GREENHOUSE GAS (GHG) INVENTORY REPORT 2017-2018

Office of Sustainability, April 2019
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EXECUTIVE SUMMARY

Dalhousie University first established a greenhouse gas (GHG) inventory base year for the 2009 fiscal year (April 1, 2008 - March 31, 2009). The base year was 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.

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

The results of Dalhousie’s annual GHG reports are published on the Office of Sustainability website. The Dalhousie University Climate Change Plan (2010) outlines the University’s climate change mitigation and adaptation strategies and targets. A second edition of the Climate Change Plan will be released in 2019. For the 2017/2018 fiscal year, several projects were undertaken in accordance to this plan, including: 178 trees planted as part of the biomass replacement policy; high efficiency pumps, motors and fan installations; building recommissioning; steam pipe insulation; and more. In 2018, Dalhousie released its second three-year sustainability progress report and the University received a Gold rating from the Sustainability Tracking Assessment Rating System (STARS). 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). This is the first year that Dalhousie has included paper and water emissions in its Scope 3 calculations.

Total greenhouse gas emissions (all campuses) were reduced in 2017-2018 over the base year for Scope 1 and 2 emissions by a total of 21% (Figure 0.1; Figure 0.2).
Figure 0.1. Comparison of Scope 1 & 2 emissions between 2009-10 (the base year) and 2017-18 for all campuses

Figure 0.2. Emission breakdown by scope and geographical location
Furthermore, comparisons with square footage and campus populations were conducted between the base year and 2017-18. As shown in Figure 0.3 and Figure 0.4, there was a 36% decrease in emissions per square footage and a 31% decrease in emissions per weighted population.

Figure 0.3. Comparison between the base year and 2017-18 on a per square footage basis

Figure 0.4. Comparison between the base year and 2017-18 on a per capita basis
To provide a visual aid, summary graphs were created to show the annual emissions separated into the three scopes. Figure 0.5 shows the emissions separated by scope, with data labels, and demonstrate the continual decrease since the greenhouse gas report has been implemented.

Figure 0.6 is adjusted to show the percentage breakdown of each scope.

Figure 0.5. Comparison of annual emissions by scope between the base year and 2017-18

Figure 0.6. Percentage breakdown of each scope.
To gauge success of reduction of greenhouse gases, a table has also been generated tracking current and past emissions for easy comparison (Table 0.2). 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:

\[
\text{# weighted campus users} = \text{# on-campus residence} + 0.75 \times (\text{# full-time employees and students}) + 0.5 \times (\text{# part-time employees and students})
\]

Table 0.2. Dalhousie University (all campuses) GHG emissions breakdown (in tCO₂e) from the base year to 2017-18

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Scope 1</td>
<td>40,122</td>
<td>35,808</td>
<td>33,774</td>
<td>31,913</td>
<td>35,065</td>
<td>34,132</td>
<td>31,395</td>
<td>31,134</td>
<td>31,166</td>
</tr>
<tr>
<td>Scope 2</td>
<td>66,066</td>
<td>66,185</td>
<td>62,742</td>
<td>63,468</td>
<td>60,923</td>
<td>56,154</td>
<td>52,194</td>
<td>55,922</td>
<td>52,694</td>
</tr>
<tr>
<td>Scope 3</td>
<td>19,622</td>
<td>20,242</td>
<td>13,541</td>
<td>11,320</td>
<td>11,160</td>
<td>10,562</td>
<td>10,383</td>
<td>11,289</td>
<td>10,286</td>
</tr>
<tr>
<td>Total emissions</td>
<td>125,810</td>
<td>122,235</td>
<td>110,057</td>
<td>106,701</td>
<td>107,148</td>
<td>100,848</td>
<td>93,972</td>
<td>98,345</td>
<td>94,147</td>
</tr>
</tbody>
</table>
*Scope 3 emissions in 2017-18 main tables includes commuter data from the Agricultural and Halifax campuses. This year, water and paper data (Scope 3 emissions) from the Halifax campuses were also analysed (Figure 0.7. Additional Scope 3 emissions (paper and water) for the Halifax campuses, 2017-18). Figure 0.7). Water and paper data from the Agricultural campus currently is not available.
1. INTRODUCTION

On December 11, 2009, Dalhousie’s President signed the University and College’s Climate Change Statement for Canada. This statement requires a comprehensive inventory of GHG emissions to be completed within one year of signing, and within two years of signing this document a climate plan with targets must be released. In 2010, Dalhousie released its first University Climate Change Plan and baseline GHG inventory. The plan includes a clear vision and targets (Error! Reference source not found.). The annual GHG inventory report is a follow up to the baseline GHG inventory which allows comparisons to determine the progress of the University to meet the predetermined targets. In 2019, the second version of the Climate Change Plan will be released. It will include updated targets for all campuses.

**VISION:** Dalhousie University is an institutional model for reducing greenhouse gases, implementing adaptation strategies, and increasing knowledge of climate change issues of students and employees.

**TARGETS:** Dalhousie aims to reduce GHGs 15% by 2013; 20% by 2016 and 50% by 2020 below the 2008-2009 baseline year scope 1 and 2 emissions.


Periodically (i.e., in 2010, 2014, and 2017), a third-party consulting firm has also been hired to review GHG processes and reporting. Feedback from the third-party review of this report resulted in removal of R22 in reporting requirements for refrigerants, making small emission factor corrections, and claiming all district energy heating emissions including those related to energy provided to third-party customers. Other recommendations included formatting and notes clarifications for calculations in spreadsheets.

![Figure 1.1. Dalhousie’s vision and targets](image)

![Figure 1.2. Testing new triple-pane windows for water leakage](image)
1.1. BOUNDARIES

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

Dalhousie University owns 97 buildings 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-five percent of these buildings and some of the houses are on a district energy (DE) system where steam is created from natural gas at the Central Services Building. Steam and hot water 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 4,776,466 square feet (Appendix C). During the 2017-18 fiscal year, the University also leased a small amount of space in hospitals and retail locations in Halifax.

The AC campus includes 45 buildings and houses totalling 812,810 square feet (Appendix C). Over 95% of all building space is on a district energy (DE) system fed from a central biomass plant that uses fuel oil during the summer months and primarily wood chips during the rest of the year. During the 2017-18 fiscal year, two properties were leased to Nova Scotia’s Department of Agriculture. Emissions from buildings that are leased are included in greenhouse gas calculations as Dalhousie maintains operational control.

Leased space and facilities that are owned, but not financially operated by Dalhousie (such as Peter Green Hall) 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 2.1) are:

- **Scope 1** (direct emissions): greenhouse gas emissions from sources within the entity’s organizational boundaries that the reporting entity owns or controls. These are further divided into: stationary combustion, mobile combustion, physical and chemical processes, and fugitive sources (The Climate Registry, 2016).
  - **Note: Biogenic CO₂** (biomass emissions): the IPCC Guidelines for National Greenhouse Gas Inventories requires that CO₂ emissions from biogenic sources be reported separately from any scope because the carbon in biomass was recently contained in living organic matter (The Climate Registry, 2016).

- **Scope 2** (indirect emissions): greenhouse gas emissions that are a consequence of activities that take place within the organizational boundaries of the reporting entity, but that occur at sources owned or controlled by another entity, e.g. emissions associated with consumption of purchased electricity (The Climate Registry, 2016).
• **Scope 3** (other indirect emissions): other emissions whose recording are optional e.g. upstream emissions from the transportation of purchased materials or goods, or employees and students commuting to and from campus (The Climate Registry, 2016).

The Dalhousie GHG inventory identifies all direct (Scope 1) and indirect (Scope 2) emissions, as well as biogenic CO₂ emissions. Where credible data exists, Dalhousie also reports on optional indirect emissions sources that arise as a function of its business and educational operations (Scope 3).

### 1.2. GHG EMISSION SOURCES

Emissions included in the GHG inventory report include:

1. **Scope 1: Direct GHG emissions and removals**
   a. **Stationary combustion**
      - Emissions incurred through combustion of natural gas in the Halifax central plant for steam, hot water, cooling production, and some kitchens. Bunker B is used for back-up or peak shaving in Halifax. Light fuel oil is a summer fuel at the AC campus when biomass is not burned.
      - Emissions incurred through combustion of propane for food services and lab use on all campuses.
      - On-site heating fuel oil and natural gas for combustion in smaller houses in Halifax. At the AC, oil and electricity (heat pumps) is used for heating houses.
      - On campus diesel combustion for backup generators on all campuses.
      - Fugitive refrigerant losses from cooling units on all campuses.
      - Methane and nitrous oxide emissions generated by combustion of biomass at the AC central plant.
   b. **Mobile combustion**
      - Combustion of vehicle fleet gasoline and diesel.

2. **Biogenic CO₂ emissions**
   - CO₂ emissions from biomass combustion at facilities operated by Dalhousie.

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

4. **Scope 3: Other indirect GHG emissions**
   - Inclusion of other sources of emissions based on internal reporting needs or intended use of the inventory. This includes: students and employees commuting to and from campus, paper consumption, and emissions from transport and distribution of water to and from campus.
   - Future years may report other sources, such as other sources of waste and the natural environment and may refine methodologies for sources reported for the first time in 2017-18 (i.e., paper consumption and water usage).

### 1.3. REPORTED GHG EMISSIONS

Emissions of the following greenhouse gases will be reported. Definition information is provided by (Environment and Climate Change Canada, 2018).
• **Carbon dioxide (CO\(_2\)):** CO\(_2\) is a naturally occurring, colourless, odourless, incombustible gas formed during respiration, combustion, decomposition of organic substances, and the reaction of acids with carbonates. It is present in the Earth’s atmosphere at low concentrations and acts as a GHG. The global carbon cycle is made up of large carbon flows and reservoirs. Through these, CO\(_2\) is constantly being removed from the air by its direct absorption into water and by plants through photosynthesis and, in turn, is naturally released into the air by plant and animal respiration, decay of plant and soil organic matter, and outgassing from water surfaces. Small amounts of carbon dioxide are also injected directly into the atmosphere by volcanic emissions and through slow geological processes such as the weathering of rock... Anthropogenic sources of CO\(_2\) emissions include the combustion of fossil fuels and biomass to produce energy, building heating and cooling, transportation, land-use changes including deforestation, the manufacture of cement, and other industrial processes.

• **Methane (CH\(_4\)):** CH\(_4\) is a colourless, odourless, flammable gas that is the simplest hydrocarbon. CH\(_4\) is present in the Earth’s atmosphere at low concentrations and acts as a GHG. CH\(_4\) is usually in the form of natural gas, is used as feedstock in the chemical industry (e.g. hydrogen and methanol production), and as fuel for various purposes (e.g. heating homes and operating vehicles). CH\(_4\) is produced naturally during the decomposition of plant or organic matter in the absence of oxygen, as well as released from wetlands (including rice paddies), and through the digestive processes of certain insects and animals such as termites, sheep and cattle. CH\(_4\) is also released from industrial processes, fossil fuel extraction, coal mines, incomplete fossil fuel combustion and garbage decomposition in landfills.

• **Nitrous oxide (N\(_2\)O):** N\(_2\)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\(_2\)O is most commonly produced via the heating of ammonium nitrate (NH\(_4\)NO\(_3\)). It is also released naturally from oceans, by bacteria in soils, and from animal wastes. Other sources of N\(_2\)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\(_6\)):** SF\(_6\) is a synthetic gas that is colourless, odourless, and non-toxic (except when exposed to extreme temperatures), and acts as a GHG due to its very high heat-trapping capacity. SF\(_6\) is primarily used in the electricity industry as insulating gas for high-voltage equipment. It is also used as a cover gas in the magnesium industry to prevent oxidation (combustion) of molten magnesium. In lesser amounts, SF\(_6\) is used in the electronics industry in the manufacturing of semiconductors, and also as a tracer gas for gas dispersion studies in industrial and laboratory settings.

• **Nitrogen Trifluoride (NF\(_3\)):** NF\(_3\) is a colourless, non-flammable gas that is used in the electronics industry as a replacement for PFCs and SF\(_6\). It has a higher percentage of conversion to fluorine, which is the active agent
in the industrial process, than PFCs and SF₆ for the same amount of electronics production. It is used in the manufacture of semi-conductors, liquid crystal display (LCD) panels and photovoltaics.

### 1.4. GHG EMISSION CALCULATIONS

Greenhouse gas emissions are calculated by methods outlined in The Climate Registry (TCR) General Reporting Protocol (GRP) v.2.1, 2016 (The Climate Registry, 2016). The data and calculations used for this inventory are shown in detail in the following sections of this report. Emission factors were found in The Climate Registry’s 2018 Default Emission Factors (The Climate Registry, 2018), apart from emission factors for electricity, which were obtained from Nova Scotia Power (Nova Scotia Power Inc., 2018).

![Efficient Variable Refrigerant Flow System](image_url)

*Figure 1.3. Efficient Variable Refrigerant Flow System used for Heating and Cooling at LeMarchant Place*
2. GHG EMISSIONS INVENTORY

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

2.1. SCOPE 1 EMISSIONS

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

2.1.1. Overview

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

Houses have individual oil fired or gas furnaces, though a few houses on Seymour and Henry Street are connected to the steam line. One building, O’Brien Hall, is not connected to the distribution system and is using electric heat. A limited amount of propane is used on campus primarily for lab and cooking purposes. Diesel back-up generators are located in some major lab and residence buildings and the central heating plant. Solar thermal and air systems reduce load on three buildings.

**Fuels (Agricultural campus):** Dalhousie University has a central plant, located at 43 River Rd., which provides heating to most AC buildings through a district energy system. The central heating plant consumes biomass (wood chips) and #2 fuel oil (furnace oil) to produce 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 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 fuel 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 2017/2018 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 by Dalhousie that operate within and between the campuses in Halifax and the AC. The Dalhousie fleet vehicles are used for landscaping, mail deliveries, farming, snow removal, security, field research, garbage collection, and other purposes. A list of fleet vehicles and owners (Appendix D) was provided by the University Risk Manager, who oversees the insurance of all Dalhousie owned vehicles. Where possible, fuel purchase records were obtained for each vehicle and used to estimate fuel consumption. If data were missing, vehicle managers were contacted to obtain mileage or hourly usage data as a proxy for fuel consumption.

This method 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 had to be used in some cases, this method is expected to more accurately capture the majority of Dalhousie’s fleet emissions.

### 2.1.2. Calculations

**Fuels:**
- Central Heating Plant – natural gas (with back up Bunker B 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.

The available data for CO$_2$, CH$_4$, and N$_2$O emissions from stationary combustion is assessed according to the TCR: GRP 2.1 methodology and qualifications (formerly Data Quality Tiers) (The Climate Registry, 2016). The current qualifications are based on data availability during preparation of this report.

Direct emissions monitoring is not currently in place, which would require sensors to be placed at exit points to allow for continuous recording of data. Direct carbon and heat values are not delivered by the supplier and have not been tested in a controlled laboratory environment. Therefore, direct CO$_2$ emissions data from stationary combustion currently falls under **GRP ST-04-CO$_2$** (formerly Tier C), where default emission factors are used based on fuel type. Values for CH$_4$ and N$_2$O emissions are not currently measured either, but the technology type used is known, therefore it falls under **GRP ST-06-CH$_4$ & N$_2$O** (formerly Tier B).

According to TCR: GRP 2.1 (The Climate Registry, 2016), biogenic CO$_2$ emissions (BioCO$_2$) must be reported separately from fossil fuel emissions, while biogenic CH$_4$ and N$_2$O emissions must be reported with fossil fuel emissions.
emissions. This is assuming the amount of CO$_2$ released to the atmosphere during the combustion of biomass is equal to the amount of CO$_2$ absorbed during plant growth (B.C. Ministry of Environment, 2013).

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 2018 Default Emission Factors in grams of CO$_2$ / unit of fuel combusted, grams of CH$_4$ and grams of N$_2$O / unit of fuel combusted. Relevant emission factors for the Dalhousie campuses are highlighted below (Table 2.1. **Scope 1: Summary of Emission Factors** Table 2.1; shown in full in Appendix E (CO$_2$) and Appendix F (CH$_4$ and N$_2$O)).

Table 2.1. **Scope 1: Summary of Emission Factors for Stationary Combustion** (*The Climate Registry, 2018*)

<table>
<thead>
<tr>
<th>Scope 1 Emissions</th>
<th>CO$_2$ Emission Factor</th>
<th>CH$_4$ Emission Factor</th>
<th>N$_2$O Emission Factor</th>
<th>Unit</th>
<th>Methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bunker B</td>
<td>3075.4</td>
<td>0.0972</td>
<td>0.0574</td>
<td>grams/L</td>
<td>1/5 &quot;Light Fuel Oil Industrial&quot; and 4/5 &quot;Heavy Fuel Oil Industrial&quot; - Table 12.2 and 12.4 in TCR</td>
</tr>
<tr>
<td>1/5 Light Fuel Oil</td>
<td>1/5*2753</td>
<td>1/5*0.006</td>
<td>1/5*0.031</td>
<td>grams/L</td>
<td>&quot;Light Fuel Oil Residential&quot; - Table 12.2 and 12.4 in TCR</td>
</tr>
<tr>
<td>+ 4/5 Heavy Fuel Oil</td>
<td>4/5*3156</td>
<td>4/5*0.120</td>
<td>4/5*0.064</td>
<td>grams/L</td>
<td>&quot;Propane&quot; and “Propane (All other uses)” – Table 12.2 and 12.4 in TCR</td>
</tr>
<tr>
<td>Diesel</td>
<td>2690</td>
<td>0.133</td>
<td>0.4</td>
<td>grams/L</td>
<td>&quot;Diesel&quot; (CO$_2$) and &quot;Diesel (Refineries and others)&quot; (CH$_4$ and N$_2$O) - Table 12.2 and 12.4 in TCR</td>
</tr>
<tr>
<td>Furnace Oil</td>
<td>2753</td>
<td>0.026</td>
<td>0.006</td>
<td>grams/L</td>
<td>&quot;Propane&quot; and “Propane (All other uses)” – Table 12.2 and 12.4 in TCR</td>
</tr>
<tr>
<td>Propane</td>
<td>1515</td>
<td>0.024</td>
<td>0.108</td>
<td>grams/L</td>
<td>&quot;Nova Scotia Marketable” (Table 12.2) and “Residential” (Table 12.4)</td>
</tr>
<tr>
<td>Natural gas</td>
<td>1901</td>
<td>0.037</td>
<td>0.035</td>
<td>grams/m$^3$</td>
<td>&quot;Wood Fuel/ Wood Waste&quot; - Table 12.2 and 12.4 in TCR</td>
</tr>
<tr>
<td>Biomass</td>
<td>840</td>
<td>0.06</td>
<td>0.06</td>
<td>grams/kg</td>
<td>&quot;Wood Fuel/ Wood Waste&quot; - Table 12.2 and 12.4 in TCR</td>
</tr>
</tbody>
</table>
3. Calculate the CO$_2$ emissions for each fuel type and convert to metric tonnes (The Climate Registry, 2016)

\[
\text{Fuel A CO}_2\text{ Emissions (metric tons) } = \frac{\text{Fuel Consumed (gallons)} \times \text{Emission Factor (kg CO}_2\text{/gallon)}}{1,000} \text{ (kg/metric ton)}
\]

\[
\text{Fuel B CO}_2\text{ Emissions (metric tons) } = \frac{\text{Fuel Consumed (gallons)} \times \text{Emission Factor (kg CO}_2\text{/gallon)}}{1,000} \text{ (kg/metric ton)}
\]

\[
\text{Total CO}_2\text{ Emissions (metric tons) } = \sum \left( \frac{\text{CO}_2\text{ from Fuel A} + \text{CO}_2\text{ from Fuel B} + \ldots}{\text{(metric tons) (metric tons) \ldots}} \right)
\]

**Canadian Emission Factor Equivalent:**

\[
\text{Fuel A CO}_2\text{ Emissions (metric tons) } = \text{Fuel consumed (litres) x Emission Factor (metric ton CO}_2\text{ / litre)}
\]

4. Calculate the CH$_4$ and N$_2$O emissions for each fuel type (The Climate Registry, 2016)

\[
\text{Fuel/Technology Type A CH}_4\text{ Emissions } = \frac{\text{Fuel Use (MMBtu)} \times \text{Emission Factor (g CH}_4\text{/MMBtu)}}{1,000,000} \text{ (g/metric ton)}
\]

\[
\text{Fuel/Technology Type A CH}_4\text{ Emissions } = \frac{\text{Fuel Use (Litres)} \times \text{Emission Factor (g CH}_4\text{/L)}}{1,000,000} \text{ (g/metric ton)}
\]

\[
\text{Fuel/Technology Type A N}_2\text{O Emissions } = \frac{\text{Fuel Use (MMBtu)} \times \text{Emission Factor (g CH}_4\text{/MMBtu)}}{1,000,000} \text{ (g/metric ton)}
\]

\[
\text{Fuel/Technology Type A N}_2\text{O Emissions } = \frac{\text{Fuel Use (Litres)} \times \text{Emission Factor (g CH}_4\text{/L)}}{1,000,000} \text{ (g/metric ton)}
\]

**Canadian Emission Factor Equivalent:**

\[
\text{Fuel/Technology Type A CH}_4\text{ Emissions } = \frac{\text{Fuel Use (Litres)} \times \text{Emission Factor (g CH}_4\text{/L)}}{1,000,000} \text{ (g/metric ton)}
\]

5. Convert CH$_4$ and N$_2$O emissions to units of CO$_2$ equivalence (CO$_2$e) and determine total emissions from stationary combustion

\[
\text{CO}_2\text{ Emissions (mt CO}_2\text{e) } = \frac{\text{CO}_2\text{ Emissions x 1}}{\text{(mt) (GWP)}}
\]

\[
\text{CH}_4\text{ Emissions (mt CO}_2\text{e) } = \frac{\text{CH}_4\text{ Emissions x 28}}{\text{(mt) (GWP)}}
\]

\[
\text{N}_2\text{O Emissions (mt CO}_2\text{e) } = \frac{\text{N}_2\text{O Emissions x 265}}{\text{(mt) (GWP)}}
\]
The results of the above calculations are presented in Table 2.2 and Table 2.3. The emission factors shown are the cumulative emission factors for CO$_2$, CH$_4$, and N$_2$O, as shown in Table 2.1.

Table 2.2. Scope 1: Summary of Direct Emissions from Stationary Combustion, Halifax Campuses and external properties connected to the Dalhousie’s District Energy System (April 2017-March 2018)

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Consumption</th>
<th>Unit</th>
<th>CO$_2$e Emission Factor (tCO$_2$e/unit)</th>
<th>GHG Emissions CO$_2$ (tCO$_2$e)</th>
<th>GHG Emissions CH$_4$ (tCO$_2$e)</th>
<th>GHG Emissions N$_2$O (tCO$_2$e)</th>
<th>Total GHG Emissions (tCO$_2$e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furnace Oil</td>
<td>26,084</td>
<td>L</td>
<td>0.0027553</td>
<td>71.81</td>
<td>0.02</td>
<td>0.04</td>
<td>72</td>
</tr>
<tr>
<td>Bunker B Oil</td>
<td>73,525</td>
<td>L</td>
<td>0.0030933</td>
<td>226.12</td>
<td>0.20</td>
<td>1.12</td>
<td>227</td>
</tr>
<tr>
<td>Diesel</td>
<td>14,044</td>
<td>L</td>
<td>0.0027997</td>
<td>37.78</td>
<td>0.05</td>
<td>1.49</td>
<td>39</td>
</tr>
<tr>
<td>Propane</td>
<td>9,041</td>
<td>L</td>
<td>0.0015443</td>
<td>13.70</td>
<td>0.01</td>
<td>0.26</td>
<td>14</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>533,037</td>
<td>GJ</td>
<td>0.00487082</td>
<td>25,823.22</td>
<td>14.07</td>
<td>125.99</td>
<td>25,963</td>
</tr>
<tr>
<td>Sub Total</td>
<td></td>
<td></td>
<td></td>
<td>26,172.63</td>
<td>14.35</td>
<td>128.90</td>
<td>26,316</td>
</tr>
<tr>
<td>Total GHG emissions (Halifax)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>26,316</td>
</tr>
</tbody>
</table>

*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 425,050. The fuel used to create steam and hot water for Dalhousie properties and these external properties is included in the numbers above.

Table 2.3. Scope 1: Summary of Direct Emissions from Stationary Combustion, AC (April 2017-March 2018)

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Consumption</th>
<th>Unit</th>
<th>CO$_2$e Emission Factor (tCO$_2$e/unit)</th>
<th>GHG Emissions CO$_2$ (tCO$_2$e)</th>
<th>GHG Emissions CH$_4$ (tCO$_2$e)</th>
<th>GHG Emissions N$_2$O (tCO$_2$e)</th>
<th>Total GHG Emissions (tCO$_2$e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furnace Oil</td>
<td>1,371,023</td>
<td>L</td>
<td>0.0027553</td>
<td>3,774.43</td>
<td>1.00</td>
<td>2.18</td>
<td>3,778</td>
</tr>
<tr>
<td>Diesel</td>
<td>2,665</td>
<td>L</td>
<td>0.0027997</td>
<td>7.17</td>
<td>0.01</td>
<td>0.28</td>
<td>7</td>
</tr>
<tr>
<td>Propane</td>
<td>74,094</td>
<td>L</td>
<td>0.0015443</td>
<td>112.25</td>
<td>0.05</td>
<td>2.12</td>
<td>114</td>
</tr>
<tr>
<td>Wood</td>
<td>571,348</td>
<td>kg</td>
<td>0.0008584</td>
<td>-</td>
<td>1.44</td>
<td>9.08</td>
<td>11</td>
</tr>
<tr>
<td>Total GHG emissions (AC)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3,910</td>
</tr>
</tbody>
</table>

BioCO$_2$, as previously mentioned, is not recorded as a direct emission. It must be calculated but is omitted from the totals shown above. For 2017-18, wood consumption at the AC resulted in **480 tonnes of BioCO$_2$**.
Refrigerants

The TCR: GRP 2.1 FG-02 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$_2$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. These values are converted into metric tonnes and multiplied by the appropriate emission factor for each refrigerant. Emission factors are obtained from TCR’s 2018 Default Emissions Factors (Tables B.1 and B.2, shown in Appendix G) in tonnes of CO$_2$e / tonne of refrigerant (The Climate Registry, 2018).

The results of the above calculations are shown in Table 2.4 and Table 2.5 below.

Table 2.4. Scope 1: Summary of Refrigerant GHG Emissions, Halifax Campuses (April 2017 – March 2018)

<table>
<thead>
<tr>
<th>Refrigerant Name</th>
<th>Consumption (Loss) (tRefrigerant)</th>
<th>GWP (tCO$_2$e/ tRefrigerant)</th>
<th>Total GHG Emissions (tCO$_2$e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R134A</td>
<td>0.02087</td>
<td>1300</td>
<td>27.13</td>
</tr>
<tr>
<td>R401A</td>
<td>0.00680</td>
<td>17.94</td>
<td>0.12</td>
</tr>
<tr>
<td>R404A</td>
<td>0.01270</td>
<td>3943</td>
<td>50.08</td>
</tr>
<tr>
<td>R407C</td>
<td>0.00454</td>
<td>1624</td>
<td>7.37</td>
</tr>
<tr>
<td>R410A</td>
<td>0.11975</td>
<td>1924</td>
<td>230.40</td>
</tr>
<tr>
<td>R438A</td>
<td>0.00544</td>
<td>2059</td>
<td>11.21</td>
</tr>
<tr>
<td>RS52*</td>
<td>0.00454</td>
<td>3417</td>
<td>15.50</td>
</tr>
<tr>
<td><strong>Total GHG Emissions</strong></td>
<td></td>
<td></td>
<td><strong>341.80</strong></td>
</tr>
</tbody>
</table>

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

Table 2.5. Scope 1: Summary of Refrigerant GHG Emissions, AC (April 2017 – March 2018)

<table>
<thead>
<tr>
<th>Refrigerant Name</th>
<th>Consumption (Loss) (tRefrigerant)</th>
<th>GWP (tCO$_2$e/ tRefrigerant)</th>
<th>Total GHG Emissions (tCO$_2$e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R404A</td>
<td>0.00227</td>
<td>3943</td>
<td>8.94</td>
</tr>
<tr>
<td>R437A</td>
<td>0.00204</td>
<td>1639</td>
<td>3.35</td>
</tr>
</tbody>
</table>
Fleet Vehicles

The methodology for mobile combustion was followed as per the TCR: GRP 2.1 (Appendix H), using emission factors from TCR’s 2018 Default Emission Factors (The Climate Registry, 2018).

Mobile combustion CO\(_2\) emissions were determined primarily using the methodology GRP MO-03-CO\(_2\) in which fuel use is measured directly from purchasing data and default CO\(_2\) emission factors by fuel type are applied. This methodology represents a change from previous inventories, in which GRP MO-04-CO\(_2\) was used by estimating fuel use based on distance. This methodology was still applied for several vehicles (< 25) where fuel purchase data was not available.

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

CH\(_4\) and N\(_2\)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\(_4\) and N\(_2\)O using method GRP MO-06-CH\(_4\) & N\(_2\)O. Given that mobile combustion emissions have consistently represented <1% of Dalhousie’s Scope 1 emissions, a simplified method was considered appropriate for calculating these emissions.

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

1) Calculate CO\(_2\) emissions from mobile combustion
   a. Identify total annual fuel consumption by fuel type, using purchase records, mileage and proxies

Fuel purchase data was obtained from the University Corporate Card Manager. These data were compared to the list of fleet vehicles (Appendix D), obtained from University Risk Manager, to determine which vehicles had fuel records and which used gasoline or diesel. The total amount spent on gasoline and on diesel was compared to the average retail price per litre of fuel in Halifax for 2017-18. For simplicity, it was assumed that geography (i.e., purchasing gas near the AC campus) would have minimal impact on average price. In 2017-18, the average price of regular unleaded gasoline was $1.10 / litre, while diesel fuel was $1.07 / litre (Statistics Canada, 2018).

Where records of fuel purchases for vehicles were missing, individual vehicle managers were contacted to verify if the vehicle had been driven in 2017-18 and to collect mileage data (following GRP MO-04-CO\(_2\)).
Fuel economies were estimated using an 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 1400 L was used (the average for the remainder of the fleet). This method was applied to nine vehicles.

b. Select appropriate CO$_2$ emission factor for each fuel type from TCR’s Table 13.2 (The Climate Registry, 2018)

c. Calculate total CO$_2$ emissions and convert to metric tonnes (The Climate Registry, 2016)

\[
\text{Fuel Use} = \frac{\text{Distance}}{\text{City FE}} \quad \text{(liters)} \div \text{(km)} = \text{(L/km)}
\]

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Carbon Content (kg C / GJ)</th>
<th>Heat Content (GJ/kiloliter)</th>
<th>Fraction Oxidized</th>
<th>CO$_2$ Emission Factors (g CO$_2$ / L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor Gasoline</td>
<td>n/a</td>
<td>35.00</td>
<td>1</td>
<td>2316</td>
</tr>
<tr>
<td>Diesel</td>
<td>n/a</td>
<td>38.30</td>
<td>1</td>
<td>2690</td>
</tr>
</tbody>
</table>

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

Canadian Conversion:

\[
\text{Fuel A CO$_2$ Emissions} = \text{Fuel Consumed} \times \text{Emission Factor} \quad \text{(metric tonnes) \times (litres) = (metric tonne CO$_2$ / litre)}
\]

2) Calculate CH$_4$ and N$_2$O emissions from mobile combustion

The CH$_4$ and N$_2$O emissions of Dalhousie’s fleet vehicles were calculated by using the TCR’s 2018 Default Emission Factors: “Factors for Estimating CH$_4$ and N$_2$O Emissions from Gasoline and Diesel Vehicles (SEM)” in Table 13.9. This method bases the estimate of CH$_4$ and N$_2$O emissions off of total CO$_2$ emissions.
3) Convert CH₄ and N₂O emissions to units of CO₂ equivalence and determine total emissions

<table>
<thead>
<tr>
<th>CO₂ Emissions (mt CO₂e)</th>
<th>CO₂ Emissions x 1 (GWP)</th>
<th>CH₄ Emissions x 28 (GWP)</th>
<th>N₂O Emissions x 265 (GWP)</th>
<th>Total GHG Emissions (tCO₂e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH₄ Emissions (mt CO₂e)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N₂O Emissions (mt CO₂e)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mobile combustion emission calculation results are presented in Table 2.6 and Table 2.7.

Table 2.6. Scope 1: Fleet Vehicle Emissions, Halifax Campuses (April 2017 – March 2018)

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Consumption</th>
<th>Unit</th>
<th>CO₂ Emission Factor (tCO₂ / unit)</th>
<th>CH₄ Emissions (tCH₄)</th>
<th>N₂O Emissions (tN₂O)</th>
<th>Total GHG Emissions (tCO₂e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>28,907</td>
<td>Litres</td>
<td>0.00232</td>
<td>0.00181</td>
<td>0.00296</td>
<td>67.78</td>
</tr>
<tr>
<td>Diesel Fuel</td>
<td>69,311</td>
<td>Litres</td>
<td>0.00269</td>
<td>0.00503</td>
<td>0.00824</td>
<td>188.8</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>256.6</td>
</tr>
</tbody>
</table>

*CH₄ emissions and N₂O emissions are multiplied by 28 and 265 respectively to convert them to tCO₂e.

Table 2.7. Scope 1: Fleet Vehicle Emissions, AC (April 2017 – March 2018)

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Consumption</th>
<th>Unit</th>
<th>CO₂ Emission Factor (tCO₂ / unit)</th>
<th>CH₄ Emissions (tCH₄)</th>
<th>N₂O Emissions (tN₂O)</th>
<th>Total GHG Emissions (tCO₂e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>61,344</td>
<td>Litres</td>
<td>0.00232</td>
<td>0.00384</td>
<td>0.00628</td>
<td>143.8</td>
</tr>
<tr>
<td>Diesel Fuel</td>
<td>27,890</td>
<td>Litres</td>
<td>0.00269</td>
<td>0.00203</td>
<td>0.00332</td>
<td>75.96</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>219.8</td>
</tr>
</tbody>
</table>

*CH₄ emissions and N₂O emissions are multiplied by 28 and 265 respectively to convert them to tCO₂e.
<table>
<thead>
<tr>
<th></th>
<th>Stationary Combustion</th>
<th>Refrigerants</th>
<th>Fleet</th>
<th>Total GHG Emissions (tCO₂e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Halifax 2017-18</td>
<td>26,316</td>
<td>342</td>
<td>256</td>
<td>26,914</td>
</tr>
<tr>
<td>AC 2017-18</td>
<td>3,910</td>
<td>122</td>
<td>220</td>
<td>4,252</td>
</tr>
<tr>
<td>Combined</td>
<td>30,226</td>
<td>464</td>
<td>476</td>
<td>31,166</td>
</tr>
</tbody>
</table>

### 2.2. SCOPE 2 EMISSIONS

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

#### 2.2.1. Overview

**Halifax campuses:** Electricity is provided to the Halifax campuses by Nova Scotia Power. A large main feed comes to the Weldon Law Building and is distributed to many of the large buildings on Studley and Carleton campuses. Furthermore, many buildings on Sexton campus are supplied downstream of a street feed to the B building. Other buildings and houses have individual accounts and are fed from the street power lines. Electricity is used for lights, HVAC systems, labs, equipment, and for cooling (electric chiller) and heating in some limited locations.

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

#### 2.2.2. Calculations

**Indirect Emissions from Electricity**

Emission factors are available directly from Nova Scotia Power Inc. (NSPI) (Nova Scotia Power Inc., 2018), which satisfies the standards of GRP ST-01-CO₂ and GRP ST-05-CH₄ & N₂O (formerly Tier A) in determining indirect emissions from electricity (Appendix I).

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

1) **Determine annual electricity consumption**

Electricity consumption data is obtained from Tableau Reader for both the Halifax and Agricultural campuses. Consumption is recorded in kWh (Table 2.9 and Table 2.10).

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 J). CH₄ and N₂O are already factored into emission intensities. The recently published coefficient for total system emission intensity in 2017 is 656.5 g CO₂e/kWh (Nova Scotia Power Inc., 2018), allowing for accurate calculations associated with purchased electricity.

3) **Determine total emissions and convert to metric tonnes CO₂e**

\[
\text{Total emissions} = \text{Electricity Consumption (kWh) } \times \text{ Emission Intensity (metric tonne CO₂e/kWh)}
\]

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

### Table 2.9. Scope 2: Summary of Electricity GHG Emissions, Halifax Campuses (April 2017 – March 2018)

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Consumption</th>
<th>Unit</th>
<th>Emission Factor (tCO₂e / unit)</th>
<th>Total GHG Emissions (tCO₂e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>69,737,626</td>
<td>kWh</td>
<td>0.0006565</td>
<td>45,783</td>
</tr>
</tbody>
</table>

### Table 2.10. Scope 2: Summary of Electricity GHG Emissions, AC (April 2017 – March 2018)

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Consumption</th>
<th>Unit</th>
<th>Emission Factor (tCO₂e / unit)</th>
<th>Total GHG Emissions (tCO₂e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>10,528,159</td>
<td>kWh</td>
<td>0.0006565</td>
<td>6,912</td>
</tr>
</tbody>
</table>

### 2.3. SCOPE 3 EMISSIONS

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

#### 2.3.1. Overview

**Commuting:** Commuting emissions are emissions created from employees and students travelling to and from Dalhousie University. Transportation statistics are gathered annually by the Dalhousie University Annual Sustainability and Commuting Survey, conducted this year in the fall of 2017 (DalTRAC, 2018). 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, but Dalhousie indirectly contributes to the release of emissions through its water consumption.

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

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

### 2.3.2. Calculations

**Indirect Emissions from Commuting**

Commuter travel emission calculations rely on several assumptions, as vehicle fuel economy is averaged, the
number of full-time/part-time student and employee commuter days is averaged, and survey data is
extrapolated and applied across the entire campus population. The commuter transportation emission
calculations focus on travel to and from campus for work and educational purposes, and do not include
intercampus or business travel. An estimated value of emissions for commuter travel was deemed important to
gauge for future transportation demand management planning. Business travel data is currently not easily
accessible. When this data is available, analysis and reporting will be undertaken.

Indirect emissions from commuting were calculated as follows:

1. **Identify total number of trips for employees and students who travelled by each mode**
   
   a. Survey data was used to identify travel mode percentages (DalTRAC, 2018)
Figure 2.1 and Figure 2.2 show the blended (where full time = 1, part time = 0.5) percentages at the Halifax and agricultural campuses of modes of transportation used during the past year by students, staff, and faculty.

**Figure 2.1. Blended commuting mode percentages, Halifax campuses (2017-18)**

- **Auto - Drive Alone**: 32%
- **Auto - Carpool**: 14%
- **Bicycle**: 7%
- **Walking**: 1%
- **Public Transit**: 31%

**Figure 2.2. Blended commuting mode percentages, Agricultural campus (2017-18)**

- **Auto - Drive Alone**: 32%
- **Auto - Carpool**: 32%
- **Bicycle**: 7%
- **Walking**: 1%
- **Public Transit**: 28%

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 K 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.

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, 2018).

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

3. **Multiply total kilometres travelled by emission factors**

   Transport Canada’s commuting emission factor was used in calculations for driving by car (alone and carpooling), at a value of 258 grams CO₂e per kilometre driven (shown in Appendix L) (Transport Canada, 2011). For public transit, the EPA provides an emission factor of 66.59 grams CO₂e per kilometer driven per passenger (EPA, 2008).

<table>
<thead>
<tr>
<th>Commuter</th>
<th>Annual Distance (km)</th>
<th>Emission Factor (tCO₂e/km)</th>
<th>Total GHG Emissions (tCO₂e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drive Alone</td>
<td>21,497,165</td>
<td>0.000258</td>
<td>5,546</td>
</tr>
<tr>
<td>Car Pool</td>
<td>9,405,010</td>
<td>0.000258</td>
<td>2,426</td>
</tr>
<tr>
<td>Transit</td>
<td>21,497,165</td>
<td>0.00006659</td>
<td>1,431</td>
</tr>
<tr>
<td><strong>Total Emissions Created:</strong></td>
<td></td>
<td></td>
<td><strong>9,404</strong></td>
</tr>
<tr>
<td>Bicycle</td>
<td>1,175,626</td>
<td>-0.000258</td>
<td><strong>(303)</strong></td>
</tr>
<tr>
<td>Walking</td>
<td>3,123,807</td>
<td>-0.000258</td>
<td><strong>(806)</strong></td>
</tr>
</tbody>
</table>
Total Emissions Avoided: \(1,109\)

Table 2.12. Scope 3: Summary of Commuting GHG Emissions and Emissions avoided through Active Transport, AC (April 2017 - March 2018)

<table>
<thead>
<tr>
<th>Commuter</th>
<th>Annual Distance (km)</th>
<th>Emission Factor (tCO(_2)e/km)</th>
<th>Total GHG Emissions (tCO(_2)e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drive Alone</td>
<td>2,371,086</td>
<td>0.000258</td>
<td>612</td>
</tr>
<tr>
<td>Car Pool</td>
<td>1,037,350</td>
<td>0.000258</td>
<td>268</td>
</tr>
<tr>
<td>Transit</td>
<td>37,048</td>
<td>0.0006659</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total Emissions Created:</strong></td>
<td><strong>882</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bicycle</td>
<td>64,834</td>
<td>-0.000258</td>
<td>(17)</td>
</tr>
<tr>
<td>Walking</td>
<td>177,831</td>
<td>-0.000258</td>
<td>(46)</td>
</tr>
<tr>
<td><strong>Total Emissions Avoided:</strong></td>
<td></td>
<td>(63)</td>
<td></td>
</tr>
</tbody>
</table>

**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 both the Halifax and Agricultural campuses is provided in number of sheets by Procurement. 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 M).

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 2017-18. Each package contains 500 sheets and weighs approximately 2.27 kg (B.C. Ministry of Environment, 2016). As per the Paper Policy, all paper is 100% PCR content. 11 x 17-inch sheets are treated as two sheets of 8.5 x 11-inch sheets in the calculations.

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\(_2\)e for each kilogram of paper consumed. The total weight of paper purchased in 2017-18 was multiplied by the appropriate emission factor for 100% PCR content (0.00177 tonnes of CO\(_2\)e emissions per kilogram of paper) (B.C. Ministry of Environment, 2016).

Total emissions from paper usage are shown below.
### Table 2.13. Scope 3: Summary of Paper GHG Emissions, All Campuses (April 2017 – March 2018)

<table>
<thead>
<tr>
<th>Paper Emissions</th>
<th>Paper consumption (kg)</th>
<th>Emission Factor (t CO2e/kg)</th>
<th>Total GHG Emissions (tCO2e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% PCR content</td>
<td>0</td>
<td>0.00280</td>
<td>0</td>
</tr>
<tr>
<td>10% PCR content</td>
<td>0</td>
<td>0.00270</td>
<td>0</td>
</tr>
<tr>
<td>20% PCR content</td>
<td>0</td>
<td>0.00259</td>
<td>0</td>
</tr>
<tr>
<td>30% PCR content</td>
<td>0</td>
<td>0.00248</td>
<td>0</td>
</tr>
<tr>
<td>40% PCR content</td>
<td>0</td>
<td>0.00239</td>
<td>0</td>
</tr>
<tr>
<td>50% PCR content</td>
<td>0</td>
<td>0.00228</td>
<td>0</td>
</tr>
<tr>
<td>60% PCR content</td>
<td>0</td>
<td>0.00218</td>
<td>0</td>
</tr>
<tr>
<td>70% PCR content</td>
<td>0</td>
<td>0.00208</td>
<td>0</td>
</tr>
<tr>
<td>80% PCR content</td>
<td>0</td>
<td>0.00197</td>
<td>0</td>
</tr>
<tr>
<td>90% PCR content</td>
<td>0</td>
<td>0.00187</td>
<td>0</td>
</tr>
<tr>
<td>100% PCR content</td>
<td>93,138</td>
<td>0.00177</td>
<td>164.5303</td>
</tr>
<tr>
<td>Total Emissions Created:</td>
<td></td>
<td></td>
<td>164.5303</td>
</tr>
</tbody>
</table>

### 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 results in the following greenhouse gas (GHG) emission factors, provided by Halifax Water:

- Treatment – 197 g CO2e per m³ water (0.000197 tonnes per m³)
- Distribution – 25 g CO2e per m³ water (0.000025 tonnes 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.

1. Personal communications – J. Stewart, Project Manager, Halifax Wastewater Treatment Facility
such as low-flow water fixtures and research equipment retrofits. Since 2010, water usage on campus has decreased by 55%. Total consumption in 2009-10 was 1,162,692 litres; in comparison, consumption was 527,642 litres.

**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 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.

Energy use associated with collecting and treating the wastewater resulting in the following GHG emissions:

- Collection – 136 g CO₂e per m³ water (0.000136 tonnes)
- Treatment – 186 g CO₂e per m³ water (0.000186 tonnes)

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

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

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

**Calculations**

In the 2018 fiscal year, primary water consumption for the Halifax campuses was 527,642 m³ of water. Using the same value for primary water consumption, Scope 3 emissions from water output are therefore calculated using the emission factors provided by Halifax Water (Table 2.14).

<table>
<thead>
<tr>
<th>Commuter</th>
<th>Water Consumption (L)</th>
<th>Emission Factor (tCO₂e/L)</th>
<th>Total GHG Emissions (tCO₂e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water – Treatment</td>
<td>527,642</td>
<td>0.000197</td>
<td>103.945</td>
</tr>
<tr>
<td>Water – Distribution</td>
<td>527,642</td>
<td>0.00025</td>
<td>13.191</td>
</tr>
<tr>
<td>Wastewater – Collection</td>
<td>527,642</td>
<td>0.000136</td>
<td>71.76</td>
</tr>
</tbody>
</table>
3. REDUCING GHG EMISSIONS

The first edition of the Dalhousie Climate Change Plan was released in 2010. A second version of the plan including the AC will be issued in 2019. In the last nine years, the University and partners have invested over $93 million in sustainability-related projects many of them which are energy and climate related.

In the 2017-18 fiscal year, a variety of projects were undertaken to reduce greenhouse gases and mitigate the impacts of climate change including:

- Final implementation of a major energy and water efficiency upgrade of the Tupper Medical Building.
- Working with Facilities Management planners and project managers/operators to build energy and water efficiency into operational and facilities renewal. Examples of implemented projects: air handler upgrades, variable-air-volume conversions, and fume hood upgrades.
- Using energy management information systems (EMIS) to troubleshoot and solve operational energy issues.
- Retrofitting systems to use high efficiency pumps, fans, and motors.
- Implementation of indoor and outdoor bicycle parking.
- Planting over 170 trees on campus.
- Participation of 320 employees in the Employee Bus Program. Dalhousie also has a student bus pass program.

![Figure 3.1. LED lights in the Fitness Centre](image)
4. NEXT STEPS

Several projects that will significantly reduce Dalhousie University’s GHG emissions are currently being planned and/or in the implementation stage. They include both small and large sustainability retrofits. Dalhousie has over 5.5 million square feet of building space and over 150 buildings/houses on all four campuses. Business cases have been developed and approved in 2017-18 for future work, including:

- Water turbine study;
- Arts Centre energy efficiency upgrades;
- Energy performance study of the Chemistry and Killam library;
- Distilled water upgrades; and
- District Energy upgrades at the Halifax campus.

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

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

Office staff are exploring other GHG mitigating solutions such as renewable natural gas procurement and renewable energy power purchase agreements.
5. BIBLIOGRAPHY


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

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

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

**carbon dioxide equivalent (CO\textsubscript{2}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\textsubscript{2}), methane (CH\textsubscript{4}), nitrous oxide (N\textsubscript{2}O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF\textsubscript{6})

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

**greenhouse gas emission or removal factor** - factor relating activity data to GHG emissions or removals  
NOTE: A greenhouse gas emission or removal factor could include an oxidation component

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

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

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

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

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

**other indirect greenhouse gas emission** - GHG emission, other than energy indirect GHG emissions, which is a consequence of an organization’s activities, but arises from greenhouse gas sources that are owned or controlled by other organizations
Appendix B: Campus Maps (Dalhousie University, 2014)

Halifax (Studley and Carleton campuses, 2014)
AC (Agricultural Campus, 2014)
## Appendix C: List of Campus Buildings

### Halifax Campuses

<table>
<thead>
<tr>
<th>Site</th>
<th>ID</th>
<th>Description</th>
<th>Building Address</th>
<th>Bldg Area (GSF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STUDLEY</td>
<td>E282</td>
<td>CENTRAL SRV-PARKADE</td>
<td>1236 HENRY STREET</td>
<td>40,830</td>
</tr>
<tr>
<td>STUDLEY</td>
<td>A050</td>
<td>COBURG ROAD 6414</td>
<td>6414 COBURG ROAD</td>
<td>5,529</td>
</tr>
<tr>
<td>STUDLEY</td>
<td>A100</td>
<td>COBURG ROAD 6420</td>
<td>6420 COBURG ROAD</td>
<td>3,200</td>
</tr>
<tr>
<td>STUDLEY</td>
<td>A160</td>
<td>PRESIDENT'S RES</td>
<td>1460 OXFORD STREET</td>
<td>8,750</td>
</tr>
<tr>
<td>STUDLEY</td>
<td>B100</td>
<td>DALPLEX</td>
<td>6260 SOUTH STREET</td>
<td>178,767</td>
</tr>
<tr>
<td>STUDLEY</td>
<td>B200</td>
<td>HEALTH &amp; HUMAN PERFORMANCE (H&amp;HP)</td>
<td>6230 SOUTH STREET</td>
<td>6,800</td>
</tr>
<tr>
<td>STUDLEY</td>
<td>C140</td>
<td>STORAGE FACILITY/WAREHOUSE</td>
<td>1459 OXFORD ST.</td>
<td>11,899</td>
</tr>
<tr>
<td>STUDLEY</td>
<td>C201</td>
<td>LSC-BIO&amp;EARTH</td>
<td>1355 OXFORD STREET</td>
<td>161,394</td>
</tr>
<tr>
<td>STUDLEY</td>
<td>C202</td>
<td>LSC-OCEANOGRAPH</td>
<td>1355 OXFORD STREET</td>
<td>107,079</td>
</tr>
<tr>
<td>STUDLEY</td>
<td>C203</td>
<td>LSC-PSYCHOLOGY</td>
<td>1355 OXFORD STREET</td>
<td>123,710</td>
</tr>
<tr>
<td>STUDLEY</td>
<td>C204</td>
<td>LSC-COMMON AREA</td>
<td>1355 OXFORD STREET</td>
<td>57,856</td>
</tr>
<tr>
<td>STUDLEY</td>
<td>C210</td>
<td>WALLACE MCCAIN LEARNING COMMONS</td>
<td>1355 OXFORD STREET</td>
<td>13,600</td>
</tr>
<tr>
<td>STUDLEY</td>
<td>C220</td>
<td>SHIRREFF HALL</td>
<td>6385 SOUTH STREET</td>
<td>171,775</td>
</tr>
<tr>
<td>STUDLEY</td>
<td>C230</td>
<td>STEELE OCEAN SCIENCES BUILDING</td>
<td>1355 OXFORD STREET</td>
<td>76,000</td>
</tr>
<tr>
<td>STUDLEY</td>
<td>C260</td>
<td>DUNN BUILDING</td>
<td>6310 COBURG ROAD</td>
<td>89,991</td>
</tr>
<tr>
<td>STUDLEY</td>
<td>C280</td>
<td>CHASE BLDG</td>
<td>6316 COBURG ROAD</td>
<td>28,801</td>
</tr>
<tr>
<td>STUDLEY</td>
<td>C300</td>
<td>HENRY HICKS ACADEMI</td>
<td>6299 SOUTH STREET</td>
<td>106,613</td>
</tr>
<tr>
<td>STUDLEY</td>
<td>C381</td>
<td>CHEMISTRY</td>
<td>6274 COBURG ROAD</td>
<td>74,992</td>
</tr>
<tr>
<td>STUDLEY</td>
<td>C382</td>
<td>CHEMISTRY PODIUM</td>
<td>6274 COBURG ROAD</td>
<td>34,997</td>
</tr>
<tr>
<td>STUDLEY</td>
<td>C383</td>
<td>CHEMICAL STOR FACIL</td>
<td>6274 COBURG ROAD</td>
<td>10,608</td>
</tr>
<tr>
<td>STUDLEY</td>
<td>C400</td>
<td>MACDONALD BLDG</td>
<td>6300 COBURG ROAD</td>
<td>19,998</td>
</tr>
<tr>
<td>STUDLEY</td>
<td>C440</td>
<td>UNIVERSITY CLUB</td>
<td>6259 ALUMNI CRESCENT</td>
<td>14,877</td>
</tr>
<tr>
<td>STUDLEY</td>
<td>C520</td>
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**Total** 5,239,878

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<td>INTERN GUEST HOUSE AND GARAGE</td>
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<td>P402</td>
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<td>PLUMDALE FARM, SERVICE BLDG</td>
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<td>AGRICULTURE</td>
<td>L120</td>
<td>PLUMDALE FARM STORAGE BARN</td>
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<td>AGRICULTURE</td>
<td>L521</td>
<td>BLUEBERRY STORAGE SHED 2</td>
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*Gardens and Sheds not included

Total 812,810
### Appendix D: Fleet Vehicles on Campus

#### Halifax Fleet

<table>
<thead>
<tr>
<th>Year</th>
<th>Model Description</th>
<th>Year</th>
<th>Model Description</th>
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<tbody>
<tr>
<td>2011</td>
<td>Ford Escape XLT 4WD</td>
<td>2007</td>
<td>E-Z-Go Golf Cart</td>
</tr>
<tr>
<td>2012</td>
<td>Dodge Grand Caravan</td>
<td>2012</td>
<td>Dodge Grand Caravan</td>
</tr>
<tr>
<td>2012</td>
<td>Dodge Grand Caravan</td>
<td>2010</td>
<td>Chevrolet Silverado 2500</td>
</tr>
<tr>
<td>2004</td>
<td>Ford F150 Truck with Extended Cab</td>
<td>2015</td>
<td>Ford F-series F150 4x4 Crewcab</td>
</tr>
<tr>
<td>2013</td>
<td>Ram 2500 ST Crewcab Truck</td>
<td>1994</td>
<td>Diahatsu HiJet Pickup</td>
</tr>
<tr>
<td>2018</td>
<td>Toyota Tacoma 4x4</td>
<td>2010</td>
<td>Bobcat S185 Skid Steer Loader</td>
</tr>
<tr>
<td>2015</td>
<td>John Deere 1575 Terraincut w 60 in 7-iron side discharge deck</td>
<td>2010</td>
<td>John Deere 2520 Tractor</td>
</tr>
<tr>
<td>2010</td>
<td>John Deere 2320 Tractor</td>
<td>2013</td>
<td>HINO 16' W/Lift Gate 155-2</td>
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<tr>
<td>2011</td>
<td>Ford Econoline Cutaway Van</td>
<td>1995</td>
<td>Diahatsu HiJet Pickup</td>
</tr>
<tr>
<td>2018</td>
<td>Toyota Tacoma 4x2</td>
<td>2016</td>
<td>HINO 155-2 complete with 16' Transit dry freight body and Maxon TE20 lift gate (diesel)</td>
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<tr>
<td>2009</td>
<td>Dodge Ram 1500 Pickup Truck</td>
<td>2011</td>
<td>GMC Sierra 1500</td>
</tr>
<tr>
<td>2007</td>
<td>John Deere 2320 Tractor</td>
<td>2011</td>
<td>Ford Transit Connect</td>
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<tr>
<td>2012</td>
<td>Dodge Ram C/V (Van)</td>
<td>2015</td>
<td>HINO 155-2 complete with 2015 transit dry freight body and Maxon TE20 lift gate</td>
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<tr>
<td>2011</td>
<td>Dodge Grand Caravan</td>
<td>2013</td>
<td>Chev Silverado 2500</td>
</tr>
<tr>
<td>2011</td>
<td>Dodge Ram 2500</td>
<td>2011</td>
<td>TOYOTA RAV 4 2WD</td>
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<tr>
<td>2016</td>
<td>Ford F250 4x4 Crew Cab 156.0 XLT</td>
<td>2014</td>
<td>Chevrolet Silverado 1500</td>
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<tr>
<td>2013</td>
<td>GMC Sierra Crew Cab 4x4</td>
<td>2015</td>
<td>Chevrolet Volt</td>
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<tr>
<td>2011</td>
<td>Ford Ranger Supercab Pickup</td>
<td>2017</td>
<td>Hyundai Sonata</td>
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### Agricultural Campus Fleet

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<tr>
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<td>Toyota Camry LE</td>
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<tr>
<td>2013</td>
<td>GMC Sierra 2500 SLE</td>
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<tr>
<td>2009</td>
<td>DODGE RAM</td>
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<tr>
<td>1980</td>
<td>JOHN DEERE TRACTOR 1640</td>
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<tr>
<td>2008</td>
<td>KIOTI FARM TRACTOR DK65SC</td>
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<tr>
<td>2007</td>
<td>DODGE Ram 2500 Quad</td>
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<tr>
<td>2014</td>
<td>Chev Silverado 1500</td>
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<tr>
<td>2014</td>
<td>Dodge Ram 1500 Truck</td>
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<td>2014</td>
<td>Chevrolet Silverado</td>
</tr>
<tr>
<td>2002</td>
<td>CHEV SILVERADO 1500</td>
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<td>CHEV SILVERADO 1500</td>
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<tr>
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<td>GMC SAFARI 2WD</td>
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<td>GMC SAVANA 1500</td>
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<td>2010</td>
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<td>2011</td>
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<td>Chev Topkick 3 Tonne Truck</td>
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<td>Description</td>
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<tr>
<td>------</td>
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<tr>
<td>2016</td>
<td>Dodge Ram 5500 Dual wheel 4x4</td>
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<td>1967</td>
<td>MASSEY FERGUSON TRACTOR</td>
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<td>JOHN DEERE 3032E Tractor</td>
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<td>Toro Groundsmaster 3500D with mulching kit - Farm Tractor</td>
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<td>John Deere7400 Terraincut Mower</td>
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<td>Massey Ferguson Utility Tractor 1030 with Hardy Front End Loader</td>
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<td>John Deere 2520 Utility Tractor with Front End Loader &amp; Mower Deck</td>
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<td>2008</td>
<td>Toro Groundsmaster 3280D</td>
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### Appendix E: Canadian Default Factors for Calculating CO₂ Emissions from Combustion of Natural Gas, Petroleum Products, and Biomass (Table 12.2, 2018 Default Emissions Factors) (The Climate Registry, 2018)

<table>
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<tr>
<th>Natural Gas</th>
<th>kg C / GJ</th>
<th>GJ / megalitre</th>
<th>g CO₂ / m³</th>
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<tbody>
<tr>
<td>Electric Utilities, Industry, Commercial, Pipelines, Agriculture, Residential*</td>
<td>n/a</td>
<td>39.00</td>
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<tr>
<td>Producer Consumption*</td>
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<tr>
<td>Newfoundland and Labrador</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Marketable</td>
<td>n/a</td>
<td>39.24</td>
<td>1</td>
</tr>
<tr>
<td>NonMarketable</td>
<td>n/a</td>
<td>39.24</td>
<td>1</td>
</tr>
<tr>
<td>Nova Scotia</td>
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<tr>
<td>Marketable</td>
<td>n/a</td>
<td>39.24</td>
<td>1</td>
</tr>
<tr>
<td>NonMarketable</td>
<td>n/a</td>
<td>39.24</td>
<td>1</td>
</tr>
<tr>
<td>Natural Gas Liquids</td>
<td>kg C / GJ</td>
<td>GJ / Kilolitre</td>
<td>g CO₂ / L</td>
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<td></td>
<td></td>
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<tr>
<td>Propane: Residential Propane</td>
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<td>25.31</td>
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<tr>
<td>Propane: Other Uses Propane</td>
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</tr>
<tr>
<td>Petroleum Products</td>
<td>kg C / GJ</td>
<td>GJ / Kilolitre</td>
<td>g CO₂ / L</td>
</tr>
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<td>-----------</td>
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<td>----------</td>
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<tr>
<td>Light Fuel Oil Residential</td>
<td>n/a</td>
<td>38.60</td>
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<tr>
<td>Light Fuel Oil Forestry, Construction, Public Administration, Commercial/Institutional</td>
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<tr>
<td>Heavy Fuel Oil (Electric Utility, Industrial, Forestry, Construction, Public Administration, Commercial/Institutional)</td>
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<td>42.50</td>
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<tr>
<td>Heavy Fuel Oil (Residential)</td>
<td>n/a</td>
<td>42.50</td>
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</tr>
<tr>
<td>Heavy Fuel Oil (Producer Consumption)</td>
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<td>42.50</td>
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<tr>
<td>Kerosene (Electric Utility, Industrial, Producer Consumption, Residential, Forestry, Construction, Public Administration, Commercial/Institutional)</td>
<td>n/a</td>
<td>37.68</td>
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<tr>
<td>Diesel</td>
<td>n/a</td>
<td>38.30</td>
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<table>
<thead>
<tr>
<th>Biomass</th>
<th>kg C / GJ</th>
<th>GJ / t</th>
<th>g CO₂ / kg</th>
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<tbody>
<tr>
<td>Wood Fuel/Wood Waste</td>
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## Appendix F: Canadian Default Factors for Calculating CH₄ and N₂O Emissions from Combustion of Natural Gas, Petroleum Products, and Biomass (Table 12.2, 2018 Default Emissions Factors) (The Climate Registry, 2018)

<table>
<thead>
<tr>
<th>Natural Gas</th>
<th>g CH₄ / m³</th>
<th>g N₂O / m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Utilities</td>
<td>0.490</td>
<td>0.049</td>
</tr>
<tr>
<td>Industrial</td>
<td>0.037</td>
<td>0.033</td>
</tr>
<tr>
<td>Producer Consumption (Non Marketable)</td>
<td>6.400</td>
<td>0.060</td>
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<tr>
<td>Pipelines</td>
<td>1.900</td>
<td>0.050</td>
</tr>
<tr>
<td>Cement</td>
<td>0.037</td>
<td>0.034</td>
</tr>
<tr>
<td>Manufacturing Industries</td>
<td>0.037</td>
<td>0.033</td>
</tr>
<tr>
<td>Residential, Construction, Commercial/Institutional, Agriculture</td>
<td>0.037</td>
<td>0.035</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Natural Gas Liquids</th>
<th>g CH₄ / L</th>
<th>g N₂O / L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propane (Residential)</td>
<td>0.027</td>
<td>0.108</td>
</tr>
<tr>
<td>Propane (All Other Uses)</td>
<td>0.024</td>
<td>0.108</td>
</tr>
<tr>
<td>Refined Petroleum Products</td>
<td>g CH₄ / L</td>
<td>g N₂O / L</td>
</tr>
<tr>
<td>---------------------------------------------------------------------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>Light Fuel Oil (Electric Utilities)</td>
<td>0.180</td>
<td>0.031</td>
</tr>
<tr>
<td>Light Fuel Oil (Industrial and Producer Consumption)</td>
<td>0.006</td>
<td>0.031</td>
</tr>
<tr>
<td>Light Fuel Oil (Residential)</td>
<td>0.026</td>
<td>0.006</td>
</tr>
<tr>
<td>Light Fuel Oil (Forestry, Construction, Public Administration, and Commercial/Institutional)</td>
<td>0.026</td>
<td>0.031</td>
</tr>
<tr>
<td>Heavy Fuel Oil (Electric Utilities)</td>
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<td>0.064</td>
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<tr>
<td>Heavy Fuel Oil (Industrial and Producer Consumption)</td>
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<td>0.064</td>
</tr>
<tr>
<td>Heavy Fuel Oil (Residential, Forestry, Construction, Public Administration, and Commercial/Institutional)</td>
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<td>0.064</td>
</tr>
<tr>
<td>Kerosene (Electric Utilities, Industrial, and Producer Consumption)</td>
<td>0.006</td>
<td>0.031</td>
</tr>
<tr>
<td>Kerosene (Residential)</td>
<td>0.026</td>
<td>0.005</td>
</tr>
<tr>
<td>Kerosene (Forestry, Construction, Public Administration, and Commercial/Institutional)</td>
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<td>0.031</td>
</tr>
<tr>
<td>Diesel (Refineries and Others)</td>
<td>0.133</td>
<td>0.400</td>
</tr>
<tr>
<td>Diesel (Upgraders)</td>
<td>0.147</td>
<td>1.100</td>
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</table>

<table>
<thead>
<tr>
<th>Biomass</th>
<th>g CH₄ / kg</th>
<th>g N₂O / kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood Fuel/Wood Waste (Industrial Combustion)</td>
<td>0.09</td>
<td>0.06</td>
</tr>
<tr>
<td>Spent Pulping Liquor (Industrial Combustion)</td>
<td>0.02</td>
<td>0.02</td>
</tr>
</tbody>
</table>
### Appendix G: Global Warming Potentials of Refrigerants and Blends (Tables B.1 and B.2, 2018 Climate Registry Default Emission Factors, p. 75-83)

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Formula</th>
<th>Chemical Name</th>
<th>SAR</th>
<th>TAR</th>
<th>AR4</th>
<th>AR5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide</td>
<td>CO₂</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Methane</td>
<td>CH₄</td>
<td></td>
<td>21</td>
<td>23</td>
<td>25</td>
<td>28</td>
</tr>
<tr>
<td>Nitrous oxide</td>
<td>N₂O</td>
<td></td>
<td>310</td>
<td>296</td>
<td>298</td>
<td>265</td>
</tr>
<tr>
<td>Nitrogen trifluoride</td>
<td>NF₃</td>
<td></td>
<td>n/a</td>
<td>10,800</td>
<td>17,200</td>
<td>16,100</td>
</tr>
<tr>
<td>Sulfur hexafluoride</td>
<td>SF₆</td>
<td></td>
<td>23,900</td>
<td>22,200</td>
<td>22,800</td>
<td>23,500</td>
</tr>
</tbody>
</table>

**Hydrofluorocarbons (HFCs)**

<p>| HFC (R-23) | CHF₃   | trifluoromethane | 11,700 | 12,000 | 14,800 | 12,400 |
| HFC-32 (R-32) | CH₃F₂ | difluoromethane | 650 | 550 | 675 | 677 |
| HFC-41 (R-41) | CH₃F | fluoromethane | 150 | 97 | 92 | 116 |
| HFC-125 (R-125) | C₂HF₆ | pentafluoroethane | 2,800 | 3,400 | 3,500 | 3,170 |
| HFC-134 (R-134) | C₂H₂F₄ | 1,1,2,2-tetrafluoroethane | 1,000 | 1,100 | 1,100 | 1,120 |
| HFC-134a (R-134a) | C₂H₂F₄ | 1,1,1,2-tetrafluoroethane | 1,300 | 1,300 | 1,430 | 1,300 |
| HFC-143 (R-143) | C₂H₃F₃ | 1,1,2-trifluoroethane | 300 | 330 | 353 | 328 |</p>
<table>
<thead>
<tr>
<th>Refrigerant Blend</th>
<th>Gas</th>
<th>SAR</th>
<th>TAR</th>
<th>AR4</th>
<th>AR5</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-401A</td>
<td>HFC</td>
<td>18.2</td>
<td>15.6</td>
<td>16.12</td>
<td>17.94</td>
</tr>
<tr>
<td>R-401B</td>
<td>HFC</td>
<td>15</td>
<td>13</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>R-401C</td>
<td>HFC</td>
<td>21</td>
<td>18</td>
<td>18.6</td>
<td>20.7</td>
</tr>
<tr>
<td>R-402A</td>
<td>HFC</td>
<td>1680</td>
<td>2040</td>
<td>2100</td>
<td>1902</td>
</tr>
<tr>
<td>R-402B</td>
<td>HFC</td>
<td>1064</td>
<td>1292</td>
<td>1330</td>
<td>1205</td>
</tr>
<tr>
<td>R-403A</td>
<td>PFC</td>
<td>1400</td>
<td>1720</td>
<td>1766</td>
<td>1780</td>
</tr>
<tr>
<td>R-403B</td>
<td>PFC</td>
<td>2730</td>
<td>3354</td>
<td>3444</td>
<td>3471</td>
</tr>
<tr>
<td>R-404A</td>
<td>HFC</td>
<td>3260</td>
<td>3784</td>
<td>3922</td>
<td>3943</td>
</tr>
<tr>
<td>R-407A</td>
<td>HFC</td>
<td>1770</td>
<td>1990</td>
<td>2107</td>
<td>1923</td>
</tr>
<tr>
<td>R-407B</td>
<td>HFC</td>
<td>2285</td>
<td>2696</td>
<td>2804</td>
<td>2547</td>
</tr>
<tr>
<td>R-407C</td>
<td>HFC</td>
<td>1526</td>
<td>1653</td>
<td>1774</td>
<td>1624</td>
</tr>
<tr>
<td>R-407D</td>
<td>HFC</td>
<td>1428</td>
<td>1503</td>
<td>1627</td>
<td>1487</td>
</tr>
<tr>
<td>R-407E</td>
<td>HFC</td>
<td>1363</td>
<td>1428</td>
<td>1552</td>
<td>1425</td>
</tr>
<tr>
<td>R-407F</td>
<td>HFC</td>
<td>1555</td>
<td>1705</td>
<td>1825</td>
<td>1674</td>
</tr>
<tr>
<td>R-408A</td>
<td>HFC</td>
<td>1944</td>
<td>2216</td>
<td>2301</td>
<td>2430</td>
</tr>
<tr>
<td>R-410A</td>
<td>HFC</td>
<td>1725</td>
<td>1975</td>
<td>2088</td>
<td>1924</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td></td>
</tr>
<tr>
<td>R-422E</td>
<td>HFC</td>
<td>2135</td>
<td>2483</td>
<td>2592</td>
<td>2350</td>
</tr>
<tr>
<td>R-423A</td>
<td>HFC</td>
<td>2060</td>
<td>2345</td>
<td>2280</td>
<td>2274</td>
</tr>
<tr>
<td>R-424A</td>
<td>HFC</td>
<td>2025</td>
<td>2328</td>
<td>2440</td>
<td>2212</td>
</tr>
<tr>
<td>R-425A</td>
<td>HFC</td>
<td>1372</td>
<td>1425</td>
<td>1505</td>
<td>1431</td>
</tr>
<tr>
<td>R-426A</td>
<td>HFC</td>
<td>1352</td>
<td>1382</td>
<td>1508</td>
<td>1371</td>
</tr>
<tr>
<td>R-427A</td>
<td>HFC</td>
<td>1828</td>
<td>2013</td>
<td>2138</td>
<td>2024</td>
</tr>
<tr>
<td>R-428A</td>
<td>HFC</td>
<td>2930</td>
<td>3495</td>
<td>3607</td>
<td>3417</td>
</tr>
<tr>
<td>R-429A</td>
<td>HFC</td>
<td>14</td>
<td>12</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>R-430A</td>
<td>HFC</td>
<td>106.4</td>
<td>91.2</td>
<td>94.24</td>
<td>104.88</td>
</tr>
<tr>
<td>R-431A</td>
<td>HFC</td>
<td>41</td>
<td>35</td>
<td>36</td>
<td>40</td>
</tr>
<tr>
<td>R-434A</td>
<td>HFC</td>
<td>2662</td>
<td>3131</td>
<td>3245</td>
<td>3075</td>
</tr>
<tr>
<td>R-435A</td>
<td>HFC</td>
<td>28</td>
<td>24</td>
<td>25</td>
<td>28</td>
</tr>
<tr>
<td>R-437A</td>
<td>HFC</td>
<td>1567</td>
<td>1684</td>
<td>1805</td>
<td>1639</td>
</tr>
<tr>
<td>R-438A</td>
<td>HFC</td>
<td>1890</td>
<td>2151</td>
<td>2264</td>
<td>2059</td>
</tr>
<tr>
<td>R-439A</td>
<td>HFC</td>
<td>1641</td>
<td>1873</td>
<td>1983</td>
<td>1828</td>
</tr>
<tr>
<td>R-440A</td>
<td>HFC</td>
<td>158</td>
<td>139</td>
<td>144</td>
<td>156</td>
</tr>
<tr>
<td>R-442A</td>
<td>HFC</td>
<td>1609</td>
<td>1793</td>
<td>1888</td>
<td>1754</td>
</tr>
<tr>
<td>R-444A</td>
<td>HFC</td>
<td>85</td>
<td>72</td>
<td>87</td>
<td>88</td>
</tr>
<tr>
<td>R-444B</td>
<td>HFC</td>
<td>85</td>
<td>72</td>
<td>87</td>
<td>88</td>
</tr>
<tr>
<td>R-445A</td>
<td>HFC</td>
<td>117</td>
<td>117</td>
<td>128.7</td>
<td>117</td>
</tr>
<tr>
<td>R-507 or R-507A</td>
<td>HFC</td>
<td>3300</td>
<td>3850</td>
<td>3985</td>
<td>3985</td>
</tr>
</tbody>
</table>
Appendix H: Data Quality Tiers for Mobile Combustion Emissions (The Climate Registry, 2016)

### Direct CO₂ Emissions From Mobile Combustion

<table>
<thead>
<tr>
<th>Method</th>
<th>Type of Method</th>
<th>Data Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRP MO-01-CO₂</td>
<td>Fuel use</td>
<td>• Measured carbon content (per unit mass) and measured density of fuels; or</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Measured carbon content (per unit energy) and measured heat content of fuels.</td>
</tr>
<tr>
<td>GRP MO-02-CO₂</td>
<td>Fuel use</td>
<td>• Measured heat content of fuels and default carbon content (per unit energy); or</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Measured carbon content (per unit energy) and default heat content of fuels.</td>
</tr>
<tr>
<td>GRP MO-03-CO₂</td>
<td>Fuel use</td>
<td>Default CO₂ emission factors by fuel type</td>
</tr>
<tr>
<td>GRP MO-04-CO₂</td>
<td>Fuel use estimated using vehicle miles</td>
<td>Default CO₂ emission factors by fuel type</td>
</tr>
<tr>
<td></td>
<td>traveled and vehicle fuel economy</td>
<td></td>
</tr>
</tbody>
</table>

### Direct CH₄ & N₂O Emissions From Mobile Combustion (Highway Vehicles)

<table>
<thead>
<tr>
<th>Method</th>
<th>Type of Method</th>
<th>Data Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRP MO-05-CH₄</td>
<td>Miles traveled by vehicle type</td>
<td>Default emission factors by vehicle technology</td>
</tr>
<tr>
<td>&amp; N₂O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GRP MO-06-CH₄</td>
<td>Miles traveled by vehicle type</td>
<td>Default emission factors by vehicle type based on model year</td>
</tr>
<tr>
<td>&amp; N₂O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GRP MO-07-CH₄</td>
<td>Distance estimated using fuel use and</td>
<td>Default emission factors by vehicle type based on vehicle technology or model year</td>
</tr>
<tr>
<td>&amp; N₂O</td>
<td>vehicle fuel economy</td>
<td></td>
</tr>
</tbody>
</table>

### Direct CH₄ & N₂O Emissions From Mobile Combustion (Non-Highway Vehicles)

<table>
<thead>
<tr>
<th>Method</th>
<th>Type of Method</th>
<th>Data Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRP MO-08-CH₄</td>
<td>Fuel use</td>
<td>Default emission factors by vehicle type and fuel type</td>
</tr>
<tr>
<td>&amp; N₂O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GRP MO-09-CH₄</td>
<td>Fuel use estimated using vehicle miles</td>
<td>Default emission factors by vehicle type and fuel type</td>
</tr>
<tr>
<td>&amp; N₂O</td>
<td>traveled and vehicle fuel economy</td>
<td></td>
</tr>
<tr>
<td>GRP MO-10-CH₄</td>
<td>Total landing and takeoff (LTO) cycles</td>
<td>Default emission factors by aircraft type and LTO</td>
</tr>
<tr>
<td>&amp; N₂O</td>
<td>(acceptable for jet aircraft only)</td>
<td></td>
</tr>
</tbody>
</table>
Appendix I: Data Quality Tiers for Electricity (The Climate Registry, 2016)

<table>
<thead>
<tr>
<th>Method</th>
<th>Type of Method</th>
<th>Data Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRP-IE-01-CO₂, CH₄ &amp; N₂O</td>
<td>Known electricity use</td>
<td>Monthly electric bills or electric meter records (kWh, MWh)</td>
</tr>
</tbody>
</table>
| GRP-IE-02-CO₂, CH₄ & N₂O | Estimated electricity use (Area and cost methods)  | Area method:  
  - Total building area (square feet);  
  - Area of entity's space (square feet);  
  - Total building annual electricity use (kWh); and,  
  - Building occupancy rate.  
Cost method:  
  - Electricity expenditures; and,  
  - Average kWh costs. |
| GRP-IE-03-CO₂, CH₄ & N₂O | Estimated electricity use (Average intensity and models) | Average intensity method:  
  - Leased square footage; and,  
  - Average electricity intensity.  
Model methods:  
  - Sampled power consumption and time of use information; or,  
  - Equipment specifications and time of use information. |
## Appendix J: Nova Scotia Power Emission Factors

(Nova Scotia Power Inc., 2018)

<table>
<thead>
<tr>
<th>Year</th>
<th>Mercury (g/GWh)</th>
<th>Sulphur Dioxide (g/kWh)</th>
<th>Carbon Dioxide Equivalent (g/kWh)</th>
<th>Nitrogen Oxide (g/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>9.03</td>
<td>8.92</td>
<td>915.08</td>
<td>2.78</td>
</tr>
<tr>
<td>2006</td>
<td>15.37</td>
<td>10.15</td>
<td>927.64</td>
<td>2.67</td>
</tr>
<tr>
<td>2007</td>
<td>13.19</td>
<td>9.15</td>
<td>855.25</td>
<td>2.18</td>
</tr>
<tr>
<td>2008</td>
<td>13.84</td>
<td>9.13</td>
<td>830.96</td>
<td>1.82</td>
</tr>
<tr>
<td>2009</td>
<td>12.38</td>
<td>8.92</td>
<td>829.32</td>
<td>1.51</td>
</tr>
<tr>
<td>2010</td>
<td>7.11</td>
<td>5.40</td>
<td>807.52</td>
<td>1.59</td>
</tr>
<tr>
<td>2011</td>
<td>8.44</td>
<td>5.78</td>
<td>764.79</td>
<td>1.12</td>
</tr>
<tr>
<td>2012</td>
<td>9.50</td>
<td>6.77</td>
<td>781.19</td>
<td>1.60</td>
</tr>
<tr>
<td>2013</td>
<td>6.93</td>
<td>6.48</td>
<td>747.45</td>
<td>1.62</td>
</tr>
<tr>
<td>2014</td>
<td>5.24</td>
<td>5.92</td>
<td>706.1</td>
<td>1.64</td>
</tr>
<tr>
<td>2015</td>
<td>5.27</td>
<td>5.82</td>
<td>686.6</td>
<td>1.44</td>
</tr>
<tr>
<td>2016</td>
<td>6.0</td>
<td>6.1</td>
<td>700.1</td>
<td>1.5</td>
</tr>
<tr>
<td>2017</td>
<td>6.4</td>
<td>6.2</td>
<td>656.5</td>
<td>1.5</td>
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</tbody>
</table>
### Appendix K: Annual Commuting Travel Days

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

*142 day average*
Appendix L: Commuting Emissions by Province from Transport Canada (Transport Canada, 2011)

Pollutant emissions 
(g of pollutant per day)

\[ \text{VKT (vehicle-km per day)} \times \text{Emission factor (g of pollutant per vehicle-km)} \]

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

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

<table>
<thead>
<tr>
<th>Province or territory</th>
<th>GHG (CO2e)</th>
<th>CO</th>
<th>NOx</th>
<th>SO2</th>
<th>VOC</th>
<th>TPM</th>
<th>PM10</th>
<th>PM2.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>British Columbia</td>
<td>263</td>
<td>11.4</td>
<td>0.610</td>
<td>0.00423</td>
<td>0.672</td>
<td>0.0168</td>
<td>0.0165</td>
<td>0.00803</td>
</tr>
<tr>
<td>Alberta</td>
<td>263</td>
<td>11.5</td>
<td>0.612</td>
<td>0.00424</td>
<td>0.673</td>
<td>0.0166</td>
<td>0.0165</td>
<td>0.00804</td>
</tr>
<tr>
<td>Saskatchewan</td>
<td>262</td>
<td>11.4</td>
<td>0.609</td>
<td>0.00421</td>
<td>0.672</td>
<td>0.0168</td>
<td>0.0165</td>
<td>0.00803</td>
</tr>
<tr>
<td>Manitoba</td>
<td>261</td>
<td>11.4</td>
<td>0.608</td>
<td>0.00420</td>
<td>0.671</td>
<td>0.0168</td>
<td>0.0165</td>
<td>0.00802</td>
</tr>
<tr>
<td>Ontario</td>
<td>258</td>
<td>11.3</td>
<td>0.601</td>
<td>0.00415</td>
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<td>0.0165</td>
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<tr>
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<td>11.3</td>
<td>0.602</td>
<td>0.00416</td>
<td>0.669</td>
<td>0.0168</td>
<td>0.0165</td>
<td>0.00800</td>
</tr>
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<td>257</td>
<td>11.3</td>
<td>0.599</td>
<td>0.00414</td>
<td>0.668</td>
<td>0.0168</td>
<td>0.0165</td>
<td>0.00799</td>
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<tr>
<td>Newfoundland and Labrador</td>
<td>261</td>
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<td>0.00420</td>
<td>0.671</td>
<td>0.0168</td>
<td>0.0165</td>
<td>0.00802</td>
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<tr>
<td>Yukon/Northwest Territories/Nunavut</td>
<td>263</td>
<td>11.4</td>
<td>0.610</td>
<td>0.00423</td>
<td>0.672</td>
<td>0.0168</td>
<td>0.0165</td>
<td>0.00803</td>
</tr>
<tr>
<td>National average (weighted by provincial population, 2006)</td>
<td>258</td>
<td>11.3</td>
<td>0.602</td>
<td>0.00416</td>
<td>0.669</td>
<td>0.0168</td>
<td>0.0165</td>
<td>0.00800</td>
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Table 6: Office Paper

<table>
<thead>
<tr>
<th>PCR Content (%)</th>
<th>Emission Factor (kg CO₂e/ pkg)</th>
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<tbody>
<tr>
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<td>8.5&quot; x 11&quot;</td>
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<tr>
<td>0</td>
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<td>4.010</td>
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</table>

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.