GREENHOUSE GAS (GHG) INVENTORY REPORT 2022 - 2023

Fall 2023

Photo by: Julian Parkinson
[www.julianparkinson.ca]

DALHOUSIE UNIVERSITY | OFFICE OF SUSTAINABILITY

Table of Contents

List of Figures

List of Tables

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 subsequently updated to the 2010 fiscal year (April 1, 2009 – March 31, 2010), as more reliable and complete data records became available. This GHG inventory report is a follow-up to these previous assessments to compare GHG emissions from the 2023 fiscal year (April 1, 2022 – March 31, 2023) to the base year.

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 inventory reports are published on the Office of Sustainability website. The third version of the Dalhousie University Climate Change Plan (2022) (originally published in 2010) outlines the university's updated climate change mitigation and adaptation strategies and targets. For the 2022-2023 fiscal year, several projects were undertaken in accordance with this plan, including: continuation of Campus wide LED retrofits; building recommissioning, planning for a deep retrofit of the Killam library, toothed fan belt implementation, high efficiency pumping at Sexton campus, district energy flow control for Sexton campus and ongoing commissioning. Through our energy management information system (EMIS) we are identifying ongoing opportunities and issues. Campus activities have reverted to normal on-campus operations, though there is more hybrid work and class opportunities than before the pandemic.

The Dalhousie GHG inventory identifies all direct (Scope 1) and indirect (Scope 2) emissions under the university's operational control, as well as other indirect (Scope 3) emissions (commuting travel, paper, and water). In 2018, Dalhousie began including paper and water emissions in its Scope 3 calculations. Each year further research is undertaken related to additional Scope 3 emissions. Goals, strategies, and reduction reporting for Scope 3 activities are found in the Sustainability Plan Progress Reports.

Total greenhouse gas emissions (all campuses) were reduced in 2022-2023 over the base year for Scope 1 and 2 emissions by a total of 41% (Figure 0.1) with electricity still contributing the largest emissions impact (Figure 0.2).

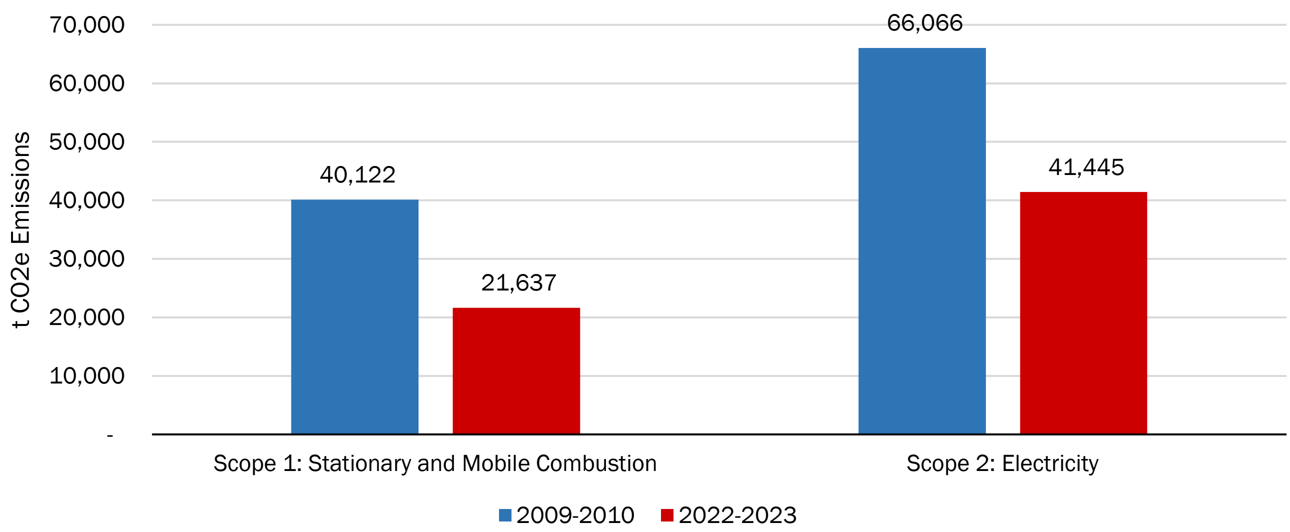


Figure 0.1. Comparison of Scope 1 & 2 emissions between 2009-10 (the base year) and 2022-23 for all campuses

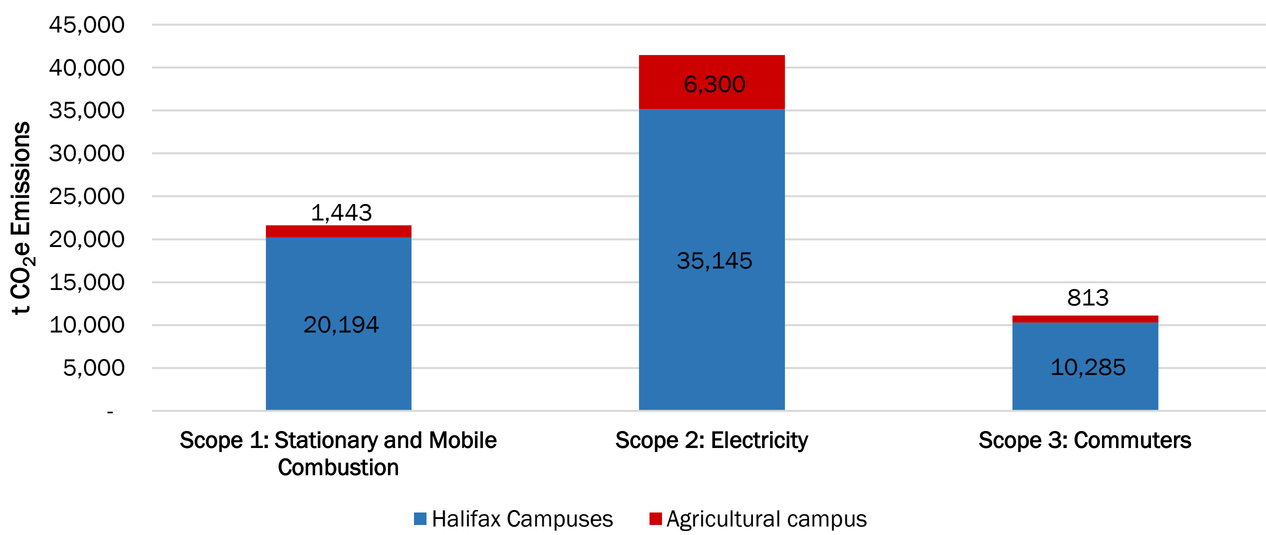


Figure 0.2. Emission breakdown by scope and geographical location

Furthermore, comparisons with square footage and campus populations were conducted between the base year and 2022-23 for scope 1, scope 2, and scope 3 commuting. As shown in Figure 0.3 and 0.4, there was a 38% decrease in emissions per square footage and a 54% decrease in emissions per weighted population. Emissions include the Dalhousie district energy system which provides service to square footage owned by Dalhousie and external entities (approximately 7% of the system). Population numbers include Dalhousie's population and not external entities. Including an estimate of external populations reduces the number of 3.0 to 2.9 tonnes per C02e.

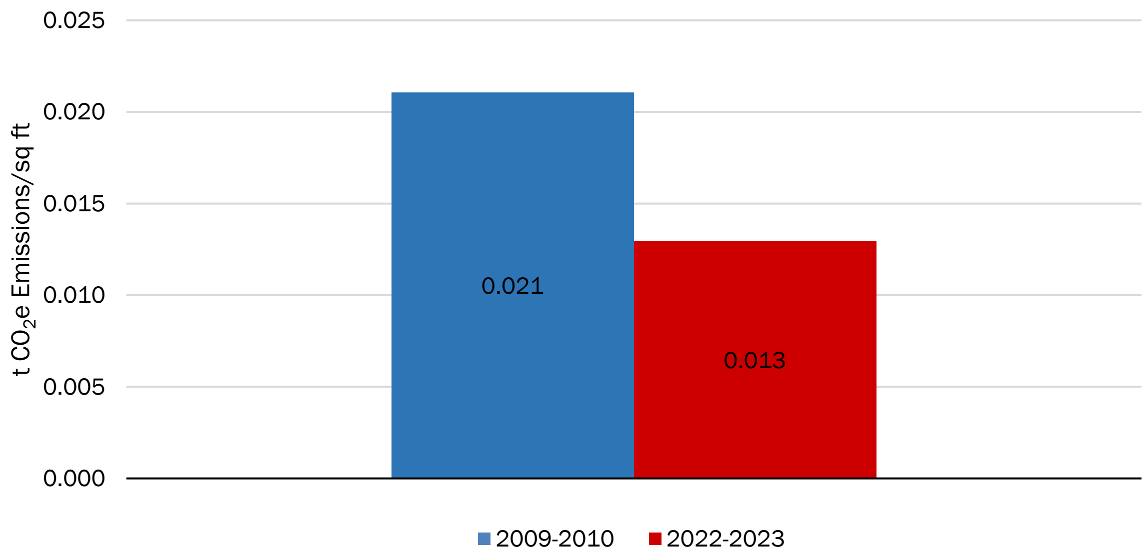


Figure 0.3. Comparison between the base year and 2022-23 on a per square footage basis

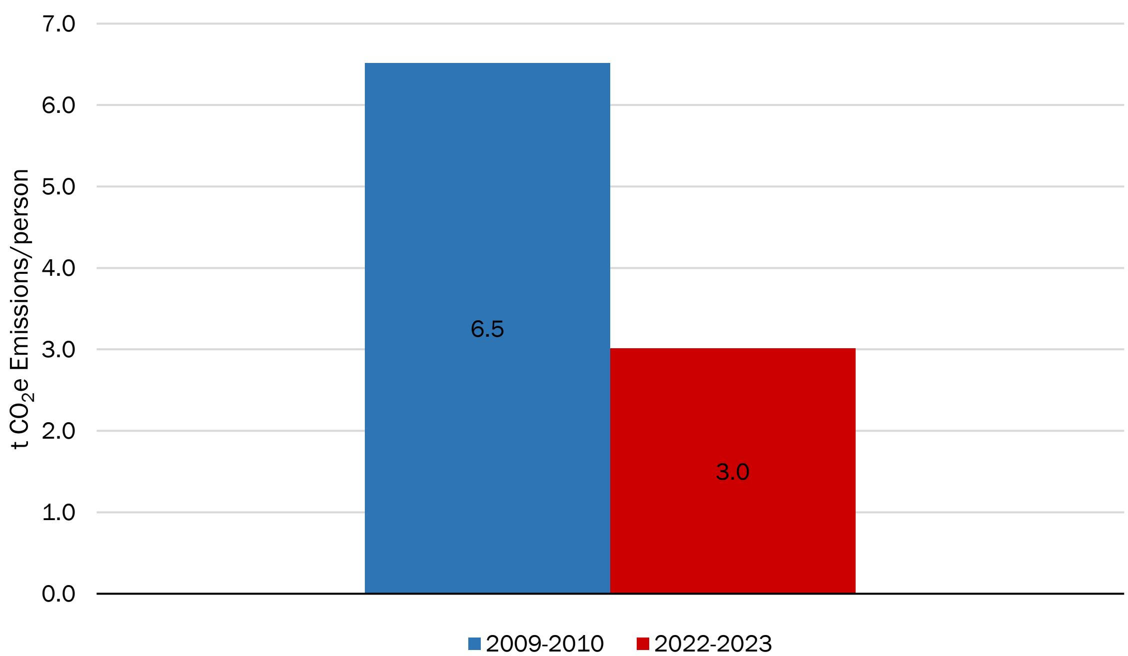


Figure0.4.Comparison between the base year and 2022-23 on a per capita basis

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 decrease since greenhouse gas reporting has been implemented. Figure 0.6 is adjusted to show the percentage breakdown of each scope.

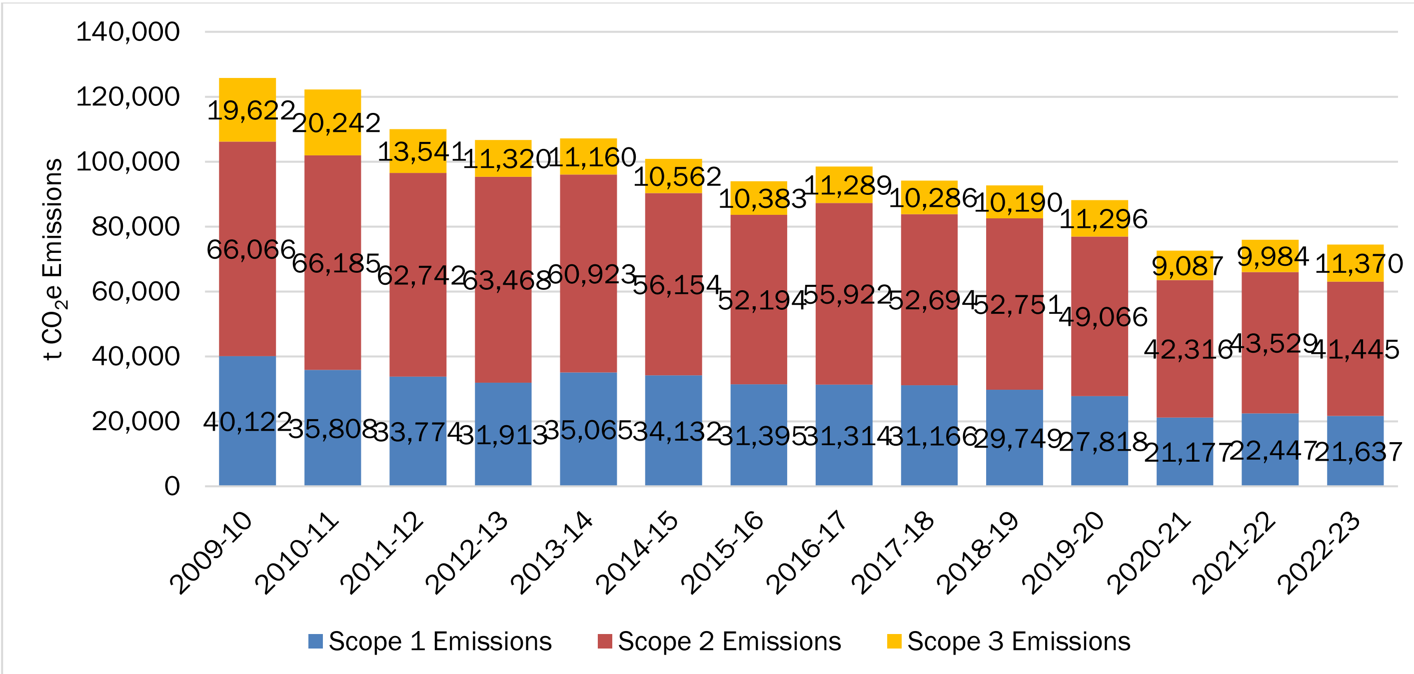


Figure 0.5. Comparison of annual emissions by scope between the base year and 2022-23

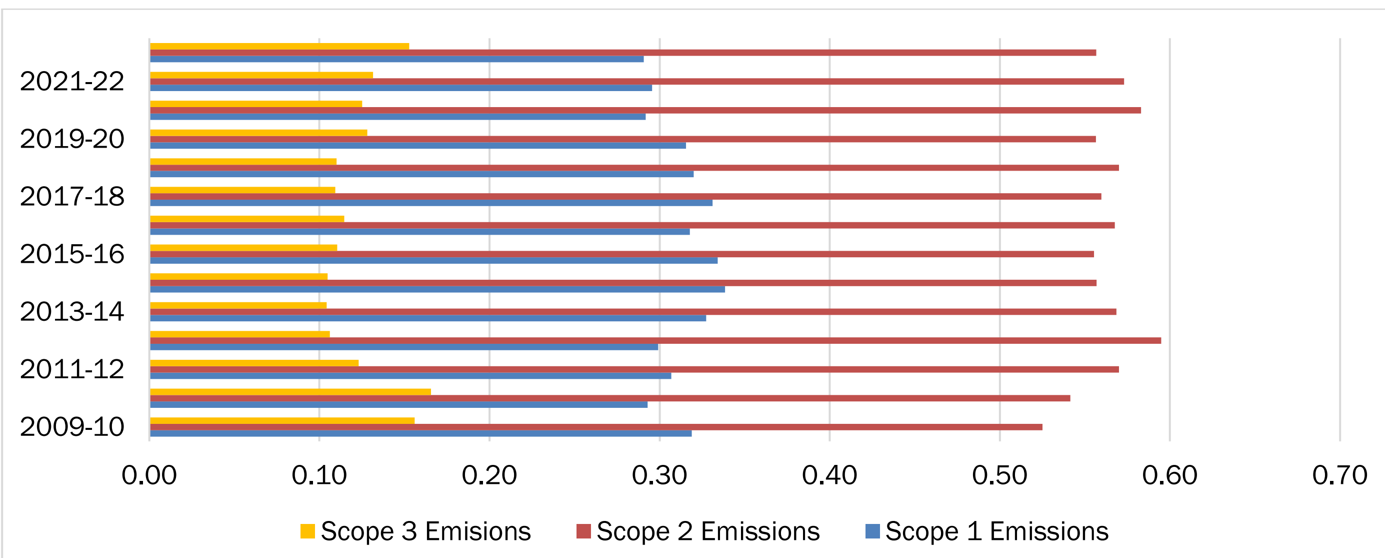


Figure 0.6. Annual emissions by scope shown as percentage totals between the base year and 2022-23

To gauge success of reduction of greenhouse gases, a table has also been generated tracking current and past emissions for easy comparison (Table 0.1) After 2017 Scope 3 emissions also includes water and paper. To determine the per capita emissions ratio, a weighted campus user metric is determined. This value is based on time spent on campus, which is calculated as follows:

 # Weighted campus users = # on-campus residence + 0.75(# full-time employees and students) + 0.5*(# part-time employees and students)*

Table 0.1. Dalhousie University (all campuses) GHG emissions breakdown (in tCO_2e) from the base year to 2021-2022

Dalhousie University (All Campuses) GHG Emissions (tCO2e)														
	2009-2010	**2010-2011**	**2011-2012**	**2012-2013**	**2013-2014**	**2014-2015**	**2015-2016**	**2016-2017**	**2017-2018**	**2018-2019**	**2019-2020**	**2020-2021**	**2021-2022**	**2022-2023**
Scope 1	40,122	35,808	33,774	31,913	35,065	34,132	31,395	31,314	31,166	29,749	27,818	21,177	22,447	21,637
Scope 2	66,066	66,185	62,742	63,468	60,923	56,154	52,194	55,922	52,694	52,751	49,066	42,316	43,529	41,445
Scope 3	19,622	20,242	13,541	11,320	11,160	10,562	10,383	11,289	10,286	10,190	11,296	9,087	9,984	11,370
Total emissions	125,810	122,235	110,057	106,701	107,148	100,848	93,972	98,525	94,147	92,690	88,180	72,580	75,960	74,452
Total emissions /person	6.521	6.108	5.319	5.244	5.241	4.838	4.508	4.747	4.501	4.427	4.180	3.398	3.210	3.020
Total emissions /square foot	0.025	0.024	0.021	0.020	0.020	0.018	0.017	0.018	0.016	0.016	0.015	0.012	0.013	0.012

Note: Commuter data only until 2017 for Scope 3, and then commuter, paper and water data included

Figure 0.7 shows Scope 3 emission of paper and water consumption. Paper data from the Agricultural campus is now included in 2022-23 while it was not available in 2021-22.

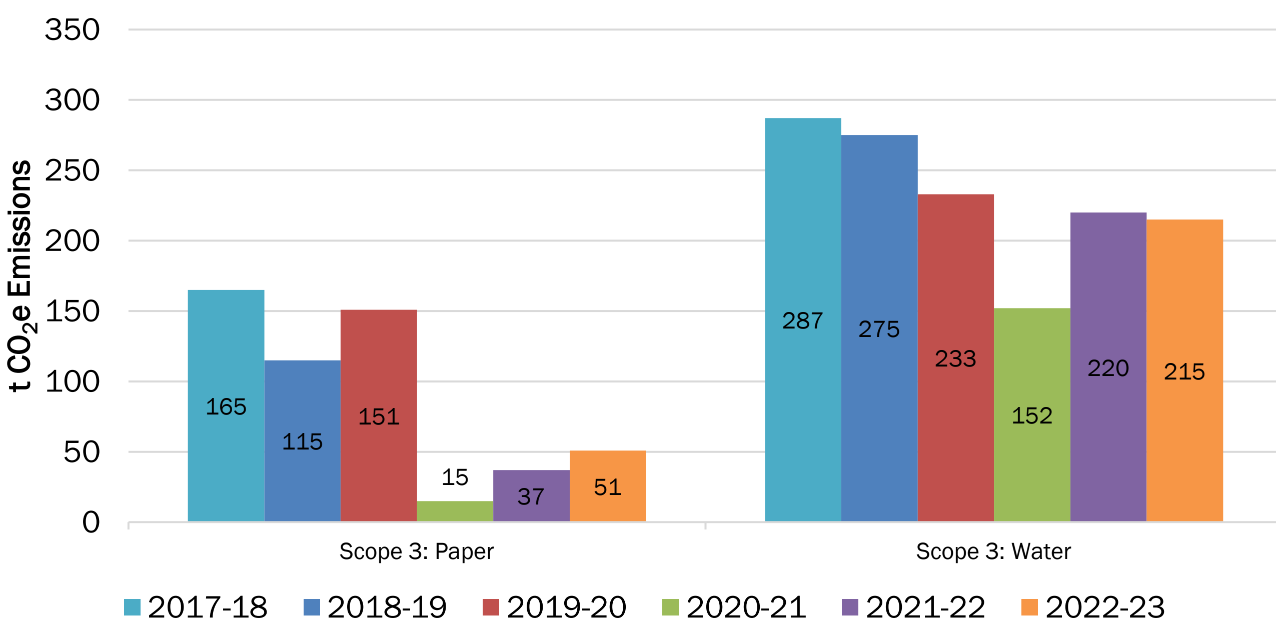


Figure 0.7. Additional Scope 3 emissions (paper and water) for the Halifax campuses, compared between 2022-23 and the first year of reporting (2017-18).

1. INTRODUCTION

On December 11, 2009, Dalhousie's President signed the University and College's Climate Change Statement for Canada. This statement required a comprehensive inventory of GHG emissions to be completed within one year of signing and, within two years of signing this document, the release of a climate plan with targets. In 2010, Dalhousie released its first University Climate Change Plan and baseline GHG inventory; a third version of the University Climate Change Plan was released in 2022. The 2022 plan establishes new targets for the university but continues to use 2009-10 as the baseline year. The annual GHG inventory reports are a follow up to the baseline GHG inventory, which allows comparisons to determine the progress of the university to meet the predetermined targets. The strategy in the next decade is on campus and local off campus projects for emissions reduction and adaptation as opposed to a strategy of offsets. Project cost estimation is over $200 million dollars.

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 30% by 2025; 55% by 2030; and 80% by 2040 below the 2009-2010 baseline year scope 1 and 2 emissions. Dalhousie also aims to achieve carbon neutrality before 2050.

Figure 1.1. Dalhousie's vision and targets

The *CAN/CSA-ISO 14064-1-20 Greenhouse Gases - Part 1: Specification with Guidance at the Organization Level for Quantification and Reporting of Greenhouse Gas Emissions and Removals (Adopted ISO 14064-1:2018, first edition, 2018-12-01)* standard is used as a framework for this GHG inventory report. Calculations are derived from The Climate Registry (TCR) – General Reporting Protocol – Version 3.0 (TCR: GRP 3.0), May 2019 (The Climate Registry, 2023). Emission factors used are taken from TCR 2023 Default Emission Factors (The Climate Registry, 2023), and Nova Scotia Power (Nova Scotia Power Inc., 2023). Terms and definitions are provided in Appendix A (National Standard of Canada, 2018). This report has been reviewed by staff of the Office of Sustainability.

Periodically (i.e., in 2010, 2014, 2017, and 2020), a third-party consulting firm has also been hired to review GHG processes and reporting. Feedback provided by Stantec Consulting Ltd after reviewing the initial draft of this GHG report was incorporated into this final report.

Figure 1.2. Green Labs energy, waste and water conservation educational materials.

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 it has direct operational control.

Dalhousie University owns 96 building structures and houses (including additions) across each of the three Halifax campuses: Studley, Carleton, and Sexton (Appendix B), as well as a property at 2209 Gottingen Street. Ninety-six 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 are 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 5,013,120 square feet (Appendix C). During the 2022-23 fiscal year, the University also leased a small amount of space in hospitals and commercial locations in Halifax.

The AC campus includes 45 buildings and houses totalling 837,400 square feet (Appendix C). Over 95% of all building space at the AC is on a district energy (DE) system fed from a central biomass plant. The conversion of the district energy (DE) distribution from steam to hot water was completed in the fall of 2017. In September 2018, a renewed central heating plant became operational, though was in the commissioning phase for a number of months after the start date, resulting in systems being on and offline and relying on oil back up. The old wood biomass steam boiler (approximately 30 years old) has been replaced with a biomass fired based thermal oil heater. Biomass sources comes from sawmill residue from two local sawmill facilities. The thermal oil heat moves a 1 MW turbine used to create electricity. This organic rankine cycle (ORC) system is a first installation of its kind at a university campus in North America. Process thermal energy is used for heating the campus. An enhanced air emissions management system was added along with two fuel storage bays. High efficiency pumps have been integrated to circulate hot water.

The electricity produced (approximately 70% of what the campus uses) is supplied to the grid. The carbon attributes associated with the electricity is claimed by the power utility through a Community Feed and Tariff agreement. The campus GHG reports reflect the overall NS emission factor for electricity (Scope 2) as we do not own the renewable electricity credits for this project. The energy and associated carbon used to create heating for the campus is identified in Scope 1. This is the fifth year that co-generation reporting calculations are used to determine carbon attributes associated with Scope 1.

During the 2022-23 fiscal year, two properties were leased to Nova Scotia's Department of Agriculture. 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 and a couple of houses) are considered to be outside the scope of the GHG inventory. The University provides steam and hot water to University of King's College buildings, a National Research Council building (Oxford St and Coburg Road), the Halifax Law Court (Spring Garden Road), and a local apartment building (6101 South Street). The GHG emissions associated with the natural gas used to create steam and hot water for these properties are included in Dalhousie GHG totals as the central heating plant services are under Dalhousie's control. To create an accurate emissions calculation of tonnes per square foot, the square footage of Dalhousie properties plus the square footage of the properties above (463,412 square feet) are added together. Further, 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 3.0) 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, 2023).

  - **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, 2023).

- **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, 2023).
- **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, 2023).

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). The University Sustainability Plan, 2022 and Climate Change Plan, 2022 have strategies and targets to reduce all emissions (Scope 1, 2, and 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. Fuel oil is used for back-up or peak shaving in Halifax. Light fuel oil is the back-up 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, natural gas combustion and electricity for heat pumps 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, including the AC central plant.

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 includes students and employees commuting to and from campus, paper consumption, and emissions from transport and distribution of water to and from campus.
- Future years may report other sources, such as other sources of waste and the natural environment and may refine methodologies for sources reported for the first time in 2017-18 (i.e., paper consumption and water usage).

1.3. REPORTED GHG EMISSIONS

Emissions of the following greenhouse gases will be reported. Definition information is provided by (Environment and Climate Change Canada, 2018).

- **Carbon dioxide (CO_2):** CO_2 is a naturally occurring, colourless, odourless, incombustible gas formed during respiration, combustion, decomposition of organic substances, and the reaction of acids with carbonates. It is present in the Earth's atmosphere at low concentrations and acts as a GHG. The global carbon cycle is made up of large carbon flows and reservoirs. Through these, CO_2 is constantly being removed from the air by its direct absorption into water and by plants through photosynthesis and, in turn, is naturally released into the e through slow geological processes such as the weathering of rock… Anthropogenic sources of CO_2 emissions include the combustion of fossil fuels and biomass to produce energy, building heating and cooling, transportation, land-use changes including deforestation, the manufacture of cement, and other industrial processes.
- **Methane (CH_4):** CH_4 is a colourless, odourless, flammable gas that is the simplest hydrocarbon. CH_4 is present in the Earth's atmosphere at low concentrations and acts as a GHG. CH_4 usually in the form of natural gas, is used as feedstock in the chemical industry (e.g., hydrogen and methanol production), and as fuel for various purposes (e.g., heating homes and operating vehicles). CH_4 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), and through the digestive processes of certain insects and animals such as termites, sheep, and cattle. $CH_4$is also released from industrial processes, fossil fuel extraction, coal mines, incomplete fossil fuel combustion and garbage decomposition in landfills.
- **Nitrous oxide (N_2O):** N_2O is a colourless, non-flammable, sweet-smelling gas that is heavier than air. Used as an anaesthetic in dentistry and surgery, as well as a propellant in aerosol cans, N_2O is most commonly produced via the heating of ammonium nitrate (NH_4NO_3). It is also released naturally from oceans, by bacteria in soils, and from animal wastes. Other sources of N_2O 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):** HFCs are a class of human-made chemical compounds that contain only fluorine, carbon, and hydrogen, and are powerful GHGs. As HFCs do not deplete the ozone layer, they are commonly used as replacements for ODSs such as chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) and halons in various applications including refrigeration, fire-extinguishing, semiconductor manufacturing and foam blowing.

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

- **Perfluorocarbons (PFCs):** PFCs are a group of human-made chemicals composed of carbon and fluorine only. These powerful GHGs were introduced as alternatives to ozone-depleting substances (ODSs) such as chlorofluorocarbons (CFCs) in manufacturing semiconductors. PFCs are also used as solvents in the electronics industry, and as refrigerants in some specialized refrigeration systems. In addition to being released during consumption, they are emitted as a by-product during aluminium production.

- **Sulphur Hexafluoride (SF_6):** SF_6 is a synthetic gas that is colourless, odourless, and non-toxic (except when exposed to extreme temperatures), and acts as a GHG due to its very high heat-trapping capacity. SF_6 is primarily used in the electricity industry as insulating gas for high-voltage equipment. It is also used as a cover gas in the magnesium industry to prevent oxidation (combustion) of molten magnesium. In lesser amounts, SF_6 is used in the electronics industry in the manufacturing of semiconductors, and also as a tracer gas for gas dispersion studies in industrial and laboratory settings.
- **Nitrogen Trifluoride (NF_3):** NF_3 is a colourless, non-flammable gas that is used in the electronics industry as a replacement for PFCs and SF_6. It has a higher percentage of conversion to fluorine, which is the active agent in the industrial process, than PFCs and SF_6 for the same amount of electronics production. It is used in the manufacture of semi-conductors, liquid crystal display (LCD) panels and photovoltaics.

1.4. GHG EMISSION CALCULATIONS

Greenhouse gas emissions are calculated by methods that are outlined in The Climate Registry (TCR) General Reporting Protocol (GRP) v.3.0, 2019 (The Climate Registry, 2023). Emission factors were found in The Climate Registry's 2022 Default Emission Factors (The Climate Registry, 2023), apart from emission factors for electricity, which were obtained from Nova Scotia Power (Nova Scotia Power Inc., 2023), and for Scope 3 emissions (various sources). The data and calculations used for this inventory are shown in detail in the following sections of this report.

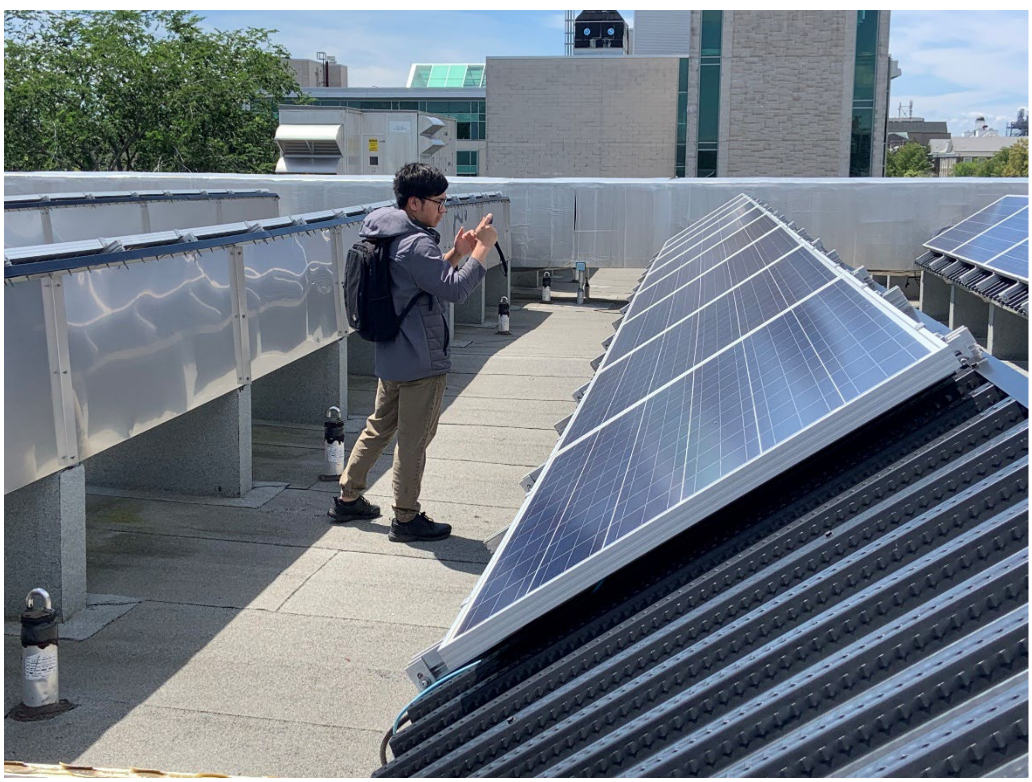


Figure 1.3.Office of Sustainability Summer intern analyzing solar panel hot spots.

2. GHG EMISSIONS INVENTORY

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

2.1. SCOPE 1 EMISSIONS

Scope 1 emissions include all "direct anthropogenic greenhouse gas emissions" (The Climate Registry, 2023).

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 Building (Carleton campus). From this building, a direct buried insulated hot water line runs 1 km to the Sexton campus. At the Sexton campus 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 #2 light fuel (furnace 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 until 2021 where a switch again was made to Furnace oil. Cooling is also provided to newer buildings through individual cooling systems. Some buildings do not have air conditioning.

Houses have individual oil fired, gas-fired, or heat pump heating systems. One building, O'Brien Hall, is not connected to the distribution system and is using electric and gas heating. 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, solar PV, solar air, and air and geo (geo-exchange) heat pump systems reduce the need for district energy in some buildings. Our newest buildings starting roughly 20 years ago rely on electricity (Heat pump systems – air and geo) with the district energy system as the back up or supplemental heat.

Fuels (Agricultural campus): Dalhousie University has a central plant, located at 43 Sipu Awti Rd., which provides heating to most AC buildings through a district energy system. The central heating plant consumes biomass (wood chips from sawmill residue) and uses for back up #2 fuel oil (furnace oil) to produce hot water 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 purposes. Heating systems use electricity, oil, and geo-exchange. In 2017, the steam distribution system was upgraded to hot water. In 2018-2019 a new biomass thermal oil heater and Organic Rankine Cycle turbine was installed. It creates electricity which is exported to the grid and waste heat is used for heating the campus.

For both the Halifax and Agricultural campuses, the Department of Facilities Management inputs energy consumption data into FAMIS which is read by Tableau Reader software accessible to the Office of Sustainability. This report presents historical consumption data retrieved from 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 2022-23 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.

Fleet (Halifax and Agricultural campuses): The Dalhousie fleet consists of vehicles owned and leased 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 D) was provided by the University Risk Manager, who oversees the insurance of all Dalhousie owned vehicles. Where possible, fuel purchase records were obtained for each vehicle and used to estimate fuel consumption. If data was missing, vehicle managers were contacted to obtain mileage or hourly usage data as a proxy for fuel consumption, or an average fuel consumption (assumed to be 1600 L) was applied.

This method, adopted in 2017-18, marks a change from previous years wherein mileage was the primary means of estimating fuel consumption for each vehicle. However, an independent assessment of the estimates from both mileage and fuel purchases suggested that the mileage method underestimates fuel consumption. Many Dalhousie vehicles are driven primarily within the city centre and may have lower fuel efficiency than reported averages, introducing error into the calculations. Further, data collection is simplified with this approach, limiting the need to contact individual vehicle managers to obtain mileage estimates for most vehicles. Although proxies are used in some cases, this method is expected to capture the majority of Dalhousie's fleet emissions more accurately.

2.1.2. Calculations

<u>Fuels</u>:

- Central Heating Plant – natural gas (with back up light fuel (furnace) oil and biomass (at the AC) with light fuel oil as back up;
- House heating and small amount of domestic hot water – furnace oil and natural gas;
- Back-up generators – diesel; and
- Cooking, lab equipment, warehouse space heating – propane.
- *electrically heated and cooled spaces consumption is in Scope 2.

The available data for CO_2, CH_4, and N_2O emissions from stationary combustion is assessed according to the TCR: GRP 3.0 methodology and qualifications (formerly Data Quality Tiers) (The Climate Registry, 2023). 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, this report calculates CO_2 emissions from stationary combustion using the standard method outlined in TCR: GRP 3.0, where default emission factors (found in Tables 1.1-1.3 in TCR) are used based on fuel type (rather than advanced methods that use heat or carbon content). Direct monitoring of CH_4 and N_2O emissions is not currently applied, so default emission factors are also used (determined based on fuel type and the type of combustion equipment; Table 1.4 in TCR).

According to TCR: GRP 3.0 (The Climate Registry, 2023), biogenic CO_2 emissions ($BioCO_2$) must be reported separately from fossil fuel emissions, while biogenic CH_4 and N_2O 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 plant growth (B.C. Ministry of Environment, 2020). Dalhousie does not count a net neutral contribution from biomass for electricity. The grid electricity emission factor is used as outlined in Scope 2 calculations

Direct stationary combustion emissions were calculated by using the following steps:

1. <u>Determine annual fuel consumption at each campus</u>

Fuel consumption data for Bunker B oil, furnace oil, diesel, propane, and natural gas (Halifax) and biomass and light fuel oil (AC) are obtained from Tableau Reader for both the Halifax and Agricultural campuses. Fuel consumption is recorded in litres for all fuels, except natural gas (reported in gigajoules) and biomass (in kilograms).

2. <u>Determine appropriate emission factors for each fuel</u>

Emission factors are based on TCR's 2023 Default Emission Factors in grams of CO_2 / unit of fuel combusted, grams of CH_4 and grams of N_2O / unit of fuel combusted. Relevant emission factors for the Dalhousie campuses are highlighted below (**Table 2.1. Scope 1: Summary of Emission Factors** Table 2.1; shown in full in Appendix E (CO_2) and Appendix F (CH_4 and N_2O).

Table 2.1. Scope 1: Summary of Emission Factors for Stationary Combustion (The Climate Registry, 2023)

Scope 1 Emissions	CO_2 Emission Factor	CH_4 Emission Factor	N_2O Emission Factor	Unit	Methodology
Bunker B	3075.4	0.0972	0.0574	grams / L	20% "Light Fuel Oil Industrial" and 80% "Heavy Fuel Oil Industrial" - Table 1.2 and 1.4 in TCR
1/5 Light Fuel Oil	0.2*2753	0.2*0.006	0.2*0.031	grams/L	
+ 4/5 Heavy Fuel Oil	0.8*3156	0.8*0.120	0.8*0.064	grams/L	
Diesel	2681	0.078	0.022	grams / L	"Diesel" (CO_2) and "Diesel (Refineries and others)" (CH_4 and N_2O) - Table 1.2 and 1.4 in TCR
Furnace Oil	2753	0.026	0.031	grams / L	"Light Fuel Oil Commercial" - Table 1.2 and 1.4
Propane	1515	0.024	0.108	grams / L	"Propane - all other uses" - Table 1.2 and 1.4
Natural gas	1921	0.037	0.033	grams /m^3	"Nova Scotia - Marketable" - Table 1.2 and 1.4
Biomass	1715	0.10	0.07	grams / kg	"Wood Fuel/ Wood Waste" - Table 1.2 and 1.4 in TCR

3. Calculate the CO_2 emissions for each fuel type and convert to metric tonnes

For all fuels except natural gas, the total fuel consumption in litres (or kilograms for biomass) was multiplied by the relevant emission factor to determine the CO_2 emissions for each fuel. Each emission factor was first converted from **grams** CO_2 / unit volume to **metric tonnes** CO_2 / unit volume.

For natural gas, energy consumption in gigajoules was divided by the heat content of the fuel (39.28 GJ/ML; Table 1.2 in TCR) and then converted to cubic metres (1 ML = 1000 m^3). Total natural gas consumption by volume was then multiplied by the emission factor in Table 2.1 (converted to metric tonnes per m^3).

4. Calculate the CH_4 and N_2O emissions for each fuel type

The calculations in Step 3 were repeated, except each fuel consumption value was multiplied by the relevant emissions factor for CH_4 and N_2O respectively from Table 2.1. Each emission factor was first converted from **grams** CH_4 or N_2O / unit volume to **metric tonnes** CH_4 or N_2O / unit volume.

5. Convert CH_4 and N_2O emissions to units of CO_2 equivalence (CO_2e) and determine total emissions from stationary combustion

CO_2 Emissions (mt CO_2e)	=	CO_2 Emissions **x** (mt)	1 (GWP)
CH_4 Emissions (mt CO_2e)	=	CH_4 Emissions **x** (mt)	28 (GWP)
N_2O Emissions (mt CO_2e)	=	N_2O Emissions **x** (mt)	265 (GWP)

The results of the above calculations are presented in Table 2.2 and Table 2.3. The emission factors shown are the cumulative emission factors for CO_2, CH_4, and N_2O, as shown in Table 2.1, and expressed in metric tonnes CO_2e / unit.

Table 2.2. Scope 1: Summary of Direct Emissions from Stationary Combustion, Halifax Campuses and external properties connected to the Dalhousie's District Energy System (April 2022-March 2023)

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)
Fuel Oil	47,387	L	0.0027619	130	0.03	0.39	**130.9**
Bunker B Oil	0	L	0.0030933	0	0.00	0.00	**-**
Diesel	62,668	L	0.0026890	168	0.14	0.37	**168.5**
Propane	24,505	L	0.0015443	37	0.02	0.7	**37.8**
Natural Gas	394,471	GJ	0.0487082	19,292	10.40	87.82	**19,389.9**
Total GHG emissions (Halifax)				**19,627***	**10.59**	**89.28**	**19,727.2**

*Dalhousie provides steam and hot water through its gas fired District Energy System to the National Research Council, Provincial Law Courts, the University of Kings College, and Killam Properties. Total square feet of these properties are 463,412. The fuel used to create steam and hot water for Dalhousie properties and these external properties is included in the numbers above.

Table 2.3. Scope 1: Summary of Direct Emissions from Stationary Combustion, AC (April 2022-March 2023)

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)
Fuel Oil	125,989	L	0.0027619	346.85	0.09	1.03	**348.0**
Diesel	13,286	L	0.0026890	35.62	0.03	0.08	35.7
Propane	99,968	L	0.0015443	151.45	0.07	2.86	154.4
Wood	26,183,963	kg	0.0017364	-	73.32	485.71	559.0
Total GHG emissions (AC)				**533.92**	**73.5**	**489.69**	**1,097**

BioCO_2, as previously mentioned, is not recorded as a direct emission. It must be calculated but is omitted from the totals shown above as per universal reporting requirements. For 2022-23, total wood consumption at the AC resulted in **44906 tonnes of biogenic CO_2** and **559 tonnes of CO_2** comprised of CH_4 and N_2O emissions. GHG inventory reporting methods focus on combustion emissions only. Data from published literature on the life-cycle emissions of all fuel types has been gathered to help guide management decision-making regarding the more complete carbon impacts of fuel types and to continue to work on improving the efficiency of all systems.

<u>Note on biomass cogeneration</u>

The TCR: GRP 3.0 states that when two or more parties receive the energy streams from combined heat and power (cogeneration) plants, GHG emissions must be allocated separately for heat production and electricity production. At Dalhousie University, the waste heat produced by the cogeneration plant is used to heat buildings on the AC. If the turbine is offline, heat can be provided by oil or biomass. Electricity, however, is sold to the provincial grid (and the campus receives grid-based power, as reported under Scope 2 emissions).

Although all biomass consumed at the AC results in Scope 1 and biogenic emissions, this report provides a breakdown of the amount of emissions attributable to both heat and electricity. The methodology is summarized below and shown in Appendix G.

1. <u>Calculate the total direct emissions from the CHP system</u>

Total biomass (wood) consumed by the cogeneration plant was **26,183,963** kg. If the system is offline heat has been provided by the oil furnace or biomass thermal wood heater. Using the steps outlined above and the emission factors for biomass in Table 2.1, this resulted in the following GHG emissions:

- 44906 CO_2 metric tonnes CO_2e
- 73.32 CH_4 metric tonnes CO_2e
- 485.71 N_2O metric tonnes CO_2e

2. <u>Determine the total hot water (heat) and electricity output for the CHP system</u>

Total electricity production and total hot water production (total campus heating energy consumed) were obtained from utility bills, central plant controls data and building meter data. Both measures were reported in kWh (equivalent kWh for heating energy consumed).

3. Determine the efficiencies of hot water (heat) and electricity production

The Nova Scotia Department of Energy has defined total system efficiency as "The annual overall efficiency is the total electricity generation plus the useful thermal energy, plus merchantable bio-products, divided by the biomass input heat content." (Nova Scotia Department of Energy, 2013).

The efficiencies of the hot water efficiency of the system were determined based on the calculation the biomass consumed by the system, the energy content for biomass fuel (NRCan, 2013) and the electricity production. Similarly, heat efficiency is calculated from the energy content of biomass, the biomass consumed, and the total campus heating energy.

Electrical efficiency was 16% and heating efficiency was 32.9%. **Overall system efficiency was 44%.** Determine the fraction of total emissions allocated to heat and electricity production

The following formula was used to allocate total emissions to heat and electricity (The Climate Registry, 2023):

ALLOCATING CHP EMISSIONS TO STEAM AND ELECTRICITY

STEP 1:

$$E_H = \frac{\frac{H}{e_H} \times E_T}{\frac{H}{e_H} + \frac{P}{e_P}}$$

STEP 2:

$$E_P = E_T - E_H$$

Where:

E_H = Emissions allocated to steam production

H = Total steam (or heat) output (MMBtu)

e_H = Efficiency of steam (or heat) production

P = Total electricity output (MMBtu)

e_P = Efficiency of electricity generation

E_T = Total direct emissions of the CHP system

E_P = Emissions allocated to electricity production

Using the values outlined in Steps 1-3, the emissions can be allocated as shown in Table 2.4. Per the above, all emissions from CO_2 are excluded from Scope 1 emissions and reported separately as BioCO_2. As more heating load comes back on at the campus system efficiencies will go up. A study was commissioned and completed on the opportunity to use available waste heat in the summer for cooling a new data centre.

Table 2.4. Allocation of emissions from cogeneration between heat production and electricity production (April 2022-March 2023).

Allocation Source	GHG Emissions CO_2 (tCO_2e)	GHG Emissions CH_4 (tCO_2e)	GHG Emissions N_2O (tCO_2e)	Total GHG Emissions (tCO_2e)
Heat	**32,250**	**53**	**349**	**32,652**
Electricity	12,655	21	137	12,813

Refrigerants

The TCR: GRP 3.0 Method A simplified mass balance approach is used to calculate fugitive refrigerant emissions. The subsequent steps were followed:

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

Reported losses (in pounds) of each type of refrigerant used on the Halifax campuses and the AC are provided by third party contractors and recorded in a separate spreadsheet. As the quantity of refrigerant recycled is not collected, or reported in the simplified mass balance equation, the total GHG emissions for refrigerants would be conservative estimates. These values are converted into metric tonnes and multiplied by the appropriate emission factor for each refrigerant. Emission factors are obtained from TCR's 2023 Default Emissions Factors (Tables 5.1 and 5.2, shown in Appendix H) in tonnes of CO_2e / tonne of refrigerant (The Climate Registry, 2023).

The results of the above calculations are shown in Table 2.5 and Table 2.6 below.

Table 2.5. Scope 1: Summary of Refrigerant GHG Emissions, Halifax Campuses (April 2022 – March 2023)

Refrigerant Name	Consumption (Loss) (tRefrigerant)	GWP (tCO2e/ tRefrigerant)	Total GHG Emissions (tCO2e)
R134A	0.01270	1300	16.51
R401A	0.00181	17.94	0.03
R402A	0.00000	1902	0.00
R404A	0.01179	3943	46.50
R407C	0.00136	1624	2.21
R410A	0.12746	1924	245.24
R422A	0.00000	2847	0.00
R437A	0.00000	1639	0.00
R438A	0.00000	2059	0.00
R508B	0.00000	11698	0.00
RS24	0.00000	1371	0.00
Total GHG Emissions			**310.49**

*RS24 is listed as a common name for R426A (The Linde Group, 2018); the GWP for R426A from TCR Table 5.2 is used.
**RS52 is listed as a common name for R428A (The Linde Group, 2018); the GWP for R428A from TCR Table 5.2 is used.

Table 2.6. Scope 1: Summary of Refrigerant GHG Emissions, AC (April 2022 – March 2023)

Refrigerant Name	Consumption (Loss) (tRefrigerant)	GWP (tCO2e/ tRefrigerant)	Total GHG Emissions (tCO2e)
R134A	0.00	1300	0
R401A	0.00	17.94	0
R402A	0.00	1902	0
R404A	0.04	3943	161
R407C	0.00	1624	0
R410A	0.00	1924	0
R422A	0.01	2847	32
R437A	0.00	1639	0
R438A	0.00	2059	0
R508B	0.00	11698	0
RS24	0.00	1371	0
RS52	0.00	3417	0
Total GHG Emissions			**193.25**

*Other refrigerants are used on campus. Information is reported on leaking systems.

*Refrigerant data from Conroy on the AC campus has been approximated using the last 2020-2022 data

<u>Fleet Vehicles</u>

The methodology for mobile combustion was followed as per the TCR: GRP 3.0, using emission factors from TCR's 2022 Default Emission Factors (The Climate Registry, 2023).

Mobile combustion CO_2 emissions were determined primarily using *Method A: Actual Fuel Use* (previously GRP MO-03-CO_2) in which fuel use is measured directly from purchasing data and default CO_2 emission factors by fuel type are applied. This methodology represents a change from previous inventories, in which *Method B: Estimation Based on Distance* (previously GRP MO-04-CO_2) was used by estimating fuel use by annual mileage and fuel economy. This methodology may still be applied where fuel purchase data is not available (< 25 vehicles); otherwise, proxy values based on the average fuel consumption per vehicle are applied.

Fuel purchase data was easier to collect than mileage since fleet vehicle fuel is purchased using either fleet or purchasing cards and can be obtained from a single source. In contrast, mileage data is collected from individual vehicle managers or is estimated where data is missing. Calculating fuel use from mileage also relies on average values for fuel economy, which may not reflect the actual performance of the individual vehicles.

CH_4 and N_2O emissions were calculated using TCR's **Simplified Estimation Method** for mobile combustion (gasoline and diesel passenger cars and light-duty trucks). By switching to using fuel purchase data, mileage data is no longer collected from which to calculate CH_4 and N_2O using the standard method outlined in TCR: GRP 3.0. However, given that mobile combustion emissions have consistently represented <1% of Dalhousie's

Scope 1 emissions, a simplified method was considered appropriate for calculating these emissions. Thus, CH_4 and N_2O emissions are calculated based on an emission factor per tonnes CO_2 generated.

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, using purchase records, mileage, and proxies

Fuel purchase data was obtained from the University Corporate Card Manager. These data were compared to the list of fleet vehicles (Appendix D), obtained from University Risk Manager, to determine which vehicles had fuel records and which used gasoline or diesel. The total amount spent on gasoline and on diesel was compared to the average retail price per litre of fuel in Halifax for 2022-23. For simplicity, it was assumed that geography (i.e., purchasing gas near the AC campus) would have minimal impact on average price. In 2022-23, the average price of regular unleaded gasoline was **$1.682 / litre**, while diesel fuel was **$2.044 / litre** (Statistics Canada, 2023).

In certain cases, where records of fuel purchases for vehicles were missing, individual vehicle managers were contacted to verify if the vehicle had been driven in 2022-23 and to collect mileage (or hourly usage) data.

Fuel economies were estimated using online fuel consumption ratings search tool (Natural Resources Canada, 2018). In some situations where data was incomplete, a proxy amount was entered based on similar vehicle type and use. In general, where multiple fuel economies were listed per vehicle, the highest was selected to provide a slight overestimate rather than an underestimate of fuel consumption.

Where no mileage or fuel data was available, a proxy of 1600 L was used (the average for the remainder of the fleet). This method was applied to 26 vehicles.

    b. Select appropriate CO_2 emission factor for each fuel type from TCR's Table 13.2 (The Climate Registry, 2023)

Diesel	n/a	38.30	1	2681
Petroleum Coke from Upgrading Facilities	n/a	40.57	1	3494
Petroleum Coke from Refineries & Others	n/a	46.35	1	3826
Motor Gasoline	n/a	35.00	1	2307

2) Calculate CH_4 and N_2O emissions from mobile combustion

The CH_4 and N_2O emissions of Dalhousie's fleet vehicles were calculated by using the TCR's 2023 Default Emission Factors: "Factors for Estimating CH_4 and N_2O Emissions from Gasoline and Diesel Vehicles (SEM)" in Table 2.9. This method bases the estimate of CH_4 and N_2O emissions off of total CO_2 emissions.

GHG	MT GHG per MT of CO_2
CH_4	2.04E-05
N_2O	2.19E-05

3) Convert CH_4 and N_2O emissions to units of CO_2 equivalence and determine total emissions

CO_2 Emissions (mt CO_2e)	=	CO_2 Emissions **x** (mt)	1 (GWP)
CH_4 Emissions (mt CO_2e)	=	CH_4 Emissions **x** (mt)	28 (GWP)
N_2O Emissions (mt CO_2e)	=	N_2O Emissions **x** (mt)	265 (GWP)

Mobile combustion emission calculation results are presented in Table 2.7 and 2.8 with a total summary of Scope 1 emissions in Table 2.9.

Table 2.7. Scope 1: Fleet Vehicle Emissions, Halifax Campuses (April 2022 – March 2023)

Energy Source	Consumption	Unit	CO_2 Emission Factor (tCO_2 / unit)	CH_4 Emissions (tCH_4)	N_2O Emissions (tN_2O)	Total GHG Emissions (tCO_2e)
Gasoline	42,931	Litres	0.00231	0.00585	0.00354	**100.1**
Diesel Fuel	20,763	Litres	0.00268	0.00329	0.00199	**56.3**
Total						**156.4**

*CH_4 emissions and N_2O emissions are multiplied by 28 and 265 respectively to convert them to tCO_2e.

Table 2.8. Scope 1: Fleet Vehicle Emissions, AC (April 2022 – March 2023)

Energy Source	Consumption	Unit	CO_2 Emission Factor (tCO_2 / unit)	CH_4 Emissions (tCH_4)	N_2O Emissions (tN_2O)	Total GHG Emissions (tCO_2e)
Gasoline	61,941	Litres	0.00231	0.01034	0.00625	**177.0**
Diesel Fuel	56,730	Litres	0.00268	0.00211	0.00127	**36.0**
Total						**213.0**

*CH_4 emissions and N_2O emissions are multiplied by 28 and 265 respectively to convert them to tCO_2e.

Table 2.9. Scope 1: Summary of Emissions (April 2022 – March 2023)

	Stationary Combustion	Refrigerants	Fleet	Total GHG Emissions (tCO_2e)
Halifax	19,727	310	156	21,194
AC	1,097	132	213	1,443
Combined	20,824	443	369	**21,637**

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, 2023).

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, many buildings on Sexton campus are supplied downstream of a street feed to the IDEA 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. (NSPI) (Nova Scotia Power Inc., 2023), which satisfies the standards of TCR: GRP 3.0 in determining indirect emissions from electricity (i.e., *Location-B: Regional or Subnational Emission Factors*).

Scope 2 electricity emissions were calculated by using the following steps:

1) Determine annual electricity consumption

Electricity consumption data is obtained from Tableau Reader for both the Halifax and Agricultural campuses. Consumption is recorded in kWh (Table 2.10 and 2.11). Data from Tableau comes from utility bills and university building electrical sub-meters.

2) Select appropriate emissions factors

Generator-specific emission factors are used as per NSPI's emission intensity table, which provides GHG emission intensities in grams of carbon dioxide equivalent (Appendix I). CH_4 and N_2O are already factored into emission intensities. The recently published coefficient for total system emission intensity in 2022-2023 (2022) is **557.2 g CO_2e/kWh** (Nova Scotia Power Inc., 2023), allowing for accurate calculations associated with purchased electricity.

3) Determine total emissions and convert to metric tonnes CO_2e

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

GHG emissions associated with purchased electricity at Dalhousie are presented below.

Table 2.10. Scope 2: Summary of Electricity GHG Emissions, Halifax Campuses (April 2022 – March 2023)

Energy Source	Consumption	Unit	Emission Factor (tCO_2e/ unit)	Total GHG Emissions (tCO_2e)
Electricity	63,073,808	kWh	0.000557	**35,145**

Table 2.11. Scope 2: Summary of Electricity GHG Emissions, AC (April 2022 – March 2023)

Energy Source	Consumption	Unit	Emission Factor (tCO_2e/ unit)	Total GHG Emissions (tCO_2e)
Electricity	11,305,847	kWh	0.000557	**6,300**

<u>Electricity generated by biomass co-generation</u>

Although both the Halifax and agricultural campuses are supplied with electricity from the provincial grid, the agricultural campus co-generates heat and power through a biomass-cogeneration system. The greenhouse gases associated with grid powered electricity is counted as opposed to the electricity produced by the biomass co-generation system for the grid as Nova Scotia Power owns the renewable energy credits associated with the biomass produced power.

2.3. SCOPE 3 EMISSIONS

Scope 3 emissions are "all other (non-Scope 2) indirect anthropogenic GHG emissions that occur in the value chain" (The Climate Registry, 2023). Scope 3 emissions are other organizations Scope 1 and 2 emissions. 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

In 2021-2022, research was conducted to understand the changing methods, categorization, and challenges/opportunities in accounting for Scope 3 emissions. The GreenHouse Gas Protocol (June 2022) defines Scope 3 categories as upstream and downstream with 15 categories from employee commuting to investments.

Upstream or downstream	*Scope 3 category*
Upstream scope 3 emissions	**1.** Purchased goods and services **2.** Capital goods **3.** Fuel- and energy-related activities (not included in scope 1 or scope 2) **4.** Upstream transportation and distribution **5.** Waste generated in operations **6.** Business travel **7.** Employee commuting **8.** Upstream leased assets
Downstream scope 3 emissions	**9.** Downstream transportation and distribution **10.** Processing of sold products **11.** Use of sold products **12.** End-of-life treatment of sold products **13.** Downstream leased assets **14.** Franchises **15.** Investments

A scan was undertaken of the U15 universities in Canada, Stanford, Cornell, Yale and Cambridge. The average Scope 3 categories reported in the U15 was 2.33 with some universities reporting 0 and one reporting 6 categories. Dalhousie currently reports three categories and modeled a fourth (waste) but at this time is concerned with the validity of the output. Stanford reported on the most categories (7) and has published methods discussion paper. There are a number of methods and data accuracy issues in calculating Scope 3. The 2023-2024 report will elaborate on the methods discussion and add new scopes were data is available including examination of farm based activities.

2.3.1. Overview

Commuting: Commuting emissions are emissions created from employees and students travelling to and from Dalhousie University. Transportation statistics are gathered annually by the Dalhousie University Annual Sustainability and Commuting Survey, conducted this year in the winter of 2023 (DalTRAC, 2023). The statistics include estimates of commuters who drive alone, carpool, bicycle, walk or take public transit to and from campus. Each non-active mode of transportation generates associated emissions; in contrast, active transportation (cycling and walking) generates no emissions and is assumed to be equivalent to taking one car off the road for each person who commutes via one of these modes.

Paper: Paper emissions are emissions associated with production, use, and disposal of paper products such as copy paper, newspapers, corrugated paper, and paperboard. Life-cycle analyses are needed to capture the range of emissions produced from specific types of pulp and paper products; however, in general, average emission factors can be calculated using paper size and the percentage of post-consumer recycled content (B.C. Ministry of Environment, 2016).

In 2013, Dalhousie instituted a Paper Policy to increase the efficiency of paper usage and maximize sourcing of sustainable paper. The base paper that Dalhousie units purchase was switched to 100% post-consumer recycled content paper. The volume of paper purchased is collected and reported on annually, allowing life-cycle emissions associated with Dalhousie's consumption to be estimated using default emission factors.

Water: Dalhousie uses large volumes of water on its campuses, including in laboratory facilities, the Studley campus Aquatron, showers and washroom facilities, and supplying drinking water. Emissions are associated with the distribution, collection and treatment of both water and wastewater. These processes are completed by Halifax Water and Town of Truro, but Dalhousie indirectly contributes to the release of emissions through its water consumption.

As with fuel consumption, the Department of Facilities Management inputs water utility data into FAMIS that is read by Tableau Reader and used in calculations in this report.

Paper data is available for the Halifax campuses but not presently for the Agricultural campus.

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. The commuter transportation emission calculations focus on travel to and from campus for work and educational purposes, and do not include intercampus or business travel. An estimated value of emissions for commuter travel was deemed important to gauge for future transportation demand management planning. Business travel data is currently not easily accessible. When this data is available, analysis and reporting will be undertaken.

Indirect emissions from commuting were calculated as follows:

1. Identify total number of trips for employees and students who travelled by each mode
    a. Survey data was used to identify travel mode percentages (DalTRAC, 2023)

Figure 2.1 and Figure 2.2 show the blended (where full time = 100% of the time, part time = 50% of the time) percentages at the Halifax and Agricultural campuses of modes of transportation used during the 2022-23 fiscal year by students, staff, and faculty.

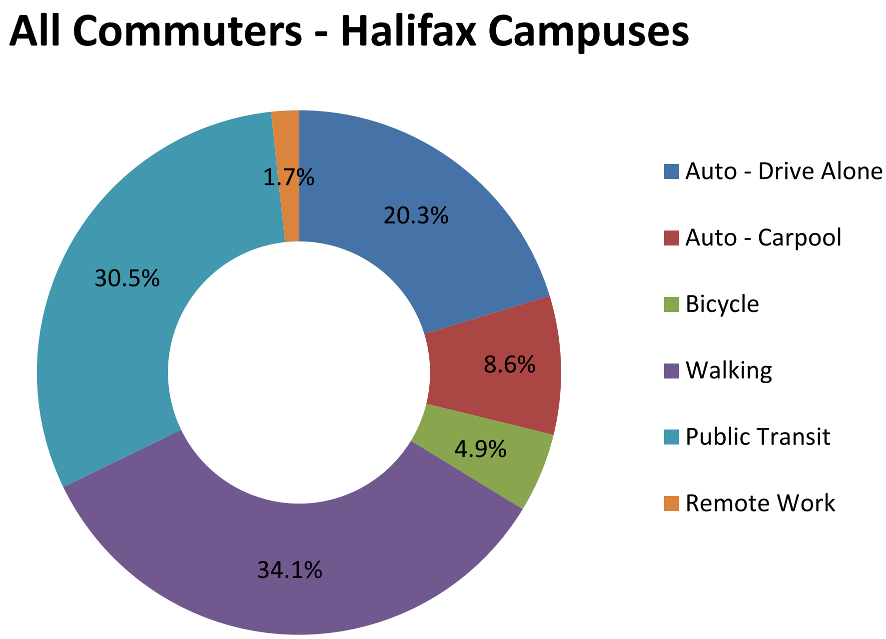


Figure 2.1. Blended commuting mode percentages, Halifax campuses (2022-23)

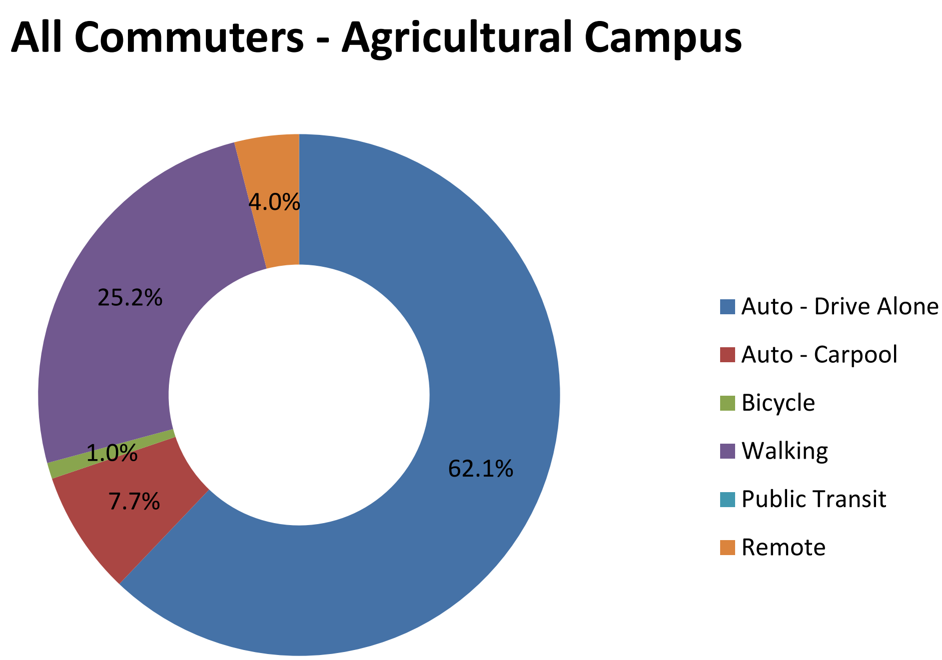


*Figure 2.2. Blended commuting mode percentages, Agricultural campus (2022-23)*No public transit available*

b. Travel mode percentages are multiplied by the weighted campus population (i.e., the number of full-time equivalents per year, where part-time = 0.5 full time) for both students and employees.
c. The resulting value (weighted campus population percentages for each travel mode) is then multiplied by the number of days travelled per year for both students and employees. Appendix J identifies the 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.
d. The % of remote work (remote and hybrid) is calculated based on survey data and is used to reduce the total numbers.

2. Determine total kilometres travelled for each mode

a. Set the average number of kilometres travelled daily by mode.

For travel by car, the average distance is set as 40 kilometres round trip. For carpooling, the drive-alone distance was divided in half during the emissions calculations (assuming an average of two people per vehicle, or 20 kilometres attributed to each person). Because the public transit system typically operates only within the Halifax Regional Municipality, an average of 20 km round trip was also used for commuting emissions from public transit.

To demonstrate how much GHG emissions are reduced by switching to active transportation: 4 km was assumed to be 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 (DalTRAC, 2023).

b. Multiple the average kilometres travelled per mode by the total number of trips identified in Step 1 for both students and employees.

3. Multiply total kilometres travelled by emission factors

Transport Canada's commuting emission factor was used in calculations for driving by car (alone and carpooling), at a value of 253 grams CO_2e per kilometre driven – average across all vehicle types for 2020 (shown in Appendix K) (NRCan, 2020). For public transit, the EPA provides an emission factor of 66.59 grams CO_2e per kilometer driven per passenger (EPA, 2008).

Table 2.12. Scope 3: Summary of Commuting GHG Emissions and Emissions avoided through Active Transport, Halifax Campuses (April 2022 - March 2023)

Commuter	Annual Distance (km)	Emission Factor (tCO2e/km)	Total GHG Emissions (tCO2e)
Drive alone	28,351,130	0.000256	**7,257.9**
Carpool	6,152,194	0.000256	**1,575.0**
Transit	21,812,323	0.00006659	**1,452.5**
Total Emissions Created:			**10,285.3**

Table 2.13. Scope 3: Summary of Commuting GHG Emissions and Emissions avoided through Active Transport, AC (April 2022 - March 2023)

Commuter	Annual Distance (km)	Emission Factor (tCO_2e/km)	Total GHG Emissions (tCO_2e)
Drive alone	2,988,969	0.000256	**765.2**
Carpool	185,306	0.000256	**47.4**
Transit	0	0.00006659	**0.0**

Indirect Emissions from Paper

Paper emissions are dependent on several factors, including the type of fuels used to generate pulp, energy use during harvesting, and end-of-life treatment, including whether paper is recycled or landfilled. Different types of pulp and paper have different associated emissions, although there is limited literature available on the emission intensity of specific paper brands. Thus, proxy values based on paper size and percentage of post-consumer recycled content (PCR) are used to calculate indirect emissions from paper consumption.

As a teaching and research institution, Dalhousie purchases large volumes of copy paper. The total amount for the Halifax is provided in number of sheets by procurement department. An estimated value of emissions for paper consumption is calculated using British Columbia's guidance on GHG inventories (B.C. Ministry of Environment, 2016), which provides emission factors per package of paper consumed (Appendix L).

1) Identify the amount and weight of paper purchased

Information from Procurement was obtained to determine the number of packages of paper purchased by Dalhousie in 2021-22. Data was collected for all white Bond paper, including 8.5 x 11 sheets, 8.5 x 14 sheets, and 11 x 17 sheets. To calculate the weight in kilograms, pre-determined weight estimates for 500-sheet packages of each paper type were used (i.e., 500 sheets of 8.5 x 11 = 2.27 kg; 500 sheets of 8.5 x 14 = 2.89 kg; 500 sheets of 11 x 17 = 4.55 kg) (B.C. Ministry of Environment, 2016). As per the Paper Policy, the majority of paper is 100% PCR content; however, a small amount of 30% PCR and 0% PCR content paper was also purchased in 2022-23.

2) Multiply paper consumption by B.C.'s emission factor for carbon dioxide equivalence

B.C. Ministry of Environment provides emission factors for paper by size and by PCR content (increments of 10%). A reference table was generated to calculate tonnes of CO_2e for each kilogram of paper consumed. The total weights of paper purchased in 2022-23 were multiplied by the appropriate emission factor for 30% and 100% PCR content (0.00248 and 0.00177 tonnes of CO_2e emissions respectively per kilogram of paper) (B.C. Ministry of Environment, 2016).

Total emissions from paper usage are shown below.

Table 2.14. Scope 3: Summary of Paper GHG Emissions, All Campuses (April 2022 – March 2023)

Paper Emissions	Paper consumption (kg)	Emission Factor (t CO2e/kg)	Total GHG Emissions (tCO2e)
0% PCR content	2,474	0.00280	6.9
10% PCR content	0	0.00270	0.0
20% PCR content	0	0.00259	0.0
30% PCR content	4,362	0.00248	10.8
40% PCR content	0	0.00239	0.0
50% PCR content	0	0.00228	0.0
60% PCR content	0	0.00218	0.0
70% PCR content	0	0.00208	0.0
80% PCR content	0	0.00197	0.0
90% PCR content	0	0.00187	0.0
100% PCR content	18,718	0.00177	33.1
Total Emissions Created:			**50.8**

<u>Indirect Emissions from Water</u>

Source: Dalhousie is supplied with water from the J. Douglas Kline Water Supply Plant, which sources water from nearby Pockwock Lake in Upper Hammonds Plains. Water is pumped from the lake into the supply plant, where the water is then treated using direct dual media filtration. This process is energy-intensive and relies on the addition of chemicals (e.g., coagulants and disinfectants), pumping, and filtration to achieve drinking water quality standards. A combination of grid-based electricity, oil, and natural gas is used to power the facility.

Water from the supply plant travels to the city of Halifax and surrounding areas primarily through gravity-fed pipes, but three small pumping stations aid in the distribution of the water.

Energy use associated with treatment and distribution of the water (including wastewater) results in the following greenhouse gas (GHG) emission factors, provided by Halifax Water[1]:

[1] Personal communications – J. Stewart, Project Manager, Halifax Wastewater Treatment Facility

Water supply		
Treatment	0.000207	tCO2e per M3
Distribution	0.000026	tCO2e per M3
Wastewater treatment		
Collection	0.000106	tCO2e per M3
Treatment	0.000166	tCO2e per M3

Use: Dalhousie uses water on campus for a variety of purposes, including drinking water, plumbing systems, heating (e.g., steam and hot water), and research and laboratory facilities (e.g., the Aquatron). The campus has undertaken steps to reduce and monitor water consumption, including implementing water efficiency projects such as low-flow water fixtures and research equipment retrofits. Since 2010, water usage on campus has decreased by 62%. Total consumption in 2009-10 was 1,162,692 m^3; in comparison, consumption was 437,945 m^3 in 2022-23.

Outgoing water: 100% of the water pumped into Halifax is subsequently treated in the Halifax Wastewater Treatment Facility (WWTF). The WWTF uses advanced primary wastewater treatment technology to filter the water, removing up to 70% of suspended solids by passing it thought a series of screens. The wastewater is clarified into liquid sludge, which is then is then dewatered to form 25% stable biosolids. Remaining water is disinfected using UV light and released as effluent into the harbour. The biosolids are trucked to Aerotech Business Park in Enfield, NS, and treated using an N-Viro alkaline stabilization process (i.e., adding lime or fly ash to raise the pH and destroy pathogens). The result is a soil amendment product that can be used in agriculture.

Other emissions may arise from the use of chemicals in the treatment process and from nitrogen release from the biosolids during agricultural use.

Stormwater management: The WWTF treats both stormwater and wastewater. The two sources are collected through different systems but combined for the treatment process in some sections of the city. Wastewater is collected via the sanitary sewer systems, while stormwater filters into ditches, drains and catch basins that are then channeled into joint sanitary and runoff water lines.

Dalhousie contributes to both wastewater and stormwater. It is assumed that 100% of the water used on campus is returned to the water treatment system through wastewater distribution. Additionally, stormwater runoff accumulates due the presence of impervious surfaces on campus, such as buildings, walkways, parking lots, and other paved surfaces. At this time, Dalhousie does not have an accurate estimate of the volume of water that it contributes to stormwater runoff. Therefore, emissions in this edition of the GHG inventory are based solely off primary water consumption; future editions may be expanded to include stormwater runoff, as well as other sources of emission from water treatment (e.g., specific emission factors for chemicals added during treatment).

Calculations

In the 2023 fiscal year, primary water consumption for the Halifax campuses was **408,033 m³** of water. Using the same value for primary water consumption, Scope 3 emissions from water output are therefore calculated using the emission factors provided by Halifax Water (Table 2.15).

Table 2.15. Scope 3: Summary of Water GHG Emissions, Halifax Campuses (April 2022 – March 2023)

Commuter	Water Consumption (m3)	Emission Factor (tCO_2e/L)	Total GHG Emissions (tCO_2e)
Water – Treatment	408,033	0.000207	84.5
Water – Distribution	408,033	0.000026	10.6
Wastewater – Collection	408,033	0.000106	43.3
Wastewater – Treatment	408,033	0.000166	67.7
Total Emissions Created			**206.06**

Most of the AC water is provided by the Town of Truro through their surface water supply approximately 7 km away. Some well water is used for aquaculture research. The Municipality of Colchester provides sewage treatment to the campus. Sewage lines connect to main lines on College Road. Material is pumped to the Colchester wastewater treatment facility roughly 8 km from campus. Some stormwater is released on campus. As water supply and wastewater treatment emission factors were not provided by the Town of Truro in time for this report, the emission factors provided by Halifax Water were used as a proxy (Table 2.16).

Table 2.16. Scope 3: Summary of Water GHG Emissions, Truro Campus (April 2022 – March 2023)

Commuter	Water Consumption (m3)	Emission Factor (tCO_2e/L)	Total GHG Emissions (tCO_2e)
Water – Treatment	29,912	0.000207	6.2
Water – Distribution	29,912	0.000026	0.8
Wastewater – Collection	29,912	0.000106	3.2
Wastewater – Treatment	29,912	0.000166	5.0
Total Emissions Created			**15.2**

3. REDUCING GHG EMISSIONS

In the 2022-23 fiscal year, a variety of projects were undertaken to reduce greenhouse gases and mitigate the impacts of climate change including:

- projects in the planning phase such as an assessment of using waste heat for heating campus buildings at Halifax campuses, expanding the geo-exchange system at Sexton, recommissioning buildings list, solar photovoltaics (PV) building assessment, and assessment of Dalhousie's energy management practices with ISO 50001 certification.
- projects moving into the implementation stage include Killam Library deep retrofit, lighting for the Chemistry building, and Arts Centre solar, lighting and recommissioning.

A number of projects are in final stages or the measurement and verification stage including a back up power study for all campuses, ventilation controls in Sherriff Hall, LED tube lighting replacement on all campuses, toothed fan belt implementation, high efficiency pumping at Sexton campus, district energy flow control for Sexton campus and ongoing commissioning. Through our energy management information system (EMIS) we identify ongoing opportunities and issues.

A number of annual programs and assessments are run by OS and partners including the employee bus program, safe cycling sessions, active transportation planning, annual commuter survey, efficient and low emission vehicle use education. In addition to these initiatives, designs and costs for fleet electric campus chargers was completed along with additional ideas around reducing, right sizing and procurement of fleet.

Each year the OS in conjunction with Facilities Management, Departments and students to maintain, and add biodiversity to campus spaces and support education efforts. This years student led project included an ecosystem triangle bed planting to mimic the general succession of the Wabanaki forest including grasses and asters woody plants like bayberry surrounded by existing oak trees and tree plantings.

Figure 3.1. Landscape Architecture students planting trees at the AC

4. NEXT STEPS

Projects are in an ongoing process of being planned, implemented, and monitored. Business cases that have been developed and approved in 2022-2023 for future work, including:

- A deep retrofit project for Killam library.
- Geo-exchange expansion
- Heat recovery at the Central Services Bldg,

Projects that are underway include:

- Chemistry building lighting and assessment of vacuum aspirators.
- Arts Centre upgrades;
- Efficient pumping, fan, and motor projects; and
- Recommissioning and controls projects.

The Office takes part in the planning of other facilities renewal projects and 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 sustainability, carbon, and energy performance

Office staff are actively exploring GHG mitigating solutions such as renewable energy power purchase agreements.

5. BIBLIOGRAPHY

B.C. Ministry of Environment. (2016). *2016 B.C. Best Practices Methodology for Quantifying Greenhouse Gas Emissions.* Retrieved from https://www2.gov.bc.ca/assets/gov/environment/climate-change/cng/methodology/2016-17-pso-methodology.pdf

B.C. Ministry of Environment. (2020). *2020 B.C. Best Practices Methodology for Quantifying Greenhouse Gas Emissions.* Victoria, B.C., Canada.

Dalhousie University. (2014). *Campus Map.* Retrieved July 6, 2013, from Dalhousie University Inspiring Minds: campusmaps.dal.ca/

DalTRAC. (2023). *Dalhousie University Commuter Study 2022-2023.* DalTRAC, Dalhousie Transportation Collaboratory, Halifax.

Environment and Climate Change Canada. (2018). *National Inventory Report 1990–2016: Greenhouse Gas Sources and Sinks in Canada.* Retrieved July 19, 2018, from https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions.html

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. (2018). Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals. *International Standard*, 1-5.

Natural Resources Canada. (2018). *Fuel consumption ratings search tool - conventional vehicles.* Retrieved from http://oee.nrcan.gc.ca/fcr-rcf/public/index-e.cfm

Nova Scotia Power Inc. (2023). *Total Emissions (All Plants).* Retrieved July 30, 2016, from Nova Scotia Power: An Emera Company: https://www.nspower.ca/clean-energy/air-emissions-reporting

NRCan. (2020, August 12). *Fuel Consumption Rating.* Retrieved July 11, 2013, from Government of Canada - Open Government: https://open.canada.ca/data/en/dataset/98f1a129-f628-4ce4-b24d-6f16bf24dd64

Statistics Canada. (2023). *Monthly average retail prices for gasoline and fuel oil, by geography*. Retrieved from https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1810000101

The Climate Registry. (2023, June). *2023 Default Emission Factors.* Retrieved from The Climate Registry: https://theclimateregistry.org/wp-content/uploads/2023/06/2023-Default-Emission-Factors-Final-1.pdf

The Climate Registry. (2023, May). General Reporting Protocol for the Voluntary Reporting Program. California, United States.

The Linde Group. (2018). *Industrial Gases - Refrigerants.* Retrieved from http://www.linde-gas.com/en/legacy/attachment?files=tcm:ry17-108590,tcm:y17-108590,tcm:17-108590

5.1. Appendix A: Terms and Definitions (National Standard of Canada, 2018)

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

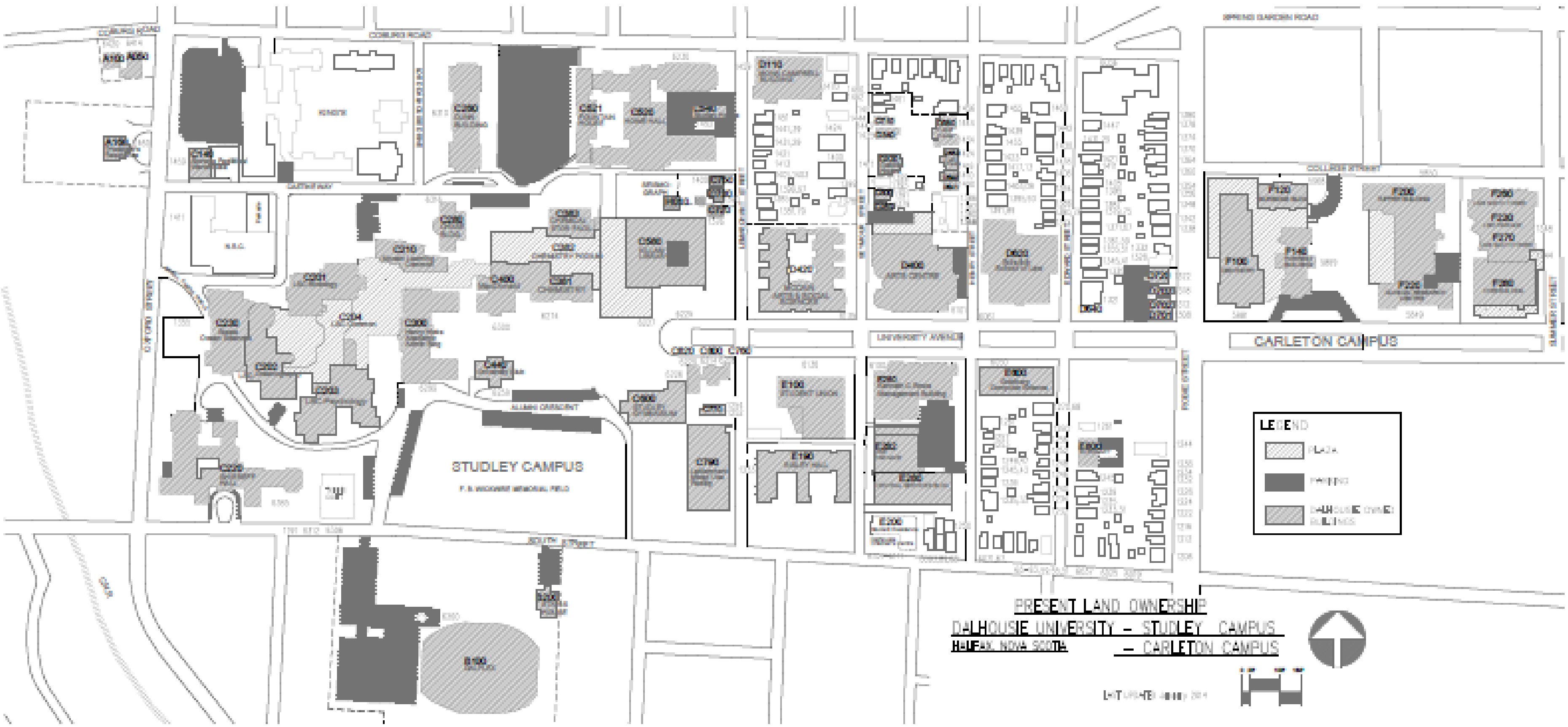
greenhouse gas source - physical unit or process that releases a GHG into the atmosphere

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

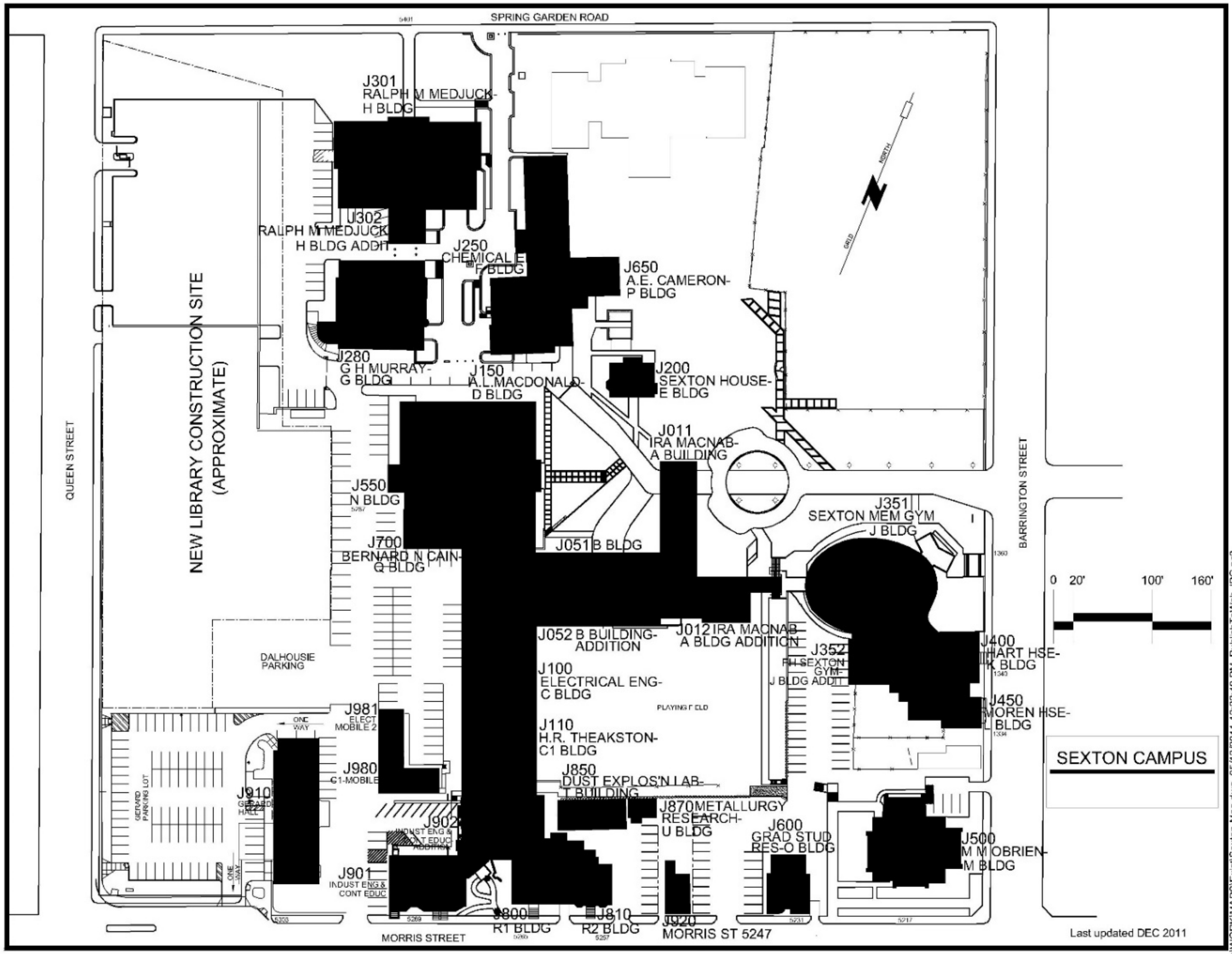
other indirect greenhouse gas emission - GHG emission, other than energy indirect GHG emissions, which is a consequence of an organization's activities, but arises from greenhouse gas sources that are owned or controlled by other organizations

5.2.Appendix B: Campus Maps (Dalhousie University, 2014)

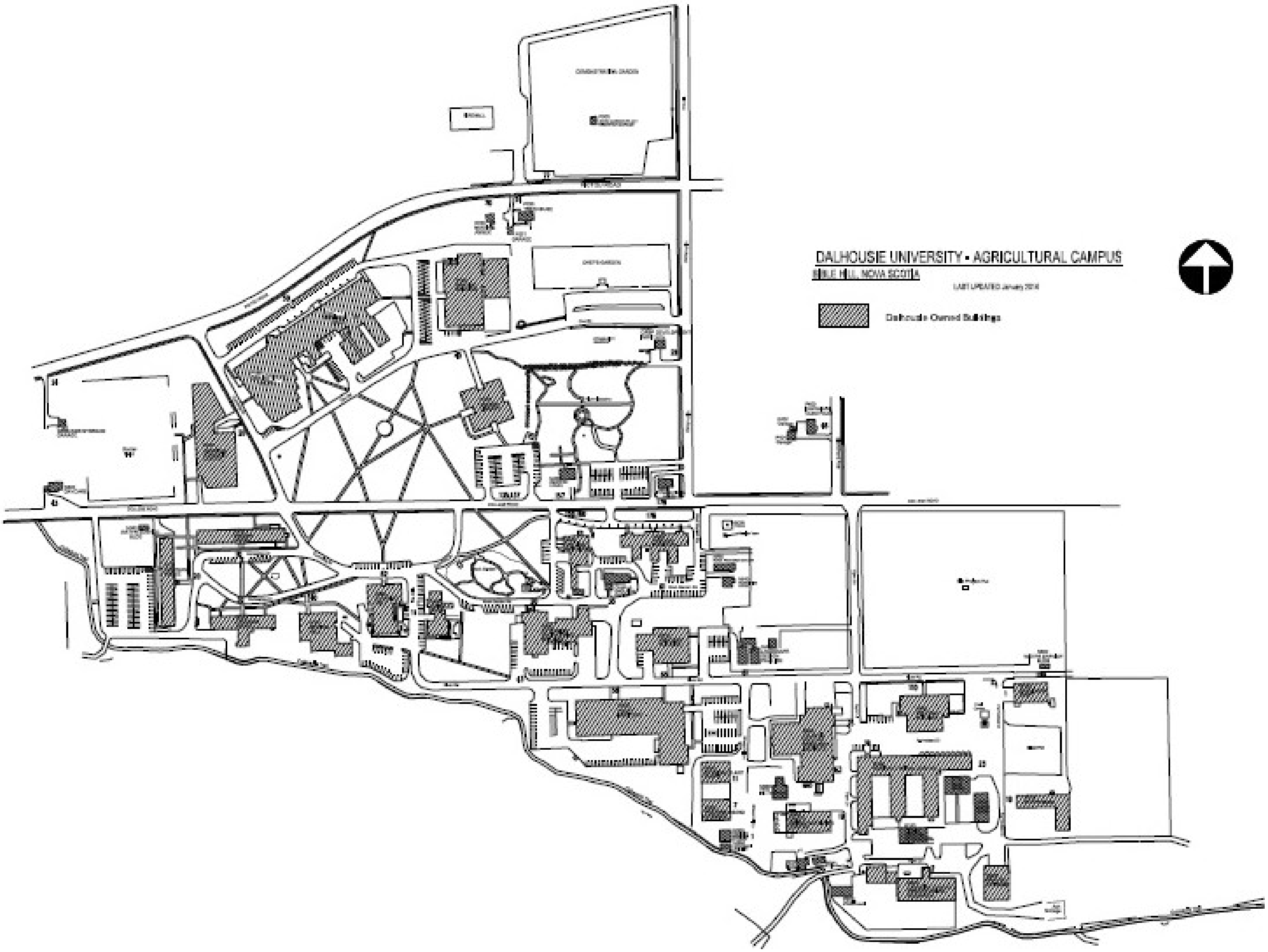
Halifax (Studley and Carleton campuses, 2014)



Halifax (Sexton campus, 2011)



AC (Agricultural Campus, 2014)



5.3.Appendix C: List of Campus Buildings

Halifax Campuses

Site	ID	Description	Building Address	Bldg. Area (GSF)
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	9,319
STUDLEY	B100	DALPLEX	6260 SOUTH STREET	178,767
STUDLEY	B300	FITNESS CENTRE	6260 SOUTH STREET	56,900
STUDLEY	B200	HEALTH & HUMAN PERFORMANCE (H&HP)	6230 SOUTH STREET	6,800
STUDLEY	C140	STORAGE FACILITY/WAREHOUSE	1459 OXFORD ST.	26,218
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	D340	SEYMOUR ST 1435	1435 SEYMOUR STREET	4,130
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	119,154
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	121,897
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	E282	CENTRAL SRV-PARKADE	1236 HENRY STREET	40,830
STUDLEY	E600	GOLDBERG COMPUTER SCIENCE BUILDING	6050 UNIVERSITY AVE	70,638
STUDLEY	E800	GLENGARY	1253 EDWARD STREET	16,270
STUDLEY	H010	SEISMOGRAPH		750
CARLETON	F100	DENTISTRY	5981 UNIVERSITY AVENUE	210,620
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	F270	LSRI-SOUTH TOWER	1344 SUMMER STREET	50,433
CARLETON	F280	COLLABORATIVE HEALTH EDUC BLDG	5793 UNIVERSITY AVE	107,000
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	J120	EMERA IDEA	1345 NORMA EDDY LANE	78,076
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	44,297
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	8,241
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	J960	DESIGN BLD	5257 MORRIS STREET	58,588
SEXTON	J910	GERARD HALL	5303 MORRIS ST.	94,269
EXTERNAL		NATIONAL RESEARCH COUNCIL	1411 OXFORD STREET	129,210
EXTERNAL		UNIVERSITY OF KINGS COLLEGE	6350 COBURG ROAD	245,000
EXTERNAL		PROVINCIAL LAW COURTS	5250 SPRING GARDEN RD	50,840
EXTERNAL		SOUTH STREET APARTMENTS	6101 SOUTH STREET	38,362
			Total	**5,013,120**
			Tableau Total	**5,008,869**

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	o	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**
			Tableau Total	**837,400**

5.4. Appendix D: Fleet Vehicles on Campus

<u>Halifax Fleet</u>

2022	Nissan Frontier
2022	Chevrolet Colorado
2022	Apogee ADAPT-X 400
2022	Apogee ADAPT-X 400
2021	Ford Ranger Supercab Pickup
2021	Load-Rite Boat trailer
2021	Karavan Move 1 trailer (Doug Wallace's Trailer)
2020	Chevrolet Colorado 4WD
2020	Dodge Grand Caravan
2020	Ram 2500 Pick up
2020	Toyota Camry Hybrid
2020	Chevrolet Colorado 4WD
2019	Kubota B2650HSDC
2019	Chevrolet Colorado
2019	Chevrolet Silverado 1500 4x4
2019	Ram Promaster City
2019	S70 Bobcat Skidsteer loader
2019	Chevrolet Silverado
2019	Ram 2500
2019	Load-Rite Boat trailer
2019	Amera-lite utility trailer
2019	Stirling 60-284-RDR trailer
2018	Toyota Tacoma 4x2
2018	Toyota Tacoma 4x4
2017	Venture VR-2850
2017	Hyundai Sonata
2017	Hyundai Elantra GT
2016	HINO 155-2 complete with 16' Transit dry freight body and Maxon TE20 lift gate (diesel)
2016	Ford F250 4x4 Crew Cab 156.0 XLT
2015	Ford F-series F150 4x4 Crewcab
2015	John Deere 1575 Terraincut w 60 in 7-iron side discharge deck
2015	HINO 155-2 complete with 2015 transit dry freight body and Maxon TE20 lift gate

2014	Chevrolet Silverado
2014	Chevrolet Silverado 1500
2013	Ram 2500 ST Crewcab Truck
2013	Pace Cargo Trailer
2013	HINO 16' W/Lift Gate 155-2
2013	Chev Silverado 2500
2013	GMC Sierra Crew Cab 4x4
2012	Dodge Grand Caravan
2012	Dodge Grand Caravan
2012	Dodge Grand Caravan
2011	Ford Escape XLT 4WD
2011	Normand Dump Trailer
2011	Ford Transit Connect
2011	Dodge Grand Caravan
2011	Ford Ranger Supercab Pickup
2010	Bobcat S185 Skid Steer Loader
2010	John Deere 2320 Tractor
2010	John Deere 2520 Tractor
2010	Chevrolet Silverado 2500
2009	Dodge Ram 1500 Pickup Truck
2009	Normand 1920-8 Utility /Dump Trailer
2009	Caron 5x10 GW welding trailer
2009	Load Rite 16F1200 Boat Trailer
2007	E-Z-Go Golf Cart
2007	John Deere 2320 Tractor
2004	Ford F150 Truck with Extended Cab
2004	Haulmark Utility Trailer
2004	Prono 503 Utility Trailer
2003	Boat Trailer - Venture Model VB-1300
2003	Boat Trailer - Venture Model VB-700
1981	EZ Load Boat Trailer

Agricultural Campus Fleet

2022	Ford F150
2022	Case Maxxum 150 with loader
2022	Case IH Farmall 120A with loader
2022	Case IH Farmall 120C
2022	CASE IH Vestrum 130
2022	Case Vestrum 130 with loader
2022	Case IH Magnum 220
2022	GMC 150 Sierra Crew Cab Pro
2021	Case IH Farmall 75C
2021	CASE IH Farmall 100C
2021	CASE IH Baler
2021	CASE IH Magnum 220
2021	Unverferth Perfecta Model 12 3PT 18' folding harrow
2021	CASE IH Farmall 90C
2021	CASE IH Farmall 120 U with loader
2021	Case IH Farmall 120C
2020	Ram 2500
2020	Toyota Pneeumatic forklift with rotator
2020	CASE IH Maxxum 135
2020	CASE IH Maxxum 145 with loader factory installed
2020	RB 455 Baler
2020	Big Jim 15' folding land roller
2020	Weberlane Utility Trailer
2020	Kubota B2650
2019	Ram 2500 ProMaster Cargo Van
2019	Kubota Flail Mower SE2230P
2019	Nissan NV3500 12 passenger van
2018	Nissan NV3500 SL (12 passenger van)
2018	Dodge Ram 2500 4WD 3/4 ton
2018	Kioti Mechron 2200 UTV
2018	Dodge Grand Caravan
2018	Lamar Dump Trailer
2018	Dodge Ram 2500
2018	Toyota Prius
2017	Toyota Camry LE
2017	Ford Transit Cargo Van
2017	HLA 275 Bale Wagon with 30' mesh deck (85030FL)

2017	Toro Groundsmaster GM3500D sidewinder Model 30807
2016	Canada Trailers, UT510-3K utility trailer
2016	John Deere 5085 MFWD Utility tractor w Blueberry BBH picker experimental blueberry harvester head, Blueberry BHH picker experimental blueberry harvester head, Blueberry Bin Loader
2016	Dodge Grand Caravan
2016	Dodge Grand Caravan
2016	Dodge Ram 5500 Dual wheel 4x4
2016	CHEV SILVERADO LT 2500 Crew Cab 4WD
2015	CASE IH - SR200 Skidsteer Loader
2014	Dodge Ram 1500 Truck
2014	Chev Silverado 1500
2014	Dodge Grand Caravan
2014	GMC Sierra
2014	KUBOTA Utility RTV 900XT
2014	Canada Trailers, CE716-10K Platform Trailer
2014	Kubota Z Turn Mower and grass catcher
2014	John Deere7400 Terraincut Mower
2013	GMC Sierra 2500 SLE
2013	Ford Econoline Van E-250
2013	GMC Yukon
2013	Ford F350 Truck
2012	Mission MU 5x 10W-R Utility Trailer
2012	FORD ECONOLINE E250 VAN
2012	FORD F150 Supercrew
2012	KUBOTA RTV1140PH
2012	John Deere 2520 Utility Tractor with Front End Loader & Mower Deck
2011	Ford Ranger s/cab
2011	Dodge Grand Caravan
2011	INTERNATIONAL 7500 SBA 4X2
2011	TOYOTA RAV 4 2WD
2011	CHEV SILVERADO 1500
2010	Fries Carhauler Utility Trailer
2010	FORD LGT CONVTNL 'F'
2010	CHEV SILVERADO
2010	SNOWBEAR TRAILER

2010	GMC Canyon
2010	JOHN DEERE 3032E Tractor
2009	DODGE RAM
2009	FORD F150 SUPERCAB
2009	Arctic Cat Prowler X
2008	KIOTI FARM TRACTOR DK65SC
2008	GMC Sierra 1500
2008	CHEV SILVERADO 1500
2008	DODGE Ram 1500 Quad
2008	Toro Groundsmaster 3280D
2008	Ford F350 Super Duty
2007	DODGE Ram 2500 Quad
2007	Belmont Dump Trailer
2007	GMC Sierra 2500 HD
2007	DODGE RAM 1500 Quad 4X4
2007	DODGE RAM 1500
2007	Mazda B4000 pickup
2006	FORD ECONOLINE E350
2005	YAMA ATV YXR66FATGR
2005	CHALLENGER TRACTOR MT295B
2005	Toro Groundsmaster 3500D with mulching kit - Farm Tractor
2005	Smithco Sweep Star 60
2001	GMC Sierra 1500
2000	FEATHERLITE TRLR 5595
2000	JOHN DEERE TRCTR 7510
1999	Ford New Holland Tractor 8360
1998	LIVESTOCK TRAILER Featherlite 8000 series
1996	FORD TRACTOR WD 7840SLE
1995	JOHN DEER F925 MOWER Tractor
1994	KAWASAKI MULE BG033
1994	FORD TRACTOR 7740
1993	Chev Topkick 3 Tonne Truck
1993	HEGE COMBINE 125C
1992	NOVA TANDEM Trailer
1992	KUBOTA DECK MOWER F2100E
1990	CASE 1640 AXIAL FLOW COMBINE
1990	JOHNDEERE 1070 Tractor
1989	SCOTT TAG-A-LONG(trailer)

1988	DEUTZ-AL TRACTOR
1985	HEGGE COMBINE
1985	TYM TRACTOR
1984	HALDRUP 1500 HARVESTER
1983	HALDRUP FORAGE1500 Harvester
1983	Massey Ferguson Utility Tractor 1030 with Hardy Front End Loader
1980	JOHN DEERE TRACTOR 1640
1979	FORD 60HP Tractor
1978	KUBOTA TRACTOR
1967	MASSEY FERGUSON TRACTOR
1959	Oliver Tractor
	Pottinger HIT 4.54, 4-rotor tedder
	New Holland FP230 Forage Harvester
	Salford- 1-5100 Series Harrow 16ft

5.5. Appendix E: Canadian Default Factors for Calculating CO_2 Emissions from Combustion of Natural Gas, Petroleum Products, and Biomass (Table 1.2, 2020 Default Emissions Factors) (The Climate Registry, 2023)

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 / m3**
All Provinces				
Still gas (Upgrading Facilities)	n/a	43.24	1	2140
Still gas (Refineries & Others)	n/a	36.08	1	1797
Newfoundland and Labrador				
Marketable	n/a	39.28	1	1901
NonMarketable	n/a	39.28	1	2494
Nova Scotia				
Marketable	n/a	39.28	1	1901
NonMarketable	n/a	39.28	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

Fuel Type	Carbon Content (Per Unit Energy)	Heat Content	Fraction Oxidized	CO_2 Emission Factor (Per Unit Mass or Volume)
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
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	2681

Biomass	kg C / GJ	GJ / t		g CO_2 / kg
Wood Fuel/Wood Waste	n/a	18.00	1	1715

5.6. Appendix F: Canadian Default Factors for Calculating CH4 and N2O Emissions from Combustion of Natural Gas, Petroleum Products, and Biomass (Table 1.4, 2020 Default Emissions Factors) (The Climate Registry, 2023)

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)	6.4	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
Refined Petroleum Products	**g CH_4 / L**	**g N_2O / L**
Light Fuel Oil (Electric Utilities)	0.18	0.031
Light Fuel Oil (Industrial and Producer Consumption)	0.006	0.031

Fuel Type	CH_4 Emission Factor (Per Unit Mass or Volume)	N_2O Emission Factor (Per Unit Mass or Volume)
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)	0.12	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)	0.078	0.022

Biomass	**g CH_4 / kg**	**g N_2O / kg**
Wood Fuel/Wood Waste (Industrial Combustion)	0.10	0.07
Spent Pulping Liquor (Industrial Combustion)	0.03	0.005

5.7.Appendix G: Methodology for Allocating Emissions from Combined Heat and Power (The Climate Registry, 2023)

1. Determine the Total Direct Emissions from the CHP System

Calculate total direct GHG emissions using the methods for quantifying direct emissions from stationary combustion. Like the guidance for non-CHP stationary combustion, calculating total emissions from CHP systems is based on either CEMS or fuel input data.

2. Determine the Total Steam and Electricity Output for the CHP System

To determine the total energy output of the CHP system attributable to steam production, use published tables that provide energy content (enthalpy) values for steam at different temperature and pressure conditions.[9] Energy content values multiplied by the quantity of steam produced at the temperature and pressure of the CHP system yield energy output values in units of MMBtu. Alternatively, determine net heat (or steam) production (in MMBtu) by subtracting the heat of return condensate (MMBtu) from the heat of steam export (MMBtu). To convert total electricity production from MWh to MMBtu, multiply by 3.412 MMBtu/MWh.

3. Determine the Efficiencies of Steam and Electricity Production

Identify steam (or heat) and electricity production efficiencies. If actual efficiencies of the CHP system are not known, use a default value of 80% for steam and a default value of 35% for electricity. The use of default efficiency values may, in some cases, violate the energy balance constraints of some CHP systems. However, total emissions will still be allocated between the energy outputs. If the constraints are not satisfied, the efficiencies of the steam and electricity can be modified until constraints are met.

4. Determine the Fraction of Total Emissions Allocated to Steam and Electricity Production

Allocate the emissions from the CHP system to the steam (or heat) and electricity product streams by using the equation below.

ALLOCATING CHP EMISSIONS TO STEAM AND ELECTRICITY	
STEP 1:	$$E_H = \frac{\frac{H}{e_H} \times E_T}{\frac{H}{e_H} + \frac{P}{e_P}}$$
STEP 2:	$$E_P = E_T - E_H$$

Where:

E_H = Emissions allocated to steam production

H = Total steam (or heat) output (MMBtu)

e_H = Efficiency of steam (or heat) production

P = Total electricity output (MMBtu)

e_P = Efficiency of electricity generation

E_T = Total direct emissions of the CHP system

E_P = Emissions allocated to electricity production

5.8. Appendix H: Global Warming Potentials of Refrigerants and Blends (Tables 5.1 and 5.2, 2022 Climate Registry Default Emission Factors, p. 75-83)

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

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-407G	HFC	1321	1334	1463	1331
R-407H	HFC	1314	1371	1495	1378
R-407I	HFC	1301	1332	1459	1337
R-408A	HFC	1944	2216	2301	2430
R-410A	HFC	1725	1975	2088	1924
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-444B	HFC	284	240	293	295
R-445A	HFC	117	117	128.7	117

Note: R508B is a 39%/61% blend of HFC-23 and PFC-116 respectively. The GWP of R508B was based on this percent composition using the respective GWP of each blend.

5.9. Appendix I: Nova Scotia Power Emission Factors (Nova Scotia Power Inc., 2023)

SYSTEM TOTALS - EMISSION INTENSITIES				
YEAR	MERCURY (G/GWH)	SULPHUR DIOXIDE (G/KWH)	CARBON DIOXIDE EQUIVALENT (G/KWH)	NITROGEN OXIDE (G/KWH)
2005	9.0	8.9	915.1	2.8
2006	15.4	10.2	927.6	2.7
2007	13.2	9.2	855.3	2.2
2008	13.8	9.1	831.0	1.8
2009	12.4	8.9	829.3	1.5
2010	7.1	5.4	808.3	1.6
2011	8.4	5.8	765.2	1.1
2012	9.6	6.8	781.3	1.6
2013	6.9	6.5	747.9	1.6
2014	5.2	5.9	705.7	1.6
2015	5.3	5.8	685.7	1.4
2016	6.0	6.1	700.1	1.5
2017	6.4	6.2	660.4	1.5
2018	6.0	5.9	654.9	1.4
2019	5.6	4.9	630.9	1.4
2020	6.0	5.1	629.7	1.4
2021	3.9	4.9	602.9	1.2
2022	4.9	4.8	557.2	1.1

Emissions intensity numbers based on electricity sales

CO2 intensity is based on emissions from generation in NS and electricity imports

5.10. Appendix J: Annual Commuting Travel Days

Days not Commuting to Campus	Employees	Students (90%)	Students (10%)
Canada Day	1		1
Natal Day	1		1
Labor 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	

5.11. Appendix K: Commuting Emissions by Vehicle Type (NRCan, 2020)

Note: The average CO_2 emissions factors are based on all models within each Manufacturer's lineup.

Row Labels	Average of CO2 Emissions (g CO2 /km)
2021	**253.48**
Acura	231.67
Alfa Romeo	237.50
Aston Martin	311.17
Audi	260.77
Bentley	338.13
BMW	273.46
Bugatti	565.00
Buick	221.67
Cadillac	243.24
Chevrolet	274.14
Chrysler	261.00
Dodge	313.55
FIAT	221.00
Ford	257.23
Genesis	261.50
GMC	290.46
Honda	185.00
Hyundai	194.96
Infiniti	268.50
Jaguar	259.67
Jeep	259.31
Kia	196.88
Lamborghini	437.33
Lexus	231.04
Lincoln	260.43
Maserati	312.82
Mazda	198.03
Mercedes-Benz	259.82
MINI	194.95
Mitsubishi	186.20
Nissan	219.18
Porsche	276.57
Ram	293.93
Rolls-Royce	390.00
Subaru	213.06
Toyota	200.14
Volkswagen	215.81
Volvo	222.23

5.12. Appendix L: Emission Factors for Office Paper (B.C. Ministry of Environment, 2016)

Table 6: Office Paper

PCR Content (%)	Emission Factor (kg CO_2e/ pkg)		
	8.5” x 11”	8.5” x 14”	11” x 17”
0	6.358	8.094	12.743
10	6.123	7.795	12.272
20	5.888	7.496	11.802
30	5.653	7.197	11.331
40	5.418	6.898	10.860
50	5.184	6.599	10.390
60	4.949	6.300	9.919
70	4.714	6.001	9.449
80	4.479	5.703	8.978
90	4.244	5.404	8.508
100	4.010	5.105	8.037

Note: emission factors for office paper are based on a 500-sheet package of 20-pound bond paper weighing 2.27, 2.89 and 4.55 kg, respectively, for the three paper sizes.