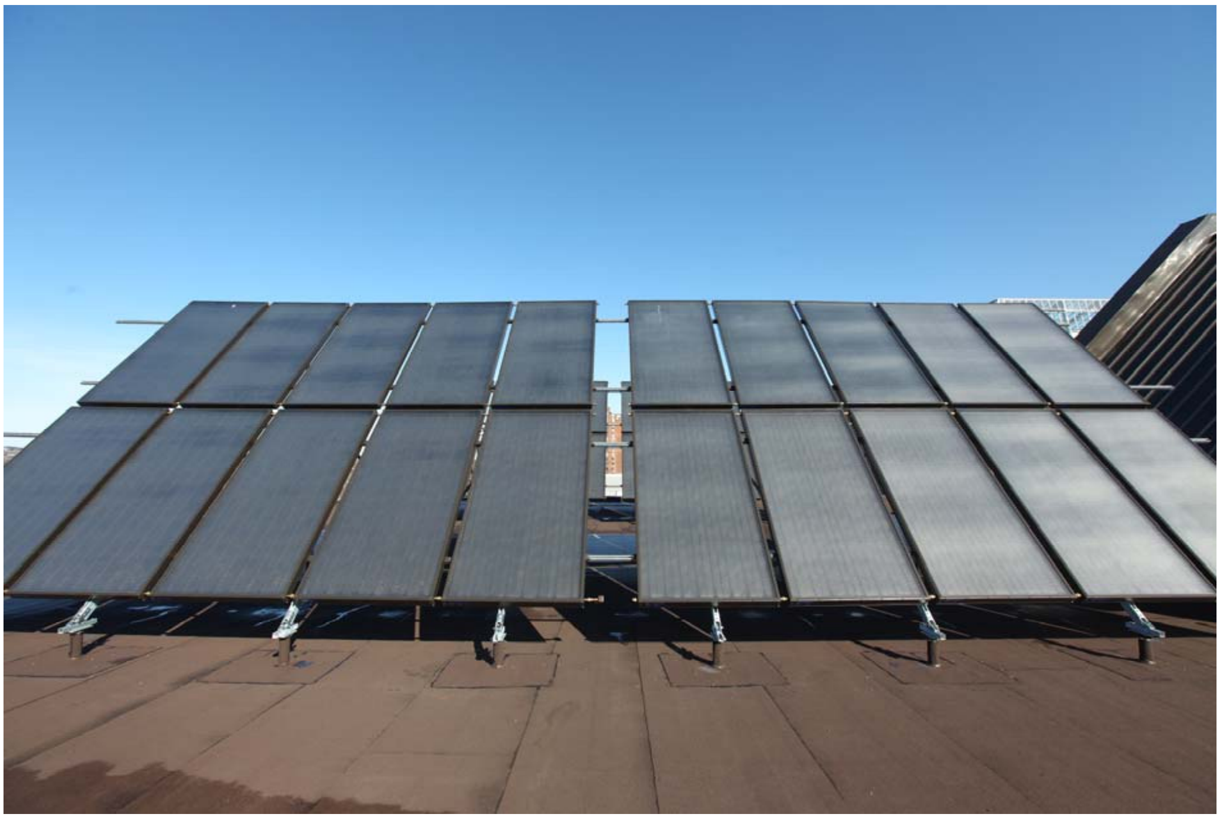
GREENHOUSE GAS (GHG) INVENTORY REPORT 2010-2011



Caption. LSC Solar thermal panels installed 2010-2011.

Dalhousie Office of Sustainability

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*Photos - Dalhousie Creative Services

EXECUTIVE SUMMARY

April 2008 – March 2009 is established as the base calculation year for the first Dalhousie University Greenhouse Gas Inventory report, while April 2009 – March 2010 is the base comparison year. This base calculation year was chosen as previous to 2008, data records are harder to collect and confirm. The CSA standard - "Greenhouse Gases - Part 1: Specification with Guidance at the Organization Level for Quantification and Reporting of Greenhouse Gas Emissions and Removals" (Adopted ISO 14064-1:2006, first edition, 2006-03-01) is used as a framework for this report. Calculations and emission factors are derived from The Climate Registry (TCR), Nova Scotia Power, and Environment Canada.

The results of the annual GHG analysis are published on the Office of Sustainability website. The Dalhousie University Climate Change Plan (2010) outlines climate change mitigation and adaptation strategies and targets for the next number of years. For the 2010-2011 fiscal year, a number of projects were undertaken in accordance to this plan such as natural gas conversion of the central heating plant and a number of smaller properties, CFL and LED exit sign replacement across campus, and lighting upgrades in university houses.

The Dalhousie GHG inventory identifies all direct (Scope 1) and indirect (Scope 2) emissions [Figure 1]. Where credible data exists, Dalhousie will also report on optional indirect emissions sources that arise as a function of its educational and business operations (Scope 3). This report provides a baseline of Scope 1 and 2 emissions plus commuting emissions (Scope 3). Travel emissions do not include business travel or intercampus travel due to the lack of credible data [Figure 2].

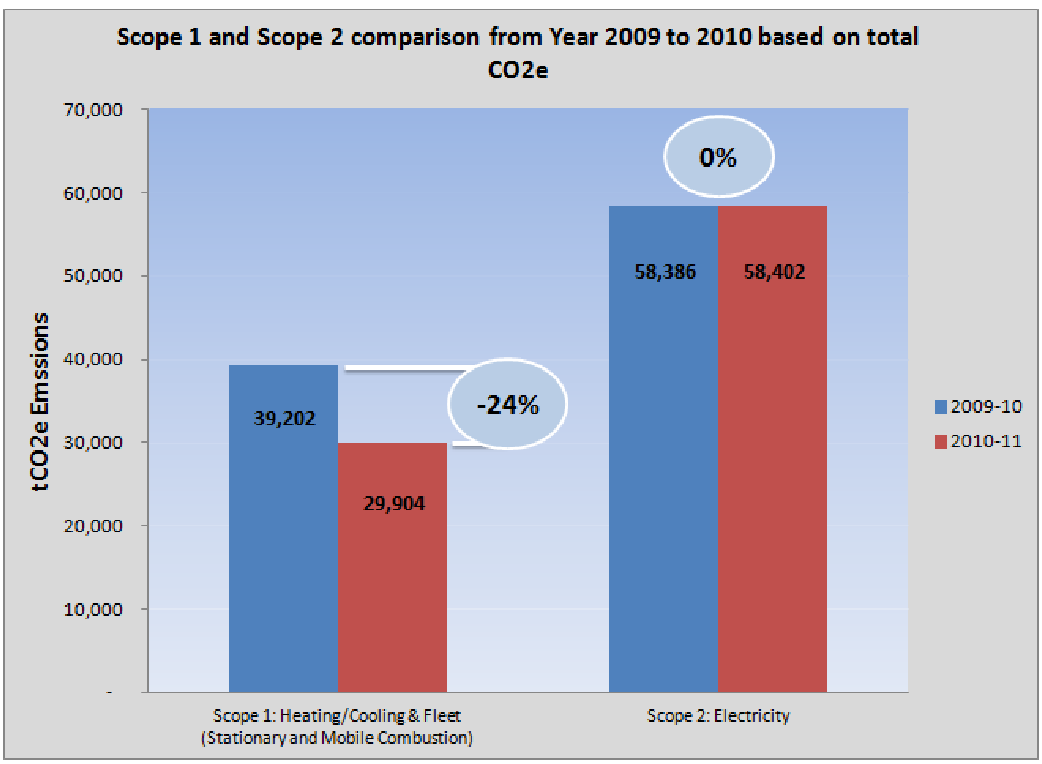


Figure 1 Comparison and percentage change of Scope 1 & 2 emissions

Total greenhouse gas emissions were reduced in 2010-2011 over the base comparison year for Scope 1 and remained consistent for Scope 2 emissions [Figure 1]. A variety of factors shape energy consumption trends and GHG emissions including the amount of building space owned, total population, energy efficiency retrofits, green building construction, behavioural and operational programs, weather, utility provider emissions profiles, and data reliability. The total building space owned by the University was increased by 97,303 square feet through the opening of the Mona Campbell building. Total population increased by 804 new full/part-time staff. Energy efficiency projects were implemented and measured. The total GHG tonnes per person by scope 1 & 2 decreased by 13% while the figure by square foot decreased by 12% from the base comparison year [Figure 3].

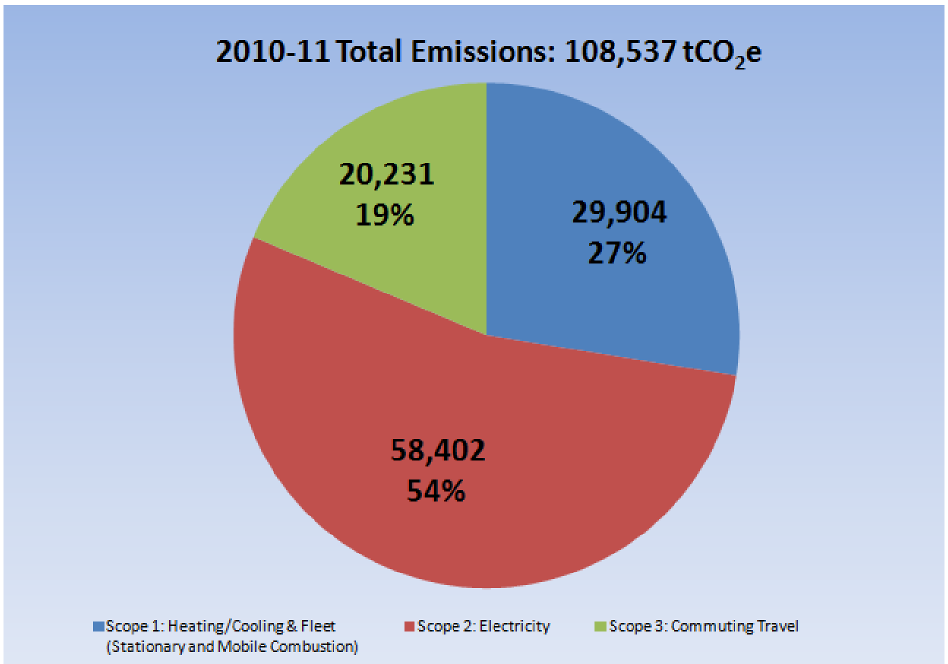
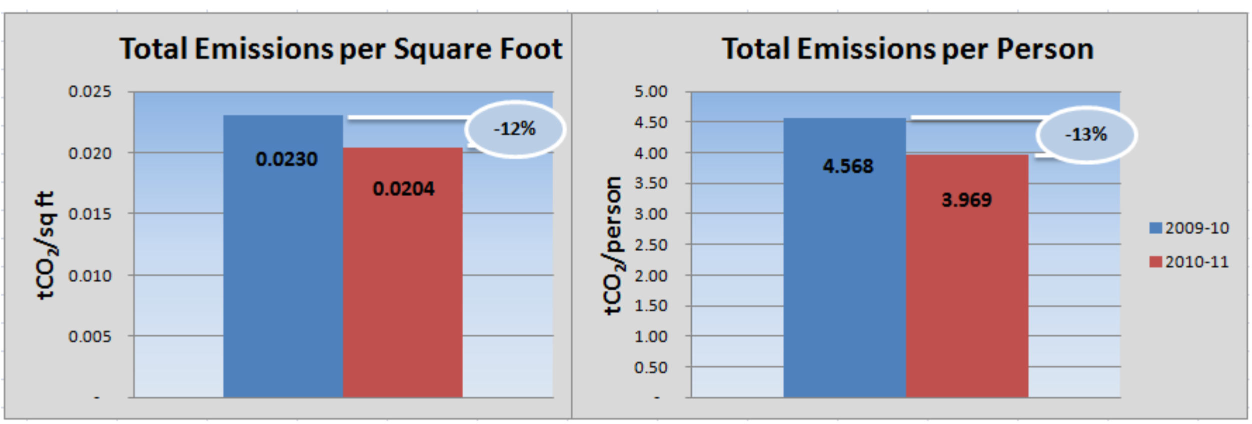


Figure 2 Total Emissions by Scope



(a) (b)

Figure 3 (a) Emissions per person (b) Emissions per Sq. Ft

INTRODUCTION

On December 11, 2009, Dalhousie's President Tom Traves signed the University and College's Climate Change Statement for Canada. A commitment to this statement requires that within one year of signing this document, a comprehensive inventory of greenhouse gas emissions is completed and within two years of signing this document, a climate plan with targets is released. In 2010, Dalhousie released the first University Climate Change Plan and GHG baseline inventory. The plan includes a clear vision, targets and strategies [Figure 4].

VISION: Dalhousie University is an institutional model for reducing of greenhouse gases, implementing adaptation strategies, and increasing knowledge of climate change issues of students and employees.	**TARGETS**: Dalhousie aims to reduce GHGs 15% by 2013; 20% by 2016 and 50% by 2020 below the 2008-2009 baseline year scope 1 and 2 emissions. A Long-term objective of carbon neutrality, as outlined in Figure 6, is highlighted for 2050.

Figure 4 Dalhousie's Vision, targets and strategies

The CSA standard - "Greenhouse Gases - Part 1: Specification with Guidance at the Organization Level for Quantification and Reporting of Greenhouse Gas Emissions and Removals" (Adopted ISO 14064-1:2006, first edition, 2006-03-01) was used as a framework for this report. Terms and Definitions are provided in Appendix A. Calculations are derived from The Climate Registry (TCR) - General Reporting Protocol - version 1.1, May 2008. Emissions factors are derived from TCR spreadsheet January 06, 2012, and the Nova Scotia Power website. Scope 1, 2, and some Scope 3 emissions are reported. The report has been reviewed by staff of the Office of Sustainability. The review does not constitute third-party verification.

1.1. BOUNDARIES

Organizational

Dalhousie University owns 100 buildings and houses (including additions) across three campuses (Studley, Carleton, and Sexton) (Appendix B) and a property at 2209 Gottigen Street and 1094 Wellington Street. All properties are in downtown Halifax, NS. The total building spaced owned equalled 4,331,547 square feet (Appendix C). During this time the University leased a small amount of space in hospitals and retail locations in the Halifax Regional Municipality (HRM).

A financial and operational control approach is taken to identify the boundaries for the GHG inventory, thus University owned and financially controlled facilities are considered. Leased space and facilities owned but not financially operated by Dalhousie (Peter Green Hall) are considered to be outside the scope of the GHG inventory. The University sells steam to University of Kings College buildings, National Research Council building near (Oxford St. and Coburg Rd.), and the Halifax Law Court on Spring Garden Rd. The GHGs associated with this steam is not included in the Dalhousie GHG totals as Dalhousie does not own these facilities. Fleet vehicles are included as part of the inventory calculations however rental or leased transportation used for recreational purposes are not. The GHG emissions from University owned facilities are consolidated into one Facility Group. All universities facilities are considered as one Facility group.

Operational

The operational boundaries identify the emissions sources to be captured in the inventory as defined by ISO 14064-1:2006. Sources are defined in categories called scopes.

The three main categories include:

- Scope 1 (direct emissions): are emissions from sources within the entity's organizational boundaries that the reporting entity owns or controls. These are further divided into: stationary combustion, mobile combustion, physical and chemical processes, and fugitive sources (TRC, 2008).

- Scope 2 (Indirect emissions): emissions that are a consequence of activities that take place within the organizational boundaries of the reporting entity, but that occur at sources owned or controlled by another entity e.g. emissions associated with consumption of purchased electricity (TRC, 2008).

- Scope 3 emissions (optional reporting): Other emissions whose recording are optional e.g. upstream emissions from the transportation of purchased materials or goods, or employees and students commuting to and from work (TRC, 2008).

The Dalhousie GHG inventory identifies all direct (Scope 1) and indirect (Scope 2) emissions. Where credible data exists, Dalhousie will also report on optional indirect emissions sources that arise as a function of its educational and business operations (Scope 3).

1.2. GHG EMISSION SOURCES

Emissions included in the GHG inventory report include:

1. **Scope 1: Direct GHG emissions and removals**
   a. Stationery combustion
      - Emissions incurred through combustion of Bunker C oil in central plant for steam, hot water, and cooling production.
      - Natural gas for central plant for steam, hot water, and cooling production and some furnaces for houses.
      - Emissions incurred through combustion of propane for food services and lab use.
      - On-site heating oil combustion in smaller houses.
      - On campus diesel combustion for backup generators.
      - Fugitive refrigerant losses from cooling units on campus.

   b. Mobile combustion
      - Combustion of vehicle fleet gasoline and diesel.

2. **Scope 2: Energy indirect GHG emissions**
   - Indirect emissions from the generation of imported electricity incurred by Nova Scotia Power during the production of electricity used on campus.

3. **Scope 3: Other indirect GHG emissions**
   - Inclusion of other sources of emissions based on internal reporting needs or intended use of the inventory. This will include students and employees commuting to and from campus.

Information on emissions reporting in Section Three will be categorized as **Building Emissions** (Scope 1 and 2); and **Transportation Emissions** [Scope 1 (fleet) and Scope 3 (commuting travel)].

1.3. REPORTED GHG EMISSIONS

GHG emissions from the following greenhouse gases will be reported on. Definition information is provided by Environment Canada.

- **Carbon dioxide (CO_2):** Carbon dioxide, also called carbonic acid gas, is a naturally occurring colourless, odorless, incombustible gas formed during respiration, combustion, decomposition of organic substances, and the reaction of acids with carbonates. Carbon dioxide acts as a greenhouse gas and anthropogenic sources of CO_2 emissions include combustion of fossil fuels and biomass to produce energy, building heating and cooling, land-use changes including deforestation, manufacture of cement, and other industrial processes.
- **Methane (CH_4):** Methane is a colorless, odorless, flammable gas that is the simplest hydrocarbon and is the major constituent of natural gas. Methane is also released from industrial processes, fossil fuel extraction, coal mines, incomplete fossil fuel combustion, and garbage decomposition in landfills.
- **Nitrous oxide (N_2O):** Nitrous oxide is a colourless, nonflammable, sweet-smelling gas. Anthropogenic sources of nitrous oxide emissions include the industrial production of nylon and

nitric acid, combustion of fossil fuels and biomass, soil cultivation practices, and the use of commercial and organic fertilizers

- **Hydrofluorocarbons (HFCs):** Hydrofluorocarbons (HFCs) are a class of synthetic chemical compounds that contain only fluorine, carbon and hydrogen. They are commonly used as replacements for ozone-depleting substances, such as chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) and halons in various applications including refrigeration, fire-extinguishing, semi-conductor manufacturing, and foam blowing. HFCs do not deplete the ozone layer; however they are powerful greenhouse gases.

1.4. GHG EMISSION CALCULATIONS

GHG emissions are calculated using formulas provided from The Climate Registry (TCR) - General Reporting Protocol - v.1.1, 2008. Calculations and data used are shown in detail in following sections of the report. This provides an open and transparent record of how emissions totals are created. The Nova Scotia Power (NSP) provincial emission factor for electricity is used rather than Environment Canada's factor. The NSP provincial emission factor for 2010 is reported as 828.39 g CO_2e/kWh. Other emission factors are derived from TCR's Jan. 2012 emission factor spreadsheet.

Caption. Natural gas conversion (Fall 2010)

2. GHG EMISSIONS INVENTORY

2.1. BUILDING EMISSIONS

Overview

Scope 1:

Fuels: Dalhousie University has a central plant (1236 Henry Street) that provides heating to most campus buildings through a steam line and cooling through a chilled water loop to key buildings on the Studley campus. At the central plant cooling is generated through an electric and absorption (steam) chiller. The central plant boilers were fuelled by Bunker C until October 2012 when the plant was converted to natural gas. Cooling is also provided to newer buildings through individual cooling towers. Some buildings do not have air conditioning. Some of the 36 houses have individual oil fired furnaces though a few houses on Seymour and Henry Street are connected to the steam line and others were converted to natural gas if distribution was available.

A limited amount of propane is used on campus primarily for lab and cooking purposes. Diesel back-up generators are located in some major lab and residence buildings and the central heating plant.

Refrigerants: Primary refrigerant use is in air conditioning systems on campus.

Scope 2:

Electricity is provided to the University by Nova Scotia Power. A large main feed comes to the Weldon Law Building and is distributed to many of the large buildings on Studley and Carelton campus. Other building and houses have individual accounts and are fed from the street. Electricity is used for lights, HVAC, lab, and commercial kitchen equipment, and for cooling (electric chiller) and heating in some limited locations.

Data:

Consumption data used in calculations is provided by Facilities Management in the format of an Excel spreadsheet. Data from the spreadsheet is extrapolated from Facilities Management – management software FAMIS for the fiscal year April 2010-March 2011. In addition, correspondence with Facilities staff verified operational practices. The Office of Sustainability has number of supporting spreadsheets for the fiscal year (April 2010-March 2011) by fuel type and for electricity.

Calculations

Scope 1: Direct Emissions from Stationary Combustion - [Central Heating Plant (Bunker C and Natural Gas), House Heating (Furnace Oil and natural gas), Back-up Generators (Diesel), Cooking and Lab Equipment (propane)].

The available data quality for CO_2, CH_4 and N_2O emissions from stationary combustion is assessed according to the CR:GRP Data Quality Tiers as shown in (Appendix D). The current qualifications are based on data availability during preparation of this report. Direct monitoring is not currently in place, which would require sensors placed at exit points and continuous recording of data. Direct carbon and heat values are not delivered by the supplier, and have not been tested in a controlled laboratory environment. Therefore direct CO_2 emissions data from stationary combustion currently falls under Tier C, where default emission factors are used based on fuel type. Values for CH_4 and N_2O emissions are not currently measured either, but the technology type is known to be a residual fuel oil boiler.

Direct emissions were calculated using the following steps:

1. Determine annual consumption of each fuel combusted at facility group.

2. Determine appropriate CO_2 emission factor for each fuel type.

Emissions factors are based on the established default emissions factors in grams CO_2 / L of fuel oil combusted, as found in the Environment Canada National Inventory Report (1990-2005) (Appendix E lists the various emissions factors established by the CR:GRP, with those for petroleum products of relevancy to direct emissions on campus).

3. Determine the appropriate CH_4 and N_2O emission factor for each fuel.

In this case the data for CH_4 and N_2O emissions are able to be used at a Tier B level (Appendix F), as the fuel type and basic technology are known. The two types used on campus are residual fuel and gas/diesel oil boilers, both with liquid fuel.

4. Calculate each fuel's CO_2 emissions and convert to metric tonnes (Source - CR:GHG):

Fuel A CO_2 Emissions (metric tons) =
Fuel Consumed (gallons) × Emission Factor (kg CO_2/gallon) ÷ 1,000 (kg/metric ton)

Fuel B CO_2 Emissions (metric tons) =
Fuel Consumed (gallons) × Emission Factor (kg CO_2/gallon) ÷ 1,000 (kg/metric ton)

Total CO_2 Emissions (metric tons) =
CO_2 from Fuel A (metric tons) + CO_2 from Fuel B (metric tons) + ... (metric tons)

Canadian Emission Factor Equivalent:

Fuel A CO_2 Emissions (metric tonnes) =
Fuel consumed (litres) x Emission Factor (kg CO_2 / litre) / 1000 (kg / metric tonne)

5. Calculate each fuel's CH_4 and N_2O emissions (Source – CR:GHG)

Fuel/Technology Type A
N_2O Emissions (metric tons) = Fuel Use (MMBtu) × Emission Factor (g N_2O/MMBtu) ÷ 1,000,000 (g/metric ton)

6. Convert CH_4 and N_2O emissions to units of CO_2 equivalence and determine total emissions from stationary combustion (Source – CR:GRP):

$$\text{CO}_2\ \textbf{Emissions}\ (\text{metric tons } CO_2e) = CO_2\ \text{Emissions (metric tons)} \times 1\ \text{(GWP)}$$

$$\text{CH}_4\ \textbf{Emissions}\ (\text{metric tons } CO_2e) = CH_4\ \text{Emissions (metric tons)} \times 21\ \text{(GWP)}$$

$$\text{N}_2\text{O}\ \textbf{Emissions}\ (\text{metric tons } CO_2e) = N_2O\ \text{Emissions (metric tons)} \times 310\ \text{(GWP)}$$

$$\textbf{Total Emissions}\ (\text{metric tons } CO_2e) = CO_2 + CH_4 + N_2O\ (\text{metric tons } CO_2e)$$

Table 1 - Scope 1: Summary of Direct Emissions from Stationary Combustion tCO2e (2010-2011)

Energy Source	Consumption	Units	Emission Factor ($t\ CO_2e$ / unit)	GHG Emissions CO2 (t CO2e)	GHG Emissions CH4 ($t\ CO_2e$)	GHG Emissions N2O ($t\ CO_2e$)	TOTAL GHG Emissions ($t\ CO_2e$)
Furnace Oil	200,330	Litres	0.00275225	551	0.76	1.93	**554**
Bunker C Oil	5,723,263	Litres	0.00315524	18,058	14	114	**18,186**
Diesel	44,967	Litres	0.00268963	121	0.13	5.58	**127**
Propane	53,547	Litres	0.00157755	81	0.03	1.79	**83**
Natural Gas	267,942	GJ	0.049861496	13,309	5	76	**13,391**
Sub Total				**32,120**	**20**	**199**	**32,341**
Dalhousie provides steam to University of Kings College (235,651 sq/f) NRC (30,000), Halifax Law Courts (100,000+) = approx. 365,651 sq/feet or 9% of total steam based on square footage. More accurate meter measurement will be used in future reporting.				**[-1,625 BunkerC] + [-1,198 Natural Gas]** **-2,823**	**[-1.26 BunkerC] + [-0.45 Natural Gas]** **-1.71**	**[-10 BunkerC] + [-7 Natural Gas]** **-17**	**[-1,637 BunkerC] + [-1,205 Natural Gas]** **-2,842**
Total Dalhousie GHG emissions				**29,297**	**18**	**182**	**29,499**

Table 2 - Scope 1: Summary of Direct Emissions from Stationary Combustion tCO_2e (2009-2010)

Energy Source	Consumption		Emissions (tCO_2e)
	UNIT	2009-10	2009-10
Furnace Oil	Litres	502,529	1,383
Bunker C	Litres	12,888,567	40,955
Diesel	Litres	8,756	25
Propane	Litres	49,668	77

Natural Gas	GJ	-	-
Emissions from steam provided to U. King College, NRC & Law Court			-3,686
DAL TOTAL EMISSIONS			38,754

Scope 1: Direct Emissions and Removals [Refrigerants]

Refrigerants and air conditioning units are a major source of hydrofluorocarbons (HFCs) which have a much higher global warming potential than carbon dioxide (Appendix G). Fugitive emissions from refrigeration and air conditioning units are therefore an important consideration in calculating an institution's greenhouse gas emissions.

The type and amounts of refrigerant added during the fiscal year were supplied by Hussmann (contractor to Dalhousie) in an Excel spreadsheet. The emission factors from The National Inventory Report are used to determine the equivalent CO_2e values associated with these releases (Table 3/4).

Emissions from refrigerants at the University are less than 5% of the total emissions therefore a screening method approach is used:

1. Determine the types and quantities of refrigerants used
2. Estimate annual emissions of each type of HFC and PFC
3. Convert to units of CO_2e and determine total HFC and PFC emissions

Table 3 - Scope 1: Summary of Refrigerant GHG Emissions (2010-2011)

Refrigerant Name and GWP	Consumption (Loss)	Units	Emission Factor (t CO_2e / unit)	TOTAL GHG Emissions (t CO_2e)
R134A	10.91	Kg	1430	**16**
R12	0	Kg	10900	**0**
R22	130.45	Kg	1810	**236**
R401A	15.91	Kg	18	**0**
R401B	11.36	Kg	15	**0**
R402A	2.27	Kg	1680	**4**
R404A	4.55	Kg	3260	**15**
R407C	4.09	Kg	1526	**6**
R409A	0.45	Kg	0	**0**
R410A	16.36	Kg	1725	**28**
Total				**305**

Table 4 - Scope 1: Summary of Refrigerant GHG Emissions (2009-2010)

Emissions Source	Emissions (t CO2e)
	2009-10
Refrigerant loss	**332**

Scope 2: Indirect Emissions from Electricity

Emission factors are available directly from Nova Scotia Power Inc., thus data quality satisfies TCR-GRP Tier A indirect emissions from electricity (Appendix H).
The steps to estimate the emissions generated from purchased electricity are as follows:

1. Determine annual electricity consumption
2. Select appropriate emissions factors
3. Determine total emissions and convert to metric tonnes CO_2e

> **Total emissions =**
> Electricity Consumption (kWh) x Emission Intensity (metric tonne CO_2e/kWh)

Tier A: Generator specific emissions factors are used as per Nova Scotia Power Inc. emission intensity table as shown in (Appendix I).

These recently published coefficients for emission intensity values from NSPI allow for accurate calculations of the emissions associated with purchased electricity. Emission factors from the NSPI total system were used.

GHG emissions associated with purchased electricity at Dalhousie are described in Table 5/6.

Table 5 - Scope 2: Summary of Electricity GHG Emissions (2010-2011)

Energy Source	Consumption	Units	Emission Factor (t CO_2e / unit)	GHG Emissions CO2 (t CO2e)	TOTAL GHG Emissions (t CO_2e)
Electricity	70,500,933	kWh	0.00082839	58,402	**58,402**

Table 6 - Scope 2: Summary of Electricity GHG Emissions (2009-2010)

Energy Source	Consumption		Emissions (t CO2e)
	UNIT	2009-10	2009-10
Purchased Electricity	**kWh**	**69,513,597**	**58,386**

Note: Total tCO2e includes CH4 and N2O as Emissions factor used by NS Power has already factored their associated emissions

2.2. TRANSPORTATION EMISSIONS

Scope 1: Dalhousie's fleet included twenty-five trucks and three passenger cars.
Scope 3: Commuting travel emissions from employees and students are included.

Data:
A list of fleet vehicles and owners was provided by the University Risk Manager who oversees the insurance of all University owned vehicles. Tracking fuel purchases for every vehicle does not result in a complete data set; however, km data was obtained for all vehicles through an online survey to vehicle managers**.** Commuting and business travel km data was obtained through an online transportation

survey. Commuting surveys are conducted annually. January 2009 (2008 report), November 2010 (2009-2010 and 2010-2011), November 2011 (2011-2012).

Calculations

Scope 1: Fleet Vehicles

Vehicle emissions are generated and released as by-products of the fuel combustion process required to power vehicles. Common fuels include gasoline, diesel fuel, and biodiesel. The majority of fleet vehicles use is in a city setting (on campus or inter-campus). Therefore, fuel consumption will be at its highest as opposed to highway mileage. The data quality tiers for mobile combustion as per the CR:GRP are shown in (Appendix J). Factors from 2012-Climate-Registry-Default-Emissions-Factors – released on Jan-06, 2012 were used.

Through departmental records, CO_2 emissions can be determined by mileage travelled, which qualifies for Tier C. Emissions calculations for CH_4 and N_20 qualify for Tier B, as the model year and mileage travelled by each vehicle are known. The data for CO_2 will likely only have a future possibility of Tier B, unless the fuel being used in each fleet vehicle comes from a known and controlled source that can be tested. Data for CH_4 and N_2O could possibly reach Tier A, requiring an inspection of each vehicle to determine what type of vehicle technology is being used in the engine. Table 7/8 summarize the emissions from Dalhousie fleet vehicles.

Following the CR:GRP processes, direct emissions from mobile combustion are calculated using the following steps:

<u>1. Calculate CO_2 emissions from mobile combustion.</u>

a) Identify total annual fuel consumption by fuel type

Tier C Method: Estimation based on miles travelled and fuel economy (Source – CR:GRP)

Fuel Use (gallons) =

$$\underset{\text{(miles)}}{\text{Distance}} \div \left[\left(\underset{\text{(mpg)}}{\text{City FE}} \times \text{City \%}\right) + \left(\underset{\text{(mpg)}}{\text{Highway FE}} \times \text{Hwy \%}\right)\right]$$

FE = Fuel Economy

<u>Canadian Conversion</u> (neglecting highway fuel efficiency, fleet vehicles almost entirely in-city travel):

Fuel Use (litres) = Distance (km) / City FE (L/km)

Fuel economies were estimated using the online tool fueleconomy.gov as recommended by the CR:GR. Appendix K lists the vehicles used on campus during the 2010-2011 fiscal year, associated fuel consumptions, and the litres of fuel calculated based on the formulas above.

<u>2. Select appropriate CO_2 emission factor for each fuel type.</u>

Relevant Canadian Factors:

Gasoline – 2396 g CO_2/litre
Diesel – 2772 g CO_2/litre

Canadian Conversion:

Fuel A CO_2 Emissions (metric tonnes) = Fuel consumed (litres) x Emission Factor (kg CO_2 / litre) / 1000 (kg / metric tonne)

3. Calculate total CO_2 emissions and convert to metric tonnes (Source – CR:GRP):

Fuel A CO_2 Emissions (metric tons) =
Fuel Consumed (gallons) × Emission Factor (kg CO_2/gallon) ÷ 1,000 (kg/metric ton)

Canadian Conversion:

Fuel A CO_2 Emissions (metric tonnes) =
Fuel consumed (litres) x Emission Factor (kg CO_2 / litre) / 1000 (kg / metric tonne)

4. Calculate CH_4 and N_20 emissions from mobile combustion.

Appendix L shows the Co_2, CH_4 and N_2O emissions of Dal's Fleet Vehicles calculated by using the CR: GRP Default CH4 and N2O Emission Factors for Gasoline and Diesel Highway Vehicles by Model Year.

5. Convert CH_4 and N_2O emissions to units of CO_2 equivalence and determine total emissions.

Table 7 - Fleet Vehicle Emissions (2010-2011)

Energy Source	Consumption	Units	Emission Factor (t CO_2e / unit)	GHG Emissions CO2 (t CO2e)	GHG Emissions CH4 (t CO_2e)	GHG Emissions N2O (t CO_2e)	TOTAL GHG Emissions (t CO_2e)
Regular Gasoline	35,252	Litres	0.000002312	81	0.056	1	**82**
Diesel Fuel	4,664	Litres	0.000002690	13	0.0203	4.490	**17**
Total				**94**	**0.26**	**5.38**	**100**

Table 8 - Fleet Vehicle Emissions (2009-2010)

Emissions Source	Emissions (t CO2e)
	2009-10
Fleet Vehicle	**117**

Scope 3: Emissions from Commuter Travel

Transportation statistics were gathered through the Commuting Survey 2010 (Figure 5). In the summer of 2010, students and faculty at the School of Planning cleaned the data for enhanced reliability. Final commuting percentages by mode are referenced in DalTrac report 2010 - *Travel Behaviour Study of Commuters: Results from the 2010 Dalhousie University Sustainability Survey*. In addition postal code data of all employees and students were analyzed for comparison to survey data. Creating a calculation for commuter travel is less precise than Scope 1 and Scope 2 emission calculations because averaged figures for fuel economy, commuting days, and extrapolation of survey data to the full campus populations are used. This is also complicated by calculations for days travelled by part-time vs. full - time employees and students. An estimated value for emissions for commuter travel was deemed important to gauge for future transportation demand management planning. In future years, annual commuter data will captured each November for inclusion in the annual GHG report.

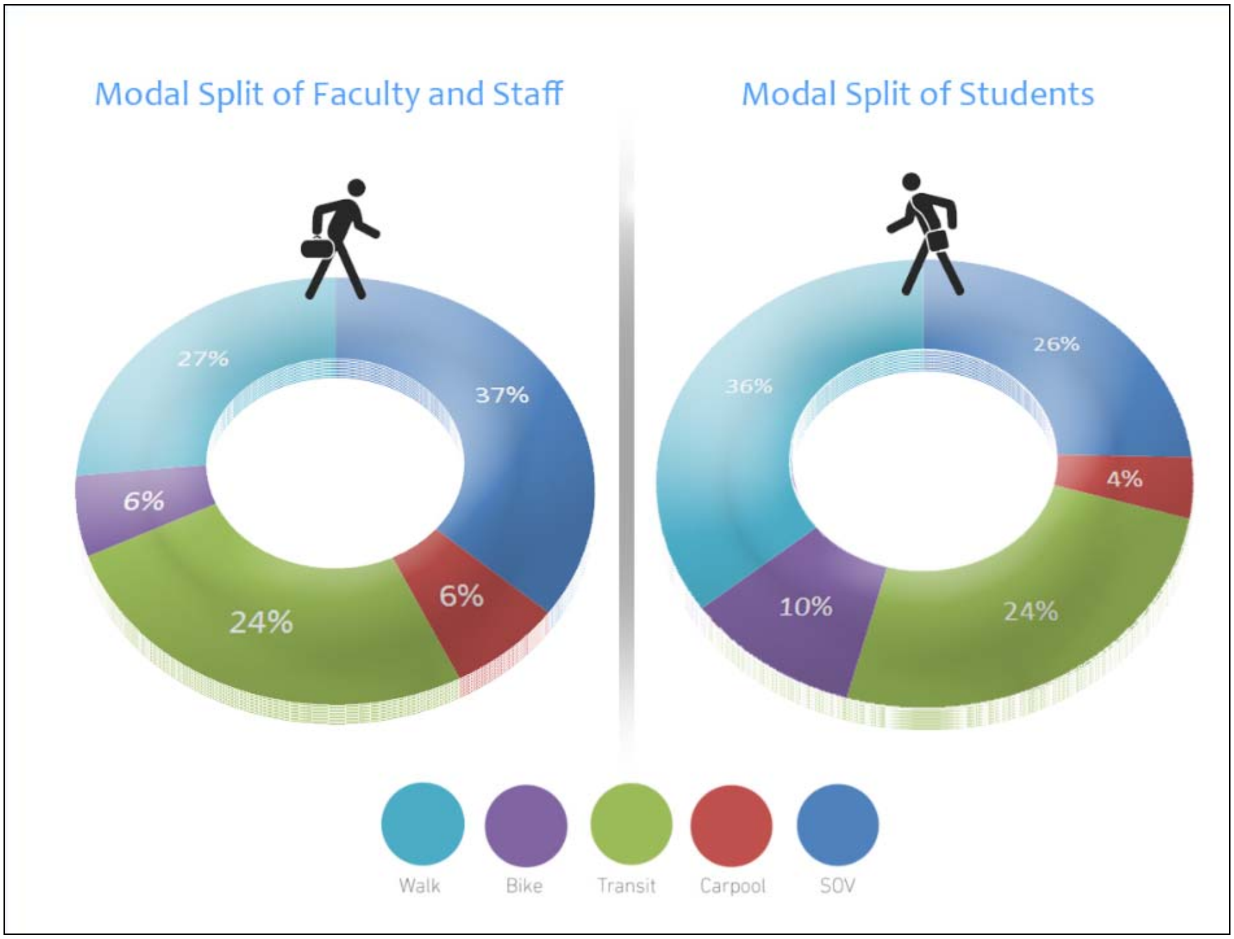


Figure 5. Blended - Modal Split employees and students 2010

The focus of the commuter transportation calculation is to and from campus for work and class purposes. This does not include intercampus or business travel. When more reliable data is available these calculations will be created.

Calculations:

TCR 2010 gasoline emission factors were used for drive alone, carpool, and transit calculations. In Halifax Regional Municipality (HRM), transit buses use a mix of 20% biodiesel/80% diesel blend, thus making the emission factor similar to a gasoline factor. Transport Canada, May 2008, emission factors do not include a 20/80 biodiesel blend and thus a gasoline factor was used. The following steps were used to calculate commuting travel emissions (Tables 9/10):

1. Identify number of employees and students who travelled by mode.

a) Use survey data to identify percentage by mode (drive alone, car pool, transit) (DalTrac, 2011). This is calculated by using primary mode% x.75 + secondary mode% x .25. Survey should have statistically significant numbers to be extrapolated to the full campus. 436 employees responded to the 2010 survey and 315 students.
b) Extrapolate modal percentage to full campus population by students (16,693 of which 2,094 are part-time) and employees (7,046 of which 889 are part-time). Campus population numbers were provided by Human Resources for employees and The Registrar's Office for students for the same term period in spring 2010.
c) Identify the number of part-time students versus full time students and employees. Divide part-time students and employee numbers by 2 to reflect fewer days travelled to campus. Multiple mode % by full-time employee/student + mode % by part-time employee/2.

2. Determine km travelled by mode.

a) Identify the average number of km travelled daily by mode based on survey. Determined average is 40 km daily for drive alone, 20 km for carpool and transit. To demonstrate how much GHGS are reduced use 8 km for cycling and 5 km walking.
b) Determine the number of days in the year travelled. Appendix M identifies average number of days travelled by employees, 90% of student that are at Dalhousie for three terms, and 10% of students that are at Dalhousie for four terms.
c) Multiply average km travelled by mode x number of days travelled per year x number of people to determine kms.

3. Convert km to litres

a) Multiply km x fuel economy rating per mode. NRCan fuel consumption ratings were used to identify an average fuel economy rating for all modes of 12 litres per 100 km.

4. Multiply emission factors for Co_2, CH4 and N_2O for gasoline as outlined under Fleet vehicles x litres for drive alone, x litres/3 for carpool, and x litres/40 for an average bus (Transport Canada – May 2008, User Guide for Urban Transportation Emissions).

Table 9 - Summary of Commuting GHG Emissions (2010-2011)

Commuter	Annual Distance	Units	TOTAL GHG Emissions (t CO_2e)
Faculty/Staff - Drive alone	31,178,046	Km	8,865
Students - Drive Alone	35,452,318	Km	10,081
Faculty/Staff - Car Pool	5,484,183	Km	520
Students - Car Pool	6,029,092	Km	571
Faculty/Staff - Transit	10,277,545	Km	73
Students - Transit	16,925,420	Km	120
Total			20,231

Table 10 - Summary of Commuting GHG Emissions (2009-2010)

Emissions Source	Emissions (t CO2e)
	2009-10
Commuting Travel	19,542

Table 11 - Summary of GHGs avoided by active transport (2010-2011)

Commuter	Fuel saved	Units	TOTAL GHG Emissions (t CO_2e)
Faculty/Staff - Cycling	74,793	Litres	179
Students - Cycling	204,319	Litres	486
Faculty/Staff - Walking	202,923	Litres	481
Students - Walking	455,385	Litres	1,079
Total Emissions AVOIDED			2,226

Table 12 - Summary of GHGs avoided by active transport (2009-2010)

Emissions Source	Emissions (t CO2e)
	2009-10
Active Transportation	2,138

2.3. SUMMARY OF GHG EMISSIONS 2010-2011

2.3.1. Total Emissions by source

Building GHG Emissions							
Energy Source	**Consumption**	**Units**	**Emission Factor (t CO_2e / unit)**	**GHG Emissions CO2 (t CO2e)**	**GHG Emissions CH4 (t CO_2e)**	**GHG Emissions N2O (t CO_2e)**	**TOTAL GHG Emissions (t CO_2e)**
Electricity	70,500,933	kWh	0.00082839	58,402			**58,402**
Furnace Oil	200,330	Litres	0.00275225	551	0.76	1.93	**554**
Bunker C Oil	5,723,263	Litres	0.00315524	18,058	14	114	**18,186 [16,549 Dal]**
Diesel	44,967	Litres	0.00268963	121	0.13	5.58	**127**
Propane	53,547	Litres	0.00157755	81	0.03	1.79	**83**
Natural Gas	267,942	GJ	0.049861496	13,309	5	76	**13,391 [12,186 Dal]**
Total							**87,901**

Refrigerant GHG Emissions							
Refrigerant Name and GWP	**Consumption (Loss)**	**Units**	**Emission Factor (t CO_2e / unit)**	**GHG Emissions CO2 (t CO2e)**	**GHG Emissions CH4 (t CO_2e)**	**GHG Emissions N2O (t CO_2e)**	**TOTAL GHG Emissions (t CO_2e)**
R134A	10.91	Kg	1430	**16**			**16**
R12	0	Kg	10900	**0**			**-**
R22	130.45	Kg	1810	**236**			**236**
R401A	15.91	Kg	18	**0**			**0**
R401B	11.36	Kg	15	**0**			**0**
R402A	2.27	Kg	1680	**4**			**4**
R404A	4.55	Kg	3260	**15**			**15**
R407C		Kg	1526	**6**			**6**

	4.09						
R409A	0.45	Kg	0	**0**			**0**
R410A	16.36	Kg	1725	**28**			**28**
Total				**305**			**305**

Vehicle GHG Emissions							
Energy Source	**Consumption**	**Units**	**Emission Factor (t CO_2e / unit)**	**GHG Emissions CO2 (t CO2e)**	**GHG Emissions CH4 (t CO_2e)**	**GHG Emissions N2O (t CO_2e)**	**TOTAL GHG Emissions (t CO_2e)**
Regular Gasoline	**35,252**	**Litres**	**0.000002312**	81	0.056	1	**82**
Diesel Fuel	**4,664**	**Litres**	**0.000002690**	13	0.203	4.490	**17**
Total				**94**	**0.26**	**5.38**	**100**

Transportation GHG Emissions							
Commuter	**Annual Distance**	**Units**		**GHG Emissions CO2 (t CO2e)**	**GHG Emissions CH4 (t CO_2e)**	**GHG Emissions N2O (t CO_2e)**	**TOTAL GHG Emissions (t CO_2e)**
Faculty/Staff - Drive alone	**31,178,046**	**Km**		**8,865**			**8,865**
Students - Drive Alone	**35,452,318**	**Km**		**10,081**			**10,081**
Faculty/Staff - Car Pool	**5,484,183**	**Km**		**520**			**520**
Students - Car Pool	**6,029,092**	**Km**		**571**			**571**
Faculty/Staff - Transit	**10,277,545**	**Km**		**73**			**73**
Students - Transit	**16,925,420**	**Km**		**120**			**120**
Total				**20,231**	**-**	**-**	**20,231**
TOTAL GHG EMISSIONS							**108,537**

2.3.2. Total Emissions by Scope

Total Emissions by Scope	TOTAL GHG Emissions (t CO_2e)
Scope 1: Heating/Cooling & Fleet (Stationary and Mobile Combustion)	29,904
Scope 2: Electricity	58,386
Scope 3: Commuting Travel	19,542
Total Emissions	108,537

2.3.3. Summary Of avoided GHG emissions (2010-2011)

Summary of GHG Avoided due to Active Transportation 2010-2011			
Commuter	Fuel saved	Units	TOTAL GHG Emissions (t CO_2e)
Faculty/Staff - Cycling	74,793	Litres	179
Students - Cycling	204,319	Litres	486
Faculty/Staff - Walking	202,923	Litres	481
Students - Walking	455,385	Litres	1,079
Total Emissions AVOIDED			2,226

4. REDUCING GHG EMISSIONS

The quantification of current GHG emissions is a first step in establishing current conditions and impacts. The second necessary step is to determine methods of mitigating these impacts and reducing the overall carbon footprint. The following wedge diagram (Figure 6) shows the different mitigation strategies targets for aiding the university to become carbon neutral by the year 2050. After all other possible options for reducing emissions have been exhausted, the final step will be to invest in carbon offsetting.

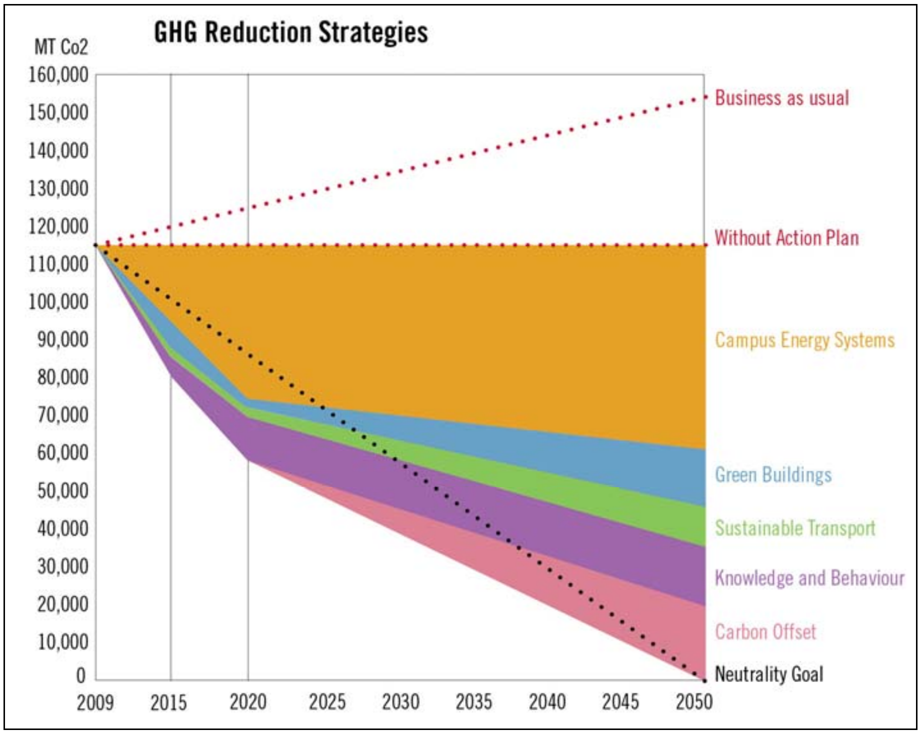


Figure 6 GHG Reduction Strategy Targets

The Dalhousie University Climate Change Plan details mitigation and adaptation strategies and specific targets. In the 2010-2011 fiscal year a variety of projects were undertaken to reduce greenhouse gases including:

- installation of 40 solar thermal panels on the Life Sciences Centre,
- conversion of the heating plant and houses to natural gas,
- replacing hundreds of incandescent to CFLs and LEDs,
- installing high efficiency T8s in houses,
- upgrading lighting, HVAC, and fume hoods in LSC, and
- implementing ENERGY STAR education and procurement programs.

5. NEXT STEPS

The results of the annual GHG analysis will be published on the Office of Sustainability website each year. A number of next steps recommended in the 2008-2009 plan are underway including:

1) Creating a refrigerant management plan listing all refrigeration units at the University including stationary and mobile sources.

2) Developing and verify a listing of all leased properties for each year's inventory.

3) Examining the benefits of online fleet vehicle GPS tracking software that captures data electronically on vehicle location, speed, idling time and km, and/or examine the utility of a university fleet gas card that has associated litres tracking.

4) Enhancing building metering to accurately capture building level emissions and help to identify mitigation solutions.

Each year, in the future an annual transportation survey with more detailed questions on campus, intercampus, and business travel will be implemented.

Future work needs to explore business process techniques that decrease human resource time and enhance data capture. Specific examples include:

a. Support the transfer of paper-based travel claim to an electronic system that would include fields for capturing mode type and distance.
b. Support electronic utility billing efforts for energy, water, and waste.

6. APPENDICES

Appendix A: Terms and Definitions

The following terms hold relevance throughout this report, with definitions adapted from CSA ISO 14064-1:2006(E):

base calculation year - initial year of data collection used only to provide an outline for future GHG calculations
NOTE: Base-year emissions or removals may be quantified based on a specific period (e.g. a year) or averaged from several periods (e.g. several years).

base comparison year - historical period specified for the purpose of comparing GHG emissions or removals or other GHG-related information over time
NOTE: Base-year emissions or removals may be quantified based on a specific period (e.g. a year) or averaged from several periods (e.g. several years).

carbon dioxide equivalent (CO_2e) - unit for comparing the radiative forcing of a GHG to carbon dioxide
NOTE: The carbon dioxide equivalent is calculated using the mass of a given GHG multiplied by its global warming potential

direct greenhouse gas emission - GHG emission from greenhouse gas sources owned or controlled by the organization

energy indirect greenhouse gas emission - GHG emission from the generation of imported electricity, heat or steam consumed by the organization

facility - single installation, set of installations or production processes (stationary or mobile), which can be defined within a single geographical boundary, organizational unit or production process

global warming potential (GWP) - factor describing the radiative forcing impact of one mass-based unit of a given GHG relative to an equivalent unit of carbon dioxide over a given period of time

greenhouse gas (GHG) - gaseous constituent of the atmosphere, both natural and anthropogenic, that absorbs and emits radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere, and clouds
NOTE: GHGs include carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF6).

greenhouse gas emission - total mass of a GHG released to the atmosphere over a specified period of time

greenhouse gas emission or removal factor - factor relating activity data to GHG emissions or removals

greenhouse gas inventory - an organization's greenhouse gas sources, greenhouse gas sinks, greenhouse gas emissions and removals

greenhouse gas removal - total mass of a GHG removed from the atmosphere over a specified period of time

greenhouse gas report - stand-alone document intended to communicate an organization's or project's GHG-related information to its intended users

greenhouse gas sink - physical unit or process that removes a GHG from the atmosphere

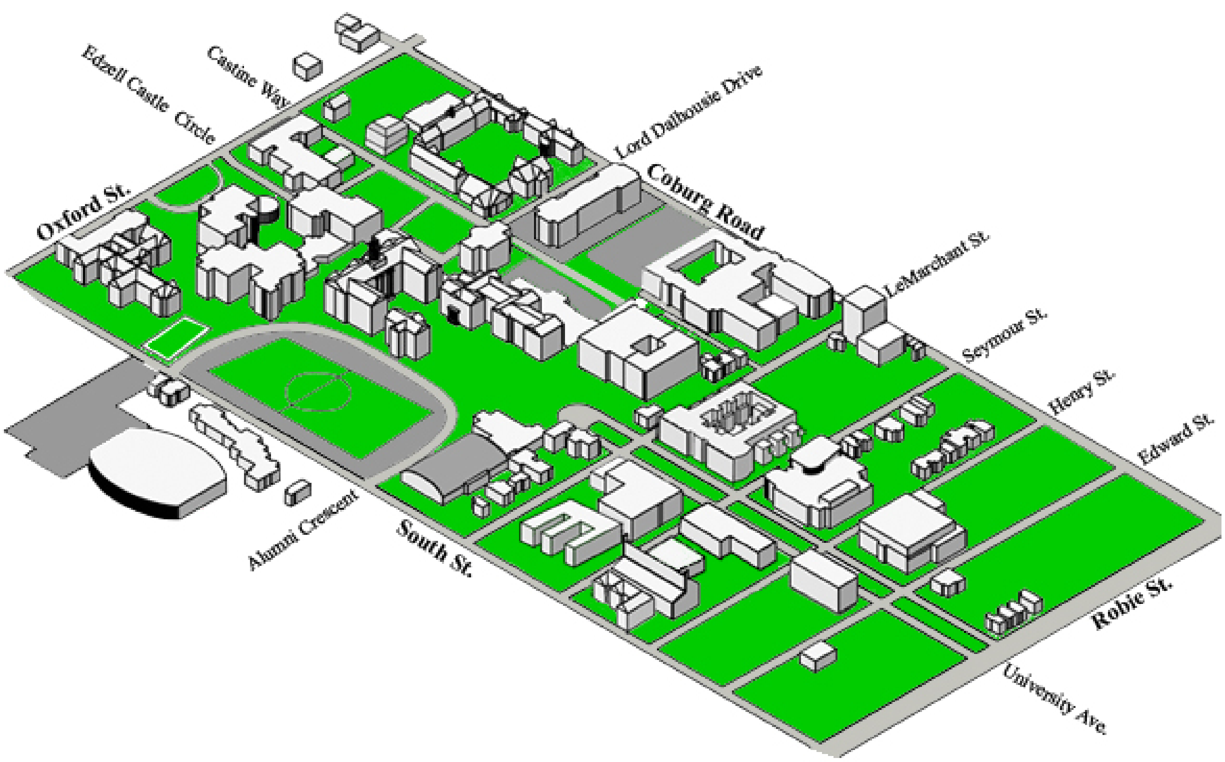
greenhouse gas source - physical unit or process that releases a GHG into the atmosphere

organization - company, corporation, firm, enterprise, authority or institution, or part or combination thereof, whether incorporated or not, public or private, that has its own functions and administration

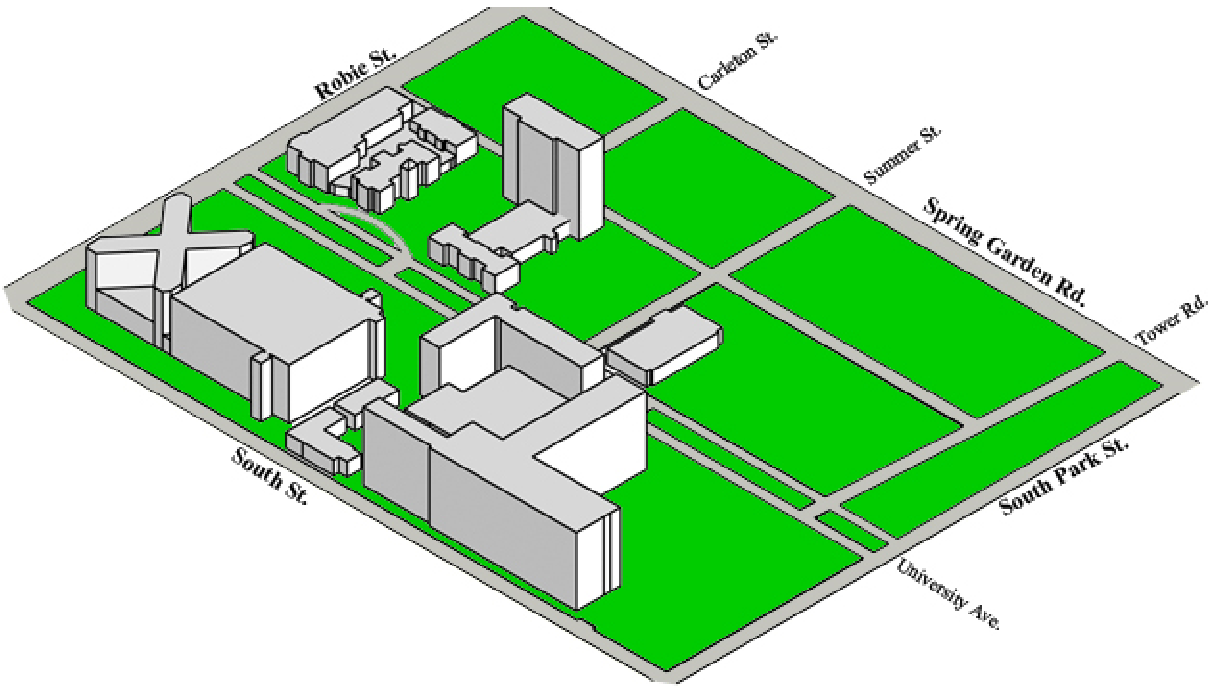
other indirect greenhouse gas emission - GHG emission, other than energy indirect GHG emissions, which is a consequence of an organization's activities, but arises from greenhouse gas sources that are owned or controlled by other organizations

Appendix B: Campus Map

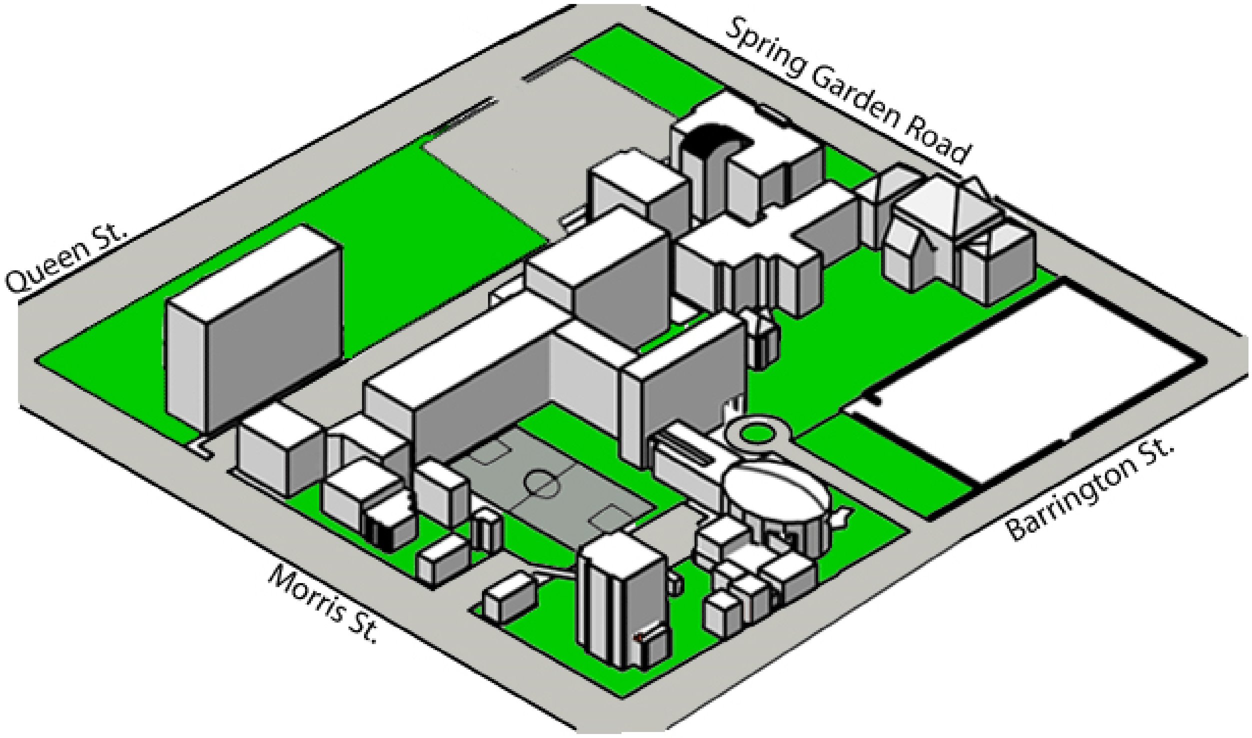
Studley campus



Carleton Campus



Sexton campus



Appendix C: List of Campus Buildings

	Bldn gCod e	BUILDING NAME	BUILDING ADDRESS	CAMPUS	Space Use	GROSS AREA (Sq.Ft)
1	A050	COBURG ROAD 6414	6414 Coburg Road	Studley	ACADEMIC DEPARTMENTAL OFFICES AND RELATED	5,529
2	A100	COBURG ROAD 6420	6420 Coburg Road	Studley	ACADEMIC DEPARTMENTAL OFFICES AND RELATED	3,200
3	A160	PRESIDENT'S RES	1460 Oxford Street	Studley	RESIDENTIAL SPACE	8,750
4	B100	DALPLEX	6260 South Street	Studley	RECREATION/ATHLETIC SPACE	178,769
5.a	B120	ELIZA RITCHIE HALL	6250 South Street	Studley	RESIDENTIAL SPACE	23,997
6	B200	STAIRS HOUSE	6230 South Street	Studley	ACADEMIC DEPARTMENTAL OFFICES AND RELATED	6,800
5.b.	B220	ELIZA RITCHIE-HSE	6250 South Street	Studley	RESIDENTIAL SPACE	2,520
7	B260	SOUTH STREET 6280	6280 South Street	Studley	CENTRAL ADMINISTRATIVE OFFICE AND RELATED	4,000
8	B280	SOUTH STREET 6286	6286 South Street	Studley	CENTRAL ADMINISTRATIVE OFFICE AND RELATED	3,000
9	C140	STORAGE FACILITY/WAREHOUSE	1459 Oxford Street	Studley	PLANT MAINTENANCE	11,900
10.a	C201	LSC-BIOL&EARTH	1355 Oxford Street	Studley	RESEARCH LABORATORY SPACE	161,395
10.b	C202	LSC-OCEANOGRAPH	1355 Oxford Street	Studley	RESEARCH LABORATORY SPACE	107,080

10.c	C203	LSC-PSYCHOLOGY	1355 Oxford Street	Studley	RESEARCH LABORATORY SPACE	123,720
10.d	C204	LSC-COMMON AREA	1355 Oxford Street	Studley	RESEARCH LABORATORY SPACE	57,856
11	C220	SHIRREFF HALL	6385 South Street	Studley	RESIDENTIAL SPACE	171,776
12	C260	DUNN BUILDING	6310 Coburg Road	Studley	RESEARCH LABORATORY SPACE	89,991
13	C280	CHASE BLDG	6316 Coburg Road	Studley	ACADEMIC DEPARTMENTAL OFFICES AND RELATED	28,801
14	C300	HENRY HICKS ACADEMI	6299 South Street	Studley	CENTRAL ADMINISTRATIVE OFFICE AND RELATED	106,614
15.a	C381	CHEMISTRY	6274 Coburg Road	Studley	RESEARCH LABORATORY SPACE	74,993
15.b	C382	CHEMISTRY PODIUM	6274 Coburg Road	Studley	RESEARCH LABORATORY SPACE	34,997
15.c	C383	CHEMICAL STOR FACIL	6274 Coburg Road	Studley	RESEARCH LABORATORY SPACE	10,608
16	C400	MACDONALD BLDG	6300 Coburg Road	Studley	CENTRAL ADMINISTRATIVE OFFICE AND RELATED	19,998
17	C440	UNIVERSITY CLUB	6259 Alumni Crescent	Studley	ASSEMBLY AND EXHIBITION FACILITIES	14,877
18.a	C520	HOWE HALL	6230 Coburg Road	Studley	RESIDENTIAL SPACE	158,347
18.b	C521	HOWE-FOUNTAIN HOUSE	6230 Coburg Road	Studley	RESIDENTIAL SPACE	65,380
19	C540	STUDLEY HOUSE	1452 Lemarchant Street	Studley	RESIDENTIAL SPACE	16,000
20	C580	KILLAM LIBRARY	6225 University Avenue	Studley	LIBRARY FACILITIES AND CAMPUS STUDY SPACE	250,520
21	C600	STUDLEY GYMNASIUM	6226 University Avenue	Studley	RECREATION/ATHLETIC SPACE	36,196
22	C620	MEMORIAL ARENA	6185 South Street	Studley	RECREATION/ATHLETIC SPACE	34,997
23	C710	SEYMOUR ST 1443	1443 Seymour Street	Studley	CENTRAL ADMINISTRATIVE OFFICE AND RELATED	3,140
24	C720	LEMARCHANT ST 1376	1376 Lemarchant Street	Studley	ACADEMIC DEPARTMENTAL OFFICES AND RELATED	4,000
25	C730	LEMARCHANT ST 1390	1390 Lemarchant Street	Studley	ACADEMIC DEPARTMENTAL OFFICES AND RELATED	3,000
26	C750	LEMARCHANT ST 1400	1400 Lemarchant Street	Studley	ACADEMIC DEPARTMENTAL OFFICES AND RELATED	3,000
27	C760	UNIVERSITY AVE 6206	6206 University Avenue	Studley	ACADEMIC DEPARTMENTAL OFFICES AND RELATED	2,760
28	C770	LEMARCHANT 1252-54	1252-54 Lemarchant Street	Studley	RESIDENTIAL SPACE	5,400
29	C800	UNIVERSITY AVE 6214	6214 University Avenue	Studley	ACADEMIC DEPARTMENTAL OFFICES AND RELATED	3,000
30	C820	UNIVERSITY AVE 6220	6220 Universiy Avenue	Studley	ACADEMIC DEPARTMENTAL OFFICES AND RELATED	4,274
31	D110	MONA CAMPBELL BUILDING	1459 Lemarchant Street	Studley	ACADEMIC DEPARTMENTAL OFFICES AND RELATED	101,303
32	D280	SEYMOUR ST 1379	1379 Seymour Street	Studley	CENTRAL ADMINISTRATIVE OFFICE AND RELATED	2,777
33	D300	SEYMOUR ST 1391	1391 Seymour Street	Studley	CENTRAL ADMINISTRATIVE OFFICE AND RELATED	2,343
34	D320	DE MILLE HOUSE	1411 Seymour Street	Studley	RESIDENTIAL SPACE	6,570
35	D340	SEYMOUR ST 1435	1435 Seymour Street	Studley	RESIDENTIAL SPACE	4,130
36	D400	ARTS CENTRE	6101 University Avenue	Studley	ASSEMBLY AND EXHIBITION FACILITIES	175,308
37	D420	MCCAIN ARTS&SS	6135 University Avenue	Studley	ACADEMIC DEPARTMENTAL OFFICES AND RELATED	153,843
38	D541	HENRY ST 1400	1400 Henry Street	Studley	RESIDENTIAL SPACE	

						2,840
39	D542	HENRY ST 1410	1410 Henry Street	Studley	RESIDENTIAL SPACE	3,110
40	D550	LYALL HOUSE	1416-1424 Henry Street	Studley	RESIDENTIAL SPACE	5,520
41	D580	COLPITT HOUSE	1434-1444 Henry Street	Studley	RESIDENTIAL SPACE	8,070
42	D620	WELDON LAW	6061 University Avenue	Studley	LIBRARY FACILITIES AND CAMPUS STUDY SPACE	99,991
43	D640	EDWARD ST 1321	1321 Edward Street	Studley	ACADEMIC DEPARTMENTAL OFFICES AND RELATED	4,520
44	D701	ROBIE ST 1308	1308 Robie Street	Studley	ACADEMIC DEPARTMENTAL OFFICES AND RELATED	2,263
45	D702	ROBIE ST 1312	1312 Robie Street	Studley	ACADEMIC DEPARTMENTAL OFFICES AND RELATED	2,263
46	D703	ROBIE ST 1318	1318 Robie Street	Studley	ACADEMIC DEPARTMENTAL OFFICES AND RELATED	3,289
47	D720	ROBIE ST 1322	1322 Robie Street	Studley	ACADEMIC DEPARTMENTAL OFFICES AND RELATED	3,785
48	E100	STUD. UNION BLDG	6136 University Avenue	Studley	BOOKSTORE AND OTHER MERCHANDISING FACILITIES	124,378
49	E190	RISLEY HALL	1233 Lemarchant	Studley	RESIDENTIAL SPACE	177,100
50	E260	KENNETH C ROWE MANA	6100 University Ave	Studley	ACADEMIC DEPARTMENTAL OFFICES AND RELATED	122,054
51.a	E280	CENTRAL SRVC	1236 Henry Street	Studley	NON-ASSIGNABLE	80,463
51.b	E282	CENTRAL SRV-PARKADE	1236 Henry Street	Studley	OTHER UNIVERSITY FACILITIES	40,830
52	E600	GOLDBERG COMPUTER SCIENCE BUILDING	6050 University Avenue	Studley	RESEARCH LABORATORY SPACE	70,640
53	E800	GLENGARY	1253 Edward Street	Studley	RESIDENTIAL SPACE	16,270
54	F100	DENTISTRY	5981 University Avenue	Carleton	LABORATORY-UNDERGRADUATE	207,187
55	F120	BURBIDGE	5968 College Street	Carleton	CLASSROOM FACILITIES	33,771
56	F140	FORREST	5869 University Avenue	Carleton	LABORATORY-UNDERGRADUATE	61,542
57	F200	TUPPER BLDG	5850 College Street	Carleton	RESEARCH LABORATORY SPACE	379,218
58	F220	CLIN RES CTR	5849 University Avenue	Carleton	ACADEMIC DEPARTMENTAL OFFICES AND RELATED	24,486
59	G200	P.GREEN HALL	1094 Wellington Street	No Campus	RESIDENTIAL SPACE	146,982
60	H010	SEISMOGRAPH	Behind Killiam Library	Studley	LABORATORY-UNDERGRADUATE	750
61	H130	GOTTINGEN ST 2209	2209 Gottingen Street	Sexton	CENTRAL ADMINISTRATIVE OFFICE AND RELATED	12,475
62.a	J011	IRA MACNAB-A BLDG	1360 Barrington Street	Sexton	LIBRARY FACILITIES AND CAMPUS STUDY SPACE	27,795
62.b	J012	I MACNAB-A BLD ADDI	1360 Barrington Street	Sexton	CENTRAL SERVICES(Computing)	4,681
63a.	J051	B BUILDING	1360 Barrington Street	Sexton	CENTRAL ADMINISTRATIVE OFFICE AND RELATED	23,946
63.b	J052	B BUILDING ADDITION	1360 Barrington Street	Sexton	CLASSROOM FACILITIES	13,823
64.a	J100	ELECT ENG-C BLDG	1360 Barrington Street	Sexton	LABORATORY-UNDERGRADUATE	22,115
64.b	J110	H THEAKSTON-C1 BLDG	5269 Morris Street	Sexton	LABORATORY-UNDERGRADUATE	31,440
65	J150	A. MACDONALD-D BLDG	1360 Barrington Street	Sexton	RESEARCH LABORATORY SPACE	64,946
66	J200	SEXTON HOUSE-E BLDG	1360 Barrington Street	Sexton	ACADEMIC DEPARTMENTAL OFFICES AND RELATED	5,198

67	J250	CHEMICAL ENG-F BLDG	1360 Barrington Street	Sexton	RESEARCH LABORATORY SPACE	24,146
68	J280	G.H. MURRAY-G BLDG	1360 Barrington Street	Sexton	RESEARCH LABORATORY SPACE	20,843
69.a	J301	RALPH M MEDJUCK BLD	5410 Spring Garden Road	Sexton	CLASSROOM FACILITIES	43,831
69.b	J302	RALPH MEDJUCK-ADDIT	5410 Spring Garden Road	Sexton	ASSEMBLY AND EXHIBITION FACILITIES	5,840
70.a	J351	SEXTON MEMORIAL GYM	1360 Barrington Street	Sexton	RECREATION/ATHLETIC SPACE	21,546
70.b	J352	SEXTON GYM-ADDITION	1360 Barrington Street	Sexton	RECREATION/ATHLETIC SPACE	9,073
71	J400	HART HOUSE-K BLDG	1340 Barrington Street	Sexton	ACADEMIC DEPARTMENTAL OFFICES AND RELATED	6,320
72	J450	MOREN HOUSE-L BLDG	1334 Barrington Street	Sexton	ACADEMIC DEPARTMENTAL OFFICES AND RELATED	4,793
73	J500	M.M. O'BRIEN-M BLDG	5217 Morris Street	Sexton	RESIDENTIAL SPACE	37,541
74	J550	N BUILDING	1360 Barrington Street	Sexton	RESEARCH LABORATORY SPACE	21,268
75	J600	GRAD STUD RES-O BLDG	5231 Morris Street	Sexton	RESIDENTIAL SPACE	7,413
76	J650	A.E. CAMERON-P BLDG	1360 Barrington Street	Sexton	RESEARCH LABORATORY SPACE	5,472
77	J700	BERNARD CAIN-Q BLDG	1360 Barrington Street	Sexton	RESEARCH LABORATORY SPACE	5,800
78	J800	R1-BUILDING	5265 Morris Street	Sexton	RESEARCH LABORATORY SPACE	5,856
79	J810	R2-BUILDING	5257 Morris Street	Sexton	CENTRAL ADMINISTRATIVE OFFICE AND RELATED	6,610
80	J850	DUST EXPLOSION-T	1360 Barrington Street	Sexton	RESEARCH LABORATORY SPACE	1,066
81	J870	METALLURGY RES-U	1360 Barrington Street	Sexton	RESEARCH LABORATORY SPACE	952
82a.	J901	IND ENG&CONT ED	5269 MORRIS	Sexton	ACADEMIC DEPARTMENTAL OFFICES AND RELATED	16,470
82.b	J902	IND ENG&CON ED ADDI	5269 MORRIS	Sexton	OTHER UNIVERSITY FACILITIES	17,350
83	J910	GERARD HALL	5303 Morris Street	Sexton	RESIDENTIAL SPACE	94,270
84	J920	MORRIS 5247	5247 MORRIS ST	Sexton	RESIDENTIAL SPACE	4,405
85	J980	C1-MOBILE	1360 Barrington Street	Sexton	RESEARCH LABORATORY SPACE	1,440
86	J981	ELECTRICAL MOBILE 2	1360 Barrington Street	Sexton	RESEARCH LABORATORY SPACE	1,024
	TOTAL (86 buildings/houses, excluding additions 100 buildings/houses, including additions)					**4,478,529**
	* Peter Green Hall is owned by Dalhousie but is financially controlled by the Student Family Housing Coop **Total withouth Peter Green Hall**					**4,331,547**

Appendix D: Data Quality Tiers Direct Emissions from Stationary Combustion

Data Quality Tiers: Direct CO_2 Emissions From Stationary Combustion		
Tier	**Method**	**Emission Factors**
A1	Direct Monitoring	Continuous emissions monitoring (CEMS) in accordance with 40 CFR Part 75
A2	Calculation Based on Fuel Use	• Measured carbon content of fuels (per unit mass or volume), or • Measured carbon content of fuels (per unit energy) and measured heat content of fuels
B	Calculation Based on Fuel Use	• Measured heat content of fuels and default carbon content (per unit energy), or • Measured carbon content (per unit energy) and default heat content of fuels
C	Calculation Based on Fuel Use	Default CO_2 emission factors by fuel type

Data Quality Tiers: Direct CH_4 and N_2O Emissions From Stationary Combustion		
Tier	**Method**	**Emission Factors**
A	Direct Measurement	Continuous emissions monitoring or periodic direct measurements
B	Calculation Based on Fuel Use	Default emission factors by sector and technology type
C	Calculation Based on Fuel Use	Default emission factors by sector and fuel type

Appendix E: Canadian Default Factors for Calculating CO2 Emissions from Combustion of Natural Gas, Petroleum Products, and Biomass (Source – TCR-GRP - 2012 Climate Registry Default Emissions Factors)

Fuel Type	Carbon Content (Per Unit Energy)	Heat Content	Fraction Oxidized	CO_2 Emission Factor (Per Unit Mass or Volume)
Natural Gas	**kg C / GJ**	**GJ / megalitre**		**g CO_2 / m^3**
Electric Utilities, Industry, Commercial, Pipelines, Agriculture, Residential*	n/a	38.26	1	1900.46
Producer Consumption*	n/a	38.26	1	2400.95
Newfoundland and Labrador				
Marketable	n/a	38.26	1	1900.46
NonMarketable	n/a	38.26	1	2494.41
Nova Scotia				
Marketable	n/a	38.26	1	1900.46
NonMarketable	n/a	38.26	1	2494.41
New Brunswick				
Marketable		38.26	1	1900.46
NonMarketable		38.26	1	NO
Quebec				
Marketable	n/a	38.26	1	1887.39
NonMarketable	n/a	38.26	1	NO
Ontario				
Marketable	n/a	38.26	1	1888.40
NonMarketable	n/a	38.26	1	NO
Manitoba				
Marketable	n/a	38.26	1	1886.39
NonMarketable	n/a	38.26	1	NO
Saskatchewan				
Marketable	n/a	38.26	1	1829.10
NonMarketable	n/a	38.26	1	2441.15
Alberta				
Marketable	n/a	38.26	1	1927.59
NonMarketable	n/a	38.26	1	2391.90
British Columbia				
Marketable	n/a	38.26	1	1925.58
NonMarketable	n/a	38.26	1	2161.76
Northwest Territories				
Marketable	n/a	38.26	1	2466.27
NonMarketable	n/a	38.26	1	2466.27

Fuel Type	Carbon Content (Per Unit Energy)	Heat Content	Fraction Oxidized	CO_2 Emission Factor (Per Unit Mass or Volume)
Natural Gas Liquids	**kg C / GJ**	**GJ / kilolitre**		**g CO_2 / L**
Propane				
Residential Propane	n/a	25.31	1	1517.55
Other Uses Propane	n/a	25.31	1	1517.55
Ethane	n/a	17.22	1	980.88
Butane	n/a	28.44	1	1738.65
Petroleum Products	**kg C / GJ**	**GJ / kilolitre**		**g CO_2 / L**
Light Fuel Oil Electric Utilities	n/a	38.80	1	2752.25
Light Fuel Oil Industrial	n/a	38.80	1	2752.25
Light Fuel Oil Producer Consumption	n/a	38.80	1	2669.43
Light Fuel Oil Residential	n/a	38.80	1	2752.25
Light Fuel Oil Forestry, Construction, Public Administration, Commercial/Institutional	n/a	38.80	1	2752.25
Heavy Fuel Oil (Electric Utility, Industrial, Forestry, Construction, Public Administration, Commercial/Institutional)	n/a	42.50	1	3155.24
Heavy Fuel Oil (Residential)	n/a	42.50	1	3155.24
Heavy Fuel Oil (Producer Consumption)	n/a	42.50	1	3189.58
Kerosene (Electric Utility, Industrial, Producer Consumption, Residential, Forestry, Construction, Public Administration, Commercial/Institutional)	n/a	37.68	1	2559.34
Diesel	n/a	38.30	1	2689.63
Petroleum Coke from Upgrading Facilities	n/a	40.57	1	3528.94
Petroleum Coke from Refineries & Others	n/a	46.35	1	3854.16
Still Gas	**kg C / TJ**	**TJ / GL**		**g / m^3**
Upgrading Facilities	n/a	43.24	1	2161.4
Refineries & Others	n/a	36.08	1	1740.23

Appendix F: Tier B Method: Default CH_4 and N_2O Emission Factors by Technology Type for the Commercial Sector (Source – CR:GRP - 2012 Climate Registry Default Emissions Factors)

Fuel Type and Basic Technology	Configuration	CH_4 (g / MMBtu)	N_2O (g / MMBtu)
Liquid Fuels			
Residual Fuel Oil Boilers		1.4	0.3
Gas/Diesel Oil Boilers		0.7	0.4
Liquefied Petroleum Gases Boilers		0.9	4
Solid Fuels			
Other Bituminous/Sub-bit. Overfeed Stoker Boilers		1	0.7
Other Bituminous/Sub-bit. Underfeed Stoker Boilers		14	0.7
Other Bituminous/Sub-bit. Hand-fed Units		87.2	0.7
Other Bituminous/Sub-bituminous Pulverized Boilers	Dry Bottom, wall fired	0.7	0.5
	Dry Bottom, tangentially fired	0.7	1.4
	Wet Bottom	0.9	1.4
Other Bituminous Spreader Stokers		1	0.7
Other Bituminous/Sub-bit. Fluidized Bed Combustor	Circulating Bed	1	61.1
	Bubbling Bed	1	61.1
Natural Gas			
Boilers		0.9	0.9
Gas-Fired Gas Turbines >3MWa		3.8	1.3
Biomass			
Wood/Wood Waste Boilers		9.3	5.9
Source: IPCC, Guidelines for National Greenhouse Gas Inventories (2006), Chapter 2: Stationary Combustion, Table 2.10. Values were converted from LHV to HHV assuming that LHV are five percent lower than HHV for coal and oil, 10 percent lower for natural gas, and 20 percent lower for dry wood. (The IPCC converted the original factors from units of HHV to LHV, so the same conversion rates used by the IPCC were used here to obtain the original values in units of HHV.) Values were converted from kg/TJ to g/MMBtu using 1 kg = 1000 g and 1 MMBtu = 0.001055 TJ.			

Appendix G: Total Annual Refrigerant Loss and Emissions by Refrigerant Type (2010-2011)

Type of equipment	Refrigerant	Group	Loss (Lbs/year)	Loss (Kg/year)	Emission Factor (GWP)	Fiscal Year Emissions (MT CO2e)
Vehicles/HVAC	R134A	HFC	24	10.91	1,430	16
AC / Refrigeration	R12	CFC	0	-	0	0
AC / Refrigeration	R22	HCFC	287	130.45	1,810	236
AC / Refrigeration	R401A	HCFC	35	15.91	18	0
AC / Refrigeration	R401B	HCFC	25	11.36	15	0
AC / Refrigeration	R402A	HFC	5	2.27	1,680	4
AC / Refrigeration	R404A	HFC	10	4.55	3,260	15
AC / Refrigeration	R407C	HFC	9	4.09	1,526	6
AC / Refrigeration	R409A	HCFC	1	0.45	-	-

AC / Refrigeration	R-410A	HFC	36	16.36	1,725	28
						305

Appendix H: Data Quality Tiers for Electricity

Data Quality Tiers: Indirect CO_2, CH_4 and N_2O Emissions From Electricity		
Tier	**Activity Data**	**Emission Factors**
A	Known electricity use (Metered readings or utility bills)	Generator-specific emission factors
B	Known electricity use (Metered readings or utility bills)	eGRID power pool-specific factors
C	Estimated electricity use (Area method)	Generator-specific or eGRID power pool-specific factors

Appendix I: Nova Scotia Power Emission Factors

Year	System Totals - Emission Intensities			
	Mercury (g/GWh)	Sulphur Dioxide (g/kWh)	Carbon Dioxide Equivalent (g/kWh)	Nitrogen Oxide (g/kWh)
2005	8.79	8.68	890.82	2.70
2006	14.75	9.74	890.17	2.56
2007	12.99	9.01	842.28	2.15
2008	13.95	9.21	837.95	1.83
2009	12.54	9.04	840.06	1.53
2010	7.3	5.54	828.39	1.63
2011	8.88	6.09	804.76	1.69
2012	9.91	6.99	799.07	1.65

Appendix J: Data Quality Tiers for Mobile Combustion Emissions

Data Quality Tiers: Direct CO_2 Emissions From Mobile Combustion		
Tier	**Activity Data**	**Emission Factors**
A1	Fuel use	• Measured carbon content (per unit mass) and measured density of fuels, or • Measured carbon content (per unit energy) and measured heat content of fuels
A2	Fuel use	• Measured heat content of fuels and default carbon content (per unit energy), or • Measured carbon content (per unit energy) and default heat content of fuels
B	Fuel use	Default CO_2 emission factors by fuel type
C	Fuel use estimated using vehicle miles traveled and vehicle fuel economy	Default CO_2 emission factors by fuel type

Data Quality Tiers: Direct CH_4 & N_2O Emissions From Mobile Combustion (Highway Vehicles)		
Tier	**Activity Data**	**Emission Factors**
A	Miles traveled by vehicle type	Default emission factors by vehicle type based on vehicle technology
B	Miles traveled by vehicle type	Default emission factors by vehicle type based on model year
C	Distance estimated using fuel use and vehicle fuel economy	Default emission factors by vehicle type based on vehicle technology or model year

Appendix K: Fleet Vehicles on Campus

Year	Fuel Type	Vehicle Type	Vehicle's Use Category	Fuel Efficiency (L/100 km)	Mileage 2010-2011 (KMs)	Annual Consump 2010-2011 (Lts)
1998	Gas	Light Truck	Field Research	14.70	8,546	**1,256**
1998	Gas	Light Truck	Field Research	14.70	5,344	**1,560**
2004	Gas	Light Truck	Field Research	17.20	14,000	**2,408**
2002	Gas	Light Truck	Field Research	12.90	14,521	**1,873**
2010	Gas	Light Truck	Field Research	11.20	8,010	**897**
1995	Gas	Light Truck	Field Research	18.10	3,734	**1,332**
2004	Gas	Light Truck	Field Research	14.30	29,055	**4,155**
2006	Gas	Light Truck	Recycling collection, compost collection	34.00	8,913	**3,030**
2008	Gas	Light Truck	Landscaping, snow removal, garbage collection	13.90	9,965	**1,385**
2009	Gas	Light Truck	Landscaping, snow removal, garbage collection	15.40	4,555	**701**
2009	Gas	Light Truck	Landscaping, snow removal, garbage collection	15.00	9,473	**1,421**
2004	Gas	Light Truck	Mail Deliveries	16.80	9,909	**1,665**
2011	Gas	Light Truck	Landscaping, snow removal, garbage collection	10.23	-	**-**
2011	Gas	Light Truck	Recycling collection, compost collection	13.84	-	**-**
2011	Gas	Light Truck	Mail Deliveries	10.23	-	**-**
2011	Gas	Light Truck	Security	9.80	-	**-**
2010	Gas	Passenger	Security	10.69	8,837	**945**
2011	Gas	Passenger	General services	11.76	-	**-**
2004	Gas	Light Truck	Custodial services	16.80	4,069	**684**
2006	Gas	Light Truck	General services	21.10	16,888	**3,563**
2006	Gas	Light Truck	General services	29.00	5,537	**1,606**
2006	Gas	Light Truck	General services	34.00	8,118	**2,760**

2011	Gas	Light Truck	General services	14.70	-	-
1999	Gas	Light Truck	Field Research	17.30	14,151	**2,448**
2007	Gas	Passenger	Commuting	10.90	14,338	**1,563**
					TOTAL GAS	**35,252**

2010	Diesel	Light Truck	Field Research	16.80	15,528	**2,609**
2002	Diesel	Light Truck	Recycling collection, compost collection	19.20	10,705	**2,055**
2009	Diesel	Loader	Landscaping, snow removal			
2003	Diesel	Loader	Landscaping, snow removal			
2007	Diesel	Tractor	Landscaping, snow removal, garbage collection			
2007	Diesel	Tractor	Landscaping, snow removal, garbage collection			
2009	Diesel	Tractor	Landscaping, snow removal, garbage collection			
2010	Diesel	Tractor	Landscaping, snow removal, garbage collection			
					TOTAL DIESEL	**4,664**

Bought in 2011, therefore emissions not calculated for 2010-11 inventory

For fuel efficiency: http://www.fueleconomy.gov/feg/findacar.shtml

For MPG to L/100 conv: http://calculator-converter.com/l_100km_mpg_convert_mpg_to_l_per_100_km.php

Appendix L: Canadian Default CO_2, N_20 and CH_4 Emission Factors for Transport Fuels (Source - CR:GRP – 2012 Climate Registry Default Emissions Factors)

Vehicle Type and Year	CH_4 (g / mi)	N_2O (g / mi)
Gasoline Passenger Cars		
Model Years 1984-1993	0.0704	0.0647
Model Year 1994	0.0531	0.0560
Model Year 1995	0.0358	0.0473
Model Year 1996	0.0272	0.0426
Model Year 1997	0.0268	0.0422
Model Year 1998	0.0249	0.0393
Model Year 1999	0.0216	0.0337
Model Year 2000	0.0178	0.0273
Model Year 2001	0.0110	0.0158
Model Year 2002	0.0107	0.0153
Model Year 2003	0.0114	0.0135
Model Year 2004	0.0145	0.0083
Model Year 2005	0.0147	0.0079
Model Year 2006	0.0161	0.0057
Model Year 2007	0.0170	0.0041
Model Year 2008	0.0172	0.0038
Model Year 2009	0.0173	0.0036
Gasoline Light Trucks (Vans, Pickup Trucks, SUVs)		
Model Years 1987-1993	0.0813	0.1035
Model Year 1994	0.0646	0.0982
Model Year 1995	0.0517	0.0908
Model Year 1996	0.0452	0.0871
Model Year 1997	0.0452	0.0871
Model Year 1998	0.0391	0.0728
Model Year 1999	0.0321	0.0564
Model Year 2000	0.0346	0.0621
Model Year 2001	0.0151	0.0164
Model Year 2002	0.0178	0.0228
Model Year 2003	0.0155	0.0114
Model Year 2004	0.0152	0.0132
Model Year 2005	0.0157	0.0101
Model Year 2006	0.0159	0.0089
Model Year 2007	0.0161	0.0079
Model Year 2008	0.0163	0.0066
Model Year 2009	0.0163	0.0066

Vehicle Type and Year	CH_4 (g / mi)	N_2O (g / mi)
Gasoline Medium and Heavy-Duty Trucks and Busses		
Model Years 1985-1986	0.4090	0.0515
Model Year 1987	0.3675	0.0849
Model Years 1988-1989	0.3492	0.0933
Model Years 1990-1995	0.3246	0.1142
Model Year 1996	0.1278	0.1680
Model Year 1997	0.0924	0.1726
Model Year 1998	0.0641	0.1693
Model Year 1999	0.0578	0.1435
Model Year 2000	0.0493	0.1092
Model Year 2001	0.0528	0.1235
Model Year 2002	0.0526	0.1307
Model Year 2003	0.0533	0.1240
Model Year 2004	0.0341	0.0285
Model Year 2005	0.0326	0.0177
Model Year 2006	0.0326	0.0175
Model Year 2007	0.0327	0.0173
Model Year 2008	0.0327	0.0171
Model Year 2009	0.0327	0.0169
Diesel Passenger Cars		
Model Years 1960-1982	0.0006	0.0012
Model Years 1983-2009	0.0005	0.001
Diesel Light Duty Trucks		
Model Years 1960-1982	0.001	0.0017
Model Years 1983-1995	0.0009	0.0014
Model Years 1996-2009	0.001	0.0015
Diesel Medium and Heavy-Duty Trucks and Busses		
All Model Years 1960-2009	0.0051	0.0048

Source: US Inventory of Greenhouse Gas Emissions and Sinks 1990-2009 (April 2011) Annex 3, Tables A-97 - A-101.

Fuel Type	Carbon Content (kg C / GJ)	Heat Content	Fraction Oxidized	CO_2 Emission Factors
		GJ / kiloliter		g CO_2 / L
Gasoline	n/a	35.00	1	2311.89
Diesel	n/a	38.30	1	2689.63
Light Fuel Oil	n/a	38.80	1	2752.25
Heavy Fuel Oil	n/a	42.50	1	3155.24
Aviation Gasoline	n/a	33.52	1	2365.42
Aviation Turbo Fuel	n/a	37.40	1	2559.34
Propane	n/a	25.31	1	1532.65
Ethanol	n/a	n/a	1	1568.70
Biodiesel	n/a	n/a	1	2571.45
		GJ / megaliter		g CO_2 / L
Natural Gas	n/a	38.26	1	1.92

Source: Default CO_2 Emission Factors: Environment Canada, National Inventory Report, 1990-2009: Greenhouse Gas Sources and Sinks in Canada (2011) Annex 8: Emission Factors, Table A8-11 (2009 data); Default Heat Content: Statistics Canada, Report on Energy Supply and Demand in Canada, 2008 (2011), Energy conversion factors, p. 125; Default Carbon Content: Not available for Canada, If you cannot obtain measured carbon content values specific to your fuels, you should use the default emission factor. Default Fraction Oxidized: A value of 1.00 is used following the Intergovernmental Panel on Climate Change (IPCC), *Guidelines for National Greenhouse Gas Inventories* (2006).
Note: CO_2 emission factors from Environment Canada originally included fraction oxidized factors of less than 100%. Values were converted to 100% oxidation rate using 99% for all fuels except natural gas and propane, where a value of 99.5% was used, and Ethanol, where a value of 95% was used, based on the rates used to calculate the original factors.

Appendix M: Annual Commuting Travel Days

Travel days	Employees	Students
Canada Day	1	1
Natal Day	1	1
Labour Day	1	1
Thanksgiving	1	1
Remembrance Day	1	1
Dec. Holidays	7	14
Munroe Day (Dal)	1	1
Easter	1	1
Victoria Day	1	1
Vacation/leave	20	30
Vacation/leave (90%) students		120
	35	
Total Travel Days		
Employees	321	
Students (4 terms) - 10% of population	304	
Students (3 terms) - 90% of population	214	