# TECHNICAL METHODS AND GUIDANCE DOCUMENT FOR 2007 CEEI REPORTS:

## COMMUNITY ENERGY AND EMISSIONS INVENTORY (CEEI) INITIATIVE


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Ministry of Environment

Victoria, B.C.

# Technical Methods and Guidance Document for 2007 CEEI Reports – Community Energy and Emissions Inventory Initiative

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# ACKNOWLEDGEMENTS AND FURTHER INFORMATION

## Acknowledgements

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Report production and editorial services have been provided by Colin Rankin and Louise Beinhauer of C. Rankin & Associates.

## Further Information

Copies of this report, as well as each B.C. local government's Updated 2007 CEEI Reports (Expanded Editions) and additional information on the CEEI initiative and background reports, can be found at the Ministry of Environment's website at: http://www.env.gov.bc.ca/cas/mitigation/ceei/index.html.

B.C. local governments looking for additional information on approaches and best practices for undertaking corporate operations and/or community-wide energy conservation and greenhouse gas emissions reduction initiatives are encouraged to visit: http://www.toolkit.bc.ca/.

Comments or questions regarding this 2007 CEEI Technical Methods and Guidance Document can be sent to: CEEIRPT@gov.bc.ca.

# 1. INTRODUCTION

## 1.1 Community Energy and Emissions Inventory (CEEI) Initiative

Local government involvement is an essential element of climate action. An estimated 45% of British Columbia's greenhouse gas (GHG) emissions are under the direct or indirect control or influence of municipal governments.

The Government of British Columbia, the Union of B.C. Municipalities and over 178 local governments across the province have signed the "Climate Action Charter" [1] – collectively committing signatory local governments to develop strategies and take actions to achieve the following goals:

- being carbon neutral in respect of their operations by 2012;
- measuring and reporting on their community's GHG emissions profile; and
- creating complete, compact, more energy efficient rural and urban communities.

The Community Energy and Emissions Inventory (CEEI) initiative supports the Charter, providing a provincial framework for tracking and reporting energy and greenhouse gas (GHG) emission indicators at a community-wide scale.

The CEEI is intended to provide a cost-effective, rigorous and flexible data collection, analysis and reporting system for B.C. local governments and other interested parties. The system establishes and enables inventory baselines, ongoing monitoring and periodic reporting – to inform community decision making and support provincial objectives related to energy use and GHG emissions.

The CEEI initiative is supported by a multi-agency committee (the CEEI Working Group) led by the Ministry of Environment.[2] The CEEI working group was formed in 2007 and has continued to work with local governments and contractors since that time to establish and refine inventory and reporting methods and formats.

## 1.2 CEEI Reports

CEEI Reports for British Columbian regional districts and communities report on energy and GHG emission estimates in three primary sectors – buildings, on-road transportation and solid waste – and five "supporting indicators" – housing type, residential density, commute to work, commute distance, and green space. The reports also include additional emissions information at the regional district level on land-use change from deforestation and enteric fermentation from agricultural livestock. These "memo item" emissions categories (see text box) are provided for information purposes only and are not included in total "reported" emissions profiles. Another memo item at both the municipal and regional district levels is emissions from "large industrial facilities".

[1] See: www.cd.gov.bc.ca/ministry/docs/climate_action_charter.pdf. Additional resources can be found at the "Climate Action Toolkit" (www.toolkit.bc.ca) – provided through collaboration between UBCM and the Province

[2] See Appendix 1.

The first *draft* 2007 CEEI Reports for B.C. local governments were prepared in February 2009. Updated 2007 CEEI Reports (Expanded Edition), based on the technical methods and guidance set out in this document, have been posted on the B.C. Climate Action Secretariat website – http://www.env.gov.bc.ca/cas/mitigation/ceei/index.html – and linked to B.C.'s Climate Action Toolkit for easy access by all B.C. local governments. With these updated 2007 reports, improvements have been made from the original *draft* 2007 CEEI Reports posted in Spring 2009. The new reports include estimates for residential heating oil, propane and wood use, break out small and medium from large industrial buildings, include updated land-use change and new agricultural sectors as "memo items", and provide the first of a suite of "supporting indicators".

**National and Provincial GHG Reporting – Emissions Sectors and "Memo Items"**

**Canada** produces a National Inventory Report using reporting categories and methodologies for estimating greenhouse gas emissions and removals set out in the United Nations Framework Convention on Climate Change (UNFCCC). GHG emissions and removals are grouped into six sectors: Energy; Industrial Processes; Solvent and Other Product Use; Agriculture; Land Use, Land-Use Change; and Forestry and Waste.
See: www.ec.gc.ca/pdb/GHG/inventory_e.cfm.

**British Columbia** also follows UNFCCC conventions and categories, utilizing national and provincial inventory data to produce the B.C. GHG Inventory Report. See: www.env.gov.bc.ca/epd/climate/ghg-inventory/index.htm#7.

GHG inventories can include both **reported** emissions and removals that are "counted" in GHG emission totals, and "**memo items**" that are not included in totals but are documented for transparency and GHG accounting purposes.

Future CEEI Reports may include additional inventory components and supporting indicators, as may be advised by emerging international protocols and information needs of local governments; though potential enhancements may be equally constrained by availability of data and resources.

## 1.3 Purpose and Structure of the Technical Methods and Guidance Document

This Technical Methods and Guidance Document describes the principles, methods and sources used for collection and analysis of the data used for the Updated 2007 CEEI Reports (Expanded Edition). This document is intended to:

- provide a reference source for ongoing preparation of CEEI Reports;
- support local governments' understanding and refinement of the methods used to report energy and GHG emissions, transparently and in a straightforward manner;
- support local governments interested in accessing and utilizing energy and GHG emission data to further develop or review targets, policies or actions as part of their GHG planning process; and
- identify planned improvements in data collection and analysis for energy and GHG emissions reporting.

The document includes background and context information, suggestions for using CEEI Reports, and the methodologies and data sources for each of the sectors included in the 2007 CEEI Reports (Expanded Edition).

Section 2 outlines the context for CEEI reporting, including the relevant protocols and guidance for community-scale GHG inventories from organizations outside of British Columbia, and related B.C. GHG inventory efforts.

Section 3 describes the purpose, principles and intended use of CEEI reporting.

Section 4 provides a description of CEEI reporting foundations – greenhouse gases and emissions sources that are included in the inventory, units of measure, emissions calculations and common data sources, the format of CEEI Reports and the methods used for defining boundaries.

Sections 5 to 9 provide the methods and guidance for each of the "sectors" reported in CEEI inventories: on-road transportation; residential, commercial and industrial buildings; municipal solid waste; land-use change; and agricultural livestock. Protocols and guidance used to prepare the inventory for the sector are reviewed and any deviations from existing protocols are noted. An assessment of the data and methods used for each sector against the CEEI guiding principles is provided. Components included and excluded are stated and a complete methodology, including data sources, is provided. Confidentiality issues are noted where appropriate and comments on data accuracy are provided. Each section concludes with a summary of planned improvements to future CEEI inventories for that sector.

Section 10 describes information related to "supporting energy and emissions indicators" that are included in the Updated 2007 CEEI Reports, following a similar format used for the above sectors (sections 5-9).

This document also includes a bibliography, glossary of terms and table of acronyms, and appendices with information about: the CEEI Working Group; and local governments with electrical and/or natural gas consumption data "withheld".

A companion document to the 2007 CEEI Reports – the 2007 CEEI Summary Report – provides an overall summary of the total energy and GHG emissions in the three sectors reported in the 2007 CEEI inventories. Each sector begins with a quantitative summary of the share of that sector's energy and GHG emissions as a percentage of the 2007 CEEI total.

**Note:** Estimates of GHG emissions from large industrial facilities, land-use change and agriculture are included in CEEI Reports, but are for information only (i.e., "Memo Items") and, as such, do not form part of the CEEI totals.

# 2. CONTEXT FOR CEEI REPORTING

This section provides: (1) brief summaries and links to some of the international best practices that underlie community-level greenhouse gas emissions reporting; and (2) a summary of related British Columbia GHG inventories.

## 2.1 Protocols and Guidance for Community Inventories

There are presently no nationally or internationally required protocols[3] regarding monitoring and reporting of community-wide energy and emissions. A number of national and international level documents have been developed however that support or describe community GHG emissions inventories. These efforts have informed development of the CEEI reporting framework and are briefly described below.

### 2.1.1 Federation of Canadian Municipalities – Partners for Climate Protection

The current standard inventory guidelines for local governments in Canada are provided by the Federation of Canadian Municipalities (FCM) Partners for Climate Protection (PCP).[4] This guidance document (FCM 2008) has been used by a number of the 200 members of the PCP across Canada. In B.C., 61 jurisdictions are signatories to the Partners for Climate Protection program.

In Spring 2010, an advisory group formed to assist the Canadian Standards Association (CSA Standards) in developing a foundation document for guiding energy and greenhouse gas emissions characterizations at the local government operational and community-wide levels. This document is intended to include elements of existing and emerging guides, standards and protocols for the quantification of community energy production and consumption.

### 2.1.2 World Resources Institute (WRI)

The CEEI initiative has adopted the spirit and intent of the overarching accounting principles in the World Resources Institute/World Business Council for Sustainable Development (WRI/WBCSD) GHG Protocol *Corporate Accounting and Reporting Standard* (2005 WRI/WBCSD).[5]

These principles are intended to ensure a fair, faithful, and truthful representation of GHG emissions and are based on accounting principles to be used as guidance when deciding how to count emissions and the methodologies to be employed. The principles have been designed with corporate GHG accounting in mind and are not intended to define how community emissions inventories should be developed – decisions that are often intrinsic to data availability and quality, and other limitations.

### 2.1.3 ICLEI – Local Governments for Sustainability

ICLEI – Local Governments for Sustainability[6] is "an international association of local governments as well as national and regional local government organizations that have made a commitment to

[3] 'Protocol', for CEEI purposes, is intended to represent common conventions and a standardized approach to applying energy and emissions estimation methodologies
[4] See: www.sustainablecommunities.fcm.ca/partners-for-climate-protection
[5] See: www.wri.org
[6] See: www.iclei.org

sustainable development". The association has introduced the *International Local Government GHG Emissions Analysis Protocol* (ICLEI 2008).[7] The protocol is the most thorough of all existing documents describing community GHG emissions inventories, strictly adhering to the principles found in the World Resources Institute (WRI) GHG Protocol and the guidance provided in Standards Council of Canada or ISO protocols. However, the document does not fully consider the feasibility and/or practicality of applying some of the written protocols when developing community inventories.

### 2.1.4 Other Relevant Organizations or Initiatives

**The Climate Registry**[8] – may in future support and recommend use of other standards for community inventories in support of their members. The Province of B.C. is a founding member and founding reporter to the Climate Registry.

**The Standards Council of Canada**[9] – is associated with the International Organization for Standardization (ISO) and provides documentation relevant to GHG emissions inventories through Technical Committee 207 on Environmental Management.[10] One document in particular, *Greenhouse Gases - Part 1: Specification with guidance at the organizational level for quantification and reporting of greenhouse gas emissions and removals*[11] is relevant to CEEI inventories. The FCM PCP framework document and the ICLEI protocol reference this document.

**International Panel on Climate Change** (IPPC) – methods and standards for emissions inventories are rooted in guidelines produced by the International Panel on Climate Change (IPCC 1996).[12] The subsequent revision – *IPCC Guidelines for National Greenhouse Gas Inventories* (2006) – provides methodologies for estimating national inventories of anthropogenic emissions by sources and removals by sinks of greenhouse gases. The scope and detail of this document is not targeted to local government however it provides overarching guidance generic to all such inventory reporting.

## 2.2 Related British Columbia GHG Inventory Efforts

### 2.2.1 Provincial GHG Inventory Reporting

Provincial GHG inventory reporting is intended to provide sound, science-based, comparable and consistent reporting of GHG sources and sinks in British Columbia – in support of the *Greenhouse Gas Reductions Target Act*[13] (GGRTA), as well as national and international reporting processes and related initiatives. 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.

[7] See: www.iclei.org/fileadmin/user_upload/documents/Global/Progams/GHG/LGGHGEmissionsProtocol_01.pdf
[8] www.theclimateregistry.org
[9] www.scc.ca/en/web/scc-ccn
[10] www.tc207.org
[11] ISO (2006), International Standard ISO/TC 207 WG5 N162. Greenhouse Gases - Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals. 28pp.
[12] www.ipcc.ch
[13] See: www.env.gov.bc.ca/epd/codes/ggrta/index.htm

A GHG sources and sinks inventory is a comprehensive account of emission releases from anthropogenic sources (e.g., fuel combustion, industrial processes) and removals[14] by sinks (e.g., growing plants and trees) for a defined area (e.g., nation or province) over a specified period of time.

The first B.C. emissions report – *British Columbia Greenhouse Gas Inventory Report 2007* – provides total B.C. emissions estimates that represent the 2007 baseline against which progress towards emissions reduction targets will be measured. Following the 2007 report, the Ministry of Environment intends to prepare a B.C. GHG inventory report for every even subsequent year (i.e., 2008, 2010, 2012 and beyond) of data. The report, a summary document and additional information are available at: http://www.env.gov.bc.ca/cas/mitigation/ghg_inventory/index.html.

Distinct from provincial GHG emissions reporting, the methods used to establish CEEI Reports are based on community-level needs and available consumption and/or activity data. National and provincial reporting follows data aggregation and methodologies determined by international, national and provincial agreements and obligations. Hence, direct comparisons or cross-utilization of emissions data between CEEI community-level and provincial reports are inappropriate.

### 2.2.2 B.C. Government (Public Sector) Carbon Neutral Inventories

As part of the provincial government's commitment to achieve carbon neutrality under the *Greenhouse Gas Reduction Targets Act*, provincial public sector organizations (provincial ministries, agencies, crown corporations, health authorities, boards of education and post supporting institutions) must measure, reduce, report and offset the carbon emissions from their operations. This inventory includes buildings and fleet vehicles owned or leased by public sector organizations, their paper use and in the case of provincial ministries, their business travel as well. Shared Services B.C. has developed an online emissions measurement and reporting tool known as – "SMARTTool" – introduced in 2008 to standardize measurement and reporting of emissions across the Province's public sector organizations. The requirement to be "carbon neutral" begins January 1, 2010.

### 2.2.3 Local Government (Corporate) Carbon Neutral Inventories

To date over 178 local governments have signed the B.C. Climate Action Charter. One of the three commitments under the Charter is for local governments to become carbon neutral in respect of their corporate operations by 2012. Corporate operations encompass activities that are under control of or directly managed by municipalities (such as energy use from buildings, travel and corporate fleets) utilizing data collected and reported by municipalities. Protocols or traditional boundaries for these inventories have been developed by the Green Communities Committee, a joint committee involving provincial agencies and UBCM members and representatives. The protocols strive to utilize existing inventories and resources to reduce data entry requirements and streamline the "Carbon Neutral Local Government" reporting process. Currently local governments are piloting the use of "SMARTTool" to determine its effectiveness as a tool to inventory local government corporate GHG emissions.

A "Draft Guidance: Carbon Neutral Local Government Workbook" has been developed to support municipalities in this effort – available through the B.C. Climate Action Toolkit website.[15]

[14] 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. CEEI REPORTING – PURPOSE, PRINCIPLES AND USE

This section documents the intent and framework that underlies the CEEI initiative, as well as some of the uses that CEEI Reports can support.

## 3.1 CEEI Purpose and Objectives

The purpose of Community Energy and Emissions Inventory (CEEI) Reports is to provide local governments and other users with accurate, consistent and relevant community-level energy and greenhouse gas (GHG) emissions information.

CEEI Reports strive to meet agreed-to standards, be reproducible across communities and time, and be available to B.C. local and provincial governments and other agencies in a user-friendly, transparent format.

## 3.2 CEEI Guiding Principles

The CEEI initiative is guided by the following principles, consistent with international and North American GHG inventory protocols:

**Relevance** – CEEIs serve as the primary inventory information resource of energy consumption and greenhouse gas emissions for B.C. local governments. The more CEEIs accurately reflect energy consumption and greenhouse gas emissions at the local government community scale, and the more a representative suite of relevant supporting indicators are developed, the more CEEI Reports will serve the decision making needs of its primary users – Councils, staff and community participants. The information is intended to support policy development and planning addressing energy consumption/conservation and GHG reduction initiatives. CEEI Reports are user-friendly and available in an easily readable and understandable format, enabling presentations to Councils and community participants.

**Completeness** – CEEI generates standardized reports – accounting for key energy and greenhouse gas emission sources and activities within regional district and municipal boundaries. The structure and contents of CEEI Reports are guided by international and inter-jurisdictional protocols and standards for reporting sectors, sub-sectors and "memo items" – with supporting sources and any specific "exclusions" noted.

**Consistency** – Methods and approaches used for CEEI reporting are documented and consistently applied to enable meaningful analysis of energy and emissions between communities and over time. As data collection and analysis methods improve or are revised, inventory information will be revised and documented. As inventories evolve (e.g., to include additional sectors and/or sources), "base year" inventory reports will be updated to support effective use of CEEI Reports.

**Accuracy** – CEEI methods support quantification of energy use and GHG emissions that are systematically neither over nor under actual use and emissions, with reporting uncertainties reduced

[15] See: www.toolkit.bc.ca/resource/draft-guidance-carbon-neutral-local-government

as far as practicable. CEEI Reports are sufficiently accurate to provide report users with reasonable assurance as to the integrity of the reported information.

**Transparency and Confidentiality** – Methods and assumptions, including references to accounting calculation methodologies and data sources used in CEEI Reports, are documented and accessible to interested users. The CEEI initiative respects the confidentiality needs of data providers and their clients. Data that could be used to reveal unwarranted business or personal information will be aggregated to larger areas or groupings for documentation and reporting purposes. The CEEI initiative will respect competitive business rights and confidentiality obligations, while striving for transparency to the fullest extent possible. Information related to CEEI Reports is subject to the *Freedom of Information and Protection of Privacy* (FOIPP) *Act*.

**Continuous Improvement** – The CEEI Working Group recognizes that community needs, inventory data sources and reporting methodologies evolve and improve over time. The Working Group will strive to continue to improve the accuracy of data collection and analysis methods, contingent on available resources and reporting needs, on an ongoing basis. CEEI Reports and supporting materials provide information on data gaps and assumptions, and planned improvements. Where modifications or additions are incorporated in CEEI Reports, supporting materials will be updated and appropriate recalculations undertaken to maintain consistency in reported emissions and emission trends.

## 3.3 Use of CEEI Reports

Local governments committed to reducing greenhouse gases and acting on climate change can utilize CEEI Reports to fulfill a number of specific commitments or responsibilities, including:

- meeting one of the three voluntary commitments made by communities that are signatory to the Climate Action Charter[16] – to measure and report on community-level emissions;
- meeting "Milestone One" of the Federation of Canadian Municipalities Partners for Climate Protection (FCM-PCP) program[17] – an approved community energy and emissions framework;
- supporting local governments in their obligations under the *Local Government (Green Communities) Statutes Amendment Act* (2008) to develop GHG targets, energy policies and actions in Regional Growth Strategies, Official Community Plans or other local government-led plans or policies; and
- providing the provincial government, and other agreed-to users, with information on local government contributions towards reducing energy consumption and greenhouse gas emissions – including the Province's target of reducing GHG emissions by 33% from 2007 levels by 2020 and interim reductions targets.

[16] See: www.cd.gov.bc.ca/ministry/docs/climate_action_charter.pdf. The *Climate Action Charter* acknowledges the shared goals of the Province of British Columbia, Union of B.C. Municipalities and signatory local governments, and the collaborative effort required between all parties to reduce GHG emissions. As of January 2010, 177 B.C. local governments and the Islands Trust are Charter signatories: http://www.cd.gov.bc.ca/ministry/whatsnew/climate_action_charter.htm.
[17] The program includes over 60 B.C. participating communities, and over 200 across Canada. For additional information, see the FCM website: www.sustainablecommunities.fcm.ca/Partners-for-Climate-Protection.

Benefits and uses of CEEI Reports include:

- **A Recognized Inventory** – The common format, and supporting documentation of inventory and data analysis, of CEEI Reports provides individual local governments with an accepted and broadly understood reporting methodology[18] without resort to contract or staff resources – individual communities are also able to enhance or supplement CEEI Reports if and as desired to meet additional needs.
- **Forecasting** – Initial CEEI Reports provide a "snapshot" (or "base year") of energy and emissions information, and over time will provide trend data that can be used to assess assumptions and accuracy of forecasts and actions intended to influence emissions – CEEI community-level data can be used to develop and assess the utility of alternative forecasts or scenarios (e.g., using building and transportation data and emissions factors and population growth assumptions to roughly forecast energy and emissions levels into the future).[19]
- **Target-setting** – The provincial government has set targets of a 33% reduction in province-wide GHG emissions by 2020 and 80% by 2050 (from a 2007 base year) and prepares a provincial inventory report (beginning with 2007 emissions) to support documentation and assessment of progress towards those targets. CEEI Reports can be used in a parallel manner to support municipal governments in setting targets and assessing initiatives aimed to achieving targets.[20] Provincial legislation now requires all local governments to include GHG reduction targets, policies and actions in their Official Community Plan (OCP) and Regional Growth Strategy (RGS) by 2010 and 2011, respectively.
- **Target Periods** – As well as longer term targets, the provincial government has set interim goals and target dates (2012 and 2016) for GHG emissions reduction. CEEI Reports will be produced biennially, providing communities with the flexibility to set target-periods in common with the Province or choose other dates aligned with community-specific needs or processes (such as OCP or RGS review).
- **Developing Action Plans** – The CEEI Reports can provide a broad structure (i.e., sector and activity categories) to support communities in determining which actions to pursue in reducing energy and GHG emissions. A prioritized listing and description of actions comprise the core of any community energy and emissions plan.[21]
- **Monitoring** – Annual CEEI Reports allow communities to monitor the progress they are making in reducing energy consumption and GHG emissions. The reports also enable comparisons among jurisdictions, although analysis and comparison should be undertaken with caution as community-level emissions can vary with regional and local conditions, including weather and economic factors. Data limitations may also constrain reporting of community-level emissions trends. The effectiveness of CEEI Reports in this regard will be reviewed and addressed as part of the Working Group's commitment to the CEEI principle of continuous improvement.

[18] See "Review of Energy and GHG Emissions Characterization Methods" document, undertaken in 2009 by the Canadian Standards Association on behalf of Natural Resources Canada.
[19] A growing number of B.C. communities and practitioners are using GHG modeling techniques to develop future scenarios of community-level energy consumption and greenhouse gas emissions.
[20] As per 20 above, the Climate Action Toolkit - http://www.toolkit.bc.ca – showcases a number of success stories (case studies) on how such modeling has supported communities to identify ghg targets, policies and actions.
[21] The Province commissioned the Community Energy Association to develop the Community Energy and Emissions Planning Guide for local governments. See the introductory CEEI page on the Climate Action Toolkit website for more information (http://www.toolkit.bc.ca/ceei).

# 4. CEEI REPORTING FOUNDATIONS

## 4.1 Greenhouse Gases and Emissions Sources Included in CEEI

Greenhouse gases include carbon dioxide ($CO_2$), nitrous oxide ($N_2O$), methane ($CH_4$), per-fluorocarbons (PFCs), sulphur hexafluoride ($SF_6$), and hydrofluorocarbons (HFCs). CEEIs include only carbon dioxide, methane, and nitrous oxides. Fluorinated organic GHG emissions (e.g., PFCs, $SF_6$, and HFCs) are relatively insignificant "community-level" emissions and are not included in CEEI Reports. At the community level, the burning of fossil fuels is the main source of carbon dioxide emissions, automobile exhaust is the main source of nitrous oxide emissions, and landfills are the main source of methane emissions.

CEEI Reports include three main sources of GHG emissions:

1. **Direct emissions** from the burning of fossil fuels;
2. **Indirect emissions** from the production of electricity from electricity generation plants; and
3. The decomposition of biomass to greenhouse gases (including methane and $CO_2$) in landfills (i.e., "**landfill gas**").

Direct emissions are the result of consumption of an energy type by an end user and introduction of the GHG directly into the atmosphere. Indirect emissions are the result of consumption of an energy type by an energy utility upstream of consumption by the end user. For example, the use of natural gas to fire a boiler and heat a building or of gasoline by a vehicle driver is a direct emission, whereas the use of electricity by an end user (e.g., to heat a building or to charge a battery) is an indirect emission.

CEEIs report the natural gas and electricity consumed by end users and the resulting calculation of direct and indirect GHG emissions. These are examples relevant to the buildings sector. The on-road transportation sector uses direct estimates of GHG emissions produced by vehicles licensed on the road. The community solid waste sector uses methods to estimate direct GHG emissions produced by the decomposition of organic matter in landfills (and to a lesser extent, the GHG emissions associated with the incineration of solid waste).

## 4.2 Units of Measure – Emissions, Coefficients and Global Warming Potential

The standard unit used to report greenhouse gas emissions is equivalent $CO_2$, or $CO_2e$, in units of mass. The unit of mass that is used depends upon the scale of the emissions. The CEEI reports GHG emissions in tonnes $CO_2e$.

An emission coefficient is a numerical value that quantifies the amount of GHGs released into the atmosphere from a specified source. Coefficients are expressed as the mass of pollutant emitted per source unit. All sources have one or more associated emissions coefficient(s). There is one emissions coefficient for electricity, whereas there are three emissions coefficients for natural gas – one for each of the constituent greenhouse gases ($CO_2$, $N_2O$, and $CH_4$). The total $CO_2e$ for a quantity of energy burned (from natural gas) equals the sum of the three constituent greenhouse gases.

Emissions coefficients for each sector included in CEEI Reports – buildings, on-road transportation, solid waste, land-use change and agriculture – are noted in their respective sector in subsequent sections of this document.

The concept of "global warming potential" (GWP) has been developed to enable comparison of the ability of different GHGs to trap heat in the atmosphere (radiative forcing).[22] 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 following summary table lists the "100-Year GWP" (as recommended by the International Panel on Climate Change) for the major gases and groups of gases:

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

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

## 4.3 Emissions Calculations and Data Sources for the CEEIs

CEEIs are derived from consumption and activity data. Detailed methods and data sources for each inventory sector are described in subsequent sections of this document, with a summary provided below.

The following generic steps are used to assign and calculate GHG emissions for CEEI Reports:

1. Consumption and activity data is received from data providers (and if not available from primary sources, data is gathered or derived from other available reliable sources).
2. Consumption and activity data is assigned to a local government (unless already provided in appropriate geographically-segregated format, census divisions and census subdivisions, by the data provider) based on information embedded in the data received or gathered from other sources.
3. Consumption and activity data is converted to standard units – using the emissions coefficient for each fuel source or direct emission included in CEEIs.
4. Consumption and activity data is multiplied by the appropriate emissions coefficients and global warming potentials.

[22] The term "radiative forcing" refers to the amount of heat-trapping potential for a GHG, measured in units of power per unit of area (e.g., watts per metre squared) that would result from the emission of one kilogram of a GHG to that from the emission of one kilogram of carbon dioxide over a fixed period of time.

For buildings, energy and GHG emissions figures from electricity and natural gas use are based on energy consumption data ("actual") provided by BC Hydro, FortisBC, Terasen Gas and Pacific Northern Gas. Community-level consumption and emissions for heating oil, propane and wood is derived by first estimating the total energy required for heating and other uses, and then subtracting the electricity and gas consumption from this total. The remainder can then be attributed to heating oil, propane or wood – using a ratio for each based on other available data.[23]

GHG emission estimates for on-road transportation are based on activity data (e.g., the number and type of vehicles licensed for on-road use) provided by the Insurance Corporation of British Columbia, fuel consumption rates published by Natural Resources Canada and estimates of vehicle kilometres travelled (derived by sampling ICBC vehicle transfer forms).

GHG emissions estimates for community solid waste (landfills) are based on estimates of landfill gas production calculated from the mass of solid waste tipped at landfills and attributed to contributing municipalities and unincorporated areas. For 2007 CEEI Reports, this data was obtained from either regional district staff or other resource materials.

## 4.4 Format of CEEI Reports - Sectors and Supporting Indicators

Each local government's 2007 Updated CEEI Report (Expanded Edition) is typically seven to eight pages in length. These CEEI Reports provide high-level energy and GHG emissions estimates in three primary sectors – buildings, on-road transportation and solid waste – with additional information ("memo items") at the municipal level (large industrial facilities) and at the regional district level (large industrial facilities, land-use change from deforestation and enteric fermentation from agricultural livestock. Finally, the 2007 Updated CEEI Reports include a listing of five "supporting indicators". The sectors in each report and the data included in each sector are as follows:

- The buildings sector is subcategorized into residential and commercial/small-medium industrial. Large industrial facilities have been separated out from the core CEEI Reports, but still listed as a Memo Item for local government information. Most subcategories includes the number of connections, the amount of actual (not normalized[24]) energy consumed (e.g., electricity (kWh) and natural gas (GJ)), and the resulting $CO_2e$ totals for each building subcategory as well as a $CO_2e$ subtotal for the sector. Rough estimates for residential heating oil, propane and wood use have also been included where considered significant;
- The on-road transportation sector is subcategorized into several passenger and commercial vehicle classes. Each subcategory includes an estimate of the amount of fuel used (e.g., gasoline, diesel fuel, and mobile propane), and the resulting $CO_2e$ totals for each vehicle class as well as a $CO_2e$ subtotal for the sector;

[23] Refer to the report "Residential Heating Oil, Propane, and Wood Heat Estimates for BC Communities", December 2009 by Enerficiency Consulting for the CEEI Working Group; one of the CEEI Background Reports at http://www.env.gov.bc.ca/cas/mitigation/ceei/resources.html.

[24] Normalization refers to a process that removes the effect of outside influences (e.g., weather, fuel prices, economic conditions) on the use of energy in buildings year-over-year. For example, energy consumption is normalized for weather by removing the effects of abnormal winters or summers. Actual energy consumption is required under prevailing community inventory protocols, so normalization is not used.

- The solid waste sector states the estimated mass of waste disposed by each local government based on data available from community and/or regional landfill(s), with the associated $CO_2e$ (methane) net of any known landfill gas flaring, capturing, etc.;
- The total amount of energy and $CO_2e$ for each energy type and direct emission source, and the total combined energy and $CO_2e$ is presented in the Grand Total;
- Three sectors are represented solely as Memo Items in each Regional District report: Buildings - large industrial facilities, Land-use change - deforestation, and Agriculture - enteric fermentation from livestock. The land-use change (deforestation) sector includes the estimated amount of $CO_2e$ from the clearing of forests for urban development and agriculture. The agricultural sector includes the estimated amount of $CO_2e$ from enteric fermentation from livestock. Except for large industrial facilities, this data is only provided at the regional district level and as information only (e.g., the data does not form part of the total emissions profile reported); and finally
- Five supporting indicators are provided within each local government's CEEI Report to begin to monitor the extent to which local government policy tools and associated efforts are having an impact within each CEEI sector.

For future reports, the CEEI Working Group will be considering the inclusion of additional components to GHG inventories as may be advised by emerging international protocols, the information needs of local governments, and the availability of data. Additional supporting indicators will also be included in future CEEI Reports.

## 4.5 Local Government Boundaries Used for CEEI Reports

The boundary of a local government jurisdiction is a defined geographic unit. In accordance with protocols, CEEIs for local governments can only include energy and emissions data from sources that can be ascribed to specific geographic units. British Columbia "local government" units include 28 Regional Districts, one Region (Stikine) and 161 Municipalities. Municipalities can be incorporated under the following names: City, District, Town, Village, Indian Government District or Island Municipality.

Regional Districts are also described as "census divisions."[25] "Census subdivisions"[26] include municipalities and unincorporated areas within Regional Districts. "Indian Reserves", defined under the *Federal Indian Act*, and "Indian Settlements" located on Crown Land, are also identified as census subdivisions.

As CEEI reporting was initiated to support B.C. local governments, only the municipal component of census subdivisions has been addressed to-date, though a summary of unincorporated areas for each Regional District is now also provided.

[25] Definition of census division (CD) is: general term for provincially legislated areas (such as county, municipalité régionale de comté and regional district) or their equivalents. Census divisions are intermediate geographic areas between the province level and the municipality (census subdivision).

[26] Definition of census subdivision (CSD) is the general term for municipalities (as determined by provincial/territorial legislation) or areas treated as municipal equivalents for statistical purposes (e.g., Indian reserves, Indian settlements and unorganized territories).

**Table 2: Type and Count of Census Subdivisions (2007)**

| Census Subdivision | Count |
|---|---|
| *Incorporated* | |
| *City* | 48 |
| *District Municipality* | 53 |
| *Indian Government District* | 1 |
| *Island Municipality* | 1 |
| *Town* | 15 |
| *Village* | 42 |
| *Unincorporated* | |
| Indian Reserve | 507 |
| Electoral Area | 163 |
| Native Land | 5 |
| Native Village | 5 |
| Indian | 3 |

The 2007 Updated CEEI Reports are available for B.C. Regional Districts, Municipalities and Unincorporated Area "summaries" (one for each Regional District).

# 5. ON-ROAD TRANSPORTATION SECTOR

## 5.1 Protocol and Guiding Principles

Protocols for community greenhouse gas emissions suggest that local government inventories include all the emissions from fuel that is burned within the local government's geopolitical boundary. The logic behind the protocol is sensible, as ownership and responsibility for GHG emissions must be assigned to specific local governments in CEEI reports. However, there are practical difficulties in applying the protocol due to the nature of on-road transportation and in accounting for GHG emissions as vehicles cross geopolitical boundaries.

### 5.1.1 Methodology Selected

The Province commissioned a background report, *Assessing Vehicular GHG Emissions: A Comparison of Theoretical Measures and Technical Approaches*,[27] to review and assess these alternative approaches for application in CEEI reports. The report considered three approaches (or methodologies):

- **Fuel sales** – this is the simplest (but not necessarily most accurate) solution for calculating community on-road GHG emissions – relying on records of total automotive fuel purchased within specified geopolitical boundaries. However, a province-wide dataset by geopolitical boundary is not available, and furthermore even with such data, difficulties remain in assigning fuel purchased (and the corresponding consumption by a vehicle) to a specific local jurisdiction.
- **Resident-based** – utilizing the number and type of vehicles registered in a geopolitical boundary, the fuel consumption rate of individual vehicles and an estimate of the annual vehicle kilometres traveled (VKT) by various vehicle classes – to calculate GHG emissions by geopolitical area.
- **Modeling** – involves estimating GHG emissions from within a geopolitical boundary using traffic counts and software (such as EMME/2[28] or TransCAD[29]) – the report found this method to be cost prohibitive for application at a province-wide scale.

The report recommended the *resident-based* methodology, using vehicle registration data, as the most practical, accurate and cost effective province-wide approach for CEEI reporting needs. This method was selected for preparation of the 2007 CEEI Reports.

The resident-based approach provides a much finer level of detail to local governments than other methods – including the type of vehicles present in their community and the average, weighted fuel consumption rates of vehicle classes. This information supports derivation of a number of performance measures at the local government scale. For example, data showing the number of units in an area by vehicle class allows for an evaluation of the makeup of vehicles that are typically driven in a community (e.g., small cars, large cars, light trucks, vans, and SUVs) and enables trend comparisons of absolute numbers and ratios by vehicle class over time. The average weighted fuel consumption rate of vehicle classes can also be calculated for a specific year or over time (see

[27] See: www.env.gov.bc.ca/epd/climate/pdfs/ceei-comparison-study.pdf
[28] See: www.inro.ca/en/products/emme/index.php
[29] See: www.caliper.com/tcovu.htm

planned improvements). In comparison, the *fuel sales* approach provides data only for the total amount of fuel consumed in any specific year.

Table 3 presents an assessment of the on-road transportation sector calculations (using the *resident-based* methodology) against CEEI guiding principles.

**Table 3: Alignment of On-road Transportation Sector Information with Guiding Principles – Assessment of 2007 Methods and Data**

| Guiding Principles* | Alignment with Principles | Notes |
|---|---|---|
| Relevance | High | The GHG sources are appropriate for the intended user, although it could be argued that GHG emissions are not accurately assigned to geopolitical boundaries because the VKT used in the fuel calculation is not confined to a geopolitical boundary. |
| Completeness | High | All relevant information is included. |
| Consistency | High | Meaningful temporal comparisons will be possible. |
| Accuracy | Moderate | Passenger vehicle VKT estimates are statistically sound, with bias and uncertainties reduced as far as is practical. Validation of results is not yet possible at the level of census subdivision (e.g., municipality). Commercial vehicle fuel consumption and location of operations are best estimates. |
| Transparency and Confidentiality | Moderate to High | Sufficient and appropriate GHG-related information is disclosed with the exception of ICBC registration data that could compromise the privacy rights of registrants. |
| Continuous Improvement | Moderate | Improved VKT methods are being pursued for 2010. |

* ISO 14064-2:2006, Greenhouse Gases – Part 2: Specifications with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements

## 5.2 Components Included and Excluded

Vehicles included in CEEI reports are grouped into vehicle classes in the on-the-road transportation sector using a number of criteria (see Methodology). CEEI reports for 2007 report vehicles that are licensed for use on public roads. Vehicles that are not licensed to operate on public roads are not included in CEEI reports. Examples of vehicles that are not included are golf carts, snowmobiles, farm vehicles, road construction vehicles, and other industrial machinery.

CEEI reports do not include marine transportation such as ferries, recreational boats, and commercial ships. Transportation of people and freight on rail lines running through local government boundaries is also not included. Air transportation from airports is not included (note: the energy in buildings associated with airports is included in the buildings sector). One or more of these modes of transportation may be added in the future depending upon local government information needs and future community greenhouse gas emissions protocols, if any (see Planned Improvements).

## 5.3 Methodology

The 2007 CEEI Transportation Data is calculated in order to best represent the GHG emissions associated with fuel consumed by vehicles. The methodology used to calculate the GHG emissions from fuel consumption data is consistent with the Greenhouse Gas Protocol[30] developed by the World Resources Institute and World Business Council for Sustainable Development.

### 5.3.1 Fuel Consumption

Individual vehicle registration data, fuel consumption rates, and vehicle kilometers traveled are used to calculate fuel consumption using the following formula:

***vehicle X fuel consumption rate X vehicle kilometers traveled = fuel consumed*** **Equation 5-1**

Fuel consumption data is grouped into vehicle classes (see *4. Group the Vehicles into Classes*) and placed into geopolitical boundaries (see *6. Place Vehicles into Geopolitical Boundaries*).

To calculate fuel consumed, six steps are undertaken as follows:

1. **Combine and summarize the Vehicle Registration Data;**
2. **Identify vehicle characteristics using VIN and ICBC identification fields;**
3. **Match the characteristics to the NRCan's Fuel Consumption Rate;**
4. **Group the vehicles into Classes;**
5. **Determine part-time/full-time values for each vehicle;**
6. **Assign full-time equivalent quarterly VKT to the Vehicle Classes and model age; and**
7. **Place vehicles into Geopolitical Boundaries.**

#### Step 1. Combine and summarize the Vehicle Registration Data

Vehicle registration data is received in quarterly sets from the Insurance Corporation of British Columbia (ICBC) and must be combined and summarized into an annual dataset. Each record in the dataset represents a unique vehicle; although, changes to a vehicle's insurance policy will create another occurrence of the vehicle in the dataset. For example, if a vehicle changes ownership once during the year, two records for the same vehicle will appear in the dataset. If a vehicle changes location during a quarter, that vehicle is assigned to the location where it was insured for the greatest portion of the quarter.

Each record contains the percent time insured for the specific characteristics of the current insurance policy. When a change occurs to the insurance policy, the percent time insured for the old and new policy information is reflected in the dataset. If the insurance policy of a vehicle is cancelled, and no other insurance policies are taken out on the vehicle, the vehicle no longer appears in subsequent quarterly datasets. If a storage policy is taken out on a vehicle, the vehicle appears as a

[30] World Resources Institute and the World Business Council for Sustainable Development, The Greenhouse Gas Protocol; A Corporate Accounting and Reporting Standard. Revised Edition. www.ghgprotocol.org/DocRoot/7e9ttsv1gVKekh7BFhqo/ghg-protocol-revised.pdf

record in the dataset, although the vehicle does not form part of the fuel consumption estimates for the percent of the year for which the storage policy was in effect.

With this information, CEEI inventories reflect the total number of vehicles licensed on the road in the 2007 calendar year, but more importantly, the inventories accurately reflect the amount of time vehicles spend licensed for use on the road according to changes to insurance policies, if any.

### Step 2. Identify vehicle characteristics using VIN and ICBC identification fields

The reports classify vehicles in two broad categories: personal and commercial. Personal vehicles include small cars, large cars, trucks, vans and SUVs, and are classified based on body style and weight consistent with the NRCan Fuel Consumption Guide. Commercial vehicles are those heavier than 4536 kg (10000 lbs), and the classifications are based on MOBILE 6.2C. These vehicles are separated in the reports into medium duty vehicles (Class 3-7), and heavy duty vehicles (Class 8a and 8b). This is intended to separate commercial vehicles into those that tend to travel within the boundaries of a region, and those that tend to travel between regions.

The ICBC provided records of all vehicles licensed for use on public roads in British Columbia for 2007. Each record represents a unique vehicle, identified by a Vehicle Identification Number (VIN) and other information associated with the location of the registered owner of the vehicle and the region in the province that the vehicle is insured to operate.

The VIN is a 17 digit alphanumeric code assigned by the manufacturer. VINs were first described by the International Standards Organization (ISO) 3779.[31] Automobile manufacturers are required by law to affix a VIN to all vehicles manufactured for use on the road.

The coding within a VIN provides critical information that is used to assign fuel consumption rates to individual vehicles and group vehicles into the vehicle classes reported in CEEI inventories.

ICBC does not decode the VIN of an insured vehicle and therefore, many of the vehicles are not adequately identified to allow a match to a fuel consumption rate. For example, ~355 000 vehicles are described as Other Type 2 2WHDR and Other Type 2 4WHDR in the 2007 ICBC dataset. Although an average fuel consumption rate could be applied to these vehicles, by decoding their VINs, the vehicles have been matched with the fuel consumption rate reported by NRCan (see below).

The VIN decoder tables link characteristics to each of the first 10 characters of the VIN. The first digit, for example, identifies the location (country) of manufacture, the next three digits (usually) identify the make, model and sub-model; other digits identify the transmission, the fuel type, the engine size, etc. The VIN decoder only contains characteristics for passenger vehicles, which means that all vehicles past mobile 6.2 Class HDV3 are not included.

[31] www.iso.org/iso/catalogue_detail?csnumber=9305

### Step 3. Match the VIN to the NRCan Fuel Consumption Rate

Vehicle characteristics are critical in order to match an individual vehicle to its fuel consumption rate. Since there is no relationship between a vehicle and its VIN in the ICBC dataset and any of the fuel consumption tables utilized, each vehicle must be matched to its corresponding fuel consumption rate.

Individual vehicles in the ICBC dataset have their VIN decoded and then are matched to vehicles in the fuel consumption tables. In some instances, a vehicle's characteristics cannot be matched to a model in the fuel consumption tables because the model as specified does not exist in the tables. In these instances, the vehicle is manually matched to the closest model using engine and transmission criteria. For those VINs that were unable to be decoded (i.e., ~42 000 unique vehicles of a total of 3.0 million records in the 2007 ICBC dataset), fuel efficiencies are assigned based on model, body style, and GVW/NVW.

Fuel efficiency ratings for passenger vehicles from 1977 to 2008 are from NRCan. Additional fuel efficiencies for vehicle models prior to 1977 are estimated based on engine size, transmission, and other mechanical properties of the vehicle. Fuel efficiency ratings for commercial vehicles are adapted from a US Environmental Protection Agency table of miles-per-gallon estimates by MOBILE vehicle class.

### Step 4. Group the vehicles into Classes

The reports categorize vehicles into classes using various combinations of body style and Net Vehicle Weight (NVW). Vehicles are summarized into broad categorizations as follows: small passenger cars; large passenger cars; light duty trucks, vans, and SUVs; medium-duty commercial vehicles; heavy-duty commercial vehicles; buses; motor homes; and motorcycles and scooters. Each class is further broken down by fuel type.

Various criteria were used to group vehicles into classes (Table 4). Small and large passenger cars are easily grouped using net vehicle weight. Light trucks and vans are easily grouped using body style designation and net vehicle weight. Sport utility vehicles were manually coded to SUV by make, model, and body style because no criteria exists in the ICBC data or from decoding the VIN, to identify a vehicle as a, "sport utility vehicle". Commercial vehicles are easily grouped using body style. Tractor-trailer trucks, motor homes, motorcycles and mopeds, and buses are all easily grouped using body style.

**Table 4: Examples of Vehicles Included in 2007 CEEIs**

| Vehicle Class | Example 1 | Criteria |
|---|---|---|
| Small Passenger Cars | Honda Civic | Defined by NRCan as a two seater, compact, or subcompact |
| Large Passenger Cars | Audi A6 | Defined by NRCan as a midsize, full size, or wagon |
| Light Trucks, Vans and SUVs | Ford F150 | Defined by NRCan as an SUV, pickup or van less than 4 536 kg (10 000 lbs) |
| Medium Duty Vehicles | Ford E350 | MOBILE 6 classes 3-7 |
| Tractor Trailer Trucks | Kenworth | Mobile 6 classes 8a & 8b |
| Motorhomes | Gulfstream | ICBC Body Style |
| Motorcycles and Mopeds | Honda VFR | ICBC Body Style |
| Bus | Ford E350 Club | ICBC Body Style |
| * NVW = Net Vehicle Weight | | |

### Step 5. Assign VKT to the Vehicle Classes

VKT data for passenger vehicles was derived from odometer readings from the South Coast British Columbia Transportation Authority's (aka Translink) Motor Vehicle Emissions Inspection and Maintenance Program (aka AirCare).[32] To better reflect the mix of trucks, vans, and SUVs across the province, odometer readings from Fraser Valley Regional District were used as the baseline from which the rest of the province was calculated. The exception is Metro Vancouver for which the VKT was calculated separately.

Odometer readings were first converted into kilometres driven between testing periods for each vehicle and then used in an econometric analysis that related kilometres driven by different vehicle classes (e.g., small cars) to real fuel prices, real per capita incomes, age of vehicles, etc. This econometric approach results in different VKT estimates for each vehicle type and each vehicle model year.

As outlined in the VKT Study, econometric coefficients were applied to regionally-specific explanatory variables (i.e., the real price of fuel in each time period, the real median per capita income, the age of the driver, the sex of the driver, and the model age of each vehicle) and regional district level VKT were estimated. These estimates were then adjusted based on actual odometer readings from ICBC APV 9T Transfer-Tax forms, which are completed when a vehicle changes ownership. The average for each vehicle class for each regional district was calculated and the percentage difference between the actual average and the average based on the Fraser Valley coefficients for vehicle class and region were calculated.

VKT data for commercial vehicles was taken from the US EPA table of average annual mileage accumulation rates.

[32] www.env.gov.bc.ca/epd/climate/pdfs/ceei-vkt.pdf

### Step 6. Place vehicles into Geopolitical Boundaries

Each unique vehicle is allocated to census division and census subdivision based on the postal code of the registered owner. As indicated previously, a small number of records in the ICBC data do not contain a postal code (~0.05% in 2007) or the postal code of the registered owner is out of province (~0.3% in 2007). These vehicles are assigned to a CSD by either a previously registered postal code, or within the same ICBC rating territory proportional to population.

### 5.3.2 Greenhouse Gas Emissions

Greenhouse gas emissions are calculated from fuel consumption data using the following formula:

***energy consumption X emissions coefficient X global warming potential = $CO_2e$***

Table 5 provides the emissions factors for gasoline, diesel fuel, and propane which originate from Environment Canada's National Inventory Report.[33] Global Warming Potentials used are from the IPCC Second Assessment report.

**Table 5: Emission Coefficients – On-the-road Transportation**

| Fuel Type | Units | Emissions Coefficient | | |
|---|---|---|---|---|
| | | $CO_2$ | $CH_4$* | $N_2O$* |
| Gasoline | Kg/L | 2.289 | Variable | Variable |
| Diesel Fuel | Kg/L | 2.663 | Variable | Variable |
| Other Fuel (Propane & Natural Gas) | Kg/L | 1.532 | Variable | Variable |
| Global Warming Potential | | 1 | 21 | 310 |
| * assigned according to emissions technology of the vehicle | | | | |

## 5.4 Data Sources

**Vehicle Registration Data:** vehicle registration data was provided by the Insurance Corporation of British Columbia.

**Fuel Consumption Rates:** fuel consumption rates for passenger vehicles originate from Natural Resources Canada's fuel consumption tables. Fuel consumption data for commercial vehicles are default values for each age of each vehicle class from the MOBILE 6.2C model of the US EPA. US EPA adjustment factors that reflect the difference between test and real driving conditions, using a built-in algorithm, were incorporated for vehicles older than 2008 model year.

**Vehicle Kilometres Traveled (VKT):** VKT data was provided to the CEEI by Pacific Analytics' as described in their letter report of December 22, 2008 – CEEI VKT Study-Part of the CEEI Reporting Initiative.[34] The origin of the VKT data is also described in Pacific Analytic's letter report of December 22, 2008.[35]

[33] Environment Canada (2008). National Inventory Report, Table A9-11, p. 509.
[34] www.env.gov.bc.ca/epd/climate/pdfs/ceei-vkt.pdf
[35] ibid

**Postal Code File:** postal codes are contained in the Provincial Translation Master File, provided by BC Stats.

## 5.5 Data Accuracy

**Fuel Consumption Rates:** the US Environmental Protection Agency (EPA) changed the manner in which it estimates fuel efficiency beginning in 2008.[36] To compensate for real world driving conditions (e.g., faster speeds and acceleration, air conditioning, colder outside temperatures), the US EPA's fuel efficiency data was decreased between 10 and 20 percent, depending upon the type of vehicle.

For 2007 CEEI Reports, an adjustment algorithm was applied to each vehicle's fuel consumption rate, based on individual vehicle city and highway fuel efficiency rates.[37] This adjustment factor has not been applied to the fuel consumption rates for vehicles over 4 536 kg (10 000 lbs) NVW as the fuel consumption rates are not the reported values from a manufacturer's test.

Fuel consumption rates for large commercial diesel trucks is inaccurate, since fuel consumption rates are not assigned to these vehicles by their manufacturers, nor can they be estimated due to the highly variable loaded weight of large commercial trucks.

**Vehicle Kilometres Traveled:** the CEEI VKT Study #2[38] has refined the approach towards more accurate estimates of VKT across the province. In working closely with ICBC and Pacific Analytics, a driving behavior adjustment factor for each regional district in BC has been determined, with a small number of less populated districts being amalgamated due to an insufficient number of records available.

It should be noted that estimating VKT will involve some error because we are not using actual odometer readings, as outlined in the report *Assessing Vehicular GHG Emissions: A Comparison of Theoretical Measures and Technical Approaches.*[39] This is an identified data gap and efforts are underway between the Province and other agencies to obtain a more accurate measure of VKT that can be used for future CEEI reports. While a more reliable measure of VKT is desired for the future, we can be relatively confident about the VKT estimates in the 2007 CEEI reports. When the adjustment factors were applied to the VKT estimates in the CRD, the fuel sales were rationalized well, as well as in the outlying areas of the province. Previous CEEI reports used provincial estimates for vehicle classes from the National Transportation Study. The results of the VKT Study provide estimates for four vehicle classes within most census districts (regional districts) in BC.

The averages used for larger commercial trucks consuming diesel fuel are questionable and have been provided for use in CEEI reports by Pacific Analytics with a cautionary note.

[36] Note: the US EPA uses fuel efficiency reported in miles per gallon, whereas Environment Canada uses fuel consumption rates reported in litres per 100 kilometres driven.
[37] Emission factors used in "Reporting the British Columbia Government's Greenhouse Gas Emissions", October 2008.
[38] www.env.gov.bc.ca/epd/climate/pdfs/ceei-vkt.pdf
[39] See: www.env.gov.bc.ca/epd/climate/pdfs/ceei-comparison-study.pdf

**Placing Vehicles into Geopolitical Boundaries:** as vehicle registrations are assigned to communities by postal code using the Translation Master File, there are similar problems with overlapping postal codes as are found in the buildings sector.

Vehicles are assigned to a municipality or regional district according to the registered owner's postal code. Some of these vehicles may operate predominantly in other communities. This can be problematic, since vehicles in a commercial fleet may be registered at a single location, regardless of where in the Province they operate.

## 5.6 Planned Improvements

The inclusion of greenhouse gas emissions for marine, rail, air travel, and off-road vehicles may be added in the future.

The average weighted fuel consumption rate of vehicle classes should be calculated to allow for temporal comparisons within local government CEEI reports.

The Province will continue to explore other options to improve VKT data at the census subdivision level.

# 6. RESIDENTIAL COMMERCIAL AND INDUSTRIAL BUILDINGS SECTOR

## 6.1 Protocol and Guiding Principles

Protocols for community greenhouse gas emissions suggest that local government inventories include: (1) all direct emissions from fuels that are burned within the local government's geopolitical boundary; and (2) all indirect emissions from electricity that is produced by burning fuels inside or outside of the geopolitical boundary. This direction was followed in the methods and data used for the buildings sector indicator in 2007 CEEI Reports. Table 6 presents an assessment of the methods and data for the buildings sector used in 2007 CEEI Reports against guiding principles.

**Table 6: Alignment of Buildings Sector Information with Guiding Principles – Assessment of 2007 Methods and Data**

| Guiding Principles* | Alignment with Principles | Notes |
|---|---|---|
| Relevance | High | The GHG sources are appropriate for the intended user |
| Completeness | Moderate to High | All relevant information is included with the exception of energy consumption in some industrial and commercial facilities that exceed the data providers thresholds for confidentiality |
| Consistency | Moderate to High | Meaningful comparisons are possible for most buildings subsectors |
| Accuracy | Moderate | Bias and uncertainties are reduced as far as is practical although both boundary issues and the estimates for heating oil, delivered propane and wood use lessen the accuracy of some local government inventories |
| Transparency and Confidentiality | High | Sufficient and appropriate GHG-related information is disclosed with the exception of energy consumption in some industrial and commercial facilities that exceed the data providers thresholds for confidentiality |
| Continuous Improvement** | Moderate | Estimates of heating oil, propane and wood added to the Update reports. Disclosure for a number of large industries should substantially improve with the existing reporting regulation, and with potential individual agreements with large industry. |

* ISO 14064-2:2006, Greenhouse Gases – Part 2: Specifications with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements

** Continuous improvement is additional to ISO Principles. This principle will monitor the progressiveness of the CEEI initiative over time.

## 6.2 Components Included and Excluded

All electricity and natural gas consumed within a local government boundary is included in 2007 CEEI inventories where confidentiality rights permit. Estimates of heating oil, delivered propane and wood are also included in version 2 reports.

Greenhouse gas emissions from non-energy industrial processes are not included in 2007 CEEI inventories as this data in neither available through the utilities nor under as much influence from local governments. This includes GHG emissions caused by non-energy consuming processes such as chemical reactions during the production of industrial goods.

In addition to those regional districts and municipalities existing in 2007, several new local governments have been created in B.C. since that time; jurisdictions who may value 2007-based CEEI data. Table 7 lists new local government in British Columbia since January 1, 2007, and for which 2007 CEEI data has now been included.

**Table 7: Change in Local Governments in British Columbia in 2007**

| Local Government | Change | Local Government Type |
|---|---|---|
| Comox-Strathcona Regional District | Dissolved | Census Division |
| Comox Regional District | Created | Census Division |
| Strathcona Regional District | Created | Census Division |
| Barriere | Created | Census Subdivision |
| Clearwater | Created | Census Subdivision |
| West Kelowna | Created | Census Subdivision |

Data classed as "remote communities" is not included in CEEI Reports.

Electricity purchases by local governments from FortisBC are listed in the buildings sector of 2007 CEEI inventories as "Wholesale". This term is used by the electric utilities to indicate that the local government purchases bulk electricity for resale to its own customers. A list of these local government wholesale purchasers is provided in Table 8.

**Table 8: Local Governments Purchasing Electricity from FortisBC**

| Community Name | Utility | # of Customers | (GWh) |
|---|---|---|---|
| City of Grand Forks | FortisBC | 2 849 | 370 |
| City of Kelowna | FortisBC | 13 206 | 313 |
| City of Nelson (Total Urban and Rural) | FortisBC | 9 529 | 61 |
| City of Penticton | FortisBC | 16 250 | 333 |
| District of Summerland | FortisBC | 5 310 | 86 |
| TOTAL | | 47 144 | 831 |

One local government in B.C. – the City of New Westminster – also purchases wholesale electricity from BC Hydro.

Also excluded is electricity distributed by systems not owned or operated by BC Hydro, Fortis BC, or Nelson Hydro.

CCEI Reports for municipalities purchasing "wholesale" power – with the exception of Nelson and New Westminster – do not separate these wholesale amounts into residential, commercial and industrial subsectors.

### 6.2.1 Methodology

Greenhouse gas accounting and tracking used in CCEI reporting has been designed to calculate and manage the GHG emissions associated with energy consumption in buildings. The methodology for calculating GHG emissions is consistent with the Greenhouse Gas Protocol[40] developed by the World Resources Institute and World Business Council for Sustainable Development.

Electricity and natural gas consumption data is obtained from the energy utilities as described previously. The calculation for GHG emissions in buildings is:

$$energy\ consumption \times emissions\ factor/coefficient \times Global\ Warming\ Potential = CO_2e$$ **Equation 6-1**

Table 9 provides the emissions factors for natural gas and piped propane which originate from Environment Canada's National Inventory Report.[41] The three-year (2005-2006-2007 rolling emission factor for BC Hydro was drawn from BC Hydro reports.[42] The emission factors for FortisBC and Nelson Hydro electricity originate from the "Emission Factors for Use in Reporting Public Sector Greenhouse Gas Emissions".[43]

**Table 9: 2007 Source Emission Factors – Buildings Sector**

| Fuel Type | Units | Emissions Coefficient | | | Emission Factor |
|---|---|---|---|---|---|
| | | $CO_2$ | $CH_4$ | $N_20$ | $CO_2e$ |
| Electricity | Tonnes/GWh | | | | |
| BC Hydro | | | | | 24.666 |
| Fortis BC | | | | | 6 |
| Nelson Hydro | | | | | 3 |
| Natural Gas | Kg/GJ | 50.00 | 0.0010 | 0.0009 | |
| Propane | Kg/GJ | 59.66 | 0.0010 | 0.0043 | |
| Heating Oil | Kg/GJ | 70.23 | 0.0007 | 0.0008 | |
| Wood | Kg/GJ | 0 | 0.0028 | 0.0010 | |

Total energy, reported in GJ, for each of the residential, commercial and industrial subsectors is based on the consumption of electricity and natural gas for each connection.

### 6.2.2 Heating Oil, Propane, and Wood

Consumption data for electricity, natural gas and piped propane is obtained directly from utilities. However, no such data is easily available for heating oil, delivered propane or wood. Because these fuels are significant for some local governments in B.C., an effort has been made to estimate these emissions. As these results are best estimates only, they should be used with caution.

[40] World Resources Institute and the World Business Council for Sustainable Development, The Greenhouse Gas Protocol; A Corporate Accounting and Reporting Standard. Revised Edition. www.ghgprotocol.org/DocRoot/7e9ttsv1gVKekh7Bfhqo/ghg-protocol-revised.pdf

[41] Environment Canada (2008). National Inventory Report, Table A9-11, p. 509.

[42] See: www.bchydro.com/about/company_information/reports/gri_index/f2009_environmental_EN16_2.html

[43] Climate Action Secretariat, Ministry of Environment (2009), Emission Factors for Use in Reporting Public Sector Greenhouse Gas Emissions, version 2.0, Table 3, page 7.

The estimates are based on the number and type of dwellings within each jurisdiction and the average dwelling consumption by region from the BC Hydro Conservation Potential Review. Actual electricity and natural gas consumption was subtracted from the total, with the remainder assumed to be heating oil, propane, or wood. A more detailed explanation is provided in the report Residential Heating Oil, Propane, and Wood Consumption Estimates for B.C. Communities[44].

### 6.2.3 Buildings Subcategories

Although the term "buildings" is used to describe this sector, energy consumption reported in subsectors includes electricity and natural gas that may be used for purposes other than consumption in a building. For example, commercial electrical energy consumption data includes streetlights.

Energy consumption data in the buildings sector is organized into subsectors as:

1. residential;
2. commercial/small-medium industrial facilities; and
3. large industrial.

For each subsector, the energy consumed and the related greenhouse gas emissions are shown, along with the number of physical connections or accounts reported by the utility.

**"Residential buildings"** are defined as buildings occupied as people's residences, but not necessarily occupied as a full time residence. This subsector includes single family housing, row housing, multi-family housing and other housing types (such as mobile homes and cottages). Note however that most large multi-family buildings are charged for natural gas under a commercial rate and have been included in the commercial/small-medium industrial subsector.

**"Commercial and small to medium industrial buildings"** are reported as a single category as it is difficult to clearly delineate further subcategories within this grouping. This subsector includes offices, commercial retail outlets, government buildings (such as schools and hospitals), other institutions and small to medium industrial facilities. This category also includes any other customers that do not fall under the residential or large industrial subsectors. These include irrigation and streetlights.

**"Large industrial"** subsector for electricity was defined as industrial customers using more than 7 GWh per year. For natural gas the definition was based on the rate structure that the customer was charged under. Some very large commercial/institutional customers (such as universities) purchase gas at industrial rates and are included under this ("large industrial") subsector.

[44] To access this report, go to the CEEI Background Resources website @ http://www.env.gov.bc.ca/epd/climate/ceei/resources.htm.

## 6.3 Data Sources

There are four significant electricity and natural gas utilities in the Province: British Columbia Power and Hydro Authority (BC Hydro); FortisBC Inc. (FortisBC); Terasen Gas Inc. (Terasen); and Pacific Northern Gas (NE) Ltd. (PNG).
Table 10 presents the type of energy data provided by each energy utility. Where possible, each utility provided consumption data for their respective customers within local government boundaries in British Columbia.

**Table 10: Energy Types Provided by Supply/Distribution Companies**

| Supplier/Distributor | Energy Type |
|---|---|
| BC Hydro | Electricity |
| FortisBC | Electricity |
| Terasen | Natural Gas and Piped Propane |
| PNG | Natural Gas and Piped Propane |

## 6.4 Confidentiality Issues

Energy utilities are primarily responsible for the confidentiality of customer information. For this reason, utilities are withholding data when a single customer exceeds 50% of the local government's total consumption in the subsector to which it belongs.

Large industrial customers may dominate energy consumption within a municipality (e.g., census subdivision) or regional district (e.g., census division). Examples of these types of large industrial customers are cement plants, pulp and paper mills, saw mills, and mining operations. In most of these cases, energy utilities withhold all consumption data so that a large industrial operation's energy consumption cannot be reverse calculated. Therefore, industrial data for a number of 2007 CEEI inventories has been withheld.

This is one of the primary reasons that large industrial facilities are considered as a "memo item" in the Updated 2007 CEEI Reports. In instances where energy consumption data in the industrial sector has been withheld by the utilities, the number of connections appears as a line item within the industrial listing, but is annotated as "withheld" to indicate that data from one or more facilities cannot be provided.

If there are no industrial or commercial customers (for either electricity or natural gas) within a local government boundary, the respective line item (for industrial and commercial buildings) will still appear in the CEEI inventory, but with the number of connections noted as "0".

## 6.5 Data Accuracy

The most significant data accuracy issues in this sector are due to an inconsistent ability of energy utilities to assign consumption data by local government region. Energy utilities employ information management systems to track consumption for the purposes of customer billing however, these systems were not necessarily designed to aggregate data to local government boundaries. In some

areas of the province, these issues are particularly acute and relate to electrical consumption data provided by BC Hydro (see Planned Improvements – BC Hydro intends to resolve this issue in the near future).

Other data accuracy issues are associated with the inconsistent manner in which the utilities assign customers to building subcategories (e.g., residential, commercial, and industrial).

Table 11 provides a listing of the level of aggregation to local government boundaries provided by each energy utility. For example, BC Hydro has aggregated (i.e., combined) all electricity consumption data to the census division and census subdivision level, while Terasen Gas has aggregated data to census subdivision level only (i.e., natural gas consumption data for census divisions was aggregated by the CEEI working group).

**Table 11: Level of Aggregation Provided by Energy Utilities**

| Energy Utility | Energy Type | Census Division | Census Subdivision |
|---|---|---|---|
| BC Hydro | Electricity | Aggregated | Aggregated |
| FortisBC | Electricity | Not Aggregated | Not aggregated |
| Nelson Hydro | Electricity | - | Not aggregated |
| Terasen Gas Inc. | Natural Gas and Piped Propane | Not Aggregated | Aggregated |
| PNG | Natural Gas | Not Aggregated | Aggregated |

The estimated accuracy of data used in each of buildings subsectors is provided in Table 12.

**Table 12: Estimated Accuracy of Energy Consumption Data by Buildings Subsector**

| Supplier/ Distributor | Energy Type | Building Subsector | | |
|---|---|---|---|---|
| | | Residential | Commercial/Small-Med Industrial | Large Industrial |
| BC Hydro | Electricity | Very Accurate | Very Accurate | Very Accurate |
| FortisBC | Electricity | Very Accurate, except where there is also wholesale data. | Very Accurate, except where there is also wholesale data. | Very Accurate, except where there is also wholesale data. |
| Terasen Gas Inc. | Natural Gas and Piped Propane | Accurate, but some multi-unit customers may be included as commercial customers | Accurate, but some residential, multi-unit customers may be included and some large commercial customers may be included in large industrial. | Accurate, but some large commercial customers may be included |
| PNG | Natural Gas and Piped Propane | Very Accurate | Very Accurate | Very Accurate |

Each utility has assigned accounts to the three buildings subsectors using their own criteria, although the specific definitions used for categorization have not been made available to the CEEI working group.

Utilities have classifications for customer accounts, assigned in accordance with the business rules in place at the time each account was opened. These classifications are much more detailed than the broad CEEI subsectors (which align with the subsectors that have been historically used in community GHG emissions inventories). However, customer data cannot be readily manipulated and sorted to address CEEI needs (i.e., sorting by CEEI geographic unit and subcategory) given the large number of customers involved (e.g., BC Hydro – 1.75 million customers, FortisBC – 105 000 customers, Terasen – 915 000 customers and PNG – 39 000 customers).

In some instances, the energy consumption in buildings cannot be assigned to a specific subsector. For example, a mixed-use building with commercial and residential occupants cannot necessarily be assigned to either subsector. This can lead to differences in the number of accounts and consumption assigned to the subsectors by each energy utility. For these reasons, subsector breakdowns should be used with care. Also, by direct contact, local governments may be successful in securing data from large industry in their communities

## 6.6 Planned Improvements

The boundary issues associated with energy consumption data, and in particular electricity consumption data provided by BC Hydro, is a focus for planned improvements. CEEI is working with BC Hydro and other energy utilities on alternative methods of providing more accurate and comparable CEEI data in the near future. For example, GPS coordinates can provide a method of establishing the exact location of a meter, thereby eliminating the need to aggregate data to geopolitical boundary by postal code. This method however, requires consumption data attached to the spatial coordinates of the meter – to enable extraction and summary of consumption by geopolitical boundary.

Some of the methodology and data issues in this sector may be resolved with the completion of "AddressBC" – a project managed by the Integrated Cadastral Information Society (ICIS)[45] and intended as a central, point-based civic address registry for British Columbia to provide the precise location of a property, building or access point. Once in place, it is anticipated that users (such as energy utilities) will be able to retrieve address points and locations quickly and accurately.

Also, as the province's utilities look to revise their classification systems to align more closely with each other and with that of the British Columbia Assessment Authority, there may be an opportunity to provide further breakdowns of building subsectors (e.g., categorization of residential buildings into single family detached homes, townhomes, condominiums and apartments).

Diesel fuel consumption used for electricity production in remote communities should be available for those communities with central generators that provide electricity to many homes. Consumption data for diesel fuel, particularly in more remote communities, may be considered in preparation for undertaking 2010 CEEI Reports.

In the future, the provincial government may undertake agreements with large industrial customers to allow for the release of currently withheld consumption data for use in CEEI reports. Currently, the authority to release currently withheld data lies with the customer and not the energy utility and/or the Province of B.C.

[45] See: www.icisociety.ca/address-bc/news.htm

# 7. MUNICIPAL SOLID WASTE SECTOR

Municipal solid waste (MSW) is produced within municipalities and regional districts and disposed at regional landfills and waste incineration facilities. The decomposition of MSW over time in landfills results in the release of embedded carbon as $CH_4$ under anaerobic conditions (in absence of oxygen) and $CO_2$ under aerobic conditions (in presence of oxygen). Combustion of MSW in incineration facilities results in $CO_2$, $CH_4$ and $N_2O$ emissions.

## 7.1 Protocol and Guiding Principles in CEEI

### 7.1.1 Carbon Neutral Emissions

$CO_2$ emissions from biogenic MSW decomposition or incineration are considered "carbon-neutral"[46] and not included in GHG totals from municipalities and regional districts. $CH_4$ and $N_2O$ emissions are included in GHG totals.

### 7.1.2 Allocating GHG Emissions to Municipalities

GHG emissions from a disposal facility are attributable to the municipality or regional district that produced the MSW and not the municipality or regional district where the disposal facility is located.

**Table 13: Alignment of Solid Waste Sector Information with Guiding Principles – Assessment of 2007 Methods and Data**

| Guiding Principles* | Alignment with Principles | Notes |
|---|---|---|
| Relevance | High | The GHG sources, W-I-P methodology and attribution appropriate for the intended user. |
| Completeness | High | All relevant information is included, though extrapolations were made where historical records were incomplete. |
| Consistency | Moderate to High | Results are provided consistently for each regional district and municipality. Data is used from a combination of best sources per landfill and per attribution to census subdivisions. |
| Accuracy | Low to Moderate | Data is considered "highly uncertain" due to the mixed data sources and level of landfill management records sophistication, particularly in attributing regional landfill waste to member municipalities. |
| Transparency and Confidentiality | Moderate | Full disclosure of available data and methodological approach. Not all managed landfills reported directly in, however. |
| Continuous Improvement | Moderate to High | Significant improvements in accuracy anticipated as landfill gas capture systems are installed, and related reporting requirements followed under the Landfill Gas Management Regulation. |

* ISO 14064-2:2006, Greenhouse Gases – Part 2: Specifications with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements

[46] "Carbon neutral" refers to greenhouse gas emissions that result in no net increase in greenhouse gases in the atmosphere over the long term. The carbon portion of organic materials in MSW – biogenic MSW - is derived from $CO_2$ in the atmosphere, which is absorbed by plant tissue and converted to organic matter. When biogenic MSW decomposes or is incinerated, part of the carbon is released to the atmosphere as $CO_2$. Thus, the atmosphere sees no net increase in $CO_2$ emissions.

## 7.2 Inclusions and Exclusions

The 2007 CEEI Reports include estimates of the historic annual MSW tonnages disposed of at all regional district landfills and each community's estimated share of greenhouse gas emissions. Inventories include greenhouse gas emissions from:

- landfills;
- unmanaged landfills; and
- incineration facilities.

The Metro Vancouver Waste-to-Energy facility is the only MSW incineration facility identified and included in the CEEI.

CEEI Reports do not include GHG emissions from:

- MSW that is not deposited at a regionally operated landfill (for example, a forestry landfill);
- biogenic MSW sent to compost centres (as it decomposes aerobically and releases only $CO_2$); or
- demolition, land clearing and construction waste (to the extent these amounts were identified and have been separated out of landfill tonnage calculations).

## 7.3 Methodology

### 7.3.1 Methane Emissions at Landfills

Historically, two fundamentally different methodologies have been used to estimate GHG emissions from landfills: Waste-in-Place (WIP) and Waste Commitment (WC).

#### *Waste-In-Place*

WIP is a method to estimate the actual annual emissions from a landfill based on the decomposition of all MSW previously disposed at the landfill. This method requires information on historical MSW tonnages sent to a landfill and on the decay rate and methane generation potential of the MSW. Decay rate and methane generation potential varies with precipitation, waste composition and other factors. GHG emissions using the WIP method are calculated using the first-order decay equation presented in the US EPA's LandGEM model and shown in Equation 7-1:

$$E_Y = \sum_{i=1}^{N} \sum_{j=1}^{10} kL_0 \left(\frac{M_i}{10}\right) e^{-k\left(N-i+\frac{(j-1)}{10}\right)} \qquad \textbf{Equation 7-1}$$

where: $E_Y$ is the methane emission ($m^3$ $CH_4$) from the landfill in year Y, the year for which the calculations are made
$M_i$ is the mass of MSW disposed in year "i" (tonnes)
j is the time increment in $1/10^{th}$ years
N is the number of years that MSW disposal is accounted for
k is the decay rate (/year)
$L_0$ is the methane generation potential of MSW ($m^3$ $CH_4$/tonne MSW)

Based on this equation, MSW most recently disposed to the landfill generates the most methane. The further back in time MSW was disposed, the less methane is generated in the year for which calculations are made.

An example is shown in Figure 1 for methane emissions from a hypothetical wet landfill (high k value) and a hypothetical dry landfill (low k value) in 2010. The graph shows that MSW disposed in 2009 is responsible for about 9% of the methane generated in 2010 for the wet landfill and 2% of the methane generated for the dry landfill. MSW disposed in 1975 is responsible for about 0.5% of the methane generated in 2010 from the wet landfill and 1% of methane generated from the dry landfill.

MSW decomposes much more quickly in wet landfills than dry landfills, as shown in Figure 1. Accurate quantification of GHG emissions from dry landfills requires longer historical time horizons than from wet landfills. In Figure 1, for example, tracking MSW disposed in the wet landfill to 1975 captures 96% of the GHG emissions from the landfill in 2010. The remaining 4% of emissions are from MSW disposed prior to 1975. For the dry landfill, tracking MSW disposed to 1975 captures only 52% of the GHG emissions from the landfill in 2010, with the remaining 48% of emissions due to MSW disposed before 1975.

The 2006 IPCC Guidelines for National Greenhouse Gas Inventories[47] suggests using waste disposal data "for at least 50 years". However, accuracy gained by further historical accounting is offset by the uncertainty and/or lack of data regarding solid waste production and disposal this far into the past. For British Columbia, given historical data availability and uncertainty, a reasonable compromise between quantification and uncertainty suggests that 1977 be the earliest year to account for in emissions calculations. The start year for the WIP calculation of methane emissions for each B.C. landfill is set as 1977 or the year the landfill opened, whichever is more recent.

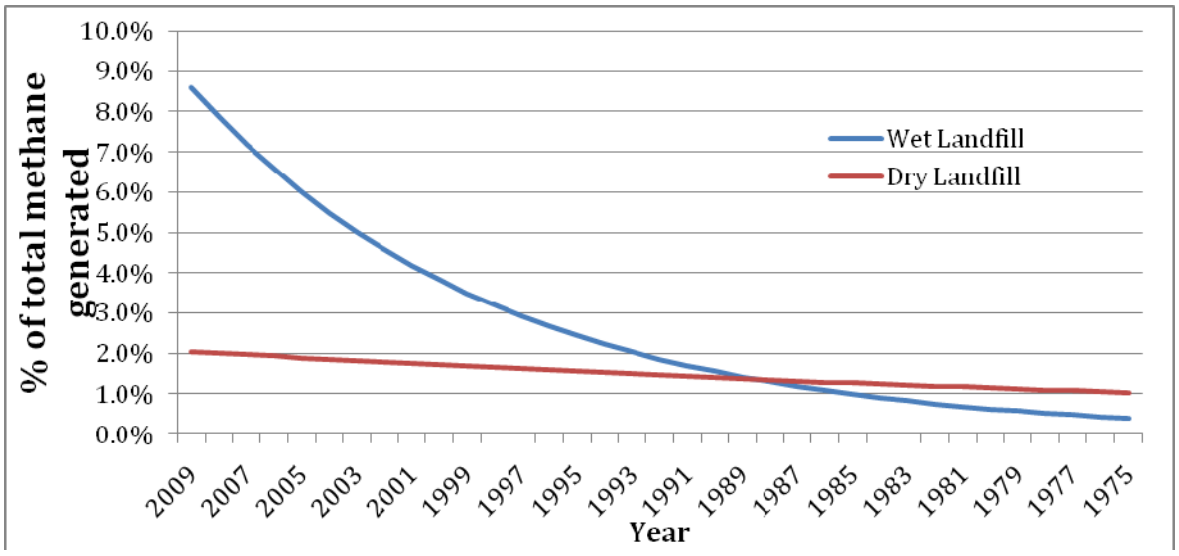


**Figure 1: Methane released in 2010 and contributions from historical MSW tonnages**

[47] Intergovernmental Panel on Climate Change (IPCC), 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Prepared by the National Greenhouse Gas Inventories Programme, H. S. Eggleston, L. Buendia, K. Miwa, T. Ngara, K. Tanabe, Eds. (Institute for Global Environmental Strategies, Hayama, Japan, 2006).

### *Waste Commitment*

Waste commitment (WC) is a method that has been used to estimate GHG emissions in the absence of historical waste data, based on a solid waste disposed in a given year. Therefore, this method requires only MSW tonnage data for a single year. GHG emissions are calculated by multiplying the mass of MSW disposed by a standard emission factor, according to Equation 7-2.

$$E = MSW \times EF$$ **Equation 7-2**

Where: E is the estimated emission (tonnes $CO_2e$)
MSW is the mass of solid waste disposed in a given year (tonnes)
EF is the standard GHG emission factor (tonnes $CO_2e$/tonne MSW)

The waste commitment method is poorly suited for estimating actual annual emissions at a landfill. First, it ignores the contribution to emissions of previously disposed waste. Second, it is equivalent to assuming that all deposited waste in a year decomposes instantaneously instead of over tens of years.

## 7.3.2 Choice of Emissions Quantification Methodology

GHG emissions from a landfill that are reported in the CEEI are estimated using the waste-in-place (WIP) method. This methodology was chosen for the following reasons:

- the WIP method is used to estimate emissions both in the Ministry's British Columbia Greenhouse Gas Inventory Report 2007 and the Landfill Gas Management Regulation; and
- it complements the other CEEI Report sectors, best estimating emissions over the reporting period (i.e., 2007).

The WIP method is recommended for estimating actual annual emissions.

A method different than WIP, however, is needed to demonstrate the avoided waste emissions in the future that would be attained from reductions in annual MSW disposal due to change in behavior in the present. For example, if in 2008 a Regional District reduced its MSW tonnage by 50% from 2007, there would be, misleadingly, only a small difference (~5%) between 2008 and 2009 GHG emissions estimates using WIP methodology.

Instead, the relevant calculation should cover the avoided waste emissions for the period of significant decomposition of MSW (had it made it to the landfill, that MSW would have emitted significant methane amounts for up to tens of years into the future).

In practice, the avoided-waste-emissions (AWE) would be calculated for a reference period between the time waste reduction happened and a year in the future – either a fixed reference period (say, 25 years into the future), a fixed reference year (say, from present to 2030), or a fixed amount of decomposition (say, 90%).

Using a fixed reference year, if in 2008 a Regional District reduced its MSW tonnage by 50% from 2007, total avoided waste emissions from 2009 to, say, 2030, from waste reduced in 2008, can be estimated as follows:

$$E^R = \sum_{i=1}^{N} \left[ \sum_{j=1}^{10} kL_0 \left( \frac{M^R_{2008}}{10} \right) e^{\left[ -k\left( N - t_i - \frac{(j-1)}{10} \right) \right]} \right]$$

**Equation 7-3**

where: $E^R$ is the total avoided waste emission for the reference period (here 2009-2030)
$M^R_{2008}$ is reduction in MSW disposal in a given year (here 2008)
N is the number of years in the reference period (here 22).

The avoided-waste-emissions (AWE) methodology, as illustrated in equation 7-3 above, provides an estimate of avoided emissions using the same type of physically-based, first order decay equation as the WIP methodology. Combining the two methods presents a dual picture: the present day effect of our past actions (WIP) and the future effect of our present day actions (AWE).

The AWE methodology is recommended for estimating the effect of waste reduction on waste emissions. GHG emission estimates using the AWE method will appear as a supporting indicator[48] for local governments in measuring progress towards emission reductions.

### *Estimated Values*

Despite the various data sources (see 7.4 below), significant data gaps remained both for MSW produced by regional districts and municipalities and MSW tonnages sent to landfills between 1977 and 2007. Two estimation methods were used where there was missing data for MSW tonnage sent to landfills for the years 1977 to 2006.

The first method – in cases where the total MSW disposed between 1977 and 2006 had been provided by the Regional District or the Golder Associate Report – utilized equation 7-4 to estimate historical MSW tonnages for specific years:

$$MSW_i = \frac{\left( MSW_{1977-2006} - \sum_j^N MSW_{known,j} \right)}{Y} \times \frac{TPC_i}{TPC_{average}} \times \frac{P_i}{P_{average}}$$

**Equation 7-4**

where: $MSW_i$ is the estimated MSW disposed at the landfill in year "i"
$MSW_{1977-2006}$ is the total reported MSW tonnage disposed at the landfill between 1977 and 2006
$MSW_{known,j}$ is the reported MSW tonnage disposed at the landfill in year "j"
*N* is the number of years with reported MSW tonnage disposed at the landfill
Y is the number of years with unknown MSW tonnage disposed at the landfill
$TPC_i$ is the MSW tonnage per capita for the Regional District in year "i"
$TPC_{average}$ is the average MSW tonnage per capita for the Regional District between 1977 and 2006
$P_i$ is the population of the Regional District in year "i"
$P_{average}$ is the average population of the Regional District between 1977 and 2006

Tonnage per capita (TPC) data for each Regional District are primarily from the RCBC Municipal Solid Waste Tracking Reports, which provide data for the years 1990 and 2001-2006. TPC data from

[48] Refer to Section 10 for more information on supporting indicators.

1977 to 1989 are assumed to be the same as 1990. TPC data between 1991 and 2000 are estimated by linear extrapolation between the reported 1990 and 2001 TPG values. 1977 to 2007 population data for regional districts are from B.C. Stats.[49]

The second method – in cases where the total MSW disposed between 1977 and 2006 is not known – utilized Equation 7-5 to estimate historical MSW tonnages for specific years.

$$MSW_t - TPC_t \times P_t$$ **Equation 7-5**

### *Determining $L_0$ and k values*

Methane generation potential ($L_0$) and methane decomposition rate (k) are key variables in calculating GHG emissions from landfills using the WIP method. These variables can vary significantly between landfills – dependent on multiple factors, including: precipitation; waste composition (especially organic content and moisture content); temperature; pH and buffer capacity; availability of nutrients; waste density and particle size; and landfill characteristics (e.g., depth of landfill, leachate runoff).[50]

Accurate $L_0$ and k values require detailed site-specific measurements at each landfill. Site specific data are not available for the large majority of landfills in B.C., therefore estimates of $L_0$ and k are used. The Ministry of Environment recently published the "Landfill Gas Generation Assessment Procedure Guidance Report" intended for use by landfill managers to estimate GHG emissions from their landfills as required under the Landfill Gas Management Regulation. The guidance document lists default values for $L_0$ and k (shown in Table 14 and Table 15 below). These stated values assume that when the carbon component of MSW decomposes, it is converted into 50% methane and 50% carbon dioxide.[51]

**Table 14: Methane Generation Potential based on Waste Characterization**

| Waste Characterization | Methane Generation Potential ($L_0$) ($m^3$ $CH_4$/tonne MSW) |
|---|---|
| Relatively Inert | 20 |
| Moderately Decomposable | 120 |
| Decomposable | 160 |

[49] See: www.bcstats.gov.bc.ca/DATA/pop/pop/estspop.asp#totpop
[50] See Section 8.2 of Environment Canada's National Inventory Report 1990-2007: Greenhouse Gas Sources and Sinks in Canada
[51] Carbon dioxide emissions are not included in GHG totals since they are considered carbon-neutral.

**Table 15: Methane Generation Rate based on Waste Characterization and Precipitation**

| Annual Precipitation | Methane Generation Rate | | |
|---|---|---|---|
| | Relatively Inert | Moderately Decomposable | Decomposable |
| < 250 mm | 0.01 | 0.01 | 0.03 |
| >250 to <500 mm | 0.01 | 0.02 | 0.05 |
| >500 to <1,000 mm | 0.02 | 0.04 | 0.09 |
| >1,000 to <2,000 mm | 0.02 | 0.06 | 0.11 |
| >2,000 TO <3,000 mm | 0.03 | 0.07 | 0.12 |
| >3,000 mm | 0.03 | 0.08 | 0.13 |

Appendix A of the guidance document categorizes different waste types as relatively inert, moderately decomposable and decomposable. MSW composition data and precipitation data for a given landfill can then be used to determine $L_0$ and k values.

A section on MSW composition was included in the CEEI survey sent to Regional Districts in August 2009. Average $L_0$ and k values for B.C landfills were determined on the basis of reported compositions. These averages are summarized in Table 16 and Table 17. The average annual precipitation data for the nearest weather station was used to determine k values for each landfill.[52]

**Table 16: Average Waste Composition for B.C. Landfills**

| Waste Characterization | B.C. Average |
|---|---|
| Relatively Inert | 28.0% |
| Moderately Decomposable | 44.7% |
| Decomposable | 27.4% |

**Table 17: Average $L_0$ and k values for B.C. Landfills**

| Variable | Average Value |
|---|---|
| $L_0$ ($m^3$ $CH_4$/tonne) | 100 |
| K (/year) | |
| < 250 mm | 0.019 |
| >250 to <500 mm | 0.031 |
| >500 to <1,000 mm | 0.057 |
| >1,000 to <2,000 mm | 0.071 |
| >2,000 TO <3,000 mm | 0.081 |
| >3,000 mm | 0.088 |

[52] Refer to Environment Canada's Climate Data Archive: http://climate.weatheroffice.ec.gc.ca/climateData/canada_e.html

### Proportioning GHG Emissions to Municipalities

Where MSW contributions by municipality in 2007 have not been reported by the regional district, they are estimated based on B.C. Stats population statistics, using Equation 7-6:

$$MSW_m = MSW_{RD} \times \frac{P_m}{P_{RD}}$$ **Equation 7-6**

Where:
$MSW_m$ is the MSW tonnage attributed to the municipality
$MSW_{RD}$ is the MSW tonnage produced by the Regional District
$P_m$ is the municipality population in 2007
$P_{RD}$ is the Regional District population in 2007

### Converting Methane Volume to $CO_2$-Equivalent Mass

GHG emissions calculated under the WIP method are in units of $m^3$ $CH_4$. To convert to $CO_2e$ units in mass, Equation 7-7 is used:

$$GHG_{CO2e,mass} = GHG_{CH4,volume} \times 0.6785 \frac{kg\ CH4}{m3\ CH4} \times 21 \times 0.001$$ **Equation 7-7**

where: $GHG_{CO2e,mass}$ is emissions reported as $CO_2e$ in units of mass (tonnes)
$GHG_{CH4,volume}$ is emissions reported as $CH_4$ in units of volume ($m^3$)
0.6781 is the density of methane at standard temperature of 15 deg.C and pressure of 1 atm ($kg/m^3$)
21 is the global warming potential of $CH_4$
0.001 is the conversion factor from kilograms to tones.

### Landfill Gas Capture

Several landfills in B.C have an active landfill gas capture system in place – reducing GHG emissions from the landfill by capturing and combusting $CH_4$ (in the process releasing $CO_2$ emissions – which is carbon neutral). Therefore, the landfill gas captured by the applicable landfill in 2007 is subtracted from the total estimated GHG emissions from the landfill before emissions are attributed to associated Regional Districts and Municipalities.

The primary data source for landfill gas capture in 2007 was obtained directly from Regional Districts (see Data Sources below). The supporting data source was the Golder Consultant report "Inventory of Greenhouse Gas Generation from Landfills in British Columbia".

### Waste to Energy Facility

An emission factor of 0.42 tonnes $CO_2e$/tonne MSW was used for MSW combustion at the Metro Vancouver Waste-to-Energy facility. This factor was provided by Metro Vancouver.

### *Metro Vancouver GHG Allocation*

The Metro Vancouver area produces by far the largest amount of MSW in the province and sends MSW to three very different waste disposal facilities:

1. Cache Creek Landfill (dry landfill, k = 0.019)
2. Vancouver Landfill (wet landfill, k = 0.071)
3. Waste-to-Energy Facility (incineration facility)

MSW from each municipality in Metro Vancouver can be sent to any of the three disposal sites and the municipality is not involved in the choice of disposal site. As a tonne of MSW will produce very different GHG emissions dependent on which disposal site is used, it is difficult to precisely assign GHG emissions among Metro Vancouver municipalities.

To address this issue, and at the request of Metro Vancouver, it is assumed that each municipality contributes MSW to each of the three disposal facilities proportionate to its share of population in the Metro Vancouver region. Municipalities are thus attributed GHG emissions based on the average from the three disposal sites. GHG emissions from municipalities in Metro Vancouver can then be reasonably compared.

## 7.4 Data Sources

Historical MSW tonnage sent to landfills are key input variables into the WIP method for calculating GHG emissions. Required information includes the historical tonnages sent to landfills, as well as the contributions of MSW from individual municipalities and regional districts in 2007. Several data sources were used to determine: (1) the MSW tonnages sent to landfills; and (2) the municipalities and regional districts from which the solid waste was produced. This section describes these data sources in order of import (i.e., beginning with primary sources).

### 7.4.1 Data Supplied by Regional Districts

In August 2009, a survey was sent to solid waste managers of each regional district in B.C. The survey requested the following information regarding MSW tonnages:

- total MSW produced in the regional district in 2007;
- breakdown of MSW produced by municipality and electoral area;
- landfills where MSW was sent in 2007; and
- estimate of total MSW sent to landfills between 1977 and 2006.

About half of regional districts responded to the survey – with varying levels of detail. As most of the largest regional districts responded, accurate information for at least 90% of the estimated total MSW generated in B.C. can be accounted for, including both 2007 and historical MSW tonnages. Alternate data sources (described below) were used for the remainder of MSW tonnages not reported directly by regional district.

In addition to completing the survey, many regional districts publish frequent solid waste annual reports. These reports often include MSW tonnages generated in the regional district, as well as the landfills where MSW is sent. Data from these reports were used whenever possible.

### 7.4.2 Data Supplied by Ministry of Environment

Many Ministry of Environment compliance officers maintain internal records of MSW tonnages for regional districts and landfills. A request sent in October 2009 to Ministry regional offices resulted in useful information concerning both total MSW tonnages produced by a number of regional districts and MSW tonnages sent to landfills in specific years.

### 7.4.3 Recycling Council of B.C. Reports

The Recycling Council of B.C. (RCBC) was contracted by the Ministry of Environment to publish "B.C. Municipal Solid Waste Tracking Reports" from 1997/98 up until the 2006 calendar year. These reports include total MSW produced by most regional districts for certain years, as well as MSW tonnages sent to landfills. The reports are somewhat limited in that completion of the survey by regional districts was voluntary and not all regional districts had good information on MSW tonnages. In many cases however, relevant information was provided for MSW tonnages between 2003 and 2005, with less complete data for 2006.

### 7.4.4 Golder Report

In February 2008, Golder Associates was contracted by the Ministry of Environment to produce a report entitled "Inventory of Greenhouse Gas Generation from Landfills in British Columbia". The purpose of the report was to obtain a preliminary indication of GHG production at the 35 largest landfills in B.C. to inform development of the Ministry's Landfill Gas Management Regulation. Included within the report are MSW tonnages sent to each of the 35 landfills from 1977 to 2007, colour-coded based on whether the data was provided to Golder Associates, obtained from Recycling Council of B.C. reports or estimated by Golder Associates.

No data sources were listed for the MSW tonnage data provided to Golder Associates. Therefore, these data were used only when data from sources described in Sections 7.4.4.1 through 7.4.4.3 were not available or complete. Similarly, no documentation was provided on how MSW tonnages were estimated by Golder Associates where data gaps existed. Therefore, these estimates were not used in the CEEI reports.

## 7.5 Data Accuracy

GHG emission estimates from solid waste disposal as reported in the CEEI are highly uncertain. There are several reasons for this uncertainty.

First, estimated emissions depend crucially on the $L_0$ and k values assigned to the landfill. A slight variance in these values results in a large variance in estimated GHG emissions. The majority of $L_0$ and k values are estimated and only a small number are based on a site-specific study. For the latter, these studies are often limited in scope and do not account for all characteristics of the landfill. Though the determination of $L_0$ and k values is continually improving, there is still significant uncertainty surrounding the accuracy of these values.

Second, MSW tonnages produced by regional districts and municipalities are often estimated based on population and tonnage per capita data. This estimation method is an approximation and actual MSW production may vary significantly from what is reported in the CEEI.

Third, there is significant uncertainty regarding the operational characteristics of landfills operating in B.C. In many cases, there are several unknown variables including the landfill opening date, historical tonnages sent to the landfill, and the municipalities and Regional Districts that contribute to the landfill. In addition, there is uncertainty around landfills that may have closed in previous years. If historical MSW tonnages sent to a closed landfill are neither reported nor estimated, then total GHG emissions attributed to a regional district or municipality will be underestimated.

## 7.6 Planned Improvements

There should be significant improvements in the accuracy of GHG emissions from solid waste disposal in future CEEI Reports. As landfills in B.C. begin to install landfill gas capture systems in accordance with the Ministry's Landfill Gas Management Regulation, substantial data on landfill gas generation rates will result. These data can be used to significantly improve the accuracy of $L_0$ and k values for the largest landfills in B.C., thus improving the accuracy of GHG emissions.

In addition, CEEI surveys sent to regional districts will continue into 2010 and will align with mandatory reporting under the Landfill Gas Management Regulation. As regional districts continue to report directly on MSW tonnages, there will be less reliance on population-based estimates. As a result, GHG emission estimates will improve in accuracy.

# 8. LAND-USE CHANGE – DEFORESTATION SECTOR

The 2007 Updated CEEI Reports include estimates of hectares of deforestation for each regional district which have been broken down into agriculture and urban development along with resulting $CO_2e$ emissions. Estimates are not included for municipalities and electoral areas.

The reported deforestation data has been provided for information only (i.e., as "memo items") and are not counted in the total emissions in CEEIs for regional districts. This information should not be used for decision-making purposes.

## 8.1 Protocol and Guiding Principles

Following the boundary protocol, all deforestation events and the resulting greenhouse gas emissions are assigned to geopolitical units. In the case of Land-Use Change for 2007 CEEIs, the smallest geopolitical unit reported is a census division (e.g., regional district).

Table 18 presents an assessment of the guiding principles for the land-use change – deforestation sector.

**Table 18: Evaluation of Guiding Principle for the Land-Use Change – Deforestation Sector**

| Guiding Principles* | Relative Compliance | Notes |
|---|---|---|
| Relevance | Moderate to high | Data will be useful for policy proposals related to the *Zero Net Deforestation Act*. |
| Completeness | Low to moderate | Only deforestation data is included. |
| Consistency | Moderate | With completed recalculation of data, spatial and temporal comparisons are possible and meaningful. As the resolution of the method improves over time some temporal comparisons of datasets may become less meaningful. |
| Accuracy | Medium | Sample rate is small and the size of the area sampled is large. Boundary issues lessen the accuracy of some local government data. Due to variable sample rates, some regional districts may be more accurately estimated than others. Average rates for 2000-2007 have been used to estimate 2007. Levels. |
| Transparency and Confidentiality | High | Sufficient and appropriate GHG-related information is disclosed. |
| Continuous Improvement | High | Options to reduce uncertainty at the scale of a municipality are being explored. |

*ISO 14064-2:2006, Greenhouse Gases – Part 2: Specifications with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements

## 8.2 Components Included and Excluded

The CEEI inventories include deforestation, but the reports do not include afforestation or the conversion of non-forested land to forest.

For the purposes of greenhouse gas accounting, deforestation is defined as "the direct human-induced conversion of forested land to non-forested land". Deforestation includes activities such as

clearing of forest for urban development or agriculture. Human activities that do not cause a land-use change, such as forest harvesting followed by regeneration of a new forest and natural events such as beetle-killed forests or forest fires, are excluded.

British Columbia is using the same criteria for a deforestation event that Canada is using internationally as follows:

***1 hectare minimum area, 20 metres minimum width, 5 metres minimum tree height at maturity, and 25% minimum crown closure***.[53]

## 8.3 Methodology

CEEI uses deforestation emissions estimated by the Canadian Forest Service (CFS) and Environment Canada for reporting of Canada's emissions in the Environment Canada National Inventory Report: Greenhouse Gas Sources and Sinks in Canada, 1990-2007[54] . Satellite images and aerial photographs from various years were compared and interpreted to determine whether or not deforestation had occurred.

The CFS chose sample plots to provide reasonable estimates within each terrestrial ecozone[55] across Canada. The CFS sample plot network, including mapped deforestation events, was overlaid (e.g., intersected) with a map of the Census Divisions to obtain estimates of deforestation.

The amount of greenhouse gas emissions from each hectare of land that was deforested was modeled by the Canadian Forest Service[56] based on the general age, type, and density of forest prior to deforestation as mapped from the satellite imagery and aerial photographs within each combination of terrestrial ecozone and province. These calculations assume that all carbon contained in the forest above ground is released to the atmosphere either during or in the years following a deforestation event.

## 8.4 Data Sources

The origin of the data for the Land Use Change: Deforestation sector is the Canadian Forest Service[57] [58] and Environment Canada. Table 19 presents the data used in the 2007 CEEI Reports.

[53] Crown closure is the proportion of tree canopy overlying the forest floor. "25% crown closure" implies that 1/4 of the ground surface area has tree growth above it.
[54] See: http://www.ec.gc.ca/pdb/ghg/inventory_e.cfm
[55] Terrestrial Ecozones are a Canada-wide ecosystem classification. B.C. contains three zones (see www.ec.gc.ca/soer-ree/English/vignettes/Terrestrial/terr.cfm). Terrestrial ecozones are on a similar scale to B.C. Ecodomains in the Ecoregions of British Columbia series.
[56] See: http://carbon.cfs.nrcan.gc.ca/ForestCarbonAccount_e.html
[57] http://carbon.cfs.nrcan.gc.ca/TrackingLandUse_e.html
[58] http://carbon.cfs.nrcan.gc.ca/deforestation_e.html

Table 19: Deforestation by Regional District (2000 – 2007)

| Regional District | Total Area – Agriculture and Settlement (ha/year) | Total $CO_2e$ (tonnes) |
|---|---|---|
| ALBERNI-CLAYOQUOT | 49 | 43 000 |
| BULKLEY-NECHAKO | 338 | 156 000 |
| CAPITAL | 18 | 16 000 |
| CARIBOO | 201 | 95 000 |
| CENTRAL COAST | 6 | 6 000 |
| CENTRAL KOOTENAY | 144 | 69 000 |
| CENTRAL OKANAGAN | 95 | 46 000 |
| COLUMBIA SHUSWAP | 296 | 140 000 |
| COMOX VALLEY | 46 | 38 000 |
| COWICHAN VALLEY | 44 | 35 000 |
| EAST KOOTENAY | 202 | 97 000 |
| FRASER VALLEY | 169 | 80 000 |
| FRASER-FORT GEORGE | 297 | 137 000 |
| GREATER VANCOUVER | 382 | 329 000 |
| KITIMAT-STIKINE | 67 | 31 000 |
| KOOTENAY BOUNDARY | 7 | 3 000 |
| MOUNT WADDINGTON | 163 | 142 000 |
| NANAIMO | 114 | 96 000 |
| NORTH OKANAGAN | 29 | 14 000 |
| NORTHERN ROCKIES | 658 | 320 000 |
| OKANAGAN-SIMILKAMEEN | 10 | 5 000 |
| PEACE RIVER | 2504 | 1 059 000 |
| POWELL RIVER | 33 | 29 000 |
| SKEENA-QUEEN CHARLOTTE | 6 | 6 000 |
| SQUAMISH-LILLOOET | 58 | 28 000 |
| STIKINE | 70 | 31 000 |
| STRATHCONA | 28 | 24 000 |
| SUNSHINE COAST | 46 | 39 000 |
| THOMPSON-NICOLA | 139 | 66 000 |

## 8.5 Data Accuracy

The accuracy of the data as reported by provincial staff is considered to be of medium accuracy because mapping was completed to provide estimates at the provincial and national level, not at the regional district level. To achieve these large-scale estimates, a low sampling rate for most regional districts was employed. Samples were designed to provide accurate estimates for areas 200 kilometres by 200 kilometres in area, not to provide accurate estimates at the regional district level.

In addition, the information reported in 2007 CEEIs was extrapolated to the year 2007 from interpretations of 2000 and 2007 satellite imagery and aerial photographs, and therefore the extrapolated data is not specific to the CEEI inventory year of 2007.

To reduce uncertainties noted in the previous CEEI Reports, the Canadian Forest Service and the Province of British Columbia significantly updated the sample plot mapping to both extend the deforestation sample plot network and add deforestation interpretation for the 2000-2007 time period.

## 8.6 Planned Improvements

Options to reduce uncertainty at the scale of a municipality are being explored.

# 9. AGRICULTURE – ENTERIC FERMENTATION SECTOR

## 9.1 Protocol and Guiding Principles

The CEEI Agricultural sector in the 2007 inventory measures only enteric fermentation, with the same titles and emission factors as in the B.C. Provincial Inventory Report (BCPIR), which in turn match those used in the National GHG Inventory (NIR) from Environment Canada.

The NIR includes three categories of emissions for the agricultural sector:

1. Enteric fermentation,
2. Manure management, and
3. $N_2O$ emissions from agricultural soils.

Section 6 (Agriculture) of the 1990-2006 National Inventory Report describes how the Agriculture section was developed.

See a copy of the complete 1990-2007 NIR (as a PDF inside a .zip file) at http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/4771.php . It is also available from Environment Canada by e-mail request at http://www.ec.gc.ca/pdb/ghg/inventory_e.cfm.

The inventory of emissions from agricultural sources in CEEI is incomplete and uncertain. Therefore, agricultural emissions are included only as an "memo item" and not added into the total emissions for each government area. Regional Districts are the smallest geographic unit reported in the Agriculture sector.

The NIR estimates that total emissions in 2007 from the three categories in B.C. were about 2.3 million tonnes of $CO_2e$ (2.3 MT), composed of approximately 1.1 MT $CO_2e$ from enteric fermentation, 0.37 MT $CO_2e$ from manure management, and 0.85 MT $CO_2e$ as nitrous oxide from soils and manure.

**Table 20: Evaluation of Guiding Principle for the Agriculture – Enteric Fermentation Sector**

| Guiding Principles* | Relative Compliance | Notes |
|---|---|---|
| Relevance | Low | Local governments have limited influence on livestock populations under the B.C. *Right to Farm Act*. Measures to reduce emissions per animal are not reflected in the CEEI calculations. Also see 'Completeness' below. |
| Completeness | Low | Due to data and scientific challenges noted in this section, only one type of emissions is attributed to agriculture. This leaves out most of the sector. |
| Consistency | High | Animal populations are taken from the well established Census of Agriculture. Emissions calculations are consistent with the N.I.R. and IPCC methods. |

| Guiding Principles* | Relative Compliance | Notes |
|---|---|---|
| Accuracy | Moderate | The census of agriculture is believed accurate, but the emissions per animal are based on national figures which do not include regional variation |
| Transparency and Confidentiality | High | Animal populations are from Statistics Canada which follows rigorous legislated methods to ensure confidentiality of its sources. Calculation methods are available and documented in the Methods and Standards. |
| Continuous Improvement | Medium | Emissions from manure management and agricultural soils may be added in the future to reflect other types of primary agricultural activities. |

*ISO 14064-2:2006, Greenhouse Gases – Part 2: Specifications with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements

## 9.2 Components Included and Excluded

The 2007 CEEI reports include only enteric fermentation. Manure Management and Agricultural Soils are excluded (for reasons explained in 9.3.2 and 9.3.3 below).

Even the categories in the NIR do not include all GHG emissions resulting from agricultural operations. For example, emissions from use of diesel in trucks to deliver hay are included in "transportation". Emissions from water heaters and space heaters are included in "buildings". Emissions from diesel used in tractors would be an "off-road" emission. None of these are included in the "Agriculture" sector of CEEI.

## 9.3 Methodology

### 9.3.1 Enteric Fermentation

To quote from the 2006 NIR 6.2.1:

***$CH_4$ emissions are calculated for each animal category/subcategory, for each province, by multiplying the animal population of a given category/sub-category by its corresponding emission factor.***

CEEI calculates emissions based on the number of cattle, hogs and other animals in each Regional District. For each regional district, the number of animals is multiplied by the estimated methane emissions from each animal (from the NIR) to give total methane ($CH_4$) emissions. These are multiplied by a factor converting methane ($CH_4$) emissions to carbon dioxide equivalents ($CO_2e$) using the same conversion factor as the NIR and BCPIR for 2007.

The 2007 NIR table A3-18 shows "$CH_4$ Emission Factors for Enteric Fermentation for Cattle from 1990 to 2007". It contains factors for 8 different types of cattle, and the factors for each vary from year to year. The 2007CEEI uses 2007 factors from this table.

**Table 21: $CH_4$ Emission Factors for Enteric Fermentation for Cattle[59] [60]**

| | EF(EF)T – kg $CH_4$/head/year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Dairy Cows | Dairy Heifers | Bulls | Beef Cows | Beef Heifers | Heifers for Slaughter | Steers | Calves |
| 2007 | 116.5 | 74.6 | 87.8 | 84.7 | 71.4 | 68.0 | 59.6 | 43.3 |

Methane emissions from other animals were taken from Table A12-21: $CH_4$ Emission Factors for Enteric Fermentation for Non-cattle Animals in a different version of the 1990-2007 NIR obtained by the Ministry, which are the IPCC Tier 1 default emission factors (IPCC/OECD/IEA 1997):

**Table 22: Non-cattle Animal Category – Enteric Fermentation Emission Factor**

| Non-cattle Animal Category - Enteric Fermentation Emission Factor (kg $CH_4$/head/year) | |
|---|---|
| Pigs, Boars, Sows (all weights) | 1.5 |
| OTHER LIVESTOCK | |
| Sheep, Lambs | 8 |
| Goats | 5 |
| Horses | 18 |
| Buffalo, Bison[61] | 55 |
| POULTRY[62] | |
| Chickens, Hens, Turkeys | N/A |

### 9.3.2 Manure Management

To quote from the 2006 NIR 6.3.1.1:

***Shortly after manure is excreted, the decomposition process begins. If little oxygen is present, the decomposition is mainly anaerobic and produces $CH_4$. The quantity of $CH_4$ produced depends on the manure characteristics linked to animal types and diets and on the type of manure management system.***

Manure management is excluded from CEEI because the emissions values used by the NIR do not reflect regional and local variation in the way that manure is stored and used. Emissions from manure vary considerably with the method of storage, length of storage, and moisture content. This variation can greatly affect methane emissions from manure, but there is currently no systematic observation of farm practices in B.C.

[59] From Table A3-18, Environment Canada National Inventory Report 1990-2007, p. 311
[60] <<Find reference to these numbers in the IPCC publications>>
[61] This emission factor is for water buffalo. There are no recognized studies of enteric emissions from bison, so the IPCC Tier 1 water buffalo figure is used here, as it is in the N.I.R.
[62] Note: poultry does not generate significant methane by enteric fermentation, so poultry was not counted in CEEI

### 9.3.3 Agricultural Soils

To quote from the 2006 NIR 6.4 and 6.4.1:

***Emissions of $N_2O$ from agricultural soils consist of direct and indirect emissions as well as emissions from animal manure on pasture, range, and paddock. The emissions of $N_2O$ that result from anthropogenic N inputs occur directly from the soils to which the N is added, and also indirectly through two pathways: i) volatilization of N from synthetic fertilizer and manure as $NH_3$ and NOx and its subsequent deposition off-site; and ii) leaching and runoff of N.***

***Direct sources of $N_2O$ from soils include synthetic fertilizers, animal manure applied as fertilizer, crop residue decomposition, modification of tillage practices, summer fallow, irrigation, and cultivation of histosols.***

Emissions from agricultural soils are not included because we have insufficient information about them at a local level. Fertilizer sales are a large factor in soil emissions, but are only released on a provincial basis, so we know only one quantity for all of B.C.

## 9.4 Data Sources

CEEI determined livestock counts from the 2006 Census of Agriculture, and based emissions calculations on this population. The counts were not altered to account for changes in livestock numbers between 2006 and 2007.

The Statistics Canada Census of Agriculture is collected every five years as mandated by the *Statistics Act*. It includes most farm animals, and tabulates them by type and local government area. The B.C. Ministry of Agriculture and Lands statistics section has access to this data and provided it to CEEI.

The Census of Agriculture reports by Census Division (CD) which is equivalent to a regional district (RD) in B.C., and by Census Subdivisions (CSD), which is equivalent to a city, municipality, or regional district electoral area in B.C.

Some animal counts are suppressed (not shown) in the Census of Agriculture totals where they would identify operations of individual farm operators. Most of these suppressions occur at the level of Census Subdivision, so agricultural livestock emissions for cities, municipalities and electoral areas are not included in the CEEI reports.

CEEI only reports on agricultural inventory emissions based on livestock counts for regional districts.

There were 73 cases across B.C. where livestock counts were suppressed even at the regional district level due to a small number of farms. In these cases, the Ministry of Agriculture relied on field staff familiar with the areas to provide estimates of livestock counts. These estimated counts were multiplied by the same emission factors so that the reports would include GHG emissions estimates from livestock in all regional districts.

## 9.5 Data Accuracy

The Census of Agriculture by – definition of "census" – is intended to be a complete livestock count, not based on a sample. Therefore the counts are as accurate as possible.

The same estimates of methane emissions from enteric fermentation are used for all Canadian livestock and therefore do not reflect regional variations.

## 9.6 Planned Improvements

Future versions of CEEI reports may include the other two categories, Manure Management and Agricultural Soils. Their inclusion depends on data availability at a regional district scale, and sufficient accuracy (reflecting local conditions) to make the inventory meaningful.

Future versions of CEEI reports may add higher resolution by reporting by CSD (municipality, city, or village). Livestock emissions are the most likely candidate for this as the Census of Agriculture contains information by CSD.

# 10. SUPPORTING INDICATORS

## 10.1 Guiding Principles

Supporting indicators are not typically included in inventories of community-wide GHG emissions. Supporting indicators are included, however, as part of the Updated 2007 CEEI Reports (Expanded Edition) in recognition of the important influence these community characteristics have on community-wide emission reduction. The purpose of including these policy relevant, supporting indicators in the Updated 2007 CEEI Reports (Expanded Edition) are primarily to help to inform local and provincial government climate action policy and decision-making. In particular, supporting indicators are intended to:

- assist in monitoring the relative effectiveness of local and provincial government policy measures to reduce GHG emissions and energy consumption;
- support local government GHG emission target setting in Official Community Plans and Regional Growth Strategies;
- assist with efforts to model land use scenarios and their impacts on GHG emissions;
- publicly profile community progress to encourage community dialogue and friendly competition; and
- complement other sustainability indicators that may have been developed by the community.

The present list of CEEI supporting indicators have been developed in consultation with representatives from local governments, Provincial ministries, utilities, and other stakeholders, through workshops, research and follow up analysis. The Green Communities Performance Measurement Technical Working Group has provided advice and direct input during key stages of the development of the CEEI supporting indicators. This technical working group is made up of local government staff from across BC representing a diversity of roles at the local government level.

Throughout the selection process preference has been given to those indicators that best met the following indicator selection criteria:

1. within the influence of local government;
2. meaningful (i.e. policy relevant);
3. easily understood by a broad range of readers and audiences;
4. comparable (i.e. to indicators used by other municipalities, regional districts and others);
5. focused on results rather than processes/actions;
6. measurable (i.e. data is currently available or could be generated);
7. easily, affordably and consistently measured over time; and
8. data available from a 3rd party.

For more information on the supporting indicators, refer to the forthcoming "Supporting Indicators in the Updated 2007 CEEI Reports (Expanded Edition)" document.[63]

A rapidly growing number of governments around the world are recognizing the value of establishing energy and climate action indicators and targets: "what gets measured, gets done". Nevertheless, being mindful of the limitations of indicators is useful, e.g. indicators are often considered "proxy" or "surrogate" in nature. As such, indicators should be supplemented by observation, studies, survey research, detailed assessment, and both qualitative and quantitative analysis on a community-by-community basis. While the intention of the CEEI supporting indicators is to provide a common set of measures applicable to all communities across the Province, "local context" is invaluable to help inform both local government decision making, as well as, to better understand the successes or challenges each community is having in reducing fossil fuel-based energy use and GHG emissions relative to other communities.

The existing sector-based CEEI framework has been used to organize the supporting indicators: On-Road Transportation, Buildings, Solid Waste, and Land-Use Change, with the exception, as yet, of Agriculture. In addition, a new sector has been added, i.e. Community and Renewable Energy Supply.

Supporting indicators are not calculated into emissions, and as such, they are not included in the total emissions for each local government.

## 10.2 Components Included and Excluded

Five supporting indicators are being provided with data in the Updated 2007 CEEI Reports (Expanded Edition):

- **Housing Type:** Private dwellings by structural type;
- **Commute to Work:** Employed labour force by mode of commute;
- **Commute Distance:** Employed labour force by commuting distance;
- **Residential Density:** Population per net land area; and
- **Parks and Protected Greenspace:** Land area that is parks and protected greenspace.

Thirteen additional supporting indicators are included in the Updated 2007 CEEI Reports (Expanded Edition) as "placeholders". These "placeholder" supporting indicators are under consideration for inclusion in future CEEI reports (http://csd.cogix.com/ViewsFlash/servlet/viewsflash?cmd=page&pollid=ENV_CAS!2007CEEI_UpdatesSurvey):

**On-Road Transportation (and Land Use)**

- **Proximity to Transit:** Persons, dwelling units and employment within 400 m of "quality" transit stop/line;
- **Proximity to Services:** Persons and dwelling units within 400 m of services, e.g. groceries, schools, pharmacy, banking, etc.;

[63] http://www.env.gov.bc.ca/cas/mitigation/ceei/resources.html.

- **Transit Ridership:** Annual per capita transit ridership;

**Buildings**

- **Residential Energy Intensity:** Average residential energy use per person per square metre of floor space; and
- **Residential Floor Space:** Average dwelling unit size.

**Solid Waste (and Water)**

- **Solid Waste Diverted:** Tonnes of solid waste diverted from landfill;
- **Avoided Waste Emissions:** Tonnes of CO2e of avoided future emissions due to reduced waste since 2007; and
- **Water Use:** Per capita water use.

**Land-Use Change**

- **Impervious Surface Cover:** % change in impervious surface cover; and
- **Tree Canopy Cover:** % change in tree canopy cover.

**Community and Renewable Energy Supply**

- **District Energy:** # and energy output (e.g. buildings connected, energy consumed in GJ or kWh) of district energy systems by energy type (e.g. renewable or non-renewable);
- **On-site Renewable Energy:** # and energy output (in GJ or kWh) from households producing and/or consuming on-site renewable heat (e.g. biomass, solar, thermal, geo-exchange) and/or electrical (e.g. solar photovoltaic, small wind, small scale hydro) energy; and
- **Energy Recovery From Waste:** Energy (GJ or kWh) recovered from waste, e.g. from landfill, sewage treatment, industrial operations, and farms.

The Updated 2007 CEEI Reports (Expanded Edition) do not include supporting indicators relating to:

- corporate operations; and
- "context" or "sustainability" characteristics that do not directly reflect efforts to reduce community energy consumption from traditional fossil fuels, and related reductions in GHG emissions.

## 10.3 Methodology

### 10.3.1 Census Data: Housing Type, Commute to Work and Commute Distance

Data for Housing Type, Commute to Work, and Commute Distance is collected every five years in the Census of Canada. The data included in the Updated 2007 CEEI Reports (Expanded Edition) for these indicators is from the 2006 Census, and the 2001 and 1996 Census, where available. A short Census questionnaire (8 questions) is distributed to 80% of all households in Canada. Twenty percent of households receive a long questionnaire (61 questions), except in northern areas, remote areas and Indian reserves. In those areas, all households complete a long questionnaire, since sampling is unlikely to produce accurate data for such small populations. With the exception of the Housing Type data from the 2001 and 2006 Census, this data is taken from the long questionnaire.

To ensure that all households are enumerated, enumerators undertake a process called Block Canvass. The Block Canvass is a physical verification and validation field exercise intended to produce a complete and reliable list of addresses, including all suites. For Census dictionary, please see: www12.statcan.gc.ca/census-recensement/2006/ref/dict/index-eng.cfm.

### Housing Type: Private Dwellings by Structural Type

Structural type by dwelling defines the characteristics of a dwelling's structure. Dwelling characteristics differentiate a single-detached house, a semi-detached house, a row house, an apartment and flat in a duplex. In 2006, improvements to the enumeration process and changes in structural type classification have affected the historical comparability of the "structural type of dwelling" variable. In 2006, "apartment or flat in a duplex" replaced "apartment or flat in a detached duplex" and included duplexes attached to other dwellings or buildings. This is a change from the 2001 Census where duplexes attached to other dwellings or buildings were classified as an "apartment in a building that has fewer than five storeys".

### Commute to Work: Employed labour force by mode of commute

Mode of commute is defined as the main means a person uses to travel between home and place of work (by car, on foot, on public transit, or by some other means). Residents (excluding institutional residents) 15 years of age and over who worked at some time since January 1, 2005, who indicate in the place of work question that they either had no fixed workplace address, or specified a usual workplace address, were asked to identify the mode of transportation they usually use to commute from home to work. The variable usually relates to the individual's job in the week prior to enumeration. However, if the person did not work during that week but had worked at some time since January 1, 2005, the information relates to the job held longest during that period.

Persons who use more than one mode of transportation are asked to identify the single mode they use for most of the travel distance. As a result, the question provides data on the primary mode of transportation to work. The question does not measure multiple modes of transportation, nor does it measure the seasonal variation in mode of transportation or trips made for purposes other than the commute from home to work.

### Commute Distance: Employed labour force by commuting distance

Commute distance is calculated as a straight-line distance, in km, between a respondent's home and place of work. The variable relates to the population 15 years of age and over, excluding institutional residents, who worked at some time since January 1, 2005, and who had a usual place of work. The variable usually relates to the individual's job held in the week prior to enumeration. However, if the person did not work during that week but had worked at some time since January 1, 2005, the information relates to the job held longest during that period.

Workplace locations are coded to a geographic point location. This geographic point location is a block-face, dissemination block, dissemination area or census subdivision representative point. Commuting distance is calculated as the straight-line distance between the residential block representative point and the workplace location representative point. In most cases, this underestimates the distance travelled to work because workers seldom have a route that minimizes the distance they travel (such as a straight line) between their home and workplace.

For persons who work outside the areas covered by census metropolitan areas or census agglomerations, the workplace location is coded to a single representative point for the census subdivision of work. This can affect the calculated commuting distance, particularly when the census subdivision of work has a large area. These representative points may change from census to census, so users should be cautious when comparing commuting distances between censuses.

### 10.3.2 Residential Density and Parks and Protected Greenspace

**Residential Density**

Residential density is calculated by dividing total population of a local municipality by the "net" land area. All land data used to compute residential density represents totals as of the end of 2009. Residential density has only been calculated for municipalities and for the islands within the Islands Trust. The population figures are taken from the 2009 BC Statistics Population Estimates, which are the official municipal population estimates for BC. These population figures have been divided by the "net" land area. This is the total land area with the following areas subtracted from the total: unsurveyed Crown land; federal, provincial, and local parks and protected areas; Indian Reserves; water features (i.e. lakes, main rivers); Agricultural Land Reserve; waste disposal sites; and airports where digitally available. By excluding these parcels, the intention is to get a more precise picture of where people live or where future development could occur, and thus be able to track over time how population densities are changing within those areas.

**Parks and Protected Greenspace**

Parks and protected greenspace has been calculated using GIS mapping of provincial, local and federal data sets representing totals as of the end of 2009. Marine areas have been excluded from both the total area calculations as well as the total parks calculations. In addition, Indian Reserves have been excluded from all totals.

## 10.4 Data Sources

The data for the Housing Type, Commute to Work, and Commute Distance comes directly from the Census of Canada every five years. The CEEI reports this data as reported within the Census. Data is provided for the 1996, 2001 and 2006 Census years for Housing Type and Commute to Work. For Commute Distance, only 2006 Census data is included. In addition, Commute Distance data is only provided for those municipalities located within Census metropolitan areas and Census agglomerations (i.e. areas with an urban core population of at least 10,000).

For 2009, residential density has the following data sources:

- **Population:** BC Stats, 2009;
- **Total Land Area:** a GIS calculation based on best available digital information representing municipalities of BC from Tantalis (GeoBC), Feb. 2010;
- **Unsurveyed Crown Land:** January 2010;
- **Parks and Protected Areas:** Tantalis Parks, Canada Lands Administrative Boundaries (CLAB), various regional districts and local governments, January 2010;
- **First Nations Reserve Lands:** CLAB, January 2010;
- **Water Features:** TRIM, January 2010;

- **Agricultural Land Reserve:** Agricultural Land Commission, February 2010;
- **Waste Disposal Sites:** *Land Act* Data – February 23, 2010; and
- **Airports:** various data sources, February, 2010

For 2009, parks and protected greenspace has the following data sources:

- **Total Land Area:** a GIS calculation based on best available digital information representing municipalities of BC from Tantalis (GeoBC), February 2010;
- **First Nations Reserve Lands:** CLAB, January 2010;
- **Federal Parks:** CLAB Federal Parks, January 2010;
- **Provincial Parks and Protected Areas:** Tantalis Parks, January 2010;
- **Local Greenspaces:** Various regional and municipal datasets and Land Titles Office research results, January 2010; and
- **Agricultural Land Reserve:** Agricultural Land Commission, February 2010.

Data sources for the 13 "placeholder" indicators are still being researched and confirmed. As part of the CEEI principle of "continuous improvement", input on available and relevant data sources from local governments and measurement professionals alike will continue to be welcome. (http://csd.cogix.com/ViewsFlash/servlet/viewsflash?cmd=page&pollid=ENV_CAS!2007CEEI_UpdatesSurvey)

## 10.5 Data Accuracy

Regarding the data for Housing Type, Commute to Work, and Commute Distance, although significant effort is made to ensure data accuracy within the Census of Canada, there will be times when the Census report does not align with a local government's own data, e.g. from building permits, zoning, trip diary surveys etc. As discussed earlier, local data, research and analysis is invaluable to help inform local government climate action decision making.

For more specific information on data quality from Stats Canada in relation to sampling errors etc. see: http://www12.statcan.gc.ca/census-recensement/2006/ref/dict/overview-apercu/pop7-eng.cfm

For more specific information on mechanisms used by Statistics Canada to ensure confidentiality within the Census such as rounding and area suppression etc. see: http://www12.statcan.gc.ca/census-recensement/2006/ref/dict/overview-apercu/pop3-eng.cfm

It is important to note that, in 2006, improvements to the enumeration process and changes in structural type classification affect the historical comparability of the "structural type of dwelling" variable. For more specific information on data quality for Housing Type from Stats Canada see: http://www12.statcan.ca/census-recensement/2006/ref/rp-guides/housing-logement-eng.cfm

For more specific information on data quality for Commute to Work and Commute Distance see: http://www12.statcan.ca/census-recensement/2006/ref/rp-guides/journey-to-work-deplacement-domicile-travail-eng.cfm

For Census dictionary, please see: http://www12.statcan.gc.ca/census-recensement/2006/ref/dict/index-eng.cfm

For both population density and parks and protected greenspace, data is accurate to the degree that provincial datasets are accurate. Several potential future refinements have been noted during this year's data collection process, e.g. work with local government to refine provincial data sets. Specifically, in the case noted in the table below, it is possible that the quantity of local parkland may be underestimated.

| | | | | |
|---|---|---|---|---|
| 100 Mile House,<br>Alert Bay,<br>Armstrong,<br>Ashcroft,<br>Bowen Island,<br>Burnaby,<br>Burns Lake,<br>Castlegar,<br>Chetwynd,<br>Clinton,<br>Coldstream,<br>Coquitlam,<br>Courtenay,<br>Cranbrook,<br>Creston,<br>Elkford, | Enderby,<br>Fort Nelson,<br>Fort St. James,<br>Fort St. John,<br>Fraser Lake,<br>Gold River,<br>Granisle,<br>Harrison Hot Springs<br>Hazelton,<br>Houston,<br>Kaslo,<br>Keremeos,<br>Kimberley,<br>Kitimat,<br>Ladysmith,<br>Lantzville, | Lions Bay,<br>Logan Lake,<br>Lumby,<br>Lytton,<br>Mackenzie,<br>Masset,<br>McBride,<br>Merritt.<br>Nanaimo,<br>New Denver,<br>North Cowichan,<br>Osoyoos,<br>Peachland,<br>Pemberton,<br>Penticton,<br>Port Alberni, | Port Clements,<br>Port McNeill,<br>Port Moody,<br>Pouce Coupe,<br>Prince George,<br>Prince Rupert,<br>Qualicum Beach,<br>Radium Hot Springs<br>Richmond,<br>Saanich,<br>Salmo,<br>Sayward,<br>Sicamous,<br>Slocan<br>Spallumcheen,<br>Surrey, | Tahsis,<br>Taylor,<br>Telkwa,<br>Terrace,<br>Trail,<br>Tumbler Ridge,<br>Ucluelet,<br>Valemount,<br>Vancouver,<br>Vanderhoof,<br>Vernon,<br>Victoria,<br>View Royal,<br>Warfield,<br>Williams Lake,<br>Zeballo |

## 10.6 Planned Improvements

### Housing Type: Private dwellings by structural type

Other data sources (e.g. building permits) may be pursued to augment this Census of Canada measure, in part to increase the frequency and accuracy of the data.

### Commute to Work: Employed labour force by mode of commute

In recognition of the fact that commute to work only captures a portion of total trips, alternative methods for gathering data on all trips, e.g. through a trip diary survey, may be pursued. In local governments (such as Metro Vancouver and the Capital Regional District) where trip diary data may already exist, commute to work data may be able to be refined in future reports. In the meantime, local governments with access to such locally-specific data are encouraged to consider its use to the extent it can inform and monitor changes in mode patterns for all trip types.

### Commute Distance: Employed labour force by commuting distance

In recognition of the fact that commute distance only captures a portion of total trips, alternative methods for gathering data on all trips, e.g. through a trip diary survey, may be pursued. In local governments (such as Metro Vancouver and the Capital Regional District) where trip diary data may already exist, data may be able to be refined in future reports. In the meantime, local governments with access to such locally-specific data are encouraged to consider its use to the extent it can inform and monitor changes in commute distances. In addition, providing commute distance data for all local governments will be explored.

### Residential Density

In addition to calculating residential density by using persons per net hectare, in future reports, there are also plans to calculate dwelling units per net hectare. Also, where potential future refinements have been noted during this year's data collection process, e.g. work with local government to refine provincial data sets, efforts will be made to improve this data.

### Parks and Protected Greenspace

While parks and protected greenspace is a valuable indicator in its own right, the addition of the "placeholder" indicators such as tree canopy cover and impervious surface cover in future reports will provide even more meaningful information to local governments for monitoring efforts to protect carbon sinks and mitigate the heat island effect. Also, where potential future refinements have been noted during this year's data collection process, e.g. work with local government to refine provincial data sets, efforts will be made to improve this data.

### "Placeholder" Supporting Indicators

Thirteen "placeholder" supporting indicators are listed in the Updated 2007 CEEI Reports (Expanded Edition) as under consideration for future reports. The intent of including these "placeholder" supporting indicators is twofold:

1. We want feedback from local government on the policy relevance of the CEEI "placeholder" supporting indicators under consideration (http://csd.cogix.com/ViewsFlash/servlet/viewsflash?cmd=page&pollid=ENV_CAS!2007CEEI_UpdatesSurvey).

2. In light of the legislative requirements to include targets, policies and actions in Official Community Plans (OCPs) by May 2010, and Regional Growth Strategies (RGSs) by May 2011, it is recognized that providing an indication of the CEEI supporting indicators that may be tracked in the future could assist in supporting decision-making and target-setting in the present.

However, it is important to stress that although these indicators are under consideration, further research into data availability, as well as feedback from local governments on the policy relevance of these "placeholder" indicators, will shape the ultimate supporting indicator data sets to be provided in future CEEI reports. For more detailed information on the thirteen "placeholder" supporting indicators under consideration, please see the "Supporting Indicators in the Updated 2007 CEEI Reports (Expanded Edition)" document.

# BIBLIOGRAPHY

IPCC (1995). The Science of Climate Change, Contribution of Working Group I to the Second Assessment Report, Cambridge University Press, U.K.

IPCC (1996a). 1995 Summary for Policy Makers – A Report of Working Group I of the Intergovernmental Panel on Climate Change.

IPCC (1996b). Second Assessment Synthesis of Scientific –Technical Information Relevant to Interpreting Article 2 of the UN Convention on Climate Change.

IPCC (1997). Greenhouse Gas Inventory Reporting Instructions, Volume 1; and Greenhouse Gas Inventory Reference Manual, Volume 3, Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Intergovernmental Panel on Climate Change, Bracknell, U.K.

IPCC (2001). Climate Change 2001: The Scientific Basis, Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change, J.T. Houghton, Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, and D. Xiaosu (eds.), Cambridge University Press, U.K. 944 pp.

IPCC/OECD/IEA (2000). IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, Intergovernmental Panel on Climate Change, Organisation for Economic Co-operation and Development, and International Energy Agency, Tokyo.

ISO (2006). ISO 14065-2:2006, Greenhouse Gases – Part 2: Specifications with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements, International Organization for Standardization, Geneva.

Jacques, A.P. (1992). Canada's Greenhouse Gas Emissions: Estimates for 1990, Environment Canada, Report EPS 5/AP/4.

Jacques, A.P., F. Neitzert, and P. Boileau (1997). Trends in Canada's Greenhouse Gas Emissions 1990–1995, Environment Canada, En49-5/5-8E, April.

Statistics Canada (2002). Quarterly Report on Energy Supply – Demand in Canada, Statistics Canada, Catalogue No. 57-003.

# GLOSSARY OF TERMS

**Base Year** – The emissions level against which to measure change over time, comprised of the annual emissions by activities within the boundaries of the analysis for a selected year.

**Carbon Dioxide ($CO_2$) –** The most common GHG, consisting of a single carbon atom and two oxygen atoms. $CO_2$ is released by respiration the burning of fossil fuels, and is removed from the atmosphere by photosynthesis in green plants.

**Carbon Dioxide equivalents –** See "$CO_2e$".

**Chlorofluorocarbons (CFCs) –** Compounds of carbon containing both chlorine and fluorine. They are non-poisonous and inert at ordinary temperatures and easily liquifiable under pressure, which make them excellent refrigerants, solvents, foam-makers and for use in aerosol sprays. Chlorofluorocarbons (CFCs) do not occur naturally. The use of CFCs is strictly regulated.

**$CO_2e$ (Carbon Dioxide Equivalents) –** A common unit for combining emissions of greenhouse gases with different levels of impact on climate change. It is a measure of the impact that each gas has on climate change and is expressed in terms of the potency of carbon dioxide. For carbon dioxide itself, emissions in tons of $CO_2$ and tons of $CO_2e$ are the same, whereas for nitrous oxide and methane, stronger greenhouse gases, one ton of emissions is equal to 310 tons and 21 tons of $CO_2e$ respectively.

**Coefficients –** See "Emission Factors".

**Community Scope Definitions**

- Scope 1 emissions are all sources located within the geographic boundary of the jurisdiction (e.g., use of fuels such as heavy fuel oil, natural gas or propane used for heating buildings);
- Scope 2 emissions are indirect emissions that result as a consequence of activity within the jurisdiction's geographic boundary but which may occur outside of the jurisdiction (i.e., purchased electricity from hydroelectricity generation elsewhere);
- Scope 3 emissions are regional sources of emissions that occur outside of the jurisdiction's geographic boundary but which are the result of consumption patterns of residents or businesses in the jurisdiction (e.g., fuel used by an airport).

**Direct Emissions –** Emissions from assets that are owned or controlled by the reporting organization.

**Emission Coefficients –** See "Emission Factors".

**Electoral Area –** A grouping of unincorporated areas that are represented by one director in the regional district.

**Emission Factors/Coefficients –** A unique value for determining the amount of a GHG emitted for a given quantity of fossil fuel consumed. These factors are expressed in terms of the ratio of emissions of a particular pollutant (e.g. carbon dioxide) to the quantity of the fuel used (e.g. kilograms of coal). For example, when burned, 1 ton of coal = 2.071 tons of $CO_2$.

**Gigajoule (GJ) –** A joule is a measurement of energy equal to energy needed to apply one Newton of force to move an object a distance of one metre. One joule is the equivalent of lifting an apple one metre. A gigajoule is the equivalent of one billion joules, a barrel of oil contains roughly 6 GJ of energy.

**Global Warming Potential (GWP) –** The ratio of radiative forcing that would result from the emission of one kilogram of a GHG to that from the emission of one kilogram of carbon dioxide over a fixed period of time.

**Greenhouse Effect –** The effect of heat retention in the lower atmosphere as a result of absorption and re-radiation by clouds and various greenhouse gases of long-wave terrestrial radiation. Incoming, short-wave radiation, including visible light and heat, is absorbed by materials which then behave as black bodies re-radiating at longer wavelengths. Certain substances (e.g. carbon dioxide) absorb long-wave radiation, are heated by it, and then begin to radiate it, still as long-wave radiation, in all directions, some of it downwards. Despite its name, the actual heating in a real greenhouse is caused mainly by the physical obstruction of the glass, which prevents warm air from leaving and cooler air from entering.

**Greenhouse Gases (GHG) –** Gases which are transparent to solar (short-wave or light) radiation but opaque to long-wave (infrared or heat) radiation, thus preventing long-wave radiant energy from leaving Earth's atmosphere. Thereby reducing the amount of earth's radiation that escapes to space, with consequent warming of the lower atmosphere and the earth's surface (see Greenhouse Effect). For the purposes of this standard, GHGs are the six gases listed in the Kyoto Protocol: carbon dioxide ($CO_2$); methane ($CH_4$); nitrous oxide ($N_2O$); hydroflurocarbons (HFCs); perfluorocarbons (PFCs); and sulphur hexafluoride ($SF_6$).

**Hydrofluorocarbons (HFCs) –** GHGs used primarily as a refrigerant, comprising a class of gases containing hydrogen, fluorine, and carbon.

**Indirect Emissions –** Emissions that occur because of a local government's actions, but are produced by sources owned or controlled by another entity. For example, the purchase of electricity that was generated by emission-producing fuel outside of the jurisdiction's boundaries.

**Intergovernmental Panel on Climate Change (IPCC) –** An organization established jointly by the United Nations Environment Programme and the World Meteorological Organization in 1988 to assess information in the scientific and technical literature related to all significant components of the issue of climate change, and providing technical analysis of the science of climate change as well as guidance on the quantification of GHG emissions.

**Kilowatt Hour (kWh) –** The electrical energy unit of measure equal to one thousand watts of power supplied to, or taken from, an electric circuit steadily for one hour. (A Watt is the unit of electrical power equal to one ampere under a pressure of one volt, or 1/746 horsepower.)

**Landfill Gas (LFG) Production –** Estimation of the amount of methane gas produced by the decomposition of organic solid waste. LFG can be estimated by two methods: waste commitment and waste-in-place.

**Measures –** These are the actions by local government or other community stakeholders that are undertaken to reduce GHG emissions.

**Methane ($CH_4$) –** A GHG resulting from the anaerobic decomposition of vegetative materials in wetlands, urban landfills, and rice paddies, the production and distribution of natural gas and petroleum, coal production, and incomplete fossil fuel combustion. The principle constituent of natural gas, methane is a single carbon atom linked to four hydrogen atoms.

**Municipality –** An administrative entity composed of a clearly define territory and its population. Municipalities can be incorporated under a variety of names such as City, District, Town, Village, Indian Government District, etc.

**Municipal Solid Waste (MSW) –** More commonly known as garbage, MSW includes all waste produced within a municipalities boundaries that require disposal at a regional landfill or other waste facility. MSW includes demolition, land clearing and construction waste.

**Nitrous Oxide ($N_2O$) –** A potent greenhouse gas produced in relatively small quantities. It is composed of a two nitrogen atoms and a single oxygen atom and is typically generated as a result of soil cultivation practices, particularly the use of commercial and organic fertilizers, fossil fuel combustion, nitric acid production, and biomass burning.

**Perfluorocarbons (PFCs) –** A GHG consisting of a class of gases containing carbon and fluorine. Originally introduced as alternatives to ozone depleting substances they are typically emitted as by-products of industrial and manufacturing processes.

**Regional District –** An administrative entity composed of regional municipalities and electoral areas. Regional districts provide a government for unincorporated areas, a forum for intermunicipal cooperation and are an organization upon which provincial mandates can by imposed such as for regional waste management planning.

**Sectors –** Records are organized into sectors that contain similar activities or emissions sources. Key community sectors include: residential, commercial and industrial buildings; transportation; and waste.

**Sulfur Hexafluoride ($SF_6$) –** a GHG consisting of a single sulfur atom and six fluoride atoms. Primarily used in electrical transmission and distribution systems.

**Vehicle Kilometres Traveled (VKT) –** A standard measure of vehicular traffic in a community. A VKT is equivalent to a single vehicle traveling one kilometre (regardless of the number of passengers).

**Vehicle Identification Number (VIN) –** A unique and identifying 17 digit alphanumeric code assigned to a vehicle by the manufacturer.

# ACRONYMS

| Acronym or Abbreviation | Full Name or Definition |
|---|---|
| **B.C.** | British Columbia |
| **CD** | Census Division |
| **CEEI** | Community Energy and Emissions Inventory |
| **CFS** | Canadian Forest Service |
| **$CH_4$** | Methane |
| **$CO_2$** | Carbon dioxide |
| **$CO_2e$** | Carbon dioxide (global warming) equivalent |
| **CSD** | Census Subdivision |
| **DLC** | Demolition, Land clearing, and Construction waste |
| **DOC** | Degradable Organic Carbon content |
| **EERMS™** | Energy and Emissions Reporting and Monitoring System |
| **EPA** | (US) Environmental Protection Agency |
| **FCM** | Federation of Canadian Municipalities |
| **GHG** | Greenhouse Gas |
| **GVW** | Gross Vehicle Weight |
| **HES** | Hyla Environmental Services Ltd. |
| **HFC** | Hydrofluorocarbon |
| **ICBC** | Insurance Company of British Columbia |
| **ICIS** | Integrated Cadastral Information Society |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **ISO** | International Organization for Standardization |
| **LFG** | Landfill Gas |
| **MSW** | Municipal Solid Waste |
| **NRCan** | Natural Resources Canada |
| **NVW** | Net Vehicle Weight |
| **PCP** | Partners for Climate Protection |
| **PFC** | Perfluorocarbons |
| **PNG** | Pacific Northern Gas (NE) Ltd. |
| **$SF_6$** | Sulphur hexafluoride |
| **SUV** | Sports Utility Vehicle |
| **TEEM™** | Transportation Energy and Emissions Module |
| **TMF** | Translation Master File |
| **VIN** | Vehicle Identification Number |

# APPENDIX 1: THE CEEI WORKING GROUP

## CEEI Working Group

In 2007, the CEEI Working Group committed to:

- establish a cost-effective provincially-sponsored, rigorous yet flexible, data collection, analysis and reporting system (the "community energy and emissions inventory" system);
- provide B.C. local governments with inventory baselines, ongoing monitoring and periodic reports; and
- help inform community decision making and support provincial objectives.

## Work to Date

To date, the following major project tasks have been completed:

- Prior to the formal establishment of the Community Energy and Emissions Inventory[64] (CEEI) initiative and Working Group, two studies were undertaken, and energy and emissions data was gathered to serve six pilot communities in the Province – Squamish, Smithers, Kamloops, Port Moody, Vanderhoof and Chilliwack. The resulting July 2007 "Streamlined Community Energy and Emissions Planning" (SEEP) report, captures views from those communities. In addition, Dawson Creek's inventory was completed in September, and the next 14 communities participating in the Province's CAEE program were also provided with draft inventories in the Fall 2007.
- A project Working Group was created in Spring 2007. The initial role of the Working Group included: overseeing the work of the successful consultants; and providing relevant advice from their agencies' perspectives.
- A Project Charter was drafted in May 2007, and has been periodically updated, confirming the project scope, key deliverables, project timing, and the broad role of Working Group.
- The first five CEEI background reports[65] were undertaken: two contracts were completed by the end of the calendar year 2007, and three additional contracts by July 2008:
  - *1/ B.C. inventory practices* – A scan of corporate and community-wide energy and greenhouse gas emissions inventorying being undertaken by B.C. local governments;
  - *2/ International best practices* – A "high level" view of the typical protocol(s), systems being used by a sampling of local governments in North America, and practices undertaken to complete energy and emissions inventories.
  - *3/ "User needs" analysis* – A survey of B.C. local and provincial government contacts, exploring their experiences and/or perceived needs for a provincially-sponsored community energy and emissions data warehouse, analysis and reporting system.
  - *4/ Supporting indicators* – An initial listing of indicators for each of the sectors – land use, transportation, buildings and solid waste. This has subsequently been undertaken by the Ministry of Community Services.

[65] A listing of all CEEI background reports and other relevant resources can be found on the CEEI Background Reports and Resource website @ http://www.env.gov.bc.ca/epd/climate/ceei/resources.htm.

  - *5/ Data and system requirements* – A Systems Needs and Gap Analysis was contracted out and, though incomplete at the time, the report was the genesis for a Systems Request for Information (RFI). An associated Data Requirements contract was let to Hyla Environmental Services in early 2008.
- By February of 2009, draft 2007 CEEI Reports were posted on a newly created Ministry of Environment website – www.env.gov.bc.ca/epd/climate/ceei/reports.htm – and subsequently linked to B.C. local governments' "first stop" on climate change website – www.toolkit.bc.ca/ceei – administered by the Fraser Basin Council.

## Planned Improvements

The Province of British Columbia will keep abreast of all relevant existing and new greenhouse gas emissions reporting programs, related protocols, and new approaches with the intent to continue to improve the nature and quality of CEEI reporting to local governments. CEEI will be annually reviewed for scope (e.g., pursue the inclusion of additional sectors or subsectors) and data updating.

Consistent with the spirit and intent of emerging community-based energy and emissions protocols, CEEI recognizes a number of the outstanding challenges that will require "continuous improvement" and work with both the sponsors of the relevant protocols and standards to overcome challenges facing the nature of such "geopolitical" inventories, and with B.C. communities themselves to ensure these "improvements" resonate with respect to their practical application:

- Confirming the "boundaries" for each emissions sector (the Province argues that while some existing protocol attempts to limit transportation emissions to within the geopolitical boundary, identifying the vehicles registered within that boundary is more practical and can be more meaningful for communities).
- Identifying and accessing suitable data sources (data such as fuel oil and propane are difficult to gather for all corners of the province).
- Continuing to improve data quality intended from various data sources, specifically for CEEI reporting. For example:
  - part or all of a "commercial" vehicle fleet may not be registered in the same community(ies) in which it operates;
  - in lieu of vehicle-specific kilometres travelled data (vkts from odometer readings), "proxy" measures, such as the use of ICBC vehicle transfer forms will have to suffice;
  - consistent "coding" classifications between utilities are required to more accurately align residential, commercial and industrial building classifications; and
  - continually improving landfill gas estimations towards and beyond 2012 legislative reporting requirements.
- Establishing a flexible baseline reporting structure for local governments that provide for reporting of additional modules.


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