August 2009

A Carbon Calculator for use by Climate-Friendly Families in New Brunswick

Guidance Documentation

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Guidance Document for a Carbon Calculator for Climate-friendly Families in New Brunswick

Importance of this Calculator

Families can have a large carbon footprint when the greenhouse gas (GHG) emissions from travel, buildings energy use, water heating and waste are considered. There are options that exist, however, to reduce emissions as related to the actions of families in New Brunswick. The calculator provides the means for these residents to both understand the breadth and scale of emissions resulting from their day-to-day activities and the impacts on emissions that could result from taking appropriate action to make their lifestyles and homes as climate friendly as possible.

The Carbon Calculator for Climate-friendly Families allows residents to measure the GHG emissions resulting from a range of their activities. It does so by analysing information input by the user on a person's travel, the operation and maintenance of their dwelling and land, and the materials they consume and waste they produce. In particular, the Carbon Calculator for Climate-friendly Families calculates the total GHG emissions associated with a person's annual travel, home energy use, waste, and lawn care. It then provides the user with a number of functionalities:

- the ability to compare the current with the previous years for which they might have completed an analysis of their emissions
- the ability to compare annual emissions to the "average" New Brunswick family of a similar size and in terms of the type and technical characteristics of home (i.e. size, whether it is a detached home, attached home, apartment, or mobile home, type of home heating system, etc)
- the ability to see the emission impacts of actions to reduce emissions, including changing home heating system, changing modes of travel, etc.

Scope of Activity and Emissions

The Carbon Calculator for Climate-friendly Families includes emissions associated with:

a) Daily travel
b) Vacation, business, and other travel
c) Home energy use (both in terms of the primary fuel used for end-uses such as space heating and emissions from electricity)
d) The disposal, recycling, or composting of waste
e) Lawn and garden care

Required User Inputs

The GHG emissions estimates produced by the calculator are based on the information entered by the user. In order to be as accessible and transparent as possible, the Carbon Calculator for Climate-friendly Families has been designed to be user friendly with minimal data inputs.

Data Inputs Associated with Travel Module

The trip calculator can be used to estimate the emissions associated with all of your family's annual travel, including travel associated with commuting to work, leisure/errands, or vacations/business trips. To estimate the emissions associated with your travel, it is suggested that you separate your travel by trip purpose and estimate emissions separately for each. To do so, the calculator allows you to add individual trips by trip purpose. For those trip purposes with multiple trips per year (e.g. commuting to work), you can use the 'Calculate # Trips' button to quickly determine the number of trips you might make per year.

Field 1: Trip purpose (drop down list including: commuting (i.e. traveling to work), education, errands (shopping, etc), business/vacation travel)

Field 2: Departing address

Field 3: Arriving address

Field 4: Travel mode

Field 5: One way or two way trip

Field 6: Trips per year (you are provided a mini calculator to help you calculate the number of trips)

Data Inputs Associated with Building Module

There are seven input fields required to generate estimates of GHG emissions associated with the building(s):

Field 1 - 3: Annual energy consumption by fuel type (available from utility records);

This is used as the primary source of information to estimate emissions from the home dwelling. This then allows a comparison to be made to the average dwelling with the same size and technical characteristics. This information is gained from inputs 2 through 6. A further benefit of using the information collected in inputs 2 through 7 is that energy and emissions can be allocated to end-use.

Field 4: Type of dwelling (single attached, single detached, apartment, mobile home);

Field 5: Building size;

Field 6: Vintage (i.e. age) of dwelling (options available from dropdown list);

Field 7: Type of heating system (Heating Oil – Normal Efficiency, Heating Oil – Medium Efficiency, Heating Oil – High Efficiency, Natural Gas – Normal Efficiency, Natural Gas – Medium Efficiency, Natural Gas – High Efficiency, Electric Baseboard, Heat Pump Other (coal), Wood, Wood/Electric, Wood/Heating Oil, Natural Gas/Electric, Heating Oil/Electric)

Field 8: Type of hot water heater (electric, natural gas)

Field 9: If there is air conditioning (yes or no)

Data Inputs Associated Waste Management Module

The data inputs required for this module include the disposal and management of waste. There are three input fields required:

Field 1: amount of waste generated each week (number of bags). This includes ***both*** waste disposed in landfills ***and*** waste recycled. Defaults are provided based on per capita waste generation data available from Statistics Canada. It is assumed that the average bag of garbage put out on the curb equals 15 kgs.

Field 2: What components of the waste stream are recycled and if organics are composted. The calculator provides the ability to understand the emission impacts of recycling and composting the following waste streams:

In terms of recycling:

- Newsprint
- Cardboard and boxboard
- Other paper
- Metals (including aluminum and metal cans, etc).
- Glass
- Plastics

In terms of composting:

- Food scraps
- Yard waste

Field 3: Over the course of a year, the quantity and waste disposal methods of the following household items:

- Personal Computers (recycled or disposed in landfill)
- Televisions (recycled or disposed in landfill)
- Microwaves (recycled or disposed in landfill)
- VCRs (recycled or disposed in landfill)
- Tires (recycled or disposed in landfill)

***It is important to note, the "net emissions" that include the full lifecycle emissions and emission reductions associated with recycling can be negative. This reflects the fact that recycling takes away from the need to produce virgin material. For many waste streams, this results in a significant upstream reduction in energy requirements and emissions since it means that often energy intensive manufacturing processes are not required. For example, pulp and paper production is an energy and emission intensive process. Many pulp mills in Canada have the ability to produce paper from recycled content, a process which requires significantly less energy than producing paper from virgin content. Nonetheless, it is recognized that some recycled material are not in fact recycled in Canada, but transported overseas to lower cost centres or to regions where there is higher demand for these inputs into the manufacturing process.**

Data Inputs Associated with Lawn Maintenance Module

The data inputs required for this module are applicable to maintenance of a lawn. There are four input fields required:

Field 1: Size of lawn in acres (e.g. ¼, ½, 1 acre, etc)

Field 2: If an electric, gas, push-propelled (i.e. no gas) lawnmower or tractor is used

Field 3: If nitrogen-based fertilizer is used, how many bags of fertilizer are used per year

Field 4: The percentage of nitrogen in the fertilizer

Underlying Method and Data Sources

The Carbon Calculator for Climate-friendly Families includes estimates of GHG emissions from daily travel, vacation, business, and other travel, building energy use, waste disposal/management, and lawn maintenance. The methods and data sources for each of these sources vary, as explained and summarized in the sub sections that follow.

Daily Travel Module

The travel module includes GHG emissions from daily travel activities.

Emissions from daily travel activity are estimating using the following equations.

Equation 1: *Estimating Emissions from Daily Travel Activity – Personal Passenger Vehicles*

$$PPV_{Emissions} = VKT_{VehicleType} * EmissionIntensity_{VehicleType}$$

Where

$VKT_{VehicleType}$ = Vehicle kilometres traveled (VKT) by vehicle type (activity), by year
$EmissionIntensity_{VehicleType}$ = emission intensity by vehicle type (emission intensity of activity), in kg CO_2e per VKT

Equation 2: *Estimating Emissions from Daily Travel Activity – Urban Transit*

$$PPV_{Emissions} = PKT * EmissionIntensity$$

Where

PKT = Passenger kilometres traveled (PKT) on public transit
EmissionIntensity = emission intensity (kg CO_2e per passenger kilometre traveled) of bus travel (there is no light rail servicing commuters in New Brunswick)

Estimating Activity

Activity in regards to personal vehicle travel should be taken from odometer readings, or estimated using odometer readings as a basis. The average vehicle in Canada travels about 17,000 km a year.

Estimating Emission Intensity of Personal Passenger Vehicles

The estimation of GHG emissions from the personal passenger vehicle is complicated due to 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 Carbon Calculator for Climate-friendly Families uses vehicle-specific fuel consumption and emission intensities based upon information contained in the Fuel Consumption Rating Guide produced by Natural Resources Canada.[1] This requires the user to select the model and profile of the car they are driving in order.

For urban bus transportation, the GHG emissions factor used was 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 urban bus in Canada. Analysis of this data suggests a GHG emission intensity of 71.37 grams (0.07137 kg) of CO_2e per passenger kilometre traveled. GHG emissions from business, vacation, and other long distance travel are a function of passenger kilometres traveled and the GHG emission intensity of this travel. Since the type of vehicle or mode of travel has a significant impact on the GHG emissions associated with business travel, it is important to differentiate between the modes of transportation used for each trip. Options include airplane, bus, train, or personal passenger vehicle (the personal passenger vehicle category includes options for selecting the specific year and make of car (including minivan, SUV and truck).

Comment [CU1]: This number will be updated

The approach for estimating GHG emissions from hotel employee travel can be formulized as follows.

Equation 3: Estimating emissions from business, vacation, and other travel

$$\mathbf{BusinessTravel_{Emissions} = PKT_{Mode} * EmInt_{Mode})}$$

Where

$BusinessTravel_{Emissions}$ = total emissions from travel
PKT_{Mode} = total passenger kilometres, by mode
$EmInt_{Mode}$ = emission intensity (kg CO_2e/PKT), by mode

The mode-specific methods used to establish each term of equation 3 are provided in the sub sections which follow.

Business, Vacation, and Other Travel Module

The first step in estimating the emissions associated with business, vacation, and other travel is establishing the passenger kilometres traveled (PKT), by mode. The precise measure of distance

[1] See http://oee.nrcan.gc.ca/transportation/tools/fuel-consumption-guide/fuel-consumption-guide.cfm

traveled depends upon the mode of travel and the geographical location of the origin and destination of the travel.

Estimating Passenger Kilometres Traveled

To determine the distance traveled as easily and accurately as possible, for all modes of travel the calculator relies on the web-based Google Maps application. [2] To do so, the calculator requires information on departure address and destination address for all trips and uses the mapping application to determine the total distance of the trip:

- **For air travel:** PKT by airplane are based on the great circle distance function. In this case the Google Maps application calculates the distance between the origin and destination points based on the great circle formula (this is the most direct route after 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.

  A factor that influences the distance of any given flight are stop-overs, re-routes, head winds, refuelling stops, or other factors that can take a lane of its optimal flight path. Therefore, and as 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 in table 3:

  Table 3 Correction factors used to estimate flight distance

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

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

Emission Intensities per Passenger Kilometre Traveled

Personal Passenger Vehicle

The estimation of GHG emissions for the passenger vehicle is more complex due to the wide-range of cars and trucks available and the variations in GHG emissions intensities across vehicle type. In order to accurately reflect the complexities of GHG emissions for personal passenger vehicles, the calculator includes vehicle specific fuel consumption information (obtained from

[2] http://maps.google.com/

the Fuel Consumption Rating Guide produced by Natural Resources Canada). This requires the user to select the model and profile of the car they are driving.

Air Travel

The GHG emissions resulting from a trip by airplane are a function of both distance traveled 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 airplane to 30,000 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. The length of a trip can be determined based on the origin and destination of a trip and using the great circle formula to determine the distance between these points. 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 for the Hotel Business Travel Module, 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 (explained in more detail below).

3. Airplane engine type:

    While jet engines are still dominant for most continental and intercontinental flights, turbo prop engines are now rising in use with the emergence of such air carriers as Porter Airlines and passenger preference for the higher energy efficiencies associated with turbo prop engines (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). The type of the airplane engine specific to the flight taken (jet engine versus turbo prop engine) is determined by the user of the calculator.

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 emissions are reflected by the FCR used in estimating these (i.e. 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, in the 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.

6. Class of seat:

   Each class of seat on an aircraft is responsible for a certain amount of emissions based on the “foot print” of that seat – i.e., how much space is taken up. Namely, 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.

7. Seat configuration of aircraft:

   The configuration of seats on an airplane will have important implications for the GHG emissions intensity of air travel. In particular, the more passengers on an airplane, the lower the GHG emissions intensity on a per passenger basis. Since flights with business class seats can carry fewer passengers than a flight with only economy class seating, the average GHG emission intensity of each seat on that flight would be higher than compared to a plane with all economy seating.

8. 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. Nonetheless, to be conservative, a value of 75% for all flights is used in this calculator.

In order to simplify the complexities associated with estimating GHG emissions resulting from air travel, flights are categorized by those greater than 1,600 km, those equal to or less than 1,600 km, and those less than 500 km in line. Flights equal to or below 1,600 km are further broken down by flights on large planes with both executive and economy seat classes, flights on large planes but with only economy class, flights on smaller regional aircraft with jet engines (e.g. the CRJ), and flights on regional aircraft with turbo prop engines. Aircraft used for short haul flights are assumed to have emission characteristics reflective of such aircraft as the Dash 8.

The parameters that characterize these different categories, and in turn, influence the emission intensity of each are summarized in table 4.

Table 4. Parameters affecting the emissions associated with air travel, by trip length and type of aircraft

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	Canadian regional jet	1.67	50-70		544	
<1,600 and >500	Regional turbo prop aircraft[c]	1.02	50-70		544	
<=500	Dash 8	0.49	37		544	

Table notes:

a) Fuel burn rates are for the cruise cycle, and are 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).

The resulting GHG emission intensities for passenger travel on flights are shown in table 5.

Table 5 Emission intensities for air travel used in the air travel calculator

Flight distance (km)	Configuration	Cruise emission intensity* (kg CO2/PKT)		LTO emission intensity* (kg CO2/seat)		Passenger to freight ration (%)	Passenger emission intensity (kg CO2/PKT)	
		Economy	*Executive*	*Economy*	*Executive*	*All*	**Economy**	**Executive**
> 1,600	Economy and executive	0.10	0.18	28.82	54.74	80.00%	**0.16**	**0.29**
<=1,600	Large aircraft: economy and executive	0.09	0.14	23.98	34.17	85.00%	**0.15**	**0.21**
<=1,600	Large aircraft: Only economy class	0.14		25.55		95.00%	**0.18**	
<=1,600	Small regional jet (e.g. CRJ-2)	0.21		17.52		95.00%	**0.25**	
<=1,600	Turbo prop (e.g. NexGen Q400)	0.13		10.73		97.00%	**0.15**	
Under 500 km	Smallest regional jet (e.g 30 seater Dash 8)	0.10		12.51		100.00%	**0.13**	

Bus

For passenger bus transportation, the GHG emissions 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

For passenger train transportation, the GHG emissions factor is generated from data available from Transport Canada's T-Facts website.3 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.

Residential Building Module

The most accurate way to generate an estimate of the emissions attributed to a buildings energy use is to derive this from records of the primary fuel (i.e. natural gas, heating oil, diesel, or wood) and electricity purchased over the course of a year. Fuel consumption totals can then be multiplied by fuel- and electricity-specific emission factors.[4] The building owner or user can then compare their energy use and emissions with the average building/dwelling with the same technical characteristics (i.e. type of dwelling, vintage, size, etc). Such a comparison can be made based on information on the energy use characteristics of residential buildings in New Brunswick as made available from the Office of Energy Efficiency (OEE) at Natural Resources Canada.[5] In addition, using this information, users of the calculator can see approximately for what end-uses they use energy, and the resulting emissions resulting from this energy use since the data available from the OEE allows the energy use and emissions attributed to the residential dwelling to be allocated to end-use. This is useful for the user of the calculator since it will allow them to understand approximately where they use energy in the home and to understand the emissions attributed to these energy end-uses.[6]

A closer look at the energy and emission characteristics of residential buildings

It is important for users of the calculator to first note that there are variations in the emission intensity of the different types of residential dwellings in New Brunswick. This reflects the different technical characteristics of each type of dwelling in terms of space heating (e.g. apartments require less energy for space heating because they have less exposed surfaces to the outside), lighting (e.g. detached homes require more lights on the outside of the building whereas apartments do not), and in terms of appliances and water heating (typically apartments and mobile homes have a higher energy and emission intensity in terms for both of these energy end-

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

[4] National Inventory Report 1990-2005: Greenhouse Gas Sources and Sinks in Canada - The Canadian Government's Submission to the UN Framework Convention on Climate Change, April 2007

[5] The Office of Energy Efficiency compile, on an annual basis, estimates of energy and 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 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/comprehensive_tables/index.cfm?attr=0

[6] Emission intensities vary based upon the age of dwelling, type of dwelling (including detached houses, attached houses, apartments/condos, and mobile homes for residential buildings, or sector for commercial buildings), the types of heating systems used, the thermal properties of the different dwelling types, and the technical characteristics of cooling systems, appliances, and lighting.

uses since they are generally smaller in size, but still require this equipment). This is shown in terms of the emissions associated with each square metre of building space over the course of a year for the average dwelling built between 2001 and 2006. Both emissions from primary energy sources and emissions associated with purchased electricity are included.

Figure 1 Emissions by end use and dwelling type for dwellings constructed between 2001 and 2006, in kg CO2e/m2/year

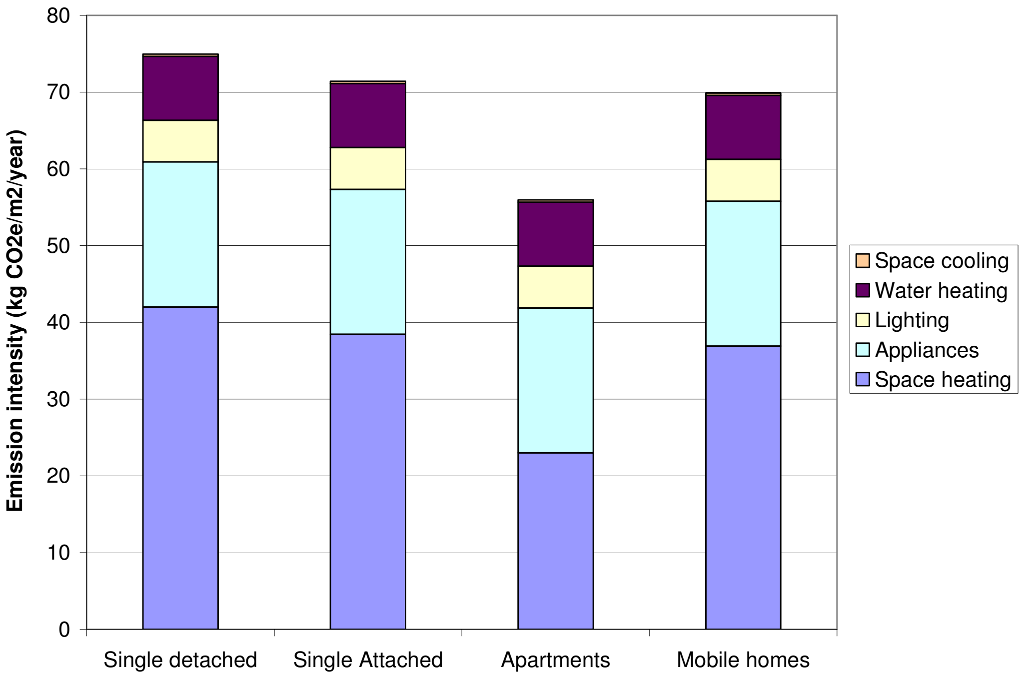


Table notes: Emission intensities reflect the "average" dwelling type constructed between 2001 and 2006 in New Brunswick, and thus are reflective of the average energy intensity and fuel mix of the dwelling types that make up the categories consider. The emission intensities provided in the figure also include emissions attributed to space cooling.

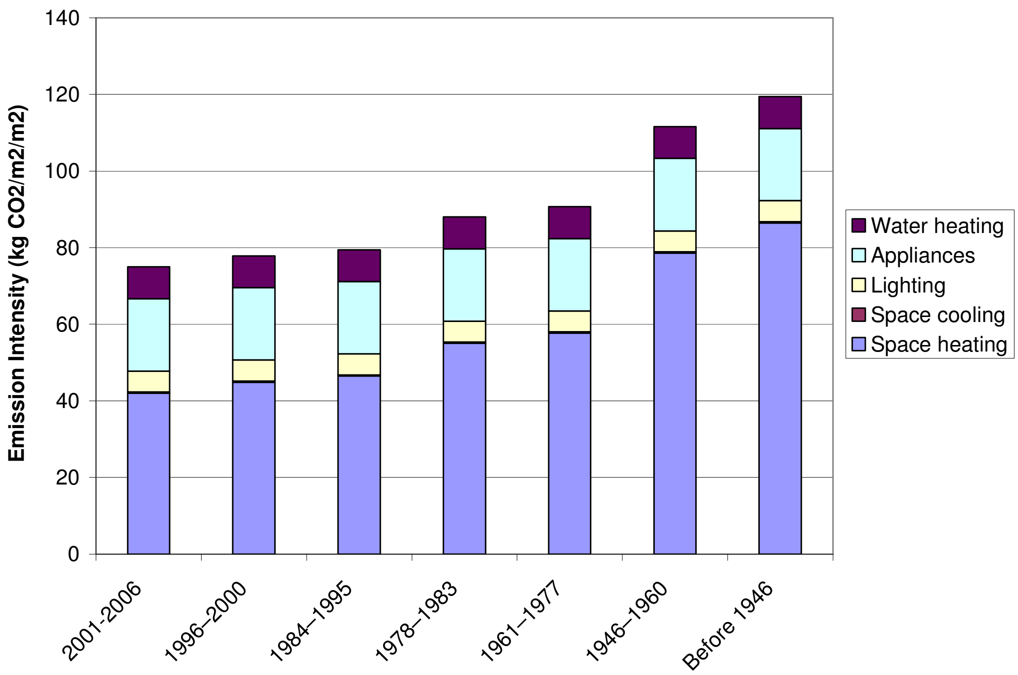
The most emission intensive type of dwelling in New Brunswick is the single attached home, with the least emission intensive being apartments. This is because, even though the attached home uses about 10% less energy when measured on a per metre basis, more of these dwellings rely on fuel oil or electricity for heat (whereas detached homes have a higher prominence of using wood stoves). In addition, attached homes are usually smaller, but generally have the same number of appliances (i.e. stove, fridge, freezer, dishwasher, etc).

The varying emission intensities for the different dwelling types reflect differences in emissions associated with all energy end-uses, with home heating being the factor of most importance.

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, the average single attached home requires 10% to 12% less energy on a square metres basis than compared to a single detached home since less of the building envelope is exposed to the outside elements (thus, it is more 'energy efficient'), although this is countered somewhat in terms of emissions by the fact that more wood is used to heat detached homes.

Emission intensities also vary based upon the age of the structure. This is illustrated in terms of the average detached house in New Brunswick (the most common type of dwelling). Again, both emissions from primary energy sources and emissions associated with purchased electricity are included in the emission intensities.

Figure 2 Emission intensities for the average New Brunswick detached house, by end-use and vintage



The emission intensity of a home increases consistently the older the home is. The average detached home built between 2001-2006, for example, results in nearly 40% less emissions than a home that was constructed before the end of the Second World War. This is reflective of the lower levels of insulation in these buildings as well as lower efficient heating systems.
The type of heating system and fuel type used is another important factor that determines the amount of emissions resulting from the operation of a home. This is illustrated by considering

figure 3 which shows the emission intensity associated with different home heating systems in use in New Brunswick.

Table 6 Average Emission Intensities of Home Heating Systems in New Brunswick (kg CO2e/m2/year)

	Emission intensities (kg CO2e/m2/year)			
	Single Detached	**Single Attached**	**Apartments**	**Mobile Homes**
Average energy intensity	42	38	23	37
Heating Oil – Normal Efficiency	68	60	45	98
Heating Oil – Medium Efficiency	54	48	36	78
Heating Oil – High Efficiency	48	42	31	69
Natural Gas – Normal Efficiency	45	40	30	65
Natural Gas – Medium Efficiency	36	32	23	52
Natural Gas – High Efficiency	31	27	20	45
Electric Baseboard	71	63	46	102
Heat Pump	37	33	24	54
Other[1]	88	77	57	126
Wood	0	0	0	0
Wood/Electric	47	42	31	68
Wood/Heating Oil	33	29	21	47
Natural Gas/Electric	56	49	36	80
Heating Oil/Electric	64	56	42	92

Table notes: Emission intensities reflect the "average" dwelling type in New Brunswick, inclusive of all vintages. Other refers to homes heated by coal.

The most common type of home energy system in New Brunswick is the electric base board, making up about 53.1% of the home heating systems in 2006. The next most prominent type of home heating system is the "normal" rated heating oil system, making up about 12.5% of the home heating systems in the province. Meanwhile, wood, or wood combination heating systems (e.g. wood/electric mix), make up just less than 25% of the total home heating system stock in the province.

Procurement and Waste Management Module

Residents of New Brunswick can help reduce GHG emissions to the atmosphere by choices in how much and what they consume and, subsequently, if they recycle or if they dispose of their waste in a landfill.

In order to illustrate to users of the Calculator the emission impacts of disposing of their waste and the emission benefits of recycling, composting, or source reduction, two separate numbers are provided to the user a) the emissions if all of the waste generated by the household was disposed of in a landfill and b) the "net" emissions in terms of those resulting from the waste disposed of in a landfill and in terms of the emission impacts of recycling and composting. In terms of this latter number, this includes the "avoided" emissions resulting from the fact that less "virgin" material would have to be produced due to the recycling of household material. The details of this lifecycle approach to estimating the emission benefits of recycling are discussed in later sections.

This dual process of estimating emissions from waste disposal and the benefits of recycling, source reduction, or composting is represented by the following equations:

Equation 4: Estimating emissions from waste management of only waste disposed in landfill

$$\mathbf{Waste_{Emissions} = Waste_{Disposed} * EmInt_{WasteInLandfill}}$$

Where

$Waste_{Emissions}$ = total emissions from waste just considering waste disposed in a landfill
$Waste_{Disposed}$ = total amount of waste disposed in landfill
$EmInt_{WasteInLandfill}$ = emission intensity (kg CO2e/kg waste) of waste in landfill

Equation 5: Estimating emissions from waste management of waste disposed in landfill, net of material recycled and composted

$$\mathbf{Waste_{NetEmissions} = [(Waste_{Disposed} * EmInt_{WasteInLandfill}) + (RMaterial_{Type} * LCEmInt_{Type})]}$$

Where

$Waste_{NetEmissions}$ = Net emissions from waste considering waste disposed in a landfill and the emission reductions resulting from recycling and composting
$RMaterial_{Type}$ = Recycled and composted material, by type
$LCEmInt_{WasteInLandfill}$ = life cycle emission intensity (kg CO2e/kg waste) of waste recycled or composted

Waste disposed

In order to use this module, the calculator user will have to input data on the amount of waste generated per week and how this waste is managed. The data inputs are in terms of the volume of waste generated (based on the number of bags of garbage (whether destined to a landfill or recycling centre), which is then converted to a weight measurement.

To help users understand how much waste a typical person, and household, generates per year, a default waste generation number is provided. This is based on data available from Statistics Canada on residential waste generation and population. This is summarized for New Brunswick as well as for all other provinces and in terms of the Canadian average for what occurred in 2006 (see table 7.

Table 7 Waste Generation Statistics for New Brunswick and other provinces (2006)

Province	Residential generation of waste (ktonnes)	Population (1,000's)	Annual waste generation rate (tonnes/person/year)	Weekly waste generation rate (kg/person/ week)	Weekly waste generation rate (15 kgbag/ person/ week)	Waste generate rate - family of four (15 kg bags per week)
New Brunswick	***216***	***746***	***0.29***	***5.57***	***0.4***	***1.5***
Newfoundland	228	510	0.45	8.59	0.6	2.3
Nova Scotia	169	938	0.18	3.46	0.2	0.9
Quebec	2,184	7,632	0.29	5.50	0.4	1.5
Ontario	3,705	12,665	0.29	5.63	0.4	1.5
Manitoba	455	1,184	0.38	7.39	0.5	2.0
Saskatchewan	296	992	0.30	5.74	0.4	1.5
Alberta	974	3,421	0.28	5.47	0.4	1.5
British Columbia	957	4,244	0.23	4.34	0.3	1.2
Canada	9,238	32,576	0.28	5.45	0.4	1.5

From the waste generation data available, it is estimated that the average 4-person household in the province of New Brunswick generates about one and a half 15 kg bags of garbage and recycled material per week. This is the same as the Canadian average. The highest waste generation rate in Canada is in Newfoundland, while the lowest is in Nova Scotia.

Estimating emission from waste disposed on in a landfill

The GHG emission impacts of sending waste to a landfill are estimated by considering only the GHG emissions resulting from the anaerobic degradation of waste in the landfill. Thus, this does not account for the upstream GHG emissions from originally producing the products or the GHG emissions from producing replacement products for those send to landfill. This way, GHG emissions are not double counted across the life cycle of a product.

The GHG emission intensity of waste in a landfill 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 generation of these emission intensities for any given year therefore requires two pieces of information – the amount of emissions from landfilled waste, and the amount of waste sent to the landfill. This is summarized in table 8 below.

Table 8 Emission intensities for waste disposal

Waste disposed to landfill[a]

	(kilotonnes)				
	Residential sources	Non-residential sources	All sources	GHG emissions[b] (kt CO2e)	Emission intensity[c] (tonne CO2e/ tonne landfilled)
Newfoundland and Labrador	228	180	408	600	1.47
Nova Scotia	169	232	402	520	1.29
New Brunswick	216	234	450	590	1.31
Quebec	2,184	4,625	6,808	4600	0.68
Ontario	3,705	6,733	10,438	6600	0.63
Manitoba	455	569	1,024	960	0.94
Saskatchewan	296	538	834	990	1.19
Alberta	974	2,846	3,820	2400	0.63
British Columbia	957	1,960	2,917	3400	1.17
Canada	9,238	18,011	27,249	21000	0.77

Table notes:

a. From Statistics Canada's Waste Management Industry Survey, "Disposal of waste — by source and by province and territory"
b. From Environment Canada, " National Inventory Report: 1990 to 2006"
c. 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

Estimating emissions from waste recycled

Two numbers are provided to the user to help demonstrate the impact of recycling on emissions. The second number provided to the user is meant to illustrate to the user the benefits of recycling, and therefore reflects the full lifecycle impacts of recycling in terms of the avoided organics sent to the landfill, the avoided energy and emissions associated with production of the virgin material, and the additional energy required to recycle. By doing so, users can appreciate the magnitude of the emission reductions from recycling versus if this waste was sent to a landfill. [7]

Composition of waste in Canada

For the purposes of understanding the emission impacts of households, it is necessary to understand the composition of the waste generated by the household. This is provided in terms of the Canadian average waste generated in both the residential and commercial sectors since no known data was available specific for household waste composition nor was information available specific for New Brunswick (see figure 3).

[7] Some propose that recycling is in fact more energy and GHG emissions intensive than producing materials from virgin sources. Full analysis, however, and the metrics that account for the full life cycle indicate that recycling, as with source reduction, has significant GHG emissions reductions benefits.

Figure 3 Composition of waste (Canadian average)*

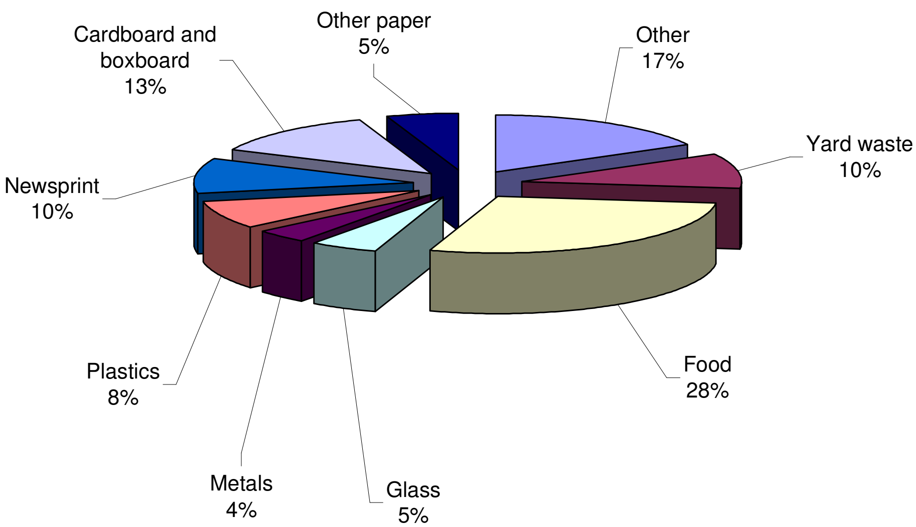


Figure notes: derived from
http://www.rcbc.bc.ca/documents/events/2007_con_presentations/rcbc_con_golder.swf

According to the data presented above, approximately 45% of the amount of waste generated by a household is "recyclable", 28% is kitchen and yard waste, while approximately 26% are residuals.

The respective lifecycle GHG intensities for the various waste streams are provided in table 10. 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), and the third column shows the GHG emissions impacts of composting (relative to landfill disposal). The last four columns, alternatively, show the emissions resulting from landfilling waste. Emission intensities are provided for the national average landfill, landfills without land-fill-gas collection, landfills with landfill-gas collection, and landfills with land-fill-gas collection and energy recovery systems in place. For the purposes of the Climate Friendly Carbon Calculator, the emission intensities associated with landfills without landfill-gas collection systems is used. Not only is this conservative, none of the six landfills in New Brunswick currently has landfill-gas collection systems in place.

Table 10 Emission effects of different waste management practices, by type of material
(kg CO2e/kg of waste)

Material	Net Source Reduction Emissions	Net Recycling Emissions	Net Composting Emissions	Net Anaerobic Digestion Emissions	Net Combustion Emissions	Net Landfilling Emissions (NLE) - National Average	NLE Without Landfill Gas (LFG) Collection	NLE With LFG Collection and Flaring	NLE With LFG Collection and Energy Recovery
Newsprint	(3.81)	(2.81)	NA	(0.49)	(0.05)	(1.22)	(1.13)	(1.36)	(1.36)
Fine Paper	(5.93)	(3.33)	NA	(0.34)	(0.04)	1.18	1.71	0.31	0.28
Cardboard	(5.22)	(3.34)	NA	(0.32)	(0.04)	0.29	0.75	(0.48)	(0.51)
Other Paper	(5.51)	(3.36)	NA	(0.23)	(0.04)	0.71	1.19	(0.07)	(0.10)
Aluminum	(4.55)	(6.49)	NA	0.01	0.01	0.01	0.01	0.01	0.01
Steel	(1.95)	(1.15)	NA	0.01	(0.99)	0.01	0.01	0.01	0.01
Copper Wire	(6.26)	(4.10)	NA	0.01	0.01	0.01	0.01	0.01	0.01
Glass	(0.40)	(0.10)	NA	0.01	0.01	0.01	0.01	0.01	0.01
HDPE	(2.74)	(2.27)	NA	0.01	2.85	0.01	0.01	0.01	0.01
PET	(3.50)	(3.63)	NA	0.01	2.13	0.01	0.01	0.01	0.01
Other Plastic	(3.01)	(1.80)	NA	0.01	2.63	0.01	0.01	0.01	0.01
Food Scraps	NA	NA	(0.24)	(0.10)	0.02	0.80	1.14	0.23	0.21
Yard Trimmings	NA	NA	(0.24)	(0.15)	0.01	(0.33)	(0.17)	(0.60)	(0.61)
White Goods	NA	(1.44)	NA	0.01	(0.24)	0.01	0.01	0.01	0.01
Personal Computers	NA	(1.59)	NA	0.01	0.41	0.01	0.01	0.01	0.01
Televisions	NA	(0.22)	NA	0.01	0.74	0.01	0.01	0.01	0.01
Microwaves	NA	(1.24)	NA	0.01	(0.52)	0.01	0.01	0.01	0.01
VCRs	NA	(0.94)	NA	0.01	0.16	0.01	0.01	0.01	0.01
Tires	NA	(3.29)	NA	0.01	(0.49)	0.01	0.01	0.01	0.01

Table notes: From "*Determination of the Impact of Waste Management Activities on Greenhouse Gas Emissions 2005 Update*", available from http://www.recycle.ab.ca/images/stories/Download/GHG_Impacts_Summary.pdf.

Lawn Maintenance Module

Emissions from lawn maintenance include those resulting from the cutting of lawns and also from fertilizer use.

The options for cutting a lawn in the carbon calculator include a walk behind push mower, riding lawn mower, and a no-gas push lawn mower.

Based on a review of information available on the technical characteristics of lawn equipment, it was determined that the fuel consumption rates of lawn equipment vary quite significantly depending on size of equipment and the model, and from this review, a conservative range of fuel consumption rates have been approximated based on the size and type of equipment. This is provided in terms of the amount of fuel consumed and emissions per area of lawn, and is summarized in table 11.

Table 11 Fuel consumption rates and emission intensities of lawnmowers

Equipment type	Fuel consumption rate (litres/acre, except kWh per acre for electric lawn mowers)	Emission rate (kg CO2e/acre)
Small push-behind gas lawn mower	2.5 litres/acre	6.25
Large push-behind gas lawn mower	3.5 litres/acre	8.75
New ride-on lawn tractor (4 years or newer)	4.5 litres/acre	11.25
Old ride-on lawn tractor (older than 4 years)	6 litres/acre	15.00
Electric lawn mower	19 kWh/acre	8.65

Table notes: The electricity consumption of an electric lawn mower was determined was based upon the assumption that lawn mower engines operate at an efficiency of 40%. The resulting energy requirements were used to determine the electricity consumption of the electric lawn mower, assuming that these operate at 90% efficiency. Energy contents and conversions are available from http://www.neb.gc.ca/clf-nsi/rnrgynfmtn/sttstc/nrgycnvrsntbl/nrgycnvrsntbl-eng.html

To determine emissions from nitrogen fertilizer usage, a method is used similar to that used to estimate emissions from nitrogen fertilizer use in the provincial and national emission inventory in terms of nitrogen use in the agriculture sector. Specifically, the volume of nitrogen used is multiplied by coefficients which represent the potential loss from direct and indirect sources. Direct sources are direct losses of nitrogen fertilizer through processes of nitration, etc, while indirect sources include those from the loss of nitrogen into waterways or other routes into the environment. Combined, these factors mean a loss of about 2% of nitrogen to the atmosphere of the total amount applied (a conservative figure).

Nitrogen (N), phosphorus (P), and potassium (K) are the three major nutrients needed by lawns. Nitrogen is the nutrient required most. Percent nitrogen (by weight) is always the first of three numbers on the fertilizer bag, followed by phosphorus and potassium.[8] For example, 18-6-12 fertilizer contains 18% nitrogen. Therefore, a 25 kg bag of 18-6-12 fertilizer would contain about 4.5 kgs of nitrogen. In this case, it could be expected that 0.09 kg of N would be released to the atmosphere per year. This would be equal to about 28 kg of carbon dioxide equivalent, considering that N has a global warming potential of 310 relative to CO_2.

Using the Calculator

The Carbon Calculator for Climate-Friendly Families is an important tool for measuring a resident of New Brunswick's carbon footprint. The Calculator can produce a meaningful estimate of the GHG emissions resulting from travel, home energy usage, waste disposal and management, and lawn care. This baseline measurement is in turn the starting point for planning how to reduce GHG emissions in future years.

8 http://www.fairgreensod.com/lawn-fertilizer.htm

Understanding changes over time in a household's emission profile

Users of the calculator can save their emission profile for one year and track changes in consecutive years. This will allow users to understand how their household's emission profile is changing with time. However, it is important in doing so that users recognize the influence of external factors, such as weather, on changes in emissions in any given year, and to not attribute emission reductions to personal life style choices or projects implemented in the home in error.

Understanding the emission impacts of life style choices

Future development work of the emissions calculator will include the ability to understand the impacts of actions taken in the household and in the house to reduce emissions. The following lifestyle choices and emission projects implemented in the home will be considered in the calculator:

Life style choices:

- Reducing the distance traveled on personal passenger vehicles or public transit by walking, biking, or other zero emission forms of transportation
- Changing the mode of transportation used for vacation/business/or other travel
- Increasing the amount of waste that is recycled, thereby reducing the amount of waste sent to the landfill
- Changing a lawn mower from gasoline powered to human powered (i.e. self propelled)
- Reducing the amount of fertilizer put on a lawn

Projects in the home

- Changing the home heating system (i.e. from electric base board to high efficiency natural gas)
- Increasing the R-value of insulation
- Changes windows new more efficient windows