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GREENHOUSE GAS EMISSIONS

CANADIAN ENVIRONMENTAL SUSTAINABILITY INDICATORS

Canada

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CANADIAN ENVIRONMENTAL SUSTAINABILITY INDICATORS

GREENHOUSE GAS EMISSIONS

April 2022

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Greenhouse gas emissions

Climate change is one of the most important environmental issues of our time. Climate change is caused by the increase in concentrations of greenhouse gases (GHGs) in the atmosphere. These increases are primarily due to GHG emissions resulting from human activities such as the use of fossil fuels or agriculture. This changing climate has impacts on the environment, human health and the economy. The indicators report estimates of Canada's emissions of GHGs over time.

Since 2015 and the signing of the Paris Agreement, Canada adopted 2005 as the base year for its GHG emission reduction target. In 2021, Canada committed to reduce its GHG emissions by 40-45 percent below 2005 levels by 2030. Historically, following the Canada's ratification of the Kyoto Protocol, the base year was 1990.

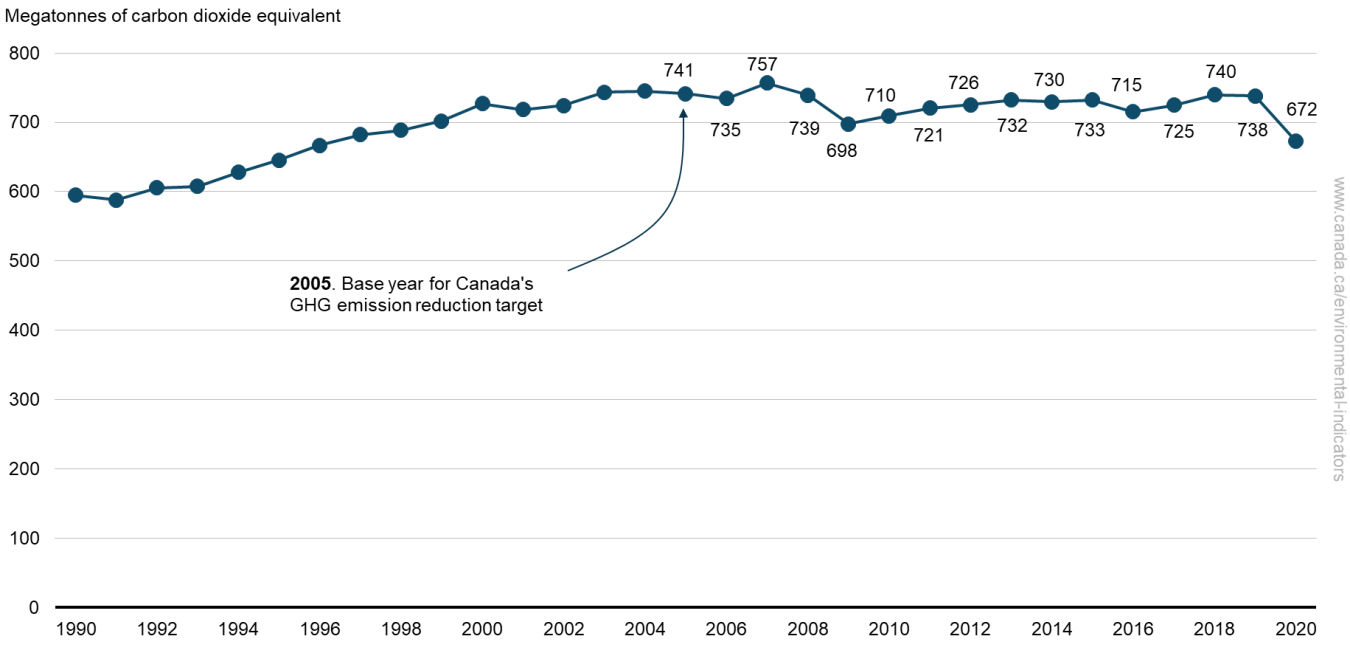
The latest year reported (2020) coincides with the 1st year of the COVID-19 pandemic which strongly affected a wide range of economic sectors, including the energy and transport sectors. The long-term trends presented must be interpreted with caution as the economic slowdown influenced results from 2019 to 2020.

National greenhouse gas emissions

Key results

- Canada's total GHG emissions in 2020 were 672 megatonnes of carbon dioxide equivalent (Mt CO_2 eq), a 8.9% decrease from 738 Mt CO_2 eq in 2019
- From 2005 to 2020, Canada's GHG emissions decreased by 9.3% (69 Mt CO_2 eq)
- Between 1990 and 2020, Canada's GHG emissions increased by 13.1% (78 Mt CO_2 eq)

Figure 1. Greenhouse gas emissions, Canada, 1990 to 2020



Data for Figure 1

Note: Data are presented as rounded figures. The national indicator tracks 7 greenhouse gases released by human activity: carbon dioxide, methane, nitrous oxide, sulphur hexafluoride, perfluorocarbons, hydrofluorocarbons and nitrogen trifluoride. Emission levels for some years have been revised in light of improvements to estimation methods and availability of new data. Emissions and removals from the land use, land use change and forestry sector (LULUCF) are excluded from national totals to allow for a focus on greenhouse gas released from human activity only.
Source: Environment and Climate Change Canada (2022) National Inventory Report 1990-2020: Greenhouse Gas Sources and Sinks in Canada.

While the overall trend between 1990 and 2020 was an increase in GHG emissions there were certain sectors that saw a growth in GHG emissions over the time period whereas others saw a decrease.

Canada's overall emissions growth over the 1990 to 2020 period was driven primarily by increased emissions from oil and gas extraction as well as transport.

The 9.3% decrease in GHG emissions between 2005 and 2020 was mainly a result of emission reductions from the electricity and heavy industry sectors.

The confinement measures introduced in 2020 due to the pandemic created an industrial slowdown and important reductions in trade and travel by air and land. These impacts contributed to the GHG emission decrease, especially in the transport sector where a 14% decrease was observed between 2019 and 2020.

According to the greenhouse gas equivalencies calculator developed by Natural Resources Canada, the 69 Mt CO_2 eq emission reduction for the period from 2005 to 2020 is equivalent to:

- removing over 21 000 000 gas-powered passenger vehicles from the roads for 1 year, or
- the energy-based emissions from around 16 150 000 homes for 1 year

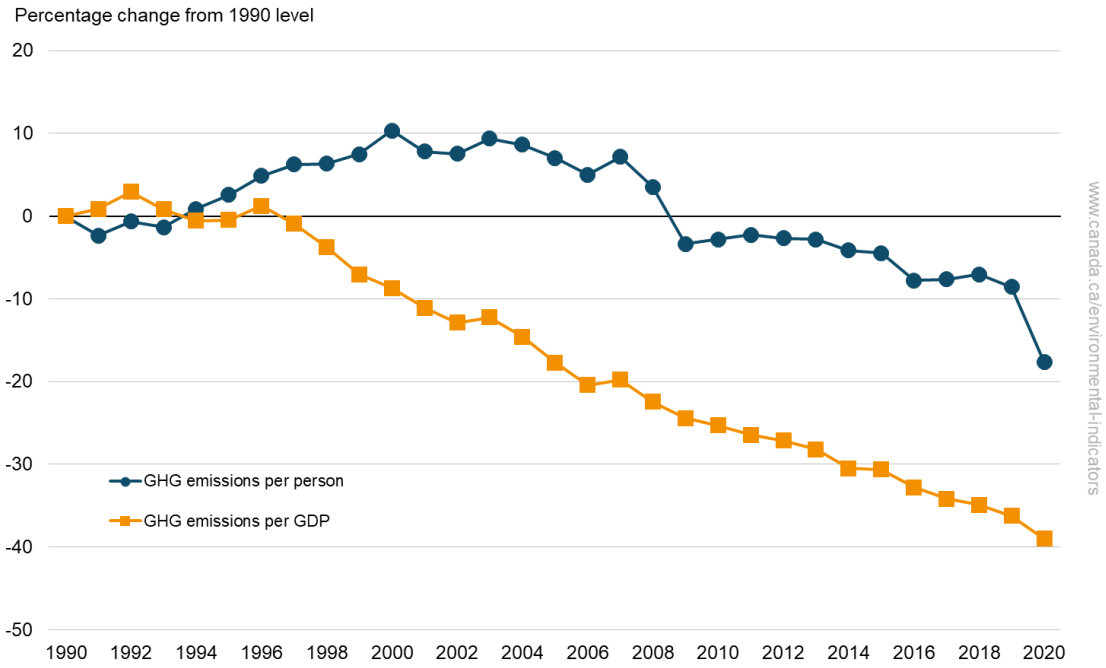
Greenhouse gas emissions per person and per unit of GDP

While the overall value of GHG emitted is important to measure, the relationship between GHG emissions and economic activity and/or population is useful to monitor the transition to a low-carbon economy. These indicators present the GHG emission intensities relative to Canada's population and its economic activity. GHG emission intensity compares the amount of GHGs emitted per unit of activity or any other specific metric. Decreasing trends would mean that less GHGs are emitted for one unit of the selected metric.

Key results

- Between 1990 and 2020, the amount of GHGs emitted per person decreased 18% from 21.5 to 17.7 tonnes of carbon dioxide equivalent (CO_2 eq) per person
- Over the same period, 39% less GHGs were emitted to produce 1 billion dollars worth of goods and services (from 0.54 to 0.33 megatonnes CO_2 eq per billion dollars of GDP)

Figure 2. Indexed trend in greenhouse gas emissions per person and per unit of GDP, Canada, 1990 to 2020



Data for Figure 2

Note: The chart presents the ratio of annual GHG emissions per person and per unit of GDP relative to those values in 1990 (that is the values are indexed to 1990). Greenhouse gas emissions per unit of GDP is calculated using real inflation-adjusted GDP in 2012 dollars. Emission levels for some years have been revised in light of improvements to estimation methods and availability of new data.
Source: Environment and Climate Change Canada (2022) National Inventory Report 1990-2020: Greenhouse Gas Sources and Sinks in Canada. Statistics Canada (2022) Table 17-10-0005-01 - Estimates of population, by age group and sex for July 1, Canada, provinces and territories, annual. Statistics Canada (2022) Table 36-10-0369-01 - Gross domestic product at 2012 constant prices, expenditure-based, annual.

Decreases in emissions per person and per unit of GDP are attributable to a number of factors. More efficient industrial processes, a shift to a more service-based economy and a decrease in the emissions associated with electricity generation are all contributing to these decreases.

Between 2019 and 2020, GHG emissions per person decreased more rapidly than GHG emissions per unit of GDP. A positive population growth rate (+1.2%) combined with a significant decrease in GHG emissions (-8.9%) resulted in a 10% decrease in GHG emissions per person. In the meantime, lockdown measures resulting from the pandemic severely affected the economy and, for the first time since 2009, national GDP growth was negative (-4.8%) in 2020. Since the decrease in GHG emissions was larger than the decrease in GDP, the emissions per unit of GDP still decreased (-4.3%), but to a lesser extent compared to GHG emissions per person.

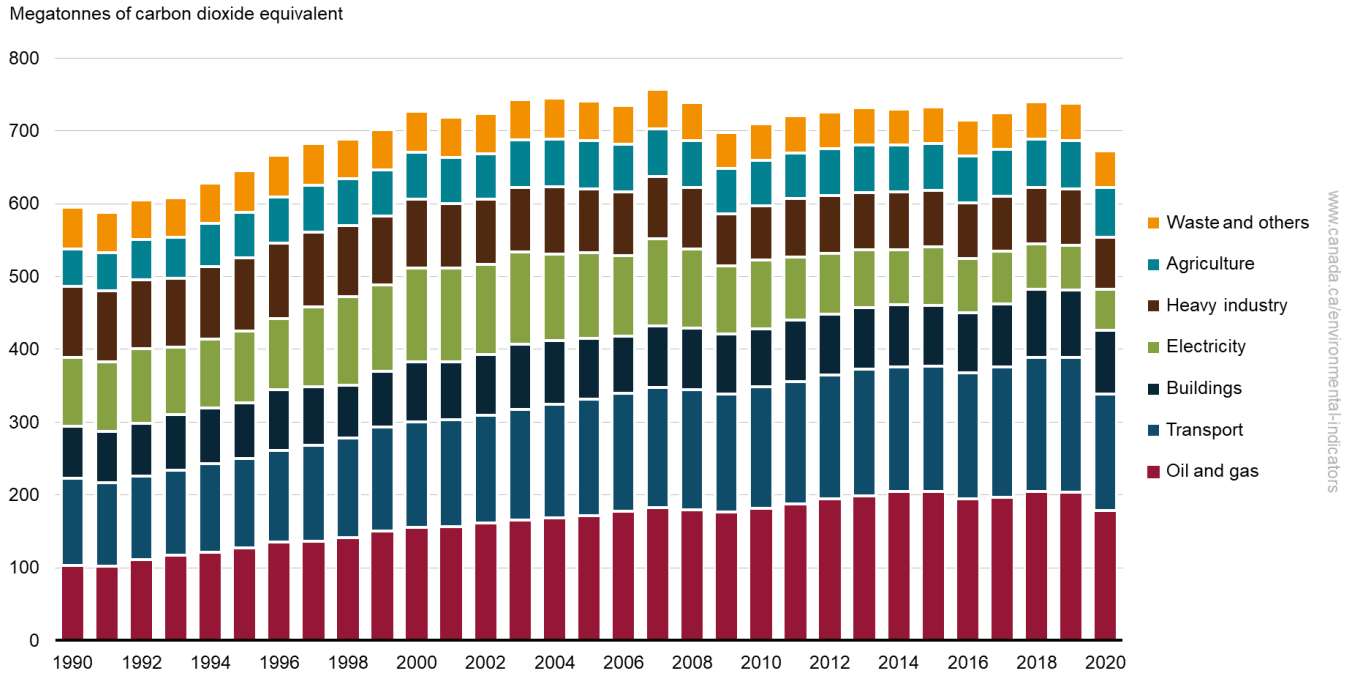
Greenhouse gas emissions by economic sector

This indicator shows GHG emissions reported by economic sector in which they are generated. Indicators focusing specifically on the oil and gas, transport, agriculture and electricity sectors follow.

Key results

- In 2020, the oil and gas sector and transport sector were the largest GHG emitters in Canada, accounting for 27% and 24% of total emissions, respectively
- From 2019 to 2020, GHG emissions from all individual sectors decreased by 4% to 14%, except for the agriculture sector where emissions grew by 3%
- Since 1990, GHG emissions from these sectors had similar overall changes than what is observed since 2005, except for the transport sector that showed an increase (+32%) for the period from 1990 to 2020

Figure 3. Greenhouse gas emissions by economic sector, Canada, 1990 to 2020



Data for Figure 3

Note: "Others" in the Waste and others sector consists of emissions from light manufacturing, construction, forest resources and coal production. The Heavy industry sector consists of emissions from mining, smelting and refining, pulp and paper, iron and steel, cement, lime and gypsum, and chemicals and fertilizers.
Source: Environment and Climate Change Canada (2022) National Inventory Report 1990-2020: Greenhouse Gas Sources and Sinks in Canada.

Between 1990 and 2020, the increase in total GHG emissions observed was mostly due to a 74% (76 Mt CO_2 eq) increase in emissions from the oil and gas sector and a 32% (39 Mt CO_2 eq) increase from the transport sector. These increases were partially offset by a 39 Mt CO_2 eq decrease in emissions from the electricity sector and a 25 Mt CO_2 eq decrease in emissions from heavy industry.

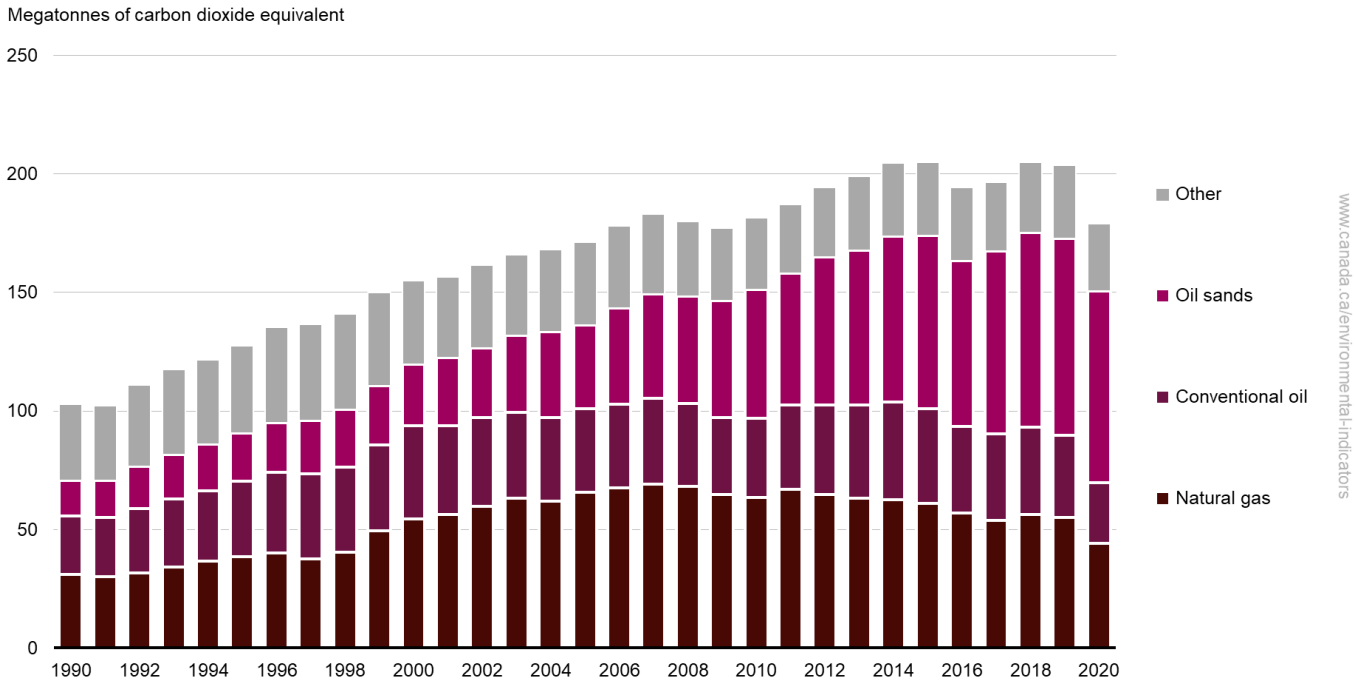
Between 2005 and 2020, the overall 69 Mt CO_2 eq decrease resulted mainly from a 61 Mt CO_2 eq. (-52%) reduction in emissions from the electricity sector and a 15 Mt CO_2 eq. (-18%) reduction from the heavy industry sector. Over that period, GHG emissions have also decreased for the transport (-1%), and the waste and others (-9%) sectors, while emissions from the oil and gas, buildings and agriculture sectors increased.

Greenhouse gas emissions from the oil and gas sector

Key results

- In 2020, the oil and gas sector was the largest source of GHG emissions, accounting for 27% of total national emissions with 179 megatonnes of carbon dioxide equivalent (Mt CO_2 eq) emitted
- In 2020, the sector's GHG emissions were 12% lower than in 2019, the largest decrease since 1990
- Over the period from 1990 to 2020, the sector's GHG emissions have increased by 74%

Figure 4. Oil and gas sector greenhouse gas emissions, Canada, 1990 to 2020



Data for Figure 4

Note: Conventional oil includes production from frontier, light and heavy oil fields. The Other category includes downstream oil and gas emissions (combustion and fugitive emissions from the production of refined petroleum products and the distribution of natural gas to end consumers) and oil and gas transmission emissions (combustion and fugitive emissions from transmission, storage and delivery activities).
Source: Environment and Climate Change Canada (2022) National Inventory Report 1990-2020: Greenhouse Gas Sources and Sinks in Canada.

Between 1990 and 2020, crude oil production more than doubled in Canada. This was mostly driven by a rapid increase in production from the oil sands, which are more GHG-intensive than conventional sources (that is, more GHGs are emitted per unit cubic meters of oil produced). This change thus had a major impact on total GHG emissions from the sector.

Over that period, GHG emissions from conventional oil production have increased by 4%, while emissions from oil sands production have increased by 437%. More than half of the increase in emissions from oil sands production over this period came from the growth of on site (*in situ*) production. Over the same period, production of natural gas from unconventional sources, such as those requiring the use of multi-stage fracturing techniques, also increased significantly. It resulted in a 42% increase in GHG emissions.

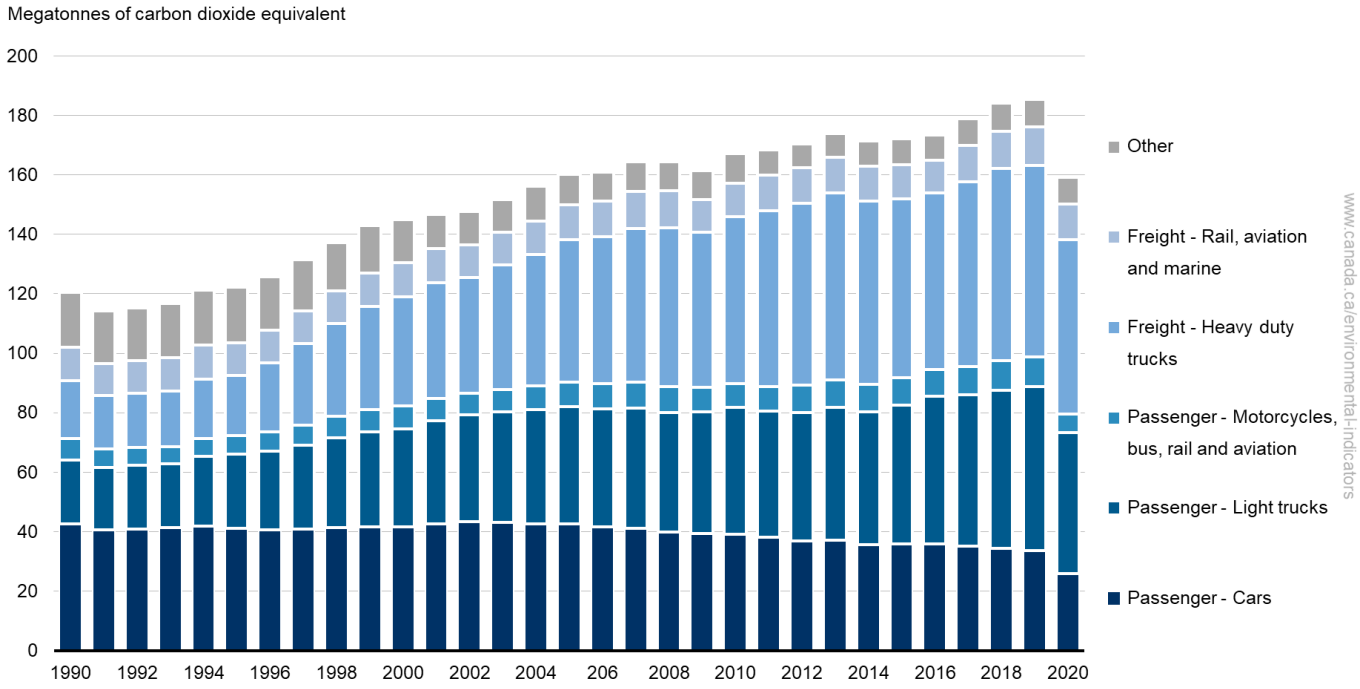
Similar trends were observed between 2005 and 2020, leading to a 4% increase in GHG emissions for that period. Note that the emissions increased by 32 Mt CO_2 eq. (+19%) between 2005 and 2019 before being largely offset by a 24 Mt CO_2 eq. reduction between 2019 and 2020. This emission reduction is the highest annual decrease since 1990 and was likely influenced, along with other factors, by the impacts of the COVID-19 pandemic on the energy sector.

Greenhouse gas emissions from the transport sector

Key results

- In 2020, the transport sector was the second largest source of GHG emissions, accounting for 24% of total national emissions with 159 megatonnes of carbon dioxide equivalent (Mt CO_2 eq) emitted
- In 2020, the sector GHG emissions were 14% lower than in 2019, the largest decrease since 1990
- Between 1990 and 2020, GHG emissions from the transport sector grew by 32%. The growth in emissions was mostly driven by increases from freight trucks and passenger light trucks

Figure 5. Transport sector greenhouse gas emissions, Canada, 1990 to 2020



Data for Figure 5

Note: The Other category includes other recreational, commercial and residential uses. Categories have been adapted from the classification used in Annex 10 of the National Inventory Report. For more details, please consult the "Methods" section.
Source: Environment and Climate Change Canada (2022) National Inventory Report 1990-2020: Greenhouse Gas Sources and Sinks in Canada.

Between 1990 and 2020, part of the GHG emissions increase was due to a higher number of vehicles on the road and to changes in vehicle type used. Although total emissions from passenger transport grew by 12%, emissions from cars declined by 40%, while emissions from light trucks (including trucks, vans and sport utility vehicles) more than doubled. Emissions from freight travel grew by 130% between 1990 and 2020. Specifically emissions from freight trucks more than tripled and emissions from other modes of freight transport increased by 6%.

Emissions from passenger and freight transport are influenced by a variety of factors, including population and economic growth, vehicle type, fuel efficiency and fuel type. Changes in the mix of vehicle type used, such as the increasing preference of passenger vehicle owners for light trucks rather than more fuel-efficient passenger cars, played an important role in shaping the evolution of GHG emissions.

Since 1990, the number of light trucks increased much faster than the increase of other passenger on-road vehicles. While there have been continual improvements in the fuel efficiency of both passenger cars and light

trucks over the last few decades,[1] these improvements were not sufficient to offset the increases in emissions due to the change in composition of the vehicle fleet.

Between 2005 and 2020, GHG emissions from the transport sector decreased by less than 1%. The reduction in emissions was mostly driven by decreases from passenger cars. However, it should be noted that GHG emissions increased by 25 Mt CO_2 eq. (+16%) between 2005 and 2019 before being completely offset by a 26 Mt CO_2 eq. reduction between 2019 and 2020. This emission reduction is the highest annual decrease since 1990 and was likely influenced by the impacts of the COVID-19 pandemic on the transport sector (fewer kilometres driven and a decrease in air traffic).

Greenhouse gas emissions from the agriculture sector

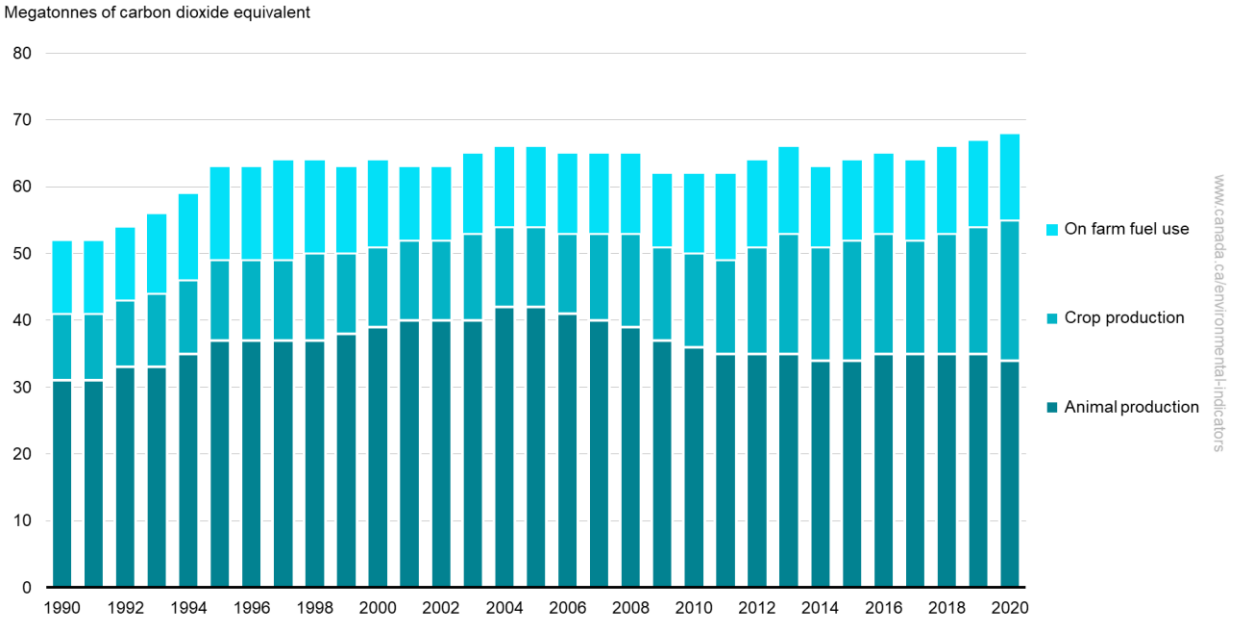
Greenhouse gas emissions from the agriculture sector are essentially attributable to crop production, such as cereals and oilseeds, and animal production (beef, dairy, poultry and swine) activities. Those activities include emissions resulting from the following:

- Crop production: application of biosolids and inorganic nitrogen fertilizers, decomposition of crop residues, loss of soil organic carbon, cultivation of organic soils, indirect emissions from leaching and volatilization, field burning of agricultural residues, liming, and urea application
- Animal production: animal housing, manure storage, manure deposited by grazing animals, and application of manure to managed soils

Key results

- In 2020, the agriculture sector was the fifth largest source of GHG emissions, accounting for 10% of total national emissions with 69 megatonnes of carbon dioxide equivalent (Mt CO_2 eq) emitted
- In 2020, the sector GHG emissions were 3% higher than in 2019 and reached a record high level
- Between 1990 and 2020, GHG emissions from the agriculture sector grew by 33%, mostly driven by an increase in emissions related to crop production

Figure 6. Agriculture sector greenhouse gas emissions, Canada, 1990 to 2020



Data for Figure 6

[1] Natural Resources Canada (2019) Energy efficiency for transportation and alternative fuels.

Source: Environment and Climate Change Canada (2022) National Inventory Report 1990-2020: Greenhouse Gas Sources and Sinks in Canada.

Between 1990 and 2020, emissions increased from 52 Mt CO_2 eq to 69 Mt CO_2 eq. This increase is primarily attributable to the doubling of crop production emissions.

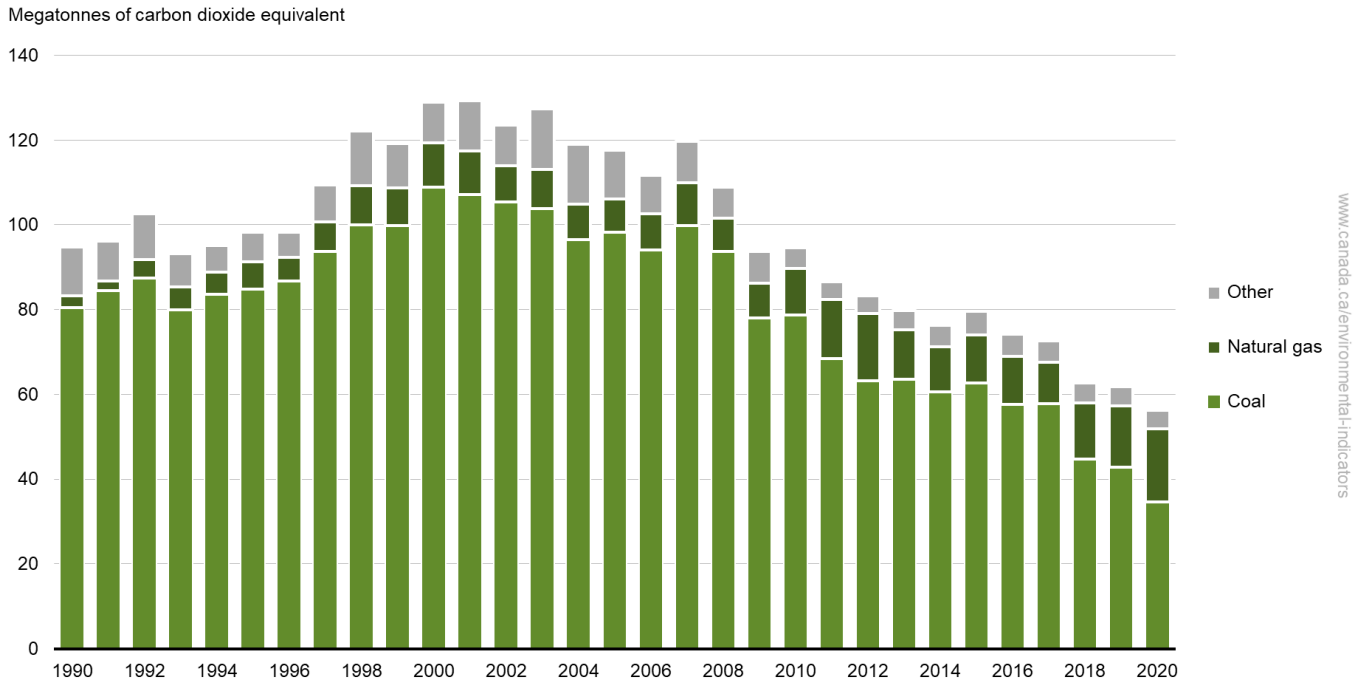
Between 2005 and 2020, GHG emissions from the agriculture sector increased by 3%. Even though emissions from animal production have always represented at least half of the total agriculture GHG emissions, since 2005, the proportion of emissions from the crop production rose constantly, reaching its highest level in 2020 (31%). Consequently, the share of animal production emissions dropped to its lowest level over the same period (from 64% to 50%). The drivers of the change are a reduction of cattle populations combined with a continued increase of crop production and fertilizer use.

Greenhouse gas emissions from the electricity sector

Key results

- In 2020, the electricity sector was the sixth largest source of GHG emissions, accounting for 8.4% of total national emissions with 56 megatonnes of carbon dioxide equivalent (Mt CO_2 eq) emitted
- In 2020, the sector GHG emissions were 9% lower than in 2019
- Between 2005 and 2020, greenhouse gas emissions from combustion-based electricity generation have decreased by 52%
- Between 1990 and 2020, greenhouse gas emissions from combustion-based electricity generation have decreased by 41%

Figure 7. Electricity sector greenhouse gas emissions, Canada, 1990 to 2020



Data for Figure 7

Note: The Other category includes diesel fuel oil, heavy fuel oil, light fuel oil, motor gasoline, petroleum coke, own use of primary electricity, solid wood waste, still gas and non-fuel related emissions.
Source: Environment and Climate Change Canada (2022) National Inventory Report 1990-2020: Greenhouse Gas Sources and Sinks in Canada.

Greenhouse gas emissions from combustion-based electricity generation have decreased from 95 megatonnes of carbon dioxide equivalent (Mt CO_2 eq) in 1990 to 56 Mt CO_2 eq in 2020. The growing share of electricity generated from low-GHG-emitting sources (such as hydro, other renewables and nuclear) and from fuels less

GHG-intensive than coal contributed to the decline in GHG emissions from electricity generation. This transition can be observed in the fuel type shares, with coal's share of all combustion emissions having decreased from 85% in 1990 to 62% in 2020, while natural gas share increased from 2.9% to 31%. Similar trends were observed between 2005 and 2020, leading to a 52% decrease from 118 Mt CO_2 eq. to 56 Mt CO_2 eq.

Electricity generation technologies have various levels of GHG emission intensity (which is defined as the quantity of GHGs emitted per unit of electricity produced). Hydroelectricity and nuclear power are low emitters of GHGs, while coal-burning power plants have a higher GHG intensity than natural gas-burning power plants. The general decline in the GHG intensity of electricity generation of public electric utilities can be attributed partly to a reduction in the use of coal and increases in other power plant types.

The electricity sector GHG emissions were 9% lower in 2020 than in 2019. The impact of the pandemic on these emissions is uncertain since the sector's emissions have been decreasing for 12 of the last 15 years, sometimes at a rate similar or higher than 9%. The observed reduction can be considered similar to year-to-year fluctuations.

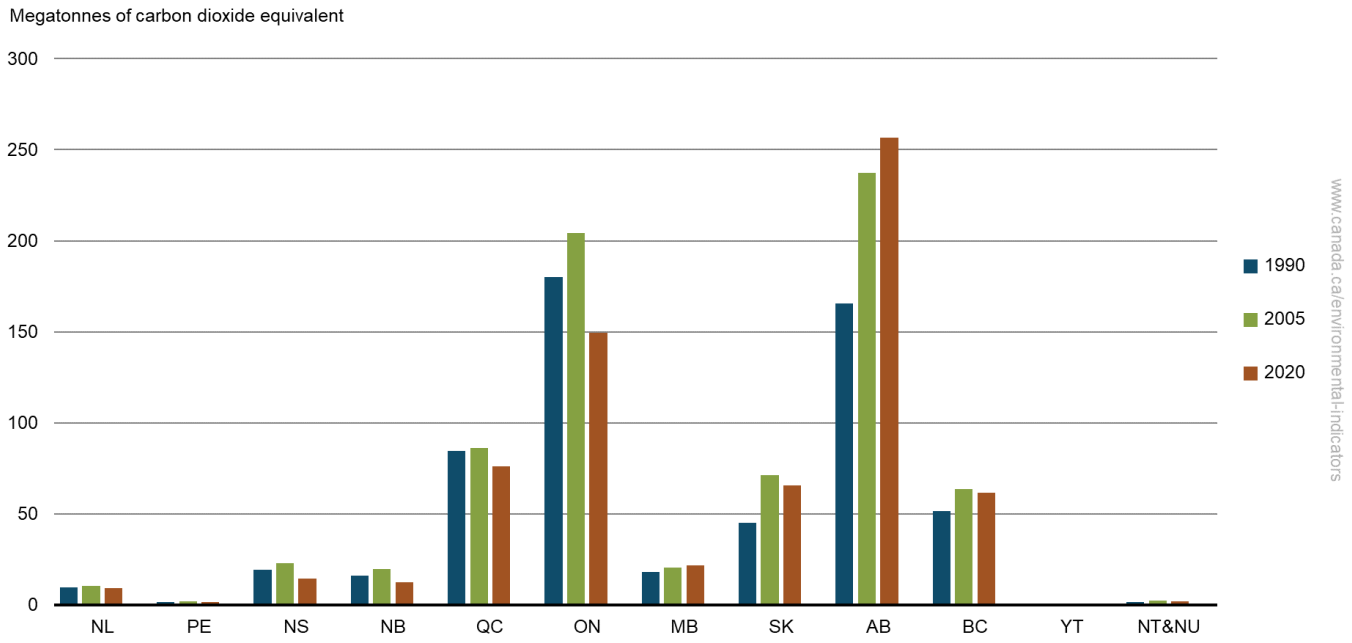
Greenhouse gas emissions by province and territory

Emissions vary significantly by province. The level of emissions depends on factors such as population, climate, energy sources and economic base. Provinces and territories that are the most populated, have economies based on resource extraction or are relying on fossil fuels to generate electricity will tend to have higher emission levels.

Key results

- In 2020, the top 5 emitters (Alberta, Ontario, Quebec, Saskatchewan and British Columbia) together released 91% of Canada's national total GHG emissions
- Of the top 5 emitters, greenhouse gas emissions were lower in 2020 than in 1990 for Ontario (-17%) and Quebec (-10%)

Figure 8. Greenhouse gas emissions by province and territory, Canada, 1990, 2005 and 2020



Data for Figure 8

Note: The years selected correspond to the first (1990) and last (2020) years of the dataset and to the base year (2005) for Canada's GHG emission reduction targets.
Source: Environment and Climate Change Canada (2022) National Inventory Report 1990-2020: Greenhouse Gas Sources and Sinks in Canada.

Between 1990 and 2005, GHG emissions increased in all provinces and territories. In 1990, Ontario's GHG emissions were higher than those from the other provinces because of its large manufacturing industry. Alberta's emissions subsequently surpassed Ontario's and increased by 55% over the period from 1990 to 2020, primarily due to the increasing activity of the oil and gas industry.

Of the top 5 emitters, GHG emissions were lower in 2020 than in 2005 for Ontario (-27%), Quebec (-12%), Saskatchewan (-8%) and British Columbia (-3%).

- Ontario's emissions decrease was primarily driven by the closure of coal-fired electricity generation plants.
- Quebec had a 12% (10.1 Mt CO_2 eq) decrease from its 2005 emissions level; mainly attributable to decreasing emissions from the residential sector, aluminium production and petroleum refining industries.
- Emissions in Saskatchewan decreased by 8% (5.4 Mt CO_2 eq), primarily due to emission reductions from the oil and gas sector (-40% or 11.6 Mt CO_2 eq).
- Emissions from British Columbia showed a decrease of 2.9% (1.8 Mt CO_2 eq); essentially due to decreasing emissions from the light manufacturing, heavy industry and waste sectors.

Over the first year into the pandemic, from 2019 to 2020, a reduction in GHG emissions was observed for all provinces and territories. Emissions from all top 5 emitters decreased by 5% to 16%, with Quebec, Alberta and Saskatchewan experiencing their largest decrease and Ontario and British Columbia their second largest.

About the indicators

What the indicators measure

The indicators show trends in anthropogenic (human-made) greenhouse gas (GHG) emissions. It includes emissions for 7 greenhouse gases (carbon dioxide, methane, nitrous oxide, sulphur hexafluoride, perfluorocarbons, hydrofluorocarbons and nitrogen trifluoride). Emissions are presented:

- at the national level (total emissions, emissions per person and emissions per unit of gross domestic product)
- by economic sector
- at the provincial/territorial level

The indicators do not capture:

- emissions from natural processes (for example, material decay, plant and animal respiration, volcanic and thermal venting)
- removal of emissions from the atmosphere by natural sinks (for example, forests, oceans)

Why these indicators are important

Greenhouse gases trap heat in the Earth's atmosphere, just as the glass of a greenhouse keeps warm air inside. Human activity increases the amount of GHGs in the atmosphere, contributing to a warming of the Earth's surface. This is called the enhanced greenhouse effect.

Over the past 200 years in particular, humans have released GHGs into the atmosphere primarily from burning fossil fuels. As a result, more heat is being trapped and the temperature of the planet is increasing. Sea levels are rising as the Arctic ice melts, and there are changes to the climate, such as more severe storms and heat waves. All of this impacts the environment, the economy and human health.

The Greenhouse gas emissions indicators are used to track the progress of Canada's efforts to lower emissions and reach environmental performance objectives. They also support decision making on sustainable development.

As an Annex I Party to the United Nations Framework Convention on Climate Change, Canada is required to prepare and submit a national inventory of anthropogenic sources and sinks of GHGs on an annual basis.

Effective action on climate change

These indicators track progress on the 2019 to 2022 Federal Sustainable Development Strategy, supporting the target: By 2030, reduce Canada's total GHG emissions by 30%, relative to 2005 emission levels. The most recent data available shows that, in 2020, emissions were 9.3% lower than 2005 emissions. This decrease was driven by emission reductions from the electricity and heavy industry sectors. The confinement measures introduced in 2020 due to the pandemic created an industrial slowdown and important reductions in trade and travel by air and land. These impacts contributed to the GHG emission decrease, especially in the transport sector where a 14% decrease was observed between 2019 and 2020.

These indicators are being proposed to track progress in the draft 2022 to 2026 Federal Sustainable Development Strategy.

In addition, the indicators contribute to the Sustainable Development Goals of the 2030 Agenda for Sustainable Development. They are linked to Goal 9, Industry, Innovation and Infrastructure and Goal 13: "Climate Action"; more specifically to Target 9.4, "By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities" and Target 13.2, "Integrate climate change measures into national policies, strategies and planning."

Related indicators

The Greenhouse gas emissions from large facilities indicator reports GHG emissions from the largest GHG emitters in Canada (industrial and other types of facilities).

The Progress towards Canada's greenhouse gas emissions reduction target indicator provides an overview of Canada's projected GHG emissions up to 2030.

The Global greenhouse gas emissions indicator provides a global perspective on Canada's share of global GHG emissions.

The Carbon dioxide emissions from a consumption perspective indicator shows the impact of Canada's consumption of goods and services, regardless of where they are produced, on the levels of carbon dioxide released into the atmosphere.

The Land-based greenhouse gas emissions and removals indicator tracks exchanges of greenhouse gas emissions and removals between the atmosphere and Canada's managed lands.

The Greenhouse gas concentrations indicators present atmospheric concentrations as measured from sites in Canada and at a global scale for 2 greenhouse gases: carbon dioxide and methane.

Data sources and methods

Data sources

The Greenhouse gas emissions indicators are based on greenhouse gas (GHG) emissions data taken from Environment and Climate Change Canada's National Inventory Report 1990-2020: Greenhouse Gas Sources and Sinks in Canada.

More information

Data used to develop the emission and removal estimates presented in the National Inventory Report are drawn from published and unpublished sources from various government departments, industry sources and scientific papers.

Greenhouse gas emission estimates are provided at the national level, by economic sectors and at the provincial/territorial level. The greenhouse gas emission estimates are compiled annually and reported for the period from 1990 to 2020. Complete details of the temporal coverage for each data source used for the indicators can be found in chapters 3 through 7 of the National Inventory Report.

Preparation of the GHG emissions inventory takes almost 16 months from the end of the reporting year because of the time needed to collect, validate, calculate and interpret the data. Between November and January, emission estimates are prepared by Environment and Climate Change Canada's Pollutant Inventories and Reporting Division with input from numerous experts and scientists across Canada. From January through March, the National Inventory Report text and accompanying emissions data tables are developed. This material is reviewed by external experts and Environment and Climate Change Canada officials, and finally submitted electronically to the United Nations Framework Convention on Climate Change, typically by mid-April.

Methods

The National Inventory Report estimates the emissions by combining activity data with the activity's emissions factor. It provides estimates at a sectoral and provincial/territorial level without attribution to individual emitters. The emissions estimates are developed using guidelines produced by the Intergovernmental Panel on Climate Change. Annex 3 of the National Inventory Report describes the methods used to estimate Canada's GHG emissions.

More information

Since direct measurement of emissions from all sources is not possible, the United Nations Framework Convention on Climate Change requires that countries develop, update, publish and maintain national inventories using internationally approved and comparable emissions and removals estimation methods

for 7 GHGs (carbon dioxide, methane, nitrous oxide, sulphur hexafluoride, perfluorocarbons, hydrofluorocarbons and nitrogen trifluoride). Canada's inventory is developed in accordance with the recently revised United Nations Framework Convention on Climate Change Inventory Reporting Guidelines for Annex I Parties (PDF; 1.67 MB) which require the use of the 2006 methodological guidance developed by the Intergovernmental Panel on Climate Change. The Intergovernmental Panel on Climate Change guidelines are based on the best available science and developed through an international process that involves testing of methods through ongoing inventory development, country studies, technical and regional workshops, and national and international experts consultations.

Emissions calculation

In general, GHG emissions are estimated by multiplying activity data by the associated emission factor.

Emissions = activity data × emission factor

Activity data refer to the quantitative amount of human activity resulting in emissions during a given time period. The annual activity data for fuel combustion sources, for example, are the total amounts of fuel burned over a year.

Emission factors are based on samples of measurement data, and are representative rates of emissions for a given activity level under a given set of operating conditions. It is the estimated average emission rate of a given pollutant for a given source, relative to units of activity.

Guidelines produced by the Intergovernmental Panel on Climate Change for countries reporting to the United Nations Framework Convention on Climate Change provide various methods for calculating GHG emissions from a given human activity. The methods for estimating emissions are divided into "tiers," each encompassing different levels of activity and technological detail. The same general structure is used for all tiers, while the level of detail at which the calculations are carried out can vary. Annex 3 of the National Inventory Report describes the methods used to estimate Canada's GHG emissions and illustrates that the selection of Intergovernmental Panel on Climate Change method type is highly dependent on the importance of each category and the availability of data.

Carbon dioxide equivalents

Greenhouse gas emissions are reported in carbon dioxide equivalents (CO_2 eq), determined by multiplying the amount of emissions of a particular greenhouse gas by the global warming potential of that gas. Greenhouse gases differ in their ability to absorb heat in the atmosphere due to their differing chemical properties and atmospheric lifetimes. For example, over a period of 100 years, methane's potential to trap heat in the atmosphere is 25 times greater than carbon dioxide's potential. Therefore, methane is considered to have a global warming potential of 25. The Intergovernmental Panel on Climate Change publishes the global warming potentials and atmospheric lifetimes for each GHG; these can be found in Table 1-1 of the National Inventory Report.

Greenhouse gas emissions by economic sector

The Greenhouse gas emissions by economic sector indicator represents a different classification than the activity sector emissions prescribed by the Intergovernmental Panel on Climate Change's methodological guidance and United Nations Framework Convention on Climate Change's reporting guidelines. Instead of reporting on Canada's emissions by activity, GHG emissions have been allocated to the economic sector in which they are generated (for example, transport emissions directly supporting an industrial activity, like off-road trucks in mining activities, have been allocated to the economic sector in which they are generated rather than to the transportation "activity" sector). A comprehensive detailing of the emissions reported by economic sector can be found in chapter 2 and Annex 10 of the National Inventory Report.

Greenhouse gas emissions from the transport sector

The Greenhouse gas emissions from the transport sector indicator was calculated using a classification adapted from the one presented in Annex 10 of the National Inventory Report.

For the passenger transport, National Inventory Report's "Cars, light trucks and motorcycles" category was split into 2 separate categories ("Cars" and "Light trucks"), and the "Motorcycles" data were combined with the existing "Bus, rail and aviation" category.

For the freight transport, National Inventory Report's "Heavy duty trucks and rail" category was split into 2 separate categories. "Rail" data were then combined with the existing "Aviation and marine" category.

No change was made to the "Other: recreational, commercial and residential" category.

Quality assurance, quality control and uncertainty

Quality assurance and quality control procedures are an essential requirement of the GHG inventory development and submission process. Quality assurance and quality control procedures ensure and improve transparency, consistency, comparability, completeness and confidence in the national emissions for the purpose of meeting Canada's reporting commitments under the United Nations Framework Convention on Climate Change. Chapter 1 (section 1.3) of the National Inventory Report provides a complete description of the quality assurance and quality control procedures.

Uncertainty analysis helps to prioritize improvements and to guide decisions on methodological choices. Annex 2 of the National Inventory Report presents the uncertainty assessment for Canada's GHG emissions. Further details on uncertainty related to specific sectors can be found in the uncertainty sections of chapters 3 through 7 of the National Inventory Report.

Recent changes

Recalculations are performed annually on Canada's previously reported greenhouse gas emissions estimates to reflect updates to source data and estimation methodology. Chapter 8 of the National Inventory Report provides a summary of the recalculations that occurred due to methodological changes and/or refinements since the previous submission. The summary includes:

- brief description, justification and summary of individual impacts on previously reported emission estimates
- details on specific inventory improvements implemented in 2022 as well as planned improvements

Caveats and limitations

The Greenhouse gas emissions indicators are comprehensive but some emission sources have not been included in the indicators because they are not reported in the National Inventory Report. Owing to their relatively small contributions to the total emissions, these excluded sources do not significantly affect the overall completeness of the inventory. A detailed explanation of the excluded emission sources can be found in Annex 5 of the National Inventory Report.

Although reported in the National Inventory Report, emissions and removals from the land use, land use change and forestry sector are excluded from national totals and subsequently not reported as part of the Greenhouse gas emissions indicators.

The latest year reported (2020) coincides with the first year of the COVID-19 pandemic which had an impact on a wide range of economic sectors, especially the energy and transport sectors. The emissions change for the periods from 1990 to 2020, and from 2005 to 2020 must be interpreted with caution as the level of incidence of the pandemic on the emissions is not discussed in detail in the indicators.

Resources

References

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Related information

Greenhouse gas emissions: drivers and impacts

Canada's action on climate change

Climate change

Guidelines for National Greenhouse Gas Inventories

Annex

Annex A. Data tables for the figures presented in this document

Table A.1. Data for Figure 1. Greenhouse gas emissions, Canada, 1990 to 2020

Year	Total greenhouse gas emissions (megatonnes of carbon dioxide equivalent)
1990	595
1991	588
1992	605
1993	608
1994	628
1995	645
1996	667
1997	682
1998	689
1999	702
2000	727
2001	718
2002	724
2003	743
2004	745
2005	741
2006	735
2007	757
2008	739
2009	698
2010	710
2011	721
2012	726
2013	732
2014	730
2015	733
2016	715
2017	725
2018	740
2019	738
2020	672

Note: Data are presented as rounded figures. The national indicator tracks 7 greenhouse gases released by human activity: carbon dioxide, methane, nitrous oxide, sulphur hexafluoride, perfluorocarbons, hydrofluorocarbons and nitrogen trifluoride. Emission levels for some years have been revised in light of improvements to estimation methods and availability of new data. Emissions and removals from the land use, land use change and forestry sector (LULUCF) are excluded from national totals to allow for a focus on greenhouse gas released from human activity only.
Source: Environment and Climate Change Canada (2022) National Inventory Report 1990-2020: Greenhouse Gas Sources and Sinks in Canada.

Table A.2. Data for Figure 2. Indexed trend in greenhouse gas emissions per person and per unit of GDP, Canada, 1990 to 2020

Year	Greenhouse gas emissions per person (tonnes of carbon dioxide equivalent per person)	Indexed greenhouse gas emissions per person (percentage change from 1990 level)	Greenhouse gas emissions per unit of gross domestic product (megatonnes of carbon dioxide equivalent per billion dollars gross domestic product)	Indexed greenhouse gas emissions per unit of gross domestic product (percentage change from 1990 level)
1990	21.5	0.0	0.54	0.0
1991	21.0	-2.4	0.55	0.8
1992	21.3	-0.7	0.56	2.9
1993	21.2	-1.4	0.55	0.8
1994	21.7	0.9	0.54	-0.6
1995	22.0	2.6	0.54	-0.5
1996	22.5	4.8	0.55	1.2
1997	22.8	6.2	0.54	-0.9
1998	22.8	6.3	0.52	-3.7
1999	23.1	7.5	0.51	-7.0
2000	23.7	10.3	0.50	-8.7
2001	23.2	7.8	0.48	-11.1
2002	23.1	7.5	0.47	-12.9
2003	23.5	9.4	0.48	-12.3
2004	23.3	8.6	0.47	-14.6
2005	23.0	7.0	0.45	-17.7
2006	22.6	5.0	0.43	-20.4
2007	23.0	7.1	0.44	-19.8
2008	22.2	3.5	0.42	-22.5
2009	20.7	-3.4	0.41	-24.4
2010	20.9	-2.8	0.41	-25.3
2011	21.0	-2.3	0.40	-26.4
2012	20.9	-2.7	0.40	-27.1
2013	20.9	-2.8	0.39	-28.2
2014	20.6	-4.1	0.38	-30.5
2015	20.5	-4.5	0.38	-30.6
2016	19.8	-7.8	0.37	-32.8
2017	19.8	-7.6	0.36	-34.2
2018	20.0	-7.0	0.35	-34.9
2019	19.6	-8.6	0.35	-36.2
2020	17.7	-17.7	0.33	-39.0

Note: Data are presented as rounded figures. However, all calculations have been performed using unrounded data. The table presents the ratio of annual greenhouse gas emissions per person and per unit of gross domestic product relative to those values in 1990 (that is the values are indexed to 1990). Greenhouse gas per unit of gross domestic product is calculated using real inflation-adjusted gross domestic product in 2012 dollars. Emission levels for some years have been revised in light of improvements to estimation methods and availability of new data.
Source: Environment and Climate Change Canada (2022) National Inventory Report 1990-2020: Greenhouse Gas Sources and Sinks in Canada. Statistics Canada (2022) Table 17-10-0005-01 - Estimates of population, by age group and sex for July 1, Canada, provinces and territories, annual. Statistics Canada (2022) Table 36-10-0369-01 - Gross domestic product at 2012 constant prices, expenditure-based, annual.

Table A.3. Data for Figure 3. Greenhouse gas emissions by economic sector, Canada, 1990 to 2020

Year	Oil and gas (megatonnes of carbon dioxide equivalent)	Transport (megatonnes of carbon dioxide equivalent)	Buildings (megatonnes of carbon dioxide equivalent)	Electricity (megatonnes of carbon dioxide equivalent)	Heavy industry (megatonnes of carbon dioxide equivalent)	Agriculture (megatonnes of carbon dioxide equivalent)	Waste and others (megatonnes of carbon dioxide equivalent)
1990	102.6	120.5	71.2	94.7	97.2	51.7	56.7
1991	102.2	114.3	70.6	96.1	97.1	52.3	55.3
1992	110.8	115.2	72.4	102.5	94.6	54.7	54.9
1993	117.5	116.7	76.0	93.1	94.1	56.5	53.7
1994	121.5	121.3	76.3	95.1	99.7	59.1	55.1
1995	127.6	122.1	77.0	98.2	100.4	62.2	57.9
1996	135.4	125.7	83.3	98.2	103.2	63.4	57.5
1997	136.5	131.5	80.8	109.4	102.6	64.0	57.5
1998	140.9	137.3	72.4	122.1	97.6	63.8	54.5
1999	149.9	143.0	76.3	119.1	94.7	63.5	55.2
2000	155.1	144.9	82.8	129.0	94.1	64.1	56.9
2001	156.6	146.6	79.5	129.2	88.3	62.9	55.2
2002	161.5	147.7	83.8	123.6	89.0	62.9	55.7
2003	165.9	151.7	89.0	127.3	88.3	65.1	55.9
2004	168.2	156.1	87.6	119.0	92.2	65.9	56.2
2005	171.3	160.1	83.7	117.5	87.2	66.4	55.0
2006	178.0	161.0	78.5	111.6	87.0	65.0	53.5
2007	183.0	164.4	84.3	119.6	86.0	65.0	54.5
2008	179.9	164.5	84.2	108.8	84.5	64.2	52.9
2009	176.9	161.5	82.6	93.7	71.5	61.9	49.5
2010	181.4	167.2	79.4	94.6	74.6	61.9	50.5
2011	187.2	168.3	84.7	86.6	80.4	62.4	51.3
2012	194.2	170.5	83.2	83.3	80.2	63.7	50.5
2013	198.9	174.0	84.3	79.7	78.6	65.4	51.3
2014	204.5	171.5	84.9	76.3	79.4	63.8	49.3
2015	204.8	172.1	83.8	79.7	77.8	64.6	49.8
2016	194.4	173.5	82.2	74.3	76.3	64.9	49.5
2017	196.5	178.9	86.6	72.6	75.5	64.3	50.5
2018	205.0	184.1	92.9	62.8	77.5	66.3	51.5
2019	203.5	185.5	92.0	61.8	77.4	66.7	51.5
2020	178.8	159.2	87.8	56.2	71.8	68.7	50.0

Note: Data are presented as rounded figures. "Others" in the Waste and others sector consists of emissions from light manufacturing, construction, forest resources and coal production. The Heavy industry sector consists of emissions from mining, smelting and refining, pulp and paper, iron and steel, cement, lime and gypsum, and chemicals and fertilizers.
Source: Environment and Climate Change Canada (2022) National Inventory Report 1990-2020: Greenhouse Gas Sources and Sinks in Canada.

Table A.4. Data for Figure 4. Oil and gas sector greenhouse gas emissions, Canada, 1990 to 2020

Year	Natural gas (megatonnes of carbon dioxide equivalent)	Conventional oil (megatonnes of carbon dioxide equivalent)	Oil sands, mining and extraction (megatonnes of carbon dioxide equivalent)	Oil sands, in situ (megatonnes of carbon dioxide equivalent)	Oil sands, upgrading (megatonnes of carbon dioxide equivalent)	Other (megatonnes of carbon dioxide equivalent)
1990	31.2	24.4	2.2	4.5	8.4	32.0
1991	30.0	25.0	2.3	4.3	9.0	31.6
1992	31.6	27.3	2.4	4.3	10.9	34.3
1993	34.1	28.8	2.5	4.3	12.0	35.7
1994	36.6	29.7	2.7	4.5	12.7	35.4
1995	38.4	32.1	2.8	4.9	12.4	36.9
1996	40.2	34.0	2.9	5.2	12.6	40.4
1997	37.7	35.8	2.8	7.3	12.3	40.6
1998	40.4	35.8	2.9	9.0	12.7	40.0
1999	49.4	36.3	3.1	8.4	13.4	39.4
2000	54.5	39.3	3.2	9.0	13.7	35.3
2001	56.4	37.5	4.2	9.2	15.1	34.2
2002	59.9	37.3	4.3	9.1	16.1	34.9
2003	63.2	36.1	5.3	10.3	16.9	34.1
2004	62.1	35.2	5.8	11.3	18.9	34.8
2005	65.8	35.2	5.6	12.2	17.3	35.2
2006	67.7	35.1	6.2	14.2	20.3	34.5
2007	69.2	36.0	6.8	15.7	21.6	33.7
2008	68.2	35.0	7.2	18.4	19.6	31.5
2009	64.8	32.5	7.7	19.8	21.7	30.5
2010	63.6	33.4	8.5	22.7	23.0	30.3
2011	67.0	35.6	8.4	24.5	22.6	29.0
2012	64.7	37.9	9.1	29.2	23.9	29.3
2013	63.1	39.5	9.9	30.9	24.5	31.0
2014	62.6	41.2	10.5	35.2	24.3	30.7
2015	61.0	40.1	11.1	38.1	23.6	30.9
2016	56.8	36.6	11.3	37.8	21.0	30.9
2017	53.9	36.5	12.9	41.5	22.5	29.1
2018	56.3	36.8	14.8	43.6	23.6	29.9
2019	55.0	34.8	15.4	42.9	24.5	30.9
2020	44.2	25.4	14.9	41.2	24.7	28.4

Note: Data are presented as rounded figures. Conventional oil includes production from frontier, light and heavy oil fields. The Other category includes downstream oil and gas emissions (combustion and fugitive emissions from the production of refined petroleum products and the distribution of natural gas to end consumers) and oil and gas transmission emissions (combustion and fugitive emissions from transmission, storage and delivery activities).
Source: Environment and Climate Change Canada (2022) National Inventory Report 1990-2020: Greenhouse Gas Sources and Sinks in Canada.

Table A.5. Data for Figure 5. Transport sector greenhouse gas emissions, Canada, 1990 to 2020

Year	Passenger - Cars (megatonnes of carbon dioxide equivalent)	Passenger - Light trucks (megatonnes of carbon dioxide equivalent)	Passenger - Motorcycles, bus, rail and aviation (megatonnes of carbon dioxide equivalent)	Freight - Heavy duty trucks (megatonnes of carbon dioxide equivalent)	Freight - Rail, aviation and marine (megatonnes of carbon dioxide equivalent)	Other (megatonnes of carbon dioxide equivalent)
1990	42.5	21.6	7.2	19.4	11.3	18.5
1991	40.7	20.9	6.2	18.0	10.7	17.7
1992	41.0	21.3	6.2	18.0	11.0	17.8
1993	41.4	21.4	5.8	18.7	11.0	18.3
1994	41.8	23.5	6.1	20.0	11.4	18.5
1995	41.0	24.9	6.2	20.4	10.9	18.7
1996	40.7	26.3	6.7	23.2	10.8	18.0
1997	40.9	28.1	6.9	27.3	11.0	17.3
1998	41.3	30.1	7.3	31.4	10.8	16.4
1999	41.5	31.9	7.7	34.6	11.3	16.0
2000	41.6	32.9	7.8	36.7	11.5	14.5
2001	42.7	34.7	7.4	39.1	11.3	11.5
2002	43.2	36.0	7.2	39.2	10.9	11.2
2003	43.1	37.3	7.5	41.9	11.0	11.0
2004	42.6	38.4	8.0	44.3	11.2	11.6
2005	42.7	39.3	8.4	47.9	11.8	10.0
2006	41.6	39.7	8.5	49.4	12.0	9.9
2007	41.1	40.4	8.8	51.8	12.3	10.1
2008	39.8	40.1	8.7	53.4	12.5	9.9
2009	39.4	41.0	8.0	52.2	11.2	9.7
2010	39.2	42.5	8.1	56.3	11.1	10.1
2011	38.0	42.7	8.2	59.2	11.9	8.4
2012	36.9	43.2	9.1	61.1	12.1	8.0
2013	37.1	44.6	9.4	62.9	11.8	8.2
2014	35.6	44.8	9.1	61.7	11.9	8.5
2015	35.9	46.7	9.1	60.2	11.4	8.7
2016	35.9	49.7	8.9	59.4	11.0	8.6
2017	35.1	51.1	9.4	62.2	12.2	9.1
2018	34.3	53.1	10.1	64.6	12.6	9.3
2019	33.6	55.1	10.0	64.5	13.1	9.2
2020	26.0	47.2	6.5	58.5	12.0	9.0

Note: Data are presented as rounded figures. However, all calculations have been performed using unrounded data. The Other category includes other recreational, commercial and residential uses. Categories have been adapted from the classification used in Annex 10 of the National Inventory Report. For more details, consult the "Methods" section.
Source: Environment and Climate Change Canada (2022) National Inventory Report 1990-2020: Greenhouse Gas Sources and Sinks in Canada.

Table A.6. Data for Figure 6. Agriculture sector greenhouse gas emissions, Canada, 1990 to 2020

Year	On farm fuel use (megatonnes of carbon dioxide equivalent)	Crop production (megatonnes of carbon dioxide equivalent)	Animal production (megatonnes of carbon dioxide equivalent)
1990	10.5	10.4	30.8
1991	10.9	10.0	31.4
1992	11.5	10.4	32.8
1993	12.2	11.0	33.4
1994	12.9	11.4	34.8
1995	14.0	11.6	36.6
1996	14.3	12.1	37.1
1997	14.6	12.3	37.1
1998	13.7	12.7	37.4
1999	13.3	12.4	37.7
2000	13.1	12.4	38.6
2001	11.4	11.7	39.7
2002	11.4	11.6	39.9
2003	12.2	12.7	40.3
2004	12.3	12.1	41.5
2005	12.3	11.7	42.5
2006	11.6	12.1	41.3
2007	12.1	13.0	39.9
2008	11.8	13.6	38.8
2009	11.4	13.7	36.8
2010	12.3	14.0	35.6
2011	13.1	14.5	34.8
2012	12.6	16.2	34.9
2013	12.6	17.9	34.9
2014	12.5	16.8	34.5
2015	12.3	18.0	34.4
2016	11.9	18.3	34.8
2017	12.3	17.3	34.8
2018	13.1	18.5	34.7
2019	13.4	18.7	34.6
2020	13.5	21.0	34.2

Note: Data are presented as rounded figures.
Source: Environment and Climate Change Canada (2022) National Inventory Report 1990-2020: Greenhouse Gas Sources and Sinks in Canada.

Table A.7. Data for Figure 7. Electricity sector greenhouse gas emissions, Canada, 1990 to 2020

Year	Coal (megatonnes of carbon dioxide equivalent)	Natural gas (megatonnes of carbon dioxide equivalent)	Other (megatonnes of carbon dioxide equivalent)
1990	80.5	2.7	11.5
1991	84.5	2.2	9.4
1992	87.4	4.4	10.7
1993	79.9	5.4	7.8
1994	83.6	5.3	6.3
1995	84.8	6.4	7.0
1996	86.8	5.5	5.9
1997	93.7	6.9	8.8
1998	100.0	9.2	12.9
1999	99.9	8.9	10.4
2000	108.9	10.5	9.6
2001	107.2	10.3	11.8
2002	105.5	8.5	9.6
2003	103.9	9.2	14.2
2004	96.5	8.4	14.1
2005	98.2	7.9	11.4
2006	94.1	8.5	9.0
2007	99.7	10.2	9.7
2008	93.6	8.0	7.2
2009	78.0	8.2	7.5
2010	78.7	11.0	4.9
2011	68.4	13.9	4.2
2012	63.2	15.8	4.2
2013	63.5	11.6	4.5
2014	60.7	10.6	5.1
2015	62.7	11.3	5.7
2016	57.6	11.3	5.3
2017	57.7	9.9	5.0
2018	44.7	13.2	4.9
2019	42.8	14.5	4.4
2020	34.7	17.3	4.2

Note: Data are presented as rounded figures. The Other category includes diesel fuel oil, heavy fuel oil, light fuel oil, motor gasoline, petroleum coke, own use of primary electricity, solid wood waste, still gas and non-fuel related emissions.
Source: Environment and Climate Change Canada (2022) National Inventory Report 1990-2020: Greenhouse Gas Sources and Sinks in Canada.

Table A.8. Data for Figure 8. Greenhouse gas emissions by province and territory, Canada, 1990, 2005 and 2020

Province or territory	1990 greenhouse gas emissions (megatonnes of carbon dioxide equivalent)	2005 greenhouse gas emissions (megatonnes of carbon dioxide equivalent)	2020 greenhouse gas emissions (megatonnes of carbon dioxide equivalent)
Newfoundland and Labrador (NL)	9.6	10.5	9.5
Prince Edward Island (PE)	1.8	1.9	1.6
Nova Scotia (NS)	19.5	23.0	14.6
New Brunswick (NB)	16.2	19.8	12.4
Quebec (QC)	84.5	86.3	76.2
Ontario (ON)	180.0	204.4	149.6
Manitoba (MB)	18.3	20.5	21.7
Saskatchewan (SK)	45.1	71.3	65.9
Alberta (AB)	165.6	237.1	256.5
British Columbia (BC)	51.7	63.6	61.7
Yukon (YT)	0.6	0.6	0.6
Northwest Territories (NT)	1.8[A]	1.7	1.4
Nunavut (NU)[A]	n/a	0.6	0.6

Note: [A] 1990 emissions data for the Northwest Territories include emissions for Nunavut, which was part of the Northwest Territories until 1999. n/a = not applicable. Data are presented as rounded figures. However, all calculations have been performed using unrounded data. The years selected correspond to the first (1990) and last (2020) years of the dataset and to the base year (2005) for Canada's GHG emission reduction targets.
Source: Environment and Climate Change Canada (2022) National Inventory Report 1990-2020: Greenhouse Gas Sources and Sinks in Canada.

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