Canada's Greenhouse Gas Inventory

GHG Trends Information from Environment Canada's Greenhouse Gas Division

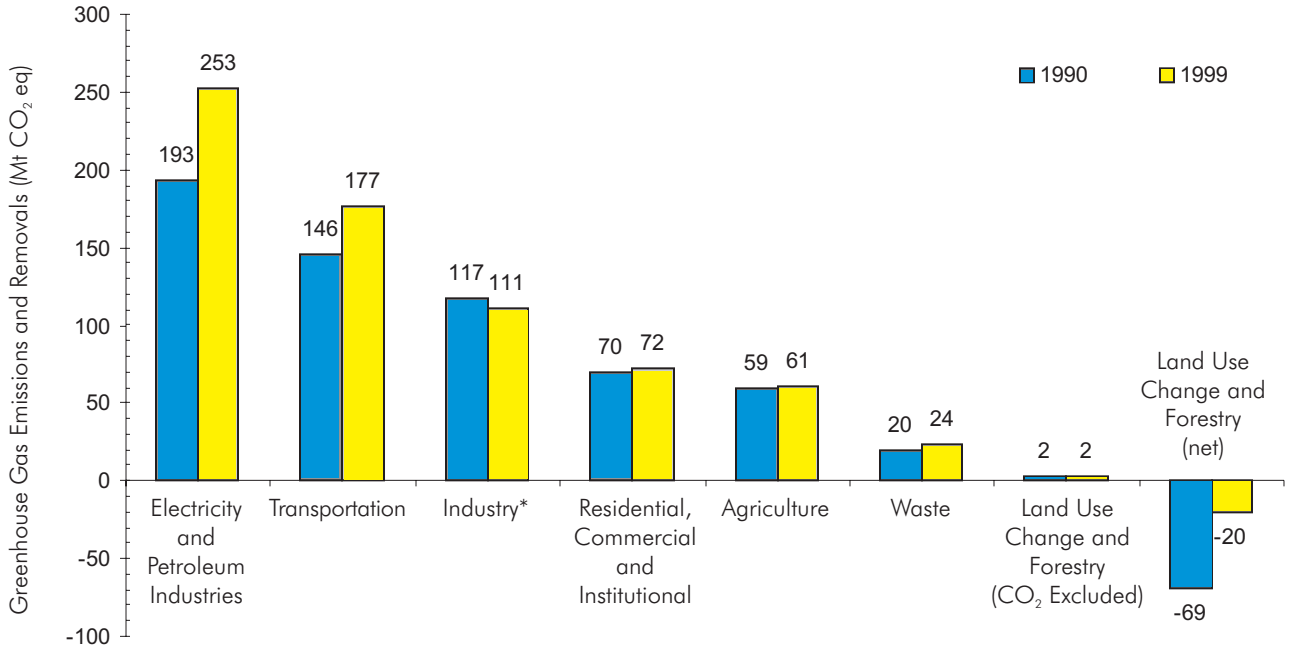
Overview: 1990-1999

In 1999, Canadians emitted 699 megatonnes of carbon dioxide equivalent* (Mt CO_2 eq) of greenhouse gases into the atmosphere. In the short-term, emissions rose 1.4% since 1998, while between 1990 and 1999, emissions increased 15.1%. Although emissions have been rising since 1990, the upward trend is slowing (for example, 1.4% annual growth in 1999 versus 3.5% in 1994). Comparatively, over the 1990 to 1999 period, Canada's Gross Domestic Product (GDP) grew nearly 25%, total domestic energy consumption increased 13%, and population rose 10%.

- On a greenhouse gas basis, carbon dioxide was the dominant gas, accounting for 78.1% (546 Mt) of 1999 emissions, while methane and nitrous oxide contributed the next largest shares at 12.9% (90 Mt) and 7.8% (54 Mt), respectively.
- The greatest sector contributions to emissions in 1999 are from the Electricity and Petroleum Industries, which accounted for 36% of total national emissions (253 Mt), and the Transportation sector, which contributed 25% (177 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 6% decrease in emissions between 1990 and 1999, despite increases in sector GDP and production. The reduction 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 only 8% to the total emissions growth over the period.
- Net carbon dioxide *removals* by sinks associated with the Land-Use Change and Forestry sector declined 67% since 1990, to an estimated 20 Mt in 1999, but are not included in the national inventory totals.

**Unless otherwise indicated, all emissions are reported in Mt CO_2 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 1999



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

Canada's Greenhouse Gas Inventory

Canada's National 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). 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 (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), 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 1999 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* (%)
1994	3.5%	4.7%
1995	2.6%	2.8%
1996	2.2%	1.5%
1997	1.4%	4.4%
1998	1.1%	3.3%
1999	1.4%	4.5%

* Statistics Canada, CANSIM 9028.

Canada's Greenhouse Gas Inventory 1990-1999: Trends Fact Sheet Series

The 1990-1999 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, are detailed in Environment Canada's latest report entitled, Canada's Greenhouse Gas Inventory 1990-1999: Emission and Removal Estimation Practices and Methods, April 2001, which was published in the fall of 2001.

In addition to this fact sheet, which contains a national overview of Canada's greenhouse gas trends since 1990, seven sectors have been analyzed:

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.

National Trends

Total Canadian emissions of greenhouse gases in 1999 were 699 Mt, 1.4% above the 1998 estimate of 689 Mt and 15.1% higher than the 1990 level of 607 Mt. Although emissions have been rising since 1990, the upward trend is slowing (see text box). For example, in 1994 emissions growth peaked at over 3.5% per year, while in 1998-1999, the annual emissions increase was 1.4%. The increase in emissions during the past decade outpaced the 10% growth in population (Statistics Canada, #91-213), as well an increase in total domestic energy consumption, which grew 13% (Statistics Canada, #57-003). Growth in total

Table 1. Canada's Greenhouse Gas Emissions Summary by Sector, 1990 to 1999

GHG Source Category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Mt CO_2 equivalent									
Electricity and Petroleum Industries	193	195	208	203	209	220	223	230	249	253
Transportation	146	140	143	146	154	157	161	168	171	177
Industry*	117	115	113	113	118	119	124	123	114	111
Residential, Commercial and Institutional	70	69	71	74	74	74	79	76	68	72
Agriculture	59	58	58	58	60	61	61	61	61	61
Land-Use Change and Forestry	2	3	3	3	4	5	2	1	3	2
Waste	20	21	21	22	22	22	22	23	23	24
TOTAL	607	600	616	619	641	658	672	682	689	699

*Includes emissions from Solvents and Other Product Use.

Due to rounding, individual values may not add up to totals.

emissions, however, was well short of the almost 25% increase in GDP between 1990 and 1999.

Figure 2 indicates that greenhouse gas emissions per unit of GDP decreased between 1990 and 1999. This was mainly the result of fuel substitution away from fossil fuels in the industrial, residential, and commercial sectors and gains in energy efficiency. Greenhouse gas emissions per capita increased over the period, and was influenced by changing characteristics in various sectors. Such factors that affected 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 1999 Figure 3). In this period, total energy production increased 46% and total energy exported increased 159%, while emissions associated with exports increased 111%. The proportion of emissions from all oil and gas production and processing activities that is attributable to exports increased from 22 Mt in 1990 to over 45 Mt in 1999.

Sector Trends in Canada's GHG Emissions and Removals: 1990 to 1999

Electricity and Petroleum Industries

- The Electricity and Petroleum Industries contributed 253 Mt, or 36.2% of total national emissions in 1999 (electricity-related emissions accounted for 47% and petroleum-related emissions 53% of the total emissions in this category).
- Since 1990, emissions grew almost 33%. On a sector basis, electricity generation increased 19% but emissions grew 24%, due to an increased proportion of fossil fuel-generated electricity in the latter 1990s.
- The Petroleum Industries' emissions increased 38% over the period, in which upstream emissions rose 52% while downstream emissions decreased 9%. The rise in Upstream Industry emissions is a 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.

Figure 2. Canada's Trends in Greenhouse Gas Intensity of GDP and Population, 1990 to 1999

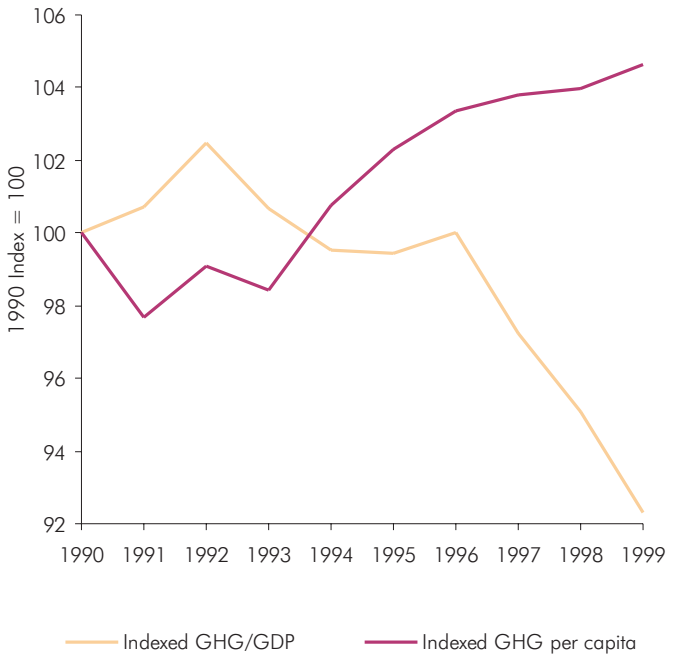
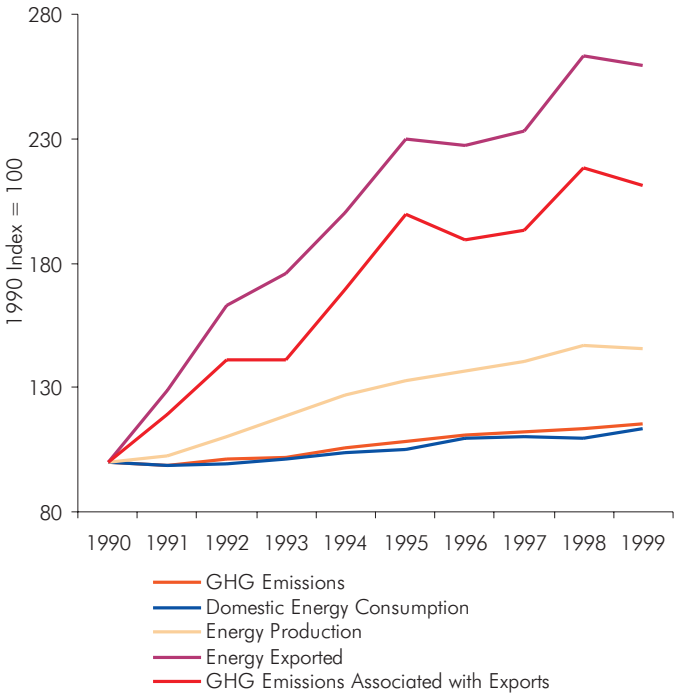


Figure 3. Energy Production, Net Export and Greenhouse Gas Emission Trends, 1990 to 1999



Transportation

- The Transportation sector represents one of the largest sources of emissions in Canada, accounting for 25.3% of total emissions in 1999 (177 Mt).
- Emissions increased 21% between 1990 and 1999. On-road transportation was the largest contributor to emissions in this sector, at 73.7%. Nearly all emissions growth can be attributed to Light-Duty Gasoline Trucks (LDGT, this includes sport utility vehicles and minivans), which contributed 42% or 13.0 Mt of this sector's growth and Heavy-duty Diesel Vehicles (HDDV), which accounted for 40% (12.3 Mt) of the growth.

Industry

- The Industry sector contributed 15.6% (109 Mt) of Canada's total emissions in 1999. Of these emissions, combustion emissions accounted for 57%, industrial process emissions 42% and fugitive emissions 1%.
- Key sub-sectors include the *Other Manufacturing* and *Industrial Chemicals Industries* (41%, or 45 Mt, of total sector emissions), while *Smelting and Refining Industries* and *Primary and Other Steel Industries* combined accounted for a further 29%.
- Industry's emissions decreased 6% between 1990 and 1999. The sector has reduced its emissions despite an increase for most sub-sector industries in production and GDP. Emissions reductions occurred mainly as a result of a 5 Mt reduction in process emissions largely 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 1999 were 71.9 Mt and accounted for 10.3% of Canada's total emissions (43 Mt from the Residential sub-sector and 28.9 Mt from the Commercial and Institutional sub-sector).
- Overall, emissions grew 3% from 1990 to 1999, with varying changes in the sub-sectors (2.3% decline in Residential emissions while Commercial and Institutional emissions grew 12.0%). 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 1999, Agriculture greenhouse gas emissions totalled 60.7 Mt, and contributed 8.7% of the total national emissions. This sector accounted for 69% of Canada's total emissions of nitrous oxide and 25% of methane.
- On a category basis, agricultural soils contributed 56% of the sector's emissions (33.6 Mt) in 1999, enteric fermentation emissions from domestic animals 29% (17.8 Mt), and manure management 15% (9.3 Mt).
- While total sector emissions rose 3% between 1990 and 1999, emissions from manure management rose 13% and enteric fermentation emissions increased 11%. Net carbon dioxide emissions from agricultural soils partially offset these increases, having declined from 7.3 Mt to 0.2 Mt, while nitrous oxide emissions from soils rose 23%.

Land-Use Change and Forestry (LUCF)

- The LUCF sector was a net sink in 1999, as it removed from the atmosphere an estimated 18 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 also amounted to a

sink (20 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 3% in 1999. Non-carbon dioxide emissions, however, are included in the national totals and amounted to 2 Mt in 1999. Under the terms of the Kyoto Protocol, net removals by sinks from land-use change and forestry activities will be accounted for separately during the commitment period (2008-2012).

- Between 1990 and 1999, the LUCF sector overall remained a net sink but exhibited a 70% decline in the net removal over the period (from 59 Mt to 18 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 nearly 24 Mt, representing 3.4% of Canada's total emissions in 1999. 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 (22.3 Mt) were methane.
- Since 1990, waste-related emissions rose by over 17%, of which 95% of the increase is attributable to a rise in landfill emissions. Although emissions from solid waste disposal on land rose nearly 18%, 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 2 provides a summary of greenhouse gas emissions by province and territory for 1990 and 1999 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.

As evident from Table 2, 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. In 1999, the largest provincial contributions to the national emissions total were from Alberta with 214 Mt (representing about 30% of Canada's total emissions), and Ontario, which accounted for 28% of the national emissions (195 Mt). In terms of emissions growth, all provinces except Newfoundland and Labrador experienced an increase in emissions over the 1990 to 1999 period. Saskatchewan incurred the largest emissions growth, at 31%, while Alberta, British Columbia and New Brunswick exhibited increases ranging between 20% and 25%.

For those provinces that experienced an increase in emissions since 1990, their relative contribution to the total national emissions growth is illustrated in Figure 4. From the figure, it is shown that four provinces collectively contributed over 90% of the total national increase in emissions; specifically, Alberta accounted for 48% of the total growth, while Saskatchewan and Ontario each contributed 16%, and British Columbia added 12%.

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 1999 inclusive, consult Environment Canada's *Greenhouse Gas Emissions* web site at:
http:www.ec.gc.ca/pdb/ghg/english/ehome.html.

References

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Intergovernmental Panel on Climate Change (IPCC), *Greenhouse Gas Inventory Reporting Instructions*, Vol. 1; and *Greenhouse Gas Inventory Reference Manual*, Vol. 3, Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, 1997.

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T.J. McCann and Associates, et al., *Fossil Fuel Energy Trade & Greenhouse Gas Emissions*, Prepared for Environment Canada, 1997.

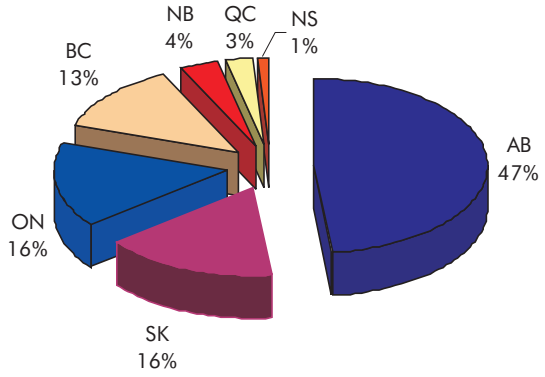
United Nations Framework Convention on Climate Change, *Review of the Implementation of Commitments and of Other Provisions of the Convention*, FCCC/CP/1999/7.

Table 2. Summary of Provincial and Territorial Greenhouse Gas Emissions by Sector, 1990 and 1999

	NF	PE	NS	NB	QC	ON	MB	SK	AB	BC	NT & NU	YT
1990 GHG Emissions by Sector						kt CO_2 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	20	40	200	200	100	40	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	20,400	46,800	171,000	52,700	1,280	504
1999 GHG Emissions by Sector												
Energy	8,310	1,480	18,700	17,600	61,300	156,000	12,800	47,800	182,000	52,600	1,390	537
Industrial Processes	92	3	290	240	12,000	19,000	450	2,000	12,000	2,900	3	0
Solvent and Other Product Use	8	2	14	11	110	170	17	15	45	61	1	0
Agriculture	81	430	610	520	8,000	12,000	6,900	11,000	19,000	2,600	0	0
Land-Use Change and Forestry	40	3	40	60	400	300	200	100	300	800	70	50
Waste	430	90	690	590	6,300	8,200	590	610	1,100	4,900	18	8
Total	8,960	2,000	20,300	19,100	88,400	195,000	20,900	61,300	214,000	63,900	1,480	595
Absolute Change (kt)												
1990-1999	-480	40	900	3,200	2,300	14,000	500	14,500	43,000	11,200	200	91
Relative Change (%)												
1990-1999	-5.1%	2.0%	4.6%	20.1%	2.7%	7.7%	2.5%	31.0%	25.1%	21.3%	15.6%	18.1%
1999 GHG per capita* (tonne/person)	16.6	14.5	21.6	25.3	12.0	16.9	18.3	59.6	72.2	15.9	21.6	19.4
(National average - 22.9 tonnes/person)												

Notes:
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 for population data: Statistics Canada, Catalogue #91-213.

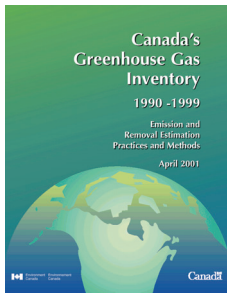
Figure 4. Relative Provincial Contribution to the Absolute Growth in Canadian Emissions between 1990 and 1999



MB, NT, NU, YT & PE combined contribute less than 1%.

Also available in this series:
Overview * Residential, Commercial & Institutional
Transportation * Electricity and Petroleum Industries
Land Use Change and Forestry * Agriculture
Industry * Waste

Also available in French



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