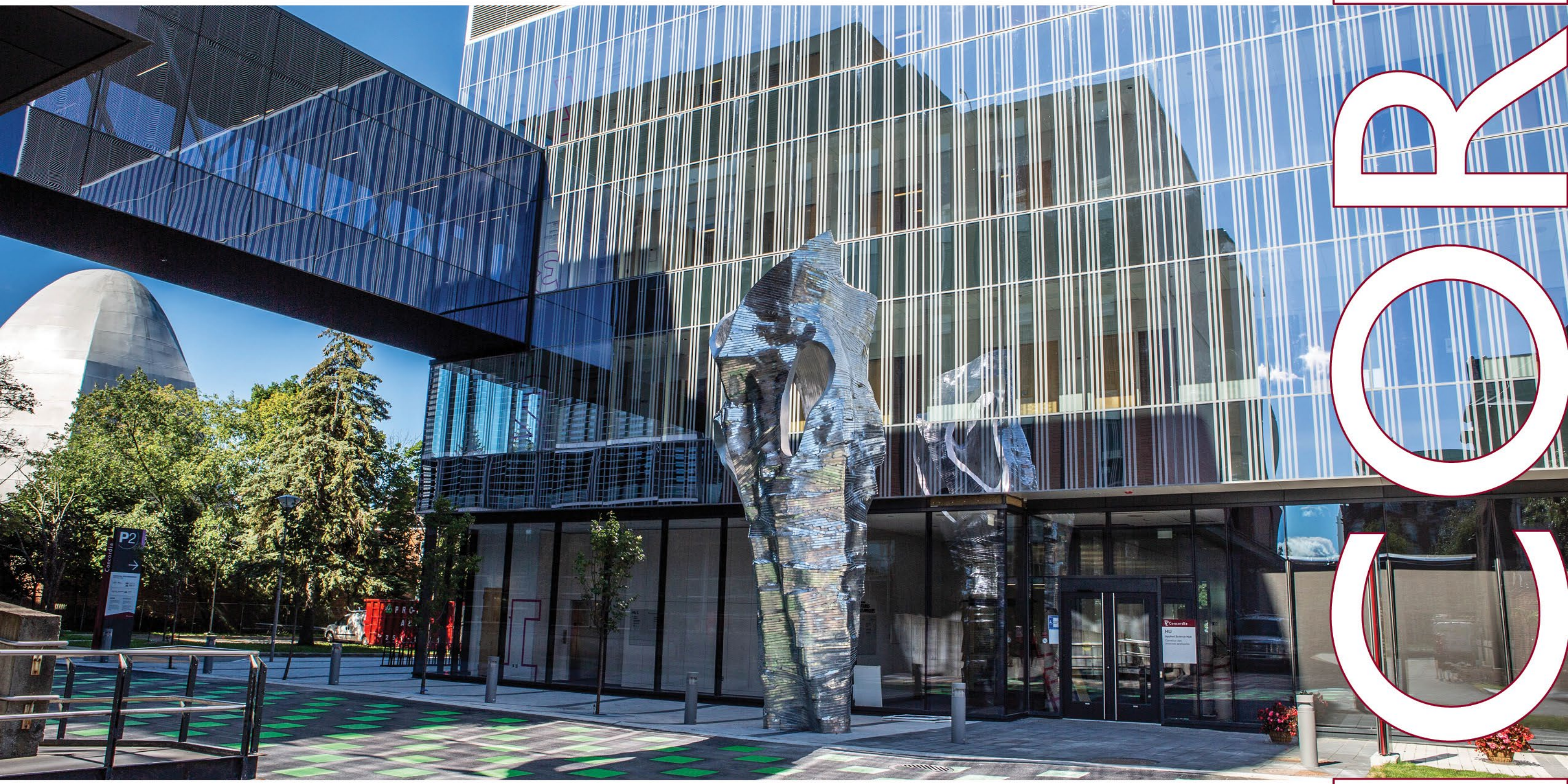
UNIVERSITÉ Concordia UNIVERSITY



# GREENHOUSE GAS INVENTORY 2022-23 REPORT

APRIL 2024

JESSICA KREJCIK, ANALYST,
OFFICE OF SUSTAINABILITY

# EXECUTIVE SUMMARY

Concordia's total greenhouse gas emissions in 2022-23 were approximately 27,000 tCO2e.

Direct Scope 1 emissions account for 34% 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 65% of total emissions. Commuter emissions are the largest source of Scope 3 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 32% of overall GHG emissions and make up 94% of direct (Scope 1) emissions.
- Overall, direct emissions from buildings decreased by 5%, from 9,306 tonnes CO2e in 2010-11 to 8,813 tonnes CO2e in 2022-23.
- Emissions from buildings at the Loyola campus decreased by 26%, from 4,930 tonnes CO2e in 2010-11 to 3,639 in 2022-23. 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 16%, from 4,594 tonnes CO2e in 2010-11 to 5,307 tonnes CO2e in 2022-23.

**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 9%, from 15,221 tonnes CO2e in 2010-11 to 13,795 tonnes CO2e in 2022-23. Despite an increase in community population size from 47,170 to 53,216, emissions decreased because of 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 2022-23**

Consolidation Approach: **Operational Control**

Operational Boundary: **Operations of Concordia University**

| | **tCO2e** |
|---|---|
| **Scope 1 (Direct) Emissions** | |
| Stationary Combustion | 8,813 |
| Mobile Combustion | 327 |
| Fugitive Emissions | 209 |
| Process Emissions | 5 |
| **Total Scope 1 Emissions** | **9,340** |
| **Scope 2 (Indirect) Emissions** | |
| Purchased electricity | 132 |
| **Total Scope 2 Emissions** | **132** |
| **Scope 3 (Indirect) Emissions** | |
| Landfill waste | 346 |
| Commuting | 13,795 |
| Student exchange travel | 752 |
| Fuel and energy related activities | 2,849 |
| Office paper production | 160 |
| Electricity T&D losses | 8 |
| **Total Scope 3 Emissions** | **17,909** |
| **Total Emissions, Academic Year 2022-2023** | **27,397** |

CONCORDIA

# 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, 2014-15 and 2018-19 academic years. The last report was published in August 2023 by the Office of Sustainability.

### 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.

CONCORDIA

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

***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 2022-23 academic year, 45,488 students were enrolled for credit at Concordia. The number of students in residence was approximately 929. At the same time the university also employed 6,731 people. The university has four academic divisions and 53 academic departments.

# 2. INVENTORY BOUNDARY

## 2.1 TEMPORAL BOUNDARY

The reporting period for this inventory is from May 1, 2022 to April 30, 2023.

## 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 nine buildings were excluded from the inventory. The CL, SI, ER, GS, SA and CV buildings were excluded from the inventory because the spaces are not owned by the University. The LC, LD and ET 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.

There are several new buildings included in the 2022-23 inventory. These include the following buildings on SGW campus: GA, LS, MK, MM, MN, MO, MV, MW, NB, VR and WR. On Loyola campus, the HU and PB buildings have been added since the last inventory. 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 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).

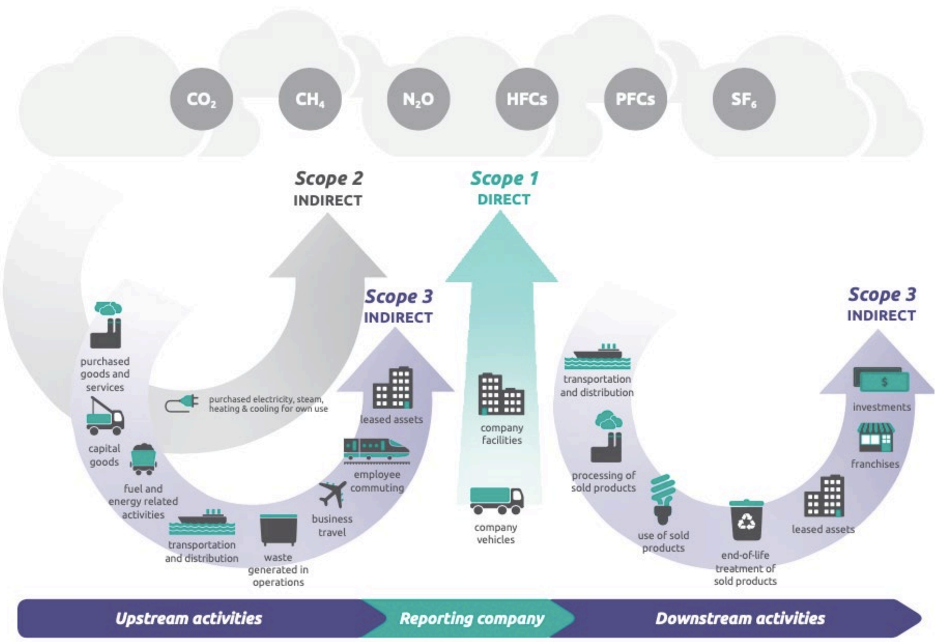



*Figure 2- An organization's sources of emissions (WBCSD & WRI, 2011, p. 31)*

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 reported separately from the inventory are detailed in table 3.

*Table 2 - Sources of emissions included in Concordia's 2022-23 GHG inventory.*

| Scope | Category | Source | Fuel or gas |
|---|---|---|---|
| **Scope 1** | Stationary combustion | Buildings | Natural gas |
| | Mobile combustion | Campus fleet | Gasoline, diesel |
| | | Varsity coach buses | Diesel |
| | | Concordia shuttle buses | B20 biodiesel (diesel portion) |
| | | Zamboni | Propane |
| | Process emissions | Laboratory materials | Gaseous $CO_2$ tanks, dry ice nuggets |
| | Fugitive emissions | Refrigerants | HCFC-22, CFC-12, R744, HFC-410a, HFC-134a, HFC-404a |
| **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, propane |
| | | Transmission and distribution losses from purchased electricity | N/A |
| | Student and employee commuting | Commuting via various modes | N/A |
| | Student exchange travel | Air travel for student exchange program | N/A |
| | Waste generated in operations | Landfilled waste | N/A |

*Table 3 - Sources of emissions reported separately from Concordia's GHG inventory.*

| Scope | Category | Source | Fuel or gas |
|---|---|---|---|
| **Scope 1** | Stationary combustion | Buildings | Renewable natural gas |
| | Mobile combustion | Concordia shuttle bus | B20 Biodiesel (biogenic portion) |

# 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 |
| Chlorofluorocarbon | CFC-12 | 11,400 |
| 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 |
| | HFC-410a | 4751 |

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 2022-23 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 5 - List of emission factor references by activity.*

| Activity or Fuel | Unit | Reference |
|---|---|---|
| Natural gas (stationary combustion) | kg/m$^3$ | Environment Canada (2023), NIR Part 2 |
| Propane (mobile combustion) | kg/L | |
| Gasoline (mobile combustion) | kg/L | |
| Diesel (mobile combustion) | kg/L | |
| B20 biodiesel (mobile combustion) | kg/L | |
| Electricity | kg/kWh | Environment Canada (2023), NIR Part 3 |
| Natural gas production | kg/m$^3$ | Natural Resources Canada (2022), |

| | | |
|---|---|---|
| Gasoline production | kg/L | GHGenius v5.02b |
| Diesel production | kg/L | |
| Propane production | kg/L | |
| Solid waste in landfill | kg/tonne | Environmental Protection Agency (2024). GHG Emissions Factor Hub |
| Electricity transmission and distribution losses | kg/kWh | Derived from Environment Canada (2023) 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 except for the CL, ER, ET, GS, LC, LD, CV, and SI buildings.

#### 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. The 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.

### 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.

### Mobile Combustion – Zamboni

- 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 2022-23 academic year was calculated based on six sources of refrigerants: HCFC-R22, CFC-R12, $CO_2$ (R744), HFC-R410a, HFC-134a, HFC-404a. The quantity of HFC-407a and HFC-407c could not be found and therefore was assumed to be zero.

### *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 the 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 2023. 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.

### Student exchange travel

- 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 2023. 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.

### 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.

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

$CO_2e$ 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 2022-23 academic year, total GHG emissions for Concordia University were approximately 27,397 tCO2e. An estimated 35% of Concordia's emissions were Scope 1 and 2 emissions while the remaining emissions were Scope 3.

As shown in table 6 and Figure 3, the largest source of emissions at Concordia was from commuting which was responsible for just under half of total emissions (50%). The second biggest source of emissions is from the use of natural gas to heat buildings (32%) and the third is from the offsite production of fuel and energy used by Concordia at 10% of total emissions.

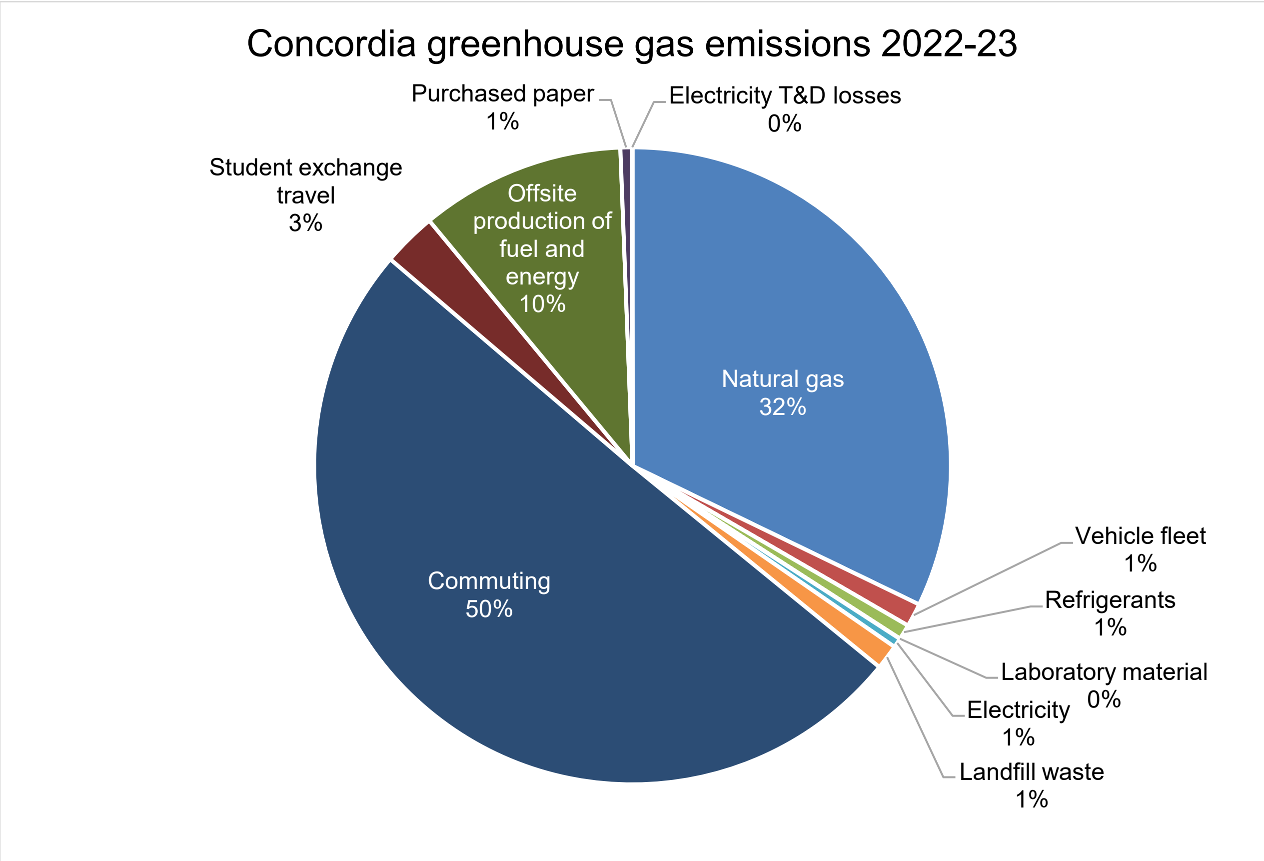



*Figure 3 - Concordia's GHG emissions by Scope and source for 2022-23*

*Table 6 - Concordia's total GHG emissions by Scope for 2022-23*

| Category | Activity | Fuel type | Measure | Quantity | Emissions ($tCO_2e$) | % of total emissions |
|---|---|---|---|---|---|---|
| **Scope 1 - Direct Emissions** | | | | | | |
| Stationary combustion | Buildings | Natural gas | cubic meters | 4,546,169 | 8813 | 32% |
| Mobile combustion | Campus fleet | Diesel | liters | 10,030 | 28 | 0% |
| | | Gasoline | liters | 16,649 | 39 | 0% |
| | Concordia shuttle bus | B20 biodiesel | liters | 96,650 | 212 | 1% |
| | Varsity coach bus | Diesel | liters | 14,784 | 40 | 0% |
| | Zamboni | Propane | liters | 4,890 | 8 | 0% |
| Fugitive emissions | Refrigerants | Multiple | kilograms | 59.06 | 209 | 1% |
| Process emissions | Laboratory material | $CO_2$ | kg | 4,529 | 5 | 0% |
| **Total Scope 1** | | | | | **9354** | **34%** |
| **Scope 2 – Indirect emissions** | | | | | | |
| Purchased electricity | Purchased electricity | Electricity | kWh | 101,471,288 | 132 | 0.48% |
| **Total Scope 2** | | | | | **132** | **0.48%** |
| **Scope 3 – Indirect emissions** | | | | | | |
| Commuting | Vehicles and public transit | Various | -- | | 13,795 | 50% |
| Student exchange travel | Student exchange travel | Air travel | -- | | 752 | 3% |
| Fuel- & Energy-related activities | Buildings, campus fleet | Natural gas | cubic meters | 4,546,169 | 2,806 | 10% |
| | | Gasoline | liters | 16,649 | 16 | 0% |
| | | Diesel | liters | 24,814 | 27 | 0% |
| | | Propane | liters | 4,890 | 2 | 0% |
| Purchased goods & services | Paper consumption | Various | tonnes | 19 | 160 | 1% |
| Waste generated from operations | Landfill waste | -- | tonnes | 581 | 346 | 1% |
| Electricity Transmission & Distribution Losses | Purchased electricity | Electricity | kWh | 101,471,288 | 8 | 0% |
| **Total Scope 3** | | | | | **17,911** | **65%** |
| **TOTAL SCOPE 1, 2 & 3** | | | | | **27,397** | |

CONCORDIA

# 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 2018-19 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.

## 5.1 COMPARISON OF 2022-23 GHG EMISSIONS WITH BASELINE YEAR

In 2022-23, total greenhouse gas emissions at Concordia decreased by 8% from the 2010-11 baseline year (table 7).

### *SCOPE 1 – DIRECT EMISSIONS*

Scope 1 emissions have decreased slightly (-7%) from the baseline year because of a decrease in stationary combustion (-5%) from Concordia's buildings and a reduction (-57%) in fugitive emissions from refrigerants.

### *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 101.5 million kWh in 2022-23. 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 9%, primarily from a decrease in electricity transmission and distribution losses.
- Landfill waste emissions have also decreased significantly by 25% since 2010-11.
- There was a 9% reduction in commuter emissions from 2010-11. 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 propane 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 possible that emissions from paper production are higher than 160 tCO2e.

*Table 7 - Comparison of 2022-23 GHG emissions with baseline year*

| Category | Activity | Fuel type | 2010-11 Emissions (tCO2e) | 2022-23 Emissions (tCO2e) | Percentage change |
|---|---|---|---|---|---|
| **Scope 1 - Direct Emissions** | | | | | |
| Stationary combustion | Buildings | Natural gas | 9298 | 8813 | -5% |
| | | Heating oil | 8 | 0 | -100% |
| Mobile combustion | Campus fleet | Diesel | 23 | 28 | 20% |
| | | Gasoline | 35 | 39 | 12% |
| | Concordia shuttle bus | B20 biodiesel | 215 | 212 | -1% |
| | Varsity coach bus | Diesel | 36 | 40 | 12% |
| | Zamboni | Propane | 3 | 8 | 157% |
| Fugitive emissions | Refrigerants | Multiple | 484 | 209 | -57% |
| Process emissions | Laboratory material | CO2 | 2 | 5 | 166% |
| **Total Scope 1** | | | **10104** | **9354** | **-7%** |
| **Scope 2 – Indirect emissions** | | | | | |
| Purchased electricity | Purchased electricity | Electricity | 216 | 132 | -39% |
| **Total Scope 2** | | | **216** | **132** | **-39%** |
| **Scope 3 – Indirect emissions** | | | | | |
| Commuting | Student and Employee Commuting | Various | 15,221 | 13,795 | -9% |
| Student exchange travel | Student exchange travel | Air travel | N/A | 752 | 0% |

| | | | | | |
|---|---|---|---|---|---|
| Fuel- & Energy-related activities | Buildings, campus fleet | Natural gas | 3,142 | 2,806 | -11% |
| | | Gasoline | 16 | 16 | 1% |
| | | Diesel | 25 | 27 | 7% |
| | | Heating oil | 2 | 0 | -100% |
| | | Propane | 1 | 2 | 145% |
| Purchased goods & services | Paper consumption | Various | 179 | 160 | -11% |
| Waste generated from operations | Landfill waste | -- | 459 | 346 | -25% |
| Electricity Transmission & Distribution Losses | Purchased electricity | Electricity | 543 | 8 | -99% |
| **Total Scope 3** | | | **19,588** | **17,911** | **-9%** |
| **TOTAL SCOPE 1, 2 & 3** | | | **29,908** | **27,397** | **-8%** |

## 5.2 COMPARISON OF GHG EMISSIONS OVER TIME

As shown in Figure 4, Scope 1 emissions have fluctuated slightly over time. In general, they have been increasing as the volume of natural gas consumed to heat buildings increases (Figure 5). In 2014-15, there was a milder winter and less natural gas was needed to heat buildings. Emissions increased again in 2018-19, but decreased by 9% in 2022-23 due to the purchase of biogas.

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 decreased between 2010-11 and 2018-19 because of fuel efficiency in the commuting category. However, indirect emissions increased again by 13% in 2022-23, partially due to the new inclusion of student exchange travel. 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 at their lowest since 2010-11 and emissions from electricity transmission and distribution losses have been significantly reduced because of improvements in electricity transmission and distribution.

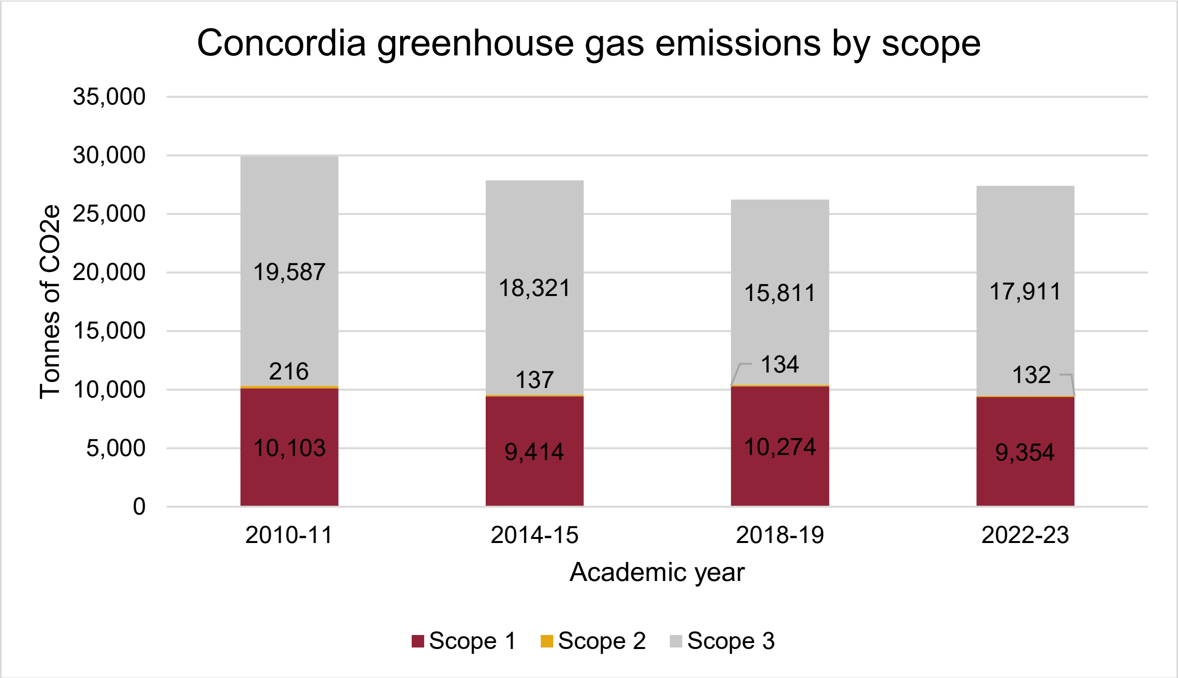



*Figure 4 - Concordia greenhouse gas emissions by scope over time*

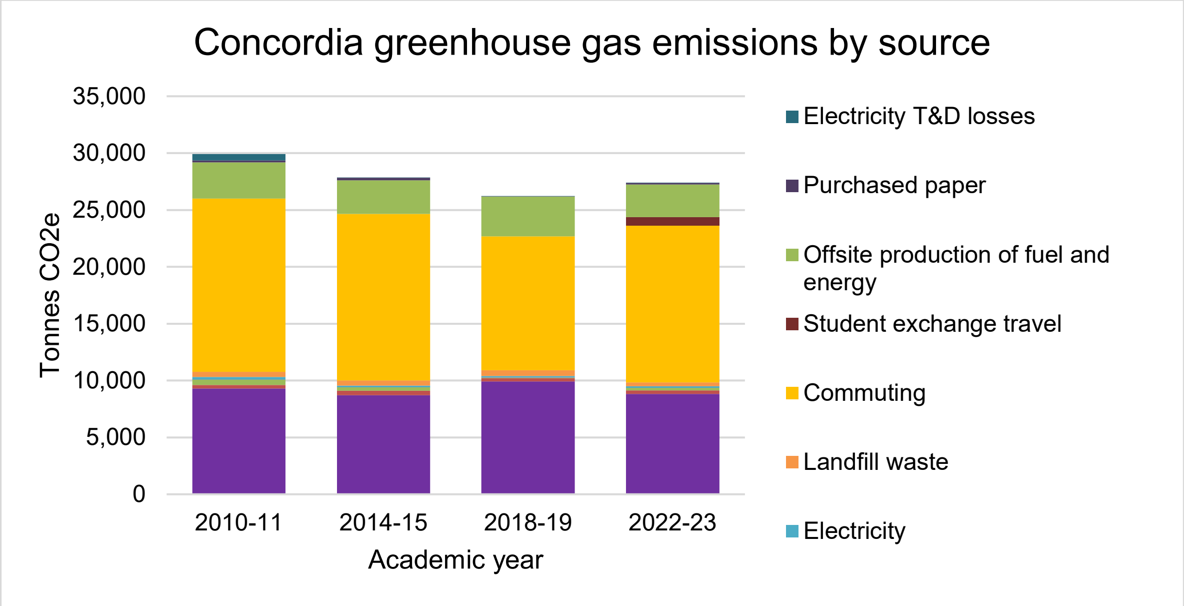



*Figure 5 - Concordia greenhouse gas emissions by source over time*

# 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.

### 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. Purchased goods and services
2. Business travel
3. Water supply and treatment
4. Investments

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.

Carbon offsetting is a mechanism that enables access to emissions reduction and carbon removal outside a company's or institution's organizational boundary. This takes place through the purchase of carbon credits, tradable units that represent one tonne of carbon dioxide or the equivalent amount of a different greenhouse gas (tCO2e) reduced, avoided, or sequestered. Offsetting projects must generate real, quantifiable and verifiable GHG reductions while preserving environmental and social integrity.

However, skepticism and confusion around the validity of carbon offsets as a means of reducing atmospheric carbon levels are common among researchers, scientists and environmental organizations, creating a division in the community. In part, this is due to the lack of standardization that offsetting projects have, as carbon-offset providers generally follow the standard of their choice for validation and verification, usually with a low degree of transparency and accountability. Another concern that has arisen with the use of carbon offsets is the misconception that the purchase of carbon credits can act as a substitute for more ambitious efforts towards direct GHG emissions reduction, as a way for individuals and companies to "greenwash" and make claims about going net-zero or reaching carbon neutrality without needing to change their practices.

For an offsetting project to be considered of high quality, it needs to comply with certain criteria:

1. ***Additionality:*** *GHG reductions are additional if they would have not occurred in the absence of the offset purchase, the project is not already required by current regulations, or it faces economical or technological barriers;*
2. ***Accurate quantification:*** *including a precise quantification of baselines emissions and the avoidance of over-estimation of CO2e reductions;*
3. ***Third-party auditing:*** *to get validation before the project and verification during the development of it by credible and qualified third-party auditors;*
4. ***Unique ownership:*** *the buyer of carbon credits needs to be assured that there is sole ownership of the purchased offsets;*
5. ***Permanence:*** *the project's benefit to the atmosphere should be irreversible;*
6. ***Accounting for unforeseen emissions leakage through buffer pools:*** *having credits accounted as insurance to secure the permanence of the emissions reductions.*

When selecting mission-linked offsetting projects, the following considerations should be assessed:

1. ***Carbon footprint calculation and reduction of emissions:*** *the first step for any institution is to understand what their major emission sources are through carbon calculators, then reduce their emissions as much as possible, and only after reductions are made, a company should purchase carbon credits to offset the remainder of emissions that cannot be reduced yet;*
2. ***Type of project****: there are different types of offsetting projects available, these include renewable energy (displacing fossil-fuel emissions), energy efficiency, capture and destruction of greenhouse gases like methane (CH4), nitrous oxide (N2O), or hydrofluorocarbons (HFCs) from agriculture, livestock and landfill, and biological carbon sequestration through reforestation, afforestation and avoided deforestation;*
3. ***Standard under which the project is certified:*** *choosing a project that follows a stringent and reliable standard can help ensure that key quality criteria are met.*
4. ***Location:*** *prioritizing local, state and regional projects allows a more realistic measurement of CO2e emissions reductions and evaluation of co-benefits, always considering on whose land the projects take place, so the local people's rights are at best interest;*
5. ***Crediting lifetime:*** *the longer this period is, the greater the risk that the baseline has become outdated and inaccurate, some guides suggest a period of eight years as a reasonable balance between certainty and environmental integrity;*
6. ***Price:*** *oftentimes but not always, there is a correlation between price and quality;*
7. ***Sustainability considerations:*** *choosing projects with low risks and great co-benefits for the local communities and the environment, for example, developing employment opportunities, improving the air quality of an area, and enabling sustainable development through improved energy access, community empowerment, health improvements and biodiversity conservation.*

Therefore, a close examination of the value and options available to offset Concordia's emissions will be necessary before implementing a carbon offsetting framework.

# REFERENCES

Broekhoff et al. (2019). *Securing Climate Benefit: A Guide to Using Carbon Offsets*. Stockholm Environment Institute & Greenhouse Gas Management Institute. Offsetguide.org/pdf-download/

Cornell University. (2014). *Cornell Leadership for Climate Neutrality: Strategies & 12 – Month Milestones to Accelerate the Climate Action Plan*. http://csc-production/2015/PublicClimateActionAccelerationReport.pdf

Davidson, E., Hong, B., et al. (2014, July). *Re: Recommendation to accurately account for warming effects of methane*. https://www.eenews.net/assets/2014/07/30/document_gw_02.pdf

David Suzuki Foundation & Pembina Institute. (2009). *Purchasing carbon offsets: A guide for Canadian consumers, businesses and organizations.* https://davidsuzuki.org/science-learning-centre-article/purchasing-carbon-offsets-a-guide-for-canadian-consumers-busi nesses-and-organizations/

Duke Carbon Offsets Initiative. (2014). *Duke Carbon Offsets Initiative 2014 Annual Report*. Duke University. http://sustainability.duke.edu/carbon_offsets/resources/AnnualReport_2014.pdf.

Environment and Climate Change Canada. (2020). *National Inventory Report 1990–2018: Greenhouse Gas Sources and Sinks in Canada. Part 3*. https://publications.gc.ca/collections/collection_2020/eccc/En81-4-2018-3-eng.pdf

Environment and Climate Change Change. (2020). *National Inventory Report 1990–2018: Greenhouse Gas Sources and Sinks in Canada. Part 2.* https://publications.gc.ca/collections/collection_2020/eccc/En81-4-2018-2-eng.pdf

European FluoroCarbons Technical Committee. (2020, July). *Major HFC, HFO and HCFOs; HCFC molecules used as feedstocks. Environmental properties and main applications.* https://www.fluorocarbons.org/wp-content/uploads/2020/07/2020_07_27_Fluorocarbon-Molecules-environmental-properties-and-main-applications-2020-July.pdf

Government of Canada. (2015, May). *Proposed revisions to the Ozone-Depleting Substances Regulations: chapter 3 - Canada.ca*. https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/publications/proposed-revisions-ozone-substances-regulations/chapter-3.html

Helppi et al. (2023). *Review of carbon emissions offsetting guidelines using instructional criteria*. Int J Life Cycle Assess 28, 924–932. https://doi.org/10.1007/s11367-023-02166w

Hyams, K. and Fawcett, T. (2013). *The ethics of carbon offsetting*. WIREs Clim Change, 4: 91-98. https://doi.org/10.1002/wcc.207\

Intergovernmental Panel on Climate Change (IPCC). (2013). *Climate Change 2013: The Physical Science Basis*. Cambridge University Press. https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_all_final.pdf

Kollmuss et al. (2015). *Overview of Carbon Offset Programs*." World Bank. https://openknowledge.worldbank.org/bitstream/handle/10986/21353/COP_eBook.pdf?sequence=1.

Ministry of Environment and Climate Change Strategy. (2021, April). *B.C Best Practices Methodology for Quantifying Greenhouse Gas Emissions*. British Columbia Provincial Government. https://www2.gov.bc.ca/assets/gov/environment/climate-change/cng/methodology/2020-pso-methodology.pdf

Moore, T. (2022). *Here's How Carbon Offsets Can Live up to Their Bold Promises*. Time Magazine. https://time.com/6213480/carbon-offsets-bold-promises-climate-change/

Natural Resources Canada. (2016). *The GHGenius*. Government of Canada. https://www.nrcan.gc.ca/energy/energy-sources-distribution/offshore-oil-and-gas/transportation/the-ghgenius/7597

Terrapass. (2023). *RECs vs. carbon offsets: Demystifying green credit purchases*. https://terrapass.com/blog/recs-vs-carbon-offsets-demystifying-green-credit-purchases/

U.S. Environmental Protection Agency. (2020, November). *Documentation for Greenhouse Gas Emission and Energy Factors Used in Waste Reduction Model (WARM): Organic Materials Chapter*. https://www.epa.gov/sites/production/files/2020-12/documents/warm_organic_materials_v15_10-29-2020.pdf

Ville de Montréal. (2015, December 15). *Montréal Climate Plan: Objective carbon-neutral by 2050*. https://montreal.ca/en/articles/montreal-climate-plan-objective-carbon-neutral-2050-7613

WBCSD & WRI. (2015). *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (revised edition)*. https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf

World Business Council for Sustainable Development & World Resources Institute (WBCSD & WRI). (2015a). *A Corporate Accounting and Reporting Standard*. https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf

World Business Council for Sustainable Development & World Resources Institute (WBCSD & WRI). (2015b). *GHG Protocol Scope 2 Guidance*. https://ghgprotocol.org/sites/default/files/standards/Scope%202%20Guidance_Final_Sept26.pdf

World Business Council for Sustainable Development & World Resources Institute (WBCSD & WRI). (2011). *Corporate Value Chain (Scope 3) Accounting and Reporting Standard*. https://ghgprotocol.org/sites/default/files/standards/Corporate-Value-Chain-Accounting-Reporing-Standard_041613_2.pdf

# APPENDIX A – DETAILED LIST OF SPACES

CU = Concordia University

| **Sir George Williams 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 |
| ER | 2155, Guy Street | Third party | CU, third party | Excluded |
| ES | 2135, Guy Street | CU | CU | Included |
| ET | 2135, Guy Street | CU | Third party | Excluded |
| 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 | 1610 Ste. Catherine W. | CU | CU, third party | Included |
| GA (new) | 1211-1215 St-Mathieu St. | CU | CU | Included |
| GM | 1550 de Maisonneuve | CU | CU, third party | Included |
| GN | 1190 Guy | CU | CU | Included |
| GS | 1538, Sherbrooke W | Third party | CU, third party | Excluded |
| 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 |
| LS (new) | 1535 de Maisonneuve | CU | CU | Included |
| M | 2135 MacKay | CU | CU | Included |
| MB | 1450 Guy | CU | CU | Included |
| MI | 2130 Bishop | CU | CU | Included |
| MK (new) | 2000-2002 MacKay | CU | Third party | Included |
| MM (new) | 1209 Guy | CU | CU | Included |
| MN (new) | 1205-1207 Guy | CU | CU | Included |
| MO (new) | 1201 Guy | CU | CU | Included |
| MT | 1195 Guy | CU | CU | Included |
| MU | 2170 Bishop | CU | CU | Included |
| MV (new) | 1189 Guy | CU | CU | Included |
| MW (new) | 1181 Guy | CU | CU | Included |
| NB (new) | 2081-2087 Guy | CU | Third party | 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 |
| SA | 4710, rue St-Ambroise | Third party | CU, third party | Excluded |
| 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 |
| VR (new) | 2130 Mackay | CU | CU, Third party | Included |
| WR (new) | 2142-2144 Mackay | CU | CU, Third party | Included |
| X | 2080 MacKay | CU | CU | Included |
| Z | 2090 MacKay | CU | CU | Included |

| Loyola Campus | | | | |
|---|---|---|---|---|
| **Building** | **Address** | **Space type** | | **Included/ Excluded in inventory** |
| | | **Ownership** | **Usage** | |
| AD | 7141 Sherbrooke W. | CU | CU | Included |
| BB | 3502 Belmore | CU | Third-party | Included |
| BH | 3500 Belmore | CU | Third party | Included |
| CC | 7141 Sherbrooke W. | CU | CU | Included |
| CJ | 7141 Sherbrooke W. | CU | CU | Included |
| CV | 5800, boulevard Cavendish | Third party | CU | Excluded |
| 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 |
| HU (new) | 7141 Sherbrooke W. | CU | CU | Included |
| JR | 7141 Sherbrooke W. | CU | CU | Included |
| PB (new) | 7200 Sherbrooke W. | 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 | 7075 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

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

$CO_2e$ 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**

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

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 2023 Commuter Habits Survey

**SCOPE 3 FUEL- & ENERGY-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 $CO_2$