

A photograph of an industrial facility, likely a power plant or refinery, featuring several tall smokestacks and large concrete structures. The scene is partially obscured by lush green trees in the foreground. The sky is a clear, bright blue. A large yellow speech bubble is overlaid on the lower half of the image, containing the title text.

# **GREENHOUSE GAS (GHG) INVENTORY**

## **2023-2024 REPORT**

PUBLISHED NOVEMBER 2024



**DALHOUSIE** | OFFICE OF  
UNIVERSITY | SUSTAINABILITY

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### 3 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 2024 fiscal year (April 1, 2023 – March 31, 2024) 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 2023-2024 fiscal year, several projects were undertaken in accordance with this plan, including: building recommissioning, the deep retrofit underway at the Killam library, solar PV installation on the new Arts Centre addition, planning for the expansion of the geothermal system at the Sexton Campus, the stack economizer waste heat recovery project, high efficiency pumping at Sexton campus, and ongoing commissioning. Through our energy management information system (EMIS) we are identifying ongoing opportunities and issues.

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 2023-2024 over the base year for Scope 1 and 2 emissions by a total of 46% (Figure 1) with electricity still contributing the largest emissions impact (Figure 2).

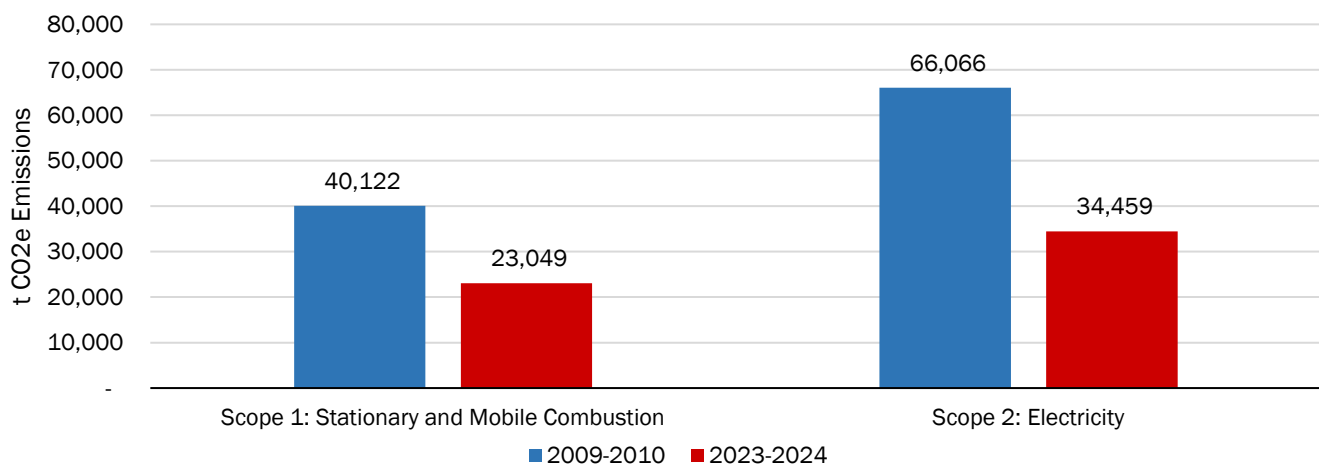


Figure 1. Comparison of Scope 1 & 2 emissions between 2009-10 (the base year) and 2023-24 for all campuses.

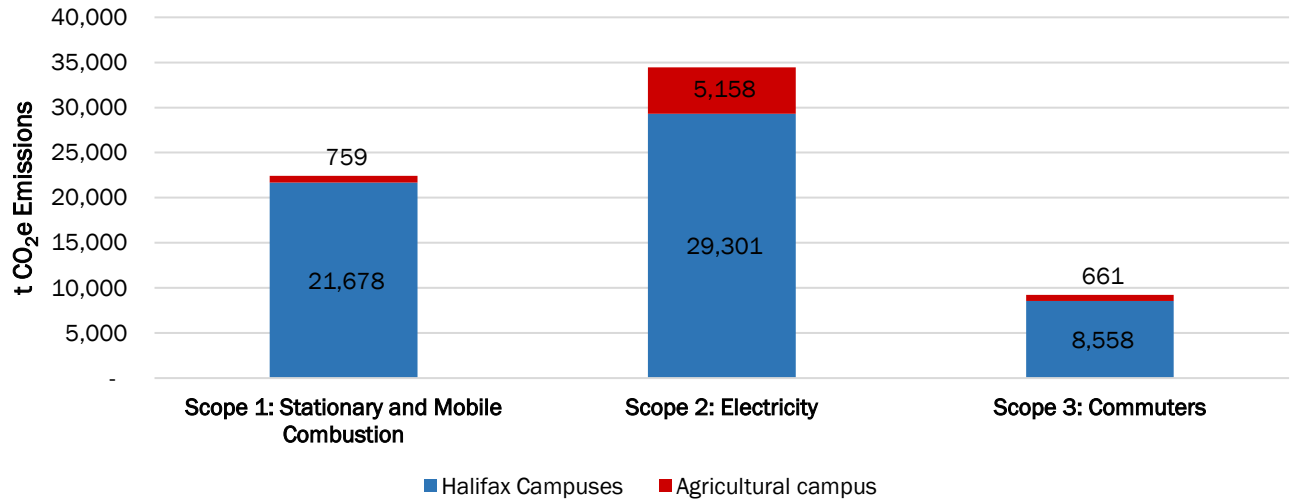


Figure 2. Emission breakdown by scope and geographical location.

Furthermore, comparisons with square footage and campus populations were conducted between the base year and 2023-24 for scope 1, scope 2, and scope 3 commuting. As shown in Figure 3 and 4, there was a 48% decrease in emissions per square footage and a 57% 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.

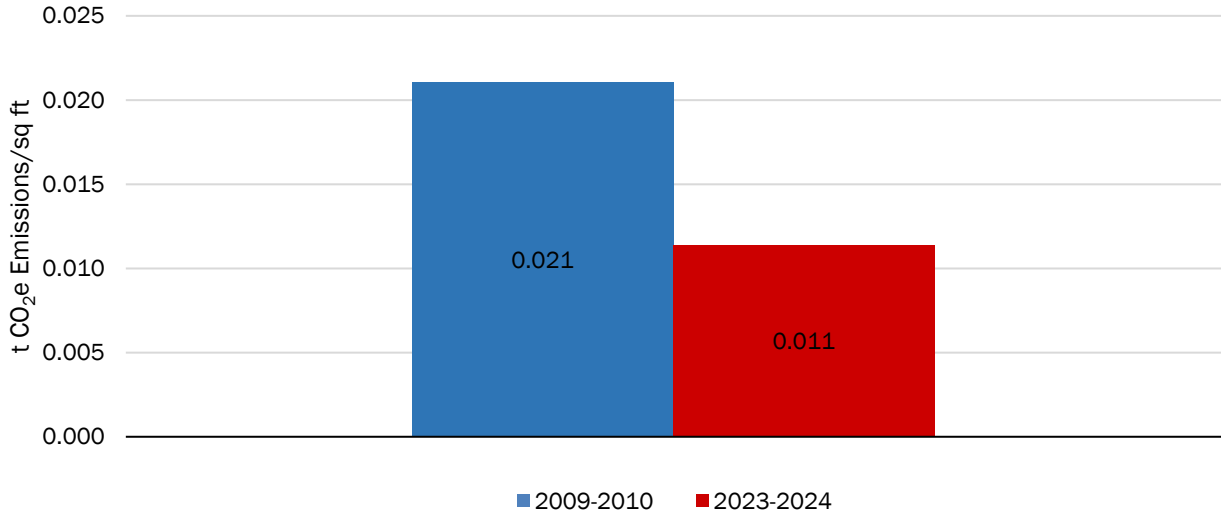


Figure 3. Comparison between the base year and 2023-24 on a per square footage basis.

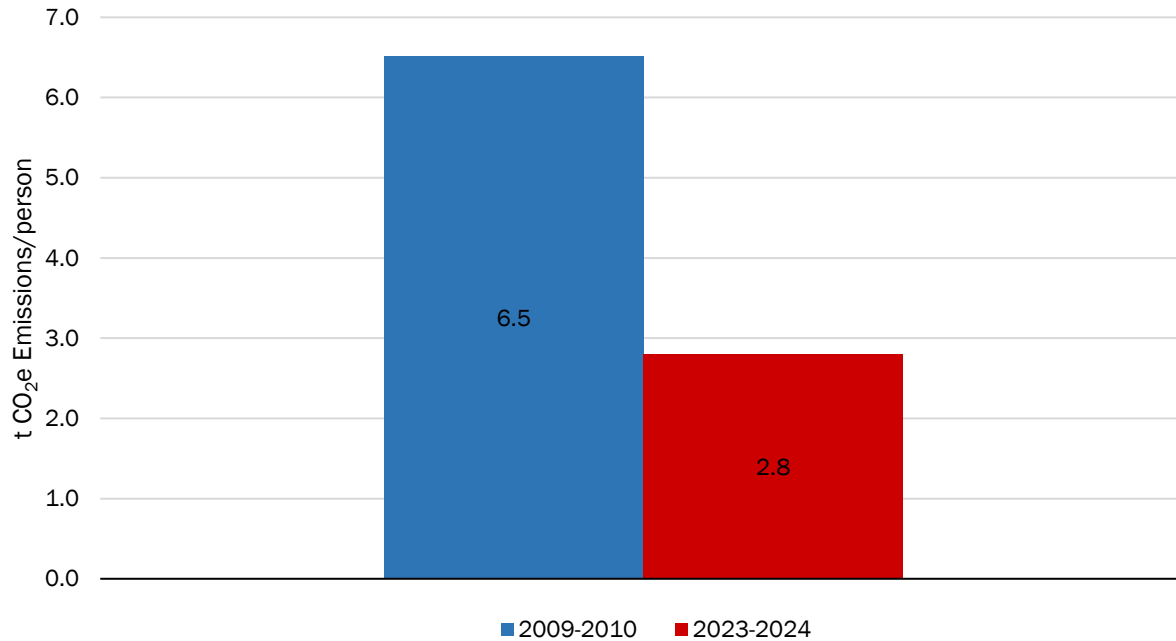


Figure 4. Comparison between the base year and 2023-24 on a per capita basis

To provide a visual aid, summary graphs were created to show the annual emissions separated into the three scopes. Figure 5 shows the emissions separated by scope, with data labels, and demonstrates the decrease since greenhouse gas reporting has been implemented. Figure 6 is adjusted to show the percentage breakdown of each scope.

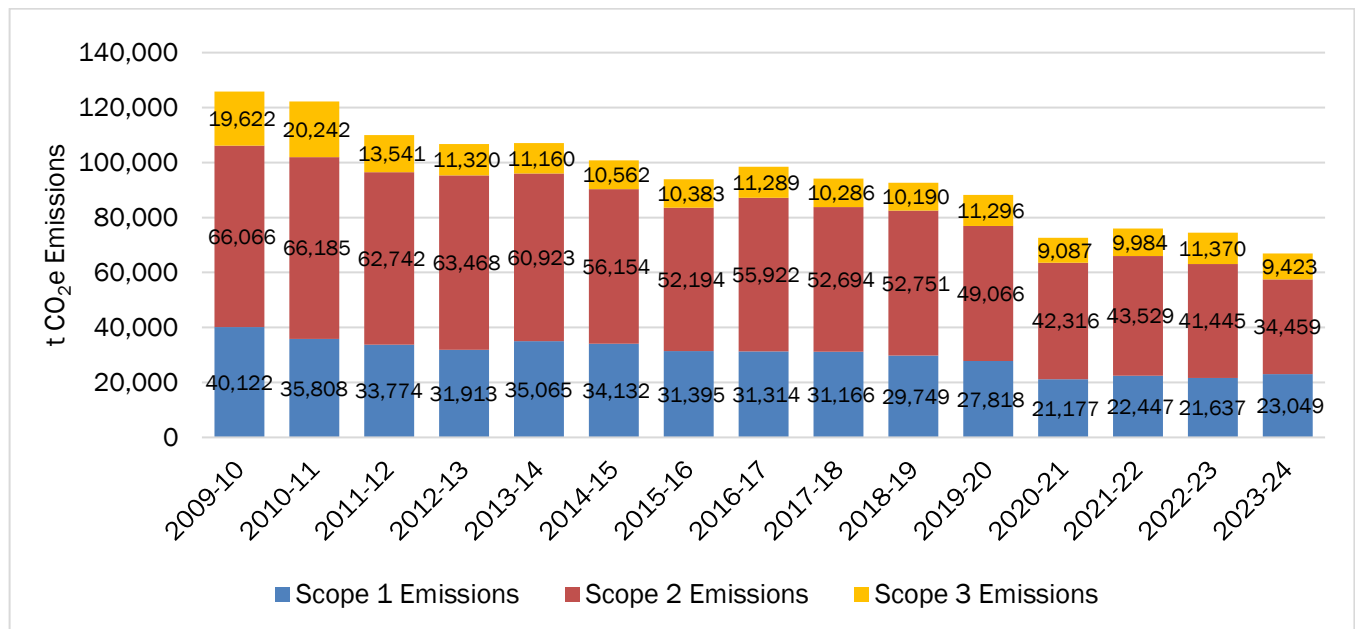


Figure 5. Comparison of annual emissions by scope between the base year and 2023-24.

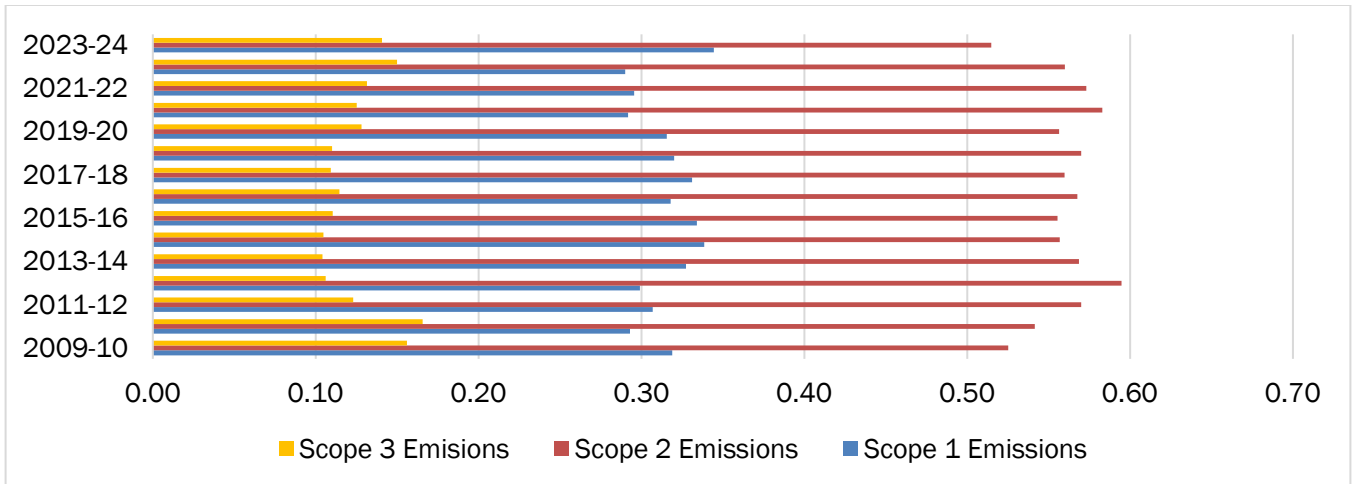


Figure 6. Annual emissions by scope shown as percentage totals between the base year and 2023-24.

To gauge success of reduction of greenhouse gases, a table has also been generated tracking current and past emissions for easy comparison (Table 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:

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

Table 1. Dalhousie University (all campuses) GHG emissions breakdown (in tCO2e) from the base year to 2023-2024.

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	2023-2024
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	23,049
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	34,459
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	9,423
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	66,930
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	2.800
Total emissions /sqft.	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	0.011

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



Figure 7 shows Scope 3 emission of paper and water consumption. Paper data from the Agricultural campus was included as of 2023-24. It was not available in 2021-22.

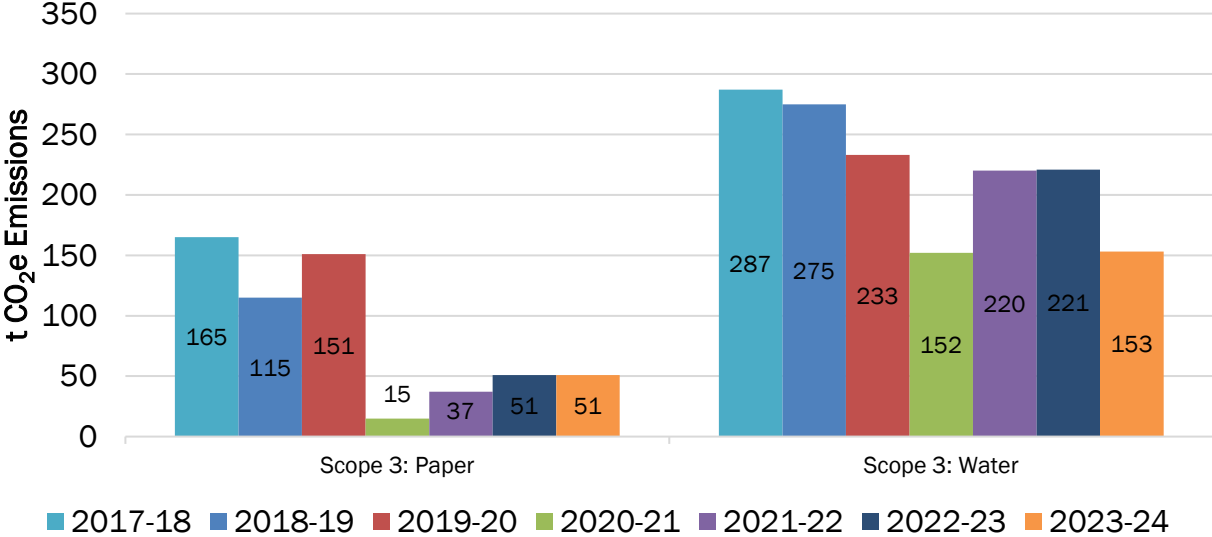


Figure 7. Additional Scope 3 emissions (paper and water) for the Halifax campuses, compared between 2023-24 and the first year of reporting (2017-18).

#### 4 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.

<p><b>VISION:</b> 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.</p>	<p><b>TARGETS:</b> 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.</p>
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Figure 8. 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, 2024). Emission factors used are taken from TCR 2024 Default Emission Factors (The Climate Registry, 2024), and Nova Scotia Power (Nova Scotia Power Inc., 2024). 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.

## **4.1 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 2023-24 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 847,091 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. 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 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, 2024).
  - **Note: Biogenic CO<sub>2</sub>** (biomass emissions): the IPCC Guidelines for National Greenhouse Gas Inventories requires that CO<sub>2</sub> 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, 2024).
- **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, 2024).
- **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, 2024).

The Dalhousie GHG inventory identifies all direct (Scope 1) and indirect (Scope 2) emissions, as well as biogenic CO<sub>2</sub> 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).

## 4.2 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<sub>2</sub> emissions**
  - CO<sub>2</sub> 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).

### 4.3 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<sub>2</sub>):** CO<sub>2</sub> 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<sub>2</sub> 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 atmosphere through slow geological processes such as the weathering of rock. Anthropogenic sources of CO<sub>2</sub> 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<sub>4</sub>):** CH<sub>4</sub> is a colourless, odourless, flammable gas that is the simplest hydrocarbon. CH<sub>4</sub> is present in the Earth's atmosphere at low concentrations and acts as a GHG. CH<sub>4</sub> 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<sub>4</sub> 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<sub>4</sub> is also released from industrial processes, fossil fuel extraction, coal mines, incomplete fossil fuel combustion and garbage decomposition in landfills.
- **Nitrous oxide (N<sub>2</sub>O):** N<sub>2</sub>O 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<sub>2</sub>O is most commonly produced via the heating of ammonium nitrate (NH<sub>4</sub>NO<sub>3</sub>). It is also released naturally from oceans, by bacteria in soils, and from animal wastes. Other sources of N<sub>2</sub>O 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<sub>6</sub>):** SF<sub>6</sub> 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<sub>6</sub> 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<sub>6</sub> 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<sub>3</sub>):** NF<sub>3</sub> is a colourless, non-flammable gas that is used in the electronics industry as a replacement for PFCs and SF<sub>6</sub>. It has a higher percentage of conversion to fluorine, which is the active agent in the industrial process, than PFCs and SF<sub>6</sub> for the same amount of electronics production. It is used in the manufacture of semi-conductors, liquid crystal display (LCD) panels and photovoltaics.

#### 4.4 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, 2024). Emission factors were found in The Climate Registry's 2024 Default Emission Factors (The Climate Registry, 2024), apart from emission factors for electricity, which were obtained from Nova Scotia Power (Nova Scotia Power Inc., 2024), 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 9. Tour of solar PV array and garden on the rooftop of the Emera IDEA Building.*

## 5 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.

### 5.1 SCOPE 1 EMISSIONS

Scope 1 emissions include all “direct anthropogenic greenhouse gas emissions” (The Climate Registry, 2024).

#### 5.1.1 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 ground source) with the district energy system as the backup 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 2023-24 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 and Insurance 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 1200 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.

## 5.1.2 Calculations

### Fuels:

- 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<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O emissions from stationary combustion is assessed according to the TCR: GRP 3.0 methodology and qualifications (formerly Data Quality Tiers) (The Climate Registry, 2024). 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<sub>2</sub> 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<sub>4</sub> and N<sub>2</sub>O 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, 2024), biogenic CO<sub>2</sub> emissions (BioCO<sub>2</sub>) must be reported separately from fossil fuel emissions, while biogenic CH<sub>4</sub> and N<sub>2</sub>O emissions must be reported with fossil fuel

emissions. This is assuming the amount of CO<sub>2</sub> released to the atmosphere during the combustion of biomass is equal to the amount of CO<sub>2</sub> 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. Determine annual fuel consumption at each campus

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. Determine appropriate emission factors for each fuel

Emission factors are based on TCR's 2024 Default Emission Factors in grams of CO<sub>2</sub> / unit of fuel combusted, grams of CH<sub>4</sub> and grams of N<sub>2</sub>O / unit of fuel combusted. Relevant emission factors for the Dalhousie campuses are highlighted below (Table 2. Scope 1: Summary of Emission Factors; shown in full in Appendix E (CO<sub>2</sub>) and Appendix F (CH<sub>4</sub> and N<sub>2</sub>O)).

Table 2. Scope 1: Summary of Emission Factors for Stationary Combustion (The Climate Registry, 2024).

Scope 1 Emissions	CO <sub>2</sub> Emission Factor	CH <sub>4</sub> Emission Factor	N <sub>2</sub> O Emission Factor	Unit	Methodology
<i>Bunker B</i>	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
<i>1/5 Light Fuel Oil</i>	0.2*2753	0.2*0.006	0.2*0.031	grams/L	
<i>+ 4/5 Heavy Fuel Oil</i>	0.8*3156	0.8*0.120	0.8*0.064	grams/L	
<i>Diesel</i>	2681	0.078	0.022	grams / L	"Diesel" (CO <sub>2</sub> ) and "Diesel (Refineries and others)" (CH <sub>4</sub> and N <sub>2</sub> O) - Table 1.2 and 1.4 in TCR
<i>Furnace Oil</i>	2753	0.026	0.031	grams / L	"Light Fuel Oil Commercial" - Table 1.2 and 1.4
<i>Propane</i>	1544	0.024	0.108	grams / L	"Propane - all other uses" - Table 1.2 and 1.4
<i>Natural gas</i>	1919	0.037	0.033	grams /m <sup>3</sup>	"Nova Scotia - Marketable" - Table 1.2 and 1.4
<i>Biomass</i>	1715	0.10	0.07	grams / kg	"Wood Fuel/ Wood Waste" - Table 1.2 and 1.4 in TCR



3. Calculate the CO<sub>2</sub> 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<sub>2</sub> emissions for each fuel. Each emission factor was first converted from **grams CO<sub>2</sub> / unit volume** to **metric tonnes CO<sub>2</sub> / 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<sup>3</sup>). Total natural gas consumption by volume was then multiplied by the emission factor in Table 2.1 (converted to metric tonnes per m<sup>3</sup>).

4. Calculate the CH<sub>4</sub> and N<sub>2</sub>O 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<sub>4</sub> and N<sub>2</sub>O respectively from Table 2.1. Each emission factor was first converted from **grams CH<sub>4</sub> or N<sub>2</sub>O / unit volume** to **metric tonnes CH<sub>4</sub> or N<sub>2</sub>O / unit volume**.

5. Convert CH<sub>4</sub> and N<sub>2</sub>O emissions to units of CO<sub>2</sub> equivalence (CO<sub>2</sub>e) and determine total emissions from stationary combustion

<b>CO<sub>2</sub> Emissions</b> (mt CO <sub>2</sub> e)	=	CO <sub>2</sub> Emissions x (mt)	1 (GWP)
<b>CH<sub>4</sub> Emissions</b> (mt CO <sub>2</sub> e)	=	CH <sub>4</sub> Emissions x (mt)	28 (GWP)
<b>N<sub>2</sub>O Emissions</b> (mt CO <sub>2</sub> e)	=	N <sub>2</sub> O Emissions x (mt)	265 (GWP)

The results of the above calculations are presented in Table 3 and Table 4. The emission factors shown are the cumulative emission factors for CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O, as shown in Table 2, and expressed in metric tonnes CO<sub>2</sub>e / unit.

Table 3. Scope 1: Summary of Direct Emissions from Stationary Combustion, Halifax Campuses and external properties connected to the Dalhousie's District Energy System (April 2023-March 2024).

Energy Source	Consumption	Unit	CO <sub>2</sub> e Emission Factor (tCO <sub>2</sub> e/unit)	GHG Emissions			Total GHG Emissions (tCO <sub>2</sub> e)
				CO <sub>2</sub> (tCO <sub>2</sub> e)	CH <sub>4</sub> (tCO <sub>2</sub> e)	N <sub>2</sub> O (tCO <sub>2</sub> e)	
Fuel Oil	4,152	L	0.0027619	11	0.00	0.03	11.5
Bunker B Oil	0	L	0.0030933	0	0.00	0.00	-
Diesel	36,396	L	0.0026890	98	0.08	0.21	97.9
Propane	29,879	L	0.0015443	45	0.02	0.86	46.1
Natural Gas	424,608	GJ	0.0491534	20,744	11.20	94.53	20,849.7
<b>Total GHG emissions (Halifax)</b>				<b>20,898</b>	<b>11.30</b>	<b>95.63</b>	<b>21,005.2</b>

\*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 4. Scope 1: Summary of Direct Emissions from Stationary Combustion, AC (April 2023-March 2024).

Energy Source	Consumption	Unit	CO <sub>2</sub> e	GHG Emissions	GHG Emissions	GHG Emissions	Total
			Emission Factor	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	GHG Emissions
			(tCO <sub>2</sub> e/unit)	(tCO <sub>2</sub> e)	(tCO <sub>2</sub> e)	(tCO <sub>2</sub> e)	(tCO <sub>2</sub> e)
Fuel Oil	142,868	L	0.0027619	393.32	0.10	1.17	394.6
Diesel	8,079	L	0.0026890	21.66	0.02	0.05	21.7
Propane	61,486	L	0.0015443	93.15	0.04	1.76	95.0
Wood	28,656,068	kg	0.0017364	-	80.24	531.57	611.8
<b>Total GHG emissions (AC)</b>				<b>508.13</b>	<b>80.40</b>	<b>534.55</b>	<b>1,123</b>

BioCO<sub>2</sub>, 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 2023-24, total wood consumption at the AC resulted in **49,145 tonnes of biogenic CO<sub>2</sub>** and **612 tonnes of CO<sub>2</sub>** comprised of CH<sub>4</sub> and N<sub>2</sub>O 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.

**Note on biomass cogeneration**

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. Calculate the total direct emissions from the CHP system

Total biomass (wood) consumed by the cogeneration plant was **28,656,068 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:

- 49,145 CO<sub>2</sub> metric tonnes CO<sub>2</sub>e
- 80.24 CH<sub>4</sub> metric tonnes CO<sub>2</sub>e
- 531.55 N<sub>2</sub>O metric tonnes CO<sub>2</sub>e

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

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 15% and heating efficiency was 31.4%. **Overall system efficiency was 41%.** 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, 2024):

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:	$E_P = E_T - E_H$
<p><b>Where:</b></p> <p><math>E_H</math> = Emissions allocated to steam production  H = Total steam (or heat) output (MMBtu)  <math>e_H</math> = Efficiency of steam (or heat) production  P = Total electricity output (MMBtu)  <math>e_P</math> = Efficiency of electricity generation  <math>E_T</math> = Total direct emissions of the CHP system  <math>E_P</math> = Emissions allocated to electricity production</p>	

Using the values outlined in Steps 1-3, the emissions can be allocated as shown in Table 5. Per the above, all emissions from CO<sub>2</sub> are excluded from Scope 1 emissions and reported separately as BioCO<sub>2</sub>. 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 5. Allocation of emissions from cogeneration between heat production and electricity production (April 2023-March 2024).

Allocation Source	GHG Emissions			Total GHG Emissions (tCO <sub>2</sub> e)
	CO <sub>2</sub> (tCO <sub>2</sub> e)	CH <sub>4</sub> (tCO <sub>2</sub> e)	N <sub>2</sub> O (tCO <sub>2</sub> e)	
Heat	35,942	59	389	36,389
Electricity	13,203	22	143	13,368

## 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<sub>2</sub>e 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 2024 Default Emissions Factors (Tables 5.1 and 5.2, shown in Appendix F) in tonnes of CO<sub>2</sub>e / tonne of refrigerant (The Climate Registry, 2024). The results of the above calculations are shown in Table 6 and Table 7 below.

*Table 6. Scope 1: Summary of Refrigerant GHG Emissions, Halifax Campuses (April 2023 – March 2024).*

Refrigerant Name	Consumption (Loss) (tRefrigerant)	GWP (tCO <sub>2</sub> e/ tRefrigerant)	Total GHG Emissions (tCO <sub>2</sub> e)
R134A	0.08981	1530	137.41
R401A	0.00000	21	0.00
R402A	0.00000	2244	0.00
R404A	0.03493	4278	149.42
R407C	0.00000	1908	0.00
R410A	0.11159	2256	251.74
R422A	0.00000	3359	0.00
R437A	0.00181	1930	3.50
R438A	0.00045	2425	1.10
R508B	0.00000	13412	0.00
RS24	0.00000	1371	0.00
<b>Total GHG Emissions</b>			<b>543.17</b>

\*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 7. Scope 1: Summary of Refrigerant GHG Emissions, AC (April 2023 – March 2024).

Refrigerant Name	Consumption (Loss) (tRefrigerant)	GWP (tCO <sub>2</sub> e/ tRefrigerant)	Total GHG Emissions (tCO <sub>2</sub> e)
R134A	0.00	1530	0
R401A	0.00	21	0
R402A	0.00	2244	0
R404A	0.01	4278	58
R407C	0.00	1908	0
R410A	0.00	2256	0
R422A	0.00	3359	0
R437A	0.00	1930	0
R438A	0.00	2425	0
R508B	0.00	13412	0
RS24	0.00	1371	0
RS52	0.00	3417	0
<b>Total GHG Emissions</b>			<b>58.22</b>

\*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

### Fleet Vehicles

The methodology for mobile combustion was followed as per the TCR: GRP 3.0, using emission factors from TCR’s 2024 Default Emission Factors (The Climate Registry, 2024).

Mobile combustion CO<sub>2</sub> emissions were determined primarily using *Method A: Actual Fuel Use* (previously GRP MO-03-CO<sub>2</sub>) in which fuel use is measured directly from purchasing data and default CO<sub>2</sub> 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<sub>2</sub>) 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<sub>4</sub> and N<sub>2</sub>O 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<sub>4</sub> and N<sub>2</sub>O using the standard method outlined in TCR: GRP 3.0. However, given that mobile combustion emissions have consistently represented <2% of Dalhousie’s

Scope 1 emissions, a simplified method was considered appropriate for calculating these emissions. Thus, CH<sub>4</sub> and N<sub>2</sub>O emissions are calculated based on an emission factor per tonnes CO<sub>2</sub> generated.

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

1) Calculate CO<sub>2</sub> 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 2023-24. For simplicity, it was assumed that geography (i.e., purchasing gas near the AC campus) would have minimal impact on average price. In 2023-24, the average price of regular unleaded gasoline was **\$1.64 / litre**, while diesel fuel was **\$1.82 / litre** (Statistics Canada, 2024).

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 2023-24 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 1200 L was used (the average for the remainder of the fleet). This method was applied to 31 vehicles.

- b. Select appropriate CO<sub>2</sub> emission factor for each fuel type from TCR’s Table 1.2 (The Climate Registry, 2024)

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	3877	
Motor Gasoline	n/a	35.00	1	2307	

- c. Calculate total CO<sub>2</sub> emissions and convert to metric tonnes (The Climate Registry, 2024)

<b>Fuel A CO<sub>2</sub> Emissions</b> = Fuel Consumed × Emission Factor			
(metric tonnes)	(gallons)		(metric tonne CO <sub>2</sub> /gallon)
<b>Canadian Conversion:</b>			
<b>Fuel A CO<sub>2</sub> Emissions</b> = Fuel Consumed x Emission Factor			
(metric tonnes)	(litres)		(metric tonne CO <sub>2</sub> / litre)

2) Calculate CH<sub>4</sub> and N<sub>2</sub>O emissions from mobile combustion

The CH<sub>4</sub> and N<sub>2</sub>O emissions of Dalhousie’s fleet vehicles were calculated by using the TCR’s 2024 Default Emission Factors: “Factors for Estimating CH<sub>4</sub> and N<sub>2</sub>O Emissions from Gasoline and Diesel Vehicles (SEM)” in Table 2.9. This method bases the estimate of CH<sub>4</sub> and N<sub>2</sub>O emissions off of total CO<sub>2</sub> emissions.

GHG	MT GHG per MT of CO2
CH4	2.80E-05
N2O	2.26E-05

3) Convert CH<sub>4</sub> and N<sub>2</sub>O emissions to units of CO<sub>2</sub> equivalence and determine total emissions

<b>CO<sub>2</sub> Emissions</b> (mt CO <sub>2</sub> e)	=	CO <sub>2</sub> Emissions x (mt)	1 (GWP)
<b>CH<sub>4</sub> Emissions</b> (mt CO <sub>2</sub> e)	=	CH <sub>4</sub> Emissions x (mt)	28 (GWP)
<b>N<sub>2</sub>O Emissions</b> (mt CO <sub>2</sub> e)	=	N <sub>2</sub> O Emissions x (mt)	265 (GWP)

Mobile combustion emission calculation results are presented in Table 8 and Table 9 with a total summary of Scope 1 emissions in Table 10.

*Table 8. Scope 1: Fleet Vehicle Emissions, Halifax Campuses (April 2023 – March 2024).*

Energy Source	Consumption	Unit	CO <sub>2</sub> Emission Factor (tCO <sub>2</sub> / unit)	CH <sub>4</sub> Emissions (tCH <sub>4</sub> )	N <sub>2</sub> O Emissions (tN <sub>2</sub> O)	Total GHG Emissions (tCO <sub>2</sub> e)
Gasoline	47,887	Litres	0.00231	0.00309	0.00250	111.2
Diesel Fuel	6,484	Litres	0.00268	0.00049	0.00039	17.5
<b>Total</b>						<b>128.7</b>

\*CH<sub>4</sub> emissions and N<sub>2</sub>O emissions are multiplied by 28 and 265 respectively to convert them to tCO<sub>2</sub>e.

*Table 9. Scope 1: Fleet Vehicle Emissions, AC (April 2023 – March 2024).*

Energy Source	Consumption	Unit	CO <sub>2</sub> Emission Factor (tCO <sub>2</sub> / unit)	CH <sub>4</sub> Emissions (tCH <sub>4</sub> )	N <sub>2</sub> O Emissions (tN <sub>2</sub> O)	Total GHG Emissions (tCO <sub>2</sub> e)
Gasoline	46,946	Litres	0.00231	0.00303	0.00245	109.0
Diesel Fuel	29,415	Litres	0.00268	0.00211	0.00178	79.4
<b>Total</b>						<b>188.4</b>

\*CH<sub>4</sub> emissions and N<sub>2</sub>O emissions are multiplied by 28 and 265 respectively to convert them to tCO<sub>2</sub>e.

*Table 10. Scope 1: Summary of Emissions (April 2023 – March 2024).*

	Stationary Combustion	Refrigerants	Fleet	Total GHG Emissions (tCO <sub>2</sub> e)
Halifax	21,005	543	129	21,678
AC	1,123	58	188	1,370
<b>Combined</b>	<b>22,128</b>	<b>601</b>	<b>317</b>	<b>23,048</b>

## 5.2 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, 2024).

### 5.2.1 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 several smaller buildings and houses that have individual accounts and are fed from the street power lines.

### 5.2.2 Calculations

#### Indirect Emissions from Electricity

Emission factors are available directly from Nova Scotia Power Inc. (NSPI) (Nova Scotia Power Inc., 2024), 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 11 and 12). 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<sub>4</sub> and N<sub>2</sub>O are already factored into emission intensities. The recently published coefficient for total system emission intensity in 2023-2024 (2022) is **451 g CO<sub>2</sub>e/kWh** (Nova Scotia Power Inc., 2024), allowing for accurate calculations associated with purchased electricity.

3) Determine total emissions and convert to metric tonnes CO<sub>2</sub>e

<b>Total emissions</b> = Electricity Consumption (kWh) x Emission Intensity (metric tonne CO <sub>2</sub> e/kWh)
--

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



Table 11. Scope 2: Summary of Electricity GHG Emissions, Halifax Campuses (April 2023 – March 2024).

Energy Source	Consumption	Unit	Emission Factor (tCO2e/ unit)	Total GHG Emissions (tCO2e)
Electricity	65,025,745	kWh	0.0004506	29,301

Table 12. Scope 2: Summary of Electricity GHG Emissions, AC (April 2023 – March 2024).

Energy Source	Consumption	Unit	Emission Factor (tCO2e/ unit)	Total GHG Emissions (tCO2e)
Electricity	11,447,942	kWh	0.0004506	5,158

### Electricity generated by biomass co-generation

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.

## 5.3 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, 2024). 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
<p><b>Upstream scope 3 emissions</b></p>	<ol style="list-style-type: none"> <li>1. Purchased goods and services</li> <li>2. Capital goods</li> <li>3. Fuel- and energy-related activities (not included in scope 1 or scope 2)</li> <li>4. Upstream transportation and distribution</li> <li>5. Waste generated in operations</li> <li>6. Business travel</li> <li>7. Employee commuting</li> <li>8. Upstream leased assets</li> </ol>
<p><b>Downstream scope 3 emissions</b></p>	<ol style="list-style-type: none"> <li>9. Downstream transportation and distribution</li> <li>10. Processing of sold products</li> <li>11. Use of sold products</li> <li>12. End-of-life treatment of sold products</li> <li>13. Downstream leased assets</li> <li>14. Franchises</li> <li>15. Investments</li> </ol>

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 several methods and data accuracy issues in calculating Scope 3. The 2024-2025 report will elaborate on the methods discussion and add new scopes where accurate data is available.

### 5.3.1 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 2024 (DalTRAC, 2024). 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.

### 5.3.2 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, 2024)

Figure 10 and Figure 11 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 2023-24 fiscal year by students, staff, and faculty.

#### **All Commuters - Halifax Campuses**

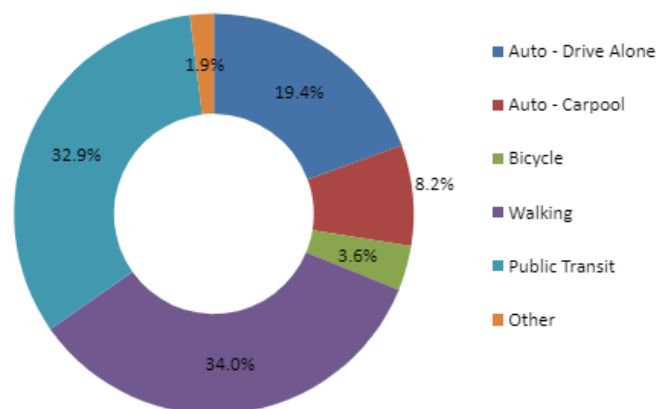


Figure 10. Blended commuting mode percentages, Halifax campuses (2023-24).

## All Commuters - Agricultural Campus

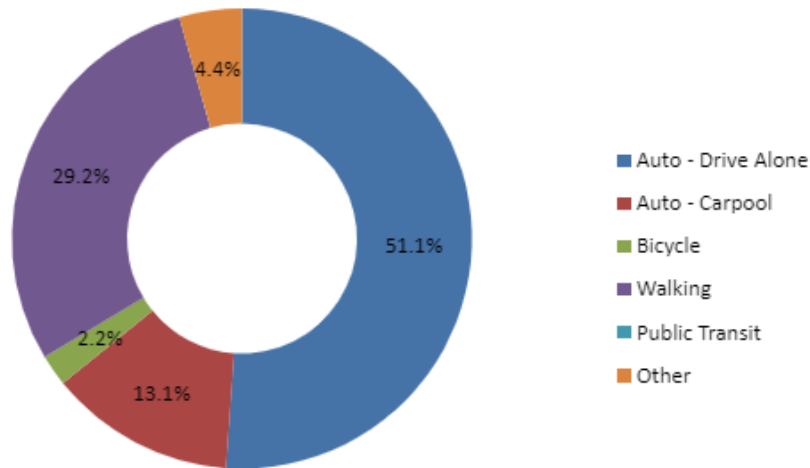


Figure 11. Blended commuting mode percentages, Agricultural campus (2023 - 24) \*No public transit available.

- 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, 2024).

- 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 emissions factor was used in calculations for driving by car (alone and carpooling), at a value of 256 grams CO<sub>2</sub>e 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<sub>2</sub>e per kilometer driven per passenger (EPA, 2008).

*Table 13. Scope 3: Summary of Commuting GHG Emissions and Emissions avoided through Active Transport, Halifax Campuses (April 2023 - March 2024).*

Commuter	Annual Distance (km)	Emission Factor (tCO <sub>2</sub> e/km)	Total GHG Emissions (tCO <sub>2</sub> e)
Drive alone	23,376,256	0.000256	5,984.3
Carpool	4,910,837	0.000256	1,257.2
Transit	19,773,129	0.00006659	1,316.7
<b>Total Emissions Created:</b>			<b>8,558.2</b>

*Table 14. Scope 3: Summary of Commuting GHG Emissions and Emissions avoided through Active Transport, AC (April 2023 - March 2024).*

Commuter	Annual Distance (km)	Emission Factor (tCO <sub>2</sub> e/km)	Total GHG Emissions (tCO <sub>2</sub> e)
Drive alone	2,287,113	0.000256	585.5
Carpool	293,162	0.000256	75.0
Transit	0	0.00006659	0.0
<b>Total Emissions Created:</b>			<b>660.6</b>

### 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, most paper is 100% PCR content; however, some 30% PCR and 0% PCR content paper was also purchased in 2023-24.

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<sub>2</sub>e for each kilogram of paper consumed. The total weights of paper purchased in 2023-24 were multiplied by the appropriate emission factor for 30% and 100% PCR content (0.00248 and 0.00177 tonnes of CO<sub>2</sub>e emissions respectively per kilogram of paper) (B.C. Ministry of Environment, 2016).

Total emissions from paper usage are shown below.

*Table 15. Scope 3: Summary of Paper GHG Emissions, All Campuses (April 2023 – March 2024).*

Paper Emissions	Paper consumption (kg)	Emission Factor (t CO <sub>2</sub> e/kg)	Total GHG Emissions (tCO <sub>2</sub> e)
0% PCR content	7,252	0.00280	20.3
10% PCR content	0	0.00270	0.0
20% PCR content	0	0.00259	0.0
30% PCR content	6,416	0.00248	15.9
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	13,364	0.00177	23.6
<b>Total Emissions Created:</b>			<b>59.8</b>

Indirect Emissions from Water

**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<sup>1</sup>:

*Table 16. Scope 3: Emissions factors for water and wastewater treatment from Halifax Water (2023-2024).*

<b><u>Water supply</u></b>		
Treatment	0.000131	tCO2e per M3
Distribution	0.000016	tCO2e per M3
<b><u>Wastewater treatment</u></b>		
Collection	0.000069	tCO2e per M3
Treatment	0.000111	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 60%. Total consumption in 2009-10 was 1,162,692 m<sup>3</sup>; in comparison, consumption was 468,843 m<sup>3</sup> in 2023-24.

**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 through a series of screens. The wastewater is clarified into liquid sludge, which 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. Currently, 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,

<sup>1</sup> Personal communications – J. Stewart, Project Manager, Halifax Wastewater Treatment Facility

as well as other sources of emission from water treatment (e.g., specific emission factors for chemicals added during treatment).

Calculations

In the 2024 fiscal year, primary water consumption for the Halifax campuses was **399,053 m<sup>3</sup>** 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 17).

*Table 17. Scope 3: Summary of Water GHG Emissions, Halifax Campuses (April 2023 – March 2024).*

Commuter	Water Consumption (m3)	Emission Factor (tCO <sub>2</sub> e/L)	Total GHG Emissions (tCO <sub>2</sub> e)
Water – Treatment	399,053	0.000131	52.3
Water – Distribution	399,053	0.000016	6.4
Wastewater – Collection	399,053	0.000069	27.5
Wastewater – Treatment	399,053	0.000111	44.3
<b>Total Emissions Created</b>			<b>130.49</b>

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 18).

*Table 18. Scope 3: Summary of Water GHG Emissions, Truro Campus (April 2023 – March 2024).*

Commuter	Water Consumption (m3)	Emission Factor (tCO <sub>2</sub> e/L)	Total GHG Emissions (tCO <sub>2</sub> e)
Water – Treatment	69,790	0.000131	9.1
Water – Distribution	69,790	0.000016	1.1
Wastewater – Collection	69,790	0.000069	4.8
Wastewater – Treatment	69,790	0.000111	7.7
<b>Total Emissions Created</b>			<b>22.8</b>

**6 REDUCING GHG EMISSIONS**

In the 2023-24 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, LSC recommissioning and recommissioning other buildings, and solar photovoltaics (PV) buildings assessment.
- projects moving into or in the implementation stage include Chemistry lighting upgrades, expanding the geo-exchange system at Sexton, Killam library deep energy retrofit, replacement of the electric vehicle charging stations in the Dalplex, Arts Centre lighting upgrades, new and existing HVAC upgrades



and solar PV, Dentistry recommissioning, Jenkins Hall heat pump installation and lighting and recommissioning.

A number of projects are in final stages or the measurement and verification stage the installation of variable frequency drive (VFD) controls on pumps at the Arts Centre and LSC, high efficiency pumps at Sexton campus, Jenkins Hall heat pumps, 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, and sustainable labs program (which includes an focus on energy savings and carbon reduction).

Each year the OS works in conjunction with Facilities Management, various departments and students to maintain, and add biodiversity to campus spaces and support education efforts.



*Figure 12. Student using bike rack on HRM Transit bus.*

## 7 NEXT STEPS

Projects are in an ongoing process of being planned, implemented, and monitored. Projects that are underway include:

- Deep energy retrofit in Killam Library;
- Geoexchange expansion on the Sexton Campus;
- Efficient pumping, fan, and motor projects;
- Recommissioning and controls projects; and
- Replacement of the EV charging stations at Dalplex

The Office takes part in the planning of other facilities renewal projects and large capital projects as part of project team for the LEED and other green building certification programming for new construction with emphasis on sustainability, carbon reduction, and energy performance

Office staff are actively working on finalizing GHG mitigating solutions such as renewable energy power purchase agreements that will contribute to renewable energy projects in Nova Scotia.

## 8 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.
- 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](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. (2024, February). *2024 Default Emission Factors*. Retrieved from The Climate Registry: [https://theclimateregistry.org/wp-content/uploads/2024/03/2024-Emission-Factor-Documents\\_FINAL.pdf](https://theclimateregistry.org/wp-content/uploads/2024/03/2024-Emission-Factor-Documents_FINAL.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>

## 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<sub>2</sub>e)** - 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<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF<sub>6</sub>)

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

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

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

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

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

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

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

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

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

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

## Appendix B: 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
			<b>Total</b>	<b>5,013,120</b>
			<b>Tableau Total</b>	<b>5,008,869</b>

## 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			<b>Total</b>	<b>812,810</b>
			<b>Tableau Total</b>	<b>847,091</b>

**Appendix C: Canadian Default Factors for Calculating CO<sub>2</sub> Emissions from Combustion of Natural Gas, Petroleum Products, and Biomass (Table 1.2, Default Emissions Factors) (The Climate Registry, 2024)**

Fuel Type	Carbon Content (Per Unit Energy)	Heat Content	Fraction Oxidized	CO <sub>2</sub> Emission Factor (Per Unit Mass or Volume)
<b>Natural Gas</b>	<b>kg C / GJ</b>	<b>GJ / megalitre</b>		<b>g CO<sub>2</sub> / m<sup>3</sup></b>
<b>All Provinces</b>				
Still gas (Upgrading Facilities)	n/a	43.24	1	2140
Still gas (Refineries & Others)	n/a	36.08	1	1775
<b>Newfoundland and Labrador</b>				
Marketable	n/a	39.28	1	1919
NonMarketable	n/a	39.28	1	2202
<b>Nova Scotia</b>				
Marketable	n/a	39.28	1	1919
NonMarketable	n/a	39.28	1	2494
<b>New Brunswick</b>				
Marketable	n/a	39.28	1	1919
NonMarketable	n/a	39.28	1	2401

<b>Natural Gas Liquids</b>	<b>kg C / GJ</b>	<b>GJ / Kilolitre</b>		<b>g CO<sub>2</sub> / L</b>
Propane: Residential Propane	n/a	25.31	1	1515
Propane: Other Uses Propane	n/a	25.31	1	1515

Petroleum Products	kg C / GJ	GJ / Kilolitre		g CO2 / L
Light Fuel Oil Electric Utilities	n/a	38.80	1	2753
Light Fuel Oil Industrial	n/a	38.80	1	2753
Light Fuel Oil Producer Consumption	n/a	38.80	1	2670
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 CO2 / kg
Wood Fuel/Wood Waste	n/a	18.00	1	1715

**Appendix D: Canadian Default Factors for Calculating CH<sub>4</sub> and N<sub>2</sub>O Emissions from Combustion of Natural Gas, Petroleum Products, and Biomass (Table 1.4, Default Emissions Factors) (The Climate Registry, 2024)**

<b>Fuel Type</b>	<b>CH<sub>4</sub> Emission Factor (Per Unit Mass or Volume)</b>	<b>N<sub>2</sub>O Emission Factor (Per Unit Mass or Volume)</b>
<b>Natural Gas</b>	<b>g CH<sub>4</sub> / m<sup>3</sup></b>	<b>g N<sub>2</sub>O / m<sup>3</sup></b>
Electric Utilities	0.490	0.049
Industrial	0.037	0.033
Producer Consumption (Non-marketable)	6.4	0.060
Producer Consumption (Non-marketable) - Newfoundland and Labrador	0.490	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
<b>Natural Gas Liquids</b>	<b>g CH<sub>4</sub> / L</b>	<b>g N<sub>2</sub>O / L</b>
Propane (Residential)	0.027	0.108
Propane (All Other Uses)	0.024	0.108
Ethane	0.024	0.108
Butane	0.024	0.108
Refinery LPGs	0.024	0.108
<b>Refined Petroleum Products</b>	<b>g CH<sub>4</sub> / L</b>	<b>g N<sub>2</sub>O / L</b>
Light Fuel Oil (Electric Utilities)	0.18	0.031
Light Fuel Oil (Industrial and Producer Consumption)	0.006	0.031

<b>Refined Petroleum Products</b>	<b>g CH<sub>4</sub> / L</b>	<b>g N<sub>2</sub>O / L</b>
Light Fuel Oil (Electric Utilities)	0.18	0.031
Light Fuel Oil (Industrial and Producer Consumption)	0.006	0.031
Light Fuel Oil (Residential)	0.026	0.006
Light Fuel Oil (Forestry, Construction, Public Administration, and Commercial/Institutional)	0.026	0.031
Heavy Fuel Oil (Electric Utilities)	0.034	0.064
Heavy Fuel Oil (Industrial and Producer Consumption)	0.12	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

<b>Biomass</b>	<b>g CH<sub>4</sub> / kg</b>	<b>g N<sub>2</sub>O / kg</b>
Wood Fuel/Wood Waste (Industrial Combustion)	0.10	0.07
Spent Pulping Liquor (Industrial Combustion)	0.03	0.005

## Appendix E: Methodology for Allocating Emissions from Combined Heat and Power (The Climate Registry, 2024)

### 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.<sup>9</sup> 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:	$E_P = E_T - E_H$
<p><b>Where:</b></p> <p><math>E_H</math> = Emissions allocated to steam production</p> <p>H = Total steam (or heat) output (MMBtu)</p> <p><math>e_H</math> = Efficiency of steam (or heat) production</p> <p>P = Total electricity output (MMBtu)</p> <p><math>e_P</math> = Efficiency of electricity generation</p> <p><math>E_T</math> = Total direct emissions of the CHP system</p> <p><math>E_P</math> = Emissions allocated to electricity production</p>	

**Appendix F: Global Warming Potentials of Refrigerants and Blends (Tables 5.1 and 5.2, 2024 Climate Registry Default Emission Factors, p. 61-83)**

Common Name	Formula	Chemical Name	SAR	TAR	AR4	AR5	AR6
Carbon dioxide	CO2		1	1	1	1	1
Methane	CH4		21	23	25	28	27
Nitrous oxide	N2O		310	296	298	265	273
Nitrogen trifluoride	NF3		n/a	10,800	17,200	16,100	17,400
Sulfur hexafluoride	SF6		23,900	22,200	22,800	23,500	24,300
<b>Hydrofluorocarbons (HFCs)</b>							
HFC-23 (R-23)	CHF3	trifluoromethane	11,700	12,000	14,800	12,400	14,600
HFC-32 (R-32)	CH2F2	difluoromethane	650	550	675	677	771
HFC-41 (R-41)	CH3F	fluoromethane	150	97	92	116	135
HFC-125 (R-125)	C2HF5	pentafluoroethane	2,800	3,400	3,500	3,170	3,740
HFC-134 (R-134)	C2H2F4	1,1,2,2-tetrafluoroethane	1,000	1,100	1,100	1,120	1,260
HFC-134a (R-134a)	C2H2F4	1,1,1,2-tetrafluoroethane	1,300	1,300	1,430	1,300	1,530
HFC-143 (R-143)	C2H3F3	1,1,2-trifluoroethane	300	330	353	328	364



Refrigerant Blend	Gas	SAR	TAR	AR4	AR5	AR6
R-401A	HFC	18	16	16	18	21
R-401B	HFC	15	13	14	15	18
R-401C	HFC	21	18	19	21	25
R-402A	HFC	1680	2040	2100	1902	2244
R-402B	HFC	1064	1292	1330	1205	1421
R-403A	PFC	1400	1720	1766	1780	1858
R-403B	PFC	2730	3354	3444	3471	3623
R-404A	HFC	3260	3784	3922	3943	4728
R-407A	HFC	1770	1990	2107	1923	2262
R-407B	HFC	2285	2695	2804	2547	3001
R-407C	HFC	1526	1653	1774	1624	1908
R-407D	HFC	1428	1503	1627	1487	1748
R-407E	HFC	1363	1428	1552	1425	1672
R-407F	HFC	1555	1705	1825	1674	1965
R-407G	HFC	1321	1334	1463	1331	1566
R-407H	HFC	1314	1371	1495	1378	1615
R-407I	HFC	1301	1332	1459	1337	1570
R-408A	HFC	1944	2216	2301	2430	2934
R-410A	HFC	1725	1975	2088	1924	2256
R-410B	HFC	1833	2118	2229	2048	2404
R-411A	HFC	15	13	14	15	18
R-411B	HFC	4	4	4	4	5
R-412A	PFC	350	430	442	445	465
R-415A	HFC	25	22	22	25	30
R-415B	HFC	105	90	93	104	123
R-416A	HFC	767	767	844	767	903
R-417A	HFC	1955	2234	2346	2127	2508
R-417B	HFC	2450	2924	3027	2742	3235
R-417C	HFC	1570	1687	1809	1643	1935
R-418A	HFC	4	3	3	3	4
R-419A	HFC	2403	2865	2967	2688	3171
R-419B	HFC	1982	2273	2384	2161	2548
R-420A	HFC	1144	1144	1258	1144	1346
R-421A	HFC	2170	2518	2631	2385	2812

Refrigerant Blend	Gas	SAR	TAR	AR4	AR5
R-411B	HFC	4.2	3.6	3.72	4.14
R-412A	PFC	350	430	442	445
R-415A	HFC	25.2	21.6	22.32	24.84
R-415B	HFC	105	90	93	104
R-416A	HFC	767	767	843.7	767
R-417A	HFC	1955	2234	2346	2127
R-417B	HFC	2450	2924	3027	2742
R-417C	HFC	1570	1687	1809	1643
R-418A	HFC	3.5	3	3.1	3.45
R-419A	HFC	2403	2865	2967	2688
R-419B	HFC	1982	2273	2384	2161
R-420A	HFC	1144	1144	1258	1144
R-421A	HFC	2170	2518	2631	2385
R-421B	HFC	2575	3085	3190	2890
R-422A	HFC	2532	3043	3143	2847
R-422B	HFC	2086	2416	2526	2290
R-422C	HFC	2491	2983	3085	2794
R-422D	HFC	2232	2623	2729	2473
R-422E	HFC	2135	2483	2592	2350
R-423A	HFC	2060	2345	2280	2274
R-424A	HFC	2025	2328	2440	2212
R-425A	HFC	1372	1425	1505	1431
R-426A	HFC	1352	1382	1508	1371

Refrigerant Blend	Gas	SAR	TAR	AR4	AR5
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.

## Appendix G: Nova Scotia Power Emission Factors (Nova Scotia Power Inc., 2024)

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
2023	3.6	3.3	450.6	0.8

Emissions intensity numbers are based on electricity sales, CO2 intensity is based on emissions from generation in Nova Scotia and electricity imports.

## Appendix H: 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
Truth and Reconciliation Day	1	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 <i>not</i> travelling	142	233	147
<b>Total Travel Days</b>	<b>225</b>	<b>133</b>	<b>219</b>
		*142-day average	

## Appendix I: Commuting Emissions by Vehicle Type (NRCan, 2020)

Note: The average CO2 emissions factors are based on all models within each Manufacturer's lineup.

Row Labels	Average of CO2 Emissions (g CO2 /km)
<b>2021</b>	<b>253.48</b>
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

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

Table 6: Office Paper

PCR Content (%)	Emission Factor (kg CO <sub>2</sub> e/ 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.