CANADA'S 2008 GREENHOUSE GAS INVENTORY

A Summary of Trends: 1990–2008

Snapshot of National Emission Trends

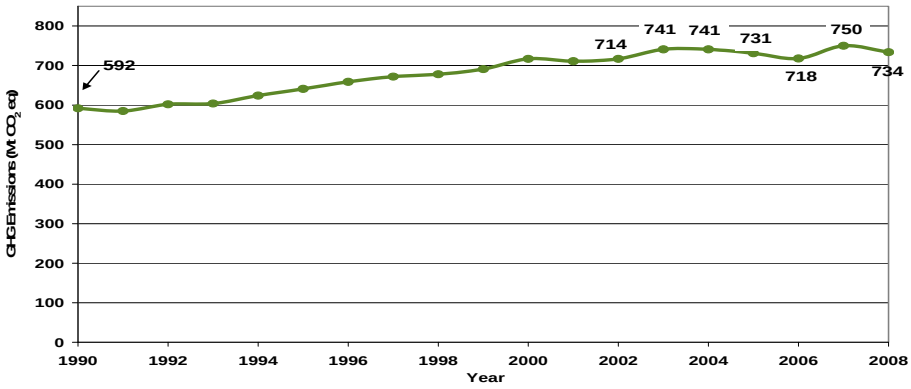
Each year, Canada prepares a national inventory of human-induced greenhouse gas (GHG) emissions from sources (e.g., fuel combustion, industrial processes) and removals by sinks (e.g., growing trees). This summary presents information on Canadian GHG emissions and removals from the most recent national inventory and *Canada's National Inventory Report: 1990–2008.*

Total GHG emissions in Canada in 2008 were 734 megatonnes of carbon dioxide equivalent[1] (Mt of CO_2 eq), approximately 81% of which was generated from energy sources, (includes all energy production and consumption). The remaining 19% was largely generated by agricultural sources and industrial processes, with smaller contributions from waste and solvent and other product uses.

The GHGs 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 hydrofluorocarbons (HFCs). CO_2 is the largest contributor to Canada's GHG Emissions, accounting for 78.2% of all emissions.

Canada's 2008 GHG emissions decreased 2.1% from 2007 levels, attributed partly to a slowdown in economic growth which began in 2008, and the utilization of greater amounts of hydropower for electricity generation. Although emissions in 2008 were 24% above the 1990 total of 592 Mt (see Figure 1 below), the growth trend has slowed in recent years; emissions since 2003 have decreased by 0.8%.

Figure 1 – Canada's GHG Emissions 1990–2008



National Inventory

As an Annex I Party (Developed Countries) to the United Nations Framework Convention on Climate Change (UNFCCC), Canada is required to prepare and submit a national inventory of human-induced greenhouse gas emissions from sources and removals by sinks in the form of a National Inventory Report (NIR) and a set of Common Reporting Format (CRF) tables. The National Inventory must meet international reporting guidelines and quality standards, and is reviewed annually by a UNFCCC Expert Review Team.

This year's inventory covers the period from 1990 to 2008 and incorporates updates to the 2007 year.

Importantly, this year's submission to the UNFCCC represents Canada's annual report under Article 7.1 of the Kyoto Protocol. It complies with all elements of the reporting requirements of the Kyoto Protocol and the UNFCCC. The 2008 inventory year is the first of five in the Kyoto reporting period (2008–2012).

[1] Each greenhouse gas has a different impact on warming. To account for this, scientists assign each gas a numeric "global warming potential" (GWP), based on the gas' ability to contribute to climate change. Carbon dioxide is set as the baseline with a global warming potential of 1, while other gases have larger values (for example, the GWP for methane (CH_4) is 21).

Canada

Short-Term Trends and Comparisons: 2003-2008

Since 2003, total Canadian GHG emissions have decreased by 6.2 Mt (0.8%). Although Gross Domestic Product (GDP) rose between 2003 and 2008 (see Table 1), growth peaked in 2005 and slowed thereafter. The recent economic recession began in the last quarter of 2008.

Table 1: Trends in Emissions and Economic Indicators for Selected Years (1990–2008)

	1990	1995	2000	2003	2005	2006	2007	2008
Total GHG (Mt)	**592**	**641**	**717**	**741**	**731**	**718**	**750**	**734**
Change Since 1990 (%)	*N/A*	*8.3*	*21.2*	*25.1*	*23.5*	*21.4*	*26.8*	*24.1*
*Annual Change (%)***	*N/A*	*2.8*	*3.8*	*3.3*	*-1.3*	*-1.7*	*4.5*	*-2.1*
*Average Annual Change (%)**	*N/A*	*1.7*	*2.1*	*1.9*	*1.6*	*1.3*	*1.6*	*1.3*
GDP (Billions 1997$)	***825***	***899***	***1101***	***1175***	***1248***	***1283***	***1316***	***1321***
Change Since 1990 (%)	*N/A*	*8.9*	*33.3*	*42.3*	*51.2*	*55.5*	*59.4*	*60.1*
*Annual Change (%)***	*N/A*	*2.8*	*5.2*	*1.9*	*3.0*	*2.9*	*2.5*	*0.4*
GHG Intensity (Mt/$B GDP)	**0.72**	**0.71**	**0.65**	**0.63**	**0.59**	**0.56**	**0.57**	**0.56**
Change Since 1990 (%)	*N/A*	*-0.5*	*-9.1*	*-12.1*	*-18.3*	*-22.0*	*-20.5*	*-22.5*
*Annual Change (%)***	*N/A*	*0.0*	*-1.4*	*1.4*	*-4.2*	*-4.5*	*1.9*	*-2.5*

*Average annual change since 1990.

GDP: Statistics Canada - Table 384-0002 - Expenditure-based, annual (Millions) (Jan 13, 2010)

**Annual Change: Represents change over previous calendar year.

Fluctuations in emissions levels since 2003 are due primarily to changes in the mix of sources used for electricity production (coal use varied with the availability of hydro and nuclear generation); changing emissions from fossil fuel production (as a result of the level of petroleum extraction activities); and varying demand for heating fuels for winters. Large increases in areas such as Transportation and Mining and Oil and Gas Extraction were offset by declines in Industrial Processes and Manufacturing Industries, as well as combustion emissions from both the Electricity and Heat Generation, and Commercial & Institutional subsectors. The following are further details on the short-term trends and comparisons (refer also to Table 2).

- In 2008, GHG emissions from electricity and heat generation shrank by 6.5 Mt from 2007 levels. Between 2003 and 2008, however, there were large emission fluctuations. Against a backdrop of increasing coal power usage in some areas, fossil fuel generation varied with the availability of electricity from hydro, nuclear and, to some extent, wind power sources. Hydroelectric power generation increased throughout Canada as a result of increased hydro-generating capacity and higher water levels (precipitation in 2005 was the highest on record while 2008 was the 12th-wettest year since 1948). At the same time, efforts have been made in Ontario to decrease coal generation. These efforts were more successful in 2006 and 2008 than 2007, when some nuclear outages necessitated increased coal generation (and hence, emissions). Growing demand for electricity in Alberta has been met primarily through increased generation from coal and natural-gas-fuelled power plants.

- Emissions from manufacturing[2] dropped by 5 Mt (5%) between 2003 and 2008, due to significantly lowered production evidenced by a 5.2 % fall in manufacturing GDP.

- The fossil fuel industries[3], consisting of oil, gas and coal production, refining and transmission, showed a 1.0 Mt decrease (0.7%) in GHG emissions between 2003 and 2008. During this period, crude oil exports increased by 17%, while crude oil production increased by 10%. In contrast, domestic consumption of crude decreased by approximately 3.9%. In the same interim, crude prices peaked, in 2008, at more than twice their 2003 value.

- Although not shown in Table 2, analysis indicates that the GHG emissions associated with oil sands activities alone increased by about 8 Mt (27%) between 2003 and 2008.

- Canadian homes and businesses required fluctuating amounts of energy for heating between 2003 and 2008 because of widely varying average winter temperatures. In 2006, heating degree-days, an indicator of the necessity for space heating in response to the severity of cold weather, were down about 12% on a national basis, but were up 11% again (close to the 2003 level) in 2008. This had an impact on fossil fuel consumption, in

2. Manufacturing includes the Manufacturing Industries subsector (*Energy Sector*) and the Industrial Processes Sector

3. Fossil fuel industries comprise the sum of the Mining and Oil and Gas Extraction, Fossil Fuel Production and Refining, Pipelines (Transportation) and Fugitive releases.

particular in the Residential and Commercial & Institutional sectors, where emissions decreased by 11.5% between 2003 and 2006 and increased by 6% between 2006 and 2008.

Long-Term Trends and Comparisons by Sector: 1990–2008

Between 1990 and 2008, the net increase in Canada's annual GHG emissions totalled about 142 Mt. Table 2 provides a breakdown of GHG emissions by sector. While the long-term trend has shown an overall increase of 24% since 1990, the trend in more recent years (starting in 2000) has shown a decline in the rate of emissions increase. From 1990 to 2000 the average annual growth in emissions was 2.1%, while in contrast, between 2000 and 2008, the average annual emission growth was 0.3%.

The change in the rate of growth in emissions since 2000 can be attributed to:

- Increases in efficiency, modernization of industrial processes, and structural changes in the composition of the economy, which are long term trends that have had an increased impact on emissions since the late 1990s.

  - The structural changes have involved a move from an industrial-oriented economy to a more service-based economy. Between 2000 and 2008, the GDP of the service industries has risen by 28%, while heavy industries and manufacturing together have grown by only 3%. Since service industries have a much lower economic GHG intensity than that of the goods-producing industries, this ongoing change has lowered Canadian GHG emissions.

  - Together, efficiency increases and technology and structural changes have resulted in a continuing weakening of the link between GDP growth and emissions, so that the GHG intensity of the economy (that is, GHG emissions per $ GDP) has decreased on average by 2.2% per year since 1997 (see Figure 2). This has allowed the economy to grow much more rapidly than emissions.

- Leveling off of emissions from electric power generation, which had been rising rapidly until then. In 2000, coal generation was at or close to its highest level ever. Since then, the contribution of coal generation to the electricity supply mix has been declining.

- Production of conventional oil peaked in 1998 in Canada and gas production leveled off in 2002. In both cases, this was the result of limited conventional reserves, which has offset the impact of oil sands growth since about 2000.

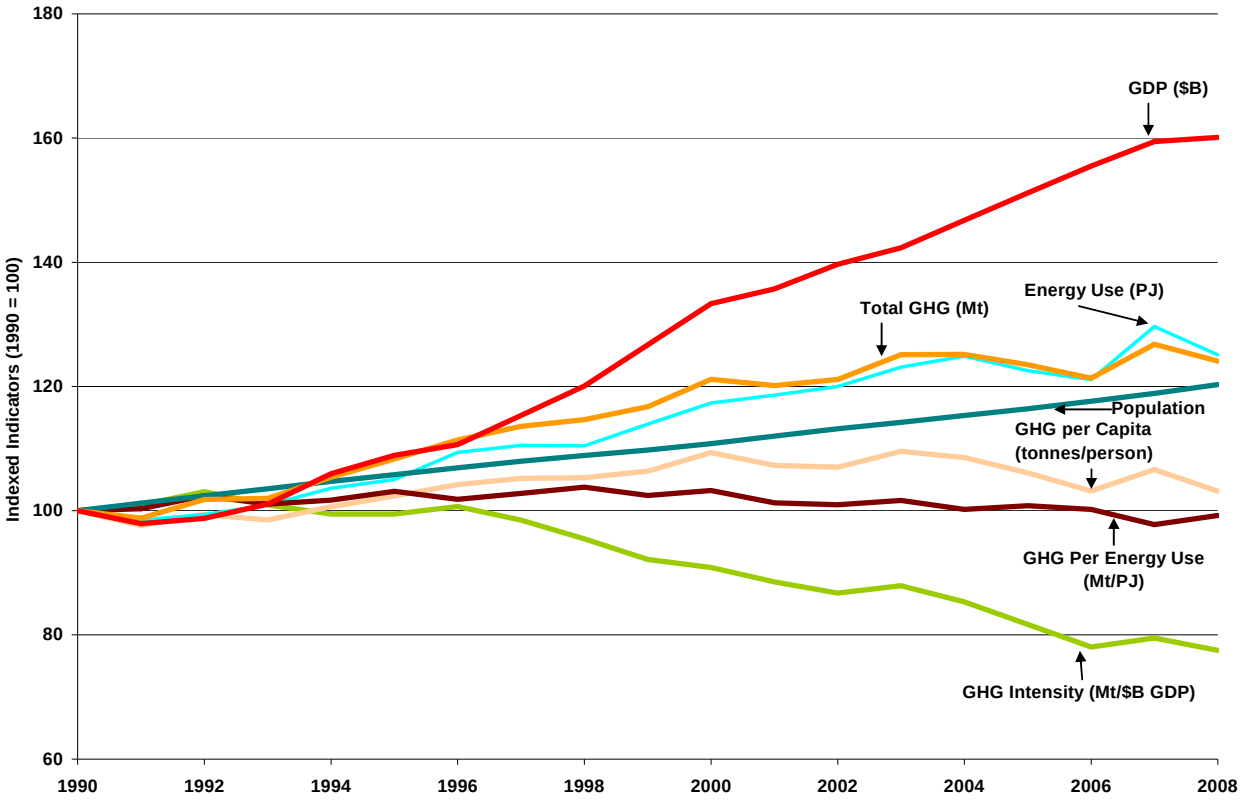
Returning to the overall long term greenhouse gas emission trend from 1990 to 2008, there are a number of factors which have contributed to the noted growth.

- Between 1990 and 2008, major increases in oil and gas production (much of it for export), as well a large increase in the number of motor vehicles and greater reliance on coal-fired electricity generation, have resulted in a significant rise in emissions. The rise in GHG emissions since 1990 largely mirrors an increase in primary energy use, although emissions per unit of energy consumed fell slightly (Figure 2).

- Over the same period, emissions from the energy industries[4] and transportation areas rose by about 130 Mt, accounting for most of the overall increase. Within these two energy areas, the greatest contributors to the overall increase were the 116% increase from light-duty gasoline trucks, the 24% increase from electricity and heat generation, and the 90% increase from heavy-duty diesel vehicles. Much of the increase in fossil fuel production is attributable to the rapid growth in crude oil and natural gas exports to the United States over the period.
- The Industrial Processes, Agriculture and Waste Sectors contributed to changes in emissions levels; they showed a 2.2 Mt decrease, a 14.0 Mt increase and a 2.8 Mt increase, respectively, since 1990.

4 Energy Industries comprise: the fossil fuel Fossil Fuel Production and Refining Subsectors (Energy Sector) and the Electricity and Heat Generation subsector (Energy).

Figure 2: Key GHG Emission Indicators



Energy Sector

- Emissions from the energy industries rose by about 79 Mt between 1990 and 2008. Almost half of that increase (38.4 Mt) was from the Fossil Fuel Production and Refining, Pipelines, and Fugitive Sources subsectors, a product of the increase in oil and gas production over the period. The remainder of the increase in the energy industries (41 Mt) was from the Electricity and Heat Generation subsector, a result of greater electricity demand being met by fossil fuel generation, and the Mining and Oil and Gas Extraction subsector, a result of expanded oil sands development.
- Emissions from the Mining and Oil and Gas Extraction subsector have risen 17.7 Mt or 287% since 1990. While this subsector does include emissions from coal, metals and minerals mining, a rapidly increasing proportion of the emissions are from activities associated with Canada's oil sands.
- The Fugitive Sources subsector (e.g. venting and flaring from oil production, methane leaks from pipelines) contributed significantly to GHG emissions. The current estimates show an increase of 21.2 Mt between 1990 and 2008, a growth of about 50%. Much of this increase was the result of higher crude oil and natural gas exports. Since about 2000, though, when natural gas and conventional oil production peaked, fugitive emission growth has flattened.

Transportation Subsector

- Emissions in the Transportation subsector rose by about 53.0 Mt, or 36.4% from 1990 to 2008. Of particular note in this sector is a 24.1 Mt-increase (more than 116%) in the emissions from light-duty gasoline trucks, reflecting the growing popularity of sport utility vehicles.
- Emissions from heavy-duty diesel vehicles increased 18.7 Mt over the period, indicative of greater heavy-truck transport. Offsetting these increases were reductions of 5.2 Mt from gasoline-fuelled cars and 1.3 Mt from alternatively fuelled cars.

Residential Subsector

- Residential emissions were marginally less in 2008 than they were in 1990 (down 1.4% or 0.6 Mt). The impact of the long-term trend of improved energy standards for homes and the adoption of higher-efficiency furnaces and other improved appliances has served to reduce emissions.

Canada

Industrial Processes Sector

- Emissions in the Industrial Processes Sector decreased 2.2 Mt, or 4.1%, from 1990 to 2008. Although some subsectors within this group did show significant increases, (e.g. emissions from use of HFCs in refrigeration and air conditioning, which are substitutes to ozone-depleting substances, have grown by over 5 Mt since 1995—over a 1000% increase), there were some significant reductions that more than made up for the increases.
- Emissions of N_2O—from Canada's sole adipic acid manufacturing plant—decreased by 8.3 Mt following the installation of N_2O abatement technology. Also, process emissions from the aluminium industry decreased by 1.9 Mt, or 20.4%, from 1990 to 2008 because of improved PFC emission-control technologies.

Agriculture Sector

- The Agriculture Sector consists exclusively of emissions of CH_4 and N_2O from agricultural production systems. In 2008, it represented 8.5% of total national emissions. Emissions from this sector have increased by 28.8% (14.0 Mt) since 1990, accounting for almost 10% of the national trend. The main drivers of the emission trend in the Agriculture Sector are the expansion of the beef cattle and swine populations, and increases in the application of synthetic nitrogen fertilizer in the Prairies. These were partially offset by a 28% reduction of the dairy population, itself explained by higher rates of milk production per animal while total milk production has remained stable.
- There has been little change in overall emissions from the Agriculture Sector since 2005, because the effects of higher consumption of synthetic nitrogen fertilizers and crop production were offset by a recent decline in beef cattle population.

Waste Sector

- From 1990 to 2008, GHG emissions from the Waste Sector increased by about 2.8 Mt, or 14.8%—lower than the population growth of approximately 20%. The vast majority of this growth is due to the generation of increasing amounts of waste in landfills. This increase would have been larger but for the implementation of landfill gas recovery projects and waste diversion programs (composting and recycling) in Canada.

Land Use, Land-Use Change and Forestry Sector (not included in national totals)

- The trend in emissions from sources and removals by sinks in Land Use, Land-Use Change and Forestry (LULCF) (i.e., agricultural soils, managed forests, managed wetlands and land-use change) shows that the whole sector can either be a net sink (removing CO_2 from the atmosphere) or a net source of GHGs to the atmosphere. In 2008, the LULUCF sector amounted to a net sink of 13 Mt. Trends in the sector are primarily driven by changes occurring in managed forests and cropland.
- Net fluxes in managed forests reflect the erratic pattern of forest fires, the trends in management activities such as harvest, and the long-term impact of major forest infestations like the mountain pine beetle in British Columbia. For the first time since 2001 and the beginning of the mountain pine beetle infestation, managed forests acted as net sinks in 2008 (18 Mt), due to the combined effect of the lowest annual harvest rate of the entire period, and lowest fire emissions since 2001.
- The cropland category includes the effect of agricultural practices on CO_2 emissions and removals from arable soils (soils suitable for growing crops) and the impact of converting forest and grassland to cropland. In 2008, carbon sequestration in arable soils more than made up for emissions from lands converted to cropland with, as a result, a net sink of 4.4 Mt. The continued adoption of no-till and reduced-tillage practices and the reduction of summer fallow have resulted in a steadily increasing ability of cultivated soils to behave like sinks.
- Forest land converted to cropland, wetlands and settlements (not shown in the summary table) amount to emissions of about 19 Mt in 2008, down from 27 Mt in 1990. The conversion of forest and grassland to cropland alone shows a steady decrease in GHG emissions from 14 Mt in 1990 to 7 Mt in 2008.
- Of note, this year includes the first reporting of Land Use, Land Use Change and Forestry activities under articles 3.3 and 3.4 of the Kyoto Protocol, with emission and removal estimates for afforestation and deforestation (mandatory), and cropland management (elected by Canada) for the year 2008. These estimates do not affect the national totals, and will only be accounted for at the end of the five-year commitment period (2012 inventory year).

Table 2: Sectoral GHG Emission Summary

Sectoral Greenhouse Gas Emission Summary

Source Categories	1990	2003	2007	2008	2007 to 2008 Change		1990 to 2008 Change	
		kt CO_2 eq			Absolute	%	Absolute	%
TOTAL[1]	**592 000**	**741 000**	**750 000**	**734 000**	**-15,909**	**-2.1**	**142,627**	**24.1**
ENERGY	**469 000**	**609 000**	**614 000**	**597 000**	**-16,775**	**-2.7**	**127,941**	**27.3**
a. Stationary Sources	**281 000**	**360 000**	**350 000**	**335 000**	**-14,786**	**-4.2**	**53,785**	**19.1**
Electricity and Heat Generation	95 000	135 000	125 000	119 000	-6,463	-5.2	23,338	24.4
Fossil Fuel Production and Refining	51 000	74 000	70 000	68 000	-2,194	-3.1	16,659	32.4
Mining and Oil and Gas Extraction	6 200	15 800	23 200	23 900	662	2.9	17,681	285.6
Manufacturing Industries	55 000	49 800	49 400	43 400	-6,056	-12.3	-11,652	-21.2
Construction	1 870	1 290	1 290	1 260	-30	-2.3	-611	-32.7
Commercial & Institutional	25 700	37 700	34 900	34 900	-32	-0.1	9,175	35.7
Residential	43 000	45 000	44 000	43 000	-607	-1.4	-589	-1.4
Agriculture & Forestry	2 390	2 190	2 240	2 170	-66	-2.9	-215	-9.0
b. Transportation	**145 000**	**183 000**	**199 000**	**198 000**	**-1,088**	**-0.5**	**52,976**	**36.4**
Domestic Aviation	6 400	7 200	8 800	8 500	-307	-3.5	2,172	34.1
Gasoline Automobile	45 800	41 400	41 000	40 600	-358	-0.9	-5,200	-11.3
Light-duty Gasoline Trucks	20 700	40 500	44 800	44 800	-45	-0.1	24,089	116.4
Heavy-duty Gasoline Vehicles	7 810	6 050	6 620	6 660	33	0.5	-1,154	-14.8
Motorcycles	146	226	264	264	1	0.3	118	80.4
Diesel Automobiles	355	398	448	446	-2	-0.4	91	25.7
Light-duty Diesel Vehicles	710	1 880	2 320	2 370	46	2.0	1,659	234.7
Heavy-duty Diesel Vehicles	20 680	34 110	40 010	39 390	-625	-1.6	18,704	90.4
Propane & Natural Gas Vehicles	2 210	820	830	880	46	5.5	-1,335	-60.3
Railways	7 000	6 000	7 000	7 000	319	4.7	154	2.2
Domestic Marine	5 000	6 100	6 100	5 800	-283	-4.6	790	15.7
Off-road Gasoline	6 700	7 800	7 100	6 300	-817	-11.5	-373	-5.6
Off-road Diesel	15 000	22 000	25 000	28 000	2,381	9.4	12,650	84.1
Pipelines	6 850	9 050	8 940	7 460	-1,478	-16.5	610	8.9
c. Fugitives	**42 700**	**65 700**	**64 700**	**63 800**	**-901**	**-1.4**	**21,180**	**49.7**
Coal Mining	1 900	900	800	800	-10	-1.3	-1,160	-60.6
Oil	4 180	5 780	5 810	5 520	-289	-5.0	1,340	32.0
Natural Gas	12 900	20 100	21 300	21 300	61	0.3	8,419	65.3
Venting	19 300	33 300	31 600	30 800	-874	-2.8	11,506	59.8
Flaring	4 400	5 700	5 300	5 500	212	4.0	1,075	24.4
INDUSTRIAL PROCESSES	**54 800**	**51 200**	**53 200**	**52 600**	**-643**	**-1.2**	**-2,241**	**-4.1**
a. Mineral Production	8 300	9 100	9 300	8 500	**-790**	**-8.5**	**235**	**2.8**
b. Chemical Industry	16 700	8 500	8 900	10 300	**1,468**	**16.6**	**-6,395**	**-38.2**
c. Metal Production	19 500	17 200	15 500	15 300	**-220**	**-1.4**	**-4,162**	**-21.4**
d. Consumption of Halocarbons	2 300	6 000	6 700	7 300	**562**	**8.4**	**4,978**	**215.9**
e. Other & Undifferentiated Production	8 000	10 000	13 000	11 000	**-1,663**	**-13.0**	**3,103**	**38.6**
SOLVENT & OTHER PRODUCT USE	**170**	**220**	**320**	**330**	**11**	**3.3**	**155**	**88.7**
AGRICULTURE	**48 000**	**60 000**	**61 000**	**62 000**	**1,218**	**2.0**	**13,974**	**28.8**
a. Enteric Fermentation	17 000	22 000	23 000	22 000	-152	-0.7	5,556	32.8
b. Manure Management	6 000	7 800	7 800	7 500	-292	-3.7	1,517	25.3
c. Agriculture Soils	26 000	29 000	31 000	32 000	1,661	5.4	6,901	27.0
WASTE	**19 000**	**21 000**	**21 000**	**22 000**	**280**	**1.3**	**2,798**	**14.8**
a. Solid Waste Disposal on Land	18 000	19 000	20 000	20 000	270	1.3	2,750	15.5
b. Wastewater Handling	740	890	930	940	5	0.5	197	26.8
c. Waste Incineration	400	230	250	250	5	2.1	-149	-37.2
LAND USE, LAND-USE CHANGE AND FORESTRY	**-52 000**	**56 000**	**45 000**	**-13 000**	**-58,280**	**-128.2**	**38,739**	**-75.1**
a. Forest Land	-79 000	46 000	38 000	-18 000	-56,596	-147.6	60,461	-76.8
b. Cropland	12 700	- 500	-3 400	-4 400	-1,037	30.6	-17,094	-135.0
c. Grassland	0	-	-	-	NA	NA	NA	NA
d. Wetlands	5 000	3 000	3 000	2 000	-157	-5.9	-2,464	-49.7
e. Settlements	10 000	8 000	8 000	7 000	-490	-6.2	-2,164	-22.7
LAND USE, LAND-USE CHANGE AND FORESTRY Activities under the Kyoto Protocol								
a. Article 3.3								
Afforestation / reforestation	NA	NA	NA	-1,000	NA	NA	NA	NA
Deforestation	NA	NA	NA	15,000	NA	NA	NA	NA
b. Article 3.4								
Cropland Management	4,000	NA	NA	-12,000	NA	NA	-15,775	-369.3

Notes:

NA = Not Applicable

1. National totals exclude all GHGs from the Land Use, Land-use Change and Forestry Sector.

2. Absolute and percent changes shown are based on UNROUNDED values.

3. Due to rounding, totals may not add up.

Red text identifies an INCREASE

Green text identifies a DECREASE

Canada