Guidance Document

Community Led Emissions Reduction (CLER) Program
Neighbourhood Greenhouse Gas Emissions Calculator

Prepared by the greenregistry.org | 2009

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Importance of this Calculator

In 2008, the Province of Manitoba launched Kyoto and Beyond. This document outlined Manitoba's blueprint to reach and go beyond its legislated Kyoto target to reduce greenhouse gas (GHG) emissions by six per cent below 1990 levels by 2012.

The many individual decisions and actions in our daily activities add up to have significant impact on climate change. This is particularly true in Manitoba where there are few large emitters and the availability of hydro power. Individuals and local governments, who provide services to their communities, are key partners in mitigating climate change.

Fourteen rural and urban centres, including six neighbourhood organizations, have been selected for funding under a new four-year (2008-2012), Community Led Emissions Reduction (CLER) pilot program. Manitobans have already demonstrated a leadership role in developing grassroots solutions to climate change and participants in this program will receive added support to develop and implement community-initiated projects and activities that reduce GHG emission reductions and build toward long-term, lasting changes.

The pilot program will be delivered in two streams:

- one in partnership with local governments and aimed at reducing corporate and community GHG emissions; and,
- one in partnership with non-profit neighbourhood based organizations aimed at reducing community GHG emissions through individual behavioural change and neighbourhood efforts.

Community groups participating in the pilot program may initiate projects or activities in the following areas:

- waste-reduction measures such as recycling or reusing salvageable goods, or composting;

- water-conservation measures through home or building retrofits, rain water capture and reduced water usage;

- transportation measures such as commuting programs, trail or bike path development, driving techniques to reduce fuel consumption, or anti-idling campaigns;

- energy measures through home or building retrofits or more efficient lighting choices;

- green procurement or purchasing choices such as choosing products that use less packaging, or contain recycled content or reusing products; and,

- green landscaping and lawn-care measures such as community gardens, tree planting, tree banding or developing naturalized landscapes that require reduced mowing, watering and pesticide use;

Over the course of the next three years, program participants will:

1. Establish a neighbourhood GHG emissions inventory that shows the total GHG emissions produced from building energy use, transportation, waste and lawn care activities.

2. Set GHG emission reduction goals.

3. Develop a local neighbourhood climate change action plan with community input.

4. Implement GHG emissions reduction projects and activities.

5. Monitor progress and report results.

Why Should I Complete a Calculator?

More information about the impact of your daily decisions - Individual households, businesses, organizations and community-based institutions (schools, faith based organizations) who complete the calculator will gain and understanding of how the daily choices they make contribute to climate change.

Reducing your carbon footprint has many added benefits such as cost savings, health, safety, job creation and local economic development.

Inform future decision-making that impacts you – Completing the Neighbourhood GHG Emissions Calculator may lead you to make different personal decisions but it will also inform broader community decisions that impact you. Community organizations participating in this pilot will use the information you contribute to prioritize and develop local GHG emission reduction projects and activities. Participating may help you influence those broader community discussions.

Track your progress against a goal –If you have a picture of what you're producing now you can track and measure your progress over time.

The Neighbourhood GHG Emissions Calculator provides you with your own personal carbon footprint for energy, waste, transportation and lawn care decisions by:

- analysing your responses about daily activities;

- translating the data into a Manitoba context by using customized Manitoba data and GHG emission factors, and

- estimating the associated GHG gas emissions produced.

What Will This Information Be Used for?

It's your chance to have a say!

The Neighbourhood GHG Emissions Calculator will establish a picture of where GHG emissions are coming from, both for individual residents and the neighbourhood as a whole.

The community organizations participating in this program will use the inventory information to develop a local climate change action plan with community input.

Community plans will identify and prioritize GHG reduction projects and activities neighbourhood residents want expanded or developed in their community.

Scope of Activity and GHG Emissions Included

The Neighbourhood GHG Emissions Calculator includes 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 four different sources of GHG emissions are included for each:

a) GHG emissions associated with typical or routine transportation activity;
b) GHG emissions associated with building energy use (including both direct fuel use onsite for things like heating, and indirect use of electricity generated offsite);
c) GHG emissions associated with consumption of materials and the disposal, recycling, or composting of waste;
d) GHG emissions associated with lawn care.

Common GHG emission regulatory mechanisms and international standards require the monitoring and reporting of six GHGs, namely; carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). Only carbon dioxide, methane, and nitrous oxide are emitted from typical community activities and are included in the scope of the Neighbourhood GHG Emissions Calculator. In order to present a single metric for GHG emissions, the three GHGs included are normalized to their carbon dioxide equivalency (CO_2e) and the total GHG emission of all three gases is presented as CO_2e. For the breakdown of GHG emissions by type of gas see Appendix A.

Calculator Data Requirements and User Inputs

The GHG emissions estimates produced by the Neighbourhood GHG Emissions Calculator are developed using the information provided directly by the users and customized Manitoba GHG emission factors provided in the methodology. In order to be as accessible and transparent as possible, the Neighbourhood GHG Emissions Calculator includes information on data sources and GHG emission factors used. There are several basic categories of data required in order to generate estimates of GHG emissions associated with community programs. These have been organized according to buildings, routine transportation, travel events, waste management and lawn care.

Data Inputs for Information Management

In order to sort user data by community and track GHG emission reductions over time, the users must establish an account on the www.greenregistry.org site that allows their data to be managed effectively. There are five pieces of information that are first 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);

Field 4: Location (neighbourhood) of the residence, business, organization or institution;

All personal information collected through the Neighbourhood GHG Emissions Calculator will be collected and stored in a manner consistent with the *Freedom of Information and Privacy Act* of Manitoba (C.C.S.M. c. F175).

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 you provide 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 emission profiles will be stored separately in secure password protected data bases. Access to the database is limited to authorized CSA and CLER program staff.

Data Inputs Associated with Routine Travel

There are two different possible sources of GHG emissions considered in the routine travel module, these are; GHG emissions associated with the use of personal passenger vehicles (cars and light trucks), and GHG emissions associated with the use of public transportation. Only buses are considered for public transportation since there is no light rail in Manitoba.

For travel by personal passenger vehicles

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

Field 2: types of vehicle(s) owned and operated;

Field 3: number of vehicle kilometres per year, by vehicle;

For travel on 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.

Data Inputs Associated with Residential Buildings

GHG emissions from residential 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 residential building size and performance.

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

Field 1: Annual energy consumption by fuel type (available from utility records), including kWh of electricity, m^3 or kg of natural gas, propane, and heating oil for all energy needs;

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 dwelling (e.g., single attached, single detached, apartment, mobile home);

Field 2: Vintage (i.e., age) of dwelling (options available from dropdown list);

Field 3: Size of dwelling (square feet or square metres of floor space);

Field 4: Type of heating system (electric, natural gas, heating oil, other);

Field 5: Type of space cooling (if any);

Field 6: Type of hot water heater (electric, natural gas).

Data Inputs Associated with Commercial and Institutional Buildings

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 providing one full year of energy use, including kWh of electricity, m^3 or kg of natural gas, propane, and heating oil 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, Hospital, Retail, Food and Accommodation, etc);

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

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

Field 4: Efficiency of heating system (if known);

Field 5: Type of hot water heater (electric, natural gas);

Field 6: If building has air conditioning (yes or no);

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

Data Inputs Associated with Municipal Curbside Waste Management

Residents, businesses and institutions using the municipal curbside waste collection service can use this calculation methodology. The data inputs required for this module include the disposal and management of municipal solid waste. There are three input fields required:

Field 1: Amount of solid waste generated each week (number of bags set out for curbside collection and disposal at landfill);

Field 2: Use of any materials with post-consumer recycled content;

Field 3: Amount of material recycled each week (number of bags or boxes of material set out for curbside collection for recycling). These inputs include the types of material recycled, with options including paper, cardboard, plastics, and metal;

Field 4: Amount of material composted each week (number of average size kitchen garbage bags in backyard or neighbourhood composter).

Data Inputs Associated with Commercial Waste Management

Businesses and institutions using private waste management companies and dumpsters for collecting waste will use this calculator. The data inputs required for this module include the disposal and management of industrial, commercial and institutional solid waste. There are three input fields required:

Field 1: Amount of solid waste generated each week (cubic yards placed in dumpsters for disposal at landfill);

Field 2: Use of any materials with post-consumer recycled content;

Field 3: Amount of material recycled each week (cubic yards placed in dumpsters for recycling). These inputs include the types of material recycled, with options including paper, cardboard, plastics, and metal;

Field 4: Amount of material composted each week (cubic yards placed in dumpsters for composting, or placed in onsite composter).

Data Inputs Associated with Lawn and Garden Care

Residents, commercial businesses and institutions using the calculators will use this module on lawn and garden care. There are three input fields required:

Field 1: Size of maintained lawn in acres (e.g. from 0.1 acres to several acres);

Field 2: Type of lawn mower used (e.g., walk behind electric or gas, push-propelled (i.e. no gas), riding mower or garden tractor);

Field 3: Amount of nitrogen-based synthetic fertilizer applied to lawn per year.

Underlying Methods and Data Sources

The Neighbourhood GHG Emissions Calculator includes estimates of GHG emissions from routine transportation, residential and commercial/institutional building energy use, waste management, and lawn care using the data entry fields described above.

Routine Transportation Module

The routine transportation module includes GHG emissions from common local transportation activities. GHG emissions from routine transportation activity are estimated using the following equations and GHG emission factors found in Appendix B.

Equation 1: *Estimating GHG emissions from Routine Transportation Activity – Personal Passenger Vehicles*

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

Where:

$\mathbf{PPV}_{Emissions}$ = Emissions from use of personal passenger vehicle
$\mathbf{VKT}_{VehicleType}$ = Vehicle kilometres traveled (VKT) by vehicle type (activity)
$\mathbf{EmissionIntensity}_{VehicleType}$ = GHG emission intensity by vehicle type (GHG emission intensity of activity) as found in Appendix B.

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

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 Neighbourhood GHG Emissions Calculator uses vehicle-specific fuel consumption based upon information contained in the Fuel Consumption Rating Guide produced by Natural Resources Canada in order to produce vehicle specific GHG emission intensities.[1] This requires the user to select the year model and profile of the car they are driving.

Equation 2: *Estimating GHG emissions from Routine Transportation Activity – Public Transit*

$$\mathbf{PT}_{Emissions} = \mathbf{PKT} * \mathbf{EmissionIntensity}_{Bus}$$

Where

$\mathbf{PT}_{Emissions}$ = Emissions from use of public transit
PKT = Passenger kilometres traveled (PKT) on public transit (activity)
$\mathbf{EmissionIntensity}_{Bus}$ = GHG emission intensity per passenger kilometre traveled by bus (GHG emission intensity of activity) as found in Appendix B.

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

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.

Residential, Commercial and Institutional Building Module

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, or wood) 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 generated in Manitoba.[2] The building owner or user can then compare their energy use and GHG emissions with the average building/dwelling in their particular sector (in terms of commercial buildings) and buildings with same technical characteristics (i.e. vintage, size, etc). This information is based on building stock energy use statistics for Manitoba as made available from the Office of Energy Efficiency (OEE) at Natural Resources Canada.[3] Based on this same information, users can see approximately for what end-uses they use energy, and the resulting GHG emissions resulting from this energy use.

The data available from the OEE allows the energy use and GHG emissions attributed to the commercial building or residential dwelling 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 dwelling, type of dwelling (including detached houses, attached houses, apartments/condos, and mobile homes for residential buildings, or sector for commercial and institutional buildings), the types of heating systems used, the thermal properties of the different building types, and the technical characteristics of cooling systems, appliances, and lighting.

The Neighbourhood GHG Emissions Calculator includes the ability to account for electricity use and primary fuel consumption (e.g., natural gas, fuel oil, or diesel). This information is available on all utility bills and makes for a more precise quantification of the GHG emission than if activity data is used for estimating. This calculation is repeated for electricity and each fuel used in the building using the GHG emission factors for the various fuel types found in Appendix C.

[2] 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

[3] 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

Equation 3: *Estimating GHG emissions from buildings using utility use records:*

$$\mathbf{Build_{EUE}} = \sum_{\text{allfueltypes}} \left\{ \mathbf{EmFactor_{fueltype}} * \mathbf{EnergyConsumption_{fueltype}} \right\}$$

Where:

$\mathbf{Build_{EUE}}$ = Buildings energy use GHG emissions
$\mathbf{EmFactor_{fueltype}}$ = Emission factor for electricity and primary fuels (Appendix C)
$\mathbf{EnergyConsumption_{fueltype}}$ = Energy used in a year, by type of primary fuel or electricity in kWh or m^3

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. kg m^2/day of CO_2e) based on a few key aspects of the building. The building type options and associated GHG emission factors are found in Appendix C.

Equation 4: *Estimating GHG emissions from buildings using floor area:*

$$\mathbf{Build_{EUE}} = \mathbf{EmFactor_{buildingtype}} * \mathbf{HotelArea}$$

Where:

$\mathbf{Build_{EUE}}$ = Buildings energy use GHG emissions
$\mathbf{EmFactor_{buildingtype}}$ = Emission factor for building specifics (Appendix C)
HotelArea = Total floor area for the building in m^2 or square feet

The GHG emission intensity values provided (see Appendix C) 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.

Procurement and Waste Management Module

In order to use this module, the Neighbourhood GHG Emissions Calculator user will have to input data on the amount of material used and how waste is managed. The CLER Calculator includes the ability to account for the GHG emissions for waste material sent to the landfill, recycled or in the case of organics, composted.

The Neighbourhood GHG Emissions Calculator includes the GHG emission for waste sent to landfill by residents, commercial businesses and community based institutions. The only data requirement is the volume of waste generated and sent to landfill over a one year period. This amount is then applied to the GHG emission factor for the waste sent to landfill in Manitoba (as provided in Appendix D). Businesses and institutions can acquire the data on the total amount of waste generated over one year from the waste management records from their waste management service provider. Residents, businesses and institutions using municipal curbside waste collection will have to estimate the number of bags of waste they produce per year.

Equation 5: *Estimating GHG emissions from waste sent to landfill:*

$$\mathbf{SolidWaste_{Emissions} = Waste * EmInt_{Waste}}$$

Where

$SolidWaste_{Emissions}$ = total GHG emission from solid waste sent to landfill
Waste = total mass of solid waste generated and sent to landfill in tonnes
$EmInt_{Waste}$ = GHG emission intensity for landfill waste in Manitoba

The GHG emission impacts of sending waste to landfill are estimated by considering only the GHG emissions resulting from the anaerobic degradation of waste in the landfill. The Neighbourhood GHG Emissions Calculator does not account for the GHG emission from originally producing products or the GHG emission from producing replacement products for those send to landfill. This way, GHG emissions are not double counted across the life cycle of a product. Nonetheless, estimates of the GHG emission reductions achieved through recycling or composting organics do consider the full lifecycle of the source reduction and the GHG emission associated with recycling material that would otherwise be sent to the landfill. By doing so, the Neighbourhood GHG Emissions Calculator user can appreciate the “true” impact of recycling in terms of the avoided organics sent to the landfill, the energy required to recycle, and the avoided GHG emission due to the reduced need to produce virgin material.

Lawn and Garden Care Module

GHG Emissions from lawn and garden care include those resulting from operating lawn cutting equipment and also from applying synthetic fertilizer. The options for cutting a lawn in the Neighbourhood GHG Emissions Calculator include a walk behind power mower (gas or electric), riding lawn mower (garden tractor), and a human-powered 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 and model of equipment. However, a conservative range of fuel consumption rates have been approximated on size and type of equipment. This is provided in terms of the amount of fuel consumed per area of lawn, and is summarized in Appendix E. GHG emissions are then estimated by multiplying the fuel/electricity consumption by the appropriate GHG emission factor.

Equation 6: *Estimating GHG emissions from operating lawn cutting equipment:*

$$\textbf{LawnMowing}_{\textbf{Emissions}} = \textbf{EmissionIntensity}_{\text{MowerType}} * \textbf{LawnArea}$$

Where:

$\textbf{LawnMowing}_{\textbf{Emissions}}$ = Lawn mower operations GHG emissions
$\textbf{EmissionIntensity}_{\text{MowerType}}$ = Emission factor for lawn mower specifics (Appendix C)
LawnArea = Total area for the lawn care in acres

To determine GHG emissions from nitrogen fertilizer usage, a method is used similar to that used to estimate GHG emissions from nitrogen fertilizer use in the provincial and national GHG emission inventory. 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 lead to a loss of about 2% of nitrogen to the atmosphere.

Equation 7: *Estimating GHG emissions from lawn care using synthetic fertilizer:*

$$\textbf{Fertilizer}_{\textbf{Emissions}} = \textbf{NitrogenLoss}_{\textbf{Coefficient}} * \textbf{FertilizerUse}$$

Where:

$\textbf{Fertilizer}_{\textbf{Emissions}}$ = GHG emission estimates for nitrogen fertilizer
$\textbf{NitrogenLoss}_{\textbf{Coefficient}}$ = Coefficient of nitrogen loss to atmosphere at two per cent
FertilizerUse = Total volume of nitrogen content of fertilizer used per year

Using the Calculator

The Neighbourhood GHG Emissions Calculator can produce a meaningful estimate of the GHG emissions from residents, businesses and community based organizations and institutions in a community. This baseline GHG emissions inventory is a starting point for the development of local climate action plans and measuring the GHG emission reduction activities the community undertakes.

Appendix A. GHG Emission Factors by Greenhouse Gas

Stationary Combustion	Emission Factors (g/m^3)		
	CO_2	CH_4	N_2O
Natural Gas			
Manufacturing Industries	1,891	0.037	0.033
Residential, Construction, Commercial/Institutional, Agriculture	1,891	0.037	0.035
Propane			
Residential	1,510	0.027	0.108
All Other Uses	1,510	0.024	0.108
Light Fuel Oil			
Residential	2,725	0.026	0.006
Forestry, Construction, Public Administration, and Commercial/Institutional	2,725	0.026	0.031
Diesel	2,663	0.133	0.4

Mobile Sources	Emission Factors (g/litre)		
	CO_2	CH_4	N_2O
Light-Duty Gasoline Vehicles (LDGVs)			
Oxidation Catalyst	2,289	0.52	0.202
Non-Catalyst Controlled	2,289	0.46	0.0282
Light-Duty Gasoline Trucks (LDGTs)			
Oxidation Catalyst	2,289	0.43	0.202
Non-Catalyst Controlled	2,289	0.56	0.0282
Heavy-Duty Gasoline Vehicles (HDGVs)			
Three-Way Catalyst	2,289	0.68	0.204
Uncontrolled	2,289	0.49	0.0842
Motorcycles			
Non-Catalytic Controlled	2,289	1.42	0.0452
Uncontrolled	2,289	2.32	0.0482
Light-Duty Diesel Vehicles (LDDVs)			
Advance Control	2,663	0.051	0.222
Moderate Control	2,663	0.068	0.212
Uncontrolled	2,663	0.1	0.162
Heavy-Duty Diesel Vehicles (HDDVs)			
Advance Control	2,663	0.12	0.0822
Uncontrolled	2,663	0.15	0.0752
Natural Gas Vehicles	1,893	9×10-3	6×10-52
Propane Vehicles	1,510	0.64	0.0282
Off-Road Gasoline	2,289	2.7	0.0502
Off-Road Diesel	2,663	0.15	1.12
Diesel Train	2,663	0.15	1.12
Gasoline Boats	2,289	1.3	0.0662
Aviation Turbo Fuel	2,534	0.08	0.231
Ethanol	1,494	**	**

Source: 2006 National Inventory

Appendix B. GHG Emission Factors for Transportation

Table 2. GHG Emission Factors for Mobile Fuel Use

Primary Fuel	CO_2e (tonnes/litre)
Motor gasoline	0.00250
Diesel fuel oil	0.00279
Light fuel oil	0.00274
Heavy fuel oil	0.00314
	CO_2e (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

	Fuel consumption (L/100 km)			Emission Intensity CO_2e (tonnes/km)	
Type of Vehicle	**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_2e (tonnes/PKT)
Bus	0.00007137
Train	0.00019020

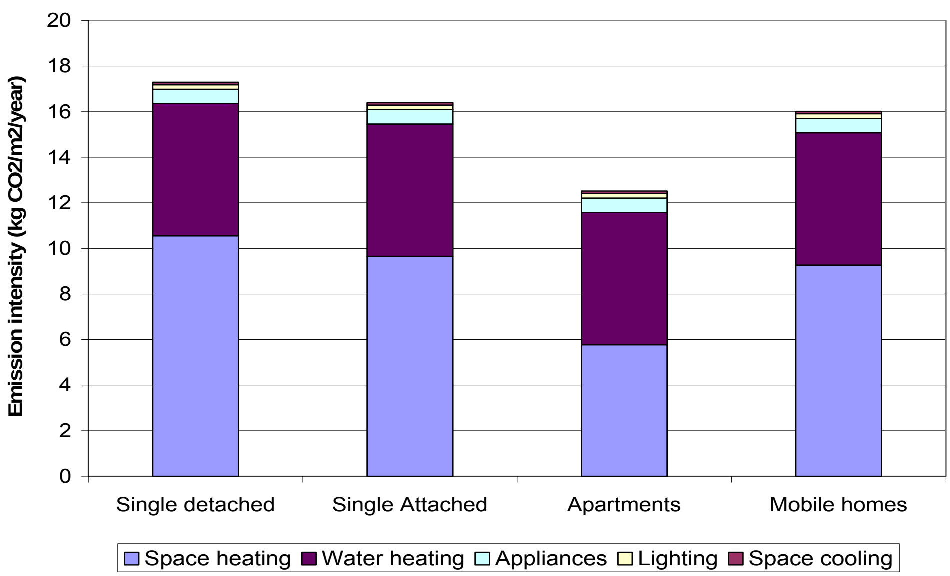
The OEE provide estimates of GHG emissions and passenger kilometre traveled by urban bus in Canada. Analysis of this data suggests a GHG emission intensity of 71.37 grams (0.07137 kg) of CO_2e per passenger kilometre traveled.

Appendix C. GHG Emission Factors for Building Energy Use

Energy and GHG emission characteristics of residential buildings

For illustrative purposes, these variations in GHG emissions are shown for the different energy-uses for the different types of residential dwellings in Manitoba. This is shown in terms of the emissions associated with each square metre of building floor space, over the course of a year for the average dwelling built between 2001 and 2005. Both emissions from primary energy sources and emissions associated with purchased electricity are included.

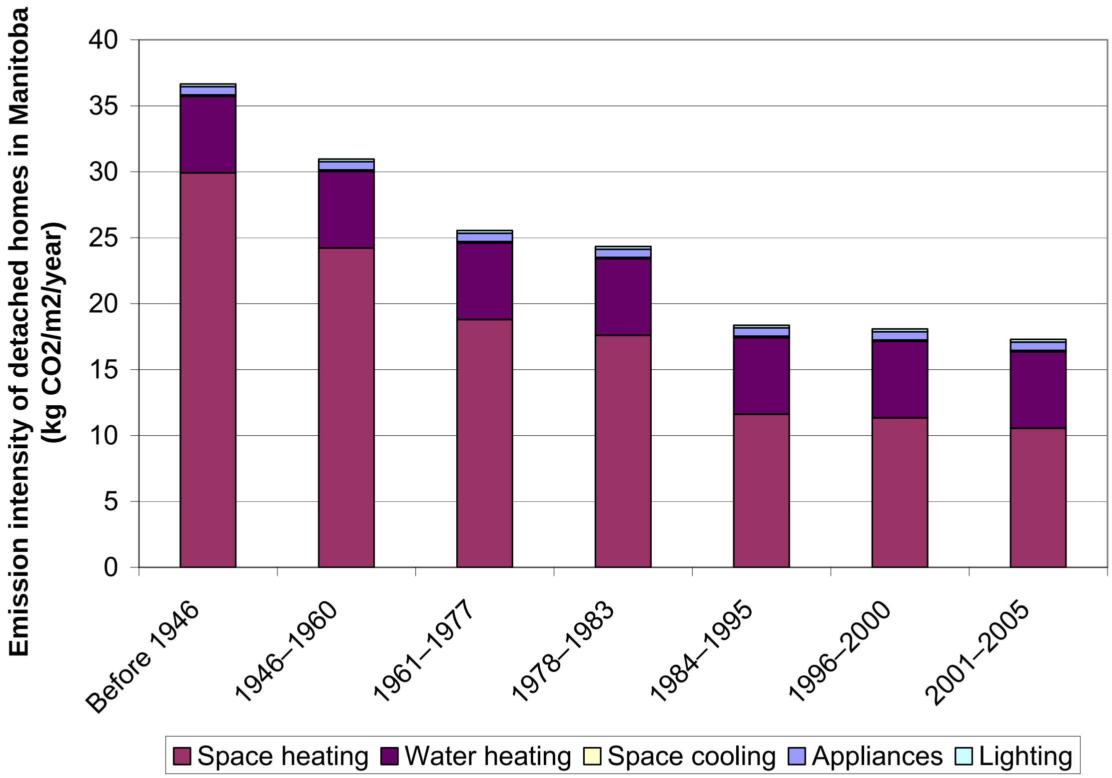
Figure 1. GHG Emissions by Use and Dwelling Type for 2001 to 2005 (kg CO_2e/m^2/year)



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 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.

Emission intensities also vary based upon the age of the structure. This is illustrated in terms of the average detached house in Manitoba (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 GHG Emission intensities for Manitoba Detached Houses by Vintage

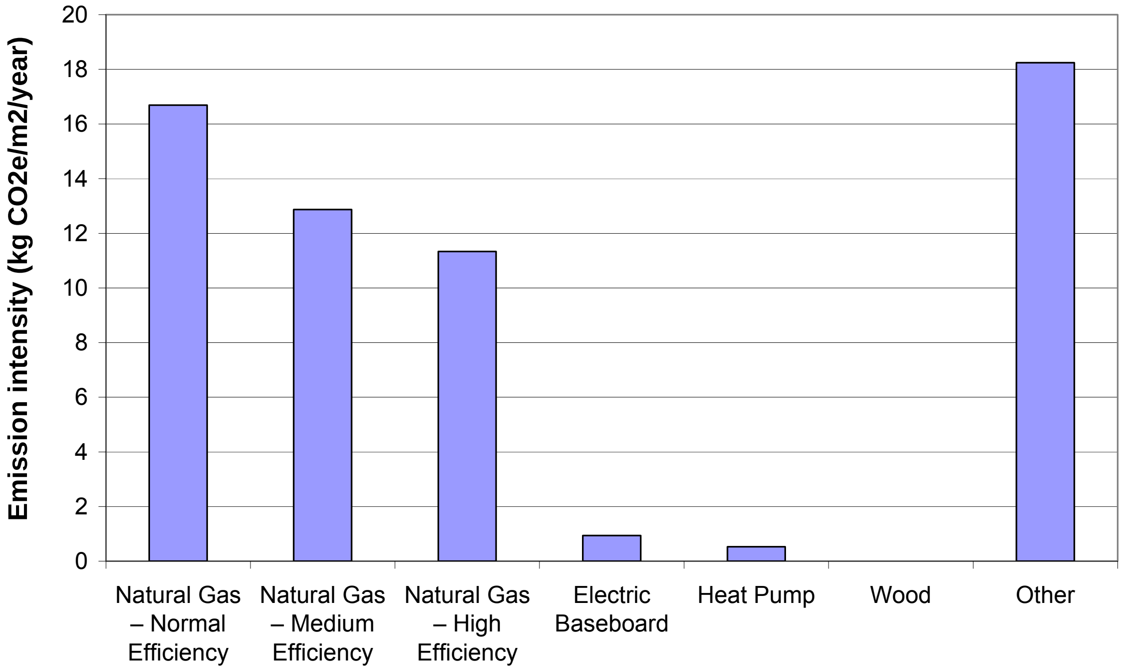


A number of points are emphasized in terms of the above figure. First, the figure helps illustrate that in terms of the emission attributable to space heating, on a percentage of total emissions, this increases from approximately 62% for homes built between 2001 and 2005, to approximately 81% for homes built before 1946. This increase reflects both the lower technical efficiency of the home heating systems in these older buildings, and the lower thermal efficiency of the building envelopes.

The second point emphasized again concerns the relative importance of space heating and water heating to total emissions. In particular, it is important to note that the larger contribution of these two end-uses not only reflects the energy requirements of these, but also the fact that for most appliances, space cooling, and all of lighting, electricity is the energy carrier. Since most electricity in Manitoba is generated from hydro-electric sources, these end-uses result in lower emissions when compared to activities such as home heating, and also if the residential dwelling was located in a province with more emission intensive electricity, such as Alberta or Ontario.

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 (see figure 3). We assume that variations in emission intensity on a unit basis are representative of variations in emission intensity on an area basis.

Figure 3. GHG Emission Intensities for Home Heating in Detached Manitoba Homes (kg $CO_2e/m^2/year$)[4]



As can be seen, emission intensities vary from approximately 18.25 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.[5]

Energy and GHG emission characteristics of 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.

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[4] The specific energy efficiencies of the different home heating systems are shown below:

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%

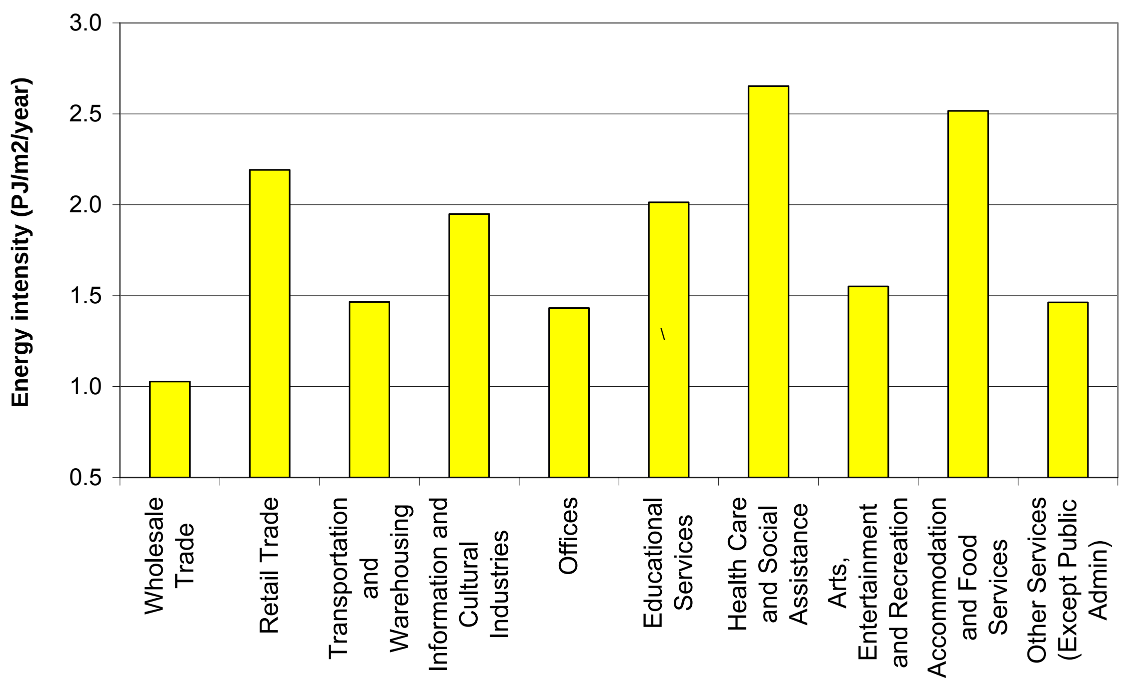
[5] The emission factor for the combustion of wood only includes CH4 and N20 released during biomass combustion, and does not include the CO2 attributable to the loss of wood from the forest. This is the same approach as used in the National Inventory of Greenhouse Gas Emissions, where these emissions 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.

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.

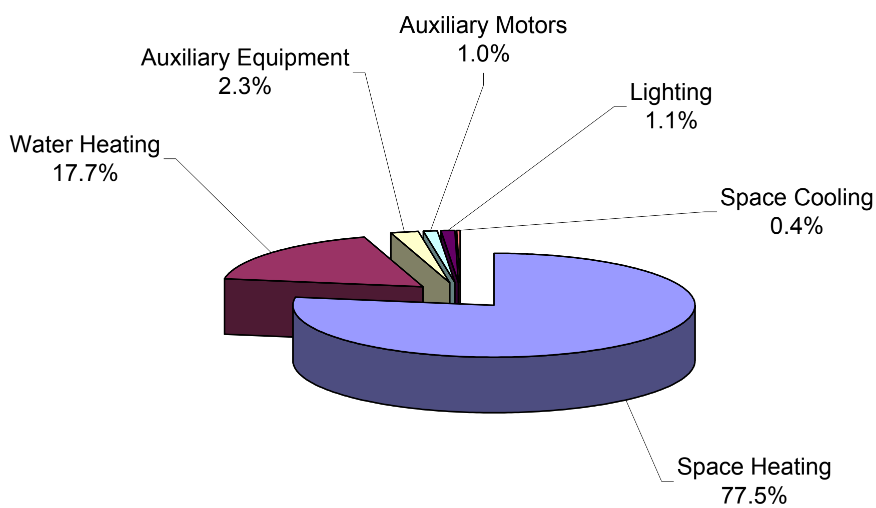
Figure 4. Energy intensities in the commercial and institutional sub sectors



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.

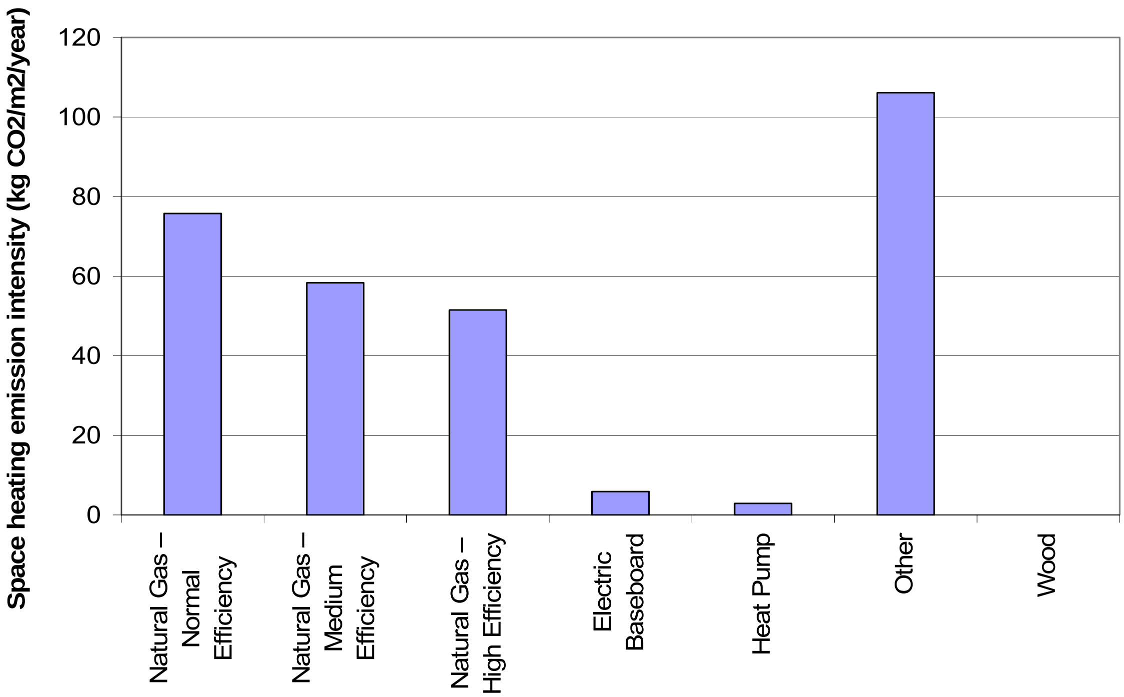
The emission intensities associated with these sectors largely reflects the range in energy intensities since the proportional mix of energy use by end use, and the types of fuels used are similar amongst the various sub sectors considered. Specifically, emission intensities range from about 34 kg CO_2e/m^2/year to about 88 kg CO_2e/m^2/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 Manitoba'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 Manitoba's economy.

Figure 6 Emission intensities for different home heating systems operated in health care and social service centres in Manitoba (kg CO_2e/m^2/year)[6]



As can be seen, emission intensities vary from approximately 106 kg CO_2e/m^2/year for heating systems fuelled by propane, heating oil, or coal (i.e. the 'Other' category), to less than 0.5 g CO_2e/m^2/year for homes fuelled only by wood.[7]

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.

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[6] 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%

[7] The emission factor for the combustion of wood only includes CH4 and N20 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 D. GHG Emission Factors for Landfill Waste

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_2e/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

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

Waste Disposed to landfill[a] (kilotonnes)				
Residential sources	Non-residential sources	All sources	GHG emissions[b] (kt CO_2e)	Emission intensity[c] CO_2e (tonnes/tonne of waste)
455	569	1,024	960	0.94

a. *From Statistics Canada's Waste Management Industry Survey, "Disposal of waste by source and province"*
b. *From Environment Canada, " National Inventory Report: 1990 to 2006"*
c. *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 are disposed in the respective provincial landfills*

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 E. GHG Emission Factors for Lawn Care

Lawn Cutting Equipment Use

Table 8. Fuel consumption rates of lawnmowers

Equipment type	Fuel consumption rate (litres/acre), except electric lawn mowers (kWh/acre)	GHG emissions in CO_2e (tonnes/acre)
Small walk-behind gas lawn mower	2.5 litres/acre	0.00625
Large walk-behind gas lawn mower	3.5 litres/acre	0.00875
New ride-on lawn tractor (2 years or newer)	4.5 litres/acre	0.01125
Old ride-on lawn tractor (older than 2 years)	6 litres/acre	0.01500
Electric lawn mower	19 kWh/acre	0.00019

Notes: The fuel consumption of a gas lawn mower was determined assuming that that lawn mower engines operate at an efficiency of 40%., whereas the electricity consumption of an electric lawn mower was determined assuming that these operate at 90% efficiency. Energy contents and conversion are available from http://www.neb.gc.ca/clf-nsi/rnrgynfmtn/sttstc/nrgycnvrsntbl/nrgycnvrsntbl-eng.html

NOTE: One Acre = 43,560 square feet, therefore:

$$\frac{\text{GHG emissions in } CO_2\text{e (tonnes/acre)}}{43{,}560} = \text{GHG emissions in } CO_2\text{e (tonnes/square foot)}$$

Nitrogen Fertilizer Application

Nitrogen (N), phosphorus (P), and potassium (K) are the three major nutrients needed by lawns with Nitrogen being the most crucial. 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 nitrogen would be released to the atmosphere per year. This would be equal to about 28 kg of carbon dioxide equivalent, considering that nitrogen has a global warming potential of 310 relative to CO_2.

Example: Application of 25 kg of 18-6-12 fertilizer

25 kg fertilizer x 18% nitrogen = 4.5 kg nitrogen.

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