

CANADA'S GREENHOUSE GAS INVENTORY

GHG Trends Information from Environment Canada's Greenhouse Gas Division

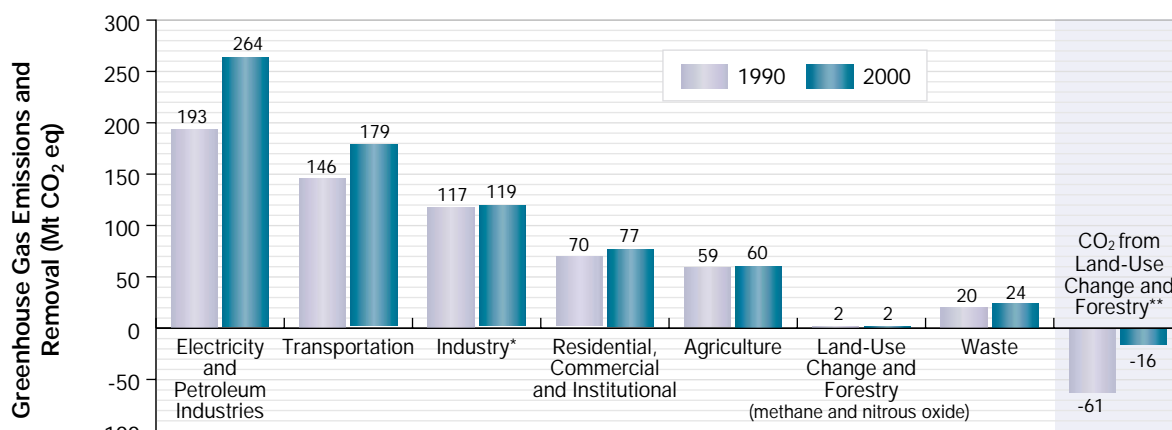
Overview: 1990-2000

Total Canadian emissions of greenhouse gases to the atmosphere were estimated to be 726 megatonnes carbon dioxide equivalent* (Mt CO₂ eq) in 2000, up 3.2% over 1999 levels. This year-to-year rate of increase is the second highest since 1990 and is largely a result of above average increases in energy use for heating and an increase in overall productivity in the Canadian economy, which was 4.6% greater in 2000 than 1999. Between 1990 and 2000, emissions increased 19.6%, or 119 Mt, while Canada's Gross Domestic Product (GDP) grew nearly 33%, total domestic energy consumption increased 17%, and population rose 11%.

- On a greenhouse gas basis, carbon dioxide was the dominant gas, accounting for 78.7% (571 Mt) of 2000 emissions, while methane and nitrous oxide contributed the next largest shares at 12.6% (91 Mt) and 7.4% (54 Mt), respectively.
- The greatest sector contributions to emissions in 2000 are from the Electricity and Petroleum Industries, which accounted for 36% of total national emissions (264 Mt), and the Transportation sector, which contributed 25% (179 Mt). These sectors are also responsible for nearly all of the growth in Canadian emissions since 1990. This is mainly the result of an increase in fossil fuel consumption for electricity generation, a rise in transportation energy consumption, as well as growth in fossil fuel production, largely for export.
- The Industry sector exhibited a 1% increase in emissions between 1990 and 2000, despite significant increases in sector GDP and production. The stability in emissions is largely due to a decline in process emissions from adipic acid production, as well as increased energy efficiency and fuel substitution. Other sectors, such as Residential, Commercial and Institutional (RCI), Agriculture, and Waste, contributed 11% to the total emissions growth over the period.
- Net carbon dioxide removals by sinks associated with the Land-Use Change and Forestry sector declined 73% since 1990, but are not included in the national inventory totals.

*Unless otherwise indicated, all emissions are reported in Mt CO₂ eq. For brevity, this has been shortened to Mt. This concept provides a relative measure of the impacts of different greenhouse gases on global warming, with the effect of carbon dioxide being equal to one.

Figure 1 Canadian Greenhouse Gas Emissions and Removals, 1990 and 2000



*Value illustrated includes emissions due to Solvent and Other Product Use

**Carbon dioxide emissions from the Land-Use Change and Forestry sector are not included in the national inventory totals.



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Canada's Greenhouse Gas Inventory (CGHGI)

The Canadian Greenhouse Gas Inventory is developed, compiled, and reported annually by the Greenhouse Gas Division of Environment Canada. The inventory is prepared in accordance with the Framework Convention on Climate Change (UNFCCC) and particularly Decision 3/C.P. 5 which states Annex 1 parties should annually submit by April 15 national inventories in accordance with the UNFCCC Guidelines on annual inventories (UNFCCC/CP/1999/7).

Canada's Greenhouse Gas Inventory 1990-2000: Trends Fact Sheet Series

The 1990-2000 CGHGI Fact Sheet Series provides a discussion of the trends in Canadian greenhouse gas emissions and removals on a sector basis, and presents an understanding of the nature, causes and sources of the trends. Methodologies for estimating quantities of emissions and removals, while not included in the fact sheet series, will be detailed in Environment Canada's upcoming report entitled, *Canada's Greenhouse Gas Inventory 1990-2000*, due for release later in 2002.

In addition to this fact sheet, which contains a national overview of Canada's greenhouse gas trends since 1990, the 2000 CGHGI Fact Sheet Series will also include detailed trends analyses in the following seven sectors* :

1. **Electricity and Petroleum Industries:** is comprised of two sectors:
 - *Electricity Generation* - includes emissions from fuel combustion; and
 - *Petroleum Industries* - includes fuel combustion, industrial process and fugitive emissions within the upstream (e.g. oil and gas exploration, production and transport) and downstream (e.g. refining of oil products and natural gas distribution) petroleum industry sub-sectors.
2. **Transportation:** includes fuel combustion emissions from mobile sources - on-road, air, marine, rail, and off-road modes.
3. **Industry:** consists of fuel combustion, industrial process and fugitive emissions from a diverse array of industries - from steel, auto, and electronic manufacturing to pharmaceutical, fertiliser, pulp and paper and food production.
4. **Residential, Commercial and Institutional Sector:** includes fuel combustion emissions within the Residential and Commercial and Institutional sub-sectors.
5. **Agriculture:** includes the contribution to greenhouse gas emissions from livestock, manure management, and agricultural soils.
6. **Land-Use Change and Forestry:** includes greenhouse gas emissions and removals from changes in forest and other woody biomass stocks, human-induced fires, and land-use changes.
7. **Waste:** includes emissions from solid waste disposal on land, wastewater handling and waste incineration.

*The remaining fact sheets in the 2000 series will be available later in 2002.

Inventory estimates are determined by methods and models developed in-house by engineering and scientific staff, as well as from published data, data developed by industry, or methods developed by the Intergovernmental Panel on Climate Change (IPCC, 1997).

The greenhouse gases that have been estimated in the national inventory are carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), sulphur hexafluoride (SF₆), perfluorocarbons (PFCs), and hydro fluorocarbons (HFCs).

The inventory uses an internationally agreed to reporting format that groups emissions and removals into the following six sectors: Energy, Industrial Processes, Solvent and Other Product Use, Agriculture, Land-Use Change and Forestry, and Waste.

The 2000 Trends Fact Sheet Series, while presenting the latest information on Canadian greenhouse gas emissions and removals derived from the latest national inventory, use a modified sector approach to facilitate the use of information by the public.

Canada's Gross Domestic Product (GDP) has been growing more rapidly as greenhouse gas emission growth has slowed.

| Year | Annual Growth in GHG Emissions (%) | Annual Growth in GDP* (%) |
|------|------------------------------------|---------------------------|
| 1991 | -1.2% | -1.9% |
| 1992 | 2.7% | 1.0% |
| 1993 | 0.4% | 2.4% |
| 1994 | 3.6% | 4.8% |
| 1995 | 2.7% | 2.7% |
| 1996 | 2.1% | 1.5% |
| 1997 | 1.4% | 4.5% |
| 1998 | 1.1% | 4.0% |
| 1999 | 2.0% | 5.2% |
| 2000 | 3.2% | 4.6% |

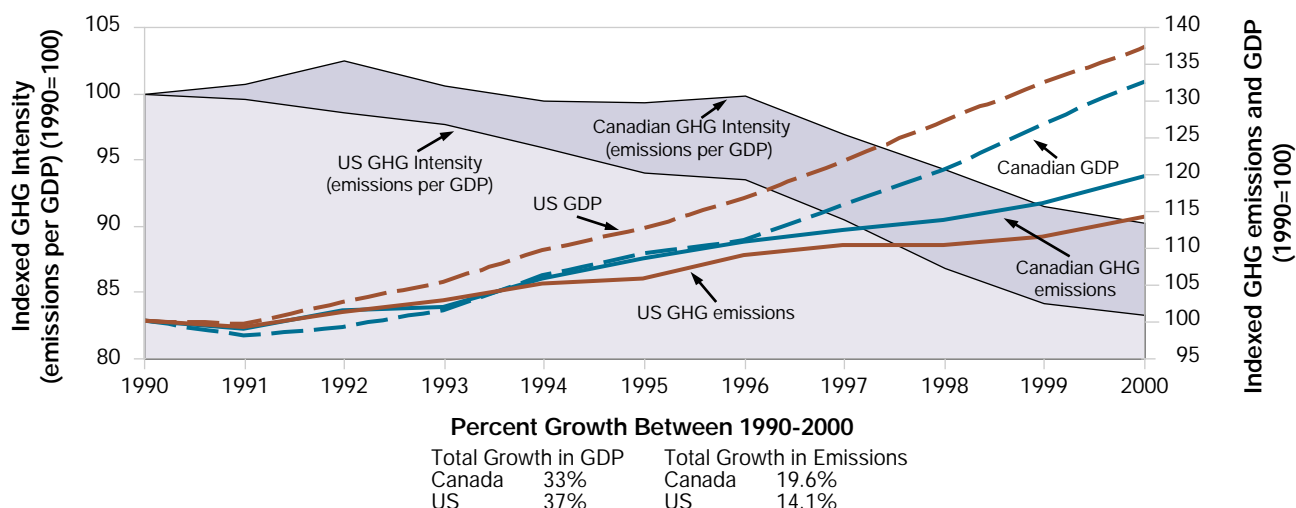
* Statistics Canada, Table 384-0002

National Trends

Total Canadian emissions of greenhouse gases in 2000 were 726 Mt, 19.6% higher than the 1990 level of 607 Mt. In the short-term, emissions rose 3.2% since 1999. This is the second highest annual growth rate of the decade and is largely a result of above average increases in energy use for heating and an increase in overall productivity in the Canadian economy, which was 4.6% greater in 2000 than 1999. In 1994, emissions

Figure 2

Trends in Greenhouse Gas Emissions, GDP and Greenhouse Gas Intensity (GHG Intensity) for Canada and the United States, 1990 to 2000



Sources: Canadian GHG: Environment Canada, *Canada's Greenhouse Gas Inventory 1990-2000* (in press); Canadian GDP: Statistics Canada, CANSIM II, Table 384-0002; US GHG: US EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2000* (draft, February 2002); US GDP: BEA, 2000.

Table 1 **Energy Production, Export and Greenhouse Gas Emission Trends, 1990 to 2000**

| Year | 1990 | 2000 | Change Since 1990 (%) |
|--|---------|-----------|-----------------------|
| Greenhouse Gas Emissions ¹ (Mt CO ₂ eq) | 607 | 726 | 19.6% |
| GDP ² - Expense (Millions of 1997\$) | 764,386 | 1,012,809 | 32.5% |
| Domestic Energy Consumption ³ (PJ) | 9,230 | 10,815 | 17% |
| Energy Production ³ (PJ) | 7,752 | 11,729 | 51% |
| Energy Exported ³ (PJ) | 3,049 | 7,044 | 131% |
| NET Energy Exported ³ (PJ) | 1,755 | 4,822 | 175% |
| Emissions Associated with Exports ⁴ (Mt CO ₂ eq) | 28 | 65 | 134% |
| Emissions Associated with NET Exports ⁴ (Mt CO ₂ eq) | 22 | 48 | 121% |

Sources: ¹ Environment Canada, *Canada's Greenhouse Gas Inventory 1990-2000* (in press);

² Statistics Canada, CANSIM II, Table 384-0002;

³ Statistics Canada, Catalogue # 57-003;

⁴ For years 1990 to 1995, values were taken from McCann, T.J., et al. *Fossil Fuel Energy Trade & Greenhouse Gas Emissions: A Quantitative Assessment of Emissions Related to Imports and Exports*, Prepared for Environment Canada, 1997. Years 1996 to 2000 values were extrapolated from the report.

growth peaked at over 3.6% per year and fell consistently thereafter until 1999, when emissions rose 2.0% over the previous year (see text box). The increase in emissions during the past decade outpaced the 11% growth in population (Statistics Canada, #91-213), as well as an increase in total domestic energy consumption, which grew 17% (Statistics Canada, #57-003). Moreover, growth in total emissions was well short of the almost 33% increase in GDP between 1990 and 2000.

Figure 2 compares the trends in greenhouse gas emissions, GDP, and greenhouse gas intensity (a measure of the amount of greenhouse gases per unit of economic activity) for Canada and the United States between 1990 and 2000. Both countries experienced an improvement (meaning a reduction) in greenhouse gas intensity over the period. For example, Canada's greenhouse gas emissions per unit of GDP decreased by almost 10%, while the US experienced nearly a 17% reduction since 1990. It must be noted that a

reduction in greenhouse gas intensity does not necessarily reflect a reduction in emissions; it can also indicate changes in the structure of the economy. A closer examination of the individual trends in emissions and GDP for the two countries reveals that Canada's emissions are growing faster while our GDP is growing slower than that of the US. Factors that affected Canadian emissions growth include increases in fossil fuel consumption for electricity generation, increased energy consumption in the transportation sector, and growth in fossil fuel production, largely for export.

In fact, growth in oil and gas exports, primarily to the United States, contributed significantly to emissions growth between 1990 and 2000 (Table 1). In this period, total energy production increased 51% and gross energy exported increased 131%, while emissions associated with those exports increased 134%. Emissions from all oil and gas production, processing and transmission activities that are attributable to gross exports accounted for over 30% of the total increase in Canada's greenhouse gas emissions over the period 1990-2000, increasing from 28 Mt in 1990 to 65 Mt in 2000.

Sector Trends in Canada's GHG Emissions and Removals: 1990 to 2000

Electricity and Petroleum Industries

- The Electricity and Petroleum Industries contributed 264 Mt, or 36% of total national emissions in 2000 (electricity-related emissions accounted for 48% and petroleum-related emissions 52% of the total emissions in this category).
- Since 1990, emissions grew almost 38%. On a sector basis, electricity generation increased 25% but emissions grew 35%, due to an increased proportion of fossil fuel-generated electricity in the latter 1990s.
- The Petroleum Industries' emissions increased 40% over the period, in which upstream emissions rose 54% while downstream emissions decreased 6%. The rise in Upstream Industry emissions is largely the result of increased production of oil and gas for export, whereas increased production efficiency in the refining of oil products contributed to the emissions decline in the Downstream Industry.

Table 2 Canada's Greenhouse Gas Emissions Summary by Sector, 1990 to 2000

| GHG Source Category | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|--|-------------------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| | Mt CO ₂ equivalent | | | | | | | | | | |
| Electricity and Petroleum Industries | 193 | 194 | 208 | 203 | 209 | 220 | 223 | 230 | 249 | 256 | 264 |
| Transportation | 146 | 140 | 143 | 146 | 154 | 157 | 161 | 168 | 171 | 176 | 179 |
| Industry* | 117 | 115 | 113 | 113 | 118 | 119 | 124 | 123 | 114 | 112 | 119 |
| Residential, Commercial and Institutional | 70 | 69 | 71 | 74 | 74 | 74 | 79 | 76 | 68 | 72 | 77 |
| Agriculture | 59 | 58 | 58 | 58 | 60 | 61 | 61 | 61 | 61 | 61 | 60 |
| Land-Use Change and Forestry (methane and nitrous oxide) | 2 | 3 | 3 | 3 | 4 | 5 | 2 | 1 | 3 | 2 | 2 |
| Waste | 20 | 21 | 21 | 22 | 22 | 22 | 22 | 23 | 23 | 24 | 24 |
| TOTAL | 607 | 600 | 616 | 619 | 641 | 658 | 672 | 682 | 689 | 703 | 726 |

*Includes emissions from Solvents and Other Product Use.
Due to rounding, individual values may not add up to totals.

Transportation

- The Transportation sector represents one of the largest sources of emissions in Canada, accounting for 24.7% of total emissions in 2000 (179 Mt).
- Emissions increased 23% between 1990 and 2000. On-road transportation was the largest contributor to emissions in this sector, at 72.7%. Nearly all emissions growth can be attributed to Light-Duty Gasoline Trucks (LDGT, this includes sport utility vehicles and minivans), which contributed 44% or 14.7 Mt of this sector's growth and Heavy-duty Diesel Vehicles (HDDV), which accounted for 40% or 13.3 Mt of the growth.

Industry

- The Industry sector contributed 16% (118 Mt) of Canada's total emissions in 2000. Of these emissions, combustion emissions accounted for 59%, industrial process emissions 41% and fugitive emissions less than 1%.
- Key sub-sectors include the *Other Manufacturing and Industrial Chemicals Industries* (27% and 17% of total sector emissions, respectively), while *Smelting and Refining Industries and Primary and Other Steel Industries* combined accounted for a further 28%.
- Industry's emissions increased 1% between 1990 and 2000. The sector has stabilised its emissions despite an increase for most sub-sector industries in production and GDP. Emissions reductions occurred mainly as a result of a 8 Mt reduction in process emissions from adipic acid production improvements, as well as lowered GHG emission intensities through increased energy efficiency and fuel switching.

Residential, Commercial and Institutional (RCI) Sector

- RCI sector emissions in 2000 were 77 Mt and accounted for 10.6% of Canada's total emissions (45 Mt from the Residential sub-sector and 31.9 Mt from the Commercial and Institutional sub-sector).
- Overall, emissions grew 3% from 1990 to 2000, while on a sub-sector basis Residential emissions increased 2.3% and Commercial & Institutional emissions grew 23.4%. Changes in emissions resulted from an increase in energy use due to sub-sector growth. This was partially

offset by energy efficiency improvements in building stock, warmer weather, and substitution of fuel oil by natural gas.

Agriculture

- In 2000, Agriculture greenhouse gas emissions totalled 60 Mt, and contributed 8.3% of the total national emissions. This sector accounted for 70% of Canada's total emissions of nitrous oxide and 25% of methane.
- On a category basis, agricultural soils contributed 55% of the sector's emissions (33.4 Mt) in 2000, enteric fermentation emissions from domestic animals 29% (17.7 Mt), and manure management 16% (9.4 Mt).
- While total sector emissions rose 3% between 1990 and 2000, emissions from manure management rose 13% and enteric fermentation emissions increased 11%. Net carbon dioxide emissions from agricultural soils partially offset these increases, changing from a net source of 7.3 Mt in 1990 to a net sink of 0.2 Mt in 2000. Nitrous oxide emissions from soils, however, rose 23% over the period.

Land-Use Change and Forestry (LUCF)

- The LUCF sector was a net sink in 2000, as it removed from the atmosphere an estimated 14 Mt. This estimate represents the sum of the net carbon dioxide flux and non-carbon dioxide (methane and nitrous oxide) emissions.
- The net carbon dioxide flux alone amounted to a sink (16 Mt); however, LUCF carbon dioxide fluxes are not included in the national inventory totals. If they were included, it would have resulted in a reduction of total Canadian emissions of 10% in 1990 and 2% in 2000. Non-carbon dioxide emissions, however, are included in the national totals and amounted to 2 Mt in 2000. Under the terms of the Kyoto Protocol, sources and sinks from some land-use change and forestry activities will be included and accounted for separately during the commitment period (2008-2012).
- Between 1990 and 2000, the LUCF sector overall remained a net sink but exhibited a 76% decline in the net removal over the period (from 59 Mt to 14 Mt).
- Overall, the trends observed in the LUCF category largely reflect the changing levels of industrial forestry activity during the 1990s.

Waste

- Waste sector emissions totalled 24 Mt, representing 3.3% of Canada's total emissions in 2000. The primary emissions source is solid waste disposal on land, which accounted for 93% of the sector's emissions. Ninety-five percent of the emissions (23 Mt) were methane.
- Since 1990, waste-related emissions rose by over 21%, of which 96% of the increase is attributable to a rise in landfill emissions. Although emissions from solid waste disposal on land rose nearly 22%, increased landfill gas capture reduced the rate of emissions growth from landfills in the early to middle 1990s.

Provincial and Territorial Greenhouse Gas Emissions

Table 3 provides a summary of greenhouse gas emissions by province and territory for 1990 and 2000 by sector (as defined by the UNFCCC). Although the UNFCCC Guidelines on annual inventories only require that national-level detail be reported, it is considered important to provide these details due to the distinct regional differences which exist within Canada. Also, it must be noted that provincial and territorial emission estimates do not sum exactly to the national totals. The differences are due to two factors - rounding and a suppression of confidential provincial activity data.

Table 3

Summary of Provincial and Territorial Greenhouse Gas Emissions by Sector, 1990 and 2000

| | NF | PE | NS | NB | QC | ON | MB | SK | AB | BC | NT & NU | YT |
|---|-------------------------------------|--------------|---------------|---------------|---------------|----------------|---------------|---------------|----------------|---------------|--------------|------------|
| 1990 GHG Emissions by Sector | kt CO₂ equivalent | | | | | | | | | | | |
| Energy | 8,890 | 1,470 | 17,800 | 14,700 | 59,400 | 136,000 | 12,600 | 34,500 | 143,000 | 42,100 | 1,250 | 486 |
| Industrial Processes | 77 | 3 | 300 | 150 | 13,000 | 27,000 | 450 | 590 | 8,800 | 2,800 | 3 | 1 |
| Solvent and Other Product Use | 9 | 2 | 14 | 11 | 110 | 160 | 17 | 15 | 38 | 50 | 1 | 0 |
| Agriculture | 75 | 410 | 610 | 490 | 8,000 | 12,000 | 6,800 | 11,000 | 17,000 | 2,500 | 0 | 0 |
| Land-Use Change and Forestry | 30 | 1 | 40 | 20 | 200 | 200 | 40 | 100 | 100 | 2,000 | 6 | 10 |
| Waste | 360 | 77 | 590 | 500 | 5,800 | 7,200 | 420 | 500 | 1,000 | 3,600 | 14 | 7 |
| Total | 9,440 | 1,960 | 19,400 | 15,900 | 86,100 | 181,000 | 20,300 | 46,900 | 171,000 | 52,700 | 1,280 | 504 |
| 2000 GHG Emissions by Sector | | | | | | | | | | | | |
| Energy | 8,160 | 1,620 | 19,800 | 18,800 | 62,300 | 168,000 | 13,300 | 47,900 | 190,000 | 54,300 | 1,740 | 471 |
| Industrial Processes | 85 | 2 | 270 | 230 | 13,000 | 18,000 | 470 | 2,000 | 11,000 | 3,200 | 4 | 0 |
| Solvent and Other Product Use | 8 | 2 | 14 | 11 | 110 | 180 | 17 | 15 | 45 | 61 | 1 | 0 |
| Agriculture | 80 | 430 | 610 | 530 | 7,700 | 11,000 | 6,900 | 11,000 | 19,000 | 2,500 | 0 | 0 |
| Land-Use Change and Forestry | 40 | 3 | 50 | 50 | 400 | 400 | 100 | 200 | 300 | 800 | 60 | 50 |
| Waste | 430 | 91 | 700 | 600 | 6,700 | 8,300 | 600 | 610 | 1,200 | 5,000 | 19 | 8 |
| Total | 8,810 | 2,150 | 21,500 | 20,200 | 90,400 | 207,000 | 21,400 | 61,800 | 223,000 | 65,900 | 1,830 | 529 |
| Change since 1990 | | | | | | | | | | | | |
| kilo tonnes | -630 | 190 | 2,100 | 4,300 | 4,300 | 26,000 | 1,100 | 14,900 | 52,000 | 13,200 | 550 | 25 |
| % | -7% | 10% | 11% | 27% | 5% | 14% | 5% | 32% | 30% | 25% | 43% | 5% |
| 2000 GHG per capita^{1*} (tonnes GHG/person) (National average - 23.6 tonnes/person) | 16.4 | 15.5 | 22.8 | 26.7 | 12.3 | 17.7 | 18.6 | 60.4 | 74.4 | 16.2 | 26.2 | 17.3 |
| 2000 GHG Intensity of GDP² (GHG kt CO₂ eq/\$GDP) (National value - 0.72) | 0.69 | 0.68 | 0.94 | 1.09 | 0.42 | 0.49 | 0.65 | 1.97 | 1.85 | 0.53 | 0.58 | 0.49 |

Due to rounding, individual values may not add up to totals (zero values may represent estimated quantities too small to display). Emissions associated with the use of HFCs, PFCs, limestone and soda ash are reported in the national total.

Source: Emissions data from Environment Canada, Canada's Greenhouse Gas Inventory 1990-2000 (in press); ¹Population data from Statistics Canada, 2000, Catalogue #91-213; ²GDP data from Statistics Canada, CANSIM II, Table 384-0002.

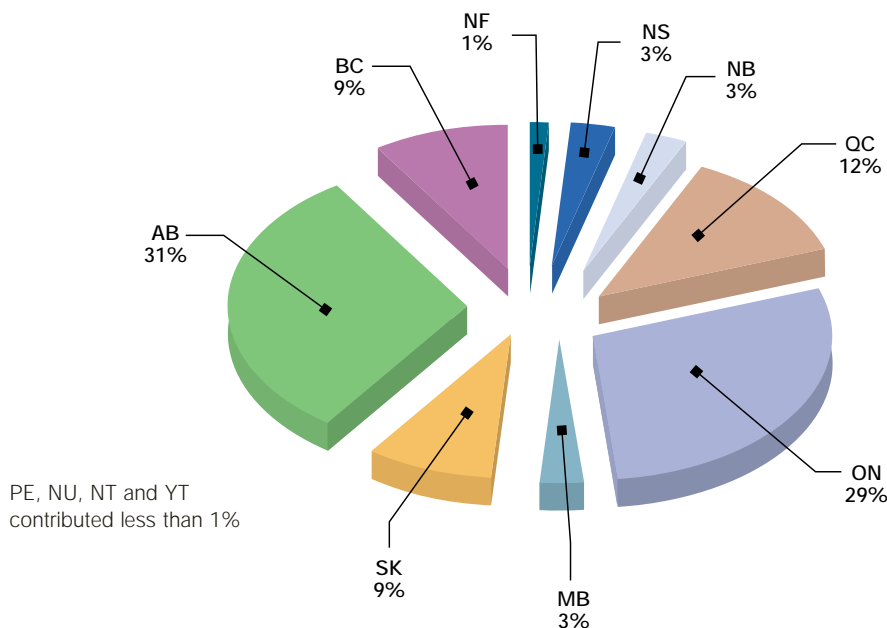
Greenhouse gas emissions across Canada are not distributed evenly. Regional differences in factors such as climate, resources available for energy production and/or industry, as well as travel patterns, all contribute to different patterns of emissions. Figure 3 illustrates the provincial and territorial contributions to Canada's total emissions in 2000. The largest provincial contributors were Alberta with 31% of Canada's total emissions (223 Mt), and Ontario, which accounted for 29% of the national total (207 Mt). The next largest contribution to national emissions was from Quebec, at 12%, while British Columbia and Saskatchewan each contributed 9%. The remainder of the emissions in 2000 were from Manitoba, Nova Scotia and New Brunswick (each accounting for about 3%), Newfoundland and Labrador added 1%, while Prince Edward Island and the territories together contributed less than 1% to the total national emissions in 2000.

In terms of emissions growth, all provinces and territories except Newfoundland and Labrador experienced an increase in their emissions over the 1990 to 2000 period. Emissions from Saskatchewan rose 32%, while Alberta, British Columbia and New Brunswick exhibited increases ranging between 25% and 30%. In addition, during this ten year period four provinces were responsible for almost 90% of the **total national growth** in emissions - Alberta accounted for 44% of the total growth, while Ontario and Saskatchewan contributed 22% and 13%, respectively, and British Columbia added 11%.

An in-depth breakdown of provincial and territorial greenhouse gas emissions is beyond the scope of this fact sheet; however, for a complete summary of provincial and territorial emissions for the years 1990 through 2000 inclusive, consult Environment Canada's *Greenhouse Gas Emissions* web site at <http://www.ec.gc.ca/pdb/ghg/>

Figure 3

Provincial and Territorial Contributions to Canada's Greenhouse Gas Emissions in 2000



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