reports (table 20, p.19) 0.05, 0.23 and 0.36 kg VS/1,000 kg animal mass/day. The ERT noted that the methodological information provided in the NIR and in the spreadsheets is not sufficient to identify the steps, equations and exact parameters used to estimate the VS or to replicate the reported values. The ERT recommends that Canada provide in the NIR a detailed description of the methodologies used in estimating the VS of swine, as well as the values of the parameters by subcategory and region (i.e. weight, weight gain, VS and any other parameter used) and explicit references to the sources of data (i.e. document, page, table, row and column). Where the Party uses assumptions for the selection of the parameters, the ERT recommends that it provide detailed information on the assumptions in line with the protocol for expert elicitation included in annex 2A.1, chapter 2, volume 1 of the 2006 IPCC Guidelines.	
A.20	3.B.5 Indirect N_2O emissions – N_2O	Canada reported $Frac_{GasMS}$ in the NIR for dairy cattle (part 2, table A3-50) and swine (table A3-51). However, it did not provide the source of these values. During the review, Canada explained that instead of using the fixed $Frac_{GasMS}$ factor from the 2006 IPCC Guidelines, it calculated the values using the time series of country-specific volatilization factors by manure system type proposed by Sheppard et al. (2010). $Frac_{GasMS}$ is defined in the 2006 IPCC Guidelines (vol. 4, section 10.5.1) as the percentage of managed manure N for the livestock category that volatilizes as NH_3 and NO_X in manure management systems. However, the values from Sheppard et al. (2010) only include volatilization as NH_3 and the values for $Frac_{GasMS}$ provided by Canada are significantly lower than the IPCC default values. During the review, Canada acknowledged that the reported $Frac_{GasMS}$ only includes NH_3 volatilization, and explained that the total effect of including NO_X volatilization in emissions is expected to be minor on the basis of some rough estimates. The ERT recommends that Canada estimate the percentage of managed manure N for the livestock category that volatilizes as NH_3 and NO_X taking into account the volatilization of both NH_3 and NO_X in line with the 2006 IPCC Guidelines.	Yes. Accuracy
A.21	3.G Liming – CO_2	Under category 3.G (liming) Canada only reports AD and CO_2 emissions for limestone use (in CRF table 3.G-I). For dolomite use, Canada reported "IE". However, the documentation box states that emissions from limestone include dolomite, and that an adjusted EF of 0.1224 was used to account for dolomite. In the NIR (part 2, section A3.4.8.1), Canada noted that the ratio of dolomite was derived on the basis of an expert consultation with the Canadian Fertilizer Institute. However, no AD on limestone and dolomite use are presented in the NIR. In response to a question raised by the ERT during the review, Canada explained that it does not have consistent AD throughout the time series to quantify the amounts of limestone and dolomite independently, and therefore developed a weighted EF based on the estimated proportion of limestone and dolomite derived from the expert consultation with the Canadian Fertilizer Institute. The limestone EF of 0.12 and dolomite EF of 0.13 were weighted, resulting in a national EF of 0.1224. Canada also explained that it reports "IE" for dolomite because limestone and dolomite emissions are calculated together and reported under limestone. The ERT concluded that Canada reflected its assumptions about limestone and dolomite use in the IEF for limestone use.	Yes. Comparability

ID#	*Finding classification*	*Description of the finding with recommendation or encouragement*	*Is finding an issue?*[a]
		For transparency and comparability reasons, however, the ERT recommends that Canada develop the underlying AD time series for limestone and dolomite, for example, by using the ratio of limestone to dolomite used to calculate the weighted EF, and use the corresponding IPCC default EFs separately for limestone and dolomite, as specified in the 2006 IPCC Guidelines (vol. 4, section 11.3.2). The ERT recommends that Canada report separately the emissions from limestone and dolomite assumed to be applied to soils in CRF table 3.G-I in its next submission.	
LULUCF			
L.18	Land representation – CO_2, CH_4 and N_2O	For all years, for the land-use categories cropland, grassland (managed), wetlands (managed) and settlements reported in the land-use matrix (table 4.1), the final area reported for a given category differs from the initial area reported for the subsequent year for the same category. The ERT analysed the time series 2011–2017 and found that, for cropland, there was an increase of 500,130 ha between the initial area in 2011 to the final area in 2017, but Canada only reported 47,330 ha in the land-use matrices reported in CRF table 4.1, while the rest went unreported. For grassland (managed), the area decreased by 215,570 ha from the initial area in 2011 to the final area in 2017, but the Party did not report an area change in the land-use matrices for any of the years. For wetlands (managed), the area decreased by 41,300 ha, but Canada reported a net increase in the area of managed wetlands of 38,040 ha during the same period. For settlements, the area increased by 64,870 ha, but Canada reported a net increase in the land-use matrices of 263,790 ha. For settlements, the annual increase in area reported in the land-use matrices is more or less counterbalanced by a similar annual loss in the area of settlements that went unreported. During the review, Canada explained that those differences occurred because it only reported managed land for grassland, wetlands and settlements, and not total areas, while for cropland this was due to the interpolation and extrapolation processes that take place between different agricultural censuses. However, the ERT noted that these differences are significant and, in many cases, the changes between the years are much larger than what is reported in the land-use matrices. Furthermore, the differences are more or less consistent in size and direction for all of the investigated years. As some of these land-use changes are associated with emissions and removals, it is important that they are reflected not only in the land-use matrices but also in CRF tables 4.B, 4.C, 4.D and 4.E. The ERT recommends that Canada ensure that, for all years and all land-use categories in its land-use matrix, the values reported for year X–1 in the "final area" row in CRF table 4.1 equal the values reported in year X in the "initial area" column to improve the consistency of the land use and land-use change reported and ensure consistency with the area changes reported in the sectoral background tables. The ERT also recommends that the Party recalculate the associated emissions and removals, where appropriate. The ERT further recommends that Canada explain in the NIR the reason for recalculating the associated GHG emissions and removals as a result of the land-transition matrices being revised.	Yes. Accuracy
L.19	4.A.1 Forest land remaining forest land – CO_2	Canada considered all stand-replacing forest fires in managed lands as wildfires and natural disturbances and all associated emissions and subsequent removals as non-anthropogenic (NIR, part 2, section A3.5.3.). Consequently, Canada excluded all emissions and subsequent removals associated with these events from the GHG estimates reported for managed forest land. However, the NIR does not justify the assumption that anthropogenic stand-replacing fires do not occur in Canada and that past and present human activities have no impact on emissions and removals associated with such disturbances. During the review, Canada explained that it considers wildfires as natural disturbances that are part of the forest ecological cycle, regardless of their origin.	Yes. Transparency

ID#	*Finding classification*	*Description of the finding with recommendation or encouragement*	*Is finding an issue?*[a]
		During the review, the Party also explained that 97 per cent of the total area burned across the country is caused by wildfires originating from lightning, and provided supporting references to documents and statistics. It further explained that it was not possible to differentiate between natural and anthropogenic fires. However, the ERT noted that analyses of the anthropogenic influence on wildfire activities were conducted by Robinne et al. (2016) for the province of Alberta. Further, no information was reported in the NIR on the impact of past and present human activities on the emissions and removals associated with wildfires or on how that anthropogenic component is identified and quantified (see the 2006 IPCC Guidelines, vol. 1, chap. 1, p.4).	
		The ERT recommends that Canada include and document its justification for the assumption that all emissions and subsequent removals due to stand-replacing fires in managed forest land are not anthropogenic. The ERT also recommends that Canada include information on how these non-anthropogenic circumstances, which are the source of significant emissions, are beyond the control of, and not materially influenced by the country, and tend to average out across time, as described in the managed land proxy definition.	
L.20	4.A.1 Forest land remaining forest land – CO_2	In the NIR (part 1, chap. 6, p.160), Canada explained that under forest land it included all managed forest areas comprising areas of anthropogenic impacts and areas of natural disturbance impacts. Canada also explained in the NIR (part 1, chap. 6, p.163) that estimates of net removals from forest land excluded impacts of non-anthropogenic natural disturbances (wildfires, insect infestations and windthrow) and that stands affected by a natural disturbance are excluded from the reporting until they reach commercial maturity for a given region. In response to a question raised by the ERT during the review, Canada explained that the total area of managed forest is reported in CRF table 4.A, but only the anthropogenic emissions and removals are reported in the same CRF table, with emissions and removals from natural disturbances reported in chapter 6 of the NIR. The ERT noted that reporting the total managed land in CRF table 4.A, but only the emissions and removals from anthropogenic activities, makes it difficult to replicate and assess the estimates.	Yes. Transparency
		The ERT recommends that Canada improve the transparency of its reporting by further disaggregating the AD on each forest land subdivision in CRF table 4.A with a row for forest land not affected by natural disturbance and a row for forest land affected by natural disturbance, and include in the NIR a land-use matrix that shows the annual changes of areas of forest land that qualify as being subject to natural disturbances, together with a table containing their emissions and removals.	
L.21	4.A.1 Forest land remaining forest land – CO_2	Since its 2017 submission, Canada has implemented an approach that excludes the impacts of non-anthropogenic natural disturbances from estimates of net removals from forest land. In the chapter on the energy sector of the NIR (part 2, p.242), Canada explained that the carbon emitted as CO_2 during forest fires is considered in the forest carbon balance. During the review, Canada clarified that the NIR text had not been updated to reflect the implementation of the new methodology, and would be modified in the next inventory submission.	Yes. Convention reporting adherence
		The ERT recommends that Canada update the text in the NIR chapter on the energy sector which states that carbon emitted as CO_2 during forest fires is considered in the forest carbon balance in order to prevent misunderstanding and improve the consistency of its reporting.	
L.22	4.A.2.1 Cropland converted to forest land – CO_2	In CRF table 4.A for cropland converted to forest land in subcategory RZ15, Canada reported areas of mineral soils and net CSC in soils for those areas for 2016 and 2017. However, CSC for living biomass, deadwood and litter are reported as "NO". For previous years and the same subcategory, CSC for living biomass, deadwood and litter were reported. During the review, Canada explained that net CSC in living biomass and dead organic	Yes. Accuracy

ID#	*Finding classification*	*Description of the finding with recommendation or encouragement*	*Is finding an issue?*[a]
		matter were related to residual emissions (and small subsequent removals) owing to afforestation events during 1992–1996 and very small conversions in 2003–2004 and, consequently, they were almost zero for those years. Canada also explained that the living biomass of the cropland present before the conversion was assumed to be zero when the afforestation occurred. The ERT noted that that assumption is correct when applying the tier 1 methodology from the 2006 IPCC Guidelines. However, as Canada applied a country-specific model for estimating and reporting biomass stock changes, it should follow the tier 3 methodology guidance provided in the 2006 IPCC Guidelines (vol. 4, chap. 2, p.2.20). The ERT also noted that, for the years when the activity occurred but emissions from the pool were zero, the correct notation key is "NA" rather than "NO" and (see ID# L.10 in table 3).	
		The ERT recommends that Canada report carbon losses due to the conversion of cropland to forest land applying at least a tier 2 methodology using default values provided in the 2006 IPCC Guidelines for biomass in annual cropland for years when cropland is converted to forest land and if the analysis demonstrates that the likely level of emissions meets the criteria in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines use the notation key "NE", and, for years when conversion did not occur, if emissions or removals did not occur in those pools, report them as "NA".	
L.23	4.D.2.2 Land converted to flooded land – CO_2	In CRF table 4.D Canada reported organic soil areas as "NO" for some subdivisions of other land converted to flooded land for several years (e.g. 2009, 2014, 2015, 2016 and 2017), but reported the net CSC in organic soils for those areas as "IE". During the review, the Party explained that the use of "IE" for organic soils when there was no activity in a specific year was an inputting error in the CRF tables, which will be corrected in the next inventory submission.	Yes. Convention reporting adherence
		The ERT recommends that Canada correct the error in its reporting of emissions from organic soils (i.e. reporting CSC in organic soils for some subdivisions of other land converted to flooded land as "IE", when area of organic soils is reported as "NO", instead of reporting it as "NO"). The ERT encourages Canada to use the Wetlands Supplement when preparing its future annual inventories for land converted to flooded land.	
L.24	4.G HWP – CO_2	In line with a recommendation from a previous ERT in 2015, data for 1900–1940 for estimating emissions from HWP were included in the GHG inventory (see ID# L.16 in table 3). Moreover, Canada explained in the NIR (part 2, section A3.5.3) that this information on historical harvests was obtained from historical commodity production data from Statistics Canada. However, no information on the approach or methods applied for calculating and reporting the pool was reported in the NIR or in the CRF tables. During the review, Canada explained that the calculation was made by extrapolating production data for 1941–1989, while the consumed and exported magnitudes were calculated using average proportions from statistics for the five-year period from 1961 to 1965.	Yes. Transparency
		The ERT recommends that Canada include in the NIR a clear explanation of the assumptions and methods applied for estimating emissions from HWP for 1900–1940.	
L.25	4.G HWP – CO_2	Canada reported on category 4.G using the simple decay approach and a country-specific model (National Forest Carbon Monitoring, Accounting and Reporting System for Harvested Wood Products). Using this approach, Canada tracked and reported HWP produced and consumed domestically and exported to other parts of the world. Canada explained in the NIR (part 2, annex 3.5, p.138) that the exported products considered were sawn wood and other industrial round wood, wood-based panels, and paper and market pulp. However, the	Yes. Transparency

ID#	*Finding classification*	*Description of the finding with recommendation or encouragement*	*Is finding an issue?*[a]
		ERT noted that information on how emissions from the export of wood chips and pellets were taken into account was not provided in the NIR, which could have resulted in emissions being underestimated. In response to a question raised by the ERT, Canada explained that emissions from exports of wood chips and pellets were not included owing to a lack of information on firewood produced in the country. However, it clarified that all wood transferred from the forest to the HWP pool is included in the HWP model, but some of the products associated with parts of the wood, such as wood chips and pellets, were not explicitly identified. Canada also explained that a project is ongoing aimed at improving the firewood AD used for the LULUCF inventory in order to better identify the sources and volumes of firewood produced. The ERT recommends that Canada improve the transparency of its reporting by including in the NIR the explanation and clarifications on the treatment of firewood in the HWP model provided during the review, and include information on the amount of wood chips and pellets exported and revise the emission estimates, if needed, when new information on sources and volumes of firewood produced become available.	
L.26	4.G HWP – CO_2	Canada reported on the transfer of carbon from managed forests to wood products solely under category 4.G (in addition to the CO_2 emissions from the manufacturing, use and disposal of wood products), and did not report them as losses from the living biomass pool in CRF tables 4.A–4.F. Furthermore, Canada reported the net emissions and removals from HWP in CRF table 4.Gs1 using the simple decay approach and a country-specific model. Owing to the structure of the CRF tables and the different approach used by Canada compared with other Parties to estimate HWP emissions, it is difficult to interpret the data provided in CRF table 4.Gs1 and compare them with those of other countries. During the review, Canada explained the assumptions it used to complete the table and how to interpret the information provided therein. The ERT recommends that Canada improve the transparency of its reporting by including in the NIR and the documentation box to the CRF tables a detailed explanation of the origin of the data for each column in table 4.Gs1 and the assumptions used.	Yes. Transparency
L.27	4.G HWP – CO_2	For estimating CO_2 emissions from use and disposal of HWP, Canada applied different half-life parameters (years) to HWP in use, which were listed in table A3-68 of the NIR. Regarding firewood, Canada explained in the footnote to that table that all firewood is combusted in the year of collection (instantaneous oxidation) in line with the assumptions used in the energy sector. However, the ERT noted that firewood was included in table 6-7 of the NIR as well as in CRF table 4.Gs1 with a half-life value of one year. During the review, Canada confirmed the assumption of instantaneous oxidation for firewood and explained that the half-life value of one year reported was an error and will be corrected in its next inventory submission. The ERT recommends that Canada include the correct half-life parameters for firewood in the NIR and the CRF tables.	Yes. Comparability
Waste			
W.12	5.A Solid waste disposal on land – CH_4	In the NIR (part 2, section A3.6.4.1.1), Canada explained that sludge from municipal wastewater treatment is typically either disposed to landfill, applied to soils or incinerated, and emissions from the disposal of municipal and industrial sludge are estimated and accounted for under the MSW landfill categories. However, it was not clear to the ERT how emissions from landfilled sludge were included in the inventory. During the review, the Party explained that, contrary to what is stated in the NIR, sewage sludge had not yet been included	Yes. Accuracy

ID#	*Finding classification*	*Description of the finding with recommendation or encouragement*	*Is finding an issue?*[a]
		in the estimates of emissions from landfills. In response to an encouragement from a previous review report, Canada stated that a detailed waste balance of sewage sludge will be provided in the future. The ERT recommends that Canada implement its plan to collect data on landfilled sewage sludge, include it in its model for estimating emissions from landfills and report the resulting emissions in future submissions.	
W.13	5.A.1 Managed waste disposal sites – CH_4	Under category 5.A.1.a (managed waste disposal sites), the value for DOC_f is reported as 0.5 (i.e. as a fraction). However, CRF table 5.A requires DOC_f to be reported as a percentage (50 per cent), in the same way as it is reported for category 5.A.2. The ERT recommends that Canada report the same values consistently as a percentage within the same CRF table.	Yes. Comparability
W.14	5.A.1 Managed waste disposal sites – CH_4	According to the NIR (part 2, p.177) Canada used equation A3-87 for estimating the DOC content of waste. The ERT noted that rubber and leather are included in this equation with a DOC value of 39 per cent. However, the 2006 IPCC Guidelines (vol. 5, p.2.11) state that ash, dust, rubber and leather also contain certain amounts of non-fossil carbon that hardly degrades. During the review, the Party explained that the default DOC value of 39 per cent for rubber and leather from the 2006 IPCC Guidelines was used and no additional information on the DOC content is available. The ERT recommends that Canada either provide in the NIR additional information that supports the assumption that biogenic carbon from rubber and leather would degrade in disposal sites, or include the estimated DOC of rubber and leather in the first order decay model used for calculating CH_4 emissions from landfills.	Yes. Accuracy
W.15	5.A.2 Unmanaged waste disposal sites – CH_4	In the NIR (part 2, section A3.6.1.3.2) the Party stated that the default recommended OX of 0.1 from the 2006 IPCC Guidelines is also applied for wood waste landfills. However, Canada reported wood waste landfills under category 5.A.2. For unmanaged SWDS, the IPCC default value of OX is 0 (2006 IPCC Guidelines, table 3.2). During the review, the Party explained that, owing to the unique nature of wood waste composition (solely surplus wood residues from sawmills and/or pulp and paper operations), it believes that the top layer of the landfill can act as a medium for methanotrophic bacteria, which in effect act as a landfill cover. Thus, it considered the default OX value of 0.1 (managed waste disposal sites covered with CH_4 oxidizing material) to be more appropriate under these circumstances. However, according to the 2006 IPCC Guidelines (vol. 5, p.3.15), the use of the OX of 0.1 is justified for covered, well-managed SWDS to estimate both diffusion through the cap and escape through cracks and fissures. The ERT recommends that Canada either justify in the NIR applying the default OX for well-managed SWDS together with the default CH_4 correction factor for unmanaged SWDS, or use the default value of OX (0) for unmanaged waste disposal sites.	Yes. Accuracy
W.16	5.C.1 Waste incineration – CO_2	Canada reported CH_4 and N_2O emissions from sewage sludge incineration. CO_2 emissions were not estimated despite the 2006 IPCC Guidelines (vol. 5, table 5.2) containing default carbon content values for sewage sludge. AD were reported for dry weight, whereas the column header of CRF table 5.C indicates “kt wet weight”. During the review, the Party expressed its willingness to calculate CO_2 emissions from sewage sludge incineration and, although these are not included in the national total owing to their biogenic origin, report these emissions for the sake of completeness. The ERT agrees that CO_2 emissions from sewage sludge of biogenic origin should not be included in the national total, but recommends that Canada report CO_2 emissions from sewage sludge incineration in CRF	Yes. Completeness

ID#	*Finding classification*	*Description of the finding with recommendation or encouragement*	*Is finding an issue?*[a]
		table 5.C under "biogenic" as a memo item in its next submission by reporting emission values (rather than reporting them as "NE"), and ensure that AD are reported in a consistent manner (either in line with the column header of CRF table 5.C (kt wet weight) or in a comment specifying that the AD refer to the dry weight).	
W.17	5.D Wastewater treatment and discharge – CH_4	Canada reported "NA" for the AD (total organic product, degradable organic component) for both municipal and industrial wastewater in CRF table 5.D, whereas the NIR (part 2, p.193) states that per capita organic loading to wastewater and the population served by treatment type are the primary AD for estimating CH_4 emissions. During the review, Canada explained that AD were omitted in error from the CRF table, and provided the ERT with estimates of the degradable organic component for 2017 (i.e. 803.91 kt BOD (five-day test) and 260.8 kt chemical oxygen demand for municipal and industrial wastewater, respectively).	Yes. Transparency
		The ERT recommends that Canada include the total organic product in CRF table 5.D for both municipal and industrial wastewater in its next submission.	
W.18	5.D Wastewater treatment and discharge – N_2O	In CRF table 5.D, under additional information, Canada reported "NO" for the fraction of N in protein. However, the default value of 0.16 kg N/kg protein (2006 IPCC Guidelines, vol. 5, p.6.25) was used in the calculations, as reported in the NIR (part 2, equation A3-105, p.198). During the review, Canada confirmed that it used the default value of 0.16 kg N/kg protein.	Yes. Comparability
		The ERT recommends that Canada report in CRF table 5.D the value used for the fraction of N in protein in its next submission.	
W.19	5.D Wastewater treatment and discharge – N_2O	Although the NIR (part 2, p.A3.6.4.1.1) states that emissions from the application of sludge to soils were estimated and accounted for under agriculture, both N_2O emissions from sewage sludge applied to soils and the relevant AD (N input from sewage sludge applied to soils) were reported as "NE" in CRF table 3.D (see ID# A.8 in table 3). During the review, the Party confirmed that it did not include emissions from sewage sludge applied to soils in the inventory, but plans to include them.	Yes. Transparency
		The ERT recommends that if the planned improvement to report emissions from sewage sludge applied to soils under the agriculture sector (see ID# A.8 in table 3) is delayed, Canada remove the reference to the agriculture sector from the wastewater chapter of the NIR.	
W.20	5.D.1 Domestic wastewater – CH_4	The NIR (part 2, p.195) states that municipal treatment systems serve both people and industrial users. Equation 6.3 from the 2006 IPCC Guidelines contains a correction factor for additional industrial BOD discharged into sewers with a default value of 1.25 for collected wastewater. However, this correction factor was not included in equation A3-101 in the NIR (part 2, p.195), and therefore it was not clear whether the additional industrial organic load was taken into account when calculating the organic load and CH_4 emissions for domestic wastewater treatment.	Yes. Accuracy
		During the review, Canada explained that the correction factor for industrial load was not included in the calculations, partly for historical reasons and partly on the basis of preliminary analysis of available BOD (five-day test) values received in the influent at wastewater treatment facilities. However, the Party pointed out that new data (received after completion of the 2019 inventory) from a greater number of wastewater treatment facilities, including in more industrialized regions, indicated that the mean organic loading received at wastewater treatment facilities could be higher.	

ID#	*Finding classification*	*Description of the finding with recommendation or encouragement*	*Is finding an issue?*[a]
		The ERT recommends that Canada either include the default industrial correction factor in the total organic product (BOD, five-day test) calculation for collected wastewater, or use country-specific values on the basis of the analysis of new data from wastewater treatment plants in future submissions.	
W.21	5.D.1 Domestic wastewater – CH_4	The ERT commends Canada for implementing its planned improvement to revise the percentages of the population served by different types of wastewater treatment. The results were presented in figures 7-1 and A3-33 of the NIR, and the methodological description had been greatly enhanced in the NIR (part 2, section A3.6.4.1.1). Moreover, the above-mentioned background information was presented by province, which provides a sound overview of territorial differences. However, the ERT believes that nationwide aggregates would further enhance the transparency of the reporting. During the review, the Party explained that the total percentage of population using each wastewater treatment type (including septic) will be aggregated at the national level as well as the provincial level for future submissions.	Not an issue
		The ERT encourages Canada to add information on the total percentage of the population using each type of wastewater treatment (including septic tanks as the main source of emissions), aggregated at the national level and provincial level, in its next submission.	
W.22	5.D.2 Industrial wastewater – CH_4	In the NIR (part 2, section 3.6.4.2.1) Canada stated that the industrial wastewater facilities provided volumes of biogas vented, flared and used for heat or energy purposes. However, in CRF table 5.D, "NO" was reported for the amount of CH_4 flared under category 5.D.2. During the review, the Party confirmed that the value of CH_4 flared under category 5.D.2 is available from facilities with on-site anaerobic wastewater treatment, and the omission of this from CRF table 5.D and the use of "NO" were errors.	Yes. Convention reporting adherence
		The ERT recommends that Canada include the amount of CH_4 flared in CRF table 5.D, replacing "NO" where relevant, in its next submission.	
W.23	5.D.2 Industrial wastewater – CH_4	Canada reported the same values for CH_4 emissions (0.55 kt) and amount of CH_4 for energy recovery (18.60 kt) in CRF table 5.D for the third consecutive year (2015–2017). The ERT cross-checked the reported amount of CH_4 for energy recovery with the apparent consumption of gas biomass reported under the energy sector in CRF table 1.A(b) and found that Canada had not included all biogas reported for energy recovery in the waste sector under the energy sector. During the review, the Party explained that emissions from industrial wastewater are currently being reported as constant, pending methodological improvements to this category. A survey of AD for wastewater and alternative data sources will be reviewed and updated, and results may be available in time for the 2021 or 2022 submission, depending on data availability and the amount of work required. Canada confirmed that, at present, only landfill gas is included under the energy sector.	Yes. Completeness
		The ERT recommends that Canada report updated information on sewage sludge gas used for energy recovery and the resulting CH_4 emissions as soon as they becomes available, and ensure that all biogas reported for energy recovery in the waste sector is included under the energy sector.	

[a] Recommendations made by the ERT during the review are related to issues as defined in para. 81 of the UNFCCC review guidelines.

Annex I

Overview of greenhouse gas emissions and removals for Canada for submission year 2019, as submitted by Canada

1. Table 1 shows total GHG emissions, including and excluding LULUCF and, for Parties that have decided to report indirect CO_2 emissions, with and without indirect CO_2. Tables 2–3 show GHG emissions reported under the Convention by Canada by gas and by sector, respectively.

Table 1
Total greenhouse gas emissions for Canada, 1990–2017
(kt CO_2 eq)

	Total GHG emissions excluding indirect CO_2 emissions		*Total GHG emissions including indirect CO_2 emissions*[a]	
	Total including LULUCF	*Total excluding LULUCF*	*Total including LULUCF*	*Total excluding LULUCF*
1990	533 943.16	602 184.44	534 748.21	NA
1995	601 824.04	651 011.02	602 955.95	NA
2000	688 681.75	730 587.60	689 648.27	NA
2010	660 211.36	692 618.85	660 845.43	NA
2011	670 561.33	703 378.95	671 171.89	NA
2012	675 506.66	711 023.23	676 138.36	NA
2013	689 517.76	722 062.81	690 181.56	NA
2014	691 261.92	723 090.99	691 853.99	NA
2015	696 853.64	721 992.08	697 460.21	NA
2016	682 315.91	707 727.17	682 880.06	NA
2017	692 026.54	715 749.23	692 572.35	NA

Note: Emissions and removals reported in the sector other (sector 6) are not included in the total GHG emissions.
[a] Canada reported indirect CO_2 emissions in CRF table 6.

Table 2
Greenhouse gas emissions by gas for Canada, excluding land use, land-use change and forestry, 1990–2017
(kt CO_2 eq)

	CO_2[a]	*CH_4*	*N_2O*	*HFCs*	*PFCs*	*Unspecified mix of HFCs and PFCs*	*SF_6*	*NF_3*
1990	462 502.18	89 031.99	38 895.59	970.54	7 557.90	NA	3 225.92	0.32
1995	494 241.05	106 237.41	41 449.67	460.51	6 346.94	NA	2 275.16	0.28

	CO_2[a]	*CH_4*	*N_2O*	*HFCs*	*PFCs*	*Unspecified mix of HFCs and PFCs*	*SF_6*	*NF_3*
2000	571 507.35	112 545.82	35 891.91	2 754.84	4 984.49	NA	2 902.96	0.24
2010	556 420.25	92 741.71	33 367.76	7 774.50	1 859.27	NA	455.21	0.15
2011	566 674.48	92 409.92	33 589.37	8 599.05	1 687.45	NA	418.54	0.15
2012	570 157.63	94 539.13	35 007.89	9 079.56	1 798.72	NA	440.15	0.15
2013	577 346.38	96 294.67	36 930.97	9 440.56	1 617.20	NA	432.88	0.15
2014	577 359.55	98 396.79	35 741.47	10 084.98	1 088.13	NA	419.94	0.12
2015	576 756.85	96 240.70	36 516.97	11 047.12	968.01	NA	462.30	0.12
2016	564 068.42	93 165.29	37 233.06	12 023.41	764.61	NA	472.26	0.12
2017	571 138.88	92 847.91	38 037.40	12 573.46	743.98	NA	407.49	0.12
Per cent change 1990–2017	**23.5**	**4.3**	**–2.2**	**1 195.5**	**–90.2**	**NA**	**–87.4**	**–63.0**

Note: Emissions and removals reported in the sector other (sector 6) are not included in the total GHG emissions.
[a] Canada did not report indirect CO_2 emissions in CRF table 6, except for indirect CO_2 emissions from the LULUCF sector.

Table 3
Greenhouse gas emissions by sector for Canada, 1990–2017
(kt CO_2 eq)

	Energy	*IPPU*	*Agriculture*	*LULUCF*	*Waste*	*Other*
1990	479 391.44	56 635.59	46 875.65	–67 436.23	19 281.76	NA
1995	519 465.50	57 821.53	53 870.83	–48 055.07	19 853.16	NA
2000	600 233.01	53 215.95	56 938.86	–40 939.33	20 199.77	NA
2010	568 735.05	50 550.57	54 952.01	–31 773.42	18 381.22	NA
2011	576 225.23	54 128.01	54 787.43	–32 207.06	18 238.28	NA
2012	578 288.23	58 246.24	56 761.29	–34 884.88	17 727.46	NA
2013	589 362.85	55 251.55	59 214.52	–31 881.25	18 233.90	NA
2014	594 122.48	52 689.24	57 581.25	–31 237.00	18 698.01	NA
2015	592 118.34	52 934.62	58 156.83	–24 531.87	18 782.29	NA
2016	575 302.77	54 516.35	59 211.53	–24 847.11	18 696.52	NA
2017	583 292.70	53 791.50	59 906.64	23 176.89	18 758.39	NA
Per cent change 1990–2017	**21.7**	**–5.0**	**27.8**	**–65.6**	**–2.7**	**NA**

Notes: (1) Emissions and removals reported in the sector other (sector 6) are not included in the total GHG emissions. (2) Totals include indirect CO_2 emissions reported in CRF table 6.

Annex II

Additional information to support findings in table 2 in this report

Missing categories that may affect completeness

The categories for which methods are included in the 2006 IPCC Guidelines that were reported as "NE" or for which the ERT otherwise determined that there may be an issue with the completeness of the reporting in the Party's inventory are the following:

(a) 2.A.4.a other process uses of carbonates – ceramics (CO_2) (see ID# I.2 in table 3 in this report);

(b) 2 general (IPPU) – other uses of urea produced from CO_2 recovered for downstream use (CO_2) (see ID# I.4 in table 3 in this report);

(c) 2.B.8.d ethylene oxide (CO_2 and CH_4) (see ID# I.9 in table 3 in this report);

(d) 2.F.4 aerosols (PFCs) (see ID# I.33 in table 5 in this report);

(e) 2.G.2 SF_6 and PFCs from other product use (PFCs and SF_6) (see ID# I.34 in table 5 in this report);

(f) 3.D.a.2.b direct N_2O emissions from sewage sludge applied to soils (N_2O) (see ID# A.8 in table 3 in this report);

(g) 3.D.a.2.c direct N_2O emissions from other organic fertilizers applied to soils (N_2O) (see ID# A.8 in table 3 in this report);

(h) 3.D.b indirect N_2O emissions from application of sewage sludge and other organic fertilizers to soils (N_2O) (see ID# A.9 in table 3 in this report);

(i) 4.A forest land – drained forest soils (CO_2) (see ID# L.7 in table 3 in this report);

(j) 4.A.2.1 cropland converted to forest land – loss of living biomass (CO_2) (see ID# L.10 in table 3 in this report);

(k) 4.B wetlands and settlements converted to cropland – all carbon pools (CO_2) (see ID# L.2 in table 3 in this report);

(l) 4.C grassland remaining grassland –organic and mineral soils (CO_2) (see ID# L.1 in table 3 in this report);

(m) 4.E grassland converted to settlements – dead organic matter and soil pools (CO_2) (see ID# L.1 in table 3 in this report);

(n) 4.E cropland and wetlands converted to settlements – all pools (CO_2) (see ID# L.1 in table 3 in this report);

(o) 4(III) direct N_2O emissions from N mineralization/immobilization and 4(IV) indirect N_2O emissions from managed soils (N_2O) (see ID# L.13 in table 3 in this report);

(p) 5.C.1 waste incineration – sewage sludge (CO_2) (see ID# W.16 in table 5 in this report).

Annex III

Reference documents

A. Reports of the Intergovernmental Panel on Climate Change

IPCC. 2000. *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*. J Penman, D Kruger, I Galbally, et al. (eds.). Hayama, Japan: IPCC/Organisation for Economic Co-operation and Development/International Energy Agency/Institute for Global Environmental Strategies. Available at http://www.ipcc-nggip.iges.or.jp/public/gp/english/.

IPCC. 2006. *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. S Eggleston, L Buendia, K Miwa, et al. (eds.). Hayama, Japan: Institute for Global Environmental Strategies. Available at http://www.ipcc-nggip.iges.or.jp/public/2006gl.

IPCC. 2011. Use of Models and Facility-Level Data in Greenhouse Gas Inventories. *In*: HS Eggleston, N Srivastava, K Tanabe, et al. (eds.). *Report of the IPCC Expert Meeting on Use of Models and Measurements in Greenhouse Gas Inventories, Sydney, Australia, 9–11 August 2010*.

IPCC. 2014. *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol*. T Hiraishi, T Krug, K Tanabe, et al. (eds.). Hayama, Japan: Institute for Global Environmental Strategies. Available at http://www.ipcc-nggip.iges.or.jp/public/kpsg.

IPCC. 2014. *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands*. T Hiraishi, T Krug, K Tanabe, et al. (eds.). Geneva: IPCC. Available at http://www.ipcc-nggip.iges.or.jp/public/wetlands/.

B. UNFCCC documents

Inventory review reports

Reports on the individual reviews of the 2013, 2014, 2015, 2016 and 2017 inventory submissions of Canada, contained in documents FCCC/ARR/2013/CAN, FCCC/ARR/2014/CAN, FCCC/ARR/2015/CAN, FCCC/ARR/2016/CAN and FCCC/ARR/2017/CAN, respectively.

Other

Aggregate information on GHG emissions by sources and removals by sinks for Parties included in Annex I to the Convention. Note by the secretariat. Available at https://unfccc.int/sites/default/files/resource/AGI%202019.pdf.

Annual status report for Canada for 2019. Available at https://unfccc.int/sites/default/files/resource/asr2019_CAN.pdf.

C. Other documents used during the review

Responses to questions during the review were received from Raphaëlle Pelland St-Pierre (ECCC), including additional material on the methodology and assumptions used. The following references are reproduced as received:

Boadi DA, Ominski KH, Fulawka DL, Wittenberg KM. 2004. Improving Estimates of Methane Emissions Associated with Enteric Fermentation of Cattle in Canada by Adopting an IPCC (Intergovernmental Panel on Climate Change) Tier-2 Methodology.

Cheminfo Services. 2010. Study of Potential Additions and Updates to the Industrial Process Sources of GHGs in the Canadian GHG Inventory, and Development of Canadian-Specific Methodologies and Emission Estimates for such Sources.

Compilation of Air Pollutant Emissions Factors of the United States Environmental Protection Agency.

Marinier, M., Clark, K., Wagner-Riddle, C. 2004. *Improving Estimates of Methane Emissions Associated with Animal Waste Management Systems in Canada by Adopting an IPCC Tier 2 Methodology*.

McCann TJ. 2000. *1998 Fossil Fuel and Derivative Factors.* Report prepared by T.J. McCann and Associates for Environment Canada.

Robinne, F.-N.; Parisien, M.-A.; Flannigan, M.D. *Anthropogenic influence on wildfire activity in Alberta,Canada.* Int. J. Wildl. Fire 2016, 25, 1131–1143.

Report on Energy Supply and Demand in Canada (Statistics Canada, 2016) https://www150.statcan.gc.ca/n1/en/catalogue/57-003-X.

Sheppard, S. C., Bittman, S., Swift, M. L. and Tait, J. 2010. *Farm practices survey and modelling to estimate monthly NH3 emissions from swine production in 12 Ecoregions of Canada*. Can. J. Anim. Sci. 90: 145-158.

Shawn Tobin. 2017. *Updated CO2 Emission Factors for Gasoline and Diesel Fuel*, Environment and Climate Change Canada.