GREENHOUSE GAS INVENTORY 2018-19 REPORT

AUGUST 2023

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EXECUTIVE SUMMARY

Concordia's total greenhouse gas emissions in 2018-19 were approximately 26,200 tCO2e. Direct Scope 1 emissions account for nearly 40% of total emissions. The largest source of Scope 1 emissions is from the consumption of natural gas for heating buildings. Indirect Scope 2 emissions from the purchasing of electricity decreased even as annual electricity consumption increased because of changes in the average emission intensity of the electrical grids. Indirect Scope 3 emissions account for nearly 60% of total emissions. Commuter emissions are the largest source of emissions at Concordia. Despite an increase in community population size, emissions decreased because of efficiencies in transportation emission factors over the ten-year period.

Highlights

Buildings

- Buildings are responsible for 39% of overall GHG emissions and make up 99% of direct (Scope 1) emissions.
- Overall, emissions from buildings increased by 5.5%, from 9,525 tonnes CO2e in 2010-11 to 10,051 tonnes CO2e in 2018-19. In general, they have been increasing as the volume of natural gas consumed to heat buildings increases. In 2014-15, there was a milder winter and less natural gas was needed to heat buildings.
- Emissions from buildings at the Loyola campus decreased by 28%, from 4,930 tonnes CO2e in 2010-11 to 3,551 in 2018-19. This was due to the conversion from natural gas heating system to electrical in one area of the campus.
- Emissions from buildings at the SGW campus increased by 41%, from 4,594 tonnes CO2e in 2010-11 to 6,500 tonnes CO2e in 2018-19.

Commuting

- Commuter emissions are responsible for 45% of overall GHG emissions and make up 74% of indirect (Scope 3) emissions.
- Overall, emissions from commuting decreased by 23%, from 15,221 tonnes CO2e in 2010-11 to 11,766 tonnes CO2e in 2018-19. Despite an increase in community population size from 47,170 to 53,216, emissions decreased because a modal shift toward active transport as well as an improvement in fuel efficiencies in the transportation sector over ten years.
- Commuter emissions from past inventories were extrapolated from the amount calculated in the 2019 Commuter Habits Survey because the 2019 inventory included emissions from all modes of transportation. Applying the estimate from the 2019 survey has its shortcomings, as the habits of the Concordia population and the location of dwellings in

past years are not necessarily consistent with the figures from the 2019 Commuter Habits Survey, but it was important to have a placeholder for non-vehicle commuting emissions to have the results be comparable over time.

Greenhouse Gas Inventory Report

Reporting Entity: **Concordia University**

Reporting Year**: Academic Year 2018-19**

Consolidation Approach: **Operational Control**

Operational Boundary: **Operations of Concordia University**

	tCO2e
Scope 1 (Direct) Emissions	
Stationary Combustion	9,917
Mobile Combustion	298
Fugitive Emissions	47
Process Emissions	11
Total Scope 1 Emissions	**10,274**
Scope 2 (Indirect) Emissions	
Purchased electricity	134
Total Scope 2 Emissions	**134**
Scope 3 (Indirect) Emissions	
Landfill waste	509
Commuting	11,766
Fuel and energy related activities	3,484
Office paper production	44
Electricity T&D losses	8
Total Scope 3 Emissions	**15,811**
Total Emissions, AY 2018-19	**26,219**

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INTRODUCTION

A greenhouse gas (GHG) emission inventory is an exercise designed to quantify and report the greenhouse gas emissions related to an organization's activities. This exercise is becoming increasingly widespread in an attempt to understand and mitigate an organization's contributions to climate change. At the regional level, the main objective of the Montreal Climate Plan is for the city to become carbon-neutral by 2050 (Ville de Montreal, 2015). The Provincial and Federal Governments have committed to the same timeframe thereby becoming carbon neutral by 2050.

Concordia University has formalized its commitment to reducing its greenhouse gas emissions in its Climate Action Plan. The 20-year (2040) targets include:

1) Elimination of CO_2 and other greenhouse gas emissions from all sources controlled and operated by Concordia University, including all building energy use and transportation operations
2) Full electrification of all transportation infrastructure at Concordia, including both vehicle fleets and university parking facilities
3) Carbon neutrality across all remaining sources of emissions

Reporting targets include performing and publishing a bi-annual GHG inventory, beginning to include more detailed Scope 3 emissions, and developing a comprehensive plan for offsetting Scope 3 emissions, all by 2025.

Concordia has quantified and reported its greenhouse gas emissions for the 2010-11 and 2014-15 academic years. The last report was published in March 2016 by the Office of Environmental Health and Safety and was updated in November 2020 by the Office of Sustainability. The objectives of the last GHG inventory were to create a baseline for the Climate Action Plan, identify high-impact areas for reducing GHG emissions and to communicate results and emission reduction efforts to the Concordia community.

1.1 FRAMEWORK FOR INVENTORY

Concordia uses the Greenhouse Gas Protocol Corporate Standard (hereafter referred to as *the Protocol*) as a framework for quantifying and reporting its emissions. In 2004, the Protocol was created in collaboration by the World Resources Institute and the World Business Council for Sustainable Development. It was originally designed to provide a standardized tool for businesses to measure their GHG emissions. However, it can and has been used by a variety of other types of organizations such as NGOs, government agencies and universities. The Protocol accounts for emissions from six greenhouse gases covered by the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6). A primary objective of the Protocol is to provide organizations

with information that can be used to build an effective strategy to manage and reduce GHG emissions.

To report in accordance with the GHG Protocol Corporate Standard, reporting and accounting shall be based on the following principles:[1]

Relevance: *Ensure the GHG inventory appropriately reflects the GHG emissions of the organization and serves the decision-making needs of users – both internal and external to the organization.*

Completeness: *Account for and report on all GHG emission sources and activities within the chosen inventory boundary. Disclose and justify any specific exclusions.*

Consistency: *Use consistent methodologies to allow for meaningful comparisons of emissions over time. Transparently document any changes to the data, inventory boundary, methods, or any other relevant factors in the time series.*

Transparency: *Address all relevant issues in a factual and coherent manner, based on a clear audit trail. Disclose any relevant assumptions and make appropriate references to the accounting and calculation methodologies and data sources used.*

Accuracy: *Ensure that the quantification of GHG emissions is systematically neither over nor under actual emissions, as far as can be judged, and that uncertainties are reduced as far as practicable. Achieve sufficient accuracy to enable users to make decisions with reasonable assurance as to the integrity of the reported information.*

In 2011, the *Corporate Value Chain (Scope 3) Accounting and Reporting Standard* (hereafter referred to as the Scope 3 Standard) was created as a supplement to the GHG Protocol Corporate Accounting and Reporting Standard. Concordia will use this standard as a framework for measuring its Scope 3 GHG emissions.

1.2 DESCRIPTION OF THE INSTITUTION

Concordia University has two campuses based in Montreal, Quebec: the Sir George Williams campus in downtown Montreal, and the Loyola Campus located approximately 7 km west in the borough of Notre-Dame-de-Grace. The university is a publicly funded institution and provides education up to the doctoral/research level. In the 2018-19 academic year, 46,829 students were enrolled for credit at Concordia. The number of students in residence was approximately 900. At the same time the university also employed 6,387 people. The university has four academic divisions and 53 academic departments.

[1] WBCSD & WRI. (2015). The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (revised edition). Retrieved June 7, 2023 from https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf

2. INVENTORY BOUNDARY

2.1 TEMPORAL BOUNDARY

The reporting period for this inventory is from May 1, 2018 to April 30, 2019.[2]

2.2 ORGANIZATIONAL BOUNDARIES

The Protocol offers two approaches for setting the organizational boundaries for the inventory. Firstly, the equity share approach which accounts for emissions from operations according to an organization's share of equity in the operation. Secondly, the control approach where organizations account for 100 percent of the GHG emissions from operations over which it has control. The control approach can be defined as financial or operational control. If the organization has the ability to direct the financial and operating policies of an operation with the purpose of gaining economic benefits from its activities, it is categorized as having financial control. Operational control is characterized by an organization, or its subsidiaries having full authority to introduce and implement its operating policies at the operation (WBCSD & WRI, 2015a).

The operational control approach was chosen for Concordia's inventory as this was consistent with the last report. In order to determine which spaces the university has operational control over, an inventory of all associated spaces to Concordia was created. Ownership and usage of spaces were identified, and all spaces owned by Concordia were included in the inventory. Spaces not owned but used by the University were not included in the GHG inventory since the University is contractually restricted and does not have full operational control.

A total of four buildings were excluded from the inventory. The CL and the SI building were excluded from the inventory because the spaces are not owned by the University. The LC and LD buildings are owned by Concordia however Concordia has limited operational control. It was noted that acquiring energy consumption data from the tenants is very difficult. For a complete list of spaces included in the inventory see Appendix A.

2.3 OPERATIONAL BOUNDARIES

The next step was to set an operational boundary. This requires organizations to identify emissions from its operations and decide if and how these emissions will be accounted for. Following the Protocol, at minimum organizations are required to quantify and report Scope 1 and Scope 2 emissions. Reporting on Scope 3 emissions is optional, however best practice is to

[2] Note that this is the last full academic year before campus operations were drastically altered due to the COVID-19 pandemic and campus closures.

report on activities that are relevant to the organization and its goals. The Protocol organizes emissions by different Scopes to improve transparency and facilitate planning for different types of climate policies or strategic goals. Definitions for each Scope are provided in Figure 1. Source categories for Scope 1 emissions are defined in table 1.

Emissions type	Scope	Definition	Examples
Direct emissions	Scope 1	Emissions from operations that are owned or controlled by the reporting company	Emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc.; emissions from chemical production in owned or controlled process equipment
Indirect emissions	Scope 2	Emissions from the generation of purchased or acquired electricity, steam, heating, or cooling consumed by the reporting company	Use of purchased electricity, steam, heating, or cooling
	Scope 3	All indirect emissions (not included in scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions	Production of purchased products, transportation of purchased products, or use of sold products

Figure 1 - Emission Scope definitions and examples (WBCSD & WRI, 2011, p.28). Please note that carbon dioxide (CO_2) emissions created by the combustion of biomass are reported separately.

Stationary combustion	Combustion of fuels in stationary equipment such as boilers, furnaces, burners, turbines, heaters, incinerators, engines, flares, etc.
Mobile combustion	Combustion of fuels in transportation devices such as automobiles, trucks, buses, trains, airplanes, boats, ships etc.
Process emissions	Emissions from physical or chemical processes such as CO_2 from the calcination step in cement manufacturing etc.
Fugitive emissions	Intentional and unintentional releases such as equipment leaks from joints, seals, packing, gaskets, as well as fugitive emissions from coal piles, wastewater treatment, pits, cooling towers, gas processing facilities, etc.

Table 1 - Categories of Scope 1 emissions (WBCSD & WRI, 2011, p. 27)

As previously mentioned, the Scope 3 Standard was created in 2011 as a supplement to the GHG Protocol Corporate Accounting and Reporting Standard created in 2004. The purpose of the Scope 3 Standard was to provide a framework to make accounting for Scope 3 emissions easier and more accessible. As illustrated in Figure 2, Scope 3 emissions are separated into upstream and downstream activities and then further categorized into fifteen categories. However, not every category will be relevant to all organizations. Upstream emissions are indirect emissions from the purchasing or acquisition of goods and services for example waste generated from operations. Conversely, downstream emissions are indirect emissions from the sale of goods and services for example an organization's investments. The fifteen categories of Scope 3 emissions provide organizations with a systematic framework for reporting, minimizes the likelihood of double counting and encourages accounting for a large range of sources (WBCSD & WRI, 2011).

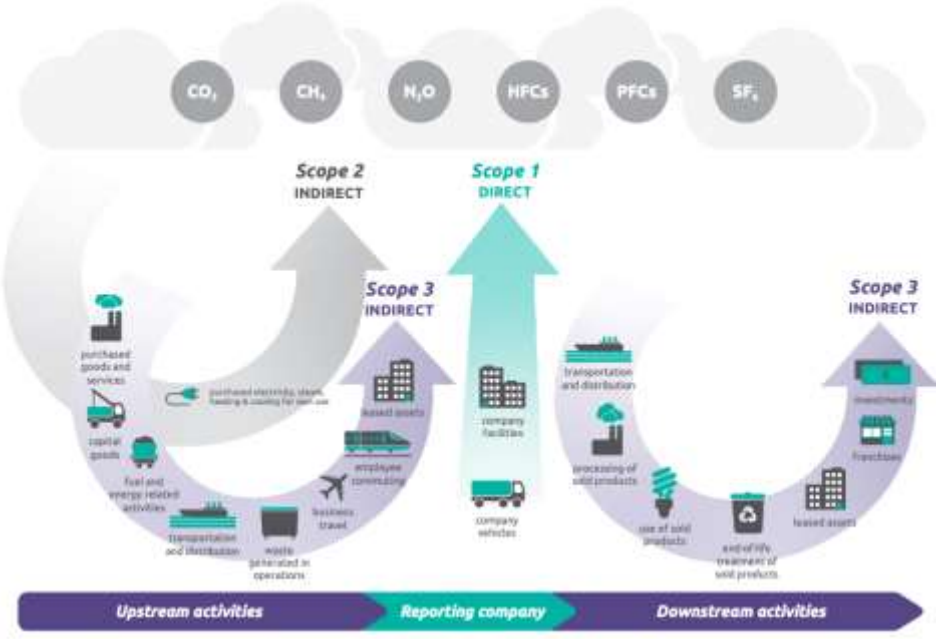

Figure 2- An organization's sources of emissions (WBCSD & WRI, 2011, p. 31)

The Scope 3 Standard requires organizations to account for emissions from each Scope 3 category and disclose and justify any exclusions. The Protocol also requires a list specifying which types of activities are covered in Scope 3.

Table 2 outlines the sources of emissions included in Concordia's inventory. The sources are organized by Scope, category and identify the type of fuel/gas used (if applicable). Any sources excluded from the inventory are detailed and justified in table 3.

Table 2 - Sources of emissions included in Concordia's 2018-19 GHG inventory

Scope	Category	Source	Fuel or gas
Scope 1	Stationary combustion	Buildings	Natural gas, heating oil
	Mobile combustion	Campus fleet	Gasoline, diesel
		Varsity coach buses	Diesel
		Concordia shuttle buses[3]	B20 biodiesel (diesel portion)
	Process emissions	Laboratory materials	Gaseous CO_2, N_2O and CH_4 tanks, dry ice nuggets
	Fugitive emissions	Refrigerants	HFC-134a, HFC-404a, HFC-407a, HFC-407c
Scope 2	Purchased electricity	Buildings	N/A
Scope 3	Purchased goods and services	Paper purchased	N/A
	Fuel- and energy-related activities	Production of fuels used for buildings and campus fleet	Gasoline, diesel, natural gas, heating oil
		Transmission and distribution losses from purchased electricity	N/A
	Student and employee commuting	Commuting via various modes	N/A
	Waste generated in operations	Landfilled waste	N/A

Table 3 - Sources of emissions excluded from Concordia's GHG inventory

Scope	Category	Source	Reason for exclusion
Scope 3	Upstream transportation and distribution	Transportation and distribution of products purchased by Concordia	Data not available
	Business travel	Transportation of employees for business-related activities	
	Investments	Investments	
	Waste generated in operations	Wastewater treatment	

[3] Direct CO2 emissions from the combustion of biomass are reported separately as per the Protocol.

3. CALCULATING EMISSIONS

After the inventory boundaries have been set and the sources of emissions have been identified, the next step was to select a calculation approach. The calculation approach for most emission sources involves collecting operational data and then multiplying quantities by the appropriate emission factor and the global warming potential of applicable greenhouse gases. The process of calculating emissions is discussed in further detail below.

3.1 GLOBAL WARMING POTENTIAL

A Global Warming Potential (GWP) is a relative measure of how much heat a greenhouse gas traps in the atmosphere. It compares the amount of heat trapped by a certain mass of greenhouse gas to the amount of heat trapped by a similar mass of carbon dioxide (CO_2 equivalent). The GWPs used for the inventory are listed in table 4 and are taken from the Intergovernmental Panel on Climate Change (IPCC) sixth assessment report (2021).

Table 4 - List of 20-year Global Warming Potentials used for this assessment

Greenhouse gas	Chemical formula	GWP
Carbon dioxide	CO_2	1
Methane	CH_4	82.5
Nitrous oxide	N_2O	273
Hydrochlorofluorocarbons	HCFC-22	5,690
Hydrofluorocarbons	HFC-32	2,690
	HFC-125	6,740
	HFC-134a	4,140
	HFC-143a	7,840
Blend of HFCs	HFC-404a	7,208
	HFC-407a	4,890
	HFC-407c	4,457

The Intergovernmental Panel on Climate Change (IPCC) reports indicates that despite high uncertainties in the carbon cycle, it is likely that GWPs that include the climate-carbon feedbacks for non-CO_2 gases (such as hydrofluorocarbons and methane), instead of only for CO_2, provides a better estimate of the metric values. It also states that this inclusion provides a more consistent methodology (IPCC, 2013).

3.2 EMISSION FACTORS

An emission factor is the average emission rate of a given greenhouse gas for a given source, relative to the units of activity (e.g., per unit of volume, of mass, of energy). Emission factors for

the 2018-19 GHG inventory are listed in table 5 and were obtained from a number of sources, most notably Environment Canada's National Inventory Report (NIR) on greenhouse gas sources and sinks in Canada.

Table 4 - List of emission factor references by activity

Activity or Fuel	Unit	Reference
Natural gas (stationary combustion)	kg/m^3	Environment Canada (2021), NIR Part 2
Light fuel oil (stationary combustion)	kg/L	
Gasoline (mobile combustion)	kg/L	
Diesel (mobile combustion)	kg/L	
B20 biodiesel (mobile combustion)	kg/L	
Electricity	kg/kWh	Environment Canada (2021), NIR Part 3
Natural gas production	kg/m^3	Natural Resources Canada (2020), GHGenius v5.01f
Gasoline production	kg/L	
Diesel production	kg/L	
Light fuel oil production	kg/L	
Propane production	kg/L	
Solid waste in landfill	kg/tonne	Environmental Protection Agency (2021). GHG Emissions Factor Hub
Paper purchased	tonne/tonne	B.C. Ministry of Environment (2021), Best Practices Methodology for Quantifying GHG emissions
Electricity transmission and distribution losses	kg/kWh	Derived from Environment Canada (2021) by Ecometrica Ltd

3.3 DATA SOURCES AND ASSUMPTIONS

SCOPE 1 – DIRECT EMISSIONS

Stationary Combustion

- Data on building energy consumption was provided by the Building Performance Coordinator in Facilities Management.
- All buildings owned by Concordia University were included in the inventory with the exception of the LC and LD buildings.
- It was not possible to calculate how much heating oil was used in the reporting period. Therefore, heating oil consumption was based on how much heating oil was billed during the reporting period.

Mobile Combustion – Campus Fleet

- Data on the campus fleet (campus vehicle list, fuel invoices) was provided by the Environmental Coordinator in Facilities Management in collaboration with the Insurance department.
- Vehicle emission factors are organized by tiers and light/heavy duty vehicles or trucks. Tiers refer to increasingly stringent emission standards over time, enabled through advancements in emission control technologies. Transport Canada uses a four-tier classification system. Tier 0 applies to models before 1994, Tier-1 applies to model years 1994-2003, Tier-2 applies to model years 2004-2017 and Tier-3 applies to model years 2017-2025. Environment Canada's NIR does not have Tier-3 emission factors listed yet. The NIR defines light-duty cars and trucks (including SUVs and minivans) as those with a Gross Vehicle Weight Rating (GVWR) of 3,900 kg or less and heavy-duty as those vehicles with a GVWR greater than 3,900 kg.
- Advanced control diesel emission factors were used for Tier-2 diesel vehicles.
- Total fuel consumption for vehicles owned by Concordia was calculated based on fuel invoices. Invoices provided the number of liters, type of fuel and cost of the transaction. In most cases, multiple vehicles were associated with a single credit card for invoicing purposes. In the case when vehicles grouped together belonged to different Tiers, the lower Tier was chosen for calculations following the precautionary principle.
- Fuel consumption for vehicles owned by Concordia used by faculty members for academic purposes was difficult to obtain. It was noted that faculty members did not regularly keep track of fuel consumption. Two methods were used based on the data available 1) calculation of fuel consumption based on mileage 2) calculation of fuel consumption based on fuel invoices. Data for the Ford F150-XLT (2009) and the Chevrolet Suburban (2000) used for academic purposes was unavailable.
- The Facilities Assistant for Recreation and Athletics at Concordia confirmed that the Zamboni was used year-round. It was also confirmed that an electric Zamboni was used in the 2018-2019 academic year.

Mobile Combustion – Varsity coach bus

- Travel records and bus details were provided by the Recreation/Athletics department.
- The Varsity coach bus travel records included the destination of each trip. It was assumed that the distance travelled was equal to that of the fastest route identified on Google maps. The distance travelled was then multiplied by the coach bus's fuel efficiency to calculate the total fuel consumed during the trip.
- The Varsity coach bus model is a 52-seater. It was assumed based on research of similar models that its GVWR is greater than 3,900 kg and therefore should be classified as a heavy-duty truck.

Mobile Combustion – Concordia shuttle bus

- Fuel invoices were provided by the Facilities Management department.

- It was confirmed that Concordia's shuttle buses use B20 biodiesel (6% to 20% biodiesel). It was assumed that all shuttle buses use B20 biodiesel all of the time.

Process emissions – Laboratory material

- A purchase report was provided by the Business Process Office.
- It was assumed that all laboratory material purchased in the reporting year would be consumed in the same year.

Fugitive emissions – Refrigerants

- An inventory of refrigerant use at the SGW campus was provided by the SGW refrigeration mechanic.
- To calculate emissions, the amount of refrigerant added annually in a system is assumed to be equal to the amount of refrigerant that was lost/emitted annually by that same system. The amount of refrigerant lost annually due to leaks is not available.
- Data regarding the amount of refrigerant added annually in the system on the Loyola campus for the 2018-2019 academic year could not be found. An estimate could not be provided by the refrigeration mechanic and therefore was assumed to be zero. This is a significant underestimation as the Loyola campus includes a skating rink that is operated year-round and several older, less energy-efficient buildings.

SCOPE 2 – INDIRECT EMISSIONS

To calculate Scope 2 emissions the location-based method was used as recommended in the GHG Protocol 2 Guidance report. The location-based method quantifies emissions using the average emission intensity of grids on which energy consumption occurs (WBCSD & WRI, 2015b).

Purchased electricity

- A report of electricity purchased from Hydro-Québec was provided by the Building Performance Coordinator in Facilities Management.
- The emission factor for purchased electricity was taken from Environment Canada's NIR. It represents the average greenhouse gas intensity (grams of GHG/ kWh electricity generated) for the province of Quebec.

SCOPE 3 – INDIRECT EMISSIONS

Purchased goods and services – Paper

- A report of volume of paper purchased was provided by the Business Process Office.
- Two reports were provided by the Business Process Office to calculate total paper consumption. The first report consisted of paper purchase orders processed through the

University's procurement department. The other report included the paper purchase orders (for use, not sale) from the University bookstore (Concordia-owned at the time).
- For simplicity, all paper ordered was assumed to be the standard size 8.5" x 11".

Fuel- and energy-related activities – Buildings and campus fleet

- Same data sources as for stationary and mobile combustion categories in Scope 1.
- Emission factors for offsite fuel- and energy-related activities were in grams per gigajoule of energy. To create an emission factor per cubic meter or litre of fuel, the original emission factor needed to be multiplied by the energy density (GJ/tonne) and density (g/L) of the fuel.

Student and employee commuting

- A Commuter Habits Survey was created by the Office of Sustainability and the Office of Institutional Planning and Analysis.
- Total emissions from commuting were calculated using data obtained from the Commuter Habits Survey conducted in 2019. Responses included information about the Concordia community's frequency, origin, and mode(s) of commuting to and from their primary campus in the fall, winter and spring/summer. The distance between participants' home and primary campus was calculated and multiplied by the emission factor of the associated mode of transportation. This number was then multiplied by the frequency of commuting to estimate annual emissions. An average commuter emissions per student and faculty/staff was calculated based on the survey results and extrapolated to the Concordia population to estimate total annual commuter emissions for the Concordia community.
- Emissions from commuters using the Concordia shuttle bus were not counted because these emissions were already accounted for in the Scope 1 category.

Waste generated in operations – Landfill waste

- A report on landfill waste was provided by the Environmental Coordinator in Facilities Management.
- The total weight of landfill waste was calculated from invoices provided to Concordia from our waste collection service provider.

3.4 CALCULATION METHODOLOGY

In general, the methodology below was used to calculate emissions. Specific calculation methods for each source of emission can be found in Appendix B.

$$CO_2e = \sum_{i=1}^{n} Fuel_i * (EF_{CO2,i} * GWP_{CO2} + EF_{CH4,i} * GWP_{CH4} + EF_{N2O,i} * GWP_{N2O})$$

CO_2e is the total annual greenhouse gas emissions in carbon dioxide (CO_2) equivalent
Index *i* refers to each activity
n is the total number of activities
$Fuel_i$ is the amount of fuel consumed during the reporting period
$EF_{CO2,i}$ is the CO_2 emission factor for activity i
GWP_{CO2} is the global warming potential of CO_2

4. RESULTS

4.1 SUMMARY OF RESULTS

For the 2018-19 academic year, total GHG emissions for Concordia University were approximately 26,219 tCO2e. An estimated 40% of Concordia's emissions were Scope 1 and 2 emissions while the remaining emissions were Scope 3.

As shown in table 7 and Figure 3, the largest source of emissions at Concordia was from commuting which was responsible for just under half of total emissions (45%). The second biggest source of emissions is from the use of natural gas to heat buildings (38%) and the third is from the offsite production of fuel and energy used by Concordia at 13% of total emissions.

Table 5 - Concordia's total GHG emissions by Scope for 2018-19

Category	Activity	Fuel type	Measure	Quantity	Emissions (tCO_2e)	Percentage of total emissions
Scope 1 - Direct Emissions						
Stationary combustion	Buildings	Natural gas	cubic meters	5,213,760	9,904	38%
		Heating oil	liters	4,742	13	0.0%
Mobile combustion	Campus fleet	Diesel	liters	9,291	26	0.1%
		Gasoline	liters	19,378	45	0.2%
	Concordia shuttle bus	B20 biodiesel	liters	90,027	198	0.8%
	Varsity coach bus	Diesel	liters	11,008	30	0.1%
Fugitive emissions	Refrigerants	HFCs	kilograms	10	47	0.2%
Process emissions	Laboratory material	CO_2, N_2O	kilograms	3479	12	0%
Total Scope 1					**10,274**	**39%**
Scope 2 – Indirect emissions						
Purchased electricity	Purchased electricity	Electricity	kWh	104,425,596	134	0.5%

Total Scope 2					**134**	**0.51%**
Scope 3 – Indirect emissions						
Commuting	Student and employee commuting	Various	--	--	11,766	45%
Fuel- & Energy-related activities	Buildings, campus fleet	Natural gas	cubic meters	5,213,760	3,436	13%
		Gasoline	liters	19,379	20	0.1%
		Diesel	liters	20,299	23	0.1%
		Heating oil	liters	4,742	4	0%
Purchased goods & services	Paper purchased	--	tonnes	18	44	0.2%
Waste generated from operations	Landfill waste	--	tonnes	889	509	2%
Electricity transmission and distribution losses	Purchased electricity	Electricity	kWh	104,425,596	8	0%
Total Scope 3					**15,811**	**60%**
TOTAL SCOPE 1, 2 & 3					**26,219**	

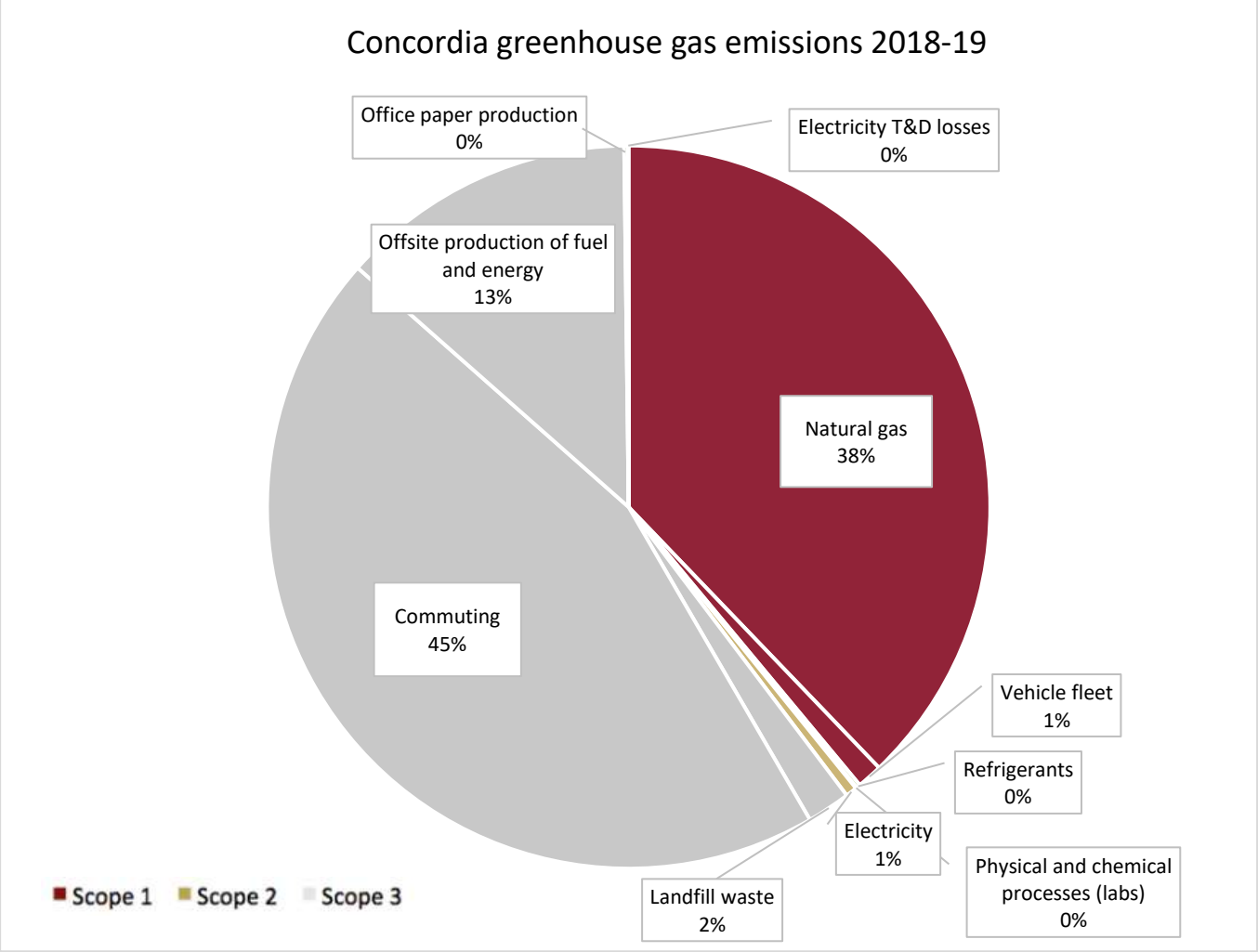

Figure 3 - Concordia's GHG emissions by Scope and source for 2018-19

5. COMPARISON OF EMISSIONS OVER TIME

The chosen baseline year is the period from May 1, 2010, to April 30, 2011. This baseline year was chosen as it is the oldest year for which reliable and verifiable emissions data are available. It was also chosen to be consistent with the previous GHG inventory conducted in 2016 that used the 2010-11 academic year as a baseline. It is important to note, however, that the 2014-15 GHG inventory is used as a target baseline year for several goals outlined in the Sustainability Action Plan.

For consistency, the 2010-11 and 2014-15 GHG inventories have been recalculated following the methodology described in the next section.

5.1 RECALCULATING BASELINE YEAR AND 2014-15 GHG INVENTORIES

According to the Protocol, there are several circumstances that trigger the recalculation of previous greenhouse gas emission inventories. They are listed below:

a) Structural change in the reporting organization such as mergers, acquisitions, and outsourcing/insourcing of emitting activities.
b) Changes in calculation methodology or improvements in the accuracy of emission factors.
c) Discovery of significant errors.

The changes and subsequent adjustments to Concordia's baseline year and 2014-15 inventories are described in table 8. It is important to note that because the inventories span two calendar years the emission factors (EFs) for each year have been pro-rated. In other words, for the 2010-11 inventory, the 2010 emission factors were used for eight months and the 2011 emission factors for four months[4]. The most recent global warming potentials (GWP) from the IPCC sixth assessment report (2021) report were used for all the inventories. For more information on the GWP see section 3.1.

Table 6 - Changes and adjustments to 2010-11 and 2014-15 GHG inventories

Scope and source of emission	Reason for change	Adjustment
Scope 1 - Campus fleet	Discovery of errors	The type of fuel consumption has been corrected for the Dodge Sprinter 2500 (2006) and John Deere Trail-gator HPX (2005). The Concordia-owned Zamboni was added to the campus fleet. In 2010-11 and 2014-15 the Zamboni was propane-operated however in 2018-19 it was replaced by an electric Zamboni. The emissions from the electric Zamboni are included in Scope 2 emissions.
Scope 1 - Concordia shuttle bus	Changes in calculation methodology	The fuel type for Concordia's shuttle bus has been updated to reflect the use of B20 biodiesel. The EF has also been changed to a heavy-duty diesel vehicle rather than light-duty.

[4] Previously, the same emission factors from 2015 were used for both the 2014-2015 and 2010-11 inventory. The 2010-11 inventory has been retroactively updated to use emission factors from 2010 and 2011.

Scope 1 - Varsity coach bus	Discovery of significant error	The fuel efficiency, EF and estimate of total distance travelled for the Varsity Coach buses has been corrected. The 2014-15 estimate was calculated using travel logs from the Athletics Department. Travel logs did not exist for 2010-11 academic year therefore the 2014-15 figure was used as an estimate.
Scope 1 - Physical and chemical processes (labs)	Discovery of error	An error in the amount of laboratory materials was found and updated for the 2014-15 inventory. It is possible there are errors in the 2010-11 inventory however purchasing orders no longer exist for that year.
Scope 3 - Commuting	Changes in calculation methodology	The emissions from commuting for 2010-11 and 2014-15 only considered emissions from personal vehicle transportation. The 2018-19 emissions from commuting based on the commuter habits survey included all modes of transportation. It was used to extrapolate emissions for the 2010-11 and 2014-15 inventory while using the appropriate emission factors for the given years.
Scope 3 - Fuel- and energy-related activities	Discovery of error	Emissions from the offsite production of propane were added to the 2010-11 and 2014-15 inventories.
Scope 3 - Solid waste in landfill	Discovery of significant error	The values/calculations have also been updated upon the discovery of a unit conversion error. The original landfill waste value for 2014-15 was also believed to be underestimated and was replaced by the 2010-11 estimate.
Scope 3 - Paper purchased	Improvements in the accuracy of emission factors	The EFs have been updated and are sourced from a more accurate reference.

5.2 COMPARISON OF 2018-19 GHG EMISSIONS WITH BASELINE YEAR

In 2018-19, total greenhouse gas emissions at Concordia decreased by 12% from the 2010-11 baseline year (table 9).

SCOPE 1 – DIRECT EMISSIONS

Scope 1 emissions have increased very slightly from the baseline year because of the acquisition and construction of additional buildings on campus; the increase was moderated by the relative efficiency of new constructions. The Concordia shuttle buses and Varsity coach buses travelled less in 2018-19 which contributed to a reduction in emissions from mobile combustion.

Table 7 - Comparison of 2018-19 GHG emissions with baseline year

Category	Activity	Fuel type	2010-11 Emissions (tCO_2e)	2018-19 Emissions (tCO_2e)	Percentage change
Scope 1 - Direct emissions					
Stationary combustion	Buildings	Natural gas	9,298	9,904	7%
		Heating oil	8	13	63%
Mobile combustion	Campus fleet	Diesel	23	26	13%
		Gasoline	35	45	29%
		Propane	3	0	-100%
	Concordia shuttle bus	B20 biodiesel	215	198	-8%
	Varsity coach bus	Diesel	36	30	-14%
Fugitive emissions	Refrigerants	HFCs	484	47[5]	-90%
Process emissions	Laboratory material	CO_2, CH_4	1.7	11[6]	547%
Total Scope 1			**10,103**	**10,274**	**1.7%**
Scope 2 – Indirect emissions					
Purchased electricity	Purchased electricity		216	134	-38%

[5] Fugitive emissions cannot be compared because emissions from 2018-19 are incomplete. However, Concordia no longer uses chlorodifluoromethane (HCFC-22), a hydrochlorofluorocarbon with a high global warming potential.

[6] Process emissions should be compared with caution because of uncertainty in the data source. The quantity of laboratory material was derived from purchase orders. Numerous purchase orders only included a description of the product and a product identification number. Actual quantities of materials ordered had to be estimated, thus a moderate level of uncertainty can be attributed to these emissions.

Total Scope 2			**216**	**134**	**-38%**
Scope 3 – Indirect emissions					
Commuting	Concordia community commuting	Various	15,221	11,766	-23%
Fuel- & Energy-related activities	Buildings, campus fleet	Natural gas	3,142	3,436	9%
		Gasoline	16	20	25%
		Diesel	25	23	-8%
		Heating oil	2	4	100%
		Propane	1	0	-100%
Purchased goods & services	Paper purchased	Various	179	44	-75%
Waste generated from operations	Landfill waste		459	509	11%
Electricity T&D losses	Purchased electricity		543	8	-99%
Total Scope 3			**19,587**	**15,811**	**-19%**
TOTAL SCOPE 1, 2 & 3			**29,906**	**26,219**	**-12%**

SCOPE 2 – INDIRECT EMISSIONS

There was a significant reduction of almost 40% in Scope 2 emissions. This decrease occurred even as annual electricity consumption increased from approximately 88.3 million kWh in 2010-11 to 104.4 million kWh in 2018-19. This reduction in emissions results from changes in the average emission intensity of the electrical grids that Concordia uses.

SCOPE 3 – INDIRECT EMISSIONS

- Indirect Scope 3 emissions were reduced by 19%, primarily from a reduction in commuter emissions. Despite an increase in community population size from 47,170 to 53,216, emissions decreased because of efficiencies in transportation emission factors over ten years.
- Emissions from the offsite production of fuel and energy used for Concordia's stationary and mobile combustion increased due to the increase in the total volume of natural gas used for heating.
- Similar to the uncertainties for process emissions, emissions from purchased paper are unreliable because of a lack of detail in the purchasing orders. It is likely that emissions from paper production is higher than 44 tCO2e.

- Landfill waste emissions have increased since 2010-11.
- Emissions from electricity transmission and distribution losses have been significantly reduced because of improvements in electricity transmission and distribution.

5.3 CONCORDIA GHG EMISSIONS OVER TIME

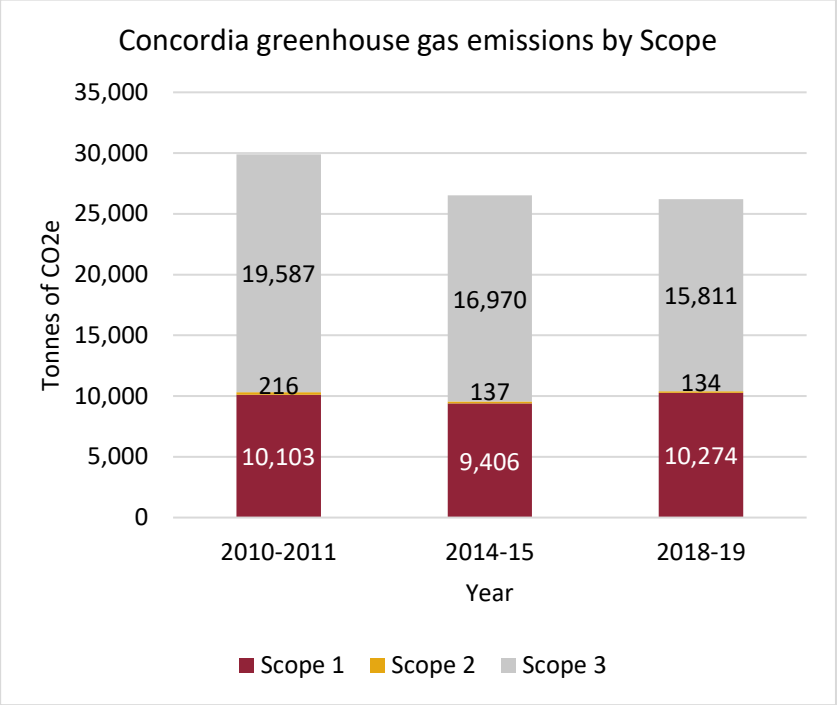

Figure 5 – Concordia greenhouse gas emissions by scope over time

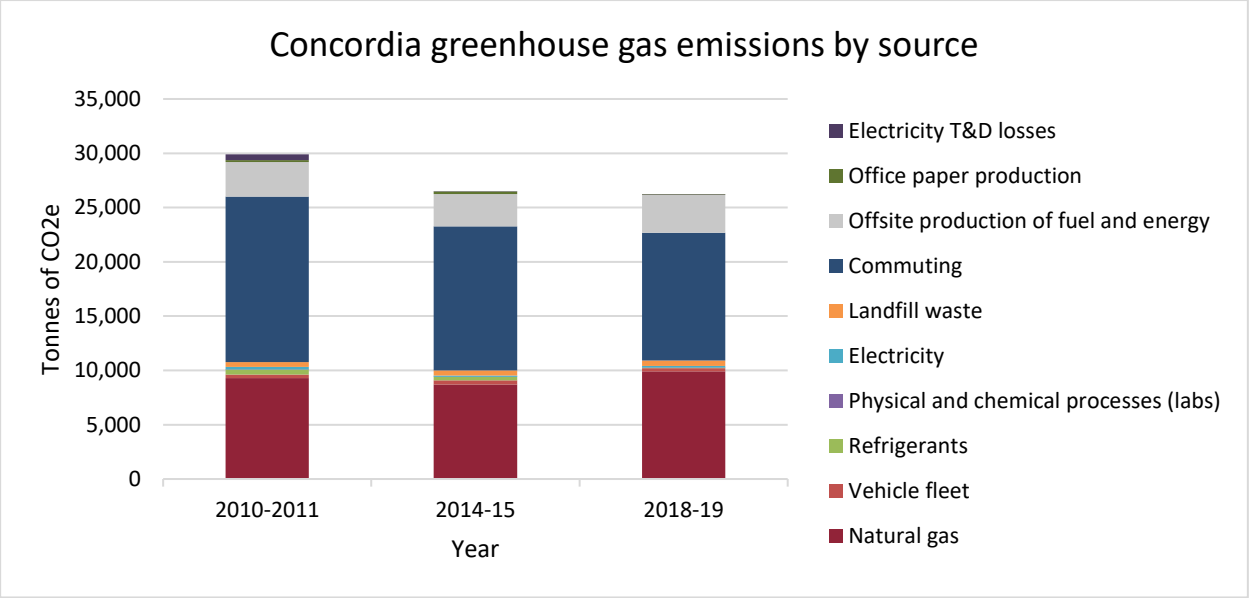

Figure 6 - Concordia greenhouse gas emissions by source over time

Scope 1 emissions have fluctuated slightly overtime, as shown in Figure 5. In general, they have been increasing as the volume of natural gas consumed to heat buildings increases. In 2014-15, there was a milder winter and less natural gas was needed to heat buildings.

Electricity consumption at Concordia has been increasing overtime. However, indirect Scope 2 emissions from purchased electricity decreased because of a reduction in the average emission intensity of the electrical grid. Concordia does not have control over the emission intensity from the grid.

Indirect emissions (Scope 3) at Concordia have been decreasing significantly as illustrated in Figure 5, because of fuel efficiency in the commuting category. Emissions from the offsite production of fuel and energy fluctuate with the annual quantity of natural gas consumed at the university. Landfill waste emissions are believed to be marginally higher in 2018-19 because of improved waste tracking methods. Emissions from electricity transmission and distribution losses have been significantly reduced because of improvements in electricity transmission and distribution.

6. RECOMMENDATIONS

6.1 DATA COLLECTION

It is recommended that a person from the Facilities Management team be involved in the planning phase, as they manage a significant amount of data required for the inventory. The data collection process should be endorsed by the Office of the Vice President, Services and Sustainability for each department involved in submitting information for the inventory. This would encourage participation in the process and act as recognition of the importance of the inventory at the University.

6.2 REPORTING CYCLES

The Standard strongly recommends that organizations have their GHG inventory verified by an independent party. The goal of the verification process is to instill confidence in the users of the report that the data and statements presented are a faithful account of the organization's emissions. The verification ultimately increases the quality and the transparency of the report. The 2018-19 inventory was reviewed by a PhD student from Concordia's Climate Scenarios, Impacts and Modelling (CSIM) Lab. The 2010-11 and 2014-15 inventories were reviewed by members in our Office of Sustainability.

To track progress and create emission reduction strategies towards Concordia's short-term and long-term carbon neutrality goals, it is recommended to report on the university's emissions annually.

6.3 ADDITIONAL SOURCES OF EMISSIONS AND CONSIDERATIONS

An effort has been made to include as many sources of emissions at Concordia in the inventory as possible without compromising the integrity of the report. Most of Concordia's Scope 1 and Scope 2 emissions have been captured in the report. Several Scope 3 emissions remain to be measured. Below is a list of Scope 3 emissions that could be explored and possibly included in the next inventory.

1. Food purchasing and transportation
2. Purchased goods and services
3. Business travel
4. Study abroad travel
5. International student travel to / from home
6. Wastewater
7. Hazardous waste disposal

8. Investments
9. Offsite production of biodiesel

When comparing total emissions from year to year, it would be relevant to normalize them by community population size, building gross floor area and heating/cooling degree days as these are likely factors influencing emissions. Degree days are a representation of outside air-temperature data used to normalize the effect of outside air temperature on building energy consumption. Techniques and methods for estimating emissions should be explored in absence of reliable actual data.

6.4 CARBON OFFSETS

As previously mentioned, Concordia's Climate Action Plan has as one of its targets for 2025 to create a comprehensive plan for offsetting the University's Scope 3 GHG emissions. Research into possible carbon offsets with an emphasis on local projects should be completed for the next inventory. It is important to note that reduction in emissions is the main priority and focus of the University. However, offsets could serve as a final solution when reduction strategies have been exhausted or when emissions are outside of the University's control.

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APPENDIX A – DETAILED LIST OF SPACES

CU = Concordia University

SGW Campus				
Building	**Address**	**Space type**		**Included/ Excluded in inventory**
		Ownership	**Usage**	
B	2160 Bishop	CU	CU	Included
CI	2149 MacKay	CU	CU	Included
CL	1665 Ste Catherine W.	Third party	CU	Excluded
D	2140 Bishop	CU	CU	Included
EN	2070 MacKay	CU	CU	Included
EV	1515 Ste. Catherine W.	CU	CU, third party	Included
FA	2060 MacKay	CU	CU	Included
FB	1250 Guy	CU	CU, third party	Included
FG	1616 Ste. Catherine W.	CU	CU, third party	Included
GM	1550 de Maisonneuve	CU	CU, third party	Included
GN	1190 Guy	CU	CU	Included
H	1455 de Maisonneuve	CU	CU	Included
K	2150 Bishop	CU	CU	Included
LB	1400 de Maisonneuve	CU	CU	Included
LC	1426 Bishop	CU	Third party	Excluded
LD	1424 Bishop	CU	Third party	Excluded
M	2135 MacKay	CU	CU	Included
MB	1450 Guy	CU	CU	Included
MI	2130 Bishop	CU	CU	Included
MT	1195 Guy	CU	CU	Included
MU	2170 Bishop	CU	CU	Included
P	2020 MacKay	CU	CU	Included
PR	2100 MacKay	CU	CU	Included
Q	2010 MacKay	CU	CU	Included
R	2050 MacKay	CU	CU	Included
RR	2040 MacKay	CU	CU	Included
S	2145 MacKay	CU	CU	Included
SB	1590 Dr. Penfield	CU	CU, third party	Included
T	2030 MacKay	CU	CU	Included
TD	1410 Guy	CU	CU, third party	Included
V	2110 MacKay	CU	CU	Included

VA	1395 Rene Levesque	CU	CU	Included
X	2080 MacKay	CU	CU	Included
Z	2090 MacKay	CU	CU	Included

LOY Campus				
Building	**Address**	**Space type**		**Included/ Excluded in inventory**
		Ownership	**Usage**	
AD	7141 Sherbrooke W.	CU	CU	Included
BB	3502 Belmore	CU	CU, third-party	Included
BH	3500 Belmore	CU	CU, third party	Included
CC	7141 Sherbrooke W.	CU	CU	Included
CJ	7141 Sherbrooke W.	CU	CU	Included
DO	7141 Sherbrooke W.	CU	CU, third party	Included
FC	7141 Sherbrooke W.	CU	CU	Included
GE	7141 Sherbrooke W.	CU	CU	Included
HA	7141 Sherbrooke W.	CU	CU	Included
HB	7141 Sherbrooke W.	CU	CU	Included
HC	7141 Sherbrooke W.	CU	CU	Included
JR	7141 Sherbrooke W.	CU	CU	Included
MM	7075 Terrebonne	CU	CU	Included
PC	7200 Sherbrooke W.	CU	CU	Included
PS	7141 Sherbrooke W.	CU	CU	Included
PT	7141 Sherbrooke W.	CU	CU	Included
PY	7141 Sherbrooke W.	CU	CU	Included
RA	7200 Sherbrooke W.	CU	CU	Included
RF	7141 Sherbrooke W.	CU	CU	Included
SC	7141 Sherbrooke W.	CU	CU	Included
SH	7141 Sherbrooke W.	CU	CU	Included
SI	4455 Broadway	Third-party	CU	Excluded
SP	7141 Sherbrooke W.	CU	CU	Included
TA	7079 Terrebonne	CU	CU	Included
TB	7079 Terrebonne	CU	CU	Included
VE	7141 Sherbrooke W.	CU	CU	Included
VL	7141 Sherbrooke W.	CU	CU	Included

APPENDIX B – DETAILED CALCULATIONS

SCOPE 1 STATIONARY COMBUSTION AND MOBILE COMBUSTION

$$CO_2e = \sum_{i=1}^{n} Fuel_i * (EF_{CO2,i} * GWP_{CO2} + EF_{CH4,i} * GWP_{CH4} + EF_{N2O,i} * GWP_{N2O})$$

CO_2e is the total annual greenhouse gas emissions in CO_2 equivalent
Index *i* refers to each activity
n is the total number of activities
$Fuel_i$ is the amount of fuel consumed during the reporting period
$EF_{CO2,i}$ is the CO_2 emission factor for activity i
GWP_{CO2} is the global warming potential of CO_2

SCOPE 1 MOBILE COMBUSTION: B20 BIODIESEL

B20 biodiesel is a biofuel blended with diesel. The proportion of biodiesel in B20 can be between 6-20% biodiesel. It was assumed in the case of the Concordia shuttle bus that the proportion of biodiesel in B20 was 20% and 80% diesel. Therefore, the emission factors for B20 are a weighted average of the biofuel and diesel emission factors.

$$CO_2e = Liters\ of\ B20 * (EF_{CO2,B20} * GWP_{CO2} + EF_{CH4,B20} * GWP_{CH4} + EF_{N2O,B20} * GWP_{N2O})$$

Where CO_2e is the total annual greenhouse gas emissions in CO_2 equivalent
Liters of B20 is the annual number of litres of B20 biofuel consumed by the shuttle bus

$EF_{CO2,B20} = EF_{CO2,DIESEL} * 80\%$
$EF_{CH4,B20} = EF_{CH4,B100} * 20\% + EF_{CH4,DIESEL} * 80\%$
$EF_{N2O,B20} = EF_{N2O,B100} * 20\% + EF_{N2O,DIESEL} * 80\%$

$EF_{CO2,B100}$ is the emission factor for 100% Biodiesel fuel
$EF_{CO2,\ DIESEL}$ is the emission factor for heavy-duty diesel trucks

SCOPE 1 FUGITIVE EMISSIONS: REFRIGERANTS

$$CO_2e = Quantity\ of\ added\ refrigerant * GWP\ of\ specific\ refrigerant$$

Where CO_2e is the total annual greenhouse gas emissions in CO_2 equivalent
Quantity of added refrigerant is the annual amount of refrigerant added to the system in kg

SCOPE 1 PROCESS EMISSIONS

$$CO_2e = Quantity\ of\ gas\ purchased * GWP\ of\ specific\ gas$$

Where CO_2e is the total annual greenhouse gas emissions in CO_2 equivalent
Quantity of gas purchased is the annual amount of gas purchased (e.g., CO2 dry ice nuggets) in kg

SCOPE 2 PURCHASED ELECTRICITY EMISSIONS

$$CO_2e = Quantity\ of\ electricty\ purchased * (EF_{CO2,EC} * GWP_{CO2} + EF_{CH4,EC} * GWP_{CH4} + EF_{N2O,EC} * GWP_{N2O} + EF_{SF6})$$

Where CO_2e is the total annual greenhouse gas emissions in CO_2 equivalent
Quantity of electricity purchased is the annual amount of electricity purchased in kWh
$EF_{CO2,EC}$ is the emission factor for electricity purchased (same for $EF_{CH4,EC}$ and $EF_{N20,EC}$)
EF_{SF6} is the sulphur hexafluoride emission factor for electricity purchased. It is already expressed in CO_{2e} equivalent

SCOPE 3 WASTE GENERATED FROM OPERATIONS

$$CO_2e = Quantity\ of\ waste\ sent\ to\ landfill * (EF_{CH4,WA} * GWP_{CH4} + EF_{N2O,WA} * GWP_{N2O})$$

Where CO_2e is the total annual greenhouse gas emissions in CO_2 equivalent
Quantity of waste sent to landfill is the annual amount of waste sent to landfill in tonnes

SCOPE 3 STUDENT AND EMPLOYEE COMMUTING EMISSIONS

Detailed calculation methodology provided in 2019 Commuter Habits Survey

SCOPE 3 FUEL- & ENERGRY-RELATED ACTIVITIES EMISSIONS

$$CO_2e = \sum_{i=1}^{n} Fuel_i * (EF_{CO2,i} * GWP_{CO2} + EF_{CH4,i} * GWP_{CH4} + EF_{N2O,i} * GWP_{N2O})$$

CO_2e is the total annual greenhouse gas emissions in CO_2 equivalent
Index *i* refers to each activity
n is the total number of activities
$Fuel_i$ is the amount of fuel consumed during the reporting period
$EF_{CO2,i}$ is the CO_2 emission factor for activity i
GWP_{CO2} is the global warming potential of CO_2

SCOPE 3 PAPER PURCHASED EMISSIONS

$$CO_2e = \sum_{i=1}^{n} P_i * (EF_{CO2,i} * GWP_{CO2})$$

CO_2e total annual greenhouse gas emissions from paper production in CO_2 equivalent
Index *i* refers to each paper
n is the total number of paper
P_i is the quantity of paper with X% PCF purchased during the reporting period
$EF_{CO2,i}$ is the CO_2 emission factor for paper i
GWP_{CO2} is the global warming potential of CO_2

SCOPE 3 ELECTRICITY T&D LOSSES EMISSIONS

$$CO_2e = E * (EF_{CO2} * GWP_{CO2})$$

CO_2e total annual greenhouse gas emissions from electricity T&D losses in CO_2 equivalent
E refers to total kWh of electricity purchased
EF_{CO2} is the CO_2 emission factor for T&D losses
GWP_{CO2} is the global warming potential of CO_2