

BRITISH COLUMBIA

GREENHOUSE GAS

INVENTORY REPORT 2007



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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/epd/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 2007* (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 removals² 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 represents the 2007 baseline against which progress towards these targets will be measured. Following the 2007 report, the Ministry of Environment (the ministry) will prepare a B.C. GHG inventory report for every even subsequent year (i.e., 2008, 2010, 2012 and beyond) of data.

This report has been prepared by the ministry, working with staff in other provincial ministries and with federal counterparts, to determine and report the 2007 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 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/epd/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 is the same data presented in Environment Canada's *National Inventory Report on Greenhouse Gases and Sinks in Canada* (National Inventory Report – NIR). The B.C. GHG inventory report also includes data provided to the ministry by the GHG Division of Environment Canada that is not published in the NIR, where needed to report emissions at a provincial scale.
- ♦ 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/epd/codes/ggta/index.htm

² The term “removal” is used to describe the removal of CO₂ 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 (e.g., for business confidentiality reasons).
- ◆ The ministry will continue to use NIR data exclusively in future B.C. GHG inventory reports, and will continue to work collaboratively with federal counterparts to review and update GHG quantification methodologies used in the NIR.
- ◆ Where needed to address legislated and policy responsibilities, the ministry will establish sound and consistent methodologies, based on recognized best practices, for B.C.-specific GHG source and sink reporting not included in the NIR. Emissions from these sources and sinks will not be counted towards B.C.'s 2007 base year emissions and will not be used to measure progress against targets until such a time that these sources and sinks are included in the NIR. The ministry will document the methodologies and any recalculations involved in such practices, refine reporting practices and work with national counterparts to incorporate any findings into the national reporting process as appropriate.
- ◆ The ministry will continue 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 SF₆, 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; 2) emissions from hydrofluorocarbon, soda ash, limestone and dolomite use reported under the “industrial processes” sector; and 3) SF₆ from electrical generation, transmission and distribution equipment. As a result of including these categories, reported emissions in this B.C. Provincial GHG Report are 4.2 megatonnes CO₂e (6.7%) higher than the emissions reported for B.C. in the National Inventory 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 2007 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 report also includes annexes listing acronyms used in the document, emission factors used in calculating emissions and other supporting information.

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 CO₂e) 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.

³ See: www.ec.gc.ca/pdb/ghg/inventory_e.cfm

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 that are influenced by human activities that are of interest:

- ♦ Carbon dioxide (CO₂)
- ♦ Methane (CH₄)
- ♦ Nitrous oxide (N₂O)
- ♦ Synthetic (not naturally occurring) fluorinated gases – sulphur hexafluoride (SF₆), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs)

Atmospheric concentrations of GHGs have grown significantly in the past centuries – since 1750 the concentration of CO₂ has increased by 35%, of CH₄ by 155% and of N₂O by 18%. These trends can be largely attributed to human activities, mostly fossil fuel use and permanent loss of forest cover.⁴

The concept of “global warming potential” (GWP or CO₂e) has been developed to enable comparison of the ability of different GHGs to trap heat in the atmosphere (radiative forcing).⁵ By definition, the GWP from the release of 1 kg of CO₂ is one, with the GWP of other GHGs stated relative to CO₂. 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 summary table lists the “100-Year GWP” (as recommended by the International Panel on Climate Change) for the major gases and groups of gases.^{6,7}

⁴ This data is drawn from the third assessment report (AR3) of the Intergovernmental Panel on Climate Change (IPCC). The IPCC Climate Change 2007 Synthesis Report “Summary for Policymakers” is a brief and authoritative reference for further information on climate change science. For additional information regarding climate change and GHG emissions inventories, see www.ipcc.ch/index.htm or the introductory chapter of the (Canadian) National Inventory Report.

⁵ 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).

⁶ 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.

⁷ The ministry is following developments regarding emerging greenhouse gases such as nitrogen trifluoride (NF₃), trifluoromethyl sulphur pentafluoride (SF₅CF₃), fluorinated ethers, perfluoropolyethers, hydrocarbons 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

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 ₂ O)	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 CO₂ emitted per litre diesel burned, 0.4 kg of CH₄ 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 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.

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,

⁸ See: <http://unfccc.int>

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 of GHGs in a given year are required to report emissions to Environment Canada.⁹ Emissions data by facility is made publicly available. In 2007, 350 facilities across Canada reported GHG emissions for the 2007 calendar year, totaling 278 Mt of GHGs (37% of national total). Of this number, 41 facilities were located in B.C., and were responsible for 12.7 Mt of emissions (19% of provincial total). 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 Inventory Efforts

The provincial government has indicated its intent to require annual facility-specific greenhouse gas inventory reports under the authority of the *Greenhouse Gas Reduction (Cap and Trade) Act*.¹⁰ Ministry of Environment staff will ensure that any data collected under this legislation will support provincial and national emissions facility and inventory reporting. Ministry staff will work collaboratively with federal counterparts to develop and improve current and scientifically rigorous best practices and methodologies used to quantify GHG emissions.

The Ministry of Environment has also initiated a province-wide Community Energy and Emissions Inventory (CEEI)¹¹ to support tracking and reporting energy use and GHG emissions at a community level. CEEI will provide local governments across B.C. with consistent GHG inventory baseline data, analysis, ongoing monitoring and periodic reports. The CEEI will inform and support community-level understanding and decision making, as well as provincial GHG reduction objectives.

Data collected under facility-specific reporting and the CEEI may be used to refine (where applicable) the GHG quantification methodologies used in the NIR and also, consequently, the B.C. GHG inventory report.

⁹ See: http://www.ec.gc.ca/pdb/ghg/facility_e.cfm for both a description of the reporting system and a link to the public data download site.

¹⁰ See: www.env.gov.bc.ca/epd/codes/ggrcta

¹¹ See: www.env.gov.bc.ca/epd/climate/ceei/index.htm

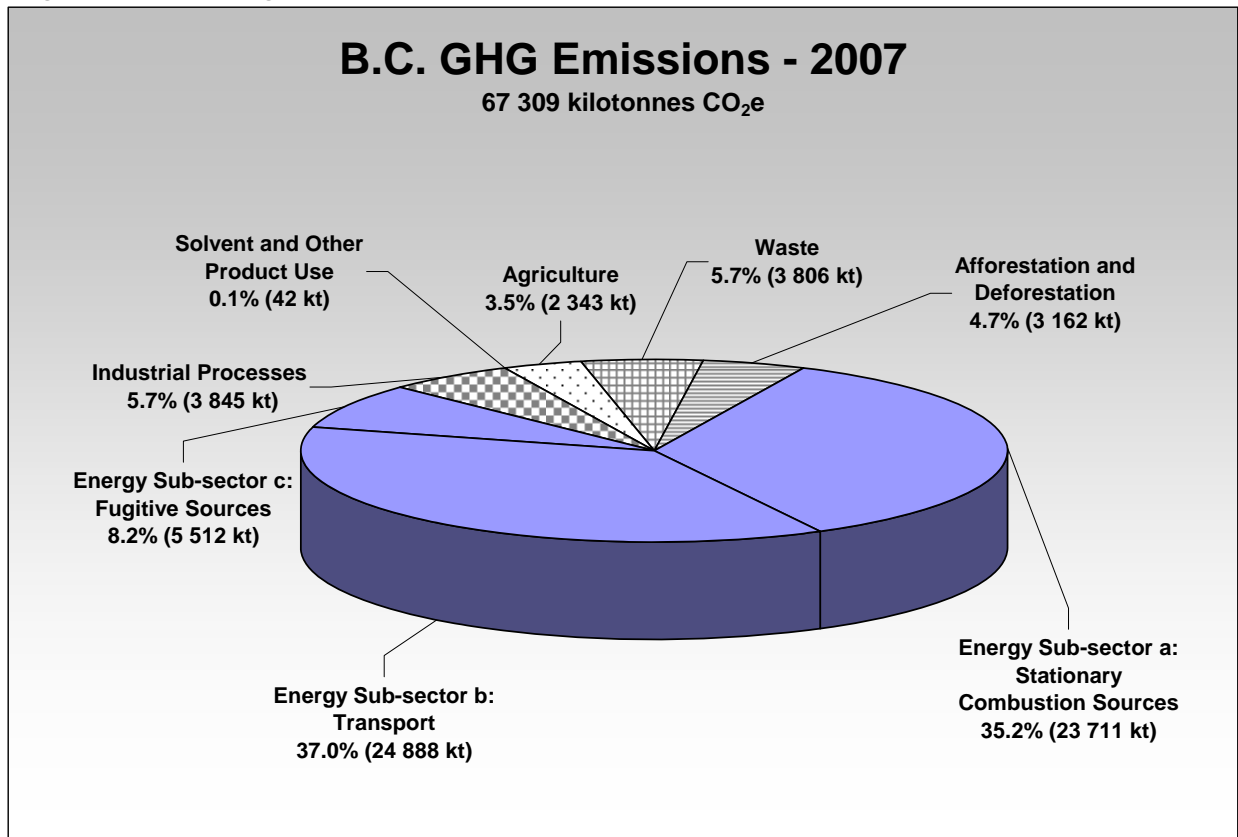
3. B.C. GHG EMISSIONS – 2007

3.1 B.C. GHG Emissions by Sector – 2007

The year 2007 was established under the provincial *Greenhouse Gas Reductions Target Act*¹² as the base year for calculation of B.C. GHG emissions targets.

Total greenhouse gas emissions in British Columbia in 2007 were 67.3 megatonnes (Mt) CO₂e.¹³

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 2007 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.



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

Figure 1: B.C. GHG Emissions – 2007

¹² 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 2007 levels by 2050. See: www.env.gov.bc.ca/epd/codes/ggrta

¹³ One megatonne (1 Mt) is one million tonnes. One kilotonne (1 kt) is one thousand tonnes. This figure (67.3 Mt CO₂e) 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 4.2 Mt (6.7%) higher than the emissions of 63.1 Mt reported for B.C. in the NIR.

Table 2: Sector Descriptions and 2007 GHG Emissions¹⁴

Sector	Description	GHG Emissions (kt CO ₂ e)	% of B.C. Emissions
ENERGY	Emissions from stationary and transport fuel combustion and fugitive emissions from the fossil fuel industry	54 111	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)	23 711	35.2%
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)	24 888	37.0%
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	5 512	8.2%
INDUSTRIAL PROCESSES	Emissions from chemical reactions used in industry that physically or chemically transform materials	3 845	5.7%
SOLVENT & OTHER PRODUCT USE	Nitrous oxide emissions when used as an anaesthetic or propellant	42	0.1%
AGRICULTURE	Emissions from enteric fermentation, manure management and non-CO ₂ emissions from agricultural soils	2 343	3.5%
WASTE	Emissions from solid waste disposal, wastewater treatment and waste incineration	3 806	5.7%
AFFORESTATION & DEFORESTATION	Emissions from deforestation and removals from afforestation	3 162	4.7%
TOTAL		67 309	

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

3.2 B.C. GHG Emissions by Greenhouse Gas – 2007

For emissions reporting, most sectors are further categorized into sub-sectors, a number of which are further sub-divided into finer categories.¹⁵ Table 3 provides a summary of emissions by greenhouse gas (in terms of kt and kt CO₂e) 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.

Carbon dioxide (CO₂) accounts for most of the GHG emissions in the province (82.8% of total CO₂e), followed by methane (CH₄) which accounts for 12.3% of total emissions and nitrous oxide (N₂O) which accounts for 3.7% of total emissions.

¹⁴ 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 CO₂e) rounded to the nearest whole number.

¹⁵ These sub-sectors and categories are described in detail in subsequent sections of this report.

Table 3: B.C. Emissions by GHG and Reporting Category – 2007

Greenhouse Gas	CO ₂	CH ₄	CH ₄	N ₂ O	N ₂ O	PFCs	HFCs and SF ₆	TOTAL
Unit	kt	kt	kt CO ₂ e	kt	kt CO ₂ e	kt CO ₂ e	kt CO ₂ e	kt CO ₂ e
GHG Source Category								
TOTAL	54 914	395	8 289	8.1	2 505	577	1 023	67 309
ENERGY	49 506	157	3 292	4.2	1 312			54 111
a. Stationary Combustion Sources	22 944	24	506	0.8	261			23 711
Electricity and Heat Generation	1 548	0	4.7	0	12			1 565
Fossil Fuel Industries	5 908	16	331	0	50			6 289
Mining and Oil & Gas Extraction	1 033	0	0.4	0	3.1			1 039
Manufacturing Industries	6 798	0.8	18	0	123			6 939
Construction	117	0	0.0	0	0.7			117
Commercial & Institutional	3 305	0	1.3	0	20			3 326
Residential	4 172	7.2	151	0	48.8			4 372
Agriculture & Forestry	64	0	0	0	0.5			64
b. Transport	23 775	2.9	62	3.4	1 051			24 888
Domestic Aviation	1 358	0.1	1.5	0.1	38			1 397
Road Transportation	15 122	1.1	23	1.4	430			15 574
Light-Duty Gasoline Vehicles	3 976	0.3	6.5	0.5	149			4 131
Light-Duty Gasoline Trucks	4 548	0.3	6.4	0.5	198			4 752
Heavy-Duty Gasoline Vehicles	1 612	0.1	2.1	0.1	34			1 648
Motorcycles	27	0	0.4	0	0.2			27
Light-Duty Diesel Vehicles	45	0	0	0	1.1			46
Light-Duty Diesel Trucks	56	0	0	0	1.4			58
Heavy-Duty Diesel Vehicles	4 637	0.2	4.5	0.1	44			4 686
Propane & Natural Gas Vehicles	222	0.1	2.7	0	1.3			226
Railways	356	0	0.4	0.1	46			402
Domestic Marine	2 442	0.2	4.0	0.4	120			2 566
Other Transportation	4 498	1.6	33	1.3	417			4 948
Off-Road Gasoline	436	0.5	11	0	3.0			449
Off-Road Diesel	3 155	0.2	3.7	1.3	406			3 565
Pipelines	907	1	19	0	7.5			933
c. Fugitive Sources	2 787	130	2 725					5 512
Coal Mining		X	X					X
Oil and Natural Gas	X	X	X					X
INDUSTRIAL PROCESSES	2 246					577	1 023	3 845
a. Mineral Products	1 418							1 418
Cement Production	1 194							1 194
Lime Production	162							162
Limestone and Dolomite Use	35							35
Soda Ash Production and Use	28							28

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Greenhouse Gas	CO ₂	CH ₄	CH ₄	N ₂ O	N ₂ O	PFCs	HFCs and SF ₆	TOTAL
Unit	kt	kt	kt CO ₂ e	kt	kt CO ₂ e	kt CO ₂ e	kt CO ₂ e	kt CO ₂ e
GHG Source Category								
b. Chemical Industry								-
Nitric Acid Production								-
Adipic Acid Production								-
c. Metal Production	524					577		1 101
Iron and Steel Production								-
Aluminium Production	524					577		1 101
SF ₆ Used in Magnesium Smelters and Casters ²							X	X
d. Consumption of Halocarbons and SF₆							1023	1023
e. Other & Undifferentiated Production	303							303
SOLVENT & OTHER PRODUCT USE				0.1	42			42
AGRICULTURE		63	1 313	3.3	1 030			2 343
a. Enteric Fermentation		55	1 149					1 149
b. Manure Management		7.8	164	0.7	204			368
c. Agriculture Soils				2.7	826			826
Direct Sources				1.0	300			300
Pasture, Range and Paddock Manure				0.8	251			251
Indirect Sources				0.9	275			275
WASTE	57	174	3 650	0.3	99			3 806
a. Solid Waste Disposal on Land		173	3 629					3 629
b. Wastewater Handling		1.0	21	0.3	88			109
c. Waste Incineration	57			0.0	12			68
AFFORESTATION & DEFORESTATION	3 105	1.7	35	0.1	22			3 162
a. Afforestation	-16 ¹							-16
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								52 453
<i>a. Forest Land Remaining Forest Land</i>								52 095
<i>b. Cropland Remaining Cropland</i>								305
<i>c. Wetlands Remaining Wetlands</i>								53

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 SF₆ use in magnesium casters is confidential – hence, the small amount of SF₆ emissions for this category are reported (with HFC emissions) under "Consumption of Halocarbons and SF₆"

3.3 B.C. GHG Emissions by Sector – 1990 to 2007

Table 4 provides a summary of GHG emissions for B.C. by category for 1990, 1995, 1997, 2000, 2004, 2005, 2006 and 2007. 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 1990-2007

GHG Source Category	Year	1990	1995	1997	2000	2004	2005	2006	2007
GHG Emissions (kt CO ₂ e)									
TOTAL EMISSIONS		55 678	62 671	62 557	66 241	68 157	65 682	64 835	67 309
ENERGY		40 517	47 971	47 671	51 365	54 247	51 833	51 280	54 111
a. Stationary Combustion Sources		18 812	20 989	19 149	22 387	23 186	21 639	21 643	23 711
Electricity and Heat Generation		1 183	2 734	1 200	2 513	1 871	1 485	1 539	1 565
Fossil Fuel Industries		3 502	3 516	2 790	3 767	6 521	5 768	5 780	6 289
Mining and Oil & Gas Extraction		255	164	347	318	494	299	1 000	1 039
Manufacturing Industries		6 078	6 387	6 531	7 336	6 614	6 189	5 362	6 939
Construction		306	200	127	76	101	107	111	117
Commercial & Institutional		2 838	3 398	3 319	3 423	3 522	3 399	3 362	3 326
Residential		4 329	4 439	4 566	4 638	3 995	4 325	4 424	4 372
Agriculture & Forestry		321	152	268	315	68	66	66	64
b. Transport		18 385	22 006	23 192	23 705	25 934	24 953	24 314	24 888
Domestic Aviation		1 067	1 228	1 313	1 414	1 505	1 489	1 479	1 397
Road Transportation		11 444	13 183	13 912	14 677	15 733	15 334	15 284	15 574
Light-Duty Gasoline Vehicles		3 850	4 428	4 580	4 453	4 439	4 169	4 096	4 131
Light-Duty Gasoline Trucks		2 200	3 387	3 948	4 473	4 999	4 774	4 709	4 752
Heavy-Duty Gasoline Vehicles		2 042	1 828	1 818	1 672	1 719	1 641	1 629	1 648
Motorcycles		18	13	12	16	26	27	27	27
Light-Duty Diesel Vehicles		26	29	32	38	44	46	45	46
Light-Duty Diesel Trucks		35	63	66	65	57	56	57	58
Heavy-Duty Diesel Vehicles		2 490	2 864	3 054	3 631	4 188	4 428	4 530	4 686
Propane & Natural Gas Vehicles		782	570	400	329	260	194	191	226
Railways		1 441	1 650	1 439	1 268	388	414	400	402
Domestic Marine		1 025	1 232	1 033	1 235	2 656	2 544	2 461	2 566
Other Transportation		3 409	4 713	5 496	5 111	5 652	5 173	4 690	4 948
Off Road		2 553	3 328	4 049	3 457	4 520	4 183	3 916	4 014
Off-Road Gasoline		350	421	461	493	505	451	447	449
Off-Road Diesel		2 203	2 907	3 588	2 964	4 015	3 732	3 469	3 565
Pipelines		856	1 385	1 446	1 655	1 131	989	774	933
c. Fugitive Sources		3 320	4 976	5 330	5 273	5 127	5 241	5 323	5 512
Coal Mining		487	569	657	478	X	X	X	X
Oil and Natural Gas		2 833	4 407	4 673	4 794	X	X	X	X

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GHG Source Category	Year	1990	1995	1997	2000	2004	2005	2006	2007
	GHG Emissions (kt CO ₂ e)								
TOTAL EMISSIONS		55 678	62 671	62 557	66 241	68 157	65 682	64 835	67 309
INDUSTRIAL PROCESSES		3 582	3 883	4 283	4 779	4 087	4 137	3 952	3 845
a. Mineral Products		871	1 023	1 138	1 348	1 407	1 376	1 397	1 418
Cement Production		613	758	861	1 054	1 175	1 149	1 171	1 194
Lime Production		162	192	195	218	191	181	166	162
Limestone and Dolomite Use		75	52	56	49	21	21	35	35
Soda Ash Production and Use		22	21	25	27	20	24	25	28
b. Chemical Industry		-	-	-	-	-	-	-	-
Nitric Acid Production		-	-	-	-	-	-	-	-
Adipic Acid Production		-	-	-	-	-	-	-	-
c. Metal Production		1 507	1 687	1 795	1 820	1 357	1 131	1 015	1 101
Iron and Steel Production		-	-	-	-	-	-	-	-
Aluminium Production		1 507	1 687	1 795	1 820	1 357	1 131	1 015	1 101
SF ₆ Used in Magnesium Smelters and Casters ²		-	-	X	X	X	X	X	X
d. Consumption of Halocarbons and SF₆		427	492	545	822	892	1 073	1 133	1 023
e. Other & Undifferentiated Production		777	681	805	789	431	557	407	303
SOLVENT & OTHER PRODUCT USE		21	27	30	32	27	23	42	42
AGRICULTURE		2 171	2 392	2 455	2 432	2 686	2 639	2 397	2 343
a. Enteric Fermentation		996	1 160	1 166	1 187	1 333	1 298	1 199	1 149
b. Manure Management		315	356	362	377	404	396	377	368
c. Agriculture Soils		860	876	928	867	949	945	821	826
Direct Sources		375	342	376	316	339	346	286	300
Pasture Range and Paddock Manure		198	240	239	260	292	285	261	251
Indirect Sources		288	293	313	291	317	315	273	275
WASTE		3 420	3 761	3 998	3 863	3 788	3 714	3 790	3 806
a. Solid Waste Disposal on Land		3 269	3 590	3 823	3 688	3 612	3 540	3 615	3 629
b. Wastewater Handling		85	98	102	105	107	106	107	109
c. Waste Incineration		66	73	73	70	69	69	68	68
AFFORESTATION & DEFORESTATION		5 967	4 637	4 120	3 770	3 322	3 335	3 374	3 162
a. Afforestation¹		-14	-14	-14	-14	-15	-16	-15	-16
b. Deforestation		5 980	4 651	4 134	3 784	3 337	3 351	3 390	3 178
MEMO ITEMS	(categories presented for information purposes but not included in B.C. total GHG emissions)								MEMO ITEMS
OTHER LAND USE		-27 464	-41 331	-46 481	-36 116	43 380	28 268	50 021	52 453
<i>a. Forest Land Remaining Forest Land</i>		-27 692	-41 623	-46 800	-36 463	43 025	27 904	49 655	52 095
<i>b. Cropland Remaining Cropland</i>		98	171	216	263	291	303	309	305
<i>c. Wetlands Remaining Wetlands</i>		117	120	103	83	64	60	57	53

Note: "X" indicates confidential data, "-" 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 SF₆ use in casters is confidential – hence, SF₆ emissions for this category are reported (with HFC emissions) under "Consumption of Halocarbons and SF₆"

3.4 Trends in Emissions

Total annual GHG emissions in British Columbia increased by 3.8% from 2006 to 2007 (from 64.8 Mt to 67.3 Mt CO₂e), decreased by 1.2% between 2004 and 2007 (from 68.2 Mt in 2004) and increased by 7.6% (from 62.6 Mt) over the ten year period from 1997 to 2007. 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., snow pack, heating/cooling degree days), methodological changes and data anomalies on reported emission levels. Longer term comparisons (i.e., three and ten year periods) provide more useful trend information.

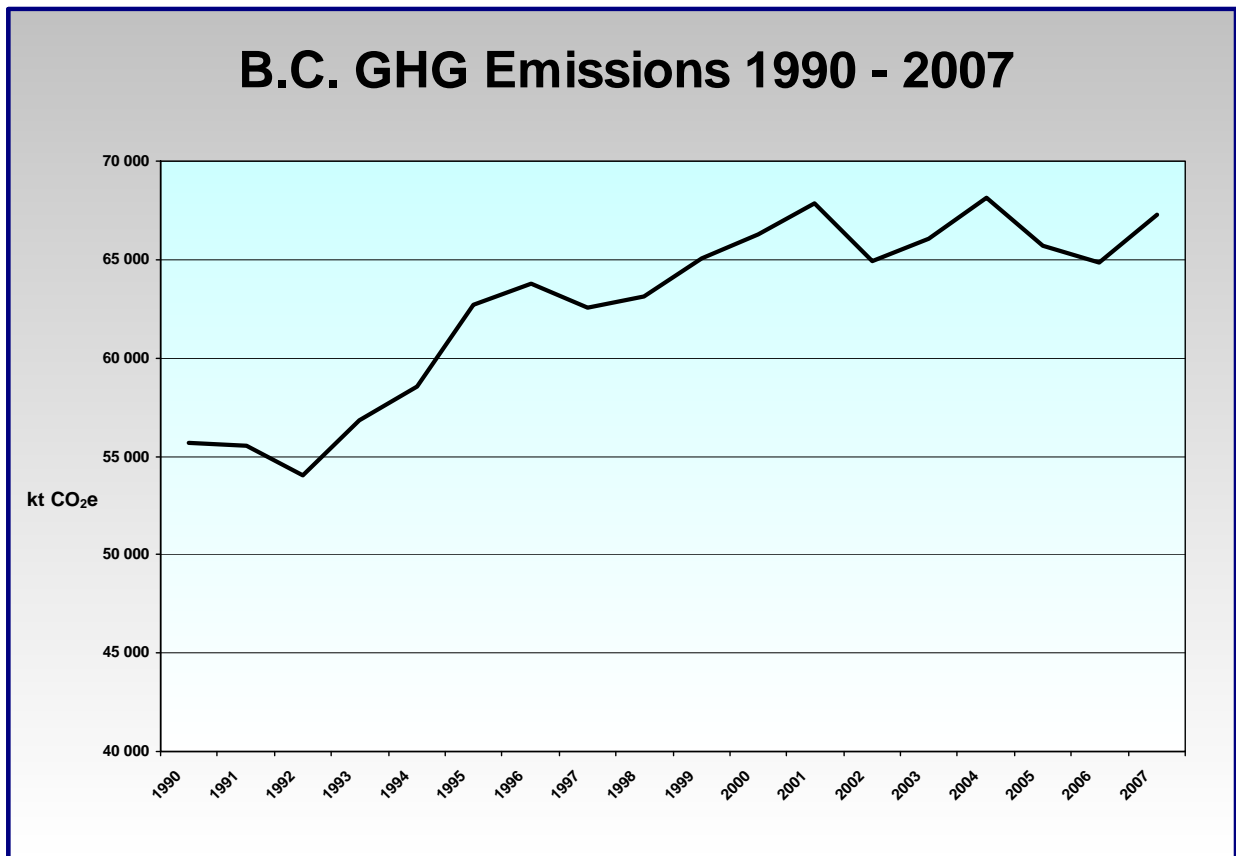


Figure 2: B.C. GHG Emissions – 1990-2007 Trends

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	2007 GHG Emissions (kt CO ₂ e)	3-Year Change (2004-2007)	10-Year Change (1997-2007)	Key Factors Influencing Changes in Emissions
ENERGY	54 111	-0.3%	+13.5%	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	3 845	-5.9%	-10.2%	Closure of ammonia and methanol plants, use of improved control technology for PFC emissions in aluminium production ⁴
SOLVENT & OTHER PRODUCT USE	42	+55.6%	+40.0%	Use of nitrous oxide as anaesthetic and propellant ⁵
AGRICULTURE	2 343	-12.8%	-4.6%	Agricultural production and soil management ⁶
WASTE	3 806	+0.5%	-4.8%	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	3 162	-4.8%	-23.3%	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 Alcan B.C. 2007 Performance Report

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 Section 10.4 for detailed data

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

In 2007, British Columbia emissions were an average of: 15.6 tonnes CO₂e/person;¹⁶ 409 tonnes CO₂e/\$ million of Gross Domestic Product (GDP);¹⁷ and 71.1 tonnes CO₂e/terajoule (TJ) of energy use.¹⁸

GHG emissions per capita have been relatively consistent over the last decade (1997-2007) – ranging between 15.2 and 16.5 tonnes CO₂e/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-third between 1997 and 2007. GHG

¹⁶ B.C. population data from Statistics Canada CANSIM Table 051-0001: Population by sex and age group, by province and territory.

¹⁷ 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.

¹⁸ 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 ₂ e/\$ million GDP)	GHG per Energy Use (tonnes CO ₂ e/TJ energy use)
2007	15.6	409.0	71.1
3-Year Trend (2004 to 2007)	16.5 (2004) -5.5%	465.1 (2004) -12.1%	74.2 (2004) -4.1%
10-Year Trend (1997 to 2007)	15.8 (1997) -1.4%	516.2 (1997) -20.8%	71.9 (1997) -1.1%

Figure 3 shows the trends in these indicators from 1990 to 2007. 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 2007, 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.

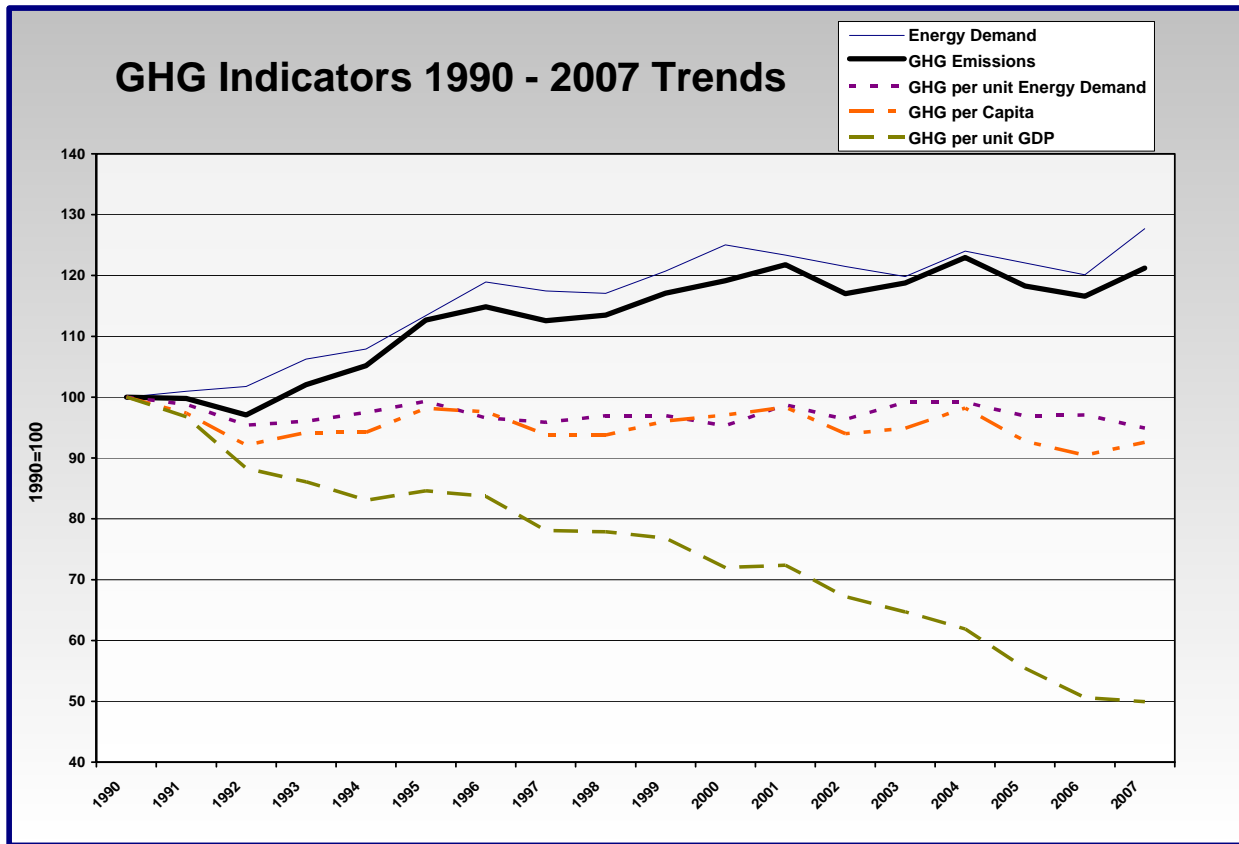


Figure 3: GHG Indicators – 1990-2007 Trends

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 2007 were 54.1 megatonnes (Mt) CO₂e – 80.4% of total B.C. emissions.

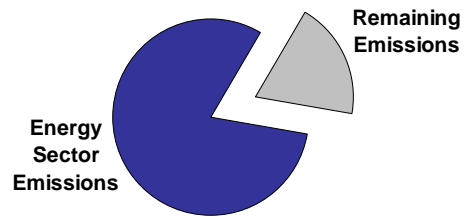


Figure 4 shows energy sector emissions as accounted by each of the sub-sectors.

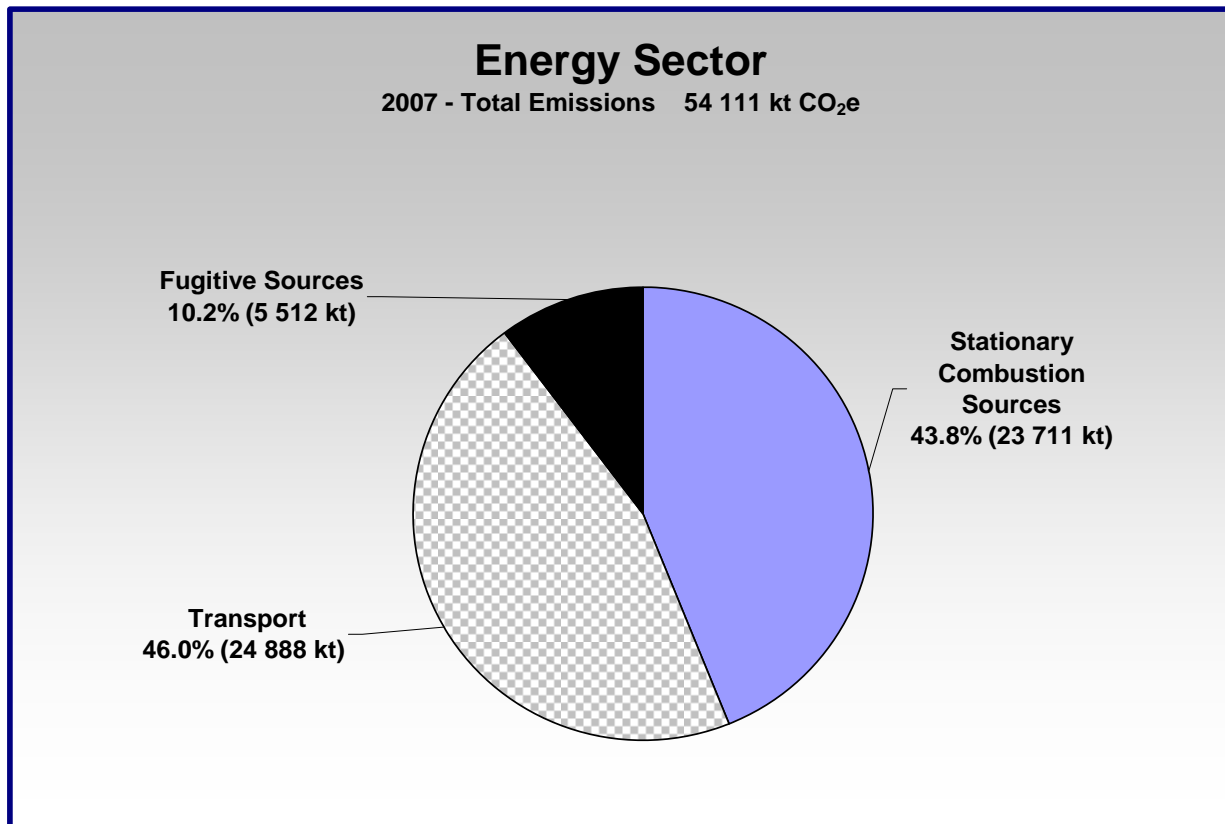


Figure 4: Energy Sector GHG Emissions – 2007

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 5.5% from 2006 to 2007, decreased by 0.3% between 2004 and 2007 and increased by 13.5% over the ten year period from 1997 to 2007. The trend in GHG emissions between 1990 and 2007 is shown for each of the energy sub-sectors in Figure 5.

The short-term (2006-2007) increase can be attributed largely to increased emissions from the “manufacturing” sub-sector of the stationary combustion sources category – which increased by 29.3% between 2006 and 2007 – contributing to the 9.6% increase in emissions from stationary combustion sources over the period.¹⁹ The decrease in energy sector emissions between 2004 and 2007 can be attributed to the transport sub-sector. Emissions in the transport sub-sector decreased by 4.0% over the period, while stationary combustion emissions increased by 2.3% and fugitive emissions increased by 7.5% over the same period.

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

¹⁹ Note that reported data that has led to this significant increase in “manufacturing” emissions is currently under review and may be subject to change.

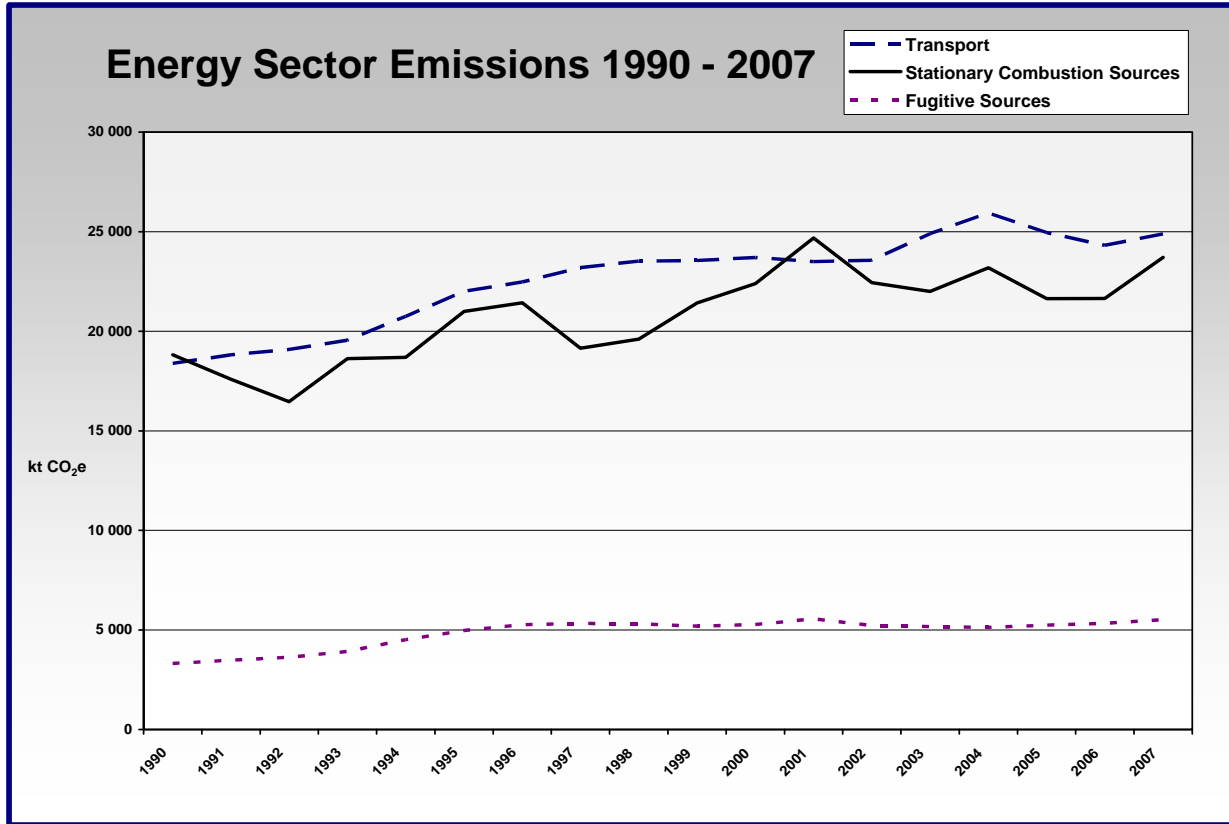


Figure 5: Energy Sector Emissions – 1990-2007 Trends

4.3 Energy Sub-sector a: Stationary Combustion Sources

Total emissions from stationary combustion sources were 23.7 megatonnes (Mt) CO₂e in 2007 – 43.8% of energy sector emissions (35.2% 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.

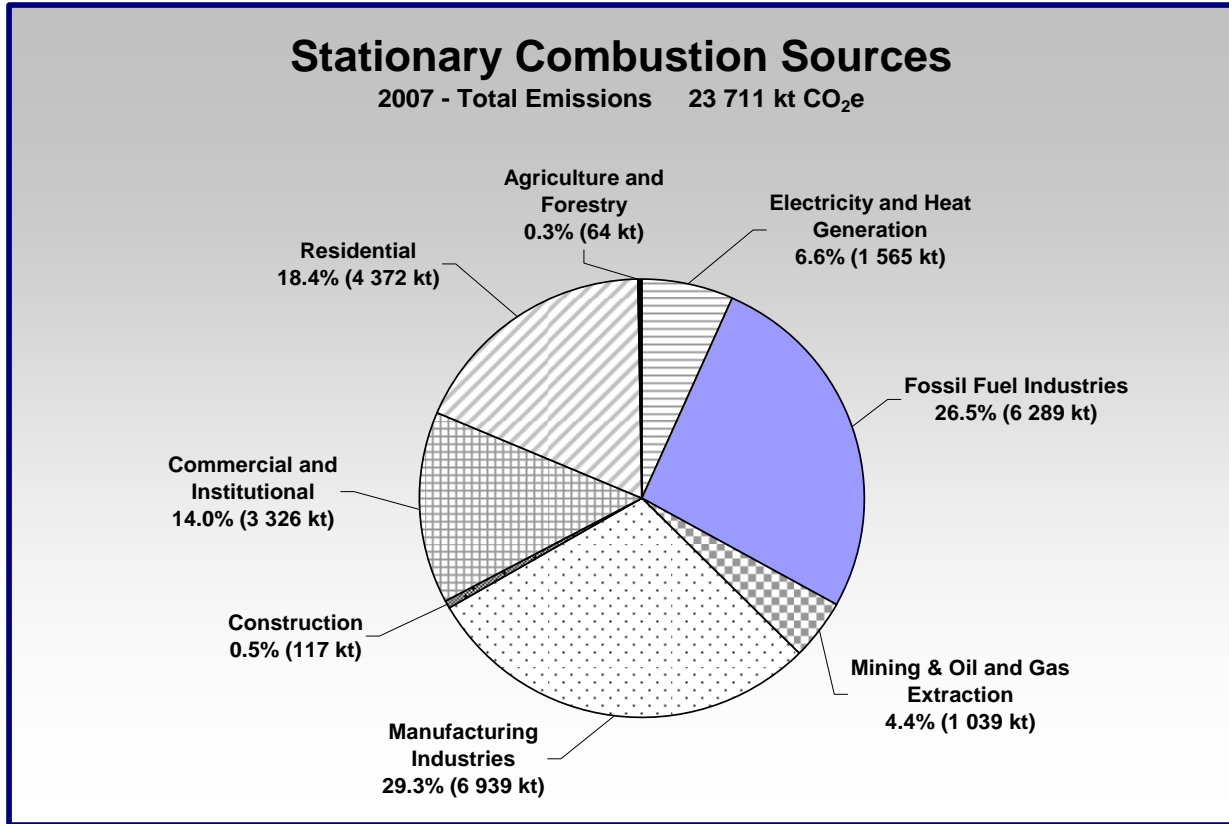


Figure 6: Stationary Combustion Sub-sector GHG Emissions by Category – 2007

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 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
Electricity and Heat Generation	-16.4%	+30.4%	Demand for electricity, ¹ variation in relative amounts of hydro-generated and fossil fuel-generated electricity ¹
Fossil Fuel Industries	-3.6%	+125.4%	Production volumes of refined petroleum products and natural gas ¹
Mining and Oil & Gas Extraction	+110.3%	+199.4%	Extraction of coal and natural gas ¹
Manufacturing Industries	+4.9%	+6.3%	Production from manufacturing industries, ² fuel sources (e.g., use of biomass rather than fossil fuel sources ¹)
Construction	+15.8%	-7.9%	Number of annual housing starts ³ and commercial/ institutional starts requiring fossil fuel and electricity use in construction
Commercial and Institutional	-5.6%	+0.2%	Area of floor space requiring heating and electric loads, ⁴ mitigated by energy efficiency actions ⁴
Residential	+9.4%	-4.3%	Area of floor space requiring heating and electric loads, ⁵ mitigated by energy efficiency actions ⁵
Agriculture and Forestry	-5.9%	-76.1%	Production in forestry sector ² , fuel sources (e.g., switching to biomass) ¹

¹ Statistics Canada Report on Energy Supply and Demand in Canada

² Statistics Canada CANSIM Table 304-0015: Manufacturing sales, by North American Industry Classification System (NAICS) and province, monthly (dollars)

³ B.C. Stats – British Columbia Housing Starts for Urban Areas and Communities

⁴ NRCan Office of Energy Efficiency: Commercial/Institutional Sector British Columbia and Territories Table 3: Secondary Energy Use and GHG Emissions by Activity Type

⁵ 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

GHG emissions in the energy sector 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 CO₂e 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 7 shows that between 1990 and 2006, residential floor space in B.C. increased by 44% while annual energy demand to heat residential buildings has increased by only 11% 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.

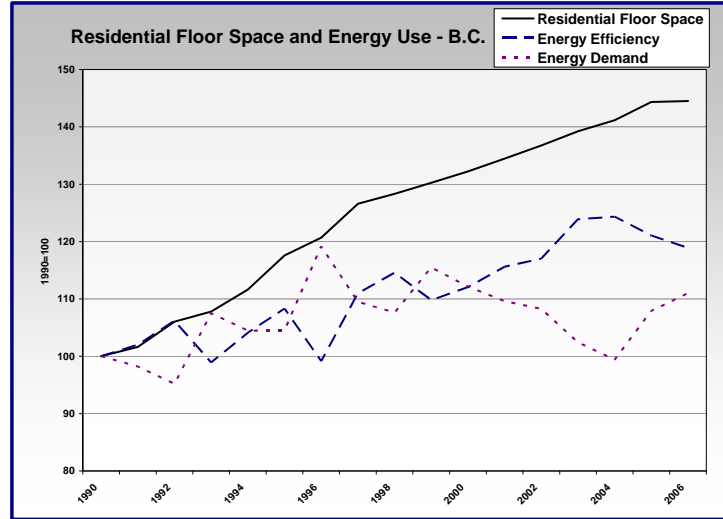


Figure 7: Residential Floor Space and Energy Use – B.C. Trends

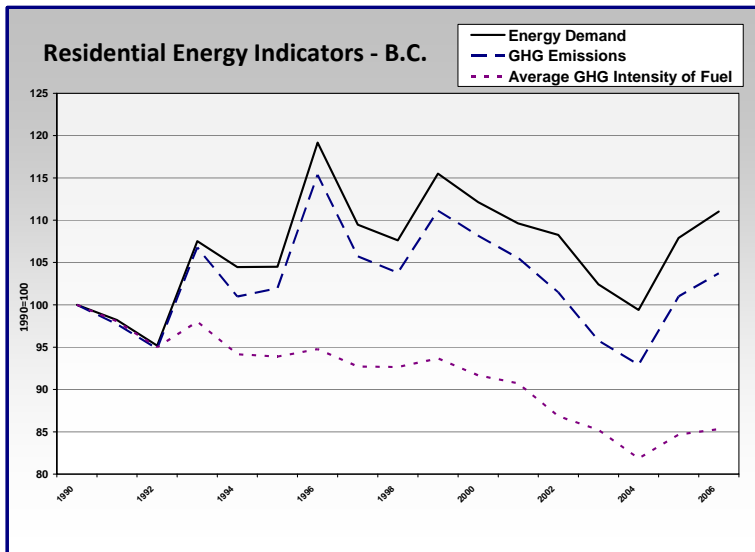


Figure 8: Residential Energy Indicators – B.C. Trends

Figure 8 illustrates the linkages between energy demand, fuel types and GHG emissions. Between 1990 and 2006, 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 2006 fuel switching has decreased the average GHG intensity of residential fuels per unit energy by about 15%.

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

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 7 and Figure 8: 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 24.9 megatonnes (Mt) CO₂e in 2007, accounting for 46.0% of energy sector emissions (37.2% of total B.C. emissions). Emissions by category in the transport sub-sector are shown in Figure 9, 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.

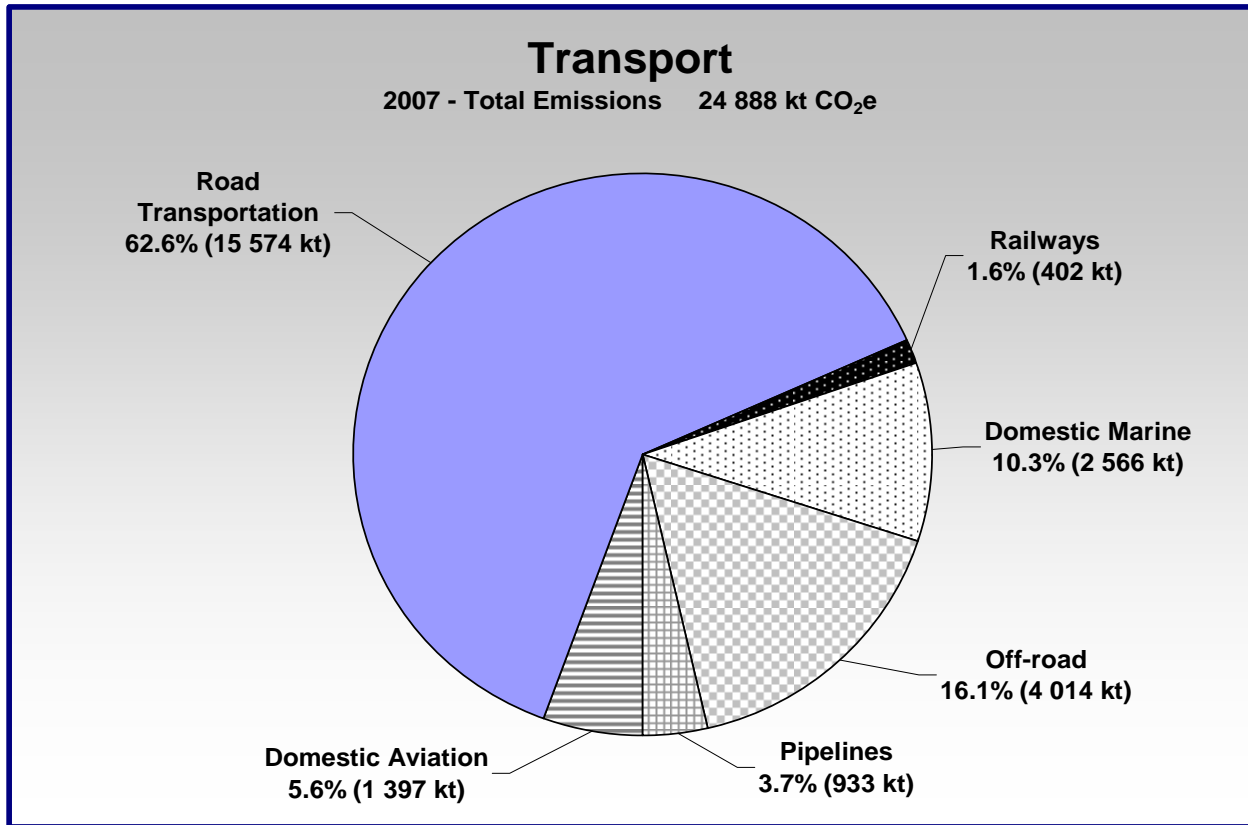


Figure 9: Transport Sub-sector GHG Emissions by Category – 2007

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
Domestic Aviation	-7.2%	+6.4%	Weight of freight transported, passenger loads and distance traveled ¹
Road Transportation (On-Road Vehicles)	-1.0%	+12.0%	Number of vehicles on road and distance travelled, ² average fuel efficiency of vehicles ³
Railways	+3.6%	-72.1%	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	-3.4%	+148.4%	Volume of import and export between international trading partners ⁵ (e.g., wood product exports)
Off-road vehicles (Gasoline and Diesel)	-11.2%	-0.9%	Forest, mining and agriculture off-road vehicle activity
Pipelines	-17.5%	-35.5%	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

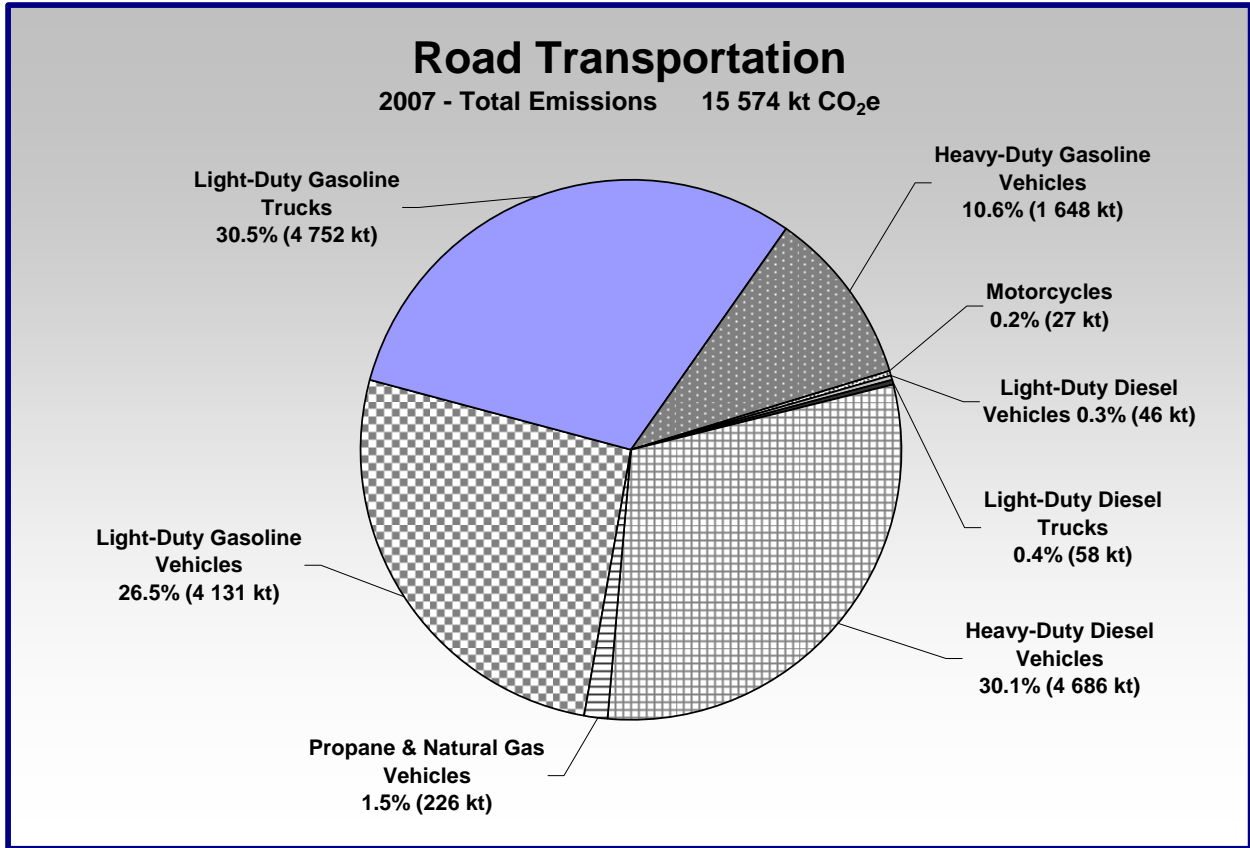
⁴ Statistics Canada Catalogue 52-216-X: Rail in Canada

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 (23.1%) of 2007 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 10.



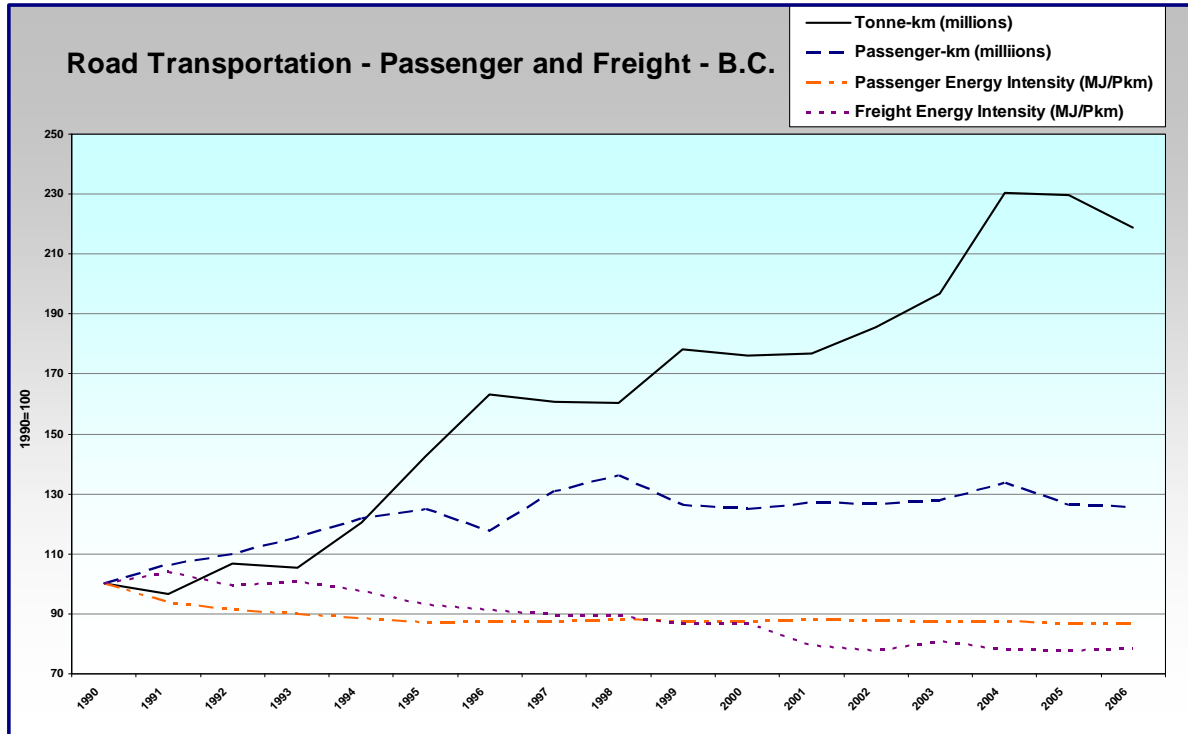
Note: "Light-duty" vehicles (including cars, pickups, minivans and sport utility vehicles) are less than or equal to 3.9 tonnes. "Heavy duty" vehicles are over 3.9 tonnes in weight.

Figure 10: Road Transportation Category and Sub-category GHG Emissions – 2007

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 11 shows trends since 1990 in passenger-kilometres¹ traveled and engine efficiencies for passenger and freight road transportation. While energy intensity for both passenger and freight transportation has decreased between 1990 and 2007, 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



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

Figure 11: 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 2007 were 5.5 megatonnes (Mt) CO₂e, accounting for 10.2% of energy sector emissions (8.2% of total B.C. emissions). Annual emissions increased by 3.6% from 2006 to 2007, 7.5% from 2004 to 2007 and 3.4% between 1997 and 2007.

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. Note that three and ten-year trends are not

provided for these emissions categories – as the National Inventory Report (NIR) does not include this level of detail.

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

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 (2007 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 separated 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 13.

²⁰ Refer to Section 3.1.3 of the NIR for more information.

Table 13: Fugitive Emission Categories, Associated Activities and Data Sources

Emission Category	Associated Activities	Data Sources
Conventional Crude Oil Extraction and Processing	<ul style="list-style-type: none"> ▪ Releases from wells, flow lines and batteries ▪ Venting of casing and solution gas ▪ Evaporative losses from storage facilities 	<p>Report on Energy Supply and Demand in Canada (RESD), Statistics Canada</p> <p>A National Inventory of Greenhouse Gas (GHG), Criteria Air Contaminant (CAC) and Hydrogen Sulphide (H₂S) Emissions by the Upstream Oil and Gas Industry, Canadian Association of Petroleum Producers (CAPP) 2005</p> <p>Supply and Disposition of Crude Oil and Equivalent, CANSIM Table 126-0001, Statistics Canada</p> <p>Industry Facts and Information by Region and Province, CAPP</p> <p>Drilling and Production Statistics, British Columbia Ministry of Energy, Mines and Petroleum Resources (MEMPR)</p>
Natural Gas Extraction and Processing	<ul style="list-style-type: none"> ▪ Releases from wells, gathering systems, field facilities and gas batteries ▪ Seal leaks ▪ Line cleaning operations 	<p>RESD, Statistics Canada</p> <p>A National Inventory of Greenhouse Gas (GHG), Criteria Air Contaminant (CAC) and Hydrogen Sulphide (H₂S) Emissions by the Upstream Oil and Gas Industry, CAPP 2005</p> <p>Supply and Disposition of Natural Gas, Monthly, CANSIM Table 131-0001, Statistics Canada</p> <p>Drilling and Production Statistics, MEMPR</p>
Petroleum Refining	<ul style="list-style-type: none"> ▪ Equipment leaks, wastewater treatment, cooling towers, storage tanks and loading operations ▪ Flaring of excess gas 	<p>Economic and Environmental Impacts of Removing Sulphur from Canadian Gasoline and Distillate Production, Canadian Petroleum Products Institute (CPPI) 2004</p> <p>RESD, Statistics Canada</p>
Coal Mining	<ul style="list-style-type: none"> ▪ Releases from exposed coal surfaces, coal rubble and venting within coal deposit ▪ Post-mining activities including preparation, non-vehicular transportation, storage and final processing 	<p>Management of Methane Emissions from Coal Mines: Environmental, Engineering, Economic and Institutional Implications of Options. King 1994</p> <p>Coal and Coke Statistics, Catalogue No. 45-002, Statistics Canada</p>
Natural Gas Transmission	<ul style="list-style-type: none"> ▪ Equipment leaks, compressor start-up venting, purging of lines during maintenance 	<p>CH₄ and VOC Emissions from the Canadian Upstream Oil and Gas Industry—Draft Report, CAPP</p> <p>Natural Gas Transportation and Distribution, Catalogue No. 57-205, Statistics Canada</p>
Natural Gas Distribution	<ul style="list-style-type: none"> ▪ Equipment leaks, compressor start-up venting, purging of lines during maintenance 	<p>1995 Air Inventory of the Canadian Natural Gas Industry, Canadian Gas Association (CGA) 1997</p> <p>Natural Gas Transportation and Distribution, Catalogue No. 57-205, Statistics Canada</p>
Oil Transmission in Pipelines	<ul style="list-style-type: none"> ▪ Loading and unloading of tankers, storage losses, equipment leaks, process venting 	<p>A National Inventory of Greenhouse Gas (GHG), Criteria Air Contaminant (CAC) and Hydrogen Sulphide (H₂S) Emissions by the Upstream Oil and Gas Industry, CAPP 2005</p>

5. INDUSTRIAL PROCESSES SECTOR EMISSIONS

5.1 Summary

Total emissions in the industrial process sector category in 2007 were 3.8 megatonnes (Mt) CO₂e – 5.7% of total B.C. emissions.

Figure 12 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 SF₆ and “other and undifferentiated production” (including lead and zinc production) – described in Table 14.

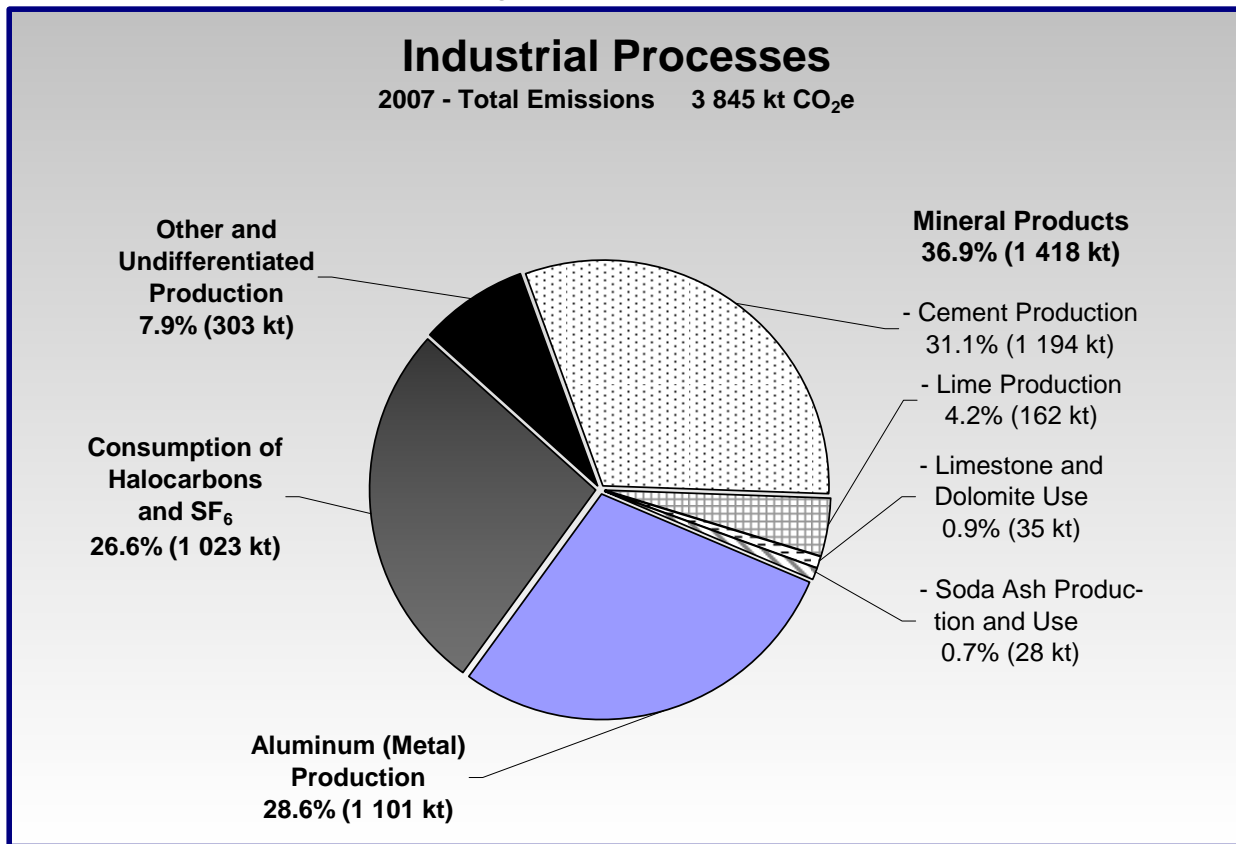
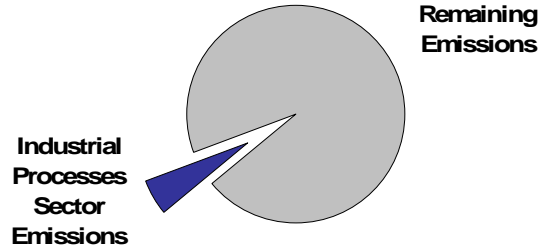


Figure 12: Industrial Processes GHG Emissions by Category – 2007

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 14: 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 ₂ CO 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 ₂ F ₆ (PFCs), as well as CO ₂ , formed during the aluminium smelting process – including electrolytic reduction of alumina (Al ₂ O ₃) with carbon-based anodes, pre-baking of carbon anodes and anode effects
d. Consumption of Halocarbons and SF₆	
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 decreased by 2.7% between 2006 and 2007, 5.9% between 2004 and 2007 and 10.2% between 1997 and 2007. Factors influencing these overall reductions include decreases in process emissions from the production of aluminium, consumption of halocarbons and SF₆ and decreases in other and undifferentiated production. Overall reductions have been mitigated in part by increases in process emissions from cement production.

The trend in industrial processes sector GHG emissions between 1990 and 2007 is shown in Figure 13.

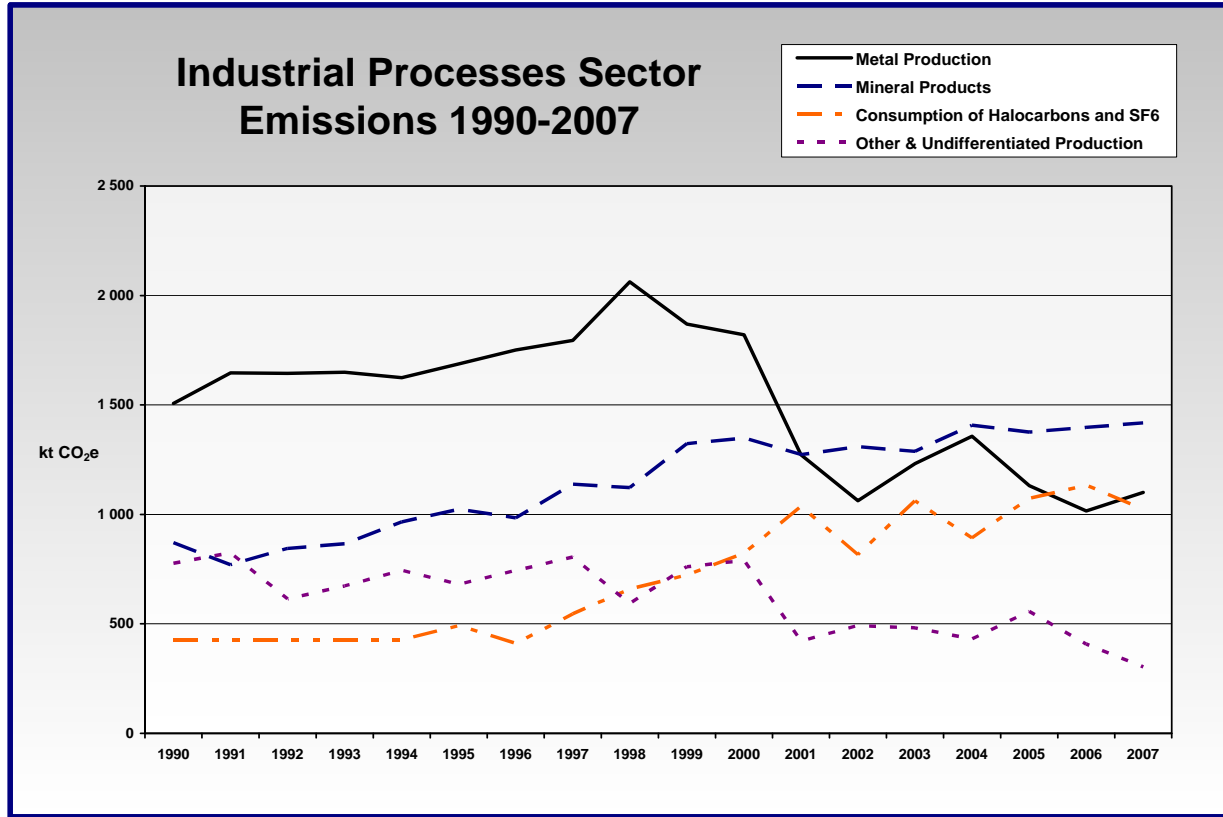


Figure 13: Industrial Processes Emissions – 1990-2007 Trends

Table 15: Industrial Process Categories, Trends and Key Factors Influencing Changes

Emission Category	3-Year Trend	10-Year Trend	Key Factors Influencing Changes in Emissions
a. Mineral Products			
Cement Production	+1.6%	+38.7%	Annual cement production ¹
Lime Production	-15.2%	-16.9%	Annual lime production ²
Limestone and Dolomite Use	+66.7%	-37.5%	Annual pulp and paper production ³
Soda Ash Use	+40.0%	+12.0%	Annual production in industries that utilize soda ash (e.g., pulp and paper, glass and chemical industries) ³
c. Metal Production (Aluminium Production)			
	-18.9%	-38.7%	Control measures to reduce PFC emissions from anode effects ⁴
d. Consumption of Halocarbons and SF₆			
	+14.7%	+87.7%	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			
	-29.7%	-62.4%	Closure of ammonia and methanol plants in Kitimat, lime 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. 2007 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

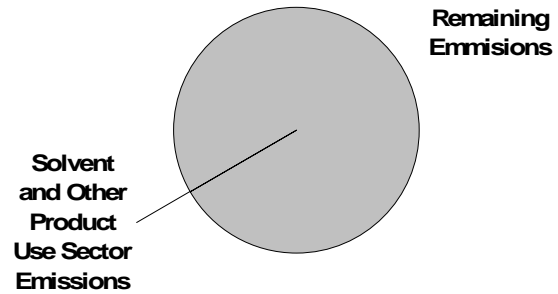
5.3 Data Sources

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 aluminium production which necessitate use of more elaborate formulae. Additional details on such methodologies can be found in Annex 3.2 of the NIR. Table 16 summarizes the data sources used to compile activity data and emission factors for each emission category.

Table 16: 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) 2007 Clinker production 1997-2004: Catalogue #44-001, Statistics Canada Clinker production 2005-2007: CANSIM Table 303-0060, Statistics Canada Clinker capacity: 1990-2007: Canadian Minerals Yearbook, Natural Resources Canada (NRCan) Emission factor: Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, Intergovernmental Panel on Climate Change (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 N₂O used as an anaesthetic or as a propellant in pressure and aerosol products. Total emissions in this sector were 42 kilotonnes CO₂e in 2007, 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 did not change between 2006 and 2007 however they increased by 55.6% between 2004 and 2007 and 40.0% between 1997 and 2007. Changes in emissions reflect increases in the amount of N₂O used for anaesthetic and as propellant.

6.3 Data Sources

The data on domestic sales of Canadian N₂O production provided by Nitrous Oxide Canada and N₂O 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 N₂O 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 2007 were 2.3 megatonnes (Mt) CO₂e – 3.5% of total B.C. emissions. GHG emissions reported in the agriculture sector include: CH₄

emissions from enteric fermentation; CH₄ and N₂O emission from manure management; and N₂O emissions from agricultural soils (including direct and indirect sources and pasture, range and paddock manure). Figure 14 shows the percentage of emissions as accounted by each of these sub-sectors and Table 17 provides a description of agriculture sector emission categories.

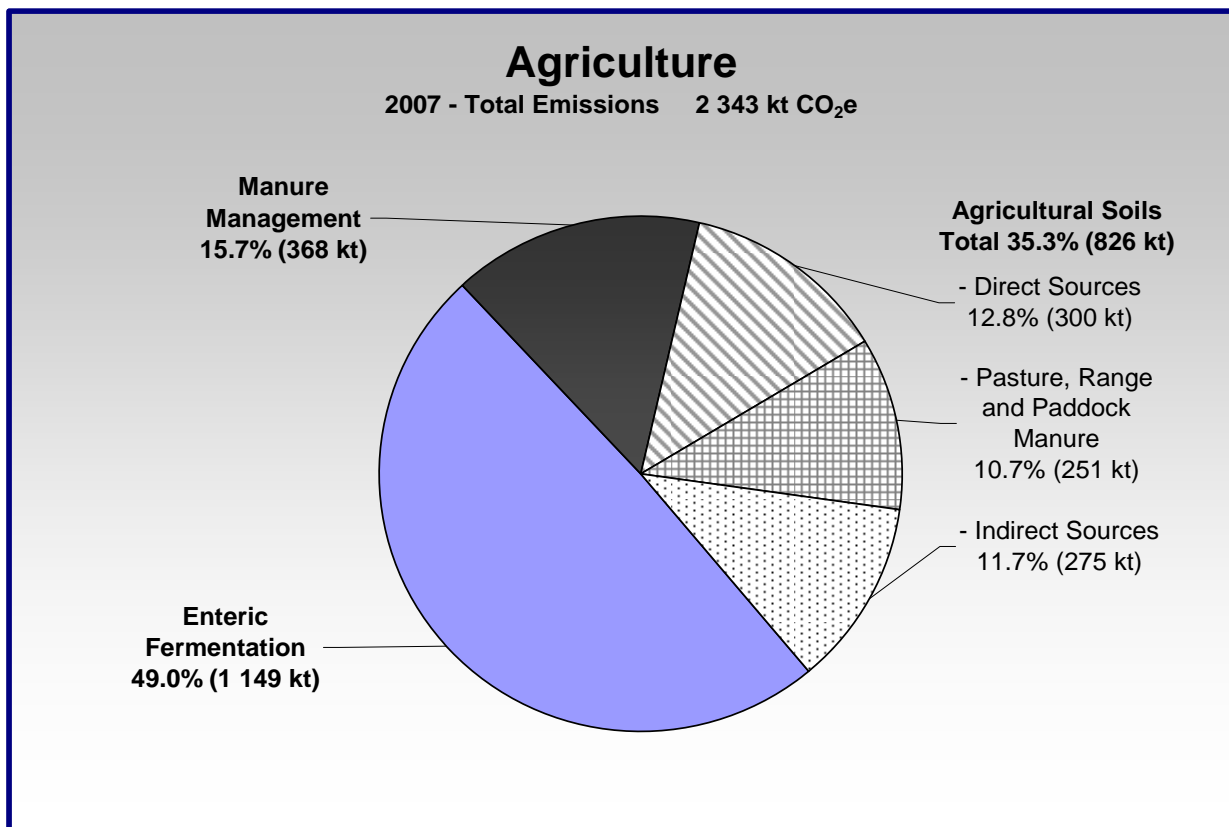
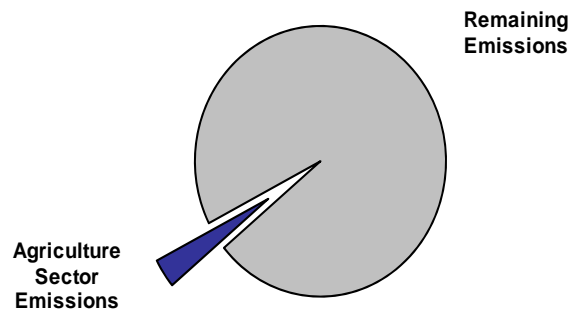


Figure 14: Agriculture Sector GHG Emissions by Category – 2007

Table 17: 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 ₂ O. Factors impacting the production of CH ₄ and N ₂ O include manure characteristics and the aeration levels in various types of manure management systems
c. Agriculture Soils	
Direct Emissions	Direct sources of N ₂ O 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 ₂ O 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 ₂ O emissions

7.2 Trends in Agriculture Sector Emissions

Annual agriculture sector emissions decreased by 2.3% between 2006 and 2007, 12.8% between 2004 and 2007 and 4.6% between 1997 and 2007. These decreases can be attributed for the most part to reductions in CH₄ emissions from enteric fermentation (the largest source of agriculture sector emissions).

Figure 15 depicts agriculture sub-sector emissions between 1990 and 2007 and Table 18 provides three and ten-year trend percentages and a summary of key factors influencing changes in emissions.

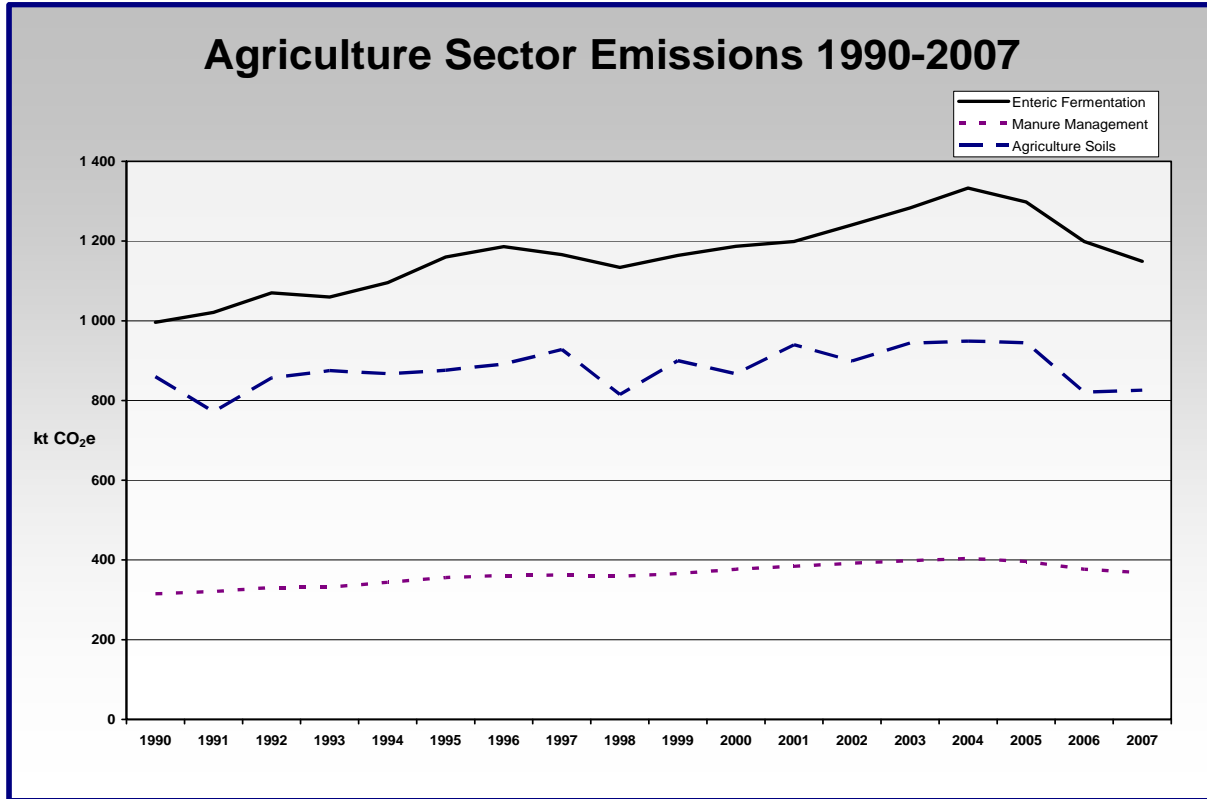


Figure 15: Agriculture Sector Emissions – 1990-2007 Trends

Table 18: Agriculture Sector Trends and Key Factors Influencing Changes

Emission Category	3-Year Trend	10-Year Trend	Key Factors Influencing Changes in Emissions
a. Enteric Fermentation	-13.8%	-1.5%	Cattle populations, ¹ hog populations ²
b. Manure Management	-8.9%	+1.7%	Cattle populations, ¹ hog populations ²
c. Agriculture Soils	-13.0%	-11.0%	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)

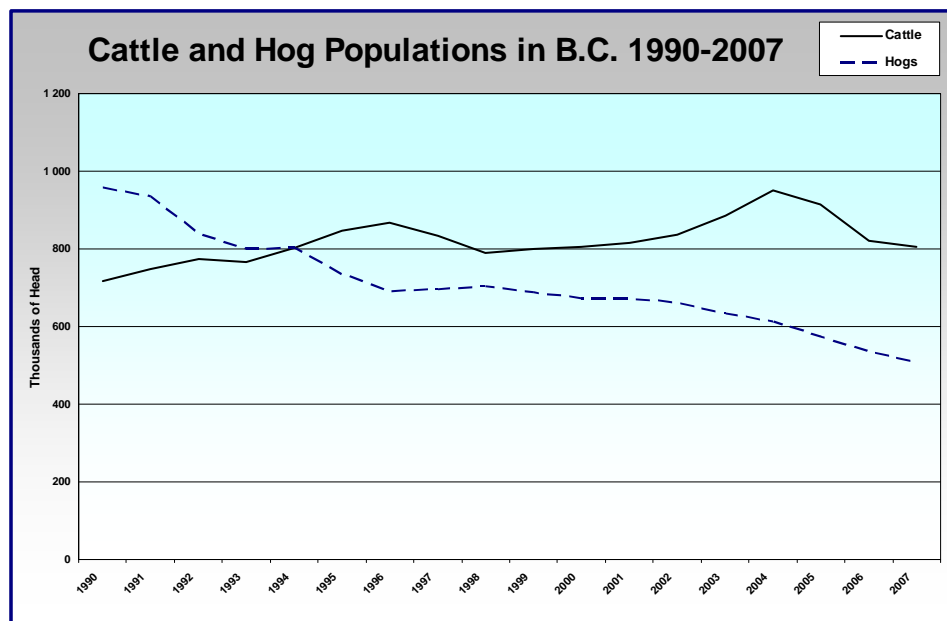
² CANSIM Table 003-0004: Number of hogs on farms at end of quarter, quarterly (head)

Understanding trends in agriculture emissions

Trends in agriculture emissions have been predominately influenced by cattle and hog populations. As Figure 16 shows, both hog and cattle populations have been in decline since 2004, with hog populations showing a steady decline since 1990.

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

Figure 16: Cattle and Hog Populations – B.C. Trends



7.3 Data Sources

Agriculture sector emissions are calculated by multiplying activity data (e.g., number of livestock) by an appropriate emission factor. Table 19 summarizes the data sources used to compile activity data and emission factors for each agriculture sector emission category.

Table 19: Agriculture Sector Categories, Associated Activities and Data Sources

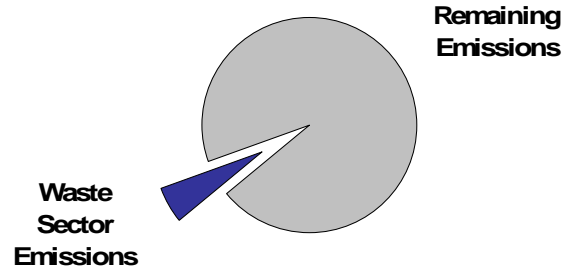
Emission Category	Activity	Data Sources
a: Enteric Fermentation	Domestic animal populations	Animal populations: Various Statistics Canada publications and CANSIM tables. Refer to Table 6-2 in the National Inventory Report (NIR) for specific references Emission Factors: Improving Estimates of Methane 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 6-2 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 Methodology, Department of Land Resource Science. University of Guelph, Marinier et al. 2004 N ₂ O Emission Factors: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Intergovernmental Panel on Climate Change (IPCC)

Emission Category	Activity	Data Sources
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, 1990–2007 (Annual). Catalogue No. 22-002, Statistics Canada. Nitrogen in crop residue: The fate of nitrogen in agroecosystems: an illustration using Canadian estimates, <i>Nutrient Cycling in Agroecosystems</i> . 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 ₂ O emissions from agricultural soils in Canada. I. Development of a country-specific methodology. <i>Canadian Journal of Soil Science</i> 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 6-2 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 6-2 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) CO₂e in 2007 – 5.7% 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: CH₄ emissions from landfills; CH₄ and N₂O emissions from wastewater treatment; and CO₂, CH₄ and N₂O emissions from waste incineration. CO₂ 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 17 and Table 20 provide a summary and description of waste sector emissions by each sub-sector.

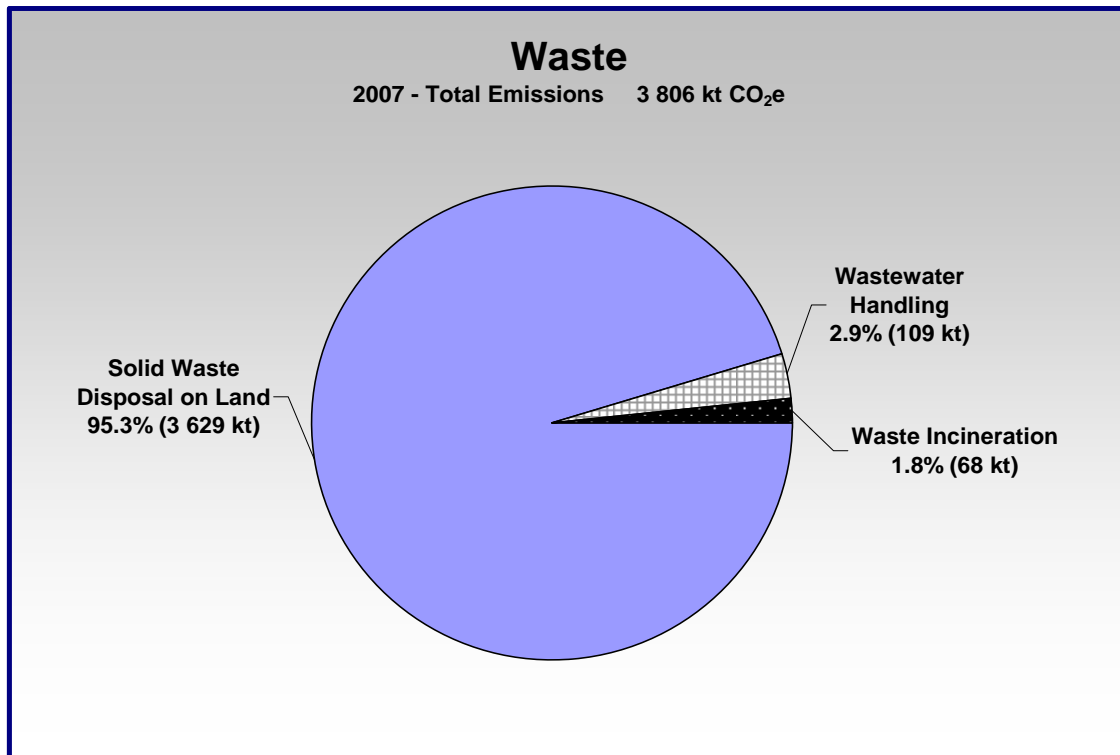


Figure 17: Waste Sector GHG Emissions – 2007

²² “Carbon-neutral” refers to fuels that neither contribute to nor reduce the amount of CO₂ in the atmosphere. For biomass, the CO₂ released to the atmosphere during combustion is the same quantity that has been absorbed from the atmosphere during plant growth. Because CO₂ 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 CO₂ 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 CO₂ 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 CO₂ levels in the atmosphere – thus, fossil fuels are not termed “carbon-neutral”.

Table 20: 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 ₂ O 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 ₂ O 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 increased 0.4% between 2006 and 2007 and 0.5% between 2004 and 2007. Between 1997 and 2007 emissions decreased by 4.8%. Recent increases are attributed to increases in the quantity of waste generated and sent to landfills. This increase has overshadowed the emissions reductions associated with the diversion of wastes and the capture, flaring and beneficial use²³ of CH₄ at landfills.

Table 21 and Figure 18 provide emission trend information for the waste sector.

Table 21: Waste Sector Trends and Key Drivers

Emission Category	3-Year Trend	10-Year Trend	Key Factors Influencing Changes in Emissions
Solid Waste Disposal on Land	+0.5%	-5.1%	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	+1.9%	+6.9%	Population growth ² and related water demand
Waste Incineration	-1.4%	-6.9%	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 CH₄ 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 CH₄ to CO₂, a less potent GHG, thus reducing overall GHG emissions from the landfill.

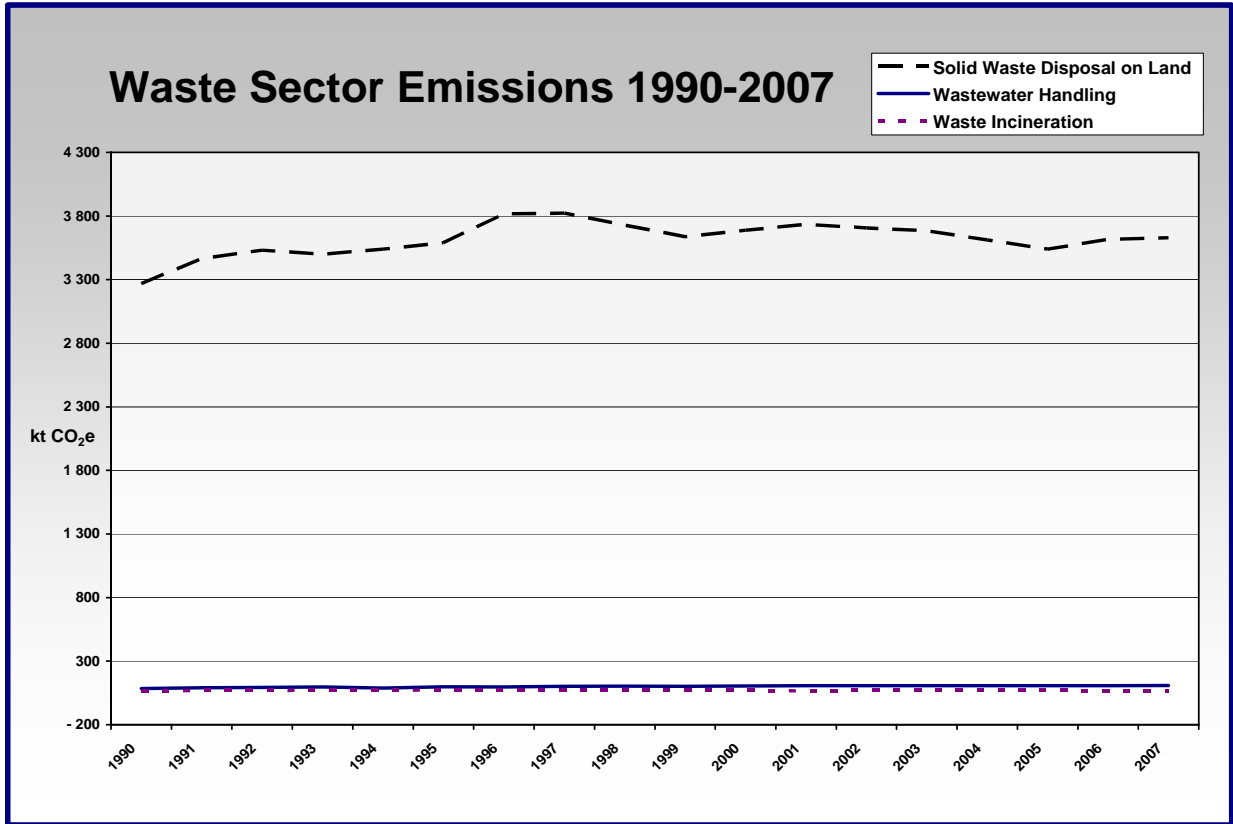


Figure 18: Waste Sector GHG Emissions – 1990-2007 Trends

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 19 shows that although the amount of waste diverted (i.e., reused, recycled or composted) from landfills has increased slightly between 1996 and 2007, 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.

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

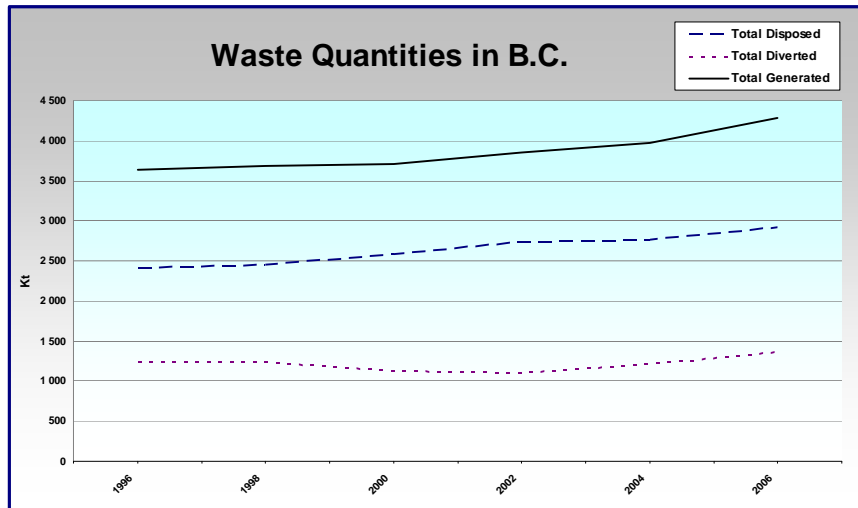


Figure 19: Waste Quantities in B.C.

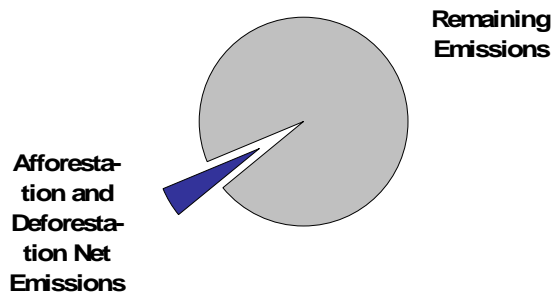
8.3 Data Sources

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 CH₄ emissions. Table 22 summarizes the data sources used to compile activity data and derive emission factors for each emission category.

Table 22: 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 2007, 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 Annual Demographic Estimates: Canada, Provinces and Territories.
	Quantity of N ₂ O emitted per capita protein consumption	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 afforestation²⁴ and deforestation²⁵ were 3.2 megatonnes (Mt) CO₂e in 2007 – amounting to 4.7% 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 2007. 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 52.1 Mt from forest land (i.e., “forest land remaining forest land”), 0.3 Mt from cropland (i.e., “cropland remaining cropland”) and 0.05 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 23 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 23: 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. Table 24 summarizes the land use categories and land-use changes that are “estimated” (i.e., addressed), “not estimated” and “not occurring” under NIR methodologies. The B.C. GHG inventory report addresses only those land uses and land-use changes that are estimated in the NIR (highlighted in italics in Table 24).

Table 24: Land Use, Land-use Change and Forestry Sector Categories Estimated in Report

INITIAL USE	FINAL USE				
	Forest Land	Cropland	Grassland	Wetlands	Settlements
Forest Land	<i>Estimated</i>	<i>Estimated</i>	Not occurring	<i>Estimated</i>	<i>Estimated</i>
Cropland	<i>Estimated</i>	<i>Estimated</i>	Not occurring	Not estimated	Not estimated
Grassland	Not estimated	<i>Estimated</i>	Not estimated	Not estimated	<i>Estimated</i>
Wetlands	Not occurring	Not estimated	Not occurring	<i>Estimated</i>	Not estimated
Settlements	Not occurring	Not estimated	Not occurring	Not occurring	Not estimated

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 CO₂ from the atmosphere) include the uptake of CO₂ 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 CO₂, CH₄, N₂O and CO emissions from burning, carbon stored in wood and soils (reported as CO₂) and CO₂ emissions from soils and biomass decomposition.

Table 25: Afforestation and Deforestation LULUCF Sector Categories and GHG Emissions 2007

LULUCF Category	Description	Net GHG Emissions (kt CO ₂ e)
TOTAL AFFORESTATION AND DEFORESTATION EMISSIONS (Included in Total Provincial GHG Emissions)		3 162
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.	-15.5
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

²⁸ Under current international accounting protocols, all carbon stored in removed biomass is considered to be converted to CO₂ and emitted to the atmosphere immediately.

Table 26: “Memo Item” LULUCF Sector Categories and GHG Emissions 2007

LULUCF Category	Description	Net GHG Emissions (kt CO ₂ e)
TOTAL “MEMO ITEM” LULUCF EMISSIONS (not included in Total Provincial GHG Emissions)		52 453
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.	52 095
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.	305
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.	53.4
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 3.2 megatonnes CO₂e in 2007, 4.7% of total B.C. emissions. This included 3.18 Mt CO₂e of emissions from deforestation and 0.016 Mt CO₂e of removals from afforestation. Emission and removal trends from 1990 to 2007 are shown in Figure 20.

Three-year and ten-year trends are described in Table 27, with CO₂ emissions and removals described by land conversion types as reported under international reporting protocols. Net GHG emissions from afforestation and deforestation decreased 4.8% between 2004 and 2007 and 23.3% between 1997 and 2007.

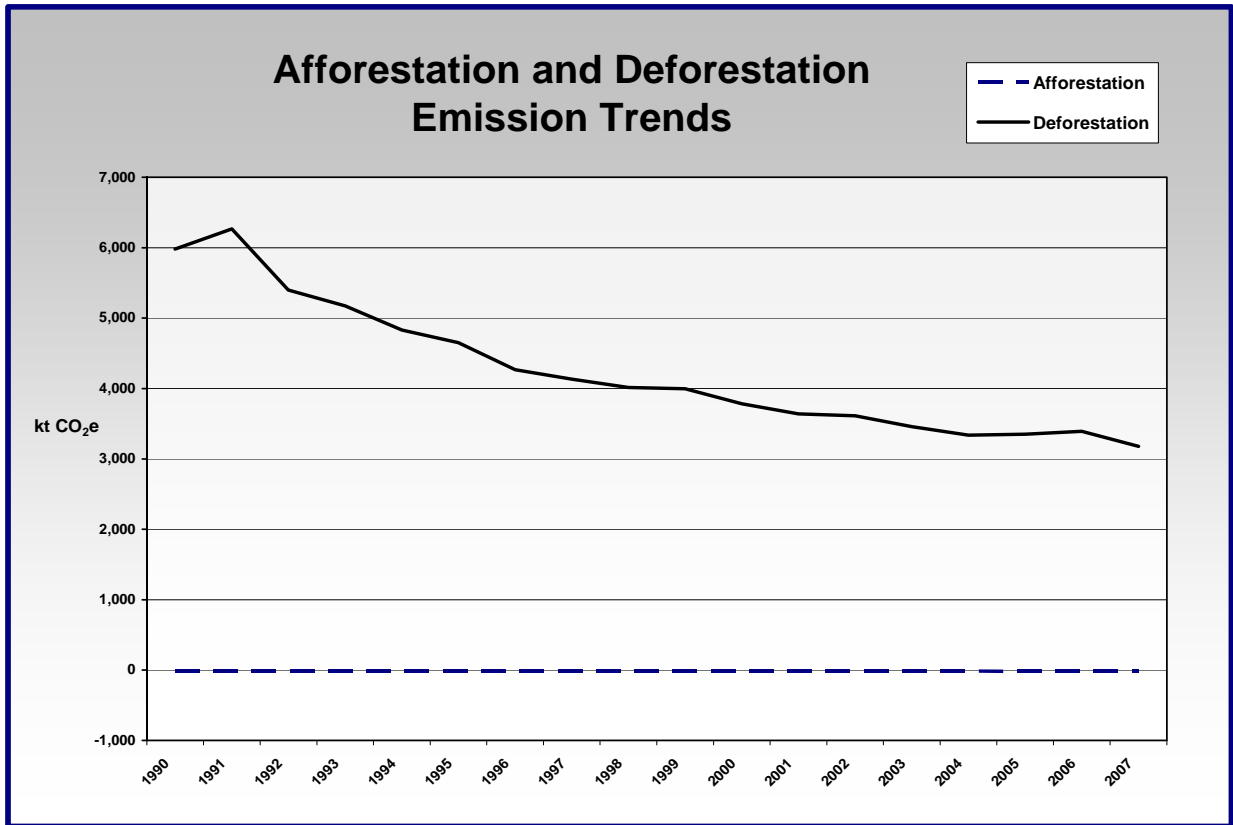


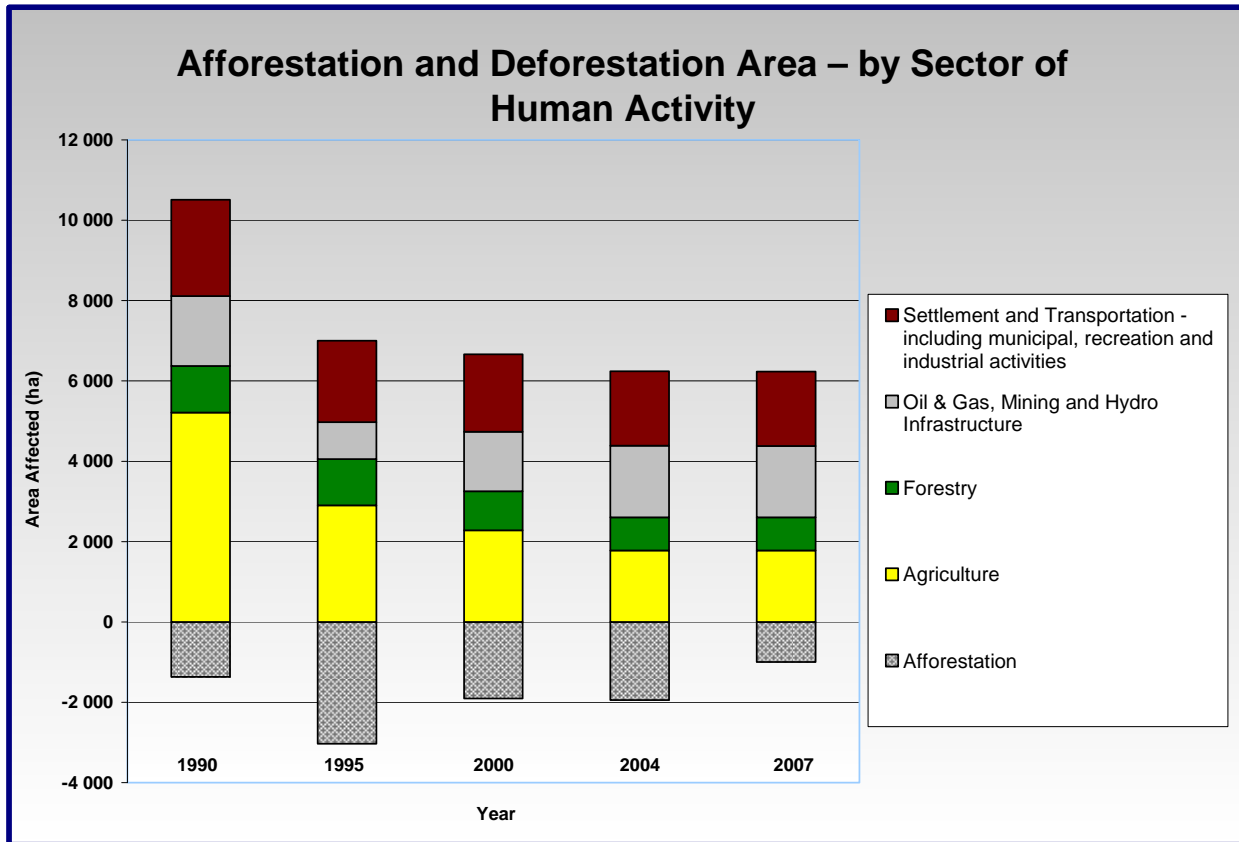
Figure 20: Afforestation and Deforestation Emission Trends

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
Cropland converted to Forest Land (Afforestation)	+1.4%	+13.1%	Afforestation rates on areas previously cropland
Forest Land converted to Cropland (Deforestation)	-27.3%	-50.0%	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)	+4.5 %	-9.1%	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., light and heavy industrial buildings/sites, shopping malls, prisons, schools, universities and similar infrastructure), mining (e.g., open pit coal, copper/molybdenum, limestone, zinc 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 21. 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 38.



Note: Afforestation is shown in this figure as a negative value – all other activities involve deforestation (increasing the “area affected”) while afforestation decreases the “area affected” (i.e., increasing the area of forest land)

Figure 21: Afforestation and Deforestation Area – by Sector of Human Activity

A total area of 6 220 hectares was deforested in 2007, having decreased 9.3% from the 6 861 ha 1997.³¹ 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/northeastern 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

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 found in the Boreal Plains terrestrial ecozone (where there is relatively more agricultural-related deforestation), thus, emissions per hectare deforested are also higher. See www.ec.gc.ca/soer-ree/English/vignettes/default.cfm for a description of terrestrial ecozones in Canada.

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 2007 as deforestation areas between 2000 and 2007 are based on interpretations of satellite image data taken in 2000 and 2007 that have been averaged and interpolated.

activity. On average, across all terrestrial ecozones, 393 tonnes of greenhouse gases are released from combined initial biomass removal and residual biomass decomposition from one hectare of deforestation in B.C.

Afforestation area data for 2007 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 52.1 megatonnes (Mt) CO₂e in 2007. These emissions are being reported as a “memo item”.³³ Emissions in this category included net -33.6 Mt CO₂e sequestered through net primary production (NPP) and decay of dead organic matter,³⁴ 72.7 Mt CO₂e emitted due to harvesting,³⁵ 4.8 Mt CO₂e emitted due to wildfires and 8.2 Mt CO₂e emitted due to slash burning.³⁶

Trends in emissions from 1990 to 2007 are shown in Figure 22. 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 CO₂ 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 CO₂ 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.

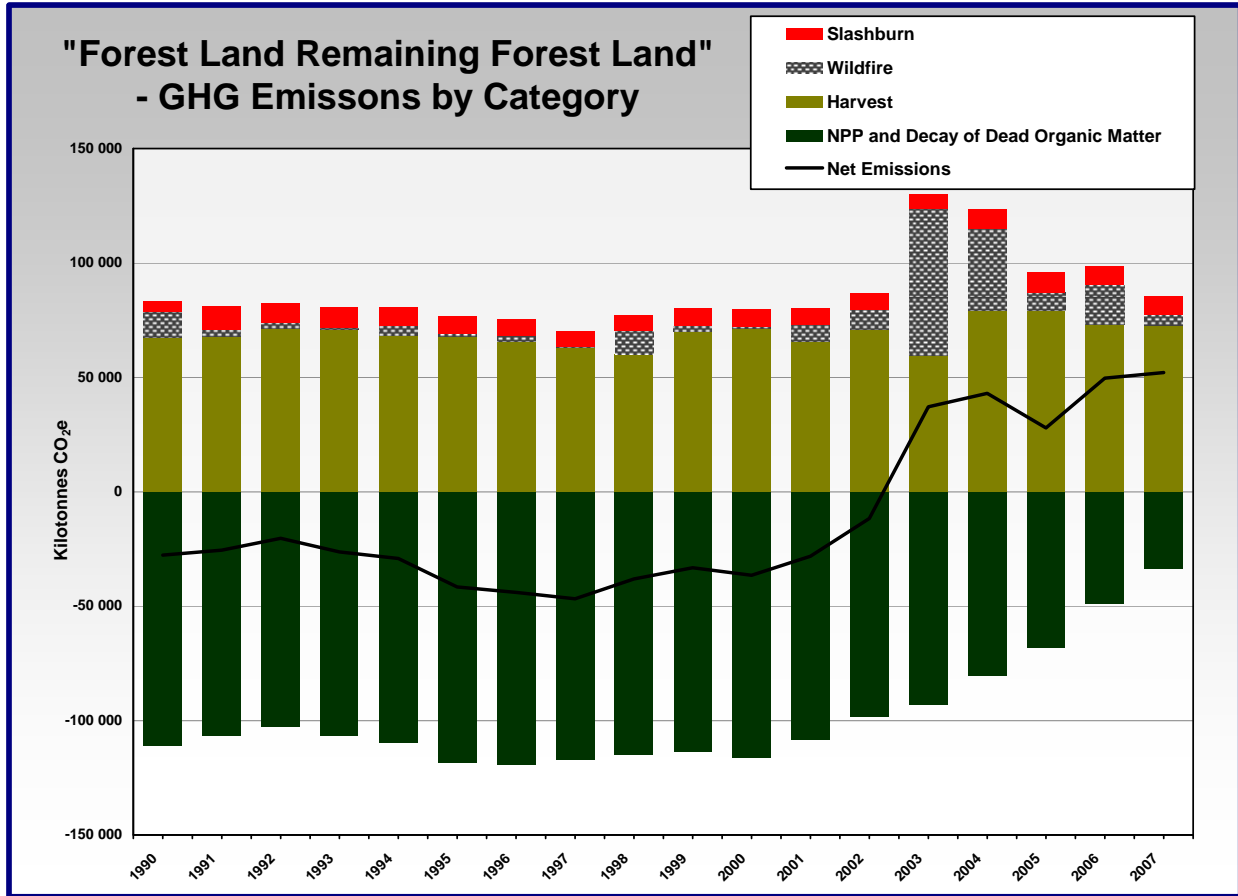


Figure 22: “Forest Land Remaining Forest Land” – GHG Emissions by Category

Three-year and ten-year trends are described in Table 28. Total (net) GHG emissions were approximately 21% higher in 2007 compared to 2004. This increase is predominately attributed to decreased removals from net primary production and increased emissions from decay of dead organic matter (emissions) as a result of the increasing severity of MPB infestation in B.C.’s forests.

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
Net Primary Production and Decay of Dead Organic Matter (removal)	-58.2%	-71.3%	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)	-86.4%	+2 749%	Forest fire location and intensity – note that emissions due to wildfires vary greatly from year to year and 1997 was a year of exceptionally low emissions
Harvest (emission)	-8.4%	+15.0%	Amount of harvest
Slash Burning (emission)	-5.0%	+19.4%	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 2007 is illustrated in Figure 23.³⁹ Area affected by MPB has increased nearly 100-fold between 1997 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.

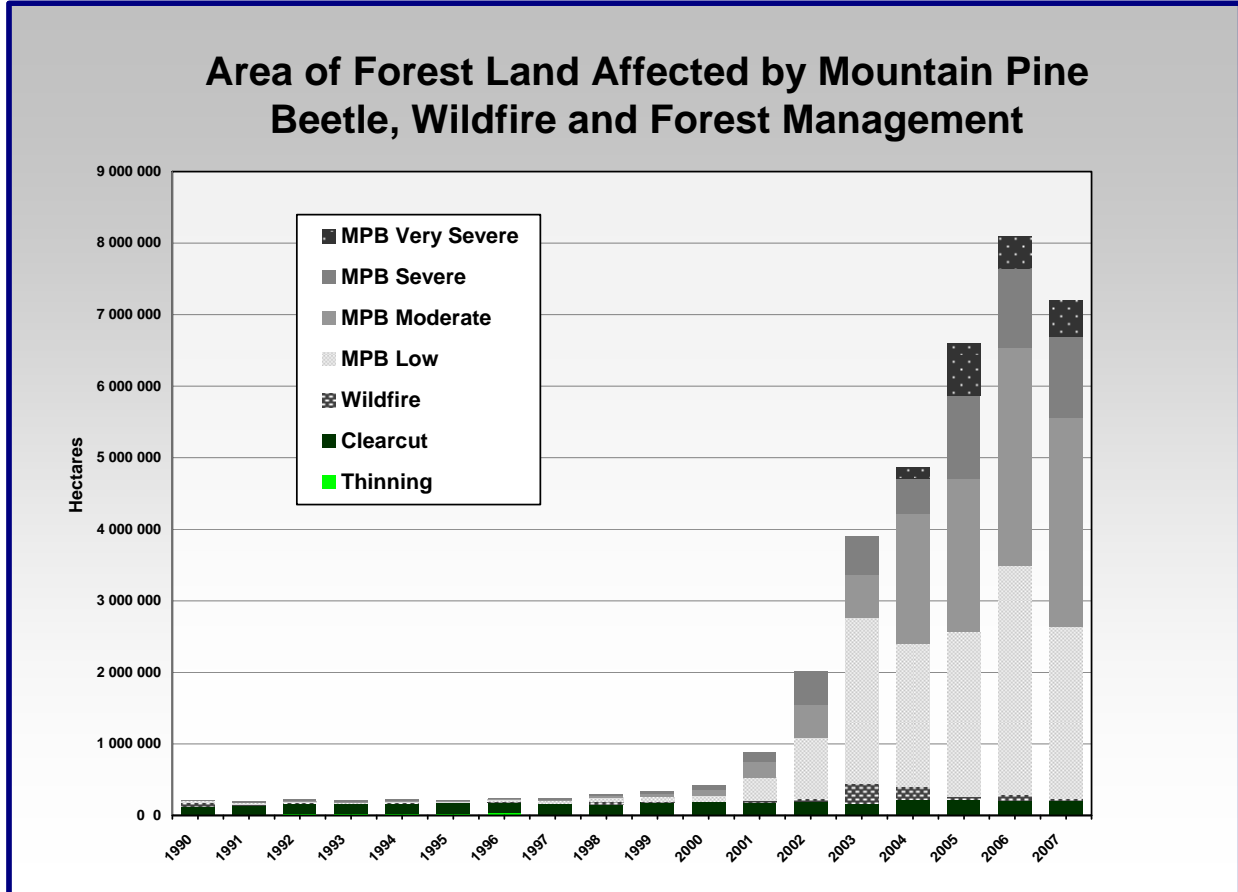


Figure 23: Area of Forest Land Affected by Mountain Pine Beetle, Wildfire and Forest Management

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

“Cropland Remaining Cropland” Category

Emissions from cropland (i.e., the “cropland remaining cropland” category) were 305 kilotonnes of CO₂e in 2007. These emissions are being reported as a “memo item”. This is a 4.9% increase from 2004 and a 41.4% increase from 1997 emissions. This increase can be attributed, in part, to an increase in the area of cropland in the province. Total cropland area in 2007 was 6.1% higher than in 2004, and 19.9% higher than in 1997. Trends in emissions and cropland area from 1990 to 2007 are shown in Figure 24. 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

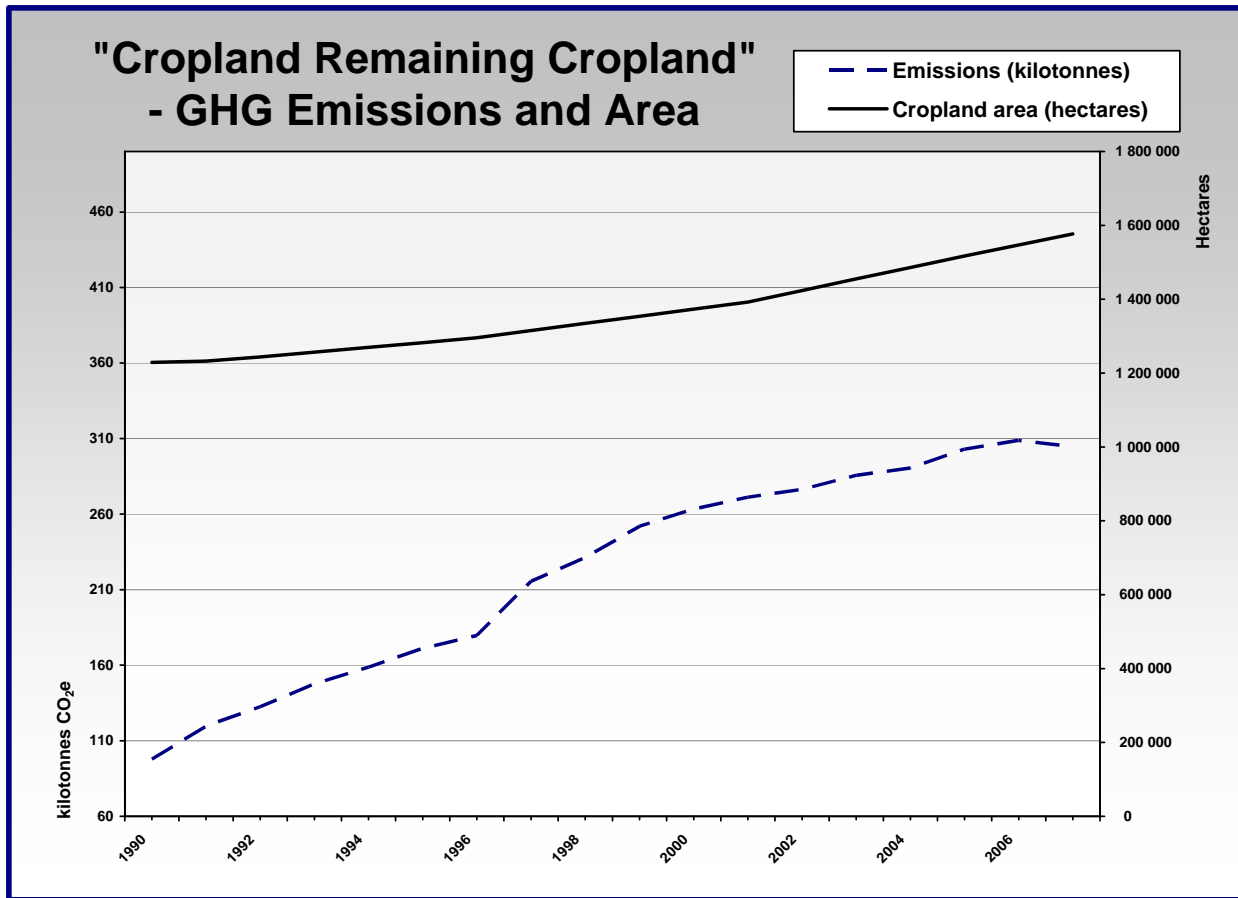


Figure 24: “Cropland Remaining Cropland” – Net GHG Emissions and Area

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 53 kilotonnes CO₂e in 2007. These emissions are being reported as a “memo item”. This is a 16.7% decrease from 2004 and a 48.2% decrease from 1997. The emissions trend for B.C. between 1990 and 2007 is shown in Figure 25. 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.

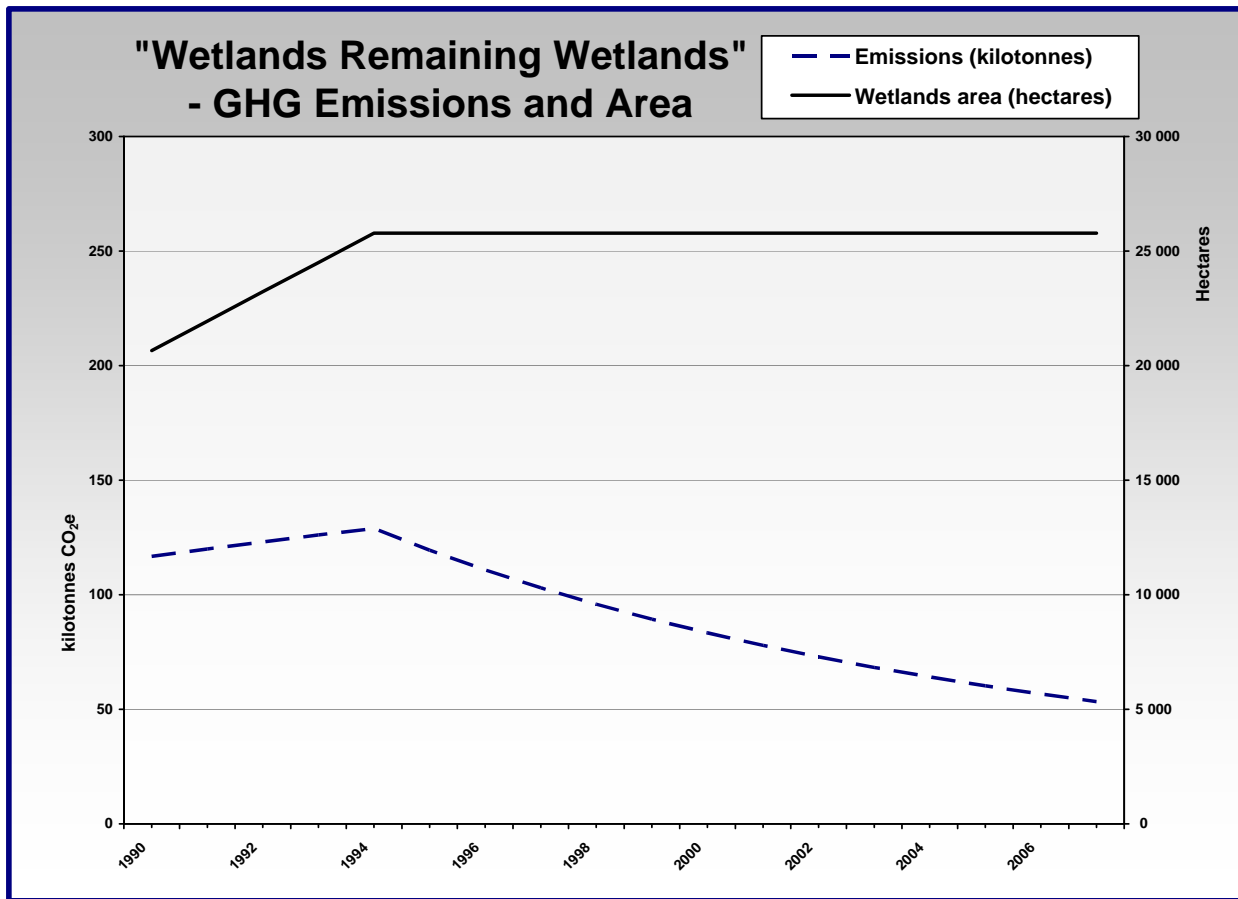


Figure 25: “Wetlands Remaining Wetlands” – Net GHG Emissions and Area

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 (c.f. Table 24).

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 2007, 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 2007 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.

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

Table 29: Activity Data and Data Sources for Afforestation 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 2005-2007 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
Afforestation, Deforestation, Forest Land	Quantity of CO ₂ removals due to tree growth Quantity of CO ₂ eq. emitted due to decomposition, fire and harvest Quantity of CO ₂ removals due to crop growth	Canadian Forest Service Carbon Budget Model (CBM-CFS3) Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories 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 ₂ O 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	<i>Canadian Environmental Protection Act</i>
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 ₂ e	Carbon dioxide equivalent – 1 CO ₂ e 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	<i>Greenhouse Gas Reductions Target Act</i>
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)
NAICS	North American Industry Classification System
NIR	National Inventory Report
N ₂ O	Nitrous oxide
NPP	Net primary production
NRCan	Natural Resources Canada
PFCs	Perfluorocarbons
QA/QC	Quality assurance/quality control
RESO	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 Gases⁴²

GHG	Formula	100-Year GWP
Carbon Dioxide	CO ₂	1
Methane	CH ₄	21
Nitrous Oxide	N ₂ O	310
Sulphur Hexafluoride	SF ₆	23 900
Hydrofluorocarbons (HFCs)		
- HFC-23	CHF ₃	11 700
- HFC-32	CH ₂ F ₂	650
- HFC-41	CH ₃ F	150
- HFC-43-10mee	C ₅ H ₂ F ₁₀	1 300
- HFC-125	C ₂ HF ₅	2 800
- HFC-134	C ₂ H ₂ F ₄ (CHF ₂ CHF ₂)	1 000
- HFC-134a	C ₂ H ₂ F ₄ (CH ₂ FCF ₃)	1 300
- HFC-143	C ₂ H ₃ F ₃ (CHF ₂ CH ₂ F)	300
- HFC-143a	C ₂ H ₃ F ₃ (CF ₃ CH ₃)	3 800
- HFC-152a	C ₂ H ₄ F ₂ (CH ₃ CHF ₂)	140
- HFC-227ea	C ₃ HF ₇	2 900
- HFC-236fa	C ₃ H ₂ F ₆	6 300
- HFC-245ca	C ₃ H ₃ F ₅	560
Perfluorocarbons (PFCs)		
- Perfluoromethane	CF ₄	6 500
- Perfluoroethane	C ₂ F ₆	9 200
- Perfluoropropane	C ₃ F ₈	7 000
- Perfluorobutane	C ₄ F ₁₀	7 000
- Perfluorocyclobutane	c-C ₄ F ₈	8 700
- Perfluoropentane	C ₅ F ₁₂	7 500
- Perfluorohexane	C ₆ F ₁₄	7 400

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

10.3 Emission Factors

The following emission factors are drawn or derived from those listed in Annex 12 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.

Emission Factors for Fuel Combustion

Table 34: Emission Factors for Fuel Consumption

Fuel Type	CO ₂	CH ₄	CH ₄ (CO ₂ e)	N ₂ O	N ₂ O (CO ₂ e)	CO ₂ e	Units
Natural Gas - Producer Consumption	2 151	6.5	136.5	0.06	18.6	2 306.1	g/m ³
Natural Gas - Industrial Consumption ¹	1 916	0.037	0.777	0.033	10.23	1 927.0	g/m ³
Natural Gas - Pipelines	1 916	1.9	39.9	0.05	15.5	1 971.4	g/m ³
Natural Gas - Vehicles at STP	1 890	9	189	0.06	18.6	2 097.6	g/m ³
Natural Gas - Vehicles, Compressed ²	2 723	13	272	0.086	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	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 - Industrial Consumption	2 663	0.133	2.793	0.4	124	2 789.8	g/L
Diesel - On Road Vehicles 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 (including MGO)	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
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/m ³
Coke Oven Gas	1 600	0.037	0.777	0.035	10.85	1 611.6	g/m ³
Still Gas - Upgrading Facilities	2 140	0	0	0.000022	0.00682	2 140.0	g/m ³
Still Gas - Refineries and Others	1750	0	0	0.000022	0.00682	1750.0	g/m ³
Wood Waste (50% moisture content)	950	0.05	1.05	0.02	6.2	957.3	g/kg

Fuel Type	CO ₂	CH ₄	CH ₄ (CO ₂ e)	N ₂ O	N ₂ O (CO ₂ e)	CO ₂ e	Units
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

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/m³ 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's , Inventory of Greenhouse Gas Emissions and Sinks: 1990-2007 (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 ₂ F 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
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 (dolo-mitic 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	4568	kg/tonne product
	Electrolysis - Horizontal stud Søderberg	1 700	0	0.04	0.03	2236	kg/tonne product
	Electrolysis - Vertical Stud Søderberg	1 700	0	0.8	0.04	7268	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	1995	2000	2004	2005	2006	2007
Category	Electricity Generation (GWh)						
Refined Petroleum Products	100	30	50	60	30	40	50
Natural Gas	1 260	4 670	3 890	2 940	3 010	2 690	2 950
Hydro	46 400	38 900	50 800	45 000	50 300	44 500	54 700
Total	47 800	43 600	54 700	48 000	53 400	47 200	57 700
	Greenhouse Gas Intensity (tonnes GHG per GWh electricity produced)						
CO ₂ Intensity (tonnes/GWh)	17	51	33	17	16	18	17
CH ₄ Intensity (tonnes/GWh)	0.004	0.01	0.008	0.004	0.004	0.004	0.002
N ₂ O Intensity (tonnes/GWh)	0.001	0.001	0.001	0.0005	0.0004	0.0005	0.00014
Overall Intensity (tonnes CO₂e/GWh)	17.4	51.5	33.5	17.2	16.2	18.2	17.1

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 underground 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)

Industrial Sector	Affected Area (hectares)								
	Year	1990	1995	1997	2000	2004	2005	2006	2007
Afforestation ¹		-1 370	-3 030	-1 900	-1 900	-1 950	- 2 428	INC ²	INC ²
Deforestation		10 510	7 000	6 860	6 650	6 230	6 200	6 220	6 220
Agriculture		5 210	2 900	2 650	2 280	1 780	1 780	1 780	1 780
Forestry		1 160	1 150	1 080	970	820	820	820	820
Hydro Infrastructure		850	0	<10	0	0	0	30	30
Industry		150	100	120	140	170	170	170	170
Mining		650	590	650	690	620	620	620	620
Municipal		1 680	1 480	1 460	1 450	1 420	1 420	1 420	1 420
Oil and Gas		240	330	500	790	1 170	1 130	1 130	1 130
Recreation		230	250	220	170	110	110	110	110
Transportation		340	200	180	170	150	150	150	150

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

² 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: Area of Forest Land Affected – by Category of Activity⁴³

Activity Category	Thinning	Clear-cut	Wildfire	MPB Low	MPB Moderate	MPB Severe	MPB Very Severe	Total MPB
Year	Area Affected (hectares)							
1990	10 440	120 950	49 730	24 660	6 230	7 140	0	38 030
1991	14 160	130 790	14 160	16 020	9 690	21 410	0	47 120
1992	23 700	141 910	11 520	16 430	6 340	20 890	0	43 670
1993	25 480	146 750	990	10 250	14 950	19 240	0	44 440
1994	20 870	150 630	17 030	4 570	11 680	14 830	0	31 070
1995	24 460	158 680	3 780	10 710	7 880	8 040	0	26 630
1996	28 750	153 340	10 490	30 190	7 110	6 840	0	44 140
1997	10 220	154 140	980	38 530	17 920	13 060	0	69 510
1998	8 860	149 050	43 510	48 340	26 760	20 600	0	95 700
1999	7 110	176 090	7 910	69 280	44 900	31 500	0	145 670
2000	10 850	185 400	2 170	81 700	79 490	68 560	0	229 750
2001	8 170	170 920	30 510	322 500	213 580	133 480	0	669 550
2002	9 160	187 550	37 640	850 760	470 450	467 760	0	1 788 970
2003	6 880	162 400	279 940	2 306 800	607 820	536 090	0	3 450 720
2004	6 650	216 660	181 850	1 997 870	1 817 090	490 520	147 560	4 453 040
2005	4 310	224 530	37 660	2 298 650	2 137 790	1 171 520	727 430	6 335 380
2006	4 030	211 920	77 940	3 201 390	3 039 250	1 117 090	448 470	7 806 200
2007	4 080	213 510	18 600	2 399 970	2 928 680	1 128 790	507 960	6 965 410

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 2007



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