

2013 B.C. BEST PRACTICES
METHODOLOGY FOR QUANTIFYING
GREENHOUSE GAS EMISSIONS
INCLUDING GUIDANCE FOR PUBLIC SECTOR
ORGANIZATIONS, LOCAL GOVERNMENTS AND
COMMUNITY EMISSIONS



Ministry of Environment
Victoria, B.C.
December, 2013

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1. Introduction

This document sets out the current best practices for quantifying and reporting greenhouse gas emissions from B.C.'s provincial public sector organizations, local governments and communities. B.C.'s best practices represent a robust and continually improving catalogue of emissions factors and emissions calculation methodologies that have drawn heavily on protocols established by the World Resources Institute and the Climate Registry, and published emission factors from authoritative sources such as: Natural Resources Canada, Environment Canada, the US Environmental Protection Agency and the UK Department of Environment, Food and Rural Affairs. This document also represents the consolidation of the previously stand alone versions of Public Sector, Local Government and Community Energy and Emissions Inventory emissions methodology guides. It can be used by anyone using these other documents, or other groups who wish to calculate their organization's corporate emissions. (Please note that the private sector entities subject to the B.C. Greenhouse Gas Inventory Report and Reporting Regulation must utilize quantification methods prescribed by the Regulation.)

Measuring greenhouse gas emissions is an important first step for improving the management of those emissions, and the activities/operations responsible for producing those emissions. Whether or not an organization plans to go carbon neutral, measuring and managing emissions can result in cost savings, increased organizational efficiencies and better asset management.

This document provides a consistent approach for measuring emissions that will allow any organization that is required to or wishes to voluntarily measure their greenhouse gas emissions a way to do so that is consistent with up to date best practices, and provides comparable emissions reporting province-wide.

1.1 Principles for Specifying Emission Factors

The following principles have been established by the province to guide the development of the greenhouse gas emissions (GHG) emission factors and estimation methods found in this document:

- 1) If information allows, the preference is to identify emission factors that best reflect individual circumstances, for example, an organization's particular source of electricity or fuel. Over time the government will seek to develop and apply B.C.-specific emission factors to improve the accuracy of GHG tracking.
- 2) Where B.C.-specific information is not available, standardized emission factors from national and international data sources will be used. In particular, factors will be taken from Canada's National GHG Inventory Report (NIR),¹ and other recognized sources (see Section 1.3).
- 3) A key principle is to facilitate emissions tracking and ensure that measurement and reporting requirements are not overly burdensome or costly. Therefore, in certain cases (such as where an emissions source is too small to justify additional data gathering by an organization) the government will provide simplified methods for estimating emissions.

¹ Environment Canada. (2013). *National Inventory Report: Greenhouse Gas Sources and Sinks in Canada 1990-2011*. Submission to the United Nations Framework Convention on Climate Change.

- 4) In developing simplified estimation methods, upper bound assumptions will be used in accordance with the principle of conservativeness – erring on the side of overestimating rather than underestimating emissions.

1.2 GHG Emission Factors Defined

Emission factors are expressed in kilograms (kg) or metric tonnes (t) of GHG emissions per unit of consumption activity. Typically, the factors for a given category of activity – for example, building energy or fleet fuel consumption – are expressed in common units to enable comparison across different fuel types, travel modes, etc.

The Carbon Neutral Government Regulation lists six distinct greenhouse gases or groups of gases: carbon dioxide (CO₂); methane (CH₄); nitrous oxide (N₂O); hydrofluorocarbons (HFCs); sulphur hexafluoride (SF₆); and perfluorocarbons (PFCs). For most organizations, the primary GHGs emitted in significant amounts are the three principal gases associated with fuel combustion for energy (CO₂, CH₄ and N₂O) and, to a much lesser extent, HFCs released from refrigeration and air conditioning equipment.²

In the case of liquid fossil fuel blends with biofuel (e.g., ethanol, biodiesel), gasoline or diesel are combined with varying proportions of biofuels (e.g., E10, B5, B20), resulting in emission factors that are weighted averages of the biofuel and fossil fuel factors. However, since international rules require the separate reporting of biogenic emissions from combustion (see Section 2.1); the CO₂ emissions from the biofuel component (Bio CO₂) must be calculated and reported separately from those of the fossil fuel component.

Wherever possible, emission factors are specified by individual gas. In certain instances, an aggregate factor for multiple gases is provided in kg or t of CO₂ equivalent (CO₂e) emissions. CO₂e is the standard unit for measuring and comparing emissions across GHGs of varying potency in the atmosphere (see Section 1.3).

1.3 Global Warming Potentials and Emissions Calculations

Greenhouse gases vary in their ability to trap heat in the atmosphere (radiative forcing)³. “Global warming potential” (GWP) is a measure of this ability. The GWP of a GHG accounts for both the immediate radiative forcing due to an increase in the concentration of the gas in the atmosphere, and the lifetime of the gas. The GWP for each GHG is expressed as the ratio of its heat trapping ability relative to that for CO₂. By definition then, the GWP of CO₂ equals one while CH₄, for example, has a GWP of 21, indicating that it’s radiative forcing is 21 times that of CO₂. In other words, releasing one tonne of CH₄ is equivalent to releasing 21 tonnes of CO₂, which can also be expressed as 21 tonnes of carbon dioxide equivalent (CO₂e). See Annex 8.2 for complete list of GWPs for all gases covered by the *Greenhouse Gas Reductions Targets Act (GGRTA)*.

² In British Columbia, PFCs and SF₆ are produced primarily in aluminum and magnesium smelting/processing and semiconductor manufacturing. SF₆ is also used as a cover gas in electricity transmission equipment.

³ The term “radiative forcing” refers to the amount of heat-trapping potential for a GHG, measured in units of power per unit of area (watts per metre squared).

GWPs are particularly important within the context of emissions reporting since international protocols require the reporting of both individual GHGs and their carbon dioxide equivalents (CO₂e). For this reason, the calculation of GHG emissions generally involves (1) multiplying the emission factor for a GHG by an appropriate measure of consumption (activity) to produce the corresponding emissions for that GHG and then (2) multiplying those emissions by its GWP to produce the corresponding CO₂e emissions.

The primary source document for emission factors is the *British Columbia Greenhouse Gas Inventory Report 2010* (PIR).⁴ Where provincial data is not available, the factors from Environment Canada's *National Inventory Report: Greenhouse Gas Sources and Sinks in Canada 1990-2011* have been used.^{5,6}

International documents, such as the Climate Registry's *General Reporting Protocol*,⁷ have been used for some emission factors. B.C.-specific emission factors have been developed in other cases, using data provided by energy companies and business travel providers.

The emission factors reported in this document represent the B.C. government's understanding of the factors appropriate for emission sources and fuel types in 2013. As experience is gained with estimating GHG emissions, the list of emission factors may be expanded. It is also expected that the factors themselves and other key inputs (e.g., energy conversion factors, GWPs) will be updated as GHG measurement methodologies and data sources evolve.

1.4 Users/Audience

1.4.1 Public Sector Organizations

In November 2007, British Columbia enacted legislation to establish provincial goals for reducing greenhouse gas (GHG) emissions. Under the *Greenhouse Gas Reductions Targets Act (GGRTA)*, the B.C. public sector must be carbon neutral in its operations for 2010 and every year thereafter.⁸ Beginning for the 2008 calendar year, provincial public sector organizations (PSOs)⁹ are required to report annually, in accordance with the *GGRTA* and the *Carbon Neutral Government Regulation (CNGR)*.

The *CNGR* defines the activities or emission sources that are "in scope" for the purposes of PSO emission reporting and offsetting. Since it was introduced in 2008, "in scope" activities/sources have been clarified through a series of policy decisions, which have been summarized in the Scope Summary Document which is available at the following [link](#).

⁴ British Columbia (2012). *British Columbia Greenhouse Gas Inventory Report 2010*. Annex 10.3 provides standardized factors for stationary and mobile fuel consumption and other emitting activities.

⁵ Environment Canada (2013). *National Inventory Report: Greenhouse Gas Sources and Sinks in Canada 1990-2011*.

⁶ The PIR factors match most of those found in the NIR, however, for simplicity and ease of use, the PIR factors will be referenced throughout this document where the data is available in both documents.

⁷ The Climate Registry (2013). *General Reporting Protocol*, Version 2.0 & 2013 Climate Registry Default Emission Factors. B.C. is a member of the Climate Registry, which is a cross-border initiative to develop common measurement, verification and reporting requirements for GHG emissions. See: www.theclimateregistry.org.

⁸ See www.env.gov.bc.ca/cas/legislation/index.html#GGRTA, for the *Greenhouse Gas Reduction Targets Act*, Bill 44 – 2007 and the *Carbon Neutral Government Regulation*, B.C. Reg. 392/2008. The legislation also requires core government business travel to be carbon neutral as of October 2007. This requirement does not apply to the broader provincial public sector, as defined in Note 12.

⁹ PSOs encompass core government entities funded through the Consolidated Revenue Fund (e.g., ministries, special offices, and tribunals) and broader public sector agencies – health authorities, school districts (K-12), colleges and universities, and Crown corporations under the Government Reporting Entity.

The government has developed its own web-based applications to assist with GHG measurement and reporting. “SMARTTool” calculates and reports the emissions from PSO buildings, supplies (paper) and fleet vehicles and equipment. “SMARTTEC,” the SMART Travel Emissions Calculator, computes the GHGs from government business travel and reports the emissions through SMARTTool. The emission factors and methodologies documented in this report are used by both applications to estimate GHG emissions.

The following sections of this document apply directly to PSOs for their in-scope activities:

- Section 2: Stationary Sources: Buildings, Etc
- Section 3: Indirect Emissions: Supplies (Paper)
- Section 4: Mobile Sources: Fleet
- Section 5: Business Travel (Provincial Government only)¹⁰
- Section 7: Sample Calculation
- Section 8: Annexes – Glossary of Terms, Global Warming Potentials, Building Energy Estimation Methods, etc.

For each activity category, a brief description is given along with an explanation of data sources and emission factor calculations.

1.4.2 Local Governments

The majority of local governments in B.C. have voluntarily signed the Climate Action Charter (CAC), committing to develop strategies and take actions to achieve the following goals:

- being carbon neutral in respect of their operations by 2012;¹¹
- measuring and reporting on their community’s GHG emissions profile; and
- creating complete, compact, more energy efficient rural and urban communities

Under the Climate Action Charter the joint Provincial Government – Union of British Columbia Municipalities (UBCM) Green Communities Committee (GCC) was created to support local governments in planning and implementing climate change initiatives. The Carbon Neutral Working Group (the working group) was established to advise the GCC in carrying out this mandate with respect to corporate carbon neutrality. The GCC and the working group collaborated to produce the Carbon Neutral Workbook (the Workbook), which provides guidance to local governments on what is in scope to measure and offset within the boundaries of their corporate emissions. The boundaries for calculating emissions are based on the energy used in the delivery of traditional local government services:¹²

- Administration and Governance;
- Drinking, Storm and Waste Water;

¹¹ Solid waste facilities regulated under *the Environmental Management Act* are not included in operations for the purposes of this Charter.

¹² Within the traditional service sectors not all emissions will be captured. Any emissions related to the operation and maintenance of traditional services are included. Emissions related to new construction, business travel, employee commuting and materials are not included.

- Solid Waste Collection, Transportation and Diversion;
- Roads and Traffic Operations;
- Arts, Recreational and Cultural Services; and
- Fire Protection.

With its own commitment to a carbon neutral public sector for 2010, the BC government developed a web-based application to assist with GHG measurement and reporting. “SMARTTool” calculates and reports the GHG emissions from buildings, fleet vehicles and equipment, paper and travel (the latter for core government only).

Local governments may choose to use SMARTTool, but the GCC also supports the use of other GHG measurement tools for the purposes of the Climate Action Charter. To ensure methodology, emission factors and outputs from other tools are consistent and comparable with SMARTTool results, a local government choosing to use another inventory and reporting tool will be required to meet the following standards:

1. Use the same corporate boundaries as defined in the Workbook;
2. Use the GHG measurement methods and emission factors in this guide, and updates as provided by the Climate Action Secretariat
3. Complete and adhere to the Business Processes Checklist
4. Report on annual total corporate emissions and offsets as calculated by a GHG inventory tool (via an Energy Consumption Summary Reporting Template); and
5. Obtain Chief Administrative Officer (CAO)/ Chief Financial Officer (CFO) attestation that all of the above listed actions were taken (via the *Self Certified Business Process Checklist*).

All of the supporting materials for these standards are available on the Climate Action Toolkit website at: <http://www.toolkit.bc.ca/resource/becoming-carbon-neutral-workbook-and-guidebook>

The primary purpose of this document is to detail the emission factors and methodology used for calculating and reporting local government emissions. Emission factors express the mass of GHGs resulting from a specific kind of activity (e.g., how many kilograms of carbon dioxide are produced by burning one litre of gasoline in a car). The document is also designed to provide background information regarding how the emissions factors were determined; including references to source materials and any calculations applied to emissions factors.

This document will be periodically revised to reflect changes or clarifications to the emission factors, methodologies and scope. Local government users should ensure that they are using the most current version of this document each year. These will be housed on the Toolkit website at: www.toolkit.bc.ca

By understanding and applying the information contained in this methodology document and completing the *Self Certified Business Process Checklist for SMARTTool/ Alternative Tool* available at www.toolkit.bc.ca, local governments can be assured that their GHG emissions inventory are accurate and consistent with those being developed by local governments across British Columbia

1.4.3 Other Users (Communities/Academics/Consultants/etc.)

Other potential users of this document include the broad community of users of the Community Energy and Emissions Inventory (CEEI) reports, energy and emissions modelling and planning consultants, energy utilities, academic researchers and non-governmental organizations. It is also worth noting that the CEEI is gaining increasing exposure outside of B.C. as international audiences begin to recognize the leading-edge work that is occurring.

Typically the CEEI reports are released along with a Technical Methods and Guidance Document that details the process by which the greenhouse gas emissions estimates in the CEEI reports are produced. Using common emission factors and referring to this document in the specific guidance material for the CEEI program will ensure comparability across the different programs referenced above.

1.5 Structure of this Report

The remainder of this report provides the information necessary to understand how the emissions factors were determined, what they are and how to apply them to calculate emissions from a given activity/source. The information provided in this document should be used by organizations to calculate emissions and ensure their inventories are consistently based on the standard approach developed by Ministry of Environment and used by SMARTTool.

Sections 2, 3, 4, 5 and 6 provide the emissions factors for stationary, indirect, mobile, business travel and agricultural sources respectively. In each of these sections and for each activity category, a brief description is provided along with an explanation of data sources and emission factor calculations. The data sources and calculations are provided to ensure accountability and transparency in emissions reporting.

Section 7 provides a sample calculation based on the emission factor, energy conversion factor and global warming potentials provided in this document. It provides an example for how emissions are calculated from a given activity, and can be used as the basis for calculating emissions factors using the information provided in this document.

2. Stationary Sources: Buildings, Etc

GHG emissions are produced from activities associated with the lighting, heating and cooling of facilities, and the powering of machinery and equipment within those facilities.¹³

2.1 Direct Emissions: Stationary Fuel Combustion

Description: Several different fossil fuels may be consumed in buildings: natural gas; propane; light fuel oil (No. 2 heating oil); kerosene; marine diesel; diesel fuel; and gasoline. In addition, several organizations burn wood fuel and wood waste in some of their buildings. For the purposes of SMARTTool reporting and in alignment with international reporting requirements, biogenic

¹³ See www.env.gov.bc.ca/cas/legislation/index.html#GGRTA for the *Carbon Neutral Government Regulation*, B.C. Reg. 392/2008.

emissions (BioCO₂) from biomass combustion, including wood, wood waste, ethanol, biodiesel and biomethane must be reported.¹⁴

For biomass combustion, BioCO₂ emissions must be reported separately from CH₄ and N₂O emissions¹⁵. PSOs are only required to offset the CH₄ and N₂O emissions from biomass combustion. Any organization considering biomass should be aware that there are ongoing international discussions around the proper treatment of biomass and how to best account for the BioCO₂ storage and emissions of different harvested wood products (e.g. waste wood vs. virgin wood) and the associated forest management practices occurring on the land base. The risk of future accounting changes will be minimized to the extent that biomass is diverted from waste streams, that biomass is used for the most appropriate long-term purposes and that non-waste biomass comes from sustainably managed forest lands.

In SMARTTool, stationary fuel consumption data are entered either in common units of energy usage (i.e., Gigajoules – GJ) or are converted to GJ within the application itself.

Data sources: The standardized emission factors for stationary fuel combustion can be found in two sources; Table 34 of the 2010 PIR,¹⁶ and the 1990-2011 NIR as follows.¹⁷

- The natural gas CO₂ emission factor is taken from Table A8-1 (NIR) under the entry “British Columbia – Marketable”.
- The natural gas CH₄ and N₂O emission factors are taken from Table A8-2 (NIR) under “Residential, Construction, Commercial/Institutional, Agriculture”.
- The propane emission factors are taken from Table A8-3 (NIR) under the entries for “All Other Uses”.
- The light fuel oil, kerosene and diesel emissions factors are taken from Table A8-4 (NIR) (with light fuel oil and kerosene falling under “Forestry, Construction, Public Administration and Commercial/Institutional” and diesel falling under “Refineries and Others”).
- The gasoline and marine diesel emissions factors are taken from Table A8-11 (NIR) under the respective entries for “Off-Road Gasoline” and “Diesel Ships”.
- The wood emissions factors are taken from Table A8-26 (NIR) under the entries for “Wood Fuel/Wood Waste Industrial Combustion” and “Conventional Stoves Residential Combustion”.

¹⁴ The CO₂ released to the atmosphere during combustion of biomass is assumed to be the same quantity that had been absorbed from the atmosphere during plant growth. Because CO₂ absorption from plant growth and the emissions from combustion occur within a relatively short timeframe to one another (typically 100-200 years), there is no long-term change in atmospheric CO₂ levels. For this reason, biomass is often considered “carbon-neutral” and the Intergovernmental Panel on Climate Change (IPCC) *Guidelines for National Greenhouse Gas Inventories* specifies the separate reporting of CO₂ emissions from biomass combustion. See: IPCC (2006), *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, p. 5.5; and the Climate Registry (2013), *General Reporting Protocol Version 2.0*, p. 36.

¹⁵ Based on current international standards, British Columbia already reports the CH₄ and N₂O portions of biomass combustion as line items in the Provincial Inventory Report. BioCO₂ biomass emissions are currently reported as memo items.

¹⁶ British Columbia (2012). *British Columbia Greenhouse Gas Inventory Report 2010*, pp. 67-68.

¹⁷ Environment Canada (2013). *National Inventory Report: Greenhouse Gas Sources and Sinks in Canada 1990-2011*, Annex 8 pp. 193-207.

Energy conversion factors to convert to GJ from cubic metres of natural gas and litres of liquid fuels are from Statistics Canada’s most recent *Report on Energy Supply and Demand in Canada (RESO)*.¹⁸

Calculations: In B.C., the *Renewable and Low Carbon Fuel Requirements Regulation (RLCFR)*¹⁹ sets benchmarks for the amount of renewable fuel in the provinces transportation and heating fuel blends. Effective January 1st, 2011, fuel suppliers are required to incorporate renewable fuel contents of 5% for gasoline and 4% for diesel into the sum of total fuel sold at a provincial level. In SMARTTool, for any given volume of reported gasoline consumption, 95% of the fuel is fossil fuel gasoline and the remaining 5% is ethanol. For Diesel, 96% is fossil fuel diesel and 4% is biodiesel.

Additionally, FORTIS has launched its renewable natural gas product for customers in the Lower Mainland, Fraser Valley, Interior and the Kootenays. Eligible customers have the option of designating a percentage of their natural gas usage as renewable natural gas by paying a percentage premium. FORTIS purchases biogas, inserts it into its distribution network and allocates it to customers according to the percentage premium they paid. The renewable natural gas component displaces the equivalent amount of conventional natural gas and is a renewable fuel source. For any given volume of reported FORTIS natural gas where the biomethane premium has been purchased; customers will enter the premium portion as biomethane consumption in GJs into SMARTTool, and the remainder will be entered as natural gas consumption in GJs into SMARTTool. The emission factors in Table 1 have been calculated by applying the energy conversion factors shown to the emission factors in Table 2: Source Emission Factors – Stationary Fuel Combustion. The original emission factors were adjusted only to convert them from grams to kg per unit of fuel use, except in the case of gasoline and diesel fuels, where the numbers were adjusted to account for the renewable fuel content under the *RLCFR*.

Table 1: Stationary Fuel Combustion

Fuel Type	Energy Conversion Factor	Emission Factor (kg/ GJ)				
		Bio CO ₂	CO ₂	CH ₄	N ₂ O	CO ₂ e
Natural Gas	0.03856 GJ/ m ³	–	49.69	0.0010	0.0009	49.99
Propane	0.02531 GJ/ L	–	59.54	0.0009	0.0043	60.88
Acetylene ²⁰	0.05480 GJ / m ³	–	67.87	*	*	67.87
Light Fuel Oil	0.03880 GJ/ L	2.75	67.42	0.0007	0.0008	67.68
Kerosene	0.03768 GJ/ L	–	67.25	0.0007	0.0008	67.51
Diesel Fuel	0.03830 GJ/ L	2.75	66.75	0.0035	0.0104	70.05
Marine Diesel	0.03830 GJ/L	2.75	66.75	0.0039	0.0287	75.73
Gasoline	0.03500 GJ/ L	3.19	62.13	0.0771	0.0014	64.18
Wood Fuel – Industrial (50% moisture)	0.00900 GJ/ kg	93.33	–	0.0100	0.0067	2.29
Wood Fuel - Residential	0.01800 GJ/ kg	94.22	–	0.8333	0.0089	20.26

¹⁸ Statistics Canada (2013). *Report on Energy Supply and Demand in Canada 2011*, p. 121.

¹⁹ See <http://www.empr.gov.bc.ca/RET/RLCFRR/Pages/default.aspx> for the *Renewable and Low Carbon Fuel Requirements Regulation*, B.C. Reg. 394/2008.

²⁰ Values were calculated based on data from: The Climate Registry (2013). *General Reporting Protocol*, Climate Registry default emission factors Released April 2, 2013. These values can be used as conservative estimates for all welding gases.

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Ethanol (E100)	0.02342 GJ/L	63.79	–	a	a	a
Biodiesel (B100)	0.03567 GJ/L	68.66	–	b	b	b
Biomethane	0.03135 GJ/ m ³	49.35	–	c	c	c

^a Gasoline CH₄ and N₂O emission factors (by mode and technology) are used for ethanol.

^b Diesel CH₄ and N₂O emission factors (by mode and technology) are used for biodiesel.

^c Natural Gas CH₄ and N₂O emission factors (by mode and technology) are used for biomethane.

* Note: Literature on CH₄ and N₂O emissions from Acetylene could not be obtained.

Table 2: Source Emission Factors – Stationary Fuel Combustion²¹

Fuel Type	Units	Bio CO ₂	CO ₂	CH ₄	N ₂ O	CO ₂ e
Natural Gas	kg/ m ³	–	1.916	0.000037	0.000035	1.928
Propane	kg/ L	–	1.507	0.000024	0.000108	1.541
Acetylene	kg/m ³	–	3.719	*	*	3.719
Light Fuel Oil	kg/ L	0.0980	2.616	0.000026	0.000031	2.626
Kerosene	kg/ L	–	2.534	0.000026	0.000031	2.544
Diesel Fuel	kg/ L	0.0980	2.557	0.000133	0.0004	2.684
Marine Diesel	Kg/L	0.0980	2.557	0.00015	0.0011	2.901
Gasoline	kg/ L	0.0747	2.175	0.0027	0.00005	2.247
Wood Fuel – Industrial (50% moisture)	kg/ kg	0.840	–	0.00009	0.00006	0.020
Wood Fuel - Residential	kg/ kg	1.696	–	0.015	0.00016	0.365
Ethanol (E100)	Kg/L	1.494	–	a	a	a
Biodiesel (B100)	Kg/L	2.449	–	b	b	b
Biomethane	Kg/m ³	1.547	–	c	c	c

^a Gasoline CH₄ and N₂O emission factors (by mode and technology) are used for ethanol.

^b Diesel CH₄ and N₂O emission factors (by mode and technology) are used for biodiesel.

^c Natural Gas CH₄ and N₂O emission factors (by mode and technology) are used for biomethane.

* Note: Literature on CH₄ and N₂O emissions from Acetylene could not be obtained.

2.2 Indirect Emissions: Purchased Electricity for Stationary Sources

Description: In a hydroelectric-based power system such as British Columbia's, the GHG emissions from electricity can vary significantly from year to year. This variation is influenced by both the quantity purchased by consumers, and variation in water supply conditions and reservoir levels. During years with low stream flows and/or low reservoir levels, available hydro power must be supplemented through fossil-fuel (thermally) generated electricity purchased from neighbouring jurisdictions and/or through increased use of local thermal generation leading to higher provincial

²¹ See Environment Canada (2013). *National Inventory Report: Greenhouse Gas Sources and Sinks in Canada 1990-2011.*, and British Columbia (2012). *British Columbia Greenhouse Gas Inventory Report 2010.*

GHG emissions. During years with higher stream flows and/or high reservoir levels, less thermal power is needed and GHG emissions are relatively lower.

Emissions also differ among B.C.'s electric utilities with each having different ratios of hydro to thermal power in their supply mixes. Depending on their building locations, consuming organizations may acquire electricity from BC Hydro, FortisBC or a municipal distributor.²² In addition, some organizations may currently have properties in other provinces (e.g. Alberta and Ontario) and countries (e.g. England, Japan and China).

Some organizations purchase Renewable Energy Certificates (REC's), Green Rights or Green Power from Green Power suppliers. In the case of PSOs, emissions reduced by purchasing RECs are only recognized in jurisdictions where 50% or more of the power is produced from fossil fuel generators and where it has been demonstrated there is a reasonable level of assurance that the REC's are appropriately verified.

SMARTTool captures data on electricity consumption in kilowatt-hours (kWh) and makes the conversion to GJ of energy.

Data sources: BC Hydro reported GHG emissions in its Annual Report and as part of a Global Reporting Initiative (GRI) Index up until 2013.²³ This reporting included domestic purchases of electricity from independent power producers (IPPs), which together accounted for the largest share of BC Hydro's reported emissions (74 percent in 2010). They now report their GHG emissions on their website.²⁴ The emissions associated with electricity imports for domestic use are not included. This exclusion will be evaluated as more information becomes available and as policy evolves in regard to imported electricity.²⁵ Taken from the BC Hydro website, the emission factor reported in Table 3 below for BC Hydro represents the sum of emissions from BC Hydro power facilities and IPP purchases, divided by the electricity generated at those sources.²⁶

While FortisBC and the municipal distributors do not publicly report GHG emissions, their emissions can be estimated from electricity supply data. Information on the recent (2009) supply mix was obtained directly from utility contacts.

For all provinces, the NIR reports annually on total GHG emissions, electricity generation and GHG intensity for public utilities as a whole,²⁷ thus the most recent version of the NIR is used for buildings in other provinces.

²² There are six municipal electric utilities, respectively serving Grand Forks, Kelowna, Nelson, New Westminster, Penticton and Summerland.

²³ See Indicator EN16(2) of the GRI Index at: http://www.bchydro.com/about/accountability_reports/2011_gri/f2011_environmental_EN16_2.html

²⁴ See http://www.bchydro.com/about/sustainability/climate_action/greenhouse_gases.html

²⁵ Under voluntary international GHG protocols, BC Hydro is not required to measure and report the emissions from purchased electricity – either domestic or imported – that is passed on to consumers. BC Hydro has chosen to voluntarily report the emissions from domestic IPP purchases, but import-related emissions are not yet included in its GHG inventory. Starting in 2011, importers of electricity are required to report GHG emissions associated with the generation of this electricity under B.C.'s *Reporting Regulation*.

²⁶ See http://www.bchydro.com/about/sustainability/climate_action/greenhouse_gases.html

²⁷ See, Environment Canada (2013). *National Inventory Report 1990-2011 Part 3*, Table A13-7 for Ontario, and A13-10 for Alberta.

For properties in other countries, information is available from the International Energy Agency (IEA) on CO₂ emissions per kWh from electricity and heat generation.²⁸ The published three year rolling averages (2008-2010) for individual countries were incorporated into this report. These data can be used to estimate emission factors for fossil fuel combustion in international cities.

Calculations: In Table 3 below, the BC Hydro emission factor is based on the reported GHG Intensity for the utility's total domestic supply. The emission factor of 14 tonnes CO₂e per Gigawatt-hour (GWh) has been calculated as an average of BC Hydro's GHG intensities for 2010 through 2012.²⁹ A rolling three-year average is used to partially smooth out the annual fluctuation in the electricity emission factor due to changing water conditions.³⁰

The FortisBC emission factor of 3 tCO₂e/ GWh has been estimated using a weighted average of the GHG intensity of Fortis' own hydroelectric plants, purchased hydro and other renewable electricity, and purchases from BC Hydro. In calculating this average, a zero emission factor was assigned to existing hydro and other renewable (energy from wood waste) generation and purchases, which accounted for just over three-quarters of the utility's 2009 supply.³¹ The BC Hydro emission factor was then applied to the remaining purchases in the supply mix.

Since the cities of Grand Forks, Kelowna, Penticton and Kelowna acquire all of their electricity from FortisBC, they are assigned the FortisBC emission factor. Likewise, the City of New Westminster is redistributes BC Hydro electricity and so is given its emission factor. The City of Nelson's municipal utility, Nelson Hydro, generates about 55 percent of its annual electricity requirements from a local hydro plant and purchases the rest from Fortis.³² These supply shares and the Fortis emission factor have been used to estimate a weighted average emission factor of 1.4 tCO₂e/GWh.

The electricity emission factors for Alberta and Ontario are the three-year (2009-2011) average values reported for "Overall Greenhouse Gas Intensity" in the 1990-2011 NIR.³³ Their large magnitude relative to the B.C. emission factors reflects the substantially higher shares of fossil-fired generation in the supply mix, particularly in Alberta's case. Going forward, if additional emission factors are needed for facilities in other provinces, they will be calculated in the same manner as those for Alberta and Ontario.

The emission factors for the U.K., India, Japan, China and Hong Kong required no further calculations as their values were already calculated and published as CO₂e emissions per kWh from electricity and heat generation³⁴.

²⁸ See IEA (2012), *2012 CO₂ Emissions for Fuel Combustion – Highlights*, pp. 111-113.

²⁹ The reported GHG intensities were 23, 9 and 9 tCO₂e/GWh, respectively, for 2010, 2011 and 2012.

³⁰ Since there is a lag in collecting and reporting GHG emissions data, the emission factor estimated for the most recent calendar year of data available (e.g., 2011) may not necessarily reflect the water conditions in the current year for which emissions are being measured (e.g., 2013). Averaging over a three-year period will reduce the year-to-year differences.

³¹ Wood waste generated electricity has been assigned a zero emission factor given that the CO₂ emissions from biomass are not included in Fortis' GHG inventory under international reporting rules.

³² See: www.nelson.ca/EN/main/services/electrical-services.html.

³³ Environment Canada (2013). *National Inventory Report 1990-2011 Part 3*, Table A13-7, p. 72 for Ontario, and Table A13-10, p. 75 for Alberta.

³⁴ See IEA (2012), *2012 CO₂ Emissions for Fuel Combustion – Highlights*, pp. 111-113.

Table 3: Purchased Electricity

Public Utility	Emission Factor (tCO ₂ e/ GWh)	Emission Factor (kgCO ₂ e/ GJ)
BC Hydro ³⁵	14	4
Kyuquot Power	14	4
FortisBC	3	1
City of Grand Forks	3	1
City of Kelowna	3	1
Nelson Hydro	1.4	0.4
City of New Westminster	14	4
City of Penticton	3	1
City of Summerland	3	1
Alberta	823	229
Ontario	111	31
United Kingdom	470	131
India	936	260
Japan	424	118
China	790	219
Hong Kong	748	208

Note: Energy Conversion Factor = 0.0036 GJ/kWh

2.3 Indirect Emissions: District Energy Systems, Purchased Steam, Hot Water, Etc. for Stationary Sources

Description: A number of organizations use energy such as steam to heat buildings. Some (e.g., UBC, Vancouver Coastal Health Authority) produce heat, use a portion for their own consumption and sell the surplus. Others purchase heating and/or cooling from a commercial district energy supplier, such as Vancouver’s Central Heat Distribution Ltd. These providers meet the definition of a District Energy System: *a community scale network of pipes that with the aid of steam, hot or chilled water carry thermal (i.e. heating and/or cooling) energy services to a collection of buildings in a defined geographic area.* This thermal energy can be created using a variety of input feedstock fuels including biomass (forest, agricultural, municipal solid waste), biogas, renewable energy forms (e.g. geo-exchange), natural gas, and cool water. As such, it provides the opportunity to utilize locally available fuels to generate hot and cool space conditioning at a community scale and, importantly, the opportunity to centrally substitute feedstock fuels over time. This is an important way for communities to create sustainable,

³⁵ The BC Hydro emissions factor also applies to emissions from 74 independent power projects that are off of the North American grid, but that sell power to BC Hydro. Some of these include the Central Coast Power Corporation (Ocean Falls in Bella Bella), the Clean Power Operating Trust (Hluey Lake in Dease Lake), the Coastal Rivers Power LP (Sandspit), and XEITL Limited Partnership (Pine Creek in Atlin).

resilient energy delivery systems and manage risks of being dependent on any one fuel or technology.”³⁶

Where an organization produces heating or cooling for its own consumption, the resulting GHG emissions are determined by applying the appropriate combustion emission factors to the quantity of fuels consumed by the system (refer to section 2.1). Where an organization purchases heating or cooling from another entity, estimating emissions requires information on the fuels consumed as well as and the generation, distribution and system efficiencies.

Data sources: The average efficiency of district energy systems can vary significantly depending on characteristics such as the age of the plant, distribution losses and operation and maintenance practices. A District Energy emissions calculator based on the General Reporting Protocol³⁷ has been developed for the 2013 reporting year for organizations to help them determine which of the tiers in Table 4 below they should use for emissions measurement and reporting purposes. Having calculated an emissions intensity using the calculator, an organization should compare it with the thresholds set out in Table 4. The organization should select the one tier where the calculated value falls between the upper and lower thresholds. The calculator can be found at: <http://www.env.gov.bc.ca/cas/mitigation/pdfs/DES-Calculator.xlsx>. Organizations that previously entered their purchased steam in pounds or kg into SMARTTool for conversion into GJ of energy will be able to continue doing so. Note the previous tiered steam emission factors for steam (Natural Gas at 65%, 75%, and 85%) from the 2012 BC Best Practices Document have been carried over into the new tiers in Table 4. The RESD provides an average conversion factor for translating kg of steam into GJ of energy³⁸

Organizations should document all of the variables they input into the calculator as a record for the reference of other/future staff, for annual Self Certification purposes and possible third party verification. This documentation should be updated on an annual basis as system efficiencies will vary based on local climate, exposure, occupancy patterns, heating controls, insulation, and other factors. Documentation should also be sent to climateactionsecretariat@gov.bc.ca. Use the same email address for any questions about the foregoing.

Note: Where a PSO produces heating/cooling energy and sells a portion to another PSO, the producer must either report that quantity of energy sold as a negative value in SMARTTool, or separately identify the emissions from the sales using the District Energy calculator. These emissions are then deducted from the producer’s GHG inventory to avoid double counting when aggregating emissions across the B.C. public sector. However, if an organization produces heating/cooling energy and sells a portion to another organization that is not a PSO, they must report in full the emissions produced from the generation and distribution of that energy.

³⁶ See the International District Energy Associations (2013) definition at: <http://www.districtenergy.org/what-is-district-energy>

³⁷ The Climate Registry (2013). *General Reporting Protocol*, Version 2.0

³⁸ Statistics Canada (2013). *Report on Energy Supply and Demand in Canada 2011*. p. 121

Table 4: District Energy Systems: Emission Tiers/Thresholds

Example Fuel Type(s) and System	Tier	tCO ₂ e/GWh	tCO ₂ e/GJ
		Lower – Upper Thresholds	Lower – Upper Thresholds
Biomass at 65% system efficiency	1	50.45 - 84.39	0.0140 - 0.0233
25% Natural Gas / 75% Renewable at 75% system efficiency	2	84.40 – 118.29	0.0234 - 0.0328
50% Natural Gas / 50% Renewable at 85% system efficiency	3	118.30 - 152.19	0.0329 - 0.0422
50% Biomass / 50% Natural Gas at 65% system efficiency	4	152.20 - 186.09	0.0423 - 0.0516
75% Natural Gas / 25% Renewable at 75% system efficiency	5	186.10 – 220.09	0.0517 - 0.0610
Natural Gas at 85% system efficiency	6	220.00 - 253.89	0.0611 - 0.0704
Natural Gas at 75% system efficiency	7	253.90 - 287.79	0.0705 - 0.0798
Natural Gas at 65% system efficiency	8	287.80 - 321.69	0.0799 - 0.0893
Gasoline at 75% system efficiency	9	321.70 - 355.59	0.0894 - 0.0987
Gasoline at 65% system efficiency	10	355.60 and higher	0.0988 and higher

2.4 Direct Fugitive Emissions: Stationary Air Conditioning and Refrigeration

Description: Fugitive emissions from stationary air cooling are attributed to the leakage and loss of HFC and PFC based coolants from air conditioning and commercial type refrigeration systems. Coolant loss can occur during the manufacturing, operation, and disposal of such equipment.

Data sources: The Climate Registry offers three methods for reporting and/or estimating emissions from stationary air conditioning and refrigeration. The “Mass Balance” and “Simplified Mass Balance” methods can be used to measure and report coolant loss when information on system charges, top-ups, coolant disposal and coolant recycling is available. The Climate Registry also provides a “Screening Method” to estimate fugitive emission releases from HFC and PFC coolants when detailed information is not available.³⁹

Calculations: Emissions from stationary air conditioning and refrigeration for the BC Government were calculated using both the “Simplified Mass Balance” and “Screening Method” using HVAC incident report log and equipment inventory information.

Table 5: GHG Emissions from Stationary Air Conditioning and Refrigeration across the B.C. Government (Consolidated Revenue Fund) Portfolio

Year	Calculation Method	Calculated tCO ₂ e	Total 2008 CRF GHG tCO ₂ e	HFC Composition
2007	Simplified Mass Balance	2.33	104,753	0.0022%
2008	Simplified Mass Balance	6.61	104,753	0.0063%
2007/8	Screening Method	2.75	104,753	0.0026%

³⁹ The Climate Registry (2013). *General Reporting Protocol Version 2.0*, pp. 123-133.

Use of either method produced emissions estimates significantly less than 1% for PSOs. This is attributable in part to the prevalence of R-22, an HCFC based coolant that is not in scope for reporting under the CNGR, and in widespread use amongst PSO's.

Based on these estimates, it is expected that the fugitive emissions from stationary cooling are significantly less than 1% (approximately 0.01%) of each PSOs/local governments' total GHG footprint. If these fugitive emissions are also onerous to measure and collect, PSOs/local governments should examine the "how to treat small emissions" decision tree in the Annex 8.3.

Organizations who wish to voluntarily report on HFC and PFC emissions from stationary cooling may use the "Mass Balance" or "Simplified Mass Balance" methods as described in Chapter 16 of Climate Registry's General Reporting Protocol⁴⁰ to calculate and report emissions from these sources. Depending on the method chosen, organizations may require detailed information on refrigeration system purchases, servicing, and retirement.

3. Indirect Emissions: Supplies (Paper)

Another source of indirect emissions is the purchase of paper.

Description: Emission factors for office paper are differentiated by size and the percentage of post-consumer recycled (PCR) content. In practice, the PCR content can range between 0 and 100 percent.⁴¹

Three different sizes of office paper (any colour) are currently in scope – 8.5" x 11", 8.5" x 14" and 11" x 17". In each case, data on the number of 500-sheet (20lb) packages are entered into SMARTTool.

Some organizations may have begun to use alternative paper types such as wheat, eucalyptus, sugarcane, bamboo, etc. While these papers likely have emission factors that differ from conventional paper, limited literature is currently available on their carbon intensity. As a best approximation, the emission factors in Table 6 for 100% PCR of the corresponding paper size should be applied to these alternative papers.

Data sources: Ideally, it would be best to specify emission factors that accurately reflected the manufacturing process for specific paper purchases. In the absence of paper-specific information, proxy emission factors have been derived from the Environmental Paper Network (EPN) Paper Calculator.⁴² This tool assesses the lifecycle impacts of paper production and disposal and is updated regularly with peer-reviewed data.

The Paper Calculator inputs the paper grade (e.g., copy paper), quantity by weight and PCR content and estimates the associated GHG emissions in pounds of CO₂e.

⁴⁰ The Climate Registry (2013). *General Reporting Protocol Version 2.0*, pp. 123-133.

⁴¹ See the Copaper Database at www.canopyplanet.org/EPD/index.php for a listing of papers available in the Canadian marketplace and their PCR contents.

⁴² See: <http://c.environmentalpaper.org/baseline>

Table 6: Office Paper

PCR Content (%)	Emission Factor (kg CO ₂ e/ pkg)		
	8.5" x 11"	8.5" x 14"	11" x 17"
0	6.358	8.094	12.743
10	6.123	7.795	12.272
20	5.888	7.496	11.802
30	5.653	7.197	11.331
40	5.418	6.898	10.860
50	5.184	6.599	10.390
60	4.949	6.300	9.919
70	4.714	6.001	9.449
80	4.479	5.703	8.978
90	4.244	5.404	8.508
100	4.010	5.105	8.037

Note: emission factors for office paper are based on a 500-sheet package of 20-pound bond paper weighing 2.27, 2.89 and 4.55 kg, respectively, for the three paper sizes.

Calculations: To generate the emission factors in Table 6, the weight of a 500-sheet package was first determined for each paper size. This weight (in metric tons) and the PCR content were then entered into the Paper Calculator and the resulting estimate of GHG emissions was converted from lbs to kg CO₂e. Emission factors for other PCR contents (e.g., 85 percent) can be interpolated by averaging between the values shown.

It should be noted that, unlike the other emission factors within this document, the entries in Table 6 are lifecycle emission factors.⁴³

4. Mobile Sources: Fleet

An organization's fleet of vehicles and equipment is a further source of GHG emissions. Two categories of emissions are tracked:

- ◆ Direct emissions from fossil fuels combustion in vehicles and equipment; and
- ◆ Fugitive emissions from mobile air conditioning systems.

4.1 Direct Emissions: Mobile Fuel Combustion

Description: Emission factors are specified for seven transport modes:

- ◆ Light-duty vehicles
- ◆ Light-duty trucks (including SUVs and minivans)
- ◆ Heavy-duty

⁴³ Lifecycle emissions account for all emissions relating to the production, use and disposal of a product, including the extraction of raw materials, product manufacturing and intermediate transport steps.

- ◆ Motorcycles
- ◆ Off-road vehicles and equipment (e.g., snowmobiles, ATVs, lawnmowers and trimmers, tractors, construction equipment)
- ◆ Marine
- ◆ Aviation

Ten fuel types have different emission factors associated with them:

- ◆ Gasoline
- ◆ Diesel
- ◆ Propane
- ◆ Natural gas
- ◆ Biodiesel
- ◆ Ethanol
- ◆ Marine Gasoline
- ◆ Marine Diesel
- ◆ Aviation Gasoline
- ◆ Aviation Turbo Fuel

SMARTTool captures data on fuel consumption in litres by mode of transport and fuel type. This information is required because the emission factors for CH₄ and N₂O vary by vehicle type and transport mode.

Hybrid electric vehicles are not identified separately since their fuel consumption is captured under gasoline cars and trucks. The higher fuel economy of these vehicles relative to conventional gasoline cars and trucks is reflected in lower overall fuel consumption, and therefore lower GHG emissions. Hydrogen powered transit busses and electric vehicles produce zero emissions at the tail-pipe and are therefore not included in emissions reporting.

Data sources: Table A8-11 of the 1990-2011 NIR and Table 34 of the 2010 PIR⁴⁴ provide emission factors for mobile fuel combustion sources.⁴⁵ The factors for gasoline and diesel cars and trucks vary with emission control technology which correlates with vehicle age⁴⁶.

For the purposes of estimating an organization's emissions, the default emission factors are "Tier 1" for gasoline-fuelled light cars and trucks, "Three-Way Catalyst" for gasoline heavy trucks and "Advance Control" for all diesel-fuelled on-road vehicles.⁴⁷ The majority of fleets are likely vehicles dating from the mid-1990s, when the introduction of these technologies began in the U.S. Table A8-11 in the NIR also contains emission factors for propane and natural gas vehicles, motorcycles ("Non-Catalytic Controlled"), off-road vehicles, gasoline boats, diesel ships, aviation gasoline and turbo fuel and renewable or biofuels (biodiesel and ethanol). In practice, biofuels are blended with fossil fuels, specifically gasoline or diesel, in varying proportions (e.g., E10, B5, B20), so that the actual emission factor is a weighted average of the biofuel and fossil fuel factors.

⁴⁴ British Columbia (2012). *British Columbia Greenhouse Gas Inventory Report 2010*, p. 67-68.

⁴⁵ Environment Canada (2013). *National Inventory Report 1990-2011*, Part 2, p. 198.

⁴⁶ *Ibid.*, pp.42-44

⁴⁷ The NIR defines light-duty cars and trucks as those with a Gross Vehicle Weight Rating (GVWR) of 3,900 kg or less and heavy duty as those vehicles with a GVWR greater than 3,900 kg. *Ibid.*, p. 42.

However, since international rules require the separate reporting of biogenic emissions from combustion (see Section 2.1) the CO₂ emissions from the biofuel component must be calculated and reported separately from those of the fossil fuel component.

In B.C., the *RLCFR* sets benchmarks for the amount of renewable fuel in the province's transportation and heating fuel blends.⁴⁸ Effective January 1st, 2011, fuel suppliers are required to incorporate renewable fuel contents of 5% for gasoline and 4% for diesel into the sum of total fuel sold at a provincial level. For any given volume of reported gasoline consumption, 95% of the fuel is fossil fuel gasoline and the remaining 5% is ethanol. For Diesel, 96% is fossil fuel diesel and 4% is biodiesel. Where applicable, the emissions factors listed in Table 7 below have been adjusted to account for the renewable fuel content under the *RLCFR*. Please note that the regulation does not affect the CH₄ or N₂O factors.

Calculations: With the exception of natural gas, the NIR emissions factors in Table 7 have been converted from grams to kilograms by fuel consumption. This is the only change that has been applied to these factors, except in the case of gasoline and diesel fuels, where the numbers were adjusted to account for the renewable fuel content under the *RLCFR*.

The natural gas emission factor has been converted from kg/L to kg/kg of compressed natural gas – the form in which the fuel is dispensed at the pump. Table 8 outlines how this conversion is done.

⁴⁸ Aviation fuels have no similar regulation

Table 7: Fleet Fuel Consumption

Transport Mode	Fuel Type	Units	Emission Factor				
			Bio CO ₂	CO ₂	CH ₄	N ₂ O	CO ₂ e
Light-duty Vehicle ^a	Gasoline	kg/ L	0.0747	2.175	0.00023	0.00047	2.326
	Diesel	kg/ L	0.0980	2.556	0.000051	0.00022	2.625
	Propane	kg/ L	–	1.510	0.00064	0.000028	1.532
	Natural Gas ^b	kg/ kg	–	2.723	0.013	0.000086	3.023
Light-duty Truck (includes SUV and Minivan) ^a	Gasoline	kg/ L	0.0747	2.175	0.00024	0.00058	2.360
	Diesel	kg/ L	0.0980	2.556	0.000068	0.00022	2.626
	Propane	kg/ L	–	1.510	0.00064	0.000028	1.532
	Natural Gas ^b	kg/ kg	–	2.723	0.013	0.000086	3.023
Heavy-duty ^a	Gasoline	kg/ L	0.0747	2.175	0.000068	0.00020	2.238
	Diesel	kg/ L	0.0980	2.556	0.00011	0.000151	2.605
Motorcycle	Gasoline	kg/ L	0.0747	2.175	0.00077	0.000041	2.204
Off-Road (Vehicle/ Equipment)	Gasoline	kg/ L	0.0747	2.175	0.0027	0.00005	2.247
	Diesel	kg/ L	0.0980	2.556	0.00015	0.0011	2.900
Marine	Gasoline	kg/ L	0.0747	2.175	0.0013	0.000066	2.223
	Diesel	kg/ L	0.0980	2.556	0.00015	0.0011	2.900
Aviation	Gasoline	kg/ L	–	2.342	0.0022	0.00023	2.460
	Turbo Fuel	kg/ L	–	2.534	0.000034	0.000071	2.557
Various	Biodiesel ^c	Kg/ L	2.449	0	e	e	e
	Ethanol ^d	kg/ L	1.494	0	f	f	f

Note: emission factors for fleet fuel consumption are based on Tier 1 or Advance Control emission control technologies.

^a Based on Tier 1 or Advance Control emission control technologies.

^b Adapted from Table 34 of the 2010 PIR factors and converted to kg of compressed natural gas.

^c Diesel CH₄ and N₂O emission factors (by transport mode) used for biodiesel.

^d Gasoline CH₄ and N₂O emission factors (by transport mode) used for ethanol.

^e Diesel CH₄ and N₂O emission factors (by mode and technology) are used for biodiesel.

^f Gasoline CH₄ and N₂O emission factors (by mode and technology) are used for ethanol.

4.2 Natural Gas Vehicle Emission Factors

Light-duty natural gas vehicles are fuelled with compressed natural gas, which is measured in kilograms. Federal regulations require that natural gas be dispensed on a cents per kilogram basis; however some receipts may show consumption in GLEs (Gasoline Litre Equivalent). In this case, multiply the per GLE pump price by 1.516 to arrive at kilograms of natural gas. One kilogram of

natural gas has the same amount of energy as 1.516 litres of gasoline⁴⁹. The NIR and PIR provide emission factors for the mobile combustion of natural gas in grams per litre (g/ L).^{50, 51} As a result, these factors do not align with the common unit for compressed natural gas measurement at the pump.

SMARTTool specifies emission factors in kg of emissions per unit of consumption – also kg in the case of compressed natural gas. Table 8 shows the calculations that have been performed to convert the 1990-2011 NIR/2010 PIR emission factors to the format used by SMARTTool. In particular, this involves adjusting for the density of natural gas in its gaseous state at standard temperature and pressure (STP).⁵²

Table 8: Natural Gas Vehicle Emission Factor Calculations

Step	Units	CO ₂	CH ₄	N ₂ O
1. Obtain natural gas emission factors from the 2010 NIR (at STP)	g/ L	1.89	0.009	0.00006
2. Convert to g/ m ³ by multiplying by 1,000 (L/ m ³)	g/ m ³	1,890	9	0.06
3. Convert to g/ kg by dividing by 0.694 (density of natural gas at STP in kg/ m ³)	g/ kg	2,723.3	13.0	0.086
4. Convert to kg/ kg by dividing by 1 000 (g/ kg)	kg/ kg	2.723	0.013	0.000086

4.3 Direct Fugitive Emissions: Mobile Air Conditioning

Description: Atmospheric releases of HFCs can occur throughout the lifecycle of motor vehicle air conditioning (MVAC) units. Unlike a building’s HVAC, however, MVAC servicing is not part of the regular service schedule. Moreover, fuel consumption, which is measurable, does not provide insight into MVAC use. Given differences in climate, usage on the coast is likely to be very different from that in the interior.

Data sources: The Climate Registry offers a “Screening Method” for estimating emissions based on an upper bound capacity charge for MVAC equipment multiplied by an operating emission factor.⁵³ This method has been used to calculate a default emission factor, in kg of HFCs per vehicle. In order to apply the default factor, organizations must provide the number of vehicles in its fleet with MVAC.

The Climate Registry recommends an upper bound capacity charge of 1.5 kg and an operating emission factor of 20 percent of capacity per year for mobile air conditioning.⁵⁴ The most common refrigerant used in MVAC is HFC-134A, with a global warming potential of 1,300.

⁴⁹ Canadian Natural Gas Vehicle Alliance: <http://www.cngva.org/en/home/vehicles-stations/natural-gas-refuelling-stations.aspx>

⁵⁰ Environment Canada (2013). *National Inventory Report 1990-2011 Part 2*, p. 198. These emission factors relate to natural gas in its gaseous state as it flows through a pipeline, prior to compression.

⁵¹ British Columbia (2012). *British Columbia Greenhouse Gas Inventory Report 2010*, p. 67.

⁵² The natural gas density of 0.694 kg/m³ at STP is based on the *British Columbia Greenhouse Gas Inventory Report 2010*, p. 68

⁵³ The Climate Registry (2013). *General Reporting Protocol Version 2.0*, pp. 128-133.

⁵⁴ The Climate Registry (2013). 2013 Climate Registry Default Emission Factors – Released April 2, 2013, Table 16.2, p. 41.

Calculations: Multiplying the 1.5 kg capacity charge by the 20 percent operating emission factor and converting to CO₂e emissions yields a default emission factor of 390 kg CO₂e per vehicle per year. Using this emission factor in conjunction with fleet inventory information, the total estimate for emissions from mobile cooling was less than 1% of the BC Government’s (Consolidated Revenue Fund) total GHG inventory for 2008.

Table 9: Per Vehicle Estimate of HFCs from Mobile Air Conditioning

Greenhouse Gas (kg)	Emissions per Vehicle per Year (kg CO ₂ e)
Hydrofluorocarbons	390

^a default emission factor for HFCs from mobile air conditioning are emissions which consist of HFC-134a.

Organizations typically have two options for calculating and reporting mobile cooling emissions.

Organizations with information on the MVAC servicing for their fleets (e.g., for transit fleets) may use these data to report their HFC emissions directly using the Climate Registry’s “Simplified Mass Balance Approach.”⁵⁵ This method requires information on the quantities of each refrigerant used and recovered from MVAC equipment reported directly.

Organizations without access to detailed mobile refrigerant information may estimate and report their annual refrigerant use at 390 kg CO₂e per each vehicle with air conditioning. This value provides a conservative estimate of emissions resulting from HFC-134a use.

5. Business Travel

Under the Carbon Neutral Public Sector commitment, only core government organizations that report through the Consolidated Revenue Fund (e.g., ministries, special offices, tribunals) are required to track and report the emissions from the business travel of public officials.

Calculating indirect emissions from business travel requires methodologies that differ from those for buildings and fleet emissions. Typically, information on volumes of fuel consumed is not readily available for business travel modes because it is proprietary to private entities such as airlines, taxi companies and rental car agencies. Consequently, depending on the travel mode, one of two methodologies for calculating GHG emissions was used:

1. Estimating fuel consumption using an average fuel efficiency and distance travelled, and then applying an emission factor; or
2. Applying an emission factor in GHGs per passenger-kilometre travelled to the estimated travel distance.

5.1 Travel Emissions Based on Fuel Efficiency

Description: For taxis, rental cars and business use of personal vehicles, average fuel efficiencies have been estimated by vehicle and fuel type. Vehicle types are: (1) cars (including hybrid electric

⁵⁵ The Climate Registry (2013). *General Reporting Protocol Version 2.0*, pp. 123-133.

vehicles); and (2) pickup trucks/SUVs. Fuel types are: (1) gasoline; (2) diesel; (3) propane; and (4) natural gas. Fuel efficiencies are expressed in litres per 100 kilometres driven.

In the case of ferries, an average fuel efficiency has been similarly estimated, expressed in litres per passenger-100 km travelled.

Data sources: For road travel, both the US Environmental Protection Agency (EPA) and NRCan publish “city” and “highway” fuel economy ratings by vehicle manufacturer and model.⁵⁶ It is expected that most government travel falls between the conditions modeled for city and highway driving, tending closer to city estimates.⁵⁷

In 2008, the EPA established new best practices for measuring fuel economy that indicated lower fuel efficiency – or increased L/100 km – than previous measurements.⁵⁸ Accordingly, fuel economy ratings that predate 2008 need to be adjusted upwards.

The Insurance Corporation of British Columbia (ICBC) maintains non-public records of the composition of the provincial vehicle fleet. These data were used to develop weighted average fuel efficiencies for the vehicle and fuel types in Table 10.

Distances for road travel were derived from the Ministry of Transportation’s DriveBC road distance calculator.⁵⁹

For ferry travel, neither BC Ferries nor Environment Canada currently publishes comprehensive data on GHG emissions. However, public data on fuel consumption, route length and passenger capacity have been previously available from various BC Ferries sources and have been used in estimating average fuel efficiency.⁶⁰

An average fuel efficiency factor of 0.2 kWh/km has been supplied for electric vehicles.⁶¹ It should be noted that when charging an electric vehicle at a building owned by your organization, the emissions for charging the vehicle will likely already be attributed to your organization’s stationary emissions profile.

Calculations: In the case of road travel, an uplift factor of 7.8 percent was applied to the 2007 NRCan fuel economy ratings for city driving – to better reflect real-world fuel efficiencies. NRCan city ratings were then applied to 2007 ICBC data on the provincial vehicle stock by model, year, fuel type and other characteristics to derive average fuel efficiency estimates for each vehicle/fuel type listed in Table 10.

⁵⁶ US EPA (2013). *Model Year 2013 Fuel Economy Guide*, and NRCan (2013), *Fuel Consumption Guide 2013*.

⁵⁷ The NRCan city ratings have been used here for a number of reasons. For example, most highway driving in the province’s metropolitan areas is characterized by considerable congestion, leading to higher fuel consumption. In the Interior, fuel efficiencies are likely to be higher than the theoretical (best practices) NRCan ratings, given weather and terrain. As a result, the city ratings can be assumed to capture some of the actual highway driving efficiencies in B.C. and lead to a more conservative estimate of the GHG emissions from business road travel.

⁵⁸ See: www.epa.gov/fueleconomy/.

⁵⁹ See: www.th.gov.bc.ca/popular-topics/distances/calculator.asp.

⁶⁰ British Columbia Ferry Services Inc. (2006). *Fuel Consumption Reduction Plan*, p. 8; BC Ferries (2013). *Routes and Schedules Regional Index*; and BC Ferries (2013). *Variety...The Spice of Our Fleet*.

⁶¹ See: <http://www.livesmartbc.ca/blog/2012/plugin-BC-ready-set-charge.html>

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To calculate GHG emissions, the quantity of fuel consumption was first estimated by multiplying the average fuel efficiency for the particular vehicle/fuel type by the kilometres driven. Then, the appropriate emission factor was applied to this fuel consumption estimate.

For ferries, the average fuel efficiency in Table 19 (Annex 8.4) has been estimated using 2005/06 data on diesel consumption for five ferry routes. These fuel data were extrapolated to all 22 ferry routes based on route distance and horsepower. Fuel efficiencies in litres per passenger-100 km were then calculated by dividing the total diesel consumption for each route by the route distance and the estimated passenger load (assuming 80 percent of the ferry's total passenger capacity). These fuel efficiencies were then averaged over the 22 routes to yield 5.1 L/passenger-100 km.

To calculate ferry emissions, the average fuel efficiency was multiplied by the passenger distance travelled and the emission factor for marine diesel then applied to the resulting fuel consumption figure. Distance travelled is based on route length as travelled by the ship, as opposed to the straight line distance between starting and destination points. For more information refer to Annex 8.4.

Table 10: Travel, Fuel Efficiency Based Emission Calculations

Travel Mode	Vehicle/Fuel Type	Average Fuel Efficiency ^a	Emission Factor (kg/L) ^b				
			Bio CO ₂	CO ₂	CH ₄	N ₂ O	CO _{2e}
Car (includes Taxi)	Gasoline	10.3 L/100 km	0.0747	2.175	0.00023	0.00047	2.326
	Diesel	7.7 L/100 km	0.0980	2.557	0.000051	0.00022	2.626
Car (includes Taxi)	Hybrid	7 L/100 km	0.0747	2.175	0.00023	0.00047	2.326
	Natural Gas ^c	5.4 kg/100 km ^d	–	2.723	0.013	0.000086	3.023
	Propane	8.2 L/100 km	–	1.510	0.00064	0.000028	1.532
Light Truck (includes SUV and Minivan)	Gasoline	14.7 L/100 km	0.0747	2.175	0.00024	0.00058	2.360
	Diesel	12.5 L/100 km	0.0980	2.557	0.000068	0.00022	2.627
	Hybrid	10 L/100 km	0.0747	2.175	0.00024	0.00058	2.360
	Natural Gas ^c	8.3 kg/100 km ^d	–	2.723	0.013	0.000086	3.023
	Propane	12.6 L/100 km	–	1.510	0.00064	0.000028	1.532
Electric Vehicle	Electricity	20 kWh/100 km	–	0.025 ^e	–	–	0.025 ^e
Ferry	Diesel	5.1 L/psg-100 km	0.0980	2.557	0.00015	0.0011	2.901

^a From Natural Resources Canada, ICBC, and BC Ferries sources (see Data Sources, below.)

^b From Environment Canada 1990-2010 NIR.

^c Emission factors adapted from NIR figures, converted to kg of natural gas, the common units for vehicle natural gas.

^d kg/ 100km figure for Natural Gas calculated based on 1.516 L/ kg gasoline equivalency.

^e kgCO₂ per kWh

5.2 Travel Emission Based on Travel Distance

Description: GHG emissions for bus, skytrain, sea bus, rail, airplane and helicopter travel are all calculated using emission factors in kg CO₂e per passenger-kilometre. The categorization of airplane travel into three ranges of haul distance attempts to reduce the significant variation in emissions, since trips of comparable length are more likely to have similar aircraft types and flight patterns. However, it is recognized that the emission factors in Table 11 below are approximations and that actual emissions from airplane travel varies significantly from one trip to the next.

Data sources: NRCan publishes information on total Canadian GHG emissions and passenger-km for a number of transportation modes, including urban transit (city buses) and inter-city buses.⁶² The most recent year of data is 2010.

While NRCan also publishes aggregate data on GHG emissions and passenger-km for air travel, no breakdown is provided for haul distance. In contrast, the UK Department of Environment, Food and Rural Affairs (DEFRA) has estimated emission factors for three categories of flights: (1) domestic; (2) short haul international; and (3) long haul international.⁶³ For the B.C. government's purposes, these categories have been adopted as follows: (1) the DEFRA domestic emission factor has been applied to short haul flights; (2) the short haul international emission factor has been applied to medium haul flights; and (3) the long haul international emission factor has been applied to long haul flights.⁶⁴

Calculations: The emission factors for urban and inter-city buses were calculated by dividing the NRCan data on total GHG emissions for 2010 by the total passenger-kilometres. To calculate emissions, these emission factors in kg CO₂e/psg-km were then multiplied by the distance travelled. The emissions factors for Skytrain⁶⁵ and Sea Bus^{66,67} travel were calculated in previous years based on emissions data and the total passenger kilometers. For the 2013 reporting year, emissions factors were calculated in the same way based on data directly obtained from TransLink.

The emission factor for rail was calculated by dividing the Transport Canada data on total passenger services fuel consumption in litres for VIA Rail Canada by the corresponding revenue passenger-kilometres⁶⁸.

The airplane emission factors from DEFRA include a nine percent uplift factor. This adjustment is recommended by the Intergovernmental Panel on Climate Change (IPCC) to account for discrepancies between geographical distance and actual flight distance.⁶⁹ These discrepancies can

⁶² NRCan (2013). *Energy Use Data Handbook, 1990 to 2010*, pp. 118 - 125.

⁶³ DEFRA (2013). 2013 Government GHG Conversion Factors for Company Reporting: Methodology Paper for Emission Factors, July 2013, Table 33.

⁶⁴ The DEFRA categories are applied on the basis of distance rather than destination because conditions of European air travel vary substantially from those in B.C. (e.g., a typical Canadian domestic flight is likely to be much longer than a typical UK domestic flight). DEFRA information also includes emissions listed by flight class. However, for ease of use purposes, the average emissions factor for distance-based flight provided in the DEFRA document were used in this document.

⁶⁵ TransLink Sustainability Report (2010). Psg-km data: Appendix 2.7, p.88; Emission data: Appendix 2.8, p.89

⁶⁶ TransLink Sustainability Report (2010). p.88; Emission data: Appendix 2.8, p.89

⁶⁷ TransLink Annual Report (2008). Psg-km data: p. 2

⁶⁸ Transport Canada (2013). Traffic and Fuel Consumption Data, <http://www.tc.gc.ca/eng/programs/environment-ecofreight-rail-report2009-2727.htm>

⁶⁹ IPCC (1999). *Aviation and the Global Atmosphere*, Section 8.2.2.3.

result from conditions such as non-linear routing that is not the shortest direct distance, delays or circling and routings of take-off and landing.

In SMARTTEC, the specified distance is the shortest geographical distance between the starting point and the destination. The nine percent uplift factor was used to adjust for the difference between this shortest distance calculation and the actual travel of the aircraft.

The emission factor for helicopter and floatplane travel was calculated based on 2007 fuel consumption data provided by carriers operating flights between Vancouver harbour and Victoria harbour (Helijet and Harbour Air). Also incorporated in the emission factor is the average passenger load reported by Canadian airlines for 2007 and an estimated flight distance that accounts for the non-direct route between Vancouver and Victoria harbours.

Table 11: Travel Distance Based Emission Calculations

Travel Mode	Vehicle Type	Emission Factor (kg CO₂e/psg-km)
Bus	City	0.1158
	Other (Inter-city)	0.0488
Skytrain		0.0034355
Sea Bus		0.155466
Rail		0.125236
Airplane	Float Plane	0.213
	Short Haul (0 km-463 km)	0.174356
	Medium Haul (463 km-1,108 km)	0.1027
	Long Haul (>1,108 km)	0.120892
Helicopter		0.447

Note: B.C. Government emission factors for travel, distance based emission calculations are derived from NRCan, Transport Canada, DEFRA, Helijet and Translink BC sources (see text).

5.3 Indirect Emissions - Accommodation

Description: In addition to transportation-related GHGs from business travel, indirect emissions result from employee stays in hotels, bed and breakfasts and private accommodation.

Data sources: In March of 2011, InterVISTAS Consulting Inc. published a GHG report on the accommodation emissions for Coast Hotels and Resorts in 2009⁷⁰. The report followed the accounting and reporting guidelines of *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard, Revised Edition* published by World Resources Institute and the World Business Council for Sustainable Development.

A total of five properties were evaluated (two in Vancouver, one in Edmonton, one in Victoria and one in Prince George). The properties in Western Canada provide a spatial sampling of locations in

⁷⁰ InterVISTAS Consulting Inc. (2011), *Coast Hotels & Resorts: Greenhouse Gas Report Fiscal Year 2009*

different climates to represent different energy consumption patterns. The properties varied in size from 132 rooms in Victoria to 299 in Edmonton. The intensity based indicators for those five hotels were then extrapolated to 22 hotels in BC and 7 in Alberta.

Calculations: In Table 12 below, the emission factor for a night’s stay has been calculated by dividing the total GHG emissions for the sample hotels by the number of potential room nights assuming full occupancy:

$$\text{Emission Factor (kg/ CO}_2\text{e/ night)} = 51,310 \text{ tonnes CO}_2\text{e} \times 1000 / (7,238 \text{ rooms} \times 365 \text{ nights})$$

From this method, both a domestic BC emissions value (11.90 kg CO_{2e} / night) and a national/international emissions value (20.78 CO_{2e} / night) were derived. The national/international value is a conservative estimate as it incorporates data from electricity generation in Alberta, which results in significantly greater emissions per kilowatt hour than in the rest of Canada due to coal being the primary energy source. Based on 2012 accommodation data from SMARTTEC, 94.03% of core government accommodation stays were domestic within BC and 5.97% were national or international. Based on these figures a weighted average can be calculated to derive a single accommodation factor of 12.43 kg CO_{2e} / night.

This emission factor for hotels has been assigned to the other categories of private accommodation and bed and breakfasts in the absence of available information for those categories.

Table 12: Accommodation

Accommodation Type	Emission Factor^a (kg CO_{2e}/ night)
Hotel Room	12.43
Private	12.43
Bed and Breakfast	12.43

^a Hotel room emission factor is applied to all accommodation types.

6. Community Energy and Emissions Inventory (CEEI) Emission Factors – Agricultural Emission Factors

The 2007 CEEI reports include only enteric fermentation⁷¹. Manure management is excluded because the emissions values used by the NIR do not reflect regional and local variations in the storage and use of manure, and agricultural soils are excluded because we have insufficient information about them at a local level. The CEEI Working Group is currently exploring the possibility of including manure management and agricultural soils emissions in the 2012 CEEI reports, scheduled to be released in 2014.

Furthermore, 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”. Emis-

⁷¹ Enteric fermentation is a digestive process by which carbohydrates are broken down by microorganisms into simple molecules for absorption into the bloodstream of an animal.

sions from diesel used in tractors would be an “off-road” emission. None of these are included in the “Agriculture” sector of CEEI.

To quote from the 2013 NIR 6.2.2:

“CH₄ 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 (CH₄) emissions. These are multiplied by a factor converting methane (CH₄) emissions to carbon dioxide equivalents (CO₂e) using the same conversion factor as the NIR and BCPIR for 2010.

Tables 13 below present’s data from the 2013 NIR table A3-17 which shows “CH₄ Emission Factors for Enteric Fermentation for Cattle from 1990 to 2011”. It contains factors for eight different types of cattle, and the factors for each vary from year to year. The 2007 CEEI Reports use 2007 factors (2007 NIR) from this table.

Table 13: CH₄ Emission Factors for Enteric Fermentation for Cattle^{72, 73}

Year	EF(EF)T – kg CH ₄ /head/year							
	Dairy Cows	Dairy Heifers	Bulls	Beef Cows	Beef Heifers	Heifers for Slaughter	Steers	Calves
2007 (2007 NIR)	116.5	74.6	87.8	84.7	71.4	68.0	59.6	43.3
2007 (2013 NIR)	125.0	72.4	87.6	88.1	72.5	61.2	54.5	39.5
2011	127.6	72.4	88.0	85.0	70.2	61.0	54.8	39.6

Table 14 below presents methane emissions from animals other than cattle taken from Table A8-22: CH₄ Emission Factors for Enteric Fermentation for Non-cattle Animals in a version of the 1990-2011 NIR obtained by the ministry. These values are the IPCC Tier 1 default emission factors (IPCC/OECD/IEA 1997).

⁷² Environment Canada (2013). National Inventory Report: Greenhouse Gas Sources and Sinks in Canada 1990-2011, Table A3-17

⁷³ See IPCC website for related publications, for example: www.ipcc-nggip.iges.or.jp/public/gp/bgp/4_2_CH4_and_N2O_Livestock_Manure.pdf

Table 14: Non-cattle Animal Category – Enteric Fermentation Emission Factor

Non-cattle Animal Category – Enteric Fermentation Emission Factor (kg CH₄/head/year)	
Pigs, Boars, Sows (all weights)	1.5
OTHER LIVESTOCK	
Sheep, Lambs	8
Goats	5
Horses	18
Buffalo, Bison ⁷⁴	55
POULTRY⁷⁵	

⁷⁴ 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.

⁷⁵ Note: poultry does not generate significant methane by enteric fermentation, so poultry was not counted in CEEI

7. Sample Calculation

Table 15 provides a sample application of an emission factor to calculate GHG emissions, based on 100 litres of propane consumption in buildings.

Table 15: Sample Emissions Calculation

Step	Formula	Calculation		
1. Convert the actual consumption to a common unit of measurement.	Actual Consumption (L) x Energy Conversion Factor (GJ/ L) = Converted Fuel Consumption (GJ)	100 L x 0.02531 GJ/ L = 2.531 GJ		
2. Calculate the emissions of each GHG using the appropriate emission factor		CO₂	CH₄	N₂O
	Converted Fuel Consumption (GJ) x Emission Factor by GHG (kg/ GJ) = Emissions by GHG	2.531 GJ x 59.66 kg CO₂ / GJ = 151.0 kg CO₂	2.531 GJ x .0009 kg CH₄ / GJ = 0.0023 kg CH₄	2.531 GJ x 0.0043 kg N₂O / GJ = 0.0109 kg N₂O
3. Convert the emissions of each greenhouse gas to CO ₂ equivalency (CO ₂ e) using the appropriate Global Warming Potential		CO₂	CH₄	N₂O
	Emissions by GHG x GWP = Emissions (kg CO ₂ e)	151.0 kg CO₂ x 1 = 151.0 kg CO₂e	0.0023 kg CH₄ x 21 = 0.0483 kg CO₂e	0.0109 kg N₂O x 310 = 3.379 kg CO₂e
4. Sum across the gases to calculate total CO ₂ e emissions	CO₂ + CH₄ + N₂O (all in kg CO ₂ e) = Total CO₂e	151.0 kg CO₂e + 0.0483 kg CO₂e + 3.379 kg CO₂e = 154.4kg CO₂e		
5. Convert total emissions from kg to tonnes for reporting purposes.	Emissions in kg CO ₂ e / 1 000 kg / t = Emissions in tonnes CO ₂ e	154.4 kg CO₂e / 1 000 kg / t = 0.154 t CO₂e		

8. Annexes

8.1 Glossary of Terms and Acronyms

Note: Definitions derived from:

- LiveSmart BC, Glossary (available at: www.livesmartbc.ca/learn/glossary.html).
- IPCC Third Assessment Report, Glossary of Terms (available at: www.ipcc.ch/pdf/glossary/tar-ipcc-terms-en.pdf).
- Market Advisory Committee to the California Air Resources Board (2007), “Recommendations for Designing a Greenhouse Gas Cap-and-Trade System for California.”
- World Business Council for Sustainable Development and World Resources Institute (2004), *The Greenhouse Gas Protocol, A Corporate Accounting and Reporting Standard – Revised Edition*, pp. 96-102.
- The Climate Registry (2013), *General Reporting Protocol Version 2.0*, pp. 160-166.

Table 16: Terms and Acronyms

Abbreviation, Acronym or Measure	Definition
Carbon dioxide (CO₂)	A naturally occurring gas (0.03% of atmosphere) that is also a by-product of the combustion of fossil fuels and biomass, land-use changes, and other industrial processes. It is the principal anthropogenic greenhouse gas. It is the reference gas against which other greenhouse gases are measured and therefore has a Global Warming Potential of 1. (IPCC)
Carbon-equivalent (CO₂e)	“The universal unit of measurement to indicate the global warming potential (GWP) of each of the six greenhouse gases, expressed in terms of the GWP of one unit of carbon dioxide.” (GHG Protocol) Expressing all GHGs in terms of tonnes of CO ₂ e allows the different gases to be aggregated (LiveSmart BC).
Community Energy and Emissions Inventory	The Community Energy and Emissions Inventory (CEEI) represents energy consumption and greenhouse gas emissions from community activities in on-road transportation, buildings and solid waste. Estimates of land-use change from deforestation activities and enteric fermentation from livestock under the Agricultural sector are also available at the Regional District level.
Biofuel	A fuel produced from dry organic matter or combustible oils produced by plants. Examples of biofuel include alcohol (from fermented sugar), black liquor from the paper manufacturing process, wood and soybean oil.
Direct emissions	Emissions from sources that are owned or leased by a PSO or sources used by local governments to deliver traditional local government services
EDF	Environmental Defense Fund, a US-based environmental organization.
Emission factor	“A factor allowing GHG emissions to be estimated from a unit of available activity data (e.g. tonnes of fuel consumed, tonnes of product produced) and absolute GHG emissions” (GHG Protocol)
Emissions	“The release of substances (e.g., greenhouse gases) into the atmosphere. Emissions occur both through natural processes and as a result of human activities.” (CARB)
Enteric fermentation	Enteric fermentation is a digestive process by which carbohydrates are broken down by microorganisms into simple molecules for absorption into the bloodstream of an animal.

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Abbreviation, Acronym or Measure	Definition
Energy conversion factor	A factor used to convert a quantity of energy from its original physical unit into a common unit of measurement (e.g., GJ).
EPA	(U.S.) Environmental Protection Agency
Fugitive emissions	The unintended or incidental release of greenhouse gases from the transmission, processing, storage, use, or transportation of fossil fuels, GHGs, other substances, including but not limited to HFC emissions from refrigeration leaks and SF ₆ from electric power distribution equipment.
Gigajoule (GJ)	One billion joules, where a joule is a common unit of energy for comparing across fuel types and electricity.
Gigawatt-hour (GWh)	One million kilowatt-hours, enough electricity to power 100 homes for a year.
Global Warming Potential (GWP)	“Greenhouse gases differ in their effect on the Earth’s radiation balance depending on their concentration, residence time in the atmosphere, and physical properties with respect to absorbing and emitting radiant energy. By convention, the effect of carbon dioxide is assigned a value of one (1) (i.e., the GWP of carbon dioxide =1) and the GWPs of other gases are expressed relative to carbon dioxide. For example, in the U.S. national inventory, the GWP of nitrous oxide is 310 and that of methane 21, indicating that a tonne of nitrous oxide has 310 times the effect on warming as a ton of carbon dioxide. Slightly different GWP values for greenhouse gases have been estimated in other reports. Some industrially produced gases such as sulfur hexafluoride (SF ₆), perfluorocarbons (PFCs), and hydrofluorocarbons (HFCs) have extremely high GWPs. Emissions of these gases have a much greater effect on global warming than an equal emission (by mass) of the naturally occurring gases. Most of these gases have GWPs of 1,300 - 23,900 times that of CO ₂ . The US and other Parties to the UNFCCC report national greenhouse gas inventories using GWPs from the IPCC’s Second Assessment Report (SAR). SAR GWPs are also used for the Kyoto Protocol and the EU ETS. GWPs indicated in this document also refer to the IPCC’s Second Assessment Report.” (CARB)
Global Reporting Initiative (GRI)	An international initiative that has developed a sustainability reporting framework for organizations to measure and report on their economic, environmental and social performance (see: www.globalreporting.org).
Greenhouse gases (GHGs)	“Greenhouse gases include a wide variety of gases that trap heat near the Earth’s surface, slowing its escape into space. Greenhouse gases include carbon dioxide, methane, nitrous oxide and water vapor and other gases. While greenhouse gases occur naturally in the atmosphere, human activities also result in additional greenhouse gas emissions. Humans have also manufactured some gaseous compounds not found in nature that also slow the release of radiant energy into space.” (CARB)
HVAC	Heating, Ventilating and Air Conditioning
Hydrofluorocarbons (HFCs)	“One of the six primary GHGs. Synthetic industrial gases, primarily used in refrigeration and other applications as commercial substitutes for chlorofluorocarbons (CFCs). There are no natural sources of HFCs. The atmospheric lifetime of HFCs is decades to centuries, and they have "global warming potentials" thousands of times that of CO ₂ , depending on the gas. HFCs are among the six greenhouse gases to be curbed under the Kyoto Protocol.” (CARB)
Indirect emissions	Emissions that are a consequence of the operations of the reporting organization (i.e., PSO, local government, community), but occur at sources owned or controlled by another organization.

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Abbreviation, Acronym or Measure	Definition
Intergovernmental Panel on Climate Change (IPCC)	“Recognizing the problem of potential global climate change, the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) established the Intergovernmental Panel on Climate Change (IPCC) in 1988. It is open to all members of the UN and WMO. The role of the IPCC is to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation. The IPCC does not carry out research nor does it monitor climate related data or other relevant parameters. It bases its assessment mainly on peer reviewed and published scientific/technical literature.” (CARB)
Inventory	“A greenhouse gas inventory is an accounting of the amount of greenhouse gases emitted to or removed from the atmosphere over a specific period of time (e.g., one year). A greenhouse gas inventory also provides information on the activities that cause emissions and removals, as well as background on the methods used to make the calculations. Policy makers use greenhouse gas inventories to track emission trends, develop strategies and policies and assess progress. Scientists use greenhouse gas inventories as inputs to atmospheric and economic models” (CARB)
IPP	Independent Power Producer
kg	Kilogram
kilotonne	1,000 tonnes
km	Kilometre
kWh	kilowatt-hour
L	Litre
lb	pound (weight)
m³	cubic metre
Methane (CH₄)	“One of the six greenhouse gases to be curbed under the Kyoto Protocol. Atmospheric CH ₄ is produced in nature, but human related sources such as landfills, livestock feedlots, natural gas and petroleum systems, coal mines, rice fields, and wastewater treatment plants also generate substantial CH ₄ emissions. CH ₄ has a relatively short atmospheric lifetime of approximately 10 years, but its 100-year GWP is currently estimated to be approximately 21 times that of CO ₂ .” (CARB)
MVAC	Motor Vehicle Air Conditioning
NIR	National Inventory Report (Environment Canada)
Nitrous oxide (N₂O)	“One of the six greenhouse gases to be curbed under the Kyoto Protocol. N ₂ O is produced by natural processes, but substantial emissions are also produced by such human activities as farming and fossil fuel combustion. The atmospheric lifetime of N ₂ O is approximately 100 years, and its 100-year GWP is currently estimated to be 310 times that of CO ₂ .” (CARB)
Office Paper	Multipurpose copy paper for use in laser printers, fax machines and photocopiers or multifunction devices.
Perfluorocarbons (PFCs)	“PFCs are among the six greenhouse gases to be curbed under the Kyoto Protocol. PFCs are synthetic industrial gases generated as a by-product of aluminum smelting and uranium enrichment. They also are used in the manufacture of semiconductors. There are no natural sources of PFCs. PFCs have atmospheric lifetimes of thousands to tens of thousands of years and 100-year GWPs thousands of times that of CO ₂ , depending on the specific PFC.” (CARB)
pkg	Package
PIR	British Columbia's Provincial Greenhouse Gas Inventory Report (Ministry of Environment)

Abbreviation, Acronym or Measure	Definition
PSO	A B.C. public sector organization subject to the government's carbon neutral commitment under the <i>Greenhouse Gas Reduction Targets Act</i> .
RESO	Report on Energy Supply and Demand (Statistics Canada).
STP	Standard Temperature and Pressure
Sulphur Hexafluoride (SF ₆)	One of the six greenhouse gases to be curbed under the Kyoto Protocol. SF ₆ is a synthetic industrial gas largely used in heavy industry to insulate high-voltage equipment and to assist in the manufacturing of cable-cooling systems. There are no natural sources of SF ₆ . SF ₆ has an atmospheric lifetime of 3,200 years. Its 100-year GWP is currently estimated to be 22,200 times that of CO ₂ ." (CARB)
t	metric tonne, a standard measurement for the mass of GHG emissions, equivalent to 1,000 kg, 1,204.6 pounds, or 1.1 short tons.
U.S.	United States (of America)

8.2 Global Warming Potentials

Table 17 presents the 100-year Global Warming Potentials for the GHGs being tracked by the B.C. public sector. These GWPs are listed in the Carbon Neutral Government Regulation and are the 1995 values from the IPCC's *Second Assessment Report*, as endorsed by Environment Canada and British Columbia, as such, they represent the standard emission factors to be used at this time in greenhouse gas emissions calculations in British Columbia.^{76, 77, 78} These GWP values will likely be updated for 2014 calendar year emissions in parallel with the implementation of updates by the United Nations Framework Convention on Climate Change for national inventory reporting.

Table 17: Global Warming Potentials

Greenhouse Gas	Chemical Formula	100-Year GWP
Carbon dioxide	CO ₂	1
Methane	CH ₄	21
Nitrous oxide	N ₂ O	310
HFC-23	CHF ₃	11 700
HFC-32	CH ₂ F ₂	650
HFC-41	CH ₃ F	150
HFC-43-10mee	C ₅ H ₂ F ₁₀	1 300
HFC-125	C ₂ HF ₅	2 800

⁷⁶ Environment Canada (2013). *National Inventory Report 1990-2011*, p.33.

⁷⁷ British Columbia (2012). *British Columbia Greenhouse Gas Inventory Report 2010*, p. 66

⁷⁸ Greenhouse Gases marked with an asterisk (*) were added from the *Reporting Regulation*.

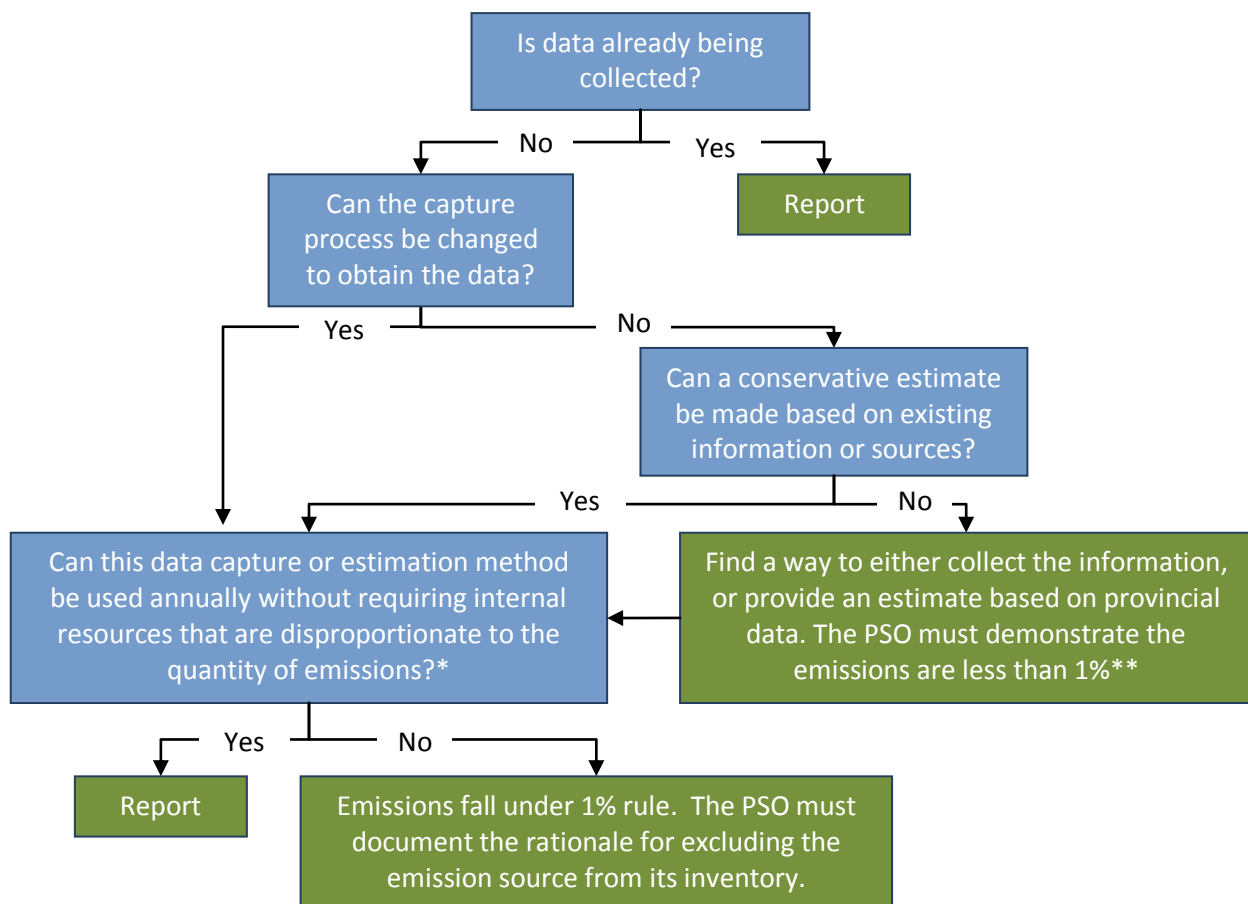
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HFC-134	$C_2H_2F_4$ (CHF_2CHF_2)	1 000
HFC-134a	$C_2H_2F_4$ (CH_2FCF_3)	1 300
HFC-143	$C_2H_3F_3$ (CHF_2CH_2F)	300
HFC-143a	$C_2H_3F_3$ (CF_3CH_3)	3 800
HFC-152 (*)	$C_2H_4F_2$	43
HFC-152a	$C_2H_4F_2$ (CH_3CHF_2)	140
HFC-161 (*)	C_2H_5F	12
HFC-227ea	C_3HF_7	2 900
HFC-236cb (*)	$C_3H_2F_6$	1 300
HFC-236ea (*)	$C_3H_2F_6$	1 200
HFC-236fa	$C_3H_2F_6$	6 300
HFC-245ca	$C_3H_3F_5$	560
HFC-245fa (*)	$C_3H_3F_5$	950
HFC-365mfc (*)	$C_4H_5F_5$	890
Perfluoromethane (*)	CF_4	6 500
Perfluoroethane (*)	C_2F_6	9 200
Perfluoropropane (*)	C_3F_8	7 000
Perfluorobutane (*)	C_4F_{10}	7 000
Perfluorocyclobutane (*)	c- C_4F_8	8 700
Perfluoropentane (*)	C_5F_{12}	7 500
Perfluorohexane (*)	C_6F_{14}	7 400
Sulphur hexafluoride	SF_6	23 900

8.3 How to Treat Small Emissions Sources

For many organizations, dealing with small emissions sources can be challenging. For Public Sector Organizations, if an emissions source is onerous to collect and is estimated to comprise less than 1% of the organization’s total emissions inventory, it is considered out of scope. This decision tree below was developed to help PSO/LGs determine whether or not a certain source of emissions falls under this rule, which states that **if an emissions source is estimated to comprise of less than 1% of an organization’s total emissions and is onerous to collect, it is considered out of scope**. It is suggested that other types of organizations follow a similar procedure. If an emissions source is expected to fall under 1% of an organization’s total emissions, the organization should use the following decision tree to determine whether or not it is considered onerous and can be excepted using this rule. Organizations may also refer to alternative methods to address small emission sources such as those outlined in the General Reporting Protocol⁷⁹. For PSOs, if, after using this decision tree, an emissions source is considered out-of-scope under this rule, the source of the emission and the rationale for its exemption should be included as a part of the Carbon Neutral Action Report.

Table 18: How to Treat Small Emissions Decision Tree



* e.g. excessive person-hours of time are required to collect the information that could be put towards data collection and quality control for larger emissions sources

** Is there an alternative method for estimating? Can a formula be created to produce a conservative estimates based on available provincial data? How did you come to the conclusion that it was likely less than 1%?

8.4 Review of Fuel Efficiency Calculation for Ferries

BC Ferries has not yet published a verified emission factor that can be applied to travel calculations. Some data on fuel consumption, route length and passenger capacity however, is available from sources on the BC Ferries website.⁸⁰ Data from these sources has been used in estimating average fuel efficiency.

Fuel consumption information, along with published route and vessel data, was used to determine an average of HP/ L/ km. This information is displayed in Table 19 below.

Table 19: Average Horsepower/ Litre/ Kilometre Calculation for Ferries

Route	Vessel Class	HP	Distance (km)	Fuel Consumption (L)	L/ km	HP/ L/ km
Vancouver – Victoria	Spirit Class	21 394	44.4	4200	95	226.1651
Vancouver – Victoria	V Class	8 941	44.4	2400	54	165.4085
West Van – Bowen Island		7 305	5.6	135	24	303.0222
Alliford Bay – Skidegate		730	6.5	66	10	71.8939
Vancouver – Salt Spring Island		6 000	40.7	1515	37	161.1882
Average HP/ L / km =						185.5356

Diesel fuel consumption was then estimated based on: (1) the calculated average HP/ L/ km figure; (2) route distance; and (3) vessel horsepower information. This was calculated for twenty-two BC Ferry routes based on available information.

Estimated diesel fuel consumption for each route was divided by 80% of each vessel's stated passenger capacity to derive an estimate of fuel consumption per passenger (L/ passenger (psg)). This number was then divided by the route distance to get a fuel efficiency calculation for each route (L/ psg/ km).

Fuel efficiency numbers for calculated routes were an average of 0.051 L/ psg/ km. Fuel efficiency factors in SMARTTEC are stated per 100km, therefore, this factor was multiplied by 100 which results in a figure of 5.10 L/ psg/ 100 km. This fuel efficiency factor was used to estimate fuel consumption for calculating emissions associated with ferry travel.

It was assumed that all fuel consumed for ferry travel by BC Ferries vessels is marine diesel. Emission factors for marine diesel published by Environment Canada were used to calculate emissions detailed in Table 19.

⁸⁰ British Columbia Ferry Services Inc. (2006) www.bcferries.com/; *Fuel Consumption Reduction Plan*, p. 8; BC Ferries (20013), *Routes and Schedules Regional Index*; and BC Ferries (2013), *Variety...The Spice of Our Fleet*.

8.5 SMARTTool Buildings Energy Estimation Method Summary

8.5.1 Introduction

The following information is intended to provide a summary of the three building energy estimation methods which are currently available in SMARTTool. These methods assist organizations in estimating building energy consumption when energy consumption data for an in-scope building is not readily available.

Table 20: Building Estimation Methods Summary

Method	Description	Usage
Gross-up Factor	The gross up factor is used to increase building energy consumption by a factor derived from the ratio of total floor space to floor space where the consumption is known.	Primarily used by BC Government (CRF) organizations to estimate energy consumption for floor space where Shared Services BC does not have access to utility information.
Regional Calculated Energy Intensity Unit (Regional Calc EIU)	Energy estimate is applied using a calculated energy intensity based on reported energy consumption for buildings sharing the same region and energy usage profile.	Primarily used in situations where an organization reports energy consumption for buildings with a profile similar to that which needs to be estimated.
Fixed Energy Intensity Unit (Fixed EIU)	An energy estimate is applied using pre-determined intensity factors which have been calculated using energy intensities from Natural Resources Canada.	Primarily used in situations where organizations do not have sufficient reported data from which to estimate energy consumption for the building that requires it.

8.5.2 Estimation Method Details

Gross-Up Factor:

The basic assumption underlying this approach is that an organization's energy consumption per square meter is the same in buildings where energy data is available and in the buildings where no data is available. The mechanics of this method simply involve dividing the total area of the buildings occupied by the organization by the area for which energy data is available. The resulting ratio is referred to as the Gross Up Factor (GUF). The GUF is then applied to the organization's known energy consumption to estimate its total energy consumption. Gross-up factors can be defined for specific date ranges.

Regional Calculated Energy Intensity Unit (Regional Calc EIU)

The Regional Calculated EIU estimation method allows an organization to estimate its unknown energy use, by building type, from data available from their own similar buildings within the same region, and thus provides a more accurate estimation for disparate regions across the Province.

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For this approach to be useful, there must be sufficient known energy per region per building type within the organization.

This approach requires the calculation of energy use per square meter (i.e., energy intensity) and the application of that energy intensity to the area of like-use buildings. Once consumption is estimated in this way, one applies the appropriate emission factors and GWP to estimate related greenhouse gas emissions.

Table 21: Regional Energy Intensity Unit Estimation Calculation

Step	Formula for each Fuel
1. For similar buildings (i.e.: office) determine the annual consumption amount of each fuel and divide floor space of all the buildings	$\frac{\text{Total fuel use}}{\text{Total square meters of Floor space}} = \text{Annual Energy Intensity Factor (EIU/m}^2\text{)}$
2. Estimate the quantity of each fuel used in the leased space	$\text{Area of leased building} \times \text{Annual Energy Intensity Factor (EIU/m}^2\text{)} = \text{Annual Fuel Use in Leased building (GJ)}$
3. Apply the emission factor by fuel to yield total emissions by fuel	$\text{Emission Factor (kg/GJ)} \times \text{Consumption (GJ)} = \text{Emissions by GHG (kg)}$
4. Apply the global warming potentials to yield total emissions	$\text{Emissions by GHG (kg)} \times \text{GWP} = \text{Emissions (kg CO}_2\text{e)}$
6. Sum across the gases to calculate total CO ₂ e emissions	$\text{CO}_2 + \text{CH}_4 + \text{N}_2\text{O (all in kg CO}_2\text{e)} = \text{Total CO}_2\text{e}$
7. Convert total emissions from kg to tonnes for reporting purposes.	$\frac{\text{Emissions in kg CO}_2\text{e}}{1\,000 \text{ kg / t}} = \text{Emissions in tonnes CO}_2\text{e}$

Fixed Energy Intensity Unit (Fixed EIU)

The Fixed Energy Intensity Unit (EIU) estimation method applies pre-determined energy intensity factors published by Natural Resources Canada (NRC) through the Office of Energy Efficiency

(OEE) Comprehensive Energy Use Database⁸¹. This database includes statistics on energy use by province, building use, type and fuel.

Calculation:

Table 22: Fixed Energy Intensity Unit Estimation Calculation

Step	Formula for each Fuel
1. For each fuel, determine the annual consumption amount.	$\begin{aligned} & \text{EIU (GJ/m}^2\text{)} \times \text{Share(\%)} / 100 \\ & \times \\ & \text{square meters of space} \\ & = \\ & \text{annual consumption amount (GJ)} \end{aligned}$
2. Apply the emission factor by fuel to yield total emissions by fuel	$\begin{aligned} & \text{Emission Factor (kg/GJ)} \\ & \times \\ & \text{Consumption (GJ)} \\ & = \\ & \text{Emissions by GHG (kg)} \end{aligned}$
3. Apply the global warming potentials to yield total emissions	$\begin{aligned} & \text{Emissions by GHG (kg)} \\ & \times \\ & \text{GWP} \\ & = \\ & \text{Emissions (kg CO}_2\text{e)} \end{aligned}$
4. Sum across the gases to calculate total CO ₂ e emissions	$\begin{aligned} & \text{CO}_2 + \text{CH}_4 + \text{N}_2\text{O (all in kg CO}_2\text{e)} \\ & = \\ & \text{Total CO}_2\text{e} \end{aligned}$
5. Convert total emissions from kg to tonnes for reporting purposes.	$\begin{aligned} & \text{Emissions in kg CO}_2\text{e} / 1\,000 \text{ kg / t} \\ & = \\ & \text{Emissions in tonnes CO}_2\text{e} \end{aligned}$

Hybrid Energy Estimations

In some instances, energy data may be available for one fuel in a building; but not for another. It is appropriate then to estimate the unknown fuel using one of the methods above.

Similarly, the regional calculation may be used to estimate one fuel type within a building if similar reported data is available, while other fuels in the same building may use the Fixed EIU for lack of available reported data.

⁸¹ Natural Resources Canada (NRC) through the Office of Energy Efficiency (OEE) Comprehensive Energy Use Database (2011):
http://oee.mcan.gc.ca/corporate/statistics/neud/dpa/trends_com_bct.cfm

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