

Carbon Calculator

Methodology

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1. Purpose of this Calculator Methodology

This greenhouse gas (GHG) calculator methodology has been developed for the province of Nova Scotia to inform the development of a suite of online GHG calculators. These tools will allow Nova Scotia residents and businesses to quickly and easily estimate the GHG emissions resulting from common activities.

This project supports the public education activities of the Nova Scotia Environment Climate Change Directorate. The objective is to allow Nova Scotia citizens, businesses and organizations to estimate the GHG emissions resulting from common activities. Understanding how actions affect climate is an important step in motivating positive behavioural changes.

2. Scope of Activity and GHG Emissions Included

The **Nova Scotia GHG Emissions Calculator** addresses GHG emissions from residential, commercial business and community based institutional sector participants. Different methods are used to estimate GHG emissions from residents, businesses and institutions and two different sets of calculators are included.

1. Residential Calculator:

- a. Home Energy Use
- b. Personal Transportation/Commuting
- c. Vacation Travel

2. Business Calculator:

- a. Building Energy Use
- b. Business Travel
- c. Conference/Meeting Hosting

Common GHG emission regulatory mechanisms and international standards require the monitoring and reporting of six GHGs, namely; carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and sulphur hexafluoride (SF₆). Only carbon dioxide, methane, and nitrous oxide are emitted from common activities and are included in the scope of the **Nova Scotia GHG Emissions Calculator** Methodology.

In order to present a single metric for GHG emissions, the three GHGs included are normalized to their carbon dioxide equivalency (CO₂e) using the global warming potential of each gas. The total GHG emissions from all three gases are then aggregated and presented as one figure in terms of tonnes of carbon dioxide equivalent, or tCO₂e.

The customized calculators use Nova Scotia specific GHG emission intensities and include all of the significant direct emissions and indirect (electricity use) emissions. The calculators are appropriate for producing GHG emission estimates only and not for producing GHG inventories in conformance with ISO 14064-1 or verification for listing on the GHG CleanStart™ Registry.

3. Administrative Data Requirements

The GHG emission estimates generated by the **Nova Scotia GHG Emissions Calculator** are based on information input online by the users and generally accepted GHG emission factors for common activities. Specific calculations use customized Nova Scotia data and GHG emission methodologies designed by CSA Standards for this project. In order to make the calculators as accessible and transparent as possible, the methodology includes information about data sources and the GHG emission factors used. There are several basic categories of data required to generate estimates of GHG emissions and these have been organized into calculators for buildings (residential and commercial), routine transportation (commuting, business operations), vacation travel, business travel, and conference or event hosting.

In order to manage user inputs and track GHG emission reductions over time, the online interface allows users the option to establish an account. This allows sorting of the data by individual account holder and provides Nova Scotia with a database of GHG emissions information. There are only three pieces of information that are required of the user:

Field 1: User email address

Field 2: User selected password

Field 3: Nature of user (i.e., residential, commercial or institutional)

An email address is required to create a log-in ID and reset passwords if necessary. It will not be used for any other purpose or shared with anyone unless the user provides permission to do so. All other information requested is required to estimate GHG emissions and will not be used for any other purpose or shared with anyone.

Email addresses and GHG profiles will be stored separately in secure password protected data bases. Access to the database is limited to authorized Nova Scotia Government staff.

4. Residential Home Energy Use Calculator

Data Input Requirements for Residential Home Energy Use

GHG emissions from residential buildings may be quantified in one of two ways; a) using records of energy and fuel use obtained from utility bills, or; b) using information on residential building size and equipment details provided by the user and performance metrics available from government sources.

The calculator will invite users to enter the energy and fuel use data if possible as this is the most accurate option. If this information is not available the calculator will have to estimate based on the user provided building profile. This is less accurate for several reasons. The user may not enter the precise building information (such as floor area or efficiency of heating system). Any error will decrease the accuracy of the estimate. Secondly the calculator has to rely on average or typical emissions for related buildings. There are many other factors that influence a building's efficiency that are not accounted for here. As such the option to estimate home energy emissions based on the building profile are less accurate than using utility records.

If data on residential building energy use from utility bills is available:

Field 1: Annual energy consumption by fuel type for all electricity and fuel use in the building (available from utility use records), including; electricity (kWh), natural gas (gigajoules), fuel oil (litres), propane (litres) and wood (cord);

Field 2: Identification of any renewable energy purchasing agreements, including non-GHG emitting electricity, biofuels and renewable energy certificates.

If data on residential building energy use from utility bills is not available:

Field 1: Type of building (e.g., single attached, single detached, apartment, mobile home);

Field 2: Age of building (selected from a dropdown list);

Field 3: Size of building (measured in square feet or square metres of floor space);

Field 4: Type of heating system (electric, natural gas, heating oil, propane, or wood);

Field 5: Type of space cooling (with options for electric, natural gas or none);

Field 6: Type of hot water heater (electric, natural gas, oil or none);

Field 7: Use of onsite renewable energy generation from geothermal or solar hot water;

Field 8: Identification of any renewable energy purchasing agreements, including non-GHG emitting electricity, biofuels and renewable energy certificates.

Calculation Methodology for Residential Home Energy Use

The most accurate way to generate an estimate of the GHG emissions attributed to home energy use is to derive this from records of the fuel (i.e., natural gas, fuel oil, propane, or wood) and electricity purchased over the course of a year to operate the home. This information is available on utility bills and makes for a more precise quantification of the GHG emission than if activity

data is used for estimating. Fuel consumption totals can be multiplied by GHG emission factors for primary fuels and electricity by the regional electricity grid intensity factor for Nova Scotia.¹

The calculation is performed for electricity and repeated for each fuel used in the home using the GHG emission factors for the various fuel types found in Appendix A.

When calculating GHG emissions from electricity, the electricity consumption total is first discounted by the total amount of electricity from renewable energy certificates (RECs) purchased (if any) before the electricity use total kWh is applied.

Equation 1: *Estimating GHG emissions from Home Energy Use using utility records:*

$$\mathbf{Home}_{EUE} = \sum_{\text{Fuels}} \{ \mathbf{EF}_{\text{FuelType}} * \mathbf{FC}_{\text{FuelType}} \} + \mathbf{EF}_{\text{Electricity}} * (\mathbf{EC}_{\text{Electricity}} - \mathbf{REC})$$

Where:

Home_{EUE} = Home energy use GHG emissions

EF_{FuelType} = Emission factor for primary fuels in tCO₂e per unit (Appendix A)

FC_{FuelType} = Consumption per year of primary fuel in units

EF_{Electricity} = Emission factor for Nova Scotia electricity grid in tCO₂e per kWh

EC_{Electricity} = Consumption per year of electricity in kWh

REC = Total amount of renewable energy purchased per year in kWh

If fuel and electricity records are not available, then information about the specific home profile provided by the user is used to estimate GHG emissions based on building stock energy use statistics for Nova Scotia provided by the Office of Energy Efficiency (OEE) at Natural Resources Canada.² In this case the GHG emissions may be estimated less precisely by multiplying the building floor area by the GHG emission intensity (i.e., tCO₂e per m²/day) based on user-provided home profile information. The home-type options and associated GHG emission factors are found in Appendix B.

Users identifying the existence of geothermal heating for the home shall have their space heating and space cooling components of Home Energy Use discounted by 50%. This is consistent with a Natural Resources Canada estimated contribution geothermal heat pumps make to home heating and cooling.

Users identifying the existence of solar hot water heating shall have their emissions from water heating discounted by 50%. This is consistent with a Natural Resources Canada estimated contribution solar hot water systems make to meeting the energy demands for water heating.

¹ Nova Scotia Power:

http://www.nspower.ca/en/home/environment/reportsandmetrics/archivedemissionslevels/co2e_emissionintensity.aspx

² The Office of Energy Efficiency compile, on an annual basis, estimates of emissions attributable to the residential sector for each province in Canada. This is done using a model of the Canadian residential sector that includes details of the building stock (number, size of dwellings, etc), data on fuel sources, heating systems, cooling systems, appliances contained in the home, etc. This modeling is calibrated to the Report on Energy Supply and Demand in Canada published by Statistics Canada. See http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/trends_res_ns.cfm

Equation 2: *Estimating GHG emissions from Home Energy Use using floor area:*

$$\mathbf{Home}_{EUE} = \mathbf{EF}_{HomeType} * \mathbf{Home}_{FloorArea}$$

Where:

Home_{EUE} = Home energy use GHG emissions

EF_{HomeType} = Emission factor for the specific home type (Appendix B)

Home_{FloorArea} = Total floor area for the home in m² or square feet

The GHG emission intensity values for specific home types (Appendix B) are based on the total amount of energy used in the home, including heating and air conditioning, water heating, electric appliances and lighting. The GHG emission intensities vary based on the following parameters:

- Building age;
- Type of heating system;
- Efficiency rating of heating system;
- Presence or absence of cooling system;
- Fuel used for water heating;
- Use of geothermal or solar hot water systems;
- Discounted energy emissions through purchase of green power certificates.

5. Personal Transportation/Commuting Calculator

Data Input Requirements for Personal Transportation/Commuting

There are two sources of GHG emissions included in the **Personal Transportation/Commuting Calculator**, these are; GHG emissions associated with the use of personal passenger vehicles (i.e., cars and light trucks), and GHG emissions associated with the use of public transportation.

For the use of personal passenger vehicles, the calculator includes two ways to estimate GHG emissions; based on total kilometres travelled per year using odometer readings, or estimated distance travelled based on annual total trips information. It is also possible to estimate GHG emissions from total volume of fuel consumed per year, however this option is not included in the calculator as this information is not available to most residents.

For travel by personal passenger vehicles using total kilometres per year (known or estimated)

Field 1: number of vehicles operated by the household, business or institution;

Field 2: types of vehicle(s) owned and operated (selected from a dropdown list);

Field 3: number of fuel litres consumed per year or total vehicle kilometres per year, by vehicle using odometer readings or estimates based on commute distance and frequency.

For travel by public transportation

Field 1: mode of transportation;

Field 2: typical number of trips taken per week (clarifying one-way or round-trips);

Field 3: number of weeks per year that this is part of the routine;

Field 4: estimated average distance of each one-way trip.

Calculation Methodology for Personal Transportation/Commuting

The **Personal Transportation/Commuting Calculator** includes GHG emissions from routine transportation activities. GHG emissions from routine transportation activity are estimated using the following equations and GHG emission factors found in Appendix C.

Equation 3 below is for personal passenger vehicle use while equation 4 is for public transit.

Equation 3: *Estimating GHG emissions from Personal Transportation/Commuting for the Personal Passenger Vehicle portion*

$$\mathbf{PPV}_{\text{Emissions}} = \mathbf{VKT}_{\text{VehicleType}} * \mathbf{EF}_{\text{VehicleType}}$$

Where:

PPV_{Emissions} = Emissions from use of personal passenger vehicle

VKT_{VehicleType} = Vehicle kilometres traveled (VKT) by vehicle type (activity)

EF_{VehicleType} = GHG emission factor for the vehicle type (Appendix C)

Activity data for this equation refers to the total kilometres travelled in a year. The average personal vehicle in Canada travels about 17,000 km a year. If this is not available then the calculator allows the user to enter information on the departure and arrival addresses for routine commute and this is used to calculate the distance. The estimation of GHG emissions from the personal passenger vehicle is complicated by the wide-range of cars and trucks that could be involved and the variations in GHG emissions intensity by vehicle type. To accurately reflect the complexities of GHG emissions for personal passenger vehicles, the Calculator uses vehicle-specific fuel consumption rates based upon information contained in the Fuel Consumption Rating Guide produced by Natural Resources Canada in order to produce vehicle specific GHG emission intensities.³ This requires the user to select the year model and profile of the vehicle they are driving.

³ See <http://oee.nrcan.gc.ca/transportation/tools/fuel-consumption-guide/fuel-consumption-guide.cfm>

Equation 4: *Estimating GHG emissions from Personal Transportation/Commuting for the Public Transportation portion*

$$PT_{\text{Emissions}} = PKT * EI_{\text{PublicTransit}}$$

Where:

PT_{Emissions} = Emissions from use of public transit

PKT = Passenger kilometres traveled (PKT) on public transit (activity)

EI_{PublicTransit} = GHG emission intensity per passenger kilometre traveled on public transit (Appendix C)

For routine transportation using public transit, the GHG emission factor is derived from data available from the transportation tables contained in the Comprehensive Energy Use Database provided by the Office of Energy Efficiency.

6. Vacation Travel Calculator

Data Input Requirements for Vacation Travel

The **Vacation Travel Calculator** requires user inputs regarding specific travel events and uses this information to estimate distances travelled and applies emission factors for type of travel to generate estimates of GHG emissions associated with personal travel.

Field 1: The mode of travel, including; airplane, bus, train, or personal passenger vehicle;

Field 2: In the case of travel using personal passenger vehicle, the category includes options for selecting the specific make, model and year of vehicle and the engine size, transmission type and fuel. The selections are provided in the form of a drop-down menu;

Field 3: In the case of travel using personal passenger vehicle, the number of passengers in the vehicle. GHG emissions are estimated for each person going on the trip. In the case of travel by personal passenger vehicle the GHG emissions total for the trip are divided by the number of passengers. Any whole number is an acceptable input;

Field 4: In the case of travel by air, the airplane category includes options for selecting the category of aircraft, flight (long or short) and type of ticket (economy or business class);

Field 5: Distance from departure to arrival locations. Providing departure and arrival locations allows the calculator to determine the distance travelled for each trip. This can be provided by specifying the city and the country (e.g., Halifax, Nova Scotia) or a full address (e.g., 5151 Terminal Road, Halifax, Nova Scotia, Canada) of the departure and arrival points. The calculator then uses its mapping application to estimate the total distance travelled;

Field 6: Round trip. The calculator allows the user to identify a one-way trip using one mode of transportation and a one-way trip home again using an alternate mode. This allows the user to be more precise when the trip is of a more complicated nature and the travel plans include multiple modes of transportation.

Calculation Methodology for Vacation Travel

The **Vacation Travel Calculator** includes GHG emission calculations for four different forms of travel, namely; airplane, bus, train, and personal passenger vehicle. Calculating GHG emissions involves the multiplication of activity (i.e., passenger kilometres traveled or PKT) by the GHG emission intensity for that activity. Although the overarching approach to calculating the GHG emissions is the same, each mode relies on different analytical steps and data sources.

The approach for estimating GHG emissions from vacation travel is formulized as:

Equation 5: *Estimating GHG emissions from Vacation Travel:*

$$VT_{\text{Emissions}} = \sum_{\text{alltravel}} \{ PKT_{\text{Mode}} * EI_{\text{Mode}} \}$$

Where:

$VT_{\text{Emissions}}$ = Total GHG emissions from vacation travel per year

PKT_{Mode} = Total passenger kilometres travelled by mode per year (activity)

EI_{Mode} = GHG emission intensity per passenger by mode (Appendix D)

Estimating Activity

For all forms of travel, the first step is finding the passenger kilometres traveled. The precise measure of distance traveled depends upon the mode of travel and the geographical location of the origin and destination. To get the distance traveled as easily and accurately as possible, the calculator relies on a web-based mapping application.⁴ This allows the user to enter their departure and destination addresses and let the mapping application determine the total distance.

Passenger kilometres traveled (PKT) by airplane is based on the linear function of the online mapping application. In this case the mapping application calculates the distance between the origin and destination points based on the great circle formula (this is the most direct route accounting for the curvature of the earth). A similar approach is used for rail, with the assumption that rail transportation infrastructure follows closely the most direct route between major centres.

⁴ <http://maps.google.com/>

To generate estimates of PKT for bus and personal passenger vehicle modes, a different functionality of the mapping application is used. Rather than relying on the great circle distance, the mapping application traces the road network from point of departure to point of destination, selecting the shortest distance along the road network.

Estimating Emissions

Central to the estimation of GHG emissions associated with personal travel is the use of GHG emissions intensities provided on a tCO_{2e} per PKT basis. GHG emissions intensities for PKT are especially relevant for modes which carry multiple passengers, such as airplanes, trains, and buses. Otherwise, GHG emissions associated with vehicle movements would be allocated only to one passenger, whereas they should be distributed proportionally to all passengers. The process to generate PKT GHG emissions intensities differs for each mode and draws upon a range of data sources and methodologies. The mode-specific methods used to establish each term of equation 5 are in Appendix D.

7. Commercial Building Energy Use Calculator

Data Input Requirements for Commercial Building Energy Use

GHG emissions from commercial and institutional buildings are quantified according to records of energy use obtained from utility bills wherever possible. If this data is not available, then GHG emission estimates are made based on building size and performance.

If data on commercial and institutional building energy use from utility bills is available:

Field 1: Listing of all energy sources and fuels used in the buildings;

Field 2: Utility use records for one full year, including electricity (kWh), natural gas (gigajoules), fuel oil (litres), propane (litres) and wood (cords) for all energy needs;

Field 3: Identification of any renewable energy purchasing agreements, including non-GHG emitting electricity, biofuels and renewable energy certificates.

If data on building energy use from utility bills is not available:

Field 1: Sector (education, health care, retail, food and accommodation, office, warehouse, arts and recreational facility);

Field 2: Size of building (square feet or square metres of floor space);

Field 3: Type and efficiency of heating system (electric, natural gas, heating oil, other);

Field 4: Type of hot water heater (electric, natural gas);

Field 5: If building has air conditioning (yes or no);

Field 7: Types of fuels used for auxiliary equipment (if known);

Field 8: Use of onsite renewable energy generation from geothermal or solar hot water;

Field 8: Identification of any renewable energy purchasing agreements, including non-GHG emitting electricity, biofuels and renewable energy certificates.

Calculation Methodology for Commercial Building Energy Use

The most accurate way to generate an estimate of the GHG emissions attributed to building energy use is to derive this from records of the primary fuel (i.e. natural gas, heating oil, diesel) and electricity purchased over the course of a year. Fuel consumption totals can be multiplied by GHG emission factors for primary fuels and for the electricity grid factor for Nova Scotia.⁵

In the case where energy user records are not available the building energy use emissions are estimated based on building stock energy use statistics for Nova Scotia available from the Office of Energy Efficiency (OEE) at Natural Resources Canada.⁶ The data available from the OEE allows the energy use and GHG emissions attributed to the building to be allocated to end-use, even if this information is not provided or is not known. It is important to note that this allocation, and the associated GHG emission intensities, vary based upon the age of the building, the types of heating system, the thermal properties of the building type, and the technical characteristics of cooling systems, appliances, and lighting.

Equation 9: *Estimating GHG emissions from Commercial Building energy use using utility records:*

$$\mathbf{Build}_{EUE} = \sum_{\text{AllFuelTypes}} \{ \mathbf{EF}_{\text{FuelType}} * \mathbf{EC}_{\text{FuelType}} \} + \mathbf{EF}_{\text{Electricity}} * (\mathbf{EC}_{\text{Electricity}} - \mathbf{REC})$$

Where:

Build_{EUE} = Buildings energy use GHG emissions

EF_{FuelType} = Emission factor for primary fuels in tCO₂e per unit (Appendix A)

EC_{FuelType} = Consumption per year of primary fuel in units

EF_{Electricity} = Emission factor for Nova Scotia electricity grid in tCO₂e per kWh

EC_{Electricity} = Consumption per year of electricity in kWh

REC = Total amount of renewable energy purchased per year in kWh

⁵ Nova Scotia Power: http://www.nspower.ca/en/home/environment/reportsandmetrics/archivedemissionslevels/co2e_emissionintensity.aspx

⁶ The Office of Energy Efficiency compile, on an annual basis, estimates of energy and emissions attributable to the commercial sector for each province in Canada. This modeling is calibrated to the Report on Energy Supply and Demand in Canada published by Statistics Canada to both maintain consistency with national energy demand and supply totals, as well as to improve the accuracy of the estimations produced. Please see http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/trends_com_atl.cfm

When calculating GHG emissions from electricity, the electricity consumption total should first be discounted by the total amount of electricity renewable energy certificates (RECs) purchased (if any) before the electricity use total kWh is applied.

In the case that utility use records are not available, the building GHG emissions may be estimated less precisely by multiplying the building floor area with a GHG emission intensity (i.e., tCO₂e per m²/day) based on a few key aspects of the building. The building type options and associated GHG emission factors are found in Appendix F.

Users identifying the existence of geothermal heating for the building shall have their space heating and space cooling components of Building Energy Use discounted by 50%. This is consistent with a Natural Resources Canada estimated contribution geothermal heat pumps make to home heating and cooling.

Users identifying the existence of solar hot water heating shall have their emissions from water heating discounted by 50%. This is consistent with a Natural Resources Canada estimated contribution solar hot water systems make to meeting the energy demands for water heating.

Equation 10: *Estimating GHG emissions from Commercial Building energy use using floor area:*

$$\mathbf{Build}_{EUE} = \mathbf{EF}_{BuildingType} * \mathbf{Building}_{FloorArea}$$

Where:

Build_{EUE} = Buildings energy use GHG emissions

EmFactor_{buildingtype} = Emission factor for building specifics (Appendix F)

Building_{FloorArea} = Total floor area for the building in m² or square feet

The GHG emission intensity values provided (see Appendix F) are based on the entire amount of energy used in the building, including space heating and cooling, water heating and lighting and auxiliary equipment (if applicable). The GHG emission intensities thus vary based on the following parameters:

- Type of heating system;
- Efficiency rating of heating system;
- Presence or absence of cooling system;
- Fuel used for water heating;
- Auxiliary equipment;
- Use of geothermal or solar hot water systems
- Purchase of green power certificates.

8. Business Travel Calculator

Data Input Requirements for Business Travel

The **Business Travel Calculator** requires user inputs regarding specific travel events and uses this information to estimate distances travelled and emission factors that are required to generate estimates of GHG emissions associated with business trips.

Field 1: The mode of travel, including; airplane, bus, train, or personal passenger vehicle;

Field 2: In the case of travel using personal passenger vehicle, the category includes options for selecting the specific make, model and year of vehicle and the engine size, transmission type and fuel. The selections are provided in the form of a drop-down menu;

Field 3: In the case of travel using personal passenger vehicle, the number of passengers in the vehicle. GHG emissions are estimated for each person going on the trip. In the case of travel by personal passenger vehicle the GHG emissions total for the trip are divided by the number of passengers. Any whole number is an acceptable input;

Field 4: In the case of travel by air, the airplane category includes options for selecting the category of flight (long or short) and type of ticket (economy or business class);

Field 5: Distance from departure to arrival locations. Providing departure and arrival locations allows the calculator to determine the distance travelled for each trip. This can be provided by specifying the city and the country (e.g., Halifax, Nova Scotia) or a full address (e.g., 5151 Terminal Road, Halifax, Nova Scotia, Canada) of the departure and arrival points. The calculator then uses its mapping application to estimate the total distance travelled;

Field 6: Round trip. The calculator allows the user to identify a one-way trip using one mode of transportation and a one-way trip home again using an alternate mode. This allows the user to be more precise when the trip is of a more complicated nature and the travel plans include multiple modes of transportation.

Calculation Methodology for Business Travel

The **Business Travel Calculator** includes GHG emission calculations for four different forms of travel, namely; airplane, bus, train, and personal passenger vehicle. Calculating GHG emissions involves the multiplication of activity (i.e., passenger kilometres traveled or PKT) by the GHG emission intensity for that activity. Although the overarching approach to calculating the GHG emissions is the same, each mode relies on different analytical steps and data sources.

The approach for estimating GHG emissions from vacation travel is formulated as:

Equation 11: *Estimating GHG emissions from Business Travel:*

$$\mathbf{BT}_{\text{Emissions}} = \sum_{\text{alltravel}} \{ \mathbf{PKT}_{\text{Mode}} * \mathbf{EI}_{\text{Mode}} \}$$

Where:

BT_{Emissions} = Total GHG emissions from business travel per year

PKT_{Mode} = Total passenger kilometres travelled by mode per year (activity)

EI_{Mode} = GHG emission intensity per passenger by mode (Appendix D)

Estimating Activity

For all forms of travel, the first step is finding the passenger kilometres traveled. The precise measure of distance traveled depends upon the mode of travel and the geographical location of the origin and destination. To get the distance traveled as easily and accurately as possible, the calculator relies on a web-based mapping application.⁷ This allows the user to enter their departure and destination addresses and let the mapping application determine the total distance.

Passenger kilometres traveled (PKT) by airplane is based on the linear function of the online mapping application. In this case the mapping application calculates the distance between the origin and destination points based on the great circle formula (this is the most direct route accounting for the curvature of the earth). A similar approach is used for rail, with the assumption that rail transportation infrastructure follows closely the most direct route between major centres.

To generate estimates of PKT for bus and personal passenger vehicle modes, a different functionality of the mapping application is used. Rather than relying on the great circle distance, the mapping application traces the road network from point of departure to point of destination, selecting the shortest distance along the road network.

Estimating Emissions

Central to the estimation of GHG emissions associated with personal travel is the use of GHG emissions intensities provided on a tCO₂e per PKT basis. GHG emissions intensities for PKT are especially relevant for modes which carry multiple passengers, such as airplanes, trains, and buses. Otherwise, GHG emissions associated with vehicle movements would be allocated only to one passenger, whereas they should be distributed proportionally to all passengers. The process to generate PKT GHG emissions intensities differs for each mode and draws upon a range of data sources and methodologies. The mode-specific methods used to establish each term of equation 11 are provided in Appendix D.

⁷ <http://maps.google.com/>

9. Conference and Meeting Hosting Calculator

Data Input Requirements for Conference and Meeting Hosting

The GHG emission estimates for hosting a conference or meeting are based on the information entered by the user about the event and emission factors for event-related activities. There are three categories of activity accounted for in the calculator, namely; attendee travel, facility energy use, and event-related waste generation.

For conference or meeting facility and accommodation energy use

Input 1 The location of the event facility;

Input 2 The duration of the conference or meeting in total number of days and total number of nights;

Input 3 Total number of attendee's and the length of stay for each;

For conference or meeting catering and waste management

Input 1: Event catering options including; number of meals provided (breakfast, lunch and dinner), and details regarding the types of meals (locally sourced, organic, vegetarian, red meat-free and regular);

Input 2: Waste disposal options including; landfill, recycling, and organics composting.

Input 1: Distribution of hard copy conference delegate's packages;

For conference or meeting attendee travel

Input 1: The number of attendees travelling to the event;

Input 4: The mode of each attendee's travel (e.g., airplane, bus, rail, or passenger vehicle).

Input 2: The origin of each attendee's trip to the event;

Calculation Methodology for Conference and Meeting Hosting

The **Conference and Meeting Hosting Calculator** includes estimates of GHG emissions from three different sources associated with an event, namely; attendee travel, facility energy use, and

event-related waste generation. Methodology for calculating GHG emissions from these three sources are outlined below.

Facility Energy Use

The approach for estimating GHG emissions associated with conference or meeting hosting assumes an amount of floor space required per attendee multiplied by the total number of attendees. Attendees require a portion of floor space for the actual conference or meeting and occupancy of hotel guest rooms. The method is to multiply the space requirements for each attendee with a GHG emissions factor that reflects the GHG emissions generated per area of floor space per day.

There is no industry standard for floor space required for conferences. It is assumed that the average conference attendee will require 400 square metres of facility space, including guest room and conference meeting facilities. The 400 square meter figure is derived from a review of hotel guest room sizes for popular hotel chains in Canada and occupancy allowances per room size for conference room booking. The GHG emissions estimate also includes all GHG emissions attributed to space and water heating, cooling, lighting, and auxiliary equipment in the facility. This is represented by the formula:

Equation 6: *Estimating GHG emissions from Conference or Meeting facilities energy use:*

$$\text{Facility}_{\text{EUE}} = \text{Attendee} * \text{Time}_{\text{Occupancy}} * \text{EI}_{\text{SquareMetre,Time}} * 400$$

Where:

Facility_{EUE} = Conference or Meeting facility energy use GHG emissions

Attendee = Number of conference or meeting attendees

Time_{Occupancy} = Length of occupancy

EI_{SquareMetre,Time} = Emission intensity per floor area (m²) per day

400 = Each attendee requires 400 m² of facility floor space per day

In order to arrive at a metric that reflects the amount of floor area that can be attributed to a hotel stay, CSA undertook a survey of available carbon calculators that involve event planning and hotel stays as well as research on typical sizes of hotels in respect of the number of rooms available.

Event-related Catering and Waste Generation

The **Conference and Meeting Hosting Calculator** includes the GHG emission for event-related catering and waste disposal. Below is the methodology used for this calculation.

Equation 7: *Estimating GHG emissions from Conference or Meeting catering and waste generation:*

$$\mathbf{EventCW}_{\text{Emissions}} = \mathbf{Catering} * \mathbf{EI}_{\text{catering}} + \mathbf{Waste} * \mathbf{EI}_{\text{Waste}}$$

Where

EventCW_{Emissions} = Total GHG emissions from catering and waste generation

Catering = Total amount of food provided during the event

EI_{catering} = GHG emission intensity (tCO₂e/guest) for catering selections

Waste = Total mass of waste generated and sent to landfill in tonnes

EI_{Waste} = GHG emission intensity (tCO₂e/tonne of waste) for waste

Attendee Travel

The attendee travel section includes GHG emission estimates for four different modes of travel to the event: airplane, bus, rail or personal passenger vehicle. The approach used to estimate GHG emissions from attendee travel is the same as in the vacation travel calculator applied to each attendee separately.

The approach for estimating GHG emissions from event travel is formulized as:

Equation 6: *Estimating GHG emissions from Conference or Meeting attendee travel:*

$$\mathbf{ET}_{\text{Emissions}} = \sum_{\text{alltravel}} \{ \mathbf{PKT}_{\text{Mode}} * \mathbf{EI}_{\text{Mode}} \}$$

Where

ET_{Emissions} = Total GHG emissions from event travel

PKT_{Mode} = Total passenger kilometres travelled by mode for each attendee

EI_{Mode} = GHG emission intensity per passenger by mode (Appendix D)

Appendix A. GHG Emission Factors by Greenhouse Gas

Stationary Combustion		Emission Factors (g/m³)			
		CO₂	CH₄	N₂O	CO₂e
Natural Gas					
	<i>Manufacturing Industries</i>	1,891	0.037	0.033	1,902
	<i>Residential, Construction, Commercial/Institutional, Agriculture</i>	1,891	0.037	0.035	1,903
Propane					
	<i>Residential</i>	1,510	0.027	0.108	1,544
	<i>All Other Uses</i>	1,510	0.024	0.108	1,544
Light Fuel Oil					
	<i>Residential</i>	2,725	0.026	0.006	2,727
	<i>Forestry, Construction, Public Administration, Commercial/Institutional</i>	2,725	0.026	0.031	2,735
Diesel		2,663	0.133	0.4	2,790
Mobile Sources		Emission Factors (g/litre)			
		CO₂	CH₄	N₂O	CO₂e
Light-Duty Gasoline Vehicles (LDGVs)					
	<i>Oxidation Catalyst</i>	2,289	0.52	0.202	2,363
	<i>Non-Catalyst Controlled</i>	2,289	0.46	0.0282	2,307
Light-Duty Gasoline Trucks (LDGTs)					
	<i>Oxidation Catalyst</i>	2,289	0.43	0.202	2,361
	<i>Non-Catalyst Controlled</i>	2,289	0.56	0.0282	2,310
Heavy-Duty Gasoline Vehicles (HDGVs)					
	<i>Three-Way Catalyst</i>	2,289	0.68	0.204	2,367
	<i>Uncontrolled</i>	2,289	0.49	0.0842	2,325
Motorcycles					
	<i>Non-Catalytic Controlled</i>	2,289	1.42	0.0452	2,333
	<i>Uncontrolled</i>	2,289	2.32	0.0482	2,353
Light-Duty Diesel Vehicles (LDDVs)					
	<i>Advance Control</i>	2,663	0.051	0.222	2,733
	<i>Moderate Control</i>	2,663	0.068	0.212	2,730
	<i>Uncontrolled</i>	2,663	0.1	0.162	2,715
Heavy-Duty Diesel Vehicles (HDDVs)					
	<i>Advance Control</i>	2,663	0.12	0.0822	2,691
	<i>Uncontrolled</i>	2,663	0.15	0.0752	2,689
Natural Gas Vehicles		1,893	9×10 ⁻³	6×10 ⁻⁵²	1,893
Propane Vehicles		1,510	0.64	0.0282	1,532
Off-Road Gasoline		2,289	2.7	0.0502	2,361
Off-Road Diesel		2,663	0.15	1.12	3,013
Diesel Train		2,663	0.15	1.12	3,013
Gasoline Boats		2,289	1.3	0.0662	2,337
Aviation Turbo Fuel		2,534	0.08	0.231	2,607
Ethanol		1,494	**	**	1,494

Source: 2006 National Inventory

Appendix B. GHG Emission Factors for Home Energy Use

The data available from the OEE allows the energy use and GHG emissions attributed to the home to be allocated to end-use, even if this information is not provided or is not known. It is important to note that this allocation, and the associated GHG emission intensities, vary based upon the age, type (e.g., detached houses, attached houses, apartment/condo, or mobile home), the type of heating system, the thermal properties, and the technical characteristics of cooling systems, appliances, and lighting in the home.

The varying emission intensities for the different dwelling types largely reflect differences in emissions associated with space heating. Home heating contributes to much of the total energy used in a home (60% to 80%, depending on category and vintage), but with the requirements for space heating differing based upon the areal extent of building envelope that is exposed to outside elements. For example, a single attached home will require less energy and result in less emissions when measured on a square metres of floor space basis since less of the building envelope is exposed to the outside elements (thus, it is more ‘energy efficient’). It is assumed though that on an areal basis, there are no differences in the requirements stock lighting, space heating, or water heating when comparing different dwelling types.

To help understand how emissions vary based upon the type of heating system used in the home, the OEE provides energy and emissions by home heating system along with information on the stocks of the heating systems in service. This allows emission intensities to be produced on unit basis. It is assumed that variations in emission intensity on a unit basis are representative of variations in emission intensity on an area basis.⁸

The GHG emissions from electricity use Nova Scotia Power CO₂ Emission Intensity.

Year	Lingan	Trenton	Point Tupper	Point Aconi	Tufts Cove	Overall System
2004	930.88	897.72	916.87	1354.53	784.76	868.30
2005	954.75	967.90	927.17	1370.76	767.95	890.82
2006	947.24	989.26	918.85	1283.99	694.26	890.17
2007	920.02	971.92	929.15	1085.96	631.10	842.28
2008	948.68	951.86	923.85	1138.75	631.97	837.93

⁸ The emission factor for the combustion of wood only includes CH₄ and N₂O released during biomass combustion, and does not include the CO₂ attributable to the loss of wood from the forest. This is the same approach as used in the National Inventory of Greenhouse Gas Emissions, where these emissions are included only in the ‘Land Use, land Use Change, and Forestry’ sector. These emissions are currently not counted towards Canada’s national inventory totals as considered for the purposes of the Kyoto Protocol.

Appendix C. GHG Emission Factors by Transportation Mode

Table 2. GHG Emission Factors for Mobile Fuel Use

Primary Fuel	CO ₂ e (tonnes/litre)
Motor gasoline	0.00250
Diesel fuel oil	0.00279
Light fuel oil	0.00274
Heavy fuel oil	0.00314
	CO ₂ e (tonnes/m ³)
Natural gas	0.00189

Source: 2006 National Inventory Report, Environment Canada

Table 3. Fuel Efficiency Ratings and Emission Intensity for Typical Personal Vehicles

Type of Vehicle	Fuel consumption (L/100 km)			Emission Intensity CO ₂ e (tonnes/100 km)	
	City	Highway	Blended	Gas	Diesel
Sub-compact (Honda Civic)	8.2	5.7	6.8	0.0001632	0.0001836
Compact (Mazda 3)	9.2	6.7	7.8	0.0001872	0.0002106
Mid-size (Chevrolet Malibu)	12.2	7.8	9.8	0.0002352	0.0002646
Full-size (Ford Crown Victoria)	13.4	8.6	10.8	0.0002592	0.0002916
Station Wagon (Volkswagen Passat Wagon)	12.7	8.3	10.3	0.0002472	0.0002781
Pickup Truck (Dodge Dakota)	14.4	9.8	11.9	0.0002856	0.0003213
Special Purpose (SUV) (Cadillac Escalade)	17.7	10.8	13.9	0.0003336	0.0003753
Minivan (Chrysler Town & Country)	12.2	7.9	9.8	0.0002352	0.0002646
Large Van (GMC Savana)	15.4	11.2	13.1	0.0003144	0.0003537

Source: Natural Resources Canada Vehicle Fuel Efficiency Guide 2009

Table 4. GHG Emission Factors for Public Transit

Mode	Emission Intensity CO ₂ e (tonnes/PKT)
Bus	0.00007137
Train	0.00019020

The OEE provide estimates of GHG emissions and passenger kilometre traveled by urban bus in Canada. Analysis of this data suggests a GHG emission intensity of 71.37 grams (0.07137 kg) of CO₂e per passenger kilometre traveled.⁹

⁹ Source; http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/tablestrends2/tran_ns_22_e_4.cfm?attr=0

Appendix D GHG Emission Factors for Travel

Table 1. GHG Emission Intensities for Travel by Personal Passenger Vehicle

Type of Vehicle	Fuel consumption (L/100 km)			Emission Intensity CO ₂ e (tonnes/km)	
	City	Highway	Blended	Gas	Diesel
Sub-compact (Honda Civic)	8.2	5.7	6.8	0.0001632	0.0001836
Compact (Mazda 3)	9.2	6.7	7.8	0.0001872	0.0002106
Mid-size (Chevrolet Malibu)	12.2	7.8	9.8	0.0002352	0.0002646
Full-size (Ford Crown Victoria)	13.4	8.6	10.8	0.0002592	0.0002916
Station Wagon (Volkswagen Passat Wagon)	12.7	8.3	10.3	0.0002472	0.0002781
Pickup Truck (Dodge Dakota)	14.4	9.8	11.9	0.0002856	0.0003213
Special Purpose (SUV) (Cadillac Escalade)	17.7	10.8	13.9	0.0003336	0.0003753
Minivan (Chrysler Town & Country)	12.2	7.9	9.8	0.0002352	0.0002646
Large Van (GMC Savana)	15.4	11.2	13.1	0.0003144	0.0003537

Source: Natural Resources Canada Vehicle Fuel Efficiency Guide 2009

Table 1 includes representative GHG emission intensities for common vehicle classes. These intensities may not precisely reflect the intensities of the vehicles actually used. For a precise calculation of GHG emissions from personal passenger vehicles identify the specific vehicles used in the Natural Resources Canada Vehicle Fuel Efficiency Guide 2009. The fuel consumption ratings (in L/100 km) found in the guide should be multiplied by a GHG emission factor of 2.4 kg/L for gasoline and 2.7 kg/L for diesel.

Table 2. GHG Emission Intensities for Travel by Mode and Type of Trip

Mode	Emission Intensity CO ₂ e (tonnes/PKT)
Bus	0.00007137
Train	0.0001902
Airplane:	
Short haul (under 500 km) small jet (e.g., Dash 8), all seating	0.00014
Medium haul (500 to 1600 km) regional jet (e.g. CRJ-2), economy seating	0.00012
Medium haul (500 to 1600 km) regional jet (e.g. CRJ-2), business class	0.00017
Medium haul (500 to 1600 km) turbo prop (e.g., NexGen Q400), all seating	0.00011
Long haul (over 1600 km) large jet (e.g., Boeing 767), economy seating	0.00011
Long haul (over 1600 km) large jet (e.g., Boeing 767),business class seating	0.00021

Source: GHG emission intensity estimates shown here are estimated using the methodology described below using fuel GHG emission estimates from Statistics Canada Energy Statistics Handbook 2008, and EMEP/CORINAIR Emission Inventory Guidebook (EIG)

Estimating Distance Traveled and GHG Emission Factors

The first step in estimating the GHG emission associated with vacation travel is establishing the passenger kilometres traveled (PKT) associated with travel by mode. The precise measure of distance traveled depends upon the mode of travel and the geographical location of the origin and destination of the trip.

To determine the distance traveled the calculator relies on a mapping application such as the web-based Google Maps application¹⁰ or similar tool using departure and destination address for all trips:

Airplane

- PKT by airplane are based on the great circle distance function calculating the distance between the origin and destination points (this is the most direct route after accounting for the curvature of the earth).

Great Circle Distance is calculated as:

$$d = a \cos^{-1} [\cos \delta_1 \cos \delta_2 \cos (\lambda_1 - \lambda_2) + \sin \delta_1 \sin \delta_2].$$

Source : <http://mathworld.wolfram.com/GreatCircle.html>

- Factors that influences the distance of a flight include re-routes, head winds, refuelling stops, or other factors that can take a plane off of its optimal flight path. Therefore following the approach used by the International Civil Aviation Organization (ICAO), correction factors are applied to the estimated PKT based on the distance of each flight. These are provided below:

Table 3. Correction Factors Used to Estimate Flight Distances

Flight Distance	Correction to Flight Distance
Less than 50 km	+ 50 km
Between 550 km and 5500 km	+ 100 km
Above 5500 km	+ 125 km

- The GHG emission resulting from a trip by airplane is a function of both distance travelled and the GHG emission intensity of the specific trip. The GHG emission intensity of air travel is a function of a number of independent and interdependent factors which in some cases are known and in some cases must be assumed, including:

1. Trip length:

The length of a flight dictates the type and size of the aircraft used and the total amount of fuel used in the flight. In particular, since more fuel is required to lift an

¹⁰ <http://maps.google.com/>

airplane to 3,000 feet (termed the landing and take-off cycle, or LTO) than is required during the 'cruise' phase of the flight, shorter trips will be more GHG emission intensive when measured on a flight or a passenger kilometre traveled (PKT) basis. This assumes that an aircraft flies directly between these two airports. A 10% correction factor is applied to account for things like circling, adjustments of flight routes, headwinds, etc.

2. Aircraft type and size:

It is also important to note that there are large variations in the fuel burn rates (FBRs) and the subsequent GHG emission intensities within the different categories of aircraft. For example, for flights above 1,600 km, the aircraft used might be a Boeing 767 300 series, an Airbus 343, or a Boeing 767 299 series, all of which have different seat configurations and technical efficiencies. In order to provide a suitable metric, a representative sample of aircraft within each distance range has been taken in order to generate an average FBR and GHG emissions intensities based on a series of distance categories.

3. Airplane engine type:

While jet engines are still dominant for most continental and intercontinental flights, turbo prop engines are now used by some airlines. Industry literature suggests that for similar size airplane, turbo prop engines can be between 30% and 40% more efficient than aircraft powered by jet engines. This type of airplane is an option available for user selection.

4. Airplane age:

Due to technological improvements, change in materials, improvements in aerodynamics, amongst other factors, and a drive to become more cost efficient and competitive, there are continuous improvements in the efficiency of newer airplanes. The effects of aircraft age on GHG emissions are reflected by the FCR used in estimating these. This is not a required user input.

5. Proportion of passengers to freight

The proportion of passengers to freight on any given flight will influence the emission intensity of passenger travel. If passengers are carried on a flight, then all the emissions generated by the movement of the aircraft is distributed to the passengers. However, if freight is also moved, in order to be accurate, the emissions associated with the freight must be allocated proportionally based on the weight of this freight. In Canada as is the case in other countries, it is generally the wide bodied aircraft that carry the most freight as a proportion of total weight of the passenger/freight load. The allocation of emissions to passengers and freight is made according to statistics available from ICAO where it is assumed that wide bodied aircraft (used for long haul) may have freight contributing to upwards of 20% of their total load, and narrow bodied aircraft having freight contribute less than 5% to total load. This is not a required user input.

6. Class of seat:

Each class of seat on an aircraft is responsible for a certain amount of the total GHG emission based on the “foot print” of that seat – i.e., how much space is taken up. Since seats in first/executive/business class can require up to twice the space of those in economy class, these seats account for more GHG emissions on a per passenger basis. Users can select the seating option in the calculator.

7. Airplane occupancy:

The occupancy of a flight has an inverse relationship with the emission intensity of air travel since the more seats that are occupied on an airplane, the lower the average GHG emissions intensity of that flight per passenger. The same holds true in terms of fuel consumption, and is why airline companies continuously try to increase occupancy rates by strategic flight scheduling, etc. Aircraft occupancies have been steadily rising in Canada over the last number of years, and recent estimates are that occupancies are over 80% on most domestic flights. To be conservative, a value of 75% for all flights is used in this calculator. This is not a required user input.

- The parameters that characterize these different categories, and in turn, influence the emission intensity of each are summarized in table 3.

Table 3. Aspects of Air Travel Affective Fuel Burn Rate


Flight distance (km)	Example of aircraft type	FBR (kg/km) ^a	Number of seats ^b		Footprint of seat (pitch * height) (inches ²) ^b	
			Economy	Executive	Economy	Executive
> 1,600	Boeing 767 300 series	5.26	173	30	605	1 230
<1,600 and >500	Airbus 320	3.36	120	20	544	777
<1,600 and >500	Boeing 737 300 series (only economy class)	3.01	137		544	
<1,600 and >500	Regional jet	1.67	50-70		544	
<1,600 and >500	Regional turbo prop ^c	1.02	50-70		544	
<=500	Dash 8	0.49	37		544	

Table notes:

- a) Fuel burn rates are for the cruise cycle from the EMEP/CORINAIR Emission Inventory Guidebook (EIG)
- b) The number and size of seats on each type of aircraft is taken from www.seatguru.com.
- c) For regional turbo prop aircraft, industry data indicated that these aircraft are 30%-40% more fuel efficient than comparable regional jets (<http://www.q400.com/q400/en/turbo.jsp>).

In the case that “airplane” is selected for Step 1: Airplanes can vary greatly in their fuel consumption and efficiency according to their size, engine type, seating configuration, aerodynamics, and other variables. Therefore, the user is asked to identify the type of airplane that they will be flying. The airplane type is dependant upon the length and type of trip and includes: long haul jet (used for intercontinental trips), large jet (used for continental trips), regional jet (for regional inter-city flights), small regional jet (often flying to near-by smaller centres), or turbo prop (used by some airlines for regional inter-city flights). The chart below provides a further description of the airplane types to choose from.

Table 1. Airplane Types

Plane Type	Example Photo	Number of Seats
Long Haul Jets (Intercontinental)		Boeing 777-300ER 349 Seats: <i>42 Executive</i> <i>307 Economy</i>
Large Jets (Continental)		Airbus A321-200 174 Seats: <i>20 Executive</i> <i>154 Economy</i>
Regional Jets		Boeing 737-700 136 Seats
Small Regional Jets		CRJ-705 75 Seats: <i>10 Executive</i> <i>65 Economy</i>
Turbo Prop		Bombardier Q400 70 Seats

Airplane Travel Class

Because travelling in executive class takes up more space on the airplane than travelling in economy class, the travel class is taken into account when calculating the resulting GHG emissions of the trip. The GHG emissions for an airplane trip are distributed across the number of passengers on the flight. A flight with business class seats can carry fewer passengers than a flight with only economy class seating because of the extra space required for each business class seat. The total GHG emissions then are divided by fewer travellers and thus each passenger’s carbon footprint would be higher. To appropriately apportion this additional carbon footprint burden, the calculator allocated these GHG emissions to the business class passengers instead of equally across all passengers.

Airplane Indirect Flights

In cases where air travel involves indirect flights the user input must include descriptions of the separate legs of the journey. The calculator assumes that all flights are direct and calculates emissions on that basis. For indirect flights users must enter the data for each leg of the journey separately so that the GHG emission calculations can be made for each separate flight.

Personal Passenger Vehicle

- To generate estimates of PKT for personal passenger vehicle, actual km travelled as per a mapping application that traces the road network from point of departure to point of destination, selecting the shortest distance along the road network.

- The estimation of the GHG emission for a passenger vehicle is more complex than other modes due to the wide-range of cars and trucks available and the variations in GHG emission intensities across vehicle type. Table 1 in Appendix A provides a list of typical vehicle fuel efficiencies and GHG emission intensities. To more precisely estimate the GHG emission for personal passenger vehicles, the Natural Resources Canada Vehicle Fuel Efficiency Guide 2009 may be used to identify the specific vehicle fuel consumption rating (in L/100 km) which can then be multiplied by a GHG emission factor of 2.4 kg/L for gasoline and 2.7 kg/L for diesel.

Bus

- To generate estimates of PKT for rail, a mapping application that traces the road network from point of departure to point of destination, selecting the shortest distance along the road network.
- For passenger bus transportation, the GHG emission factor is generated from data available from the transportation tables contained in the Comprehensive Energy Use Database provided by the Office of Energy Efficiency. Specifically, the OEE provide estimates of GHG emissions and passenger kilometre traveled by intercity-bus in Canada. Analysis of this data suggests an emission intensity of 71.37 grams (0.07137 kg) of CO₂e per passenger kilometre traveled on intercity-bus.

Train

- To generate estimates of PKT for rail, a mapping application using the great circle distance function calculating the distance between the origin and destination points (this is the most direct route after accounting for the curvature of the earth) is used. This is based on the assumption that rail transportation infrastructure follows closely the most direct route between major centres.
- For passenger train transportation, the GHG emission factor is generated from data available from Transport Canada's T-Facts website.¹¹ For passenger rail transportation, this provides data on total passenger PKT, as well as the fuel consumption associated with this activity. This allowed the calculation of GHG emissions, resulting in a GHG emissions intensity of 190.2 grams (0.1902 kg) of CO₂e per PKT.

¹¹ http://www.tc.gc.ca/pol/en/T-Facts3/Statmenu_e.asp?type=pu&file=rail&Lang=

Appendix E. GHG Emission Factors for Conference or Meeting

Attendee Travel

Attendee travel emissions use the same methodology as the Vacation Travel Calculator outlined in Appendix C.

Facility Energy Use

Conference or Meeting facility emissions are calculated using building efficiency estimates.

The primary source for the data used to develop GHG emissions intensities by time and floor area are data tables on energy and GHG emissions associated with the accommodation and food services sub-sector in Canada available from the CUED. This source provides estimates of the GHG emissions associated with primary fuels used in these buildings for all energy end uses, as well as data on electricity demand. This information is provided at the provincial and territorial level for the time period from 1990 to 2005. Data is also provided on the square metres associated with the sub-sector (also by geography and by year). This data allows for the construction of GHG emissions intensities that reflect both regional and temporal dimensions (see table 2).

Table 2 provides an example of the emission intensities that can be used for conference building energy use

	Emission intensity per area and time (kg CO ₂ /m ² /day)		
	1990	2000	2005
	British Columbia	0.31	0.29
Alberta	0.95	0.93	0.87
Saskatchewan	0.47	0.58	0.48
Manitoba	0.25	0.28	0.23
Ontario	0.40	0.51	0.43
Quebec	0.20	0.22	0.25
Atlantic Canada	0.39	0.40	0.53

In this case GHG emissions intensities vary both by time and by region. This reflects the underlying fuel efficiency characteristics of each province in terms of both primary energy and electricity generation. For example, Alberta has the highest GHG emissions intensity of any province for any given year. This largely reflects the GHG emissions intensity of electricity generated in the province since most of this is generated from burning coal. Meanwhile, the temporal variation in GHG emissions intensities reflects both changes in the fuel mix of electricity, and increases in the efficiency of the building stock and the auxiliary equipment included in the building stock.

Event Waste Generation

Table 7. GHG Emission Intensities for Waste Directed to Landfill for Disposal

Region	Waste Disposed to landfill ^a (kilotonnes)			Total GHG Emissions ^b (kt CO ₂ e)	Emission intensity ^c CO ₂ e (tonnes/tonne of waste landfilled)
	Residential sources	Non-residential sources	All sources		
Nova Scotia	169	232	402	520	1.29
Canada	9,238	18,011	27,249	21000	0.77

- From Statistics Canada's Waste Management Industry Survey, "Disposal of waste — by source and by province and territory"
- From Environment Canada, "National Inventory Report: 1990 to 2006"
- It should be noted that the emission intensities calculated don't reflect the amount of waste exported or imported into a province, but are based on the assumption that all provincial waste reported as entering disposed in a landfill are disposed in the respective provincial landfills

The GHG emission intensity of landfill waste is a function of the age of a landfill, the mix of waste in the landfill, climate conditions, and if landfill gas collection systems are in place. The GHG emission totals resulting from waste generation is available for the various regions across Canada from the National Inventory Report. The amount of waste sent to landfill is estimated based on data from the Waste Management Survey completed by Statistics Canada.

Sending waste to landfill results in GHG emissions from the processes of anaerobic digestion. Reducing consumption and recycling eliminate the need to produce associated products from virgin materials, thus reducing upstream energy use and GHG emissions. However, recycling does require energy inputs and does result in GHG emissions. Overall, recycling and source reduction have GHG emission reductions benefits. The respective GHG emissions intensities for a variety of waste management activities are provided in the table below. The first column shows the GHG emissions impacts of source reduction (relative to landfill disposal), the second column shows the GHG emissions impacts of recycling (relative to landfill disposal), the third column shows the GHG emissions impacts of composting (relative to landfill disposal), and the last column shows the GHG emissions impacts of sending waste to landfill.

Table 6. GHG Emission Implications of Waste Management Options

Material	Net source reduction	Net recycling GHG emission	Net composting GHG emission	Net landfill GHG emission (tonnes CO ₂ e/tonne)
Newsprint	-3.81	-2.81		-1.22
Fine Paper	-5.93	-3.33		1.18
Cardboard	-5.22	-3.34		0.29
Other Paper	-5.51	-3.36		0.71
Aluminum	-4.55	-6.49		0.01
Glass	-0.40	-0.10		0.01
HDPE	-2.74	-2.27		0.01
PET	-3.50	-3.63		0.01
Other Plastics	-3.01	-1.80		0.01
Food Scraps			-0.24	0.90

Table notes: For newsprint, it is assumed that carbon is sequestered into the landfill

From http://www.recycle.ab.ca/Download/GHG_Impacts_Summary.pdf

Conversion Factor 1. Waste Volume Conversion to Weight

Material	Volume	Weight
Uncompacted Commercial Waste	1 cubic metre	0.25 tonnes

Factor from: Ontario Ministry of Environment. Guide to Waste Audits and Reduction Workplans for Industrial, Commercial and Institutional Sectors, As Required Under Ontario Regulation 102/94 (3Rs Regulations).

Appendix F. GHG Emission Factors for Commercial Buildings

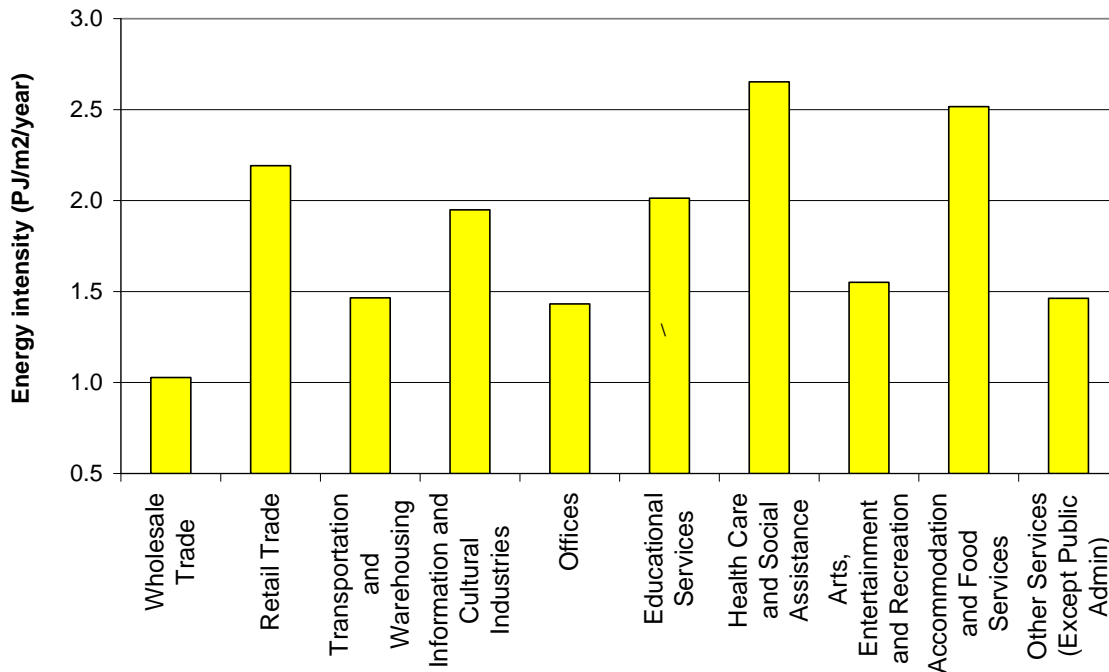
The commercial and institutional sub sectors include the business and public entities that provide services such as health care, education, retail, or leisure services to Canadians, including the following sub sectors.

Table 5. Commercial and Institutional Sub-Sectors Included in the Calculator

Sub sector	Definition
Wholesale Trade	Businesses involved in the whole sale trade. When businesses, government agencies, or institutions, such as universities or hospitals, need to purchase goods, they normally buy them from wholesale trade establishments.
Retail Trade	Businesses involved in retail trade, or shopping malls. These are largely entities selling products or services to the consumer
Transportation and Warehousing	Businesses involved in delivering goods and warehousing services for the temporary storage of goods
Information and Cultural Industries	Art galleries, libraries, etc
Offices	Office space used for business services, including financial, real estate, etc
Educational Services	Schools, colleges, and universities
Health Care and Social Assistance	Hospitals, health care centres, community centres
Arts, Entertainment and Recreation	Cinemas, theatres, stadiums, recreation centres
Accommodation and Food Services	Restaurants, hotels, conference centres, etc

The emission intensity of a building varies by sub sector, with this variation largely depending upon the amount of equipment inside the building which requires energy. To help understand how and why emissions vary amongst the various sub sectors of the commercial and institutional sector, we provide first an overview of the range in energy intensities of each. Again, this is shown in terms of the amount of energy (in petajoules, of PJ) consumed per square metre of building space, per year.

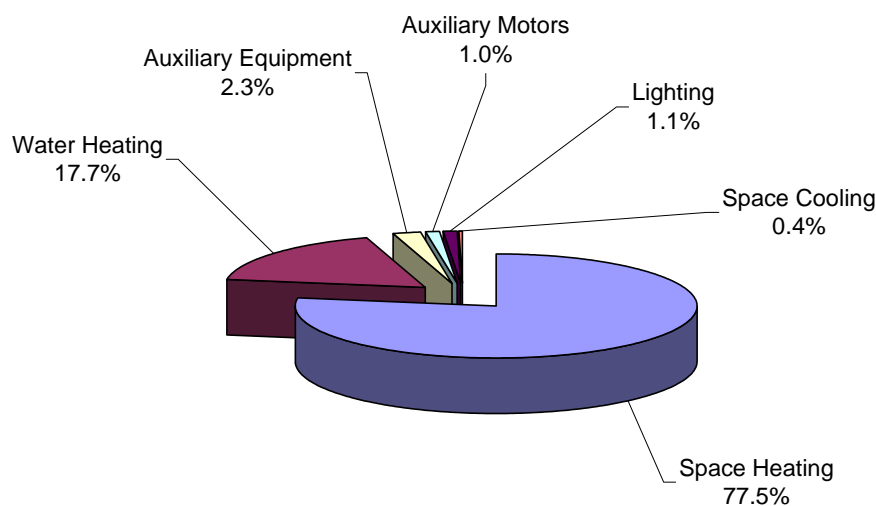
Figure 4. Energy intensities in the commercial and institutional sub sectors



The ‘Health Care and Social Assistance’ sub sector is the most energy intensive, with each square metre of building space requiring about 2.7 PJ of energy per year. This is nearly 1.5 times higher than the sub sector with the lowest energy intensity, whole sale trade. The health care sector is largely comprised of hospital buildings, with their relatively high energy intensity reflecting the amount of medical equipment contained in these buildings. The sub sector with the second highest energy intensity is the ‘accommodation and food services’ sub sector. Again, this industry requires significant amounts of equipment to operate and deliver the services attributable to it.

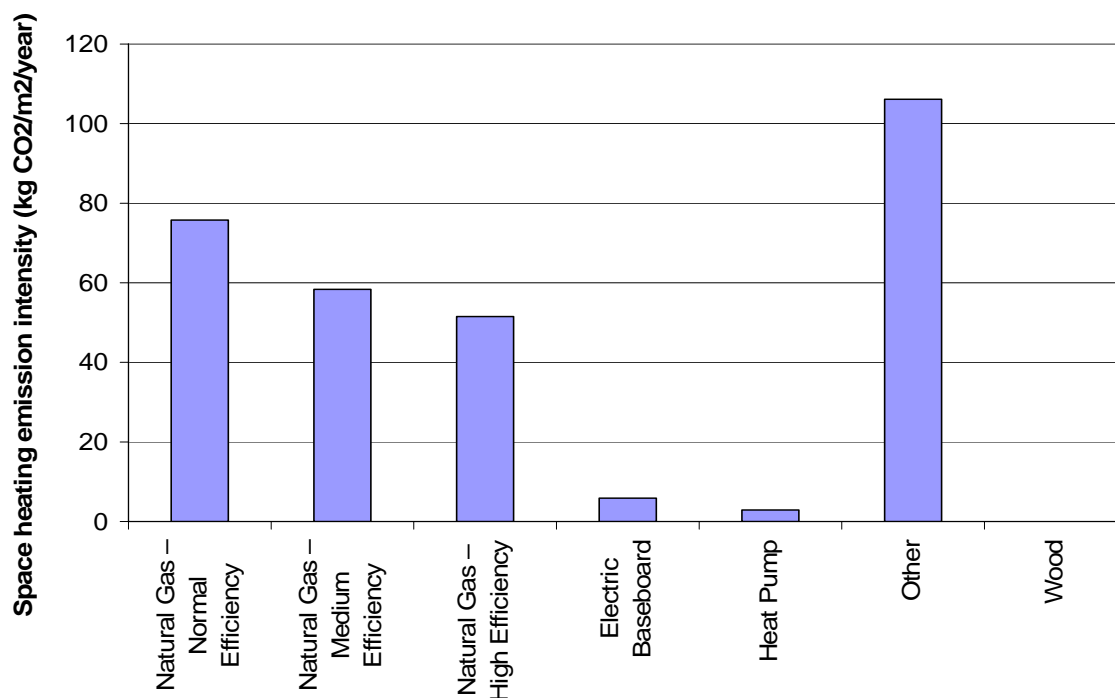
The emission intensities associated with these sectors largely reflects the range in energy intensities since the proportional mix of energy use by end use, and the types of fuels used are similar amongst the various sub sectors considered. Specifically, emission intensities range from about 34 kg CO₂e/m²/year to about 88 kg CO₂e/m²/year for the health care sector. As suggested, the distribution of emissions across the various end uses is similar across sub sector. This breakdown is shown in figure 5.

Figure 5. Proportional Breakdown of GHG Emissions in the Commercial/Institutional Sector, by End Use



As indicated by the pie chart, space heating contributes to the vast majority of emissions attributable to commercial and institutional buildings. However, it is important to note that this varies based upon the type of heating system in place. Depending on the sub sector, natural gas fuelled heating systems make up between 80% to 84% of all of the heating systems operated in Nova Scotia's commercial and institutional sector. It is assumed that the majority of these are operating at 'normal' efficiency (defined by Natural Resources Canada as heating systems that are about 60% efficient). To help understand how emissions vary based upon the type of heating system used, the OEE provides energy and emissions by heating system along with information on the stocks of the heating systems in service. This allows emission intensities to be produced on unit basis (see figure 6). We assume that variations in emission intensity on a unit basis are representative of variations in emission intensity on an area basis. For illustrative purposes, we show emission intensities for heating systems operated in buildings in the health care and social services sector of Nova Scotia's economy.

Figure 6 Emission intensities for different home heating systems operated in health care and social service centres in Nova Scotia (kg CO₂e/m²/year)¹²



As can be seen, emission intensities vary from approximately 106 kg CO₂e/m²/year for heating systems fuelled by propane, heating oil, or coal (i.e. the ‘Other’ category), to less than 0.5 g CO₂e/m²/year for homes fuelled only by wood.¹³

Within the emission calculator itself, emission factors are included for over 2,000 different buildings depending on the sub sector, space heating system, water heating system, space cooling system, and auxiliary system involved.

¹² The specific energy efficiencies of different heating systems included in the CNRD.C are:

Heating Oil – Normal Efficiency	60%	Natural Gas – Normal Efficiency	62%
Heating Oil – Medium Efficiency	78%	Natural Gas – Medium Efficiency	80%
Heating Oil – High Efficiency	85%	Natural Gas – High Efficiency	90%
Electric Baseboards	100%	Wood	50%
Heat Pump	190%	Other (propane, coal)	50%

¹³ The emission factor for the combustion of wood only includes CH₄ and N₂O released during biomass combustion, and does not include the CO₂ attributable to the loss of wood from the forest. This is the same approach as used in the National Inventory of Greenhouse Gas Emissions, where these emissions are included only in the ‘Land Use, land Use Change, and Forestry’ sector. These emissions are currently not counted towards Canada’s national inventory totals as considered for the purposes of the Kyoto Protocol.

Appendix G. Global Warming Potentials

Species	Chemical formula	Lifetime (years)	Global Warming Potential (Time Horizon)		
			20 years	100 years	500 years
CO ₂	CO ₂	variable §	1	1	1
Methane *	CH ₄	12±3	56	21	6.5
Nitrous oxide	N ₂ O	120	280	310	170
HFC-23	CHF ₃	264	9,100	11,700	9,800
HFC-32	CH ₂ F ₂	5.6	2,100	650	200
HFC-41	CH ₃ F	3.7	490	150	45
HFC-43-10mee	C ₅ H ₂ F ₁₀	17.1	3,000	1,300	400
HFC-125	C ₂ HF ₅	32.6	4,600	2,800	920
HFC-134	C ₂ H ₂ F ₄	10.6	2,900	1,000	310
HFC-134a	CH ₂ FCF ₃	14.6	3,400	1,300	420
HFC-152a	C ₂ H ₄ F ₂	1.5	460	140	42
HFC-143	C ₂ H ₃ F ₃	3.8	1,000	300	94
HFC-143a	C ₂ H ₃ F ₃	48.3	5,000	3,800	1,400
HFC-227ea	C ₃ HF ₇	36.5	4,300	2,900	950
HFC-236fa	C ₃ H ₂ F ₆	209	5,100	6,300	4,700
HFC-245ca	C ₃ H ₃ F ₅	6.6	1,800	560	170
Sulphur hexafluoride	SF ₆	3,200	16,300	23,900	34,900
Perfluoromethane	CF ₄	50,000	4,400	6,500	10,000
Perfluoroethane	C ₂ F ₆	10,000	6,200	9,200	14,000
Perfluoropropane	C ₃ F ₈	2,600	4,800	7,000	10,100
Perfluorobutane	C ₄ F ₁₀	2,600	4,800	7,000	10,100
Perfluorocyclobutane	c-C ₄ F ₈	3,200	6,000	8,700	12,700
Perfluoropentane	C ₅ F ₁₂	4100	5,100	7,500	11,000
Perfluorohexane	C ₆ F ₁₄	3,200	5,000	7,400	10,700

Source: UNFCCC Global Warming Potentials Table (http://unfccc.int/ghg_data/items/3825.php)