VERSION 1

Greenhouse Gas Emission Assessment Guide

For British Columbia Local Governments

February 20, 2008

IMPORTANT:

This Guide will be updated frequently
Please ensure you are using the most up-to-date version

This is the first version of the Greenhouse Gas Assessment Guide for Local Government Projects. It is a "live" document, and will be updated frequently. Digital copies and updates will be made available through the "Examples/Best Practices" pages on the Provincial LocalMotion (www.localmotion.gov.bc.ca/examples.html) and Towns for Tomorrow (www.townsfortomorrow.gov.bc.ca/examples.html) grant program websites. As this is a "live" document feedback is appreciated.

The guide has been developed in a partnership between the Community Energy Association and the Ministry of Community Services.

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1. Overview

Climate change is one of the greatest challenges facing British Columbia and the world. Governments, businesses and individuals around the world are learning how to change their practices and procedures to meet this challenge, by identifying ways to reduce emissions of the greenhouse gases that cause climate change.

This guide provides local governments with background information and guidance for calculating greenhouse gas (GHG) emissions reductions for various common infrastructure types. It will:

- build capacity in understanding and calculating GHG emissions;
- provide a resource to complete infrastructure grant applications and program requirements for such programs as the Provincial Towns for Tomorrow and LocalMotion programs, and the Federal/Provincial/Union of BC Municipalities Gas Tax Program;
- support local government British Columbia Climate Action Charter commitments; and
- encourage overall GHG reduction for communities.

The main aim of the guide is to assist local governments in estimating the GHG emissions reductions that will arise from infrastructure projects. These estimates will be approximate, and GHG calculation need not be a daunting or complex task. The guide will also aim to provide suggestions for further resources, enabling local governments to find further help in estimating GHG emissions reductions.

The guide does not provide the basis for a detailed and rigorous assessment of GHG reductions. Rather, it will provide an introduction to the approaches and principles of a GHG assessment, and enough information to provide approximate estimates of the GHG reductions that may arise from some infrastructure projects.

The guide is organized into four sections: Section one introduces the context of climate change from a local government perspective. Section two provides an overview of GHG emissions assessment, while section three provides the key parameters necessary for calculating GHG emissions. Finally, section four provides calculation methodologies for specific types of local government project.

1.1 Climate change and local government

Climate change is a priority for British Columbia. The impacts of climate change are already felt in many communities in British Columbia, from the economic and environmental devastation of the Mountain Pine Beetle epidemic to storms and floods which have affected communities across the Province.

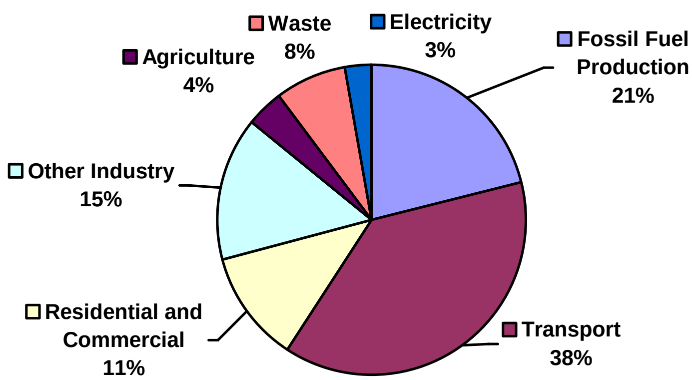
The provincial government, and many local governments, have committed to significant reductions in GHG emissions to help mitigate the impacts of climate change. The provincial government has committed to cutting GHG emissions by 33% by 2020, from 2007 levels. This target, along with an 80% reduction in GHG emissions by 2050, has been passed into law. The provincial government has also committed to becoming ‘carbon neutral’ in its operations by 2010, and is encouraging local governments to follow this example by becoming carbon neutral in their operations by 2012 through signing and implementing the Climate Action Charter[1]. As of February 2008, ninety five local governments have signed on to the Charter and are beginning to develop options for reducing their GHG emissions.

Local governments play a central role in implementing GHG reduction strategies:

- Providing strong Council and staff leadership – by setting an example at a local level, local governments can help foster behaviour changes;
- Reducing corporate GHG emissions (e.g. fleet management, constructing energy efficient civic buildings);
- Constructing infrastructure that enables the community at large to reduce GHG emissions (e.g. multi use commuter trails, and renewable district energy systems);
- Making land use planning decisions that enable GHG emissions reductions throughout the community (e.g. transit orientated urban design, and orientation of buildings to foster passive solar heating).

Local governments have significant influence over GHGs. In addition to GHGs that are directly emitted by local government operations (e.g. buildings, vehicles, infrastructure, landfills), local governments have indirect influence on around 45% of BC’s GHG emissions[2]. This is because local government decisions around land use and infrastructure greatly influence buildings (residential and commercial sectors), transportation (urban sprawl and the use of transit vs. driving) and waste.

B.C. Greenhouse Gas Emissions (2005)



Source: BC Ministry of Environment

1.2 Greenhouse gases

This guide focuses solely on greenhouse gases (GHGs), which are the main cause of climate change. The guide does not address approaches to reducing other air pollutants. There are many GHGs, but the most important are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). These gases differ in the degree to which they contribute to climate change. For example, methane is over 20 times more damaging than the same amount of carbon dioxide. However, it is customary to report all greenhouses gases as a single figure, measured in “tonnes of carbon dioxide equivalent” or tCO_2e. The emissions factors used to calculate GHGs in this guide are all reported in tCO_2e, so there is no need to do separate calculations for different GHGs.

Major sources of GHGs include:

1. **Combustion of fossil fuels used to generate electricity**. Although most of the electricity produced in BC is generated in hydroelectric stations, a small amount is generated in diesel and natural-gas-fired power stations. BC also imports power from other jurisdictions outside of the province, many of which produce power less cleanly than BC (for example, from coal).
2. **Combustion of fossil fuels in transportation**. Most of our transportation modes (shipping, aviation, trains and cars) are powered directly by the combustion of fossil fuels. Transportation is the single largest contributor to GHG emissions in BC.
3. **Combustion of fossil fuels for space and water heating**. In BC, buildings account for around 11% of GHG emissions[3]. The majority of this is from natural gas consumption, although propane and heating oil also play a role.
4. **Decomposition of organic wastes**. Organic wastes, including paper, wood, waste food and sewage solids all emit GHGs as they decompose. In aerobic conditions, decomposition largely produces carbon dioxide. However, under anaerobic conditions, such as in landfills and some sewage lagoons, decomposition produces significant quantities of methane, a more potent GHG.
5. **Destruction of “carbon sinks”**. Trees, other plants and soils absorb and store carbon dioxide from the atmosphere. Destruction of forests, green space and other ecosystems within a community causes the release of that carbon dioxide into the atmosphere, and prevents the ecosystem from absorbing further carbon dioxide.

Because methane is such a potent greenhouse gas, the projects that reduce methane emissions may create the greatest reductions for the size of the project. Such projects include the capture and destruction (e.g. flaring) or beneficial use (e.g. energy production) of landfill gas and digester gas arising from anaerobic digestion of sewage.

1.3 Infrastructure projects that reduce greenhouse gas emissions

Local government infrastructure projects will influence greenhouse gas emissions in a number of ways. The table below shows how some common kinds of projects will lead to GHG emissions reductions. This guide does not currently cover all sources of GHGs, nor does it cover all types of local government infrastructure project. However, the approaches and principles laid out in this guide can be adapted to other types of project where necessary.

Project category	Example project	GHG emissions reduction
Transportation Infrastructure	Bike paths on commuter route	Reduction in use of vehicles for commuting, leading to reduced use of fossil fuels
	Transit amenities	Increased use of transit, reduced use of vehicles for commuting, and therefore reduced use of fossil fuels
Energy Systems	Installation of renewable energy equipment	Reduced use of conventionally generated electricity and/or fossil fuels
Buildings	Energy efficiency retrofits (e.g. new lights, efficient boiler, etc.)	Reduced use of electricity and/or fossil fuels
	Construction of new "green" buildings that are more energy efficient than normal buildings.	Reduced use of electricity and/or fossil fuels
Water and Wastewater	Increased efficiency of system components (e.g. pumps, UV lamps, etc.)	Reduced use of electricity
	Water use reduction (e.g. water meters, leak detection and repair etc)	Reduction in requirement to pump and treat water/wastewater, leading to reduced use of electricity
Solid Waste	Waste Diversion (e.g. recycling, reducing and re-use programs, composting, etc.)	Reduced volume of waste at land fill and subsequent emissions of landfill gas
	Landfill gas collection	Reduced emissions of landfill gas
	Landfill gas use for energy	Reduced use of conventionally generated electricity and/or fossil fuels

Note that it is possible for a single project to lead to GHG emissions reductions in a number of different ways. For example, a wastewater treatment plant upgrade might include energy efficiency upgrades to the building/system; new equipment that reduces water use; and wastewater heat recovery technology that supplies energy to a district heating system. The reductions from each source should be calculated separately and totalled. Using the example above, the total GHG emission reductions from the wastewater treatment plant upgrade are calculated by adding up the following:

energy efficiency upgrade reductions + water efficiency upgrade reductions + district heating reductions.

This edition of the guide will not cover carbon sequestration – that is, the absorption of carbon dioxide from the atmosphere by vegetation or other carbon 'sinks'. This information may be included in later versions of the guide.

Carbon "Neutral" and Offsets

Many BC local governments have committed to becoming 'carbon neutral' by 2012, through signing the Climate Action Charter. This means that they will emit no *net* GHG emissions from local government operations. This can be achieved by first reducing GHG emissions as much as practical, and then offsetting the remaining GHG emissions through various strategies. This guide will not deal with offsets. The standards of rigour to validate and verify carbon reductions that are sold as offsets are much higher than the simplified calculation approaches introduced here. Further editions of this guide may help provide further guidance to local governments on these issues.

2. Calculating GHG emissions reductions

2.1 Use of this guide

This guide provides a starting point for a basic assessment of likely GHG emissions reductions. **Use the results with caution, and be modest about the accuracy of the emissions reduction estimates.** A comprehensive assessment of likely GHG emissions reductions can be an expensive and detailed process, which would likely require the involvement of expertise from outside local government. Local governments seeking to provide more robust assessments of GHG emissions reductions arising from projects should seek help from expert consultants.

2.2 Basic principles of GHG assessment

1. *Conservativeness*
   There will always be some uncertainty in GHG emissions calculations. Always make assumptions that will tend to under-estimate emission reductions, rather than over-estimate, particularly when uncertainty is high.

2. *Transparency*
   Document the sources of all data and describe assumptions when reporting estimated GHG emissions reductions.

3. *Accuracy*
   Attempt to reduce uncertainty as much as possible, by using the most accurate available data, and by considering all possible project impacts on GHG sources.

4. *Relevance*
   Data and assumptions should be relevant to the task of estimating GHG emissions reductions. Where possible, use locally-specific data. For some factors, the guide provides provincial or national average figures to be used where no local data is available. For example, the average cycle commuter distance in Canada is 5km[4]. In Kelowna, however, the figure is 8km[5] and the commuter distance may be lower than the national average. When reliable local data is available it should be used in place of the provincial or national average figures provided in section 3.3 of this guide. Where possible, this guide has identified resources to enable local governments to determine local data.

2.3 Absolute and relative GHG emissions reductions

Not all infrastructure projects will lead to net GHG emissions reductions. For example the construction of new infrastructure will often lead to a net increase in GHG emissions. However, where these projects take steps to reduce the likely GHG emissions arising from the project, it is still possible to report emissions reductions relative to a 'business-as-usual' future. For example, a new building will lead to an increase in overall greenhouse gas emissions even if it is highly energy efficient. However, a highly energy efficient building will reduce emissions in comparison to a business-as-usual building.

The table below provides examples of projects likely to lead to absolute and relative GHG emissions reductions.

Projects leading to <u>absolute</u> GHG emission reductions (GHG emissions after the project lower than emissions before the project)	**Projects leading to <u>relative</u> GHG emission reductions** (GHG emissions after the project higher than emissions before the project, but lower than a business-as-usual project)
▪ Energy efficiency retrofits in existing buildings and facilities ▪ Renewable electricity projects ▪ Commuter bike routes ▪ Water conservation projects ▪ Upgrades to existing water and wastewater infrastructure that result in energy reduction	▪ New energy efficient and "green" buildings (such as a state-of-the-art energy efficient ice arena) ▪ New water treatment facilities that are more energy efficient than industry standard

2.4 Baselines

Whether the reductions are absolute or relative, they will be calculated in relation to a 'baseline' future.

- For projects that will lead to absolute emissions reductions, the baseline will usually be current emissions, or current energy use. For example, the baseline for a building energy efficiency retrofit program is the current energy use. This is available from energy bills or the utility service provider (e.g. BC Hydro).
- For projects that lead to relative emissions reductions, the baseline will usually be the standard emissions for new infrastructure of that type. For example, the baseline for a new building might be the minimum energy efficiency requirements laid out in the forthcoming updates to the BC Building Code.

For the project types covered by the guide, baseline considerations will be highlighted in each calculation. In general, the guide uses the simplest possible baseline approach. However, it is worth pointing out that a more thorough and detailed emissions reduction assessment would require a more advanced approach to setting an appropriate baseline:

- ***Baseline time limit*.** Any baseline is only valid for a limited time period. If an appropriate valid time period for a baseline has not been assessed, it is impossible to say what a project's lifetime GHG emissions reductions will be. Instead, it is only possible to calculate annual reductions over the short term.

  This guide will not set a baseline time limit. Thus local governments can only report expected emissions that will arise in the short term (next few years).

- ***Static vs. dynamic baselines***.
  For many types of infrastructure, the emissions are not expected to change significantly from year to year. For example, a building will use a similar amount of natural gas for heating from year to year. In these cases, a '**static**' **baseline** is acceptable.

  However, some emissions sources do change significantly over time. For example, electricity consumed in BC is likely to become significantly less GHG intensive between now and 2016, following the 2007 BC Energy Plan's commitment to become less dependant on imported electricity (which is produced less cleanly than energy in BC). In theory, baseline emissions arising from electricity consumption will fall year by year, and a '**dynamic baseline**' should be used to reflect this.

  This guide will only consider static baselines.

2.5 Primary and secondary effects

Most attention should be paid to the major effects of a project on emissions. For example, the primary effect of installing a renewable energy system in a local government building is reduced use of conventionally generated electricity and/or natural gas, leading to emissions reductions. However, local governments should also consider 'secondary effects'. These are additional ways in which the project might affect GHG emissions.

There are two major kinds of secondary effects:

- ***One-time effects***. For some projects, there may be significant GHG emissions associated with the development or construction of a project. These might include the clearance of carbon 'sinks' (such as trees and other vegetation); GHGs emitted during construction (e.g. excavator's fuel use); and GHGs emitted during the production of certain materials, particularly cement. Where possible, local government projects should seek to reduce these emissions (e.g. utilizing high-volume fly-ash cement).
- ***Upstream and downstream effects***. Some kinds of projects may reduce emissions for the project itself, but cause emissions to increase elsewhere. For example, a project that used significant quantities of biomass energy might result in a local shortage of biomass fuel, causing other local institutions to use fossil fuels, rather than biomass. These kinds of effects are often mediated through market prices, and are likely to be negligible for most local government projects.

A thorough examination of the possible secondary effects arising from projects is beyond the scope of this guide. However, local governments are encouraged to research and report these if known in order to achieve the most accurate GHG inventory for a given project.

3. Key Parameters

All GHG emissions should be reported in metric tonnes of carbon dioxide equivalent (tCO_2e) emitted per year. Usually, this will be straightforward, because emissions factors for fossil fuel use and electricity have all been provided in terms of tCO_2e. However, in cases where these are not relevant (for example, with landfill gas emissions), it may be necessary to convert methane (CH_4) or nitrous oxide (N_2O) figures into tCO_2e:

1 tonne of CO_2 = 1 tonne of CO_2e
1 tonne of CH_4 = 21 tonnes of CO_2e
1 tonne of N_2O = 310 tonnes of CO_2e
Source: Environment Canada.
These figures are known as the "global warming potentials" of CO_2, CH_4 and N_2O.

3.1 GHG factors

The use of electricity and fossil fuels lead to GHG emissions. This table provides data on the amount of GHGs emitted for each unit of electricity or fossil fuels used.

GHG source	GHG factor	Data source and notes
Conventional electricity (grid-connected)	0.000022 tCO_2e/kWh	This number will change every year, since the relative contributions of hydro and fossil-fuel-fired electricity generating facilities changes every year. This number does not include imported electricity (future editions of the guide may). This figure is the GHG factor currently recommended by the BC Climate Action Secretariat
Natural gas	0.051 tCO_2e/GJ	Environment Canada[6]
Propane	0.00154 tCO_2e/litre	Environment Canada[7]
Heating oil	0.00284 tCO_2e/litre	Environment Canada[8]
Gasoline	0.00241 tCO_2e/litre	Environment Canada[9]
Diesel	0.00276 tCO_2e/litre	Environment Canada[10]

This edition of the guide will not cover alternative vehicle fuels such as biodiesel or hydrogen. That information may be included in later versions of the guide.

3.2 Unit conversions

It is important to ensure that all parameters are converted into the appropriate units before GHG emissions are calculated. The table below provides some useful conversion factors.

GHGs and sources	Preferred units	Common conversions
Electricity	kWh (Kilowatt hours)	1kWh = 0.0036 GJ
Natural gas	GJ (Gigajoules)	1 GJ = 26.9m^3 = 949 cubic feet = 0.948 million BTUs
Propane, heating oil, gasoline and diesel	litre	1 litre = 0.220 imp. gallons = 0.265 US gallons

Other conversion units are available found from the National Energy Board of Canada, at: http://www.neb.gc.ca/clf-nsi/rnrgynfmtn/sttstc/nrgycnvrsntbl/nrgycnvrsntbl-eng.html

3.3 Benchmark data

Benchmark figures are regional or national averages for energy consumption or GHG emissions that arise from particular processes or facilities. They can be used as a basis for calculating GHG emissions reductions when locally-specific data is not available, for example, where no engineering or transportation studies have been undertaken. Local data provides the best reference to calculate GHG emissions.

This section provides some benchmarks that can be used where local data is not available. It is important to recognize that these benchmarks are approximate, and GHG emissions calculations based on these benchmarks will be less accurate than those using locally-specific data. **It is recommended that benchmarks be only used where local data is not available or in such examples where it is cost prohibitive to collect such data. It is important to justify why local data has not been collected.**

Buildings benchmarks[11]
Electricity use in existing institutional buildings: 150 kWh/m^2 This figure includes office buildings and libraries, but is not appropriate for recreation centres.
Natural gas use in existing institutional buildings: 0.6 GJ/m^2 This figure includes office buildings and libraries, but is not appropriate for recreation centres.
Transportation benchmarks
% of non-recreational cyclists who would have driven, if they were not cycling[12]: 50%
Average BC cycling commuter distance[13]: 5km each way[14], 10km return trip
GHG factor for vehicle transportation: 0.000277 tonnes CO_2/km (based on average fuel efficiency of cars, SUVs and light trucks in BC of 11.5l/100km[15], and the GHG factor for gasoline).
Water benchmarks[16]
Average energy use for supply and treatment of groundwater: 0.482 kWh/m^3
Average energy use for supply and treatment of surface water: 0.375 kWh/m^3
Average BC resident daily water use[17]: 0.426m^3/day.
Wastewater benchmarks[18]
Average energy use for collection and primary treatment of sewage: 0.175 kWh/m^3
Average energy use for collection and secondary treatment of sewage: 0.320 kWh/m^3

4. Example project types and outline assessment methodologies

The current draft of the guide covers project examples in the categories of:

- Renewable energy (heating and electricity) systems
- Buildings
- Transportation
- Water and wastewater

This guide does not currently cover projects related to solid waste, with the exception of the energy-related reductions that will occur as a result of waste-to-energy or landfill gas utilization projects. Future versions of the guide may address these.

4.1 Renewable energy systems

Renewable energy systems reduce the amount of conventionally generated energy used. Since conventional energy (whether electricity, natural gas or other fossil fuels) leads to GHG emissions, the use of renewable energy will lead to reductions in GHG emissions.

Methodologies are provided here for estimating the GHG emissions reductions arising from both heat and electricity generating technologies. In general, renewable heating systems that reduce direct use of fossil fuels such as natural gas or propane will create the greatest GHG emissions reductions. Examples of local government renewable heating systems can be found in the Community Energy Association's renewable energy guide *Heating Our Communities*[19].

Project category	**Renewable Heating Systems**
Project types	Biomass heating system, renewable district heating system, solar, air and water heating systems, geoexchange (ground-source heat pumps) and heat recovery systems.
Description	The use of renewable heating systems will decrease the use of conventional energy (electricity, natural gas or other fossil fuels). Electricity and fossil fuels use creates GHG emissions; reductions in their use results in a decrease in GHG emissions.
GHG sources	Conventional heating systems, which may be powered with: Natural gas, electricity, other fuels (propane, fuel oil). For the purposes of this guide, biomass heating systems are considered to have no net GHG emissions[20].
Information required	Expected reductions in the use of conventional energy for heating. This information will be available from feasibility studies carried out for the project.

Calculation methodology	GHG emission reductions will depend on the amount of conventional energy avoided as a result of using the renewable energy system. The GHG emissions factor depends on the kind of heating system that is already being used, or that would have been used if the renewable energy system was not being installed (i.e. electric, natural gas or propane). For renewable heating systems in new buildings, the feasibility study for the system should identify what a 'base case' non-renewable heating system would have been. This provides the 'baseline', against which the renewable heating system is compared (e.g. solar water heating instead of a natural gas water heater).
Calculation	GHG emissions reductions = expected reduction in use of conventional heating * GHG factor for conventional heating system (electricity, gas, propane or fuel oil)
Notes	Requires local government to have adequate data on expected conventional energy use reductions associated with the project. These expected energy savings should already have been identified in the feasibility studies undertaken for the energy project.
Example	The Lillooet Recreation Centre was fitted with a solar water heating system in 1998. The solar water heating system reduced the use of propane by 18,000 litres per year. The GHG factor for propane is 0.00154 tCO2e/L. GHG emissions reduction = 18,000 L * 0.00154 tCO2e/L = 27.7 tCO2e per year
Information sources/links	▪ The energy savings expected from alternative energy systems can be calculated using RETScreen, a free software tool available from Natural Resources Canada. www.retscreen.net. ▪ The Community Energy Association (www.communityenergy.bc.ca) can provide advice and guidance on local government energy projects.

Project category	**Renewable Electricity Systems**
Project types	Solar photovoltaic panels, microhydro, landfill gas utilization, biomass-fired-cogeneration.
Project description:	The electricity generated can either be used within local government facilities or can be sold to the grid (via BC Hydro's Net Metering or Standing Offer Program)[21]. The use of renewable electricity systems will decrease the use of conventional electricity. Conventional electricity use creates GHG emissions; and reductions in this use result in a decrease in GHG emissions.
GHG sources	Conventional electricity generation.
Information required	Expected renewable electricity production, in kWh/year. This will be available from the feasibility studies that will have been undertaken for the project.
Calculation methodology	Emissions reductions will simply be the amount of electricity produced by the renewable energy system, multiplied by the GHG factor for conventional electricity.
Calculation	GHG emissions reductions = electricity produced * GHG factor for electricity
Notes	This methodology is only appropriate for projects connected to the main BC electricity grid. Off-grid facilities that are currently powered by diesel generators will have to calculate their expected reductions in diesel use in order to estimate emissions reductions.
Examples	An 80kW solar photovoltaic system in Abbotsford would be expected to produce around 97,000 kWh per year[22]. The GHG factor for electricity is 0.000022 tCO2e/kWh. Electricity produced = 97,000 kWh/year GHG emissions reduction = 97,000 kWh * 0.000022 tCO_2e/kWh (GHG factor for electricity) = 2.1 tonnes of CO_2e per year
Information sources/links	▪ The energy savings expected from alternative energy systems can be calculated using RETScreen, a free software tool available from Natural Resources Canada. www.retscreen.net. ▪ The Community Energy Association www.communityenergy.bc.ca can provide advice and guidance on local government energy projects.

4.2 Energy efficiency in buildings

Buildings – through their heating, lighting, ventilation and other services – consume significant amounts of energy, which leads to GHG emissions. Existing buildings can be retrofit with energy efficiency technologies that will reduce energy use and hence reduce GHG emissions.

While the construction of new buildings will lead to a net increase in GHG emissions, highly energy efficient 'green' buildings will have reduced GHG emissions compared to a 'business-as-usual' building. Methodologies are provided here both for estimating GHG emissions reductions arising from building energy efficiency retrofits, and for estimating the relative GHG emissions reductions that arise from the construction of new energy efficient buildings. Where possible, it is better to reduce emissions from existing buildings, rather than to build new energy efficiency buildings. Rather than constructing new buildings, consider redeveloping vacant or under-used buildings.

Note that energy efficient buildings and retrofits are likely to generate long term financial savings as a result of reduced energy costs. The buildings that will likely yield the biggest savings, both financial and in terms of GHGs, are swimming pools and ice arenas, since these both use significant amounts of energy for heating and cooling. Opportunities may include using the waste heat from an ice arena to heat water for the swimming pool, resulting in significant cost and GHG emissions savings.

For advice and support about energy efficiency in new and existing buildings, contact Green Buildings BC for Local Governments www.greenbuildingsbc.com.

Project Category	**Buildings**
Project types	Building energy efficiency retrofits or upgrades
Description	Energy efficiency retrofits or equipment upgrades will reduce the consumption of electricity and fossil fuels used within the building, resulting in a decrease in GHG emissions.
GHG sources	Natural gas, electricity, other fuels (propane, fuel oil)
Information required	Feasibility study, or existing energy consumption and percentage savings estimate.
Calculation methodology	Energy savings from undertaking the retrofit or upgrade. In most cases savings will be determined through a feasibility study (Recommended). If not available, rough savings can be estimated using existing consumption and percentage savings. Most retrofit projects will save between 10% and 30% of a building's energy[23]. Usually, the more comprehensive the retrofit (longer-paybacks, more capital investment), the higher the savings. If a retrofit only addresses electrical systems (e.g. lighting), the savings should not be applied to natural gas or other fuels, and vice-versa. Existing consumption can be found from past utility bills, or by calling your utility representative.
Calculations	Energy savings = Existing consumption * % savings (or from feasibility study - recommended)

	GHG emissions reductions = energy savings * GHG factor
Notes	• Feasibility studies or other energy calculations should be performed by a qualified professional. Estimates calculated by others (e.g. equipment suppliers, contractors) should be checked against existing consumption. • Some projects may also result in water savings. However, GHG reductions from water conservation on individual buildings may be too small to be calculated. See the Water Project Category for GHG reductions due to water conservation.
Examples	An energy retrofit feasibility study for the Parkinson Recreation Centre in Kelowna in 2003 indicated potential annual savings of 10,400 GJ natural gas and 592,000 kWh electricity. Measures assessed included HVAC upgrades, lighting upgrades and retrofits of new efficient mechanical equipment such as pumps. The GHG factor for natural gas is 0.051 tCO2e/GJ and for electricity is 0.000022 tCO2e/kWh. Natural gas GHG emission reductions = 10,400 GJ * 0.051 tCO2e/GJ = 520 tonnes CO_2e Electricity GHG emission reductions = 592,000 kWh * 0.000022 tCO2e/kWh = 13 tonnes CO_2e Therefore, total GHG emission reductions for this project = 520 tonnes CO_2e (from natural gas) + 13 tonnes CO_2e (from electricity) = 533 tonnes CO_2e per year
Information sources/links	▪ Green Buildings BC for Local Governments can provide information and case studies on energy retrofit projects. www.greenbuildingsbc.com

Project Category	**Buildings**
Project type	New buildings that are more energy efficient than current 'business-as-usual' practice. Typically this will be a certified 'green' building using a standard such as LEED (Leadership in Energy and Environmental Design).
Description	New buildings that incorporate energy efficiency features or are built to a higher energy standard (e.g. LEED), will use less electricity and fossil fuels, and therefore produce fewer GHGs, than an average new building.
GHG sources	Natural gas, electricity, other fuels (propane, fuel oil)
Information required	Energy study with estimated energy savings compared to a typical new building of the same type.
Calculation methodology	Energy savings will be determined through an energy study comparing the new building to the baseline. The baseline is the typical energy use of a similar type of new building. In most cases energy savings estimates will be available through a feasibility study or computer simulation. If the savings are in comparison to a typical building, they can be used directly (recommended). If there is no feasibility study, a benchmark figure for a typical building can be used, although this will lead to a less accurate GHG estimate. ▪ Benchmark electricity use in institutional buildings: 150 kWh/m^2 ▪ Benchmark natural gas use in institutional buildings: 0.6 GJ/m^2 Note that some feasibility studies will determine savings relative to the Model National Energy Code for Buildings (MNECB)[24]. This is an old standard and current construction practices have become considerably more efficient; ask your consultant to estimate the savings in comparison to a typical new building.
Calculations	Energy savings should come from a feasibility/energy study. GHG emissions reductions = energy savings (versus a conventional building) * GHG factor Where this is not available, a benchmark approach can be used: Energy savings = building floor area (m^2) * energy use benchmark * % energy savings
Notes	• Emissions reductions arising from energy efficiency measures in new buildings will be relative, not absolute reductions (see section 2.3 for an explanation of relative vs. absolute reductions). • In most cases, energy use in new buildings should be viewed from a whole building perspective, rather than by individual system (e.g. lighting, boilers, etc.). Comparisons to recognized standards such as ASHRAE 90.1[25] are the most appropriate. Exceptions to this would include systems not covered under ASHRAE 90.1 (e.g. ice rink refrigeration systems). Energy savings for such systems should be determined by a qualified professional. • Some projects may also result in water savings. However, GHG reductions from water conservation on individual buildings may be too small to be calculated. See Water section for calculations of GHG reductions due to water conservation.

Examples	A new 6,000 m² municipal hall is proposed to be LEED Gold, with estimated annual energy savings of 200,000 kWh and 500 GJ compared to a typical municipal hall. GHG factor for electricity is 0.000022 tCO2e/kWh and GHG factor for natural gas is 0.051 tCO2e/GJ. Natural gas GHG emission reductions = 500 GJ * 0.051 tCO2e/GJ (natural gas GHG factor) = 25.5 tCO_2e reduced Electricity GHG emission reductions = 200,000 kWh * 0.000022 tCO2e/kWh (electricity GHG factor) = 4.4 tCO_2e Therefore total GHG emission reductions from this project = 29.9 tonnes CO_2e per year
Information sources/links	▪ LEED Canada - www.cagbc.org ▪ BC Building Code - http://www.housing.gov.bc.ca/building/green/index.htm ▪ ASHRAE 90.1-2004 - http://www.ashrae.org/technology/page/548 ▪ MNECB - http://www.nationalcodes.ca/mnecb/index_e.shtml ▪ Green Buildings BC for Local Governments can provide information and case studies on energy retrofit projects. www.greenbuildingsbc.com

4.3 Transportation

Transportation is the single largest contributor to GHG emissions in British Columbia. Local governments have significant influence over transportation, through land use planning decisions, and through the construction of local transportation infrastructure.

The methodology below has been developed to estimate GHG emissions reductions arising from non-recreational bike paths and lanes. Other transportation-related infrastructure projects may also lead to emissions reductions, including construction of transit amenities, the provision of transit buses, or upgrades to local government fleets. In each case, the methodology involves estimating either:

- reduction in use of single-occupancy vehicles; and/or
- reduction in fuel consumption from fleet upgrades.

These estimations are very specific to the characteristics of the project and community; they cannot be accurately described within this guide.

Advice for reducing emissions from **fleet vehicles** is available from the E3Fleet program, administered by Fraser Basin Council (www.e3fleet.com). The GHG Protocol Initiative has developed a spreadsheet tool for calculating emissions from fleet vehicles, called "*CO_2 emissions from transport or mobile sources*". The tool is freely available, but users must first register with the GHG Protocol website.
http://www.ghgprotocol.org/calculation-tools/service-sector

Project Category	**Transportation**
Project type	Non-recreational bike paths and bike lanes
Description	Bike paths and bike lanes provide safe environments for cyclists, either off-road or on-road. The construction of bike paths and lanes can encourage people to use bikes, instead of cars, for utilitarian purposes (i.e., to and from work, school, shopping), thus reducing GHG emissions from vehicles.
GHG Sources	Vehicle fuel consumption
Information required	▪ Estimated number of non-recreational users of the bike path ▪ Average distance cycled ▪ Percentage of non-recreational users of the bike path who would have driven by car
Calculation methodology	The GHG emission reductions are calculated by estimating the numbers of commuters who will use the bike facility instead of driving to their destination, and then calculating the resulting emissions avoided. Assessing the **likely number of users of a bike path or lane** is a key variable in establishing an emissions estimate. If this number has already been estimated using local data and bicycle counts, use this locally-derived number[26].

	A US tool to estimate demand for bike paths is available at: http://www.bicyclinginfo.org/bikecost/step1.cfm. It is tailored for use in the US, but can be used by BC communities. Information required includes population density in the area surrounding the bike path, and the percentage of total trips in the area already made by bicycle. Where this is not known, use the BC average figure of 2%[27]. More detailed guidance on methods for estimating the likely number of users is available from the governments of New Zealand[28], US[29], UK[30] and Australia[31]. However, these tend to be lengthy documents. The guidance from New Zealand may be of most direct use. **Other important parameters** include the percentage of cyclists using the bike path that would otherwise have driven, and the average bike trip length. Where locally-specific data is not available, the following benchmarks may be used: ▪ % of non-recreational cyclists who would have driven, if they were not cycling[32]: 50%. ▪ Average BC cycling commuter distance: 5km each way[33], 10km return trip.
Calculations	Vehicle kilometres avoided = Number of bike path users/year * % of users that would have driven * average bike user trip length GHG emissions reductions = vehicle kilometres avoided * GHG factor for vehicles (0.000277 tCO_2e/km)
Notes	This calculation methodology is only relevant where bike facilities are constructed on commuter routes, or to other major destinations to which people travel by car. Recreational bike paths will not lead to a reduction in emissions, and may even lead to an increase in emissions, since people may drive to them. Where bike path construction involves the destruction of natural ecosystems (not recommended), such as forest, or the use of materials whose manufacture involves significant carbon emissions (such as cement), there may be a significant one-time increase in emissions associated with the project. In cases where expected ridership is low, such one-time effects should be reported. Where possible, steps should be taken to reduce the one-time impacts of construction.
Examples	A new bike path is built between a major subdivision and downtown. It is expected that 80 people will make return trips using the path each day (this is an average annual figure, accounting for seasonal variation and differences between week and weekend travel). Although the bike path is 7 km long, the average distance from homes in the subdivision to downtown is only 4 km. It is expected that 50% of users would have otherwise driven. Average vehicle emissions are 0.000277 tCO_2e/km. Number of bike path users per year = 80 trips/day * 365 days/year = 29,200 Vehicle kilometres avoided per year = 29,200 * 8 km round trip * 50% = 116,800 km GHG emissions reductions per year = 116,800 km * 0.000277 tCO_2e/km = 32.4 tonnes CO_2e

Information sources/links	▪ Better Environmentally Sound Transport, a BC organization dedicated to advancing sustainable transportation: www.best.bc.ca ▪ Victoria Transport Policy Institute, providing research and information on a variety of transportation topics: www.vtpi.org ▪ http://www.bicyclinginfo.org/bikecost/step1.cfm A tool to estimate demand for new bike paths.

4.4 Water and wastewater projects

Water supply and treatment, and wastewater collection and treatment, use significant amounts of energy, which in turn leads to GHG gas emissions.

The methodology below is appropriate for projects that reduce water and wastewater flow in existing infrastructure and buildings.

Where projects upgrade or replace water system equipment with more energy-efficient equivalents (such as new pumps), the feasibility work for upgrades should have identified and quantified likely electricity savings or electricity requirements of the new equipment (the latter can then be compared against known current energy use). These electricity savings can then be directly used to estimate emissions reductions by multiplying them by the GHG factor for electricity (0.000022tCO_2e/kWh).

New water supply, wastewater collection or treatment facilities would have to be compared against a baseline, which would be current industry standard practice or energy performance of alternatives being considered (e.g. through a feasibility study of options). Given the highly varied nature of water treatment systems, a benchmark figure for standard practice is not provided here. Unless an engineering study is available to compare the proposed project with a base case, it may not be possible to calculate relative emissions reductions arising from new water infrastructure.

Decomposition of organic materials in sewage also leads to GHG emissions. CO_2 arising from this process is not counted towards emissions inventories, since it is the inevitable result of the decomposition of organic wastes[34]. Under anaerobic conditions, methane is also produced. Methane can be captured and burned. Nitrous oxide can also be produced as a result of the decomposition of sewage. Where possible, local governments should identify and report these emissions sources (particularly whether methane will be captured from anaerobic digesters). However, this draft of the guide will not provide further guidance on methane and nitrous oxide emissions from wastewater treatment.

Project Category	**Water and Wastewater**
Project type	Reducing water flow in the water system and in buildings. Projects of this type include: ▪ Repair of leaks and other water conservation measures in the water supply system ▪ Low-water appliances in buildings (either existing or retrofit), such as low-flow toilets, low-water use taps ▪ Water meter programs
Description	Water supply and wastewater treatment both involve the use of energy, particularly to pump water through the system. A reduction in the volume of water passing through a supply/collection and treatment system will lead to a reduction in energy use, and hence a reduction in GHG emissions.
GHG sources	Electricity

Information required	▪ Expected reductions in water and wastewater flow (in m^3) arising from the water use reduction measures ▪ Energy use for water supply and treatment as well as from wastewater collection and treatment systems (e.g. can be found through electricity bills).
Calculation methodology	GHG reduction is calculated based on the estimated reduction in water and wastewater flow, and the resulting reductions in electricity use.
Calculations	Water electricity savings = expected reductions in flow (m^3 per year) * electricity use in water supply system (kWh) Wastewater electricity savings = expected reductions in flow (m^3) * electricity use in wastewater treatment system (kWh) Therefore total GHG emission reductions: =(Electricity savings from water supply + electricity savings from wastewater treatment) * GHG factor for electricity.
Notes	If there is locally available data on electricity used in the water supply/collection and treatment, this should be used. Only if this is not available should the benchmark data be used. Many water conservation measures will also result in an equivalent reduction in wastewater (e.g. low-flow toilets or showers). However, some measures, such as reducing lawn irrigation, will not result in any wastewater flow reduction if the water does not go into the sewer system. Areas using septic fields would also fall into this category. Where this is the case, only GHG reductions from the water supply should be calculated.
Example	A new water-metering program is expected to reduce water consumption by 30%, and wastewater flows by 15%. Total water consumption is currently 5,000,000 m^3/year and total wastewater flow is 3,000,000 m^3/year. The local government has calculated its energy use for water supply and treatment to be 0.40 kWh/m^3 and for wastewater collection and treatment to be 0.30 kWh/m^3. The GHG factor for electricity is 0.000022 tCO_2e/kWh. Water electricity savings = 5,000,000 m^3 per year * 30% * 0.40 kWh/m^3 = 600,000 kWh per year Wastewater electricity savings = 3,000,000 m^3 per year * 15% * 0.30 kWh/m^3 = 135,000 kWh per year Water electricity savings + wastewater electricity savings = 735,000 kWh per year Therefore total GHG emission reductions from this project = 735,000 kWh x 0.000022 tCO_2e/kWh (GHG electricity emissions factor) = 16.2 tonnes CO_2e per year

Information sources/links	▪ http://epa.gov/watersense/pubs/guide.htm A guide produced by the United States Environmental Protection Agency to help develop water conservation plans. ▪ www.waterdsm.org A project of the POLIS Project on Ecological Governance at the University of Victoria that provides research and analysis on water conservation measures. ▪ http://www.nationalbenchmarking.ca A project that enables Canadian municipal water and wastewater utilities to measure, track and report on their water utility performance.

Endnotes

[1] BC Climate Action Charter: http://ubcm.ihostez.com/content/pdfstorage/27805820A3714D389CFBE558FC06F7B9-ClimateActionCharter.pdf
[2] Figure estimated by the Community Energy Association, based on Environment Canada's 2004 emissions data for British Columbia.
[3] BC Ministry of Environment and Climate Action Secretariat 2007. The British Columbia GHG Emissions Profile. Victoria.
[4] [4] This 5km figure is used by the Ministry of Transportation as a rule-of-thumb for planning. It is consistent with data recently collected in Metro Vancouver as part of the University of British Columbia's Cycling in Cities project.
[5] http://www.kelowna.ca/CM/Page1057.aspx
[6] Environment Canada, National Inventory Report 1990-2005, Annex 12. Based on residential & commercial/institutional use. http://www.ec.gc.ca/pdb/ghg/inventory_report/2005_report/a12_eng.cfm#a12_1
[7] Environment Canada, National Inventory Report 1990-2005, Annex 12. Based on residential use. http://www.ec.gc.ca/pdb/ghg/inventory_report/2005_report/a12_eng.cfm#a12_1
[8] Environment Canada, National Inventory Report 1990-2005, Annex 12.: http://www.ec.gc.ca/pdb/ghg/inventory_report/2005_report/a12_eng.cfm#a12_1
[9] US EPA Guidance on estimating vehicle GHG emissions Environment Canada, National Inventory Report 1990-2005, Annex 12. Based on Tier 1 light duty vehicles.: http://www.ec.gc.ca/pdb/ghg/inventory_report/2005_report/a12_eng.cfm#a12_1
[10] US EPA Guidance on estimating vehicle GHG emissions Environment Canada, National Inventory Report 1990-2005, Annex 12. Based on Advanced control heavy duty vehicles.: http://www.ec.gc.ca/pdb/ghg/inventory_report/2005_report/a12_eng.cfm#a12_1
[11] The benchmarks for existing buildings in BC have been estimated using data from NRCan's 2005 survey of commercial and institutional energy consumption. http://oee.nrcan.gc.ca/Publications/statistics/cices05/index.cfm
[12] This figure is an estimate, partly based on the overall share of single occupancy vehicle trips as a proportion of total trips, which is 75% http://www12.statcan.ca/english/census01/products/analytic/companion/pow/bycar.cfm. However, it is thought likely that disproportionately more cyclists are shifting out of transit, rather than out of single occupancy vehicles. Although it is difficult to confirm this, a conservative assumption of 50% is recommended.
[13] Note that the BC median commuter distance is only 6.4km http://tinyurl.com/22jdad
[14] This 5km figure is used by the Ministry of Transportation as a rule-of-thumb for planning. It is consistent with data recently collected in Metro Vancouver as part of the University of British Columbia's Cycling in Cities project.
[15] NRCan Canadian Vehicle Survey 2005: http://oee.nrcan.gc.ca/Publications/statistics/cvs05/introduction.cfm?attr=0
[16] Electric Power Research Institute, 2002. *Water & Sustainability (Volume 4): U.S. Electricity Consumption for Water Supply & Treatment—The Next Half Century*. Available from www.epri.com Provides average figures for the US, which are likely similar to that in Canada
[17] Average BC residential water use in 2004, from Ministry of Environment: http://www.env.gov.bc.ca/soe/et07/03_fresh_water/water_use.html
[18] Electric Power Research Institute, 2002. *Water & Sustainability (Volume 4): U.S. Electricity Consumption for Water Supply & Treatment—The Next Half Century*. Available from www.epri.com Provides average figures for the US, which are likely similar to that in Canada

[19] Community Energy Association (2007) *Heating our Communities: renewable energy guide for local governments in British Columbia*. Vancouver. Available from www.communityenergy.bc.ca
[20] Biomass consumption is considered to incur no net GHG emissions: http://www.ghgreporting.gc.ca/GHGInfo/Pages/page15_c2.aspx#s24
[21] BC Hydro – Standing Offer Program (http://www.bchydro.com/info/ipp/ipp51323.html) and Net Metering Program (http://www.bchydro.com/info/ipp/ipp8842.html). For information about how local governments can establish renewable electricity projects and utilities, see the Community Energy Association's *Utilities and Financing: a module of the renewable energy guide for local governments in British Columbia*.
[22] Calculations based on RETScreen analysis, using climate data from Abbotsford and real solar PV system product data. RETScreen is freely available at www.retscreen.net
[23] Figure provided by Green Buildings BC for Local Governments.
[24] The Model National Energy Code for Buildings is a model energy code published by the National Research Council Canada. It was released in 1997 and has not been updated since.
[25] ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings is an internationally recognized energy efficiency standard produced by the American Society of Heating, Refrigerating and Air-Conditioning Engineers.
[26] Guidance on conducting bicycle counts is available from the Ministry of Transportation, in section seven their guidelines for completing an application to the Cycling Infrastructure Partnership Program: http://www.th.gov.bc.ca/popular-topics/cycling/cipp/Documents/CIPP_Guidelines.pdf
[27] In BC, bike share of total trips is 2% http://www12.statcan.ca/english/census01/products/analytic/companion/pow/ftorbike.cfm.
[28] New Zealand guidance on estimating bike path demand http://www.landtransport.govt.nz/road-user-safety/walking-and-cycling/cycle-network/chapter7.html
[29] http://www.fhwa.dot.gov/tfhrc/safety/pubs/vol1/Contents.htm
[30] UK guidance on estimating local demand for greenways: http://www.countryside.gov.uk/LAR/Recreation/Greenways/GreenwaysHandbook/SECTION2/Step3AssessingDemand/GreenwayDemandInTheLocalContext/index.asp
[31] Australia guidance on estimating bike path demand: http://www.austroads.com.au/documents/418_AP_R194_1.pdf
[32] This figure is an estimate, partly based on the overall share of single occupancy vehicle trips as a proportion of total trips, which is 75% http://www12.statcan.ca/english/census01/products/analytic/companion/pow/bycar.cfm. However, it is thought likely that disproportionately more cyclists are shifting out of transit, rather than out of single occupancy vehicles. Although it is difficult to confirm this, a conservative assumption of 50% is recommended.
[33] This 5km figure is used by the Ministry of Transportation as a rule-of-thumb for planning. It is consistent with data recently collected in Metro Vancouver as part of the University of British Columbia's Cycling in Cities project.
[34] See IPCC guidance on wastewater treatment CO_2 emissions for inventory purposes: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol5.htm