

NATIONAL INVENTORY REPORT 1990–2016: GREENHOUSE GAS SOURCES AND SINKS IN CANADA

CANADA'S SUBMISSION TO THE UNITED NATIONS FRAMEWORK
CONVENTION ON CLIMATE CHANGE

EXECUTIVE SUMMARY

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1. Greenhouse gases—Canada—Measurement—Periodicals
 2. Methane—Environmental aspects—Canada—Periodicals
 3. Nitrous oxide—Environmental aspects—Canada—Periodicals
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EXECUTIVE SUMMARY

ES.1. Introduction

The United Nations Framework Convention on Climate Change (UNFCCC) is an international treaty established in 1992 to cooperatively address climate change issues. The ultimate objective of the UNFCCC is to stabilize atmospheric greenhouse gas (GHG) concentrations at a level that would prevent dangerous interference with the climate system. Canada ratified the UNFCCC in December 1992, and the Convention came into force in March 1994.

To achieve its objective and implement its provisions, the UNFCCC lays out several guiding principles and commitments. Specifically, Articles 4 and 12 commit all Parties to develop, periodically update, publish and make available to the Conference of the Parties (COP) their national inventories of anthropogenic emissions by sources and removals by sinks of all GHGs not controlled by the Montreal Protocol.¹

Canada's National Inventory is prepared and submitted annually to the UNFCCC by April 15 of each year, in accordance with revised *Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual inventories* (UNFCCC Reporting Guidelines), adopted through Decision 24/CP.19 at COP 19 in Warsaw in 2013. The annual inventory submission consists of the National Inventory Report (NIR) and the Common Reporting Format (CRF) tables.

The inventory GHG estimates include carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), sulphur hexafluoride (SF₆) and nitrogen trifluoride (NF₃) in the following five sectors: Energy; Industrial Processes and Product Use; Agriculture; Waste; and Land Use, Land-Use Change and Forestry (LULUCF). The GHG emission and removal estimates contained in Canada's GHG inventory are developed using methodologies consistent with the Intergovernmental Panel on Climate Change's (IPCC) 2006 Guidelines for the preparation of National GHG Inventories. In line with the principle of continuous improvement, the underlying data and methodology for estimating emissions are revised over time; hence, total emissions in all years are subject to change as both data and methods are improved.

In May 2015, Canada indicated its intent to reduce GHG emissions by 30% below 2005 levels by 2030. In December 2015 at COP 21, Canada, alongside the other countries of the world, reached an ambitious and balanced agreement to fight climate change. Since 2005 was adopted as a base year for both Canada's 2020 and 2030 targets many of the metrics in this report are presented in that context, in addition to the 1990 base year as required by the UNFCCC Reporting Guidelines.

¹ Under the United Nations Environment Programme (UNEP), the Montreal Protocol on Substances that Deplete the Ozone Layer is an international agreement designed to reduce the global consumption and production of ozone-depleting substances.

The Pan-Canadian Framework on Clean Growth and Climate Change

Established on December 9, 2016, the Pan-Canadian Framework on Clean Growth and Climate Change is a comprehensive plan to reduce emissions across all sectors of Canada's economy, as well as to stimulate clean economic growth and build resilience to the impacts of climate change. The Framework was developed collaboratively by Canada's federal, provincial and territorial governments with input from Indigenous Peoples as well as from businesses, non-governmental organizations and Canadians across the country. It builds on the early leadership of provinces and territories and the diverse array of policies and measures already in place across Canada to reduce greenhouse gas emissions and enhance resilience in all sectors of the economy.

Actions taken under the Pan-Canadian Framework, supported by significant federal investments, will support Canada's efforts to meet its target to reduce GHG emissions by 30% below 2005 levels by 2030, as committed under the Paris Agreement. Canada's latest emissions projections, which were published in the Seventh National Communication and Third Biennial Report to the UNFCCC in December 2017, indicate that the policies in the Pan-Canadian Framework are putting the country on track to meet its target. The Pan-Canadian Framework will drive both near- and longer-term reductions and has established processes to enhance ambition over time, setting Canada on a pathway consistent with its **Mid-Century Long-Term Low-GHG Development Strategy**. Canada's GHG inventory plays a key role in keeping Canadians informed of progress made in reducing GHG emissions.

Pricing carbon pollution is central to Canada's plan. The Government of Canada has outlined a benchmark for pricing carbon pollution that will build on existing provincial systems, and which gives provinces and territories the flexibility to implement either an explicit price-based system or cap-and-trade systems. It sets common criteria that all systems must meet, in order to ensure that they are fair and effective. As part of the benchmark, the federal government committed to develop and implement a federal carbon pricing backstop system in any province or territory that requests it or that does not have a carbon pricing system in place in 2018 that meets the benchmark. Carbon pricing will help influence investment and purchasing decisions towards lower carbon-intensive options.

In addition to carbon pricing, the complementary mitigation measures included in the Framework will enable Canada to achieve emissions reductions across all sectors, both in the near-term and as part of a longer-term strategy.

Expanding the use of clean electricity and low-carbon fuels are foundational actions that will reduce emissions across the economy. Canada is taking action to reduce energy use by improving energy efficiency, encouraging fuel switching and supporting innovative alternatives. In the built environment sector, this includes developing "net-zero energy ready" building codes.

Actions in the transportation sector include increasingly stringent standards for light- and heavy-duty vehicles, as well as taking action to improve efficiency and support fuel switching in the rail, aviation, marine and off-road sectors. Zero-emissions vehicles will be supported through the development of a national strategy and through investments in supportive infrastructure such as charging stations. To reduce emissions from industrial sectors, Canada published draft regulations to achieve a reduction in methane emissions from the oil and gas sector, including offshore activities, by 40%–45% by 2025. Canada has also finalized regulations to phase down the use of hydrofluorocarbons in line with the Kigali Amendment to the Montreal Protocol.

The Pan-Canadian Framework also recognizes the importance of building climate resilience and sets out measures to help Canadians understand, plan for and take action to adapt to the unavoidable impacts of climate change. A number of measures are being developed in this area with a focus on infrastructure, information and capacity-building, and health. This includes a particular focus on supporting Canada's Indigenous Peoples and northern and remote communities, which are particularly vulnerable to the effects of climate change.

The Framework also includes support for clean technology and innovation, including for early-stage technology development, establishing international partnerships and encouraging "mission-oriented" research to help generate innovative new opportunities to reduce emissions.

In its first year of implementation, federal, provincial and territorial governments have already made good progress in putting the Pan-Canadian Framework into action, as reported on December 9, 2017, in the First Annual Synthesis Report on the Status of Implementation (ECCC 2017). Governance, reporting and oversight structures have been established to track progress and ensure success. Funding has been mobilized to support many of the new actions included in the Framework, including significant transfers from the federal government to the provincial and territorial governments. Work is underway to implement carbon pricing systems across Canada, and governments have made significant progress on complementary measures to reduce emissions across the economy.

Section ES.2 of this Executive Summary summarizes the latest information on Canada's net anthropogenic (i.e. human-induced) GHG emissions over the 2005–2016 period and links this information to relevant indicators of the Canadian economy. Section ES.3 outlines the major trends in emissions from each of the IPCC sectors.

For the purposes of analyzing economic trends and policies, it is useful to allocate emissions to the economic sector from which they originate. Section ES.4 presents Canada's emissions by the following economic sectors: Oil and Gas, Electricity, Transportation, Heavy Industry, Buildings, Agriculture, Waste and Others. Throughout this report, the word “sector” generally refers to activity sectors as defined by the IPCC for national GHG inventories; exceptions occur when the expression “economic sectors” is used in reference to the Canadian context.

Section ES.5 details GHG emissions for Canada's 13 sub-national jurisdictions. Finally, as Canada's annual inventory submission to the UNFCCC embodies almost two decades of learning and

improvements, Section ES.6 provides some detail on the components of this submission and outlines key elements of its preparation.

ES.2. Overview, National GHG Emissions

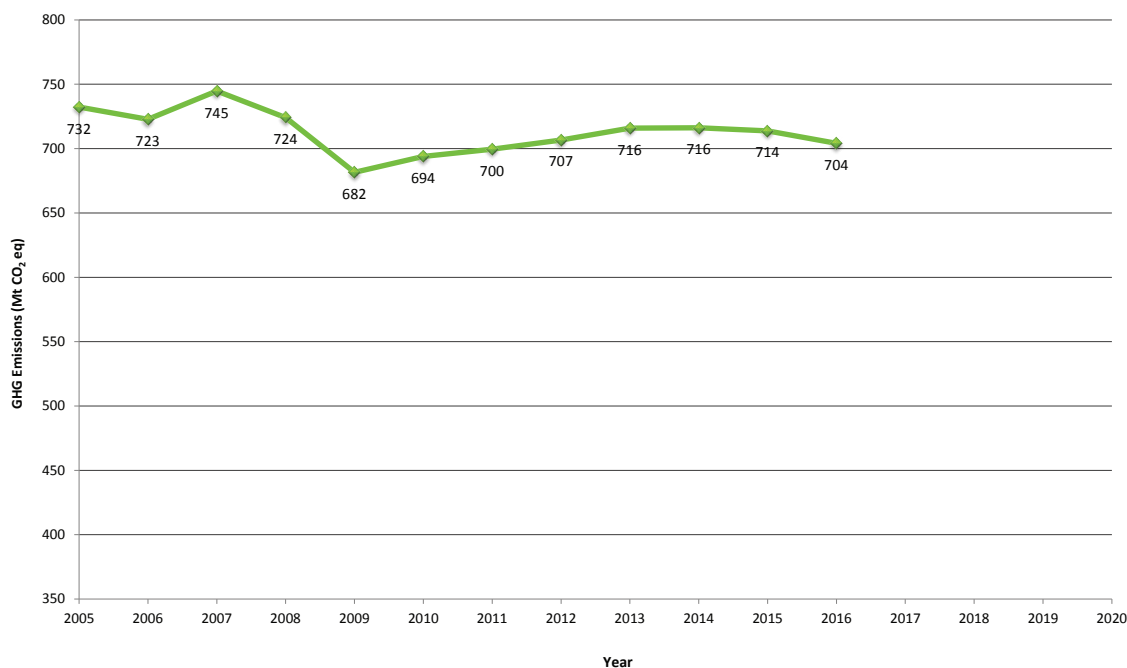
In 2016, the most recent annual dataset in this report, Canada's GHG emissions were 704 megatonnes of carbon dioxide equivalent (Mt CO₂ eq),² a net decrease of 28 Mt or 3.8% from 2005 emissions (Figure S-1).³ Annual emissions fluctuated between 2005 and 2008, dropped in 2009 and gradually increased thereafter.

In 2016, the Energy Sector (consisting of Stationary Combustion, Transport and Fugitive Sources) emitted 572 Mt of greenhouse gases, or 81% of

² Unless explicitly stated otherwise, all emission estimates given in Mt represent emissions of GHGs in Mt CO₂ eq.

³ Throughout this report, data are presented as rounded figures. However, all calculations (including percentages) have been performed using unrounded data.

Figure S-1 Canadian GHG Emissions Trend (2005–2016) (excluding LULUCF)



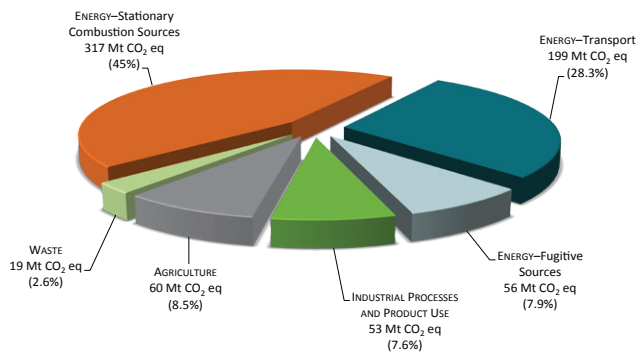
Canada's total GHG emissions (Figure S-2). The remaining emissions were largely generated by the Agriculture and Industrial Processes and Product Use Sectors (approximately 8% each), with minor contributions from the Waste Sector (3%). In 2016, the LULUCF Sector removed 28 Mt of CO₂ from the atmosphere, 7 Mt more than in 2005.

Canada's emissions profile is similar to that of most industrialized countries, in that CO₂ is the largest contributor to total emissions, accounting for 79% of total emissions in 2016 (Figure S-3). The majority of the CO₂ emissions in Canada result from the combustion of fossil fuels. Methane (CH₄) emissions in 2016

amounted to 96 Mt or 14% of Canada's total. These emissions consist largely of fugitive emissions from oil and natural gas systems, agriculture and landfills. Nitrous oxide (N₂O) emissions mostly arise from agricultural soil management and transport, and accounted for 37 Mt or 5% of Canada's emissions in 2016. Emissions of synthetic gases (HFCs, PFCs, SF₆ and NF₃) constituted slightly less than 2%.

Over the long term, Canada's economy has grown more rapidly than its GHG emissions. As a result, the emissions intensity for the entire economy (GHG per GDP) has declined by 35% since 1990 and 19% since 2005 (Figure S-4 and Table S-1).

Figure S-2 Breakdown of Canada's Emissions by IPCC Sector (2016)*



*Note: Totals may not add up due to rounding.

Total: 704 Mt CO₂ eq

Figure S-3 Breakdown of Canada's Emissions by GHG (2016)*

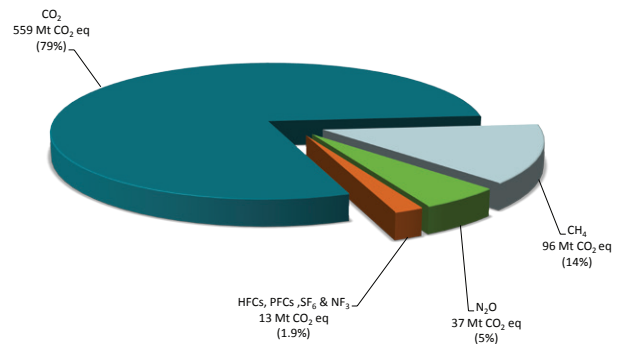
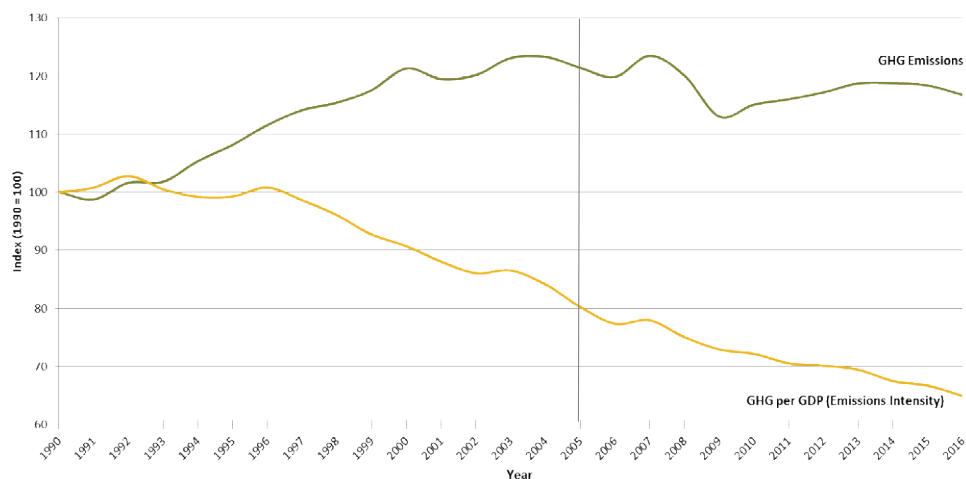


Figure S-4 Indexed Trend in GHG Emissions and GHG Emissions Intensity (1990–2016)



The decline in emissions intensity since 1995 (Figure S-4) can be attributed to fuel switching, increases in efficiency, the modernization of industrial processes and structural changes in the economy. Section ES.3 provides more information on trends in GHG emissions.

Canada represented approximately 1.6% of total global GHG emissions in 2014 (CAIT 2017), although it is one of the highest per capita emitters. Canada's per capita emissions have dropped substantially since 2005, when this indicator was 22.7t, reaching a new low of 19.4 in 2016 (Figure S-5).

ES.3. Emissions and Trends by IPCC Sectors

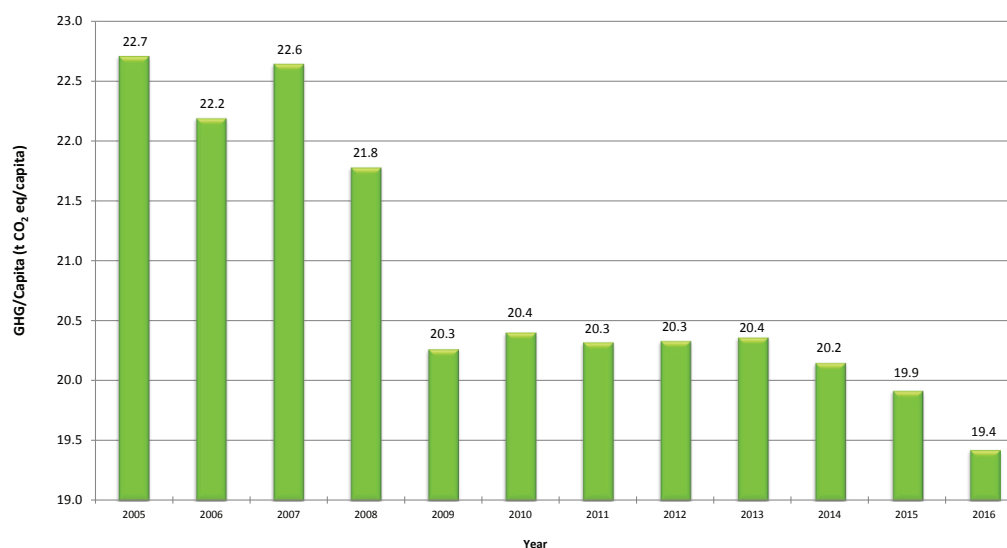
Trends in Emissions

Over the 2005–2016 period, total emissions decreased by 28 Mt or 3.8% (Figure S-6). The Energy Sector dominated this trend, with emission decreases of 25 Mt (7%) in Stationary Combustion Sources and 5 Mt (8%) in Fugitive Sources (Table S-2). In addition, there was a decrease of 2 Mt (3%) in the IPPU Sector, a decrease of 1 Mt (1%) in the Agriculture Sector and a decrease of 3 Mt (12%) in the Waste Sector. Over the same period, emissions

Table S-1 Trends in Emissions and Economic Indicators, Selected Years								
Year	2005	2010	2011	2012	2013	2014	2015	2016
Total GHG (Mt)	732	694	700	707	716	716	714	704
Change since 2005 (%)	NA	-5.2%	-4.5%	-3.5%	-2.2%	-2.2%	-2.5%	-3.8%
GDP (Billion 2007\$)	1 503	1 584	1 633	1 659	1 698	1 747	1 763	1 787
Change since 2005 (%)	NA	5.4%	8.7%	10.4%	13.0%	16.3%	17.3%	18.9%
GHG Intensity (Mt/\$B GDP)	0.49	0.44	0.43	0.43	0.42	0.41	0.40	0.39
Change since 2005 (%)	NA	-10.1%	-12.1%	-12.6%	-13.5%	-15.9%	-16.9%	-19.1%

Notes:
 GDP data source: Statistics Canada a
 NA = not applicable

Figure S-5 Canadian per Capita GHG Emissions (2005–2015)



Population data source: Statistics Canada b

from Transport increased by 7 Mt (4%) partially offsetting the decreases from the other sectors (Figure S-7).

Since 2009, when emissions were at their lowest in recent years, emission increases can be attributed to increases in Mining and Upstream Oil and Gas Production (21 Mt); in the number of light-duty

gasoline trucks (8 Mt) and heavy-duty diesel vehicles in operation (5 Mt); in the consumption of halocarbons, SF₆ and NF₃ (5 Mt); and in the application of inorganic nitrogen fertilizers (3 Mt). During the same period, there was a 16 Mt decrease in emissions from electricity generation, which partly offset the growth in emissions.

Figure S-6 Trends in Canadian GHG Emissions by IPCC Sector (2005–2016)

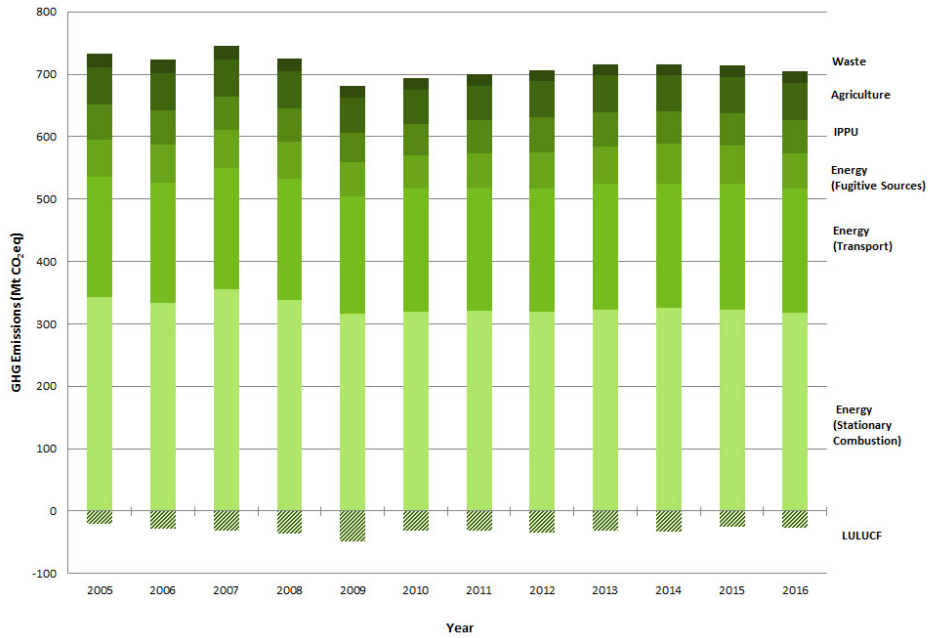


Figure S-7 Changes in Emissions by IPCC Sector (2005–2016)

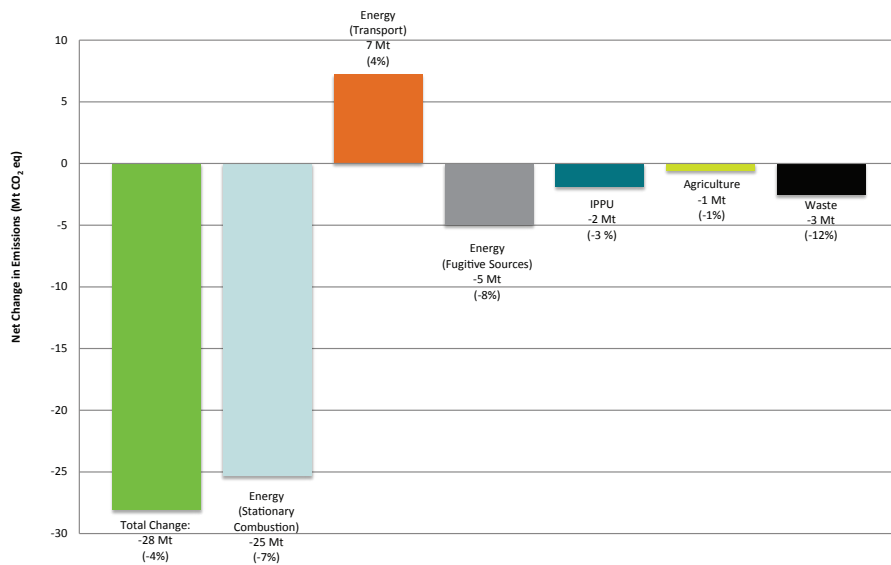


Table S-2 **Canada's GHG Emissions by IPCC Sector, Selected Years**

Greenhouse Gas Categories	2005	2011	2012	2013	2014	2015	2016
Mt CO ₂ equivalent							
TOTAL^{1,2}	732	700	707	716	716	714	704
ENERGY	595	573	574	584	588	585	572
a. Stationary Combustion Sources	342	320	319	322	325	322	317
Public Electricity and Heat Production	125	94	91	87	84	87	84
Petroleum Refining Industries	20	18	19	18	18	17	17
Mining and Upstream Oil and Gas Production	68	83	89	93	96	96	100
Manufacturing Industries	48	44	44	45	45	44	42
Construction	1	1	1	1	1	1	1
Commercial and Institutional	32	30	28	29	31	30	30
Residential	46	46	42	44	46	43	39
Agriculture and Forestry	2	4	4	4	4	4	4
b. Transport	192	197	197	202	200	202	199
Domestic Aviation	8	6	7	8	7	7	7
Road Transportation	129	139	140	144	141	142	143
Railways	7	8	8	7	8	7	7
Domestic Navigation	6	6	6	5	5	5	4
Other Transportation	43	39	36	38	40	41	40
c. Fugitive Sources	61	55	58	60	63	61	56
Coal Mining	1	1	1	2	1	1	1
Oil and Natural Gas	59	54	57	59	62	60	55
d. CO ₂ Transport and Storage	0	0	0	0	0	0	0
INDUSTRIAL PROCESSES AND PRODUCT USE	55	53	57	54	52	51	53
a. Mineral Products	10	8	9	8	8	8	8
b. Chemical Industry	9	6	6	6	6	7	7
c. Metal Production	20	17	17	15	15	14	16
d. Production and Consumption of Halocarbons, SF ₆ and NF ₃	5	9	9	9	10	11	12
e. Non-Energy Products from Fuels and Solvent Use	10	13	16	15	13	11	11
f. Other Product Manufacture and Use	1	0	0	1	0	0	1
AGRICULTURE	60	55	57	59	58	59	60
a. Enteric Fermentation	31	25	25	25	25	24	25
b. Manure Management	9	8	8	8	8	8	8
c. Agricultural Soils	19	20	22	24	23	23	24
d. Field Burning of Agricultural Residues	0.05	0.03	0.04	0.05	0.05	0.05	0.05
e. Liming, Urea Application and Other Carbon-containing Fertilizers	1	2	2	3	2	3	3
WASTE	21	19	18	18	18	19	19
a. Solid Waste Disposal	19	17	16	16	16	16	16
b. Biological Treatment of Solid Waste	0	0	0	0	1	1	1
c. Wastewater Treatment and Discharge	1	1	1	1	1	1	1
d. Incineration and Open Burning of Waste	1	1	1	1	1	1	1
LAND USE, LAND-USE CHANGE AND FORESTRY	-21	-32	-34	-32	-33	-26	-28
a. Forest Land	-160	-160	-160	-160	-160	-150	-150
b. Cropland	-11	-12	-12	-12	-12	-11	-11
c. Grassland	1	1	2	2	1	1	1
d. Wetlands	3	3	3	3	3	3	3
e. Settlements	4	4	4	4	4	4	4
f. Harvested Wood Products	140	130	130	130	130	130	130

Notes:

1. National totals exclude all GHGs from the Land Use, Land-Use Change and Forestry Sector.
2. This summary data is presented in more detail at open.canada.ca.

Going forward, the measures established through the Pan-Canadian Framework on Clean Growth and Climate Change have been designed to influence emissions trends across all sectors. Carbon pricing will apply to a broad set of emission sources throughout Canada, while complementary mitigation actions across the economy aim to support additional emissions reductions. This includes a broad suite of measures to further decarbonize Canada's electricity sector; reduce emissions from fuels used in transportation, buildings and industry; improve the efficiency of transportation systems, buildings and industrial operations; and protect and enhance Canada's carbon sinks. In addition, support for clean technology and innovation will support new emission reduction opportunities.

Chapter 2 provides more information on trends in GHG emissions from both 1990 and 2005 and their drivers.⁴ Further breakdowns of emissions and a complete time series can be found at open.canada.ca.

The following describes the emissions and trends of each IPCC sector in further detail.

Energy – 2016 GHG Emissions (572 Mt)

In 2016, GHG emissions from the IPCC Energy Sector (572 Mt) were 3.9% lower than in 2005 (595 Mt). Within the Energy Sector, the 32 Mt increase in emissions from Mining and Upstream Oil and Gas Production was offset by a 41 Mt decrease in emissions from Public Electricity and Heat Production.

Decreasing energy generation from coal and oil, accompanied by an increase in hydro, nuclear and wind generation, was the largest driver of the 32% decrease in emissions associated with Electricity and Heat Production between 2005 and 2016. The permanent closure of all coal generating stations in Ontario by 2014 was the driving factor.⁵ Minor emission fluctuations over the period reflect variations in the mix of electricity generation sources.⁶

GHG emissions from Manufacturing Industries decreased by 5.8 Mt between 2005 and 2016,

consistent with both a 16% decrease in energy use and an observed decline in output⁷ in these industries.

Oil production has been driven primarily by a rapid rise in the extraction of bitumen and synthetic crude oil from Canada's oil sands operations, where total output has increased by 145% since 2005. This rising production has contributed to the 32 Mt increase in fuel consumption emissions from Mining and Upstream Oil and Gas Production. However, from 2010 to 2016 the emission intensity of oil sands operations themselves dropped by approximately 15% as a result of technological and efficiency improvements, fewer venting emissions and reductions in the percentage of crude bitumen being upgraded to synthetic crude oil.

The majority of transport emissions in Canada are related to Road Transportation, which includes personal transportation (light-duty vehicles and trucks) and heavy-duty vehicles. The growth in road transport emissions is largely due to more driving. Despite a reduction in kilometres driven per vehicle, the total vehicle fleet has increased by 38% since 2005, most notably for trucks (both light- and heavy-duty), leading to more kilometres driven overall.

Industrial Processes and Product Use – 2016 GHG Emissions (53 Mt)

The Industrial Processes and Product Use Sector covers non-energy GHG emissions that result from manufacturing processes and use of products, such as limestone calcination in cement production and the use of HFCs and PFCs as replacement refrigerants for ozone-depleting substances (ODSs). Emissions from the IPPU Sector contributed 53 Mt (7.6%) to Canada's 2016 emissions.

Emissions from most industries decreased in 2008 and 2009 compared with the previous year respectively. A notable exception is the 6.9 Mt (136%) increase in emissions from the use of HFCs between 2005 and 2016.

The aluminium industry has decreased its process emissions since 1990, largely due to technological improvements introduced to mitigate PFC emissions. The overall decrease in GHG emissions

⁴ The complete NIR can be accessed here: http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/10566.php

⁵ *Ontario Power Generation News*, April 15, 2014; <http://www.opg.com/news-and-media/news-releases/Pages/news-releases.aspx?year=2014>, accessed 2018 January).

⁶ The mix of electricity generation sources is characterized by the amount of fossil fuel vs. hydro, other renewable sources and nuclear sources. In general, only fossil fuel sources generate net GHG emissions.

⁷ See, for example, *Energy Consumption by the Manufacturing Sector, 2016*, Statistics Canada Daily, October 31, 2016; <http://www.statcan.gc.ca/daily-quotidien/161031/dq161031d-eng.pdf> (accessed 2018 January 9).

from chemical industries since 1990 is primarily the result of the closure in 2009 of the sole Canadian adipic acid plant located in Ontario; since 2009 the emissions from chemical industries have remained relatively stable.

Agriculture – 2016 GHG Emissions (60 Mt)

The Agriculture Sector covers non-energy GHG emissions relating to the production of crops and livestock. Emissions from Agriculture accounted for 60 Mt, or 8.5% of total GHG emissions for Canada in 2016, down 1% (0.6 Mt) from their peak in 2005.

In 2016, Agriculture accounted for 30% of national CH₄ emissions and 77% of national N₂O emissions.

The main drivers of the emission trend in the Agriculture Sector are the fluctuations in livestock populations and the application of inorganic nitrogen fertilizers to agricultural soils in the Prairie provinces. Since 2005, fertilizer use has increased, while livestock populations peaked in 2005 and decreased sharply until 2011. In 2016, emissions from livestock digestion (enteric fermentation) accounted for 41% of total agricultural emissions, and the application of inorganic nitrogen fertilizers accounted for 22% of total agricultural emissions.

Waste – 2016 GHG Emissions (19 Mt)

The Waste Sector includes GHG emissions from the treatment and disposal of liquid and solid wastes. Emissions from Waste contributed 19 Mt (2.6%) to Canada's total emissions in 2016 and 21 Mt (2.9%) in 2005.

The primary source of emissions in the Waste Sector is Solid Waste Disposal (SWD) (16.4 Mt CO₂ eq in 2016), which includes municipal solid waste (MSW) landfills (12.9 Mt in 2016) and wood waste landfills (3.5 Mt in 2016). In 2016, Solid Waste Disposal accounted for 88% of Waste emissions, while Biological Treatment of Solid Waste (composting), Wastewater Treatment and Discharge, and Incineration and Open Burning of Waste contributed the remaining 12%.

Methane emissions from publicly and privately owned MSW landfills make up 96% of emissions from SWD; these emissions decreased by 14% between 2005 and 2016. Of the 26 Mt CO₂ eq of CH₄ generated by MSW landfills in 2016, only 13 Mt

(50%) were actually emitted to the atmosphere. A small portion (6% or 1 Mt) of the generated CH₄ was oxidized by landfill cover material. A larger portion (44% or 11 Mt) was captured by landfill gas collection facilities compared with 32% of generated CH₄ captured in 2005.

Land Use, Land-Use Change and Forestry – 2016 (Net GHG Removals of 28 Mt)

The Land Use, Land-Use Change and Forestry (LULUCF) Sector reports anthropogenic GHG fluxes between the atmosphere and Canada's managed lands, including those associated with land-use change and emissions from Harvested Wood Products (HWPs), which are closely linked to Forest Land.

In this sector, the net flux is calculated as the sum of CO₂ and non-CO₂ emissions to the atmosphere and CO₂ removals from the atmosphere. In 2016, this net flux amounted to removals of 28 Mt, which, if included, would decrease total Canadian GHG emissions by 3.9%. The LULUCF estimates separate the impact of significant natural disturbances on managed forests (wildfires and insects), revealing trends associated with anthropogenic forest management activities. Additional information on the changes made this year can be found in Chapter 6.

Net removals from the LULUCF Sector have fluctuated over recent years, increasing from 21 Mt in 2005 to 49 Mt in 2009 and have since decreased to 28 Mt in 2016. Fluctuations are driven mainly by variations in emissions from HWP and removals from Forest Land that are closely tied to harvest rates.

Net removals from Forest Land have fluctuated between 160 Mt to a minimum of 150 Mt over the period between 2005 and 2016, as forests recover from peak harvest rates and insect disturbance in the mid-2000s. Over this same period, emissions from HWPs originating from domestic harvest declined from 140 Mt in 2005 to a low of 120 Mt in 2009 (the year of the lowest harvest rates), and have since increased to 130 Mt in 2016. Approximately 29% of HWP emissions result from long-lived wood products reaching the end of their economic life decades after the wood was harvested. Hence emission and removal patterns in both HWPs and Forest Land are influenced by recent forest management trends and by the long-term impact of forest management that occurred in past decades.

Current net removals from Cropland are similar to those in 2005. GHG removals in cropland peaked in 2009 at 12.1 Mt and have since declined as a result of an increase in the conversion of perennial to annual crops on the Prairies, the declining effect of conversion to conservation tillage and slower rates of agricultural expansion onto forest land.

The conversion of forests⁸ to other land uses is a prevalent, yet declining, practice in Canada and is mainly due to forest conversion to settlements for resource extraction and cropland expansion. Emissions due to forest conversion fell from 16 Mt in 2005 to 14 Mt in 2016.

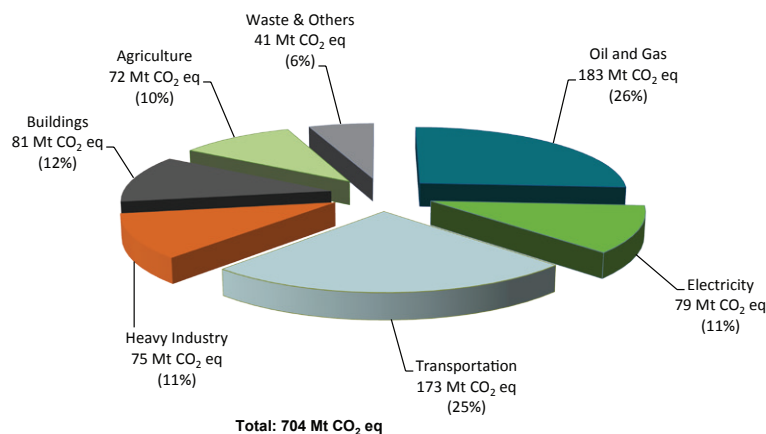
⁸ Forest conversion emissions are incorporated within sums of emissions of other land-use categories; therefore, the values of 14 and 16 Mt reported here are included in the sums associated with the other land-use category totals.

ES.4. Canadian Economic Sectors

For the purposes of analyzing economic trends and policies, it is useful to allocate emissions to the economic sector from which the emissions originate. In general, a comprehensive emission profile for a specific economic sector is developed by reallocating the relevant proportion of emissions from various IPCC subcategories. This reallocation simply recategorizes emissions under different headings and does not change the overall magnitude of Canadian emissions estimates.

GHG emissions trends in Canada's economic sectors from 2005 to 2016 are consistent with those described for IPCC sectors, with the Oil and Gas and Transportation economic sectors showing emission increases of 16% and 7% respectively since 2005 (Figure S-8 and Table S-3). These increases have been

Figure S-8 Breakdown of Canada's Emissions by Economic Sector (2016)



Note: Totals may not add up due to rounding.

Table S-3 Canada's GHG Emissions by Economic Sector, Selected Years

	1990	2005	2011	2012	2013	2014	2015	2016
Mt CO ₂ equivalent								
NATIONAL GHG TOTAL	603	732	700	707	716	716	714	704
Oil and Gas	107	158	161	172	180	187	184	183
Electricity	94	120	88	85	82	79	81	79
Transportation	122	162	171	173	176	173	174	173
Heavy Industry ¹	97	86	80	79	77	77	76	75
Buildings	74	86	87	85	86	88	85	81
Agriculture	58	73	69	70	73	71	72	72
Waste & Others ²	51	48	44	43	43	41	42	41

Notes:

Totals may not add up due to rounding.

Estimates presented here are under continuous improvement. Historical emissions may be changed in future publications as new data becomes available and methods and models are refined and improved.

1. Heavy Industry represents emissions arising from non-coal, -oil and -gas mining activities, smelting and refining, and the production and processing of industrial goods such as paper or cement.
2. "Others" includes Coal Production, Light Manufacturing, Construction & Forest Resources.

more than offset by emission decreases in Electricity (34%), Heavy Industry (13%) and Waste & Others (13%).

Further information on economic sector trends can be found in Chapter 2. Additional information on the IPCC and economic sector definitions, as well as a detailed cross-walk between IPCC and economic sector categories can be found in Part 3 of this report.

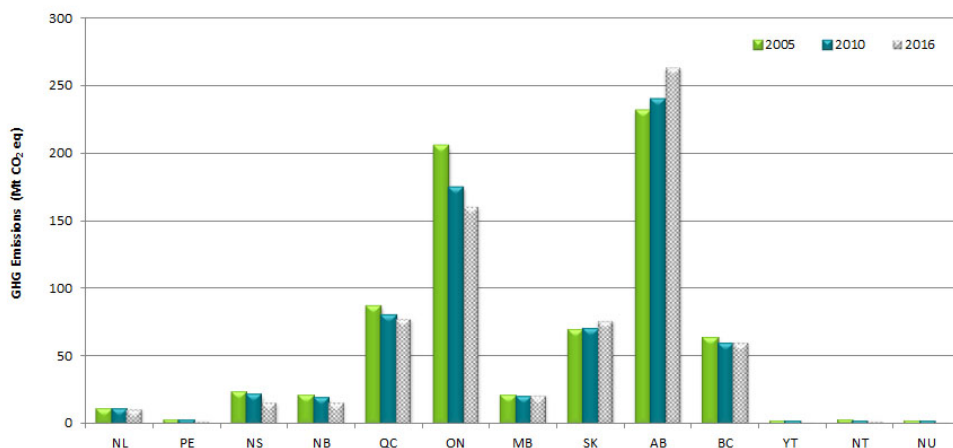
ES.5. Provincial and Territorial GHG Emissions

Emissions vary significantly by province as a result of population, energy sources and economic structure. All else being equal, economies based on

resource extraction will tend to have higher emission levels than service-based economies. Likewise, provinces that rely on fossil fuels for their electricity generation emit relatively more greenhouse gases than those that rely more on hydroelectricity.

Historically, Alberta and Ontario have been the highest emitting provinces. Since 2005, emission patterns in these two provinces have diverged. Emissions in Alberta increased from 231 Mt in 2005 to 263 Mt in 2016 (14%), primarily as a result of the expansion of oil and gas operations (Figure S-9 and Table S-4). In contrast, Ontario's emissions have steadily decreased since 2005 (by 44 Mt or 22%), owing primarily to the closure of coal-fired electricity generation plants.

Figure S-9 Emissions by Province in 2005, 2010 and 2016



Year	GHG Emissions (Mt CO ₂ eq) ¹								Change (%)
	1990	2005	2011	2012	2013	2014	2015	2016	
GHG Total (Canada)	603	732	700	707	716	716	714	704	-3.8%
NL	9.3	9.9	10.0	9.4	9.4	10.4	10.6	10.8	8.7%
PE	1.9	2.0	2.1	2.0	1.7	1.7	1.7	1.8	-10%
NS	19.6	23.2	20.9	19.2	18.2	16.4	16.6	15.6	-33%
NB	16.1	20.1	18.7	16.8	14.8	14.4	14.3	15.3	-24%
QC	86.6	86.5	81.7	79.5	79.9	78.0	78.4	77.3	-11%
ON	179.2	204.7	172.5	169.1	168.4	165.4	162.9	160.6	-22%
MB	18.3	20.2	19.0	20.2	20.9	20.9	20.8	20.9	3.5%
SK	44.7	68.9	69.0	71.3	74.0	77.4	79.5	76.3	10.7%
AB	174.1	231.0	243.8	256.1	264.9	268.6	266.9	262.9	14%
BC	51.1	63.3	59.3	60.3	60.9	60.4	59.4	60.1	-5.1%
YT	0.5	0.5	0.7	0.7	0.6	0.4	0.5	0.4	-19%
NT	NA	1.6	1.4	1.5	1.4	1.5	1.7	1.6	3%
NU	NA	0.4	0.5	0.6	0.7	0.7	0.6	0.7	58%

Notes:
1. Totals may not add up due to rounding.

Quebec experienced a 9.2 Mt (11%) decrease from its 2005 emissions level, while British Columbia had a decline of 3.2 Mt (5.1%). Emissions in Saskatchewan increased by 7.4 Mt (11%) between 2005 and 2016 as a result of activities in the oil and gas industry, potash and uranium mining and transportation. Emissions in Manitoba as well as Newfoundland and Labrador have also increased since 2005, but to a lesser extent (0.7 Mt or 3.5% and 0.9 Mt or 8.7% respectively). Provinces which have seen more significant decreases in emissions include New Brunswick (4.8 Mt, or a 24% reduction), Nova Scotia (7.6 Mt, or a 33% reduction) and Prince Edward Island (0.2 Mt, or a 10% reduction).

ES.6. National Inventory Arrangements

Environment and Climate Change Canada is the single national entity with responsibility for preparing and submitting the National Inventory to the UNFCCC and for managing the supporting processes and procedures.

The institutional arrangements for the preparation of the inventory include formal agreements supporting data collection and estimate development; a quality management plan, including an improvement plan; the ability to identify key categories and generate quantitative uncertainty analysis; a process for performing recalculations due to improvements; procedures for official approval; and a working archive system to facilitate third-party review.

Submission of information regarding the national inventory arrangements, including details on institutional arrangements for inventory preparation, is also an annual requirement under the UNFCCC reporting guidelines on annual inventories (see Chapter 1, Section 1.2).

Structure of Submission

The UNFCCC requirements include the annual compilation and submission of both the National Inventory Report (NIR) and the Common Reporting Format (CRF) tables. The CRF tables are a series of standardized data tables, containing mainly numerical information, which are submitted

electronically. The NIR contains the information to support the CRF tables, including a comprehensive description of the methodologies used in compiling the inventory, the data sources, the institutional structures, and the quality assurance and quality control procedures.

Part 1 of the NIR includes Chapters 1 to 8. Chapter 1 (Introduction) provides an overview of Canada's legal, institutional and procedural arrangements for producing the inventory (i.e. the national inventory arrangements), quality assurance and quality control procedures as well as a description of Canada's facility emission-reporting system. Chapter 2 provides an analysis of Canada's GHG emission trends in accordance with the UNFCCC reporting structure, as well as a breakdown of emission trends by Canadian economic sectors. Chapters 3 to 7 provide descriptions and additional analysis for each sector, according to UNFCCC reporting requirements. Chapter 8 presents a summary of recalculations and planned improvements.

Part 2 of the NIR consists of Annexes 1 to 7, which provide a key category analysis, an inventory uncertainty assessment, detailed explanations of estimation methodologies, Canada's energy balance, completeness assessments, emission factors and information on ozone and aerosol precursors.

Part 3 comprises Annexes 8 to 13, which present rounding procedures, summary tables of GHG emissions at the national level and for each provincial and territorial jurisdiction, sector and gas, as well as additional details on the GHG intensity of electricity generation. Detailed GHG data is also available on the Government of Canada's Open Data website: <http://open.canada.ca/data/en/dataset/779c7bcf-4982-47eb-af1b-a33618a05e5b>.

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