DALHOUSIE UNIVERSITY

GREENHOUSE GAS (GHG) INVENTORY REPORT 2016-2017

Office of Sustainability, February 2018

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EXECUTIVE SUMMARY

Dalhousie University first established a greenhouse gas (GHG) inventory base year for the 2009 fiscal year (April 1, 2008 - March 31, 2009). The base year was updated to the 2010 fiscal year (April 1, 2009 - March 31, 2010), as more reliable and complete data records were available. This GHG inventory report is a follow-up to these previous assessments.

In September 2012, the Nova Scotia Agricultural College merged with Dalhousie University to become the Dalhousie Faculty of Agriculture at the Agricultural Campus (AC). The AC is located in Bible Hill, Nova Scotia, which is 100 kilometers from the Halifax campuses. This report standardizes the base year (2009-2010) to include the AC and the Halifax campuses.

The results of Dalhousie's annual GHG reports are published on the Office of Sustainability website. The Dalhousie University Climate Change Plan (2010) outlines the university's climate change mitigation and adaptation strategies and targets for the next several years. A second edition of the Climate Change Plan will be released in 2018. For the 2016/2017 fiscal year, several projects were undertaken in accordance to this plan such as AC campus lighting upgrade, new buildings meeting high energy standards, solar PV development, administering an Employee Bus Pass program, and supporting an Energy Efficiency Advisor from Efficiency NS to work with Dalhousie Office of Sustainability. The Dalhousie GHG inventory identifies all direct (Scope 1) and indirect (Scope 2) emissions under the university's operational control, as well as commuting travel (Scope 3) emissions.

Total greenhouse gas emissions (all campuses) were reduced in 2016-2017 over the base year for Scope 1 and 2 emissions by a total of 18% (Figure 0.1).

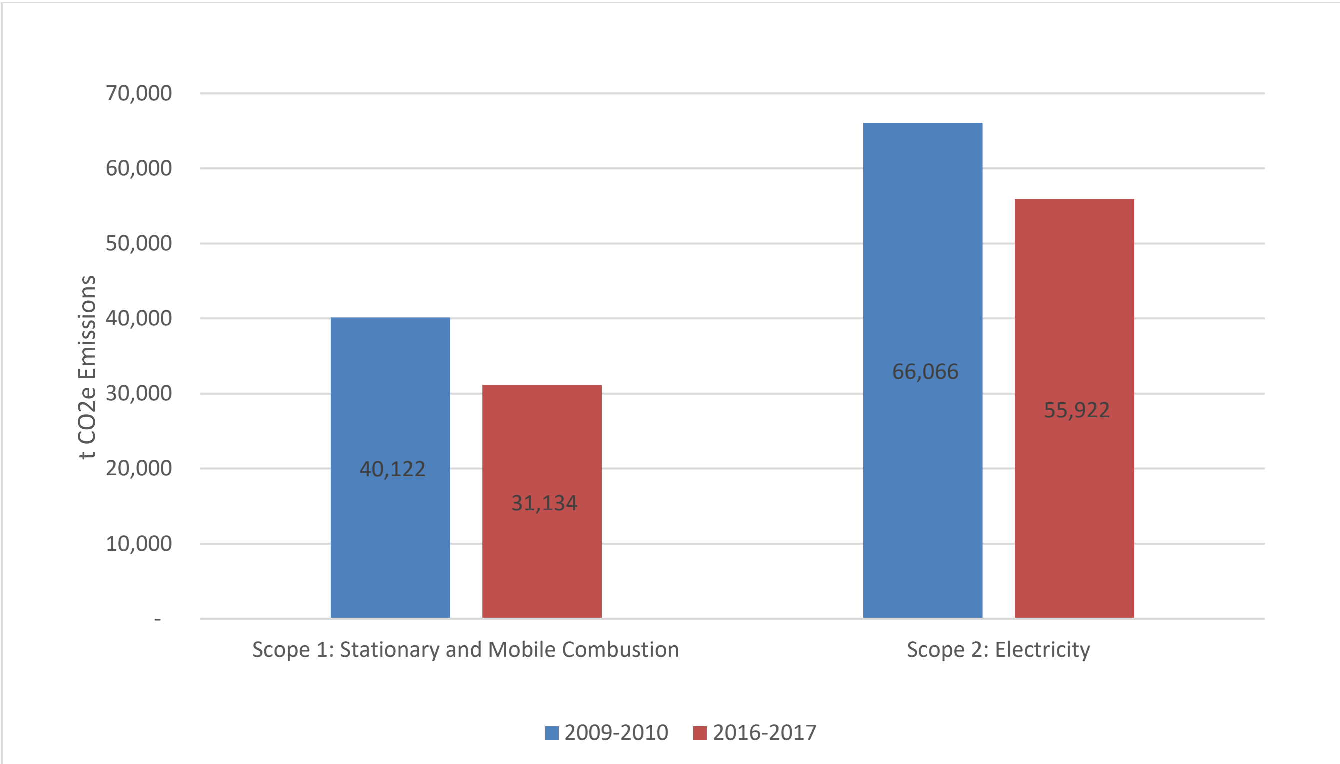


Figure 0.1 Comparison of Scope 1 & 2 emissions between 2009/10 (base year) and 2016/17 for all campuses

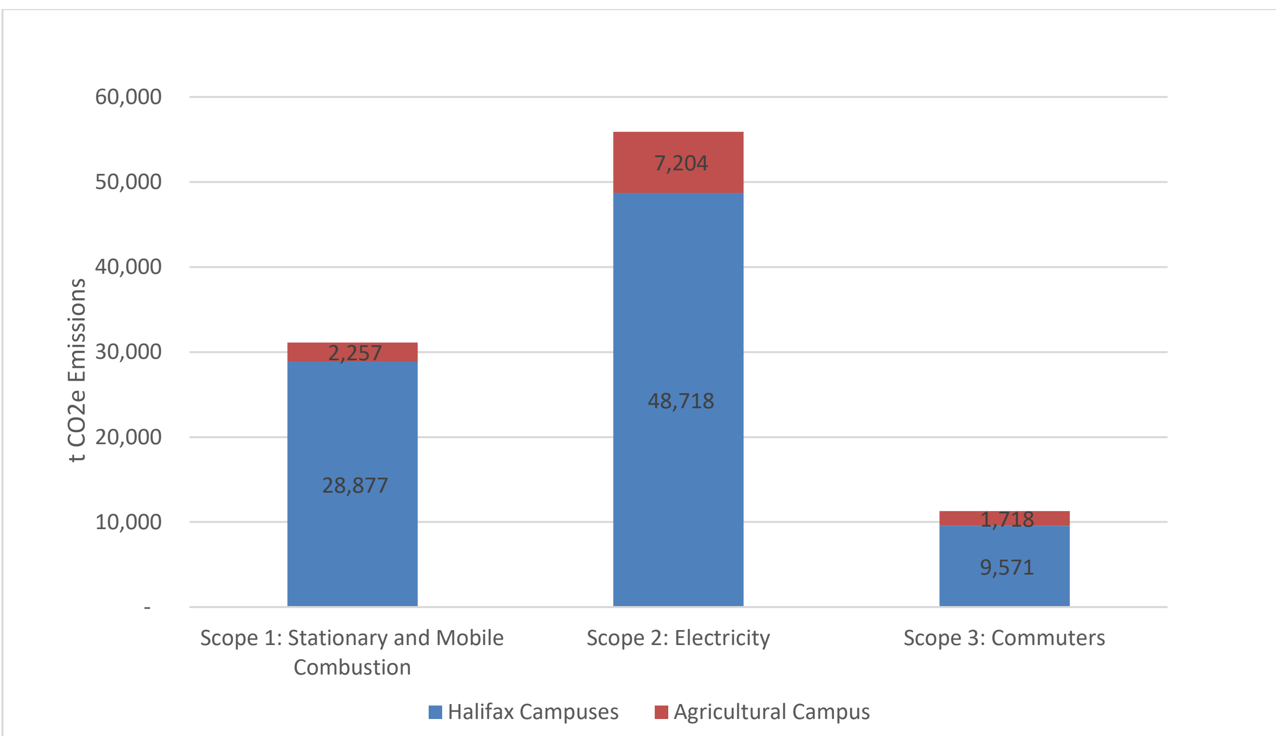


Figure 0.2 Emission breakdown by scope and geographical location

Furthermore, comparisons on square footage and campus populations were conducted between the base year and 2016/17. As shown in Figure 0.3 and Figure 0.4, there was a 23% decrease in emissions per square footage and a 27% decrease in emissions per weighted population.

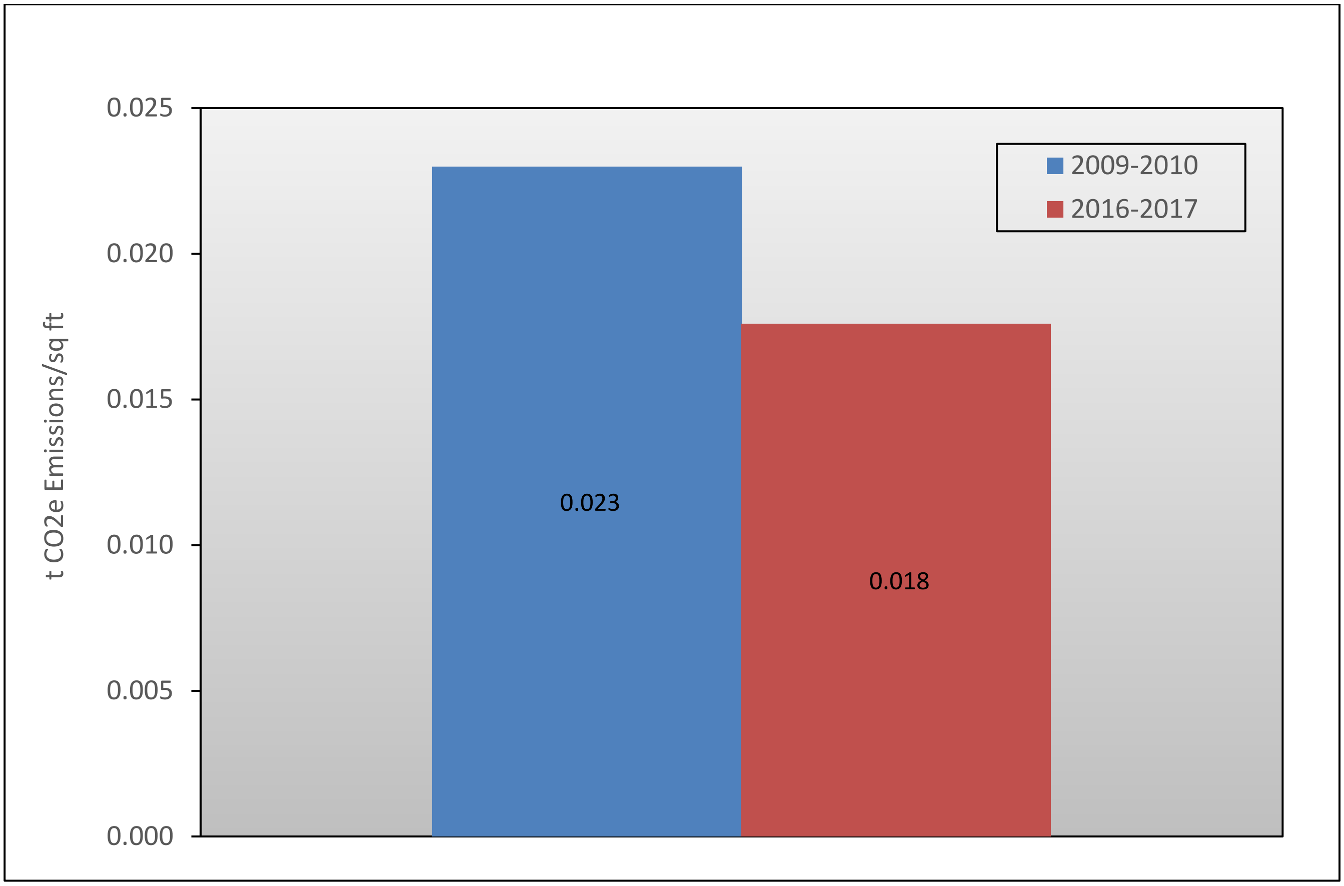


Figure 0.3 Comparison between base year and 2016/17 on a per square footage basis

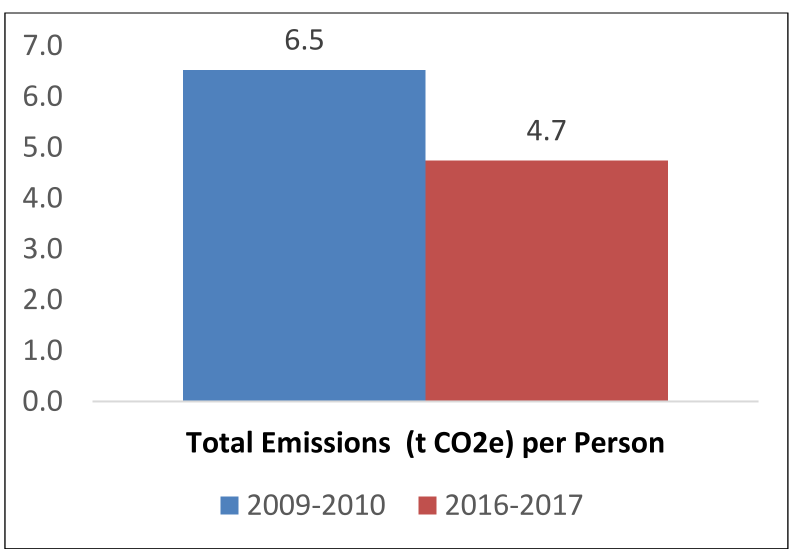


Figure 0.4 Comparison between base year and 2016/17 on a per person basis

To provide a visual aid, summary graphs were created to show the annual emissions separated into the three scopes. Figure 0.5 shows the emissions separated by scope, with data labels, and demonstrates the continual decrease since the greenhouse gas report has been implemented. Figure 0.6 is adjusted to show the percentage breakdown of each scope.

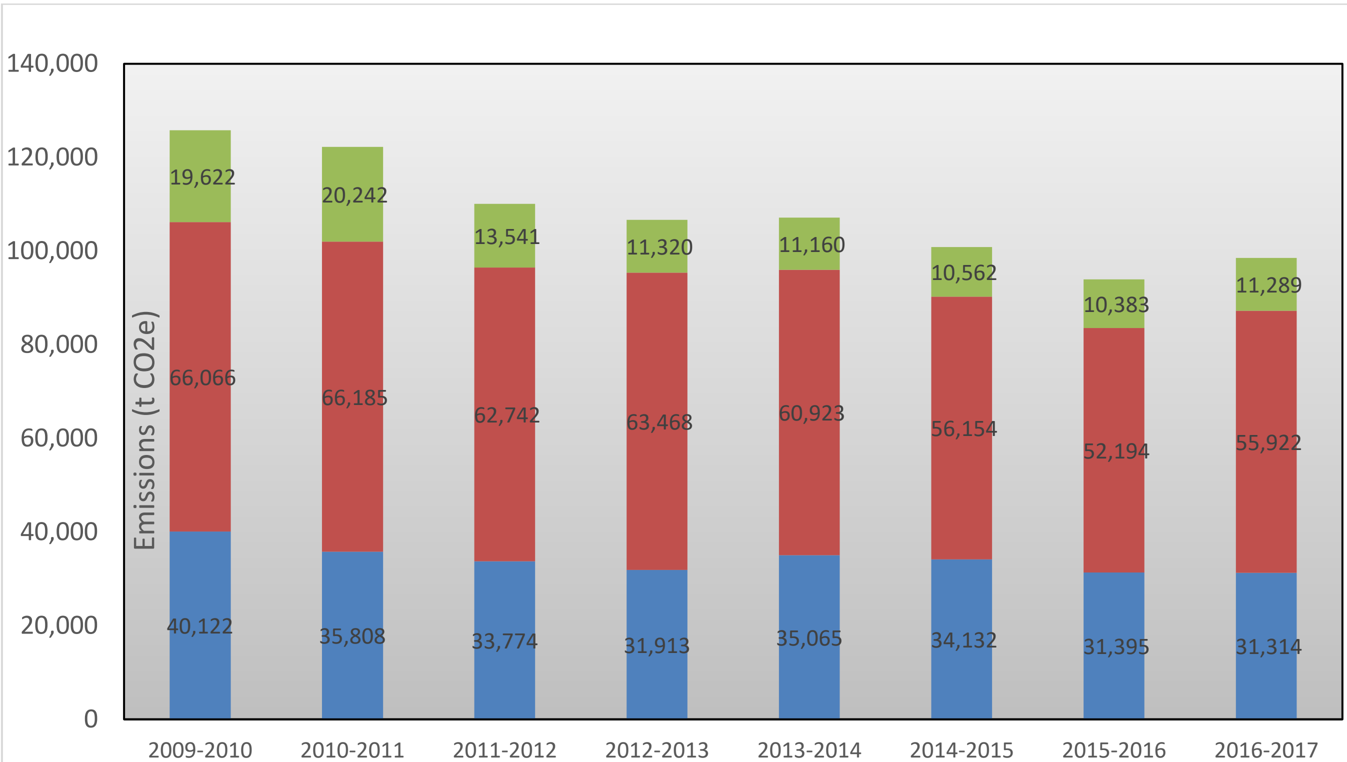


Figure 0.5 Comparison of annual emissions by scope for each year (Scope 1 is blue, Scope 2 is red, and Scope 3 is green)

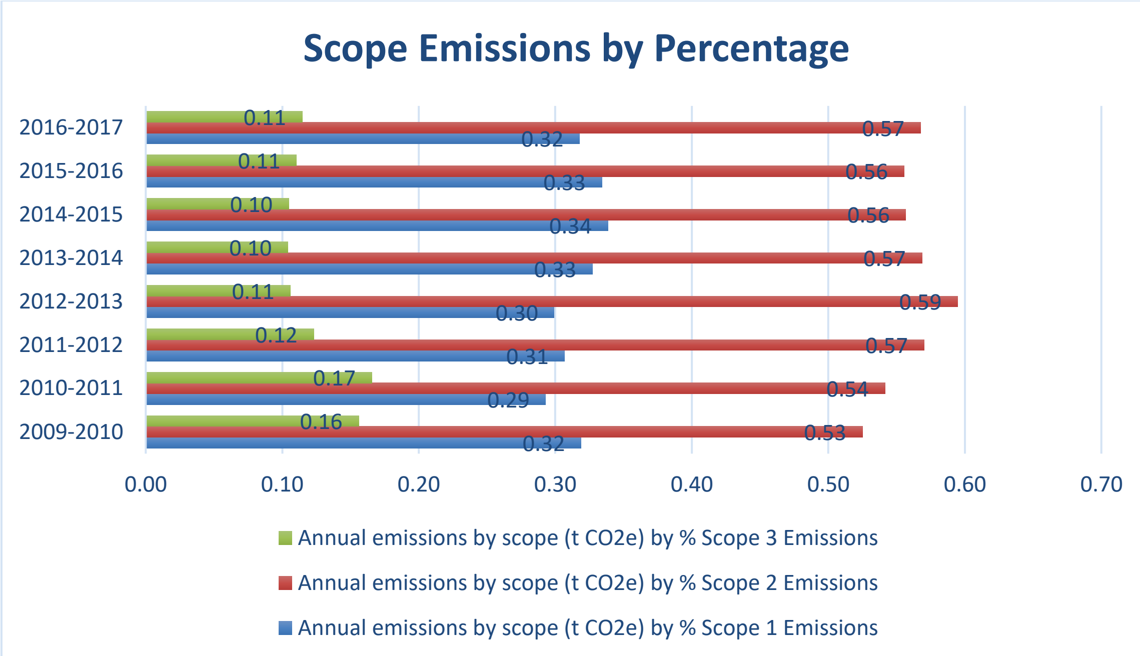


Figure 0.6 Annual emissions shown as percentage totals and scopes for each year

To gauge success of reduction of greenhouse gases, tables have been generated to track current and past emissions for easy comparison (Table 0.1). To determine the per person emissions ratio, a weighted campus user is determined. This value is based on time spent on campus, which is calculated as follows:

weighted campus users = # oncampus residence + 0.75(# full time employees and students) + 0.5(# part time employees and students)

Table 0.1 Dalhousie University emissions breakdown from 2009/10 to 2016/17

Dalhousie University (All Campuses) GHG Emissions (tCO2e)								
	2009-2010	**2010-2011**	**2011-2012**	**2012-2013**	**2013-2014**	**2014-2015**	**2015-2016**	**2016-2017**
Scope 1	40,122	35,808	33,774	31,913	35,065	34,132	31,395	31,134
Scope 2	66,066	66,185	62,742	63,468	60,923	56,154	52,194	55,922
Scope 3	19,622	20,242	13,541	11,320	11,160	10,562	10,383	11,289
Total emissions	125,810	122,235	110,057	106,701	107,148	100,848	93,972	98,345
Total emissions /person	6.521	6.108	5.319	5.244	5.241	4.838	4.508	4.738
Total emissions /square foot	0.025	0.024	0.021	0.020	0.020	0.018	0.017	0.018

1. INTRODUCTION

On December 11, 2009, Dalhousie's President signed the University and College's Climate Change Statement for Canada. This statement requires a comprehensive inventory of GHG emissions to be completed within one year of signing, and within two years of signing this document a climate plan with targets must be released. In 2010, Dalhousie released its first University Climate Change Plan and baseline GHG inventory. The plan includes a clear vision and targets (Figure 1.1). The annual GHG inventory report is a follow up to the baseline GHG inventory which allows comparisons to determine the progress of the university to meet the predetermined targets.

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.

Figure 1.1. Dalhousie's vision and targets

The *CAN/CSA-ISO 14064-1-06 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)* standard is used as a framework for this GHG inventory report. Calculations are derived from The Climate Registry (TCR) - General Reporting Protocol - version 2.1, January 2016 (The Climate Registry, 2016). Emission factors used are taken from TCR 2017 Default Emission (The Climate Registry, 2017), and Nova Scotia Power (Nova Scotia Power Inc., 2017). Terms and definitions are provided in Appendix A: Terms and Definitions . This report has been reviewed by staff of the Office of Sustainability. Periodically (2010, 2014, 2017) a third-party consulting firm has been hired to review GHG processes and reporting. Feedback from the third-party review of this report resulted in removal of R22 in reporting requirements for refrigerants, making small emission factor corrections, and claiming all district energy heating emissions including those related to energy provided to third-party customers. Other recommendations included formatting and notes clarifications for spreadsheets.

Figure 1.2. Investigating lighting upgrades at AC greenhouses

1.1. BOUNDARIES

An operational control approach was chosen by Dalhousie for this GHG inventory report, which requires the University to account for 100% of the GHG emissions over which they have direct operational control.

Dalhousie University owns 98 buildings and houses (including additions) across each of the three Halifax campuses: Studley, Carleton, and Sexton (Appendix C: List of Campus Buildings), as well as a property at 2209 Gottigen Street. Ninety-five percent of these buildings and some of the houses are on a district energy (DE) system where steam is created from natural gas at the Central Services Building. Steam and hot water is used for heating and some cooling. All properties are located on the peninsula of Halifax, NS. The total building floor space owned and operated by Dalhousie in Halifax is 4,776,466 square feet (Appendix C). During the 2016-2017 fiscal year, the University leased a small amount of space in hospitals and retail locations in Halifax.

The AC campus includes 45 buildings and houses totalling 812,810 square feet (Appendix C: List of Campus Buildings). Over 95% of all building space is on a DE system fed from a central biomass plant that uses fuel oil during the summer months and primarily wood chips during the rest of the year. During the 2016-2017 fiscal year, two properties were leased to Nova Scotia's Department of Agriculture. Note that emissions from buildings that are leased are included in greenhouse gas calculations as Dalhousie maintains operational control.

Leased space and facilities that are owned, but not financially operated by Dalhousie (such as Peter Green Hall) are considered to be outside the scope of the GHG inventory. The University sells steam to University of Kings College buildings, a National Research Council building (Oxford St. and Coburg Road), and the Halifax Law Court (Spring Garden Road). The GHG emissions associated with this steam is not included in the Dalhousie GHG totals as Dalhousie does not own these facilities. Emissions from fleet vehicles are included as part of the inventory calculations; however, rental and leased transportation use is not included due to insufficient tracking of the data to date.

The three main categories of GHG emissions (referred to as "Scope" by TCR:GRP 2.1) are:

- **Scope 1** (direct emissions): greenhouse gas 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 (The Climate Registry, 2016).
    - **Note: Biogenic CO_2** (biomass emissions): the *IPCC Guidelines for National Greenhouse Gas Inventories* requires that CO_2 emissions from biogenic sources be reported separately from any scope because the carbon in biomass was recently contained in living organic matter (The Climate Registry, 2016).

- **Scope 2** (indirect emissions): greenhouse gas 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 (The Climate Registry, 2016).

- **Scope 3** (other indirect emissions): 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 campus (The Climate Registry, 2016).

The Dalhousie GHG inventory identifies all direct (Scope 1) and indirect (Scope 2) emissions, as well as biogenic CO_2 emissions. Where credible data exists, Dalhousie also reports on optional indirect emissions sources that arise as a function of its business and educational 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. Stationary combustion
      - Emissions incurred through combustion of natural gas in the Halifax central plant for steam, hot water, cooling production, and some kitchens. Bunker B is on hand for back-up or peak shaving in Halifax. Light fuel oil is a summer fuel at the AC campus when biomass is not burned.
      - Emissions incurred through combustion of propane for food services and lab use on all campuses.
      - On-site heating fuel oil and natural gas for combustion in smaller houses in Halifax. At the AC, oil and electricity (heat pumps) is used for heating houses.
      - On campus diesel combustion for backup generators on all campuses.
      - Fugitive refrigerant losses from cooling units on all campuses.
      - Methane and nitrous oxide emissions generated by combustion of biomass at the AC central plant.

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

2. **Biogenic CO_2 emissions**
   - CO_2 emissions from biomass combustion at facilities operated by Dalhousie.

3. **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.

4. **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.
   - Future years may report other sources, such as waste, water, and natural environment.

1.3. REPORTED GHG EMISSIONS

GHG emissions from the following greenhouse gases will be reported. Definition information is provided by Environment Canada (Environment Canada, 2013) except NF_3 (Gore, 2013).

- **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. CO_2 is used: in carbonated drinks, in fire extinguishers, as dry ice for refrigeration, as well as many other things. CO_2 is present in the Earth's atmosphere at low concentrations and is constantly being removed from the air by its direct absorption into water and by plants through photosynthesis. In turn, it is naturally released into the air by plant and animal respiration, decay of plant and soil organic matter, and outgassing from water surfaces. Small amounts of CO_2 are also injected directly into the atmosphere by volcanic emissions and through slow geological processes such as the weathering of rock. 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. Like carbon dioxide, methane is exchanged naturally between the Earth's surface and the atmosphere, however, methane is removed from the atmosphere primarily through chemical processes involving the chemical hydroxyl radical, OH. These chemical interactions finally produce water and carbon dioxide. A small amount of methane is also absorbed directly by soils. Methane is present in the Earth's atmosphere at low concentrations and acts as a greenhouse gas. Methane is produced naturally during the decomposition of plant or organic matter in the absence of oxygen, as well as released from wetlands (including rice paddies), through the digestive processes of certain insects and ruminant animals such as termites, sheep, and cattle. 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. Used as an anesthetic in dentistry and surgery, nitrous oxide is released naturally from oceans, by bacteria in soils, and from animal wastes. Other 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. Nitrous oxide is present in the Earth's atmosphere at low concentrations and acts as a greenhouse gas.
- **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.

Emissions are not reported for the following GHGs because they are not used or emitted on Dalhousie property:

- **Perfluorocarbons (PFCs):** Perfluorocarbons (PFCs) are a group of synthetic chemicals composed of carbon and fluorine only. PFCs are powerful greenhouse gases that were introduced as alternatives to ozone depleting substances. PFCs replace chlorofluorocarbons (CFCs) in manufacturing semiconductors and are also emitted as a by-product of industrial processes and manufacturing.
- **Sulphur Hexafluoride (SF_6):** Sulphur hexafluoride (SF_6) is a synthetic gas that is colourless, odorless, non-toxic (except when exposed to extreme temperatures), and non-flammable. SF_6 acts as a greenhouse gas due to its very high heat trapping capacity. SF_6 is primarily used in the electricity industry as an insulating gas for high voltage equipment and as cover gas in the magnesium industry to prevent oxidation (combustion) of molten magnesium. In lesser amounts, SF_6 is used in the electronic industry in manufacturing of semiconductors, and also as tracer gas for gas dispersion studies in the industrial and laboratory settings.
- **Nitrogen Trifluoride (NF_3):** Nitrogen trifluoride has been recently added to the GHG protocol. NF_3 is an inorganic chemical used in high-tech industrial processes. Through manufacturing of products such as semiconductors, some solar panels, and semi-conductors, NF_3 can be released.

1.4. GHG EMISSION CALCULATIONS

Greenhouse gas emissions are calculated by methods outlined in The Climate Registry (TCR) General Reporting Protocol (GRP) v.2.1, 2016 (The Climate Registry, 2016). The data and calculations used for this inventory are shown in detail in the following sections of this report. Emission factors were found in The Climate Registry's 2017 Default Emission Factors (The Climate Registry, 2017), with the exception of emission factors for electricity, which were obtained from Nova Scotia Power (Nova Scotia Power Inc., 2017).

Figure 1.3 Steam Pipe Insulation saves energy from steam distribution system.

2. GHG EMISSIONS INVENTORY

When calculating the annual greenhouse gas emissions created by Dalhousie University, three main subsets are assessed: Scope 1, Scope 2, and Scope 3. Within each subset, the focus of the data was divided into two further subsets: a description of where the data is from, as well as a detailed breakdown of the calculations.

2.1 SCOPE 1 EMISSIONS

Scope 1 emissions include “all direct anthropogenic greenhouse gas emissions” (The Climate Registry, 2016).

2.1.1. Overview

Fuels (Halifax campuses): Dalhousie University has a central plant, located at 1236 Henry Street, which provides heating to most Halifax campus buildings through a district energy system. Steam is provided to Studley and Carleton campus buildings. The steam is converted to hot water at the Tupper Bld (Carleton campus). From this building, a direct buried insulated hot water line runs 1 km to the Sexton campus. At the Sexton campus all buildings connected to the network use hot water for heating. The plant also provides central cooling through a chilled water loop to key buildings on the Studley and Carleton campuses. At the central plant, cooling is generated through an electric and absorption (steam) chiller. The central plant boilers are fuelled by natural gas with back up heating as Bunker B oil. Prior to 2012, Bunker C was used, then a change to Bunker A was implemented in 2012 and 2013, followed by a change to Bunker B from 2014 onward. Cooling is also provided to newer buildings through individual cooling systems. Some buildings do not have air conditioning. Houses have individual oil fired or gas furnaces, though a few houses on Seymour and Henry Street are connected to the steam line. One building, O’Brien Hall, is not connected to the distribution system and is using electric heat. 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. Solar thermal and air systems reduce load on three buildings.

Fuels (Agricultural campus): Dalhousie University has a central plant, located at 43 River Rd., which provides heating to most AC buildings through a district energy system. The central heating plant consumes biomass (wood chips) and #2 fuel oil (furnace oil) to produce steam for the main Agricultural Campus. Diesel is used for back-up generators, as well as for fleet vehicles and equipment. Propane is used in kitchen services and labs. Some smaller houses not connected to the District Energy System use oil and electricity (heat pumps). There are a handful of smaller buildings/houses off the main campus that are used for research purpose. Heating systems use electricity, oil, and geo-exchange.

The Department of Facilities Management inputs fuel consumption data into FAMIS which is read by Tableau Reader software accessible to the Office of Sustainability. This GHG Inventory Report presents historical consumption data found in Tableau Reader.

Refrigerants (Halifax and Agricultural campuses): Primary refrigerant use occurs in air conditioning systems on campuses.

Refrigerants and air conditioning units are a major source of hydrofluorocarbons (HFCs), which have a much higher global warming potential than carbon dioxide. Fugitive emissions from refrigeration and air conditioning equipment are therefore important considerations in calculating an institution’s GHG emissions.

Dalhousie's Halifax campuses 2016/2017 refrigerant loss data was supplied to the Office of Sustainability from Hussmann and Trane (3rd party contractors for the Halifax campuses). Ainsworth and Conroy (3rd party contractors for the Agricultural campus) provide data for refrigerants for the AC.

The global warming potentials used in the refrigerant emissions calculations were sourced from The Climate Registry's 2017 Default Emission Factors (The Climate Registry, 2017).

Appendix G: Global Warming Potentials of Refrigerants and Blends (Tables B.1, B.2, and B.3, 2017 Climate Registry Default Emission Factors, p. 75-83)).

Fleet (Halifax and Agricultural campuses): The Dalhousie fleet consists of vehicles owned by Dalhousie that operate within and between the campuses in Halifax and the AC. The Dalhousie fleet vehicles are used for landscaping, mail deliveries, farming, snow removal, security, field research, garbage collection, and other purposes. A list of fleet vehicles and owners (Appendix K: Fleet Vehicles on Campus) was provided by the University Risk Manager who oversees the insurance of all Dalhousie owned vehicles. Fuel purchase records are not kept for every vehicle and therefore mileage of each fleet vehicle during the reporting period was obtained through an online survey to vehicle managers. If there is missing data, estimates are used based on a proxy of comparable reported vehicle data.

2.1.2. Calculations

Fuels: Central Heating Plant - natural gas (back up bunker B) and biomass (at the AC); House heating (furnace oil and natural gas); Back-up generators (diesel); Cooking and lab equipment (propane).

The available data for CO_2, CH_4, and N_2O emissions from stationary combustion is assessed according to the TCR:GRP 2.1 methodology and qualifications (formally Data Quality Tiers) (The Climate Registry, 2016). The current qualifications are based on data availability during preparation of this report.

Direct emissions monitoring is not currently in place, which would require sensors to be placed at exit points to allow for 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 GRP ST-04-CO_2 (formally 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 used is known, therefore it falls under GRP ST-06-CH_4 & N_2O (formally Tier B).

According to TCR:GRP 2.1 (The Climate Registry, 2016), biogenic CO_2 emissions ($BioCO_2$) must be reported separately from fossil fuel emissions, while biogenic CH_4 and N_20 emissions must be reported with fossil fuel emissions. This is assuming the amount of CO_2 released to the atmosphere during the combustion of biomass is equal to the amount of CO_2 absorbed during the plant growth (B.C. Ministry of Environment, 2013).

Direct stationary combustion emissions were calculated by using the following steps:
1. Determine annual fuel consumption at each campus
2. Determine appropriate CO_2 emission factor for each fuel type

Emissions factors are based on TCR's 2017 Default Emission Factors in grams of CO_2 / unit of fuel combusted (Appendix E: Canadian Default Factors for Calculating CO2 Emissions from Combustion of Natural Gas, Petroleum Products, and Biomass (Table 12.2, 2017 Climate Registry Default Emissions Factors)

Determine the appropriate CH_4 and N_2O emission factor for each fuel

Emissions factors are based on TCR's 2017 Default Emission Factors in grams of CH_4 / unit and grams of N_2O / unit of fuel combusted.

Light Fuel Oil Residential	n/a	38.80	1	2753
Light Fuel Oil Forestry, Construction, Public Administration, Commercial/Institutional	n/a	38.80	1	2753
Heavy Fuel Oil (Electric Utility, Industrial, Forestry, Construction, Public Administration, Commercial/Institutional)	n/a	42.50	1	3156
Heavy Fuel Oil (Residential)	n/a	42.50	1	3156
Heavy Fuel Oil (Producer Consumption)	n/a	42.50	1	3190
Kerosene (Electric Utility, Industrial, Producer Consumption, Residential, Forestry, Construction, Public Administration, Commercial/Institutional)	n/a	37.68	1	2560
Diesel	n/a	38.30	1	2690
Petroleum Coke from Upgrading Facilities	n/a	40.57	1	3494
Petroleum Coke from Refineries & Others	n/a	46.35	1	3826
Still gas (Upgrading Facilities)	n/a	43.24	1	2140
Still gas (Refineries & Others)	n/a	36.08	1	1919

Appendix F: Default CH4 and N2O Emission Factors by Technology Type for the Commercial Sector (Table 12.4, 2017 Climate Registry Default Emissions Factors)), 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.

3. Calculate the CO_2 emissions for each fuel type and convert to metric tonnes (The Climate Registry, 2016)

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

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

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

Canadian Emission Factor Equivalent:

Fuel A CO_2 Emissions (metric tons) =
Fuel consumed (litres) x Emission Factor (metric ton CO_2 / litre)

4. Calculate the CH_4 and N_2O emissions for each fuel type (The Climate Registry, 2016)

Fuel/Technology Type A
CH_4 Emissions = Fuel Use × Emission Factor ÷ 1,000,000
(metric tons) (MMBtu) (g CH_4/MMBtu) (g/metric ton)

Canadian Emission Factor Equivalent:

Fuel/Technology Type A
CH_4 Emissions = Fuel Use × Emission Factor
(metric tons) (Litres) (metric tons CH_4/L)

Fuel/Technology Type A
N_2O Emissions = Fuel Use × Emission Factor ÷ 1,000,000
(metric tons) (MMBtu) (g CH_4/MMBtu) (g/metric ton)

Canadian Emission Factor Equivalent:

Fuel/Technology Type A
N_2O Emissions = Fuel Use × Emission Factor
(metric tons) (Litres) (metric tons N_2O/L)

5. Convert CH_4 and N_2O emissions to units of CO_2 equivalence and determine total emissions from stationary combustion (The Climate Registry, 2016)

$$\underset{\text{(metric tons } CO_2e)}{\mathbf{CO_2\ Emissions}} = \underset{\text{(metric tons)}}{CO_2\text{ Emissions}} \times \underset{\text{(GWP)}}{1}$$

$$\underset{\text{(metric tons } CO_2e)}{\mathbf{CH_4\ Emissions}} = \underset{\text{(metric tons)}}{CH_4\text{ Emissions}} \times \underset{\text{(GWP)}}{21}$$

$$\underset{\text{(metric tons } CO_2e)}{\mathbf{N_2O\ Emissions}} = \underset{\text{(metric tons)}}{N_2O\text{ Emissions}} \times \underset{\text{(GWP)}}{310}$$

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

The results of the above calculations are presented in Table 2.1 and

Table 2.2. The emission factor shown is the cumulative emission factor for CO_2, CH_4, and N_2O.

Table 2.1 Scope 1: Summary of Direct Emissions from Stationary Combustion, Halifax Campuses (April 2016-March 2017)

Energy Source	Consumption	Unit	CO_2e Emission Factor (tCO_2e/unit)	GHG Emissions CO_2 (tCO_2e)	GHG Emissions CH_4 (tCO_2e)	GHG Emissions N_2O (tCO_2e)	Total GHG Emissions (tCO_2e)
Furnace Oil	28,226	L	0.002753	77.71	0.02	0.04	**78**
Bunker B Oil	506,236	L	0.0030754	1,556.88	1.38	7.70	**1,566**
Diesel	35,093	L	0.00269	94.40	0.13	3.72	**98**
Propane	10,550	L	0.001515	15.98	0.01	0.30	**16**
Natural Gas	533,649	GJ	0.04968636	26,515.08	14.45	129.37	**26,659**
Sub Total				**28,260.04**	**15.99**	**141.13**	**28,417**
Dalhousie provides steam to University of King's College (235,651 sq/f) NRC (30,000), Halifax Law Courts (100,000+) = (external steam/total steam)*total emissions.							
Total GHG emissions (Halifax)							**28,417**

Table 2.2 Scope 1: Summary of Direct Emissions from Stationary Combustion, AC (April 2016-March 2017)

Energy Source	Consumption	Unit	CO2e Emission Factor (tCO_2e/unit)	GHG Emissions CO_2 (tCO_2e)	GHG Emissions CH_4 (tCO_2e)	GHG Emissions N_2O (tCO_2e)	Total GHG Emissions (tCO_2e)
Furnace Oil	621,767	L	0.00275225	1,711.26	2.35	5.98	**1,720**
Diesel	2,657	L	0.00269	7.15	0.01	0.33	**7**
Propane	55,728	L	0.001515	84.43	0.03	1.87	**86**
Wood	8,579,977	kg	0.000848	-	21.62	136.42	**158**
Total				**1802.83**	**24.01**	**144.59**	**1,971**

BioC0₂, as previously mentioned, is not recorded as a direct emission. It must be calculated, but is omitted from the total emissions as shown in

Table 2.2. For the 2016-2017 fiscal year, the wood consumption at the AC resulted in 8,580 of $tBioCO_2$.

Refrigerants

The TCR:GRP 2.1 FG-02 simplified mass balance approach is used to calculate fugitive refrigerant emissions. The following steps were followed (Table 2.3 and Table 2.4):

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

Table 2.3 Scope 1: Summary of Refrigerant GHG Emissions, Halifax Campuses (April 2016 - March 2017)

Refrigerant Name	Consumption (Loss) (tRefrigerant)	GWP (tCO_2e/tRefrigerant)	Total GHG Emissions (tCO_2e)
R134A	0.04536	1300	58.97
R401A	0.00907	18	0.16
R402A	0.01361	1902	25.88
R404A	0.01315	3943	51.87
R407C	0.03810	1624	61.88
R410A	0.03266	1924	62.84
RS52	0.02177	3607	78.53
Total GHG Emissions			**340.13**

***The global warming potential was obtained from Refrigerant Solutions Ltd. (RSL, Refrigerant Solutions Ltd, 2012) and the Climate Registry's 2017 Default Emission Factors.**

Table 2.4 Scope 1: Summary of Refrigerant GHG Emissions, AC (April 2016 - March 2017)

Refrigerant Name	Consumption (Loss) (tRefrigerant)	GWP (tCO_2e/tRefrigerant)	Total GHG Emissions (tCO_2e)
R134A	0.00272	1300	3.54
R437A	0.01270	1639	20.82
R438A	0.00227	2059	4.67
R507A	0.03402	3895	132.51
Total GHG Emissions			**161.53**

Fleet Vehicles

The methodology for mobile combustion as per the TCR:GRP 2.1 was followed (Appendix J: Data Quality Tiers for Mobile Combustion Emissions). Factors from TCR 2017 Default Emission Factors (The Climate Registry, 2017) were used.

Mobile combustion CO_2 emissions were determined using the methodology GRP MO-04-CO_2 (formally Tier C) in which fuel use is estimated by using vehicle mileage and vehicle fuel economy, and default CO_2 emission factors by fuel type. CH_4 and N_20 emissions were calculated using methodology GRP MO-06-CH_4 & N_2O (formally Tier B), as the model year and mileage travelled by each vehicle can be determined.

Direct emissions from mobile combustion are calculated using the following steps:

1. Calculate CO_2 emissions from mobile combustion

a) Identify total annual fuel consumption by fuel type

Tier C Method: Estimation based on miles travelled and fuel economy (The Climate Registry, 2016)

$$\underset{\text{(gallons)}}{\textbf{Fuel Use}} = \underset{\text{(miles)}}{\text{Distance}} \div [(\underset{\text{(mpg)}}{\text{City FE}} \times \text{City \%}) + (\underset{\text{(mpg)}}{\text{Highway FE}} \times \text{Hwy \%})]$$

FE = Fuel Economy

Canadian Conversion (neglecting highway fuel efficiency because fleet vehicles are almost entirely driven in city):

$$\underset{\text{(liters)}}{\textbf{Fuel Use}} = \underset{\text{(km)}}{\text{Distance}} \div \underset{\text{(L/km)}}{\text{City FE}}$$

Fuel economies were estimated using the online tool Natural Resources Canada Fuel Consumption Guide. Appendix K: Fleet Vehicles on Campus lists the vehicles used on campus during the 2016-2017 fiscal year. In some situations where data was incomplete, a proxy amount was entered based on similar vehicle type and use.

2. Select appropriate CO_2 emission factor for each fuel type (The Climate Registry, 2017)

3. Calculate total CO_2 emissions and convert to metric tonnes (The Climate Registry, 2016)

$$\underset{\text{(metric tonnes)}}{\textbf{Fuel A CO}_2\textbf{ Emissions}} = \underset{\text{(gallons)}}{\text{Fuel Consumed}} \times \underset{\text{(metric tonne CO}_2\text{/gallon)}}{\text{Emission Factor}}$$

Canadian Conversion:

$$\underset{\textbf{(metric tonnes)}}{\textbf{Fuel A CO}_2\textbf{ Emissions}} = \underset{\text{(litres)}}{\text{Fuel consumed}} \times \underset{\text{(metric tonne CO}_2\text{ / litre)}}{\text{Emission Factor}}$$

4. Calculate CH_4 and N_20 emissions from mobile combustion

The CH_4 and N_2O emissions of Dalhousie's fleet vehicles were calculated by using the TCR Default Emission Factors: "CH_4 and N_2O Emission Factors for Highway Vehicles by Model Year" (Appendix L: Canadian Default Co2, N20 and CH4 Emission Factors for Transport Fuels (Table 13.2 & 13.3, 2017 Climate Registry Default Emissions Factors)).

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

Mobile combustion emission calculation results are presented in Table 2.5 and Table 2.6:

Table 2.5 Scope 1: Fleet Vehicle Emissions, Halifax Campuses (April 2016 - March 2017)

Energy Source	Consumption	Unit	Emission Factor (tCO_2 / unit)	Total GHG Emissions (tCO_2e)
Gasoline	34,473	Litres	0.00232	**80.23**
Diesel Fuel	14,647	Litres	0.00269	**39.56**
Total				**120**

Table 2.6 Scope 1: Fleet Vehicle Emissions, AC (April 2016 - March 2017)

Energy Source	Consumption	Unit	Emission Factor (tCO_2 / unit)	Total GHG Emissions (tCO_2e)
Gasoline	34,473	Litres	0.00232	**51.99**
Diesel Fuel	14,647	Litres	0.00269	**71.48**
Total				**123**

Table 2.7 Scope 1: Summary of Emissions (April 2016 - March 2017)

	Stationary Combustion	Refrigerants	Fleet	Total GHG Emissions (tCO_2e)
HFX 2016-2017	28,417	340	120	28,877
AC 2016-2017	1,972	162	123	2,257
Combined	30,389	502	243	**31,134**

2.2. SCOPE 2 EMISSIONS

Scope 2 emissions are "indirect anthropogenic greenhouse gas emissions associated with the consumption of purchased or acquired electricity, steam, heating, or cooling" (The Climate Registry, 2016).

2.2.1. Overview

Halifax campuses: Electricity is provided to the Halifax campuses 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 Carleton campuses. Furthermore, most of the buildings on Sexton campus are supplied downstream from a main feed in the B

Building. Other buildings and houses have individual accounts and are fed from the street power lines. Electricity is used for lights, HVAC systems, labs, equipment, and for cooling (electric chiller) and heating in some limited locations.

Agricultural campus: Electricity is provided to the agricultural campus by Nova Scotia Power. There are two main electrical feeds on campus that include campus transformers. These feeds provide electricity to main buildings. There are a number of smaller buildings and houses that have individual accounts and are fed from the street power lines.

2.2.2. Calculations

Indirect Emissions from Electricity

Emission factors are available directly from Nova Scotia Power Inc. (Nova Scotia Power Inc., 2017), which satisfies the standards of GRP ST-01-CO_2 and GRP ST-05-CH_4 & N_2O (formally Tier A) in determining indirect emissions from electricity (Appendix H: Data Quality Tiers for Electricity).
Scope 2 electricity emissions were calculated by using the following steps:

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. (NSPI) emission intensity table (Appendix I: Nova Scotia Power Emission Factors).
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 presented in Table 2.8 and Table 2.9.

Table 2.8 Scope 2: Summary of Electricity GHG Emissions, Halifax Campuses (April 2016 -March 2017)

Energy Source	Consumption	Unit	Emission Factor (tCO_2e / unit)	Total GHG Emissions (tCO_2e)
Electricity	69,586,506	kWh	0.0007	**48,718**

Table 2.9 Scope 2: Summary of Electricity GHG Emissions, AC (April 2015-March 2016)

Energy Source	Consumption	Unit	Emission Factor (tCO_2e / unit)	Total GHG Emissions (tCO_2e)

Electricity	10,290,282	kWh	0.0007	**7,204**

Note: Total tCO_2e includes CH_4 and N_2O as emission factors used by NS Power has already factored their associated emissions.

2.3. SCOPE 3 EMISSIONS

Scope 3 emissions are **"**all other (non-scope 2) indirect anthropogenic GHG emissions that occur in the value chain. Examples of scope 3 emissions include emissions resulting from the extraction and production of purchased materials (such as paper) and fuel, employee commuting and business travel, use of sold products and services, and waste disposal" (The Climate Registry, 2016).

2.3.1. Overview

Commuting: Commuting emissions are emissions created from employees and students travelling to and from Dalhousie University.

Transportation statistics were gathered from the Dalhousie University Annual Sustainability and Commuting Survey conducted in March 2017 (DalTRAC, 2017).

2.3.2. Calculations

Indirect Emissions from Commuting

Commuter travel emission calculations rely on several assumptions, as vehicle fuel economy is averaged, the number of full-time/part-time student and employee commuter days is averaged, and survey data is extrapolated and applied across the entire campus population. An estimated value of emissions for commuter travel was deemed important to gauge for future transportation demand management planning.

Figure 2.1 shows the blended (where full time = 1, part time = 0.5) percentages at the Halifax campuses (Figure 2.2 shows the Truro campus) of modes of transportation used during the past year by students, staff, and faculty.

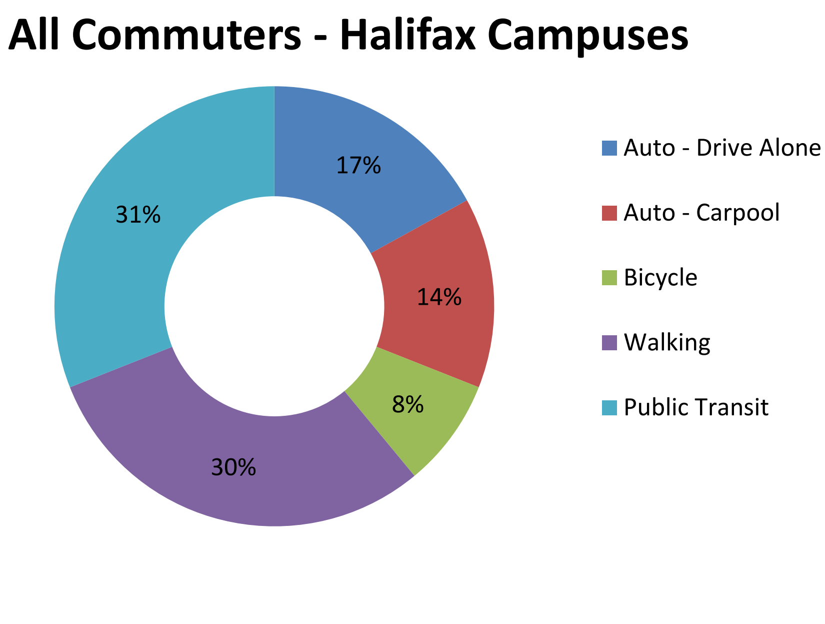


Figure 2.1 Blended Commuting Mode Percentages (Halifax campuses)

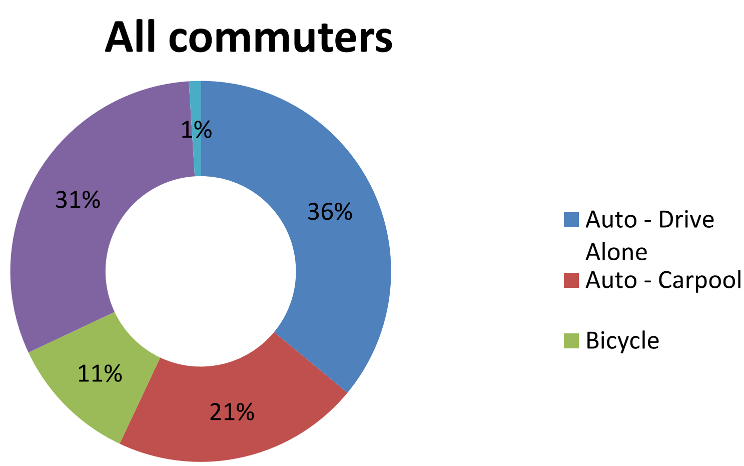


Figure 2.2 Blended Commuting Mode Percentages (AC)

The commuter transportation emission calculations focus on travel to and from campus for work and educational purposes. This does not include intercampus or business travel.

Calculations:

Transport Canada's commuting emission factor was used in transit calculations (Transport Canada, 2011) (Appendix N: Commuting Emissions by Province from Transport Canada . The following steps were used to calculate commuting travel emissions (Table 2.10 and Table 2.11), as well as the emissions avoided by using active transportation (Table 2.12 and Table 2.13):

<u>1. Identify number of employees and students who travelled by mode</u>

a) Survey data was used to identify travel mode percentages (DalTRAC, 2017).
b) Travel mode percentages are multiplied by the number of full time equivalents for that year (weighted campus population number).
c) The percentage of students and employee days on campus were multiplied by each transportation mode percentage by the weighted campus population percentages for students and employees.

<u>2. Determine kilometers travelled by mode</u>

a) Set the average number of kilometers travelled daily by mode. The average is 40 kilometers round trip.
For carpooling, the drive alone distance was divided in half during the emissions calculations.
Because the public transit system typically operates only within the Halifax Regional Municipality, an average of 20 km round trip was used for commuting emissions calculations.
To demonstrate how much GHG emissions are reduced, 4 km was assumed the maximum distance from campus for cycling (8 km round trip), so an average of 5 km round trip was used
For walking, 2.5 km was assumed the maximum distance from campus (5 km round trip), so an average of 3 km round trip was used. The same distances for walking and bicycling were used for both Halifax and AC. These numbers are reflected in time usage data also reported on by mode in the Commuter Report.

Determined the number of days in the year traveled.

Moderate Control	0.068	0.21
Uncontrolled	0.10	0.16
Light-Duty Diesel Trucks (LDDTs)		
Advance Control*	0.068	0.22
Moderate Control	0.068	0.21
Uncontrolled	0.085	0.16
Heavy-Duty Diesel Vehicles (HDDVs)		
Advance Control	0.11	0.151
Moderate Control	0.14	0.082
Uncontrolled	0.15	0.075
Gas Fueled Vehicles		
Natural Gas Vehicles	0.009	6E-05
Propane Vehicles	0.64	0.028
Off-Road Vehicles		
Off-Road Gasoline	2.7	0.05
Off-Road Diesel	0.15	1
Railways		
Diesel Train	0.15	1
Marine		
Gasoline Boats	0.23	0.067
Diesel Ships	0.25	0.073
Light Fuel Oil Ships	0.25	0.073
Heavy Fuel Oil Ships	0.28	0.08
Aviation		
Aviation Gasoline	2.2	0.23
Aviation Turbo Fuel	0.029	0.071

b) Appendix M: Annual Commuting Travel Days identifies average number of days travelled by employees and students. It is important to note that approximately 90% of students are at Dalhousie for eight months, while 10% of students are at Dalhousie for twelve months.
c) Multiplied the average kilometers travelled by mode by the number of days travelled per year by the number of commuters to determine the total kilometers traveled.

<u>3. Multiply kilometers travelled by Transport Canada's emission factor for CO_2, CH_4, and N_2O for driving, use EPA emission factor for bus emissions</u>

a) Transport Canada supplies an emission factor of 258 grams of CO_2e emissions per each kilometer driven (Transport Canada, 2011) (Appendix N: Commuting Emissions by Province from Transport Canada , and the EPA provides an emission factor of 66.69 grams of CO_2e emissions per each kilometer driven and passenger (EPA, 2008).

<u>4. Divide drive alone emissions to find carpooling emissions</u>

a) Divide kilometers travelled while carpooling by two to determine the emissions created by carpooling (SmartTrip Dalhousie , n.d.).

Table 2.10 Scope 3: Summary of Commuting GHG Emissions, Halifax Campuses (April 2016 - March 2017)

Commuter	Annual Distance (km)	Emission Factor (tCO_2e/km)	Total GHG Emissions (tCO_2e)
Drive alone	22,523,330	0.000258	**5,811**
Car Pool	9,274,312	0.000258	**2,393**
Transit	20,535,977	0.00006659	**1,367**
Total Emissions Created:			**9,571**

Table 2.11 Scope 3: Summary of Commuting GHG Emissions, AC (April 2016 - March 2017)

Commuter	Annual Distance (km)	Emission Factor (tCO_2e/km)	Total GHG Emissions (tCO_2e)
Drive alone	2,783,862	0.000258	**718**
Car Pool	3,863,199	0.000258	**997**
Transit	38,665	0.00006659	**3**
Total Emissions Created:			**1,718**

Table 2.12 Scope 3: Summary of GHG Emissions avoided by Active Transport, Halifax Campuses (April 2016-March 2017)

Commuter	Annual Distance (km)	Emission Factor (tCO_2e/km)	Total GHG Emissions

			(tCO$_2$e)
Bicycle	1,324,902	-0.000258	**-342**
Walking	2,981,029	-0.000258	**-769**
Total Emissions Created:			**-1,111**

Table 2.13 Scope 3: Summary of GHG Emissions avoided by Active Transport, AC (April 2016 - March 2017)

Commuter	Annual Distance (km)	Emission Factor (tCO$_2$e/km)	Total GHG Emissions (tCO$_2$e)
Bicycle	106,328	-0.000258	**-27**
Walking	179,791	-0.000258	**-46**
Total Emissions Created:			**-74**

3. REDUCING GHG EMISSIONS

The first edition of the Dalhousie Climate Change Plan was released in 2010. A second version of the plan including the AC will be issued in 2018. In preparation for the revision of the plan, students and staff of the Office of Sustainability and external advisors have been working on climate modelling and additional surveying. In the last seven years, the university and partners have invested over $90 million in sustainability-related projects many of them which are energy and climate related.

In the 2016-2017 fiscal year, a variety of projects were undertaken to reduce greenhouse gases and mitigate the impacts of climate change including:

- implementation of major energy and water efficiency projects for the Tupper Medical Building and Student Union Building.
- working with FM planners and project managers/operators to build energy and water efficiency into operational and facilities renewal. Examples of implemented projects include conversion of Sexton steam line to hot water line, thermal envelope enhancements to buildings, steam pipe insulation, and set back schedules.
- re-commissioning phase 2 of a major building.
- Implementing building solar pv systems on campus.
- campus-wide lighting upgrades at the Agricultural campus.
- implementation of bicycle parking.
- participation of 300 employees in the Employee Bus Program. Dal also has a student bus pass.

Figure 2.3 Weldon Law PV system

4. NEXT STEPS

Several projects that will significantly reduce Dalhousie University's GHG emissions are currently being planned. They include:

- Sustainability retrofitting projects – small to large: Dalhousie has over 5.5 million square feet of building space and over 150 buildings/houses on all four campuses. Business cases have been developed and approved in 2016-2017 for future work include:
    - Steam pipe insulation (phase Two);
    - LSC solar optimization and pumping;
    - Building envelope thermal study and standards development; and
    - Full building retrofit of Chemistry Building
    - Greenhouses Study
    - IDEA Project at Sexton Campus (includes a number of energy features)
    - Central Heating Plant (AC): Co-generation biomass system and steam to hot water conversion

The Office is taking part in the planning of other large capital projects as part of project team for the:

- Central Heating Plant (HFX) Renewal and co-generation
- LEED programming for New Construction with emphasis on energy performance

Office staff are exploring other GHG mitigating solutions such as renewable natural gas procurement, renewable energy power purchase agreements, carbon offsetting (focused on local renewable energy and land protection); and District Energy upgrades.

5. Bibliography

B.C. Ministry of Environment. (2013). *2013 B.C. Best Practices Methodology for Quantifying Greenhouse Gas Emissions.* Victoria, B.C., Canada.

Balakrishnan, P. (2014). *Refrigerant Management Plan for Dalhousie University's Agricultural Campus.* Dalhousie Office of Sustainability & Department of Facilities Management.

Dalhousie University. (n.d.). *Campus Map.* Retrieved July 6, 2013, from Dalhousie University Inspiring Minds: campusmaps.dal.ca/

DalTRAC. (2017). *Dalhousie University Commuter Study 2017.* DalTRAC, Dalhousie Transportation Collaboratory, Halifax.

Environment Canada. (2013, June 21). *Environment Canada*. Retrieved July 15, 2013, from Definitions and Glossary: http://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=B710AE51-1#footnote2

Environment Canada. (2017). *National Inventory Report 1990–2015: Greenhouse Gas Sources and Sinks in Canada.* Retrieved July 19, 2017

EPA. (2008, May). *Optional Emissions from Commuting, Business Travel and Product Transport.* Retrieved December 23, 2013, from EPA Climate Leaders: http://www.epa.gov/climateleadership/documents/resources/commute_travel_product.pdf

Gore, J. (2013, May 28). *GHG Protocol adds NF3 to reporting guidelines: What is it and why does it matter?* Retrieved December 23, 2013, from 2degrees: https://www.2degreesnetwork.com/groups/energy-carbon-management/resources/ghg-protocol-adds-nf3-reporting-guidelines-what-it-and-why-does-it-matter/

National Standard of Canada. (2006). Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals. *International Standard*, 1-5.

Nova Scotia Power Inc. (2017). *Total Emissions (All Plants).* Retrieved July 30, 2016, from Nova Scotia Power: An Emera Company: http://www.nspower.ca/en/home/about-us/environmental-commitment/air-emissions-reporting/total-system-emissions-all-plants.aspx

RSL, Refrigerant Solutions Ltd. (2012). *RS-24 (R426A).* Altrincham, England.

SmartTrip Dalhousie . (n.d.). *Dalhousie University*. Retrieved December 23, 2017, from Rideshare Parking: https://www.dal.ca/dept/sustainability/smart-trip/parking/carpool-parking.html

The Climate Registry. (2016, January). General Reporting Protocol for the Voluntary Reporting Program. California, United States.

The Climate Registry. (2017, March). *2017 Default Emission Factors.* Retrieved from The Climate Registry: https://www.theclimateregistry.org/tools-resources/reporting-protocols/general-reporting-protocol/

Transport Canada. (2011, August 12). *Workplace Travel Plans – Guidance for Canadian Employers.* Retrieved July 11, 2013, from Urban Transportation Emission Calculator - Case Studies: http://wwwapps.tc.gc.ca/Prog/2/UTEC-CETU/HTML/casestudies.htm

U.S. Environmental Protection Agency. (2010). *Transitioning Low-GWP Alternatives in Commercial Refrigeration.*

6. APPENDICES

Appendix A: Terms and Definitions (National Standard of Canada, 2006)

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

base 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
NOTE: This part of ISO 14064 uses the concepts of financial and operational control to establish an organization's operational boundaries

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 (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6)

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
NOTE: A greenhouse gas emission or removal factor could include an oxidation component

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

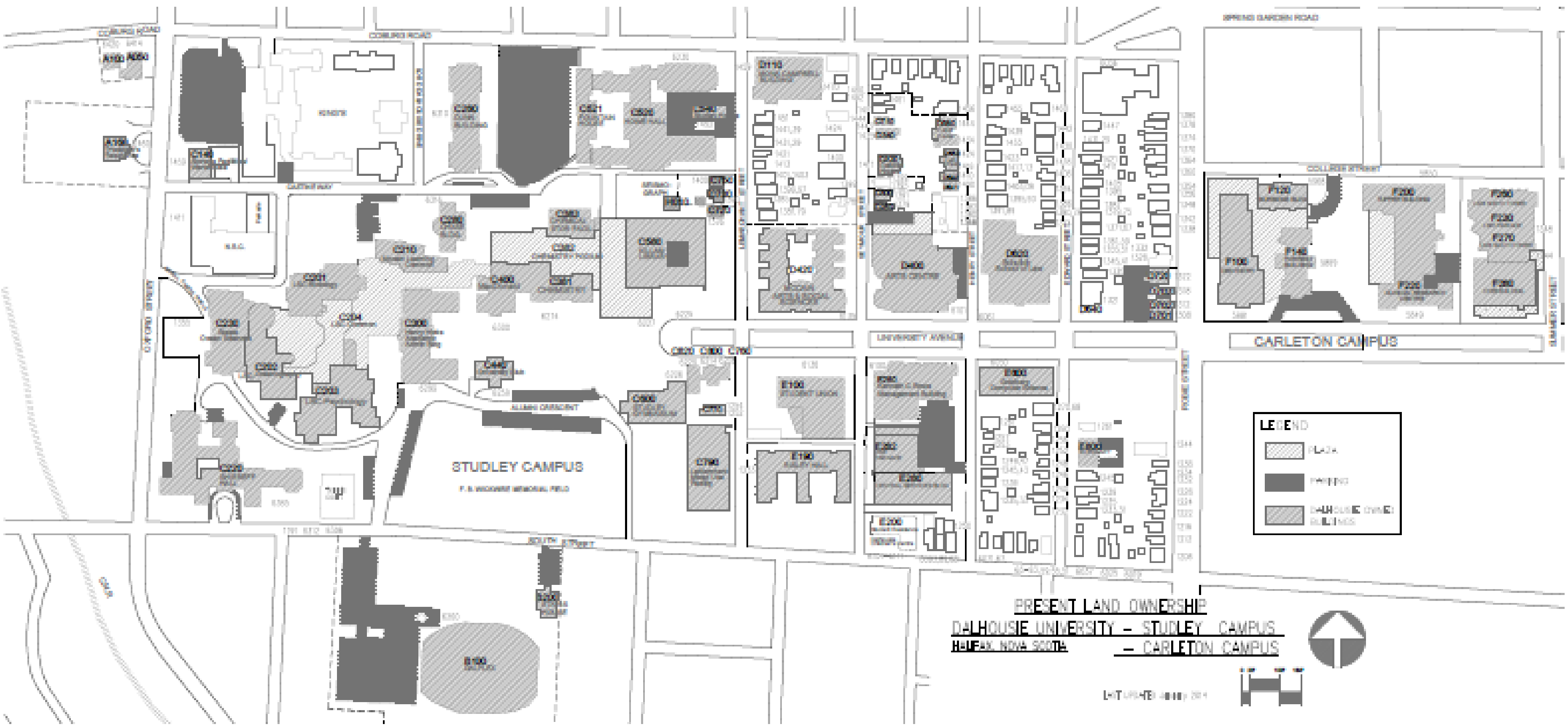
greenhouse gas source - physical unit or process that releases a GHG into the atmosphere

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

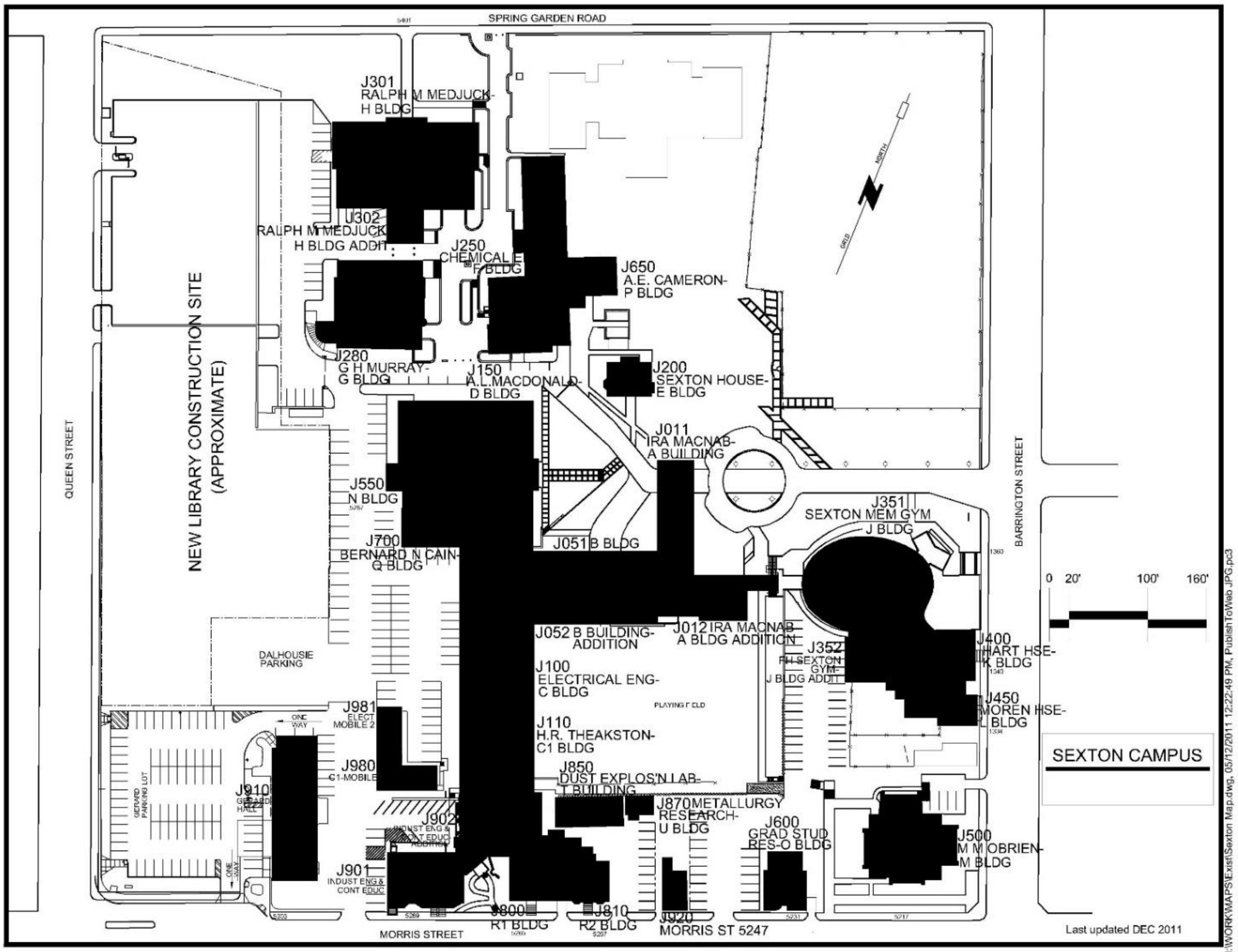
other indirect greenhouse gas emission - GHG emission, other than energy indirect GHG emissions, which is a consequence of an organization's activities, but arises from greenhouse gas sources that are owned or controlled by other organizations

Appendix B: Campus Maps (Dalhousie University)

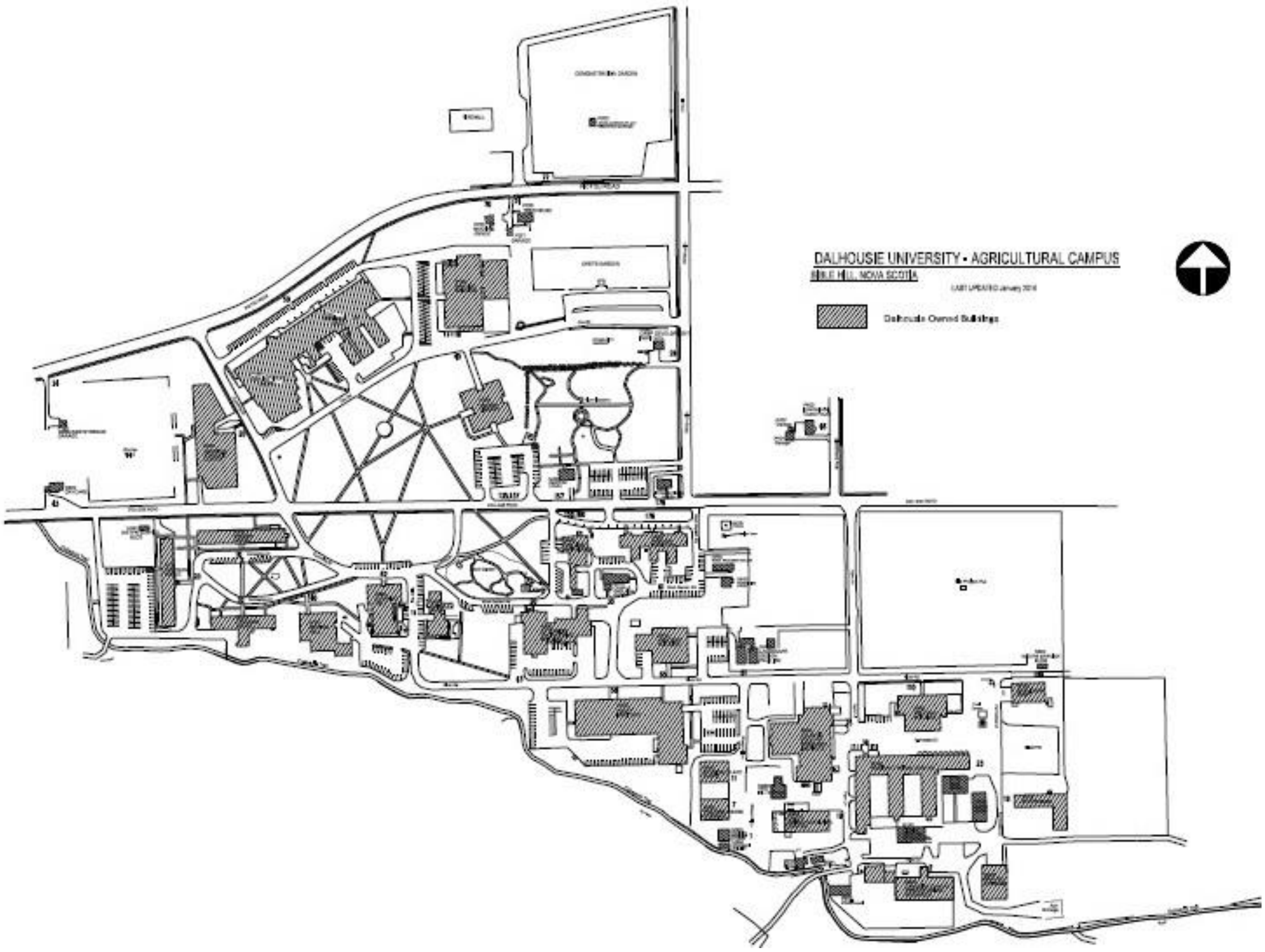
Halifax (Studley and Carleton campuses, 2014)



Halifax (Sexton campus, 2011)



AC (Agricultural Campus, 2014)



Appendix C: List of Campus Buildings

Halifax Campuses

Halifax Campuses				
Site	ID	Description	Building Address	Bldg Area (GSF)
STUDLEY	E282	CENTRAL SRV-PARKADE	1236 HENRY STREET	40,830
STUDLEY	A050	COBURG ROAD 6414	6414 COBURG ROAD	5,529
STUDLEY	A100	COBURG ROAD 6420	6420 COBURG ROAD	3,200
STUDLEY	A160	PRESIDENT'S RES	1460 OXFORD STREET	8,750
STUDLEY	B100	DALPLEX	6260 SOUTH STREET	178,767
STUDLEY	B200	HEALTH & HUMAN PERFORMANCE (H&HP)	6230 SOUTH STREET	6,800
STUDLEY	C140	STORAGE FACILITY/WAREHOUSE	1459 OXFORD ST.	11,899
STUDLEY	C201	LSC-BIOL&EARTH	1355 OXFORD STREET	161,394
STUDLEY	C202	LSC-OCEANOGRAPH	1355 OXFORD STREET	107,079
STUDLEY	C203	LSC-PSYCHOLOGY	1355 OXFORD STREET	123,710
STUDLEY	C204	LSC-COMMON AREA	1355 OXFORD STREET	57,856
STUDLEY	C210	WALLACE MCCAIN LEARNING COMMONS	1355 OXFORD STREET	13,600
STUDLEY	C220	SHIRREFF HALL	6385 SOUTH STREET	171,775
STUDLEY	C230	STEELE OCEAN SCIENCES BUILDING	1355 OXFORD STREET	76,000
STUDLEY	C260	DUNN BUILDING	6310 COBURG ROAD	89,991
STUDLEY	C280	CHASE BLDG	6316 COBURG ROAD	28,801
STUDLEY	C300	HENRY HICKS ACADEMI	6299 SOUTH STREET	106,613
STUDLEY	C381	CHEMISTRY	6274 COBURG ROAD	74,992
STUDLEY	C382	CHEMISTRY PODIUM	6274 COBURG ROAD	34,997
STUDLEY	C383	CHEMICAL STOR FACIL	6274 COBURG ROAD	10,608
STUDLEY	C400	MACDONALD BLDG	6300 COBURG ROAD	19,998
STUDLEY	C440	UNIVERSITY CLUB	6259 ALUMNI CRESCENT	14,877
STUDLEY	C520	HOWE HALL	6230 COBURG ROAD	158,346
STUDLEY	C521	HOWE-FOUNTAIN HOUSE	6230 COBURG RD	65,380
STUDLEY	C540	STUDLEY HOUSE	1452 LEMARCHANT STREET	10,588
STUDLEY	C580	KILLAM LIBRARY	6225-6227 UNIVERSITY AVENUE	250,518
STUDLEY	C600	STUDLEY GYMNASIUM	6185 SOUTH STREET	36,196
STUDLEY	C710	SEYMOUR ST 1443	1443 SEYMOUR STREET	3,140
STUDLEY	C720	LEMARCHANT ST 1376	1376 LEMARCHANT STREET	4,000
STUDLEY	C730	LEMARCHANT ST 1390	1390 LEMARCHANT STREET	3,000

STUDLEY	C750	LEMARCHANT ST 1400	1400 LEMARCHANT STREET	3,000
STUDLEY	C760	UNIVERSITY AVE 6206	6206 UNIVERSITY AVENUE	2,760
STUDLEY	C770	LEMARCHANT 1252-54	1252-54 LEMARCHANT STREET	5,400
STUDLEY	C790	LEMARCHANT PLACE	1246 LEMARCHANT STREET	173,056
STUDLEY	C800	UNIVERSITY AVE 6214	6214 UNIVERSITY AVENUE	3,000
STUDLEY	C820	UNIVERSITY AVE 6220	6220 UNIVERSITY AVENUE	4,274
STUDLEY	D110	MONA CAMPBELL BUILDING	1459 LEMARCHANT STREET	101,303
STUDLEY	D280	SEYMOUR ST 1379	1379 SEYMOUR STREET	2,777
STUDLEY	D300	SEYMOUR ST 1391	1391 SEYMOUR STREET	2,343
STUDLEY	D320	DE MILLE HOUSE	1411 SEYMOUR STREET	6,570
STUDLEY	D340	SEYMOUR ST 1435	1435 SEYMOUR STREET	4,130
STUDLEY	D360	SEYMOUR 1395/99	1395/99 SEYMOUR STREET	2,777
STUDLEY	D400	ARTS CENTRE	6101 UNIVERSITY AVENUE	175,306
STUDLEY	D420	MCCAIN ARTS&SS	6135 UNIVERSITY AVE.	153,838
STUDLEY	D541	HENRY ST 1400	1400 HENRY ST.	2,840
STUDLEY	D542	HENRY ST 1410	1410 HENRY ST.	3,110
STUDLEY	D550	LYALL HOUSE	1416 - 1424 HENRY STREET	5,520
STUDLEY	D580	COLPITT HOUSE	1434-1444 HENRY ST.	8,070
STUDLEY	D620	WELDON LAW	6061 UNIVERSITY AVENUE	99,990
STUDLEY	D640	EDWARD ST 1321	1321 EDWARD STREET	4,520
STUDLEY	D701	ROBIE ST 1308	1308 ROBIE STREET	2,263
STUDLEY	D702	ROBIE ST 1312	1312 ROBIE STREET	2,263
STUDLEY	D703	ROBIE ST 1318	1318 ROBIE STREET	3,289
STUDLEY	D720	ROBIE ST 1322	1322 ROBIE STREET	3,785
STUDLEY	E100	STUD. UNION BLDG	6136 UNIVERSITY AVENUE	124,377
STUDLEY	E190	RISLEY HALL	1233 LEMARCHANT ST	177,100
STUDLEY	E260	KENNETH C ROWE MANA	6100 UNIVERSITY AVE	122,054
STUDLEY	E280	CENTRAL SRVC	1236 HENRY STREET	80,462
STUDLEY	E600	GOLDBERG COMPUTER SCIENCE BUILDING	6050 UNIVERSITY AVE	70,638
STUDLEY	E800	GLENGARY	1253 EDWARD STREET	16,270
STUDLEY	H010	SEISMOGRAPH		750

STUDLEY	B300	FITNESS CENTRE	6260 SOUTH STREET	in construction
CARLETON	F100	DENTISTRY	5981 UNIVERSITY AVENUE	207,187
CARLETON	F120	BURBIDGE	5968 COLLEGE STREET	33,771
CARLETON	F140	FORREST	5869 UNIVERSITY AVENUE	61,542
CARLETON	F200	TUPPER BLDG	5850 COLLEGE ST.	379,214
CARLETON	F220	CLIN RES CTR	5849 UNIVERSITY AVENUE	24,486
CARLETON	F230	LSRI-PARKADE	1348 SUMMER STREET	24,104
CARLETON	F260	LSRI-NORTH TOWER	1348 SUMMER STREET	88,937
CARLETON	F280	COLLABORATIVE HEALTH EDUC BLDG	5793 UNIVERSITY AVE	107,000
CARLETON	F270	LSRI-SOUTH TOWER	1344 SUMMER STREET	50,433
CARLETON	G200	PETER GREEN HALL	1094 WELLINGTON STREET	146,981
SEXTON	H130	GOTTINGEN ST 2209	2209 GOTTINGEN STREET	12,475
SEXTON	J011	IRA MACNAB-A BLDG	1360 BARRINGTON STREET	27,795
SEXTON	J012	I MACNAB-A BLD ADDI	1360 BARRINGTON STREET	4,681
SEXTON	J051	B BUILDING	1360 BARRINGTON STREET	23,945
SEXTON	J052	B BUILDING ADDITION	1360 BARRINGTON STREET	13,823
SEXTON	J100	ELECT ENG-C BLDG	1360 BARRINGTON STREET	22,115
SEXTON	J110	H THEAKSTON-C1 BLDG	5269 MORRIS STREET	31,440
SEXTON	J150	A. MACDONALD-D BLDG	1360 BARRINGTON STREET	64,946
SEXTON	J200	SEXTON HOUSE-E BLDG	1360 BARRINGTON STREET	5,197
SEXTON	J250	CHEMICAL ENG-F BLDG	1360 BARRINGTON STREET	24,146
SEXTON	J280	G.H. MURRAY-G BLDG	1360 BARRINGTON STREET	20,843
SEXTON	J301	RALPH M MEDJUCK BLD	5410 SPRING GARDEN ROAD	43,831
SEXTON	J302	RALPH MEDJUCK-ADDIT	5410 SPRING GARDEN ROAD	5,840
SEXTON	J351	SEXTON MEMORIAL GYM	1360 BARRINGTON STREET	21,546
SEXTON	J352	SEXTON GYM-ADDITION	1360 BARRINGTON STREET	9,073

SEXTON	J400	HART HOUSE-K BLDG	1340 BARRINGTON STREET	6,320
SEXTON	J450	MOREN HOUSE-L BLDG	1334 BARRINGTON STREET	4,793
SEXTON	J500	M.M. O'BRIEN-M BLDG	5217 MORRIS STREET	37,541
SEXTON	J550	N BUILDING	5287 MORRIS STREET	21,268
SEXTON	J600	GRAD STUD RES-O BLDG	5231 MORRIS STREET	7,413
SEXTON	J650	A.E. CAMERON-P BLDG	1360 BARRINGTON STREET	5,472
SEXTON	J700	BERNARD CAIN-Q BLDG	1360 BARRINGTON STREET	5,799
SEXTON	J901	IND ENG&CONT ED	5269 MORRIS STREET	16,397
SEXTON	J902	IND ENG&CON ED ADDI	5269 MORRIS STREET	17,350
SEXTON	J920	MORRIS 5247	5247 MORRIS STREET	4,405
SEXTON	J910	GERARD HALL	5303 MORRIS ST.	94,269
* Do not operate Peter Green Hall			Total	4,776,466

Agricultural Campus

AGRICULTURE Campus			Building Address	Bldg Area (GSF)
AGRICULTURE	N500	PUMP HOUSE		
AGRICULTURE	L300	ROCK GARDEN	626 COLLEGE RD	29,777
AGRICULTURE	L500	BLUEBERRY INSTITUTE	168 DAKOTA RD	2,961
AGRICULTURE	M100	MACHINERY SHED	1 FARMSTEAD COURT	5,376
AGRICULTURE	M120	SHEEP BARN	19 FARMSTEAD COURT	7,367
AGRICULTURE	M130	RAM PACK BARN	23 FARMSTEAD COURT	3,500
AGRICULTURE	M140	BEEF BARN	23 FARMSTEAD COURT	3,400
AGRICULTURE	M150	RUMINANT ANIMAL CENTRE	39 FARMSTEAD COURT	34,934
AGRICULTURE	M180	LIQUID MANURE Storage		
AGRICULTURE	M200	MANURE STORAGE	FARM LANE	
AGRICULTURE	M220	BARON'S PRIDE STABLE	FARM LANE	930
AGRICULTURE	M300	PESTICIDE/HERBICIDE STORAGE	1 SHEEP HILL LANE	1,024
AGRICULTURE	M320	PASTURE BOARD AND P I STORAGE	7 SHEEP HILL LANE	
AGRICULTURE	M340	PHYSICAL PLANT MAINTEN SHOP	11 SHEEP HILL LANE	4,800
AGRICULTURE	M360	WOODSMAN STORAGE BUILDING	SHEEP HILL LANE	
AGRICULTURE	M400	DAIRY BUILDING	11 RIVER ROAD	9,265
AGRICULTURE	M420	HALEY INSTITUTE	58 RIVER RD	75,660

AGRICULTURE	M440	HANCOCK VETERINARY BUILDING	65 RIVER ROAD	15,663
AGRICULTURE	M460	LANDSCAPE DESIGN PAVILION	81 RIVER RD	
AGRICULTURE	M480	BOULDEN BUILDING	110 RIVER ROAD	12,728
AGRICULTURE	M600	FUR UNIT STORAGE BARN	FARM LANE	2,276
AGRICULTURE	M620	CDN CTR FOR FUR ANIMAL RESCH	2 FARM LANE	15,480
AGRICULTURE	M640	CHUTE ANIMAL NUTRITION CENTRE	19 FARM LANE	10,955
AGRICULTURE	M641	ELECTRICAL GENERATOR SHED		
AGRICULTURE	M642	STORAGE SHED		
AGRICULTURE	M660	FORMER FEED MILL	21 FARM LANE	
AGRICULTURE	M680	ATLANTIC POULTRY RESCH CTR	25 FARM LANE	27,990
AGRICULTURE	N100	FRASER HOUSE	10 HORSESHOE CRESCENT	39,970
AGRICULTURE	N120	CHAPMAN HOUSE	20 HORSESHOE CRESCENT	39,547
AGRICULTURE	N140	TRUEMAN HOUSE	30 HORSESHOE CRESCENT	32,011
AGRICULTURE	N160	JENKINS HALL	40 HORSESHOE CRESCENT	23,506
AGRICULTURE	N300	DAYCARE	43 COLLEGE ROAD	1,630
AGRICULTURE	N340	WATER SERVICE BUILDING	62 COLLEGE RD	
AGRICULTURE	N380	MACRAE LIBRARY	135,137 COLLEGE RD & 40 COX RD	46,337
AGRICULTURE	N400	DEWOLFE HOUSE	157 COLLEGE ROAD	2,866
AGRICULTURE	N420	COLLINS BUILDING	158-160 COLLEGE ROAD	11,545
AGRICULTURE	N460	HARLOW INSTITUTE	61 ROCKGARDEN & 176 COLLEGE	20,943
AGRICULTURE	N480	INTERNATIONAL HOUSE	179 COLLEGE ROAD	1,663
AGRICULTURE	N600	ELEVATED WATER TOWER		
AGRICULTURE	N800	ENG EXT-CENTRAL HEATING PLANT	20 ROCKGARDEN ROAD/43 RIVER RD	27,028
AGRICULTURE	N820	THE FRIENDS OF THE GARDEN BUILDING	35 ROCK GARDEN ROAD	2,892
AGRICULTURE	N840	HUMANITIES HOUSE	56 ROCKGARDEN ROAD	1,844
AGRICULTURE	N860	RURAL RESEARCH CENTRE	58 ROCK GARDEN ROAD	1,453
AGRICULTURE	N900	LANGILLE ATHLETIC CENTRE	20 CUMMING DRIVE	40,303
AGRICULTURE	N920	CUMMING HALL	62 CUMMING DRIVE	34,989
AGRICULTURE	P100	BANTING BUILDING	39 COX ROAD	30,854
AGRICULTURE	P101	BANTING BUILDING STORAGE FACILITY		7,754

AGRICULTURE	P120	GROUNDS STORAGE GARAGE	PICTOU ROAD	
AGRICULTURE	P150	AGRICULTURAL COX INSTITUTE	50 PICTOU ROAD AND 21 COX ROAD	164,020
AGRICULTURE	P200	BANTING ANNEX	70 PICTOU ROAD	1,777
AGRICULTURE	P220	TREE HOUSE	74 PICTOU ROAD	1,044
AGRICULTURE	P221	TREE HOUSE GARAGE		
AGRICULTURE	P300	DEMO GARDEN	77 PICTOU RD	
AGRICULTURE	P400	INTERN GUEST HOUSE AND GARAGE	48 BLANCHARD AVENUE	1,750
AGRICULTURE	P401	INTERN GUEST HOUSE AND GARAGE1	48 BLANCHARD AVENUE	529
AGRICULTURE	P402	INTERN GUEST HOUSE AND GARAGE2	48 BLANCHARD AVENUE	139
AGRICULTURE	P420	CROP DEVELOPMENT INSTITUTE	29 VIMY ROAD	1,248
AGRICULTURE	P500	TURF RESEARCH BUILDING	20 ROCK GARDEN ROAD	572
AGRICULTURE	P840	BIO-ENVIRONMENTAL ENG CTR BEEC	80 DISCOVERY DRIVE	4,926
AGRICULTURE	P860	CROPPING SYSTEMS RESEARCH BLDG	79 DISCOVERY DRIVE	2,896
AGRICULTURE	P880	HATCHERY	39 DISCOVERY DRIVE	2,688
AGRICULTURE	L520	BLUEBERRY FIELDS MACH STR SHED	432 DAKOTA ROAD	
AGRICULTURE	L100	PLUMDALE FARM, SERVICE BLDG	614 COLLEGE ROAD	
AGRICULTURE	L120	PLUMDALE FARM STORAGE BARN	614 COLLEGE ROAD	
AGRICULTURE	L521	BLUEBERRY STORAGE SHED 2		
*Gardens and Sheds not included			Total	812,810

Appendix D: Data Quality Tiers Direct Emissions from Stationary Combustion (The Climate Registry, 2016)

Direct CO_2 Emissions From Stationary Combustion		
Method	**Type of Method**	**Data Requirements**
GRP ST-01-CO_2	Direct Monitoring	Continuous Emissions Monitoring Systems (CEMS)
GRP ST-02-CO_2	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
GRP ST-03-CO_2	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
GRP ST-04-CO_2	Calculation Based on Fuel Use	Default CO_2 emission factors by fuel type

Direct CH_4 and N_2O Emissions From Stationary Combustion		
Method	**Type of Method**	**Data Requirements**
GRP ST-05-CH_4 & N_2O	Direct Measurement	Continuous emissions monitoring or periodic direct measurements
GRP ST-06-CH_4 & N_2O	Calculation Based on Fuel Use	Default emission factors by sector and technology type
GRP ST-07-CH_4 & N_2O	Calculation Based on Fuel Use	Default emission factors by sector and fuel type

Appendix E: Canadian Default Factors for Calculating CO_2 Emissions from Combustion of Natural Gas, Petroleum Products, and Biomass (Table 12.2, 2017 Climate Registry Default Emissions Factors)

The Climate Registry

Table 12.2 Canadian Default Factors for Calculating CO_2 Emissions from Combustion of Natural Gas, Petroleum Products, and Biomass

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	39.00	1	1900
Producer Consumption*	n/a	39.00	1	2401
Newfoundland and Labrador				
Marketable	n/a	39.00	1	1901
NonMarketable	n/a	39.00	1	2494
Nova Scotia				
Marketable	n/a	39.00	1	1901
NonMarketable	n/a	39.00	1	2494

Natural Gas Liquids	kg C / GJ	GJ / Kilolitre		$g CO_2 / L$
Propane: Residential Propane	n/a	25.31	1	1515
Propane: Other Uses Propane	n/a	25.31	1	1515
Ethane	n/a	17.22	1	986
Butane	n/a	28.44	1	1747
Refinery LPGs (All Stationary)	n/a	n/a	1	1629
Petroleum Products	**kg C / GJ**	**GJ / Kilolitre**		**$g CO_2 / L$**
Light Fuel Oil Electric Utilities	n/a	38.80	1	2753
Light Fuel Oil Industrial	n/a	38.80	1	2753
Light Fuel Oil Producer Consumption	n/a	38.80	1	2670

Biomass	kg C / GJ	GJ / t		$g CO_2 / kg$
Wood Fuel/Wood Waste	n/a	18.00	1	848
Spent Pulping Liquor	n/a	14.00	1	891
Landfill Gas	n/a	n/a	1	2752

Light Fuel Oil Residential	n/a	38.80	1	2753
Light Fuel Oil Forestry, Construction, Public Administration, Commercial/Institutional	n/a	38.80	1	2753
Heavy Fuel Oil (Electric Utility, Industrial, Forestry, Construction, Public Administration, Commercial/Institutional)	n/a	42.50	1	3156
Heavy Fuel Oil (Residential)	n/a	42.50	1	3156
Heavy Fuel Oil (Producer Consumption)	n/a	42.50	1	3190
Kerosene (Electric Utility, Industrial, Producer Consumption, Residential, Forestry, Construction, Public Administration, Commercial/Institutional)	n/a	37.68	1	2560
Diesel	n/a	38.30	1	2690
Petroleum Coke from Upgrading Facilities	n/a	40.57	1	3494
Petroleum Coke from Refineries & Others	n/a	46.35	1	3826
Still gas (Upgrading Facilities)	n/a	43.24	1	2140
Still gas (Refineries & Others)	n/a	36.08	1	1919

Appendix F: Default CH_4 and N_2O Emission Factors by Technology Type for the Commercial Sector (Table 12.4, 2017 Climate Registry Default Emissions Factors)

The Climate Registry

Table 12.4 Canadian Default Factors for Calculating CH_4 and N_2O Emissions from Combustion of Natural Gas, Petroleum Products, Coal, and Biomass

Fuel Type	CH_4 Emission Factor (Per Unit Mass or Volume)	N_2O Emission Factor (Per Unit Mass or Volume)
Natural Gas	**$g\ CH_4 / m^3$**	**$g\ N_2O / m^3$**
Electric Utilities	0.490	0.049
Industrial	0.037	0.033
Producer Consumption (NonMarketable)	6.400	0.060
Pipelines	1.900	0.050
Cement	0.037	0.034
Manufacturing Industries	0.037	0.033
Residential, Construction, Commercial/Institutional, Agriculture	0.037	0.035
Natural Gas Liquids	**$g\ CH_4 / L$**	**$g\ N_2O / L$**
Propane (Residential)	0.027	0.108
Propane (All Other Uses)	0.024	0.108
Ethane	0.024	0.108

Butane	0.024	0.108
Refinery LPGs	0.024	0.108
Refined Petroleum Products	**g CH_4 / L**	**g N_2O / L**
Light Fuel Oil (Electric Utilities)	0.180	0.031
Light Fuel Oil (Industrial and Producer Consumption)	0.006	0.031
Light Fuel Oil (Residential)	0.026	0.006
Light Fuel Oil (Forestry, Construction, Public Administration, and Commercial/Institutional)	0.026	0.031
Heavy Fuel Oil (Electric Utilities)	0.034	0.064
Heavy Fuel Oil (Industrial and Producer Consumption)	0.120	0.064
Heavy Fuel Oil (Residential, Forestry, Construction, Public Administration, and Commercial/Institutional)	0.057	0.064
Kerosene (Electric Utilities, Industrial, and Producer Consumption)	0.006	0.031
Kerosene (Residential)	0.026	0.006
Kerosene (Forestry, Construction, Public Administration, and Commercial/Institutional)	0.026	0.031
Diesel (Refineries and Others)	0.133	0.400
Diesel (Upgraders)	0.147	1.100
Still Gas (Refineries and Others)	0.031	2E-05

Still Gas (Upgraders)	0.039	2E-05
Petroleum Coke	**g CH_4 / L**	**g N_2O / L**
Upgrading Facilities	0.12	0.02
Refineries & Others	0.12	0.03
Coal	**g CH_4 / kg**	**g N_2O / kg**
Coal (Electric Utilities)	0.02	0.03
Coal (Industry and Heat & Steam Plants)	0.03	0.02
Coal (Residential, Public Administration)	4.00	0.02
Coke	0.03	0.02
Coal(gas)	**g CH_4 / m^3**	**g N_2O / m^3**
Coke Oven Gas	0.04	0.04
Biomass	**g CH_4 / kg**	**g N_2O / kg**
Wood Fuel/Wood Waste (Industrial Combustion)	0.09	0.06
Spent Pulping Liquor (Industrial Combustion)	0.02	0.02
Stoves and Fireplaces (Advance Technology or Catalytic Control)	5.7	0.12
Stoves and Fireplaces (Conventional, Inserts)	12.3	0.12

Appendix G: Global Warming Potentials of Refrigerants and Blends (Tables B.1, B.2, and B.3, 2017 Climate Registry Default Emission Factors, p. 75-83)

The Climate Registry

Table B.1. Global Warming Potential Factors for Required Greenhouse Gases

Common Name	Formula	Chemical Name	SAR	TAR	AR4	AR5
Carbon dioxide	CO_2		1	1	1	1
Methane	CH_4		21	23	25	28
Nitrous oxide	N_2O		310	296	298	265
Nitrogen trifluoride	NF_3		n/a	10,800	17,200	16,100
Sulfur hexafluoride	SF_6		23,900	22,200	22,800	23,500
Hydrofluorocarbons (HFCs)						
HFC-23 (R-23)	CHF_3	trifluoromethane	11,700	12,000	14,800	12,400
HFC-32 (R-32)	CH_2F_2	difluoromethane	650	550	675	677
HFC-41 (R-41)	CH_3F	fluoromethane	150	97	92	116
HFC-125 (R-125)	C_2HF_5	pentafluoroethane	2,800	3,400	3,500	3,170
HFC-134 (R-134)	$C_2H_2F_4$	1,1,2,2-tetrafluoroethane	1,000	1,100	1,100	1,120
HFC-134a (R-134a)	$C_2H_2F_4$	1,1,1,2-tetrafluoroethane	1,300	1,300	1,430	1,300
HFC-143 (R-143)	$C_2H_3F_3$	1,1,2-trifluoroethane	300	330	353	328
HFC-143a (R-143a)	$C_2H_3F_3$	1,1,1-trifluoroethane	3,800	4,300	4,470	4,800
HFC-152 (R-152)	$C_2H_4F_2$	1,2-difluoroethane	n/a	43	53	16

Source: Intergovernmental Panel on Climate Change (IPCC) Second Assessment Report (SAR) published in 1995, Third Assessment Report (TAR) published in 2001, Fourth Assessment Report (AR4) published in 2007, and Fifth Assessment Report published in 2013. All defaults 100-year GWP values. For any defaults provided as a range, use exact value provided for the purpose of reporting to The Registry. n/a=data not available.
Note: Complete reporters must include emissions of all Kyoto-defined GHGs (including all HFCs and PFCs) in inventory reports. If HFCs or PFCs are emitted that are not listed above, complete reporters must use industry best practices to calculate CO_2e from those gases.

HFC-152a (R-152a)	$C_2H_4F_2$	1,1-difluoroethane	140	120	124	138
HFC-161 (R-161)	C_2H_5F	fluoroethane	n/a	12	12	4
HFC-227ea (R-227ea)	C_3HF_7	1,1,1,2,3,3,3-heptafluoropropane	2,900	3,500	3,220	3,350
HFC-236cb (R-236cb)	$C_3H_2F_6$	1,1,1,2,2,3-hexafluoropropane	n/a	1,300	1,340	1,120
HFC-236ea (R-236ea)	$C_3H_2F_6$	1,1,1,2,3,3-hexafluoropropane	n/a	1,200	1,370	1,330
HFC-236fa (R-236fa)	$C_3H_2F_6$	1,1,1,3,3,3-hexafluoropropane	6,300	9,400	9,810	8,060
HFC-245ca (R-245ca)	$C_3H_3F_5$	1,1,2,2,3-pentafluoropropane	560	640	693	716
HFC-245fa (R-245fa)	$C_3H_3F_5$	1,1,1,3,3-pentafluoropropane	n/a	950	1,030	858
HFC-365mfc	$C_4H_5F_5$	1,1,1,3,3-pentafluorobutane	n/a	890	794	804
HFC-43-10mee (R-4310)	$C_5H_2F_{10}$	1,1,1,2,3,4,4,5,5,5-decafluoropentane	1,300	1,500	1,640	1,650
Perfluorocarbons (PFCs)						
PFC-14 (Perfluoromethane)	CF_4	tetrafluoromethane	6,500	5,700	7,390	6,630
PFC-116 (Perfluoroethane)	C_2F_6	hexafluoroethane	9,200	11,900	12,200	11,100
PFC-218 (Perfluoropropane)	C_3F_8	octafluoropropane	7,000	8,600	8,830	8,900
PFC-318 (Perfluorocyclobutane)	$c\text{-}C_4F_8$	octafluorocyclobutane	8,700	10,000	10,300	9,540
PFC-3-1-10 (Perfluorobutane)	C_4F_{10}	decafluorobutane	7,000	8,600	8,860	9,200
PFC-4-1-12 (Perfluoropentane)	C_5F_{12}	dodecafluoropentane	n/a	8,900	9,160	8,550
PFC-5-1-14 (Perfluorohexane)	C_6F_{14}	tetradecafluorohexane	7,400	9,000	9,300	7,910
PFC-9-1-18 (Perfluorodecalin)	$C_{10}F_{18}$		n/a	n/a	>7,500	7,190

Table B.2. Global Warming Potentials of Refrigerant Blends

Refrigerant Blend	Gas	SAR	TAR	AR4	AR5
R-401A	HFC	18.2	15.6	16.12	17.94
R-401B	HFC	15	13	14	15
R-401C	HFC	21	18	18.6	20.7
R-402A	HFC	1680	2040	2100	1902
R-402B	HFC	1064	1292	1330	1205
R-403A	PFC	1400	1720	1766	1780
R-403B	PFC	2730	3354	3444	3471
R-404A	HFC	3260	3784	3922	3943
R-407A	HFC	1770	1990	2107	1923
R-407B	HFC	2285	2695	2804	2547
R-407C	HFC	1526	1653	1774	1624
R-407D	HFC	1428	1503	1627	1487
R-407E	HFC	1363	1428	1552	1425
R-407F	HFC	1555	1705	1825	1674
R-408A	HFC	1944	2216	2301	2430
R-410A	HFC	1725	1975	2088	1924

R-410B	HFC	1833	2118	2229	2048
R-411A	HFC	15	13	14	15
R-411B	HFC	4.2	3.6	3.72	4.14
R-412A	PFC	350	430	442	445
R-415A	HFC	25.2	21.6	22.32	24.84
R-415B	HFC	105	90	93	104
R-416A	HFC	767	767	843.7	767
R-417A	HFC	1955	2234	2346	2127
R-417B	HFC	2450	2924	3027	2742
R-417C	HFC	1570	1687	1809	1643
R-418A	HFC	3.5	3	3.1	3.45
R-419A	HFC	2403	2865	2967	2688
R-419B	HFC	1982	2273	2384	2161
R-420A	HFC	1144	1144	1258	1144
R-421A	HFC	2170	2518	2631	2385
R-421B	HFC	2575	3085	3190	2890
R-422A	HFC	2532	3043	3143	2847
R-422B	HFC	2086	2416	2526	2290
R-422C	HFC	2491	2983	3085	2794
R-422D	HFC	2232	2623	2729	2473

R-422E	HFC	2135	2483	2592	2350
R-423A	HFC	2060	2345	2280	2274
R-424A	HFC	2025	2328	2440	2212
R-425A	HFC	1372	1425	1505	1431
R-426A	HFC	1352	1382	1508	1371
R-427A	HFC	1828	2013	2138	2024
R-428A	HFC	2930	3495	3607	3417
R-429A	HFC	14	12	12	14
R-430A	HFC	106.4	91.2	94.24	104.88
R-431A	HFC	41	35	36	40
R-434A	HFC	2662	3131	3245	3075
R-435A	HFC	28	24	25	28
R-437A	HFC	1567	1684	1805	1639
R-438A	HFC	1890	2151	2264	2059
R-439A	HFC	1641	1873	1983	1828
R-440A	HFC	158	139	144	156
R-442A	HFC	1609	1793	1888	1754
R-444A	HFC	85	72	87	88
R-445A	HFC	117	117	128.7	117

R-446A	HFC	442	374	459	460
R-447A	HFC	540	493	582	571
R-447B	HFC	666	646	739	714
R-448A	HFC	1170	1300	1386	1273
R-449A	HFC	1184	1308	1396	1282
R-449B	HFC	1199	1320	1411	1296
R-449C	HFC	1067	1167	1250	1146
R-450A	HFC	546	546	600.6	546
R-451A	HFC	132.6	132.6	145.86	132.6
R-451B	HFC	145.6	145.6	160.16	145.6
R-452A	HFC	1724	2067	2139	1945
R-452B	HFC	632	607	697	675
R-452C	HFC	1789	2143	2219	2018
R-453A	HFC	1534	1664	1765	1636
R-454A	HFC	228	193	236	237
R-454B	HFC	448	379	465	466
R-454C	HFC	140	118	145	146
R-456A	HFC	624	618	684	626
R-457A	HFC	131	113	136	138
R-458A	HFC	1457	1576	1650	1564

R-500	HFC	37	31	32	36
R-503	HFC	4692	4812	5935	4972
R-504	HFC	313	265	325	326
R-507 or R-507A	HFC	3300	3850	3985	3985
R-509 or R-509A	PFC	3920	4816	4945	4984
R-512A	HFC	198	179	189.3	196.1
R-513A	HFC	572	572	629.2	572
R-513B	HFC	540	539.5	593	539.5
R-515A	HFC	348	420	386	402

Source: Refrigerant blend GWPs are calculated using a weighted average from the blend composition and the IPCC GWP values. The blend compositions are from ASHRAE Standard 34-2016. The GWP values are 100-year values from the Intergovernmental Panel on Climate Change (IPCC) Second Assessment Report (SAR) published in 1995, Third Assessment Report (TAR) published in 2001, Fourth Assessment Report (AR4) published in 2007, and Fifth Assessment Report (AR5) published in 2013.

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Table B.3. Refrigerant Blends (Contain HFCs and PFCs)

Blend	Constituents	Composition (%)
R-405A	HCFC-22/HFC-152a/HCFC-142b/PFC-318	(45.0/7.0/5.5/42.5)
R-413A	PFC-218/HFC-134a/HC-600a	(9.0/88.0/3.0)
R-508A	HFC-23/PFC-116	(39.0/61.0)
R-508B	HFC-23/PFC-116	(46.0/54.0)

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3, Table 7.8, page 7.44.

Appendix H: Data Quality Tiers for Electricity (The Climate Registry, 2016)

Calculating Activity Data from Indirect CO_2, CH_4 & N_2O From Electricity Use		
Method	**Type of Method**	**Data Requirements**
GRP-IE-01-CO_2, CH_4 & N_2O	Known electricity use	Monthly electric bills or electric meter records (kWh, MWh)
GRP-IE-02-CO_2, CH_4 & N_2O	Estimated electricity use (Area and cost methods)	Area method: • Total building area (square feet); • Area of entity's space (square feet); • Total building annual electricity use (kWh); and, • Building occupancy rate. Cost method: • Electricity expenditures; and, • Average kWh costs.
GRP-IE-03-CO_2, CH_4 & N_2O	Estimated electricity use (Average intensity and models)	Average intensity method: • Leased square footage; and, • Average electricity intensity. Model methods: • Sampled power consumption and time of use information; or, • Equipment specifications and time of use information.

Appendix I: Nova Scotia Power Emission Factors (Nova Scotia Power Inc., 2017)

SYSTEM TOTALS - EMISSION INTENSITIES				
Year	**Mercury (g/GWh)**	**Sulphur Dioxide (g/kWh)**	**Carbon Dioxide Equivalent (g/kWh)**	**Nitrogen Oxide (g/kWh)**
2005	9.03	8.92	915.08	2.78
2006	15.37	10.15	927.64	2.67
2007	13.19	9.15	855.25	2.18
2008	13.84	9.13	830.96	1.82
2009	12.38	8.92	829.32	1.51
2010	7.11	5.40	807.52	1.59
2011	8.44	5.78	764.79	1.12
2012	9.60	6.77	781.19	1.60
2013	6.93	6.48	747.45	1.62
2014	5.24	5.92	692.98	1.64
2015	5.27	5.82	652	1.44
2016	6.0	6.1	700.1	1.5

Appendix J: Data Quality Tiers for Mobile Combustion Emissions (The Climate Registry, 2016)

Direct CO_2 Emissions From Mobile Combustion		
Method	**Type of Method**	**Data Requirements**
GRP MO-01-CO_2	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.
GRP MO-02-CO_2	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.
GRP MO-03-CO_2	Fuel use	Default CO_2 emission factors by fuel type
GRP MO-04-CO_2	Fuel use estimated using vehicle miles traveled and vehicle fuel economy	Default CO_2 emission factors by fuel type

Direct CH_4 & N_2O Emissions From Mobile Combustion (Highway Vehicles)		
Method	**Type of Method**	**Data Requirements**
GRP MO-05-CH_4 & N_2O	Miles traveled by vehicle type	Default emission factors by vehicle type based on vehicle technology
GRP MO-06-CH_4 & N_2O	Miles traveled by vehicle type	Default emission factors by vehicle type based on model year
GRP MO-07-CH_4 & N_2O	Distance estimated using fuel use and vehicle fuel economy	Default emission factors by vehicle type based on vehicle technology or model year

Direct CH_4 & N_2O Emissions From Mobile Combustion (Non-Highway Vehicles)		
Method	**Type of Method**	**Data Requirements**
GRP MO-08-CH_4 & N_2O	Fuel use	Default emission factors by vehicle type and fuel type
GRP MO-09-CH_4 & N_2O	Fuel use estimated using vehicle miles traveled and vehicle fuel economy	Default emission factors by vehicle type and fuel type
GRP MO-10-CH_4 & N_2O	Total landing and takeoff (LTO) cycles (*acceptable for jet aircraft only*)	Default emission factors by aircraft type and LTO

Appendix K: Fleet Vehicles on Campus

Halifax Fleet

2011	Ford Escape XLT 4WD
2007	E-Z-Go Golf Cart
2012	Dodge Grand Caravan
2012	Dodge Grand Caravan
2012	Dodge Grand Caravan
2010	Chevrolet Silverado 2500
2004	Ford F150 Truck with Extended Cab
2015	Ford F-series F150 4x4 Crewcab
2013	Ram 2500 ST Crewcab Truck
2014	Chevrolet Silverado
2013	Chev Silverado 2500
2015	HINO 155-2 complete with 2015 transit dry freight body and Maxon TE20 lift gate
2010	Bobcat S185 Skid Steer Loader
2009	Chev Silverado 1500
2009	Dodge Ram 1500 Pickup Truck
2011	Ford Econoline Cutaway Van
2011	GMC Sierra 1500
2016	HINO 155-2 complete with 16' Transit dry freight body and Maxon TE20 lift gate
2015	John Deere 1575 Terraincut w 60 in 7-iron side discharge deck
2010	John Deere 2320 Tractor
2010	John Deere 2520 Tractor
2007	John Deere 2320 Tractor
2012	Dodge Ram C/V (Van)
2011	Ford Transit Connect
2011	Dodge Grand Caravan
2011	Dodge Ram 2500
2006	GMC - C4500, Pickup
2013	HINO 16' W/Lift Gate 155-2
2015	Chevrolet Volt
2003	Club Car Golf Cart
2011	Ford Ranger Supercab Pickup
2016	Ford F250 4x4 Crew Cab 156.0 XLT
2014	Chevrolet Silverado 1500
2013	GMC Sierra Crew Cab 4x4
2012	Ford Escape XLT

Agricultural Campus Fleet

2006	GMC SAVANA 3500 EXT
2013	GMC Sierra 2500 SLE
2009	DODGE RAM
2002	Chev Silverado 2500HD 4X4
2011	INTERNATIONAL 7500 SBA 4X2
2002	GMC SIERRA 2500 HD
2008	FORD F350 Superduty 4X4
2014	GMC Sierra
1993	Chev Topkick 3 Tonne Truck
2016	Dodge Ram 5500 Dual wheel 4x4
1999	DAEWO FORKLIFT
1999	Ford New Holland Tractor 8360
1979	FORD 60HP Tractor
1985	INTERN'L TRACTOR
2003	THOMAS 135 LOADER 704T133
1996	FORD TRACTOR WD 7840SLE
1990	CASE INTERNATIONAL TRACTOR 585
1990	CASE 1640 AXIAL FLOW COMBINE
2000	JOHN DEERE TRCTR 7510
1994	FORD TRACTOR 7740
2016	CASE IH - Farmall 90C with loader, mower and bucket
2016	Case IH - Farmall 90C Tractor
2016	Case IH - Farmall 75C Tractor
2016	Case IH - Magnum 240 Tractor
2016	Case IH - Maxxum 115 with loader YGWLL51036
2016	Case IH - Farmall 90C Tractor with loader
2015	CASE IH - SR175 Skidsteer Loader
2017	Case IH - Farmall 110C Tractor
2017	Case IH - Puma 150 tractor
2017	Case IH - Puma 200 Tractor
2006	Weberlane Utility Trailer
2016	John Deere 5085 MFWD Utility tractor
2008	DODGE Ram 1500 Quad
2003	DODGE Ram 1500
2013	GMC Yukon
2010	JOHN DEERE 3032E Tractor
1967	MASSEY FERGUSON TRACTOR
1985	HEGGE COMBINE

1988	DEUTZ-AL TRACTOR
1984	HALDRUP 1500 HARVESTER
1985	TYM TRACTOR
1978	KUBOTA TRACTOR
1993	HEGE COMBINE 125C
1984	JOHNDEER 650 TRACTOR
1992	KUBOTA DECK MOWER F2100E
1983	HALDRUP FORAGE1500 Harvester
1995	JOHN DEER F925 MOWER Tractor
2007	DODGE RAM 1500 Quad 4X4
2007	GMC Sierra 2500 HD
1993	CHEV 1 TON
2007	DODGE RAM 1500
2006	FORD ECONOLINE E350
2014	KUBOTA Utility RTV 900XT
1990	JOHNDEERE 1070 Tractor
2005	CHALLENGER TRACTOR MT295B
2005	Toro Groundsmaster 3500D with mulching kit - Farm Tractor
2005	Smithco Sweep Star 60
2014	Kubota Z Turn Mower and grass catcher
2014	John Deere7400 Terraincut Mower
2008	Toro Groundsmaster 3280D
2012	FORD F150 Supercrew
2005	YAMA ATV YXR66FATGR
2016	CHEV SILVERADO LT 2500 Crew Cab 4WD
1983	Massey Ferguson Utility Tractor 1030 with Hardy Front End Loader
2012	John Deere 2520 Utility Tractor with Front End Loader & Mower Deck
2002	MAZDA B4000 Cab Plus Pickup
2010	CHEV SILVERADO
2005	FORD RANGER Supercab
2002	CHEV VENTURE
2000	GMC SIERRA 1500
2005	FORD RANGER Supercab
2011	CHEV SILVERADO 1500
2010	GMC Canyon
2012	KUBOTA RTV1140PH
1994	KAWASAKI MULE BG033
1980	JOHN DEERE TRACTOR 1640

2008	KIOTI FARM TRACTOR DK65SC
2007	DODGE Ram 2500 Quad
2014	Chev Silverado 1500
2014	Dodge Ram 1500 Truck
2011	TOYOTA RAV 4 2WD
2002	CHEV SILVERADO 1500
2008	GMC Sierra 1500
2008	CHEV SILVERADO 1500
2005	GMC SAFARI 2WD
2008	GMC SAVANA 1500
2010	FORD LGT CONVTNL 'F'
2012	FORD ECONOLINE E250 VAN
2016	Dodge Grand Caravan
2016	Dodge Grand Caravan
2008	Dodge Caravan
2002	Chev Express
2002	Chev Silverado 2500
2009	FORD GOSHEN E450 GCII BUS (22 passenger)
2017	Toyota Camry LE

Appendix L: Canadian Default Co2, N20 and CH_4 Emission Factors for Transport Fuels (Table 13.2 & 13.3, 2017 Climate Registry Default Emissions Factors)

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Table 13.2 Canadian Default CO_2 Emission Factors for Transport Fuels

Fuel Type	Carbon Content (kg C / GJ)	Heat Content	Fraction Oxidized	CO_2 Emission Factors
		GJ / kiloliter		g CO_2 / L
Motor Gasoline	n/a	35.00	1	2316
Diesel	n/a	38.30	1	2690
Light Fuel Oil	n/a	38.80	1	2753
Heavy Fuel Oil	n/a	42.50	1	3156
Aviation Gasoline	n/a	33.52	1	2365
Aviation Turbo Fuel	n/a	37.40	1	2560
Propane	n/a	25.31	1	1515
Ethanol	n/a	n/a	1	1509
Biodiesel	n/a	n/a	1	2474
		GJ / megaliter		g CO_2 / L
Natural Gas	n/a	39.00	1	1.9

Source: Default CO_2 Emission Factors: Environment Canada, National Inventory Report, 1990-2014: Greenhouse Gas Sources and Sinks in Canada (2016) Annex 6: Emission Factors, Table A6-12; Default Heat Content: Statistics Canada, Report on Energy Supply and Demand in Canada, 2014-Preliminary (2016), Energy conversion factors, p. 123; 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).

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Table 13.3 Canadian Default Factors for Calculating CH_4 and N_2O Emissions from Mobile Combustion

Vehicle Type	CH_4 Emission Factor (g CH_4/L)	N_2O Emission Factor (g N_2O/L)
Light-Duty Gasoline Vehicles (LDGVs)		
Tier 2	0.14	0.022
Tier 1	0.23	0.47
Tier 0	0.32	0.66
Oxidation Catalyst	0.52	0.2
Non-Catalytic Controlled	0.46	0.028
Light-Duty Gasoline Trucks (LDGTs)		
Tier 2	0.14	0.022
Tier 1	0.24	0.58
Tier 0	0.21	0.66
Oxidation Catalyst	0.43	0.2
Non-Catalytic Controlled	0.56	0.028
Heavy-Duty Gasoline Vehicles (HDGVs)		
Three-Way Catalyst	0.068	0.2
Non-Catalytic Controlled	0.29	0.047
Uncontrolled	0.49	0.084
Gasoline Motorcycles		
Non-Catalytic Controlled	0.77	0.041
Uncontrolled	2.3	0.048
Light-Duty Diesel Vehicles (LDDVs)		
Advance Control*	0.051	0.22

Moderate Control	0.068	0.21
Uncontrolled	0.10	0.16
Light-Duty Diesel Trucks (LDDTs)		
Advance Control*	0.068	0.22
Moderate Control	0.068	0.21
Uncontrolled	0.085	0.16
Heavy-Duty Diesel Vehicles (HDDVs)		
Advance Control	0.11	0.151
Moderate Control	0.14	0.082
Uncontrolled	0.15	0.075
Gas Fueled Vehicles		
Natural Gas Vehicles	0.009	6E-05
Propane Vehicles	0.64	0.028
Off-Road Vehicles		
Off-Road Gasoline	2.7	0.05
Off-Road Diesel	0.15	1
Railways		
Diesel Train	0.15	1
Marine		
Gasoline Boats	0.23	0.067
Diesel Ships	0.25	0.073
Light Fuel Oil Ships	0.25	0.073
Heavy Fuel Oil Ships	0.28	0.08
Aviation		
Aviation Gasoline	2.2	0.23
Aviation Turbo Fuel	0.029	0.071

Appendix M: Annual Commuting Travel Days

Days not Commuting to Campus	Employees	Students (90%)	Students (10%)
Canada Day	1		1
Natal Day	1		1
Labour Day	1		1
Thanksgiving	1	1	1
Fall Reading Week (Includes Remembrance Day)	1	5	5
Dec. Holidays	7	15	15
Munroe Day (Dal)	1	1	1
Winter Reading Weeks (Includes Family Day)	1	5	5
Easter	1	1	1
Victoria Day	1		1
Vacation	20		
Summer Leave		100	10
Weekends (2 days/week * 52 weeks)	104	104	104
Total days *not* travelling	140	232	146
Total Travel Days	225	133	219
		*142 day average	

Appendix N: Commuting Emissions by Province from Transport Canada (Transport Canada, 2011)

Pollutant emissions (g of pollutant per day) = VKT(vehicle-km per day) x Emission factor (g of pollutant per vehicle-km)

Suggested emission factors for each province and Canada were derived from UTEC. As noted in the Guide, the factors:

- Are given in grams of pollutant per vehicle-kilometres travelled.
- Reflect 2006 ratios between cars and light trucks within the light-duty passenger vehicle fleet of each jurisdiction.
- Assume a 98.5:1.5 ratio of gasoline-powered and diesel-powered passenger vehicles.
- Assume a 25:75 ratio between highway and city driving.
- The factors reflect vehicle operations only, and exclude upstream emissions from fuel production, refining and transportation.

Exhibit 0.4: Emissions Factors presented in Workplace Travel Plans Case Study

Province or territory	GHG (CO_2e)	CO	NO_x	SO_2	VOC	TPM	PM_{10}	$PM_{2.5}$
British Columbia	263	11.4	0.610	0.00423	0.672	0.0168	0.0165	0.00803
Alberta	263	11.5	0.612	0.00424	0.673	0.0168	0.0166	0.00804
Saskatchewan	262	11.4	0.609	0.00421	0.672	0.0168	0.0165	0.00803
Manitoba	261	11.4	0.608	0.00420	0.671	0.0168	0.0165	0.00802
Ontario	258	11.3	0.601	0.00415	0.669	0.0168	0.0165	0.00799
Quebec	254	11.2	0.593	0.00409	0.667	0.0167	0.0165	0.00797
New Brunswick	260	11.4	0.605	0.00418	0.670	0.0168	0.0165	0.00801
Nova Scotia	258	11.3	0.602	0.00416	0.669	0.0168	0.0165	0.00800
Prince Edward Island	257	11.3	0.599	0.00414	0.668	0.0168	0.0165	0.00799
Newfoundland and Labrador	261	11.4	0.608	0.00420	0.671	0.0168	0.0165	0.00802
Yukon/Northwest Territories/Nunavut	263	11.4	0.610	0.00423	0.672	0.0168	0.0165	0.00803
National average (weighted by provincial population, 2006)	258	11.3	0.602	0.00416	0.669	0.0168	0.0165	0.00800