

CANADA'S GREENHOUSE GAS INVENTORY

GHG Trends Information from Environment Canada's Greenhouse Gas Division

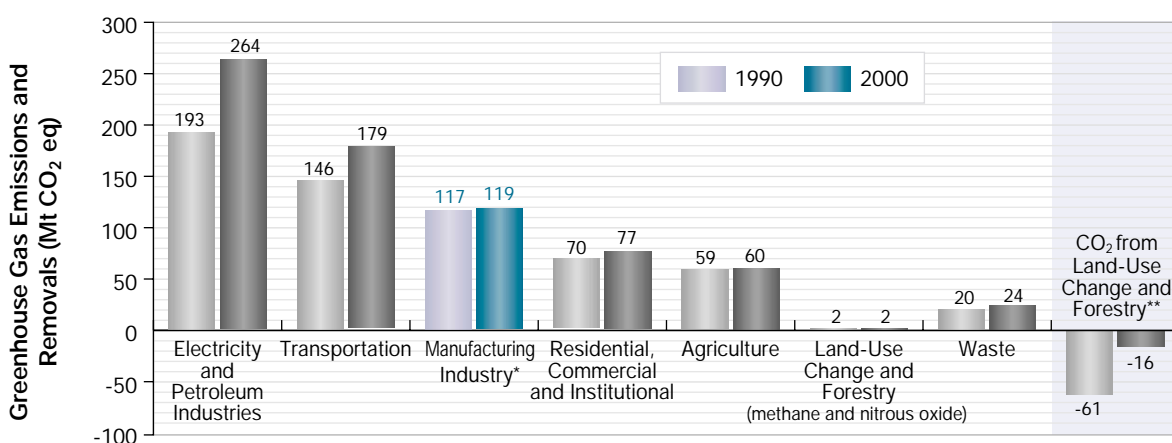
Manufacturing Industry: 1990-2000

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

- In 2000, the Manufacturing Industry contributed 118 megatonnes of carbon dioxide equivalent* (Mt of CO₂ eq) emissions, representing 16% of Canada's total emissions (726 Mt). Combustion emissions accounted for 59% of the sector's emissions while industrial process emissions contributed 40%. Fugitive emissions of methane from coal mining were a minor component (about 1%) of total sector emissions. Key sub-sectors include the *Other Manufacturing* and *Industrial Chemicals Industries*, which comprised 44% (52 Mt) of the total emissions in the sector, while the *Smelting and Refining Industries* and the *Primary and Other Steel Industries* combined for a further 28% of sector emissions.
- Between 1990 and 2000, Manufacturing Industry's emissions increased by only 1.2% and this sector's contribution to Canada's total greenhouse gas emissions declined from 19% to 16%. Overall industrial process emissions decreased from 51 Mt to 48 Mt, a 3 Mt reduction, largely from improvements in adipic acid production in the latter part of the decade. Combustion emissions increased from 63.7 Mt to 69.4 Mt, while fugitive emissions declined by half (from 2 Mt to 1 Mt). Reductions in industrial process emissions, as well as lowered emission intensities through increased energy efficiency and fuel switching, are considered to be the main factors in the relatively stable emission levels 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 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.



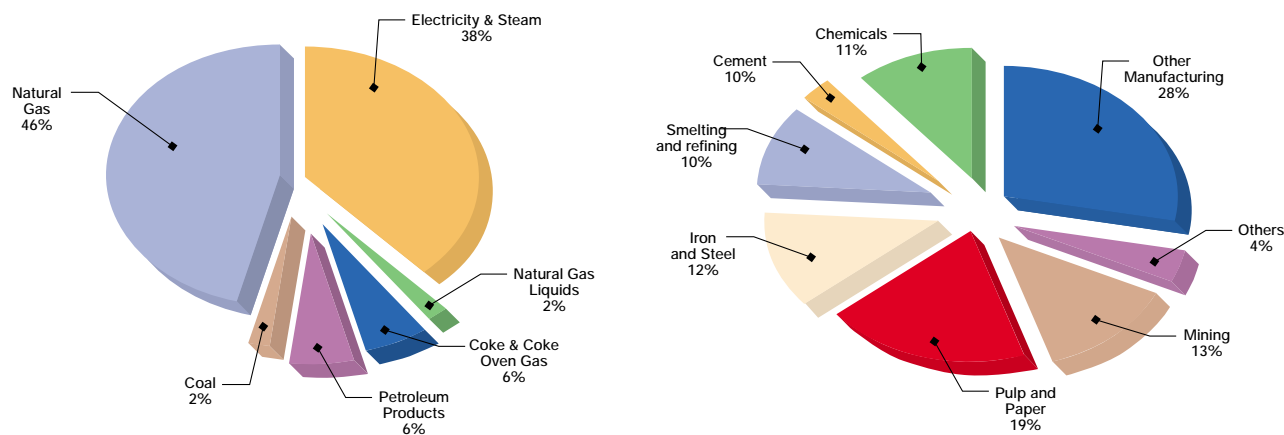
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Figure 2 Manufacturing Industry's Energy Consumption, 2000

Energy Consumed: 2230 PJ



Others - includes stationary use of energy in the Forestry, Construction and Agricultural industries

Mining - includes use of natural gas by the oilsands industry

Canada's Industrial Sector

Greenhouse gas emissions in the Manufacturing Industry result from fossil fuel combustion, industrial processes, as well as fugitive releases. Combustion emissions result from the burning of fossil fuels such as natural gas, coal, and refined petroleum products (RPP) for thermal heat loads. Electricity is also a major energy source and

emissions associated with the generation of electricity are discussed in more detail in the 'Electricity and Petroleum Industries: 1990-2000' fact sheet. Natural gas and electricity are the main energy sources for manufacturing industries and in 2000 contributed 46% and 38%, respectively, with respect to total demand (Figure 2).

Process emissions are due to chemical reactions and direct atmospheric releases from the use of sulphur hexafluoride and halocarbons. Fugitive emissions consist of methane releases from coal mining.

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: 1990-2000);
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, while process related emissions are included in Other Manufacturing;

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 hydrofluorocarbons (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, uses a modified sector approach to facilitate the use of information by the public.

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 combustion emissions from all other manufacturing not listed above and also consist of process emissions from the following industrial activities; the Pulp & Paper Industry, the use of halocarbons and limestone, the production of lime and lubricating oils etc.; and
8. *Other Industries:* consists of stationary fuel combustion emissions from the construction, forestry and agricultural industry.

Manufacturing Industry's Emission Trends: 1990 to 2000

In the 1990 to 2000 period, sector emissions increased by 1.2% from 117 Mt to 118 Mt. Table 1 provides the emission contributions from fuel combustion, process and fugitive sources. As is evident from the table, due to the many industries within the Manufacturing Industry sector, a variety of sub-sector trends contribute to the overall emissions.

Since 1990, process emissions decreased from 51 Mt to 48 Mt, while fuel combustion emissions increased from 63.7 Mt to 69.4 Mt. The addition of emission mitigation technology in adipic acid production has reduced process emissions within the Industrial Chemical Industries by about 10 Mt.

The only fugitive emissions are from coal mining, which are a minor contributor to sector totals. Due to mine closures, fugitive emissions from coal mines between 1990 and 2000 decreased from 2 Mt to 1 Mt.

Sector trends in greenhouse gas emissions result from changes in:

- Production output within the industry (product demands);
- Fuel Switching (switching to less greenhouse gas intensive fuels); and
- Production processes and process efficiency (installation of emission abatement technologies or using fuel more efficiently);

Overall, the sector has seen a slight increase of 1.2% in emissions relative to a 50% increase in gross production output and a 36% increase in Gross Domestic Product (GDP). (CIEEDAC, 2002) Process emission reductions and lowering of emission intensities through fuel switching to less GHG intensive fuels and energy efficiency measures have contributed to the relatively stable emission levels of the sector. 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 Manufacturing Industry sector. Fuel use trends, however, indicate increasing use of less GHG intensive fuels by the Pulp & Paper Industry and Primary and other Steel Industry.

Sub-Sector Emission Trends

Greenhouse gas emission trends within the Manufacturing Industry are influenced by changes within key sub-sector industries. Figure 3 provides the 1990 to 2000 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.

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Table 1

Manufacturing Industry's Emission Trends by Combustion, Process and Fugitive Sources, 1990 to 2000, Mt CO₂ eq

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
MANUFACTURING INDUSTRIES	117	114	113	113	118	118	123	122	114	112	118
Fuel Combustion	63.7	60.3	60.1	59.7	62.4	62.8	66.1	66.4	62.7	62.7	69.4
Mining ¹	5.0	3.8	3.6	6.1	6.3	5.9	7.2	7.6	6.5	6.0	7.9
Smelting and Refining Industries	3.2	2.6	2.8	2.7	3.3	3.1	3.5	3.2	3.4	3.3	2.8
Pulp and Paper and Sawmills	13.5	12.8	12.1	12.0	11.8	11.5	12.0	11.8	11.0	11.0	10.8
Primary & Other Steel Industries	6.5	6.5	6.7	6.7	7.5	7.0	7.3	7.3	7.0	7.3	7.2
Cement	3.7	3.2	3.2	3.2	3.6	3.7	3.6	3.6	3.7	4.0	4.0
Industrial Chemical Industries	7.1	7.5	7.5	7.3	8.5	8.5	8.8	8.9	8.6	8.5	8.4
Other Manufacturing all others not included elsewhere	20.5	19.5	19.2	17.2	17.5	19.1	19.4	19.8	18.8	18.8	24.8
Other Industries	4.3	4.4	5.0	4.4	4.0	4.0	4.2	4.2	3.7	3.9	3.6
Industrial Process	51	52	51	52	54	54	55	54	50	48	48
Smelting and Refining Industries	13	14	13	14	14	12	12	12	12	13	14
Primary & Other Steel Industries	7.6	8.9	9.1	8.8	8.1	8.4	8.3	8.1	8.3	8.5	8.5
Cement	5.9	4.7	4.3	4.7	5.3	5.4	5.8	5.9	6.1	6.3	6.3
Industrial Chemical Industries	21	21	20	20	22	22	23	22	17	14	12
Other Manufacturing all others not included elsewhere	4.1	4.2	4.1	4.4	4.7	5.4	6.3	6.8	6.6	6.6	6.7
Fugitive (Mining¹)	2	2	2	2	2	2	2	2	1	1	1

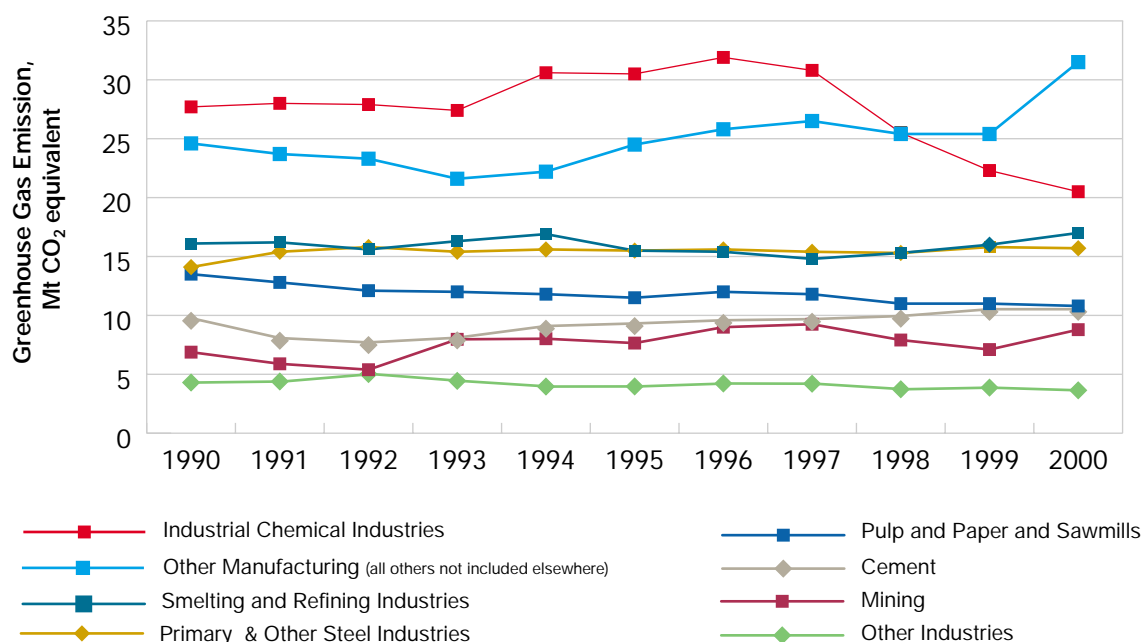
Notes: Due to rounding, individual values may not add up to totals.

¹ A small proportion of emissions from the Upstream Petroleum Industry is accounted for in the Mining sector due to data limitations.

Mining

Overall, the mining industry emitted 7.4% more greenhouse gas emissions in 2000 than in 1990, of which 89% of emissions were due to the combustion of fossil fuels. Combustion emissions

increased 58% and total energy use rose 28% over the period (Table 1); however, no dramatic trends in fuel switching have been observed. In addition, fugitive emissions of methane from underground coal mines dropped by over 50% due to mine closures.

Figure 3 Manufacturing Industry's Greenhouse Gas Emission Trends, 1990 to 2000

Smelting and Refining Industries

Emissions from the Smelting and Refining Industries sub-sector increased by about 5% over the 1990 to 2000 period. During this period, combustion emission decreased by 13%, while process emission increased by 10% (Table 1). Within the sub-sector, process emissions from magnesium smelting decreased more substantially. Magnesium producers have improved process controls which has resulted in a 20% reduction in SF₆ emissions since 1990, despite a 300% increase in production (NRCan, 2002). From 1990 to 2000, aluminium production increased 52% while process emissions increased by only 17% (NRCan, 2002). Process emissions for aluminium production are due to anode events during the reduction of alumina to aluminium creating high global warming potential greenhouse gases called perfluorocarbons (PFCs) (which includes carbon tetrafluoride (CF₄) and hexafluoroethane (C₂F₆)). Reduced emissions can be attributed to better control of smelting through electronic monitoring (Figure 4).

Pulp and Paper and Sawmills

Greenhouse gas emissions from the pulp and paper industry decreased 20% from 1990 to 2000, while product output increased 12% (CIEEDAC, 2002). (Figure 5) These diverging trends result from a 41% reduction in coal and fuel oil use and increased use of natural gas and electricity by 10% and 26%, respectively. (Statistics Canada, 2001) 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 10%, the use of the more GHG intensive fuels has decreased by 40% since 1990.

Primary and Other Steel Industries

While primary steel industry production grew 35% from 1990 to 2000 (CIEEDAC, 2002) greenhouse gas emissions increased by only 12%. Both process and combustion-related emissions have increased by 11% and 12%, respectively. Process emissions are primarily from the use of coke in reducing iron while combustion emissions are for all ferrous metal industry production.

Figure 4 Smelting and Refining Industries - Indexed Emission Trends, 1990 - 2000

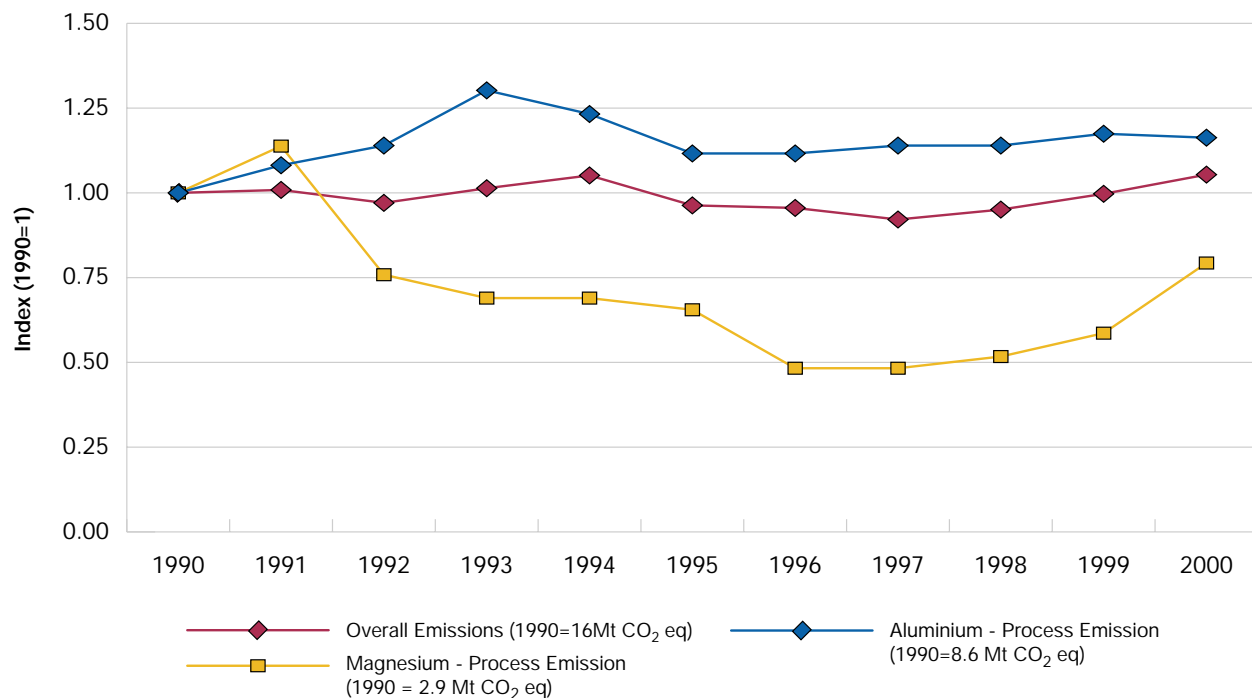


Figure 5 Cement, Primary & Other Steel and Pulp & Paper Industries' Emission Intensities, 1990-2000

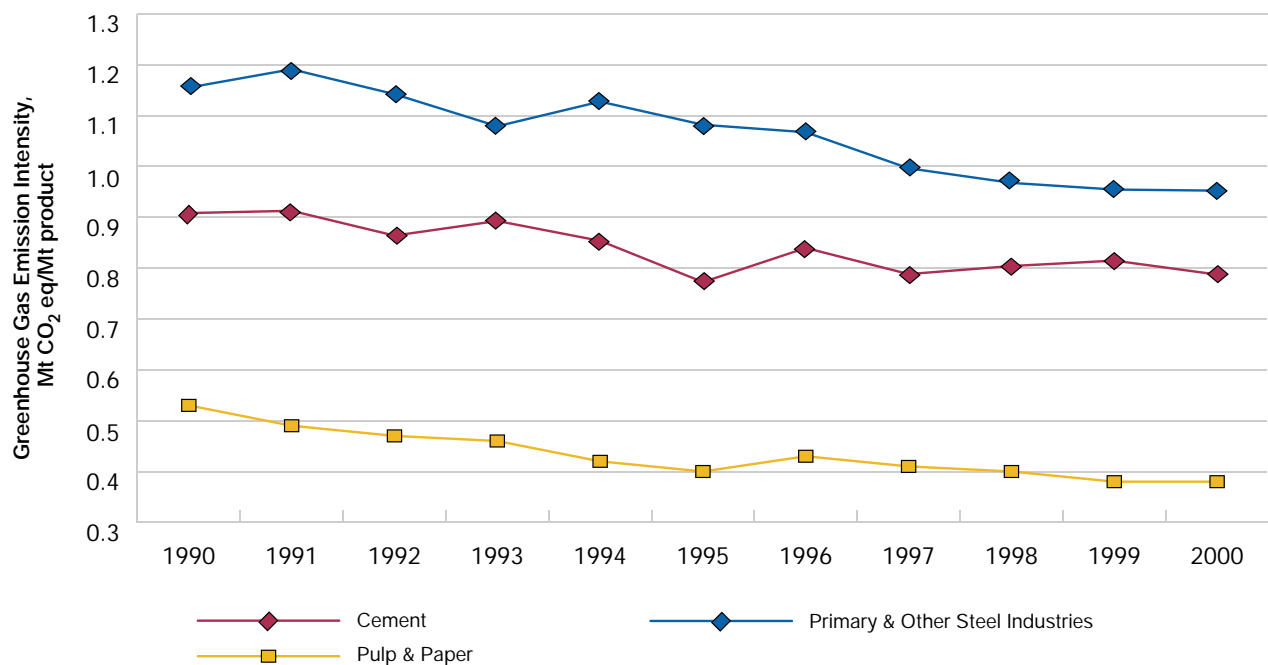
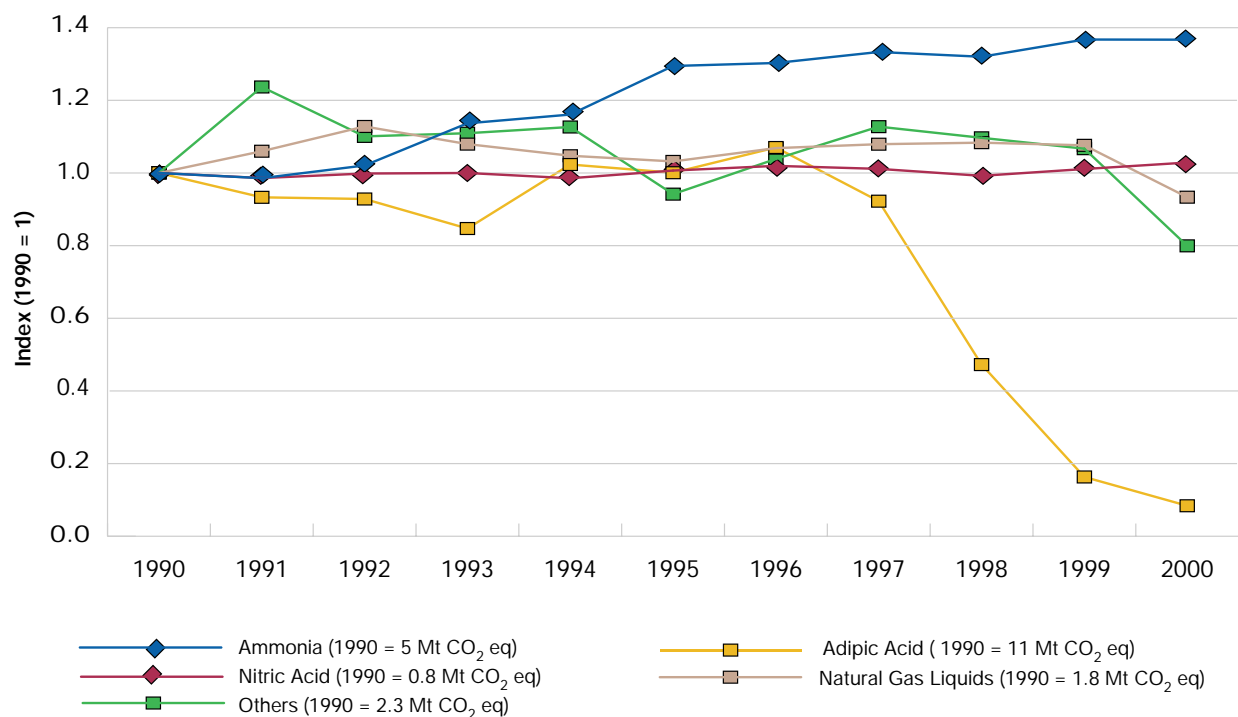


Figure 6 Industrial Chemicals – Process Emission Indexed Trends, 1990-2000

Data indicate that decreasing combustion emission intensities are due to increased efficiencies in energy use, as well a 52% increased use of natural gas, with an accompanying 33% decline in the use of refined petroleum products. (Figure 5)

Cement

Emissions from cement production were 10 Mt in 2000, an increase of 0.7 Mt from the 1990 level. The trends in emissions closely follow cement production levels. Process emissions constitute 62% of total emissions in this category and result from the release of carbon dioxide during clinker production. While overall emission intensity decreased by 13%, combustion emissions have increased due to fuel switching toward more GHG intensive fuels. The use of natural gas has decreased by 24% since 1990, while there was a 23% rise in coal and 60% rise in 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 20 Mt over the 1990 to 2000 period. Approximately three-quarters of the sub-sector's total greenhouse gas emissions are process emissions, which decreased 41% since 1990.

The installation of emission abatement technology at the sole adipic acid production plant in Canada, has resulted in a 10 Mt reduction of process related nitrous oxide emissions (Figure 6). On the other hand, ammonia production process emissions increased 37% over the period, while process emissions associated with nitric acid production increased slightly by 3%. The sub-sector has seen a 22% increase in GDP since 1990 (CIEEDAC, 2002). The resulting 39% decline in GHG intensity is due in large part to reductions in adipic acid process emissions.

Industrial Chemical Industries' combustion emission grew by 18%, from 7.1 Mt to 8.4 Mt since 1990. In terms of energy sources, natural gas is the primary fuel for combustion purposes in this sub-sector; its use grew by over 18% while the minor usage of refined petroleum increased 22%.

Other Manufacturing

Overall emissions in the Other Manufacturing sub-sector increased 28% from 25 Mt in 1990 to 32 Mt in 2000. Fuel combustion produced nearly 80% of emissions in this sub-sector; these emissions increased by 21% since 1990.

The increase in emissions may be due to increased activity and therefore increased fuel use. For instance, this sub-sector, which is heavily dependent on natural gas, has increased its use by 26% since 1990. Coal and coke use has respectively risen by 32% and 8%. Refined petroleum products use grew by 6% and natural gas liquid use has declined by about 41%, while electricity consumption has increased by 25% (Statistics Canada, #57-003).

In 2000, 0.9 Mt (3%) of overall greenhouse gas emissions from Other Manufacturing industries resulted from the use of halocarbons (HFCs/PFCs). Halocarbon emissions have increased by 0.4 Mt from 1995 levels. Halocarbons are used as ozone depleting substance replacements, such as CFCs and are primarily used as coolants in refrigeration and in both stationary and mobile air conditioning units. Other industrial uses of HFCs/PFCs consist of the electronics industry, the semiconductor industry, and by aerosol and fire extinguisher producers.

Other Industries

In 2000, 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 3.6 Mt, a decline of about 0.7 Mt from 1990.

Solvents and Other Product Use Sector

This sector accounted for less than 0.1% (0.5 Mt) of Canada's total greenhouse gas emissions in 2000. Emissions in this sector are from the use of nitrous oxide as anaesthetic and propellant; and have increased by 11% since 1990.

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