

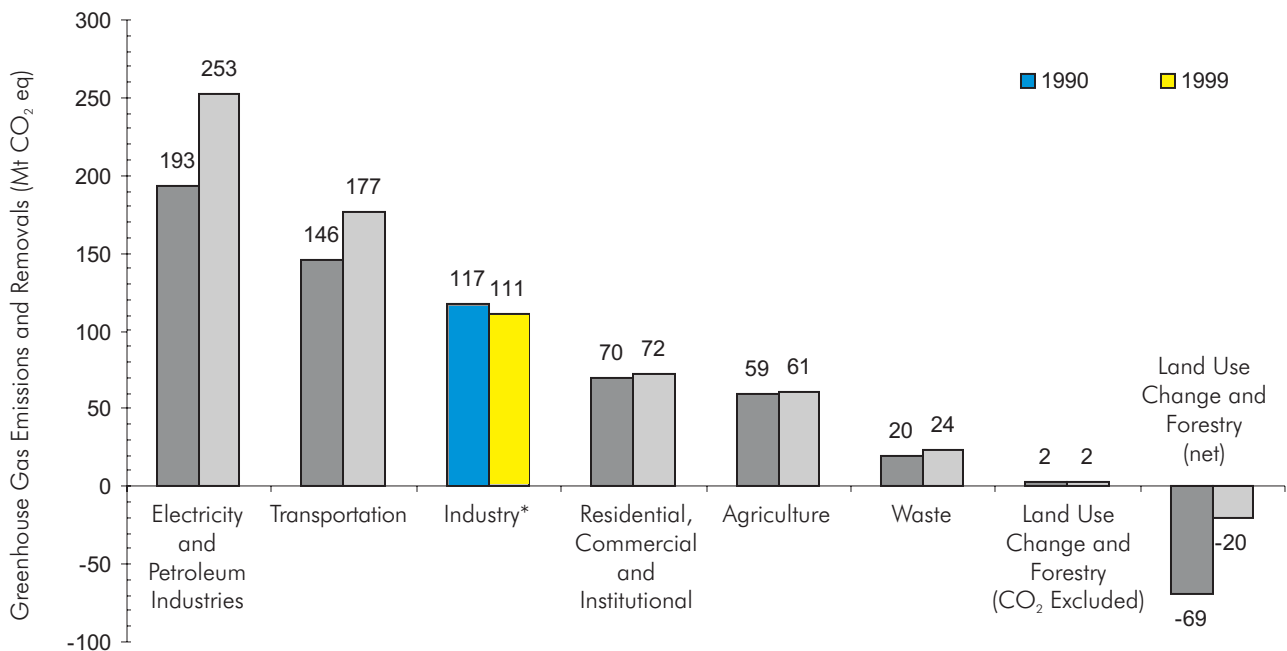
Industry: 1990-1999

This sector encompasses a diverse array of industries - from steel, auto, and electronic manufacturing to pharmaceutical, fertilizers, pulp and paper and food production. Emissions from the various manufacturing industries result from fossil fuel combustion for thermal heat loads and energy supply, from industrial processes in which greenhouse gases are emitted as a direct by-product of those processes, and from the fugitive release of methane during the mining of coal.

- In 1999*, this sector contributed 109 megatonnes of carbon dioxide equivalent* (Mt of CO₂ eq) of greenhouse gases, representing 16% of Canada's total emissions (699 Mt) in 1999. Combustion emissions accounted for 57% of the sector's emissions while process emissions contributed 42%. Fugitive emissions of methane from coal mining were a minor component (1%) of total sector emissions in 1999. Key sub-sectors include the Other Manufacturing and Industrial Chemicals Industries, which comprised 41% (45 Mt) of the total emissions in the sector, while Smelting and Refining Industries and Primary and Other Steel Industries combined accounted for a further 29% of sector emissions.
- Between 1990 and 1999*, Industry's emissions decreased 6% and this sector's contribution to Canada's total greenhouse gas emissions declined from 19% to 16%. The majority of the emissions reduction in this sector is due to a 5 Mt reduction in process emissions, partially from improvements in adipic acid production in the latter part of the decade. Combustion emissions decreased from 64 Mt to 62 Mt, while fugitive emissions declined by half (from 2 Mt to 1 Mt). Overall, the sector has decreased its emissions despite an increase for most sub-sector industries in production and GDP. Reductions in process emissions, as well as lowered emission intensities through increased energy efficiency and fuel switching, are considered to be the main factors in the decline of emissions in this sector.

*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 1999



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

Canada's Industrial Sector

Greenhouse gas emissions in the Industrial sector result from fossil fuel combustion, industrial processes, as well as fugitive release. Combustion emissions consist of carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O) created during the burning of fossil fuels for thermal heat loads. The sector uses natural gas, coal, refined petroleum products (RPP), natural gas liquids (NGL) and coke with coke oven gas, all of which contribute to emissions (Figure 2). Electricity is a major energy source, but for accounting purposes is not considered a source of emissions within this sector. Natural gas and electricity are the main energy sources, contributing 41 and 39%, respectively, of energy used in 1999.

Process emissions are due to non-combustive chemical reactions and processes that release carbon dioxide, nitrous oxide, sulphur hexafluoride (SF₆), and perfluorocarbons (PFCs). Fugitive emissions consist of methane releases from coal mining, a minor contributor to greenhouse gas emissions in this sector.

The Canadian Greenhouse Gas Inventory (CGHGI)

The Canadian Greenhouse Gas Inventory is developed, compiled, and reported annually by the Greenhouse Gas Division of Environment Canada, and utilizes methods and models developed in-house by engineering and scientific staff, as well as 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 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.

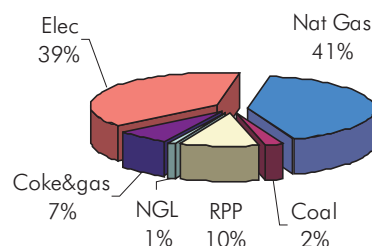
GHG Emissions from Electricity Generation in Canada

For accounting purposes throughout the CGHGI, electricity is considered a source of emissions only at the generation source. Consequently, emissions from electricity consumption within the Industry sector are accounted for in Fact Sheet #2 - Electricity and Petroleum Industries: 1990-1999.

The Industry sector is comprised of eight sub-sectors:

1. *Mining*: includes all combustion and fugitive emissions of mining activity except heavy oil mining (this is included in *Fact Sheet #2 - Electricity and Petroleum Industries: 1990-1999*);
2. *Smelting and Refining Industries*: is comprised of process emissions from aluminium and magnesium production, as well as fuel combustion emissions;
3. *Pulp and Paper and Sawmills*: consists of combustion emissions due to energy consumption in pulp and paper facilities and sawmills;
4. *Primary and Other Steel Industries*: includes process emissions, primarily from the use of coke in reducing iron, and combustion emissions for ferrous metal industry production;
5. *Cement*: is comprised of fuel combustion emissions, as well as process emissions from the release of carbon dioxide during clinker production;
6. *Industrial Chemical Industries*: includes process emissions from the production of chemicals and combustion emissions;
7. *Other Manufacturing*: consists of emissions from all other manufacturing not listed above (for example, lime, limestone, lubricating oil, grease, food, etc.); and
8. *Other Industries*: consists of stationary fuel combustion emissions from construction, forestry and agriculture.

Figure 2. Industry Energy Consumption for 1999



Industry Emission Trends: 1990 to 1999

In the 1990 to 1999 period, sector emissions declined 6% from 117 Mt to 109 Mt. Table 1 provides the total sector emissions by contributions from fuel combustion, process and fugitive sources. As is evident from the table, due to the many industries within the Industry sector, a variety of sub-sector trends contribute to the overall emissions reduction.

Since 1990, process emissions decreased from 51 Mt to 46 Mt, while fuel combustion emissions declined slightly from 64 Mt to 62 Mt. Most significant to the reduction has been the addition of emission mitigation technology in adipic acid production that reduced process emissions by 9 Mt over three years.

The only fugitive emissions are from coal mining, which are a minor contributor to sector totals. Between 1990 and 1999, fugitive emissions decreased from 2 Mt to 1 Mt.

Sector trends in greenhouse gas emissions result from changes in:

- production output within the industry;
- combustion fuels for the same process (e.g. switching to less greenhouse gas (GHG) intensive fuels);
- production processes and process efficiency (e.g. using fuel more efficiently or producing fewer process emissions); and
- fugitive emissions (e.g. the capture of methane releases in coal mines).

Overall, the sector has seen a decrease in emissions despite an increase for most sub-sector industries in production and Gross Domestic Product (GDP) output. The decrease has been the result not only of process emission reductions but also the lowering of emission

intensities through fuel switching to less GHG intensive fuels and energy efficiency measures. The precise contributions to changing emissions of fuel switching and efficiency factors are difficult to identify because of the complex and multilayered use of energy in the Industry sector. Fuel use trends, however, indicate increasing use of less GHG intensive fuels and movement away from or unchanged use of more GHG intensive fuels.

Sub-Sector Emission Trends

Greenhouse gas emission trends within the Industry sub-sectors are influenced by changes within key industries in the sub-sector. Table 2 provides the 1990 to 1999 trends for eight sub-sectors. Only the Industrial Chemical Industries category exhibited a significant decline in overall emissions, but there are no large sub-sector increases.

While large absolute emission changes are not immediately evident, there have been changes within specific industry categories. These emission trends are discussed below on a sub-sector and industry category basis. To link emission trends to industry performance, production trends have been tracked based on physical output. When production data are not available, GDP output data are used, although this is a less certain means of tracking performance*.

* Industrial GDP output can be misleading as a trend indicator because of fluctuations in industry sub-sector commodity prices not accounted for by the consumer price index adjustments.

Mining

Overall, the mining industry emitted 7% more greenhouse gas emissions in 1999 than in 1990, of which 85% of those emissions were due to the combustion of fossil fuels. Combustion emissions increased 25% and total energy use rose 26% over the period; however, no dramatic trends in fuel switching have been observed. In addition, fugitive

Table 1. Greenhouse Gas Emissions in the Industry Sector by Contribution Type, 1990 and 1999

Greenhouse Gas Emissions (Mt CO ₂ eq)	Fuel Combustion		Industrial Process		Fugitive	
	1990	1999	1990	1999	1990	1999
Mining	5.0	6.3			1.9	1.1
Smelting and Refining Industries	3.2	3.4	12.9	12.4		
Pulp and Paper and Sawmills	13.5	11.0				
Primary and Other Steel Industries	6.5	7.2	7.6	8.5		
Cement	3.7	4.0	5.9	6.3		
Industrial Chemical Industries	7.1	8.5	20.6	13.8		
Other Manufacturing	20.5	17.6	4.1	5.2		
Other Industries	4.3	3.9				
TOTAL Industry Sector	63.7	61.9	51.1	46.3	1.9	1.1

Table 2. Industry Emissions by Sub-Sector, 1990 to 1999

Sector (NAICS Code)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Mt CO ₂ equivalent									
Mining (212)	6.9	5.9	5.4	8.0	8.0	7.7	9.0	9.3	7.9	7.3
Smelting and Refining Industries (3313, 3314 & 33152)	16.1	16.2	15.6	16.3	16.9	15.5	15.4	14.8	15.3	15.9
Pulp and Paper and Sawmills (322)	13.5	12.8	12.1	12.0	11.8	11.5	12.0	11.8	11.0	11.0
Primary & Other Steel Industries (3311, 3312 & 33151)	14.1	15.4	15.8	15.4	15.6	15.5	15.6	15.4	15.3	15.7
Cement (32721)	9.5	7.9	7.5	7.9	8.9	9.1	9.4	9.5	9.7	10.3
Industrial Chemical Industries (3251 & 3253)	27.7	28.0	27.9	27.4	30.6	30.5	31.9	30.8	25.5	22.3
Other Manufacturing (all others not included elsewhere)	24.6	23.7	23.3	21.6	22.2	24.0	24.9	25.7	24.2	22.8
Other Industries (23, 111-114 & 1151-1153)	4.3	4.4	5.0	4.4	4.0	4.0	4.2	4.2	3.7	3.9
Total Mining and Manufacturing Industries	117	114	113	113	118	118	122	121	113	109

emissions of methane from underground coal mines dropped by over 50% because of production cutbacks.

Smelting and Refining Industries

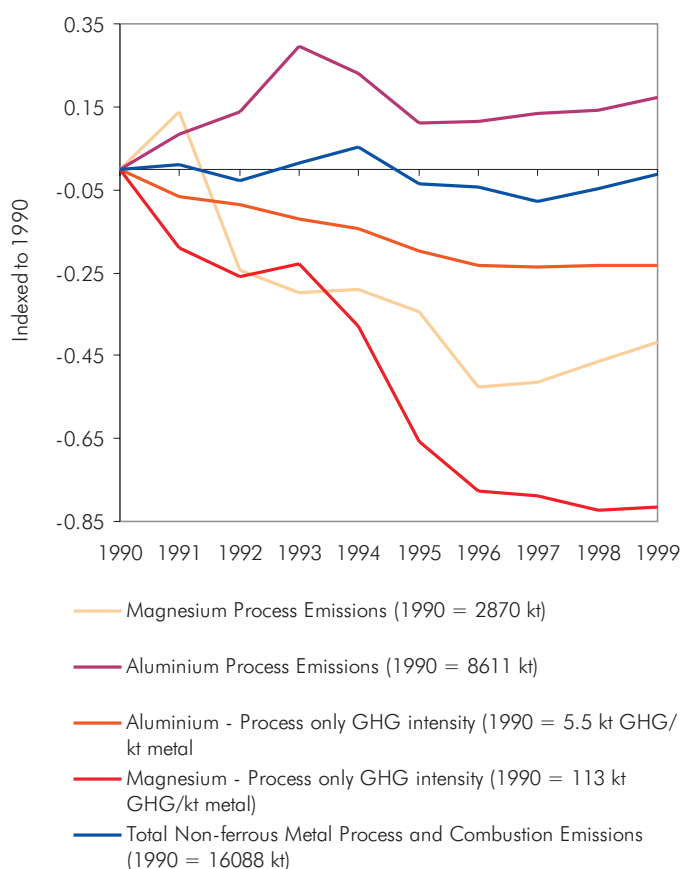
Emissions from the Smelting and Refining Industries sub-sector decreased by about 1% over the 1990 to 1999 period. Within the sub-sector, greenhouse gas process emissions from magnesium and other metal smelting and refining decreased more substantially. Magnesium producers have added process controls to monitor additions of sulphur hexafluoride (SF₆) which has resulted in an emissions reduction of 40% since 1990, despite a doubling of production (Natural Resources Canada, 2001). Magnesium production emission intensity declined 80% as a result (Figure 3).

From 1990 to 1999, aluminum production increased 53% (Natural Resources Canada, 2001) while process emissions increased by only 17%. This has led to a decline in emission intensity of 23% over the period. Process emissions for aluminium production are due to the creation of high global warming potential greenhouse gases called perfluorocarbons (PFCs) (which includes carbon tetrafluoride (CF₄) and hexafluoroethane (C₂F₆)), at anodes during the reduction of alumina to aluminum. Reduced emissions can be attributed to better control of smelting anode effects through electronic monitoring.

Pulp and Paper and Sawmills

Greenhouse gas emissions from the pulp and paper industry decreased 19% from 1990 to 1999, while product output increased 27%. These diverging trends result from a 42% reduction in coal and heavy fuel oil use, increased use of natural gas and electricity, as well as energy efficiency improvements (CIEEDAC, 2000a). For example, natural gas provides more than twice the energy supplied by coal and refined petroleum products to the sub-sector. While natural gas demand has increased by

Figure 3. Non-Ferrous Metal Smelting and Refining - Emissions and GHG Intensity of Production, 1990 to 1999



15%, the use of the more GHG intensive fuels has decreased by 40 to 50% since 1990 (Statistics Canada, #57-003).

Primary and Other Steel Industries

While primary steel industry product output grew 30% from 1990 to 1998 (CIEEDAC, 2000b) greenhouse gas emissions increased by only 12% (Figure 4). Both process and combustion-related emissions have increased in the same proportion. Process emissions are primarily from the

use of coke in reducing iron while combustion emissions are for all ferrous metal industry production. Data indicate that decreasing combustion emission intensities are due to increased efficiencies in energy use, as well as increased natural gas use, with an accompanying decline in the demand for refined petroleum products.

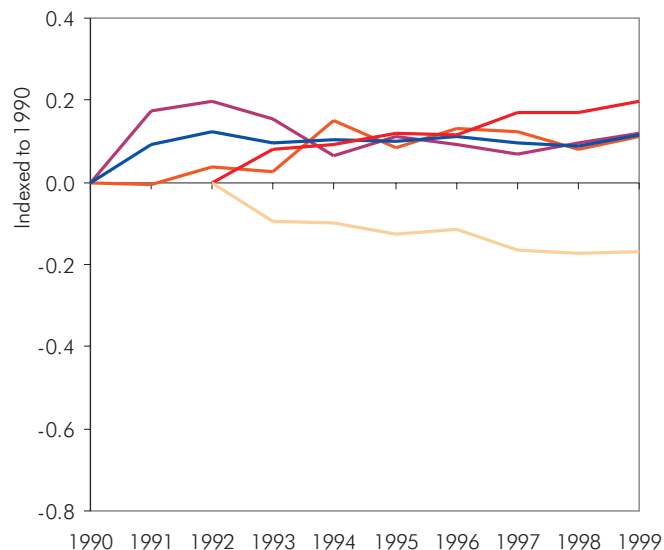
Cement

Emissions from cement production were 10 Mt in 1999, an increase of 770 kilotonnes (kt) from the 1990 level. The trends in emissions closely follow cement production levels. Process emissions constitute 61% of the total emissions in this category and result from the release of carbon dioxide during clinker production (Figure 9). Combustion emissions have increased in intensity because of fuel switching toward more GHG intensive fuels. Use of natural gas declined over the period while there was a rise in coal and coke use (Statistics Canada, #57-003). Total emissions track production closely, with little change in GHG intensity over the period (Figure 5).

Industrial Chemical Industries

Emissions from the Industrial Chemical Industries sub-sector decreased from nearly 28 Mt to 22 Mt over the 1990 to 1999 period. Approximately three-quarters of the

Figure 4. Primary and Other Steel Industries Indexed Greenhouse Gas Emissions and GHG Intensity, 1990 to 1999



- Combustion Emissions (1990 = 6487 kt)
- Process Emissions (1990 = 7590 kt)
- Primary & Other Steel Industry total GHG Emissions (1990 = 14072 kt)
- Total GDP (1992 = 7,328 mil\$)
- GHG/GDP (kt GHG/million\$GDP - indexed to 1992)

sub-sector's total greenhouse gas emissions are process emissions, which decreased 33% since 1990.

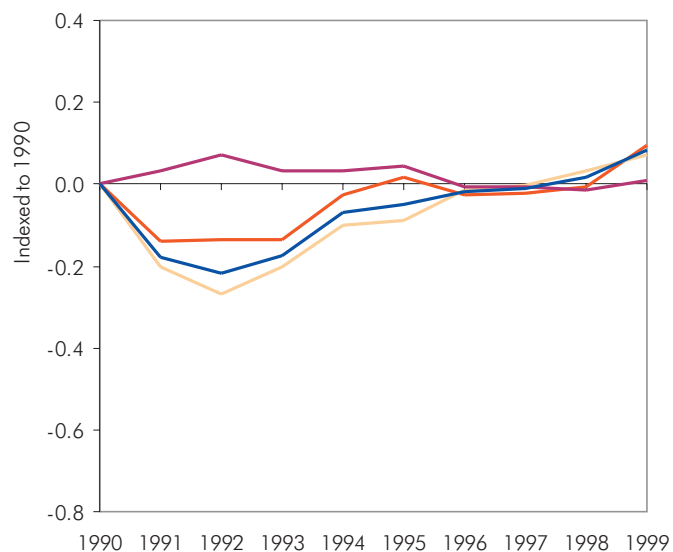
Reductions in nitrous oxide emissions from adipic acid production (occurring at the only Canadian facility, situated in Ontario) resulted in a 9 Mt decline in that industry category's process emissions. On the other hand, ammonia production process emissions increased 25% over the period. In fact, Figure 6 illustrates that all sub-sector category emissions increased over the period except those of adipic acid. The sub-sector has seen an increase in GDP of 31% since 1990 (Statistics Canada, #15-001) The resulting decline in GHG intensity is due in large part to reductions in adipic acid process emissions.

In terms of energy sources, natural gas is the primary fuel for combustion purposes in this sub-sector; its use grew by over 20% while the minor usage of refined petroleum increased 10%.

Other Manufacturing

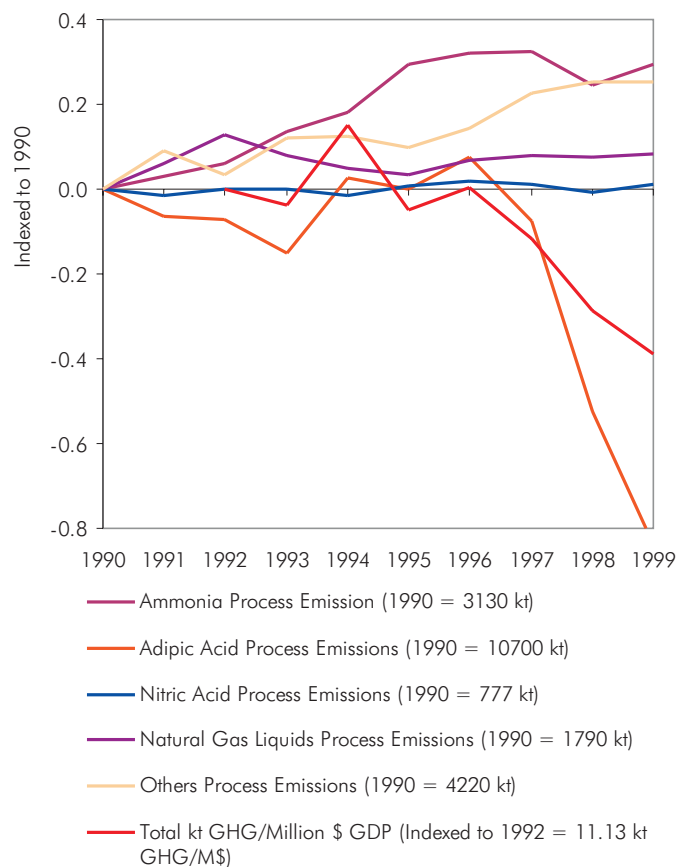
Overall emissions in the Other Manufacturing sub-sector decreased 7% from 25 Mt in 1990 to 23 Mt in 1999. Fuel combustion produced nearly 80% of emissions in this sub-sector; these emissions decreased 14% since 1990. The

Figure 5. Cement Production Indexed Emissions and GHG Intensity, 1990 to 1999



- Cement Fuel Combustion Emissions (1990 = 3672 kt)
- Cement Production (kt)
- kt GHG/kt Production (1990 = 0.81 kt GHG/kt cement)
- Total Emissions (1990 = 9544 kt)

Figure 6. Industrial Chemicals - Indexed Emissions and GHG Intensity of GDP, 1990 to 1999



decline in emissions may be due to fuel switching, as well as to decreased activity. For instance, this sub-sector, which is heavily dependent on natural gas, has reduced its use by over 10% since 1990. Coal and coke use has risen but in the latter part of the period decreased to below 1990 levels. Refined petroleum products and natural gas liquid use has declined by about 20%, while electricity consumption has increased by over 10% (Statistics Canada, #57-003).

Other Industries

In 1999, the stationary fuel combustion contribution of greenhouse gas emissions by the Other Industries sub-sector (which includes the categories of construction, agriculture and forestry) was 3.9 Mt, a decline of 434 kt from 1990.

Solvents and Other Product Use Sector

While accounting for only 0.2% (1.4 Mt) of Canada's total greenhouse gas emissions in 1999, emissions in this sector have more than tripled since 1990 (by nearly 1 Mt). Use of HFCs and PFCs as ozone-depleting substance replacements (in the semiconductor and electronic industries, for refrigeration and air conditioning manufacturing/equipment use, and aerosol cans, etc.) has contributed from 53% of this category's total emissions in 1995 to 67% in 1999. Emissions from the use of nitrous oxide as anaesthetic and propellant increased by 10% since 1990.

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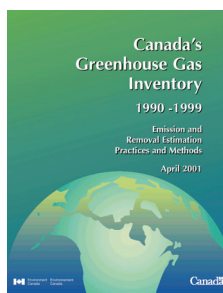
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