BRITISH COLUMBIA

GREENHOUSE GAS

INVENTORY REPORT 2010

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British Columbia Greenhouse Gas Inventory Report 2010

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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: http://www.env.gov.bc.ca/cas/mitigation/ghg_inventory/index.html

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

1. REPORT PURPOSE, STRUCTURE AND REPORTING OF DATA

1.1 Purpose of the British Columbia Greenhouse Gas Inventory Report

The *British Columbia Greenhouse Gas Inventory Report 2010* (B.C. GHG inventory report or Provincial Inventory Report – PIR) has been prepared to provide sound, science-based, comparable and consistent reporting of GHG sources and sinks in British Columbia – in support of section 4(a) of the *Greenhouse Gas Reductions Target Act* [1] (GGRTA), as well as national and international reporting processes and related initiatives. A GHG sources and sinks inventory is a comprehensive account of emission releases from anthropogenic sources (e.g., fuel combustion, industrial processes) and removals[2] by sinks (e.g., growing plants and trees) for a defined area (such as a nation or province) over a specified period of time.

The GGRTA establishes legislated targets for reducing British Columbia's GHG emissions. As compared to 2007 levels, emissions must be reduced by a minimum of 33% by 2020 and 80% by 2050. Interim reduction targets of 6% by 2012 and 18% by 2016 have also been set by Ministerial Order. The total B.C. emissions estimate provided in this report are the third measure of change against the 2007 baseline established under the GGRTA. Following this 2010 report, the Ministry of Environment (the ministry) will prepare a B.C. GHG inventory report for every even subsequent year (i.e., 2012 and beyond). Updates to data tables showing annual emission levels and some other parameters will be provided for odd calendar years (i.e., 2011 and beyond).

This report has been prepared by the ministry, working with staff in other provincial ministries and with federal counterparts, to determine and report the 2010 GHG emissions level for B.C. In keeping with national and international GHG inventory procedures it is expected that GHG estimates, including the 2007 baseline, will continue to be updated annually or periodically to reflect resolution of data anomalies and improved quantification methods and input data.

A separate summary of this B.C. GHG inventory report, as well as additional information, is available at: http://www.env.gov.bc.ca/cas/mitigation/ghg_inventory/index.html.

Progress to Targets Report

The Progress to Targets Report[3] is published by the Ministry of Environment in parallel with the Provincial Inventory Report (PIR). The PIR addresses the legal requirement in section 4(a) of the *Greenhouse Gas Reduction Targets Act* to determine provincial emission levels. The Progress to Targets Report documents the progress made toward achieving the targets, actions that have been taken to achieve that progress and the plans to further that progress (requirements under sections 4(b), (c) and (d) of the *Act*).

[1] See: http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/00_07042_01

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

[3] See: http://www.env.gov.bc.ca/cas/pdfs/2012-Progress-to-Targets.pdf

1.2 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 Environment Canada's *National Inventory Report on Greenhouse Gases and Sinks in Canada* (National Inventory Report – NIR), grouped in the following sector and sub-sector headings:

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

This report includes the following B.C.-specific emissions currently not reported at the provincial level in the NIR: emission sources and sinks reported under the "land use, land-use change and forestry" sector. As a result of including these categories, reported emissions in this B.C. Provincial GHG Report are 2.9 megatonnes CO_2e (4.7%) 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 2 for specific figures and percentages of emissions by sector). Emissions for the year 2010 for each sector are documented, as well as trends in relation to preceding years to provide short and longer term context and factors influencing emissions. Data sources are summarized for each sector. The final section of the report provides annexes listing acronyms used in the document, emission factors used in calculating emissions and other supporting information.

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

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

Readers wishing detailed information regarding methodologies and protocols for emissions reporting and recalculation – as well as Quality Assurance/Quality Control (QA/QC), data sources and planned improvements – can refer to the extensive set of background and methodological documents provided on the Environment Canada GHG website.[4]

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

Understanding British Columbia GHG Inventories

British Columbia has developed and maintained four provincial-level greenhouse gas inventories, each serving a different purpose (see figure 1). Together the inventories provide a comprehensive view of the sources of provincial emissions. Insights gained through the collection of data for facility-specific reporting and the CEEI may be used to refine (where applicable) the GHG quantification methodologies used in the NIR and consequently also the B.C. GHG inventory report.

Figure 1: Related British Columbia GHG Inventories

Provincial Greenhouse Gas Inventory Report (PIR)

The Provincial Greenhouse Gas Inventory Report[5] (PIR) is the top-down, aggregate report on all greenhouse gas emissions occurring within the geographic boundaries of British Columbia. The PIR is the foundation on which progress towards the legislated *Greenhouse Gas Reduction Targets Act* (GGRTA) targets is measured and provides a coarse level view of emissions for the province, for each sector, as well as emissions factors and background information.

Community Energy and Emissions Inventory (CEEI)

The Community Energy Emissions Inventory[6] (CEEI) supports tracking and reporting of energy use and GHG emissions at a community level, in order to improve community-level understanding and decision making. The reports provide buildings, transportation and waste emissions profiles for the entire geographic area of the 187 municipalities and 29 regional districts within British Columbia. Deforestation and agricultural emissions data is also reported at the regional district level.

Carbon Neutral Action Reports (CNAR)

Carbon Neutral Action Reports[7] comply with *Greenhouse Gas Reduction Targets Act*[8] obligations for B.C. to document buildings, fleet and paper emissions from crown corporations, post-secondary institutions, school districts and health authorities and core government (government ministries and agencies). Core government also reports on business travel. Local government reports[9] will likely be similar to the carbon neutral government reports, addressing the corporate operations of local governments that have signed the Climate Action Charter.

[5] http://www.env.gov.bc.ca/cas/mitigation/ghg_inventory/index.html
[6] http://www.env.gov.bc.ca/cas/mitigation/ceei/index.html
[7] http://www.livesmartbc.ca/government/carbon_neutral/neutral_action_reports.html
[8] http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/00_07042_01
[9] http://www.env.gov.bc.ca/cas/mitigation/charter.html

Reporting Regulation Greenhouse Gas Emissions Report Summaries

The Reporting Regulation Greenhouse Gas Emissions Report Summaries[10] document emissions and geographic location for each industrial facility emitting 10,000 tonnes or more of greenhouse gas emissions within British Columbia, as well as the aggregate of all oil & gas and electricity transmission emissions for facilities with emissions less than 10,000 tonnes that are owned or operated by the same company. Given that the Reporting Regulation data provide a complete or near-complete profile of greenhouse gas emissions for some industrial sectors (e.g., oil and gas, most industrial process emissions, electricity generation), the Province is considering using the data to refine some of the coarser estimates in Canada's National Inventory Report, as was done this year for oil and gas combustion emissions.

1.3 Approach to Data Used for Reporting Emissions

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

- Unless discrepancies in provincial data are noticed in QA/QC processes, the data presented in this report is provided entirely by Environment Canada and the Canadian Forest Service and is the same data presented in the National Inventory Report (NIR). Where needed to report emissions at a provincial scale the B.C. GHG inventory report includes data provided to the ministry by the GHG Division of Environment Canada that is not published in the NIR (but that is included in NIR national totals).
- The ministry supports and works in collaboration with federal counterparts responsible for preparation of the NIR to develop current and scientifically rigorous best practices and methodologies for GHG quantification, consistent with international standards and practices.
- The ministry follows protocols established by Environment Canada to maintain confidentiality of data as and where appropriate.
- The ministry uses "memo item" categories where needed to address important source and sink categories not otherwise included or cumulated into national totals (see discussion under reporting of "land use, land-use change and forestry" sector memo items).
- The ministry continues to use a QA/QC process to ensure that the NIR data presented in the B.C. GHG inventory report is accurate and representative.
- New text boxes are included in the 1990-2010 PIR to provide supplemental information of international GHG accounting updates and standards and context of the PIR in relation to other inventories (see section 2.3).
- As a discrepancy was noticed in the Fossil Fuel Production and Refining line item for B.C. in the NIR, this line item was recalculated for the 1990-2010 PIR. This recalculation is explained under section 4.3 (energy sub-sector a: stationary combustion sources) on page 22.

[10] http://www.env.gov.bc.ca/cas/mitigation/ggrcta/reporting-regulation/2010-emissions-reports.html

1.4 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 mandatory under greenhouse gas reporting protocols established by the United Nations Framework Convention on Climate Change (UNFCCC). To this date, while the federal government reports GHG emissions from the entire sector, only afforestation and deforestation emissions are included in its emissions target accounting.

The B.C. GHG inventory report 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 were counted towards Canada's assigned amount under Article 3.3 of the Kyoto Protocol, while emissions from Land Use and Forestry were 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.

1.5 Year to Year Changes in GHG Emissions

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

Statistics Canada is undertaking a historical backcast (review and update) on the Report on Energy Supply and Demand (RESD), using the Secondary Distributors Survey. As a result of this work reported emissions in the energy subsectors may change however, figures for total energy sector emissions should remain relatively constant. This reattribution of energy sector emissions is planned to be complete in time for incorporation in the 1990-2011 NIR.

2. BACKGROUND INFORMATION

2.1 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[11] that are influenced by human activities that are of interest:

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

Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. For example, the global atmospheric concentration of carbon dioxide has increased from a pre-industrial value of about 280 parts per million (ppm) to 390 ppm in 2010[12]. The globally averaged atmospheric concentration of carbon dioxide in 2010 exceeds by far the natural range over the last 650,000 years (180 to 300 ppm) as determined from ice cores. The global increases in carbon dioxide concentration are due primarily to fossil fuel use and land-use change, while those of methane and nitrous oxide are primarily due to agriculture.[13]

The concept of "global warming potential" (GWP or CO_2e) has been developed to enable comparison of the ability of different GHGs to trap heat in the atmosphere (radiative forcing).[14] By definition, the GWP from the release of 1 kg of CO_2 is one, with the GWP of other GHGs stated relative to CO_2. The GWP of a GHG accounts for both the immediate radiative forcing due to an increase in the concentration of the gas in the atmosphere, and the lifetime of the gas. The following summary table

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

[12] Earth System Research Laboratory "Trends in Atmospheric Carbon Dioxide" www.esrl.noaa.gov/gmd/ccgg/trends/

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

[14] 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).

lists the "100-Year GWP" (as recommended by the International Panel on Climate Change) for the major gases and groups of gases.[15] In line with current UNFCCC protocols, B.C. 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 (see additional discussion under the "international updates" text box in section 2.3).

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

GHG	100-Year GWP (IPCC SAR 1995)	100-Year GWP (IPCC 4AR 2007)
Carbon Dioxide (CO_2)	1	1
Methane (CH_4)	21	25
Nitrous Oxide (N_2O)	310	298
Nitrogen Trifluoride (NF_3)	-	17,200
Sulphur Hexafluoride (SF_6)	23,900	22,800
Hydrofluorocarbon - 23 (CHF_3)	11,700	14,800
Hydrofluorocarbon - 32 (CH_2F_2)	650	675
Perfluorocarbons – 116 (C_2F_6)	9,200	12,200

2.2 Emission Factors

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

2.3 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).[16] 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.

[15] A complete table with specific figures for each GHG is included in Annex 10.2 Global Warming Potentials for Greenhouse Gases of this report.
[16] See: http://unfccc.int

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.

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

Emissions from individual emitters may be measured or estimated from individual plant data, or from facility throughput and emission factors. Under the British Columbia Reporting Regulation,[17] One hundred companies, comprising 120 total reporting operations, reported emissions of 10,000 tonnes or more of GHGs in 2010. Total emissions from industrial operations over 25,000 tonnes were 18.5 megatonnes (Mt) of carbon dioxide equivalent (CO_2 eq), which is 30 percent of total provincial emissions. Emissions data by facility is made publicly available.

Under Environment Canada's Greenhouse Gas Emissions Reporting program,[18] all facilities in Canada emitting over 50,000 tonnes of GHGs in a given year are required to report emissions to Environment Canada. For the 2010 calendar year, 537 facilities across Canada reported their greenhouse gas (GHG) emissions to Environment Canada. Total reported emissions were 262 Mt CO_2 eq. This represents an increase of 4.3% from a revised 2009 total of 251 Mt. The GHG emissions data collected from facilities represent just over one-third (38%) of Canada's total GHG emissions and 59% of Canada's industrial GHG emissions.

Generally, data reported under this system are not used in the NIR, with the exception of limited industrial process emissions data. Due to a known error in the Fossil Fuel Production and Refining line item of the 1990-2010 NIR, the B.C. Reporting Regulation facility data referenced above was used to estimate emissions for that sector. This is explained in more detail in section 4.3 of this report.

[17] See: http://www.env.gov.bc.ca/cas/mitigation/ggrcta/reporting-regulation/ for details on the British Columbia Reporting Regulation, including 2010 Emission Report Summaries.
[18] See: http://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=040E378D-1 for both a description of the reporting system and a link to the public data download sit

International Updates

At the 17th United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP 17) in Durban, South Africa,[19] the UNFCCC Reporting Guidelines for greenhouse gas inventories[20] were revised to allow for implementation of the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories[21], which contain updates in scope and methods, and to incorporate recent science.

Science updates include the addition of nitrogen trifluoride (NF_3, used in electronics manufacturing and likely insignificant in B.C.) in the standard list of greenhouse gases, the adoption of the IPCC 4th Assessment Report (AR4)[22] global warming potentials, reporting of emissions from wood products when they occur rather than immediately upon harvest and inclusion of new (mostly industrial) source and sink categories. The most significant changes for B.C. are (i) the 20% increase in the global warming potential of methane, which will raise the relative importance of fugitive oil and gas, coal mine and agricultural methane emissions in the inventory and; (ii) the time sensitive reporting of emissions from wood products which is expected to reduce reported emissions from logging by approximately 48%.

The revised UNFCCC reporting guidelines and IPCC 2006 guidelines will be in effect internationally starting with the 2015 submission of the national inventory reports, subject to a final decision by the Conference/Meeting of the Parties in late 2013. Once in effect, all years from 1990-2013 will be recalculated based on the new guidelines and new global warming potentials. Given the importance of international standardization, British Columbia will follow the same timeframe and approach.

Other chemical compounds, including short-lived climate forcers [23] such as black carbon (soot from forest fires, slash burning and diesel engines), [24] are known to have an impact on climate change. British Columbia is tracking the accounting and science related to these compounds and will consider incorporating them into its greenhouse gas inventory if they are required under international guidelines.

Forestry Accounting Updates

At the 17th Conference of the Parties (COP-17) in Durban, South Africa, the UNFCCC agreed on rules for land use, land use change and forestry accounting for the second commitment period of the Kyoto Protocol (which starts in 2013) for countries that are taking on targets for that period. How the Durban rules will be applied to national inventories and which accounting approaches will be used is still under discussion.

The new rules for forest carbon accounting will address some of the issues associated with interim rules used in the first Kyoto commitment period:

1. The use of wood products, by definition, resulted in no positive or negative carbon impacts
2. All uses of wood were treated equally and with no time dimension, such as using wood for one-time energy or long term wood products (carbon in harvested wood and was deemed to be immediately emitted to the atmosphere irrespective of use)
3. The management of wood for bioenergy was not considered
4. No incentive to improve forest management and carbon sequestration was inherent in the rules
5. Emissions from natural disturbances (e.g., forest fires or insect outbreaks) were included in estimates for forest management

[19] http://unfccc.int/meetings/durban_nov_2011/meeting/6245.php
[20] http://unfccc.int/national_reports/annex_i_ghg_inventories/reporting_requirements/items/2759.php
[21] http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html
[22] http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm
[23] http://www.unep.org/dewa/Portals/67/pdf/SL_climateforcers_02.pdf
[24] http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-5-4.html

It is clear that, once adopted, the COP-17 decisions will significantly change the forest carbon accounting rules, and would support improved accounting of the greenhouse gas impacts of both forest management activities and harvested wood products:

1. Emissions would be accounted as they occur: carbon stored in harvested wood products produced by a country would be accounted for as it is emitted (not immediately at the time of harvest) while wood used for bioenergy would be treated as an immediate emission (with the source of wood for bioenergy of importance for accounting)
2. Forward-looking reference levels (baselines) for forest management[25] would ensure that the existing state of a jurisdiction's forest is factored into the accounting
3. Emissions from natural disturbances (such as insect outbreaks and wild fire) would be factored out of the accounting, ensuring that a jurisdiction is not unduly penalized by factors over which it has little or no control

In the future it is expected that B.C. GHG inventory estimates will incorporate similar improvements for reporting on harvested wood products and excluding the impact of natural disturbances. This will improve accounting for carbon flows and provide incentives for better forest management and GHG reductions.

Territoriality and Reporting

The UNFCCC Reporting Guidelines use a strict geographic territoriality approach to reporting of greenhouse gas emissions. A jurisdiction is responsible to report only those emissions that occur within its boundaries. Emissions that occur within the source jurisdiction for imported products and emissions that occur within receiving jurisdictions from exported products are reported in the source and receiving jurisdiction, respectively. For example, future responsibility for harvested wood products will rest with the jurisdiction that produces rather than consumes the wood.

This approach keeps both reporting boundaries very clear and presumes that emissions are best counted at their source. However, geographic territoriality can simplify relationships when emissions in one jurisdiction may be considered the sole or primary responsibility of another jurisdiction. For example, the emissions associated with a thermal power plant supplying electricity to a neighbouring jurisdiction and having limited market or sales within its home jurisdiction. These emissions could theoretically be considered the responsibility of the neighbouring (purchasing) jurisdiction, rather than the home (producing) jurisdiction.

As there has to be one standardized method of reporting internationally on GHG emissions to avoid double-counting and missing some emissions completely, one cannot selectively choose to depart from the territorial principle for reporting of some products and not for others. Keeping strictly to the principle of territorial reporting (or territoriality) is powerful in aligning emissions with the jurisdiction that can do the most to manage and reduce those emissions. Accounting rules (such as those under the Kyoto Protocol) may however differ from inventory reporting rules and can allow for trade of emissions reductions, offsets and similar instruments across geographic borders.

B.C. is collecting GHG imported electricity emissions data as part of its standardized industry reporting system. Since this type of information is already publically available, a future PIR could include a summary as a memo item.

[25] See: http://unfccc.int/files/kyoto_protocol/application/pdf/lulucf_-_canada_-_september_2009_informal_submission.pdf

3. B.C. GHG EMISSIONS – 2010

3.1 B.C. GHG Emissions by Sector – 2010

Total greenhouse gas emissions in British Columbia in 2010 were 62.0 megatonnes (Mt) CO_2e.[26]

In 2007, the base year for calculation of B.C. GHG emissions targets established under the provincial *Greenhouse Gas Reductions Target Act,*[27] GHG emissions were 64.9 Mt CO_2e.[28]

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 2010 from each of the sectors is shown in Figure 2. 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.

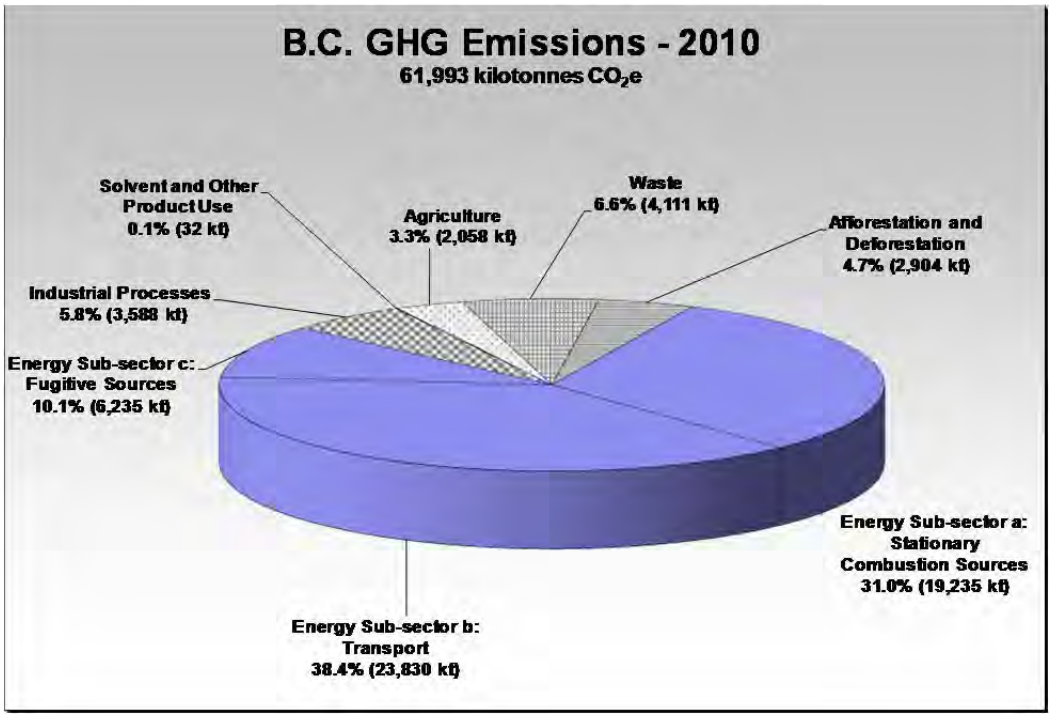


Figure 2: B.C. GHG Emissions – 2010

[26] One megatonne (1 Mt) is one million tonnes. One kilotonne (1 kt) is one thousand tonnes. This figure (62.0 Mt CO_2e) includes B.C.-specific emissions currently not reported at the provincial level in the National Inventory Report (NIR). The figure also includes a recalculation of the Fossil Fuel Production and Refining line item presented in the National Inventory Report. As a result, reported emissions are 5.9 Mt (10.5%) higher than the emissions of 56.1 Mt reported for B.C. in the NIR. Note that totals and percentages may not sum due to rounding protocols.

[27] The *Greenhouse Gas Reductions Targets Act* puts into law British Columbia's target of reducing greenhouse gas emissions by at least 33% below 2007 levels by 2020 and includes the long-term target of an 80% reduction below 2008 levels by 2050. See: http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/00_07042_01

[28] Note that under international protocols, GHG emissions estimates are reviewed and revised to incorporate methodological refinements and improved data. The 2010 GHG emissions estimate (as well as all figures used in calculating trends and changes in emissions from previous years) in this report reflects the revised emissions estimates determined and reported by Environment Canada in the National Inventory Report.

Table 2: Sector Descriptions and 2010 GHG Emissions[29]

Sector	Description	GHG Emissions (kt CO_2e)	% of B.C. Emissions
ENERGY	Emissions from stationary and transport fuel combustion and fugitive emissions from the fossil fuel industry	49,300	79.5%
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)	19,235	31.0%
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)	23,830	38.4%
Sub-sector c: Fugitive Emissions	Intentional or unintentional emissions from the production, processing, transmission, storage, and delivery of fossil fuels; and from the combustion of fossil fuels not used to generate useful heat or electricity	6,235	10.1%
INDUSTRIAL PROCESSES	Emissions from chemical reactions used in industry that physically or chemically transform materials	3,588	5.8%
SOLVENT & OTHER PRODUCT USE	Nitrous oxide emissions when used as an anaesthetic or propellant	32	0.1%
AGRICULTURE	Emissions from enteric fermentation, manure management and non-CO_2 emissions from agricultural soils	2,058	3.3%
WASTE	Emissions from solid waste disposal, wastewater treatment and waste incineration	4,111	6.6%
AFFORESTATION & DEFORESTATION	Emissions from deforestation and removals from afforestation	2,904	4.7%
	TOTAL	61,993	

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

3.2 B.C. GHG Emissions by Greenhouse Gas – 2010

For emissions reporting, most sectors are further categorized into sub-sectors, a number of which are further sub-divided into finer categories.[30]

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

Carbon dioxide (CO_2) accounts for most of the GHG emissions in the province (79.6% of total CO_2e), followed by methane (CH_4) which accounts for 14.0% of total emissions and nitrous oxide (N_2O) which accounts for 4.0% of total emissions.

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

[30] 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 – 2010

Greenhouse Gas	CO_2	CH_4	CH_4	N_2O	N_2O	PFCs	HFCs and	TOTAL
Unit	kt	kt	kt CO_2e	kt	kt CO_2e	kt CO_2e	kt CO_2e	kt CO_2e
TOTAL	49,369	413	8,676	8	2,468	402	1,077	61,993
ENERGY	44,345	172.8	3,629	4.3	1,325			49,300
a. Stationary Combustion Sources	18,391	25	534	1.0	309			19,235
Electricity and Heat Generation	1,421	0.0	6	0.0	117			1,438
Fossil Fuel Industries	4,890	12.7	266	0.0	45			5,202
Mining and Oil & Gas Extraction	1,652	0.0		0.0	9			1,662
Manufacturing Industries	4,063	1.0	15	1.0	166			4,243
Construction	81	0.0	0	0.0	1			82
Commercial & Institutional	2,482	0.0	1	0.0	16			2,499
Residential	3,498	12	246	0.0	60			3,804
Agriculture & Forestry	304	0.0	0	0.0	2			306
b. Transport	22,756	2.8	59	3.3	1,015			23,830
Domestic Aviation	1,115	0.0	1	0.0	10			1,126
Road Transportation	14,942	1.2	24	1.6	4926			15,458
Light-Duty Gasoline Vehicles	3,768	0.4	7	0.5	158			3,933
Light-Duty Gasoline Trucks	4,306	0.4	8	0.7	2025			4,515
Heavy-Duty Gasoline Vehicles	1,731	0.1	2	0.1	43			1,776
Motorcycles	28	0.0	0	0.0	0			29
Light-Duty Diesel Vehicles	81	0.0	0	0.0	2			83
Light-Duty Diesel Trucks	62	0.0	0	0.0	2			63
Heavy-Duty Diesel Vehicles	4,767	0.2	4	0.3	83			4,855
Propane & Natural Gas Vehicles	200	0.1	3	0.0	1			204
Railways	454	0.0	1	0.2	60			515
Domestic Marine	2,588	0.2	4	0.4	112			2,704
Other Transportation	3,657	1.3	28	1.1	3426			4,027
Off-Road Gasoline	320	0.4	8	0.0	2			331
Off-Road Diesel	2,525	0.1	3	1.1	333			2,860
Pipelines	813	0.8	17	0.0	7			836
c. Fugitive Sources	3,198	144.6	3,037	0.0				6,235
Coal Mining		36.4	764	0				764
Oil and Natural Gas	3,198	108.2	2,273	0.0				5,471
INDUSTRIAL PROCESSES	2,109					402	1,077	3,588
a. Mineral Products	1,164							1,164
Cement Production	956							956
Lime Production	169							169
Mineral Product Use[1]	38							38
b. Chemical Industry								0
Nitric Acid Production								0
Adipic Acid Production								0

Greenhouse Gas	CO_2	CH_4	CH_4	N_2O	N_2O	PFCs	HFCs and	TOTAL
Unit	kt	kt	kt CO_2e	kt	kt CO_2e	kt CO_2e	kt CO_2e	kt CO_2e
c. Metal Production	383					402		785
Iron and Steel Production								0
Aluminium Production	383					402		785
SF_6 Used in Magnesium Smelters and Casters[2]								0
d. Consumption of Halocarbons and SF_6							1,077	1,077
e. Other & Undifferentiated Production	562							562
SOLVENT & OTHER PRODUCT USE				0.1	32.1			32
AGRICULTURE		53.1	1,114	3.0	944			2,058
a. Enteric Fermentation		45.1	947	0	0			947
b. Manure Management		16.1	339	0	0			339
c. Agriculture Soils				2.5	773			773
Direct Sources				1.1	333			333
Pasture, Range and Paddock Manure				0.6	171			171
Indirect Sources				0.9	269			269
Field Burning of Agricultural Residues								0
WASTE	72.7	185	3,894	0.5	144			4,111
a. Solid Waste Disposal on Land		184	3,870					3,870
b. Wastewater Handling		1.2	25	0.4	132			157
c. Waste Incineration	72.7			0.0	11			84
AFFORESTATION & DEFORESTATION	2,843	1.5	37	0.1	23			2,903
a. Afforestation	-18[1]							-18
b. Deforestation	2,861	2	37	0	23	0	0	2,922
MEMO ITEMS (categories presented for information purposes but not included in B.C. total GHG emissions)							MEMO ITEMS	
OTHER LAND USE (not included in total B.C. emissions)	*73,412*	*241.6*	*5,074*	*10.2*	*3,151*			*81,637*
a. Forest Management	*73,141*	*241.6*	*5,074*	*10.2*	*3,151*			*81,366*
b. Cropland Management	*228*	*0*	*0*	*0*	*0*			*228*
c. Wetland Management	*43*	*0*	*0*	*0*	*0*			*43*

Notes:

Totals may not sum due to rounding protocols

"X" indicates confidential data

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

[1] This includes values for "Limestone and Dolomite Use" and "Soda Ash Production and Use"

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

3.3 B.C. GHG Emissions by Sector – 1990 to 2010

Table 4 provides a summary of GHG emissions for B.C. by category for 1990, 1995, 2000, 2005 and 2007-2010. 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 1990-2010

GHG Source Categories	1990	1995	2000	2005	2007	2008	2009	2010
	GHG Emissions (kt CO_2 e)							
TOTAL (with afforestation and deforestation)	55,518	61,924	65,754	65,554	64,897	65,417	61,522	61,993
ENERGY	41,216	48,197	51,767	52,156	51,186	52,260	48,704	49,300
a. Stationary Combustion Sources	18,940	21,327	22,514	21,676	20,515	20,460	19,465	19,235
Electricity and Heat Generation	803	2,234	1,813	1,552	1,299	1,665	1,558	1,438
Fossil Fuel Industries	3,555	3,773	3,781	5,097	4,990	4,914	4,901	5,202
Mining & Oil and Gas Extraction	328	174	730	635	1,336	1,632	1,574	1,662
Manufacturing Industries	6,461	6,958	7,705	6,138	4,916	4,250	4,017	4,243
Construction	306	200	76	107	117	100	63	81
Commercial & Institutional	2,838	3,398	3,424	3,659	3,318	3,372	2,755	2,499
Residential	4,329	4,439	4,670	4,421	4,475	4,470	4,551	3,803
Agriculture & Forestry	321	152	316	66	64	56	46	306
b. Transportation	18,610	22,040	23,908	25,033	24,906	25,372	23,148	23,830
Domestic Aviation	1,285	1,254	1,482	1,507	1,422	1,331	1,202	1,126
Road Transportation	11,407	13,153	14,754	15,374	15,487	15,398	15,530	15,458
Light-Duty Gasoline Vehicles	3,735	4,331	4,397	4,153	4,060	4,024	4,095	3,933
Light-Duty Gasoline Trucks	2,134	3,330	4,470	4,726	4,636	4,604	4,694	4,515
Heavy-Duty Gasoline Vehicles	2,224	1,985	1,822	1,771	1,772	1,778	1,831	1,776
Motorcycles	19	14	18	29	29	29	30	29
Light-Duty Diesel Vehicles	34	39	51	63	66	71	78	83
Light-Duty Diesel Trucks	40	73	72	58	59	60	63	63
Heavy-Duty Diesel Vehicles	2,438	2,811	3,595	4,381	4,638	4,580	4,540	4,855
Propane & Natural Gas Vehicles	782	570	329	194	226	253	201	204
Railways	1,441	1,650	1,268	414	402	626	444	515
Domestic Marine	1,025	1,232	1,235	2,547	2,586	2,525	2,653	2,704
Others	3,453	4,752	5,169	5,192	5,009	5,492	3,318	4,027
Off Road (sum of gasoline and diesel below)	2,597	3,366	3,514	4,196	4,076	4,597	2,450	3,191
Off-Road Gasoline	350	421	517	447	442	351	255	331
Off-Road Diesel	2,247	2,946	2,997	3,750	3,634	4,246	2,195	2,860
Pipelines	856	1,385	1,655	995	933	895	868	836
c. Fugitive Sources	3,666	4,829	5,345	5,447	5,765	6,428	6,091	6,235
Coal Mining	686	753	669	780	728	701	621	764
Oil and Natural Gas	2,980	4,076	4,677	4,667	5,036	5,727	5,469	5,471
INDUSTRIAL PROCESSES	2,674	3,058	3,792	3,540	3,772	3,723	3,579	3,588
a. Mineral Products	850	1,009	1,336	1,427	1,404	1,273	1,036	1,164

GHG Source Categories	1990	1995	2000	2005	2007	2008	2009	2010
	GHG Emissions (kt CO_2 e)							
TOTAL (with afforestation and deforestation)	55,518	61,924	65,754	65,554	64,897	65,417	61,522	61,993
Cement Production	613	758	1,054	1,189	1,186	1,069	857	956
Lime Production	162	192	218	181	162	157	141	169
Mineral Products Use[1]	76	59	64	57	57	48	38	38
b. Chemical Industry	0	0	0	0	0	0	0	0
Nitric Acid Production	-	-	-	-	-	-	-	-
Adipic Acid Production	-	-	-	-	-	-	-	-
Petrochemical Production	0	0	0	0	-	-	-	-
c. Metal Production	1,507	1,687	1,820	1,131	1,101	1,150	1,148	785
Iron and Steel Production	-	-	-	-	-	-	-	-
Aluminium Production	1,507	1,687	1,820	1,131	1,101	1,150	1,148	785
SF_6 Used in Magnesium Smelters and Casters[2]	-	-	-	-	-	-	-	-
SF_6 used in electrical equipment	60	60	59	50	49	66	61	61
Consumption of Halocarbons and SF_6	0	65	394	750	781	800	916	1016
d. TOTAL - Consumption of HFC and SF_6	60	125	453	800	831	865	977	1,077
e. Other & Undifferentiated Production	257	237	184	182	436	434	418	562
SOLVENT & OTHER PRODUCT USE	21	27	59	49	43	45	34	32
AGRICULTURE	2,106	2,320	2,373	2,554	2,331	2,255	2,113	2,058
a. Enteric Fermentation	976	1,137	1,177	1,275	1,129	1,081	1,002	947
b. Manure Management	314	354	377	395	367	359	348	339
c. Agriculture Soils	815	829	820	884	835	814	764	773
Direct Sources	369	338	312	338	335	331	315	333
Pasture, Range and Paddock Manure	168	207	226	244	214	203	184	171
Indirect Sources	279	284	282	302	286	280	265	269
Field Burning of Agricultural Residues	0	0	0	0	0	0	0	0
WASTE	3,355	3,685	3,902	3,923	4,059	4,059	4,111	4,111
a. Solid Waste Disposal on Land	3,166	3,465	3,671	3,690	3,821	3,822	3,872	3,870
b. Wastewater Handling	108	129	144	148	153	153	155	157
c. Waste Incineration	81	90	87	85	84	85	84	84
AFFORESTATION AND DEFORESTATION	6,146	4,637	3,860	3,331	3,507	3,075	2,980	2,904
Afforestation	0	1	-3	-9	-13	-14	-16	-18
Deforestation	6,146	4,636	3,863	3,341	3,520	3,089	2,996	2,922
MEMO ITEMS (categories presented for information purposes but not included in B.C. total GHG emissions)							MEMO ITEMS	
OTHER LAND USE (Not included in total B.C. emissions)	-25,288	-31,313	-30,696	32,227	43,637	27,441	63,661	81,637
Forest Management	-25,488	-31,563	-30,997	31,929	43,349	27,158	63,382	81,366
Cropland Management	96	144	225	242	238	236	234	228
Wetland Management	104	105	75	56	50	47	45	43

Notes:

"-" indicates no emissions

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

[1] This includes values for "Limestone and Dolomite Use" and "Soda Ash Production and Use"

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

3.4 Trends in Emissions

Total annual GHG emissions in British Columbia increased by 0.8% from 2009 to 2010 (from 61.5 Mt to 62.0 Mt CO_2e), decreased by 4.5% between 2007 and 2010 (from 64.9 Mt in 2007) and decreased by 5.7% (from 65.8 Mt) over the ten year period from 2000 to 2010. The trend in total annual B.C. GHG emissions since 1990 is shown in Figure 3.

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

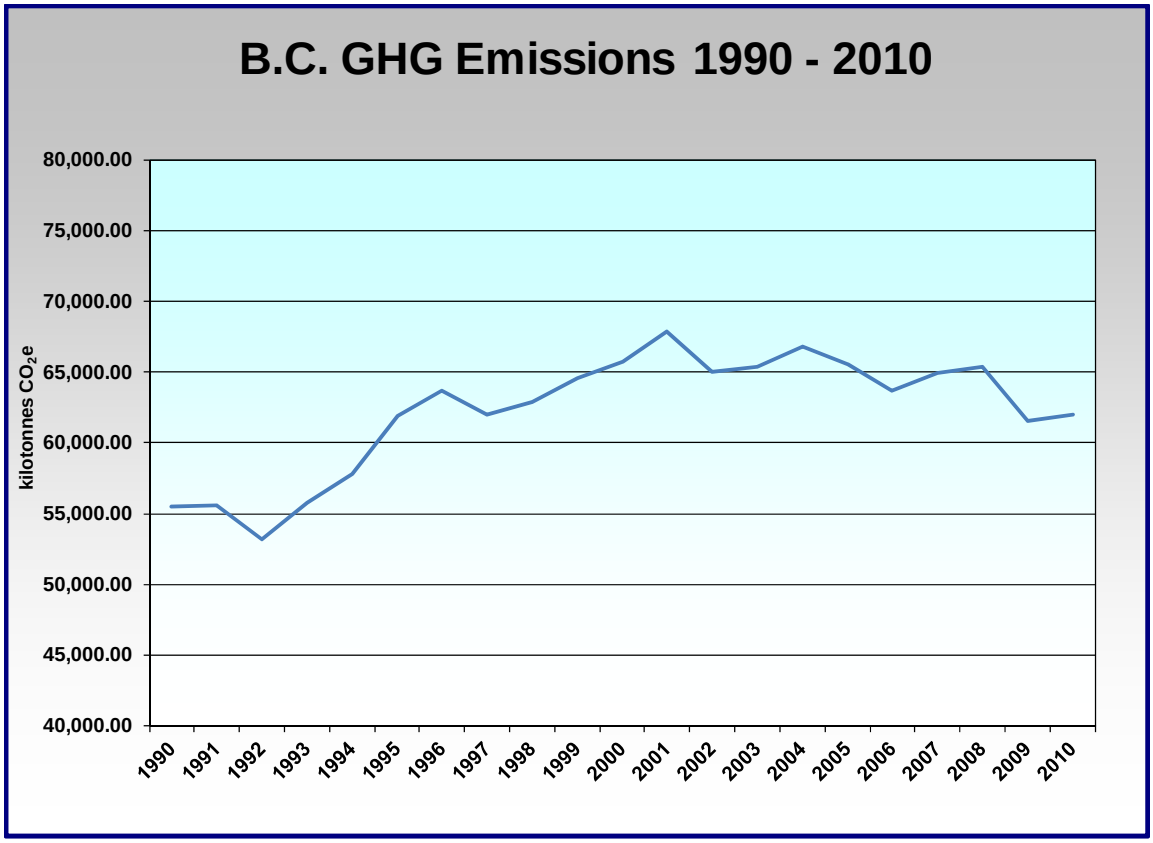


Figure 3: B.C. GHG Emissions – 1990-2010 Trends

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	2010 GHG Emissions (kt CO_2e)	3-Year Change (2007-2010)	10-Year Change (2000-2010)	Key Factors Influencing Changes in Emissions
ENERGY	49,300	-3.7%	-4.8%	Oil and gas extraction and processing activities[1], use of natural gas for electricity generation,[1] use of heavy-duty diesel vehicles,[2] fugitive oil and natural gas emissions[3]
INDUSTRIAL PROCESSES	3,588	-4.9%	-5.4%	Closure of ammonia and methanol plants, use of improved control technology for PFC emissions in aluminum production[4]
SOLVENT & OTHER PRODUCT USE	32	-24.8%	-45.7%	Use of nitrous oxide as anaesthetic and propellant[5]
AGRICULTURE	2,058	-11.7%	-13.3%	Cattle and hog populations, fertilizer use, soil management practices[6]
WASTE	4,111	+1.3%	+5.4%	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	2,904	-17.2%	-24.8%	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]

Sources:

[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. Reporting Regulation 2010 Facility GHG Emission Report Summaries

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

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

[6] Statistics Canada Census of Agriculture

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

[8] Refer to Annex 10.4 for detailed data

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

In 2010, British Columbia emissions were an average of:

- 13.7 tonnes CO_2e/person;[31]
- 371 tonnes CO_2e/$ million of Gross Domestic Product (GDP);[32] and
- 68.1 tonnes CO_2e/terajoule (TJ) per energy use.[33]

GHG emissions per capita have been relatively consistent over the last decade (2000-2010) – ranging between 13.7 and 16.6 tonnes CO_2e/person/year. As measured in terms of economic GHG intensity (the amount of GHG emitted per unit of economic activity), GHG emissions per unit of Gross Domestic Product (GDP) have decreased by about one quarter between 2000 and 2010.

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

[32] 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.

[33] Final-use energy data from Statistics Canada Report on Energy Supply and Demand in Canada.

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

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

Period	GHG per Capita (tonnes CO_2 e/person)	GHG per GDP (tonnes CO_2e/$ million GDP)	GHG per Energy Use (tonnes CO_2e/TJ energy use)
2010	13.7	370.9	68.1
3-Year Trend (2007 to 2010)	15.1 (2007) -9.1%	394.5 (2007) -6.0%	68.6 (2007) -0.7%
10-Year Trend (2000 to 2010)	16.3 (2000) -15.9%	496.0 (2000) -25.2%	71.0 (2000) -4.1%

Figure 4 shows the trends in these indicators from 1990 to 2010. 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 2010, 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.

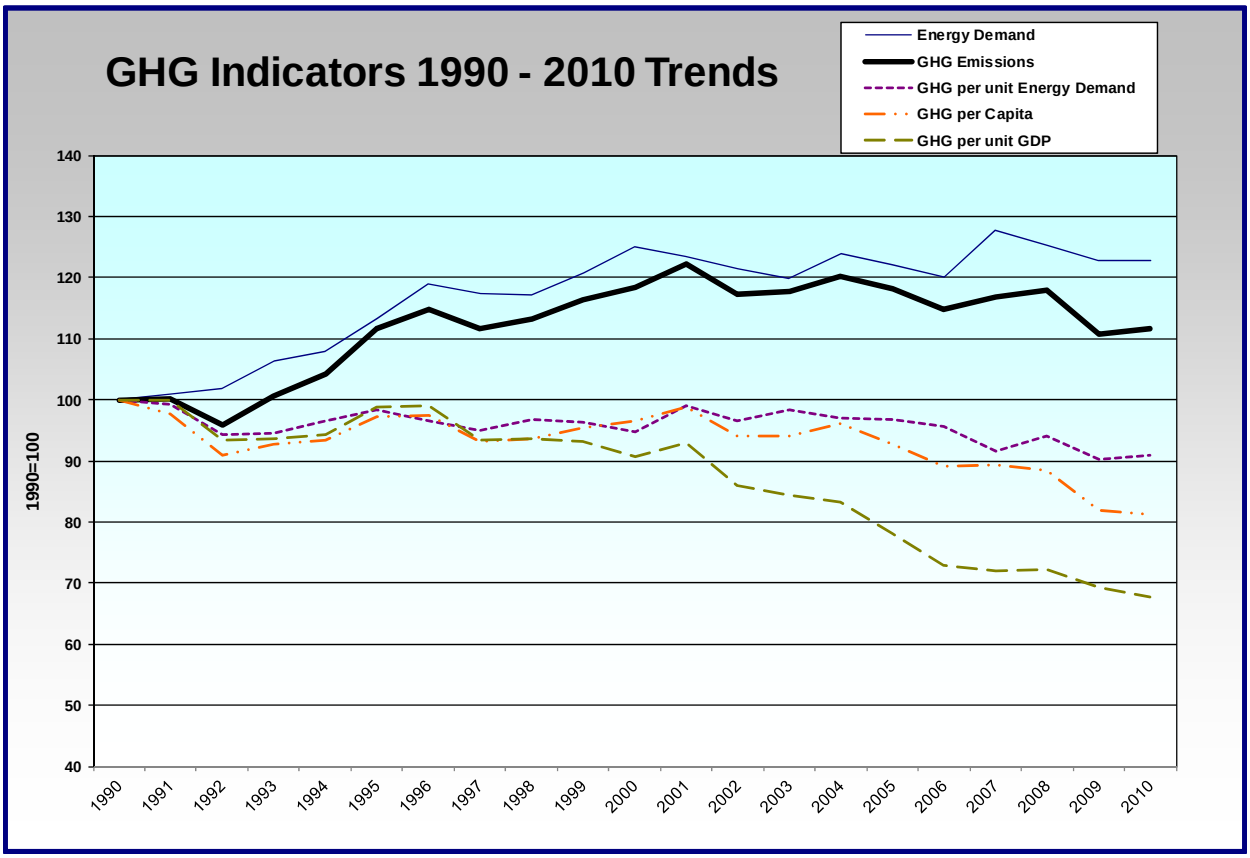


Figure 4: GHG Indicators – 1990-2010 Trends

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 2010 were 49.3 megatonnes (Mt) CO_2e – 79.5% of total B.C. emissions.

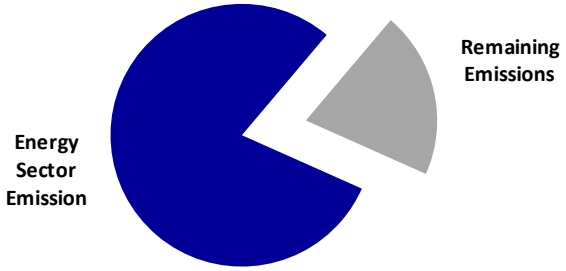


Figure 5 shows energy sector emissions as accounted by each of the sub-sectors.

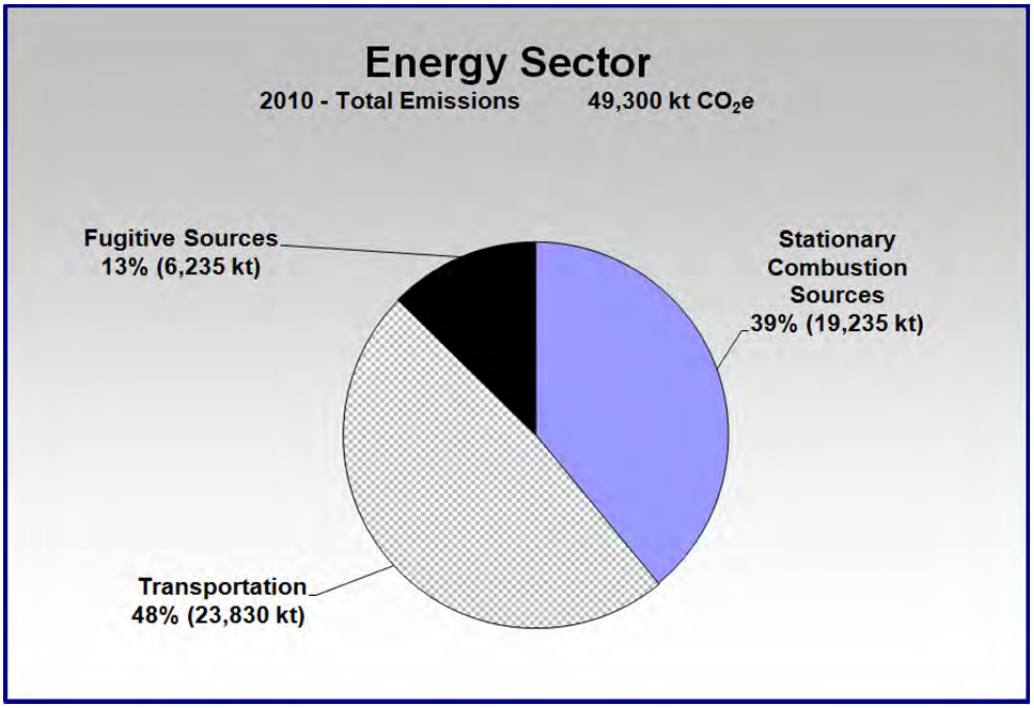


Figure 5: Energy Sector GHG Emissions – 2010

Table 7: Energy Sub-sector Descriptions

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

4.2 Trends in Energy Sector Emissions

Annual energy sector emissions increased by 1.2% from 2009 to 2010, decreased by 3.7% between 2007 and 2010 and decreased by 4.8% over the ten year period from 2000 to 2010. The trend in GHG emissions between 1990 and 2010 is shown for each of the energy sub-sectors in Figure 6.

The short-term (2009-2010) increase can be attributed to increased emissions from several categories of the transport sub-sector (including off-road diesel transportation, domestic aviation and railways) and from fugitive sources related to oil and gas. Emissions between 2007 and 2010 varied by sub-sector and category. Emissions from mining and oil & gas extraction and railways increased by 24.4% and 28.0%, respectively. In contrast emissions decreased for propane and natural gas vehicles (by 9.8%), construction (by 30.6%), and off-road gasoline and diesel transportation (by 25.2% and 21.3% respectively).

Within the energy sector over the three-year period between 2007 and 2010 transportation emissions decreased by 4.3%, emissions from fugitive sources increased by 8.2% and emissions from stationary combustion sources decreased by 6.2%.

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

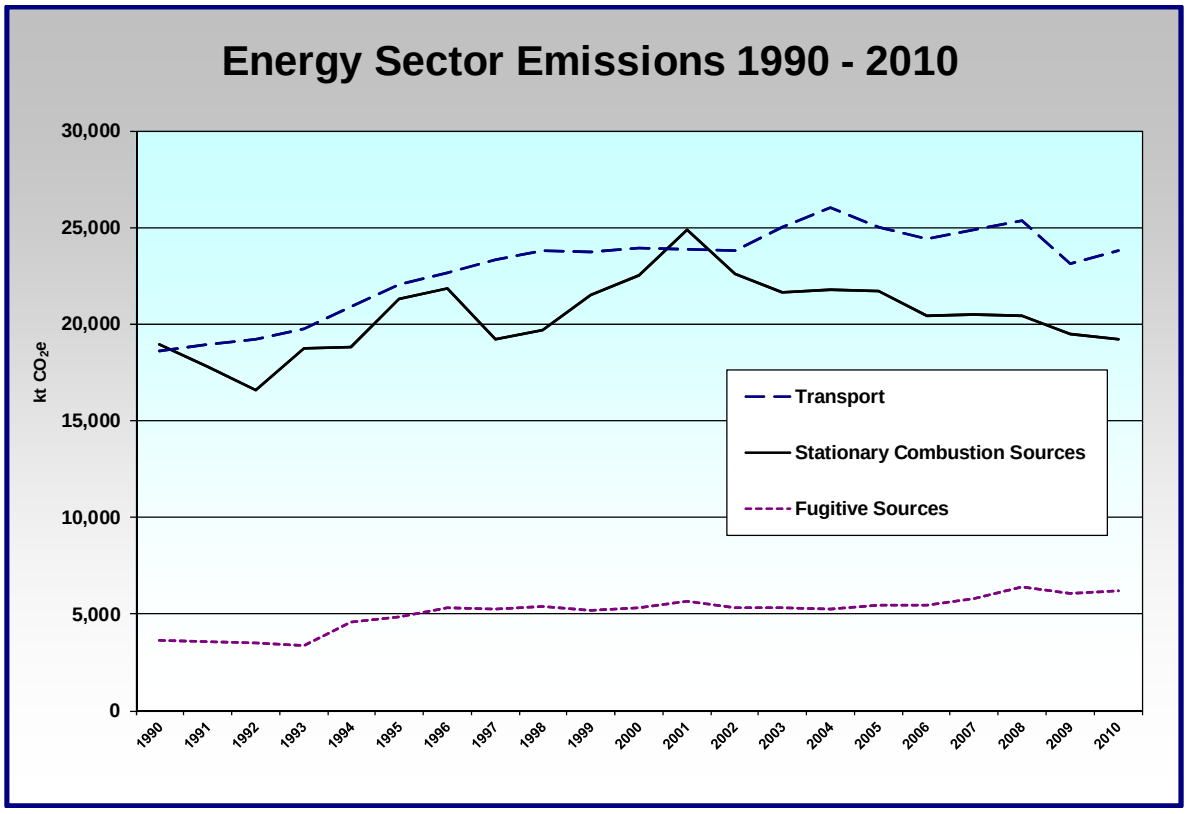


Figure 6: Energy Sector Emissions – 1990-2010 Trends

4.3 Energy Sub-sector a: Stationary Combustion Sources

Total emissions from stationary combustion sources were 19.2 megatonnes (Mt) CO_2e in 2010 – 39.0% of energy sector emissions (31.0% of total B.C. emissions). Emissions by category in the stationary combustion sources sub-sector are shown in Figure 7.

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.

A significant discrepancy in the "Fossil Fuel Production and Refining" line item was identified in provincial review of the 1990-2010 NIR. This discrepancy was caused by a data automation issue and affected data provided by the B.C. Ministry of Energy and Mines to Statistics Canada and used by Environment Canada. Though this issue will be resolved for the 1990-2011 NIR, it was not possible for the parties involved to address the discrepancy in the 1990-2010 NIR publication. To ensure that the B.C. reported Fossil Fuel Production and Refining inventory estimates were reasonable, the line item was recalculated for 2004 to 2010 using the following method:

1. 2010 upstream oil and natural gas energy use emissions were extracted from the 2010 Reporting Regulation emission report summaries (the Reporting Regulation has essentially complete coverage of the upstream oil and gas industry).
2. 2004-2009 emissions were prorated using known B.C. natural gas production levels.[34]
3. Refining energy use was added for 2004-2010.[35]

This recalculation is considered to provide a reasonable estimate of the Fossil Fuel Production and Refining emission levels.

Environment Canada and Statistics Canada have indicated that the Secondary Distributors of Refined Petroleum Products Survey[36] has been used to help allocate energy sector fuel usage to the various subsectors for the 2010 inventory year. As the reallocation for 1995-2009 years is currently in progress and has not yet been incorporated in these emission estimates, comparison of trends within energy subsectors may give erroneous results due to differing methods being used for different years. Total emissions for the sector for each year are not affected by the reallocation. Revised estimates for the energy sector and subsectors are due to be published in the National Inventory Report 1990-2011 as well as updated British Columbia data tables for the 1990-2011 inventory.

[34] Marketable natural gas volumes provided by the B.C. Ministry of Energy and Mines was used for this purpose.
[35] B.C. Reporting Regulation data was used for this purpose. See: http://www.env.gov.bc.ca/cas/mitigation/ggrcta/reporting-regulation/2010-emissions-reports.html
[36] See: http://www.statcan.gc.ca/survey-enquete/business-entreprise/5168-eng.htm

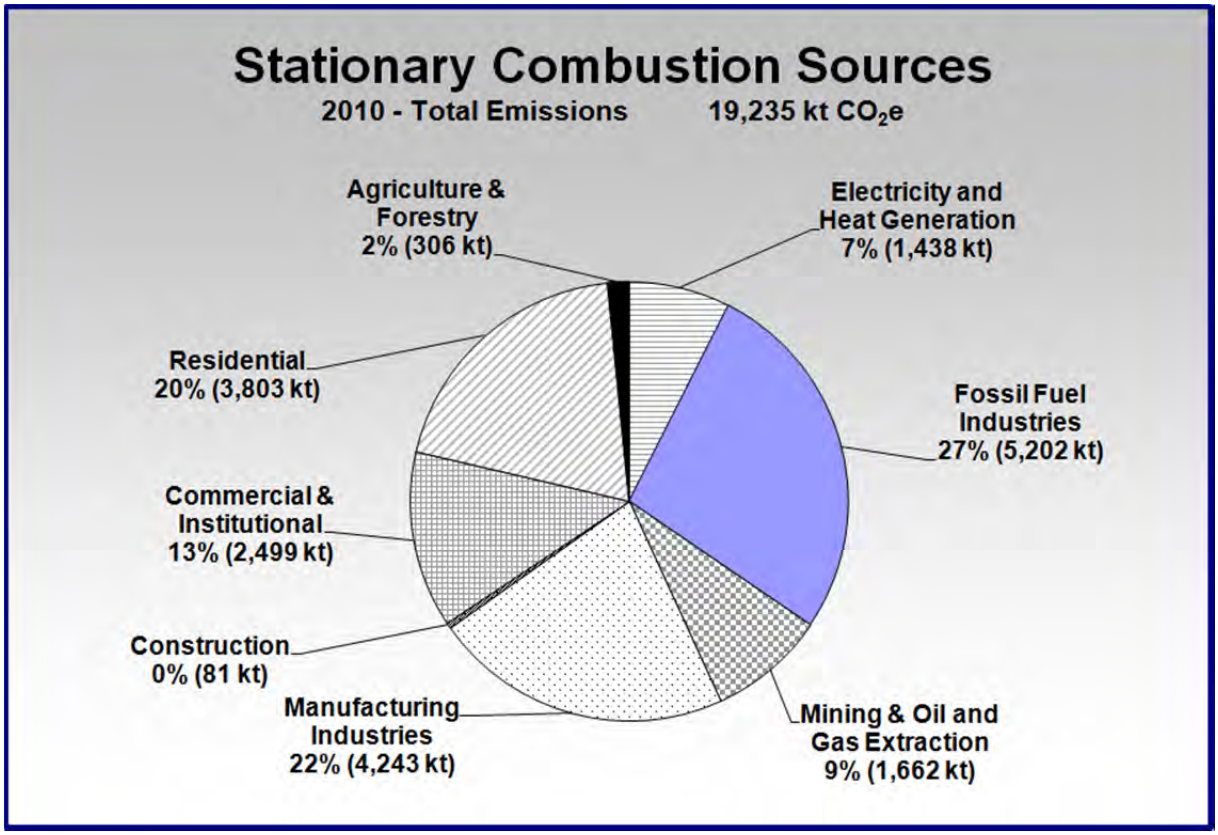


Figure 7: Stationary Combustion Sub-sector GHG Emissions by Category – 2010

Table 8: Stationary Combustion Category Descriptions

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

Table 9: Stationary Combustion Trends[7]

Emission Category	3-Year Trend	10-Year Trend	Key Factors Influencing Changes in Emissions
STATIONARY COMBUSTION SUB-SECTOR	-6.2%	-14.6%	
Electricity and Heat Generation	+10.7%	-20.7%	Demand for electricity,[1] precipitation,[2] variation in relative amounts of hydro-generated and fossil fuel-generated electricity[1]
Fossil Fuel Industries	+4.3%	X[37]	Production volumes of refined petroleum products and natural gas[1]
Mining and Oil & Gas Extraction	+24.4%	+127.6%	Extraction of coal, metals and natural gas[1]
Manufacturing Industries	-13.7%	-44.9%	Production from manufacturing industries,[3] fuel sources (e.g., use of biomass rather than fossil fuel sources[1])
Construction	-30.6%	+7.3%	Number of annual housing starts and commercial/ institutional starts requiring fossil fuel and electricity use in construction[4],[5,6]
Commercial and Institutional	-24.7%	-27.0%	Area of floor space requiring heating and electric loads,[5] mitigated by energy efficiency actions,[5] temperature[2]
Residential	-15.0%	-18.6%	Area of floor space requiring heating and electric loads,[6] mitigated by energy efficiency actions,[6] temperature[2]
Agriculture and Forestry	376.7%	-3.2%	Production in forestry sector,[3] fuel sources (e.g., switching to biomass)[1]

Sources and Notes:

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

[2] Weather data – Environment Canada B.C. Climate Network and BC River Forecast Centre (snowpack)

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

[4] B.C. Stats – British Columbia Housing Starts for Urban Areas and Communities; Commercial, Industrial and Institutional & Government Building Permits

[5] NRCan Office of Energy Efficiency: Commercial/Institutional Sector British Columbia Table 2: Secondary Energy Use and GHG Emissions by End-Use

[6] NRCan Office of Energy Efficiency: Residential Sector British Columbia Table 2: Secondary Energy Use and GHG Emissions by End-Use

[7] Environment Canada and Statistics Canada have indicated that the Secondary Distributors of Refined Petroleum Products Survey (http://www.statcan.gc.ca/survey-enquete/business-entreprise/5168-eng.htm) has been used to help allocate energy sector fuel usage to the various subsectors for the 2010 inventory year. As the reallocation for 1995-2009 years is currently in progress and has not yet been incorporated in these emission estimates, comparison of trends within energy subsectors may give erroneous results due to differing methods being used for different years. Total emissions for the sector for each year are not affected by the reallocation. Revised estimates for the energy sector and subsectors are due be published in the National Inventory Report 1990-2011 as well as updated British Columbia data tables for the 1990-2011 inventory.

[37] Separate calculation methods were used for 2000 and 2010 so no 10-year trend is available.

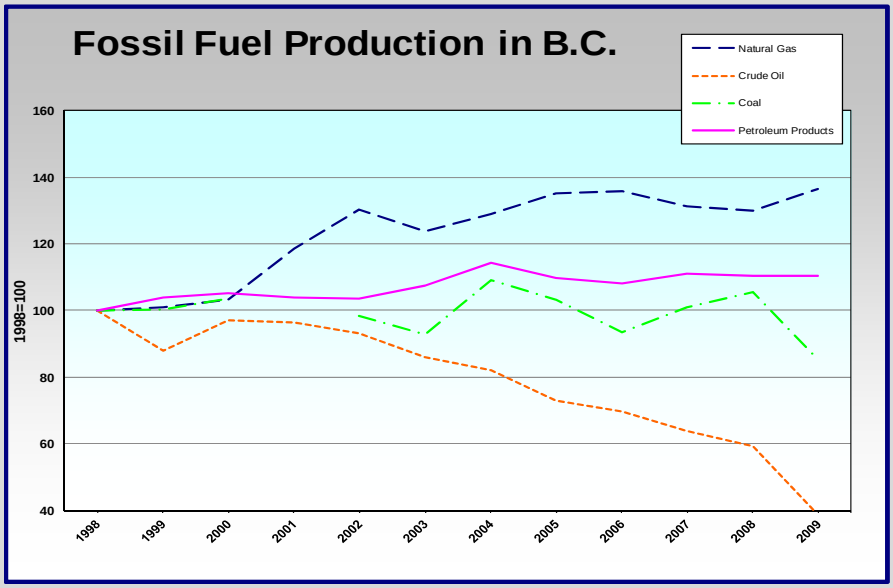
Understanding trends in energy sector emissions – fossil fuel production in B.C.

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

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

Figure 8 shows that since 1999, production of crude oil in B.C. decreased considerably while natural gas and petroleum product production increased (with natural gas production increasing by about 35% in 2009 over the period).[1] The increase in emissions outpaces changes in the levels of production, indicating that the increase is due to other factors. These factors could include extraction of fuels with higher carbon dioxide content or changes in the methods for calculating GHG emissions.

About 28% of the raw natural gas produced in B.C. is consumed within the province with the remainder exported.[2] Emissions related to consumption of any fossil fuel are allocated to the jurisdiction of consumption (not of production).



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

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

Figure 8: Fossil fuel production in B.C.

B.C.'s coal production volume between 1999 and 2009 has varied cyclically within a range of about plus or minus 15%. This fluctuation can be attributed largely to export market conditions as B.C. consumption represents only 2.5% of total coal produced.[1] Emissions associated with coal production are related to energy consumption for extraction, drying and transportation and fugitive emissions. Fugitive emissions from coal mining have remained relatively consistent in the years between 1998 and 2010 (see Table 4). Transportation emissions associated with the mining of coal are a portion of the 2.9 Mt reported in the off-road diesel subcategory.

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

[2] Canadian Association of Petroleum Producers and StatsCan table 128-0017

Understanding trends in energy sector emissions – heating residential buildings

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

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

Examining the energy use associated with heating residential buildings illustrates the interplay of these three factors. Figure 9 shows that between 1990 and 2009, residential floor space in B.C. increased by 71% while annual energy demand to heat residential buildings has increased by only 12.3% 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.

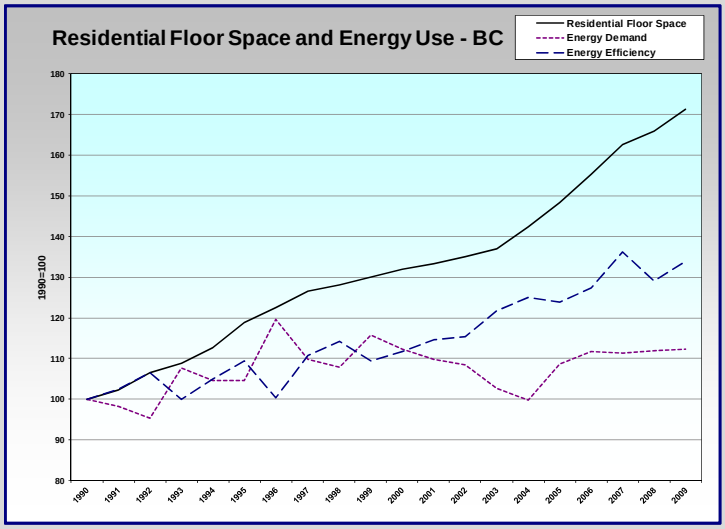


Figure 9: Residential Floor Space and Energy Use – B.C. Trends

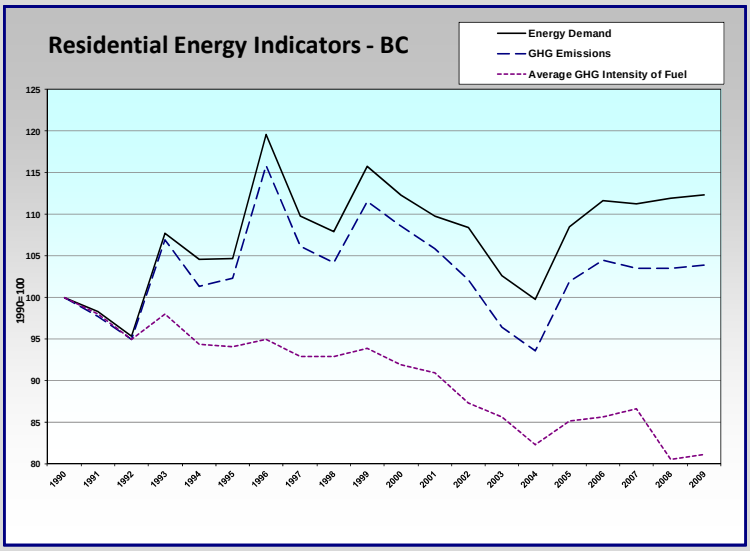


Figure 10 illustrates the linkages between energy demand, fuel types and GHG emissions. Between 1990 and 2009, for example, the GHG intensity of fuels used to heat residential buildings has notably decreased (attributed to fuel switching from GHG-intensive fuels such as heating oil, coal and propane 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 2009 fuel switching has decreased the average GHG emissions of residential fuels per unit energy by about 19%.

Figure 10: Residential Energy Indicators – B.C. Trends

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

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

Data source for Figure 9 and Figure 10: 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 23.8 megatonnes (Mt) CO_2e in 2010, accounting for 48.3% of energy sector emissions (38.4% of total B.C. emissions). Emissions by category in the transport sub-sector are shown in Figure 11, 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.[38]

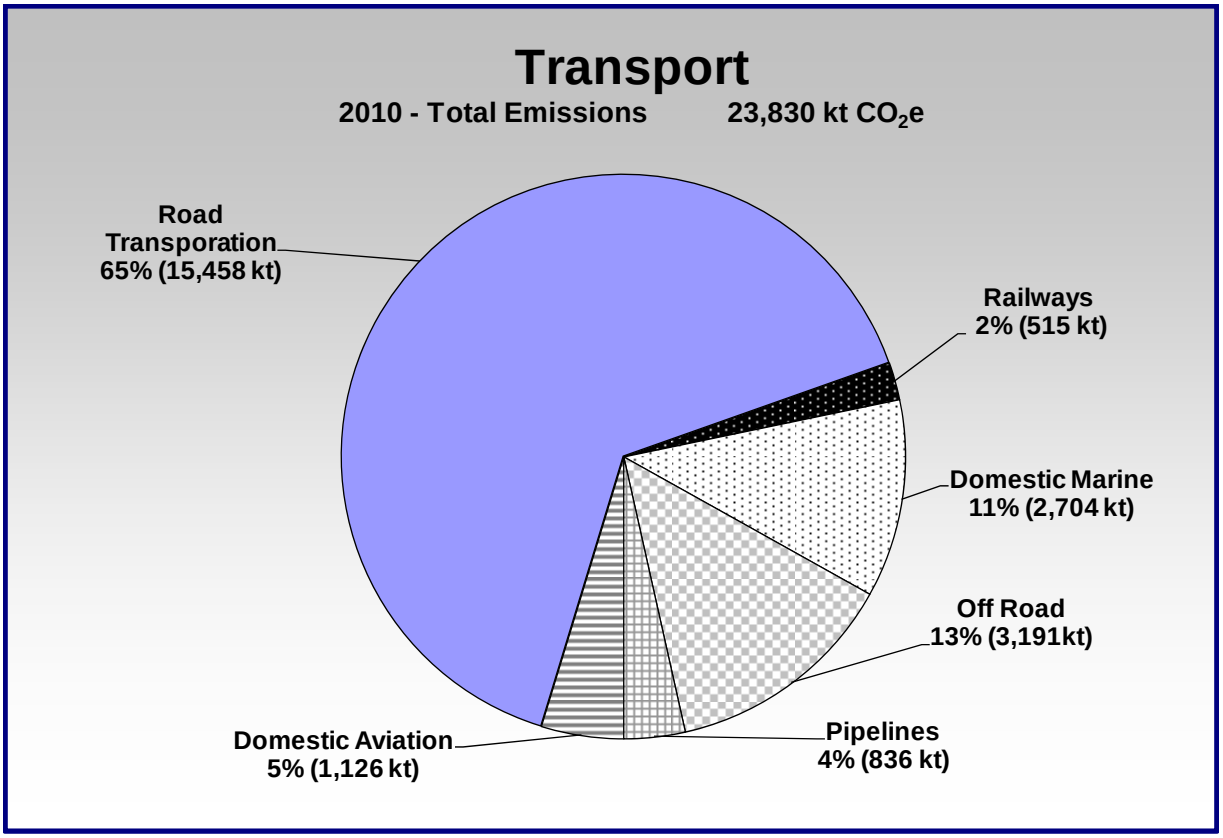


Figure 11: Transport Sub-sector GHG Emissions by Category – 2010

[38] Environment Canada and Statistics Canada have indicated that the Secondary Distributors of Refined Petroleum Products Survey (http://www.statcan.gc.ca/survey-enquete/business-entreprise/5168-eng.htm) has been used to help allocate energy sector fuel usage to the various subsectors for the 2010 inventory year. As the reallocation for 1995-2009 years is currently in progress and has not yet been incorporated in these emission estimates, comparison of trends within energy subsectors may give erroneous results due to differing methods being used for different years. Total emissions for the sector for each year are not affected by the reallocation. Revised estimates for the energy sector and subsectors are due be published in the National Inventory Report 1990-2011 as well as updated British Columbia data tables for the 1990-2011 inventory.

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[7]

Emission Category	3-Year Trend	10-Year Trend	Key Factors Influencing Changes in Emissions
TRANSPORT SUB-SECTOR	-4.3%	-0.3%	
Domestic Aviation	-20.9%	-24.0%	Weight of freight transported, passenger loads and distance traveled[1]
Road Transportation (On-road Vehicles)	-0.2%	+4.8%	Number of vehicles on road and distance travelled,[2] average fuel efficiency of vehicles[3]
Railways	+28.0%	-59.4%	Passenger ridership, freight shipped by locomotive of major B.C. products (coal, wood chips and wood pulp), trans-continental freight shipped by locomotive through B.C.[4]
Domestic Marine	+4.6%	+119.0%	Volume of import and export between international trading partners[5] (e.g., wood product and coal exports)
Off-road vehicles (Gasoline and Diesel)	-21.7%	-9.2%	Forest, mining and agriculture off-road vehicle activity
Pipelines	-10.4%	-49.5%	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

[7] Environment Canada and Statistics Canada have indicated that the Secondary Distributors of Refined Petroleum Products Survey (http://www.statcan.gc.ca/survey-enquete/business-entreprise/5168-eng.htm) has been used to help allocate energy sector fuel usage to the various subsectors for the 2010 inventory year. As the reallocation for 1995-2009 years is currently in progress and has not yet been incorporated in these emission estimates, comparison of trends within energy subsectors may give erroneous results due to differing methods being used for different years. Total emissions for the sector for each year are not affected by the reallocation. Revised estimates for the energy sector and subsectors are due be published in the National Inventory Report 1990-2011 as well as updated British Columbia data tables for the 1990-2011 inventory.

Road Transportation Emissions

As the road transportation category accounted for a significant proportion (24.9%) of 2010 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 12.

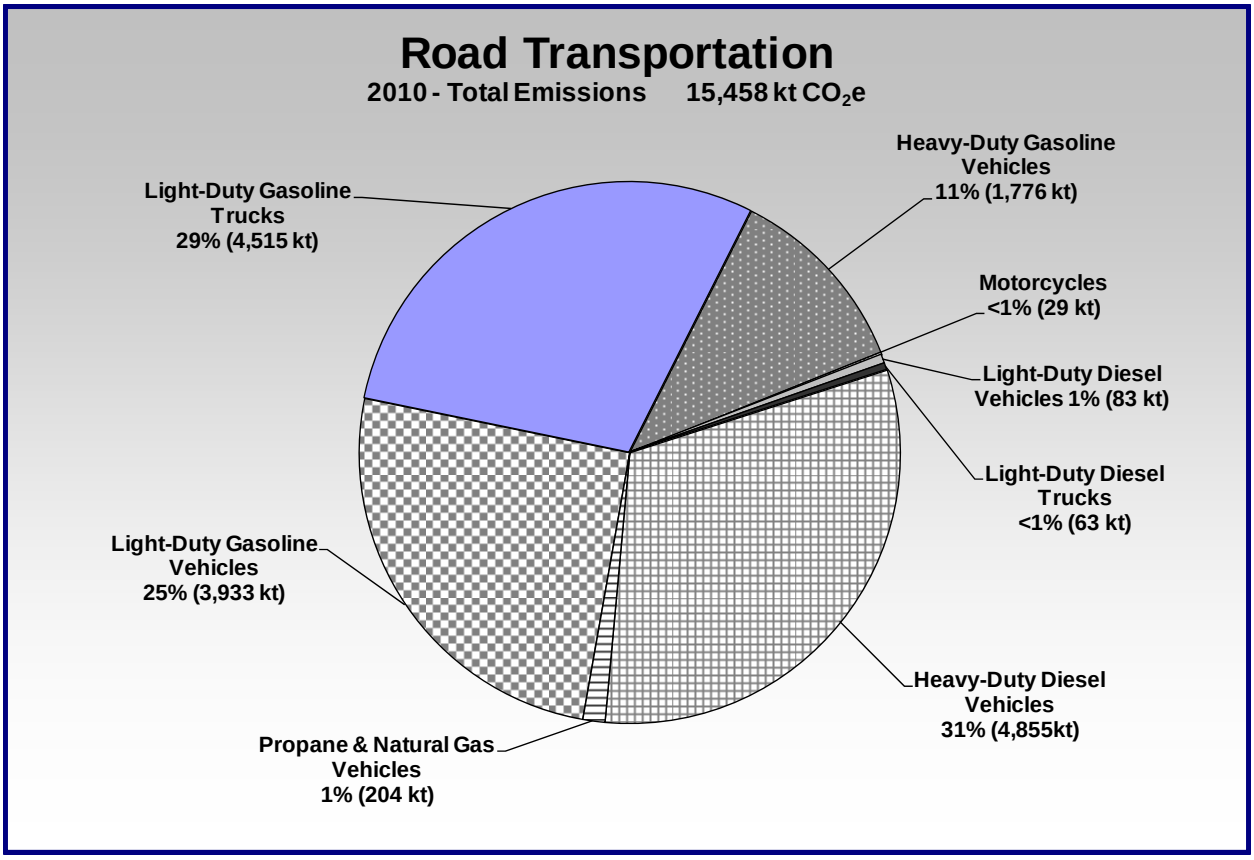


Figure 12: Road Transportation Category and Sub-category GHG Emissions – 2010

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 13 shows trends since 1990 in passenger-kilometres (Pkm)[1] traveled and engine efficiencies for passenger and freight road transportation. While energy intensity for both passenger and freight transportation has decreased between 1990 and 2005, passenger kilometres and GHG emissions have both increased over this period. Note that there has been a small decrease in passenger energy intensity (from 88 to 83 MJ/Pkm) since 1995 since increases in fuel efficiency have been offset by an increase in average vehicle size.[2]

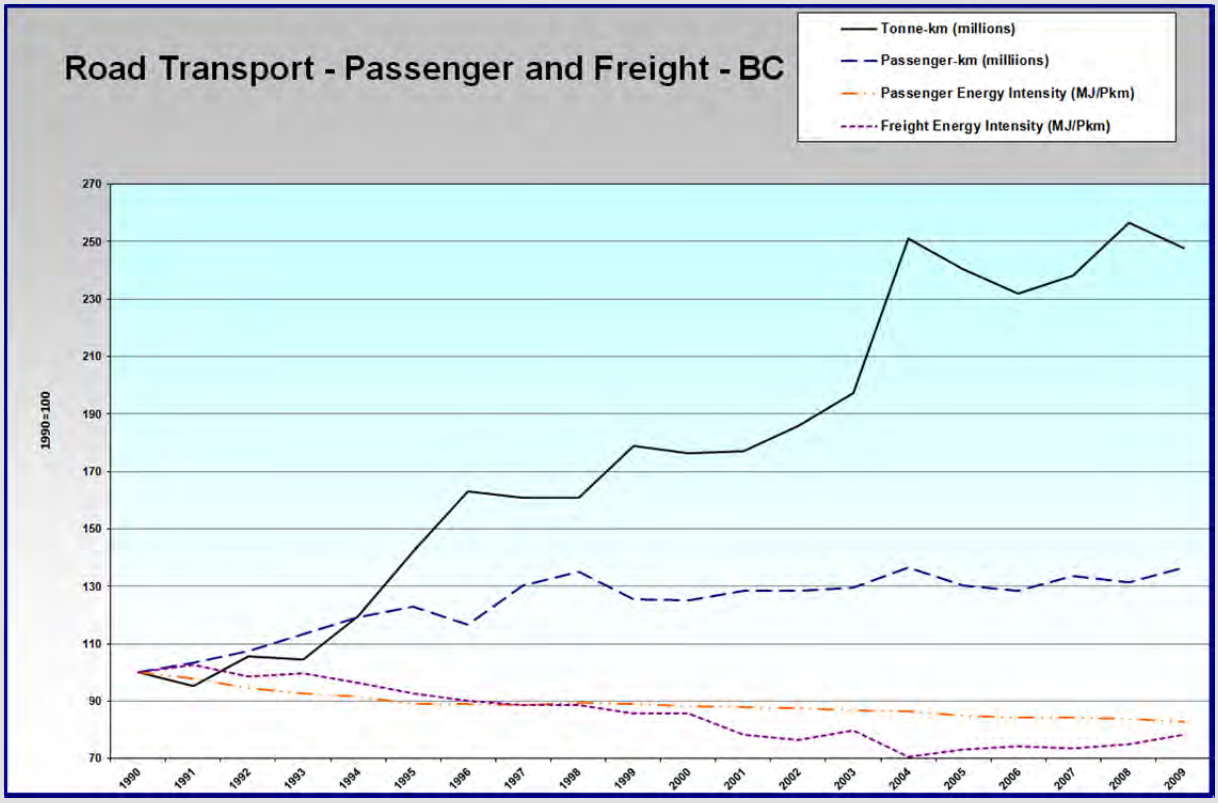


Figure 13: Road Transportation – Passenger and Freight – B.C. Trends

[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 2010 were 6.2 megatonnes (Mt) CO_2e, accounting for 12.6% of energy sector emissions (10.1% of total B.C. emissions). Annual emissions increased by 2.4% from 2009 to 2010, 8.2% from 2007 to 2010 and 16.6% between 2000 and 2010.

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

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

Table 12: Fugitive Sources Sub-sector Descriptions and Trends

Emission Category	Description	Key Factors Influencing Changes in Emissions
Conventional Crude Oil Extraction and Processing	Releases from wells, flow lines and batteries; venting of casing and solution gas; and evaporative losses from storage facilities	Annual crude oil production[1]
Natural Gas Extraction and Processing	Releases from wells, gathering systems, field facilities and gas batteries; seal leaks; line cleaning operations; formation CO_2 removal and pneumatic devices	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, methane content in active coal mines[1]
Natural Gas Transmission	Equipment leaks, compressor start-up venting and purging of lines during maintenance	Annual natural gas throughput in pipelines[2] and energy efficiency of equipment.
Oil Transmission in Pipelines	Loading and unloading of tankers, storage losses, equipment leaks and process venting	Annual crude oil throughput through pipelines[3] and energy efficiency of equipment.

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

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

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

Table 13: Fugitive Emission Trends

Emission Category	3-Year Trend	10-Year Trend	Key Factors Influencing Changes in Emissions
FUGITIVE SOURCES SUB-SECTOR	+8.2%	+16.6%	
Coal Mining	+4.9%	+14.2%	Coal mine production[1]
Oil and Natural Gas	+8.6%	+17.0%	Natural gas production[2]

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

[2] Statistics Canada Energy Statistics Handbook

4.6 Data Sources

The principal data source for estimating stationary combustion and transport emissions is the *Report on Energy Supply and Demand in Canada* (RESD), prepared annually by Statistics Canada (2008 Report #57-003). The report is a compilation of data from fuel producers and consumers drawn from annual and monthly censuses and surveys from industries, federal agencies and provincial energy departments. The data provides estimates of the supply of and demand for energy in Canada 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). Some significant sub-sector recalculations (not affecting total Energy sector emissions) are expected in the 2010 RESD (and also in the 1990-2011 NIR) due to a historical back cast being conducted that will better allocate sub-category emissions using the Statistics Canada Secondary Distributors Survey.[36]

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.[39]

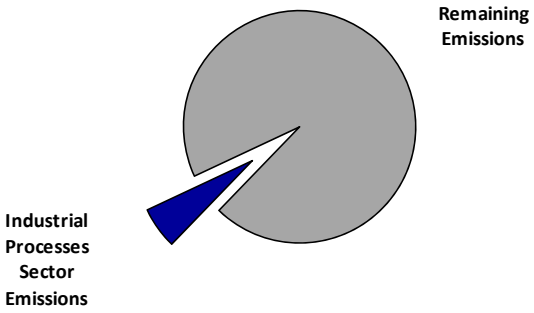
Fugitive emissions are more difficult to estimate than combustion emissions. Numerous reports from government organizations and industry groups are used in the development of emission quantification for fugitive emissions. Data sources specific to fugitive emissions are listed in Table 14.

[39] Refer to Section 1 of the NIR for more information.

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

Emission Category	Associated Activities	Data Sources
Conventional Crude Oil Extraction and Processing	▪ Releases from wells, flow lines and batteries ▪ Venting of casing and solution gas ▪ Evaporative losses from storage facilities	Report on Energy Supply and Demand in Canada (RESD), Statistics Canada A National Inventory of Greenhouse Gas (GHG), Criteria Air Contaminant (CAC) and Hydrogen Sulphide (H_2S) Emissions by the Upstream Oil and Gas Industry, Canadian Association of Petroleum Producers (CAPP) 2005 Supply and Disposition of Crude Oil and Equivalent, CANSIM Table 126-0001, Statistics Canada Industry Facts and Information by Region and Province, CAPP Drilling and Production Statistics, British Columbia Ministry of Energy and Mines (MEM)
Natural Gas Extraction and Processing	▪ Releases from wells, gathering systems, field facilities and gas batteries ▪ Seal leaks ▪ Line cleaning operations	RESD, Statistics Canada A National Inventory of Greenhouse Gas (GHG), Criteria Air Contaminant (CAC) and Hydrogen Sulphide (H_2S) Emissions by the Upstream Oil and Gas Industry, CAPP 2005 Supply and Disposition of Natural Gas, Monthly, CANSIM Table 131-0001, Statistics Canada Drilling and Production Statistics, MEM
Petroleum Refining	▪ Equipment leaks, wastewater treatment, cooling towers, storage tanks and loading operations ▪ Flaring of excess gas	Economic and Environmental Impacts of Removing Sulphur from Canadian Gasoline and Distillate Production, Canadian Petroleum Products Institute (CPPI) 2004 RESD, Statistics Canada
Coal Mining	▪ Releases from exposed coal surfaces, coal rubble and venting within coal deposit ▪ Post-mining activities including preparation, non-vehicular transportation, storage and final processing	Management of Methane Emissions from Coal Mines: Environmental, Engineering, Economic and Institutional Implications of Options. King 1994 Coal and Coke Statistics, Catalogue No. 45-002, Statistics Canada
Natural Gas Transmission	▪ Equipment leaks, compressor start-up venting, purging of lines during maintenance	CH_4 and VOC Emissions from the Canadian Upstream Oil and Gas Industry—Draft Report, CAPP Natural Gas Transportation and Distribution, Catalogue No. 57-205, Statistics Canada
Natural Gas Distribution	▪ Equipment leaks, compressor start-up venting, purging of lines during maintenance	1995 Air Inventory of the Canadian Natural Gas Industry, Canadian Gas Association (CGA) 1997 Natural Gas Transportation and Distribution, Catalogue No. 57-205, Statistics Canada
Oil Transmission in Pipelines	▪ Loading and unloading of tankers, storage losses, equipment leaks, process venting	A National Inventory of Greenhouse Gas (GHG), Criteria Air Contaminant (CAC) and Hydrogen Sulphide (H_2S) Emissions by the Upstream Oil and Gas Industry, CAPP 2005

5. INDUSTRIAL PROCESSES SECTOR EMISSIONS



5.1 Summary

Total emissions in the industrial process sector category in 2010 were 3.6 megatonnes (Mt) CO_2e – 5.8% of total B.C. emissions. Figure 14 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 includes five sub-sectors – mineral products (including cement and lime production, and soda ash, limestone and dolomite production and use), chemical industry, metal production,[40] consumption of halocarbons and SF_6 and "other and undifferentiated production" (including lead and zinc production) – described in Table 15.

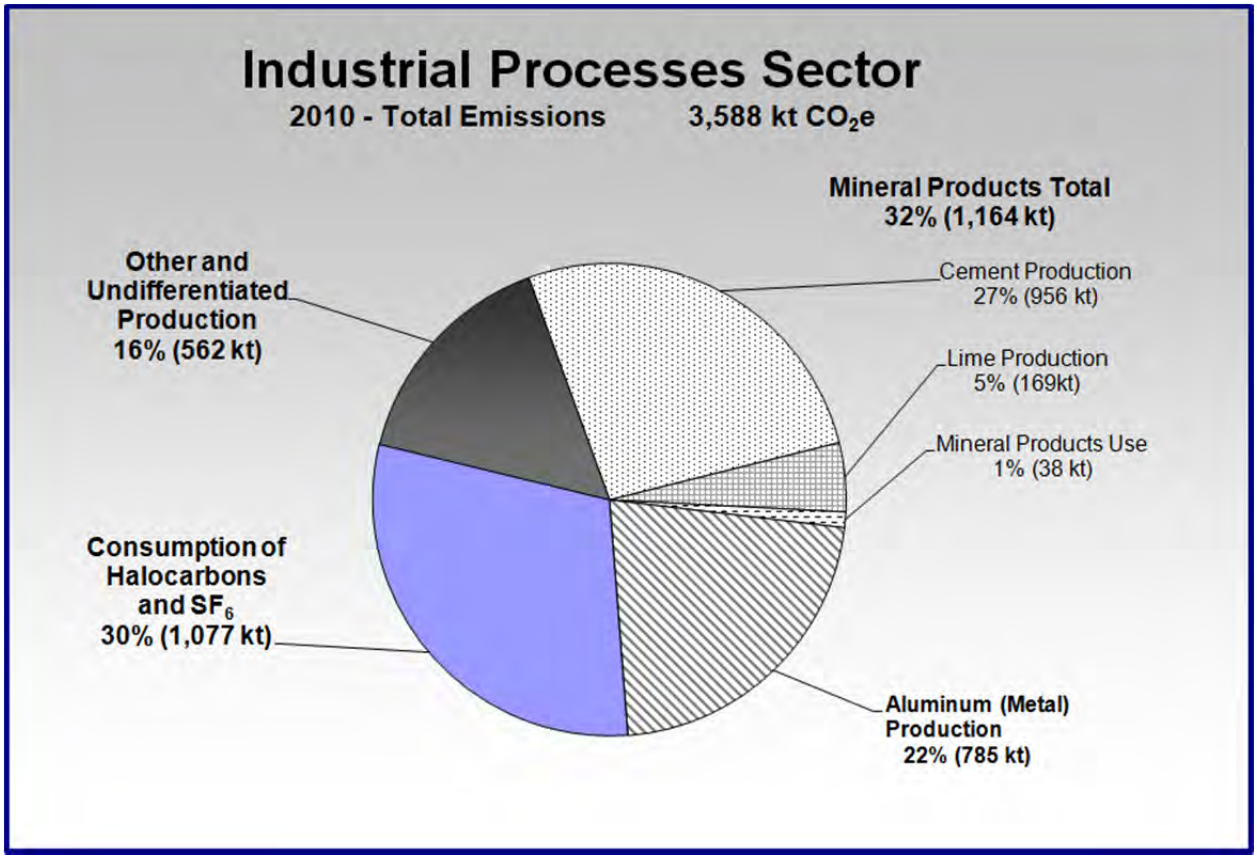


Figure 14: Industrial Processes GHG Emissions by Category – 2010

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

Table 15: Industrial Processes Sub-sector and Category Descriptions

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

5.2 Trends in Industrial Process Sector Emissions

Emissions reported under the industrial process category emissions increased by 0.2% between 2009 and 2010, decreased by 4.9% between 2007 and 2010 and decreased by 5.4% between 2000 and 2010. Factors influencing these trends include decreases in process emissions from the production of aluminum, increased consumption of halocarbons and changes in other and undifferentiated production.

The trend in industrial processes sector GHG emissions between 1990 and 2010 is shown in Figure 15.

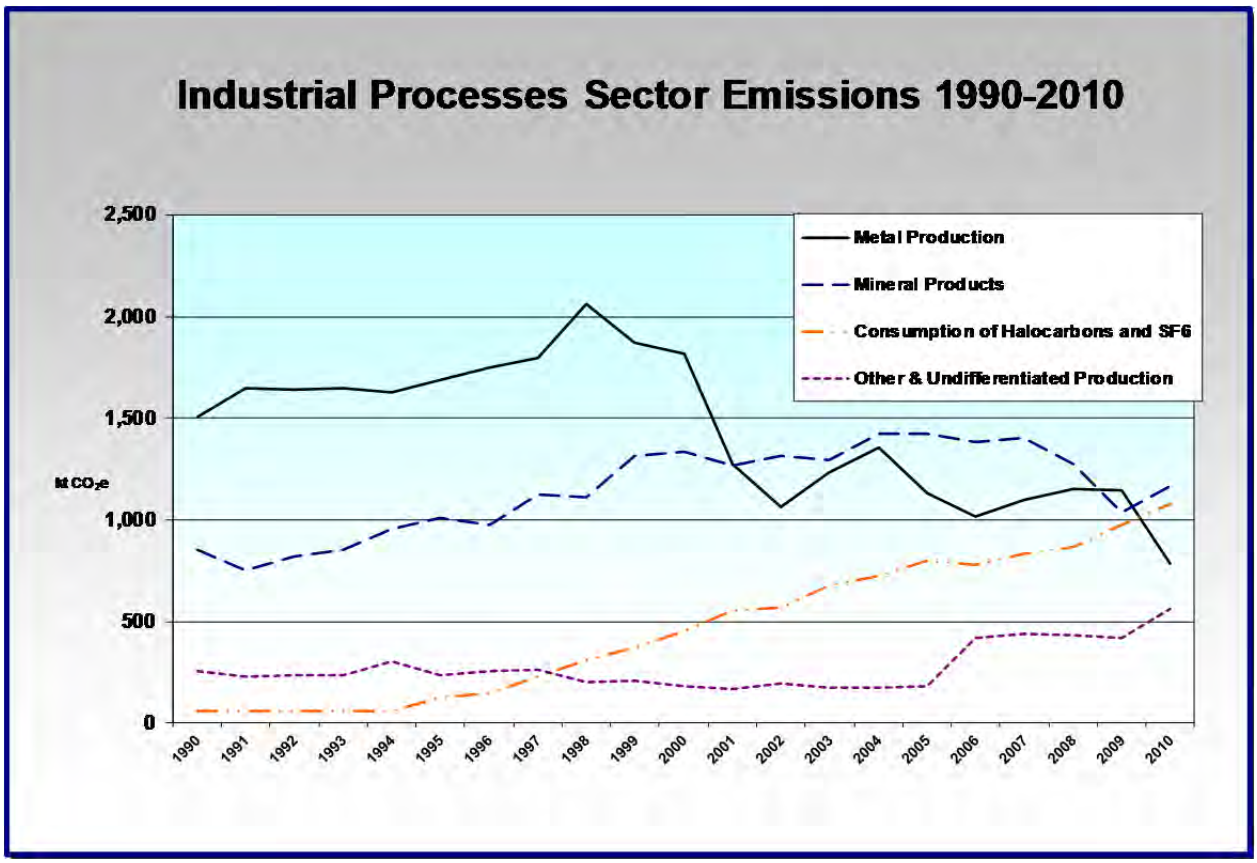


Figure 15: Industrial Processes Emissions – 1990-2010 Trends

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

Emission Category	3-Year Trend	10-Year Trend	Key Factors Influencing Changes in Emissions
INDUSTRIAL PROCESSES	-4.9%	-5.4%	
a. Mineral Products			
Cement Production	-19.3%	-9.2%	Annual cement production[1]
Lime Production	+4.6%	-22.4%	Annual lime production[2]
Mineral Products Use	-32.4%	-40.4%	Annual production in industries that utilize soda ash (e.g., pulp and paper, glass and chemical industries)[3], and limestone or dolomite (annual pulp and paper production)[3]
c. Metal Production (Aluminum Production)	-28.7%	-56.9%	Control measures to reduce PFC emissions from anode effects[4]
d. Consumption of Halo-carbons and SF_6	+29.6%	+137.9%	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	+28.9%	+205.7%	Aluminum production[4], lead and zinc production[8], natural gas liquids, oil refinery petrochemical feedstocks, closure of ammonia and methanol plants in Kitimat

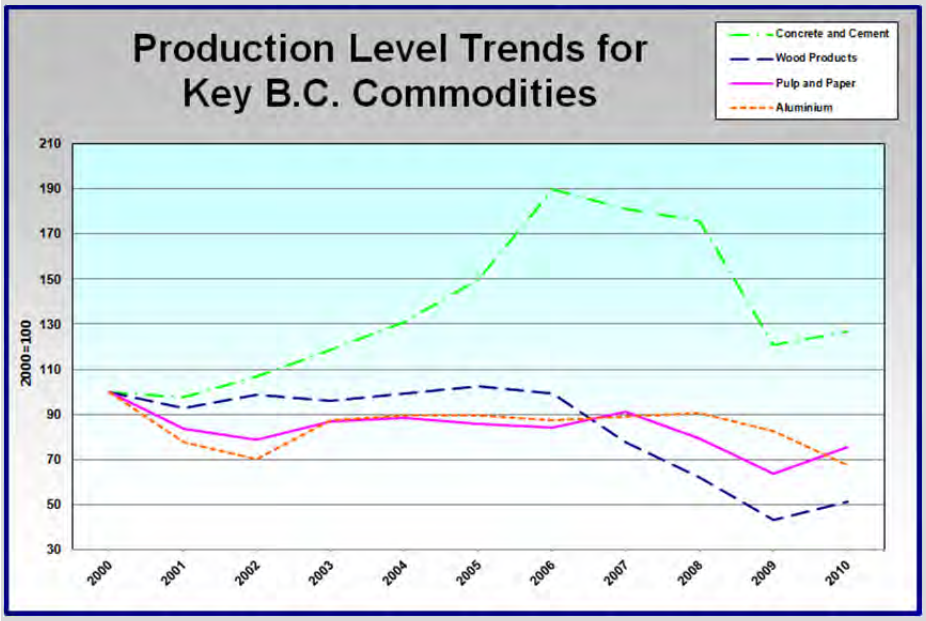
Sources:

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

Understanding trends in industrial emissions

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

Figure 16 illustrates the variation in production levels for several key B.C. commodities between 1998 and 2010. Over the time period (2000-2010), production of cement[2] increased by 26%, while aluminium production[3] decreased by around 33%. Over the time period (2000-2010), GHG emissions associated with cement production decreased by 9.2% and those associated with aluminium production decreased by 56.9% (see Table 16). For both industrial products – and aluminium in particular – emissions decreased by a relatively larger amount than production, indicating an increase in production efficiency (in relation to greenhouse gases). Efficiencies in aluminium production are in large part due to increased control measures to reduce PFC emissions from anode effects.



Production of pulp and paper[4] and wood products (manufacturing)[5] over this period peaked in 2000 and dropped significantly between 2007 and 2009 before rising slightly in 2010. Since both are cyclical industries, production varies with economic and market cycles. Trends of switching from fossil fuels to biomass, and increased production efficiencies, have led to substantial decreases in greenhouse gas emissions for these sectors.[6]

Figure 16: Production level trends for Key B.C. Commodities

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

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

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

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

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

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

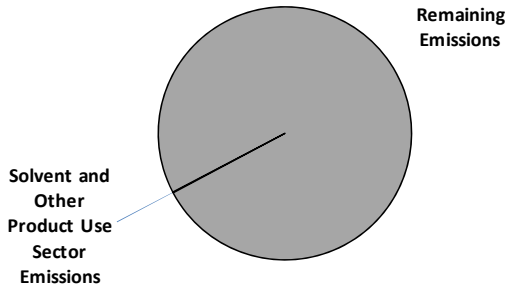
5.3 Data Sources

In general, industrial process emissions are calculated by multiplying activity data (e.g., quantity of the product produced) by an appropriate emission factor. However, there are more complex categories such as 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 17 summarizes the data sources used to compile activity data and emission factors for each emission category.

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

Emission Category	Associated Activities	Data Sources
Cement Production	Quantity of clinker produced	Clinker production 1990-1996: A Review of Energy Consumption and Related Data: Canadian Cement Manufacturing Industry, 1990-2007, Canadian Industrial Energy End-Use Data and Analysis Centre (CIEEDAC) 2009 Clinker production 1997-2004: Catalogue #44-001, Statistics Canada Clinker production 2005-2008: CANSIM Table 303-0060, Statistics Canada Clinker capacity: 1990-2008: Canadian Minerals Yearbook, Natural Resources Canada (NRCan) Emission factor: Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, IPCC
Lime Production	Quantity of lime produced	Lime production: Canadian Minerals Yearbook, NRCan Emission factor: Canadian Lime Institute
Limestone and Dolomite Use	Quantity of limestone or dolomite consumed	Limestone and dolomite consumption: Canadian Minerals Yearbook, NRCan Emission factor: Identifying and Updating Industrial Process Activity Data in the Minerals Sector for the Canadian Greenhouse Gas Inventory, AMEC Earth & Environmental
Soda Ash Use	Quantity of soda ash consumed	Soda Ash consumption: Global Trade Information Services (GTIS) Emission factor: mass balance stoichiometry
Aluminium Production	Quantity of aluminium produced	Aluminium production: Aluminium Association of Canada Emission factors: Aluminium Association of Canada
Consumption of Halocarbons and SF_6	Quantity of halocarbons and SF_6 consumed	HFC Consumption and SF_6 Use Data: Environment Canada voluntary survey for HFC importers and distributors, and magnesium casters, total Canadian/ B.C. SF_6 use Emission factors: Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, IPCC
Other Undifferentiated Production	Quantity of fuel used for non-energy purposes	Fuel consumed: RESD Emission factors: Canada's Greenhouse Gas Emissions: Estimates for 1990, prepared for Environment Canada, Jaques, AP; 1998 Fossil Fuel and Derivative Factors, McCann, TJ; A Review of Energy Consumption in Canadian Oil Refineries 1990, 1994 to 2004, CIEEDAC

6. SOLVENT AND OTHER PRODUCT USE SECTOR EMISSIONS



6.1 Summary

The solvent and other product use category encompasses emissions of N_2O used as an anaesthetic or as a propellant in pressure and aerosol products. Total emissions in this sector were 32 kilotonnes CO_2e in 2010, accounting for 0.1% of total emissions in the province.

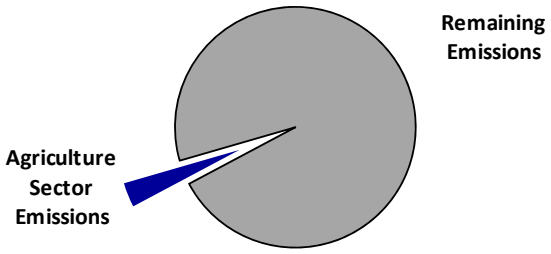
6.2 Trends in Solvent and Other Product Use Sector Emissions

Annual emissions for this sector decreased by 6.8% between 2009 and 2010, by 24.8% between 2007 and 2010 and by 45.7% between 2000 and 2010. Changes in emissions reflect decreases in the amount of N_2O used for anaesthetic and as propellant.

6.3 Data Sources

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

7. AGRICULTURE SECTOR EMISSIONS



7.1 Summary

Total emissions in the agricultural sector category in 2010 were 2.1 megatonnes (Mt) CO_2e – 3.3% of total B.C. emissions. GHG emissions reported in the agriculture sector include: CH_4 emissions from enteric fermentation; CH_4 and N_2O emission from manure management; and N_2O emissions from agricultural soils (including direct and indirect sources and pasture, range and paddock manure). Figure 17 shows the percentage of emissions as accounted by each of these sub-sectors and Table 18 provides a description of agriculture sector emission categories.

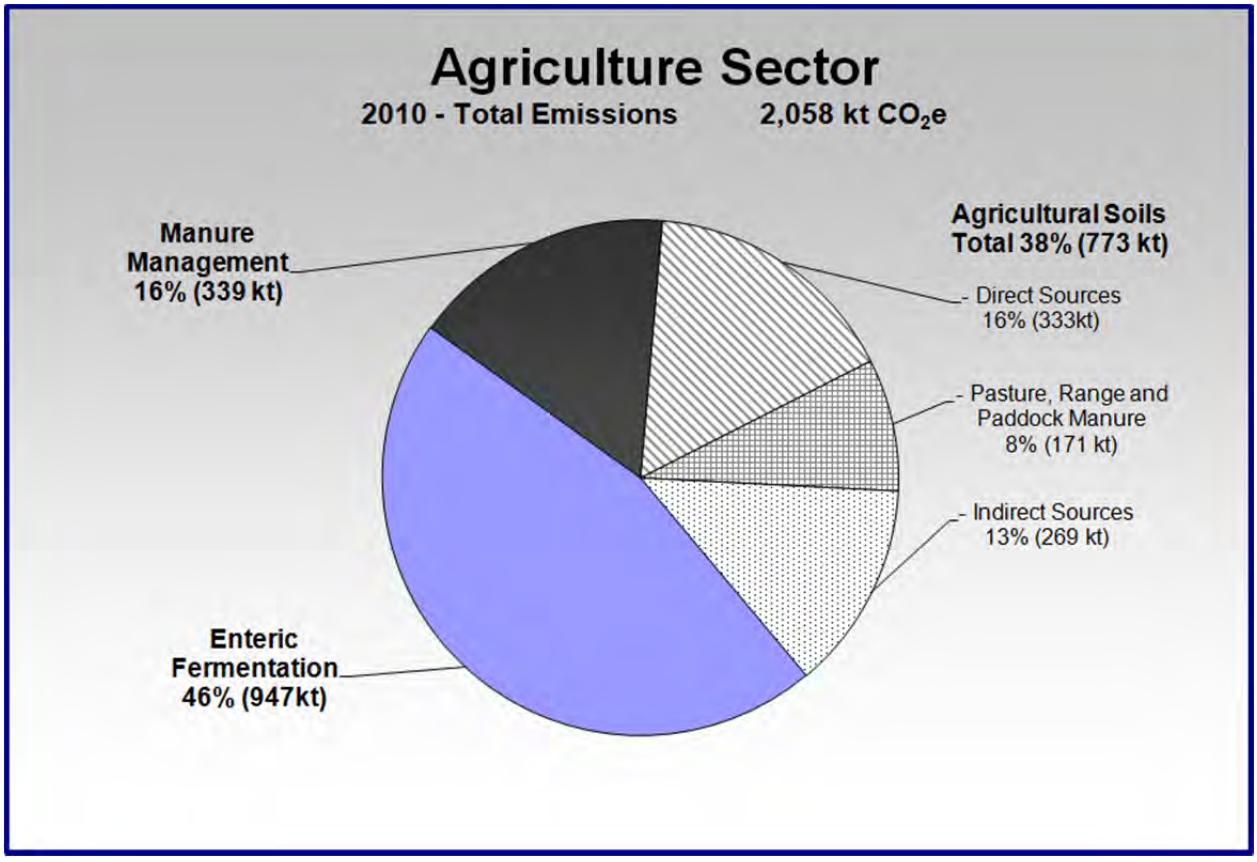


Figure 17: Agriculture Sector GHG Emissions by Category – 2010

Table 18: Agriculture Sub-sector and Category Descriptions

Emission Source	Description
a. Enteric Fermentation	The digestive process of ruminant animals (such as cattle) involves microbial fermentation in the rumen, which produces CH_4 emissions as a by-product
b. Manure Management	The decomposition of manure by microbial organisms produces CH_4 emissions as a by-product. The nitrification and denitrification of nitrogen-containing compounds in manure results in the production of N_2O. Factors impacting the production of CH_4 and N_2O include manure characteristics and the aeration levels in various types of manure management systems
c. Agriculture Soils	
Direct Emissions	Direct sources of N_2O emissions include application of synthetic and manure-based fertilizers, decomposition of crop residue, irrigation, cultivation of hisotosols and changes to tillage practices and summer fallow
Pasture, Range and Paddock	Grazing animals excrete manure on pastures, ranges and paddocks. This manure undergoes nitrification and denitrification, producing N_2O emissions
Indirect Emissions	Nitrogen present in crop residue and in synthetic and organic fertilizers (e.g., manure) applied to agricultural fields may be transported off-site through volatilization and subsequent redeposition or leaching, erosion and runoff. A portion of this nitrogen may later undergo nitrification and denitrification, producing N2O emissions

7.2 Trends in Agriculture Sector Emissions

Annual agriculture sector emissions decreased by 2.6% between 2009 and 2010, by 11.7% between 2007 and 2010 and by 13.3% between 2000 and 2010. Changes can be attributed in most part to changes in livestock (e.g., cattle) population. The largest source of agriculture emissions is methane (CH_4) emissions from enteric fermentation.

Figure 18 depicts agriculture sub-sector emissions between 1990 and 2010 and Table 19 provides three and ten-year trend percentages and a summary of key factors influencing changes in emissions.

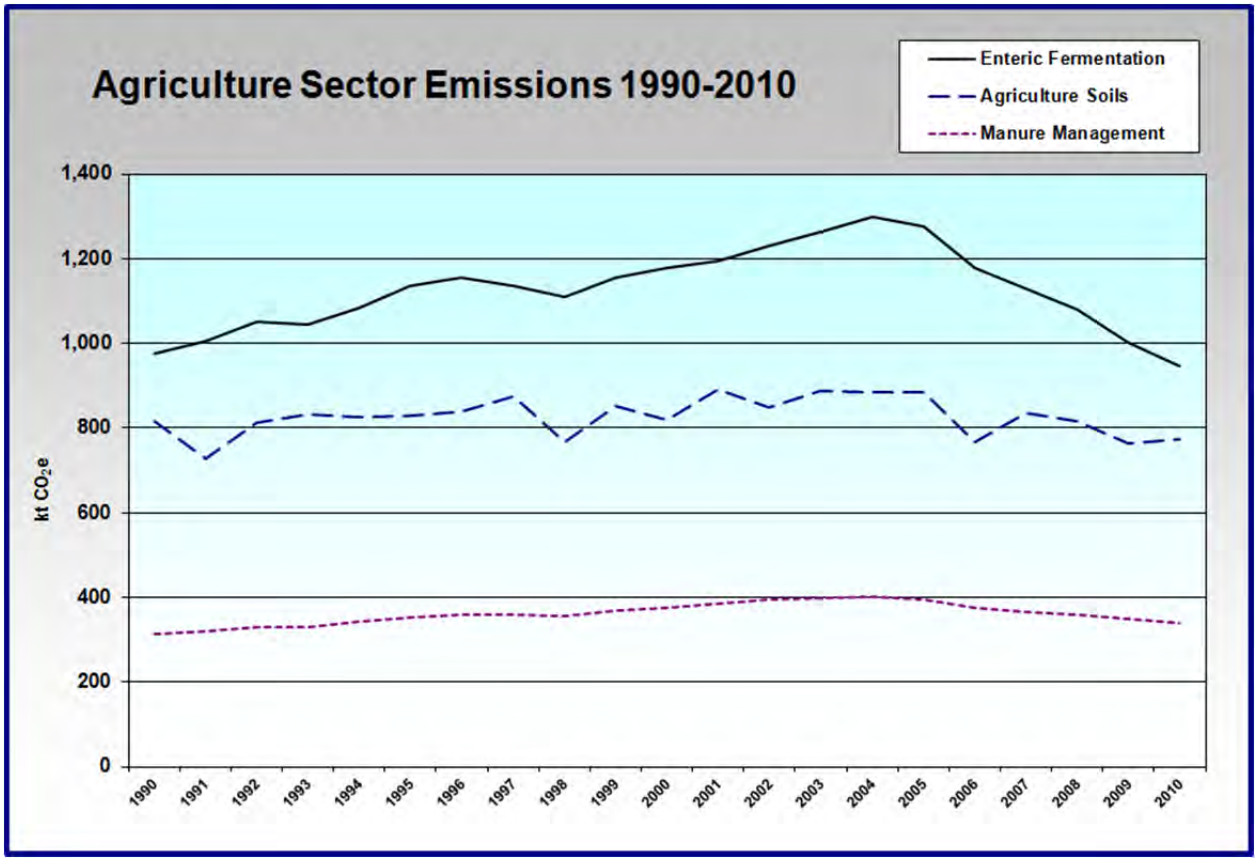


Figure 18: Agriculture Sector Emissions – 1990-2010 Trends

Table 19: Agriculture Sector Trends and Key Factors Influencing Changes

Emission Category	3-Year Trend	10-Year Trend	Key Factors Influencing Changes in Emissions
AGRICULTURE	-11.7%	-13.3%	
a. Enteric Fermentation	-16.1%	-19.6%	Cattle populations[1]
b. Manure Management	-7.5%	-10.1%	Cattle populations[1]
c. Agriculture Soils	-7.5%	-5.7%	Cattle populations,[1] fertilizer use, soil management practices

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

Understanding trends in agriculture emissions

Trends in agriculture emissions have been predominately influenced by cattle populations. As Figure 19 shows, both hog and cattle populations have been in decline since 2004, with hog populations trending downward since 1990.

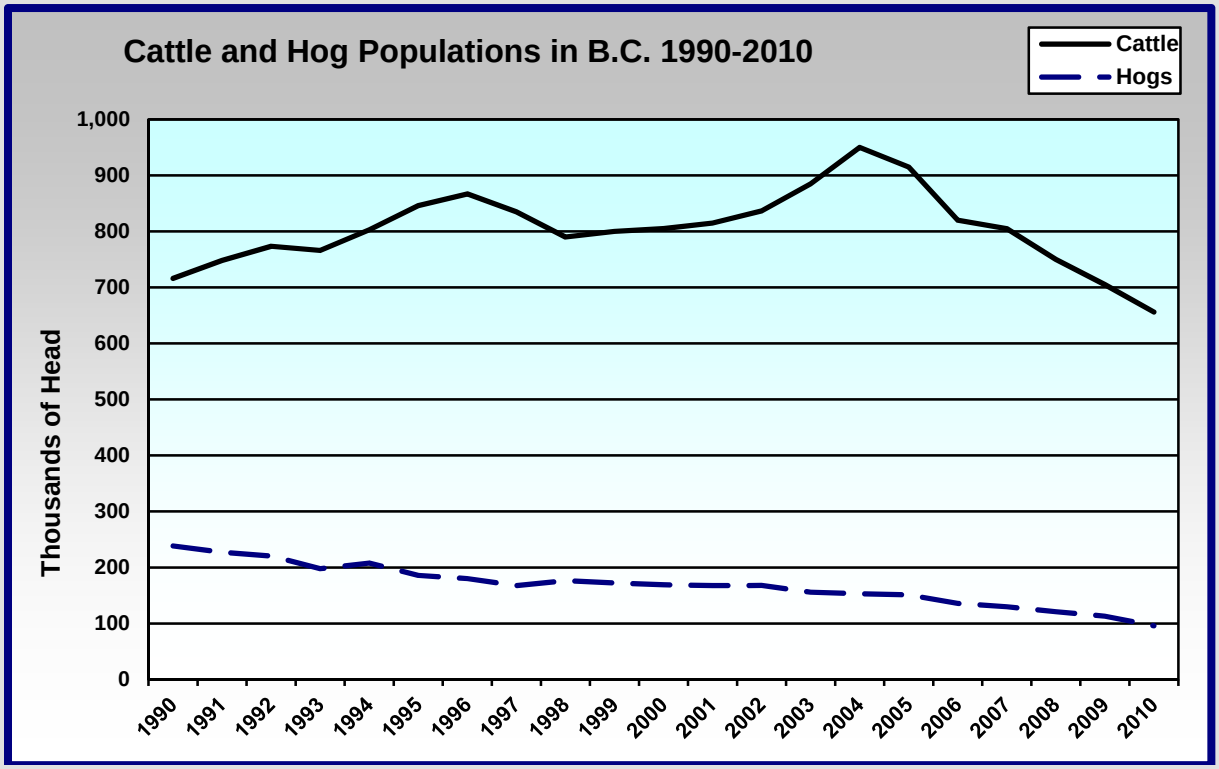


Figure 19: Cattle and Hog Populations – B.C. Trends

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

7.3 Data Sources

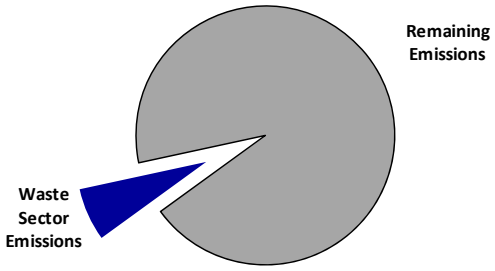
Agriculture sector emissions are calculated by multiplying activity data (e.g., number of livestock) by an appropriate emission factor. Table 20 summarizes the data sources used to compile activity data and emission factors for each agriculture sector emission category.

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

Emission Category	Activity	Data Sources
a: Enteric Fermentation	Domestic animal populations	Animal populations: Various Statistics Canada publications and CANSIM tables. Refer to Table 6-3 in the National Inventory Report (NIR) for specific references Emission Factors: Improving Estimates of Methane Emissions Associated with Enteric Fermentation of Cattle in Canada by Adopting an IPCC Tier-2 Methodology, Department of Animal Science, University of Manitoba, Boadi DA, Ominski KH, Fulawka DL, Wittenberg KM, 2004
b: Manure Management	Domestic animal populations	Animal populations: Various Statistics Canada publications and CANSIM tables – refer to Table 6-3 in the NIR for specific references CH_4 Emission Factors: Boadi et al. 2004; Improving Estimates of Methane Emissions Associated with Animal Waste Management Systems in Canada by Adopting an IPCC Tier 2 Methodology, Department of Land Resource Science. University of Guelph, Marinier et al. 2004 N_2O Emission Factors: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Intergovernmental Panel on Climate Change (IPCC)
c: Agriculture Soils		
Direct Emissions: - Fertilizer application	Fertilizer sales	Fertilizer sales and nitrogen content data: Canadian Fertilizer Institute
- Crop residues	Amount of nitrogen in crop residue	Crop Production: Field Crop Reporting Series, 1990–2008 (Annual). Catalogue No. 22-002, Statistics Canada Nitrogen in crop residue: The fate of nitrogen in agroecosystems: an illustration using Canadian estimates, Nutrient Cycling in Agroecosystems. 67: 85–102, Janzen et al. 2003
- Cultivated histosols	Area of cultivated histosols	Area of cultivated histosols: G. Padbury and G. Patterson, personal communication with Environment Canada Emission Factor: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, IPCC
- Changes in tillage	Area estimates of non-tillage and reduced tillage	Area estimates of non-tillage and reduced tillage: Census of Agriculture Emission reduction estimates: Estimation of N_2O emissions from agricultural soils in Canada. I. Development of a country-specific methodology. Canadian Journal of Soil Science 88: 641–654, Rochette P, Worth DE, Lemke RL, McConkey BG, Pennock DJ, Wagner-Riddle C, Desjardins RL. 2008
- Irrigation	Area of irrigated cropland	Area of irrigated cropland: Census of Agriculture, Statistics Canada Emission Factor: Rochette et al. 2008
- Summer fallow	Area of summer fallow	Area of summer fallow: Census of Agriculture, Statistics Canada Emission Factor: Rochette et al. 2008
Pasture, Range and Paddock	Domestic animal populations	Animal populations: Various Statistics Canada publications and CANSIM tables – refer to Table 6-3 in the NIR for specific references Emission Factors: IPCC 2006 Guidelines for National Greenhouse Gas Inventories, IPCC
Indirect Sources	Fertilizer sales Domestic animal populations	Fertilizer sales and nitrogen content data: Canadian Fertilizer Institute Animal populations: Various Statistics Canada publications and CANSIM tables – refer to Table 6-3 in the NIR for specific references Emission Factors: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, IPCC

8. WASTE SECTOR EMISSIONS

8.1 Summary



Total emissions in the waste sector category were 4.1 megatonnes (Mt) CO_2e in 2010 – 6.6% of total B.C. emissions.

GHG emissions from the waste sector are related to the treatment and disposal of solid waste and wastewater. Sources include: CH_4 emissions from landfills; CH_4 and N_2O emissions from wastewater treatment; and CO_2, CH_4 and N_2O emissions from waste incineration. CO_2 emissions of biogenic origin (i.e., wood, wood products and biomass-based wastes) are not included in this inventory category, and instead are currently reported as memo-items in the Land Use, Land Use Change and Forestry sector. Figure 20 and Table 21 provide a summary and description of waste sector emissions by each sub-sector.

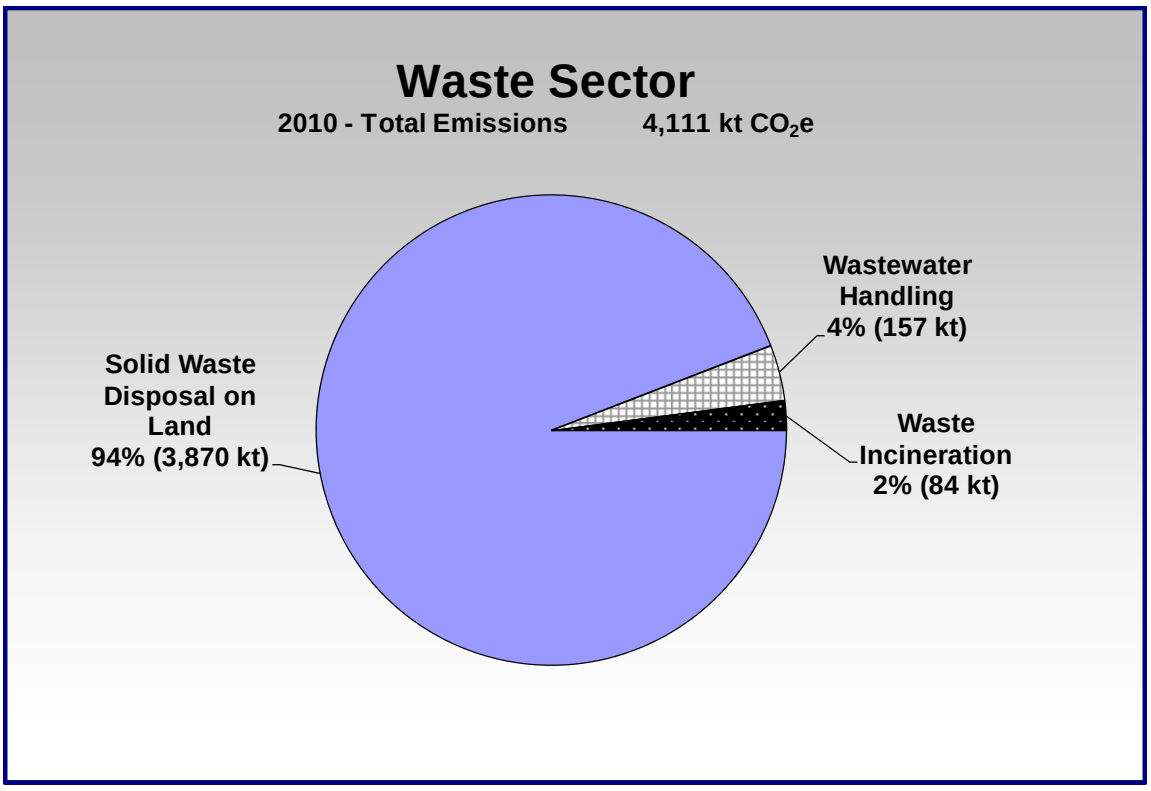


Figure 20: Waste Sector GHG Emissions – 2010

Table 21: Waste Sub-sector Descriptions

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

8.2 Trends in Waste Sector Emissions

Waste sector emissions decreased marginally (by 0.01%) between 2009 and 2010, increased by 1.3% between 2007 and 2010, and increased by 5.4% between 2000 and 2010. Increases in the quantity of waste generated and sent to landfills have recently been balanced by the emissions reductions associated with diversion of wastes and the capture, flaring and beneficial use of CH_4 at landfills.[41]

Table 22 and Figure 21 provide emission trend information for the waste sector. Note that due to the large difference in emissions among categories for this sector, Figure 21 shows emissions for the solid waste disposal on land category on a separate scale (left side y-axis) than emissions for the wastewater handling and waste incineration categories (right side y-axis).

Table 22: Waste Sector Trends and Key Drivers

Emission Category	3-Year Trend	10-Year Trend	Key Factors Influencing Changes in Emissions
WASTE	+1.3%	+5.4%	
Solid Waste Disposal on Land	+1.3%	+5.4%	Annual quantity of solid waste generated,[1] quantity of waste sent to landfill,[1] diversion rates (i.e., recycling and composting),[1] capturing and flaring of CH_4 emissions from landfills
Wastewater Handling	+2.5%	+8.9%	Population growth[2] and related water demand
Waste Incineration	-0.8%	-3.3%	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

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

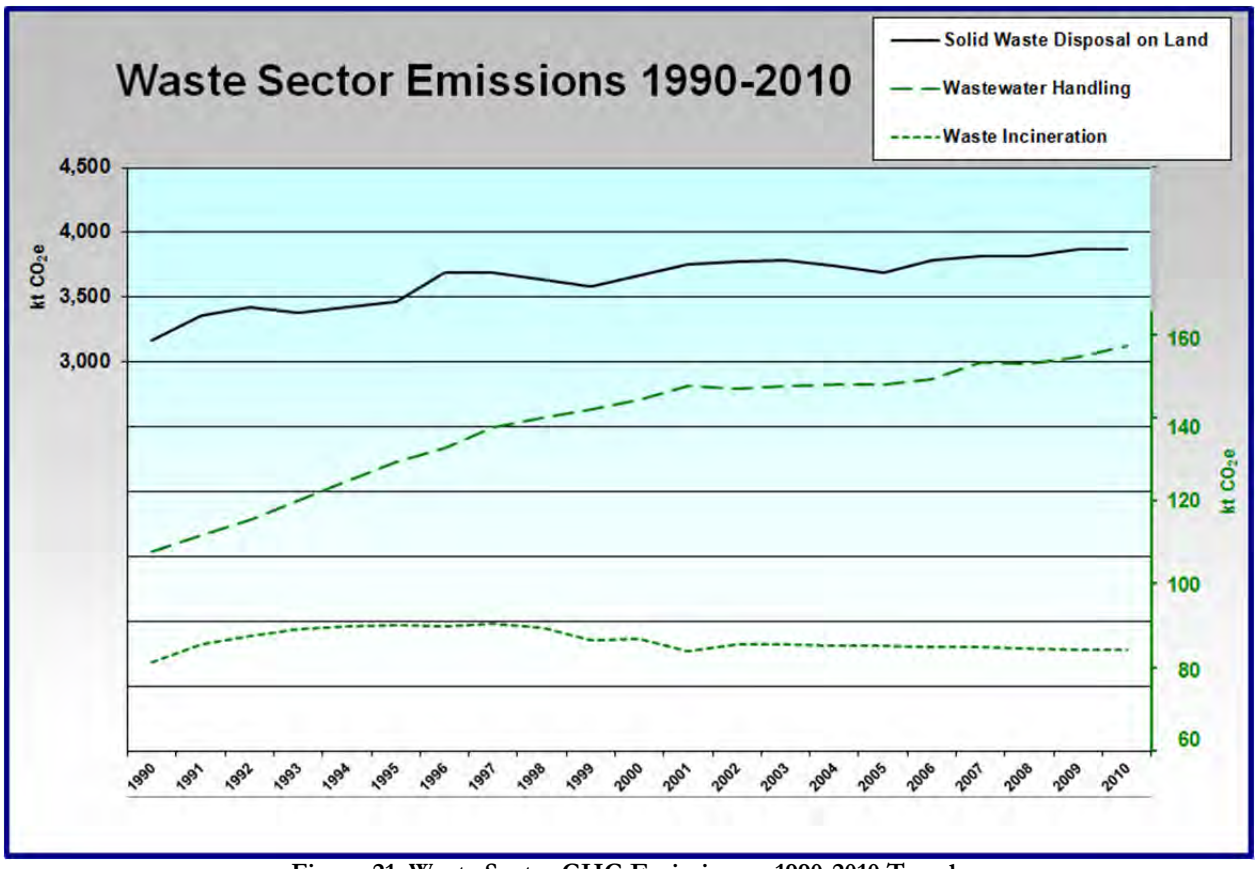


Figure 21: Waste Sector GHG Emissions – 1990-2010 Trends

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 22 shows that although the amount of waste diverted (i.e., reused, recycled or composted) from landfills has increased slightly between 1998 and 2008, the total waste generated and disposed in landfills has also increased. Diversion has not reduced waste generation sufficiently to reduce the amount of waste disposed of in landfills.

Figure 22: Waste Quantities in B.C.

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

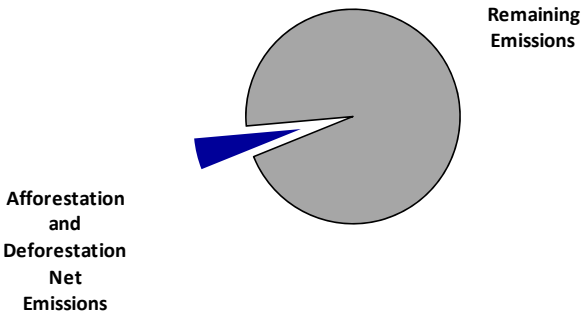
8.3 Data Sources

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

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

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

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



9.1 Summary

Net GHG emissions from afforestation[42] and deforestation[43] were approximately 2.9 megatonnes (Mt) CO_2e in 2010 – 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 2010. 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.[44]

The memo items include emissions of approximately 81.4 Mt from forest land (i.e., "forest land remaining forest land"), 0.23 Mt from cropland (i.e., "cropland remaining cropland") and 0.043 Mt from wetlands (i.e., "wetlands remaining wetlands").

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

Table 24 lists descriptions and notes for the various categories of lands in this sector, consistent with definitions used in the National Inventory Report (NIR).[45]

[42] "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.
[43] "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).
[44] See discussion of reporting land use, land-use change and forestry sector memo items in section 1 of this report.
[45] For complete definitions, see IPCC Guidelines at: http://carbon.cfs.nrcan.gc.ca/ForestInventory_e.html and www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Glossary_Acronyms_BasicInfo/Glossary.pdf

Table 24: Land Categories and Descriptions

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

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

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

Table 26 provides a description of the categories and related GHG emissions and removals relating to "memo item" LULUCF categories (i.e., forest land, cropland and wetlands). Sources of emissions include biomass taken from managed lands,[46] biomass decomposition, biomass burning and changes in soil composition. Removals (of CO_2 from the atmosphere) include the uptake of CO_2 by vegetation through photosynthesis and subsequent storage of carbon in biomass and soils. Types of GHGs associated with emissions and removals in this sector include CO_2, CH_4, N_2O and CO emissions from burning carbon stored in wood and soils (reported as CO_2) and CO_2 emissions from soils and biomass decomposition.

[46] Under current international accounting protocols, all carbon stored in removed biomass (including harvested wood products) is considered to be converted to CO_2 and emitted to the atmosphere immediately.

Table 25: Afforestation and Deforestation LULUCF Sector Categories and GHG Emissions 2010

LULUCF Category	Description	Net GHG Emissions (kt CO_2e)
TOTAL AFFORESTATION AND DEFORESTATION EMISSIONS (Included in Total Provincial GHG Emissions)		2,904
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.	-18.3
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.	740.2
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.	2,182
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).	

Table 26: "Memo Item" LULUCF Sector Categories and GHG Emissions 2010

LULUCF Category	Description	Net GHG Emissions (kt CO_2e)
TOTAL "MEMO ITEM" LULUCF EMISSIONS (not included in Total Provincial GHG Emissions)		81,637
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.	81,366
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.	228
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.	43

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

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

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

Afforestation and Deforestation

Net emissions in the afforestation and deforestation sub-category were approximately 2.9 megatonnes CO_2e in 2010, 4.7% of total B.C. emissions. This included 2.92 Mt CO_2e of emissions from deforestation and 0.018 Mt CO_2e of removals from afforestation. Emission and removal trends from 1990 to 2010 are shown in Figure 23.

Three-year and ten-year trends are described in Table 27, with CO_2 emissions and removals described by land conversion types as reported under international reporting protocols. Net GHG emissions from afforestation and deforestation decreased by 17.2% between 2007 and 2010, and by 24.8% between 2000 and 2010.

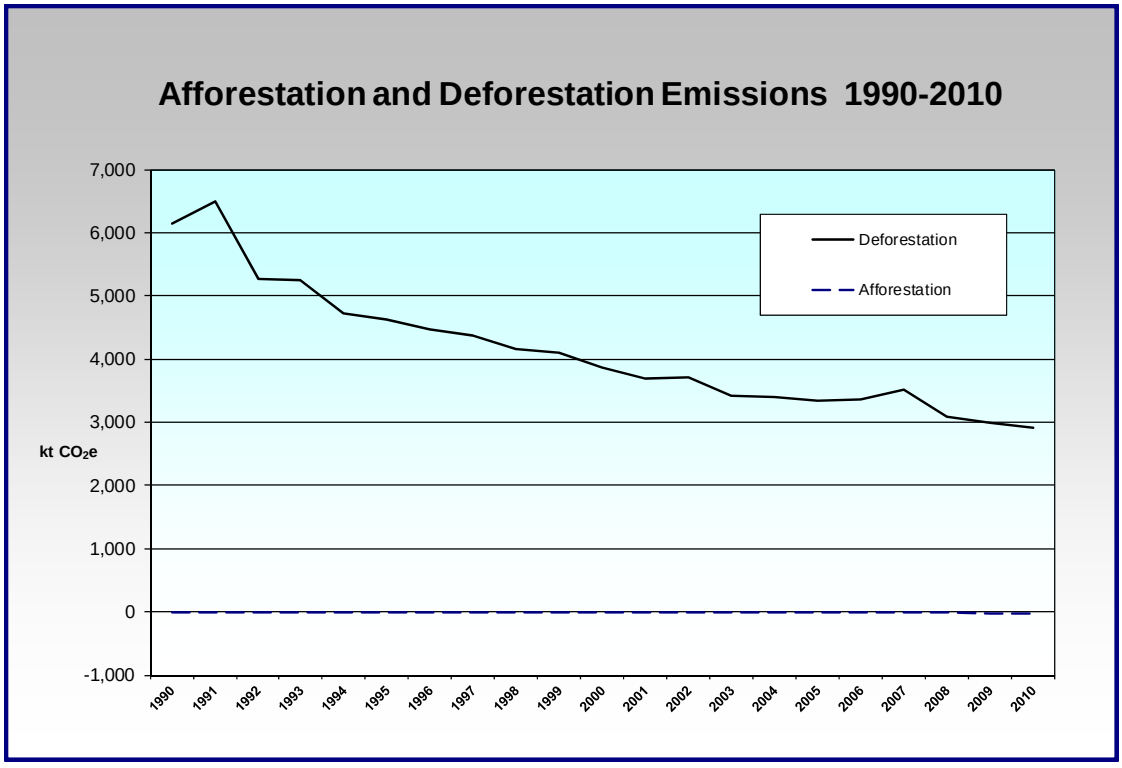


Figure 23: Afforestation and Deforestation Emission Trends

Table 27: Afforestation and Deforestation Sector Trends and Key Drivers

Emission / Activity Data Category	3-Year Trend	10-Year Trend	Key Factors Influencing Changes in Emissions
AFFORESTATION-DEFORESTATION	-17.2%	-24.8%	
Cropland converted to Forest Land (Afforestation)	+40.2%	+502.7%	Afforestation rates on areas previously cropland
Forest Land converted to Cropland (Deforestation)	-24.1%	-33.0%	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)	-14.3%	-20.9%	Expansion rates for transportation infrastructure (e.g., highways, logging roads, railways, airstrips), energy infrastructure (e.g., hydro line rights-of-way, hydro dams and earth fills, pipelines, well pads, seismic lines), municipal developments (e.g., urban and rural residential developments, open fields, gravel pits/quarries (and resource extraction activities), industry (e.g., industrial buildings/sites, shopping malls, prisons, schools, universities and similar infrastructure), mining (e.g., open pit coal, limestone and other mines. Infrastructure for underground mines) and recreation (e.g., campgrounds, golf courses, ski runs)
Forest Land converted to Wetlands (Deforestation)	No change	No change	Flooded area and timber cleared for hydro dams and other reservoirs, peat production

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

Annual rates of emissions associated with deforestation and removals from afforested land are in part influenced by the area of land involved (as well as by geographic location, growing conditions, tree species, density and age).[47] Area of land affected by afforestation and deforestation for selected years are illustrated in Figure 24. In the figure, area affected by deforestation is grouped into specific "sectors of human activity" (described in the figure's legend).[48] Disaggregated descriptions of these activities and detailed trend data for each are provided in Table 38 in the Annexes.

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

[48] 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.

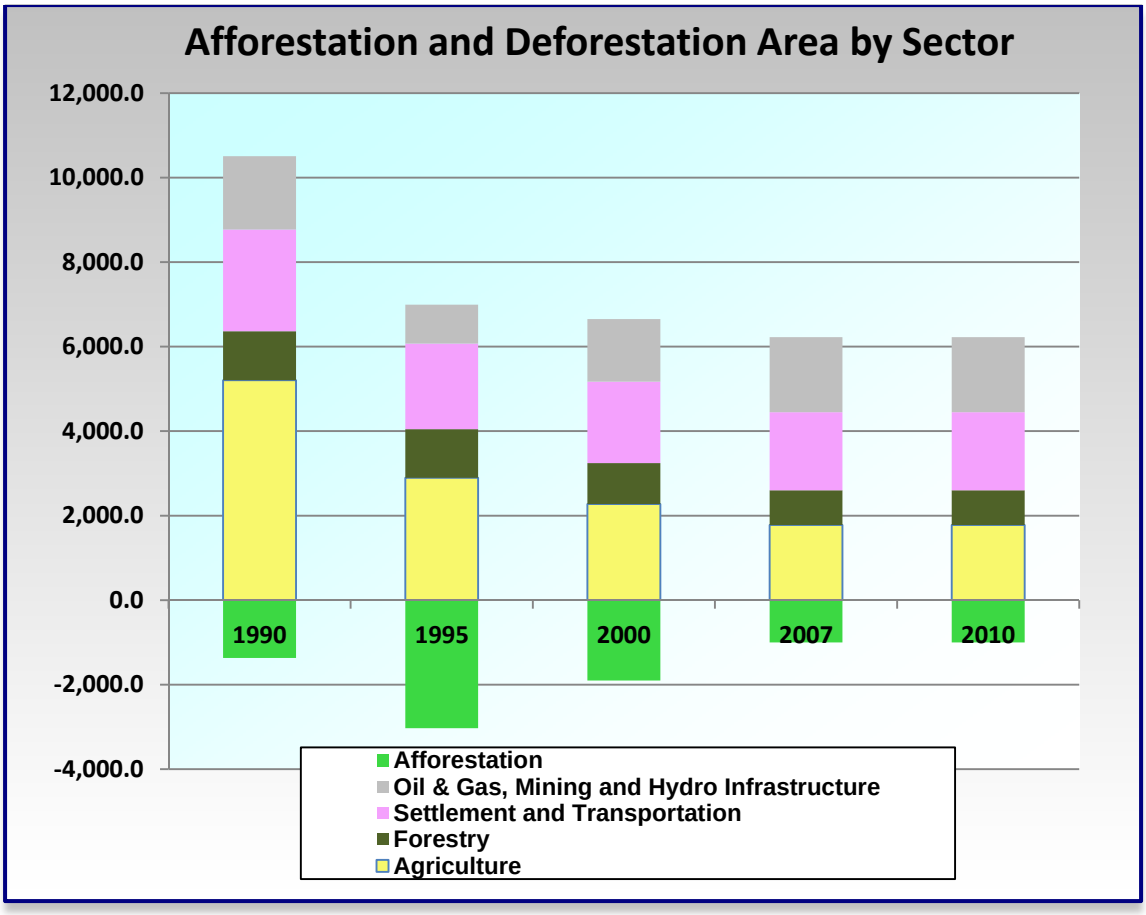


Figure 24: Afforestation and Deforestation Area – by Sector of Human Activity.

Approximately 6,230 hectares was deforested in 2010, a decrease of 6.5% from the 6,656 hectares in 2000.[49] Deforested areas are not evenly distributed across the province but are concentrated in the lower mainland, east Vancouver Island (both in the Pacific Maritime ecozone), and north central/north-eastern B.C. (Boreal Cordillera, Montane Cordillera and Taiga Plains and Boreal Plains ecozones). These areas are subject to settlement growth, agricultural development or oil and gas activity. On average, across all terrestrial ecozones, 530 and 255 tonnes (for settlement and agriculture-related deforestation, respectively) of greenhouse gases are released from combined initial biomass removal and 20-year residual biomass decomposition from one hectare of deforestation in B.C.[50]

Afforestation area data for 2010 is presently incomplete. In 2005 the latest year for which complete afforestation data is available, approximately 2,430 hectares (primarily unused farmland) was afforested.[51] 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

[49] A deforestation trend cannot be inferred for 2007 to 2010 as deforestation areas between 2000 and 2010 are based on interpretations of satellite image data taken in 2000 and 2008 that have been averaged and interpolated or extrapolated.
[50] Ministry of Forests, Lands and Natural Resource Operations
[51] 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.

new forests. As trees planted after 1990 mature however, the volume of carbon sequestered will increase substantially.

"Forest Land Remaining Forest Land" Category

Emissions from forest land (i.e., "forest land remaining forest land") were approximately 81.4 megatonnes (Mt) CO_2e in 2010. These emissions are being reported as a "memo item".[52] Emissions in this category included net -36.4 Mt CO_2e sequestered through net primary production (NPP) and decay of dead organic matter,[53] 43.8 Mt CO_2e emitted due to harvesting,[54] 66.5 Mt CO_2e emitted due to wildfires and 7.5 Mt CO_2e emitted due to slash burning.[55] [56]

Trends in emissions from 1990 to 2010 are shown in Figure 25. 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,[57] wildfires and partly to increases in wood harvesting.[58]

[52] "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

[53] 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.

[54] All carbon stored in harvested wood products is assumed under current international accounting protocols to be converted to CO_2 and emitted immediately to the atmosphere. This is an overestimation of emissions since carbon embedded in wood products is sequestered for an extended period of time prior to the eventual decay of wood products and release of emissions. These protocols may be subject to change in future international negotiations.

[55] 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.

[56] Forest carbon accounting involves complex simulations. Research by the Canadian Forest Service and the Ministry of Forests, Lands and Natural Resource Operations indicates that greenhouse gas emissions from deforestation, harvesting, and wildfire may be overestimated in B.C. Scientific research is occurring to validate and implement the updates in the carbon accounting models.

[57] The mountain pine beetle infestation has resulted in dead pine trees, whose decomposition releases CO_2 emissions. In addition, the death of pine trees temporarily reduces the capacity of the forest to remove carbon dioxide from the atmosphere before new trees grow to a significant size. In the long term, as trees re-grow in mountain pine beetle affected areas, the forest's capacity to act as a GHG sink will increase and the rate of carbon sequestration could increase substantially. Hence, this change should not be considered as a "permanent" loss.

[58] 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.

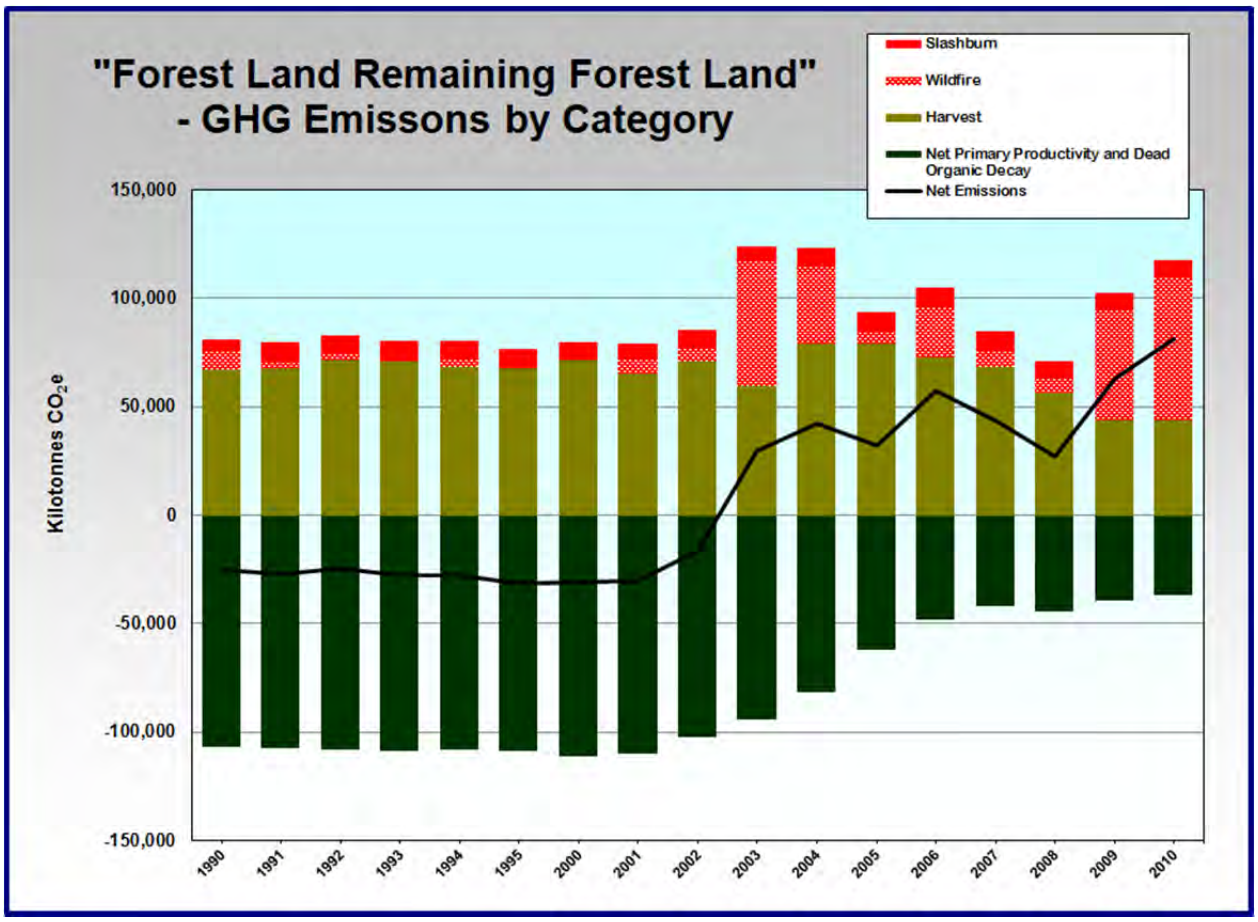


Figure 25: "Forest Land Remaining Forest Land" – GHG Emissions by Category

Three-year and ten-year trends are described in Table 28. Total (net) GHG emissions increased by approximately 88% in 2010 compared to 2007, while increasing by 363% between 2000 and 2010. The three-year trend can be attributed to a combination of counterbalancing factors: decreasing emissions from harvesting, increased emissions from wildfires; and relatively higher "removals" (i.e., sequestration) as the impact of the Mountain Pine Beetle (MPB) infestation in B.C.'s forests starts to lessen. The ten-year trend can be attributed to the significant decrease in "removals" (starting in 2001) due to decay of dead organic matter associated with the Mountain Pine Beetle infestation and increased emissions from the amount of area burnt in forest fires.

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

Emission/Activity Data Category	3-Year Trend	10-Year Trend	Key Factors Influencing Changes in Emissions
FOREST LAND REMAIN-ING FOREST LAND	+87.7%	-362.5%	Note: ten year trend moved from a negative figure in 2000 (indicating a sink) to a positive figure in 2010 (indicating an emissions source)
Net Primary Production and Decay of Dead Organic Matter (removal)	-12.0%	-67.1%	Growth of trees and other vegetation (including regeneration after harvesting, forest fires and insect/disease), decomposition of dead organic matter and intensity of insect and disease attack
Wildfires (emission)	+786.5%	+15,302.7%	Forest fire location and intensity – note that emissions due to wildfires vary greatly from year to year
Harvest (emission)	-36.3%	-38.8%	Amount of harvest
Slash Burning (emission)	-10.8%	-4.0%	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 2010 is illustrated in Figure 26.[59] Area affected by MPB increased by two orders of magnitude between 1990 levels and peak years of 2005, 2006 and 2007. The area of land impacted by wildfires varies greatly from year to year, with significant spikes in 2003-2006, 2009 and 2010 and lows in 1993, 1997 and 2000.

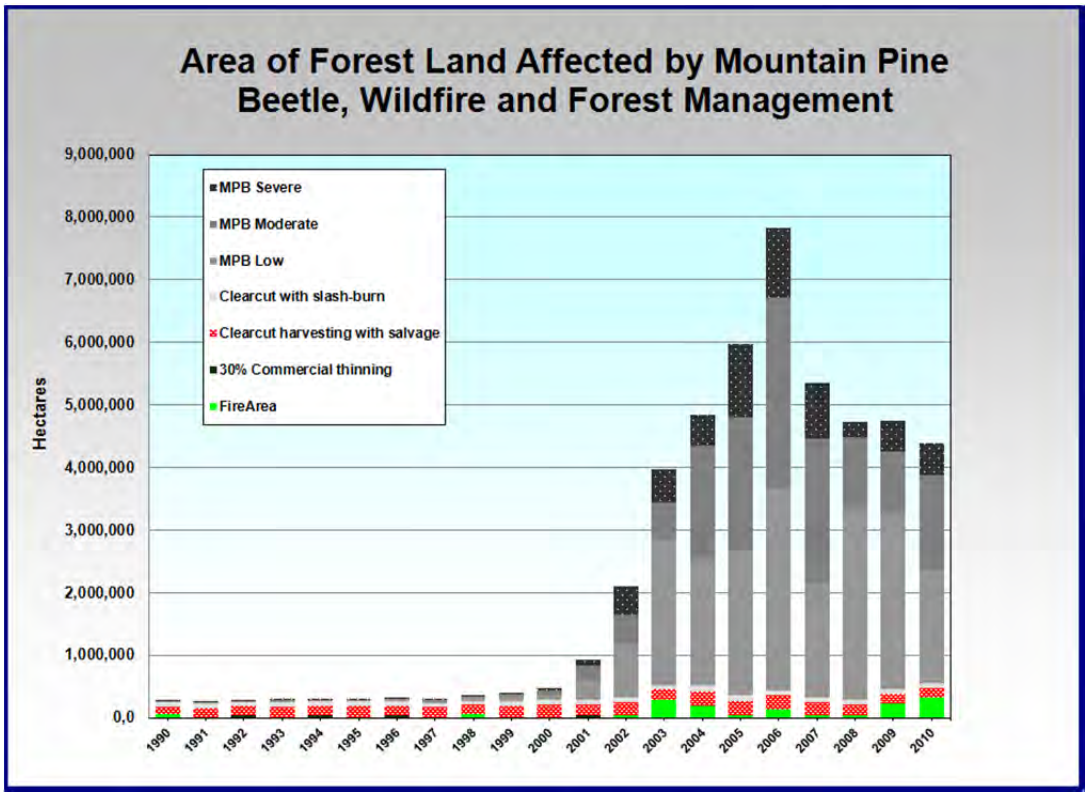


Figure 26: Area of Forest Land Affected by Mountain Pine Beetle, Wildfire and Forest Management

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

"Cropland Remaining Cropland" Category

Emissions from cropland (i.e., the "cropland remaining cropland" category) were 228.4 kilotonnes of CO_2e in 2010. These emissions are being reported as a "memo item". This is a decrease of 4.0% between 2007 and 2010 and an increase of 1.4% from 2000 emissions. These changes can be attributed, in part, to changes in the area of cropland in the province. Total cropland area in 2010 (1,681,260 hectares) was 5.1% higher than in 2007, and 21.2% higher than in 2000. Trends in emissions and cropland area from 1990 to 2010 are shown in Figure 27: "Cropland Remaining Cropland" – Net GHG Emissions and Area. Other factors impacting emissions from cropland management include lime application, cultivation of organic soils, changes in the management of mineral soils and changes in woody biomass.[60]

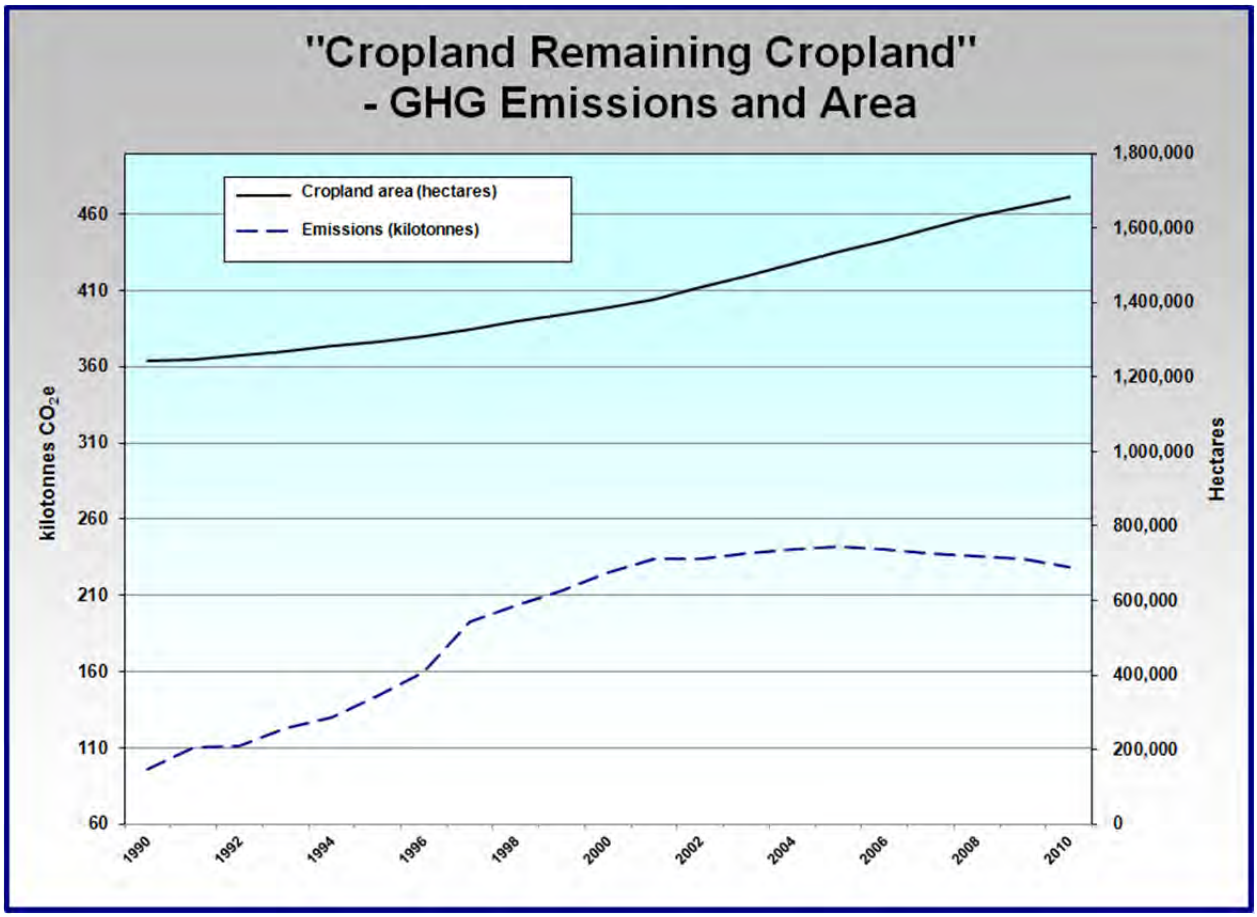


Figure 27: "Cropland Remaining Cropland" – Net GHG Emissions and Area

[60] 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 42.5 kilotonnes CO_2e in 2010. These emissions are being reported as a "memo item". This is a 14.7% decrease from 2007 and a 43.6% decrease from 2000. The emissions trend for B.C. between 1990 and 2010 is shown in Figure 28. 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.

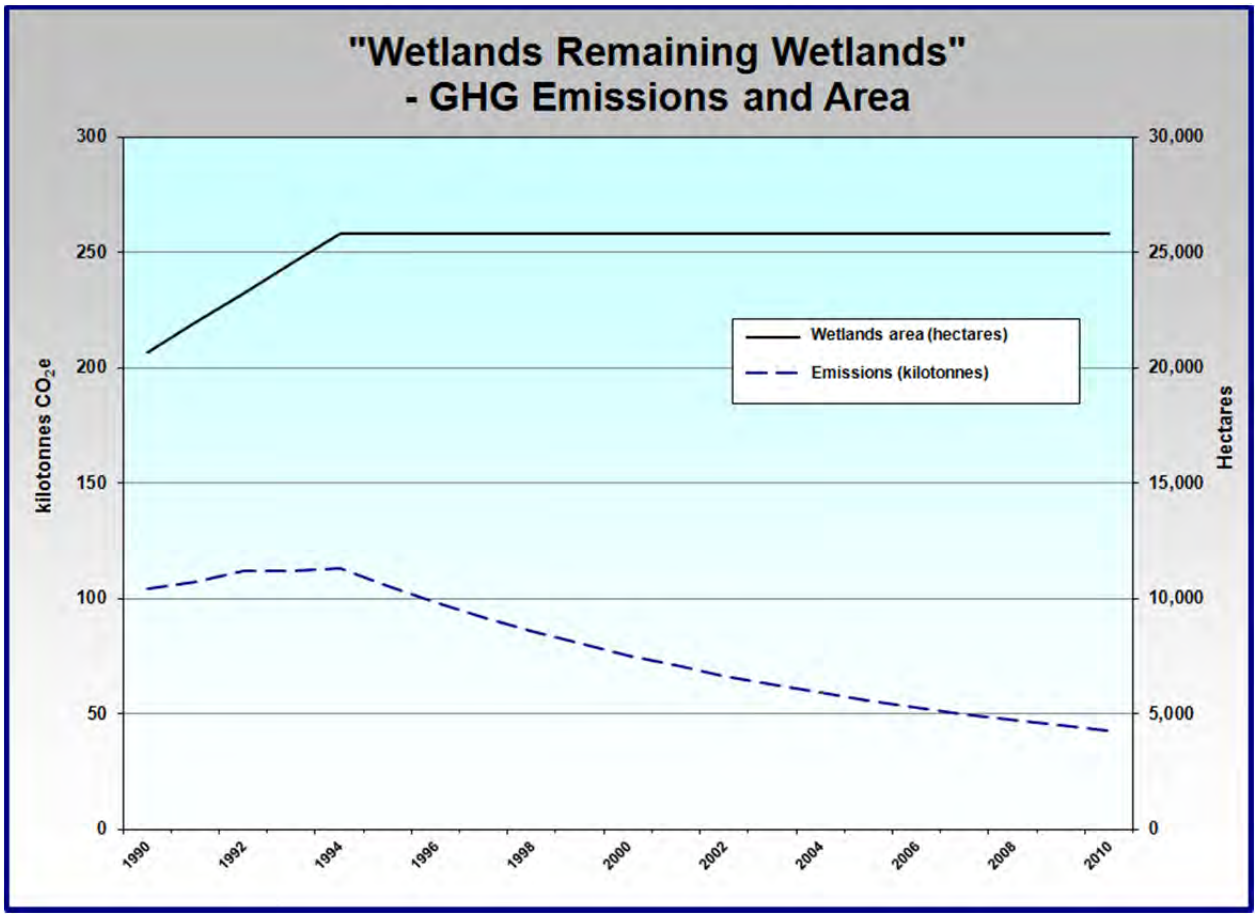


Figure 28: "Wetlands Remaining Wetlands" – Net GHG Emissions and Area

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-Part 2 (section A3.4). Note also that this report does not document data sources for categories in which the emissions are zero (c.f. Table 25) or for which an estimation has not been provided in this report.

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

Version 3 of the Carbon Budget Model (CBM) of the Canadian Forest Service (CFS)[61] 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, Lands and Natural Resource Operations, Environment and Agriculture. Recent updates include a more complete account of afforestation projects that occurred between 2005 to 2008, a significant expansion of the CFS deforestation sample network in B.C. and refinement of deforestation satellite image mapping (incorporating new high resolution data sources and expert validation, as well as an update to include the 2000 to 2008 time period). This work has utilized existing national reporting methodologies, and has been incorporated into the 1990-2010 National Inventory Report.

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

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

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

Emission Category	Activity	Data Sources
Afforestation	Area of afforestation	Canadian Forest Service National Afforestation Inventory, with Ministry of Forests update to database for 2005-2008 years
Deforestation	Area of deforestation	Canadian Forest Service Deforestation Event GIS Database – sample based satellite and aerial photograph interpretation combined with records data
Forest Land	Area of forest Growth rates Area of wildfire Area of mountain pine beetle impact Quantity of wood harvested	Ministry of Forests and Range
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_2O_3	Alumina
B.C.	British Columbia
CAC	Criteria Air Contaminant
CANSIM	Canadian Socio-economic Information Management System (Statistics Canada)
CAPP	Canadian Association of Petroleum Producers
CBM	Carbon Budget Model
CEEI	Community Energy and Emissions Inventory
CEPA	*Canadian Environmental Protection Act*
c.f.	refer to
CFCs	Chlorofluorocarbons
CFS	Canadian Forest Service
CGA	Canadian Gas Association
CH_4	Methane
CIEEDAC	Canadian Industrial Energy End-Use Data and Analysis Centre
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent – 1 CO_2e is the GWP from the release of 1 kg of CO_2
COP	Committee of Parties (under the UNFCCC)
CPPI	Canadian Petroleum Products Institute
EC	Environment Canada
e.g.	for example
g	grams
GDP	Gross domestic product
GGRTA	*Greenhouse Gas Reductions Target Act*
GHG	Greenhouse gas
GWh	gigawatt hours
GWP	Global warming potential
GJ	gigajoule
GTIS	Global Trade Information Services

Abbreviation, Acronym or Measure	Definition
ha	hectares
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
MEM	(B.C.) Ministry of Energy and Mines
MGEM	Mobile Greenhouse Gas Emission Model
MGO	Marine gas oil
Mha	mega hectares (million hectares)
MPB	Mountain Pine Beetle (infested forest)
Mt	megatonnes (million tonnes)
N/A	Not applicable
NAICS	North American Industry Classification System
NF_3	Nitrogen trifluoride
NIR	National Inventory Report
N_2O	Nitrous oxide
NPP	Net primary production
NRCan	Natural Resources Canada
PFCs	Perfluorocarbons
ppm	parts per million
QA/QC	Quality assurance/quality control
RESD	Report on Energy Supply and Demand in Canada
SF_6	Sulphur hexafluoride
STP	Standard temperature and pressure
TJ	terajoule
UNFCCC	United Nations Framework Convention on Climate Change
VOC	Volatile organic compound

10.2 Global Warming Potentials for Greenhouse Gases

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

Table 33: Global Warming Potentials for Greenhouse Gases[62]

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

[62] B.C. 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 8 of the National Inventory Report and are those most commonly used in British Columbia. Additional emission factors are provided in the NIR and/or are developed on the basis of site, time and source-specific fuel testing. For additional information regarding the purpose and use of emission factors see section 2 of this report.

Table 34: Emission Factors for Fuel Combustion[63]

Fuel Type	CO_2	CH_4	CH_4 (CO_2e)	N_2O	N_2O (CO_2e)	Total CO_2e	Units
Natural Gas - Producer Consumption	2,151	6.5	136.5	0.06	18.6	2,306	g/m^3
Natural Gas – Industrial Consumption[1]	1,916	0.037	0.777	0.033	10.23	1,927	g/m^3
Natural Gas – Pipelines	1,916	1.9	39.9	0.05	15.5	1,971	g/m^3
Natural Gas – Vehicles at STP	1,890	9	189	0.06	18.6	2,098	g/m^3
Natural Gas – Vehicles, Compressed[2]	2,723	13	273	0.086	26.66	3,023	g/kg
Gasoline – On Road Vehicles[3]	2,289	0.12	2.52	0.16	49.6	2,341	g/L
Gasoline – Off-Road	2,289	2.7	56.7	0.05	15.5	2,361	g/L
Gasoline – Boats	2,289	1.3	27.3	0.066	20.46	2,337	g/L
Diesel (Light-duty On Road Vehicles) [3]	2,663	0.068	1.428	0.21	65.1	2,730	g/L
Diesel (Heavy-duty On Road Vehicles)	2,663	0.14	2.94	0.082	25.42	2,691	g/L
Diesel - Off road	2,663	0.15	3.15	1.1	341	3,007	g/L
Diesel - general	2,663	0.133	2.793	0.4	124	2,790	g/L
Diesel - Train	2,663	0.15	3.15	1.1	341	3,007	g/L
Diesel - Ships	2,663	0.15	3.15	1.1	341	3,007	g/L
Light Fuel Oil - Ships	2,725	0.26	5.46	0.073	22.63	2,753	g/L
Light Fuel Oil - Industrial [4]	2,725	0.006	0.126	0.031	9.61	2,735	g/L
Light Fuel Oil - Residential	2,725	0.026	0.546	0.006	1.86	2,727	g/L
Light Fuel Oil - Commercial and Institutional	2,725	0.026	0.546	0.031	9.61	2,735	g/L
Heavy Fuel Oil – Ships	3,124	0.28	5.88	0.079	24.49	3,154	g/L
Heavy Fuel Oil – Industrial[4]	3,124	0.12	2.52	0.064	19.84	3,146	g/L
Aviation Gasoline	2,342	2.2	46.2	0.23	71.3	2,460	g/L
Aviation Turbo Fuel	2,534	0.028	0.588	0.071	22.01	2,557	g/L
Kerosene (Electric Utilities, Industrial, Producer Consumption)[4]	2,534	0.006	0.126	0.031	9.61	2,544	g/kg
Coal – Canadian Bituminous[4]	2,190	0.03	0.63	0.02	6.2	2,197	g/kg
Coal – Sub-Bituminous[4]	1,725	0.03	0.63	0.02	6.2	1,732	g/kg
Coal – Foreign Bituminous[4]	2,541	0.03	0.63	0.02	6.2	2,548	g/kg
Coal Coke	2,480	0.03	0.63	0.02	6.2	2,487	g/kg
Petroleum Coke – Upgrading Facilities	3,494	0.12	2.52	0.0231	7.161	3,504	g/L

[63] Unless otherwise noted, emission factors are from the National Inventory Report 1990-2010.

Fuel Type	CO_2	CH_4	CH_4 (CO_2e)	N_2O	N_2O (CO_2e)	Total CO_2e	Units
Petroleum coke – Refineries and Others	3,816	0.12	2.52	0.0265	8.215	3,827	g/L
Propane – Residential[5]	1,510	0.027	0.567	0.108	33.48	1,544	g/L
Propane Vehicles	1,510	0.64	13.44	0.028	8.68	1,532	g/L
Butane	1,730	0.024	0.504	0.108	33.48	1,764	g/L
Ethane	976	0	0	0	0	976	g/m^3
Coke Oven Gas	879	0.037	0.777	0.035	10.85	891	g/m^3
Still Gas – Upgrading Facilities	2,140	0	0	0.00002	0.0062	2,140	g/m^3
Still Gas – Refineries and Others	1,723	0	0	0.00002	0.0062	1,723	g/m^3
Wood Waste (50% moisture content)	840	0.09	1.89	0.02	6.2	848	g/kg
Spent Pulping Liquor (i.e. Black Liquor)	891	0.02	0.42	0.02	6.2	898	g/kg
Biodiesel[3]	2449	0.12	2.52	0.082	25.42	2,477	g/L
Ethanol[3]	1494	0.12	2.52	0.16	49.6	1,546	g/L
Tires - Cement	80.8	NA	0	NA	0	81	kg/GJ
Landfill Gas - Industrial combustion	54600	1	21	0.1	31	54,652	kg/TJ
Petrochemical Feedstocks	500	0	0	0	0	500	g/L
Napthas	625	0	0	0	0	625	g/L
Lubricating Oils and Greases	1410	0	0	0	0	1,410	g/L
Petroleum Used for Other Products	1450	0	0	0	0	1,450	g/L

Notes and Sources:

[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) 1990-2010

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

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

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

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

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

Emission Factors for Fugitive Emissions and Industrial Processes[64]

Table 35: Emission Factors for Fugitive Emissions and Industrial Processes

Industrial Process[1]	Activity	Emission Factors					Unit
		CO_2	CH_4	CF_4	C_2F_6	CO_2 e	
Coal Mining	Underground Coal Production	0	2.78	0	0	58.4	kg/tonne coal
	Surface Coal Production	0	0.65	0	0	13.7	kg/tonne coal
Limestone Use	Glass production, non-ferrous metal production, pulp and paper mills, other chemical uses	418	0	0	0	418	kg/tonne feed
Dolomite Use	Glass production, magnesium production, smelting of iron and steel	468	0	0	0	468	kg/tonne product
Soda Ash Use	Glass manufacturing	415	0	0	0	415	kg/tonne feed
Cement Production	Limestone calcination	507	0	0	0	507	kg/tonne product
Lime Production	Limestone calcination (high calcium lime)	751	0	0	0	751	kg/tonne product
	Limestone calcination (dolomitic lime)	889	0	0	0	889	kg/tonne product
Primary Aluminium[1]	Electrolysis - Side-worked pre-baked	1,600	0	1.6	0.4	15,680	kg/tonne product
	Electrolysis - Centre-worked pre-baked	1,600	0	0.4	0.04	4,568	kg/tonne product
	Electrolysis - Horizontal stud Søderberg	1,700	0	0.4	0.03	4,576	kg/tonne product
	Electrolysis - Vertical Stud Søderberg	1,700	0	0.8	0.04	7,268	kg/tonne product

Notes:

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

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

[64] Data from National Inventory Report 1990-2010

Emission Factors for Electricity[65]

Table 36: Emission Factors for Electricity

Year	1990	1995	2000	2005	2006	2007	2008	2009	2010
Category	Electricity Generation (GWh)								
Refined Petroleum Products	100	30	40	60	10	70	70	100	80
Natural Gas	1,260	4,490	3,350	3,140	2,970	2,660	3,080	2,610	2,430
Hydro	46,400	38,900	50,800	50,300	44,500	54,700	48,600	46,300	44,400
Biomass	0	180	550	550	550	670	560	400	630
Total	47,760	43,600	54,740	54,050	48,030	58,100	52,310	49,410	47,540
	Greenhouse Gas Intensity (g GHG per kWh electricity produced)								
CO_2 Intensity (g CO_2/kWh)	17.0	50.6	33.0	28.0	30.0	22.0	31.0	31.0	29.0
CH_4 Intensity (g CH_4/kWh)	0.004	0.01	0.008	0.007	0.007	0.005	0.007	0.006	0.006
N_2O Intensity (g N_20/kWh)	0.001	0.001	0.001	0.0008	0.0008	0.0005	0.0008	0.0008	0.0007
Overall Intensity (g CO_2 eq/kWh)	17	51	33	28	30	22	31	31	29

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

Table 37: Activities Considered as Deforestation by Industrial Sector

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

[65] Data from the National Inventory Report 1990-2010

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

Year	1990	1995	1998	2000	2005	2007	2008	2009	2010
Industrial Sector	Area Affected (hectares)								
Afforestation Total[1]	-1,370	-3,032	-1,902	-1,902	-2,428	INC	INC	INC	INC
Deforestation Total	10,509	6,998	6,782	6,656	6,197	6,223	6,223	6,223	6,223
Sectors contributing to deforestation									
Agriculture	5 207	2,897	2,523	2,275	1,777	1,777	1,777	1,777	1,777
Forestry	1,159	1,151	1,042	969	824	824	824	824	824
Oil & Gas, Mining and Hydro Infrastructure	1,733	922	1,249	1,484	1,749	1,774	1,774	1,774	1,774
Oil and Gas	243	334	575	793	1,134	1,134	1,134	1,134	1,134
Mining	645	588	674	691	615	615	615	615	615
Hydro Infrastructure	845	0	0	0	0	25	25	25	25
Settlement and Transportation	2,409	2,025	1,966	1,926	1,847	1,847	1,847	1,847	1,847
Industry	152	102	126	142	174	174	174	174	174
Municipal	1,684	1,478	1,458	1,446	1,420	1,420	1,420	1,420	1,420
Recreation	229	249	202	171	108	108	108	108	108
Transportation	344	196	179	168	145	145	145	145	145

Notes and Sources:

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

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

Data from Ministry of Environment, Ministry of Forests, Range and Natural Resource Operations and the Canadian Forest Service, Natural Resources Canada

Table 39: Approximate Forestry Emissions - by Terrestrial Ecozone

Year	1990	1995	2000	2005	2007	2008	2009	2010
Approximate Forestry Emissions (kt) [1]								
Terrestrial Ecozone								
Pacific Maritime (net emissions)	37,744	27,483	29,953	33,264	23,977	16,481	6,964	5,662
NPP and Decay of Dead Organic Matter (net)	9,309	2,033	308	-144	-1,489	-3,074	-10,600	-11,739
Harvest	26,114	23,804	28,000	31,324	24,170	18,732	14,945	14,845
Wildfire	679	228	-	792	237	346	2,248	2,188
Slashburn	1,641	1,419	1,645	1,293	1,060	477	371	368
All Other[2] Ecozones (net emissions)	-64,508	-60,356	-61,036	3,769	28,321	16,353	56,417	75,704
NPP and Decay of Dead Organic Matter (net)	-64,508	-112,041	-111,663	-59,375	-32,195	-33,893	-28,483	-24,694
Harvest	41,240	44,244	43,545	47,902	44,632	36,577	28,853	28,953
Wildfire	7,580	588	374	6,963	8,081	6,209	48,359	64,278
Slashburn	3,720	6,852	6,707	8,279	7,803	7,460	7,688	7,166
PROVINCIAL TOTAL (net emissions)	-25,488	-31,563	-30,997	31,929	43,348	27,158	63,382	81,366
NPP and Decay of Dead Organic Matter (net)	-106,519	-108,343	-110,820	-62,120	-41,399	-44,241	-39,083	-36,433
Harvest	67,354	68,048	71,545	79,226	68,801	55,309	43,798	43,799
Wildfire	8,260	816	374	7,754	8,318	6,555	50,607	66,466
Slashburn	5,361	8,271	8,352	9,572	8,863	7,937	8,059	7,535

Notes and Sources:

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

[1] Data from Ministry of Forests, Range and Natural Resource Operations and the Canadian Forest Service, Natural Resources Canada

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

Table 40: Area of Forest Land Affected – by Category of Activity[66] [67]

Activity Category	Forest Fire	30% Commercial thinning	Clearcut harvesting with salvage	Clearcut with slash-burn	MPB Low	MPB Moderate	MPB Severe	MPB Very Severe	Total MPB
Year	Area Affected (hectares)								
1990	49,733	11,036	119,715	60,441	24,662	6,226	7,140		38,028
1991	14,163	14,814	132,363	67,421	16,019	9,692	18,069		43,780
1992	11,780	25,072	145,450	65,947	16,429	6,343	18,111		40,883
1993	992	26,957	151,763	73,986	10,251	14,946	16,673		41,870
1994	17,939	22,166	154,946	69,924	4,571	11,675	9,533		25,779
1995	3,781	25,939	157,767	70,444	10,707	7,876	5,085		23,668
1996	10,619	30,381	154,469	67,417	30,193	7,111	2,450		39,754
1997	1,377	10,792	157,395	67,194	38,529	17,920	2,758		59,207
1998	49,704	9,344	152,184	64,792	48,340	26,763	4,853		79,956
1999	7,912	7,493	181,934	76,124	69,278	44,897	19,575		133,750
2000	2,173	11,474	187,246	77,566	85,513	78,572	24,722		188,807
2001	30,506	8,631	175,073	71,706	326,311	213,576	106,502		646,389
2002	37,639	9,711	192,661	77,710	854,573	470,450	461,697		1,786,720
2003	279,935	7,303	164,333	67,041	2,310,618	607,822	534,680		3,453,121
2004	187,776	7,072	224,773	90,301	2,025,861	1,817,089	486,637	124,778	4,454,365
2005	38,838	4,640	230,569	91,492	2,304,865	2,137,337	1,167,649	670,295	6,280,146
2006	132,758	3,823	217,630	86,348	3,237,651	3,038,038	1,112,094	335,442	7,723,225
2007	32,782	4,381	209,908	85,712	1,826,366	2,298,427	895,868	421,087	5,441,748
2008	31,183	1,856	178,347	78,907	3,066,004	1,125,995	236,654	66,227	4,494,880
2009	236,865	1,473	140,697	80,835	2,794,605	1,002,404	499,233	86,843	4,383,085
2010	325,621	296	142,385	77,606	1,813,513	1,512,848	515,561	17,768	3,859,690

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

[67] Data from Ministry of Forests, Range and Natural Resource Operations and the Canadian Forest Service, Natural Resources Canada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