BRITISH COLUMBIA

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INVENTORY REPORT 2008

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Further Information

Copies of this report, as well as additional information, can be downloaded from the Ministry of Environment website at: www.env.gov.bc.ca/cas/climate/ghg-inventory/index.htm

Comments or questions regarding the report can be sent to: GHGInventory@gov.bc.ca

1. REPORT PURPOSE, CONTENTS AND STRUCTURE

Purpose of the British Columbia Greenhouse Gas Inventory Report

The *British Columbia Greenhouse Gas Inventory Report 2008* (B.C. GHG inventory report) has been prepared to provide sound, science-based, comparable and consistent reporting of GHG sources and sinks in British Columbia – in support of the *Greenhouse Gas Reductions Target Act* [1] (GGRTA), as well as national and international reporting processes and related initiatives. A GHG sources and sinks inventory is a comprehensive account of emission releases from anthropogenic sources (e.g., fuel combustion, industrial processes) and removals[2] by sinks (e.g., growing plants and trees) for a defined area (such as a nation or province) over a specified period of time.

The GGRTA establishes legislated targets for reducing British Columbia's GHG emissions. As compared to 2007 levels, emissions must be reduced by a minimum of 33% by 2020 and 80% by 2050. Interim reduction targets of 6% by 2012 and 18% by 2016 have also been set by Ministerial Order. The total B.C. emissions estimate provided in this report are the first measure of change against the 2007 baseline established under the GGRTA. Following this 2008 report, the Ministry of Environment (the ministry) will prepare a B.C. GHG inventory report for every even subsequent year (i.e., 2010, 2012 and beyond).

This report has been prepared by the ministry, working with staff in other provincial ministries and with federal counterparts, to determine and report the 2008 GHG emissions level for B.C. In keeping with national and international GHG inventory procedures, it is expected that GHG estimates, including the 2007 baseline, will continue to be updated annually or periodically to reflect improved quantification methods and input data, as well as resolution of data anomalies.

A separate summary of this B.C. GHG inventory report, as well as additional information, is available at: www.env.gov.bc.ca/cas/climate/ghg-inventory/index.htm

Approach to Data Used for Reporting Emissions

The ministry uses the following approach to data used for reporting emissions:

- The data presented in this report is provided entirely by Environment Canada and the Canadian Forest Service and is the same data presented in Environment Canada's *National Inventory Report on Greenhouse Gases and Sinks in Canada* (National Inventory Report – NIR). Where needed to report emissions at a provincial scale, the B.C. GHG inventory report includes data provided to the ministry by the GHG Division of Environment Canada that is not published in the NIR (but that is included in NIR national totals).
- The ministry supports and works in collaboration with federal counterparts responsible for preparation of the NIR to develop current and scientifically rigorous best practices and methodologies for GHG quantification, consistent with international standards and practices.

[1] See: www.env.gov.bc.ca/cas/codes/ggrta/index.htm

[2] The term "removal" is used to describe the removal of CO_2 from the atmosphere (e.g., through storage of carbon by vegetation or physical processes). Processes that remove more carbon dioxide from the atmosphere than they release, as part of the carbon cycle, are often referred to as carbon sinks. For example, forests and oceans can act as carbon sinks.

- The ministry follows protocols established by Environment Canada to maintain confidentiality of data as and where appropriate.
- The ministry uses "memo item" categories where needed to address important source and sink categories not otherwise included or cumulated into national totals (see discussion of "reporting memo items" below).
- The ministry continues to use a Quality Assurance/Quality Control (QA/QC) process to ensure that the NIR data presented in the B.C. GHG inventory report is accurate and representative.

Structure and Contents of the Report

The B.C. GHG inventory report is structured using the same categorical breakdown of GHG sources and sinks presented in the NIR, grouped in the following "sector" and "sub-sector" headings:

- *Energy* – stationary combustion sources, transportation and fugitive sources
- *Industrial processes* – mineral products, chemical industry, metal production, consumption of halocarbons and SF_6, and other and undifferentiated production
- *Solvent and other product use*
- *Agriculture* – enteric fermentation, manure management and agricultural soils
- *Waste* – solid waste disposal on land, wastewater handling and waste incineration
- *Land Use, Land-use Change and Forestry* – afforestation, deforestation, forest land, cropland and wetlands

This report includes the following B.C.-specific emissions currently not reported at the provincial level in the NIR: 1) emission sources and sinks reported under the "land use, land-use change and forestry" sector; and 2) SF_6 from electrical generation, transmission and distribution equipment. As a result of including these categories, reported emissions in this B.C. Provincial GHG Report are 3.6 megatonnes CO_2e (5.5%) higher than the emissions reported for B.C. in the National Inventory Report. Limestone and dolomite use and soda ash production and use are reported together under "Mineral Products Use" in the NIR but are presented separately in this report.

The report provides a brief background to climate change and greenhouse gas emissions, a section summarizing provincial emissions by GHG gas and "sector", followed by more detailed sector-specific information. The initial "summary" section for each sector includes a small pie-chart schematic showing emissions for the sector in relation to "remaining emissions" from other sectors (see Figure 1 for specific figures and percentages of emissions by sector). Emissions for the year 2008 for each sector are documented, as well as trends in relation to preceding years to provide short and longer term context and factors influencing emissions. Data sources are summarized for each sector. The final section of the report provides annexes listing acronyms used in the document, emission factors used in calculating emissions and other supporting information.

The report also includes several "understanding trends" text boxes with example-specific figures and commentary using supplementary data sources. This information is provided as a sample of the analyses that can be undertaken to inform or utilize the data presented in the report. Readers are invited to access the data files that accompany the report for further needs-specific analysis.

Note that emission percentages presented in tables and figures are rounded to the nearest tenth of a percent. Unless otherwise stated in the report, all emissions are presented in kilotonnes carbon dioxide equivalent (kt CO_2e) rounded to the nearest whole number.

Readers wishing detailed information regarding methodologies and protocols for emissions reporting and recalculation – as well as Quality Assurance/Quality Control (QA/QC), data sources and planned improvements – can refer to the extensive set of background and methodological documents provided on the Environment Canada GHG website.[3]

Reporting of "Land Use, Land-use Change and Forestry" Sector "Memo Items"

The inclusion of emissions and removals under the "land use, land-use change and forestry" (LULUCF) sector towards national GHG totals is not mandatory under protocols established by the United Nations Framework Convention on Climate Change (UNFCCC). The federal government has elected to report GHG emissions in this sector as "memo items" – that is, emissions not included in national GHG emission totals but reported for transparency and GHG accounting purposes. The B.C. GHG inventory report, however, includes emissions from the afforestation and deforestation components of the LULUCF sector towards provincial GHG emission totals for the following reasons:

- Afforestation and deforestation in B.C. are quantified using accounting protocols that do not introduce bias into reported emission levels.
- There is greater anthropogenic control over afforestation and deforestation than other sources and sinks in this sector.
- Reporting of net afforestation and deforestation emissions are in accordance with the "Net-Zero Deforestation" policy outlined in B.C.'s Climate Action Plan.
- Afforestation and deforestation sources and sinks are counted towards Canada's assigned amount under Article 3.3 of the Kyoto Protocol, while emissions from Land Use and Forestry are not counted, as per Canada's election under Article 3.4 of the Kyoto Protocol.

Emissions designated as "memo items" in the LULUCF sector are included in this report under the categories of "forest land remaining forest land", "cropland remaining cropland" and "wetlands remaining wetlands" – in accordance with international reporting protocols. These categories are sometimes referred to as forest land, cropland and wetlands, respectively. See section 9 for additional detail and description of categories and associated emissions and removals.

Year to Year Changes in GHG Emissions

Caution should be exercised when interpreting year to year changes in GHG emissions. Some changes may be due to data collection gaps, methodology or error correction refinements. Other changes in emissions figures may be the result of one-time or specific events or actions (such as natural disasters or production disruptions). Changes over three and ten year (or longer) periods provide a better indication of trends in emissions.

[3] See links to "Climate Change" and "Canada's Greenhouse Inventory" under the Environment Canada website.

2. BACKGROUND INFORMATION

Climate Change and Greenhouse Gases

Over the geological timescale of millions of years, the global climate changes dramatically in response to natural processes. Climate change in the context of this document however, refers to changes in climate and weather patterns over periods of decades to centuries – caused in large part by human activities that alter the chemical composition of the atmosphere through buildup of GHGs. The addition of GHGs from human sources is significantly enhancing the amount of solar energy trapped by the earth's atmosphere – leading to warming of the global climate system.

There are four major gases or groups of gases[4] that are influenced by human activities that are of interest:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Synthetic (not naturally occurring) fluorinated gases – sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs)

Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. For example, the global atmospheric concentration of carbon dioxide has increased from a pre-industrial value of about 280 parts per million (ppm) to 386 ppm in 2009. The globally averaged atmospheric concentration of carbon dioxide in 2009 exceeds by far the natural range over the last 650,000 years (180 to 300 ppm) as determined from ice cores. The global increases in carbon dioxide concentration are due primarily to fossil fuel use and land-use change, while those of methane and nitrous oxide are primarily due to agriculture.[5]

The concept of "global warming potential" (GWP or CO_2e) has been developed to enable comparison of the ability of different GHGs to trap heat in the atmosphere (radiative forcing).[6] By definition, the GWP from the release of 1 kg of CO_2 is one, with the GWP of other GHGs stated relative to CO_2. The GWP of a GHG accounts for both the immediate radiative forcing due to an increase in the concentration of the gas in the atmosphere, and the lifetime of the gas. The following sum-

[4] The ministry is following developments regarding emerging greenhouse gases such as nitrogen trifluoride (NF_3), trifluoromethyl sulphur pentafluoride (SF_5CF_3), fluorinated ethers, perfluoropolyethers, hydrocarbons (black carbon) and other compounds – and may also include these within the B.C. provincial GHG inventory report at the appropriate time. Further information can be found at: http://unfccc.int/national_reports/annex_i_ghg_inventories/items/4624.php

[5] For additional information regarding climate change and GHG emissions inventories, see reports of the Intergovernmental Panel on Climate Change (IPCC) at www.ipcc.ch or the introductory chapter of the (Canadian) National Inventory Report (follow "climate change" and "Canada's GHG emissions" links under www.ec.gc.ca). The data in this paragraph is drawn from the Fourth Assessment Report of the IPCC Summary for Policy Makers (*Climate Change 2007: Working Group I: The Physical Science Basis*) and from Dr. Pieter Tans, National Oceanic and Atmospheric Administration, Earth System Research Laboratory. U.S. Department of Commerce. See: www.esrl.noaa.gov/gmd/ccgg/trends/ and www.ipcc.ch/publications_and_data/ar4/wg1/en/spm.html.

[6] The term "radiative forcing" refers to the amount of heat-trapping potential for a GHG, measured in units of power per unit of area (watts per metre squared).

mary table lists the "100-Year GWP" (as recommended by the International Panel on Climate Change) for the major gases and groups of gases.[7]

Table 1: Global Warming Potential (GWP) for GHGs – Summary

GHG	100-Year GWP
Carbon Dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous Oxide (N_2O)	310
Sulphur Hexafluoride (SF_6)	23 900
Hydrofluorocarbons (HFCs)	140 – 11 700
Perfluorocarbons (PFCs)	2 600 – 50 000

Emission Factors

GHG emissions are typically estimated using emission factors – metrics that relate quantity of emissions released to unit levels of activity data (e.g., 2.8 kg CO_2 emitted per litre diesel burned, 0.4 kg of CH_4 emitted per head of cattle per year). Emission factors are determined using mass balance, stoichiometry or other relationships under average conditions. The factors can be averaged across various geographical ranges – nationally, provincially or even at a facility-specific level. Emission factors used in calculations for fuel combustion, industrial processes and electricity emissions are listed under separate tables in Annex 10.3 of this report.

GHG Sources and Sinks – Canada's Inventory and Reporting System

Canada's national GHG emissions inventory system has been established under authority of the *Canadian Environmental Protection Act* (CEPA) – and meets the requirements under the United Nations Framework Convention on Climate Change (UNFCCC).[8] The UNFCCC sets out reporting categories and methodologies for estimating emissions and removals of specified GHGs.

Environment Canada Greenhouse Gas Division is the lead agency for GHG inventory reporting in Canada. To prepare and verify inventory information, Environment Canada works closely with other federal agencies (such as Statistics Canada and Natural Resources Canada), provincial governments (including British Columbia), academic and consulting groups, and industries responsible for facility GHG data reporting.

Inventory data can be derived using "bottom up" methods (i.e., site-specific quantification of emissions), or by "top down" approaches (that utilize aggregated statistical data to estimate emissions). Canada's inventory is prepared using predominately top down approaches, providing estimates at a

[7] A complete table with specific figures for each GHG is included in Annex 10.2 Global Warming Potentials for Greenhouse Gases of this report. In line with current UNFCCC protocols, BC currently uses IPCC second assessment report GWPs and will likely update the GWPs in parallel with implementation of updates by the UNFCCC for national inventory reporting.

[8] See: http://unfccc.int

sectoral and provincial/territorial level of segregation, without attribution to individual emitters. A bottom-up approach is used for a limited number of emission sources.

Non-point (or "area") sources of emissions are spatially diffuse and/or very numerous (e.g., burning of fossil fuels for transportation). These are typically calculated using technology-specific or average emission factor calculations, or "mass balance" equations (the difference between the amounts of a component – such as carbon – contained in feed materials or fuels and the amounts contained in the products, wastes or non-emitted residuals). Environment Canada has, for example, developed average emission factors for many inventory categories in consultation with other government departments, industry associations and agencies – reflecting the most accurate available methodologies and international (IPCC and UNFCCC) standards and practices.

Emissions from individual emitters may be measured or estimated from individual plant data, or from facility throughput and emission factors. Under Environment Canada's "Facility GHG Reporting" system, all facilities in Canada emitting over 100 kilotonnes (for 2009 reports, the threshold is 50 kilotonnes) of GHGs in a given year are required to report emissions to Environment Canada.[9] Emissions data by facility is made publicly available. In 2009, 348 facilities across Canada reported GHG emissions for the 2008 calendar year, totaling 263 Mt of GHGs (36% of total national emissions). Of this number, 38 facilities were located in B.C., and were responsible for 13.2 Mt of emissions (19% of total provincial emissions). Generally, data reported under this system are not used in the NIR, with the exception of limited industrial process emissions data.

Related British Columbia GHG Inventories

The Reporting Regulation under the *Greenhouse Gas Reduction (Cap and Trade) Act*, brought into force in November 2009, requires any facility emitting 10,000 tonnes or more of "attributable" greenhouse gases to report those emissions to the Ministry of Environment.[10] The Ministry will use the data collected under this legislation to support provincial and national inventory reporting when it becomes available in 2011.

The Ministry of Environment's province-wide Community Energy and Emissions Inventory (CEEI)[11] supports tracking and reporting of energy use and GHG emissions at a community level. CEEI provides local governments across B.C. with consistent GHG inventory baseline data, analysis, ongoing monitoring and periodic reports. The initiative informs and supports community-level understanding and decision making, as well as provincial GHG reduction objectives.

Insights gained through the collection of data for facility-specific reporting and the CEEI may be used to refine (where applicable) the GHG quantification methodologies used in the NIR and consequently also the B.C. GHG inventory report.

[9] See the "facility GHG reporting" link under the "climate change" page of the Environment Canada website for both a description of the reporting system and a link to the public data download site.
[10] See: www.env.gov.bc.ca/cas/codes/ggrcta/reporting-regulation/index.htm
[11] See: www.env.gov.bc.ca/cas/climate/ceei/index.htm

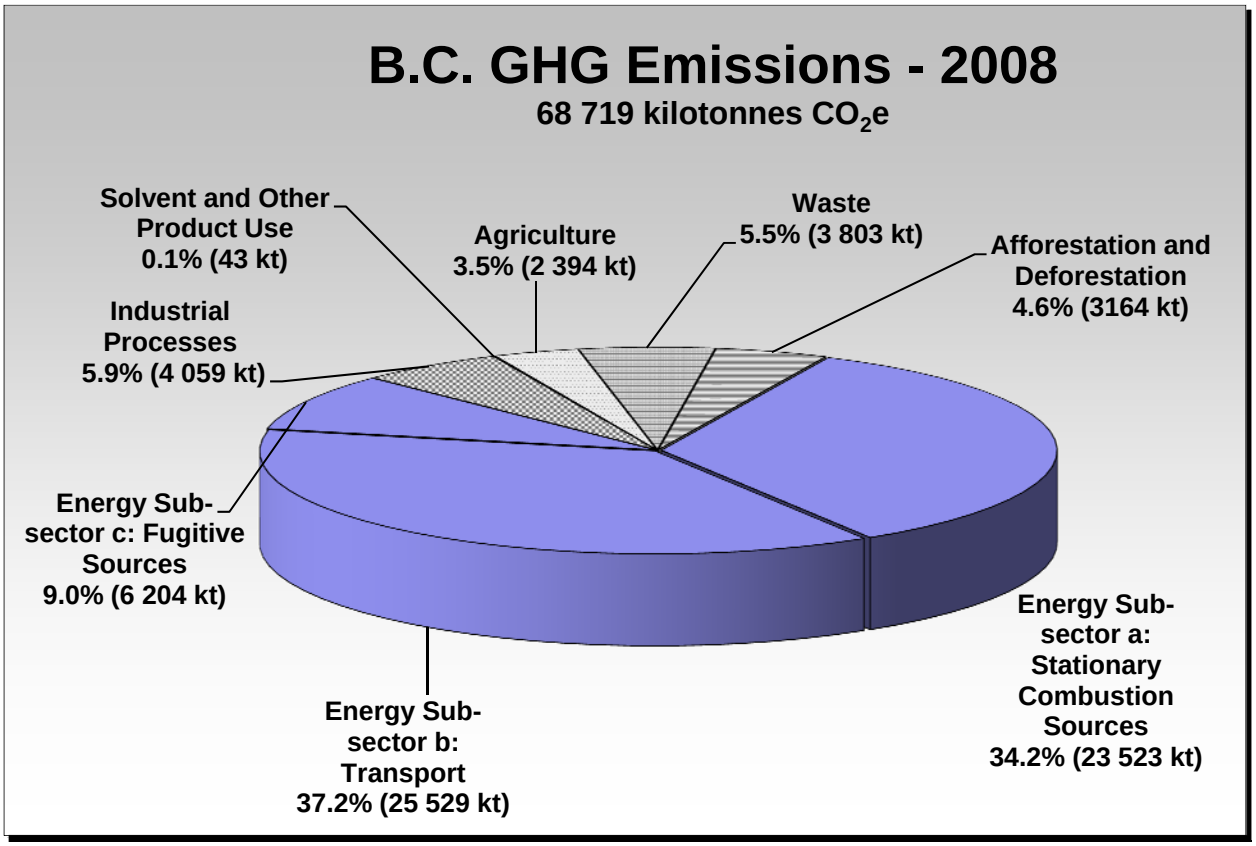
3. B.C. GHG EMISSIONS – 2008

3.1 B.C. GHG Emissions by Sector – 2008

Total greenhouse gas emissions in British Columbia in 2008 were 68.7 megatonnes (Mt) CO_2e.[12]

In 2007, the base year for calculation of B.C. GHG emissions targets established under the provincial *Greenhouse Gas Reductions Target Act,*[13] GHG emissions were 68.0 Mt CO_2e.[14]

GHG emissions are attributed to six defined sectors: energy; industrial processes; solvents and other product use; agriculture; waste; and afforestation and deforestation. A brief description of these sectors and their attributed GHG emissions is provided in Table 2 and total GHG emissions in 2008 from each of the sectors is shown in Figure 1. Note that the table and figure describe emissions from the three energy sub-sectors (stationary combustion sources, transport and fugitive sources) as a significant percentage of total emissions are attributed to these sub-sectors.



[12] One megatonne (1 Mt) is one million tonnes. One kilotonne (1 kt) is one thousand tonnes. This figure (68.7 Mt CO_2e) includes B.C.-specific emissions currently not reported at the provincial level in the National Inventory Report (NIR). As a result of including these categories, reported emissions are 3.6 Mt (5.5%) higher than the emissions of 65.1 Mt reported for B.C. in the NIR. Note that totals and percentages may not sum due to rounding protocols.

[13] The Act puts into law British Columbia's target of reducing greenhouse gas emissions by at least 33% below 2007 levels by 2020 and includes the long-term target of an 80% reduction below 2008 levels by 2050.
See: www.env.gov.bc.ca/cas/codes/ggrta

[14] Note that under international protocols, GHG emissions estimates are reviewed and revised to incorporate methodological refinements and improved data. The 2008 GHG emissions estimate (as well as all figures used in calculating trends and changes in emissions from previous years) in this report reflects the revised emissions estimates determined and reported by Environment Canada in the National Inventory Report.

Figure 1: B.C. GHG Emissions – 2008
Table 2: Sector Descriptions and 2008 GHG Emissions[15]

Sector	Description	GHG Emissions (kt CO_2e)	% of B.C. Emissions
ENERGY	Emissions from stationary and transport fuel combustion and fugitive emissions from the fossil fuel industry	55 256	80.4%
Sub-sector a: Stationary Combustion	Emissions from stationary devices that combust solid, liquid, or gaseous fuel in order to generate useful heat or electricity (excluding devices used in pipeline transport)	23 523	34.2%
Sub-sector b: Transport	Emissions from mobile devices that combust liquid or gaseous fuels for the purpose of generating useful energy (including stationary devices used in pipeline transport)	25 529	37.2%
Sub-sector c: Fugitive Emissions	Intentional or unintentional emissions from the production, processing, transmission, storage, and delivery of fossil fuels; and from the combustion of fossil fuels not used to generate useful heat or electricity	6 204	9.0%
INDUSTRIAL PROCESSES	Emissions from chemical reactions used in industry that physically or chemically transform materials	4 059	5.9%
SOLVENT & OTHER PRODUCT USE	Nitrous oxide emissions when used as an anaesthetic or propellant	43	0.1%
AGRICULTURE	Emissions from enteric fermentation, manure management and non-CO_2 emissions from agricultural soils	2 394	3.5%
WASTE	Emissions from solid waste disposal, wastewater treatment and waste incineration	3 803	5.5%
AFFORESTATION & DEFORESTATION	Emissions from deforestation and removals from afforestation	3 164	4.6%
	TOTAL	68 719	

Note: Totals and percentages may not sum due to rounding.

3.2 B.C. GHG Emissions by Greenhouse Gas – 2008

For emissions reporting, most sectors are further categorized into sub-sectors, a number of which are further sub-divided into finer categories.[16] Table 3 provides a summary of emissions by greenhouse gas (in terms of kt and kt CO_2e) for each reporting category, including sub-sectors in the land use, land-use change and forestry (LULUCF) sector where emissions and removals for afforestation and deforestation are included in the provincial total and forest land, cropland and wetlands are reported as memo items. Note that these "memo item" emissions do not contribute to the "total emissions" figure reported in the first row of the table.

[15] Note that emission percentages presented in tables and figures are rounded to the nearest tenth of a percent. Unless otherwise stated in the report, all emissions are presented in kilotonnes carbon dioxide equivalent (kt CO_2e) rounded to the nearest whole number.
[16] These sub-sectors and categories are described in detail in subsequent sections of this report.

Carbon dioxide (CO_2) accounts for most of the GHG emissions in the province (81.3% of total CO_2e), followed by methane (CH_4) which accounts for 12.1% of total emissions and nitrous oxide (N_2O) which accounts for 3.8% of total emissions.

Table 3: B.C. Emissions by GHG and Reporting Category – 2008

Greenhouse Gas	CO_2	CH_4	CH_4	N_2O	N_2O	PFCs	HFCs and SF_6	TOTAL
Unit	kt	kt	kt CO_2e	kt	kt CO_2e	kt CO_2e	kt CO_2e	kt CO_2e
GHG Source Category								
TOTAL	55 863	395	8 303	8	2 622	641	1 290	68 719
ENERGY	50 573	157	3 294	4	1 389			55 256
a. Stationary Combustion Sources	22 770	24	502	1	250			23 523
Electricity and Heat Generation	1 505	0	4.4	0	10.4			1 520
Fossil Fuel Industries	5 857	16	332.3	0	49.2			6 238
Mining and Oil & Gas Extraction	1 340	0	0.5	0	7.8			1 348
Manufacturing Industries	6 409	1	15.8	0	112.4			6 537
Construction	100	0	0.0	0	0.7			100
Commercial & Institutional	3 352	0	1.3	0	21.1			3 374
Residential	4 152	7	148.0	0	48.3			4 349
Agriculture & Forestry	56	0	0.0	0	0.5			56
b. Transport	24 332	2.8	58.7	3.7	1 138.9			25 529
Domestic Aviation	1 461	0.1	1.4	0.1	41.2			1 504
Road Transportation	14 944	1.0	21.9	1.3	405.4			15 371
Light-Duty Gasoline Vehicles	3 905	0.3	6.1	0.4	135.1			4 046
Light-Duty Gasoline Trucks	4 485	0.3	6.1	0.6	187.2			4 678
Heavy-Duty Gasoline Vehicles	1 596	0.1	2.0	0.1	35.1			1 634
Motorcycles	27	0.0	0.4	0.0	0.2			27
Light-Duty Diesel Vehicles	44	0.0	0.0	0.0	1.1			45
Light-Duty Diesel Trucks	57	0.0	0.0	0.0	1.4			58
Heavy-Duty Diesel Vehicles	4 581	0.2	4.4	0.1	43.9			4 630
Propane & Natural Gas Vehicles	248	0.1	2.9	0.0	1.5			253
Railways	554	0.0	0.6	0.2	71.3			626
Domestic Marine	2 381	0.2	3.8	0.4	124.8			2 510
Other Transportation	4 992	1.5	30.9	1.6	496.3			5 519
Off-Road Gasoline	342	0.4	8.5	0.0	2.3			352
Off-Road Diesel	3 780	0.2	4.4	1.6	486.7			4 272
Pipelines	870	1	18.0	0	7.2			895
c. Fugitive Sources	3 471	130.2	2 733.3					6 204
Coal Mining		24.1	506.7					507
Oil and Natural Gas	3 471	106.0	2 226.6					5 697
INDUSTRIAL PROCESSES	2 129					641	1 290	4 059
a. Mineral Products	1 281							1 281
Cement Production	1 086							1 086

Greenhouse Gas	CO_2	CH_4	CH_4	N_2O	N_2O	PFCs	HFCs and SF_6	TOTAL
Unit	kt	kt	kt CO_2e	kt	kt CO_2e	kt CO_2e	kt CO_2e	kt CO_2e
GHG Source Category								
Lime Production	157							157
Limestone and Dolomite Use	38							38
Soda Ash Production and Use								0
b. Chemical Industry								0
Nitric Acid Production								0
Adipic Acid Production								0
c. Metal Production	510					641		1 150
Iron and Steel Production								0
Aluminium Production	510					641		1 150
SF_6 Used in Magnesium Smelters and Casters[2]							X	X
d. Consumption of Halocarbons and SF_6							1 290	1 290
e. Other & Undifferentiated Production	338							338
SOLVENT & OTHER PRODUCT USE				0.1	43.4			43
AGRICULTURE		63.2	1 326	3.4	1 067			2 394
a. Enteric Fermentation		55.1	1 157					1 157
b. Manure Management		8.1	169	0.6	199			368
c. Agriculture Soils				2.8	869			869
Direct Sources				1.1	338			338
Pasture, Range and Paddock Manure				0.8	239			239
Indirect Sources				0.9	292			292
WASTE	56.7	174	3 647	0.3	100			3 803
a. Solid Waste Disposal on Land		173	3 626					3 626
b. Wastewater Handling		1.0	21	0.3	88			109
c. Waste Incineration	56.7			0.0	11.4			68
AFFORESTATION & DEFORESTATION	3 106	1.7	35	0.1	22			3 164
a. Afforestation	-14[1]							-14
b. Deforestation	3 120	1.7	35	0.1	22			3 178
MEMO ITEMS (categories presented for information purposes but not included in B.C. total GHG emissions)								MEMO ITEMS
OTHER LAND USE								*33 126*
a. Forest Land Remaining Forest Land								*32 834*
b. Cropland Remaining Cropland								*252*
c. Wetland s Remaining Wetlands								*40*

Note: Totals may not sum due to rounding protocols

Note: "X" indicates confidential data

[1] A negative number indicates that the estimate is a sink (i.e., the activity removes carbon from the atmosphere)

[2] Information on SF_6 use in magnesium casters is confidential – hence, the small amount of SF_6 emissions for this category are reported (with HFC emissions) under "Consumption of Halocarbons and SF_6"

3.3 B.C. GHG Emissions by Sector – 1990 to 2008

Table 4 provides a summary of GHG emissions for B.C. by category for 1990, 1995, 1997, 2000, 2005, 2006, 2007 and 2008. In addition to "afforestation and deforestation" emissions counted in B.C.'s emissions reporting, the table includes other categories in the "land use, land-use change and forestry" sector where emissions and removals are reported as "memo items." (Note that these "memo item" emissions do not contribute to the "total emissions" figure reported in the first row of the table.)

Table 4: B.C. GHG Emissions 1990-2008

Year	1990	1995	1998	2000	2005	2006	2007	2008
GHG Source Category	GHG Emissions (kt CO_2e)							
TOTAL EMISSIONS	55 678	62 671	63 107	66 241	65 682	64 835	68 019	68 719
ENERGY	40 517	47 971	48 434	51 365	51 833	51 280	54 651	55 256
a. Stationary Combustion Sources	18 812	20 989	19 606	22 387	21 639	21 643	24 222	23 523
Electricity and Heat Generation	1 183	2 734	1 866	2 513	1 485	1 539	1 461	1 520
Fossil Fuel Industries	3 502	3 516	3 513	3 767	5 768	5 780	6 222	6 238
Mining and Oil & Gas Extraction	255	164	338	318	299	1 000	1 309	1 348
Manufacturing Industries	6 078	6 387	6 145	7 336	6 189	5 362	7 364	6 537
Construction	306	200	101	76	107	111	117	100
Commercial & Institutional	2 838	3 398	2 908	3 423	3 399	3 362	3 326	3 374
Residential	4 329	4 439	4 484	4 638	4 325	4 424	4 361	4 349
Agriculture & Forestry	321	152	250	315	66	66	64	56
b. Transport	18 385	22 006	23 521	23 705	24 953	24 314	24 917	25 529
Domestic Aviation	1 067	1 228	1 300	1 414	1 489	1 479	1 425	1 504
Road Transportation	11 444	13 183	14 771	14 677	15 334	15 284	15 574	15 371
Light-Duty Gasoline Vehicles	3 850	4 428	4 590	4 453	4 169	4 096	4 131	4 046
Light-Duty Gasoline Trucks	2 200	3 387	4 331	4 473	4 774	4 709	4 752	4 678
Heavy-Duty Gasoline Vehicles	2 042	1 828	1 908	1 672	1 641	1 629	1 648	1 634
Motorcycles	18	13	16	16	27	27	27	27
Light-Duty Diesel Vehicles	26	29	36	38	46	45	46	45
Light-Duty Diesel Trucks	35	63	74	65	56	57	58	58
Heavy-Duty Diesel Vehicles	2 490	2 864	3 335	3 631	4 428	4 530	4 686	4 630
Propane & Natural Gas Vehicles	782	570	481	329	194	191	226	253
Railways	1 441	1 650	1 374	1 268	414	400	402	626
Domestic Marine	1 025	1 232	1 006	1 235	2 544	2 461	2 566	2 510
Other Transportation	3 409	4 713	5 069	5 111	5 173	4 690	4 948	5 519
Off Road	2 553	3 328	3 492	3 457	4 183	3 916	4 014	4 624
Off-Road Gasoline	350	421	437	493	451	447	449	352
Off-Road Diesel	2 203	2 907	3 055	2 964	3 732	3 469	3 567	4 272
Pipelines	856	1 385	1 577	1 655	989	774	933	895
c. Fugitive Sources	3 320	4 976	5 307	5 273	5 241	5 323	5 512	6204
Coal Mining	487	569	553	478	543	468	521	507
Oil and Natural Gas	2 833	4 407	4 754	4 794	4 699	4 854	4 991	5 697

Year	1990	1995	1998	2000	2005	2006	2007	2008
GHG Source Category	GHG Emissions (kt CO_2 e)							
TOTAL EMISSIONS	55 678	62 671	63 107	66 241	65 682	64 835	68 019	68 719
INDUSTRIAL PROCESSES	3 582	3 884	4 434	4 776	4 139	3 957	3 950	4 059
a. Mineral Products	871	1 023	1 122	1 348	1 376	1 397	1 411	1 281
Cement Production	613	758	866	1 054	1 149	1 171	1 206	1 086
Lime Production	162	192	195	218	181	166	162	157
Limestone and Dolomite Use	75	52	43	49	22	39	16	15
Soda Ash Production and Use	22	21	19	27	22	23	27	23
b. Chemical Industry	–	–	–	–	–	–	–	–
Nitric Acid Production	–	–	–	–	–	–	–	–
Adipic Acid Production	–	–	–	–	–	–	–	–
c. Metal Production	1 507	1 687	2 062	1 820	1 131	1 015	1 101	1 150
Iron and Steel Production	–	–	–	–	–	–	–	–
Aluminium Production	1 507	1 687	2 062	1 820	1 131	1 015	1 191	1 150
SF_6 Used in Magnesium Smelters and Casters[2]	–	–	–	–	–	–	–	–
d. Consumption of Halocarbons and SF_6	427	493	658	819	1 075	1 138	1 136	1 290
e. Other & Undifferentiated Production	777	681	592	789	557	407	302	338
SOLVENT & OTHER PRODUCT USE	21	27	27	32	23	42	42	43
AGRICULTURE	2 171	2 392	2 308	2 432	2 639	2 397	2 409	2 394
a. Enteric Fermentation	996	1 160	1 134	1 187	1 298	1 199	1 149	1 157
b. Manure Management	315	356	359	377	396	377	368	368
c. Agriculture Soils	860	876	815	867	945	821	892	869
Direct Sources	375	342	302	316	346	286	343	338
Pasture Range and Paddock Manure	198	240	238	260	285	261	251	239
Indirect Sources	288	293	275	291	315	273	298	292
WASTE	3 420	3 761	3 903	3 863	3 714	3 790	3 806	3 803
a. Solid Waste Disposal on Land	3 269	3 590	3 728	3 688	3 540	3 615	3 629	3 626
b. Wastewater Handling	85	98	103	105	106	107	109	109
c. Waste Incineration	66	73	72	70	69	68	68	68
AFFORESTATION & DEFORESTATION	5 967	4 637	4 000	3 770	3 335	3 374	3 162	3 164
a. Afforestation[1]	-14	-14	-14	-14	-16	-15	-16	-14
b. Deforestation	5 980	4 651	4 014	3 784	3 351	3 390	3 178	3 178
OTHER LAND USE ("Memo Items")	*-26 549*	*-32 582*	*-32 748*	*-30 737*	*37 397*	*65 273*	*52 656*	*33 126*
a. Forest Land Remaining Forest Land	*-26 764*	*-32 873*	*-33 076*	*-31 083*	*37 034*	*64 907*	*52 298*	*32 834*
b. Cropland Remaining Cropland	*98*	*171*	*231*	*263*	*303*	*309*	*305*	*252*
c. Wetlands Remaining Wetlands	*117*	*120*	*96*	*83*	*60*	*57*	*53*	*40*

Note: "-" indicates no emissions

[1] A negative number indicates that the estimate is a sink (i.e., the activity removes carbon from the atmosphere)

[2] Information on SF_6 use in casters is confidential – hence, SF_6 emissions for this category are reported (with HFC emissions) under "Consumption of Halocarbons and SF_6"

3.4 Trends in Emissions

Total annual GHG emissions in British Columbia increased by 1.0% from 2007 to 2008 (from 68.0 Mt to 68.7 Mt CO_2e), increased by 4.6% between 2005 and 2008 (from 65.7 Mt in 2005) and increased by 8.9% (from 63.1 Mt) over the ten year period from 1998 to 2008. The trend in total annual B.C. GHG emissions since 1990 is shown in Figure 2.

Interpretation of short-term (i.e., year-to-year) changes in emissions should be undertaken with caution due to the influence and variability of annual weather conditions (e.g., precipitation on electricity generation, heating/cooling degree days on building energy use), methodological changes and data anomalies on reported emission levels. Longer term comparisons (i.e., three and ten year periods) provide more useful trend information.

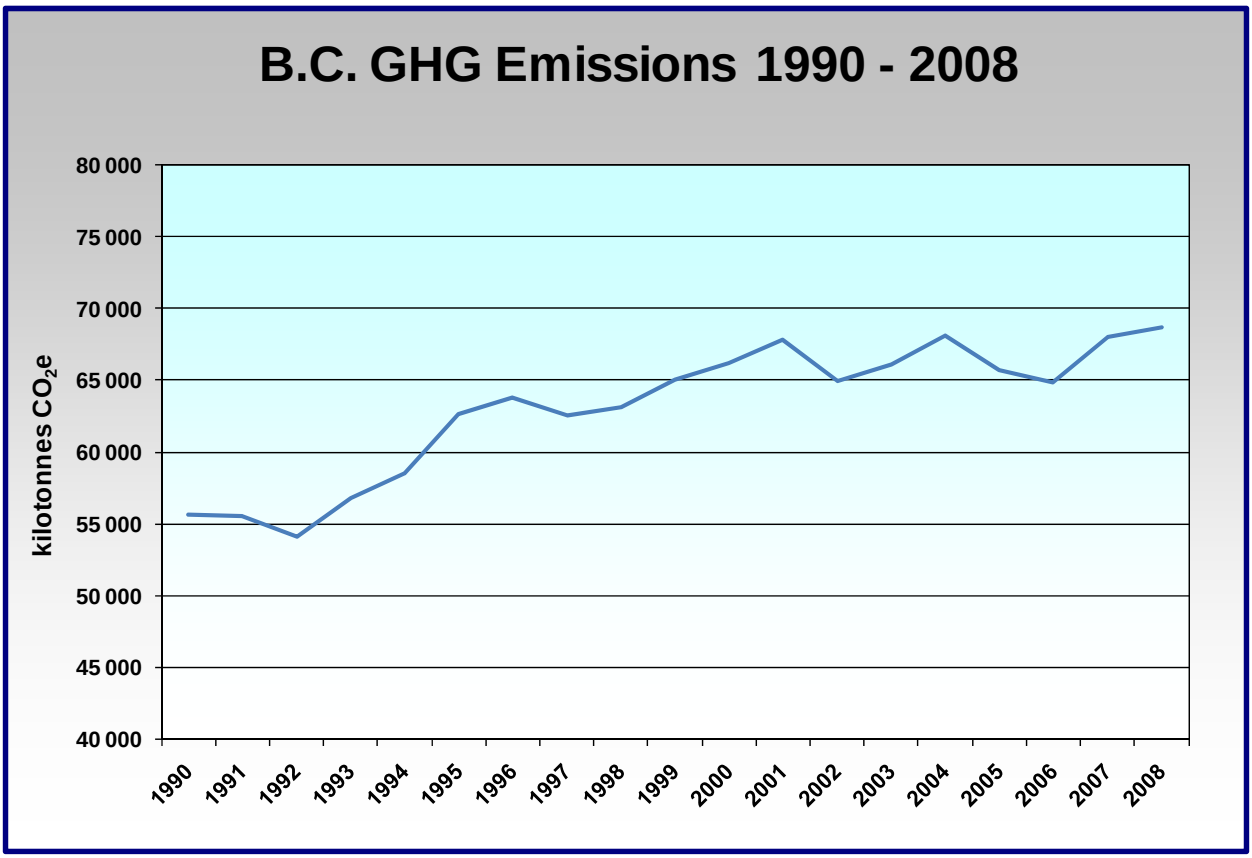


Figure 2: B.C. GHG Emissions – 1990-2008 Trends

Table 5 lists three and ten-year trends in GHG emissions by sector, as well as some of the key factors influencing changes in emissions. More detailed descriptions of each sector (with emissions by category within each sector) and discussion of GHG emission trends are provided in Sections 4 through 9 of this document.

Table 5: Factors Influencing Emissions – Three and Ten-Year Trends

Sector	2008 GHG Emissions (kt CO_2e)	3-Year Change (2005-2008)	10-Year Change (1998-2008)	Key Factors Influencing Changes in Emissions
ENERGY	55 256	+6.6%	+14.1%	Oil and gas extraction and processing activities[1], use of natural gas for electricity generation,[1] use of heavy-duty diesel vehicles,[2] fuels used for marine shipping – volumes of imports and exports with international trading partners[3]
INDUSTRIAL PROCESSES	4 059	-1.9%	-8.5%	Closure of ammonia and methanol plants, use of improved control technology for PFC emissions in aluminium production[4]
SOLVENT & OTHER PRODUCT USE	43	+87.0%	+59.3%	Use of nitrous oxide as anaesthetic and propellant[5]
AGRICULTURE	2 394	-9.3%	+3.7%	Cattle and hog populations, fertilizer use, soil management practices[6]
WASTE	3 803	+2.4%	-2.6%	Annual waste generated and quantities sent to landfills,[7] rates of diversion (i.e., recycling and composting),[7] capturing and flaring of CH_4 emissions from landfills
AFFORESTATION & DEFORESTATION	3 164	-5.1%	-20.9%	Area of deforested land (i.e., conversion of forest land to settlement or cropland) and afforested land (e.g., conversion of cropland to forest land)[8]

[1] Statistics Canada Report on Energy Supply and Demand in Canada

[2] Statistics Canada CANSIM Table 405-0008: Canadian vehicle survey, vehicle-km, by type of vehicle, province and territory, quarterly

[3] B.C. Statistics: B.C. International and Interprovincial Trade Flows

[4] Rio Tinto Alcan Primary Metal B.C. Operations Annual Performance Reports

[5] Statistics Canada International Merchandise Trade Database and Nitrous Oxide Canada

[6] Statistics Canada Census of Agriculture

[7] Statistics Canada Waste Management Industry Survey: Business and Government Sectors

[8] Refer to Annex 10.4 for detailed data

3.5 Emissions per Capita, per Unit of Economic Activity and Energy Use

In 2008, British Columbia emissions were an average of: 15.7 tonnes CO_2e/person;[17] 418 tonnes CO_2e/ $ million of Gross Domestic Product (GDP);[18] and 74.0 tonnes CO_2e/terajoule (TJ) of energy use.[19]

GHG emissions per capita have been relatively consistent over the last decade (1998-2008) – ranging between 15.3 and 16.6 tonnes CO_2e/person/year. As measured in terms of "economic GHG intensity" (the amount of GHG emitted per unit of economic activity), GHG emissions per unit of Gross Domestic Product (GDP) have decreased by about one-fifth between 1998 and 2008. GHG

[17] B.C. population data from Statistics Canada CANSIM Table 051-0001: Population by sex and age group, by province and territory.

[18] GDP data from Statistics Canada Catalogue no. 13-213-PIB: Provincial economic accounts, annual estimates: tables and analytical document. Prices are in 2002 chained dollars and account for inflation.

[19] Final-use Energy Data from Statistics Canada Report on Energy Supply and Demand in Canada.

emissions per unit energy use have also remained relatively consistent over the last decade, and are influenced primarily by proportions of hydro and fossil fuel-generated electricity. Three and ten-year trend figures for each of these indicators are provided in Table 6.

Table 6: GHG Emission Trends – per Person and per Unit GDP

Period	GHG per Capita (tonnes CO_2 e/person)	GHG per GDP (tonnes CO_2e/$ million GDP)	GHG per Energy Use (tonnes CO_2e/TJ energy use)
2008	15.6	417.7	74.0
3-Year Trend (2005 to 2008)	15.7 (2005) +0.2%	427.9 (2005) -2.4%	72.6 (2005) +1.9%
10-Year Trend (1998 to 2008)	15.8 (1998) -1.0%	514.0 (1998) -18.7%	72.8 (1998) +1.7%

Figure 3 shows the trends in these indicators from 1990 to 2008. Data points are indexed to a starting point of 100 at 1990, with cumulative increases or decreases for each year plotted as a percentage of the 1990 figure for each indicator. Between 1990 and 2008, GHG emissions and energy demand have increased. GHG emissions per capita and emissions per unit of energy demand have decreased slightly. The emissions per unit of GDP ("economic GHG intensity") indicator has decreased over the period.

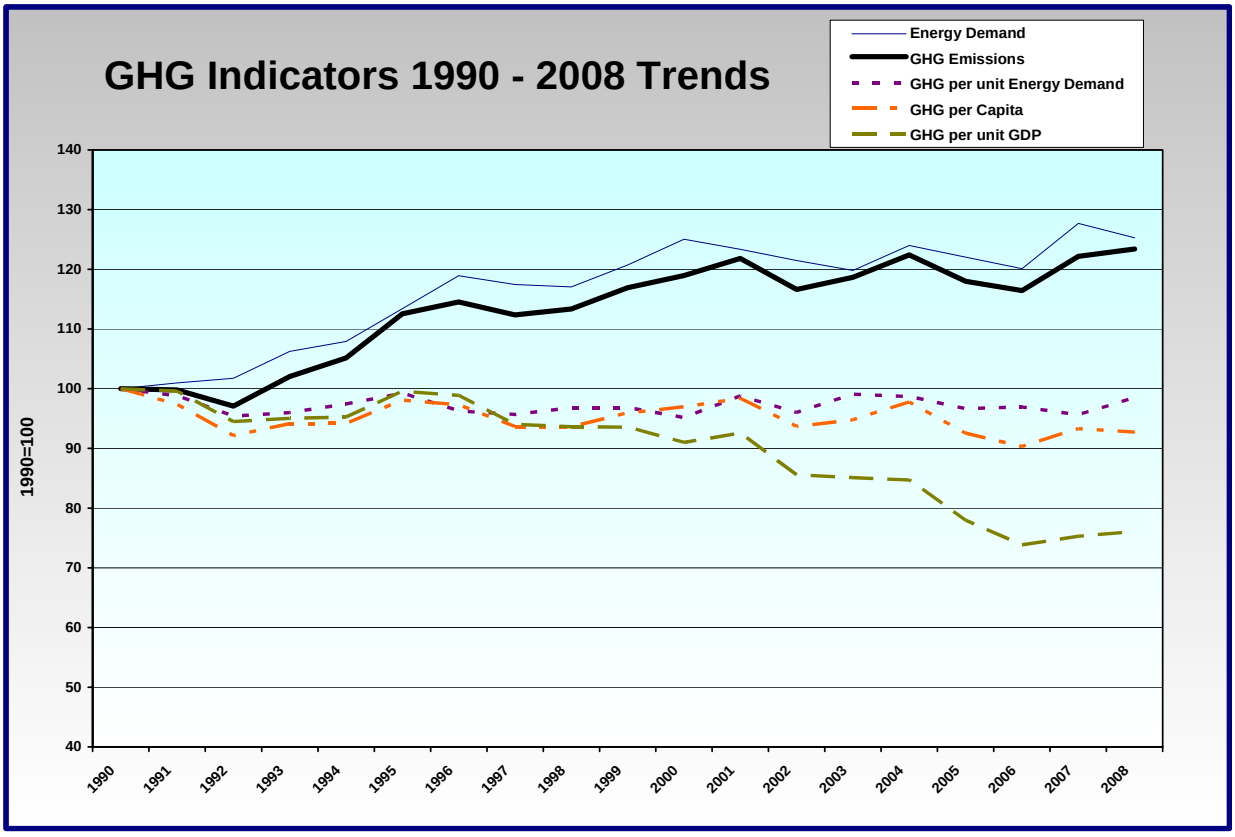
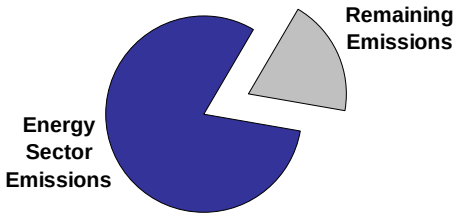


Figure 3: GHG Indicators – 1990-2008 Trends

4. ENERGY SECTOR EMISSIONS

4.1 Summary



The energy sector is subdivided into three sub-sectors – stationary combustion, transport and fugitive emissions – described in Table 7. Total emissions accounted in the energy sector category in 2008 were 55.3 megatonnes (Mt) CO_2e – 80.4% of total B.C. emissions.

Figure 4 shows energy sector emissions as accounted by each of the sub-sectors.

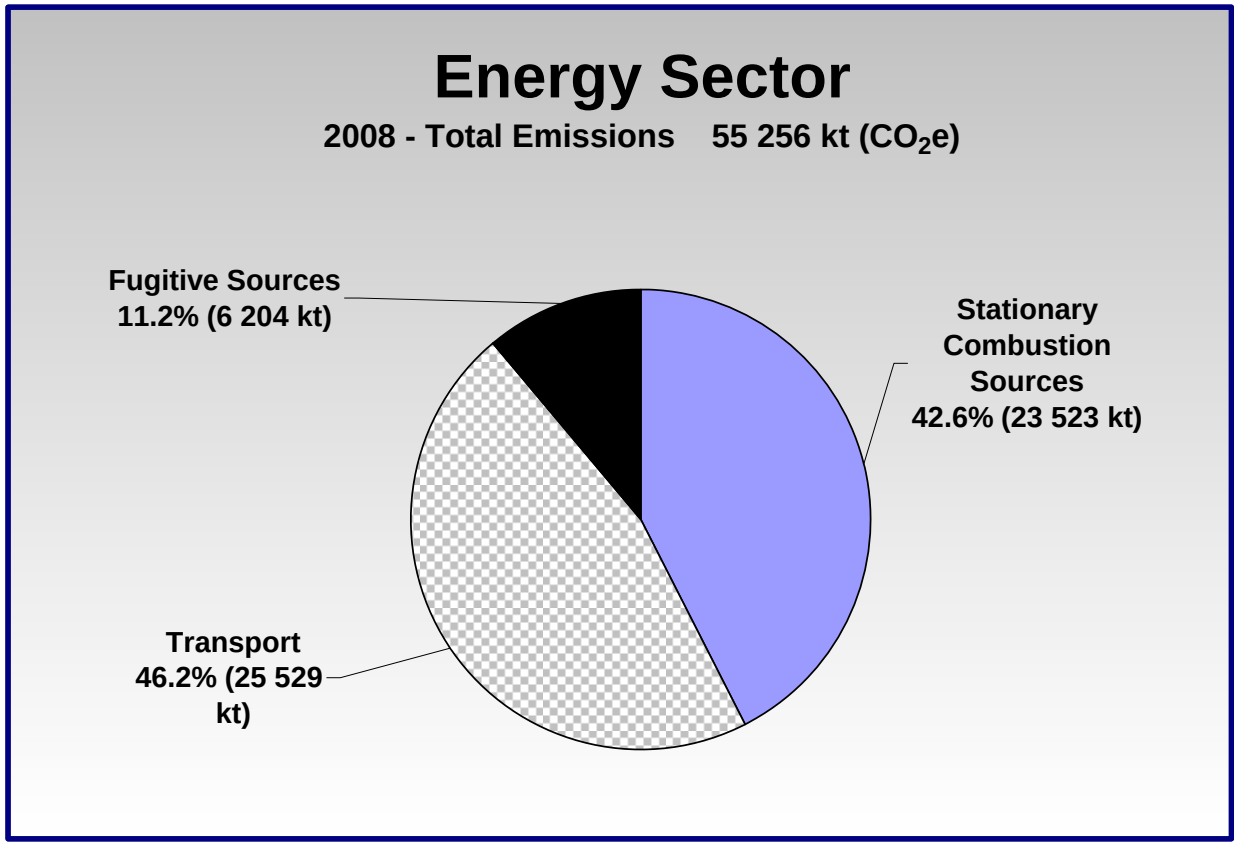


Figure 4: Energy Sector GHG Emissions – 2008

Table 7: Energy Sub-sector Descriptions

Sub-sector	Description
a. Stationary Combustion Sources	Emissions from stationary devices that combust solid, liquid or gaseous fuel in order to generate useful heat or electricity. Sources include boilers, combustion turbines, engines, incinerators and process heaters. Devices used to transport oil and gas through pipelines are not included in this sub-sector.
b. Transport	Emissions from mobile devices that combust liquid or gaseous fuels for the purpose of generating useful energy for propulsion. Sources include road vehicle, marine and jet engines. Emissions from stationary combustion devices used to transport oil and gas through pipelines are also included in this sub-sector.
c. Fugitive Emissions	Unintentional emissions from the production, processing, transmission, storage and delivery of fossil fuels; as well as the intentional combustion of fossil fuels not used to generate useful heat or electricity.

4.2 Trends in Energy Sector Emissions

Annual energy sector emissions increased by 1.1% from 2007 to 2008, increased by 6.6% between 2005 and 2008 and increased by 14.1% over the ten year period from 1998 to 2008. The trend in GHG emissions between 1990 and 2008 is shown for each of the energy sub-sectors in Figure 5.

The short-term (2007-2008) increase can be attributed to increased emissions from several categories of the transport sub-sector (including off-road diesel transportation, domestic aviation and railways) and from fugitive sources related to oil and gas. Emissions between 2005 and 2008 increased across all sub-sectors and many categories – with the largest percentage increases in the "mining and oil and gas extraction" category, railways (increased over 50% over the period), propane and natural gas vehicles (30%), oil and natural gas fugitive sources (over 20%) and off-road diesel transportation (15%). Within the energy sector over the three-year period between 2005 and 2008, transport emissions increased at the lowest rate (+2.3%) while emissions from fugitive sources increased by close to 20% and emissions from stationary combustion sources increased by about 9%.

Further data and analyses of emissions and trends for each of the energy sub-sectors are provided in Sections 4.3 through 4.5.

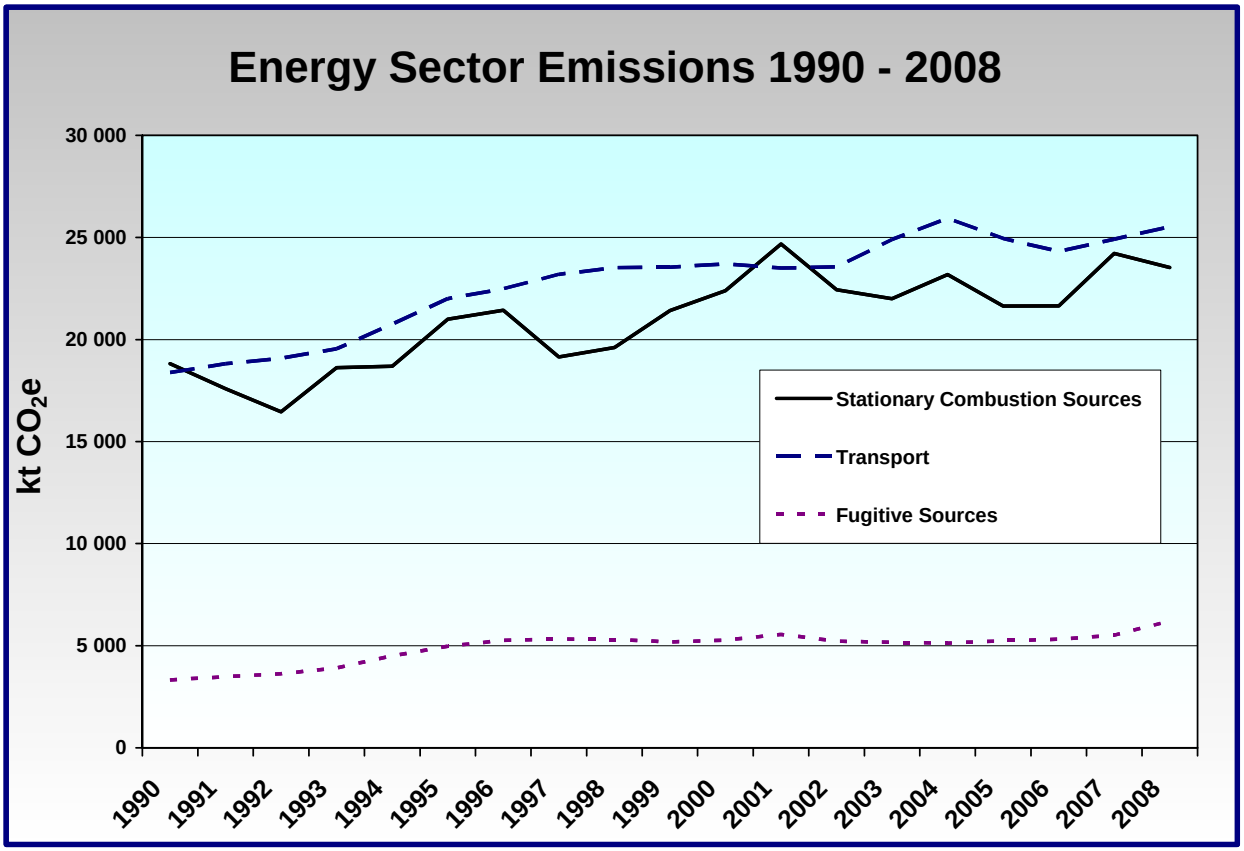


Figure 5: Energy Sector Emissions – 1990-2008 Trends

4.3 Energy Sub-sector a: Stationary Combustion Sources

Total emissions from stationary combustion sources were 23.5 megatonnes (Mt) CO_2e in 2008 – 42.6% of energy sector emissions (34.2% of total B.C. emissions). Emissions by category in the stationary combustion sources sub-sector are shown in Figure 6.

Category descriptions are provided in Table 8. The percentage change in emissions over three and ten years, and the key factors influencing changes in emissions, for each of the categories are summarized in Table 9.

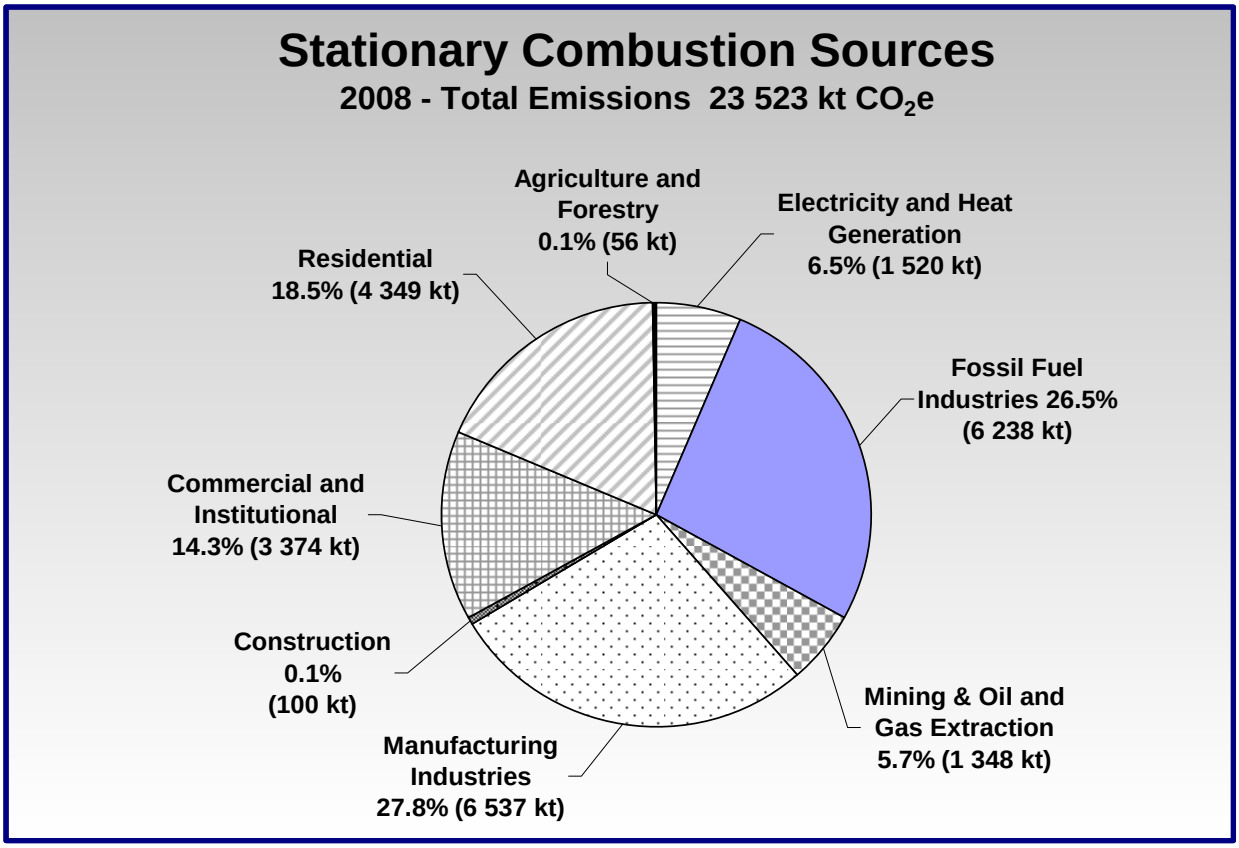


Figure 6: Stationary Combustion Sub-sector GHG Emissions by Category – 2008

Table 8: Stationary Combustion Category Descriptions

Emission Category	Description
Electricity and Heat Generation	Production of electricity and useful heat in thermal power plants in both the public and private sector
Fossil Fuel Industries	Petroleum refineries, and natural gas and conventional oil production facilities
Mining and Oil and Gas Extraction	Metal and non-metal mines, stone quarries and gravel pits, oil and gas extraction facilities, mineral exploration and contract drilling operations
Manufacturing Industries	Production of non-ferrous metals (e.g., aluminium, lead, zinc, copper), pulp and paper, cement, lime and other non-metallic mineral products
Construction	Building and road construction, and other construction activities
Commercial and Institutional	Service industries related to mining, communication, wholesale and retail trade, finance and insurance, real estate, education, etc.; government establishments; National Defence and Canadian Coast Guard; train stations, airports; buildings and warehouses
Residential	Personal residences including homes, apartment hotels, condominiums and farm-houses
Agriculture and Forestry	Forestry, logging service, agricultural, hunting and trapping “industry” activities (excluding food processing and farm machinery manufacturing and repair)

Table 9: Stationary Combustion Trends

Emission Category	3-Year Trend	10-Year Trend	Key Factors Influencing Changes in Emissions
STATIONARY COMBUSTION SUB-SECTOR	+8.7%	+20.0%	
Electricity and Heat Generation	+2.4%	-18.5%	Demand for electricity,[1] precipitation,[2] variation in relative amounts of hydro-generated and fossil fuel-generated electricity[1]
Fossil Fuel Industries	+8.1%	+77.6%	Production volumes of refined petroleum products and natural gas[1]
Mining and Oil & Gas Extraction	+350.8%	+298.8%	Extraction of coal, metals and natural gas[1]
Manufacturing Industries	+5.6%	+6.4%	Production from manufacturing industries,[3] fuel sources (e.g., use of biomass rather than fossil fuel sources[1])
Construction	-6.5%	-1.0%	Number of annual housing starts and commercial/ institutional starts requiring fossil fuel and electricity use in construction[5,6]
Commercial and Institutional	-0.7%	+16.0%	Area of floor space requiring heating and electric loads,[5] mitigated by energy efficiency actions[5], temperature[2]
Residential	+0.6%	-3.1%	Area of floor space requiring heating and electric loads,[6] mitigated by energy efficiency actions[6], temperature[2]
Agriculture and Forestry	-15.2%	-77.6%	Production in forestry sector,[3] fuel sources (e.g., switching to biomass)[1]

[1] Statistics Canada Report on Energy Supply and Demand in Canada
[2] Weather data – Environment Canada B.C. Climate Network and BC River Forecast Centre (snowpack)
[3] Statistics Canada CANSIM Table 304-0015: Manufacturing sales, by North American Industry Classification System (NAICS) and province, monthly (dollars)
[4] B.C. Stats – British Columbia Housing Starts for Urban Areas and Communities; Commercial, Industrial and Institutional & Government Building Permits
[5] NRCan Office of Energy Efficiency: Commercial/Institutional Sector British Columbia Table 2: Secondary Energy Use and GHG Emissions by End-Use
[6] NRCan Office of Energy Efficiency: Residential Sector British Columbia Table 2: Secondary Energy Use and GHG Emissions by End-Use

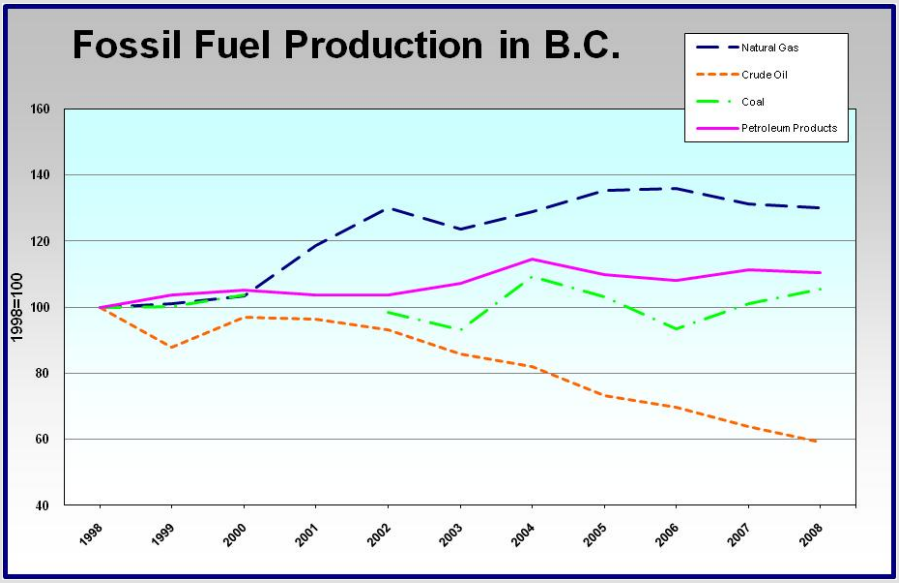
Understanding trends in energy sector emissions – fossil fuel production in B.C.

GHG emissions are associated with the production (as well as the consumption) of fossil fuels. Emissions associated with fossil fuel production depend on:

- Volume of fuel produced (e.g., tonnes of coal)
- Type of production (e.g., underground/surface mining, conventional natural gas/shale gas)
- Production equipment (e.g., mining haulers)
- Associated secondary emissions (e.g., fugitive emissions from exposed coal mine faces)
- Emissions control measures

Figure 7 shows that since 1998, production of crude oil in B.C. decreased considerably while natural gas and petroleum product production increased (with natural gas production increasing by about 30% over the period).[1] Emissions from fossil fuel industries increased by 78% over this period (see Table 9). The increase in emissions outpaces changes in the levels of production, indicating that the increase is due to other factors - these could include extraction of fuels with higher carbon dioxide content or changes in the methods for calculating GHG emissions.

About 35% of the natural gas produced in B.C. is consumed within the province with the remainder exported.[1] Emissions related to consumption of any fossil fuel are allocated to the jurisdiction of consumption (not of production).



Control measures available to reduce emissions related to fossil fuel production include:

- Carbon capture and sequestration
- Capture and beneficial use of methane from coal mines and faces
- Reducing flaring and fugitive emissions from oil and gas production equipment

Figure 7: Fossil fuel production in B.C.

B.C.'s coal production volume between 1998 and 2008 has varied cyclically within a range of about plus or minus 10%. This fluctuation can be attributed largely to export market conditions as B.C. consumption represents only 2.5% of total coal produced.[1] Emissions associated with coal production are related to energy consumption for extraction and transportation and fugitive emissions. Fugitive emissions from exposed coal seams have remained relatively consistent in the years between 1998 and 2008, with a low of 430 kt in 2003 and a high of 520 kt CO_2e in 2001 and 2007. Transportation emissions associated with the mining of coal are a portion of the 4.3 Mt reported in the off-road diesel subcategory.

[1] Statistics Canada Report on Energy Supply and Demand in Canada (RESD) – Table 2-12 Primary and secondary energy, terajoules – British Columbia

Understanding trends in energy sector emissions – heating residential buildings

GHG emissions in the energy sector generally depend on three factors:

- *Activity level* (e.g., quantity of cement produced, number of vehicle-kilometres travelled)
- *Energy efficiency* (e.g., natural gas combusted per unit mass cement produced, electricity use per unit floor space, gasoline combusted per kilometre travelled)
- *GHG intensity of fuels used* (e.g., mass of CO_2e per unit volume of natural gas or gasoline, per kWh of electricity)

Examining the energy use associated with heating residential buildings illustrates the interplay of these three factors. Figure 8 shows that between 1990 and 2007, residential floor space in B.C. increased by 70% while annual energy demand to heat residential buildings has increased by only 12% over the same time period. The increased energy efficiency of residential buildings is attributed to more efficient heating systems and additional thermal insulation in building envelopes.

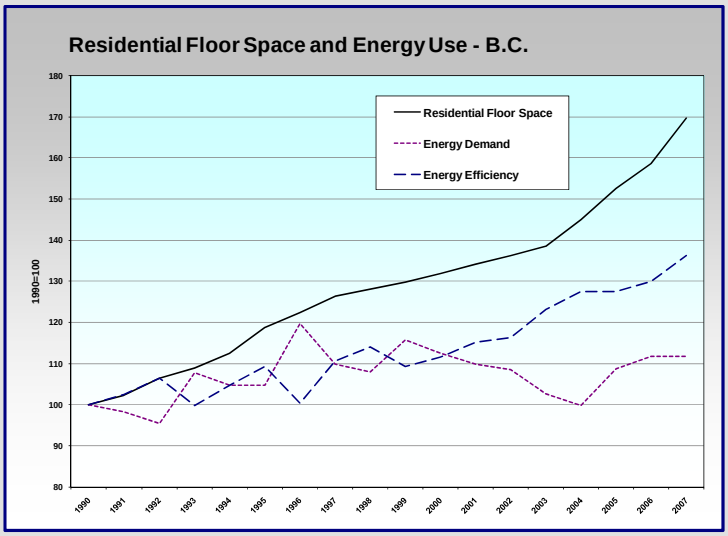


Figure 8: Residential Floor Space and Energy Use – B.C. Trends

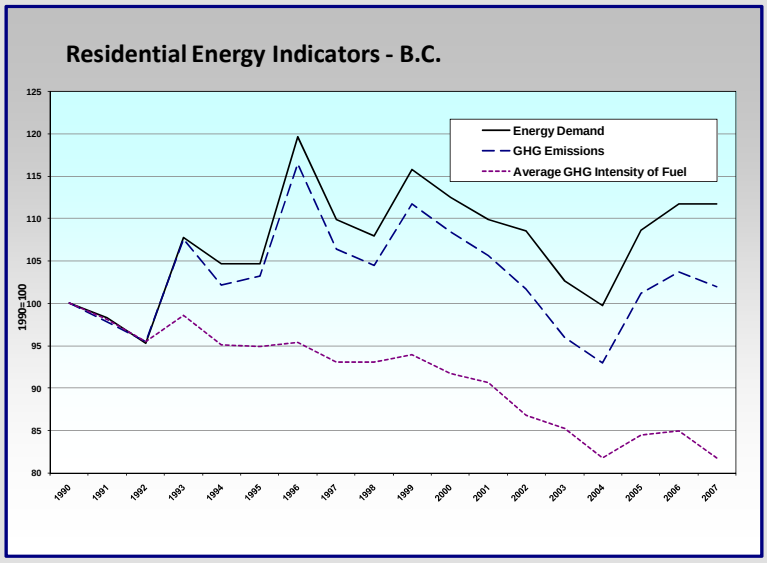


Figure 9 illustrates the linkages between energy demand, fuel types and GHG emissions. Between 1990 and 2007, for example, the GHG intensity of fuels used to heat residential buildings has notably decreased (attributed to fuel switching from GHG-intensive fuels such as heating oil, coal and propane towards less intensive fuels such as natural gas and wood), resulting in a steadily widening difference between energy demand and GHG emissions. Between 1990 and 2007 fuel switching has decreased the average GHG intensity of residential fuels per unit energy by about 18%.

Figure 9: Residential Energy Indicators – B.C. Trends

Notes: Electricity use is not considered in this analysis as related GHGs are reported under the "electricity and heat generation" rather than the "residential building" category in the NIR. Consequently, such activities as air-conditioning are not included.

Fluctuations in annual energy demand are reflective of average annual outdoor temperatures (e.g., a lower average annual temperature generally results in a higher annual energy use).

Data source for Figure 8 and Figure 9: NRCan Office of Energy Efficiency: Residential Sector British Columbia Table 2: Secondary Energy Use and GHG Emissions by End-Use.

4.4 Energy Sub-sector b: Transport

Total emissions for the transport sub-sector were 25.5 megatonnes (Mt) CO_2e in 2008, accounting for 46.2% of energy sector emissions (37.2% of total B.C. emissions). Emissions by category in the transport sub-sector are shown in Figure 10, with descriptions of the categories provided in Table 10.

The percentage change in emissions over three and ten years, and the key factors influencing changes in emissions, for each of the categories are provided in Table 11.

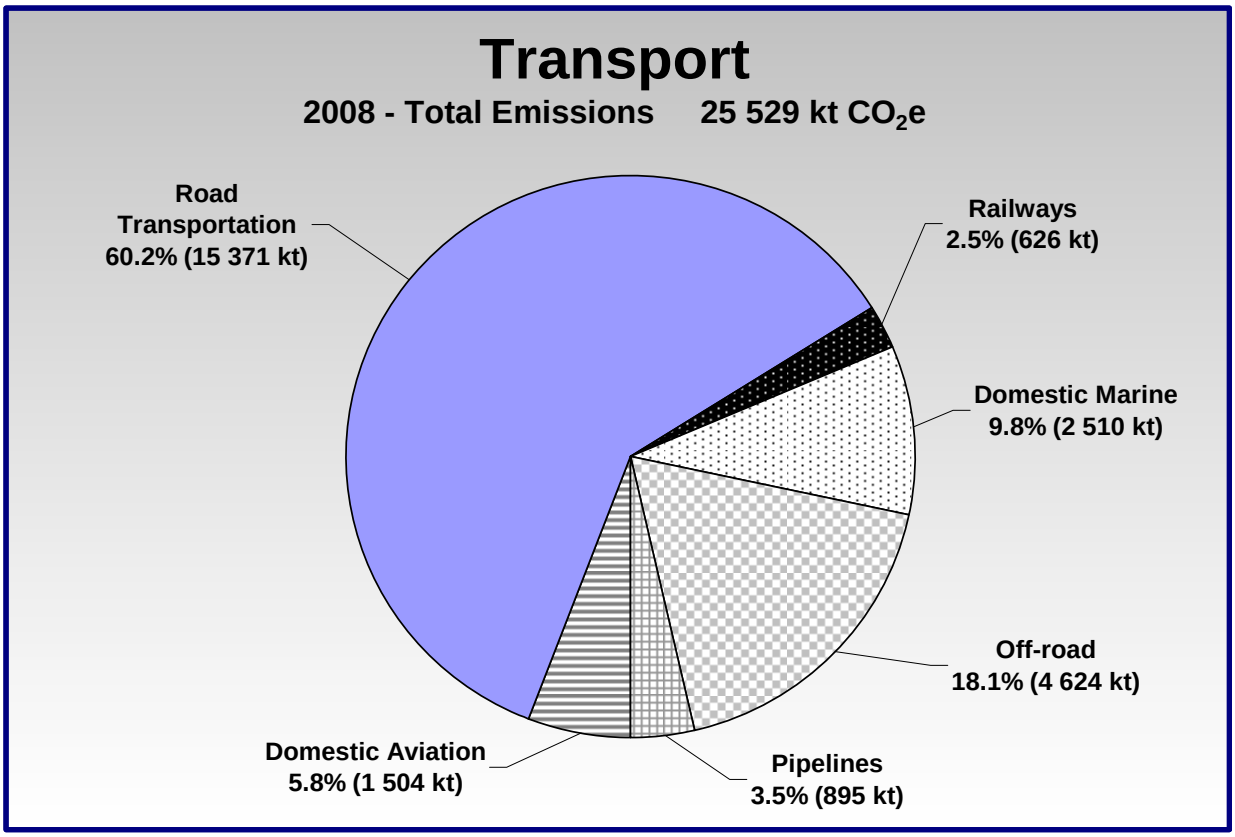


Figure 10: Transport Sub-sector GHG Emissions by Category – 2008

Table 10: Transportation Category Descriptions

Emission Category	Description
Domestic Aviation	Canadian registered airlines flying domestically within Canada and originating in B.C., including commercial, private, military, and agricultural flights
Road Transportation (On-road Vehicles)	Vehicles in B.C. licensed to operate on roads
Railways	Locomotives operating in B.C.
Domestic Marine	Canadian registered marine vessels fuelled domestically in B.C.
Off-road vehicles (Gasoline and Diesel)	Vehicles in B.C. not licensed to operate on roads, including farm tractors, logging skidders, tracked-construction vehicles and mining vehicles
Pipelines	Transportation and distribution of crude oil, natural gas and other products through a pipeline

Table 11: Transportation Trends

Emission Category	3-Year Trend	10-Year Trend	Key Factors Influencing Changes in Emissions
TRANSPORT SUB-SECTOR	+2.3%	+8.5%	
Domestic Aviation	+1.0%	+15.7%	Weight of freight transported, passenger loads and distance traveled[1]
Road Transportation (On-road Vehicles)	+0.2%	+4.1%	Number of vehicles on road and distance travelled,[2] average fuel efficiency of vehicles[3]
Railways	+51.2%	-54.4%	Passenger ridership, freight shipped by locomotive of major B.C. products (coal, wood chips and wood pulp), trans-continental freight shipped by locomotive through B.C.[4]
Domestic Marine	-1.3%	+150.0%	Volume of import and export between international trading partners[5] (e.g., wood product and coal exports)
Off-road vehicles (Gasoline and Diesel)	+10.5%	+32.42%	Forest, mining and agriculture off-road vehicle activity
Pipelines	-9.5%	-43.3%	Throughput,[6] equipment efficiency, computer automation, matching of throughput to pipeline capacity

[1] Statistics Canada CANSIM Table 401-0001: Operating and financial statistics of major Canadian airlines, monthly

[2] Statistics Canada CANSIM Table 405-0008: Canadian vehicle survey, vehicle-km, by type of vehicle, province and territory, quarterly

[3] NRCan Office of Energy Efficiency: Transportation Sector British Columbia and Territories Table 9: Road Transportation Secondary Energy Use and GHG Emissions by Energy Source

[4] Statistics Canada Catalogue 52-216-X: Rail in Canada

[5] B.C. STATS: B.C. International and Interprovincial Trade Flows

[6] Statistics Canada CANSIM Table 133-0003: Summary of Pipeline Movements, monthly

Road Transportation Emissions

As the road transportation category accounted for a significant proportion (22.4%) of 2008 total B.C. emissions and almost two-thirds of total transportation sub-sector emissions, additional "sub-category" level information for road transportation is provided in Figure 11.

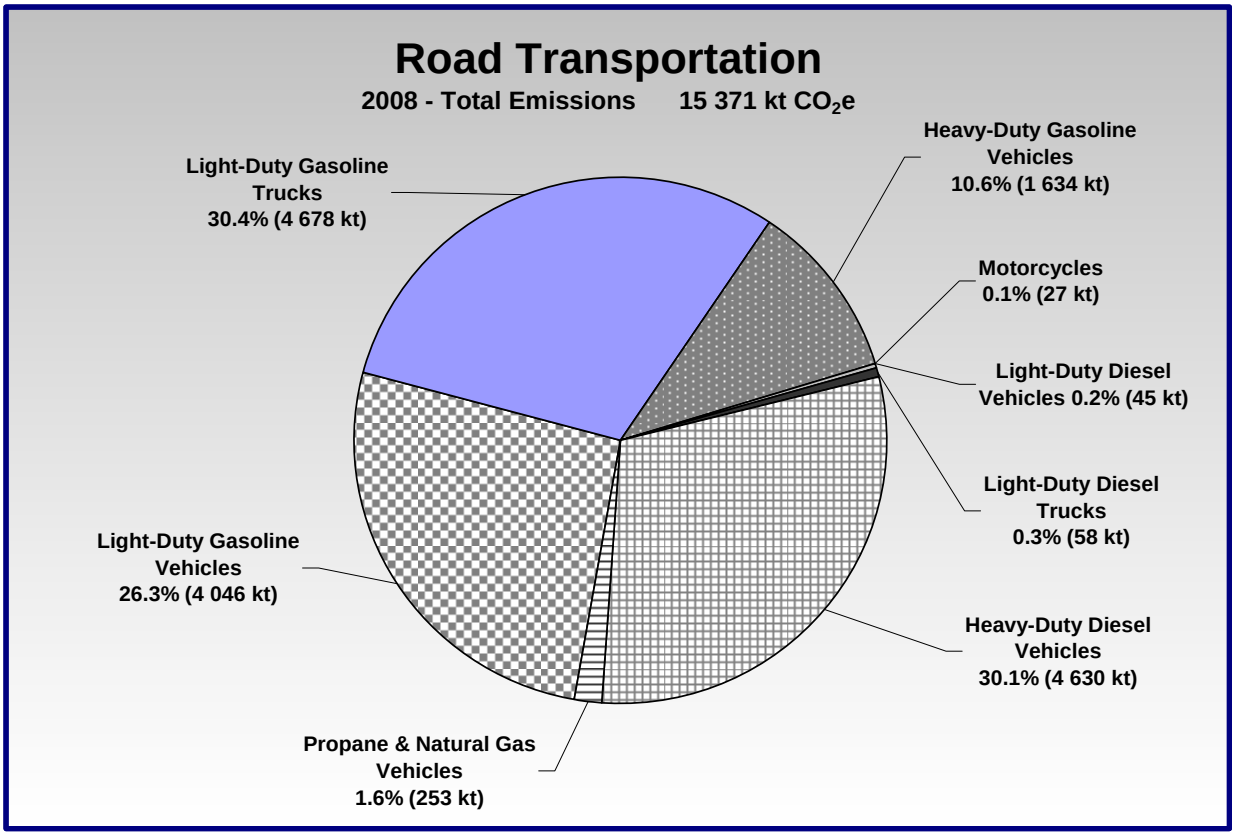


Figure 11: Road Transportation Category and Sub-category GHG Emissions – 2008

Understanding trends in road transportation emissions

Trends in road transportation emissions are influenced by kilometres travelled (i.e., activity level), engine efficiency and fuel types.

Figure 12 shows trends since 1990 in passenger-kilometres[1] traveled and engine efficiencies for passenger and freight road transportation. While energy intensity for both passenger and freight transportation has decreased between 1990 and 2008, passenger kilometres and GHG emissions have both increased over this period. Note that there has been little decrease in passenger energy intensity since 1995 due to increases in average vehicle size.[2]

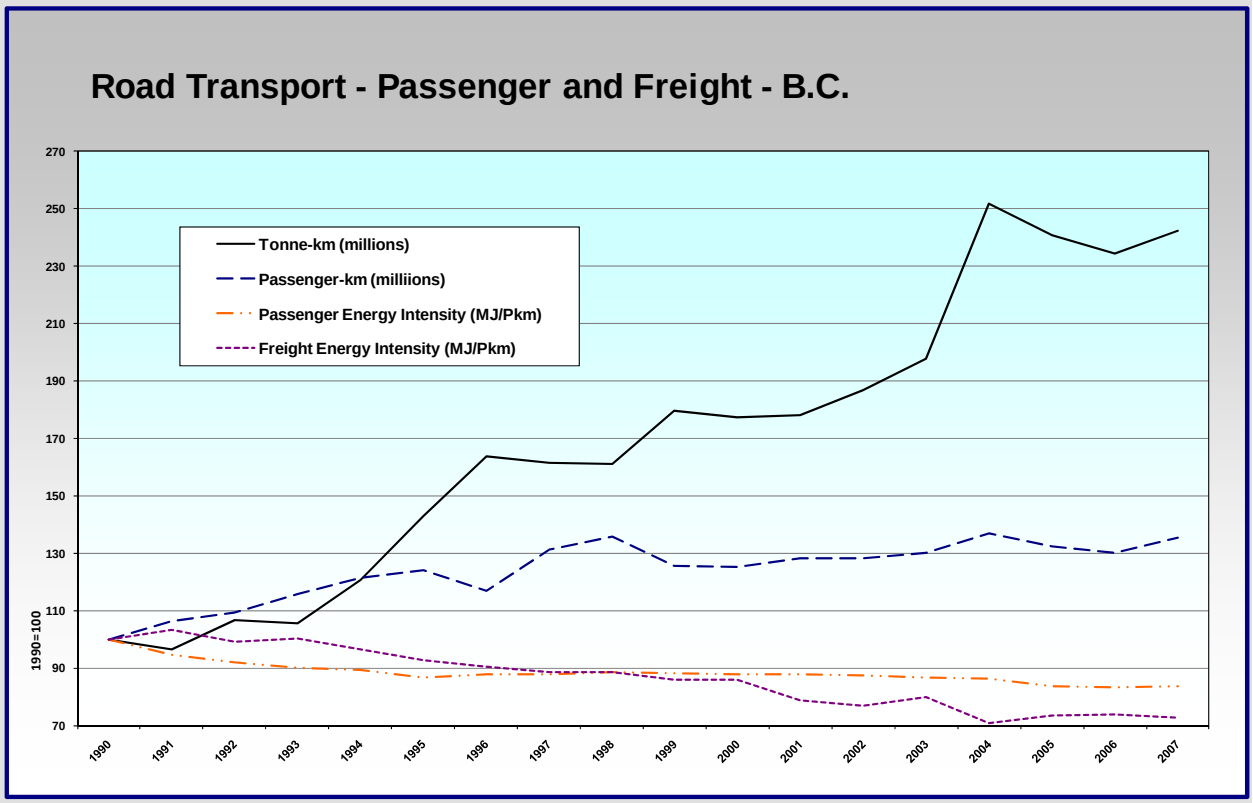


Figure 12: Road Transportation – Passenger and Freight – B.C. Trends

[1] Number of passengers in a vehicle multiplied by the number of kilometres travelled.

[2] Refer to Statistics Canada CANSIM Table 079-0003: New Motor Vehicle Sales, Canada, provinces and territories, monthly.

4.5 Energy Sub-sector c: Fugitive Sources

Emissions from the fugitive sources sub-sector in 2008 were 6.2 megatonnes (Mt) CO_2e, accounting for 9.0% of energy sector emissions (8.2% of total B.C. emissions). Annual emissions increased by 12.6% from 2007 to 2008, 18.4% from 2005 to 2008 and 16.9% between 1998 and 2008.

A description of each category under this sub-sector, and the key factors influencing changes in emissions in each category, are provided in Table 12.

The percentage change in emissions over three and ten years, and the key factors influencing changes in emissions, for each of the categories are provided in Table 13.

Table 12: Fugitive Sources Sub-sector Descriptions and Trends

Emission Category	Description	Key Factors Influencing Changes in Emissions
Conventional Crude Oil Extraction and Processing	Releases from wells, flow lines and batteries; venting of casing and solution gas; and evaporative losses from storage facilities	Annual crude oil production[1]
Natural Gas Extraction and Processing	Releases from wells, gathering systems, field facilities and gas batteries; seal leaks; and line cleaning operations	Annual natural gas production[1]
Petroleum Refining	Equipment leaks, wastewater treatment, cooling towers, storage tanks and loading operations; and flaring of excess gas	Annual production of refined petroleum products[1]
Coal Mining	Releases from exposed coal surfaces, coal rubble and venting within coal deposits; and post-mining activities including preparation, transportation, storage and final processing	Annual production of coal[1]
Natural Gas Transmission	Equipment leaks, compressor start-up venting and purging of lines during maintenance	Annual natural gas throughput in pipelines[2] and energy efficiency of equipment.
Oil Transmission in Pipelines	Loading and unloading of tankers, storage losses, equipment leaks and process venting	Annual crude oil throughput through pipelines[3] and energy efficiency of equipment.

[1] Statistics Canada Report on Energy Supply and Demand in Canada

[2] Statistics Canada CANSIM Table 131-0001: Supply and Disposition of Natural Gas

[3] Statistics Canada CANSIM Table 133-0003: Summary of Pipeline Movements, monthly

Table 13: Fugitive Emission Trends

Emission Category	3-Year Trend	10-Year Trend	Key Factors Influencing Changes in Emissions
FUGITIVE SOURCES SUB-SECTOR	+18.4%	+16.9%	
Coal Mining	-6.6%	-8.3%	Coal mine production[1]
Oil and Natural Gas	+21.2%	+19.8%	Natural gas production[2]

[1] CANSIM Table 152-0005 – Principal statistics of mineral industries, by North American Industry Classification System (NAICS) Category 2121 – Coal Mining

[2] Statistics Canada Energy Statistics Handbook

4.6 Data Sources

The principal data source for estimating stationary combustion and transport emissions is the *Report on Energy Supply and Demand in Canada* (RESD), prepared annually by Statistics Canada (2008 Report #57-003). The report is a compilation of data from fuel producers and consumers drawn from annual and monthly censuses and surveys from industries, federal agencies and provincial energy departments. The data provides estimates of the supply of and demand for energy in Canada separ-

ated into categories such as import/export, producer consumption and final demand. Data are also disaggregated into broad industrial sectors and transport types (e.g., manufacturing, mining, airlines, road transportation).

Emissions in the transport sub-sector are allocated using Canada's Mobile Greenhouse Gas Emission Model (MGEM), which disaggregates reported fuel consumption from the RESD into 23 vehicle categories based on model year, fuel, and vehicle type.[20]

Fugitive emissions are more difficult to estimate than combustion emissions. Numerous reports from government organizations and industry groups are used in the development of emission quantification for fugitive emissions. Data sources specific to fugitive emissions are listed in Table 14.

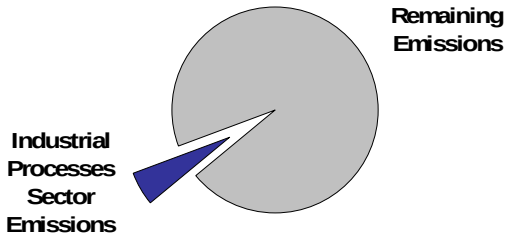
Table 14: Fugitive Emission Categories, Associated Activities and Data Sources

Emission Category	Associated Activities	Data Sources
Conventional Crude Oil Extraction and Processing	▪ Releases from wells, flow lines and batteries ▪ Venting of casing and solution gas ▪ Evaporative losses from storage facilities	Report on Energy Supply and Demand in Canada (RESD), Statistics Canada A National Inventory of Greenhouse Gas (GHG), Criteria Air Contaminant (CAC) and Hydrogen Sulphide (H_2S) Emissions by the Upstream Oil and Gas Industry, Canadian Association of Petroleum Producers (CAPP) 2005 Supply and Disposition of Crude Oil and Equivalent, CANSIM Table 126-0001, Statistics Canada Industry Facts and Information by Region and Province, CAPP Drilling and Production Statistics, British Columbia Ministry of Energy, Mines and Petroleum Resources (MEMPR)
Natural Gas Extraction and Processing	▪ Releases from wells, gathering systems, field facilities and gas batteries ▪ Seal leaks ▪ Line cleaning operations	RESD, Statistics Canada A National Inventory of Greenhouse Gas (GHG), Criteria Air Contaminant (CAC) and Hydrogen Sulphide (H_2S) Emissions by the Upstream Oil and Gas Industry, CAPP 2005 Supply and Disposition of Natural Gas, Monthly, CANSIM Table 131-0001, Statistics Canada Drilling and Production Statistics, MEMPR
Petroleum Refining	▪ Equipment leaks, wastewater treatment, cooling towers, storage tanks and loading operations ▪ Flaring of excess gas	Economic and Environmental Impacts of Removing Sulphur from Canadian Gasoline and Distillate Production, Canadian Petroleum Products Institute (CPPI) 2004 RESD, Statistics Canada
Coal Mining	▪ Releases from exposed coal surfaces, coal rubble and venting within coal deposit ▪ Post-mining activities including preparation, non-vehicular transportation, storage and final processing	Management of Methane Emissions from Coal Mines: Environmental, Engineering, Economic and Institutional Implications of Options. King 1994 Coal and Coke Statistics, Catalogue No. 45-002, Statistics Canada

[20] Refer to Section 3 of the NIR for more information.

Emission Category	Associated Activities	Data Sources
Natural Gas Transmission	▪ Equipment leaks, compressor start-up venting, purging of lines during maintenance	CH_4 and VOC Emissions from the Canadian Upstream Oil and Gas Industry—Draft Report, CAPP Natural Gas Transportation and Distribution, Catalogue No. 57-205, Statistics Canada
Natural Gas Distribution	▪ Equipment leaks, compressor start-up venting, purging of lines during maintenance	1995 Air Inventory of the Canadian Natural Gas Industry, Canadian Gas Association (CGA) 1997 Natural Gas Transportation and Distribution, Catalogue No. 57-205, Statistics Canada
Oil Transmission in Pipelines	▪ Loading and unloading of tankers, storage losses, equipment leaks, process venting	A National Inventory of Greenhouse Gas (GHG), Criteria Air Contaminant (CAC) and Hydrogen Sulphide (H_2S) Emissions by the Upstream Oil and Gas Industry, CAPP 2005

5. INDUSTRIAL PROCESSES SECTOR EMISSIONS



5.1 Summary

Total emissions in the industrial process sector category in 2008 were 4.1 megatonnes (Mt) CO_2e – 5.9% of total B.C. emissions. Figure 13 shows industrial processes sector emissions as accounted by each of the sub-sectors.

Industrial processes include GHG emissions from industrial activities which do not derive from the combustion of a hydrocarbon fuel, but rather from a different type of reaction which chemically or physically transform materials. This sector of emissions includes five sub-sectors – mineral products (including cement and lime production, and soda ash, limestone and dolomite production and use), chemical industry, metal production,[21] consumption of halocarbons and SF_6 and "other and undifferentiated production" (including lead and zinc production) – described in Table 15.

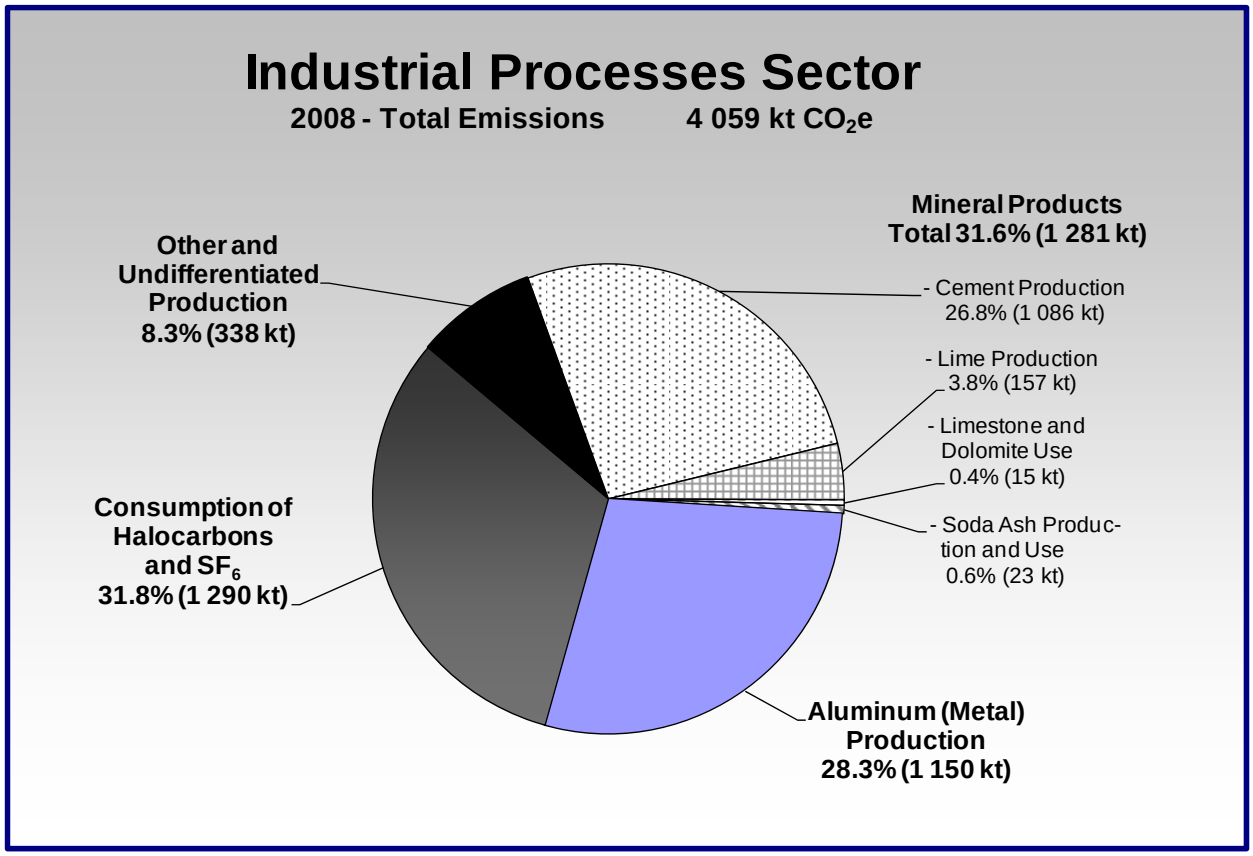


Figure 13: Industrial Processes GHG Emissions by Category – 2008

[21] Aluminium, lead, zinc, copper and molybdenum are produced in B.C. Industrial process emissions from aluminium production are reported individually under the "Metal Production" sub-sector. Industrial process emissions from lead, zinc and copper relate to the use of fossil fuel as reducing agents and are aggregated under the "Other and Undifferentiated Production" sub-sector. There are no industrial process emissions associated with molybdenum production.

Table 15: Industrial Processes Sub-sector and Category Descriptions

Emission Source	Description and Notes
a. Mineral Products	
Cement Production	Lime (used in cement clinker) is formed by the heating of limestone to decompose carbonates through calcination, which releases CO_2
Lime Production	Lime is formed by the heating of limestone to decompose carbonates through calcination, which releases CO_2
Limestone and Dolomite Use	Calcination of limestone or dolomite into lime for purposes other than cement or lime production – these include glass manufacturing and non-ferrous metal production, pulp and paper production, flue gas desulphurization and wastewater treatment/neutralization
Soda Ash Production and Use	CO_2 is released during the decomposition of soda ash (Na_2CO_3), used in glass manufacturing, chemical production, pulp and paper manufacturing and wastewater treatment
b. Chemical Industry	There are no B.C. emissions sources under this category
c. Metal Production	All B.C. emissions in this sub-sector are associated with aluminium production – SF_6 emissions from magnesium casting are included under "Consumption of Halocarbons and SF_6" due to confidentiality reasons
Aluminium Production	GHG emissions include CF_4 and C_2F_6 (PFCs), as well as CO_2, formed during the aluminium smelting process – including electrolytic reduction of alumina (Al_2O_3) with carbon-based anodes, pre-baking of carbon anodes and anode effects
d. Consumption of Halocarbons and SF_6	Fugitive releases of HFCs used in refrigeration and air conditioning, fire suppression, aerosols, solvent cleaning, foam blowing, and other applications – also includes emissions of SF_6 from electrical generation, transmission and distribution equipment and magnesium casting
e. Other and Undifferentiated Production	GHG emissions from the non-energy use of fossil fuels, including the use of fossil fuels as a reducing agent in base metal smelting (i.e., lead and zinc), natural gas liquids in the chemical industry and the use of lubricants

5.2 Trends in Industrial Process Sector Emissions

Emissions reported under the industrial process category emissions increased by 2.8% between 2007 and 2008, decreased by 1.9% between 2004 and 2008 and decreased by 8.5% between 1998 and 2008. Factors influencing these overall reductions include decreases in process emissions from the production of aluminium, consumption of halocarbons and SF_6 and decreases in other and undifferentiated production. Overall reductions have been moderated in part by increases in process emissions from cement production.

The trend in industrial processes sector GHG emissions between 1990 and 2008 is shown in Figure 14.

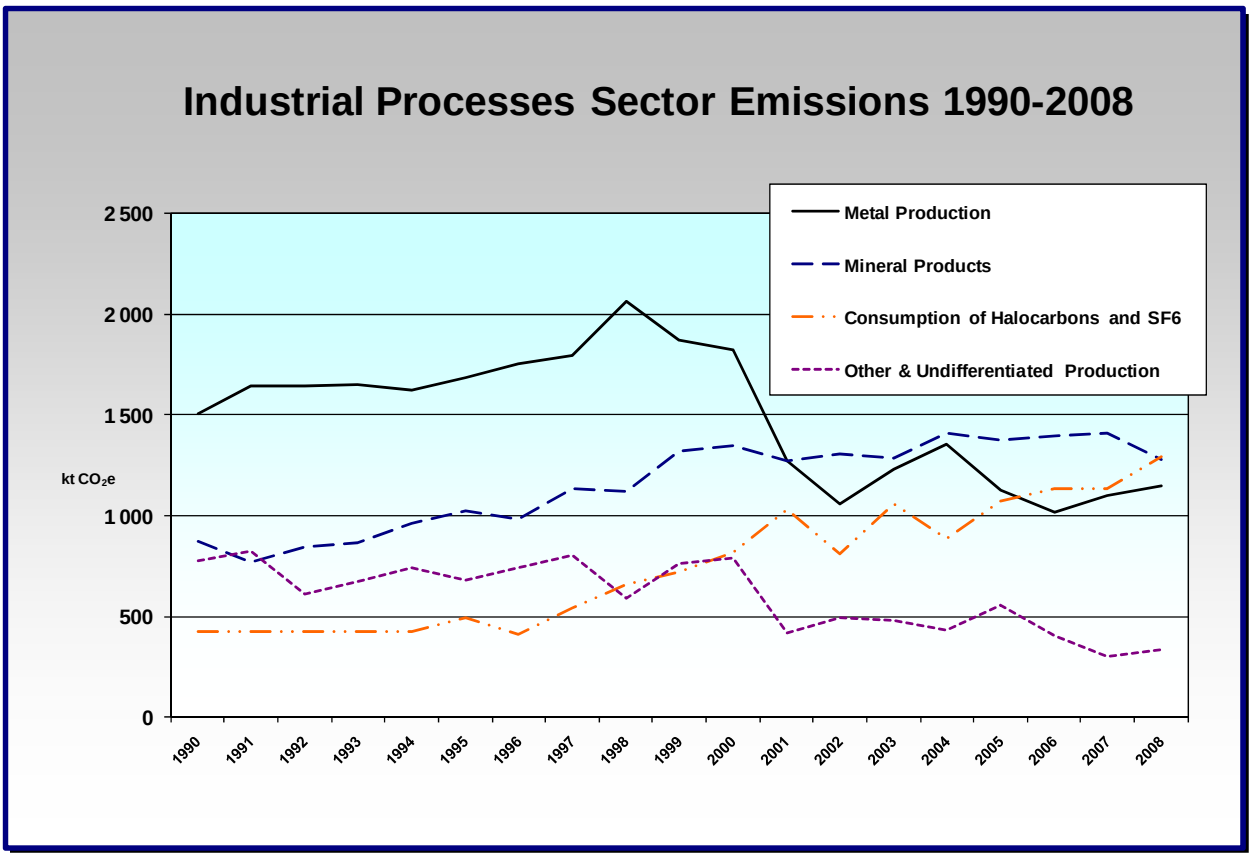


Figure 14: Industrial Processes Emissions – 1990-2008 Trends

Table 16: Industrial Process Categories, Trends and Key Factors Influencing Changes

Emission Category	3-Year Trend	10-Year Trend	Key Factors Influencing Changes in Emissions
INDUSTRIAL PROCESSES	-1.9%	-8.5%	
a. Mineral Products			
Cement Production	-5.5%	+25.4%	Annual cement production[1]
Lime Production	-13.3%	-19.5%	Annual lime production[2]
Limestone and Dolomite Use	-30.3%	-64.3%	Annual pulp and paper production[3]
Soda Ash Use	+4.1%	+21.3%	Annual production in industries that utilize soda ash (e.g., pulp and paper, glass and chemical industries)[3]
c. Metal Production (Aluminium Production)	+1.7%	-44.2%	Control measures to reduce PFC emissions from anode effects[4]
d. Consumption of Halo-carbons and SF_6	+19.9%	+96.0%	Displacement of banned CFCs in 1996, demand for HFCs associated with building space[5,6] and vehicle-kilometres travelled;[7] SF_6 used in electrical generation, transmission and distribution equipment
e. Other & Undifferentiated Production	-39.3%	-42.9%	Closure of ammonia and methanol plants in Kitimat, lead and zinc production[8]

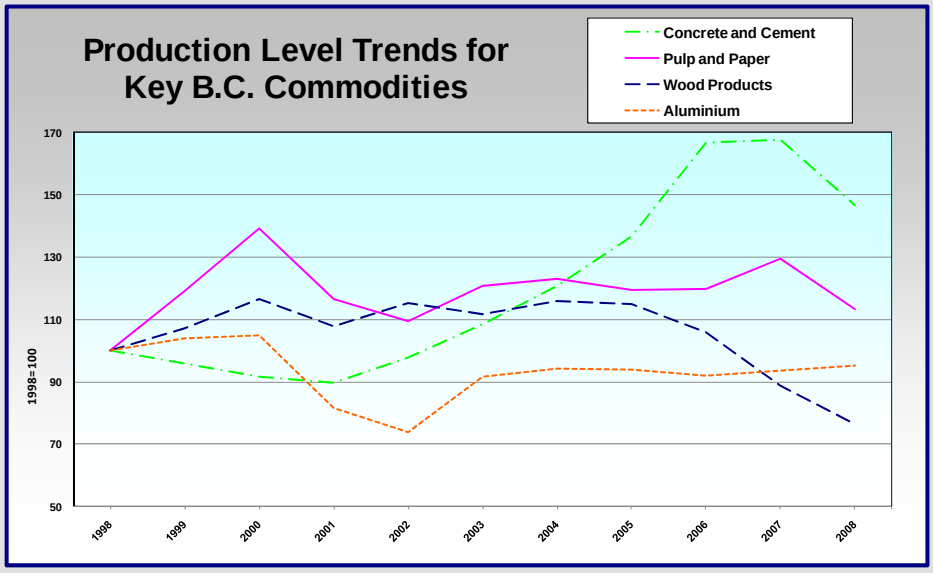
[1] Cement Association of Canada
[2] NRCan Canadian Minerals Yearbook

[3] CANSIM Table 304-0015: Manufacturing sales, by North American Industry Classification System (NAICS) and province, monthly (dollars), Jan 1992 to Jan 2009
[4] Alcan B.C. 2008 Performance Report
[5] NRCan Office of Energy Efficiency: Commercial/Institutional Sector British Columbia and Territories Table 3: Secondary Energy Use and GHG Emissions by Activity Type
[6] NRCan Office of Energy Efficiency: Residential Sector B.C. Table 2: Secondary Energy Use and GHG Emissions by End-Use
[7] CANSIM Table 405-0008: Canadian vehicle survey, vehicle-km, by type of vehicle, province and territory, quarterly
[8] Teck-Cominco, Trail Operations: Operation and Site Performance

Understanding trends in industrial emissions

Industrial process emissions[1] are primarily related to production levels, chemical relationships and efficiencies in production technologies.

Figure 15 illustrates the variation in production levels for several key B.C. commodities between 1998 and 2008. Over this time period production of cement[2] increased by 45%, while aluminium production [3] decreased by around 5%. Over this period GHG emissions associated with cement production increased by only 25% and those associated with aluminum production decreased by 44% (see Table 16). For both industrial products – and aluminum in particular – emissions decreased by a relatively larger amount than production, indicating an increase in production efficiency (in relation to greenhouse gases). Efficiencies in aluminium production are in large part due to increased control measures to reduce PFC emissions from anode effects.



Production of pulp and paper[4] and wood products (manufacturing)[5] over this period peaked in 2000 and dropped between 2007 and 2008. Since both are cyclical industries, production varies with economic and market cycles. Trends of switching from fossil fuels to biomass, and increased production efficiencies, have led to substantial decreases in greenhouse gas emissions for these sectors.[6]

Figure 15: Production level trends for Key B.C. Commodities

[1] Although wood products manufacturing and pulp and paper are not considered "industrial processes" under reporting conventions, they are included in this figure to illustrate associations between production levels and GHG emissions.

[2] CANSIM table 304-0015: Manufacturing sales, by North American Industry Classification System; British Columbia; Sales of goods manufactured (shipments); Unadjusted; Cement and concrete product manufacturing [3273]

[3] Alcan Performance Reports: www.riotintoalcaninbc.com/pages/media/performance-reports.php

[4] CANSIM Table 304-0015: Manufacturing sales, by North American Industry Classification System; British Columbia; Sales of goods manufactured (shipments)

[5] Statistics Canada Industry Price Indexes, March 2009 –Table 2-1 Industrial product price indexes, by commodity and commodity aggregations — Summary, and Table 3-8 Industrial product price indexes by industry and industry groups— Paper manufacturing

[6] See: www.statcan.gc.ca/pub/16-002-x/2009004/article/11030-eng.htm#a1 for more information

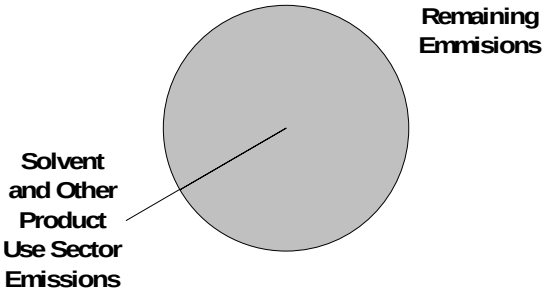
5.3 Data Sources

In general, industrial process emissions are calculated by multiplying activity data (e.g., quantity of the product produced) by an appropriate emission factor. However, there are more complex categories such as aluminum production which necessitate use of more elaborate formulae. Additional details on such methodologies can be found in Annex 3.2 of the NIR. Table 17 summarizes the data sources used to compile activity data and emission factors for each emission category.

Table 17: Industrial Processes Sector Categories, Associated Activities and Data Sources

Emission Category	Associated Activities	Data Sources
Cement Production	Quantity of clinker produced	Clinker production 1990-1996: A Review of Energy Consumption and Related Data: Canadian Cement Manufacturing Industry, 1990-2004, Canadian Industrial Energy End-Use Data and Analysis Centre (CIEEDAC) 2008 Clinker production 1997-2004: Catalogue #44-001, Statistics Canada Clinker production 2005-2008: CANSIM Table 303-0060, Statistics Canada Clinker capacity: 1990-2008: Canadian Minerals Yearbook, Natural Resources Canada (NRCan) Emission factor: Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, IPCC
Lime Production	Quantity of lime produced	Lime production: Canadian Minerals Yearbook, NRCan Emission factor: Canadian Lime Institute
Limestone and Dolomite Use	Quantity of limestone or dolomite consumed	Limestone and dolomite consumption: Canadian Minerals Yearbook, NRCan Emission factor: Identifying and Updating Industrial Process Activity Data in the Minerals Sector for the Canadian Greenhouse Gas Inventory, AMEC Earth & Environmental
Soda Ash Use	Quantity of soda ash consumed	Soda Ash consumption: Global Trade Information Services (GTIS) Emission factor: mass balance stoichiometry
Aluminium Production	Quantity of aluminium produced	Aluminium production: Aluminium Association of Canada Emission factors: Aluminium Association of Canada
Consumption of Halocarbons and SF_6	Quantity of halocarbons and SF_6 consumed	HFC Consumption and SF_6 Use Data: Environment Canada voluntary survey for HFC importers and distributors, and magnesium casters, total Canadian/ B.C. SF_6 use Emission factors: Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, IPCC
Other Undifferentiated Production	Quantity of fuel used for non-energy purposes	Fuel consumed: RESD Emission factors: Canada's Greenhouse Gas Emissions: Estimates for 1990, prepared for Environment Canada, Jaques, AP; 1998 Fossil Fuel and Derivative Factors, McCann, TJ; A Review of Energy Consumption in Canadian Oil Refineries 1990, 1994 to 2004, CIEEDAC

6. SOLVENT AND OTHER PRODUCT USE SECTOR EMISSIONS



6.1 Summary

The solvent and other product use category encompasses emissions of N_2O used as an anaesthetic or as a propellant in pressure and aerosol products. Total emissions in this sector were 43 kilotonnes CO_2e in 2008, accounting for 0.1% of total emissions in the province.

6.2 Trends in Solvent and Other Product Use Sector Emissions

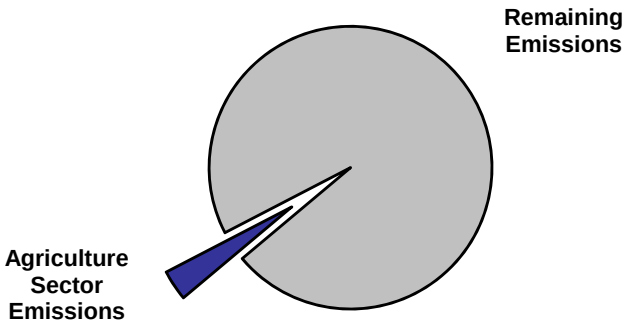
Annual emissions for this sector increased minimally between 2007 and 2008 however increased by 87.0% between 2005 and 2008 and 59.3% between 1998 and 2008. Changes in emissions reflect increases in the amount of N_2O used for anaesthetic and as propellant.

6.3 Data Sources

The data on domestic sales of Canadian N_2O production provided by Nitrous Oxide Canada and N_2O import data purchased from Statistics Canada's merchandise trade database are used to estimate the total national sales. It is assumed that 97.5% of N_2O sold for anaesthetic is emitted into the atmosphere, while the remaining 2.5% is metabolized. Emissions are apportioned to B.C. based on a national emission per capita factor multiplied by the population of B.C.

7. AGRICULTURE SECTOR EMISSIONS

7.1 Summary



Total emissions in the agricultural sector category in 2008 were 2.4 megatonnes (Mt) CO_2e – 3.5% of total B.C. emissions. GHG emissions reported in the agriculture sector include: CH_4 emissions from enteric fermentation; CH_4 and N_2O emission from manure management; and N_2O emissions from agricultural soils (including direct and indirect sources and pasture, range and paddock manure). Figure 16 shows the percentage of emissions as accounted by each of these sub-sectors and Table 18 provides a description of agriculture sector emission categories.

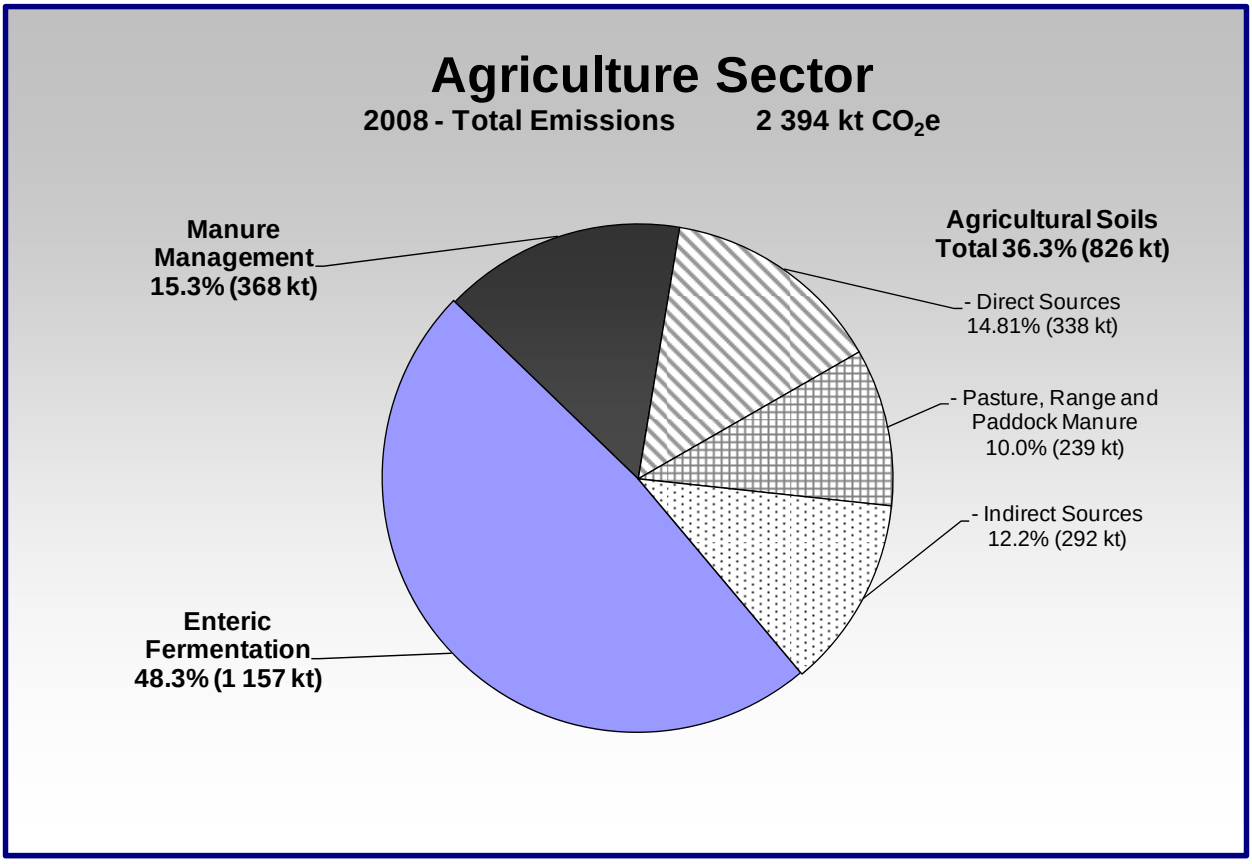


Figure 16: Agriculture Sector GHG Emissions by Category – 2008

Table 18: Agriculture Sub-sector and Category Descriptions

Emission Source	Description
a. Enteric Fermentation	The digestive process of ruminant animals (such as cattle) involves microbial fermentation in the rumen, which produces CH_4 emissions as a by-product
b. Manure Management	The decomposition of manure by microbial organisms produces CH_4 emissions as a by-product. The nitrification and denitrification of nitrogen-containing compounds in manure results in the production of N_2O. Factors impacting the production of CH_4 and N_2O include manure characteristics and the aeration levels in various types of manure management systems
c. Agriculture Soils	
Direct Emissions	Direct sources of N_2O emissions include application of synthetic and manure-based fertilizers, decomposition of crop residue, irrigation, cultivation of hisotosols and changes to tillage practices and summer fallow
Pasture, Range and Paddock	Grazing animals excrete manure on pastures, ranges and paddocks. This manure undergoes nitrification and denitrification, producing N_2O emissions
Indirect Emissions	Nitrogen present in crop residue and in synthetic and organic fertilizers (e.g., manure) applied to agricultural fields may be transported off-site through volatilization and subsequent redeposition or leaching, erosion and runoff. A portion of this nitrogen may later undergo nitrification and denitrification, producing N_2O emissions

7.2 Trends in Agriculture Sector Emissions

Annual agriculture sector emissions decreased by 0.6% between 2007 and 2008 and by 9.3% between 2005 and 2008 however, increased by 3.7% between 1998 and 2008. Changes can be attributed in most part to changes in livestock (e.g., cattle, hog) population. The largest source of agriculture emissions is methane (CH_4) emissions from enteric fermentation.

Figure 17 depicts agriculture sub-sector emissions between 1990 and 2008 and Table 19 provides three and ten-year trend percentages and a summary of key factors influencing changes in emissions.

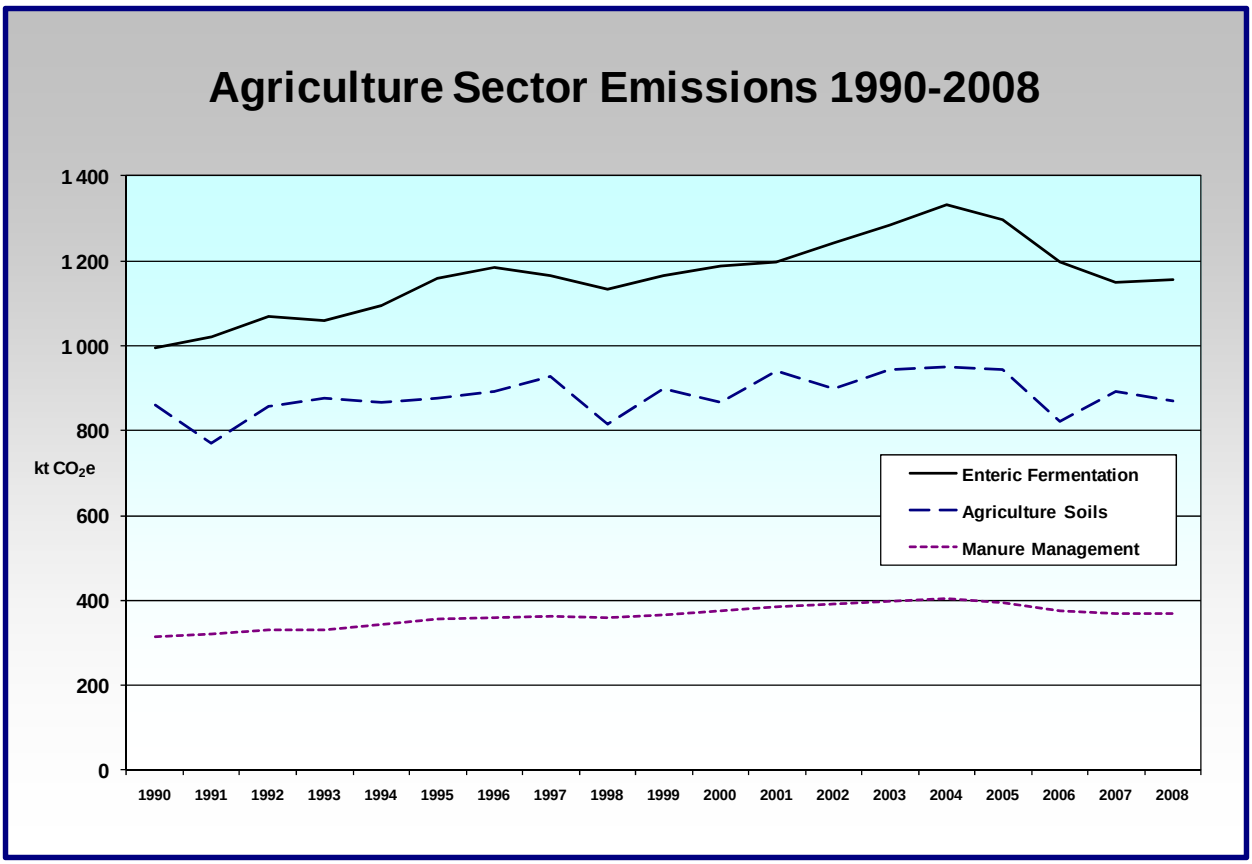


Figure 17: Agriculture Sector Emissions – 1990-2008 Trends

Table 19: Agriculture Sector Trends and Key Factors Influencing Changes

Emission Category	3-Year Trend	10-Year Trend	Key Factors Influencing Changes in Emissions
AGRICULTURE	-9.3%	+3.7%	
a. Enteric Fermentation	-10.9%	+2.0%	Cattle populations,[1] hog populations[2]
b. Manure Management	-7.0%	+2.6%	Cattle populations,[1] hog populations[2]
c. Agriculture Soils	-8.1%	+6.6%	Cattle and hog populations,[1,2] fertilizer use, soil management practices

[1] CANSIM Table 003-0032: Number of cattle, by class and farm type, annual (head)

[2] CANSIM Table 003-0004: Number of hogs on farms at end of quarter, quarterly (head)

Understanding trends in agriculture emissions

Trends in agriculture emissions have been predominately influenced by cattle and hog populations. As Figure 18 shows, both hog and cattle populations have been in decline since 2004, with hog populations showing a steady decline since 1990.

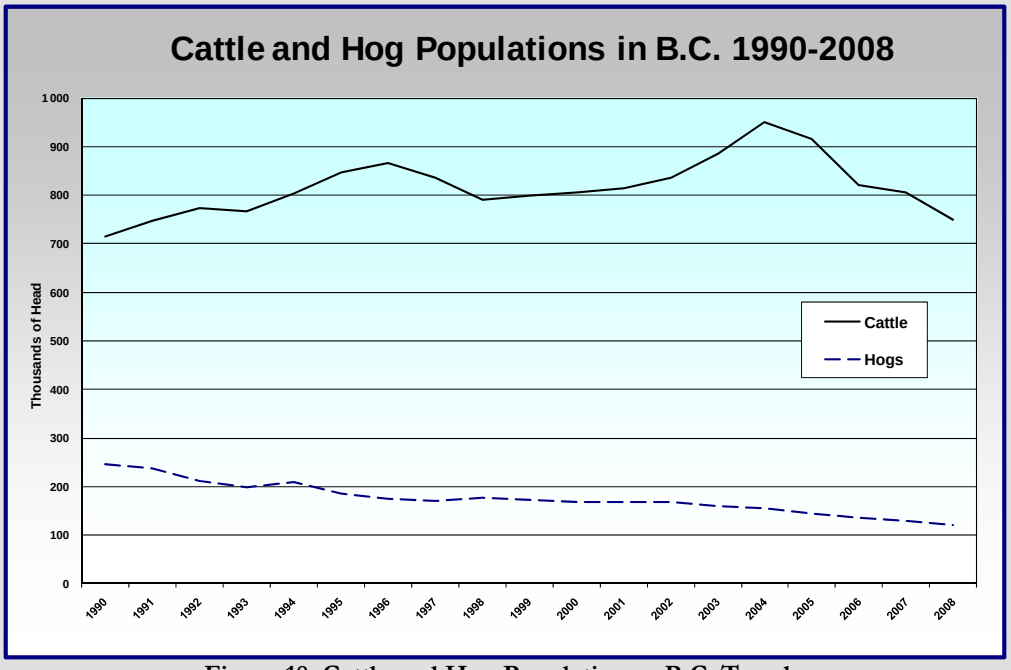


Figure 18: Cattle and Hog Populations – B.C. Trends

Data sources: CANSIM Tables 003-0032 and 003-0004

7.3 Data Sources

Agriculture sector emissions are calculated by multiplying activity data (e.g., number of livestock) by an appropriate emission factor. Table 20 summarizes the data sources used to compile activity data and emission factors for each agriculture sector emission category.

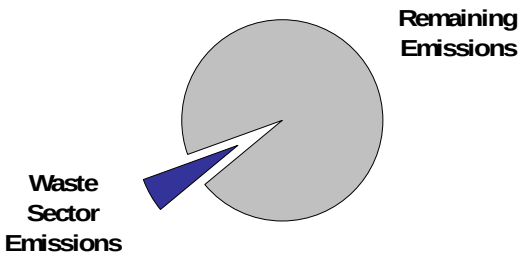
Table 20: Agriculture Sector Categories, Associated Activities and Data Sources

Emission Category	Activity	Data Sources
a: Enteric Fermentation	Domestic animal populations	Animal populations: Various Statistics Canada publications and CANSIM tables. Refer to Table 6-3 in the National Inventory Report (NIR) for specific references Emission Factors: Improving Estimates of Methane Emissions Associated with Enteric Fermentation of Cattle in Canada by Adopting an IPCC Tier-2 Methodology, Department of Animal Science, University of Manitoba, Boadi DA, Ominski KH, Fulawka DL, Wittenberg KM, 2004
b: Manure Management	Domestic animal populations	Animal populations: Various Statistics Canada publications and CANSIM tables – refer to Table 6-3 in the NIR for specific references CH_4 Emission Factors: Boadi et al. 2004; Improving Estimates of Methane Emissions Associated with Animal Waste Management Systems in Canada by Adopting an IPCC Tier 2

Emission Category	Activity	Data Sources
		Methodology, Department of Land Resource Science. University of Guelph, Marinier et al. 2004 N_2O Emission Factors: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Intergovernmental Panel on Climate Change (IPCC)
c: Agriculture Soils		
Direct Emissions: - Fertilizer application	Fertilizer sales	Fertilizer sales and nitrogen content data: Canadian Fertilizer Institute
- Crop residues	Amount of nitrogen in crop residue	Crop Production: Field Crop Reporting Series, 1990–2008 (Annual). Catalogue No. 22-002, Statistics Canada. Nitrogen in crop residue: The fate of nitrogen in agroecosystems: an illustration using Canadian estimates, Nutrient Cycling in Agroecosystems. 67: 85–102, Janzen et al. 2003
- Cultivated histosols	Area of cultivated histosols	Area of cultivated histosols: G. Padbury and G. Patterson, personal communication with Environment Canada Emission Factor: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, IPCC
- Changes in tillage	Area estimates of non-tillage and reduced tillage	Area estimates of non-tillage and reduced tillage: Census of Agriculture Emission reduction estimates: Estimation of N_2O emissions from agricultural soils in Canada. I. Development of a country-specific methodology. Canadian Journal of Soil Science 88: 641–654, Rochette P, Worth DE, Lemke RL, McConkey BG, Pennock DJ, Wagner-Riddle C, Desjardins RL. 2008
- Irrigation	Area of irrigated cropland	Area of irrigated cropland: Census of Agriculture, Statistics Canada Emission Factor: Rochette et al. 2008
- Summer fallow	Area of summer fallow	Area of summer fallow: Census of Agriculture, Statistics Canada Emission Factor: Rochette et al. 2008
Pasture, Range and Paddock	Domestic animal populations	Animal populations: Various Statistics Canada publications and CANSIM tables – refer to Table 6-3 in the NIR for specific references Emission Factors: IPCC 2006 Guidelines for National Greenhouse Gas Inventories, IPCC
Indirect Sources	Fertilizer sales Domestic animal populations	Fertilizer sales and nitrogen content data: Canadian Fertilizer Institute Animal populations: Various Statistics Canada publications and CANSIM tables – refer to Table 6-3 in the NIR for specific references Emission Factors: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, IPCC

8. WASTE SECTOR EMISSIONS

8.1 Summary



Total emissions in the waste sector category were 3.8 megatonnes (Mt) CO_2e in 2008 – 5.5% of total B.C. emissions.

GHG emissions from the waste sector are related to the treatment and disposal of solid waste and wastewater. Sources include: CH_4 emissions from landfills; CH_4 and N_2O emissions from wastewater treatment; and CO_2, CH_4 and N_2O emissions from waste incineration. CO_2 emissions of biogenic origin (i.e., wood, wood products and biomass-based wastes) are considered to be "carbon-neutral"[22] and are not included in this inventory category. Figure 19 and Table 21 provide a summary and description of waste sector emissions by each sub-sector.

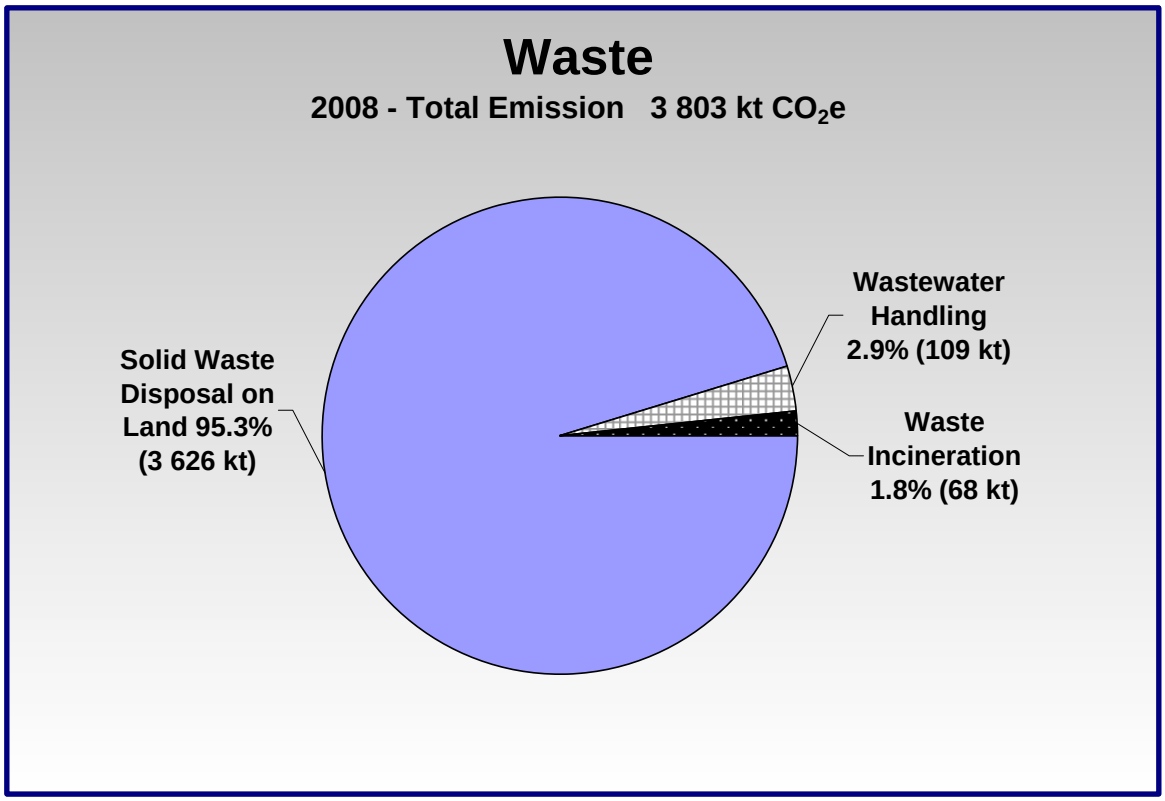


Figure 19: Waste Sector GHG Emissions – 2008

[22] "Carbon-neutral" refers to fuels that neither contribute to nor reduce the amount of CO_2 in the atmosphere. For biomass, the CO_2 released *to* the atmosphere during combustion is the same quantity that has been absorbed *from* the atmosphere during plant growth. Because CO_2 absorption from plant growth and emissions from combustion occur within a relatively short timeframe to one another (typically 100-200 years), there is no long term change in the CO_2 levels in the atmosphere provided that a similar volume of a similar type of biomass is regrown on the same site; thus, in most cases biomass is carbon-neutral. For fossil fuels, absorption of CO_2 from plant growth and emissions from combustion are separated by much longer time scales, typically millions of years. Consequently, there is a long term increase in CO_2 levels in the atmosphere – thus, fossil fuels are not termed "carbon-neutral".

Table 21: Waste Sub-sector Descriptions

Emission Source	Description
a. Solid Waste Disposal on Land	Organic wastes sent to landfills are decomposed through anaerobic (i.e., without oxygen) digestion by bacteria and other microorganisms. By-products of this process include GHG emissions. This category includes CH_4 emissions from municipal solid waste landfills and wood waste landfills
b. Wastewater Handling	The amount of organic matter and microorganisms in wastewater is reduced through aerobic (i.e., "with oxygen") and anaerobic digestion. Both methods involve addition of bacteria to wastewater to break down organic matter and microorganisms. By-products of this process include GHG emissions. This category includes CH_4 and N_2O emissions from municipal wastewater treatment operations
c. Waste Incineration	Some municipalities incinerate waste to reduce the amount of solid waste sent to landfills. By-products of incineration of bio-based and hydrocarbon-based wastes include GHG emissions. This category includes CO_2 and N_2O emissions from waste incineration, excluding CO_2 emissions from bio-based waste, which is considered carbon-neutral. CH_4 emissions are not included due to lack of data

8.2 Trends in Waste Sector Emissions

Waste sector emissions decreased by 0.1% between 2007 and 2008, increased by 2.4% between 2005 and 2008, and decreased by 2.6% between 1998 and 2008. Increases in the quantity of waste generated and sent to landfills have recently tended to overshadow the emissions reductions associated with diversion of wastes and the capture, flaring and beneficial use[23] of CH_4 at landfills.

Table 22 and Figure 20 provide emission trend information for the waste sector. Note that due to the large difference in emissions among categories for this sector, Figure 20 shows emissions for the solid waste disposal on land category on a separate scale (left side y-axis) than emissions for the wastewater handling and waste incineration categories (right side y-axis).

Table 22: Waste Sector Trends and Key Drivers

Emission Category	3-Year Trend	10-Year Trend	Key Factors Influencing Changes in Emissions
WASTE	+2.4%	-2.6%	
Solid Waste Disposal on Land	+2.4%	-2.7%	Annual quantity of solid waste generated,[1] quantity of waste sent to landfill,[1] diversion rates (i.e., recycling and composting),[1] capturing and flaring of CH_4 emissions from landfills
Wastewater Handling	+2.6%	+5.6%	Population growth[2] and related water demand
Waste Incineration	-1.3%	-5.4%	Annual quantity of solid waste sent to landfill,[1] percentage of waste incinerated

[1] Statistics Canada Waste Management Industry Survey: Business and Government Sectors

[2] B.C. Stats: Population and Demographics

[23] CH_4 emissions from landfills can be captured through piping systems and sent to a stationary unit (e.g., flare, boiler, gas turbine) for combustion, often for the purposes of generating electricity. Combustion converts the CH_4 to CO_2, a less potent GHG, thus reducing overall GHG emissions from the landfill.

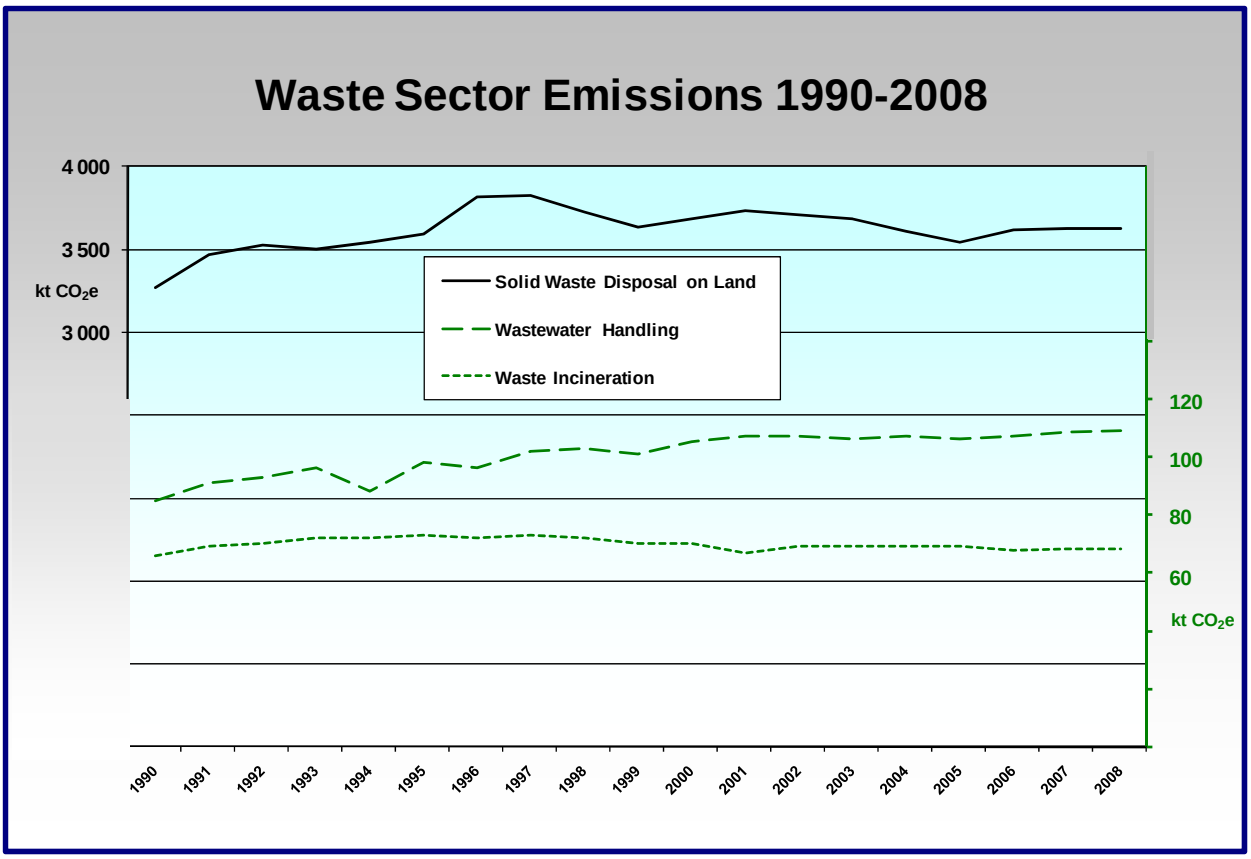


Figure 20: Waste Sector GHG Emissions – 1990-2008 Trends

Understanding trends in waste emissions

Waste sector emissions are influenced by the quantity of waste sent to, as well as the amount of methane gas captured from landfills.

Figure 21 shows that although the amount of waste diverted (i.e., reused, recycled or composted) from landfills has increased slightly between 1996 and 2006, the total waste generated and disposed in landfills has also increased. Diversion has not reduced waste generation sufficiently to reduce the amount of waste disposed of in landfills.

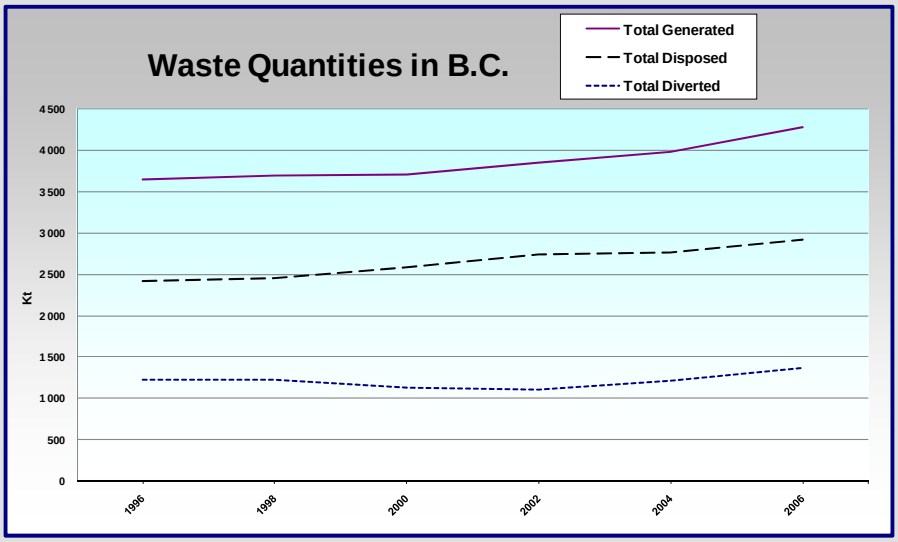


Figure 21: Waste Quantities in B.C.

Data Source: Statistics Canada Waste Management Industry Survey: Business and Government Sectors

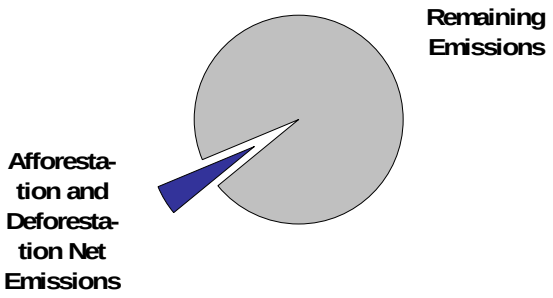
8.3 Data Sources

Emissions from wastewater treatment and waste incineration are estimated by multiplying an appropriate emission factor by relevant activity data (i.e., demographic population and quantity of waste incinerated). Emissions from solid waste disposal are estimated through modelling of decomposition of waste in landfills using the Scholl Canyon model. The model uses relevant activity data and site characteristics (i.e., historical quantities of waste disposed in landfill, precipitation levels, landfill depth and other characteristics) to model the various stages of decomposition of solid waste in a landfill and thus estimate CH_4 emissions. Table 23 summarizes the data sources used to compile activity data and derive emission factors for each emission category.

Table 23: Waste Sector Categories, Associated Activities and Data Sources

Emission Category	Activity	Data Sources
Solid Waste Disposal on Land	Quantity of waste sent to landfills	Waste Management Industry Survey, Statistics Canada
		National Wood Residue Database, Natural Resources Canada (NRCan)
	Historical composition of waste sent to landfills	Recommendations for Improving the Canadian Methane Generation Model for Landfills. Natural Resources Institute, University of Manitoba
	Quantity of CH_4 captured and flared	Calculation Tools for Estimating Greenhouse Gas Emissions from Wood Products Manufacturing Facilities, National Council for Air and Stream Improvement, Inc.
		An Analysis of Resource Recovery Opportunities in Canada and the Projection of Greenhouse Gas Emission Implications, NRCan
		An Inventory of Landfill Gas Recovery and Utilization in Canada 2005, Greenhouse Gas Division of Environment Canada
		An Inventory of Landfill Gas Recovery and Utilization in Canada 2006 and 2008, Greenhouse Gas Division of Environment Canada (Unpublished report) 2009
		National Waste Composition (1967). Table 1.1-9: Summary of International Refuse Composition, of the Handbook of Environmental Control. Volume II: Solid Waste, CRC Press
		Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Intergovernmental Panel on Climate Change (IPCC)
		Inventory of Landfill Gas Recovery and Utilization in Canada. National Office of Pollution Prevention, Environment Canada
Wastewater Handling	Quantity of CH_4 emitted per capita	Demographic Statistics (Annual). Catalogue No. 91-213-XIB, Statistics Canada
	Quantity of N_20 emitted per capita protein consumption	Annual Demographic Estimates: Canada, Provinces and Territories. Demography Division, Catalogue no. 91-215-X, Statistics Canada Inventory Methods Manual for Estimating Canadian Emissions of Greenhouse Gases, Environment Canada
	Population of B.C.	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, IPCC
	Protein consumption per capita in Canada	Food Statistics – 2006, Catalogue No. 21-020-XIE, Statistics Canada
Waste Incineration	Quantity of waste incinerated	Municipal Solid Waste Incineration in Canada: An Update on Operations 1999–2001, Environment Canada
	Amount of carbon per unit mass of waste	Integrated Solid Waste Management, GH Tchobanoglous, Theisen H, Vigil S, 1993
		Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, IPCC

9. LAND USE, LAND-USE CHANGE AND FORESTRY (INCLUDING AFFORESTATION AND DEFORESTATION)



9.1 Summary

Net GHG emissions from afforestation[24] and deforestation[25] were approximately 3.2 megatonnes (Mt) CO_2e in 2008 – amounting to 4.6% of total B.C. emissions.

Afforestation and deforestation are the only categories in the land use, land-use change and forestry (LULUCF) sector counted in B.C. emissions totals for 2008. Other emissions and removals in this sector are considered as "memo items" (i.e., not counted in emissions totals) and are included in this report for transparency purposes.[26]

The memo items include emissions of approximately 32.8 Mt from forest land (i.e., "forest land remaining forest land"), 0.3 Mt from cropland (i.e., "cropland remaining cropland") and 0.04 Mt from wetlands (i.e., "wetlands remaining wetlands").

Emission estimates for the LULUCF sector have a high degree of uncertainty relative to estimates in other sectors. Sources of uncertainty include the limited size of sampled land area relative to the total land area of the province (for deforestation) and the difficulty in accounting complex ecological processes such as carbon uptake by vegetation and soil decomposition. Thus, emission estimates presented in this report are approximate and will be subject to change in future years with improvements to accounting methodologies and increased sampling densities.

Table 24 lists descriptions and notes for the various categories of lands in this sector, consistent with definitions used in the National Inventory Report (NIR).[27]

[24] "Afforestation" is defined in accordance with current international definitions as the direct human-induced conversion of land that has not been forested since 31 December 1989 to forested land through planting, seeding and/or the human-induced promotion of natural seed sources. See: http://unfccc.int/cop7/documents/accords_draft.pdf. Note that the international afforestation and reforestation definitions have been combined into the term "afforestation" for use in B.C. to avoid confusion with the conventional B.C. use of the term reforestation within a forest management context.
[25] "Deforestation" is defined as the direct human-induced conversion of forested land to non-forested land. Harvesting, when followed by regeneration, is not deforestation. Forestry operations, however, can cause deforestation (e.g., when permanent roads and landings are established).
[26] See discussion of reporting land use, land-use change and forestry sector memo items in section 1 of this report.
[27] For complete definitions, see IPCC Guidelines at: http://carbon.cfs.nrcan.gc.ca/ForestInventory_e.html and www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Glossary_Acronyms_BasicInfo/Glossary.pdf

Table 24: Land Categories and Descriptions

Land Category	Description and Notes
Forest Land	Forest land includes all land with woody vegetation consistent with the following thresholds used to define forest land in the NIR: (i) 1 ha minimum land area; (ii) 25% minimum tree crown cover (at maturity); (iii) 5 metre minimum tree height (at maturity); (iv) 20 metre minimum width (distance between trunks). These thresholds underestimate total afforestation and deforestation area. In particular, small linear land clearings from minor forest service roads and oil and gas right of ways and seismic lines will be excluded, as well as any deforestation event in itself less than 1 ha in size and similarly small afforestation events. Forest land also includes systems with vegetation that currently fall below, but are expected to exceed, the threshold of the forest land category.
Cropland	Cropland includes all lands in annual crops, summer fallow, and perennial crops (mostly forage, but also including berries, grapes, nursery crops, vegetables, and fruit trees and orchards). Cropland also includes non-forested pasture or rangeland used for grazing domestic livestock that does not meet the definition of grassland. Note that this definition of cropland is broader than some definitions in common use in B.C. due to the inclusion of non-forested land used for pasture and grazing.
Grassland	Grassland includes unimproved pasture or rangeland that is only used for grazing domestic livestock and occur only in geographical areas where the grassland would not naturally re-grow to forest if unused. In addition, vegetated areas that do not and will not meet the definition of forest land or cropland are generally included in this category. Note that this categorization of grassland differs from other definitions and uses of the term. Some studies classify grassland by vegetation while others characterize them by climate, soils and human use of the ecosystem.
Wetlands	Wetlands are areas where permanent or recurrent saturated conditions allow the establishment of vegetation and soil development typical of these conditions and that are not already in forest land, cropland or agricultural grassland. Wetlands include reservoirs as a managed sub-division and natural rivers and lakes as unmanaged sub-divisions.
Settlements	Settlements include all built-up land: urban, rural residential, land devoted to industrial and recreational use; roads, rights-of-way and other transportation infrastructure; and resource exploration, extraction and distribution (mining, oil and gas).

Changes to GHG emissions can arise from conversion from one type of land use to another, as well as from changes in the management or character of a particular land use. The B.C. GHG inventory report addresses land uses and land-use changes for which recognized NIR methodologies have been developed and that are estimated in the NIR (these categories are described in Table 25 and Table 26.

Table 25 provides a description of the categories and related GHG emissions (sources) and removals (sinks) relating to afforestation and deforestation.

Table 26 provides a description of the categories and related GHG emissions and removals relating to "memo item" LULUCF categories (i.e., forest land, cropland and wetlands). Sources of emissions include biomass taken from managed lands,[28] biomass decomposition, biomass burning and changes in soil composition. Removals (of CO_2 from the atmosphere) include the uptake of CO_2 by vegetation through photosynthesis and subsequent storage of carbon in biomass and soils. Types of GHGs associated with emissions and removals in this sector include CO_2, CH_4, N_2O and CO emissions from burning, carbon stored in wood and soils (reported as CO_2) and CO_2 emissions from soils and biomass decomposition.

[28] Under current international accounting protocols, all carbon stored in removed biomass is considered to be converted to CO_2 and emitted to the atmosphere immediately.

Table 25: Afforestation and Deforestation LULUCF Sector Categories and GHG Emissions 2008

LULUCF Category	Description	Net GHG Emissions (kt CO_2e)
TOTAL AFFORESTATION AND DEFORESTATION EMISSIONS (Included in Total Provincial GHG Emissions)		3 164
Cropland converted to Forest Land (Afforestation)	The direct conversion by humans of unused cropland into forest land results in increased sequestration of CO_2 and minor emissions of GHGs due to the decay of dead organic matter. Post-harvest tree planting and the natural growth of vegetation in unused cropland are not included in this category.	-14
Forest Land converted to Cropland (Deforestation)	The clearing of forest land for agricultural use results in GHG emissions from the removal of biomass, the decay of dead organic matter, changes in soil composition and changes in soil management practices. In addition, the ability of the land area to remove CO_2 from the atmosphere is diminished.	710
Forest Land converted to Settlements (Deforestation)	The clearing of forest land for transportation and energy infrastructure, municipal development, resource extraction activities and recreation results in GHG emissions from the removal of biomass and from the decay of dead organic matter. In addition, the ability of the land area to remove CO_2 from the atmosphere is diminished.	2 468
Forest Land converted to Wetlands (Deforestation)	The clearing of forest land for hydroelectric or municipal reservoirs or peat harvesting results in GHG emissions from the decomposition of cleared biomass and the decomposition of submerged soils and organic matter. In addition, the ability of the land area to remove CO_2 from the atmosphere is diminished. Emissions are reported in this category for 10 years following the year of flooding. Emissions occurring after 10 years are reported in the "wetlands remaining wetlands" category (see Table 26).	0

Table 26: "Memo Item" LULUCF Sector Categories and GHG Emissions 2008

LULUCF Category	Description	Net GHG Emissions (kt CO_2e)
TOTAL "MEMO ITEM" LULUCF EMISSIONS (not included in Total Provincial GHG Emissions)		33 126
Forest Land remaining Forest Land	The growth of biomass in forest land results in increased CO_2 sequestration in biomass and soils. Vegetation respiration, the decay of organic matter (natural or due to insect infestation) in biomass and soils, logging, controlled burning, and wildfires result in GHG emissions. In addition, the removal of biomass temporarily reduces the forest's capacity to remove CO_2 from the atmosphere.	32 834
Cropland remaining Cropland	The amount of organic carbon retained in agricultural crops and soils is a balance between CO_2 sequestration by crops, transfer and storage in soils and emissions through soil and crop decomposition. Factors that determine whether agricultural soils are a net source or sink of CO_2 emissions include lime application, cultivation of organic soils, changes in the management of mineral soils and changes in woody biomass.	252
Wetlands remaining Wetlands	The burning of biomass prior to flooding, the residual decay of biomass cleared from the land, and the decomposition of soils in areas flooded for hydroelectric reservoirs and peat harvesting results in CO_2 emissions. Emissions from residual decay of cleared biomass are reported in this category beginning 10 years after the year of flooding. Emissions occurring in the first 10 years are reported in the "forest land converted to wetlands" category. Small hydroelectric reservoirs are not included in this category.	40

LULUCF Category	Description	Net GHG Emissions (kt CO_2e)
Grassland converted to Cropland[1]	The clearing of grassland for agricultural use may result in GHG emissions due to the decay of dead organic matter, changes in soil composition and changes in soil management practices. In addition, the ability of the land area to remove CO_2 from the atmosphere may be increased or diminished.	0
Grassland converted to Settlements[1]	The clearing of grassland for transportation and energy infrastructure, municipal development and resource extraction activities result in GHG emissions from the decay of dead organic matter. In addition, the ability of the land area to remove CO_2 from the atmosphere is diminished.	0

[1] Not currently estimated in the NIR due to uncertainty in quantification methods

9.2 Trends in Land Use, Land-use Change and Forestry Sector Emissions

Afforestation and Deforestation

Net emissions in the afforestation and deforestation sub-category were approximately 3.2 megatonnes CO_2e in 2008, 4.6% of total B.C. emissions. This included 3.18 Mt CO_2e of emissions from deforestation and 0.014 Mt CO_2e of removals from afforestation. Emission and removal trends from 1990 to 2008 are shown in
Figure 22.

Three-year and ten-year trends are described in Table 27, with CO_2 emissions and removals described by land conversion types as reported under international reporting protocols. Net GHG emissions from afforestation and deforestation decreased 5.1% between 2005 and 2008 and 20.9% between 1998 and 2008.

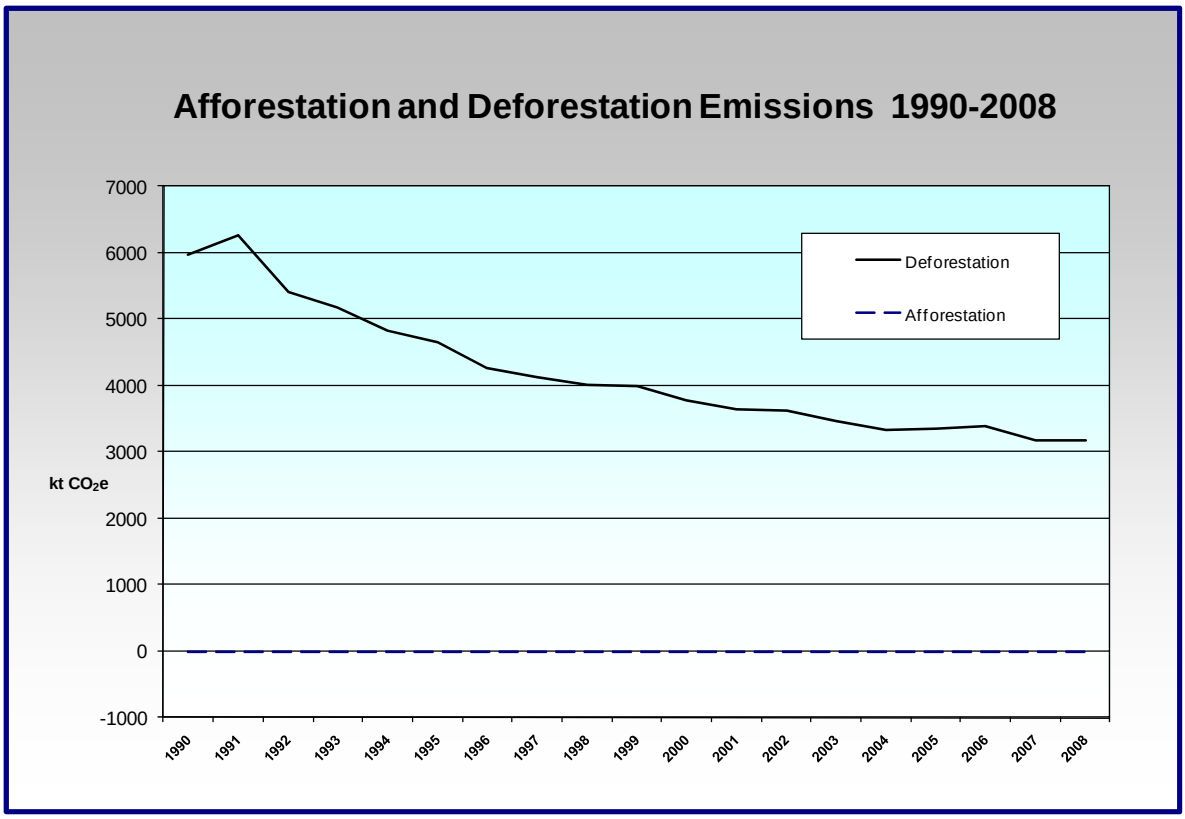


Figure 22: Afforestation and Deforestation Emission Trends

Table 27: Afforestation and Deforestation Sector Trends and Key Drivers

Emission / Activity Data Category	3-Year Trend	10-Year Trend	Key Factors Influencing Changes in Emissions
AFFORESTATION-DEFORESTATION	-5.1%	-20.9%	
Cropland converted to Forest Land (Afforestation)	-10.9%	+0.9%	Afforestation rates on areas previously cropland
Forest Land converted to Cropland (Deforestation)	-15.4%	-46.2%	Clearing for annual crops, permanent tree clearing for pasture and rangeland, head of cattle, conversion of forest to vineyards and orchards, expansion of cleared areas within existing farms
Forest Land converted to Settlement (Deforestation)	-1.7 %	-8.4%	Expansion rates for transportation infrastructure (e.g., highways, logging roads, railways, airstrips), energy infrastructure (e.g., hydro line rights-of-way, hydro dams and earthfills, pipelines, well pads, seismic lines), municipal developments (e.g., urban and rural residential developments, open fields, gravel pits/quarries (and resource extraction activities), industry (e.g., industrial buildings/sites, shopping malls, prisons, schools, universities and similar infrastructure), mining (e.g., open pit coal, limestone and other mines. Infrastructure for underground mines) and recreation (e.g., campgrounds, golf courses, ski runs)
Forest Land converted to Wetlands (Deforestation)	No change	No change	Flooded area and timber cleared for hydro dams and other reservoirs, peat production

Note: a negative trend indicates a decrease in carbon dioxide removals (or emissions); a positive trend indicates an increase

Annual rates of emissions associated with deforestation and removals from afforested land are in part influenced by the area of land involved (as well as by geographic location, growing conditions, tree species, density and age).[29] Area of land affected by afforestation and deforestation for selected years are illustrated in Figure 23. In the figure, area affected by deforestation is grouped into specific "sectors of human activity" (described in the figure's legend).[30] Disaggregated descriptions of these activities and detailed trend data for each are provided in Table 39 in the Annexes.

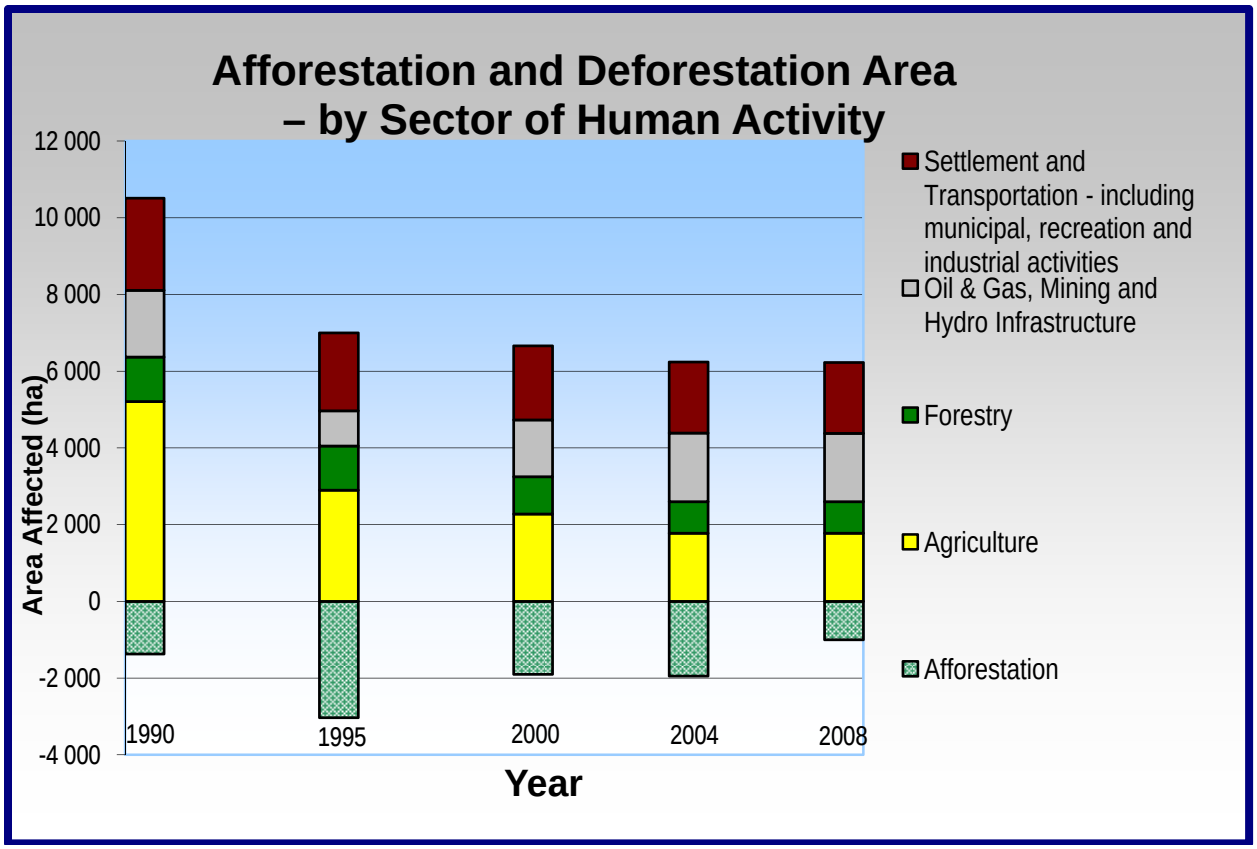


Figure 23: Afforestation and Deforestation Area – by Sector of Human Activity

Approximately 6 230 hectares was deforested in 2008, a decrease of 8.2% from the 6 780 ha 1998.[31] Deforested areas are not evenly distributed across the province but are concentrated in the lower mainland, east Vancouver Island (both in the Pacific Maritime ecozone), and north central/north-eastern B.C. (Boreal Cordillera, Montane Cordillera and Taiga Plains and Boreal Plains ecozones). These areas are subject to settlement growth, agricultural development or oil and gas activity. On average, across all terrestrial ecozones, 508 tonnes of greenhouse gases are released from combined

[29] For example, in the Pacific Maritime terrestrial ecozone (where there is relatively more settlement-related deforestation) the standing tree volume per unit hectare is higher than that in the Boreal Plains terrestrial ecozone (where there is relatively more agricultural-related deforestation), thus, emissions per hectare deforested are also higher. See Environment Canada's website for further information about Canada's terrestrial ecosystems and habitats.

[30] This figure uses sector category aggregations based on those used by the Canadian Forest Service in its estimation procedures. However, for international reporting, the categorical breakdown shown in Table 25 is used.

[31] A deforestation trend cannot be inferred for 2004 to 2008 as deforestation areas between 2000 and 2008 are based on interpretations of satellite image data taken in 2000 and 2008 that have been averaged and interpolated.

initial biomass removal and residual biomass decomposition from one hectare of deforestation in B.C.

Afforestation area data for 2008 is presently incomplete. In 2005 the latest year for which complete afforestation data is available, approximately 2 430 hectares (primarily unused farmland) was afforested.[32] Between 1997 and 2005, an average of 1 966 ha per year was afforested in B.C. Carbon sequestration associated with afforested lands has been relatively low due to the young age of the new forests. As trees planted after 1990 mature however, the volume of carbon sequestered will increase substantially.

"Forest Land Remaining Forest Land" Category

Emissions from forest land (i.e., "forest land remaining forest land") were approximately 32.8 megatonnes (Mt) CO_2e in 2008. These emissions are being reported as a "memo item".[33] Emissions in this category included net -37.0 Mt CO_2e sequestered through net primary production (NPP) and decay of dead organic matter,[34] 55.3 Mt CO_2e emitted due to harvesting,[35] 6.6 Mt CO_2e emitted due to wildfires and 7.9 Mt CO_2e emitted due to slash burning.[36]

Trends in emissions from 1990 to 2008 are shown in Figure 24. From 1990 to 2002, British Columbia's managed forests were a net sink of GHGs – absorbing more GHGs than were emitted. From 2002 onwards, managed forests became net sources of GHGs. The transition from sink to source can be attributed in large part to the mountain pine beetle (MPB) outbreak,[37] wildfires and partly to increases in wood harvesting.[38]

[32] Historical afforestation data has not been collected on an annual basis – data is periodically collected and interpolated and extrapolated to appropriate years. Thus, year-to-year trends based on this data are not representative of true trends.
[33] "Memo item" emissions are not "counted" toward British Columbia's total emissions. See discussion of reporting "land use, land-use change and forestry" sector "memo items" in section 1 of this report
[34] Net primary production (NPP) is a measurement of plant growth, calculated as the quantity of carbon dioxide absorbed from the atmosphere and stored as carbon by vegetation. NPP is equal to photosynthesis minus respiration and is measured in units of carbon per year. It is sometimes expressed in grams of carbon per square metre per year.
[35] All carbon stored in harvested wood products is assumed under current international accounting protocols to be converted to CO_2 and emitted immediately to the atmosphere. This is an overestimation of emissions since carbon embedded in wood products is sequestered for an extended period of time prior to the eventual decay of wood products and release of emissions. These protocols may be subject to change in future international negotiations.
[36] The removal of biomass due to burning temporarily reduces the capacity of the forest to remove carbon dioxide from the atmosphere before regenerating trees grow to a significant size.
[37] The mountain pine beetle infestation has resulted in dead pine trees, whose decomposition releases CO_2 emissions. In addition, the death of pine trees temporarily reduces the capacity of the forest to remove carbon dioxide from the atmosphere before new trees grow to a significant size. In the long term, as trees re-grow in mountain pine beetle affected areas, the forest's capacity to act as a GHG sink will increase and the rate of carbon sequestration could increase substantially. Hence, this change should not be considered as a "permanent" loss.
[38] In addition to removing stored carbon, the harvesting of woody biomass temporarily reduces the capacity of the forest to remove carbon dioxide from the atmosphere before regenerating trees grow to a significant size.

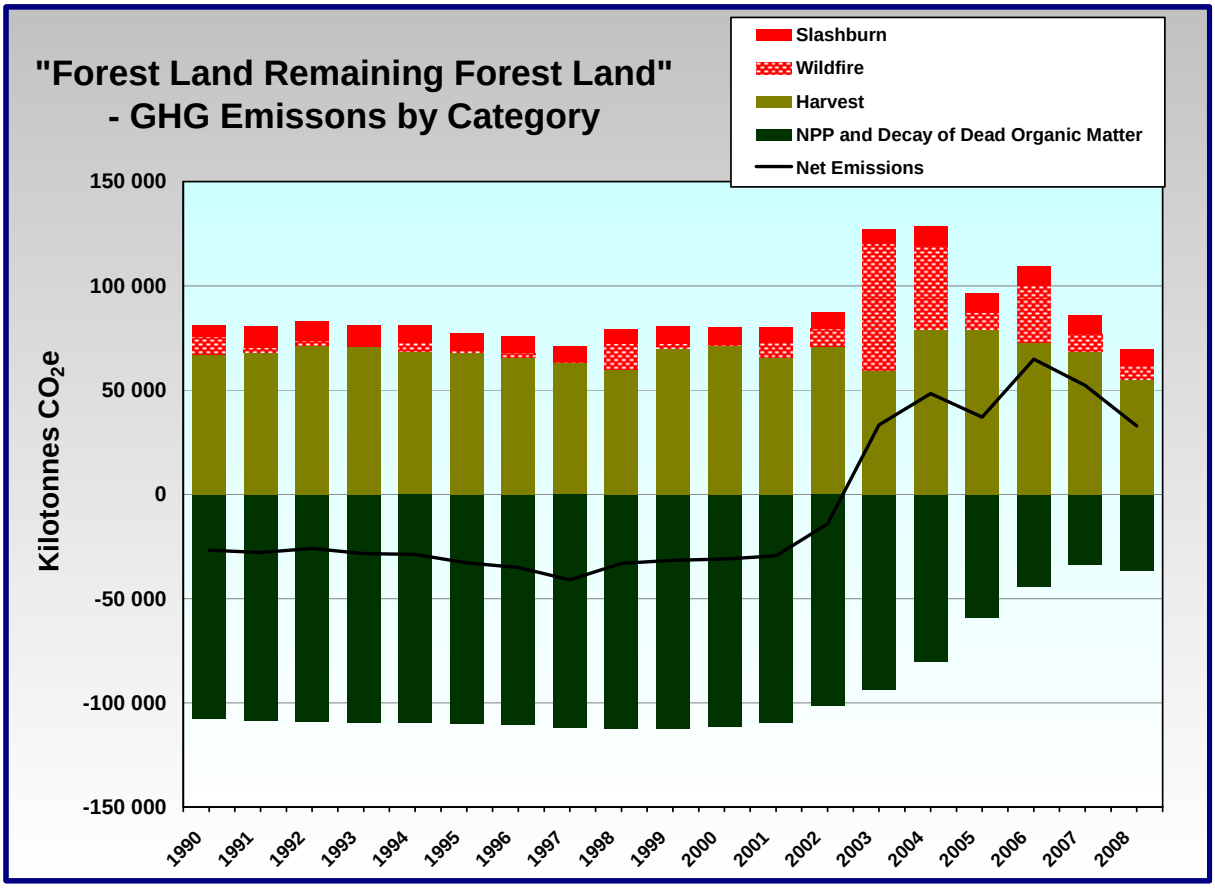


Figure 24: "Forest Land Remaining Forest Land" – GHG Emissions by Category

Three-year and ten-year trends are described in Table 28. Total (net) GHG emissions decreased by approximately 11% in 2008 compared to 2005, while increasing by almost 200% between 1998 and 2008. The three-year trend can be attributed to a combination of counterbalancing factors: decreasing emissions from harvesting and wildfires; and relatively higher "removals" (i.e., sequestration) as the impact of the Mountain Pine Beetle (MPB) infestation in B.C.'s forests starts to lessen. The ten-year trend can be attributed to the significant decrease in "removals" (starting in 2001) due to decay of dead organic matter associated with the Mountain Pine Beetle infestation.

Table 28: Forest Land Remaining Forest Land Sector Categories, Trends and Key Drivers

Emission/Activity Data Category	3-Year Trend	10-Year Trend	Key Factors Influencing Changes in Emissions
FOREST LAND REMAINING FOREST LAND	-11.3%	+199% (Absolute)	Note: ten year trend moved from a negative figure in 1998 (indicating a sink) to a positive figure in 2008 (indicating an emissions source)
Net Primary Production and Decay of Dead Organic Matter (removal)	-37.9%	-67.1%	Growth of trees and other vegetation (including regeneration after harvesting, forest fires and insect/disease), decomposition of dead organic matter and intensity of insect and disease attack
Wildfires (emission)	-15.5%	-45.8%	Forest fire location and intensity – note that emissions due to wildfires vary greatly from year to year
Harvest (emission)	-30.2%	-8.0%	Amount of harvest
Slash Burning (emission)	-17.1%	+10.7%	Amount of slash pile burning

Note: a negative trend indicates a decrease in carbon dioxide emissions and removals; a positive trend indicates an increase

Area of forest land impacted by MPB, wildfires, thinning and clear-cutting from 1990 to 2008 is illustrated in Figure 25.[39] Area affected by MPB increased by two orders of magnitude between 1990 levels and peak years of 2005, 2006 and 2007. The area of land impacted by wildfires varies greatly from year to year, with significant spikes in 2003 and 2004 and lows in 1993, 1997 and 2000. Clear-cut and thinned forest area has been relatively consistent since 1990.

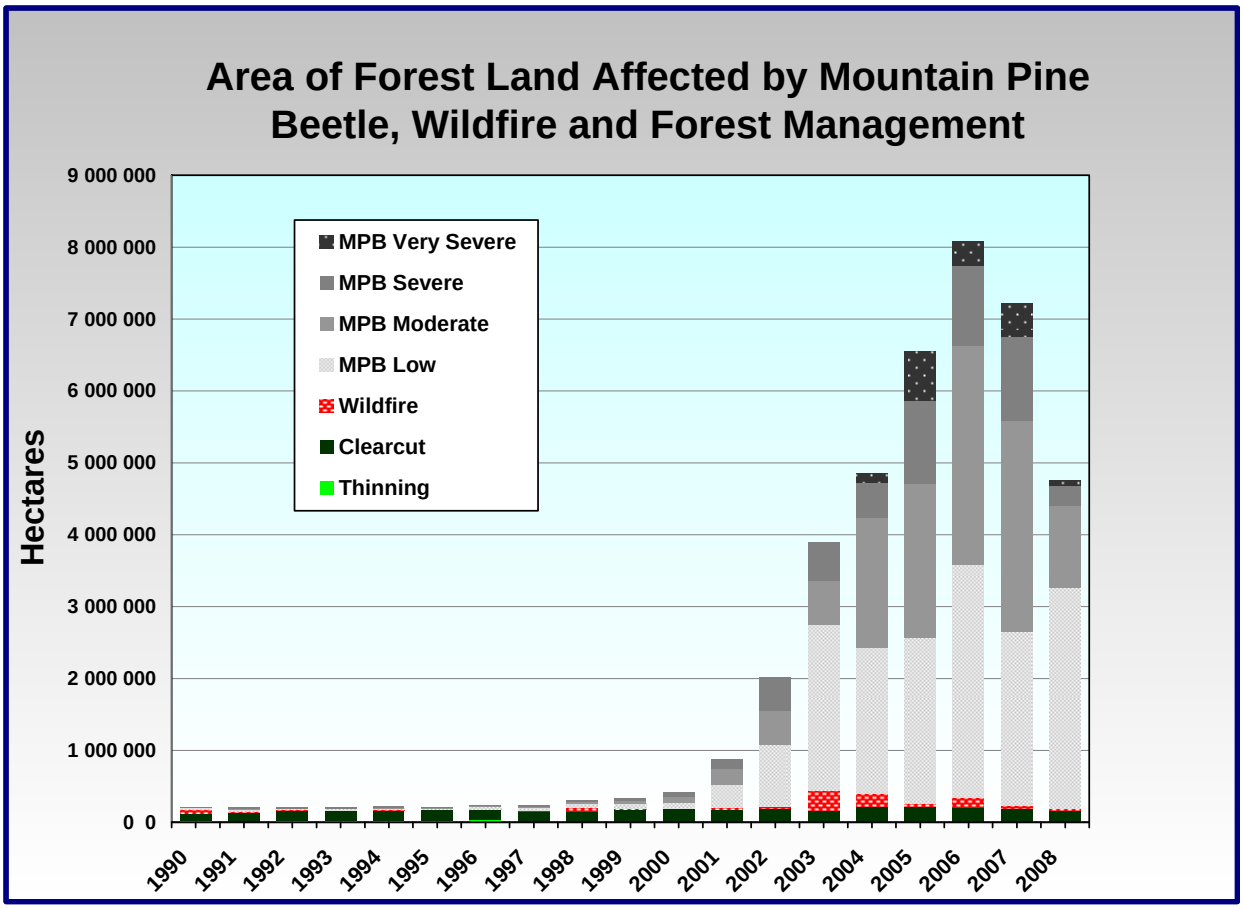


Figure 25: Area of Forest Land Affected by Mountain Pine Beetle, Wildfire and Forest Management

[39] Detailed data on area affected by various factors can be found in Table 40.

"Cropland Remaining Cropland" Category

Emissions from cropland (i.e., the "cropland remaining cropland" category) were 252 kilotonnes of CO_2e in 2008. These emissions are being reported as a "memo item". This is a decrease of 16.7% between 2005 and 2008 and an increase of 9.1% from 1998 emissions. These changes can be attributed, in part, to changes in the area of cropland in the province. Total cropland area in 2008 (1 627 500 hectares) was 7.3% higher than in 2005, and 22.0% higher than in 1998. Trends in emissions and cropland area from 1990 to 2008 are shown in Figure 26: "Cropland Remaining Cropland" – Net GHG Emissions and Area. Other factors impacting emissions from cropland management include lime application, cultivation of organic soils, changes in the management of mineral soils and changes in woody biomass.[40] Note that the drop in emissions between 2008 and 2006 is due to a change in NIR methodology where only the 2007 and 2008 estimates were updated. The actual short-term emission changes will become evident with the release of 1990-2009 data.

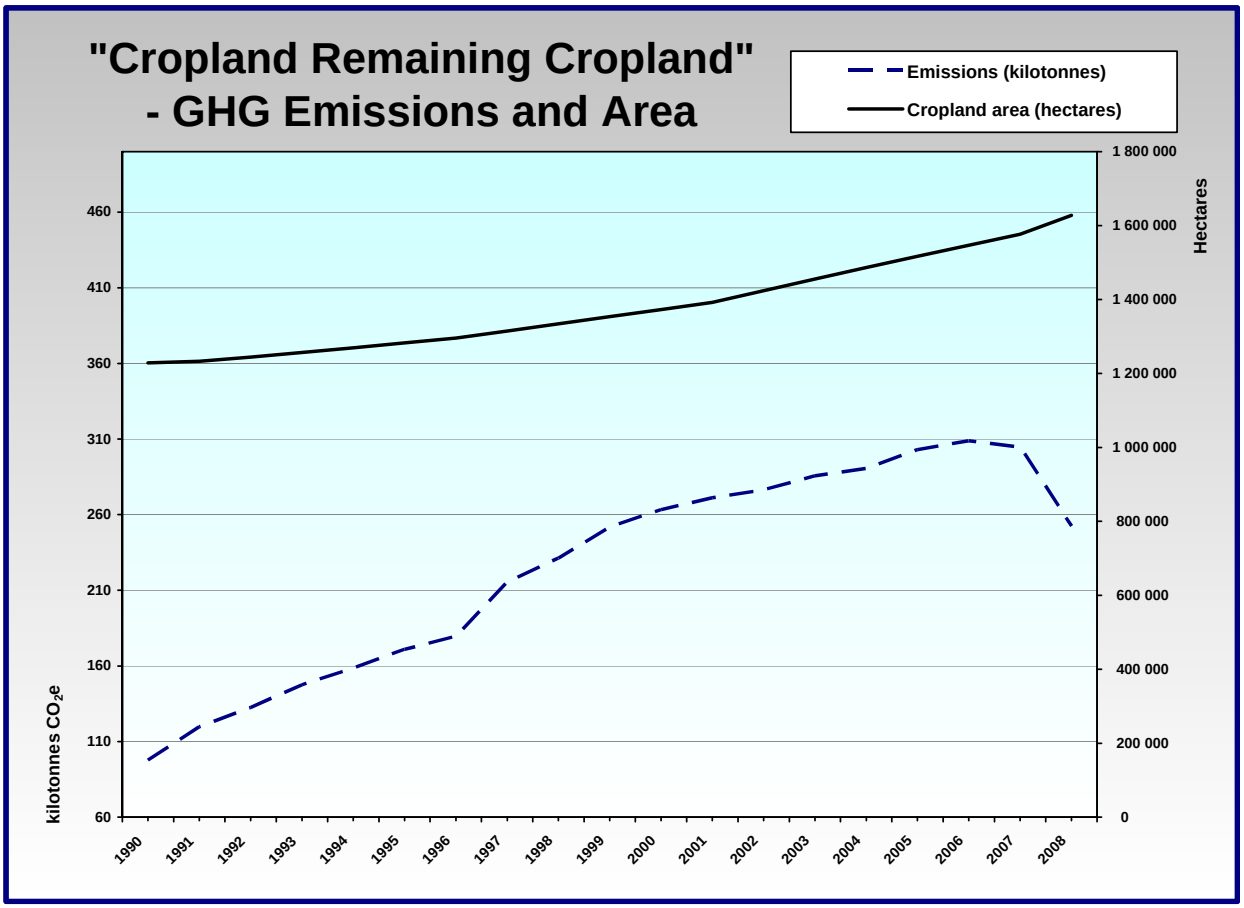


Figure 26: "Cropland Remaining Cropland" – Net GHG Emissions and Area

[40] Refer to the national inventory report for further description of these factors.

"Wetlands Remaining Wetlands" Category

Emissions from wetlands (i.e., the "wetlands remaining wetlands" category) were 40 kilotonnes CO_2e in 2008. These emissions are being reported as a "memo item". This is a 33.2% decrease from 2005 and a 58.0% decrease from 1998. The emissions trend for B.C. between 1990 and 2008 is shown in Figure 27. The steady decline in emissions is attributed to the fact that no new flooded area has been reported since 1993. As a result, there have been steady reductions in the residual decay of flooded biomass that was either cleared prior to reservoir flooding or left standing. Note that the drop in emissions between 2008 and 2006 is due to a change in NIR methodology where only the 2007 and 2008 estimates were updated. The actual short-term emission changes will become evident with the release of 1990-2009 data.

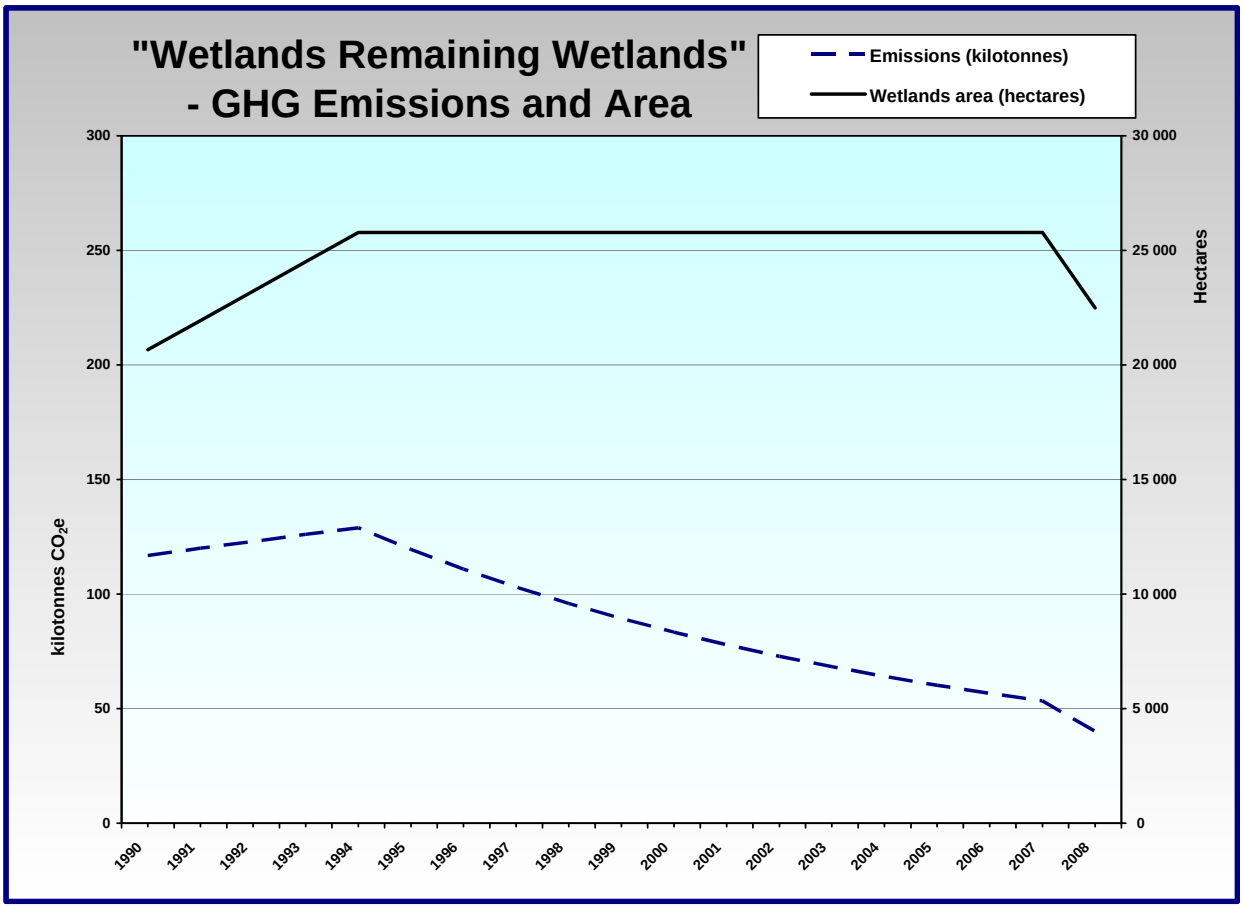


Figure 27: "Wetlands Remaining Wetlands" – Net GHG Emissions and Area

9.3 Data Sources

Estimation of GHG emissions in the land use, land-use change and forestry sector requires extensive modeling of variables and parameters developed from a wide range of data sources. This section of the report provides an overview of modeling and data sources – a more detailed description of modeling procedures and data sources can be found in the NIR (section A3.4). Note also that this report does not document data sources for categories in which the emissions are zero (c.f. Table 25) or for which an estimation has not been provided in this report.

Afforestation, Deforestation and "Forest Land Remaining Forest Land" Category

Version 3 of the Carbon Budget Model (CBM) of the Canadian Forest Service (CFS)[41] was used to estimate GHG emissions and removals related to B.C.'s managed forests. This is a comprehensive modeling system that accounts for various data pertaining to managed forests, including:

- Forest inventory information including forest age, area and species composition
- Ecosystem processes including growth, litter fall, natural tree mortality and decomposition
- Natural disturbances (e.g., wildfires)
- Management activities including commercial thinning, clear-cutting, partial-cutting, salvage-cutting and controlled burning of harvest residues
- Carbon transfers between the atmosphere and forest sinks including dead organic matter, woody debris, standing volume and soil carbon
- Removals of merchantable biomass (i.e., logging)
- Conversion of forests for other land use (i.e., deforestation)
- Conversion of other land types into forested land (i.e., afforestation)

Activity data used in the CBM are compiled by the CFS in collaboration with experts in the B.C. government. Significant updates have been made to the CBM through joint effort between the CFS and provincial Ministries of Forests and Range, Environment and Agriculture and Lands. Recent updates include a more complete account of afforestation projects that occurred between 2005 to 2008, a significant expansion of the CFS deforestation sample network in B.C. and refinement of deforestation satellite image mapping (incorporating new high resolution data sources and expert validation, as well as an update to include the 2000 to 2008 time period). This work has utilized existing national reporting methodologies, and with the intention that it will be incorporated into upcoming national inventory reports.

A description of activity data and data sources for the various emission sources/sinks in this category are given in Table 29.

Table 29: Activity Data and Data Sources for Afforestion and Deforestation and Forest Land Categories

Emission Category	Activity	Data Sources
Afforestation	Area of afforestation	Canadian Forest Service National Afforestation Inventory, with Ministry of Forests update to database for 2005-2008 years
Deforestation	Area of deforestation	Canadian Forest Service Deforestation Event GIS Database – sample based satellite and aerial photograph interpretation combined with records data
Forest Land	Area of forest Growth rates Area of wildfire Area of mountain pine beetle impact Quantity of wood harvested	Ministry of Forests and Range

[41] See: http://carbon.cfs.nrcan.gc.ca/index_e.html

Emission Category	Activity	Data Sources
Afforestation, Deforestation, Forest Land	Quantity of CO_2 removals due to tree growth	Canadian Forest Service Carbon Budget Model (CBM-CFS3)
	Quantity of CO_2 eq. emitted due to decomposition, fire and harvest	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories
	Quantity of CO_2 removals due to crop growth	Inventory Methods Manual for Estimating Canadian Emissions of Greenhouse Gases, Environment Canada
		CBM-CFS3: A model of carbon-dynamics in forestry and land-use change implementing IPCC standards. Ecological Modelling 220(4): 480-504. Kurz, W. A., C. C. Dymond, White, T. M., Stinson, G., Shaw, C. H., Rampley, G. J., Smyth, C., Simpson, B. N., Neilson, E. T., Trofymow, J. A., Metsaranta, J., Apps, M. J. 2009
		Developing Canada's National Forest Carbon Monitoring, Accounting and Reporting System to meet the reporting requirements of the Kyoto Protocol. Mitigation and Adaptation Strategies for Global Change 11(1): 33-43. Kurz, W. A. and M. J. Apps 2006
		Good Practice Guidance for Land Use, Land-Use Change and Forestry. IPCC National Greenhouse Gas Inventories Programme. Published by the Institute for Global Environmental Strategies (IGES) for the IPCC. : 4.91-4.124. IPCC 2004
		Coordinating the Interaction of National Greenhouse Gas Accounting Systems for Forestry and Agriculture, Victoria, B.C. Canada, Canadian Forest Service, Natural Resources Canada and Agriculture and Agri-Foods Canada. Kurz, W. A. and B. McConkey 2003
		National Carbon and Greenhouse-Gas Emission Accounting and Verification System for Agriculture (NCGAVS). OECD Expert Meeting on Soil Organic Carbon Indicators for Agricultural Land, Ottawa, Canada. McConkey, B. G., C. M. Monreal, et al. 2002

"Cropland Remaining Cropland" Category

A description of activity data and data sources for the various emission sources/sinks in this category are given in Table 30.

Table 30: Activity Data and Data Sources for Cropland Remaining Cropland

Emission Category	Activity	Data Sources
CO_2 emissions and removals in mineral soils	Relative proportion of annual and perennial crops Tillage practices Area of summer fallow	Census of Agriculture
CO_2 emissions and removals from cultivation of organic soils	Area of cultivated soils	Land area: Soil and crop specialists reporting to Environment Canada Emission factor: IPCC 2006 Guidelines for National Greenhouse Gas Inventories
CO_2 emissions and removals in woody biomass	Area of vineyards, fruit orchards and Christmas tree plantations	Census of Agriculture

"Wetlands Remaining Wetlands" Category

A description of activity data and data sources for the various emission sources/sinks in this category are given in Table 31.

Table 31: Activity Data and Data Sources for Wetlands Remaining Wetlands

Emission Category	Activity	Data Sources
CO_2 emissions from reservoir surface	Decomposition of soil organic carbon from flooded land	Canadian Reservoir Database. Duchemin 2002
CO_2 emissions from cleared biomass	Decomposition of organic matter cleared prior to flooding and placed outside the reservoir and/or burning of cleared biomass	Canadian Forest Service Carbon Budget Model (CBM-CFS3)

10. ANNEXES

10.1 Abbreviations, Acronyms and Measures

Table 32: Abbreviations, Acronyms and Measures

Abbreviation, Acronym or Measure	Definition
Al_2O_3	Alumina
B.C.	British Columbia
CAC	Criteria Air Contaminant
CANSIM	Canadian Socio-economic Information Management System (Statistics Canada)
CAPP	Canadian Association of Petroleum Producers
CBM	Carbon Budget Model
CEEI	Community Energy and Emissions Inventory
CEPA	*Canadian Environmental Protection Act*
c.f.	refer to
CFCs	Chlorofluorocarbons
CFS	Canadian Forest Service
CGA	Canadian Gas Association
CH_4	Methane
CIEEDAC	Canadian Industrial Energy End-Use Data and Analysis Centre
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent – 1 CO_2e is the GWP from the release of 1 kg of CO_2
CPPI	Canadian Petroleum Products Institute
EC	Environment Canada
e.g.	for example
g	grams
GDP	Gross domestic product
GGRTA	*Greenhouse Gas Reductions Target Act*
GHG	Greenhouse gas
GWh	gigawatt hours
GWP	Global warming potential
GJ	gigajoule
GTIS	Global Trade Information Services
ha	hectares

Abbreviation, Acronym or Measure	Definition
HFCs	Hydrofluorocarbons
i.e.	that is
IPCC	Intergovernmental Panel on Climate Change
kg	kilograms
km	kilometres
kt	kilotonnes (thousand tonnes)
kWh	kilowatt hours
L	litres
LULUCF	Land use, land-use change and forestry (sector of emissions)
m^3	cubic metres
MEMPR	(B.C.) Ministry of Energy, Mines and Petroleum Resources
MGEM	Mobile Greenhouse Gas Emission Model
MGO	Marine gas oil
Mha	mega hectares (million hectares)
MPB	Mountain Pine Beetle (infested forest)
Mt	megatonnes (million tonnes)
N/A	Not applicable
NAICS	North American Industry Classification System
NIR	National Inventory Report
N_2O	Nitrous oxide
NPP	Net primary production
NRCan	Natural Resources Canada
PFCs	Perfluorocarbons
ppm	parts per million
QA/QC	Quality assurance/quality control
RESD	Report on Energy Supply and Demand in Canada
SF_6	Sulphur hexafluoride
STP	Standard temperature and pressure
TJ	terajoule
UNFCCC	United Nations Framework Convention on Climate Change
VOC	Volatile organic compound

10.2 Global Warming Potentials for Greenhouse Gases

For an explanation of global warming potential (GWP) and sources for additional information see section 2 of this report.

Table 33: Global Warming Potentials for Greenhouse Gases[42]

GHG	Formula	100-Year GWP
Carbon Dioxide	CO_2	1
Methane	CH_4	21
Nitrous Oxide	N_2O	310
Sulphur Hexafluoride	SF_6	23 900
Hydrofluorocarbons (HFCs)		
- HFC-23	CHF_3	11 700
- HFC-32	CH_2F_2	650
- HFC-41	CH_3F	150
- HFC-43-10mee	$C_5H_2F_{10}$	1 300
- HFC-125	C_2HF_5	2 800
- HFC-134	$C_2H_2F_4$ (CHF_2CHF_2)	1 000
- HFC-134a	$C_2H_2F_4$ (CH_2FCF_3)	1 300
- HFC-143	$C_2H_3F_3$ (CHF_2CH_2F)	300
- HFC-143a	$C_2H_3F_3$ (CF_3CH_3)	3 800
- HFC-152a	$C_2H_4F_2$ (CH_3CHF_2)	140
- HFC-227ea	C_3HF_7	2 900
- HFC-236fa	$C_3H_2F_6$	6 300
- HFC-245ca	$C_3H_3F_5$	560
Perfluorocarbons (PFCs)		
- Perfluoromethane	CF_4	6 500
- Perfluoroethane	C_2F_6	9 200
- Perfluoropropane	C_3F_8	7 000
- Perfluorobutane	C_4F_{10}	7 000
- Perfluorocyclobutane	c-C_4F_8	8 700
- Perfluoropentane	C_5F_{12}	7 500
- Perfluorohexane	C_6F_{14}	7 400

10.3 Emission Factors

The following emission factors are drawn or derived from those listed in Annex 8 of the National Inventory Report and are those most commonly used in British Columbia. Additional emission factors are provided in the NIR and/or are developed on the basis of site, time and source-specific fuel testing. For additional information regarding the purpose and use of emission factors see section 2 of this report.

[42] BC currently uses global warming potentials established in the IPCC second assessment report. See www.ipcc.ch/index.htm

Emission Factors for Fuel Combustion

Table 34: Emission Factors for Fuel Consumption

Fuel Type	CO_2	CH_4	CH_4 (CO_2e)	N_2O	N_2O (CO_2e)	CO_2e	Units
Natural Gas - Producer Consumption	2 151	6.5	136.5	0.06	18.6	2 306.1	g/m³
Natural Gas – Industrial Consumption[1]	1 916	0.037	0.777	0.033	10.23	1 927.0	g/m³
Natural Gas – Pipelines	1 916	1.9	39.9	0.05	15.5	1 971.4	g/m³
Natural Gas – Vehicles at STP	1 890	9	189	0.06	18.6	2 097.6	g/m³
Natural Gas – Vehicles, Compressed[2]	2 723	13.0	272.3	0.1	26.8	3 022.5	g/kg
Gasoline – On-road Vehicles[3]	2 289	0.12	2.52	0.16	49.6	2 341.1	g/L
Gasoline – Off-road Vehicles	2 289	2.7	56.7	0.05	15.5	2 361.2	g/L
Gasoline – Boats	2 289	1.3	27.3	0.066	20.46	2 336.8	g/L
Diesel – Stationary Combustion	2 663	0.133	2.793	0.4	124	2 789.8	g/L
Diesel – On-road Vehicles - Light Duty	2 663	0.068	1.428	0.22	68.2	2 732.6	g/L
Diesel – On Road Vehicles - Heavy Duty[3]	2 663	0.12	2.52	0.082	25.42	2 690.9	g/L
Diesel – Off-Road Vehicles	2 663	0.15	3.15	1.1	341	3 007.2	g/L
Diesel – Train	2 663	0.15	3.15	1.1	341	3 007.2	g/L
Diesel – Ships	2 663	0.15	3.15	1.1	341	3 007.2	g/L
Light Fuel Oil – Ships	2 725	0.26	5.46	0.073	22.63	2 753.1	g/L
Light Fuel Oil – Industrial[4]	2 725	0.006	0.126	0.031	9.61	2 734.7	g/L
Light Fuel Oil – Residential	2 725	0.026	0.546	0.006	1.86	2 727.4	g/L
Light Fuel Oil – Commercial and Institutional[6]	2 725	0.026	0.546	0.031	9.61	2 735.2	g/L
Heavy Fuel Oil – Ships	3 124	0.28	5.88	0.079	24.49	3 154.4	g/L
Heavy Fuel Oil – Industrial[4]	3 124	0.12	2.52	0.064	19.84	3 146.4	g/L
Aviation Gasoline	2 342	2.2	46.2	0.23	71.3	2 459.5	g/L
Aviation Turbo Fuel	2 534	0.08	1.68	0.23	71.3	2 607.0	g/L
Kerosene[4]	2 534	0.006	0.126	0.031	9.61	2 543.7	g/kg
Coal – Canadian Bituminous [4]	2 070	0.03	0.63	0.02	6.2	2 076.8	g/kg
Coal – Sub-Bituminous [4]	1 770	0.03	0.63	0.02	6.2	1 776.8	g/kg
Coal – Foreign Bituminous [4]	2 430	0.03	0.63	0.02	6.2	2 436.8	g/kg
Coal Coke	2 480	0.03	0.63	0.02	6.2	2 486.8	g/L
Petroleum Coke – Upgrading Facilities	3 494	0.12	2.52	0.0231	7.161	3 503.7	g/L
Petroleum coke – Refineries and Others	3 826	0.12	2.52	0.0265	8.215	3 836.7	g/L
Propane – Residential[5]	1 510	0.027	0.567	0.108	33.48	1 544.0	g/L
Propane Vehicles	1 510	0.64	13.44	0.028	8.68	1 532.1	g/L
Butane	1 730	0.024	0.504	0.108	33.48	1 764.0	g/L
Ethane	976	0	0	0	0	976.0	g/m³
Coke Oven Gas	1 600	0.037	0.777	0.035	10.85	1 611.6	g/m³
Still Gas – Upgrading Facilities	2 140	0	0	0.000022	0.00682	2 140.0	g/m³
Still Gas – Refineries and Others	1750	0	0	0.000022	0.00682	1750.0	g/m³
Tires - Cement	85	N/A	N/A	N/A	N/A	85.0	Kg/GJ
Wood Waste (50% moisture content)	950	0.05	1.05	0.02	6.2	957.3	g/kg
Wood Waste (15% moisture content)[6]	1 590	0.51	10.71	0.068	21.08	1 621.8	g/kg
Spent Pulping Liquor (i.e., black liquor)	1 428	0.05	1.05	0.02	6.2	1 435.3	g/kg
Biodiesel[3]	2 449	0.12	2.52	0.082	25.42	2 476.9	g/L
Ethanol[3]	1 494	0.12	2.52	0.16	49.6	1 546.1	g/L

Fuel Type	CO_2	CH_4	CH_4 (CO_2e)	N_2O	N_2O (CO_2e)	CO_2e	Units
Landfill Gas - Industrial Consumption	54 600	1	21	0.1	31	54 652	Kg/TJ
Petrochemical Feedstocks	500	0	0	0	0	500	g/L
Napthas	625	0	0	0	0	625	g/L
Lubricating Oils and Greases	1 410	0	0	0	0	1 410	g/L
Petroleum Used for Other Products	1 450	0	0	0	0	1 450	g/L

[1] Emission factors applicable to manufacturing and other industry. For emission factors for other sectors – including electric utilities, construction, commercial/institutional, residential and agriculture – refer to the National Inventory Report (NIR).

[2] Density of natural gas is 0.694 kg/m^3 at STP. Estimate provided by B.C. Ministry of Energy Mines and Petroleum Resources.

[3] Emission factor varies slightly for different vehicle types and technologies – refer to the NIR for specific values.

[4] Emission factor for industrial use. Emission factors for other uses may vary slightly – refer to the NIR for these values.

[5] Emission factor varies slightly for other uses of propane – refer to NIR for these values.

[6] Sourced from U.S. Environmental Protection Agency, Inventory of Greenhouse Gas Emissions and Sinks: 1990-2008 (2009).

Emission Factors for Fugitive Emissions and Industrial Processes

Table 35: Emission Factors for Fugitive Emissions and Industrial Processes

Industrial Process[2]	Activity	Emission Factors					Unit
		CO_2	CH_4	CF_4	C_2F_6	CO_2 e	
Coal Mining	Underground Coal Production	0	4.1	0	0	86.1	kg/tonne coal
	Surface Coal Production	0	0.58	0	0	12.2	kg/tonne coal
Limestone Use	Glass production, non-ferrous metal production, pulp and paper mills, other chemical uses	418	0	0	0	418	kg/tonne feed
Dolomite Use	Glass production, magnesium production, smelting of iron and steel	468	0	0	0	468	kg/tonne product
Soda Ash Use	Glass manufacturing	415	0	0	0	415	kg/tonne feed
Cement Production	Limestone calcination	507	0	0	0	507	kg/tonne product
Lime Production	Limestone calcination (high calcium lime)	751	0	0	0	751	kg/tonne product
	Limestone calcination (dolomitic lime)	889	0	0	0	889	kg/tonne product
Primary Aluminium[1]	Electrolysis - Side-worked pre-baked	1 600	0	1.6	0.4	15 680	kg/tonne product
	Electrolysis - Centre-worked pre-baked	1 600	0	0.4	0.04	4 568	kg/tonne product
	Electrolysis - Horizontal stud Søderberg	1 700	0	0.04	0.03	2 236	kg/tonne product
	Electrolysis - Vertical Stud Søderberg	1 700	0	0.8	0.04	7 268	kg/tonne product

[1] Emission factors are average factors and are not used for developing emission estimates for recent years

[2] Refer to the NIR for emission factors pertaining to "other and undifferentiated production"

Emission Factors for Electricity

Table 36: Emission Factors for Electricity

Year	1990	2000	2004	2005	2006	2007	2008
Category	Electricity Generation (GWh)						
Refined Petroleum Products	98	40	45	26	28	60	87
Natural Gas	1 258	3 346	2 233	2 368	2 075	2 991	4 074
Hydro	46 438	50 798	45 024	50 305	44 464	54 706	48 634
Biomass	0	547	716	650	620	846	0
Total	47 794	54 731	48 018	53 350	47 187	58 603	52 795
	Greenhouse Gas Intensity (tonnes GHG per GWh electricity produced)						
CO_2 Intensity (tonnes/GWh)	17	33	17	17	18	15	15.4
CH_4 Intensity (tonnes/GWh)	0	0	0	0	0	0	0
N_2O Intensity (tonnes/GWh)	0	0	0	0	0	0	0
Overall Intensity (tonnes CO_2e/GWh)	17	33	17	17	18	15	15.4

10.4 Land Use, Land-use Change and Forestry Sector Data Tables

Table 37: Activities Considered as Deforestation by Industrial Sector

Industrial Sector	Description of Activities Considered to be "Deforestation" of Forest Lands
Forestry	Construction of permanent forest roads and logging landings, forest road and human-induced rock slide scars
Hydro infrastructure	Clearing of hydro line right of ways, hydro dam and "earthfill" infrastructure
Industry	Light and heavy industrial buildings/sites, shopping malls, prisons, parking lots, schools, universities and similar infrastructure
Mining	Open pit coal, copper/molybdenum, limestone, zinc and other mines, as well as infrastructure for under-ground mines
Municipal	Urban and rural residential developments (including some roads), open fields, gravel pits/quarries
Oil and gas	Well pads, pipelines and seismic lines
Recreation	Campgrounds, golf courses, ski runs, etc.
Transportation	Highways, railways, airstrips, etc.
Agriculture	Conversion to croplands and cleared pasture

Table 38: Area of Afforestation and Deforestation - by Industrial Sector

Year	1990	1995	1998	2000	2004	2005	2006	2007	2008
Industrial Sector	Area Affected (hectares)								
Afforestation Total[1]	-1 370	-3 032	-1 902	-1 902	-1 948	-2 428	INC[2]	INC[2]	INC[2]
Deforestation Total	10 509	6 998	6 782	6 656	6 233	6 197	6 223	6 223	6 623
Sectors contributing to deforestation									
Agriculture	5 207	2 897	2 523	2 275	1 777	1 777	1 777	1 777	1 777
Forestry	1 159	1 151	1 042	969	824	824	824	824	824
Oil & Gas, Mining and Hydro Infrastructure	1 733	922	1 249	1 484	1785	1 749	1 774	1 774	1 774
Oil and Gas	243	334	575	793	1 170	1 134	1 134	1 134	1 134
Mining	645	588	674	691	615	615	615	615	615
Hydro Infrastructure	845	0	0	0	0	0	25	25	25
Settlement and Transportation	2 409	2 025	1 966	1 926	1 847	1 847	1 847	1 847	1 847
Industry	152	102	126	142	174	174	174	174	174
Municipal	1 684	1 478	1 458	1 446	1 420	1 420	1 420	1 420	1 420
Recreation	229	249	202	171	108	108	108	108	108
Transportation	344	196	179	168	145	145	145	145	145

[1] Negative sign signifies area added to forest lands (i.e., "removed" from affected area of forest)

[2] Incomplete data: Current estimates in 2006 and 2007 are 28 and 430 hectares, respectively. These likely represent only a portion of the total afforestation area in the province. Efforts are underway to collect a more complete dataset.

Table 39: Approximate Forestry Emissions - by Terrestrial Ecozone

Year	1990	1995	1998	2000	2004	2005	2006	2007	2008
	Approximate Forestry Emissions (kt)								
Terrestrial Ecozone									
Pacific Maritime (net emissions)	37 744	27 483	26 372	29 953	35 672	33 264	27 118	23 977	16 481
NPP and Decay of Dead Organic Matter (net)	9 309	2 033	107	308	-521	-144	-582	-1 489	-3 074
Harvest	26 114	23 804	24 570	28 000	30 791	31 324	26 760	24 170	18 732
Wildfire	679	228	578	-	4 816	792	236	237	346
Slashburn	1 641	1 419	1 117	1 645	587	1 293	705	1 060	477
All Other[1] Ecozones (net emissions)	-64 508	-60 356	-59 448	-61 036	12 680	3 769	37 788	28 321	16 353
NPP and Decay of Dead Organic Matter (net)	-64 508	-112 041	-112 586	-111 663	-79 728	-59 375	-43 765	-32 195	-33 893
Harvest	41 240	44 244	35 559	43 545	48 543	47 902	46 246	44 632	36 577
Wildfire	7 580	588	11 525	374	35 125	6 963	26 844	8 081	6 209
Slashburn	3 720	6 852	6 053	6 707	8 740	8 279	8 464	7 803	7 460
PROVINCIAL TOTAL (net emissions)	-26 764	-32 873	-33 076	-31 083	48 353	37 034	64 906	52 298	32 834
NPP and Decay of Dead Organic Matter (net)	-107 738	-110 008	-111 556	-111 355	-80 249	-59 519	-44 347	-33 684	-36 967
Harvest	67 354	68 048	60 129	71 545	79 334	79 226	73 006	68 802	55 309
Wildfire	8 260	816	12 103	374	39 941	7 755	2 920	8 318	6 555
Slashburn	5 361	8271	7 170	8352	9 327	9 572	9 169	8 863	7 937

Note: a negative value indicates removals of carbon dioxide equivalent (a sink, or sequestration); a positive value indicates a release (or source)

[1] Montane Cordillera, Boreal Cordillera, Boreal Plains and Taiga Plains

Table 40: Area of Forest Land Affected – by Category of Activity[43]

Activity Category	Thinning	Clear-cut	Wildfire	MPB Low	MPB Moderate	MPB Severe	MPB Very Severe	Total MPB
Year	Area Affected (hectares)							
1990	10 545	114 345	49 733	24 662	6 226	7 137	-	38 025
1991	14 351	127 755	14 163	16 019	9 692	21 407	-	47 118
1992	23 842	138 232	11 780	16 429	6 343	20 893	-	43 665
1993	25 637	144 278	991	10 251	14 946	19 242	-	44 439
1994	20 958	146 524	17 939	4 571	11 675	14 825	-	31 071
1995	24 553	149 283	3 781	10 707	7 876	8 044	-	26 627
1996	28 900	146 919	10 619	30 193	7 111	6 784	-	44 088
1997	10 287	150 141	1 377	38 529	17 920	12 970	-	69 419
1998	8 924	145 556	49 704	48 340	26 763	20 595	-	95 698
1999	7 173	173 632	7 912	69 278	44 897	31 497	-	145 672
2000	10 971	178 627	2 173	81 698	79 483	68 564	-	229 745
2001	8 231	166 744	30 506	322 496	213 576	132 581	-	668 653
2002	9 245	183 059	37 639	850 758	470 450	467 892	-	1 789 100
2003	6 938	155 679	279 935	2 306 803	609 931	536 303	-	3 453 037
2004	6 672	210 978	187 776	2 015 498	1 817 089	493 301	126 219	4 452 107
2005	4 330	215 163	38 838	2 306 430	2 138 578	1 171 516	669 892	6 286 416
2006	3 085	203 933	132 758	3 245 821	3 041 564	1 117 089	332 509	7 736 983
2007	3 491	196 561	34 769	2 411 795	2 933 054	1 178 847	459 638	6 983 333
2008	2 816	161 278	32 873	3 061 167	1 149 534	283 431	65 094	4 559 226

[43] For comparative purposes and as part of the provincial inventory compilation in collaboration with the Canadian Forest Service, the total area of forest in B.C. was estimated by the Ministry of Forests and Range to be 66 821 657 ha in 2008.

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